

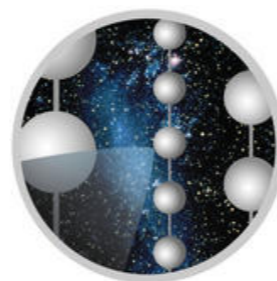
Search for High-Energy Neutrinos from Tidal Disruption Events (TDEs)

Astroparticle School 2018

Robert Stein



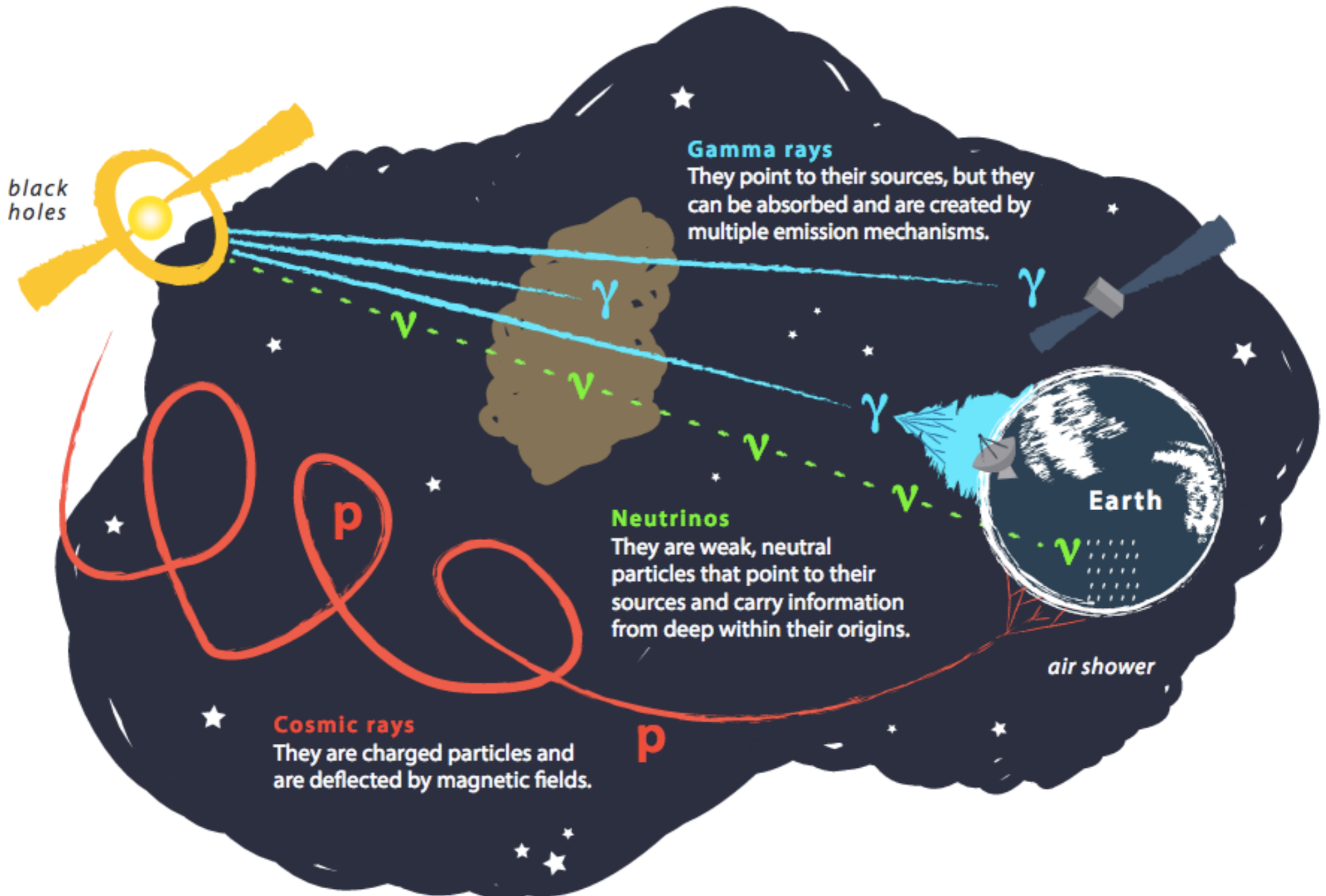
HELMHOLTZ
Young Investigators



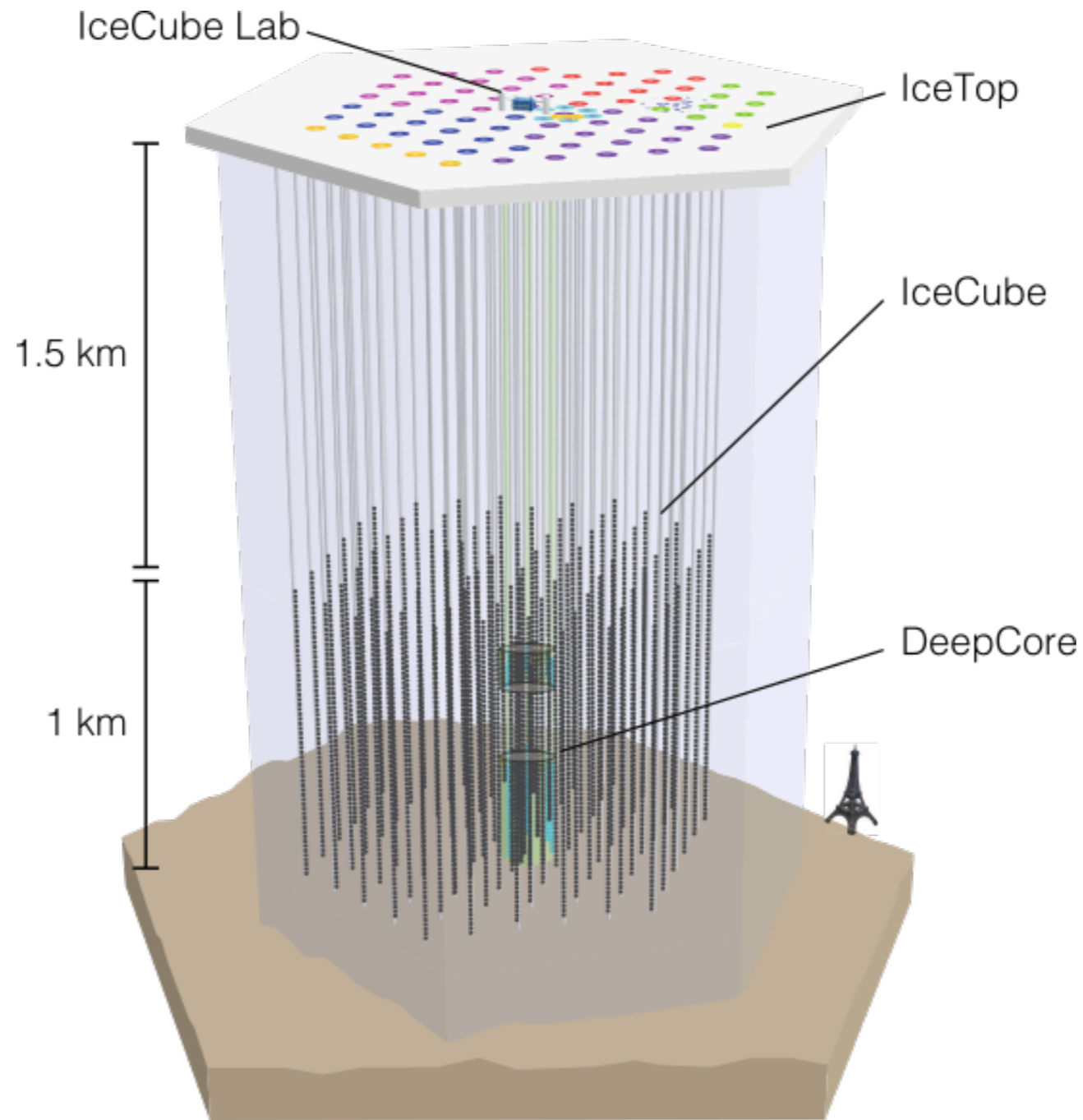
