T 57: Neutrino physics 7

Time: Wednesday 16:00–18:00 Location: Geb. 30.21: Gerthsen-HS

T 57.1 Wed 16:00 Geb. 30.21: Gerthsen-HS

The Taishan Antineutrino Observatory — •Hans Theodor Josef Steiger — Physik-Department, Technische Universität München, James-Franck-Str. 1, 85748 Garching, Germany — Johannes Gutenberg University Mainz, Cluster of Excellence PRISMA+, Staudingerweg 9, 55128 Mainz, Germany

The Taishan Antineutrino Observatory (TAO or JUNO-TAO) is a satellite detector for the Jiangmen Underground Neutrino Observatory (JUNO). JUNO will use reactor antineutrinos at a baseline of about 53 km to probe the interference effects between the two atmospheric mass-squared differences, which are sensitive to the sign of the mass ordering. Located near the Taishan-1 reactor, TAO independently measures the antineutrino energy spectrum of the reactor with unprecedented energy resolution and by that uncovering its fine structure for the first time. Beyond that, TAO is expected to make world-leading time-resolved measurements of the yield and energy spectra of the main isotopes involved in the antineutrino emission of nuclear reactors. By that TAO will provide a unique reference for other experiments and nuclear databases. In order to achieve its goals, TAO is relying on cutting-edge technology, both in photosensor and liquid scintillator (LS) development which is expected to have an impact on future neutrino and Dark Matter detectors. In this talk, the design of the TAO detector with special focus on its new detection technologies will be introduced. In addition, an overview of the progress currently being made in the R&D for photosensor and LS technology in the frame of the TAO project will be presented.

T 57.2 Wed 16:15 Geb. 30.21: Gerthsen-HS

Time Profile Measurements of the Cooled TAO Liquid Scintillator — •Matthias Raphael Stock[1], Hans Th. J. Steiger[1,2], Manuel Böhles[2], David Dörflinger[1], Ulrike Fahrendholz[1], Meishu Lu[1], Lothar Oberauer[1], and Korbinian Stangler[1] — [1]Technical University of Munich, TUM School of Natural Sciences, Physics Department, James-Franck-Str. 1, 85748 Garching — [2]Johannes Gutenberg University Mainz, Cluster of Excellence PRISMA+, Staudingerweg 9, 55128 Mainz

The main physics goal of Jiangmen Underground Neutrino Observatory (JUNO) is the determination of the neutrino mass ordering by the detection of the oscillated electron antineutrino energy spectrum from reactors at medium-baselines. JUNO will have a satellite detector called Taishan Antineutrino Observatory (JUNO-TAO) to measure the unoscillated spectrum at unprecedented resolution. The novel detector technologies require TAO to have an operation temperature of minus 50 degrees. We studied the fluorescence time profile of the TAO liquid scintillator at room and cold temperatures. We performed measurements using radioactive sources and pulsed neutron beams of different energies at the CN accelerator of INFN Laboratori Nazionali di Legnaro. Different time profiles after recoil electron and recoil proton excitation allow to perform pulse shape discrimination and therefore advance the ability to distinguish the neutrino signal from background.

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T 57.3 Wed 16:30 Geb. 30.21: Gerthsen-HS

CRES demonstrator design optimization based on CRES signal decoding with likelihood techniques — •René Reimann, Florian Thomas, Sebastian Böser, and Martin Fertl for the Project 8-Collaboration — Institute of Physics and Cluster of Excellence PRISMA+, Johannes Gutenberg University Mainz, 55099 Mainz, Germany

While neutrino flavor oscillations prove neutrinos have mass, the absolute neutrino mass remains undetermined. Direct kinetic approaches rely on the high-resolution measurement of the beta decay electron spectrum close to its endpoint. The current state-of-the-art MAC-E filter technique is not scalable to larger sources and statistics; therefore, the cyclotron radiation emission spectroscopy (CRES) method has been proposed as an alternative method with potentially greater sensitivity reach. For CRES, the beta-decay electron emits cyclotron radiation in a magnetic mirror trap. The radiation is picked up by receivers, amplified and digitized. For competitive neutrino mass searches, the CRES technique must be scaled up and demonstrated in large-scale volumes. The signal structure from the measured electron radiation is complex, and the impact of apparatus design choices, e.g. the magnetic trap shape, is not straightforward. Therefore, we apply a likelihood-based reconstruction method to investigate the likelihood landscape with simulated data in the region around the Monte Carlo truth to extract the complete information encoded in the signal. As an example, we discuss the impact of magnetic trap designs on the energy resolution obtained by the likelihood reconstruction.

T 57.4 Wed 16:45 Geb. 30.21: Gerthsen-HS

Simulation and event reconstruction in NuDoubt++ — Manuel Böhles[1], Sebastian Böser[1], Magdalena Eisenhuth[1], Chloé Girard-Carillo[1], Bastian Kessler[1], •Kyra Mossel[1], Stefan Schoppmann[2], Alfons Weber[1], and Michael Wurm[1] for the NuDoubt-Collaboration — [1]Johannes Gutenberg-Universität Mainz, Institut für Physik, 55128 Mainz, Germany — [2]Johannes Gutenberg-Universität Mainz, Detektorlabor, Exzellenzcluster PRISMA+, 55128 Mainz, Germany

NuDoubt^{++} searches for neutrinoless double beta plus decay with opaque scintillators. These scintillators have a very short scattering length but long absorption length and can be used to confine the light emitted after particle interactions in a small detector volume. A dense grid of wavelength shifting optical fibers deployed in the scintillating material and equipped with SiPMs then enables the detection of a significant fraction of the emitted photons. This approach allows efficient identification of particles as well as a precise reconstruction of the particles energy.

