

KM3NeT/ARCA status and results

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on behalf of the

KM3NeT Collaboration

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IceCube Particle Astrophysics Symposium - 2026

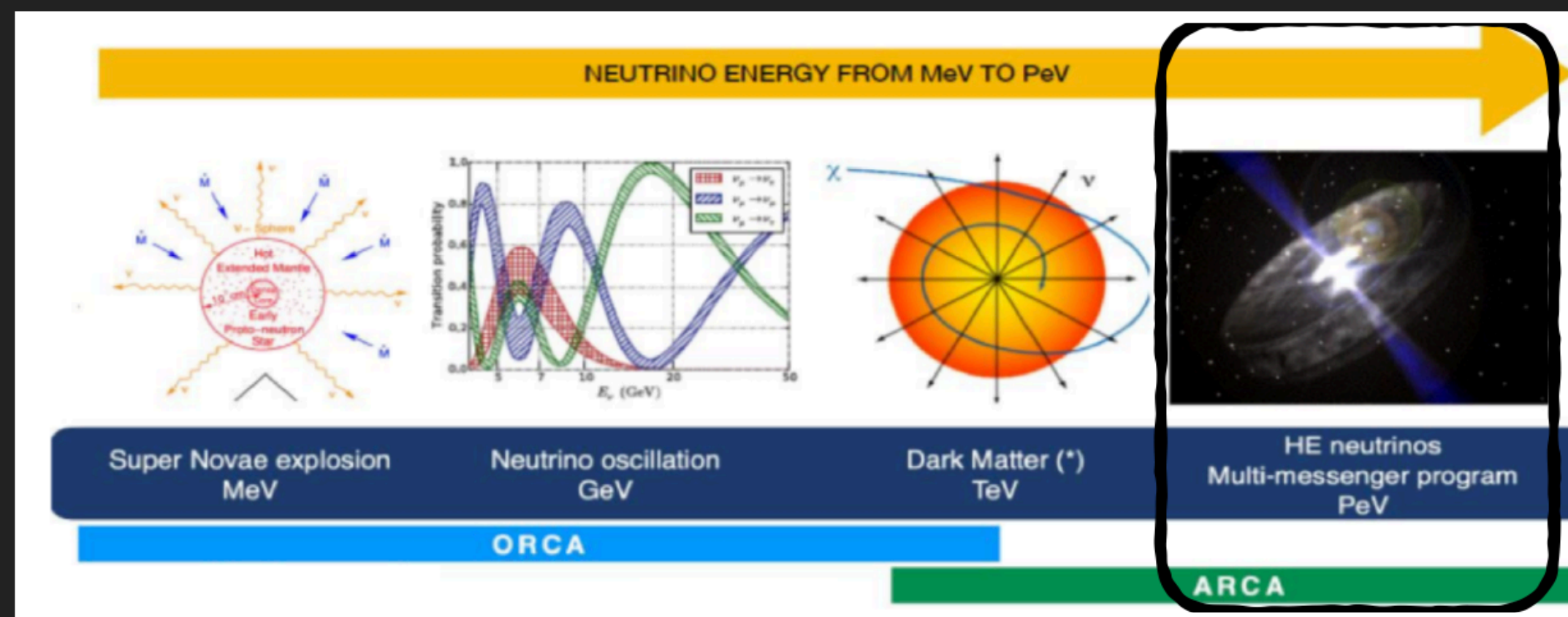
KM3NeT (Cubic Kilometer Neutrino Telescope) is a Cherenkov neutrino detector currently under-construction in the deep Mediterranean sea

Two different sites:

Detectors under-construction, but already in data taking

- KM3NeT/ARCA (*Astroparticle Research with Cosmics in the Abyss*): the telescope is designed to detect high-energy (up to PeVs) neutrino originated by astrophysical sources. Detector installed at a depth of 3500m offshore Capo Passero (Sicily-Italy).
- KM3NeT/ORCA (*Oscillation Research with Cosmics in the Abyss*): the detector is designed for low-energies studies (neutrino oscillations, mass hierarchy, etc..). Detector installed at a depth of 2500m offshore Toulon (France)

Neutrino energy range:



→ **ORCA main goal:** neutrino oscillation (1-100 GeV)

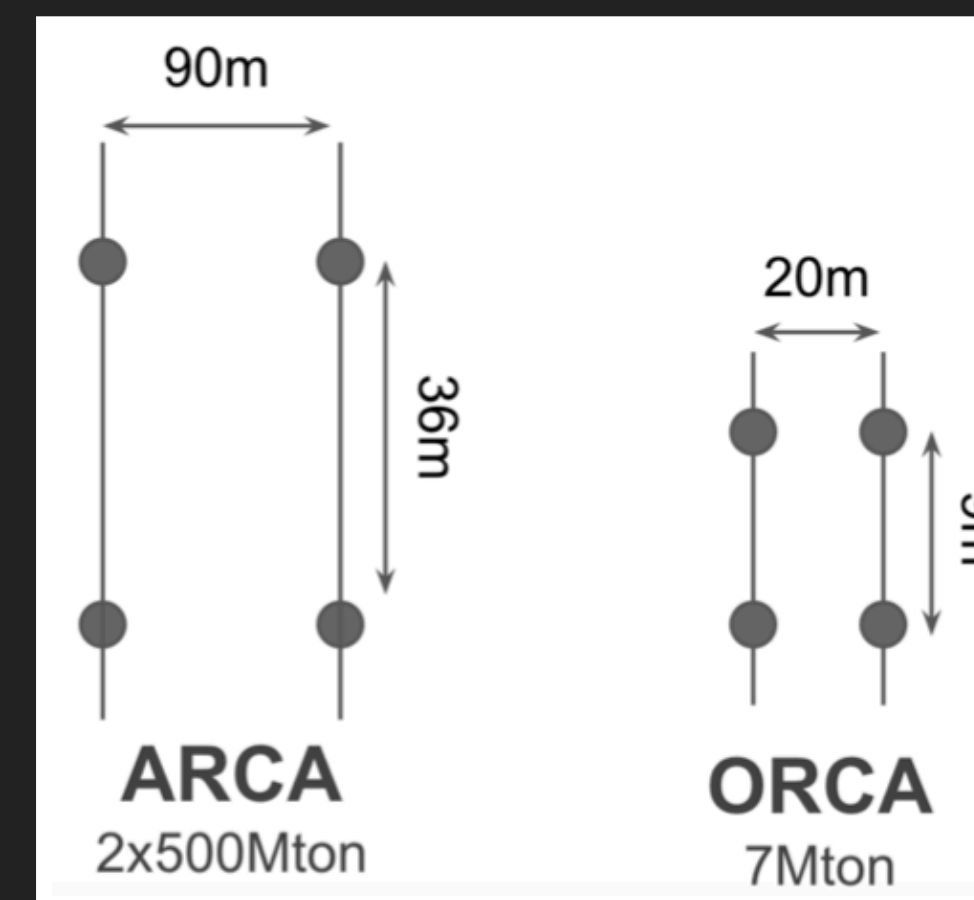
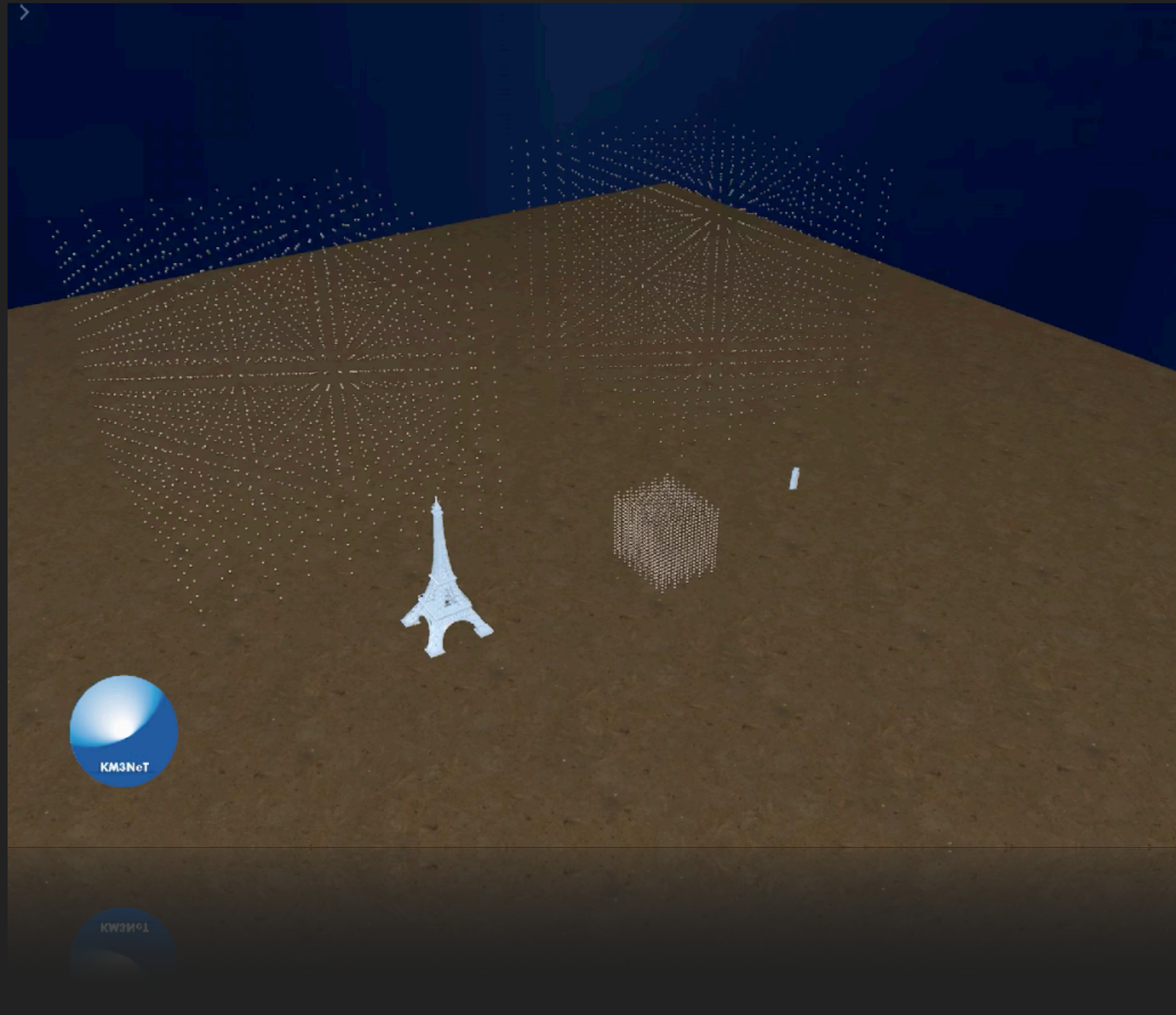
→ **ARCA main goal:** cosmic high-energy neutrino (TeV-PeV)

ORCA

- Depth at 2500m
- Final configuration: one block of about 100 Detection Units

ARCA

- Depth at 3500m
- Final configuration: two blocks of about 115 Detection Units each
- Final volume: 1km^3



Different DOM vertical spacing, horizontal difference and detector size

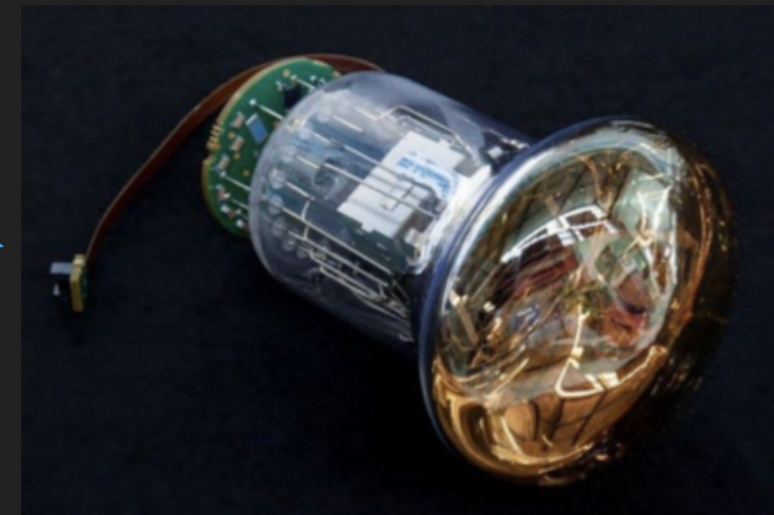
Both detectors share the same technologies, but different dimensions

KM3NeT EXPERIMENT

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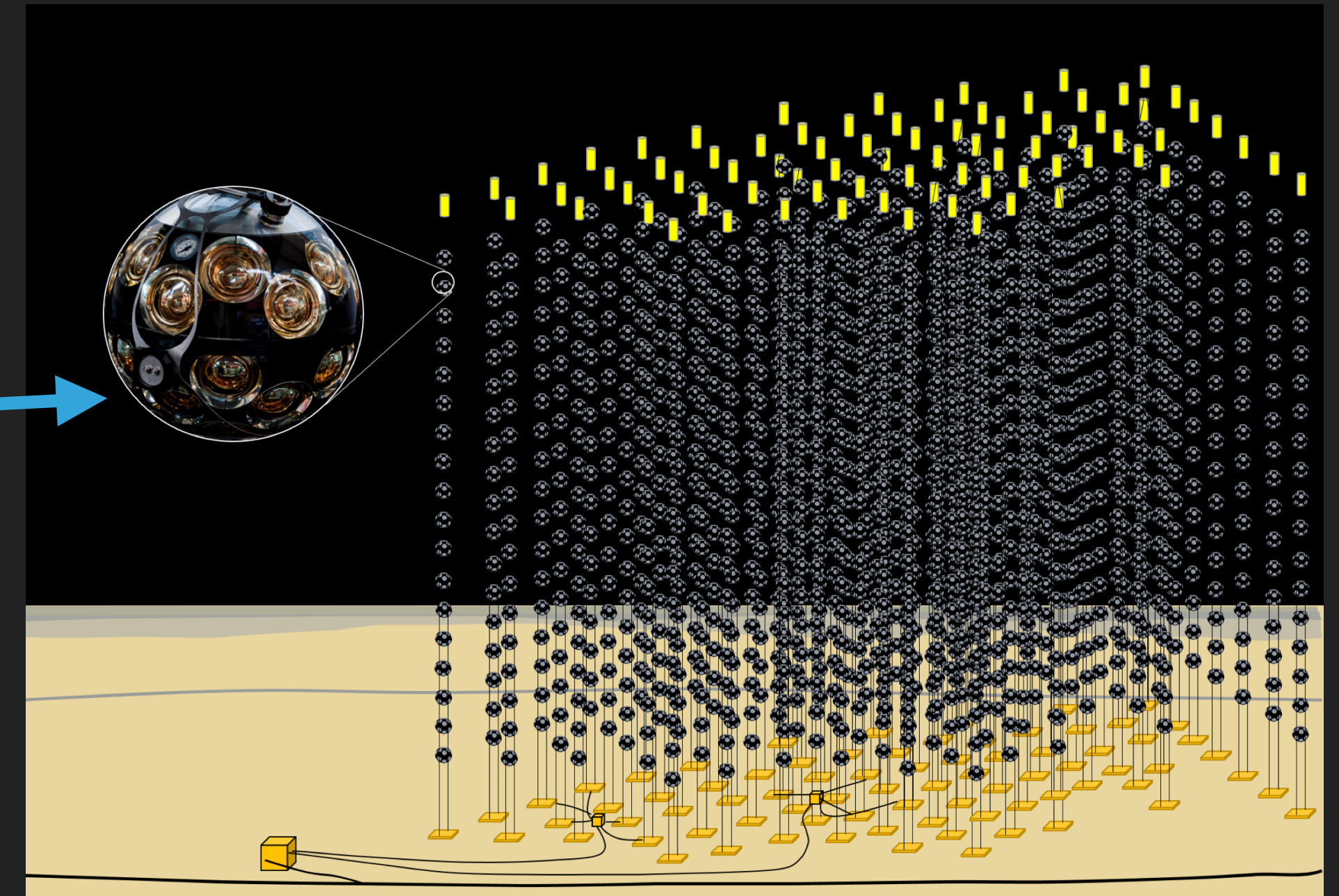


Digital optical module (DOM)



Photomultiplier (PMT)

The DOMs are designed in order to detect the Cherenkov light produced by the secondary particles originated by neutrino interactions close the detector instrumented volume.



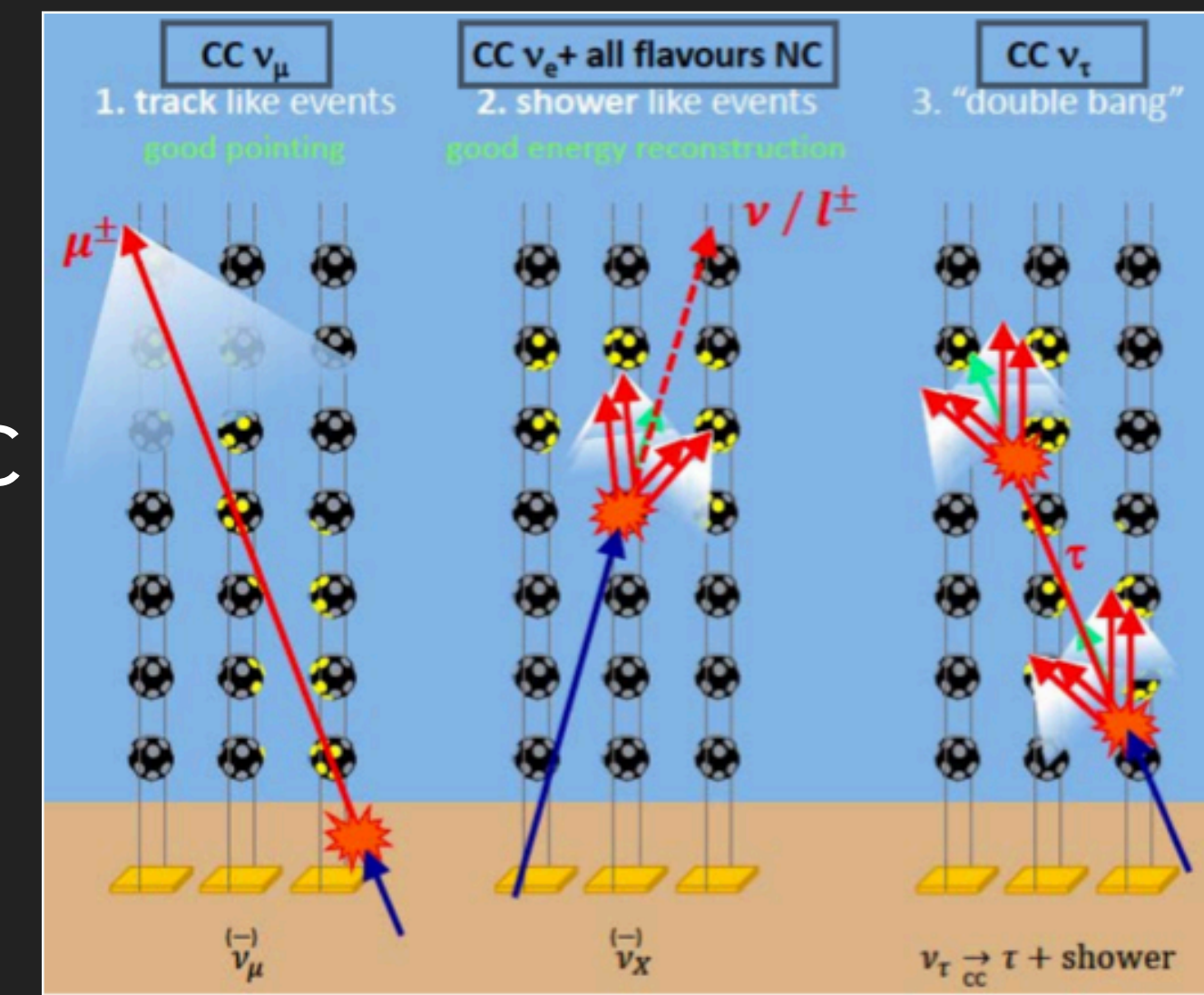
The detectors consist in three-dimensional array of detection units (DUs).

