T 13: Detectors 2 (scintillators, other)

Time: Monday 16:00–18:00 Location: Geb. 30.23: 2/17

T 13.1 Mon 16:00 Geb. 30.23: 2/17

A novel cryogenic VUV spectrofluorometer for the characterization of wavelength shifters for the LEGEND-200 experiment — •Andreas Leonhardt[1], Maximilian Goldbrunner[1], Brennan Hackett[2], and Stefan Schönert[1] — [1]Technical University of Munich, TUM School of Natural Sciences, Garching, Germany — [2]Max Planck Institute for Physics, Garching, Germany

We present a novel cryogenic VUV spectrofluorometer designed to characterize wavelength shifters (WLS) crucial for experiments based on liquid argon (LAr) scintillation light detection. Wavelength shifters like tetraphenyl butadiene (TPB) or polyethylene naphthalate (PEN) are used in these experiments to shift the VUV scintillation light to the visible region. Precise knowledge of the optical properties of the WLS at LAr temperature (87 K) and LAr scintillation wavelength (128 nm) is necessary to model and understand the detector response. The cryogenic VUV spectrofluorometer was commissioned to measure the emission spectra and relative wavelength shifting efficiency (WLSE) of samples between 300 K and 87 K for VUV (128 nm to 190 nm) and UV (310 nm) excitation. The TPB-based wavelength shifting reflector (WLSR) and amorphous PEN featured in the neutrinoless double-beta decay experiment LEGEND-200 were characterized as part of this work. A first measurement of their relative WLSE and emission spectrum at RT and 87 K is presented. Lastly, the response of the wavelength-shifting fibers used in LEGEND-200 to visible blue excitation is studied. This research is supported by the DFG through the Excellence Cluster ORIGINS and the SFB1258.

T 13.2 Mon 16:15 Geb. 30.23: 2/17

Opaque Scintillator for Neutrino Physics — Christian Buck[1], Benjamin Gramlich[1], and •Stefan Schoppmann[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]JGU Mainz, Exzellenzcluster PRISMA$^+$, Detektorlabor, Staudingerweg 9, 55128 Mainz, Germany

A new scintillator system was developed based on admixtures of wax in organic scintillators. The opacity and viscosity of this gel-like material can be tuned by temperature adjustment and wax concentration. Whereas it is a colourless transparent liquid at temperatures above 40°C, it has a milky wax structure below.

Due to its light confinement, the scintillator system is expected to exhibit unprecedented particle ID via the topology of energy depositions. Moreover, a high degree of metal loading is feasible.

In this presentation, the production and properties of such a scintillator as well as its advantages compared to transparent liquids are described.

T 13.3 Mon 16:30 Geb. 30.23: 2/17

Spectral Measurements of Liquid Scintillators for a LiquidO Detector System — •Anatol Tunc, Alfons Weber, and Stefan Schoppmann — Johannes Gutenberg-Universität Mainz

LiquidO denotes an international consortium focusing on a new approach for liquid scintillation detectors (LSDs). In contrast to conventional methods striving for maximum transparency with light readout outside of the detection volume, the LiquidO ansatz utilises a deliberate opacity of the scintillator medium by means of reducing the scattering length via wax loading. The effective confinement of scintillation light around interaction vertices results in a particle specific topology of so-called 'light balls'. Local light readout by a dense array of wavelength shifting fibres running through the detector medium thus enables unprecedented spatial resolution and particle identification/discrimination for LSDs in the MeV range. This talk presents research efforts with a variety of scintillator solvents, wavelength shifters and combinations thereof considering employment in a LiquidO detector system. The research includes emission and absorption spectra, light yield measurements to estimate the response to monoenergetic gammas as well as the development of a small scale LiquidO detector enabling local testing of scintillator performance.

T 13.4 Mon 16:45 Geb. 30.23: 2/17

Development of a Precision Characterization Facility based on a Tagged 252Cf Neutron Source for Novel Scintillation Materials — Hans Steiger[1,2], •E. Fischer[1], U. Fahrendholz[1], L. Kayser[1], L. Oberauer[1], and M. R. Stock[1] — [1]Physik-Department, Technische Universität München, James-Franck-Str. 1, 85748 Garching — [2]Johannes Gutenberg University Mainz, Cluster of Excellence PRISMA+, Staudingerweg 9, 55128 Mainz

The techniques used to search for dark matter particles or detect neutrinos usually require the detection of a secondary recoiling nucleus in a detector to indicate the rare collision of such a particle with a nucleus. Therefore, neutrons are ideal probes to study the response of these detection media. For this R&D work, particle accelerator-driven neutron sources are usually used, which allow neutrons and gamma radiation to be distinguished by the Time-of-Flight (ToF) method. The aim of the work presented here was to develop a setup that can be operated on a lab scale and without a particle accelerator. Therefore, a fission-neutron time-of-flight experiment was realized. Several liquid scintillators for future kt-scale neutrino detectors were already irradiated and the neutron spectrum of the 252Cf source characterized. In this talk, the current status and perspectives of this facility is presented. This work has been supported by the Cluster of Excellence PRISMA+, the Cluster of Excellence ORIGINS as well as the Collaborative Research Center Neutrinos and Dark Matter in Astro- and Particle Physics (SFB1258) and the DFG Research Units 2319 and 5519.

