T 53: Dark Matter II

Time: Wednesday 16:30–19:00 Location: H-HS XIV

T 53.1 Wed 16:30 H-HS XIV

Hardware R&D Towards DARWIN: Construction of a Radon Emanation Chamber — •Daniel Baur — Albert-Ludwigs-Universität, Freiburg, Germany

Liquid xenon-based experiments are currently leading the search for WIMP dark matter. Their electronic recoil background in the energy region of interest is dominated by the "naked" (i.e. not accompanied by the coincident emission of a gamma-ray) beta decays of ^{214}Pb, a progeny of ^{222}Rn which is emanated from all material surfaces. Consequently, the reduction of ^{222}Rn emanation is mandatory for the success of next-generation dark matter experiments with multi-ton xenon targets such as DARWIN.

The ^{222}Rn surface emanation can be measured directly with a radon emanation chamber, where the daughters of ^{222}Rn are collected electrostatically on a silicon PIN diode and the subsequent alpha decays are detected. We present a new radon emanation chamber which is being constructed in Freiburg and show first results.

T 53.2 Wed 16:45 H-HS XIV

First results of a fully functional single-phase TPC — •Patrick Meinhardt — Physikalisches Insitut, Freiburg, Germany

Liquid-xenon dual-phase Time Projection Chambers (TPCs) are leading the field of direct dark matter search for WIMP masses above a few GeV/c^2. As an alternative approach to overcome several challenges appearing when scaling up the dual-phase concept up to the size of the future DARWIN detector we investigate proportional scintillation in liquid xenon. In such single-phase TPC the charge signal is generated in the liquid phase by proportional scintillation close to very thin wires. The XeBRA (Xenon Based Research Apparatus) platform provides the possibility to run a small-scale TPC either in dual- or single-phase mode. First comparative results of the two individual detection concepts will be presented in this talk.

T 53.3 Wed 17:00 H-HS XIV

The xenon gas system for the DARWIN demonstrator — •Julia Müller — Physikalisches Institut, Albert-Ludwigs Universität Freiburg, Germany

DARWIN will be the ultimate liquid xenon-based dark matter detector with a sensitivity covering the entire accessible WIMP parameter space. With linear scales of about 2.6m its central low-background time projection chamber (TPC) and its technical realization will be challenging. We are currently setting up a large-scale demonstrator platform at the University of Freiburg which will feature a 2.8m diameter, flat (0.25m) cryostat for R&D in a liquid/gas xenon environment. Its maximal xenon content will be around 400 kg. This talk will present the xenon gas system required for xenon filling, purification, recuperation and long-term storage.

T 53.4 Wed 17:15 H-HS XIV

The LEGEND Liquid Argon Monitoring Apparatus (LLAMA) — •Mario Schwarz, Patrick Krause, Laszlo Papp, and Stefan Schönert — Physik-Department, Technische Universität München, Garching, Germany

Large volume liquid argon (LAr) detectors require a precise assessment of optical key parameters for both modeling and interpreting the data. Looking at neutrinoless double beta decay experiments, both the state-of-the-art GERDA experiment as well as the next-generation LEGEND detector employ the LAr technology as part of their active veto system. Therefore, modeling the LAr veto efficiency requires knowledge of the optical parameters in LAr, which depend on the actual impurity concentration in the liquid. To this end, a dedicated setup has been designed for in-situ measurements of the light yield, the triplet lifetime and the attenuation length of the 128 nm primary emission wavelength. The setup uses a triggered LAr scintillation light source and will be used both to measure the LAr properties of GERDA as well as a monitor for the LAr in LEGEND, where it will reside permanently. Hence, it is referred to as the LEGEND Liquid Argon Monitoring Apparatus (LLAMA).

An overview of LLAMA, as well as results of the characterization and testing campaign carried out at TUM will be shown.

The work has been supported in part by the German Federal Ministry for Education and Research (BMBF) Verbundforschung.

