IceCube-Gen2 Calibration Workshop

Wednesday 07 April 2021 - Friday 09 April 2021

Book of Abstracts

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Continuous calibration of scintillators after deployment

Author: Matt Kauer[1]

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Present on a proposed plan for the continuous in-situ calibration of the surface scintillator panels.

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Calibration of surface radio antennas after deployment

Author: Hrvoje Dujmovic[1]

[1] *Karlsruhe Institute of Technology*

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In this talk I will discuss how we can do in situ calibration of the surface radio antennas and present the work that has been done so far with the prototype antennas deployed at the South Pole.

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LED Flashers in Gen2

Author: Martin Rongen[1]

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Are they any good?

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Calibrating IceCube track reconstructions by using DM-Ice coincidence events using 2012-2020 data

Authors: Teppei Katori[1]; Rogan Clark[1]; Matt Kauer[2]; Antonia Hubbard[2]

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DMIce-17 comprises of two 8.5kg NaI(Tl) scintillator crystals located beneath the IceCube array. We demonstrate that it is possible to distinguish muons detected in DMIce-17 from background, and then use this to determine the coincidence rate between high energy tracks measured in IceCube and said muons for data covering 2012-2020. Finally, we discuss how this may be used to improve the track reconstruction of IceCube.

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Simulation of radio signals from air showers measured by in-ice radio antennas [Time: 10+3]

Authors: Simon De Kockere[1]; Krijn de Vries[1]; Tim Huege[2]; Uzair Latif[3]; Nick van Eijndhoven[1]

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We give an overview of the current state of the simulation of radio signals from air showers measured by in-ice radio antennas. We start with a short summary about the propagation of in-air radio emission into ice, and then focus on the propagation of the particle shower itself through ice. The Corsika Monte Carlo code was used to simulate the in-air part of air showers, which was combined with the Geant4 simulation toolkit for its propagation through ice. We discuss the general features of the in-ice particle cascade and give a parameterization of both the longitudinal particle development as well as the lateral cascade front distribution. We conclude air-shower induced in-ice particle cascades are very similar to neutrino induced in-ice particle cascades, indicating that air showers could serve as an in-situ calibration source for neutrino observatories. We show first Monte Carlo estimates of the expected radio signal coming from this in-ice particle cascades. Finally, we give a short status update on Corsika 8, which aims to include the simulation of radio signals from air showers measured by in-ice radio antennas.

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Calibration of the Radio Components for the Surface Array at KIT

Author: Roxanne Turcotte[1]

[1] *Karlsruhe Institute of Technology*

Corresponding Author: roxanne.turcotte@icecube.wisc.edu

I will present the individual calibration of all the components in the radio electronics chain. This will focus only on the calibration carried out at KIT.

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Calibration of the Gen2 in-ice arrays using the surface array

Author: Frank Schroeder[1]

[1] *University of Delaware / Karlsruhe Institute of Technology*

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Summary of idea on how the Gen2 surface array can contribute to the calibration of the in-ice arrays. In particular, the surface array provides and in-situ measurement of the cosmic-ray flux, which is the source of the atmospheric backgrounds in the ince.

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In-situ calibration device for the measurement of the snow accumulation and the index-of-refraction profile [Time: 10+3]

Author: Jakob Beise[1]

[1] *Uppsala Universitet*

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High-precision neutrino energy reconstruction requires a real time monitoring of the firn properties (snow accumulation h and the index-of-refraction profile n(z)). In this talk, I will present a design for an in-situ calibration device applicable to an IceCube-Gen2 radio array, consisting of two shallow emitter antennas and a receiver at 15m depth. The optimal configuration of the emitters, that yields the best reconstruction in h and a two-parameter n(z) model, is determined. A simplified version of this technique has already been tested in-situ at one ARIANNA station at the Ross Ice Shelf to continuously measure the snow accumulation.

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Calibrating the IceCube's optical array with cosmic ray events

Author: Xinhua Bai[1]

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Corresponding Author: xinhua.bai@sdsmt.edu

This talk summarizes what we did before for AMANDA and IceCube using cosmic ray events measured by SPASE-2 and IceTop. Calibrations and associated systematics a surface array may provide for Gen2 optical array will be outlined for discussion.

