Search for Astrophysical Neutrinos from 1FLE Blazars with IceCube

Paper by IceCube Collaboration

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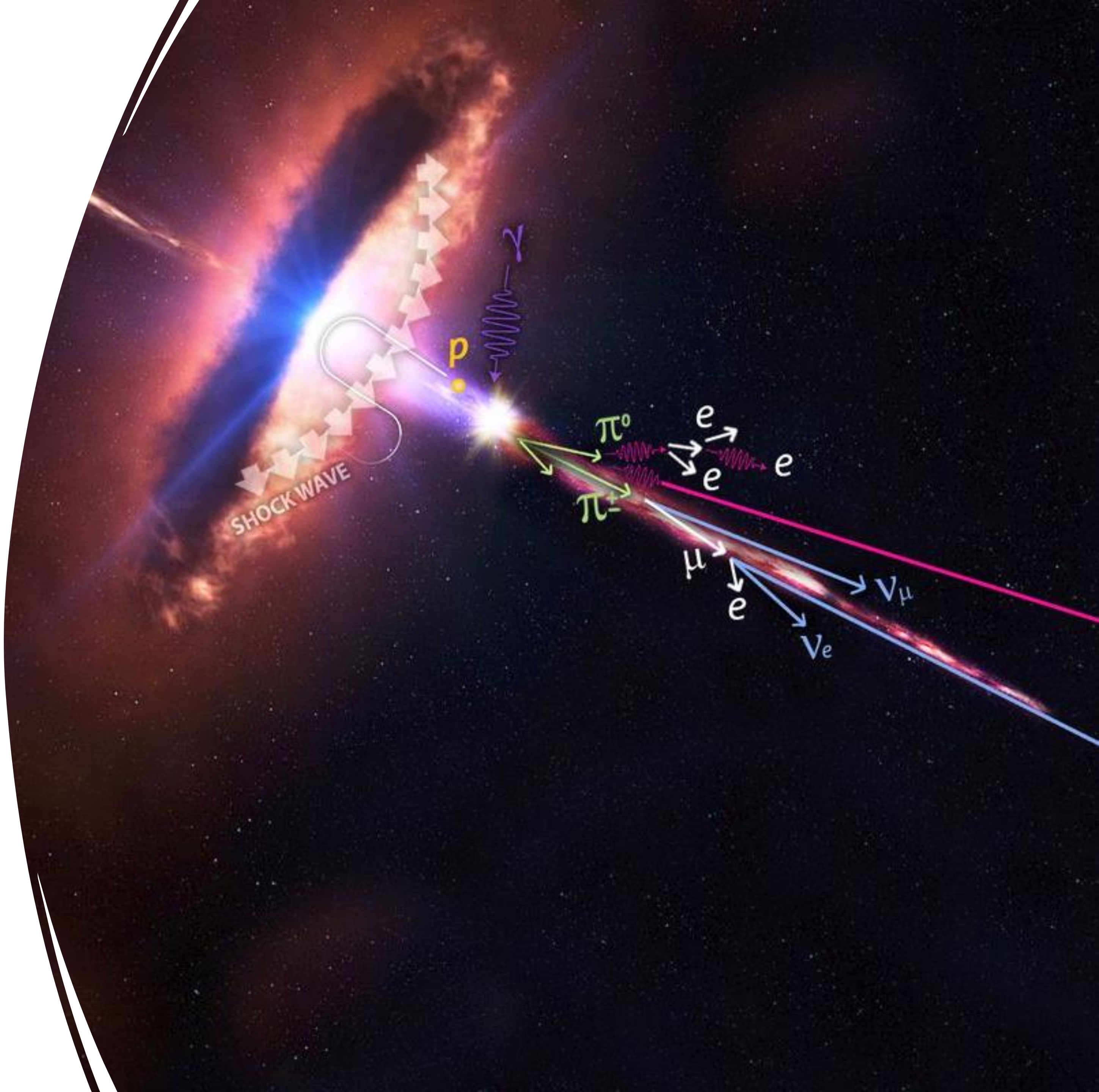
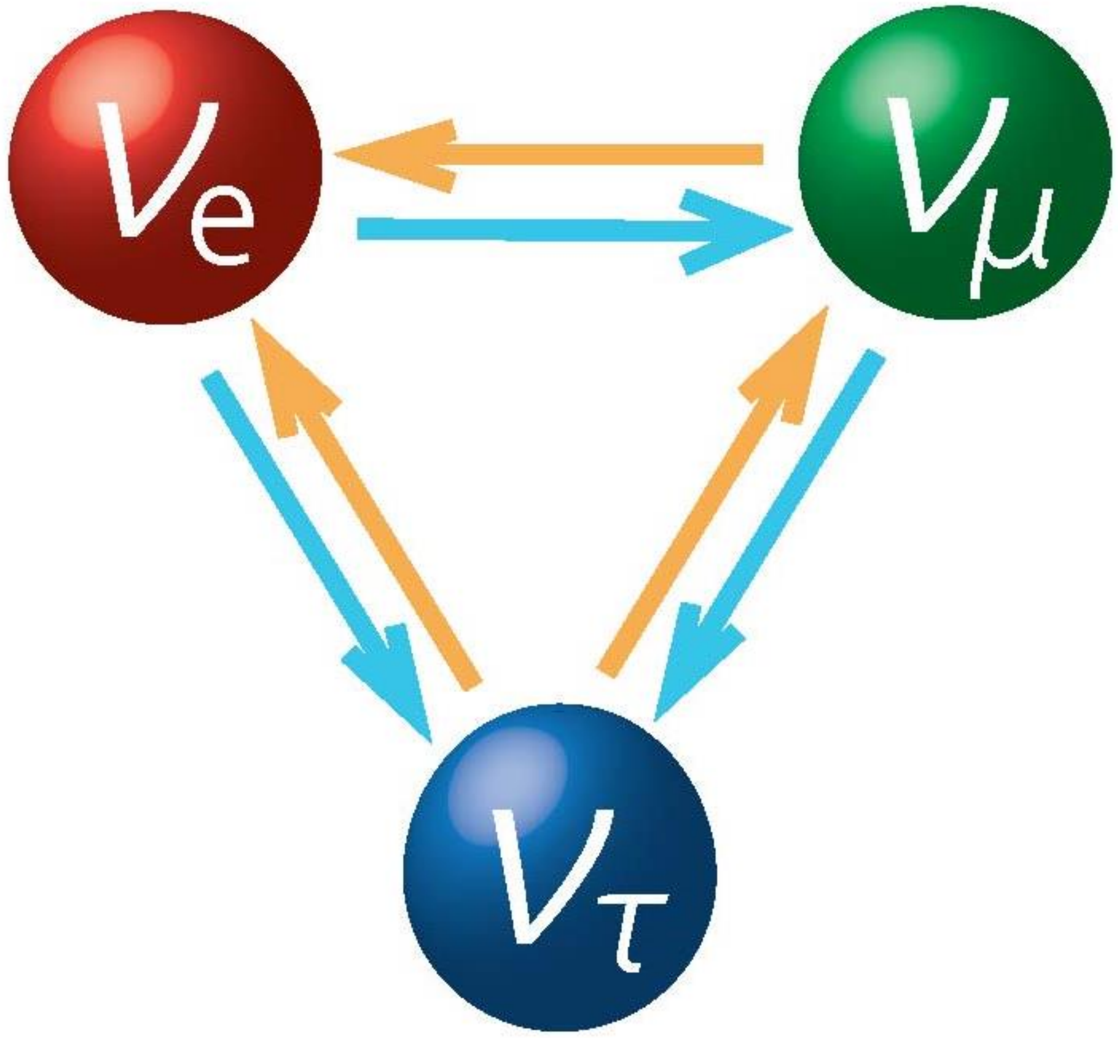
BACKGROUND

