T 72: Experimental techniques in astroparticle physics III

Time: Wednesday 16:00–18:30 Location: Tv

T 72.1 Wed 16:00 Tv

PMT afterpulse studies in XENONnT — •Luisa Hötzsch for the XENON-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg

The XENONnT detector is the next generation direct dark matter detector in the XENON experiment series, utilizing in total 8.4 tonnes of xenon in a dual-phase liquid xenon time projection chamber. The scintillation light produced by particle interactions in the xenon target is detected by 494 Hamamatsu R11410-21 photomultiplier tubes (PMTs), chosen for their high quantum efficiency and low intrinsic radioactivity. One of the main PMT-intrinsic backgrounds is the effect of ion afterpulsing. Due to their typically short delay times of up to only a few microseconds, afterpulses can seriously impact the data quality in rare event searches. In particular, increasing afterpulse rates caused by a gradual vacuum degradation in the PMT can induce time-dependent background effects. In this talk I will present studies on the ion afterpulses in the XENONnT PMTs, using in-situ LED data taken during the XENONnT commissioning phase, as well as the afterpulse monitoring tools developed for future science data runs of XENONnT.

T 72.2 Wed 16:15 Tv

Radon removal system for the XENONnT experiment — •Denny Schulte, Michael Murra, Christian Huhmann, Philipp Schulte, and Christian Weinheimer for the XENON-Collaboration — Westfählische Wilhelms Universität, Münster, Germany

The direct dark matter search experiment XENONnT, located at Laboratori Nazionali del Gran Sasso, uses 8.3 tonnes of liquid xenon aiming for the direct detection of the Weakly Interacting Massive Particle (WIMP) and the search for other very rare processes. Intrinsic radioactive isotopes within the liquid xenon like Kr-85 and Rn-222 create the dominant electronic recoil background of the experiment and cannot be reduced by shielding or fiducialisation. A proven removal technique is cryogenic distillation using the different vapor pressures of krypton, radon and xenon. While the krypton removal can be done once before the detector is filled, radon is continously emanating from detector components. Therefore, a novel radon removal system based on an efficient thermodynamic concept ensuring a high xenon throughput has been developed and is now under commissioning at the XENONnT experiment.

This talk will zoom in on the thermodynamic idea and design along with first characterization measurements.

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

T 72.3 Wed 16:30 Tv

Measuring xenon scintillation light transmission through PTFE — •Dominick Cichon[1], Guillaume Eurin[1,2], Florian Jörg[1], Teresa Marrodán Undagoitia[1], and Natascha Rupp[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]IRFU, CEA/Saclay, France

Xenon has proven itself to be a well-suited target material to be used in detectors searching for rare events predicted by new physics. This is because of its properties, which include a high stopping power and the availability of both scintillation and charge signal channels. The latter allows for effective particle discrimination.

Detectors which utilize liquid xenon (LXe), such as LXe time projection chambers (TPCs), commonly use polytetrafluoroethylene (PTFE) to maximize the collection of scintillation photons and to optically decouple the intended sensitive volume from other detector regions. The reason is PTFE's high reflectivity at xenon's peak emission wavelength.

For rare event searches, the amount of PTFE used for the purposes mentioned above should be as small as possible in order to reduce the material budget and the accompanying radiogenic background. Furthermore, some detector applications necessitate the attenuation of the scintillation signal because of photosensor constraints. Motivated by these considerations, this talk presents measurements of the transmittance of PTFE for xenon scintillation light, both in gaseous and in liquid xenon. The results can be applied to estimate the amount of PTFE needed for optical decoupling and to construct xenon scintillation light attenuators made out of PTFE.

