T 81: Neutrino Physics VI

Time: Thursday 16:15–18:15 Location: VG 3.103

T 81.1 Thu 16:15 VG 3.103

A full Monte Carlo simulation for keV-sterile neutrino searches with the KATRIN experiment — •Claudio Silva for the KATRIN-Collaboration — Karlsruhe Institute of Technology, IAP, Campus North, Geb. 401, 76344, Germany

Sterile neutrinos are predicted by several extensions to the Standard Model and, if their mass falls within the keV range, they present a compelling dark matter candidate. One potential searching method involves looking for a kink-like distortion in the β spectrum. The Karlsruhe Tritium Neutrino Experiment (KATRIN) uses a tritium source to measure the neutrino effective mass, focusing on the endpoint where the mass effect is the clearest

The next phase of the KATRIN experiment, known as TRISTAN, seeks to extend this search across the entire tritium spectrum. This phase requires the installation of a new multi-pixel silicon drift detector and a specialized readout system, as well as significant modifications to the KATRIN beamline to improve sensitivity.

In this phase, sensitivity to keV sterile neutrinos is strongly influenced by systematic effects, including electron scattering in the source, detector response, and other factors. Addressing these challenges requires a highly efficient Monte Carlo (MC) simulation of the entire KATRIN beamline, capable of generating high-statistics datasets.

In this presentation, we introduce the KATRIN full MC simulation developed using Geant4. We will outline its key components, assess its performance, and present preliminary studies of systematic uncertainties affecting the search for keV-scale sterile neutrinos.

T 81.2 Thu 16:30 VG 3.103

Monte Carlo Simulation for Electron Scattering in the KATRIN Tritium Source — •Leo Laschinger for the KATRIN-Collaboration — Technische Universität München — Max-Planck-Institut für Kernphysik, Heidelberg

The KATRIN experiment is designed and currently being operated to measure the effective electron antineutrino mass by studying the endpoint region of the tritium beta decay spectrum. It also provides an opportunity to search for keV-scale sterile neutrinos. To that end, an investigation of the full beta spectrum is planned after the completion of the neutrino mass campaign. Electron scattering on tritium molecules in the gaseous tritium source is an important systematic effect in the KATRIN experiment, both for the ongoing neutrino mass measurement and for the upcoming search for keV-scale sterile neutrinos. In order to model this effect and its impact on the measured beta spectrum, an event-by-event Monte Carlo simulation utilizing Markov Chains for efficient cross section sampling has been developed. In this talk, I will present the working principles of the simulation, highlight the key results obtained, and discuss their implications for the KATRIN analysis. This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6). This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programme (grant agreement No. 852845).

T 81.3 Thu 16:45 VG 3.103

The Monte Carlo Simulation of JUNO's pre-detector OSIRIS — •Lukas Bieger, Dhanushka Bandara, Silvia Cengia, Adrian Keiderling, Florian Kirsch, Tobias Lachenmaier, Anurag Sharma, and Tobias Sterr — Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose neutrino experiment with a 20 kt liquid scintillator detector in the final phase of construction in southern China. Its primary objective is to determine the neutrino mass hierarchy by precisely measuring the oscillated energy spectrum of electron antineutrinos from nearby nuclear power plants. The Online Scintillator Internal Radioactivity Investigation System (OSIRIS) will monitor the radio-purity of the liquid scintillator during the filling of JUNO, to ensure that the required contamination levels are met. OSIRIS itself is a 18 t liquid scintillator detector, instrumented with 64 20-inch PMTs to collect the light produced by events in the detector's sensitive volume. A precise Monte Carlo simulation is essential for understanding the detector's performance and optimizing analysis methods. This talk will present the comprehensive simulation framework developed for OSIRIS and will discuss the agreement of the simulation output with respect to source calibration data. Furthermore, ongoing MC tuning using calibration data to improve the accuracy is reported. This work is supported by the Deutsche Forschungsgemeinschaft.

T 81.4 Thu 17:00 VG 3.103

LiquidO: Simulations for Cloud Detector — •Susanna Wakely for the CLOUD-Collaboration — Johannes Gutenberg University

LiquidO is an innovative technology that uses opaque liquid scintillators for particle detection. A LiquidO scintillator combines a short scattering length and a long absorption length to stochastically confine optical photons close to their creation point. A fine array of wavelength-shifting fibres collects and transports the scintillation light for readout by SiPMs. A LiquidO detector will have unprecedented position resolution compared to current transparent scintillators and be capable of particle identification via event topology. LiquidO prototypes have demonstrated proof of principle of stochastic light confinement.

The Cloud collaboration is designing a 5-10 ton LiquidO antineutrino detector. This will be an above-ground ultra-near reactor neutrino detector located in the Chooz nuclear power plant, in France.

