T 22: Experimental techniques in astroparticle physics I

Time: Monday 16:00–18:35 Location: Tv

Group Report T 22.1 Mon 16:00 Tv

The IceCube Upgrade Project — •Martin Rongen for the IceCube-Collaboration — Johannes Gutenberg Universität Mainz, Institut für Physik

The IceCube Neutrino Observatory instruments about 1 km^3 of deep, glacial ice at the geographic South Pole with 5160 photomultipliers to detect Cherenkov light of charged relativistic particles. Exact models of the optical properties of the natural ice are crucial since their shortcomings are a major source of systematic uncertainty in physics analyses.

Following IceCube's recent success in the discovery of an astrophysical neutrino flux, strong indications for the first neutrino point sources, and competitive measurements of neutrino oscillation parameters, the detector is now set to be upgraded. This IceCube Upgrade will consist of seven new strings to be deployed near the center of the existing IceCube array in 2022/23.

In addition to a further 700 novel optical sensors (of various designs including variants with a segmented photocathode and enhanced-UV sensitivity), enabling world-leading neutrino oscillation physics, the Upgrade strings will include unique calibration devices designed to improve the understanding of the ice. The refined calibration resulting from the Upgrade will be applied to the entire archival IceCube data set, improving in particular point source sensitivities. This talk will give an overview of the IceCube Upgrade project including its instrumentation and will detail how we anticipate the improved calibration to impact physics results.

T 22.2 Mon 16:20 Tv

Hole Ice, Cables, and Non-Spherical Detector Modules in Light-Propagation Simulations for the IceCube Experiment — •Sebastian Fiedlschuster for the IceCube-Collaboration — Erlangen Centre for Astroparticle Physics, Erwin-Rommel-Str. 1, 91054 Erlangen

IceCube is a neutrino observatory located at Earth's South Pole that uses glacial ice as detector medium where particles from neutrino interactions produce Cherenkov light as they move through the ice. The light is then detected by an array of photo detectors deployed within the ice.

Aiming to improve detector calibration for the current IceCube detector as well as for the upcoming detector upgrade, a modified ray-tracing algorithm based on IceCube photon-propagation software is used to account for regions of different optical properties in light-propagation simulations. Of particular interest are the drill-hole regions (*hole ice*) of the detector medium, opaque cables of the detector instrumentation as well as light-sensitive detector modules of different shapes. This talk will outline the simulation method and present current and future applications.

T 22.3 Mon 16:35 Tv

Trilateration-based Geometry Calibration of the IceCube Detector — •Matthias Boddenberg[1], Christian Haack[3], Saskia Philippen[1], Martin Rongen[2], and Christopher Wiebusch[1] for the IceCube-Collaboration — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]Johannes Gutenberg-Universität Mainz — [3]TU München

The IceCube Neutrino Observatory detects charged particles by measuring their Cherenkov light using photomultipliers embedded in the deep Antarctic ice at the South Pole. Reconstruction of the particle directions relies on arrival times of Cherenkov photons at the position of these photomultipliers. Their currently assumed positions are only accurate to about a meter. Goal of this work is improving the calibration of these sensor positions. For this, we measure the transit times of light emitted from LEDs within the sensor modules and received by neighboring sensors. From these transit times the sensor distances can be derived using models for the light propagation in ice. In this talk, we present a novel method for calibrating the detector geometry based on the trilateration of these distances within a global likelihood analysis.

T 22.4 Mon 16:50 Tv

Comparison of directional reconstruction algorithms for muons using the Moon shadow in IceCube — •Sebastian Schindler, Thorsten Glüsenkamp, and Gisela Anton for the IceCube-Collaboration — Erlangen Centre for Astroparticle Physics (ECAP), University Erlangen-Nürnberg, Germany

IceCube is a cubic-kilometer-sized neutrino observatory located at the Geographic South Pole. In IceCube, arrival directions of muon neutrinos are determined from resulting muon tracks in the detector. Atmospheric muons, which originate from cosmic rays, produce a similar signature in the detector, and can therefore be used to test directional reconstruction algorithms. The Moon acts as a calibration source for directional reconstructions using atmospheric muons, by producing an easy-to-observe localized reduction of the mostly uniform cosmic-ray flux.

The directional accuracy of two new muon-reconstruction algorithms is tested by using the abundant flux of cosmic rays in a Moon analysis. One reconstruction is a further development of the currently best reconstruction used in IceCube, and the other is a machine-learning-based approach. The results of the accuracy comparison with the currently best reconstruction will be presented.

