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 multilayer 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.