Combined search for cosmic neutrino sources with ANTARES and KM3NeT/ARCA

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Summary

We present a combined analysis of the full ANTARES dataset (2007–2022) together with KM3NeT/ARCA data recorded between May 2021 and September 2023—during which the detector geometry evolved up to 21 detection lines. The study performs targeted searches for both point-like and spatially extended neutrino emission using a comprehensive catalogue of gamma-ray emitters (Galactic sources from TeVCat, VLBI-selected extragalactic AGNs, and IceCube candidates). The joint ANTARES–ARCA dataset yields improved sensitivity from a few TeV to several PeV, with a marked advantage for the Southern sky, thereby strengthening multi-messenger efforts to identify the origins of cosmic neutrinos.

ANTARES and KM3NeT/ARCA detectors

- **Detection Principle:** 3D array of optical modules that detect Cherenkov light emitted by the secondary particles produced in neutrino interactions. **Location:** Mediterranean Sea.
- **ANTARES[1]:** operated for more than 15 years near Toulon (France). Volume ~0.01 km^3
- **KM3NeT/ARCA[2]:** currently under construction near Capo Passero (Italy). Once completed, the full detector will comprise 230 detection lines, instrumenting approximately 1 km³ of seawater.

- **Datasets** (lifetime/days):
  - ANTARES: tracks+ showers (4541 days)
  - ARCA6*: only tracks (92 days)
  - ARCA8*: only tracks (212 days)
  - ARCA19*: only tracks (48 days)
  - ARCA21*: only tracks (287 days)
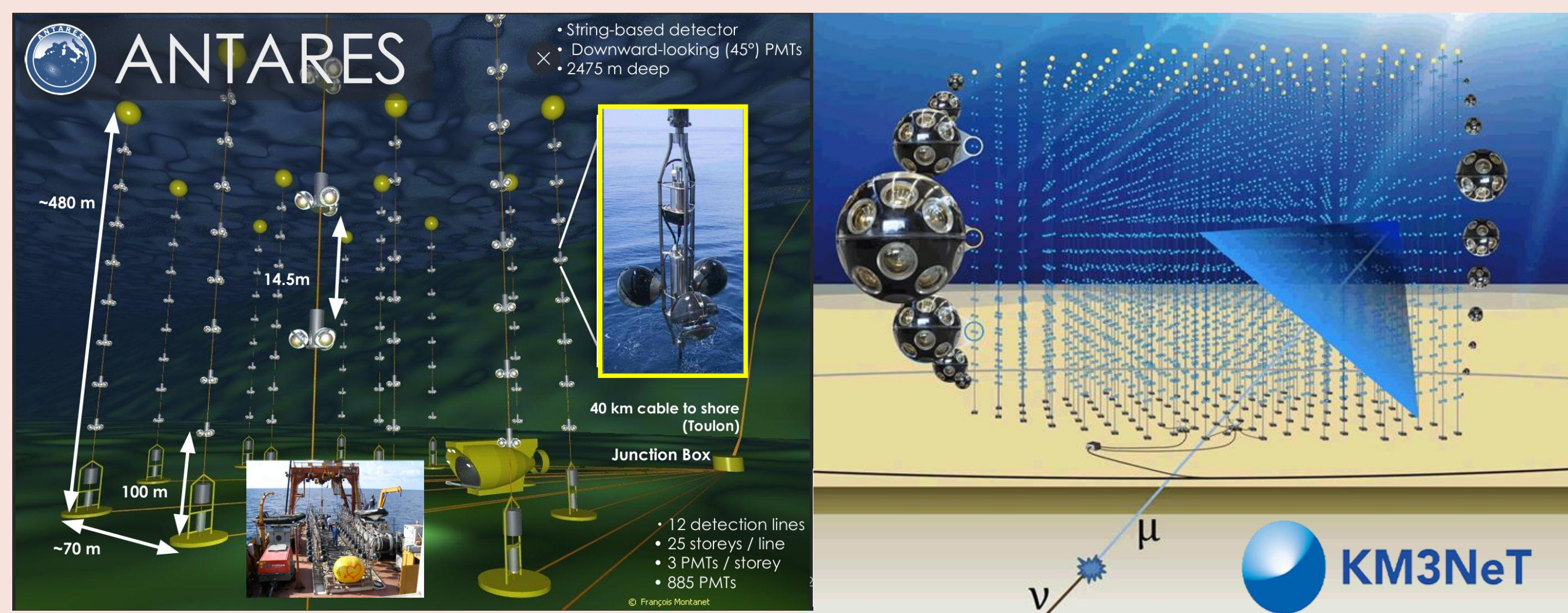
Event Topology