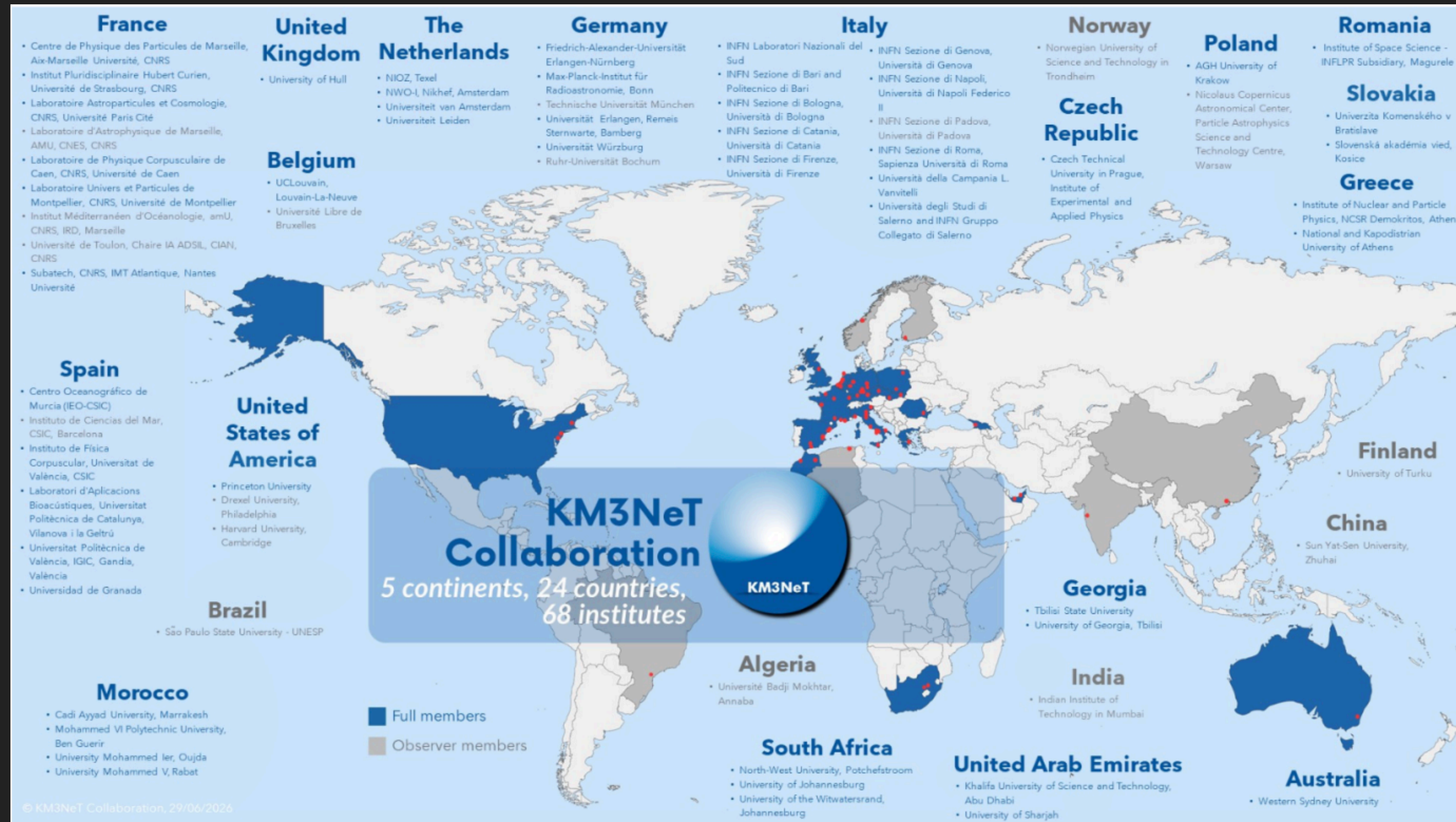
A DOM is a pressure resistant glass sphere containing 31 photomultipliers, covering 4π steradian.

Description: "<https://doi.org/10.48550/arXiv.2203.10048>"

Event topology:

- Track-like events: $\nu_\mu/\bar{\nu}_\mu$ CC
- Shower-like events: $\nu_e/\bar{\nu}_e$ CC, ν_x NC
- Double-bang events: ν_τ CC

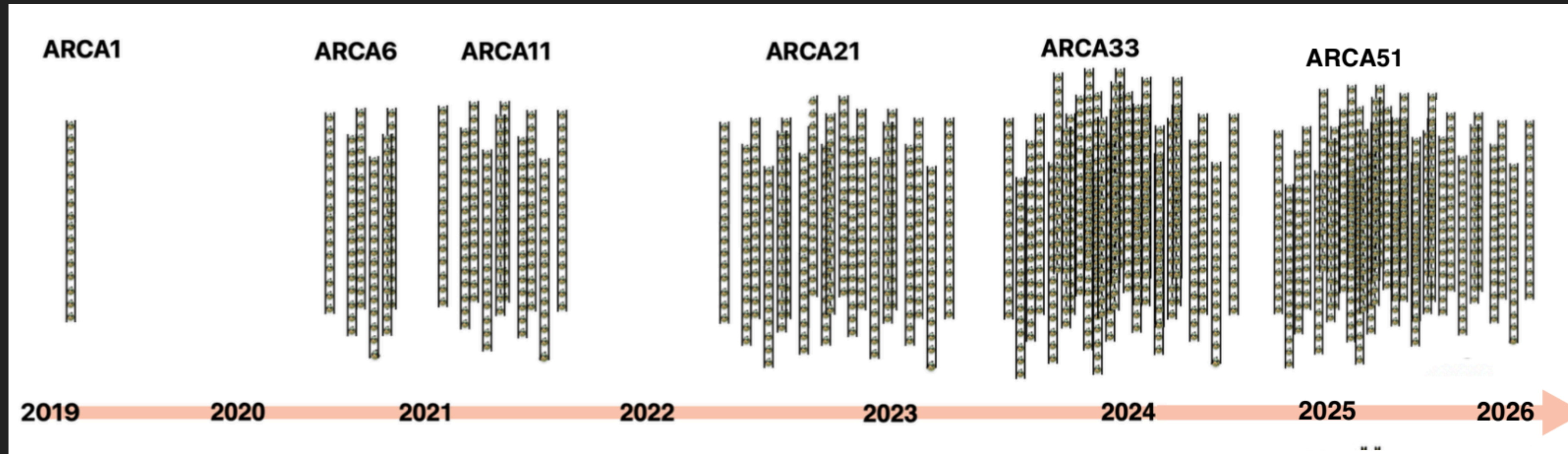




68 institutes across 24 countries and five continents, one collaboration building and operating ARCA and ORCA.

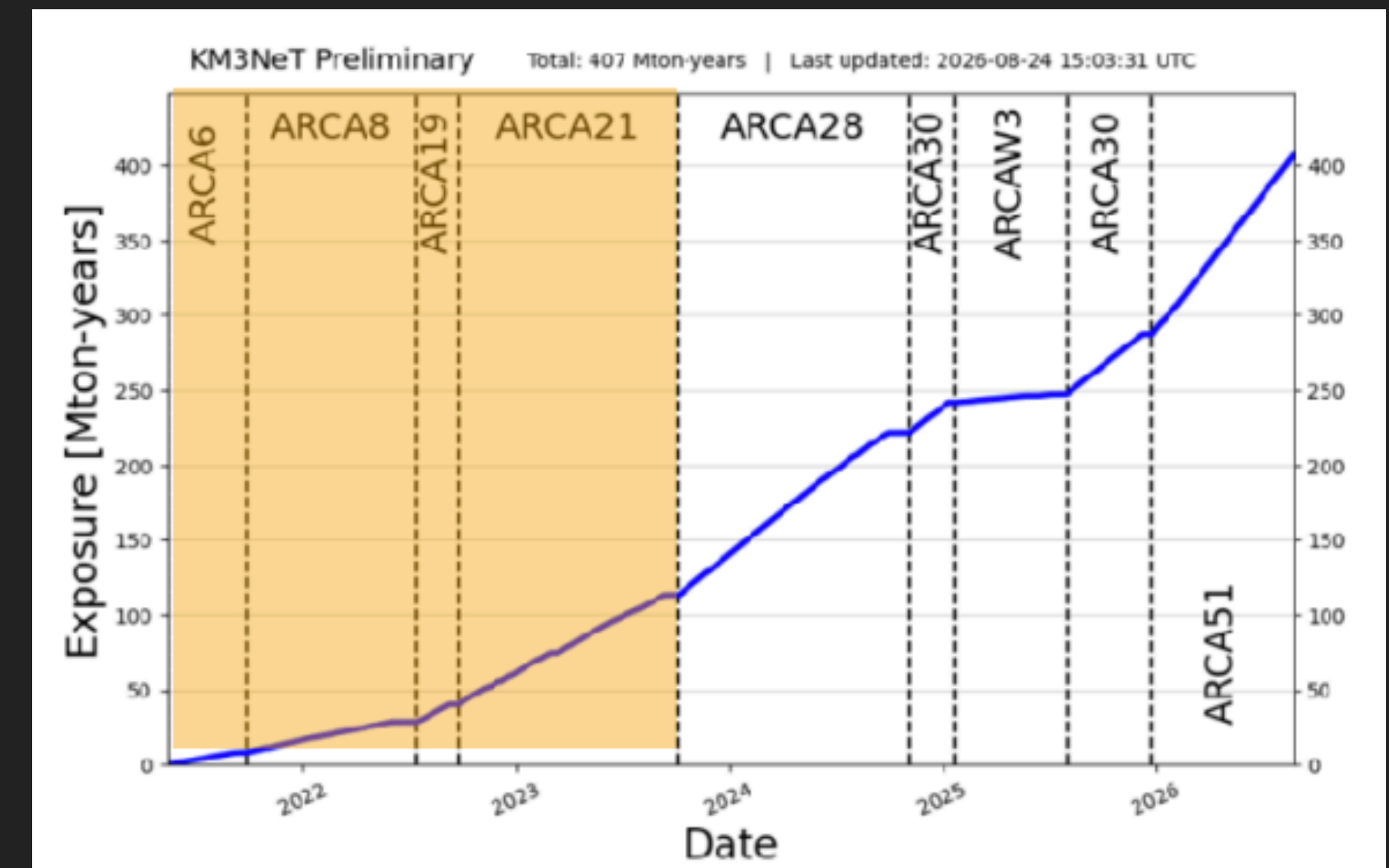
KM3NeT EXPERIMENT: ARCA status

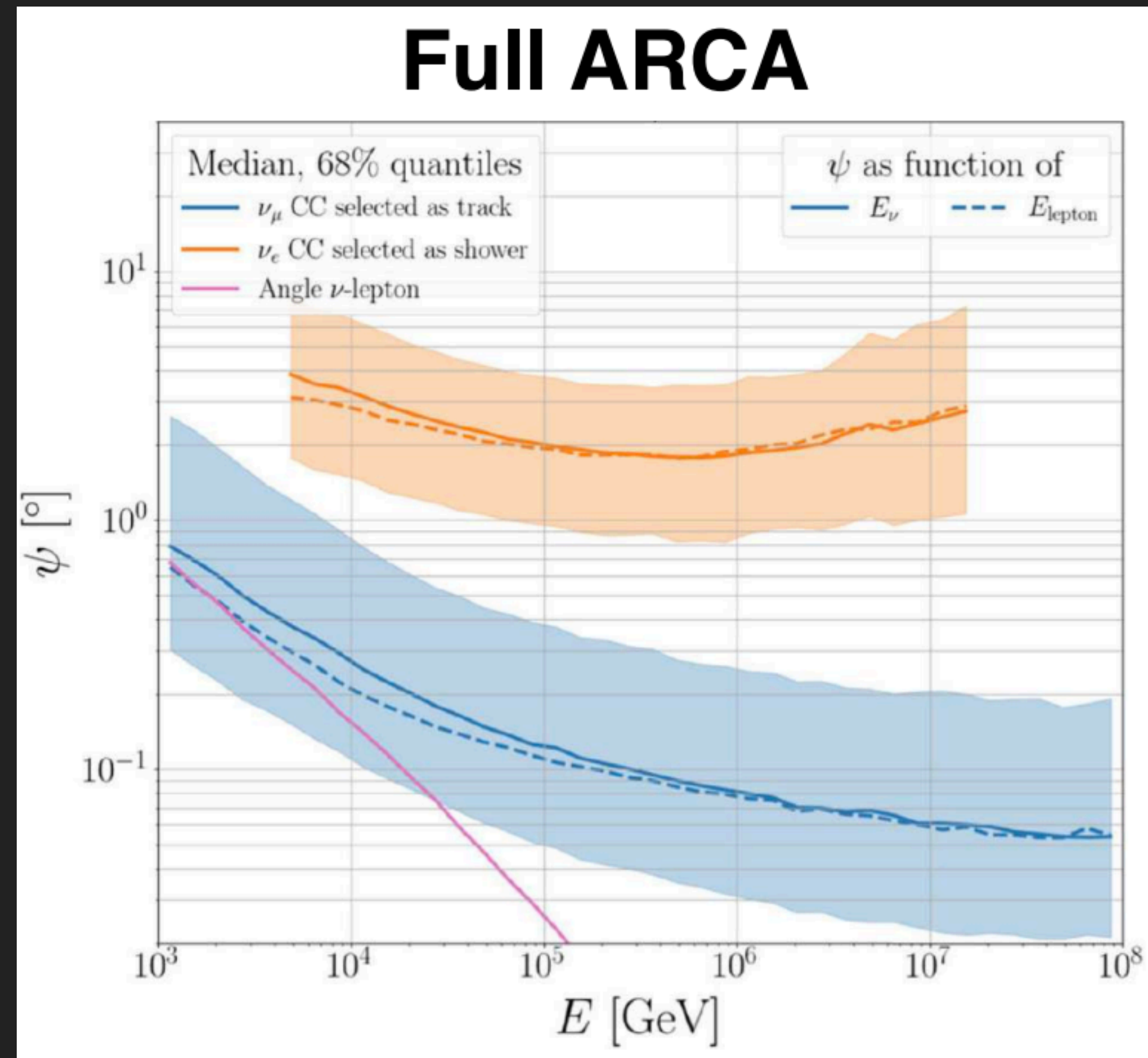
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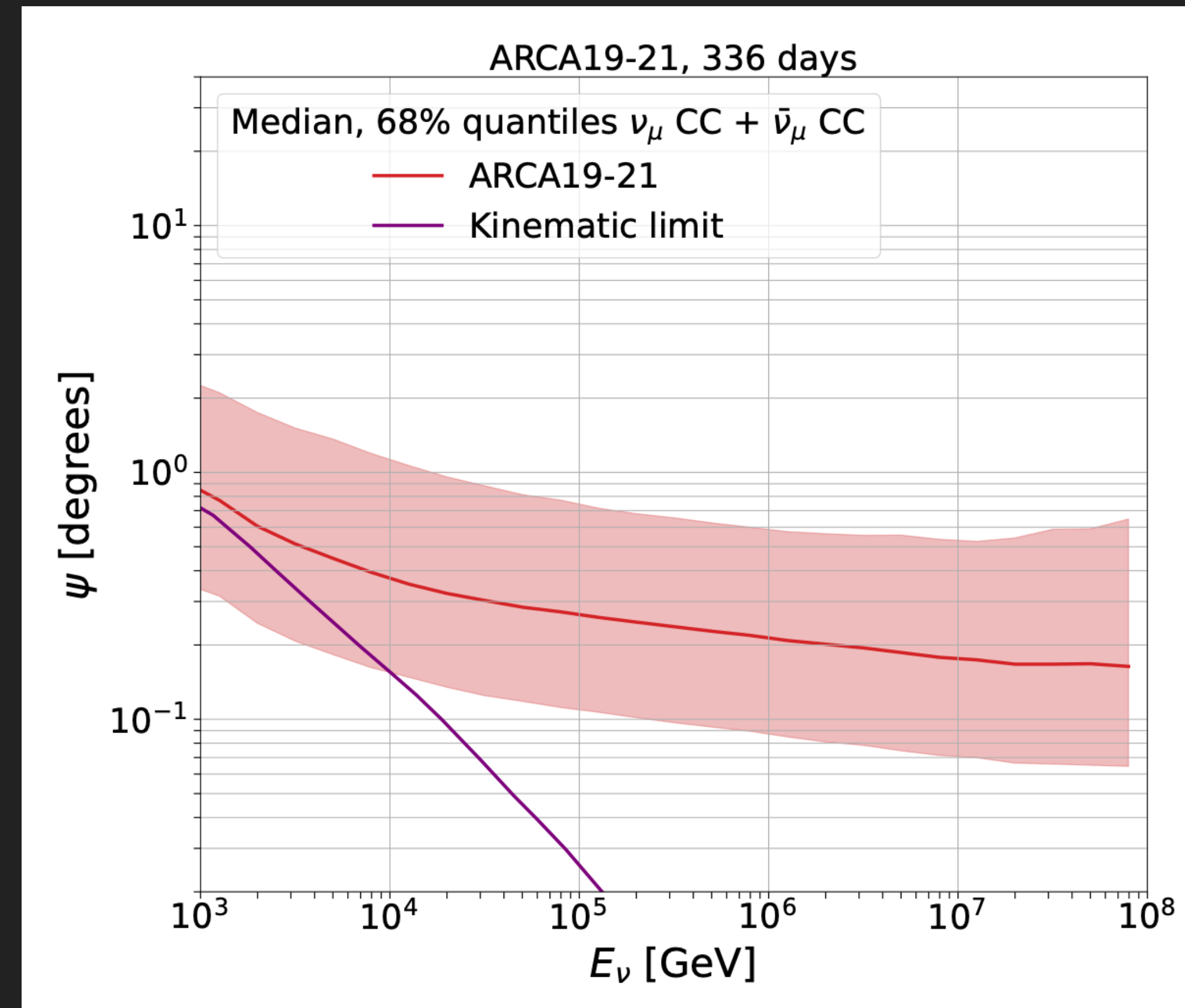
KM3NeT/ARCA: detector growth and exposure:

