The Hunt for Extraterrestrial Neutrino Counterparts

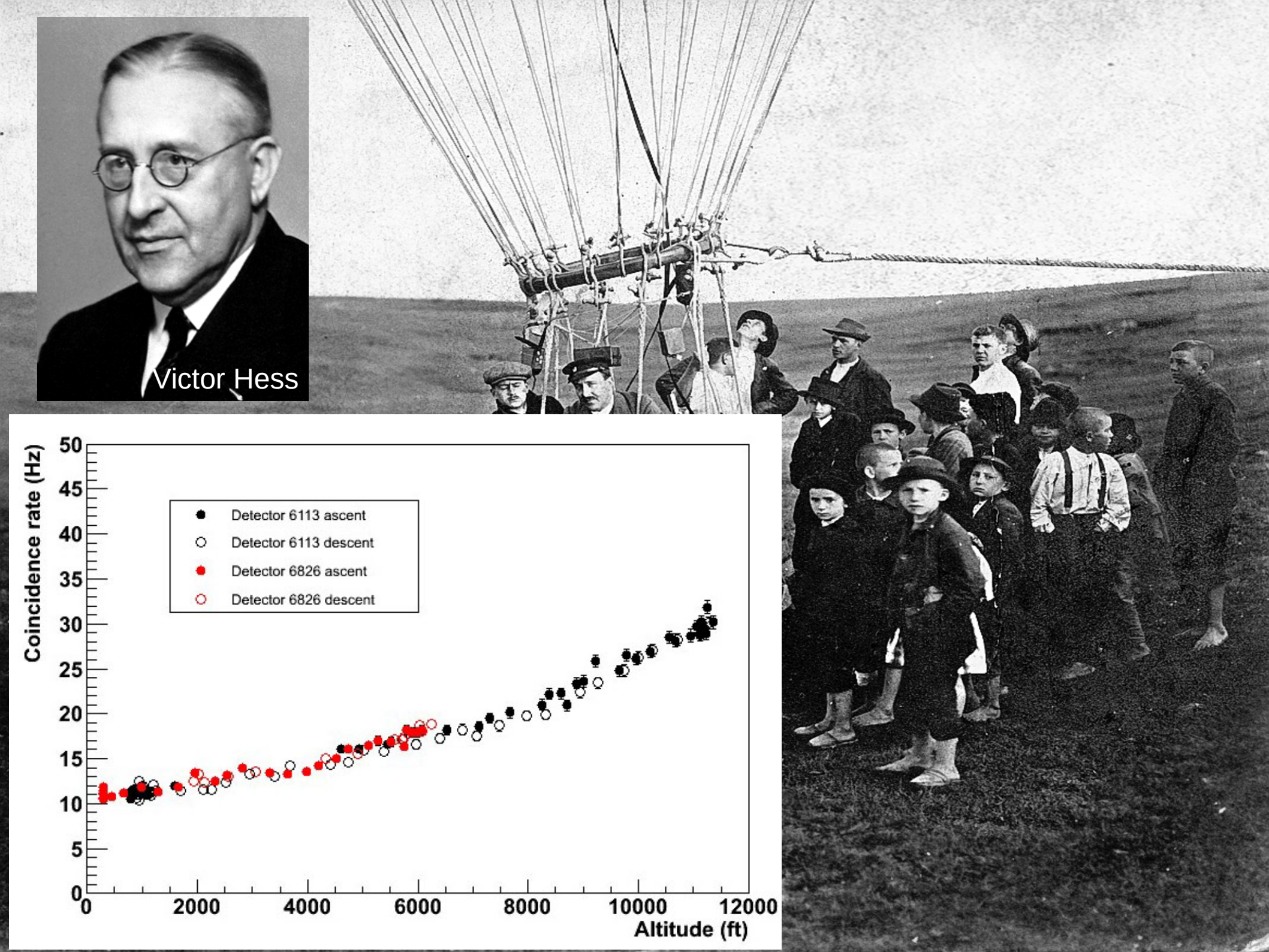
I. Liodakis

Finnish Centre for Astronomy with ESO

Institute for Cosmic Ray Research

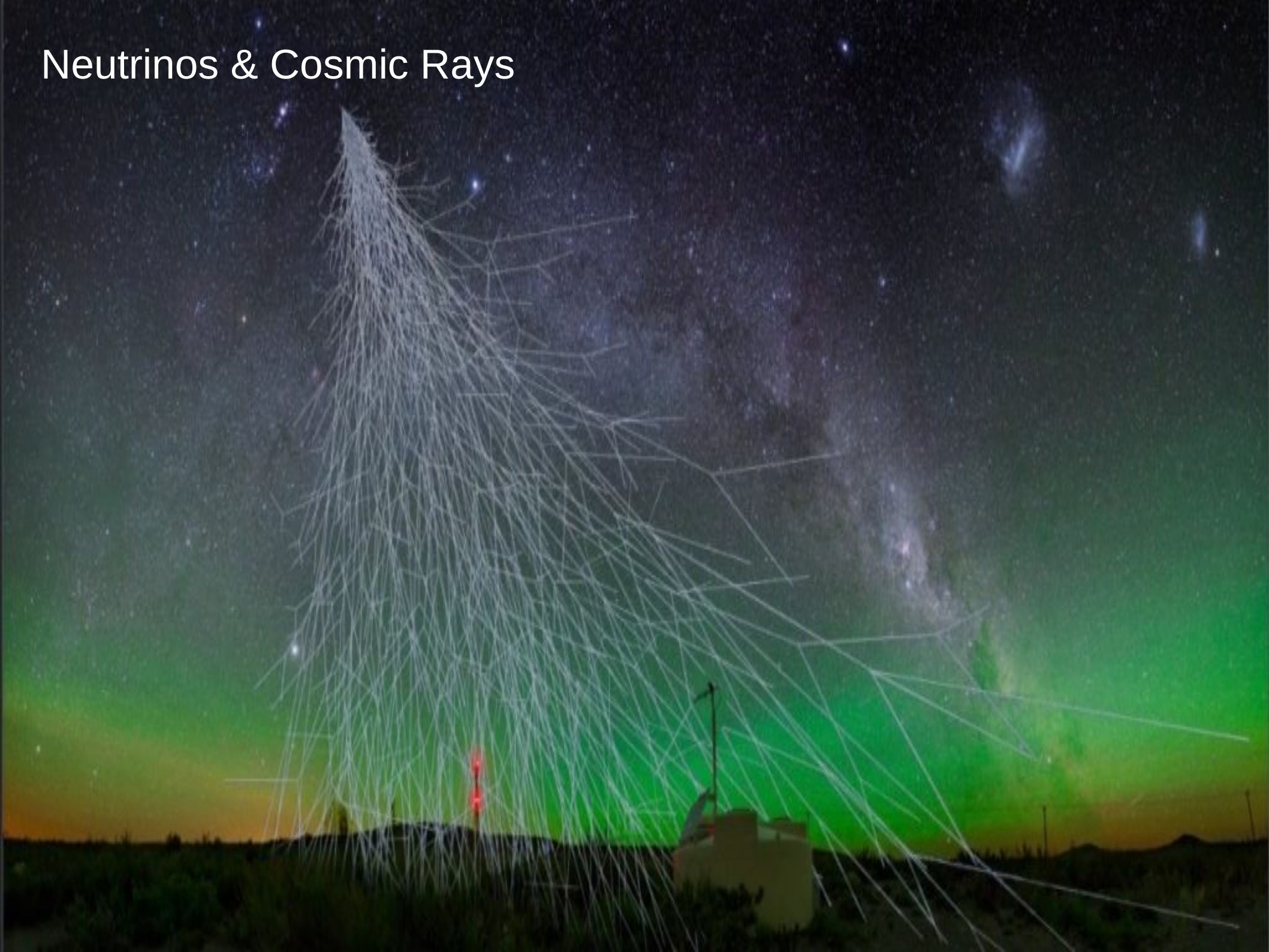
18 May 2022

Victor Hess

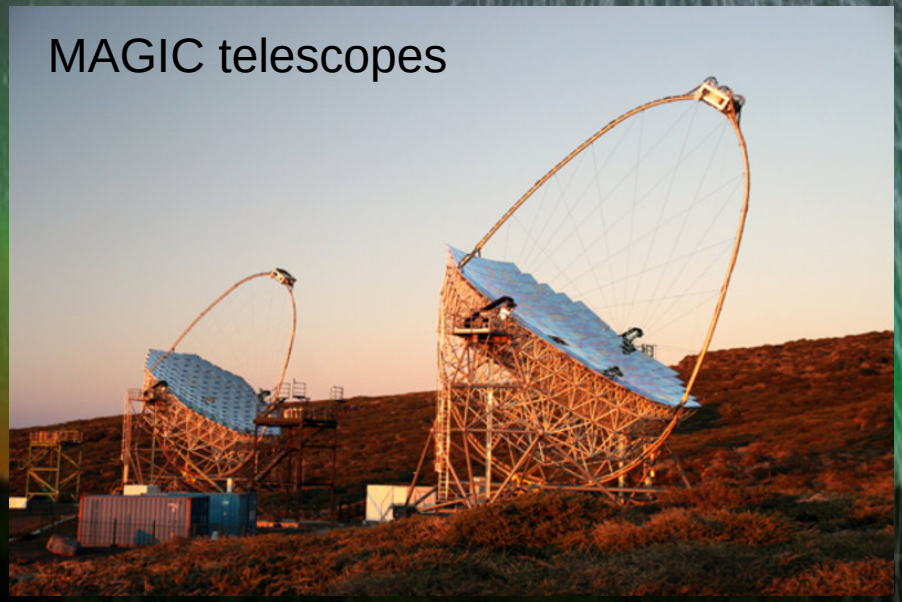


Coincidence rate (Hz)
50
45
40
35
30
25
20
15
10
5
0
0
2000
4000
6000
8000
10000
12000
Altitude (ft)
Detector 6113 ascent
Detector 6113 descent
Detector 6826 ascent
Detector 6826 descent