- **Track-like:** CC ν_μ.
- **Shower-like:** CC ν_e +all flavours NC .
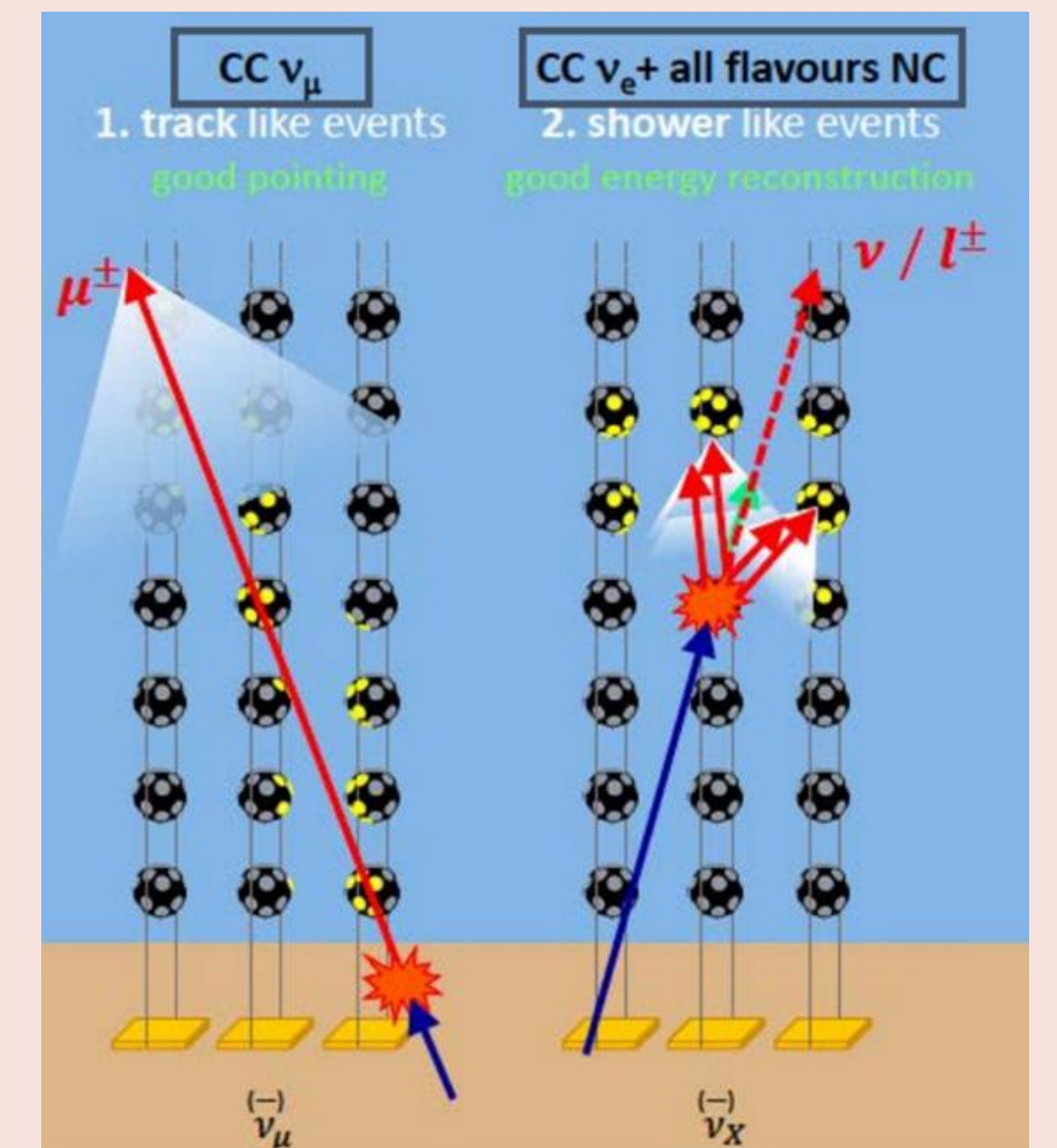
## Event Selection for KM3NeT/ARCA DATA

Selection Criteria:
- Select horizontal / upgoing tracks ($\cos\theta > -0.1$).
- Select events with high number of hits used in the reconstruction.
- Select events with good fit quality (based on the likelihood of the reconstruction).

