T 43: Neutrino physics without accelerators II

Time: Tuesday 16:00–18:30 Location: Tr

T 43.1 Tue 16:00 Tr

Column Density Determination for the KATRIN Neutrino Mass Measurement — Fabian Block[1], •Christoph Köhler[2], and Alexander Marsteller[1] for the KATRIN-Collaboration — [1]Karlsruhe Institute of Technology — [2]Technical University of Munich/Max Planck Institute for Physics

The KATRIN experiment aims to model-independently probe the effective electron anti-neutrino mass with a sensitivity of 0.2 eV (90% C.L.) by investigating the endpoint region of the tritium beta decay spectrum. To achieve this goal the gas quantity of the windowless gaseous tritium source, characterized by the column density, has to be known with great accuracy.
This contribution describes the principle of measuring the column density with an angular resolved photoelectron source. Moreover, we report on the monitoring accuracy of the column density achieved with dedicated activity monitoring devices in 5 and 7 weeks long neutrino mass measurement campaigns of KATRIN. The influence of the column density uncertainty on the neutrino mass determination is then discussed in light of KATRIN's world-leading direct upper limit on the neutrino mass and the ongoing further data-taking.
This work is supported by the Technical University of Munich, the Max Planck Society, the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), the GRK 1694, and the Helmholtz Young Investigator Group (VH-NG-1055).

T 43.2 Tue 16:15 Tr

Towards a better understanding of KATRIN's global magnetic field for neutrino mass measurements — Jan Behrens and •Fabian Block for the KATRIN-Collaboration — Institute for Astroparticle Physics and Institute of Experimental Particle Physics, Karlsruhe Institute of Technology

The KATRIN experiment aims to determine the effective electron anti-neutrino mass with a sensitivity of 0.2 eV (90% C.L.) by investigating the endpoint region of the tritium decay spectrum. The experimental setup of KATRIN consists of a high-luminosity windowless gaseous tritium source, from which the beta electrons are adiabatically guided in a magnetic flux tube to the spectrometer and detector section, which measures the integrated beta decay spectrum.
The global magnetic field in KATRIN's experimental setup plays a crucial role in the experiment's response function. To avoid a bias on the neutrino mass measurement, the magnetic field needs to be known with high accuracy. We present in this talk techniques to determine the magnetic fields in the source and spectrometer sections in KATRIN. Additionally, the influence of the magnetic field uncertainty on the neutrino mass determination is discussed in light of KATRIN's first neutrino mass results and the on-going further data-taking.
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), the GRK 1694, and the Helmholtz Young Investigator Group (VH-NG-1055).

T 43.3 Tue 16:30 Tr

KATRIN neutrino mass results from the second science run — Wonqook Choi, Stephanie Hickford, and •Leonard Köllenberger for the KATRIN-Collaboration — Institute for Astroparticle Physics and Institute of Experimental Particle 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. The first four-week KATRIN science run was taken in Spring 2019, and yielded a neutrino mass limit of $m_\nu \leq 1.1\,\mathrm{eV}$ 90 % CL).

The second KATRIN science run was taken in Autumn 2019. This measurement data was taken over seven weeks with a substantially higher tritium column density in the source, leading to approximately twice the statistics collected compared to the first KATRIN science run. One of the neutrino mass analyses of this data was performed using the `KASPER` software framework including systematics via free parameters with constraints. This analysis and the neutrino mass results 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 43.4 Tue 16:45 Tr

Precision measurement of the energy loss of e^--T_2 scattering in the source of KATRIN — •Lutz Schimpf for the KATRIN-Collaboration — ETP, Karlsruhe Institute of Technology (KIT)

The **Ka**rlsruhe **Tri**tium **N**eutrino experiment (KATRIN) is targeted to measure the effective neutrino mass $m(\nu_e)$ with a sensitivity of 0.2 eV at 90 % CL. In order to determine the neutrino mass, an integrated β-decay spectrum close to the endpoint is measured and a fit to the data comprising $m(\nu_e)$ as a free parameter is performed. A number of systematic effects on the measured spectrum need to be taken into account in the spectral analysis. One of these is the energy loss of the β-electrons from inelastic scatterings with the source gas. The probability distribution of the energy losses of 18.6 keV electrons scattering off molecular tritium can be determined in-situ with KATRIN by using a pulsed monoenergetic source of photoelectrons, allowing for time-of-flight spectroscopy. The measurement is analysed by fitting a newly developed, semi-empirical energy-loss model to a combined data set of integral and differential spectra. With this measurement and analysis technique, an analytical description of the energy loss function with unprecedented precision is obtained. In this contribution, the latest analysis results will be presented and discussed in the context of the neutrino-mass systematics budget of KATRIN.

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

T 43.5 Tue 17:00 Tr

Analysis of New KATRIN Neutrino Mass Data using Monte Carlo Propagation — •Christian Karl[1,2], Susanne Mertens[1,2], and Martin Slezák[1] — [1]Max-Planck-Institut für Physik — [2]Technische Universität München

The KATRIN experiment is designed to measure the effective electron anti-neutrino mass by investigating the energy spectrum of tritium beta-decay. Here we will focus on the second data taking phase which took place in autumn 2019. For this period, the source activity was set to about 84 % of the nominal value and around 4.2 million electrons were collected in the region of interest. This corresponds to an improval of the statistical uncertainty of about a factor of three compared to the first measurement phase published in 2019.

This talk presents one of the analysis strategies pursued which is based upon Monte Carlo propagation of uncertainties. After briefly describing the model and systematics treatment we will present the sensitivity on MC-data and prospectively also our results on the unblinded data set including an updated confidence interval using the sensitivity limit method of Lokhov and Tkachov.

