T 53: Scintillator Detectors II

Time: Wednesday 16:15–18:30 Location: KH 01.014

T 53.1 Wed 16:15 KH 01.014

3d-Printing of Structured Plastic Scintillators — •Philipp Karl Kollar, Fabian Piermaier, Sebastian Ritter, Steffen Schönfelder, and Quirin Weitzel — JGU Mainz

Future experiments at high energy colliders call for calorimeters with high granularity. For scintillator-based sampling calorimeters, scintillator tiles, combined with a SiPM-based readout system, have established as a scalable solution to achieve such high granularity. To simplify production and assembly, structured scintillators-large scintillator plates, divided into optically isolated sections-offer a promising approach. Such structured scintillators can be produced in one single step by 3d-printing, while keeping the design customizable. In this presentation, the quality of 3d-printed scintillators will be discussed based on measurements utilizing cosmic muons. Additionally a comparison to injection-molded scintillators will be presented together with approaches for optimizing printing and polishing methods.

T 53.2 Wed 16:30 KH 01.014

Increasing Photon Capture Rate of Wavelength-Shifting Fibers for Opaque Scintillator Experiments — •Bastian Kessler and Sebastian Böser for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz

Wavelength-shifting optical fibers are widely used to collect and guide scintillation light from large detector volumes to photosensors, making them ideal for water Cherenkov and scintillator-based detectors. A key limitation, however, is their low photon capture efficiency, which degrades energy resolution of fiber-based detectors.

Building on prior work, we show that capture efficiency can be enhanced by optimizing the fibers absorption profile and adding a low-refractive-index outer cladding to boost total internal reflection. Although this reduces the fibers effective active area - rendering it less suitable for transparent detectors - it is advantageous in opaque scintillators, where photons remain localized and may hit the fiber multiple times before they get absorbed in the scintillator.

In this work, we study the impact on photon capture rate, cluster size, and timing performance in the hybrid opaque scintillator experiment NuDoubt++. Also, results of the first prototypes of optimized wavelength-shifting fibers (OWLs) are shown.

T 53.3 Wed 16:45 KH 01.014

Update on the Constuction of SuperSANDI for ANNIE — •Philipp Kern, Michael Wurm, Noah Goehlke, Amala Augusthy, and Johann Martyn — JGU Mainz

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a CHerenkov neutrino detector at the Booster Neutrino Beam (BNB) at Fermilab. To also allow measurements with scintillation light, a water based scintillator (WbLS) is installed inside the detector. The advantage of WbLS in the detector is that it is possible to extreact the energy of the neutrinos with the scintillation light as well as the trajectory of it with the Cherenkov cone. To allow us to observe the full potential of the water based scintillator by a full reconstruction of extended neutrino event vertices, a vessel made of nylon holding 8000 litres will be deployed in 2026. To be able to deploy this vessel into ANNIE it must be inflatable to be able to fill out the whole volume of the detector. We will present you with the current status of the development of this vessel, SuperSANDI, which has unique challenges because of its size and the properties of the WbLS.

T 53.4 Wed 17:00 KH 01.014

Characterisation of internal backgrounds in JUNO using BiPo-214 decays — •Ujwal Santhosh[1,2] and Livia Ludhova[1,2] — [1]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany — [2]Institute of Physics and EC PRISMA+, Johannes Gutenberg Universität Mainz, Mainz, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) operates at a depth of 700 m underground in South China. The detector has multiple ambitious physics goals, but to achieve them, JUNO must maintain the radiopurity of the scintillator at very high levels. This work focuses on the ^{238}U decay chain, which is assumed to be in secular equilibrium because of its long lifetime and can therefore be determined by measuring ^{214}BiPo coincidences. ^{214}Bi decays into ^{214}Po with a characteristic prompt-delayed signature that can be isolated using spatial and temporal coincidence. However, the secular equilibrium of isotopes below ^{222}Rn in the ^{238}U chain can be disturbed by radon influx from the surrounding air. This is characterised by an increase in the BiPo-214 rate, as they are the decay products of radon. Such contamination can typically occur during detector filling in the presence of small leaks. In a closed system, the broken equilibrium is then restored in weeks due to the relatively short lifetime of radon. This study follows the ^{214}BiPo rate during filling to search for radon leaks and later in a stable data-taking period to extract the ^{238}U level.

T 53.5 Wed 17:15 KH 01.014

First light in the MANGO target cell — •Elena Winiker[1], Daniela Fetzer[1], Michael Wurm[1], Manuel Böhles[1], Hans Steiger[2], and Kai Loo[3] — [1]Johannes Gutenberg-Universität Mainz — [2]Technische Universität München — [3]University of Jyväskylä

The Mainz Advanced Neutron Gamma Observatory (MANGO), currently in the final stages of construction in Mainz, is designed as a testing facility for scintillating detector materials used in neutrino experiments, such as JUNO.

High energy photons up to 9 MeV are generated by neutron capture on a converter and subsequently Compton scattered on the detector material. Varying the selected scattering angle enables the measurement of characteristics such as the linearity of the scintillation response across a wide range of energy depositions in the target, which is an important systematic for measuring the neutrino mass ordering in JUNO.

