T 75: Neutrino Physics without Accelerators 6

Time: Wednesday 16:15–18:35 Location: T-H34

Group Report T 75.1 Wed 16:15 T-H34

Overview of LEGEND and the Commissioning Status of LEGEND-200 — •Patrick Krause for the LEGEND-Collaboration — Physik-Department, Technische Universität München, Garching

The discovery that neutrinos are Majorana fermions would have profound implications for particle physics and cosmology. The Majorana character of neutrinos would make neutrinoless double-beta ($0\nu\beta\beta$) decay, a matter-creating process without the balancing emission of antimatter, possible. The LEGEND Collaboration pursues a phased, ^{76}Ge-based double-beta decay experimental program with discovery potential covering the inverted hierarchy. The first phase, LEGEND-200, will have a discovery potential of 10^{27} years and a background index of 0.6 cts/(ROI t yr). The second phase, LEGEND-1000, will deploy 1000 kg of enriched germanium and will have a discovery sensitivity beyond 10^{28} years. This talk will give an overview of LEGEND and will report on the currently ongoing commissioning work in LEGEND-200. This research is supported in part by the BMBF through the Verbundforschung 05A2020, the MPG, the DFG through the Excellence Cluster ORIGINS and the SFB1258, and the through the ERC Advanced Grant 786430 - GemX

T 75.2 Wed 16:35 T-H34

ASIC based readout electronics for high-purity Germanium detectors in LEGEND-1000 — •Florian Henkes, Frank Edzards, Susanne Mertens, and Michael Willers for the LEGEND-Collaboration — Technische Universität München, München, Deutschland

The **L**arge **E**nriched **G**ermanium **E**xperiment for **N**eutrinoless $\beta\beta$ **D**ecay (LEGEND) is a ton-scale, ^{76}Ge-based, neutrinoless double-beta ($0\nu\beta\beta$) decay experimental program with discovery potential at half-lifes greater than 10^{28} years.

Signal readout electronics are essential in order to achieve the experiment's sensitivity on $0\nu\beta\beta$-decay. The close proximity to the detectors poses unique challenges to balance electronic performance with radiopurity requirements. In LEGEND-200, the readout system consists of a charge sensitive amplifier realised from discrete components with an ultra radiopure first stage close to the detectors and a second stage from less radiopure commercial components. In LEGEND-1000, the use of **A**pplication-**S**pecific **I**ntegrated **C**ircuit (ASIC) technology would allow to implement the entire charge sensitive amplifier into a single low-mass chip with ultimate electronic noise performance and signal fidelity while ideally further reducing backgrounds.

In this contribution, the current status of the LEGEND-1000 ASIC based readout development at the Technical University of Munich will be presented and prospects for future developments of ASIC based charge sensitive amplifiers for high-purity germanium detectors will be discussed.

T 75.3 Wed 16:50 T-H34

Constraining the $^{77(m)}$Ge Production with GERDA Data and Implications for LEGEND-1000 — •Moritz Neuberger[1], Luigi Pertoldi[1], Stefan Schönert[1], and Christph Wiesinger[1,2] for the GERDA-Collaboration — [1]Physik-Department E15, Technische Universität München — [2]Max-Planck-Institut für Physik (Werner-Heisenberg-Institut) Föhringer Ring 6 80805 München

The delayed decay of $^{77(m)}$Ge, produced by neutron capture on ^{76}Ge, is a potential background for the next-generation neutrino-less double-beta decay experiment LEGEND-1000, especially when considering the alternative LNGS site. Based on Monte Carlo simulations, various mitigation strategies and suppression techniques have been proposed to tackle this background [1,2]. In this talk we will present first results on $^{77(m)}$Ge searches in the full GERDA data. Given the very similar configuration - bare germanium detectors in liquid argon - it serves as a benchmark for our LEGEND-1000 predictions. This research was supported by the BMBF through the Verbundforschung 05A20WO2 and by the DFG through the SFB1258 and Excellence Cluster ORIGINS.

