T 53: Neutrino physics 6

Time: Wednesday 16:00–18:00 Location: Geb. 20.30: 2.058

T 53.1 Wed 16:00 Geb. 20.30: 2.058

Differential spectrum modeling for keV sterile neutrino search at KATRIN — •Martin Descher — Karlsruhe Institute of Technology

Starting in 2026, the KATRIN experiment will conduct a high-statistics measurement of the differential tritium β-spectrum to energies deep below the kinematic endpoint. This enables the search for keV sterile neutrinos with masses $m_4 \leq 18\,\mathrm{keV}$, aiming for a statistical sensitivity of $|U_{\mathrm{e4}}|^2 = \sin^2\theta \sim 10^{-6}$. The differential spectrum is obtained by decreasing the retarding potential of KATRIN's main spectrometer, and by determining the β-electron energies by their energy deposition in the new TRISTAN SDD array. In this mode of operation, the existing integral model of the tritium spectrum is insufficient, and a novel differential model is developed. So far, the model includes 20 systematics and can perform comprehensive sensitivity studies. The gained insights are employed to find the optimal beamline configuration for the measurement and to investigate potential hardware upgrades that significantly improve the sensitivity. This talk provides a summary of the systematics, the model approach, and shows how the impact of several dominant systematics can be reduced. 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 53.2 Wed 16:15 Geb. 20.30: 2.058

Mitigation of rear wall backscattering for keV sterile neutrino search at KATRIN — •Kerstin Trost — Karlsruhe Institute of Technology (KIT)

The Karlsruhe Tritium Neutrino (KATRIN) experiment aims to determine the absolute neutrino mass scale by measuring the endpoint region of the tritium β-decay spectrum with high precision. Furthermore, a measurement of the differential spectrum to energies deep below the endpoint will be conducted using the new TRISTAN detector. This enables the search for keV-scale sterile neutrinos that would cause subtle distortions several keV below the endpoint. The differential spectrum measurement requires modifications to the beamline setup, and it is subject to many new systematics.

This talk focuses on strategies to minimize the leading systematic effect of rear wall backscattering. Various scenarios are explored with simulations, including the selection of the rear wall material and the influence of magnetic fields at the rear wall and along the beamline. The primary objective is to identify an optimized beamline configuration that significantly enhances sensitivity for the detection of keV-scale sterile neutrinos.

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 53.3 Wed 16:30 Geb. 20.30: 2.058

Backscattering reduction with a micro-structured rear wall at KATRIN — •Tom Geigle — Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

The TRISTAN detector upgrade represents the subsequent phase of the KATRIN experiment, designed with the objective of searching a sterile neutrino at the keV scale through its impact on the tritium beta spectrum. A crucial aspect of this project is the detection of beta electrons down to a few keV, which previously did not have to be included in the KATRIN endpoint measurement.

Of particular significance are beta electrons that undergo scattering on the rear wall of the experimental setup before reaching the detector. This phenomenon introduces a distortion in the shape of the measured spectrum within the region of interest, necessitating mitigation strategies to attain the anticipated sensitivity levels.

To address this challenge, diverse configurations of micro-structured rear walls are being examined through Geant4 simulations. These simulations aim to identify an optimal solution that effectively minimizes the impact of scattered beta electrons on the measured spectrum, thereby facilitating the realization of the planned sensitivity goals.

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 53.4 Wed 16:45 Geb. 20.30: 2.058

Particle Identification in Liquid Argon for LEGEND — •Niko Lay for the LEGEND-Collaboration — Technical University of Munich, Garching, Germany

The LEGEND experiment searches for neutrinoless double beta ($0\nu\beta\beta$) decay in ^{76}Ge using high-purity germanium detectors immersed in liquid argon (LAr), which acts both as a coolant and active shield from background radiation. Ionizing particles traversing LAr produce, depending on their linear energy transfer, different ratios of argon unstable singlet and metastable triplet state excimers, which emit 128 nm scintillation light upon their decay. By measuring the time structure of the scintillation events, the LEGEND LAr instrumentation can identify background particles. In this talk, we present the event topology classifier (ETC), which is based on the singlet-to-triplet ratio of scintillation events, and its application to support the tagging of ^{214}Bi-Po coincidence events. The ETC is used to estimate the ^{222}Rn activity in the LEGEND LAr cryostat during commissioning. Finally, we explore the ETC performance of a different experimental setup, the shallow-underground LAr cryostat SCARF at TU-Munich, and investigate discriminating fast scintillation light emitted by polyethylene naphthalate (PEN) from LAr scintillation light. This research is supported by the BMBF through the Verbundforschung 05A20WO2 and the SFB1258.

