T 62: Search for Dark Matter III

Time: Wednesday 16:15–18:30 Location: VG 4.102

T 62.1 Wed 16:15 VG 4.102

Primordial Black Hole: from very early universe to Dark Matter — •Maël Gonin[1,2], Günther Hasinger[1,2], and David Blaschke[3,4,5] — [1]Deutsches Zentrum für Astrophysik, Görlitz 02826, Germany — [2]IKTP TU Dresden, Zellescher Weg 19, 01069 Dresden, Germany — [3]Institute of Theoretical Physics, University of Wroclaw, Wroclaw, Poland — [4]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [5]Center for Advanced Systems Understanding, 02826 Görlitz, Germany

Dark Matter (DM), comprising 30% of the universe's energy, remains one of cosmology*s greatest mysteries. Primordial Black Holes (PBHs), theorized by Hawking and Carr (1971), are compelling DM candidates as purely gravitational, non-baryonic objects. Though unproven, PBHs offer a unique alternative to particle DM (pDM) and insights into the early universe. We develop a novel PBH mass spectrum based on the equation of state (EoS) of the early universe, where phase transitions enhance PBH formation probabilities. Using advanced quark matter simulations, we also explore lepton flavor asymmetry and the possibility of a 17 MeV boson observed in electron-positron pair production. Additionally, N-body simulations using PeTar examine PBH detectability, focusing on globular cluster dynamics and PBH-star binaries, such as those observed by the Gaia collaboration. This presentation will discuss these approaches and their implications for identifying PBHs as DM candidates.

T 62.2 Wed 16:30 VG 4.102

SNAX: Supernova Neutrino Analysis in XENONnT — •Melih Kara for the XENON-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

Core-collapse supernovae emit 99% of their energy as neutrinos, preceding any optical signals, offering a unique opportunity to study the physics of these explosive events. While traditional neutrino detectors are optimized for specific flavors, dark matter experiments like XENONnT leverage coherent elastic neutrino-nucleus scattering (CEνNS), enabling detection of neutrinos across all flavors at low energies.

This presentation focuses on the methods developed within the XENONnT framework to identify supernova neutrino signals promptly. We discuss the simulation of neutrino interactions, strategies for detecting CEνNS signals in real-time, and the integration of an active software trigger to communicate with the Supernova Early Warning System (SNEWS). These techniques ensure efficient and timely detection, allowing dark matter detectors to complement traditional neutrino observatories.

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T 62.3 Wed 16:45 VG 4.102

Novel Peak(let) Classification for the XENONnT Experiment — •Johannes Merz for the XENON-Collaboration — Johannes Gutenberg-Universität Mainz, Institut für Physik & Exzellenzcluster PRISMA+

The XENONnT Experiment is a dual phase time projection chamber searching for nuclear recoil signals generated by WIMP dark matter. Interactions with the liquid xenon in the bulk of the detector result in a prompt light signal (S1) and a secondary scintillation signal (S2), due to ionization electrons drifted in a moderate electric field to the liquid surface, where they are extracted to the gas phase in a strong field between two wire electrodes, called gate and anode.

These electrons lead to proportional scintillation in the gas phase and hence to an amplified S2 signal. XENONnT features a substantial background rate of single electrons, largely due to photoionization of neutral impurities, leading to numerous small S2 signals. These can be confused with S1 signals of similar size.

This presentation will show new machine learning classification methods used in XENONnT which will help to improve the discrimination between the two signal types and identify interesting signal populations in our data.

T 62.4 Wed 17:00 VG 4.102

DARWIN forecasted sensitivities — •Maike Doerenkamp — Physikalisches Institut, Universität Heidelberg

DARWIN, as a proposed next generation xenon based direct detection experiment, aims to explore new parameter-space of WIMP-nucleon interactions through nuclear recoil, all the way to neutrino dominated regimes. This requires extensive simulation of detector parameters and their impact on detection efficiencies, as well as a good understanding of relevant backgrounds and their mitigation strategies. This talk gives an overview of the used methods and obtained sensitivity estimates for the DARWIN observatory.

