T 36: Search for Dark Matter II

Time: Tuesday 16:15–18:30 Location: AM 00.014

T 36.1 Tue 16:15 AM 00.014

A large-diameter, dual-phase liquid xenon TPC in the unshielded PANCAKE facility — •Sebastian Lindemann — University of Freiburg, Germany

Future liquid xenon (LXe) based observatories searching for rare processes, such as XLZD, require testing of large components and subassemblies in cryogenic liquid or gaseous xenon environments. In this talk, I will present results from operating a 1.5 m diameter, 3 cm deep, dual-phase LXe time projection chamber (TPC) in the unshielded PANCAKE platform without underground suppression of cosmic ray backgrounds.

Measurements of various detector- and LXe-specific quantities, such as the electron lifetime dependent on purity and the electron drift velocity dependent on electric field, demonstrate that operating a large-diameter TPC is feasible in a high-background environment.

T 36.2 Tue 16:30 AM 00.014

Radon removal by cryogenic distillation for future liquid xenon detectors — •Robert Braun, Lutz Althueser, David Koke, Volker Hannen, Christian Huhmann, Ying-Ting Lin, Philipp Schulte, Patrick Unkhoff, Daniel Wenz, and Christian Weinheimer — Universität Münster

Radon emanation from detector materials is a dominant background source in liquid xenon (LXe) detectors used for rare event searches including dark matter and neutrinoless double beta decay. Because of the continuous emanation of radon it is necessary to remove radon faster than its half-life of 3.8 days in order to effectively reduce the radon concentration of the detector itself. For the large detector masses of next generation LXe experiments (e.g. XLZD) this requirement corresponds to a total xenon flow of up to 1600 kg/h, which is more than an order of magnitude higher than those achieved by current systems of about 80 kg/h.

In the LowRAD project a cryogenic distillation setup is developed for reducing the concentration of radon to unprecedented levels. To investigate the scalability of the system, the required heating and cooling power is provided by an hermetically separated heat pump cycle, for which a first demonstrator with about 10 slpm is now scaled to a "XENONnT-sized" heat pump with 300 slpm. This talk will present the design and commissioning of the radon distillation column and its subsystems, with a particular emphasis on the integrated radon-decay detector enabling continuous online monitoring of radon concentrations. Supported by the ERC Advanced Grant "LowRad" (101055063).

T 36.3 Tue 16:45 AM 00.014

Beyond standard model physics with electronic recoil data of XENONnT — •Sebastian Vetter — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

The XENONnT detector is among the world leading experiments in the direct search for Weakly Interacting Massive Particles (WIMPs), one of the prime candidates to form particle Dark Matter (DM). XENONnT uses liquid Xe in a dual-phase time projection chamber (TPC) as a detector target. One of the great advantages of a TPC is the ability to discriminate between energy deposits from incoming particles on the target nuclei, nuclear recoils (NRs), or on the electron clouds of the atoms, electron recoils (ERs). While WIMPs are expected to interact via NRs, many signals of scientific interest can occur as ERs. The ER data allows us to explore the flux of solar neutrinos from the pp chain, and look beyond the standard model for other than WIMP DM candidates like Dark Photons or Axion Like Particles.

In this talk, I will highlight challenges and opportunities, as well as the latest status, in the analysis of XENONnT ER data in a wide energy range from keV to MeV scale.

This work is supported in part through the Helmholtz Initiative and Networking Fund (grant agreement no.~W2/W3-118) and through the grant 05A23VK3 within the ErUM-Pro funding line by the German Federal Ministry of Research, Technology and Space. In addition, support by the KIT graduate school KSETA is gratefully acknowledged.

T 36.4 Tue 17:00 AM 00.014

Characterization of anomalous electron backgrounds in XENONnT — •Alexis Michel for the XENON-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

Dual-phase xenon time projection chambers like XENONnT are widely used in searches for rare events. These detectors have a layer of gaseous xenon (GXe) above a target of liquid xenon (LXe). Interactions in the LXe produce scintillation light and ionization electrons. With electric fields generated by electrodes, clouds of such ionization electrons are drifted upwards in the liquid and then extracted into the gas, where they produce a secondary proportional scintillation light signal.

Such xenon-based TPCs commonly see various forms of spurious emission that are associated with electrical fields and electrode operation. One such emission type are so-called e^--bursts that were observed in XENONnT and other detectors. These e^--bursts are large and clustered delayed electron signals observed where the extraction of the initial electron cloud at the LXe-GXe interface was incomplete and electrons got trapped at the LXe surface. Another such spurious emission type is from so-called hot-spots, which are spatially localized sources of continuous and intermittent single electron emission.

In this talk I will present the recent results on the studies of spurious electron emission phenomena in XENONnT and their implications for the next generation of xenon-based detectors such as XLZD.

This work has been supported in part by the Federal Ministry of Research, Technology and Space (BMFTR) through the grant 05A23VK3 within the ErUM-Pro funding line.