Additional Selection for ARCA19/21 samples[4]:
- Select events with a long reconstructed track length.
- Select events with a small value of the error in the reconstructed direction.
- Boosted decision tree.
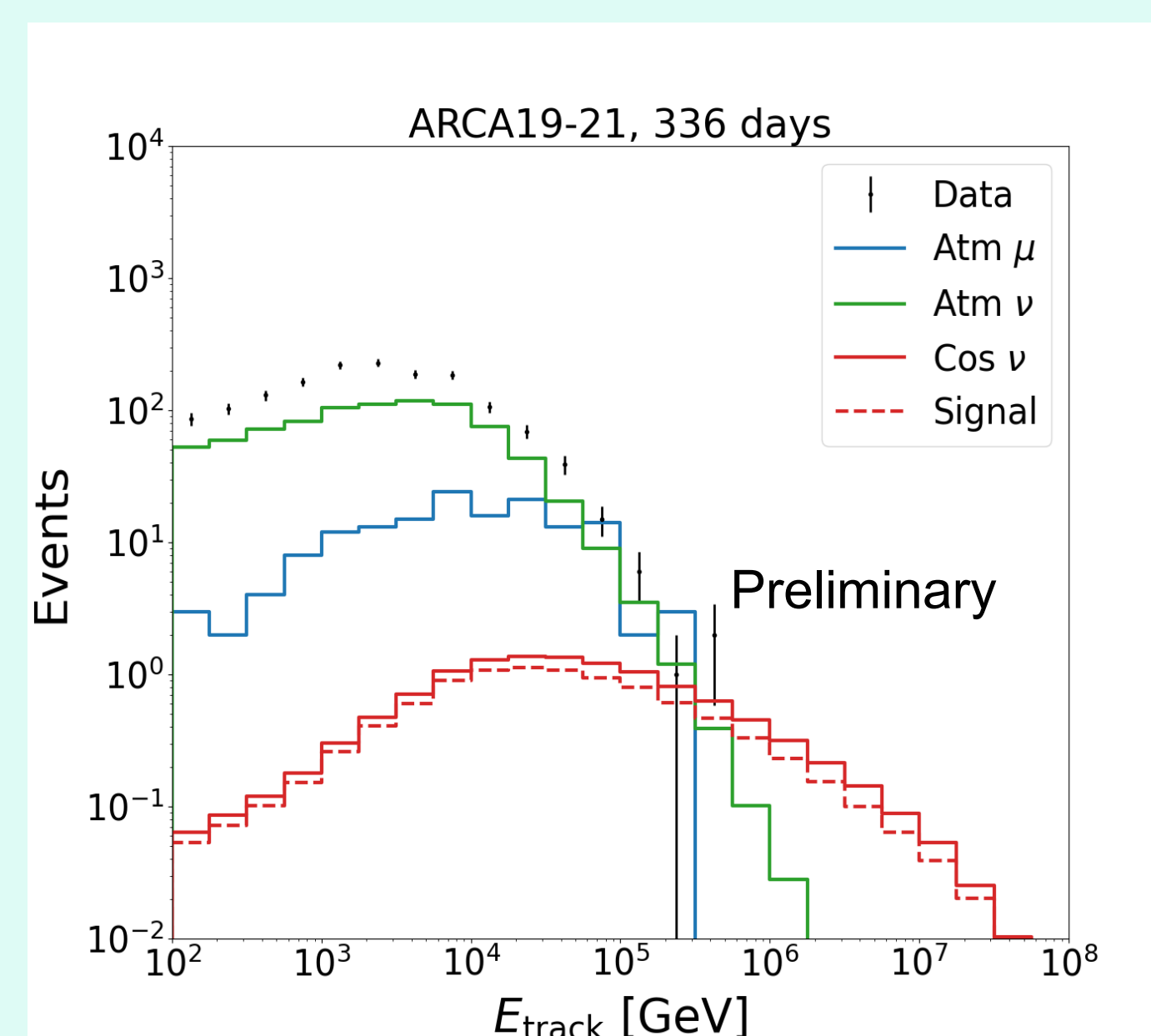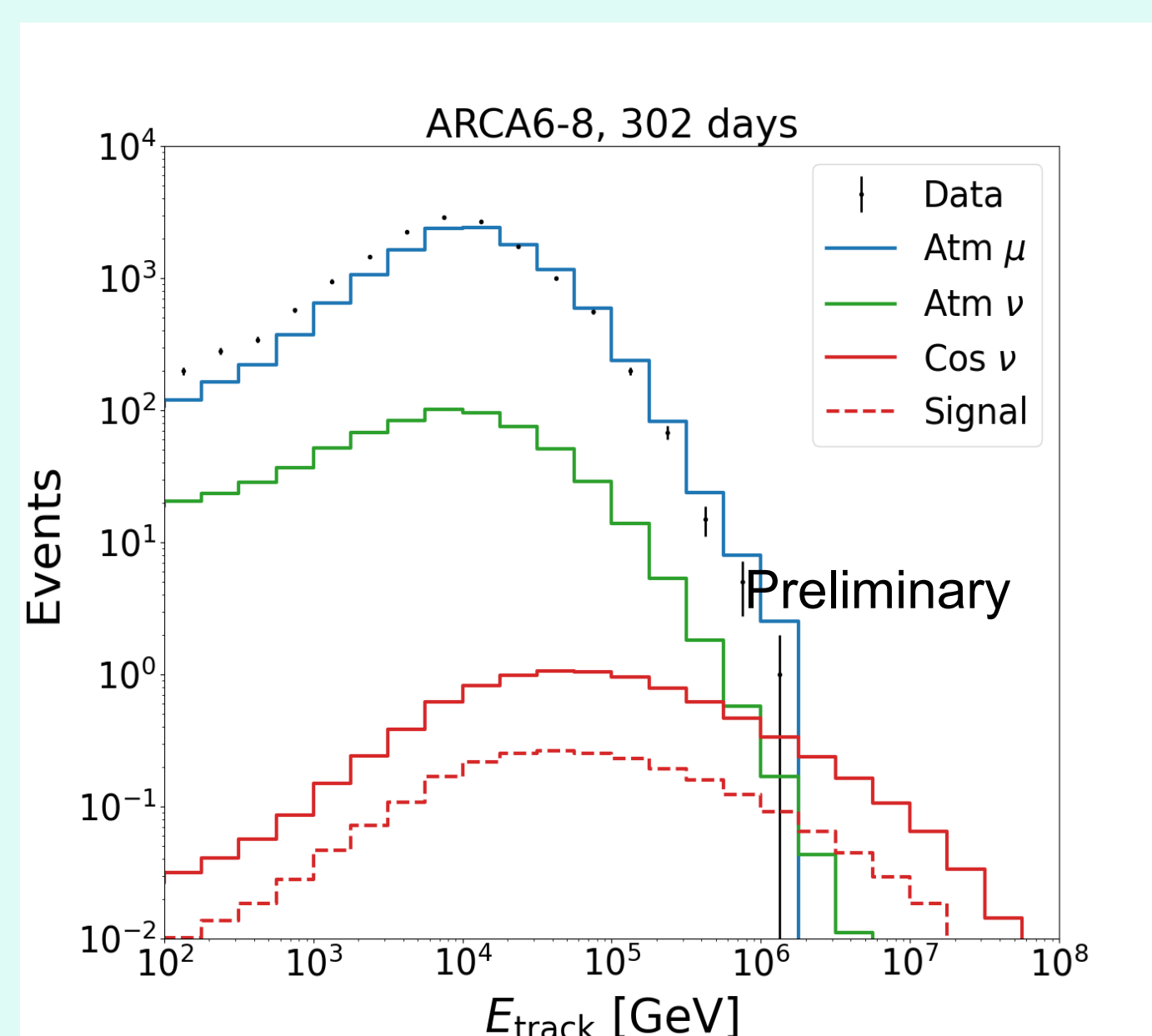
