T 31: Scintillator Detectors I

Time: Tuesday 16:15–18:15 Location: KH 01.014

T 31.1 Tue 16:15 KH 01.014

Commissioning of the Mu3e Tile Detector — •Erik Steinkamp for the Mu3e-Collaboration — Kirchhoff-Institut für Physik, Heidelberg, Germany

The Mu3e experiment has been designed with the objective of detecting the charged lepton flavour violating decay $\mu \rightarrow eee$ with an ultimate branching ratio of 10^{-16}. To achieve this sensitivity, the Mu3e experiment needs precise vertexing and tracking as well as very precise timing.

The Mu3e tile detector is a scintillator-based timing detector with SiPM readout that aims at a timing resolution of less than 100 ps. The final detector modules are currently being assembled and installed in the Mu3e experiment. A first commissioning beamtime of the Mu3e detector with three out of a total of 14 tile modules took place in mid-2025. In preparation for the first physics beamtime in late 2026, this data is being used to improve the performance of the tile detector through a comprehensive offline calibration procedure, as well as a robust clustering algorithm to combine individual channel hits into clusters for track matching. This talk will present the current status of the commissioning of the Mu3e tile detector, focusing on results from the 2025 beamtime, the qualification of existing modules and further developments.

T 31.2 Tue 16:30 KH 01.014

Timing performance of multiple prototypes of the Surrounding Background Tagger of the SHiP experiment — •Alessia Brignoli for the SHiP-SBT-Collaboration — Humboldt Universität zu Berlin

SHiP (Searching for Hidden Particles) is a beam-dump experiment that will be built at CERN, to search for new feebly interacting particles. A crucial component of the SHiP experiment is the Surrounding Background Tagger (SBT), a liquid scintillator based detector designed to suppress background arising from muons entering the helium-filled decay volume, as well as from muon/neutrino inelastic interactions occurring within the decay volume and its surroundings. The SBT consists of about 900 cells filled with liquid scintillator (LAB+PPO). Light collection is achieved through two PMMA wavelength-shifting optical modules (WOMs) per cell, each optically coupled to an array of 40 SiPMs. This work presents a collection of results from timing performance studies of SBT prototypes developed and tested between 2022 and 2025 at the CERN PS and at DESY Hamburg. The prototypes differ in the cell construction material as well as in the materials used to enhance the reflectivity of the inner walls, which is a crucial factor for light collection. In addition to the timing performance, the detector's capability of reconstruct particle crossing point and direction was studied. Finally, the experimental results were compared with Geant4-based photon transport simulations, providing further insight into the detector response and the overall quality of the constructed prototypes.

T 31.3 Tue 16:45 KH 01.014

Results from the November 2025 Test Beam measurements of SHiP's Surrounding Background Tagger prototypes — •Hannes Braune for the SHiP-SBT-Collaboration — Humboldt-Universität zu Berlin

The SHiP (Search for Hidden Particles) experiment, scheduled to start operation in 2032 at the CERN SPS Beam Dump Facility, aims to search for as-yet undiscovered feebly interacting long-lived particles. A large $\mathcal{O}(50\,\mathrm{m})$ long decay volume filled with helium together with a spectrometer allows the reconstruction of their decay products. The decay volume is surrounded by the Surrounding Background Tagger (SBT) to tag muons entering from outside and muon or neutrino inelastic interactions in helium. The SBT consists of $\mathcal{O}(900)$ cells forming a continuous 20 cm thick layer of LAB+PPO liquid scintillator around the entire volume, and is read out with wavelength-shifting optical modules (WOMs) coupled to SiPM arrays. In November 2025, the long-term performance as well as different cell sizes and WOM configurations were tested in dedicated test beam measurements at the CERN PS.

T 31.4 Tue 17:00 KH 01.014

Large liquid scintillator detectors in SHiP - Hardware and electronics — •Tilman Rock for the SHiP-SBT-Collaboration — Albert-Ludwigs-Universität, Freiburg, Germany

In the search for particles in the hidden sector, the SHiP (Search for Hidden Particles) experiment, a high-intensity, general-purpose beam-dump experiment, is in preparation. The primary objective is to search for weakly interacting particles within the GeV mass range, which requires a zero-background level. To this end, SHiP's large, helium-filled decay volume is encircled by the Surrounding Background Tagger (SBT), which is essentially a large array of about 900 individual mirror-polished aluminum cells filled with liquid organic scintillator. The SBT is designed to identify particles entering the decay volume and neutrino-induced reactions within it. To efficiently collect light, the cells have UV-reflective walls and wavelength-shifting optical modules (WOMs) for light collection. The collected light is detected by 40 silicon photomultipliers arranged in a circle, which are optically coupled to each of the WOMs. In this presentation, different types of optical coupling will be compared. Additionally, temperature-dependent gain variations will be compensated by changing the operating voltages. To measure the temperature-dependent breakdown voltages of the SiPMs, a dedicated test setup has been developed that measures the dark currents of entire arrays of 40 SiPMs for varying bias voltages and temperatures. The setup will be explained and first results will be presented.

