Particle Physics Division
Fachverband Teilchenphysik (T)

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Overview of Invited Talks and Sessions

(Lecture halls ZHG010, ZHG011, ZHG104, ZHG105, VG 0.110, VG 0.111, VG 1.101, VG 1.102, VG 1.103, VG 1.104, VG 1.105, VG 2.101, VG 2.102, VG 2.103, VG 3.101, VG 3.102, VG 3.103, VG 3.104, VG 4.101, and VG 4.102)

Invited Overview Talks

T 42.1	Wed	11:00–11:30	ZHG011	**Direct neutrino-mass measurements - current and next generations** — •Magnus Schlösser
T 42.2	Wed	11:30–12:00	ZHG011	**Mapping out the Higgs Boson: Highlights from the LHC Experiments** — •Elisabeth Schopf
T 42.3	Wed	12:00–12:30	ZHG011	**Computing at the LHC and its transformation towards the HL-LHC** — •Sebastian Wozniewski
T 43.1	Wed	13:45–14:15	ZHG011	**Advances in Silicon Detectors** — •Matthias Hamer
T 43.2	Wed	14:15–14:45	ZHG011	**Exploring the dark universe: the experimental quest for axions and ALPs** — •Julia K. Vogel
T 43.3	Wed	14:45–15:15	ZHG011	**Overview on coherent elastic neutrino nucleus scattering and successful first detections** — •Janina Hakenmüller
T 43.4	Wed	15:15–15:45	ZHG011	**Shifting paradigms in Gravitational-wave Astrophysics** — •Imre Bartos
T 63.1	Thu	11:00–11:30	ZHG011	**Neutrino properties from the laboratory and the cosmos** — •Thomas Schwetz-Mangold
T 63.2	Thu	11:30–12:00	ZHG011	**Highlights from Standard Model physics at the LHC in the precision era** — •Daniel Savoiu
T 63.3	Thu	12:00–12:30	ZHG011	**Cosmological results from the Dark Energy Spectroscopic Instrument** — •Daniel Gruen
T 105.1	Fri	11:00–11:30	ZHG011	**Galactic Astrophysics with H.E.S.S.** — •Lars Mohrmann
T 105.2	Fri	11:30–12:00	ZHG011	**Physics in the era of big data: AI in particle and astroparticle physics** — •Jonas Glombitza
T 105.3	Fri	12:00–12:30	ZHG011	**What the LHC tells us about the top quark, the heaviest particle in nature** — •Matthias Komm
T 105.4	Fri	12:30–13:00	ZHG011	**The flavor intensity frontier: latest results from Belle II and LHCb** — •Daniel Greenwald

Invited Topical Talks

T 20.1	Tue	13:45–14:15	ZHG011	**An introduction to gas electron multipliers and their time to shine during the CMS phase 2 upgrade** — •Shawn Zaleski
T 20.2	Tue	14:15–14:45	ZHG011	**Searches for rare Higgs boson decays** — •Martina Laura Ojeda
T 20.3	Tue	14:45–15:15	ZHG011	**Novel opportunities with the LHCb Software Trigger** — •Titus Mombächer
T 20.4	Tue	15:15–15:45	ZHG011	**Dark sector searches with invisible and displaced signatures at Belle II** — •Giacomo De Pietro
T 21.1	Tue	13:45–14:15	ZHG010	**The KM3NeT Ultra-High Energy Neutrino and its Possible Astrophysical Origins** — •Massimiliano Lincetto

T 21.2	Tue	14:15–14:45	ZHG010	**Multimessenger astronomy with ultra-high-energy cosmic rays and high-energy neutrinos** — •Foteini Oikonomou
T 21.3	Tue	14:45–15:15	ZHG010	**Peering into the Cosmos from Deep Underground – Astroparticle Physics with Xenon Detectors** — •Christian Wittweg
T 21.4	Tue	15:15–15:45	ZHG010	**Feebly Interacting Particles in the Early Universe** — •Mathias Becker
T 64.1	Thu	13:45–14:15	ZHG011	**Performance of the ATLAS New Small Wheels** — •Fabian Vogel
T 64.2	Thu	14:15–14:45	ZHG011	**Top quark and friends** — •Jan van der Linden
T 64.3	Thu	14:45–15:15	ZHG011	**Searching for New Physics in Soft Unclustered Energy Patterns** — •Alexander Lory
T 64.4	Thu	15:15–15:45	ZHG011	**Alignment and calibration at the LHCb experiment** — •Biljana Mitreska
T 65.1	Thu	13:45–14:15	ZHG010	**Searching for Axions and other Light Bosons at DESY** — •Jacob Egge
T 65.2	Thu	14:15–14:45	ZHG010	**14 years of coordinated outreach for particle physics: methods, impact and prospects** — •Saskia Plura, Uta Bilow, Michael Kobel, Achim Denig, Heike Vormstein, Mirco Christmann
T 65.3	Thu	14:45–15:15	ZHG010	**The Emerging Population of Seyfert Galaxies as Neutrino Sources in IceCube** — •Chiara Bellenghi, Tomas Kontrimas, Elena Manao
T 65.4	Thu	15:15–15:45	ZHG010	**First detection of neutrinos in water-based liquid scintillator at ANNIE** — •Johann Martyn

Invited Talks of the joint Symposium SMuK Dissertation Prize 2025 (SYMD)

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:15–14:45	ZHG011	**Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma** — •Federica Capellino
SYMD 1.2	Mon	14:45–15:15	ZHG011	**Fast and faithful effective-one-body models for gravitational waves from generic compact binaries** — •Rossella Gamba
SYMD 1.3	Mon	15:15–15:45	ZHG011	**Nuclear Structure Near Doubly Magic Nuclei** — •Lukas Nies
SYMD 1.4	Mon	15:45–16:15	ZHG011	**Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers** — •Tim Ziegler

Invited Talks of the joint Awards Symposium (SYAS)

See SYAS for the full program of the symposium.

SYAS 1.1	Tue	11:05–11:35	ZHG011	**Zum Verhältnis von Physikdidaktik und Physikunterricht** — •Rita Wodzinski
SYAS 1.2	Tue	11:35–12:05	ZHG011	**(Quanten-)Physik für alle mit dem PhotonLab** — •Silke Stähler-Schöpf
SYAS 1.3	Tue	12:05–12:35	ZHG011	**Searching for the fingerprints of new phenomena with top quarks** — •Katharina Behr

Sessions

T 1.1–1.7	Mon	16:45–18:30	ZHG010	**Searches/BSM I (HNL, ETmiss+X)**
T 2.1–2.8	Mon	16:45–18:45	ZHG104	**Higgs Physics I (HH and trilinear coupling)**
T 3.1–3.7	Mon	16:45–18:30	ZHG105	**Higgs Physics II (BSM Higgs)**
T 4.1–4.6	Mon	16:45–18:15	VG 0.110	**Detectors I (Scintillators)**
T 5.1–5.6	Mon	16:45–18:15	VG 0.111	**Silicon Detectors I (ATLAS + CMS)**
T 6.1–6.6	Mon	16:45–18:15	VG 1.101	**Silicon Detectors II (Belle II, Tristan)**
T 7.1–7.5	Mon	16:45–18:00	VG 1.102	**Detectors II (Gaseous Detectors)**
T 8.1–8.6	Mon	16:45–18:15	VG 1.103	**Top Physics I (tt+X)**
T 9.1–9.6	Mon	16:45–18:15	VG 1.104	**Flavour Physics I**
T 10.1–10.7	Mon	16:45–18:30	VG 1.105	**Neutrino Astronomy I**
T 11.1–11.5	Mon	16:45–18:00	VG 2.101	**Data, AI, Computing, Electronics I (Statistical Methods, Applications)**
T 12.1–12.6	Mon	16:45–18:15	VG 2.102	**Data, AI, Computing, Electronics II (Data Management, Workflow)**
T 13.1–13.4	Mon	16:45–17:45	VG 2.103	**Sustainability**

T 14.1–14.5	Mon	16:45–18:00	VG 3.101	**Methods in Astroparticle Physics I**
T 15.1–15.6	Mon	16:45–18:15	VG 3.102	**Cosmic Rays I**
T 16.1–16.6	Mon	16:45–18:15	VG 3.103	**Neutrino Physics I**
T 17.1–17.6	Mon	16:45–18:15	VG 3.104	**Neutrino Physics II**
T 18.1–18.7	Mon	16:45–18:30	VG 4.101	**Methods in Particle Physics I (Calo, Jets, Tagging)**
T 19.1–19.8	Mon	16:45–18:45	VG 4.102	**Search for Dark Matter I**
T 20.1–20.4	Tue	13:45–15:45	ZHG011	**Invited Topical Talks I**
T 21.1–21.4	Tue	13:45–15:45	ZHG010	**Invited Topical Talks II**
T 22.1–22.1	Tue	12:35–13:45	ZHG011	**Annual Meeting of Young Scientists in High Energy Physics**
T 23.1–23.7	Tue	16:15–18:00	ZHG010	**Searches/BSM II (Non-collider)**
T 24.1–24.6	Tue	16:15–17:45	ZHG104	**Higgs Physics III (boson final states)**
T 25.1–25.6	Tue	16:15–17:45	ZHG105	**Higgs Physics IV (BSM Higgs)**
T 26.1–26.6	Tue	16:15–17:45	VG 0.110	**Axions/ALPs I**
T 27.1–27.8	Tue	16:15–18:15	VG 0.111	**Silicon Detectors III (ATLAS + CMS production)**
T 28.1–28.6	Tue	16:15–17:45	VG 1.101	**Silicon Detectors IV (SiPMs, HG timing)**
T 29.1–29.5	Tue	16:15–17:30	VG 1.102	**Detectors III (Scintillators)**
T 30.1–30.6	Tue	16:15–17:45	VG 1.103	**Top Physics II (Properties)**
T 31.1–31.8	Tue	16:15–18:15	VG 1.104	**Flavour physics II**
T 32.1–32.7	Tue	16:15–18:00	VG 1.105	**Neutrino Astronomy II**
T 33.1–33.6	Tue	16:15–17:45	VG 2.101	**Data, AI, Computing, Electronics III (ML in Jet Tagging, Misc.)**
T 34.1–34.8	Tue	16:15–18:15	VG 2.102	**Data, AI, Computing, Electronics IV (DAQ, Detector Electronics)**
T 35.1–35.6	Tue	16:15–17:45	VG 2.103	**Electroweak Physics I (Weak Mixing Angle, Tau Production)**
T 36.1–36.6	Tue	16:15–17:45	VG 3.101	**Methods in Astroparticle Physics II**
T 37.1–37.6	Tue	16:15–17:45	VG 3.102	**Cosmic Rays II**
T 38.1–38.7	Tue	16:15–18:00	VG 3.103	**Neutrino Physics III**
T 39.1–39.6	Tue	16:15–17:45	VG 3.104	**Neutrino Physics IV**
T 40.1–40.7	Tue	16:15–18:00	VG 4.101	**Methods in Particle Physics II (Misc.)**
T 41.1–41.7	Tue	16:15–18:00	VG 4.102	**Search for Dark Matter II**
T 42.1–42.3	Wed	11:00–12:30	ZHG011	**Invited Overview Talks I**
T 43.1–43.4	Wed	13:45–15:45	ZHG011	**Invited Overview Talks II**
T 44.1–44.8	Wed	16:15–18:15	ZHG010	**Searches/BSM III (Long-lived, Misc.)**
T 45.1–45.8	Wed	16:15–18:15	ZHG104	**Higgs Physics V (HH and Trilinear Coupling)**
T 46.1–46.8	Wed	16:15–18:15	ZHG105	**Higgs Physics VI (top-Higgs Coupling)**
T 47.1–47.8	Wed	16:15–18:15	VG 0.110	**Axions/ALPs II**
T 48.1–48.10	Wed	16:15–18:45	VG 0.111	**Silicon Detectors V (R&D, Simulation)**
T 49.1–49.6	Wed	16:15–17:45	VG 1.101	**Detectors IV (Scintillators)**
T 50.1–50.4	Wed	16:15–17:15	VG 1.102	**Detectors V (Misc.)**
T 51.1–51.8	Wed	16:15–18:15	VG 1.103	**Top Physics III (Cross Sections, Entanglement)**
T 52.1–52.8	Wed	16:15–18:15	VG 1.104	**Flavour Physics III**
T 53.1–53.8	Wed	16:15–18:15	VG 1.105	**Neutrino Astronomy III**
T 54.1–54.8	Wed	16:15–18:15	VG 2.101	**Data, AI, Computing, Electronics V (Anomaly Detection, Event Selection)**
T 55.1–55.9	Wed	16:15–18:30	VG 2.102	**Data, AI, Computing, Electronics VI (DAQ and Trigger)**
T 56.1–56.7	Wed	16:15–18:00	VG 2.103	**Electroweak Physics II (Multi-boson Processes)**
T 57.1–57.8	Wed	16:15–18:15	VG 3.101	**Gamma Astronomy I**
T 58.1–58.7	Wed	16:15–18:00	VG 3.102	**Cosmic Rays III**
T 59.1–59.9	Wed	16:15–18:30	VG 3.103	**Neutrino Physics V**
T 60.1–60.7	Wed	16:15–18:00	VG 3.104	**Gravitational Waves**
T 61.1–61.8	Wed	16:15–18:15	VG 4.101	**Methods in Particle Physics III (Tracking)**
T 62.1–62.9	Wed	16:15–18:30	VG 4.102	**Search for Dark Matter III**
T 63.1–63.3	Thu	11:00–12:30	ZHG011	**Invited Overview Talks III**
T 64.1–64.4	Thu	13:45–15:45	ZHG011	**Invited Topical Talks III**
T 65.1–65.4	Thu	13:45–15:45	ZHG010	**Invited Topical Talks IV**
T 66.1–66.7	Thu	16:15–18:00	ZHG010	**Searches/BSM IV (BSM with Tops, LQs)**
T 67.1–67.10	Thu	16:15–18:45	ZHG104	**Higgs Physics VII (HH and Trilinear Coupling)**
T 68.1–68.9	Thu	16:15–18:30	ZHG105	**Higgs Physics VIII (CP)**
T 69.1–69.8	Thu	16:15–18:15	VG 0.110	**Strong Interaction / QCD**
T 70.1–70.9	Thu	16:15–18:30	VG 0.111	**Silicon Detectors VI (MAPS, Mighty Tracker)**
T 71.1–71.8	Thu	16:15–18:15	VG 1.101	**Detectors VI (Gaseous Detectors)**

T 72.1–72.9	Thu	16:15–18:30	VG 1.102	**Detectors VII (Calorimeters)**
T 73.1–73.9	Thu	16:15–18:30	VG 1.103	**Flavour Physics IV**
T 74.1–74.8	Thu	16:15–18:15	VG 1.104	**Flavour Physics V**
T 75.1–75.9	Thu	16:15–18:30	VG 1.105	**Neutrino Astronomy IV**
T 76.1–76.10	Thu	16:15–18:45	VG 2.101	**Data, AI, Computing, Electronics VII (Generative AI, MC Generators)**
T 77.1–77.8	Thu	16:15–18:15	VG 2.102	**Data, AI, Computing, Electronics VIII (Fast ML, Triggers)**
T 78.1–78.8	Thu	16:15–18:15	VG 2.103	**Gamma Astronomy II**
T 79.1–79.8	Thu	16:15–18:15	VG 3.101	**Methods in Astroparticle Physics III**
T 80.1–80.7	Thu	16:15–18:00	VG 3.102	**Cosmic Rays IV**
T 81.1–81.8	Thu	16:15–18:15	VG 3.103	**Neutrino Physics VI**
T 82.1–82.8	Thu	16:15–18:15	VG 3.104	**Neutrino Physics VII**
T 83.1–83.10	Thu	16:15–18:45	VG 4.101	**Methods in Particle Physics IV (Lepton Reconstruction)**
T 84.1–84.10	Thu	16:15–18:45	VG 4.102	**Search for Dark Matter IV**
T 85	Thu	19:00–20:00	ZHG104	**Members' Assembly**
T 86.1–86.6	Fri	9:00–10:30	ZHG010	**Searches/BSM V (Misc.)**
T 87.1–87.5	Fri	9:00–10:15	ZHG104	**Higgs physics IX (Charm and Tau Final States)**
T 88.1–88.6	Fri	9:00–10:30	ZHG105	**Miscellaneous**
T 89.1–89.6	Fri	9:00–10:30	VG 0.110	**Axions/ALPs III**
T 90.1–90.6	Fri	9:00–10:30	VG 0.111	**Silicon Detectors VII (ATLAS + CMS phase-2)**
T 91.1–91.6	Fri	9:00–10:30	VG 1.101	**Silicon Detectors VIII (MAPS, misc.)**
T 92.1–92.6	Fri	9:00–10:30	VG 1.102	**Detectors VIII (Gaseous Detectors)**
T 93.1–93.4	Fri	9:00–10:00	VG 1.103	**Top Physics IV (Misc.)**
T 94.1–94.6	Fri	9:00–10:30	VG 1.104	**Flavour Physics VI**
T 95.1–95.5	Fri	9:00–10:15	VG 1.105	**Outreach**
T 96.1–96.6	Fri	9:00–10:30	VG 2.101	**Detectors IX (Calorimeters)**
T 97.1–97.6	Fri	9:00–10:30	VG 2.102	**Data, AI, Computing, Electronics IX (AI-based Object Reconstruction)**
T 98.1–98.6	Fri	9:00–10:30	VG 2.103	**Electroweak Physics III (W/Z Production and Properties)**
T 99.1–99.6	Fri	9:00–10:30	VG 3.101	**Methods in Astroparticle Physics IV**
T 100.1–100.5	Fri	9:00–10:15	VG 3.102	**Cosmic Rays V**
T 101.1–101.6	Fri	9:00–10:30	VG 3.103	**Neutrino Physics VIII**
T 102.1–102.6	Fri	9:00–10:30	VG 3.104	**Neutrino Physics IX**
T 103.1–103.6	Fri	9:00–10:30	VG 4.101	**Methods in Particle Physics V (Event Reconstruction, PID)**
T 104.1–104.6	Fri	9:00–10:30	VG 4.102	**Search for Dark Matter V**
T 105.1–105.4	Fri	11:00–13:00	ZHG011	**Invited Overview Talks IV**

Members' Assembly of the Particle Physics Division

Thursday 19:00–20:00 ZHG104

T 1: Searches/BSM I (HNL, ETmiss+X)

Time: Monday 16:45–18:30 Location: ZHG010

T 1.1 Mon 16:45 ZHG010

Simulation of heavy neutral lepton production and decays with the Sherpa event generator — •Antonia Bähr — TU Dresden - Institute for Nuclear and Particle Physics

The physics of neutrinos still pose some questions, particularly why they are so much lighter than other leptons. One explanation for this is the seesaw mechanism, where right-handed neutrinos are introduced to the Standard Model. This results in the Lagrangian density not only containing a Dirac but also a Majorana mass term. Because of this, there are two neutrino mass eigenstates, a light and a heavy one. The light neutrino is expected to be the one that has already been observed in numerous experiments, while the heavy one would be a new kind of particle, a heavy neutral lepton. Since the heavy neutral lepton would mostly be right-handed, it is not easily detectable as it would not be affected by any of the fundamental forces, apart from gravity. However, current research at the LHC investigate the decay products of heavy neutral leptons, in order to prove their existence. To achieve this, we are simulating the production of heavy neutral leptons in proton-proton collisions and their decay using Sherpa, a Monte Carlo event generator for the simulation of high-energy reactions.

In this study, we will especially include the hadronic decays of the heavy neutral leptons and the vertex offsets, as heavy neutral leptons are relatively long lived particles and therefore do not decay immediately. In this talk I will present the first results from these simulations in context of a typical LHC setup.

T 1.2 Mon 17:00 ZHG010

Search for heavy neutral leptons in decays of W bosons using leptonic and semi-leptonic displaced vertices in center-of-mass energy of 13 TeV p p collisions with the ATLAS detector — •Marzieh Bahmani — Humboldt university, Berlin, Germany

In this talk, I will present a search for long-lived heavy neutral leptons (HNLs), which are produced through the decay of a W-boson into a muon or electron and an HNL. We investigate two distinct decay channels: a leptonic channel, where the HNL decays into two leptons and a neutrino, and a semi-leptonic channel, where the HNL decays into a lepton and a charged pion. This search is based on 140 fb-1 of proton-proton collision data in center-of-mass energy of 13 TeV, collected by the ATLAS detector during Run 2 of the LHC. I will discuss the results within the context of both single-flavor and multi-flavor mixing scenarios and their implications for future searches in this exciting area of particle physics.

T 1.3 Mon 17:15 ZHG010

Searching for type I seesaw mechanism in a two Heavy Neutral Leptons scenario at FCC-ee — Sehar Ajmal[1], Patrizia Azzi[2], •Sofia Giappichini[3], Markus Klute[3], Orlando Panella[1], Matteo Presilla[3], and Xunwu Zuo[3] — [1]INFN Perugia, Perugia, Italy — [2]INFN Padova, Padova, Italy — [3]KIT, Karlsruhe, Germany

This contribution reports the search for heavy neutral leptons (HNL) in the type I seesaw mechanism at the Future Circular Collider in its e+*e* stage (FCC-ee), considering an integrated luminosity of 204 ab^{-1} collected at the Z pole. The study examines two generations of heavy neutral leptons produced in association with Standard Model (SM) neutrinos and decaying to a purely leptonic final state. This theoretical framework can explain neutrino oscillations and other open questions of the SM, providing a broader perspective on the relevance of this experimental search. The analysis is performed using a fast simulation of the IDEA detector concept to study potential HNL interactions at the FCC-ee. The sensitivity contours are obtained from a selection of kinematic variables aimed at improving the signal-to-background ratio for the prompt production case. In the case of long-lived HNLs, the background can be almost fully eliminated by exploiting their displaced decay vertices. The study shows that the FCC-ee has a significant sensitivity to observing these objects in a region of the phase space not accessible by other experiments.

T 1.4 Mon 17:30 ZHG010

Searching for heavy neutral leptons at the NA62 experiment in beam dump mode — •Jonathan Schubert — Max-Planck-Institut for Physics (Werner-Heisenberg-Institut), Boltzmannstr. 8, 85748 Garching, Germany — Technical University of Munich, TUM School of Natural Sciences, Physics Department, Chair for Data Science in Physics, 85748 Garching, Germany

Heavy neutral leptons are a commonly considered hypothetical class of particles with the potential to explain several puzzles of fundamental physics. The NA62 experiment at the CERN SPS can be operated in beam-dump mode, where 400 GeV protons are dumped on an absorber. Due to the large number of interactions in the dump feebly interacting particles like heavy neutral leptons may be produced abundantly. Their downstream decays could be observed with excellent sensitivity using the existing detector apparatus. We report on the status of the first search at NA62 for such decay signatures.

T 1.5 Mon 17:45 ZHG010

Search for new physics in the electron plus missing transverse momentum channel using Run-3 CMS data — Thomas Hebbeker, Kerstin Hoepfner, •Mirac Noyan Özdemir, Valentina Sarkisovi, Alexander Schmidt, and Karl Joseph Schumacher — III. Physikalisches Institut A, RWTH Aachen University

There are many Beyond the Standard Model (BSM) theories that predict new particles in the final state with a high-energy lepton and missing transverse momentum as their experimental signature. Now, using the newly acquired data of the CMS detector from the ongoing Run-3 at an unprecedented center-of-mass energy of 13.6 TeV, a new window is opened for searches in the high-energy regions.

This talk presents the main ideas behind a high-energy physics search and the analysis strategy in the electron plus missing transverse momentum channel. First results, like the comparison of 2022+2023 data to the Standard Model background, the resulting exclusion limit on the Sequential Standard Model (SSM) W' boson mass, as well as the variable coupling strength limit and a model independent (MI) limit, are being shown.

T 1.6 Mon 18:00 ZHG010

Search for New Physics in Events With an Energetic Jet and Missing Transverse Momentum With the ATLAS Experiment — •Moritz Hesping, Volker Büscher, Christian Schmitt, and Duc Bao Ta — Johannes Gutenberg Universität Mainz

A wide range of theories beyond the Standard Model predict particles which only weakly interact with SM particles. If such particles are produced in collisions at the Large Hadron Collider, they are invisible to the detector. However, their presence can be inferred from a large missing transverse momentum when they recoil off a highly energetic jet. This requires a precise estimation of the SM processes resulting in a similar signature, such as the production of Z bosons decaying to neutrinos.

Searches for new physics in such events have been previously carried out at the ATLAS experiment using the full 140 fb^{-1} dataset of the LHC Run 2 (2015-2018). This talk shows the progress of an updated analysis using data from the ongoing LHC Run 3, which has already exceeded Run 2 in luminosity, including an overview of the analysis strategy and data-simulation comparisons in the control regions.

T 1.7 Mon 18:15 ZHG010

Search for new physics in the final state with a tau lepton and missing transverse momentum. — •Valentina Sarkisovi, Kerstin Hoepfner, Alexander Schmidt, and Thomas Hebbeker — III. Physikalisches Institut A

Various Beyond the Standard Model (BSM) theories anticipate the existence of new particles that could decay into final states characterized by the presence of a charged lepton and missing transverse momentum (pT_miss) as their most distinctive experimental signature. The CMS detector at the CERN LHC is used to hunt for novel physics in the high mass region of final states containing a tau lepton and pT_miss. Efficient identification and reconstruction of TeV tau leptons, good description of the high mass region and effective search for the wide range of BSM models are crucial in a tau + pT_miss search for such phenomena. CMS data recorded in 2022 and 2023 in pp collisions with the center-of-mass energy of 13.6 TeV have been analysed. This talk addresses the key concepts of the analysis techniques employed in the search for new physics in the final state with a tau lepton and pT_miss, including various theoretical interpretations. Models with enhanced coupling to third generation leptons are of special interest.

T 2: Higgs Physics I (HH and trilinear coupling)

Time: Monday 16:45–18:45 Location: ZHG104

T 2.1 Mon 16:45 ZHG104

Status for Run3 in the $HH \longrightarrow b\bar{b}\tau^+\tau^-$ channel with the CMS Experiment — •Bogdan Wiederspan, Nathan Prouvost, Ana Andrade, Marcel Rieger, Philip Keicher, Anas Haddad, Tobias Kramer, and Peter Schleper — University Hamburg, Hamburg, Germany

Since its discovery at the Large Hadron Collider (LHC) in 2012, the Higgs boson advanced our understanding of the Standard Model. Despite significant progress, several of its fundamental properties and couplings remain elusive. Among these is the concrete form of the Higgs potential, which depends on the still-undiscovered trilinear self-coupling, often denoted in the kappa framework as κ_λ. The Di-Higgs production with subsequent decays into pairs of bottom quarks and tau leptons, holds particular interest to probe aforementioned coupling, due to its combination of a strong identifiable signature and substantially large statistics.

Given the challenges posed by the small predicted cross section of Di-Higgs processes and the large background contribution, machine learning proves to be an essential tool for enhancing the sensitivity of searches. This talk presents the current efforts of developing a stronger discriminator trained with partial Run3 data recorded with the CMS experiment, to classify events in the $HH \longrightarrow b\bar{b}\tau^+\tau^-$ channel and further increasing sensitivity.

T 2.2 Mon 17:00 ZHG104

Search for Di-Higgs Pair Production in the bbtautau decay channel using Run2+Run3 Data with the ATLAS Detector at the LHC. — •Bhupesh Dixit[1,2], Carl Gwilliam[3], Jordy Degens[4], and Katharina Behr[5] — [1]University of Liverpool, United Kingdom — [2]DESY, Hamburg — [3]University of Liverpool, United Kingdom — [4]University of Liverpool, United Kingdom — [5]DESY, Hamburg

Di-Higgs studies provide the possibility of probing the full shape of the Higgs potential via constraints on the Higgs trilinear coupling. Among all the di-Higgs decay channels, di-Higgs decays to two b-jets and two tau-leptons lies in the sweetspot for the study of di-Higgs owing to its relatively low background and significant branching ratio, making it the most sensitive channel among the ATLAS Run-2 searches for the study of Higgs self-coupling. Using Run2+Run3 data with improved analysis techniques a significant improvement is expected in the sensitivity to Higgs boson pair production. I will present an overview of the analysis strategy and current status with emphasis on the estimate of the important background from SM ttbar production.

T 2.3 Mon 17:15 ZHG104

Phase Space Optimization for the $b\bar{b}\tau^-\tau^+$ Di-Higgs Analysis using Machine Learning with the CMS Experiment — Ana Andrade, •Anas Haddad, Philip Keicher, Tobias Kramer, Nathan Prouvost, Marcel Rieger, Peter Schleper, and Bogdan Wiederspan — Institute for experimental physics, University of Hamburg, Hamburg, Germany

This year marks the twelfth anniversary of the Higgs boson discovery. Yet, many of its properties and couplings remain unexplored. Particularly interesting are the couplings producing a Di-Higgs system in the final state, which are modulated as κ_λ and κ_{2V} in the κ-framework and pose a significant challenge for analyses due to the extremely low cross-sections of their production processes.

Since an efficient usage of the available data is crucial in such analyses, the selection is an important part and decisive for all following analysis steps and resulting measurements. However, one is always confronted with the dilemma of having to trade off higher event statistics for large background contamination in the selected phase space, or vice versa.

This study aims to move away from a fully cut-based selection, usually based on a certain topology, towards a more data-driven approach. The latter utilizes a NN on top of a loose preselection with the goal of optimizing the event selection in the search for Di-Higgs production in the $b\bar{b}\tau^-\tau^+$ channel and enhancing the sensitivity of this analysis.

T 2.4 Mon 17:30 ZHG104

Neural-network-based di-tau mass reconstruction in Higgs boson pair production in the final state with two b quarks and two tau leptons — •Jonathan Pampel, Tatjana Lenz Lenz, and Jochen Dingfelder — Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn

The Higgs boson self interaction could not yet be observed at the Large Hadron Collider due to the rarity of associated processes, such as Higgs boson pair production. Upper limits on the Higgs self-coupling strength have been set using ATLAS and CMS pp data from LHC Run 2. Run 3 data will improve the limits on the HH production cross section and on the Higgs self coupling.

Tau leptons provide a relatively distinct signature (triggering) during data taking and with a probability of about 6% for Higgs bosons to decay into tau pairs, this process is rather frequent. However, the most abundant decay mode for Higgs bosons is the decay into two b quarks. The HH->bb$\tau\tau$ decay mode benefits from both advantages.

One of the challenges of studying this decay mode is the reconstruction of the invariant mass of the di-tau system. This has long been done using a fitting tool – the missing mass calculator (MMC) – which performs well, but is computationally expensive and sometimes does not converge. To mitigate this issue, a neural network (NN) can be used since its evaluation is faster and there is no convergence issue.

This talk will present the training and the performance of the NN-based method for di-tau mass reconstruction, applied to ATLAS pp collision data from Runs 2 and 3.

T 2.5 Mon 17:45 ZHG104

Study of b+tau triggers in the $HH \to bb\tau\tau$ analysis with the ATLAS experiment — •Pim Bijl, Karl Jakobs, Benedict Winter, Christian Weiser, and Yingjie Wei — Insitute of Physics, Albert Ludwigs Universitaet, Freiburg, Germany

In order to search for di-Higgs production at the Large Hadron Collider (LHC) with the ATLAS experiment, a very efficient event selection is necessary. The first step in the event selection are triggers that decide what LHC collision events are kept for further analysis. This talk will present a study of newly introduced triggers that target the presence of a b-quark jet and a hadronically decaying tau lepton. These triggers are of great interest to the search for di-Higgs production, as they target the signature of the $HH \to bb\tau\tau$ decay channel. This decay channel has one of the largest branching ratios of di-Higgs decays and provides a clean decay signature. A comparison will be made to the efficiency of the triggers that are currently in use in the $HH \to bb\tau\tau$ search. Finally, the impact of the new triggers on the sensitivity to the production of di-Higgs in the $bb\tau\tau$ decay channel will be summarized.

T 2.6 Mon 18:00 ZHG104

Improving the sensitivity to the Higgs boson self-coupling in the $HH \to bb\tau\tau$ channel with the ATLAS experiment — •Katharina Häussler[1], Karl Jakobs[1], Karsten Köneke[2], Yingjie Wei[1], Christian Weiser[1], and Benedict Winter[1] — [1]University of Freiburg — [2]University of Göttingen

The Standard Model (SM) predicts final states with multiple Higgs bosons, involving processes with Higgs boson self-interactions, which have yet to be observed experimentally. Higgs boson pair production provides the most sensitive test of triple Higgs boson self-interactions and the $bb\tau\tau$ final state presents a good compromise between expected signal yield and background contamination, making it one of the three golden channels to explore this phenomenon.

This talk focuses on improvements that can be made in future analyses to increase the sensitivity to the Higgs boson self-coupling modifier κ_λ. Significant deviations from the SM prediction would provide a strong indication of physics beyond the Standard Model.

T 2.7 Mon 18:15 ZHG104

$\tau\tau$ background estimation with the τ-embedding method of CMS in Run3 — •Jannik Demand, Christian Winter, Artur Gottmann, Roger Wolf, and Günter Quast — ETP, Karlsruhe Institute of Technology, Karlsruhe, Germany

In $H \to \tau\tau$ analyses a major source of background are genuine tau leptons, mostly originating from $Z \to \tau\tau$ decays. The τ-embedding method is a method to estimate this background from data, by replacing muons in selected events in data with simulated τ-decays. This talk will explain the method and gives a report on its applicability on

Run3 data.

T 2.8 Mon 18:30 ZHG104

BSM X → YH searches in bb$\tau\tau$ final states with the CMS experiment — •Quanshan Li, Moritz Molch, Nikita Shadskiy, Roger Wolf, and Ulrich Husemann — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

BSM theory introduces additional Higgs bosons with different masses next to the Standard Model Higgs boson H. This talk presents a search for the decay of a heavy scalar boson X into two lighter scalar bosons Y and H with the data recorded during the LHC Run 2.

To distinguish the signal from backgrounds, a parametric neural network is used, enabling the training and evaluation of one single deep neural network for various X and Y mass hypotheses. Data-driven methods are utilized for background estimation. In addition, a comparison of the background prediction with data is shown in control regions.

T 3: Higgs Physics II (BSM Higgs)

Time: Monday 16:45–18:30 Location: ZHG105

T 3.1 Mon 16:45 ZHG105

Search for light pseudoscalar Higgs bosons in the four-kaon final state with the CMS detector — Nils Faltermann[1], •Johannes Hornung[1], Markus Klute[1], and Benedikt Maier[2] — [1]Karlsruhe Institute of Technologie, Karlsruhe, Germany — [2]Imperial College, London, United Kingdom

Since the discovery of the Higgs boson, extensive measurements of its properties have set upper limits on the branching ratio of its yet undetected decay modes. The branching ratio encompasses immediate decays into SM particles that are not detectable, as well as decays into BSM particles. This talk focuses on a search for Higgs boson decays into pairs of hypothetical pseudoscalar Higgs bosons a, as predicted in models like the NMSSM. Specifically, the search strategy, current status, and expected limits of an analysis targeting prompt decays H -> aa -> KKKK using data collected by the CMS detector during Run 2 of the LHC will be discussed.

T 3.2 Mon 17:00 ZHG105

Higgs Mass Predictions in the CP-Violating High-Scale NMSSM — •Christoph Borschensky[1], Thi Nhung Dao[2], Martin Gabelmann[3], Margarete Mühlleitner[1], and Heidi Rzehak[3] — [1]Karlsruher Institut für Technologie, Germany — [2]PHENIKAA University, Hanoi, Vietnam — [3]Albert-Ludwigs-Universität Freiburg, Germany

In a supersymmetric theory, large mass hierarchies can lead to large uncertainties in fixed-order calculations of the SM-like Higgs mass. A reliable prediction is then obtained by performing the calculation in an effective field theory (EFT) framework, involving the matching to the full supersymmetric theory at the high scale to include contributions from the heavy particles, and a subsequent renormalization-group running down to the low scale.

In my talk, I report on the prediction of the SM-like Higgs mass within the CP-violating Next-to-Minimal Supersymmetric extension of the SM (NMSSM) in a scenario where all non-SM particles feature TeV-scale masses. The matching conditions are calculated at full one-loop order using two approaches. These are the matching of the quartic Higgs couplings as well as of the SM-like Higgs pole masses of the low- and high-scale theory. A comparison between the two methods allows for an estimate of the size of terms suppressed by the heavy mass scale that are neglected in a pure EFT calculation as given by the quartic-coupling matching. The calculation is implemented in a new version of the public program package NMSSMCALC.

T 3.3 Mon 17:15 ZHG105

Planck Safe Phase Transitions in a Complex Singlet Model — •Moritz Bosse and Gudrun Hiller — TU Dormund University, Dortmund, Germany

In this work, we investigate the implications of Beyond the Standard Model Higgs portal couplings on vacuum metastability and strong first-order electroweak phase transitions (SFOEWPT), which are necessary for electroweak baryogenesis. The analysis focuses on the minimal but phenomenologically rich complex singlet model (CxSM) that also provides potential dark matter candidates. It is shown that portal couplings allow for the stabilization of the vacuum up to the Planck scale while simultaneously enhancing the strength of the phase transition to become a SFOEWPT. By adopting Planck safety as a guiding principle for bottom-up model building, we derive new bounds for different dark matter scenarios compatible with SFOEWPTs. The results show that there is significant parameter space available for Planck-safe phase transitions in the CxSM and we explore how this parameter space can be probed at the LHC and beyond.

T 3.4 Mon 17:30 ZHG105

Electroweak spin-1 resonances in Composite Higgs models, pt. 1 — Rosy Caliri[1], •Jan Hadlik[1], Manuel Kunkel[1], Werner Porod[1], and Christian Verollet[2] — [1]Institut für Theoretische Physik und Astrophysik, Universität Würzburg, Germany — [2]Institut de Physique des 2 Infinis de Lyon (IP2I), 69100 Villeurbanne Cedex, France

Composite Higgs models offer an elegant solution to the hierarchy problem by assuming that the Higgs boson is not an elementary particle but a composite state. The Higgs emerges as a pseudo-Nambu-Goldstone boson due to spontaneous symmetry breaking within a new strongly interacting sector. The resulting low-energy dynamics are described by the Coleman-Callan-Wess-Zumino (CCWZ) formalism. These models predict a rich spectrum of additional bound states, including vector resonances, which can arise naturally from an extended hidden global symmetry that is fully gauged. We investigate models where the unbroken subgroup of the strong sector contains $SU(2)_L \times SU(2)_R$ and demonstrate that a generic prediction of these models is the existence of two neutral and one charged spin-1 resonance that mix significantly with the electroweak gauge bosons. Consequently, these states are of considerable interest for phenomenological studies.

T 3.5 Mon 17:45 ZHG105

Electroweak spin-1 resonances in composite Higgs models pt.2 — •Rosy Caliri[1], Jan Hadlik[1], Manuel Kunkel[1], Werner Porod[1], and Christian Verollet[2] — [1]Institut für Theoretische Physik und Astrophysik, Uni Würzburg, D-97074 Würzburg, Germany — [2]Institut de Physique des 2 Infinis de Lyon (IP2I), 69100 Villeurbanne Cedex, France

Composite Higgs theories with partial compositeness are gauge theories, where the Higgs boson arises as a pseudo-Nambu-Goldstone boson (pNGB) and top-partners appear as bound states of three hyperfermions coming from a UV completion. These models offer a promising solution to the Higgs sector's Naturalness problem and predict extra pNGBs and spin-1 resonances. Our focus is on the electroweak spin-1 resonances. We find that three of those states have an important mixing with the SM gauge bosons, allowing their single production in Drell-Yan like processes at LHC. We explore the rich LHC phenomenology of these states and find scenarios where their masses could be as low as 1.5 TeV.

T 3.6 Mon 18:00 ZHG105

Seesaw mechanism in the Georgi-Machacek model — •Colin Heckmeyer[1], Heidi Rzehak[2], and Emilia Welte[1] — [1]Institut für theoretische Physik, Universität Tübingen — [2]Physikalisches Institut, Universität Freiburg

The current experimental measurements of the Higgs properties conform so far with the Standard Model (SM), however allow also for a more complex Higgs sector than the SM one. This opens the door for various extensions, one of which is the Georgi-Machacek model (GM). This model includes a complex SU(2) Higgs triplet state, a real SU(2) Higgs triplet state, and a real SU(2) Higgs doublet state. It is particularly appealing because it allows for the introduction of a type II seesaw mechanism term, an interaction term between the complex triplet and the leptons, generating a mass term for neutrinos. In this model, the neutrinos are assumed to be Majorana particles.

In this talk, a model combining the GM and the seesaw mechanism is introduced. Within this model, the leading-order (LO) decay of an SM-like Higgs boson is presented. One of the key features of the GM is maintaining the rho parameter at unity at LO. The rho parameter is a conserved quantity of custodial symmetry. This symmetry, however is violated at next-to-leading order (NLO) and requires taking custodial symmetry violating terms at LO into account for a proper renormalization procedure. Using this approach, a NLO analysis of the decay of the SM-like Higgs boson is discussed.

T 3.7 Mon 18:15 ZHG105

A note on the Brout-Englert-Higgs mechanism — •Jochum van der Bij — Albert-Ludwigs Universitaet Freiburg, Deutschland

To generate masses for the particles in the standard model a Brout-Englert-Higgs (BEH) field is necessary. However a field is not a particle. I present here a construction whereby the BEH-field has a partly continuous spectrum. The theory is a renormalizable theory beyond the textbook examples. It is only mildly constrained by the LHC data. In order to fully test the theory both an e+e- collider and a muon collider are needed. These experiments can give us information about extra dimensions beyond the three known ones, that are not accessible to charged particles.

T 4: Detectors I (Scintillators)

Time: Monday 16:45–18:15 Location: VG 0.110

T 4.1 Mon 16:45 VG 0.110

Track position reconstruction with of a fiber-structured plastic scintillator detector (using a likelihood-based method) — Alessia Brignoli[1], Andrew Picot Conabo[1], Valery Dormenev[2], Christian Dreisbach[3], Karl Eichhorn[3], Jan Friedrich[3], Heiko Markus Lacker[1], Martin J. Losekamm[3], Anupama Reghunath[1], Christian Scharf[1], Ben Skodda[1], Valerian von Nicolai[1], Ida Woestheinrich[1], Hans-Georg Zaunick[2], and •Jasmin Weiss[1] — [1]Humboldt-Universität zu Berlin — [2]Justus-Liebig-Universität Gießen — [3]Technische Universität München

The CheapCal project aims to develop a low-cost, position-sensitive sampling calorimeter based on plastic scintillators. A prototype detector has been developed with 32 wavelength-shifting (WLS) fibers embedded in perpendicular grooves on the front and the back of a $(25 \times 25 \times 0.7)$ cm^3 scintillator plate. The WLS fibers are read out on both ends by Silicon Photomultipliers. The relatively short light attenuation length of the extruded scintillator material limits the photon collection primarily to fibers adjacent to a particle hit. We will present results from 100 GeV muon test beam data, comparing a weighted arithmetic mean hit position reconstruction technique with a likelihood-based approach. We acknowledge funding from BMBF, grant number 05H2021.

T 4.2 Mon 17:00 VG 0.110

Time resolution of a wavelength-shifting fibre structured plastic scintillator detector — Alessia Brignoli[1], Andrew Picot Conaboy[1], Valery Dormenev[2], Christian Dreisbach[3], Karl Eichhorn[3], Jan Friedrich[3], Heiko Markus Lacker[1], Martin J. Losekamm[3], Anupama Reghunath[1], Christian Scharf[1], Ben Skodda[1], Anubandh Sreekeessoon[1], Valerian von Nicolai[1], Jasmin Weiss[1], •Ida Wöstheinrich[1], and Hans-Georg Zaunick[2] — [1]Humboldt-Universität zu Berlin — [2]Justus- Liebig-Universität Gießen — [3]Technische Universität München

The CheapCal project aims to create a cost-effective, position-sensitive sampling calorimeter using extruded plastic scintillators. The prototype detector consists of a $(25 \times 25 \times 0.7)\,\mathrm{cm}^3$ scintillator plate with 32 wavelength-shifting (WLS) fibers embedded in perpendicular grooves on its front and back surfaces. Silicon photomultipliers read out the WLS fibers on both ends. Due to the scintillator's short light attenuation length, photons generated in the scintillator by charged-particle hits are collected primarily by the fibers closest to the particle hit.

We will present the timing measurement results obtained in the lab using a radioactive Sr-90 source and Kuraray Y-11 fibers with charge-sensitive pre-amplifiers. Combining the timing information from the closest fibers to the source position, we achieved a timing resolution below 750 ps(standard deviation). We are performing additional studies on improving time resolution using alternative WLS fibers such as Kuraray YS-2 and alternative pre-amplifiers optimized for time resolution.

T 4.3 Mon 17:15 VG 0.110

Opaque Scintillators for Neutrino Physics — Christian Buck[1], Benjamin Gramlich[1], and •Stefan Schoppmann[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]JGU Mainz, Exzellenzcluster PRISMA$^+$, Detektorlabor, Staudingerweg 9, 55128 Mainz, Germany

A new scintillator system was developed based on admixtures of wax in organic scintillators. The opacity and viscosity of this gel-like material can be tuned by temperature adjustment, wax concentration, and wax type. Whereas it is a colourless transparent liquid at high temperatures, it has a milky wax structure below.

Due to its light confinement, the scintillator system is expected to exhibit unprecedented particle ID via the topology of energy depositions. Moreover, a high degree of metal loading is feasible, e.g. in the context of searches for double beta decays or neutron capture.

In this presentation, the production and properties of such a scintillator as well as its advantages compared to transparent scintillator are described.

T 4.4 Mon 17:30 VG 0.110

Wavelength shifting fibers with high photon capture rate — •Bastian Kessler and Sebastian Böser for the NuDoubt-Collaboration — JGU Mainz - Institut für Physik

Wavelength-shifting optical fibers are commonly used to collect light from large detector volumes and guide towards photosensors, making them particularly interesting for water Cherenkov or scintillator based detectors. However, one problem is their low photon capture rate, leading to a degradation in the energy resolution of fiber-based detectors.

Building on previous work, it was shown that the photon capture rate can be increased by optimizing the design of the photon absorption zone. In this work, this concept was applied to wavelength shifting fiber to increase the light output of the hybrid opaque scintillator experiment NuDoubt^{++}.

However, the first prototype fibers suffer still from a relative high attenuation, losing this advantage for fiber lengths over 2 meters and losing efficiency compared to commercial fibers. In this presentation we will discuss about the further development of the fibers and the effect of adapted production methods on the attenuation length.

T 4.5 Mon 17:45 VG 0.110

Development of an integrated photon and phonon detector for use with scintillators — •Ashish Jadhav, Christian Enss, Andreas Fleischmann, Daniel Hengstler, Cagla Mahanoglu, Ioana-Alexandra Nitu, Christian Ritter, Andreas Reifenberger, Daniel Unger, and Loredana Gastaldo — Kirchhoff Institute for Physics, Heidelberg University

The AMoRE project searches for $0\nu\beta\beta$ decay in ^{100}Mo using scintillating crystals coupled with metallic magnetic calorimeters (MMCs) operated at 20mK. The current setup utilizes separate phonon and photon detectors to simultaneously measure the crystal's temperature rise and emitted light. We present the development of an integrated photon-phonon detector (P2) for a potential improvement in energy resolution and background suppression. In the P2 design, the central part of a 3" silicon wafer is separated from the rest of the wafer by trenches produced through silicon etching, leaving only six narrow bridges for thermal connection. This central part serves as a photon detector with the MMC sensor having stripline geometry and thermally isolated from the rest of the wafer by trenches produced through silicon etching techniques. The outer region of the wafer hosts three MMC units that are coupled to the scintillating crystal to monitor temperature changes. This configuration would help study a position-dependent signal shape, improving event discrimination for multi-site events. The primary challenges in developing a P2 detector are the fabrication of the thermally isolated photon absorber area and the reliable, support-free mounting of the scintillating crystal onto the wafer.

T 4.6 Mon 18:00 VG 0.110

Development of a Novel Te-doped Liquid Scintillator with Slow Light Emission for $0\nu\beta\beta$-Decay Searches in a Hybrid Neutrino Detector — •Hans Theodor Josef Steiger[1], Manuel Böhles[2], Matthias Raphael Stock[1], Meishu Lu[1], Ulrike Fahrendholz[1], Ronja Huber[1], Lothar Oberauer[1], Franz von Feilitzsch[1], and Michael Wurm[2] — [1]Physik-Department, Technische Universität München, James-Franck-Str. 1, 85748 Garching, Germany — [2]Johannes Gutenberg Universität, Staudingerweg 7, 55128 Mainz, Germany

It is a long-standing paradigm that organic scintillators allow excellent energy resolution but no directional reconstruction. Here we show the foundation for overcoming this by scintillators with slow light emission, paving the way for hybrid detectors that combine the advantages of Cherenkov and scintillation detectors. In such slow liquid scintillators, it is possible to reconstruct directional and topological information from Cherenkov light, while the high light yield of an organic scintillator ensures excellent energy resolution and low thresholds necessary for many applications in neutrino and particle physics such as the search for the $0\nu\beta\beta$ decay. We also developed a novel loading technique for these scintillators with 130Te and show studies of fundamental properties of these scintillators and the novel dopant. This work is supported by the Clusters of Excellence PRISMA+ and ORIGINS and the Collaborative Research Center 1258.

T 5: Silicon Detectors I (ATLAS + CMS)

Time: Monday 16:45–18:15 Location: VG 0.111

T 5.1 Mon 16:45 VG 0.111

The operational experience and performance of the ATLAS SCT during LHC Run-3 operations — •Alessandro Guida — Humboldt University, Berlin, Germany

The ATLAS SemiConductor Tracker (SCT) restarted operations in LHC Run-3. The SCT successfully operated in LHC Run-2 (2015-2018) which came with high instantaneous luminosity and pileup conditions that were far in excess of what the SCT was originally designed to meet. Similar conditions are now faced during the on-going Run-3 and first significant effects of radiation damage in the SCT are observed.

This talk will summarise the operational experience, challenges and performance of the SCT during the first years of Run-3 operations. The observation and prospect of radiation damage on SCT silicon strip sensors will also be presented.

T 5.2 Mon 17:00 VG 0.111

Thermal cycling in Aachen and grading procedures for 2S modules for the CMS Phase-2 Tracker Upgrade — •Max Beckers[2], Lutz Feld[1], Nina Höflich[2], Katja Klein[1], Martin Lipinski[1], Alexander Pauls[1], Oliver Pooth[2], Nicolas Röwert[1], Vanessa Oppenländer[1], and Lennart Wilde[2] — [1]I. Physikalisches Institut B, RWTH Aachen University — [2]III. Physikalisches Institut B, RWTH Aachen University

For the CMS Phase-2 Outer Tracker upgrade, new silicon strip detector modules consisting of two silicon strip sensors, so-called 2S modules, are developed and produced. This process is distributed along multiple assembly centers worldwide.

RWTH Aachen University will build around 1000 2S modules. The assembled modules are then shipped to DESY, where they are thermally cycled in the "Burn-in" setup. In addition, a multi module cold box is available in Aachen to perform thermal cycles for up to 4 modules.

The POTATO software is the centrally developped software to validate the test results and apply the grading procedures. The gradings are based on different electrical and readout parameters of the module and then stored in the central database.

This talk presents the cold box setup at Aachen together with cyclings performed on preproduction 2S modules. In addition to the cycling results, the grading procedures are explained, and the POTATO software is presented.

T 5.3 Mon 17:15 VG 0.111

Thermal qualification of the silicon detector modules for the Phase-2 upgrade of the CMS Outer Tracker — •Niyathikrishna Meenamthuruthil Radhakrishnan, Alexander Dierlamm, Ulrich Husemann, Markus Klute, Stefan Maier, Lea Stockmaier, Tobias Barvich, and Bernd Berger — Karlsruhe Institute of Technology, Karlsruhe, Germnay

The LHC is about to enter its high-luminosity era in 2029. In order to prepare the particle detectors to deal with the high particle rate and radiation damage, the detector components must be upgraded. One upgrade project is the replacement of the tracking system of the CMS detector. The new Outer Tracker will consist of two types of silicon sensor modules: 5592 PS modules which are made of one pixel sensor and one strip sensor and 7608 2S modules with two strip sensors.

Production and testing of these modules are carried out at 10 sites and one of the centers producing the 2S modules is KIT. In the tracker, these modules will be operated with a coolant temperature of around -35. It must be verified that the modules can function flawlessly at this temperature prior to installation in the detector. In order to do that, modules are placed inside a thermally insulated box with active cooling, called burn-in station, to perform temperature cycles and expose the modules to thermal stress for up to 48 hours. The electrical functionality of the modules is monitored during this period.

The talk will give a summary of the current status of the burn-in station at KIT and present the thermal qualification of the station as well as results with the first production modules.

T 5.4 Mon 17:30 VG 0.111

ITk Pixel DCS: Pixel System Monitoring Readout — •Anne Gaa and Stan Lai — Friedrich-Hund Platz 1, 37077 Goettingen

The ATLAS experiment is developing the new Inner Tracker (ITk) in preparation for the High-Luminosity LHC Upgrade. The ITk pixel Outer Barrel demonstrator, as a system prototype, recently passed its final design review phase in preparation of the construction of the finished detector. The Detector Control System (DCS) is responsible for monitoring and controlling the detector and its sub-systems.

Part of the DCS is the readout chain of the Monitoring of Pixel System (MOPS), which provides an independent monitoring of the temperature and voltage of the front-end pixel modules. The MOPS-Hub is the bidirectional interface between the local DCS station and the MOPS chips. The MOPS chips are connected via CAN buses to an FPGA, which sends the monitored data over an OPC UA server to the local DCS control station. Testing sites for the Outer Barrel local supports, as well as the OB demonstrator will use the next iteration of the MOPS readout in the near future, featuring a new FPGA and a new OPC UA server. The OPC UA server will gain the functionality to read and write to the shared register on the FPGA via its device classes. As a first step, this server will be developed in the environment of a register simulation. This talk presents new developments of the MOPS readout.

T 5.5 Mon 17:45 VG 0.111

Testing of ATLAS ITk pixel detector modules — Markus Cristinziani[1], Qader Dorosti[1], •Luke Hammer[1], Stefan Heidbrink[2], Lasse Jäderberg[1], Nils Krengel[1], Nico Malinowski[1], Denise Müller[1], Jason Müller[1], Noah Siegemund[1], Waldemar Stroh[2], Wolfgang Walkowiak[1], Jens Winter[2], Michael Ziolkowski[2], and Alessia Zuev[1] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Elektronikentwicklungslabor Physik, Universität Siegen

The upcoming High-Luminosity LHC upgrade will significantly increase the LHC's instantaneous luminosity by a factor of 5 starting in 2030. The ATLAS detector upgrade introduces a comprehensive, all-silicon inner tracking system (ITk), comprising sophisticated silicon strip and pixel modules that will completely replace the existing Inner Detector. At the University of Siegen, modules of the Outer Barrel Pixel detector will be assembled and tested, requiring complex setups and intensive quality control procedures to ensure the precision, functionality and reliability of each detector module. In this talk these test setups will be presented. They comprise a comprehensive electrical testing system with integrated interlock mechanisms to protect module integrity during characterization, and a sophisticated thermocycling setup designed to assess module performance after extreme temperature variations.

T 5.6 Mon 18:00 VG 0.111

Quality Control Tests of ITK Pixel Modules — •Ruben Förster, Jörn Grosse-Knetter, and Arnulf Quadt — II. Physikalisches Institut, Georg-August-Universität Göttingen

The High Luminosity upgrade of the Large Hadron Collider (HL-LHC) presents significant challenges for the subcomponents of the ATLAS experiment. Consequently, it necessitates the construction of an all-silicon Inner Tracker (ITk) able to deal with increased particle fluxes and radiation levels.

ITk will feature both hybrid pixel and strip detectors, with the pixels forming the inner part. The ITk pixel detector will consist of about 10,000 separate modules, with approximately 600 of them expected to be processed at the University of Göttingen.

Performing Quality Control (QC) tests is vital to ensure the performance of the modules at the time of installation and during the promised 10 years of operation. The QC tests evaluate the overall functionality and electrical properties of the modules, as well as the performance of individual pixels. QC tests are conducted at different stages of the production process to ensure that the modules are within the specifications and that no damage has occurred during the previous assembly steps. As part of the preproduction phase, work has been undertaken to ensure the feasibility of performing QC tests while also automating and optimizing the processes to ensure that modules can be produced in a timely manner.

T 6: Silicon Detectors II (Belle II, Tristan)

Time: Monday 16:45–18:15 Location: VG 1.101

T 6.1 Mon 16:45 VG 1.101

Performance study of the proposed Belle II vertex detector upgrade — •Lukas Herzberg[1], Benjamin Schwenker[1], Thibaud Humier[1,2], and Ariane Frey[1] — [1]Georg August-Universität Göttingen, Göttingen — [2]DESY, Hamburg

The proposed Belle II vertex detector upgrade intends to replace the current vertex detector (VXD), consisting of pixel and strip subdetectors with a unified silicon pixel detector (VTX). This upgrade is scheduled to take place during long shutdown 2 in 2032. The main purpose of the vertex detector in Belle II is to improve the analyses of time dependent CP violation. To quantify the impact of the upgrade on performance, we investigated three variables.
The *effective flavor tagging efficiency* is a measure of how good the detector can differentiate between B^0 and $\overline{B}^0$ which directly affects the statistical power of any CP violation analyses in the B^0 system. The *reconstruction efficiency* is the fraction of correctly reconstructed events. The *vertex resolution* is the accuracy of the decay positions. It is measured separately for the two B mesons in the event. These three performance variables can be measured in simulation for both the VXD and the VTX. Finally a fit of the unitary triangle parameter β was performed as an example of a full time dependent CP violation analyses.

T 6.2 Mon 17:00 VG 1.101

Investigation of high backside currents in DePFET pixel sensors for the Belle II experiment using dedicated test structures — Florian Bernlochner, Jochen Dingfelder, •Georgios Giakoustidis, and Botho Paschen — University of Bonn, Germany

For the Belle II experiment at KEK (Tsukuba, Japan) the KEKB accelerator was upgraded to deliver e^+e^- collisions at a center-of-mass energy of $E_{CM} = 10.58\ GeV$ and it has reached a record-breaking instantaneous luminosity of $4.7 \cdot 10^{34}\ cm^{-2}s^{-1}$. During the so-called Long Shutdown 1 (LS1) the innermost part of the Belle II detector, the initially descoped PiXel Detector (PXD1) with 20 modules, based on Depleted P-channel Field Effect Transistor (DePFET) technology, was replaced by a fully-populated, two-layer PXD with 40 modules. As the detector closest to the experiment's interaction region, the PXD is most exposed to radiation from the accelerator. Throughout the operation of the PXD1 a steady increase of backside current with irradiation was observed in several modules. Doping-profile measurements and electric field simulations show that this is a consequence of (partially) shorted guard rings at the backside leading to high electric fields and avalanche current multiplication. Irradiation results of dedicated test structures to further investigate the mechanism will be presented.

T 6.3 Mon 17:15 VG 1.101

Characterization of new BELLE-type DePFET pixel test-structures — •Erik Büchau, Florian Bernlochner, Jochen Dingfelder, Georgios Giakoustidis, and Jannes Schmitz — University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

Silicon-based detectors are a fundamental component of particle tracking systems in modern High Energy Physics (HEP) experiments. The BELLE II experiment in Japan employs the Depleted P-channel Field Effect Transistor (DePFET) technology in its PiXel Detector (PXD), taking advantage of its low material budget while keeping low intrinsic noise at high signal-to-noise ratio. DePFET pixel technology is subject to extensive research and development, leading to the production of a new technology variation, PXD13. Due to its similarity to the existing PXD9 design, the PXD13 mini-matrices can be tested using the same infrastructure. Dedicated full system demonstrators (Hybrid5), containing the minimum amounts of all necessary components, are used for laboratory tests and characterization. First characterization results on transistor level, as well as signal response studies on Belle-type PXD13 mini matrices will be covered in this talk.

T 6.4 Mon 17:30 VG 1.101

Investigation of TID damage in the Drain Current Digitizer chip of the Belle II Pixel Detector — •Nikolas Pässler, Jannes Schmitz, Georgios Giakoustidis, Jochen Dingfelder, and Florian Bernlochner — University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

The Belle II experiment at the SuperKEKB collider in Tsukuba, Japan, explores e^+e^- collisions at a center-of-mass energy of 10.58 GeV and achieved a record luminosity of $4.7 \cdot 10^{34}\,\mathrm{cm^{-2}s^{-1}}$. During the Long Shutdown 1 (LS1) from 2022 to 2023, the initial partially installed PiXel Detector (PXD1) was upgraded to a fully-populated two-layer PXD with 40 modules. These modules consist of a 250×768 pixel matrix, based on Depleted P-channel Field Effect Transistor (DePFET) technology and 3 types of row control and readout ASICs. As the PXD is positioned closest to the interaction region, it has to withstand the highest radiation levels.

Radiation damage leads to increasing levels of noise in the Drain Current Digitizer (DCD) ASIC. Since the exact nature and manifestation of this noise are not yet well understood, further investigation and the development of enhanced calibration routines are required.

In this talk, results from a dedicated X-ray irradiation campaign for the DCD will be presented, focusing on identifying and disentangling the noise effects from the rest of the system. Strategies for mitigating these issues will also be discussed.

T 6.5 Mon 17:45 VG 1.101

Towards Sterile Neutrino Detection: TRISTAN Detector Characterization with a UV-Light-Induced Electron Source — •Daniela Spreng for the KATRIN-Collaboration — TUM School of Natural Sciences - Physics Department, Garching, Germany

The search for keV-scale sterile neutrinos, a potential dark matter candidate, is a major goal in neutrino physics. These neutrinos, if they exist, create subtle distortions in the beta-decay spectrum due to their mixing with active flavors. The KATRIN experiment aims to detect these effects using TRISTAN, a modular multi-pixel silicon drift detector.

This talk focuses on the operation of three TRISTAN detector modules integrated into a KATRIN-like setup. We present characterization measurements of the detector's electron response, emphasizing tests with a UV-light-induced electron source. This partial implementation is a crucial step toward validating the system's performance and readiness to detect sterile neutrino signatures.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6).

T 6.6 Mon 18:00 VG 1.101

Characterization of TRISTAN Detector Modules in a KATRIN-like Detector Section with 83mKr — •Christian Forstner for the KATRIN-Collaboration — TUM School of Natural Sciences - Physics Department, Garching, Germany

Sterile neutrinos, a minimal extension of the Standard Model of particle physics, are a promising dark matter candidate if their mass is in the keV-range. The Karlsruhe Tritium Neutrino experiment (KATRIN) will be equipped with a multi-pixel silicon drift detector array, the TRISTAN detector, to search for a keV-scale sterile neutrino signature in the tritium β-decay spectrum. This measurement will follow the completion of KATRIN's neutrino mass measurement campaign. In this work, we report on the first simultaneous operation of three TRISTAN detector modules. The detector system has been installed in a KATRIN-like detector section and is characterized using a 83mKr source. This talk will focus on the first light observed with the detectors to validate the progress of the system and its readiness for the sterile neutrino operation.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6).

T 7: Detectors II (Gaseous Detectors)

Time: Monday 16:45–18:00 Location: VG 1.102

T 7.1 Mon 16:45 VG 1.102

Development of a 3D read-out scheme for drift-tube chambers — Davide Cieri, Francesco Fallavolita, Oliver Kortner, Sandra Kortner, Hubert Kroha, •Nick Meier, Giorgia Proto, and Elena Voevodina — Max-Planck-Institute for Physics, Garching, Germany

Current drift-tube chambers only measure the coordinates of charged particle trajectories in the plane orthogonal to their anode wires. This limitation is usually overcome by a second set of detectors providing the coordinates along the anode wires. In this contribution the development of a 3D read-out scheme utilizing the propagation delay of the signals between both ends of a tube is presented. A achievable spatial resolution of about 20 cm along the wire is demonstrated for ATLAS monitored drift-tube chambers. This is limited by the resolution of the ATLAS TDC. Improvements with higher resolution TDC are under investigation for applications of drift tube detectors in experiments at future circular electron position and hadron colliders.

T 7.2 Mon 17:00 VG 1.102

Small-Diameter Muon Drift Tube Detector Chambers for the ATLAS Phase-II Upgrade: Performance Testing and Certification with New Readout — •Bastian Wesely, Fan Zhou, Oliver Kortner, Hubert Kroha, Nick Kube, Nick Meier, and Elena Voevodina — Max-Planck-Institute for Physics, Munich, Germany

To meet the requirements of the High-Luminosity LHC (HL-LHC), the Muon Drift Tube (MDT) chambers in the inner barrel layer (BIS) of the ATLAS muon spectrometer are being replaced with small-diameter Muon Drift Tube (sMDT) chambers. These advanced chambers will be integrated with triplets of thin-gap Resistive Plate Chambers (RPCs) to enhance the acceptance and robustness of the barrel muon trigger system. The sMDT chambers, designed with drift tubes that are half the diameter of the original MDT chambers, deliver an order-of-magnitude improvement in background rate capability. A total of 96 new sMDT chambers were constructed between January 2021 and September 2023 at two production sites. 50% of these chambers were produced at the Max Planck Institute for Physics (MPP) in Munich, and they are now being equipped with final readout electronics at BB5, CERN. In this contribution, we will present the certification methods and performance test results from the CERN BB5 facility, comparing them with the initial testing campaign conducted at the Max Planck Institute for Physics.

T 7.3 Mon 17:15 VG 1.102

Quality Control Framework for the CMS Drift Tube Electronics Upgrade — Dmitry Eliseev, •Nils Esper, Thomas Hebbeker, Kerstin Hoepfner, Markus Merschmeyer, Carsten Presser, and Alexander Schmidt — III. Physikalisches Institut A, RWTH Aachen University

The Drift Tube (DT) system is one of the muon subdetectors in the barrel region of the Compact Muon Solenoid (CMS) experiment. As part of the Phase-2 Upgrade for the High-Luminosity Large Hadron Collider (HL-LHC), the electronics of the DT system will be upgraded. This includes exchanging the minicrate electronics, which are mounted on each DT chamber. The new electronics feature the On-Board Electronics for Drift Tubes (OBDT) boards, responsible for the time-precise hit acquisition from the chamber front-ends and upstreaming of the hit data. The OBDTs also provide slow control functionalities for the chamber infrastructure. As part of the upgrade efforts, quality control instruments and procedures have been developed to be deployed at the minicrate assembly sites and at CERN. This talk describes the current status of the Phase-2 Upgrade activities, focussing on the minicrate testing framework.

T 7.4 Mon 17:30 VG 1.102

Upgrade of the MDT Front-end Electronics of the LMU Cosmic Ray Facility — •Eshita Kumar, Otmar Biebel, Valerio D'Amico, Stefanie Götz, Daniel Grewe, Ralf Hertenberger, Nirmal Mathew, Nick Schneider, Chrysostomos Valderanis, and Fabian Vogel — LMU München

As part of the Phase-II Upgrade of the ATLAS Muon Spectrometer for the High Luminosity LHC (HL-LHC), a new and enhanced trigger and readout system for the Monitored Drift Tube (MDT) chambers is being installed. To evaluate the Phase-II upgrades on an MDT chamber outside the ATLAS detector and independently of ongoing upgrade activities at CERN, the LMU Cosmic Ray Facility (CRF) in Garching serves as an ideal testing site. Equipped with two fully operational MDT chambers and scintillators for triggering, the facility has been upgraded with Phase-II front-end electronics to facilitate a comprehensive test. These new front-end electronics are tested using the MiniDAQ readout system. In this talk, the current status of the project and first results will be shown. A comparison between the performance of the original CRF electronics and the new Phase-II electronics will be presented.

T 7.5 Mon 17:45 VG 1.102

Development and Implementation of a new Trigger System in the LMU Cosmic Ray Facility for Level-0 MDT Trigger Processor Testing — •Nick Schneider, Otmar Biebel, Valerio D'Amico, Stefanie Götz, Ralf Hertenberger, Eshita Kumar, Chrysostomos Valderanis, Fabian Vogel, Daniel Grewe, and Nirmal Mathew — LMU München

The Phase-II Upgrade of the ATLAS Muon Spectrometer for the High Luminosity LHC (HL-LHC) includes the installation of a new and more efficient trigger and readout system for the Monitored Drift Tube (MDT) chambers. One of the components is the new Level-0 MDT Trigger Processor (L0MDT). The LMU Cosmic Ray Facility (CRF) is a test stand equipped with two ATLAS series production MDT BOS chambers and a scintillator hodoscope for triggering. It could be used to test L0MDT under realistic conditions. Since it is running on unsupported legacy electronics an upgrade to ALTAS Phase-II standard has to be done first. This also ensures that the CRF remains operational in the future. For the new electronics an upgrade of the trigger system is needed. In addition the regular Phase-II trigger path has to be changed such that it fits the specifications of the CRF including emulators for not yet available electronics. This talk will cover the operating principal and the hardware implementation of this new trigger system and will present some first results. The readout electronics will not be covered in this talk. A first aim after the full upgrade of the trigger and the readout electronics is to enable full testing of L0MDT in a realistic environment.

T 8: Top Physics I (tt+X)

Time: Monday 16:45–18:15 Location: VG 1.103

T 8.1 Mon 16:45 VG 1.103

Measurement of the associated production of top quark pairs with a photon at $\sqrt{s}$ = 13.6 TeV with the ATLAS detector — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], Arpan Ghosal[1], Gabriel Gomes[1], •Jan Joachim Hahn[1], Vadim Kostyukhin[1], Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], Sebastian Rentschler[1], Elisabeth Schopf[1], Katharina Voss[1], Wolfgang Walkowiak[1], Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

The production of top quark pairs in association with a photon ($t\bar{t}\gamma$) is an important process to investigate the coupling between the photon and the top quark. Precise measurements of this interaction allow testing the Standard Model (SM) and set limits on physics beyond the SM phenomena which affect the electroweak couplings of the top quark. The increased centre-of-mass energy of 13.6 TeV and luminosity of the ongoing LHC Run 3 allow for more precise measurement of this process, compared to the recent result for Run 2. In this talk, the ongoing measurement of the $t\bar{t}\gamma$ production using Run 3 data taken with the ATLAS experiment is presented, including first data-driven measurements of relevant background processes.

T 8.2 Mon 17:00 VG 1.103

Event classification for the measurement of differential cross-sections in single-top + photon events at the ATLAS experiment with $\sqrt{s}$ = 13 TeV — •Lucas Cremer[1], Nils Julius Abicht[1], Tomas Dado[2], and Andrea Helen Knue[1] — [1]TU Dortmund, Experimentelle Physik — [2]CERN

After the observation of single-top quark production in association with a photon at the ATLAS experiment, differential cross-sections of this process are measured. The resulting distributions will be unfolded and interpreted in terms of effective-field-theory operators.

An important step in the analysis is the classification of signal and background events. This classification will be used to define a signal region enriched with $tq\gamma$ events, allowing for a stable unfolding of observables sensitive to physics beyond the Standard Model. A deep feed-forward neural network is trained to classify the events based on the kinematic properties of the objects in the final state. Furthermore, the sensitivity of various high-level variables is studied to optimize the performance of the neural network. The training is applied to the complete ATLAS Run-2 dataset, corresponding to an integrated luminosity of 140 fb^{-1}.

T 8.3 Mon 17:15 VG 1.103

Search for $t\bar{t}\gamma\gamma$ production in lepton+jets channel in pp collisions at $\sqrt{s}$=13 TeV with the ATLAS detector — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], •Arpan Ghosal[1], Gabriel Gomes[1], Jan Joachim Hahn[1], Vadim Kostyukhin[1], Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], Sebastian Rentschler[1], Elisabeth Schopf[1], Katharina Voss[1], Wolfgang Walkowiak[1], Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

The top quark pair production ($t\bar{t}$) in association with one or more photons is a key Standard Model process for measuring the strength of the electroweak coupling of the top quark with the photon. While the production of $t\bar{t}$ with one photon is well-studied, the rarer $t\bar{t}$ production with two photons ($t\bar{t}\gamma\gamma$) still remains unobserved. The $t\bar{t}\gamma\gamma$ process is not only a good candidate for probing the electroweak coupling of the top quark, but it is also an irreducible background to the $t\bar{t}$ production in association with a Higgs boson decaying to two photons. Understanding the $t\bar{t}\gamma\gamma$ process can help tighten constraints on anomalous electric and magnetic dipole moments, through which new CP-violating sources can manifest. The talk will discuss the ongoing efforts in the search for the $t\bar{t}\gamma\gamma$ process in the single-lepton $t\bar{t}$ decay channel using the full Run 2 dataset collected by the ATLAS detector at $\sqrt{s}$ = 13 TeV.

T 8.4 Mon 17:30 VG 1.103

Measurement of tt+X (heavy flavour) processes at the CMS experiment — •Rufa Kunnilan Muhammed Rafeek, Ulrich Husemann, and Emanuel Pfeffer — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Top quark - antiquark pairs (tt) produced in association with other particles (X) where X can be the Higgs boson, Z/W boson or QCD-initiated heavy flavour jets (bb/cc), plays a significant role in experimental studies at the LHC. The analysis is challenging as these processes, particularly when the bosons decay into heavy flavour quarks, like for example, tt+H(bb) and tt+bb or tt+Z(bb), share the same signature and very similar kinematic features. These high jet multiplicity final states create ambiguities in the reconstruction and identification of these processes and thus, it is hard to differentiate them from each other. The complex task of simultaneously measuring these tt + X processes is addressed by exploring advanced ML techniques such as Graph Neural Networks. The primary objective is to distinguish the additional heavy flavour jets (not part of the tt-system). This differentiation is crucial for subsequent multi-class event classification, encompassing categories such as tt + bb, tt + (bb), tt + (bb) and tt + cc. Effectively, this involves two classification tasks: a binary classification to identify additional jets and a multi-class classification for event categorization, culminating in promising classification results for tt+X events. In this talk, an overview of the ongoing analysis, designed with the Run-2 data of the LHC using the tt single lepton channel, is given.

T 8.5 Mon 17:45 VG 1.103

Search for vector-like leptons and the $t\bar{t}$+heavy flavour jets modelling — •Mahsana Haleem — JMU-Würzburg, Würzburg, Germnay

Vector-like fermions are predicted by several phenomenological models that extend the Standard Model (SM) with renormalisable frameworks to address the hierarchy problem. Examples include the SU(4) × SU(3)' × SU(2)$_L$ × U(1)' theory, also known as the 4321 model, and composite Higgs models. At the LHC, vector-like leptons can be produced via electroweak interactions, leading to rich and intriguing signatures within the 4321 model framework. Through decay chains involving the vector leptoquark, these particles can produce diverse final states, including multiple top quarks, b-quarks, neutrinos, and charged leptons. The sensitivity of this search depends significantly on the precise modeling of the SM top-quark pair production in association with heavy-flavor jets. In this talk, I will present recent ATLAS measurements of $t\bar{t}$+b-jets, along with the results of the ATLAS search for vector-like leptons.

T 8.6 Mon 18:00 VG 1.103

Development of General Purpose $t\bar{t}+X$ and $t+X$ Classifiers with ATLAS — •Clinton Gonsalves, Steffen Korn, and Arnulf Quadt — I Physikalisches Institut, Georg-August-Universität Goettingen, Friedrich-Hund-Platz 1, 37077 Goettingen

The study of $t\bar{t}+X$ and $t+X$ processes is important for understanding the Standard Model (SM) and exploring potential new physics beyond it. These processes involve the production of a top quark pair ($t\bar{t}$) or a single top quark (t) in association with an additional boson, such as a W, Z, Higgs boson (H), or a photon (γ). Accurately identifying these events is crucial for measuring properties such as the top Yukawa coupling in $t\bar{t}+H$ production and for studying rare electroweak processes such as associated $t-Z$ production. However, the rarity of these events and their similarity to background processes, such as $t\bar{t}$ + jets, make their classification challenging.

This talk presents the development of a neural network-based classifier for $t\bar{t}+X$ and $t+X$ events. The classifier is trained on kinematic variables, event-level observables such as transverse momentum p_T^{Miss} and missing transverse energy E_T^{Miss}, and object counts, including jets, leptons, and b-tagged jets. The neural network architecture is optimised to effectively distinguish signal events from background events by learning correlations in the input features.

T 9: Flavour Physics I

Time: Monday 16:45–18:15 Location: VG 1.104

T 9.1 Mon 16:45 VG 1.104

Search for $B^+ \to K^{*+}\tau\ell$ with hadronic tagging at the Belle II experiment — •Lara Fuchs, Torben Ferber, Pablo Goldenzweig, and Raynette van Tonder — Institute of Experimental Particle, Karlsruhe Institute of Technology, Karlsruhe, Germany

Current measurements of semileptonic B meson decays are in tension with Standard Model predictions, giving rise to a plethora of proposed New Physics models to explain the observed results. These models not only incorporate lepton flavor violation, but also predict significantly enhanced rates for lepton flavor violating decays involving second- and third-generation leptons. Among these processes, flavor-changing neutral current transitions such as $b \to s\tau\ell$ are further suppressed, and thus especially sensitive to New Physics contributions.

In this talk, we present the status of the first search for $B^+ \to K^{*+}\tau\ell$, conducted at the Belle II experiment, located at the SuperKEKB asymmetric e^+e^- collider. We employ a hadronic tagging approach where the accompanying B meson in $e^+e^- \to \Upsilon(4S) \to B^+B^-$ events is fully reconstructed via hadronic decay chains. The complete knowledge of the tag-side particle's four-momentum combined with the well-known event energy allow for a direct determination of the invariant mass of the system recoiling against the $B_{\text{tag}}K^{*+}\ell$ system. This provides a reliable method for signal extraction despite the presence of missing energy in the decay, making Belle II an excellent experiment for conducting this search.

T 9.2 Mon 17:00 VG 1.104

CP violation in $\tau \to K^0h(\geq 0\pi^0)\nu_\tau$ decays at Belle * — •Katarina Dugic[1,2], Daniel Greenwald[1], and Stephan Paul[1] — [1]Technical University Munich — [2]Max Planck Institute for Physics

In 2012, Babar measured a CP-violating decay-rate asymmetry in $\tau \to K_S\pi(\geq 0\pi^0)\nu_\tau$ that deviates from the standard-model prediction by 2.8σ. We present studies for measuring this asymmetry in $\tau \to K^0h(\geq 0\pi^0)\nu_\tau$ using data from the Belle experiment.

*Funded by the DFG under Germany's Excellence Strategy - EXC2094 - 390783311 and BMBF Verbundforschung (05H21WOKBA BELLE2).

T 9.3 Mon 17:15 VG 1.104

Study of $B \to D(^*)\pi\ell\nu$ decays — Florian Bernlochner, Markus Prim, Valerio Bertacchi, and •Nada Gharbi — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The excited states of charmed D mesons beyond the 1S ground state are not well explored and entails a lot of puzzles. One such puzzle arises from the observation that the masses of the $D_0^*(2300)$ and $D_{s0}^*(2317)$ mesons, as reported by the Particle Data Group, are nearly equal: $M_{D_0^*(2300)} \simeq M_{D_{s0}^*(2317)}$. This mass similarity contradicts expectations from SU(3) flavor symmetry breaking, which should account for the strangeness of the $D_{s0}^*(2317)$. Beyond the quark model, these excited charmed mesons can be interpreted as hadronic molecules. Using unitarized chiral perturbation theory (UChPT), it has been theoretically shown that the true SU(3) flavour partner of the $D_{s0}^*(2317)$ is the $D_0^*(2100)$, resolving this mass discrepancy and providing a compelling explanation for the observed phenomena and other puzzles. To investigate this theory, we analyse Belle II data focusing on the invariant mass spectrum of the $D^{(*)}\pi$ system from the decay $B \to D^{(*)}\pi\ell\nu$. By extracting the S-wave contribution in this spectrum, one can make a comparison between the Belle II data and the UChPT predictions. A deeper understanding of the $B \to D^{**}\ell\nu$ decays could significantly reduce the systematic uncertainties in the measurement of R(D$^{()}$), a key observable that points to possible deviations from the Standard Model.

T 9.4 Mon 17:30 VG 1.104

Partial-Wave Analysis for $B \to J/\psi K\pi$ at Belle and Belle II — •Martin Bartl, Stefan Wallner, and Hans-Günther Moser — Max-Planck-Institut für Physik, München

We will present initial input-output studies based on simulated data for a partial-wave analysis (PWA) of $B^0 \to J/\psi K^+\pi^-$ at Belle and Belle II. The PWA disentangles contributions from numerous intermediate resonances, e.g. K^* mesons in the $K\pi$ subsystem. We will discuss the search for exotic, i.e. non $q\bar{q}$, states, which may appear in the $J/\psi K$ and $J/\psi\pi$ subsystems, complementing recent observations by LHCb.

In addition, we will present plans to study isospin related channels, e.g. $B^+ \to J/\psi K^+\pi^0$ and $B^+ \to J/\psi K_S^0\pi^+$.

T 9.5 Mon 17:45 VG 1.104

Dalitz analysis of $B^- \to D^+\pi^-\pi^-$ and $\overline{B}^0 \to D^+\pi^-\pi^0$ — Florian Bernlochner, Markus Prim, Valerio Bertacchi, Agrim Aggarwal, and •Melisa Akdag — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, Germany

Recent studies have provided strong evidence that the D_0^* meson is better described by an amplitude modeled using unitarized chiral perturbation theory rather than a traditional Breit-Wigner distribution. This finding underscores the importance of a more nuanced approach to modeling these states. The $D^+\pi^-\pi^-$ decay is dominated by a loop diagram that includes the ρ meson, resulting in significant theoretical uncertainties. To mitigate these uncertainties, we directly access the ρ meson in the analysis by incorporating the isospin conjugated modes which include the π^0 via the decay chain $\overline{B}^0 \to D^+\rho^-$ into our considerations. To achieve these goals, it is crucial to analyze not only the $B^- \to D^+\pi^-\pi^-$ final state, which the LHCb experiment can measure with high precision, but also decays involving neutral pions, emerging from $\overline{B}^0 \to D^+\pi^-\pi^0$, where the Belle II experiment can uniquely contribute. This allows us to study the orbitally excited charmed mesons, the D_0^* and the D_2^* in the $D\pi\pi$ final state, and the D_1, D_1' and D_2^* in the $D^*\pi\pi$ final state. By studying both processes we can test heavy quark spin symmetry in these final states.

T 9.6 Mon 18:00 VG 1.104

Group summary: Plans for hadron spectroscopy analyses at LHCb using Run 3 data — Mikhail Mikhasenko and •Marian Stahl — Ruhr University Bochum, Bochum, Germany

The LHCb experiment has undergone a major upgrade to be able to collect data at a five-fold increased instantaneous luminosity during Runs 3 and 4 of the LHC. With the removal of the hardware trigger, the detectors are readout at the LHC collision rate of 30 MHz and the data is processed in real-time by a heterogeneous two-stage software trigger. This leads to improved efficiencies in the event reconstruction, in particular that of fully hadronic decay channels. For spectroscopy, this opens up possibilities to search for particles with low production rates, or to measure properties of known states with improved precision or in new decay modes. I will give a comprehensive overview of LHCb's potential for spectroscopy measurements in Run 3 and highlight topics of the immediate effort within the German spectroscopy community.

T 10: Neutrino Astronomy I

Time: Monday 16:45–18:30 Location: VG 1.105

T 10.1 Mon 16:45 VG 1.105

Classification of incoming neutrino events in IceCube using machine learning — •Sophie Loipolder, Rasmus Ørsøe, and Chiara Bellenghi for the IceCube-Collaboration — Technical University of Munich, Munich, Germany

In neutrino telescopes, event topologies differ depending on the neutrino flavor, the energy and the interaction type. For the reconstruction of the energy and direction of an incoming event, it is best to know the event type in advance to apply the suitable reconstruction algorithm for the respective topology.

This presentation discusses the development and implementation of a neural network-based classifier designed to improve the identification of event topologies in IceCube, a neutrino telescope located at the South Pole. Considering the continuous advances in machine learning, this approach aims to enhance the performance of existing methods currently in use for the classification of real-time neutrino event topologies.

T 10.2 Mon 17:00 VG 1.105

Machine Learning Tools for IceCube-Gen2 — •Francisco Javier Vara Carbonell and Alexander Kappes for the IceCube-Gen2-Collaboration — Universität Münster, Institut für Kernphysik

Machine learning tools, especially neural networks, have triggered a revolution in many areas, including neutrino astronomy. They have great potential for future neutrino telescopes such as IceCube-Gen2 with a large number of small photomultipliers. Neural networks are well suited to tackle high-dimensional problems and can naturally incorporate the segmentation of these new optical sensors. Moreover, they have a fast inference time compared to conventional algorithms, which enables the processing of the high event rates expected from IceCube-Gen2. This talk will present potential applications of neural networks in IceCube-Gen2 in areas such as simulation, event reconstruction and noise reduction, covering the current state of their development and implementation.

T 10.3 Mon 17:15 VG 1.105

Stacking Likelihood Analysis of Extreme Blazars with IceCube Public Data — •Juan Manuel Cano Vila[1,2], Chiara Bellenghi[1], and Paolo Padovani[3] — [1]Technical University of Munich, TUM School of Natural Sciences, Department of Physics, James-Franck-Straße 1, D-85748 Garching bei München, Germany — [2]Arnold Sommerfeld Center, Ludwig-Maximilians University, 80333 Munich, Germany — [3]European Southern Observatory, Karl- Schwarzschild-Straße 2, D-85748 Garching bei München, Germany

Since the confirmation of the existence of high-energy astrophysical neutrinos more than 10 years ago, researchers have been trying to identify which kind of objects emit them. The results have been limited, and the origin of the majority of this astrophysical neutrino flux remains unknown. For the last few years, IceCube has released several datasets to the public that allow any research group to test their hypothesis. One of the available tools designed to study this data is SkyLLH, an open source Python package that provides a framework for implementing custom likelihood functions and executing log-likelihood ratio hypothesis tests. In this project, we developed a new functionality to perform stacking log-likelihood analysis, where one studies the joint signal from multiple selected sources, which enhances the statistics by a population-wide study and allows to test different hypothesis by selecting the weights of each source of the population. We apply this tool to a selected population of blazars characterized by their extreme luminosities in radio and γ-rays.

T 10.4 Mon 17:30 VG 1.105

Investigating the connection of blazars to IceCube alert events with public data — •Julian Kuhlmann and Francesca Capel — Max-Planck-Institut für Physik, Garching, DE

The IceCube collaboration has recently found evidence for neutrino emission from TXS 0506+056. Different mechanisms in various emission regions have been invoked to explain the combined neutrino and multi-wavelength observations. Motivated by spatial associations of IceCube alert events with blazars, such as TXS 0506+056, we analyse a sample of similar blazars for neutrino emission, using a Bayesian hierarchical analysis framework. Utilising the framework's capability of handling many free parameters we go beyond power-laws and employ neutrino spectra typical of proton-gamma interactions. We further use priors on spectral parameters informed by lepto-hadronic modelling of multi-wavelength observations. Among the sample blazars, three sources stand out with considerable association probabilities to neutrino events. Unaccounted for systematics in event reconstruction, as well as limited simultaneous multi-wavelength data currently pose the largest restrictions on firmly identifying the sources of high-energy alert events.

T 10.5 Mon 17:45 VG 1.105

Determination of Systematic Uncertainties in Air Shower Production — •Celina Kortmann — Technische Universität Dortmund

In experimental astrophysics, physical quantities are estimated from measurements using various reconstruction techniques. The physical results can have large systematic uncertainties depending on the properties of the detectors, the analysis, and its underlying assumptions.

Our goal is to quantify and understand the systematic uncertainties associated with predictions based on Monte Carlo simulations in air shower physics. This study is of particular interest for neutrino experiments such as IceCube, whose background consists of atmospheric neutrinos and muons, and IACTs such as MAGIC, whose background contains protons and heavier nuclei, inducing air showers with a pattern similar to gamma rays. In the past, measurements of the atmospheric muon and muon-neutrino flux and of the proton flux have been made.

Using CORSIKA, a program for Monte Carlo simulations of air showers, we compare the fluxes resulting from the same showers to estimate the correlation between the muonic and electromagnetic components of air showers. The current state of the analysis is presented.

T 10.6 Mon 18:00 VG 1.105

Combined sensitivity of JUNO and Super-K on the Black Hole Fraction — •Tim Charissé[1,2], George Parker[2], David Maksimović[2], and Michael Wurm[2] — [1]Helmholtzzentrum für Schwerionenforschung, Planckstrasse 1, D-64291 Darmstadt, Germany — [2]Johannes Gutenberg-Universität Mainz, Institute of Physics and EC PRISMA+

The Diffuse Supernova Neutrino Background (DSNB) is the integrated signal of neutrinos emitted by all core-collapse supernovae (CCSNe) that occurred in the visible universe. Studying it offers insights into the inner workings of CCSNe as well as cosmological properties. The Jiangmen Underground Neutrino Observatory (JUNO), which will soon begin data taking, and the already established Super-Kamiokande (Super-K) detector are promising candidates to measure the DSNB in the near future.

While most CCSNe explode and leave behind a neutron star, an undetermined fraction of CCSNe do not explode due to prior black hole formation and hence cannot be seen by optical telescopes. However, these black hole-forming CCSNe still emit a massive amount of neutrinos which have a different spectral contribution to the DSNB than those emitted by exploding CCSNe. Therefore, the overall fraction of CCSNe that are black hole-forming might be inferred from a measurement of the DSNB spectrum. We are investigating the potential sensitivity of combined DSNB measurements by JUNO and Super-K to the black hole fraction.

T 10.7 Mon 18:15 VG 1.105

Search for the DSNB in JUNO: Development of new Methods for Background Event Identification — •Matthias Mayer, Lothar Oberauer, Hans Steiger, Simon Basten, Ulrike Fahrendholz, Meishu Lu, Konstantin Schweizer, Korbinian Stangler, and Raphael Stock — Physik-Department, TU München, James-Frank-Str. 1, 85748 Garching b. München, Deutschland

The diffuse supernova neutrino background (DSNB) describes the constant flux of neutrinos from past core-collapse supernovae over the entire visible universe. The Jiangmen Underground Neutrino Observatory (JUNO), a 20 kton liquid scintillator detector, expects to observe the DSNB through the inverse beta decay (IBD) detection channel. While other $\bar{\nu}_e$ sources will cause irreducible background in the IBD channel, we aim to reduce non-IBD backgrounds such as spallation-induced fast neutrons and atmospheric neutrino NC interactions by careful pulse-shape discrimination (PSD). For this talk, I compare the performance of different PSD techniques regarding the fiducial volume choice for the DSNB search and look at recent measurements for the energy dependence of the neutron fluorescence time profile in the JUNO scintillator. I will also give an outlook into our recent publication regarding the DSNB detection potential. This work has been supported by the Clusters of Excellence PRISMA+ and ORIGINS as well as the DFG Collaborative Research Center "NDM" (SFB1258) and the DFG Research Units 2319 and 5519.

T 11: Data, AI, Computing, Electronics I (Statistical Methods, Applications)

Time: Monday 16:45–18:00 Location: VG 2.101

T 11.1 Mon 16:45 VG 2.101

Performance measurements of Tau identification tools in ATLAS — •David Dahiya, Christian Schmidt, Arno Straessner, and Asma Hadef — Technische Universität Dresden

Tau leptons are fundamental in a variety of Standard Model and Beyond Standard Model processes currently being studied at the LHC. Their identification is crucial for exploring new physics, as they often serve as key signatures in searches for novel particles and interactions. This work focuses on improving Tau Lepton Identification (TauID) by conducting performance measurements and comparing different TauID models. Current tau identification approaches utilize Recurrent Neural Networks (RNNs), which are trained on a combination of tracks, clusters, and high-level variables to produce a predictive score for each tau candidate. However, recent advancements in machine learning introduce Graph Neural Networks (GNNs) as a promising alternative. GNNs are trained on jet and track-level variables and exploit graph-based attributes to predict features such as vertex position, jet flavor, and track origin, potentially offering a more robust and detailed analysis. This study provides a comparison of the performance of RNN-based and GNN-based models to evaluate the impact of GNNs' added complexity on tau identification. Additionally, GNNs are used to compare and evaluate tau fake factors based on a control data set using the latest Run 3 data.

T 11.2 Mon 17:00 VG 2.101

Adaptation and Optimization of Large Radius Tracking in Athena — •Doğa Elitez[1], Paul Gessinger[1], and Lucia Masetti[2] — [1]CERN — [2]Johannes Gutenberg University of Mainz

Large Radius Tracking (LRT), is a specialized tuning of charged particle track reconstruction algorithms, designed for particles originating far from the main interaction point. It has been integrated into the ATLAS experiment's primary particle reconstruction workflow as of Run-3. For the upcoming High Luminosity upgrade of the LHC, the inner detector is planned to be replaced by an all-silicon inner tracker, ITk, and the implementation of tracking algorithms plays a crucial role. This presentation describes the work focusing on the necessary adaptation and optimization of the LRT workflow within the offline ATLAS track reconstruction software, the Athena framework. The effectiveness of the LRT workflow, strongly linked to both physics and computing performance, is also examined in this study.

T 11.3 Mon 17:15 VG 2.101

Making your analysis reusable with model-agnostic likelihoods and their serialization — •Lorenz Gärtner[1], Thomas Kuhr[1], Slavomira Stefkova[2], Danny van Dyk[3], Lukas Heinrich[4], Méril Reboud[5], Nikolai Krug[1], and Malin Horstmann[4] — [1]LMU, Munich, Germany — [2]University of Bonn, Bonn, Germany — [3]IPPP Durham, United Kingdom — [4]Technical University Munich, Germany — [5]Université Paris-Saclay, France

What constitutes a "signal" in particle physics? Typically, a signal is defined by a specific physical process of interest. Using simulations, we approximate the probability densities of such processes and compare them to known backgrounds through likelihood-based methods.

What happens when parameters for the process need to be revised? What if more precise theoretical predictions become available? How can we search for an entire class of similar processes parameterized by multiple variables? Moreover, can we leverage results from multiple analyses to constrain these parameters?

We address these questions with a simple and efficient reinterpretation approach. We construct model-agnostic likelihoods by employing kinematic reweighting techniques, enabling flexible exchanges of signal models and inference on underlying physical parameters. This method's generality ensures compatibility across analyses, while its straightforward serialization facilitates easy distribution and reuse.

To demonstrate the power and simplicity of our approach, we use the likelihoods of the Belle II $B^+ \to K^+\nu\bar{\nu}$ analysis to constrain theory parameters.

T 11.4 Mon 17:30 VG 2.101

Hypothesis tests and model parameter estimation on data sets with missing correlation information — •Lukas Koch — JGU Mainz

Ideally, all analyses of normally distributed data should include the full covariance information between all data points. In practice, the full covariance matrix between all data points is not always available. Either because a result was published without a covariance matrix, or because one tries to combine multiple results from separate publications. For simple hypothesis tests, it is possible to define robust test statistics that will behave conservatively in the presence on unknown correlations. For model parameter fits, one can inflate the variance by factor to ensure that things remain conservative at least up to a chosen confidence level. In this talk I will describe a class of robust test statistics for simple hypothesis tests, as well as an algorithm to determine the necessary inflation factor for model parameter fits.

T 11.5 Mon 17:45 VG 2.101

Impact and improvement of handling uncertainties regarding R(D) and R(D*) combining algorithms — •Stefanie Meinert, Ilias Tsaklidis, Florian Bernlochner, and Markus Prim — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

Unexplained phenomena like the matter-antimatter asymmetry and neutrino masses motivate precise measurements of Standard Model (SM) parameters. Testing Lepton Flavor Universality (LFU), which predicts equal coupling of all lepton flavors to the W boson, offers a promising approach to uncover new physics. The analysis of $R(D)$ and $R(D^*)$ in semileptonic B decays is ideal due to its theoretical predictability and experimental accessibility.
HFLAV combined results from LHCb, BaBar, Belle, and Belle II to estimate $R(D)$ and $R(D^*)$, finding deviations of 1.6σ and 2.5σ from SM predictions. Their χ^2-based Combination Code (CoCo), which accounts for statistical and systematic correlations, yields a significance of 3.31σ relative to the SM, indicating potential new physics.
These results rely on assumptions and approximations about systematic correlations, and inconsistent reporting of uncertainties challenges result combinations. Using HFLAV data, we explore the impact of systematic uncertainty variations and present a first average of $R(D)$ and $R(D^*)$ from three internal Belle II measurements via likelihood combinations, leveraging pyhf and SysVar, a Python-based package developed at the University of Bonn for consistent treatment of systematic uncertainties.

T 12: Data, AI, Computing, Electronics II (Data Management, Workflow)

Time: Monday 16:45–18:15 Location: VG 2.102

T 12.1 Mon 16:45 VG 2.102

Adaptation of the HammerCloud visualization to state-of-the-art tools - online and offline — •Lea Kuttler, Michael Böhler, and Markus Schumacher — Institute of Physics, Albert-Ludwigs-University Freiburg, Freiburg, Germany

HammerCloud (HC) is a framework for automated testing designed to monitor the resources of the Worldwide LHC Computing Grid (WLCG). It uses test jobs that mimic realistic physics analysis or production jobs to identify potential issues within the infrastructure of WLCG computing sites.

HC's web interface provides site administrators with detailed insights and visual summaries of test results. After almost two decades of successful operation, these visualizations, which previously relied on Google Image Charts, were upgraded to interactive Highcharts, offering a more dynamic, and user-friendly experience.

Complementing the detailed insights available on the HC website, the Tier-2-Report provides a broader overview by summarizing important test metrics over weekly or monthly periods to analyze overall performance trends. The generation of these Tier-2-Reports is fully automated, using a tool initially developed to present and discuss HC statistics for the GridKa cloud. A recent update has made this tool applicable for generating similar reports for any other cloud. Additionally, this update introduced a redesigned report layout and enhanced representations of test metrics.