ICECUBE
SOUTH POLE NEUTRINO OBSERVATORY



The dawn of Multi-messenger Astronomy

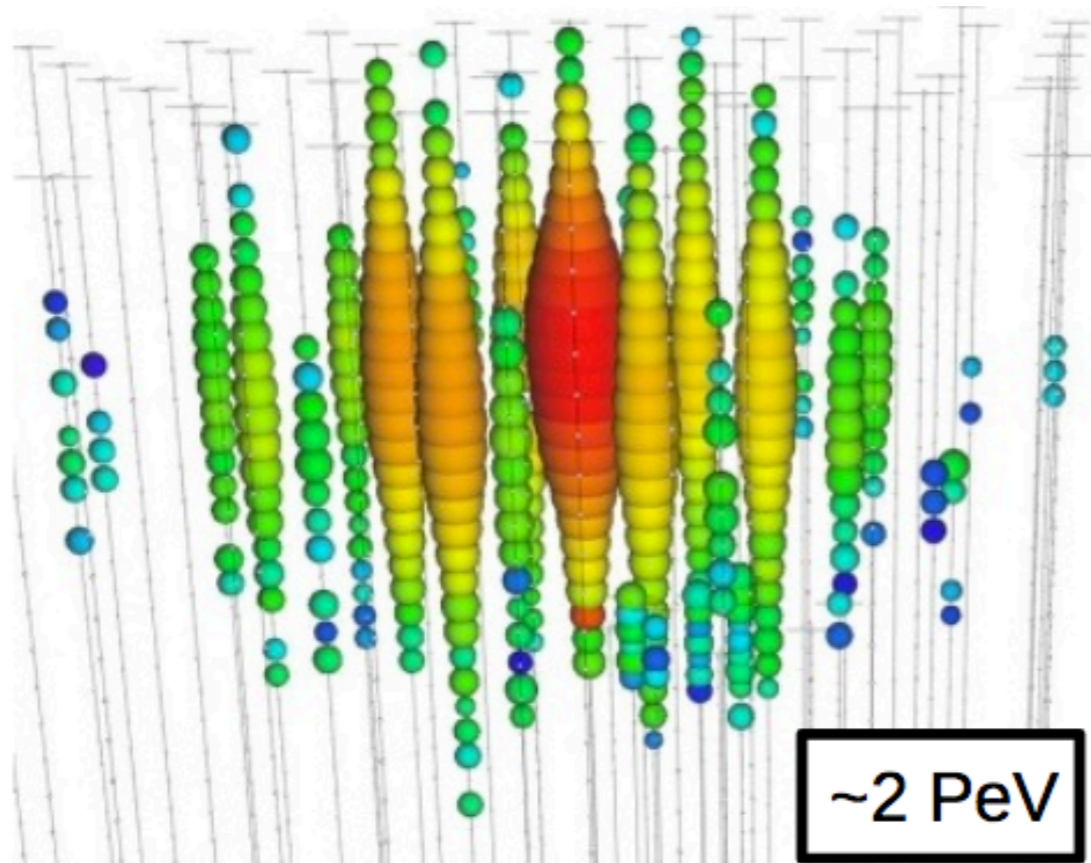


Introducing the IceCube Neutrino Observatory...

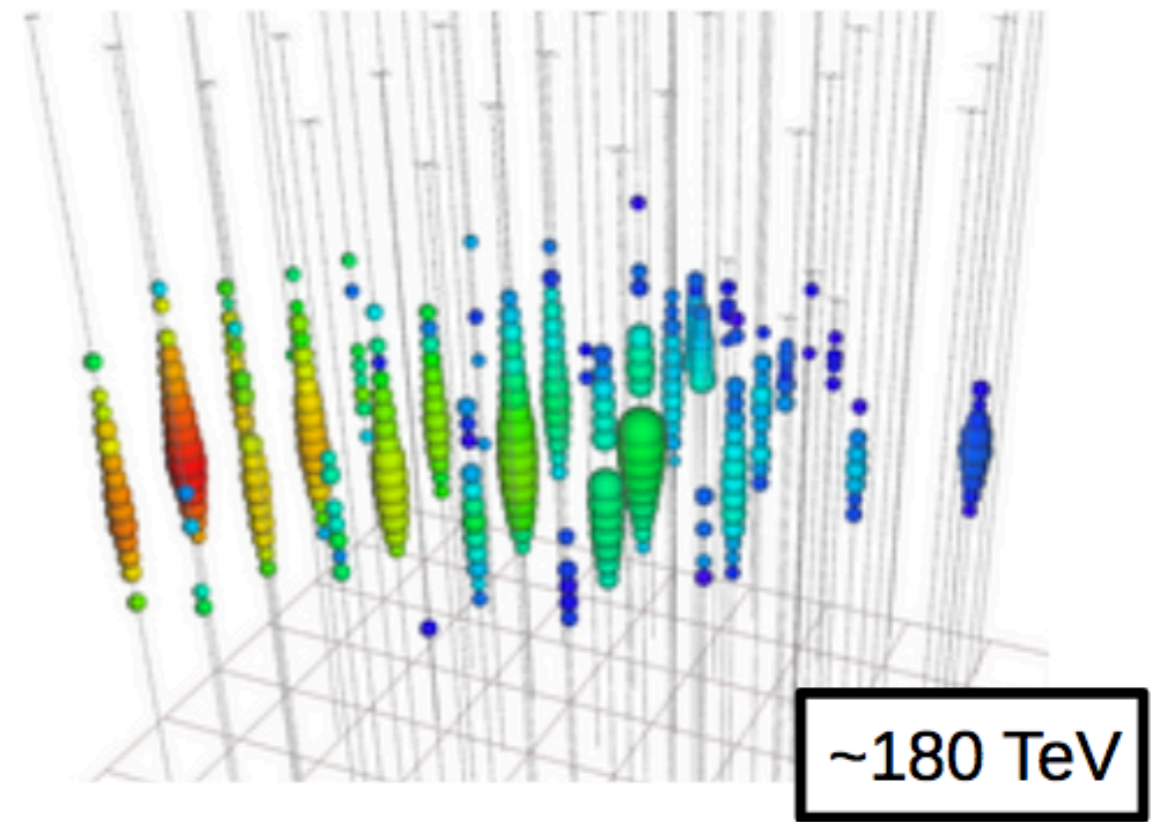


What does IceCube actually see?