Neutrinos & Cosmic Rays



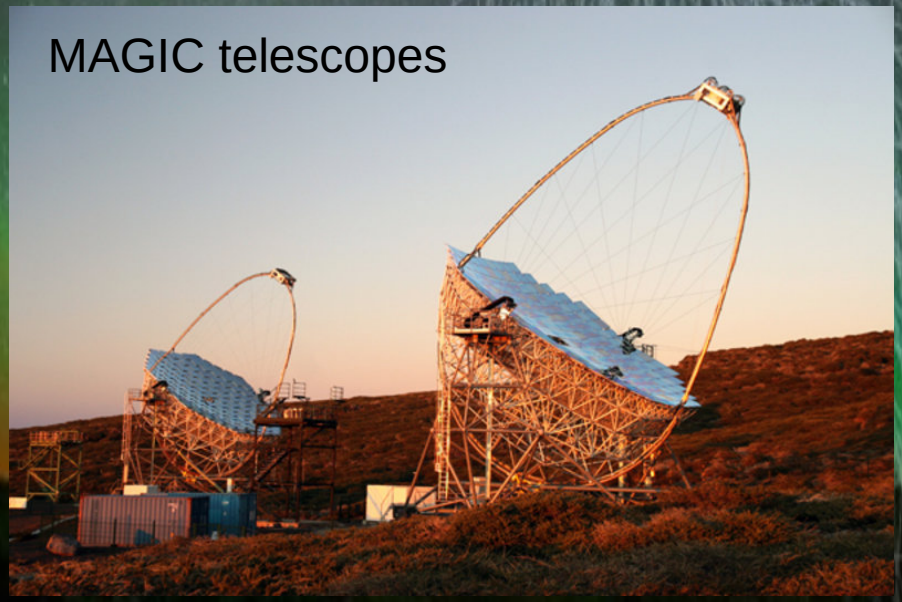
Neutrinos & Cosmic Rays



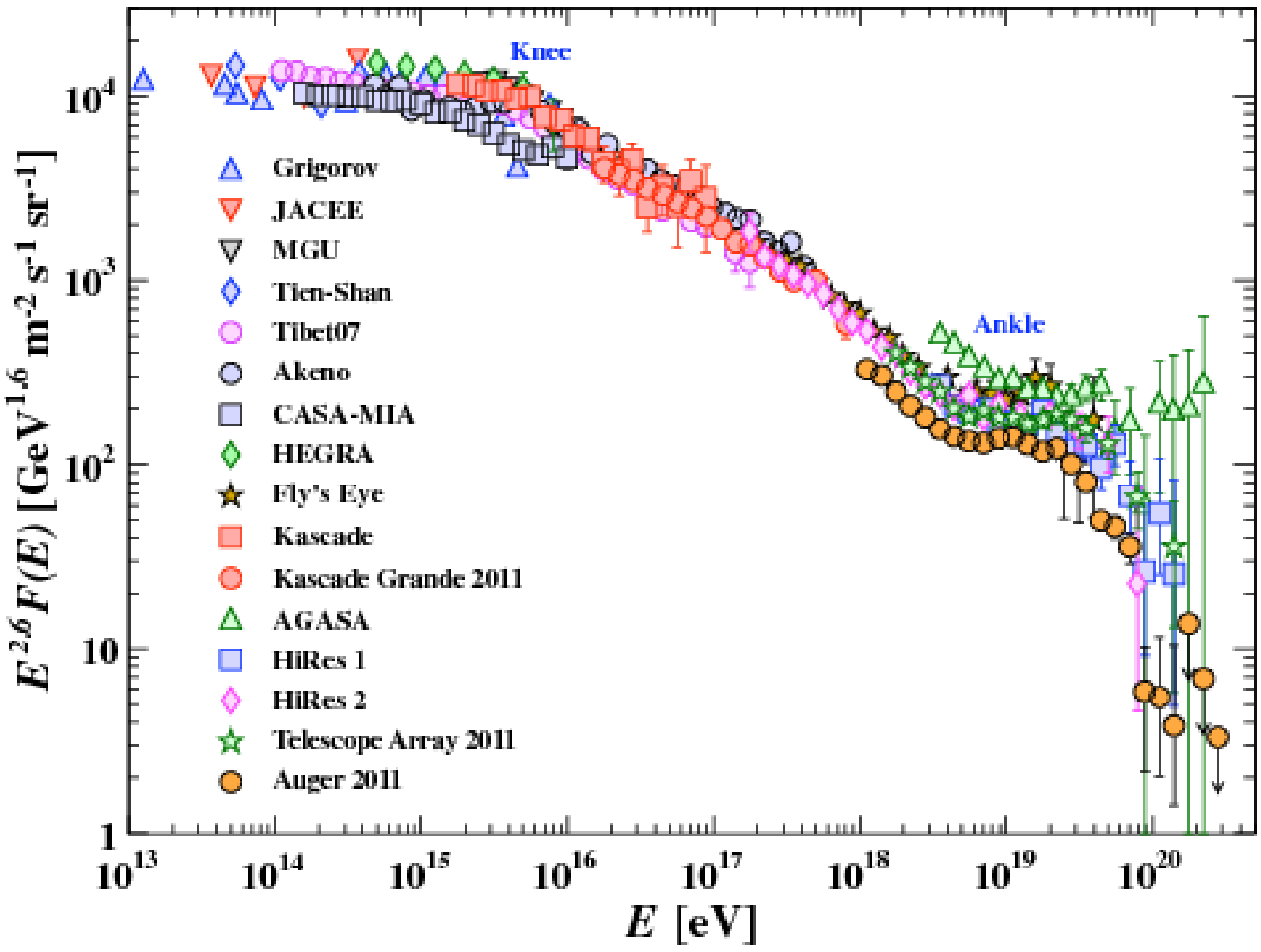
Neutrinos & Cosmic Rays

Pierre Auger Observatory

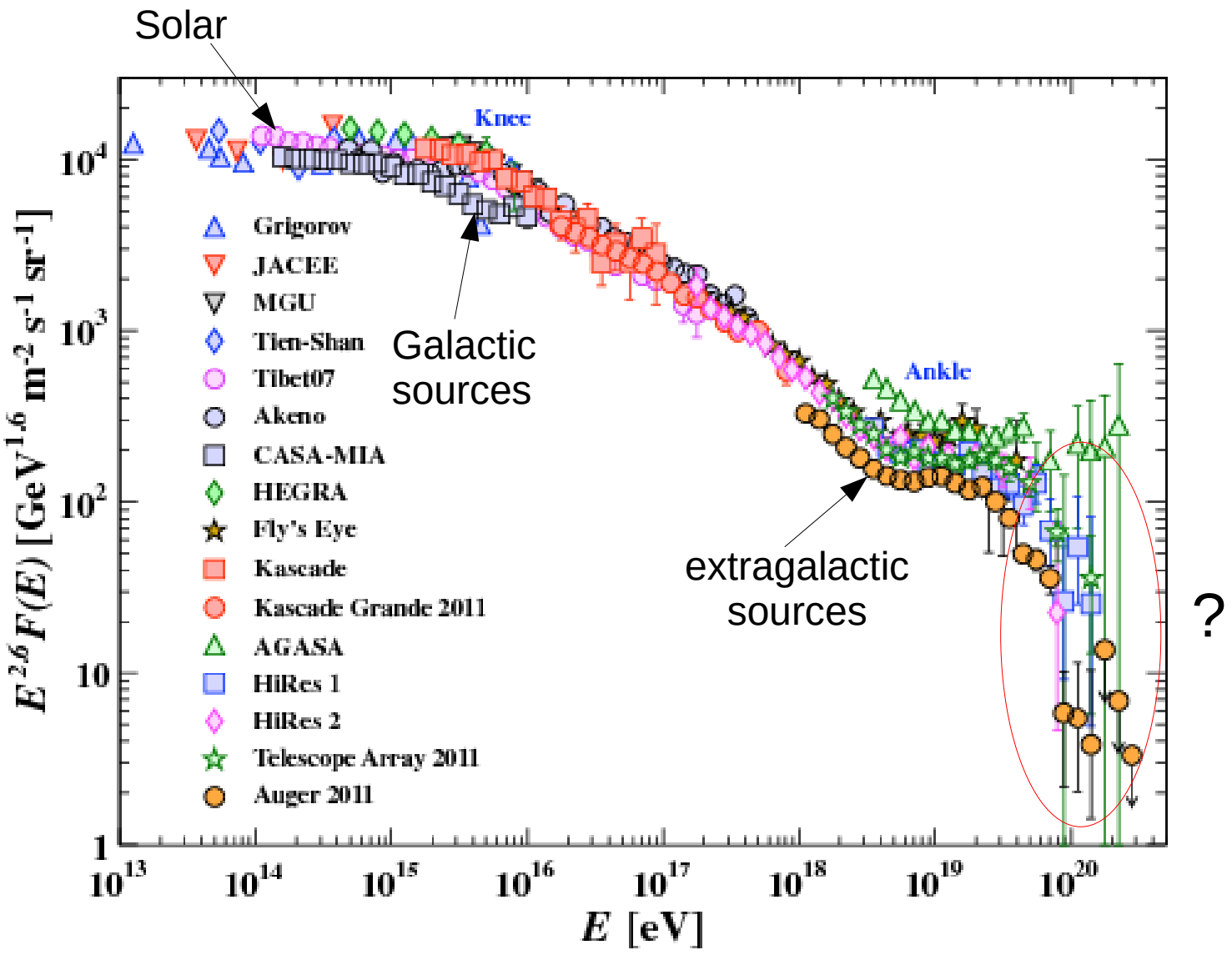
MAGIC telescopes



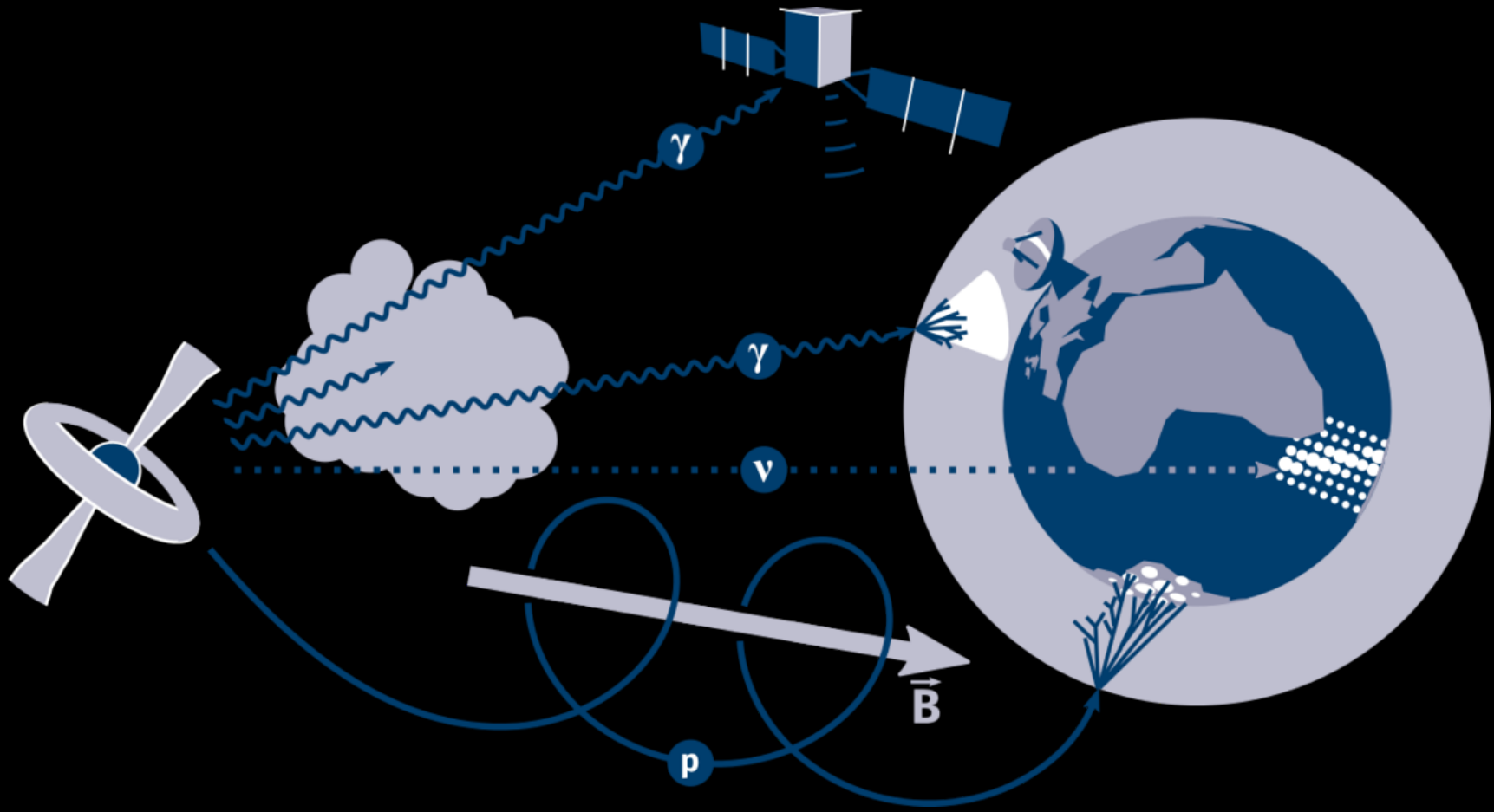
Neutrinos & Cosmic Rays



Neutrinos & Cosmic Rays

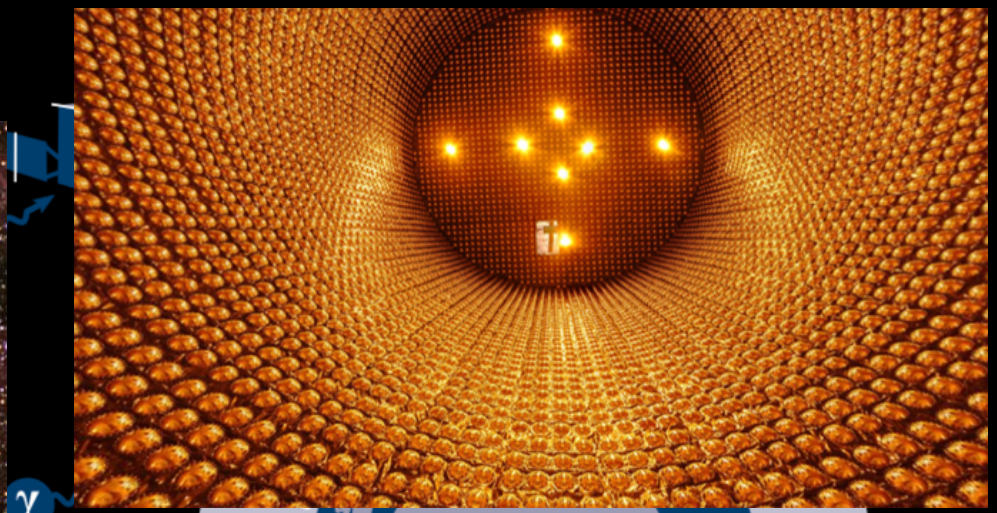


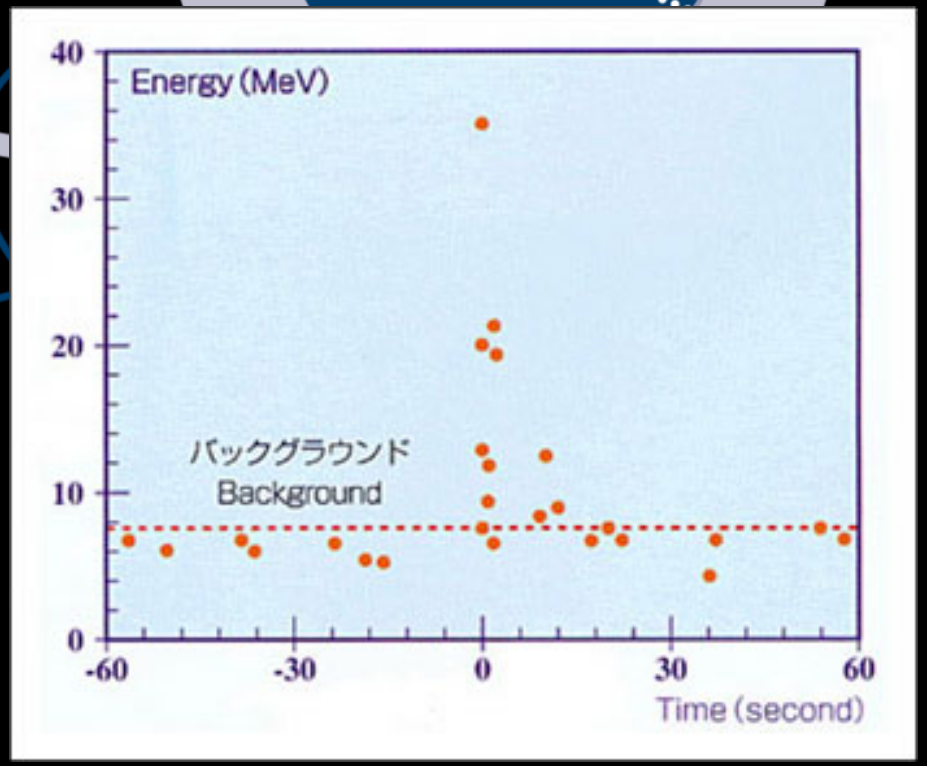
Neutrinos & Cosmic Rays



Galactic neutrino sources

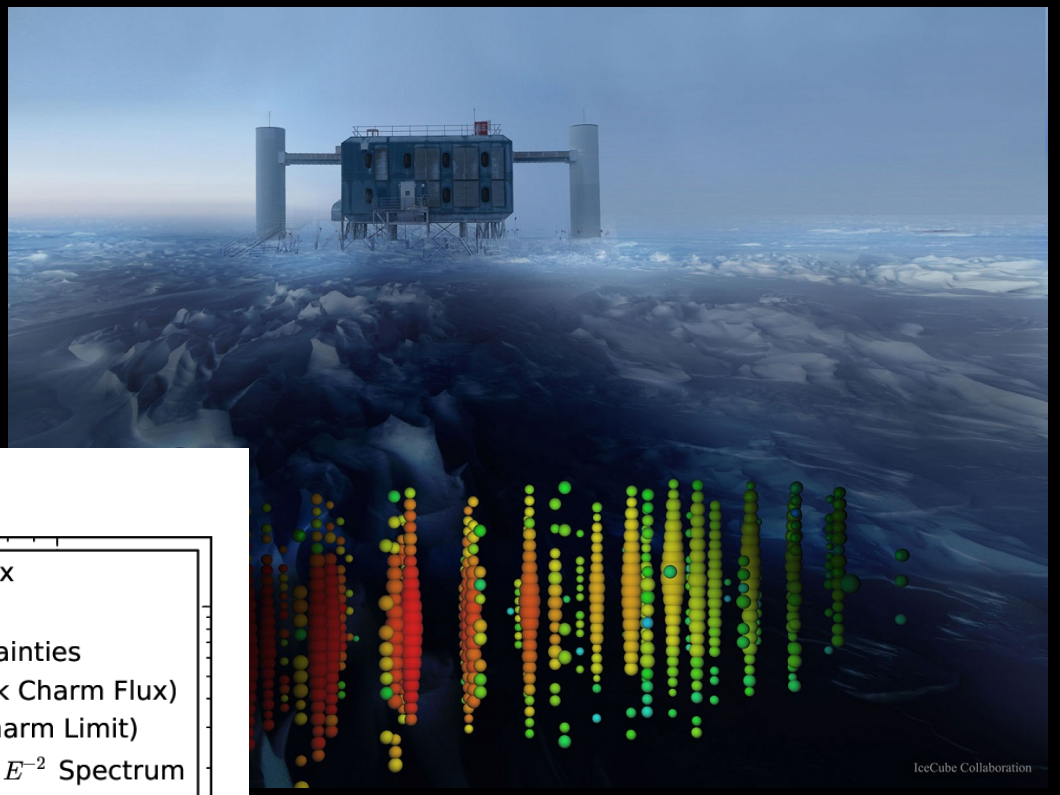
SN 1987A



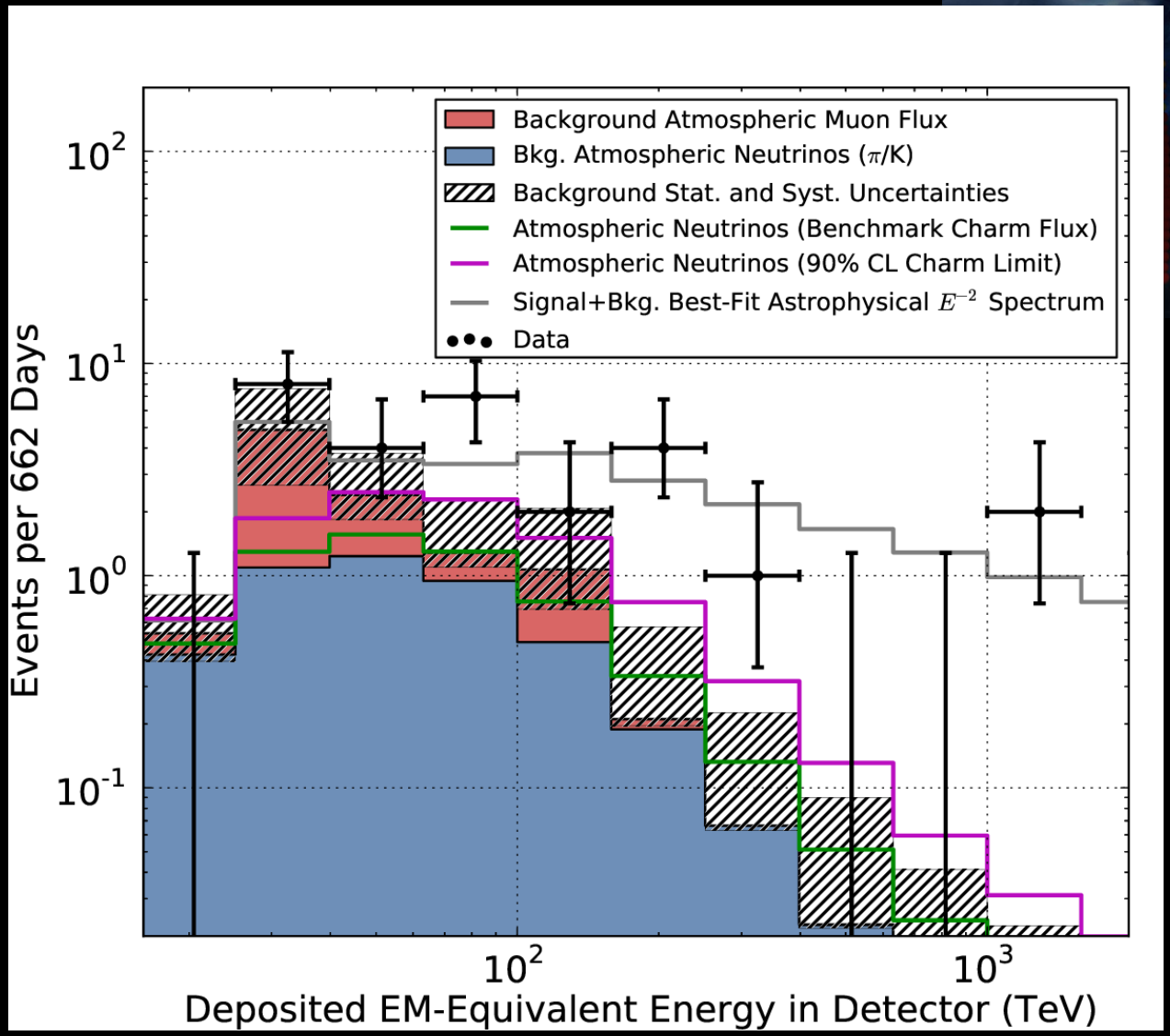


Super-kamiokande

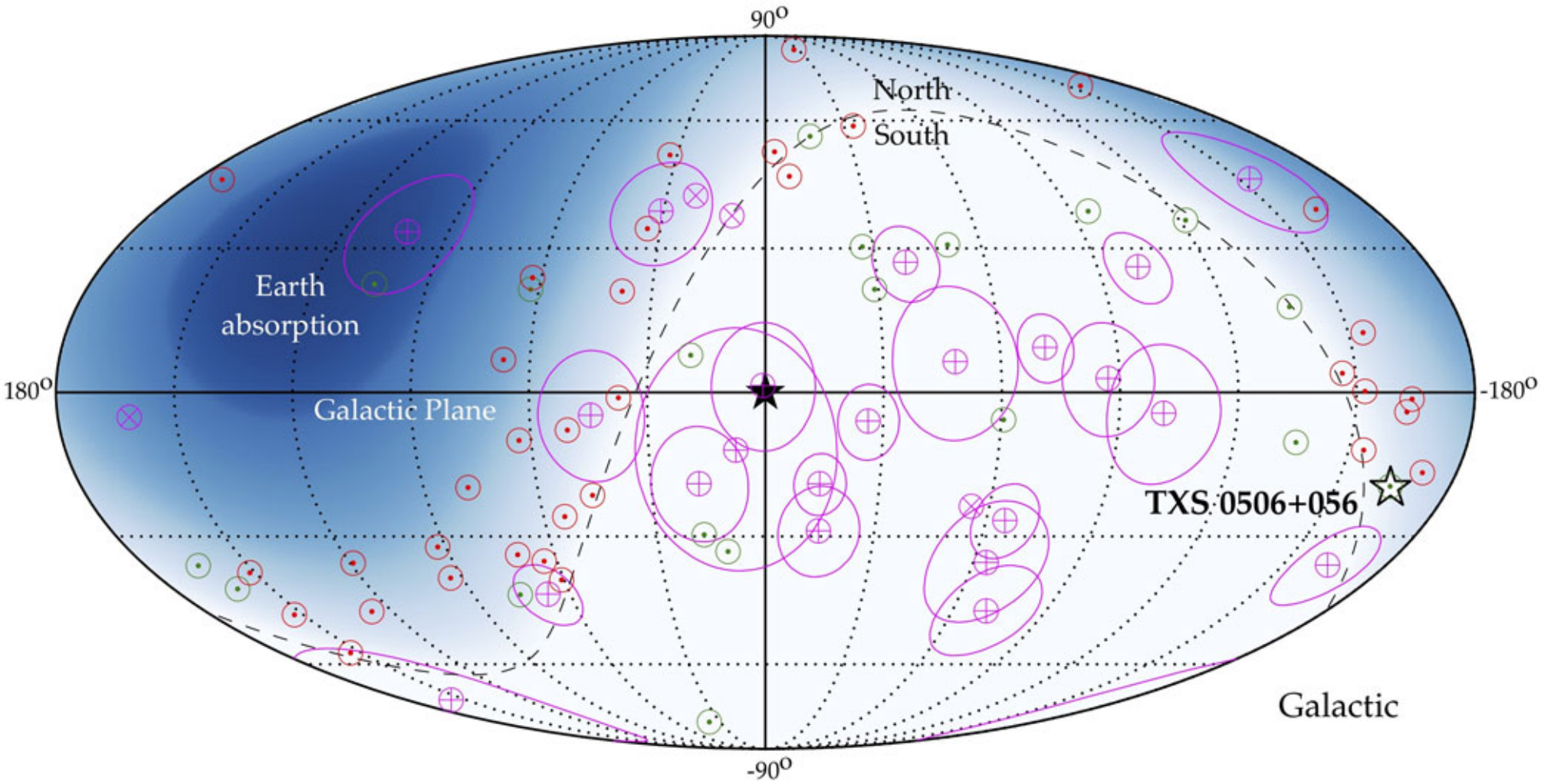
Extragalactic neutrino sources?



