T 69: Neutrino physics without accelerators VI

Time: Wednesday 16:00–18:35 Location: Ts

Group Report T 69.1 Wed 16:00 Ts

First constraints on coherent elastic neutrino nucleus scattering by CONUS — •Thomas Hugle for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik (MPIK), Heidelberg, Germany

The CONUS experiment, located in Brokdorf, Germany, at one of the most powerful nuclear power plants in the world, aims at the detection of elastic neutrino nucleus scattering in the fully coherent regime below 10 MeV neutrino energy. This talk will describe the experimental setup of the four CONUS germanium detectors with a very low energy threshold in an elaborate shield at 17 m distance from the 3.9 GW thermal power generating reactor core. A first full spectral analysis of 248.7 kg·d reactor on and 58.8 kg·d reactor off (background) data will be presented, including all relevant systematic uncertainties and a complete Monte Carlo description of the background. This data set allows to place the current best limit on the coherent elastic scattering of reactor antineutrinos.

T 69.2 Wed 16:20 Ts

Quenching factor measurements for keV range nuclear recoils in germanium — •Aurélie Bonhomme for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik, 69117 Heidelberg

Coherent elastic neutrino-nucleus scattering (CEvNS) and Dark Matter search experiments are looking for nuclear recoils induced by neutrinos or Weakly Interacting Massive Particles. Their interpretation crucially relies on the understanding of the stopping process of the recoiling ion in the detecting media. In particular for detectors measuring ionization yields, such as high-purity germanium detectors (HPGe), it is of primary importance to know which fraction of the initial energy goes into ionization, while the rest is being dissipated as heat. This quantity, commonly called quenching factor, suffers from large uncertainties in the keV range - the region of interest for reactor-based CEvNS experiments like CONUS.

Recently, a dedicated quenching measurement was carried out by the CONUS group of MPIK in cooperation with the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig, Germany. It is expected that the results will significantly reduce the dominant uncertainty of the signal prediction of currently running CEvNS experiments using HPGe detectors. For this measurement, collimated monoenergetic neutron beams obtained via Li(p,n) reactions were used to probe nuclear recoils energies between 0.8 and 6 keV in a thin HPGe target. In this talk, the experimental setup and preliminary insights into the data will be presented.

T 69.3 Wed 16:35 Ts

The CONUS experiment - SM and BSM opportunities with recent and future data — •Thomas Rink for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik (MPIK), Heidelberg, Deutschland

The discovery of coherent elastic neutrino nucleus scattering (CEνNS) by the COHERENT experiment in 2017 set the stage for new opportunities within and beyond the Standard Model's neutrino sector. In 2020, the CONUS experiment located at the nuclear power plant in Brokdorf (Germany) was able to set the world's best limit in the challenging fully coherent regime at reactor site. In particular, the application of ultra-low threshold, high-purity Germanium detectors within a sophisticated shielding design in close vicinity to a nuclear reactor core describes the next milestone towards high-statistic neutrino physics. Moreover, the acquired and future CONUS data sets allow further investigations of yet undetected neutrino channels and properties such as neutrino magnetic moments and non-standard neutrino-quark interactions. Sensitivities to the Weinberg angle at MeV-scale and the reactor's antineutrino spectrum persist as well. Measurements at reactor site not only complement CEνNS investigations with neutrino beams, but might also affect other branches like dark matter or supernova physics. This talk gives an overview of the rich CEνNS phenomenology that can be addressed with recent and future experiments while highlighting the unique possibilities of the CONUS concept at nuclear power plants.

T 69.4 Wed 16:50 Ts

Background decomposition of the CONUS Experiment — •Janina Hakenmüller for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The CONUS experiment uses four low energy threshold high-purity Germanium (Ge) spectrometers to look for coherent elastic neutrino nucleus scattering (CEνNS) at the nuclear power plant of Brokdorf, Germany, which provides a high antineutrino flux with energies below 10 MeV. A successful background suppression is crucial to the success of the experiment. It is achieved with an elaborated shell-like shield design including an active muon veto. The latter provides reduction of cosmic radiation, as at the nuclear power plant only an overburden of 24 m w.e. is available. The background composition and its reduction through the shield is studied with Monte Carlo (MC) simulations with the Geant4-based framework MaGe. Any potential reactor correlated background at the location of the experiment was examined in a dedicated measurement and simulation campaign. In the talk, it will be shown that the contribution is negligible within the shield. A full description of the remaining non-reactor correlated background components inside the shield within the region of interest for CEνNS below 1 keV$_{ee}$ will be presented. Special attention is paid to time-dependent backgrounds such as the decay of cosmogenically activated isotopes and airborne radon. An outlook on possibilities to further suppress the remaining background will be given.