Cascades

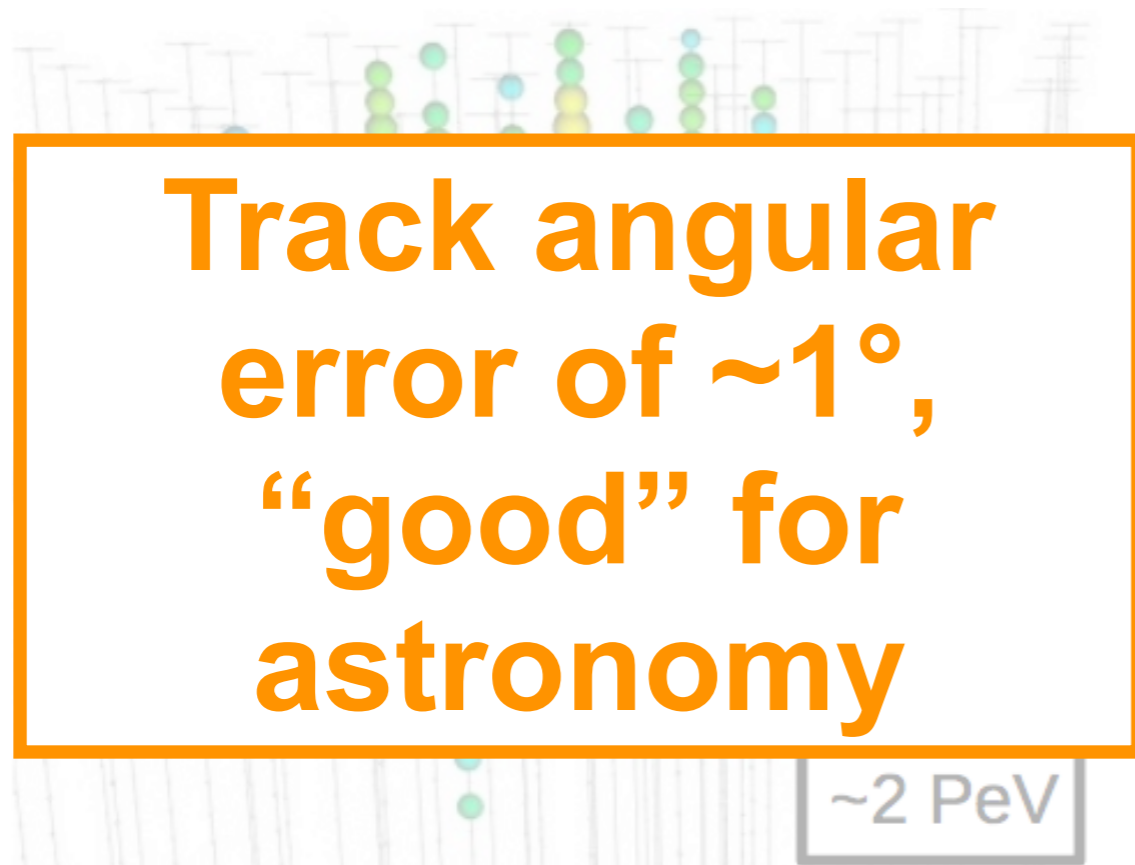


Tracks

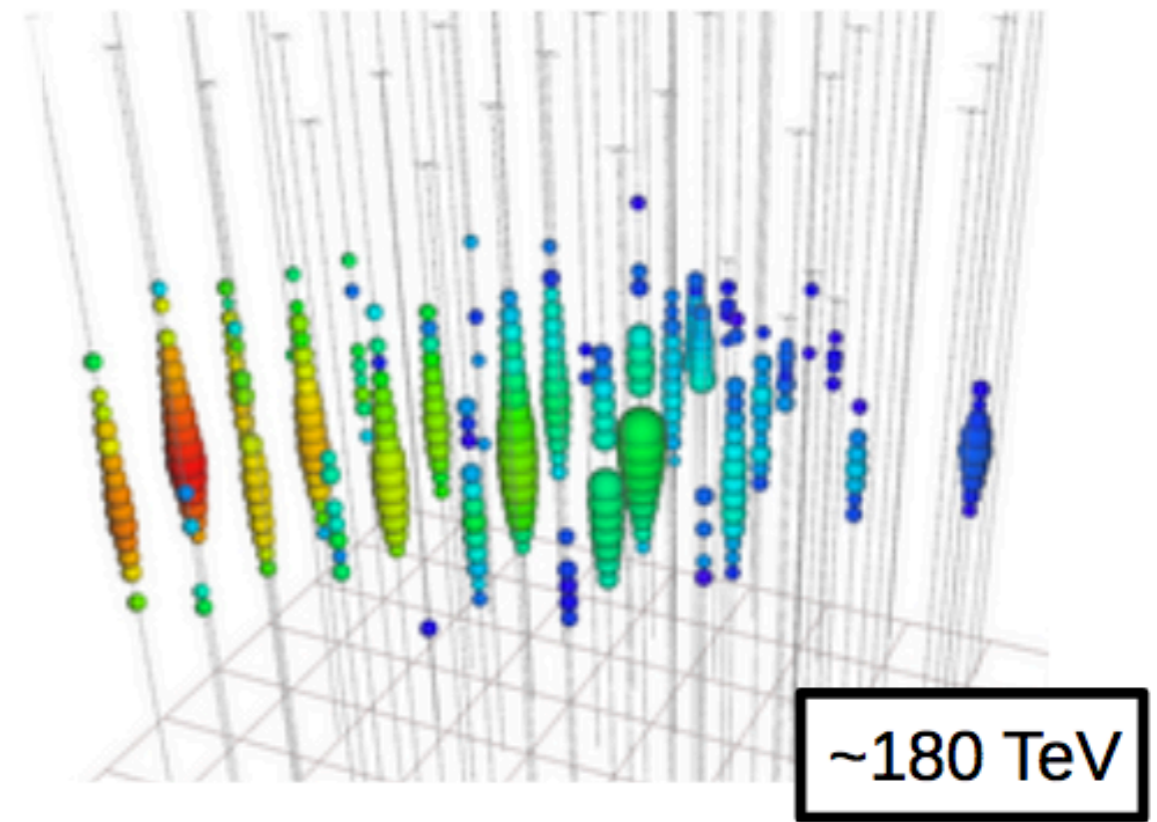


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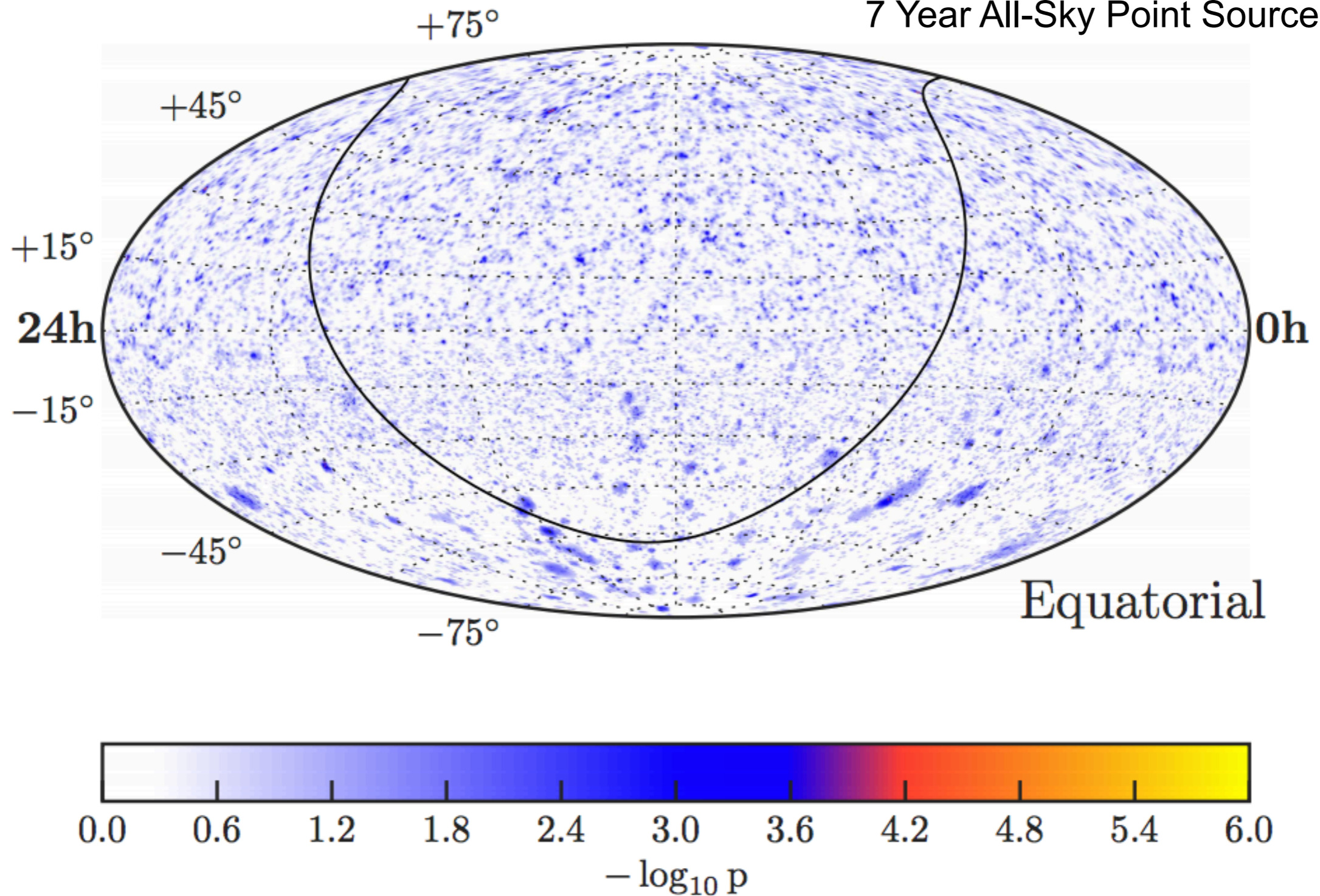


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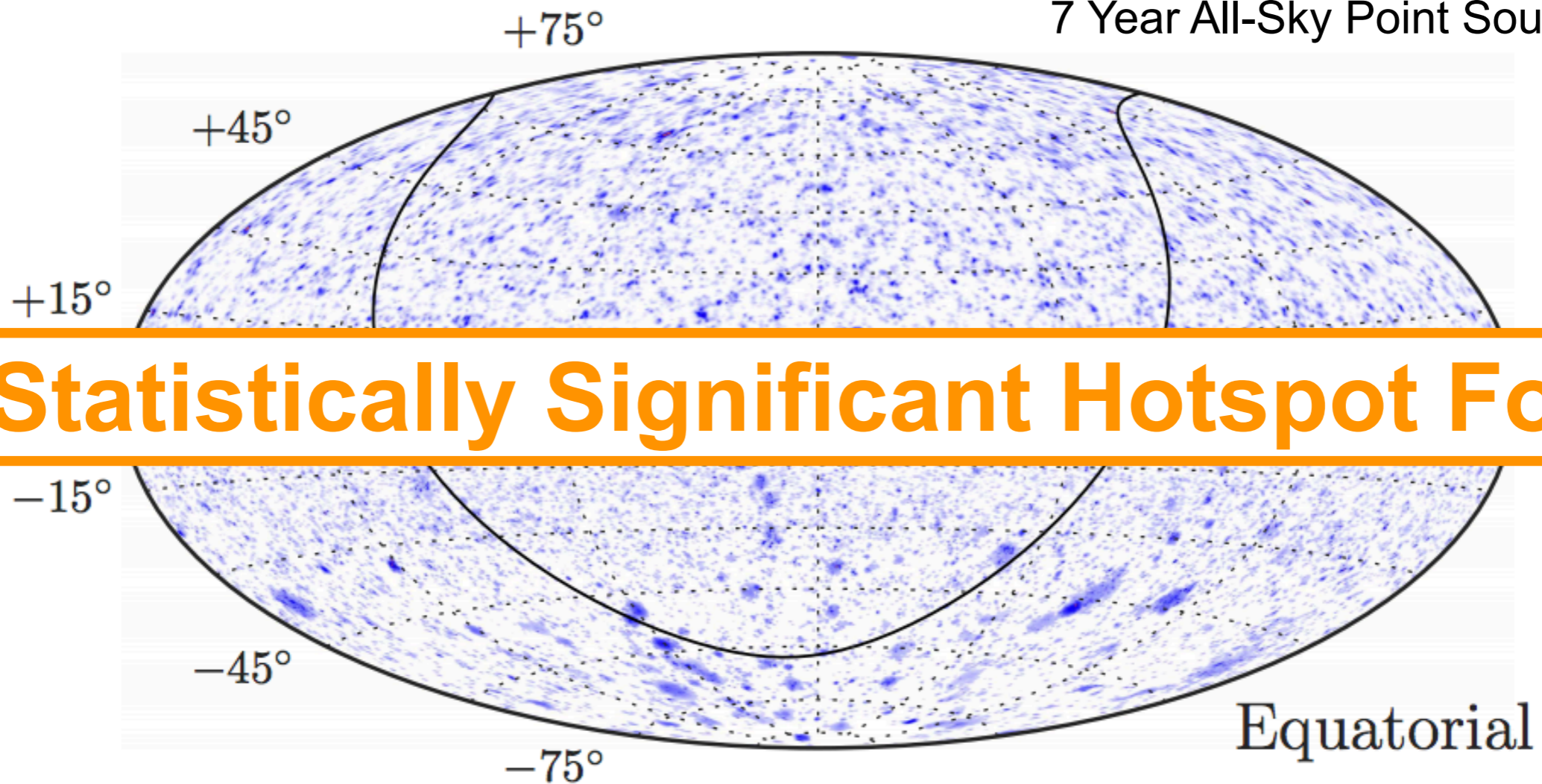
The neutrino sky...

