T 103: Neutrino Physics without Accelerators 8

Time: Thursday 16:15–18:30 Location: T-H35

T 103.1 Thu 16:15 T-H35

Status of tau appearance sensitivities and measurements with KM3NeT/ORCA — •Nicole Geisselbrecht for the ANTARES-KM3NET-ERLANGEN-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

KM3NeT/ORCA is a water Cherenkov detector currently under construction in the Mediterranean Sea. The primary goals are the study of neutrino oscillations and the determination of the neutrino mass ordering. One of the main physics objectives in the early phase of ORCA is a measurement of the appearance of tau neutrinos.

Tau neutrinos detected by ORCA are a pure product of neutrino oscillations since ORCA is optimized for atmospheric neutrinos that are almost exclusively produced as electron and muon neutrinos. Even though they can only be measured indirectly as an excess of shower-like events compared to the non-oscillation scenario, their detection will offer valuable information.

One of the first requirements for this study is a reliable particle identification (PID). Therefore, existing PID algorithms need to be optimized with regard to charged current tau neutrino interactions. This talk will report about the first efforts and results using classical machine learning techniques based on boosted decision trees

T 103.2 Thu 16:30 T-H35

Neutrino decoherence effects with KM3NeT — •Nadja Lessing for the ANTARES-KM3NET-ERLANGEN-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg

Quantum decoherence of neutrino states is an effect that is proposed in different theories of quantum gravity. It is envisaged to emerge from interactions of the neutrino as a quantum system with the environment and could modify the probabilities of neutrino flavour oscillations in various ways. Therefore, neutrino telescopes such as KM3NeT, that are sensitive to different flavours and to oscillations in a wide range of neutrino energies, can ideally probe this effect. ORCA and ARCA are water Cherenkov detectors that are currently under construction by the KM3NeT Collaboration in the Mediterranean Sea. While ARCA is primarily designed to detect high energy cosmic neutrinos, ORCA aims at the precise measurement of atmospheric neutrino oscillations. This contribution reports on the decoherence sensitivity for both detectors using a phenomenological model in a three-family framework including matter effects. It is shown that, considering different energy dependencies of the phenomenon, either ORCA or ARCA might be capable of improving current bounds on the strength of decoherence effects.

T 103.3 Thu 16:45 T-H35

GiBUU based neutrino interaction simulations in KM3NeT — •Johannes Schumann for the ANTARES-KM3NET-ERLANGEN-Collaboration — Friedrich-Alexander-Universität, Erlangen, Germany

The characteristics of the primary neutrino interaction and the subsequent secondaries determine the reconstruction of the primary neutrino properties in neutrino detection experiments. As part of the evaluation of the detector performances, neutrino interactions are simulated via so-called neutrino generators. In order to reduce the computational complexity, these use different approximations which in turn lead to systematic uncertainties on the science output of the experiments. The use of different neutrino generators can therefore help to understand and reduce the systematic uncertainties associated with the simulation of neutrino interactions. GiBUU is a generator that utilises the Boltzmann-Uehling-Uhlenbeck equation in order to propagate the secondary particles through the nucleus. The KM3BUU software package has been developed to adapt GiBUU simulations to the geometry and data format of the KM3NeT neutrino telescope, which is under construction in the Mediterranean Sea. The current status of KM3BUU and first results obtained with this new software package will be presented.

T 103.4 Thu 17:00 T-H35

Modelling Seasonal Variations of Atmospheric Muon Neutrinos using MCEq — •Jakob Böttcher, Hannah Erpenbeck, Philipp Fürst, and Christopher Wiebusch for the IceCube-Collaboration — RWTH Aachen, III. Physikalisches Institut b

The IceCube Neutrino Observatory measures the flux of atmospheric muon neutrinos with unprecedented statistics. These muon neutrinos are produced in cosmic-ray air-showers in the atmosphere, and their flux depends on meteorological quantities such as air temperature and density. The analysis of the resulting seasonal variations improves the understanding of the production of atmospheric neutrinos and provides a novel method for testing hadronic interaction models for air-showers. This talk compares the results of analysing four years of IceCube neutrino data to predictions using the numeric cascade equation solver MCEq. The predictions are based on detailed daily calculations of the atmospheric neutrino flux. These use latitude and longitude dependent vertical temperature profiles of the atmosphere as provided by the AIRS instrument on NASA's Aqua satellite.

T 103.5 Thu 17:15 T-H35

Neutrino oscillation sensitivity studies with IceCube Upgrade — •Martin Ha Minh for the IceCube-Collaboration — Technische Universität München

IceCube is a kiloton-scale neutrino telescope embedded in the Antarctic ice of the South-Pole and it's equipped with over 5000 optical modules. IceCube has delivered world-leading measurements on the neutrino oscillation parameters and plans to further constrain the parameter space with the IceCube Upgrade. The IceCube Upgrade is an augmentation of the detector consisting of 7 detector additional detector strings with new optional modules to improve the directional resolution and lower the energy threshold of particle detection. The construction of this extension will be started in the coming years. In the past, sensitivity curves on the oscillation parameters were based on assumptions of how we expect future event reconstruction resolutions, as we did not have a fully operational algorithms at that time. Now however we developed a Graph Neural Network-based reconstruction algorithm, which allows us to make more realistic predictions about the oscillation analysis performance. In this work we present projections on the sensitivity of the IceCube Upgrade on neutrino oscillation parameters, such as the mixing angle θ_{23}, the squared mass difference m^2_{23}, and the ratio of expected and recorded ν_τ flux.

