GNN Monthly
The Global Neutrino Network
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A new MoU for GNN

The Memorandum of Understanding of GNN is meanwhile about a decade old – time to thoroughly revise and update the existing text. Now, the new MoU is in place. Different to the original MoU, the text now includes the possibility of accepting new projects as members. See the text at https://www.globalneutrinonetwork.org under „Documents". Note that a new GNN webpage is under development, to be hosted by UW Madison.

News from the Experiments

IceCube

The South Pole season will be winding down over the next couple of weeks, and the team preparing the Upgrade operations in 2025/26 will leave the Pole around February 12. Read below a selection of news sent out by Vivian O'Dell (UW Madison), based on daily and weekly reporting by Kurt Studt, IceCube Upgrade drill manager (Physics Science Lab, Madison).

Over the last three weeks, the team has performed an impressive amount of work, with outstanding support from the Antarctic Services Contractor (ASC). The general work plan is for ASC to drag the mobile drill structures (there are roughly 40 in total) to the work site near the South Pole station (the "Cryo building"), where they are tested, refurbished, and commissioned. Then the buildings are winterized. This includes anything that cannot survive the South Pole winter being pulled out and stored in a special heated area. Most buildings are then moved to "drill camp" or the Seasonal Equipment Site (SES); some are moved to the berm for over-wintering. Temperatures are dropping, at around 40 degrees below zero, and with the wind chill around 50 degrees below zero (in either Fahrenheit or Centigrade!).

Right now, the drill team consists of 13 persons, see the photo below. Most of the team members are engineering staff from UW-PSL. Additional drill engineers are from Sweden, and one is from Thailand.

The team is still working on the refurbishment of the drill – the three generators, the Pre-Heat system and the Main Heating Plant (MHP) for the drill. The MHP consists of four buildings that heat the water for the hot water drill. The MHPs will be commissioned and then winterized and moved to the SES. The High Pressure Pump (which supplies pre-heated water to the main heating plants) and the PreHeat System (which controls the water temperature going into the

High Pressure Pump) are complete, and the buildings moved to the SES.

Other activities included the ARA drill (where ARA stands now for “Antarctic Rodwell Apparatus” and not anymore for “Antarctic Radio Array”) and the two Tower Operations Sites (TOS1 and TOS2) which are the towers plus buildings (mated together) that are moved to each hole to lower the string of detectors.

Two large tanks for the drilling water (K. Studt IceCube/NSF)

The ARA drill (K. Studt, IceCube/NSF)

Positioning TOS2 over the trench to allow access to the skis and remove compacting snow inside the skis. (K. Studt, IceCube / NSF)

View of Seasonal Equipment Site showing the 3 generators, 3 out of 4 Main Heating Plants, and a Water Tank. (K. Studt, IceCube/NSF)

P-ONE

The Erlangen Centre for Astroparticle Physics (ECAP) has hosted a workshop on the science prospects and optimization of P-ONE in the second week of January. Over the course of three days, and despite freezing temperatures and train strikes, about 18 young (and young at heart) researchers gathered at ECAP. The participants presented, discussed and dissected the existing simulation and analysis pipelines to identify missing bits and pieces.

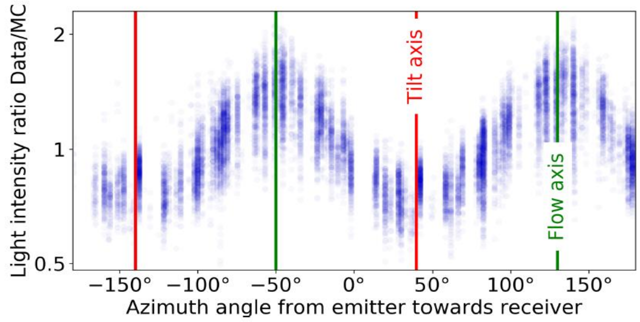
Two goals were at the core of the discussions: identifying the main science goals for optimizing the P-ONE geometry and readying the simulation pipeline for comparison to first-light data of the first P-ONE string, P-ONE-1.