[1] C. Wiesinger et al., Eur. Phys. J. C (2018) 78: 597
[2] LEGEND-1000 pCDR, arXiv 2107.11462

T 75.4 Wed 17:05 T-H34

First light in LEGEND-200 — •Rosanna Deckert, Patrick Krause, Laszlo Papp, and Stefan Schönert — Technische Universität München

LEGEND (Large Enriched Germanium Experiment for Neutrinoless $\beta\beta$ Decay) is a ton-scale experiment to search for neutrinoless double beta ($0\nu\beta\beta$) decay using high-purity germanium detectors enriched in ^{76}Ge. An observation of $0\nu\beta\beta$ decay would prove the existence of lepton number violation and provide insight into the nature of neutrino masses. The first phase of the experiment LEGEND-200 will deploy 200 kg of enriched material and aims for a sensitivity of 10^{27} years on the $0\nu\beta\beta$ half-life. To achieve this, the germanium detectors will be operated in liquid argon (LAr), instrumented as an active detector to detect the scintillation light produced by backgrounds from trace radioactive contaminants.

Commissioning of the LAr instrumentation, consisting of wavelength-shifting fibers, a wavelength-shifting reflector and silicon photomultiplier arrays, started in August 2021 at the Laboratori Nazionali del Gran Sasso. In this talk, the analysis of the first LAr commissioning data for LEGEND-200 will be presented.

This research is supported by the BMBF through the Verbundforschung 05A20WO2 and by the DFG through the Excellence Cluster ORIGINS and the SFB1258.

T 75.5 Wed 17:20 T-H34

New Limit on the radiative 0νECEC of ^{36}Ar from GERDA Phase II Data — •Michele Korosec[1], Elisabetta Bossio[1], and Christoph Wiesinger[2] for the GERDA-Collaboration — [1]Physik-Department, Technische Universität München — [2]Max-Planck-Institut für Physik, München

Neutrinoless double electron capture (0νECEC) is a theoretically possible decay that would prove lepton number violation, which is forbidden by the Standard Model of Physics, and therefore provide evidence for the Majorana nature of neutrinos. The GERmanium Detector Array (GERDA) experiment offers the possibility to search for 0νECEC of ^{36}Ar which is one of the isotopes that theoretically allows this rare decay.

A search for neutrinoless double electron capture of ^{36}Ar was conducted based on Phase II data from the GERDA experiment, located at the Gran Sasso Laboratory of INFN, Italy. A simultaneous fit to multiple datasets has been performed in which no signal for the decay has been observed. However, a new, preliminary experimental lower limit on the half-life of 0νECEC in ^{36}Ar has been established with the CLs method at $T_{1/2} > 1.22 \cdot 10^{22}$ yr (90% C.L.) which will take over from the previous best limit of $T_{1/2} > 3.6 \cdot 10^{21}$ years (90% C.I.) [1] which was found in GERDA Phase I.

This research is supported by the BMBF through the Verbundforschung 05A20WO2 and by the DFG through the Excellence Cluster ORIGINS and the SFB1258. [1] GERDA Collaboration, Eur.Phys.J.C 76 (2016) 12, 652

T 75.6 Wed 17:35 T-H34

***In-situ* characterization of germanium detectors from ^{39}Ar decays for low-energy data modeling in GERDA and LEGEND** — •Luigi Pertoldi for the GERDA-Collaboration — TU München, Germany

A reliable estimate of the active volume of high-purity germanium (HPGe) detectors, defined as the internal volume in which charge collection efficiency (CCE) reaches its maximum, is a fundamental piece of a detector's response model. Typical HPGe detectors feature a null or incomplete CCE in correspondence with the lithium-doped, high-voltage bias contact. In this contribution, a new method for determining the active volume of HPGe detectors immersed in liquid argon (LAr), will be presented. The method exploits the shape of the low-energy distribution of ^{39}Ar β^- decays, naturally occurring in atmospheric LAr and recorded by the detectors, which strongly depends on the CCE profile. The technique is applied to physics data by the GERDA experiment and used to characterize the deployed detectors *in-situ*. As a consequence, a first model of the low-energy data spectrum recorded by the experiment will also be shown. The developed technique will be useful for the LEGEND experiment, which aims to perform searches of new-physics phenomena at low energies. Moreover, by using these novel ^{39}Ar-based active volume estimates, we aim to obtain a precise and unbiased estimate of the two-neutrino double-beta decay rate of ^{76}Ge. This research is supported by the BMBF

through the Verbundforschung 05A20WO2 and by the DFG through the Excellence Cluster ORIGINS and the SFB1258.