T 22.5 Mon 17:05 Tv

The mDOM - a multi-PMT optical module for the IceCube Upgrade — •Martin Antonio Unland Elorrieta for the IceCube-Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, Münster

The IceCube detector at the South Pole, currently the largest neutrino observatory worldwide, is being upgraded with seven new strings. New sensors with increased sensitivity have been developed for this project, the IceCube Upgrade. More than half of the modules installed will be Multi-PMT Digital Optical Modules (mDOMs), which feature 24 isotropically aligned photomultipliers (PMTs) in a pressure vessel. This design provides, among other things, an effective photosensitive area more than twice that of IceCube's current optical sensor, near-uniform angular coverage, and the ability to exploit local coincidence between PMTs of the same module. The presentation provides an overview of the module design.

T 22.6 Mon 17:20 Tv

Analyzing PMT characterization measurements for the IceCube mDOM with the python/numpy-based package PeeEmTee — •Jonas Reubelt and Judith Schneider for the IceCube-Collaboration — ECAP, Universität Erlangen-Nürnberg

Photomultiplier tubes (PMTs) are frequently used as high-sensitivity light sensors in modern physics detectors like IceCube. Precision measurements employing PMTs require a detailed understanding of the sensors' behavior in low-light-level environments. The PeeEmTee package (https://github.com/JonasReubelt/PeeEmTee) provides functionalities fundamental for PMT characterization under such conditions. Concept and functionality of the package will be presented in the context of recent PMT characterization measurements for the IceCube mDOM.

T 22.7 Mon 17:35 Tv

Test der Linearität der Photomultiplier für das mDOM des IceCube Upgrades — •Charlotte Benning, Lasse Halve und Christopher Wiebusch für die IceCube-Kollaboration — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Das IceCube Upgrade wird das aktuelle IceCube Neutrino Observatorium um sieben zusätzliche Instrumentenstränge erweitern. Mehr als 400 multiple-PMT Digital Optical Modules [mDOM] mit jeweils 24 3" Photomultiplier Tubes [PMT] werden eingesetzt. Vor der Integration in die Module müssen die mehr als 10.000 neuen PMTs auf Einhaltung der Herstelleranforderungen geprüft und kalibriert werden. Eine dieser Anforderungen an die PMTs ist die Linearität der Ladungsantwort von 90% bei bis zu 100 instantanen Photoelektronen. In diesem Vortrag wird das Prinzip der Messung der Linearität durch Variationen der Lichtintensität sowie vorbereitende Messungen für die Massentests vorgestellt.

T 22.8 Mon 17:50 Tv

First light of the PMT characterisation facility for the IceCube mDOM at the TU Dortmund — •Johannes Werthebach for the IceCube-Collaboration — TU Dortmund

The IceCube Neutrino Observatory measured the first astrophysical high-energy neutrino flux back in 2013. One substantial part of the upcoming low energy expansion is the multi-PMT optical module, mDOM. It consists of 24 3-inch PMTs spherically arranged within the mDOM. To provide a consistent signal quality more than 10.000 PMTs need to be tested and characterised before they are installed into the mDOM.

A large scale testing facility is build in Aachen and Dortmund. To provide a fast and reliable solution 98 PMTs can be characterised in a single test cycle at temperatures as low as -20°C. The setup and first measurements from the site at the TU Dortmund are presented.

T 22.9 Mon 18:05 Tv

Characterization of the analog front-end of the mDOM for the IceCube Upgrade at different temperatures — •Judith Schneider — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

In the framework of a planned upgrade of the IceCube Neutrino Observatory and a next-generation neutrino telescope at the South Pole, new optical modules are being developed, which are expected to significantly increase the detector sensitivity. One of such concepts is the multi-PMT Digital Optical Module (mDOM) which features 24 three-inch PMTs inside a pressure vessel resulting in a homogeneous directional sensitivity. An interacting neutrino creates secondary particles producing Cherenkov light which is detected by the PMTs. The PMT signal is processed by an analog front-end (AFE). All 24 channels are digitized separately with a 125 MSPS ADC. We present characterization measurements of the AFE of the mDOM for the IceCube Upgrade at different temperatures including -40°C as a proof of concept.

T 22.10 Mon 18:20 Tv

Calibration LEDs for the IceCube Upgrade mDOM Modules — •Theodoros Manoussos, Sebastian Böser, and Martin Rongen for the IceCube-Collaboration — Institut für Physik, JGU Mainz

The IceCube Neutrino Observatory detects charged particles by measuring their Cherenkov light using photomultipliers embedded in the deep Antarctic ice at the South Pole. The IceCube Upgrade is planned to be deployed in the 2022/2023 Antarctic summer and will include about 700 new multi-PMT digital optical modules (mDOM). Each of those will be equipped with LEDs (mDOM flashers), two daisy chains with five LEDs each. The upgraded flasher system aims for the better understanding of the optical properties of the glacial ice and therefore plays an essential role to further reduce the systematic uncertainties in IceCube. In this talk the design, production and testing of this flasher system is presented.