GNN Monthly
The Global Neutrino Network 83th Edition February 29, 2024

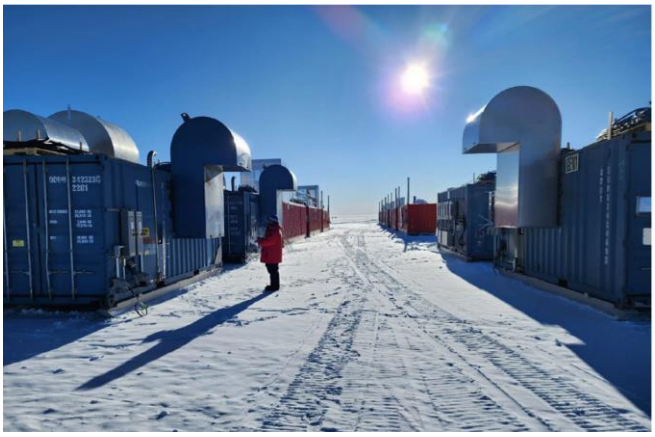
News from the Experiments

IceCube

The last summer visitors have left the Pole on February 17. For IceCube's Upgrade Team, the season has ended a bit earlier. They all left the South Pole on February 9, then spent a week in McMurdo waiting to fly out. In the meantime, most of them are back home.

During the last three weeks of the season, the team continued to perform an impressive amount of work. The drill camp components have been finalized for this field season, the mobile drill structures winterized and either moved to drill camp or the storage berm for the winter. Actually, only a small amount of work has been deferred until next season, when the drill system will be brought into operational condition and drill tests will be performed (the first drilling operation since 2010!). As reported several times before, the 7-string Upgrade installation is planned for 25/26.

Moving the ARA drill back to the winter berm for storage (remember: ARA stands here for "Antarctic Rodwell Apparatus" and not for "Antarctic Radio Array")



Top: View of "Seasonal Equipment Site" (SES) with the IceCube Laboratory in the background. In the foreground are the main heating plants. Bottom: view down the aisle of the SES showing the generators in the foreground, water tanks and main heating plants in the distance. (Photo: K. Studt, IceCube/NSF)

IceCube's spring 2024 collaboration meeting will be held in person in Münster, Germany from March 17-22. Around 200 IceCube community members have already registered for the meeting. Throughout the week, there will be daily sessions, including plenary and parallel talks, and special events. Highlights and a summary of events from the meeting will be covered in the March edition of GNN Monthly.

KM3NeT

The KM3NeT collaboration meeting was held in Bologna, 12-16 Feb 2024, with 127 registered participants. UC Louvain (Gwen De Wasseige) became a full member and Drexel University (Naoko Kurahashi) a new observer, as well as U. Würzburg (Sara Buson). Fortunately, the membership of NCBJ Warsaw could be revived with the new PI Artur Ukleja. Cássius Anderson Miquele de Melo (UNIFAL, Brazil) became an associated member.

Two Giorgios Androlakis Impact Prizes have been awarded: that for Early Career Scientists to Dr. Agustín Sánchez Losa, IFIC "*for his long-standing, diverse and essential contributions to the KM3NeT detector calibration*", and that for Technicians and Engineers to Riccardo Bruno, INFN Catania "*for his dedicated, leading and vital contributions to the KM3NeT project, in particular in: setting up the software tool for functional and acceptance tests for WWRS DOMs; developing the White Rabbit system; construction of the WWRS DOM prototypes; his support of the integration teams producing WWRS DOMs.*" Agustín was also winner of the 2016 GNN dissertation prize.

Agustín Sánchez Losa

Riccardo Bruno

Baikal GVD

At February 16, the first twenty expedition participants arrived at Lake Baikal and started to install the ice camp. Severe frosts (down to minus 30 degrees) had produced a strong ice cover, well sufficient for the movement of cars and for installing the camp. The divers who make the connection to the upper buoys have done their job and first strings have been raised for repair.

