T 45: Searches for Dark Matter I

Time: Tuesday 16:00–18:30 Location: Tt

T 45.1 Tue 16:00 Tt

Sub-GeV WIMP search with a SuperCDMS R&D device — •Alexander Zaytsev, Lea Burmeister, Hanno Meyer zu Theenhausen, Fatema Thasrawala, Matthew Willson, and Belina von Krosigk — Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

The SuperCDMS experiment is an underground cryogenic direct dark matter search experiment with a potential to discover WIMPs or alternative light dark matter candidates. During the SuperCDMS R&D program, a surface run with a gram-scale silicon detector was performed. Offline optimal filter triggering applied to these data allowed for an extremely low analysis threshold of 9.2 eV, opening the possibility to probe new parameter space in the low-mass region. We present preliminary results for the dark matter nuclear recoil exclusion limit obtained with the data collected during this run.

T 45.2 Tue 16:15 Tt

Charakterisierung von SuperCDMS Hintergrund Spektren in HVeV-Detektor Daten — •Lea Burmeister, Hanno Meyer zu Theenhausen, Fatema Thasrawala, Matthew Wilson, Alexander Zaytsev und Belina von Krosigk — Universität Hamburg

SuperCDMS ist ein Experiment zur direkten Suche nach dunkler Materie. Ziel ist es die Interaktion zwischen dunkler Materie, z. B. WIMPs, und Silizium- oder Germanium-Detektoren bei ca. 15mK nachzuweisen. Vorbereitend werden R&D-Detektoren genutzt, bestehend aus 0.93g Silizium. Mögliche Ereignisse werden als Phononensignal detektiert, welches durch den Neganov-Luke-Effekt verstärkt wird. Mit einem dieser R&D-Detektoren wurden Daten sowohl an der Erdoberfläche als auch 100m unter der Erde genommen. In diesem Vortrag geht es um die Charakterisierung und den Vergleich der Hintergrundspektren ober- und unterhalb der Erdoberfläche.

T 45.3 Tue 16:30 Tt

Na-22 source study in the SuperCDMS experiment — •Fatema Khozema Thasrawala, Alexander Zaytsev, Hanno Meyer zu Theenhausen, Lea Burmeister, Matthew Wilson, and Belina Von Krosigk — University of Hamburg

The SuperCDMS experiment focuses on searching for WIMPs and light dark matter particles. SuperCDMS detectors are designed with the primary function of detecting the minute crystal lattice vibrations (phonons) and ionization (charge) generated within the crystal by low-mass dark matter particles and elastic collisions between crystal nuclei or electrons. An applied bias voltage across the detector amplifies event signals and allows for low-energy collisions to be measured. An analysis is underway to investigate the effects a radioactive source has on the events observed. One of the sources studied was sodium-22 with an activity of 4.6uCi which was placed near the detector. We present preliminary results about this study performed using the radioactive source at various bias voltages applied to the detector.

T 45.4 Tue 16:45 Tt

Investigation of coating methods for radon background reduction in liquid xenon experiments — •Mona Piotter, Hardy Simgen, and Florian Jörg for the XENON-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg

Several cosmological and astrophysical observations hint that a large fraction of the energy density of today's universe is present in the form of non-luminous matter. One candidate for this so-called dark matter is the WIMP (weakly interacting massive particle). Liquid xenon detectors are being used to search for their rare interactions with baryonic matter for which a very low background is necessary. The biggest source of background in these experiments originates from radon. To reduce this background, studies are carried out to examine the radon mitigation properties of surface coatings applied by electrodeposition. Previous investigations already showed that electrodeposited copper layers can offer a significant reduction in radon emanation. The various parameters of this coating method have now been systematically analyzed, with the focus being placed on the surface current density. The results of these investigations will be discussed during the talk.

T 45.5 Tue 17:00 Tt

XENONnT Rn222 budget — •Joaquim Palacio Navarro for the XENON-Collaboration — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117, Heidelberg, Germany

XENONnt operates a 5.9 ton liquid xenon (LXe) Time Projection Chamber (TPC) to probe WIMP cross sections down to $1.5{\cdot}10^{-48}$cm^2 at 90% confidence level for a 50 GeV particle. Such a low background experiment can only be achieved by the combination of shielding from external radiation plus mitigation of the effects from internal detector materials. Among the dominant contributions is emanation of ^{222}Rn, produced by the decay of residual ^{226}Ra present in nearly all materials. Once released, ^{222}Rn may reach the LXe target, inducing low-energetic background events within the sensitive volume. Long-lived daughters ^{222}Rn, can end up located at TPC walls and, due to partial signal lost, can mimic a typical WIMP signal.

Direct ^{222}Rn emanation measurements are hence, very important to prevent higher emanating materials to end up being, directly or indirectly, in contact with the LXe. Even more, a deep understanding of the location from the different ^{222}Rn sources within the system is crucial to define potential mitigation strategies during operation. Through very low-background techniques and the usage of alpha detectors, as proportional counters or radon monitors, we are sensitive to the different alphas produced through the decay chain of emanated ^{222}Rn. In this talk I show the most up-to-date XENONnT ^{222}Rn mapping and present preliminary results on the achieved radon concentration in LXe.

