T 44: Neutrino physics without accelerators V

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

Group Report T 44.1 Tue 16:00 Ts

Prospects, Design and Status of JUNO — •Hans Steiger on behalf of the JUNO Collaboration — Cluster of Excellence PRISMA+, Johannes Gutenberg University Mainz (JGU), Staudingerweg 9, D-55128 Mainz

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton multi-purpose liquid scintillator detector currently being built in a dedicated underground laboratory in Jiangmen (PR China). Data taking is expected to start in 2021. JUNO's main physics goal is the determination of the neutrino mass ordering using electron anti-neutrinos from two nuclear power plants at a baseline of about 53 km. JUNO aims for an unprecedented energy resolution of 3% at 1 MeV for the central detector, to be able to determine the mass ordering with 3 - 4 σ significance within six years of operation. Besides this fundamental aim, JUNO will have a very rich physics program. It includes the measurement (at a sub-percent level) of the solar neutrino oscillation parameters, the detection of low-energy neutrinos coming from galactic core-collapse supernovae, the first measurement of the diffuse supernova neutrino background, the detection of neutrinos coming from the Sun, the Earth and the Earth's atmosphere. Moreover, JUNO will be sensitive to searches for nucleon decays and neutrinos resulting from dark matter annihilation in the Sun. In this talk JUNO's design, physics prospects as well as the status of its construction will be presented, together with a short excursion into its rich R&D program.

T 44.2 Tue 16:20 Ts

Relative Light Yield Determination for the Future Neutrino Experiments JUNO and THEIA — •David Dörflinger[1], Lothar Oberauer[1], Hans Steiger[1,2], Raphael Stock[1], Konstantin Schweizer[1], Ulrike Fahrendholz[1], Stefan Schoppmann[3], Ludwig Wallner[1], Matthias Mayer[1], Sebastian Zwickel[1], and Andreas Steiger[1] — [1]Technische Universität München (TUM), Physik-Department, James-Franck-Straße 1, 85748 Garching bei München — [2]Institute of Physics and Excellence Cluster PRISMA+, Johannes Gutenberg-Universität (JGU) Mainz, Staudingerweg 9, 55099 Mainz — [3]University of California, Department of Physics, Berkeley, CA 94720-7300, USA and Lawrence Berkeley National Laboratory, Berkeley, CA 94720-8153, USA

The Jiangmen Underground Neutrino Observatory (JUNO) aims to detect neutrinos using 20 kton of organic liquid scintillator (LS) based on LAB (Linear AlkylBenzene). The THEIA experiment, which is currently being designed, has similar scientific goals but will additionally measure long baseline neutrinos. Therefore, it will take a different approach on the detector design and is expected to use 100 kt of a water based liquid scintillator (WbLS). Still, in order to understand the detector response, a precise knowledge of the used liquid scintillator's light yield is needed. In this talk a way to measure the relative light yield of a given LS sample will be presented. This work is supported by the Bundesministerium für Bildung und Forschung (BMBF) for THEIA (Verbundprojekt 05H2018: R&D Detectors and Scintillators) and the DFG Research Unit JUNO (FOR2319).

T 44.3 Tue 16:35 Ts

Muon veto restriction with Topological Track Reconstruction in JUNO — •David Meyhöfer, Henning Rebber, Malte Stender, and Björn Wonsak — Institut für Experimentalphysik, Universität Hamburg, Germany

The main signal at Jiangmen Underground Neutrino Observatory (JUNO) is the inverse beta decay (IBD) and the muon veto has the largest impact on IBD efficiency. Therefore an improvement of the muon veto strategy can yield more active volume, which in turn will enable more signal in the same time or the same signal in less measurement time. This talk will focus on the reduction of dead volume in JUNO with the restriction of muon vetoes to points of interest along muon tracks. This method is enabled by the reconstruction capabilities of the topological track reconstruction approach, which can determine shower positions along muon tracks.