This contribution presents the updated methods for visualizing and discussing test results within the HC framework.

T 12.2 Mon 17:00 VG 2.102

A new document server and publication process tool for Belle II — •David Koch and Thomas Kuhr — Ludwig-Maximilians-Universität

An integral part of working in science and in large collaborations in particular is the documentation of work in progress and results, be it in the form of slides, internal notes and reports or papers targeted for publication. Especially the latter however involves much more than just a single document. The process starts from an analysis and includes writing multiple versions of a draft that has to go through many stages and internal approvals until it can be submitted to a journal. The Belle II experiment recently launched its own in-house developed document server, PubDB, that is also a tool to follow the entire process of bringing an analysis to publication. In this talk we show how Belle II uses PubDB to implement its publication procedure policy in a uniform, streamlined and traceable manner. We share ideas and lessons learned that are valuable to the community as a whole.

T 12.3 Mon 17:15 VG 2.102

Orchestrated columnar-based analysis with columnflow — •Mathis Frahm, Johannes Haller, Philip Keicher, Nathan Provoust, Marcel Rieger, Daniel Savoiu, Peter Schleper, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

The large datasets and increasing complexity of modern physics analysis in high energy collider physics pose a major challenge to the analysis workflows. Systems are required that can efficiently process large amounts of data, while keeping the execution of the complete analysis manageable. In this talk, we present Columnflow, a tool for columnar-based data analysis. Columnflow provides an orchestrated, yet flexible workflow that automatically handles the bookkeeping of results and dependencies. Typical analysis tasks such as propagation of systematic uncertainties, machine learning applications, and statistical inference are transparently integrated into the workflow. The implemented workflow allows the use of distributed computing resources and is fully configurable, yet accessible to newcomers.

T 12.4 Mon 17:30 VG 2.102

Pre-cache tests with the WLCG Tier-2 centre GoeGrid and the NHR HPC cluster Emmy using workflows of the ATLAS collaboration at the LHC — •Inga Łakomiec, Saidev Polisetty, Arnulf Quadt, and Sebastian Wozniewski — II Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The GoeGrid centre in Goettingen is one of the WLCG Tier-2 sites and contributes to the ATLAS job processing and data storage. The HPC cluster Emmy by the National High Performance Computing (NHR) has been successfully connected with GoeGrid and ATLAS jobs can be run on its resources. However, there is no large local mass storage at Emmy for the WLCG operations. Therefore, data for jobs that are processed at Emmy is currently provided by the GoeGrid storage. A transition of storage and computing resources to the Helmholtz Centres and NHR sites respectively from the university based Tier-2 centres is planned in Germany in the next years. Since some NHR clusters will serve as a big computing centres without a large local mass storage, there is a need to prepare proper caching solutions and validate them.

Small local storage can be available at Emmy for the WLCG tasks after the storage centralisation. The current ATLAS workflow management has been tested for Emmy computing resources together with the small local storage (pre-cache) instance at GoeGrid. Results will be presented for the different number of CPU cores used by heavier workloads exclusively or a mix of production jobs. Then, the transfer and deletion of data in terms of a small disc size will be shown.

T 12.5 Mon 17:45 VG 2.102

Research Data Management at HZDR with HELIPORT — •Stefan E. Müller[1], Thomas Gruber[1], Oliver Knodel[1], Mani Lokamani[1], David Pape[1], Martin Voigt[1,2], and Guido Juckeland[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Technische Universität Dresden, Dresden, Germany

The researchers at the Helmholtz-Zentrum Dresden-Rossendorf rely on a large variety of tools and systems when it comes to administer research data. The project planning phase (proposal submission to a beamtime proposal management system, creation of data management plans and data policies), the documentation during experiments or simulation campaigns (electronic laboratory notebooks, wiki pages), backup- and archival systems as well as the final journal and data publications (using collaborative authoring tools, meta-data catalogs, software and data repositories, publication systems) are all processes which involve research data management. Also, modern research projects often require to interact with a variety of software stacks and workflow management systems to allow reproducibility on the underlying IT infrastructure. The "HELmholtz ScIentific Project WORkflow PlaTform" (HELIPORT), which is currently developed by researchers at HZDR and their collaborators, facilitates the management of research data and metadata by providing an overarching guidance system which combines all the information by interfacing the underlying processes. It also includes a workflow engine which can be used to automate processes like automated data publication or data analysis.

T 12.6 Mon 18:00 VG 2.102

Status and Plans for the CMS Grid at Aachen — Manuel Giffels[1], •Alexander Jung[2], Thomas Kress[3], Martin Lipinski[4], Andreas Nowack[3], Valentina Sarkisovi[2], Alexander Schmidt[2], and Shawn Zaleski[2] — [1]Institut für Experimentelle Teilchenphysik, KIT — [2]III. Physikalisches Institut A, RWTH Aachen — [3]III. Physikalisches Institut B, RWTH Aachen — [4]I. Physikalisches Institut B, RWTH Aachen

From 2025 onwards, the German CMS Grid Tier-2 model will evolve to incorporate external storage from Helmholtz centers and CPU resources provided by the NHR consortium.

In this presentation, we will provide an overview of the current status and outline our plans for utilizing NHR resources for this purpose, with a focus on the Aachen CMS Grid.

T 13: Sustainability

Time: Monday 16:45–17:45 Location: VG 2.103

T 13.1 Mon 16:45 VG 2.103

Users help shaping the path to a sustainably operated VISPA computing cluster — Niclas Eich, Johannes Erdmann, Martin Erdmann, Benjamin Fischer, •Paul Gilles, Tim Hauptreif, and Jan Kelleter — RWTH Aachen University

As climate change progresses, it is evident that computing for physical research needs to become more sustainable. Although the capacity of renewable energy resources is increasing every year, we are currently still dependent on the use of fossil electricity generation. Due to the dynamic nature of renewable energy, it is essential to target smart, adaptive power consumption for more sustainable research.

In this talk, we will present approaches and results within the VISPA project to show users their personal energy consumption in the computing cluster and enable them to automatically schedule their HTCondor jobs based on the availability of renewable energy. We also present our digital twin of the VISPA cluster, which is primarily used to develop and test new resource-saving planning methods.

T 13.2 Mon 17:00 VG 2.103

Photovoltaics for MAGIC telescopes — •Katharina Kürschner and Tristan Franziskus Gradetzke — TU Dortmund, Germany

The energy supply for the MAGIC telescopes on the Canary Island of La Palma, Spain, poses a particular challenge due to its remote location. The feasibility of using photovoltaic technologies are being investigated, with a focus on concentrated photovoltaics (CPV). CPV systems potentially offer higher efficiencies than conventional photovoltaic systems by using lenses or mirrors to concentrate light, but they are technically more demanding and more expensive. At present, the MAGIC telescopes are only used at night as Cherenkov telescopes. Since the MAGIC telescopes already have mirrors, the possibility of using these mirrors for energy generation during the day is being examined. Such a concept has not yet been implemented and could provide an innovative solution to the energy challenges faced by telescopes. Various aspects of CPV are compared with conventional solar systems to assess their suitability for meeting the energy needs of the MAGIC telescopes. The current status of the analysis and initial results will be presented in this talk.

T 13.3 Mon 17:15 VG 2.103

Sustainability at Belle II — Fabian Becherer[2], Florian Bernlochner[3], Lorenz Gärtner[1], Andreas Gellrich[2], David Koch[1], •Thomas Kuhr[1], Caspar Schmitt[1], and Christian Wessel[2] — [1]LMU München — [2]DESY Hamburg — [3]Rheinische Friedrich-Wilhelms-Universität Bonn

In the Belle II collaboration, a discussion of the sustainability topic began in 2023. A survey showed that many Belle II members care about the topic. A grassroots initiative formed and made first estimates of the footprint due to detector operation, computing, and travel.

T 13.4 Mon 17:30 VG 2.103

Know Your Footprint: Evaluating the Environmental Footprint of Individual Researchers — Valerie Lang[1], Naman Kumar Bhalla[1], •Simran Gurdasani[2], and Pardis Niknejadi[2] — [1]Albert-Ludwigs-Universität Freiburg, Freiburg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg and Zeuthen, Germany

Mitigating the environmental impact of particle physics is essential for addressing the broader challenges of sustainability, particularly given the resource-intensive nature of the field. The *Know your footprint* initiative, developed within the young High Energy Physicists Germany, provides a self-evaluation survey to quantify an individual's professional footprint by considering four key areas: Experiment, representing the large infrastructure within HEP collaborations; Institute, accounting for emissions from research institutes and universities; Computing, covering resource consumption for data analysis and simulations; and Travel, related to business trips for conferences, workshops, and meetings. The methodology behind the survey is presented, along with a first look at the data collected during its first year of activity. The *Know your footprint* initiative aims to raise awareness, facilitate data-driven discussions, and encourage the adoption of more sustainable research practices within the community.

T 14: Methods in Astroparticle Physics I

Time: Monday 16:45–18:00 Location: VG 3.101

T 14.1 Mon 16:45 VG 3.101

Construction, Calibration, and Operational Plans of the Acoustic Module for the IceCube Upgrade — •Andreas Nöll, Jan Audehm, Jürgen Borowka, Pierre Dierichs, Mia Giang Do, Christoph Günther, Dirk Heinen, Joëlle Savelberg, Christopher Wiebusch, and Simon Zierke — III. Physikalisches Institut B, RWTH Aachen University

The IceCube Neutrino Observatory is a cubic kilometer-sized detector located at the geographic South Pole, consisting of 5160 Digital Optical Modules (DOMs). In the Antarctic summer 2025/26 more than 700 new modules will be installed as part of the IceCube Upgrade. These include ten Acoustic Modules (AMs), capable of transmitting and receiving acoustic signals between 5 and 30kHz. Additionally, up to 30 acoustic receivers will be located in new DOMs. The goal of these devices is to improve the geometry calibration based on multilateration of the measured acoustic propagation times, as well as enhance our understanding of the acoustic properties of the ice. This talk presents the construction and calibration of AMs, including the acoustic transducer and its internal electronics, as well as an overview of the planned operations of this system.

T 14.2 Mon 17:00 VG 3.101

Development and Construction of the Wavelength-shifting Optical Module for the IceCube Upgrade — •Yuriy Popovych[1], Sebastian Böser[1], Enrico Ellinger[2], Klaus Helbing[2], Adam Rifaie[2], Lea Schlickmann[1], and Nick Schmeisser[2] for the IceCube-Collaboration — [1]Johannes Gutenberg-Universität Mainz — [2]Bergische Universität Wuppertal

The Wavelength-shifting Optical Module (WOM) is an innovative photosensor concept set to be deployed in the IceCube Upgrade during austral summer 2025/26. Utilizing wavelength-shifting and total internal reflection techniques, the WOM is well suited for detecting low-energy neutrinos thanks to its low noise rate. Its photosensitive area consists of a cylindrical tube coated with wavelength-shifting paint, which converts UV-photons and guides them to coupled Photomultiplier Tubes (PMTs) at both ends. This optical design decouples the photosensitive area from the PMTs, achieving a high signal-to-noise ratio and effective coverage of the UV-region of the Cherenkov spectrum.

A total of 11 WOMs are planned for deployment, with 5 already shipped. This presentation will provide insights into the production process, highlight key engineering challenges, and discuss results from optical acceptance testing. Additionally, recent design improvements and the production status of the second batch, scheduled for shipment this summer, will be featured.

T 14.3 Mon 17:15 VG 3.101

In-situ Calibration Routines for IceCube Upgrade mDOMs without Artificial Light Sources — •Carolin Klein[1] and Summer Blot[2] — [1]Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [2]DESY, Zeuthen, Germany

Calibration is crucial for the success of every physics experiment. Over the last decade, the IceCube Neutrino Observatory has yielded important results in neutrino astronomy and neutrino oscillations. Building on this progress, the IceCube Upgrade project is set to expand the current detector array during the austral summer 2025/26. It will enhance the detector's overall sensitivity and lower its energy threshold by reducing the spacing between strings, enabling more detailed studies of atmospheric neutrinos.

In this talk, in-situ calibration routines without artificial light sources for the IceCube Upgrade multi-PMT digital optical modules (mDOMs) are proposed. This includes the calibration of the mDOM mainboard electronics using front-end pulsers, as well as the PMT gain and relative transit time calibration using the natural radioactivity from the glass vessel. The latter approach allows for a long-term monitoring of the PMT gain and the relative transit time without downtimes of the modules. First results of the routines will be presented in this talk.

T 14.4 Mon 17:30 VG 3.101

Drone-Based Calibration of AugerPrime Radio Antennas at the Pierre Auger Observatory — •Alex Reuzki, Maximilian Straub, and Martin Erdmann — III. Physikalisches Institut A, RWTH Aachen

Radio emissions of extensive air showers can be observed at the Pierre Auger Observatory with the AugerPrime radio detector (RD). As part of the AugerPrime upgrade, RD is being installed on 1660 water-Cherenkov detectors on an area of about 3000 km^2 and consists of dual-polarized Short Aperiodic Loaded Loop Antennas (SALLA). To achieve high measurement precision, RD needs to be well-calibrated, which requires the antenna response pattern to be well-known. We introduce a method to measure the directional response of the SALLA using a well-defined biconical antenna mounted to a drone. The drone-based setup possesses active stabilization and precise pointing with the use of a gimbal. Additionally, the drone's position is tracked using differential GPS with $\mathcal{O}$(cm) precision. This setup allows us to precisely extract the antenna response pattern from any direction in the frequency range of $30 - 80$ MHz. In a recent in-situ campaign, calibration measurements of the AugerPrime radio detector have been performed. The measurements are interpolated using information field theory to obtain the full antenna response pattern for all directions and frequencies. First results are presented and compared to simulations.

T 14.5 Mon 17:45 VG 3.101

Reconstruction of Extensive Air Showers from Radio Detector Data using Information Field Theory — •Simon Strähnz[1], Tim Huege[1,2], Philipp Frank[3], and Torsten Ensslin[3] — [1]Karlsruher Institut für Technologie, Deutschland — [2]Astrophysical Institute, Vrije Universiteit Brussel, Belgien — [3]Max Planck-Institut für Astrophysik, Garching, Deutschland

Using radio detectors for cosmic rays is a very appealing approach, as they are cost-effective, have a duty cycle of nearly 100% and can directly probe the electromagnetic component of extensive air showers. However, reconstructing the electric field from the measured voltages in an antenna by unfolding the antenna response comes with several challenges, mainly because of measurement noise. These issues could be solved by Bayesian inference. The challenge with that approach is that the electric field is continuous, which would lead to an infinite-dimensional latent space. Information field theory (IFT) has been developed to deal with this problem and allow for Bayesian reasoning on fields. We will present a signal model that can be used with IFT based inference algorithms that can successfully reconstruct the electric field measured by a single antenna. The performance of this method has been demonstrated with Monte Carlo simulations of air shower radio signals. We will also show extended models being developed to combine the data from all antennas in a given array and reconstruct entire events. Since Bayesian inference provides the posterior distribution, this method also provides an estimate of the uncertainty of the measured field.

T 15: Cosmic Rays I

Time: Monday 16:45–18:15 Location: VG 3.102

T 15.1 Mon 16:45 VG 3.102

Beamforming with the SKA-Low array for detection of gamma rays at PeV energies. — •Subhadip Saha[1,2] and Tim Huege[1] for the SKA High-Energy Cosmic Particles Science Working Group-Collaboration — [1]Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]Indian Institute of Technology Kanpur, Kanpur, India.

SKA-Low (Square Kilometer Array) is globally recognized as the next-generation radio-astronomical observatory at frequencies below 350 MHz. We are focusing on its dense core region and aim to perform beamforming with thousands of antennas to detect the radio emission from particle showers initiated by cosmic or gamma rays in the atmosphere. Beamforming is expected to lower the radio-detection threshold for air showers considerably. With thousands of these antennas, the beamforming approach has significant potential to lower the detection threshold down to as low as 1 PeV. The strength of the beamformed signal can be scaled with the number of antennas and energy to estimate the number of antennas required to detect these low-energetic energetic air showers. We are investigating how far the detection threshold can essentially be brought down with the beamforming application and if the detection of PeV gamma rays would be possible.

T 15.2 Mon 17:00 VG 3.102

Advancing Cosmic-Ray Studies with LOFAR and the LORA Scintillator Array — •Stuti Sharma[1] and Anna Nelles[1,2] for the LOFAR-Cosmic ray key science project-Collaboration — [1]ECAP, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Zeuthen, Germany

The Low Frequency Array (LOFAR) is a radio telescope with antenna fields across Netherlands and Europe. Designed to observe the radio sky at low frequencies, it also provides precision measurements of the radio emission of cosmic-ray air showers in the range of 30-80 MHz. Central to LOFAR's cosmic-ray key science project is the LOFAR Radboud Air Shower Array (LORA), an array of 40 scintillation detectors in LOFAR's dense core. LORA measures particle densities from air showers, serving as a trigger for the LOFAR antennas and providing initial estimates of shower direction, energy, and core position. It detects cosmic rays above 1e16 eV, with nanosecond timing ensuring precise reconstruction of shower geometry and radio footprint. The LORA upgrade doubled the detector count, expanding the effective area and increasing trigger rates for high-energy events by 45%. This enhancement reduces composition bias and improves sensitivity to proton and iron primaries, essential for exploring the galactic-to-extragalactic cosmic-ray transition. Our goal is to incorporate data from LORA into the radio reconstruction framework, facilitating both standalone and integrated analyses of cosmic ray in particle and radio data.

T 15.3 Mon 17:15 VG 3.102

Monitoring Large-Scale Radio-Detection Arrays with Machine Learning — •Johann Luca Kastner for the GRAND-Collaboration — Karlsruher Institut für Technologie, Institut für Astroteilchenphysik

In recent years, radio-detection techniques, such as those employed in the GRAND experiment, have emerged as a promising method for detecting ultra-high-energy cosmic rays (UHECRs). One of the key advantages of radio detection is its cost-effectiveness, allowing for the deployment of large arrays that can cover vast areas necessary for measuring the low fluxes of UHECRs. However, this comes with the challenge of monitoring the functionality of a massive number of antennas (up to tens of thousands) over a vast area (tens of thousands of km^2). In this talk, we will present an approach to addressing this challenge using a combination of dimensionality reduction (UMAP) and clustering (DBSCAN) algorithms applied to periodically triggered monitoring data of a GRAND prototype setup. Our method aims to identify malfunctions and periods of poor operation, enabling efficient maintenance and optimization of the radio-detection system.

T 15.4 Mon 17:30 VG 3.102

The holy grail of air shower triggers: Tests towards a self-standing radio trigger at the Pierre Auger Observatory* — •Jannis Pawlowsky and Julian Rautenberg for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Wuppertal, Germany

The Pierre Auger Observatory is the largest facility for the detection of ultra-high-energy cosmic rays. Key aspects to achieve the highest sensitivity are the particle triggers, which are responsible for maximizing station data read-out of reconstructable air showers within limited communication bandwidth. This system works excellent for the majority of hadron-induced air showers. However, it can be improved for air showers induced by neutral primaries such as photons and neutrinos. A radio trigger implemented for the AugerPrime Radio Detector provides an alternative when particle detectors become less efficient. The feasibility of such a radio trigger is heavily dependent on the noise environment, dominated by anthropogenic sources.

This work presents the efforts made to develop a bandwidth-compatible trigger. The design of the trigger is discussed, which was also employed in multiple field tests. The results of these tests are shown, yielding conclusions on the radio noise environment at the Observatory and the compatibility of the trigger with the communication bandwidth. Furthermore, planned improvements are discussed.

**Supported by BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A23PX1)*

T 15.5 Mon 17:45 VG 3.102

Status of the antennas at the IceCube Surface Array Enhancement — •Megha Venugopal for the IceCube-Collaboration — Institute of Astroparticle Physics (IAP), Karlsruhe Institute of Technology, Germany

IceCube is a cubic km detector at the South Pole comprising two main components, the neutrino detector that measures neutrinos in-ice, the IceCube Neutrino Observatory and IceTop, a surface cosmic-ray detector constituting 81 pairs of ice-filled Cherenkov tanks. An extension with multiple stations, each station equipped with 8 elevated scintillators and 3 antennas, was planned on the IceTop footprint to complement existing measurement methods and to serve as part of a larger surface array for IceCube-Gen2. In early 2023, the scintillators of the single deployed station of the IceCube Surface Enhancement were upgraded, increasing the dynamic range and enabling the reconstruction of more coincident air showers. An updated dataset combining data from radio and IceTop detectors is presented. Additionally, the current status of the deployment of new stations is discussed.

T 15.6 Mon 18:00 VG 3.102

Status and Performance of the Scintillation detectors of the IceCube Surface Array Enhancement — •S Shefali for the IceCube-Collaboration — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany

The IceCube Neutrino Observatory is a multipurpose detector which includes a unique surface array, IceTop, highly instrumental for cosmic-ray studies in addition to its capability of vetoing for astrophysical neutrino searches for the IceCube in-ice instrumentation. An enhancement of the surface array, with scintillation and radio detectors, in order to facilitate multi-component cosmic ray studies, as well as improving the IceTop detectors calibration by accounting for the snow accumulation on them, has been ongoing. The existing prototype station was upgraded with improved Scintillation detectors at the beginning of January 2023. This contribution will discuss the performance of the scintillation detectors following the 2 years of successful air shower measurements with this upgrade.

T 16: Neutrino Physics I

Time: Monday 16:45–18:15 Location: VG 3.103

T 16.1 Mon 16:45 VG 3.103

Recent advances in the search for $0\nu\beta\beta$ decay of 76Ge with LEGEND-200 — •Moritz Neuberger for the LEGEND-Collaboration — Physik-Department E15 Technische Universität München James-Franck-Straße D-85748 Garching Germany

The LEGEND collaboration's objective is to detect neutrinoless double-beta ($0\nu\beta\beta$) decay in ^{76}Ge using state-of-the-art enriched high-purity germanium (HPGe) detectors. In its first phase, LEGEND-200, the experiment has collected physics data for over a year, employing 140 kg of HPGe detectors in a liquid argon cryostat. This talk presents the results of the $0\nu\beta\beta$ decay analysis based on this data set. Furthermore, we will provide updates on integrating additional HPGe detectors and discuss auxiliary studies used to develop our background model further.

This research is supported by the DFG through the Excellence Cluster ORIGINS EXC 2094 - 390783311, the SFB1258, and by the BMBF Verbundprojekt 05A2023.

T 16.2 Mon 17:00 VG 3.103

Muon Veto of LEGEND-200: Analysis and Simulations — •Gina Grünauer — Physikalisches Institut, Eberhard Karls Universität Tübingen

The **L**arge **E**nriched **G**ermanium **E**xperiment for **N**eutrinoless $\beta\beta$ **D**ecay (LEGEND) is an phased experimental program dedicated to the search for neutrinoless double beta ($0\nu\beta\beta$) decay of ^{76}Ge. To reach the aimed discovery sensitivity for a half-life of more than 10^{28} years, a background rate of less than 10^{-5} cts/(keV·kg·yr) is required. A Water-Cherenkov-Veto operates for this purpose for the current experimental phase LEGEND-200. It uses photomultiplier tubes (PMTs) as light detectors in a water-tank lined with a reflective foil to increase the light yield within the system. This contribution provides the working principle as well as the ongoing data analysis and simulations of the Muon Veto of LEGEND-200.

This work is supported by the U.S. DOE and the NSF, the LANL, ORNL and LBNL LDRD programs; the European ERC and Horizon programs; the German DFG, BMBF, and MPG; the Italian INFN; the Polish NCN and MNiSW; the Czech MEYS; the Slovak RDA; the Swiss SNF; the UK STFC; the Canadian NSERC and CFI; the LNGS and SURF facilities.

T 16.3 Mon 17:15 VG 3.103

Search for Neutrinoless Double Beta Plus Decays with NuDoubt^{++} — •Cloé Girard-Carillo for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz

The discovery of neutrino oscillations revealed the possibility of neutrinos having masses, which could originate from Majorana particles and result in lepton number violation. One way to observe this violation is through neutrinoless double beta decay, where neutrinos are exchanged internally without appearing as external particles.

Most experiments so far have focused on double electron emission. However, advancements in new scintillator technologies, offering enhanced particle identification, now make it feasible to investigate double positron emission processes as well.

This presentation introduces the NuDoubt++ experiment, which uses a hybrid opaque scintillator with isotope loading to search for such a process. This combination makes it possible to separate signal from background using event topology and the ratio of Cherenkov to scintillation light. We will also explain how we plan to load $\beta\beta$ isotopes into the scintillator and describe a new proposal for collecting light more efficiently. We present the latest progress on the project, including recent developments in detector design and performance.

T 16.4 Mon 17:30 VG 3.103

Event Classification for the Hybrid Opaque Scintillator Experiment NuDoubt^{++} — •Kyra Mossel for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz, Institut für Physik, 55128 Mainz, Germany

Neutrinoless double beta decay is a hypothetical nuclear process assuming that could occur if the neutrino is its own antiparticle. In this process, two neutrons (protons) decay into two protons (neutrons), emitting two electrons (positrons) but no neutrinos, thereby violating lepton number conservation and demonstrating the Majorana nature of the neutrino. Detecting this extremely rare decay requires exceptionally low background levels and reliable particle identification mechanisms.

The NuDoubt^{++} experiment, designed to study double beta plus decays, addresses this challenge using a novel hybrid and opaque scintillator which is permeated by a fine grid of optical fibers. This setup utilizes both the topology of energy deposits and the ratio of Cherenkov to scintillation light to enhance background discrimination and particle identification.

This presentation focuses on the Cherenkov-to-scintillation light ratio as a tool for background discrimination. The expected photon arrival time distributions for different background event types are shown as well as the experiment's anticipated performance to distinguish them from signal events.

T 16.5 Mon 17:45 VG 3.103

Studies on general neutrino interactions with the KATRIN experiment — •Hanna Henke and Caroline Fengler for the KATRIN-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany

The KATRIN Experiment aims to determine the neutrino mass using precision spectroscopy of electrons from tritium β-decay. Recently, KATRIN published an improved upper bound of 0.45 eV at 90% C.L. [1] on the effective electron-neutrino mass; the latest step in an ongoing effort to reach a target sensitivity of below 0.3 eV. Supplementary to the neutrino mass measurement the high-precision spectroscopy allows to probe beyond standard model physics, for instance general neutrino interactions (GNI), which can be examined through shape deformations in the integral β-energy spectrum. For the GNI a model-independent approach combines each theoretically allowed interaction term into one effective field theory to describe the impact of energy-dependent spectrum contributions as an indicator for novel weak processes. Recently, first constraints on general neutrino interactions based on KATRIN data were released [2]. This talk will give an overview of the GNI framework and analysis, and present further GNI studies.

This work is supported by the Helmholtz Association, through the Helmholtz Initiative and Networking Fund (grant no. W2/W3-118), and by BMBF (grant no. 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6)

[1] arXiv:2406.13516, [2] arXiv:2410.13895

T 16.6 Mon 18:00 VG 3.103

Adiabatic characteristics of the KATRIN beamline in the

TRISTAN phase — •Justus Beisenkötter for the KATRIN-Collaboration — Intitut für Kernphysik, Universität Münster

After the end of the neutrino mass search with KATRIN, the current focal plane detector will be replaced by the new TRISTAN detector with significantly better energy resolution and higher granularity, to enable a search deep into the tritium beta-decay spectrum for keV sterile neutrinos. In this new measurement phase, the retarding potential of the KATRIN main spectrometer will be reduced from the current level near the spectral end point to a few kV. This will lead to much higher surplus energies in the spectrometer, so that the magnetic moment $\mu = E_{\perp}/B$ of the beta electrons is no longer constant and the adiabatic approximation for electron tranport is no longer valid. Simulations have shown that by changing the field configuration, moving the highest magnetic field from the detector side of the main spectrometer to the source side, the non-adiabatic effects can be suppressed. The talk will present the results of measurements of this new magnetic field setup and a comparison with simulation results. This work is supported by BMBF ErUM-Pro 05A23PMA.

T 17: Neutrino Physics II

Time: Monday 16:45–18:15 Location: VG 3.104

T 17.1 Mon 16:45 VG 3.104

Novel constraints on neutrino physics beyond the standard model of elementary particles from the CONUS and CONUS+ experiments — •Dario Piani, Nicola Ackermann, Hannes Bonet, Christian Buck, Janina Hakenmüller, Janine Hempfling, Gerd Heusser, Manfred Lindner, Werner Maneschg, Kaixiang Ni, Thomas Rink, Edgar Sánchez García, and Herbert Strecker — MPIK, Heidelberg, Germany

The detection of coherent elastic neutrino-nucleus scattering (CEνNS) opens up new opportunities for neutrino physics within and beyond the standard model of elementary particles. Constantly refining the setup, the experiments CONUS (until 2022) and CONUS+ (since 2023) provide valuable data towards the detection of such events from reactor (anti)neutrinos emitted by the powerful (3.9 GW and 3.6 GW) reactors of the nuclear power plants in Brokdorf (Germany) and Leibstadt (Switzerland). The acquired and future CONUS/CONUS+ data sets enable further investigations on neutrino physics beyond the standard model, such as yet undetected neutrino channels and electromagnetic properties. This talk will explore constraints on beyond the standard model neutrino phenomenology from not yet analyzed data. Bounds on non-standard neutrino-quark interactions of vector and tensor type from CEνNS are presented. Furthermore, the parameter space of simplified scalar and vector mediators probed by CEνNS and elastic neutrino-electron scattering is discussed. Finally, limits on an effective neutrino magnetic moment and effective neutrino millicharge are given.

T 17.2 Mon 17:00 VG 3.104

First result of the CONUS+ experiment — •Nicola Ackermann for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

With the CONUS+ reactor antineutrino experiment, the coherent elastic neutrino nucleus scattering (CEνNS) on germanium nuclei is currently studied at the nuclear power plant in Leibstadt, Switzerland. Very low energy thresholds down to 160 eV were achieved in four 1 kg point contact germanium detectors equipped with electric cryocooling. The setup is positioned at a distance of about 20 m from the center of the reactor core. The detector performances and first CONUS+ results after few months of data taking will be presented. In November 2024 three detectors were replaced by newer models with higher Ge crystal masses of 2.4 kg each to further improve the sensitivity of the experiment.

T 17.3 Mon 17:15 VG 3.104

Precise Determination of the Background in Electronic Recoil Channel from XENONnT — •Ying-Ting Lin for the XENON-Collaboration — Saupfercheckweg 1, 69117 Heidelberg, Germany

The XENONnT experiment, utilizing a 5.9-tonne liquid xenon dual-phase time projection chamber (TPC), is searching for dark matter and other rare physical phenomena. Having achieved an unprecedentedly low background level in the electron-recoil (ER) channel, the detector will be capable of detecting proton-proton (pp) chain solar neutrinos via elastic neutrino-electron scattering, while at the same time setting new limits to search of Beyond the Standard Model (BSM) physics such as solar axions, neutrino magnetic moments, axion-like particles (ALPs), and dark photons. To achieve such sensitivity, it is critical to determine the precise levels of the two major background sources, ^{222}Rn and ^{85}Kr. For ^{222}Rn, a dedicated ^{222}Rn calibration was performed. Together with an analysis framework that tracks the ^{222}Rn alpha decay, this background contribution can be constrained to an order of 10% precision. For krypton, the Rare Gas Mass Spectrometer (RGMS) at the Max Planck Institute for Nuclear Physics (MPIK) has demonstrated the world-leading detection limit of 8 parts per quadrillion (ppq) to the krypton concentration in our xenon TPC, providing a stringent constraint to ^{85}Kr. The highlight will cover the analysis results for both background estimates.

T 17.4 Mon 17:30 VG 3.104

Prospects of Solar Neutrino Detection via Delayed Coincidence Signatures in ^{136}Xe Charged Current Interactions with XENONnT — •Henning Schulze Eissing for the XENON-Collaboration — Institut für Kernphysik, Universität Münster

The XENONnT experiment, located at the INFN Laboratori Nazionali del Gran Sasso, is a dual-phase time projection chamber containing a target mass of 5.9 tonnes of liquid xenon designed for direct dark matter detection. Its unprecedented low background level in the electronic recoil channel enable searches for rare processes beyond its primary science goal.

A search strategy for solar neutrino charged current interactions with ^{136}Xe into an excited state of ^{136}Cs is being developed, exploiting the unique de-excitation signature of ^{136}Cs* caused by low-lying isomeric states with lifetimes on the order of 100 nanoseconds. This characteristic delayed coincidence signature provides powerful background discrimination in XENONnT's already low-background environment. The analysis methodology employs two complementary machine learning approaches: a classifier trained to identify the characteristic multi-peak events in the scintillation waveforms, and a reconstruction algorithm capable of resolving individual scintillation signals within merged waveforms. The development of these ML models, their validation, and initial studies of the detection efficiency are presented along with a overview of the search strategy, demonstrating the potential of this approach for solar neutrino measurements with XENONnT.

This work is supported by BMBF ErUM-Pro 05A23PM1.

T 17.5 Mon 17:45 VG 3.104

Neutron Detection with SANDI II in ANNIE — •Amala Augusthy, Noah Goehlke, Philipp Kern, David Maksimovic, Johann Martyn, Daniel Schmid, Michael Wurm, and Dorina Zundel for the ANNIE-Collaboration — Institut für Physik and EC PRISMA+, JGU Mainz, Mainz 55128, Germany

ANNIE is an accelerator neutrino experiment at the Booster Neutrino Beam at Fermilab. It is a 26-ton Gadolinium-loaded water Cherenkov detector designed to measure CC interaction cross-sections and neutron multiplicity. In addition, ANNIE serves as a testbed for novel detector technologies amongst which is Water-based Liquid Scintillator (WbLS). WbLS is a novel detection medium that allows the simultaneous detection of scintillation and Cherenkov light. To test the detection capabilities with WbLS, a 366 L cylindrical vessel, filled with Gadolinium (Gd) loaded WbLS, dubbed SANDI II was deployed in ANNIE, in fall 2024. Neutrons are a major source of systematic uncertainty in long baseline neutrino oscillation experiments, hence it is very important to tag neutrons efficiently. To investigate the enhanced neutron detection capabilities of Gd loaded WbLS, an AmBe neutron calibration source was deployed in ANNIE. This talk gives an overview of the preliminary results of the analysis of AmBe data with Gd loaded WbLS. This project is supported by DFG ANNIE and DFG Graduate School GRK 2796: Particle Detectors.

T 17.6 Mon 18:00 VG 3.104

First Water-based Liquid Scintillator (WbLS) measurement with DISCO — •Noah Goehlke[1], Amala Augusthy[1],

Manuel Böhles[1], Daniele Guffanti[3], Benedict Kaiser[4], Tobias Lachenmaier[4], Hans Steiger[2], and Michael Wurm[1] — [1]Johannes Gutenberg-Universität Mainz — [2]Technical University of Munich — [3]University of Milano-Bicocca — [4]Eberhard Karls Universität Tübingen

Water based liquid scintillator (WbLS) is a novel detection medium, consisting of liquid scintillator dissolved in water with the help of a surfactant. It allows for the simultaneous measurement of Cherenkov and scintillation light. This hybrid event topology can be used for event reconstruction including sub-Cherenkov particles but also enhanced background rejection, for example for measuring the DSNB. Thus, WbLS is being considered as detection medium for future neutrino detectors like Theia. DISCO is a lab-scale experiment, designed to investigate the Cherenkov-scintillation separation and to characterize WbLS, using cosmic muons. The detector has a cylindrical 15 l test-cell which can be filled with water, WbLS or liquid scintillator. The light is detected by 16 fast 1" PMTs with the option to install in addition an LAPPD (Large Area Picosecond PhotoDetector). The fast photon detectors allow DISCO to investigate a time-based separation of the fast Cherenkov and slower scintillation light. Above the test-cell is a muon tracker, used as a trigger and to reconstruct the muon tracks. This talk presents results of the first WbLS run with DISCO. This work is supported by the Research Training Group "Particle Detectors".

T 18: Methods in Particle Physics I (Calo, Jets, Tagging)

Time: Monday 16:45–18:30 Location: VG 4.101

T 18.1 Mon 16:45 VG 4.101

Calibration of calorimeter signals in theATLAS experiment using an uncertainty-awareneural network — •Isabel Sainz Saenz-Diez — Kirchhoff Institute for Physics, Heidelberg University

Measuring energy deposits in the calorimeters are a key aspect of particle reconstruction. In the case of the ATLAS experiment at the Large Hadron Collider (LHC), the calorimeter signals are reconstructed as clusters of topologically connected cells (topo-clusters). These are calibrated in such way that they correctly measure the energy deposited by electromagnetic showers, but they do not compensate for the fraction of energy that does not contribute to the signal, which is part of the hadronic showers. In order to account for this energy, a local hadronic calibration of topo-clusters is applied. Machine Learning (ML) methods have been proposed as an alternative to the current hadronic calibration in ATLAS. Both a Deep Neural Net (DNN) and a Bayesian Neural Net (BNN) yield continuous unbinned calibration functions with an improved performance with respect to the standard calibration. Additionally, the BNN provide an estimation on the uncertainties of the calibration output. The talk will present the current status of the implementation and performance of the proposed models.

T 18.2 Mon 17:00 VG 4.101

Understanding punch-through effects on jet calibration using Run 2 and Run 3 data with the ATLAS detector — •Chiara Deponte and Chris Malena Delitzsch — Technische Universität Dortmund, Deutschland

At high energies, jets can penetrate beyond the calorimeter and deposit energy in the muon spectrometer, a phenomenon known as the punch-through. Since energy depositions in the muon spectrometer are not accounted for during jet reconstruction, the resulting jet energy tends to be smaller. To address this, corrections are applied during the jet energy calibration process to improve the jet energy resolution. In the ATLAS experiment, the Global Sequential Calibration mitigates punch-through effects by utilizing the number of muon segments associated with small-radius (R = 0.4) jets. The performance of this correction was studied using Monte Carlo simulation for Run 2 and 3, comparing both fast and full simulation.

T 18.3 Mon 17:15 VG 4.101

In-Situ Calibration of Small-Radius Jets Using the MPF Method with γ+jets Events in ATLAS — •Simone Ruscelli and Chris M. Delitzsch — Technische Universität Dortmund (Germany)

The V+jets calibration is a pivotal component of the in-situ jet calibration in ATLAS to correct for differences in the jet energy scale between data and Monte Carlo simulation due to the imperfect simulation of e.g. the detector materials, pile-up and jet formation. This presentation focuses on the γ+jets calibration of small-radius (R=0.4) jets, reconstructed from particle flow objects, using data collected with the ATLAS detector during Run 2. The Missing-E_T Projection Fraction (MPF) technique is used, which takes into account the full hadronic recoil in an event as opposed to the Direct Balance (DB) method, which only considers the balancing jet. The MPF method has numerous advantages, e.g. it is not strongly affected by the jet definition and is also robust to both pile-up and the underlying event.

T 18.4 Mon 17:30 VG 4.101

Run 3 performance and advancement of Heavy-Flavor Jet Identification in CMS — SVENJA DIEKMANN[1], MING-YAN LEE[1], SPANDAN MONDAL[2], •UTTIYA SARKAR[1], ALEXANDAR SCHMIDT[1], and SEBASTIAN WUCHTERL[3] — [1]III. Physikalisches Institut A, RWTH Aachen University, Germany — [2]Brown University, Providence, USA — [3]European Organization for Nuclear Research (CERN), Geneva, Switzerland

The identification of heavy-flavor jets is essential for many high-energy physics analyses, including studies of the top quark, Higgs boson, and new physics searches. Recent advances in machine learning, including graph networks, and transformers namely UParT (Unified Particle Transformer) algorithm, have significantly improved tagging performance for heavy-flavor (b, c) and hadronic tau jets. This talk presents the latest development of flavor taggers, their deployment in the CMS High Level Trigger (HLT) system and offline performances in proton-proton collision with the Run 3 data.

T 18.5 Mon 17:45 VG 4.101

Optimizing charm-jet tagging in ATLAS — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], Arpan Ghosal[1], Gabriel Gomes[1], Jan Joachim Hahn[1], Vadim Kostyukhin[1], Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], Sebastian Rentschler[1], Elisabeth Schopf[1], Katharina Voss[1], Wolfgang Walkowiak[1], •Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

Classifying jets based on the flavour of the parton that initiates the jet is a crucial task in analyses involving final states with b- or c-quarks. In recent years, jet flavour taggers in ATLAS have seen significant improvements, largely thanks to the adoption of end-to-end transformer models that directly use track-level inputs to predict the jet class. While b-jet identification remains the strongest feature of these models due to the distinct characteristics of b-jets, they can also be used for c-jet tagging. This talk will focus on charm tagging using GN2, the latest flavour tagging model developed by ATLAS. The presentation will cover the challenges of simultaneous b- and c-tagging, the trade-offs in parameter choices, and the performance of the model in terms of efficiencies and rejection rates for benchmark samples.

T 18.6 Mon 18:00 VG 4.101

Material interactions in ATLAS jet flavour tagging — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], Arpan Ghosal[1], Gabriel Gomes[1], Jan Joachim Hahn[1], Vadim Kostyukhin[1], •Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], Sebastian Rentschler[1], Elisabeth Schopf[1], Katharina Voss[1], Wolfgang Walkowiak[1], Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

Jet flavour tagging plays a crucial role in understanding particle physics processes. In the continuous effort to enhance flavour tagging performance the ATLAS Collaboration is currently deploying deep learning transformer models.

Jets originating from a b-quark are easy to tag because of the characteristic bottom hadron decays. Due to long lifetimes, B-hadrons decay far from the primary event vertex, producing a significant number of tracks with big impact parameters. However, this feature can be mimicked by interactions of particles with the detector material, also producing displaced tracks.

This presentation will demonstrate how material interactions may lead to the misidentification of jets originating from quarks of lighter flavour as *b*-jets, and it will discuss first results of an attempt to mitigate the influence of material interactions. This attempt consists of adding an auxiliary task, which identifies these interactions, to the flavour tagging machine learning model.

T 18.7 Mon 18:15 VG 4.101

Flavour Tagging with ParticleNet at ILD — •Ulrich Einhaus[1] and Bryan Bliewert[2,3] — [1]Karlsruhe Institut für Technologie KIT — [2]Deutsches Elektronen-Synchrotron DESY — [3]Universität Hamburg

With the exploitation of the LHC in full swing, the particle physics community is turning its focus on the next flagship collider, an e^+e^- Higgs factory. Many studies are ongoing studying physics prospects and optimising detector designs. In recent years, machine learning approaches to reconstruction algorithms have moved to neural network architectures, showing the performance advantages of their optimised exploitation of detector-level information. One area of application are flavour taggers, where several neural network approaches are actively under development.

This talk presents an implementation of the ParticleNet flavour tagger for the ILD detector concept, with data in full simulation. It covers the structure and performance, in particular the new strange tag, and highlights the dependence on specific observables and their impact on selected physics channels, informing further detector development.

T 19: Search for Dark Matter I

Time: Monday 16:45–18:45 Location: VG 4.102

T 19.1 Mon 16:45 VG 4.102

The Direct search Experiment for Light Dark Matter (DELight): Overview and Perspectives — •Eleanor Fascione for the DELight-Collaboration — Heidelberg University

There is vast unexplored parameter space for dark matter masses below a few GeV, and the field of direct dark matter detection is constantly expanding to new frontiers. In particular, low mass dark matter candidates necessitate novel detector designs with lower thresholds and alternative target materials compared to e.g. the xenon-based experiments currently providing the strongest overall constraints on many dark matter models.

The Direct search Experiment for Light dark matter (DELight) will deploy a target of superfluid ^{4}He instrumented with large area microcalorimeters (LAMCALs) based on magnetic microcalorimeter (MMC) technology in a setup optimized for low mass dark matter searches. In this talk an overview of this novel upcoming experiment will be presented, including preliminary background models and sensitivity projections.

T 19.2 Mon 17:00 VG 4.102

Signal partitioning in superfluid ^{4}He: A Monte Carlo approach — •Francesco Toschi for the DELight-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics — Heidelberg University, Kirchhoff-Institute for Physics

Superfluid ^{4}He presents a compelling target for direct detection of light dark matter (LDM), offering both a low nuclear mass and a low energy detection threshold through quasiparticle generation. This talk will discuss the physical processes involved in the deposition of energy in superfluid ^{4}He, focusing on the response to nuclear and electronic recoils, which are crucial for the detection of LDM. A Monte Carlo simulation framework has been developed to model the distribution of deposited energy across distinct signal channels for various recoil types. This work is essential for optimizing the design and performance of next-generation detectors such as the DELight experiment.

T 19.3 Mon 17:15 VG 4.102

Simulation of Particle Induced Damage Tracks in Crystal Detectors — •Lukas Scherne and Alexey Elykov — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

A new approach to detecting Dark Matter (DM) involves so-called "Paleo Detectors" (PD)-minerals that may have accumulated DM-induced damage tracks over billions of years. These damage tracks could potentially form when a DM interaction leads to a nuclear recoil in the mineral's lattice. Modern microscopy techniques could have the potential to image these nanometer-sized features. Additionally, PDs could be used as a new way for the detection and study of neutrinos.
However, there are many research and development challenges to face, before PDs can be realized. A pilot project at the KIT's Institute for Astroparticle Physics, in collaboration with geologists from Heidelberg University and microscopy experts from KIT's Laboratory for Electron Microscopy and Institute of Nanotechnology, aims to address several key challenges. In the scope of this project, we aim to perform a series of calibration studies, irradiating a range of mineral samples with ions and neutrons of known energy. These samples will then be imaged and analyzed for the presence of particle-induced damage tracks.
To support these studies, we perform a series of simulations to study track formation and morphology in specific minerals. Ultimately, we seek to establish a clear correlation between the deposited energy and the resulting track morphology.
In this talk, I will report on the current state of these simulation studies and their implications for PDs.

T 19.4 Mon 17:30 VG 4.102

INCIDENCE - Impact of Crystal Effects on Cryogenic Detectors for Dark Matter Searches — •Holger Kluck[1], Jens Burkhart[1], Miroslav Macko[2], and Veronika Palušová[2,3] — [1]Institut für Hochenergiephysik der Österreichischen Akademie der Wissenschaften, 1050 Wien, Österreich — [2]Institute of Experimental and Applied Physics, Czech Technical University in Prague, 110 00 Prague 1, Czech Republic — [3]Johannes Gutenberg-Universität Mainz, Institut für Physik, 55128 Mainz, Germany

Nuclear recoils in cryogenic detectors are used to search for Dark Matter (DM) and for the prospective measurement of Coherent Elastic Neutrino-Nucleus Scattering (CEνNS). Experiments like CRESST or NUCLEUS reached detection thresholds for nuclear recoils in $CaWO_4$ and Al_2O_3 at the 20 eV-scale.

At this scale, solid-state effects can no longer be neglect, as they affect the observable energy. Once a DM particle or a neutrino induced a Primary Knock-On Atom in the detector crystal, the resulting displacement cascade can produce crystal defects that reduce the observable energy. Together with the ELOISE project, INCIDENCE aims to use Molecular Dynamics simulation to study this effect in $CaWO_4$ and Al_2O_3 at energies which are relevant for DM and CEνNS experiments.

In this contribution we will motivate the impact on the field, summarize the physics of the displacement cascade, present first results of defect creation in Al_2O_3 and give an outlook on the ongoing work for $CaWO_4$.

T 19.5 Mon 17:45 VG 4.102

New results from the SuperCDMS-HVeV program — •Emanuele Michielin for the SuperCDMS-Collaboration — Karlsruher Institut für Technologie, Institut für Astroteilchenphysik, 76344, Eggenstein-Leopoldshafen, Germany

SuperCDMS SNOLAB is a direct detection dark matter (DM) experiment currently under construction two kilometers underground at the SNOLAB laboratory near Sudbury, Canada. Its goal is to achieve world-leading sensitivity to DM-nucleus scattering within a mass range of 0.5 to 5 GeV. In parallel, gram-scale prototype detectors, known as HVeV devices, have been developed. These detectors achieve energy resolutions at the eV scale, enabling the detection of single electron-hole pairs when operated under high-voltage bias. HVeV devices present a unique opportunity to probe low-mass dark matter, study charge propagation, and refine calibration techniques that will also be implemented in SuperCDMS SNOLAB operations.

In this talk the latest results from the fourth data taking campaign with HVeV detectors in the NEXUS underground facility at Fermilab will be presented. A recent search for electron recoil DM candidates will be highlighted, which takes advantage of a new detector holder designed to eliminate luminescence-induced background from printed circuit boards. Additionally, a novel calibration method using Compton step spectral features in the low-energy region will be discussed. Finally, updates from the latest HVeV data-taking campaign at the SNOLAB laboratory will be introduced.

T 19.6 Mon 18:00 VG 4.102

The SuperCDMS HVeV run at CUTE — •Julius Viol for the SuperCDMS-Collaboration — Kirchhoff-Institut für Physik, Uni Heidelberg

The SuperCDMS HVeV detectors are gram-scale cryogenic semiconductor devices used for the direct search of dark matter. They have achieved eV-scale energy resolution through the application of an electric field, enabling the amplification of the phonon signal of ionizing particle interactions via the Neganov-Trofimov-Luke effect, resulting in great sensitivity to low-mass dark matter candidates. The energy resolution of these detectors also allows the investigation of the excess of low-energy events that has been systematically observed by cryogenic low-threshold experiments. In this talk I will present details of a recent run of HVeV detectors that was conducted at CUTE (Cryogenic Underground TEst facility), a test facility at the SNOLAB underground laboratory near Sudbury, Canada. This was the first time in which such sensitive detectors were operated deep underground in a low-background environment. I will describe the goals of this run, the payload, as well as provide a first peek into the results of the ongoing data analysis.

T 19.7 Mon 18:15 VG 4.102

Study of Low Energy Excess in the CRESST experiment — •Eleonora Rebecca Cipelli — Max Planck Institute für Physik

The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) experiment operates Transition Edge Sensors (TESs) at millikelvin temperatures to directly search for dark matter, with a focus on the sub-GeV mass range. Located in the ultra-low-background environment of the Laboratori Nazionali del Gran Sasso (LNGS) in Italy, CRESST is one of the leading experiments in the field thanks to its extremely low energy threshold. However, its sensitivity is affected by an increasing event rate at low energies (below ~200eV), known as the Low Energy Excess, whose origin remains unclear. While several potential causes have been ruled out, ongoing measurements and efforts to develop new detector designs aim to provide deeper insights into these observations. In this talk, the studies and latest results of Low Energy Excess performed by CRESST are presented.

T 19.8 Mon 18:30 VG 4.102

Results of the double-TES in the CRESST experiment — •Felix Dominsky — Max-Planck-Institut für Physik

CRESST is a leading direct dark matter search experiment that employs transition edge sensors (TES) to detect energy depositions in cryogenic target crystals. Like many experiments in this field, CRESST observes an excess of events near the detector threshold, commonly referred to as the low-energy excess (LEE). This phenomenon poses a significant challenge to the sensitivity of the experiment, particularly for light dark matter detection. To investigate the origin of the LEE, CRESST has developed the double-TES module, featuring two identical TESs on a single target crystal. A particle interaction in the bulk of the crystal is sensed in both TES, whereas events detected in only one TES can be excluded as valid particle interactions. This presentation will detail the operating principle of the double-TES and highlight new insights into the LEE derived from this technology.

T 20: Invited Topical Talks I

Time: Tuesday 13:45–15:45 Location: ZHG011

Invited Topical Talk T 20.1 Tue 13:45 ZHG011

An introduction to gas electron multipliers and their time to shine during the CMS phase 2 upgrade — •Shawn Zaleski — III. Physikalisches Institut A, RWTH Aachen University

Gas electron multipliers (GEMs) are a sub-class of micro-pattern gaseous detectors in which passing charged particles ionize the gas inside to create an electronic avalanche through multiple stages of amplification. Each GEM foil is copper-cladded Kapton with a chemically etched micro-pattern of holes allowing electrons to pass through and be amplified. Each amplification stage allows a moderate amplification gain per GEM foil to be achieved, yielding an overall gain of $\mathcal{O}(10^5)$.

The CMS GEM project makes use of the largest area GEM chambers up to now. GEMs were first installed in the first muon station of the CMS end caps during the last long shutdown (LS2) in 2021 and 2022. These chambers compliment the existing cathode strip chamber system improving the transverse momentum measurement of muons traversing the CMS end caps. A new addition to the GEM system, so-called ME0, will be installed adjacent to the planned high-granularity hadron calorimeter (HGCAL) in the nose of the CMS end caps. This will extend the pseudorapidity reach of the muon system from 2.4 to 2.8. The ME0 stacks, sets of six triple GEM chambers are planned to be installed during the next LHC long shutdown (LS3). Production of the ME0 stacks is currently underway and the first stacks are already undergoing quality control (QC) checks to test detector readiness. The production status and initial QC results will be presented.

Invited Topical Talk T 20.2 Tue 14:15 ZHG011

Searches for rare Higgs boson decays — •Martina Laura Ojeda — CERN, Geneva, Switzerland

Throughout the decade that has elapsed since the discovery of the Higgs boson, a considerable amount of effort has been put into precise measurements of its properties. Higgs boson couplings to vector bosons, τ leptons, bottom/top quarks, and (via loop processes) photons and gluons have now been established. As all current measurements point to the Higgs boson being Standard Model (SM)-like, rare and unobserved Higgs boson decay modes are an important contribution to further test the SM. This is particularly true for decay modes mediated by loops, which can be especially sensitive to physics beyond the SM.

This talk will focus on challenges and opportunities associated with rare decay searches, and highlight one such ATLAS search: the yet-unobserved $H \to Z/\gamma^* + \gamma$ decay. While not sensitive enough to claim observation of this decay process, current results hint at a slight tension with the SM expectation, with a $H \to Z\gamma$ decay rate of $(2.2 \pm 0.7)\times$ the SM prediction.

Invited Topical Talk T 20.3 Tue 14:45 ZHG011

Novel opportunities with the LHCb Software Trigger — •Titus Mombächer — CERN, Geneva, Switzerland

The LHCb experiment at the LHC has a unique acceptance and a highly flexible trigger system which enables a rich physics program, while keeping the processed and stored data sizes at a manageable level. Since the beginning of the current data taking period its flexibility got further enhanced by relying fully on a software-only trigger. This talk will describe the LHCb trigger system and illustrate its potential far beyond the design goals with examples from past, present and future, focusing on rare strange decays and particles with exotic signatures.

Invited Topical Talk T 20.4 Tue 15:15 ZHG011

Dark sector searches with invisible and displaced signatures at Belle II — •Giacomo De Pietro — Institut für Experimentelle Teilchenphysik, Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany

Experimental evidence points to the existence of so-called dark matter, which makes up 85The Belle II experiment is collecting samples of e^+e^- collision data at center-of-mass energies near the $\Upsilon(4S)$ resonance. These data have constrained kinematics and low multiplicity, allowing searches for dark sector particles in the mass range from a few MeV to O(10) GeV. In this talk I will review some of the recent dark sector searches at Belle II, focusing on the results with invisible and displaced signatures.

T 21: Invited Topical Talks II

Time: Tuesday 13:45–15:45 Location: ZHG010

Invited Topical Talk T 21.1 Tue 13:45 ZHG010

The KM3NeT Ultra-High Energy Neutrino and its Possible Astrophysical Origins — •Massimiliano Lincetto — Lehrstuhl für Astronomie, Julius-Maximilians-Universität Würzburg, Würzburg, Germany — Deutsches Elektronen-Synchrotron (DESY), Zeuthen, Germany

High-energy astrophysical neutrinos, first discovered by the IceCube Neutrino Observatory, are key messengers for the understanding of hadronic acceleration processes in the Universe, with the potential to unveil the sources of ultra-high energy cosmic rays. The KM3NeT Collaboration is building two neutrino detectors in the Mediterranean Sea by instrumenting large volumes of seawater with photomultiplier tubes, sensitive to the Cherenkov light induced by secondary particles produced in neutrino interactions. KM3NeT has recently reported the observation of an ultra-high energy neutrino in the tens of PeV range, possibly the most energetic neutrino observed to date. The particle's incoming direction points slightly below the horizon, where atmospheric backgrounds are negligible, indicating a most likely cosmic origin. This talk will report on the KM3NeT detection of this exceptional event and its implications for our knowledge of astrophysical neutrinos. The talk will explore the neutrino's potential origins, including the search and characterisation of candidate extragalactic astrophysical counterparts.

Invited Topical Talk T 21.2 Tue 14:15 ZHG010

Multimessenger astronomy with ultra-high-energy cosmic rays and high-energy neutrinos — •Foteini Oikonomou — Norwegian University of Science and Technology

Multi-messenger astrophysics has advanced rapidly in the last decade, owing, primarily, to the newly discovered and growing body of observations of high-energy neutrinos and gravitational waves. Meanwhile, ultra-high energy cosmic ray experiments have made groundbreaking observations during this time, such as the discovery of dipole anisotropy in the UHECR arrival directions, which have revitalised the field of ultra-high energy cosmic ray astronomy. In this talk, I will review recent results in the search for the origin of high-energy neutrinos and ultra-high-energy cosmic rays. I will also summarise our current understanding of the role of active galactic nuclei, gamma-ray bursts, and tidal-disruption events as high-energy-cosmic-ray accelerators based on the latest multimessenger observations.

Invited Topical Talk T 21.3 Tue 14:45 ZHG010

Peering into the Cosmos from Deep Underground – Astroparticle Physics with Xenon Detectors — •Christian Wittweg for the XENON-Collaboration — Physik-Institut, University of Zürich, 8057 Zürich, Switzerland

What is the dark matter in the Universe? Astronomical observations at all scales provide indirect evidence of weakly interacting and non-baryonic particles with possible masses spanning many orders of magnitude. However, a direct detection in an experiment is still pending. Xenon time projection chambers located deep underground lead the worldwide searches for dark matter in the form of weakly interacting massive particles (WIMPs) with masses of few GeV to hundreds of TeV. WIMPs are well-motivated dark matter candidates, but the expected signals are feeble and interaction rates would be on the order of few events per tonne of xenon and year. Therefore, detectors such as XENONnT need multi-tonne targets, ultra-low backgrounds and energy thresholds of few keV. Incidentally, this makes them ideal observatories for many astroparticle physics signals beyond WIMPs: neutrinos from various sources, alternative dark matter candidates and rare nuclear decays. The talk will present recent results from XENONnT and provide an outlook on the future XLZD/DARWIN observatory as the Swiss army knife of low-energy astroparticle physics.

Invited Topical Talk T 21.4 Tue 15:15 ZHG010

Feebly Interacting Particles in the Early Universe — •Mathias Becker — University of Padova

Feebly interacting particles (FIPs) have gained attention as a compelling alternative to WIMP dark matter. In this talk, I will present recent advancements in the precise determination of FIP production rates from a thermal plasma, emphasizing the role of finite-temperature effects. I will also discuss how experimental searches, including long-lived particle and direct detection experiments, can probe FIPs and potentially reveal insights into early universe phenomena such as inflationary reheating.

T 22: Annual Meeting of Young Scientists in High Energy Physics

Time: Tuesday 12:35–13:45 Location: ZHG011

T 22.1 Tue 12:35 ZHG011

Annual Meeting of Young Scientists in High Energy Physics (yHEP) — •Michael Lupberger — University of Bonn — yHEP Management Board

In our report, we will present our last year's activities. This includes the work with the committees and the organisation of events, e.g. for the Update of the European Strategy for Particle Physics. We give updates of the Know-your-Footprint campaign and our statement on the reform of the law for fixed-term contracts (WissZeitVG) and other topics. There is also some room for a discussion. However, the currently most relevant topics in our work on issues with residence permits and the WissZeitVG will be discussed in a separate session organised with the jDPG on Wednesday evening.

All students, doctoral candidates, post-docs and scientists on temporary contracts are cordially invited.

Please register to our mailing list which can be found from yhep.desy.de to receive details on the meeting.

T 23: Searches/BSM II (Non-collider)

Time: Tuesday 16:15–18:00 Location: ZHG010

T 23.1 Tue 16:15 ZHG010

Stringent Constraints on Pseudoscalar Couplings from Precision Hyperfine Splitting Measurements — •Cedric Quint[1], Zoltán Harman[1], Joerg Jaeckel[2], Fabian Heisse[1], Lutz Leimenstoll[2], and Christoph H. Keitel[1] — [1]Max Planck Insitute for Nuclear Physics, Heidelberg, Germany — [2]Institute for Theoretical Physics, Heidelberg, Germany

Axion-like particles and similar new pseudoscalar bosons coupled to nucleons and electrons are known to lead to spin-dependent forces in atoms and ions. Hyperfine structure measurements are a sensitive probe to this effect. Specific differences, which are meant to reduce uncertainties due to nuclear effects in hyperfine structure calculations and measurements, yield stringent bounds on these couplings. We show that existing measurements on Be provide competitive limits in the region $m_\phi \gtrsim 100\,\mathrm{keV}$. We find that measurements on Cs and B have discovery potential. We also discuss various other candidate elements and evaluate their prospects.

T 23.2 Tue 16:30 ZHG010

Nonlinear calcium King plot constrains new bosons and nuclear properties — •Agnese Mariotti[1], Alexander Wilzewski[2], Lukas J. Spiess[2], Malte Wehrheim[2], Shuying Chen[2], Steven A.

King[2], Peter Micke[2], Melina Filzinger[2], Martin R. Steinel[2], Nils Huntemann[2], Erik Benkler[2], Piet O. Schmidt[2,7], Luca I. Huber[3], Jeremy Flannery[3], Roland Matt[3], Martin Stadler[3], Robin Oswald[3], Fabian Schmid[3], Daniel Kienzle[3], Jonathan Home[3], Diana Prado Lopez Aude Craik[3], Menno Door[4], Sergey Eliseev[4], Pavel Filianin[4], Jost Herkenhof[4], Kathrin Kromer[4], Klaus Blaum[4], Vladimir A. Yerokhin[4], Igor A. Valuev[4], Natalia S. Oreshkina[4], Chunhai Lyu[4], Sreya Banerjee[4], Christoph H. Keitel[4], Zoltan Harman[4], Julian C. Berengut[6], Anna Viatkina[2,5], Jan Gilles[2,5], Andrey Surzhykov[2,5], Michael K. Rosner[4], Jose R. Crespo Lopez-Urrutia[4], Jan Richter[1,2], and Elina Fuchs[1,2] — [1]LUH-ITP — [2]PTB — [3]LUH-IQE — [4]MPI — [5]TUB-IMP — [6]UNSW — [7]LUH-IQ

The SM predicts isotope shifts (IS), i.e. differential measurements of the same electronic transition in different isotopes of an element, to follow a linear relation: the King plot (KP). Nonlinearities in KP set constraints on the existence of new interactions. We measure IS in Ca14+ and in Ca+, as well as isotope masses of calcium, observing for the first time a nonlinearity in this system. Combining these with the calculation of the next-to-leading SM term, we are able to improve the bounds on the existence of a new light boson coupling electrons and neutrons.

T 23.3 Tue 16:45 ZHG010

BDF/SHiP @CERN (NA67): Search for Hidden Particles at a Future Beam Dump Facility — •Annika Hollnagel for the SHiP-Collaboration — JGU Mainz (DE)

The Search for Hidden Particles (SHiP) experiment has been selected as the new flagship project of the CERN Physics Beyond Colliders intensity frontier, featuring a dedicated Beam Dump Facility (BDF) at CERN's North Area ECN3 to exploit the full potential of the 400GeV SPS proton beam.

The experiment will be realised by a two-fold detector setup enabling a diverse physics program: While the Hidden Sector (HS) detector is going to study the decay of Heavy Neutral Leptons (HNL), Axion-Like Particles (ALPs), and other Feebly-Interacting Particles (FIPs) in a broad range of masses and coupling inaccessible to colliders, the upstream Scattering and Neutrino Detector (SND) will enable a direct search for Light Dark Matter (LDM), as well as measurements in neutrino physics with unprecedented precision. With the detector located closely downstream of the dense proton target, a major challenge will be the reduction of beam-related backgrounds. Following the hadron stopper, a magnetic muon shield will deflect most of these particles from the detector acceptance, and the 50m-long HS decay volume will be enveloped by a Surrounding Background Tagger (SBT). This talk will give an overview of the detector technologies and physics capabilities of the proposed experiment.

Having recently been approved by the CERN Research Board, this is the ideal time for new groups to join the project.

T 23.4 Tue 17:00 ZHG010

Background suppression in the SHiP experiment with the Surround Background Tagger — •Katharina Albrecht for the SHiP-SBT-Collaboration — Institut für Physik, Humboldt-Universität zu Berlin, Berlin, Germany

SHiP (Search for Hidden Particles) is an experiment that will be installed in a dedicated beam-dump facility in the ECN3 cavern, located in the CERN north area. SHiP will search for feebly interacting particles (FIPs) produced by 400 GeV/c protons from the SPS impinging on a heavy-metal target. Over a 15-year span, the objective is to accumulate 6×10^{20} protons on target with a detector setup that allows suppression of possible background to a negligible level. The experiment focuses on optimizing the sensitivity for models featuring long-lived FIPs below 10 GeV/c^2 by minimizing backgrounds induced by the huge flux of neutrinos and muons emerging from the beam-dump target. The Surround Background Tagger (SBT) is a critical component surrounding the 50 m long helium-filled decay volume. The SBT is instrumental to detect charged particles entering the decay volume from the sides as well as inelastic interactions of neutrinos and muons taking place inside the helium-filled decay volume, but also in the SBT itself. The presentation will discuss simulation studies on the background suppression strategies with focusing on role of the SBT.

T 23.5 Tue 17:15 ZHG010

Search for Sub-Relativistic Magnetic Monopoles with the IceCube Neutrino Observatory — •Jonas Häussler, Jakob Böttcher, Christopher Wiebusch, and Peter-John Cusack — RWTH Aachen University, Aachen, Germany

Magnetic monopoles are Beyond-Standard-Model particles, predicted by Grand Unified Theories (GUTs) to be created during their freeze-out in the early universe. At typical masses of the GUT-scale - above 10^{14} GeV - these particles would move at sub-relativistic speeds. The Rubakov-Callan effect predicts that magnetic monopoles can catalyze proton decays. This results in a unique signature of small particle cascades along the trajectory of the slow-moving particle. Since 2012, a dedicated Slow-Particle Filter has been implemented in the IceCube Neutrino Observatory for the detection of magnetic monopoles. The low, if existent, flux of the monopoles requires exceptional background rejection and signal efficiency. This is accomplished using machine learning methods. For this analysis we use a multi-level Boosted-Decision-Tree classifier. We present the strategy behind the background and signal simulation, the classification efficiency, and the projected sensitivity of IceCube for the detection of sub-relativistic magnetic monopoles.

T 23.6 Tue 17:30 ZHG010

Faint non-standard model particles in IceCube — •Nick Jannis Schmeisser, Timo Stürwald, and Christian Locatelli for the IceCube-Collaboration — Bergische Universität Wuppertal

Fractionally Charged Particles (FCPs) are particles that carry a fraction of the elementary charge e, which are predicted by multiple extensions of the standard model of particle physics. Relativistic FCPs produce Cherenkov light in the IceCube Neutrino Observatory. Due to the charge dependence of the Cherenkov light yield, the particles produce faint tracks in the detector. To increase the sensitivity for these faint signatures, the Faint Particle Trigger (FPT) was developed and deployed in 2023.

This presentation shows simulation studies optimizing the reconstruction of events triggered by the FPT. Different timing-based reconstruction techniques are compared based on their performance in reconstructing simulated FCP events. The reconstruction performance especially depends on the reduction of noise hits in the detector, which are dominant in comparison to the number of signal hits produced by FCPs. First efforts towards a Machine-Learning based analysis searching for FCPs using events triggered by the FPT are shown. A first reduction of background events includes the Faint Particle Filter utilizing results from the optimized event reconstruction.

T 23.7 Tue 17:45 ZHG010

Exploring beta decay with light boson emission in the KATRIN experiment — •Joscha Lauer for the KATRIN-Collaboration — Karlsruhe Institute of Technology (KIT)

The Karlsruhe Tritium Neutrino (KATRIN) experiment is designed to measure the effective electron antineutrino mass with a sensitivity better than $m_\nu c^2 = 0.3\,\mathrm{eV}$ (90% C.L.) in a kinematic approach by applying precision electron spectroscopy to the beta decay of molecular tritium. The measurement focuses on the spectral endpoint (E_0) region, extending up to tens of eV below $E_0 \approx 18.6\,\mathrm{keV}$.

Light neutral pseudoscalars and vector bosons are predicted in many theories beyond the Standard Model (BSM). Constraints on the couplings of such particles to neutrinos or electrons can be derived from cosmological, astrophysical and laboratory observations. With high-statistics beta spectroscopy, KATRIN complements these approaches, as the emission of an additional light state in tritium beta decay introduces characteristic modifications to the observed electron spectrum. We present the computation of these spectra, based on JHEP 01 (2019) 206. Preliminary analysis of the second KATRIN measurement campaign explores the parameter space of boson couplings, offering perspectives for BSM physics.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2, and 05A23WO6).

T 24: Higgs Physics III (boson final states)

Time: Tuesday 16:15–17:45 Location: ZHG104

T 24.1 Tue 16:15 ZHG104

Measurement of $H \to \gamma\gamma$ fiducial cross sections with 13.6 TeV CMS data — Caio Daumann, Johannes Erdmann, Florian Mausolf, •Jan Lukas Späh, and Maximilian Wrabetz — III. Physikalisches Institut A, RWTH Aachen University

The Higgs boson is of fundamental importance for the understanding of particle physics. Since its discovery in 2012, it has been studied extensively by the ATLAS and CMS collaborations. The measurement of Higgs boson production cross sections is crucial to study deviations from the standard model in the scalar sector.

In this presentation, the measurement of Higgs boson production cross sections in the diphoton decay channel with the CMS experiment is presented. The data used in this analysis were collected in proton-proton collisions at $\sqrt{s} = 13.6\,\text{TeV}$ in 2022 and correspond to an integrated luminosity of $34.7\,\text{fb}^{-1}$. To reduce extrapolation uncertainties and improve the model independence of the measurement, the cross sections are measured in a fiducial phase space at particle level. Special emphasis is placed on the statistical analysis in this talk. This includes the simulation-based signal modelling, the data-driven background modelling, and the treatment of uncertainties.

This analysis lays the foundation for further measurements of Higgs boson processes in the diphoton decay channel by the CMS collaboration in Run 3 of the LHC and beyond. A brief outlook for future measurements and the potential of such analyses to constrain Higgs boson couplings to light quarks is given.

T 24.2 Tue 16:30 ZHG104

Studies for H $\to \gamma\gamma$ cross-section measurements with 13.6 TeV CMS data — Caio Daumann, Johannes Erdmann, Florian Mausolf, Jan Lukas Späh, and •Maximilian Wrabetz — III. Physikalisches Institut A, RWTH Aachen University

Precise measurements of Higgs boson production cross-sections are crucial for testing the Standard Model. In this presentation, studies for cross-section measurements of Higgs boson production in the diphoton decay channel, based on proton-proton collision data collected at $\sqrt{s} = 13.6\,\text{TeV}$ by the CMS experiment in 2022 and 2023, are shown. They are performed in a fiducial phase space to reduce extrapolation uncertainties and enhance model independence.
The latest studies for a cross-section measurement of LHC Run 3 data are presented. These include the optimization of the categories for the analysis that are based on the estimated diphoton mass resolution and the decorrelation of that estimate with respect to the invariant diphoton mass.

T 24.3 Tue 16:45 ZHG104

Measurement of differential cross-sections in the $H \to ZZ^* \to 4\ell$ decay channel with the ATLAS Run 3 data — •Elena Cuppini, Alice Reed, Sandra Kortner, Oliver Kortner, and Tae Hyoun Park — Max-Planck-Institut für Physik

The decay of the Higgs boson into two Z bosons, which subsequently decay to four leptons ($H \to ZZ^* \to 4\ell$), offers a clean signature and high signal-to-background ratio for studying the properties of the Higgs boson. The measurement of differential fiducial cross-sections in this decay channel is performed for the first time with the Run 3 proton-proton collision data at a previously unexplored centre-of-mass energy $\sqrt{s} = 13.6\,\text{TeV}$. The data collected with the ATLAS detector during 2022 and 2023 corresponds to an integrated luminosity of $56\,\text{fb}^{-1}$.

The analysis minimises model dependence by employing fiducial phase-space selections that closely match the experimental acceptance, along with corrections for detector effects. Results will be compared to Standard Model predictions, with an emphasis on key differential observables.

Strategies for upcoming differential fiducial cross-section measurements with about three times more Run 3 data from the ATLAS detector collected by the end of 2024 will be discussed.

T 24.4 Tue 17:00 ZHG104

Optimization of machine learning-based measurements of Higgs production processes in the $H \to 4\ell$ decay channel with ATLAS Run 3 data — •Luca Spitzauer, Sandra Kortner, Hubert Kroha, Alice Reed, Elena Cuppini, and Tae Hyoun Park — Max-Planck-Institut für Physik

Cross-section measurements for various Higgs boson production and decay processes are crucial for exploring Higgs boson properties and have high sensitivity to potential physics beyond the Standard Model. The decay of a Higgs boson into a pair of Z bosons, each subsequently decaying into two leptons ($H \to ZZ^* \to 4\ell$), is particularly important for these measurements due to its exceptionally clear signal.

Within the framework of Simplified Template Cross Sections (STXS), exclusive regions of phase space are defined for each Higgs boson production mode. Optimized classification of reconstructed events according to the STXS production regions is essential to enhance signal sensitivity and reduce uncertainties. The previous round of STXS measurements in the $H \to 4\ell$ channel using the Run 2 ATLAS dataset employed a Neural Network classification approach. With the new Run 3 dataset at a center-of-mass energy of 13.6 TeV, we are exploring potential optimizations of this classification using a new Deep Set machine-learning approach.

T 24.5 Tue 17:15 ZHG104

Measurement of gluon fusion and vector-boson fusion Higgs-boson production cross sections in $H \to WW^* \to l\nu l\nu$ decays with the ATLAS detector — •Ahmed Markhoos, Karl Jakobs, and Benedict Winter — University of Freiburg, Freiburg im Breisgau, Germany

As the Higgs boson decay with the second largest branching fraction, the decay to two W bosons ($H \to WW^*$) is not only advantageous due to its sizable signal yield. It also has a relatively clean signature with moderate backgrounds. This allows for accurate measurements of the total and differential cross-sections for Higgs boson production through the gluon-gluon fusion (ggF), vector boson fusion (VBF) and Higgs strahlung modes. Throughout the past decade, this decay channel has been analyzed with improving accuracy, directly testing the Standard Model predictions and measuring the Higgs boson's couplings. In this talk, an overview of the ongoing $H \to WW^* \to l\nu l\nu$ ggF and VBF Simplified Template Cross-Section (STXS) measurement of the full Run 2 ATLAS dataset is presented. The analysis greatly improves on the previously published Run 2 analysis by extending the use of multivariate techniques and considering Higgs-boson decays to light leptons of the same flavor ($e\nu\ e\nu/\mu\nu\ \mu\nu$), which had been disregarded, in addition to different flavor decays ($e\nu\ \mu\nu$). This enables a more granular and precise STXS measurement with a considerably higher sensitivity.

T 24.6 Tue 17:30 ZHG104

Quantum tomography using machine learning to infer incomplete information in $H \to WW \to \ell\nu\ell\nu$ — Carsten Burgard[1], Vince Croft[2], Andre Sopczak[3], •Andrii Vak[3], and Lennart Völz[1] — [1]TU Dortmund University — [2]Leiden University — [3]Czech Technical University in Prague

Potential entanglement originating from the scalar nature of the Higgs boson can translate to variables that could be accessible at collider experiments such as ATLAS at the LHC. The entanglement is mediated through the parity violation from weak decay vertices, affecting for example the angular properties of the dilepton system in $H \to WW \to \ell\nu\ell\nu$ decays. Thus, the analysis of multiple neutrinos in the final state is interesting for quantum tomography measurements. This study uses advanced machine learning methods for regression and inference of missing kinematic information.

T 25: Higgs Physics IV (BSM Higgs)

Time: Tuesday 16:15–17:45 Location: ZHG105

T 25.1 Tue 16:15 ZHG105

Search for heavy neutral Higgs bosons in the $t\bar{t}Z$ channel at CMS — •Yannick Fischer, Matteo Bonanomi, Lukas Ebeling, Johannes Haller, Daniel Hundhausen, Matthias Schröder, and Bianca Weidner — Institut für Experimentalphysik, Universität Hamburg

All measurements of the Higgs boson at 125 GeV so far agree with the standard model (SM) prediction, however the observed resonance could still be part of an extended Higgs sector. Such an extended Higgs sector is predicted by many theories of physics beyond the SM. Two Higgs Doublet Models (2HDM) assume the existence of a second Higgs doublet, giving rise to a total of five physical Higgs bosons. This talk will present a search for a hypothetical CP-odd Higgs boson A decaying into a hypothetical CP-even heavy Higgs boson H and a Z boson, with the H decaying into a top anti-top quark pair. This channel has been dubbed the smoking gun channel for various 2HDMs in the context of electroweak baryogenesis. We will focus on the fully hadronic decay of the $t\bar{t}$ pair, presenting improvements of the analysis strategy and first results with data measured by CMS at 13.6 TeV.

T 25.2 Tue 16:30 ZHG105

Improving the search for heavy neutral Higgs bosons in the $t\bar{t}Z$ channel at CMS using parameterized neural networks — •Bianca Weidner, Matteo Bonanomi, Lukas Ebeling, Yannick Fischer, Johannes Haller, Daniel Hundhausen, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

Many theories of physics beyond the Standard Model, such as Two Higgs Doublet Models (2HDM), suggest that the Higgs boson measured at 125 GeV might be part of an extended Higgs sector with five physical Higgs bosons. In this talk, we will explore a promising decay channel involving a hypothetical CP-odd heavy Higgs boson (A), which decays into a CP-even heavy Higgs boson (H) and a Z boson. The H boson then decays into a top quark-antiquark pair. Current analyses exclude signals of up to approximately 1.2 TeV for these hypothetical particles. We will focus on optimizing the analysis by investigating the impact of a parameterized neural network to separate signal events from the background. This approach improves the sensitivity to a potential signal and thus allows probing a larger region of the 2HDM parameter space.

T 25.3 Tue 16:45 ZHG105

Search for a light CP-odd Higgs boson decaying into a pair of τ-leptons in proton–proton collisions at $\sqrt{s} = 13\,\text{TeV}$ with the ATLAS detector — •Manuel Gutsche, Asma Hadef, Tom Kresse, Christian Schmidt, and Arno Straessner — Technische Universität Dresden

The two-Higgs-doublet model (2HDM) continues to be one of the most well-motivated extensions of the Standard Model. The theory postulates a second Higgs doublet, thus predicting the existence of in total five Higgs bosons h, H, $H^{\pm}$, A, of which the latter A boson is electrically neutral and CP-odd. A certain choice of the model's parameters leads to the flavour-aligned 2HDM, which is able to explain discrepancies in the anomalous magnetic moment of the muon for an A boson mass of less than m_Z as well as large couplings to leptons and up-type quarks.

This talk presents a search for a CP-odd Higgs boson which is produced via gluon fusion and decays into two τ-leptons in the mass range of 20 GeV to 90 GeV. For this, the analysis uses 140 fb^{-1} of data recorded by the ATLAS detector at $\sqrt{s}$ = 13 TeV, focusing on the leptonic decays of the τ-leptons to exactly one electron and one muon.

After explaining the analysis strategy and event selection, an overview of fake-lepton estimation and most impactful systematic uncertainties is given. The expected and observed exclusion limits for the model-independent production cross-section, as well as for the coupling parameter to up-type quarks interpreted in the flavour-aligned 2HDM, are presented.

T 25.4 Tue 17:00 ZHG105

Updates on the Yukawa Type I for 2HDMS with a 95 GeV Higgs boson — •Dominik Heintz[1], Sven Heinemeyer[3], Cheng Li[4], and Gudrid Moortgat-Pick[1,2] — [1]II. Institut für Theoretische Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]DESY, Notkestraße 85, 22607 Hamburg, Germany — [3]Instituto de Física Teórica UAM-CSIC, Cantoblanco, 28049, Madrid, Spain — [4]School of Science, Sun Yat-Sen University, Gongchang Road 66, 518107 Shenzhen, China

The **2HDM** (Two-Higgs-Doublet Model) can be extended by a real singlet, **N2HDM**, or a complex singlet, **2HDMS**. Both models are promising candidates to describe the excess at $\sim 95\,\text{GeV}$ observed both at **CMS** and at **ATLAS** in the $\gamma\gamma$ channel with $\sim 2.9\sigma$ and $\sim 1.7\sigma$, respectively, as well as in the $b\bar{b}$ decay channel at **LEP** with $\sim 2.3\sigma$. The lightest Higgs boson in the models, h_1 was interpreted as a new particle at $\sim 95\,\text{GeV}$. Studies so far focused on the Yukawa types II and IV. However, the signal strength in the $\gamma\gamma$ channel went down substantially over the last years. This allows a greater freedom for $\frac{c_{h_1 bb}}{c_{h_1 tt}}$, the ratio of the coupling modifiers of the light Higgs to bottom and top quarks, respectively. This motivates the phenomenological study of the **2HDMS** in the Yukawa type I. The study includes current theoretical and experimental constraints using **HiggsTools** (**HiggsBounds** and **HiggsSignals**) and incorporates the most recent signal rates from **ATLAS**.

T 25.5 Tue 17:15 ZHG105

Searches for charged Higgs bosons in $H^{\pm} \to W^{\pm}h$ decays with the ATLAS detector — Dominik Duda[2], •Simon Grewe[1], Sandra Kortner[1], and Hubert Kroha[1] — [1]Max Planck Institut für Physik — [2]University of Edinburg

Many theories beyond the Standard Model predict the existence of charged Higgs bosons. The main production mode of these new particles depends on their mass. For large $H^{\pm}$ masses, the dominant mode of production is in association with a top quark and a bottom quark ($tbH^{\pm}$). In the alignment limit of the Two-Higgs-Doublet Model, heavy charged Higgs bosons decay almost exclusively via $H^{\pm} \to tb$. In other models such as the Georgi-Machacek model, however, significant branching ratios for $H^{\pm} \to W^{\pm}h$ are possible.

A search for charged Higgs bosons in $H^{\pm} \to W^{\pm}h$ (m_h=125 GeV) decays produced in association with a top and bottom quark is presented, based on the full Run-2 dataset of the ATLAS experiment. This is the first search for this decay at the LHC.

Two analysis strategies are employed to ensure high sensitivity for both low and high $H^{\pm}$ masses. For low $H^{\pm}$ masses the decay products have a relatively low Lorentz-boost and the $h \to b\bar{b}$ can be resolved by two small-radius jets. For high $H^{\pm}$ masses the final state particles acquire a lot of Lorentz-boost and the neutral Higgs boson decay has to be reconstructed via a single large-radius jet. The invariant mass of the charged Higgs boson is reconstructed and used as the discriminating variable. No significant deviation from the SM expectation is observed and upper limits are set on $\sigma(pp \to tbH^{\pm}) \times BR(H^{\pm} \to W^{\pm}h)$.

T 25.6 Tue 17:30 ZHG105

tbH$^+$ Analysis with Multileptons Using Run-2 ATLAS Data — •Azad Afandizada and Andre Sopczak — Czech Technical University in Prague

The latest results with Run-2 ATLAS data are presented for the search tbH$^+$ in the multilepton channel.

T 26: Axions/ALPs I

Time: Tuesday 16:15–17:45 Location: VG 0.110

T 26.1 Tue 16:15 VG 0.110

Towards a low background SDD for IAXO — Joanna Bilicki[1], Patrick Bongratz[1,2], Frank Edzards[1], Susanne Mertens[1,2], •Lucinda Schönfeld[1,2], Juan Pablo Ulloa Beteta[1], Christoph Wiesinger[1,2], and Michael Willers[1,2] for the IAXO-Collaboration — [1]Technische Universität München, Garching, DE — [2]Max Planck Institut für Kernphysik, Heidelberg, DE

Axions are hypothetical particles that solve the strong CP problem and are candidates for dark matter. The International Axion Observatory (IAXO) is aiming to find these elusive particles by converting solar axions to X-rays. Detecting this rare signal requires highly efficient ultra-low background X-ray detectors, for which Silicon Drift Detectors (SDDs) are well suited. I will present the current status of the TRISTAN SDD for IAXO (TAXO) project, which is developing such an SDD. A particular focus will be the latest results of background measurements above ground at TUM and deep underground at the Canfranc underground laboratory.

This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programme (grant agreement No. 852845). It has also been supported by the DFG through the Excellence Cluster ORIGINS.

T 26.2 Tue 16:30 VG 0.110

X-ray focus on axions: optics for the International AXion Observatory (IAXO) — •Julia K. Vogel for the IAXO-Collaboration — Fakultät für Physik, TU Dortmund, Otto-Hahn-Str. 4, Dortmund D-44221, Germany

Axions are one of the leading candidates for the hypothetical, non-baryonic dark matter expected to account for about 27% of the energy density of the Universe. Axion helioscopes are experiments searching for axions and axion-like particles (ALPs) produced in the core of the Sun via the Primakoff effect by utilizing strong magnetic fields, x-ray optics and ultralow-background detectors. The International Axion Observatory (IAXO) is a next generation axion helioscope aiming at a sensitivity to the axion-photon coupling of $1-1.5$ orders of magnitude beyond the current most sensitive axion helioscope, the CERN Axion Solar Telescope (CAST). BabyIAXO (BIAXO) is an intermediate scale helioscope with sensitivities to axion-photon couplings down to a few 10^{-11} GeV^{-1} reducing risks for IAXO while delivering first significant physics results. The optics for (B)IAXO are a key part of the experiment and consist of multilayer-coated Wolter-I approximations. Two pathfinder optics have been successfully tested at CAST and at the Panter x-ray test facility of MPE. Here we briefly introduce (B)IAXO and detail the optics and coating design along with the pathfinder performances.

T 26.3 Tue 16:45 VG 0.110

Development of a GridPix Detector for the International AXion Observatory — •Johanna von Oy, Klaus Desch, Jochen Kaminski, Tobias Schiffer, Sebastian Schmidt, and Markus Gruber for the IAXO-Collaboration — Physikalisches Institut der Universität Bonn

Axion searches with helioscope experiments like the International AXion Observatory (IAXO) focus mainly on the solar axion production. With its dense and high temperature environment, the sun's core can produce a high flux of axions through the Primakoff effect and ABC processes. To detect these solar axions, IAXO and also its intermediate stage BabyIAXO, will consist of a magnet that follows the sun for twelve hours a day. In the magnetic field the axions couple to X-rays which can then be focused onto dedicated detectors.

One of these detectors will be built in Bonn. Thanks to the solar axions' small coupling strengths and energies of about $\sim$1 keV the two main requirements for a detector are an ultra low background and the ability to detect low energy X-rays.

A GridPix based gas-filled detector made out of very radiopure materials is therefore a good fit for a helioscope experiment. The ultra-thin vacuum-tight window will allow for low energy X-rays to enter the gas volume and produce electrons. The aluminium grid on top of a pixelated readout chip, the Timepix3, makes the detection of single electrons and therefore low energy X-rays possible.

This talk will focus on the development and challenges of a GridPix based detector for axion searches with IAXO and BabyIAXO.

T 26.4 Tue 17:00 VG 0.110

Optimization of a dielectric haloscope for axion dark matter detection, MADMAX — •Dominik Bergermann for the MADMAX-Collaboration — III. Physikalisches Institut A, RWTH Aachen University

Axions are promising candidates for cold dark matter and the absence of CP violation in strong interaction. The **MA**gnetized **D**isc and **M**irror **A**xion e**X**periment is a dielectric haloscope experiment targeting axion dark matter in a mass range of 40 to 400 μeV. It consists of multiple, consecutive and movable dielectric discs to amplify the weak microwave signal of axion photon conversion in a strong magnetic field.

Covering this range with a single experimental setup, while simultaneously being able to finetune the resonance on potential signals, necessitates repositioning the hardware continuously and automatically. The disc positions as parameter-space can be optimized to produce desired signal shapes. Multiple different optimization algorithms have been tested.

This talk discusses the strategies for optimizing a physical MADMAX-like setup in-place based on it's electrical microwave responses. Challenges are the sparse set of information, the time requirement of repositioning and the reliability of the algorithms.

T 26.5 Tue 17:15 VG 0.110

Probing electric fields insida a test setup for the dielectric axion haloscope MADMAX — •Max Zimmermann for the MADMAX-Collaboration — III. Physikalisches Institut A, RWTH Aachen University

Axions are promising candidates for cold dark matter and the absence of CP violation in strong interaction. The **MA**gnetized **D**isc and **M**irror **A**xion e**X**periment is a dielectric haloscope experiment targeting axion dark matter in a mass range of 40 to 400 μeV. It consists of multiple, consecutive and movable dielectric discs to amplify the weak microwave signal of axion photon conversion in a strong magnetic field.

Without measuring an axion signal, the problem of calibrating the amplification of the microwave signal occurs. The Bead-pull method and the Gradient method will be presented and their results will be compared. The two methods can both be used to calibrate the setup.

The methods rely on the perturbation of the electric field and the measurement of the reflection. The Bead-pull method uses a bead to perturb the fields in the booster, allowing to probe them in three dimensions from the systems reflectivity. But this will not be possible in the final design of the MADMAX experiment. Instead, with the Gradient method the dielectric disks are moved to perturb the field. This yields less information of the electric field, but may be realized in the final setup.

T 26.6 Tue 17:30 VG 0.110

Development of a Cosmic Muon and Neutron Veto System for BabyIAXO — •Dhruv Chouhan[1], Elisa Ruiz Choliz[2], and Matthias Schott[1] for the IAXO-Collaboration — [1]Rhenish Friedrich Wilhelm University of Bonn, Germany — [2]Johannes Gutenberg University of Mainz, Germany

The International Axion Observatory (IAXO) experiment is a cutting-edge helioscope designed to search for axions and axion-like particles (ALPs) produced in the Sun. As a preliminary step, the BabyIAXO project has been proposed as a smaller-scale version of the helioscope, with the capability to achieve a sensitivity to the axion-photon coupling of $1.5 \cdot 10^{-11}\,\mathrm{GeV}^{-1}$ for axion masses up to $0.25\,\mathrm{eV}$. This region of parameter space is particularly intriguing for axion physics.

A key challenge of the experiment lies in the design of a cosmic muon and neutron veto system, which will ensure an ultra-low-background environment for the x-ray detection system. This talk highlights the simulation and hardware advancements in developing the BabyIAXO cosmic-ray veto system, which leverages light-guided organic plastic scintillators coupled with Silicon Photomultiplier (SiPM) sensors.

To further optimize the veto system, Geant4 simulation studies have been conducted to replicate the performance of scintillators integrated with embedded wavelength-shifting fibers, accurately modeling energy deposition by various interacting particles.

T 27: Silicon Detectors III (ATLAS + CMS production)

Time: Tuesday 16:15–18:15 Location: VG 0.111

T 27.1 Tue 16:15 VG 0.111

Production of Outer Barrel Pixel Detector Modules for the ATLAS ITk Pixel Detector – From Wafer Probing to Assembly — Yannick Dieter, Wolfgang Dietsche, Walter Honerbach, Fabian Hügging, Hans Krüger, •Maximilian Mucha, Matthias Schüssler, and Jochen Dingfelder — University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

The High-Luminosity upgrade of the Large Hadron Collider (LHC) aims to enhance its performance by increasing luminosity by a factor of 5. This upgrade introduces unprecedented challenges for the ATLAS detector, driven by elevated hit rates and radiation levels far exceeding current operational conditions. To address these challenges, the ATLAS Inner Detector will be replaced with the new all-silicon Inner Tracking Detector (ITk).

The ITk production phase involves the assembly of approximately 10,000 hybrid pixel detector modules, each of which must meet strict quality requirements to ensure reliable performance. The process begins with functionality testing at wafer level, where roughly 700 wafers containing 131 readout chips each are characterized to ensure chip functionality. External vendors then hybridize the readout chips with silicon sensor dies to construct bare modules. Subsequently, these bare modules are assembled into fully operational ITkPix modules at dedicated institutes worldwide.

This talk provides an overview of the complete ITkPix module production chain, with a focus on wafer probing and assembly.

T 27.2 Tue 16:30 VG 0.111

Production of Outer Barrel pixel detector modules for the ATLAS ITk pixel detector - Quality control during electrical testing — Yannick Dieter, Jochen Dingfelder, Matthias Hamer, Florian Hinterkeuser, Fabian Hügging, Hans Krüger, Maximilian Mucha, •Matthias Schüssler, and Alexandra Wald — University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

With the upgrade of the Large Hadron Collider (LHC) to the High-Luminosity LHC (HL-LHC), the instantaneous luminosity will increase by a factor of 5 with respect to its design value from 2029 onward. This results in unprecedented hit rates and radiation levels which require major upgrades of the detectors at the HL-LHC to meet these challenging requirements.

For the upgrade of the ATLAS detector, a new all-silicon inner tracking detector (ITk detector) consisting of silicon strip and pixel modules will be installed to replace the currently operated Inner Detector. In total, approximately 10.000 new pixel detector modules have to be built and carefully tested to ensure that only functional detector modules are installed. During the 2-year production of the ATLAS ITk pixel detector, approximately 1200 pixel detector modules will be built and tested at the Forschungs- und Technologiezentrum Detektorphysik (FTD) in Bonn. This large-scale production requires a dedicated quality control (QC) effort to assure the functionality of the final detector. This talk provides an overview of the electrical testing procedures for assembled modules that will be performed at the FTD in Bonn.

T 27.3 Tue 16:45 VG 0.111

Production and Quality Control of CMS Phase-2 Inner Tracker Pixel Modules — •Chin-Chia Kuo, Massimiliano Antonello, Erika Garutti, Bianca Raciti, Jörn Schwandt, and Georg Steinbrück — University of Hamburg, 22761, Luruper Chaussee 149, Hamburg, Germany

A quad module for the Phase-2 upgrade of the CMS Inner Tracker is a hybrid detector consisting of four (2×2) CMS readout chips manufactured in 65 nm CMOS technology (RD53B_CMS) and a silicon pixel sensor. The sensor with 100×25 μm^2 pixel size and 150 μm thickness is coupled to the chips via fine-pitch flip-chip bump bonding. Module production and quality control procedures are presented in this talk, including threshold tuning and data transmission tests of the readout chip, IV measurements for sensors, open bump bond identification, and thermal stress tests. In addition, the performance of pre-production modules is included in this presentation.

T 27.4 Tue 17:00 VG 0.111

From Kick-Off to Production - Aachen as an Assembly Center for the CMS Phase-2 Outer Tracker Upgrade — Max Beckers[1], Clara Ebisch[2], Lutz Feld[2], Nina Höflich[1], Katja Klein[2], Martin Lipinski[2], Daniel Louis[2], •Vanessa Oppenländer[2], Alexander Pauls[2], Oliver Pooth[1], Nicolas Röwert[2], Jan Terörde[2], Lennart Wilde[1], Michael Wlochal[2], and Wioletta Wyszkowska[1] — [1]3. Physikalisches Institut B, RWTH Aachen — [2]1. Physikalisches Institut B, RWTH Aachen

The new operating conditions of the future HL-LHC require a replacement of the complete silicon tracking system of the CMS experiment as part of the CMS Phase-2 Upgrade. For the Phase-2 Outer Tracker new so-called 2S modules have been developed that consist of two silicon sensors stacked on top of each other. By correlating the measured hits of both sensors, this module design enables the inclusion of tracking information in the Level-1 trigger at CMS for the first time. The production of 2S modules requires a careful and precise assembly. Within the CMS Collaboration the 2S module assembly is distributed over several institutes across the US, Europe and Asia. The RWTH Aachen University represents one of those assembly centers with a contribution of around 1000 2S modules. In the last two years the project went through several stages which include a so-called kick-off batch, a preseries and is now ramping up from pre-production to production. In this talk important results from the different stages will be presented as well as the qualification steps that have been carried out showing that the Assembly Center in Aachen is well prepared for production.

T 27.5 Tue 17:15 VG 0.111

Glue dispensing and assembly of CMS 2S modules at RWTH Aachen — •Lennart Wilde[1], Max Beckers[1], Nina Höflich[1], Oliver Pooth[1], Wioletta Wyszkowska[1], Lutz Feld[2], Katja Klein[2], Clara Ebisch[2], Michael Wlochal[2], Daniel Louis[2], Vanessa Oppenländer[2], Nicolas Röwert[2], Martin Lipinski[2], and Alexander Pauls[2] — [1]III. Physikalisches Institut B, RWTH Aachen University, Aachen — [2]I. Physikalisches Institut B, RWTH Aachen University, Aachen

For the Phase 2 Upgrade of the Compact Muon Solenoid (CMS) experiment, a full reconstruction of the Outer Tracker is planned, involving novel silicon detector modules. These modules, referred to as 2S modules, utilize two silicon strip sensors to facilitate both tracking and Level-1 trigger functionalities. To minimize the material budget associated with these modules, all components will be bonded using adhesive methods.

Among the numerous 2S modules produced in module production centers worldwide, RWTH Aachen University has taken the task of assembling approx. 1,000 2S modules. This introduces significant challenges related to maintaining high-quality standards throughout the assembly process while achieving peak production rates of up to four modules per day.

This presentation will introduce a new custom made glue dispensing device that enhances existing volumetric dispensing technologies. The proposed device employs readily available components and demonstrates superior repeatability compared to previously utilized systems.