T 72.4 Wed 16:45 Tv

Offline xenon purity monitoring combining APIMS and gas chromatography — •Veronica Pizzella and Hardy Simgen — Max-Planck-Institut für Kernphysik, Heidelberg

Dual-phase xenon TPCs are among the most sensitive detectors for Dark Matter in direct searches. For the success of these experiments, it is necessary to use xenon with low concentration impurities. Two classes of impurities are of concern: radioactive impurities such as Kr-85 and H-3, since they increase the background; electronegative molecules such as oxygen, since they reduce the amount of electrons in the TPC. In this presentation, an offline purity monitor is presented using the technique of Atmospheric Pressure Ionization Mass Spectrometry (APIMS), with a commercial APIX dQ from Thermo Fisher and a custom-designed chromatography setup. The presented system is able to detect chemical impurities at the sub-ppb level. The calibration of the system and some results are presented.

T 72.5 Wed 17:00 Tv

Transmission of VUV light through PTFE — •Lutz Althueser[1], Sebastian Lindemann[2], Michael Murra[1], Marc Schumann[2], Christian Wittweg[1], and Christian Weinheimer[1] — [1]Institut für Kernphysik, WWU Münster, Germany — [2]Physikalisches Institut, Universität Freiburg, Germany

Polytetrafluoroethylene (PTFE, Teflon^{TM}) is commonly used in liquid xenon (LXe) based detectors to optimize the xenon scintillation light collection and to reduce the radioactive background rate from detector materials. The active LXe volume of such detectors is encapsulated in PTFE due to its high reflectance for VUV LXe scintillation light with peak emission at 178 nm. The thickness of these PTFE detector components specifies the reflectance, transmission and material radioactivity introduced into the detector.

The talk will present VUV transmission measurements for PTFE samples of various thicknesses in vacuum as well as in gaseous xenon using collimated light at a wavelength of 178 nm [1]. The Kubelka and Munk model will be introduced and applied to describe the light transmission over the full range of PTFE thicknesses.

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[1] L. Althueser et al., JINST 15 (2020) P12021

T 72.6 Wed 17:15 Tv

Production and characterization of a ^{226}Ra implanted stainless steel radon source — •Florian Jörg[1], Hardy Simgen[1], and Guillaume Eurin[1,2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Present Address: IRFU, CEA, Université Paris-Saclay, F-91191 Gif-sur-Yvette, France

Future liquid xenon detectors require unprecedented low levels of intrinsic radioactive backgrounds. Particularly, ^{222}Rn represents a background source threatening the design goals for the experiments sensitivity. Therefore extensive radon screening campaigns as well as studies on novel approaches for radon mitigation need to be carried out. Both of which crucially depend on infrastructure allowing to measure radon at very low activities. For the correct quantification of detection efficiencies as well as radon mitigation factors, reliable sources of known and stable radon emanation are necessary.

A new approach to produce clean and dry radon sources by implantation of ^{226}Ra ions into stainless steel has been investigated. In a proof of principle study, two 4 cm^2 large stainless steel plates have been implanted in collaboration with the ISOLDE facility located at CERN. Results from a first characterization of the sources will be presented. Measurements using electrostatic radon monitors and miniaturized proportional counters showed a ^{222}Rn emanation rate of about 2 Bq for each sample. Additional measurements using HPGe screening, alpha spectroscopy as well as measurements of their radon emanation rate at varying temperatures and pressures were carried out.

T 72.7 Wed 17:30 Tv

Modeling the response of non-uniform SiPM arrays — •Christoph Wiesinger, Patrick Krause, Stefan Schönert, and Mario Schwarz — Physik-Department, Technische Universität München, Garching

With typical silicon photomultipliers (SiPMs) having a photo-sensitive area of $O(1)$ cm^2, large-scale installations of > 1 m^2 photo coverage still represent a technical challenge. The usual workaround is to use light guides, e.g. optical fibers, and/or a common read-out of multiple SiPMs in a parallel array configuration. As it is not necessarily granted that each device features equal response, non-uniformities have to be considered an additional source of non-linearity. An analytical response model providing a continuous description of SiPM array spectra, containing on-top optical crosstalk and afterpulsing, has been developed. Its application is intended for the upcoming LEGEND experiment, where secondary event information is provided by scintillation light read-out at liquid argon temperatures.

