GNN Monthly

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News from the Experiments

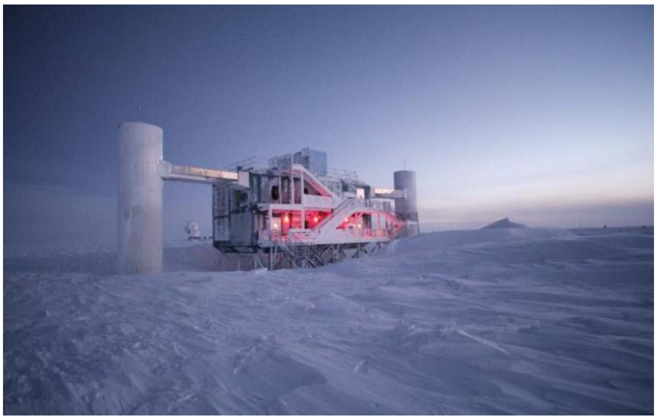
KM3NeT

The KM3NeT collaboration plans a 3 week-long ARCA sea operation starting end of September. The goal is to deploy 2 junction boxes, 19 new DUs (2/3 of what has been deployed until now!) and an improved acoustic positioning of the elements on the seafloor.

The collaboration has also submitted a first oscillation publication with the ORCA 6 array (see below under Publications).

IceCube

Summer is approaching at the South Pole. The brighter skies make it much easier to observe the effect of heavy snow accumulation after a long and windy winter – see the picture taken by winterover Connor Duffy.



IceCube will send over twenty people to the South Pole this season. The main task will be to prepare the drill for the final construction season in the Antarctic summer 25/26 when seven strings will be deployed. IceCube receives the logistical support required to do the work.

Optical modules for two strings, including all DEgg Optical Modules from Chiba University, Japan, will be delivered to the Pole already this fall and be tested there. Also, cables will be installed from the surface junction boxes to the IceCube lab.

On the operations side, in addition to some IceCube maintenance, there will be some maintenance done on ARA stations.

Meanwhile, the collaboration is going to held its autumn meeting in Madison, Sept 23-27.

RNO-G

Read Anna Nelles' RNO-G season recap, sent from the collaboration meeting in Uppsala:

During the summer of 2024, RNO-G refurbished their stations with new electronics and wind-turbines and added another station bringing the total count now up to 8 RNO-G stations providing excellent data from Greenland. The early electronics still carried the burden from being developed and constructed during COVID. The new system is more future-proof and the addition of commercial wind turbines with a dedicated re-developed power system promises more year-round life time. As everyone working in polar environments knows: wind-power is hard but promises a large return on investment, in particular in a scenario like RNO-G where cabled power is logistically impossible. Also, new firmware now enables the simultaneous recording of down-going cosmic-ray signals in deep and shallow antennas, and RNO-G is now fully using the strength of the phased array as primary neutrino trigger.

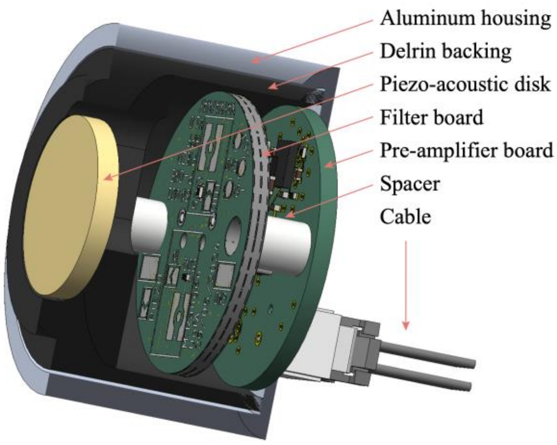
The collaboration met for one week in Uppsala not only to discuss the successes of the last installation season, but also take a look at the critical items. The BigRAID drill, the largest mechanical drill of its size, remains a worry. This season saw the drill getting stuck twice in the ice at several tens of meters of depth due to not fully understood reasons. The drill was always safely released, however, incurring several days of delay each time and uncertainty for the schedule. The 2025 season will therefore focus on drilling. With reallocated priorities, the collaboration is determined to identify whether drilling such large holes is a feasible and reliable route going forward. Alternatively, the design could fall back to smaller holes, at the cost of the sensitivity to the horizontal signal polarization and a redesign of the instrument.