7 Year All-Sky Point Source Search

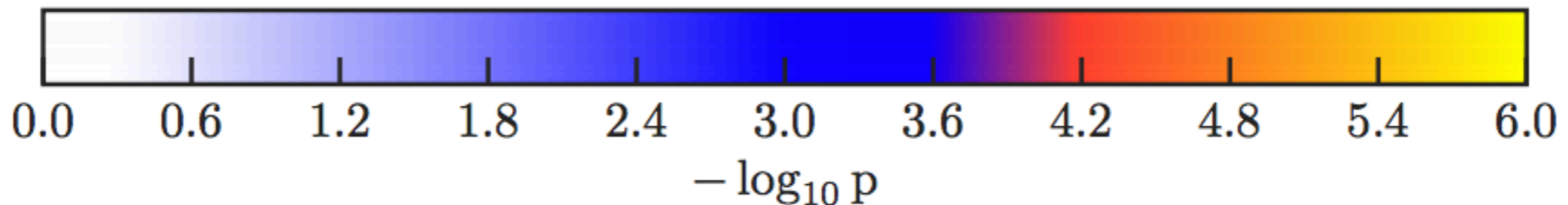


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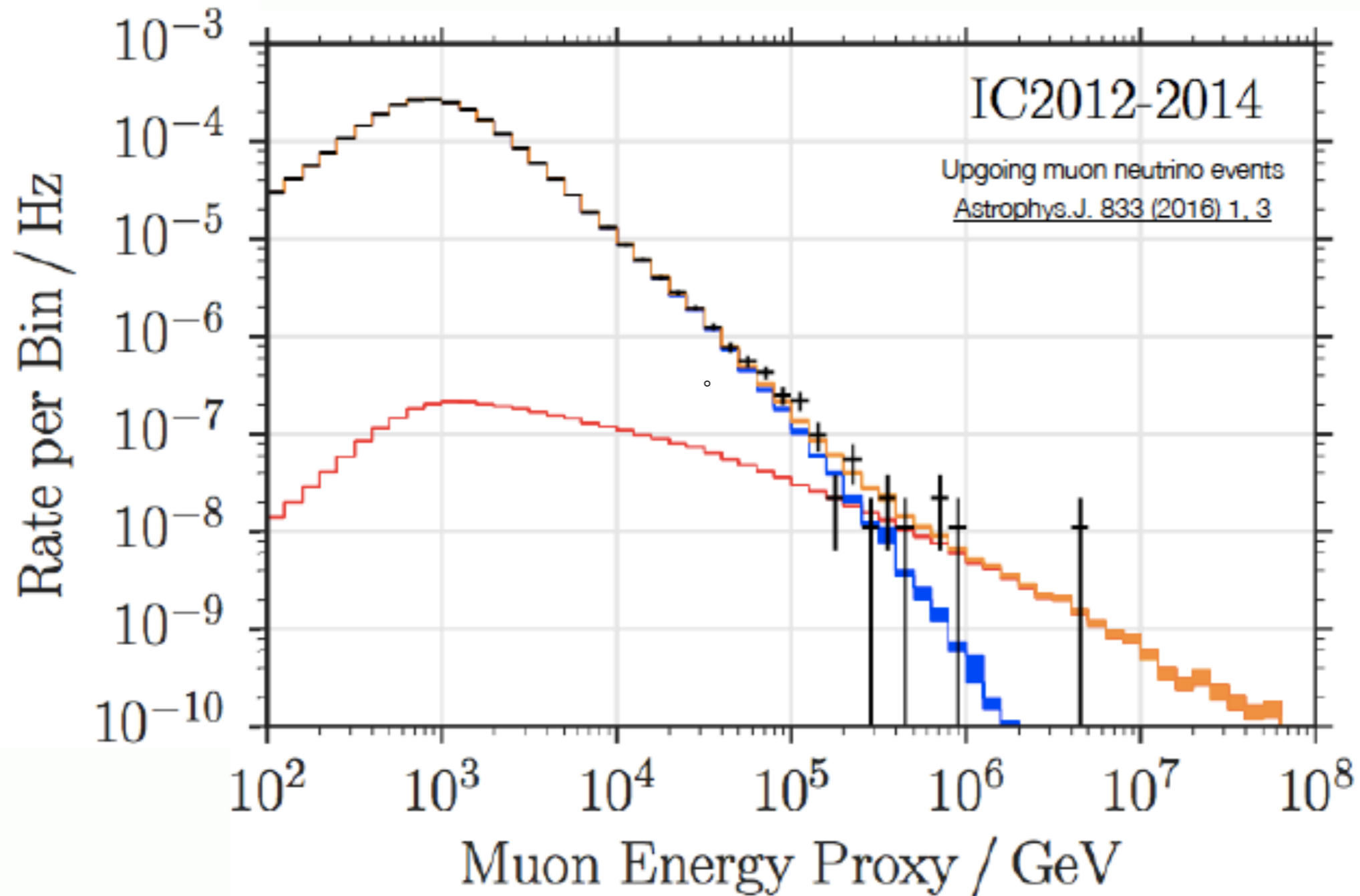


No Statistically Significant Hotspot Found!



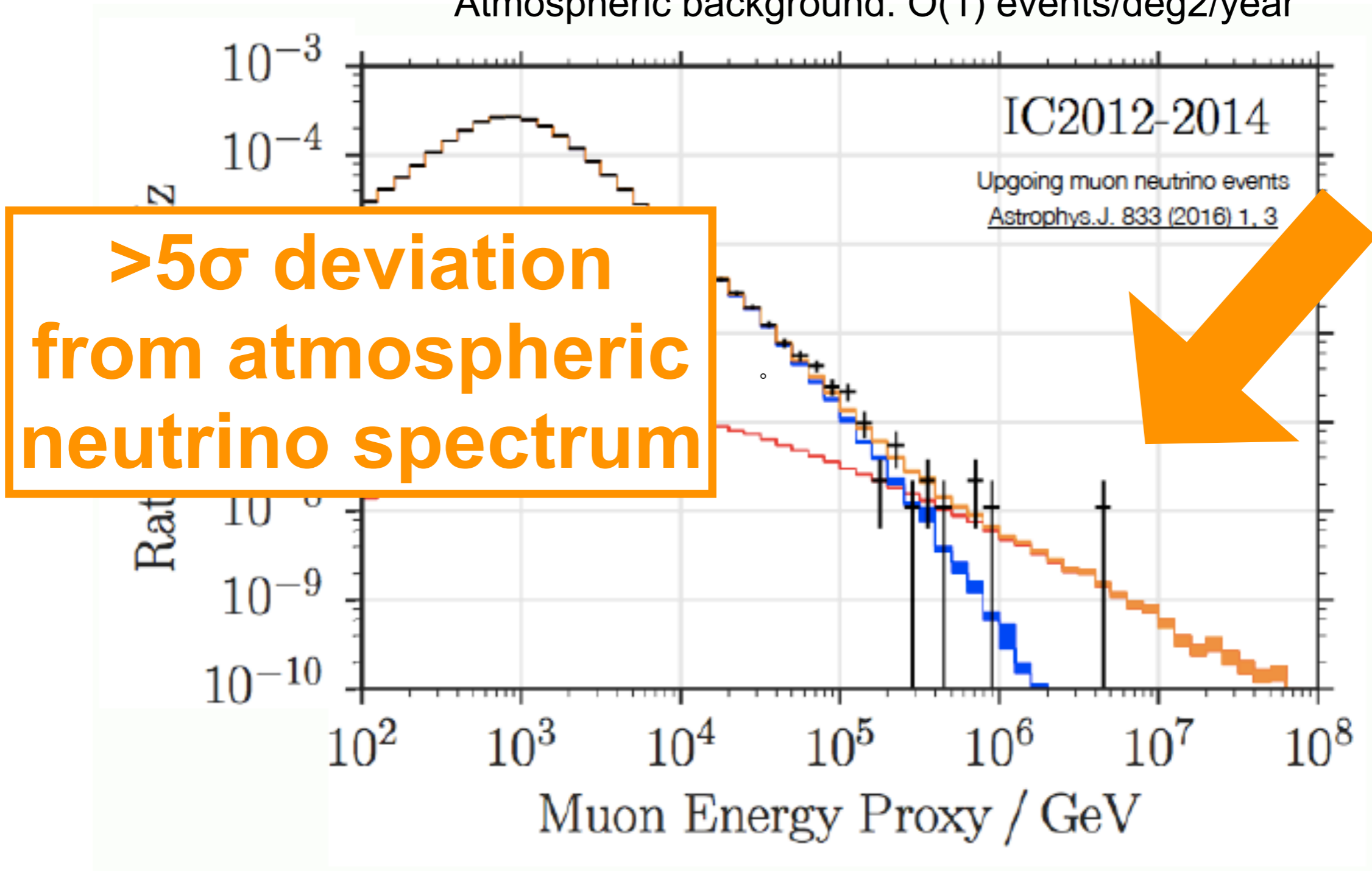
Hunting astrophysical neutrinos...

