T 45: Neutrino Physics III

Time: Wednesday 16:15–18:30 Location: AudiMax

T 45.1 Wed 16:15 AudiMax

Upgrading the ECHo-1k experimental setup — •Margareta Chill for the ECHo-Collaboration — Kirchhoff-Institute for Physics

With the ECHo experiment, the effective electron neutrino mass can be determined via the high energy resolution measurement of the ^{163}Ho electron capture spectrum. In ECHo, large arrays of metallic magnetic calorimeters hosting ^{163}Ho are operated at millikelvin. For the ECHo-1k phase, two MMC arrays have been used for acquiring 200 million ^{163}Ho events with an energy resolution of about 7 eV FWHM at 1800 eV. For that experiment, only about one half of the channels could be read out due to failures in several SQUID channels. We present the upgrade of the ECHo-1k set-ups by the exchange of the SQUID read-out. We discuss the performance achieved with one of those set-ups and the implication for a coming small scale experiment aiming to reach a sensitivity on the effective neutrino mass below 5 eV/e^2.

T 45.2 Wed 16:30 AudiMax

Principal Component Analysis for Pile-up Event Detection in the ECHo Experiment — •Domenic Klumpp for the ECHo-Collaboration — Kirchhof Institut of Physics, Heidelberg, Germany

The ECHo (Electron Capture in Holmium-163) experiment uses metallic magnetic calorimeter (MMC) detectors to calorimetrically measure the electron capture spectrum of Ho-163 with the goal of determining the effective electron neutrino mass via the analysis of the endpoint region. In the data analysis, a significant challenge is the identification and rejection of pile-up events for which the time interval is of the order or smaller than the rise time of the pulse signal. Those events represent an intrinsic background distorting the spectrum and therefore affecting the accuracy of neutrino mass determination. We present an approach using Principal Component Analysis (PCA) to identify pile-up events. Simulated events preserving the shape and noise of real events have been generated according to the shape of the Ho-163 spectrum, including pile-up events to test the developed algorithms. For the ECHo-LE experiment the unresolved pile up fraction, given as product of the pixel activity times the time resolution, should be kept below 10^{-6}, which for an activity of 10 Bq per pixel, implies a time resolution of 100 ns. We present the preliminary results obtained with the simulated data and discuss the implication of then in respect to the requirements for ECHo-LE.

T 45.3 Wed 16:45 AudiMax

Sterile-neutrino search based on 259 days of KATRIN data — •Xaver Stribl and Susanne Mertens for the KATRIN-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland

Light sterile neutrinos with a mass on the eV-scale could explain several anomalies observed in short-baseline oscillation experiments. The Karlsruhe Tritium Neutrino (KATRIN) experiment is designed to directly determine the effective electron anti-neutrino mass by measuring the tritium beta decay spectrum. The measured spectrum can also be investigated for the signature of light sterile neutrinos.

In this talk we present the result of the light sterile neutrino analysis of the first five KATRIN measurement campaigns. To handle the computational challenge, a neural network is used. The obtained result is compared to results from other experiments and anomalies in the field of light sterile neutrinos.

T 45.4 Wed 17:00 AudiMax

Qualification Measurements Toward a New KATRIN Rear Wall — •Kerstin Trost[1], Dominic Batzler[1], Marco Röllig[1], Marius Schaufelberger[1], Marie Schäfer[1], Michael Sturm[1], and Mart van den Bosch[2] for the KATRIN-Collaboration — [1]Karlsruhe Institute of Technology, Germany — [2]Eindhoven University of Technology, Netherlands

Starting this year, the KATRIN experiment is undergoing a major upgrade to enable the search for sterile neutrinos in the keV mass range. This upgrade introduces a significant systematic uncertainty arising from electron backscattering at the upstream end of the tritium source, the Rear Wall (RW). To mitigate this effect, two new RW candidates, beryllium and microstructured silicon, are currently under investigation as they are expected to reduce the backscattering probability significantly.

This presentation discusses the ongoing qualification program for these Rear Wall candidates, including systematic studies of tritium accumulation as well as an ozone-based decontamination procedure. The stability of both materials under ozone exposure is assessed to ensure long-term compatibility with routine decontamination cycles. Furthermore, charge-up effects and potential surface modifications induced by ozone treatments are analyzed using Auger Electron Spectroscopy (AES). These characterization measurements form a crucial step toward implementing an optimized Rear Wall for the upcoming KATRIN keV sterile neutrino measurement phase.