T 27.6 Tue 17:30 VG 0.111

ATLAS ITk Strips sensor cracking mitigation efforts — Jan-Hendrik Ahrling, Sergio Diez, •Konstantin Mauer, and Ingrid Gregor — Deutsches Elektronen-Synchrotron DESY, Hamburg

The upcoming High-Luminosity upgrade of the Large Hadron Collider (HL-LHC) will significantly increase its instantaneous luminosity. This will lead to a higher track density, a higher hit rate and thus an increased amount of radiation damage in the experiments. For this reason, the ATLAS experiment will be upgraded and a new all-silicon inner tracking (ITk) detector has been designed, consisting of strip and pixel detector modules.

The strip modules are glued onto local support structures. During the pre-production for the detector such fully loaded structures where thermal cycled below operational temperatures. A coefficient of thermal expansion (CTE) mismatch in the layers of a module in combination with the gluing method creates localized stress points at low temperatures. This results at fracturing of the sensor accompanied by an early sensor breakdown. To prevent the loss off several detector modules in certain cooling scenarios, a mitigation strategy was sought.

In this talk, alternative methods of loading modules onto the local support are presented which are reducing the amount of stress in the sensor. The measurements comparing these methods and their impact on sensor cracking are discussed.

T 27.7 Tue 17:45 VG 0.111

Module assembly for the ATLAS High Granularity timing detector — •Hendrik Smitmanns[1], Jessica Höfner[1], Annika Stein[1], Frederic Maximilian Matthias Silvan Fischer[1], Lucia Masetti[1], Theodorus Manoussos[1], Jan Ehrecke[1], Andrea Brogna[2], Atila Kurt[2], Fabian Piermaier[2], Antonin Zeman[2], Quirin Weitzel[2], and Steffen Schoenfelder[2] — [1]University Mainz, Insitut for Physics — [2]University Mainz, PRISMA+ Detector Lab

To meet the challenges of the High Luminosity Large Hadron Collider (HL-LHC), especially the increase of pile-up interactions, the ATLAS detector will need to be upgraded. One of the foreseen upgrades is the installation of the High-Granularity Timing Detector (HGTD). The HGTD will mitigate the effects of pile-up in the ATLAS forward region, providing a time resolution of about 30-50 ps per track. The active area consists of 2 double-sided disks per end-cap. Two 2x2 cm^2 Low Gain Avalanche Detectors (LGAD) bump-bonded to two ASICs and glued to a flexible PCB form the HGTD basic unit, the so-called module. Multiple modules are glued onto a support unit to form a detector unit, which will be built into the final detector at CERN. Pre-production started at the beginning of 2025 and over the next two years around 1000 modules, 10% of the total detector, will be assembled at Johannes Gutenberg University Mainz, as one of the six production sites. The full module assembly procedure with focus on wire bonding, metrology and the initial testing of the assembled modules is presented.

T 27.8 Tue 18:00 VG 0.111

Development of the Production Database of the High-Granularity Timing Detector for the ATLAS Phase-II Upgrade — •Annika Stein[1], Luca Cadamuro[2], Jan Ehrecke[1], Frederic Fischer[1], Jessica Höfner[1], Muhammad Imran[3], Yun-Ju Lu[4], Lucia Masetti[1], Muhammad Atif Shad Rao[3], Hendrik Smitmanns[1], and Song-Ming Wang[4] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz — [2]IJCLab, Orsay Cedex — [3]Experimental Physics Dep., CERN — [4]Academia Sinica, Taipei

During the production of components for the new High-Granularity Timing Detector, to be installed during the ATLAS Phase-II upgrade, assembly and testing sites need to keep track of the individual parts. The properties and measurement results, along with the relations between parts, need to be documented and readily accessible at different sites. There are metrology data, electrical measurements and binary files like images of parts to be recorded and retrieved in an efficient manner. Besides the work that is required on the backend-side of the application, i.e. the database with its tables and views, a special focus is laid on the visualization of results with the frontend application. Web tools like Grafana querying the database information through API requests, and customized webpages aiding the users in selecting the correct parts based on predefined labeling schemes are used to enter new information and display existing data.

In this presentation, the current status of implemented components, their attributes and relations, as well as the graphical interface will be explained.

T 28: Silicon Detectors IV (SiPMs, HG timing)

Time: Tuesday 16:15–17:45 Location: VG 1.101

T 28.1 Tue 16:15 VG 1.101

Electrical and mechanical tests of Flexible Printed Circuit cables for the ATLAS High Granularity Timing Detector — •Frederic Fischer[1], Lucia Masetti[1], Hendrik Smitmanns[1], Jessica Höfner[1], Annika Stein[1], Jan Ehrecke[1], Theodoros Manoussos[1], Andrea Brogna[2], Atila Kurt[2], Fabian Piermaier[2], Steffen Schönfelder[2], Antonin Zeman[2], and Quirin Weitzel[2] — [1]Johannes Gutenberg-Universität Mainz, Institut für Physik — [2]Johannes Gutenberg-Universität Mainz, PRISMA+ Detector Lab

The High Granularity Timing Detector (HGTD) for the ATLAS upgrade is under construction to meet the challenges of the HL-LHC. The silicon detectors along with the electronics are installed in two double-sided disks per end-cap and consist of modules connected to the peripheral electronics by flexible printed circuit cables (flex tails), which serve as interconnections for power, communication signals and HV bias. Their final version has been designed and several prototypes have been produced with mechanical as well as electrical tests offering promising results so far. The results of the latest tests both in the lab and at a demonstrator with the full readout chain will be presented. Mechanical aspects towards integration in the final detector are also considered.

T 28.2 Tue 16:30 VG 1.101

Gluing proceedings for the module assembly and the DU loading for the ATLAS High-Granularity timing detector — •Jessica Höfner[1], Annika Stein[1], Frederic Fischer[1], Lucia Masetti[1], Hendrik Smitmanns[1], Steffen Schönfelder[2], Jan Ehrecke[1], Theodorus Manoussos[1], Andrea Brogna[2], Atila Kurt[2], Fabian Piermaier[2], Antonin Zeman[2], and Quirin Weitzel[2] — [1]University Mainz, Insitute for physics — [2]University Mainz, PRISMA+ Detector Lab

One of the challenges of the high luminosity upgrade for the LHC (HL-LHC) is the increase of pileup interactions. The way to address this challenge is to exploit the time spread of the interactions to distinguish between collisions occurring very close in space but well separated in time. For this the ATLAS detector needs to be upgraded. One of the updates will be the installation of the High-Granularity Timing Detector (HGTD). The device will provide a timing resolution of 30-50 ps for minimum ionizing particles and therefore will improve significantly the performance in the forward region of the detector. The active area consists of 2 double sided disks per end-cap filled with modules made of two 2x2 cm^2 Low Gain Avalanche detectors dump-bounded to two ASICs and glued to a flexible PCB. Several modules will be glued onto a support unit to form a detector unit. The Mainz ATLAS group contributes to the assembly of modules and their loading onto DU's. Therefore, the gluing procedure needs to be set up. The current setup for the gluing and the loading procedure itself will be presented in this talk.

T 28.3 Tue 16:45 VG 1.101

The ATLAS High Granularity Timing Detector: Test-Beam and Test-Bench Results — •Theodoros Manoussos[1,2], Xiao Yang[1], Giulia Di Gregorio[1], Stefano Manzoni[1], Dominik Dannheim[1], Stefan Guindon[1], and Lucia Masetti[2] — [1]CERN — [2]Johannes Gutenberg-Universität Mainz, Germany

The increase of the instantaneous luminosity at the HL-LHC will be a challenge for the ATLAS detector. The pile-up is expected to increase up to 200 interactions per bunch crossing, resulting in poorer performance of the currently used reconstruction algorithms, in particular in the forward region. To mitigate these effects, a High Granularity Timing Detector (HGTD) will be integrated in the end-cap regions of ATLAS, covering a pseudo-rapidity range of $2.4 < |\eta| < 4.0$. HGTD, which also serves as a luminosity monitor, aims for a single-track time resolution for MIPs of 30 ps at the beginning of the lifetime, up to 50 ps after a maximum fluence of $2.5 \times 10^{15}\,\frac{\mathrm{neq}}{\mathrm{cm}^2}$. The high-precision timing information improves the correct assignment of tracks to vertices. HGTD sensors are based on the novel Low Gain Avalanche Detector (LGAD) technology. They provide a moderate gain, resulting in fast rise time and large signal-to-noise ratio, required for excellent time resolution. Each sensor is a 15×15 array of $1.3 \times 1.3\,\mathrm{mm}^2$ LGAD pads. A dedicated read-out ASIC, ALTIROC, was developed. ASICs are bump-bonded to sensors forming hybrids. Sensors and hybrids have been extensively tested in test-beam campaigns and with radioactive sources. The recent test-beam and test-bench results for sensors and hybrids before and after irradiation are presented in this talk.

T 28.4 Tue 17:00 VG 1.101

Optimizing Silicon Photomultiplier Readout for Particle Physics Detectors — •Johannes Wenk — ALU Freiburg, Physikalisches Institut,79104 Freiburg (DE)

To optimize the performance of silicon photomultiplier (SiPM) detectors and their readout electronics, we have developed a robust, light-tight calibration and test setup providing a reproducible environment for precise SiPM measurements. This system features a pulsed laser with adjustable intensity to simulate a wide range of experimental light conditions, critical for evaluating the linearity and dynamic range of SiPMs. The setup also enables measurements of SiPM response at variable bias voltages, intrinsic noise characteristics through dark count analysis, and temperature stability during operation. Its modular design accommodates diverse SiPM geometries and configurations, facilitating systematic comparisons of different types and designs. By providing a controlled, versatile testing environment, this calibration setup supports the optimization of detectors for high-energy physics experiments such as AMBER and SHiP at CERN, where SiPM performance is critical for achieving precise measurements. * Gefördert durch das BMBF

T 28.5 Tue 17:15 VG 1.101

MIP detection on a plastic scintillator and SiPM system in very noisy environments — •Katjana Neumann, Massimiliano Antonello, Erika Garutti, and Jörn Schwandt — Universität Hamburg, Hamburg, Germany

A system consisting of a plastic scintillator tile directly couple to a SiPM is used to detect minimum ionizing particles (MIP) from a Sr90 source. The design of the single channel in inspired by the tiles for the CMS HGCAL calorimeter upgrade.

The signal to noise (S/N) separation provided by the system is well above 10 at the beginning of the detector lifetime. Radiation damage of the SiPM, as that experienced during the lifetime of the HGCAL detector, increase the dark current and degrade the S/N separation and by that the MIP detection efficiency.

We investigate the degradation as a function of the dark current increase. The increase of dark current after irradiation can be mitigated by cooling the SiPM or lowering its operation voltage. The systematic dependence of S/N separation on these parameters will be discussed in the presentation.

T 28.6 Tue 17:30 VG 1.101

Correction of Non-Linear Response of Silicon Photomultipliers — •Lukas Brinkmann, Massimiliano Antonello, Erika Garutti, and Jörn Schwandt — Universität Hamburg, Hamburg, Germany

The finite number of pixels in a silicon photomultiplier (SiPM) limits its dynamic range. The SiPM response deviates from linear by more than 5% already for signals comparable to 50-60% of the total number of pixels. Correcting the non-linear response is essential to extend the SiPMs dynamic range. One challenge in determining the non-linear response correction is providing a reference linear light source. Instead, the single-step method used to calibrate PMTs is applied, based on the difference in responses to two light sources. With this method, the response of various SiPMs with different pixel geometries was measured and corrected. The study shows that the response function does not depend on the operation voltage in the range $2-4$ V overvoltage and it is only mildly dependent on temperature over a range of 40 K. Linearity within 1% can be restored by applying a single correction function in a range of ± 5 K and ± 2 V around the original conditions of the measurement.

T 29: Detectors III (Scintillators)

Time: Tuesday 16:15–17:30 Location: VG 1.102

T 29.1 Tue 16:15 VG 1.102

Status of cosmogenic studies in the JUNO pre-detector OSIRIS — •Marcel Büchner[1,2], Arshak Jafar[1,2], George Parker[1,2], Michael Wurm[1,2], Oliver Pilarczyk[1,2], Tim Charisse[1,2], and Manuel Böhles[1,2] — [1]Johannes Gutenberg-University, Mainz, Germany — [2]EC PRISMA+

OSIRIS as the pre-detector of the JUNO reactor neutrino measurement, is meant to monitor the radio-purity of the scintillator used. The monitoring of the scintillators radio-purity relies on an in situ measurement of radioactive decays in the 20-ton scintillator volume. Therefore, the scintillator volume is surrounded by 500 tons of water for external shielding and all detector materials have been carefully selected for radiopurity. To ensure that the background is as low as possible, OSIRIS is located approximately 700m under ground. Even at that depth, a relevant level of background events originates from cosmic muons, which not only cause a signal themselves but they can interact with the detector material and cause the creation of radioactive isotopes. This talk presents the ongoing work of the implementation of a muon tracking for OSIRIS. Utilizing the charge information of 64 PMTs inside OSIRIS, an estimate of the muon path will be calculated. This estimate will later be used as an input of a chi-squared-minimazation, to further improve the accuracy of the muon tracking. Based on the tracking of these muons and using spatial and tem poral correlations, cosmogenic neutrons and radioactive isotopes (e.g. C-11) can be identified. This Project is funded by the DFG Research Unit FOR 5519.

T 29.2 Tue 16:30 VG 1.102

Large Area MMC-based Photon detector - LAMP — •Christian Ritter, Christian Enss, Andreas Fleishmann, Daniel Hengstler, Ashish Jadhav, Cagla Mahanoglu, Ioana-Alexandra Nitu, Andreas Reifenberger, Daniel Unger, and Loredana Gastaldo — Kirchhoff Institute for Physics, Heidelberg University

Using scintillating crystals coupled to temperature sensors and a photon sensor to detect the scintillation light emitted upon a particle interaction plays a very important role in experiments for rare event searches. Comparing the amplitude of the signal from the temperature sensor and the one of the photon sensor allows for discriminating light particles from heavy particles. We present the development and first characterization of a large area (metallic magnetic calorimeters) MMC-based photon detector (LAMP). This detector features an MMC sensor with stripline geometry fabricated onto a silicon substrate that is used as a photon absorber. The LAMP detector has been conceived to be used as a photon detector in the AMoRE experiment for the search of neutrinoless double beta decay in Mo-100 using calcium molybdate scintillating crystals. We discuss the achieved performance in relation to the requirement of the AMoRE experiment and the suitability of the LAMP detector design to be part of a combined photon and phonon detector sharing the same Si substrate.

T 29.3 Tue 16:45 VG 1.102

Construction and operation of a scintillation detector with full waveform analysis for spatial resolution enhancement. — •Erik Ehlert, Dmitry Eliseev, Markus Merschmeyer, Thomas Hebbeker, and Alexander Schmidt — III. Physikalisches Institut A, RWTH Aachen University

Increasing the resolution in large area scintillation detectors usually demands a higher number of readout channels. In order to study ways of increasing spatial resolution for fewer readout channels, a setup of two detectors, a reference and large scintillaton tile, was developed. In addition, to demonstrate the plausibility of the concept, a Geant4 simulation of the entire detector setup was performed.

The reference detector consists of two layers of arrays of scintillator strips coupled to pairs of silicon photomultipliers (SiPMs). This detector is used to provide reference measurements for the single scintillator tile. The tile is read out by only four SiPMs. The signals from the reference and tile detector are digitized by an FPGA-based setup developed in-house. With the information about the exact hit position and the full SiPM-waveform data, an analysis for enhancing the spatial resolution was set up.

The talk provides an overview of the entire detector setup, simulation, analysis, and will showcase the achieved enhancement in spatial resolution.

T 29.4 Tue 17:00 VG 1.102

Osiris DAQ and Single Event Analysis — •Arshak Jafar, Michael Wurm, Oliver Pilarczyk, Tim Charisse, Marcel Buchner, and George Parker — JGU Mainz, Institute of Physics and EC PRISMA+

The Jiangmen Underground Neutrino Observatory (JUNO), under construction in southern China, will determine the neutrino mass hierarchy (MH) by observing neutrinos from nuclear reactors at a distance of 53 km. To reach the desired sensitivity ($> 3\sigma$) for MH, the radiopurity of the different detector components plays a crucial role. To ensure the purity of the 20 kt liquid scintillator (LS) target of JUNO, the Online Scintillator Internal Radioactivity Investigation System (OSIRIS) is being constructed. The 20-ton pre-detector will monitor the radiopurity of the LS during its production and the filling phase of the central detector of JUNO. This talk will focus on the design principles and working of the data acquisition system (DAQ) of the OSIRIS predetector as well as the single event analysis of the data to estimate the rate of radioactive contaminants in the liquid scintillator.

This work is supported by DFG, Research Unit FOR 5519.

T 29.5 Tue 17:15 VG 1.102

Quenching Studies to Increase JUNO's Sensitivity to Proton Decay — •Ulrike Fahrendholz, Lothar Oberauer, Matthias Raphael Stock, Selina Rudolph, and Hans Steiger — TUM School of Natural Sciences, Physics Department, James-Franck-Str. 1, 85748 Garching

The hypothetical proton decay $p \to K^+ + \bar{\nu}$ generates a distinctive threefold coincidence signal in the Jiangmen Underground Neutrino Observatory (JUNO). JUNO features 20 kton of liquid scintillator, which requires precise characterization of its scintillation response to achieve the high sensitivity necessary for proton decay searches.

This talk presents the results of quenching studies on protons at kinetic energies of the order of 100 MeV. Additionally, measurements of ^{12}C will be discussed, offering insights also relevant for the interpretation of supernova neutrino events.

From the proton quenching, the light emission behavior of kaons is extrapolated. These results can be used to increase the event selection efficiency for $p \to K^+\bar{\nu}$ in JUNO.

This work is supported by the Clusters of Excellence Origins and PRISMA$^+$ and the DFG Collaborative Research Center "NDM" (SFB1258).

T 30: Top Physics II (Properties)

Time: Tuesday 16:15–17:45 Location: VG 1.103

T 30.1 Tue 16:15 VG 1.103

Towards Top Quark Mass Measurements in the Fully Hadronic $t\bar{t}$ Decay Channel using the Full Run 2 Dataset — •Tom Davids, Johannes Lange, Peter Schleper, and Hartmut Stadie — Institute of Experimental Physics, University Hamburg, Germany

Precision measurements of the mass of the top quark are an important test of Standard Model predictions. In this talk, the current progress towards a top quark mass measurement in the fully hadronic top quark pair ($t\bar{t}$) decay channel is presented. The fully hadronic decay channel of $t\bar{t}$-pairs has the largest branching ratio of the three dominant decay channels and has no undetectable neutrino in its final state. However, it has a large multijet background. The aim of this analysis is to evaluate data taken by the CMS detector at the LHC during Run 2 at $\sqrt{s} = 13\,\text{TeV}$ from 2016 to 2018. This dataset corresponds to an integrated luminosity of $115.13\,\text{fb}^{-1}$ considering only data recorded with the selected triggers for this final state. This talk presents studies of these triggers and discusses the background prediction for the multijet background by making use of Columnflow, a highly parallelized Python-based analysis framework.

T 30.2 Tue 16:30 VG 1.103

Optimizing Jet-Parton Assignments in Fully Hadronic Top-Quark Decays: A Comparison of SPANet and Traditional Methods — •Nico Rehberg, Johannes Lange, Hartmut Stadie, and Peter Schleper — Institute of Experimental Physics, Hamburg University, Germany

Accurate jet-parton assignments in fully hadronic top-quark decays are crucial for the precise reconstruction of the top-quark mass. Traditional approaches, such as applying a kinematic fit, provide reliable results but are limited by the rapid increase in possible permutations as the number of jets grows. These methods become less efficient due to combinatorics in case of high jet multiplicities, and they do not make use of dynamical properties of $t\bar{t}$ processes. The Symmetry Preserving Attention Network (SPANet), a machine learning-based approach, addresses these challenges by exploiting the inherent symmetries of the assignment problem, resulting in improved scaling during inference. This talk provides a brief overview of the network's structure and presents a comparison of assignment results between SPANet and traditional approaches, including the χ^2-method and kinematic fit.

T 30.3 Tue 16:45 VG 1.103

Measurement of the top-quark mass using singly produced top-quarks in the t-channel — •Lukas Kretschmann, Dominic Hirschbühl, and Wolfgang Wagner — Bergische UniversitätWuppertal, Wuppertal, Germany

Almost all measurements of the top-quark mass have been performed using top-quark-antiquark pair-production events, measurements in other channels can be important inputs for a global combination. First studies for a measurement of the top-quark mass using t-channel single top-quark events are shown. This channel is statistically independent to the top-quark-antiquark pair-production measurements and has different systematic uncertainties associated to it, e.g. modelling uncertainties from Monte Carlo event generators. The high rate of background-events is a major challenge in this channel, for this a Graph Neural Network (GNN) is trained to enrich the selection in single top-quark t-channel events. For the determination of the top-quark mass the invariant mass of the charged lepton and the b-quark jet is used as a sensitive observable employing a maximum likelihood fit.

T 30.4 Tue 17:00 VG 1.103

Using improved $bb4\ell$ predictions for the simultaneous extraction of the top-quark mass and decay width — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], Arpan Ghosal[1], Gabriel Gomes[1], Jan Joachim Hahn[1], Vadim Kostyukhin[1], Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], Sebastian Rentschler[1], Elisabeth Schopf[1], •Katharina Voss[1], Wolfgang Walkowiak[1], Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

The sensitivity of the simultaneous measurement of the top-quark mass and decay width using the full Run-2 $\sqrt{s} = 13\,\text{TeV}$ ATLAS dataset depends critically on the accurate modeling of the $WWbb$ final state in Monte Carlo simulations. In particular, a precise description of the $t\bar{t}/tW$ interference and of the off-shell effects of the top-quark is essential. These effects are modelled at next-to-leading-order accuracy by the $bb4\ell$ POWHEG generator. We present the nominal $bb4\ell$ signal sample used in ATLAS, which is generated with a new, improved $bb4\ell$ process version, as well as a prescription to evaluate modelling uncertainties associated with this sample.

Finally, the influence of the updated $bb4\ell$ signal sample on the top-quark mass and width analysis, which targets the $WWbb$ final state in dileptonic $e\mu$ decay, is discussed.

T 30.5 Tue 17:15 VG 1.103

Measurement of top quark CKM elements at FCC-ee — Sarah Alshamaily, Sofia Giappichini, Simon Keilbach, Jan Kieseler, Markus Klute, Matteo Presilla, and •Xunwu Zuo — KIT, Karlsruhe, Germany

The CKM matrix is a central piece for the understanding of electroweak physics. Particularly, the CKM element |Vts| is not directly measurable at tree level in current experiments in a precise manner. The current most precise value, indirectly determined via Bs meson mixing, is highly model-dependent and dominated by theory uncertainties. The FCC-ee experiment expects to produce 2M $t\bar{t}$ events with a very clean environment, providing an excellent opportunity to probe the |Vts| through $t \to Ws$ decay directly and in a model-independent way. This contribution summarizes the recent study on the |Vts| measurement at FCC-ee and discuss its theory impacts.

T 30.6 Tue 17:30 VG 1.103

Searching for CPT violation with top quarks — •Nathaniel

Sherrill — Leibniz University Hannover

We present the first model-independent sensitivity to CPT violation in the top sector of the Standard Model. ATLAS and CMS measurements of the top-antitop kinematical mass difference constrain the temporal component of a CPT-violating background field to the interval [-0.13, 0.29] GeV at 95% confidence level.

T 31: Flavour physics II

Time: Tuesday 16:15–18:15 Location: VG 1.104

T 31.1 Tue 16:15 VG 1.104

Search for Quantum Disentanglement in the $B^0\overline{B}^0$ system at Belle II — •Max Kei Hattenbach, Hans-Günther Moser, and Sagar Hazra — Max-Planck-Institute for Physics, Munich, Germany

$B^0\overline{B}^0$ pairs produced at the $\Upsilon(4S)$ resonance are expected to be maximally entangled - an assumption crucial for measurements of time-dependent CP violation in experiments such as Belle, BaBar, and Belle II. If a fraction of these $B^0\overline{B}^0$ pairs becomes disentangled, regardless of the underlying mechanism, it could introduce systematic uncertainties into analyses, which are currently not accounted for. In this study, we search for possible disentanglement effects by analysing the hadronic decay mode $B^0 \to D^{(*)-}\pi^+$ using Belle II data. A signature of disentanglement would be observed as a damping and/or phase shift in the measured time-dependent asymmetry, compared to the behaviour under maximally entanglement. By examining decay time difference (Δt) of the two B mesons, we aim to test the sensitivity for time-dependent CP violation measurements using Monte Carlo studies.

T 31.2 Tue 16:30 VG 1.104

Study of Entanglement and Coherence at Belle II — •Simeon Hamurcu, Hans-Günther Moser, Sagar Hazra, and Maximilian Kei Hattenbach — MPI for Physics, Munich

Belle II is a next generation B-factory that aims to precisely measure Standard Model (SM) parameters and conduct searches for New Physics (NP) beyond the Standard Model. Electrons and positrons are asymmetrically collided at center of mass energies around the $\Upsilon(4S)$-resonance. This resonance mainly decays into a pair of B^0-mesons. In time dependent measurements it is assumed that these pairs are produced in a coherent and entangled state. This assumption however has not yet been tested at Belle II and tests at the predecessor experiment Belle still do not exclude a partial disentanglement. It is therefore necessary to conduct further studies to exclude or quantify disentanglement.

We implement models of disentanglement by adapting software from the B^0-lifetime and mixing frequency analysis. For that we compute and implement a new convolution to a resolution function of the Belle II detector and add additional disentanglement parameters to the software.

A validation is finally performed on signal Monte Carlo.

T 31.3 Tue 16:45 VG 1.104

$B_c \to \eta_c$ form factors at large recoil: Interplay of soft-quark and soft-gluon double logarithms — Guido Bell[1], Philipp Böer[2], Thorsten Feldmann[1], •Dennis Horstmann[1], and Vladyslav Shtabovenko[1] — [1]Theoretische Physik 1, Center for Particle Physics Siegen, Universität Siegen — [2]CERN, Theoretical Physics Department

Soft-Collinear Effective Theory is an important tool used for setting up factorisation theorems and achieving resummations to all orders in perturbation theory. While most conceptual problems appearing in calculations at leading power have been understood, at subleading power endpoint divergent convolution integrals appear in the factorisation theorems preventing the use of renormalization group equations for resummations. While this problem has been solved in a few collider processes, it persists in exclusive B-decays. We therefore resort to diagrammatic resummation techniques to derive the double-logarithmic series of the soft-overlap contribution to $B_c \to \eta_c$ transition form factors, assuming the scale hierarchy $m_b \gg m_c \gg \Lambda_{\rm QCD}$. We find that the leading double logarithms arise from a peculiar interplay of soft-quark endpoint logarithms from ladder diagrams with energy-ordered spectator-quark propagators, as well as standard Sudakov-type soft-gluon corrections. We elucidate the all-order systematics, and show that their resummation proceeds via a novel type of integral equations.

T 31.4 Tue 17:00 VG 1.104

Heavy-to-light form factors to three loops — Matteo Fael[1], Tobias Huber[2], Fabian Lange[3,4], •Jakob Müller[2], Kay Schönwald[3], and Matthias Steinhauser[5] — [1]Theoretical Physics Department, CERN — [2]Theoretische Physik 1, CPPS, Universität Siegen — [3]Physik-Institut, Universität Zürich — [4]Paul Scherrer Institut, Villingen — [5]Institut für Theoretische Teilchenphysik, Karlsruhe Institute of Technology

In this talk, we discuss the computation of form factors for decays of heavy into light quarks at third order in QCD for various currents. We describe the different steps of the calculation and use the results to compute the hard matching coefficients in Soft-Collinear Effective Theory for all currents. Further, we extract the hard function in $\bar{B} \to X_s\gamma$ to three loops using the tensor coefficients at light-like momentum transfer and study the impact of three-loop QCD corrections on partial decay rates in charged-current semi-leptonic $\bar{B} \to X_u l \bar{\nu}$ decays, where the newly computed corrections to the vector and axialvector coefficients constitute an essential ingredient to carry out this analysis.

T 31.5 Tue 17:15 VG 1.104

Modelling Quark-Hadron Duality Violation in Inclusive $B \to X_c\ell\bar{\nu}$ — •Ilija S. Milutin[1], Thomas Mannel[1], Rens Verkade[2,3], and K. Keri Vos[2,3] — [1]TP1, CPPS, University of Siegen, Germany — [2]GWFP, Maastricht University, The Netherlands — [3]NIKHEF, Amsterdam, The Netherlands

The Heavy Quark Expansion (HQE) is the main tool for calculating decay rates and kinematic moments of inclusive semi-leptonic B meson decays. The HQE manifests as an Operator Product Expansion (OPE) in terms of powers of the inverse heavy bottom quark mass ($1/m_b$). Using the HQE, the CKM matrix element V_{cb} has been extracted at percent-level precision from moments of inclusive $B \to X_c\ell\bar{\nu}$ decays. The calculations upon which the theoretical estimates rely are done in terms of quarks and gluons, which are not accessible for experiments. Quark Hadron Duality (QHD) allows for a translation of theoretical predictions at the quark-level to experimental observables at the hadron-level. Since the increased accuracy in HQE predictions up to $O(1/m_b^5)$, violation of the QHD may start to become a relevant limit to the achievable precision. When QHD is violated, the OPE stops being a valid expansion. In my talk, I will show how we can derive a model for the Quark Hadron Duality Violation and how it can enter different kinematic moments of the $B \to X_c\ell\bar{\nu}$ decays.

T 31.6 Tue 17:30 VG 1.104

Measurement of kinematic moments of semileptonic B-meson decays with the Run 1 data set of Belle II — Florian Bernlochner, •Munira Khan, Markus Prim, and Slavomira Stefkova — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The determination of the Cabibbo-Kobayashi-Maskawa matrix element $|V_{cb}|$ relies on $b \to c\ell^- nu_\ell$ transitions. The inclusive semileptonic process can be described with the Heavy Quark Expansion (HQE). Using the operator product expansion the total decay rate can be parameterized with a small number of non-perturbative parameters. These parameters cannot be determined from first principles, but their values are encoded into kinematic moments of the decay rate. We present the current status of measuring the full set of kinematic moments (q^2, M_X, E_ℓ) within a single analysis, which characterize the semileptonic $b \to c\ell^- nu_\ell$ and $b \to q\ell^- nu_\ell$ transitions using the Run 1 data of the Belle II experiment. This allows for the first time to properly correlate experimental uncertainties between the different moments. In addition, we present preliminary fits for $|V_{cb}|$ to simulated samples to illustrate the increase in sensitivity of this approach.

T 31.7 Tue 17:45 VG 1.104

Search for New Physics with $B^0 \to D^*\mu\nu$ angular analysis and LHCb — •Tobias Knospe[1], Johannes Albrecht[1], Biljana Mitreska[1], Hasret Nur[3], Lucia Grillo[3], Greg Ciezarek[4], Marco Gersabeck[5], Derek Yeung[2], and Manuel Schiller[3] —

[1]TU Dortmund University, Dortmund, Germany — [2]The University of Manchester, Manchester, UK — [3]University of Glasgow, Glasgow, UK — [4]CERN, Geneva, Switzerland — [5]Albert-Ludwigs-Universitaet-Freiburg, Freiburg, Germany

Studying the angular structure of $b \to c\ell\nu$ using effective field theory allows to probe potential New Physics (NP) effects. An angular analysis of the $B^0 \to D^*\mu\nu$ decay is presented, based on proton-proton collision data collected by the LHCb experiment, corresponding to an integrated luminosity of $3\,\mathrm{fb}^{-1}$. The signal decays are extracted through a multidimensional fit to the data, using templated distributions derived from both simulation and control samples in the proton-proton collision data. The real and imaginary parts of NP Wilson coefficients are measured in single-coefficient scenarios and a combined multi-parameter fit. Additionally, hadronic form factors are measured in a Standard Model scenario using CLN, BGL and BLPR parameterizations.

T 31.8 Tue 18:00 VG 1.104

Joint measurement of the $b \to c\tau\nu$ Wilson Coefficients with LHCb and Belle II. — Johannes Albrecht[1], Florian Bernlochner[2], Biljana Mitreska[1], and •Marco Colonna[1] — [1]TU Dortmund University, Dortmund, Germany — [2]University of Bonn, Germany

Semileptonic $b \to c\ell\nu$ decays are excellent probe for testing Lepton Flavour Universality and New Physics (NP) effects. A combined measurement of NP Wilson coefficients is performed using of $B \to D^*\tau\nu$ decays in proton-proton collision data collected by LHCb and electron-positron collision data from Belle II. The signal is extracted using a multidimensional fit to data using templated distributions derived from simulation and from control samples. New Physics contributions are measured via their corresponding Wilson coefficients and in several fit configurations that allow for different New Physics operators.

T 32: Neutrino Astronomy II

Time: Tuesday 16:15–18:00 Location: VG 1.105

T 32.1 Tue 16:15 VG 1.105

Design and Production of the first P-ONE detector line — •Ben Nührenbörger for the P-ONE-Collaboration — Department of Physics, Technical University of Munich, Germany

Astrophysical neutrinos at the TeV scale would open a new observational window into currently obscured and inaccessible extreme environments. Detecting them poses significant challenges due to their low rate and weak interactions with matter. The Pacific Ocean Neutrino Experiment (P-ONE) addresses this problem by instrumenting a large volume of water at a depth of 2.6 km in the Northeast Pacific Ocean, piggybacking on a large oceanographic infrastructure maintained by Ocean Networks Canada. The ocean water will be used as a detection medium for the Cherenkov light emitted by the charged secondary particles produced by a neutrino interaction at TeV and above. This is done using an array of photomultiplier tubes encapsulated in glass hemispheres. A total of 20 hemispheres are mounted on a kilometer-high mooring line and read out by a newly designed data acquisition system that ensures sub-nanosecond timing, which is critical for correlating and reconstructing signals across the detector array. This talk will provide an overview of the design and integration of the first mooring line, focusing on the construction and operation of the optical modules, the measures taken to achieve precise timing, and the data acquisition processes.

T 32.2 Tue 16:30 VG 1.105

Status and results of the KM3NeT neutrino telescope — •Thomas Eberl for the KM3NET-ERLANGEN-Collaboration — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg, Nikolaus-Fiebiger-Str. 2, 91058 Erlangen, Germany

KM3NeT is the next-generation underwater Cherenkov neutrino detector operational and under construction in the Mediterranean Sea at two different locations. The ORCA detector, close to Toulon, features a dense configuration of optical modules, optimised for the study of interactions of neutrinos with energies down to a few GeV. The same technology, albeit in a sparser configuration, is used for high-energy (TeV-PeV) neutrino astronomy with the ARCA neutrino telescope off the coast of Sicily. Both instruments are operational, take data since several years, and have been completed to more than 20% of their expected final volume. In this talk the construction plans and status will be reviewed and an overview of recent results on particle physics and neutrino astronomy will be given. The recent discovery of an extreme-energy neutrino will be discussed.

T 32.3 Tue 16:45 VG 1.105

Neutrino Event Generator Studies with NEUT — •Frederik Andersen, Thomas Eberl, and Rodrigo Gracia Ruiz for the KM3NET-ERLANGEN-Collaboration — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg, Nikolaus-Fiebiger-Str. 2, 91058 Erlangen, Germany

The KM3NeT/ORCA neutrino telescope is currently under construction in the Mediterranean Sea. It is optimized to detect atmospheric neutrinos with energies up to 100 GeV. To this end a three dimensional grid of photomultiplier tubes detects Cherenkov radiation induced by particles that result from neutrino interactions with seawater. The data recorded by the experiment is analysed by comparing to detailed Monte-Carlo simulations which implement state-of-the-art knowledge on secondary particle production and detection processes. As a first step, so-called neutrino event generator codes employ different approximations to simulate the distribution of final-state particles produced in neutrino interactions. Differences in neutrino generators can introduce biases in the interpretation of the experimental data, and lead to tensions in measurements performed by different experiments. In this talk we will present our strategy to study how using different neutrino event generators impacts KM3NeT/ORCA's scientific results. We implement an alternative simulation pipeline using NEUT, the neutrino event generator developed by Super-Kamiokande, and compare its results to the default KM3NeT pipeline employing GENIE as event generator.

T 32.4 Tue 17:00 VG 1.105

Prospects for a combined measurement of the galactic neutrino flux with KM3NeT and IceCube — •Anke Mosbrugger and Oliver Janik — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg

Observing the Galactic Plane with muon neutrinos relies on precise muon track reconstruction for accurate pointing and high detection efficiency. To suppress the dominant background from atmospheric muons, the Earth itself is used as a natural filter. This effectively yields a pure neutrino data set on the Hemisphere below the local horizon. Hence, combining data from a neutrino telescope in the Southern Hemisphere (IceCube) and the Northern Hemisphere (KM3NeT) increases the sensitivity to the astrophysical neutrino flux, especially for observations of the Galactic plane. The diffuse astrophysical neutrino flux is analyzed using a binned forward-folding likelihood approach. All statistical modeling in this work is handled by the framework NNMFit. This talk will outline the implementation of KM3NeT data in this framework and the prospects of combining data of the KM3NeT and IceCube neutrino telescopes for a measurement of the galactic neutrino flux.

T 32.5 Tue 17:15 VG 1.105

The Galactic Diffuse Neutrino Emission in a combined fit of Muon Tracks and Cascades with IceCube* — •Jonas Hellrung[1,2], Niclas Krieger[1,2], and Julia Tjus[1,2,3] for the IceCube-Collaboration — [1]Theoretical Physics IV, Plasma Astroparticle Physics, Faculty for Physics and Astronomy, Ruhr University Bochum, 44780 Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, 412 96 Gothenburg, Sweden

Although cosmic rays (CRs) were discovered more than a hundred years ago, their origin is not yet understood. One problem is that the cosmic-ray spectrum can only be measured close to Earth. However, there is a way to indirectly study the distribution of CRs in the Galaxy:

When CRs interact with the interstellar medium, they produce gamma rays and neutrinos. The first observation of this neutrino flux was published in 2023 by IceCube. Here I present plans for a new analysis combining different event topologies. IceCube measures events in two main topologies: Tracks, originating in charged current ν_μ interactions, provide a better angular resolution. In contrast cascades, from most other possible interactions, provide a better energy resolution and are able to observe the Southern sky (and therefore the Galactic Center) despite the huge background of atmospheric muons. Combining both event topologies in one analysis exploits all these advantages. Sensitivities and model discrimination power of such a measurement are discussed here. *Supported by BMBF and SFB 1491

T 32.6 Tue 17:30 VG 1.105

Unfolding the Electron Neutrino Diffuse Spectrum — •Lene van Rootselaar, Lucas Witthaus, and Pascal Gutjahr for the IceCube-Collaboration — Technische Universität Dortmund

The IceCube Neutrino Observatory, located at the geographic South Pole, is a cubic-kilometre detector designed to identify neutrinos across a wide energy range. It distinguishes between two main types of neutrino signatures: track events, caused by muons traversing the detector, and cascade events, primarily produced by Charged-Current (CC) interactions of electron neutrinos and Neutral-Current (NC) interactions of all neutrino flavours. By analysing cascade events, it becomes possible to assess a diffuse electron neutrino spectrum, provided the background from Neutral-Current tau and muon neutrino interactions is properly accounted for.

Current progress on the production of this electron neutrino spectrum will be presented. The method used for this analysis is unfolding. The analysis is based on a Monte Carlo cascade sample. Preliminary flux results will be shown and compared to theoretical models, alongside an overview of the preparatory steps leading to this approach.

T 32.7 Tue 17:45 VG 1.105

Sensitivity of IceCube Upgrade to neutrinos from the Galactic Plane — •Berit Schlüter and Alexander Kappes for the IceCube-Collaboration — Universität Münster, Institut für Kernphysik

As part of the IceCube Upgrade, the IceCube neutrino observatory will be instrumented with seven additional strings during the Antarctic summer of 2025/26 to improve sensitivity in the low-energy range from 10 GeV to 1 GeV and to achieve a significant improvement in the detector's calibration. New optical modules and calibration devices have been developed for this purpose. To evaluate the impact of the IceCube Upgrade on low-energy sensitivity, analyses are being performed on two IceCube data sets and one MC data set for the IceCube Upgrade, focusing on neutrinos from the Galactic plane. In this talk, the procedure for this analysis will be presented, and preliminary results will be shown.

T 33: Data, AI, Computing, Electronics III (ML in Jet Tagging, Misc.)

Time: Tuesday 16:15–17:45 Location: VG 2.101

T 33.1 Tue 16:15 VG 2.101

Representation Learning — •Niklas Meier — TUM, Munich, Germany

Large neutrino telescopes, such as IceCube or KM3NeT, are experiments that try to measure incident neutrinos in order to learn about their properties and origins. For the detection, these experiments employ large volumes of transparent media, along with photo-sensors, to measure the light produced by secondary processes of neutrino events.

In the pursuit of analyzing data from these large neutrino telescopes, one often runs into the problem of a high memory footprint, due to the length of representations of neutrino events. Approaches that try to circumvent this issue, e.g. by subsampling, were in the past shown to perform poorly on these long representations. Hence it is worth putting in the effort to develop a method to generate low memory representations of neutrino events.

The approach, that is presented here, regards each event as a graph, where each node corresponds to a detector response, and aims to learn assignments that map the graphs to ones with fewer nodes. Such an encoding network can be trained, e.g. in the context of an autoencoder, where a similar second network decodes back to the original graph size. Alternatively, in so called contrastive methods, the encoding network is applied twice, but with different augmentations to the data, and the learned representations are compared. In this presentation, I will show the principles of dense pooling methods in encoding networks and their performance in both frameworks.

T 33.2 Tue 16:30 VG 2.101

Aspen Open Jets: Unlocking LHC Data for Foundation Models in Particle Physics — Oz Amram[1], Luca Anzalone[2], •Joschka Birk[3], Darius A. Faroughy[4], Anna Hallin[3], Gregor Kasieczka[3], Michael Krämer[5], Ian Pang[4], Humberto Reyes-Gonzalez[5], and David Shih[4] — [1]Fermi National Accelerator Laboratory — [2]University of Bologna — [3]University of Hamburg — [4]Rutgers University — [5]RWTH Aachen University

A foundation model is a type of deep learning model that is pre-trained on a large dataset, enabling it to serve as a versatile base for being fine-tuned to various downstream tasks or other datasets. This study illustrates the utility of data gathered from the CMS experiment at the Large Hadron Collider in pre-training foundation models for High Energy Physics (HEP). We present the AspenOpenJets dataset, which comprises approximately 180 million high-p_T jets extracted from the CMS 2016 Open Data. Our findings include new studies conducted with the OmniJet-α foundation model, highlighting how pre-training on AspenOpenJets enhances performance on generative tasks that involve significant domain shifts, such as generating boosted top and QCD jets from the simulated JetClass dataset. Beyond showcasing the effectiveness of pre-training a jet-based foundation model using actual proton-proton collision data, we also offer the ML-ready AspenOpenJets dataset for public access and further research.

T 33.3 Tue 16:45 VG 2.101

LHCb's neural network-based beauty trigger: Insights from Run 3 — •Nicole Schulte[1], Johannes Albrecht[1], Gregory Max Ciezarek[2], Blaise Delaney[3], and Niklas Nolte[4] — [1]TU Dortmund University, Dortmund, Germany — [2]CERN, Geneva, Switzerland — [3]Massachusetts Institute of Technology, Cambridge, USA — [4]META AI (FAIR)

The quality of the LHCb beauty physics programme relies upon b-hadron selection algorithms, particularly topological b-hadron triggers. These triggers are optimized to identify b-hadron candidates by exploiting the distinctive decay topologies of b-hadrons and their characteristic kinematic properties. As the dominant contributor to the trigger selection bandwidth, topological triggers are essential for enabling a wide range of physics analyses at LHCb.

In Run 3, LHCb introduced a novel inclusive beauty trigger which incorporates Lipschitz monotonic neural networks to enhance robustness against fluctuating detector conditions and improve sensitivity to long-lived particle candidates.

This contribution presents the performance of the inclusive topological beauty trigger across diverse conditions during the 2024 data-taking period. We demonstrate the effectiveness of these topological triggers in maintaining stable performance under varying conditions and discuss the selection efficiency using well-understood decay modes. Additionally, we examine the advantages provided by the monotonicity constraints in the trigger design.

T 33.4 Tue 17:00 VG 2.101

Domain adaptation in the context of flavour tagging at the LHCb experiment — Johannes Albrecht[1,2], Mirko Bunse[2], and •Quentin Führing[1,2] — [1]TU Dortmund University, Dortmund, Germany — [2]Lamarr Institute for Machine Learning and Artificial Intelligence, Dortmund, Germany

Decay-time-dependent measurements of oscillating neutral B mesons at LHCb require information of the B-meson flavour at the time of its production. This information cannot be inferred from the decay products used for the reconstruction of signal candidates. Instead, multivariate algorithms are used to estimate the production flavour of B mesons, which exploit a variety of particles produced in association with the signal in the proton-proton interaction.

Simulation is often used to provide a labelled data sample for the training of these algorithms. However, known differences between simulation and recorded data are present, particularly in quantities significantly impacting the flavour tagging performance, such as the track multiplicity in fragmentation processes. As a consequence, the algorithms do not reach the same level of performance in data as in simulation.

We approach this mismatch between data and simulation with machine-learning techniques from the realm of domain adaptation. These methods prevent the multivariate algorithms from learning an implicit and undesired distinction between data and simulations. As a result, we expect improved performance on data. In this presentation, the idea and the status of the ongoing project is presented.

T 33.5 Tue 17:15 VG 2.101

Adversarial Studies on Jet-Flavor Tagging Machine Learning Algorithms using PAIReD Jets within the CMS Experiment — Alexander Jung[1], Spandan Mondal[2], Alexander Schmidt[1], Jan Schulz[1], and •Ulrich Willemsen[1] — [1]III. Physikalisches Institut A, RWTH Aachen — [2]Brown University

The PAIReD tagger is a novel jet flavor tagging algorithm in CMS that employs unconventional large-radius jets to identify Higgs boson decays to pairs of heavy-flavor quarks. In this talk, the vulnerability of machine learning-based jet flavor taggers to adversarial attacks is investigated, with a focus on the ParticleTransformer architecture used in the PAIReD tagger. It is shown that this architecture is more susceptible to adversarial perturbations than other established models. To mitigate this vulnerability, adversarial training is applied, incorporating adversarial examples into the training process. It is demonstrated that adversarial training enhances the robustness of the PAIReD tagger, recovering almost the nominal performance on both undisturbed and attacked inputs. These findings provide valuable insights into the behavior of the PAIReD tagger and the ParticleTransformer architecture for future applications in the CMS experiment.

T 33.6 Tue 17:30 VG 2.101

Gravity Gradient Noise Mitigation using Deep Learning at the Einstein Telescope — Markus Bachlechner[1], David Bertram[1], Johannes Erdmann[2], •Jan Kelleter[2], Patrick Schillings[2], and Achim Stahl[1] — [1]III. Physikalisches Institut B, RWTH Aachen — [2]III. Physikalisches Institut A, RWTH Aachen

The Einstein Telescope is a proposed gravitational wave detector of the third generation. It aims to improve sensitivity by at least an order of magnitude compared to current detectors. The dominant noise source in the region of 1 to 10 Hz is expected to be gravity gradient noise (GGN) from seismic activity in the surrounding rock. In order to reach the desired sensitivity, GGN must be actively mitigated. Seismometers will be installed in boreholes around the mirrors to measure the seismic activity. The current gold standard to predict the mirror response from seismometer measurements is the application of linear filters. In this talk, we present an approach to using neural networks in order to predict the mirror response to GGN from simulated seismometer measurements.

T 34: Data, AI, Computing, Electronics IV (DAQ, Detector Electronics)

Time: Tuesday 16:15–18:15 Location: VG 2.102

T 34.1 Tue 16:15 VG 2.102

FPGA-Based Solution Beyond High-Speed ADCs for Particle Detectors — •Dmitry Eliseev, Erik Ehlert, Carsten Presser, Markus Merschmeyer, Alexander Schmidt, and Thomas Hebbeker — III. Physikalisches Institut A, RWTH Aachen University

Modern particle detector electronics often handle a big number of channels. Field Programmable Gate Arrays (FPGAs) often serve as the core engine of multi-channel acquisition systems. However, the standard approach for acquiring energy or amplitude information for specific events often relies on high-speed multi-channel ADCs. Using such ADCs can increase complexity and raise the cost of signal acquisition electronics. The Multi-Voltage-Thresholding (MVT) method utilizes the internal digital comparators of FPGAs, partially replacing the functionality of ADCs with FPGA-internal resources. This approach enables a fast multi-channel acquisition, which is solely FPGA-based. By eliminating the need for external high-speed multi-channel ADCs, the resulting schematics are simplified, and the cost of the detector electronics is reduced.

This talk explains the MVT methodology and demonstrates its practical application using a 16x16 pixel muon detector with 64 Silicon Photo-Multipliers (SiPMs). The developed system is based on commercially available modules with System-on-Chip (Zynq MPSoC). With compact additional circuitry and developed soft- and firmware, the system features up to 16 high-speed ADC channels, each sampling at 1 GSPS and delivering the sampled data directly to module's RAM.

T 34.2 Tue 16:30 VG 2.102

The ATLAS Tile Calorimeter Trigger and Data Acquisition Interface — •Thomas Junkermann and Tigran Mkrtchyan — Kirchhoff-Institut für Physik Heidelberg

The Phase-II Upgrade of the ATLAS Tile Calorimeter (TileCal) is a replacement of the entire on- and off-detector electronics to cope with the higher amount of simultaneous proton-proton collisions of future LHC runs. New back-end electronics are designed to provide high-bandwidth data to the new Phase-II Trigger and Data Acquisition (TDAQ) system. The Tile Calorimeter Trigger and Data Acquisition Interface (TDAQi) is an ATCA rear transition module and as part of the new TileCal PreProcessor serves as the connection between the off-detector calorimeter electronics and the TDAQ system of ATLAS. After the calorimeter cell signals are received and energies reconstructed by the Compact Processor Modules, the TDAQi prepares the data for further use. Cell energies are converted to transverse energy, cells are sorted or added to larger sums for the trigger and various threshold comparisons for muon candidate identification are provided. Additionally, the TDAQi forwards these intermediate results to the DAQ system for monitoring. The TDAQi as part of the ATLAS Phase-II upgrade will be presented. Together with latest hardware validation and integration tests, the general TDAQi status is featured.

T 34.3 Tue 16:45 VG 2.102

Towards Data Transfer and Monitoring Interfaces for the future Signal Processor of the ATLAS Liquid Argon Calorimeters — •Markus Helbig, Rainer Hentges, Arno Straessner, Johann Christoph Voigt, and Philipp Welle — Institut für Kern- und Teilchenphysik, TU Dresden

During the Phase-II Upgrade of the ATLAS Liquid Argon Calorimeter System, the new LAr Signal Processor (LASP) system will be installed. With the HL-LHC starting operation in 2030, this off-detector processing system will enable the use of novel, more powerful algorithms for energy reconstruction implemented on Intel Agilex 7 FPGAs.

Beside the main readout path, the LASP will provide fine granular and pre-summed energies and energy threshold values to two new ATLAS trigger systems – the Global Event Processor (GEP) and the Forward Feature Extractor (fFEX). For both interfaces, the preferred protocol candidate is the Interlaken-based *core1990*, operating at a speed of 25.78125 Gbps. Its functionality and properties are currently being verified on the Agilex 7 FPGA.

Additionally, the LASP firmware will also contain several registers for control and monitoring purposes. The implementation is based on the *IPbus* protocol embedded in a custom framework. The physical connections are realized using a Gigabit Ethernet interface.

The presentation will summarize the challenges, recent progress and results of the LASP interface projects.

T 34.4 Tue 17:00 VG 2.102

Firmware development for temperature monitoring of electro-optical transceivers for the ATLAS Liquid Argon Signal Processor system — •Peter Maximilian Fischer, Markus Helbig, Rainer Hentges, and Arno Straessner — Institut für Kern- und Teilchenphysik, TU Dresden

As part of the Phase-II upgrade of the ATLAS detector, its Liquid Argon (LAr) calorimeters will be equipped with a new Signal Processor (LASP) system following the high luminosity upgrades to the LHC. The data transfer coming from the Front End Board (FEB2) to the

LASP and going from the LASP to the ATLAS trigger system will be handled by electro-optical transceivers of type SAMTEC Firefly, which will have to be monitored with regards to their temperature by an FPGA. For this purpose, an I^2C master has been interfaced in VHDL. A simulation in QuestaSim as well as hardware testing with a Stratix-10 FPGA on a Firefly test card and a LASP testboard were performed in order to verify the desired behaviour, with a test on an Agilex-7 based LASP testboard pending. The results and conclusions from these tests will be presented, as well as an outlook towards the implementation of a Serial Peripheral Interface (SPI) for the communication between the Agilex-7 and MAX-10 FPGAs.

T 34.5 Tue 17:15 VG 2.102

DAQ software for QC-tests of ATLAS ITk-Pixel loaded local supports — Jörn Grosse-Knetter, •Paolo Malatesta, Arnulf Quadt, and Ali Skaf — II. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The increase of luminosity at the ATLAS Large Hadron Collider (LHC), previewed in the phase 2 upgrade, will require an update of the ATLAS inner detector. A new all-silicon Inner Tracker (ITk) will be deployed resulting in an increased data rate. The 5 billion pixels comprise over 9,000 Quad Modules (QMs), which are managed by the DAQ system via FELIX hardware/software. In the ITk outer barrel, QMs send 1.28 Gb/s electrical signals to the Optoboard for conversion to optical signals, which are then transmitted off-detector to FELIX PCs and the DAQ software. The reverse path is used for QM Front-End (FE) configuration and control. To validate the DAQ system's readiness for the upgrade, a lab setup reproducing the FELIX/optoboard readout chain was tested with preproduction QMs using serial powering. Simultaneous readout enabled analysis of system behaviour under load, identifying key parameters for signal quality and reliability. DAQ performance, including configuration time, was measured as a function of enabled FEs, providing insights crucial for scaling the DAQ chain to large systems like the local supports loaded with few 10 modules and the full ITk-pixel DAQ.

T 34.6 Tue 17:30 VG 2.102

ATLAS ITk-Pixel read-out stress tests — •Matthias Drescher, Jörn Grosse-Knetter, Arnulf Quadt, and Ali Skaf — II. Physikalisches Institut, Georg-August-Universität Göttingen

The current ATLAS Inner Detector will be upgraded to an all-silicon Inner Tracker (ITk) for the Phase 2 upgrade of the experiment. The ATLAS ITk readout system is based on the FELIX hardware/software used to interface the on-detector components from the higher-level DAQ infrastructure. One FELIX card has 24 optical fibre links, which are fanned out to multiple Pixel modules by the lpGBT aggregator chip. To ensure stable operation under full load before moving to the final large-scale readout system, a stress test is being prepared populating all 24 FELIX fibres.

The data generation for the stress test takes place on several AMD FPGA boards, each containing multiple instances of lpGBT and front-end chip emulators. For this project, multiple front-end emulator flavours are developed to generate data streams according to the ITkPix production chip or the RD53A prototype chip data format. The front-end emulators use a hybrid design, where the test data is partially encoded off-FPGA and then stored in the FPGA's memory, to be fully encoded by the FPGA logic. As such, the project consists of both the FPGA design and the external software written in Python, which prepares the test data and automates the tests. Tests have been performed with both types of emulator flavours.

T 34.7 Tue 17:45 VG 2.102

Integration of SiPM-on-Tile Detectors with the Serenity Phase-2 DAQ Hardware for the CMS High Granularity Calorimeter — •Fabian Hummer[1], Luis Ardila-Perez[1], Matthias Balzer[1], Marvin Fuchs[1], Olivier Jacquemoth[1], Matthias Komm[2], Hendrik Krause[1], Katja Krüger[2], Jia-Hao Li[2], Torben Mehner[1], Mathias Reinecke[2], Frank Simon[1], Felix Sefkow[2], and Raghunandan Shukla[3] — [1]Institute for Data Processing and Electronics, Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany — [3]Department of Physics, Imperial College London, Exhibition Road, London, SW7 2BW, United Kingdom

For the upcoming high-luminosity LHC, the endcap calorimeters of the CMS experiment will be replaced by the high-granularity calorimeter (HGCAL), a sampling calorimeter using both silicon and scintillator as active materials in different regions depending on the radiation dose. This contribution describes the integration details of the scintillator-based front-end into the DAQ readout chain of HGCAL utilizing a Serenity FPGA card. Initial results from a beam test at CERN showcase stable operation of the SiPM-on-tile front-end in a 3 T magnetic field, synchronization of multiple tile modules, as well as a good understanding of the relation between trigger and DAQ data with properly calibrated modules.

T 34.8 Tue 18:00 VG 2.102

Development of a standalone drift-tube-based muon trigger for the ATLAS and CRESST experiments — D Cieri, •S Eder, O Kortner, S Kortner, A Langenkämper, M Mancuso, and F Petricca — Max Planck Institut für Physik, Garching, Germany

To operate the ATLAS experiment in the high-rate environment of the High-Luminosity Large Hadron Collider (HL-LHC), significantly improved selectivity of the first-level muon trigger is required. To achieve this, novel FPGA-based Monitored Drift Tube (MDT) trigger processor boards have been developed. These boards incorporate muon tracking information from precision MDT chambers into the first-level trigger processing chain for the first time. The new MDT chamber read-out and trigger processors must be commissioned using cosmic ray muons, necessitating the development of a dedicated muon track-finding algorithm that utilizes only information from drift-tube detectors.

This algorithm could potentially also be used to build a muon veto trigger for the CRESST experiment at Gran Sasso. The proposed experimental setup involves placing several spare MDT chambers from the ATLAS experiment around the cryogenic crystals of the CRESST detector. Events with cosmic muon tracks can then be vetoed if the signal in the crystals matches the signal from the MDT chambers, significantly reducing the experiment's output bandwidth.

In this talk, a dedicated standalone drift-tube-based muon trigger algorithm will be presented, along with its implementation in the FPGA firmware.

T 35: Electroweak Physics I (Weak Mixing Angle, Tau Production)

Time: Tuesday 16:15–17:45 Location: VG 2.103

T 35.1 Tue 16:15 VG 2.103

How to Extract the Weak Mixing Angle using Full Run2 ATLAS Experiment Data — •Lukas Bayer[1], Wells Craig[2], and Ludovica Aperio Bella[3] — [1]DESY, Hamburg, Germany — [2]DESY, Hamburg, Germany — [3]DESY, Hamburg, Germany

The full Run 2 data set from the ATLAS experiment provides sufficient statistics to measure the Drell-Yan cross-section four-fold differential in invariant mass, Z-boson rapidity and decay angles. It can be determined in the full solid angle by making use of an analytical decomposition of the final-state lepton's angular distribution. This does not only allow to probe the underlying quantum chromodynamics of Z-boson production, but also to extract the electroweak sector weak mixing angle from the forward-backward asymmetry, induced by parity violation in the neutral weak current. Sensitivity to the forward-background asymmetry is enhanced in events featuring one lepton in the forward part of the detector and correspondingly high Z-boson rapidity. Therefore, this talk will showcase recent work on forward electron performance at ATLAS, with focus on the determination of identification efficiency. Furthermore, it will present projections of the resulting sensitivity to the weak mixing angle.

T 35.2 Tue 16:30 VG 2.103

The weak mixing angle at the Belle II experiment — •Lukas Grussbach[1,2], Stephan Paul[1], and Daniel Greenwald[1] — [1]Technical University Munich — [2]Max Planck Institute for Physics

The weak mixing angle is known precisely only at high energies around the Z^0 mass. At much lower energies, NuTeV measured a value de-

viating from the standard-model prediction. At Belle II, we want to measure the weak mixing angle at a similar energy using the process $e^+e^- \to \mu^+\mu^-$.
I present concepts of such a measurement at Belle II.
*Funded by the DFG under Germany's Excellence Strategy - EXC2094 - 390783311 and BMBF Verbundforschung (05H21WOKBA BELLE2).

T 35.3 Tue 16:45 VG 2.103

Determination of the tau polarization in fully leptonic $Z \to \tau^+\tau^-$ decays from pp collisions at the ATLAS detector — •Florian Harz, Adrián Álvarez Fernández, and Stefan Tapprogge — Institut für Physik, Johannes Gutenberg-Universität, Mainz, Germany

The Z boson arises from the unification of the electromagnetism and weak forces, coupling differently to left- and right-handed particles as indicated by the effective weak mixing angle. Precisely measuring the tau polarization in $Z \to \tau^+\tau^-$ decays provides a mean to extract the weak mixing angle. The study considers the fully leptonic final state of the $Z \to \tau^+\tau^-$ decay channel and assesses its sensitivity to the tau polarization. This is accomplished by fitting templates to the visible mass derived from decays of purely left-handed or right-handed taus. This method can be verified using simulated samples. The status of these studies is presented, highlighting their potential application to real data, particularly focusing on proton-proton data collected at the ATLAS detector.

T 35.4 Tue 17:00 VG 2.103

Prospects of measuring quantum entanglement in $\tau\tau$ final states at the LHC and future colliders — •Cedric Breuning, Philip Bechtle, Klaus Desch, and Christian Grefe — Physikalisches Institut, Rheinische Friedrich-Wilhelms Universität Bonn, Nussallee 12, 53115 Bonn, Germany

We introduce a method to test quantum entanglement at colliders in the $\tau\tau$ final state. The prospects to perform these measurements in e^+e^- collisions at future colliders like the FCC-ee are evaluated using simulated events with a fast detector simulation. We will present two dedicated analyses using either $Z \to \tau\tau$ or $H \to \tau\tau$ at e^+e^- at centre of mass energies of $\sqrt{s} = 91.2\,\text{GeV}$ and $\sqrt{s} = 240\,\text{GeV}$, respectively. Prospects and limitations of doing similar measurements at the LHC will be shown. Finally, we will discuss loopholes and collider specific problematics, which influence the interpretation of the result.

T 35.5 Tue 17:15 VG 2.103

Theoretical predictions for tau-pair production in ultraperipheral hadron collisions — Stefan Dittmaier, Tim Engel, •Jose Luis Hernando Ariza, and Mathieu Pellen — University of Freiburg

The anomalous magnetic moments of the electron and the muon have been measured with remarkable precision. On the other hand, there is no precise measurement for the magnetic moment of the tau-lepton. A promising approach is to measure it via the tau-pair production in ultraperipheral collisions of lead ions at the LHC. In this talk, I will present state-of-the-art theoretical predictions for photonic tau-pair production including leptonic tau-decays. In particular, the impact of spin correlations between the tau-leptons and next-to-leading-order electroweak corrections will be discussed.

T 35.6 Tue 17:30 VG 2.103

Differential measurements of $\gamma\gamma \to \tau\tau$ and constraints on τ-lepton electromagnetic moments in ultra-peripheral Pb+Pb collisions with ATLAS — •Weronika Stanek-Maslouska — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

At the Large Hadron Collider (LHC), relativistic heavy-ion collisions produce a significant flux of equivalent photons, enabling photon-induced interactions. By studying the production of tau lepton pairs in these processes, constraints can be placed on the anomalous magnetic dipole moment (g-2) and electric dipole moment (EDM) of the tau lepton. Building on the observation of this process with ATLAS, which analyzed muonic decays of tau leptons in conjunction with electrons and particle tracks, we perform first unfolded differential cross section measurements. Additionally, new measurements of the tau lepton electromagnetic moments are performed. These results represent a substantial advancement in measuring photon-induced tau lepton pairs and probing the electromagnetic properties of the tau lepton using heavy-ion collisions.

T 36: Methods in Astroparticle Physics II

Time: Tuesday 16:15–17:45 Location: VG 3.101

T 36.1 Tue 16:15 VG 3.101

Characterisation of a SiPM Array in Liquid Xenon — •Vera H. S. Wu[1], Kaixuan Ni[2], Jianyang Qi[2], Haiwen Xu[2], and Yue Ma[2] — [1]Karlsruhe Institute of Technology, Institute for Astroparticle Physics — [2]University of California San Diego

Silicon-photomultipliers (SiPMs) have grown in attention and application among direct dark matter search and neutrino physics experiments due to some advantages compared to the traditional photomultipliers (PMTs). Using the liquid xenon detector R&D setup at the University of California San Diego, we installed 96 Hamamatsu VUV4 SiPMs surrounding a sensitive volume of about one litre, intending to detect sub-keV recoils in liquid xenon for the NUXE experiment. The number of the VUV4 SiPMs used is unprecedented for low-energy liquid xenon experiments. For a few months, we monitored the readout noise level and the gain of individual SiPM in either gaseous or liquid xenon. The gain-to-overvoltage ratio has been stable within months of measurement. We also tested the light collection efficiency (LCE) of the device in liquid xenon, as will be reported in this talk.

We acknowledge the financial support from Karlsruhe House of Young Scientists through a Research Travel Grant to visit and work at UCSD.

T 36.2 Tue 16:30 VG 3.101

Construction and commissioning of a Novel Krypton Concentrator for Next-Generation Dark Matter Experiments — •David Koke, Lutz Althüser, Volker Hannen, Christian Huhmann, Philipp Schulte, Patrick Alexander Unkhoff, Daniel Wenz, and Christian Weinheimer — Universität Münster, Germany

Future large scale dark matter experiments, such as DARWIN and XLZD, require high radiopurity in their liquid xenon detectors to probe WIMPs down to the neutrino fog. Due to the presence of the radioactive man-made isotope Kr-85, maintaining a low krypton concentration is a critical requirement. The LowRad project aims at developing a compact all-in-one xenon purification system for krypton, radon and electronegative impurities in xenon. The system's key components include a distillation column for continuous online removal, requiring a secondary distillation column as a concentrator for the krypton-enriched off-gas to avoid losses of xenon and enable monitoring of the krypton concentration. This novel krypton concentrator has been successfully constructed and commissioned, and underwent initial functionality tests. This talk will present the design and construction of the concentrator, along with the results of the first performance tests, demonstrating its capabilities. These advancements pave the way for achieving the ultra-low backgrounds necessary for future dark matter searches with next generation experiments. This work is supported by the ERC AdG project "LowRad" of C. Weinheimer (No. 101055063).

T 36.3 Tue 16:45 VG 3.101

Local coincidences in the Multi-PMT Digital Optical Module for IceCube Upgrade — •Anna-Sophia Tenbruck and Alexander Kappes for the IceCube-Collaboration — Universität Münster, Institut für Kernphysik

The IceCube Neutrino Observatory will undergo an upgrade during the Antarctic summer of 2025/26 that will significantly improve its sensitivity. Among the newly introduced components is the Multi-PMT Digital Optical Module (mDOM), a detector module equipped with multiple photomultipliers (PMTs) that enables the detection of local coincidences. This capability is particularly useful for applications such as noise suppression. In a comprehensive study conducted as part of a master's thesis, the multiplicity rate of an mDOM was measured in both air and water and compared to a Geant4 toolkit simulation. This presentation will discuss the results, focusing on the comparison between measurements and simulations.

T 36.4 Tue 17:00 VG 3.101

Determination of scintillation properties using alpha spectroscopy for IceCube's optical module — •Ines Bahloul and Alexander Kappes for the IceCube-Collaboration — Universität Münster, Institut für Kernphysik

The main optical background in IceCube's Digital Optical Modules (DOMs) arises from scintillation caused by trace amounts of radioactive isotopes in the glass of the pressure vessel. The current simulation of this background relies, among other factors, on a gamma spectroscopy measurement of the glass. However, this measurement cannot directly quantify radon and radium content. As part of my master's thesis, I aim to enhance this simulation by measuring these quantities with an alpha spectrometer. In this talk, experimental setup, calibration process, and the current progress of this study will be presented.

T 36.5 Tue 17:15 VG 3.101

Broadband Lightning Interferometry at the Pierre Auger Observatory — Markus Cristinziani[1], •Eric-Teunis de Boone[1], Qader Dorosti[1], Stefan Heidbrink[2], Noah Siegemund[1], Waldemar Stroh[2], Jens Winter[2], and Michael Ziolkowski[2] — [1]Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Elektronikentwicklungslabor der Physik, Universität Siegen

Lightning-related phenomena are known to interact with and influence all detector systems of the Pierre Auger Observatory in Argentina. Notably, the Surface Detector has recorded signals linked to Terrestrial Gamma Flashes (TGFs) which are rare phenomena linked to the initial processes of lightning. Interpreting these signals remains challenging due to the absence of a system capable of providing detailed 3D imaging of lightning propagation. To address this gap, we are developing a state-of-the-art interferometric lightning detection system that enhances the Observatory's unique capabilities for precision research on TGFs. It will consist of radio detectors that have been previously developed for the Auger Engineering Radio Array (AERA), located at strategic positions within the Auger field. This contribution highlights recent hardware developments and the initial large-scale data readouts from the first field installation, demonstrating the system's potential for advancing TGF and lightning research.

T 36.6 Tue 17:30 VG 3.101

Absolute energy calibration of the Fluorescence Telescopes at the Pierre Auger Observatory with a roving laser system* — •Rukije Uzeiroska-Geyik for the Pierre-Auger-Collaboration — ergische Universität Wuppertal, Wuppertal, Germany

The Fluorescence Detector (FD) of the Pierre Auger Observatory provides energy measurements of primary cosmic rays that are largely independent of specific interaction models. The FD energy measurement is crucial for calibrating the energy reconstruction of the Surface Detector. Consequently, the accuracy of the FD energy calibration plays a significant role in the systematic uncertainties associated with nearly all scientific results of the Observatory. To achieve high accuracy in calibration, a laser with a well-defined energy output is going to be fired in front of the FD telescopes. This method has the advantage that the response of the telescope to the laser closely simulates its reaction to an actual cosmic ray air shower, something that is not achievable with other calibration methods.

The system was designed with special attention given to the depolarization of the laser beam to ensure a consistent relationship between energy output and directional light yield. This contribution covers the ongoing development of the mobile laser system and the calibration measurements performed in the laboratory to ensure the highest precision of the in field measurements.

**Supported by BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A23PX1)*

T 37: Cosmic Rays II

Time: Tuesday 16:15–17:45 Location: VG 3.102

T 37.1 Tue 16:15 VG 3.102

Measuring the Cosmic Ray Sun Shadow with IceCube* — •Niclas Krieger[1,2], Jonas Hellrung[1,2], Lukas Merten[1,2], Julia Becker Tjus[1,2,3], and Paolo Desiati[4] for the IceCube-Collaboration — [1]Ruhr-Universität Bochum, Fakultät für Physik und Astronomie, Institut für Theoretische Physik IV, Universitätsstraße 150, 44780 Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Bochum, Germany — [3]Chalmers University of Technology, Department of Space, Earth and Environment, 412 96 Gothenburg, Sweden — [4]Department of Physics and Wisconsin IceCube Particle Astrophysics Center, University of Wisconsin-Madison, Madison, Wisconsin 53706, USA

With the IceCube Neutrino Observatory atmospheric muons are detected that are produced when cosmic rays interact with the Earth's atmosphere. On their way to Earth, cosmic rays are blocked by the Sun and the Moon. While the Moon shadow serves as an absolute pointing calibration, the Sun shadow enables an indirect observation of the Solar magnetic field since this deflects cosmic rays on their way and thus leaves its footprint in the temporal variation of the cosmic-ray shadow with the 11-year solar cycle. In this talk the methods of measuring the shadows of these celestial objects will be reviewed. Furthermore, it will be shown how these observations help to understand the Solar magnetic field better.

*Supported by DFG (SFB 1491) and BMBF

T 37.2 Tue 16:30 VG 3.102

Towards a Directional Search for Ultra-High-Energy Photons Using the Surface Detector of the Pierre Auger Observatory — •Tim Fehler, Marcus Niechciol, and Markus Risse for the Pierre-Auger-Collaboration — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

In addition to its capabilities for precise measurement of ultra-high-energy (UHE, $E \gtrsim 10^{17}$ eV) cosmic rays through the observation of extensive air showers, the Pierre Auger Observatory also offers the potential to effectively detect UHE photons. Their connection to UHE cosmic rays is manifold; constraints on their flux provide valuable hints on the elusive nature of the UHE cosmic rays. Contrary to charged cosmic rays, which are deflected by magnetic fields, UHE photons carry the inherent advantage that their origin can be traced back directly, which promotes the search for directional excesses of photon-like events in the sky. This contribution details the developments for a new direction-dependent search for UHE photons, based on the paradigm of air-shower universality. With this approach, data from the Surface Detector (SD) array of the Pierre Auger Observatory can be used to reconstruct key quantities such as the primary energy and the atmospheric depth of the shower maximum $X_{\max}$, which are essential for primary particle classification, with significantly improved precision. Furthermore, with sole dependence on the SD, one is able to take advantage of its $\sim 100\%$ duty cycle.

Supported by the BMBF Verbundforschung Astroteilchenphysik under project No. 05A23PS1.

T 37.3 Tue 16:45 VG 3.102

Inferring the Ultra-High-Energy Cosmic Ray Flux Prior to Deflections in the Galactic Magnetic Field Using Information Field Theory — Martin Erdmann, •Frederik Krieger, Josina Schulte, Michael Smolka, and Maximilian Straub — III. Physikalisches Institut A, RWTH Aachen University

Ultra-high-energy cosmic rays (UHECRs) are assumed to be charged nuclei with energies exceeding 10^{18} eV, whose origins and acceleration mechanisms are still not discovered. Upon entering the Earth's atmosphere, UHECRs interact with air molecules, initiating extensive particle showers that can be observed by cosmic ray observatories. However, as UHECRs traverse the Galactic magnetic field (GMF), they are deflected, changing their trajectories and causing the measured arrival directions to no longer point back to their sources. To address this challenge, we present a novel approach combining forward modeling and information field theory to reconstruct the UHECR flux before deflection in the GMF. We apply this method to an astrophysical model, demonstrating its potential to improve the estimation of the UHECR source distribution.

T 37.4 Tue 17:00 VG 3.102

A novel approach for air shower profile reconstruction using radio measurements with Information Field Theory — •Keito Watanabe[1], Tim Huege[1,2], Mitja Desmet[2], Stijn Buitnik[2], and Torsten Ensslin[3,4] for the LOFAR-Cosmic ray key science project-Collaboration — [1]Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany — [2]Vrije Universiteit Brussel, Astrophysical Institute, Brussels, Belgium — [3]Max Planck Institute for Astrophysics, Garching, Germany — [4]Ludwig-Maximilians-Universität, Munich, Germany

Reconstructing the profile of extensive air showers, generated from the interaction of cosmic rays in the Earth's atmosphere, is crucial to understanding their mass composition, which in turn provides valuable insight on their possible source of origin. However, current frameworks can only recover shower parameters that provide limited information on the composition and relies on computationally expensive simulations. In this work, we develop a novel framework to reconstruct the longitudinal profile of air showers using measurements from radio detectors with Information Field Theory, a state-of-the-art reconstruction framework based on Bayesian inference. We utilise prior knowledge about the physical process of radio emission to generate a fast-forward model based on template synthesis and incorporate realistic response and noise models to produce voltage traces at each antenna. We apply our framework with simulated datasets based on the LOFAR detector layout and analyse the reconstruction efficiency to highlight the performance of our framework.

T 37.5 Tue 17:15 VG 3.102

Identifying Ultra-High-Energy Photons with a Convolutional Neural Network on the Basis of Surface Detector Measurements at the Pierre Auger Observatory — •Tim Fehler, Eleonora Guido, Marcus Niechciol, Markus Risse, and Daniel Steiniger for the Pierre-Auger-Collaboration — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Towards ultra-high energies (UHE, $E \gtrsim 10^{17}$ eV), the expected flux of cosmic photons becomes so small that only the indirect detection via extensive air showers remains feasible. The quest to identify ultra-high-energy photons then fundamentally boils down to a classification problem, in which photon-induced air showers must be distinguished from the vast background of hadron-induced showers, utilizing only the limited data provided by detector sampling on an individual event basis. This work explores the application of a convolutional neural network (CNN) to this task, considering the full temporal evolution of the signal in surface-detector stations of the Pierre Auger Observatory as input. We show that with this approach, high levels of accuracy in classifying simulated shower events can be reached, providing a promising tool for future searches for UHE photons.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 945422. It is also partially supported by BMBF Verbundforschung Astroteilchenphysik under project No. 05A23PS1.

T 37.6 Tue 17:30 VG 3.102

Investigating the Expected Flux of GZK Photons — •Chiara Papior, Marcus Niechciol, and Markus Risse — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

It is expected that charged cosmic rays produce ultra-high-energy (UHE, here beyond 10 PeV) photons during their propagation over extragalactic distances via photo-pion production with the cosmic microwave background. This effect is also known as the Greisen-Zatsepin-Kuzmin (GZK) effect and the photons produced via this interaction are termed GZK photons. The flux of GZK photons depends on the parameters of the emitted cosmic-ray spectrum such as the spectral index or a potential cutoff, as well as other parameters depending on the sources, including their distances, and the composition of the cosmic rays themselves. Simulations based on different input parameters have been performed, and the expected GZK photon flux will be presented. The goal is to update the allowed range of the expected GZK photon flux based on current measurements of cosmic-ray observatories at ultra-high-energy.

This work is supported by the German Research Foundation (DFG, Project No. 508269468).

T 38: Neutrino Physics III

Time: Tuesday 16:15–18:00 Location: VG 3.103

T 38.1 Tue 16:15 VG 3.103

ESS Neutrino Super Beam Plus (ESSνSB+) Target Test Facility(ETTF) - R&D Setup — •Rishabh Moolya and Tamer Tolba — Institut für Experimentalphysik, Universität Hamburg

The ESSνSB+ Target Station will consist of a target-horn system operating under an intense 1.25 MW proton beam power, derived from the nominal 5 MW proton beam with a 14 Hz frequency provided by the European Spallation Source (ESS) Linac. An ESSνSB+ Target Test Facility (ETTF) is planned to be located at the Mechanical Measurements Lab (MML) in ESS, building upon the successful ESS Target Helium Experiments at LTH (ETHEL).

The ESSνSB+ target features a packed bed of titanium (Ti) spheres cooled with pressurized helium gas to withstand the substantial power deposition expected in the target bulk. Due to the granular structure of the target bulk, numerical CFD modeling of the thermodynamic behavior of the cooling system and target pellets is highly complex and necessitates experimental validation. The primary objective of this R&D setup is to address the challenges in simulating the mechanical and thermodynamic behavior of the target cooling system.

The proposed setup will include: a booster compressor, an electric heater, a test vessel, and a cooling heat exchanger with water on the secondary side. Current status of the commissioning of the prototype target system and the results of the aforementioned studies will be presented.

T 38.2 Tue 16:30 VG 3.103

Neutrino oscillations parameters estimation with NOvA and T2K public data — •Sofia Lonardi — Ludwig-Maximilians-Universität (LMU), Theresienstraße 37, 80333 Munich, Germany — Technical University Munich (TUM), James-Franck-Strasse 1, 85748 Garching, Germany

Neutrino flavour oscillations are a promising open window into physics beyond the standard model. Numerous experiments provide a way to estimate the angles of the mixing matrix and the mass differences. Most parameters have been determined with increasing precision and agreement between different experiments, nevertheless, some questions still need to be addressed regarding the mixing angle Θ_{23} and the CP phase δ_{CP} dependence on the neutrino mass ordering. Notably, T2K and NOvA experiments show contrasting tendencies depending on the measurement channel. This study focuses on NOvA and T2K: new independent analyses are performed using publicly accessible data, and the official results are reproduced to demonstrate their validity. The parameters are estimated through likelihood maximization, and agreements and tensions between the two datasets are evaluated in a joint fit. This talk will explain the individual data analysis chains and the global fitting setup, discussing the obtained results in the broader context of the global neutrino oscillations landscape.

T 38.3 Tue 16:45 VG 3.103

Detection of neutrons produced in neutrino-nucleus interactions — •Asit Srivastava — Johannes Gutenberg - Universität Mainz

T2K is a long-baseline experiment which measures parameters of neutrino oscillations. This can be done by analysing the interaction of neutrinos closer to the point of beam production and 295 km downstream. The detector located near the source of beam production, called ND280, primarily includes the interactions of neutrinos with carbon nuclei. The particles produced as a result of the interactions deposit energy in ND280 which is used to characterise the incoming neutrino flux and neutrino cross-sections before oscillations occur.

Out of all the particles produced in typical neutrino interactions, neutrons are by far the most challenging to detect since they are electrically neutral and do not leave a visible track in the detector. As a result, they provide uncertainties in identifying the interactions happening in the detector and measuring cross-sections. ND280 has a newly installed Super Fine-Grained Detector (SFGD) made of plastic scintillator cubes. The upgraded detector capable of better position resolution and 3D reconstruction opens up the possibilities of improving the efficiency of neutron detection. Presence of a neutron is established using cuts on energy deposits and hence, possible neutron candidates, such as based on time of flight, kinetic energy of the candidate and the separation of energy deposit from the interaction vertex. This talk will go through neutron selection and how neutrons can help in understanding nuclear effects better.

T 38.4 Tue 17:00 VG 3.103

Exploring CEvNS with the NUCLEUS Experiment — •Raimund Strauss for the NUCLEUS-Collaboration — Technische Universität München, München, Deutschland

The NUCLEUS experiment aims to the first detection of coherent elastic neutrino nucleus scattering (CEvNS) at a nuclear reactor, exploiting an innovative detection system that consists of a 10g cryogenic detector setup made of CaWO4 and Al2O3 crystals. These target detectors are capable of reaching O(10 eV) energy thresholds, making it possible to measure nuclear recoils induced by CEvNS. The detectors will be surrounded by a twofold system of instrumented cryogenic vetoes, an external passive shielding and a muon veto to improve the identification and discrimination of backgrounds. NUCLEUS has recently demonstrated the successful operation of the neutrinos target detectors in coincidence with the other sub detectors of the experiment in the so called Long Background Run, performed in the shallow underground laboratory UGL located at TUM university in Munich. The experiment is now ready for the relocation to the Chooz-B nuclear power plant in the French Ardennes. This talk will provide an overview of the experiment's current status, focusing on the latest developments and milestones achieved.

T 38.5 Tue 17:15 VG 3.103

Exploring coherent elastic neutrino-nucleus scattering: status of the NUCLEUS experiment — •Chloé Goupy for the NUCLEUS-Collaboration — Max Planck Institute for Nuclear Physics (MPIK), Heidelberg, Germany

The first detection of coherent elastic neutrino nucleus scattering (CEvNS) at a nuclear reactor remains to be achieved, especially because the corresponding nuclear recoils lie in the O(100 eV) energy regime which is difficult to measure with conventional detection technologies, and also because of the unfavorable background conditions nuclear power plant environments generally offer.

To overcome these obstacles, the NUCLEUS experiment aims to develop an innovative detection system using cryogenic detectors made of CaWO4 and Al2O3 crystals capable of reaching O(10 eV) energy thresholds. These target detectors will be surrounded by a twofold system of instrumented cryogenic vetoes, an external passive shielding and a muon veto to improve the identification and discrimination of backgrounds.

At present, the experiment is under commissioning in the shallow underground laboratory at the Technical University of Munich (TUM), and the relocation to the Chooz-B nuclear power plant in the French Ardennes in underway. In this talk, I will provide an overview of the experiment's current status, focusing on the latest developments and milestones achieved.

T 38.6 Tue 17:30 VG 3.103

Investigation of rear wall candidates for keV sterile neutrino search at KATRIN — •Kerstin Trost, Dominic Batzler, James Braun, Robin Grössle, Philipp Haag, Elizabeth Paine, Marco Röllig, Marius Schaufelberger, Marie Schäfer, and Michael Sturm — KIT

The search for keV sterile neutrinos at the KArlsruhe TRItium Neutrino (KATRIN) experiment is set to start in 2026, measuring the full energy range of the tritium beta-decay spectrum. This novel approach introduces additional systematic uncertainties that must be addressed to ensure reliable results. A key challenge is mitigating the major systematics associated with electron backscattering and radioactive contamination of the rear wall. This talk introduces current concepts for rear wall optimization and discusses experimental efforts to validate these designs. Specifically, the (de)contamination behavior of potential rear wall materials such as beryllium and micro-structured silicon tested with the TRACE experiment is presented. This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6)

T 38.7 Tue 17:45 VG 3.103

Rear Wall concepts for keV sterile neutrino search at KATRIN — •Rudolf Sack for the KATRIN-Collaboration — Karlsruhe Institute of Technology - KIT

From 2026 on KATRIN will search for keV sterile Neutrinos with a differential electron energy measurement of the Tritium beta decay. The unwanted effects of the Rear Wall, such as electron backscattering, are thought to be the leading systematic effect. This talk will explain the requirements for new rear wall materials and design concepts. Further the talk will highlight our most promising concepts and present our performed characterization measurements.

T 39: Neutrino Physics IV

Time: Tuesday 16:15–17:45 Location: VG 3.104

T 39.1 Tue 16:15 VG 3.104

Insight into the Analysis of the KATRIN Neutrino Mass Data — Christoph Köhler[1,2], Susanne Mertens[1,2], •Jan Plössner[1,2], Richard Salomon[3], Alessandro Schwemmer[1,2], Jaroslav Štorek[4], Xaver Stribl[1,2], and Christoph Wiesinger[1,2] for the KATRIN-Collaboration — [1]Max Planck Institute for Nuclear Physics — [2]Technical University of Munich — [3]University of Münster — [4]Karlsruhe Institute of Technology

The KArlsruhe TRItium Neutrino (KATRIN) experiment probes the effective electron anti-neutrino mass by a precision measurement of the tritium beta-decay spectrum near the endpoint. A world-leading upper limit of $0.45\,\mathrm{eV\,c^{-2}}$ (90 % C.L.) has been set, including the data of the first five measurement campaigns, corresponding to approximately 15 % of the final statistics. Since then, the collected data has increased by a factor of five.

In this presentation, I will provide an update on the current status of the KATRIN neutrino mass analysis beyond the fifth measurement campaign and discuss the neural network approach utilized for this analysis.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2, and 05A23WO6).

T 39.2 Tue 16:30 VG 3.104

Unbinned analysis of ^{163}Ho-spectrum endpoint region — •Frederic Böhm — Kirchhoff Institute for Physics, Heidelberg University — ECHo Collaboration

The aim of the Electron Capture in ^{163}Ho (ECHo) collaboration is to determine the effective electron neutrino mass by analysing the endpoint region of the ^{163}Ho electron capture spectrum. The spectrum is measured using metallic magnetic calorimeters (MMC) enclosing ^{163}Ho and subsequently the data is reduced to avoid the presence of artifacts before further analysis can take place. Previously, a histogram-based approach already proved to be a suitable choice for the analysis of the spectrum and, in particular, of the endpoint region. To further improve the sensitivity of the fitting algorithms to quantify the effect of tiny neutrino masses, we are testing methods of unbinned analysis like a Kernel Density Estimation (KDE) to mitigate potential artifacts of binning the continuous event energies of the low-intensity endpoint region close to the Q-value of the ^{163}Ho decay. We present the implementation of these algorithms in the analysis of the ^{163}Ho spectrum acquired within the ECHo-1k experiment and compare the results with the ones obtained with binned spectra.

T 39.3 Tue 16:45 VG 3.104

Integrated magnetic field design for next-generation neutrino mass experiment with CRES — •René Reimann and Martin Fertl for the Project 8-Collaboration — Institute of Physics and Ex-

cellence Cluster PRISMA+, Johannes Gutenberg University Mainz, 55099 Mainz, Germany

The Project 8 experiment aims to probe the absolute neutrino mass through direct kinematic measurements of the tritium beta decay spectrum using cyclotron radiation emission spectroscopy (CRES). The low-frequency apparatus (LFA) should demonstrate the coexistence of CRES electron detection and an atomic trap while increasing the effective volume and lowering the background magnetic field compared to previous CRES experiments. To achieve the required energy resolution, the magnetic field experienced by the electrons must be known to very high precision. The magnetic field consists of a carefully tuned uniform background field with a super-imposed magnetic bottle trap to confine the CRES electrons within the detection region. In addition, a high-order multipole magnet adds a strong field only near the wall to confine the cold tritium atoms whose decay provides the electrons for CRES. This contribution describes how, individually and in concert, the three elements of Project 8's magnetic field impact key performance parameters of the detector.

T 39.4 Tue 17:00 VG 3.104

Simulating the atomic beam source for Project 8 experiment : from dissociation to cooling — •Aya El Boustani[1] and Sebastian Böser[2] for the Project 8-Collaboration — [1]Institute of Physics, Johannes Gutenberg University of Mainz, Germany — [2]Institute of Physics, Johannes Gutenberg University of Mainz, Germany

The Project 8 experiment aims to determine the absolute neutrino mass using Cyclotron Radiation Emission Spectroscopy (CRES) to measure the radiation emitted by tritium beta-decay electrons near the spectrum's endpoint, where the neutrino mass effect is most significant. Achieving the desired sensitivity requires an atomic tritium source with well-characterized beam properties. In the test setup at JGU Mainz, molecular hydrogen serves as a non-radioactive tritium analog and is dissociated using a tungsten capillary heated to approximately 2300 K. The dissociated gas undergoes a multi-stage cooling process to bring the atomic beam's temperature down to 8 K. This process is critical to allow the trapping of atoms at later stages of the experiment while minimizing recombination. For this study, simulations were carried out to investigate the atomic source and the accommodator, which serves as the first cooling stage. Using the SPARTA framework, gas flow within the heated tungsten capillary was modeled to characterize atomic beam formation, quantify dissociation efficiency, and evaluate the resulting beam properties. Additional analyses of the accommodator are conducted to assess the effects of surface geometry and gas-surface dynamics on cooling efficiency and overall beam characteristics.

T 39.5 Tue 17:15 VG 3.104

MMC Design and Microfabrication for the ECHo Experiment — •Lorenzo Calza — Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany — ECHo Collaboration

The ECHo experiment is conceived to determine the electron neutrino mass through the analysis of the endpoint region of a high statistics and high energy resolution ^{163}Ho spectrum. During the ECHo-100k phase more than 10^{12} ^{163}Ho decays will be detected by large metallic magnetic calorimeter arrays in which single pixels contain up to 10 Bq of ^{163}Ho. To achieve this goal, about 10^4 MMC pixels will be operated simultaneously. A dedicated chip composed of 60 pixels and 2 temperature channels for gain correction has been designed. 40 chips are microfabricated on a 3" silicon wafer. The design and fabrication steps have been optimised for ^{163}Ho implantation on wafer-scale. We describe the single pixel optimisation for minimal heat capacity and close to 100% quantum efficiency for all decay products besides the electron neutrino, as well as the final chip design. We also present the lithographic microfabrication process and the quality control procedures. We discuss the fabrication yield and the reproducibility of detector parameters. To meet the required pixel count for ECHo-100k, 6 wafers are currently being produced.

T 39.6 Tue 17:30 VG 3.104

ECHo-100k Chip characterization — •Neltje Sophie Buermann — Kirchhoff Institute for Physics, Heidelberg University, Germany — ECHo Collaboration

The ECHo experiment is designed to search for the signature of the finite neutrino mass in the endpoint region of the ^{163}Ho electron capture spectrum. The first stage of the experiment ECHo-1k has been completed, and now the second stage ECHo-100k is under construction. This stage includes a new metallic magnetic calorimeter array with improved pixel design and thermalization. The foreseen resolution of 4 eV FWHM will be more than a factor two better than the one achieved with the ECHo-1k arrays. In this contribution, we present the results for the newly developed chips and discuss their performance in terms of the ECHo-100k requirements.

T 40: Methods in Particle Physics II (Misc.)

Time: Tuesday 16:15–18:00 Location: VG 4.101

T 40.1 Tue 16:15 VG 4.101

ATLAS Forward Proton (AFP) detector operation challenges and ToF Run-3 performance — •Viktoriia Lysenko and Andre Sopczak — Czech Technical University in Prague

Operational and data quality challenges for the ATLAS Forward Proton (AFP) detector in 2024 are presented together with performance studies of the Time-of-Flight (ToF) detector during LHC Run-3 data-taking.

T 40.2 Tue 16:30 VG 4.101

Luminosity measurements using the ATLAS Forward Proton (AFP) detector — Jan Broulim, Petr Fiedler, •Daniil Khmelnytskyi, and Andre Sopczak — Czech Technical University in Prague

The latest results of luminosity measurements using the AFP detector are presented.

T 40.3 Tue 16:45 VG 4.101

Characterization of Losses in LHCb — Johannes Albrecht[1], Federico Alessio[2], Elena Dall'Occo[2], and •David Rolf[1] — [1]TU Dortmund University, Dortmund, Germany — [2]CERN, Geneva, Switzerland

The LHCb experiment is one of the four large particle detectors at the LHC. One important aspect of the experiment is to perform very precise measurements of rare b and c quark decays.

A very clean signal is required during nominal collisions. Operating the LHC comes with different sources of background particles induced from machine operation (MIB). These particles can collide with the collimators shielding the experiment causing secondary showers onto the detector.

In this talk the sources of such losses are explained. The losses are characterized by performing dedicated loss runs. The potential effect on the detector and the physics impact is studied.

T 40.4 Tue 17:00 VG 4.101

Study of the intrinsic detection asymmetry at Belle II for a generic search for matter-antimatter asymmetries — •Beatrice Locatelli, Thomas Lück, Nikolai Krug, and Thomas Kuhr — Ludwig-Maximilians-Universität München Germany

To explain the abundance of matter over antimatter observed in the universe, the CP symmetry must be broken. The Standard Model accounts for some CP violation, but that is not sufficient to explain the magnitude of the observed baryon asymmetry. Therefore, it is crucial to search for new manifestation of CP violation that might have been overlooked so far.

The main source of background in the measurement of CP asymmetries is the intrinsic detector asymmetry. For this reason, it is essential to have a precise knowledge of the asymmetry in particle detection, which can be done by studying the different reconstruction efficiencies between particles and antiparticles. The final goal is to formulate a model-independent analysis strategy that can be applied to detect asymmetries in B-decays at Belle II.

T 40.5 Tue 17:15 VG 4.101

Background Studies for the ILD Detector Concept at the FCC-ee — •Victor Schwan[1], Jenny List[2], and Daniel Jeans[3] — [1]DESY, Universität Hamburg — [2]DESY — [3]KEK, Japan

The ILD detector concept has originally been developed for the International Linear Collider (ILC). Detailed simulations gauged against the performance of prototype components have shown that ILD in its ILC incarnation is ideally suited to pursue the physics program of a linear Higgs factory as well as of a higher energy e^+e^- collider. Recently, the ILD collaboration has started to investigate how the detector concept would need to be modified in order to operate successfully in the experimental environment of a circular Higgs factory like for instance FCCee. In particular, the interaction region, or machine-detector interface (MDI), requires substantial changes to make room for accelerator elements and to withstand backgrounds. This contribution presents the assessment of the occupancy caused by machine backgrounds in the modified detector design, especially in the tracking subdetector systems.

T 40.6 Tue 17:30 VG 4.101

Optimization of module orientation for the DUNE TMS detector — •Asa Nehm for the DUNE-Collaboration — Johannes-Gutenberg University Mainz

The Deep Underground Neutrino Experiment (DUNE), currently under construction, will use a high-intensity neutrino beam from Fermilab and observe the neutrinos in the near detector based at Fermilab and the far detector complex located at SURF. The DUNE near detector complex will host a suite of detectors that are currently in development. The experiment will make precision measurements of the neutrino oscillation parameters including the CP violation phase and the mass ordering. It is also sensitive to neutrinos from galactic supernovas.

One of the near detectors is The Muon Spectrometer (TMS) that is tasked with determining the charge and measuring the momentum by range of the muons resulting from neutrino interactions exiting the preceding near detector. TMS will consist of alternating layers of plastic scintillators, in the form of bars, and steel. The scintillator bars will be read out by WLS fibers and SiPMs and detect the scintillation light created by through-going charged particles.

The original design featured a stereo orientation plan with the bars being tilted by $\pm 3^\circ$ alternatingly by layer. This introduces a large uncertainty in the dimension along the bars and can lead to problems in determining the momentum. In this talk different orientation plans including also orthogonal modules that could solve these problems will be discussed.

T 40.7 Tue 17:45 VG 4.101

Polarized Positron Production for HALHF concept — •Malte Trautwein, Manuel Formela, and Gudrid Moortgat-Pick — University of Hamburg

The HALHF concept represents an energy-efficient and cost-effective alternative to Higgs production using plasma-accelerated electrons and SRF accelerated positrons. The energy asymmetry of electrons (500 GeV) and positrons (31.3 GeV) reduces the overall effort of the acceleration process. An optimised positron source is required for eventful collision processes and for providing polarized beams to optimze the physics potential. Therefore, CAIN simulations are used to generate photon distributions originating from a helical undulator setup. The photon spectra are influenced by parameters such as the undulator strength parameter K, the spatial period of undulator λ_u or the drive beam energy E. The aim is to optimize a set of suitable parameters to generate a matching (polarized) positron spectrum and simultaneously maximise positron yield.

T 41: Search for Dark Matter II

Time: Tuesday 16:15–18:00 Location: VG 4.102

T 41.1 Tue 16:15 VG 4.102

Indirect Searches for Dark Matter with COSI — •Haoyu Xie[1,2], Savitri Gallego[1,2], Jan Lommler[1,2], and Uwe Oberlack[1,2] — [1]Johannes Gutenberg-Universität Mainz, Institut für Physik & ETAP - Experimentelle Teilchen- und Astroteilchen Physik — [2]On behalf of the COSI Collaboration

The NASA MeV mission COSI (Compton Spectrometer and Imager), to be launched in 2027, offers significantly improved sensitivity at high energy resolution and for diffuse emission due to a large field-of-view in the 0.2-5 MeV energy range. This energy range is particularly intriguing for indirect searches of dark matter, as sub-GeV DM candidates are still little constraint by direct searches, but could be detected indirectly as they either annihilate or decay into detectable gamma rays. In this work, we study the sensitivity of COSI to DM in the framework of a dark photon portal, exploring scenarios where sub-GeV dark matter annihilates into leptons, producing continuum gamma-ray signals. We also discuss opportunities to search for primordial black holes (PBHs) and sterile neutrino decays.

