T 48: Neutrino Physics without Accelerators 3

Time: Tuesday 16:15–18:45 Location: T-H33

T 48.1 Tue 16:15 T-H33

Improved measurement of the neutrino mixing angle θ_{13} with Double Chooz — •Philipp Soldin, Lars Heuermann, Achim Stahl, and Christopher Wiebusch — III. Physics Institute B, RWTH Aachen University

Double Chooz is a reactor neutrino disappearance experiment that was operating between 2011 until 2018. Its primary purpose was the precise measurement of the neutrino mixing angle θ_{13}. The experimental setup consisted of two identical liquid scintillator detectors at average baselines of about 400 m and 1 km to two nuclear reactor cores in Chooz, France. The neutrinos were detected by measuring the inverse beta decay (IBD) signature, which consists of a prompt positron annihilation and a delayed neutron capture signal. The simultaneous measurement of the neutrino energy spectra with two detectors is used in a Poisson-based likelihood fit to obtain the neutrino mixing angle θ_{13}. This fit takes into account the respective neutrino fluxes, their energy spectra, all relevant backgrounds, and correlated uncertainties. The final data set, latest results, and novel ideas are presented in this talk.

T 48.2 Tue 16:30 T-H33

Likelihood based Sterile Neutrino Search with Double Chooz — •Lars Heuermann, Philipp Soldin, Achim Stahl, and Christopher Wiebusch — RWTH Aachen University - Physics Institute III B, Aachen, Germany

The Double Chooz experiment was a reactor electron anti-neutrino disappearance experiment with the purpose of measuring the neutrino oscillation angle θ_{13}. It used two nearly identical detectors at the respective distances of 400m and 1050m to the reactors of the nuclear power plant in Chooz, France, for this purpose.

Sterile neutrinos are hypothetical neutrino mass states, which do not participate in weak interactions, but still could participate in neutrino oscillations and thus would be measurable with Double Chooz. We present a search which focusses on a profile likelihood approach to test the data with respect to the parameters of a model with a single additional sterile neutrino state (3+1 model). A particular challenge thereby is that Wilks' theorem is not fulfilled and computationally intensive parameter scans have to be used to estimate the test statistics. The talk explains the analysis method and presents the median sensitivity for the sterile mixing parameter θ_{14} in dependence of Δm^2_{41}, as well as an analysis of the available experimental dataset.

T 48.3 Tue 16:45 T-H33

OSIRIS – a radiopurity detector for JUNO — •Christian Wysotzki for the JUNO-Collaboration — RWTH Aachen University - Physics Institute III B, Aachen, Germany

The Jiangmen Underground Neutrino Laboratory (JUNO) is a 20 kt liquid scintillator based neutrino observatory, which is currently under construction in southern China.

OSIRIS (Online Scintillator Internal Radioactivity Investigation System), as one of JUNOs subsystems, monitors the radiopurity of the liquid scintillator. Stringent limits regarding the contamination of radioactive isotopes, especially uranium and thorium have been defined to ensure the success of JUNOs physics program.

The assembly and commissioning of OSIRIS is foreseen for 2022. This talk will give an overview of the design philosophy, the detector systems, and the current status.

T 48.4 Tue 17:00 T-H33

Calibration of the JUNO pre-detector OSIRIS — •Moritz Cornelius Vollbrecht[1,2], Alexandre Göttel[1,2], Philipp Kampmann[3], Runxuan Liu[1,2], Livia Ludhova[1,2], Nikhil Mohan[1,2], Luca Pelicci[1,2], and Mariam Rifai[1,2] — [1]Forschungszentrum Jülich GmbH, Nuclear Physics Institute IKP-2, Jülich — [2]III. Physikalisches Institut B, RWTH Aachen University, Aachen — [3]GSI Helmholtzcentre for Heavy Ion Research, Darmstadt

The multi-kton liquid scintillator (LS) detector of the Jiangmen Underground Neutrino Observatory (JUNO) experiment, currently under construction in Southern China, has a vast potential for insights in several fields of (astro-) particle physics. To achieve its goals of determining the neutrino mass ordering, stringent radiopurity levels are required. To ensure these limits, the Online Scintillator Internal Radioactivity Investigation System (OSIRIS) was designed as a predetector for JUNO. In OSIRIS, 76 self-triggering intelligent PMTs (iPMTs) instrument a watershielded 20 ton liquid scintillator target. During the months-long filling of JUNO, a fraction of each purified scintillator batch passes through OSIRIS and its radiopurity is closely monitored. This enables fast countermeasures on possible contaminations. Multiple calibration systems are employed in OSIRIS. An Automatic Calibration Unit (ACU) of the Daya Bay experiment is used to calibrate energy and vertex event reconstructions as well as iPMT timing and charge responses. A separate laser system is used for the timing calibration of the iPMTs. This presentation will summarize the current status of the work concerning the calibration strategy of OSIRIS.

