T 14: Methods in Astroparticle Physics I

Time: Monday 16:45–18:00 Location: VG 3.101

T 14.1 Mon 16:45 VG 3.101

Construction, Calibration, and Operational Plans of the Acoustic Module for the IceCube Upgrade — •Andreas Nöll, Jan Audehm, Jürgen Borowka, Pierre Dierichs, Mia Giang Do, Christoph Günther, Dirk Heinen, Joëlle Savelberg, Christopher Wiebusch, and Simon Zierke — III. Physikalisches Institut B, RWTH Aachen University

The IceCube Neutrino Observatory is a cubic kilometer-sized detector located at the geographic South Pole, consisting of 5160 Digital Optical Modules (DOMs). In the Antarctic summer 2025/26 more than 700 new modules will be installed as part of the IceCube Upgrade. These include ten Acoustic Modules (AMs), capable of transmitting and receiving acoustic signals between 5 and 30kHz. Additionally, up to 30 acoustic receivers will be located in new DOMs. The goal of these devices is to improve the geometry calibration based on multilateration of the measured acoustic propagation times, as well as enhance our understanding of the acoustic properties of the ice. This talk presents the construction and calibration of AMs, including the acoustic transducer and its internal electronics, as well as an overview of the planned operations of this system.

T 14.2 Mon 17:00 VG 3.101

Development and Construction of the Wavelength-shifting Optical Module for the IceCube Upgrade — •Yuriy Popovych[1], Sebastian Böser[1], Enrico Ellinger[2], Klaus Helbing[2], Adam Rifaie[2], Lea Schlickmann[1], and Nick Schmeisser[2] for the IceCube-Collaboration — [1]Johannes Gutenberg-Universität Mainz — [2]Bergische Universität Wuppertal

The Wavelength-shifting Optical Module (WOM) is an innovative photosensor concept set to be deployed in the IceCube Upgrade during austral summer 2025/26. Utilizing wavelength-shifting and total internal reflection techniques, the WOM is well suited for detecting low-energy neutrinos thanks to its low noise rate. Its photosensitive area consists of a cylindrical tube coated with wavelength-shifting paint, which converts UV-photons and guides them to coupled Photomultiplier Tubes (PMTs) at both ends. This optical design decouples the photosensitive area from the PMTs, achieving a high signal-to-noise ratio and effective coverage of the UV-region of the Cherenkov spectrum.

A total of 11 WOMs are planned for deployment, with 5 already shipped. This presentation will provide insights into the production process, highlight key engineering challenges, and discuss results from optical acceptance testing. Additionally, recent design improvements and the production status of the second batch, scheduled for shipment this summer, will be featured.

T 14.3 Mon 17:15 VG 3.101

In-situ Calibration Routines for IceCube Upgrade mDOMs without Artificial Light Sources — •Carolin Klein[1] and Summer Blot[2] — [1]Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [2]DESY, Zeuthen, Germany

Calibration is crucial for the success of every physics experiment. Over the last decade, the IceCube Neutrino Observatory has yielded important results in neutrino astronomy and neutrino oscillations. Building on this progress, the IceCube Upgrade project is set to expand the current detector array during the austral summer 2025/26. It will enhance the detector's overall sensitivity and lower its energy threshold by reducing the spacing between strings, enabling more detailed studies of atmospheric neutrinos.

In this talk, in-situ calibration routines without artificial light sources for the IceCube Upgrade multi-PMT digital optical modules (mDOMs) are proposed. This includes the calibration of the mDOM mainboard electronics using front-end pulsers, as well as the PMT gain and relative transit time calibration using the natural radioactivity from the glass vessel. The latter approach allows for a long-term monitoring of the PMT gain and the relative transit time without downtimes of the modules. First results of the routines will be presented in this talk.

T 14.4 Mon 17:30 VG 3.101

Drone-Based Calibration of AugerPrime Radio Antennas at the Pierre Auger Observatory — •Alex Reuzki, Maximilian Straub, and Martin Erdmann — III. Physikalisches Institut A, RWTH Aachen

Radio emissions of extensive air showers can be observed at the Pierre Auger Observatory with the AugerPrime radio detector (RD). As part of the AugerPrime upgrade, RD is being installed on 1660 water-Cherenkov detectors on an area of about 3000 km^2 and consists of dual-polarized Short Aperiodic Loaded Loop Antennas (SALLA). To achieve high measurement precision, RD needs to be well-calibrated, which requires the antenna response pattern to be well-known. We introduce a method to measure the directional response of the SALLA using a well-defined biconical antenna mounted to a drone. The drone-based setup possesses active stabilization and precise pointing with the use of a gimbal. Additionally, the drone's position is tracked using differential GPS with $\mathcal{O}(\text{cm})$ precision. This setup allows us to precisely extract the antenna response pattern from any direction in the frequency range of $30-80$ MHz. In a recent in-situ campaign, calibration measurements of the AugerPrime radio detector have been performed. The measurements are interpolated using information field theory to obtain the full antenna response pattern for all directions and frequencies. First results are presented and compared to simulations.

T 14.5 Mon 17:45 VG 3.101

Reconstruction of Extensive Air Showers from Radio Detector Data using Information Field Theory — •Simon Strähnz[1], Tim Huege[1,2], Philipp Frank[3], and Torsten Ensslin[3] — [1]Karlsruher Institut für Technologie, Deutschland — [2]Astrophysical Institute, Vrije Universiteit Brussel, Belgien — [3]Max Planck-Institut für Astrophysik, Garching, Deutschland

Using radio detectors for cosmic rays is a very appealing approach, as they are cost-effective, have a duty cycle of nearly 100% and can directly probe the electromagnetic component of extensive air showers. However, reconstructing the electric field from the measured voltages in an antenna by unfolding the antenna response comes with several challenges, mainly because of measurement noise. These issues could be solved by Bayesian inference. The challenge with that approach is that the electric field is continuous, which would lead to an infinite-dimensional latent space. Information field theory (IFT) has been developed to deal with this problem and allow for Bayesian reasoning on fields. We will present a signal model that can be used with IFT based inference algorithms that can successfully reconstruct the electric field measured by a single antenna. The performance of this method has been demonstrated with Monte Carlo simulations of air shower radio signals. We will also show extended models being developed to combine the data from all antennas in a given array and reconstruct entire events. Since Bayesian inference provides the posterior distribution, this method also provides an estimate of the uncertainty of the measured field.