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Gen2 - Optical calibration / in-situ POCAM?

Authors: Felix Henningsen[1]; Tobias Pertl[1]; Nikhita Khera[1]; Christian Spannfellner[2]; Elisa Resconi[1]; Leonard Geilen[1]

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We would like to initiate a discussion about potential calibration possibilities in Gen2. One option we would like to investigate is an adapted / in-situ integrated POCAM-like light source inside the standard Gen2 module.

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Dust logging in gen2

Authors: Benjamin Jones[1]; Segev BenZvi[2]

[1] *University of Texas at Austin*

[2] *University of Rochester*

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We discuss the development of a new dust logger for gen2, including reviewing basic capabilities needed to provide the tilt map critical for event energy resolution and plans for exploration of advanced features to expand the dust logger science case.

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Intro and Gen2 Schedule

Author: Dawn Williams[1]

[1] *University of Alabama*

Corresponding Author: drwilliams3@ua.edu

Intro and Gen2 Schedule

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Gen2 Camera-based calibration system

Authors: Carsten Rott[1]; Christoph Toennis[None]; Woosik Kang[2]; Gerrit Roellinghoff[2]; Jiwoong Lee[3]

[1] *University of Utah*

[2] *Sungkyunkwan University*

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Ideas and objectives for the Gen2 Camera-based calibration system

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Acoustic Modules for Gen2

Authors: Christoph Günther[1]; Simon Zierke[1]; Dirk Heinen[1]; Jürgen Borowka[1]; Maximilian Scharf[1]; Christopher Wiebusch[1]; Lars Weinstock[1]

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The acoustic calibration system is due to its large range and high accuracy a promising candidate for the geometry calibration of the Gen2 detector. The technical design of the acoustic module and the acoustic receivers are presented and the performance of the acoustic system and strategies for the calibration of the Gen2 detector are discussed.

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Introduction to In-Ice Neutrino Radio-detection Calibration

Author: Allan Hallgren[1]

[1] *Uppsala Universitet*

Corresponding Author: allan.hallgren@physics.uu.se

I'll give a brief introduction for the workshop day on calibration of the IceCube Gen2 in-ice radio array for detection of neutrinos

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Discussion: what do we need for Gen2 Phase II proposal and Gen2 PDR?

Author: Dawn Williams[1]

[1] *University of Alabama*

Corresponding Author: drwilliams3@ua.edu

Discussion: what do we need for Gen2 Phase II proposal and Gen2 PDR?

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Calibration procedure for the hardware of RNO-G [Time: 10+3]

Author: Maddalena Cataldo[1]

[1] *DESY Zeuthen*

Corresponding Author: maddalena.cataldo@icecube.wisc.edu

Description of the test and calibration procedure for the hardware of the radio neutrino detector RNO-G: the three types of amplifier boards, which will be used in the detector, were tested with a vector network analyzer and in a temperature chamber.

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General discussion of PDR

Currently a time blocker for earnest discussion of PDR structure and responsible parties (from a calibration perspective)

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Discussion

PDR structure, responsible parties and tentative goalposts?

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Lessons learnt from radio detection of air showers [Time: 10+3]

Authors: Anna Nelles[1]; Christian Glaser[2]

[1] *DESY Zeuthen*

[2] *Uppsala Universitet*

Corresponding Authors: christian.glaser@icecube.wisc.edu, anna.nelles@icecube.wisc.edu

We will review calibration efforts as performed in radio air shower arrays (such as AERA and LOFAR) and will discuss what we can learn from this for Gen2.

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Characterisation and pre-calibration of the scintillation detectors of the IceTop surface enhancement

Author: Thomas Huber[1]

[1] *Karlsruhe Institute of Technology*

Corresponding Author: thomas.huber@icecube.wisc.edu

The IceCube Collaboration plans to upgrade IceTop with scintillation detectors augmented by radio antennas. A full prototype hybrid station was installed near the center of the IceTop array.