Atmospheric background: $O(1)$ events/deg²/year



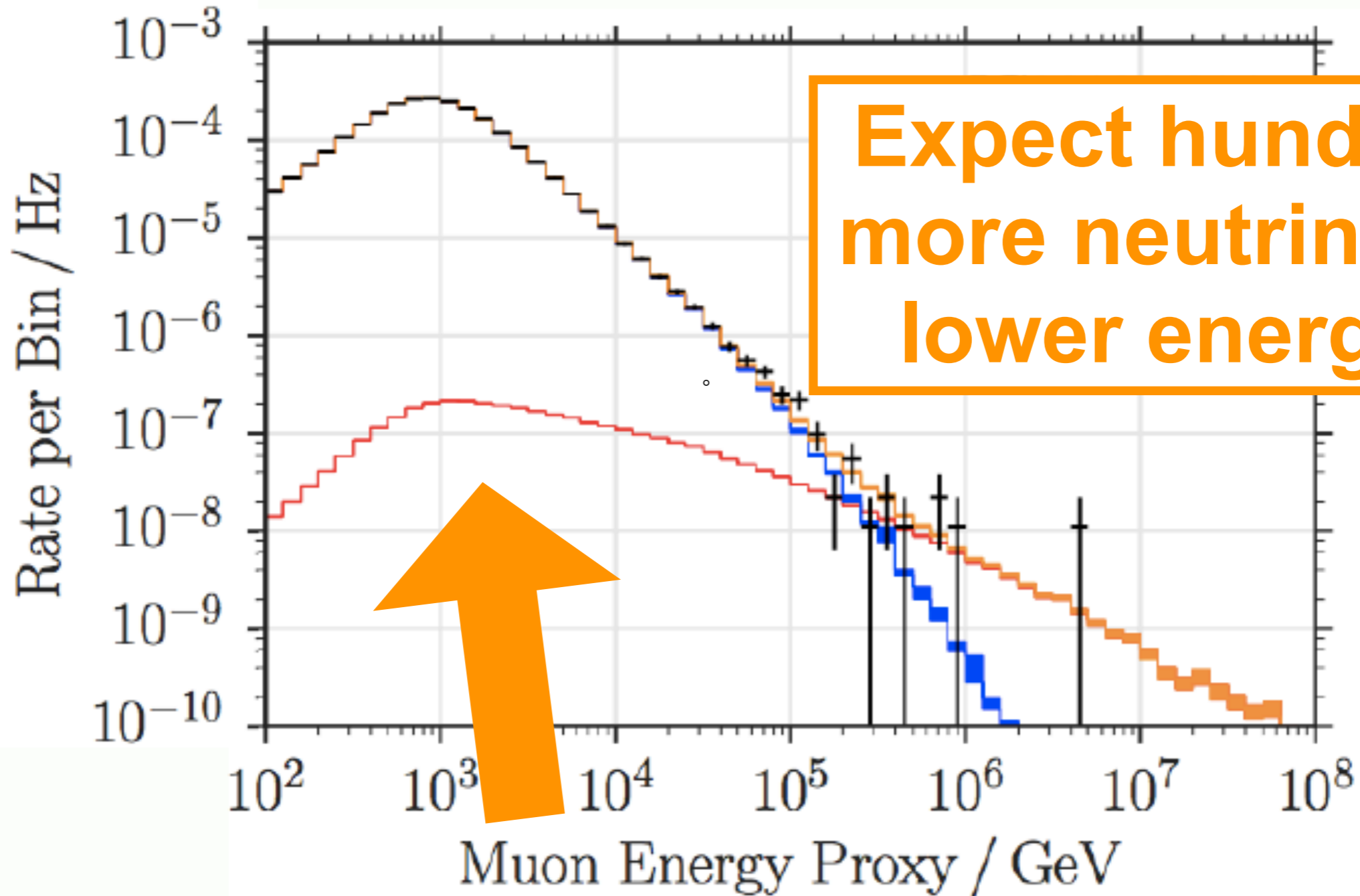
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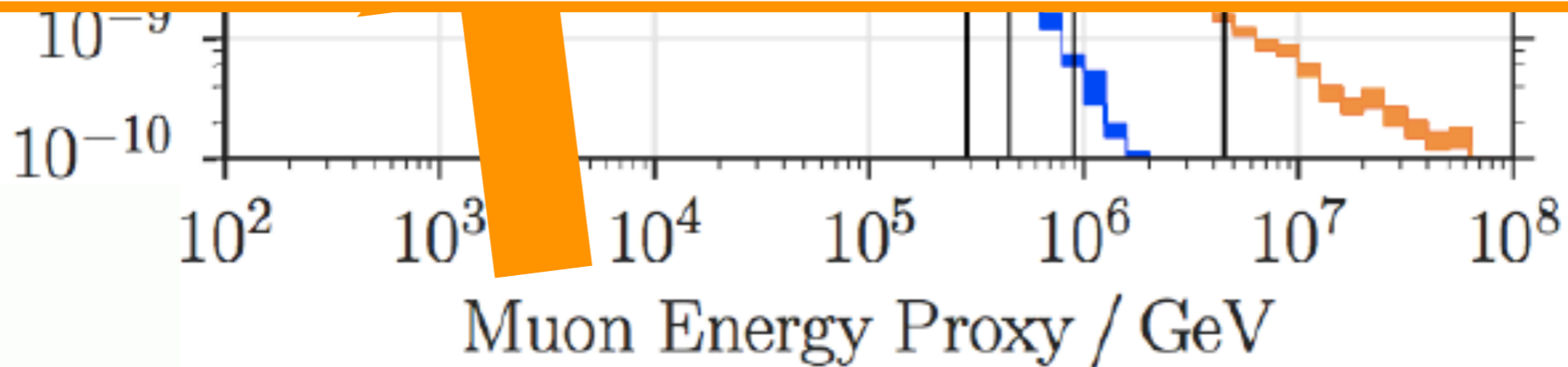


Hunting astrophysical neutrinos...

Atmospheric background: $O(1)$ events/deg²/year



Where do these
Neutrinos come
from?



Targeted Source Searches...

Fermi Blazars?



Targeted Source Searches...

Fermi Blazars?

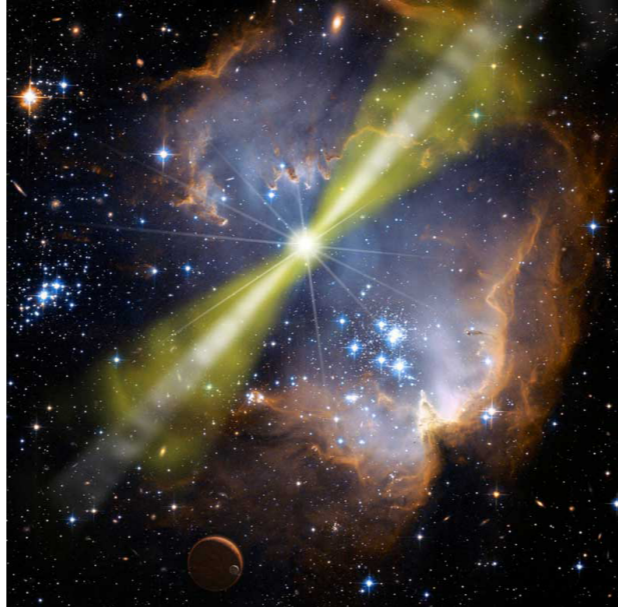


Targeted Source Searches...

Fermi Blazars?



Gamma-Bright GRBs?



Targeted Source Searches...

Fermi Blazars?



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Targeted Source Searches...

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Core-Collapse Supernovae?



Targeted Source Searches...

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Targeted Source Searches...

TXS 0506+56 ???

Fermi Blazars?



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Core-Collapse Supernovae?



Supernova Remnants?

Galactic Center?

Pulsar-Wind Nebulae?

Mrk 421?

Fast Radio Bursts?

Galactic Plane?

1ES 1959+650?

Fermi Bubbles?

Targeted Source Searches...

TXS 0506+56 ???

Fermi Blazars?

Gamma-Bright GRBs?

Core-Collapse Supernovae?



**Sources of neutrinos remain
undiscovered!**

Supernova
Remnants?

Galactic
Center?

Pulsar-Wind
Nebulae?

Mrk 421?

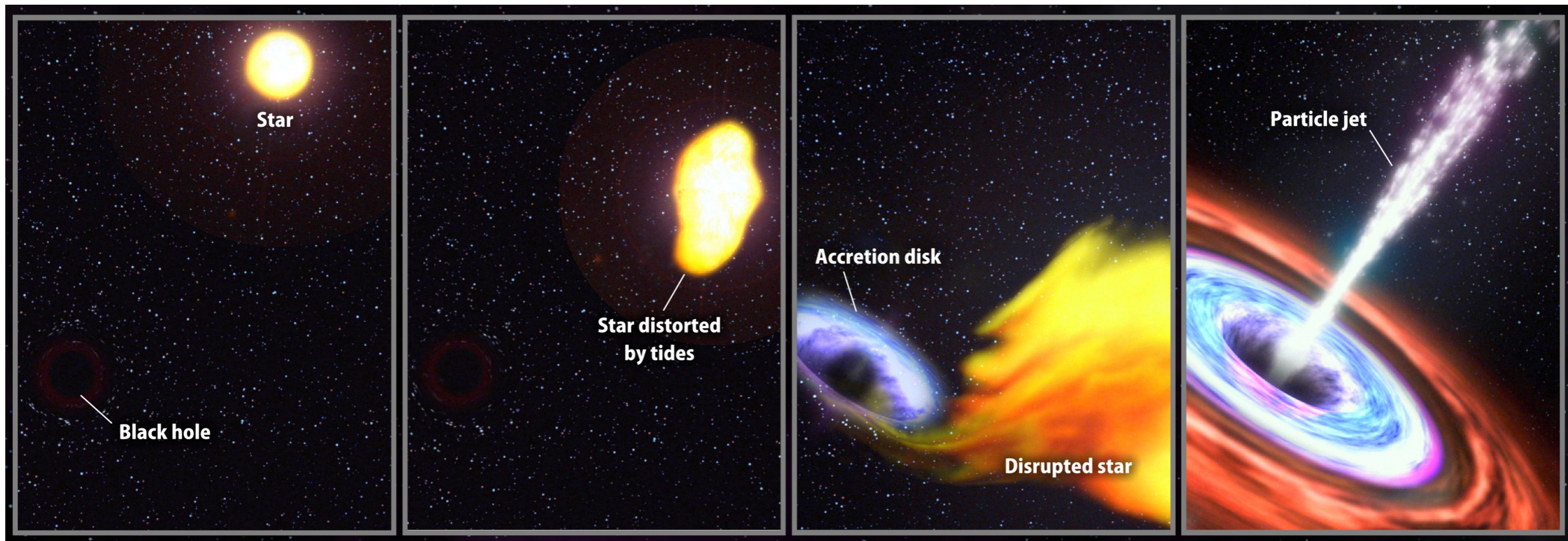
Fast Radio
Bursts?