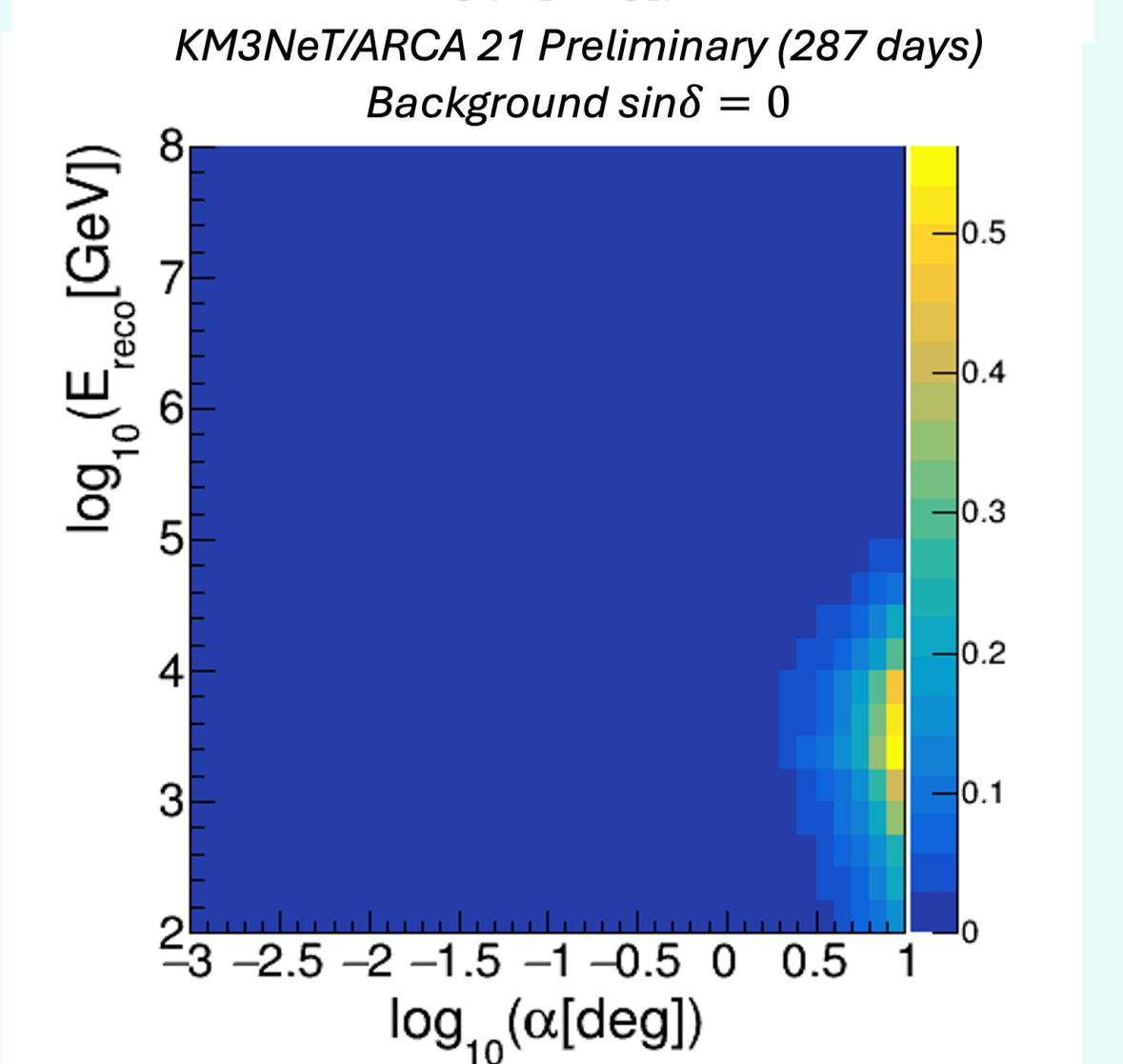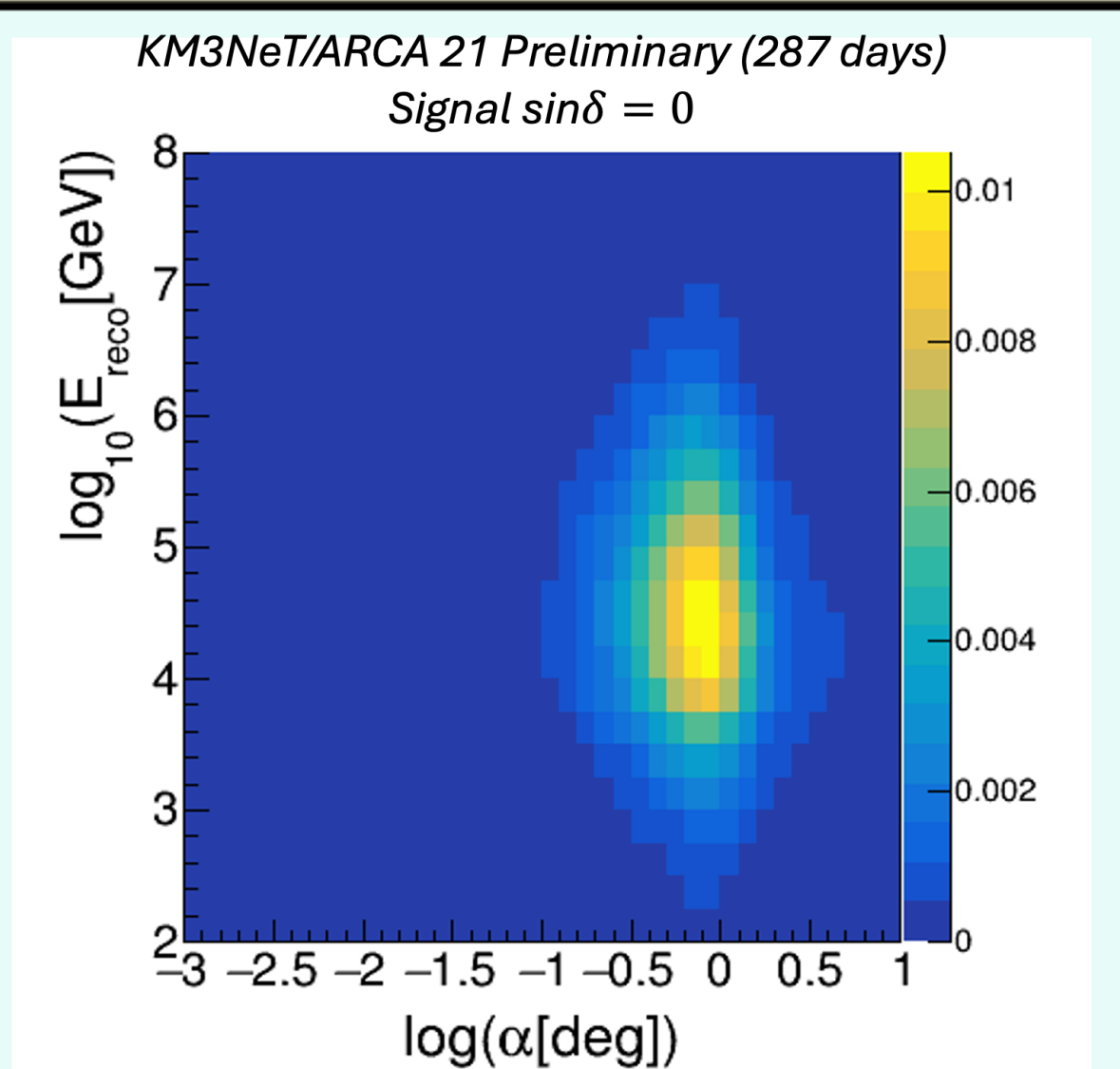**Detector Performance:** angular resolution and effective area