T 41.2 Tue 16:30 VG 4.102

The Status of the COSINUS Experiment — •Maximilian Hughes for the COSINUS-Collaboration — Max-Planck-Institut für Physik

COSINUS (Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches) is a dark matter direct detection experiment using cryogenic sodium iodide (NaI) modules. The goal is a model independent test of the DAMA/LIBRA dark matter claim. Prototype modules using the remoTES to read out heat signals from NaI have been measured and the results will be presented. The underground facility construction is complete and the dry dilution refrigerator to provide the milli-kelvin temperatures required has been commissioned. The water Cherenkov muon veto surrounding the cryostat has been installed and filled with water. The next steps include installing cabling and superconducting quantum interference devices (SQUIDs) to read out the modules. The first data taking is planned to start in 2025 with eight 30 gram NaI modules.

T 41.3 Tue 16:45 VG 4.102

The first measurement of coherent elastic nucleus scattering of solar 8B neutrinos in the XENONnT experiment. — •Daniel Wenz for the XENON-Collaboration — University of Muenster

Liquid xenon (LXe) dual-phase time projection chambers (TPC) are thanks to their low energy threshold of sub-keV level and excellent background discrimination, the leading technology in the search for WIMP dark matter. They are also well suited to study other rare and faint phenomena like the coherent elastic neutrino-nucleus scattering (CEvNS) of solar neutrinos, opening a window towards solar and neutrino physics at lowest energies.

On of the leading experiment in this field is the XENONnT experiment, a highly sensitive, low background, dual-phase TPC with a LXe target volume of 5.9 t located at the Laboratori Nazionali del Gran Sasso (LNGS). In this talk the first measurement of solar ^{8}B neutrinos through CEvNS are presented by performing a dedicated low energy blind analysis, using an exposure of $3.51\,\mathrm{t}\cdot\mathrm{yr}$. The background only hypothesis was rejected with 2.73 sigma, resulting in a measured ^{8}B flux of $(4.7^{+3.6}_{-2.3})\cdot 10^{-6}\mathrm{cm}^{-2}\mathrm{s}^{-1}$. This result not only represents the very first measurement of CEvNS in LXe, but also CEvNS from solar neutrinos in general. It is therefore an important milestone towards a future liquid xenon observatory, not only for dark matter, but also for neutrino and solar physics.

This work is supported by BMBF ErUM-Pro 05A23PM1.

T 41.4 Tue 17:00 VG 4.102

Modeling the nuclear recoil response in XENONnT — •Johanna Jakob for the XENON-Collaboration — Institut für Kernphysik, Universität Münster

XENONnT, the latest stage of the XENON Dark Matter Project, is currently running with the science goals of detecting WIMP-nucleus scattering and searching for other rare events. The detector is a dual-phase time projection chamber filled with 5.9 tonnes of liquid xenon in the active volume. In the detector, neutral particles are most likely to interact with the nucleus, resulting in nuclear recoil (NR). Potential WIMP interactions as well as the rare Standard Model process of coherent elastic neutrino-nucleus scattering (CEνNS) both produce NR interactions. Consequently, characterizing the detector response to NR is essential for such investigations. Neutrons serve as an excellent calibration source for studying this response, as their NR interactions are indistinguishable from those of WIMPs or CEνNS. This talk discusses how neutrons tagged with coincident 4.4 MeV gammas from an

$^{241}Am^{9}Be$ source are used to constrain the light and charge yield parameters of the NEST model (Noble Element Simulation Technique). This work is supported by BMBF ErUM-Pro 05A23PM1.

T 41.5 Tue 17:15 VG 4.102

Simulation and design optimization of the DARWIN observatory — •Antoine Chauvin, Maike Doerenkamp, and Stephanie Hansmann-Menzemer — Im Neuenheimer Feld 226, 69120 Heidelberg

The DARWIN observatory is a proposed future direct dark matter detection experiment. Its main science target is the detection of WIMP-like particles through WIMP-nucleus interactions, in a multi-ton liquid xenon TPC. Designing the experiment and optimizing its layout requires good modeling of the detection processes and the signal and background sources. In this talk, we report on the simulation of the detector responses to signal and background events in the DARWIN TPC. We present the sensitivity of the DARWIN baseline design to WIMP-nucleus scattering infered from these simulations and the impact of detector design choices on the DARWIN sensitivity.

T 41.6 Tue 17:30 VG 4.102

Electrode Design & Characterisation for the XLZD Observatory — •Alexey Elykov for the XLZD-Collaboration — Karlsruher Institut für Technologie, Institut für Astroteilchenphysik

The XLZD (XENON, LZ, DARWIN) collaboration aims to construct and operate the ultimate multi-tonne xenon-based direct detection astroparticle observatory. Hosting a time projection chamber (TPC) with more than 60 tonnes of liquid xenon, with a keV-range threshold and an ultra-low radioactive background it will aim to probe the entire parameter space for WIMP dark matter down to the so-called neutrino fog. XLZD scientific research program also includes searches for solar axions, axion-like particles, measurements of the solar neutrino flux and a probe of the Majorana nature of neutrinos.

High-voltage electrodes, spanning 3 m in diameter, will lie at the heart of the XLZD TPC, playing multiple key roles in signal generation and reconstruction. The electrodes need to be feasible to produce, mechanically robust, sufficiently transparent to light propagation and have minimal spurious electron and light emission from their surface.

An R&D program at KIT aims to tackle these challenges. We've developed several test setups aimed at studying emission from electrode samples and ways of mitigating it, as well as a high-voltage scanning system for electrodes. Here, we will present our recent work on electrode R&D towards XLZD-scale electrodes. This work is supported in part through the Helmholtz Initiative and Networking Fund (grant agreement no. W2/W3-118) and by BMBF (ErUM-Pro, grant no. 05A23VK3).

T 41.7 Tue 17:45 VG 4.102

Next-to-Leading-Order QCD Corrections to Dark Matter Annihilation into Wqq' in the CxSM — •Pavao Brica — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

I will present the results for our computation of the next-to-leading-order QCD corrections to the annihilation process of two dark matter particles into a W boson, a massless quark and a massless antiquark. This process contributes to the computation of the dark matter relic density. The calculation has been performed within the framework of the complex singlet extension of the Standard Model which extends the Standard Model scalar sector by a complex singlet and yields an appropriate dark matter candidate. The treatment of the UV and IR divergences that arise in the calculation is briefly addressed. The cross section as well as the relic density are presented at next-to-leading order. The impact of these corrections is analyzed.

T 42: Invited Overview Talks I

Time: Wednesday 11:00–12:30 Location: ZHG011

Invited Overview Talk T 42.1 Wed 11:00 ZHG011

Direct neutrino-mass measurements - current and next generations — •Magnus Schlösser — Karlsruhe Institute of Technology, Tritium Laboratory Karlsruhe, Karlsruhe, Germany

The precise measurement of neutrino masses represents a critical frontier in particle physics, with implications that extend beyond the Standard Model and into cosmology. Direct neutrino mass measurements are uniquely model-independent and critical for cross-validating of other approaches. The Karlsruhe Tritium Neutrino (KATRIN) experiment, employing beta-decay spectroscopy to measure the incoherent sum of neutrino masses, is in its final year of data taking. KATRIN has progressively improved the upper limit on neutrino mass, achieving m < 0.45 eV at 90% C.L. and aims to reach a final sensitivity of m < 0.3 eV. This limit represents the reach of the current state-of the-art technology. Next-generation experiments, targeting sensitivities below the inverted ordering range (m < 0.05 eV), require novel technologies, such as atomic tritium sources and differential detection methods, as explored by KATRIN++, Project8, and QTNM.

Another approach is to calorimetrically measure the energy released from electron capture reactions, e.g. from Ho-163 atoms implanted into cryogenic micro-calorimeters. This technology is currently employed by the ECHo and HOLMES collaborations with sensitivities in the order of O(10 eV). Next, their statistics will be improved by increasing the number of channels and measurement time.

This talk will present the latest results and plans for next-generation neutrino mass experiments.

Invited Overview Talk T 42.2 Wed 11:30 ZHG011

Mapping out the Higgs Boson: Highlights from the LHC Experiments — •Elisabeth Schopf — Universität Siegen

The Higgs boson holds a unique position within the Standard Model of Particle Physics; it is the only known fundamental spin-0 particle and it has intrinsic links to the mass-generation mechanisms of fundamental particles and to the evolution of the Universe. It could hold a crucial key to unlocking access to yet unknown physics.

This talk will present the latest results of Higgs-boson research at the ATLAS and CMS experiments using proton-proton collision data from the Large Hadron Collider. The unprecedented precision reached in probes of Higgs boson couplings to fundamental fermions, leptons and quarks, hone in on the question if these couplings are proportional to the fermion masses as expected in the Standard Model or reveal the existence of additional unknown sources of mass generation. More extensive measurements of differential cross-sections probe for new physics affecting Higgs-boson production. Pushing the limits on studies of the Higgs-boson self-coupling further maps out the shape of the Higgs-field potential, which is connected to the long-term stability of the Universe. New and improved searches for other Higgs-boson-like particles and exotic Higgs-boson decays are cornering theories of additional phase transitions in the early universe and theories on the nature of dark matter. This presentation will also discuss the challenges of Higgs-boson research at the Large Hadron Collider and feature recent advancements in measurement techniques.

Invited Overview Talk T 42.3 Wed 12:00 ZHG011

Computing at the LHC and its transformation towards the HL-LHC — •Sebastian Wozniewski — II. Institute of Physics, Georg-August-University, Göttingen, Germany

Together with the data taken at the LHC and the increasing number of physics analyses performed on this data, the capacity of the WLCG has grown continuously in the past. We look back on a time when the market offered data storage and computing power at a lower price year after year and thus the growing demand for resources could be covered even with a flat budget. This trend has weakened or at least requires more technological adjustments on the user side. At the same time, we are facing major challenges with regard to the large resource requirements of the HL-LHC and the necessity to provide these resources in a sustainable and environmentally friendly way. In many places, developments are being driven forward in terms of resource provision and utilisation to meet these challenges.

This presentation will provide a broad overview, with a particular focus on developments and related projects in Germany, and show a selection of highlights on the way to the future LHC Computing.

T 43: Invited Overview Talks II

Time: Wednesday 13:45–15:45 Location: ZHG011

Invited Overview Talk T 43.1 Wed 13:45 ZHG011
Advances in Silicon Detectors — •Matthias Hamer — Physikalisches Institut, Universität Bonn

Silicon detectors play a crucial role in modern particle physics experiments, highly performing in demanding environments. Many planned experiments put ever higher requirements on these detectors in terms of radiation dose, hit, data and trigger rates, timing, radiation length and more.

In my presentation I will talk about recent advances in the design of silicon detectors and detail how these advances enable upcoming experiments to meet these requirements. I will cover developments for hybrid and monolithic silicon tracking detectors and silicon calorimeters. I will highlight novel features that have been successfully implemented already, as well as the path ahead towards the realisation of some of the most challenging experiments yet.

Invited Overview Talk T 43.2 Wed 14:15 ZHG011
Exploring the dark universe: the experimental quest for axions and ALPs — •Julia K. Vogel — Fakultät für Physik, TU Dortmund, Otto-Hahn-Str. 4A, D-44227 Dortmund, Germany

Axions and axion-like particles (ALPs) are hypothetical particles predicted in extensions of the Standard Model (SM) of particle physics. Originally proposed as a solution to the strong CP problem in strong interactions, axions have since gained prominence due to their potential role as dark matter candidates. ALPs, more broadly, arise in various beyond-the-SM theories, such as string theory. Both are characterized by extremely low masses and weak couplings to ordinary matter, making them elusive yet fundamental to understanding the universe's hidden structure.

Experimental searches for axions and ALPs span a diverse range of techniques. Haloscopes, helioscopes, and laboratory-based experiments use cutting-edge technologies to detect faint axion signals, while astrophysical and cosmological observations provide indirect constraints. These efforts leverage advances in resonant cavities, magnet technology, and high-intensity lasers to probe unexplored parameter space. The ongoing quest for axions and ALPs is not only a test of theoretical models but a potential gateway to groundbreaking discoveries in physics.

In this talk we will review the landscape of axion and ALP searches introducing the various types of experimental setups employed to look for these hypothetical particles. We will also discuss current results and outline future prospects.

Invited Overview Talk T 43.3 Wed 14:45 ZHG011
Overview on coherent elastic neutrino nucleus scattering and successful first detections — •Janina Hakenmüller — Duke University, Durham, USA

Coherent elastic neutrino nucleus scattering (CEvNS) refers to the standard model process when the neutrino interacts with the nucleus as a whole. The cross section is enhanced by the neutron number squared of the target nucleus, which is ideal for a precision test of the standard model and to look for physics beyond the standard model. Neutrino energies below 50 MeV are required for a coherent interaction. The observable is the tiny recoil of the nucleus hit by the neutrino, which poses a huge challenge on the noise threshold of the detectors. A multitude of experiments with different technologies at different neutrino energies is desirable. The COHERENT collaboration was the first to observe CEvNS at the spallation neutron source at the Oak Ridge national laboratory, USA, with a CsI scintillating crystal in 2017. This was followed by two more successful observations, the most recent one in 2023 with high-purity germanium (HPGe) spectrometers. At lower neutrino energies, the CONUS collaboration also employs HPGe detectors at the Leibstadt power plant, Switzerland, to observe CEvNS for the first time at reactor site with the first data taking run concluded in 2024. The NUCLEUS experiment located at the Chooz reactor, France, and currently under commissioning aims at achieving the lowest energy threshold of these experiments with their cryogenic calorimeters. In my talk, I will present the current status of these experiments and achieved results followed by an outlook on the future.

Invited Overview Talk T 43.4 Wed 15:15 ZHG011
Shifting paradigms in Gravitational-wave Astrophysics — •Imre Bartos — University of Florida

The decade since the first detection of gravitational waves brought about several transformational discoveries. The LIGO and Virgo observatories detected more and heavier black holes than anticipated; the first detection of a neutron star merger through gravitational waves and across the electromagnetic spectrum provided invaluable insights on the production of the heaviest elements in the universe; and a particularly heavy black hole was discovered that could have not come from stellar core collapse. With the exponentially increasing rate of discoveries over the next decade and a half, gravitational waves are all but guaranteed to further shift our astrophysical paradigms. The talk will primarily focus on one of these shifting paradigms: the merger of black holes that was historically considered to be "dark" events producing only gravitational waves, but new observations point towards a brighter, more impactful, multimessenger picture.

T 44: Searches/BSM III (Long-lived, Misc.)

Time: Wednesday 16:15–18:15 Location: ZHG010

T 44.1 Wed 16:15 ZHG010
Probing Delayed Jets with Dedicated Long-Lived-Particle Triggers at ATLAS — •Tobias Stephan Heintz[1,2], Gareth Bird[2], Oleg Brandt[2], and Christopher Lester[2] — [1]Kirchhoff Institute for Physics, Heidelberg, Germany — [2]Cavendish Laboratory, Cambridge, United Kingdom

Delayed energy deposits are a compelling signature in searches for long-lived particles (LLPs) at the LHC. This talk will present an analysis strategy to search jets that arrive at the ATLAS calorimeter with a significant time delay of up to 35 ns.

These delayed signals can serve as benchmarks for exploring a hidden sector beyond the Standard Model. For instance, long-lived dark matter particles may travel slowly due to a mass hierarchy in the production mechanism $pp \rightarrow$ scalar particle $\rightarrow$ LLPs, leading to delayed signals in the ATLAS detector. In extreme cases, LLPs with velocities below $\beta \sim 0.1$ could reach the calorimeter even in the subsequent bunch crossing (BC).

Conventional triggers are inefficient for such events, but ATLAS has implemented a dedicated LLP trigger at the hardware level. This trigger specifically examines two consecutive BCs for signatures of missing transverse energy in BC $N-1$ followed by a delayed jet in BC N. This talk will discuss the motivation, implementation, and potential of this trigger in uncovering new physics at the LHC in Run-3.

T 44.2 Wed 16:30 ZHG010
Search for long-lived supersymmetric decays in CMS — •Soumyaa Vashishtha[1,2] and Isabelle Melzer-Pellmann[1] — [1]Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, D-22607 Hamburg — [2]Universität zu Köln, Albertus-Magnus-Platz, 50923 Köln

The standard model is an effective theory but a low-energy approximation to a more complete theory. Supersymmetry (SUSY) extends the Standard Model but is expected to be broken and mediated to the visible sector via mechanisms like gravity or gauge mediation. In the search for beyond the standard model processes, we present an ongoing analysis based on simplified models to study the pair production and semileptonic decay of the hypothetical SUSY partner of the tau lepton, known as the stau ($\widetilde{\tau}$) within the CMS experiment at the CERN Large Hadron Collider (LHC). In gauge-mediated SUSY-breaking scenarios, the stau has macroscopic lifetime, and decays via $\widetilde{\tau} \rightarrow \tau\widetilde{\chi}^1_0$. This study focuses on events where one tau lepton decays to a muon, and the other decays hadronically, forming a jet. Using a dedicated machine learning algorithm for displaced tau tagging, we reconstruct the stau.

T 44.3 Wed 16:45 ZHG010

Search for long-lived axion-like particles produced in Higgs boson decays at the ATLAS Experiment — •Lukas Bauckhage[1,2] and Federico Meloni[1] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]Physikalisches Institut, Universität Bonn, Bonn, Germany

Exotic Higgs decays to long-lived particles are featured in theories beyond the standard model related to hidden sectors, while (long-lived) axion-like particles are not only a prime candidate to dark matter but also part of hidden and dark sector theories. Preliminary results of an ATLAS Run 3 search for long-lived axion-like particles produced in a Higgs decay in association with a Z boson and decaying into a pair of photons are presented. The ALP decay's displacement challenges the standard photon reconstruction and calls for new techniques, such as machine learning and a new tagger utilising shower shape information. Detailed studies of the performance of these algorithms will be presented.

T 44.4 Wed 17:00 ZHG010

Search for Semivisible Jets with CMS Run 2 Scouting Data — •Marcel Gaisdörfer[1], Benedikt Maier[3], Brendan Regnery[1], Markus Klute[1], Jonas Janik[1], Kevin Pedro[4], Roberto Seidita[2], Cesare Tiziano Cazzaniga[2], Annapaola De Cosa[2], Aimar Aguado Berasaluce[2], Rebecca Natalia Hampp[2], and Celeste Holm[2] — [1]Karlsruher Institut für Technologie (KIT) — [2]ETH Zürich — [3]Imperial College London — [4]Fermilab (FNAL)

Semivisible jets are large area jets containing missing transverse momentum. These jets could be caused by a QCD-like dark sector, coupled to the SM via an additional Z' boson. The dark sector contains dark quarks, which while hadronizing form both stable and unstable dark hadrons. This hadronization process leads to large jets containing both SM particles and invisible DM particles.

This search uses data scouting, a technique that utilizes HLT reconstruction to access otherwise lost events below the typical trigger thresholds, to expand the parameter space of the existing s-channel search for a resonant Z' decaying into two semivisible jets.

This talk will present the search strategy, status and expected limits for the search for semivisible jets using scouting data collected by the CMS experiment during Run 2 of the LHC.

T 44.5 Wed 17:15 ZHG010

Search for high-mass resonances in dilepton final states with associated b-jets at the ATLAS experiment — Frank Ellinghaus and •Anna Bingham — Bergische Universität Wuppertal

An overview of a search for a Z' boson in high-mass dilepton (ee,$\mu\mu$) final states with associated b-jets is presented. The considered Z' model is a candidate explanation for potential anomalies in B hadron decays and couples to b and s quarks in the production. The search is carried out using the dataset collected by the ATLAS detector in Run-2 of the LHC corresponding to an integrated luminosity of 140 fb^{-1}. Backgrounds are estimated from MC and also by data-driven methods. Control, signal and validation regions are defined, and these regions are fitted in a profile-likelihood fit. Exclusion limits on the Z' mass are obtained based on the results of the fit.

T 44.6 Wed 17:30 ZHG010

Impact of polarized beams for Higgs, Electroweak and Dark Matter Physics — •Gudrid Moortgat-Pick — University of Hamburg, Hamburg, Germany — Wackerweg 1

Future Electron-Positron Linear Collider Designs (ILC, CLIC, HALHF) offer high-energy, polarized beams and high-precision measurements. In the talk we discuss the impact of polarized beams for the detection of the Higgs couplings, CP-violation effects and Dark Matter candidates with respect to the model distinction in different Beyond the Standard Models (MSSM, 2HDMS, inflation models). The current experimental bounds have been taken into account and involved parameter scans have been performed.

T 44.7 Wed 17:45 ZHG010

The Principle of Global Relativity — •Jochum van der Bij — Albert-Ludwigs Universitaet Freiburg, Deutschland

I present a new principle of relativity in physics. It is an alternative away from naturalness towards a new paradigm. It allows for an a priori derivation of the gauge structure of nature. In particular it can explain why there are precisely three generations of fermions. A specific form of dark matter is preferred. The standard model can only be extended in a minimalistic way.

T 44.8 Wed 18:00 ZHG010

Einstein's Basement: A new sector for hypothetical particles — •Fritz Riehle and Sebastian Ulbricht — Physikalisch-Technische Bundesanstalt Braunschweig

The extremely fruitful concept of an avoided crossing in mechanical, optical, electrical science and in quantum mechanics of molecules, quantum chemistry and others rises the question for a supplement of the relativistic physics of particles. In this new sector - dubbed as Einstein*s basement - new quasi particles with novel kinematic properties occur [1]. The new particles cannot be treated as a sector of the standard model of particles. We calculate the kinematics between the new particles and regular particles under Newtonian gravity which under special conditions can lead to repulsion of the basement particles and a modified interaction with regular matter.

[1] Fritz Riehle and Sebastian Ulbricht arXiv:2402.13679 [gr-qc]

T 45: Higgs Physics V (HH and Trilinear Coupling)

Time: Wednesday 16:15–18:15 Location: ZHG104

T 45.1 Wed 16:15 ZHG104

Estimation of the Background from $t\bar{t}$ Events with Misidentified Tau Leptons in the Search for Di-Higgs Production in the $HH \to bb\tau_{\mathbf{had}}\tau_{\mathbf{had}}$ Channel with the ATLAS Detector — •Baktash Amini, Christian Weiser, Benedict tobias Winter, Yingjie Wei, and Karl Jakobs — Albert-Ludwigs-Universität Freiburg

Interactions involving multiple Higgs bosons in the final state are yet to be observed. The di-Higgs production via gluon-gluon fusion and vector-boson fusion processes at the LHC provides a unique opportunity to study those properties and test the predictions of the Standard Model for the Higgs boson self-couplings. Thanks to a good balance of signal yield and signal purity, di-Higgs boson production with one Higgs boson decaying into two b-quarks and one into two tau leptons is one of the best channels to measure the Higgs boson self-couplings. In the $HH \to bb\tau\tau$ analysis, the second largest background is the $t\bar{t}$ fake-$\tau_{\text{had-vis}}$ process, where at least one quark- or gluon-initiated jet is misidentified as a visible tau lepton, $\tau_{\text{had-vis}}$. This background is estimated via a data-driven scale-factor method in the search for non-resonant $HH \to bb\tau_{\text{had}}\tau_{\text{had}}$ decays at the ATLAS experiment. In the talk, I will present the scale factor method for the analysis of the Run 2 and partial Run 3 datasets.

T 45.2 Wed 16:30 ZHG104

Fake-τ background estimation for the Atlas $HH \to bb\tau\tau$ analysis — •Philipp Rincke[1,2], Stan Lai[1], and Arnaud Ferrari[2] — [1]II. Physikalisches Institut, Georg-August-Universität Göttingen, Deutschland — [2]Department of Physics and Astronomy, Uppsala University, Sweden

The $HH \to bb\tau\tau$ analysis has the highest expected sensitivity to the Standard Model (SM) Higgs boson pair production signal based on the legacy Run 2 results. Several SM processes contribute to this final state as backgrounds. One of the most important backgrounds consists of processes where quark- and gluon-initiated jets are mis-identified as hadronically decaying τ leptons (fake-τ leptons), which are difficult to model precisely with simulations. A better description of these backgrounds can be achieved using data-driven methods, such as the Fake Factor method.

This talk will present the Fake Factor method which is under development for the Run 2 + Run 3 analysis to model the QCD multijet background in the $bb\tau\tau$ channel. The method relies on creating a fake-τ enriched template of events by inverting the τ lepton identification criteria. This template is then re-weighted using Fake Factors derived in control regions to model the QCD multijet background in the signal region, for which the current fake-τ background and uncertainty estimates will be shown.

T 45.3 Wed 16:45 ZHG104

Background estimation for the di-Higgs process $HH \to \bar{b}b\tau^-\tau^+$ with Run3 data from the CMS experiment — •Ana Andrade, Nathan Prouvost, Bogdan Wiederspan, Marcel Rieger, Philip Keicher, Anas Haddad, Tobias Kramer, and Peter Schleper — University of Hamburg, Hamburg, Germany

The shape of the Higgs potential plays a crucial role in our understanding of vacuum stability. The potential is directly dependent on the Higgs boson self-coupling which, despite continuous efforts, has yet to be experimentally observed. One way to probe its existence is through double Higgs boson production, where one Higgs boson directly couples to two final state Higgs bosons. The predicted cross-section of such a decay depends on the self-coupling strength and can therefore be probed with experimental data.

Since double Higgs boson production has a cross-section several orders of magnitude smaller than that of background processes, the efforts to observe the self-coupling are heavily limited by statistics. The channel $HH \to \bar{b}b\tau^-\tau^+$ is a promising target for such analyses as it offers a good compromise between sufficient statistics and reasonable background contamination. A major challenge in background estimation stems from multi-jet events, as these are notoriously difficult to simulate. In this talk, I will present techniques to model background processes in such analyses, with Run 3 data.

T 45.4 Wed 17:00 ZHG104

Morphing Di-Higgs processes — Ana Andrade, Anas Haddad, Philip Keicher, Tobias Kramer, •Nathan Prouvost, Marcel Rieger, Peter Schleper, and Bogdan Wiederspan — Universität Hamburg

The Standard Model of particle physics is currently the most successful theory describing our understanding of elementary particles and their interactions.

Currently, the investigation of the parameters of the Higgs mechanism is of utmost interest for tests of the predictions of the Standard Model. The trilinear higgs coupling is one such parameter. One of the challenges in the statistical interpretations of these measurements is the correct parametrisation of the distributions of the discriminating observable as a function of the coupling coefficients.

This talk summarizes a study on this topic based on a search for Di-Higgs production in the $bb\tau\tau$ final state at the CMS experiment.

T 45.5 Wed 17:15 ZHG104

Streamlined Optimization Studies in the Search for Di-Higgs Boson Production in the $\mathrm{b\bar{b}}\tau^+\tau^-$ channel at the ATLAS experiment — •Steffen Ludwig, Benedict Winter, Yingjie Wei, Christian Weiser, and Karl Jakobs — University of Freiburg, Institute of Physics, Freiburg im Breisgau, Germany

The Higgs boson has been studied at the Large Hadron Collider at CERN over the last decade with ever-increasing precision. However, one key quantity of electroweak symmetry breaking, the strength of the trilinear Higgs boson coupling, has not yet been observed due to the small Higgs pair production cross-section. A deviation of the coupling strength from the value predicted by the Standard Model would constitute an observation of new physics.

I will discuss prospects for improving the sensitivity of searches for the non-resonant production of Higgs boson pairs in the $\mathrm{HH} \to \mathrm{b\bar{b}}\tau^+\tau^-$ channel by using Graph Neural Networks. The study is based on the latest measurement with the Run 2 dataset using 140 fb^{-1} of proton-proton collisions at a center-of-mass energy of 13 TeV, recorded by the ATLAS detector at CERN.

To study the benefits of Graph Neural Networks and transformer models on parts of the analysis, I developed an automatization and orchestration tool, called grid-pipeline, to conduct the existing analysis and its derivatives. The tool's versatility enables the elementarization of complex computing workflows and the combination of resources from multiple computing sites. This allows for a significantly improved analysis optimization workflow and reduces the turn-around time.

T 45.6 Wed 17:30 ZHG104

Analysis for Run3 in the $HHH \to b\bar{b}b\bar{b}\tau\bar{\tau}$ channel with the CMS Experiment — •Thanh Tan Nguyen, Philip Keicher, Marcel Rieger, Nathan Prouvost, Ana Andrade, Bogdan Widerspan, Tobias Kramer, and Peter Schleper — University Hamburg, Hamburg, Germany

Understanding the Higgs mechanism is currently one of the largest fields of research at the LHC. One factor in this endeavor is the measurement of the Higgs self-coupling, which defines the shape of its potential. The sensitivity to this parameter of the standard model increases with the multiplicity of Higgs bosons. This analysis focuses on the triple Higgs production at LHC, which is sensitive to both the triple and quartic self-coupling. Here, the final state of four bottom quarks and two tau leptons is chosen; it*s a compromise between high branching ratio and clearer distinction of the decay products. The current status of this analysis is presented in this talk, with a particular focus on studies on the analysis phase space definition and the derivation of discriminating observables

T 45.7 Wed 17:45 ZHG104

Search for Higgs Boson Pair Production in Multi-Lepton Final States with the ATLAS Detector — Anamika Aggarwal, Volker Büscher, Christian Schmitt, •Niklas Schmitt, and Duc Bao Ta — Johannes Gutenberg-University, Mainz

After the discovery of the Higgs boson in 2012 at the LHC, many of its properties have already been determined precisely using 139 fb^{-1} of proton-proton collisions at $\sqrt{s} = 13$ TeV. However, one of the biggest challenges in this field remains the measurement of the coupling of the Higgs boson to itself. It allows for a deep insight into the real shape of the Higgs potential and hence has a big impact on the understanding of fundamental interactions not only at the electroweak scale. In order to constrain the trilinear self-coupling, the Di-Higgs production cross section is measured. While decay modes including b-quarks typically have larger branching fractions, leptonic final states are generally much cleaner and have less SM background. Accordingly, probing this channel as a complement to $b\bar{b}$ analyses will be very promising.

This talk will give an overview about the analysis strategy, which relies on neural networks to distinguish the signal processes from the sum of all SM backgrounds. In addition, preparations for the Run 2 + partial Run 3 analysis, based on a combined dataset of about 300 fb^{-1}, will be presented, as well as a first look at Run 3 data and comparisons to Monte Carlo.

T 45.8 Wed 18:00 ZHG104

HH Analysis with Multileptons Using Run-2 ATLAS Data — •Elizaveta Denisova and Andre Sopczak — Czech Technical University in Prague

The latest results with Run-2 ATLAS data are presented for the search HH in the multilepton channel.

T 46: Higgs Physics VI (top-Higgs Coupling)

Time: Wednesday 16:15–18:15 Location: ZHG105

T 46.1 Wed 16:15 ZHG105

Significance Studies in the Dileptonic ttH(bb) Channel Using Run 3 CMS Simulation — •Philipp Nattland[1], Danyer Perez Adan[1], Kai Adamowicz[1], Lutz Feld[1], Valeria Botta[1], Kilian Krasenbrink[1], Matin Torkian[2], and Maria Aldaya Martin[2] — [1]RWTH Aachen University — [2]DESY, Hamburg

The associated production of a top-quark pair with a Higgs boson (ttH) directly probes the top-Higgs Yukawa coupling, a key parameter in the Standard Model. This study focuses on the ttH(bb) channel with dileptonic top decays, using Run 3 CMS simulation. Building on previous measurements with Run 2 data, we optimize event selection and background suppression to enhance signal significance. A binned maximum likelihood fit is employed to extract the expected signal significance, serving as a figure of merit for the optimization.

T 46.2 Wed 16:30 ZHG105

Preliminary Studies of the ttH(bb) Process in the Dileptonic Channel with SPANet, using CMS Run3 data — •Matin Torkian[1], Maria Aldaya martin[2], Dina Leyva Pernia[2], and Henriette Petersen[2] — [1]DESY, Hamburg University, Germany — [2]DESY, Hamburg, Germany

The Standard Model (SM) of particle physics predicts that the Higgs boson couples to fermions via a Yukawa-type interaction, with a strength proportional to the fermion mass. This makes the associated production of a Higgs boson with a top-quark pair ($t\bar{t}H$) a crucial process to directly probe the top-Higgs Yukawa coupling, an essential parameter for confirming the SM nature of the Higgs boson. Among Higgs boson decays, the channel into a $b\bar{b}$ quark pair has the largest branching fraction, offering an experimentally promising final state. However, ttH(bb) process faces significant challenges regarding backgrounds, especially $t\bar{t}$+jets production, with the $t\bar{t}b\bar{b}$ background being irreducible with respect to the $t\bar{t}H, H \to b\bar{b}$ signal. Advance Machine Learning techniques are essential to improve the sensitivity to the signal process.

This work focuses on the analysis of the $t\bar{t}H, H \to b\bar{b}$ process in events with two leptons, using proton-proton collision data collected by the CMS experiment at the LHC during Run3 at $\sqrt{s} = 13.6\,\mathrm{TeV}$. ML methods are explored to significantly enhance the sensitivity to the $t\bar{t}H$ signal. For the first time in this final state we are exploring the potential of SPANet for jet-parton assignment and neutrino kinematic regressions and finally signal and background classification.

T 46.3 Wed 16:45 ZHG105

Kinematic reconstruction of $\mathbf{t\bar{t}H}$ ($\mathbf{H \to b\bar{b}}$) events in semileptonic $\mathbf{t\bar{t}}$ final states using Run 2 CMS Simulation — •Kai Adamowicz, Lutz Feld, Danyer Perez Adan, Valeria Botta, and Philipp Nattland — RWTH Aachen

The $t\bar{t}H$ process provides a direct probe of the top-Higgs Yukawa coupling, an important parameter of the Standard Model. Due to a large and difficult to accurately model $t\bar{t}b\bar{b}$ background, its measurement in the $H \to b\bar{b}$ channel proved complicated. Using the transformer-based neural network architecture "SPANet", the prospect of a kinematic reconstruction of the final states is studied on Run 2 CMS simulation. This technique may form the basis of a signal extraction via the standard "bump hunt" approach using the invariant mass of the Higgs candidate, which has been proven succesful in many searches and cross section measurements of the SM Higgs boson in various decay modes.

T 46.4 Wed 17:00 ZHG105

Analysis of tH(bb) production with ATLAS Run-2 data — Andre Sopczak and •Roman Tomchik — Czech Technical University in Prague

The latest results of the analysis tH(bb) are presented with focus on machine learning using ATLAS Run-2 data.

T 46.5 Wed 17:15 ZHG105

ttH analysis with two light leptons and one hadronically decaying tau lepton with Run-2 ATLAS data — •Alina Haitota and Andre Sopczak — Czech Technical University in Prague

The latest results of the analysis ttH in the 2lSS1tau channel are presented with focus on machine learning using ATLAS Run-2 data.

T 46.6 Wed 17:30 ZHG105

Associated production of a Higgs boson and a single top quark from t-channel production (tHq) in channels with hadronically decaying tau leptons at ATLAS — •Florian Kirfel and Ian C. Brock — Physikalisches Institut der Universtiät Bonn, Deutschland

A measurement of single top-quark production in association with a Higgs boson and a spectator light-quark (tHq) gives insight into the properties of not only the top quark but also the Higgs boson. The associated production is uniquely sensitive to the relative sign of the top quark-Higgs boson Yukawa coupling.

The decay of the Higgs boson into two tau leptons is covered by the presented analysis. Both cases in which one or two taus decay hadronically are considered and analysed based on the Run 2 LHC dataset from ATLAS.

The complete analysis workflow is covered, ranging from the treatment of light lepton and tau lepton misidentification, over the application of a categorical neural network for signal isolation with a k-fold training approach to a binned maximum likelihood estimation for the purpose of cross section estimation.

T 46.7 Wed 17:45 ZHG105

Higgs boson mass reconstruction in the analysis of tH($\tau\tau$) production with ATLAS Run-2 data — •Jiri Javora and Andre Sopczak — Czech Technical University in Prague

The latest results on the mass reconstruction in the analysis tH($\tau\tau$) are presented with focus on machine learning using ATLAS Run-2 data.

T 46.8 Wed 18:00 ZHG105

Application of the JAX-based Statistical Tool Evermore to a CMS Higgs Analysis — Peter Fackeldey[2], •Felix Zinn[1], Benjamin Fischer[1], and Martin Erdmann[1] — [1]RWTH Aachen University — [2]Princeton University

For precise measurements of the Higgs boson cross sections and coupling strengths, a likelihood based approach is typically needed for statistical inference. We introduce the python software package `evermore` which allows to define corresponding likelihood functions.

It is purely based on JAX and thus enables novel computing concepts such as automatic differentation and vectorization in the context of likelihood fitting.

We show how to build and evaluate a likelihood function in evermore with the example of an analysis of the tH and ttH production channel.

Furthermore we present how to set an upper limit on a parameter of interest. This procedure often requires the generation of pseudo data. We show how vectorized computation in `evermore` can be used for a toy-based approach.

T 47: Axions/ALPs II

Time: Wednesday 16:15–18:15 Location: VG 0.110

T 47.1 Wed 16:15 VG 0.110

Long-lived axion-like particles at the FCC-ee — Freya Blekman[1,2], Juliette Alimena[2], Lovisa Rygaard[1,2], and •Elnura Bakhishova[1] — [1]University of Hamburg, Germany — [2]Deutsche Elektronen-Synchrotron DESY, Hamburg, Germany

We study the sensitivity to long-lived particles (LLPs) of a proposed circular electron-positron collider, the FCC-ee. The very low background environments in electron-positron collisions provide exciting opportunities to search for several types of LLPs. This talk will focus on one example of a physics case resulting in a long-lived signature, namely, axion-like particles (ALPs), and it will show the sensitivity of the FCC-ee to a long-lived ALP signature.

T 47.2 Wed 16:30 VG 0.110

Searching for ALPs through Photon Fusion at the Belle II experiment — •Frederik Schmitt, Giacomo De Pietro, Torben Ferber, and Alexander Heidelbach — Institute of Experimental Particle, Karlsruhe Institute of Technology, Karlsruhe, Germany

Axion-Like Particles (ALPs) represent an extension of the standard model and may serve as a portal to a dark sector. At the high-intensity e^+e^- collider SuperKEKB, ALPs could be produced in direct e^+e^- interactions. For low masses, ALPs are predominantly produced via vector-boson fusion. Focusing on primarily electroweak couplings, specifically to photons, an interesting decay arises with $e^+e^- \to e^+e^-a$, $a \to \gamma\gamma$. This analysis investigates the sensitivity of Belle II for the given decay and its challenges which lie in the kinematic distribution of the final state particles - closely resembling radiative Bhabha-scattering. Considering the expectance of low lepton angles, the analysis considers 4 tag cases where either no, one positive/negative or both leptons are fully reconstructed. This talk will present the current status of the search and the complexities and advantages of each tag.

T 47.3 Wed 16:45 VG 0.110

Search for ALPs in $e^+e^- \to \gamma a, a \to \gamma\gamma$ at Belle II — •Alexander Heidelbach, Giacomo De Pietro, and Torben Ferber — Institute of Experimental Particle, Karlsruhe Institute of Technology, Karlsruhe, Germany

Axion-Like Particles (ALPs), predicted by theoretical extensions of the Standard Model, represent potential Dark Matter mediators. We are searching for the $e^+e^- \to \gamma a$ channel, with subsequent ALP decay into a photon pair, at the Belle II experiment. This study utilizes the Belle II detector's precision, the SuperKEKB collider's high luminosity, and a unique understanding of the initial state to explore a diverse range of ALP masses and couplings in this fully neutral three-photon final state.

Compared to the predecessor analysis based on the 2018 dataset, this analysis targets an around 1000 times larger dataset, an improved understanding of the photon reconstruction resolution, kinematic fits to the initial state, and an MVA-based candidate selection. This talk will discuss the current state of the new analysis.

T 47.4 Wed 17:00 VG 0.110

Search for the $K^+ \to \pi^+\pi^0 A$ decay — •Marco Ceoletta — Johannes Gutenberg Universitat, Mainz, Germany

This analysis aims to search for the hypothetical decay $K^+ \to \pi^+\pi^0 A$, where A is Feebly-Interacting Particle (FIP) like an Axion-like particle (ALP) or a Dark Photon, at the NA62 experiment (CERN). Obtaining a stringent upper limit on BR($K^+ \to \pi^+\pi^0 A$) is important for the verification of BSM theories. In particular the decay is sensitive to an axial-vector coupling of hypothetical pseudo-scalar particles to quarks. A search on $K^+ \to \pi^+\pi^0 A$ therefore complements the extensive work already performed on the associated two-body decay $K^+ \to \pi^+ A$, that is sensitive only to the polar-vector coupling current. A preliminary upper limit of the branching ratio to ALPs, as part of a feasibility study done in 2022, already outperformed the best previous limit using less than 20% of the available data. The presentation describes the analysis and gives an outlook on the selection and expected upper limits.

T 47.5 Wed 17:15 VG 0.110

Optimization of Background Determination Using Machine Learning with ATLAS Forward Proton Detector Data — •Andrei Aiurov, Viktoriia Lysenko, and Andre Sopczak — Czech Technical University in Prague

The neutral Standard Model Higgs boson was discovered in 2012 at CERN with a two-photon signature, and the search for further particles of extended models continues, in particular, the search for an Axion-Like-Particle (ALP). An ALP can be produced with a signature of two photons. The separation of ALP production from unwanted background reactions is crucial. In this analysis, the recorded data is used to determine the background expectation with machine learning algorithms to optimize the search for ALPs.

T 47.6 Wed 17:30 VG 0.110

Determination of the absolute X-ray detection efficiency of the TAXO SDD for IAXO — •Patrick Bongratz[1], Susanne Mertens[1,2], Lucinda Schönfeld[1], Daniel Siegmann[2], Juan Pablo Ulloa Beteta[2], and Christoph Wiesinger[2] for the IAXO-Collaboration — [1]Max Planck Institut für Kernphysik, Heidelberg, DE — [2]Physik-Department, Technische Universität München, Garching, DE

The International Axion Observatory (IAXO) aims to improve the search for solar axions by at least one order of magnitude with respect to previous helioscope experiments. In a helioscope experiment solar axions are back-converted to X-rays in a strong magnet pointed at the sun. Silicon drift detectors (SDDs) are particularly suited to detect this signal. Good noise performance allows for sub-keV thresholds, while a thin entrance window ensures high detection efficiency. In this talk, I will report on the TRISTAN SDD for IAXO (TAXO) project and the measurement of the absolute X-ray detection efficiency at the SOLEIL synchrotron facility. This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programme (grant agreement No. 852845).

T 47.7 Wed 17:45 VG 0.110

Development for an all semiconductor active-shield Detectors for IAXO — •Juan Pablo Ulloa Beteta[1], Susanne Mertens[2], Lucinda Schönfeld[2], Christoph Wiesinger[1], Michael Willers[1], and Patrick Bongratz[2] for the IAXO-Collaboration — [1]Physik- Department, Technische Universität München, Garching, DE — [2]Max Planck Institut für Kernphysik, Heidelberg, DE

The search for axions - a solution to the strong CP problem and a promising candidate for cold dark matter - is at the heart of the International Axion Observatory (IAXO). This next-generation helioscope experiment seeks to detect solar axions by converting them into X-ray photons. A critical challenge in achieving the required sensitivity for IAXO is the suppression of background caused by radioactivity and cosmic radiation. To address this, we are developing a novel all-semiconductor active-shield detector system. The system consists of a single-pixel Silicon Drift Detector (SDD) embedded within a High-Purity Germanium (HPGe) well-type detector, which serves as an active shielding to suppress background events. I will discuss the design progress and characterization studies of both the SDD and the HPGe detector, focusing on their energy resolution and noise performance. This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programme (grant agreement No. 852845). It has also been supported by the DFG through the Excellence Cluster ORIGINS.

T 47.8 Wed 18:00 VG 0.110

Searching for New Physics with Nuclear Lineshape Data — •Fiona Kirk — PTB Braunschweig Germany — Leibniz University Hannover

Because of its potential as a nuclear clock state, the exceptionally low-lying isomer thorium-229m has been the subject of intense research for several decades. Recently, this state was laser-excited for the first time, bringing us an important step closer to the realisation of nuclear clocks, but also opening up new possibilities to search for new physics that couples to the quantum chromodynamics (QCD) sector.

In this talk I will describe how new physics might affect the shape of the nuclear resonance, and explain how nuclear lineshape data can already today set competitive bounds on ultra-light dark matter coupling to the QCD sector, or more generally, on the time variation of the QCD scale.

T 48: Silicon Detectors V (R&D, Simulation)

Time: Wednesday 16:15–18:45 Location: VG 0.111

T 48.1 Wed 16:15 VG 0.111

Design and Production of Pixel Strip Modules for the P2 Tracking Detector — •Lucas Sebastian Binn for the P2-Collaboration — Institute of Nuclear Physics, Johannes Gutenberg-University Mainz

The P2 Experiment at the new Mainz Energy-Recovering Superconducting Accelerator (MESA), which is currently under construction in Mainz, will measure the weak mixing angle in electron-proton scattering at low momentum transfer with unprecedented precision.

A key parameter for the analysis, the momentum transfer Q^2, is measured by a tracking detector consisting of 4 identical modules arranged in two layers. Each module consists of two sensor planes, with pixel sensors glued and wire-bonded on rigid-flex strips.

The mechanical, electrical, and cooling design have been developed and are currently undergoing testing. For this purpose, a scaled-down protoype has been constructed.

With a total production of 260 strips, processes are semi-automated, with dedicated glue and bonding machines.

This talk gives an overview of the P2 experiment with focus on the tracking detector, as well as the current state of the development of the strip modules and readout.

T 48.2 Wed 16:30 VG 0.111

Validation of TCAD simulations of the edge of planar silicon sensors to understand breakdown — •Christian Scharf[1], Peilin Li[1], Heiko Lacker[1], Ingo Bloch[2], Ilona Stefana Ninca[2],

and Ben Brüers[2] — [1]Humboldt-Universität zu Berlin — [2]Deutsches Elektronen-Synchrotron (DESY)

Silicon sensors are widely used in high-energy physics due to their low material budget and radiation hardness. However, they are susceptible to surface breakdown, particularly under humid conditions. This study aims to improve the understanding of the underlying mechanisms by identifying the relevant defects contributing to electrical breakdown, and developing new methods to probe the electric field at the sensor's edge. Avalanche breakdown primarily occurs near the Si-SiO_2-interface, where localized electric field peaks can form between the guard ring and the edge. The local electric field is influenced by defects near the oxide surface and interface as well as the geometry of the sensor. Therefore, accurate simulations are challenging and it is essential to validate simulation parameters by comparing the simulation results to measurements.

The edge region of planar silicon diodes was simulated using Synopsis TCAD. Current, capacitance, and Transient Current Technique (TCT) simulations were performed and compared to measurements. Additionally, Allpix Squared simulations were used to determine whether the surface electric field near the edge can be extracted from top TCT measurements with 660 nm laser pulses using the prompt current method, similar to edge TCT.

T 48.3 Wed 16:45 VG 0.111

Open-Source Simulation of Semiconductor Detectors using SolidStateDetectors.jl — •Felix Hagemann, Julian Henzler, Benedikt Nagler, Ariana Pearson, and Oliver Schulz — Max Planck Institut für Physik, Garching, Deutschland

`SolidStateDetectors.jl` is a novel open-source software solution used to simulate the behavior of solid state detectors, e.g. germanium and silicon detectors. The package calculates the electric fields and weighting potentials, as well as the charge drift in the detectors and detector output signals.

Users can define arbitrary detector geometries via simple configuration files using constructive solid geometry. Detectors may also be segmented/pixelized and have more than two electrical contacts. The environment of the detector can be included in the geometry and the field calculation to simulate the effect of nearby objects on the field in detectors with large passivated surfaces.

`SolidStateDetectors.jl` features fully multi-threaded high-performance 3D field calculation in both cylindrical and Cartesian coordinates. Recent feature additions include simulation of the charge-cloud self-interactions, automatic detector capacitance calculation, GPU-support for accelerated field calculations, a simple charge trapping model and an extension to the Julia wrapper `Geant4.jl`, which allows for the simulation of realistic event distributions.

T 48.4 Wed 17:00 VG 0.111

Resistive Silicon Detector R&D for Future Detectors — •Ling Leander Grimm, Alexander Dierlamm, Umut Elicabuk, Ulrich Husemann, Markus Klute, and Brendan Regnery — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

The HL-LHC and future colliders present new challenges for the next generation of detectors, including improving pileup mitigation in high luminosity environments and particle identification. Resistive Silicon Detectors (RSDs/AC-LGADs) provide a promising solution by allowing "4D" tracking while minimizing power consumption, number of readout channels, and material budget.

RSDs combine Low Gain Avalanche Diode (LGAD) technology with a resistive cathode layer. Thanks to internal gain, the detector can be kept thin and therefore reduce material budget, while the resistive layer enables charge sharing among readout electrodes. As a result, the electrodes can be spaced further apart, which decreases the total number of required readout channels.

TCAD simulations aid in optimizing detector parameters and understanding internal functionality. Especially important is the determination of pad size and electrode shape.

This talk presents recent progress in Sentaurus TCAD simulations and experimental advances for RSD development at KIT and INFN/University of Torino.

T 48.5 Wed 17:15 VG 0.111

Measurements on the bPOL48V DC-DC Converter for a Future Particle Collider — Lutz Feld, Katja Klein, Martin Lipinski, Alexander Pauls, and •Joëlle Savelberg — 1. Physikalisches Institut B, RWTH Aachen

The bPOL48V is a DC-DC Point-Of-Load (POL) converter characterized in collaboration with CERN under the DRD7 program, a new Detector R&D initiative to develop future electronic systems and technologies for particle physics detectors. The bPOL48V enables power distribution by converting a 48V input to a 12V (adjustable) output voltage. This enables distribution at higher voltage and reduced current in supply cables, enhancing overall system efficiency by minimizing the power loss.

The bPOL48V consists of a rad-hard controller designed at CERN (GaN Controller), which is capable of continuous operation up to a high radiation limit of 50 Mrad and in magnetic fields exceeding 4 T. The GaN controller operates in conjunction with a power stage featuring a GaN chipset from EPC (EPC2152). This combination provides performance in harsh radiation and magnetic field environments, making it a potential solution for power distribution in high energy physics experiments.

This talk focuses on the tests conducted with the bPOL48V in various setups and the resulting performance. Key aspects include the converter's efficiency, temperature dependency, noise characteristics, and its ability to maintain a stable output voltage despite variations in input voltage and current.

T 48.6 Wed 17:30 VG 0.111

Characterisation and Simulation of stitched CMOS Strip Sensors — •Naomi Davis for the CMOS Strips Collaboration-Collaboration — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

In high-energy physics, there is a need to investigate silicon sensor concepts that offer large- area coverage and cost-efficiency for particle tracking detectors. Sensors based on CMOS imaging technology present a promising alternative silicon sensor concept. As this technology follows a standardised industry process, it can provide lower sensor production costs and enable fast and large-scale production from various vendors.

The CMOS Strips project is investigating passive CMOS strip sensors fabricated by LFoundry in a 150 nm technology. The stitching technique was employed to develop two different strip sensor formats. The strip implant layout varies in doping concentration and width, allowing to study various depletion concepts and electric field configurations.

The performance of unirradiated samples is evaluated based on several test beam campaigns conducted at the DESY II test beam facility. Additionally, the detector response is simulated using Monte Carlo methods combined with TCAD Device simulations.

This contribution presents studies on the test beam performance of the sensors concerning their hit detection efficiency and resolution. In particular, the simulated detector response is presented and compared to test beam data.

T 48.7 Wed 17:45 VG 0.111

A novel Low Gain Avalanche Diode design: MARTHA — •Constanze Wais[1], Alexander Bähr[2], J. Damore[2], Erika Garutti[1], Christian Koffmane[2], Jelena Ninkovic[2], Rainer Richter[2], Gerhard Schaller[2], Florian Schopper[2], Jörn Schwandt[1], Johannes Treis[2], and Annika Vauth[1] — [1]University of Hamburg — [2]Semiconductor Laboratory of the Max Planck Society

The MARTHA - 'Monolithic Array of Reach THrough Avalanche photo diodes' design aims to tackle the collapse of the electric field at the gaps of LGAD (low gain avalanche diode) pixel arrays while also preventing the pixel edges from becoming blind. By adding an additional n-doped field drop layer (FDL) between the multiplication layer and the n^+-pixel contacts, the electric field at the n^+-edges is reduced, thereby preventing them from breaking down. Since this FDL does not interrupt the multiplication layer, particle detection is also possible in the interpixel regions. A first prototype batch with test structures, such as diodes with and without a gain layer, and strip sensors based on the MARTHA principle has already been fabricated. The sensors are optimised for photon science and are expected to have a fill factor of 100%. In this talk the MARTHA concept as well as initial characterisation measurements, utilising I-V, C-V and TCT techniques, will be presented.

T 48.8 Wed 18:00 VG 0.111

Exploring the potential of 4H-SiC diodes: Electrical properties and electron-hole pair creation energy — •Silas Müller[1], Pascal Wolf[1], Patrick Ahlburg[1], Grégory Grosset[2], Tomasz Hemperek[1], and Jochen Dingfelder[1] — [1]University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany — [2]Ion Beam Services IBS, Rue Gaston Imbert prolongée, ZI Peynier Rousset, 13790 Peynier, France

Silicon detectors are often used as tracking detectors in high-energy physics experiments as they can be designed for high radiation tolerance, high granularity and fast readout needed in such experiments. Furthermore, silicon is well understood and widely available. Silicon carbide (SiC) exhibits promising characteristics for the use in high-energy physics as well. Its wide band gap of 3.23 eV results in low leakage current, allowing for operation at high temperatures. The high displacement energy of 30-40 eV compared to 13-15 eV in silicon results in potentially better radiation hardness.

This talk presents an investigation of the properties of a p-in-n 4H-SiC diode. Details regarding the electrical characteristics of the diode as well as measurements determining the energy needed to create electron-hole pairs in 4H-SiC are discussed.

T 48.9 Wed 18:15 VG 0.111

Wafer-to-wafer bonded hybrid pixel detectors for high energy physics and medical applications — Fabian Hügging[1], Kevin Kröninger[2], Maximilian Mucha[1], •Janna Vischer[2], and Jens Weingarten[2] — [1]Universität Bonn, Bonn, Germany — [2]Technische Universität Dortmund, Dortmund, Germany

Semiconductor pixel detectors allow for precisely tracking ionizing particles in high-energy physics experiments and medical applications. Previously, during the manufacturing of hybrid pixel detectors, a common practice to combine the separately manufactured sensor and its readout chip is to bump-bond two single dies together. Wafer-to-wafer bonding is a method in development for manufacturing hybrid pixel detectors, where whole detector wafers and chip wafers are bonded before being diced to their definite size. This promises detectors to have larger sensitive areas and a reduced thickness through thinning of the wafers after bonding. Currently, silicon sensor wafers have been developed for a combination with Timepix3 read-out chip wafers.

This talk will give an introduction to the first wafer-to-wafer semiconductor pixel detectors with a focus on the investigations of the still unbounded sensor wafer and a prospect of upcoming bonded wafer measurements.

T 48.10 Wed 18:30 VG 0.111

Test beam analysis of irradiated, passive CMOS strip sensors — •Fabian Lex for the CMOS Strips Collaboration-Collaboration — Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

Nearly all envisioned future high-energy particle detectors will employ silicon sensors as their main tracking devices. Due to the increased demand in performance, large areas of the detectors will have to be covered with radiation hard silicon, facilitating the need for silicon sensors produced in large quantities, reliably and cost-efficiently. A possible solution to these challenges has been found in the utilization of the CMOS process, which is an industrial standard, offering the advantage of a large choice of vendors and reduced production costs. To create the larger sensor structures typical for silicon strip trackers, the stitching process has to be used. Three variations of passive CMOS strip sensors have been designed by the University of Bonn and produced by LFoundry in a 150 nm process. Sensor samples have been irradiated up to a fluence of $1\cdot10^{16}\mathrm{n_{eq}/cm^2}$ with reactor neutrons and up to $1\cdot10^{15}\mathrm{n_{eq}/cm^2}$ with 23 GeV protons. In order to investigate the general performance of the designs, they were simulated with Sentaurus TCAD software and investigated in several test beam campaigns at the DESY-II facility. This talk will summarise the most important results of the simulation as well as the measurements of the irradiated samples.

T 49: Detectors IV (Scintillators)

Time: Wednesday 16:15–17:45 Location: VG 1.101

T 49.1 Wed 16:15 VG 1.101

Performance of Large Area Liquid Scintillator Detectors with Wavelength-shifting Optical Modules — •Andrés Krolla for the SHiP-SBT-Collaboration — ALU Freiburg, Physikalisches Institut, 79104 Freiburg (DE)

For the mitigation of background events caused by deep inelastic scattering of muons and neutrinos, a large volume tagger system is being developed. Main requirements are accurate timing information and positional reconstruction. The detector design is organic liquid scintillator based and uses immersed Wavelength-shifting Optical Modules for light collection. Of special interest is the efficiency and quality of the light collection depending on the choice of inner lining materials, which can be diffusely or specularly reflecting. Light yield heavily influences the positional reconstruction and requirements on data acquisition. Light yield measurements from detectors with barium-sulfate paint, PTFE or aluminum reflector foil coatings as well as untreated metal surfaces will be compared.

T 49.2 Wed 16:30 VG 1.101

Testbeam Performance and Signal Yields of Prototypes for the SHiP SBT — •Fairhurst Lyons for the SHiP-SBT-Collaboration — University of Freiburg, Freiburg, Germany

We present R&D towards the surrounding background tagger (SBT) of the Search for Hidden Particles (SHiP) experiment, a general-purpose detector housed at the CERN SPS accelerator to search for light, feebly interacting particles. This is a large-area detector for energy reconstruction and tracking, which consists of many individual cells filled with liquid scintillator. Each cell is equipped with two wavelength-shifting optical modules (WOMs) that capture scintillation light and transfer it to silicon photomultipliers. Multiple such cells with different detector materials were tested at a CERN SPS μ^- testbeam; analysis of performance and comparison with simulation will be presented here.

T 49.3 Wed 16:45 VG 1.101

Testbeam measurements with prototypes of the Surrounding Background Tagger of the SHiP experiment — •Alessia Brignoli for the SHiP-SBT-Collaboration — Humboldt Universität zu Berlin

The Surrounding Background Tagger (SBT) is a crucial part of the SHiP experiment to suppress background from muons entering the decay vessel of the experiment or from muon/neutrino inelastic interactions inside the decay volume and its surroundings. The SBT is based on liquid scintillator (LAB+PPO) filled cells. Light collection is performed through PMMA Wavelength-Shifting Optical Modules (WOMs), optically coupled to an array of 40 SiPMs. We present results obtained with different prototypes. The first four-cells prototype, improving of a one-cell prototype that was tested with positrons in October 2022 at DESY, was tested in spring 2024 with muons at CERN's PS. Three one-cell prototypes that were tested with muons in CERN's PS in November 2024. The different prototyes differ in the cell construction material, steel or aluminium, as well as the material used for increasing the inner walls reflectivity, crucial for the light collection. For all the prototypes, each cell was equipped with two WOM tubes. The timing performance of the detector, which is important for the background rejection capabilities of the final SBT detector, was studied. In parallel, the comparison of data with Geant4-based photon transportation simulations results allows us to gather further information about the detector response and the quality of the built prototypes.

T 49.4 Wed 17:00 VG 1.101

On Calibration and Timing of the Mu3e Tile Detector — •Erik Steinkamp for the Mu3e-Collaboration — Kirchhoff-Institut für Physik, Heidelberg, Deutschland

The Mu3e experiment has been designed with the objective of detecting the charged lepton flavour violating decay $\mu \to eee$ with a branching ratio sensitivity of 10^{-16}, which represents the final goal for the second phase of the experiment. This would represent a four-order-of-magnitude improvement on the current limit. The primary challenge associated with the Mu3e detector is excellent background suppression. This necessitates, in addition to precise vertexing and tracking using monolithic pixel sensors, the acquisition of highly precise timing data.

The Mu3e tile detector is a scintillator-based timing detector with SiPM readout that aims at a timing resolution of less than 100 ps. In order to guarantee this level of performance, it is essential to conduct a precise calibration of the detector. This presentation will focus on the calibration process, which is primarily concerned with the configuration of the readout electronics, particularly the MuTRiG ASICs, which are responsible for SiPM readout and digitization. Furthermore, the time-walk effect, which is caused by the non-linear response of the scintillator material, in addition to the time synchronisation must be realized between the various channels within and between the ASICs. In order to evaluate the timing resolution of the detector, calibration and time walk correction methods are applied to test beam data taken at DESY. The resulting performance studies and the evaluation of the detector's timing resolution will be presented.

T 49.5 Wed 17:15 VG 1.101

Timing characterization for T2K ND280Upgrade detector — •Gioele Reina — Johannes Gutenberg- Universität Mainz

The T2K experiment is a long baseline neutrino experiment, located in Japan. It studies neutrino oscillations by detecting accelerator neutrinos with a complex of near detectors and a far detector. ND280, one of the near detectors, provides a reduction of the neutrino flux and cross section uncertainties.

The new features of the upgraded ND280 detector allow to improve these capabilities. In particular, the newly installed target, the Super Fine-Grained Detector, consists of small plastic scintillator cubes read out by three WLS fibers in the three orthogonal directions. This new detector design offers high granularity and 3D reconstruction, unlocking the sensitivity to neutron detection and reconstruction by measuring its time of flight in the detector.

In such a context, the timing characterization of this detector is crucial. Here, a new methodology to perform time calibration for any high granular detector is described. By exploiting the granularity of the detector, it is possible to evaluate offsets and time walk contributions, along with the time resolution of the detector. The application and the results of this method are presented, allowing the upgraded ND280 to detect neutrons.

T 49.6 Wed 17:30 VG 1.101

Characterisation of hybrid-opaque scintillators for the *NuDoubt*$^{++}$ experiment — •Miriam Weigand for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz, Institut für Physik, 55128 Mainz, Germany

The *NuDoubt*$^{++}$ experiment is dedicated to the advanced search for double beta plus decay ($2\beta^+$), a rare nuclear disintegration process with an extremely long half-life of 10^{18} to 10^{24} years. In the Standard Model (SM), each double beta decay ($2\nu 2\beta^+$) produces two neutrinos, but there is also the possibility of non-SM neutrino-less double beta decays ($0\nu 2\beta^+$), which would suggest the Majorana nature of the neutrino.

Central to the *NuDoubt*$^{++}$ effort is the development of an innovative detector concept based on a hybrid, slow and opaque liquid scintillator loaded with the $2\beta^+$-decaying isotope. The hybrid scintillator uses slow light emission to enhance the detection of the Cherenkov and scintillation light, which allows the distinction of particle types. Wax is added to create an opaque scintillator that locally confines the produced photons. A grid of Optimised WaveLength-shifting (OWL) fibres is distributed throughout the detector to collect the light and allow detailed energy deposition patterns to be reconstructed.

This talk will discuss the demonstrator setup designed to test the new detector concept and to improve the composition and interplay of the components used.

T 50: Detectors V (Misc.)

Time: Wednesday 16:15–17:15 Location: VG 1.102

T 50.1 Wed 16:15 VG 1.102

Progress and Results of the AMoRE: Exploring Neutrinoless Double-Beta Decay with Molybdate Scintillators — •Cagla Mahanoglu, Christian Enss, Andreas Fleischmann, Daniel Hengstler, Ashish Jadhav, Ioana-Alexandra Nitu, Christian Ritter, Andreas Reifenberger, Daniel Unger, and Loredana Gastaldo — Kirchhoff Institute for Physics, Heidelberg University

The Advanced Molybdenum-based Rare process Experiment (AMoRE) aims to search for neutrinoless double-beta ($0\nu\beta\beta$) decay of the ^{100}Mo isotope using molybdate scintillating crystals. This rare nuclear process, if observed, would confirm the Majorana nature of neutrinos, provide insight into the absolute neutrino mass scale, and reveal new physics beyond the Standard Model. The experiment makes use of metallic magnetic calorimeter (MMC) sensors to achieve high energy resolution and efficient particle discrimination. AMoRE operates in three phases: AMoRE-Pilot (1.887 kg detector, 0.886 kg of ^{100}Mo), AMoRE-I (6 kg array of ^{100}Mo-enriched crystals), and AMoRE-II (large-scale 200 kg array at the Yemilab underground facility). Results from AMoRE-Pilot set a limit on the half-life of $T_{1/2} > 9.5 \times 10^{22}$ years. In AMoRE-I, a new lower limit of $T_{1/2} > 3.0 \times 10^{24}$ years (at the 90 percent confidence level) was achieved. The aim of AMoRE-II is to reach a sensitivity of $T_{1/2} > 6 \times 10^{26}$ years, which would cover the entire inverted Majorana neutrino mass hierarchy range of (15-46) meV. This talk will highlight the current status of the AMoRE, innovative advancements in detector design and optimization of analysis techniques.

T 50.2 Wed 16:30 VG 1.102

Strong-field QED measurement tests at FACET-II using new electron detector concept — •Luke Hendriks[1,3], Antonios Athanassiadis[1,2], Louis Helary[1], Ruth Magdalena Jacobs[1], Jenny List[1], Gudrid Moortgat-Pick[2], Evan Ranken[1], Ivo Schulthess[1], Matthew Wing[1,3], and E320 Collaboration[4] — [1]Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany — [2]Universität Hamburg, Hamburg, Germany — [3]University College London (UCL), London, United Kingdom — [4]SLAC National Accelerator Laboratory, Menlo Park, California, United States

Strong-Field Quantum Electrodynamics (SFQED) is an emergent field of physics, where conventional quantum electrodynamics calculations become non-perturbative due to a strong electromagnetic background field. This gives rise to non-linear Compton scattering and non-linear Breit-Wheeler pair production. Advances in laser technology have made it possible to explore this field, by colliding photons from a high-intensity laser with a high-energy electron beam. One of the experiments that will measure SFQED phenomena is LUXE, an experiment planned at DESY. Part of LUXE is its electron detection system (EDS), which will measure high rates of electrons coming from electron-laser interactions. It consists of a segmented straw Cherenkov detector, and a scintillator screen and camera set-up. A prototype of the EDS has recently made measurements with E320, an SFQED experiment at the FACET-II facility at SLAC, where it measured non-linear Compton scattering. This talk will discuss the prototype of the EDS and the first results obtained from the measurements at E320.

T 50.3 Wed 16:45 VG 1.102

Current status of the Mu2e experiment at Fermilab — •Stefan E. Müller, Anna Ferrari, Oliver Knodel, and Reuven Rachamin for the Mu2e-Collaboration — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The Mu2e experiment, which is currently under construction at the Fermi National Accelerator Laboratory near Chicago, will search for the neutrinoless direct conversion of a muon to an electron in the field of an aluminum nucleus, aiming at a sensitivity four orders of magnitude better than previous experiments. The observation of a signal would imply the violation of charged lepton flavor, and hint at physics beyond the standard model.

The design and status of the Mu2e experiment and its detector subsystems will be presented. With the large superconducting solenoid magnets guiding the muons finally arriving on site at Fermilab, the experiment enters an exciting phase of its construction towards data taking.

T 50.4 Wed 17:00 VG 1.102

On the Production and QA of the Mu3e Tile Detector — •Küpperbusch Jan for the Mu3e-Collaboration — Kirchhoff-Institut für Physik, Heidelberg, Deutschland

The Mu3e experiment aims to find or exclude the occurrence of the decay $\mu^+ \to e^+e^-e^+$ with a sensitivity of $\mathcal{O}(10^{-15})$ in phase I and $\mathcal{O}(10^{-16})$ in phase II. In order to achieve this, the Mu3e experiment will be conducted at the Paul-Scherrer-Institute (PSI) utilizing the high rate muon beam (10^8 Hz in Phase I).

The Scintillating Tile Detector is one of the timing detector systems aiming to perform with a resolution of $< 100\,\mathrm{ps}$ and is located at the two outer stations. It consists of organic scintillators precisely milled into tiles with a surface profile of roughly $5 \times 5\,\mathrm{mm}^2$. The tiles are wrapped in highly-reflective foil, glued to a Silicon Photomultiplier (SiPM) and read out by the MuTRiG, an application-specific integrated circuit (ASIC) which was developed for the Mu3e timing systems. Individual Channels are geometrically grouped onto separate PCB matrices hosting 4×4 channels, which simplifies production, calibration and quality assurance.

The talk will report on the quality assurance measurements of around 3200 individual channels including bare characterization of the SiPMs, as well as measurements of the finite assembled matrices with scintillator tiles.

T 51: Top Physics III (Cross Sections, Entanglement)

Time: Wednesday 16:15–18:15 Location: VG 1.103

T 51.1 Wed 16:15 VG 1.103

Measurement of the $t\bar{t}$ cross-section in the lepton+jets channel using pp collision data at $\sqrt{s} = 13.6$ TeV with the ATLAS experiment — •Noah Scheugenpflug and Andrea Knue — TU Dortmund

In this contribution, the measurement of the top-quark pair production cross-section in the lepton+jets channel for proton-proton collision data at $\sqrt{s} = 13.6$ TeV is studied. The data was recorded with the ATLAS detector at the LHC in 2022 and corresponds to an integrated luminosity of 29 fb-1. The cross-section is extracted using a profile likelihood fit. The configuration of the fit is validated by performing an Asimov fit. Events with exactly one electron or muon, at least four jets, with one or two of the jets being b-tagged, and missing transverse momentum are selected and divided into three signal regions according to their jet and b-tagged jet multiplicities. For each region, the signal-to-background separation power of a multitude of kinematic variables is studied. A selection of these variables is analyzed with respect to systematic uncertainties. The uncertainty is dominated by the luminosity and the $t\bar{t}$ signal modelling uncertainty.

T 51.2 Wed 16:30 VG 1.103

Observation of top-quark pair production in lead-lead collisions in the ATLAS experiment at the LHC — Anthony Badea[1], Weronika Bulanowska[2], Iwona Grabowska-Bołd[2], Santu Mondal[3], •Patrycja Potepa[2,4], and Matthias Schott[4] — [1]Harvard University, United States — [2]AGH University of Krakow, Poland — [3]Czech Technical University in Prague, Czech Republic — [4]Johannes Gutenberg University Mainz, Germany

In relativistic heavy-ion collisions, top quarks are expected to be attractive candidates for probing the quark-gluon plasma as well as to bring unique information about the time evolution of strongly interacting matter. We report the first observation of top-quark pair production in lead-lead collisions at the centre-of-mass energy of 5.02 TeV in the ATLAS experiment at the LHC. The dataset was recorded in 2015 and 2018, amounting to an integrated luminosity of 1.9 nb^{-1}. Top-quark pair production is measured in the $e\mu$ channel, with a significance of 5.0 standard deviations. The result is compared to theory predictions based on different nuclear PDF sets.

T 51.3 Wed 16:45 VG 1.103

Studies of top quark pair production with the CMS experiment in the dilepton decay channel including the boosted region — •Iakov Andreev and Olaf Behnke — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

We present an ongoing analysis of differential cross section measurements for top-pair ($t\bar{t}$) production in proton-proton collisions at a center-of-mass energy of 13 TeV, using events containing two oppositely charged leptons. The data were recorded with the CMS detector at the CERN LHC. We study kinematic distributions of the $t\bar{t}$ system, the top quark and antiquark and their decay products. For the first time in differential cross section measurements in the dilepton channel, the phase space includes events with highly boosted top quarks (with momenta above several hundred GeV). This phase space is characterised by small angular separations between the leptons and the b jets originating from the top quark decays. This necessitates the inclusion of non-isolated prompt muons and electrons in both the online trigger and the offline analysis. The talk presents the basic event selection and the adaptations made to include the region of boosted top quarks. Initial kinematic distributions are presented alongside estimates of signal and background processes.

T 51.4 Wed 17:00 VG 1.103

Towards the measurement of $t\bar{t}$ spin correlations using dilepton final states in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], Arpan Ghosal[1], Gabriel Gomes[1], Jan Joachim Hahn[1], Vadim Kostyukhin[1], Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], •Sebastian Rentschler[1], Elisabeth Schopf[1], Katharina Voss[1], Wolfgang Walkowiak[1], Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

The top quark is the heaviest known elementary particle and it decays before hadronizing. Consequently, measurements of the angular distributions of top quark decay products give access to the spin of the top quark, allowing the precise testing of perturbative QCD in the top quark- antiquark pair ($t\bar{t}$) production process. In this contributions first studies towards the measurement of the $t\bar{t}$ spin correlations are presented using the data collected using proton-protons collisions at a centre-of-mass energy of 13 TeV. The data correspond to an integrated luminosity of 140 fb^{-1} collected with the ATLAS detector. The measurements are performed using events with two oppositely charged leptons (electrons or muons) and two or more jets, where at least one of the jets is identified as originating from a bottom quark. The spin correlations are measured from the angular distributions of the two selected leptons.

T 51.5 Wed 17:15 VG 1.103

Measurement of $t\bar{t}$ spin entanglement in the lepton+jets channel in ATLAS — Katharina Behr, Eleanor Jones, and •Fiona Ann Jolly — DESY, Hamburg, Germany

The top quark, one of the heaviest known elementary particles, is mostly produced in pairs ($t\bar{t}$) at the LHC. These $t\bar{t}$ final states are sensitive to characteristic quantum effects such as quantum entanglement of $t\bar{t}$ spins. One of the kinematic regions most sensitive to entanglement is characterised by low values of the invariant mass of the $t\bar{t}$ system, just above the kinematic 'turn-on' for $t\bar{t}$ production ($m_{t\bar{t}} \geq 2m_t$) The presence of entanglement is probed via a high-precision measurement of an angular variable sensitive to the $t\bar{t}$ spin correlation in this region.

In this talk, sensitivity studies for using the lepton+jets $t\bar{t}$ decay channel for quantum entanglement measurements in the $m_{t\bar{t}}$ threshold region are presented. The calculation of the relevant angular variable relies on the identification of the down-type quark jet coming from the W boson decay, which has the highest spin-analysing power among the hadronic top quark decay products. Furthermore, the potential effects of a possible $t\bar{t}$ quasi-bound state in the turn-on region, known as "toponium", are discussed.

T 51.6 Wed 17:30 VG 1.103

Quantum Entanglement in Top Quark Pairs in the Lepton + Jets Channel Using Boosted Topologies — •Jannis Vornholt and Andrea Knue — TU Dortmund

Quantum entanglement, a fundamental prediction of quantum mechanics, had been experimentally observed with electrons and photons, earning recognition through the 2022 Nobel Prize in Physics. At the LHC, this phenomenon had been observed in top quark pairs at production threshold in 2023, providing a high-energy test of quantum mechanics. A test of quantum entanglement of top quark pairs is also possible at high $m_{t\bar{t}}$ at the LHC and is the topic of this talk. The lepton + jets channel is considered, whereby the hadronically decaying top quark is reconstructed as a large radius jet.

The angle between the decay products of the top quarks can be used

as indicator for quantum entanglement. First reconstructed properties are discussed.
The presented studies are performed with ATLAS Monte Carlo simulations under Run 2 conditions.

T 51.7 Wed 17:45 VG 1.103

Measurement of the differential t-channel production cross-section of single top quarks and top antiquarks in proton-proton collisions at 13 TeV using the full Run 2 dataset recorded with the ATLAS detector — Dominic Hirschbühl, Lukas Kretschmann, •Maren Stratmann, and Wolfgang Wagner — Bergische Universität Wuppertal, Wuppertal, Deutschland

The t-channel production is the dominant process for single top quark and single top antiquark production at the LHC. The measurement of the differential cross section can contribute to constraining proton PDFs and has not been measured with the full Run 2 dataset up to date. This measurement uses the full Run 2 dataset recorded with the ATLAS detector in the years 2015-2018. The differential production cross-sections of the top-quark and top-antiquark as well as their ratio are measured on parton level as a function of the transverse momentum p_{T} and rapidity $|y|$ of the top quark.

T 51.8 Wed 18:00 VG 1.103

Measurement of differential cross sections in the process $pp \to W^+W^-b\bar{b}$ — Daniel Britzger[1], •Johannes Hessler[1,2], and Stefan Kluth[1] — [1]Max Planck Institute for Physics, Garching, Germany — [2]Technical University Munich, Garching, Germany

Precise measurements of differential cross sections in the process $pp \to W^+W^-b\bar{b}$ offer an outstandingly rich physics potential at highest precision. Although the process is theoretically and experimentally well defined, dedicated measurements of $W^+W^-b\bar{b}$ production cross sections were not (extensively) performed in the past at the LHC. We will report on ongoing measurements in the single-lepton channel with Run-II data taken by the ATLAS experiment. The analysis comprises three signal regions, focusing on the interference between $t\bar{t}$ and tW processes, the explicit reconstruction of the kinematics of the $WbWb$ system and on phase spaces motivated by BSM searches.

T 52: Flavour Physics III

Time: Wednesday 16:15–18:15 Location: VG 1.104

T 52.1 Wed 16:15 VG 1.104

Measurement of the $\pi^0 \to e^+e^-\gamma$ decay at NA62 — •Célia Polivka — Johannes Gutenberg-Universität Mainz

The current value for the $\pi^0_D \to e^+e^-\gamma$ Dalitz decay is $\mathcal{B}r(\pi^0_D) = (1.174 \pm 0.035) \cdot 10^{-2}$ and has a large uncertainty. This is a limiting factor for other measurements that use the Dalitz decay as normalisation channel. This analysis aims to improve the precision on this measurement using data from the NA62 experiment at CERN. The π^0 mesons are tagged by $K^+ \to \pi^+\pi^0$ decays. The π^0_D is then identified by reconstruction of the three track vertex of e^+, e^- and π^+. Presented are the status of the analysis and an outlook on the precision of the measurement.

T 52.2 Wed 16:30 VG 1.104

Semileptonic Kaon decays in NA62 — •Atakan Akmete — Mainz University

The semileptonic charged kaon decays $K^+ \to \pi^0\ell^+\nu(\gamma)$ ($K_{\ell 3}$) provide a clean way to test the e-μ lepton universality and probe the first row unitarity $|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 1$ of the CKM matrix. Current results indicate a tension, known as the Cabibbo angle anomaly.

This work aims to update the branching fractions of $K_{\ell 3}$ decays, along with the other main K^+ decay channels using a minimum bias low-intensity dataset collected by the NA62 experiment (CERN) in 2024. This dataset offers high statistics in a clean environment. The measurement is performed by analyzing single positively charged tracks, allowing all six main decay modes to be measured simultaneously.

In this talk, I will present the current status of the analysis, including the expected precision on the branching fractions.

T 52.3 Wed 16:45 VG 1.104

The Anatomy of $K^+ \to \pi^+\nu\nu$ distributions — •Kai Henryk Sieja[1], Emmanuel Stamou[1], Mustafa Tabet[1], Martin Gorbahn[1,2], and Ulserik Moldanazarova[2,3] — [1]TU Dortmund University, Germany — [2]University of Liverpool, United Kingdom — [3]Karaganda Buketov University, Kazakhstan

The rare decays $K^+ \to \pi^+\nu\nu$ and $K_L \to \pi^0\nu\nu$ are among the strongest probes of Beyond-the-Standard-Model dynamics with new sources of quark-flavour violation. These decays are thus the main target for the dedicated experiments NA62 and KOTO, with new data published in 2024 by NA62. Different New Physics scenarios can have an distinctive effect on the NA62 distributions. We analyze the impact of lepton-number violating or conserving dimension-six operators on the experimentally accessible distributions within the LEFT framework. Concrete New Physics models can induce operators with different chirality, i.e., vector-, scalar, tensor-type operators, and different neutrino flavour structure. Using all published data from NA62, we assess the impact of a combined binned likelihood analysis in constraining the New Physics parameter space and how this varies for different operator types, as well as the competitiveness of correlated constraints within SMEFT.

T 52.4 Wed 17:00 VG 1.104

Charm-Quark Mass in the Heavy Quark Expansion — •Anastasia Boushmelev[1], Thomas Mannel[1], and K. Keri Vos[2] — [1]Theoretische Physik 1, Center for Particle Physics Siegen Universität Siegen, D-57068 Siegen, Germany — [2]Gravitational Waves and Fundamental Physics (GWFP), Maastricht University, Duboisdomein 30, NL-6229 GT Maastricht, the Netherlands and Nikhef, Science Park 105, NL-1098 XG Amsterdam, the Netherlands

The Heavy Quark Expansion is a powerful framework for making predictions for inclusive heavy hadron decays. It provides a method to calculate decay rates and spectra as a double expansion in powers of $\Lambda_{\mathrm{QCD}}/m_Q$ and $\alpha_s(m_Q)$ and is well established for b-decays enabling precise predictions for various observables. In this context, the quark mass in an appropriate scheme is determined with sub-percent precision, and $\alpha_s(m_Q)$ is as low as 0.1.
Though, considering the charm sector, the treatment of the quark mass has to be further investigated as these mass schemes are not suitable in this case. Here we suggest to replace the charm mass, as well as further non-perturbative quantities, directly by q^2 moments based on a similar strategy applied on b-decays using e^+e^- inverse moments studied in [1]. Following this strategy we study the impact on the perturbative series of q^2 moments, as well as the total rate.

[1] A. Boushmelev, T. Mannel and K. K. Vos, JHEP 07 (2023), 175 doi:10.1007/JHEP07(2023)175 [arXiv:2301.05607 [hep-ph]].

T 52.5 Wed 17:15 VG 1.104

Measurements of mixing parameters and search for CP violation in mixing using multibody charm hadron decays at LHCb — •Florian Reiss and Marco Gersabeck — Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

The large samples of charm hadrons collected by the LHCb experiment facilitates the measurement of the charm mixing parameters and the search for charge and parity symmetry violating (CPV) effects with high precision. Multi-body charm hadron decays are of particular interest, as the interference of intermediate resonances can enhance CPV effects in certain regions of the phase space of the decay.

We present studies performed with model-dependent approaches to describe the contribution of the intermediate resonances to the overall decay amplitude as a function of phase space and decay time to extract the parameters of interest. The acceleration of these analyses using Graphics Processing Units is demonstrated and the expected sensitivity of ongoing measurements is shown.

T 52.6 Wed 17:30 VG 1.104

Early measurement of charm mesons production asymmetries at LHCb in Run 3 — •Luca Balzani[1], Laurent Dufour[2], Paula Herrero Gascon[3], Serena Maccolini[1], Dominik Stefan Mitzel[1], Sascha Stahl[2], Giulia Tuci[3], and Francesco Zenesini[4] — [1]TU Dortmund University, Dortmund, Germany —

[2]CERN, Geneva, Switzerland — [3]Heidelberg University, Heidelberg, Germany — [4]University of Bologna, Bologna, Italy

Ahead of Run 3 of the LHC, the LHCb detector was profoundly upgraded to leverage the programmed increase in luminosity. Studying the features of the upgraded detector is of paramount importance in order to reliably perform measurements.

Production asymmetries are observables which depend on the colliding system characteristics but shall not be influenced by experimental effects. Having these latter contributions under control is essential to perform a consistent measurement. This makes production asymmetries ideal candidates to investigate the characteristics of the new LHCb detector. Being one of the first measurements done with the new data, it will also provide useful insights for their validation. Precise measurements of production asymmetries also allow for a better understanding of QCD models used in Monte Carlo generators, especially in the high-rapidity region. Finally, this analysis will lead to the first measurement of neutral charm meson production asymmetry for proton-proton collisions at the LHC energies. This contribution will discuss the general strategy and the techniques used for the measurement.

T 52.7 Wed 17:45 VG 1.104

Studies of CP violation in $D^0 \to \pi^+\pi^-\pi^0$ decays with the energy test method using LHCb Run 3 data — •Todor Todorov, Marco Gersabeck, Evelina Gersabeck, Florian Reiss, and Jan Karch — Albert-Ludwigs-Universität Freiburg, Freiburg im Breisgau, Germany

The standard model prediction for CP violation in the charm sector is relatively small and has a magnitude of the order of $\mathcal{O}(10^{-3} - 10^{-4})$. An observation of such violation has been made by the LHCb collaboration in $D^0 \to hh$ decays, but this remains the only significant experimental evidence. $D^0 \to \pi^+\pi^-\pi^0$ decays offer a promising candidate for studies of CP asymmetries, because they proceed via the same electroweak decay mode as the observation channel. Multibody decays also provide a 2 dimensional phase-space where different local contributions to CP violation can be observed even in the case of global CP symmetry. The energy test statistical method is chosen to search for local CP asymmetries due to its independence of model and choice of binning. An early study of the application of this statistical test to LHCb Run 3 data is presented, which is projected to benefit from a four-fold increase in data sample size in comparison to previous LHCb analyses.

T 52.8 Wed 18:00 VG 1.104

Studies of angular and CP asymmetries in $D^+_{(s)} \to h^+\mu^+\mu^-$ decays at LHCb — •Luca Toscano, Dominik Mitzel, and Serena Maccolini — TU Dortmund

The LHCb experiment has recorded the world's largest sample of charm hadron decays and takes a leading role in measurements of rare decays and searches for CP violation.

Rare semi-leptonic charm decays such as $D^+ \to \pi^+\mu^+\mu^-$ and $D^+_s \to K^+\mu^+\mu^-$ are sensitive to beyond-standard-model effects in flavour-changing neutral current $c \to u\mu^+\mu^-$ transitions. Observables such as angular and CP asymmetries, can be defined to test the Standard Model. Null tests on these observables are performed in the vicinity of intermediate hadronic resonances, where new physics signals can be enhanced.

In this talk, the first study of angular distributions and CP asymmetries in $D^+_{(s)} \to h^+\mu^+\mu^-$ decays is presented. The analysis uses data collected by the LHCb detector from 2015 to 2018 at a centre-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 6fb^{-1}. The preliminary results are showed.

T 53: Neutrino Astronomy III

Time: Wednesday 16:15–18:15 Location: VG 1.105

T 53.1 Wed 16:15 VG 1.105

A bayesian approach to study the multimessenger emission from AGN-starburst galaxies* — •Silvia Salvatore[1,2], Bjoern Eichmann[1,2], and Julia Becker-Tjus[1,2] — [1]Theoretische Physik IV, Ruhr Universität Bochum, Bochum, Germany — [2]RAPP-Center at Ruhr Universität Bochum, Bochum, Germany

Active Galactic Nuclei (AGN) and starburst galaxies are multimessenger sources in the Universe, emitting from radio/infrared energies to gamma-ray and neutrino energies. NGC 1068 is a Seyfert II galaxy with a starburst ring that has been proven to emit the neutrinos detected by Icecube through hadronic processes most likely happening in the AGN corona. Two high-energy neutrinos with high probability of being of astrophysical origin have recently been reported by IceCube from the direction of NGC7469 as well. In this presentation, we model the different environments of these AGN-starburst composite sources and constrain the main parameters for the AGN and starburst environments using a Monte Carlo bayesian approach, where we include the data from radio to TeV energies*Supported by DFG (SFB 1491).

T 53.2 Wed 16:30 VG 1.105

Constraining the contribution of Seyfert galaxies to the astrophysical neutrino flux using NGC 1068 as a benchmark — •Lena Saurenhaus[1], Francesca Capel[1], and Foteini Oikonomou[2] — [1]Max-Planck-Institut für Physik, 85748 Garching b. München, Germany — [2]Norwegian University of Science and Technology (NTNU), Institutt for fysikk, 7491 Trondheim, Norway

Recently, the IceCube Collaboration reported evidence for TeV neutrino emission from several nearby Seyfert galaxies, with the highest significance found for NGC 1068. The lack of observable gamma rays at TeV energies associated with NGC 1068 suggests that these neutrinos are likely produced in the AGN corona, which is opaque to high-energy gamma rays. Based on this assumption, we simulate the neutrino emission of Seyfert galaxies with different X-ray properties and fit the resulting neutrino spectrum for NGC 1068 to public IceCube data. Using the result of this fit as a benchmark, we extrapolate our model to an entire population of sources simulated based on the X-ray luminosity function of AGNs and estimate the resulting diffuse neutrino flux. By comparing our results with observations, we derive constraints on the neutrino emission properties of the source population and find that NGC 1068 has to be a particularly powerful Seyfert galaxy. In addition, we use our model to evaluate the detection prospects of other nearby Seyfert galaxies besides NGC 1068 in order to obtain a coherent picture of the contribution of these sources to astrophysical neutrino observations.

T 53.3 Wed 16:45 VG 1.105

IFT on ice: Utilizing numerical information field theory to reconstruct glacial ice parameters — •Matthias Hübl, Laurin Söding, and Philipp Mertsch — Institute for Theoretical Particle Physics and Cosmology (RWTH Aachen University)

Due to their small interaction cross-sections, the detection of high-energy neutrinos requires the use of large, natural detection volumes, like glacial ice in the case of the IceCube Neutrino Observatory. In order to extract precise information from the light that is produced by high energy neutrinos, it has to be calibrated as accurately as possible. This means in particular that the ice properties such as scattering and absorption lengths for propagating photons should be known with high accuracy and spatial resolution. Information Field Theory (IFT) adopts a Bayesian approach, building on methods from different fields of physics, especially field theory and statistical physics. The python package NIFTy (Numerical Information Field Theory) uses the concepts of IFT and implements a variational inference approach in order to reconstruct parameter fields. This is both more robust than maximum-likelihood methods and allows determining the uncertainties of the inferred fields at the same time. Here, we present two approaches for modelling the light propagation in ice that can be interfaced with NIFTy: a differentiable Monte Carlo simulation and a finite-difference code. We compare the performance of both methods and characterise the reconstruction of a mock ice model.

T 53.4 Wed 17:00 VG 1.105

Search for Ultra-High Energy Neutrinos from Gamma-Ray Bursts with the Pierre Auger Observatory — •Therese Paulsen for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Germany

Primarily designed to detect ultra-high energy (UHE) cosmic rays, the

Pierre Auger Observatory also possesses excellent sensitivity to UHE neutrinos. The Surface Detector array is used to search for highly inclined neutrino-induced air showers, which, though not observed yet, have clear characteristic signatures. Due to the null observation of UHE neutrinos, we can construct upper luminosity limits on each gamma-ray burst within the Observatory's field of view.

As the neutrino luminosity from these sources strongly depends on the modeled emission mechanisms and dissipative processes, we construct these upper limits using different neutrino spectra corresponding to distinct scenarios, for example, the one-zone fireball model. The spectra is constructed using the source code *Cosmic Ray Stochastic Interactions for Propagation* (CRISP), to compute quantities related to the propagation of heavier primaries within the source environment.

T 53.5 Wed 17:15 VG 1.105

Ultra-high-energy neutrino detection with radio antennas in the ground based observatory — •Baobiao Yue — Bergische Universität Wuppertal, Wuppertal. Germany

The detection of Ultra-High-Energy (UHE) neutrinos offers a unique opportunity to unravel the mysteries surrounding the astrophysical origins of the universe's most energetic cosmic rays. Radio detection provides significant advantages for detecting highly inclined air showers induced by UHE neutrinos, including a larger exposure range compared to particle detectors and a precise reconstruction. Furthermore, this technique improves the air shower longitudinal reconstruction, which can be used to identify neutrinos with their first interaction far below the top of the atmosphere.

The Pierre Auger Observatory is the largest instrument with radio antennas for measuring air showers produced by UHE cosmic rays and neutrinos. In this work, we use it as an example of a ground-based observatory to study UHE neutrino detection. We demonstrate how the integration of radio antennas enhances UHE neutrino detection capabilities and facilitates classification. Since shower reconstruction using radio emissions is central for neutrino identification in this work, we will emphasize the method developed for detecting inclined air showers induced by neutrinos. Finally, we present the expected neutrino detection sensitivity achievable with the radio antennas alone.

T 53.6 Wed 17:30 VG 1.105

Enhancing Sensitivity for Ultra-High Energy Down-Going Neutrino Detection with the Pierre Auger Observatory* — •Srijan Sehgal for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Wuppertal, Germany

The Pierre Auger Observatory, originally conceived to study the properties of cosmic rays, also has the capability to identify neutrino-induced extensive air showers above 10^{17} eV by using its large Surface Detector (SD) array. Two new SD triggers, Time-over-Threshold-deconvolved (ToTd) and Multiplicity-of-Positive Steps (MoPS), installed in 2014, were shown to vastly increase the detection capability for the neutrino-induced air showers in the lower energy ($E < 10^{19}$ eV) regime.

This talk explores the role of newly implemented triggers in enhancing neutrino detection for zenith angles within the range $60° < \theta < 75°$. A novel neutrino identification method, which integrates MoPS and ToTd triggers, is developed and rigorously tested on simulated neutrino-induced air showers. The method is then applied to observational data to look for neutrino-like events using a *blind* search strategy. On the basis of the null observation new constraints to point-like sources of ultra-high-energy neutrinos will be presented for the angular range explored.

*Supported by BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A23PX1)

T 53.7 Wed 17:45 VG 1.105

ML discrimination of atmospheric neutrinos for DSNB detection in JUNO — •David Maksimovic[1], Daniel Tobias Schmid[1], Dhaval J. Ajana[2], Michael Wurm[1], Marcel Büchner[1], Arshak Jafar[1], George Parker[1], Oliver Pilarczyk[1], and Tim Charisse[1] — [1]Johannes Gutenberg-University Mainz, Institute of Physics — [2]Department of Physics, Florida State University, Tallahassee, FL 32306, USA

The detection and analysis of the Diffuse Supernova Neutrino Background (DSNB) pose a significant challenge in neutrino astronomy, primarily due to backgrounds mimicking the Inverse Beta Decay (IBD) signature events. The Jiangmen Underground Neutrino Observatory (JUNO) uses a liquid scintillator to detect these neutrinos, especially challenged by Neutral-Current (NC) interactions of atmospheric neutrinos in the 12 to 30 MeV range. In this talk, we introduce novel methods employing 3D Convolutional Neural Networks (3D CNNs) and Convolutional LSTMs (ConvLSTMS) for better discrimination of DSNB events from these backgrounds. These techniques analyses time-sequenced data from photomultiplier tube (PMT) hit patterns, arranged in frames like a movie, capturing the spatial-temporal dynamics of particle interactions. Simulation studies within the JUNO detector environment show promising background reduction capabilities.

T 53.8 Wed 18:00 VG 1.105

Detecting Distant Supernovae Using Log-Likelihood Ratios — •Kashish Gupta, Thilo Birkenfeld, and Achim Stahl — Lehrstuhl für Experimentalphysik III B

The Jiangmen Underground Neutrino Observatory (JUNO) offers a robust platform for observing Core-Collapse Supernovae through neutrino emissions. In this study, the inverse beta decay (IBD) is used for Supernova search, where an electron antineutrino interacts with a proton, producing a positron and a neutron signal. The IBD channel's high cross-section and distinct event signature are particularly beneficial for detecting distant supernovae. A likelihood ratio test is applied to identify IBD events caused by a Supernova from background events dominated by reactor antineutrinos. In the first method, events are considered only within a time window corresponding to the CC-SNe duration, achieving a false alert rate (FAR) of 0.4/year for 2 IBD events and near-zero FAR for 3 IBD events.

A second method that treats arbitrary numbers of events on an equal footing is presented to improve sensitivity further.

T 54: Data, AI, Computing, Electronics V (Anomaly Detection, Event Selection)

Time: Wednesday 16:15–18:15 Location: VG 2.101

T 54.1 Wed 16:15 VG 2.101

Latest developments of CATHODE — •Tore von Schwartz, Gregor Kasieczka, Louis Moureaux, Chitrakshee Yede, and Manuel Sommerhalder — Institut für Experimentalphysik, Universität Hamburg

Despite an extensive search program at the LHC, no hints for new physics have been found so far. Anomaly detection has been introduced as a bridge between generic searches and searches targeting a specific signal. CATHODE as a model-agnostic anomaly detection method is designed to enhance resonant signals in the smoothly falling dijet invariant mass spectrum. It has been applied in the latest CMS anomaly search. We present the most recent developments to CATHODE improving its reliability and versatility in uncovering potential new physics signals.

T 54.2 Wed 16:30 VG 2.101

Anomaly Detection Using Machine Learning at Belle II — •David Giesegh, Nikolai Krug, and Thomas Kuhr — LMU Munich, Germany

In modern High Energy Physics, searches for New Physics are often inspired by specific theoretical models suggesting extensions to the Standard Model. Since, as of yet, none of these could be experimentally verified, the question arises if we are looking in the wrong places. For this reason recent years have seen increasing interest in model-agnostic alternatives to classical analyses, among them Machine Learning assisted methods such as Anomaly Detection. In this project we explored the application of two specific Anomaly Detection procedures based on autoencoders and density estimation at the Belle II Experiment. It could be shown on simulated data scenarios that both methods have the potential to increase the visibility of an unknown small signal on realistic backgrounds, providing a proof of concept for further development of such methods at Belle II.

T 54.3 Wed 16:45 VG 2.101

BGNet: A neural network for real-time background prediction and decomposition for Belle II — •Yannik Buch, Ariane Frey, Benjamin Schwenker, and Lukas Herzberg — Georg-August-Universität Göttingen, Göttingen, Deutschland

The Belle II detector investigates the b-sector by measuring the decays of the $\Upsilon(4S)$ resonance. These resonances are produced by the SuperKEKB accelerator at KEK in Tsukuba, Japan. The goal of SuperKEKB is to achieve an instantaneous luminosity of 6.5×10^{35} $\mathrm{cm^{-2}s^{-1}}$. Currently, a luminosity of 5×10^{34} $\mathrm{cm^{-2}s^{-1}}$ is reached, showing that considerable improvements to the beam focusing and increases of the ring currents are still necessary. At the same time, however, the Belle II detector must not be damaged or its performance compromised by extensive radiation and hit rates. The beam backgrounds at Belle II are mostly composed of storage backgrounds, luminosity-based backgrounds and injection backgrounds of both rings due to continuous top-up injections. BGNet is trained to predict the overall hit rates and their decomposition in terms of background source for various Belle II sub-detectors.

