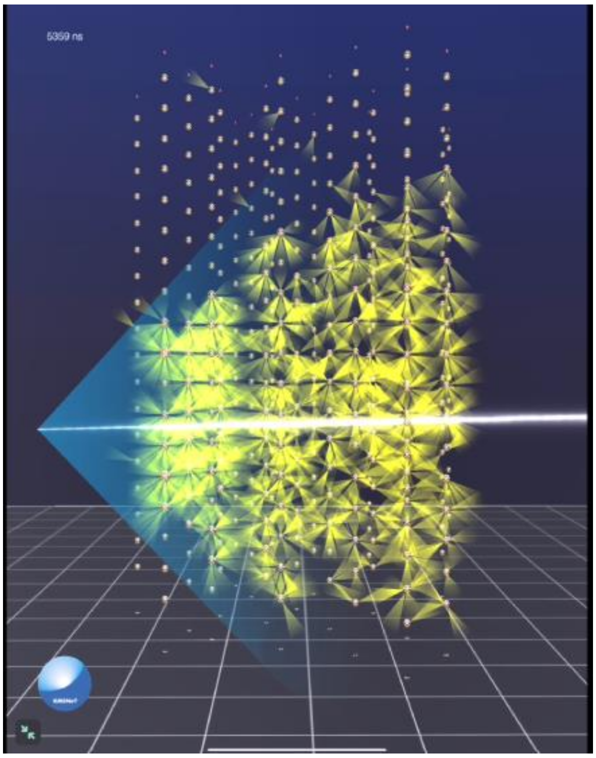
GNN Monthly

The Global Neutrino Network 87th Edition July 24, 2024

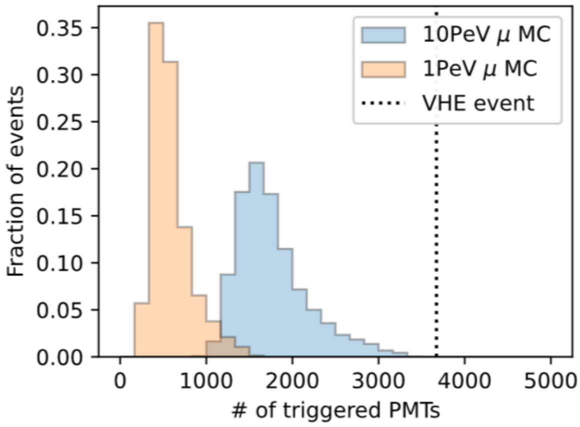
News from the Experiments

KM3NeT

The Monster Event: The ARCA detector has registered an event with 3672 triggered PMTs (35%) – see the next picture. This corresponds to a most probable energy of several tens of PeV (see picture right column)!



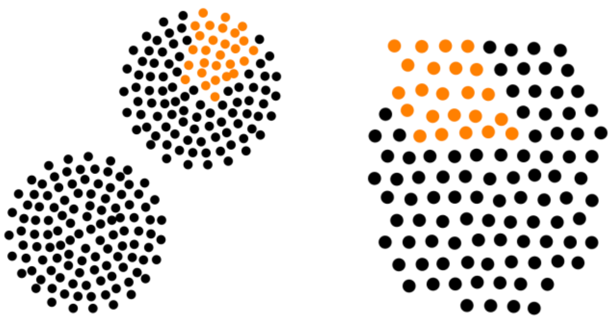
The event was presented in a talk given on June 18 by João Coelho at the Neutrino Conference in Milano. It would be by far the highest-energy neutrino event ever seen – with a detector much smaller, and after a much shorter observation time, than IceCube…



Understandably, the collaboration still keeps silence about many details. In a comment titled "*Fantastic neutrino could be the most energetic event ever found*", NATURE writes: "*The neutrino really stands out, very far away from anything else" said Coelho who is at the AstroParticle and Cosmology Laboratory in Paris. He did not disclose the precise direction from which the particle had come, nor when the observation occurred: doing so could have tipped off competitors about the possible origin of the neutrino, researchers at the conference told Nature. Coelho instead promised that these details would be published later on.*

The event comes from 1° above horizon. The light profile is consistent with at least 3 large energy depositions along the muon track – characteristic of stochastic losses from very high energy muons. The space-time distribution of light (see slides 39/40 at https://agenda.infn.it/event/37867/contributions/233917/attachments/121916/178248/JCoelho_202406_Neutrino_KM3NeT.pdf) is consistent with shower hypotheses associated with these energy depositions. As João emphasizes, low scattering is key to observing this richness of detail.

João also presented several nice results from both steadily growing detectors ARCA and ORCA – diffuse flux, point source search, oscillations, to name just three points. His talk also included top views of the actual configurations from both arrays (ARCA and ORCA). Here they are (not to scale!): ARCA (left) – 28 from 230 DUs deployed. ORCA (right) – 23 from 115 DUs deployed. Still much to come!