T 53.5 Wed 17:30 H-HS XIV

Optimization of separation columns for Kr-in-Xe assays — Hardy Simgen, Veronica Pizzella, and •Daniel Winkler — Max-Planck-Institut für Kernphysik Heidelberg

Liquid-xenon time projection chambers are among the most sensitive detectors in search for Weakly Interacting Massive Particles as dark matter. Due to the expected very low event rate, ultra-low background conditions are required. One of the most serious intrinsic backgrounds is the radioactive isotope ^{85}Kr, present in commercially available xenon. To achieve ultra-low concentrations, krypton traces are successfully reduced down to the ppq level e.g. by cryogenic distillation as for the XENONnT experiment.
The analytics of the remaining concentration can be performed off-line with a rare gas mass spectrometer (RGMS). Measuring ultra-low trace contaminations, a pre-separation of krypton in xenon by cryogenic gas-chromatography is necessary. The RGMS at the Max-Planck-Institut für Kernphysik in Heidelberg uses a homemade system with miniaturized packed adsorbent columns and UHV-tight all-metal valves well suited for high purity demands.
I present a dedicated set-up for column testing, separation and performance optimization as well as signal shape examination. First results of the set-up will be shown and an outlook for further optimization will be given.

T 53.6 Wed 17:45 H-HS XIV

Slowcontrol systems for mid-scale LXe platforms — •Jaron Grigat — Albert-Ludwigs-Universitaet Freiburg

Slowcontrol systems play a crucial role in liquid xenon experiments. Their tasks are to ensure a stable environment for data collection, to prevent damage to sensitive electronics and to avoid the loss of expensive xenon. Additionally a slowcontrol system should achieve close to 100% of up-time while the experiment is running. Widely used open-source software solutions for data processing can be used to build powerful, scalable and reliable slowcontrol systems. These possibilities will be discussed based on the newly developed system for the Freiburg R&D platform with the purpose of gaining major insight into the development challenges and opportunities of the DARWIN experiment.

T 53.7 Wed 18:00 H-HS XIV

Transition Edge Sensor Production for Rare-Event Searches — •Tobias Ortmann[1], Margarita Kaznacheeva[1], Angelina Kinast[1], Alexander Langenkämper[1], Elizabeth Mondragón[1], Luca Pattavina[1], Walter Potzel[1], Johann Riesch[2], Stefan Schönert[1], Raimund Strauss[1], and Victoria Wagner[1] — [1]Technische Universität München, Physik Department, Lehrstuhl E15, James-Franck-Str. 1, D-85748 Garching — [2]Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, D-85748 Garching

The CRESST and the NUCLEUS experiments are aiming for the detection of low-energetic nuclear recoil events (<100eV) induced by elastic scattering of dark matter particles or reactor antineutrinos, respectively. In both cases the detectors are operated as cryogenic calorimeters at mK temperatures and the phonon signals are read out by W thin-film transition edge sensors. For future large scale production, to simplify the production cycles and to improve sensitivity, the application of magnetron sputtering is investigated in terms of film quality and reproducibility. Using X-ray diffractometry we established a preselection procedure of films for cryogenic measurements. First results from a prototype TES produced at the Max Planck Institute for Plasma Physics with a transition temperature of 35 mK are presented. This work was supported by the DFG Excellenzclusters UNIVERSE and ORIGINS, the SFB 1258, the ERC StG-2018 "NU-CLEUS" and the Maier-Leibnitz-Laboratory (Garching).