T 45.5 Wed 17:15 AudiMax

Electron Backscattering at the Focal Plane Detector of KATRIN — •Philipp Lingnau for the KATRIN-Collaboration — Tritium Laboratory Karlsruhe (TLK), Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT), 76344 Eggenstein-Leopoldshafen, Germany

The KATRIN experiment has put the most stringent model-independent upper limit on the electron antineutrino mass. The goal is to limit it to < 0.3 eV. To achieve this, a large amount of tritium beta-electrions need to be spectroscopied using a MAC-E-filter type spectrometer.

One systematic effect on the neutrino mass measurement is the detector backscattering. In the past we performed an in-situ measurement using time-of-flight spectroscopy. With it, the structure in electron energy loss due to plasmon excitations inside the detector can be resolved.

I will present the analysis of the measurement, featuring various improvements, including a rigorous investigation of the impact of fluctuations of the electrical potentials, improved electric and magnetic field simulations using Kassiopeia, as well as more in-depth ToF simulations.

In the future, this measurement principle and the analysis framework can be adapted for the TRISTAN phase of KATRIN, where understanding the escape spectrum from backscattered electrons is of greater importance than for KATRIN.

T 45.6 Wed 17:30 AudiMax

Detection of neutrons produced in neutrino-nucleus interactions with T2K — •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 oscillation occurs.

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 45.7 Wed 17:45 AudiMax

Reconstruction of neutrino interactions with silicon strip detectors at the SHiP experiment — •James Webb, Christian Weiser, Yannika Matt, and Elias Bauknecht — Albert-Ludwigs-Universität Freiburg, Physikalisches Institut, 79104 Freiburg, Germany

SHiP (Search for Hidden Particles) is a general purpose fixed target facility, currently in the design phase, and to be installed at CERN at the beginning of the next decade. A 400 GeV/c proton beam will be dumped on a heavy target, yielding an expected 6 $\times 10^{20}$ proton-target collisions over 15 years of operation. The beam dump will produce a huge neutrino flux of all three flavours, making this environment ideally suited for performing neutrino physics studies: a key component of the SHiP physics programme.

A proposed detector design for the measurement of neutrino interactions consists of a passive tungsten plane, followed by a pair of silicon strip detectors, oriented such that the pair of strips are directed perpendicularly. Many such layers are envisioned to be stacked-up along the beam axis to maximise the detector mass.

This talk will discuss the potential of such a detector in terms of a tracking detector (track and vertex reconstruction) and a high-granularity calorimeter, with an emphasis on the study of tau neutrino interactions.

T 45.8 Wed 18:00 AudiMax

Data-driven pile-up systematic estimation for neutrons in T2k ND280Upgrade detector — •Gioele Reina — JGU 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 and performs cross section measurement. The new features of the upgraded ND280 detector allow to improve reduction these capabilities. In particular, the newly installed target, the Super Fine-Grained Detector, which consists of small plastic scintillator cubes read out by three WLS fibers in the three orthogonal directions, offers high granularity and 3D reconstruction. This new detector design unlocks the sensitivity to neutrons produced in charge-current interactions by measuring their time of flight in the detector.

In order to develop a selection of neutron events it is crucial to estimate the relevant systematic uncertainties. An important systematic uncertainty is related to the background contribution of the pile-up, which consists of simultaneous interactions that mimic the presence of a neutron in the signal sample. By creating a hybrid sample composed of signal events and enhanced background estimated in data, it is possible to evaluate the pile-up contribution using a data-driven approach. Here, this approach is described, along with the effects of this systematic on the signal sample selection.

T 45.9 Wed 18:15 AudiMax

Towards a High-Rate Active Neutrino Detector at FASER: Performance Studies with Deep Learning — Florian Bernlochner, Tobias Boeckh, Dhruv Chouhan, Jörn Mahlstedt, •Felix Antonio Junjiro Obando Molina, Matthias Schott, and Konstantinos Spyrou — Universität Bonn, Regina-Pacis-Weg 3, D-53113 Bonn, Germany

The FASER experiment at the LHC is a forward detector designed to study light, weakly interacting particles and has successfully established a dedicated neutrino program to measure high-energy collider neutrinos. During LHC Run-4, however, the expected increase in muon background rates will exceed the tolerable limits of the current emulsion-based neutrino detector, motivating the exploration of alternative technologies. We investigate the feasibility of an active neutrino detector concept based on multilayer active pixel sensors capable of operating at high rates. In this talk, we present a detailed study of neutrino reconstruction performance in such a detector using modern deep learning approaches, including deep neural networks (DNNs) and convolutional neural networks (CNNs), with a focus on efficient neutrino event classification in a challenging high-background environment.