- Continuous data taking throughout detector construction.
- Increasing instrumented volume and accumulated exposure.
- The astronomy results presented here use data collected up to September 2023, with configurations up to ARCA21.
- Analyses with later detector configurations are in progress.
- From last sea campaign: **KM3NeT/ARCA62**





Reference: Aiello et al. [KM3NeT], EPJC 84 (2024) 885



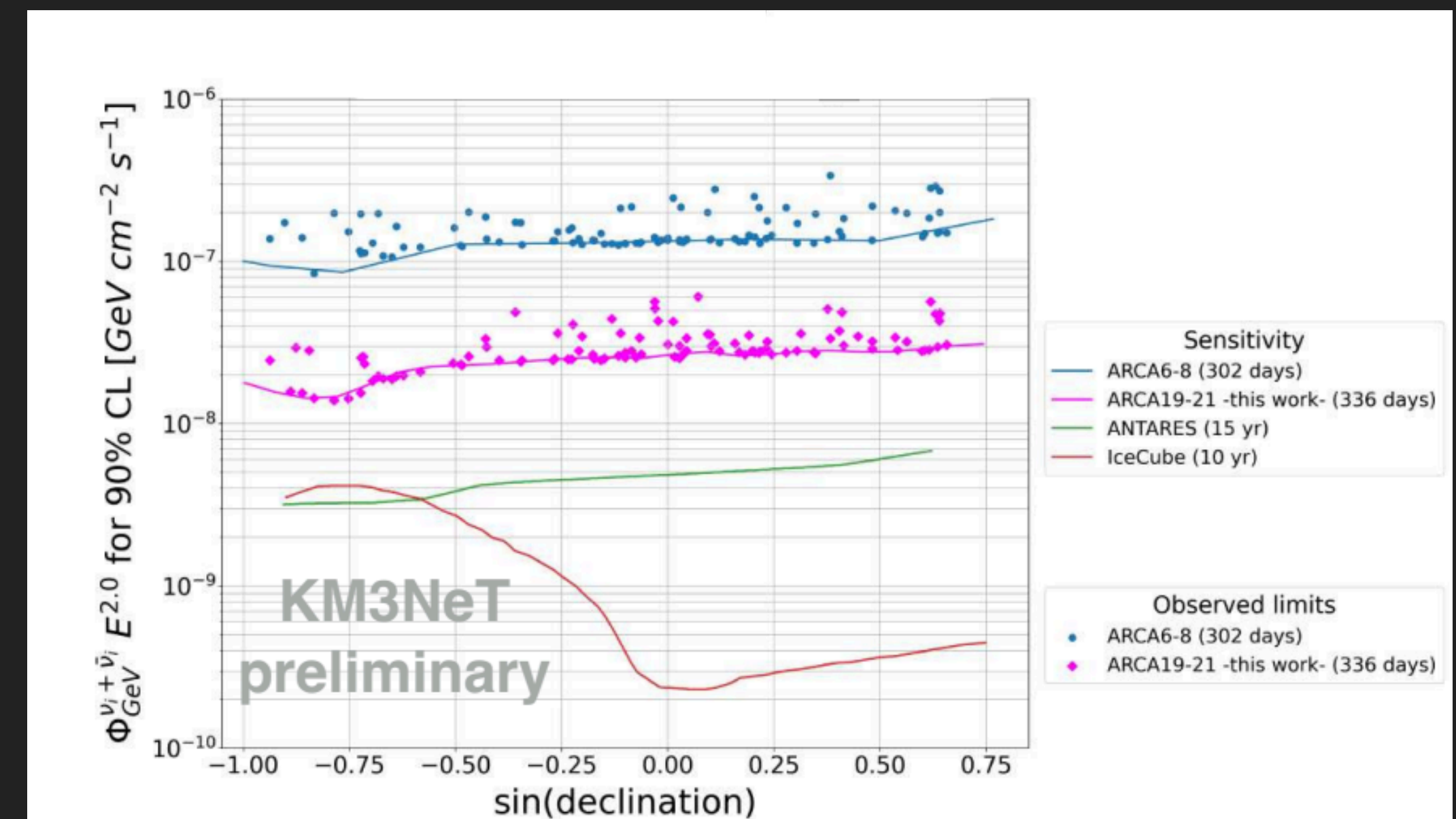
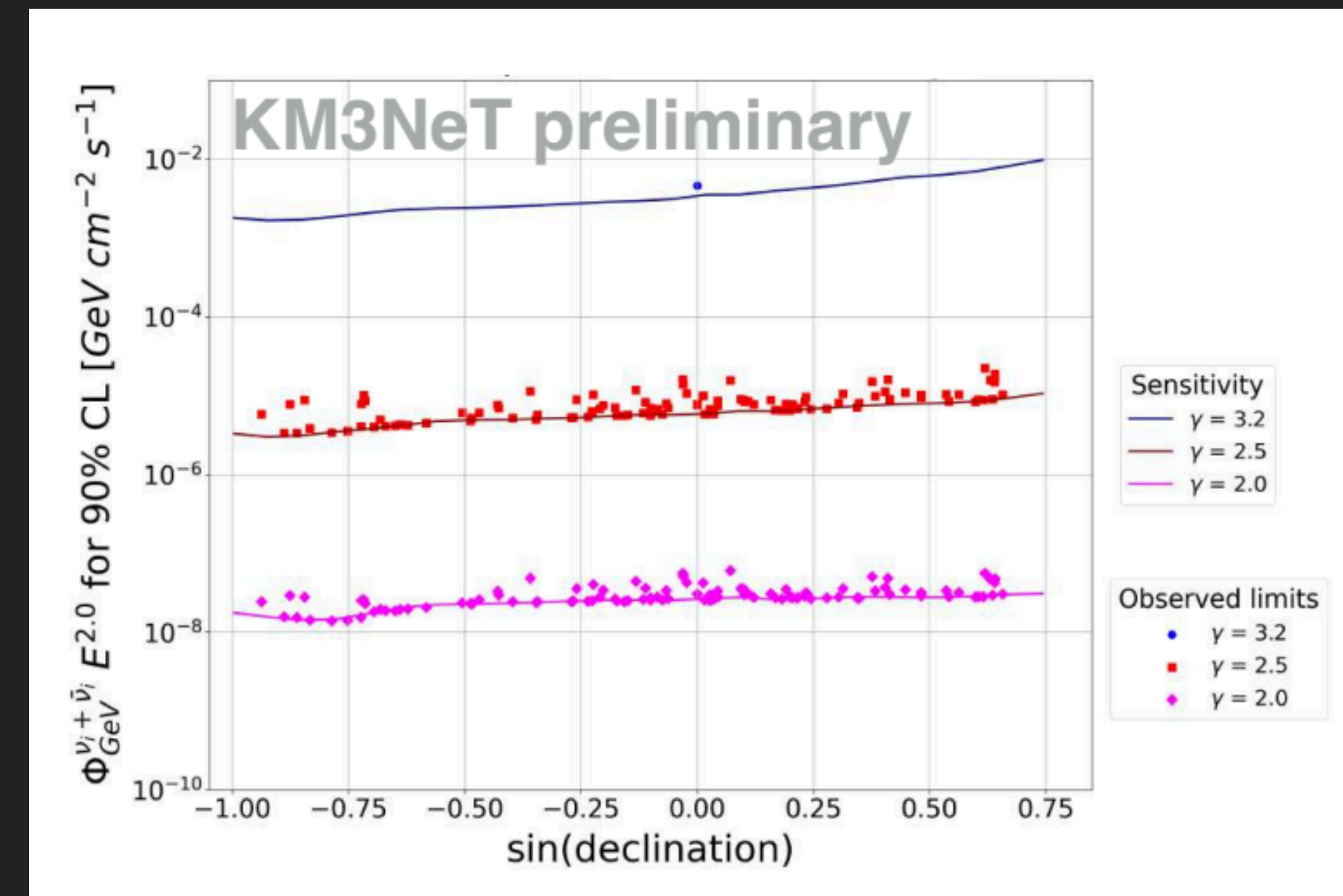
Reference: <https://doi.org/10.48550/arXiv.2609.03609>

- Track events provide sub-degree angular resolution for neutrino astronomy.
- For ARCA19-21, the median angular resolution reaches approximately 0.2° at PeV energies.
- Simulations of the full detector predict a track angular resolution below 0.1° at PeV energies.

Point-source searches: candidate catalog

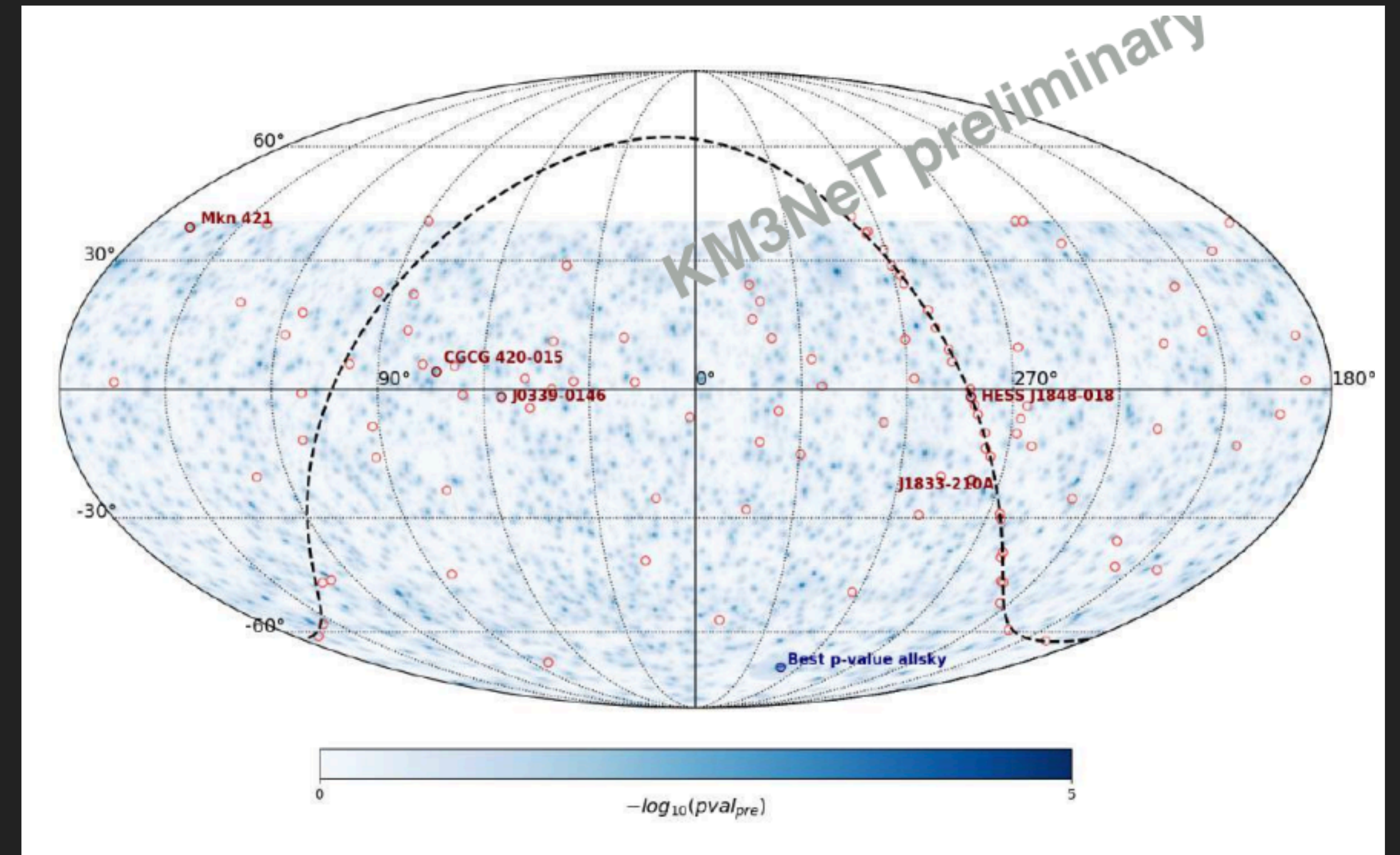
- ARCA19-21 **upgoing tracks sample**, with 336 days of livetime.
- Search for neutrino emission from 106 candidate sources.
- **Binned likelihood** using reconstructed energy and angular distance, with a background estimate derived from data (without KM3-230213A event)
- Signal spectra: E^{-2} and $E^{-2.5}$, with an additional $E^{-3.2}$ hypothesis for NGC 1068.

Lowest pre-trial p-value: 5.0×10^{-3} for CGCG 420–015 under the E^{-2} hypothesis.



Point-source searches: sky scan

- Search for localized neutrino excesses without selecting sources in advance.
- ARCA19-21 upgoing tracks, scanning declinations below $+40^\circ$.
- Approximately 2.6 million sky positions tested under an E^{-2} signal hypothesis.
- Most significant location: $RA = 310.8^\circ$, $Dec = -71.3^\circ$, with a pre-trial p-value of 4.1×10^{-5} .

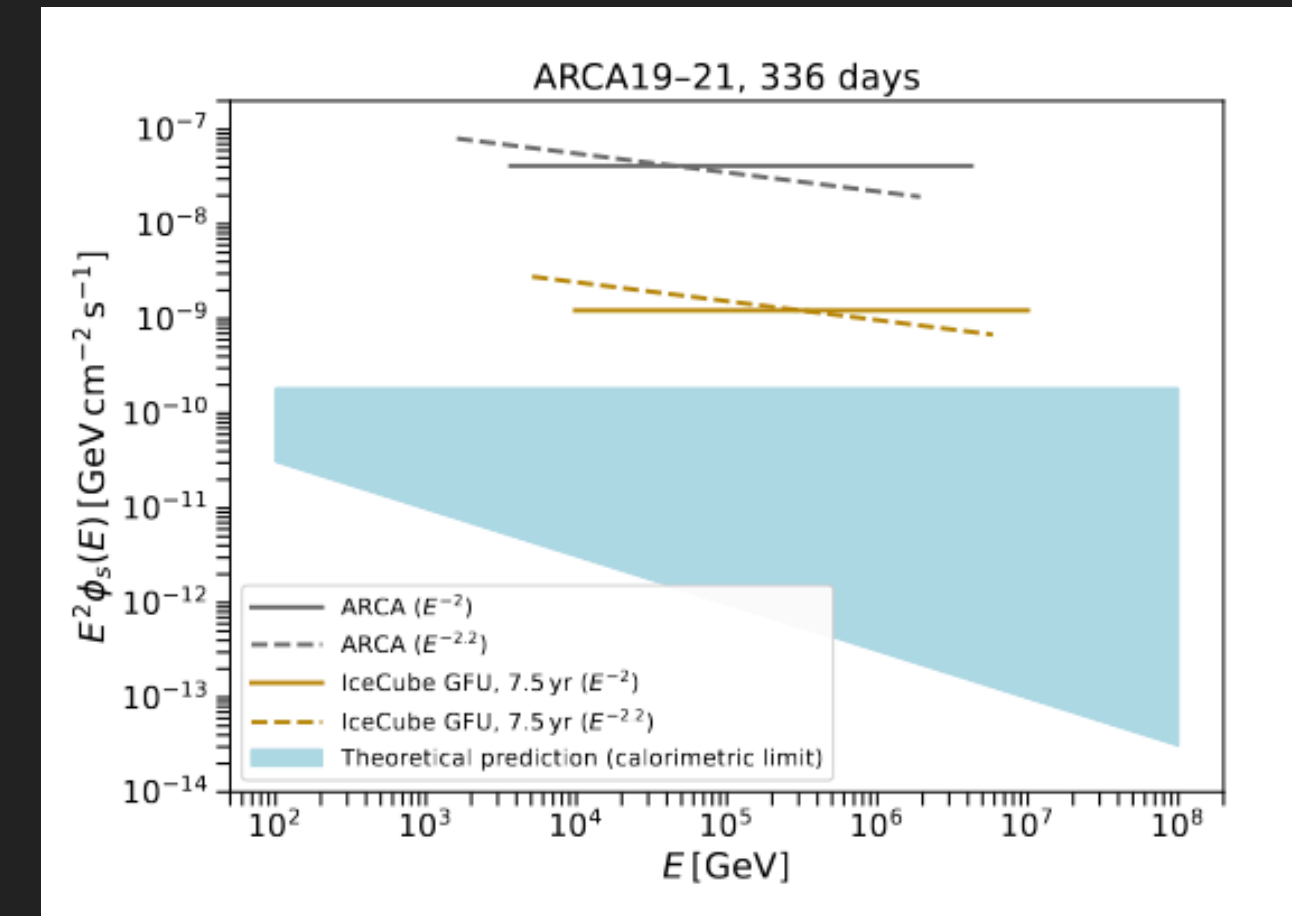


Stacking searches for source populations

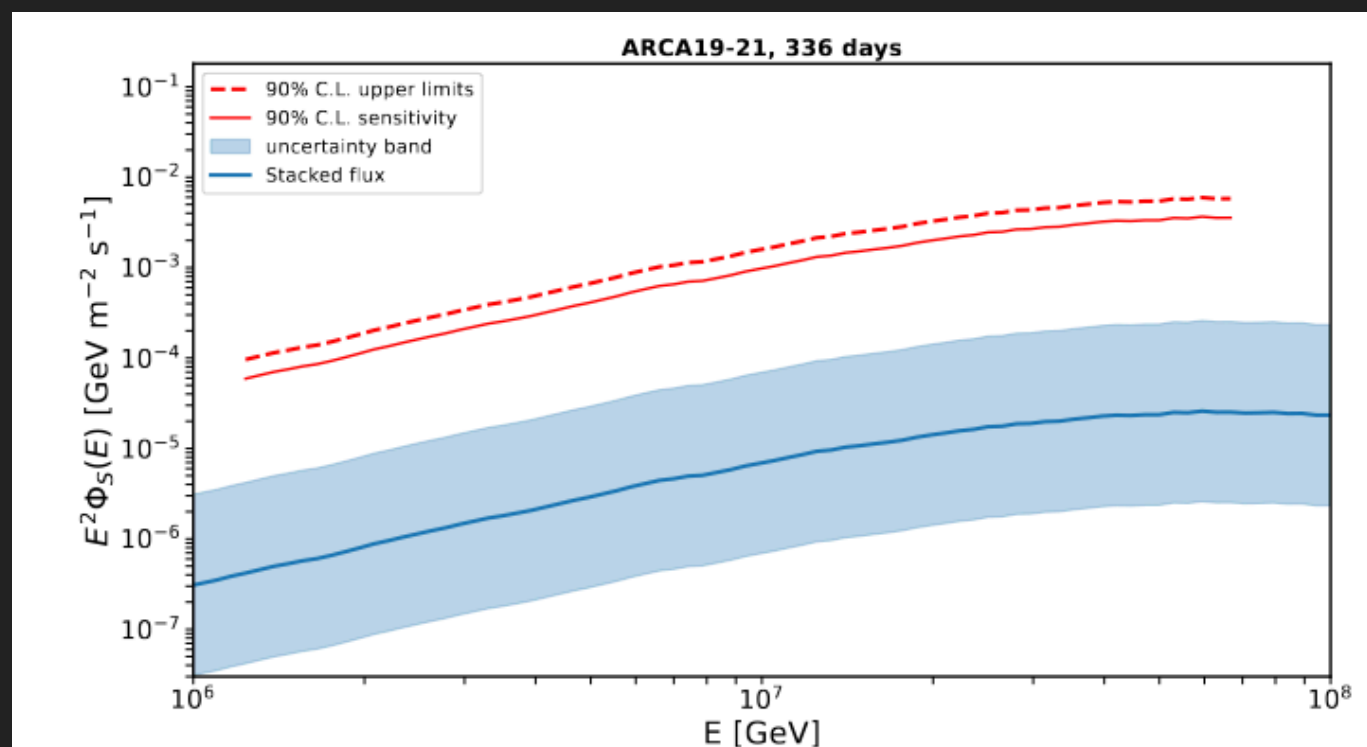
- Combining candidate sources increases sensitivity to populations whose individual members may be too faint to detect.
- ARCA19-21 upgoing tracks, with 336 days of livetime.
- Three populations tested: 75 ultra-luminous infrared galaxies, 232 HBLs and 88 EHBLS.
- ULIRG searches test power-law spectra. Blazar searches use neutrino spectra from lepto-hadronic models.

