T 69: Search for Dark Matter 3

Time: Wednesday 16:00–17:45 Location: Geb. 30.35: HSI

T 69.1 Wed 16:00 Geb. 30.35: HSI

Improved modeling of charge trapping and impact ionization in phonon-based crystal detectors used for dark matter searches — •Matthew Wilson[1], Alexander Zaytsev[1], and Belina von Krosigk[2] — [1]Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany — [2]University of Heidelberg, Kirchhoff Institute for Physics, Heidelberg, Germany

Various dark matter search experiments employ phonon-based crystal detectors operated at cryogenic temperatures. Some of these detectors, including HVeV detectors used by the SuperCDMS collaboration, are able to achieve single-charge sensitivity when a voltage bias is applied across the detector. The total amount of phonon energy measured by such a detector is proportional to the number of electron-hole pairs created by an interaction. However, crystal imperfections and surface effects can cause propagating charges to either trap inside the crystal or ionize additional charges, producing non-quantized measured energy as a result. Modeling these detector-response effects continues to be important for understanding and distinguishing between different sources of events, as well as for modeling the detector response of potential signals for dark matter searches. This presentation showcases an improved, more robust model of these detector-response effects that has fewer limitations and is capable of modeling more effects compared to previous models. This model allows for more accurate characterization of phonon-based crystal detectors and may facilitate discrimination between potential dark matter signals and background sources.

T 69.2 Wed 16:15 Geb. 30.35: HSI

Signal formation in superfluid helium-4 for the DELight experiment — •Francesco Toschi for the DELight-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics — Kirchhoff-Institut für Physik (KIP), Ruprecht-Karls-Universität Heidelberg

As xenon- and argon-based experiments dominate the search for direct interaction of dark matter particles with nuclei for weakly interacting massive particles (WIMPs) with masses above few GeV/c^2, the parameter space for light dark matter (LDM) remains mostly unexplored. Indeed, the low energy threshold needed to be sensitive to sub-GeV/c^2 LDM could be achieved so far only by solid state semiconductor detector coupled to low-temperature phonon sensors, with the disadvantage of a limited scalability. The DELight experiment will use a target of superfluid helium-4: this technology recovers the scalability of noble liquid experiments, while reaching low thresholds typical of cryogenic semiconductors thanks to its phonon channel. In addition, the light nuclear mass of helium makes it an ideal candidate for LDM searches, allowing DELight to probe LDM masses down to 100 MeV/c^2 already during its first phase which will deploy an helium-4 target of about 1 kg. This talk will present the principle of particle detection in superfluid helium-4, focusing on the signal formation processes and expected final observables for the DELight experiment.

T 69.3 Wed 16:30 Geb. 30.35: HSI

XENONnT Optical Model — •Kai Böse for XENONnT — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

XENONnT is one of the world leading direct detection experiments aiming to find or exclude dark matter candidates, especially the WIMP. The experiment is located at the Gran Sasso Underground Lab, where 8.5 tons of the target material xenon are shielded from cosmic radiation.

Particles (potentially including dark matter) recoil in the target with the xenon atoms, resulting in scintillation light. Before being detected by photomultipliers at the top and bottom of the setup, the light scatters with the xenon, can be absorbed by impurities or reflected on surfaces. This talk covers our optical model which describes how light behaves in the detector and how it is used to simulate our signals.

T 69.4 Wed 16:45 Geb. 30.35: HSI

Realistic event simulations in XENONnT — •Henning Schulze Eissing for the XENON-Collaboration — Institut für Kernphysik, Münster, Germany

The XENON Dark Matter Project uses a dual phase time projection chamber filled with liquid xenon to search for dark matter in the form of weakly interacting massive particles (WIMPs). Detailed simulations are essential for our understanding of the detector and in the various physics searches.

This talk presents the key components of the XENONnT simulation chain. Based on the geometry and particle tracking simulations in Geant4, xenon microphysics effects are simulated. The detector response is modeled, including the simulation of a proper PMT and electronics response resulting in realistic waveforms which are processed with the same analysis software as for real data.