While much is still left to be done, the participants were confident that prospects on the science capabilities of P-ONE will be ready for the summer conferences. The collaborative spirit exhibited at the workshop sets a promising tone for the next steps in the design of P-ONE.

Publications

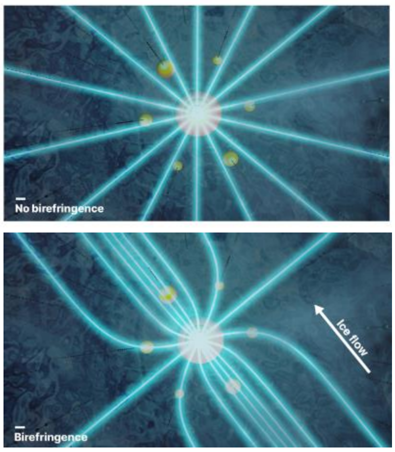
The IceCube collaboration has published a paper *In-situ estimation of ice crystal properties at the South Pole using LED calibration data from the IceCube Neutrino Observatory* (The Cryosphere, 18, 75–102, 2024 (https://doi.org/10.5194/tc-18-75-2024). Main author of the paper is Martin Rongen (ECAP).

With IceCube, an unexpected light propagation effect was observed: an anisotropic attenuation, which is aligned with the local flow direction of the ice.



Ice optical anisotropy seen as azimuth-dependent intensity excess in light flasher data. Each dot is the observed intensity ratio for one pair of light-emitting and light-detecting DOMs comparing data to a simulation with no anisotropy modeling. Tilt and flow directions are shown for reference.

The paper examines birefringent light propagation through the polycrystalline ice microstructure as a possible explanation for this effect.



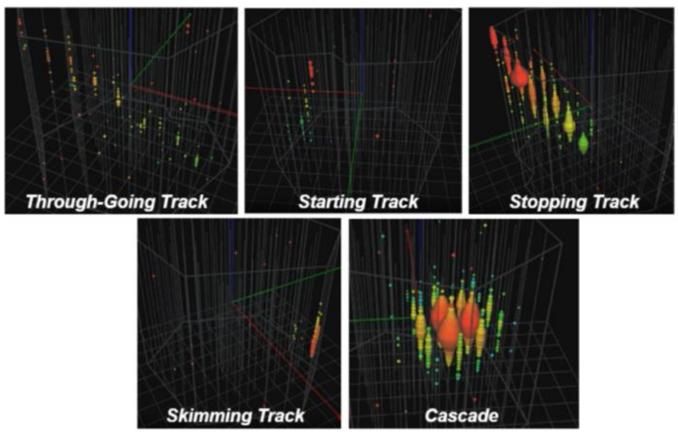
Artist illustration visualizing the deflection concept. Without birefringence light streams out radially from an isotropic light source. With birefringence rays get slowly deflected towards the flow axis. The effects of scattering and diffusion are not shown. The hexagonal pattern of the IceCube array around the light source is shown.

The predictions of a first-principles model developed for this purpose, in particular curved light trajectories resulting from "asymmetric diffusion" (see paper for explanation), provide a qualitatively good match to the main features of the data. This in turn allows to deduce ice crystal properties. Since the wavelength of the detected light is short compared to the crystal size, these crystal properties include not only the crystal orientation fabric, but also the average crystal size and shape, as a function of depth. By adding small empirical corrections to this first-principles model, a quantitatively accurate description of the optical properties of the IceCube glacial ice is obtained. The paper presents the experimental signature of ice optical anisotropy observed in Ice-Cube light-emitting diode calibration data, the theory and parametrization of the birefringence effect, the fit of these parametrizations to experimental data, and the inferred crystal properties.

The IceCube Collaboration has submitted a paper *Citizen Science for IceCube: Name that Neutrino* at 2401.11994.pdf (arxiv.org) (submitted to EPJ Plus). Main authors are Christina Love (Drexel Univ., Philadelphia) and Jim Madsen (UW Madison).