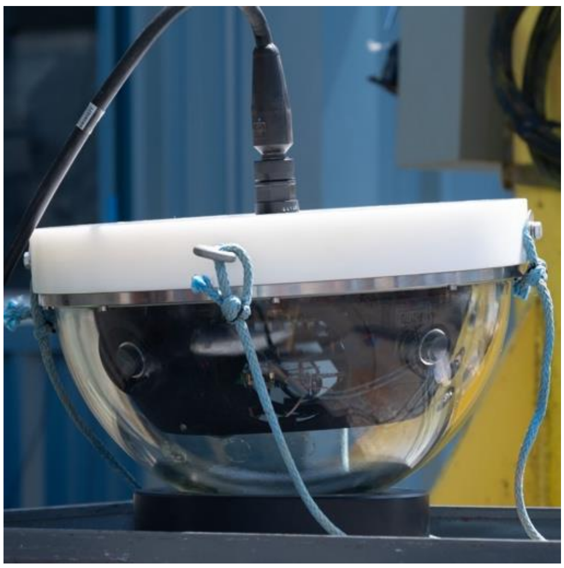
As usual, the collaboration had a great time meeting each other in person and thanks have to be extended to ours hosts in Uppsala for a very smooth organization. RNO-G only meets once a year to reduce the impact of travel. See the group photo below. The collaboration also has entered the final review of an instrument paper describing the performance of the first seven stations. It will ideally hit arXiv in time for the next GNN monthly.

P-ONE

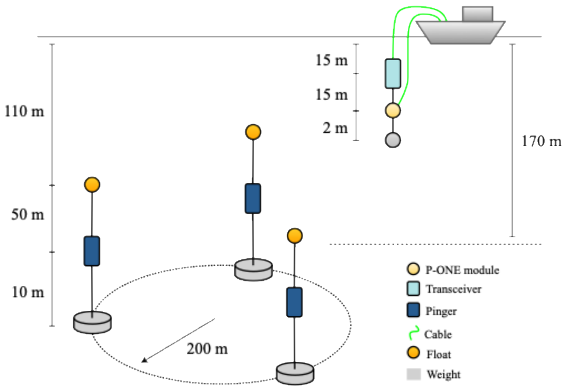
Read the following report by Matthias Danninger:

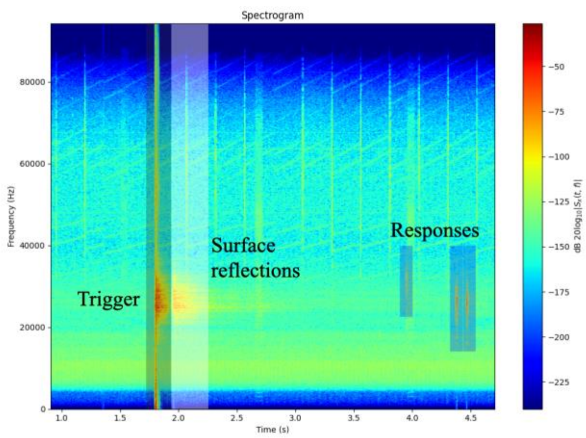
In August, the P-ONE team from Simon Fraser University performed together with collaborators from Ocean Networks Canada the final test of the P-ONE acoustic receiver system. This system will facilitate geometric calibrations in P-ONE. Acoustic beacons on the seafloor at known positions will generate acoustic pings in a frequency range of 19-35 kHz that can be detected in each of the P-ONE Optical Modules (P-OMs) by piezo-acoustic receivers integrated into the inside of all modules. The Figure below shows a schematic view of the receiver and a picture from the test module with 4 integrated receivers. Acoustic pingers and interrogators on the ocean floor will be based on a Sonardyne system using autonomous units and a cabled instrument for timed interrogation.