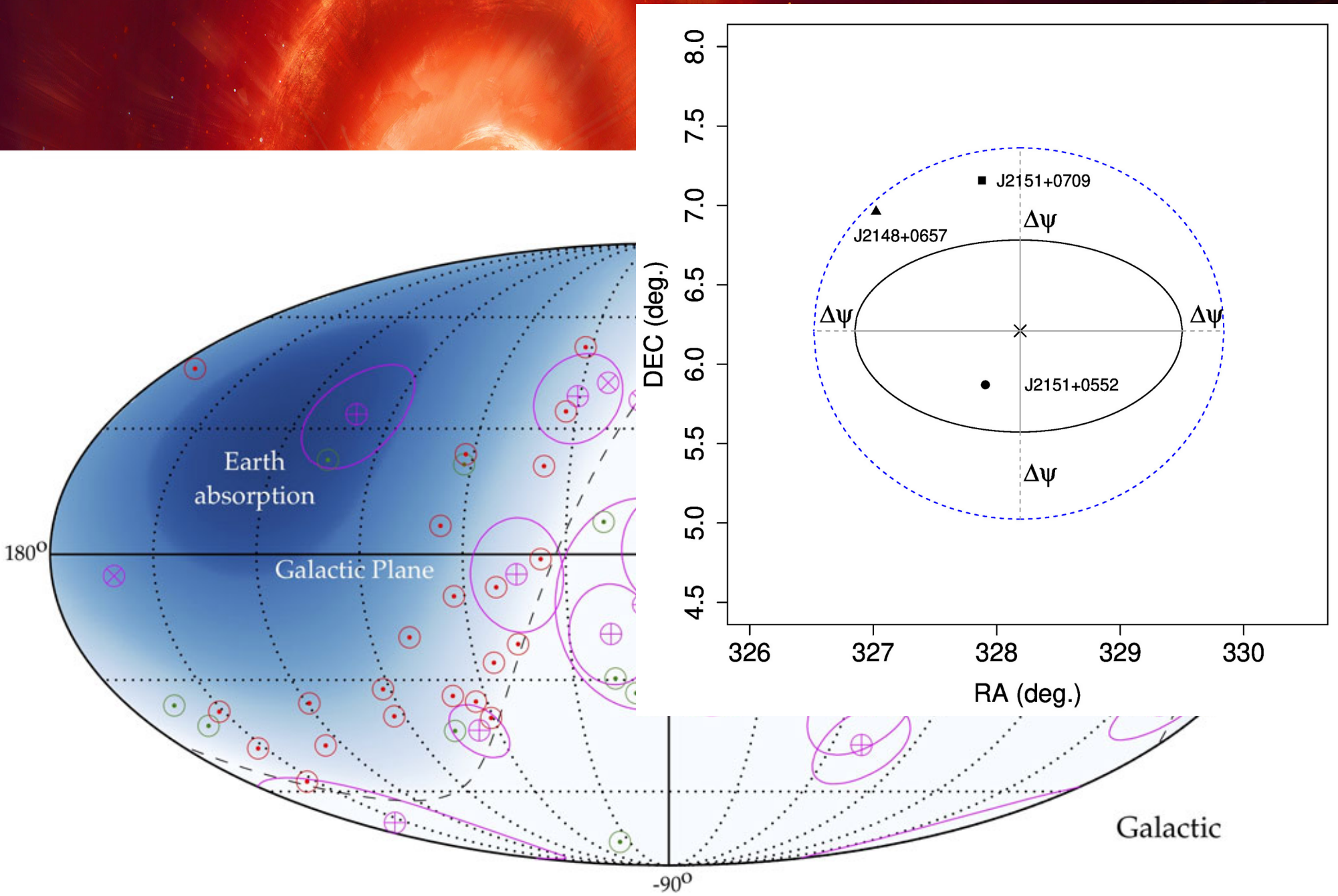
IceCube collaboration (2013)



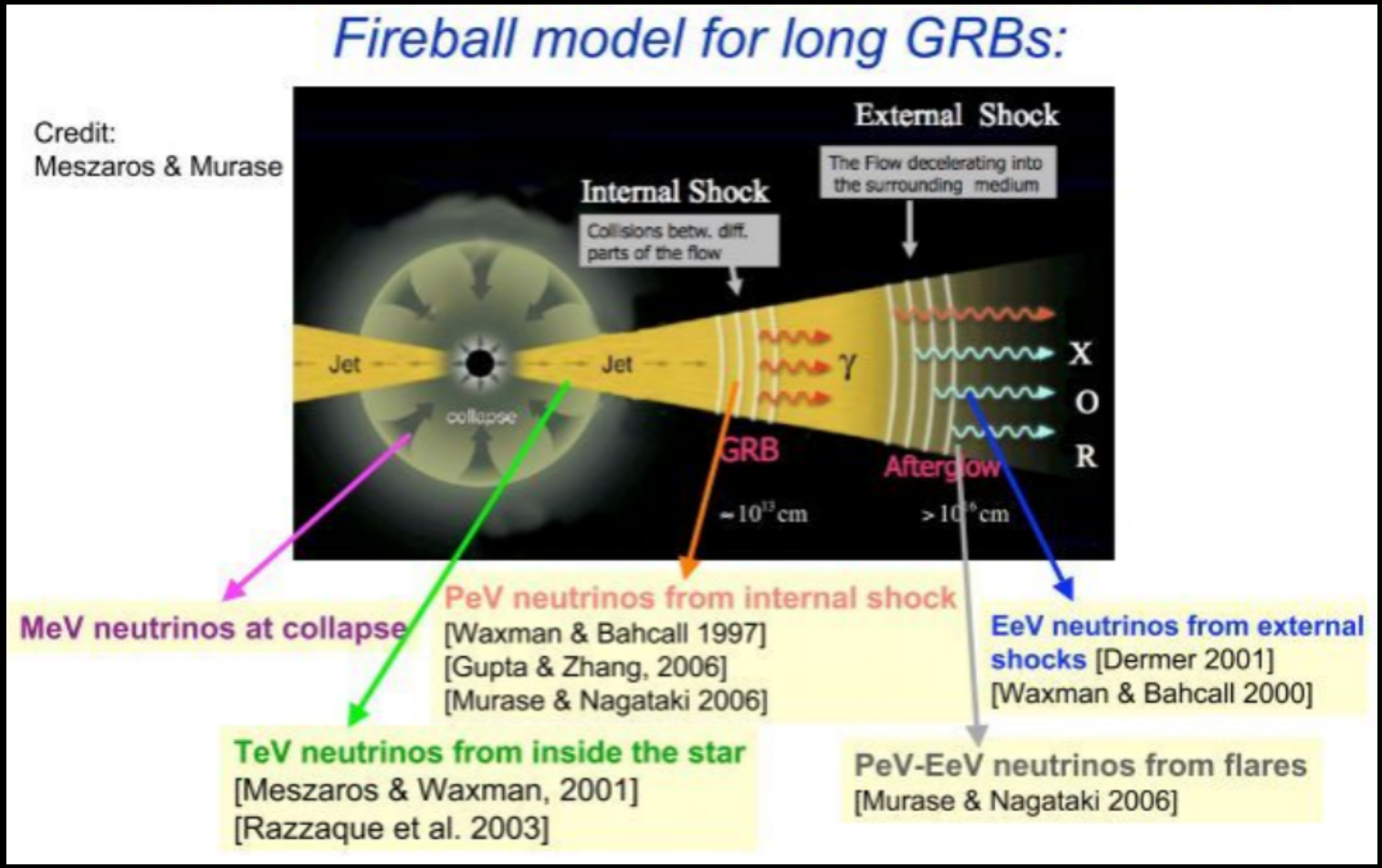
Where are neutrinos coming from?



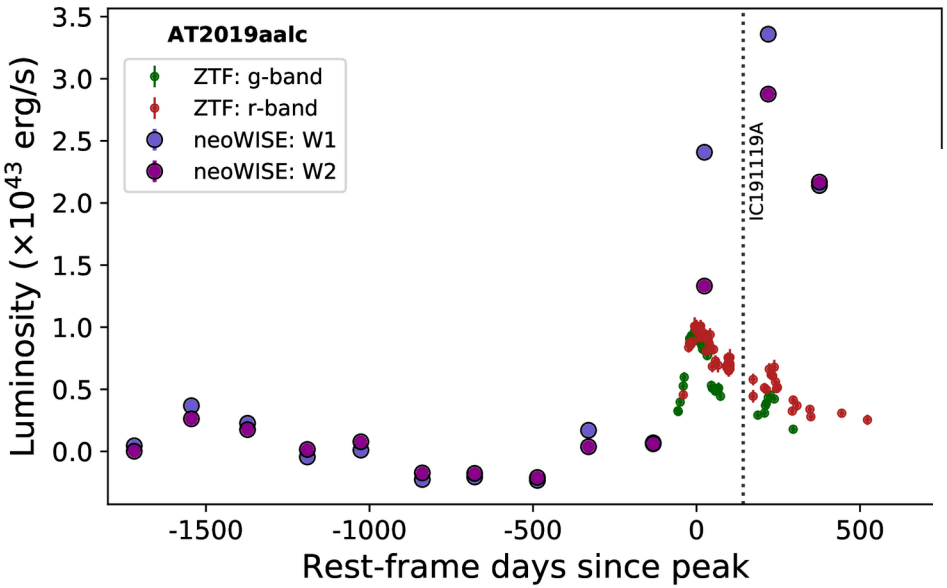
Where are neutrinos coming from?



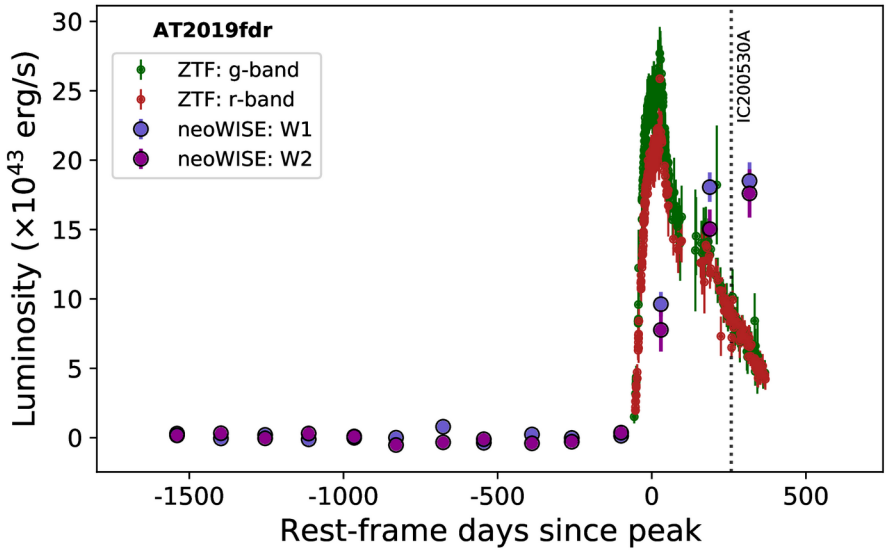
Possible source of neutrinos?



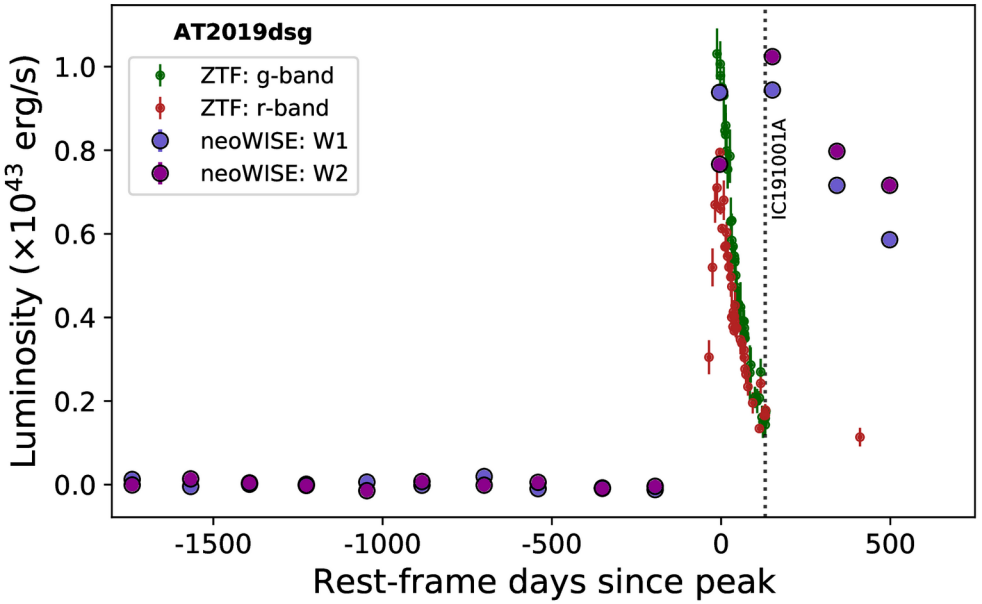
Possible source of neutrinos?



MeV neutrinos at collaps



ll model for long GRBs:

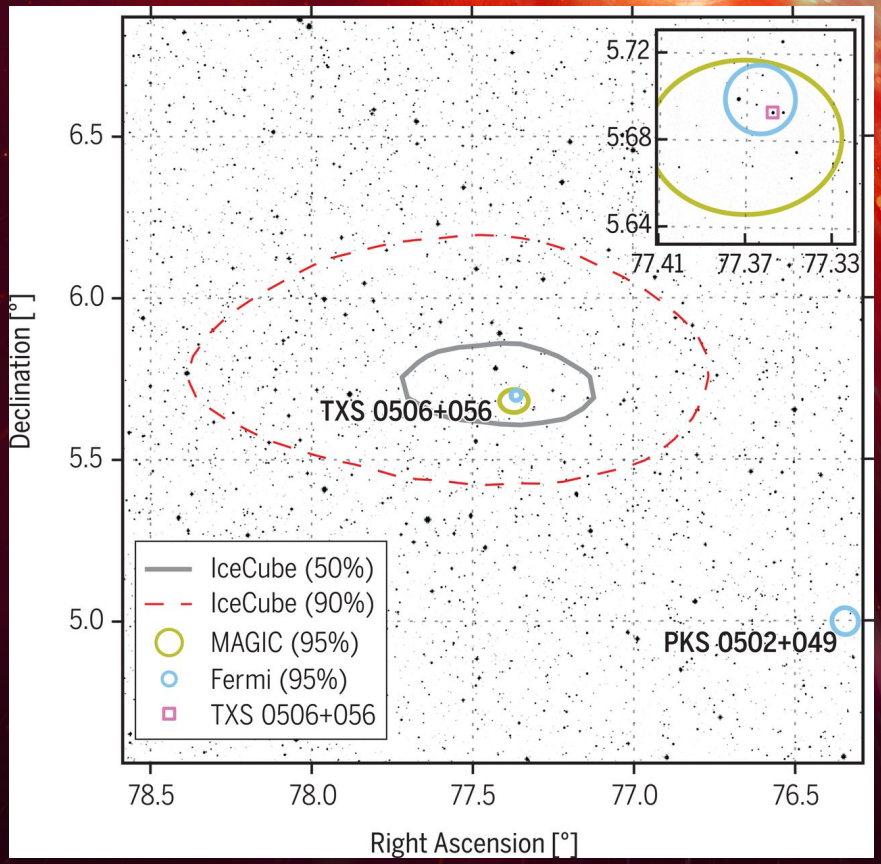


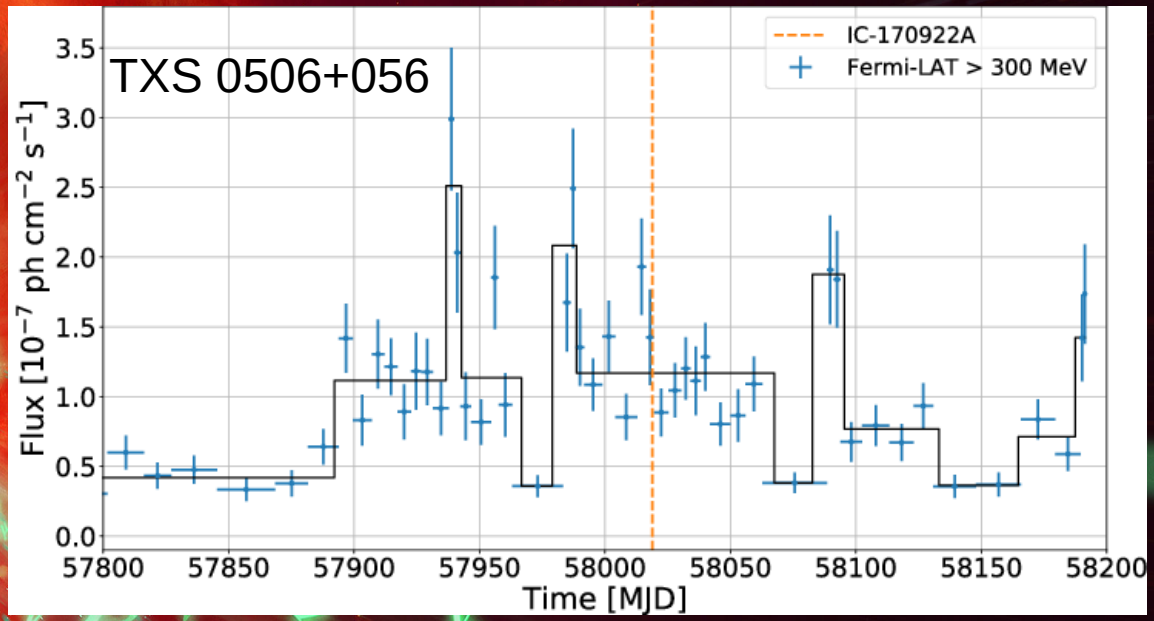
al. 2003]

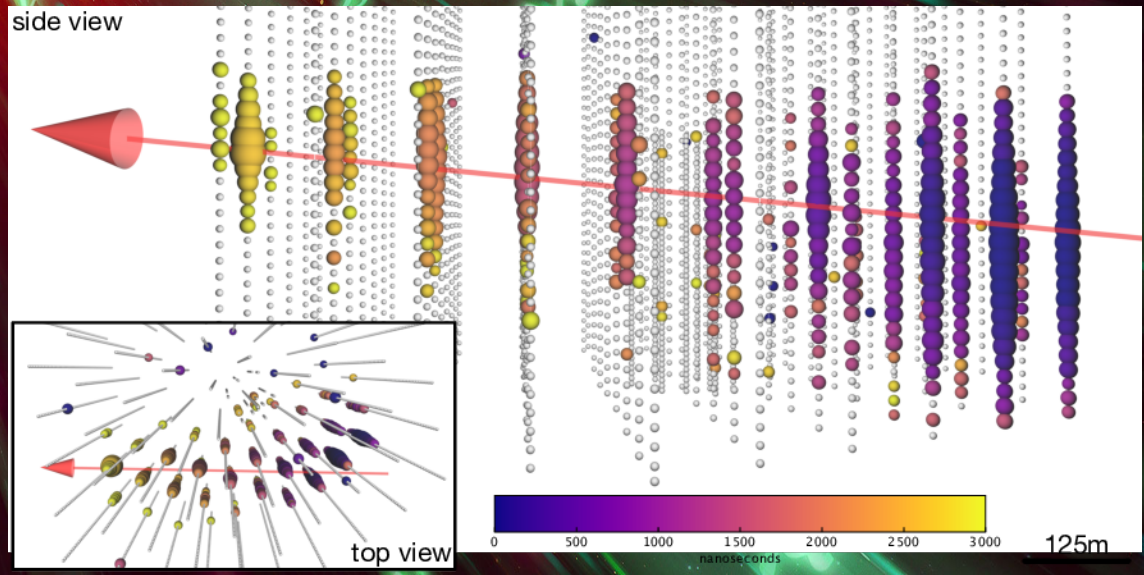
Accretion flare “dust echoes”
Van Velzen et al., (2021)

First extragalactic neutrino emitter?

