T 29: Neutrino physics 3

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

T 29.1 Tue 16:00 Geb. 20.30: 2.058

JUNO's sensitivity to the neutrino mass ordering in presence of a fine structure in the reactor antineutrino spectrum — •Tobias Heinz, Tanjina Anannya, Lukas Bieger, Marc Breisch, Jessica Eck, Benedict Kaiser, Florian Kirsch, Tobias Lachenmaier, Dhanushka Bandara, and Tobias Sterr — Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kt liquid scintillator detector with the main goal to determine the neutrino mass ordering (NMO) to 3σ within 6 years of data taking. It will measure the oscillated electron antineutrino spectrum emitted by two nuclear power plants in a distance of 53 km with an unprecedented energy resolution of better than 3% at 1 MeV. For the identification of the NMO in the oscillated spectrum, a precise knowledge of the unoscillated reactor antineutrino spectrum is crucial. However, new model calculations predict a fine structure in the spectrum that has not been observed with previous detectors due to insufficient energy resolution. For JUNO, these unknown distortions in the spectrum could impact the NMO determination. Therefore, JUNO will feature a satellite detector in a distance of 44 m from one of the reactor cores, the Taishan Antineutrino Observatory (TAO), that will provide a reference spectrum with an energy resolution of better than 2% at 1 MeV. This talk will present studies on possible implications of this fine structure on JUNO's NMO sensitivity and on the important role of the satellite detector TAO to reduce the impact of the unknown spectral distortions.

This work is supported by the Deutsche Forschungsgemeinschaft.

T 29.2 Tue 16:15 Geb. 20.30: 2.058

Feasibility study of tau appearance measurement with the ANTARES neutrino telescope. — •Michail Chadolias for the ANTARES-KM3NET-ERLANGEN-Collaboration — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg

The ANTARES detector, a water Cherenkov neutrino telescope located in the Mediterranean Sea at a depth of 2.5 kilometres, operated successfully until its decommissioning in 2022. Primarily designed for detecting high-energy neutrinos of astrophysical origin, it was also sensitive to all neutrino flavours in the atmospheric neutrino flux with an energy threshold of a few GeV. This work focuses on tau neutrino appearance, i.e. the existence of a tau neutrino atmospheric flux component due to neutrino flavour oscillations at this energy range. Exploiting the data of the full 15-year detector lifetime, we report on an exploratory analysis investigating the feasibility to detect and characterise a flux of tau neutrinos with the ANTARES detector. Strategies for the challenging event selection and the current status of the sensitivity to the tau neutrino flux normalisation will be shown.

T 29.3 Tue 16:30 Geb. 20.30: 2.058

Search for Neutrinoless Double Beta Plus Decays with NuDoubt^{++} —

Manuel Böhles[1], Sebastian Böser[1], Magdalena Eisenhuth[1], Cloé 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

The discovery of neutrino oscillations two decades ago opens the possibility for new physics as to the origin of their masses. Due to their lack of electrical charge, neutrinos could carry Majorana masses causing lepton number violation. This phenomenon could be discovered in neutrinoless double beta decays, where the participating neutrinos are exchanged only internally.

Until now, searches for neutrinoless double beta decays concentrated on double electron emission. With the recent advancement of novel scintillator types capable of unprecedented particle discrimination, the measurement of double positron emission comes into reach.

In this presentation, we introduce NuDoubt^{++}, which is going to use loaded hybrid opaque scintillator to search for double positron emission. We present its advanced particle discrimination capabilities based on topological features of energy depositions and ratios of Cherenkov and scintillation light. Moreover, we illustrate its loading techniques, as well as novel highly effective light readout.

T 29.4 Tue 16:45 Geb. 20.30: 2.058

Development of a High-Pressure Scintillator Test Cell for NuDoubt++ — Tim Charisse[1], Manuel Böhles[1], Sebastian Böser[1], Marcel Büchner[1], •Magdalena Eisenhuth[1], Cloé Girard[1], Arshak Jafar[1], Bastian Kessler[1], Kyra Mossel[1], Stefan Schoppmann[2], Alfons Weber[1], and Michael Wurm[1] for the NuDoubt-Collaboration — [1]JGU Mainz, Institute of Physics, 55128 Mainz — [2]Exzellenzcluster PRISMA+, 55128 Mainz

The investigation of two-neutrino and neutrino-less double beta decay is crucial for understanding the Dirac or Majorana nature of neutrinos. In this context, the krypton isotope Kr-78 (Q=2.88 MeV) stands out as a promising candidate for a first detection of two-neutrino ECb+ and 2b+ decays. Detectors like the proposed NuDoubt++ experiment featuring opaque scintillator or an upgrade of the OSIRIS detector with hybrid scintillator can profit from solving the krypton gas in the scintillator at high pressure to increase the loading factor. This presentation explores the progress in developing a high-pressure scintillator test cell designed to examine the krypton loading factor. We discuss the design and fabrication of this overpressure test cell and, finally, elaborate on the methodology for measuring the loading factor in the scintillator volume.

