GNN Monthly

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News from the experiments

KM3NeT

Good news for KM3NeT ARCA. In February 2022 a funding request was submitted in Italy to the Italian Minister for the University and Research. According to a recent information, this has been approved. The new funding, called KM3NeT4RR, is 67 M€ to be spent over three years. It will allow the construction of about new 55 DUs and the related sea floor infrastructure, the reinforcement of the Italian integration sites and the hiring of new manpower. Considering the already funded 75 DUs, with these new funds the collaboration can complete the first ARCA building block and start the second one.

RNO-G deployment in its second season

As this newsletter is released, the installation of RNO-G at Summit Station in Greenland is winding down again.

In 2021, the first three stations of a funded total of 35 were installed. The system builds on experiences from ARA, ARIANNA and ANITA, but the hardware was a total redesign. It was therefore great to see that the autonomously powered stations came back up after going into hibernation mode during the polar night. However, some minor but necessary changes and improvements were identified. So, in 2022, the team revamped the first 3 stations and added 4 additional stations to the array. In particular, the power system has been revisited to be able to add wind-turbines, which will allow operation all-year round. The installation of wind-turbines and performing ice-calibration measurements are the objectives of the last team and currently on-going until the field-season ends in mid-August.

All RNO-G stations are named after Greenlandic animals. After last year's Nanoq, Amaroq, and Avinngaq (polar bear, arctic wolf, arctic lemming), this year Terianniaq, Ukaleq, Ukaliatsiaq, and Qappik (arctic fox, arctic hare, stoat, wolverine) joined. Depending on part availability and drill performance, the completion of the arctic zoo is planned after another 3 installation seasons.

Installation of the "Ukaliatsiaq" station. Left: Orange towing vehicle for the drill that is hidden underneath the white tent. The tent is to keep the drill from warming up when exposed to sunlight, which may lead to freezing of the mechanical drill. Middle: markers for first trenches for log-periodic dipole antennas of the station and deployment hut, which uses the greenhouse effect to create a warm environment for the installation of the deep antennas. Front and right: two snowmobiles that are used to transport the installation team from the station.

First experimental results were released, including ice attenuation length measurements (https://arxiv.org/abs/2201.07846) and the observation of increased event rates during high-wind periods (https://arxiv.org/abs/2103.06079). First physics analyses are underway.

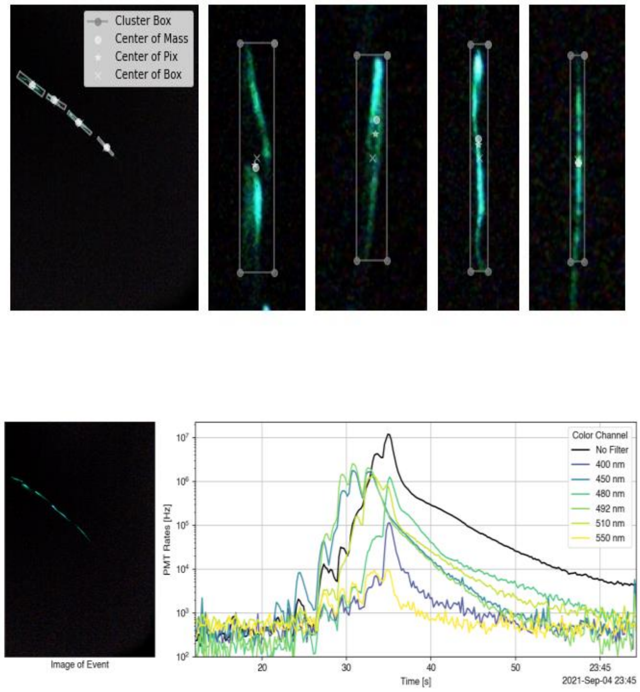
(thanks to Anna Nelles for providing text and picture)

P-ONE

P-ONE is evaluating data taken with instruments deployed in STRAW-b. This second pathfinder operates at Cascadia Basin since October 2020. It hosts several devices, of which two are multi-PMT spectrometers, one of them shown in the figure below. Each spectrometer hosts 12 PMTs, installed with 11 filters working within a specific wavelength range. Collectively, they are expected to cover the entire emission spectrum of bioluminescence. The lenses in front of every PMT's focus the incoming light onto the PMTs and limit the field of view. Specially designed 3D-printed symmetrical holding structures align the PMTs so that the refraction of the spherical glass is corrected. In the center of the spectrometer, a camera supplied by Carsten Rott and his group is installed, actually the same camera as the one planned in the IceCube Upgrade.

