T 28: Niederenergie Neutrinophysik II

Zeit: Montag 16:45–19:00 Raum: I.12.01 (HS 30)

T 28.1 Mo 16:45 I.12.01 (HS 30)

Excited state transitions in $2\nu\beta\beta$ decays of ^{76}Ge from Phase I of the GERDA experiment. — •Thomas Wester for the GERDA-Collaboration — IKTP, TU Dresden

The Germanium Detector Array GERDA is an experiment searching for the neutrinoless double beta decay in ^{76}Ge. The observation of such a decay would prove the Majorana character of the neutrino and could provide a hint about the neutrino mass and possibly identify the mass hierarchy scheme.

The half life of the neutrino accompanied double beta decay ($2\nu\beta\beta$) of ^{76}Ge has been measured by GERDA Phase I with unprecedented precision. The observed spectrum comes mostly from the transition from the 0^+ ground state of ^{76}Ge to the 0^+ ground state of ^{76}Se. However, phase space suppressed $2\nu\beta\beta$ transitions to excited states of ^{76}Se exist as well. At current state, the predicted half lives for such decays vary by several orders of magnitute, due to the large uncertainties in the nuclear matrix elements and the available nuclear models. An observation would therefore help to constrain model parameters and decrease those uncertainties.

This study investigates the $2\nu\beta\beta$ decay of ^{76}Ge into various excited states of ^{76}Se using the data from GERDA Phase I. An event counting method is performed based on coincident events between two germanium detectors. Several analysis parameters are optimized with the help of Monte Carlo simulations to maximize the sensitivity. The presentation will discuss the procedure and results of this analysis.

T 28.2 Mo 17:00 I.12.01 (HS 30)

In-situ measurement of the light attenuation in liquid argon in the GERDA cryostat — •Birgit Schneider for the GERDA-Collaboration — IKTP, TU Dresden, Germany

GERDA is an experiment searching for neutrinoless double beta decay in ^{76}Ge. It uses germanium detectors which are enriched in ^{76}Ge and operates them naked in liquid argon (LAr), which serves both as a coolant and a shield for external radiation. For phase II of GERDA it is planned to reach an exposure of 100 kg · yr with a BI of 10^{-3} cts/(kg · yr · keV). One of the major improvements to further reduce the BI is to instrument the LAr to act as an additional background veto. The attenuation of the scintillation light in LAr creates a constraint on the effective active volume of the LAr veto and is therefore a key parameter to characterize the instrumentation.

In order to measure the light attenuation in LAr, a setup was designed that could be deployed directly into the GERDA cryostat. This setup contains a movable beta source and a PMT to detect the scintillation light at different distances.

The talk will describe in detail the construction of the setup, its successful deployment in the GERDA cryostat and the consecutive analysis of the acquired data.

T 28.3 Mo 17:15 I.12.01 (HS 30)

Background Simulation for the COBRA-Experiment — •Thomas Quante for the COBRA-Collaboration — TU Dortmund, Institut für Physik , D

COBRA is a next-generation experiment searching for neutrinoless double beta ($0\nu\beta\beta$) decay using CdZnTe semiconductor detectors. The main focus is on 116Cd, with a Q-value of 2813.5 keV well above the highest dominant naturally occurring gamma lines. By measuring the half-life of the $0\nu\beta\beta$ decay, it is possible to clarify the nature of the neutrino as either Dirac or Majorana particle and furthermore to determine the effective Majorana mass.

COBRA is currently in the demonstrator phase to study possible background contributions and gain information about the longterm stability of the used detectors. For this purpose a demonstrator array made up of 64 Cadmium-Zinc-Telluride (CdZnTe) semiconductor detectors in coplanar grid configuration was designed and realised at the Gran Sasso Underground laboratory (LNGS) in Italy.

