T 21: Neutrino Physics without Accelerators 2

Time: Monday 16:15–18:35 Location: T-H34

Group Report T 21.1 Mon 16:15 T-H34

Sterile neutrino search at the keV mass scale with KATRIN — •Frank Edzards for the KATRIN collaboration[1], Marco Carminati[2,3], David Fink[1], Carlo Fiorini[2,3], Matteo Gugiatti[2,3], Pietro King[2,3], and Peter Lechner[4] — [1]Max Planck Institute for Physics, Munich, Germany — [2]DEIB, Politecnico di Milano, Milano, Italy — [3]INFN, Sezione di Milano, Milano, Italy — [4]Halbleiterlabor der Max Planck Gesellschaft, Munich, Germany

Sterile neutrinos are a natural extension of the Standard Model of particle physics. If their mass is in the keV range, they are a viable dark matter candidate. One way to search for sterile neutrinos in a laboratory-based experiment is via tritium beta decay. A sterile neutrino with a mass up to 18.6\,keV would manifest itself in the decay spectrum as a kink-like distortion. The objective of the TRISTAN project is to extend the KATRIN experiment with a novel multi-pixel silicon drift detector and readout system to search for a keV-scale sterile neutrino signal. This talk will give an overview on the current status of the project. First characterization measurement results obtained with a 166 pixel system will be shown. This work is supported by BMBF (05A17PM3, 05A17PX3, 05A17VK2, 05A17WO3), KSETA, the Max Planck society, and the Helmholtz Association.

T 21.2 Mon 16:35 T-H34

Shifted Analyzing Plane: Optimizing spectrometer potentials and fields to reduce background in KATRIN — •Benedikt Bieringer for the KATRIN-Collaboration — Institut für Kernphysik, Uni Münster, Germany

The KArlsruhe TRItium Neutrino (KATRIN) experiment aims at measuring the electron antineutrino mass to an estimated sensitivity of $0.2\,\mathrm{eV/c^2}$ at 90 % CL through spectroscopy of Tritium beta decay electrons using an electrostatic spectrometer of MAC-E filter type. For this level of precision, a low spectrometer background is required. The novel Shifted Analyzing Plane method achieves a significant reduction of this background through optimization of MAC-E filter electric potentials and magnetic fields. In this talk, computational and physical methods are presented that enabled the reduction of background of the KATRIN experiment by over a factor of two and fully eliminated measurable correlated background events from trapped high-energetic electrons. This includes a brief introduction to the inner workings of a MAC-E filter, a novel software collection to enable realtime field calculations based on Zonal Harmonic Field Expansion and background modelling for the largest ultra-high vacuum component in the KATRIN experiment.

This talk presents work funded via BMBF contract numbers 05A20VK3, 05A20PX3, 05A20PMA and 05A17WO3.

T 21.3 Mon 16:50 T-H34

Determination of Electromagnetic Fields in the Shifted Analyzing Plane of the KATRIN Main Spectrometer — •Fabian Block[1] and Alexey Lokhov[2] for the KATRIN-Collaboration — [1]Karlsruhe Institute of Technology — [2]WWU Münster

The KATRIN experiment aims to determine the effective electron antineutrino mass with a sensitivity of 0.2 eV (90 % C.L.) by high-resolution spectroscopy of the endpoint region of the tritium β decay spectrum. To reach the sensitivity goal, the experimental setup of KATRIN combines a windowless gaseous tritium source with a high-resolution MAC-E filter, called main spectrometer. The energy analysis of the β-decay electrons in the main spectrometer takes place via a complex interplay of electric and magnetic fields.

To improve the signal-to-background ratio during neutrino mass measurements, the electromagnetic field configuration in the main spectrometer is adapted to the so-called Shifted Analyzing Plane (SAP). The SAP electromagnetic fields need to be known with high precision in order for them to be taken accurately into account in the β-spectrum model applied in the fit of the data. We present in this talk the results of SAP characterization measurements employing conversion electrons of krypton-83m as sensitive probes for the electromagnetic fields.