Galactic Plane?

1ES 1959+650?

Fermi
Bubbles?

An Introduction to Tidal Disruption Events...



1

2

3

4

Why are TDEs interesting?



Why are TDEs interesting?

- They're **giant, star-eating black holes...**



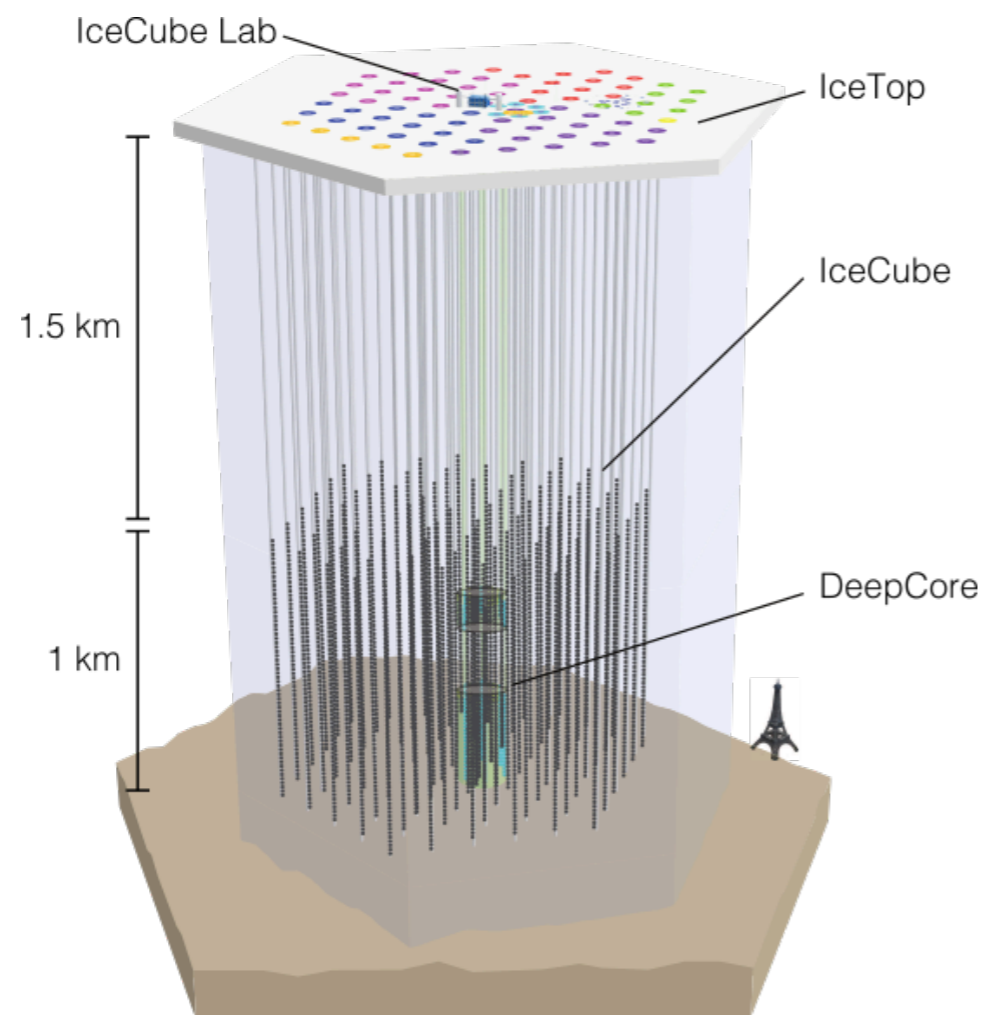
Why are TDEs interesting?

- They're **giant, star-eating black holes...**
- ...and also **extreme cosmic accelerators**



Why are TDEs interesting?

- They're **giant, star-eating black holes**...
- ...and also **extreme cosmic accelerators**
- **IceCube** is built to probe extreme cosmic accelerators through Neutrino detection



Building a TDE Catalogue...

- Catalogue based on <https://tde.space/>



Building a TDE Catalogue...

- Catalogue based on <https://tde.space/>
- **Jetted TDEs**, like “transient blazars”, launch relativistic jets pointed towards us (3)

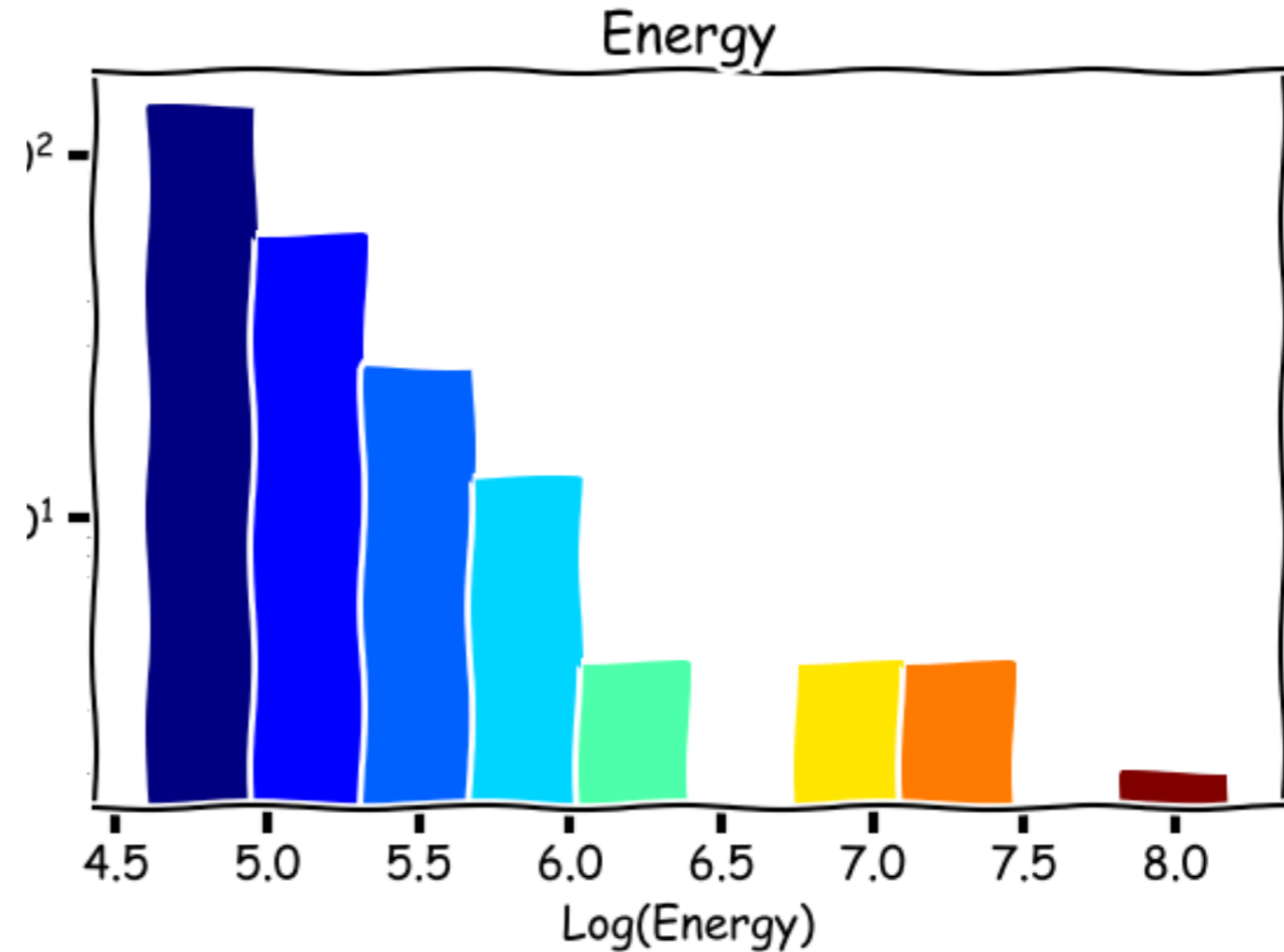
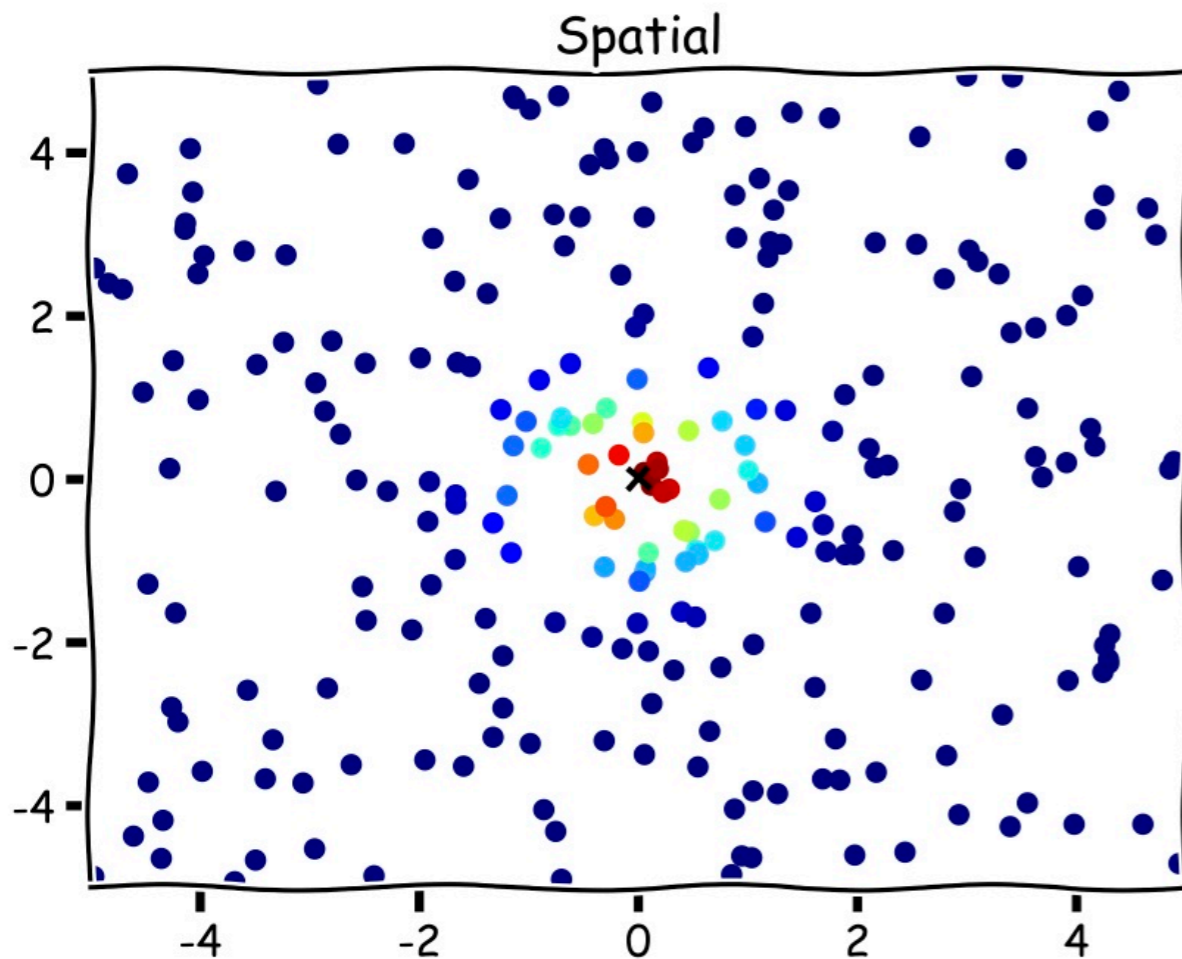