- What is neutrinos?
- What is ICE CUBE?
- What is Blazars?



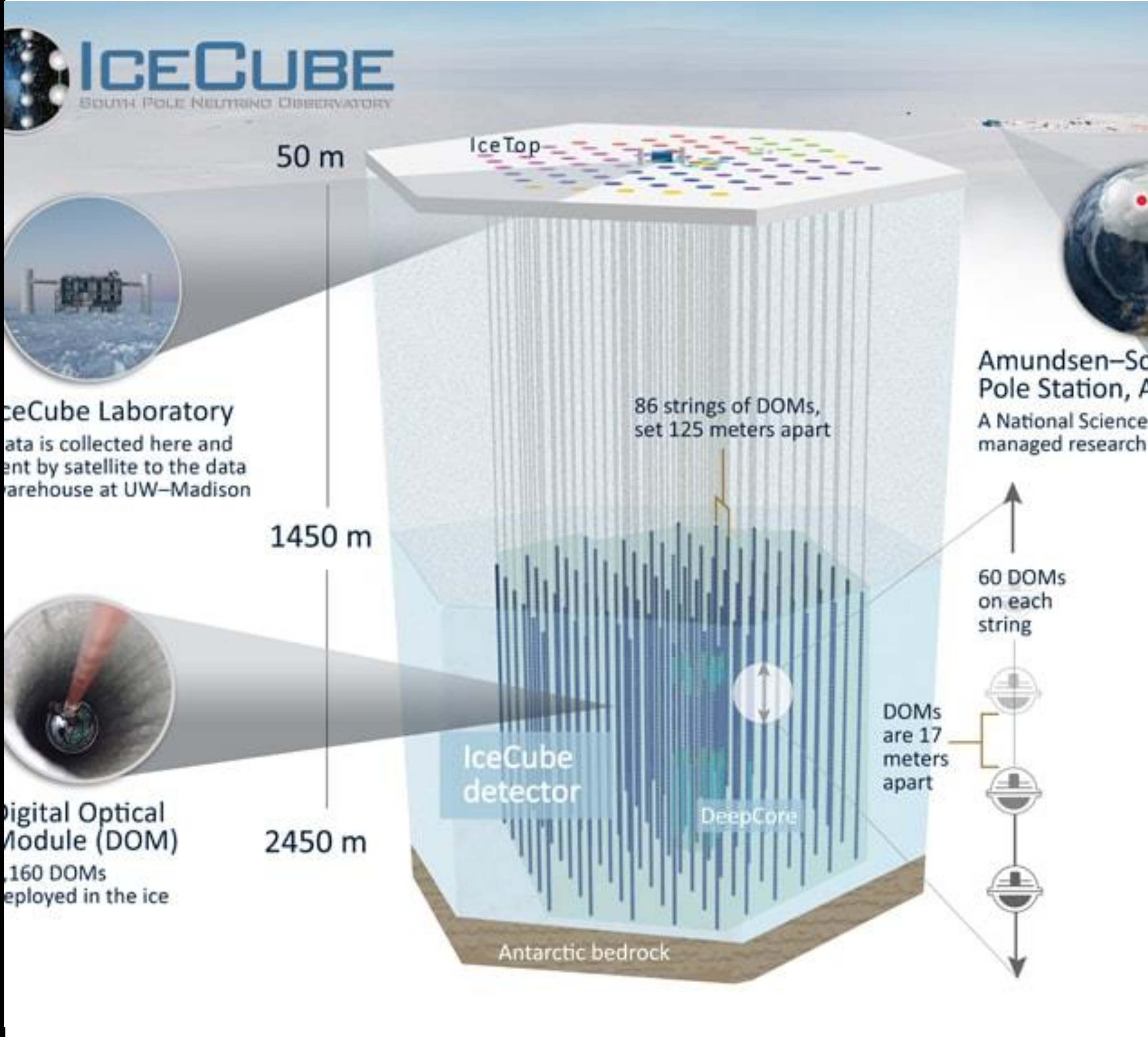
NEUTRINOS

- Neutrinos are one of the most abundant particles in the universe.
- Neutrinos only interact with the weak force.
- The emission of neutrinos is generally considered a strong sign of cosmic ray acceleration.
- Neutrino production is a sign of hadronic emission scenario.