T 45.6 Tue 17:15 Tt

Strax and Straxen: Streaming analysis for xenon experiments — •Daniel Wenz for the XENON-Collaboration — Institut für Physik & Exzellenzcluster PRISMA, J. Gutenberg-Universität Mainz, 55099 Mainz, Germany

Over the last decades noble liquid time projection chambers (TPCs) have become one of the forefront technologies for the search in WIMP dark matter. As the detector increases in size, so do the amount of data and data-rates, leading to higher demands on the analysis software. The "streaming analysis for xenon experiments" (strax) is a software package used by the XENON collaboration. It provides a framework for signal processing, data storage and reduction as well as corrections handling for noble liquid TPCs. The software is written in Python and relies heavily on the SciPy-stack. The data itself is organized in a tabular format utilizing a combination of numpy structured arrays and numba for high performances. This approach allows live online processing of the data with throughputs of 60 MB raw / sec / core. Strax is an open source project and is used by a couple of smaller liquid xenon TPCs such as XAMS and XEBRA. It is also test by the nEXO Experiment for their MC simulations. In this talk we will explain the working principle and infrastructure provided by strax. We will show how a complex processing streamline can be build up via so called strax plugins based on XENON-collaborations open source package called straxen.

T 45.7 Tue 17:30 Tt

Update on the XENONnT Gd-loaded water Cherenkov neutron veto — •Daniel Wenz for the XENON-Collaboration — Institut für Physik & Exzellenzcluster PRISMA, J. Gutenberg-Universität Mainz, 55099 Mainz, Germany

For several years, the XENON1T experiment has been the most sensitive Dark Matter experiment for WIMP-nucleon coupling at masses above 6 GeV/c2. Following this success, an upgraded experiment XENONnT with a larger and more sensitive liquid xenon time projection chamber has been constructed and is currently being commissioned at the Laboratori Nazionali del Gran Sasso in Italy. The new experiment aims at a sensitivity improvement of more than one order of magnitude. To achieve this ambitious goal, the intrinsic neutron background of the detector must be reduced as well. Neutrons are capable of mimicking a WIMP signal by undergoing single-scatter nuclear recoils, escaping the sensitive volume without interacting a second time. To suppress this background, XENONnT will be equipped with a neutron veto system based on the novel principle of a gadolinium-loaded water Cherenkov detector, as has been developed for the Sk-Gd upgrade of the Super-Kamiokande experiment. The predicted neutron tagging efficiency for the XENONnT system reaches 84%, sufficient to render the remaining neutron background insignificant. In this talk we present an overview of the neutron veto system as well as its commissioning status.

T 45.8 Tue 17:45 Tt

A 4 cylinder radon-free magnetically coupled piston pump for the XENONnT experiment — •Philipp Schulte, Denny Schulte, Christian Huhmann, Michael Murra, and Christian Weinheimer for the XENON-Collaboration — Institut für Kernphysik WWU, Münster, Germany

Since commercially available pumps often exhibit electronegative contamination from lubricants on internal components and cannot meet the requirements on radiopurity of low background noble gas experiments especially w.r.t. radon emanation, a special type of pump has been developed for the XENON1T dark matter project (E. Brown et al., EPJ C78 (2018) 604). The design uses a magnetic piston in a hermically sealed cylinder that is magnetically coupled to an outer set of permanent magnets, which are moved up and down. All materials, essentially stainless steel, copper and special high density plastic for the inner pistion sealings are selected for low radioactivity.

In order to further increase the performance for the usage in the high flux radon removal system of the subsequent XENONnT, the design was extended to a four cylinder magnetically coupled piston pump being used as compressors for a kind of heat pump. Moreover, these four-pump were synchronized in operation to a phase shifted movement such that fluctuations in pressure and flow are reduced to a minimum.

This talk is about the design of this type of pump, as well as the optimization and synchronization of the pump extension.

The project is funded by BMBF under contract 05A17PM2 and 05A20PM1.

T 45.9 Tue 18:00 Tt

The ultra-low energy calibration based on a diluted ^{37}Ar source at the XENON experiment — •Matteo Alfonsi for the XENON-Collaboration — Institut für Physik & Exzellenzcluster PRISMA+, JGU Mainz, 55099 Mainz, Germany

The XENONnT experiment for direct Dark Matter detection is currently under commissioning. It is the upgrade of the XENON1T experiment and more than 20 times better sensitivity is expected from the three times larger target mass and the six times smaller background. The calibration of the detector response for ton-scale xenon Time Projection Chambers relies mostly on the dilution of gaseous radioisotopes such as ^{83m}Kr and ^{220}Rn into the liquid xenon. A novel calibration possibility based on the injection of the gaseous ^{37}Ar isotope and the subsequent active removal by cryogenic distillation has been demonstrated at the end of the XENON1T operation. This radioactive source has been produced with high purity by neutron capture in the TRIGA research reactor in Mainz, and its decay by electron capture (causing an X-ray and Auger electrons cascade) provided two unprecedented ultra-low energy calibration lines at 2.8 keV and 270 eV, which were crucial to validate the detector response model for several XENON1T results. Due to the relatively long decay time of the ^{37}Ar, 35.0 days, the proof of the cryogenic distillation active removal method has been the key for the consideration of this technique during the XENONnT operation.

This talk reports the results of the XENON1T calibration test and describe the new ^{37}Ar injection system installed in XENONnT.

T 45.10 Tue 18:15 Tt

A cage for Dark Matter: XENONnT electric field design — •Francesco Toschi — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

The XENONnT experiment is the next phase of the XENON project and aims at the direct detection of dark matter via WIMP-nucleus scattering. Its dual-phase Time Projection Chamber (TPC) filled with 5.9 ton of liquid Xenon allows position reconstruction and interaction-type discrimination, necessary for WIMP detection. The applied electric field plays a crucial role in its detection capabilities: uniformity in the drift field means homogeneous response in the full active volume, while high intensity fields in the liquid-gas interface are needed for electron extraction and proportional signal production. Numerical simulations are important both to optimize the design of the detector and to have a better understanding of the expected signals.

This talk will focus on the field shaping elements of the TPC and how the electric field simulations drove their design.