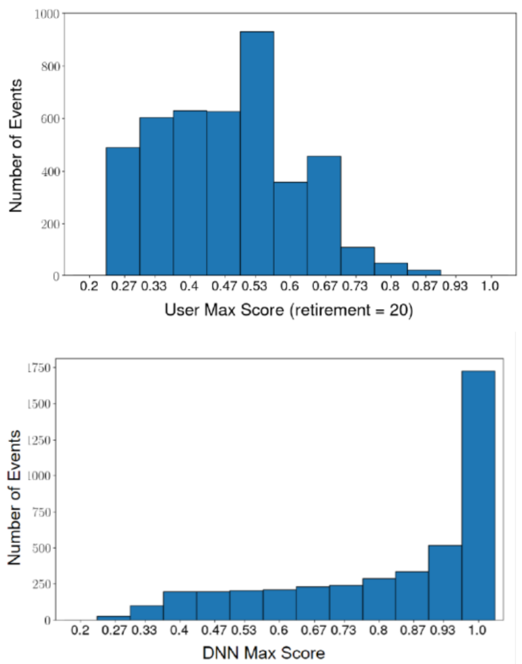
For this project, volunteers aid in classification of IceCube events. The ultimate goal is to design, develop and implement an online experience that allow novices to contribute to ongoing research. The project (https://www.zooniverse.org/projects/icecubeobservatory/name-that-neutrino) is hosted on Zooniverse (https://www.zooniverse.org/about), the largest web-based research platform of its kind with over a million volunteers world-wide.

From March 2023 to September 2023, volunteers did classifications of videos produced from simulated data of both neutrino signal and background interactions. *Name that Neutrino* obtained more than 128,000 classifications by over 1,800 registered volunteers that were compared to results obtained by a deep neural network (DNN) machine-learning algorithm and expert classifications. This exercise points to possible improvements for *Name that Neutrino*.



Examples of the five signal topologies to which an event had to be assigned (as usual red happening first, then yellow, green, and blue last).

4273 event videos have been generated. After the classification of all events by the volunteers and by DNN, a maximum score is calculated for each event. The maximum score for either the volunteers or for the DNN is the probability value of the most-likely category. For the users, the maximum score is calculated as the fraction of the total votes that the category with the most votes received. This is a proxy for confidence as it shows the level of agreement between users. A maximum score of 0.2 is the minimum possible value and indicates no preference for any classification. A maximum score of 1 means that every user chose the same classification. For the DNN, the maximum score is defined to be the highest probability among the five categories provided by the DNN.



Distribution of maximum scores for users (top) and the DNN (bottom). See the paper for details.

The distribution of maximum scores for users shown in the figure is broadly peaked around 0.53, with the majority of events achieving a maximum score less than 0.5. The low user scores signify disagreements between users and are likely related to the difficulty of classifying trigger-level events. There are no events with a maximum score below 0.25, indicating that there is always at least a weak preference for a classification. The distribution of DNN maximum scores peaks sharply at 1, indicating a high confidence in the classification. (not to be confused with "truth").

The paper also relates, event by event, the hypotheses of users and DNN in a "confusion matrix" (see the figures in the paper).

The authors conclude: "*Name that Neutrino demonstrated that citizen science is a powerful tool for public engagement for IceCube. It was not clear that there would be interest in looking at the rather abstract data, especially compared to more readily identifiable astronomical optical telescope images. Engaging with over 1,800 members of the general public with the IceCube project through 128,000 classifications and over 600 discussion board posts certainly counts as a successful start*".

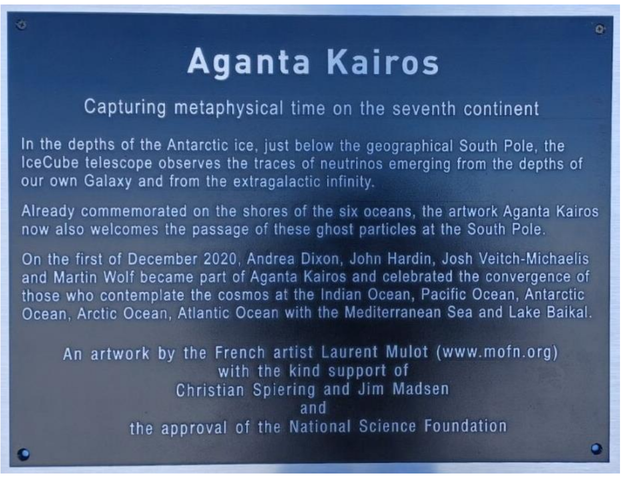
C. A. Argüelles (Harvard), P. Fernández (U. Liverpool and DIPC San Sebastian), I. Martínez-Soler, and M. Jin (both Harvard) have published a very interesting paper *Measuring Oscillations with a Million Atmospheric Neutrinos* in Phys. Rev. X 13, 041055 (2023) (see also https://arxiv.org/pdf/2211.02666.pdf)