GNN Dissertation Prize

The 2023 GNN Dissertation Prize is awarded to Ibrahim Safa (now University Columbia, formerly UW Madison) for his thesis *New Physics with PeV Astrophysical Neutrino Beams*.

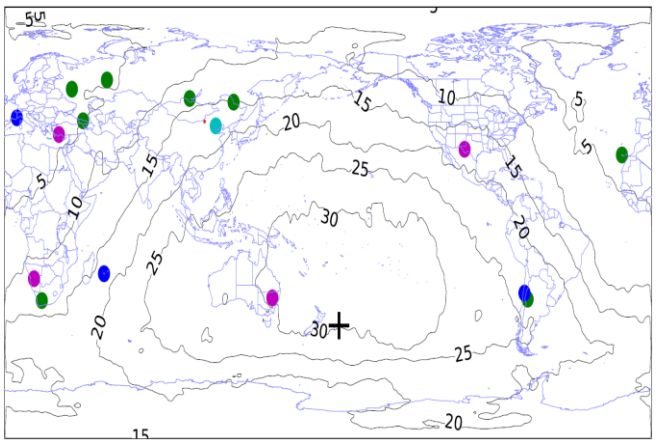
Ibrahim Safa

Ibrahim's thesis is a "multipurpose thesis for multi-purpose detectors". It addresses IceCube issues but is also relevant to other detectors. One such issue is vastly improving tau neutrino modeling at PeV energies and above. This work culminated in a public software now used by IceCube, ARA and TAMBO. The same software was used to perform IceCube's ANITA follow-up analysis which definitively ruled out the neutrino hypothesis of the anomalies. It also demonstrates the eminent role of ν_τ for super-PeV point source searches. Ibrahim also analyzed data from all relevant neutrino observatories to derive dark matter annihilation limits, including the first limit in the neutrino sector that crosses the thermal relic abundance around GeV energies. Finally, he used X-ray/optical/radio data to characterize AGNs and search for neutrino counterparts.

P-ONE new GNN member

Welcome to Elisa and her P-ONE collaboration as new members of the Global Neutrino Network!

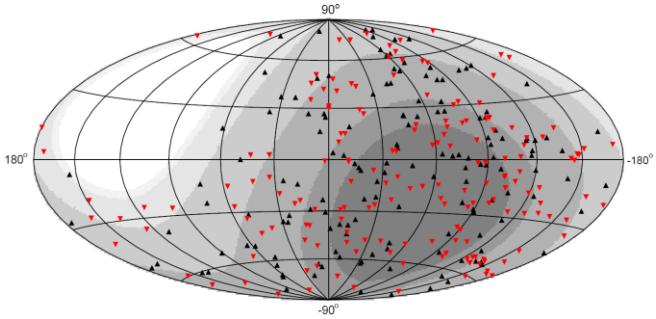
For the first time we have expanded the membership of GNN, and we hope this continues as our field continues to grow.



Follow-up iso-efficiency curves of the ANTARES alerts as a function of the location of a given telescope. The numbers indicate the percentage. The dots represent the positions of MASTER (green), ROTSE (pink), TAROT/Zadko (blue) and SVOM ground telescopes (cyan). The black cross indicates the antipode of the ANTARES location.

Publications

Erratum to last GNN's report on the 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 authors of the paper are Dmitry ("Dima") Chirkin from UW Madison and Martin Rongen from ECAP.
(I forgot Dima in my last report.)



Sky map in Galactic coordinates showing the directions of all the TAToO alerts: red and black markers correspond to alerts with early follow-up (<24 h) and with only late follow-up, respectively. The grey regions indicate the integrated ANTARES visibility, from dark grey, 100%, to white, 0%.

The ANTARES Collaboration has submitted a legacy paper on their Target-of-Opportunity program to JCAP*: Results of the follow-up of ANTARES neutrino alerts* (link). Main authors are Damien Dornic (CPPM Marseille) and Alexis Coleiro (APC Paris).

