T 32: Neutrino physics with accelerators

Time: Tuesday 17:00–18:30 Location: H-HS XV

T 32.1 Tue 17:00 H-HS XV

SHiP - The Surround Background Tagger and Liquid Scintillator Development — •Patrick Deucher, Annika Hollnagel, and Michael Wurm — Johannes Gutenberg Universität, ETAP, Mainz

SHiP is a proposed, general-purpose fixed target experiment at the SPS accelerator of the CERN Facility. Data collection is aimed for to start in 2027 focusing on the identification of Hidden Sector Particles, such as Heavy Neutral Leptons and light dark matter, and further investigation concerning tau neutrinos. When the high-intensity 400 GeV/c proton beam impinges on the hybrid target, heavy mesons and other weakly interacting particles of masses below 10 GeV/c* are created which can potentially decay into the particles of interest. After a hadron absorber and an active muon shield, the beam traverses through a vacuum vessel, where the particles are expected to decay. The products are then detected by a magnetic spectrometer and a calorimeter. To discriminate against external particle interactions, the vessel is enveloped by the Surround Background Tagger (SBT). The SBT is divided into segments and utilizes liquid scintillator and Wavelength Shifting Optical Modules (WOM) connected to SiPMs to identify throughgoing particles. In 2018/19, we have performed test beam measurements with a prototype detector cell at CERN PS and DESY. This contribution reports on the SBT in general and provides an overview on scintillator development.

T 32.2 Tue 17:15 H-HS XV

Status of the ESSνSB Target Station Design — •Tamer Tolba — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

In the quest of the CP-violation in the leptonic sector, a crucial information obtained recently from reactor and accelerator experiments; demonstrating that the value of the third neutrino-mixing angle, θ_{13}, is higher than its previously defined standard value. In the light of this new finding, an urgent need raised to improve the detection sensitivity of the current long-baseline detectors, with a key modification to place the far detectors at the second, rather than the first, oscillation maximum. The European Spallation Source Neutrino Super Beam (ESSνSB) aims at searching for CP-violation in the leptonic sector, at 5σ significance level in more than 60% of the leptonic Dirac CP violating phase range, and measure the CP phase angle with high precision by setting the neutrino source-to-detector distance at the second oscillation maximum. Several technological challenges must be precisely studied and simulated before addressing the design of the ESSνSB detector. Among these, the finite element and physics simulations of the target station and the neutrino beam considered highest priority at this phase of the ESSνSB project. Here I will shed light on the current target station design physics and FEA simulation efforts of the ESSνSB WP4 group.

T 32.3 Tue 17:30 H-HS XV

Application of the Topological Track Reconstruction to an idealised water-based liquid scintillator detector as study for Theia — Felix Benckwitz, Caren Hagner, David Meyhöfer, Henning Rebber, •Malte Stender, and Björn Wonsak — Universität Hamburg, Institut für Experimentalphysik

The Topological Track Reconstruction (TTR) was developed for unsegmented liquid scintillator detectors like JUNO and performs well in reconstructing track and point-like events in pure liquid scintillator. A next step is the application of the TTR to water-Cherenkov detectors like ANNIE and, in view of Theia, also to water-based liquid scintillator to exploit the advantages of both scintillation and Cherenkov light. Scintillation yields a high number of photons for determining the dE/dx, whereas Cherenkov light gives a handle for the particle identification via its event signature and a more precise event topology due to better time information. Furthermore, a high potential lies in the usage of newly developed photodetectors to max out the reconstruction's performance. The Large Area Picosecond Photodetectors (LAPPDs) feature a good spatial resolution of ~ 1 mm and an excellent time resolution of ~ 0.1 ns compared to the few nanoseconds PMTs typically achieve.

This contribution introduces the basic principles of the TTR and the application of the TTR to an idealised detector, which features a maximum coverage with LAPPDs and an active volume of water-based liquid scintillator. Therefore, also the detector simulation and the first results of the TTR are shown. This work is supported by the BMBF.

T 32.4 Tue 17:45 H-HS XV

Event Classification in the ANNIE experiment — •Michael Nieslony, Michael Wurm, and David Maksimovic for the ANNIE-Collaboration — Johannes Gutenberg-Universität, Mainz, Deutschland

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a 26 t Gadolinium-loaded Water Cherenkov detector on the Booster Neutrino Beam at Fermi National Accelerator Laboratory designed to measure the neutron multiplicity of neutrino nucleus interactions as well as the CC-inclusive neutrino cross-section on oxygen. Besides its physics goals, ANNIE will serve as a testbed for the new photosensor technology of Large Area Picosecond Photodetectors (LAPPDs) that achieve time resolutions below 100 ps and improve the vertex reconstruction capabilities of ANNIE.

The measurements of the neutron multiplicity and the cross-section on oxygen require a pure muon neutrino event sample and hence a need for electron/muon discrimination and multi ring event rejection capabilities. The following talk presents the current status of such classifiers for particle identification and multi-ring event rejection in ANNIE based on Machine Learning algorithms.

T 32.5 Tue 18:00 H-HS XV

Event reconstruction in a water-based liquid scintillator test cell for Theia — •Nils Brast, Daniele Guffanti, and Michael Wurm — Institut für Physik, Johannes Gutenberg-Universität Mainz, Germany

Water-based liquid scintillator (WbLS) permits to combine the benefits of Cherenkov detectors (high transparency, directionality) with the ones of Liquid Scintillator experiments (low energy threshold, good energy resolution). WbLS is considered as target medium for the ANNIE experiment at Fermilab and next-generation neutrino experiments such as Theia. Currently, a test cell for the characterization of WbLS is set up in Mainz to study the discrimination of Cherenkov and Scintillation signals. The setup will exploit the different time and spatial signatures of Cherenkov and Scintillation photons emitted by through-going cosmic muons. Accurate timing is achieved by a system of fast PMTs and offline analysis of digitized waveforms that will allow to resolve the prompt Cherenkov signal from delayed Scintillation photons. The characteristic ring-shaped hit pattern of Cherenkov photons provides another feature for separation. In this contribution we present the methods for event reconstruction developed in Monte-Carlo studies to optimize the design of the cell.

T 32.6 Tue 18:15 H-HS XV

On the road to Theia: the new Mainz WbLS test cell — •Daniele Guffanti, Michael Wurm, and Nils Brast — Institute of Physics and Excellence Cluster PRISMA, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany

One of the most promising developments in the field of neutrino detectors is the recent progress in the production of Water-based Liquid Scintillators (WbLS). This innovative detection medium is being considered by a new generation of neutrino experiments (THEIA, Watchman) for the possibility to combine the advantages of Water Cherenkov and Liquid Scintillators detectors, which opens the way to a broad physics program ranging from long baseline oscillation study to the measurement of low-energy solar neutrinos.

We present in this contribution the status of the development of a small test cell of approx. 10 l volume to be used to characterize different scintillating cocktails and probe the separation of Cherenkov and scintillation signals thanks to a fast PMT readout. Insights on the optical and scintillation properties of WbLS as well as future development and characterization of complementary ultra-fast photodetection systems (SiPM array, LAAPD) will be extremely valuable in view of the THEIA project and for the forthcoming upgrade of the ANNIE experiment.