T 44.4 Tue 16:50 Ts

On the road to THEIA: current status of the Mainz WbLS test cell — •Manuel Böhles, Nils Brast, Daniele Guffanti, Hans Steiger, and Michael Wurm — Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany

The detection of neutrinos using water-based liquid scintillators (WbLS) is a promising method in the field of detector development. Its strength lies in combining high-resolution energy determination with a low energy threshold through the use of scintillation light and in the directional reconstruction with the help of Cherenkov radiation. The spectrum of potential applications is broad, ranging from long-baseline oscillation studies to the measurement of low-energy solar neutrinos. The key point of this new technique is the discrimination between scintillation and Cherenkov photons, which can be achieved by exploiting the different chromatic features, time behaviour and angular emission. In order to characterise this innovative medium and to prove whether scintillation and Cherenkov radiation can be distinguished, our group is building a test cell (15l) equipped with fast photomultipliers that can provide useful insights towards a new generation of detectors. In addition, complementary ultrafast photodetection systems (SiPM array, LAPPD) can be investigated in future studies. This work is supported by the BMBF Verbundprojekt 05H2018: R&D Detectors and Scintillators.

T 44.5 Tue 17:05 Ts

Application of the Topological Track Reconstruction to an idealised water-based liquid scintillator detector as study for Theia — 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 $\sim 1\,\mathrm{mm}$ and an excellent time resolution of $\sim 0.1\,\mathrm{ns}$ 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 44.6 Tue 17:20 Ts

Implications of a fine structure in the reactor neutrino spectrum for JUNO — David Blum, Lukas Bieger, Marc Breisch, Jessica Eck, •Tobias Heinz, Benedict Kaiser, Frieder Kohler, Tobias Lachenmaier, Axel Müller, Tobias Sterr, Alexander Tietzsch, and Jan Züfle — Physikalisches Institut, Eberhard Karls Universität Tübingen

With the main goal to determine the neutrino mass hierarchy, the Jiangmen Underground Neutrino Observatory (JUNO) is currently constructed in the Guangdong province in southern China. To determine which mass hierarchy is realized in nature, JUNO measures the reactor neutrino spectrum from two nuclear power plants located in a distance of around 53 km. One crucial aspect is the precise knowledge of the emitted reactor neutrino spectrum. In the last years, new predictions of the spectrum revealed the possible existence of a spectral fine structure which can only be observed with the unprecedented energy resolution the JUNO detector will have. This talk will present studies on possible implications of the fine structure in the reactor neutrino spectrum for the sensitivity of the mass hierarchy determination with JUNO. This work is supported by the Deutsche Forschungsgemeinschaft.

T 44.7 Tue 17:35 Ts

Results from and Prospects for the PMT Mass Testing Container System for JUNO — •Alexander Tietzsch[1], Lukas

Bieger[1], David Blum[1], Marc Breisch[1], Jessica Eck[1], Caren Hagner[2], Tobias Heinz[1], Benedict Kaiser[1], Frieder Kohler[1], Tobias Lachenmaier[1], David Meyhöfer[2], Axel Müller[1], Henning Rebber[2], Tobias Sterr[1], Björn Wonsak[2], and Jan Züfle[1] — [1]Physikalisches Institut, Eberhard Karls Universität Tübingen — [2]Institut für Experimentalphysik, Universität Hamburg

The Jiangmen Underground Neutrino Observatory (JUNO) experiment will be a new neutrino oscillation experiment, which is currently under construction and starting in the next years, with main goal of determining the neutrino mass ordering from the oscillation pattern. Therefore a high energy resolution of 3% @ 1 MeV is required, for whose realization up to 20'000 20-inch photomultiplier tubes (PMTs) will be used in JUNO. All of these PMTs have to fulfil dedicated quality requirements for several key characteristics (dark rate, PDE, peak-to-valley ratio etc.) for which a PMT mass testing facility using commercial shipping containers has been developed. This PMT testing container system is running successfully for more than 3 years now and all 20'000 PMTs have been tested and characterized at least once. In this talk we report about the progress in PMT testing, show selected results on the PMT performance and accuracies of the testing facility and will discuss prospects for the container system and the ongoing PMT characterization campaign for JUNO. This work is supported by the Deutsche Forschungsgemeinschaft.

