T 16: Search for Dark Matter I

Time: Monday 16:15–18:15 Location: AM 00.014

T 16.1 Mon 16:15 AM 00.014

XLZD: a next-generation multi-purpose liquid xenon observatory. — •Daniel Wenz for the XLZD-Collaboration — University of Münster

Owing to their excellent detection efficiency, scalability, and ultra-low background levels, dual-phase time projection chambers (TPCs) employing multi-tonne liquid xenon (LXe) targets provide a powerful tool for the discovery and study of a broad range of rare, low-energy phenomena. Key science channels include the search for dark matter, measurements of solar neutrinos and their properties, and searches for rare processes such as the neutrinoless double beta decay of Xe-136. In addition, LXe TPCs enable flavor-independent measurements of low-energy neutrino fluxes from supernovae, contributing to multi-messenger astronomy.

The proposed XLZD experiment is a next-generation, multi-purpose liquid xenon observatory that builds upon the technologies developed by the currently world-leading experiments XENONnT and LZ, as well as the R&D program of DARWIN. The nominal detector design foresees a 60-tonne LXe target mass, with a potential upgrade path to approximately 80 tonnes. In this talk, we present an overview of the XLZD concept and its projected sensitivities across the different science channels.

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T 16.2 Mon 16:30 AM 00.014

Design, Development and Characterization of Electrodes for XENONnT and towards XLZD — •Alexey Elykov — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

Dual-phase noble gas time projection chambers (TPCs) lie at the heart of detectors that perform a wide range of rare event searches, spanning from attempts to detect particle dark matter to studies of neutrino physics. High-voltage electrodes are instrumental for the generation and interpretation of signals produced in the TPC.

The XENON collaboration currently operates a state of the art, ∼1.5 m-wide TPC, immersed in 8.9 t of liquid xenon. The XLZD (XENON, LZ, DARWIN) collaboration aims to construct and operate the ultimate xenon-based TPC, which will span ∼3 m in diameter and will host 60 t of liquid xenon. With a keV-range threshold and an ultra-low radioactive background, XLZD will aim to probe the entire parameter space for WIMP dark matter down to the so-called neutrino fog, and will conduct searches for solar axions, axion-like particles, as well as measurements of the solar neutrino flux, and a probe of the Majorana nature of neutrinos.

In this talk, we will present the successful design, development and characterization of ∼1.5 m-scale electrodes for the upgrade of the XENONnT detector and the R&D work towards electrodes for the XLZD detector [1]. 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.

[1] arXiv:2511.16408

T 16.3 Mon 16:45 AM 00.014

Modeling of signatures from charged leptonic products of dark matter annihilation — •Milena Brütting[1,2], Athithya Aravinthan[1,2], Julia Becker Tjus[1,2,3], Julien Dörner[1,2], and Jannis Wagner[1,2] — [1]Theoretical Physics IV, Ruhr-University Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Bochum, Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, Gothenburg, Sweden

The indirect search for Dark Matter (DM) has been challenging for decades due to the need for low-background environments and the ambiguity between potential DM signals and conventional astrophysical emission. A promising strategy is to model and compare signatures from different DM annihilation channels with astrophysical emission in a synthetic dwarf galaxy assuming the same total energy from both DM and astrophysical sources.

The prompt emission of DM annihilation and the secondary emission from interactions of charged products (such as electrons and positrons) with the ambient fields are modeled to help differentiate the DM and the astrophysical signal. Simulations are performed with the open-source code CRPropa 3.2, which provides a flexible and self-consistent modeling framework for particle propagation. Results reveal morphological differences between both sources. We test different DM annihilation channels, such as bottom quarks, top quarks and W gauge bosons, as well as DM density profiles, such as Einasto, Burkert and Navarro-Frenk-White.

T 16.4 Mon 17:00 AM 00.014

Direct Detection of sub-GeV Dark Matter with the CRESST experiment — •Federico Casadei for the CRESST-Collaboration — Max Planck Institut für Physik, Garching bei München, Deutschland

The Cryogenic Rare Event Search with Superconducting Thermometers (CRESST) experiment is operating at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy, where it has been pursuing the direct detection of dark matter for almost three decades. Employing scintillating crystals instrumented with Transition Edge Sensors (TESs) and operated as cryogenic calorimeters at millikelvin temperatures, CRESST has achieved energy thresholds as low as 6.7 eV. Combined with the use of targets with light nuclei, this enables CRESST to be particularly sensitive to sub-GeV dark matter particles through nuclear-recoil interactions. In this talk, an overview of the CRESST experiment is presented, highlighting detector operation and recent dark-matter results. Ongoing work to improve sensitivity and advance detector design will also be discussed, together with prospects for future explorations of low-mass dark matter.