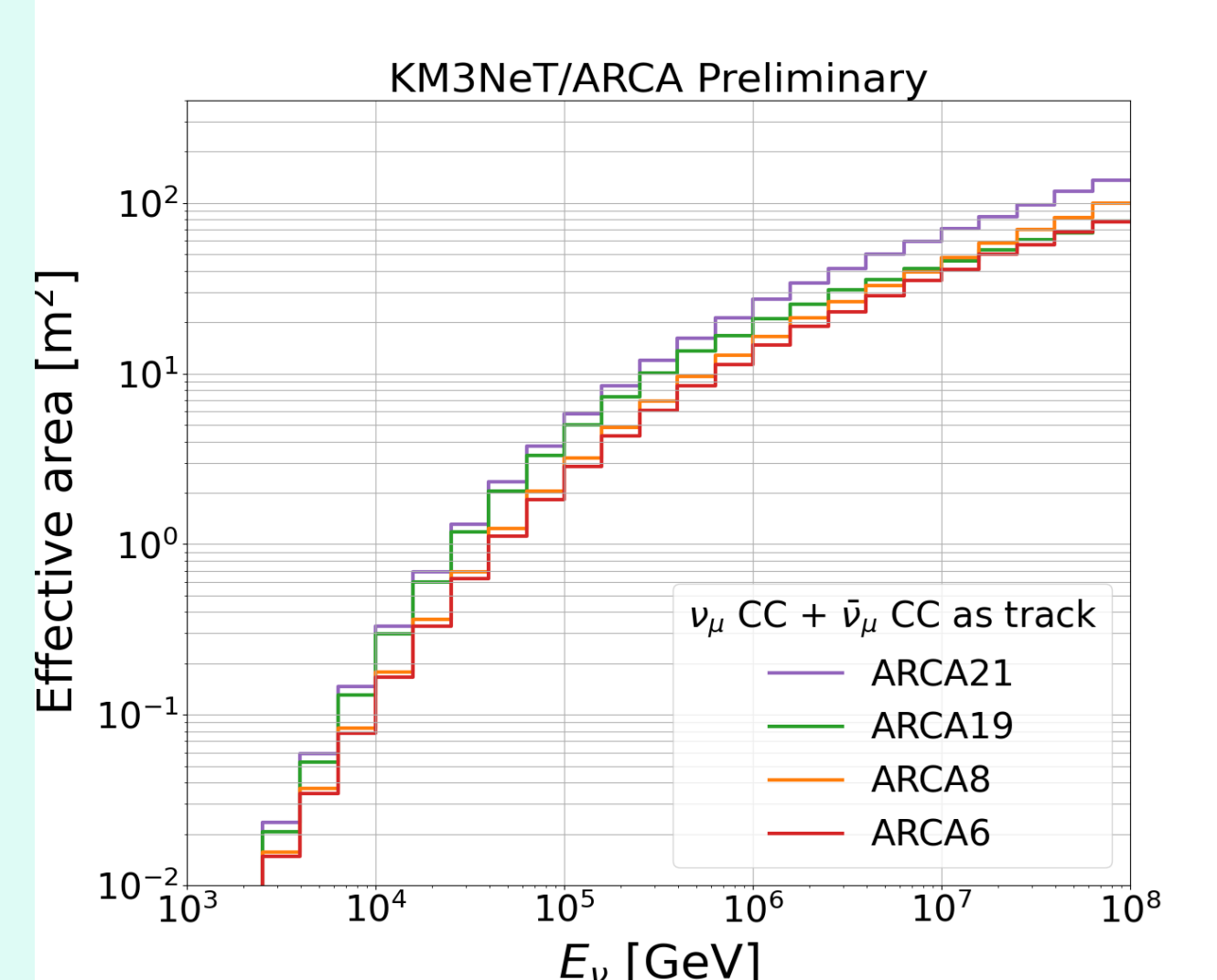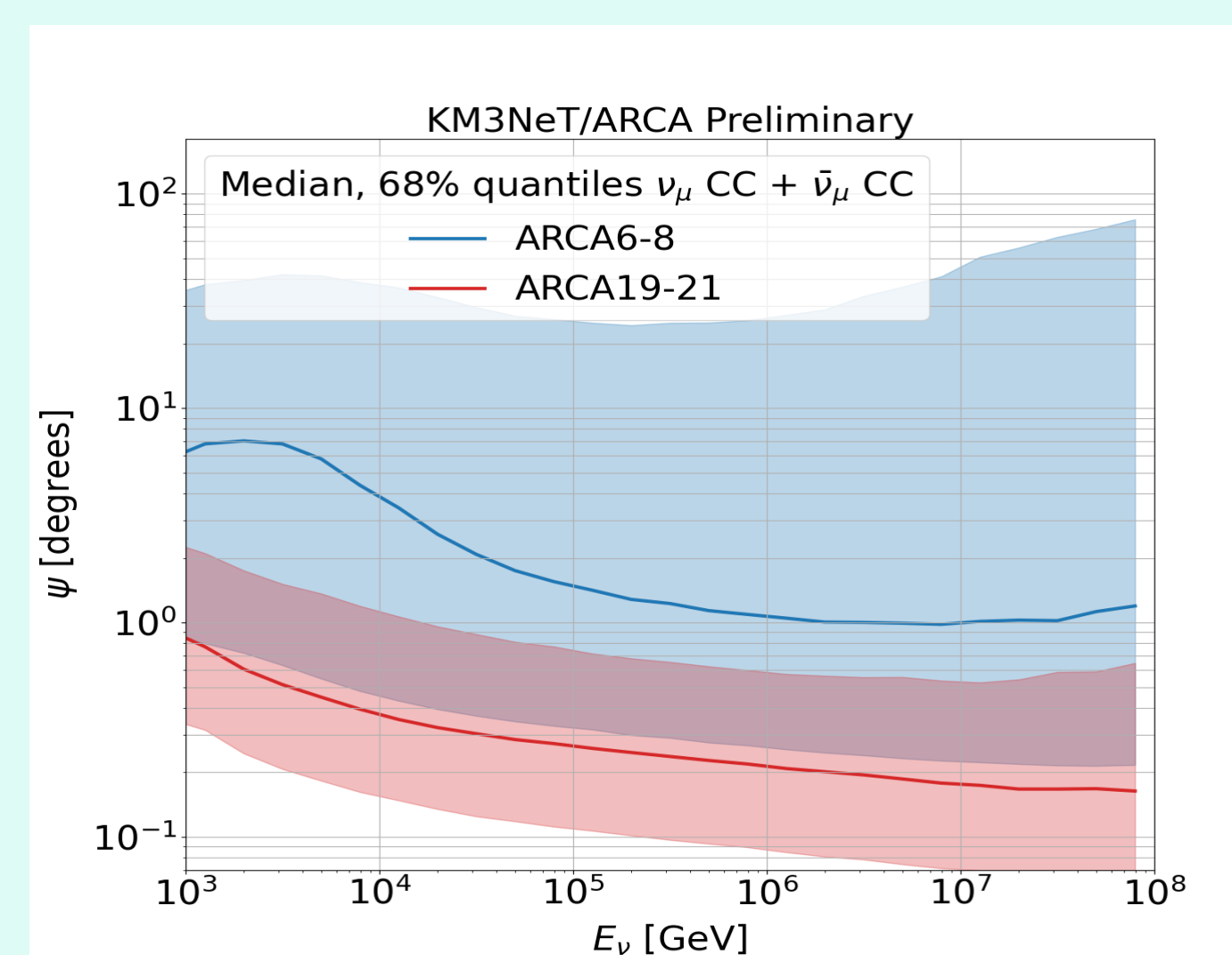
Point-like source search: binned likelihood method

