Neutrinos from Ultra-Fast Outflows

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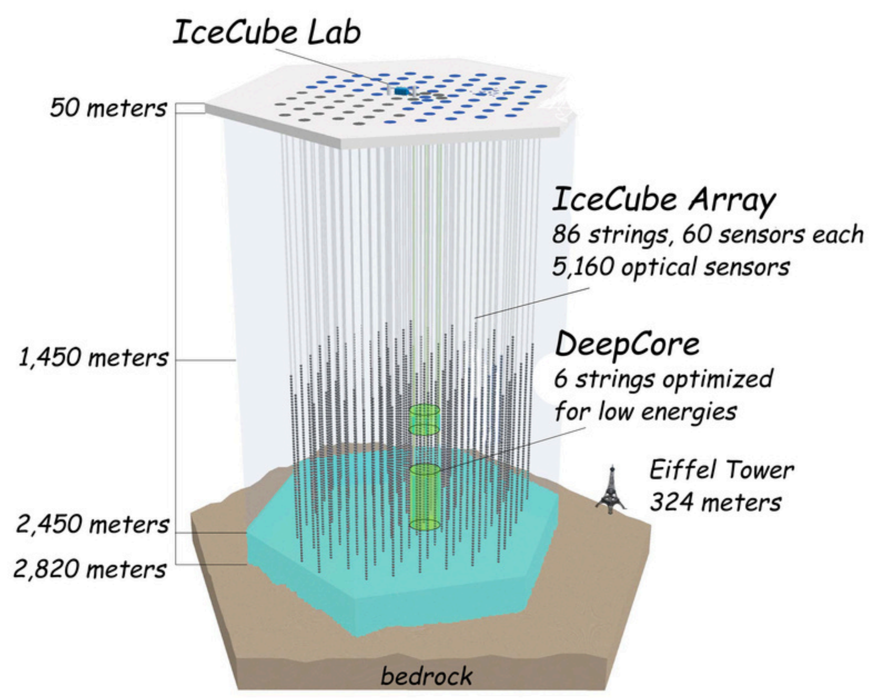
GRAD MAP SUMMER SCHOLARS

ICECUBE

The IceCube Neutrino Observatory[1] is located in the South Pole and seeks to observe high energy neutrinos and locate their origins in space.

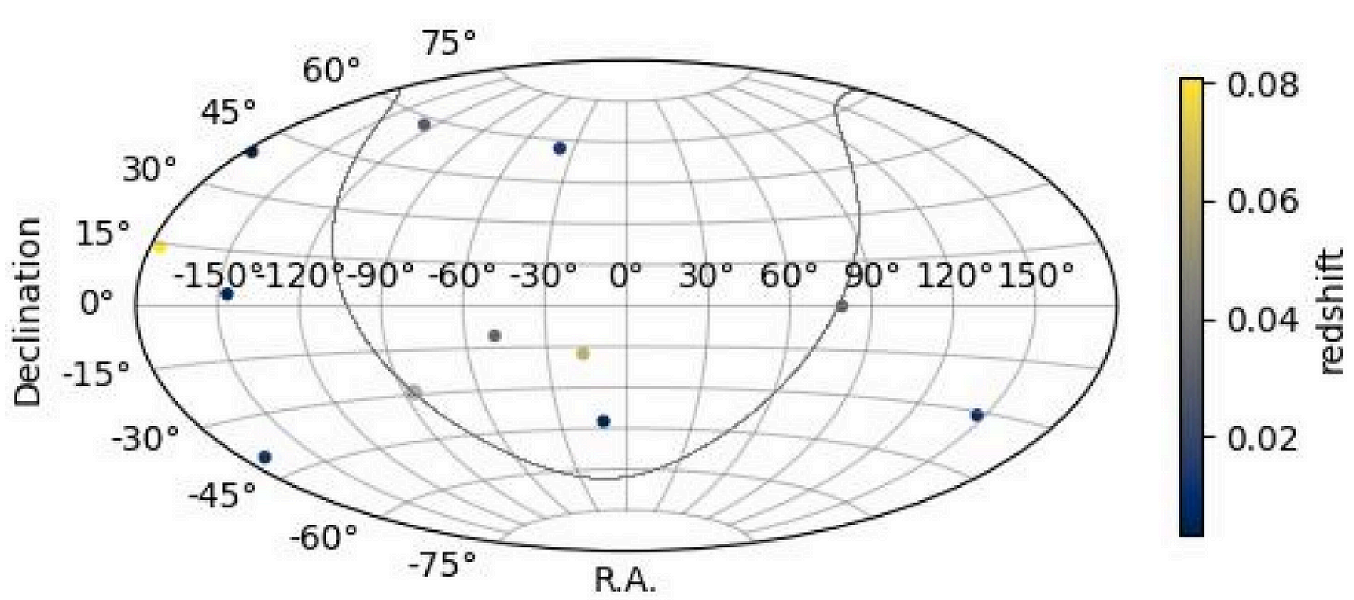


IceCube detects these neutrinos by detecting the light released when they interact with the ice. This light is called Cherenkov radiation.