The input data for BGNet are 1 Hz time series of diagnostic variables describing the state of the SuperKEKB collider subsystems. Using real-time data from the EPICS slow control system BGNet can be used to obtain a real-time beam background decomposition, enabling diagnostic background monitoring for all beam background components simultaneously.

T 54.4 Wed 17:00 VG 2.101

Using End-to-End Optimized Summary Statistics in IceCube — •Oliver Janik and Christian Haack — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg

The characterization of the astrophysical neutrino flux with the IceCube Neutrino Observatory traditionally relies on a binned forward-folding likelihood approach. However, this method is constrained by the need for sufficient Monte Carlo (MC) statistics in each bin, which limits both the granularity and dimensionality of the binning scheme. By employing a neural network to learn a one-dimensional summary statistic, it becomes possible to optimize the binning scheme for the analysis while maintaining adequate MC statistics per bin. This, for example, allows the use of a larger number of observables in order to improve the analysis performance. The talk will go into detail on the application of end-to-end optimized summary statistics in the context of analyzing and characterizing the galactic neutrino flux.

T 54.5 Wed 17:15 VG 2.101

Novel Event Selection Techniques to Discriminate between Proton Decay and Atmospheric Neutrino Backgrounds in JUNO — •Korbinian Stangler, Ulrike Fahrendholz, Lothar Oberauer, and Carsten Dittrich — TUM School of Natural Sciences, Physics Department, James-Franck-Str. 1, 85748 Garching

The Jiangmen Underground Neutrino Observatory (JUNO) is a large liquid scintillator detector, capable of searching for the hypothetical proton decay $p \to \bar{\nu} K^+$, which is predicted by supersymmetric Grand Unified Theories. As the momentum of the daughter kaon is below the Cherenkov threshold in water, JUNO will be able to provide competitive results in comparison to the current partial lifetime limit of $\tau > 5.9 \cdot 10^{33}$ years, established by the Super-Kamiokande collaboration.

This talk presents a new machine-learning based strategy to discriminate proton decay events from atmospheric neutrino interactions in JUNO. From the resulting estimated sensitivity on $p \to \bar{\nu} K^+$, an improvement of the vertex reconstruction algorithm is suggested.

T 54.6 Wed 17:30 VG 2.101

Sterile Neutrino Search with Neural Networks at KATRIN — •Luca Fallböhmer for the KATRIN-Collaboration — Technical University Munich

The KATRIN experiment aims to search for keV sterile neutrinos in the full beta decay spectrum of tritium using the TRISTAN detector and DAQ system after the end of the neutrino mass measurement. Thanks to the high source activity of KATRIN, a sterile neutrino signature can be probed down to the parts per million level. Because the modelling of the deep differential tritium spectrum is very complex and the involved Monte Carlo simulations require long computing times to reach the necessary statistics, a fit of the sterile parameters is very challenging with the current model. Thus, neural networks are used to search directly for the sterile neutrino signature. In this talk, we demonstrate the sensitivity of the neural network method to the sterile neutrino signature. Additionally, we discuss the robustness of the neural network approach in the presence of experimental effects, their uncertainties, and modelling inaccuracies.

T 54.7 Wed 17:45 VG 2.101

Enhancing the identification of $HH \to b\bar{b}b\bar{b}$ by Triplet Learning — •Bao Tai Le, Lars Linden, Otmar Biebel, Stephanie Götz, Celine Stauch, Valerio D'Amico, and Tim Rexrodt — Ludwig-Maximilians-Universität, München, Deutschland

In recent years various machine learning techniques have proven to be quite successful in particle physics replacing old methodology and introducing new ways of thinking. One of those ways is Triplet Training. Its appeal comes from its resilience against noisy data by forming a more salient feature space leading to better categorization performances across many different categorization architectures.The production of a pair of Higgs bosons is possible due to the Higgs self interaction. However, the cross section of this process is tiny and the largest branching ratio of the Higgs decay involves bottom quarks which are also abundantly produced by strong interaction in proton-proton collisions. Even though bottom quark jets can be identified e.g. by secondary decay vertices, it is an experimental challenge to maintain a high efficiency to identify the four b-quark jets from a $HH \to 4b$ event. Due to the resilience of Triplet Learning against noisy data its application seems promising for enhancing the identification efficiency of $HH \to 4b$ events.

T 54.8 Wed 18:00 VG 2.101

MVA Based Selection for $B \to K_S(\pi^+\pi^-)\,l^+\,l^-$ — Ariane Frey[1], Thibaud Humair[1,2], •Dennis Rodermund[1], and Benjamin Schwenker[1] — [1]II. Physikalisches Institut, Georg-August-Universität Göttingen, 37073 Göttingen, Germany — [2]Deutsches Elektronen Synchrotron (DESY), 22607 Hamburg, Germany

Decays of B mesons mediated by a $b \to s\,l\,l$ transition are of high interest to search for physics beyond the Standard Model. The CP-violation content of such transitions has however been explored very little to date. The $B \to K_s\,l\,l$ transitions allow for measuring the CP-violation in the interference with mixing. This decay has a very small branching fraction and hence a good selection is needed in order to isolate signal events.

This talk focuses on the selection based on a BDT. The BDT takes event- and particle based variables like Fox-Wolfram moments or angular distributions as input and tries to predict if the considered event is either signal or background. A sophisticated BDT model thus provides a way to separate signal and background processes based on the BDT output, making further analyses possible.

T 55: Data, AI, Computing, Electronics VI (DAQ and Trigger)

Time: Wednesday 16:15–18:30 Location: VG 2.102

T 55.1 Wed 16:15 VG 2.102

Development of an FPGA-based DAQ system for the OBELIX sensor for the Belle II VTX upgrade — •Tobias Blesgen[1], Maximilian Babeluk[2], Christian Bespin[1], Jochen Dingfelder[1], Hans Krüger[1], and Alexander Walsemann[1] — [1]University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany — [2]Austrian Academy of Sciences, Institute of High Energy Physics, Nikolsdorfer G. 18, Vienna, Austria

To address the demands of higher luminosities at the Belle II experiment, a new vertex detector system featuring the monolithic OBELIX pixel sensor is currently under development. The large (3 cm x 2 cm) sensor area consists of over 400,000 pixels utilizing DMAPS technology. Alongside the OBELIX chip, a dedicated readout system for laboratory and beam tests is being designed and verified. The FPGA-based

DAQ system builds upon the existing TJ-Monopix2 DAQ framework and has been adapted to include new features required to work with the OBELIX chip.

The FPGA is placed on the multi-purpose BDAQ board, originally developed for the RD53 readout for the upgrade of the ATLAS and CMS pixel detectors. TJ-Monopix2 and OBELIX exhibit the same command protocol as the RD53B chip while implementing a different hit data receiver logic to match the updated hit structure.

This talk presents the development process, key features and verification process of the data acquisition system.

T 55.2 Wed 16:30 VG 2.102

The XENONnT Data Acquisition System — •Robin Glade-Beucke for the XENON-Collaboration — Albert-Ludwigs Universität, Freiburg, Germany

The XENONnT experiment is an ultra-low background liquid xenon TPC for direct dark matter detection. Its trigger-less Data Acquisition System aims at achieving maximal total uptime and the lowest possible energy threshold. Live processing of the data allows timely insight in current data taking, even in high-rate scenarios such as during calibration. Later reprocessing with improved processing parameters is possible. The high data rates during calibration can be mitigated on-line with FPGA-based veto decision-making.

T 55.3 Wed 16:45 VG 2.102

On-Board Data Processing for a Mission to Study the Antiproton Content in Earth's Radiation Belts — •Peter Hinderberger, Martin J. Losekamm, Luise Meyer-Hetling, and Stephan Paul — School of Natural Sciences, Technical University of Munich, Garching, Germany

The Earth's magnetic field traps charged particles in the Van Allen radiation belts. We intend to precisely measure the flux of trapped antiprotons with energies of tens to hundreds of MeV using a tracking calorimeter made from scintillating plastic fibers and silicon photomultipliers. The instrument will fit on a compact satellite that will, however, restrict the power, volume, computing capacity, and transmission bandwidth available to our experiment. In addition, a low signal-to-background ratio and high event rates make data acquisition and processing challenging. To address these challenges, we are developing a hardware and software framework based on a field-programmable gate array (FPGA) that can acquire, filter, and compress data efficiently in orbit, exploiting its advantages in low-power parallel computing. Our pipelined multi-stage processing approach is designed to reliably identify, count, and partly reject clearly identifiable background events, and to compress the remaining signal candidates without losses. This minimizes the amount of data that must be transmitted to the ground without impacting our measurement. I present the motivation, current status, and short-term plans of our work. It is funded by the German Research Foundation (DFG, project number 414049180) and under Germany's Excellence Strategy-EXC2094-390783311.

T 55.4 Wed 17:00 VG 2.102

Constellation - a flexible DAQ and control system for test beam environments — •Stephan Lachnit and Simon Spannagel — Deutsches Elektronen-Synchrotron DESY

The qualification of new detectors in test beam environments presents a challenging setting that requires stable operation of diverse devices, often employing multiple Data Acquisition (DAQ). Changes to these setups are frequent, such as using different reference detectors depending on the facility. Managing this complexity necessitates a system capable of controlling the data taking, monitoring the experimental setup, facilitating seamless configuration, and easy integration of new devices.

Due to limitations in existing frameworks, collaborative efforts between DESY, DVel, Lund University, and the University of Hamburg have led to the development of Constellation - a new, flexible framework tailored towards laboratory and test beam environments. Constellation streamlines setup integration through network discovery, enhances system stability by operating autonomously, and simplifies onboarding with comprehensive documentation.

This contribution will provide a brief overview of the Constellation and insights from the first test beams with Constellation.

T 55.5 Wed 17:15 VG 2.102

Development and Tests of Python-based Control Software for a EUDET-type Beam Telescope at the ELSA Test Beam Area — •Rasmus Partzsch, Christian Bespin, Yannick Dieter, Jochen Dingfelder, Fabian Hügging, and Lars Schall — Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

Test-beam telescopes are reference tracking devices used to investigate the performance of detector prototypes. The EUDET-type beam telescope consists of six MIMOSA26 pixel detector planes. These feature a small pixel pitch (18.4 um) to enable a high spatial resolution for particle tracks. A time-reference plane is added to the ANEMONE beam telescope to provide precise timing information for individual particle tracks. The detectors are synchronized with a trigger logic unit (AIDA-TLU). One of the main requirements of the test-beam infrastructure is flexibility to accommodate different types of devices under test and different experimental setups. This flexibility applies not only to the hardware setup but also to the control software, detector readout, and analysis tools. A new Python-based control software has been developed for the control of the AIDA-TLU, implementing various trigger logic configurations and communication modes for different devices.

In this talk, the Python-based control software for a EUDET-type beam telescope setup is presented. Additionally, test results using an ATLAS ITkPix chip, designed for the ATLAS inner tracker upgrade, as the time reference plane, along with the AIDA-TLU control software at trigger rates of up to 100 kHz at the ELSA test-beam area, will be discussed.

T 55.6 Wed 17:30 VG 2.102

Compact converters for fast frame rate detectors — •Kennedy Caisley[1], Hans Krüger[1], Bart Dierickx[2], and Jochen Dingfelder[1] — [1]University of Bonn, Bonn, Germany — [2]Caeleste, Mechelen, Belgium

Frame-based radiation detectors with integrating front-ends are especially well-suited for applications like electron microscopy and X-ray imaging where hit-rates are high, spatial resolution should be maximized with simple pixels, and energy resolution is needed, but particles need not be individually discriminated in time, space, or spectrum. In an experimental setting, fast frame rates allow for real time in-situ observations. Potential subjects include rapid chemical processes, molecular dynamics of proteins, crystal nucleation and growth, material phase transitions, thermal conductivity, charge transfer, and mechanical strain.

Our work pursues the possibility of a single-reticle array larger than 1 Mpixel with a continuous frame-rate surpassing 100,000 fps. For the conjunction of these two specifications to be met, we will discuss initial investigations into a compact and power efficient bank of column-parallel data converters, which at 10-12 bit resolution churn out data at a rate in excess of 1000 Gbps. To fit within the constraints of a chip bottom, the converter fabric must respect a restricted metric of 1 W/cm^2 while exceeding a 5 ksps/μm^2 sampling rate density. Successive-approximation ADCs are identified as the optimal choice, and various topologies and techniques will be analyzed to meet our goals.

T 55.7 Wed 17:45 VG 2.102

A parametrised Kalman filter for the GPU-based first level trigger of the upgraded LHCb experiment — Michel De Cian[1,2], Stephanie Hansmann-Menzemer[1], and •Lennart Uecker[1] — [1]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Germany — [2]Department of Physics and Astronomy, University of Manchester, United Kingdom

The LHCb Upgrade I detector implements a fully software-based trigger to select a wide range of physics signatures. The first-level trigger employs 500 GPU cards to perform partial event reconstruction at the complete LHCb collision rate of 30 MHz. This includes finding charged tracks, reconstructing proton-proton collisions, particle identification and finding displaced vertices. The implementation enables an increased trigger performance, especially for hadronic channels, thus elevating signal yields above the increase in luminosity.

Kalman filters are commonly used in High Energy Physics to process pattern recognition tracks and extract optimal track parameters. However, these filters' sequential nature and substantial memory requirements make them suboptimal for GPU implementation. We developed a method that replaces computationally demanding operations with parametrized approximations, specifically material scattering calculations and state extrapolation in the magnetic field. This approach achieves high-throughput track fitting while maintaining track information quality, making it suitable for GPU-based processing in high-rate environments. In this talk we present the implementation and performance of the GPU based Kalman filter for LHCb Run 3.

T 55.8 Wed 18:00 VG 2.102

Reconstruction of photon conversion in rare decays — •Bernd Mumme — Physikalisches Institut, Heidelberg, Germany

Flavour changing decays involving the emission of an energetic photon are of great interest to study the peculiar flavour structure of the Standard Model and search for indirect signs of new dynamics at very high energy. Some of the most sensitive probes are the rare or forbidden flavour-changing neutral current decays of heavy fermions: $b \to s\gamma$, $c \to u\gamma$ and $\tau \to \mu\gamma$. Rare decays involving a photon in the decay products are reconstructed through the dielectron pair they convert to. To efficiently detect these dielectron pairs significant upgrades are being implemented in LHCb's trigger system to enhance efficiency. The trigger consists of a GPU-driven first high level trigger (HLT1) and a CPU-run second level trigger (HLT2). Improvements include the development of a new trigger line in HLT1 capable of reconstructing significantly displaced electrons from photon conversions in real time as well as incorporating these electron tracks in HLT2, both driven by modern machine learning techniques. These upgrades aim to maximize event selection efficiency and keep data throughput for rare decays manageable. This talk will outline the physics motivation for searches for flavour-changing neutral current decays and detail the technical developments in optimizing the LHCb trigger for these and similar rare decays.

T 55.9 Wed 18:15 VG 2.102

Development of an automated pixel monitoring website — Arnulf Quadt, Marcello Bindi, and •Tim Schlömer — II. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The ATLAS Pixel detector registers charged particles by the charges generated in the detector by the incoming particles. A specific number of electrons, defined by the threshold, is required to register a hit. Additionally, the time-over-threshold (TOT) is measured. The charge threshold and TOT of the Pixel Detector are regularly tuned to maintain target values as they detune with integrated luminosity, as a result of radiation damage effects. Monitoring key parameters including but not limited to charge threshold, TOT, digital-to-analogue converters, the number of masked pixels, and the number of disabled columns is crucial. Tracking these parameters over time and across integrated luminosity is essential for maintaining optimal detector performance and contributes to studies on radiation damage.

The detector operation parameters are presented via a web framework which displays relevant plots and values. A pipeline for automatic updates after each detector tuning ensures the plots are up-to-date, while older versions remain accessible for reference. The framework also allows the user to visualise the evolution of critical parameters over time and compare specific tunings belonging to different period of the detector lifetime.

T 56: Electroweak Physics II (Multi-boson Processes)

Time: Wednesday 16:15–18:00 Location: VG 2.103

T 56.1 Wed 16:15 VG 2.103

Sensitivity study of VBS WZjj semi-leptonic final states to vector boson polarisation observables — •Aryan Borkar, Thomas Trefzger, Raimund Ströhmer, and Gia Khoriauli — Julius-Maximilians-Universität Würzburg

The electroweak symmetry breaking mechanism can be experimentally tested in the electroweak vector boson scattering (VBS) processes that occur in proton-proton collisions at the LHC. The unitarity of VBS cross sections of longitudinally polarised bosons $V_{1,L}V_{2,L} \to V_{3,L}V_{4,L}$, where $(V = W^{\pm}, Z)$, in the Standard Model are preserved by including the Feynman diagrams with the Higgs boson propagator in calculations. Thus, precise measurements of VBS processes of longitudinally polarised vector bosons are important experimental tests of the validity of the Brout-Englert-Higgs mechanism. We present the preliminary study of the potential of measurements of WZ VBS polarisation observables in the Run-2 data sets collected by the ATLAS detector. VBS processes with semi-leptonic final states are considered in the study.

T 56.2 Wed 16:30 VG 2.103

Polarization Measurement in Same-Charged WW Scattering with the ATLAS Experiment — •Erik Bachmann, Frank Siegert, Max Stange, Tim Herrmann, and Mareen Hoppe — TU Dresden, Dresden, Germany

In 2023, the ATLAS experiment published the first differential cross-section measurement of same-charged W-boson scattering – an essential process for understanding electroweak symmetry breaking. Since W-bosons gain their mass and, consequently, their longitudinal polarization through the Higgs mechanism, studying the scattering of longitudinally polarized W-bosons offers a promising way to probe this mechanism and search for new physics beyond the Standard Model.

However, since W-bosons decay into a charged lepton and a neutrino, directly reconstructing their original polarization is not possible. To overcome this, the analysis presented in this talk employs neural networks to separate the longitudinal component of the same-charged W-boson scattering signal from other polarization states and background processes. This talk aims to give an overview of the analysis strategy and to discuss state of the art techniques used to include higher-order QCD and EW effects in the polarized signal prediction.

T 56.3 Wed 16:45 VG 2.103

Measurement of the differential di-boson cross-section in semileptonic final states at $\sqrt{s} = 13$ TeV in $140\,\mathrm{fb}^{-1}$ of pp collisions with the ATLAS detector — •Anubhav Gupta, Chris Malena Delitzsch, and Amartya Rej — Otto-Hahn-Str. 4A 44227 Dortmund

The measurement of electroweak vector boson pair (VV) production cross-sections is a critical test of the Standard Model (SM), probing electroweak boson self-interactions and the electroweak theory. While VV production has been well-studied in fully leptonic decay channels at $\sqrt{s} = 13\,\mathrm{TeV}$, semileptonic channels have only been measured at $\sqrt{s} = 8\,\mathrm{TeV}$.

This analysis presents the first measurement of di-boson production in the semileptonic channel (leptons and a large radius jet) at $\sqrt{s} = 13\,\mathrm{TeV}$, taking advantage of its higher branching fraction compared to fully leptonic decays and a cleaner signature than fully hadronic decays. The semileptonic channel is particularly sensitive at high energies, offering strong potential for detecting new physics beyond the SM in the tails of kinematic distributions.

The study includes particle-level inclusive and differential cross-section measurements, along with constraints on dimension-6 Effective Field Theory (EFT) operators in the Warsaw basis, affecting electroweak triple gauge couplings, at the folded level.

T 56.4 Wed 17:00 VG 2.103

Measurement of the electroweak production of a W boson accompanied by two jets at $\sqrt{s} = 13$ TeV with the ATLAS experiment — •Lisa Marie Baltes — Kirchhoff-Institute for Physics, University Heidelberg, Germany

The observation and measurement of self-interactions of weak gauge bosons provide an indirect search for physics beyond the Standard Model. The electroweak production of a W boson in association with two jets includes the vector-boson-fusion (VBF) production of a W boson and is thus sensitive to the triple gauge boson vertices WWγ and WWZ. In proton-proton collisions, the characteristic signature of VBF includes two high-momentum jets at small angles with respect to the incoming beams and a centrally produced lepton-neutrino pair originating from the W boson decay. This unique signature provides kinematic discrimination from backgrounds such as strongly produced jets associated with a W boson, $t\bar{t}$ and dijet. In this talk, the current status of the electroweak Wjj analysis including event selection and background estimation is presented.

T 56.5 Wed 17:15 VG 2.103

Computation of the parity-odd part of the three-vector vertex function without DimReg — •Nils Kreher and Wolfgang Kilian — University of Siegen, Siegen, Germany

I present the computation of the parity-odd part of the three-vector vertex function with a closed fermion loop in a generic model. The vertex function is evaluated in analytic form in manifest four-dimensional Euclidean space, retaining full dependence on masses and external momenta without making use of dimensional regularization and hence avoiding ambiguities arising from γ_5. I demonstrate that this vertex function is unambiguously determined by the parameters of the model and its symmetry structure, provided it is understood as part of the universal effective action. If the model is interpreted as a gauge theory, the divergence of this vertex function in the asymptotic limit corresponds to the well-known gauge anomaly of the model. The implications for electroweak interactions and beyond are discussed.

T 56.6 Wed 17:30 VG 2.103

Constraining Triple Gauge Boson Couplings at Future Higgs Factories — •Leonhard Reichenbach[1,2], Andre Silva[3,4], André Sailer[1], Christian Grefe[2], Philip Bechtle[2], Jenny List[3], and Klaus Desch[2] — [1]CERN, Geneva, Switzerland — [2]Universität Bonn, Germany — [3]DESY, Hamburg, Germany — [4]Universidade de Coimbra, Portugal

We provide projections on the precision of (anomalous) $ZWW/\gamma WW$ triple gauge couplings (aTGC) using an optimal observable analysis of the process $e^+e^- \to \ell\nu q\bar{q}$ at center of mass energies of 240–250 GeV. The measurements of aTGC provide crucial input to global fits of Higgs couplings and SMEFT-based searches for new physics and offer a unique test of the gauge symmetry of the electroweak interaction. The current aTGC projections for future Higgs factories are either theory-only studies, neglecting experimental effects or extrapolations of older full-simulation studies for energies of 500–1000 GeV. We perform this analysis using the Key4hep framework, which enables us to perform the same analysis using several different detector models at different Higgs factories. This way, we will for the first time present consistently obtained results for the ILD detector for the International Linear Collider (ILC) and the CLD detector for the Future Circular Collider (FCC-ee).

T 56.7 Wed 17:45 VG 2.103

Measurement of $ZZ\gamma$ final states with the ATLAS detector at the LHC — •Anke Ackermann — Kirchhoff-Institute for Physics, Heidelberg University

The Standard Model of Particle Physics (SM) predicts the rare production of triboson final states. Although suffering from small cross sections and hence a limited amount of signal events, such triboson states can be studied with the vast amount of data collected by the ATLAS detector in Run 2. In addition to validating the predictions of the SM for rare processes, sensitivity to New Physics is given via anomalous quartic couplings of e.g. four neutral gauge bosons. This talk will focus on the analysis of the simultaneous production of $ZZ\gamma$. In order to determine the cross sections of this process, it is crucial to separate signal events from events arising through background processes mimicking the signal topology. The most dominant background process contains fake photons, which are non-prompt photons within jets. Due to the limited statistics a new approach with jet ratios is applied to estimate the amount of fake photons in the signal region. Additionally, processes with misidentified leptons contribute to the background. Their contribution is estimated with the matrix method. After giving a general introduction about the triboson production of the $ZZ\gamma$ process, a summary of the analysis, including the event selection and the background estimation, is presented.

T 57: Gamma Astronomy I

Time: Wednesday 16:15–18:15 Location: VG 3.101

T 57.1 Wed 16:15 VG 3.101

MAGIC Moments from more than 20 Years of Operation — •Daniela Dorner[1] and MAGIC Collaboration[2] — [1]Universität Würzburg, Deutschland — [2]www.magic.mpp.mpg.de

The Major Atmospheric Gamma-ray Imaging Cherenkov Telescope (MAGIC) started its operation more than 20 years ago. Driven by innovative spirit and an international group of inspired scientists, the two 17-m telescopes located at the Canary Island of La Palma deliver cutting-edge science at energies above 50 GeV. Not only a variety of compelling gamma-ray physics cases are prominent in the science program, but also new fields like intensity interferometry are explored, and a collaboration with the large-size-telescope (LST) of the Cherenkov Telescope Array Observatory (CTAO) has been started. The presentation summarizes highlights from the past two decades, recent results and future prospects.

T 57.2 Wed 16:30 VG 3.101

Longterm Variability Study of the Crab Nebula with the MAGIC Telescopes — Felix Wersig and •Cyrus Walther — TU Dortmund, Germany

As the brightest steady source in the sky at very high energies, the Crab Nebula is often used for the calibration of instruments in gamma astronomy. Since 2011 multiple flares at energies > 100 MeV have been observed by AGILE and Fermi-LAT. We investigate variability at very high energies using data spanning a time period of 10 years from the MAGIC telescopes. Non-periodic variability can manifests in three ways: flares, flux increase/decrease on long-timescales or as an additional fluctuation on top of the statistical fluctuations expected in the flux. To investigate those types of variability, different tests are implemented.The presence of flares is investigated with a Bayesian Blocks algorithm, changes of the flux on long time-scales are investigated with a likelihood ratio test and the fractional variation is introduced as test statistic for a model independent test for fluctuations in the data.

T 57.3 Wed 16:45 VG 3.101

Consistent long-term analysis of VHE blazars using autoMAGIC — •Cyrus Walther and Felix Wersig — TU Dortmund University

Through the Cherenkov light emitted by particles originating from primary gamma rays interacting with the atmosphere, Imaging Atmospheric Cherenkov Telescopes (IACTs) such as MAGIC observe TeV-emitting astrophysical sources since 2003. After 20 years, this allows now for long-term analyses. While the development of consistent multi-year analysis requires a significant time commitment and is prone to bias if performed manually period by period, a database-driven software could fix those issues. An automatic analysis dubbed autoMAGIC has been developed to automatize the analysis of data from the MAGIC telescopes. In this approach, we aim to utilize autoMAGIC to perform long-term analyses of gamma-ray emitting blazars and aim to develop long-term light curves for selected blazars

T 57.4 Wed 17:00 VG 3.101

Revealing FACTs about the Harder-when-Brighter Behaviour of Mrk 421 in an Unbiased Long-Term Study — •Daniela Dorner[1], Bernd Schleicher[2], and FACT Collaboration[3] — [1]Universität Würzburg, Deutschland — [2]ETH Zürich — [3]www.fact-project.org

Featuring two peaks in their spectral energy distribution, blazars exhibit a strong variability both in X-rays and very-high-energy gamma rays. Many studies find a harder-when-brighter behaviour of the spectral index in correlation with the flux.

Within the FACT monitoring program, the blazar Mrk 421 has been observed for more than 3200 hours at TeV energies. Thanks to the unbiased observing strategy, the data sample is ideally suited for systematic long-term studies. Owing to the stable photosensors that allow for observations during bright moon and the automatic and remote operation, the 10-year data sample covers more than 1100 nights.

Results from an unprecedented study of Mrk 421 are presented, focussing on the correlation of the spectral index with the flux at very high energies and probing the often observed hard-when-brighter behaviour.

T 57.5 Wed 17:15 VG 3.101

Towards Searching for Photons with Energies beyond the PeV Range from Galactic PeVatrons — •Chiara Papior, Marcus Niechciol, and Markus Risse — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Recently, photons of cosmic origin with energies in the PeV range have been measured by several gamma-ray observatories. Such energetic photons are potentially produced during the acceleration of charged particles in so-called PeVatrons which are widely assumed to be the

sources of a large part of galactic cosmic rays. The LHAASO and HAWC observatories published catalogs of gamma-ray sources including sources with energy spectra without visible cutoffs up to the PeV range. Several of those sources have been selected and their spectra have been extrapolated up to the ultra-high-energy (UHE, here beyond 10 PeV) regime. It has been evaluated if (and under which conditions) giant air-shower observatories, for example the Pierre Auger Observatory, could contribute to testing the UHE luminosity of such PeV γ-sources. The expected fluxes and the required discrimination power to distinguish between photon- and hadron-initiated air showers will be presented. The impact of possible propagation effects is investigated as well.
This work is supported by the German Research Foundation (DFG, Project No. 508269468).

T 57.6 Wed 17:30 VG 3.101

Enabling ground-based one giga electronvolt gamma ray astronomy — •Sebastian Achim Mueller — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

Timing the variable gamma ray emission from mergers, bursts, recurring novas, flaring jets, clocking pulsars, and many more is key to constrain physical models. For good timing on account of high rates, we would ideally collect the abundant low energetic 1GeV gamma rays, for which the universe is still transparent up to high red shifts, in large areas. Satellites collect low energetic gamma rays but only in desk sized areas. Cherenkov telescopes have multi soccer field sized collecting areas but only detect the rare high energetic gamma rays above several 10GeV. We propose a ground-based instrument that detects 1GeV gamma rays in a large area and hence achieves huge gamma ray detection rates: the Cherenkov plenoscope. With a groundbreaking optics, the plenoscope enables for the first time the high-resolution imaging of low energy gamma ray air showers using a huge (71m) mirror. The plenoscope can tolerate deformations and misalignments of its mirror and camera, what reduces its cost compared to a telescope. We will introduce the plenoscope's optics and demonstrate its capabilities. By simulating a possible design we will briefly discuss the consequences for future ground based gamma ray astronomy.

T 57.7 Wed 17:45 VG 3.101

Bayesian approach to signal estimation in gamma-ray astronomy with Gammapy — •Matheus Genaro Dantas Xavier, Rodrigo Guedes Lang, Tim Unbehaun, and Stefan Funk — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg

Gamma-ray observations from Imaging Atmospheric Cherenkov Telescopes, such as H.E.S.S., are overwhelmingly dominated by a background of cosmic rays. To properly estimate the strength of the observed signal, gamma-hadron separation methods are used in conjunction to background estimation techniques, where selection cuts remove the majority of background events (inevitably loosing a fraction of the unknown signal). We are interested in applying and extending a Bayesian method to perform signal estimation - the BASiL method from D'Amico et al. (2021) - to H.E.S.S. data, in both 1-dimensional (data binned in energy) and 3-dimensional (data binned in energy and spatial coordinates) analyses. This approach utilizes all available information after event reconstruction and the probability distributions associated to gamma- and hadron-like events without selection cuts. In the Bayesian framework, the posterior probability of the signal is obtained, from which credible intervals can be computed and the probability of two competing hypotheses (source or non-source) can be assessed through the Bayes factor. From simulated data, improved precision in signal reconstruction is achieved, while flux points are obtained from a modified version of Gammapy, revealing that fluxes can be measured even in highly background-dominated datasets.

T 57.8 Wed 18:00 VG 3.101

Impact of the three-dimensional Galactic gas distribution on the modeling of the diffuse gamma-ray flux* — •Yannick Schmidt[1,2], Julien Dörner[1,2], Jonas Hellrung[1,2], and Julia Becker Tjus[1,2,3] — [1]Theoretical Physics IV, Plasma Astroparticle Physics, Faculty of Physics and Astronomy, Ruhr-University Bochum, 44780 Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, 412 96 Gothenburg, Sweden

The high-energy γ-ray sky is predominantly shaped by diffuse emissions arising from non-thermal processes, such as inverse Compton scattering, Bremsstrahlung, and the decay of neutral pions. Simulations of these emissions serve as valuable tools to constrain models of the Galactic cosmic-ray population, providing insights into their origin and propagation through the interstellar medium (ISM). The accuracy of these simulations is highly dependent on the spatial distribution of the interstellar gas. To date, many models rely on a 2D cylindrically symmetric geometry, which imposes significant limitations in terms of physical realism. In this work, we investigate the impact of explicit three-dimensional distributions for the neutral gas components of the ISM on π^0-production. This is achieved by integrating the local emissivity along the line of sight, as implemented in the HERMES software framework. The resulting γ-ray emissions are subsequently analysed and compared with those obtained using traditional two-dimensional ring models for the gas distribution. * supported by SFB1491

T 58: Cosmic Rays III

Time: Wednesday 16:15–18:00 Location: VG 3.102

T 58.1 Wed 16:15 VG 3.102

CORSIKA 8: A modern and universal framework for particle cascade simulations — •Marvin Gottowik for the CORSIKA8-Collaboration — Karlsruher Institut für Technologie, Institut für Astroteilchenphysik, Karlsruhe, Germany

CORSIKA 8 represents a major advancement in the simulation of particle showers, building on the well-established foundation of CORSIK 7. It has been entirely rewritten as a modular and modern C++ framework, addressing the limitations of its predecessor to provide a flexible platform designed to satisfy current and novel use cases. This includes applications beyond traditional air-shower scenarios, such as cross-media particle cascades and enhanced radio emission calculations. For the first time, both the endpoint formalism and ZHS algorithm can be applied to the same simulation, demonstrating convergence to within 2 % on the radiation energy for high-precision simulations. A first official "physics-complete" version has been released, supporting hadronic interactions with current-generation models and the electromagnetic cascade with PROPOSAL 7.6.2. In this presentation, we will discuss the design principles, current capabilities, and validation efforts of CORSIKA 8, highlighting its potential applications for future experiments.

T 58.2 Wed 16:30 VG 3.102

Inclined Air Showers with Corsika 8 and Pythia 8: Cracking the Muon Puzzle One Shower at a Time — •Chloé Gaudu for the CORSIKA8-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Germany

The field of air shower physics seeks to understand the development of cosmic-ray interactions with the Earth's atmosphere. A key challenge in this field is the discrepancy in the muon content of extensive air showers observed by cosmic-ray experiments, such as the Pierre Auger Observatory, compared to predictions from state-of-the-art hadronic interaction models. This discrepancy, commonly referred to as the *Muon Puzzle*, stems from limitations in modeling high-energy hadronic interactions. The Pythia 8 interaction model emerges as a promising candidate for shedding light on the Muon Puzzle, owing to its user-friendly tunability and recent advancements in the Angantyr module, which enhances its handling of nuclear interactions. With Pythia 8 now partially integrated into the Corsika 8 particle-shower simulation code, preliminary analyses of the muon content in air showers are feasible.

This work is a comparative analysis of inclined air showers induced by proton primaries at 10^{19} eV, using Corsika 8 with Pythia 8 and current state-of-the-art alternatives, focusing on how differences in hadronic interaction models are reflected in shower observables. The preliminary results offer valuable insights into how Pythia 8 can advance our understanding of the Muon Puzzle and point to directions for future developments. **Supported by DFG (SFB 1491)*

T 58.3 Wed 16:45 VG 3.102

Simulating radio emission of extensive air shower with real noise for deep learning reconstruction at the Pierre Auger Observatory* — •Sven Querchfeld and Julian Rautenberg for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal

The ErUM-Wave project aims to develop an AI model to reconstruct 3-dimensional wave fields with the goal to predict the propagation of seismic waves based on only a few measurements. To test the transferability of the developed method to other fields, it will be applied to the propagation of radio waves in the atmosphere. These waves are produced by cosmic ray-induced air showers measured with the Pierre Auger Observatory. As part of the AugerPrime upgrade, each Water Cherenkov Detector (WCD) has been equipped with an additional radio antenna, enlarging the radio detection (RD) technique to the entire array, covering $3000\,\mathrm{km}^2$. Realistic simulations of detector signals require realistic noise. With its unpredictable characteristics this needs to be extracted from real measured data. For vertical shower the particle footprint that triggers the station read-out is much larger than the radio footprint on the ground. We select noise data from outer stations which are not expected to have any radio-signal. The set of simulated events using the CoREAS extension of CORSIKA with this extracted realistic noise added will be used for first test of AI models to reconstruct the 3-dimensional wave propagation.

T 58.4 Wed 17:00 VG 3.102

Studies on Monte Carlo generator tuning for cosmic-ray induced air shower simulations — •Michael Windau and Kevin Kröninger — TU Dortmund, Fakultät Physik

Monte Carlo (MC) generators are a fundamental tool in particle and astroparticle physics. To achieve a high-quality simulation of physical processes, the hadronic interaction model of the generator must be tuned efficiently. The free parameters of MC generators are optimized with the help of experimental data and Bayesian methods. One area of application for MC generators is the simulation of cosmic-ray induced air showers in the Earth's atmosphere. Since hadronic interactions have a direct influence on the composition of secondary particles in shower formations, tuning the parameters of these hadronic models has an impact on crucial observables such as the muon number.

In this talk, studies on the tuning of the Monte Carlo generator PYTHIA for cosmic-ray induced air showers, using data from air shower experiments, are presented.

T 58.5 Wed 17:15 VG 3.102

Uncertainties in Atmospheric Interactions — •Alicia Fattorini for the IceCube-Collaboration — TU Dortmund, Dortmund, Germany

Many astrophysical measurements rely on assumptions about the absolute atmospheric flux of cosmic rays and their interaction in our atmosphere. While cosmic ray detectors such as Pierre AUGER measure cosmic rays via their secondary emissions in the atmosphere, neutrino detectors such as IceCube, and IACTs such as MAGIC are subject to a background consisting of particles from the same interactions. For all these experiments, it is particularly important to understand the processes in the atmosphere and to be able to determine the flux of the emitted secondary particles. This work focuses on uncertainties in the processes occurring in the atmosphere where secondary particles are produced in cosmic ray-induced air showers, and in the cosmic ray flux itself. The aim is to estimate the normalization of the measured spectra and to determine the origin of the systematic uncertainties.

T 58.6 Wed 17:30 VG 3.102

comparing hadronic interaction models with air shower parameters at the IceCube Neutrino Observatory — •Fahim Varsi[1], Mark Weyrauch[2], Dennis Soldin[3], and Timo Peter Lemmer[1] for the IceCube-Collaboration — [1]Karlsruhe Institute of Technology, Institute of Experimental Particle Physics, Karlsruhe, Germany — [2]Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany — [3]Department of Physics and Astronomy, University of Utah, Salt Lake City, USA

The IceCube Neutrino Observatory studies cosmic-ray extensive air showers (EASs) using a surface array of ice-Cherenkov detectors, known as IceTop, by detecting the electromagnetic component and low-energy (~GeV) muons of EASs. A new reconstruction method, utilizing different lateral distribution functions (LDFs) for the electromagnetic and muonic components of the detector signals, is applied to estimate the shower size and low-energy muon content of EASs on an event-by-event basis. However, due to systematic uncertainties in high-energy hadronic interaction models, the simulated predictions of these EAS parameters show a significant dependence on the high-energy interaction models. Consequently, a detailed study of these systematic uncertainties in the reconstructed parameters provides insights into model-dependent variations in cosmic-ray air shower studies. In this work, we compare the EAS parameters reconstructed using three hadronic interaction models: Sibyll 2.1, QGSJet-II.04, and EPOS-LHC, and the results will be presented at the conference.

T 58.7 Wed 17:45 VG 3.102

Impact of adding simulations of ultra-heavy cosmic rays on neural network-based estimators using surface detector data of the Pierre Auger Observatory — •Steffen Hahn for the Pierre-Auger-Collaboration — Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany

To understand the physics of ultra-high-energy cosmic rays (UHECRs), an accurate estimate of the masses of UHECR is crucial. Direct detection of UHECRs is not feasible and requires the study of air showers induced by the interaction of UHECRs with the atmosphere. The surface detector stations of the Pierre Auger Observatory (Auger) measure the front of such cascades, called the shower footprint. Analyzing the spatio- temporal information of these shower footprints is highly nontrivial. Neural networks (NNs) offer a convenient way to exploit the correlations in the footprints and improve the reconstruction of high-level shower observables. However, simulations of UHECRs face limitations due to incomplete understanding of the high-energy hadronic interactions. The most prominent discrepancy is the muon puzzle – a systematic deficit of muons in simulations which complicates the application of simulation-trained NNs to Auger data. Typically, training data sets for Auger consist of a mix of proton, iron, and intermediate-mass nuclei. Since the number of muons produced in an air shower correlates with the mass of the UHECR, varying the mass composition in the training dataset could impact the transition to measurements. In this contribution, we show how the inclusion of heavier UHECRs affects NN-based estimators in simulations and measurements.

T 59: Neutrino Physics V

Time: Wednesday 16:15–18:30 Location: VG 3.103

T 59.1 Wed 16:15 VG 3.103

The Taishan Antineutrino Observatory — •Hans Theodor Josef Steiger — Physik-Department, Technische Universität München, James-Franck-Str. 1, 85748 Garching, Germany

The Taishan Antineutrino Observatory (TAO or JUNO-TAO) is a satellite detector for the Jiangmen Underground Neutrino Observatory (JUNO). JUNO will use reactor antineutrinos at a baseline of about 53 km to probe the interference effects between the two atmospheric mass-squared differences, which are sensitive to the sign of the mass ordering. Located near the Taishan-1 reactor, TAO independently measures the antineutrino energy spectrum of the reactor with unprecedented energy resolution and by that uncovering its fine structure for the first time. Beyond that, TAO is expected to make world-leading time-resolved measurements of the yield and energy spectra of the main isotopes involved in the antineutrino emission of nuclear reactors. By that TAO will provide a unique reference for other experiments and nuclear databases. In order to achieve its goals, TAO is relying on cutting-edge technology, both in photosensor and liquid scintillator (LS) development which is expected to have an impact on future neutrino and Dark Matter detectors. In this talk, the design of the TAO detector with special focus on its new detection technologies will be introduced. In addition, an overview of the progress currently being made in the R&D for photosensor and LS technology in the frame of the TAO project will be presented.

T 59.2 Wed 16:30 VG 3.103

JUNOs sensitivity to the annihilation of sub-GeV dark matter in the galactic halo — •Jessica Eck, Dhanushka Bandara, Lukas Bieger, Silvia Cengia, Adrian Keiderling, Florian Kirsch, Tobias Lachenmaier, Anurag Sharma, and Tobias Sterr — Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory (JUNO) is in the final construction stage in southern China with the main goal to determine the neutrino mass hierarchy with reactor antineutrinos. Due to the large volume of 20 kt, indirect search for self-annihilating light dark matter (DM) in the mass range from 10 MeV to 1 GeV is an additional physics goal of JUNO. In this talk, the expected signal from a monoenergetic neutrino flux on Earth, originating from direct annihilation of DM particles into neutrinos, will be discussed. Furthermore, different methods to suppress background contributions in the respective energy range are presented to estimate the expected sensitivity of JUNO to DM self-annihilation in the Milky Way.

T 59.3 Wed 16:45 VG 3.103

Particle identification in JUNO with a Graph Convolutional Network — Thilo Birkenfeld, •Elisabeth Neuerburg, Philipp Soldin, and Achim Stahl — RWTH Aachen

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton liquid scintillator-based neutrino observatory. Identifying the secondary particles gives a handle on the primary neutrino type. In this talk, a method of particle identification using a Graph Convolutional Network (GCN) is presented. A fixed Graph is fed into the network, which uses partition pooling for dimensionality reduction. This method is applied to the discrimination of electrons and positrons. Their discrimination aids in distinguishing atmospheric neutrinos and antineutrinos, as well as backgrounds from the IBD signal of reactor antineutrinos.

T 59.4 Wed 17:00 VG 3.103

A novel view at using the topological track reconstruction in JUNO — •Mikhail Smirnov, Daniel Bick, Milo Charavet, Caren Hagner, and Rosmarie Wirth — Institute of Experimental Physics, University of Hamburg, Hamburg, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) represents a new generation of kiloton-scale neutrino detectors based on liquid scintillator (LSc). With a target mass of 20 kilotons, it will be the largest LSc detector in the world. Utilizing the antineutrino flux from two nuclear power plants at a baseline of approximately 53 km, JUNO aims to determine the neutrino mass ordering with at least 3σ significance and to make precise measurements of oscillation parameters. Initially, the topological track reconstruction (TTR) was developed to reconstruct muon events in unsegmented LSc detectors for particles with energies up to 10 GeV. This reconstruction algorithm uses time and spatial information from PMT hits to iteratively determine the origin and trajectory of particles inside the detection medium. This talk reviews the TTR method and its potential applications in the JUNO experiment and is supported by the DFG.

T 59.5 Wed 17:15 VG 3.103

Application of the Topological Track Reconstruction to ANNIE — Daniel Bick, Caren Hagner, and •Malte Stender for the ANNIE-Collaboration — Universität Hamburg, Institut für Experimentalphysik

The Topological Track Reconstruction (TTR) is an algorithm originally developed for reconstructing the energy depostion of muons in liquid scintillator detectors like LENA for improving veto strategies. In its development history, the TTR was successfully used for electron/positron discrimination in JUNO and for separating Cherenkov and scintillation photons in an simulated idealised Water-based liquid scintillator (WbLS) detector. The latter application can be tested on real data in the near future with the help of the Accelerator Neutrino Neutron Interaction Experiment (ANNIE).

ANNIE is a 26-ton water-Cherenkov beam-neutrino detector that - besides neutrino-nucleus cross section and neutron multiplicity measurements - aims to be a test-bed for new detector technologies like WbLS and Large Area Picosecond Photodetectors (LAPPDs). For that, the ANNIE collaboration deployed an acrylic vessel filled with WbLS for several months and intends to use a greater volume of the liquid in the future.

A necessary step for the Cherenkov/scintillation light separation algorithm is the modification and application of the TTR to ANNIE data. This is the focus of this talk together with an introduction to the ANNIE experiment and the TTR algorithm. The presented work is supported by the DFG.

T 59.6 Wed 17:30 VG 3.103

Topological reconstruction of neutrino interactions with the SHiP detector — •James Webb, Christian Weiser, and Karl Jakobs — Albert-Ludwigs-Universität Freiburg, Physikalisches Institut, 79104 Freiburg, Germany

The SHiP (Search for Hidden Particles) experiment, to be installed within ECN3 at CERN, aims to utilise a 400 GeV/c proton beam on target to probe a broad physics regime. The high energy, high intensity proton beam dump will produce a high flux of all neutrino flavours, making this environment ideally suited for performing neutrino physics studies.

A proposed detector to exploit the neutrino flux comprises a passive tungsten plane, followed by pairs of rotated silicon strip detectors; many such layers are envisioned to be stacked up along the beam axis.

This talk will discuss the potential of such a detector in terms of track and vertex reconstruction, with an emphasis on studying tau neutrino interactions.

T 59.7 Wed 17:45 VG 3.103

Tau-neutrino signal in AdvSND@LHC — Heiko Lacker and •Eduard Ursov — Humboldt University of Berlin, Berlin, Germany

The SND@LHC (Scattering and Neutrino Detector at the LHC) is a compact, stand-alone, emulsion-based experiment designed to measure neutrinos produced in proton-proton collisions at the LHC. It operates in the previously unexplored pseudo-rapidity range of $7.2 < \eta < 8.4$. In July 2023, the SND@LHC collaboration reported the observation of eight muon neutrino charged-current candidates with a significance of 6.8σ. AdvSND@LHC, a proposed fully electronic upgrade of SND@LHC, is planned to collect data during the High-Luminosity LHC era. The upgraded detector will feature two primary subsystems: a tungsten target and a hadronic calorimeter with magnetized iron as passive material. Both subsystems will be interleaved by sensitive planes composed of silicon strips. This work presents the development of a full simulation pipeline for neutrino studies at AdvSND@LHC. The pipeline encompasses the generation of proton-proton collisions at the interaction point, production of the neutrino flux, propagation of neutrinos to the detector vicinity, neutrino interactions within the detector, and digitization of the resulting signals. To study the tau-neutrino signal, a machine learning classifier based on the Boosted Decision Trees (BDT) algorithm has been developed. This classifier achieves effective separation between charged-current muon neutrino events and charged-current tau-neutrino events with subsequent leptonic decays of the tau-leptons.

T 59.8 Wed 18:00 VG 3.103

Simulation Studies on Muon Neutrino DIS Analysis at the SND@LHC Detector — Andrew Conaboy, Heiko Lacker, •Tilly Smith, and Eduard Ursov — Humboldt University Berlin

The SND@LHC experiment, located 480m downstream from the ATLAS interaction point at the LHC, aims to detect high-energy neutrinos originating from proton-proton collisions at the LHC. This standalone experiment targets the otherwise inaccessible pseudo-rapidity region of $7.2 < \eta < 8.4$ and with the data taken during the first year of running in 2022 has successfully identified 8 $\nu\mu$ CC candidates with a significance of seven standard deviations. An in-depth simulation of the detector environment as well as the muon neutrino deep inelastic scattering (DIS) interaction is being developed to further enhance this significance level.

This talk gives an overview of the developed simulation as well as its performance on MC simulated data for both signal and background processes. Details on the applied selection cuts, tracking algorithm and analysis methods are given as well as a comparison to previous performance studies. To improve the background rejection, we study the distributions of the interaction point, shower width and position, and muon angle after interaction for simulated signal and background samples.

T 59.9 Wed 18:15 VG 3.103

Detecting Collider Neutrinos at the LHC: the FASER Experiment — •Wissal Filali, Florian Bernlochner, Tobias Boeckh, and Markus Prim — Physikalisches Institut der Universität Bonn

The neutrinos produced at the Large Hadron Collider (LHC) proton-proton collision provide an opportunity to explore the TeV regime which has remained largely uncharted. The FASER experiment, located 480 meters downstream from the ATLAS interaction point and aligned with the beam collision axis, aims to measure the interaction cross section and flux of neutrinos ν_{mu} in the energy range from 400GeV to 6TeV. Using FASER's active electronic detector, charged current interactions of muon neutrinos and anti-neutrinos are identified, the neutrino flux is measured in six momentum bins and five pseudorapidity bins, with correlations between these measurements providing improved precision in the flux determination. In this presentation, we present the current status of the analysis.

T 60: Gravitational Waves

Time: Wednesday 16:15–18:00 Location: VG 3.104

T 60.1 Wed 16:15 VG 3.104

Archival search for sub-TeV neutrino counterparts to sub-threshold Gravitational Wave events with IceCube — •Tista Mukherjee for the IceCube-Collaboration — Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

The IceCube Neutrino Observatory actively participates in multi-messenger follow-ups of gravitational wave (GW) events. With the release of the Gravitational Wave Transient Catalogue (GWTC)-2.1 and -3, sub-threshold GW event information from the third observation run of the LIGO-Virgo-KAGRA (LVK) collaboration is publicly available. This offers an opportunity to search for their corresponding neutrino counterparts. For these sub-threshold GWs, identified via template-based and minimally-modelled search pipelines, archival searches for neutrinos can enhance their astrophysical significance, and improve localization.

In this contribution, we perform a catalogue-based search for sub-TeV neutrino counterparts to some shortlisted sub-threshold GWs. This study uses archival data from IceCube's dense-infill array, DeepCore. By correlating IceCube data with sub-threshold GWs, we aim to contribute to the ongoing efforts to identify common astrophysical sources of neutrino and GW. We present the current status of this search and its role in advancing multi-messenger astronomy, paving the way for deeper exploration of transient astrophysical events.

T 60.2 Wed 16:30 VG 3.104

Seaching for high frequency gravitational waves using an external magnetic field — •Jasper Jödicke, Dieter Horns, and Marios Marouder — Institut für Experimentalphysik, Universität Hamburg

Gravitational waves interacting with external electric and magnetic fields can induce electromagnetic effects, such as displacement currents. A novel approach to detecting gravitational waves in the high-frequency regime benefits from existing axion haloscopes. In this talk the GravLC experiment is introduced, which leverages the 14 T solenoidal magnetic field of the WISPLC axion haloscope at DESY in Hamburg. By employing a suitably designed pickup loop, the experiment enables searches for transient and broadband signals, such as those expected from primordial black holes and the stochastic gravitational wave background, across the frequency range of 10 kHz - 10 MHz. This technique provides a complementary method to existing gravitational wave detection approaches.

T 60.3 Wed 16:45 VG 3.104

Quantum enhanced high frequency gravitational wave searches — •Tom Krokotsch[1], Lars Fischer[1], and Gudrid Moortgat-Pick[1,2] — [1]Universität Hamburg, Hamburg, Germany — [2]Deutsches Elektronen Synchrotron DESY, Hamburg, Germany

A promising way to probe physics beyond the Standard Model is to search for gravitational wave (GW) signals at high frequencies where known astrophysical sources can not obscure the signal. Similar to the search for dark matter, microwave cavity resonators can be used to detect faint effects from GWs. This talk will focus on the possibility to apply quantum enhancement techniques like vacuum squeezing to operate such detectors beyond the standard quantum limit. In particular, we will highlight the unique benefit this would bring to transient GW sensitivities such as those for primordial black hole mergers.

T 60.4 Wed 17:00 VG 3.104

Estimating the Detection Horizon of Gravitational Waves from Core-Collapse Supernovae for the Einstein Telescope — Markus Bachlechner, Thilo Birkenfeld, •Timo Butz, and Achim Stahl — III. Physikalisches Institut B, RWTH Aachen

Core-collapse supernovae are one of the most anticipated sources for gravitational wave detectors. A detection of such an event can provide crucial information on the processes occurring during the final stages of massive stars and open perspectives in multi-messenger astronomy. The proposed Einstein Telescope (ET), as the first of the third-generation of gravitational wave detectors, is predicted to be an order of magnitude more sensitive in the whole frequency band compared to the previous generation. Therefore, an increased event rate due to the enlarged observable volume and the ability to study details of the underlying mechanism are expected. This talk presents an analysis of ET's detection horizon for core-collapse supernovae obtained with the unmodelled search algorithm *Coherent WaveBurst* and compares it to the upper limit given by optimal matched filtering.

T 60.5 Wed 17:15 VG 3.104

Characterizing the Seismic Impact of Steel- and Wood-Based Wind Turbines on the Einstein Telescope — Marc Boxberg[2], Tom Niggemann[1], •Niklas Nippe[1], Achim Stahl[1], and Florian Wagner[2] — [1]III. Physikalisches Institut B, RWTH Aachen — [2]Geophysical Imaging and Monitoring, RWTH Aachen

Knowing the seismic impact of nearby wind turbines is crucial for future gravitational wave detectors like the Einstein Telescope. In the low frequency regime, seismic and gravity gradient noise are the dominant effects impacting the sensitivity. Vibrations of nearby wind turbines (WTs) are expected to be significant contributions. Wood as an alternative tower material is known to decrease the transfer of vibrations into the ground for existing WTs. This talk will present measurements of seismic noise and simulations of the tower vibrations of a conventional steel-based WT and compare these to measurements and simulations of a wooden tower WT.

T 60.6 Wed 17:30 VG 3.104

Cavern Geometry Effects in Newtonian Noise at the Einstein Telescope — •Valentin Tempel, Markus Bachlechner, David Bertram, and Achim Stahl — III. Physikalisches Institut B, RWTH Aachen University

The Einstein Telescope (ET) is a proposed third-generation gravitational wave detector designed to surpass the sensitivity of current interferometers like LIGO and Virgo by at least an order of magnitude. This enhanced sensitivity will enable the detection of fainter gravitational waves and provide new insights into astrophysical phenomena. One of the major challenges in achieving the desired sensitivity is Newtonian Noise (NN), which dominates the expected noise budget of ET in the frequency range of 1 Hz to 5 Hz. NN arises from density fluctuations in the rock surrounding the cavern walls, leading to fluctuating gravitational forces on the mirrors. This talk presents the impact of cavern geometry on the coupling of seismic waves to the ET mirrors. Analytical and numerical approaches are applied to demonstrate how the size and shape of the cavern influence the coupling transfer functions.

T 60.7 Wed 17:45 VG 3.104

Testing noise mitigation techniques for future gravitational wave detectors — Markus Bachlechner, •Tim Johannes Kuhlbusch, and Achim Stahl — III. Physikalisches Institut B, RWTH Aachen

Future gravitational wave (GW) detectors like the Einstein Telescope aim to decrease the detector noise to measure weaker signals and to increase the precision of measurements. To measure the minuscule length changes induced by GWs, extremely low vibration levels for the test masses are required. New noise sources become relevant in reducing the residual vibrations of the detector test masses. Gravitational couplings from surrounding vibrating material, called gravity gradient noise, can not be shielded. Therefore, predicting the coupled noise from inertial sensors is essential to reduce the impact in the 1 to 10 Hertz range.

Wiener filters are a simple and robust approach to predicting coupled noise. However, the classic Wiener filter can not adapt to variations in the amplitude of the coupled noise. As variations in the amplitude over time are expected for the ambient noise sources in GW detectors, an adaptive filter is required for optimal performance. This talk will discuss adaptive filtering options including modifications to Wiener filters and neural networks. An evaluation on data from a small-scale interferometer will be presented.

T 61: Methods in Particle Physics III (Tracking)

Time: Wednesday 16:15–18:15 Location: VG 4.101

T 61.1 Wed 16:15 VG 4.101

Performance of the SciFi tracker alignment in 2024 — •Nils Breer, Biljana Mitreska, and Johannes Albrecht — TU Dortmund University, Germany

Alignment and calibration form a crucial part of the LHCb trigger system and are responsible for ensuring the best possible physics performance. The positions of the SciFi tracker need to be monitored over time using the track-based alignment software in order to find potential biases and disentangle effects coming from other tracking systems.

In 2024 the global alignment is performed utilising all of LHCb's tracking detectors. The SciFi alignment constants are analysed on a set of runs for multiple configurations as well as the stability over time of the SciFi tracker in order to validate the performance on 2024 data.

In this talk, studies on the alignment of the outermost modules of the SciFi will be presented alongside results on the performance achieved by the global alignment.

T 61.2 Wed 16:30 VG 4.101

SciFi Threshold Calibration — •Dhruvanshu Parmar[1], Xiaoxue Han[2], and Mikhail Mikhasenko[1] — [1]Ruhr-Universität Bochum, Bochum, Germany — [2]Ruprecht-Karls-Universität, Heidelberg, Germany

The Scintillating Fiber tracker (SciFi) at LHCb, operational since 2022, is the main tracker positioned downstream of the dipole magnet. Aided by upstream trackers, SciFi detects charged particles and precisely measures their momentum and trajectory with high accuracy. It consists of three stations, each composed of 5-meter high modules containing scintillating fiber mats. The ends of the tracker modules include readout boxes equipped with silicon photomultiplier sensors (SiPMs) that collect photons generated by particle interactions with the scintillating fibers. Analog signals from SiPM channels are processed by comparing them to a set of three "comparator" thresholds to discriminate signals from dark noise. Adjusting these thresholds is critical for a high hit efficiency, a low fake track rate and sustainable bandwidth. This talk summarizes the utilization of the Light Injection System (LIS) for calibrating the comparator thresholds for the full system of 524k SiPM channels and 1.5M comparators. Accurate time alignment for optimizing LIS performance and full calibration procedure of fitting SiPM spectra will be discussed. Finally, challenges faced with LIS calibration and strategies to address them will be highlighted.

T 61.3 Wed 16:45 VG 4.101

Studies of alignment systems for the LHCb Upgrade II downstream tracker — •Todor Todorov, Ksenia Solovieva, and Marco Gersabeck — Albert-Ludwigs-Universität Freiburg, Freiburg im Breisgau, Germany

For the LHCb Upgrade II in Long Shutdown 4 the instantaneous luminosity is planned to increase by at least a factor of 5 with respect to current operation. The increase in detector occupancy and pileup will be beyond the capabilities of the current scintillating fibers (SciFi) sensors utilised in the downstream tracker of the LHCb detector. A new hybrid tracker will be installed, the Mighty Tracker, which will consist of six layers of silicon pixel sensors in the most occupied regions near the beam pipe and of an improved SciFi in the remaining areas. An active hardware alignment system will be beneficial for the physics performance of LHCb but it will have to adhere to strict space and material budget constraints. A study of alignment requirements and of early prototype systems capable of fulfilling those within the above-mentioned constraints is presented.

T 61.4 Wed 17:00 VG 4.101

Track Based Software Alignment using the General Triplet Track Fit — •David Fritz, Tamasi Kar, Abhirikshma Nandi, and André Schöning — Physikalisches Institut, Universität Heidelberg, Germany

Modern particle physics experiments require very high precision and the accurate alignment of tracking detectors. While optical surveillance systems provide an initial reference, track-based software alignment is essential for achieving optimal physics performance.

A new alignment procedure based on the General Triplet Track Fit (GTTF) [1] is introduced, enabling the simultaneous determination of track and alignment parameters. The GTTF is a novel, non-iterative, triplet-based track fit that accounts for both hit uncertainties and multiple scattering effects. Its high parallelizability and scalability make it particularly well-suited for online alignment using hardware accelerators such as FPGAs or GPUs.

This talk will provide an overview of the GTTF-based alignment in the context of standard track based alignment procedures. Additionally, results from the GTTF-based alignment for a use case - the Mu3e Pixel Detector - will also be presented.

[1] A. Schöning, 2024, A General Track Fit based on Triplets, arXiv:2406.05240

T 61.5 Wed 17:15 VG 4.101

Studies of a New Track Fitting Algorithm for the ATLAS Event Filter — Abhirikshma Nandi[1], •André Schöning[1], Sebastian Dittmeier[1], and Christof Sauer[2] — [1]Physikalisches Institut, Universität Heidelberg, Heidelberg, Germany — [2]CERN, Geneva, Switzerland

The ATLAS experiment is going through a comprehensive set of upgrades in preparation for data taking at the High-Luminosity Large Hadron Collider. The Trigger and Data Acquisition (TDAQ) systems are being upgraded to handle an increased trigger rate and run more sophisticated algorithms online to retain performance in the face of increased event complexity.

The ATLAS Event Filter (EF) - running on commercial, potentially heterogeneous computing hardware - has to provide the second level of filtering, reducing the Level-0 trigger rate of 1 MHz to 10 KHz for storage. To this end, it is required to perform track reconstruction (EF Tracking) for the entire Inner Tracker (ITk) at a maximum rate of 150 kHz.

A new, parallelizable track fit, based on triplets of hits, is being studied for EF Tracking - with the aim to gain from parallel hardware, like GPUs. The General Triplet Track Fit (GTTF) is a generalization of the Multiple Scattering-only triplet fit, developed originally for the Mu3e experiment, by including hit uncertainties. The results from the studies of the GTTF will be summarized along with an overview of the work in the broader context of the EF Tracking project.

T 61.6 Wed 17:30 VG 4.101

Online Track Reconstruction for the Mu3e Experiment — •Haris Avudaiyappan Murugan — Institute of Nuclear Physics, Johannes Gutenberg University of Mainz, Germany

The Mu3e experiment aims to find or exclude the lepton flavour violating decay of a positive muon to two positrons and an electron with a branching fraction sensitivity of 10^{-16}. To observe such a rare event, we require a tracking detector from custom-designed High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) together with timing detectors made from scintillating fibre and tiles for the experiment. The detector will be streaming up to 1 TBit/s of data to the filter farm composed of graphics processing units (GPUs), in which the data rate is reduced to less than 100 MB/s and this filtered data is stored for later analysis. This reduction can be achieved by selecting potential signal events with two positrons and one electron originating from a single vertex through online track and vertex reconstruction on the GPU. The misalignment of the thin pixel tracking detectors can affect the precision of track reconstruction. Track-based alignment algorithm requires constraints from global parameters of the actual position of the pixels which can be measured using a camera alignment system. By calibrating the track reconstruction and histogramming the momentum of tracks on the GPU, the searches can be extended to observe potential two-body decays of the muon.

T 61.7 Wed 17:45 VG 4.101

Tracking efficiency studies for LHCb in Run 3 — •Rowina Caspary[1], Michel de Cian[1], Peilian Li[2], and Maurice Morgenthaler[1] — [1]Physikalisches Institut, Heidelberg University — [2]University of Chinese Academy of Sciences (UCAS)

The LHCb experiment is dedicated but not limited to the precision measurement of particles containing b- and c-quarks. It has been collecting data with an upgraded detector and a novel software-only trigger framework since 2022 at an instantaneous luminosity up to $2 \times 10^{33}\mathrm{cm}^{-1}\mathrm{s}^{-1}$at $\sqrt{s} = 13.6$ TeV.
The correct evaluation of the track reconstruction efficiency is essential for many high-precision measurements. A tag-and-probe method is developed to estimate the track reconstruction efficiency of each tracker using muonic tracks from $J/\psi \to \mu\mu$ decays, where hits from other detector systems are used to reconstruct the probe tracks. Discrepancies of the measured track reconstruction efficiency between simulation and data are evaluated, examined and corrected deliberately, taking into account various effects due to misalignment and inefficiency of the sub-detectors. An agreement between simulation and data at the subpercent level is achieved over almost the entire phase space and for all tracking sub detectors, which illustrates the excellent understanding of the upgraded LHCb detector and its reconstruction sequences. This talk presents the results of the tracking efficiency methods in 2024 data and according systematic uncertainties.

T 61.8 Wed 18:00 VG 4.101

The Resolution Study of the New Scintillating Fiber Tracker of the LHCb Detector — •Ya Zhao — Physics Institute, Heidelberg University, Germany

The LHCb experiment started data-taking in 2022 with the upgraded tracking system including Vertex Locator(Velo), Upstream Tracker(UT) and Scintillating Fiber Tracker(SciFi). The hit resolution of SciFi is an essential part of its performance. An analysis of SciFi hit resolution was performed using 2024 dataset with latest alignment condition. The strategy to calculate hit resolution and the relationships between hit resolution and SciFi layers, track momentum, track slopes will be presented. The results of hit resolution measurement will provide SciFi hit errors for Kalman Filter to improve tracking performance. The long track momentum resolution is a key metric to evaluate the performance of the tracking system of LHCb. It can be estimated from the mass resolution of reconstructed Jpsi2mumu candidates. The approach and result of long track momentum resolution using 2024 dataset will be presented.

T 62: Search for Dark Matter III

Time: Wednesday 16:15–18:30 Location: VG 4.102

T 62.1 Wed 16:15 VG 4.102

Primordial Black Hole: from very early universe to Dark Matter — •Maël Gonin[1,2], Günther Hasinger[1,2], and David Blaschke[3,4,5] — [1]Deutsches Zentrum für Astrophysik, Görlitz 02826, Germany — [2]IKTP TU Dresden, Zellescher Weg 19, 01069 Dresden, Germany — [3]Institute of Theoretical Physics, University of Wroclaw, Wroclaw, Poland — [4]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [5]Center for Advanced Systems Understanding, 02826 Görlitz, Germany

Dark Matter (DM), comprising 30% of the universe's energy, remains one of cosmology*s greatest mysteries. Primordial Black Holes (PBHs), theorized by Hawking and Carr (1971), are compelling DM candidates as purely gravitational, non-baryonic objects. Though unproven, PBHs offer a unique alternative to particle DM (pDM) and insights into the early universe. We develop a novel PBH mass spectrum based on the equation of state (EoS) of the early universe, where phase transitions enhance PBH formation probabilities. Using advanced quark matter simulations, we also explore lepton flavor asymmetry and the possibility of a 17 MeV boson observed in electron-positron pair production. Additionally, N-body simulations using PeTar examine PBH detectability, focusing on globular cluster dynamics and PBH-star binaries, such as those observed by the Gaia collaboration. This presentation will discuss these approaches and their implications for identifying PBHs as DM candidates.

T 62.2 Wed 16:30 VG 4.102

SNAX: Supernova Neutrino Analysis in XENONnT — •Melih Kara for the XENON-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

Core-collapse supernovae emit 99% of their energy as neutrinos, preceding any optical signals, offering a unique opportunity to study the physics of these explosive events. While traditional neutrino detectors are optimized for specific flavors, dark matter experiments like XENONnT leverage coherent elastic neutrino-nucleus scattering (CEνNS), enabling detection of neutrinos across all flavors at low energies.

This presentation focuses on the methods developed within the XENONnT framework to identify supernova neutrino signals promptly. We discuss the simulation of neutrino interactions, strategies for detecting CEνNS signals in real-time, and the integration of an active software trigger to communicate with the Supernova Early Warning System (SNEWS). These techniques ensure efficient and timely detection, allowing dark matter detectors to complement traditional neutrino observatories.

This work is supported in part through the Helmholtz Initiative and Networking Fund (grant no. W2/W3-118). Support by the graduate school KSETA at KIT is gratefully acknowledged.

T 62.3 Wed 16:45 VG 4.102

Novel Peak(let) Classification for the XENONnT Experiment — •Johannes Merz for the XENON-Collaboration — Johannes Gutenberg-Universität Mainz, Institut für Physik & Exzellenzcluster PRISMA+

The XENONnT Experiment is a dual phase time projection chamber searching for nuclear recoil signals generated by WIMP dark matter. Interactions with the liquid xenon in the bulk of the detector result in a prompt light signal (S1) and a secondary scintillation signal (S2), due to ionization electrons drifted in a moderate electric field to the liquid surface, where they are extracted to the gas phase in a strong field between two wire electrodes, called gate and anode.

These electrons lead to proportional scintillation in the gas phase and hence to an amplified S2 signal. XENONnT features a substantial background rate of single electrons, largely due to photoionization of neutral impurities, leading to numerous small S2 signals. These can be confused with S1 signals of similar size.

This presentation will show new machine learning classification methods used in XENONnT which will help to improve the discrimination between the two signal types and identify interesting signal populations in our data.

T 62.4 Wed 17:00 VG 4.102

DARWIN forecasted sensitivities — •Maike Doerenkamp — Physikalisches Institut, Universität Heidelberg

DARWIN, as a proposed next generation xenon based direct detection experiment, aims to explore new parameter-space of WIMP-nucleon interactions through nuclear recoil, all the way to neutrino dominated regimes. This requires extensive simulation of detector parameters and their impact on detection efficiencies, as well as a good understanding of relevant backgrounds and their mitigation strategies. This talk gives an overview of the used methods and obtained sensitivity estimates for the DARWIN observatory.

T 62.5 Wed 17:15 VG 4.102

Coating-based radon barriers for future liquid xenon detectors — •Sophie Armbruster[1], Giovanni Volta[1], Hardy Simgen[1], and Florian Jörg[2] — [1]Max Planck Institut für Kernphysik, Heidelberg — [2]Universität Zürich

Despite overwhelming evidence for dark matter in our universe, its true nature remains a mystery. In the search for dark matter, detectors using liquid xenon are currently leading in sensitivity. However, these experiments are increasingly limited by self-induced backgrounds, particularly the emanation of radon from detector materials. To address this challenge, a novel radon mitigation technique using surface coatings as radon barrier has been investigated. Systematic studies at the Max Planck Institut für Kernphysik have demonstrated that electrochemical plating with a 5 μm copper layer can reduce radon emanation by up to three orders of magnitude. This technique is currently scaled up for vessel-like geometries with a new setup.

T 62.6 Wed 17:30 VG 4.102

Exploring Sub-GeV Dark Matter with CRESST: Advances, Challenges, and Prospects — •Marco Maria Zanirato — Max Planck Institut für Physik, München, Deutschland

The Cryogenic Rare Event Search with Superconducting Thermometers (CRESST) is a forefront experiment in the direct detection of dark matter, operating at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. Utilising cryogenic calorimeters based on (mainly) scintillating crystals equipped with Transition Edge Sensors (TESs), CRESST achieves exceptional energy thresholds on the order of 30eV and operates at temperatures in the millikelvin range. These capabilities make CRESST uniquely suited to probe dark matter particles with sub-GeV masses. This talk will provide a comprehensive overview of CRESST, highlighting the working principles of its detectors, the latest results in dark matter searches, and the challenges inherent to such a cutting-edge experiment. The discussion will also include insights into ongoing efforts to refine detector designs and enhance the experiment's sensitivity, paving the way for future explorations in the quest to discover the nature of dark matter.

T 62.7 Wed 17:45 VG 4.102

Enhancing Simulation Statistics through Importance Biasing for the CRESST Experiment — •Praveen Murali for the CRESST-Collaboration — Heidelberg University

The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) experiment is a pioneering project in the search for dark matter, employing ultra-sensitive cryogenic detectors to capture rare particle interactions. These rare events demand highly efficient and accurate simulations to optimize detector performance and data analysis. Importance biasing is a technique that boosts statistical accuracy without requiring extensive repetitions, offering a solution to this challenge. In this work, we apply GEANT4's Importance Biasing to CRESST simulations, demonstrating its successful implementation and impact on improving statistical outcomes. This presentation will detail the methodology and the results of this approach for CRESST.

T 62.8 Wed 18:00 VG 4.102

Development of a Detector Module with Optimized Scintillation Light Sensitivity for the COSINUS Experiment — •Lutz Ziegele for the COSINUS-Collaboration — Max-Planck-Institut für Physik, 85748 Garching, Germany

The Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches (COSINUS) is a direct dark matter search located at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. The experiment operates sodium iodide (NaI) as cryogenic calorimeters. Particle interactions within the crystal generate phonon signals, detected by a remote Transition Edge Sensor (remoTES). Combined with the scintillation signal detected by TES on a surrounding silicon beaker-shaped light absorber, a dual channel readout is achieved, enabling particle discrimination. This contribution focuses on the development of a detector module optimized in terms of scintillation light sensitivity. This is achieved by segmenting the light-collecting silicon beaker into multiple separated wafers surrounding the NaI crystal. The reduced size of these individual light absorbers minimizes heat capacity, thereby increasing sensitivity. The primary objective is the precise characterization of the scintillation light output of the ultrapure NaI crystals, which is vital for the data analysis of the upcoming COSINUS runs. Furthermore, this development represents a foundational step toward creating a detector module with single-photon resolution - a critical advancement for future investigations of dark matter interactions with electrons proposed within the LUCE/OνDES project funded by the Klaus Tschira foundation.

T 62.9 Wed 18:15 VG 4.102

Evaporated Gold Thin-Films on NaI Crystals for remoTES based cryogenic Detectors — •Kilian Heim for the COSINUS-Collaboration — Max-Planck-Institut für Physik, Garching, Deutschland

The COSINUS (Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches) experiment plans a model-independent cross-check of the DAMA/LIBRA dark matter result. Starting its first operational phase in 2025, it will use the same target material NaI, but operated at cryogenic temperatures, enabling a dual-channel readout of both a scintillation and a phonon signal. The phonon signal is read out with a TES (transition edge sensor), but due to the low melting point and hygroscopicity of the NaI crystal, the TES cannot be deposited directly on the crystal. Therefore, the so-called remoTES setup is applied, in which the TES is located on a separate wafer and only a gold pad is required on the crystal. In the latest detector prototypes, the gold pad is deposited by an evaporation process. The first tests of this design have shown promising results. To further investigate and improve the performance and behavior of the detector design, the subsequent prototypes will be tested with different crystal masses and gold pad sizes. In this contribution, I would like to highlight the upgrades taken on the absorber part of the detector over the last year and present results of the latest detector prototype tests.

T 63: Invited Overview Talks III

Time: Thursday 11:00–12:30 Location: ZHG011

Invited Overview Talk T 63.1 Thu 11:00 ZHG011

Neutrino properties from the laboratory and the cosmos — •Thomas Schwetz-Mangold — Karlsruhe Institute of Technology, Karlsruhe, Germany

This talk reviews the present knowledge about neutrino properties, focusing on the determination of neutrino masses and PMNS mixing angles. I will review the implications of global data on neutrino oscillations and discuss the results of latest global fits, and I comment on expected near-term developements. For the determination of the absolute neutrino mass, complementary inforamtion is needed. In particular, recent results from cosmology lead to stringent upper limits on the sum of neutrino masses which start to be in slight tension with the lower bound implied by oscillation data. I will review the present status of this emerging tension and possible near future scenarios in light of upcoming data from DESI and EUKLID. A corroborated neutrino tension may be a sign of new physics in the cosmological model and/or in neutrino physics.

Invited Overview Talk T 63.2 Thu 11:30 ZHG011

Highlights from Standard Model physics at the LHC in the precision era — •Daniel Savoiu — Universität Hamburg

With the first two runs of the Large Hadron Collider (LHC) successfully completed, and Run 3 currently underway at an unprecedented center-of-mass energy of 13.6 TeV, the experiments at the LHC continue to collect a wealth of data for physics analysis. Following the discovery of the final component of the Standard Model (SM)—the Higgs boson—in 2012, the LHC physics program has entered an era of precision, aiming to measure the fundamental parameters of the SM and the properties of its constituent particles to the most precise extent possible. The quest for precision is complemented by a vast array of searches for phenomena beyond the SM (BSM), which directly benefit from the improved knowledge of the SM. In this contribution, I will present a selection of recent results from the ATLAS and CMS collaborations, focusing on SM electroweak and QCD physics, and touching upon searches for BSM phenomena.

Invited Overview Talk T 63.3 Thu 12:00 ZHG011

Cosmological results from the Dark Energy Spectroscopic Instrument — •Daniel Gruen — University Observatory, Faculty of Physics, Ludwig-Maximilians-Universität, Scheinerstr. 1, 81679 München

The Dark Energy Spectroscopic Instrument (DESI) is conducting by far the most comprehensive survey of galaxy distances to date. Its primary goal is a precision measurement of the expansion of the Universe over the past 10 billion years. This expansion may reveal more about the nature of one of the biggest mysteries of modern physics, the late-time accelerating effect called Dark Energy.

I will review the results of Baryonic Acoustic Oscillation measurements, which provide a 'standard ruler' of fixed physical scale that can be observed to track expansion from the embryonic to the adult universe. The first year of DESI data, together with cosmic microwave background and supernova observations, has provided tantalising evidence that Dark Energy indeed is not a constant vacuum energy density. The analysis of three years of DESI galaxy observations, potentially concluded by Göttingen25, will again sharpen what we know about the recent past and the future of our cosmos.

T 64: Invited Topical Talks III

Time: Thursday 13:45–15:45 Location: ZHG011

Invited Topical Talk T 64.1 Thu 13:45 ZHG011
Performance of the ATLAS New Small Wheels — •Fabian Vogel — LMU München

As the Large Hadron Collider (LHC) transitions into the High-Luminosity era (after 2029), all experiments are undergoing significant upgrades to cope with the more intense collision environment and to select the most interesting – and often rarest – events. For the ATLAS experiment, these upgrades are carried out in multiple steps. The first upgrade (Phase 1) was completed in 2022, while the second phase (Phase 2) is currently being prepared for 2026.

A major upgrade during Phase 1 was the replacement of the inner forward muon spectrometer (Small Wheels) with the New Small Wheels (NSWs) to handle the increased particle fluxes with excellent spatial and temporal resolution, effectively reducing fake triggers and pile-up. The NSWs consist of two gaseous detector technologies: small-strip Thin-Gap Chambers (sTGCs) and Micro-Mesh Gaseous Structure (Micromegas) detectors.

This talk will highlight the performance of these new detector technologies in the ATLAS muon spectrometer and assess their success in reducing pile-up while maintaining excellent spatial and temporal resolution with high efficiency and longevity during HL-LHC operation.

Further, studies on Micromegas position reconstruction will be presented, focusing on algorithms optimized for inclined particle trajectories.

Invited Topical Talk T 64.2 Thu 14:15 ZHG011
Top quark and friends — •Jan van der Linden — Gent University, Belgium

With the conclusion of Run 2 at the LHC, and a successful ongoing Run 3, the amount of data collected at the CMS experiment allows for precision measurements of rare top quark-associated processes and measurements of interesting top quark properties which have previously not been accessible.

In this talk I will highlight some of the recent CMS measurements in top quark physics, including (but not limited to) top quark-antiquark pair production in association with bosons or jets. I will discuss the improvements that have been made in recent years and what still remains unanswered.

Invited Topical Talk T 64.3 Thu 14:45 ZHG011
Searching for New Physics in Soft Unclustered Energy Patterns — •Alexander Lory — Ludwig-Maximilians-Universität Munich

Most collider-based searches for new physics focus on final states with a small number of high-momentum particles. In contrast, a Soft Unclustered Energy Pattern (SUEP) represents a distinct signature characterized by a high multiplicity of spherically distributed, low-momentum particles. Such a signature can arise from strongly coupled, quasi-conformal Hidden Valley models.

Although it may seem very exotic, such an extension of the Standard Model is well-motivated, as quantum chromodynamics exhibits similar behavior in its non-perturbative regime. However, identifying SUEPs at the LHC poses unique challenges, as their diffuse, low-momentum nature closely resembles the ubiquitous background from pile-up interactions. Furthermore, detecting them often requires pushing detector performance beyond its original design specifications.

Despite these challenges, the signature offers promising opportunities to explore new physics in uncharted regions of the kinematic phase space. This presentation reviews existing experimental searches for SUEPs and explores potential new strategies.

Invited Topical Talk T 64.4 Thu 15:15 ZHG011
Alignment and calibration at the LHCb experiment — •Biljana Mitreska — TU Dortmund University, Dortmund, Germany

The LHCb software trigger allows splitting the triggering of events in two stages, allowing to perform the detector alignment and calibration in real time. The real-time alignment and calibration procedure is a fully automatic procedure at LHCb that is executed at the beginning of each fill of the LHC. The alignment estimates the position of detector elements and is essential to achieve the best data quality. The procedure is implemented for the full tracking system at LHCb with the event reconstruction run as a multithreaded process ensuring consistency between triggered and offline selected events. The operational and technical aspects of this procedure during data-taking is discussed with the focus on the performance in the 2024 data-taking period where the first global tracker alignment was obtained.

T 65: Invited Topical Talks IV

Time: Thursday 13:45–15:45 Location: ZHG010

Invited Topical Talk T 65.1 Thu 13:45 ZHG010
Searching for Axions and other Light Bosons at DESY — •Jacob Egge — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Light bosons, including the axion and axion-like particles (ALPs) inspired by string theory, are compelling candidates for new physics. These particles are of interest not only for their potential to address the strong CP problem but also as promising dark matter candidates and mediators of novel interactions. Experimental searches for light bosons span three main approaches: haloscopes probe signals from the galactic dark matter halo; helioscopes explore particles produced in the sun; and laboratory-based experiments aim to produce and detect these particles in controlled settings.

DESY is uniquely positioned to potentially host cutting-edge experiments in all three categories, including the haloscope MADMAX, the helioscope IAXO, and the light-shining-through-wall experiment ALPSII. In this talk, I will provide an update on DESY's efforts to search for axion-like particles, highlighting the results of the initial data-taking campaigns for MADMAX and ALPSII.

Invited Topical Talk T 65.2 Thu 14:15 ZHG010
14 years of coordinated outreach for particle physics: methods, impact and prospects — •Saskia Plura[1], Uta Bilow[2], Michael Kobel[2], Achim Denig[1], Heike Vormstein[1], and Mirco Christmann[1] for the Netzwerk Teilchenwelt-Collaboration — [1]Johannes Gutenberg-Universität, Mainz — [2]TU Dresden, Dresden

The outreach program "Netzwerk Teilchenwelt" was created in 2010 as a means of opening the LHC and its data for public engagement with science, ranging from analysis of original data to research participation in high school theses. Now, 14 years later, the network has expanded to more than 30 institutions with more than 200 scientists participating and includes now also hadron, nuclear and astroparticle physics.

The impact of a coordinated, large scale outreach program is profound: by focusing mostly on high school students and teachers, "Netzwerk Teilchenwelt" has managed to bridge the gap between scientists and schools. A three step program for students provides guidance and fosters interest, while the consecutive "Fellows" program allows for direct connection between researchers and university students. Alongside these programmes, a multitude of events for the general public help push particle physics into view.

The efforts of the community have shown to have long-term effects. This talk provides insights into the methods and the achievements of "Netzwerk Teilchenwelt" as a coordinated outreach program and its future prospects.

Invited Topical Talk T 65.3 Thu 14:45 ZHG010

The Emerging Population of Seyfert Galaxies as Neutrino Sources in IceCube — •Chiara Bellenghi, Tomas Kontrimas, and Elena Manao for the IceCube-Collaboration — Technical University of Munich

The IceCube detection of neutrinos from the X-ray-bright Seyfert galaxy NGC 1068, combined with the lack of a gamma-ray counterpart, suggests that gamma-ray hidden cores of Active Galactic Nuclei (AGN) could be powerful cosmic-ray accelerators. The X-ray-bright corona, near the AGN supermassive black hole, provides a suitable environment for neutrino production and gamma-ray absorption at the same time. This talk will review recent IceCube results from searches for extragalactic neutrino sources, adding to the growing evidence that X-ray-bright, non-blazar AGN could be the first emerging population of neutrino sources.

Invited Topical Talk T 65.4 Thu 15:15 ZHG010

First detection of neutrinos in water-based liquid scintillator at ANNIE — •Johann Martyn for the ANNIE-Collaboration — Johannes Gutenberg-University Mainz

Water-based liquid scintillator (WbLS) is a novel detector medium that allows for the separation of the scintillation and Cherenkov components of a signal. As such, it is of great interest for the development of future hybrid neutrino detectors, allowing for a low energy-threshold, directional event reconstruction, reconstruction of hadronic recoils, and enhanced particle identification.

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a 26-ton gadolinium-loaded water Cherenkov neutrino detector installed on the Booster Neutrino Beam (BNB) at Fermilab. As its main physics goals the experiment aims to investigate neutrino-nucleus interactions and cross sections. Additionally, ANNIE has an equally important focus on the research and development of new detector technologies, such as WbLS and Large Area Picosecond Photodetectors (LAPPDs).

This talk presents the deployment of a 70cm x 90cm WbLS vessel in ANNIE and the subsequent first detection of neutrinos in WbLS. The successful observation of both scintillation and Cherenkov light in ANNIE corresponds to a proof-of-concept for the hybrid event detection. This allows for the development of reconstruction and particle identification algorithms, as well as dedicated analyses in ANNIE, that make use of both the Cherenkov and scintillation component.

This work is supported by the DFG (490717455).

T 66: Searches/BSM IV (BSM with Tops, LQs)

Time: Thursday 16:15–18:00 Location: ZHG010

T 66.1 Thu 16:15 ZHG010

Search for new physics in all-hadronic $t\bar{t}t\bar{t}$ using ML with the CMS experiment — •Shahzad Sanjrani[1,2], Freya Blekman[1,3], and Joel Goldstein[2] — [1]Deutsches ElektronenSynchrotron DESY, Hamburg, Germany — [2]University of Bristol, Bristol, United Kingdom — [3]University of Hamburg, Hamburg, Germany

There is current interest in searching for beyond the standard model particles produced in association with a top quark pair, $t\bar{t}+X(X \to t\bar{t})$. This project focuses on a top-philic $Z*$ resonance model that may significantly enhance the $t\bar{t}t\bar{t}$ cross section. The all-hadronic channel is explored in the resolved regime using a novel machine learning algorithm, SPA-Net, which performs permutation-invariant jet-parton assignment to reconstruct events. This talk presents initial limits using this network to discriminate signal against large QCD multijet- and $t\bar{t}$-dominated backgrounds. Studies shown use Monte Carlo simulations of proton-proton collision data gathered by the CMS detector at the LHC.

T 66.2 Thu 16:30 ZHG010

Search for 3 top BSM resonances in boosted all hadronic final state with the CMS experiment — •Lucia Ximena Coll Saravia[1], Freya Blekman[1,2], Andreas Hinzmann[1], Kuan-Yu Lin[1], and Matthias Komm[1] — [1]DESY, Hamburg, Germany — [2]University of Hamburg, Hamburg, Germany

The production of three top quarks (3-top) has been identified as a promising signal for probing new physics beyond the Standard Model (BSM). Various BSM models propose a hypothetical Z' boson that preferentially couples to top quarks, which could manifest as an enhanced 3-top signal, a scenario yet unexplored by the CMS experiment. Recent analyses by ATLAS and CMS indicate that the observed four and three top cross section fits are consistent with predictions of a three top production cross section exceeding that of the Standard Model (SM). This study explores two channels in the fully hadronic final state: tZ' and tWZ'. Studies of three boosted top quark jets for Z' masses in the TeV range and the search sensitivity of Run 2 and Run 3 will be reported.

T 66.3 Thu 16:45 ZHG010

Search for Leptoquark pair production in $b\tau b\tau$ final states with the ATLAS experiment — •Johannes Klas, Tatjana Lenz, and Jochen Dingfelder — Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn

Leptoquarks are hypothetical particles that carry lepton and baryon quantum numbers and can thus decay into a quark and a lepton, which is forbidden in the Standard Model (SM). They are predicted in various theories beyond the SM, like theories of quark-lepton unification or Grand Unified Theories. Leptoquarks may offer an explanation of some of the open questions in the SM like the anomalous magnetic moment of the muon or the anomalies observed in the decay of B-Mesons into D-Mesons. The search for pair production of leptoquarks in the $b\tau b\tau$ final state using Run 2 ATLAS pp collision data will be presented in this talk. New methods to reconstruct leptoquark events are explored and the limits on the cross section are compared to the previous ATLAS Run 2 results.

T 66.4 Thu 17:00 ZHG010

Search for resonant Leptoquark production using Run 2 pp collision data of the ATLAS experiment — •Christopher Engel, Adrian Alvarez, and Stefan Tapprogge — Institute for Physics, Johannes Gutenberg University, Mainz, Germany

A Leptoquark is a hypothetical particle that couples to both leptons and quarks and carries both lepton and quark quantum numbers. Leptoquarks are are predicted by many extensions of the Standard Model, including Grand Unified Theories, and might explain similarities between the lepton and the quark generations. One way of searching for such a particle would be to look for the production of a single Leptoquark in proton-proton collisions caused by the interaction of a lepton and a quark coming from the inner structure of protons.

This talk focuses on this resonant production of a single Leptoquark decaying into an electron and a b-quark, which results in an electron+b-jet signal in the detector. This resonant structure in the invariant mass distribution of the electron and b-jet system could be identified on top of a smoothly falling background. One of the main goals of this contribution is the presentation of the background processes, the required cut optimization and the expected exclusion limits based on the Run 2 ATLAS data with 140 fb^{-1}.

T 66.5 Thu 17:15 ZHG010

Search for dark matter production in association with a single top quark at the CMS experiment — •Moritz Molch[1], Doug Berry[2], Ulrich Husemann[1], Michael Wassmer[1], and Sebastian Wieland[1] — [1]Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT) — [2]Fermi National Accelerator

Laboratory (FNAL), Batavia, IL

This talk presents results of a search for the production of dark matter (DM) candidates in association with a single top quark in proton-proton collisions at a center-of-mass energy of $\sqrt{s} = 13$ TeV with the CMS experiment, with a data set corresponding to an integrated luminosity of 138 fb^{-1}.

Since DM candidates are expected to interact only very weakly, they are not directly detectable with the CMS detector. Therefore the final state consists of a single top quark and missing transverse momentum.

The presented analysis targets the final state in which the top quark decays hadronically. A key feature of this analysis is the use of large-radius jets in combination with multivariate techniques to separate jets which originate from a top quark decay from purely QCD-initiated jets. The major backgrounds are estimated in the maximum likelihood fit for signal extraction using data from multiple control regions. Finally, the results are interpreted in the context of a simplified model introducing a flavor-changing neutral current at tree-level by a spin-1 mediator and spin-1/2 DM candidates.

T 66.6 Thu 17:30 ZHG010

Exploring boosted top quark decays using Run 3 data collected by the CMS experiment — •Johanna Matthiesen[1], Johannes Haller[1], Roman Kogler[2], and Daniel Savoiu[1] — [1]Institut für Experimentalphysik, Universität Hamburg — [2]DESY, Hamburg

Highly energetic top quarks produced in proton-proton collisions at the LHC can result in decay products that are highly collimated, appearing as a single large-radius jet in the CMS detector. These jets exhibit a distinctive internal substructure, enabling discrimination between top quark jets and those arising from other QCD processes. However, discrepancies between distributions in recorded data and simulations require corrections to the simulations. The boosted topology offers a unique opportunity to probe for new heavy particles decaying into top-antitop quark pairs. This presentation provides first insights from the ongoing LHC Run 3, focusing on the top-antitop quark mass spectrum as a potential window to new physics phenomena.

T 66.7 Thu 17:45 ZHG010

Search for Leptoquarks in the multilepton channel with ATLAS Run-2 data — •Ondrej Matousek and Andre Sopczak — Czech Technical University in Prague

The latest results in the search for leptoquarks in the multilepton channel are presented using ATLAS Run-2 data.

T 67: Higgs Physics VII (HH and Trilinear Coupling)

Time: Thursday 16:15–18:45 Location: ZHG104

T 67.1 Thu 16:15 ZHG104

Search for non-resonant Higgs boson pair production in dilepton final states of the bbWW decay mode at CMS — •Lara Markus, Matteo Bonanomi, Mathis Frahm, Johannes Haller, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

The trilinear coupling of the Higgs boson is related to the shape of the Higgs potential, which makes it a crucial parameter of the Standard Model. The shape can be directly probed by measuring the cross section of Higgs boson pair production in pp collisions at the LHC.

This talk presents a search for non-resonant pair production of Higgs bosons decaying into a b quark anti-quark pair and two W bosons, with subsequent decays of the W bosons into leptons and neutrinos. The analysis strategy is developed using Run 3 data of the CMS experiment, with a corresponding center-of-mass energy of at 13.6 TeV. The analysis is implemented in a columnar-based framework 'columnflow'.

T 67.2 Thu 16:30 ZHG104

Search for Boosted Higgs Pair Production From Vector Boson Fusion in the Single Lepton $b\bar{b}W^+W^-$ Final State Using the ATLAS Detector — •Lars Linden, Valerio d'Amico, Celine Stauch, Stefanie Götz, Bao Tai Le, Tim Rexrodt, and Otmar Biebel — LMU Munich

The discovery of the Higgs boson solved one of the biggest problems in the standard model, the generation of particle masses. However, even more than 10 years after its discovery, not all of its properties are well know. One of these is the quartic coupling of a Higgs boson pair to a pair of electroweak gauge bosons. A process suited to constrain this coupling is given by Di-Higgs production via vector boson fusion (VBF), the second most common production mode at LHC. This talk will present some early results of a search for VBF Di-Higgs production in the $b\bar{b}W^+W^-$ final state with a single lepton, using the ATLAS run 2 and 3 datasets.

T 67.3 Thu 16:45 ZHG104

Efficiency measurements of di-lepton triggers in a search for di-Higgs production in CMS data — •Balduin Letzer, Lukas Ebeling, Mathis Frahm, Johannes Haller, Karla Kleinbölting, Finn Labe, Artur Lobanov, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

With a collision rate too large to store all events at the CMS experiment, a fast online selection (trigger selection) of interesting events is performed. The knowledge of the efficiency of this trigger selection is crucial in many physics analyses. A common method to measure the trigger efficiency in data uses a dataset selected with an orthogonal trigger selection. The method is used to measure the efficiency of different trigger selections in a search for di-Higgs production in the bbWW final state with two leptons, using data from the LHC Run-3. The results are used to derive correction factors that are applied to the simulated signal and background events in the analysis, in order to improve their modelling of the data.

T 67.4 Thu 17:00 ZHG104

Higgs self-coupling measurement at the ILC — •Bryan Bliewert[1,2], Julie Munch Torndal[1,2], and Jenny List[1] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]Universität Hamburg, Hamburg, Germany

Measuring the Higgs self-coupling represents a cornerstone of the physics program of future colliders because it gives important insights into the shape of the Higgs potential. This contribution summarizes the updated projections for the determination of the Higgs self-coupling from di-Higgs production at future e^+e^- colliders. In particular, we will present an update of the analysis of di-Higgs production at 500 GeV using full simulation of the ILD detector concept, incorporating advancements through state-of-the-art particle ID and flavor tagging as well as covering the $HH \to b\bar{b}b\bar{b}$ and $Z \to q\bar{q}/e^+e^-/\mu^+\mu^-/\bar{\nu}\nu$ channels. Based on the experience of previous analyzes, we extrapolate these to cover some of the remaining decay modes, e.g. $HH \to \bar{b}bWW$ or $Z \to \tau^+\tau^-$, as well as the contribution from the W W fusion production mode. We study the dependency of the results on the center-of-mass energy as well as on the value of the trilinear coupling realized in nature.

T 67.5 Thu 17:15 ZHG104

Top-Yukawa-induced corrections to Higgs pair production — Arunima Bhattacharya[1], Francisco Campanario[1], •Sauro Carlotti[2], Jamie Chang[3], Javier Mazzitelli[3], Milada Margarete Mühlleitner[2], Jonathan Ronca[4], and Michael Spira[3] — [1]University of Valencia-CSIC, Spain — [2]Karlsruher Institut für Technologie, Germany — [3]Paul Scherrer Institut, Switzerland — [4]University of Padua, Italy

After the discovery of the Higgs boson in 2012, the measurements of the Higgs self coupling is still a challenge for current and future experiments in particle physics. Higgs-boson pair production via gluon fusion is a loop-induced process. In order to increase the accuracy of the theoretical predictions for this process, higher-order corrections are necessary to reduce theoretical uncertainties and to describe differential distributions reliably. The next-to-leading order (NLO) corrections involve the evaluation of two-loop Feynman diagrams. In particular, for electroweak (EW) corrections, many different mass scales appear in the calculation, such as the gauge boson, bottom, top quark, and Higgs boson masses. Further complications include numerical instabilities due to virtual thresholds which require careful treatment.

In my talk, I will present results for the EW corrections induced by the top Yukawa coupling with contributions from light-quark loops without using any reduction techniques to master integrals. The calculations is done by keeping the masses as fully symbolic parameters, allowing, in the future, for a study of parametric and mass scheme/scale uncertainties.

T 67.6 Thu 17:30 ZHG104

Quark-initiated Double Higgs Production at one loop — •Philipp Rendler — Karlsruhe Institute of Technology

We present the analytic amplitude for double Higgs production in the quark-initiated channel at one loop, with full dependence on all mass scales. The calculation is performed using the method of differential equations employing a large mass expansion to fix the integration constants. The results are written in terms of iterated integrals, with integrals from simpler topologies being expressed in terms of Generalized PolyLogarithms. This amplitude forms a part of the electroweak corrections to Higgs boson pair production.