T 72.8 Wed 17:45 Tv

Measurement of Cherenkov light in Water-based Liquid Scintillators — •Dorina Carolin Zundel, Michael Wurm, and Hans Theodor Josef Steiger — Johannes Gutenberg-Universität Mainz, Institute of Physics, Staudingerweg 7, 55128 Mainz

The SCHLYP detector (Scintillation Cherenkov Light Yield Prism) is a newly developed laboratory setup, used to distinguish between scintillation and Cherenkov light in (Water-based) liquid scintillator samples. The setup uses the geometrical advantages of a hollow prism as a detector, equipped with three ultra-fast photomultipliers (PMTs), on each side. The PMTs have a rise time of 1ns and a transit time spread of 200ps. The prism is filled with a scintillator based on a variety of novel solvents (e.g., LAB (Linear AlkylBenzene), DIN (di-isopropyl naphthalene)), on which photons from a close ^{137}Cs source scatter. A fast scintillation detector based on an anorganic crystal or a plastic scintillator is placed at a distance to detect backscattered events. Due to the directionality of Cherenkov light, the two PMTs opposite to the source are able to detect Cherenkov and scintillation light, while the last PMT is only able to detect scintillation light. Analyzing the coincident events from all four PMTs, the amount of light detected by the PMTs facing the source is higher, which indicates a simultaneous detection of scintillation and Cherenkov light. In this talk the first setup and the analysis of measured data will be presented as well as a new and improved setup. This work is supported by the Bundesministerium für Bildung und Forschung (Verbundprojekt 05H2018: R&D Detectors and Scintillators).

T 72.9 Wed 18:00 Tv

Quantitative Long-Term Monitoring of the Gas Composition in the KATRIN Experiment Using Raman Spectroscopy — •Genrich Zeller — Karlsruhe Institute of Technology

The Karlsruhe Tritium Neutrino (KATRIN) experiment aims at measuring the effective electron neutrino mass with a sensitivity of 0.2 eV/c^2 (90% C.L.) by investigating the energy spectrum of tritium beta-electrons near the kinematic endpoint of 18.6 keV. Analysis of the first neutrino mass data from 2019 set the known neutrino mass limit to 1.1 eV. This achievement was made possible, because most of the system components met, or even surpassed, the requirements during long-term operation. One important component is the laser Raman (LARA) system, which provides continuous high-precision information on the composition and tritium purity of the gas in the experiment's windowless gaseous tritium source (WGTS). In this talk, the performance and achievements of the LARA system are presented. The concentrations c_x for all six hydrogen isotopologues were monitored simultaneously, with a measurement precision of the order 10^{-3} throughout the complete KATRIN data taking. From these, the tritium purity, ϵ_T, is derived with precision of $<10^{-3}$ and trueness of $< 3 \cdot 10^{-3}$, fulfilling and surpassing the requirements for KATRIN. *This work is supported by the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Young Investigator Group (VH-NG-1055).*

T 72.10 Wed 18:15 Tv

KWISP - Latest results on the chameleon hunt at the CAST experiment at CERN — •Justin Baier — Uni Freiburg

The KWISP (Kinetic Weakly Interacting Slim Particle) detector is part of the CAST experiment at CERN exploring the dark sector. It utilizes an ultra-sensitive opto-mechanical force sensor for the search for solar chameleons. Chameleons are hypothetical scalar particles postulated as dark energy candidates, which have a direct coupling to matter depending on the local density. Considering these characteristics a flux of solar chameleons hitting a solid surface at grazing incidence will, under certain conditions, reflect and exert the equivalent of a radiation pressure. To exploit this trait the KWISP sensor consists of a thin and rigid dielectric membrane placed inside a resonant optical cavity. The latest results will be presented in this talk.