ULTRA-FAST OUTFLOWS

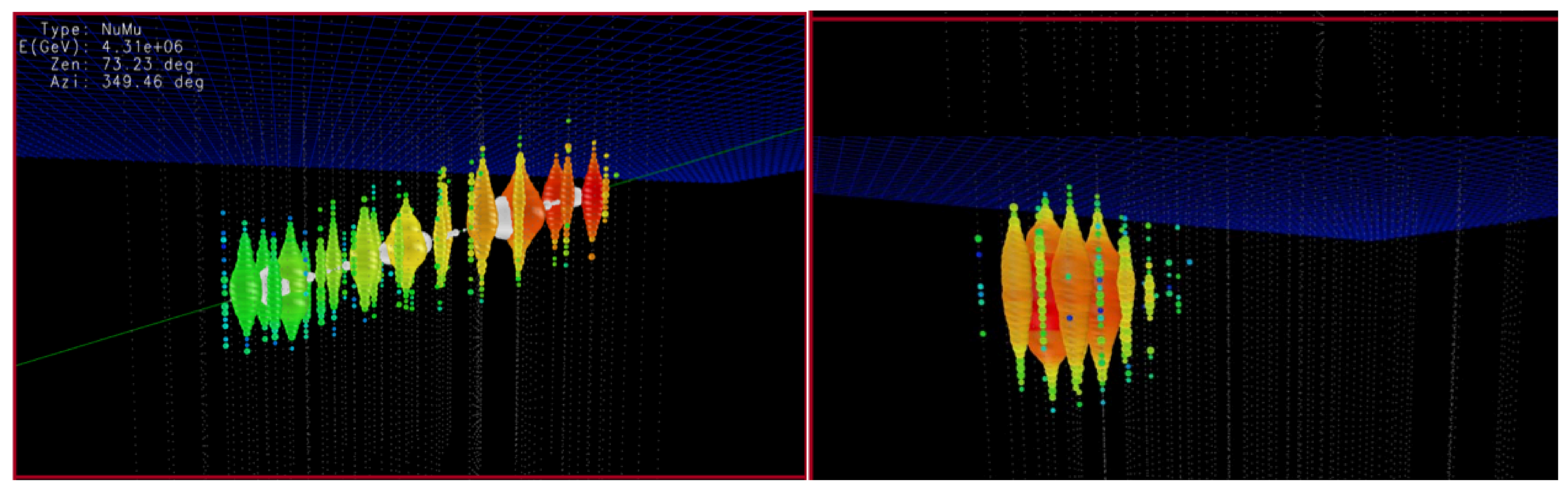
Ultra-fast outflows (UFOs) are wide-angled winds that are launch by supermassive black holes in active galactic centers[2]. These winds have velocities comparable to supernova explosions, making them good contenders to be cosmic ray accelerators.

We are looking at 11 UFOs identified by Fermi-LAT[2] as potential cosmic ray accelerators. We graphed them on a sky map to see where in the sky we are looking for the neutrinos to come from.