The final test of this system was performed in the Saanich Inlet, Canada, in a depth of up to 170 m. We temporarily deployed three acoustic pingers in a triangular pattern on the ocean floor, which we interrogated with a transceiver from the boat (see cartoon). The transceiver and the P-ONE acoustic test module were lowered from the boat and extensive ranging tests performed. Throughout a long and successful day of testing we moved the boat to several positions inside the triangle of pingers and outside up to 2 km away. In this test the transceiver interrogated the pingers, which responded with known time-delays and unique frequencies which we recorded with the P-ONE acoustic system. Example data (not post-processed) recorded from the P-ONE receivers (distance of 1.5 km to pinger setup) is shown below as a function of time and frequency. The z-scale of this spectrogram indicates the signal strength recorded. The triggering sound is clearly visible (followed by a surface reflection) and the three unique pinger responses. These data are currently being analyzed to determine the ranging precision of the future P-ONE acoustic system. Results will be compared to the internal ranging system of Sonardyne and GPS locations during the boat test.



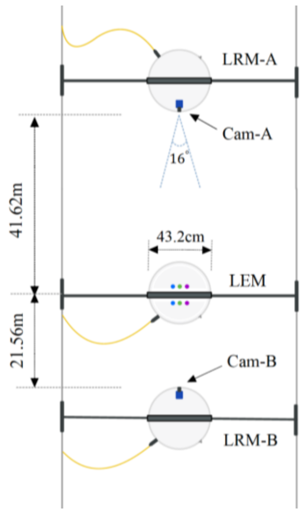


Publications

The TRIDENT collaboration has submitted a paper titled *A Real-Time Optical Calibration System Based on CMOS Camera for Water-Based Neutrino Telescopes* to NIM-A, posted at https://arXiv.org/pdf/2407.19111 . The lead author of this work is Wei Tian from the Shanghai Jiao Tong University, China.

The system has been developed for the TRopIcal DEep-sea Neutrino Telescope (TRIDENT) and addresses the challenges due to the dynamic nature and potential non-uniformity of the ocean water. This necessitates a real-time optical calibration system distributed throughout the detector array. This study introduces a custom-designed CMOS camera system equipped with rapid image processing algorithms. In September 2021, the authors have deployed camera as part of the TRIDENT Pathfinder experiment (TRIDENT Explorer, T-REX for short) in the West Pacific Ocean at a depth of 3420 meters.

The next figures sketches the T-REX apparatus.



The T-REX layout

It comprises a light emission module (LEM) and two light receiver modules (LRMs): LRM-A and LRM-B. LRM-A is positioned at a vertical distance of 21.56 ± 0.02 m from the LEM, LRM-B at 41.62 ± 0.04 m. Each LRM is equipped with a CMOS camera (Cam-A or Cam-B) and three 3-inch PMTs, capable of detecting light signals from the central LEM at two different distances. The LEM operates in two emission modes: steady mode and pulsing mode. The steady mode ensures consistent illumination for capturing clear images of the LEM by the cameras.

The next figure shows image samples of the two cameras, the following figure illustrates the extraction of water parameters from the images.