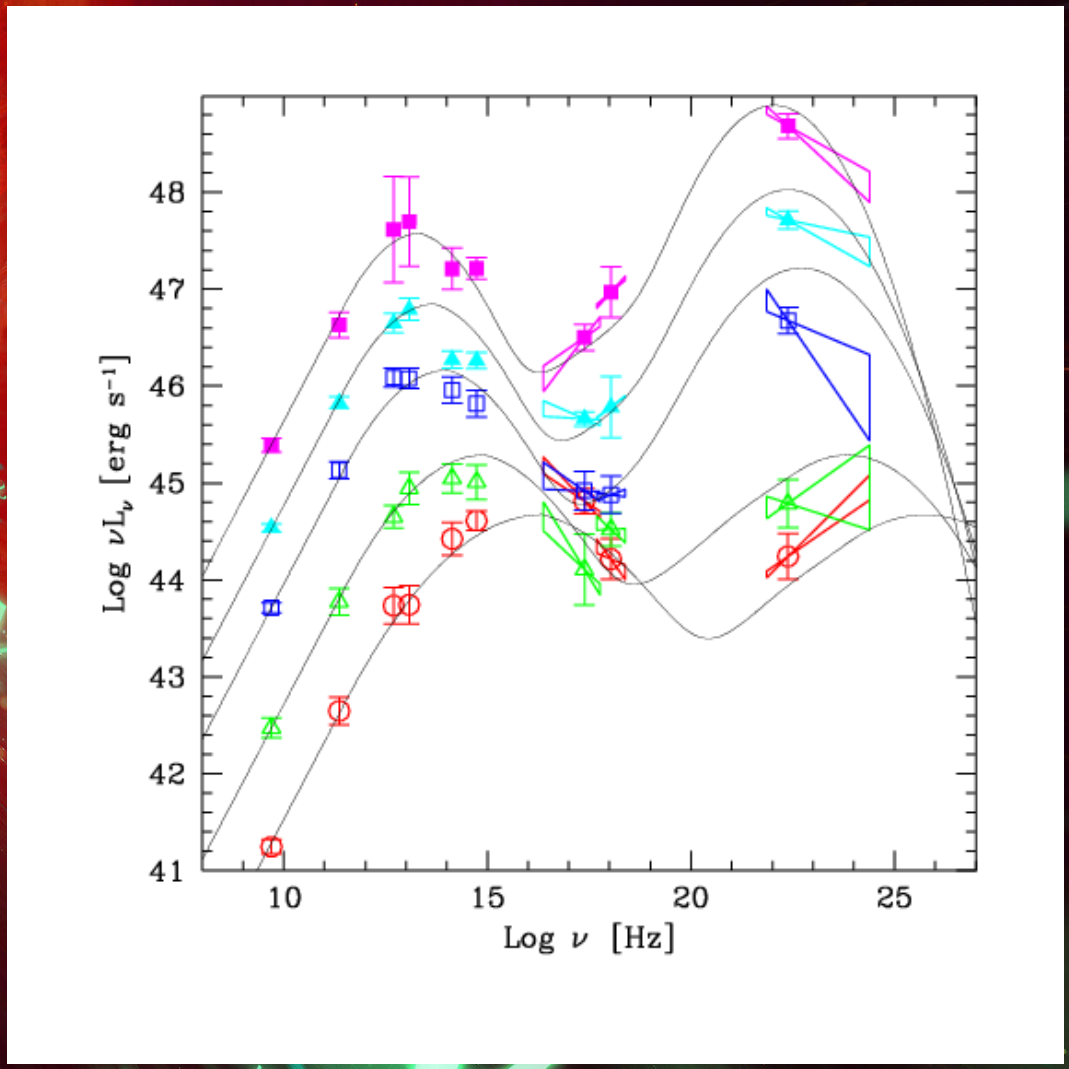
IceCube collaboration (2018)



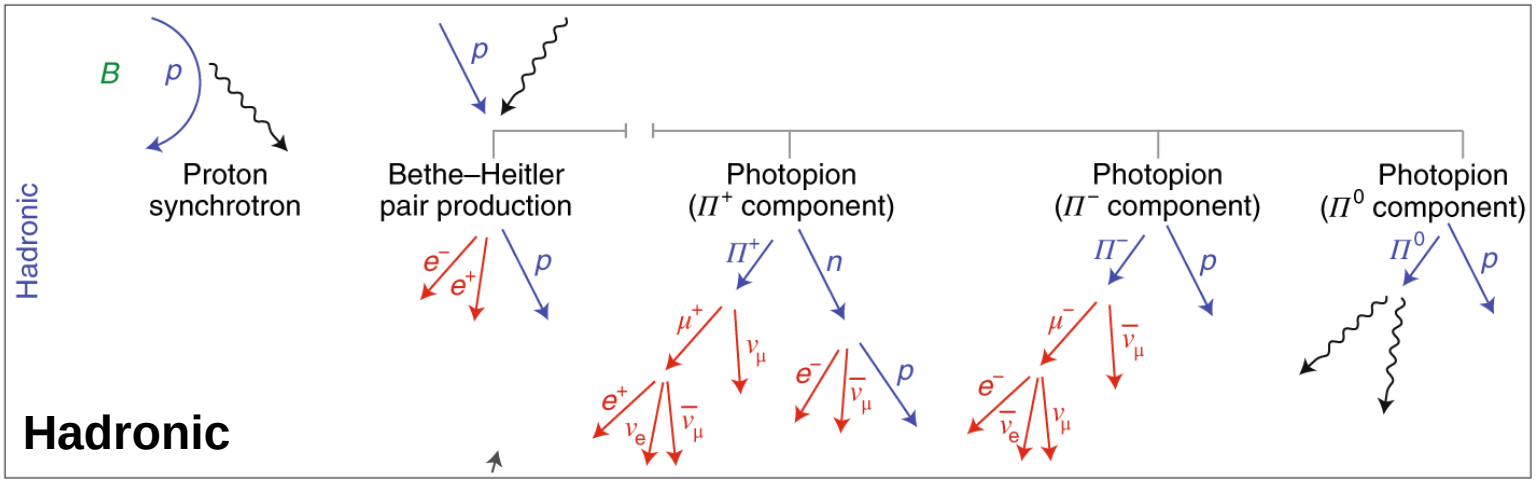


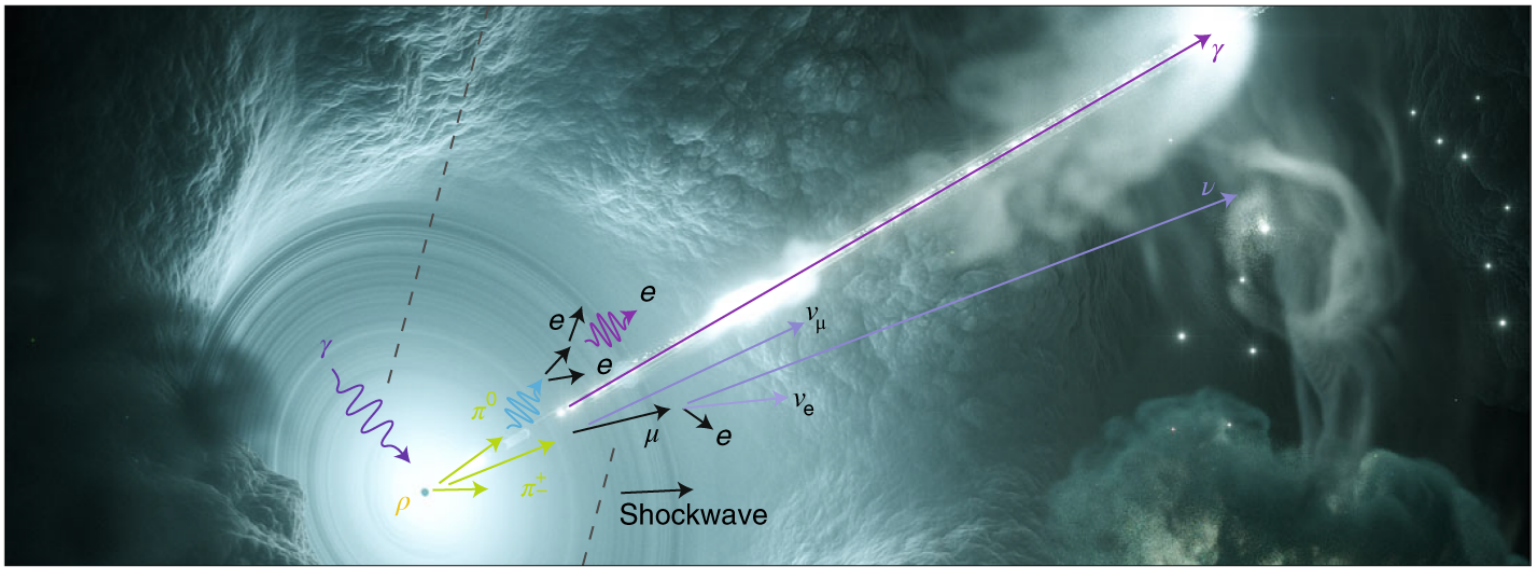


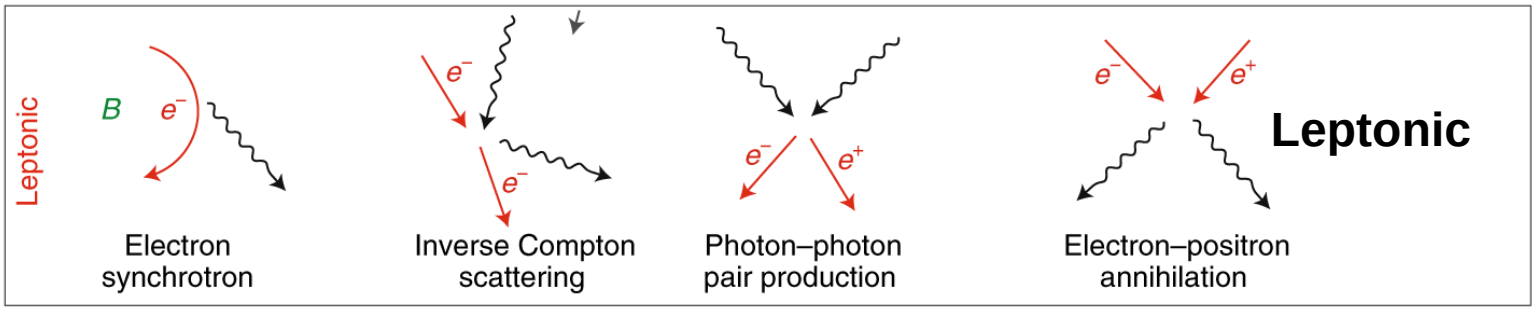
First extragalactic neutrino emitter?

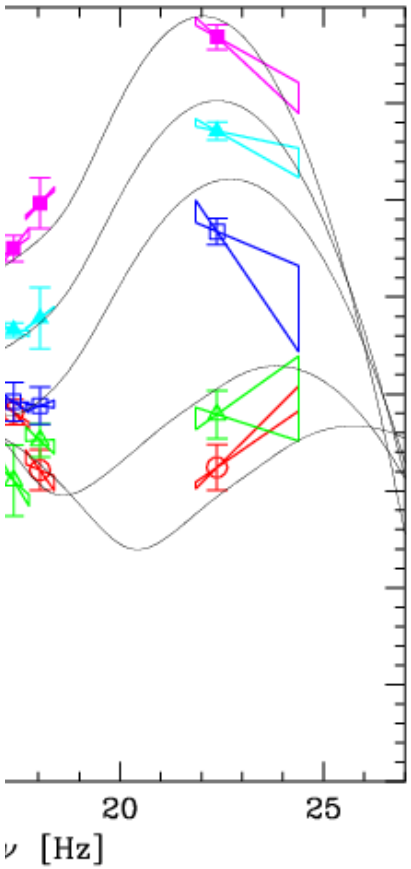


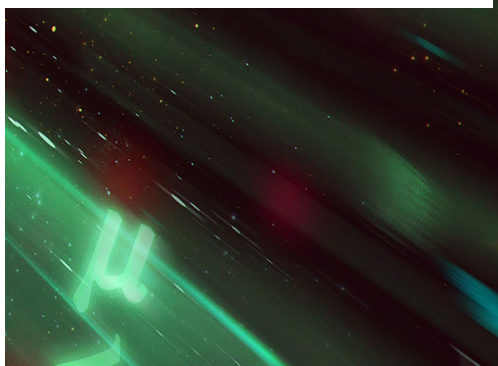
First extragalactic neutrino emitter?