The station features custom-designed DAQ electronics and consists of three radio antennas, sensitive in the MHz region and eight scintillation detectors, each having an active area of 1.5 m^2 plastic scintillators, coupled via wavelength-shifting fiber and read out by a Silicon Photomultiplier (SiPM). The enhancements also provide R&D experience for the next generation (IceCube-Gen2) detectors.

This talk will focus on the necessary characterisation and calibration measurements of the scintillation detector components before they are assembled and will explain the methods to define the efficiency and performance of the scintillators before deployment at the South Pole. In addition, it will be shown how the determination of the temperature-sensitive operational parameters is realized in the lab as contribution for enabling a temperature-independent and therefore homogeneous detector array, realized by control loops.

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Passive sources of radio calibration [Time: 8+0]

Author: Cosmin Deaconu[1]

[1] *University of Chicago*

Corresponding Author: cosmin.deaconu@icecube.wisc.edu

In this talk, I will introduce potential passive sources (i.e. ones that operate without any intervention from us) that might be useful for calibration of a radio array. Such sources include satellites, radiosondes as well as potentially airplanes and snowmobiles.

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Advanced Propagation: Greenland FDTD Case Study and the Potential for Parabolic Equation Modeling [Time: 8+4]

Author: Cosmin Deaconu[1]

[1] *University of Chicago*

Corresponding Author: cosmin.deaconu@icecube.wisc.edu

This talk covers two topics related to "advanced" radio propagation (i.e. not raytracing). The first describes the use of finite-difference time-domain (FDTD) modeling to describe a radio dataset from Greenland and the second describes the potential application of parabolic equation (PE) modeling for in-ice studies. Unlike FDTD, PE is tractable over larger scales, but still leaves much to be demonstrated for this application.

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Calibrating In-Ice Antennas: Lessons Learned from ARA [Time: 13+4]

Authors: Kaeli Hughes[1]; The ARA Collaboration[None]

[1] *University of Chicago*

Corresponding Author: kaeli.autumn.hughes@gmail.com

I will discuss the process used to calibrate the antennas at ARA Station 5, as well as the relative uncertainties introduced in the process. I will also discuss my recommendations for calibrating future in-ice radio detectors using lessons learned from ARA Station 5.

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In-situ calibration and anechoic chamber measurement for radio antenna development [Time: 13+4]

Author: Myoungchul Kim[1]

[1] *Chiba University*

Corresponding Author: myoungchul.kim@icecube.wisc.edu

In this talk, we will present the Chiba group's effort to developing an in-ice radio antenna model and slim antenna design for the future detector. We present the overview of the results from in-air antenna measurement done at the anechoic chamber and in-situ calibration performed at the ARA detector to measure the angular gain pattern of the antenna. The response of antenna in both environments was studied by the XFdtd simulation. As a result, the empirical antenna model was developed based on data. We also summarized the development of the slim antenna that was designed to deploy by RAM drill and the in-situ measurement performed at the South pole. Finally, we discuss the in-situ behavior of the ARA detector that we observed.

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Water Tank Testing and Calibration

Author: Carlos Arguelles Delgado[1]

[1] *Harvard University*

Corresponding Author: carguelles@fas.harvard.edu

In this brief talk, I will summarize the objectives/ideas behind the water tank to be built at Harvard in collaboration with the MIT and King's college groups.

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On unexplained features in ARA and other data, ice properties and goals [Time: 13+4]

Author: David Besson[1]

[1] *University of Kansas*

Corresponding Author: dbesson@icecube.wisc.edu

Current understanding of RF ice properties will be summarized, highlighting both anomalous experimental data and/or gaps in our current modeling.

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Plans for radio transmitters in distant holes in the Gen2 radio array [Time: 13+4]

Author: David Besson[1]

[1] *University of Kansas*

Corresponding Author: dbesson@icecube.wisc.edu

We address radio array calibration options for IceCube Gen2, as well as RNO-G efforts that will inform the IC Gen2 dedicated pulser layout and design. We also discuss a calibration-tower+hole (CATH) proposal to redundantly measure ice properties over neutrino-like geometries, as well as provide signal averaging to elucidate weak RF ice features.