Building a TDE Catalogue...

- Catalogue based on <https://tde.space/>
- **Jetted TDEs**, like “transient blazars”, launch relativistic jets pointed towards us (3)
- Non-jetted TDEs, like AGN, can still produce neutrinos through e.g. winds or choked jets. However, catalogues can be contaminated by AGN or SN.
- **Gold TDEs** are reliably-classified TDEs with multiple spectra (13)
- **Silver TDEs** are less clear “TDE candidates” (24)
- **Obscured TDEs** are detected only via reprocessed IR emission, so there is a delay between disruption and peak. (13)



An Unbinned Likelihood “Stacking Analysis”

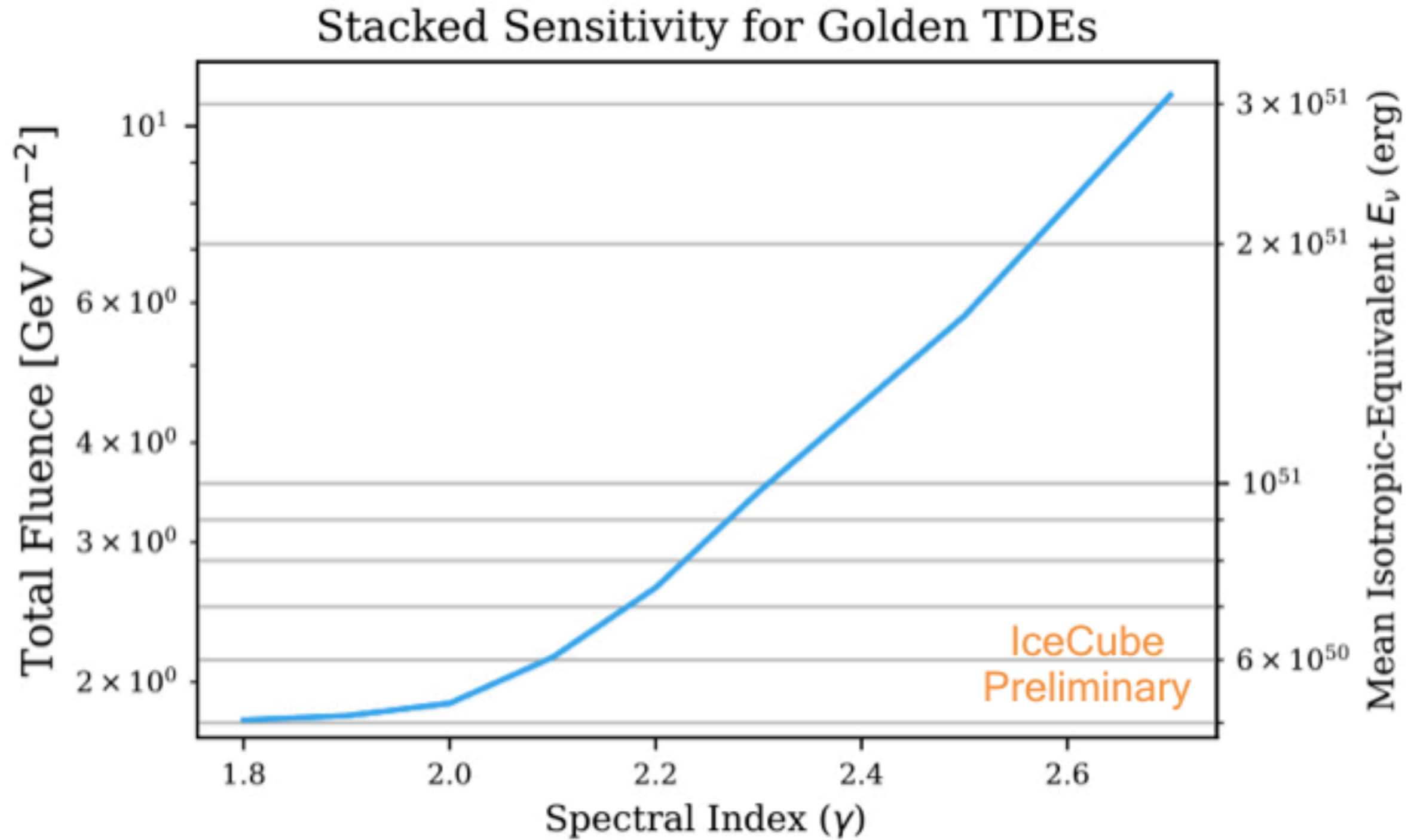


“Box” Time PDF matching EM observations

Assume sources share a spectral index, and perform likelihood minimisation

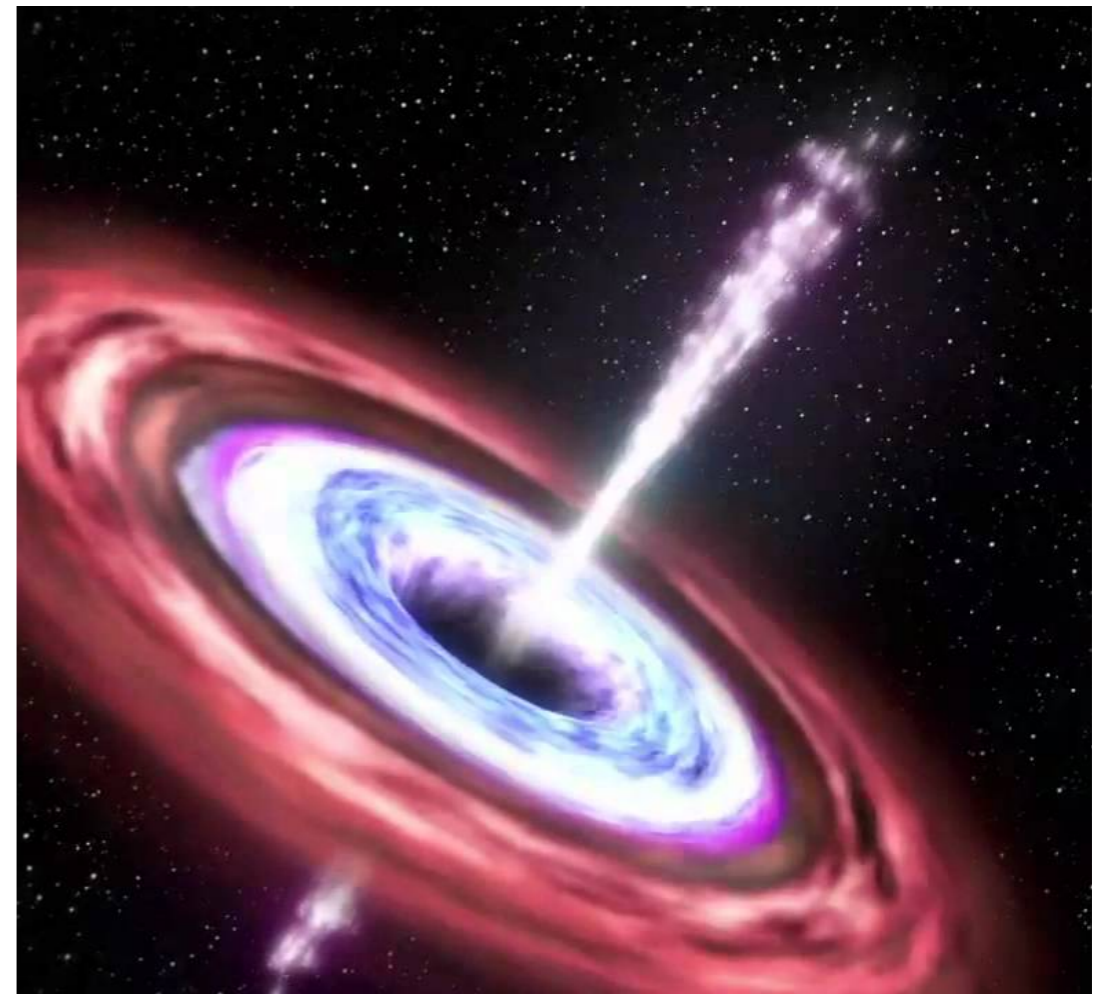
Fit weights of each source individually -> No assumptions for neutrino distribution