T 62.5 Wed 17:15 VG 4.102

Coating-based radon barriers for future liquid xenon detectors — •Sophie Armbruster[1], Giovanni Volta[1], Hardy Simgen[1], and Florian Jörg[2] — [1]Max Planck Institut für Kernphysik, Heidelberg — [2]Universität Zürich

Despite overwhelming evidence for dark matter in our universe, its true nature remains a mystery. In the search for dark matter, detectors using liquid xenon are currently leading in sensitivity. However, these experiments are increasingly limited by self-induced backgrounds, particularly the emanation of radon from detector materials. To address this challenge, a novel radon mitigation technique using surface coatings as radon barrier has been investigated. Systematic studies at the Max Planck Institut für Kernphysik have demonstrated that electrochemical plating with a 5 μm copper layer can reduce radon emanation by up to three orders of magnitude. This technique is currently scaled up for vessel-like geometries with a new setup.

T 62.6 Wed 17:30 VG 4.102

Exploring Sub-GeV Dark Matter with CRESST: Advances, Challenges, and Prospects — •Marco Maria Zanirato — 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, operating at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. Utilising cryogenic calorimeters based on (mainly) scintillating crystals equipped with Transition Edge Sensors (TESs), CRESST achieves exceptional energy thresholds on the order of 30eV and operates at temperatures in the millikelvin range. These capabilities make CRESST uniquely suited to probe dark matter particles with sub-GeV masses. This talk will provide a comprehensive overview of CRESST, highlighting the working principles of its detectors, the latest results in dark matter searches, and the challenges inherent to such a cutting-edge experiment. The discussion will also include insights into ongoing efforts to refine detector designs and enhance the experiment's sensitivity, paving the way for future explorations in the quest to discover the nature of dark matter.

T 62.7 Wed 17:45 VG 4.102

Enhancing Simulation Statistics through Importance Biasing for the CRESST Experiment — •Praveen Murali for the CRESST-Collaboration — Heidelberg University

The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) experiment is a pioneering project in the search for dark matter, employing ultra-sensitive cryogenic detectors to capture rare particle interactions. These rare events demand highly efficient and accurate simulations to optimize detector performance and data analysis. Importance biasing is a technique that boosts statistical accuracy without requiring extensive repetitions, offering a solution to this challenge. In this work, we apply GEANT4's Importance Biasing to CRESST simulations, demonstrating its successful implementation and impact on improving statistical outcomes. This presentation will detail the methodology and the results of this approach for CRESST.

T 62.8 Wed 18:00 VG 4.102

Development of a Detector Module with Optimized Scintillation Light Sensitivity for the COSINUS Experiment — •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 direct dark matter search located at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. The experiment operates sodium iodide (NaI) as cryogenic calorimeters. Particle interactions within the crystal generate phonon signals, detected by a remote Transition Edge Sensor (remoTES). Combined with the scintillation signal detected by TES on a surrounding silicon beaker-shaped light absorber, a dual channel readout is achieved, enabling particle discrimination. This contribution focuses on the development of a detector module optimized in terms of scintillation light sensitivity. This is achieved by segmenting the light-collecting silicon beaker into multiple separated wafers surrounding the NaI crystal. The reduced size of these individual light absorbers minimizes heat capacity, thereby increasing sensitivity. The primary objective is the precise characterization of the scintillation light output of the ultrapure NaI crystals, which is vital for the data analysis of the upcoming COSINUS runs. Furthermore, this development represents a foundational step toward creating a detector module with single-photon resolution - a critical advancement for future investigations of dark matter interactions with electrons proposed within the LUCE/OνDES project funded by the Klaus Tschira foundation.

T 62.9 Wed 18:15 VG 4.102

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

The COSINUS (Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches) experiment plans a model-independent cross-check of the DAMA/LIBRA dark matter result. Starting its first operational phase in 2025, it will use the same target material NaI, but operated at cryogenic temperatures, enabling a dual-channel readout of both a scintillation and a phonon signal. The phonon signal is read out with a TES (transition edge sensor), but due to the low melting point and hygroscopicity of the NaI crystal, the TES cannot be deposited directly on the crystal. Therefore, the so-called remoTES setup is applied, in which the TES is located on a separate wafer and only a gold pad is required on the crystal. In the latest detector prototypes, the gold pad is deposited by an evaporation process. The first tests of this design have shown promising results. To further investigate and improve the performance and behavior of the detector design, the subsequent prototypes will be tested with different crystal masses and gold pad sizes. In this contribution, I would like to highlight the upgrades taken on the absorber part of the detector over the last year and present results of the latest detector prototype tests.