T 31.5 Tue 17:15 KH 01.014

Data-based studies on the single hit efficiencies of the LHCb Scintillating Fibre Tracker — Blake Leverington, Ulrich Uwer, •Tom Wolf, Chishuai Wang, Miguel Ruiz Diaz, Giulia Tuci, Sebastian Bachmann, Xiaoxue Han, and Ya Zhao — Physikalisches Institut Universität Heidelberg

During 2019-2022 the LHCb detector was upgraded to allow operation at higher luminosity and full-detector read-out at 40 MHz. As core part of this upgrade, the Scintillating Fibre Tracker (SciFi) has been installed as the new main tracker. To detect charged tracks it makes use of 12 layers, constructed from 250 μm diameter scintillating fibres that are readout by silicon photomultipliers.

A principle performance parameter for the SciFi is the single hit efficiency, its ability to detect a hit when a particle track passes through one of its layers. To measure this value from data, charged particle tracks are reconstructed while excluding the layer under study, in which matching hits are then searched for. The efficiency is studied over the entire detector area, as well as over time and as a function of occupancy, to gauge the impact of the ionising radiation and luminosity delivered during Run 3 of the LHC.

T 31.6 Tue 17:30 KH 01.014

Optical simulations of plastic and $CeBr_3$ scintillator modules read out by SiPMs for the scintLaCharm Compton camera — •Kaveh Kooshkjalali, Alexander Deisting, Theresa Hahn, and Uwe Oberlack — Institute of Physics and Excellence Cluster PRISMA++

Within the framework of the ScintLaCHARM (Localization and CHAracterization of Radioactive Material) Compton Camera Project, which aims at the development of scintillation-based Compton cameras for applications such as nuclear power plant decommissioning, we present a Geant4-based optical simulation developed to study scintillation and Cherenkov light production and transport in plastic and $CeBr_3$ scintillators with silicon photomultiplier (SiPM) readout.

The detector geometry models two types of scintillation medium, reflective boundaries, and segmented top and bottom SiPM planes. Wavelength-dependent optical material properties and surface models are implemented to describe refraction, absorption, and reflection at all interfaces. Optical photon transport is tracked in detail, including absorption in the crystal, escape into the surrounding volume, and multiple reflections prior to detection. A SiPM sensitive detector records photon boundary crossings and classifies hits by detector plane, timing, and reflection history.

We study the impact of geometry and optical properties on detector performance, simulating light-collection efficiency, timing response, and detector position and energy resolution.

T 31.7 Tue 17:45 KH 01.014

Opaque Scintillators 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]Johannes Gutenberg-Universität 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, wax concentration, and wax type. Whereas it is a colourless transparent liquid at high temperatures, it has a milky wax structure below.

Due to its light confinement, the scintillator system is expected to exhibit unprecedented particle ID via the morphology of energy depositions. Moreover, a high degree of isotope loading is feasible, e.g. in the context of searches for double beta decays or neutron capture.

In this presentation, the production and properties of various opaque scintillators as well as their advantages compared to transparent scintillators are described.

T 31.8 Tue 18:00 KH 01.014

Opaque liquid scintillator prototype for Light Dark MatterSearches — •Jonas Pätschke for the MAGIX-Collaboration — Institute for Nuclear Physics, Johannes Gutenberg-University Mainz, Germany

In the ongoing search for light dark matter, the DarkMESA and NuDoubt^{++} collaborations have joined forces to explore a new region of parameter space. DarkMESA is an upcoming electron beam dump experiment at the new MESA accelerator facility in Mainz, designed to search for light dark matter particles mediated by a hypothetical dark photon γ', using a crystal calorimeter for detection. The NuDoubt^{++} experiment will employ an opaque liquid scintillator detector to investigate double beta decay ($2\beta\beta$) and the beyond Standard Model neutrinoless double beta decay ($0\nu\beta\beta$), two processes that have yet to be discovered.

This contribution will focus on the ongoing investigation into the use of opaque liquid scintillators as an additional or alternative detector medium to the DarkMESA crystal calorimeter. Such a detector would be able to reject events based on the topological signature. For this purpose, a prototype detector was designed, simulated and tested at the MAMI accelerator at energies around 10 MeV. This detector uses a 22-litre cubic volume of linear alkylbenzene (LAB) scintillator and 255 wavelength-shifting fibres attached to SiPMs arranged in a triangular grid with 10 mm pitch near a beam entrance window. A comparative analysis will be presented, evaluating the simulation and expected performance against the results of this first prototype.