T 48.5 Tue 17:15 T-H33

Liquid Handling System of the OSIRIS detector — Michael Wurm, Hans Steiger, Kai Loo, Eric Theisen, and •Oliver Pilarczyk — Johannes Gutenberg-Universität 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 $20m^3$ OSIRIS pre-detector is the last device behind these purification plants and will be constructed in a underground hall close to the main JUNO detector. Its task is to monitor the radiopurity of the purified scintillator before it is filled in the JUNO detector and it will reach sensitivity levels of $10^{-16}g/g$ on Uranium and Thorium. OSIRIS is expected to be operated in a continuous mode, which means that parts of the scintillator from the main filling line will be redirected into a bypass in which the OSIRIS detector is placed and then being send on back into the main filling line. 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. This talk covers the operation of the Liquid Handling System (LHS) and the included Level Measurement (LM) which control and oversee the operation of OSIRIS. The development is funded by the DFG Research Unit *JUNO* (FOR2319) and the Cluster of Excellence $PRISMA^+$.

T 48.6 Tue 17:30 T-H33

The Laser calibration system of the JUNO pre-detector OSIRIS — •Tobias Sterr, Lukas Bieger, David Blum, Marc Breisch, Srijan Delampady, Jessica Eck, Gina Grünauer, Tobias Heinz, Benedict Kaiser, Frieder Kohler, Tobias Lachenmaier, Axel Müller, Alexander Tietzsch, and Jan Züfle — Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory is a multi-kton, multi-purpose Neutrino observatory currently under construction in Kaiping, Southern China. It has a vast potential for progress in several field of (astro-) particle physics (e.g., the neutrino mass ordering, supernova neutrinos, geoneutrinos, etc.). To achieve the goals, a thorough control of the radiopurity levels of the liquid scintillator is required. Therefor the Online Scintillator internal Radioactivity Investigation System (OSIRIS) was introduced as a pre-detector to JUNO. OSIRIS features 76 self-triggering intelligent PMTs (iPMTs) as well as a water-shielded, 20-ton liquid scintillator target. During the filling phase of the main detector, OSIRIS will measure the radiopurity of a fraction of each batch of liquid scintillator passed to JUNO. To enable OSIRIS to reach the necessary sensitivity to perform this task, two calibration systems will be available: An automated calibration unit and a laser calibration system. This talk will focus on the laser calibration system which will be used for both, timing and charge calibration of the iPMTs. Additionally, the preliminary calibration strategy of the laser system of OSIRIS will be presented. This work is supported by the Deutsche Forschungsgemeinschft (DFG)

T 48.7 Tue 17:45 T-H33

Final Results of the PoLiDe Experiment — •Ulrike Fahrendholz[1], Lothar Oberauer[1], Hans Steiger[1,2], Raphael Stock[1], David Dörflinger[1], Mario Schwarz[1], and Konstantin Schweizer[1] — [1]Technische Universität München (TUM), Physik-Department, James-Franck-Str. 1, 85748 Garching bei München —

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The Jiangmen Underground Neutrino Observatory (JUNO) aims to determine the neutrino mass ordering by detecting reactor electron-antineutrinos. In the main detection channel, the inverse beta decay (IBD), a positron is produced, which is used to reconstruct the neutrino*s initial energy. If the positron forms a bound state with spin 1, called ortho-Positronium (o-Ps), with an electron prior to its annihilation, the time structure of the event is distorted due to the longer lifetime of o-Ps. The Positron Lifetime Determination (PoLiDe) experiment was built to determine the lifetime and formation probability of o-Ps in liquid scintillators (LSs). In this talk, the final results of the lifetime measurements for different organic LSs, including the JUNO mixture, and a water-based LS sample are presented.This work is supported by the DFG research unit "JUNO", the DFG collaborative research centre 1258 "NDM", and the DFG Cluster of Excellence "Origins.