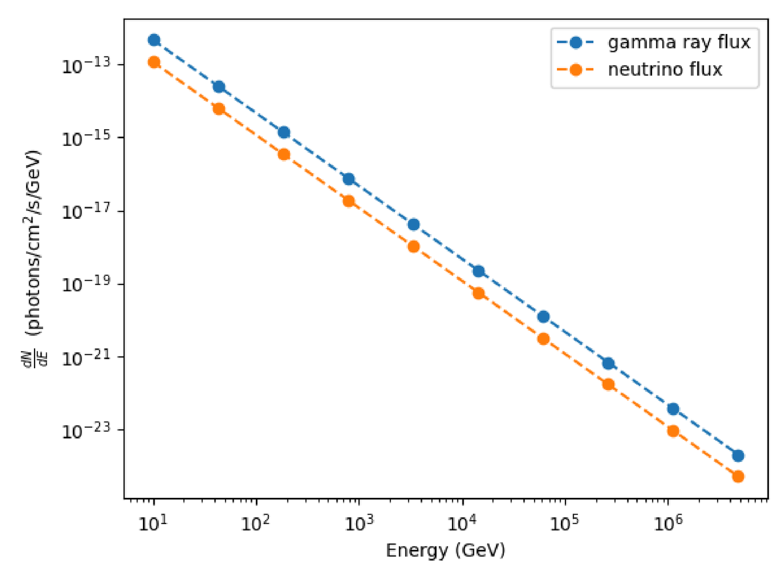
METHOD

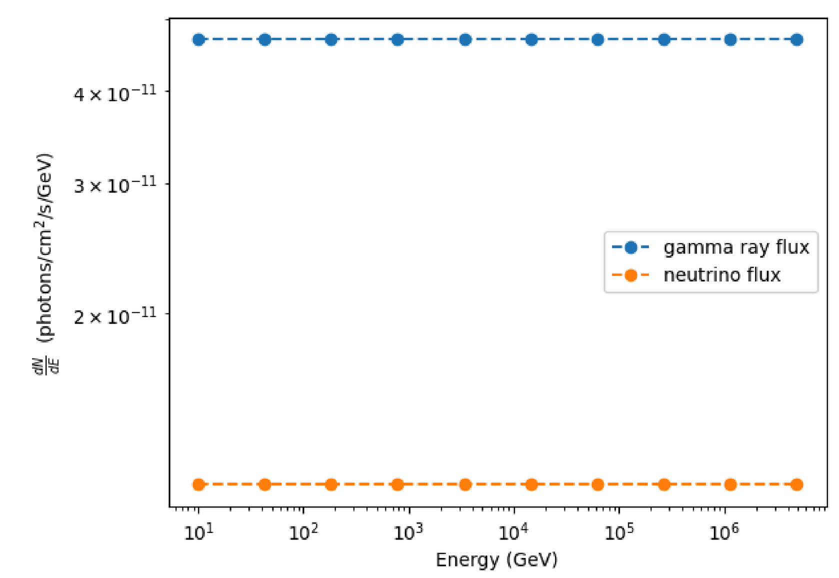
Neutrino events can be separated into two categories: tracks and cascades. Tracks occur when the neutrino releases a muon that travels in a straight path through the detector. Cascades occur when the muon also knocks loose an atom in the ice and cause a shower of other stuff that the detector picks up.



We are looking at a sample of neutrino tracks from IceCube to see if any of the neutrinos in the sample come from any of our 11 UFOs.

Fermi calculated the gamma ray flux from each of these sources that we then converted to a neutrino flux and plotted both against energy[3].

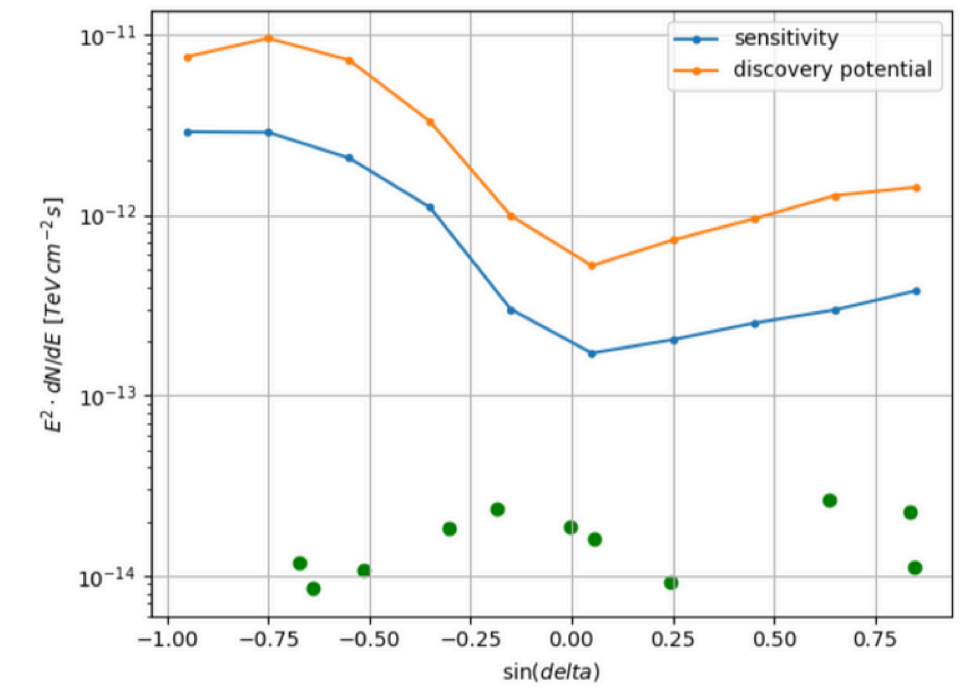




The graph for flux (dN/dE) vs. energy is converted to an E^2 * dN/dE vs. energy graph that displays a normalized value of the flux. There is a graph for each flux value (not all displayed here).