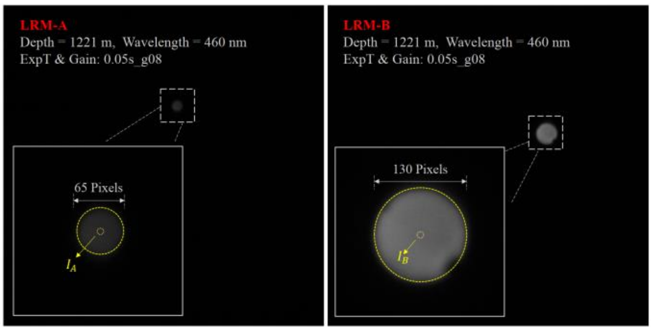
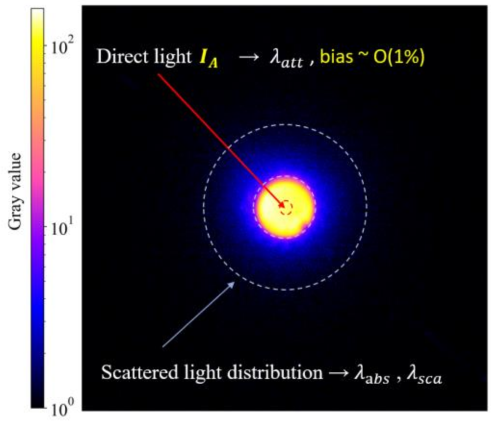
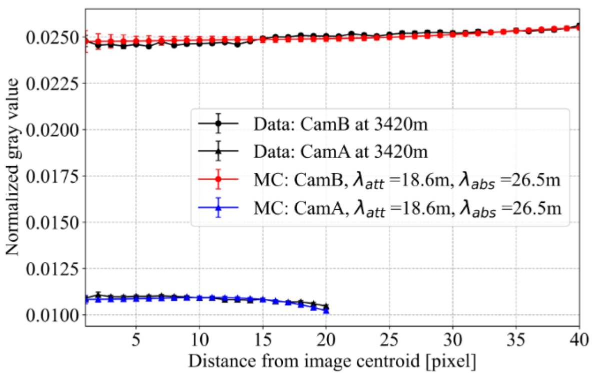


Image samples taken by the two cameras



Log-scale gray value distribution of the image

Within 30 minutes, about 3000 images of the T-REX light source were captured, allowing for the in-situ measurement of seawater attenuation and absorption lengths under three wavelengths. The next figure gives some sample results.



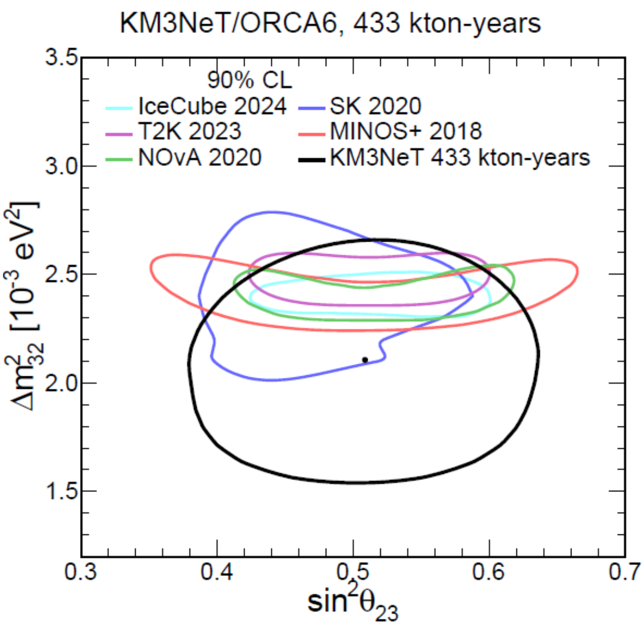
Optical parameters with the best fit to the data recorded at 3420 m. Black points: data obtained from real images, red and blue points: to the simulated data. See the paper for details.

T-REX for the first time showcased a technical demonstration of a functioning camera calibration system at a dynamic water site, solidifying a substantial part of the calibration strategies for TRIDENT.

The KM3NeT collaboration has submitted a paper *Measurement of neutrino oscillation parameters with the first six detection units of KM3NeT/ORCA* to JHEP (posted at 2408.07015 (arxiv.org)). The corresponding author is V. Carretero (U. Amsterdam and Nikef).