T 69.5 Wed 17:05 Ts

Development and operation of the OSIRIS prototype — •Oliver Pilarczyk, Wilfried Depnering, Heike Enzmann, Paul Hackspacher, Artur Meinusch, Kai Loo, Hans Steiger, Eric Theisen, and Michael Wurm — Institut für Physik, JGU Mainz

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kt liquid scintillator experiment currently under construction in Jiangmen (China). Its main scientific goal is to determine the neutrino mass ordering by measuring antielectron neutrinos from two nearby nuclear power plants at a distance of ~53 km. To achieve this goal the liquid scintillator has to go through several purification plants on site to make sure it meets the optical and radiopurity requirements.

The 20m* OSIRIS pre-detector is the last device behind these purification plants. Its task is to monitor the radiopurity of the purified scintillator before it is filled in the JUNO detector. OSIRIS is expected to be operated in a continuous mode, which means that the scintillator will be filled from the top and drained from the bottom into the main JUNO detector. To make sure every batch of the scintillator stays about 24 h inside the OSIRIS detector a temperature gradient will be established in the detection volume to help stratification of the liquid scintillator inside. This talk presents the prototype of the OSIRIS detector as developed and operated in Mainz as well as the results from the experiment. Furthermore a study on the sensitivity of the OSIRIS detector to U/Th contamination levels of the scintillator will be shown. The development is funded by the DFG Research Unit 'JUNO' (FOR2319) and the Cluster of Excellence PRISMA+.

T 69.6 Wed 17:20 Ts

Online analysis for the OSIRIS pre-detector of JUNO — •Philipp Kampmann[1], Runxuan Liu[1,2], Kai Loo[3], Livia Ludhova[1,2], Alexandre Göttel[1,2], Luca Pelicci[1,2], Mariam Rifai[1,2], Giulio Settanta[1], and Cornelius Vollbrecht[1,2] — [1]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [3]Johannes Gutenberg-Universität Mainz, Institute for Physics and EC PRISMA+, Mainz, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton liquid scintillator experiment currently under construction in the vicinity of the Pearl River Delta in Southern China. The data-taking is expected to start in 2022. JUNO aims to address a vast variety of physics goals in a broad range of energies. Its main focus lies on the determination of the Neutrino Mass Ordering measuring the oscillated reactor electron anti-neutrino spectrum from two adjacent nuclear power plants. Such measurements in the low-energy regime are affected and would suffer from high unexpected radioactive contaminations in the liquid scintillator. To ensure these strict limits, the OSIRIS pre-detector is designed to monitor the radioactivity of the liquid scintillator during the filling process of the JUNO detector. It holds 18 tons of scintillator and is instrumented via 76 large 20-inch PMTs. To provide an early warning of such a highly contaminated scintillator, the data from the OSIRIS detector needs to be evaluated in real-time. The corresponding online monitor software and analysis will be presented in this talk.

T 69.7 Wed 17:35 Ts

Vertex-Rekonstruktion für den JUNO-Vordetektor OSIRIS — •Artur Meinusch, Wilfried Depnering, Heike Enzmann, Paul Hackspacher, Kai Loo, Oliver Pilarczyk, Hans Steiger, Eric Theisen und Michael Wurm — Johannes Gutenberg-Universität Mainz, Institute of Physics and EC PRISMA$^+$, Staudingerweg 7, 55128 Mainz

Das Jiangmen Underground Neutrino Observatory (JUNO) ist ein Neutrino-Experiment, welches mehrere aktuelle Fragen zu Neutrino-Oszillationen klären soll, z.B. die Neutrino-Massenhierarchie, aber auch Sonnen-, Supernova- und Geo-Neutrinos beobachten soll. Die radioaktive Reinheit des Flüssigszintillators ist sehr wichtig für die Empfindlichkeit des Detektors. Um das Funktionieren der Reinigungsanlagen während der Befüllung des JUNO-Detektors zu gewährleisten, wurde der „Online Scintillator Internal Radioactivity Investigation System“ OSIRIS-Vordetektor entwickelt. Seine Aufgabe ist es, die intrinsische Kontamination über die Zerfälle der radioaktiven Isotope im Szintillator zu messen. Die angepeilte Empfindlichkeit von OSIRIS beträgt 10^{-16} Gramm U/Th pro Gramm Szintillator. Die Analyse stützt sich auf die Verwendung eines ausgezeichneten Referenzvolumens und die räumliche Koinzidenz von Bi-Po-Zerfällen. In diesem Vortrag werden verschiedene Rekonstruktionsalgorithmen vorgestellt, die zu diesem Zweck entwickelt wurden. Diese Arbeit wird von der DFG-Forschergruppe „JUNO“ (FOR2319) und dem Exzellenzcluster PRISMA$^+$ unterstützt.