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IceCube-Gen2 Radio Array Surface Calibration: Opportunities from Unique Transmitter and Receiver Systems [Time: 8+4]

Author: Jordan Hanson[1]

[1] *Whittier College*

Corresponding Author: jhanson2@whittier.edu

Calibration of the IceCube-Gen2 radio array requires calibrations of the RF channels of stations, and constraining effects from the ice surrounding the channels. Regarding RF channel calibration, experience with ARA and ARIANNA has demonstrated the utility of fixed heartbeat calibration pulse units that probe RF channel response from a fixed location over time. Heartbeat units are operated by station electronics and are installed beneath the surface at locations horizontally separated from RF channels. There are advantages, however, to adding calibration measurements for constraining ice effects from temporary, above-surface fixed transmitters not connected to a station. In a recent publication, the ARIANNA collaboration presented a suite of measurements collected in Moore's Bay and at the South Pole by the RICE collaboration. These measurements revealed horizontal RF propagation over kilometer distances despite expectations given the index of refraction profile of the firn. The mathematics of ray-tracing suggests that horizontal propagation is forbidden in the absence of perturbations in the index of refraction profile. Similar measurements in Greenland also reveal this effect. Repeating such measurements for IceCube-Gen2 would add value by constraining horizontal propagation and attenuation in the actual ice in which the detector is deployed. Another technique that would add value beyond heartbeat units would make use of drone borne transmitters and receivers. Heartbeat units provide single-point azimuth and zenith measurements over time, but cannot probe angular parameter space. Proposed hybrid station designs will require calibration of the radiation pattern and polarization of deployed RF channels built from both dipole and LPDA antennas at different depths and orientations. Finally, drone borne transmitters and receivers would provide a unique opportunity to constrain horizontal variations in the RF attenuation length and birefringence over kilometer distances.

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Finite Difference Time-Domain Methods for Askaryan Propagation Modeling in IceCube-Gen2 [Time: 8+0]

Author: Hanson Jordan[1]

[1] *Whittier College*

Corresponding Author: jhanson2@whittier.edu

The radio array design of IceCube-Gen2 relies on an understanding of the propagation of Askaryan radiation from UHE neutrino signals through the South Pole firn. Classical ray-tracing techniques are implemented in our standard Monte Carlo package, NuRadioMC, to solve the problem of arrival angle and location of surface signals that have curved paths through a changing index of refraction. The classical solution is based on the connection between density and RF index of refraction, and may be derived analytically while introducing just two free parameters. The model does not account for observed horizontal propagation, and it does not account for wavelength-dependent effects. MEEP is a fast, parallel computational implementation of Maxwell's equations with a time-tested suite of electromagnetic field calculation tools in media with complex dielectric constants. Based on the FDTD approach, MEEP can be used to model RF antenna response, to predict electric field strength in complex propagation problems, including analytic Askaryan RF emission model radiation propagation through firn. Finally, note that the radio array of IceCube-Gen2 includes phased arrays of identical RF elements in an environment with potentially varying index of refraction. Tools like FDTD will have to be deployed to understand the effect of the varying index on phased array properties.

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Lessons learned from the calibration of ARIANNA surface station [Time: 10+3]

Corresponding Author: barwick@hep.ps.uci.edu

In this short overview, we outline the primary challenges, remaining questions, and suggested recommendations for calibration activities associated with ice properties, antenna calibration, channel calibration, and system calibration. In addition to dedicated devices, some important calibration requirements can be met by external sources such as cosmic rays.

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Lessons learned from the calibration of ARIANNA surface station

Author: Steve Barwick[1]

[1] *University of California, Irvine*

Corresponding Author: barwick@hep.ps.uci.edu

In this short overview, we outline the primary challenges, remaining questions, and suggested recommendations for calibration activities associated with ice properties, antenna calibration, channel calibration, and system calibration. In addition to dedicated devices, some important calibration requirements can be met by external sources such as cosmic rays.

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Carsten group intro

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Introduction

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