- A **test statistic** λ is computed to quantify a possible excess of cosmic neutrino signal [3,4].
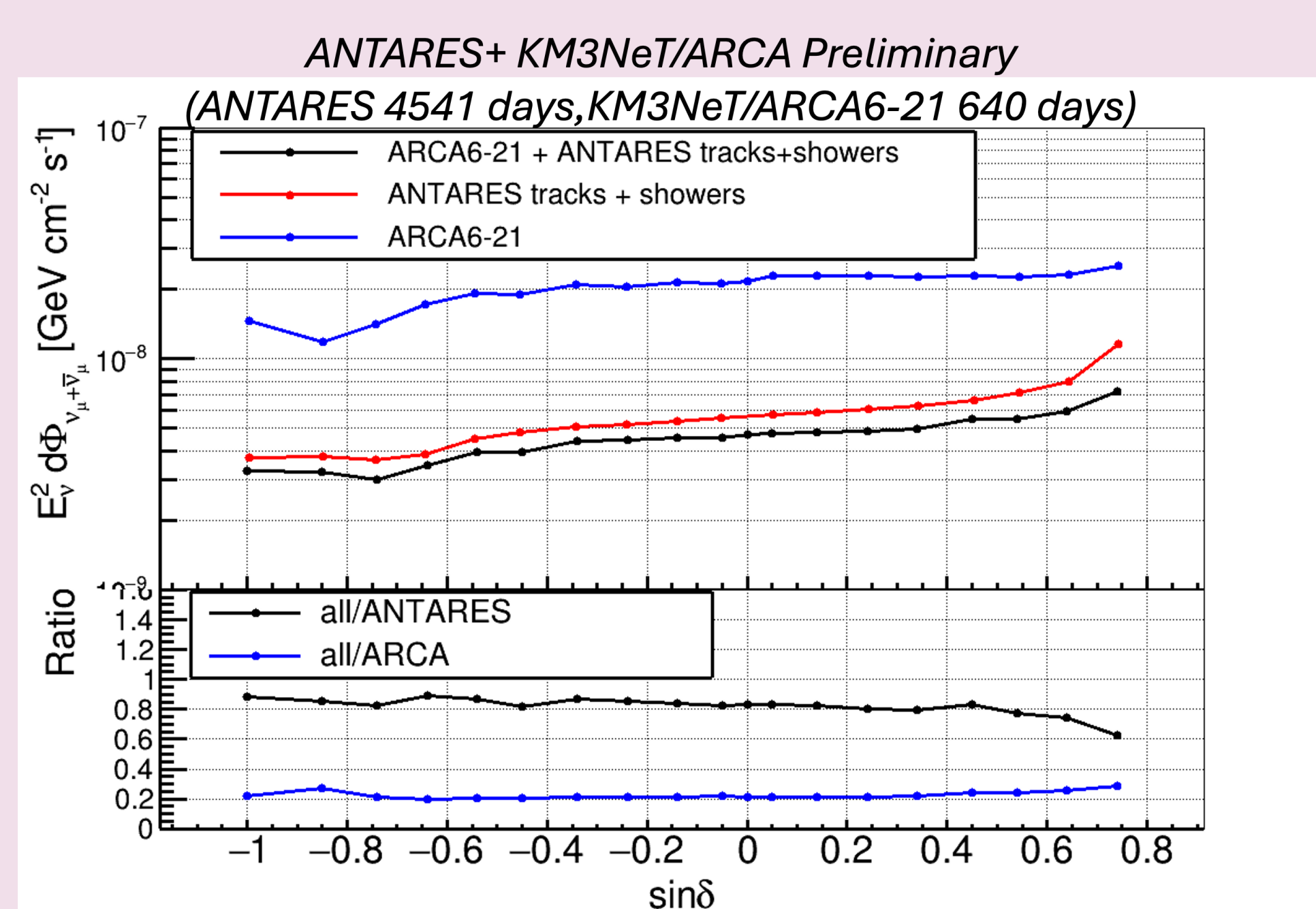
$$\lambda = \log L\left(\xi = \hat{\xi}\right) - \log L(\xi = 0)$$