With the camera and the spectrometer, the group aims to image creatures emitting bioluminescence and measure their emission spectra in-situ during their emission. For P-ONE, this gives important input for the simulation of bioluminescence, for oceanographers it helps the classification of species, potential change of them due to climate change, etc.

By now, the collaboration has collected a lot of data and several analyses are ongoing. Below you see images analyzed with a new algorithm of classification and the emission spectrum registered. The camera's exposure is about 60 sec, about 10 of these bright events per day are recorded. A paper is in preparation.



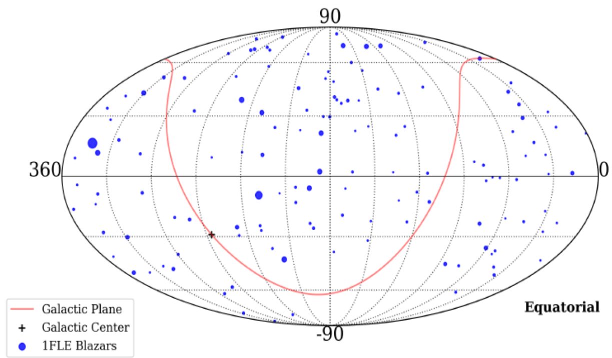
Camera pictures of bioluminescence, together with the time profile for different wavelengths.

(thanks to Elisa Resconi for providing information and pictures)

Publications

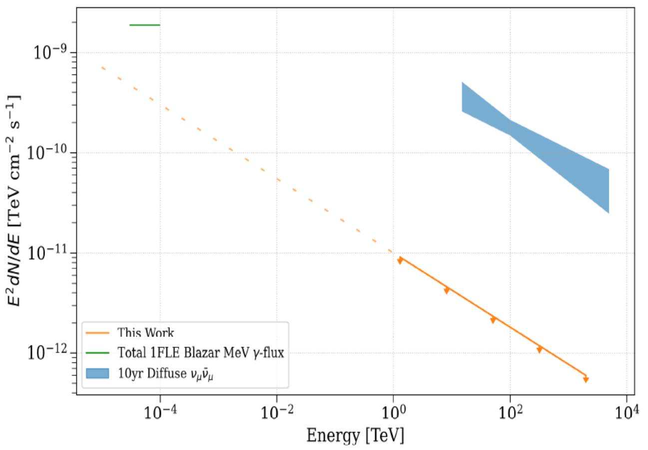
Neutrinos from 1FE Blazars? The IceCube Collaboration has submitted a paper *Search for Astrophysical Neutrinos from 1FLE Blazars with IceCube* to ApJ (posted at [2207.04946.pdf (arxiv.org)]). The analysis was performed by Michael A. Campana (Drexel U., Philadelphia).

Previous IceCube searches for neutrino emission from populations of blazars detected in GeV-TeV gamma-rays have not observed any significant neutrino excess. Recent multi-messenger results indicate that high-energy photons, co-produced with high-energy neutrinos, are likely to be absorbed and reemitted at lower energies. Thus, gamma-rays in the MeV-GeV region may be better indicators of TeV-PeV neutrino production than high-energy gamma-rays. The paper presents the first time-integrated stacking search for astrophysical neutrino emission from MeV-detected blazars in the first Fermi-LAT low-energy catalog (1FLE) using ten years of IceCube muon-neutrino data.



Sky map showing locations of 1FLE blazars used as sources in this analysis. The marker size for each blazar is proportional to its MeV gamma-ray flux.