T 48.8 Tue 18:00 T-H33

Measurements of the attenuation length and the group velocity of liquid scintillators with the CELLPALS method — •Jessica Eck, Lukas Bieger, David Blum, Marc Breisch, Srijan Delampady, Gina Grünauer, Tobias Heinz, Benedict Kaiser, Frieder Kohler, Tobias Lachenmaier, Axel Müller, Tobias Sterr, Alexander Tietzsch, and Jan Züfle — Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory (JUNO) is currently constructed in southern China with the main goal to determine the neutrino mass hierarchy by detecting reactor antineutrinos. The JUNO detector consists of a large spherical vessel filled with 20ktons of highly transparent liquid scintillator. To quantify the transparency, a measurement of the attenuation length is crucial, however, this poses a challenge for attenuation lengths of several tens of meters due to the necessity of a sufficient long light path through the sample.

This talk will present the CELLPALS method to measure the attenuation length of liquid scintillators using an optical cavity to extend the effective light path. In addition, the CELLPALS method also provides the determination of the group velocity of the sample. The experimental setup and the results for different samples will be presented.

This work is supported by the Deutsche Forschungsgemeinschaft.

T 48.9 Tue 18:15 T-H33

Fluorescence Time Profiles of the JUNO and TAO Liquid Scintillators using a Pulsed Neutron Beam in the Energy Range from 3.5 to 5.5 MeV — •Matthias Raphael Stock[1], Hans Th. J. Steiger[1,2], David Dörflinger[1], Stefan Schoppmann[3], Ulrike Fahrendholz[1], Lothar Oberauer[1], Luca Schweizer[1], Korbinian Stangler[1], and Dorina Zundel[2] — [1]Physik-Department, TU München, James-Franck-Str. 1, 85748 Garching — [2]JGU Mainz, Cluster of Excellence PRISMA+, Staudingerweg 9, 55128 Mainz — [3]University of California, Department of Physics, Berkeley, CA 94720-7300, USA

We simultaneously performed two liquid scintillator (LS) characterization experiments using a pulsed neutron beam at the CN accelerator of INFN Laboratori Nazionali di Legnaro. At energies ranging from 3.5 MeV to 5.5 MeV, one experiment measures the quenching factor of recoil protons while the one other measures the scintillation time profile of recoil protons. This talk is about the time profile experiment, where we show results of LS mixtures for the upcoming neutrino experiments JUNO and TAO in China as well as for future projects e.g., Theia, which will use a water-based LS. Differences in the time profiles after gamma and neutron excitation allows to perform pulse shape discrimination and therefore advances the ability to distinguish the neutrino signal from background. This work is supported by the BMBF Verbundforschung 05H2018 "R&D Detektoren (Szintillatoren)", the DFG research unit "JUNO", the DFG CRC 1258 "NDM" and the DFG Clusters of Excellence "PRISMA+" and "Origins".

T 48.10 Tue 18:30 T-H33

Quenching Factor Studies for Organic Liquid Scintillators with a Pulsed Neutron Beam — •Hans Th. J. Steiger[1,2], M. Raphael Stock[2], David Dörflinger[2], Stefan Schoppmann[3], Manuel Böhles[1], Ulrike Fahrendholz[2], Lothar Oberauer[2], Luca Schweizer[2], Korbinian Stangler[2], and Dorina Zundel[1] — [1]JGU Mainz, Cluster of Excellence PRISMA+, Staudingerweg 9, 55128 Mainz, Germany — [2]Physik-Department, TU München, James-Franck-Str. 1, 85748 Garching, Germany — [3]UC Berkeley, Department of Physics, CA 94720-7300, USA

Leading current multi-ton-scale neutrino experiments rely on the successful application of liquid scintillators (LS). Therefore, detailed understanding of the detectors and their detection media are crucial to construct realistic simulations and predictions of phenomena. With our measurements at the CN accelerator of the INFN Laboratori Nazionali di Legnaro, we conduct precision characterizations of LSs in terms of proton quenching and fluorescence spectra. In these experiments neutron interactions are distinguished from beam correlated gammas by time-of-flight measurements. During several beamtimes in the past two years we studied samples of scintillators from the experiments JUNO, TAO, Borexino, Theia and SNO+. Precise data about the quenching factors of proton and 12C-recoils for all measured liquid scintillators were gained for the first time. This work is supported by the Cluster of Excellence PRISMA+, the Bundesministerium für Bildung und Forschung (Verbundprojekt 05H2018: R&D Detectors and Scintillators) and the DFG Research Unit JUNO.