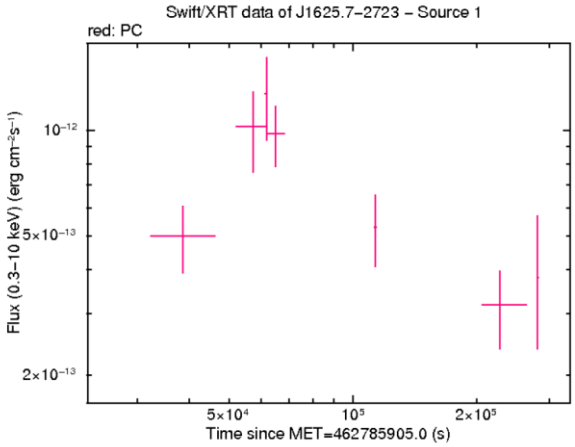
The ANTARES collaboration has run this program (named TAToO) since 2009, triggering robotic optical telescopes (MASTER, TAROT, ROTSE and the SVOM ground based telescopes) immediately after the detection of any relevant neutrino candidate, including several observations in the weeks following the detection (see the follow-up efficiency curves and the sky map with the directions of all the TAToO alerts in the next two figures).

Four online neutrino trigger criteria have been implemented in TAToO:

- High energy (HE) trigger: detection of a single high-energy neutrino with energy ≥ 5 TeV. Rate ~ 1/month.
- Very high energy (VHE) trigger: detection of a single very high-energy neutrino with energy ≥ 30 TeV (sub-sample of the HE trigger). Rate: 3–5 /year.
- Directional trigger: the detection of a single neutrino with a direction pointing toward (≤ 0.4◦) a local galaxy (≤ 20 Mpc) in the Gravitational Wave Galaxy Catalogue. Mainly introduced to enhance the chance to detect a local CCSN. Rate ~ 1/month.
- Doublet trigger: at least two neutrinos coming from close directions (≤ 3◦) within a predefined time window (15 min). No doublet trigger ever up to now.

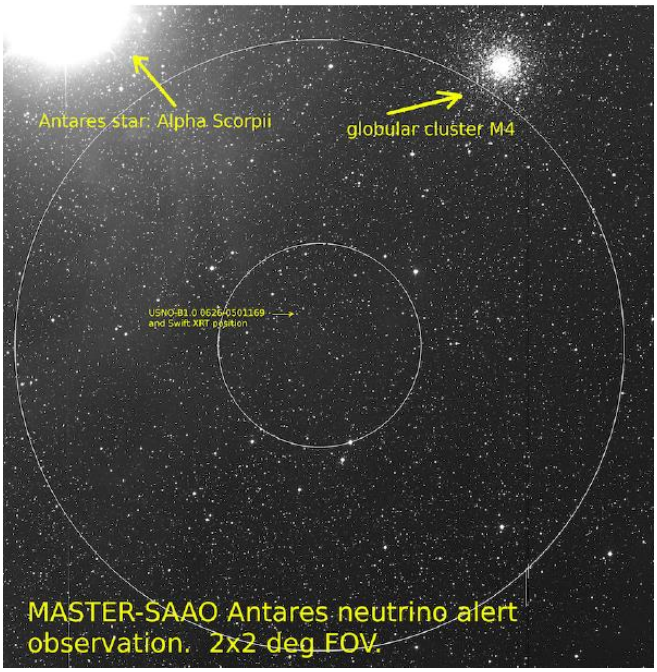
A subset of ANTARES events with highest probabilities of being of cosmic origin has also been followed by the Swift and the INTEGRAL satellites, the Murchison Widefield Array radio telescope and H.E.S.S. The paper reports results of twelve years of observations.

