T 22: Neutrino Physics II

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

T 22.1 Tue 16:15 AudiMax

Particle Identification in the Hybrid Opaque Scintillator Experiment NuDoubt++ — •Kyra Mossel for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz

Neutrinoless double beta decay is a hypothetical lepton-number-violating process whose observation would establish the Majorana nature of the neutrino. Detecting this extremely rare decay demands exceptionally low background levels and highly effective particle identification techniques.

The NuDoubt++ experiment investigates double beta plus decay modes using a novel hybrid opaque scintillator instrumented with a dense grid of optical fibers coupled to SiPMs. This detector concept enables the reconstruction of energy-deposit topology while simultaneously exploiting the ratio of Cerenkov to scintillation light to enhance background rejection and particle identification.

In this presentation, event reconstruction and particle identification methods developed for NuDoubt++ are presented. Performance studies based on Monte-Carlo simulations are shown, demonstrating the potential of this approach for rare event searches.

T 22.2 Tue 16:30 AudiMax

NuDoubt^{++}: Search for Double Beta Plus Decays — •Veronika Palusova for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz

Double beta plus decay modes ($\beta^+\beta^+$, β^+EC, and 2EC) are rare second-order weak processes converting two protons into two neutrons. Their observation is difficult due to extremely low probabilities, complex signatures, and the low natural abundance of suitable isotopes. Studying these decays offers insights into nuclear structure and fundamental symmetries. Decay rates depend on nuclear matrix elements (NMEs) and phase space factors (PSFs), crucial for interpreting data and refining theoretical models. We introduce NuDoubt^{++}, a novel detector concept for double beta plus decay searches with unprecedented sensitivity. It integrates hybrid and opaque scintillation technologies with advanced light readout to enhance positron detection. Preliminary estimates show that a 1-tonne-week exposure could reach sensitivity to $2\nu\beta^+\beta^+$ and $2\nu\beta^+$EC decays in ^{78}Kr. The design also improves background rejection and resolution, enabling exploration of $0\nu\beta^+\beta^+$ decay beyond current limits.

T 22.3 Tue 16:45 AudiMax

LEGEND-1000: Quasi Background-Free Search for Neutrinoless Double Beta Decay in ^{76}Ge at the Ton-Scale — •Lorenz Gessler for the LEGEND-Collaboration — Eberhard Karls Universität, Tübingen, Germany

In pursuit of the observation of the first lepton-number violating process, the LEGEND collaboration is progressing towards a next-generation detector – LEGEND1000. The search for the neutrinoless double beta decay of ^{76}Ge probes the Majorana nature of neutrinos as well as the absolute neutrino mass scale, directly accessing physics beyond the Standard Model. Lessons learned from GERDA, MAJORANA Demonstrator and LEGEND200 allow us to further improve background mitigation strategies and to bring state-of-the-art high-purity germanium detector technology to the ton-scale, enabling a quasi background-free regime at the design exposure. This will allow LEGEND1000 to probe the entire effective Majorana mass range of the inverted ordering, corresponding to a half-life sensitivity exceeding 10^{28} yr. This overview talk summarizes the current status of LEGEND1000 and highlights recent progress in the experimental design, background rejection strategy, and overall detector concept.

We acknowledge support from the DFG under Germany's Excellence Strategy – EXC 2094 (ORIGINS) and through the Sonderforschungsbereich SFB 1258. We acknowledge support by the BMFTR Verbundprojekt 05A2023 (LEGEND).

T 22.4 Tue 17:00 AudiMax

LEGEND-200: Recent results and experimental status — •Nadezda Rumyantseva for the LEGEND-Collaboration — Department of Physics, TUM School of Natural Sciences, Technical University of Munich, 85748 Garching b. München, Germany

LEGEND is a staged program progressing from LEGEND–200 to the ton-scale LEGEND–1000, searching for neutrinoless double-beta decay ($0\nu\beta\beta$) in ^{76}Ge. Using enriched high-purity germanium detectors, LEGEND targets discovery sensitivity to half-lives beyond 10^{28} years.

LEGEND builds on the GERDA and MAJORANA Demonstrator experiments and employs novel inverted-coaxial HPGe detectors operated in instrumented liquid argon, providing powerful signal identification and background rejection capabilities. The first LEGEND–200 physics results are based on an exposure of 61.0 kg yr and, in combination with GERDA and the MAJORANA Demonstrator, achieve a world-leading 90% confidence-level exclusion sensitivity of 2.8×10^{26} yr and set a lower limit of $T^{0\nu}_{1/2} > 1.9\times10^{26}$ yr.

This talk summarizes the LEGEND–200 experimental concept, background-reduction strategy, and latest results.

We acknowledge support from the DFG under Germany's Excellence Strategy – EXC 2094 (ORIGINS) and through the Sonderforschungsbereich SFB 1258. We also acknowledge support from the BMFTR Verbundprojekt 05A2023 (LEGEND).

T 22.5 Tue 17:15 AudiMax

First observation of reactor antineutrinos by coherent scattering with CONUS+ — •Nicola Ackermann for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The CONUS+ experiment measures coherent elastic reactor antineutrino nucleus scattering (CEvNS) on germanium nuclei. The detector is located at the KKL nuclear power plant in Leibstadt, Switzerland at a distance of 20.7 m from the reactor core. It uses four High Purity Germanium detectors with energy thresholds of ~ 160 eV. In Run 1 of the experiment, which lasted from November 2023 to August 2024, the first observation of a CEvNS signal from a nuclear reactor was achieved. In 119 days of data taking (395+-106) anti-neutrinos were measured, compared to a predicted number of (347+-59) events. For improved sensitivity, the experiment is currently taking data in Run 2 using three new 2.4 kg germanium detectors.