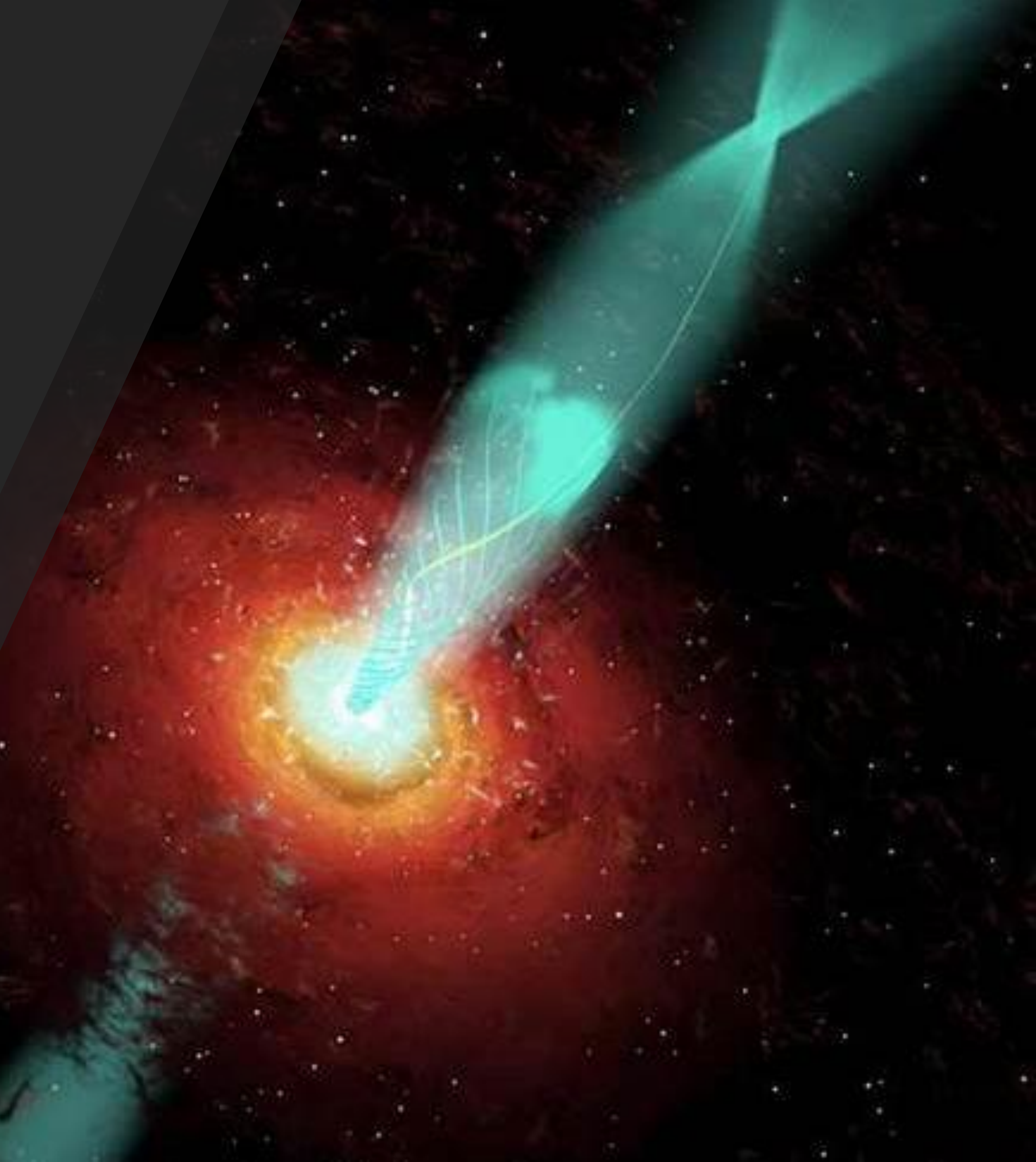
ICE CUBE

- Is a cubic-kilometer Cherenkov light detector located at the geographic South Pole.
- Can detect neutrinos and other cosmic rays.
- Looks at Neutrino energies > 100 GeV
- 1134451 track events collected between 4/6/2008 and 7/8/2018 are used for this analysis.



BLAZARS

- An **active galactic nucleus** (**AGN**) is a compact region at the center of a galaxy that has a much-higher-than-normal luminosity.
- A blazar is an AGN with a jet pointed toward the Earth.
- Current observations of blazars are unable to distinguish between leptonic, hadronic, and mixed emission scenarios.
- The paper focus on 137 Blazars in the first Fermi –LAT low energy catalog (1FLE). (30-100 MeV photon energy flux.)



Why Neutrinos and Blazars?

Neutrinos

Unknow origin high-energy cosmic rays have been observed that implies the existence of powerful astrophysical particle accelerators.

Charged particles traveling through the Universe are deflected by interstellar and intergalactic magnetic fields.

Neutrinos travel along a straight path from their sources making them useful messengers for observing cosmic ray accelerators.