T 53.8 Wed 18:15 H-HS XIV

High-Purity CaWO4 Crystals for the CRESST Dark Matter Search — •Angelina Kinast[1], Andreas Erb[1,2], Margarita Kaznacheeva[1], Alexander Langenkämper[1], Elizabeth Mondragon[1], Tobias Ortmann[1], Luca Pattavina[1], Walter Potzel[1], Stefan Schönert[1], Raimund Strauss[1], and Victoria Wagner[1] — [1]Physik Department E15, Technische Universität München, D-85748 Garching — [2]Walther-Meißner-Institut für

Tieftemperaturforschung, D-85748 Garching

The direct dark matter search experiment CRESST uses scintillating CaWO4 single crystals as a target for potential recoils of dark matter particles. For several years, CaWO4 crystals have been produced inhouse at TUM via Czochralski growth from the raw materials CaCO3 and WO3. In order to achieve the future background goals of CRESST, extensive powder purification procedures, e.g. by using the precipitation method, have been developed and applied. Recently the first crystal from this purified material was grown and has been installed as a cryogenic detector in the CRESST setup at the Gran Sasso underground laboratory. Moreover, I will present the status of a dedicated cryogenic alpha screening facility at the TUM shallow underground laboratory (UGL), which will be an important tool to characterize the intrinsic radio purity of single crystals. This research was supported by the DFG cluster of excellence Origins, by the BMBF Verbundprojekt 05A2017 CRESST-XENON and by the SFB1258.

T 53.9 Wed 18:30 H-HS XIV

Characterization of germanium detectors using positron emission tomography — •Lukas Rauscher, Josef Jochum, Katharina Kilgus, Ann-Kathrin Schütz, and Andreas Zschocke for the GERDA-Collaboration — Physikalisches Institut Tübingen, Auf der Morgenstelle 14, Tübingen, Deutschland

Pulse shape discrimination (PSD) in germanium detectors is an integral part of background reduction in several 0vbb experiments such as GERDA. The efficiency of the PSD can be cross-checked using positron emission tomography (PET), which is used for medical imaging. A PET detector is a segemented, cylindrical detector for photons originating from the annihilation of electron positron pairs. From the intensity distribution of the coincident photons the spatial distribution of the b+ emitter can be reconstructed. To characterize a germanium detector, it is irradiated with a collimated Ta-208 source generating electron positron pairs in the germanium detector. The free electron generates a pulse in the germanium detector and the positron annihilates with an electron of the bulk material generating a signal in two different pixels of the PET detector. Due to the short mean free path of the positron compared to the spatial resolution of the PET detector, the point of interaction can be fixed as the intersection of the incoming gamma beam with the connecting line of the two pixels. The pulse in the germanium detector can be mapped to the spatial position of its origin inside the germanium detector. In this talk the principle of the technique as well as first measurements regarding the functionality of the PET will be presented. This work is funded by the BMBF.

T 53.10 Wed 18:45 H-HS XIV

Charge-carrier collective effects in Ge detectors and the impact for Legend — •Tommaso Comellato, Matteo Agostini, and Stefan Schönert for the LEGEND-Collaboration — Technical University of Munich, München, Deutschland

The state-of-the-art technology in germanium crystals allows the production of detector blanks with lengths and diameters of 10cm, and a level of impurities in the range of 10^{10} atoms/cm^3. With these values, such crystals can be converted into High Purity Germanium (HPGe) detectors. In such devices, the time structure of the signal can be used to discriminate the topology of the energy deposition. This is exploited in the search for neutrinoless double beta ($0\nu\beta\beta$) decay of ^{76}Ge, where HPGe detectors enriched in ^{76}Ge are used simultaneously as source and detector (Gerda, Legend). In the effort to enlarge the detector dimensions, new geometries such as the Inverted Coaxial have been recently developed[1][2]. In this new type of detectors the time needed to collect electrons and holes is much larger than the detectors used in the current $0\nu\beta\beta$ experiments. Longer collection times lead to the observation of subleading effects in the signal formation due to the self-interaction of the electron and hole clusters during their migration. In this talk I will present the impacts that such effects have on signal shape and on pulse shape discrimination performance. This work has been supported in part by the German Federal Ministry for Education and Research (BMBF) Verbundforschung 05A17W02.

[1] R. J. Cooper et al., Nucl. Instrum. Meth. A665 (2011) 25
[2] A. Domula et al., Nucl. Instrum. Meth. A891 (2018) 106