T 53.5 Wed 17:00 Geb. 20.30: 2.058

Studying neutrinos that oscillate and decay — •George Parker[1], Joachim Kopp[1,2], and Michael Wurm[1] — [1]Institut für Physik and EC PRISMA+, Johannes Gutenberg Universität Mainz, Germany — [2]CERN Theoretical Physics Department, Geneva, Switzerland

The neutrino has a lifetime that is significantly longer than the Age of the Universe, as it can only decay radiatively via loops involving gauge bosons. However, the presence of physics Beyond the Standard Model could induce 'visible' neutrino decay between neutrino mass eigenstates. This decay process could be identified in laboratory experiments as well as from astrophysical or cosmological observations. To study neutrino systems that involve both oscillation and decay, two main formalisms have been developed—a density matrix approach and a phenomenological approach. In this work, we present an analysis of both, highlighting the physical effects captured by each framework.

T 53.6 Wed 17:15 Geb. 20.30: 2.058

atmospheric neutrino oscillation analysis with JUNO — •Mariam Rifai[1,2], Livia Ludhova[1,2], Marco Malabarba[1,2,3], Yury Malyshkyn[1,3], Cristobal Morales reveco[1,2,3], Luca Pelicci[1,2], Hexi Shi[2,3], and Apeksha Singhal[1,2] — [1]Institut für Kernphysik, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]III. Physikalisches Institut B, RWTH Aachen University, 52062 Aachen, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose liquid scintillator detector. It is currently under construction in Southern China, with its filling set to start in 2024. JUNO has a unique potential to determine the neutrino mass ordering (NMO) with a 3σ confidence level (C.L.) within 6 years. This goal will be achieved by observing the vacuum oscillation pattern of reactor antineutrinos over a baseline of 52.5 km. Equipped with a 20 kton liquid scintillator target and surrounded by 17,612 20" and 25,600 3" PMTs, JUNO's capabilities extend to probing various aspects of atmospheric neutrinos, including the neutrino interaction model, flavor discrimination, directionality, and energy reconstructions. This capability significantly enhances the NMO analysis of reactor antineutrinos by incorporating the matter-dominated oscillations of atmospheric neutrinos, which will be the main focus of this talk.

T 53.7 Wed 17:30 Geb. 20.30: 2.058

Calibration and Simulation of a Kaon Quenching Experiment for Proton Decay Search with JUNO — •Ulrike Fahrendholz[1], Sarah Braun[1], Selina Rudolph[1], Korbinian Stangler[1], Lothar Oberauer[1], Hans Th. J. Steiger[1,2], and Matthias Raphael Stock[1] — [1]TUM School of Natural Sciences, Physics Department, James-Franck-Str. 1, 85748 Garching —

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Grand Unified Theories (GUTs) are able to describe proton decay processes as they allow conversion reactions between quarks and leptons. The predictions of numerous supersymmetric GUTs are tested by searching for their main proton decay channel $p \rightarrow K^+\bar{\nu}$. Currently, the lower lifetime limit 5.9×10^{33} years has been set by the Super-Kamiokande Collaboration using a water-Cerenkov detector. By using a large liquid scintillator target mass, the Jiangmen Underground Neutrino Observatory (JUNO) aims to reach a sensitivity of 9.6×10^{33} years based on a total exposure of 200 kton · years.

JUNO's detection efficiency can be further improved by modeling the signal structure of the decay kaon, especially it's quenching behavior. The UniKaon experiment was designed to determine the kaon's Birks' factor by independent detection of the deposited energy and light output. In this talk, I present the current status of calibration and a full light propagation simulation.

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

T 53.8 Wed 17:45 Geb. 20.30: 2.058

Measurement of Proton Recoil Quenching Factors in Liquid Scintillators for Neutrino Detectors — H. Steiger[1,2], •J. Firsching[1], D. Dörflinger[1], U. Fahrendholz[1], and M. R. Stock[1] — [1]Physik-Department, Technische Universität München, James-Franck-Str. 1, 85748 Garching — [2]Johannes Gutenberg University Mainz, Cluster of Excellence PRISMA+, Staudingerweg 9, 55128 Mainz

Several next-generation neutrino detectors, such as JUNO and JUNO-TAO, are currently under construction. They, as well as the planned THEIA observatory, are intended to break new ground in neutrino physics and achieve unprecedented energy and vertex resolution. To exploit the full potential of these detectors, a robust absolute energy scale determination for several particle species is crucial. In this talk, the measurement of neutron-induced proton recoil ionization quenching utilizing quasi-monoenergetic neutrons from the 7Li(p,n)7Be nuclear reaction is presented. Therefore, bunched proton beams with 3.5 MeV to 5.5 MeV energy provided by the INFN-LNL CN Van-De-Graaff accelerator were used. Severel novel liquid scintillation cocktails were investigated. This work is supported by the Cluster of Excellence PRISMA+ at the Johannes Gutenberg University in Mainz, the Cluster of Excellence ORIGINS, the Collaborative Research Center 1258, and the DFG Research Units 2319 and 5519.