1FLE Blazars

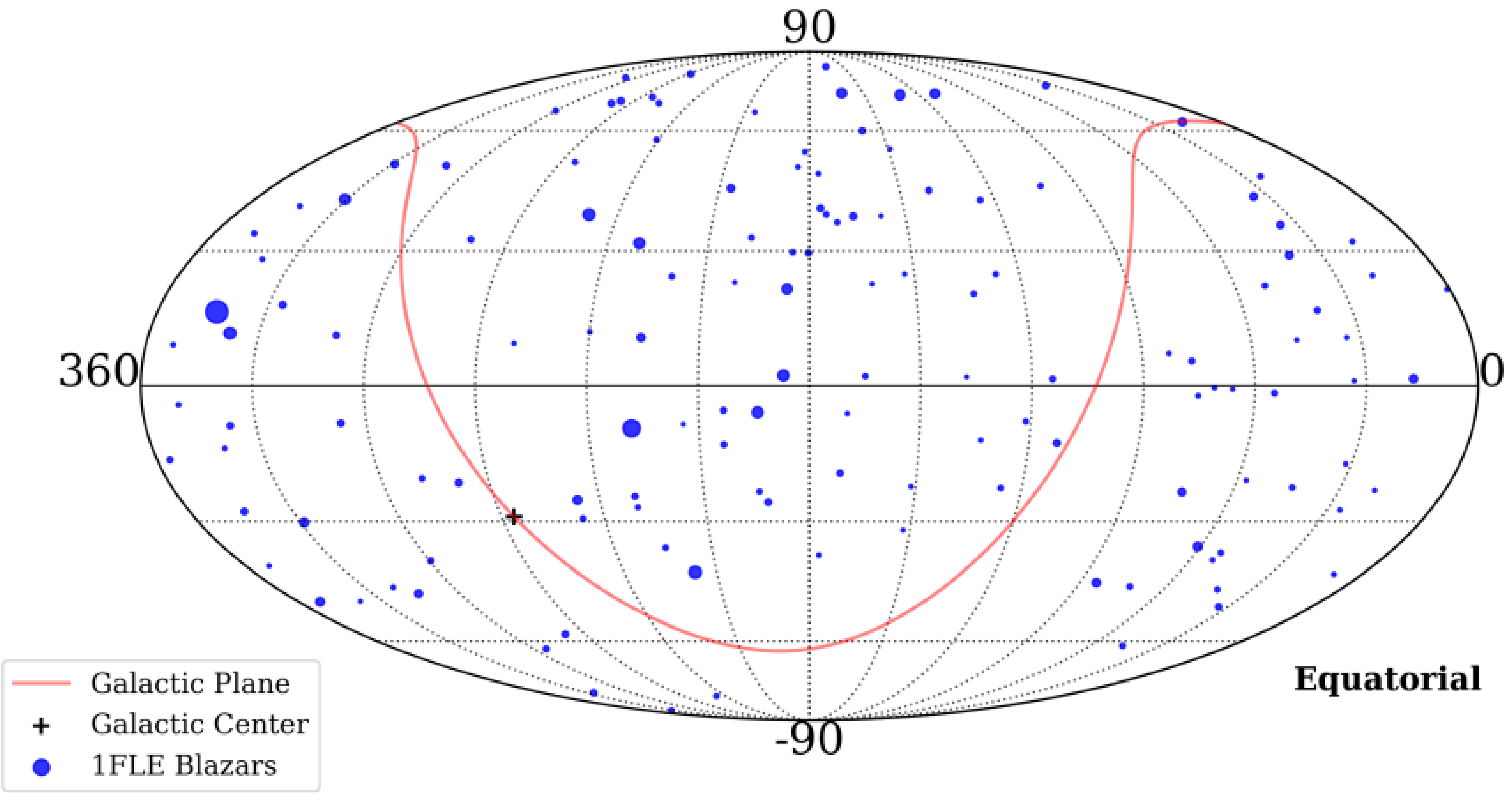
Blazars are promising source candidates for neutrino production.

Previous searches for neutrino emission from populations of blazars detected in >= GeV gamma-rays have not observed any significant neutrino excess.