T 36.5 Tue 17:15 AM 00.014

Development of Cryogenic Single-Photon Detectors to Study the Light Output of Sodium Iodide Crystals for Rare Event Searches — •Lutz Ziegele for the COSINUS-Collaboration — Max-Planck-Institut für Physik, 85748 Garching, Germany

The Cryogenic Observatory for Signatures seen in Next-generation Underground Searches (COSINUS) is a dark matter direct detection experiment located at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. It employs sodium iodide (NaI) crystals operated as cryogenic calorimeters. Particle interactions in the crystal produce phonons, which are detected by a remote Transition Edge Sensor (remoTES), while the accompanying scintillation light is absorbed by silicon absorbers equipped with Transition Edge Sensors. This dual-readout scheme enables particle discrimination and allows for an in-situ determination of energy-dependent quenching factors.

This contribution presents the development of a detector module with enhanced scintillation light sensitivity, enabling photon-number-resolved measurements. Rather than using a single large light detector, multiple smaller light absorbers are arranged around the NaI crystal. Their reduced heat capacity improves the overall sensitivity. The main goal is a precise characterization of the scintillation light yield of ultrapure NaI crystals, which is crucial for the analysis of upcoming COSINUS data. In addition, this development establishes the basis for future studies of dark matter-electron interactions within the OνDES project, funded by the Klaus Tschira Foundation.

T 36.6 Tue 17:30 AM 00.014

Tracking down the Low-Energy Excess: First results from CRESST Double-TES Modules — •Marco Zanirato for the CRESST-Collaboration — Max Planck Institut für Physik, München, Deutschland

The Cryogenic Rare Event Search with Superconducting Thermometers (CRESST) is a forefront experiment in the direct detection of dark matter, located at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. By employing cryogenic calorimeters based primarily on scintillating crystals equipped with Transition Edge Sensors (TESs), CRESST achieves energy thresholds of the order of 30 eV with a 24 g detector. However, the development of such a cutting-edge experiment presents several challenges. One of the most pressing is the unexplained rise in the number of events observed below 200 eV, commonly referred to as the Low-Energy Excess (LEE).

To investigate the origin of this excess, the current data-taking campaign utilises detector modules with two sensors per crystal, allowing the collaboration to disentangle whether the LEE is linked to the crystal or to the sensors themselves. This talk will provide an overview of the concept behind these new modules, the results obtained in above-ground tests, and the first preliminary findings from the ongoing underground run.

T 36.7 Tue 17:45 AM 00.014

The Projected Sensitivity of the DELight Experiment — •Eleanor Fascione for the DELight-Collaboration — Kirchhoff-Institut für Physik

In the search for dark matter, there is vast unexplored parameter space for masses below a few GeV, and the field of direct dark matter detection is constantly expanding to new frontiers. Low mass dark matter candidates necessitate novel detector designs with lower thresholds and alternative target materials compared to experiments currently providing the strongest overall constraints on many thermal dark matter models. The Direct search Experiment for Light dark matter (DELight) will deploy a target of superfluid ^{4}He instrumented with large area microcalorimeters (LAMCALs) based on magnetic microcalorimeter (MMC) technology in a setup optimized for light dark matter searches. In this talk an overview of this upcoming experiment will be presented along with the expected dark matter sensitivity.

T 36.8 Tue 18:00 AM 00.014

Aboveground Studies of the Low-Energy Excess in CRESST — •Eleonora Rebecca Cipelli for the CRESST-Collaboration — Max Planck Institut für Physik, Garching bei München, Deutschland

The CRESST experiment, located at the Laboratori Nazionali del Gran Sasso (LNGS), is a leading direct dark matter detection experiment. It employs cryogenic calorimeters operated at millikelvin temperatures and instrumented with Transition Edge Sensors (TESs), achieving extremely low energy thresholds (~10 eV) and high sensitivity to sub-GeV dark matter particles. However, the experiment's sensitivity is currently limited by an unexplained increase in background events below ~200 eV, known as the Low-Energy Excess (LEE).

This talk will present new investigations into possible origins of the LEE based on dedicated above-ground R&D studies. In particular, it will focus on the impact of thermal cycles on the LEE decay, as well as the influence of aluminium phonon collectors. These studies provide new insights into the nature and mechanisms of the LEE.

T 36.9 Tue 18:15 AM 00.014

Status of the MainzTPC Upgrade for Precision Low-Energy Recoil Measurements in Liquid Xenon — •Constantin Szyszka, Alexander Deisting, Christopher Hils, Peter György, Johannes Merz, and Uwe Oberlack — Institut für Physik & Exzellenzcluster PRISMA$^+$, Johannes Gutenberg-Universität Mainz

The MainzTPC is an experimental dual-phase xenon time projection chamber (TPC) dedicated to the study of scintillation and ionization processes in liquid xenon (LXe) for low-energy electronic and nuclear recoils. Its design has been optimized for use as the primary target in Compton and neutron scattering experiments to measure recoil energies in LXe down to 1 keV.

To improve position resolution in x and y the MainzTPC was redesigned to accommodate an array of silicon photomultipliers (SiPMs) in place of its monolithic top photomultiplier tube (PMT) and eight avalanche photodiodes. The goal of this upgrade is to enable the MainzTPC to perform a measurement of the Migdal effect in LXe. For this purpose, a cryogenic amplifier board housing the SiPM array was developed. To address known instabilities in the liquid level of the MainzTPC, we rebuilt the level meters and level control based on camera observations of the liquid-gas interface. We report on the status of this work.