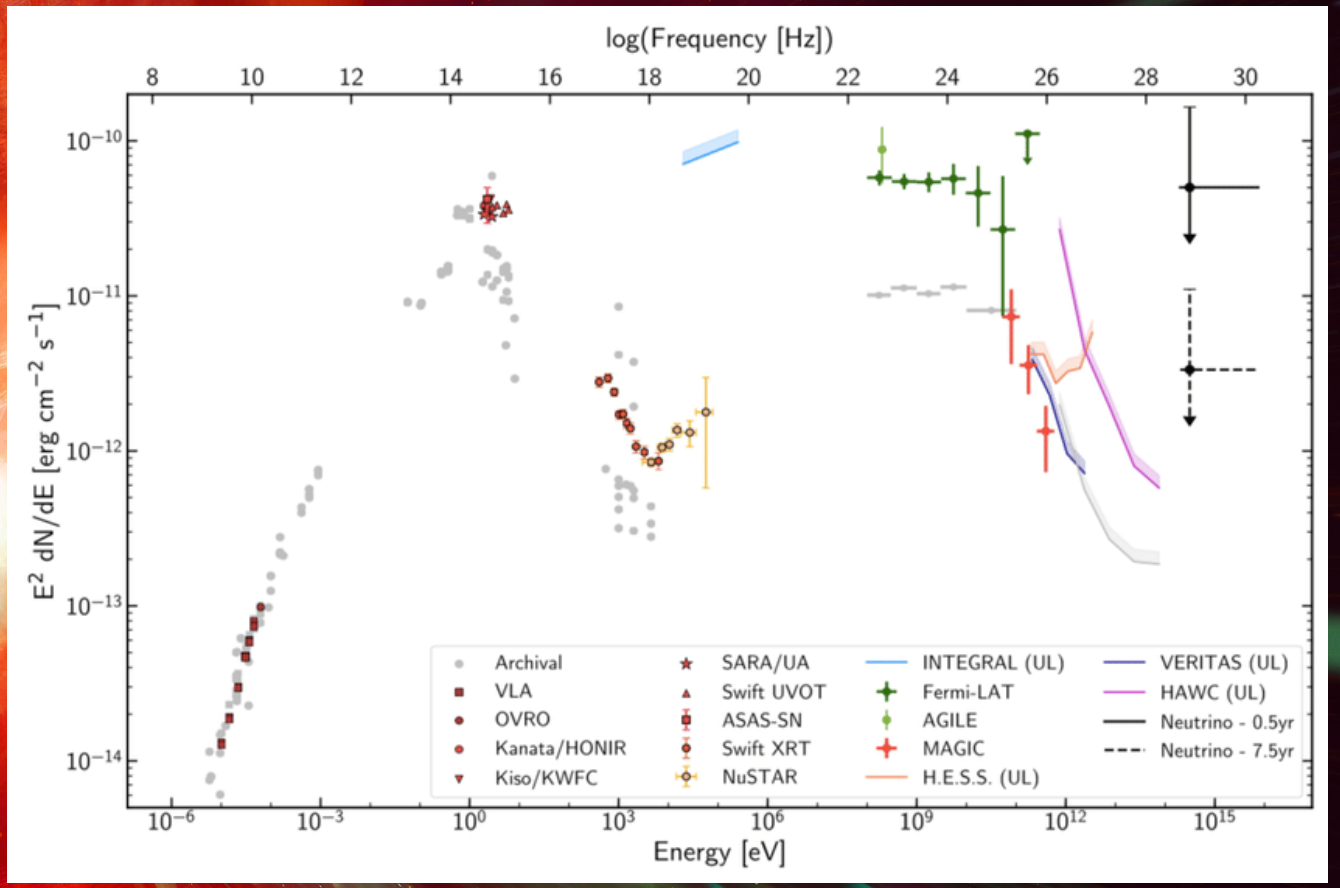






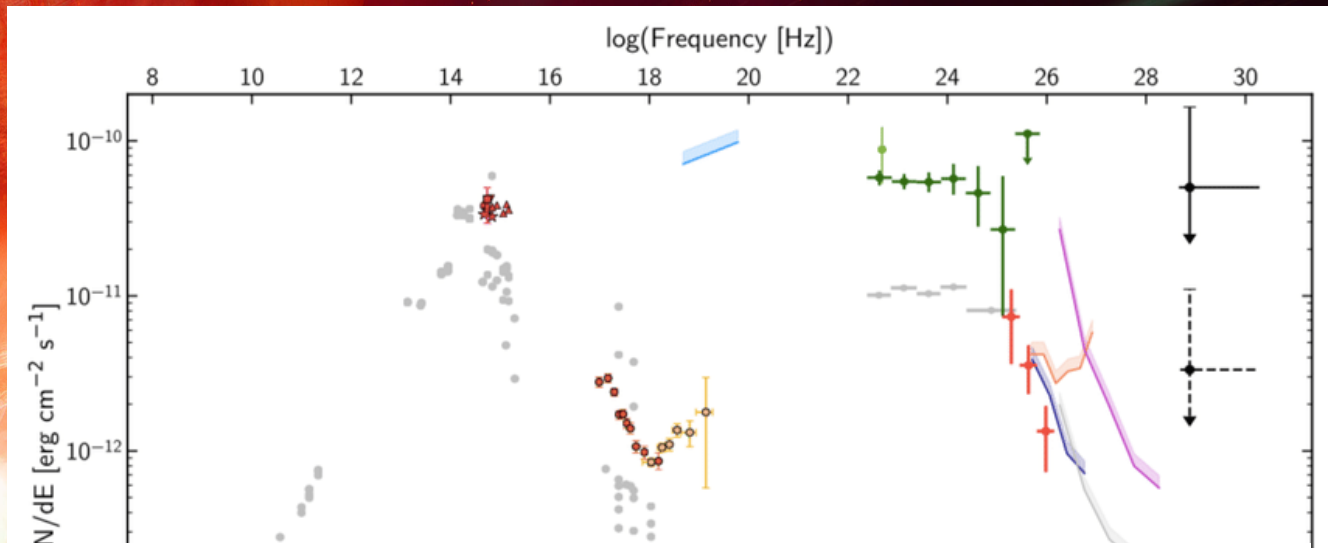


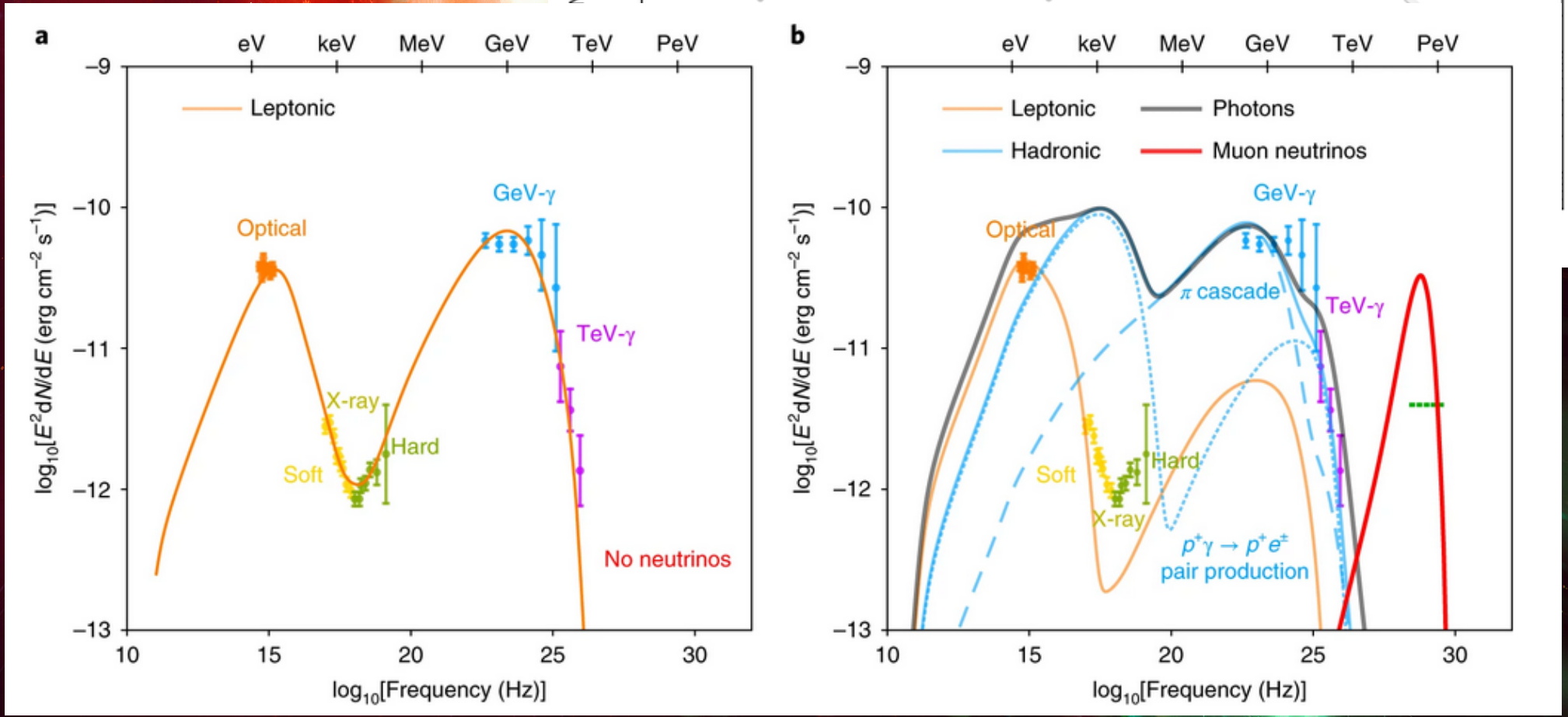
First extragalactic neutrino emitter?



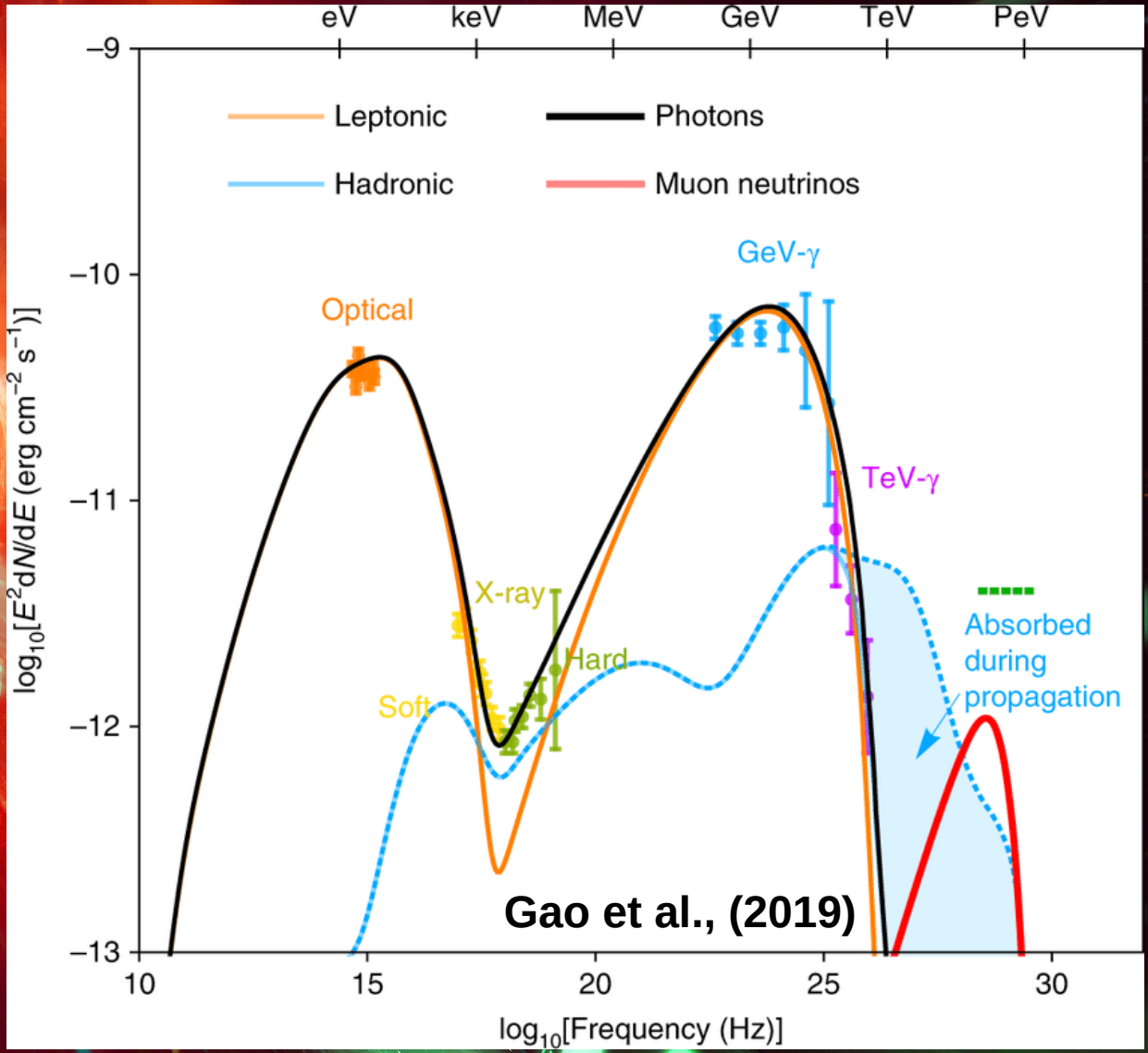
First extragalactic neutrino emitter?

Gao et al., (2019)



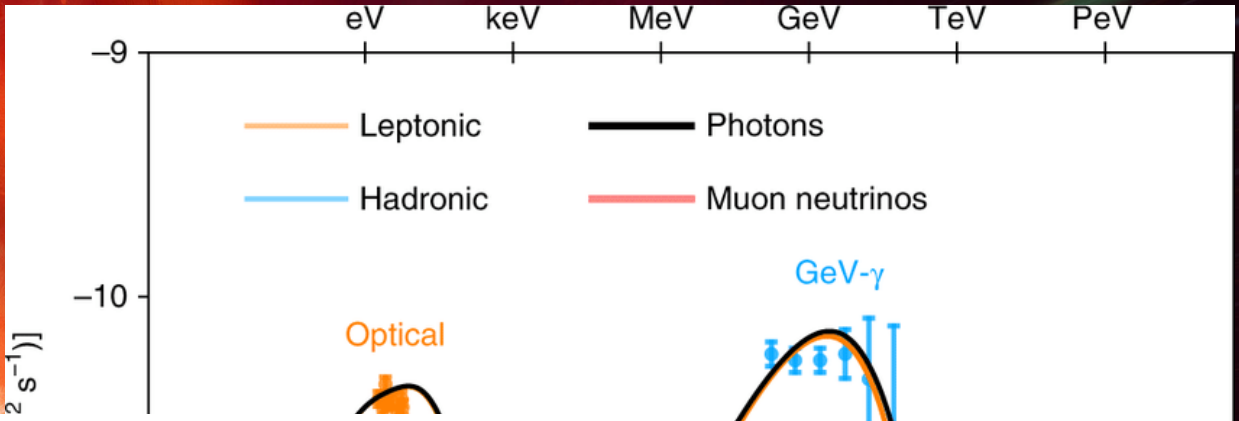


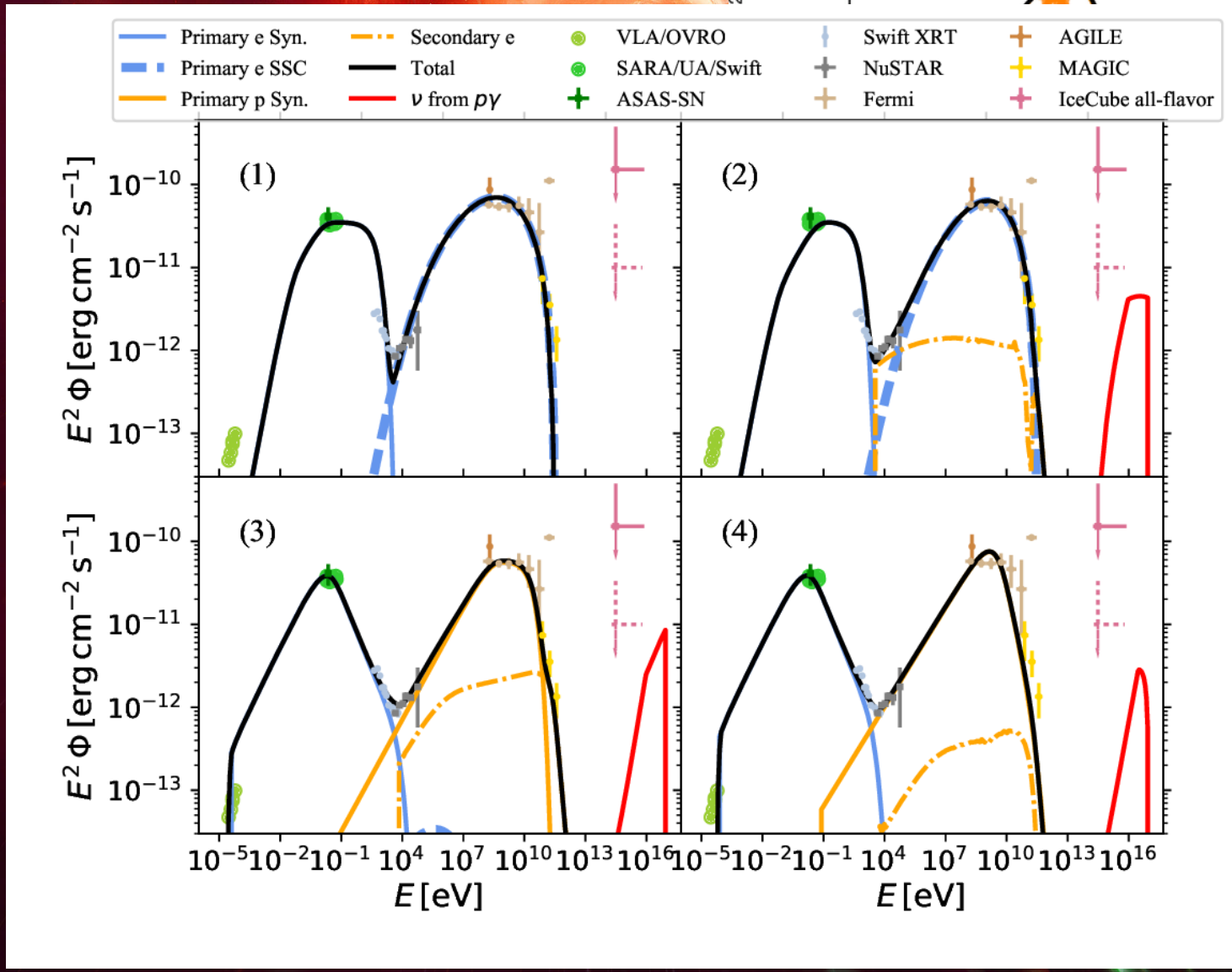
First extragalactic neutrino emitter?

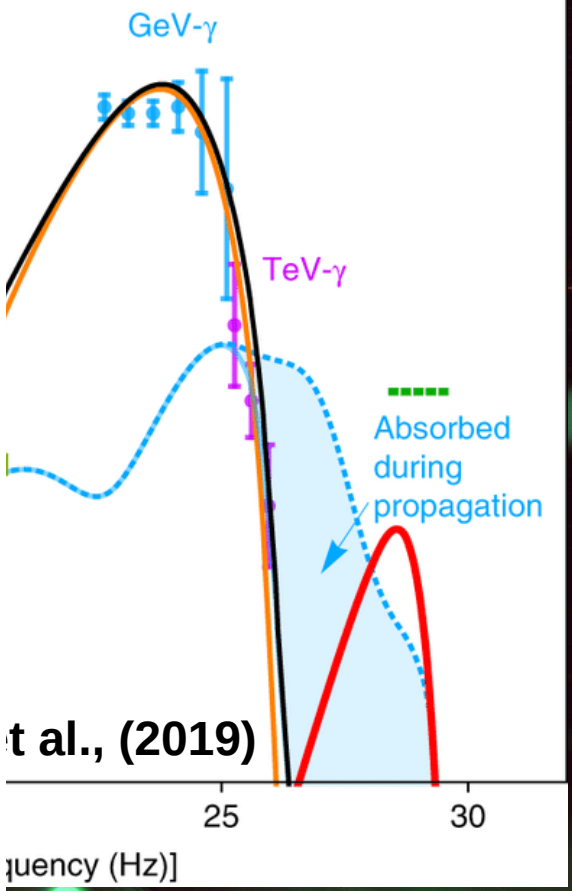


First extragalactic neutrino emitter?