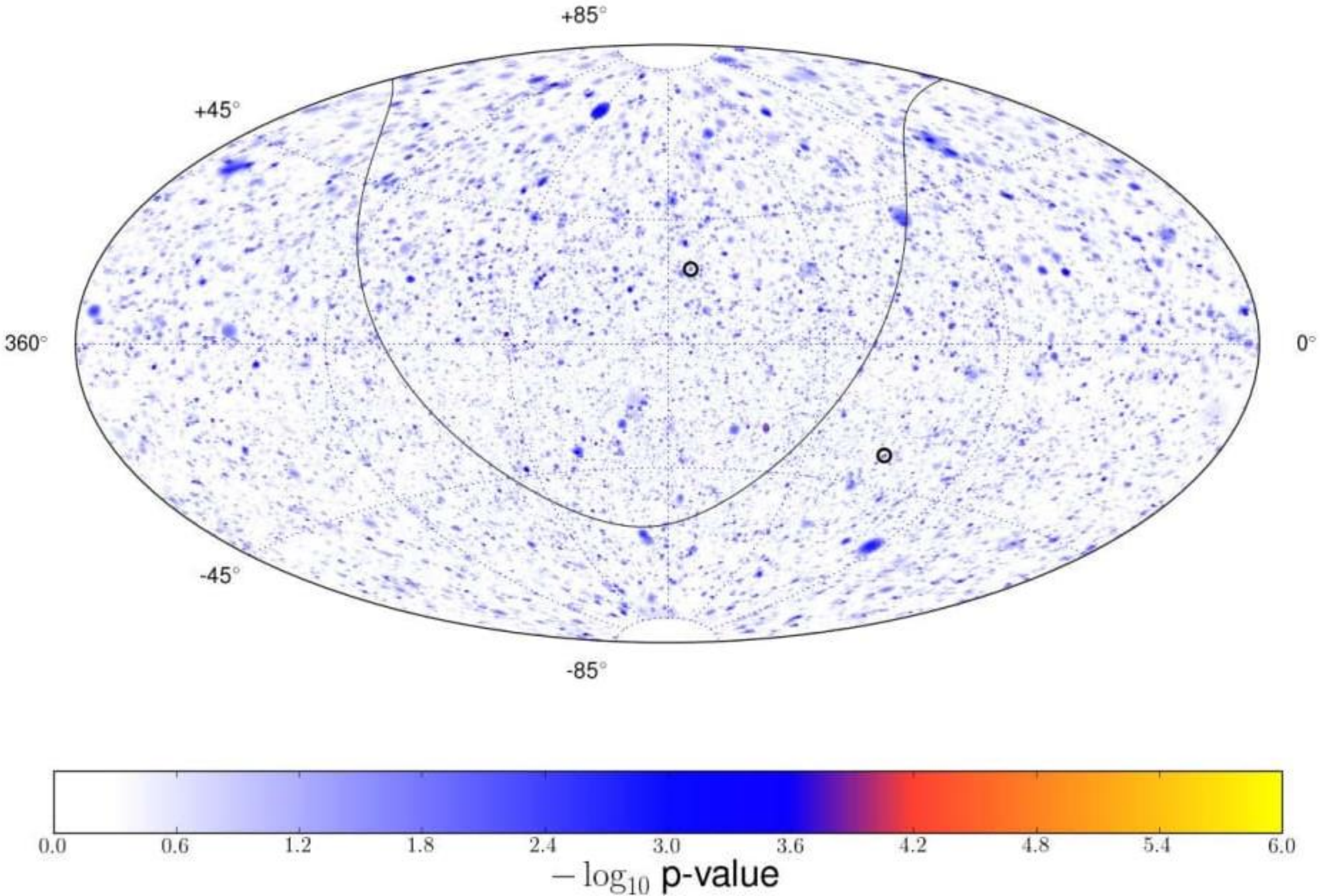
Fermi –LAT blazar sources are detected at photon energy below 100 MeV (1FLE)

Theory suggest that MeV photons could be more effective indicators of TeV-PeV neutrinos.

Sky map showing locations of 1FLE blazars



The Neutrino Sky Map



ANALYSIS METHODS

- The Maximum likelihood method makes use of location and energy information to determine a possible correlation between IceCube neutrinos and 1FLE blazars.
- A test statistic (TS) is then constructed to compare the best-fit signal hypothesis to a background-only hypothesis (zero signal events).

$$\mathcal{L}(n_s, \gamma) = \prod_i^N \left(\frac{n_s}{N} S_i + \left(1 - \frac{n_s}{N}\right) B_i \right)$$

$$\mathrm{TS} = -2 \log \left(\frac{\mathcal{L}(n_s = 0)}{\mathcal{L}(n_s, \gamma)} \right)$$

Weighting scheme (Wj): based on a chosen emission hypothesis

Equal: equally-weighted sources.

Flux: sources weighted by their integrated photon energy fluxes in the 30-100 MeV range.