No optical counterpart could be significantly associated with an ANTARES candidate neutrino signal during image analysis, resulting in constraints on transient neutrino emission. However, in September 2015, ANTARES issued a neutrino alert and during the follow-up, a potential transient counterpart was identified by Swift and MASTER (but no other of the follow-up observations). The associated neutrino (ANT150901A) had an energy of about 90 TeV with a 1σ range of 20 – 300 TeV. The probability that this neutrino was of cosmic origin is 8%.



Light curve measured by the Swift-XRT for the X-ray source identified in the follow-up of ANT150901A. The neutrino detection time is t = 0.

Optical follow-ups by the MASTER telescopes began 9 hours 45 minutes after the neutrino detection. The location corresponding to the neutrino direction was followed since the first day with two telescopes in South Africa and Canary Island. This direction was regularly followed by one of the MASTER telescopes during the 8 subsequent days. No optical transient candidate was found in the observations down to a magnitude of 18.67 (60 s exposure). At the position of the X-ray source, MASTER identified a bright star of magnitude 12.3 with a light curve showing no flux nor color variations just after the time of the alert. The next figure illustrates the field of view of MASTER. The globular cluster M4 is 0.97° away and the Antares star (Alpha Scorpii) is 1.2° away from the ANT150901A neutrino direction.



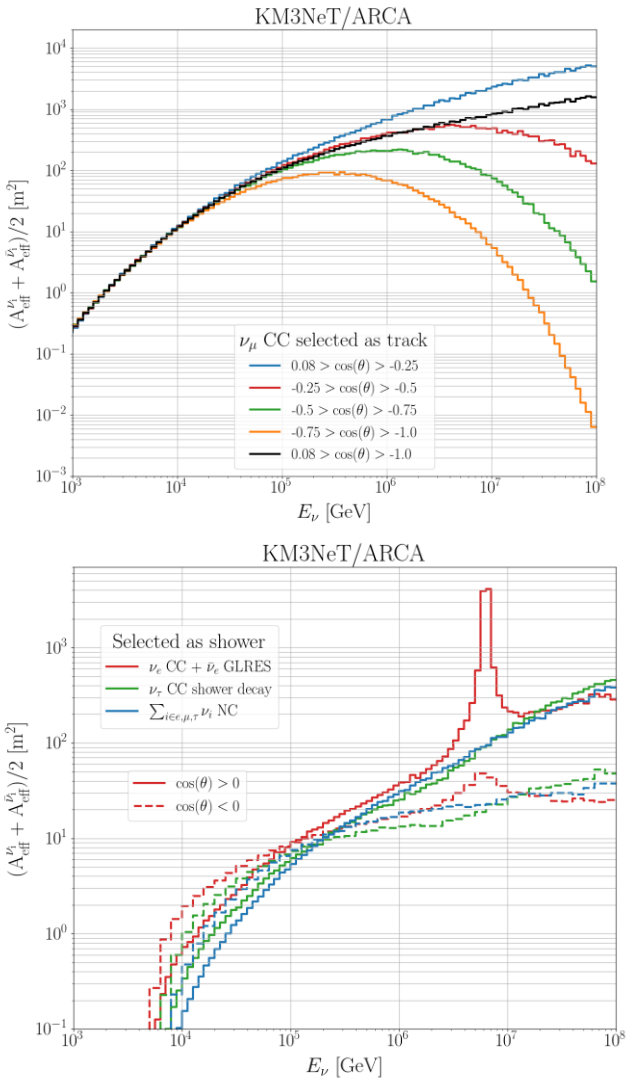
Field of view of MASTER corresponding to ANT150901A. The 2 circles have a radius of 0.3 and 0.9 degrees.

Citing the last paragraph of the conclusions: Precision is key to obtain good follow-ups. Therefore, it is important to achieve the best angular resolution in real time and a good control of the absolute pointing accuracy. Moreover, it is highly desirable to be able to properly reconstruct in real time all event topologies spread over a very large energy range, not only restricting to the high-energy muon neutrino channel. Even if the angular resolution for the other event topologies (electron and tau neutrinos produce mostly shower-like events) is limited, these channels are particularly interesting since the atmospheric background contamination is very low. In this respect, KM3NeT is starting to enter into the multi-messenger landscape and will allow multi-flavor neutrino alerts to be sent with unprecedented angular resolution.