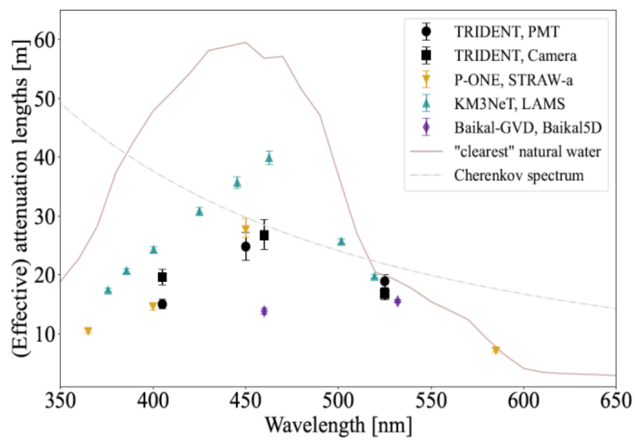
The results of this analysis are found to be consistent with a background-only hypothesis. Assuming an E^{-2} neutrino spectrum and proportionality between the blazars' MeV gamma-ray fluxes and the TeV-PeV neutrino flux, the upper limit on the 1FLE blazar energy-scaled neutrino flux is determined to be 1.64×10^{-12} TeV cm^{-2} s^{-1} at 90% confidence level. This upper limit is approximately 1% of diffuse muon-neutrino flux as measured by IceCube.



90% confidence level upper limit (without systematic uncertainties) on the energy-scaled muon neutrino + anti-neutrino flux from 1FLE blazars assuming a simple power-law (orange) which is 1.0% of IceCube's diffuse flux measurement (blue). The solid orange line covers the energy range which contributes 90% of the total sensitivity. The dashed line extrapolates this limit to lower energies. The short green line (top-left) shows the sum of integrated gamma-ray fluxes between 30 and 100 MeV for 1FLE blazars which are used as source weights in obtaining the shown upper limit. Considering the relationship between this total flux and the limit from this analysis in the 30-100 MeV range, in conjunction with a gamma-ray model, could offer insight into the contribution of hadronic interactions to the observed blazar flux distribution.

TRIDENT: TRIDENT stands for **T**he t**R**op**I**cal **DE**ep-sea **N**eutrino **T**elescope – certainly one of the most whimsically constructed acronyms I have seen. The TRIDENT collaboration consists of 20 Chinese institutions and has posted a paper *Proposal for a neutrino telescope in South China Sea* to the archive (TRIDENT Pathfinder (arxiv.org)). Corresponding author is former IceCube member Donglian Xu, now at the Shanghai Jiao Tong University. She proposed and led the development of the project.

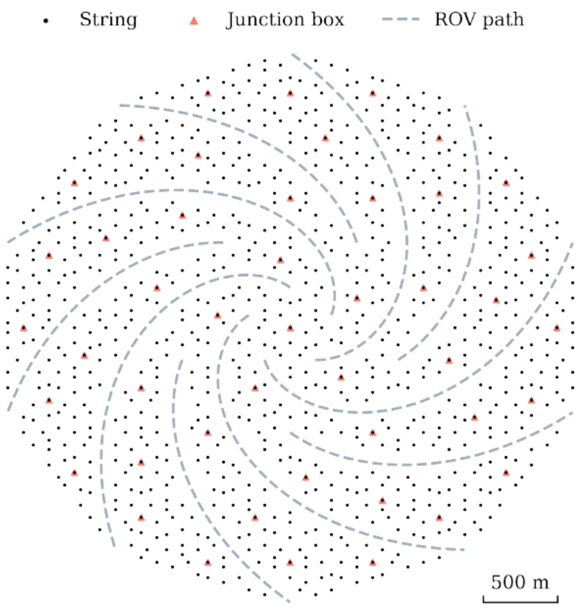
The paper reports the results from a cruise to the north-eastern region of the South China Sea. A possible neutrino telescope site was found on an abyssal plain at a depth of ~3.5 km. Below 3 km, the sea current speed was measured to be smaller than 10 cm/s and the absorption and scattering lengths for Cherenkov light as ~27 m and ~ 63 m, respectively – see also the figure (values at the wavelength of their maximum). This is better than the corresponding values in Lake Baikal, comparable to those at the P-ONE site and worse than those at the ARCA site.