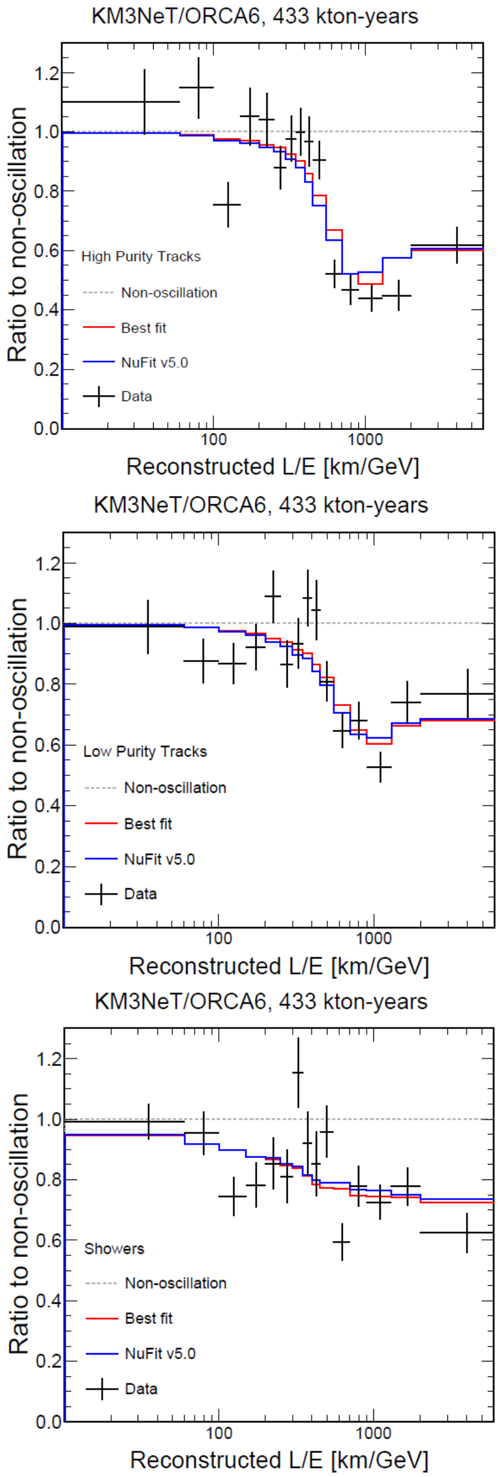
This paper focuses on the initial configuration of ORCA which comprises six out of the foreseen 115 detection units. This configuration took data from January 2020 to November 2021. A high-purity neutrino sample was extracted, corresponding to an exposure of 433 kton-years. The sample of 5828 neutrino candidates was analyzed following a binned log-likelihood method in the reconstructed energy and cosine of the zenith angle.

The following figures shows the obtained allowed region at 90% CL for ORCA6 for the oscillation parameters $\sin^2 \theta_{23}$ and Δm^2_{32} (Normal Ordering).



Allowed region at 90% CL for ORCA6 assuming NO for the oscillation parameters $\sin^2 \vartheta_{23}$ and Δm^2_{32} compared to results from other experiments.

The next figures show the L/E behavior for the three data samples analyzed.



Ratio to non-oscillation hypothesis as a function of the reconstructed propagation length over energy for High Purity Tracks (top), Low Purity Tracks (middle) and Showers (bottom). The data points are shown with error bars in black, the best fit is shown in solid red and the oscillation hypothesis (global fit NuFit 5.0*) is shown in solid blue. The non-oscillation hypothesis is indicated as a dashed horizontal line.*

These are the final parameters results of the analysis:

$$\sin^2\theta_{23} = 0.51^{+0.04}_{-0.05}$$

$$\Delta m^2_{31} = \begin{cases} 2.14^{+0.25}_{-0.35} \times 10^{-3}\ \mathrm{eV}^2, & \text{for NO} \\ [-2.25, -1.76] \times 10^{-3}\ \mathrm{eV}^2, & \text{for IO} \end{cases}$$

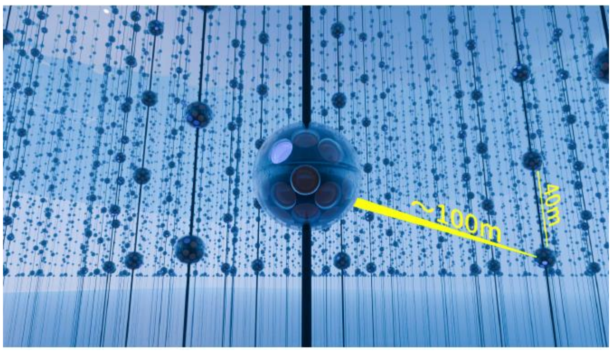
$$2\ln(L_{\mathrm{NO}}/L_{\mathrm{IO}}) = 0.31$$

The bracketed values for inverted ordering (IO) are given for 68% CL. The inverted neutrino mass ordering hypothesis is disfavored with a p-value of 0.25.