Photon propagation in such a detector can be approximated using diffusion models. However, this does not take into account shadowing effects of the deployed fibers, which can lead to significant differences in the expected photon counts. This effect can be corrected using MC simulations. In this presentation, the event reconstruction based on a diffusion model is shown.

T 57.5 Wed 17:00 Geb. 30.21: Gerthsen-HS

Update on the ECHo experiment — •Raghav Pandey for the ECHo-Collaboration — Kirchhoff Institute for Physics, Heidelberg University

In the ECHo experiment large arrays of low temperature metallic magnetic calorimeters (MMCs) enclosing Ho-163 are used for the high resolution measurement of the electron capture spectrum. The goal of the experiment is to achieve the sensitivity to detect an extremely small spectral shape distortion in the end point region due to a finite neutrino mass. Thanks to the modular construction of the experiment, several phases have been foreseen. The first phase, ECHo-1K was designed to test the properties and reproducibility of MMCs with implanted Ho-163. With a small scale experiment a sensitivity on the effective electron neutrino mass 10 times better than the present limit of 150 eV at 90% C.L. can be achieved. Presently, studies to reduce systematic effects on the interpretation of the spectrum and small experiments for the quantification of systematic errors are on-going. At the same time, preparation of large detector arrays and multiplexed readout for the ECHo-100k phase is on-going. Important milestones for detector fabrication, in particular related to Ho-163 implantation on wafer scale, have been reached. We present the status of ECHo-100k and discuss our perspectives for achieving a sensitivity at the 1 eV/c2 level for the effective electron neutrino mass.

T 57.6 Wed 17:15 Geb. 30.21: Gerthsen-HS

Activity of Ho-163 in wafer-scale implanted ECHo-100k chips — •Marta Kruhlik[1], Arnulf Barth[1], Sebastian Berndt[2,3], Terese Buchta[1], Holger Dorrer[3], Christoph E. Düllmann[3,4,5], Loredana Gastaldo[1], Daniel Hengstler[1], Nina Kneip[2], Raghav Pandey[1], Daniel Unger[1], and Klaus Wendt[2] — [1]Kirchhoff Institute for Physics, Heidelberg University — [2]Institute of Physics, Johannes Gutenberg-Universität Mainz — [3]Department of Chemistry - TRIGA Site, Johannes Gutenberg-Universität Mainz — [4]GSI Helmholtzzentrum Darmstadt — [5]Helmholtz Institute Mainz

The primary objective of the ECHo collaboration is to determine the neutrino mass scale by analysing the endpoint region of the Ho-163 electron capture spectrum. To be sensitive to the effect of a finite neutrino mass on the spectral shape, high energy resolution and the acquisition of many Ho-163 events are mandatory. Using arrays of many MMCs to acquire the spectrum, an energy resolution better than 5 eV FWHM has already been demonstrated. For the ECHo-100k phase, more than 100 chips are planned, each comprising 64 detector pixels with an activity of around 10 Bq per pixel. An efficient production of these detectors requires the possibility to implant Ho-163 on the entire 3 inch wafer. A first test of the wafer-scale implantation has been performed using the RISIKO facility at Mainz University. We present the results obtained through the characterization of several pixels in three chips and discuss the determined activity and its homogeneity across a chip and the wafer. Then we conclude with a perspective on the fabrication of the required detectors for the ECHo-100k experiment.

T 57.7 Wed 17:30 Geb. 30.21: Gerthsen-HS

Insight into the Neural Network Analysis of the KATRIN Neutrino Mass Data — Christoph Köhler, Susanne Mertens, •Jan Plössner, Alessandro Schwemmer, Xaver Stribl, and Christoph Wiesinger for the KATRIN-Collaboration — Chair for Dark Matter E47, Technical University of Munich

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. The combined sensitivity of the first five data sets with six-fold increase in statistics is below $0.5\,\mathrm{eV\,c^{-2}}$ (90 % CL). Since then, the collected statistics was increased by another factor of three. In this presentation I will talk about the neural network analysis of the KATRIN neutrino mass data and provide an update on the current status beyond the fifth neutrino mass campaign.

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T 57.8 Wed 17:45 Geb. 30.21: Gerthsen-HS

Search for Light Sterile Neutrinos with the KATRIN Experiment using a Neural Network — •Xaver Stribl and Susanne Mertens for the KATRIN-Collaboration — Chair fo Dark Matter E47, Technical Universityof Munich

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 status of the light sterile neutrino analysis of the KATRIN experiment. To handle the increasing computational challenge, a neural network is adapted for the analysis and then used to study the sensitivity of the first five measurement campaigns. The obtained sensitivity is compared to current results and anomalies in the field of light sterile neutrinos. Further, the possibility of including the active neutrino mass in the analysis with the neural network is explored.