T 75.7 Wed 17:50 T-H34

New results on the ^{76}Ge double-beta decay with neutrinos and exotic decay modes from GERDA Phase II — •Elisabetta Bossio for the GERDA-Collaboration — Physik Department, Technische Universität München, Garching, Germany

Two-neutrino double beta ($2\nu\beta\beta$) decays are amongst the rarest nuclear processes ever observed. Precision studies of the electron sum energies require ultra-low background and an excellent understanding of the experiment's response. Both are key features of the Germanium Detector Array (GERDA) experiment, which searched for neutrino-less double beta ($0\nu\beta\beta$) decay with enriched high purity germanium detectors in Liquid Argon at Laboratori Nazionali del Gran Sasso (LNGS) in Italy. The measurement of the Standard Model $2\nu\beta\beta$ decay half-life of ^{76}Ge was performed with unprecedented precision, profiting from the high signal-to-background ratio and the small systematic uncertainties. It provides essential inputs for nuclear structure calculations, that benefit the interpretation of $0\nu\beta\beta$ decay results. Furthermore, the search for distortions of the $2\nu\beta\beta$ decay spectrum allows exploring new physics, like $0\nu\beta\beta$ decay with Majorons emission, Lorentz invariance, or search for sterile neutrinos. The new results of the ^{76}Ge $2\nu\beta\beta$ decay half-life and improved limits on exotic decay modes will be presented in this talk.

This research is supported by the BMBF through the Verbundforschung 05A20WO2 and by the DFG through the Excellence Cluster ORIGINS and the SFB1258.

T 75.8 Wed 18:05 T-H34

Double weak decays of ^{124}Xe and ^{136}Xe in XENON1T and XENONnT — •Christian Wittweg for the XENON-Collaboration — Physik-Institut, Universität Zürich

In recent years xenon-based dark matter direct detection experiments have reached large enough target masses and low enough background levels to also probe rare double weak decays. Among these decays are the two-neutrino double electron capture (2νECEC) of ^{124}Xe as well as the neutrinoless double beta decay ($0\nu\beta\beta$) of ^{136}Xe. Observation of the hypothetical neutrinoless decay would provide definite proof of the neutrino's Majorana nature and indicate lepton number violation. The measurement of the Standard Model 2νECEC – first detected by XENON1T in 2018 – provides nuclear structure information that is a crucial input for the nuclear models used to interpret $0\nu\beta\beta$ experiments. This contribution will present the ^{124}Xe 2νECEC results and search for $0\nu\beta\beta$ of ^{136}Xe in XENON1T. Moreover, the sensitivity projection for a ^{136}Xe $0\nu\beta\beta$ search in XENONnT will be outlined.

T 75.9 Wed 18:20 T-H34

Latest results from XENON1T and prospects for XENONnT for $0\nu\beta\beta$ — •Tim Michael Heinz Wolf for the XENON-Collaboration — MPIK, Heidelberg, Deutschland

XENON1T was a dual-phase xenon time projection chamber (TPC) looking mainly for the direct detection of WIMP dark matter at energy depositions of up to tens of keV. This talk will focus on the high energy part of the spectrum (above hundreds of keV) where we can search for neutrinoless double beta decay ($0\nu\beta\beta$). This is a hypothetical process implying two beta decays without emitting any neutrinos. The natural isotope ^{136}Xe (abundance approximately 8.9%) is a candidate isotope to look for $0\nu\beta\beta$ which allows to carry out a search in LXe TPCs. This process tests lepton flavour conservation and it is potentially able to shed light on the nature of neutrinos (Dirac or Majorana particles) or give hints on the mass ordering of neutrinos. We present for the first time, a search for $0\nu\beta\beta$ where a limit on the $0\nu\beta\beta$ half-life of ^{136}Xe with XENON1T data is derived, and give prospects on the performance of XENONnT data.