Sensitivities for one sub-catalogue

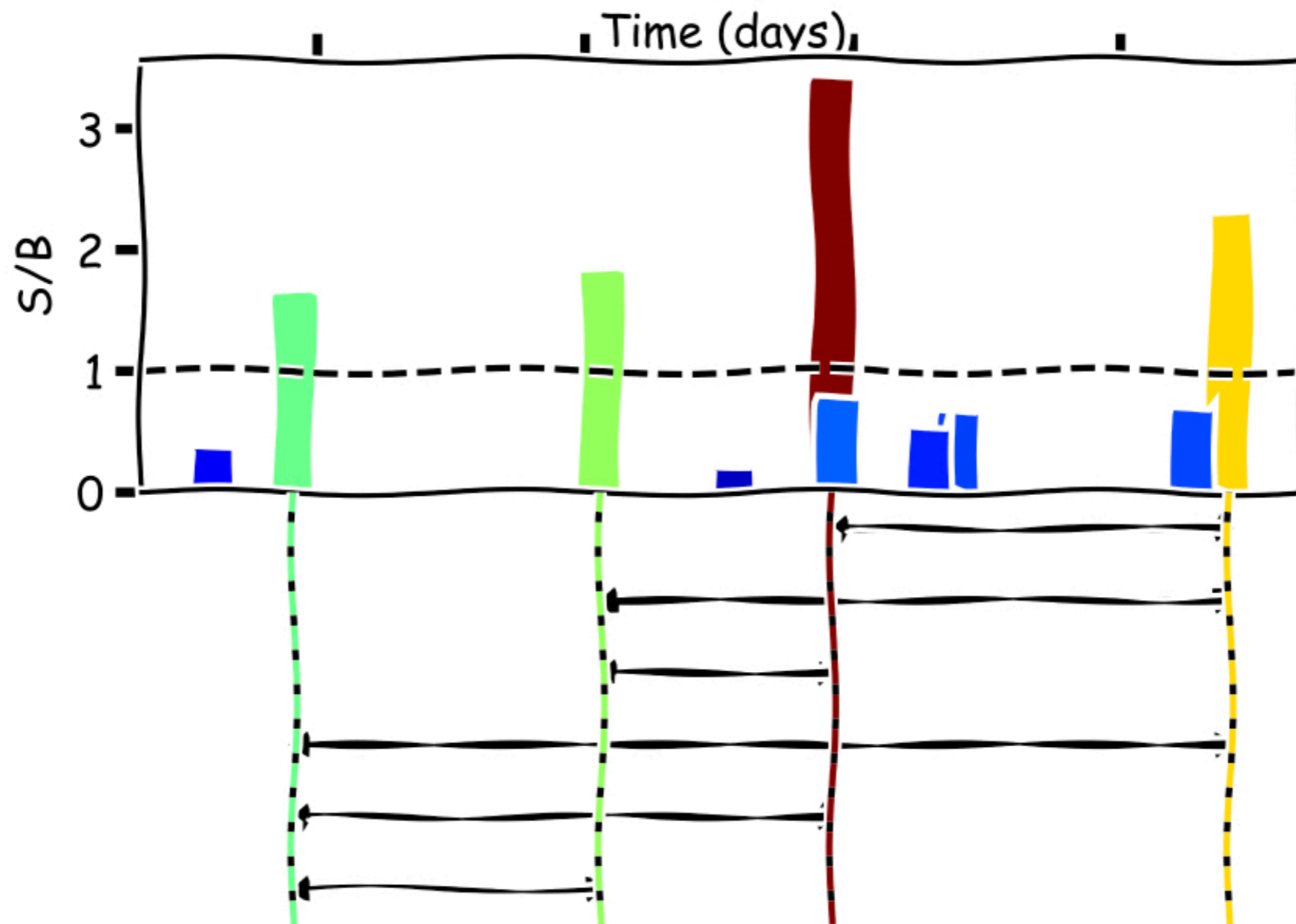


But what about the REALLY interesting ones?

- Will analyse four interesting TDEs individually
- Two are jetted TDEs, at favourable declinations
 - **Swift J1644+57**
 - **Swift J2058+05**
- Two more are reliable, nearby and bright:
 - **ASASSN-14li**
 - **XMMSL1 J0740-85**
- All with radio detections -> Relativistic Particles!
- Can search for temporal clustering on shorter timescales -> **“Neutrino Flare”**



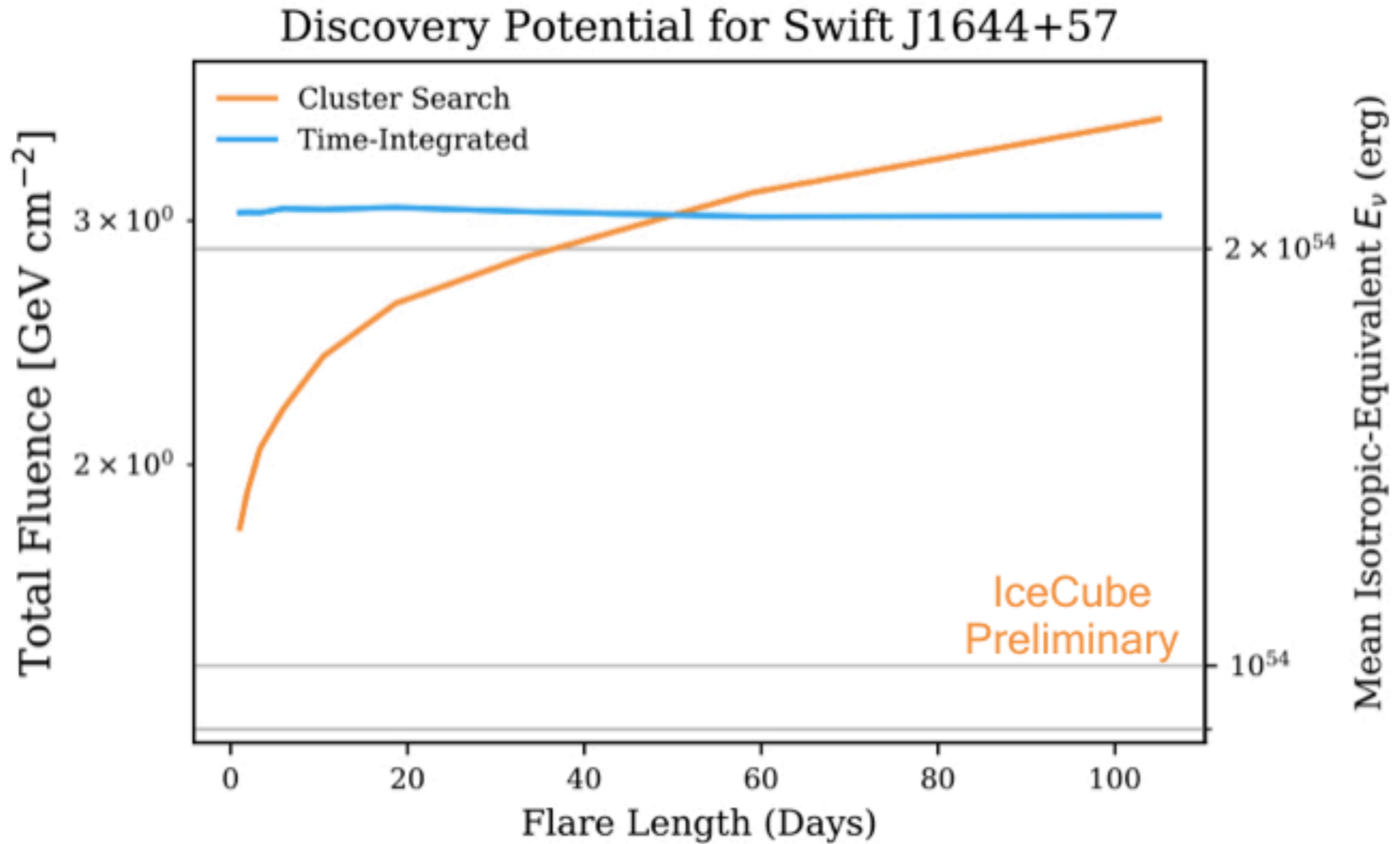
Flare Searching...



Each “significant event” is a potential start or end point for a flare

Test each potential flare, and return most significant of all flares

Threshold for Discovery...



Summary + Outlook

- IceCube has found a diffuse astrophysical neutrino flux, but not the origin of the flux
- TDEs are a promising untested neutrino source class
- Will test groups of TDEs, and search for time-clustered neutrino flares for four interesting TDEs
- We are sensitive to neutrino energies which are comparable to multi-wavelength observations for TDEs
- **Analysis will hopefully be unblinded in the next month!**