$$\log L(\xi) = \sum_{i \in bins} N_i \log(B_i + \xi S_i) - B_i - \xi S_i$$
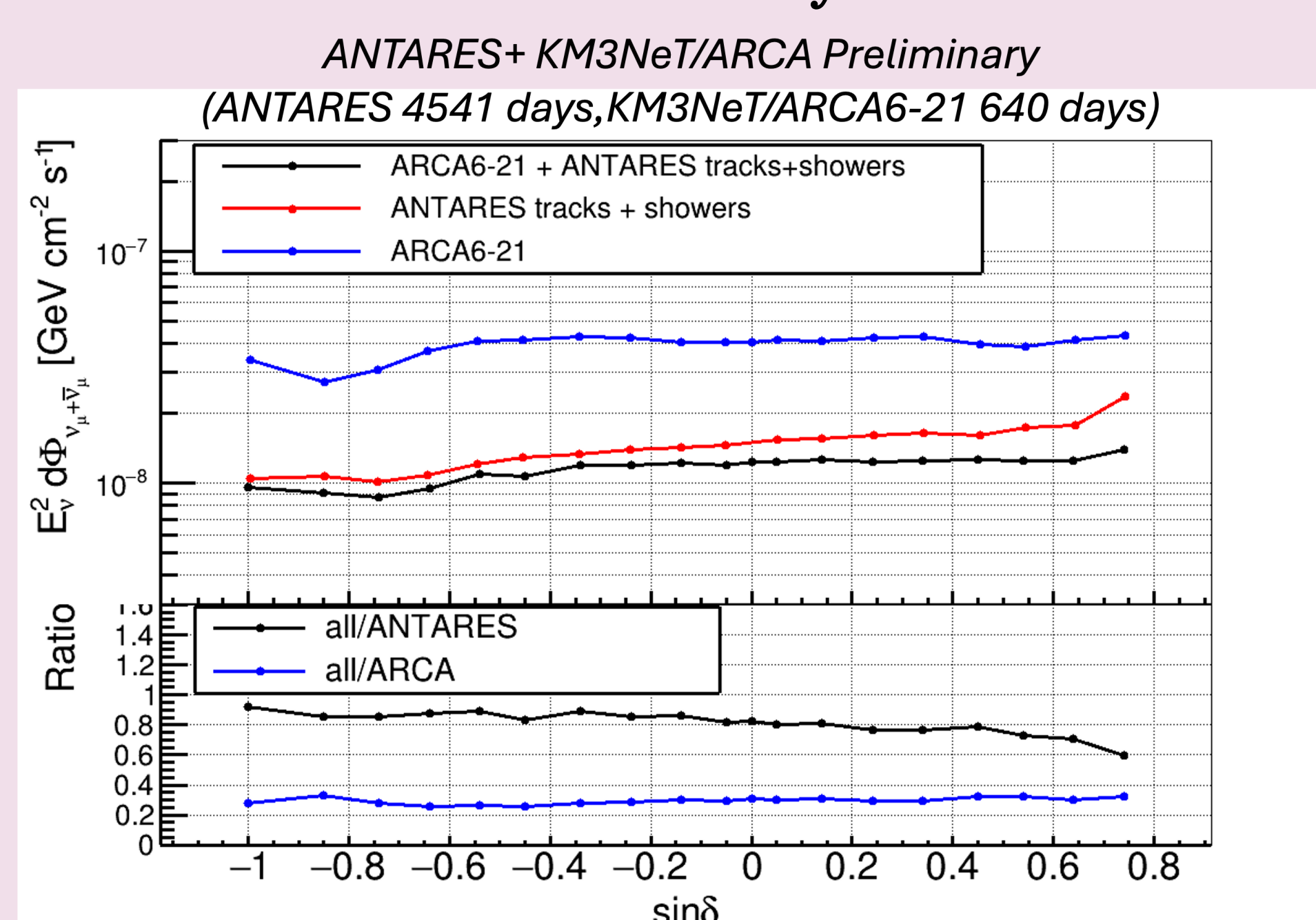

Sensitivity and Discovery

Sensitivity 90% C.L.

Discovery 5σ

Conclusions

- Sensitivity and Discovery computed using Neyman method, for the KM3NeT/ARCA and ANTARES datasets.
- ~20% improvement in sensitivity and discovery by adding the ARCA6-21 datasets to the ANTARES sample [5]

References: [1] ANTARES Collaboration Physics Report 1121(25) [2] KM3NeT Collaboration, Letter of Intent for KM3NeT 2.0. Journal of Physics G: Nuclear and Particle Physics, 43 (8), 08400 (2016) [3] R. Muller et al. PoS(ICRC2023) 444 (2023) 1018 [4] R.Muller, et al. PoS(ICRC2025) 1124 [5] B.Caiffi et al. PoS(ICRC2025) "Combined KM3NeT/ARCA and ANTARES search for point-like neutrino emission". .