No significant excess. For EHBLS, the sensitivity is approaching the predicted stacked flux.

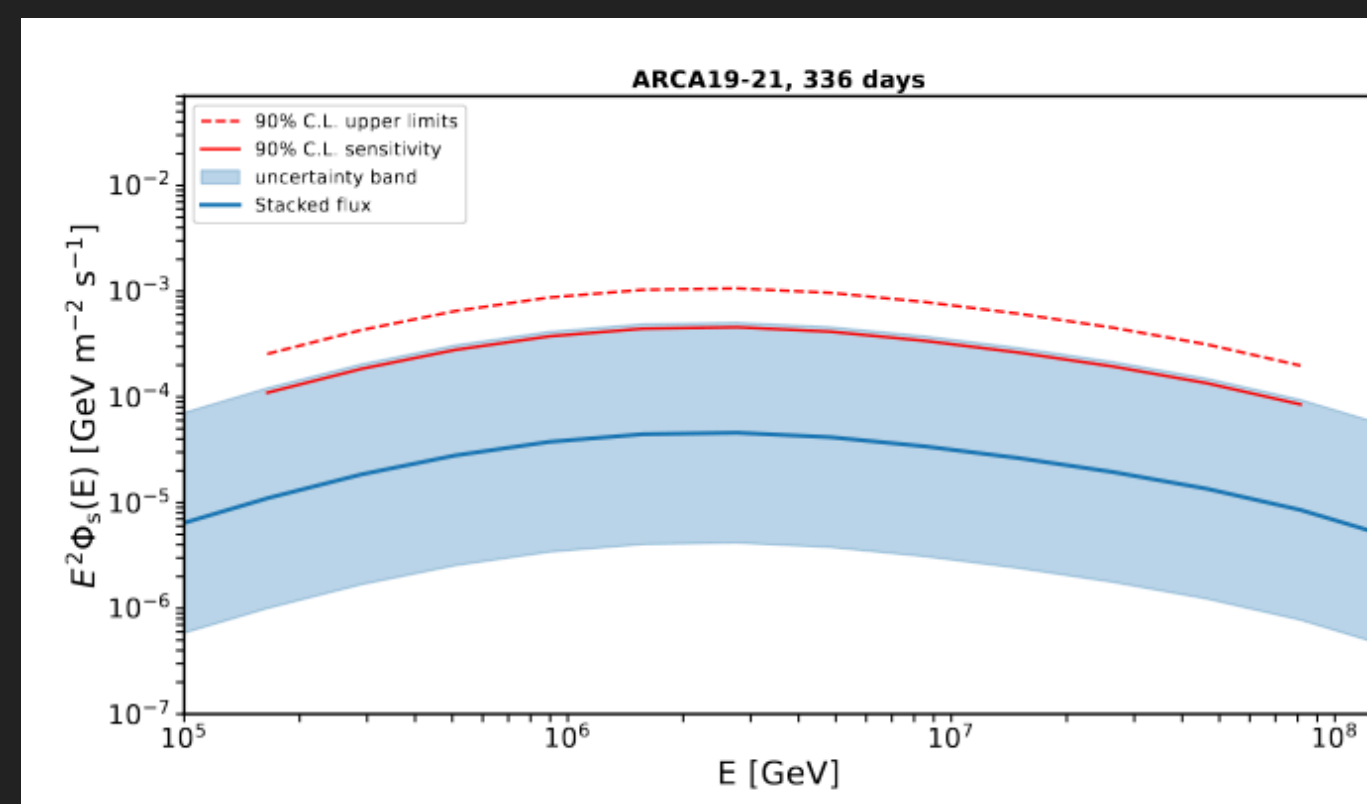
ULIGRs:



HBLs:



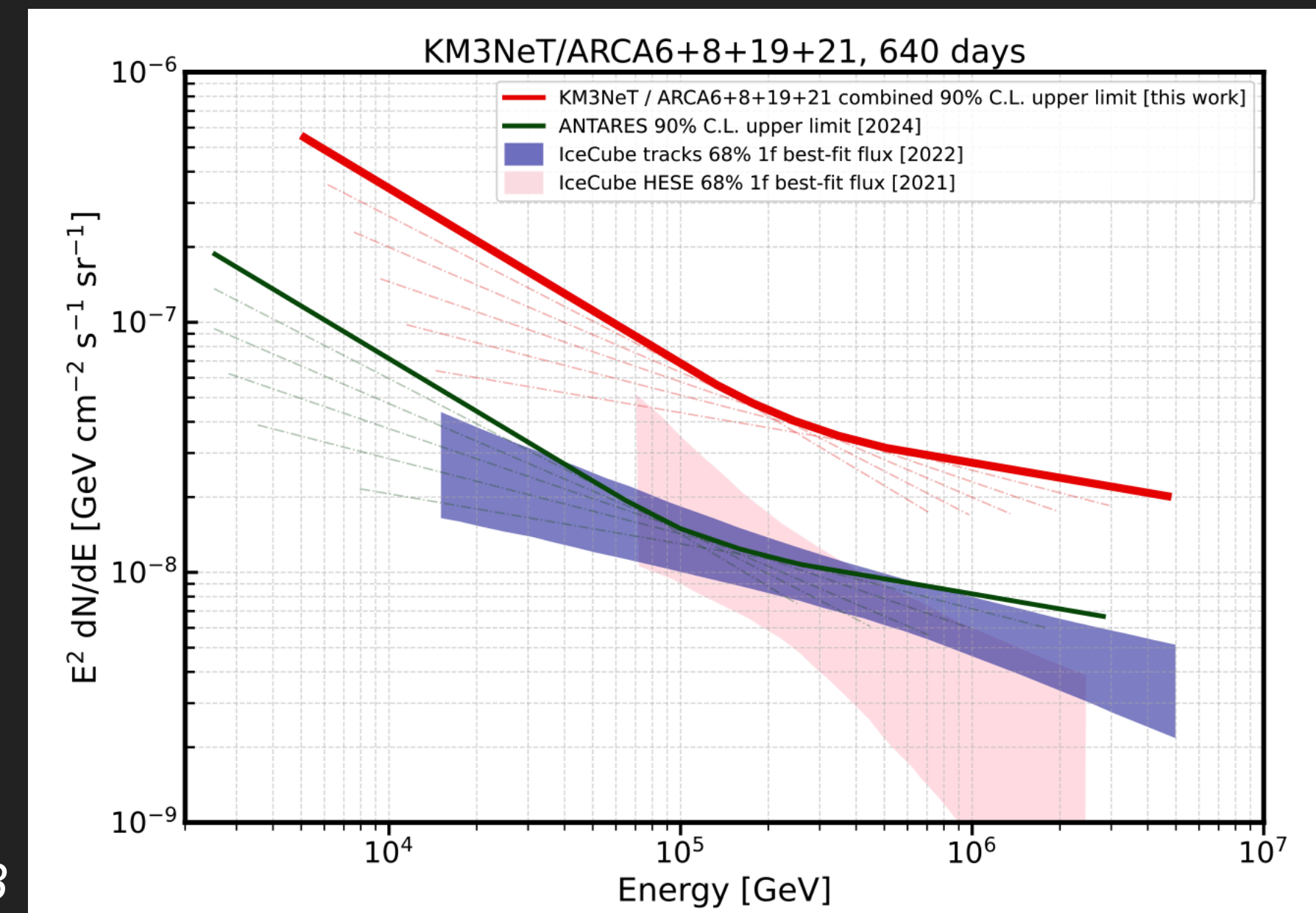
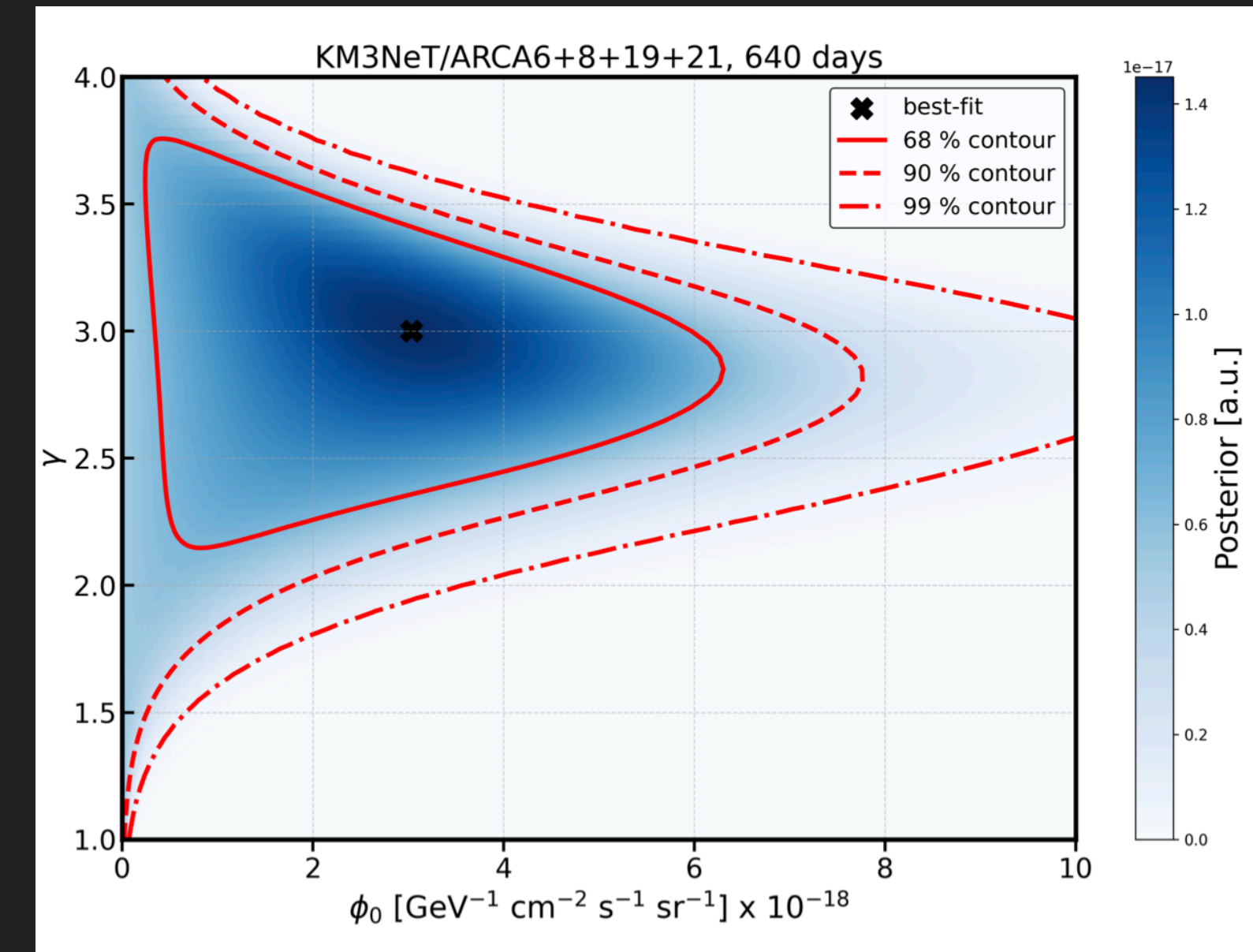
EHBLS:



Search for a diffuse astrophysical neutrino flux

- ARCA6-8-19-21 data, with 640 days of livetime.
- Upgoing tracks with an additional BDT selection to suppress atmospheric muons.
- Neutrino purity reaches approximately **97%** in the ARCA19-21 sample.
- Energy and BDT cuts optimized using the Model Rejection Factor.
- Atmospheric background estimated from simulations, including systematic uncertainties.

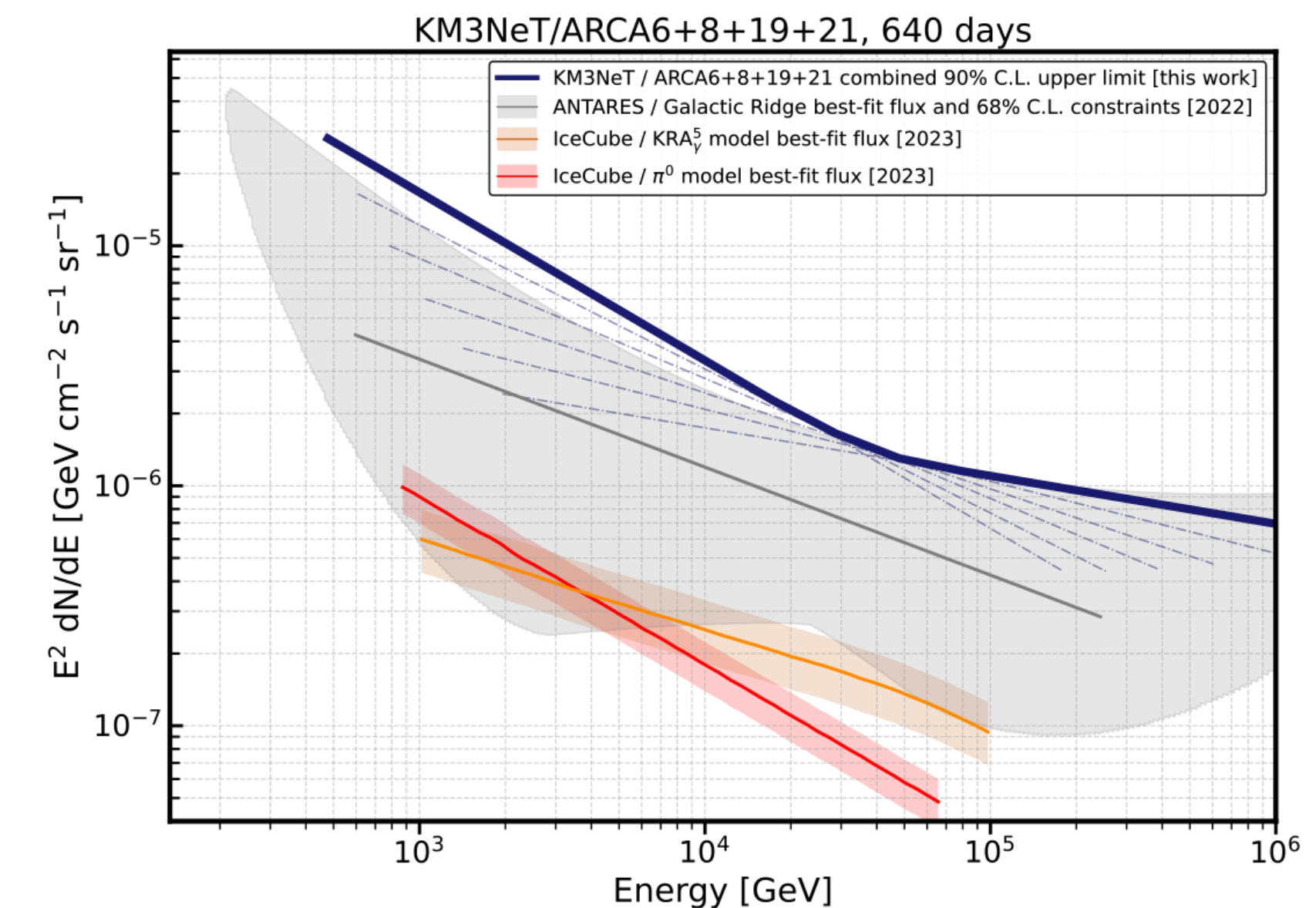
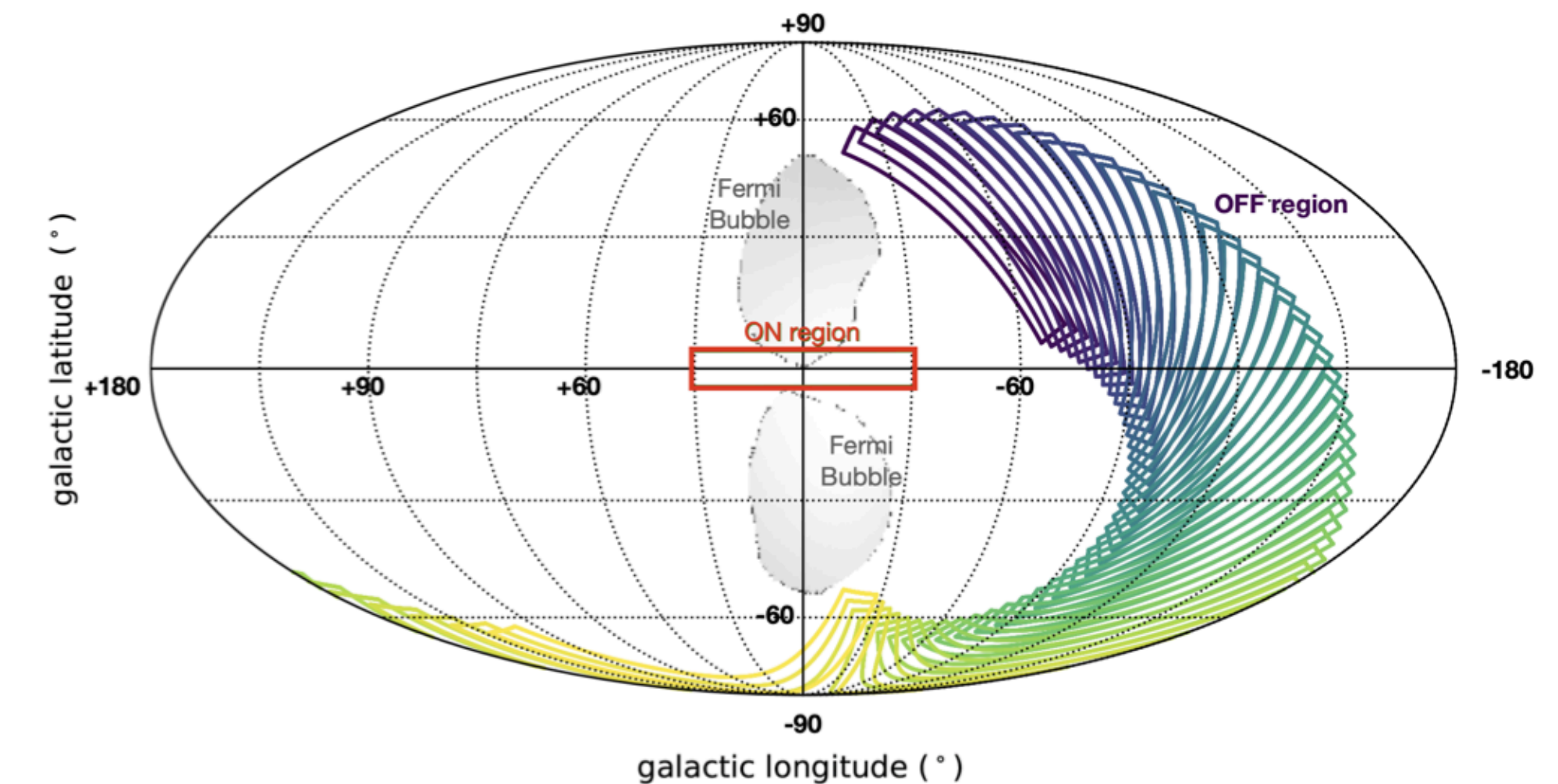
No statistically significant excess above the atmospheric background. Upper limits reported.