T 69.8 Wed 17:50 Ts

Timing Calibration of the OSIRIS detector — •Tobias Sterr, Lukas Bieger, David Blum, Marc Breisch, Jessica Eck, Tobias Heinz, Benedict Kaiser, Frieder Kohler, Tobias Lachenmaier, Axel Müller, Alexandert Tietzsch, and Jan Züfle — Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20kt liquid scintillator (LS) detector currently under construction near Kaiping in southern China. Since this detector will feature an energy resolution of 3% @ 1MeV, the radiopurity of the liquid scintillator is of high importance. For monitoring the very low background rate introduced by radio impurities of the LS filling, the OSIRIS (Online Scintillator Internal Radioactivity Investigation System) pre-detector is introduced. To enable OSIRIS to measure impurities of up to 10-16g/g of Uranium and Thorium, a good event reconstruction and control of external backgrounds is important. Therefore, a precise calibration of the timing of the PMT array of OSIRIS is necessary. This talk will present an overview on the concept, the hardware and accompanying simulations of the timing calibration system of OSIRIS, which is based on 24 diffused light injection points driven by a pico-second pulsed Laser. This work is supported by the DFG (Deutsche Forschungsgemeinschaft).

T 69.9 Wed 18:05 Ts

Development of the muon veto system for the OSIRIS predetector of JUNO — •Axel Müller, Lukas Bieger, David Blum, Marc Breisch, Jessica Eck, Tobias Heinz, Benedict Kaiser, Frieder Kohler, Tobias Lachenmaier, Tobias Sterr, Alexander Tietzsch, and Jan Züfle — Eberhard Karls Universität Tübingen

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20-kton liquid scintillator next-generation neutrino detector currently under construction in southern China. Besides the main goal of determining the neutrino mass ordering, a broad range of neutrino sources will be investigated. For the monitoring of the liquid scintillator contamination levels during the filling process, the OSIRIS pre-detector is being designed, a 20-ton liquid scintillator detector installed in the scintillator filling line. Secondary neutrons and isotopes from cosmic muons are a severe background source, which affect the OSIRIS sensitivity limits. To reject this background source a Cherenkov muon veto was developed, for which the water volume around the target volume will be instrumented with additional PMTs. Their arrangement and the optical properties of the detector surfaces were optimized based on simulations to maximize the detection of Cherenkov photons from muons and thus increasing the muon detection efficiency. In this talk the requirements on the muon veto sensitivity, the design of the veto system and its expected performance will be reported. This work is supported by the Deutsche Forschungsgemeinschaft.

T 69.10 Wed 18:20 Ts

Status update on AURORA — •Wilfried Depnering, Michael Wurm, Heike Enzmann, Paul Hackspacher, Kai Loo, Artur Meinusch, Oliver Pilarczyk, Hans Steiger, and Eric Theisen for the JUNO-Collaboration — Johannes Gutenberg University, Mainz, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a reactor antineutrino experiment which aims to determine the neutrino mass ordering. In order to reach that goal, an energy resolution of 3% @ 1 MeV and percent-level understanding of energy-scale non-linearities are crucial prerequisites. Therefore, the transparency of the liquid scintillator (LS) has to be sufficiently high (attenuation length $L \geq 20$ m @ 430 nm) and remain stable during the whole operation time.

One device for in-situ monitoring of the optical LS quality is AURORA (**A** **U**nit for **R**esearching **O**n-line the LS t**RA**nsparency) inside the central detector of JUNO. Tiltable, blue laser beams are used to measure the optical attenuation of the LS allowing the detection of aging or other potential effects on LS transparency over time.

This talk presents the current status of AURORA. The development is funded by the DFG Research Unit "JUNO"(FOR2319) and the Cluster of Excellence PRISMA$^+$.