T 13.5 Mon 17:00 Geb. 30.23: 2/17

The "LowRad"-project's cryogenic radon distillation column and heat pump development — •Philipp Schulte, Lutz Althüser, Volker Hannen, Christian Huhmann, David Koke, Andria Michael, Patrick Alexander Unkhoff, Daniel Wenz, and Christian Weinheimer — Institute for Nuclear Physics, University of Münster

In sense of continuous background reduction in dark matter research, the ongoing "LowRad"-project aims to develop the technology for the next generation of radon and krypton distillation columns. To achieve the science goals of future dark matter detector it is required to reduce the concentration of radon in a 40-tonne liquid xenon detector to less than <0.1 μBq/kg - an approximately tenfold reduction compared to the XENONnT limit of 0.8 $\mu\mu$Bq/kg. To attain this reduction, the throughput flow of the column must be increased to 750 kg/h, necessitating 21 kW power in both the evaporation of xenon during the thermal separation process and the reliquefaction of radon-depleted xenon. Therefore, a heat pump concept is needed hermetically separated from the primary circuit of the column. This talk will highlight the theoretical design, projected performance, and initial laboratory setups of this heat pump system.

Acknowledging the support of the ERC AdG project "LowRad" (101055063).

T 13.6 Mon 17:15 Geb. 30.23: 2/17

Designing cryogenic distillation systems for xenon using new calculation and visualisation tools — •Patrick Alexander Unkhoff, Lutz Althüser, Volker Hannen, Christian Huhmann, David Koke, Andria Michael, Phillipp Schulte, Daniel Wenz, and Christian Weinheimer — Institute for Nuclear Physics, University of Münster

In recent years cryogenic distillation of xenon has proven to be an effective way of reducing the intrinsic radioactive background for rare-event searches. This has been employed in the direct detection of weakly interacting massive particles (WIMPs) to remove the natural occurring isotopes ^{85}Kr and ^{222}Rn. Future experiments, such as DARWIN and XLZD, will rely on further reduction.

For this purpose, the core principles behind cryogenic distillation are revisited. Here, the differences in vapor pressure between xenon and the contaminant enable separation by repeated evaporation and condensation. The required number of such stages can be determined using the McCabe-Thiele method as well as a modified version to take advantage of the radioactive decay. Therefore, an interactive tool was developed to obtain prompt solutions using these methods.

However, further challenges in the distillation of xenon are posed by the required cryogenic temperatures. To drastically reduce the amount of external cooling as well as subsequent reheating, an energy-efficient heat pump concept is used. Consequently, another user-friendly tool was developed to solve the complex systems of equations for such thermodynamic systems.

T 13.7 Mon 17:30 Geb. 30.23: 2/17

A Xenon Cryogenic Distillation System for Krypton Removal in Next-Generation Dark Matter Experiments — •David Koke, Lutz Althüser, Volker Hannen, Christian Huhmann, Andria Michael, Philipp Schulte, Patrick Alexander Unkhoff, Daniel Wenz, and Christian Weinheimer — Universität Münster, Germany

Future dark matter experiments, such as DARWIN and XLZD, rely on liquid xenon detectors to probe WIMPs down to the neutrino fog. The prerequisite for the success of these experiments is a very low background, and therefore a very low krypton concentration. The LowRad project aims at developing a compact all-in-one xenon purification system for krypton, radon and electronegative impurities. The system's key components include a distillation column for continuous online removal requiring a secondary distillation column as a concentrator, reaching a Kr concentration of below 30 ppq $^{\mathrm{nat}}$Kr/Xe. This innovative approach enables a reduction of the amount of offgas and an increase of the offgas concentration, both by a factor of 1000 in comparison to XENONnT, effectively achieving quasi-lossless operation. This krypton removal system paves the way for achieving the ultra-low backgrounds demanded by next-generation dark matter experiments. This work is supported by the ERC AdG project "LowRad" of C. Weinheimer (No. 101055063).

T 13.8 Mon 17:45 Geb. 30.23: 2/17

Fast neutron production at the LNL Tandem from the 7Li(14N,xn)X reaction — •Hans Steiger[1,2], P. Torres-Sanchez[3], P. Mastinu[4], M. R. Stock[1], L. Oberauer[1], and I. Porras[3] — [1]Technical University of Munich, TUM School of Natural Sciences, Physics Department, James-Franck-Str. 1, 85748 Garching, Germany — [2]Cluster of Excellence PRISMA+, Johannes Gutenberg University Mainz, Staudingerweg 9, 55128 Mainz, Germany — [3]Dept. Atomic, Molecular and Nuclear Physics, University of Granada, Spain — [4]Istituto Nazionale di Fisica Nucleare, Legnaro Division, viale dell Universit'a 2, 35020 Legnaro, Italy

Fast neutron sources are of importance not only for basic nuclear physics. The list of other fields of applications includes: dosimetry, neutron detector development, fast neutron oncology, radiation protection shielding materials for accelerator based oncology and Space missions, and the study of single-neutron induced effects in digital and power electronics. This talk introduces fast neutron production using a XTU tandem accelerator at the INFN-LNL, via an 90 MeV beam of 14N6+ onto a lithium target. The commissioning results show clear agreement of the measured spectra with FLUKA simulations. The neutron spectrum is centered around the 8 MeV range with mild tails, and a maximum neutron energy above 50 MeV. This work has been supported by the Clusters of Excellence PRISMA+ and ORIGINS as well as the Collaborative Research Center SFB1258. Moreover, we are grateful for the support from the DFG Research Units 2319 and 5519.