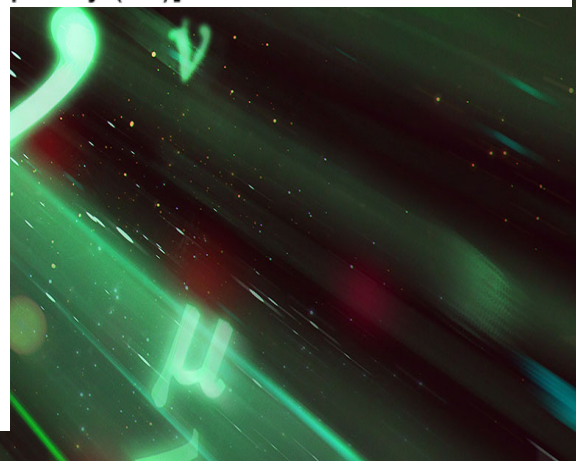
Zhang et al., (2019)



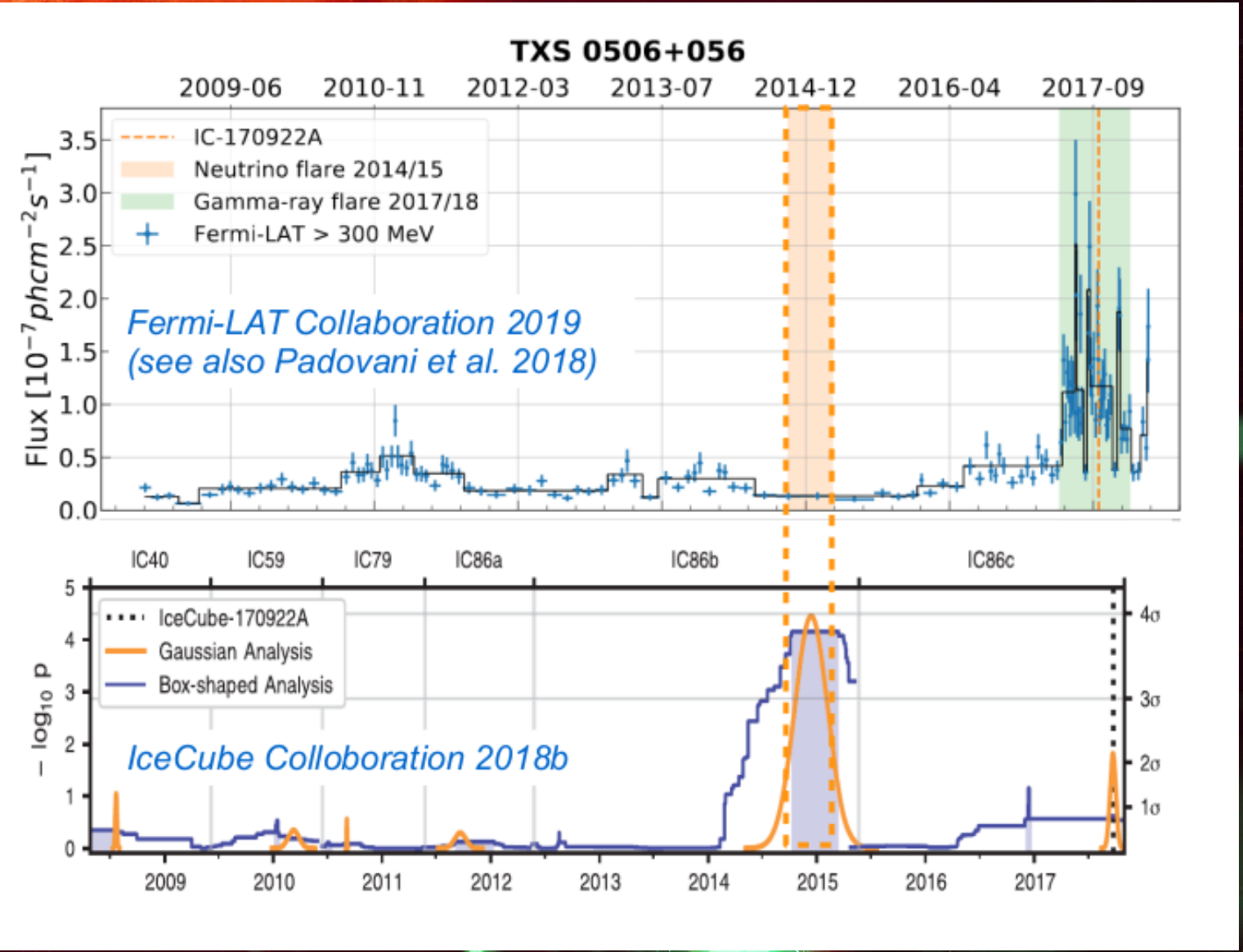




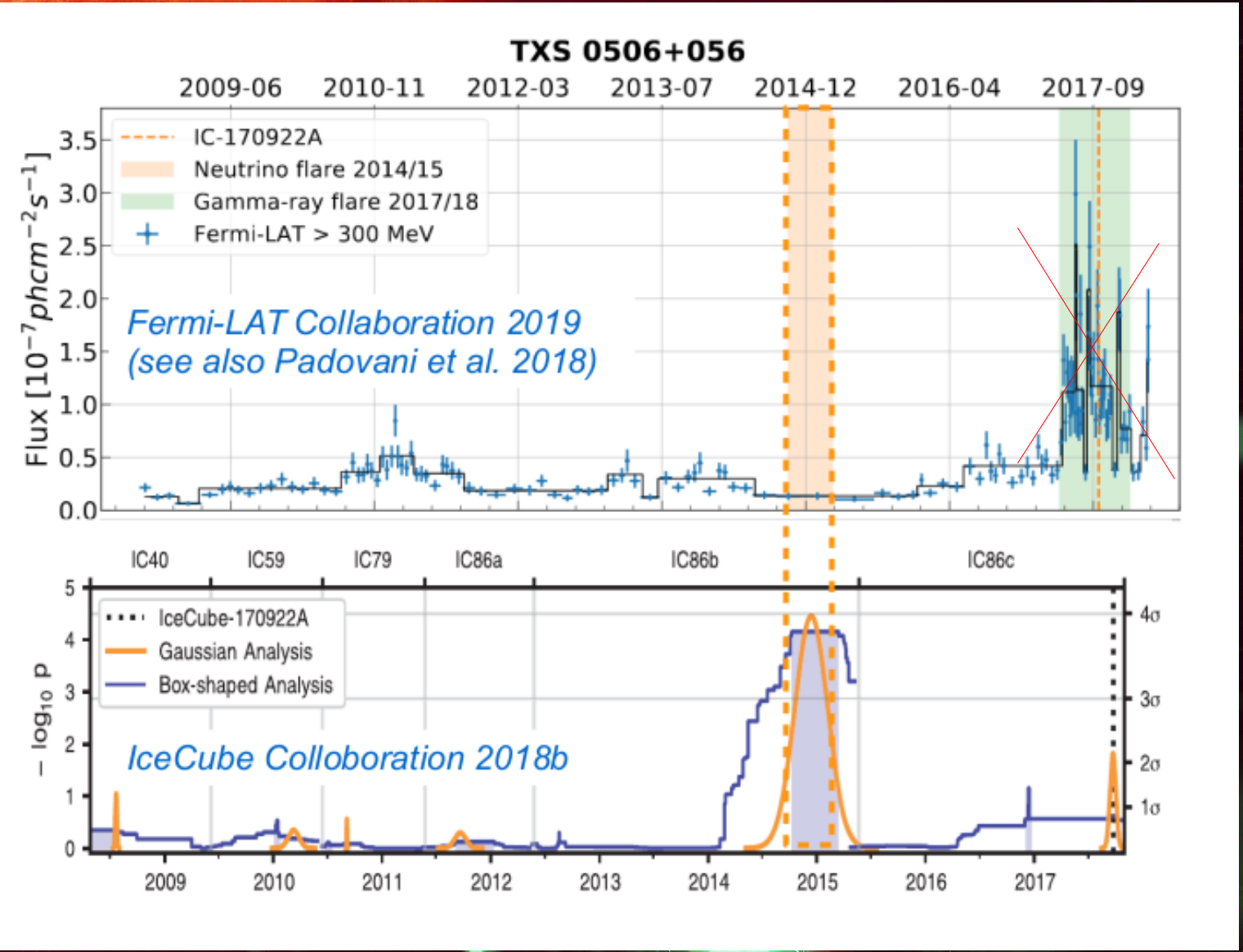
t al., (2019)



First extragalactic neutrino emitter?

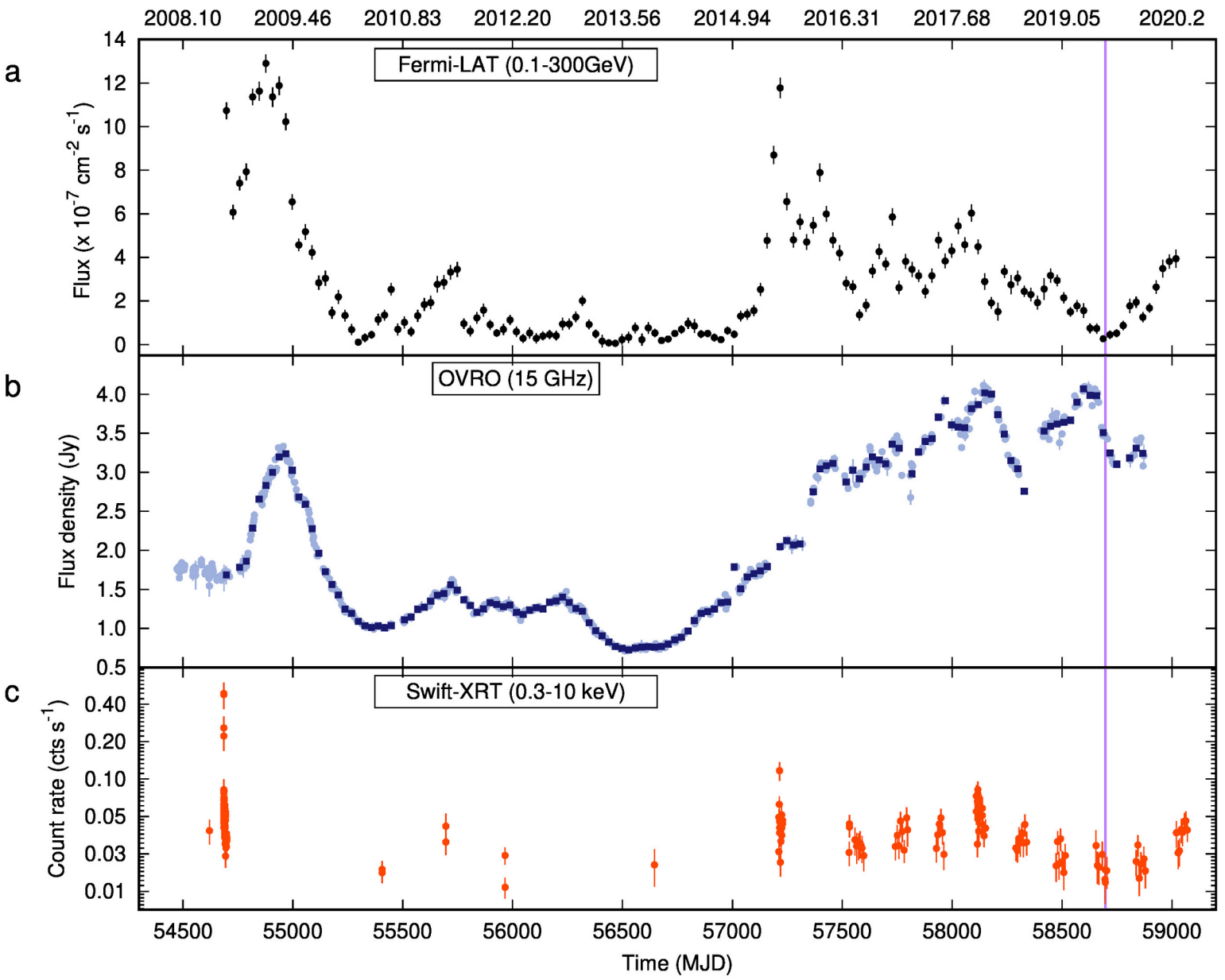


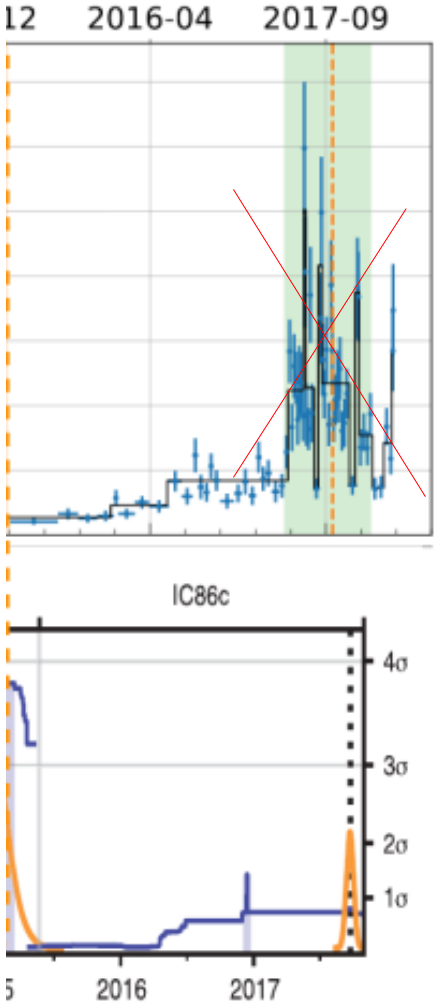
First extragalactic neutrino emitter?

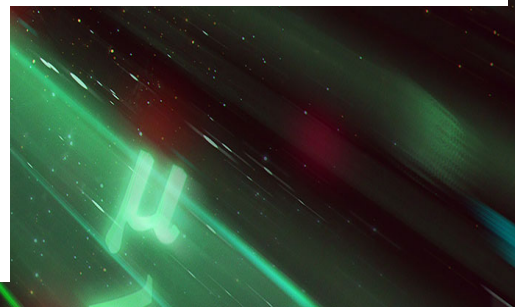


First extragalactic neutrino emitter?

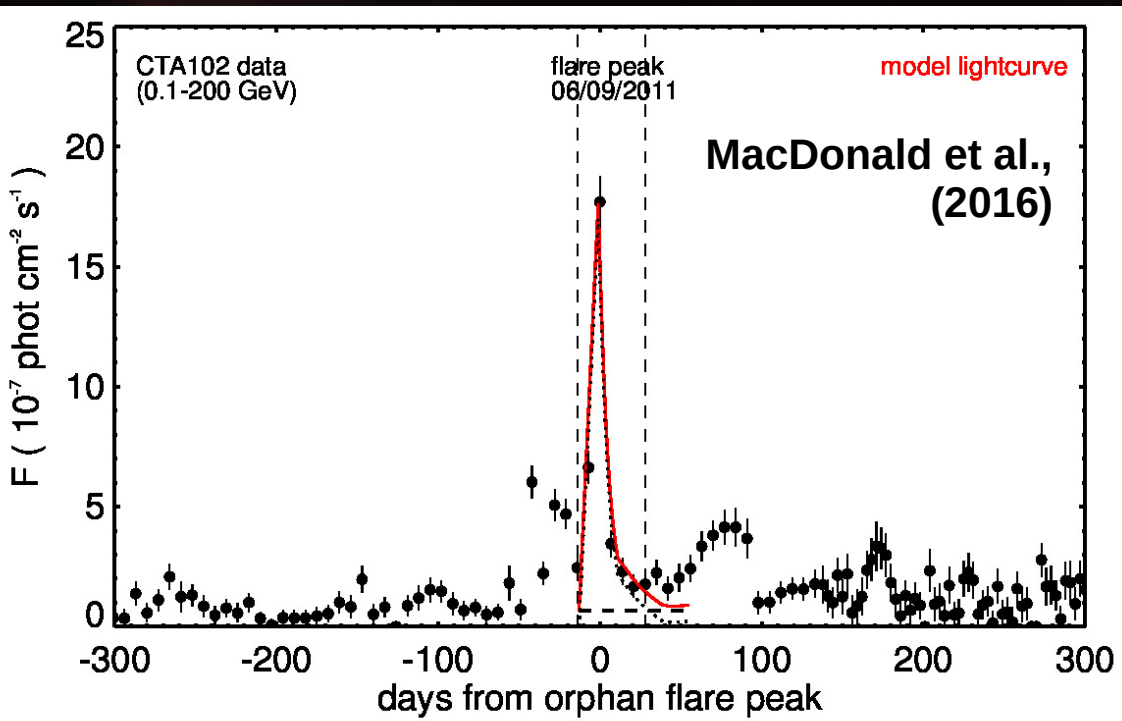
PKS1502+106, Kun et al., (2021)