T 67.7 Thu 17:45 ZHG104

Double Higgs production in vector boson fusion at NLO QCD with anomalous couplings — •Jens Braun[1], Pia Bredt[2], Gudrun Heinrich[1], and Marius Höfer[1] — [1]Institute for Theoretical Physics, Karlsruhe Institute of Technology (KIT), Wolfgang-Gaede-Str. 1, 76131 Karlsruhe, Germany — [2]Department of Physics, University of Siegen, Walter-Flex-Straße 3, 57068 Siegen, Germany

We present a calculation of the NLO QCD corrections to Higgs boson pair production in vector boson fusion, combined with the leading operators parametrising anomalous interactions in non-linear Effective Field Theory (HEFT). Based on our Monte Carlo implementation using GoSam+Whizard, we investigate the effects of anomalous Higgs couplings on various observables.

T 67.8 Thu 18:00 ZHG104

$\gamma\gamma b\bar{b}$ in a variable flavor number scheme — •Orcun Kolay[1], Stefan Höche[2], and Frank Siegert[1] — [1]Technische Universität Dresden, Germany — [2]Fermi National Accelerator Laboratory, Batavia, USA

Measuring Higgs boson pair production is crucial for directly probing the Higgs trilinear coupling, with $HH \to \gamma\gamma b\bar{b}$ emerging as one of the most sensitive final states at the HL-LHC. Given the significant continuum diphoton background, precise background modeling is essential to improve search sensitivity. This talk will present a novel approach that combines $\gamma\gamma b\bar{b}$ (4-flavor scheme, 4FS) and $\gamma\gamma$+jets processes (5-flavor scheme, 5FS) within the Sherpa framework. By incorporating b-quark mass effects and employing a variable flavor number scheme, this improved methodology enables more accurate predictions for scenarios involving fake heavy-flavor jets and aligns seamlessly with $\gamma\gamma$+jet simulations. These advancements provide a more comprehensive and precise description of the background for the $HH \to \gamma\gamma b\bar{b}$ analysis.

T 67.9 Thu 18:15 ZHG104

Comparison between off-shell and on-shell sensitivity to trilinear Higgs couplings at future colliders based on EFTs and models with an extended Higgs sector — Henning Bahl[1], Philip Bechtle[2], Johannes Braathen[3], Klaus Desch[2], Christian Grefe[2], Sven Heinemeyer[4], Jenny List[3], •Murillo Vellasco[2], and Georg Weiglein[3,5] — [1]Institute for Theoretical Physics (ITP), Universität Heidelberg, Germany — [2]Physikalisches Institut, Universität Bonn, Germany — [3]Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany — [4]Instituto de Física Teórica (UAM/CSIC), Universidad Autónoma de Madrid, Spain — [5]Institut für Theoretische Physik, Universität Hamburg, Germany

Measuring the Higgs potential is one of the main goals of the next generation of high-energy particle colliders. Studies of the future sensitivity to trilinear Higgs coupling, λ_{hhh}, have been mainly performed within the framework of EFTs, which offer some degree of model-independence. However, not only is the EFT approach not valid if BSM degrees of freedom are not fully decoupled, but one must often make a selection of relevant operators to consider out of larger set thereof.

In this work, we have investigated the sensitivity to λ_{hhh} at future colliders based on UV-complete models with extended Higgs sectors, while also comparing with results from EFT analyses. In particular, we considered cases where on-shell measurements sensitive to λ_{hhh} would show considerable deviations from the SM value, all the while avoiding large deviations in off-shell observables. The results highlight the need to go beyond EFT frameworks.

T 67.10 Thu 18:30 ZHG104

Renormalisation scheme dependence of the trilinear Higgs coupling in extended scalar sectors — •Marc Hannig[1], Marco Menen[1,2], Elina Fuchs[1,2,3], Henning Bahl[4], Georg Weiglein[3,5], and Johannes Braathen[3] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover — [2]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig — [3]Deutsches Elektronen- Synchrotron DESY, Hamburg — [4]Institut für Theoretische Physik, Universität Heidelberg — [5]II. Institut für Theoretische Physik, Universität Hamburg

The trilinear Higgs coupling λ_{hhh} of the detected Higgs boson is a critical observable for understanding of the Higgs potential. With improving experimental bounds in the future, the theoretical predictions of this coupling for constraining BSM parameters become increasingly significant. Using the public code `anyH3`, this study investigates the numerical stability of different renormalization schemes for λ_{hhh} at one-loop level in extended scalar sectors. By comparing predictions of the coupling for various schemes, this study develops algorithmic criteria for switching between renormalisation schemes depending on the parameter region of the BSM model. This approach ensures numerically stable and reliable predictions for the trilinear Higgs coupling.

T 68: Higgs Physics VIII (CP)

Time: Thursday 16:15–18:30 Location: ZHG105

T 68.1 Thu 16:15 ZHG105

Measurement of CP-properties of the top Yukawa coupling via $t\bar{t}H$ and tH production in the $H \to \gamma\gamma$ decay channel at CMS — Johannes Erdmann and •Florian Mausolf — III. Physikalisches Institut A, RWTH Aachen University

After the observation of the Higgs boson at the LHC and with continuing accumulation of data, its properties can be determined with increasing precision. Among these properties, the strength of the couplings to fermions and the CP-properties of its interactions are of particular importance. The top-quark Yukawa coupling, the Higgs boson's strongest interaction with fermions, plays a central role in theory and experiment. While a purely CP-odd structure has been experimentally excluded, the possibility of a significant CP-odd admixture remains consistent with current LHC constraints. A CP-odd component would influence both the cross-sections and kinematics of top-quark-associated Higgs production processes, $t\bar{t}H$ and tH. For example, the tH cross-section would increase significantly with the inclusion of a sizeable CP-odd component.

This talk presents the strategy and ongoing developments for a measurement of $t\bar{t}H$ and tH production cross sections and the CP-properties using events where the Higgs boson decays into two photons. A particular emphasis is placed on a novel approach to separate $t\bar{t}H$ and tH production processes, enabling individual $t\bar{t}H$ and tH cross-section measurements without relying on strong assumptions about CP-even and CP-odd coupling modifiers.

T 68.2 Thu 16:30 ZHG105

Machine Learning for Top-Associated Higgs Production: Probing CP Structure with Neural Simulation-Based Inference — •Stefan Katsarov, Stephen Jiggins, and Judith Katzy — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

The Standard Model (SM) predicts that the CP structure of the fermionic Higgs couplings is CP even. However, experimentally, a CP odd component is not yet fully excluded. Detecting an additional CP odd coupling would provide direct evidence of physics beyond the SM, with significant implications, such as explaining the baryon asymmetry in the universe. The CP structure can be directly measured in top-associated Higgs production processes (ttH and tH). However, this measurement is very challenging due to the extreme rarity of these production modes and the presence of irreducible backgrounds. I will demonstrate how Neural Simulation-Based Inference (NSBI), a novel machine-learning technique, can aid this measurement, presenting the first results of research in this direction.

T 68.3 Thu 16:45 ZHG105

Test of CP invariance in Higgs boson production via vector boson fusion exploiting the $H \rightarrow \tau_{\mathbf{had}}\tau_{\mathbf{had}}$ decay mode — •Daniel Bahner, Lorenzo Rossini, and Markus Schumacher — Albert-Ludwigs-Universität, Freiburg, Deutschland

The observed baryon asymmetry in the universe can be explained if the three Sakharov conditions are fulfilled. The violation of the CP invariance is one of them. The magnitude of CP violation encoded in the Standard Model is not enough to explain the observed asymmetry via electroweak baryogenesis. Through precision measurements of the properties of the Higgs boson, additional sources of CP violation might be found. One candidate is the vector-boson fusion (VBF) production mode of the Higgs boson. In the VBF production process, it is possible to probe CP-violating contributions to the HVV coupling vertex.

This talk is focused on the VBF Higgs boson production mode with a subsequent decay into two hadronically decaying tau leptons. The CP-odd optimal observable is used in a profile-likelihood fit to perform a test of CP invariance and to constrain the strength of new CP-violating interactions. The talk will discuss the analysis strategy, CP-odd observables, and preliminary results based on $\sqrt{s} = 13\,\mathrm{TeV}$ proton-proton collision data collected by the ATLAS detector with $\mathcal{L}_{\mathrm{int}} = 140.1\,\mathrm{fb}^{-1}$.

T 68.4 Thu 17:00 ZHG105

Search for CP violation in the tau Yukawa coupling with CMS Run 3 data — •Mathilde Witt[1,2], Andrea Cardini[3], Elisabetta Gallo[2], Anne-Catherine Le Bihan[1], Océane Poncet[1], Alexei Raspereza[2], Gourab Saha[1], and Stepan Zakharov[2] — [1]Institut pluridisciplinaire Hubert Curien, Strasbourg, France — [2]Deutsches Elektronen-Synchrotron, Hamburg. Germany — [3]Universidad de Oviedo, Oviedo, Spain

Following the discovery of the Higgs boson in 2012 by the ATLAS and CMS Collaborations, studies are required to investigate its Charge-Parity (CP) properties in the Yukawa interaction with tau leptons. This talk presents an ongoing master's thesis in the μa_1 decay channel. Different reconstruction techniques are implemented in the μa_1 channel to enhance the sensitivity to the CP properties of the Higgs boson to investigate whether its properties are CP-even, CP-odd, or CP-mixed. The a_1 channel denotes the decay $\tau \rightarrow \nu_\tau \pi\pi\pi$. The data were collected with the CMS detector during 2022-2023 at $\sqrt{s} = 13.6\,\mathrm{TeV}$, corresponding to an integrated luminosity of $63\,\mathrm{fb}^{-1}$

T 68.5 Thu 17:15 ZHG105

Construction and investigation of optimal observables for testing $\mathcal{CP}$ invariance in the decay $H \rightarrow \tau^+\tau^-$ at the LHC — •Yann Stoll, Heidi Rzehak, and Markus Schumacher — Albert-Ludwigs-Universität, Freiburg

Since the discovery of the Higgs boson, one of the most important tasks in particle physics is to measure all of its properties as precisely as possible. The Higgs boson does not only play a crucial role in understanding electroweak symmetry breaking but might also be connected to, and thus hint towards, physics beyond the Standard Model. One desirable feature of a more complete model of particle physics is additional $\mathcal{CP}$ violation in order to allow for electroweak baryogenesis.

A possibility to introduce additional $\mathcal{CP}$ violation is that the physical Higgs boson is not a $\mathcal{CP}$-eigenstate but an admixture. In this work it is investigated whether the sensitivity of $\mathcal{CP}$-tests in the decay $H \rightarrow \tau^+\tau^-$ at the LHC can be improved by using the method of optimal observables. An outline of the construction of said observables, as well as studies of their sensitivity using simulated signal events only, will be presented.

T 68.6 Thu 17:30 ZHG105

Measurements of $H \rightarrow \tau\tau$ properties at FCC-ee — •Sofia Giappichini, Jan Kieseler, Markus Klute, Matteo Presilla, Aaron Wiedl, and Xunwu Zuo — KIT, Karlsruhe

The Future Circular Collider (FCC) stands at the forefront of the European Strategy for Particle Physics as the future Higgs factory. The $H \rightarrow \tau\tau$ decay, featuring a large branching ratio, clean identification at FCC-ee environment, and the possibility to reconstruct polarization information, is an excellent channel to measure Higgs properties. The CP nature of the Htautau coupling is of particular interest because the CP-odd component only appears in Higgs gauge couplings through loop effects, while it is allowed to be sizable in the Higgs couplings to fermions. This contribution shows recent progress in the experimental setup for the $H \rightarrow \tau\tau$ analysis and reports prospective results in both the ZH, $H \rightarrow \tau\tau$ cross section measurement and CP measurement, as well as the interpretation framework based on SM effective field theory.

T 68.7 Thu 17:45 ZHG105

Probing $\mathcal{CP}$ violation in the top-Yukawa coupling at future colliders — •Vincent Riechers[1], Marco Menen[1,2], Elina Fuchs[1,2,3], and Henning Bahl[4] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover — [2]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig — [3]Deutsches Elektronen-Synchrotron DESY, Hamburg — [4]Institut für Theoretische Physik, Universität Heidelberg

The $\mathcal{CP}$-violating effects within the Standard Model (SM) are not sufficient to explain the observed baryon asymmetry of the Universe. Additional CP violation beyond the SM could be present in the Higgs boson couplings to other SM particles. The top-Yukawa coupling is of particular interest, as it is both the largest and most accessible Higgs-fermion interaction at the LHC and is expected to show the largest $\mathcal{CP}$-violating effects in many BSM models. The goal of this study is to evaluate the constraints that future colliders could impose on the $\mathcal{CP}$ structure of the Higgs-top coupling. While a future e^+e^- collider benefits from a very clean background, which allows precise measurements of final states with many quarks, a proton-proton collider like the FCC-hh offers a high luminosity and center-of-mass energy. We use a machine learning approach to distinguish between $\mathcal{CP}$-even and $\mathcal{CP}$-odd events, enhancing sensitivity to potential deviations from the SM.

T 68.8 Thu 18:00 ZHG105

Symbolic Regression for Higgs CP analyses — •Marco Menen[1,2], Henning Bahl[3], Elina Fuchs[1,2], and Tilman Plehn[3] — [1]Institut für Theoretische Physik, Universität Hannover, Germany — [2]Physikalisch-Technische Bundesanstalt Braunschweig, Germany — [3]Institut für Theoretische Physik, Universität Heidelberg, Germany

Additional sources of CP violation beyond those in the Standard Model are needed to produce a sufficient baryon asymmetry of the Universe during baryogenesis. The Higgs sector is an intriguing candidate for such sources and could provide CP violation in the Higgs couplings to fermions and gauge bosons. Recently, much work has been put into optimizing probes of CP violation with machine learning techniques. While such analysis usually outperform analyses of individual observables, the techniques used can be potentially hard to interpret accurately. We demonstrate how different approaches of Symbolic Regression can be used to obtain analytical formula. We then apply our approaches to various steps of a CP analysis, such as the signal-background classification, the classification of the CP state, or the reconstruction of a parton-level observable.

T 68.9 Thu 18:15 ZHG105

CP violation in Standard Model extensions with a Higgs singlet — Greta Bösinger[1], •Lana Dambacher[1], and Heidi Rzehak[2] — [1]Institut für Theoretische Physik, Universität Tübingen — [2]Physikalisches Institut, Universität Freiburg

In order to explain the asymmetry of matter and antimatter in our universe, a particle-physics model must contain sources of CP violation. Since the amount of CP violation provided by the Standard Model (SM) is not sufficient for this explanation, we are looking for extensions of the SM that include further sources of CP violation.

One of the simplest extensions of the SM is an extension with a complex Higgs $\mathrm{SU(2)_L}$ singlet. The singlet leads to a more involved Higgs potential, but otherwise does not couple to any other field. This results in some freedom in the definition of its CP transformation and therefore to no new CP violation. This freedom is reduced by coupling the singlet to a vector fermion, which creates the possibility of spontaneous or explicit CP violation.

In this talk the complex Higgs singlet extension with its possible CP properties is discussed.

T 69: Strong Interaction / QCD

Time: Thursday 16:15–18:15 Location: VG 0.110

T 69.1 Thu 16:15 VG 0.110

Measurement of the Z boson production cross-section in association with c-jets at $\sqrt{s} = 13$ TeV with the ATLAS detector — •Stefanie Götz[1], Otmar Biebel[1], Valerio D'Amico[1], Bao Tai Le[1], Lars Linden[1], Tim Rexrodt[1], Celine Stauch[1], and Camilla Vittori[2] — [1]LMU München — [2]CERN

Z boson production cross-section measurements in association with heavy flavour jets are important tests for perturbative quantum chromodynamics (pQCD) and the proton internal structure. This talk intends to show preliminary studies on a new cross-section measurement of the Z boson production using the full proton-proton collision data of Run-2 ($\sqrt{s} = 13$ TeV) taken by the ATLAS detector at the Large Hadron Collider (LHC). The focus will be on events containing at least one jet originating from a c quark, which may be sensitive to test the hypothesis of the intrinsic charm component of the proton, and a first glance at data-to-Monte Carlo comparison distributions will be provided.

T 69.2 Thu 16:30 VG 0.110

Non-perturbative effects in multidimensional dijet and Z+jet production at the LHC — Stefan Gieseke[1], Maximilian Horzela[2], Manjit Kaur[3], Dari Leonardi[1], Klaus Rabbertz[4], Aayushi Singla[3], and •Cedric Verstege[4] — [1]Institute of Theoretical Physics, Karlsruhe Institute of Technology — [2]II. Institute of Physics, Georg-August Universität Göttingen — [3]Department of Physics, Panjab University, Chandigarh, India — [4]Institute of Experimental Particle Physics, Karlsruhe Institute of Technology,

Comparison of precision LHC data at stable-particle level to the most accurate fixed-order calculations in perturbative QCD requires the latter to be corrected for non-perturbative effects. These effects are studied using Monte-Carlo simulation combining fixed-order predictions with parton showers and non-perturbative models for Underlying Event and hadronization.

The impact of the non-perturbative effects is studied for two well established processes, dijet and Z+jet production. Corresponding measurements may be used for precision determinations of parameters of the SM like the strong coupling constant or the proton structure. Surprising differences of the non-perturbative corrections for both processes in similar 3-dimensional phase spaces are observed. These differences also show a dependence on additional perturbative radiations, showcasing that the naive assumption of a clear differentiation between perturbative calculations and non-perturbative effects does not always hold.

T 69.3 Thu 16:45 VG 0.110

Elastic scattering with the ATLAS-ALFA detector at the LHC — •Per-Oleg Puhl, Hasko Stenzel, and Marko Milovanovic — II. Physikalisches Institut, Justus-Liebig Universität Gießen, D-35392 Gießen

The Absolute Luminosity For ATLAS (ALFA) detector is designed to detect elastic scattering protons under very small scattering angles. Elastic scattering in the very forward direction can be used for the measurement of the total pp cross section and a calibration of the luminosity.

The ALFA detector participated in several special runs of the LHC at high $\beta^\star$. In this talk the ALFA detector will be presented and results from Run 1 and Run 2 will be discussed. Special emphasis in this talk will be placed on the special runs from 2018 with $\beta^\star = 90$ m at $\sqrt{s} = 13$ TeV, corresponding to an integrated luminosity of 500 nb^{-1}. In these runs the focus is on elastic scattering at large momentum transfer t and in particular on the dip-bump structure of the differential cross section. The precision of the measurement depends crucially on the alignment of the Roman Pot detectors, for which the preliminary results will be presented.

T 69.4 Thu 17:00 VG 0.110

QCD cross-section measurements for astroparticle physics with the LHCb experiment — Johannes Albrecht[1], Hans Dembinski[1], •Lars Kolk[1], Felix Riehn[1], and Michael Schmelling[2] — [1]TU Dortmund University, Dortmund, Germany — [2]Max Planck Institut Heidelberg, Heidelberg, Germany

A long-standing issue in the field of cosmic-ray research is the discrepancy between the observed and simulated numbers of muons in cosmic-ray-induced hadronic showers in the Earth's atmosphere, which are called air showers. This discrepancy is referred to as the Muon Puzzle, as the required changes to existing models in simulation would either violate data constraints or the consistency between air shower simulations and other air shower features.
One explanation for this inconsistency lies in universal strangeness enhancement, which measurements from the ALICE and LHCb experiments show first evidence off. To further study the impact on forward-produced hadrons and to test this universality, proton-ion data from the LHCb fixed target mode are analysed. Of particular interest are proton-oxygen collisions, as they are a good proxy for air showers. Since proton-oxygen data are not yet available, the first step is to bracket oxygen with helium and neon. The current status of this analysis is presented.

Supported by DFG (SFB 1491)

T 69.5 Thu 17:15 VG 0.110

Angular analysis of J/ψ pair central exclusive production with the LHCb experiment — •Ilya Segal and Mikhail Mikhasenko — Ruhr University Bochum, Bochum, Germany

The analysis of the central exclusive production (CEP) provides possibilities to study quantum chromodynamics (QCD). Since the CEP of the double J/ψ system is dominantly carried out through the double pomeron exchange (DPE) mechanism, it can provide an understanding of the role of the pomeron in QCD. The comparison of inclusive and exclusive double J/ψ production mass spectra offers a probe into double parton scattering (DPS) effects, which are absent in exclusive processes. Previously, several intermediate states were observed in the double J/ψ spectrum, such as $T_{cc\bar{c}\bar{c}}$ tetraquark. The angular analysis can shed light on their quantum numbers. In this talk, the first results of the angular analysis based on the data sample of pp collisions collected by the LHCb experiment during Run 1 and Run 2 data-taking periods are presented.

In addition to this, work is done to improve the performance of the general-purpose Monte-Carlo generators such as Pythia, Herwig, etc. for the cases of the DPS and DPE. This can be done using the tuning procedures that involve the Rivet analysis preservation tool. The Rivet plugin is developed for the inclusive double J/ψ production previously measured by LHCb. The performance of this plugin for the test data is also presented in the talk.

T 69.6 Thu 17:30 VG 0.110

$\bar{\Lambda}^0/K^0_\mathrm{S}$ production cross-section ratio at LHCb in Run 3 — Johannes Albrecht[1], •Noah Behling[1], Lukas Calefice[2], Biljana Mitreska[1], and Titus Mombächer[3] — [1]TU Dortmund University, Dortmund, Germany — [2]Universitat de Barcelona, Barcelona, Spain — [3]CERN

Hadron production ratios are a useful probe to test and improve hadronisation models. In this work, the production ratio of K^0_S and $\bar{\Lambda}^0$ is studied with Run 3 proton-proton collision data from the upgraded LHCb experiment. These studies are also essential to calibrate and validate the performance of the upgraded detector. The proper operation of all subsystems must be ensured step-by-step to carry out precise measurements with data recorded recently and in the future. The performance of the tracking system can be evaluated with the measured ratio.

Meson-to-baryon ratios and strangeness production also contribute to the understanding of hadronic processes in cosmic-ray-induced extensive air showers, which are dominated by soft-QCD effects in the forward region. In air-shower data, an excess of muons produced with respect to Monte Carlo event generators has been observed, which could originate from mismodelling of the hadronisation process. The LHCb experiment offers a unique environment to test hadronic models in the forward region.

The current status of the analysis and recent studies on detector performance will be presented. Additionally, the connection of collider experiments to air-shower measurements will be discussed.

T 69.7 Thu 17:45 VG 0.110

Partial-Wave Analysis of $\tau^- \to \pi^-\pi^-\pi^+\nu_\tau$ at Belle II — •Claudia Perez-Orive[1], Stefan Wallner[1], Hans-Günther

Moser[1], Stephan Paul[1,2], Daniel Greenwald[2], and Andrei Rabusov[2] — [1]Max Planck Institute for Physics — [2]Technical University of Munich

$\tau^- \to \pi^-\pi^-\pi^+\nu_\tau$ decays measured at the Belle II experiment at the SuperKEKB e^+e^- collider offer a clean environment to investigate light mesons. We perform a detailed partial-wave analysis to precisely study the meson resonances appearing in the 3π system, including the $a_1(1260)$ and the $a_1(1420)$ signal observed by COMPASS.

We will present input-output studies using simulated data where we investigate resolution effects and effects caused by the unmeasured direction of the τ lepton on the partial-wave analysis. Additionally, we study how the fit depends on its initialization.

T 69.8 Thu 18:00 VG 0.110

Lattice determination of the higher-order hadronic vacuum polarization contributions to the muon g-2. — •Arnau Beltran Martínez[1] and Hartmut Wittig[1,2] — [1]PRISMA+ Cluster of Excellence and Institut für Kernphysik, Johannes Gutenberg-Universität, Mainz, Germany — [2]Helmholtz-Institut Mainz, Johannes Gutenberg-Universität, Mainz, Germany

We present initial results from a lattice QCD computation for the next-to-leading order (NLO) contribution to the hadronic vacuum polarization (HVP) of the muon $g-2$. Our approach is based on the time-momentum representation (TMR) involving three kernels needed to compute the different NLO HVP diagrams, following the framework developed by Balzani, Laporta and Passera.

For the NLO corrections involving extra photon or lepton lines, we present analytical series expansions for small values of the Euclidean time and numerical series expansions for the large time values. The NLO diagram with two QCD insertions is solved analytically and expanded across different regions of the two-dimensional Euclidean time plane.

These results are then combined with lattice QCD calculations of the vector correlator performed on more than 30 gauge ensembles using $O(a)$-improved Wilson quarks. To control the continuum limit, we implement two improvement schemes, each combining two discretizations. After correcting for finite-volume effects, we perform a combined chiral and continuum extrapolation to the physical point, yielding a final estimate for a_μ^{hvp}[NLO].

T 70: Silicon Detectors VI (MAPS, Mighty Tracker)

Time: Thursday 16:15–18:30 Location: VG 0.111

T 70.1 Thu 16:15 VG 0.111

Characterization of H2M: a MAPS produced in a 65 nm CMOS imaging process — •Sara Ruiz Daza[1,3], Rafael Ballabriga[2], Eric Buschmann[2], Michael Campbell[2], Raimon Casanova Moh[2], Dominik Dannheim[2], Ana Dorda[2], Finn King[2], Philipp Gadow[2], Ingrid-Maria Gregor[1,3], Karsten Hansen[1], Yajun He[1], Lennart Huth[1], Iraklis Kremastiotis[2], Corentin Lemoine[2], Stefano Maffessanti[1], Larissa Mendes[1,3], Younes Otarid[1], Christian Reckleben[1], Sebastien Rettie[2], Manuel Alejandro del Rio Viera[1,3], Judith Schlaadt[1], Adriana Simancas[1,3], Walter Snoeys[2], Simon Spannagel[1], Tomas Vanat[1], Anastasiia Velyka[1], Gianpiero Vignola[1,3], Håkan Wennlöf[1], and Ono Feyens[1] — [1]DESY, Hamburg, Germany — [2]CERN, Geneva, Switzerland — [3]University of Bonn, Bonn, Germany

The high energy physics community recently gained access to a 65 nm CMOS imaging process, which enables a higher density of in-pixel logic in MAPS. To explore this novel technology, the H2M (Hybrid-to-Monolithic) test chip has been designed and manufactured. The design followed a digital-on-top design workflow and ports a hybrid pixel-detector architecture into a monolithic chip.

This contribution will introduce the H2M chip and cover its characterization in the lab and test beam. A hit-detection efficiency above 99% has been measured, unaffected by thinning samples down to 21 um. Additionally, a measured non-uniformity of the in-pixel response related to the size and location of the n-wells in the analog circuitry will be discussed, as well as its impact on time resolution.

T 70.2 Thu 16:30 VG 0.111

Time and position resolved charge collection studies on a monolithic active pixel sensor — •Jona Dilg[1,3], Ono Feyens[1,4], Ingrid-Maria Gregor[1,3], Karsten Hansen[1], Yajun He[1], Lennart Huth[1], Finn King[1], Stefano Maffessanti[1], Larissa Mendes[1,3], Christian Reckleben[1], Sara Ruiz Daza[1,3], Manuel Alejandro del Rio Viera[1,3], Judith Schlaadt[1,3], Adriana Simancas[1,3], Simon Spannagel[1], Tomas Vanat[1], Anastasiia Velyka[1], Gianpiero Vignola[1,3], and Haakan Wennlöf[2] — [1]Deutsches Elektronen-Synchrotron DESY, Germany — [2]National Institute for Subatomic Physics Nikhef, Netherlands — [3]Universität Bonn, Germany — [4]Vrije Universiteit Brussel, Belgium

Monolithic Active Pixel Sensors (MAPS) are used in vertex detectors for high-energy particle colliders. They integrate sensors and readout electronics on a single chip, reducing material use compared to hybrid pixel detectors. The recent adoption of a 65 nm Complementary Metal-Oxide-Semiconductor (CMOS) imaging process enables a smaller pixel pitch with enhanced in-pixel electronics.

The DESY ER1 test chip consists of a single pixel and a 2×2 matrix with $35\times25\,\mu$m pitch, with in-pixel amplification and digitization. In contrast to complementary test structures with fully digital readouts, it allows direct measurement of amplifier output, aiding in understanding effects obscured in purely digital schemes.

This contribution presents the chip's design and the insights gained through its characterization and pulse shape analysis of laboratory and test beam measurements.

T 70.3 Thu 16:45 VG 0.111

Simulation of Hexagonal Pixels in Monolithic Active Pixel Sensors — •Larissa Mendes — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Monolithic active pixel sensors (MAPS) produced using 65 nm CMOS imaging technology are being investigated for particle physics applications, particularly in tracking detectors to meet the demands of future lepton colliders. The complex silicon doping and non-linear electric fields require precise simulations for sensor performance optimization. This study utilizes a combination of electrostatic field simulations and Monte Carlo techniques to predict the performance of different sensor designs.

A hexagonal pixel grid is explored as an alternative to traditional square or rectangular layouts, and the performance is assessed for various pixel sizes. Hexagonal pixels are particularly interesting because they can reduce electric field edge effects seen in square designs, provide a more homogeneous response over the pixel cell, and allow for a shorter drift path while maintaining adequate area for circuitry in the p-well, as well as reducing the number of neighboring pixels. While results for a thin epitaxial layer of 10 um show limited improvements in quantities like efficiency, cluster size, and spatial resolution, further investigations address design limitations and potential advantages, such as enhanced timing performance.

T 70.4 Thu 17:00 VG 0.111

Development and simulation of the LHCb Upgrade 2 tracker — Johannes Albrecht, Dominik Mitzel, •Donata Osthues, and Dirk Wiedner — TU Dortmund University, Dortmund, Germany

During the High-Luminosity LHC period, the LHCb collaboration aims to operate its detector at significantly higher instantaneous luminosities than in Run 3 data taking.

To adapt to higher radiation levels and hit occupancies, the LHCb detector will undergo a second upgrade. This includes a replacement of the SciFi-Tracker by the Mighty-Tracker, a combination of silicon-fiber modules in the outer region and MightyPix modules in the space closest to the beam pipe. The MightyPix module development includes overall module design choices, serial powering and cooling solutions as well as the MightyPix chip development.

This talk presents quantities such as overall tracking efficiencies and material budget scans that are calculated to test and verify the hardware development by using a detailed detector geometry simulation as baseline. The results help to make justified decisions during the development process.

T 70.5 Thu 17:15 VG 0.111

Timing studies of an HV-MAPS for LHCb Mighty Tracker
— •Benedict Maisano, Lucas Dittmann, Ruben Kolb, Ulrich Uwer, and Sebastian Bachmann — Physikalisches Institut, Heidelberg, Germany

For the LHC Run 5 the LHCb experiment plans to increase the instantaneous luminosity significantly. As a consequence an upgrade of the experiments detectors is pursuit. A part of this proposed LHCb Upgrade II is to replace the inner regions of the scintillating fibre tracking system with pixel detectors, tackling the increased occupancies and radiation. For this Mighty Tracker, the high-voltage monolithic active pixel sensor MightyPix is currently developed and characterised. The MightyPix utilizes an amplifier and a comparator inside every pixel.

As future MightyPix designs are likely to utilize an NMOS comparator instead of the currently used CMOS versions, it is necessary to ensure that performance is uneffected by this change. For this purpose the performance of a MightyPix predecessor with NMOS comparator, the Run2020v1, is studied. The presentation will feature results of the timing measurements performed in both the lab and testbeam setup and compare them to the timing requirement of the Mighty Tracker.

T 70.6 Thu 17:30 VG 0.111

Studies of the Depletion Region in irradiated HV-CMOS MAPS towards the LHCb Mighty-Tracker using TCT
— •Niclas Sommerfeld, Klaas Padeken, Hannah Schmitz, and Sebastian Neubert — University of Bonn

With the high luminosity upgrade to the LHC during LS3 the instantaneous luminosity at the LHCb experiment will be eventually increased by more than a factor of 6 to $1.3 \times 10^{34}\text{cm}^{-2}\text{s}^{-1}$ for Run 5. As a part of Upgrade II the downsteam tracker (Mighty-Tracker) is foreseen to be instrumented with 13m^2 of HV-CMOS MAPS arround the beam pipe. This is intended to meet the increased requirements in terms of granularity and radiation tolerance imposed by the higher luminosity.

As a part of the ongoing efforts to develop the HV-CMOS MAPS foreseen for the Mighty-Tracker, the change of the depletion region in irradiated HV-CMOS MAPS is studied. The non trivial behavior – evolving from a large size monolithic senor – is investigated in several measurements with a focus on the transient-current-technique(TCT), using a TCT setup at CERN.

T 70.7 Thu 17:45 VG 0.111

Studies on the Radiation Tolerance of HV-CMOS MAPS for the LHCb Mighty-Tracker
— •Hannah Schmitz, Klaas Padeken, Niclas Sommerfeld, and Sebastian Neubert — University of Bonn

By the start of Run 5 of the LHC the instantaneous luminosity at LHCb will increase from $2 \cdot 10^{33}\text{cm}^{-2}\text{s}^{-1}$ to $1.3 \cdot 10^{34}\text{cm}^{-2}\text{s}^{-1}$. Therefore, the overall tracking system has to be upgraded. The upgraded downstream tracker (Mighty-Tracker) is foreseen as a hybrid detector consisting of six layers of HV-CMOS MAPS with a total size of 13m^2, covering the central part of the acceptance close to the beampipe, and scintillating fibers in the outer part.

HV-CMOS MAPS are chosen to fulfill the upcoming requirements: High granularity, power consumption $\leq 150\text{mWcm}^{-2}$, time resolution $\leq 3\text{ns}$ - required to operate the trigger-less 40MHz DAQ - and a high radiation level of $3 \cdot 10^{14}$1-MeV$\text{n}_{\text{eq}}\text{cm}^{-2}$ (NIEL) and 25MRad (TID).

Performance studies of 180nm processed HV-CMOS MAPS with focus on the radiation tolerance, have been performed. Using a 14MeV proton beam at the Bonn cyclotron as well as an irradiation with x-rays, the impact of different types of radiation damages on the sensor have been investigated.

Both campaigns and the consequences induced by the radiation damage on the sensor operation with emphasis on the performance goals will be covered by this presentation.

T 70.8 Thu 18:00 VG 0.111

Support Structure Investigations for the LHCb Mighty Tracker in Upgrade II
— •Ksenia Solovieva, Todor Todorov, and Marco Gersabeck — Albert-Ludwigs-University,Freiburg

In preparation for the challenging environment of the High Luminosity LHC, the LHCb detector will undergo major improvements. The Upgrade II is scheduled to be installed during Long Shutdown 4 and includes a replacement of the downstream tracker. The current scintillating fibre tracker detector will be replaced with a hybrid system, the Mighty Tracker, comprising layers of improved scintillating fibres and 6 layers of silicon pixel detectors. The latter requires optimisation in the detector design, service routing and support structures to adhere to a strict material budget of below 1% X/X0 per layer. In this presentation, early considerations and studies of potential support structure solutions are discussed.

T 70.9 Thu 18:15 VG 0.111

Irradiation Studies related to the Bias Behaviour of the MightyPix
— Johannes Albrecht[1], •Jonas Rönsch[1], Sebastian Rüssmann[1], Klaas Padeken[2], Hannah Schmitz[2], Niclas Sommerfeld[2], Dirk Wiedner[1], and Lukas Witola[1] — [1]TU Dortmund University, Dortmund, Germany — [2]Helmholtz Institute for Radiation and Nuclear Physics, Bonn, Germany

To exploit the full flavour physics potential of the HL-LHC, the LHCb detector will be operated at an unprecedented instantaneous luminosity after long shutdown 4. Due to the new conditions, an upgrade of the tracking system is unavoidable. The Mighty Tracker will be the downstream LHCb Upgrade 2 tracking system. It combines scintillating fibres and high voltage monolithic active pixel sensors (HVMAPS) called MightyPix.

The MightyPix will be placed in the inner part of the detector. Therefore, they encounter irradiation levels up to 3×10^{14}1-MeV$\text{n}_{\text{eq}}\text{cm}^{-2}$.

As part of the radiation tolerance studies, several MightyPix were irradiated at the Isochronous Cyclotron of the Helmholtz Institute for Radiation and Nuclear Physics in Bonn up to a fluence of 3×10^{15}1-MeV$\text{n}_{\text{eq}}\text{cm}^{-2}$. The effect of the irradiation on the complex system of the monolithic sensor will be presented.

T 71: Detectors VI (Gaseous Detectors)

Time: Thursday 16:15–18:15 Location: VG 1.101

T 71.1 Thu 16:15 VG 1.101

Results of an aging study for the graphite coating of thin-gap RPCs for the ATLAS phase 2 upgrade.
— •Davide Costa[1,2], Francesco Fallavolita[2], Oliver Kortner[2], Hubert Kroha[2], and Giorgia Proto[2] — [1]Department of Physics, Technical University of Munich, Munich — [2]Max Planck Institute for Physics, Garching bei Munchen

The increase of total electrode resistance is a well-established cause of decrease in Resistive Plate Chamber (RPC) rate capability over time, as it leads to a lower effective voltage being applied across the gas gap. Additionally, a degradation of the graphite electrode might lead to non-uniformities in the field, which could become more significant over the large area of the RPC, worsening detector performance. While previous works have associated this increase in electrode resistance mostly to the degradation of the graphite coating, it is not clear that this is the case. This contribution presents preliminary results of a long-term study performed at the Max Planck Institute for Physics in Munich, which induces aging at varying rates by simulating the expected charge accumulation from 10 years of operation at the event rates predicted for the High-Luminosity LHC (HL-LHC). This study aims to confirm the expected performance of the graphite coating, and to disentangle effects due to degradation of the coating from potential contributions from the high-pressure phenolic laminate (HPL) electrode plates themselves. Further tests will investigate the potential mechanisms behind the aging phenomena.

T 71.2 Thu 16:30 VG 1.101

Quality assurance and quality control of the production of thin-gap RPCs for the ATLAS phase 2 upgrade.
— •Davide Costa[1,2], Francesco Fallavolita[2], Oliver Kortner[2], Hubert Kroha[2], Giorgia Proto[2], Pavel Maly[2], and Daniel Soyk[2] — [1]Department of Physics, Technical University of Munich, Munich — [2]Max Planck Institute for Physics, Garching bei Munchen

The planned upgrades to the ATLAS muon spectrometer for the phase

2 upgrade of the LHC have increased the demand for better-performing Resistive Plate Chambers (RPCs). The upgrade requires gas gaps reduced thickness, both of the electrode plates and the gas volume itself, which lead to improved rate-capability and longevity, as well as allowing for the installation of additional triplets of thin-gap RPCs, with the aim to improve acceptance and efficiency of the ATLAS muon trigger. In order to improve production rate and assure redundancy, facilities for the production and certification of RPCs have been set up at the Max Planck Institute for Physics (MPP) in Munich, in collaboration with German industrial partners. This contribution illustrates the role the MPP has played in setting up the infrastructure, developing quality assurance as quality control (QA/QC) standards, in order to ensure that efficient production be accompanied by high performance standards, as well as the Institute*s ongoing participation in the development of innovative solutions for detector construction that allow to more reliably reach the required performance goals.

T 71.3 Thu 16:45 VG 1.101

Effect of Different O_2 and H_2O Concentrations on MicroMegas Detector Performance in Ar-CO_2 Gas Mixtures at Various Drift Volumes — •Burkhard Böhm and Raimund Ströhmer — Universität Würzburg, Germany

In particle physics the MicroMegas detectors (MM), a prominent type of Micro-Pattern Gaseous Detectors (MPGDs), are used in several experiments. They are valued for their simple single-stage amplification and high and stable gain. However, their performance can be significantly affected by the composition of the gas mixture, including the contamination from ambient air. Since processes in multi-component gas mixtures can be highly complex, experimentally investigating the signal behavior at different levels of O_2, H_2O and their combination in an argon-based atmosphere is crucial.

To evaluate the effect of impurities in drift volume and amplification region separately, we performed studies with maximum drift distances from 5 mm to 2.5 mm. The aim is to determine the magnitude of electron attachment, a major factor in signal degradation, in the amplification stage and whether it can be mitigated by using a smaller drift volume.

Precise control of oxygen and water levels was achieved by introducing O_2 and humidified Ar-CO_2 into a resistive MM chamber. The resulting effects on gas gain, primarily due to electron attachment in the drift region, and the amplification of primary electrons were systematically studied. This research provides valuable insights into optimizing MPGDs performance in environments with varying gas impurities.

T 71.4 Thu 17:00 VG 1.101

Investigation of micro-pixel charge sharing Micromegas detectors — •Nirmal Mathew, Otmar Biebel, Valerio D'Amico, Stefanie Götz, Ralf Hertenberger, Eshita Kumar, Daniel Grewe, Nick Schneider, Chrysostomos Valderanis, and Fabian Vogel — LMU München

Micro-MEsh GAseous Structure (Micromegas) detectors are Micro Pattern Gaseous Detectors (MPGD's) used for their high-rate capability and excellent spatial resolution achieved through narrow amplification gap and fine strip pitch readouts. However, this performance comes at the expense of requiring a large number of readout channels for individual strips. The development and testing of Pixalated Avalanche Detectors (PAD's) are investigated, which leverage charge-sharing principles across multiple pixel layers, alternative to strip-based readouts in Micromegas, to reduce the number of readout channels strongly. Each successive layer is designed with larger pixels than the one below, culminating in a final layer that aggregates charge information to determine the particle hit position. This approach reduces the number of readout channels while maintaining comparable spatial resolution.

Two prototypes were tested: one with five pixel layers, and a hybrid PAD with three layers and novel strip-like readouts. The detectors were calibrated using an Fe-55 source and tested in a hodoscope setup to track cosmic muons. The performance and efficiency of these measurements will be presented, demonstrating the feasibility of PADs as a cost-effective alternative to traditional MPGDs.

T 71.5 Thu 17:15 VG 1.101

GridPix Production: Latest Developments in Bonn — •Sabine Hartung, Yevgen Bilevych, Jochen Kaminski, and Klaus Desch — Physikalisches Institut Universität Bonn

GridPix detectors are Micropattern Gaseous Detectors designed for high-resolution imaging and the detection of single primary electrons. They incorporate a highly pixelated readout ASIC chip, such as the Timepix or Timepix3, which feature 256 x 256 pixels with a pitch of 55 x 55 μm. To minimize the probability of chip damage by sparks an additional protective layer is applied to the surface of the chip. The Micromegas-like gas amplification stage is constructed on top of the chip by photolithographic postprocessing.

Until recently, this wafer-based production process was carried out at the Fraunhofer Institute IZM in Berlin. Now it is being transferred to the Forschungs- und Technologiezentrum Detektorphysik (FTD) in Bonn. The advancements of this technology at the FTD in Bonn enables not only the continuation of the established process but also the adoption of more flexible production techniques, such as new maskless methods, which allow for greater optimization possibilities.

This presentation will provide an overview of the general technological steps and outline the current status of production at the Bonn facility.

T 71.6 Thu 17:30 VG 1.101

GridPix-based X-ray Polarimeter — •Vladislavs Plesanovs, Markus Gruber, Klaus Desch, and Jochen Kaminski — Rheinische Friedrich-Wilhelms-Universität Bonn, Germany

X-rays are a powerful tool for probing the elemental composition and electromagnetic properties of matter. By measuring X-ray emission spectrum, scientists can characterize the chemical compositions of test targets, while in astrophysics, X-ray polarization unveils the intricate magnetic structures of distant galaxies and nebulae. Several testbeam campaigns with GridPix-based detectors have demonstrated impressive capabilities in reconstructing X-ray polarization.

To push the limits of performance, we are developing a novel GridPix-based polarimeter. This gaseous detector integrates a Timepix3 ASIC readout, offering a zero-suppressed 40 Mhits s^{-1} readout rate with a 55 μm pixel pitch. 1 μm thick aluminum grid mounted on 50 μm high pilars, both deposited using photolithographic methods, define the amplification gap and ensure near-perfect alignment of grid holes and pixels - allowing for precise detection of individual primary electrons.

This work presents an overview of X-ray polarimetry and the GridPix detector's production and operation. The main focus will be on the current status and development decisions of this project.

T 71.7 Thu 17:45 VG 1.101

Negative Ion Gridpix based High resolution TPC (NIGHT) detector — •Saime Gürbüz, Thomas Block, Can Cihan Çetinkaya, Klaus Desch, Jan Glowacz, Jochen Kaminski, and Michael Vogt — Physikalisches Institut, Bonn, Germany

The Negative Ion Time Projection Chamber (NITPC) equipped with a Gridpix pixelated readout represents a cutting-edge approach to high-precision particle detection, with significant potential for directional dark matter searches. The proof-of-concept detector, NIGHT, combines a Timepix ASIC with an InGrid amplification stage, offering an active area of 1.4 cm × 1.4 cm and a drift length of 3 cm.

Operating with a He:SF_6 gas mixture, the detector profits the electronegative properties of SF_6 to achieve negative ion drift, reducing diffusion and enhancing spatial resolution. As the carrier gas, Helium supports near-atmospheric operation and optimal ion transport properties. The Gridpix readout, featuring micromesh amplification, ensures high spatial and temporal resolution even for low-energy particle tracking.

The NIGHT detector's design, operational principles, and performance will be presented in this talk. Gain measurements are conducted with radioactive sources in the laboratory and further tested at the ELSA electron accelerator. These studies aim to validate the detector's capabilities and demonstrate the advantages of pixelated readouts combined with negative ion drift for precision particle detection and directional dark matter experiments.

T 71.8 Thu 18:00 VG 1.101

BODELAIRE: A Time-Projection-Chamber for Neutron Science — •Thomas Block[1], Klaus Desch[1], Saime Gürbüz[1], Jochen Kaminski[1], Markus Köhli[3,4], Michael Lupberger[1,2], and Jan Glowacz[1] — [1]Physikalisches Institut, Universität Bonn — [2]HISKP, Universität Bonn — [3]Physikalisches Institut, Universität Heidelberg — [4]StyX Neutronica GmbH, Mannheim

Due to the increase in demand and price of Helium-3 alternative approaches for developing detectors for various applications in neutron science are of utmost importance.

The Boron Detector with Light and Ionisation Reconstruction (BODELAIRE) combines the concept of a time projection chamber (TPC) with a boronated glass vessel as a neutron conversion stage. It deploys a GridPix-based readout with high granularity and high time resolution, which makes it a suitable candidate for imaging experiments. The naturally abundant isotope Boron-10 absorbs incoming neutrons and decays into an alpha particle and a Lithium ion. One ion enters the drift volume of the TPC and creates a trace of electron-ion pairs, which the readout detects. The other ion, which is emitted in the opposite direction, creates a light signal in the scintillator layer on the glass vessel, which is used to trigger the readout. The light is coupled to a FPGA-controlled silicon photomultiplier-based electronic board, which creates the trigger signal. Trigger signal thresholds can be set by the user.

In this work the detector concept of BODELAIRE and its current stage of development will be presented.

T 72: Detectors VII (Calorimeters)

Time: Thursday 16:15–18:30 Location: VG 1.102

T 72.1 Thu 16:15 VG 1.102

Results of the Megatile prototype for the CALICE AHCAL — Volker Büscher, Lucia Masetti, •Anna Rosmanitz, and Sebastian Ritter — Johannes Gutenberg-Universität Mainz

The CALICE collaboration has developped several highly granular calorimeter concepts for a future e^+e^- collider, that are designed for Particle Flow Algorithms.
The design used to produce a technological prototype of the Analog Hadronic Calorimeter (AHCAL) with more than 20k channels consists of 3x3 cm^2 scintillator tiles read out by silicon photomultipliers (SiPM). Each tile is individually wrapped in reflective foil and glued to the boards. The final AHCAL detector would countain 8 million channels.
To facilitate the assembly process, the Megatile design is developed at the University of Mainz. It is made from a large scintillator plate which houses 12x12 channels at once. The channels are separated by tilted trenches filled with a mixture of glue and TiO_2 for reflectivity and optical insulation. Optical tightness is achieved by gluing reflective foil on both faces and varnishing the edges. Until now, ten prototypes have successfully been built, continuously monitored in a cosmic test-stand in Mainz and tested in several test beam campaigns at DESY and CERN.
This talk presents the latest technical developments and preliminary results from electron beam measurements. We'll specifically focus on the Megatile's efficiency and optical cross talk.

T 72.2 Thu 16:30 VG 1.102

Fast Hadron Shower Simulation using the Discrete Cosine Transform with the CALICE AHCAL Prototype — •André Wilhahn, Zobeyer Ghafoor, and Stan Lai — II. Physikalisches Institut, Georg-August-Universität Göttingen, Deutschland

Extensive simulations of particle showers are crucial for high energy physics experiments, since they allow for a sensible interpretation of recorded calorimeter data. As many calorimeters are designed with increasing granularity, while having to cope with higher energy deposits and higher luminosity conditions, the accurate simulation of particle showers in a computationally efficient manner is of utmost importance. This talk describes preliminary investigations into a data-driven fast calorimeter simulation, based on compression algorithms, that is meant to describe particle showers accurately.

We start by investigating pion showers in the CALICE AHCAL (Analog Hadron Calorimeter) prototype, which is a highly granular hadronic calorimeter comprising a total of 38 active layers embedded in a stainless-steel absorber structure. Each active layer contains a grid of 24×24 scintillator tiles that are read out individually via silicon photomultipliers. The Discrete Cosine Transform is applied to hit energy distributions of test beam data, decomposing the distributions into distinctive cosine waves. By simulating the coefficients of these cosine waves, the goal is to develop a data-driven fast simulation with a reduced number of input values, but only limited information loss, and thus, being able to recreate energy distributions and preserving correlation factors between individual detector layers.

T 72.3 Thu 16:45 VG 1.102

CALO5D Calorimetry in five dimensions — Frank Simon[1], •Melike Akbiyik[1], Ulrich Einhaus[1], Lucia Masetti[2], Bohdan Dudar[2], Roman Pöschl[3], Xin XIA[3], Katja Krüger Krüger[4], and Vincent Boudry Boundry[5] — [1]Karlsruhe Institute of Technology, Karlsruhe , Germany — [2]Johannes Gutenberg University, Mainz, Germany — [3]IJCLab, Paris-Saclay, France — [4]DESY,Hamburg,Germany — [5]LLR, Palaiseau, France

This talk will present the collaborative research project CALO5D (Calorimetry in five dimensions) for future experiments in which a total of 4 universities (Hamburg (DESY), Karlsruhe (KIT), Mainz (JGU), Paris-Saclay (IJCLab), and Palaiseau(LLR) participate. The goal of the collaborative project is the further development of calorimeter concepts for future high-energy physics experiments, with an emphasis on meeting the requirements for future Higgs factory concepts.

CALO5D will combine detailed information on particle showers provided by imaging calorimeters (CALO) with precise time information at the cell level, in addition to space and local energy (5D). The exploitation of the information will be assisted by modern machine learning algorithm with the goal to improve the performance of energy reconstruction and particle flow algorithms. The capability of the tools will be demonstrated with performance studies on selected physics channels central to the physics case of future Higgs factories. The results of this project will have a fundamental impact on the design of the next generation high energy physics experiments.

T 72.4 Thu 17:00 VG 1.102

Kinematic reconstruction of deep-inelastic tau-neutrino interactions with SND@SHiP — Vasilisa Guliaeva[1], Heiko Lacker[2], and •Eduard Ursov[2] — [1]Constructor University, Bremen, Germany — [2]Humboldt University of Berlin, Berlin, Germany

SHiP (Search for Hidden Particles) is a general-purpose fixed-target experiment under development at CERN's SPS, aimed at exploring feebly interacting GeV-scale particles (FIPs), appearing in various extensions of the Standard Model and advancing neutrino physics studies. The experiment will feature two primary subdetectors: the Scattering and Neutrino Detector (SND@SHiP), designed to study neutrino signals and search for direct detection of FIPs, and the Hidden Sector Decay Search (HSDS) detector, dedicated to registering decay products of FIPs. This work focuses on the integration of SND into the SHiP experiment, addressing the search for the detector's optimal location and design optimization to maximize its physics potential. The SND will employ a sandwich-like structure composed of active scintillating fiber layers interleaved with magnetized iron as the passive material. To evaluate the detector's capability to identify tau-neutrino signals against a background of muon neutrino events, machine learning classifiers based on Boosted Decision Trees (BDT) and Graph Neural Networks (GNN) have been developed. The results of the classification will guide adjustments to the detector dimensions to maximize tau-neutrino signal and to improve the reconstruction of the neutrino properties.

T 72.5 Thu 17:15 VG 1.102

High Granularity Noble Liquid Calorimetry for FCC — •Martina Koppitz[1,2], Nikiforos Nikiforou[2], and Arno Straessner[1] — [1]TU Dresden — [2]CERN

Future high-energy collider experiments, such as the Future Circular Collider (FCC), demand advanced detector technologies to achieve their ambitious physics objectives. Spanning high-precision measurements around the Z-pole to direct Higgs production, the FCC's success relies on the performance of calorimeters, particularly highly-granular devices optimized for imaging and particle flow methods.

One of the proposed general-purpose detectors is Allegro (A Lepton coLlider Experiment with highly GRanular calorimetry Read-Out). Building on the proven advantages of noble liquid calorimetry, Allegro introduces a high-granularity ECAL design that incorporates multi-layer printed circuit boards (PCBs). This design features a sampling calorimeter comprising 1536 cylindrically stacked steel-clad lead or tungsten absorbers, with liquid argon or krypton serving as the active medium.

Simulations are underway to study and optimize the calorimeter's performance. Particular attention is being given to determining the optimal granularity for pi0 and photon identification, as well as developing methods to achieve the best pion rejection capabilities.

T 72.6 Thu 17:30 VG 1.102

Design of the SHiP Electromagnetic Calorimeter — •Claudia Caterina Delogu, Sebastian Ritter, and Matei Climescu — Johannes Gutenberg Universität Mainz

The SHiP (Search for Hidden Particles) experiment is designed to explore feebly interacting particles at the GeV scale at the CERN SPS beam dump facility. Central to the SHiP detector is its electromagnetic calorimeter, which is responsible for energy measurements, particle identification, and reconstruction of neutral particle directions (pointing capability).

This presentation will detail the design of the SHiP calorimeter: a modular sampling calorimeter made of iron and plastic scintillators, read out by Silicon Photomultipliers. The calorimeter is optimized to meet SHiP requirements for energy resolution and angular reconstruction. We will discuss the considerations that contribute to the design, particularly the geometric layout, and the construction of the first prototype.

T 72.7 Thu 17:45 VG 1.102

Pointing Studies with the SHiP Calorimeter Prototype — •Sebastian Ritter, Claudia Delogu, Rainer Wanke, Matei Climescu, and Volker Büscher — Johannes-Gutenberg Universität, Mainz

The SHiP experiment (Search for Hidden Particles) is an approved fixed-target experiment designed to explore the possible hidden sector of particle physics at the CERN SPS. An important component of SHiP is its electromagnetic calorimeter, which has to combine good energy resolution with the capability to reconstruct the direction of incoming neutral particles (pointing) as well as the identification of particles (PID). To validate the current design proposal, a conceptual prototype was tested at the DESY test beam facility in Hamburg. The prototype employs a modular sandwich structure with alternating layers of plastic scintillator readout by SiPMs and iron absorbers. During the test beam campaign, its performance was evaluated using electron beams with energies from 1 to 5.8 GeV and incident angles up to 7.5 degrees. Using precision tracking data, the spatial resolution, pointing accuracy, and angular reconstruction efficiency were characterized, correlating them with the prototype's design parameters. Furthermore, the impact of material alignment, layer staggering, and calibration strategies on the pointing performance were assessed. This talk presents an overview of the test beam setup, key findings, and implications for the detector design. The potential of the proposed concept to satisfy the SHiP requirements is demonstrated, paving the way for further optimization and a larger technological prototype.

T 72.8 Thu 18:00 VG 1.102

Control and safety systems for CMS high granularity calorimeter cassette assembly facility at CERN — •Maria Toms[1], Markus Klute[1], Ebru Simsek[2], Ziya Cihan Taysi[2], Bora Isildak[2], German Martinez[3], Andromachi Tsirou[4], and Piero Giorgio Verdini[5] — [1]Karlsruher Institut für Technologie, ETP, Germany — [2]Yildiz Technical University, Turkey — [3]Florida State University, US — [4]National and Kapodistrian University of Athens, Greece — [5]Universita & INFN Pisa, Italy

The CMS collaboration is building a new high-granularity calorimeter (HGCAL) as part of the CMS detector phase 2 upgrade. Silicon modules and SiPM-on-tile boards will be integrated into cassettes prior to their insertion into endcap structure. The cassette assembly will start in early 2025. After assembly, the cassettes will need to be tested in cold conditions with cosmic muons. The cold operation of cassettes inside cold boxes, specially built for this purpose, requires functional detector control (DCS) and subdetector environmental protection (SEP) systems. The purpose of those systems is to provide operators with a convenient way to control and monitor a significant amount of hardware inside and outside the cold box and to guarantee the safety of personnel and detector equipment. The experience obtained from the development and practical use of such systems for the operation of cassette assembly facility (CAF) at CERN can later be used to design control and protection systems for the final HGCAL detector at CMS. The design of control and protection systems for the HGCAL CAF at CERN and the progress on their development are presented.

T 72.9 Thu 18:15 VG 1.102

Study of effects of detector mis-calibration on energy resolution for the SiPM-on-tile section of the High Granularity Calorimeter for CMS. — •Daria Selivanova — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany

High Luminosity era of the LHC is fast approaching and the upgrades of the detector systems are now in various stages of production. The CMS experiment will receive a High Granularity Calorimeter (HGCAL) to replace the existing endcaps. Active layers of the upcoming sampling calorimeter are being constructed, and, I bring into focus work performed in the Tile Assembly Center in DESY on Scintillator tile modules of the hadronic section. The modules are constructed using the SiPM-on-tile technology, named after it's two main components: scintillating tiles coupled to Silicon Photo-Multipliers. One such pair makes a single channel of the hadronic endcap and the complete detector will feature more than 280 000 of them. Due to detector's geometry and the difference in production technics, tiles are trapezoidal in shape, range in area from 5.3 to 30.4 cm^2 and have varying light yield depending on the size. These factors necessitate establishing the optimal strategy for monitoring of tile characteristics to assure longevity of good detector performance. Quality control (QC) procedures for tiles have been established following the successful preseries campaign and are now being utilised. The acquired data are also used to add detail to the simulation of the detector to study the effects the precision of QC results has on energy resolution.

T 73: Flavour Physics IV

Time: Thursday 16:15–18:30 Location: VG 1.103

T 73.1 Thu 16:15 VG 1.103

Quantum Entanglement of neutral B-mesons at the Υ(5s) decay — •Adrian Liese — Max-Planck-Institut, Garching

We investigate the decay channel Υ(5s)$\to B^0\bar{B}^{0*}$ and its subsequent decay into $B^0\bar{B}^0$. This B-meson pair is supposed to be produced in an $J^{PC} = 1^{-+}$ entangled state which is different from a neutral B-meson pair coming from the Υ(4s) where $J^{PC} = 1^{--}$. The different C-symmetry changes the entanglement and subsequently the probability density. The Belle I data for the Υ(5s) offers the unique ability to measure $\bar{t} = t_1 + t_2$ and $\Delta t = t_2 - t_1$ individually, which is not possible for Belle II data of the Υ(4s). The new probabilities were calculated as functions of $\bar{t}$ and Δt and compared to the C=-1 entanglement as well as the disentangled system.

T 73.2 Thu 16:30 VG 1.103

Event separation at the $\Upsilon(5s)$ for entanglement studies — •Kilian Brückner — Max Planck Institut for Physics Garching

Upcoming analyses aim to study the quantum coherence (entanglement) of the $B^0/\overline{B^0}$ system at the $\Upsilon(5s)$ resonance. Doing this effectively requires the knowledge of how the $\Upsilon(5s)$ decayed, since the different decay channels have different entanglement properties. In this analysis the $B^0/\overline{B^0}$ system is reconstructed and later separated into the $B^0/\overline{B^0}$, $B^{0*}/\overline{B^{0*}}$ and $B^{0*}/\overline{B^0}$ decay channels. The separation is done mainly using the variables ΔE, which describes the difference between the beam energy and B-Meson energy, as well as M_{bc}, which describes the beam-energy-constrained mass. Since the Belle II Experiment has thus far not collected any data exactly on resonance of the $\Upsilon(5s)$, Belle I data is used for this analysis.

T 73.3 Thu 16:45 VG 1.103

Entanglement studies with Belle $\Upsilon(5S)$ data — •Vanessa Geier — Max-Planck-Institute for Physics Garching

Compared to the $\Upsilon(4S)$ the $\Upsilon(5S)$ can decay in excited B^0 giving rise to B$^{0(*)}$/ $\bar{B}^{0(*)}$ states with different quantum numbers. Directly after the decay of the $\Upsilon(5S)$ the $B^{0(*)}/\bar{B^{0(*)}}$ pairs are supposed to be in the $J^{PC} = 1^{--}$ state. After the transition of the excited state into the $B^0/\bar{B^0}$ state via photon emission, the $B^0/\bar{B^0}$ pairs are supposed to be in the states $J^{PC} = 1^{-+}$. Depending on the C parity the $B^{0(*)}/\bar{B^{0(*)}}$ can be in a symmetric or antisymmetric wave function leading to different time evolutions of the entangled states. Possibly the gamma transition of the excited state can also disrupt the entanglement. We will study these effects using $\Upsilon(5S)$ data collected by the Belle experiment. The Analysis includes the reconstruction of the signal $B^{0(*)}$ mesons as well as the tag-side reconstruction through the decay chain $B^0 \to D^-(\to K^+\pi^-\pi^-)\pi^+$. In addition the resulting $B^0/\bar{B^0}$ mesons need to be separated with the help of M_{bc} and ΔE variables. Reconstruction and selection efficiencies will be studied with MC events. Then the time evolution of the B-mesons will be investigated to study possible (dis)entanglement properties of the produced $B^0/\bar{B^0}$ meson pairs.

T 73.4 Thu 17:00 VG 1.103

Analysis of Rare $B^0_{(s)} \to \mu^+\mu^-$ Decays using Run 3 LHCb Data — Johannes Albrecht[1], Lukas Bertsch[1], Claudiu Cotirlan[2], Joel Mainusch[1], Biljana Mitreska[1], and •Jan Peter Wagner[1] — [1]TU Dortmund University, Dortmund, Germany — [2]University of Manchester, Manchester, England

In 2024, the LHCb experiment recorded an integrated luminosity of more than 9 fb^{-1} of proton-proton collisions which is larger than the samples recorded during the combined LHC data-taking periods Run 1 and Run 2. A key measurement of the LHCb collaboration are the branching fraction measurements of the statistically limited rare $B^0_{(s)} \to \mu^+\mu^-$ decays. In this contribution studies on normalisation and control channels are presented using 2024 LHCb data and simulation. These include detector performance studies and studies comparing 2024 measurements with the already published Run 2 results.

T 73.5 Thu 17:15 VG 1.103

Studies of extended selection methods for the rare decays $B^0_{s,d} \to \mu^+\mu^-$ at the LHCb experiment — Johannes Albrecht, Maik Becker, Quentin Führing, and •Katharina Popp — TU Dortmund University, Dortmund, Germany

Studies of the rare decays $B^0_{s,d} \to \mu^+\mu^-$ are core to the physics programme of the LHCb experiment as they provide sensitivity to new physics. For effective suppression of combinatorial background and improvement of signal significance, extended selection strategies in the analysis of the rare decays $B^0_{s,d} \to \mu^+\mu^-$ at the LHCb experiment are investigated. Information from the existing Flavour Tagging algorithms, as well as from the underlying tracks of the event, is taken into account in the classification of signal and background candidates. MC-simulated signal samples as well as LHCb sideband data from 2018 are used, assuming that the data contains only combinatorial background. The data is recorded during LHC Run 2 at a centre-of-mass energy of 13 TeV in proton-proton collisions and corresponding to an integrated luminosity of 2.19 fb^{-1}. The multivariate selection method developed in previous analyses used as a baseline and mistag probabilities of the existing Flavour Tagging algorithms are included. A neural network is trained analogously to the previously used multivariate approach and shows an improvement in the classification. In addition, a DeepSet neural network is trained with the original variables and information about the underlying event. This contribution discusses the effect of the different classification algorithms and input information on the performance of the classification.

T 73.6 Thu 17:30 VG 1.103

Measurement of the branching ratio and q^2-spectrum of $B \to D^{**}\ell\nu$ decays at Belle II — •Eyluel Uenlue, Thomas Lueck, and Thomas Kuhr — Ludwig-Maximilians-Universitaet Muenchen

There is currently some tension between the measured value of $R(D^*) = \mathcal{B}(B \to D^*\tau\nu_\tau)/\mathcal{B}(B \to D^*\ell\nu_\ell)$ and the Standard Model prediction, hinting at lepton universality violation. Semileptonic B meson decays to D^{**} mesons are background to the $R(D^*)$ measurement, where D^{**} denotes the orbitally excited P-wave charm mesons: $D_1(2420)$, $D_2^*(2460)$, $D_0^*(2300)$, and $D_1'(2430)$. These decays are not well understood, and there have been discrepancies between past measurements of their yields made by BaBar and Belle. Hence, improving understanding of these decays decreases an important systematic uncertainty on $R(D^*)$ measurements.

The aim of the present study is to use simulation and data from the Belle II experiment to study these decays, in particular to determine the q^2 spectrum, which is a key input for theory.

We reconstruct one of the B mesons from the $\Upsilon(4S) \to BB$ decay in the signal channel, $B \to D^{**}(D^*\pi)\ell\nu$. The other B meson is reconstructed in various hadronic modes using the Full Event Interpretation algorithm, which provides a tag B sample with well known kinematics. The signal yield is determined by a maximum likelihood fit to the mass difference $M(D^*\pi) - M(D^*)$. The resulting q^2 spectrum is fitted by a differential decay rate model after correcting for detector resolution effects. The current status of the analysis will be presented including results on simulation and some sources of systematic uncertainty.

T 73.7 Thu 17:45 VG 1.103

Measurement of angular coefficients of $\bar{B} \to D^*\ell\bar{\nu}_\ell$ using Belle II data — Florian Bernlochner[1], Markus Prim[1], Michael Hedges[2], and •Maximilian Hoverath[1] — [1]Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn — [2]Fermi National Accelerator Laboratory

A precise determination of the CKM matrix element V_{cb} is essential for understanding quark-flavor transitions within the Standard Model (SM). In addition to measuring V_{cb}, semileptonic decays provide a valuable opportunity to probe lepton-flavor universality (LFU), a fundamental feature of the SM that predicts universal gauge couplings for leptons. Any observed deviation from LFU would indicate the presence of physics beyond the SM. In this work, we analyze the exclusive semileptonic decay $\bar{B} \to D^*\ell\bar{\nu}_\ell$ using hadronic tagging and Belle II data to determine the angular coefficients. These coefficients allow for the determination of V_{cb} and the associated form factors, which parameterize the hadronic interaction in the decay. Additionally, we test LFU by measuring asymmetries between the electron and muon channels. Using helicity angles $\cos\theta_\ell$, $\cos\theta_V$, χ, and the hadronic recoil parameter w, we fully describe the kinematics of the decay product by reconstructing the angular coefficients in bins of w. We subtract the background in a model-independent way by fitting the missing mass squared and correct the measured distributions for migration and selection effects.

T 73.8 Thu 18:00 VG 1.103

Improving $R(D^{(*)})$ with hadronic FEI and leptonic tau decays with Belle II Run 1 data. — •Agrim Aggarwal, Florian Bernlochner, Markus Prim, Felix Metzner, and Ilias Ilias Tsaklidis — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, Bonn, Germany

An important postulate of the Standard Model, which has been challenged by experimental measurements, is the assumption that all leptons couple identically to the electroweak gauge bosons. In this work, the expected precision of ratios $R(D^*) = \mathcal{B}(B \to D^{(*)}\tau\bar{\nu}_\tau)/\mathcal{B}(B \to D^{(*)}\ell\bar{\nu}_\ell)$ are studied, a crucial test of lepton flavour universality, at Belle II. The Long Shutdown Run 1 (LS1) data at Belle II which corresponds to the total integrated luminosity of 365 fb^{-1} is used. A technique known as hadronic tagging is employed to fully reconstruct one of the $\mathcal{B}$ mesons and furthermore the leptonic decays of τ lepton is considered. The ratios of interest are extracted using a two-dimensional binned maximum likelihood fit with a revised signal extraction strategy, implemented via pyhf, that enables a conceptually safer treatment of the systematic uncertainties handled using the package SysVar developed in Bonn.

T 73.9 Thu 18:15 VG 1.103

Measurement of the efficiency and the partial branching fraction in a B Meson to X_c inclusive semileptonic Decay for the different q^2 (squared momentum transfer) with Belle II data — •Rajeshwari Roy, Munira Khan, Florian Bernlochner, and Markus Prim — Physikalische Institut der Rheinische Friedrich-Wilhelms- Universität Bonn, Nussallee 12, 53115, Bonn

The study of B-meson decays into charmed hadronic states (X_c) accompanied by a lepton and neutrino ($B \to X_c\ell\nu$) provides crucial insights into the dynamics of weak interactions and the structure of the Standard Model. This project focuses on the measurement of the partial branching fraction for $B \to X_c\ell\nu$ for different kinematic regions defined by cuts on the squared momentum transfer, q^2. A detailed event selection strategy is employed, leveraging kinematic constraints (moments: q^2, M_X) The use of multivariate techniques distinguishes the signal events from the backgrounds, such as continuum events and non-charmed semileptonic decays. The plots and fit results are generated using pyhf, a robust framework for statistical modeling and systematic uncertainty evaluation.The efficiency of identifying these decays is determined using simulated datasets and is given by the ratio of the number of reconstructed events to the number of generated events. Further, the partial branching fractions are determined for different q^2 thresholds, providing a refined understanding of semileptonic decay dynamics.

T 74: Flavour Physics V

Time: Thursday 16:15–18:15 Location: VG 1.104

T 74.1 Thu 16:15 VG 1.104

Flavour Tagging for the LHCb Upgrade — •Micol Olocco[1], Quentin Führing[1,2], Sara Celani[3], and Johannes Albrecht[1,2] — [1]University of Dortmund, Dortmund, Germany — [2]Lamarr Institute for Machine Learning and Artificial Intelligence, Dortmund, Germany — [3]Heidelberg University, Heidelberg, Germany

One of the primary objectives of the LHCb experiment is to study charge-parity (CP) violation by analyzing the decays of a wide variety of beauty mesons produced in proton-proton collisions at the LHC. Such studies require the knowledge of the B-signal flavour at production time which cannot be directly inferred from its decay products.

Flavour-tagging algorithms exploit the correlations between the B-meson flavour at production and the charged particles associated with the signal production, allowing for the identification of the candidate as either a B-meson or an $\overline{B}$-meson. Along with the tagging decision, it is crucial to estimate the probability of a misidentification, which is done by applying Machine Learning algorithms.

Since the LHCb detector has been upgraded and operates at an increased instantaneous luminosity, Flavour-Tagging algorithms must be updated accordingly. This contribution will present the revised strategy and ongoing developments of the Flavour-Tagging algorithms for the upgraded LHCb.

T 74.2 Thu 16:30 VG 1.104

Transformer Model for Flavour Tagging at Belle II — Ariane Frey, Lukas Herzberg, Thibaud Humair, Benjamin Schwenker, and •Tilo Wettlaufer — II. Physikalisches Institut, Universität Göttingen

At the Belle II experiment, an entangled state of two B mesons is measured. In order to perform analyses on CP violation, one B meson is fully reconstructed (signal side). Due to entanglement, reconstructing the flavour of the other B meson (tag side) determines the flavour of the signal side. This process of flavour tagging uses the characteristics of flavour specific decay products and correlates them to the tag side flavour, without an exclusive full reconstruction. Currently, both a category based algorithm is used, which reports an effective tagging efficiency of: $Q_{\text{cat.}} = 30.0(13)\,\%$, as well as a graph neural network reporting: $Q_{\text{GNN}} = 37.4(6)\,\%$. An alternative deep neural network uses raw track attributes to construct numerical representations of tracks, giving: $Q_{\text{DNN}} = 29.3(16)\,\%$ for neutral B mesons.
A new flavour tagging algorithm is presented based on the model of tabular transformers. This model uses contextual embeddings which are easier to interpret, as well as provide greater robustness against noisy or missing data compared to only using multi-layer perceptrons (MLP).

T 74.3 Thu 16:45 VG 1.104

Measurement of A^s_{fs} in $B^0_s \to D^-_s\pi^+$ at the LHCb experiment in Run 2 — Johannes Albrecht[1], Jonathan Davies[2], Agnieszka Dziurda[3], Conor Fitzpatrick[2], •James Andrew Gooding[1], Jairus Patoc[4], and Nicole Skidmore[5] — [1]TU Dortmund University, Dortmund, Germany — [2]University of Manchester, Manchester, United Kingdom — [3]Institute of Nuclear Physics PAS, Kraków, Poland — [4]University of Oxford, Oxford, United Kingdom — [5]University of Warwick, Coventry, United Kingdom

$B^0_{(s)} \to D^{(*)-}_{(s)}h^+$ decays are considered a standard candle of the SM and central to measurements of the CKM angle γ. Recently, tensions between the predicted and measured values of $B^0_{(s)} \to D^{(*)-}_{(s)}h^+$ branching fractions have emerged of up to 7σ. These tensions leave a possibility for new physics contributions which may enhance time-integrated CP asymmetries by up to 1%. In the SM, CP violation in flavour-specific $B^0_s \to D^-_s\pi^+$ decays arises only from $B^0_s-\overline{B}^0_s$ mixing, measured previously in semi-leptonic B^0_s decays as a^s_{sl}.

The high quality tracking and particle identification offered by the LHCb detector makes it well-equipped to reconstruct $B^0_s \to D^-_s\pi^+$ decays in the $D^-_s \to K^-K^+\pi^-, \pi^-\pi^+\pi^-$ decay modes, and thus to measure the time-integrated CP asymmetry A^s_{fs}. This measurement is performed for the first time using $5.9\,\text{fb}^{-1}$ of pp-collision data recorded at $\sqrt{s} = 13\,\text{TeV}$ during Run 2 of the LHC.

In this contribution, the approach and current status of the analysis is presented. An overview of the sensitivity of this analysis and considerations of detection and production asymmetries is given.

T 74.4 Thu 17:00 VG 1.104

B-$\overline{\text{B}}$ mixing to NNLO including penguin contributions — •Pascal Reeck[1], Matthias Steinhauser[1], Ulrich Nierste[1], and Vladyslav Shtabovenko[2] — [1]Karlsruher Institute für Technologie — [2]Universität Siegen

In this talk I will discuss recent advances made in the calculation of the NNLO QCD corrections to the width difference between B and $\overline{B}$ mesons. This work focuses on the perturbative high-energy part of the calculation, more specifically the matching coefficients between the $\Delta B = 1$ effective operators of the Weak Interaction and the $\Delta B = 2$ transition operator are calculated as a deep expansion in m_c/m_b.

This calculation yields novel results for the NNLO contributions with penguin operators which had not been considered previously at this order. Moreover, the NNLO contributions with two current-current operators, which were previously only known up to $\mathcal{O}(m_c^2/m_b^2)$ are calculated to a higher precision.

T 74.5 Thu 17:15 VG 1.104

Mixing Phases and Penguin Effects in B Meson Decays — Kristof De Bruyn[1,2], Robert Fleischer[1,3], and •Eleftheria Malami[4] — [1]Nikhef, Science Park 105, 1098 XG Amsterdam, Netherlands — [2]Van Swinderen Institute for Particle Physics and Gravity, University of Groningen, 9747 Groningen, Netherlands — [3]Faculty of Science, Vrije Universiteit Amsterdam, 1081 HV Amsterdam, Netherlands — [4]Center for Particle Physics Siegen (CPPS), Theoretische Physik 1, Universität Siegen, D-57068 Siegen, Germany

The phenomenon of B^0_q–$\bar{B}^0_q$ mixing ($q = d, s$) provides a sensitive probe for exploring physics beyond the Standard Model. Associated with this mixing are the phases ϕ_d and ϕ_s, which are crucial for studies of CP violation. The decays $B^0_d \to J/\psi K^0$, $B^0_s \to J/\psi\phi$, and $B^0_s \to D^+_s D^-_s$ play significant roles in determining these mixing phases. However, these decays are affected by contributions from penguin topologies, which limit the theoretical precision in the extraction of these quantities. To properly account for these penguin effects, we introduce a formalism that utilises the CP asymmetries of these decays. By applying this strategy to the most recent experimental data, we provide updated insights. Moving towards the high-precision era, with experimental data becoming more precise, this approach can provide a much sharper picture of the underlying dynamics.

T 74.6 Thu 17:30 VG 1.104

Λ_b baryon LCDAs in the short-distance expansion — Thorsten Feldmann and •Daniel Vladimirov — Theoretische Physik 1, Center for Particle Physics Siegen, Universität Siegen, 57068 Siegen, Germany

Light-cone distribution amplitudes (LCDAs) for the Λ_b baryon enter as universal hadronic matrix elements in QCD factorization approaches for energetic decays. Observables (e.g. form factors) can then be expressed as a convolution of the LCDA and a hard scattering kernel to the desired order in the strong coupling. The LCDAs are genuinely non-perturbative quantities that describe the low-energy dynamics of the hadronic bound state, which cannot directly be derived from first principles. In this work, we discuss the "radiative tail" of the 3-particle Λ_b LCDAs which can be computed in HQET perturbation theory by expanding in the light-cone separations between the light and heavy quarks in the baryonic bound state. Our results provide useful constraints on the modelling of Λ_b LCDAs in terms of a handful of HQET parameters.

T 74.7 Thu 17:45 VG 1.104

Search for radiative leptonic $B^+ \to \mu^+\nu_\mu\gamma$ decays at LHCb — Martino Borsato[1], •Fabian Glaser[2,3], and Marie-Hélène Schune[3] — [1]Milano-Bicocca University and INFN, Milano, Italy — [2]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany — [3]IJCLab, Orsay, France

The radiative leptonic decay $B^+ \to \mu^+\nu_\mu\gamma$ has never been observed but is of great interest as it is considered the golden mode to probe the B^+ meson substructure. In particular, a measurement of its branching fraction allows to probe the parameter λ_B, the first inverse moment of the B^+ meson light cone distribution amplitude (LCDA), which is a vital input for the calculation of non-leptonic B meson decays.

The reconstruction of this decay in proton-proton collisions at the LHCb experiment is extremely challenging. Selecting events in which the photon converts to an e^+e^- pair in the detector material allows to determine the displaced B decay vertex. With this approach, the background from photons produced in the proton collision is drastically reduced and the B flight direction can be used to correct for the missing neutrino momentum. This talk gives an overview of the current status of the ongoing analysis using data recorded in proton-proton collisions in Run 2.

T 74.8 Thu 18:00 VG 1.104

Search for the decays $\Xi_b^0 \to \Xi^0 J/\psi$ and $\Xi_b^0 \to \Xi^0\psi(2S)$ at the LHCb experiment — Johannes Albrecht[1], Vitalii Lisovskyi[2], •Leandra Moeser[1], and Janina Nicolini[3] — [1]TU Dortmund University, Dortmund, Germany — [2]Aix-Marseille Université, CNRS/IN2P3, CPPM, Marseille, France — [3]CERN

Weak decays of heavy-quark baryons provide an opportunity to probe for effects beyond the Standard Model, complementary to searches in meson decays. Given the high masses of b-baryons, they are primarily studied at hadron colliders. The LHCb experiment is ideally suited to investigate such weakly decaying b-baryons.

The current status of the search for the tree-level decays $\Xi_b^0 \to \Xi^0 J/\psi$ and $\Xi_b^0 \to \Xi^0\psi(2S)$ is presented. The used data was collected at the LHCb experiment from 2016 to 2018, corresponding to an integrated luminosity of $5.4\,\mathrm{fb}^{-1}$. The challenges posed by the reconstruction of neutral decay chains are discussed and the calibration of the simulation is presented.

T 75: Neutrino Astronomy IV

Time: Thursday 16:15–18:30 Location: VG 1.105

T 75.1 Thu 16:15 VG 1.105

Recent Developments in RNO-G — •Zeynep Su Selcuk[1] and Anna Nelles[1,2] — [1]DESY, Platanenallee 6, 15738 Zeuthen — [2]ECAP, Friedrich-Alexander-University Erlangen-Nuremberg, 91058 Erlangen, Germany

Astrophysical neutrinos and their origins are the focus of the Radio Neutrino Observatory Greenland (RNO-G). Due to their electrically neutral nature and low cross-section, neutrinos from astronomical sources travel without being attenuated or deflected by electromagnetic fields. The observation of highly energetic neutrinos is particularly interesting since these can bring light to some of the most extreme objects in the Universe. Studying these neutrinos also provides the opportunity to test fundamental physics at energy scales far beyond those achievable by current particle accelerators. RNO-G is currently under construction and aims to become the world's most sensitive ultra-high energy (E > 10 PeV) neutrino detector. It searches for radio signals emitted through the Askaryan mechanism after neutrinos interact with the dense Greenlandic ice sheet, which provides a large effective volume to compensate for the low neutrino flux. The ice sheet is transparent to radio emission and thanks to the large attenuation length of the radio waves, a large volume can be observed with a relatively low number of stations. RNO-G plans to cover an area of approximately 50 km^2 with 35 stations and each station consists of 24 receiver antennas. 7 of these 35 stations are already operational. The data taken from these first 7 stations will help shape the future of the project. This talk gives an update on the latest developments in RNO-G.

T 75.2 Thu 16:30 VG 1.105

Updates on the optical module for IceCube-Gen2 — •Markus Dittmer and Alexander Kappes for the IceCube-Gen2-Collaboration — Universität Münster, Institut für Kernphysik

As part of the further development of IceCube, an innovative optical module (OM) was developed for IceCube-Gen2, which builds on the successful features of the mDOMs and D-Eggs of IceCube Upgrade, but also adapts to the limitations of the smaller borehole diameter. This new OM design, which will be tested in IceCube Upgrade, will serve as a prototype for the planned mass production of 10,000 OMs for IceCube Gen2. To simplify the assembly processes, important changes had to be made to the design, especially to integrate the gel pad concept. In this presentation, the design philosophy will be reviewed and various performance metrics will be presented.

T 75.3 Thu 16:45 VG 1.105

Discrimination of Muon Bundles from Single Muons in IceCube — •Alexandra Scholz and Cristina Lagunas Gualda for the IceCube-Collaboration — Technical University of Munich, Germany

The detection of neutrino events from astrophysical sources is one of the main goals of the IceCube Neutrino Observatory, which is located at the geographic South Pole. Atmospheric muons and neutrinos produced in the interaction of cosmic ray particles with the atmosphere build a large background for such events. Atmospheric neutrinos are irreducible background and cannot be directly filtered out. Nevertheless, for IceCube's northern sky the Earth serves as a shield for atmospheric muons, which often reach the detector in bundles. However, it also filters ultra-high energy (UHE) neutrino events. In order to detect UHE events, the whole sky has to be considered, leaving us with the problem of the enormous background of atmospheric muons. The strategy of this project is to discriminate muon bundles from single muons above 100 TeV, as single muons are the signature of astrophysical neutrino events in the detector. A graph neural network (GNN) will be used to classify the events based on CORSIKA simulations.

T 75.4 Thu 17:00 VG 1.105

Improving Track Reconstruction with Direct Muon Signals in IceCube Upgrade Modules — •Simon Pick — Ruhr-Universität Bochum — DESY, Zeuthen

One of the main constraining factors in IceCube's ability to detect neutrino point sources is angular resolution. Muon track reconstruction is limited by the knowledge of the optical properties of ice and detector responses. With the addition of multi-PMT optical modules in the upcoming upgrade of the existing detector, new calibration methods will be possible.

A promising approach for an improved track reconstruction is the measurement of a direct muon signal in multiple PMTs of separate modules. This may present a technique to confine the muon track with unprecedented accuracy treating the PMTs as anchor points and thus, by using those tracks as calibration sources, enabling a general improvement for all reconstructed tracks. This talk discusses the feasibility of the idea and presents the progress of its investigation through laboratory measurements.

T 75.5 Thu 17:15 VG 1.105

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Event classification — •Shuyang Deng, Philipp Behrens, Jakob Böttcher, Lasse Düse, Philipp Fürst, Leon Hamacher, Michael Handt, Lars Marten, Philipp Soldin, and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut B RWTH Aachen University, Aachen, Germany

The IceCube Neutrino Observatory is a large neutrino detector built deep in the Antarctic ice at the South Pole. The Advanced Northern Track Selection (ANTS) framework uses a graph convolutional neural network to select neutrino-induced muon tracks. These events have different topologies and signatures within the detector, such as through-going, starting, skimming tracks as well as remaining background from cosmic-ray induced muons and cascades e.g. related to electron neutrinos. In this work, we perform the classification of these event topologies using the ANTS framework, providing an event-wise probability for each topology. This classification enables dedicated handling of these topologies in further analyses.

T 75.6 Thu 17:30 VG 1.105

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Background Rejection — •Philipp Behrens, Jakob Böttcher, Shuyang Deng, Lasse Düser, Philipp Fürst, Leon Hamacher, Michael Handt, Lars Marten, Philipp Soldin, and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen University, Aachen, Deutschland

The IceCube Neutrino Observatory is a large neutrino detector located in the ice at the geographic South Pole. It detects atmospheric and astrophysical neutrinos by Cherenkov radiation emitted by secondary particles with more than 5000 photomultipliers. A main challenge is the efficient distinction between neutrinos and air-shower-induced muons. The Advanced Northern Tracks Selection (ANTS) improves this classification using a deep graph convolutional neural network, capturing the node-like structure of the geometric arrangement of the photomultipliers inside the detector, as well as the raw sensor data. Using this architecture, both local and global features are learned. This work focuses on the evaluation and enhancement of the neural network architecture with respect to the background rejection of air-shower-induced muons.

T 75.7 Thu 17:45 VG 1.105

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Energy Reconstruction — •Lasse Düser, Philipp Behrens, Jakob Böttcher, Shuyang Deng, Philipp Fürst, Leon Hamacher, Michael Handt, Lars Marten, Philipp Soldin, and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen University, D-52056 Aachen, Germany

The IceCube Neutrino Observatory is a detector located at the geographic South Pole, consisting of more than 5000 photomultipliers (PMTs). These PMTs detect Cherenkov radiation, produced by muons induced by charged current neutrino interactions, within the instrumented ice. The identification of neutrino-induced through-going muon tracks is performed by the newly developed Advanced Northern Tracks Selection (ANTS) using a graph convolutional neural network that encodes the spatial geometry of the PMTs. A significant advantage of this network architecture is utilizing the full event information, enabling an improved reconstruction of event features like neutrino energy. This talk discusses the network's performance and compares it to existing energy reconstruction methods. The reconstruction is evaluated with respect to resolution, direction, and computational efficiency across various event topologies.

T 75.8 Thu 18:00 VG 1.105

Using CRPropa to reconstruct the high energy neutrino emission of NGC 1068 * — •Alexander Kazatsky, Julia Becker Tjus, Björn Eichmann, and Julien Dörner — Theoretical Physics IV, Faculty of Physics and Astronomy, Ruhr-University Bochum, Universitätsstraße 150, 44801 Bochum

The Seyfert 2 galaxy NGC 1068 (also known as Messier 77) is one of the closest active galaxies for which a high energy neutrino flux has been detected by the IceCube Neutrino Observatory. Previous works have concluded that the neutrino emission is likely to originate from a region of the active galactic nucleus (AGN) called the AGN corona. In this work, this neutrino emission is calculated by developing a threedimensional model for the corona of NGC 1068 using a modified version of the publically available CRPropa propagation framework. The diffusive transport of the underlying cosmic rays is solved via stochastic differential equations in 3D space and different hadronic processes are taken into account for the generation of the overall non thermal emission. The resulting neutrino flux is compared to the available IceCube data to optimise the model of the AGN environment. * Supported by SFB 1491

T 75.9 Thu 18:15 VG 1.105

Hadronic Modelling of the TXS 0506+056 2017 Flare Using CRPropa* — •Vladimir Kiselev[1,2], Leander Schlegel[1,2], Julien Dörner[1,2], and Julia Becker Tjus[1,2] — [1]Theoretische Physk IV, Fakultät für Physik, Ruhr-Universität Bochum, Universitätsstraße 150, 44801 Bochum — [2]RAPP Center, Ruhr-Universität Bochum, Universitätsstraße 150, 44801 Bochum

TXS 0506+056 is a well-studied blazar that, in 2017, was associated with a high-energy neutrino detection by IceCube during a gamma-ray flare. This event marked the first indication of detection in multi-messenger astrophysics, highlighting the need for robust theoretical models. In response, several attempts have been made to model the multi-messenger emission from this flare. Here, we present our approach to modelling the 2017 neutrino and gamma-ray flares using a modified version of CRPropa. Compared to other models, we adopt a hadronic model to explain both the Very High-Energy gamma-rays and neutrinos, incorporating particle propagation in a fully three-dimensional environment with turbulent magnetic fields. Furthermore, we validate the result using both the SED and the lightcurve of the flare.

*Supported by DFG (SFB 1491)

T 76: Data, AI, Computing, Electronics VII (Generative AI, MC Generators)

Time: Thursday 16:15–18:45 Location: VG 2.101

T 76.1 Thu 16:15 VG 2.101

Correcting the mis-modeling of photon energy deposits in the calorimeter using normalizing flows and flow matching — Caio Daumann, Johannes Erdmann, and •Lars Schiffeler — III. Physikalisches Institut A, RWTH Aachen University

Simulated events are key ingredients for almost all high-energy physics analyses. However, imperfections in their configuration can result in mis-modelling and discrepancies between the data and simulations. Normalizing flows are used in CMS to correct the high-level inputs to the photon identification algorithms, which have a low dimensionality. Improved identification algorithms, on the other hand, use information with an increased dimensionality, such as individual energy deposits in a calorimeter. This poses a challenge to normalizing flows, as they are more effective in lower-dimensional spaces. We investigate the influence of this increase in dimensionality on normalizing flows and compare their effectiveness to flow matching. To study these effects, simulations of a CMS-inspired toy calorimeter are used.

T 76.2 Thu 16:30 VG 2.101

Belle II PXD background generation with diffusion models — •Fabio Novissimo, Nikolai Hartmann, and Thomas Kuhr — Ludwig-Maximilians-Universität München

The Pixel Vertex Detector (PXD) is the innermost detector of the Belle II experiment. Information from the PXD, together with data from other detectors, allows to have a very precise vertex reconstruction. The effect of beam background on reconstruction is studied by adding measured or simulated background hit patterns to hits produced by simulated signal particles. This requires a huge sample of statistically independent PXD background noise hit patterns to avoid systematic biases, resulting in a huge amount of storage due to the high granularity of the PXD sensors. As an efficient way of producing background noise, we explore the idea of an on-demand PXD background generator realised using diffusion models. In order to evaluate the quality of generated background we measure physical quantities which are sensitive to the background in the PXD.

T 76.3 Thu 16:45 VG 2.101

Study of deep generative models for the enhancement of simulated ATLAS datasets — Boris Flach, Andre Sopczak, and •Lukas Vicenik — Czech Technical University in Prague

Numerous searches for new particles and precision measurements crucially depend on the amount of available simulated data, which has an impact on the resulting analysis uncertainties. For instance, machine learning algorithms for separating signal and background events could significantly profit from enlarged simulated datasets. We propose advanced generative models based on variational autoencoders, generative adversarial networks, and diffusion-based deep generative models to address the limitations of current simulated datasets. These models generate synthetic data that capture complex, non-homogeneous features observed in particle physics. Evaluation metrics from particle physics and machine learning are employed to assess the accuracy, diversity, and physical validity of the generated data. The augmented datasets are subsequently used to enhance signal and background separation, reduce uncertainties in analyses, and improve the overall reliability of the results.

T 76.4 Thu 17:00 VG 2.101

PointL2LFlows: How to generate Hadronic showers in ECal and HCal with CNFs — •Thorsten Buss — Institut für Experimentalphysik, Universität Hamburg, Germany

In collider experiments, Monte Carlo (MC) simulations are the essential tool for comparing experimental findings with theory predictions. However, they have a high computational demand, and future developments, such as higher event rates, are expected to increase this demand beyond availability.

Generative models provide a way of augmenting MC simulations, speeding them up, and overcoming this bottleneck. Recent works have successfully applied this approach to electromagnetic showers in electromagnetic calorimeters (ECal) and to pion showers in low-granular homogeneous calorimeters. However, applying it to pion showers developing in a highly granular ECal and continuing in a highly granular HCal remains a challenge due to their rich substructure.

This work shows how point-cloud-based continuous normalizing flows (CNF) can jointly generate pion showers in ECal and HCal. As in our L2LFlows model for EM showers, we generate one calorimeter layer at a time conditioned on the previous layers. This reduces the size of the point clouds reducing computational costs and making it easier for the model to focus on the most important structures in the showers.

T 76.5 Thu 17:15 VG 2.101

Point-Clouds based Diffusion Model on Hadronic Showers — •Martina Mozzanica — University of Hamburg

Simulating showers of particles in highly-granular detectors is a key frontier in the application of machine learning to particle physics. Achieving high accuracy and speed with generative machine learning models can enable them to augment traditional simulations and alleviate a major computing constraint. Recent developments have shown how diffusion based generative shower simulation approach that do not rely on a fixed structure, but instead generates geometry-independent point clouds, are very efficient.We present a novel attention mechanism based extension to the CaloClouds 2 architecture that was previously used for simulating electromagnetic showers in the highly granular electromagnetic calorimeter of ILD with high precision. This attention mechanism allows to generate complex hadronic showers from pions with more pronounced substructure in the electromagnetic and hadronic calorimeter together. This is the first time that ML methods are used to generate hadonic showers in highly granular imaging calorimeters.

T 76.6 Thu 17:30 VG 2.101

Generative transformers for learning point-cloud simulations — Joschka Birk[1], Frank Gaede[2], Anna Hallin[1], Gregor Kasieczka[1], Martina Mozzanica[1], and •Henning Rose[1] — [1]Institute for Experimental Physics, Universität Hamburg, Hamburg — [2]Deutsches Elektron-Synchrotron DESY, Hamburg

We successfully demonstrate the use of a generative transformer for learning point-cloud simulations of electromagnetic showers in the International Large Detector (ILD) calorimeter. By reusing the architecture and workflow of the OmniJet-α model, this transformer predicts sequences of tokens that represent energy deposits within the calorimeter. This autoregressive approach enables the model to learn the sequence length of the point cloud, supporting a variable-length and realistic shower development. Furthermore, the tokenized representation allows the model to learn the shower geometry without being restricted to a fixed voxel grid.

T 76.7 Thu 17:45 VG 2.101

AIDO - A Generalized Detector Optimization Framework using Surrogate Models — •Kylian Schmidt, Jan Kieseler, and Nikhil Krishna — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

The design of modern high-energy physics detectors is a highly intricate process, aiming to maximize their physics potential while balancing various manufacturing constraints. As detectors become larger and more sophisticated, it becomes increasingly difficult to maintain a comprehensive understanding of the entire system. To address this challenge, we aim to translate the design process into an optimization task suitable for Machine Learning by treating the parameters of the simulation as hyper-parameters of the model.

The AIDO framework is a generalized tool for the optimization of continuous and discrete detector parameters. We train a diffusion-based surrogate model on parallel Geant4 simulations with varying detector geometries, enabling the model to interpolate the expected performance across different configurations. This allows for gradient descent on the generated parameter space and identification of the optimal combination of parameters that maximizes a specific physics goal. As a demonstration, we show how this approach can be applied to generate an optimal sampling calorimeter by maximizing its energy resolution starting from a random initial composition.

T 76.8 Thu 18:00 VG 2.101

Navigating Phase Space for Event Generation: interfacing Sherpa with BAT.jl — Cornelius Grunwald[1], Timo Janssen[2], Kevin Kröninger[1], •Salvatore La Cagnina[1], and Steffen Schumann[2] — [1]TU Dortmund University, Dortmund, Germany — [2]Georg-August-Universität Göttingen, Germany

The generation of Monte Carlo events is a crucial step for all particle collider experiments. A major challenge in event generation is the efficient sampling of the phase spaces of hard scattering processes due to the potentially large number and complexity of Feynman diagrams and their interference and divergence structures. In this presentation, we address the challenges of efficient Monte Carlo event generation and demonstrate improvements that can be achieved through the application of advanced sampling techniques. We highlight that using the algorithms implemented in BAT.jl for sampling the phase spaces given by Sherpa offers great flexibility in the choice of sampling algorithms and has the potential to significantly enhance the efficiency of event generation. By interfacing BAT.jl, a package designed for Bayesian analyses that offers a collection of modern sampling algorithms, with the Sherpa event generator, we aim to improve the efficiency of phase space exploration and Monte Carlo event generation. We combine the physics-informed multi-channel sampling approach of Sherpa with advanced sampling techniques such as Markov Chain Monte Carlo (MCMC) and Nested Sampling.

T 76.9 Thu 18:15 VG 2.101

Geant4 Optimizations in ATLAS — •Mustafa Schmidt für die Mu2e-Kollaboration — Bergische Universität Wuppertal, Deutschland

The ATLAS experiment at the LHC heavily depends on simulated event samples produced by a full Geant4 detector simulations. These Monte Carlo simulations based on Geant4 were a major consumer of computing resources during the 2018 data-taking year and will remain one of the dominant resource users in the HL-LHC era. Consequently, ATLAS has continuously been working to improve the computational performance of this simulation for the Run 3 Monte Carlo campaign.

This report highlights the recent implementation of Woodcock tracking in the Electromagnetic Endcap Calorimeter and provides an overview of other implemented and upcoming optimizations that still have to be validated. These improvements include enhancements to the core Geant4 software, strategic choices in simulation configuration, simplifications in geometry and magnetic field descriptions, as well as technical refinements in the interface between ATLAS simulation code and Geant4.