Search for neutrino emission from the Galactic Ridge

- Target region: $||l| < 30^\circ$ and $|b| < 2^\circ$, where cosmic-ray spectral hardening has been reported.
- ARCA6-8-19-21 upgoing tracks, with 640 days of livetime.
- ON/OFF analysis using control regions to estimate the background directly from data.
- BDT selection reduces atmospheric-muon contamination below 5%.

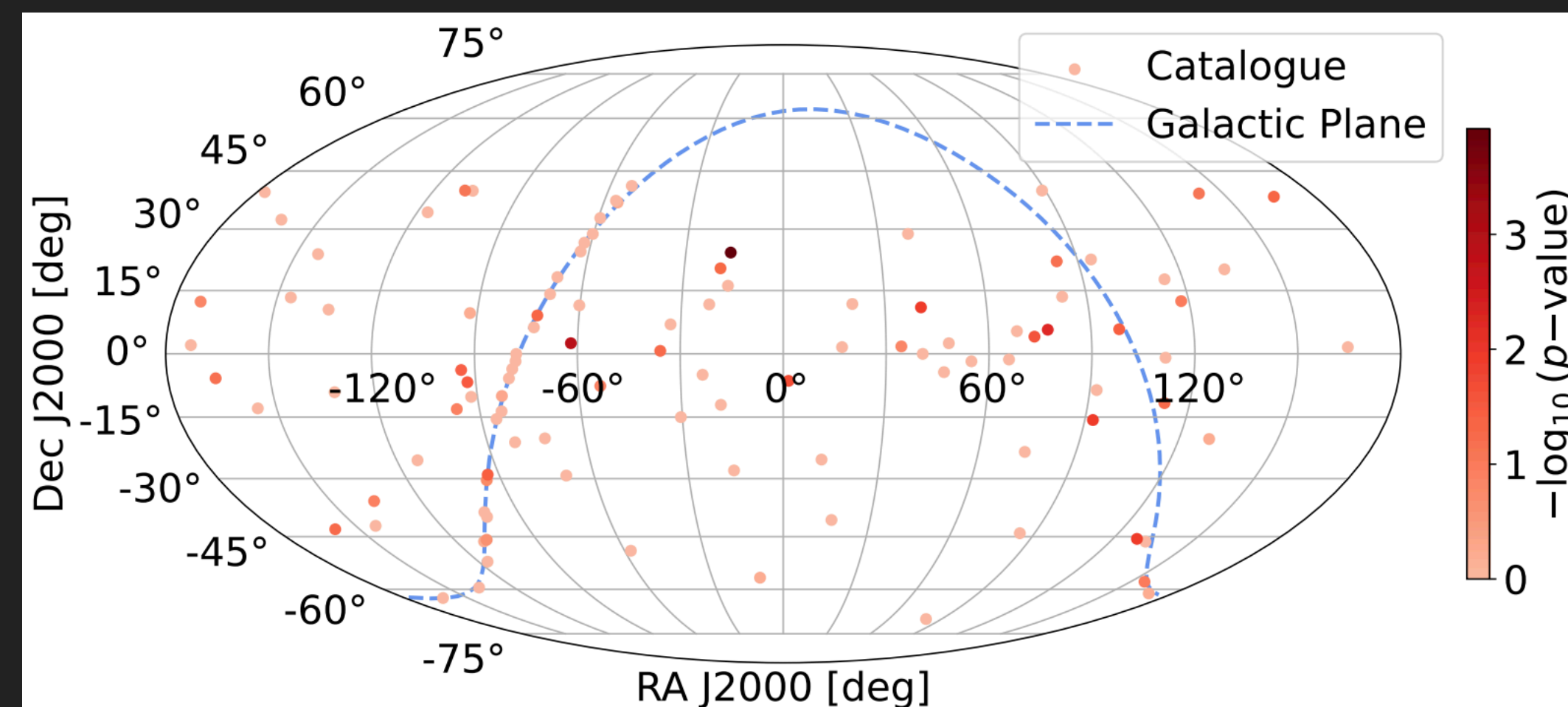
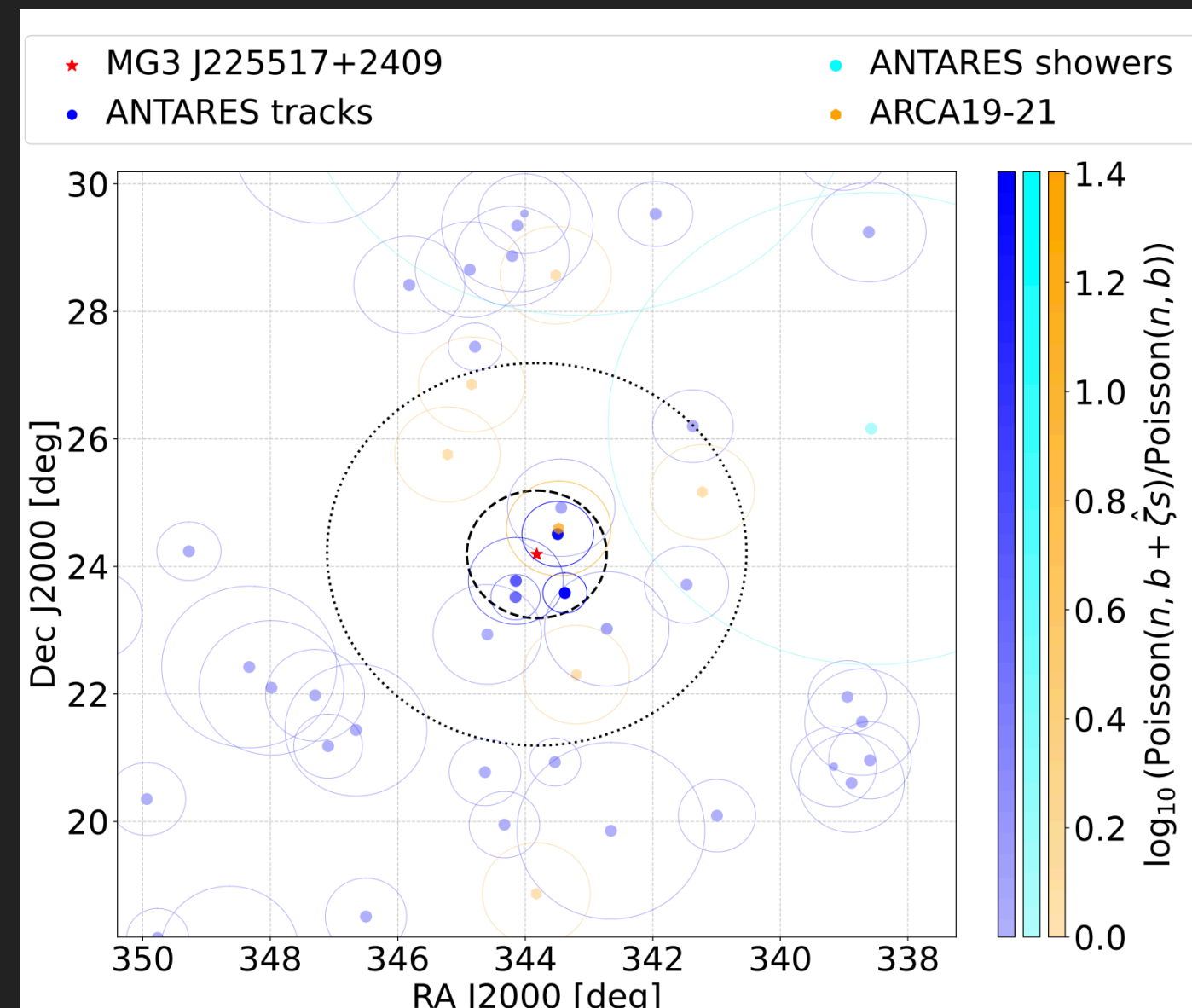
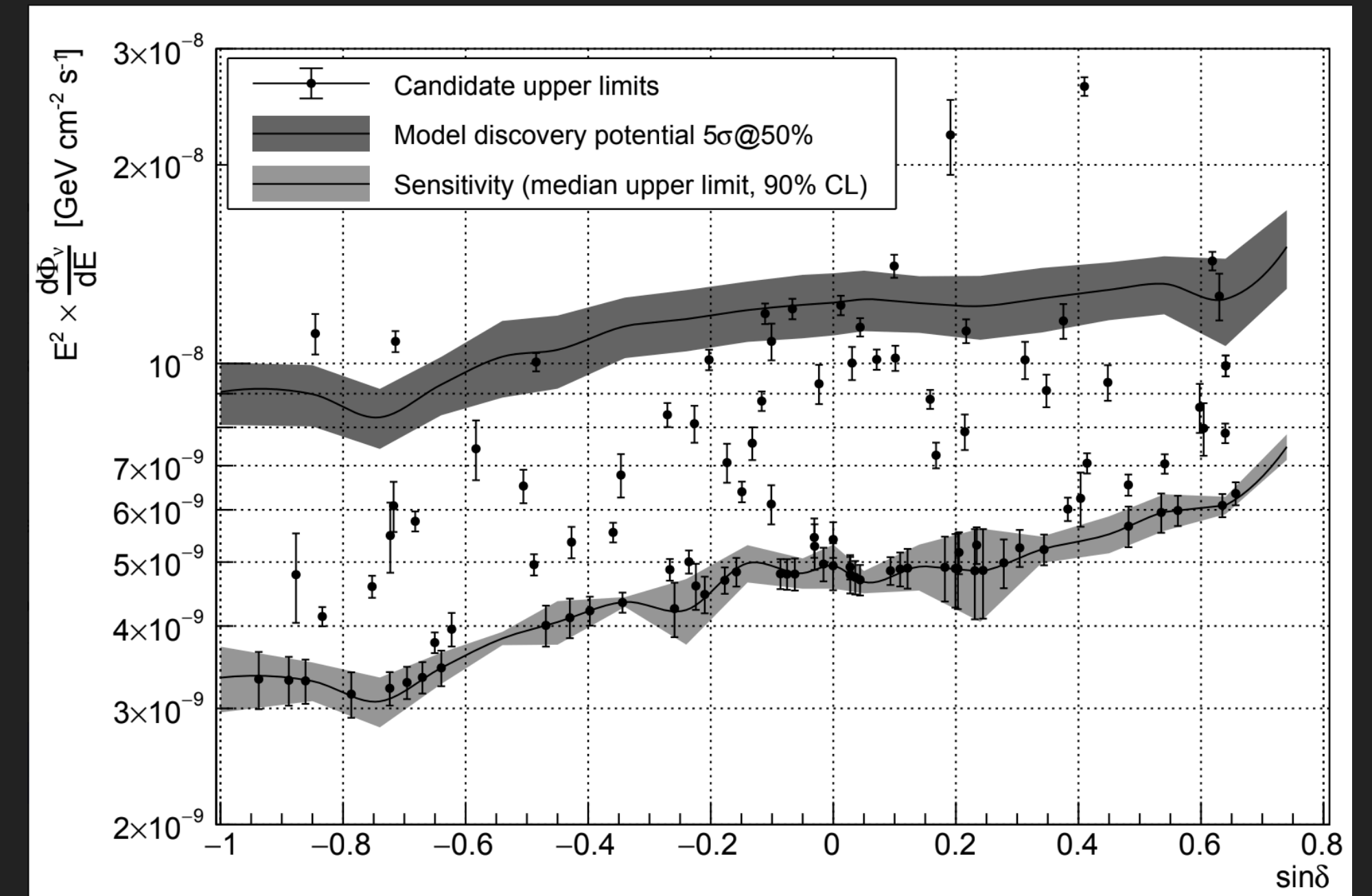
No statistically significant excess. The upper limits are approaching those obtained by ANTARES.



Combined ANTARES-ARCA point-source search

Data sample and analysis strategy:

- ANTARES tracks and showers: 4541 days of livetime.
- ARCA19-21 tracks: 336 days of livetime.
- Joint search of 106 candidate sources using a common binned likelihood framework and an E^2 spectrum.
- Approximately 20% improvement in sensitivity and discovery flux relative to ANTARES alone.



Most significant candidate: MG3 J225517+2409.

Pre-trial significance: 3.69σ .

Post-trial significance: approximately 1.3σ .

Paper in preparation

Testing neutrino emission from Seyfert hot-coronae

Data samples: ANTARES: 4541 days + KM3NeT/ARCA19-21: 336 days

Binned stacking framework as stacking KM3NeT/ARCA alone

Seyfert stacking – excluding Cen A

The upper limit lies below the nominal hot-corona prediction for the adopted source spectra and stacking weights.

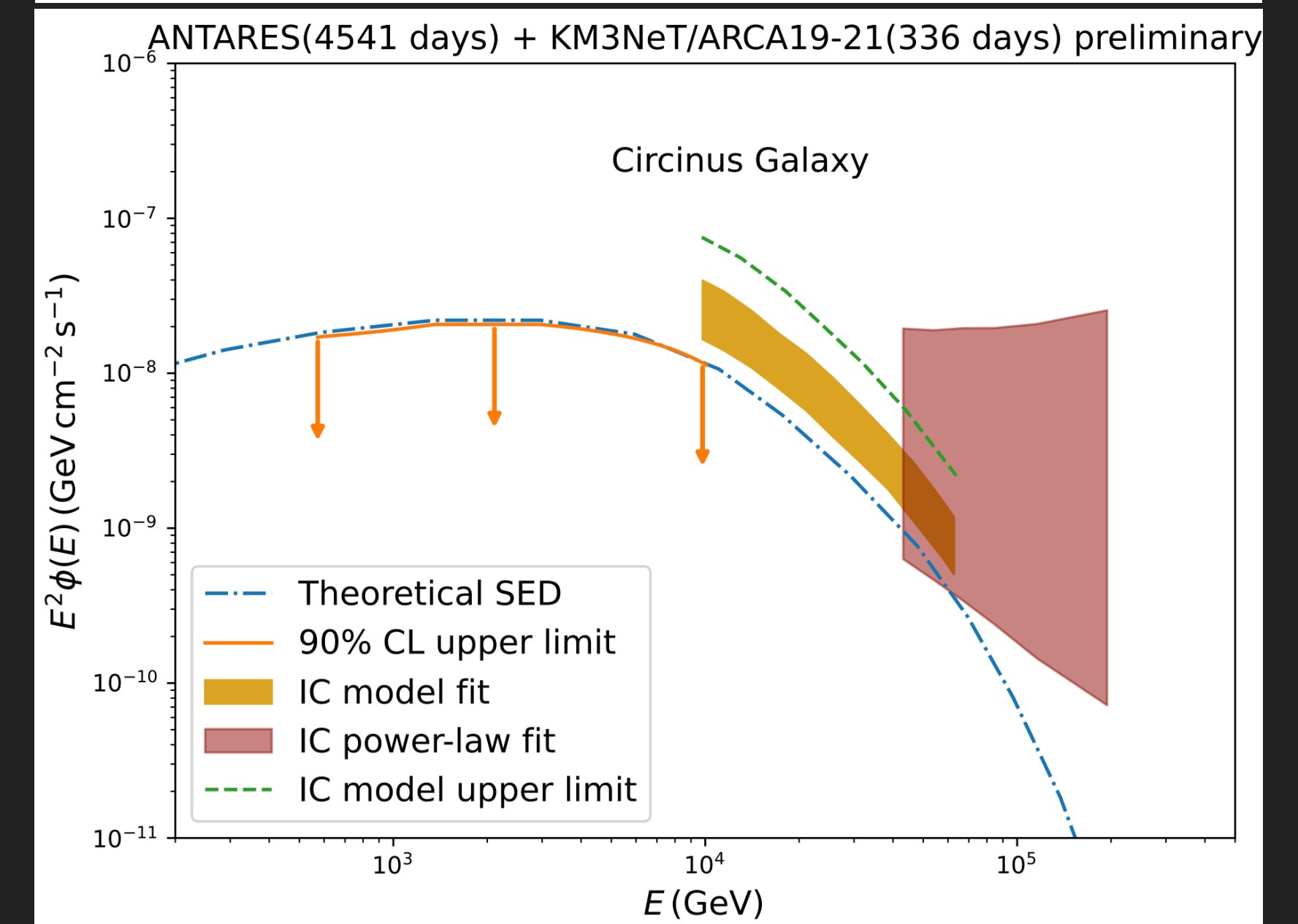
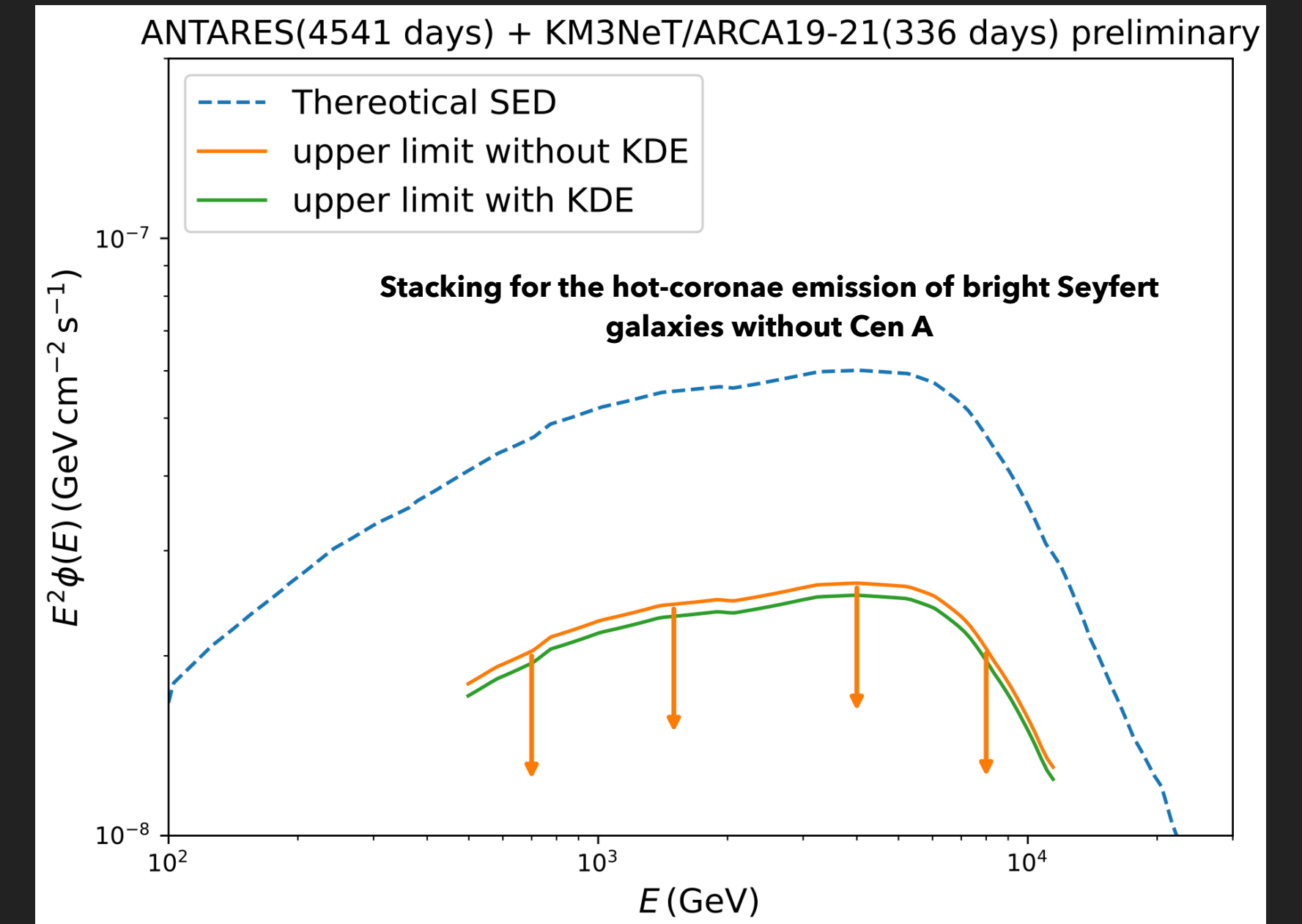
Circinus Galaxy