This work is supported by the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, 05A20PMA, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Young Investigator Group (VH-NG-1055).

T 21.4 Mon 17:05 T-H34

aTEF: Background reduction at KATRIN via an active transverse energy filter — •Sonja Schneidewind[1], Kevin Gauda[1], Volker Hannen[1], Alexey Lokhov[1], Hans-Werner Ortjohann[1], Wolfram Pernice[2], Richard Salomon[1], Maik Stappers[2], and Christian Weinheimer[1] for the KATRIN-Collaboration — [1]Institut für Kernphysik, Universität Münster, Wilhelm-Klemm-Str. 9, 48149 Münster, Germany — [2]Physikalisches Institut, Universität Münster, Heisenbergstr. 11, 48149 Münster, Germany

The Karlsruhe Tritium Neutrino Experiment (KATRIN) aims at the direct measurement of the electron antineutrino mass with $0.2\,\mathrm{eV/c^2}$ sensitivity from precision spectroscopy of the tritium beta decay. The analysis of its first two science runs yields a new upper limit of $m_\nu < 0.8\,\mathrm{eV}$ (90% C.L.). Even in the shifted-analysis-plane (SAP) mode it is required to further lower the background rate to reach the target sensitivity. The background rate is dominated by electrons originating from ionisation of highly-excited (Rydberg) atoms produced by α-decays in the spectrometer walls. Thus, they cannot be distinguished from the signal electrons by energy but they possess much smaller angles w.r.t. the beam axis and, thus, much smaller cyclotron radii in the magnetic fields of KATRIN. The aTEF idea is to construct a detector by microstructuring that is mainly sensitive to the signal electrons because of their larger cyclotron radii. Investigations of first prototypes based on microstructured silicon PIN detectors are presented in this talk. The work of the authors for KATRIN is supported by BMBF under contract number 05A20PMA.

T 21.5 Mon 17:20 T-H34

Electron tracking simulations for the active transverse energy filter at KATRIN — •Richard Salomon, Kevin Gauda, Sonja Schneidewind, Volker Hannen, Alexey Lokhov, Hans-Werner Ortjohann, and Christian Weinheimer for the KATRIN-Collaboration — Institut für Kernphysik, Wilhelm-Klemm-Straße 9, 48149 Münster, Germany

The Karlsruhe Tritium Neutrino Experiment (KATRIN) aims at determining the electron neutrino mass with a sensitivity of 0.2 $\mathrm{eV/c^2}$ from a precision measurement of the tritium β-decay spectrum. To reach the desired sensitivity it is crucial to minimize experimental background events especially in the endpoint region of the electron spectrum.

One of the dominant backgrounds identified is the ionization of highly-excited (Rydberg) atoms inside the main spectrometer. To mitigate this background source, the concept of an active transverse energy filter (aTEF) is being investigated. As the electrons emitted by ionized Rydberg atoms, in contrast to most signal electrons from tritium beta decay, possess only a small amount of energy perpendicular to the guiding magnetic field, an angular-selective detector might be able to distinguish between the two. In order to test this novel detection technique, prototypes consisting of microstructured Si-PIN diodes are currently investigated in a test setup in Münster. This talk focuses on the accompanying particle tracking simulations which are essential for the analysis and interpretation of measurement data.

This project is supported by BMBF under contract number 05A20PMA.

T 21.6 Mon 17:35 T-H34

Combined analysis of the first five KATRIN measurement campaigns with KaFit — •Stephanie Hickford and Leonard Köllenberger for the KATRIN-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology

The KATRIN collaboration aims to determine the neutrino mass with a sensitivity of $0.2\,\mathrm{eV/c^2}$ (90 % CL). This will be achieved by measuring the endpoint region of the tritium β-electron spectrum. Combined analysis of the first two KATRIN measurement campaigns yielded a neutrino mass limit of $m_\nu \leq 0.8\,\mathrm{eV}$ (90 % CL).