T 44.8 Tue 17:50 Ts

JUNO's sensitivity for indirect dark matter search — •David Blum, Lukas Bieger, Marc Breisch, Jessica Eck, Tobias Heinz, Benedict Kaiser, Frieder Kohler, Tobias Lachenmaier, Axel Müller, Tobias Sterr, Alexander Tietzsch, and Jan Züfle — Eberhard Karls Universität Tübingen

The Jiangmen Underground Neutrino Observatory (JUNO) is a multipurpose 20 kton liquid scintillator neutrino detector currently under construction in southern China. Due to the size and the excellent energy resolution (3% @ 1 MeV) of the detector, JUNO is sensitive to a potential neutrino flux produced by dark matter self-annihilation in the Milky Way. The expected neutrino signals from dark matter self-annihilation and the relevant backgrounds in the energy range from 10 MeV to 100 MeV are investigated. Moreover, effective background suppression is realized by a detailed pulse shape discrimination analysis. Results of a sensitivity study on the dark matter self-annihilation cross section based on a Bayesian analysis are presented in this talk. This work is supported by the Deutsche Forschungsgemeinschaft.

T 44.9 Tue 18:05 Ts

Reconstruction of the atmospheric neutrinos energy spectrum with JUNO — •Giulio Settanta[1], Alexandre Göttel[1,2], Philipp Kampmann[1], Runxuan Liu[1,2], Livia Ludhova[1,2], Luca Pelicci[1,2], Mariam Rifai[1,2], and Cornelius Vollbrecht[1,2] for the JUNO-Collaboration — [1]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

The atmospheric neutrino flux represents a continuous source that can be exploited to infer properties about Cosmic Rays and neutrino oscillation physics. The JUNO observatory, a 20 kt liquid scintillator (LS) currently under construction in China, will be able to detect the atmospheric flux, given the large fiducial volume and the excellent energy resolution. In this work, potential JUNO measurements in the field of atmospheric neutrinos are evaluated. A sample of Monte Carlo events has been generated from theoretical models of the atmospheric neutrino flux, through the Genie software. The events have been processed by a full Geant4- based simulation, which propagates all the particles and the light inside the detector. The different time evolution of light on the PMTs allows to discriminate the flavor of the primary neutrinos. A probabilistic unfolding method has been used, in order to infer the primary neutrino energy spectrum by looking at the detector output. Thanks to the LS low energy threshold and resolution, JUNO will be particularly sensitive in the range (100-1000) MeV, where neutrino-induced events can be fully contained within the instrumented volume.

T 44.10 Tue 18:20 Ts

Measuring the Fluorescence Time Profile of the JUNO Scintillator with Gamma and Neutron Excitation — •Matthias Raphael Stock[1], Hans Th. J. Steiger[1,2], Lothar Oberauer[1], David Dörflinger[1], Ulrike Fahrendholz[1], Konstantin Schweizer[1], Andreas Steiger[1], and Ludwig Wallner[1] — [1]Physik-Department, Technische Universität München (TUM), James-Franck-Straße 1, 85748 Garching bei München — [2]Cluster of Excellence PRISMA+, Johannes Gutenberg University Mainz (JGU), Staudingerweg 9, D-55128 Mainz

Major science goals of the Jiangmen Underground Neutrino Observatory (JUNO) in China are the determination of the neutrino mass ordering and precise measurements of the oscillation parameters as well as the search for proton decay and the detection of the diffuse supernova neutrino background. THEIA is a planned 100 kt detector using a water-based liquid scintillator (WbLS) and has a broad science program, e.g., investigating long-baseline neutrino physics. Therefore, we evaluate the pulse shape discrimination performance of liquid scintillators (LSs) using excitation by gamma radiation inducing recoil electrons as well as a pulsed neutron beam inducing recoil protons. We developed an experimental setup to characterize the time distribution of light emission for different and novel LS mixtures. We present the fluorescence time profiles of the JUNO LS, obtained during two beam times at the Maier-Leibnitz-Laboratorium. This work is supported by the DFG Research Unit "JUNO"(FOR 2319) and by the BMBF (Verbundprojekt 05H2018: R&D Detectors and Scintillators).