T 18: Search for Dark Matter 1

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

T 18.1 Mon 16:00 Geb. 30.35: HSI

Wafer calorimeter development for the Direct Search Experiment for Light Dark Matter with Superfluid Helium (DELight) — Friedrich Wagner[1], Lena Hauswald[1], Michael Müller[1], Fabienne Bauer[1], and •Sebastian Kempf[1,2] — [1]Institute of Micro- and Nanoelectronic Systems (IMS), Karlsruhe Institute of Technology, Germany. — [2]Institute for Data Processing and Electronics, Karlsruhe Institute of Technology, Germany.

The dark matter (DM)-nucleon scattering parameter space of Light Dark Matter (LDM) has been barely probed, as it requires an energy detection threshold as low as a few eV. The "Direct search Experiment for Light dark matter" (DELight) aims investigating this challenging parameter space by using superfluid ^{4}He as target material. Superfluid ^{4}He provides not only a low nuclear mass and a high radiopurity level, but also various signal channels for event classification. For signal detection, DELight will use energy- and time-resolving cryogenic wafer calorimeters with eV-scale energy resolution, some of which will be located above the liquid, while others will be immersed in the superfluid. The detectors will be based on magnetic microcalorimeters (MMCs) that are operated in athermal mode, i.e. the energy of an incident particle is converted into an athermal phonon population that is sensed via normal or superconducting phonon collectors heating up a paramagnetic temperature sensor that is situated in a weak magnetic field. Here, we present our most recent R&D efforts related to detector layout and fabrication technology, both ultimately paving the way towards wafer calorimeters with $O(20\,\mathrm{eV})$ energy threshold.

T 18.2 Mon 16:15 Geb. 30.35: HSI

A GridPix Detector for Axion Searches with IAXO — •Johanna von Oy, Klaus Desch, Jochen Kaminski, Tobias Schiffer, Sebastian Schmidt, and Markus Gruber — Physikalisches Institut der Universität Bonn

The particle axion was first introduced as a solution for the strong CP problem and has since then also become a good candidate for light dark matter. One experimental concept to discover the axion are helioscopes, which would convert solar axions into X-rays and detect those.

The International AXion Observatory (IAXO) has been proposed to be built as a next-generation helioscope. As a proof of concept and as its own experiment, the intermediate state BabyIAXO will be constructed at DESY in Hamburg.

After the solar axions have coupled to X-rays in the magnetic field of the helioscope, the X-rays are focused onto detectors. One of them is a gas-filled GridPix detector, which has a pixelated readout chip, the Timepix3, as its base with a perfectly aligned mesh on top. Thanks to this, individual electrons produced by the X-rays in the gas volume can be detected. This especially allows for the detection of axion-originated X-rays, with energies as low as $\sim$1 keV. Since the axion-photon coupling is predicted to be small and not a lot of signal events are expected, a very low background is desired and can, among other things, be achieved by building the detector from radiopure materials.

This talk will give a summary of the building principle and challenges of this GridPix detector for IAXO.

T 18.3 Mon 16:30 Geb. 30.35: HSI

High-voltage electrode development for xenon-based direct Dark Matter detectors — •Vera Hiu-Sze Wu for the XENON-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

The XENONnT detector is the current-generation experiment of the XENON Dark Matter project dedicated to direct dark matter search. It aims at reaching sensitivity for spin-independent WIMP-nucleon cross-sections down to 1.4×10^{-48} cm^2 for a 50 GeV/c^2 mass WIMP at 90% C.L. with 20 t$\times$yr exposure [1].

XENONnT has been successfully running since more than two years [2]. One of the central elements of two-phase xenon TPCs are the electrodes. With ever larger TPCs, these electrodes and their operation become a technological challenge. Therefore, a set of backup electrodes has been developed. The work encompasses different tasks, including redesigning and testing the mechanical structure of the electrodes and performing electric field and optical simulation. As the realization and manufacturing process progressed, we did extensive optical inspections and high-voltage and mechanical stability tests. Here I present our results, the assembly of these electrodes, and the lessons learned from the project towards future-generation detectors such as DARWIN.

This work is supported in part through the Helmholtz Initiative and Networking Fund (grant agreement no. W2/W3-118) and through BMBF (ErUM-Pro grant agreement no. 05A23VK3). Support by the graduate school KSETA at KIT is gratefully acknowledged.

[1] JCAP 11 (2020) 031, [2] PRL 131 (2023) 041003.

T 18.4 Mon 16:45 Geb. 30.35: HSI

Evaporated Gold Thin-Films on NaI Crystals for remoTES based Detectors — •Kilian Heim for the COSINUS-Collaboration — Max-Planck-Institut für Physik, Garching, Deutschland

The COSINUS (Cryogenic Observatory for SIgnals seen in Next generation Underground Searches) experiment aims for a model-independent cross-check of the dark matter signal claimed to be observed by the DAMA/LIBRA experiment. Starting its first operational phase at the end of 2024, COSINUS will use the same target material as the DAMA/LIBRA experiment, namely sodium iodide (NaI). The NaI crystals will be operated as cryogenic calorimeters, enabling a dual channel readout of both a scintillation and phonon signal.