Additionally, the neutron converter can be removed to investigate the detector response to a neutron signal. The energy deposition of the scattered neutrons can be ascertained from the time of flight to the secondary detector.

This talk will outline the current status of construction of MANGO, focusing in particular on test measurements of coincidence events in the target cell.

T 53.6 Wed 17:30 KH 01.014

Development and Performance of a High-Pressure Scintillator Test Cell for NuDoubt^{++} — •Magdalena Eisenhuth for the NuDoubt-Collaboration — JGU Mainz, Institute of Physics

The investigation of two-neutrino and neutrino-less double beta decay is crucial for understanding the Dirac or Majorana nature of neutrinos. In this context, the krypton isotope Kr-78 (Q=2.88 MeV) stands out as a promising candidate for a first detection of two-neutrino producing decays, electron-capture beta-plus decay (2nuECb+) and double-beta decay (2nubb+). Detectors like the NuDoubt^{++} experiment featuring hybrid opaque scintillator can profit from solving krypton gas in the scintillator at high pressure to increase the number of target nuclei, thereby enhancing the probability of observing the extremely rare double beta decay modes. This presentation explores the ongoing development of a small-scale scintillator test cell for high-pressure loading, designed to examine the loading factor of krypton in scintillator as well as the influence on scintillator properties. We discuss the calibration required for a quantitative determination of the krypton concentration. Finally, we elaborate on the light yield and overpressure performances of the test cell and possible improvements.

T 53.7 Wed 17:45 KH 01.014

status of the cosmogenic analisis in the Jiangmen underground neutrino observatory — •Marcel Büchner, Tim Charisse, Arshak Jafar, Michael Wurm, Daniela Fetzer, Oliver Pilarczyk, and Manuel Böhles — Johannes-Gutenberg-Universität Mainz

The Jiangmen underground neutrino observatory (JUNO) is a 20 Kton liquid scintillator experiment located approx. 700m underground in the Guangdong province in China. Its main physics goal is the determination of neutrino mass ordering. To achieve that goal, it measures reactor neutrinos produced by two nuclear power plants that are located approx. 53 km away from the experimental site. Even at this depth, cosmic muons pass through the detector regularly. These muons are not only a significant background source but also produce various radioactive isotopes. This presentation focuses on the selection of these cosmogenic isotopes, which while producing an additional background can also be used to calibrate the detector for higher energies.

T 53.8 Wed 18:00 KH 01.014

Quality control of wavelength-shifting optical modules for the SHiP Surrounding Background Tagger — •Ida Wöstheinrich for the SHiP-SBT-Collaboration — Humboldt-Universität zu Berlin

SHiP (Search for Hidden Particles) is a general-purpose beam dump experiment in preparation at CERN. Its goal is to search for new Feebly Interacting Particles at the GeV-scale in an environment of effectively zero background. The Surrounding Background Tagger (SBT) is a key part of SHiP's background-suppression system. It detects muons entering SHiP's helium-filled decay volume from the sides, as well as muon and neutrino inelastic interactions within the volume. The SBT is based on liquid scintillator as the active detector material, read out by Wavelength-shifting Optical Modules (WOMs). An SBT WOM consists of a PMMA tube dip-coated with a dye that absorbs scintillation photons in the range of 280 nm to 400 nm and re-emits photons in the visible spectrum. The re-emitted photons are guided to a circular Silicon photomultiplier array at the end of the WOM tube via total internal reflection inside the tube walls. Approximately 1800 WOMs are required for the SBT, and their performance must be consistent and verifiable. This talk will discuss the development of a dedicated setup for standardised quality control of the SBT WOMs, along with first results. The setup measures the amplitude and homogeneity of the response at different positions on the WOM surface using a pulsed UV LED and photomultipliers in an automated system.

T 53.9 Wed 18:15 KH 01.014

Probing hybrid scintillators for NuDoubt++ — •Dorina Zundel for the NuDoubt-Collaboration — Johannes Gutenberg Universität Mainz

Neutrinoless double beta-plus decays ($0\nu\beta^+\beta^+, 0\nu\beta^+$EC, 0νECEC) have yet to be observed, posing a significant experimental challenge in the search for rare lepton-number-violating processes. The NuDoubt++ project (Neutrino Double Beta Plus Plus) addresses this challenge by developing novel detection techniques that combine hybrid slow opaque scintillators with advanced light readout systems. The first prototype will employ enriched Krypton-78 gas at high pressure within an opaque scintillator vessel, enabling containment and detection of positrons and their annihilation photons. This configuration allows detailed reconstruction of event topology and particle identification, enhancing sensitivity to rare decay modes.

The characterization of slow scintillators is performed using the SCHLYP (**S**cintillation **CH**erenkov **L**ight **Y**ield **P**rism) laboratory setup. A hollow prism filled with scintillator samples is instrumented with three ultra-fast photomultipliers. A nearby ^{137}Cs source generates signals via Compton scattering, and a secondary detector selects recoil photons aligned with the prism geometry. Two PMTs detect Cherenkov and scintillation light, while the third detects only scintillation, allowing measurement of the relative contribution of Cherenkov and scintillation components. The talk will present improvements to the setup including a Cherenkov radiator, enabling precise determination of scintillator decay timing characteristics.