The upper limit reaches the nominal model prediction, providing an independent comparison with the IceCube-inferred flux

No statistically significant stacking excess.

Upper limits constrain the adopted hot-corona model.

Paper in preparation



REAL TIME ANALYSIS SYSTEM

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Real-time reconstruction and event classification enable searches for neutrino counterparts to electromagnetic and gravitational-wave signals.

The Real-Time Analysis program includes:

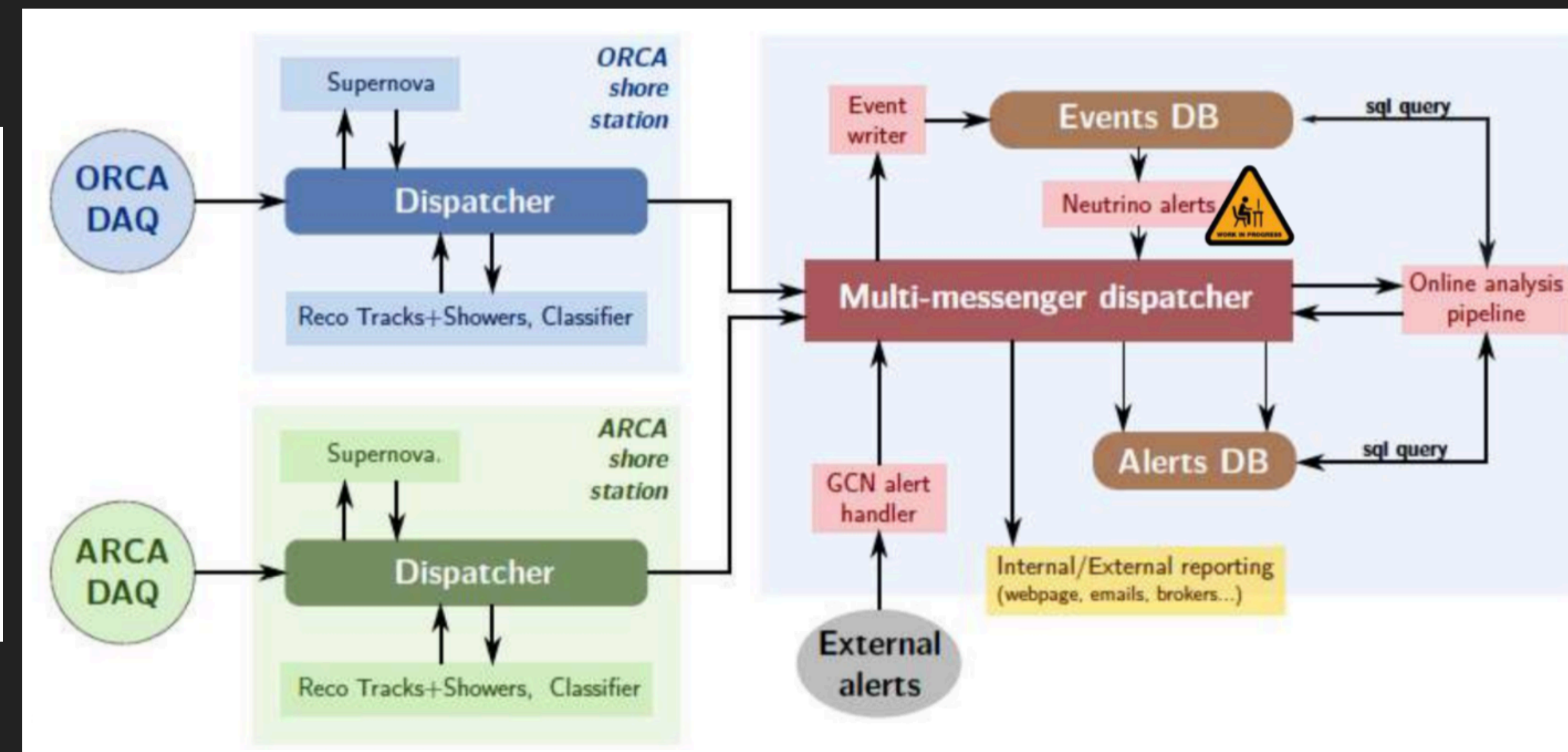
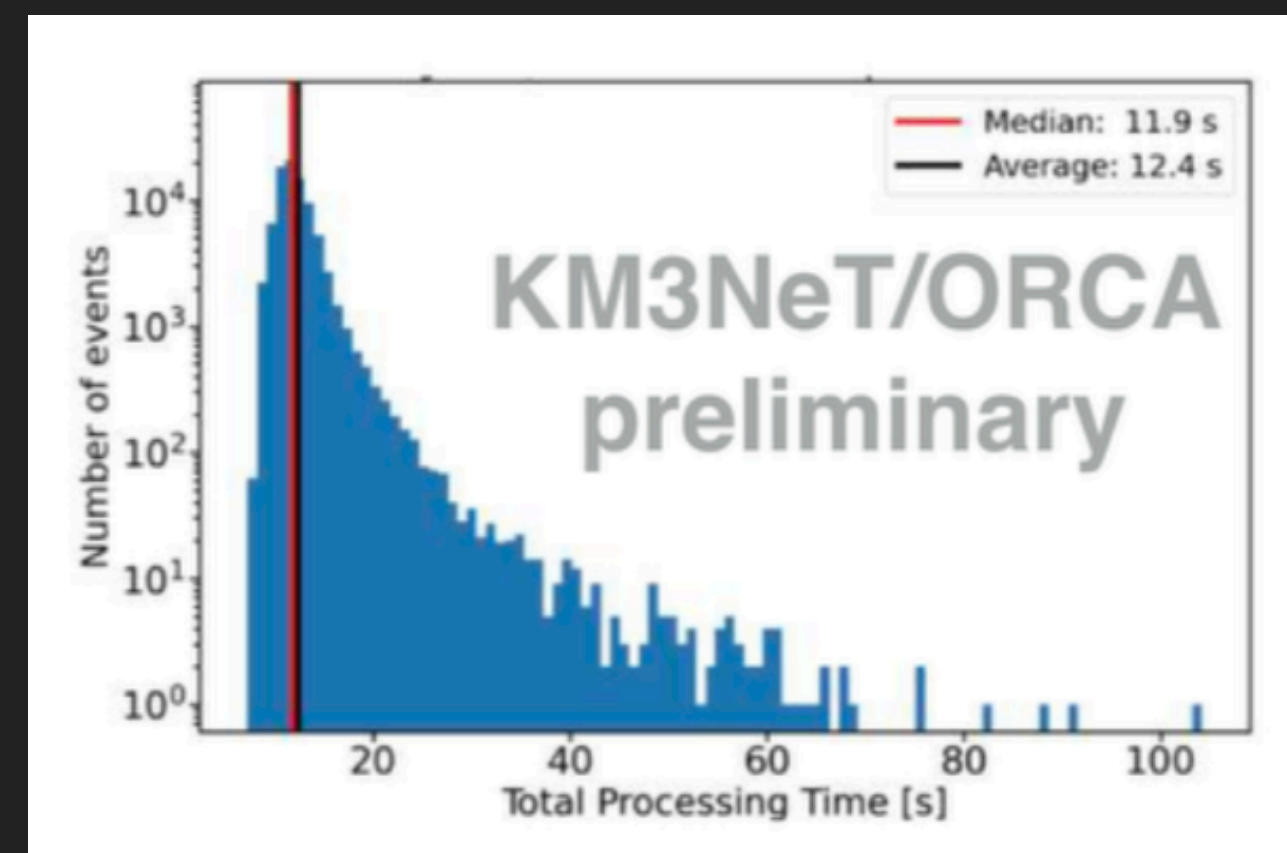
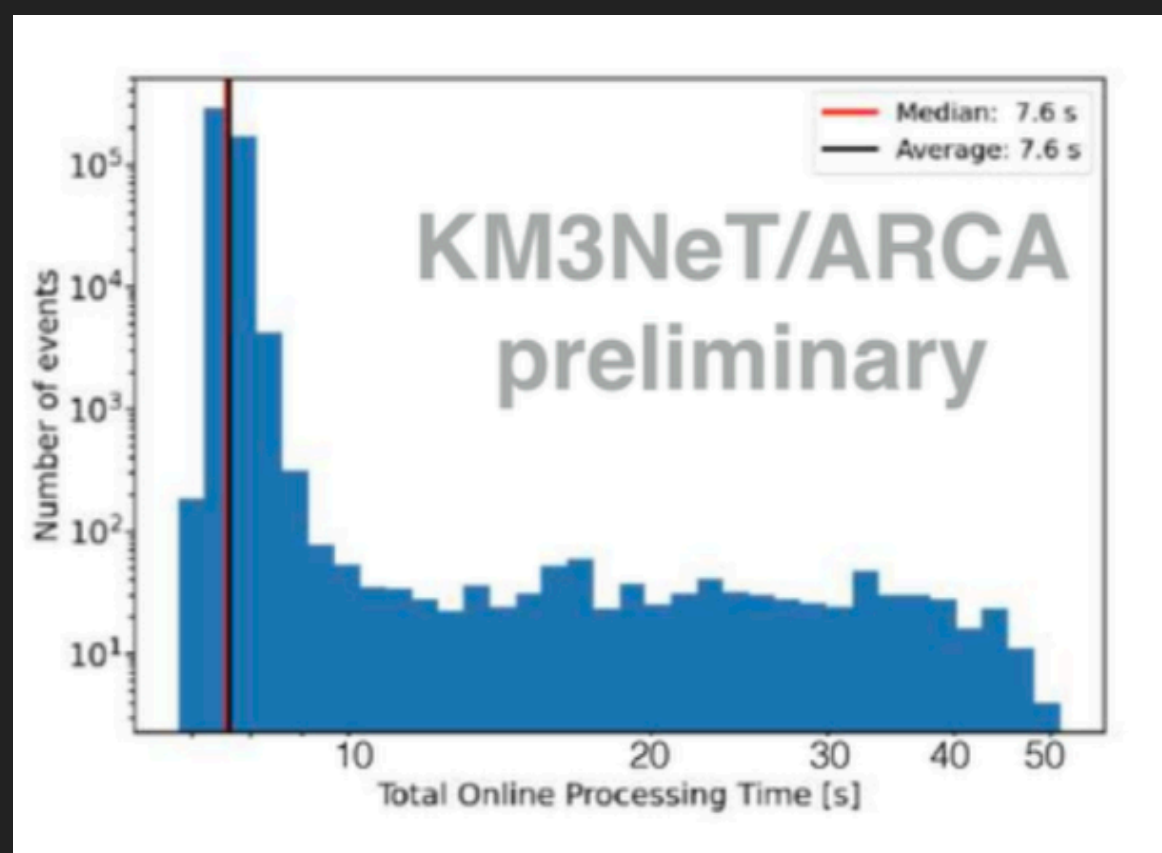
- Continuous monitoring for Supernova neutrino bursts at MeV energies.
- Follow-up of external alerts with ARCA and ORCA data.
- Development of neutrino alerts for high-energy events and multiplets.

Neutrino candidates available within approximately **20 seconds**, including reconstruction and analysis.

Neutrino alert sending

- Alert pipeline in place and undergoing commissioning.
- Final refinements before distributing alerts to partner observatories.
- Target alert rate: 1-2 alerts per month.
- Current alert latency: approximately 4 minutes, with a target of 1-2 minutes.

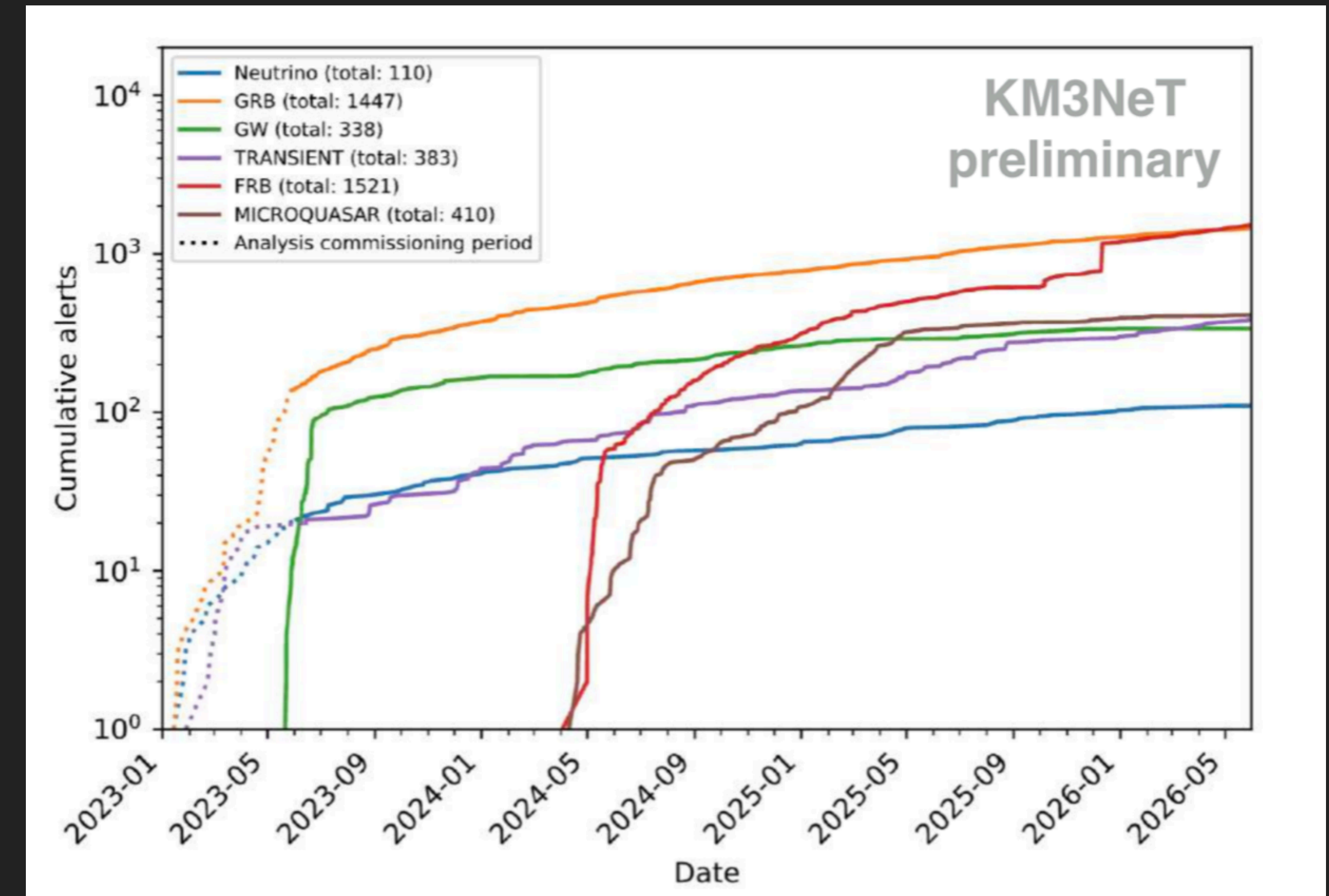
Alert distribution to partners planned



Real-time follow-up of external triggers

- External alerts from GCN, CHIME, TNS and SNEWS trigger automated searches in ARCA and ORCA.
- Dedicated pipelines cover IceCube neutrino alerts, gamma-ray bursts, gravitational waves, microquasars, core-collapse supernovae and fast radio bursts.
- Coincidence searches use upgoing track-like events.
- Searches extend over **different time windows** and incorporate updated information when available.
- **ON/OFF analyses** estimate the background and determine neutrino flux upper limits.

Thousands of external alerts followed up since 2023.



