T 20: Neutrino Physics without Accelerators 1

Time: Monday 16:15–18:40 Location: T-H33

Group Report T 20.1 Mon 16:15 T-H33

JUNO physics potential and status — •Alexandre Göttel for the JUNO-Collaboration — Forschungszentrum Jülich GmbH, Nuclear Physics Institute IKP-2, Jülich, Germany — III. Physikalisches Institut B, RWTH Aachen University, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a next-generation liquid scintillator experiment being built in the Guangdong province in China. JUNO's target mass of 20 kton will be contained in a 35.4 m acrylic vessel, itself submerged in a water pool, under about 700 m of granite overburden. Surrounding the acrylic vessel are 17612 20" PMTs and 25600 3" PMTs. The main goal of JUNO, whose construction is scheduled for completion in 2022, is a 3-4σ determination of the neutrino mass ordering (MO) using reactor neutrinos within six years, as well as a sub-percent measurement of the oscillation parameters θ_{12}, Δm^2_{21}, and Δm^2_{31}. JUNO's large target mass, low background, and dual calorimetry, leading to an excellent energy resolution and low threshold, allows for a rich physics program with many applications - including solar-, geo-, and atmospheric neutrino measurements. JUNO will also be able to measure neutrinos from galactic core-collapse supernovae, detecting about 10,000 events for a supernova at 10 kpc within 10 s, and achieve a 3σ discovery of the diffuse supernova neutrino background in ten years. JUNO is also suited for exotic searches and can be expected to give a lower limit of 8.34e33 years (90% C.L.) on the proton lifetime. This group talk covers the rich neutrino and astrophysics potential of the JUNO experiments and gives an update on the current experimental status.

T 20.2 Mon 16:35 T-H33

Studies on the sensitivity for the Neutrino Mass Ordering Measurement of JUNO — •Nikhil Mohan[1,3], Alexandre Goettel[2,3], Philipp Kampmann[1], Runxuan Liu[2,3], Livia Ludhova[2,3], Luca Pelicci[2,3], Mariam Rifai[2,3], Apeksha Singhal[2,3], and Cornelius Vollbrecht[2,3] — [1]GSI Helmholtz Centre for Heavy Ion Research, Darmstadt — [2]Forschungszentrum Jülich GmbH, Nuclear Physics Institute IKP-2, Jülich — [3]III. Physikalisches Institut B, RWTH Aachen University, Aachen

JUNO is a multipurpose 20 kton liquid scintillator detector under construction in a 700 m underground laboratory in China, positioned 53 km from Yangjiang and Taishan nuclear power plants. The central detector is being built with high photocathode coverage of 78%, provided by 17,612 20-inch PMTs (LPMTs) and 25,600 3-inch PMTs (SPMTs). The unprecedented expected energy resolution at $3\%/\sqrt{E[\mathrm{MeV}]}$ and the large fiducial volume anticipated for the JUNO detector offers exciting opportunities for addressing many important topics in neutrino and astroparticle physics.
This talk will focus on the primary physics goal of JUNO, which is the determination of Neutrino Mass Ordering (NMO) via the measurement of the vacuum oscillation pattern of the reactor antineutrinos. JUNO will detect the antineutrinos of electron flavor via the Inverse Beta Decay (IBD) interaction with a 1.8 MeV energy threshold. The estimated sensitivity to the NMO is a 3-4 σ significance with at least six years of data taking.

T 20.3 Mon 16:50 T-H33

Analysis of possible implications by the finestructure in the reactor neutrino spectrum on the JUNO NMO sensitivity — •Tobias Heinz, Lukas Bieger, David Blum, Marc Breisch, Srijan Delampady, Jessica Eck, Gina Grünauer, 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 a 20 kt liquid scintillator detector currently constructed in southern China with the main goal to determine the neutrino mass ordering (NMO). Therefore, JUNO measures the reactor neutrino spectrum from two nuclear power plants located in a distance of around 53 km. The precise knowledge of the emitted reactor neutrino spectrum is one of the major aspects for the NMO determination. In recent years, new calculations of the spectrum predicted the existence of a spectral finestructure which could impede the measurement with the unprecedented energy resolution of the JUNO detector.

This talk will discuss possibilities to study the implications of the still unknown finestructure in the reactor neutrino spectrum for the sensitivity of the mass hierarchy determination with JUNO. Further, some preliminary results of these sensitivity studies will be presented.

This work is supported by the Deutsche Forschungsgemeinschaft.

Group Report T 20.4 Mon 17:05 T-H33

The Taishan Antineutrino Observatory — •Hans Theodor Josef Steiger — Cluster of Excellence PRISMA+, Staudingweg 9, 55128 Mainz — Johannes Gutenberg Universität Mainz, Staudingerweg 7, 55128 Mainz — Physik-Department, Technische Universität München, James-Franck-Str. 1, 85748 Garching, Germany

The TAO (Taishan Antineutrino Observatory) detector is aiming for a measurement of the reactor neutrino spectrum at very low distances (<30m) to the core with a groundbreaking resolution better than 2 % at 1 MeV. The TAO experiment will realize the unprecedented neutrino detection rate of about 2000 per day, which is approximately 30 times the rate in the JUNO main detector. In order to achieve its goals, TAO is relying on yet to be developed, cutting-edge technology, both in photosensor and liquid scintillator (LS) development which is expected to have an impact on future neutrino and Dark Matter detectors. In this talk TAO'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 with a special focus on the German contribution to the development of the novel gadolinium-loaded liquid scintillator.
This work is supported by the Cluster of Excellence PRISMA+ at the Johannes Gutenberg University in Mainz and the DFG research unit JUNO.