The readout of the phonon signal is done with a transition edge sensor (TES), but due to the low melting point and hygroscopicity of the NaI crystal, the TES cannot be deposited directly on the crystal. Therefore, the novel remoTES setup is applied, which locates the TES on a separate wafer, linked to a gold pad on the crystal.

Currently, the circular gold pad is cut from a gold foil and then glued onto the crystal. As a next step, the evaporation of gold on the crystal is investigated, which could enhance the reproducibility and signal strength of the TES. In this contribution, I want to highlight the advantages of an evaporated gold pad and present first results from the way towards an improved detector setup.

T 18.5 Mon 17:00 Geb. 30.35: HSI

Recent updates on ALPS II's TES detection system — •Christina Schwemmbauer[1], Katharina-Sofie Isleif[2], Friederike Januschek[1], Axel Lindner[1], Manuel Meyer[3], Gulden Othman[4], and José Alejandro Rubiera Gimeno[1] — [1]Deutsches Elektronen-Synchrotron DESY,Hamburg, Germany — [2]Helmut-Schmidt-University,Hamburg, Germany — [3]University of Southern Denmark, Odense, Denmark — [4]Universität Hamburg, Hamburg, Germany

The ALPS II (Any Light Particle Search II) experiment is a light-shining-through-walls experiment located at DESY Hamburg, searching for axions and Axion Like Particles (ALPs). The experiment has been running successfully since May 2023, employing a heterodyne scheme for the detection of reconverted photons from ALP-photon oscillations. Upon many possible configuration changes in the next months and years is the option of using a NIST Transition Edge Sensor (TES) based detection system as an alternative to heterodyne sensing. We report on recent progress towards a dedicated TES run for ALPS II, including results on the system detection efficiency and backgrounds. Furthermore, our TES detection setup could be used for direct Dark Matter (DM) searches as well, namely through DM-electron-scattering in the superconducting TES layer at sub-eV energies.

T 18.6 Mon 17:15 Geb. 30.35: HSI

Tests of wire electrodes with the Mainz high resolution scanning set-up — •Alexander Deisting[1], Jan Lommler[1], Shumit Mitra[1], Uwe Oberlack[1,2], Fabian Piermaier[2], and Quirin Weitzel[2] — [1]Institut für Physik & Exzellenzcluster PRISMA+, Universität Mainz — [2]PRISMA Detector Laboratory, Universität Mainz

When searching for dark matter with dual-phase time projection chambers (TPCs) the quality of the TPC's electrodes is crucial for the experiments success, as the electrodes' performance affects the overall signal quality and smoothness of detector operation. For experiments similar to XENONnT, these electrodes are meshes or grids with wire diameters of $200 - 300\,\mu$m, operated at a high voltage (HV) $\gg 1$ kV. Future experiments as Darwin plan to use a similar technology.

The scanning set-up at the PRISMA Detector Laboratory in Mainz features several tools for metrology mounted on a gantry robot system: A high resolution camera (resolution: $1.4 \times 1.4\,\mu\mathrm{m}^2$), a 3D confocal microscope (resolution better than $1\,\mu$m), and a laser-distance measurement system, which can be used to measure wire sagging down to the $\mathcal{O}(10\,\mu\text{m})$ scale. The set-up allows for electrodes to be tested at HV and in an argon atmosphere.

In this talk we will discuss electrode assays utilising intentional corona discharges at the wires and lessons learned from that. Furthermore, we will report on wire sagging measurements done with XENONnT sized electrodes and on the resulting conclusions for similar studies with Darwin sized electrodes.

T 18.7 Mon 17:30 Geb. 30.35: HSI

Dark matter-electron search using cryogenic light detectors — •Vanessa Zema — Max Planck Institute for Physics, Munich, Germany

Dark matter (DM) may be constituted by MeV/c^2 particles with coupling to electrons. Nobel gas detectors or solid state materials with electronic energy gaps are employed to investigate this hypothesis. Considering the solid state detectors, the common choice is to use semiconductors and measure the charge using for example CCDs detectors or cryogenic calorimeters subjected to electromagnetic fields. In this talk we report on a different technique for DM-electron interaction search which is based on the measure of the scintillation light stimulated by a particle scattering off electrons in scintillating cryogenic calorimeters, with a focus on sodium iodide targets. We study the phenomenology and calculate the projected sensitivity on the DM-electron cross-section as a function of the DM mass to plan the detector design and estimate what is the aimed background level and energy resolution required to setup a future dedicated experiment.