Collaboration issues: Antoine Kouchner has been elected as Chairperson of the Institute Board of KM3NeT. He will take over from Uli Katz in November.

IceCube

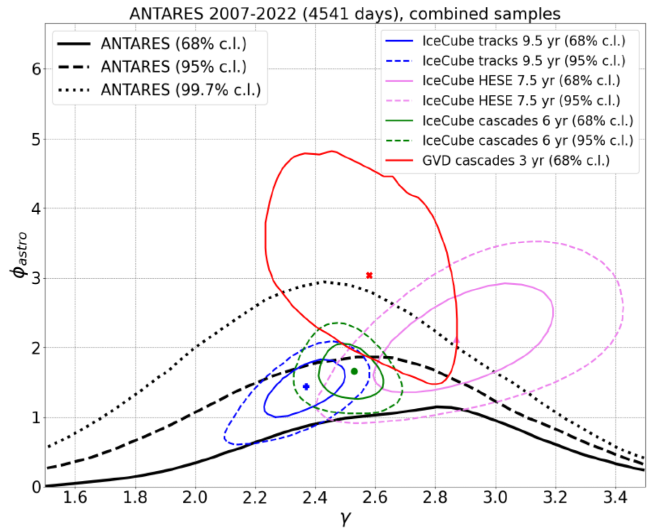
Dan Hooper of Fermilab and University Chicago will become the next WIPAC director. WIPAC (https://wipac.wisc.edu) stands for Wisconsin IceCube Particle Astrophysics Center. He will take over from Jim Madsen at November 1.

Publications

The ANTARES collaboration has submitted a paper *Constraints on the energy spectrum of the diffuse cosmic neutrino flux from the ANTARES neutrino telescope* to JCAP (posted at 2407.00328 (arxiv.org)). The corresponding author is Luigi Fusco (Universitá and INFN Salerno).

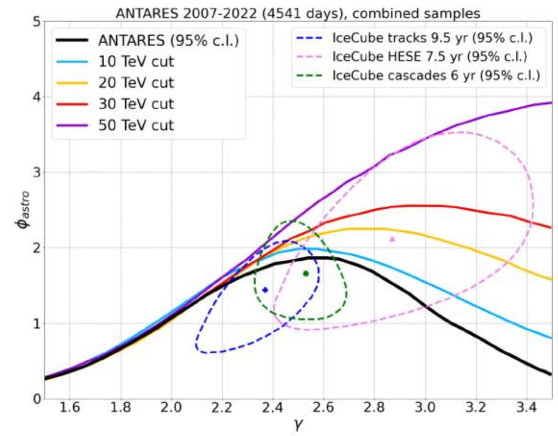
ANTARES took data from 2007 to 2022 and collected a high-purity all-flavor neutrino sample. The purer neutrino selection applied in this paper leads to reduced systematic uncertainties with respect to previous works.

The measured distributions for the selected neutrino events are statistically compatible with the background assumptions. This result is converted into limits on the properties of the cosmic neutrino spectrum – see the next figure.



Constraints on normalized flux ϕ_{astro} and spectral index γ. (normalization: 10^{-18} (GeV cm² s sr)$^{-1}$ at E_0 =100 TeV). Contours at 68% (solid) and 95% (dashed) confidence level from IceCube analyses (HESE in pink, tracks in blue, cascades in green) compared to the 68% (solid), 95% (dashed), and 99.7% (dotted) posterior probability credible areas obtained in the combined analysis of the three ANTARES samples (black lines). The IceCube best-fit points are shown with symbols. The Baikal-GVD 68% confidence level contour and best-fit point are shown in red.

Taking advantage of the larger neutrino detection efficiency of ANTARES below 50 TeV, the hypothesis of a low-energy spectral break in the single power-law energy spectrum assumption has been investigated. Soft-spectra fits of the IceCube flux extending below 10 TeV are excluded with a 99.7% Bayesian posterior probability. Such soft-spectra solutions become admissible at a 95% posterior probability only if a hard low-threshold cut-off is present at least somewhere in the 10 – 30 TeV region. The next figure shows the constraints for the broken spectra hypothesis (see the paper for details)



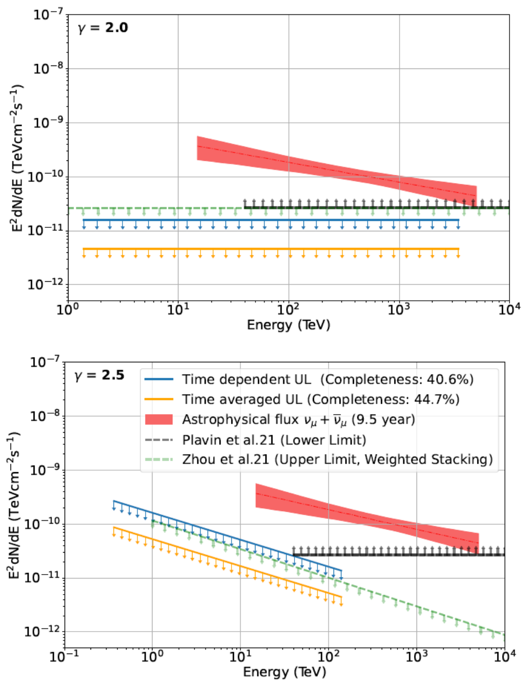
The 95% posterior probability credible areas obtained from the ANTARES fit assuming the single unbroken power-law hypothesis (black) and adding a low-energy cut in the spectrum from 10 to 50 TeV (colored lines as in the legend) are compared to the 95% confidence limit contours from the IceCube HESE (pink), tracks (blue) and cascades (green) samples, shown as dashed lines together with their respective best-fit point.