The KM3NeT collaboration has posted two papers discussing the astronomical capabilities of a full (i.e. two blocks, 230 DUs) ARCA detector. The first, *Astronomy potential of KM3NeT/ARCA,* is submitted to EPJ-C (https://arxiv.org/pdf/2402.08363.pdf). Corresponding author is Thijs van Eeden (Nikhef, Amsterdam). The second is titled *Differential Sensitivity of the KM3NeT/ARCA detector to a diffuse neutrino flux and to point-like source emission: exploring the case of the Starburst Galaxies*. It is submitted to Astropart. Physics and posted at

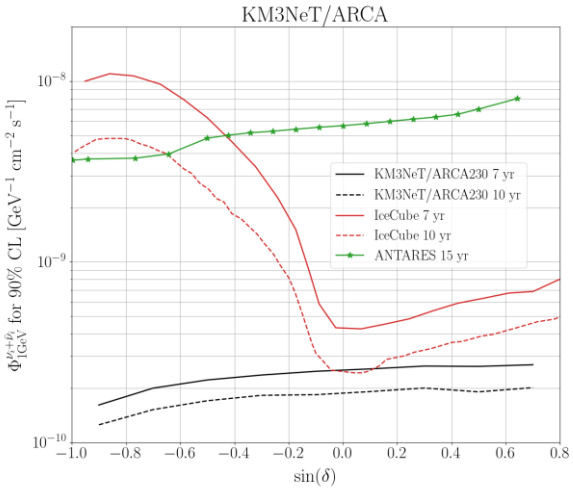
https://arxiv.org/pdf/2402.09088.pdf. Corresponding authors are Antonio Ambrosone, Walid Idrissi Ibnsalih and Antonio Marinelli (all Univ. and INFN Napoli).

The first paper covers the reconstruction of track and shower-like signatures, as well as the criteria employed for neutrino event selection. Taking advantage of both the track and shower signatures, KM3NeT/ARCA would have the capability to detect the diffuse astrophysical neutrino flux as measured by IceCube within half a year of operation, achieving a 5σ statistical significance [Note that in practice, the diffuse flux will be measured over several years by a stepwise increasing ARCA detector]. The next figure shows the effective area (trigger level) for tracks and shower events.

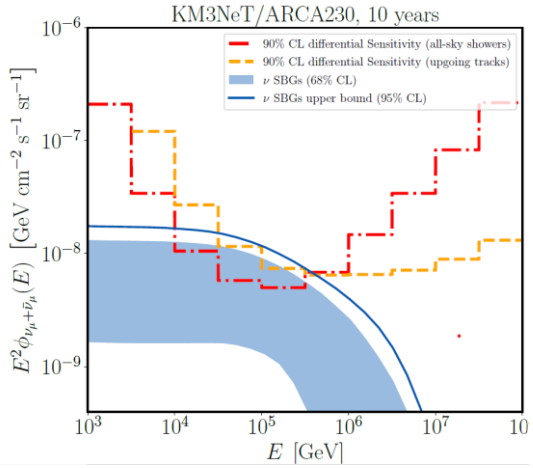


The ARCA effective area for ν_μ CC events selected as track for different cos(ϑ) ranges (top) [cos(ϑ) = -1 means vertical upward], and for the shower channel covering both upgoing and down-going events from ν_e CC, ν_τ CC and ν NC interactions (bottom).