T 16.5 Mon 17:15 AM 00.014

Illuminating the Invisible: Deep underground dark matter search with COSINUS — •Mukund Bharadwaj for the COSINUS-Collaboration — Max Planck Institute for Physics, 85748 Garching - Germany

The COSINUS experiment (Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches) is a cryogenic, low-background experiment being set up at Laboratori Nazionali del Gran Sasso, Italy. It aims to provide a model independent cross-check of the DAMA/LIBRA findings of a potential dark matter-like modulation signal. COSINUS utilizes a two-channel readout system based on transition edge sensors (TESs) that allows for particle discrimination. It consists of ultrapure scintillating sodium iodide (NaI) crystals, read out using a novel remoTES scheme to measure the phonon signal of a particle interaction. A silicon beaker surrounding the crystal is used to measure the light signal from the same particle interaction. Results from the latest measurements and updates on the setup will be presented in this contribution.

T 16.6 Mon 17:30 AM 00.014

Towards DELight: First Results from a Prototype R&D Cell — •Anna Bertolini for the DELight-Collaboration — Kirchhoff-Institut für Physik, Universität Heidelberg

As direct detection experiments continue to push down the limits on heavy WIMPs, the low-mass dark matter (DM) regime remains comparatively unexplored. Probing this region requires detectors that combine sub-keV energy thresholds with large exposures. The Direct search Experiment for Light dark matter (DELight) aims to meet this challenge by using superfluid helium-4 as a target material and magnetic micromalorimeters (MMCs), enabling excellent energy resolution and detection thresholds of only a few eV. As a first step toward the full experiment, we have developed a dedicated R&D cell to study the MMC response to particle interactions in superfluid helium. In this setup, a 300-ml copper cell is cooled to ~10 mK, where an MMC fabricated on a silicon substrate and a resistive heater are fully submerged in the superfluid. This configuration allows us to characterize the detector response to both particle induced signals in helium and controlled heater pulses. In this contribution, we present the R&D setup, its operational performance, and the first experimental results that form the foundation for the DELight experiment. This work is supported through the Heidelberg Karlsruhe Strategic Partnership (HEiKA STAR).

T 16.7 Mon 17:45 AM 00.014

Simulating DELight: the simulation framework of the DELight experiment — •Francesco Toschi for the DELight-Collaboration — Kirchhoff-Institut für Physik, Heidelberg University

The strong experimental constraints on well-motivated dark matter candidates for masses above 1 GeV/c^2 motivates the exploration of lighter alternative candidates. Probing the low-mass regime requires ultra-low energy thresholds: these are already achieved by solid-state cryogenic detectors thanks to their phonon signal and ultra-sensitive sensors. Combining this approach of ultra-low energy phonon detection with much lighter target nuclei will further enhance the low mass reach. The Direct search Experiment for Light dark matter (DELight) will use a superfluid helium-4 target instrumented with large area microcalorimeters (LAMCALs), combining the low threshold of phonon-based detection with the scalability of noble liquids. This allows DELight to explore masses below 100 MeV/c^2 with just 1 kg·d of exposure.

DELight is in its design phase, and detailed simulations play a central role in informing the design and construction of the final detector. This talk will present the DELight simulation framework, including the signal formation and propagation within the superfluid volume, as well as models of the relevant background sources.

T 16.8 Mon 18:00 AM 00.014

ImpCresst - A versatile simulation tool focusing on cryogenic solid-state detectors at sub-MeV energies — •Holger Kluck for the CRESST-Collaboration — Marietta-Blau-Institut für Teilchenphysik der Österreichischen Akademie der Wissenschaften, 1010 Wien, Österreich

We present ImpCresst, a Geant4 based Monte Carlo tool to simulate radioactive and cosmogenic backgrounds in cryogenic solid-state detectors. It is tuned for a fast-evolving and heterogeneous detector environment with a focus on physics at the sub-MeV level. ImpCresst was developed for the CRESST experiment and proved its suitability there. However, its flexibility and configurability makes it adaptable to any other experiment with a similar profile of requirements: dynamical creation of detector geometries, optionally directly from CAD files; ROOT based data persistency of the whole simulated event topology; automatic metadata annotation for data provenance; and interfacing various particle generators specialized for radioactive and cosmogenic background sources. Especially for radioactive bulk and surface contaminations, we developed a new and convenient particle generator. Detector-specific energy and time resolutions are flexibly applied based on a user-provided data set of empirical parameterization.