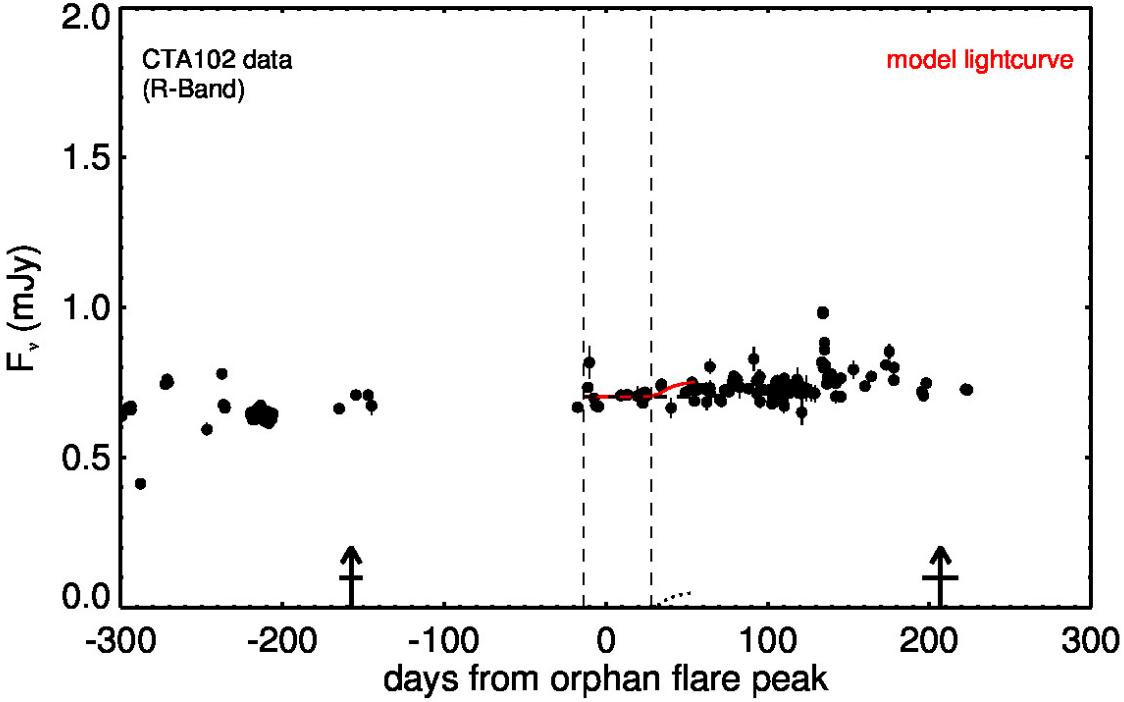




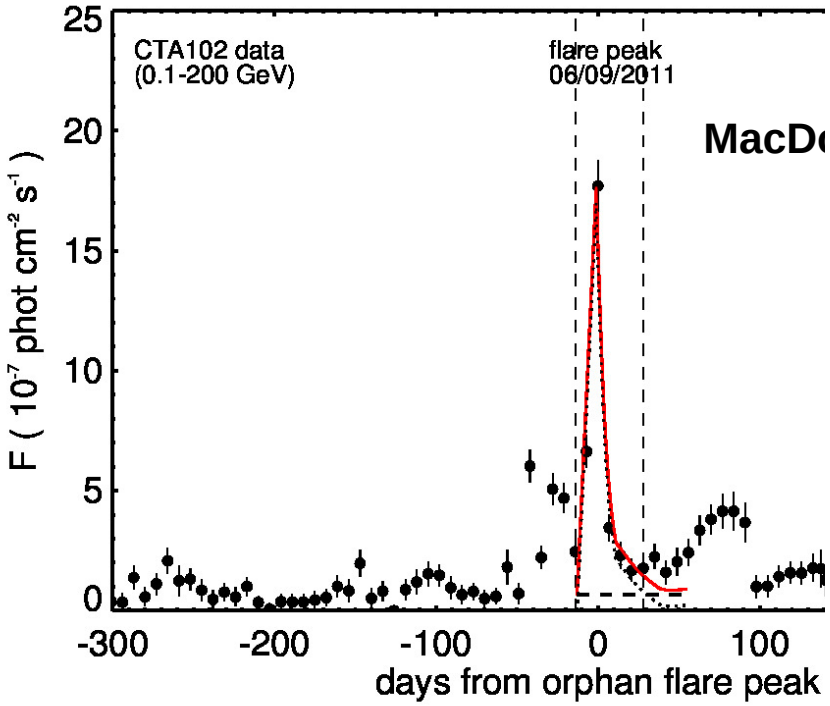


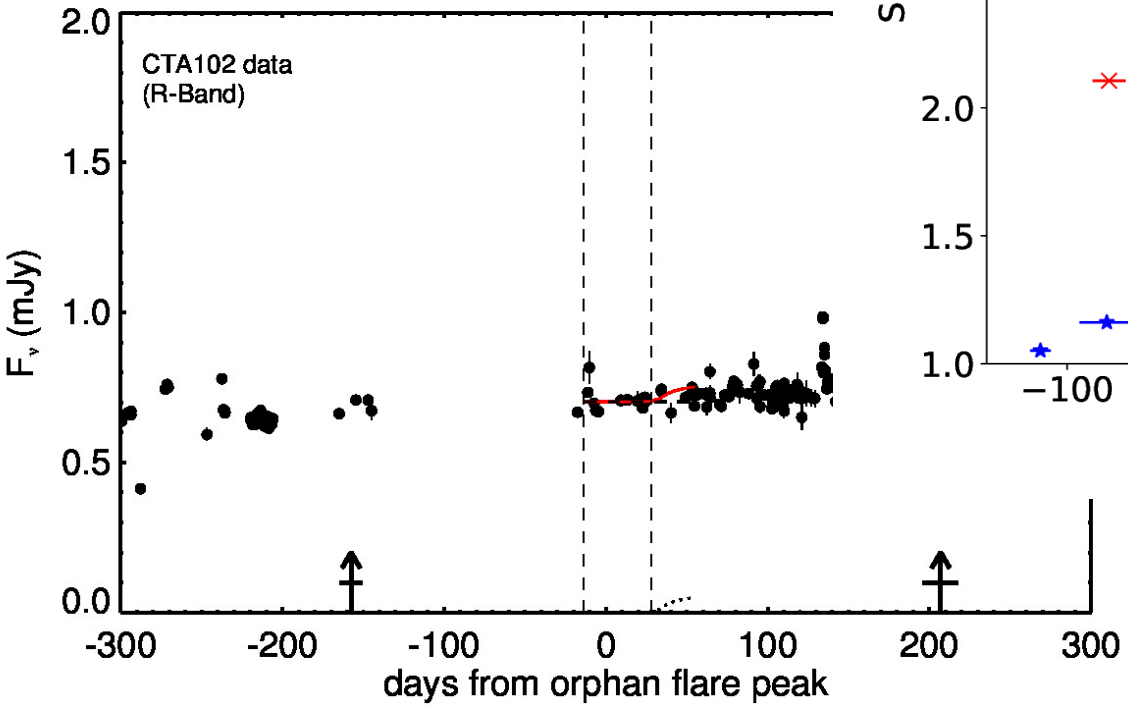
Orphan γ-ray flares?



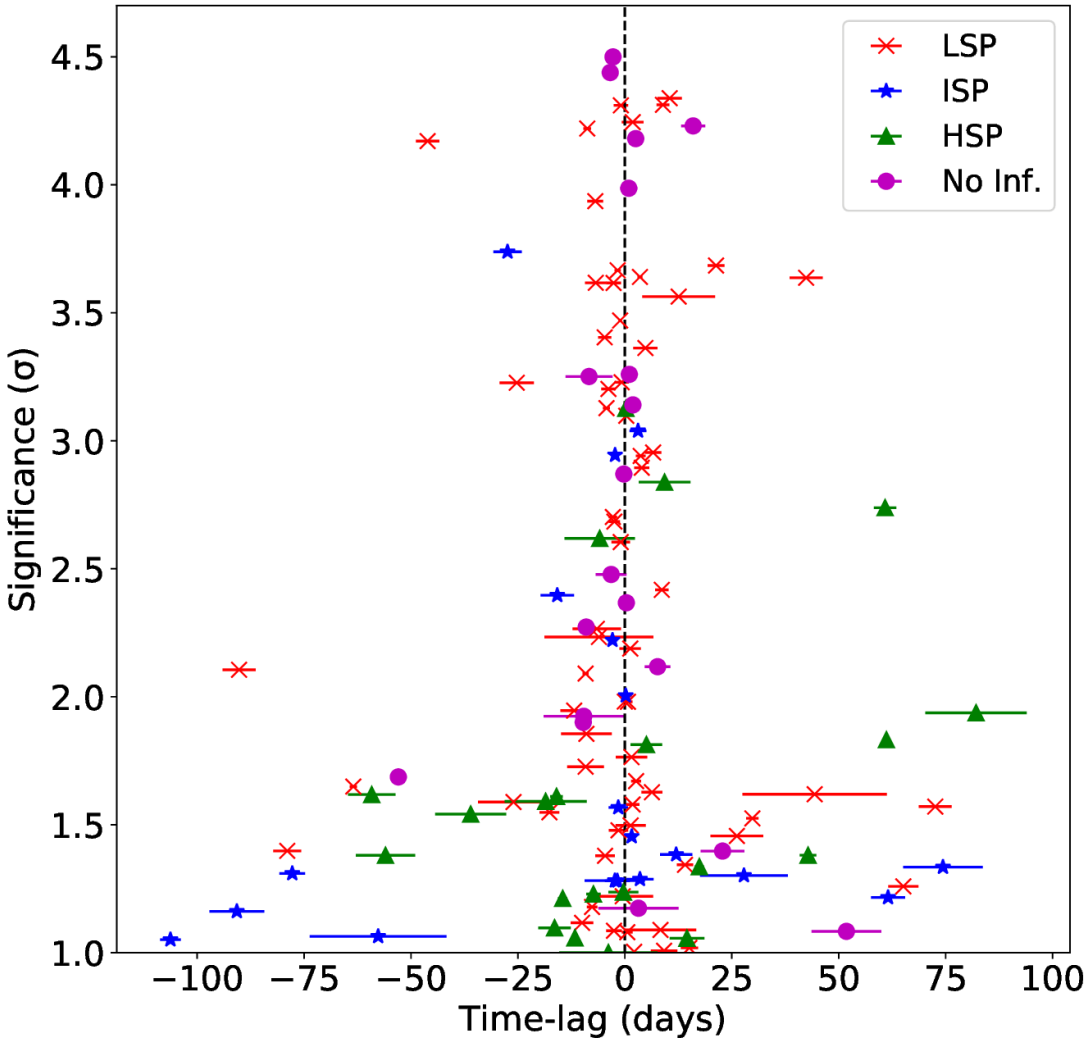


Orphan γ-ray flares?



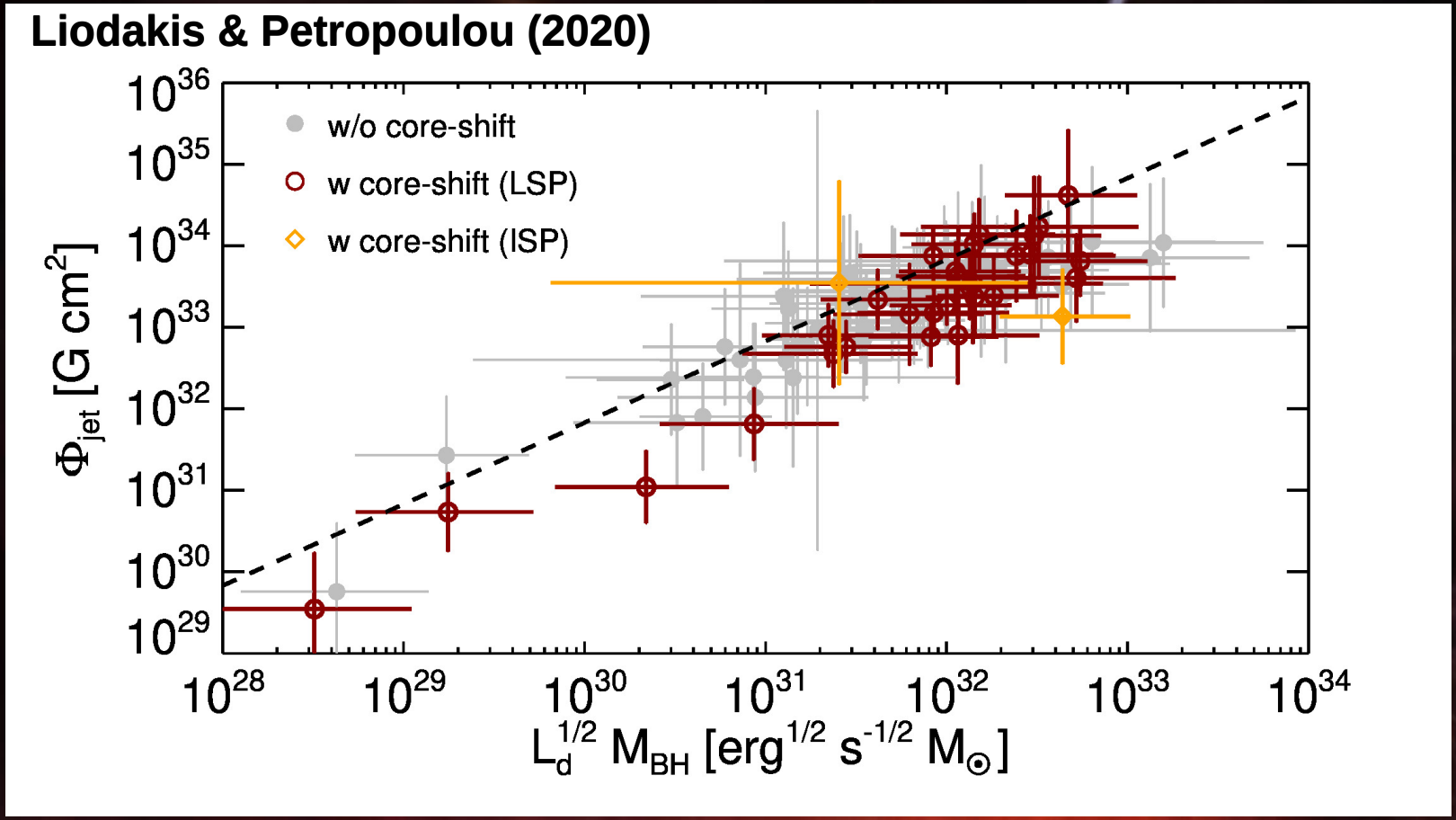


Liodakis et al., (2019)



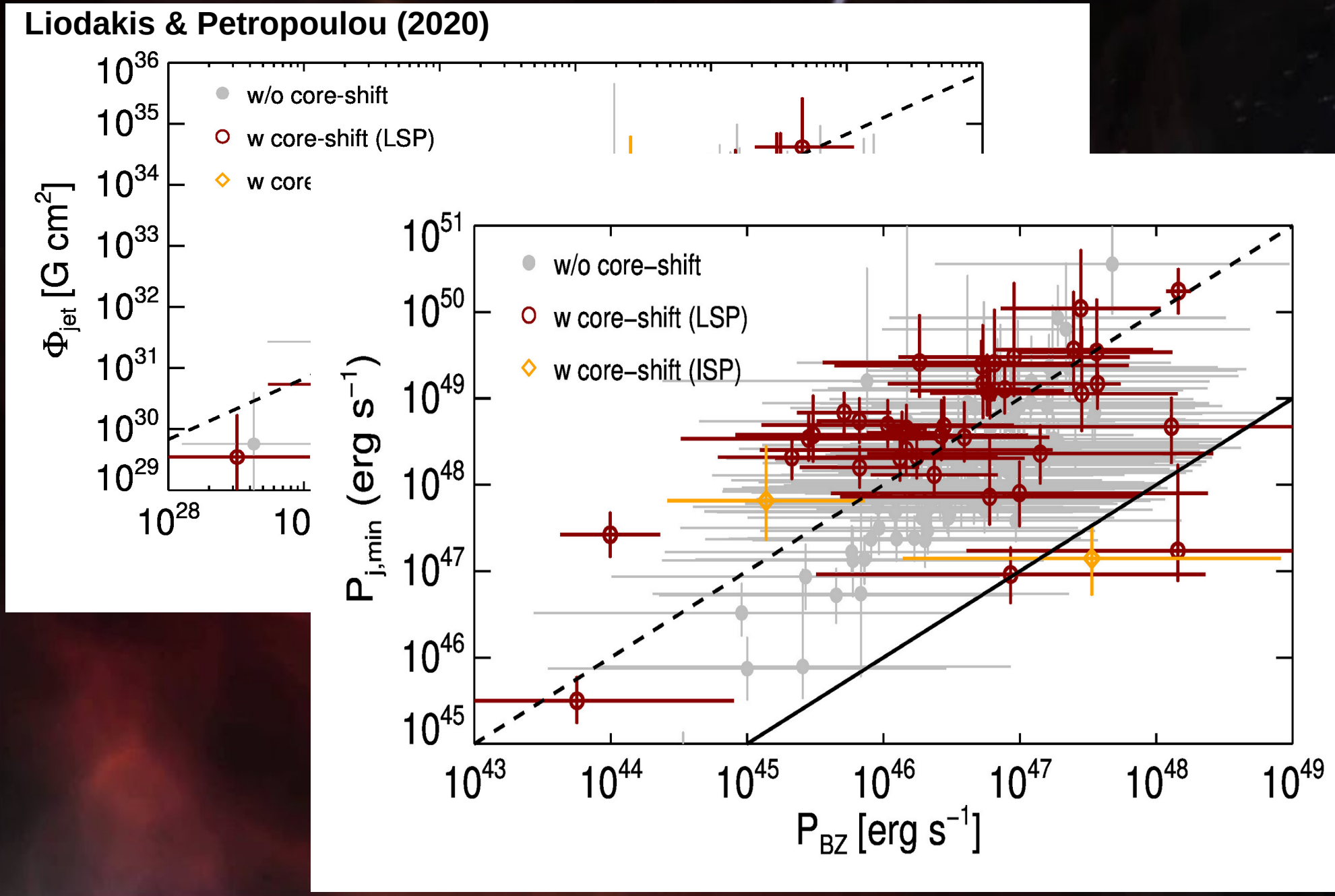
121/178 sources show a correlation
~20% of γ-flares are orphan!

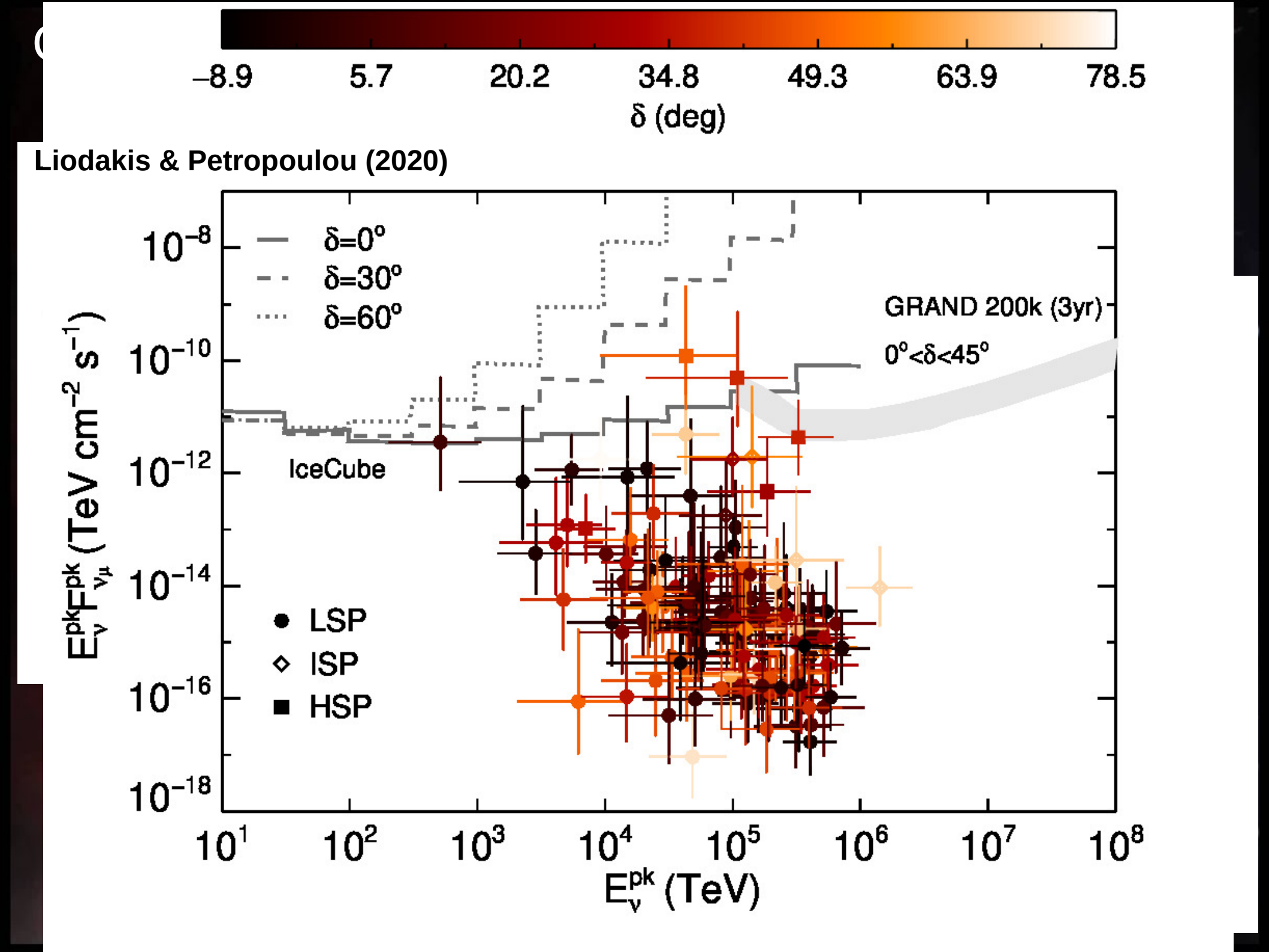
Can protons explain the high emission?