Each value of E^2 dN/dE for its respective source is plotted against the sine of its declination (in radians). We compare these to our sensitivity graph to find out if the IceCube observatory will be able to see our sources.

CONCLUSIONS



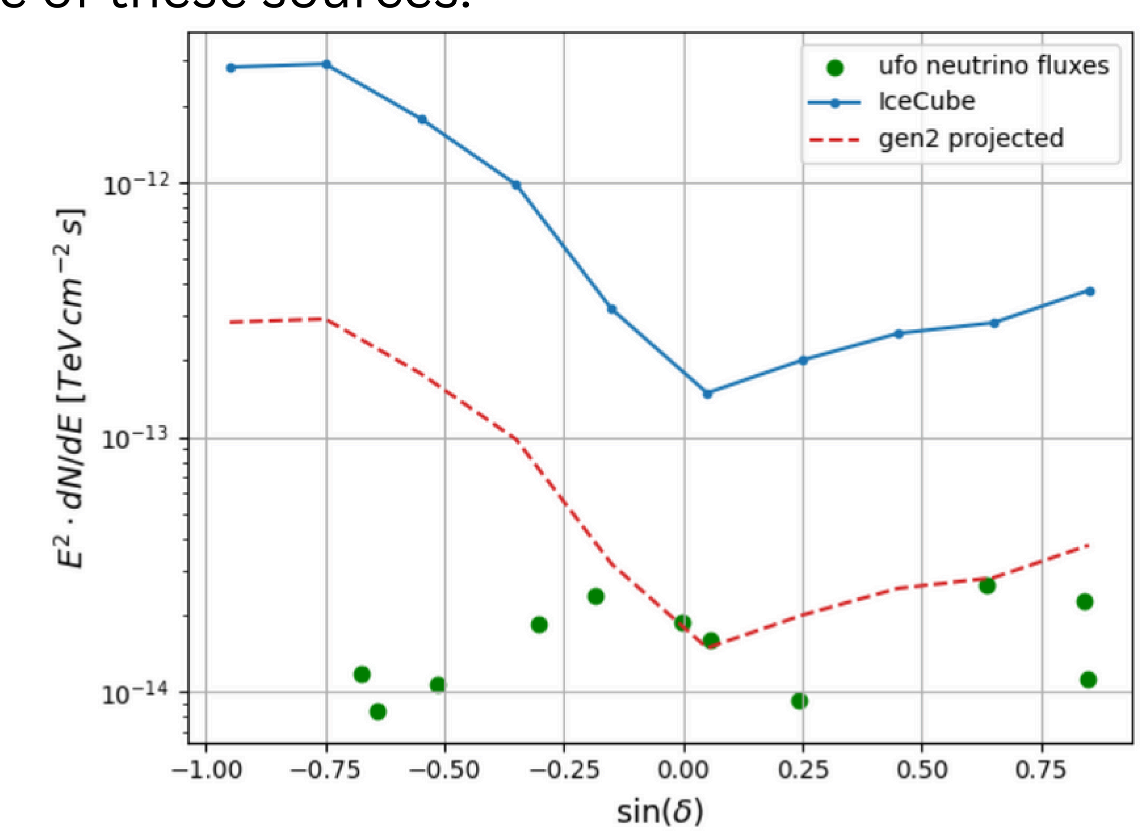
This is the resulting sensitivity graph with the neutrino fluxes (in green) plotted as individual points.

The neutrino flux from our sources is almost two orders of magnitude smaller than what IceCube needs in order to see them.

NEXT STEPS

Currently, the sensitivity is being calculated with only 800 trials. Moving forward using more trials will yield a smoother sensitivity graph. We can also look at other ufos to see if IceCube will see them.

Generation 2 of IceCube is being built and is going to be 10 times more sensitive which would allow us to see some of these sources.



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References:

[1] Halzen and Klein (2010) IceCube: An Instrument for Neutrino Astronomy https://arxiv.org/pdf/1007.1247

[2] M. Ajello et al. (2021) Gamma Rays from Fast Black-Hole Winds https://arxiv.org/pdf/2105.11469

[3] Ahlerz and Halzen (2017) IceCube: Neutrinos and multimessenger astronomy https://inspirehep.net/files/78a1dde7841cc9a2a18e9f75e639279e