This talk will discuss simulations of the inner detector, including particle identification via event topology and fibre array design. Two broad fibre array designs are considered: z-parallel and stereo. A z-parallel fibre array can achieve mm-scale resolution in x and y, with z-position obtained at lower resolution from signal timing differences. A stereo fibre array would produce the same x and y resolution while improving the z resolution but presents challenges for detector construction and signal reconstruction.

T 81.5 Thu 17:15 VG 3.103

Simulations regarding the water tank instrumentation for LEGEND-1000 — •Eric Esch — University Tübingen, Tübingen, Germany

In order to reach the challenging background goal of less than 10^{-5} cts/(keV·kg·yr) targeted by the next phase of the **L**arge **E**nriched **G**ermanium **E**xperiment for **N**eutrinoless $\beta\beta$ **D**ecay (LEGEND), new detector systems have to be planned and optimized. Previous Monte Carlo studies have revealed that the in-situ production and delayed decays of ^{77}Ge and its metastable state ^{77m}Ge constitute a significant cosmogenic background. This talk will present recent simulations exploring the instrumentation of the water tank, aimed at mitigating these contributions. Specifically, the instrumentation seeks to identify and veto events produced by neutron-showering muons, the key source of $^{77(m)}$Ge background.

T 81.6 Thu 17:30 VG 3.103

Current Status of ANNIE Monte Carlo — •Johann Martyn, Amala Augusthy, Noah Goehlke, Philipp Kern, David Maksimovic, Daniel Tobias Schmid, Michel Wurm, and Dorina Carolin Zundel for the ANNIE-Collaboration — Johannes Gutenberg-Universität, Institut für Physik, Mainz 55128, Germany

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a 26-ton water Cherenkov neutrino detector installed on the Booster Neutrino Beam (BNB) at Fermilab. Its main physics goals are to perform a measurement of the neutron yield from neutrino-nucleus interactions, as well as a measurement of the charged-current cross section of muon neutrinos. Additionally, ANNIE has strong focus on the research and development of new detector technologies and target media, such as Large Area Picosecond Photodetectors (LAPPDs) and Water-based Liquid Scintillator (WbLS). Ratpac is a simulation and analysis framework build with GEANT4, ROOT, and C++, which is currently used by multiple experiments in the investigation of WbLS. In ANNIE Ratpac simulates the full detector response, including the WbLS and LAPPDs. This talk presents the current status of the ANNIE implementation in Ratpac. his work is supported by the DFG.

T 81.7 Thu 17:45 VG 3.103

Status of the Super-SANDI deployment — •Philipp Kern, Amala Augusthy, Noah Goehlke, David Maksimociv, Johann Martyn, Daniel Schmid, Michael Wurm, and Dorina Zundel for

the ANNIE-Collaboration — Johannes Gutenberg Universität 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 in a 366 litre large vessel (SANDI). The advantage of WbLS in the detector is that it is possible to extract 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 extendet neutrino event vertices, a larger vessel made out of nylon holding 8000 litres of WbLS will be deployed in 2026. To be able to deploy this vessel, Super-SANDI into ANNIE it has to be inflatable to be able to fill out the whole volume of the detector. We will present you the current status of the development of this vessel, which has unique challenges because of its size and the properties of the WbLS.

I would like to thank the DFG and the Graduate School - Particle Detectors for their funding.

T 81.8 Thu 18:00 VG 3.103

DUNE-PRISM: An innovative technique for neutrino oscillation analysis — •Ioana Caracas for the DUNE-Collaboration — JGU Mainz

As long baseline neutrino experiments are entering the high-precision era, an increased sensitivity towards constraining the oscillation parameters space is expected. A classical approach for the oscillation predictions is prone to systematic uncertainties, due to the incompleteness of neutrinos interaction cross section modelling. This would in turn limit the capability to obtain the physics goals for modern long baseline experiments, such as the Deep Underground Neutrino Experiment (DUNE).

An innovative technique, the Precision Reaction-Independent Spectrum Measurement (PRISM) has been proposed and studied within the DUNE collaboration. This novel method is designed to measure and predict neutrino oscillated spectra on a data-driven approach, avoiding thus the most theoretical model uncertainties. In this regard, the Near Detector (ND) is designed to move off the neutrino beam axis at several locations up to a distance of 30 m. Different neutrino fluxes are thus sampled and these ND off-axis results are further used as basis to predict the neutrino oscillated spectrum at the DUNE Far Detector. The prediction obtained with the DUNE-PRISM analysis framework and preliminary results regarding the systematics impact on the oscillation parameters will be presented. Ongoing studies to improve the overall sensitivity to the oscillation parameters and reduce their dependence on the interaction model will also be discussed.