While neutrino physics is now advancing into the precision era and new long-baseline experiments being designed, they raise the question "Can atmospheric neutrino experiments also play a role?" To that end, they analyze the expected sensitivity of current and near-future water(ice)-Cherenkov atmospheric neutrino experiments in the context of standard three-flavor neutrino oscillations. In this first in-depth combined atmospheric neutrino analysis, they analyze the current shared systematic uncertainties arising from the common flux and neutrino-water interactions. They then implement the systematic uncertainties of each experiment in detail and develop the atmospheric neutrino simulations for Super-Kamiokande, with and without neutron-tagging capabilities, IceCube Upgrade, ORCA, and Hyper-Kamiokande detectors. They review the synergies and features of these experiments to examine the potential of a joint analysis of these atmospheric neutrino data for resolving the θ_{23} octant at 99% CL, and determining the mass ordering above 5σ by 2030.

Additionally, they assess the capability to constrain θ_{13} and the CP-violating phase δ_{CP} in the leptonic sector independently from reactor and accelerator neutrino data. A combination of the atmospheric neutrino measurements will enhance the sensitivity to a greater extent than the simple sum of individual experiment results reaching more than 3σ for some values of δ_{CP}. They conclude that these results will provide vital information for next-generation accelerator neutrino oscillation experiments such as DUNE and Hyper-Kamiokande.

Miscellaneous

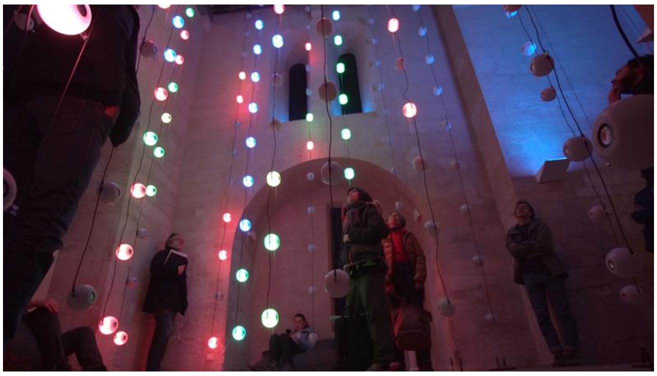
With a 3-year delay, the metallic *Aganta Kairos* plaque made it to the South Pole and was mounted at the wall of the IceCube Laboratory (three years ago, due to transport weight limitations, only a plastic version could be installed).



See more on [Aganta Kairos by Laurent Mulot | Institut français (institutfrancais.com)](institutfrancais.com).

Readers of GNN Monthly will remember Tim Otto Roth's *[aiskju:b]* installation which was created in 2018 and first presented in Berlin, then in Munich and in Aachen. From 5 December 2023 until February 2024 *[aiskju:b]* is now showcased at the Musée des Arts et Métiers in Paris – see the photo next column). The installation has been placed in the context of an exhibition named "*explorer l'infiniment…*" (explore the infinite) that runs until May 12th, and that, among others, hosts ANTARES and KM3NeT storeys: https://www.arts-et-metiers.net/musee/explorer-linfiniment

Needless to say, that the principle of the *[aiskju:b]* installation holds for all neutrino telescopes presently united in GNN.



The team having prepared the Paris presentation (from left): Alin Ilioni (APC Paris), Christopher Wiebusch (RWTH Aachen), Tim Otto Roth, Lasse Halve (RWTH), Lea Schlickmann (RWTH), Jonathan Mauro (UC Louvain), Gauvain Breyne (Musée des Arts et Métiers). And many more behind the scenes....

Impressum
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