Effective attenuation lengths (see the paper for the definition) measured by two independent optical systems, using PMT (black circle) and cameras (black square) for three wavelengths (405 nm, 450/460 nm, 525 nm).

The closest island with infrastructure is ~180 km (!) away, the distance to the mainland is ~500 km. There is no underwater infrastructure (as, e.g., for P-ONE).

Given the actual uncertainties, the presented plan for a next-generation neutrino seems extremely ambitious: a 7.5 km^3 array consisting of 1211 strings instrumented over 700 m with 20 DOMs each – see the figure next page.



Geometry layout of the TRIDENT array. Each black dot represents a string of length of ~ 0.7 km, while the dashed lines mark the paths for underwater maintenance robots.

A pilot project with three strings installed at the selected site for a technology demonstration is scheduled for ~2026. Construction of the full array is envisaged to begin after a successful demonstration, commencing measurements with the partially built configuration. The full telescope is envisioned to become live in the early 2030s.

Editorial: A reminiscence

On June 26, the Ukrainian General Staff announced in its situation report: "The Ukrainian army inflicted significant losses on the enemy near the village of Pavlivka, in the Bakhmut area. After an unsuccessful assault, the enemy retreated. The enemy used mortars, tube and rocket artillery against the Ukrainian positions in the Bakhmut area."

Bakhmut? Where is this? I googled and found out that Bakhmut is a town with about 74,000 inhabitants in the Donezk region. And, actually, I knew about the town since long, but only under the name it had from 1924 to 2016: Artyomovsk (Russian) or Artemivsk (Ukrainian).

The Bakhmut Basin is rich of deposits of rock salt. One of the salt mines housed, at 540 meters depth, a 105-ton liquid scintillation neutrino detector: The Artyomovsk Scintillation Detector (ASD). It started data taking in 1977 and was in operation until 2020. Like the Baksan scintillation detector, it was operated by Moscow physicists from the Institute of Nuclear Research (INR) which also houses the Baikal-GVD headquarter.

ASD main purpose was to watch out for neutrinos from Supernova explosions. The detector could have co-discovered SN 1987A, but – alas! – was not in operation that day.

Let me take my acquaintance with an old city under a new name (and, sadly, under conditions of a reckless war) to recall the dramatic story of SN 1987A. Actually, there are more relations between SN 1987A to the troubling world of 2022: February 24, 2022, is exactly 35 years after the light signal from SN 1987A reached the Earth (the neutrino arrived at Febr.23)!

The following is a shortened version of the story as I tell in in my book "Neutrino Astronomy – looking into hidden worlds" which was published in German by Springer Press last December https://link.springer.com/book/10.1007/978-3-662-63294-9. It may tell the younger physicists how success sometimes depends on pure luck and how close triumph and disappointment can be. And: how important a high duty cycle is – for IceCube and KM3NeT as well as for all other detectors that are waiting for neutrinos from a supernova explosion!

In 1987, there were five detectors in the world that could be used for the detection of a short neutrino burst via the reaction $\bar{\nu}_e + p \rightarrow n + e^+$ *reaction. First, the Kamiokande detector in Japan, buried under a kilometer of rock not far from the town of Kamioka and filled with 3000 tons of water. Kamiokande registered the Cherenkov light from charged particles. The same principle as Kamiokande was used for the second detector, named IMB (Irvine, Michigan, and Brookhaven). It was located in a 1570-meter-deep salt mine near Ohio and was filled with 7000 tons of water.*

The other three detectors did not contain water, but liquid scintillator. Scintillator signals are more intense than Cherenkov light in water. Therefore, these three *detectors were sensitive to lower energies than IMB and Kamiokande. In return, however, they were also much smaller – mostly because of the high cost of the scintillator.*

The first of the three was located beside the road tunnel under Mont Blanc and had been christened LSD (for Liquid Scintillator Detector). It was filled with 90 tons of scintillator. Unlike Kamiokande and IMB, LSD was specifically designed to detect supernova neutrinos. The second scintillator detector worked, and still works, in the Russian Caucasus: The Baksan Underground Scintillation Telescope (BUST). It is filled with slightly more than twice as much scintillator as LSD, namely 200 tons. The third detector was the above mentioned Artyomovsk Scintillation Detector (ASD). It contained 105 tons of liquid scintillator.