The new XENONnT simulation software fuse will be presented. fuse is build on top of the strax(en) framework, which is the core of the XENONnT analysis software. It has a modular structure where simulation steps are placed into standalone plugins. It provides a better simulation speed, easy access to intermediate simulation steps and a higher level of configurability.

This work is supported by BMBF under contract 05A23PM1 und by DFG within the Research Training Group GRK-2149.

T 69.5 Wed 17:00 Geb. 30.35: HSI

Development of a standardized analysis chain for the full COSINUS detector array — •Maximilian Gapp for the COSINUS-Collaboration — Max-Planck-Institut für Physik, Garching, Deutschland

The DAMA/LIBRA experiment located in the LNGS underground laboratory claims to detect an annual modulation in the rate of interactions in sodium iodide (NaI) crystals, which is consistent with the expected dark matter signal. The COSINUS (Cryogenic Observatory for SIgnals seen in Next-generation Underground Searches) experiment is designed to check the persistent results of the DAMA/LIBRA experiment through the use of cryogenic NaI calorimeters, by leveraging their low energy thresholds and introducing particle identification techniques through the use of an additional channel.To accomplish this, various prototypes for the detectors must be tested, which requires careful analysis of the raw data. By separating noise and real events, and removing artifacts by applying quality cuts a standard event and an optimum filter are created to enable reconstruction of the pulse height to subsequently calibrate the prototypes and determine their performance. Since the COSINUS experiment plans to operate 16 channels in the initial run and 48 in the next one the analysis process must be automated as much as possible. In this contribution, the analysis workflow to characterize new prototypes is shown and possible approaches for the automation are highlighted.

T 69.6 Wed 17:15 Geb. 30.35: HSI

ELOISE - Electronic stopping power in $CaWO_4$ and Al_2O_3 for background simulations — •Holger Kluck[1], Jens Burkhart[1], and Michael Stoeger-Pollach[2] — [1]Institut für Hochenergiephysik der Österreichischen Akademie der Wissenschaften, 1050 Wien, Österreich — [2]Technische Universität Wien, University Servicecentre for TEM, 1040 Wien, Österreich

$CaWO_4$ and Al_2O_3 are well-known target materials for experiments searching for rare events like CEνNS with NUCLEUS or hypothetical dark matter-nucleus scattering with CRESST. Pushing the detection threshold down to sub-keV energies, experiments require verified and reliable simulations of radioactive background components at sub-keV energies, such as those based on the widely used Geant4 toolkit.

The ELOISE project aims to tackle this issue for electromagnetic particle interactions in both materials. Currently, we are preparing an evaluation of Geant4's current accuracy by conducting benchmark simulations and comparing them with data from extended literature research and dedicated measurements. As sub-keV data on the electronic stopping power is rare or totally missing, ELOISE conducted dedicated measurements for $CaWO_4$ and Al_2O_3. Currently, we are deducing electronic stopping powers from our measurements.

In this contribution, I will shortly motivate the problem and outline the scope of ELOISE. Afterwards, I will report the results of ELOISE's reference measurements. Finally, I will discuss our preliminary findings for the electronic stopping power in $CaWO_4$ and Al_2O_3 at sub-keV energies.

T 69.7 Wed 17:30 Geb. 30.35: HSI

Calibration of a closed MADMAX prototype — •David Leppla-Weber for the MADMAX-Collaboration — Deutsches Elektronen-Synchrotron DESY, Germany

The **MA**gnetized **D**isk and **M**irror **A**xion e**X**periment is a dielectric haloscope aiming to detect axions from the galactic halo by resonant conversion to photons in a strong magnetic field. It uses a stack of dielectric disks, called booster, to enhance the axion-photon conversion probability over a significant mass range. In 2022, a prototype system called Closed Booster 100 (CB100) with three sapphire disks of 100 mm diameter, encased in an aluminum cylinder, was used for datataking at CERN. To be able to set limits on the axion-photon coupling, the enhancement provided by the system has to be understood precisely. This requires a noise model of the booster itself as well as the Low Noise Amplifier (LNA) connected to it, which is used to amplify the signal to detectable levels. The calibration procedure together with the resulting signal enhancement is presented, showing the potential of such a dielectric haloscope setup.