Overall, a performance improvement of around 50% regarding CPU time was achieved compared to the baseline simulation configuration utilized during Run 2.

T 76.10 Thu 18:30 VG 2.101

Exploring tomorrow's Monte-Carlo generators: MC Validation in ATLAS with PAVER — •Johanna Kraus, Anna Bingham, Frank Ellinghaus, Dominic Hirschbühl, and Mustafa Schmidt — Bergische Universität Wuppertal

Monte-Carlo (MC) simulations play a key role in high energy physics, for example at the ATLAS experiment. MC generators evolve continuously, so a periodic validation is indispensable for obtaining reliable and reproducible physics simulations. For that purpose, an automated and central validation system was developed: PMG Architecture for Validating Evgen with Rivet (PAVER). It provides an MC event generator validation procedure that allows a regular evaluation of new revisions and updates for commonly used MC generators in ATLAS as well as comparisons to measured data. The result is a robust, fast, and easily accessible MC validation setup that is constantly developed further. This way, issues in simulated samples can be detected before generating large samples for the collaboration, which is crucial for a sustainable and low-cost MC production procedure in ATLAS.

T 77: Data, AI, Computing, Electronics VIII (Fast ML, Triggers)

Time: Thursday 16:15–18:15 Location: VG 2.102

T 77.1 Thu 16:15 VG 2.102

Optimization of the muon momentum resolution in the ATLAS first-level trigger with machine learning techniques — •Francisco Resende, Davide Cieri, Oliver Kortner, and Sandra Kortner — Max-Planck-Institut für Physik, München

The ATLAS experiment is upgrading its muon trigger system for operation at the High-Luminosity LHC. The necessary significant improvement in the selectivity of muon tracks within the first-level trigger relies on, for the first time, muon tracking data from precision monitored drift-tube (MDT) chambers.

This research explores the feasibility and benefits of integrating machine learning into the challenging real-time environment of the ATLAS trigger system, aiming to enhance the experiment's discovery potential in the high-luminosity era. We investigate the use of machine learning algorithms to improve muon reconstruction for the ATLAS first-level trigger. Various neural network models were developed, with algorithms optimized for potential deployment on powerful FPGA devices. The performance of each model is evaluated and compared to that of the baseline analytic algorithm in terms of trigger efficiency and muon momentum resolution.

T 77.2 Thu 16:30 VG 2.102

Convolutional Neural Networks on FPGAs for Processing of ATLAS Liquid Argon Calorimeter Signals — Anna Franke, Manuel Gutsche, Markus Helbig, Rainer Hentges, Arno Straessner, •Johann Christoph Voigt, and Philipp Welle — Institut für Kern- und Teilchenphysik, TU Dresden

During the Phase-II upgrade of the ATLAS Liquid Argon Calorimeter, more than 500 high-performance FPGAs will be installed to allow for the energy reconstruction of all 182468 detector cells at the LHC bunch crossing frequency of 40 MHz. We trained 1-dimensional convolutional neural networks (CNNs) to improve the energy reconstruction under high-luminosity conditions with respect to the currently used Optimal Filter. The network architecture has been optimized with a hyperparameter search, where the network size is constrained to 400 parameters. This is motivated by resource estimates from the FPGA firmware prototype implementation. Quantization aware training using QKeras is used to adapt the CNNs to 18 bit fixed point numbers. A revised simulation pipeline is in development to produce training samples for clusters of similar cells. To better evaluate the physics impact of the CNN based readout, the networks are being integrated into the ATLAS common detector simulation and analysis framework, Athena. The inference code of these networks has been implemented in the hardware description language VHDL targeting an Intel Agilex FPGA. A test project targeting a Stratix-10 development kit is available to verify the behaviour of the implementation. Recent results of the CNN training and its firmware realisation will be presented.

T 77.3 Thu 16:45 VG 2.102

Using Transformer based Graph Neural Networks to Identify Hadronically Decaying Tau Leptons with the ATLAS trigger — •Athul Dev Sudhakar Ponnu and Stan Lai — II. Physikalisches Institut, Georg-August-Universitaet Goettingen.

The increased luminosity at the LHC poses challenges in efficiently selecting interesting events at the Atlas detector. Identifying events containing tau leptons is particularly difficult due to their predominantly hadronic decay, which often mimics light QCD jet signatures. Therefore, effectively discriminating against background jets during the identification of hadronically decaying tau leptons at the trigger level is crucial.

Building on the success of Transformer-based Graph Neural Networks used for offline Tau ID (GNTau) and b-tagging (GN2), this study explores their application to hadronic tau identification at the High Level Trigger (HLT). The online GNTau algorithm exhibits substantial improvements in background rejection compared to existing Deepset-based algorithms, across a wide phase space and variety of processes. After thorough evaluations, the GNTau is set to be deployed at the HLT for the 2025 data-taking period.

T 77.4 Thu 17:00 VG 2.102

Forward Electron Identification at the ATLAS First Level Trigger for the High Luminosity LHC — •Maximilian Linkert, Stefan Tapprogge, and Adrian Alvarez Fernandez — Institut für Physik, Johannes Gutenberg-Universität, Mainz

As part of the high luminosity LHC the challenge is to properly trigger events in the forward region of ATLAS covering a pseudo rapidity of $2.5 < |\eta| < 4.9$. New first level trigger modules (being under development) based on FPGAs will be used the first time to access the full (transversal and longitudinal) granularity of the calorimeters in this region to efficiently identify electrons and positrons. As a basis for reconstruction and identification a sliding window algorithm will be used. The aim is to use machine learning to gain efficiency compared to classical algorithms. The algorithms need to be optimized to run on the FPGAs, thus dealing with a simultaneous optimization of the signal efficiency, background rejection, resource consumption and latency. Moreover, the algorithm implementation needs to address non trivial changes in the geometrical calorimeter segmentation within the region under consideration. The present status of the investigations and next steps will be presented.

T 77.5 Thu 17:15 VG 2.102

First Level Trigger Algorithm for Electron Identification in ATLAS — •Julia Troppens, Maximilian Linkert, Dennis Layh, and Stefan Tapprogge — Institute for Physics, Johannes Gutenberg University, Mainz

The High Luminosity LHC upgrade aims to significantly increase the collision rate, presenting new challenges for data analysis within the detectors. Therefore, the ATLAS trigger system is being improved and expanded in the Phase II upgrade by incorporating additional information. This includes the planned implementation of a first level trigger algorithm in firmware for electron identification in the forward region (3.2<|eta|<4.9) of the ATLAS detector, based on the full granularity of calorimeters. The studies performed used simulated data to examine various approaches. The benefit of machine learning, as compared to cut-based algorithms, was investigated in terms of optimizing efficiency. Subsequently, studies were conducted to evaluate the feasibility of realising the algorithms in firmware. In conclusion, this contribution compares different algorithms in terms of their interplay between latency, resource usage, signal efficiency, and background rejection.

T 77.6 Thu 17:30 VG 2.102

Development of machine-learning based topological triggers for the CMS Level-1 trigger — •Karla Kleinbölting, Lukas Ebeling, Johannes Haller, Finn Jonathan Labe, Balduin Letzer, Artur Lobanov, Lara Markus, and Matthias Schröder — Institut für Experimentalphyisk, Universität Hamburg

At the CMS experiment, the Level-1 (L1) trigger system is pivotal in thereal-timeselectionofphysicseventsofinterest. Thistalkhighlights recent advancements in enhancing the L1 trigger performance through the integration of machine learning (ML) techniques. Using di-Higgs production as a benchmark process, the proposed ML-based trigger leverages full event topologies instead of individual object-based triggers. This approach allows the trigger system to identify and retain events in previously inaccessible low p_T regions while maintaining acceptable rates. The ML algorithms can be seamlessly integrated into the FPGA-based electronics of the trigger system using frameworks such as *hls4ml*.

T 77.7 Thu 17:45 VG 2.102

Implementation of a two-level AI-enhanced trigger on a single chip with AI cores for live reconstruction — •Patrick

Schwäbig for the Lohengrin-Collaboration — Physikalisches Institut, Universität Bonn, Deutschland

For years, data rates generated by modern detectors and the corresponding readout electronics exceeded by far the limits of data storage space and bandwidth available in many experiments. The approach of using fast triggers to discard uninteresting and irrelevant data remains a solution used to this day: Using FPGAs, ASICs or directly the readout chip, a fixed set of rules based on low level parameters is applied as a pre-selection. In contrast to this stands live track reconstruction for triggering, which was rarely possible due to limited computation power in the past. With the emergence of highly parallelized processors for AI inference, attempts to sufficiently accelerate tracking algorithms become viable. The AMD Versal Adaptive Compute Acceleration Platform (ACAP) is one such technology and combines FPGA and CPU resources with dedicated AI cores. Our approach is to implement a two-level trigger on a single chip by utilizing the tightly integrated combination of FPGA and AI cores to profit from their individual strengths. In this talk our concept for a two-level trigger setup, implemented on an AMD VC1902, including quantized AI algorithms and Timepix3 readout, will be shown. They will be used in an envisioned mid-size ultra-high rate fixed-target dark matter experiment (Lohengrin) at the ELSA accelerator at the University of Bonn.

T 77.8 Thu 18:00 VG 2.102

Performance of a Quantized Neural Network on an FPGA for Next Generation Radio Array DAQ Systems — •Adam Rifaie for the IceCube-Gen2-Collaboration — Bergische Universität Wuppertal, Wuppertal, Deutschland

The IceCube neutrino observatory is a cubic kilometer neutrino detector built into the Antarctic ice at the geographical Southpole. As a result of its success, the next-generation detector for IceCube, IceCube-Gen2, is currently being planned. This will extend the optical array to approximately 10 cubic kilometers and will include a $\sim 500\,\mathrm{km}^2$ radio array, sensitive to Ultra High Energy neutrinos. The state-of-the-art, with respect to phased radio arrays, is the Radio Neutrino Observatory Greenland (RNO-G), where currently 7 of the planned 35 stations have been deployed. These stations enable hardware testing and optimization for the DAQ system of RNO-G. A novel idea for a DAQ system would consist of an FPGA with a trained and Quantized Neural Network implemented. The neural network will read the datastream and discriminate between background and signal in real-time. This will improve the effective volume of the detector by a factor of 3 compared to a standard threshold trigger at certain energies. The performance and comparison of a quantized neural network with a regular neural network will be discussed, followed by the next steps to an all-digital DAQ system for Radio arrays.

T 78: Gamma Astronomy II

Time: Thursday 16:15–18:15 Location: VG 2.103

T 78.1 Thu 16:15 VG 2.103

Constraining the intergalactic Magnetic field with Fermi-LAT observations — •Yosef Abed, Dieter Horns, and Matías Sotomayor — Institut für Experimentalphysik, Universität Hamburg

The intergalactic magnetic field (IGMF) represents a weak and omnipresent magnetic field permeating the intergalactic medium. Its origins are unclear and a detection of the IGMF has yet to be achieved. The most sensitive method to search indirectly for evidence of the existence of the IGMF are based upon γ-ray observations.This talk presents a conservative lower limit for the IGMF, calculated from *Fermi*-LAT data and ELMAG simulations. Extended source templates for several blazars were generated using ELMAG simulations with varying magnetic field strengths of the IGMF, where its coherence length was taken into account. In the *Fermi* binned likelihood analysis of these blazars, the extended templates were added as diffuse sources and from the loglikelihood profile, the normalization with 95% confidence level was calculated for each template. Then the spectral energy distributions of the normalized fitted template and the non-fitted simulation template were compared, from which the conservative lower limit for the IGMF was estimated.

T 78.2 Thu 16:30 VG 2.103

Adaptive Sampling in Simulations for the Cherenkov Telescope Array Observatory — •Tristan Gradetzke and Luca Di Bella — TU Dortmund University

Monte Carlo simulations of particle induced extensive air showers are of crucial importance to the analysis chain of data taken by Imaging Air Cherenkov Telescopes (IACTs). Besides for the training of particle classifiers and energy estimators, they are needed to compute a mathematical description of the measurement process required for the scientific analysis, the Instrument Response Functions (IRFs). There usage however, comes at the extensive cost of computational resources. Therefore much effort has been made to this day, to make these simulations more efficient. This work aims at investigating, among others, adaptive sampling based methods to sample only phase-space regions improving event statistics and to a limited extent uncertainties in e.g. IRFs. Thus reducing the extent of Monte Carlo productions. Phase space in this context refers to, among others, detector field of view and primary particle energy . The main challenges arise from the definition of a metric, that is optimized by any given algorithm. Here, the simple case of an event-per-bin based metric is presented and an outlook is given.

T 78.3 Thu 16:45 VG 2.103

Investigating the Effects of Symmetry Assumptions in the Instrument Response of the Cherenkov Telescope Array Observatory — •Luca Davide Di Bella and Tristan Franziskus Gradetzke — TU Dortmund University, Dortmund, Germany

The Cherenkov Telescope Array Observatory is the next generation of Imaging Air Cherenkov Telescope observatories, designed to operate in an energy range between 20 GeV to 300 TeV and achieve higher sensitivities and lower systematic uncertainties than previous experiments. An important data analysis step to achieving the systematic uncertainty targets is accurate modeling of the instrument response. This is done in discrete intervals of the relevant quantities using Monte Carlo simulated events to ensure accuracy.

In order to reduce the necessary amount of simulations, the Instrument Response Functions (IRFs) are assumed to be radially symmetric over the field of view of the telescopes. Due to for example atmospheric effects, this simplification is not necessarily accurate, especially at higher zenith distances. It is thus necessary to implement computation of non-radially symmetric Instrument Response Functions and evaluate their impact on the measurement.

More complex implementations, which allow asymmetry of the IRFs, have been implemented and will be compared against the existing radially symmetric implementations using simulated data sets.

T 78.4 Thu 17:00 VG 2.103

FlashCam development and verification — •Anne Timmermans for the FlashCam-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

FlashCam is a high-performance camera design for ground-based, imaging atmospheric Cherenkov telescopes. An advanced prototype has been installed in CT5 of the H.E.S.S. experiment, and has been successfully running since December 2019.

The next generation observatory for very high energy gamma-ray astronomy will be the Cherenkov Telescope Array Observatory (CTAO). The FlashCam team, is preparing another FlashCam camera for the MST pathfinder telescope on the Southern CTAO site. Before installation in Chile, the camera will be fully characterized in the lab. This talk will give an overview of the current status and presents results on the performance measurements.

T 78.5 Thu 17:15 VG 2.103

SWGO Array Trigger Performance Evaluation — •Johannes Bennemann — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The Southern Wide-field Gamma-ray Observatory (SWGO) is a future gamma-ray instrument to be built in Chile. It will consist of more than 6000 water tanks with an almost 100% duty cycle. The amount of data produced by SWGO will be more than what can be handled by the available computing infrastructure. This makes a sophisticated trigger strategy necessary for the detector array. While data reduction is the key motivation for an array trigger, the scientific quality of the data is equally important. In this talk, the criteria for trigger performance studies will be presented. Additionally, the quality of different trigger strategies will be discussed.

T 78.6 Thu 17:30 VG 2.103

Modeling of dark matter prompt and secondary signatures in dwarf galaxies — •Athithya Aravinthan[1,2], Julia Becker Tjus[1,2,3], and Lukas Merten[1,2] — [1]Theoretische Physik IV, Ruhr-Universität Bochum, Bochum, Germany — [2]RAPP Center, Ruhr-Universität Bochum, Bochum, Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, 412 96 Gothenburg, Sweden

Dwarf galaxies are a convenient testing ground in the indirect search for Dark Matter (DM), due to their low astrophysical background in radio and gamma ray frequencies. In addition to the much explored prompt emission of DM in dwarf galaxies, one must also consider the secondary multimessenger signatures of charged DM annihilation products via synchrotron radiation and inverse Compton scattering. The consistent modeling of this secondary emission with the astrophysical background is necessary for placing stringent constraints on the nature of DM.

In this work, the multi-wavelength secondary spectrum of DM annihilation for dwarf spheroidal galaxies is calculated using the open-source code CRPropa 3.2., which allows for the self-consistent treatment of the astrophysical background and secondary emissions. The code can also be extended to treat DM particles, which is currently not available in the public version. *Supported by DFG (SFB 1491).

T 78.7 Thu 17:45 VG 2.103

Analysis of the IC 443 Supernova Remnant with H.E.S.S. Data — •Lukas Grosspietsch, Alison Mitchell, and Tina Wach for the H.E.S.S.-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg

The Jellyfish Nebula or IC 443 is one of the few observed supernova remnants (SNRs) interacting with a molecular cloud. In this contribution, we present a first spectral and spatial analysis of gamma-ray emission from IC 443 observed with the H.E.S.S. telescope array using the open source analysis package gammapy. The data show some significant emission best modeled by an extended source. Further- more, we combine our analysis with some multi-wavelength data which can best be modeled by a parent proton population producing gamma rays via neutral pion decay, indicated by the characteristic pion-bump. This analysis of the IC 443 gamma-ray emission observed by the H.E.S.S. telescope therefore again highlights IC 443 as a probe for cosmic ray acceleration in SNRs.

T 78.8 Thu 18:00 VG 2.103

Spatially coherent 3D distributions of HI and CO in the Milky Way — •Laurin Söding[1], Gordian Edenhofer[2,3], Torsten A. Ensslin[2,3,6], Philipp Frank[2], Ralf Kissmann[4], Vo Hong Minh Phan[5], Andrés Ramírez[4], Hanieh Zandinejad[2,3], and Philipp Mertsch[1] — [1]RWTH Aachen University, Aachen, Germany — [2]Max Planck Institute for Astrophysics, Garching, Germany — [3]Ludwig Maximilian University of Munich, Munich, Germany — [4]Universität Innsbruck, Innsbruck, Austria — [5]Sorbonne Université, Paris, France — [6]Excellence cluster ORIGINS, Garching, Germany

The spatial distribution of the gaseous components of the Milky Way is of great importance for a number of different fields, for example, Galactic structure, star formation, cosmic rays, and diffuse emission. We used three-dimensional (3D) Gaussian processes to model correlations in the interstellar medium, including correlations between different lines of sight, and enforce a spatially coherent structure in the prior. We inferred the spatial distributions of atomic hydrogen (HI), carbon monoxide (CO), their emission line widths, and the Galactic velocity field in a joint Bayesian inference from multiple datasets, mainly Doppler-shifted line emission. Our main result consists of a set of samples that implicitly contain statistical uncertainties. We confirm previous findings regarding the warping and flaring of the Galactic disc. A comparison with 3D dust maps reveals a good agreement on scales larger than approximately 400 pc. While our results are not free of artefacts, they present a big step forward in obtaining high-quality 3D maps of the interstellar medium.

T 79: Methods in Astroparticle Physics III

Time: Thursday 16:15–18:15 Location: VG 3.101

T 79.1 Thu 16:15 VG 3.101

Measuring Infrared Light Emission in Xenon — •Kai Böse for the XENON-Collaboration — Max-Planck-Institut für Kernphysik

Xenon is an ideal target for searching for rare events such as dark matter or neutrinoless double-beta decay. Several experiments utilize its ultraviolet scintillation to study interactions with nuclei and electrons. However, it is also known that xenon emits infrared light, which has been less extensively studied. Our group at MPIK Heidelberg has begun investigating the IR component in xenon interactions using infrared-sensitive photomultiplier tubes for future rare event search applications.

T 79.2 Thu 16:30 VG 3.101

Developing a cryogenic heat pump for liquid xenon radon removal systems — •Philipp Schulte, Lutz Althüser, Robert Braun, Hannah Ginkel, Volker Hannen, Christian Huhmann, David Koke, Patrick Unkhoff, Daniel Wenz, and Christian Weinheimer — Institute for Nuclear Physics, University of Münster

Future liquid xenon (LXe) dark matter detectors require a detector background 10 times smaller than the solar neutrino background. Achieving this requires reducing the 222Rn concentration in LXe to <0.1 μBq/kg - corresponding to less than one 222Rn atom in 160 mol xenon. The ERC project "LowRad" aims to develop the next generation of radon and krypton removal technology using cryogenic distillation. By exploiting the different vapour pressures of xenon and radon, radon is removed through repeated evaporation and condensation in a large surface area distillation column with partial reflux. To reach this low radon concentration, the throughput flow of the column must increase, as higher flow rates remove more radon per time, lowering its concentration in the detector. This requires scaling up from 65 kg/h (XENONnT) to $\sim$750 kg/h, with O(20) kW of heating and cooling power for the evaporation and reliquification. Therefore, an additional heat pump circuit using xenon as the working medium is being developed to lower the cooling requirement to the thermodynamic input of the heat pump. This talk will explain the working principle of cryogenic distillation and the heat pump, as well as the results from its development. Acknowledging the support of the ERC AdG project "LowRad" (101055063).

T 79.3 Thu 16:45 VG 3.101

Commissioning of ALMOND, a mobile neutron detector for LNGS — •Felix Kratzmeier[1], Melih Solmaz[1,2], Klaus Eitel[1], Alfredo Davide Ferella[3,4], Francesco Pompa[1,3], Kathrin Valerius[1], and Denis Tcherniakhovski[5] — [1]Karlsruhe Institute of Technology, Institute for Astroparticle Physics — [2]Heidelberg University, Kirchhoff Institute for Physics — [3]University of L'Aquila, Department of Physics and Chemistry — [4]INFN-Laboratori Nazionali del Gran Sasso — [5]Karlsruhe Institute of Technology, Institute for Data Processing and Electronics

ALMOND is a mobile low-flux neutron spectrometer for the LNGS underground laboratory based on a plastic scintillator array surrounded by Gd foils. It has been designed and built at KIT as a stand-alone system. In this talk, we will present the commissioning of the detector system at KIT including MC simulations of its performance, as well as first data taken underground at LNGS.

T 79.4 Thu 17:00 VG 3.101

ALMOND: An LNGS Mobile Neutron Detector — •Melih Solmaz[1,2], Klaus Eitel[2], Alfredo Davide Ferella[3,4], Felix Kratzmeier[2], Francesco Pompa[2,3], and Kathrin Valerius[2] — [1]Heidelberg University, Kirchhoff Institute for Physics — [2]Karlsruhe Institute of Technology, Institute for Astroparticle Physics — [3]University of L'Aquila, Department of Physics and Chemistry —

[4]INFN-Laboratori Nazionali del Gran Sasso

Environmental neutrons introduce a source of background to rare event searches, such as dark matter direct searches, neutrinoless double beta decay experiments and in cross section measurements for nuclear astrophysics, which take place in deep underground laboratories. The flux and spectrum of the ambient neutrons vary greatly with time and location. ALMOND is a mobile low-flux neutron spectrometer conceived for the LNGS underground laboratory. In this talk, we will present an overview of the design and construction of ALMOND as well as the calibration measurements performed at KIT and in Frascati, Italy. This project is supported by the German Federal Ministry of Education and Research (BMBF) under the grant number 05A21VK1. We acknowledge the support by S. Loreti and his colleagues from the Frascati Neutron Generator (FNG) facility.

T 79.5 Thu 17:15 VG 3.101

Status of the IceAct Telescopes above the IceCube Neutrino Observatory — •Lars Heuermann, Lars Marten, Andreas Nöll, Sönke Schwirn, and Chistopher Wiebusch — RWTH Aachen - III. physikalisches Institut B, Aachen, Germany

IceAct is an array of Imaging Air Cherenkov Telescopes on the ice surface above the IceCube Neutrino Observatory. Each telescope features a SiPM-based 61-pixel camera and Fresnel lens-based optics, resulting in a 12-degree field of view. The design is optimized to be operated in harsh environments, particularly at the South Pole. The setup will consist of a station of seven telescopes in a so-called fly's eye configuration, increasing the field of view to 36°, and an additional telescope 200m apart for stereoscopic observations. Three of the eight telescopes are currently taking data. Another two have been shipped and are being prepared for data taking starting in 2025. In this talk we will review the status of the installation, recent analysis results, and report on the ongoing upgrade.

T 79.6 Thu 17:30 VG 3.101

Development of a Dataset for Hybrid Cosmic-Ray Measurements using IceAct, IceTop, and IceCube — •Sönke Schwirn, Shuyang Deng, Lasse Düser, Jonas Häussler, Lars Heuermann, Lars Marten, Philipp Soldin, Julian Vogt, and Christopher Wiebusch — RWTH Aachen - III. Physikalisches Institut B, Aachen, Germany

IceAct is an array of Imaging Air-Cherenkov Telescopes stationed at the South Pole as part of the IceCube Neutrino Observatory. One of its main goals is the hybrid detection of cosmic-ray induced air showers. We combine the shower development as measured with IceAct, the surface component as measured with IceTop, and TeV muons as measured deep in the ice with IceCube. For this, accurate and robust event synchronization and matching is required to combine these complementary measurements. Furthermore, it is necessary to precisely align the geometric orientation of the IceAct telescopes for an analysis of these events. In this talk, we will present a new data processing for a hybrid dataset including an improved event matching and its application to updated geometric alignment. Finally, we present a graph convolutional network for event reconstruction.

T 79.7 Thu 17:45 VG 3.101

Analysis of AERA measurements for optimizing the lightning interferometer at the Pierre Auger Observatory* — •Melanie Joan Weitz for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Wuppertal, Germany

The Pierre Auger Observatory has detected downward terrestrial gamma-ray flashes with its water Cherenkov detectors. A key to understanding this high-energy radiation in thunderstorms is to combine such measurements with those of lightning processes in their earliest stages. The introduced lightning interferometer is a detector currently under construction for imaging lightning propagation in 3D based on radio interferometry. With eleven modified Auger Engineering Radio Array (AERA) stations and their bandwidth range from 30 – 80 MHz the necessary precision can be provided.

One step towards the lightning interferometer data acquisition is to investigate the existing AERA measurements for lightning signal traces and to study their properties. We will present their signal characteristics measured with AERA stations using external lightning information. This allows the optimization of the signal dynamical range for the modified stations.

**Supported by BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A23PX1)*

T 79.8 Thu 18:00 VG 3.101

A test system for the AERA/RD beacon at the Pierre Auger Observatory — Markus Cristinziani[1], Eric-Teunis de Boone[1], Qader Dorosti[1], Stefan Heidbrink[2], •Noah Siegemund[1], Waldemar Stroh[2], Jens Winter[2], and Michael Ziolkowski[2] — [1]Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Elektronikentwicklungslabor des Departments Physik, Universität Siegen

Precise timing is crucial in the radio detection of cosmic-ray-induced air showers, as it enables an accurate reconstruction of $X_{\max}$ through radio interferometry. GPS receivers such as those used for time synchronization in AERA/RD at the Pierre Auger Observatory cannot achieve sub-ns accuracy. To correct these inaccuracies, AERA exploits a beacon system that transmits sine waves to provide timing corrections. We are developing a test system based on the White Rabbit (WR) technology to evaluate the accuracy and scalability of the beacon. This system can tackle new challenges associated with the upgrade from AERA to RD. WR delivers precise timing in the sub-ns range over a distance up to several kilometers via fiber optic cables and serves as a reference signal for data acquisition at multiple radio stations. The recorded data is analyzed offline using interferometric signal processing techniques to assess the stability of the beacon signal. Sub-ns accuracy has been achieved in our initial tests on a short baseline. Future plans to scale the system are outlined in this contribution.

T 80: Cosmic Rays IV

Time: Thursday 16:15–18:00 Location: VG 3.102

T 80.1 Thu 16:15 VG 3.102

Investigation of the Diffusion Tensor for Different Turbulence Levels and Rigidities in the Resonant Scattering Regime — •Jan-Niklas Bohnensack[1], Julia Becker Tjus[1,2,3], and Leander Schlegel[1,2] — [1]Theoretical Physics IV: Plasma-Astroparticle Physics, Faculty for Physics & Astronomy, Ruhr-Universität Bochum, D-44780 Bochum, Germany; Supported by SFB1491 — [2]Ruhr Astroparticle And Plasma Physics Center (RAPP Center), Bochum, Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden

The quasi-linear theory (QLT) describes the interactions between charged particles and astrophysical plasmas in the limit of $b/B \ll 1$. The goal of the underlying thesis was to verify the QLT's prediction that for small turbulence levels b/B, where b is turbulent magnetic field strength and B is the homogeneous magnetic field strength, the diffusion coefficient behaves like $\kappa \propto \rho^\gamma$ with $\gamma = 1/3$. This is currently only done with smaller statistics (number of propagated particles) due to technical restrictions. To overcome those restrictions a code was developed in the underlying thesis to utilize methods of parallelization that calculate the running diffusion coefficient from particles propagated with CRPropa faster. As part of this, an algorithm was created that can verify the convergence of the given running diffusion coefficient and can stop the simulations accordingly. With diffusion coefficients that were generated for a range of reduced rigidities and turbulence levels that lie in the Resonant Scattering Regime, the behavior of the index γ for smaller b/B according to the QLT was verified.

T 80.2 Thu 16:30 VG 3.102

Anisotropy induced by a modulation of the ultra-high-energy cosmic ray flux — •Janning Meinert[1,2], Leonel Morejón[1], Veronika Vašíčková[1], and Karl-Heinz Kampert[1] — [1]Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Germany — [2]ITP Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany

We investigate the energy-dependent residence time of extragalactic cosmic rays due to the galactic magnetic field using CRPropa. We

examine whether a sudden and substantially increased flux of homogeneously injected ultra-high-energy cosmic rays (UHECR) in the past about 10-100 kiloyears leads to a dipole, as observed by the latest Auger data for proton injection only. Another observable will be the energy dependent amplitude evolution. An agreement with anisotropy data while preserving a homogeneous injection of cosmic rays could strengthen the hypothesis of *one* predominant UHECR source, such as Centaurus A, which may be isotropised due to echoes in the council of giants. While currently mild tensions between the dipole amplitude between Auger data and the simulation are apparent for the highest energies ($E \geq 32$ EeV), incorporating more realistic simulation scenarios might mitigate those tensions in the future.
**Supported by DFG under SFB 1491*

T 80.3 Thu 16:45 VG 3.102

Study on the transport behavior in blazars in anisotropic magnetic fields* — •Milena Brütting[1,2], Vladimir Kiselev[1,2], and Julia Becker Tjus[1,2] — [1]Theoretical Physics IV, Ruhr-University Bochum, Bochum, Germany — [2]RAPP-Center at Ruhr-University Bochum, Bochum, Germany

Active Galactic Nuclei (AGN) are currently considered a likely source of ultra-high-energy cosmic rays (UHECR). Blazars, in particular, represent highly interesting research objects from an astrophysical point of view due to a complex jet structure which will hopefully yield new information on particle transport behavior. Following this line of research we plan to investigate the effect of anisotropies of the magnetic field on cosmic-ray propagation in the jets of blazars. For this purpose, a modified version of the open-source code CRPropa 3.2 shall be used to allow for cosmic ray transport in blazar jets. Building on previous work, we will attempt to simulate the propagation of high-energy protons in a relativistic plasmoid and investigate their diffusive behavior in the presence of an anisotropic magnetic field.
* Supported by DFG (SFB 1491)

T 80.4 Thu 17:00 VG 3.102

Stochastic analytic expressions for efficient modeling of hadronic interactions — •Leonel Morejon — Bergische Universit\"{a}t Wuppertal, Gau{\ss}str. 20, 42119 Wuppertal

While sources of Ultra-High-Energy Cosmic Rays (UHECRs) are expected to be radiation dominated, subdominant hadronic interactions might, nevertheless, yield observable effects in the spectra of messengers like photons and neutrinos.

Hadronic interactions are usually modeled with suitable generators to create production tables that are convolved with the spectra of primary UHECRs to predict the spectra of secondary particles. This method works reasonably well when the number of interactions is sufficiently large, but does not apply when fluctuations are important, as is the case for UHECR sources.

This work shows that the stochastic behavior in optically thin scenarios can be described with analytic expressions. Such expressions are used to compute the spectra of secondaries like photons and neutrinos produced in the sources, for suitable examples.

T 80.5 Thu 17:15 VG 3.102

Cosmic-ray induced ionisation and spatio-temporal correlations between supernova remnants and molecular clouds — Hanno Jacobs[1], Vo Hong Minh Phan[2], •Mareike Berkner[1], and Philipp Mertsch[1] — [1]Institute for Theoretical Particle Physics and Cosmology, RWTH Aachen University — [2]Sorbonne Université, Observatoire de Paris, PSL Research University, LERMA, CNRS UMR 8112, 75005 Paris, France

MeV cosmic rays can penetrate dense molecular clouds and oftentimes dominate the ionisation, thus contributing to the physical and chemical dynamics of star forming regions. The effect of cosmic rays can be quantified by their ionisation rate. Interestingly, the ionisation rate predicted from the locally measured cosmic-ray fluxes is one to two orders of magnitude lower than the observed ionisation rates. This disagreement is known as the ionisation puzzle. Previously, it was shown that the point-like nature of cosmic-ray sources implies a stochastic scatter in the stochastic ionisation rates. Drawing distances between clouds and supernova remnants randomly, the discrepany between model and observations could be reduced. Here, we extend this model by considering spatial and temporal correlation between source and cloud positions. These are to be expected to a certain degree as supernova remnants are likely formed in the same cloud complexes. We will present the predictions for different assumptions on the correlations and compare to ionisation data.

T 80.6 Thu 17:30 VG 3.102

Observing the Prompt Component of the Atmospheric Muon Flux Using IceCube — •Leander Flottau — TU Dortmund University, Dortmund, Germany

Atmospheric muons are created by the decays of secondary particles generated in cosmic ray interactions with the upper atmosphere. Based on the muons' parent particles, they can be categorized into conventional muons, originating from pions and kaons, and prompt muons, generated by the decays of more short-lived particles. While the conventional component dominates at lower energies, prompt muons become dominant at high energies, around 1 PeV and above.

Measuring these muons using the IceCube neutrino telescope is useful for studying hadronic interactions at a combination of center-of-mass energies and rapidities that are difficult to replicate in any current collider experiment. Due to the low overall flux at the energies where the prompt component dominates, no analysis to date has been able to significantly measure it.

The talk will cover the process of investigating the normalization of the prompt muon flux using a forward fit. This involves testing the method's ability to identify the prompt component using simulations, as well as its intended subsequent application to actual IceCube data.

T 80.7 Thu 17:45 VG 3.102

An approach to classify the prompt neutrino component of cosmic ray showers with IceCube. — •Roman Peschin — TU Dortmund University, Dortmund, Germany

The earth's atmosphere is like a translucid veil. It is nearly transparent for the human eye, but not to high-energy cosmic particles. Our atmosphere allows these particles to interact with the air molecules, which then produce a cascade of secondary particles. Prompt neutrinos are one component of these cosmic ray showers and dominante in the energy regimes above roughly 20 TeV for electron neutrinos and above about 1 PeV for muon neutrinos. While conventional neutrinos are mainly produced by pions and kaons, prompt neutrinos originate from the decay of charmed mesons.

The IceCube Neutrino Observatory is a cubic kilometer neutrino detector located at the South Pole that is constantly gaining information about the outter space. Besides the intended detection of astrophysical neutrinos, IceCube is particularly sensitive to secondary particles, like muons, from cosmic ray showers. These muons behave like a background noise for neutrino detection and are the main challenge for the classification of the prompt neutrino component.

For that purpose we use a deep neural network as an attempt to seperate the prompt element from the muon background. One approach is to look for coincident events produced by the same cosmic ray shower. The final goal is to improve the classification of the prompt neutrinos, leading to a better understanding of the composition of cosmic rays and the mechanisms of neutrino production.

T 81: Neutrino Physics VI

Time: Thursday 16:15–18:15 Location: VG 3.103

T 81.1 Thu 16:15 VG 3.103

A full Monte Carlo simulation for keV-sterile neutrino searches with the KATRIN experiment — •Claudio Silva for the KATRIN-Collaboration — Karlsruhe Institute of Technology, IAP, Campus North, Geb. 401, 76344, Germany

Sterile neutrinos are predicted by several extensions to the Standard Model and, if their mass falls within the keV range, they present a compelling dark matter candidate. One potential searching method involves looking for a kink-like distortion in the β spectrum. The Karlsruhe Tritium Neutrino Experiment (KATRIN) uses a tritium source to measure the neutrino effective mass, focusing on the endpoint where the mass effect is the clearest

The next phase of the KATRIN experiment, known as TRISTAN, seeks to extend this search across the entire tritium spectrum. This phase requires the installation of a new multi-pixel silicon drift detector and a specialized readout system, as well as significant modifications to the KATRIN beamline to improve sensitivity.

In this phase, sensitivity to keV sterile neutrinos is strongly influenced by systematic effects, including electron scattering in the source, detector response, and other factors. Addressing these challenges requires a highly efficient Monte Carlo (MC) simulation of the entire KATRIN beamline, capable of generating high-statistics datasets.

In this presentation, we introduce the KATRIN full MC simulation developed using Geant4. We will outline its key components, assess its performance, and present preliminary studies of systematic uncertainties affecting the search for keV-scale sterile neutrinos.

T 81.2 Thu 16:30 VG 3.103

Monte Carlo Simulation for Electron Scattering in the KATRIN Tritium Source — •Leo Laschinger for the KATRIN-Collaboration — Technische Universität München — Max-Planck-Institut für Kernphysik, Heidelberg

The KATRIN experiment is designed and currently being operated to measure the effective electron antineutrino mass by studying the endpoint region of the tritium beta decay spectrum. It also provides an opportunity to search for keV-scale sterile neutrinos. To that end, an investigation of the full beta spectrum is planned after the completion of the neutrino mass campaign. Electron scattering on tritium molecules in the gaseous tritium source is an important systematic effect in the KATRIN experiment, both for the ongoing neutrino mass measurement and for the upcoming search for keV-scale sterile neutrinos. In order to model this effect and its impact on the measured beta spectrum, an event-by-event Monte Carlo simulation utilizing Markov Chains for efficient cross section sampling has been developed. In this talk, I will present the working principles of the simulation, highlight the key results obtained, and discuss their implications for the KATRIN analysis. This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6). This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programme (grant agreement No. 852845).

T 81.3 Thu 16:45 VG 3.103

The Monte Carlo Simulation of JUNO's pre-detector OSIRIS — •Lukas Bieger, Dhanushka Bandara, Silvia Cengia, Adrian Keiderling, Florian Kirsch, Tobias Lachenmaier, Anurag Sharma, and Tobias Sterr — Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose neutrino experiment with a 20 kt liquid scintillator detector in the final phase of construction in southern China. Its primary objective is to determine the neutrino mass hierarchy by precisely measuring the oscillated energy spectrum of electron antineutrinos from nearby nuclear power plants. The Online Scintillator Internal Radioactivity Investigation System (OSIRIS) will monitor the radio-purity of the liquid scintillator during the filling of JUNO, to ensure that the required contamination levels are met. OSIRIS itself is a 18 t liquid scintillator detector, instrumented with 64 20-inch PMTs to collect the light produced by events in the detector's sensitive volume. A precise Monte Carlo simulation is essential for understanding the detector's performance and optimizing analysis methods. This talk will present the comprehensive simulation framework developed for OSIRIS and will discuss the agreement of the simulation output with respect to source calibration data. Furthermore, ongoing MC tuning using calibration data to improve the accuracy is reported. This work is supported by the Deutsche Forschungsgemeinschaft.

T 81.4 Thu 17:00 VG 3.103

LiquidO: Simulations for Cloud Detector — •Susanna Wakely for the CLOUD-Collaboration — Johannes Gutenberg University

LiquidO is an innovative technology that uses opaque liquid scintillators for particle detection. A LiquidO scintillator combines a short scattering length and a long absorption length to stochastically confine optical photons close to their creation point. A fine array of wavelength-shifting fibres collects and transports the scintillation light for readout by SiPMs. A LiquidO detector will have unprecedented position resolution compared to current transparent scintillators and be capable of particle identification via event topology. LiquidO prototypes have demonstrated proof of principle of stochastic light confinement.

The Cloud collaboration is designing a 5-10 ton LiquidO antineutrino detector. This will be an above-ground ultra-near reactor neutrino detector located in the Chooz nuclear power plant, in France.

This talk will discuss simulations of the inner detector, including particle identification via event topology and fibre array design. Two broad fibre array designs are considered: z-parallel and stereo. A z-parallel fibre array can achieve mm-scale resolution in x and y, with z-position obtained at lower resolution from signal timing differences. A stereo fibre array would produce the same x and y resolution while improving the z resolution but presents challenges for detector construction and signal reconstruction.

T 81.5 Thu 17:15 VG 3.103

Simulations regarding the water tank instrumentation for LEGEND-1000 — •Eric Esch — University Tübingen, Tübingen, Germany

In order to reach the challenging background goal of less than 10^{-5} cts/(keV·kg·yr) targeted by the next phase of the **L**arge **E**nriched **G**ermanium **E**xperiment for **N**eutrinoless $\beta\beta$ **D**ecay (LEGEND), new detector systems have to be planned and optimized. Previous Monte Carlo studies have revealed that the in-situ production and delayed decays of ^{77}Ge and its metastable state ^{77m}Ge constitute a significant cosmogenic background. This talk will present recent simulations exploring the instrumentation of the water tank, aimed at mitigating these contributions. Specifically, the instrumentation seeks to identify and veto events produced by neutron-showering muons, the key source of $^{77(m)}$Ge background.

T 81.6 Thu 17:30 VG 3.103

Current Status of ANNIE Monte Carlo — •Johann Martyn, Amala Augusthy, Noah Goehlke, Philipp Kern, David Maksimovic, Daniel Tobias Schmid, Michel Wurm, and Dorina Carolin Zundel for the ANNIE-Collaboration — Johannes Gutenberg-Universität, Institut für Physik, Mainz 55128, Germany

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a 26-ton water Cherenkov neutrino detector installed on the Booster Neutrino Beam (BNB) at Fermilab. Its main physics goals are to perform a measurement of the neutron yield from neutrino-nucleus interactions, as well as a measurement of the charged-current cross section of muon neutrinos. Additionally, ANNIE has strong focus on the research and development of new detector technologies and target media, such as Large Area Picosecond Photodetectors (LAPPDs) and Water-based Liquid Scintillator (WbLS). Ratpac is a simulation and analysis framework build with GEANT4, ROOT, and C++, which is currently used by multiple experiments in the investigation of WbLS. In ANNIE Ratpac simulates the full detector response, including the WbLS and LAPPDs. This talk presents the current status of the ANNIE implementation in Ratpac. his work is supported by the DFG.

T 81.7 Thu 17:45 VG 3.103

Status of the Super-SANDI deployment — •Philipp Kern, Amala Augusthy, Noah Goehlke, David Maksimociv, Johann Martyn, Daniel Schmid, Michael Wurm, and Dorina Zundel for the ANNIE-Collaboration — Johannes Gutenberg Universität Mainz

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a Cherenkov neutrino detector at the Booster Neutrino Beam (BNB) at Fermilab. To also allow measurements with scintillation light a water based scintillator (WbLS) is installed inside the detector in a 366 litre large vessel (SANDI). The advantage of WbLS in the detector is that it is possible to extract the energy of the neutrinos with the scintillation light as well as the trajectory of it with the Cherenkov cone. To allow us to observe the full potential of the water based scintillator by a full reconstruction of extendet neutrino event vertices, a larger vessel made out of nylon holding 8000 litres of WbLS will be deployed in 2026. To be able to deploy this vessel, Super-SANDI into ANNIE it has to be inflatable to be able to fill out the whole volume of the detector. We will present you the current status of the development of this vessel, which has unique challenges because of its size and the properties of the WbLS.

I would like to thank the DFG and the Graduate School - Particle Detectors for their funding.

T 81.8 Thu 18:00 VG 3.103

DUNE-PRISM: An innovative technique for neutrino oscillation analysis — •Ioana Caracas for the DUNE-Collaboration —

JGU Mainz

As long baseline neutrino experiments are entering the high-precision era, an increased sensitivity towards constraining the oscillation parameters space is expected. A classical approach for the oscillation predictions is prone to systematic uncertainties, due to the incompleteness of neutrinos interaction cross section modelling. This would in turn limit the capability to obtain the physics goals for modern long baseline experiments, such as the Deep Underground Neutrino Experiment (DUNE).

An innovative technique, the Precision Reaction-Independent Spectrum Measurement (PRISM) has been proposed and studied within the DUNE collaboration. This novel method is designed to measure and predict neutrino oscillated spectra on a data-driven approach, avoiding thus the most theoretical model uncertainties. In this regard, the Near Detector (ND) is designed to move off the neutrino beam axis at several locations up to a distance of 30 m. Different neutrino fluxes are thus sampled and these ND off-axis results are further used as basis to predict the neutrino oscillated spectrum at the DUNE Far Detector. The prediction obtained with the DUNE-PRISM analysis framework and preliminary results regarding the systematics impact on the oscillation parameters will be presented. Ongoing studies to improve the overall sensitivity to the oscillation parameters and reduce their dependence on the interaction model will also be discussed.

T 82: Neutrino Physics VII

Time: Thursday 16:15–18:15 Location: VG 3.104

T 82.1 Thu 16:15 VG 3.104

Cherenkov source for JUNO — •Manuel Böhles[1], Tim Charissé[1], Johann Martyn[1], Oliver Pilarcyzk[1], Hans Theodor Josef Steiger[2], and Michael Wurm[1] — [1]Johannes Gutenberg University Mainz, Institute of Physics, Staudingerweg 7, 55128 Mainz, Germany — [2]Technical University of Munich, Physics Department, James-Franck-Str. 1, 85748 Garching, Germany

For the calibration of hybrid analyses of the JUNO experiment, a Cherenkov source has been developed to gain a better understanding of the light yield and propagation of Cherenkov light in JUNO. With this knowledge, the CID method (Correlated and Integrated Directionality) for the detection of solar neutrinos, which has already been successfully applied in Borexino, can be refined. The improved resolution of the ratio of Cherenkov to scintillation light can effectively suppress background events and help in the search for the Diffuse Supernova Background (DSNB).

The fundamental idea is based on the use of a beta source with a few MeV electron energy whose electrons pass through a Cherenkov radiator. In order to improve the triggering of the detector, a coincidence source is to be used (e.g. Bi-Po), the second decay of which triggers a scintillation signal in a plastic scintillator.

The development is funded by the DFG Research Unit "JUNO" (FOR5519).

T 82.2 Thu 16:30 VG 3.104

Source Calibration of the OSIRIS Radiopurity Monitor for JUNO — •Rosmarie Wirth[1], Daniel Bick[1], Caren Hagner[1], Mikhail Smirnov[1], Milo Charavet[1], and Tobias Sterr[2] — [1]Universitaet Hamburg, Hamburg, Deutschland — [2]Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory (JUNO) features a 20-kiloton liquid scintillator (LS) detector currently under construction in Jiangmen, China. Its primary scientific goal is to determine the neutrino mass ordering with a confidence level of $3\,\sigma$ within the first six years of data taking. This will be achieved by observing the oscillation spectrum of reactor anti-neutrinos at a baseline of ~ 53 km. To effectively distinguish between normal and inverted ordering, the detector requires an energy resolution of 3 % at 1 MeV, high optical coverage, and low background levels, demanding high purity liquid scintillator.

To monitor scintillator quality during the filling of JUNO, the Online Scintillator Internal Radioactivity Investigation System (OSIRIS) has been developed. OSIRIS is a 18-ton cylindrical LS detector that assesses the radio-purity of the provided scintillator through Bismuth-Polonium coincidence signals. For calibration, an Automatic Calibration Unit (ACU) from the Daya Bay experiment is implemented, allowing to submerge different sources in the scintillator, providing calibration points for energy and vertex reconstruction, as well as for the timing and charge calibration of the photomultiplier tubes (PMTs).

This presentation covers the current status of the calibration of OSIRIS using the ACU.

T 82.3 Thu 16:45 VG 3.104

Status of the Laser Calibration of the JUNO pre-detector OSIRIS — •Tobas Sterr[1], Dhanushka Bandara[1], Lukas Bieger[1], Silvia Cengia[1], Jessica Eck[1], Adrian Keiderling[1], Florian Kirsch[1], Tobias Lachenmaier[1], Anurag Sharma[1], and Rosmarie Wirth[2] — [1]Eberhard Karls Universität Tübingen, Physikalisches Institut — [2]Universität Hamburg

The 20 kt liquid scintillator (LS) detector of the Jiangmen Underground Neutrino Observatory (JUNO) experiment, currently under construction in southern China. To achieve its physics goals, stringent radiopurity requirements for the LS must be fulfilled. In order to ensure these limits, the Online Scintillator Internal Radioactivity Investigation System (OSIRIS) was designed as a pre-detector for JUNO. During the months-long filling period of JUNO, OSIRIS will assess the radiopurity of purified LS batches to allow fast countermeasures in case of contaminations. In OSIRIS, an array of 76 Photomultiplier Tubes (PMTs) instruments a water-shielded 18-ton LS target. A pico-second pulsed laser system is used for PMT timing and charge calibration. This presentation will summarize the current status of the laser calibration system, the calibration strategy of this system and first results of the calibration in the commissioning phase of OSIRIS. Furthermore, OSIRIS PMT performance parameters using the laser calibration system are presented and compared to the results of the JUNO PMT testing campaign.

This work is supported by the Deutsche Forschungsgemeinschaft.

T 82.4 Thu 17:00 VG 3.104

Charge Sensitive Amplifier R&D for the LEGEND-1000 Experiment — •Andreas Gieb, Florian Henkes, Susanne Mertens, and Michael Willers for the LEGEND-Collaboration — Technische Universität München, Deutschland

The Large Enriched Germanium Experiment for Neutrinoless Double-Beta Decay (LEGEND) uses ^{76}Ge to search for neutrinoless double-beta ($0\nu\beta\beta$) decay. The LEGEND-200 phase, currently operating at Gran Sasso, serves as a precursor to LEGEND-1000, a 1000-kg experiment designed to achieve discovery sensitivity at half-lives exceeding 10^{28} years, targeting the inverted-ordering neutrino mass scale. Reaching this sensitivity requires ultra-low background levels and exceptional energy resolution in the region of interest.

To meet these requirements, readout electronics near the detectors play a critical role. An application-specific integrated circuit (ASIC)-based front-end system has been developed to achieve low background while maintaining low noise and high energy resolution. This work presents the results of the first ASIC iteration and outlines changes for the second iteration.

We acknowledge support by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy - EXC 2094 - 390783311 and through the Sonderforschungsbereich (Collaborative Research Center) SFB1258 'Neutrinos and Dark Matter in Astro- and Particle Physics'.

T 82.5 Thu 17:15 VG 3.104

R&D efforts regarding the water tank instrumentation for LEGEND-1000 — •Lorenz Gessler — University Tübingen, Tübingen, Germany

In the pursuit of the stringent background target set by the next phase of the Large Enriched Germanium Experiment for Neutrinoless Double-Beta Decay (LEGEND), the integration and optimization of additional veto systems are essential. Among the most challenging backgrounds are those arising from muon-induced neutron showers, which can produce metastable isotopes such as ^{77m}Ge.

This talk will present ongoing R&D efforts dedicated to enhancing the LEGEND-1000 water tank instrumentation. We are investigating a range of neutron-tagging strategies, such as gadolinium-loaded plastics, alternative Gd-based compounds, and liquid scintillator solutions, using a dedicated 700 L water Cherenkov test detector in Tübingen. By comparing and refining these approaches, we aim to guide the ultimate design of the water-based veto system, thereby improving background suppression and advancing the experiment's sensitivity to the elusive $0\nu\beta\beta$ decay signal.

T 82.6 Thu 17:30 VG 3.104

Detection of Cherenkov and Scintillation light in hybrid scintillators — •Dorina C. Zundel[1], Michael Wurm[1], Manuel Böhles[1], and Hans Steiger[2] — [1]Johannes Gutenberg-Universität Mainz, Institute of Physics and Cluster of Excellence PRISMA+, Staudingerweg 7, 55128 Mainz — [2]Technische Universität München, James-Franck-Straße 1, 85748 Garching

Hybrid scintillator detectors aim at the simultaneous detection of Cherenkov and scintillation light. SCHLYP (**S**cintillation **CH**erenkov **L**ight **Y**ield **P**rism) is a newly developed laboratory setup, used to distinguish Scintillation and Cherenkov light in scintillator samples. The setup uses the geometrical advantages of a hollow prism filled with various scintillator samples as a detector, equipped with three ultrafast photomultipliers, on each side. Photons from a close-by ^{137}Cs source create a signal by Compton scattering in the scintillator. Using a secondary inorganic scintillator detector, recoil photons are selected to be aligned with the prism geometry, so that two of the PMTs detect both Cherenkov and Scintillation light, while the third PMT is only able to detect scintillation light. The samples being investigated range from slow scintillators to water-based liquid scintillators. In this talk the improved setup and the analysis of the phase II data will be presented.

T 82.7 Thu 17:45 VG 3.104

Development of a High-Pressure Scintillator Test Cell for Double Beta Experiments — •Magdalena Eisenhuth for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz, Institut für Physik, 55128 Mainz, Germany

The investigation of two-neutrino and neutrino-less double beta decay is crucial for understanding the Dirac or Majorana nature of neutrinos.

In this context, the krypton isotope Kr-78 (Q=2.88 MeV) stands out as a promising candidate for a first detection of two-neutrino ECb+ and 2b+ decays.

Detectors like the proposed NuDoubt++ experiment featuring opaque scintillator or an upgrade of the OSIRIS detector with hybrid scintillator can profit from solving the krypton gas in the scintillator at high pressure to increase the loading factor.

This presentation explores the loading process in a small-scale scintillator test cell and the characterization techniques for determining the loading factor.

T 82.8 Thu 18:00 VG 3.104

Electron scattering in cryogenic scintillating calorimeters for rare event searches — •Elisa Gaido for the COSINUS-Collaboration — Max-Planck-Institut für Physik, Munich, Germany

Cryogenic scintillating calorimeters (CSCs) are an established technology for the direct detection of dark matter through nuclear scattering. Current CSC experiments like COSINUS are starting to explore the possibility of using CSCs for the direct detection of dark matter-electron and neutrino-electron scattering, e.g. in the OνDES project. The theoretical framework for these searches is still under development. This contribution explores the possibility of detecting neutrino-electron scattering with CSCs and constraining their properties beyond the standard model of particles. This research is part of the LUCE/OνDES project funded by the Klaus Tschira foundation.

T 83: Methods in Particle Physics IV (Lepton Reconstruction)

Time: Thursday 16:15–18:45 Location: VG 4.101

T 83.1 Thu 16:15 VG 4.101

Electron Reconstruction Efficiencies in Run 2 and Run 3 at ATLAS — •Marius Melcher, Asma Hadef, and Arno Straessner — Technische Universität Dresden

Before particles detected by the ATLAS experiment can be used in physics analyses, their measured signatures undergo several analysis steps, e.g. reconstruction and identification. It is crucial that these steps and their performances are well understood. This talk will focus on the electron reconstruction and the measurement of its efficiency.

For electron reconstruction, information from different parts of the detector needs to be connected: a track from the Inner Detector is matched to energy deposits in the EM calorimeter by reconstruction algorithms. To estimate how many real electrons successfully pass these algorithms the tag-and-probe method is used for $Z \to ee$ decays to measure efficiencies both for data and Monte Carlo simulation in dependence of p_T and η. These results are then used to derive scale factors which are applied to correct MC predictions in subsequent analyses with electrons in the final state. In addition to the scale factors also their uncertainty is passed to the analyses. Understanding and controlling the systematic uncertainties of the efficiency measurement is therefore crucial.

After introducing the method and its data-driven approach for background estimation, recent results for the full Run 2 and already available Run 3 datasets are discussed.

T 83.2 Thu 16:30 VG 4.101

Likelihood Tuning for LHC Run 3 — •Max Fusté Costa[1], Martina Laura Ojeda[2], and Sarah Heim[1] — [1]DESY, Hamburg, Germany — [2]CERN, Geneva, Switzerland

A likelihood-based identification (LH ID) is used to identify the reconstructed electrons in the ATLAS detector and to reject hadronic jets and electrons from heavy flavor decays. Due to differences between Run 2 and 3 at the LHC, the LH ID needs to be retuned. The transverse momentum range of the tuning will be extended as well. This is done using Run 3 Monte Carlo samples, with observables adjusted using the Shift and Stretch (S&S) method to match the data. The performance of the tuning and the fudging are evaluated through efficiency measurements.

T 83.3 Thu 16:45 VG 4.101

Photon identification at the CMS experiment using particle flow candidates and individual calorimeter energy deposits — •Caio Daumann and Johannes Erdmann — III. Physikalisches Institut A, RWTH Aachen University

Many physics processes under study at the Large Hadron Collider are characterized by the presence of photons in the final state. Consequently, the performance of photon identification algorithms is crucial for the physics reach of the CMS experiment. Currently, the photon identification algorithm is based on a Boosted Decision Tree that utilizes high-level variables as input, such as shower shapes and isolation variables. Instead of relying on high-level variables, we investigate the performance of a photon classifier trained on low-level quantities, such as individual energy deposits in the calorimeter and particle-flow candidates surrounding the photon, from which high-level information is typically derived. Modern machine learning architectures are well-known for their ability to extract informative features directly from raw training data, often outperforming classifiers based on high-level variables. In this study, we report the performance of a classifier trained using such low-level information.

T 83.4 Thu 17:00 VG 4.101

Measurement of photon identification efficiency with the inclusive photon method using 2022 CMS data — Johannes Erdmann, •Nitish Kumar, and Jan Lukas Späh — III. Physikalisches Institut A, RWTH Aachen University

The measurement of the photon identification efficiency is an essential component of all analyses using photons. Conventionally, the CMS collaboration uses the tag-and-probe technique to measure the photon identification efficiencies up to photon p_T of 500 GeV. This method is limited by small event yields in the high-p_T region and the extrapolation beyond 500 GeV is associated with additional uncertainties, which is relevant for analyses involving high-p_T photons.

The inclusive photon method, also known as the matrix method, allows a precise measurement of the photon identification efficiencies at high photon p_T. This method uses an inclusive photon sample selected with single photon triggers. It utilizes isolation criteria to obtain the fraction of prompt photons in the whole sample and the subsample meeting the identification criteria. This allows the extraction of the photon identification efficiency in a data-driven way. In this talk, we present the preliminary measurement results of photon identification efficiencies with the inclusive photon method using data collected by the CMS experiment in 2022, including the associated systematic uncertainties.

T 83.5 Thu 17:15 VG 4.101

Determination of Universal Tau Fake Factors for the Run 3 Data Taking Period of ATLAS — •Christian Schmidt, Arno Straessner, and Asma Hadef — Institut für Kern- und Teilchenphysik, Technische Universität Dresden

Tau leptons are an important product in collision events at the LHC; they primarily decay into a hadronic final state. Hadronic jets can easily produce similar signatures inside the ATLAS detector, i.e. fake taus, so it becomes necessary to estimate the fake tau background. The Fake Factor (FF) method estimates this background from data events with non-isolated tau candidates using a correction factor which depends on the transverse momentum of the tau candidate. In addition, the FF depends on the origin of the fake-producing jets, such as quark or gluon jets. Instead of measuring the FFs in a separate control region for each physics analysis, the Universal Fake Factor (UFF) method uses an estimate of the jet composition to linearly interpolate the FFs.

This talk will present the general principles of the UFF method, the process of calculating parameters to be used for determining the UFF parameters in ATLAS Run 3 data, and current results.

T 83.6 Thu 17:30 VG 4.101

Measurement of Tau Identification Scale Factors in the $W \to \tau\nu$ Channel Using LHC Run 3 Data — •Luka Vomberg, Christian Grefe, Philip Bechtle, and Klaus Desch — Physikalisches Institut Bonn

Measurement of Tau Identification Scale Factors in the $W \to \tau\nu$ Channel Using LHC Run 3 Data

Scale factors are necessary to calibrate the selection efficiency for the identification of hadronic tau-lepton decays in simulation to the observed efficiencies in data. These factors are determined for all ATLAS analyses in dedicated tag-and-probe studies.

A measurement of tau identification (ID) scale factors using 2022 data from LHC Run 3 is presented, focusing on the $W \to \tau\nu$ channel. This channel offers a higher transverse momentum reach than $Z \to \tau\tau$ or $t\bar{t}$ due to the W-boson recoiling from a jet, and allows tight missing energy cuts because of the neutrino in the final state. The primary challenge is the large dijet QCD background, addressed using the data-driven ABCD method.

The entire measurement workflow is implemented with Snakemake, providing a novel and systematic solution to ensure easy reproducibility and interoperability - an essential but often overlooked aspect of such measurements. Additionally, new strategies for improving fake tau estimation are proposed to enhance the measurement's precision and reliability.

T 83.7 Thu 17:45 VG 4.101

Inference of the Neutral Four-Momentum of Hadronic τ-Leptons using Neural Networks in ATLAS — •Simon Thiele[1], Lukas Cieslik[1], Christian Grefe[1], Alessandra Betti[2], Philip Bechtle[1], and Klaus Desch[1] — [1]Rheinische Friedrich-Wilhelms Universität Bonn — [2]Sapienza Università di Roma

Reconstructing the four-momenta of neutral decay products of hadronically decaying τ-leptons, which are almost exclusively π^0's, allows to infer the spin of the τ. This allows for example to measure the CP of the Higgs boson. Therefore it is desirable to reconstruct this momentum as accurately as possible, which is challenging since the photons from the π^0 decays are only measured in the electromagnetic calorimeter.

Currently these neutral decay products are reconstructed in ATLAS using the Tau-Particle-Flow algorithm, which also performs a decay mode identification, classifying the tau jets by the number of charged and neutral hadrons they contain. In recent years a new neural network based decay mode classifier has been developed. This new classifier has a higher efficiency than the current algorithm. But since it is only a classifier without a reconstruction of the neutral four-momentum, this gain in efficiency is not accessible to these Higgs CP studies. Therefore we are currently working on developing a neural network based solution for that also provides inference of the neutral four-momentum.

In this talk I will first go over this motivation and the current state of the art algorithms and then discuss the performance of the new neural network solution.

T 83.8 Thu 18:00 VG 4.101

Muon Momentum Scale and Resolution Calibration for CMS — •Dorian Guthmann, Markus Klute, and Jost von den Driesch — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

Many analyses conducted with the CMS experiment at the LHC rely on a precise description of muon momenta. However, deviations between data and simulation arise due to mismodeling of the detector, such as misalignment and limited magnetic field precision. To address this, scale and resolution corrections are applied to the transverse momentum of muons, mitigating biases and aligning the theoretical description of muons with their experimental counterpart. This presentation will provide an overview of the progress made over the past year in refining and enhancing these corrections.

T 83.9 Thu 18:15 VG 4.101

Reconstruction of Stand-Alone Muons in Run 3 of ATLAS — •Celine Stauch[1], Otmar Biebel[1], Valerio D'Amico[1], Stefanie Götz[1], Lars Linden[1], Bao Tai Le[1], Tim Rexrodt[1], and Giorgia Proto[2] — [1]LMU Munich — [2]MPI Munich

The identification and reconstruction of muons is an essential aspect for precise measurements of processes including muons in the final states of the ATLAS experiment at the LHC and HL-LHC. Various important physics processes produce muons which are detected by the Muon Spectrometer with almost 100 %-efficiency and good momentum resolution. Muons in the very forward region of the detector are called stand-alone muons. These muons are outside the reach of the Inner Track detector and are reconstructed solely using the Muon Spectrometer.

The measured efficiency in Monte Carlo (MC) samples is then compared with that obtained from dataset. The agreement between the efficiency measured in data and the corresponding efficiency in MC is called Scale Factor and is used to quantify the deviation of the simulation from the real detector behavior and is then used to correct the simulation in physics analyses.

T 83.10 Thu 18:30 VG 4.101

Estimation of Non-Prompt Lepton Backgrounds with Classical and Machine Learning Techniques — Korn Steffen, Quadt Arnulf, and •Schiel Nico — II. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Non-prompt leptons are a significant background in many particle physics analyses, for example $t\bar{t}$ and HWW^* analyses. These processes depend on the modelling of parton showers and are therefore challenging to predict theoretically. Consequently, data-driven approaches are utilised to model backgrounds arising from non-prompt leptons. Often, classical methods such as the fake-factor method are used. However, machine learning based methods such as normalising flows also show promising results for modelling non-prompt leptons. In this talk, both approaches are compared with respect to their performance.

T 84: Search for Dark Matter IV

Time: Thursday 16:15–18:45 Location: VG 4.102

T 84.1 Thu 16:15 VG 4.102

Status of the DarkMESA Experiment — •Mirco Christmann for the MAGIX-Collaboration — Institute for Nuclear Physics, JGU Mainz, Germany

At the Institute for Nuclear Physics in Mainz the new electron accelerator MESA will be operational shortly. The high-power beam dump of the P2 experiment (150 MeV, 150 μA) is ideally suited for a parasitic dark sector experiment – DarkMESA.

The experiment is designed for the detection of Light Dark Matter

(LDM) which in the simplest model couples to a massive vector particle, the dark photon γ. It can potentially be produced in the beam dump by a process analogous to photon Bremsstrahlung and may then decay into Dark Matter (DM) particle pairs $\chi\bar{\chi}$. A fraction of them scatter off electrons or nuclei in the DarkMESA detectors.

This contribution discusses the extension of the simulation framework through the integration of additional models and the current status of the Phase A setup. Beyond the use of a traditional calorimeter, the possibility of utilizing a liquid scintillator for Phase B is under investigation. Initial results obtained in co-operation with the NuDoubt^{++} collaboration are presented.

T 84.2 Thu 16:30 VG 4.102

Light Dark Matter Search with DarkMESA — •Christian Stoss for the MAGIX-Collaboration — Institute for Nuclear Physics, Johannes Gutenberg-University Mainz, Germany

The existence of Dark Matter remains one of the most significant open questions in particle physics. The DarkMESA experiment aims to search for Light Dark Matter (LDM) in an unexplored mass and coupling regime. This parasitic beam dump experiment will be located downstream of the P2 experiment at the new MESA accelerator in Mainz. It is planned to operate for 10,000 hours in extracted beam mode, using a $150\mu A$ electron beam with an energy of $150MeV$.

In the simplest model of LDM, the dark matter particle χ couples to a massive vector particle, the dark photon γ'. In this framework, electrons in the beam dump can produce γ' via a Bremsstrahlung-like process. If kinematically allowed, these dark photons then decay into $\chi\bar{\chi}$ pairs. If LDM exists within the targeted parameter space, a fraction of the produced LDM will scatter off electrons or nuclei in the calorimeter's Cherenkov crystals, generating measurable signals.

This contribution will include a brief overview of the planned experimental stages of DarkMESA as well as a further study for possible improvement of the readout techniques with additional SiPMs at different operating temperatures.

T 84.3 Thu 16:45 VG 4.102

Investigation of hadronic Backgrounds for Lohengrin — •Laney Klipphahn for the Lohengrin-Collaboration — Universität Bonn

The search for dark matter has long been of interest to scientists around the world. Previous searches have so far been unsuccessful in finding proposed DM particles. A promising and not well explored family of DM models contains dark matter particles with masses below $\approx 1\,\mathrm{GeV}$ connected through a portal interaction to the standard model. The Lohengrin experiment at the ELSA electron accelerator in Bonn is a fixed target experiment designed to probe this mass range by searching for dark photons in a dark bremsstrahlung process in the target.

Lohengrin will probe the dark sector by analyzing events with a significant amount of missing momentum in the final state. Hadronic final states comprise a particularly challenging background to the dark photon search, as single nucleons or mesons can be ejected from the target at high angles, evading the detectors that are placed in forward direction. In this talk I will present the results of a MC driven background estimation for the Lohengrin experiment, and its impact on the design and layout of the detector.

T 84.4 Thu 17:00 VG 4.102

Active muon veto of the COSINUS experiment — •Kumrie Shera for the COSINUS-Collaboration — Max-Planck Institute for Physics, Munich, Germany

The Cryogenic Observatory for SIgnatures seen in Next Underground Searches (COSINUS) is a direct dark matter search experiment utilizing sodium iodide (NaI) crystals as cryogenic calorimeters. The cryogenic facility is located in hall B of the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. The NaI cryogenic detectors will be housed in a dry dilution refrigerator positioned at the center of a water tank with a diameter and height of seven meters. The water serves as passive shielding against ambient radiation.

High-energy muons can penetrate the detector's surroundings, generating muon-induced neutrons that may cause nuclear recoils, potentially mimicking a dark matter signal. To actively identify and veto these events, the water tank is equipped with 30 photomultiplier tubes (PMTs), enabling the tank to operate as an active muon veto.

This contribution outlines the installation tests, PMT testing, and the commissioning of the full muon veto system at LNGS.

T 84.5 Thu 17:15 VG 4.102

Pulse Shape Studies on the COSINUS prototypes with BAT — •Sarah Braun for the COSINUS-Collaboration — MPP Munich

The Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches (COSINUS) experiment, located at the Laboratori Nazionali del Gran Sasso (LNGS), Italy, will provide a model-independent cross-check of the DAMA/LIBRA experiment's findings of modulation signals consistent with the expected dark matter signal. It utilizes ultrapure NaI crystals operated at cryogenic temperatures, enabling a dual-channel readout of scintillation and phonon signals to discriminate different particle interactions.

This contribution focuses on fitting different pulse shape models to the COSINUS detector prototypes, using the Bayesian Analysis Toolkit (BAT) in Julia. Franz Pröbst's model for cryogenic detectors has proven effective when applied to the CRESST experiment detectors. This study explores whether similar success can be achieved with COSINUS prototypes using a remoTES. The overall objective is to understand the detector parameters and their effect on the performance, to guide and accelerate our detector R&D strategy.

T 84.6 Thu 17:30 VG 4.102

Dark matter direct detection with XENONnT experiment — •Giovanni Volta for the XENON-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Understanding the nature of Dark Matter (DM) is one of the open issues in modern physics. In this context, XENON project aims to lead the effort on DM direct detection using ton-scale xenon dual-phase time projection chamber technology, operating in a low background environment. The status of XENONnT experiment, operating at the underground LNGS (L'Aquila, Italy) laboratory, will be shown, along with the most recent DM search results.

T 84.7 Thu 17:45 VG 4.102

Study of spurious clustered electron emission signals in XENONnT — •Alexis Michel and Alexey Elykov — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

In direct search of dark matter, dual-phase xenon time projection chambers (TPCs) like XENONnT are widely used. This kind of detector has a target of liquid xenon (LXe) with a layer of gaseous xenon (GXe) above. Alongside the prompt scintillation signal, interactions in the TPC produce ionization electrons. These are drifted upward as a cloud of electrons by an applied electric field and extracted into the GXe to produce a secondary scintillation signal.

The extraction into the gas is not always complete and electrons can stay behind. What then happens to those electrons is not exactly known yet. Previous experiments often observed a number of spurious signal types, which could be associated with delayed extraction of trapped electrons. One such signal type takes the form of significantly delayed localized bursts of electrons (e-burst).

Understanding the origin of this background is of key importance for low-energy searches that look for particle interaction products down to the single- and few-electron level. Moreover, characterization of the e-burst background could shed light on the microphysics processes at the liquid-gas xenon interface, informing the operation and design of the current and future generation of xenon TPCs.

In this talk I will present the recent results and progress on studies of such signals and their correlation with detector conditions.

T 84.8 Thu 18:00 VG 4.102

.MOTION, a liquid xenon time projection chamber platform for high voltage development in dark matter detectors — •Yanina Biondi, Alexander Jansen, Steffen Lichter, Michael Schrank, Karin Vogt, and Yanina Biondi — Institute For Astroparticle Physics, Karlsruhe Institute of Technology

MOTION is a time projection chamber with 80 kg of liquid xenon (LXe), serving as a testing platform for high-voltage (HV) delivery of around -200 kV and stability in LXe for next-generation dark matter detectors. The objective of this detector is to study the breakdown voltage of liquid xenon, which might depend on different factors such as surface area of the conductor and the purity of the liquid xenon, among others. The detector also serves as a platform to study spurious electron emission from electrodes, as well as the development of high voltage feedthroughs made out exclusively of radiopure materials. This project is supported by the Young Investigator Group Preparation Program of the Karlsruhe Institute of Technology.

T 84.9 Thu 18:15 VG 4.102

Design and Commissioning of the MainzTPC2 — •Constantin Szyszka, Alexander Deisting, Christopher Hils, Peter György, Kaveh Kooshkjalali, and Uwe Oberlack — Institut für Physik & Exzellenzcluster PRISMA$^+$, Johannes Gutenberg-Universität Mainz

The MainzTPC is an experimental dual-phase xenon time projection chamber (TPC) dedicated to studying scintillation and ionization processes in liquid xenon for low-energy electronic and nuclear recoils. Its design has been optimized for use as the primary target in Compton and neutron scattering experiments to measure recoil energies in liquid xenon down to 1 keV.

To address known instabilities in the liquid level of the MainzTPC, we observed the liquid-gas interface using commercially available cameras and aim to improve the level meters and level control based on these observations. Additionally, the MainzTPC is being redesigned to accommodate an array of silicon photomultipliers (SiPMs) instead of the top photomultiplier tube (PMT) and eight avalanche photodiodes (APDs) to improve position resolution in x and y. Both of these changes require a complete redesign of the TPC and its infrastructure. We report on the status of this work.

T 84.10 Thu 18:30 VG 4.102

Simulation and Prototyping of the MainzTPC2 — •Peter Gyorgy, Alexander Deisting, Christopher Hils, Kaveh Kooshkjalali, Uwe Oberlack, and Constantin Szyszka — Johannes Gutenberg-Universität Mainz, Institut für Physik & Exzellenzcluster PRISMA+

The MainzTPC, a small-scale dual-phase xenon time projection chamber, is being redesigned. This upgrade includes the replacement of the top photomultiplier tube (PMT) with a silicon photomultiplier (SiPM) array to gain significantly improved spatial resolution in event reconstruction.

The goal is to achieve a deeper understanding of xenon scintillation and ionization yields at low energies, and to attempt to observe the elusive Migdal effect — a hybrid nuclear- electron- recoil signal that could prove key to extend to lower dark matter masses the sensitivity of large dual-phase time projection chambers, such as XENONnT or XLZD.

The prototyping process requires extensive modeling and simulations in GEANT4, exploring various design configurations. It must consider optical physics, neutron and gamma scattering, and long-term radioactive exposure. This presentation will summarize results from this simulation process.

T 85: Members' Assembly

Time: Thursday 19:00–20:00 Location: ZHG104

All members of the Particle Physics Division are invited to participate. Pretzels and drinks will be provided.

T 86: Searches/BSM V (Misc.)

Time: Friday 9:00–10:30 Location: ZHG010

T 86.1 Fri 9:00 ZHG010

BSM Searches at a 12 GeV Gamma-Gamma collider based on the European XFEL — •Marten Berger[1], Gudrid Moorgat-Pick[1,2], and Monik Wüst[1] — [1]Universität Hamburg, Hamburg, Germany — [2]DESY, Hamburg, Germany

Photon-Photon colliders have been discussed before, offering so far unrealized complimentary possibilities to any current and future linear collider. Implementing one as extension to the Beam dump of the 17.5 GeV European XFEL as the first high energy collider of its sort. It would not just be to study the concept of photon colliders but would also be a collider without competition in the region of $5 - 12$ GeV for photon-photon collision. In this range, $b\bar{b}$ and $c\bar{c}$ resonances, tetraquarks as well as mesonic molecules can be observed. Furthermore, some BSM processes can also be reached in this range making use of the polarization effects from compton backscattering. In this talk we want to discuss the possibility of observing ALPs at such a collider. We will use a simplified description of the compton backscattering process to get a first look at cross sections and extend this to the full beam dynamics included prediction.

T 86.2 Fri 9:15 ZHG010

Hunting coloured scalars with machine learning — Thomas Flacke[1], Jeong Han Kim[2], •Manuel Kunkel[3], Jun Seung Pi[2], and Werner Porod[3] — [1]Center for AI and Natural Sciences, KIAS, Seoul, Republic of Korea — [2]Department of Physics, Chungbuk National University, Republic of Korea — [3]Institut für Theoretische Physik und Astrophysik, Julius-Maximilians-Universität Würzburg, Germany

Composite Higgs models with an underlying fermionic description predict an extended scalar sector featuring also QCD coloured states. We study an electrically neutral colour octet and a colour sextet with charge 4/3. Both states couple to top quarks such that pair production leads to a four top quark signature. We train neural networks to separate these signal processes from their SM backgrounds and derive the discovery reach and expected exclusion limits at the HL-LHC. Since both states may be present simultaneously, we also assess how well the respective events can be separated by our networks.

T 86.3 Fri 9:30 ZHG010

Trigger-level search for dijet resonances at ATLAS — •Falk Bartels — Kirchhoff-Institut für Physik, Heidelberg

The search for sub-TeV dijet resonances at the LHC is statistically limited due to the reduced readout rate of lower p_T jet triggers. The ATLAS trigger-level analysis covers this part of the spectrum by recording a strongly reduced set of event-level information processed by the High Level Trigger for all events passing the seeding Level-1 trigger. This allows for lowering the minimal detectable dijet resonance mass from above 1 TeV to around 400 GeV.

With more than 1 billion events in the recorded dijet mass spectrum, an exceptional statistical precision can be achieved. Matching this level of precision poses unique challenges especially for the custom trigger-level jet calibration and the background estimate. A general overview of the well-advanced analysis is presented.

T 86.4 Fri 9:45 ZHG010

Searching for anomalous dijets in CMS data with CATHODE — •Chitrakshee Yede, Gregor Kasieczka, Louis Moureaux, Tore von Schwartz, and Manuel Sommerhalder — Institute for Experimental Physics, Universität Hamburg, Hamburg, Germany

In high-energy physics, numerous analyses conduct searches for new phenomena beyond the Standard Model. A new paradigm of model-agnostic searches has emerged based on anomaly detection which is aimed at automatically identifying deviations from the background expectation in the data using machine learning. We present the recently published analysis by the CMS Collaboration that employs such machine learning techniques. We discuss CATHODE, a method combining density estimation and weak supervision and its first-ever application on 13 TeV proton-proton collision data recorded by the CMS experiment at the LHC. This study focuses on heavy resonances decaying into two large-radius jets with anomalous substructure. This approach establishes a foundation for data-driven, model-agnostic searches, enabling the simultaneous investigation of multiple potential new physics signals within a single analysis.

T 86.5 Fri 10:00 ZHG010

Statistical analysis with anomaly detection — •Kristian Warnholz, Louis Moureaux, Gregor Kasieczka, and Manuel Sommerhalder — Universität Hamburg

Although extensive searches for new physics at the Large Hadron Collider have been conducted, no new particles beyond the Standard Model have been discovered. A key limitation may stem from the reliance on specific models to guide these searches, potentially overlooking more exotic phenomena. In response, recent years have seen the development of numerous machine learning-based, model-independent anomaly detection methods designed to uncover unexpected signals in the data. The first results using these methods have recently been published by the ATLAS and CMS Collaborations. We present a statistical analysis of the behavior of the p-values and exclusion limits derived using the anomaly detection process.

T 86.6 Fri 10:15 ZHG010

Exploring new physics at LHC with Model Unspecific Search in CMS — Alexander Schmidt, Arnd Meyer, •Chinmay Seth, Felipe Torres Da Silva De Araujo, and Thomas Hebbeker — III. Physikalisches Institut A, RWTH Aachen

The Standard Model of Particle Physics, while highly successful, has limitations and fails to provide a comprehensive description of fundamental particles. Beyond Standard Model theories explore alternative explanations for these shortcomings.

The Large Hadron Collider provides access to unprecedented energy for proton-proton collision experiments, generating data to explore theories beyond the Standard Model. Model Unspecific Search in CMS (MUSiC) is one such effort where a model-independent approach is used to look for regions of possible discrepancies between observations from the CMS detector and standard model predictions.

MUSiC classifies events into 'event classes' based on the multiplicity of specific reconstructed final state particles, such as a class with 2 muons and 1 jet. Kinematic distributions for these classes are generated using three key event variables. The algorithm calculates a p-value, considering systematic and statistical effects, and identifies regions in distributions that deviate from the statistical model. Applying further statistical corrections yields a final $\tilde{p}$-value, highlighting the most deviating event classes. If the $\tilde{p}$-value surpasses a set threshold, it signifies a potential window to new physics in that corresponding region. We discuss the concept of MUSiC, its scope, and challenges in this talk.

T 87: Higgs physics IX (Charm and Tau Final States)

Time: Friday 9:00–10:15 Location: ZHG104

T 87.1 Fri 9:00 ZHG104

NLO QCD Corrections to ZH Production via Gluon Fusion — •Dominik Grau[1], Matthias Steinhauser[1], Marco Vitti[1], Joshua Davies[2], and Kay Schönwald[3] — [1]Karlsruhe Institute of Technology , Karlsruhe, Germany — [2]The University of Liverpool, Liverpool, United Kingdom — [3]Universität Zürich, Zürich, Switzerland

The associated production of a Higgs boson with a vector boson is an important process investigated at the LHC. Formally the gluon fusion channel enters the process pp→ZH at NNLO. However, it gives sizeable contributions to the cross section and to the theoretical uncertainties which motivates the computation of NLO QCD corrections to gg→ZH. In this talk we describe an approach to obtain analytic results for the two-loop virtual corrections as an expansion around the forward limit. We show that the combination of these results with analytic high-energy expansions can cover the whole phase-space without the need of time-consuming numerical methods.

T 87.2 Fri 9:15 ZHG104

Current developments in the search for the Higgs boson decay to a charm-anticharm pair in vector boson associated production mode at CMS in Run 3 — •Valentyn Vaulin[1], Alexander Schmidt[1], Andrey Pozdnyakov[1], Jan Schulz[1], Gaetano Barone[2], Spandan Mondal[2], Trevor Russell[2], Ulrich Heintz[2], Licheng Zhang[3], Chris Palmer[3], and Braden Kronheim[3] — [1]RWTH Aachen University, Germany — [2]Brown University, USA — [3]University of Maryland, College Park, USA

During the recent years multiple analysis techniques to measure the Higgs boson coupling to charm quarks using the full Run-2 data of the CMS experiment have been established. The Higgs boson decay into a charm-anticharm pair, where the Higgs boson is produced in association with the W or Z boson, is expected to be the most sensitive channel. In this talk developments of the VH(cc) analysis, using Run-3 data at CMS, are presented. In particular, the analysis strategy and the first expected limits will be shown.

T 87.3 Fri 9:30 ZHG104

PAIReD jets in CMS: Recent developments of a novel jet tagging approach for H(cc) and H(bb) searches in the CMS experiment — Gaetano Barone[1], Alexander Jung[2], Ming-Yan Lee[2], Spandan Mondal[1], Trevor Russel[1], Uttiya Sarkar[2], Alexander Schmidt[2], •Jan Schulz[2], and Ulrich Willemsen[2] — [1]Brown University, Providence, USA — [2]III. Physikalisches Institut A, RWTH Aachen University, Germany

The identification of jet flavors based on machine learning is the most critical ingredient for the search for rare Higgs decays in two charm quarks. For the upcoming CMS analysis, a new jet tagging strategy has been developed that outperforms classical tagging approaches, especially for small Lorentz boosts of the Higgs boson. The central element of this new method is the so-called PAIReD jet, a new unconventional jet type which, in contrast to traditional AK4 jets, exploits correlations between the two charm jets. This talk will give an overview of the PAIReD approach and recent developments such as mass-decorrelated training and simultaneous jet-mass regression.

T 87.4 Fri 9:45 ZHG104

Search for the Higgs plus charm quark production mode in the $H \to WW \to e\nu\mu\nu$ channel — •Ming-Yan Lee, Alexander Schmidt, Andrey Pozdnyakov, Uttiya Sarkar, and Valentyn Vaulin — III. Physikalisches Institut A, RWTH Aachen University, Aachen, Germany

The Higgs plus charm production mode is another topology to probe the Higgs-charm Yukawa coupling complementary to H→cc channels. This topology provides the possibility to access the Higgs-charm coupling via cleaner final states. In this analysis, we aim to consider the Higgs decay into W boson to dileptonic final states with additional charm-tagged jets. The upper limit to extract H-c coupling is demonstrated using the data-taking period 2016 to 2018 of the CMS experiment at the LHC at $\sqrt{s}$ =13 TeV.

T 87.5 Fri 10:00 ZHG104

Performance of tau reconstruction with CMS — Markus Klute, Olha Lavoryk, Artur Monsch, •Jan Voss, and Roger Wolf — Institut für Experimentelle Teilchenphysik, Geb. 30.23 Wolfgang-Gaede- Str. 1 76131 Karlsruhe

The precise measurements of tau-leptons play an important part in many analyses, especially in Higgs physics. For higher precision, the use of scale factors is widespread to correct for mismodelings of the data with simulations or data driven techniques. This talk will cover the measurement of the DeepTau ID scale factors in different quantities like transverse momentum, decaymode and energy scale, as well as its technical intricacies.

T 88: Miscellaneous

Time: Friday 9:00–10:30 Location: ZHG105

T 88.1 Fri 9:00 ZHG105

A semi-classical particle model explains mass and other data quantitatively — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

We present a particle model that is an evolution of Louis de Broglie's original approach. It is mostly classical, but has properties that are largely superior to QM calculations. At first, a classical model of inertial mass is explained which, unlike the Higgs model, gives precise results without the use of free parameters. It also allows, in contrast to the mere postulations of QM, the derivation of known rules/facts such as frequency-energy, the Bohr magneton, the fine structure constant. And it derives the structure of the strong field inside particles. This was previously in great conflict with quantum chromodynamics (QCD), but is now in agreement after a recent QCD modification.

Further info: ag-physics.org/rmass

T 88.2 Fri 9:15 ZHG105

Notational invariance of the standard model — •Lello Boscoverde — Istituto della Fava Pazza, Garching, Germany

I will present the concept of notational invariance, the history of its development, and example applications relevant to contemporary particle physics.

T 88.3 Fri 9:30 ZHG105

Comment on the Sommerfeld Fine Structure Constant tension — •Manfred Geilhaupt — University of applied Sciences HS Niederrhein

In todays physics, the fine-structure constant (alpha) is a fundamental physical constant which quantifies the strength of the electromagnetic interaction between elementary charged particles. The constant alpha was introduced in 1916 by Arnold Sommerfeld. However, alpha still is an unsolved theoretical and even experimental physical problem up to now! Alpha from atomic interferometric experiments shows a large difference compared to their high accuracy:

1. 2018 Parker et al. 1/137.035999046(27), atomic interferometer experiment
2. 2020 Morel et al. 1/137.035999206(11), atomic interferometer experiment
3. 2011 More et al. 1/137.035999084(15), quantum hall experiment. The 2011 last experimental von Klitzing constant RK=25812.807442(30)Ohm accuracy can be increased by an order of magnitude today. So the RK=e^2/h makes the difference.
4. 2019 form Codata given alphaC= 1/137.035999177
5. 2019 from Codata given alphaRKC=1/137.035999127 based on RKC= 25812.807450(00)Ohm (exact defined) does not match. The presentation contains two answers to the question about tension. Critics appreciated. (A. Einstein: Ein Problem kann man nicht mit der Denkweise lösen, durch die es entstanden ist.)

T 88.4 Fri 9:45 ZHG105

Uniqueness of unification — •Christoph Schiller — Motion Moutain Research, Munich

A unified description of motion that includes general relativity and the standard model of particle physics with massive neutrinos must be unique, without inequivalent alternative, and must agree with the observed invariant Planck limits for speed, action, entropy and force. It is first argued that the Planck limits imply

* that space, horizons, wave functions and fields are neither continuous nor discrete,
* that nature at the Planck scale cannot be described with equations,
* that all motion in nature – that of quantum particles, of black hole horizons, and of curved space – results from unobservable filiform, and tangled constituents of Planck radius that follow a simple *fundamental principle*.

For fermions, this closely resembles the description used by Dirac in his lectures. Step by step, it is found that other constituents, other descriptions of quantum effects and wave functions, other gauge groups, other elementary particles, other Feynman vertices, other values of the fundamental constants, other numbers of dimensions, other theories of gravitation, and other Lagrangians contradict the observed Planck limits. As a result, a unified description of motion must be based on the topology and statistics of tangled constituents. In total, only the fundamental principle implies general relativity and the standard model with massive neutrinos. Any measurable deviation is excluded.

Details and publications at https://motionmountain.net/research

T 88.5 Fri 10:00 ZHG105

Compositeness and spatial extension of fundamental particles in a circular extra space — •Hans-Dieter Herrmann — Berlin

A particle model is proposed living in space-time as well as in an extra space complementing space-time, called basic space. The models in basic space called 'birotons' consist of two 'rotons' with nearly equal masses. Birotons have a composited spin of 1/2 h_bar and show four spinor-like states. The rotons perform a circular motion with a 4π-resp. a 2π-cycle. This geometric difference causes a symmetry violation corresponding to the weak parity violation. The mass symmetry and the spin-asymmetry between the two rotons represent an internal super-symmetry.The charge of the biroton is attached to only one of the two rotons, this results in gyromagnetic factors of 1 and 0 for the rotons, however nearly 2 for the biroton. The biroton has two modes of translation: a local mode (corpuscle-picture) and a nonlocal mode (corresponding to a picture of two parallel probability waves). In the nonlocal mode the rotons including their partial masses have different positions in space-time that causes quantum nonlocality as well as a nonlocal gravity of the same origin. The dual space-concept applied for the model contruction has a philosophical foundation, see https://philarchive.org/archive/HERACQ.

T 88.6 Fri 10:15 ZHG105

Kaluza + spin — •Thomas Schindelbeck — IRAEPH Mainz

A modified Kaluza model plus Spin 1/2 as boundary condition provides the symmetry of the elementary fermion zoo, a converging energy series that covers the range from the electron to the Higgs, as well as other particle properties such as magnetic moment or coupling constants.

The calculations are ab initio and typically yield an accuracy in the range of QED corrections.

https://zenodo.org/record/3930485

T 89: Axions/ALPs III

Time: Friday 9:00–10:30 Location: VG 0.110

T 89.1 Fri 9:00 VG 0.110

Advancing Axion Detection: Cryogenic Calibration and Dark Matter Search with MADMAX — •Juan Maldonado for the MADMAX-Collaboration — maldonad@mpp.mpg.de

Discovery of the axion could solve both the strong CP problem, fundamental in particle physics, and the dark matter problem. The MAgnetized Disc and Mirror Axion eXperiment - MADMAX - is a project based on the novel dielectric haloscope concept to detect axion dark matter in the mass range around 100 ueV through enhancement of the inverse Primakoff process. The higher precision required to operate an axion haloscope at a mass range above 40*eV corresponding to a frequencies greater than 10 GHz poses additional challenges in the realm of microwave engineering and cryogenics, with potential applications to other fields of research. In this talk, I will present the cryogenic calibration of the experimental setup and discuss a first dark matter search using a MADMAX prototype at a temperature below 10 K, performed at CERN in 2024.

T 89.2 Fri 9:15 VG 0.110

Commissioning The RADES axion haloscope of MPP — Babette Döbrich, Cristian Cogollos, José María García Barceló, and •Ziheng Yang — Max-Planck-Institut für Physik, Munich

The Axion is a pseudoscalar particle to solve the problem of the non-observation of CP violation in strong interactions, in a simple and compelling fashion. In this framework axions will have a very small mass and interact with other particles very weakly which makes they are an idea candidate for dark matter. The inverse Primakoff effect is commonly employed as detection method. Axions will transform into photons under strong magnetic fields. We report on the status of the RADES experiment at MPP Munich. In this experiment, we place the cavity at a temperature of 7mK and a magnetic field of 12T. In this talk we will also elaborate on the injection of realistic synthetic axion signals to test that the setup is performing as foreseen.

T 89.3 Fri 9:30 VG 0.110

Study of Higgs decays into long lived Axion-Like Particles with the ATLAS Experiment — •Janek Both, Christian Schmitt, Kristof Schmieden, and Volker Büscher — Johannes Gutenberg-Universität Mainz

Axion-Like Particles (ALP) or more generally, pseudoscalars that are gauge singlets under the Standard Model gauge group, appear in many well-motivated extensions of the Standard Model. These particles are naturally assumed to be light compared to the electroweak scale and might for example provide insides into the nature of dark matter. In scenarios where the ALP couples to the Higgs boson, collider searches can provide sensitivity to ALPs in the GeV range and thus offer a complementary approach to other experiments that mainly focus on lighter ALPs. Depending on the coupling strengths of the ALP, it might decay displaced from the primary vertex inside the calorimeters of the ATLAS detector. Such a signature would be almost background free and hence can be reconstructed with high efficiency. In this talk, a study of long-lived ALP decays inside the ATLAS calorimeter is presented and projected exclusion limits in the ALP mass and photon-coupling plane for an integrated luminosity of 1000 fb^{-1} are shown. The future dataset will greatly improve upon the existing ATLAS run-2 and run-3 analyses, which focus on displaced ALP decays within the tracking system.

T 89.4 Fri 9:45 VG 0.110

Solar axion couplings from the Nuclear Spectroscopic Telescope Array — •Jaime Ruz and Julia Vogel — Fakultät für Physik. Technische Universität Dortmund. Dortmund, D-44221, Germany

Data from the Nuclear Spectroscopic Telescope Array (NuSTAR) collected during the 2020 solar minimum, along with advanced solar atmospheric magnetic field models, establish a new limit on the axion-photon coupling strength $g_{a\gamma} \lesssim 6.9 \times 10^{-12}$ GeV^{-1} at 95% C.L. for axion masses $m_a \lesssim 2 \times 10^{-7}$ eV. This constraint surpasses current ground-based experimental limits, studying previously unexplored regions of the axion-photon coupling parameter space up to masses of $m_a \lesssim 5 \times 10^{-4}$ eV. These findings mark a significant advancement in our ability to probe axion properties and strengthen indirect searches for dark matter candidates.

T 89.5 Fri 10:00 VG 0.110

First search for axion dark matter using a MADMAX prototype — •David Leppla-Weber for the MADMAX-Collaboration — Deutsches Elektronen-Synchrotron DESY, Germany

The nature of dark matter is one of the biggest open questions in physics today. One possible answer is the axion, which was originally predicted as a solution to the strong CP problem but also makes for an excellent cold dark matter candidate. The MAgnetized Disk and Mirror Axion eXperiment (MADMAX) aims at detecting axions from the galactic dark matter halo in the theoretically well motivated mass range around 100 μ eV using a dielectric haloscope. It utilizes a booster system consisting of a stack of dielectric disks and a mirror to resonantly enhance the axion-photon conversion in a magnetic field. Results of the first axion dark matter search using a MADMAX prototype are shown and the calibration procedure is explained. A system with three ø 200 mm sapphire disks in a < 1.6 T magnetic field was used. No dark matter signal was observed. The results demonstrate the feasibility of such systems and their capability to reach unexplored parameter space.

T 89.6 Fri 10:15 VG 0.110

First Results of the Any Light Particle Search II (ALPS II) — •Todd Kozlowski for the ALPS-Collaboration — Deutsches Elektronen-Synchrotron DESY

The Any Light Particle Search II (ALPS II) is an ongoing 'light-shining-through-a-wall' experiment located at DESY in Hamburg, designed to probe the existence of lightweight bosons through their coupling to photons in a background magnetic field. ALPS II leverages technology developed specifically for this task, including a record-breaking long-baseline optical cavity, an ultra-sensitive detector capable of measuring coherent powers as low as 10^{-24} W, and a sophisticated optical control system. Since beginning operation in May 2023, ALPS II has conducted several successful measurement campaigns. In this talk, I will discuss the initial results and outline planned upgrades to further enhance the experiment*s sensitivity.

T 90: Silicon Detectors VII (ATLAS + CMS phase-2)

Time: Friday 9:00–10:30 Location: VG 0.111

T 90.1 Fri 9:00 VG 0.111

The ATLAS ITk cell integration site in Bonn — •Alexandra Wald, Klaus Desch, Matthias Hamer, Florian Hinterkeuser, Nico Klein, and Dominik Hauner — PI, Uni Bonn, Germany

In conjunction with the high luminosity upgrade of the Large Hadron Collider at CERN, the current tracking system of the ATLAS experiment will be replaced by the Inner Tracker (ITk), an all-silicon detector consisting of 5 layers of pixel detectors and 4 layers of strip detectors. More than 8000 modules will be installed in the pixel layers, which together have an active area of approximately 13m^2 and cover a pseudorapidity of up to 4. In order to build such a large detector in time, the integration of the ITk Pixel modules on their local support structures (so-called longerons or inclined halfrings(IHR)), as well as the quality control of individual loaded local supports will be distributed over many institutes. One of the assembly lines will be setup at the University of Bonn, with technicians from other German locations also helping with cell integration. Due to the serial powering scheme of the ITk Pixel Detector, the quality control of a loaded local support is challenging in several aspects, as the simultaneous operation of multiple modules is necessary for any tests. A large number of different components must hence be integrated into the quality control setup, such as an optical readout system, an interlocks system, industrial power supplies and a scalable DCS. In this talk, the current status of the LLS assembly line in Bonn is presented, and results from the integration of the first inclined half-ring are shown.

T 90.2 Fri 9:15 VG 0.111

Electrical testing of loaded cells for the ATLAS ITk Pixel loaded local support pre-production — •Nico Klein, Desch Klaus, Matthias Hamer, Florian Hinterkeuser, Alexandra Wald, and Dominik Hauner — Physikalisches Institut, Universität Bonn, Deutschland

The high luminosity upgrade for the Large Hadron Collider at CERN requires a complete redesign of the current tracking detector of the ATLAS experiment. The new Inner Tracker, the ITk Detector, will consist of a silicon pixel detector and a silicon strip detector. The ITk Pixel Detector is divided into three subsystems, the Outer Barrel (OB), Outer Endcaps and Inner System. In the OB, modules are loaded on thermally conducting cells (now called loaded cells) before they are mounted on the local supports (so-called longerons and half-rings). Before the loaded cells are mounted on the support structures, they are individually tested for basic functionality after shipment. In this talk I will present the results of the reception tests of the loaded cells for the first pre-production half-ring that has been assembled in Bonn.