Can protons explain the high emission?

Liodakis & Petropoulou (2020)

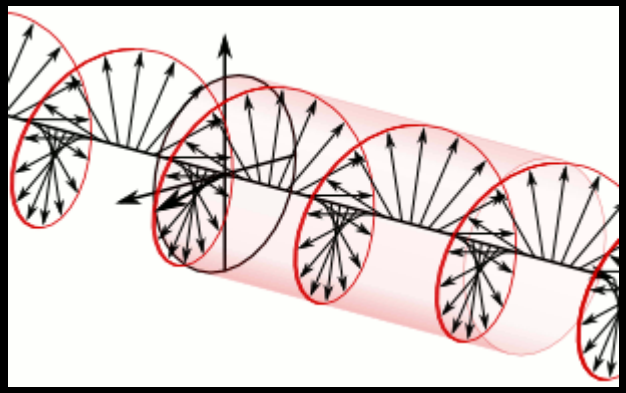


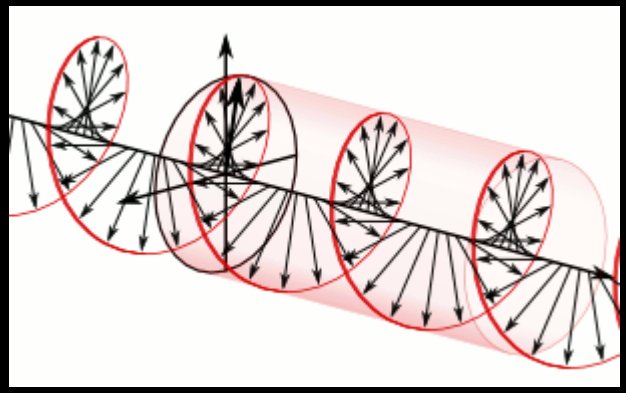


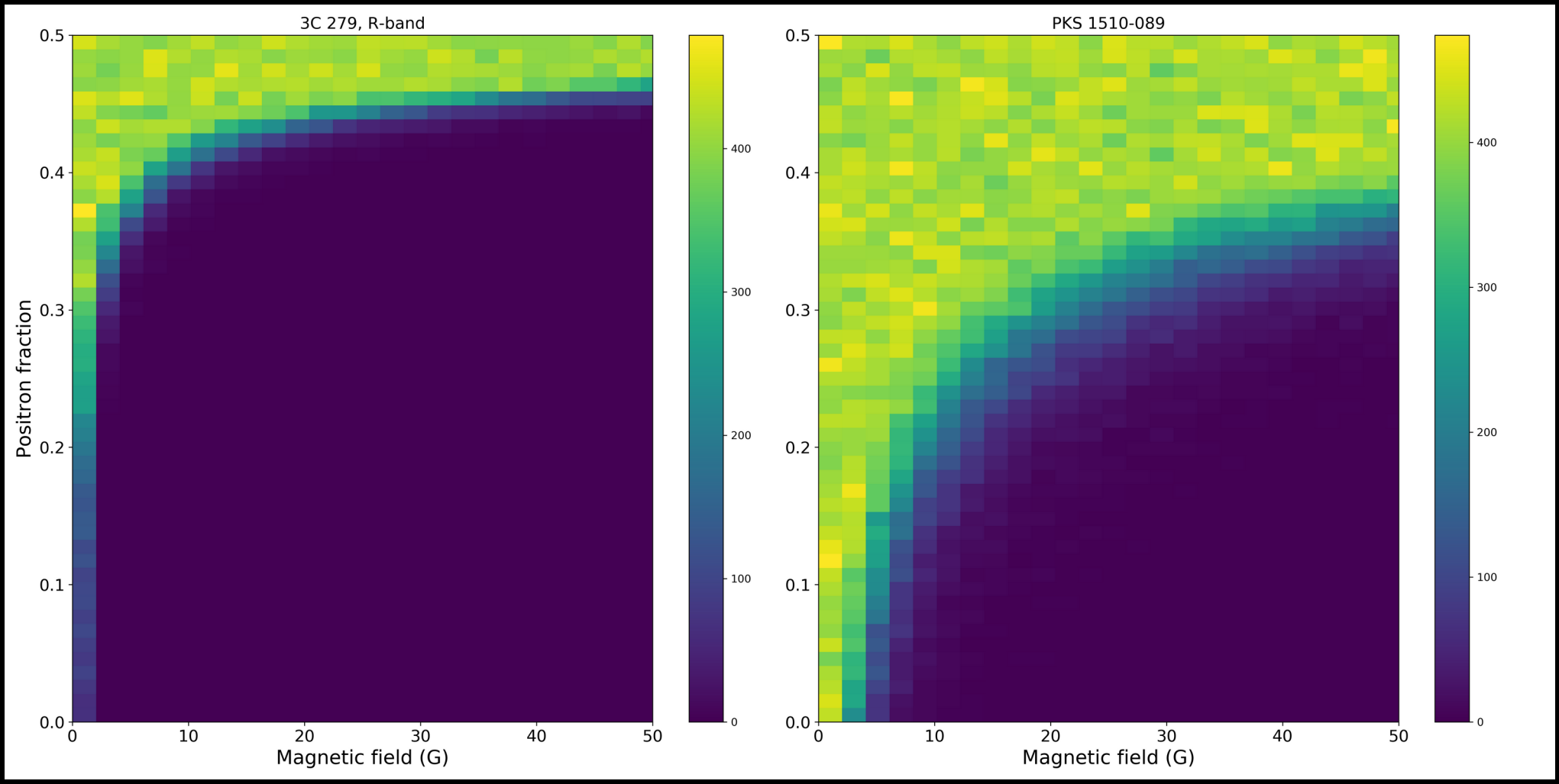
Liodakis & Petropoulou (2020)

Optical circular polarization?

Liodakis et al., (2022)



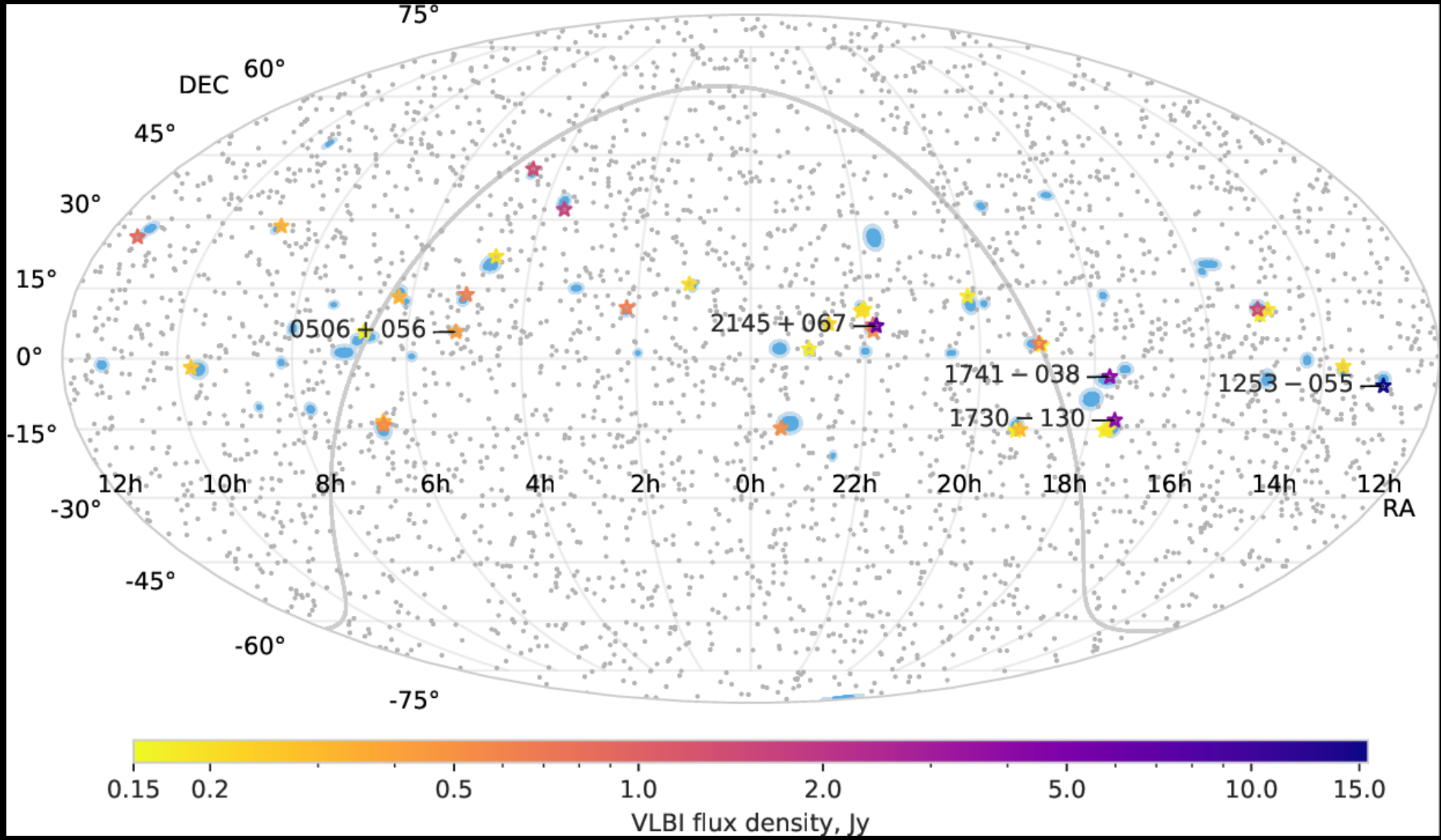




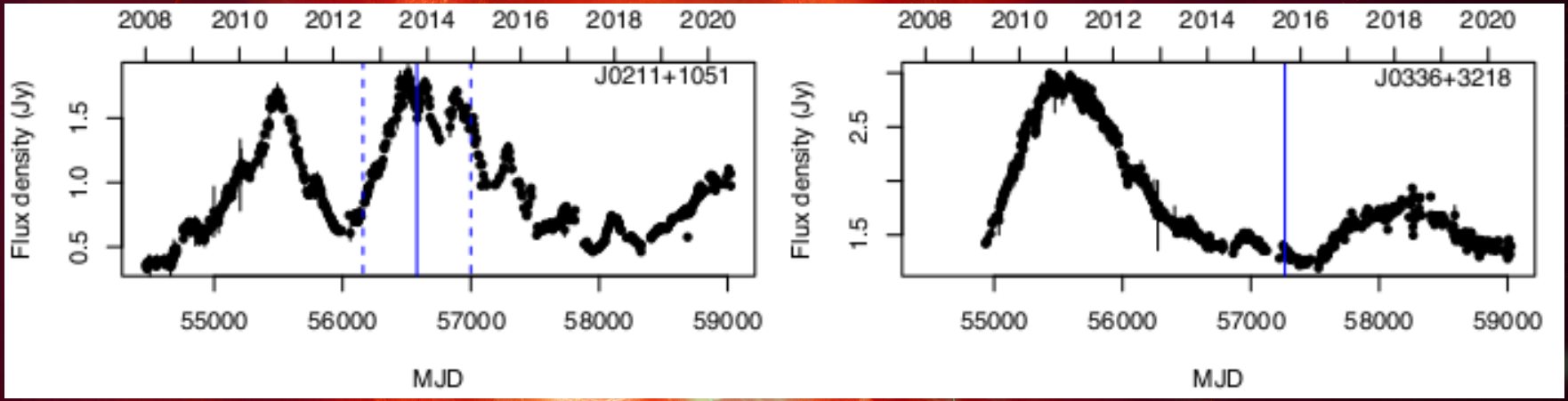
Radio emission to the rescue?

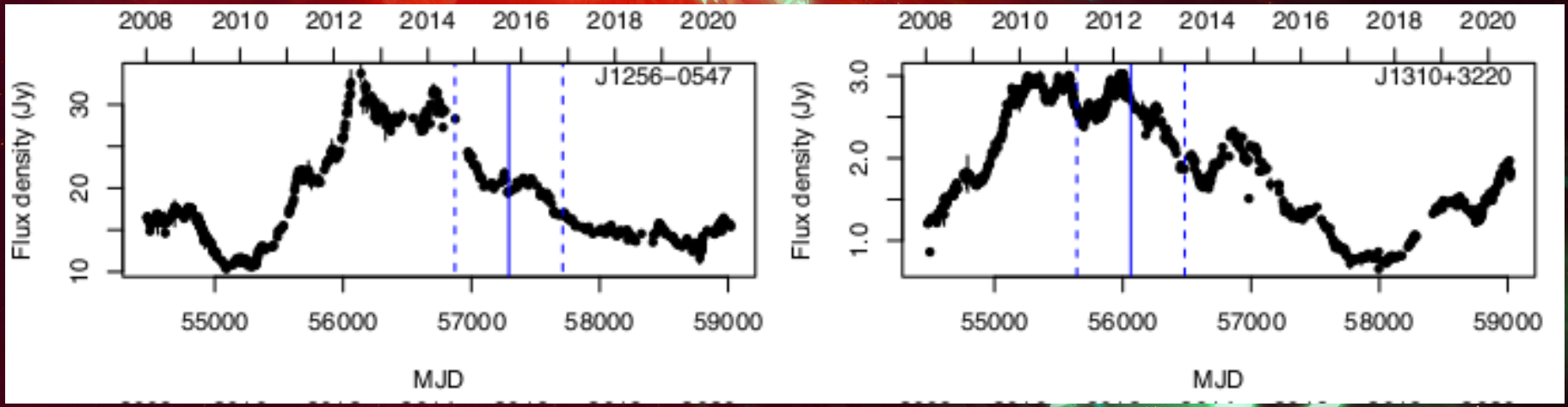
Plavin et al., 2020

3388 VLBI detected AGN at 8GHz



Radio emission to the rescue?





OVRO ~1800 jetted AGN
Hovatta et al.[+Liodakis] (2021)
~2σ association between blazars and neutrinos
9/20 sources are γ-ray dark!

OVRO’s multimessenger survey

Unbiased sample selection

Both y-ray bright and y-ray dark AGN

5500 sources

~10 day cadence for 5 years

Survey started January 2021

OVRO's multimessenger survey

Unbiased sample selection

Both γ-ray bright and γ-ray dark AGN

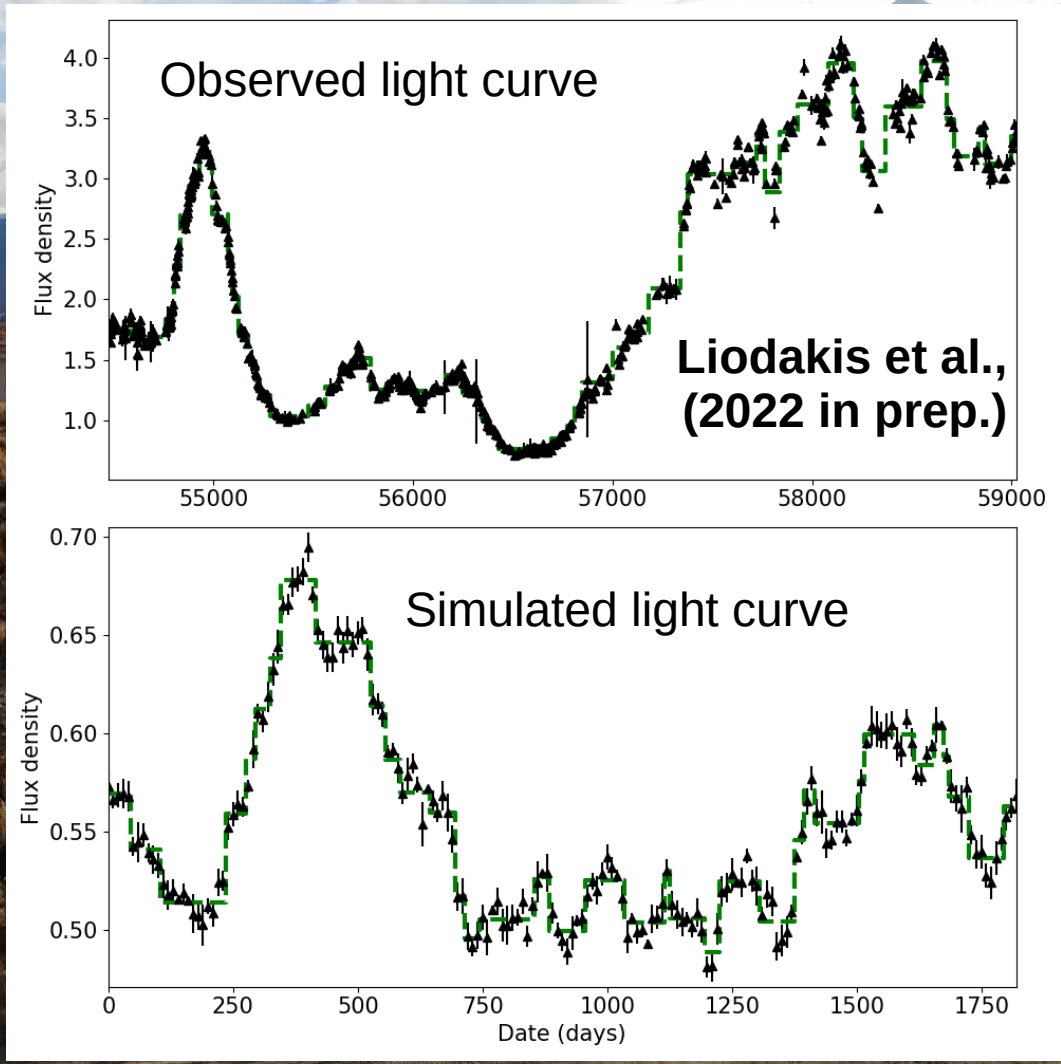
5500 sources

~10 day cadence for 5 years

Survey started January 2021

Forecasting AGN-neutrino association

If neutrino luminosity correlates with radio flux we will achieve a >4σ association



Summary

The search for extragalactic neutrinos emitters continues...

Blazars still the most promising candidate sources, but with a lot of open questions

If blazars make neutrinos, those are made through hybrid processes, most likely subdominant proton population

We may soon understand the connection between neutrinos and AGN that will gives new ways to uncover unknown particle physics.