With an angular resolution below 0.1° for tracks and under 2° for showers, the sensitivity to point-like neutrino sources surpasses existing observed limits across the entire sky, see next figure. (Note the footnote next page [1])

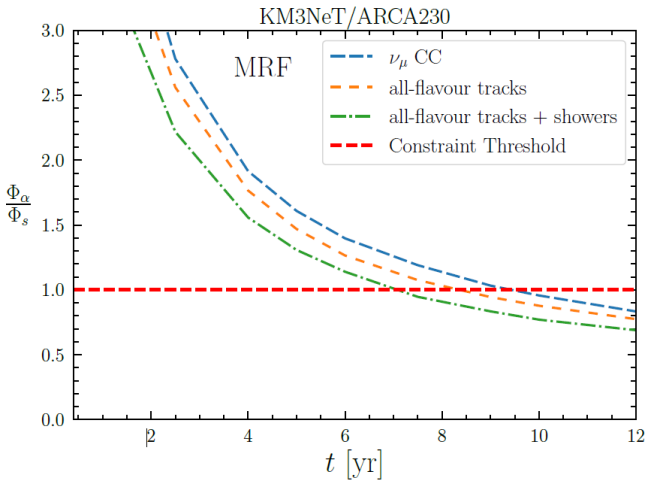


In the second paper, the integrated and differential sensitivities for KM3NeT/ARCA are presented considering the case of a diffuse neutrino flux as well as extended and point-like neutrino sources (using Monte Carlo simulations for neutrinos of all flavors). The analysis is applied to Starburst Galaxies (SBGs) demonstrating that the detector has the capability of constraining models predicting the diffuse flux from SBGs (next figure).



90% CL differential sensitivity to a diffuse neutrino flux for upgoing tracks (dashed orange) and all-sky showers (dashed-dotted red). On the left, the sensitivities are compared to the theoretical 1σ band prediction for SBGs neutrinos as obtained in [A. Ambrosone et al., Starburst galaxies strike back: a multi-messenger analysis with Fermi LAT and IceCube data https://arxiv.org/abs/2011.02483] through a multi-component fit of the extragalactic gamma-ray background measured by Fermi-LAT, and the 7.5 yr HESE neutrino flux measured by IceCube.

Also tracing TeV neutrinos from individual sources is investigated. Three SGB sources are considered (the Small Magellanic Cloud (distance 60 kpc), NGC 1068 (10-14 Mpc) and the Circinus Galaxy (4 Mpc away). After eight years, a hard power-law spectrum from the SMC can be constrained, see the next figure.



Small Magellanic Cloud: the energy-integrated Model Rejection Factor (MRF) as a function of time for different event samples. The blue line refers to ν_μ CC events, orange to the all-flavor tracks, and green to tracks + showers. The model is taken from [A. Ambrosone et al., Could Nearby Star-forming Galaxies Light Up the Pointlike Neutrino Sky? https://arxiv.org/abs/2106.13248]

Editorial on a given occasion

On 24 February it was two years since Putin's army invaded the Ukraine and brought death and devastation to an entire country. It did not come as a surprise that the war also affected our Global Neutrino Network. Joint meetings and the mutual participation in the KM3NeT and the GVD advisory committees have been cancelled. Common analyses were suspended. And GNN is not alone in this respect; many other scientific activities beyond Astroparticle Physics are subject to sanctions [1]; even further measures are currently being discussed. This reminds of the sanctions imposed on German scientists after the two great wars of the 20th century [2]. However, in both cases, early science contacts played an important healing role after the wars had ended. In GNN, we are maintaining contacts on a non-institutional level, which will hopefully help a normalization of cooperation between the Russian and Western scientific communities in due time. But right now – alas! – there is no end of the war in sight.

[1] In December 2023, the CERN Council decided to terminate the Organization's cooperation with the Russian Federation and the Republic of Belarus, including the expiry in 2024 of the corresponding International Cooperation Agreements.
[2] After the First World War it took almost three years until Germans could participate in international conferences without restrictions.

[1] Note, however, that IceCube would have taken data over more than 20 years when ARCA would reach an equivalent of 7 years full ARCA. Therefore, for steady sources, IceCube would keep the lead at the Northern hemisphere. For transient sources, however, it would be surpassed by a full ARCA].

Impressum
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