T 22.6 Tue 17:30 AudiMax

Beyond the Standard Model investigations at CONUS+ — •Dario Piani for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The detection of coherent elastic neutrino-nucleus scattering (CEνNS) opens up new opportunities for neutrino physics within and beyond the standard model (BSM) of elementary particles. The first detection of CEνNS at nuclear reactors by the CONUS+ experiment allows very valuable tests of BSM scenarios in a low momentum transfer regime. Among them, Non Standard Interactions (NSIs), light mediators (scalar and vector couplings) and electromagnetic properties were tested, setting very competitive limits in both the nuclear scattering interaction channel as well as the electron scattering channel. In particular, for vector NSIs a sensitivity to new physics of up to 145 GeV was achieved. Whereas, for the light mediators, couplings down to 10^{-6} were probed.

T 22.7 Tue 17:45 AudiMax

Exploring coherent elastic neutrino-nucleus scattering with NUCLEUS: Overview of the experiment — •Alexander Wallach for the NUCLEUS-Collaboration — Technical University Munich, Munich, Germany

Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) is a pure weak-neutral current interaction predicted within the Standard Model. The CEνNS cross section is several orders of magnitude larger than that of other low-energy neutrino interactions, enabling its study with small, highly sensitive detectors. Investigating CEνNS provides a pathway to probe neutrino properties, explore physics beyond the Standard Model, and address the CEνNS background in dark matter searches.

The NUCLEUS experiments aim to perform precision measurements of CEνNS properties using reactor antineutrinos at the Chooz nuclear power plant. In order to measure nuclear recoils below 100eV, NUCLEUS employs a multi-stage detection system, consisting of $CaWO_4$ and Al_2O_3 cryogenic calorimeters with an $\mathcal{O}(10\,\mathrm{eV})$ energy threshold, surrounded by a twofold system of instrumented cryogenic vetoes, an external passive shielding and a muon veto to improve the identification and discrimination of backgrounds.

In this talk I will give an overview of the NUCLEUS experiment, focusing on the underlying physics motivation and the detection concept.

T 22.8 Tue 18:00 AudiMax

Exploring coherent elastic neutrino-nucleus scattering: status of the NUCLEUS experiment — •Lars Wienke for the NUCLEUS-Collaboration — Technische Universität München, München, Deutschland

Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) is a Standard Model process in which a neutrino scatters coherently off an entire nucleus via weak neutral current interactions. The CEνNS cross section is several orders of magnitude larger than that of other low-energy neutrino interactions, which makes this process a powerful tool to probe various physics scenarios, motivating a worldwide effort to detect the tiny nuclear recoils it produces.

The NUCLEUS experiment aims to perform precision measurements of CEνNS properties using reactor antineutrinos at the Chooz nuclear power plant. In order to measure nuclear recoils below 100eV, NUCLEUS employs a multi-target detection system, consisting of $CaWO_4$ and Al_2O_3 cryogenic calorimeters with an O(10eV) energy threshold, surrounded by a twofold system of instrumented cryogenic vetoes, an external passive shielding and a muon veto to improve the identification and discrimination of backgrounds.

At present, the experiment is in the last steps of commissioning in the shallow underground laboratory at the Technical University of Munich (TUM), and the relocation to the Chooz-B nuclear power plant in the French Ardennes is underway. In this talk, I will provide an overview of the experiment's current status, focusing on the latest developments, milestones achieved and future plans.

T 22.9 Tue 18:15 AudiMax

Development of a Novel Te-doped Liquid Scintillator with Slow Light Emission for $0\nu\beta\beta$-Decay Searches in a Hybrid Neutrino Detector — •Hans Th. J. Steiger[1], M. Beretta[2], M. Böhles[3], A. Garfagnini[4], A. Gavrikov[4], P. Lombardi[2], K. Loo[5], E. Pasini[4], B. Rasera[4], A. Serafini[4], K. Walter[1], and M. Wurm[3] — [1]Technical University of Munich, TUM School of Natural Sciences, Garching, Germany — [2]INFN, Sezione di Milano e Università degli Studi di Milano, Dipartimento di Fisica, Italy — [3]Institute for Physics, Johannes Gutenberg University Mainz, Mainz, Germany Mainz, Germany — [4]Dipartimento di Fisica e Astronomia dell' Universita di Padova and INFN Sezione di Padova, Padova, Italy — [5]University of Jyväskylä, Department of Physics, Jyväskylä, Finland

It is a long-standing paradigm that organic scintillators allow excellent energy resolution but no directional reconstruction. Here we show the foundation for overcoming this by scintillators with slow light emission, paving the way for hybrid detectors that combine the advantages of Cherenkov and scintillation detectors. In such slow liquid scintillators, it is possible to reconstruct directional and topological information from Cherenkov light, while the high light yield of an organic scintillator ensures excellent energy resolution and low thresholds necessary for many applications in neutrino and particle physics such as the search for the $0\nu\beta\beta$ decay. We also developed a novel loading technique for these scintillators with 130Te and show studies of fundamental properties of these scintillators and the novel dopant. This work is supported by the Clusters of Excellence PRISMA+ and ORIGINS.