T 103.6 Thu 17:30 T-H35

Precision self-monitoring calibration module for the IceCube Upgrade — •Tobias Andreas Pertl and Felix Henningsen — Technische Universität München

The IceCube observatory is a large-volume neutrino observatory at the geographic South Pole. The IceCube Upgrade aims to improve the low-energy and oscillation physics sensitivities as well as re-calibrate the existing detector. This upgrade consists of seven new densely instrumented strings with various different optical and calibration modules. A novel type of precision optical calibration module – or POCAM – for large-volume detectors has been developed and will be deployed as part of the IceCube Upgrade. We report on the design, calibration and production status.

T 103.7 Thu 17:45 T-H35

Optimization of selection cuts for the directional analysis of sub-MeV solar neutrinos in Borexino — •Antonia Wessel[1,3], Alexandre Göttel[2,3], Sindhujha Kumaran[2,3], Livia Ludhova[2,3], Luca Pelicci[2,3], Ömer Penek[2,3], and Apeksha Singhal[2,3] — [1]GSI Helmholtzcentre for Heavy Ion Research, Darmstadt, Germany — [2]Forschungszentrum Jülich GmbH, Nuclear Physics Institute IKP-2, Jülich, Germany — [3]III. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany

Borexino, a liquid scintillator (LS) detector at the Gran Sasso National Laboratory in Italy, has measured all solar neutrinos thanks to its low energy threshold, high energy resolution, and unprecedented radiopurity. Although LS detectors generally cannot obtain any directional information as opposed to Water Cherenkov detectors, Borexino now achieved the first directional measurement of sub-MeV solar neutrinos. The method is based on the early Cherenkov photons which are emitted before the dominant scintillation light. The first photons of the events are then correlated to the Sun's direction. The resulting angles are summed up to form an angular distribution, which is used to measure the total number of solar neutrinos in the selected energy region of interest. For this analysis, high statistics and an excellent signal-to-background ratio are necessary. These criteria can only be met by optimizing the data selection cuts to find the best combination of the fiducial volume and the definition of the energy interval. This talk will describe the strategy for the selection cut optimization and present the resulting fiducial volume and energy region.

T 103.8 Thu 18:00 T-H35

First directional detection of sub-MeV solar neutrinos in Borexino — •Johann Martyn for the Borexino-Collaboration — Johannes Gutenberg-Universität Mainz

Borexino is a 280 t liquid scintillator detector at the Laboratori Nazionali del Gran Sasso (LNGS), Italy. Its main goal is the precision spectroscopy of solar neutrinos down to energies of 0.19 MeV and for this task it features an unprecedented high radio-purity and a high light yield of ∼10000 scintillation photons per 1 MeV deposited energy.
In this talk we present the first measurement of sub-MeV solar neutrinos around the ^{7}Be edge, using their associated Cherenkov photons in a liquid scintillation detector. In Borexino electrons with E>0.16 MeV produce Cherenkov photons but the ratio of Cherenkov photons from the neutrino scattered electrons is estimated to be $< 0.5\%$ for all PMT hits, so a typical reconstruction of the event direction is not possible. Therefore we look instead at the so called "Correlated and Integrated Directionality" (CID), where the known position of the Sun is correlated with the photon hit direction, given by the reconstructed event vertex, and integrated over all selected events. In this way it is possible to measure an angular distribution that shows the statistical contribution of Cherenkov photons from the neutrino recoil electrons. The number of solar neutrinos is then inferred from the measured angle distribution with probability density functions produced by the Geant4-based Borexino Monte Carlo simulation. This work is supported by the Cluster of Excellence No. 2118 PRISMA+, funded by the German Research Foundation (DFG).

T 103.9 Thu 18:15 T-H35

Analysis strategies used in directional analysis of sub-MeV solar neutrinos in liquid scintillator detector — •Apeksha Singhal[1,3], Alexandre Göttel[1,3], Sindhujha Kumaran[1,3], Livia Ludhova[1,3], Luca Pelicci[1,3], Ömer Penek[1,3], and Antonia Wessel[2,3] — [1]Forschungszentrum Jülich GmbH, Nuclear Physics Institute IKP-2, Jülich, Germany — [2]GSI Helmholtzcentre for Heavy Ion Reseach, Darmstadt, Germany — [3]III. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany

The sub-MeV solar neutrinos are measured in a liquid scintillator detector via their elastic scattering off electrons, which induce isotropically emitted scintillation photons that are detected by PMTs. Borexino, located at the LNGS in Italy, is liquid scintillator detector that performed real time spectroscopy of solar neutrinos from pp chain and CNO fusion cycle of the Sun. For first time, it is possible with Borexino to disentangle sub-MeV solar neutrinos detected in liquid scintillator using few Cherenkov photons emitted at early times, and in direction of scattered electrons with given energy threshold. The directional solar neutrino signal is statistically discriminated from isotropic background events by correlating well known position of the Sun and the direction of the first two time-of-flight subtracted hits of each event, with respect to the reconstructed vertex. This results in angular distribution of data, fitted with signal and background distributions from Monte Carlo simulations. This talk will describe analysis strategy used to disentangle sub-MeV solar neutrino signal in data in a liquid scintillator detector. The future scope of this method will also be discussed.