Simulations of the whole demonstrator setup are ongoing to reproduce the measured spectra for each detector. This is done in two steps. The first uses the Geant4 based framework VENOM for tracking and energy deposition inside each detector. Detector effects like the energy resolution and electron trapping have to be applied in the second step. The used detector geometry has to be verified against calibration measurements. This talk will give an overview of the current simulation status.

T 28.4 Mo 17:30 I.12.01 (HS 30)

Neutron Shielding Simulations — •Laura Vanhoefer for the GeDet-Collaboration — Max-Planck-Institut für Physik, München, Deutschland

Neutrons can create background in experiments built to search for rare events like neutrinoless double beta decays and dark matter induced recoils of nuclei. Neutrons activate the materials used in the experiment during transportation or storage. Although cosmic-ray neutrons themselves can be shielded during storage and transportation, muons penetrate and can produce neutrons inside the shield and the material to be shielded.

Cosmic-ray neutrons and muons were simulated with the GEANT4 based framework MaGe, penetrating through different materials to determine the number of neutrons and the neutron energy spectrum at different shielding depths. This allows to determine the shielding indices of the used materials. In addition, the influence of neutron backscattering was investigated. Blocks with different thicknesses were simulated and the number of outgoing neutrons was compared with the number of neutrons at the corresponding depth within a 20 m thick block. Backscattering was found to be not negligible—especially for steel.

T 28.5 Mo 17:45 I.12.01 (HS 30)

Development of phonon and photon detectors for rare events searches using scintillating crystals — •Loredana Gastaldo[1], Clemens Hassel[1], Sebastian Hendricks[1], Sebastian Kempf[1], Andreas Fleischmann[1], Christian Enss[1], Matias Rodrigues[2], Martin Loidl[2], David Gray[2], Xavier-Francois Navick[2], and Yong-Hamb Kim[3] — [1]Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany — [2]Commissariat à l'énergie atomique, Saclay, France — [3]Korean Research Institute of Standards and Science, Daejeon, Rep. of Korea

The use of scintillating crystals in cryogenic experiments searching for neutrinoless double beta decay and for direct interaction of dark matter particles allows for an efficient background reduction thanks to particle discrimination. We develop phonon and photon detectors based on metallic magnetic calorimeters (MMCs)to perform the simultaneous measurement of heat and light generated upon the interaction of a particle in a scintillating crystal. The design values for the energy resolution and signal rise-time are: $\Delta E_{\mathrm{FWHM}} < 100$ eV and $\tau < 200$ μs for the phonon detector while for the photon detector we expect $\Delta E_{\mathrm{FWHM}} < 5$ eV and $\tau < 50$ μs. Proof-of-principle experiments have been already performed within the AMoRE and LUMINEU projects by coupling first prototypes of MMC-based photon and phonon sensors to ^{100}Mo-based scintillating crystals, $CaMoO_4$ and $ZnMoO_4$. We discuss the design and the fabrication of these detectors and present recent results.

T 28.6 Mo 18:00 I.12.01 (HS 30)

Background Suppression in TeO_2 Bolometers with Neganov-Luke Amplified Cryogenic Light Detectors — •Michael Willers[1,2], Andrea Münster[1], Jean-Côme Lanfranchi[1,2], Lothar Oberauer[1,2], Walter Potzel[1], Sabine Roth[1], Stefan Schönert[1,2], Stephan Wawoczny[1], Andreas Zöller[1], and Andrea Giuliani[3] — [1]Technische Universität München, Physik Department E15, James Franck Straße, 85748 Garching — [2]Excellence Cluster Universe, Technische Universität München, Boltzmannstr. 2, 85748, Garching — [3]Centre de Sciences Nucléaires et de Sciences de la Matière, 91405 Orsay Campus, France

The Neganov-Luke (NL) effect offers a promising way to increase the sensitivity of cryogenic light detectors at low energies. In this talk we show that a highly efficient discrimination between α and e^-/γ induced events in TeO_2 crystals (used in the search for the neutrinoless double beta decay) can be achieved by measuring the Cherenkov radiation emitted by high-energetic electrons within the crystal. By using NL amplified light detectors, a suppression of $\sim 99\%$ of α-induced events with energies close to the Q-value of ^{130}Te at ~ 2.5MeV has been achieved for the first time while simultaneously accepting 99.8% of all e^-/γ-induced events.