Analyses of data from the first five measurements campaigns are currently underway. One of the combined analyses is performed using the `KaFit/SSC` model within the `KASPER` software framework. In this analysis systematic uncertainties are propagated as additional fit parameters with constraints (the “pull term” method). An overview of the collected data and the expected combined sensitivity on the neutrino mass from these five measurement campaigns will be presented in this talk.

This work is supported by the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Young Investigator Group (VH-NG-1055).

T 21.7 Mon 17:50 T-H34

Status of the KATRIN neutrino mass analysis using Monte Carlo propagation and a novel neural network approach — Christian Karl[1,2], Susanne Mertens[1,2], •Alessandro Schwemmer[1,2], and Christoph Wiesinger[1,2] for the KATRIN-Collaboration — [1]Max-Planck-Institut für Physik, München — [2]Physik Department, Technische Universität München, Garching

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 $0.8\,\mathrm{eV\,c^{-2}}$ (90 % CL) has been set with the first two measurement campaigns. New operational conditions for an improved signal-to-background ratio, the reduction of systematic uncertainties and a substantial increase in statistics allow to expand this reach.

The performance figures of three additional datasets, analysed with the Monte Carlo propagation method, and an outlook on their combination using a novel neural network technique will be presented in this talk.

T 21.8 Mon 18:05 T-H34

Measurement of the drift time in a silicon drift detector for the KATRIN experiment by laser pulsing — •Korbinian Urban[1], Marco Carminati[2,3], David Fink[1], Carlo Fiorini[2,3], Matteo Gugiatti[2,3], Pietro King[2,3], and Peter Lechner[4] for the KATRIN-Collaboration — [1]Max Planck Institute for Physics, Munich, Germany — [2]DEIB, Politecnico di Milano, Milano, Italy — [3]INFN, Sezione di Milano, Milano, Italy — [4]Halbleiterlabor der Max Planck Gesellschaft, Munich, Germany

The KATRIN experiment investigates the endpoint of the tritium beta-decay spectrum to search for the effective mass of the electron neutrino. Furthermore, the KATRIN experiment has the potential to also search for the signature of a sterile neutrino in the keV-mass regime by measuring the entire tritium beta-decay spectrum with an upgraded detector system. The new detector system, named TRISTAN, will be a multi-pixel silicon drift detector. This technology provides an improved energy resolution at high rates compared to PIN detector diodes. The radial drift of a charge cloud to the small anode of each pixel with 3 mm radius can be a significant contribution to the time resolution of the detector. This talk presents a measurement where a pulsed red laser is used to characterize the drift time in a 7-pixel TRISTAN detector device.

This work is supported by BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), KSETA, the Max Planck society, and the Helmholtz Association.

T 21.9 Mon 18:20 T-H34

SQL database caching for calculating the response function of the KATRIN experiment in HPC environments — •Jan Behrens and Fabian Block for the KATRIN-Collaboration — Institut für Astroteilchen-/Experimentelle Teilchenphysik, KIT Karlsruhe, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

The **Ka**rlsruhe **Tri**tium **N**eutrino experiment aims to determine the mass of the electron antineutrino with a sensitivity of 0.2 eV/c^2 (90% C.L.). The measurement of the shape of the tritium beta-spectrum enables a model-independent investigation of the absolute neutrino mass scale. The setup consists of a 70 m long beam line that magnetically guides electrons from a gaseous, windowless tritium source through an electrostatic spectrometer of the MAC-E filter type. The neutrino mass analysis involves a time-consuming calculation of the response function that depends on various experimental parameters, such as the magnetic fields along the beam line or the source column density. In order to facilitate a fit over hundreds of data runs with varying conditions, a caching mechanism is implemented which operates on a SQL database that can be shared between multiple users. Using a central database allows to distribute the calculations in a HPC cluster environment in order to improve the efficiency of existing parallelization techniques. *This work is supported by the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Young Investigator Group (VH-NG-1055).*