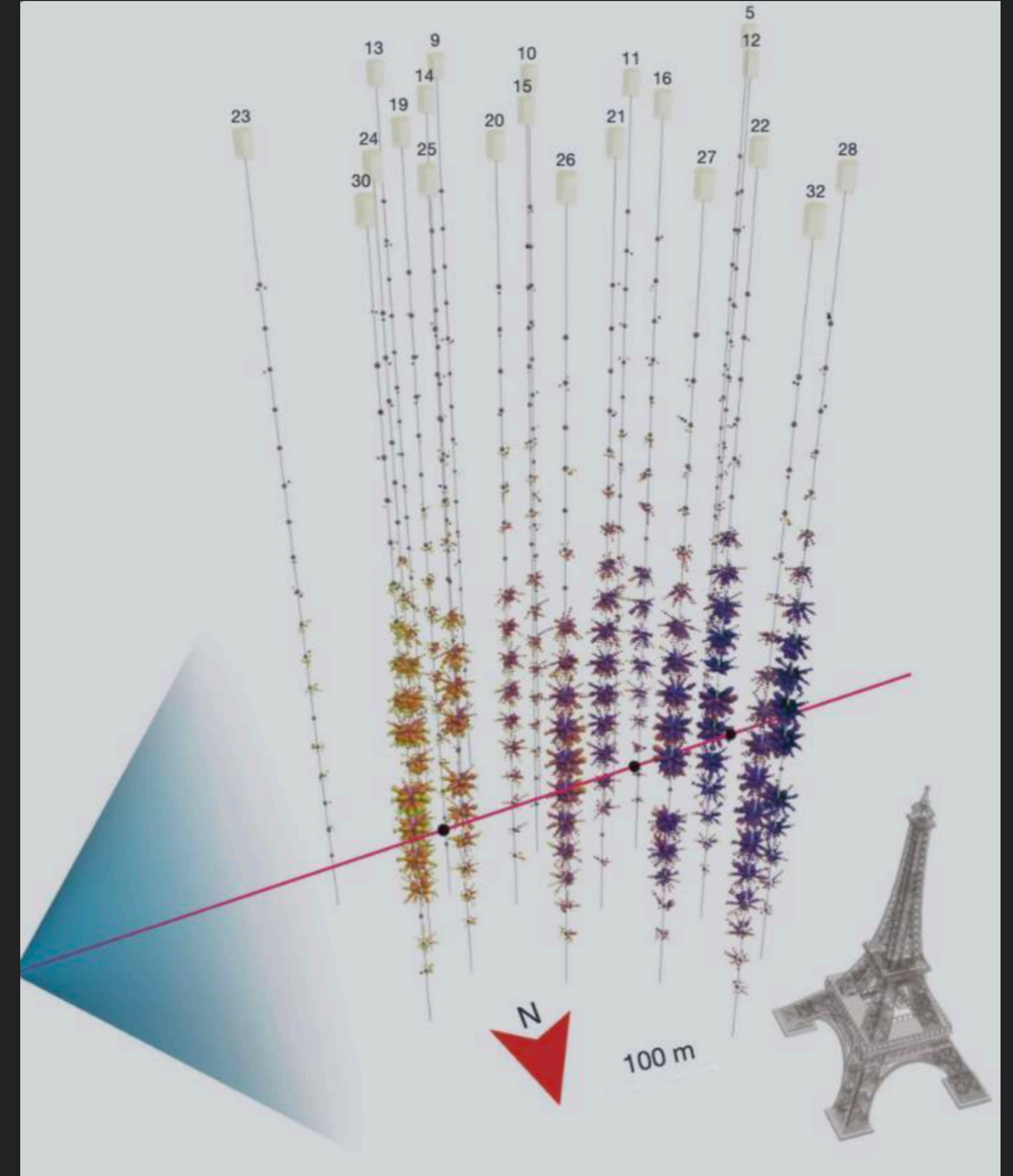
KM3-230213A: an ultra-high-energy neutrino event

- Detected on **13 February 2023 at 01:16:47 UTC** with the ARCA21 configuration.
- Bright track crossing the detector, triggering 3672 PMTs.
- Nearly horizontal direction, 0.6° above the horizon.
- Reconstructed position: $RA = 94.3^\circ$, $Dec = -7.8^\circ$.
- Angular containment: 1.5° at 68% and 2.2° at 90%.

An exceptional event observed with only a partial detector.



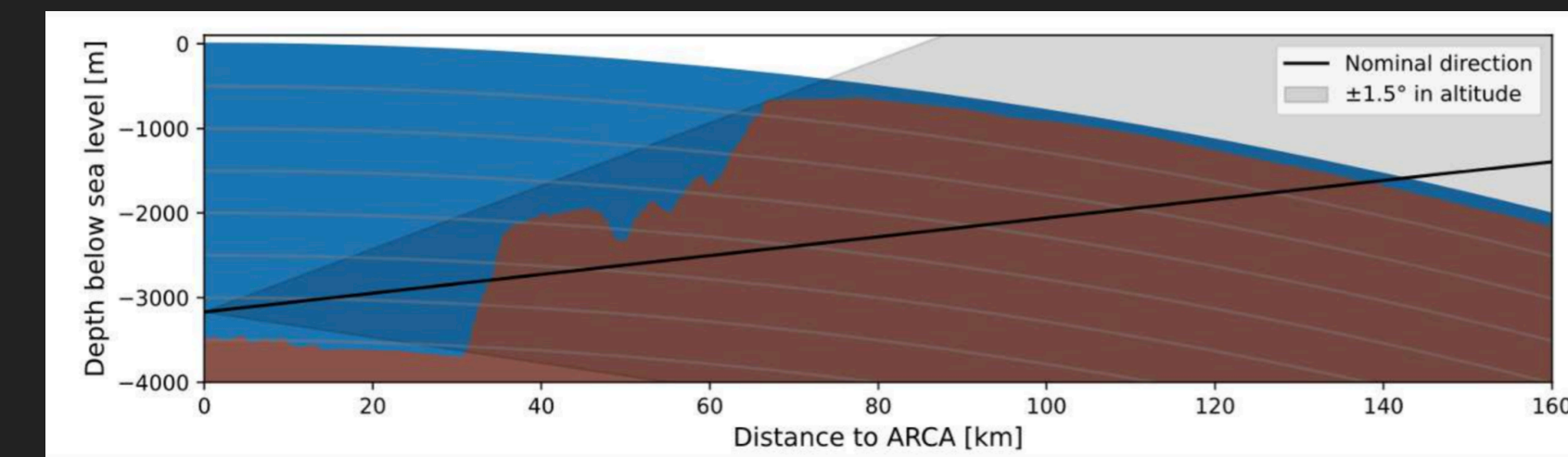
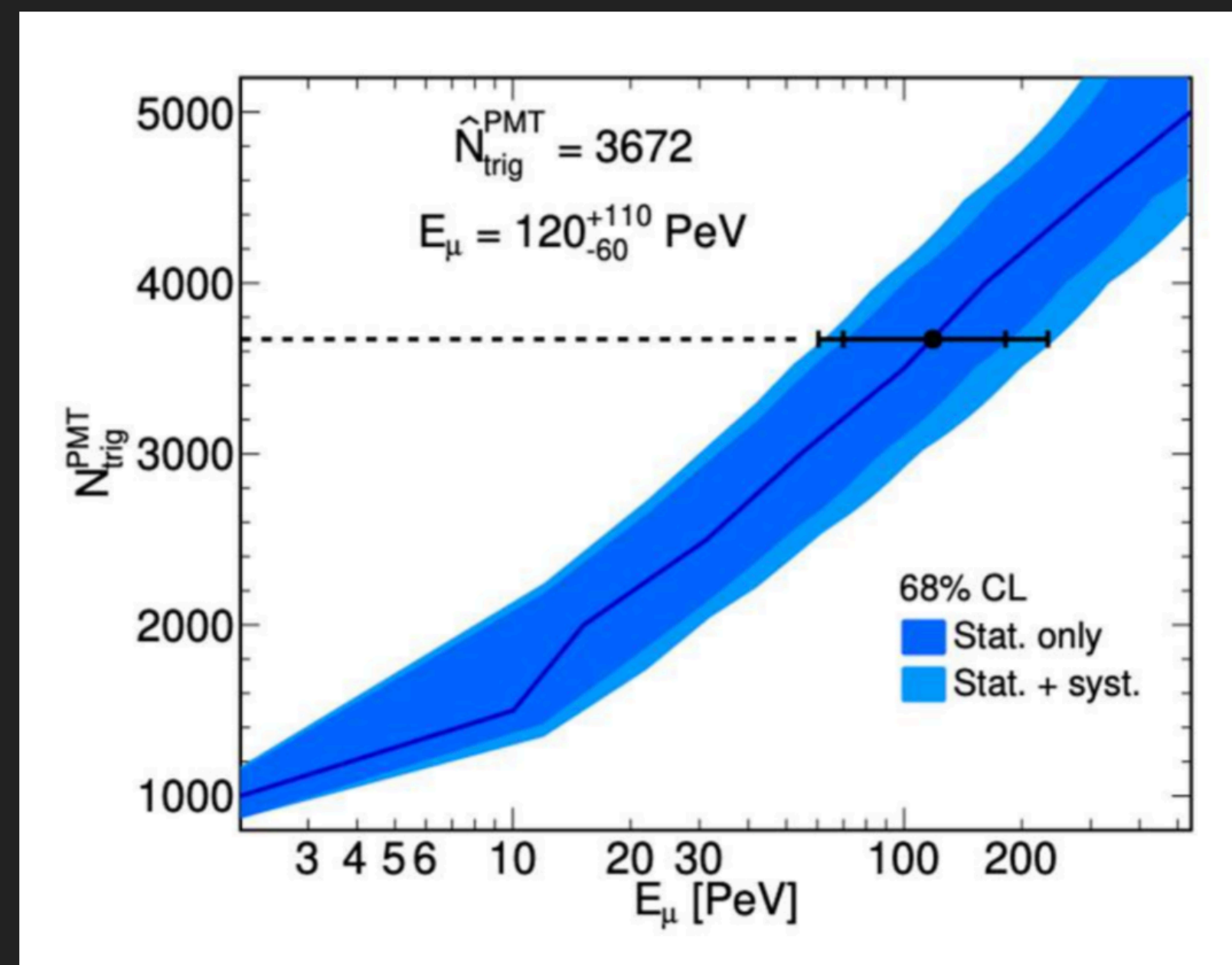
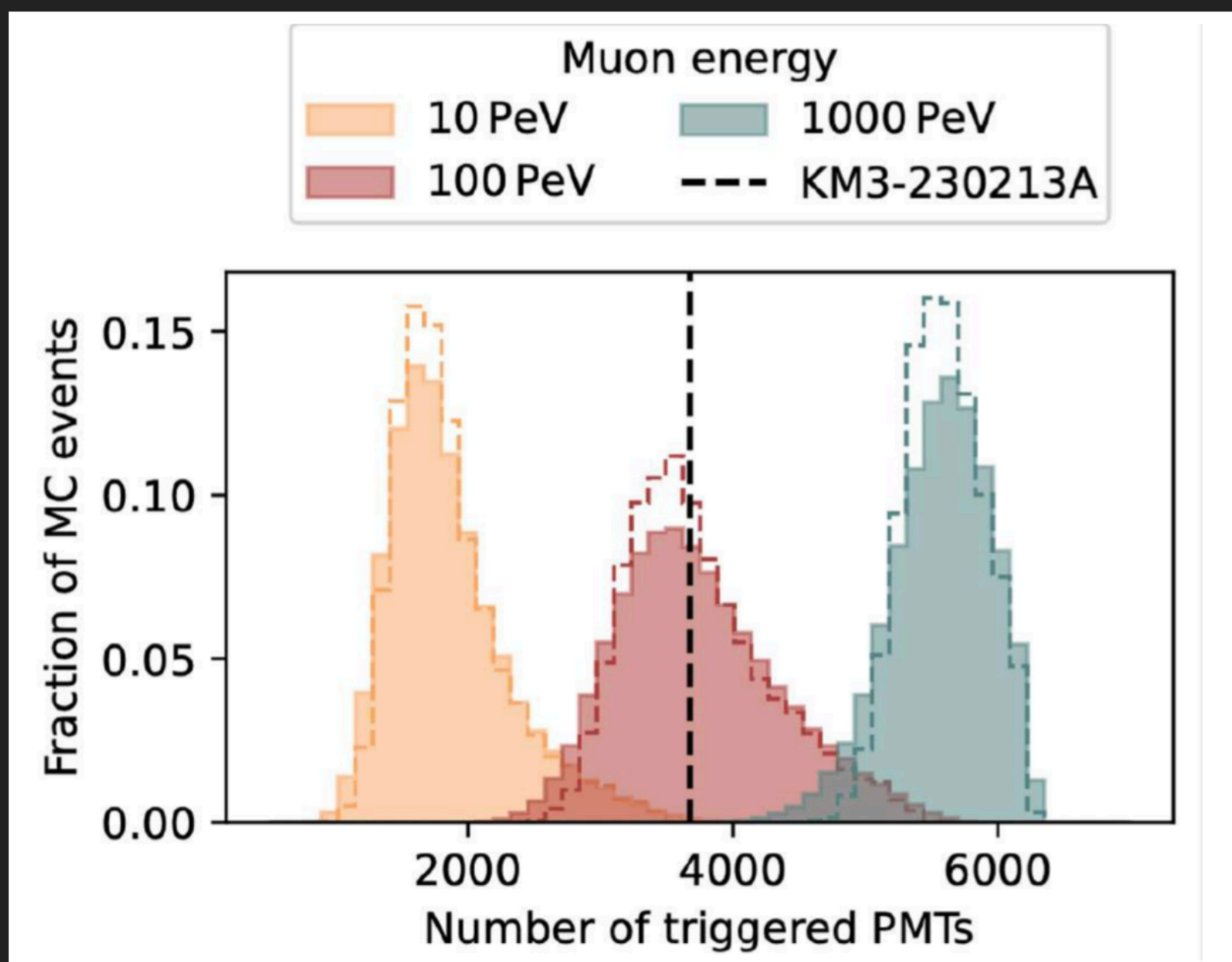
Nature 638, 376–382 (2025).

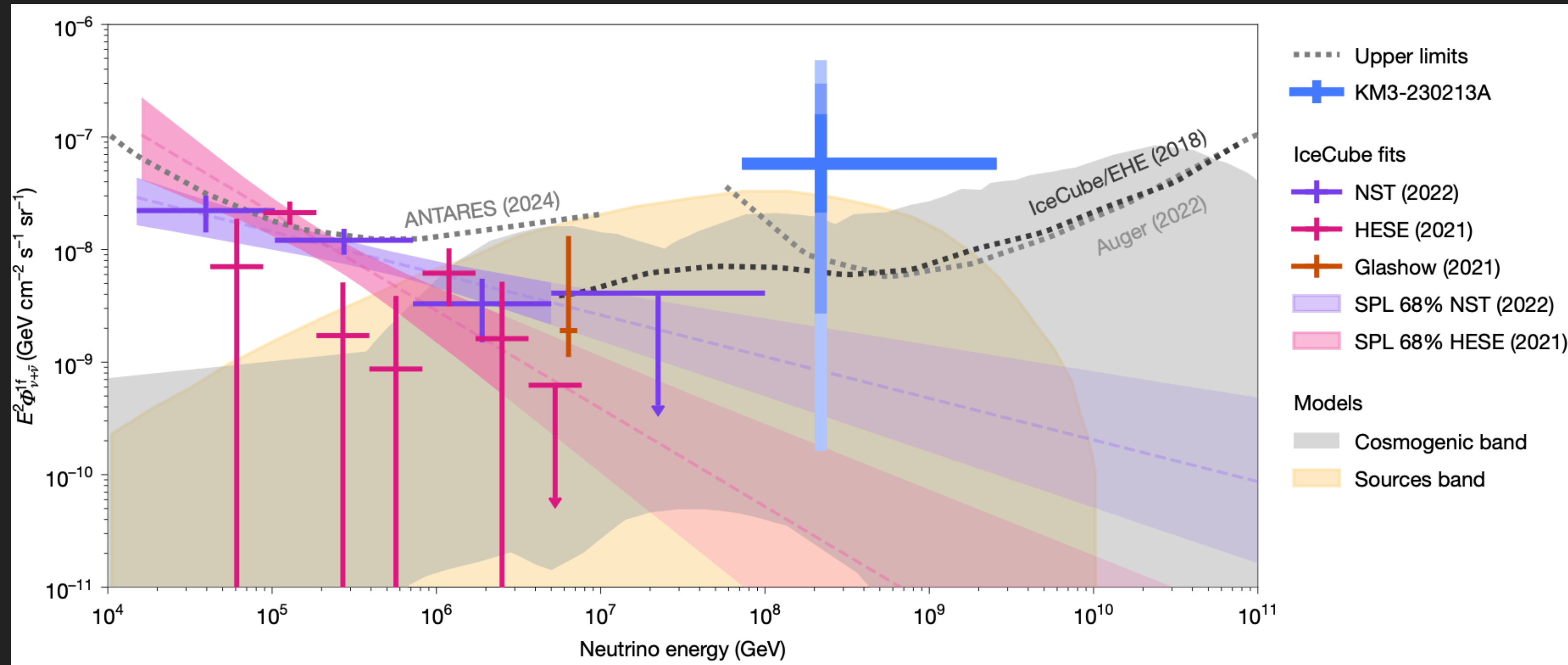


KM3-230213A: energy and cosmic origin

- Muon energy inferred from the observed light yield, including detector systematic uncertainties.
- Reconstructed muon energy: around 120 PeV.
- Median parent-neutrino energy: approximately 220 PeV, assuming an E^{-2} spectrum.
- Central 90% neutrino-energy range: 72 PeV-2.6 EeV.
- Atmospheric backgrounds are strongly suppressed at the reconstructed energy and direction.

The event probes neutrino energies beyond previous observations.