T 90.3 Fri 9:30 VG 0.111

Assembly and test procedures of silicon detector modules for the Phase-2 Upgrade of the CMS Outer Tracker and the current status of production — •Stefan Maier, Tobias Barvich, Bernd Berger, Alexander Dierlamm, Ulrich Husemann,

Markus Klute, Kai Kraemer, Waldemar Rehm, Hans Jürgen Simonis, and Lea Stockmeier — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

In preparation for the High Luminosity LHC, the entire tracker of the CMS experiment will be exchanged within the Phase-2 Upgrade until 2029. The new outer tracker will be made of approximately 13000 silicon sensor modules which come in two types: 2S modules (consisting of two parallel silicon strip sensors) and PS modules (one pixel and one strip sensor combined in a module). With these modules the tracker provides tracking information to the Level-1 trigger. By correlating the hit information of both sensor layers in the magnetic field of CMS and, thus, allowing to suppress charged particles with low transverse momentum (<2GeV/c), the corresponding hit data can be read out every 25 ns. To guarantee successful operation of the CMS detector at the HL-LHC, the production of the outer tracker modules has to fulfil strict requirements. The production is distributed among several institutes all around the world to achieve the required module assembly rates. The talk will shortly explain the assembly and test procedures of 2S modules at KIT and summarize the status of the production which started recently.

T 90.4 Fri 9:45 VG 0.111

Thermal Integration Test with 2S Module Prototypes for the Phase-2 Upgrade of the CMS Outer Tracker — •Lea Stockmeier[1], Alexander Dierlamm[1], Ulrich Husemann[1], Stefan Maier[1], and Cristiano Turrioni[2] — [1]Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT) — [2]National Institute for Nuclear Physics (INFN), Perugia Unit

To deal with the increased luminosity of the HL-LHC, the CMS experiment will be upgraded until 2029. During this Phase-2 Upgrade, the CMS Outer Tracker will be equipped with modules each assembled with two silicon sensors. Depending on the position in the tracker, these silicon sensors are pixel or strip sensors. The modules with two strip sensors are called 2S modules. In the barrel region, they are placed on mechanical structures called ladders. A fully equipped ladder contains twelve modules.

During the prototyping phase of the modules, integration tests are performed with the purpose of testing the integration procedure itself as well as the module functionality on the final detector structures. Investigations focus on the cooling performance as well as on electrical performance of the modules on the supporting structures.

This talk summarizes an integration test with twelve 2S modules on a ladder performed at CERN in cooperation with other CMS working groups. The test focuses on thermal aspects of the performance of a 2S module built with sensors irradiated with protons to the expected lifetime fluence.

T 90.5 Fri 10:00 VG 0.111

Thermal Cycling of Modules for the Upgrade of the CMS Outer Tracker — •Aenne Abel[1,2], Ana Ventura Barosso[1], Günther Eckerlin[1], and Andreas Mussgiller[1] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg — [2]University of Hamburg, Hamburg, Germany

At the high-luminosity LHC the CMS Tracker will be faced with unprecedented instantaneous luminosity. To cope with this harsh environment, the existing tracker will be replaced with a completely new system that will operate at -35 degree C. As a final step of quality control each module has to undergo several thermal cycles between room and operation temperature, which is called burn-in. The presentation will introduce the burn-in setup at DESY and discuss the current status and foreseen testing procedures.

T 90.6 Fri 10:15 VG 0.111

In-Time Efficiency of ITk pixel modules using the ITkPixV1.1 front end — •Christopher Krause, Kevin Kröninger, Jens Weingarten, and Tobias Bisanz — TU Dortmund, Germany

The ATLAS Inner Tracker (ITk) will replace the Inner Detector of the ATLAS experiment for the High-Luminosity phase of the LHC. To ensure an excellent tracking performance of the silicon pixel and strip sensors of the ITk under the harsh HL-LHC environment, their performance has to be thoroughly tested and validated in testbeam facilities before installation. A crucial property of the pixel modules is their efficiency in regard to the phase of the 40 MHz clock of the LHC and the detector systems. As these modules can only record hits during the single 25 ns long readout time frame, evaluating their performance in dependence on the time is important to ensure a high tracking efficiency. To determine the in-time efficiency of an ITk pixel module, the clock of the DUT and the BDAQ system that is used to read out the data were synchronized. This talk presents the beam test results of In-Time efficiency measurements of an unirradiated 3D pixel module using the ITkPixV1.1 front end. The collected data was analysed with the track reconstruction framework Corryvreckan.

T 91: Silicon Detectors VIII (MAPS, misc.)

Time: Friday 9:00–10:30 Location: VG 1.101

T 91.1 Fri 9:00 VG 1.101

All-Silicon Modules — Hans Krüger, Marco Vogt, •Andreas Ulm, and Jochen Dingfelder — Universität Bonn

Silicon pixel detectors are an essential part of modern tracking systems for high energy physics experiments as they meet the requirements of high spatial and time resolution, and relatively low material budget. To cover large areas in the detector volume individual chips are combined to create modules. These modules are easier to assemble to full tracking systems. However gluing, additional flex PCBs, cooling and support structures, and also structural silicon can introduce significant amounts of material.

To reduce the material budget of tracking detectors as much as possible, a new concept of module building is investigated. By post-processing monolithic chip wafers, redistribution layers can be built on top of the chips for electrical connections to 4 chips in a row. By using low-power monolithic chips air cooling may be feasible and mechanical support is not necessary for thin ladder structures of up to 15 cm in length with thicknesses around 400 microns.

This talk will discuss concepts, ideas and first steps to prototyping such all-silicon modules.

T 91.2 Fri 9:15 VG 1.101

Performance of irradiated TJ-Monopix2 depleted monolithic active pixel sensors — •Lars Schall, Christian Bespin, Ivan Caicedo, Jochen Dingfelder, Fabian Hügging, Hans Krüger, Rasmus Partzsch, Norbert Wermes, and Sinuo Zhang — Physikalisches Institut der Universität Bonn, Bonn, Germany

Monolithic active pixel sensors with depleted substrates present a promising option for pixel detectors in high-radiation environments. Leveraging high-resistivity silicon substrates and high bias voltages in commercial CMOS technologies facilitates full depletion of the charge sensitive volume and enhances the radiation tolerance and charge collection performance. TJ-Monopix2 is the most recent large-scale chip in its respective development line, originally designed for the outer layers of the ATLAS Inner Tracker. TJ-Monopix2 is designed in 180 nm TowerJazz CMOS technology and features a small charge collection electrode, which requires the separation of the in-pixel electronics into p-wells. Process modifications in form of an additional n-type implant minimize regions with low electric field and improve the charge collection efficiency impaired by the long drift distances. The small pixel size of 33 x 33 μm^2 reduces the detector capacitance to approximately 3 fF enhancing noise and power performance. This contribution focuses on the performance of TJ-Monopix2 chips after irradiation to 5e14 neq/cm^2 NIEL fluence and 100 Mrad in total ionizing dose. Latest laboratory and beam test measurements are presented.

T 91.3 Fri 9:30 VG 1.101

Grazing Angle Test Beam Studies of the Hybrid-to-Monolithic MAPS Prototype — •Ono Feyens, Sara Ruiz Daza, Finn King, and Simon Spannagel — Deutsches Elektronen-Synchrotron DESY, Germany

The TANGERINE (Towards Next Generation Silicon Detectors) project at DESY investigates and develops fully integrated Monolithic Active Pixel Sensors (MAPS) using a novel 65 nm CMOS imaging technology. MAPS are an attractive technology for vertex detectors at future lepton colliders where a unique combination of high spatial resolution ($\leq 3\ \mu$m), fast timing ($\sim$ ns) and low material budget ($\leq 50\ \mu$m) are required. The 65 nm technology enables the production of MAPS with an increased density of in-pixel logic.

The H2M (Hybrid-to-Monolithic) prototype is the latest chip in a series of technology demonstrators. Its design ports a hybrid pixel-detector architecture into a monolithic chip with a pixel matrix of 64x16 square pixels of size 35x35 μm^2. To investigate the internal electric field and charge collection characteristics of H2M, grazing angle studies are performed at the DESY II Test Beam Facility. Here, particles impinge the sensor at very shallow angles, enabling the extraction of charge collection as a function of depth. This contribution will provide an overview of the experimental setup and will show first results of the grazing angle measurements.

T 91.4 Fri 9:45 VG 1.101

Charge calibration and reconstruction from binary hit data with MALTA2 a monolithic active pixel sensor — •Lucian Fasselt[1,2] and Steven Worm[1,2] — [1]DESY, Zeuthen, Germany — [2]Humboldt University, Berlin, Germany

MALTA2 is a depleted monolithic active pixel sensor (DMAPS) designed for tracking at high rates and is produced in the modified Tower Jazz 180nm CMOS technology. The sensing layer of the pixels with 36.4um pitch consists of either high resistivity epitaxial or Czochralski silicon. A small collection electrode features a small pixel capacitance and offers low noise. Typically, the detection threshold is around 200e-. A simple procedure is developed to calibrate the threshold to electrons making use of a dedicated charge injection circuit and an Fe-55 source with main charge deposition of 1600e-.

In this contribution, MALTA2 sensors are characterised in terms of hit detection efficiency inside the pixel and cluster size at fine threshold steps, for samples produced with different doping concentration of the internal n- layer, substrate voltage and irradiation dose. Test beam data was taken at CERN SPS in 2023 and 2024, using a MALTA beam telescope consisting of multiple sensor planes with 4um spatial and 2ns timing resolution. A reconstruction of the signal amplitude from binary hit data is performed. Through the charge calibration a two-dimensional map of the collected charge is obtained with sub-pixel resolution. The presented method provides an in-beam alternative to grazing angle studies or Edge-TCT for determining a charge collection profile.

T 91.5 Fri 10:00 VG 1.101

TelePix2: A HV-CMOS pixel sensor for Fast Timing and Region of Interest Triggering — •Arianna Wintle[1], Andre Schöning[2], David Immig[2], Felix Sefkow[1], Heiko Augustin[2], Ivan Peric[3], Lennart Huth[1], Lucas Dittmann[2], Marcel Stanitzki[1], and Ruben Kolb[2] — [1]Deutsches Elektronen-Synchrotron — [2]Heidelberg University — [3]The Karlsruhe Institute of Technology

The DESY II Test Beam Facility offers electrons with a user selectable momentum from 1-6 GeV primarily for detector characterisation. TelePix2, a HV-CMOS sensor, is the latest new user infrastructure at the test beam facility used as an arbitrary Region of Interest (ROI) trigger and a timing plane, for efficient small prototype testing and ambiguity suppression.

This contribution will highlight the importance of TelePix2 in the context of user operation at the test beam facility whilst providing an insight into test beam user infrastructure. The latest performance metrics of TelePix2 including an efficiency above 99 %, a timestamp resolution below 4 ns, and a ROI trigger time resolution below 2.5 ns will be presented.

T 91.6 Fri 10:15 VG 1.101

Investigation of the Belle II Pixel Detector Power Supply Network — •Paula Scholz[1], Florian Bernlochner[1], Jochen Dingfelder[1], Hans Krüger[1], Jannes Schmitz[1], and Botho Paschen[2] — [1]Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn — [2]Lawrence Berkeley National Laboratory

During beam loss events at the particle accelerator SuperKEKB in Japan, large amounts of radiation can severely damage the innermost layers of the Belle II detector, the Pixel Detector (PXD). Due to an increasing frequency of these events, the PXD has been shut down since May 2024 to prevent further harm.

The PXD consists of silicon pixel matrices based on the DEpleted P-channel Field Effect Transistor (DEPFET) technology. To control these matrices, Application-Specific Integrated Circuits (ASICs), the so-called „switchers“, are implemented on each module. During each readout cycle (50kHz), these switchers switch voltage levels of 20 V within a few nanoseconds. Since the PXD has been shown to be safe when the switchers are unpowered, a secure method to rapidly power down modules during beam loss events is needed. However, the powering network that involves 23 interdependent voltages, complicates this task.

To address this issue, a simulation of the PXD powering scheme, which includes more than 15 m long cables, has been developed. The transmission of emergency shutdown signals is studied by comparing simulation results with experimental data. The goal is to identify hardware modifications for safe PXD operation.

T 92: Detectors VIII (Gaseous Detectors)

Time: Friday 9:00–10:30 Location: VG 1.102

T 92.1 Fri 9:00 VG 1.102

Stability and Performance studies of upgraded Gas Monitoring Chambers for the T2K Near Detector — •Ziyan Cao, Stefan Roth, David Smyczek, Jochen Steinmann, and Nick Thamm — RWTH Aachen University - Physik Institute III B, Aachen, Germany

As part of the T2K ND280 near detector upgrade, Gas Monitoring Chambers (GMCs) are used to monitor key gas parameters such as drift velocity and gain, ensuring precise calibration of Time Projection Chambers(TPCs). This work focuses on evaluating the performance of upgraded GMCs with new features, including comparative analyses of drift velocity and gas gain with previous models and simulations. Observed discrepancies prompted systematic investigations into factors such as gas flow configuration, flow rate, and chamber stability. The results from testing the newly designed Micromegas will also be presented.

T 92.2 Fri 9:15 VG 1.102

Development of a novel GEM based neutron detector with VMM readout — •Jan Glowacz[1], Thomas Block[1], Klaus Desch[1], Saime Gürbuz[1], Jochen Kaminski[1], Markus Köhli[2], and Michael Lupberger[1] — [1]University of Bonn — [2]Heidelberg University

For the neutron science community the increase in price for Helium-3 has sparked the interest in detectors based upon solid neutron converters like Boron or Gadolinum. The boron based multi stage tracking detector (BASTARD) is a neutron detector, with a focus on high spatial resolution and high readout rates. It consists of a multi layer gaseous detector chamber with boron coated cathodes for neutron conversion. The boron captures the neutrons and decays into helium and lithium ions. The ions are detected with a high position resolution. The readout allows for rates of up to 10 Mhz and is realized with VMM3a hybrids via the RD51 Scalable Readout System. A prototype detector with an active area of 10cm x 10cm is being assembled. We plan to present our first experiences with it.

T 92.3 Fri 9:30 VG 1.102

A Straw Tracker Prototype for SHiP — •Wei-Chieh Lee, Caren Hagner, and Daniel Bick — Institut für Experimentalphysik, Universität Hamburg, Hamburg, Deutschland

SHiP (Search for Hidden Particles) is a general-purpose beam-dump experiment at the CERN SPS accelerator designed for the search of feebly interacting particles. In this experiment, the spectrometer straw tracker (SST) is located downstream of the hidden sector decay volume, and tracks the decay products of the hidden particles for the reconstruction of the decay vertex, the mass and the impact parameter of these particles. As the main component of the SST, straw tubes function as wire-based gaseous detectors that are robust and have little material budget for the purpose of minimizing multiple scatterings. The University of Hamburg is participating in the design and prototyping of the SST with the goal of optimization of the mechanical stability and the assembly strategy. In this presentation, a straw tracker prototype will be introduced with the plans of its future testing.

T 92.4 Fri 9:45 VG 1.102

Development of a straw-tube chamber prototype for the inner detector of a future e^+e^- collider experiment — •Julia Okfen, Davide Cieri, Francesco Fallavollita, Oliver Kortner, Sandra Kortner, Hubert Kroha, Giorgia Proto, Robert Richter, Elena Voevodina, and Jörg Zimmermann — Max Planck Institut für Physik

The future e^+e^- collider provides a unique opportunity for precision measurements of the Higgs boson and electroweak properties. The process $e^+ + e^- \to Z^* \to Z + H$ allows Higgs detection via the recoil momentum, independent of the Higgs decay modes. The precise momentum measurement of the Z-boson decay particles is crucial, requiring an accuracy at the level of 0.1% for $p_T \approx 50$ GeV/c, commensurate with the narrow spread of the center-of-mass energy. Such precision can only be attained using silicon sensors that offer position resolutions on the order of a few μm. However, gaseous-based technologies are essential for particle identification via dE/dx measurements along charged particle trajectories. To prevent a significant compromise of momentum resolution due to excessive multiple scattering, the detector material must be minimized. Straw tube chambers meet these requirements and add advantages: each unit operates independently, so a broken wire affects only one tube. They also offer flexibility in gas choice and volume instrumentation. This contribution will present a concept for an inner detector with straw tube and the design, production, and test of a straw-tube prototype chamber.

T 92.5 Fri 10:00 VG 1.102

Research and Development of an Inverted RICH Detector — •Daniel Grewe, Otmar Biebel, Valerio D'Amico, Stefanie Götz, Ralf Hertenberger, Eshita Kumar, Nirmal Mathew, Nick Schneider, Chrysostomos Valderanis, and Fabian Vogel — LMU München

In high-energy physics experiments, Ring Imaging Cherenkov Detectors (RICH) play an important role in identifying charged particles with known momenta. An inverted RICH detector takes a novel approach by reconstructing the momentum of a known particle through the measurement of its Cherenkov cone. A previous prototype employs a Lithium Fluoride (LiF) crystal to generate Cherenkov photons, which are converted to electrons via a Cesium Iodid (CsI) photocathode. The electrons are detected using a resistive strip Micromegas. While functional, this prototype requires further optimization. The CsI photocathode is highly sensitive to humidity, prompting the exploration of Diamond-Like Carbon (DLC) photocathodes as robust alternatives. To enhance the efficiency of detecting electrons generated in the photocathode, various counting gases are examined.

This talk will introduce the fundamental principles behind the inverted RICH Detector and highlight the latest developments in its prototype design, offering insights into the challenges and innovations shaping its evolution.

T 92.6 Fri 10:15 VG 1.102

Preparations for Upgrading the ND280 Gas Monitoring Chambers — Ziyan Cao, Stefan Roth, •David Smyczek, Jochen Steinmann, and Nick Thamm — RWTH Aachen University - Physics Institute III B, Aachen, Germany

A new pair of Time Projection Chambers for high angle measurements (HATs) have been installed during the upgrade of the T2K near detector ND280. To improve their calibration, the gas parameters will be continuously monitored using upgraded Gas Monitoring Chambers (GMCs). To upgrade the current Gas Monitoring Chambers several new features in hard and software have to be tested. These features include a new preamplifier, a new temperature controlled SiPM trigger and new readout software. These new features and results of their tests will be presented.

T 93: Top Physics IV (Misc.)

Time: Friday 9:00–10:00 Location: VG 1.103

T 93.1 Fri 9:00 VG 1.103

Studying Machine Learning Techniques to Improve Statistical Precision of Monte Carlo Samples in Top Quark Measurements — •Lennert Griesing, Hartmut Stadie, Peter Schleper, and Johannes Lange — Institute of Experimental Physics, Hamburg University, Germany

Precise measurements of top quark properties at the Large Hadron Collider (LHC) are crucial for testing the Standard Model and exploring new physics. In these measurements, Monte Carlo (MC) simulations are needed to compare theoretical predictions with experimental observables. To account for systematic uncertainties, MC samples are generated for different model parameters. Due to computational costs, these samples are produced with fewer events than the large default simulation sample. Thus, the smaller sample size limits their statistical precision and poses a challenge for nuisance parameter fits. A possible solution is to modify the large default simulation sample using machine learning techniques (ML) so that their distributions reflect the variations in the different model parameters. The aim is to evaluate the precision, accuracy, and potential biases introduced by applying these ML techniques to MC simulations of top quark pair production within the CMS experiment.

T 93.2 Fri 9:15 VG 1.103

Measurement perspectives of the top-antitop energy asymmetry in the production with an additional jet in the resolved topology with ATLAS — •Jessica Höfner, Annika Stein, Frederic Fischer, and Lucia Masetti — University Mainz, Insitute for physics

The top quark is the heaviest particle in the Standard Model (SM) of particle physics and the only quark which decays before hadronization can happen. The top quark is suitable for the search of physics beyond the SM of particle physics (BSM). There could be even heavier particles and they might become observable at higher center-of-mass energies, and the top quark could potentially interact with them. At the currently reachable center-of-mass energies, however, the impact of BSM physics might only be indirectly observable via the variation of properties of the production or decay of SM particles. In the production of a top-antitop pair with an additional jet at the LHC the energy asymmetry, complementary to the rapidity asymmetry, can be measured. The energy asymmetry is expected in the SM, but also sensitive to physics beyond the SM and therefore it is of high interest to measure this observable. After a first measurement of the energy asymmetry in the topology with a collimated hadronic top decay and a semileptonic decay with the ATLAS experiment, the future goal is to measure this observable in the full phase space. Therefore the event reconstruction in the resolved topology, in which the hadronic decaying top quark is reconstructed with several small-R jets, must be optimized. This presentation shows the current progress regarding this optimization.

T 93.3 Fri 9:30 VG 1.103

Optimal Observable Machine: The case of four top quark differential cross sections with SMEFT contributions. — •Alejandro Quiroga Trivino[1], Torben Mohr[1], Matteo Defranchis[2], Jan Kieseler[1], Ankita Mehta[2], Artur Monsch[1], and Markus Klute[1] — [1]Karlsruhe institute of technology — [2]CERN

Identifying optimal observables that are maximally sensitive to Standard Model Effective Field Theory (SMEFT) coefficients, while systematically accounting for uncertainties, is crucial for constraining new physics. This study focuses on developing strategies to determine such observables, with particular attention to minimizing total uncertainties and maximizing sensitivity to SMEFT effects. As a case study, we investigate four-top quark production in proton-proton collisions at a center-of-mass energy of 13.6 TeV. This rare process, characterized by an energetic final state and a tiny cross section, provides a unique testing ground for SMEFT contributions. Specifically, we analyze the effects of a heavy-quark operator with Wilson coefficient ctt1*, employing systematic-aware training to achieve precise constraints in ctt1. This talk will present our approach, highlight progress in identifying optimal variables, and discuss the implications for measuring SMEFT coefficients and uncovering potential new physics.

T 93.4 Fri 9:45 VG 1.103

Search for heavy right-handed Majorana neutrinos in the decay of top quarks produced in proton–proton collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector — •Diptaparna Biswas[1], Markus Cristinziani[1], Nikolina Ilic[2], Lianliang Ma[3], Oğul Öncel[4], Sebastien Roy-Garand[2], Mário José da Cunha Sargedas de Sousa[5,6], and Tongbin Zhao[1,3] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen, Germany — [2]University of Toronto, Canada — [3]Shandong University, China — [4]Albert-Ludwigs-Universität Freiburg, Germany — [5]INFN Genova, Italy — [6]Università di Genova, Italy

A search for heavy right-handed Majorana neutrinos is performed with the ATLAS detector at the CERN Large Hadron Collider, using the Run-2 dataset. This search targets $t\bar{t}$ production, in which both top quarks decay into a bottom quark and a W boson, where one of the W bosons decays hadronically and the other decays into an electron or muon and a heavy neutral lepton. The heavy neutral lepton is identified through a decay into an electron or muon and another W boson, resulting in a pair of same-charge same-flavor leptons in the final state. This talk presents a search for heavy neutral leptons in the mass range of 15 − 75 GeV using $t\bar{t}$ events. No significant excess is observed over the background expectation, and upper limits are placed on the signal cross-sections. Assuming a benchmark scenario of the phenomenological type-I seesaw model, these cross-section limits are then translated into upper limits on the mixing parameters of the heavy Majorana neutrino with Standard Model neutrinos.

T 94: Flavour Physics VI

Time: Friday 9:00–10:30 Location: VG 1.104

T 94.1 Fri 9:00 VG 1.104

Test of Lepton Flavour Universality with $\Lambda_b^0 \to pK^-\ell^+\ell^-$ decays at LHCb — Johannes Albrecht[1], Vitalii Lisovskyi[2], and •Jannis Speer[1] — [1]TU Dortmund University, Dortmund, Germany — [2]CPPM, Marseille, France

Rare decays mediated by $b \to s\ell^+\ell^-$ transitions provide a diverse range of probes for the SM. These include null tests of fundamental principles of the SM, such as lepton flavour universality (LFU), which asserts that the gauge bosons couple equally to all three generations of leptons.

The LHCb experiment has performed several measurements of LFU in rare decays, most prominently the ratio of branching fractions between b-meson decays with electrons and muons in the final state. LFU can also be studied in rare b-baryon decays, which are affected by partly orthogonal experimental and theoretical uncertainties. The first measurement of the ratio of branching fractions of the decays $\Lambda_b^0 \to pK^-e^+e^-$ and $\Lambda_b^0 \to pK^-\mu^+\mu^-$, R_{pK}^{-1}, was performed by the LHCb collaboration using pp collision data corresponding to an integrated luminosity of $4.7\,\mathrm{fb}^{-1}$. The ratio was measured to be $R_{pK}^{-1} = 1.17^{+0.18}_{-0.16} \pm 0.07$ in the dilepton mass-squared range $0.1 < q^2 < 6.0\,\mathrm{GeV}^2/\mathrm{c}^4$ and the pK mass range $m(pK) < 2600\,\mathrm{MeV/c}^2$. The updated measurement of R_{pK}^{-1} aims to minimize the uncertainties by using the full $9\,\mathrm{fb}^{-1}$ LHCb pp dataset and implementing enhanced analysis techniques.

This contribution provides an update on the current progress of the ongoing analysis.

T 94.2 Fri 9:15 VG 1.104

Search for $B^+ \to K^{*+}\tau^+\tau^-$ with Hadronic Tagging at the Belle II experiment — •Lennard Damer, Torben Ferber, and Pablo Goldenzweig — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

In recent years, intriguing hints for violation of lepton flavor universality have been accumulated in semileptonic B decays with the help of various experiments.

The flavor-changing neutral current process $b \to s\tau^+\tau^-$ is particularly sensitive to models which feature large couplings to third generation leptons or couplings proportional to the particle mass. Some theoretical models allow for an increase in the branching fraction of up to three orders of magnitude compared to the Standard Model prediction, which is within the observable range of the Belle II experiment.

In this analysis, hadronic tagging is employed where the corresponding B meson partner in $\Upsilon(4S)$ decays is reconstructed in a variety of hadronic decay chains to increase the selection purity.

This talk presents the status of the first search for $B^+ \to K^{*+}\tau^+\tau^-$ decays along with an estimate on the signal sensitivity.

T 94.3 Fri 9:30 VG 1.104

Fully inclusive analysis of untagged $B \to X\ell^+\ell^-$ decays at Belle II — •Arul Prakash, Sviatoslav Bilokin, Nikolai Krug, and Thomas Kuhr — Ludwig-Maximilians-Universität München

In recent years various deviations from the standard model expectation were observed in $b \to s\ell^+\ell^-$ measurements, dominated by exclusive studies. The combined deviations, while being large, are still not above the 5σ discovery threshold, partially owing to theoretical uncertainties. Precision measurements of inclusive $B \to X\ell^+\ell^-$ decays can provide invaluable complementary information to scrutinize anomalies observed in their exclusive decay counterparts. However, limited tagging efficiency, small Standard Model signal and very high background rate make these measurements extremely challenging, with no results being published so far.

In our work, we will evaluate the chances of a 5σ result with data from the Belle and Belle II experiments and estimate systematics with Monte Carlo simulations. We will apply machine learning algorithms to tackle background rejection. We will finally measure the branching fractions $B(B \to X\mu^+\mu^-)$ and $B(B \to Xe^+e^-)$ which will be key to constrain potential New Physics contributions.

T 94.4 Fri 9:45 VG 1.104

Early measurement of $r_{J/\psi}^{K,K^*}$ with 2024 data — Johannes Albrecht[1], Michele Atzeni[2], Lukas Calefice[3], Angel Fernando Campoverde Quezada[4], James Gooding[1], Carla Marin Benito[5,3], •Lorenzo Nisi[1], Renato Quagliani[5], Alessandro Scarabotto[1], Eluned Smith[2], and Pol Vidrier Villalba[3] — [1]TU Dortmund University, Dortmund, Germany — [2]Massachusetts Institute of Technology, Cambridge, United States — [3]Universitat de Barcelona, Barcelona, Spain — [4]University of Chinese Academy of Sciences, Beijing, China — [5]CERN, Geneva, Switzerland

During 2024, the LHCb experiment collected more than 9 fb^{-1} of integrated luminosity for pp collisions, recording approximately as many collisions as between 2011 and 2018. The performance of the upgraded LHCb detector in Run 3 of the LHC must be fully understood to perform precise measurements with this new dataset.

Measurements of ratios between B meson decays to final states containing different lepton pairs can be used to study lepton flavour universality, e.g., R_{K,K^*} between $B^{+(0)} \to K^{+(0*)}\mu^+\mu^-$ and $B^{+(0)} \to K^{+(0*)}e^+e^-$ decays. The $J/\psi \to \ell\ell$ resonant modes are commonly used as control channels and their ratio $r_{J/\psi}^{K,K^*}$ is well-understood to be consistent with unity. As such $r_{J/\psi}^{K,K^*}$ can be used to validate detector performance and data-MC corrections.

This contribution presents the progress towards a measurement of $r_{J/\psi}^{K,K^*}$ using 2024 data.

T 94.5 Fri 10:00 VG 1.104

Dalitz analysis on $B^+ - > K_S^0\pi^+\pi^0$ — •Oskar Tittel, Stefan Wallner, Hans-Günther Moser, and Markus Reif — Max-Planck Institut für Physik, München

The Belle II experiment in Tsukuba, Japan, is working at the high-intensity frontier of the search for physics beyond the Standard Model (SM). A direct test of the SM is the verification of the so-called "isospin sum-rule" in the $B \to K^*\pi$ system, which depends on the branching fractions (BF's) and the direct CP asymmetries of all $B \to K^*\pi$ decay modes. These quantities can be extracted from Dalitz analyses on the decay channels $B^0 \to K^+\pi^-\pi^0$ and $B^+ \to K_S^0\pi^+\pi^0$.

I will present the Belle II experiment, introduce the isospin sum rule and show the current state of the analysis on $B^+ \to K_S^0\pi^+\pi^0$.

T 94.6 Fri 10:15 VG 1.104

Search for the $B^0 \to D^0\bar{D}^0$ decay with the LHCb experiment — Johannes Albrecht, •Jonah Blank, Quentin Führing, and Sophie Hollitt — TU Dortmund University, Dortmund, Germany

With precise measurements of B meson decays, the LHCb experi-

ment can test the integrity of the Standard Model of particle physics. $B \to DD$ decays are particularly interesting probes of CP violation, further constraining the unitarity triangle. While decays to charged $D^{\pm}$ mesons have already been well measured, the $B^0 \to \bar{D}^0 D^0$ decay channel has not yet been observed by any experiment. In this analysis, data collected in pp collisions by the LHCb experiment at $\sqrt{s} = 7$, 8 and 13 TeV corresponding to an integrated luminosity of 9 fb^{-1} is used to search for the $B^0 \to \bar{D}^0 D^0$ decay channel. The topologically similar $B^0 \to \bar{D}^0 \pi^+\pi^-$ decay channel is utilized as a normalisation mode to cancel systematic uncertainties.
An update on the current status of the analysis will be presented.

T 95: Outreach

Time: Friday 9:00–10:15 Location: VG 1.105

T 95.1 Fri 9:00 VG 1.105

Public Multi-Experiment Higgs Analysis Demonstrator — Achim Geiser and •Lucas Karwatzki — Deutsches Elektronen-Synchrotron (DESY)

Open data offers new possibilities for a wider audience to access, reproduce and complement active research. In high-energy particle physics many challenges arise, due to several different data formats and large data samples. Therefore, a transformation of the open data to a common data format is used. This enables analysis to be performed within a single workflow and reduces the amount of data and computation time by two orders of magnitude.

Here we present an anlysis demonstrator developed in the context of the PUNCH4NFDI consortium showcasing the feasibility of analyzing Open Data from CMS and ATLAS at the same time. Further an example utilizing data from multiple CMS runs will be presented. The demonstrator uses the $H \to 4\ell$ channel and features various levels of complexity to cater to a wide range of users. This framework guides users from basic visualization of the four-lepton invariant mass spectra to producing the four-lepton invariant mass spectrum from transformed datasets within hours.

The talk will showcase the latest results of the analysis demonstrator, which may be used as an access point for future open data analysis.

T 95.2 Fri 9:15 VG 1.105

Von der Schulbank ins Studium - Nachwuchsförderung — •Heike Vormstein und Mia Smit für die Netzwerk Teilchenwelt-Kollaboration — Johannes Gutenberg-Universität, Mainz, Deutschland

Bekanntermaßen wünschen wir uns mehr Physikstudierende. Um dieses Ziel zu erreichen, ist es entscheidend, jungen Menschen zu zeigen, dass Physik spannend und modern ist. Dieser Vortrag beleuchtet, wie es gelingen kann, Interesse an Physik zu wecken und langfristig bis ins Studium zu begleiten.

Bereits in der Mittelstufe entwickeln viele Jugendliche Interesse an tiefergehenden Themen. Dies bietet eine hervorragende Gelegenheit, moderne Forschung näherzubringen und Begeisterung für Physik zu wecken. Da von der Mittelstufe bis zum Studium mehrere Jahre vergehen, ist es wichtig, das Interesse aufrechtzuerhalten.

Eine ehemalige Teilnehmerin verschiedener Angebote der Mainzer Physik berichtet, wie man junge Menschen dauerhaft für Physik begeistern und sie später im Studium wiedersehen kann. Der Beitrag richtet sich an Lehrkräfte, Wissenschaftler:innen und alle, die sich für eine nachhaltige Nachwuchsförderung in der Physik einsetzen möchten.

T 95.3 Fri 9:30 VG 1.105

CMS Masterclass 2: Discovering the Higgs Boson with Python Notebooks and CMS OpenData — •Christian Winter, Artur Monsch, Cedric Verstege, and Günter Quast — ETP, Karlsruhe Institute of Technology, Karlsruhe, Germany

The current CMS Masterclass focuses on the graphical analysis of event displays to teach how analyses work in high-energy physics. This Talk focuses on the experience on executing a new CMS Masterclass. In this CMS Masterclass the students use Python Notebooks and CMS Open-Data to reconstruct the Higgs discovery channel $H \to ZZ \to 4\ell$ and measure the significance of their findings. This Masterclass was carried out for the second time as part of a week-long Science Camp for High School students, which focused on astro-/particle physics. Together with the experience gathered, improvements and the frame for such a Masterclass will be discussed. The possibility for other collaborations to have a simmilar Masterclass will be adressed, too.

T 95.4 Fri 9:45 VG 1.105

Build Your Own Particle Detector: Workshops for Schools and Universities — •Sebastian Laudage, Florian Bernlochner, and Maike Hansen for the Netzwerk Teilchenwelt-Collaboration — Physikalisches Institut, Universität Bonn, Nussalle 12, 53115 Bonn

In 2023 and 2024, we developed and tested interactive workshops at the University of Bonn under the motto "Build Your Own Particle Detector." These hands-on workshops enable participants, regardless of prior experience, to construct their own functional particle detector in just a few hours. Participants can then use these detectors to measure cosmic rays or natural background radiation, gaining direct insights into the invisible world of particle physics. Building on the lessons learned from these workshops, we are developing a next-generation detector concept designed to be versatile, user-friendly, and accessible to a broad audience, from school students to university-level participants. To ensure sustainability, we also create comprehensive educational materials that will empower other institutions to host similar workshops independently. This contribution highlights the insights gained from past workshops, outlines our plans for the upcoming year, and provides an update on the development of the new DIY detector system.

T 95.5 Fri 10:00 VG 1.105

Activities of the german LHC-Office for outreach and transfer — •Marius Hoffmann[1], Sophia Haves[2], Laura Fabietti[3], Stephanie Hansmann-Menzemer[4], Alexander Schmidt[2], and Wolfgang Wagner[5] — [1]Georg-August-Universität Göttingen} — [2]RWTH Aachen — [3]Technische Universität München — [4]Universität Heidelberg — [5]Bergische Universität Wuppertal

Communicating the scientific results to the public and fostering cooperation with partners in industry are key tasks of the german LHC research groups. For this reason in 2020, the research focuses ("Forschungsschwerpunkte" short ErUM-FSPs) of the four LHC experiments have initiated a joint "LHC-Office" which is funded by the Federal Ministry for Education and Research (BMBF). Since then, the LHC-office has established itself as a key stone of the outreach program of the german LHC-FSPs. The office has a multitude of tasks, which include organizing community events, soft skill workshops, industry fair stands and much more. This talk will give an overview of the LHC-office's work of the last years and present an outlook into future activities and possibilities to collaborate.

T 96: Detectors IX (Calorimeters)

Time: Friday 9:00–10:30 Location: VG 2.101

T 96.1 Fri 9:00 VG 2.101

Quality Control of the Tileboards for the High Granularity Calorime- ter upgrade of the CMS experiment — •Anurag Sritharan — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany

The CMS experiment will be upgrading its detectors in lieu of higher luminosities and collision rates during the High-Luminosity era of the LHC (HL-LHC). One key upgrade of the CMS detector will be its endcap calorimeters, which will be fitted with the new High Granularity Calorimeter (HGCAL). Since the HL-LHC will have 10 times more luminosity, the HGCAL will have improved radiation hardness and better background rejection that is caused due to much higher pile-up. It will consist of both the Electromagnetic and Hadronic calorimeters. Furthermore, the Hadronic calorimeter is split into two different technologies owing to the amount of radiation damage. The SiPM-on-Tile technology consists of small scintillator tiles that are linked to SiPMs (Silicon Photo-multiplier) on the PCB. The PCB without any scintillators on it is known as a tileboard. A tileboard will house 1 or 2 readout ASICs (called HGCROCs), and each HGCROC can read out 72 channels. The production tileboards have already started to be made. To test and certify the boards and the functionality of the HGCROCs, a robust quality control procedure is needed. The QC procedure, as well as some of the results, will be discussed in this presentation.

T 96.2 Fri 9:15 VG 2.101

Simulation of a cosmic muon test stand for the the CMS HGCAL upgrade — •Mohammed Adnan Ali, Andreas Hinzmann, and Freya Blekman — DESY, Notkestr. 85, 22607 Hamburg

The CMS High Granularity Calorimeter (HGCAL) upgrade requires thorough quality control during the production of its components. A cosmic muon test stand for fully assembled boards equipped with scintillator tiles, SiPMs and read-out-electronics is setup to verify that all detector components operate as expected. In this talk we present a GEANT4-based simulation in CMSSW of this test stand allowing to study energy deposition patterns, reconstructed angle accuracy, and minimum ionizing particle light yields to help the design of the test stand and for comparison to the collected data.

T 96.3 Fri 9:30 VG 2.101

Multi-Tilemodule test system using cosmic rays for the CMS HGCAL upgrade — •Jia-Hao Li — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

The CMS experiment plans to upgrade its calorimeter endcap for the high luminosity phase of the LHC with the High Granularity Calorimeter (HGCAL). The Tilemodule is one of the basic elements in the hadronic calorimeter part of the HGCAL. It uses small scintillator tiles directly coupled to SiPMs (SiPM-on-tile technology) and it is the first step in the production sequence providing an object capable of detecting particles. The Tilemodule is equipped with one or two HGCROC ASICs for data readout. To test and calibrate the Tilemodules, a cosmic ray setup capable of testing up to 9 Tilemodules simultaneously is developed for quality control and a better understanding of the property of the Tilemodules. The presentation will discuss the idea and current status of the cosmic test setup at DESY.

T 96.4 Fri 9:45 VG 2.101

Fast Hadron Shower Simulation using a Distance Based Sorting for Calorimeter Tiles with the CALICE AHCAL Prototype — •Zobeyer Ghafoor, André Wilhahn, and Stan Lai — II. Physikalisches Institut, Georg-August Universität Göttingen

The simulation of particle showers in calorimeters plays a critical role in high-energy physics research. As calorimeter precision and resolution improve, the complexity and volume of data increase substantially. This growth presents significant challenges for computational resources, data storage, and analysis, underscoring the need for innovative simulation algorithms. This talk outlines a data-driven fast simulation approach. By optimising computational efficiency, this method aims to significantly reduce the total number of hits for the simulation, thereby optimising computational efficiency. However, the reduction must preserve critical calorimeter and shower information. This study uses data from a 2018 test beam with pion beams and the CALICE AHCAL. The calorimeter features 38 active layers, each comprising 24×24 tiles that are read out individually. For the fast simulation, a distance-sorting algorithm was employed, which orders the tiles in each layer based on their distance from the event's centre-of-gravity, sorted from smallest to largest. This helps avoid complications due to necessary geometrical transformations when simulating energies based upon radial distances from the shower centre. To enhance efficiency, limitations were imposed on both the number of tiles and layers, effectively reducing the total number of readout channels while maintaining essential information for accurate event reconstruction.

T 96.5 Fri 10:00 VG 2.101

Integrated Cooling Solutions for a Highly Granular Scintillator-Based Hadronic Calorimeter and Advances in 3D-Printed Scintillators — •Andre Klotzbücher[1], Lucia Masetti[1], Bohdan Dudar[1], Quirin Weitzel[2], Steffen Schönfelder[2], Fabian Piermaier[2], and Konrad Briggl[3] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz — [2]Prisma+ Detektorlabor, Johannes Gutenberg Universität Mainz — [3]Kirchhoff-Institut für Physik, Universität Heidelberg

This talk discusses the adaptation of the analogue hadronic calorimeter (AHCAL), originally developed by the CALICE collaboration for the International Linear Collider (ILC), to meet the demanding requirements of future circular colliders. For the linear collider environment, no integrated cooling system was necessary, as power consumption was effectively managed through power pulsing. However, this approach is no longer feasible due to the significantly higher interaction rate in circular colliders, requiring the electronics to remain continuously powered. To address this challenge, an integrated cooling system is being developed, and the latest progress will be presented.

Additionally, advances in 3D-printed scintillators are opening new possibilities for detector design. Following successful tests of basic printed tiles, efforts now focus on structured scintillators with optimized surface properties for improved light collection and performance. Preliminary results on performance and key characteristics will be discussed, highlighting the potential of these technologies for next-generation detectors.

T 96.6 Fri 10:15 VG 2.101

Calorimetry in searches for collider electron neutrinos at SND@LHC — •Matei Climescu and Rainer Wanke — Johannes Gutenberg Universität Mainz

SND@LHC is an experiment located in the TI18 tunnel at LHC which leverages its unique off-axis positioning to observe outgoing neutrinos of all flavours produced at the ATLAS interaction point with knowledge of the production mechanism. Electron neutrinos are of particular interest as their emerge primarily from charm decays and may be searched for in emulsion detectors which are utilized as very-high spatial resolution calorimeters, enabling unique reconstruction techniques. These searches are presented here with a focus on calorimetric reconstruction of charged and neutral current collider neutrino interactions.

T 97: Data, AI, Computing, Electronics IX (AI-based Object Reconstruction)

Time: Friday 9:00–10:30 Location: VG 2.102

T 97.1 Fri 9:00 VG 2.102

Hit-Filtering with Graph Neural Networks for Tracking at Belle II — •Greta Heine, Giacomo De Pietro, and Torben Ferber — Karlsruher Institut für Technologie (KIT), Karlsruhe, Deutschland

Over the next few years, the Belle II Experiment will increase its instantaneous luminosity, which will also lead to a significant increase in the beam background, affecting the efficiency of both online and offline tracking algorithms. To overcome this challenge and to facilitate the identification of displaced vertices for the discovery of new physics phenomena, Belle II needs more robust tracking algorithms.

Graph Neural Networks (GNNs) are a powerful class of machine learning models capable of adapting to irregular geometries and modeling complex relationships within detector hits. In this work, GNNs are used to filter background hits in the Belle II Central Drift Chamber based on edge classification using detector-level information. By filtering the background hits, both the track fitting performance as well as the computational efficiency can be improved at high background levels.

This talk will present the performance of this filtering approach for offline tracking algorithms on both simulated and real data, showing significant improvements in tracking efficiency and robustness under varying background conditions.

T 97.2 Fri 9:15 VG 2.102

End-to-End Multi-Track Reconstruction using Graph Neural Networks at Belle II — •Lea Reuter, Giacomo De Pietro, and Torben Ferber — Institute of Experimental Particle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany

Displaced vertices are an important signature in Standard Model analyses involving K_S and many searches for New Physics. However, the current Belle II tracking algorithm falls short when dealing with particles that decay after a large distance, resulting in a decrease in tracking efficiency with increasing displacement.

In this work, we show a novel track finding algorithm that combines the Object Condensation algorithm with Graph Neural Networks. This approach simultaneously identifies all tracks in an event and determines their respective parameters. Additionally, we integrated the new track finding algorithm into the Belle II analysis software framework.

Our results show significant reconstruction improvements of more than 50% for a long-lived particle within the GeV mass range and a lifetime of 10 cm in comparison to the existing Belle II track finding algorithm. This improvement is achieved while maintaining a similar efficiency and fake rate for prompt tracks originating from the interaction point.

T 97.3 Fri 9:30 VG 2.102

Graph Neural Networks for Track Reconstruction at the ATLAS Event Filter — •Giulia Fazzino, Sebastian Dittmeier, and André Schöning — Physikalisches Institut, Universität Heidelberg, Germany

In its High-Luminosity phase, the LHC will collide particles at unprecedented luminosity scales, drastically increasing the number of interactions per bunch crossing and thus introducing the need for upgrades in the ATLAS Trigger System. In parallel, a new tracking detector, the Inner Tracker (ITk), will be installed. Its data will be used by the Event Filter in the last step of the trigger chain, for track reconstruction and, finally, event selection.

To minimize the computing resources needed by the Event Filter, the usage of hardware accelerators such as GPUs or FPGAs is studied, and significant effort is put into the development of a tracking algorithm based on Graph Neural Networks (GNNs). Such a method would first build a graph by connecting the hits in the ITk, and subsequently generate track candidates from it thanks to a GNN and a segmentation algorithm. The construction of the graph can be conducted in several ways, one of which is to use Metric Learning, a machine learning procedure connecting hits depending on their distances in a feature space.

This talk will provide an outline of GNN-based tracking for the ATLAS Event Filter, with a focus on Metric Learning, and present results on the realization and optimization of such a graph construction method for FPGA deployment.

T 97.4 Fri 9:45 VG 2.102

GCNN-based Hybrid Reconstruction of Cosmic Rays with IceAct and IceCube — •Lars Marten, Philipp Behrens, Shuyang Deng, Lasse Düser, Jonas Häussler, Lars Heuermann, Sönke Schwirn, Philipp Soldin, Julian Vogt, and Christopher Wiebusch — RWTH Aachen - III. physikalisches Institut B, Aachen, Germany

IceAct is an array of Imaging Air Cherenkov Telescopes stationed at the South Pole as part of the IceCube Neutrino Observatory. Among its goals is the combined measurement of air showers together with the in-ice detector IceCube and the IceTop surface detector. Such hybrid measurements grant the advantage of complementary information improving reconstruction capabilities. Our graph convolutional neural network has been developed using a simulation of the IceAct array with the purpose of reconstructing the direction of the primary particle of an air shower. In this talk we will present an updated version of this neural network with additional reconstruction capabilities such as primary particle energy and relative shower core position. Also, we will present our advances in including hybrid data into our network prediction.

T 97.5 Fri 10:00 VG 2.102

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Network Architecture — •Philipp Soldin, Philipp Behrens, Jakob Böttcher, Shuyang Deng, Lasse Düser, Philipp Fürst, Leon Hamacher, Michael Handt, and Christopher Wiebusch for the IceCube-Collaboration — RWTH Aachen University

The IceCube Neutrino Observatory is a large neutrino detector located in the ice at the geographic South Pole. It detects atmospheric and astrophysical neutrinos through the Cherenkov radiation emitted by secondary particles using over 5,000 photomultipliers (PMTs). One of the primary challenges is effectively distinguishing between muons induced by either neutrinos or air-showers. To address this, the Advanced Northern Tracks Selection (ANTS) employs a deep graph convolutional neural network (GCNN). This neural network takes advantage of the node-like structure of the PMT array's geometric arrangement and processes raw sensor data. By leveraging both local and global event features, the ANTS GCNN enhances classification performance. This presentation focuses on the architecture of the ANTS GCNN and evaluates its performance in rejecting background interference from air-shower-induced muons. We assess the accuracy and resolution of the reconstruction, and computational efficiency, showing significant improvements over traditional methods across various muon track topologies.

T 97.6 Fri 10:15 VG 2.102

Exploring position reconstruction of HPGe detector events in LEGEND with a deep neural network — •Christoph Seibt[1] and Aobo Li[2] — [1]TU Dresden, Germany — [2]UCSD, USA

LEGEND is searching for neutrinoless double-beta ($0\nu\beta\beta$) decay, using High-Purity Germanium (HPGe) crystals enriched in ^{76}Ge as both source and detector. With its second phase, LEGEND-1000, the experiment uses 1 ton of germanium crystals to reach a discovery potential of half-lives greater than 10^{28} years. HPGe detectors measure pulse shapes of excellent quality, which are analyzed to reconstruct the events energy and reject background-induced events. These pulse shapes depend on the location of the events in the detector. This work leverages pulse shape topology to extract positional information, utilizing a recurrent-type neural network to overcome the limitations of classical methods. Simulated pulses from random event locations are used for training and testing. The current progress on a deep neural network for position reconstruction is displayed in this presentation. It shows the current reconstruction potential and first applications to specifying detector parameters.

This work is supported by the U.S. DOE and the NSF, the LANL, ORNL and LBNL LDRD programs; the European ERC and Horizon programs; the German DFG, BMBF, and MPG; the Italian INFN; the Polish NCN and MniSW; the Czech MEYS; the Slovak SRDA; the Swiss SNF; the UK STFC; the Canadian NSERC and CFI; the LNGS, SNOLAB, and SURF facilities.

T 98: Electroweak Physics III (W/Z Production and Properties)

Time: Friday 9:00–10:30 Location: VG 2.103

T 98.1 Fri 9:00 VG 2.103

Sensitivity to lepton-flavour-violating decays of the Z boson using a data-driven background estimate with the ATLAS Experiment — •Naman Kumar Bhalla, Valerie Lang, and Markus Schumacher — Albert-Ludwigs-Universität Freiburg

One of the primary goals of the Large Hadron Collider (Lhc) program is to look for phenomena beyond the Standard Model (SM) of particle physics. One such phenomenon is lepton flavour violation (LFV), which has already been observed in neutrino oscillations, but not in processes involving charged leptons. A search for LFV in decays of the Z boson with charged leptons in the final state, such as $Z \to e\tau_\mu$ and $Z \to \mu\tau_e$, is of high interest and well motivated by various beyond-SM theories. This search can be performed using a data-driven background estimate, which takes advantage of the idempotency of SM backgrounds under the exchange of an electron and a muon. The symmetry is broken only by the difference in branching ratios between LFV decays with $e\tau$ and $\mu\tau$ final states.

This talk discusses the achievable sensitivities for the search of LFV decays of the Z boson using this data-driven background estimate. The full Run-2 data set is used, which was collected by the ATLAS detector in pp collisions at $\sqrt{s} = 13\,\text{TeV}$, corresponding to an integrated luminosity of $140\,\text{fb}^{-1}$. The data-driven estimate, the neural network used to classify the LFV signal against other background processes along with the statistical model used for the analysis are presented.

T 98.2 Fri 9:15 VG 2.103

Measurement of the differential $W \to \ell\nu$ cross section at high transverse masses at $\sqrt{s} = 13\,\text{TeV}$ with the ATLAS detector — •Tim Frederik Beumker, Johanna Wanda Kraus, and Frank Ellinghaus — Bergische Universität Wuppertal

A measurement of the double-differential cross section of the process $W \to \ell\nu$ at high transverse masses is shown. The data set analyzed is based on data from pp-collisions at a center-of-mass energy of $\sqrt{s} = 13\,\text{TeV}$, corresponding to an integrated luminosity of $\mathcal{L} = 140\,\text{fb}^{-1}$. It is taken with the ATLAS detector during LHC Run-2. The measurement is done double-differentially in the transverse mass of the W boson and the pseudorapidity of the lepton. It focuses on the region of high transverse masses between 200 GeV and 5000 GeV. The results will allow for constraints on effective field theories and parton distribution functions of the proton. An overview of the complete analysis will be presented. The talk will focus on the interpretation of the final results.

T 98.3 Fri 9:30 VG 2.103

Production of hadronically-decaying boosted vector bosons in association with jets at the ATLAS experiment — •Donna Maria Mattern and Chris Malena Delitzsch — TU Dortmund, Fakultät Physik

Due to the unprecedented energy of the proton-proton collisions at the Large Hadron Collider (LHC), massive electroweak vector bosons (W and Z bosons) are frequently produced with energies much larger than their masses, thus receiving a Lorentz boost. When these particles decay hadronically, their decay products are collimated and can be reconstructed as single large-radius jets (R=1.0). These high-transverse momentum large-radius jets have distinctive properties like their mass, and jet-substructure, which describes the internal structure of the jet. Signal events have to be distinguished from large sources of background events produced from quantum-chromodynamic processes at the LHC, which have similar, multi-jet signatures. Studies of the large-radius-jet substructure are useful to discriminate between these signal and background processes to be able to measure the production of the boosted-vector bosons. Studies on the production of W and Z bosons in association with jets in LHC Run-2 data collected with the ATLAS detector, and Monte Carlo simulated samples are presented.

T 98.4 Fri 9:45 VG 2.103

Exploring the effects of a boosted vector boson's polarisation on the jet reconstructed from their hadronic decay products — •Maren Bühring[1], Max Lehmann[1], Frank Siegert[1], Karolos Potamianos[2], Amartya Rej[3], Donna Maria Mattern[3], and Chris Malena Delitzsch[3] — [1]IKTP, Technische Universität Dresden — [2]University of Warwick — [3]Technische Universität Dortmund, Fakultät Physik

The production of W or Z bosons in association with additional jets at the Large Hadron Collider (LHC) facilitates precision tests of the Standard Model, while also constituting an important background for other vector boson related processes and new physics searches. One of the challenges in the case of hadronically decaying vector bosons is to identify the bosons' decay products among all of the other hadronic activity at the LHC. If the transverse momentum of the boson is especially high, then its decay products are likely to be reconstructed as one large radius jet, which makes the substructure of that jet one of the most useful tools in identifying them. This study explores the impact of the boson's polarisation on the resulting jet's kinematics and substructure using events simulated with Sherpa 3.0.0, with the goal of applying the results in an ATLAS analysis aiming to measure the cross section of vector boson plus jets production in the LHC Run 2 data set.

T 98.5 Fri 10:00 VG 2.103

Validating the Hadronic Recoil Calibration in the ATLAS low-$\langle\mu\rangle$ W Mass Analysis — •Mathias Backes — Kirchhoff-Institut für Physik

The measurement of the mass of the W-boson is one of the fundamental tests of the Standard Model. ATLAS (2024) and CMS (2024) published measurements presenting results for the W-mass which are in agreement with the Standard Model. These measurements are in more than 5σ tension with the value obtained by the CDF collaboration (2022). In order to investigate this tension ATLAS is currently performing an additional measurement.

The W mass is most accurately measured using the leptonic decay channel $W \to l\nu_l$ with $l \in (e, \mu)$. The low-pileup dataset of ATLAS (taken in Run-2) is especially useful because a central aspect of this analysis is the precise estimation of the hadronic recoil to infer the energy and direction of the neutrino. Since the W mass cannot be measured directly it has to be inferred through comparisons with Monte Carlo simulations in a Profile Likelihood Fit. The success of such a fit strongly depends on the quality of the simulation. It is therefore necessary to explicitly calibrate the hadronic recoil estimation in the simulation to ensure it is modeled properly. The calibration can be validated by using Z-boson events, which can also be extracted from the low-pileup dataset.

T 98.6 Fri 10:15 VG 2.103

Heavy-meson reconstruction at the FCC-ee — Kevin Kröninger[1], Romain Madar[2], Stéphane Monteil[2], and •Willy Weber[1,2] — [1]TU Dortmund University, Department of Physics, Dortmund — [2]Université Clermont-Auvergne, Laboratoire de Physique de Clermont, Clermont-Ferrand

The Future Circular Collider (FCC-ee) is a proposed electron-positron collider designed to enable high-energy collisions at unmatched scales. It is expected to produce approximately $\mathcal{O}(10^{12})$ $Z \to \bar{q}q$ events, significantly enhancing our ability to perform precision measurements of electroweak observables.

This talk presents the first steps of a study focusing on decays of charmed D-mesons, which are produced as a result of the hadronization process. D-mesons have a short lifetime (up to 10^{-12} seconds) before they decay into other particles. In particular, $D^+ \to \pi^+\nu\bar{\nu}$ and $D^0 \to \pi^0\pi^0$ are considered. Challenges of this final states are the non-detectable neutrinos ν and the hard-to-detect neutral pions π^0. To identify the two photons coming from the π^0 decay, high energy and angular resolution are required, which makes the reconstruction and then the tagging of this final state difficult.
The results of this study may contribute to the study of CP violation in the charm sector. Additionally, the insights gained from this research can contribute to design decisions of the calorimeter to be developed for the FCC-ee.

T 99: Methods in Astroparticle Physics IV

Time: Friday 9:00–10:30 Location: VG 3.101

T 99.1 Fri 9:00 VG 3.101

Comissioning a first atomic tritium source — •Leonard Hasselmann, Daniel Kurz, and Caroline Rodenbeck for the Atomic Tritium at TLK-Collaboration — KIT-IAP, Karlsruhe, Germany

The Karlsruhe Tritium Neutrino mass (KATRIN) experiment will Research a sensitivity below $0.3\,\text{eV/c}^2$. In order to increase the sensitivity on the neutrino mass a new high resolution differential measurement method is required. The maximum effective resolution which can be achieved is not limited only by the detector, but also by molecular effects in the source gas constraining it to ~1 eV FWHM for T_2. Thus, future ultimate neutrino experiments need to use differential detectors combined with atomic tritium sources. Therefore, we move forward with the development of atomic tritium sources.

At the Tritium Laboratory Karlsruhe, a system to demonstrate the production of atomic tritium is currently being comissioned. A commercially available cracking system is used for hydrogen dissociation. For beam diagnostics, a quadrupole mass spectrometer equipped with a cross beam ion source is used.

In this talk, results from the comissioning of the system with non-radioactive gases like protium and deuterium are shown.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2, and 05A23WO6)

T 99.2 Fri 9:15 VG 3.101

Reduction of the molecular background in an atomic tritium setup using different shroud configurations — •Daniel Kurz, Leonard Hasselmann, and Caroline Rodenbeck for the Atomic Tritium at TLK-Collaboration — KIT-IAP, Karlsruhe, Germany

The investigation of the tritium β-decay spectrum at its endpoint is a direct way to measure the neutrino mass. Using molecular tritium reduces the achievable sensitivity by a broadening due to rotational and vibrational excitations of the ^{3}HeT$^+$ daughter molecule. The use of atomic tritium overcomes this fundamental limitation.

After a commissioning phase with inactive hydrogen, the "Beam for an Atomic Tritium Experiment" setup at Tritium Laboratory Karlsruhe is going to demonstrate the production of atomic tritium. To dissociate the hydrogen molecules, a commercially available dissociation device, the tectra H-flux atomic hydrogen source, is used. Investigating the beam composition is done by a HIDEN DLS10 quadrupole mass spectrometer (QMS) equipped with a cross-beam ion source.

Previous results show that recombination by wall contacts produces a major molecular background. To prevent recombined molecules from reaching the QMS beam shaping skimmers and a shroud are indispensable. The latter is an actively pumped tube around the QMS. In this, two opposite holes act as a skimmer trimming the beam to the size of the QMS entrance aperture. Molecules recombined inside the QMS are pumped away.

This talk presents the results investigating the reduction of the molecular background using different shroud configurations.

T 99.3 Fri 9:30 VG 3.101

Enhancing the energy resolution of MAC-E filters using a Transverse Energy Compensator (TEC) — •Richard Salomon, Kevin Gauda, Kyrill Blümer, Christian Gönner, Volker Hannen, and Christian Weinheimer — Universität Münster - Institut für Kernphysik, Münster, Deutschland

Precise electron spectroscopy with energy resolutions on the eV-scale is currently possible using magnetic adiabatic collimation with an electrostatic filter. Such a MAC-E filter is currently in use at the Karlsruhe Tritium Neutrino (KATRIN) experiment, where an energy resolution of 2.7 eV is achieved in the standard measurement configuration.

This talk focuses on a novel method to improve the energy resolution of MAC-E filters. It can be shown that accelerating electrons in a Wideröe-type drift tube with a polynomial voltage ramp in a high magnetic field creates an angular-dependent energy gain compensating the missing longitudinal energy component in the analyzing plane. In the KATRIN example, a Transverse Energy Compensator (TEC) can lead to an improvement by up to an order of magnitude, while other configurations might benefit even more. If combined with a time-of-flight measurement, it is possible to obtain a differential spectrum measurement with a sub-eV energy resolution, which is necessary to probe the inverted neutrino mass ordering.

This idea by Christian Weinheimer has been submitted as a provisional patent application under the number 10 2024 126 381 by the University of Münster. This work is supported by BMBF ErUM-Pro 05A23PMA.

T 99.4 Fri 9:45 VG 3.101

Position Reconstruction in a Scintillating CeBr3 Crystal for the ComPol CubeSat Using Neural Networks — •Jonas Schlegel — TUM, Muenchen, Deutschland

Compact objects such as Black Hole Binaries represent extreme astrophysical environments with many unresolved questions. Their small size makes them unsuitable for imaging techniques. Precise X-ray spectra and polarization measurements are crucial for understanding their dynamics and geometry. The CubeSat mission ComPol targets the binary system Cygnus X-1, which includes a rotating black hole and a companion star. After In-Orbit Verification (IOV) on the ISS, it will operate in Low Earth Orbit (LEO), performing spectroscopy and polarimetry in the 20-200 keV hard X-ray range.

Polarimetry is based on Compton scattering kinematics in a two-layer detector system. The prototype uses Silicon Drift Detectors (SDD) to determine the recoiling electron's energy and position, while a CeBr3 scintillator records photon energy via a Silicon Photomultipliers (SiPM) matrix. The core objective is to reconstruct absorbed X-ray events in the calorimeter.

A barium source is used for detector calibration, with scans performed in the X-Y and Y-Z planes. Neural networks achieve position resolutions of 2.4-4.3 mm in the x and y plane and 2.8 mm for the z plane. Edge effects are corrected with position- and energy-dependent shifts. Data from the LARIX X-ray facility validate the expected ϕ-distribution for unpolarized X-rays, demonstrating the success of the position reconstruction methods.

T 99.5 Fri 10:00 VG 3.101

Reconstruction of atmospheric neutrino events in JUNO — •Milo Charavet, Rosmarie Wirth, Mikhail Smirnov, Caren Hagner, and Daniel Bick — Hamburg University, Hamburg, Germany

The ordering of the neutrino masses is one of the fundamental open questions in the field of neutrino physics. The Jiangmen Underground Neutrino Observatory (JUNO) is a multipurpose liquid scintillator-based experiment (LS) with a target mass of 20 kt. It aims to determine the neutrino mass ordering (NMO) with at least 3σ significance, through a measurement of the oscillation pattern of reactor neutrinos over 53 km baseline. While reactor neutrinos are the main source of sensitivity to NMO at JUNO, atmospheric neutrino oscillation can provide independent sensitivity, and enhance its overall sensitivity in the combined analysis. As one of the largest LS detectors, JUNO might be able to measure with high precision the atmospheric neutrino events and their oscillation parameters. However, accurately reconstructing atmospheric neutrinos in such a large liquid scintillator detector is a significant challenge. This talk presents reconstruction methods to analyze these atmospheric neutrino events.

T 99.6 Fri 10:15 VG 3.101

Development of a high temperature superconducting magnet for applications in space — •Christian von Byern[1], Laurenz Klein[1], Daniel Louis[1], Niklas Moldrickx[2], Irfan Özen[1], Dominik Pridöhl[1,2], Ben Rüsse[2], Stefan Schael[1], Thorsten Siedenburg[1], Myrto Theodorou[1], and Michael Wlochal[1] — [1]I. Physics Institute B, RWTH Aachen, Germany — [2]Institute of Structural Mechanics and Lightweight Design, RWTH Aachen, Germany

While AMS-02 is currently operated on board of the International Space Station, the next generation of cosmic particle detector is already planned. AMS-100 is designed for operation at Lagrange Point 2 and will feature a geometric acceptance of $100m^2sr$. With this large acceptance and improved momentum resolution a measurement of cosmic rays up to the PeV scale will be possible and an improvement of factor 1000 regarding the sensitivity of anti-matter measurements is expected. The magnetic field of the spectrometer will be generated by a High Temperature Superconducting (HTS) solenoid. This coil will include several layers of individual HTS tapes. During operation at 55K it will produce a field of 0.5T at 4.5kA current. To reduce the material budget in terms of mass and interaction length the HTS tapes will be stabilized using few millimetres of aluminium. As an intermediate step a small demonstrator coil is in preparation. In this R&D phase multiple samples, including straight cable samples, bent cable samples as well as coil samples with few windings are prepared and tested. In this talk measurement results of the different samples will be presented and interpreted.

T 100: Cosmic Rays V

Time: Friday 9:00–10:15 Location: VG 3.102

T 100.1 Fri 9:00 VG 3.102

Exploring High-Energy Atmospheric Muons with IceCube: Unfolding the Muon Flux — •Pascal Gutjahr — TU Dortmund University, Dortmund, Germany

Atmospheric muons, produced in cosmic ray air showers, can be divided into two components: conventional muons from pion and kaon decays, and prompt muons from heavy meson decays. While conventional muons dominate at TeV energies, the prompt component becomes increasingly relevant at PeV energies. Studying these muons is essential for understanding cosmic rays, refining hadronic interaction models, and reducing neutrino background in neutrino telescopes like IceCube.

This talk will present recent air shower simulations performed with CORSIKA, validated against numerical predictions from MCEq. A key focus will be on a method to unfold the atmospheric muon flux at the surface, leveraging machine learning for event reconstruction in IceCube.

T 100.2 Fri 9:15 VG 3.102

Unfolding the Atmospheric Muon Spectrum Using Stopping Muons in IceCube — •Lucas Witthaus for the IceCube-Collaboration — TU Dortmund University

The IceCube Neutrino Observatory is a neutrino detector embedded within the Antarctic ice sheet near the South Pole. Although its primary goal is the neutrino observation, the majority of detected events are attributed to atmospheric muons generated by cosmic-ray-induced air showers in the upper atmosphere. As muons enter the ice, they lose significant energy through interactions with the surrounding matter, which limits their propagation length depending on their initial energy. This talk presents the unfolding of the muon surface energy spectrum and the stopping muon depth intensity, providing information about the abundance of atmospheric muons in the South Pole ice. The study targets a specific subset of events comprising single muons that stop within the IceCube detector. The event classification as well as the reconstruction of the muon tracks are performed using deep neural networks.

T 100.3 Fri 9:30 VG 3.102

Studies of primary mass sensitivity of muons of the IceCube surface array IceTop — •Donghwa Kang for the IceCube-Collaboration — Karlsruhe Institute of Technology

The surface component of the IceCube Neutrino Observatory at the geographical South Pole, IceTop, is designed to measure the air showers of cosmic ray with energies from PeV to EeV. Based on the charge signal distribution only with IceTop, a mass-sensitive parameter was defined and estimated event by event, which is the sum of the charge signals divided by the effective area at a fixed distance from the shower core. In this contribution the estimated mass-sensitive parameter and its dependencies on the hadronic interaction models will be discussed.

T 100.4 Fri 9:45 VG 3.102

Detection of Ultra-High-Energy Cosmic Rays using the Next-Generation Prototypes of the Fluorescence-Detector Array of Single-Pixel Telescopes (FAST) — •Marcus Niechciol for the FAST-Collaboration — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Understanding the nature and origin of ultra-high-energy cosmic rays (UHECRs) remains one of the key goals in astroparticle physics. The Fluorescence-detector Array of Single-pixel Telescopes (FAST) is a proposed next-generation cosmic-ray observatory, aimed at observing UHECRs with energies above 10^{19} eV with unprecedented statistics. To achieve this, FAST will employ cost-effective, easily deployable, autonomous fluorescence telescopes, each equipped with four photomultiplier tubes with a diameter of 200 mm positioned at the focal plane of a segmented mirror with a diameter of 1.6 m. Currently, there are three prototypes in operation at the Telescope Array Experiment in the Northern hemisphere (Utah, USA) and one in the Southern hemisphere at the Pierre Auger Observatory (Malargüe, Argentina). Together, they enable observations of UHECRs in both hemispheres using the same technology. In the contribution, the current status of observations of UHECRs using the FAST prototypes is summarized. Preliminary results from the data analysis are presented, as well as recent developments towards a mini array of FAST telescopes, to be installed at the Pierre Auger Observatory.

T 100.5 Fri 10:00 VG 3.102

Diffuse emissions with stochastic cosmic ray sources — •Anton Stall and Philipp Mertsch — Institute for Theoretical Particle Physics and Cosmology (TTK), RWTH Aachen University, Aachen, Germany

Diffuse emission in gamma-rays and neutrinos are produced by the interaction of cosmic rays with the interstellar medium. Below some hundreds of TeV, the sources of theses cosmic rays are most likely Galactic. Hence, observations of high-energy gamma-rays and neutrinos can be used to probe the flux of cosmic rays in other parts of the Galaxy. Supernova remnants are usually considered as the prime candidate for the acceleration of Galactic cosmic rays. They inject cosmic rays in a point-like and specific time-dependent manner. As the precise positions and ages of the sources are not known, predictions must be obtained in a stochastic model. At GeV energies, the distribution of sources can be approximated with a smoothly varying spatial and temporal source density. At hundreds of TeV, however, the point-like nature matters as less sources contribute effectively due to shorter escape times. We have modelled diffuse emissions at hundreds of TeV, relevant for measurements by LHAASO, Tibet AS-gamma, IceCube, and the upcoming SWGO. In general, we have found its morphology to be very different from those at GeV energies, as measured by Fermi-LAT. Those differences can potentially be used to constrain source models and locate cosmic ray sources.

T 101: Neutrino Physics VIII

Time: Friday 9:00–10:30 Location: VG 3.103

T 101.1 Fri 9:00 VG 3.103

Search for Light Sterile Neutrinos with the KATRIN Experiment — •Christoph Köhler[1,2], Xaver Stribl[1,2], and Susanne Mertens[1,2] for the KATRIN-Collaboration — [1]Technical University of Munich — [2]Max Plabck Institute for Nuclear Physics

Light sterile neutrinos with a mass at the eV-scale could explain several anomalies observed in short-baseline neutrino oscillation experiments. The Karlsruhe Tritium Neutrino (KATRIN) experiment is designed to determine the effective electron anti-neutrino mass via the kinematics of tritium β–decay. The precisely measured β-spectrum can also be used to search for the signature of light sterile neutrinos.

In this talk we present the status of the light sterile neutrino analysis of the KATRIN experiment. We describe the method used to study the first five measurement campaigns. The obtained results are compared to findings of complementary experiments and anomalies in the field of light sterile neutrinos.

This work is supported by the Technical University of Munich, the Max Planck Institute for Nuclear Physics, the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2, and 05A23WO6). This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programme (grant agreement No. 852845).

T 101.2 Fri 9:15 VG 3.103

The new detector section for KATRIN for the keV sterile neutrino search — •Simon Gentner — Karlsruhe Institut für Technologie (KIT)

At the Karlsruhe Institute of Technology (KIT) a full-scale replica of the KATRIN experiment's detector system was developed to pretest the innovative TRISTAN detectors. The replica system facilitates comprehensive testing and calibration of currently three TRISTAN detectors under controlled conditions, ensuring their optimal performance prior to integration into the KATRIN beamline in 2026 which will enhance KATRIN's sensitivity in the search for keV-scale sterile neutrinos. Critical operational parameters, including energy resolution, count rate capabilities, and data aquisition, are meticulously evaluated. Preliminary results indicate that the TRISTAN modules achieve exceptional high-resolution beta spectroscopy, essential for precise neutrino mass measurements and the exploration of potential new physics. This presentation will discuss the setup, detailed test procedures and initial results that emphasize the central role of the TRISTAN upgrade in advancing neutrino research.

T 101.3 Fri 9:30 VG 3.103

Bayesian analysis of KATRIN neutrino mass data using a neural network — Philipp Krönert[1], Susanne Mertens[2], Oliver Schulz[3], and •Alessandro Schwemmer[2] for the KATRIN-Collaboration — [1]Helmholtz-Institut für Strahlen- und Kernphysik, Bonn — [2]Physik Department, Technische Universität München, Garching — [3]Max-Planck-Institut für Physik, München

The Karlsruhe Tritium Neutrino (KATRIN) experiment probes the effective electron anti-neutrino mass by precisely measuring the tritium beta-decay spectrum near its endpoint. A world-leading upper limit of $0.45\,\mathrm{eV\,c^{-2}}$ (90 % CL) has been set with the first five measurement campaigns following a frequentist analysis procedure. A neural network has been developed in this context, enabling fast and precise model calculations. Utilizing this neural network, a new Bayesian framework has been built in the Julia programming language. It allows for efficient sampling of the posterior density using Hamiltonian Monte Carlo methods implemented by BAT.jl. In this talk, we will present the current development status of the Bayesian framework and its application to the analysis of the first five KATRIN measurement campaigns.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2, and 05A23WO6).

T 101.4 Fri 9:45 VG 3.103

Sensitivity studies for a next-generation neutrino-mass experiment using tritium β-decay — •Svenja Heyns for the KATRIN-Collaboration — Karlsruhe Institute of Technology, Germany

The Karlsruhe Tritium Neutrino (KATRIN) experiment probes the absolute neutrino mass scale by precision spectroscopy of tritium β-decay. With a total of 1000 days of measurement by the end of 2025, a final sensitivity better than $300\,\mathrm{meV/c^2}$ (90% C.L.) is anticipated by the collaboration.
Taking next steps in enhancing the sensitivity, for instance towards the regime of inverted mass ordering, requires novel technological approaches to significantly improve statistics, energy resolution, and background suppression. We explore two key strategies: (1)implementing a differential detector with sub-eV energy resolution (quantum sensor detector array, time-of-flight measurement) to resolve each electron's energy individually while covering the entire energy interval of interest simultaneously and (2)exploring a large-volume atomic tritium source. In this presentation, we introduce the conceptual framework for simulations to investigate the requirements by technology and limits by physics to confine the achievable sensitivity on the neutrino mass with a differential measurement. *This work is supported by the Helmholtz Association, the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Initiative and Networking Fund (W2/W3-118).*

T 101.5 Fri 10:00 VG 3.103

Update on the ECHo Experiment — •Raghav Pandey — Kirchhoff Institute for Physics, Heidelberg University

In the ECHo experiment large arrays of low temperature metallic magnetic calorimeters (MMCs) enclosing Ho-163 are used for the high resolution measurement of the electron capture spectrum. The goal of the experiment is to achieve the sensitivity to detect an extremely small spectral shape distortion in the end point region due to a finite neutrino mass. The first phase, ECHo-1K was designed to test the properties and reproducibility of MMCs with implanted Ho-163 and the sensitivity to the effective electron neutrino mass. For 6 months between December 2019 and June 2020, Ho-163 events were acquired using about 50 MMC pixels enclosing about 1 Bq Ho-163 each. Data reduction methods were developed and applied on the acquired dataset. 'Quality Control' parameters have been defined to track and quantify the effect of the data processing algorithms devised and the selection criteria invented to eliminate unsuitable data. A Ho-163 electron capture spectrum was compiled containing more than 2×10^8 events and showing an energy resolution of 7.8 eV.

T 101.6 Fri 10:15 VG 3.103

Data reduction of the ECHo-1k-Au data — •Rasmus Jeske — Kirchhoff Institute for Physics, Heidelberg University — ECHo Collaboration

For the ECHo-1k experiment two metallic magnetic calorimeter arrays with Ho-163 implanted in the absorber have been used. They differ in the host materials in which Ho-163 was implanted, Au and Ag. Data reduction algorithms and quality control procedures have been developed and characterized for the analysis of the data acquired with detectors having Ho-163 implanted in silver. We present the application of the data reduction protocol to the data acquired with detector having Ho-163 implanted in gold, ECHo-1k-Au data. We discuss the criteria to identify and eliminate triggered noise and other possible spurious events along with the efficiency and stability of the filters. From the analysis of the obtained spectra we derive the properties of the detectors in term of energy resolution and energy calibration over the course of the experiment. In addition, we demonstrated that the probability of having spectral shape artifacts in the endpoint region due to misinterpreted bad events is smaller than the statistical error.

T 102: Neutrino Physics IX

Time: Friday 9:00–10:30 Location: VG 3.104

T 102.1 Fri 9:00 VG 3.104

Sensitivity determination for neutron flux measurements in the LEGEND experiment — •Loris Steinhart — University Tübingen, Tübingen Germany

The next phase of the Large Enriched Germanium Experiment for Neutrinoless Double-Beta Decay (LEGEND) aims to achieve unprecedented background suppression, making accurate neutron flux measurements within the detector array critical. This contribution focuses on sensitivity studies for determining the neutron flux using a Gadolinium-loaded polyethylene (GdPE) string integrated into the detector setup. This talk will present the methodology, simulation results, and initial experimental efforts, highlighting the impact of this measurement on understanding neutron-induced backgrounds and optimizing the LEGEND setup for maximum sensitivity to search for the $0\nu\beta\beta$ decay signal.

T 102.2 Fri 9:15 VG 3.104

Implementation of the Pulse Shape Discrimination Classifier within the JuLeAna Software Stack for LEGEND-200 — •Verena Aures[1], Florian Henkes[1], Felix Hagemann[2], and Susanne Mertens[1] — [1]Technische Universität München, Deutschland — [2]Max Planck Institut für Physik, Garching bei München, Deutschland

The Large Enriched Germanium Experiment for Neutrinoless $\beta\beta$ Decay (LEGEND) searches for neutrinoless double-beta decay using high-purity germanium detectors enriched in ^{76}Ge, which serve as both the source and detector. The project's final phase, LEGEND-1000, aims to set a new limit on the half-life of ^{76}Ge exceeding 10^{28} years. The first phase, LEGEND-200, is currently running at the Laboratori Nazionali del Gran Sasso in Italy with its first results presented in 2024. The experimental sensitivity is enhanced by using pulse shape discrimination (PSD) techniques to distinguish signal-like from background-like events. This work focuses on the development and optimization of the A/E classifier, a PSD tool to efficiently reject multi-site events. The implementation was performed within the Julia-based software stack JuLeAna (Julia LEGEND Analysis), focusing on the classifier's performance and the evaluation of a charge trapping correction.

T 102.3 Fri 9:30 VG 3.104

The Liquid Argon Instrumentation of LEGEND-200: Background Rejection Performance — •Rosanna Deckert for the LEGEND-Collaboration — Technical University of Munich, Garching, Germany

LEGEND-200 is an experiment designed to search for neutrinoless double beta decay of Ge-76. Located deep underground at LNGS, it operates up to 200 kg of enriched high-purity germanium detectors in a liquid argon (LAr) cryostat. To achieve ultra-low backgrounds, the LAr is instrumented as an active volume to detect scintillation light emitted upon interactions with ionizing radiation, thus tagging and rejecting backgrounds. To provide insight into the rejection capability at different origins of scintillation light generation, we require proper modeling of light propagation throughout the experimental setup, from any origin in the LAr volume to its eventual detection by the light read-out system. The optical model must be tuned on special calibration data to match the observed photo electron yield. In this contribution, I will present a first analysis of special calibration runs that were performed to benchmark the optical simulations. Additionally, I will discuss the rejection performance of the LAr instrumentation in physics data.

This research is supported by the BMBF through the Verbundforschung 05A20WO2 and by the DFG through the Excellence Cluster ORIGINS and the SFB1258.

T 102.4 Fri 9:45 VG 3.104

KATRIN++ - Development of New Detector Technologies for a Future Neutrino Mass Experiment with Tritium — •Neven Kovac[1], Fabienne Adam[1], Beate Bornschein[1], Woosik Gil[1], Ferenc Glück[1], Svenja Heyns[1], Sebastian Kempf[2,3], Andreas Kopmann[3], Michael Müller[2], Rudolf Sack[1], Magnus Schlösser[1], Frank Simon[3], Markus Steidl[1], and Kathrin Valerius[1] — [1]Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT) — [2]Institute of Micro- and Nanoelectronic Systems (IMS), Karlsruhe Institute of Technology (KIT) — [3]Institute for Data Processing and Electronics (IPE), Karlsruhe Institute of Technology (KIT)

Currently, the tightest constraints on the absolute scale of neutrino mass from a direct, model-independent approach, are obtained by the KATRIN experiment, giving an upper limit on the mass of the electron anti-neutrino of 0.45 eV (https://doi.org/10.48550/arXiv.2406.13516), with final projected sensitivity below 0.3 eV. Going beyond this limit, and probing the inverted mass ordering (and beyond), will be the task for future neutrino mass experiments. In this regard, development of new detector technologies is of utmost importance, with quantum sensor arrays currently being the front runners due to their exceptional performance and excellent energy resolution. We report on our R&D efforts aiming to demonstrate the feasibility of developing and operating large quantum sensor arrays for detection of external electrons in a KATRIN-like setup, as a basis for the next generation neutrino mass experiments with tritium.

T 102.5 Fri 10:00 VG 3.104

Determination of the absolute nuclear transition energies of $^{83\mathrm{m}}$Kr using the gaseous krypton source of KATRIN — •Benedikt Bieringer and Matthias Böttcher for the KATRIN-Collaboration — Institut für Kernphysik, Universität Münster

The KATRIN experiment aims to measure the electron neutrino mass m_ν with $0.3\,\mathrm{eV}/c^2$ (90% C.L.) sensitivity after 1000 measurement days in 2025, by measuring the T_2 β spectrum near its endpoint E_0 and performing a fit including parameters E_0 and m_ν^2. Since these are highly correlated, systematic effects influencing the obtained m_ν will also manifest in E_0 and the derived T_2 Q value. Comparing this with the $\mathrm{T}-{}^3$He mass difference from Penning-trap measurements is therefore a valuable for cross checks of our experimental procedure. Determining the KATRIN Q value with high precision requires calibration of the experimental energy scale with $^{83\mathrm{m}}$Kr conversion electrons. This is limited by knowledge of $^{83\mathrm{m}}$Kr nuclear transition energies, being known to 0.3 eV precision in the literature. The excited nucleus of $^{83\mathrm{m}}$Kr decays via a two-step cascade of 32.2 keV and 9.4 keV highly converted γ transitions, and a weak direct transition. With a gaseous Kr source, a measurement of conversion electrons from all three transitions was performed in 2023 at KATRIN. Following the method described in ref. EPJ C 82 (2022) 700 the nuclear transition energies can be determined, which can allow for a reduction of the T_2 Q value uncertainty to 0.1 eV. In this talk, we present the analysis of the measurement. This work is supported by the Helmholtz Association and BMBF (grant numbers ErUM-Pro 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6).

T 102.6 Fri 10:15 VG 3.104

$^{83\mathrm{m}}$Kr N-line spectrum measurement at KATRIN — •Jaroslav Storek[1] and Matthias Böttcher[2] for the KATRIN-Collaboration — [1]Institute for Astroparticle Physics, Karlsruhe Institute of Technology — [2]Institute of Nuclear Physics, University of Münster

Conversion electrons from $^{83\mathrm{m}}$Kr are used as a versatile calibration tool in a range of different (astro-)particle physics experiments. Favourable properties are the short half-life and narrow line spectrum of 83m-Kr as a nuclear standard. In the KArlsruhe TRItium Neutrino experiment (KATRIN) which currently provides the best direct neutrino mass upper limit of 0.45 eV/c^2 (90% C. L.), several systematic uncertainties are studied by a shape distortion of the quasi monoenergetic $^{83\mathrm{m}}$Kr spectrum. This creates high demands on precise knowledge of the undistorted spectrum.

In KATRIN we use the 32 keV N-lines lying in the high energy region of the spectrum including the weaker N_1 line. Results of a dedicated measurement of the $^{83\mathrm{m}}$Kr electron N-spectrum with emphasis on N_1 line and adjacent shake lines will be presented in this talk.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6) and the Doctoral School "Karlsruhe School of Elementary and Astroparticle Physics: Science and Technology (KSETA)" through the GSSP program of the German Academic Exchange Service (DAAD).

T 103: Methods in Particle Physics V (Event Reconstruction, PID)

Time: Friday 9:00–10:30 Location: VG 4.101

T 103.1 Fri 9:00 VG 4.101

Improving Reconstruction in the Belle II Electromagnetic Calorimeter Using Graph Neural Networks — •Jonas Eppelt and Torben Ferber — Karlsruher Institut of Technology

Belle II uses an Electromagnetic Calorimeter (ECL) built from Cesium-Iodide crystals to measure a particle's energy. The current clustering algorithm faces significant challenges from high background conditions, low momentum minimal ionizing particles, and hadronic particles creating multiple clusters. This affects energy resolutions, detection efficiencies for low energetic photons, and higher-level variables used in many analyses. Graph Neural Network(GNN) based methods can leverage more of the available information from the ECL and better represent the sparse and irregular geometry of the clusters. This talk will present ongoing efforts to reduce background, improve energy resolution, and analyze other variables.

T 103.2 Fri 9:15 VG 4.101

Event reconstruction for opaque liquid scintillator detectors. — •Kitzia Hernandez for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz

Opaque liquid scintillators represent a novel approach to particle detection. This technology uses Mie scattering to confine the scintillation light around its interaction point, conserving the topology of the event in comparison with classical transparent scintillators. However, the opacity of these detectors and their energy deposition topologies represent a new paradigm opening the way to new reconstruction methods.

Here, we explore the adaptation of the Cambridge-Aachen jet clustering algorithm, traditionally used in High-energy physics, for event reconstruction in opaque liquid scintillator detectors. By clustering optical photons in the x-y plane and incorporating timing information, this method can effectively reconstruct event position, energy, and particle type. Furthermore, it provides a robust framework for particle discrimination and is a reference point for comparing with more sophisticated approaches using Graphic Neural Networks.

T 103.3 Fri 9:30 VG 4.101

Machine Learning Assisted Reconstruction of Hadron-Collider Events using Mini-Jets — •Josef Murnauer[1], Stefan Kluth[1], Daniel Britzger[1], and Roman Kogler[2] — [1]Max-Planck-Institut für Physik, Garching — [2]DESY, Hamburg

Reconstructing impactful physical observables from hadron collider data represents challenges due to combinatorial ambiguities and experimental effects. We propose a novel approach using mini-jets (R=0.1) as the sole reconstructed objects, employing a deep neural network for observable determination. This method condenses full event information into a manageable size, demonstrating superior efficiency and generality compared to classical algorithms for future LHC analyses.

T 103.4 Fri 9:45 VG 4.101

The Heterogeneous HGCAL event reconstruction — •Wahid Redjeb[1,2], Alexander Schmidt[2], Felice Pantaleo[1], and Marco Rovere[1] — [1]CERN — [2]III. Physikalisches Institut A, RWTH Aachen

The High-Granularity Calorimeter (HGCAL) is a sampling calorimeter with both lateral and longitudinal fine granularity designed for the High-Luminosity LHC. The calorimeter will use silicon sensors in the high radiation regions, providing high pile-up mitigation, and scintillators in the low radiation regions. For the physics object reconstruction, a dedicated framework for HGCAL is currently under development: The Iterative Clustering (TICL), which utilizes the 5D (x,y,z,t,E) information from the reconstructed hits and returns particle properties and probabilities. Heterogeneous computing will play a fundamental role in the physics object reconstruction software to fully exploit the reach of the HL-LHC. We present an overview of the TICL framework, highlight the TICL Framework's capabilities to perform Particle Flow reconstruction in the challenging endcap region with dedicated algorithms for electromagnetic and hadronic objects. Additionally, we will describe how Performance Portability has been achieved through the Alpaka library, being able to run core parts of the Framework on GPU and on CPU with a single source code.

T 103.5 Fri 10:00 VG 4.101

Particle Identification at Belle II using Neural Networks — •Erik Gräter[1,2], Stefan Wallner[1], Hans-Günther Moser[1], and Martin Bartl[1] — [1]Max-Planck-Institut für Physik, München — [2]Technische Universität München

We will present advancements in the charged-particle identification at the Belle II experiment located at KEK, Japan. At Belle II we employ a neural network to combine the information from six subdetectors to identify the particle species. Improvements in the reconstruction of the subdetector information that enters the neural network were made. In the context of this we will deliver a new neural-network trained on the latest data including those improvements. With a detailed study of the performance on particle-identification Additionally, we will provide an in-depth analysis of the importance of individual neural-network input features on its classification decisions.

T 103.6 Fri 10:15 VG 4.101

Development and testing of a neutron identification algorithm for Belle II — Slavomira Stefkova, Florian Bernlochner, and •Georgios Alexandris — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

Among the various neutral Standard Model particles, neutrons and, to a lesser extent, antineutrons are considered invisible in the Belle II detector due to their weak interaction with the detector material. A better understanding of their interaction rates is therefore crucial for analyses in Belle II that involve significant missing energy. While neutrons can only interact with atomic nuclei in the electromagnetic calorimeter (ECL) and the K0L and muon detector (KLM) through inelastic and elastic scattering, antineutrons can also be identified by the products of their annihilation with matter. This project aims to investigate the interaction properties of these neutral hadrons and use their distinct characteristics to develop particle identification (PID) algorithms for identifying neutrons. Preliminary results from these studies will be presented.

T 104: Search for Dark Matter V

Time: Friday 9:00–10:30 Location: VG 4.102

T 104.1 Fri 9:00 VG 4.102

A digital SiPM in liquid xenon — •Tiffany Luce[1], Michael Keller[2], and Peter Fischer[2] — [1]Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany — [2]Institute for Computer Engineering, Heidelberg University, Germany

Silicon PhotoMultipliers (SiPMs) are photosensors commonly used in many experiments. However, achieving single-photon sensitivity in the experiments is limited by the high dark count rate (DCR) of these devices. Digital SiPMS, where the digitization happens directly on the chip, can show DCRs competitive to that of traditional photomultiplier tubes (PMTs) with the added benefit of not needing analog to digital converters and greatly reducing the data rate. This would open up to cheaper and thus larger systems. We present results of the first test of a digital SiPM in cryogenic liquid xenon, one of the most important detector target for dark matter searches.

T 104.2 Fri 9:15 VG 4.102

Development of assay techniques for the electrodes of a future xenon-filled dark matter obsevatory — •Alexander Deisting[1], Jan Lommler[1], Shumit Mitra[1], Uwe Oberlack[1,2], Fabian Piermaier[2], and Quirin Weitzel[2] — [1]Institut für Physik & Exzellenzcluster PRISMA$^+$, Johannes Gutenberg-Universität (JGU) Mainz — [2]PRISMA Detector Laboratory, JGU Mainz

Dual-phase xenon time projection chambers (TPCs) lead the search for WIMP dark matter. Current experiments (LZ, XENONnT, PandaX-4T) feature electrode diameters between 1 m and 1.5 m. The XLZD collaboration plans a next generation dual-phase TPC with 3 m height and diameter, representing an extraordinary scale for this technology.

Existing TPCs have struggled to achieve their design electric fields, making it ever more crucial for the XLZD TPC to ensure exceptional electrode quality. To address this challenge, a set-up has been developed in Mainz to evaluate electrode performance. It allows the measurement of electrostatic sagging, the analysis of wire quality with high resolution imaging and confocal microscopy, and the detection of small scale defects by measuring local currents associated with Townsend discharge in an electric field. For the latter, a custom tool was developed and mounted on a gantry together with other metrology components (camera, laser-distance sensors, and a confocal microscope). This talk benchmarks the sagging measurement capabilities and the performance of the discharge-based defect detection system. This work is part of ongoing efforts by XENONnT and DARWIN collaborators to develop improved electrodes for current and future experiments.

T 104.3 Fri 9:30 VG 4.102

Certification of 1.5m-TPC electrodes in a large liquid xenon R&D platform — •Julia Müller — University of Freiburg

Over the past decades dual-phase xenon time projection chambers (TPCs) for the direct search for dark matter continuously grew in size and became more sensitive. However, also the technical realization of these large TPCs got more and more challenging. Among the most crucial and also most complex detector components are the large-diameter TPC electrodes required to establish the electron drift field across the TPC. These electrodes need to feature a high optical transparency and high voltage resilience. The large-scale test platform PANCAKE in Freiburg allows testing such electrodes in a liquid xenon environment before they are installed into the final TPC. We will present results of a qualification campaign of three TPC electrodes of 1.5m diameter.

T 104.4 Fri 9:45 VG 4.102

RelExt: A new Tool to Search Dark Matter Relic Density Parameter Spaces — •Karim Elyaouti[1], Rodrigo Capucha[2], Johann Plotnikov[1], Milada Margarethe Mühlleitner[1], and Rui Santos[2] — [1]Karlsruher Institut für Technologie, ITP, Karlsruhe, Deutschland — [2]Centro de Física Teórica e Computacional, Lissabon, Portugal

We developed a tool which allows for efficient parameter space searches which obey the Dark Matter relic density constraint. Its goal is to find parameters for any model with a thermal Dark Matter candidate which is able to generate the full relic abundance observed by PLANCK. This is achieved by numerically solving the Boltzmann equation and providing different methods to automatically adjust the parameters such that the experimentally observed relic density is generated.

T 104.5 Fri 10:00 VG 4.102

In View of Large Detector Arrays: Automated Analysis Modules for COSINUS Direct Dark Matter Search — •Maximilian Gapp — Max Planck Institut für Physik, Garching, Deutschland

One unresolved issue is the explanation for the annual modulation in the rate of interactions in sodium iodide (NaI) crystals detected by DAMA/LIBRA, which is consistent with the expected dark matter signal. The COSINUS (Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches) experiment has been designed to cross-check the long-standing results of the DAMA/LIBRA experiment. This will be achieved by employing cryogenic NaI calorimeters, which have low energy thresholds, and by introducing particle identification techniques through the use of an additional channel. In order to achieve this, it is necessary to test and characterize a significant number of detector prototypes. Furthermore, the COSINUS experiment plans to operate 16 channels initially and 48 subsequently. Given the substantial volume of data that will be generated, it is impractical to analyze the raw data manually. One solution is to automate the analysis chain wherever feasible. This contribution presents the analysis workflow for characterizing new prototypes and highlights potential avenues for automation.

T 104.6 Fri 10:15 VG 4.102

Characterization of a Spring-Based Passive Decoupling System with Capacitive Distance Measurements for the COSINUS Experiment — •Lutz Ziegele for the COSINUS-Collaboration — Max-Planck-Institut für Physik, 85748 Garching, Germany

The COSINUS experiment (Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches) is a direct dark matter search, operating sodium iodide absorbers equipped with Transition Edge Sensors (TES) inside a dry dilution refrigerator. A spring-based passive decoupling system is used to reduce microphonics - one of the major non-particle background sources. To optimize the decoupling system, a profound understanding of its behavior is essential. However, a characterization of the decoupling system inside a closed cryostat at temperatures in the order of tens of milli-kelvin is not straightforward. This contribution discusses the capabilities and limitations of capacitive distance measurement sensors, which repurpose already existing refrigerator structures.

T 105: Invited Overview Talks IV

Time: Friday 11:00–13:00 Location: ZHG011

Invited Overview Talk T 105.1 Fri 11:00 ZHG011

Galactic Astrophysics with H.E.S.S. — •Lars Mohrmann for the H.E.S.S.-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The High Energy Stereoscopic System (H.E.S.S.) is an array of imaging atmospheric Cherenkov telescopes that has been used to observe the sky in TeV γ rays since 2004. Thanks to its unique location in the Southern Hemisphere and several upgrades to the system, the experiment continues to enable cutting-edge astrophysics despite its age. In this contribution, I will review the latest H.E.S.S. results on Galactic γ-ray sources, including pulsar wind nebulae, young massive star clusters, microquasars, and the Galactic Centre region.

Invited Overview Talk T 105.2 Fri 11:30 ZHG011

Physics in the era of big data: AI in particle and astroparticle physics — •Jonas Glombitza — Erlangen Centre for Astroparticle Physics, FAU Erlangen-Nürnberg

Physics and artificial intelligence (AI) are interconnected. The recent Nobel Prize for Physics has once again revealed this productive connection. While physics concepts laid the foundation for today's neural networks, these algorithms, in turn, enable efficient physics analyses with exceptional precision. This emerging technology opens new perspectives for the data-intensive research field of particle and astroparticle physics. In this talk, I will give an overview of the versatile applications of AI in particle and astroparticle physics, review the breakthroughs that this new technology made possible, and discuss future directions and challenges.

Invited Overview Talk T 105.3 Fri 12:00 ZHG011

What the LHC tells us about the top quark, the heaviest particle in nature — •Matthias Komm — DESY, Hamburg

The unprecedented data collected during proton-proton collisions at 13 and 13.6 TeV by the CERN LHC have significantly advanced our understanding of the top quark, the heaviest known elementary particle. This talk will highlight recent results on top quarks from the ATLAS and CMS collaborations, including precise determinations of key properties such as its mass and the production rates of rare processes, including four-top quark production. Additionally, the top quark's unique role in the Standard Model, particularly its large Yukawa coupling, close to unity, establishes a strong connection with the Higgs boson and makes it therefore a compelling focus for exploring potential new particles. Investigating top quark interactions at the highest energy scales underscores the potential of the LHC experiments to uncover fundamental new aspects of our universe.

Invited Overview Talk T 105.4 Fri 12:30 ZHG011

The flavor intensity frontier: latest results from Belle II and LHCb — •Daniel Greenwald — Technische Universität München, Garching

The study of the different flavors of quarks and leptons may answer some of the most interesting questions of particle physics, including explaining why the visible universe is built only of matter, not antimatter, and discovering new particles and forces not yet known to us. The Belle II and LHCb experiments, located at KEK in Tsukuba, Japan and at CERN in Geneva, Switzerland, precisely measure flavor phenomena using their uniquely large data sets. I will present an accessible overview of both experiments, their measurement techniques, and some of their recent results.