T 29.5 Tue 17:00 Geb. 20.30: 2.058

Radiation hardness studies of the KATRIN detector upgrade to search for keV sterile neutrinos — •Verena Wallner — Technische Universität München, Deutschland

Sterile neutrinos represent a minimal expansion of the Standard Model of particle physics and serve as potential dark matter candidates when their mass falls within the keV range. Tritium beta decay can be used to experimentally observe sterile neutrinos with a mass of up to 18.6 keV. In that case, they would display a kink-like distortion in the electron energy spectrum. Currently, a silicon drift detector upgrade (TRISTAN) is being developed for the KATRIN experiment to search for keV-scale sterile neutrinos. This presentation is about the radiation hardness to electrons of the detector system. To investigate this question, a detection module is irradiated over a short period of time with electrons such that the integrated dose corresponds to one year's data acquisition with TRISTAN.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6) and has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programm (grant agreement No. 852845).

T 29.6 Tue 17:15 Geb. 20.30: 2.058

Development of technologies for a future neutrino mass experiment at KATRIN — •Caroline Rodenbeck and Magnus Schlösser — IAP-TLK, KIT

The Karlsruhe Tritium Neutrino (KATRIN) experiment determines the neutrino mass by electron spectroscopy of the tritium beta-decay spectrum. After a total measurement time of 1000 days in 2025, a final sensitivity better than $0.3\,\mathrm{eV/c^2}$ (90% C.L.) is anticipated.

Ultimately, determining the neutrino mass may require constructing experiments with sensitivities as low as the lower boundaries obtained by neutrino oscillation experiments ($40\,\mathrm{meV/c^2}$ in case of inverted ordering, or $8\,\mathrm{meV/c^2}$ for normal ordering). To reach those sensitivities, we are developing new technologies such as a differential detector with sub-eV resolution, and an atomic tritium source.

For the differential detector, we are currently testing quantum sensors, more precisely, μm-sized cryogenic ($10\,\mathrm{mK}$) calorimeters. We aim to build a demonstrator where we couple a large quantum-sensor array of up to 10^6 channels to the existing KATRIN beamline.

Additionally, we are building a first-of-its-kind setup for creating tritium atoms. We plan to make it part of another demonstrator – after solving key challenges for future atomic sources (mK-cooling, storing of atoms) in cooperation with the global community (e.g. Project 8).

Both technology demonstrators will be paramount for the design of the ultimate neutrino mass experiment.

This work is supported by the Helmholtz Association and BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2, and 05A23WO6).

T 29.7 Tue 17:30 Geb. 20.30: 2.058

Studying atomic hydrogen generation to pave the way to the first atomic tritium source — •Leonard Hasselmann for the KATRIN-Collaboration — KIT-IAP, Karlsruhe, Germany

The Karlsruhe Tritium Neutrino mass (KATRIN) experiment is currently limited to a sensitivity of $0.2 - 0.3\,\mathrm{eV/c^2}$. In order to increase the sensitivity on the neutrino mass a new high resolution differential measurement method is required. The maximum effective resolution which can be achieved is not limited only by the detector, but also by molecular effects in the source gas constraining it to ~1 eV FWHM for T_2. Thus, future ultimate neutrino experiments need to use differential detectors combined with atomic tritium sources. Therefore, we move forward with the development of atomic tritium sources.

At the Tritium Laboratory Karlsruhe exists a system handling inactive hydrogen isotopes which acts as a test bed for the development of beam forming and beam diagnostics. In this setup, we recently fully characterized a commercially available hydrogen cracking system.

Based on experiences from the first setup, we deduced a second system capable of handling tritium. This setup, currently under construction, will demonstrate the first dissociation of tritium.

In this talk, we show results from non-radioactive gases like protium and deuterium. Furthermore, the implication for the current design and implementation status of a tritium-compatible system is presented.

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 29.8 Tue 17:45 Geb. 20.30: 2.058

Investigating Large Area Picosecond Photodetectors for future ν-detectors — •Benedict Kaiser, Tanjina Anannya, Lukas Bieger, Marc Breisch, Jessica Eck, Tobias Heinz, Florian Kirsch, Tobias Lachenmaier, Dhanushka Bandara, and Tobias Sterr — Eberhard Karls Universität Tübingen, Physikalisches Institut

Large Area Picosecond Photodetectors (LAPPDs) are novel Microchannel Plate (MCP) based photodetectors. With a gain ranging from 10^6 to 10^7 and a gain uniformity of 90% across a large active area of $373\,\mathrm{cm}^2$ they are capable of detecting single photons. They show a position resolution of 3 mm and an unparalleled time resolution better than 70 ps.

This exceptional performance is achieved by a flat, evacuated glass case accommodating a K_2NaSb photocathode, a chevron arrangement of two MCPs for electron multiplication and 28 silver anode strips dedicated to signal detection. Presently, our focus lies in validating LAPPD performance characteristics using a dedicated test stand.

This talk presents the operational principles and distinctive features of LAPPDs and provides an overview of our measurement findings so far.