This result is in agreement with the fact that, assuming a power-law extrapolation of soft-spectra fits like the one obtained in the IceCube HESE analysis, the resulting gamma-ray flux from the same hadronic interactions would overshoot the observed extra-galactic gamma-ray background.

The ANTARES data taking ended in 2022. The next step will be the combination of the first KM3NeT/ ARCA data with the 15 years of ANTARES.

The IceCube Collaboration has posted a paper *Probing the connection between IceCube neutrinos and MOJAVE AGN* at 2407.01351 (arxiv.org) (submitted to ApJ). The analysis was performed by Abhishek Desai and Justin Vandenbroucke (U. Madison).

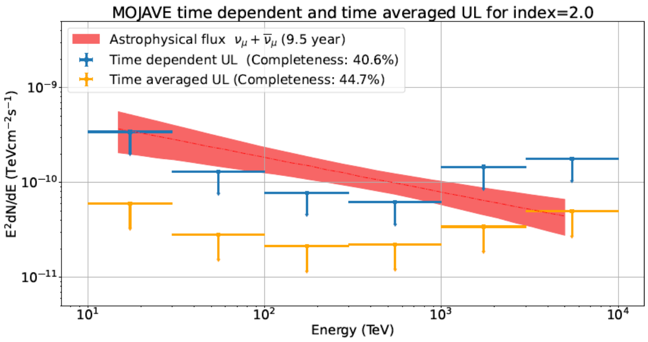
MOJAVE stands for **(M**onitoring **O**f **J**ets in **A**ctive galactic nuclei with **V**LBA **E**xperiments**).** This is a long-term program to monitor radio brightness and polarization variations in jets associated with active galaxies visible in the northern sky. Active Galactic Nuclei, on the other hand, are prime candidate sources of high-energy, astrophysical neutrinos. This is demonstrated by the real-time multi-messenger detection of the blazar TXS 0506+056 and the recent evidence of neutrino emission from NGC 1068. However, the production mechanism of the astrophysical neutrinos in AGN is not well established. It might be resolved via correlation studies with photon observations. For neutrinos produced due to photohadronic interactions in AGN, in addition to a correlation of neutrinos with high-energy photons, there would also be a correlation of neutrinos with photons emitted at radio wavelengths. In this work, an in-depth stacking study of the correlation between 15 GHz radio observations of AGN reported in the MOJAVE XV catalog, and ten years of neutrino data from IceCube is performed. The authors also use a time-dependent approach which improves the statistical power of the stacking analysis. No significant correlation was found for both analyses and upper limits are reported. When compared to the IceCube diffuse flux, at 100 TeV and for a spectral index of 2.5, the upper limits derived are ~ 3% and ~ 9% for the time-averaged and time-dependent case, respectively, see the next figure.



Upper Limits per neutrino (ν + anti-ν) flavor for spectral indices of 2.0 and 2.5, derived from a time-dependent (blue) and time-averaged (orange solid line) analysis, shown along with the lower limits (grey-dashed line) reported by Plavin et al. (2021). Note that samples and methodology used by Plavin et al. and Zhou et al. (2021) (green dashed line) and this work are different, making a 1:1 comparison difficult. The diffuse astrophysical muon neutrino flux measurements are taken from Abbasi et al. (2022). The energy range of the upper limits shown for the time-averaged analyses reflects the region where 90% of detected signal neutrinos would fall. The energy range for the time-dependent scenario is kept similar to the time-averaged case.

Note the discrepancy between the results of Plavin et al. (lower limit!) and the other results (upper limits)! However, samples and methodology used by Plavin et al. and Zhou et al. and the present work are different, making a 1:1 comparison difficult. The lines are just shown to highlight the differences in the results.

The next figure compares the differential Upper Limits derived from the time-dependent and time-averaged analyses.



Differential Upper Limits, for an index of 2.0, derived from the time-dependent (blue) and time-averaged (orange) analyses in half-decade energy bins. The diffuse astro-physical muon neutrino flux measurements are taken from Abbasi et al. (2022). Note that the upper limits shown here are differential and binned with energy, while the astro-physical flux is an energy-integrated measurement shown here only for reference.

Impressum
GNN Monthly is the Monthly Newsletter of the Global Neutrino Network
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