Ten authors from the School of Physics and Astronomy, Sun Yat-sen University in Zhuhai, China have submitted a paper *A proposed deep sea Neutrino Observatory in the Nanhai* to Astroparticle Physics and posted it at https://arxiv.org/pdf/2408.05122. With this project, we now have three Chinese plans to build a neutrino telescope on the 10 km² scale: TRIDENT, HUNT (presented already in former GNN Monthly editions) and this one, NEON, which stands for **NE**utrino **O**bservatory in the **N**anhai.

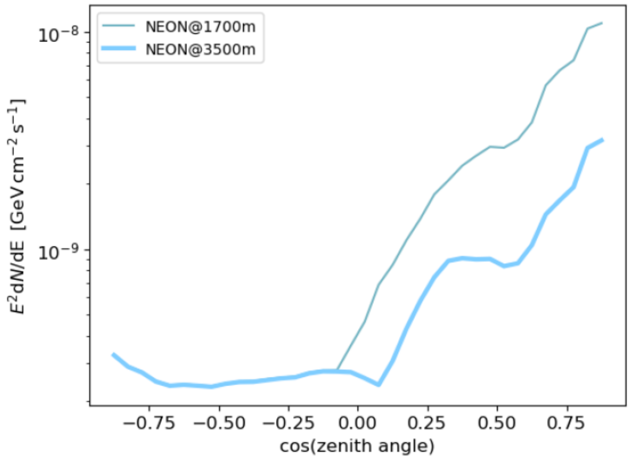
NEON is to be located in the South China Sea. The proposal describes the design and layout of the array and reports on comprehensive simulations conducted to assess its performance.

The attenuation length of light with wavelengths between 400 and 500 nm in the deep sea is 20 - 30 m, as reported by previous studies of TRIDENT. The NEON team shipped to the site in 2022 and measured the Rayleigh scattering length. At the depth of 2 km, it is 28.8m at λ=532 nm, matching other measurements. Based on these parameters, a spacing between the strings of OM ~100 m and a vertical OM spacing of about 40 m (18 OM per string) has been chosen.

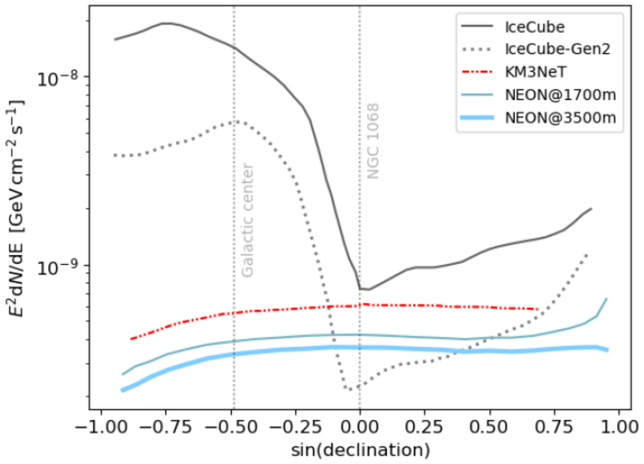


Sketch of the NEON design.

The following figure show the sensitivity as a function of zenith angle and water depth. The last figure gives the sensitivity as a function of declination and compares it to that from other experiments. It shows that the variation in depth from 1700 to 3500 meters does not significantly influence the sensitivity to steady sources.



NEON sensitivity as a function of zenith angle and depth.



NEON sensitivity as a function of declination, compared to that from other experiments.

Impressum
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