T 43.6 Tue 17:15 Tr

Spectrocopy of Kr-83m Conversion Electron Lines for Plasma Investigations at KATRIN — •Matthias Böttcher — WWU Münster

The Karlsruher Tritium Neutrino Experiment (KATRIN) aims at measuring the effective electron neutrino mass with the unprecedented sensitivity of 0.2 eV by measuring the energy spectrum of tritium β-decay electrons. The non-zero neutrino mass established in oscillation experiments introduces a change of the shape of the electron spectrum near the endpoint energy. The first neutrino mass result published by the KATRIN experiment gives a new upper limit of 1.1 eV (90 % C.L.). To improve on this limit, a detailed analysis of systematic effects in the tritium source and the main spectrometer is required. One of the tools to assess systematic uncertainties in KATRIN is the use of Krypton-83m as a calibration source, which provides mono-energetic conversion electrons. Gaseous $^{83\mathrm{m}}$Kr can be injected into KATRIN's windowless gaseous tritium source (WGTS), and can be used, among others, to study the effect of inhomogeneities in the tritium plasma. In this talk, the spectroscopy of ^{83m}Kr for investigating plasma inhomogeneities is presented.

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

T 43.7 Tue 17:30 Tr

GNN-based reconstruction of low-energy IceCube events — Martin Ha Minh and •Janus Gurth for the IceCube-Collaboration — Technische Universität München

The IceCube Neutrino Observatory is a cubic kilometer scale neutrino detector embedded in the antarctic ice of the South Pole. So far it has been providing globally competitive results in neutrino oscillation physics, such as constraints on atmospheric oscillation parameters or eV-scale sterile neutrinos.

The sparseness of observed charge in the detector for low-energy events, and the irregular detector geometry, have always been a challenge in reconstructing the detected neutrino's parameters of interest. This problem is exacerbated by the planned IceCube Upgrade, which introduces seven new detector strings with novel detector modules. Doing so will increase the detection rate of low-energy events to further constrain neutrino oscillation physics. Here we introduce a novel reconstruction algorithm based on Graph Neural Networks, which we use to reconstruct neutrino events at speeds magnitudes faster than the traditional algorithms, while providing comparable resolution.

T 43.8 Tue 17:45 Tr

Likelihood-free inference for low-energy reconstruction in IceCube DeepCore — •Jan Weldert[1], Philipp Eller[2], and Sebastian Böser[1] for the IceCube-Collaboration — [1]JGU, Mainz, Germany — [2]TUM, Munich, Germany

DeepCore, the low energy extension of the IceCube neutrino observatory at the geographic South Pole, detects neutrinos at a rate on the order of mHz resulting in unprecedentedly large event samples. Reconstructing the latest generation of these samples ($\sim$300.000 νs) is currently computationally expensive ($\sim$40s per event). In addition, the employed max. LLH method includes simplifications in the photon propagation in ice which limit the reconstruction accuracy but are hard to overcome in the current approach.

Machine learning techniques can solve problems at a tremendous speed. But they also come with disadvantages, e.g. most will just give you a point estimation without any information about the uncertainty. Likelihood-free inference is a possibility to combine the speed of neural networks with a likelihood-based approach, which is very well understood. The main idea is to let a network learn a function proportional to the likelihood, which can then be used for a max. LLH reconstruction. While this is slower than a pure deep learning approach, it offers the possibility to perform likelihood scans for error estimation or test coverage.

In my talk I will present the application of likelihood-free inference to the reconstruction of low-energy events in IceCube-DeepCore. We achieve speed-ups up to a factor of 100 at comparable resolutions.

T 43.9 Tue 18:00 Tr

Search for non-standard neutrino interactions with 8 years of IceCube DeepCore data — •Elisa Lohfink and Sebastian Böser for the IceCube-Collaboration — Institut für Physik, JGU Mainz, Deutschland

Non-standard neutrino interactions (NSI) are well motivated and result in a change of the potential that neutrinos encounter when traversing matter, hence altering their oscillation patterns. This signature can be probed using high-statistics neutrino experiments such as IceCube and its low-energy extension DeepCore which detect atmospheric neutrinos after propagating through matter at baselines up to the Earth diameter. The event selection that this search is based on includes 8 years of IceCube-DeepCore data, containing all neutrino flavors. It reaches from the few-GeV DeepCore energy threshold up to several hundred GeV and constitutes a significant increase in statistics with respect to previous searches. In addition, the treatment of systematic uncertainties, background rejection and event reconstruction have been improved substantially. This sample allows us to probe not only NSI in the μ-τ sector, as is commonly done, but also those involving the electron flavor.

T 43.10 Tue 18:15 Tr

A neutrino oscillation probability package for KM3NeT/ORCA — •Johannes Schumann for the ANTARES-KM3NeT-Erlangen-Collaboration — ECAP, Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, 91058 Erlangen

A crucial part for the prediction of neutrino event rates is the flavour transition probability based on the phenomenon of neutrino oscillations. The computation time of those transition probabilities depends on the oscillation model and the sampled resolution of the propagation path. Thus, neutrino oscillation software is required to implement different oscillation model features at a high level of computational performance. A neutrino oscillation probability package (https://github.com/KM3NeT/Neurthino.jl) using the programming language Julia has been developed for use in the data processing chain of the KM3NeT/ORCA neutrino telescope. The package is based on an n-flavour oscillation model and capable of neutrino propagation through earth. The main features of Neurthino.jl will be outlined and a performance comparison to other commonly used oscillation software packages will be presented.