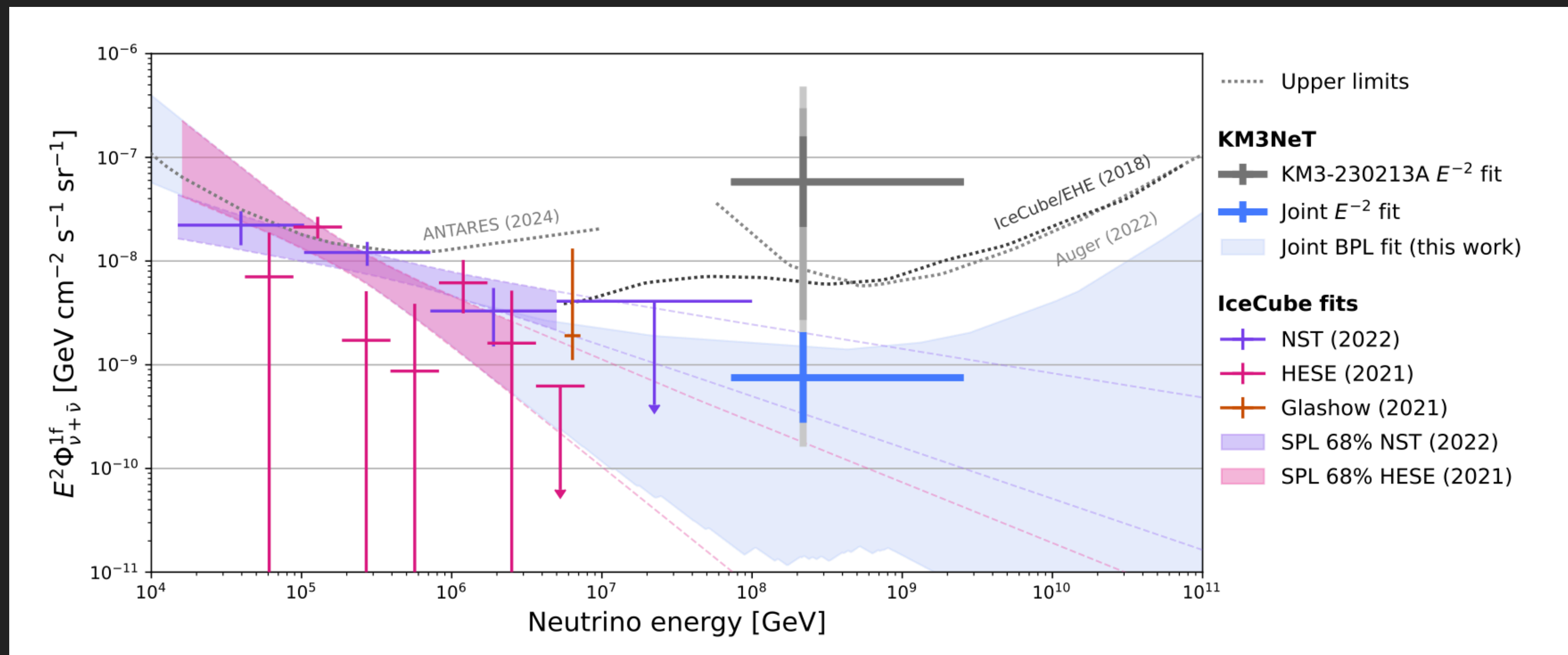
Nature 638, 376–382 (2025).

- KM3-230213A extends neutrino observations into the hundreds-of-PeV regime.
- The event provides an estimate of the diffuse flux under an isotropic E^{-2} hypothesis.
- Comparison with IceCube measurements and UHE limits.

What does this observation imply for the UHE neutrino flux?

A **global interpretation** of the neutrino flux:

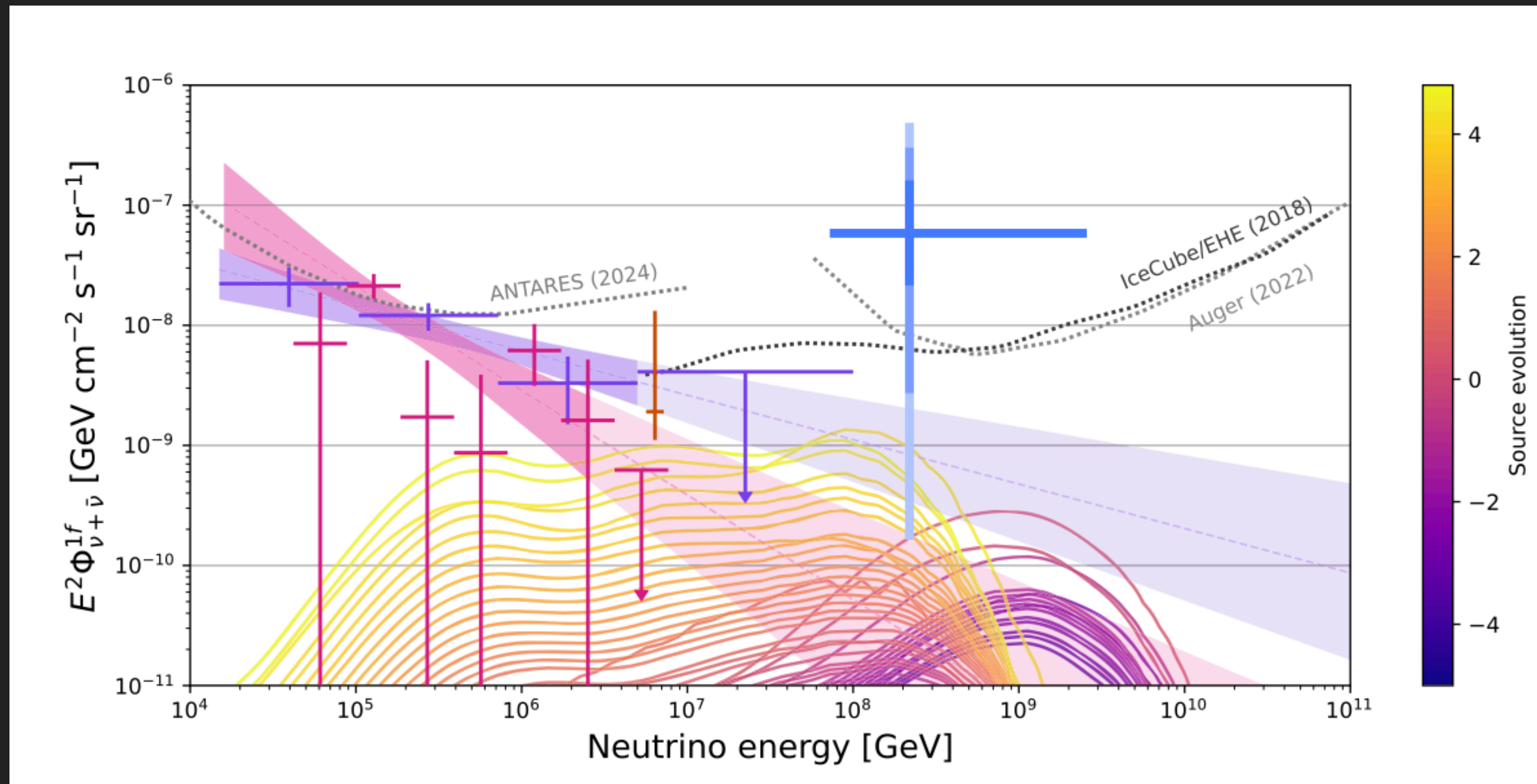
- Joint fit of KM3NeT, IceCube and Pierre Auger UHE observations.
- Combined fits include IceCube measurements at lower energies.
- Single and broken power-law spectra tested.
- Mild-to-moderate tension between datasets: approximately $1.6\text{--}2.9\sigma$.



A possible cosmogenic origin:

- Cosmogenic neutrinos originate from interactions of ultra-high-energy cosmic rays with cosmic radiation backgrounds.
- Their flux depends on cosmic-ray composition and the evolution of the source population.
- Distant sources extending to $z \approx 6$, together with a subdominant proton component, can accommodate the KM3-230213A observation.

KM3-230213A can be accommodated by cosmogenic scenarios involving distant sources and a subdominant proton component.



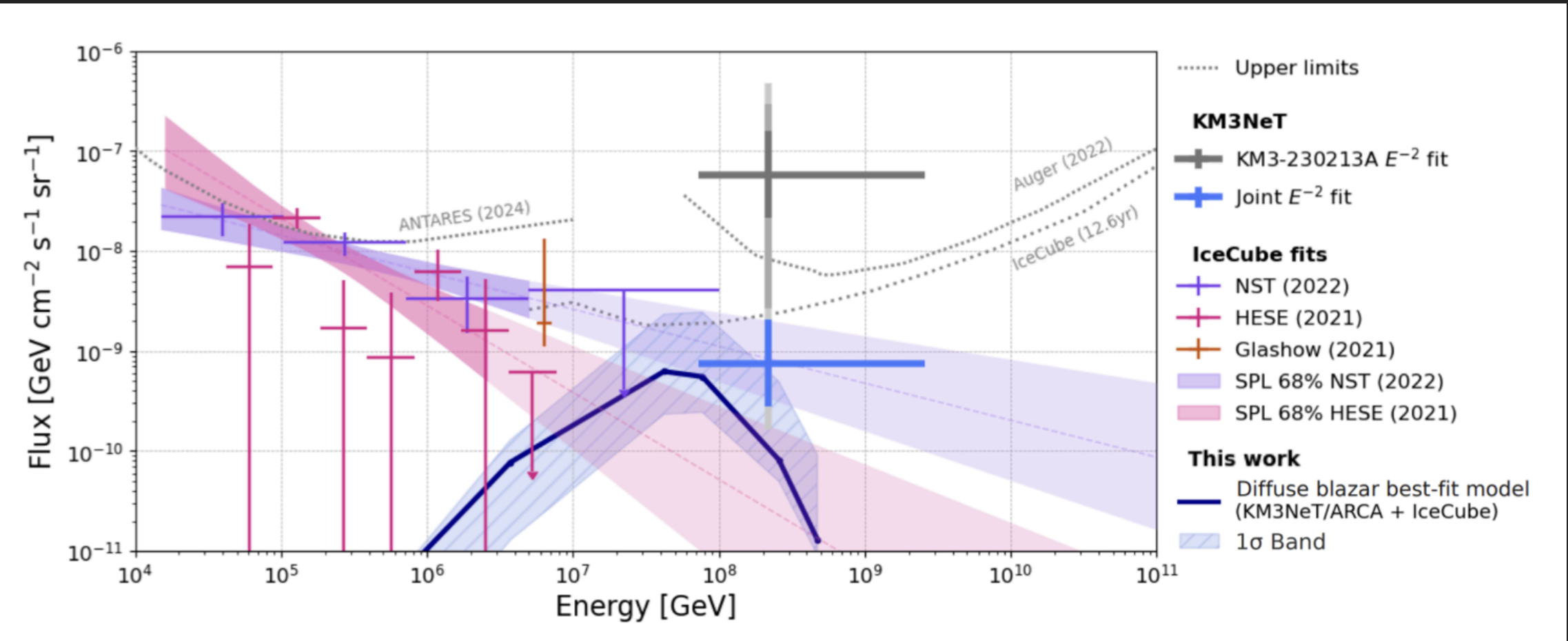
Astrophysical interpretations: blazars and GRBs

Blazar populations

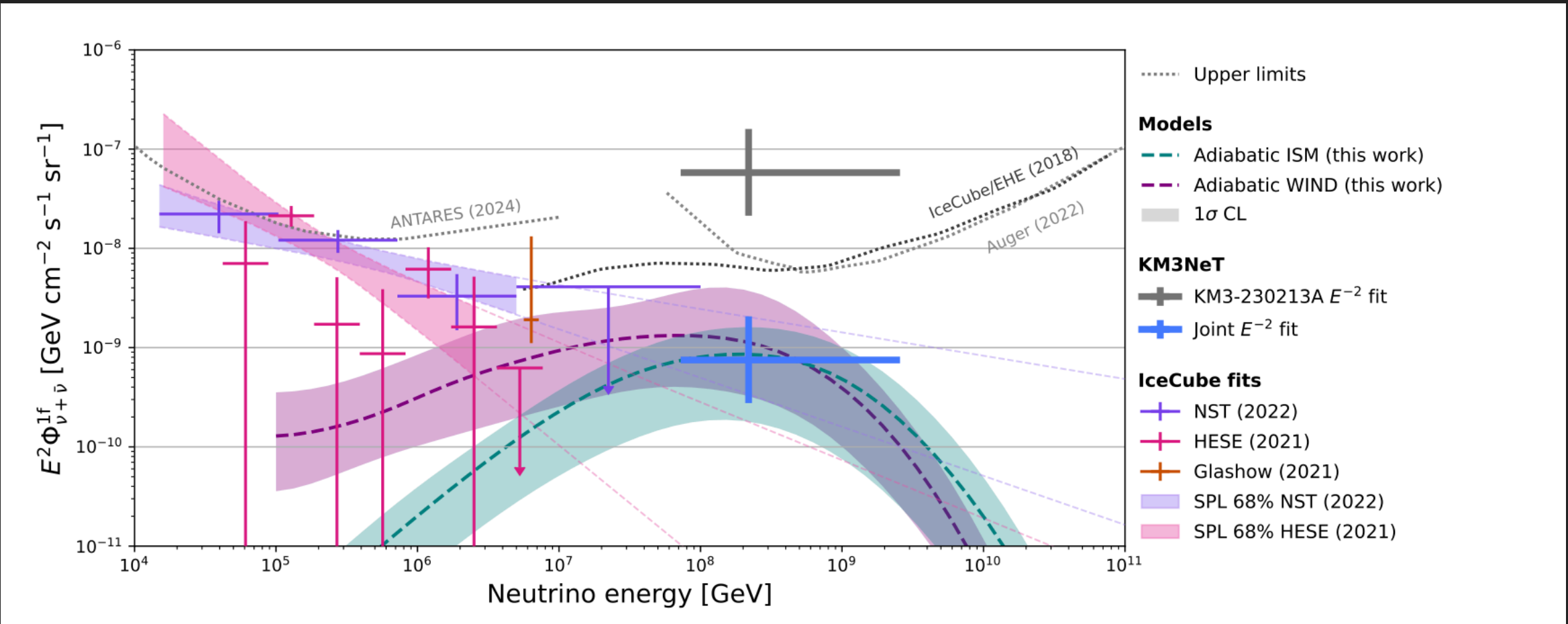
- Hadronic interactions in relativistic jets produce neutrinos and gamma rays.
- Population models can reproduce a diffuse UHE neutrino flux compatible with the KM3NeT observation.
- The associated gamma-ray emission can remain consistent with Fermi-LAT diffuse measurements.

Gamma-ray burst populations

- Long-duration GRB blastwaves provide a potential source of UHE neutrinos.
- Models consider both constant-density and stellar-wind environments.
- Joint KM3NeT, IceCube and Auger observations constrain baryon loading and ambient density.



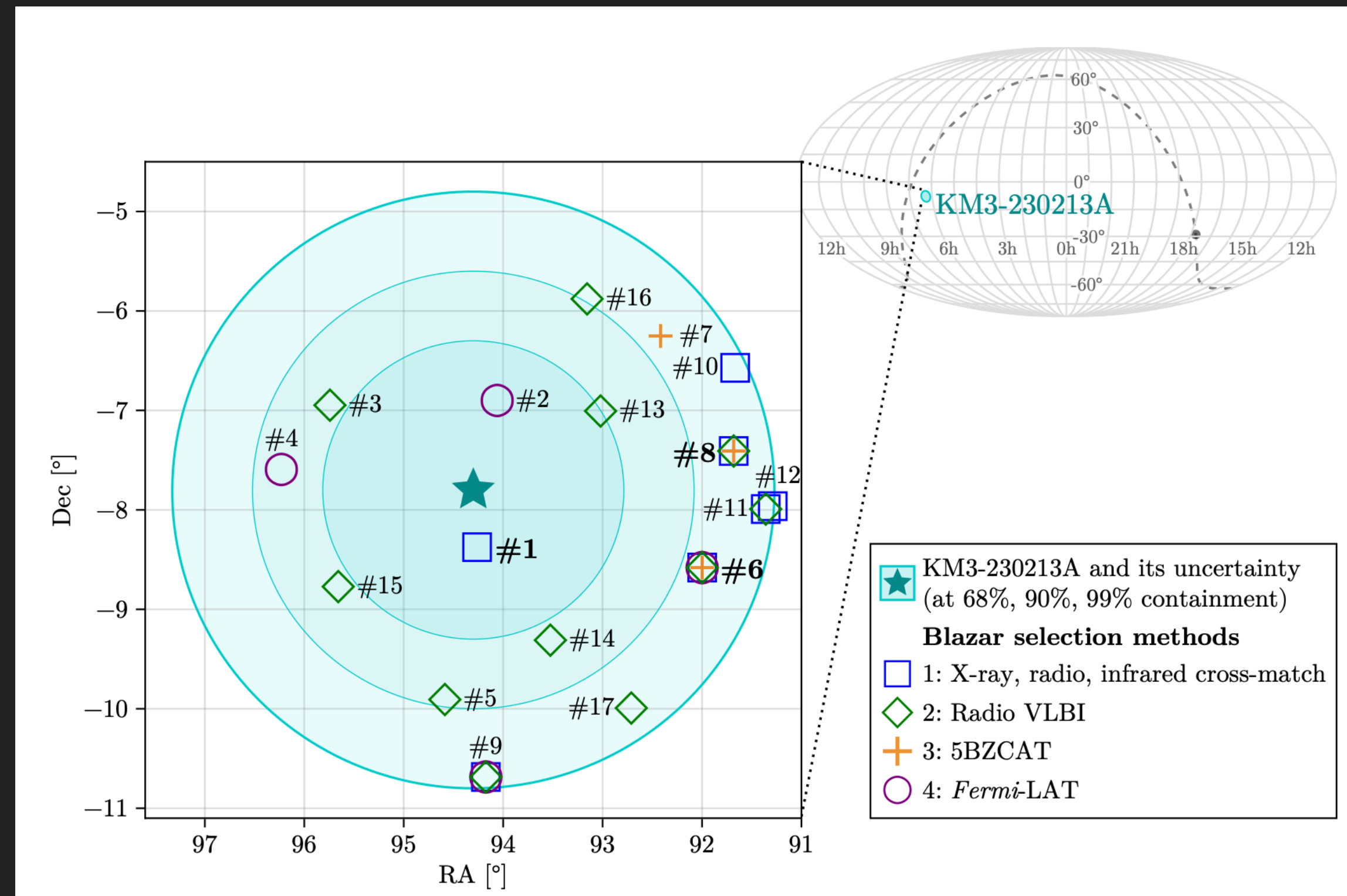
Reference:KM3NeT Coll. JCAP 03 (2026) 033



Reference: KM3NeT Coll. A&A 710, A168 (2026).

KM3-230213A: multiwavelength follow-up

- Seventeen candidate blazars identified within the 99% localization region.
- Dedicated observations and archival data cover radio, optical, X-ray and gamma-ray bands.
- PMN J0606–0724 shows a major radio flare peaking within five days of the neutrino arrival.
- Other candidates exhibit enhanced X-ray or gamma-ray activity.



The angular uncertainty of KM3-230213A will be updated using the improved absolute positioning calibration, refining the search for astrophysical counterparts.

Reference: KM3NeT Coll,
AJ 172, 139 (2026),
arXiv:2502.08484.

SUMMARY AND OUTLOOK

- **KM3NeT continues to grow while taking data.** ARCA has now reached **62 detection units**, with analyses of later detector configurations in progress.
- **A broad neutrino astronomy programme is underway**, covering point sources, source populations, diffuse emission and the Galactic Ridge.
- **Combined ANTARES-ARCA analyses** improve point-source sensitivity and constrain the neutrino flux predicted by the adopted Seyfert hot-corona model.
- **Real-time follow-up searches have been running since 2023.** The neutrino alert system is undergoing commissioning before distributing alerts.
- **KM3-230213A extends neutrino observations into the hundreds-of-PeV regime.** Its origin remains open. More events and multiwavelength observations will help distinguish the possible interpretations.

STAY TUNED