This research was supported by the DFG cluster of excellence "Origin and Structure of the Universe", the "Helmholtz Alliance for Astroparticle Phyiscs" and the "Maier-Leibnitz-Laboratorium"(Garching).

T 28.7 Mo 18:15 I.12.01 (HS 30)

Investigation of n$^+$ Surface Events in HPGe detectors for Liquid Argon Background Rejection in GERDA — •Bjoern Lehnert for the GERDA-Collaboration — TU-Dresden, Dresden

The GERDA experiment is searching for neutrinoless double beta decay ($0\nu\beta\beta$) in ^{76}Ge using an array of germanium detectors immersed in liquid argon (LAr). Phase II of the experiment aims to improve the background level by a factor 10 in order to reach 10^{-3} counts / (kg·keV·yr). A strong suppression technique is required to suppress the intrinsic LAr background of ^{42}Ar / ^{42}K. 30 newly produced p-type Broad Energy Germanium (BEGe) detectors will be deployed in Phase II. The n$^+$ electrode of the GERDA BEGe detectors is covering 96-98 % of the surface and is between 0.5 and 1.2 mm thick. Betas from the ^{42}K decay can penetrated the detector surface and deposit energies within the $0\nu\beta\beta$ region. Experiences from GERDA Phase I show that these surface events are the dominate background component without suppression.

Energy depositions inside the n$^+$ layer create pulse shapes that are slower than those from interactions in the bulk. This talk will present a rejection technique for those events. The signal development inside the n$^+$ layer is modeled and applied in Geant4 Monte Carlo simulations. The simulations are compared with data for ^{241}Am and ^{90}Sr calibration source measurements. The suppression capabilities are extrapolated for ^{42}K in GERDA Phase II.

T 28.8 Mo 18:30 I.12.01 (HS 30)

Monte Carlo simulations for the optimisation of low-background Ge detector designs — •Janina Hakenmüller[1], Gerd Heusser[1], Matthias Laubenstein[2], Werner Maneschg[1], Jochen Schreiner[1], Hardy Simgen[1], Dominik Stolzenburg[1], Herbert Strecker[1], Marc Weber[1], and Jonas Westernmann[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Laboratori Nazionali del Gran Sasso, Via G. Acitelli 22, 67100 Assergi L'Aquila, Italy

Monte Carlo simulations for the low-background Ge spectrometer Giove at the underground laboratory of MPI-K, Heidelberg, are presented. In order to reduce the cosmogenic background at the present shallow depth (15 m w.e.) the shielding of the spectrometer includes an active muon veto and a passive shielding (lead and borated PE layers). The achieved background suppression is comparable to Ge spectrometers operated in much greater depth.

The geometry of the detector and the shielding were implemented using the Geant4-based toolkit MaGe. The simulations were successfully optimised by determining the correct diode position and active volume. With the help of the validated Monte Carlo simulation the contribution of the single components to the overall background can be examined. This includes a comparison between simulated results and measurements with different fillings of the sample chamber.

Having reproduced the measured detector background in the simulation provides the possibility to improve the background by reverse engineering of the passive and active shield layers in the simulation.

T 28.9 Mo 18:45 I.12.01 (HS 30)

Characterization of the Segmented Broad Energy Germanium detector — •Heng-Ye Liao for the GeDet-Collaboration — Föhringer Ring 6 80805 München

Broad energy germanium detectors (BEGe) are used in neutrinoless double beta-decay and dark matter searches. They have excellent energy resolution and pulse shape discrimination performance. Detector segmentation can provide additional spatial information, useful to efficiently disentangle different event topologies. A novel BEGe detector with 4-fold segmentation design has been built. Results of the first measurements performed with this new type of detector will be presented.