T 20.5 Mon 17:25 T-H33

Event reconstruction for the neutrino mass ordering measurement of JUNO — •Mariam Rifai[1,2], Livia Ludhova[1,2], Philipp Kampmann[3], Luca Pelicci[1,2], Apeksha Singhal[1,2], Alexandre Goettel[1,2], Cornilius Vollbrecht[1,2], Runxuan Liu[1,2], and Nikhil Mohan[2,3] — [1]Forschungszentrum Jülich GmbH, Nuclear Physics Institute IKP-2, Jülich, Germany — [2]III. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany — [3]GSI Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a multipurpose liquid scintillator-based neutrino experiment with a target mass of 20 kt. The detector is currently under construction and plans to start the data-taking in 2023. Its main goal is the determination of the neutrino mass ordering (MO), through a measurement of the oscillation pattern of reactor neutrinos over 53 km baseline. For a successful measurement of MO with at least 3σ in 6 years, the energy resolution of JUNO must reach an unprecedented 3% at 1 MeV, which is challenging in terms of event reconstruction. Moreover, future JUNO results about neutrino MO could be further improved via a combined analysis with atmospheric neutrinos, which can be observed and reconstructed in JUNO. To achieve this target performance, a precise knowledge of the detector's energy scale has been studied and event reconstruction methods based on charge and time information of the PMTs will be presented in this talk.

T 20.6 Mon 17:40 T-H33

Machine learning based reconstruction of atmospheric neutrino events in JUNO — •Rosmarie Wirth — Hamburg University, Hamburg, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kt liquid scintillation detector. By observing reactor anti-neutrinos with a 53 km baseline, JUNO aims to determine the mass hierarchy with 3 σ significance.
Due to JUNOs large volume, it could be suitable to measure atmospheric neutrino events with high precision. In that case, this channel could deliver further measurements on the mass ordering and the atmospheric oscillation parameters. To obtain this goal sufficient reconstruction methods are needed. This talk presents machine learning based reconstruction methods to analyze these atmospheric neutrino events at JUNO.

T 20.7 Mon 17:55 T-H33

Event Reconstruction in JUNO-TAO using Deep Learing — •Vidhya Thara Hariharan — University of Hamburg

The primary goal of JUNO is to resolve the neutrino mass hierarchy using precision spectral measurements of reactor antineutrino oscillations. To achieve this goal a precise knowledge of the unoscillated reactor spectrum is required in order to constrain its fine structure. To account for this, Taishan Antineutrino Observatory (TAO), a ton-level, high energy resolution liquid scintillator detector with a baseline of about 30 m, is set up as a reference detector to JUNO. The 20% increase in the coverage of photosensors, the replacement of Photomultiplier Tubes (PMTs) with Silicon Photomultiplier (SiPM) tiles, the smaller dimension and the low temperature at -51°C, would enable TAO to achieve an yield of 4,500 p.e./MeV. Consequently TAO will achieve an energy resolution of 1.5%/E(MeV). The measurement of the reactor antineutrino spectrum with this energy resolution will provide a model-independent reference spectrum for JUNO.

The reconstruction can be performed using several approaches. However previous studies have proved Deep Learning yields competitive reconstruction results. Hence this work aims at demonstrating the general applicability of Graph neural networks (GNNs) to reconstruct vertex and energy and later at studying the directionality of TAO events.

T 20.8 Mon 18:10 T-H33

Search for the DSNB in JUNO: Development of new Methods for Background Event Identification — •Matthias Mayer[1], Lothar Oberauer[1], Raphael Stock[1], Hans Steiger[2], Konstantin Schweizer[1], Ulrike Fahrendholz[1], David Dörflinger[1], Sebastian Zwickel[1], Simon Appel[1], Carsten Dittrich[1], Vincent Rompel[1], Luca Schweizer[1], Korbinian Stangler[1], and Simon Csakli[1] for the JUNO-Collaboration — [1]Technische Universität München, München, Germany — [2]Institute of Physics and EC PRISMA+, Johannes Gutenberg Universität Mainz, Mainz, Germany

The diffuse supernova neutrino background (DSNB) is a constant, diffuse flux of relic neutrinos from past core-collapse supernovae over the entire visible universe. The upcoming Jiangmen Underground Neutrino Observatory (JUNO), a 20 kton liquid scintillator detector, expects to observe the DSNB through the inverse beta decay (IBD) detection channel. Besides IBD background from other electron antineutrino sources, there are also neutron-induced background events and NC interactions of atmospheric neutrinos of all flavours. This non-IBD background can be discriminated using pulse shape discrimination (PSD) methods. In this talk, I investigate the possibility to increase the fiducial volume available for the DSNB search using machine learning methods. Further, this talk discusses the effects of an electronics simulation and the flourescence parameter choice on the achievable PSD performance. 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 20.9 Mon 18:25 T-H33

Indirect dark matter search with neutrinos in JUNO and THEIA — Lukas Bieger, •David Blum, Marc Breisch, Srijan Delampady, Jessica Eck, Gina Grünauer, Tobias Heinz, Benedict Kaiser, Frieder Kohler, Tobias Lachenmaier, Axel Müller, Tobias Sterr, Alexander Tietzsch, and Jan Züfle — Eberhard Karls Universität, Physikalisches Institut, Tübingen, Germany

Neutrino detectors like the Jiangmen Underground Neutrino Observatory (JUNO) and the prospective neutrino detector THEIA are 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 for both neutrino detectors. Further background suppression is realized by pulse shape discrimination analysis in JUNO and by studying the ratio between Cherenkov and scintillation light in THEIA. Results of a sensitivity study of JUNO and THEIA on the dark matter self-annihilation cross section are presented in this talk. This work is supported by the Deutsche Forschungsgemeinschaft.