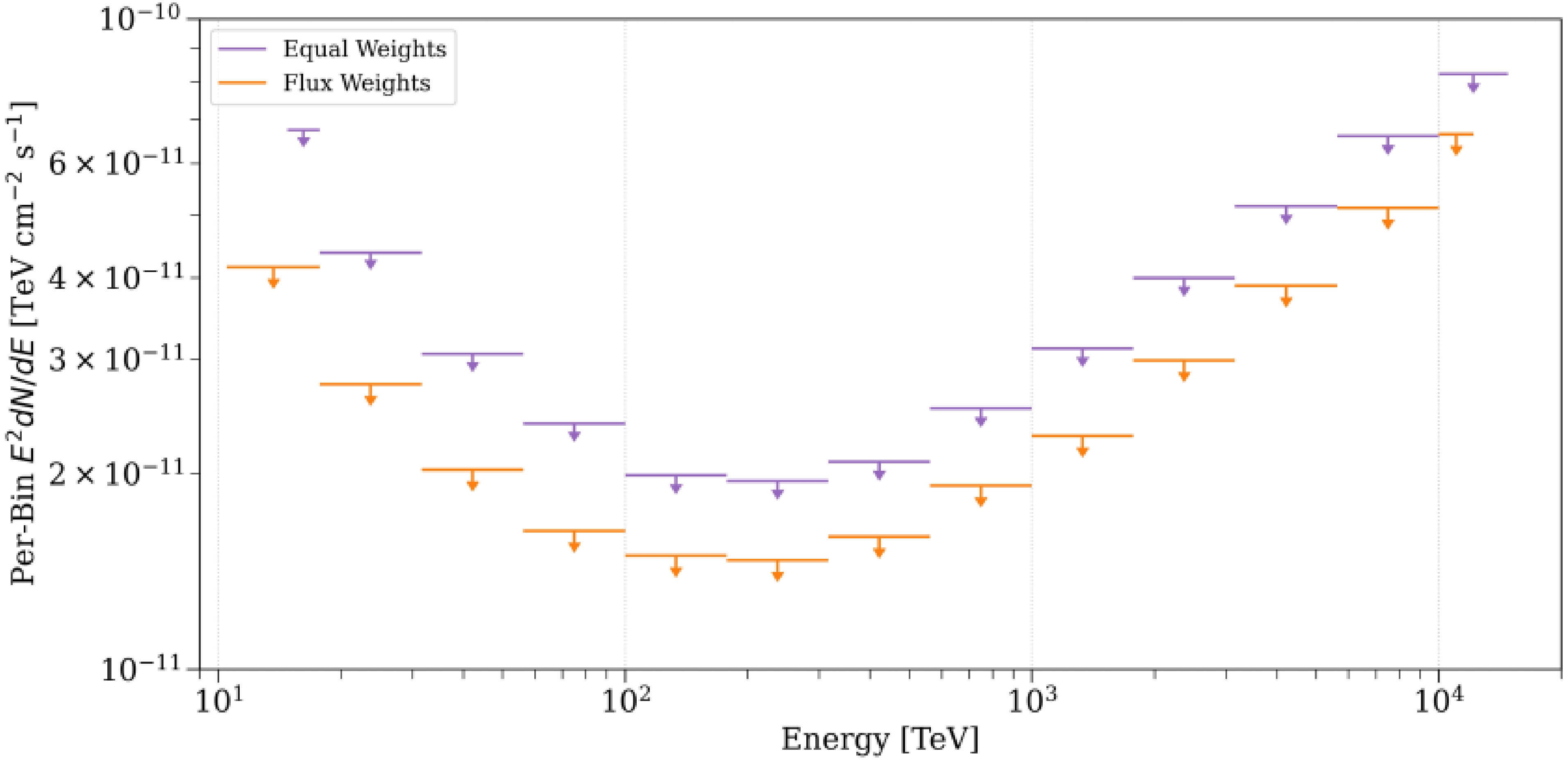
$$S_i = \sum_j^M w_j R_j S_i^j$$

Weighted Source

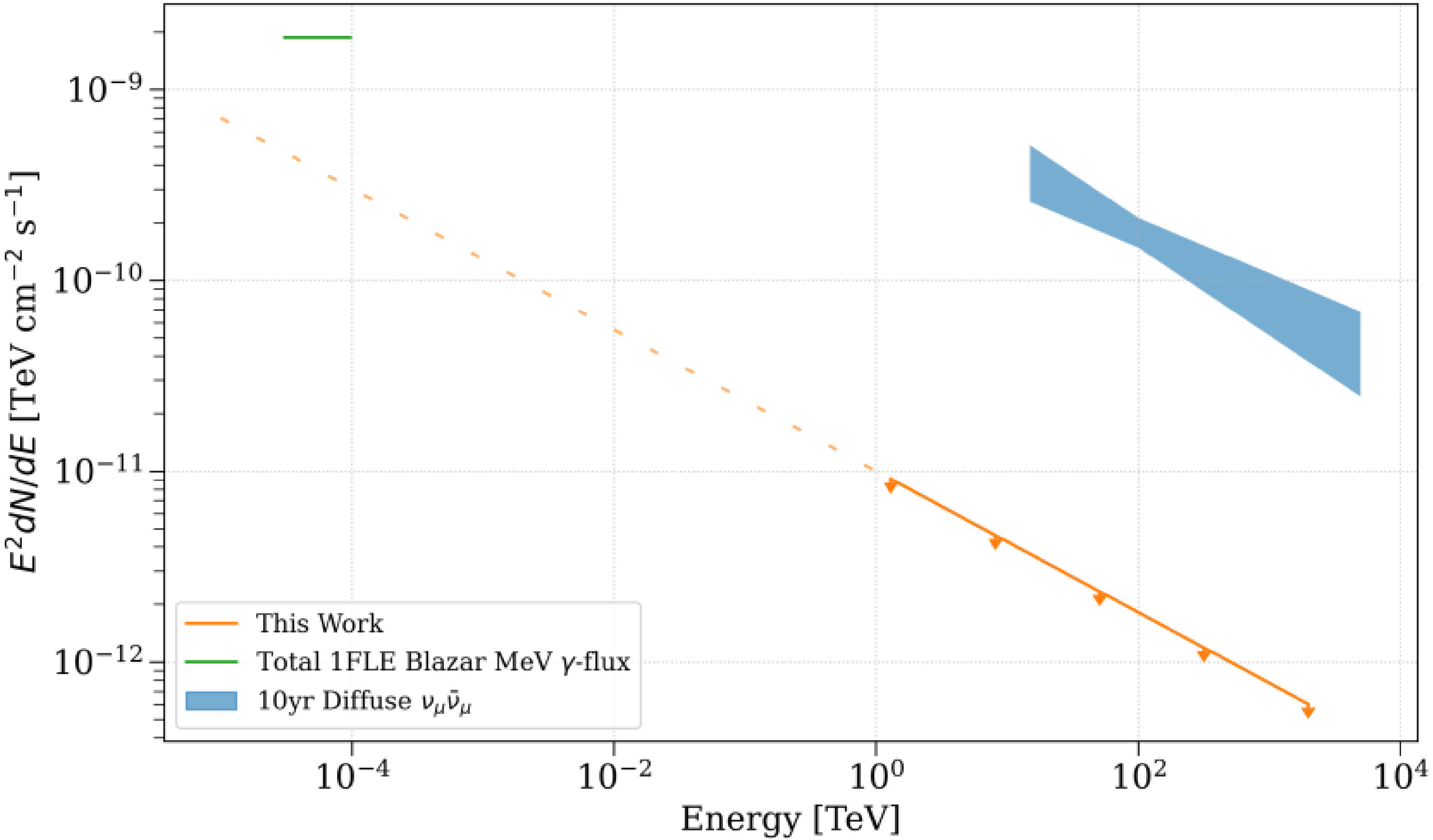
RESULTS

- The best-fit number of signal events for both source-weighting hypotheses is found to be zero, implying the background-only hypothesis for both equal and flux source weighting schemes.
- 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 a 90% confidence level (approximately 1% of IceCube's diffuse muon-neutrino flux measurement).

90% confidence level upper limits on energy-scaled neutrino (νμ + ν̄μ) flux from 1FLE blazars in four differential bins per decade of energy.



90% confidence level upper limit on energy-scaled neutrino ($\nu_\mu + \bar{\nu}_\mu$) flux from 1FLE blazars assuming a simple power-law (orange)



SUMMARY & CONCLUSION

- Neutrinos' characteristics make them useful messengers for observing cosmic ray accelerators.
- Blazars are promising source candidates for astrophysical neutrinos.
- The results of this analysis are found to be consistent with a background-only hypothesis.
- The 30-100 MeV photon energy range might not be strongly correlated with the emission of TeV-PeV astrophysical neutrinos in blazars.
- The results could offer insight into the contribution of hadronic interactions to the observed blazar flux distribution.

THE END

Thank you for listening