In all of these detectors except LSD, circumstances came into play that could easily have prevented detection. The worst case was the Artyomovsk detector. February 23 was Soviet Army Day. Although officially not a holiday, there was virtually no work on that day in many Soviet Union institutions. Presumably for this reason, the Artyomovsk detector was not in operation at the time of the neutrino signal.

The same fate could have hit the Baksan detector, but here the director was apparently aware of the fact that a supernova does not follow holidays. BUST was in operation.

Kamiokande almost missed the detection: The detector was switched off for a routine calibration two minutes after the arrival of the neutrinos. A shutdown two ridiculous minutes earlier, and Kamiokande would have been one Nobel Prize poorer! Things happened in a similarly coincidental way at the IMB detector. A few hours before the neutrinos arrived, the magnetic tape on which the data were recorded was almost full. In such cases, the energy threshold from which events were written to the tape was automatically set so high that proton decays still would have triggered a record, but supernova neutrinos and the huge number of noise events not. The neutrino signal from SN 1987A arrived on the night of February 22 (Sunday) to 23 (Monday), and fatally, the computer had switched to the higher threshold on Sunday afternoon. The supernova would have been missed by the IMB physicists, unless a proud graduate student hadn't wished to show his girlfriend the facility on Sunday evening. He drove down into the mine with her, noticed that the tape was nearly full, and exchanged it for a new one. IMB was ready for supernova neutrinos again! (thanks to Hank Sobel for telling me this story)

The first of all signals were reported by LSD. Even before the optical astronomers released their alarm, the detector had sent out an automatic alert on its own. At 2:52 a.m. Greenwich time on February 23, LSD had registered five events within seven seconds. The probability of such a cluster occurring by pure chance in the eight hours before the first optical sighting is less than one thousandth.

The physicists in the other experiments heard about this and scanned their magnetic tapes for an excess of events in a corresponding time window. Confusingly, they found nothing. Only when they broadened the search window they found an apparent signal. Kamiokande had recorded a cluster of twelve events at 7:35 a.m. on February 23, and IMB had recorded eight events at the same time. The probability that this was coincidence, however, amounted to far less than the "one-thousandth" of LSD: it was well under 10^{-20}, which is a pretty good approximation of zero.

Somewhat less pronounced than the Kamiokande and IMB signals was that of the Baksan experiment. At about the same time as the other two detectors, the Russian physicists detected a handful of events that were above the noise (three to five, depending on what was counted as signal and what as noise). On its own, this excess was not very significant (i.e., it could very well have been random), and in fact it was a bit too high for this comparatively small detector. According to the results of Kamiokande and IMB, and taking into account statistical fluctuations, Baksan should have recorded zero, one, or at most two neutrinos. Probably some of the five events were due to noise.

As much as the IMB and Kamiokande physicists reveled in triumph, the LSD researchers were disappointed. They were firmly convinced that their signal was real. After all, it was the only signal that had been reported automatically and on its own - and not a posteriori, by scanning magnetic tapes with the recorded data. The only question was: why had the others seen nothing at 2:52, and why had LSD in turn seen nothing at 7:35? The Italian and Russian LSD physicists fell for the most sophisticated and tricky arguments to explain the discrepancy and "save" their discovery. At the conferences in 1987, however, these arguments were wiped off the table by the others with (sometimes very rigorously presented) counter-arguments, and more than once it seemed as were the disputants on the brink of getting violent. Assuming that all experiments had registered two neutrino bursts, the obvious explanation would have been that with the first pulse the star would have collapsed to a *neutron star and with the second pulse to a black hole. But in retrospect, the LSD signal is considered by most experts as an extreme statistical outlier - even if the LSD protagonists would still contradict you today, with arguments hard to disprove.*

I wrote this text on June 27. Now, almost a month later, the fights around Bakhmut have flared up again in full force. How will I have to remember Bakhmut/Artyomovsk after a few weeks from now? Still primarily as the location of a missed discovery – or as another bombed city, with an infrastructure destroyed to the foundation walls and with hundreds or thousands of killed people, civilians and soldiers …

Christian Spiering