Lessons learned from modeling active galaxies

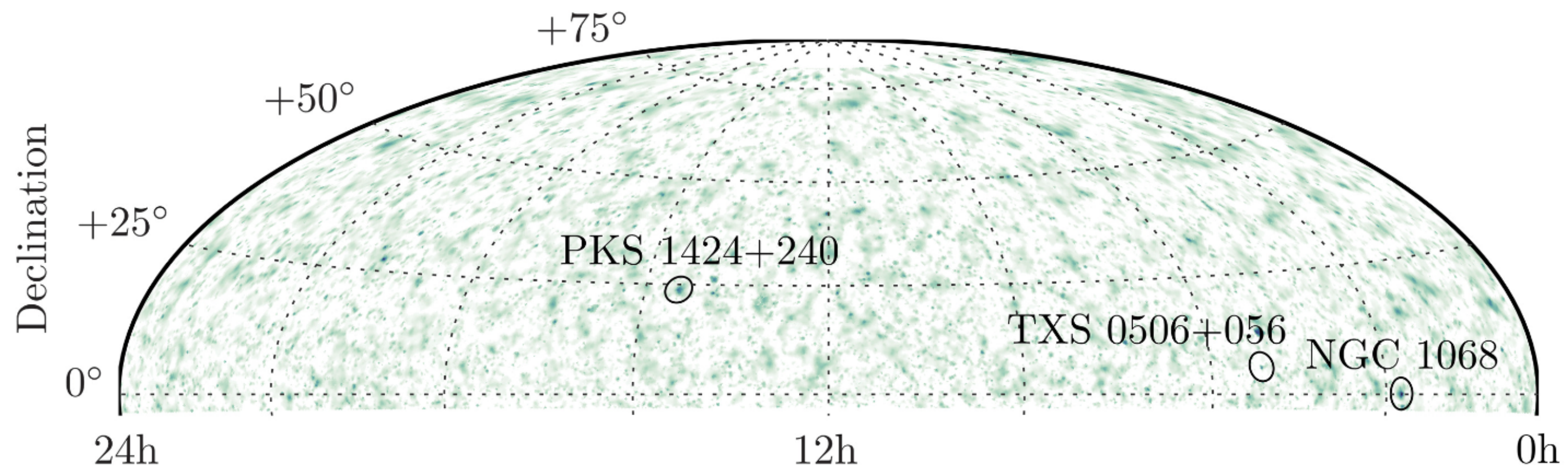Xavier **Rodrigues**

AstroParticle **Symposium**
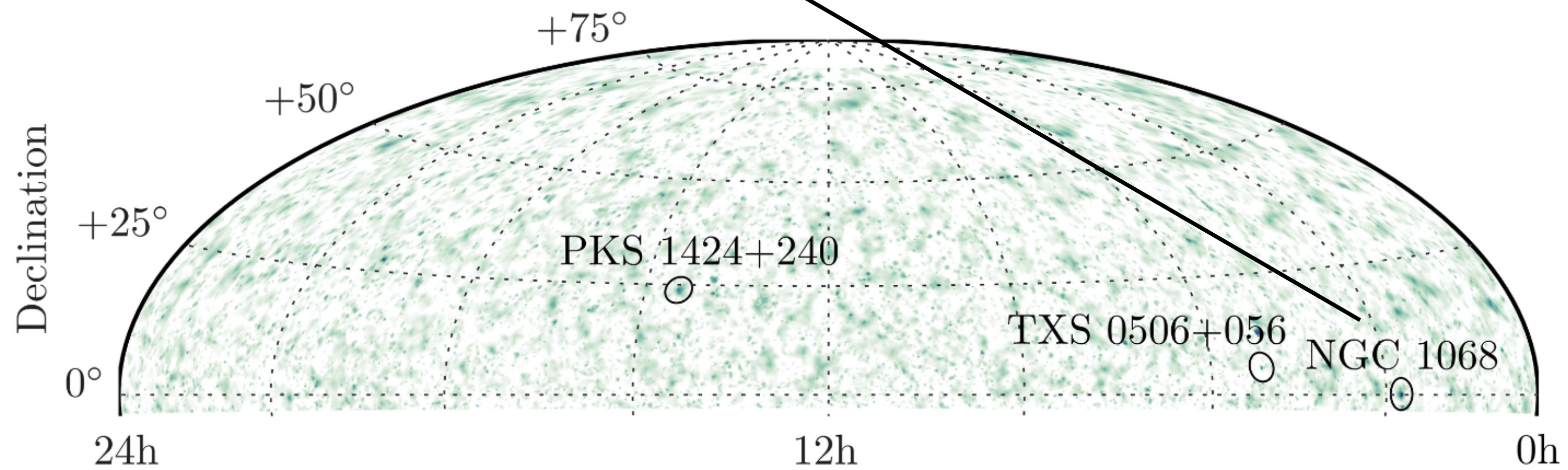Paris-Saclay
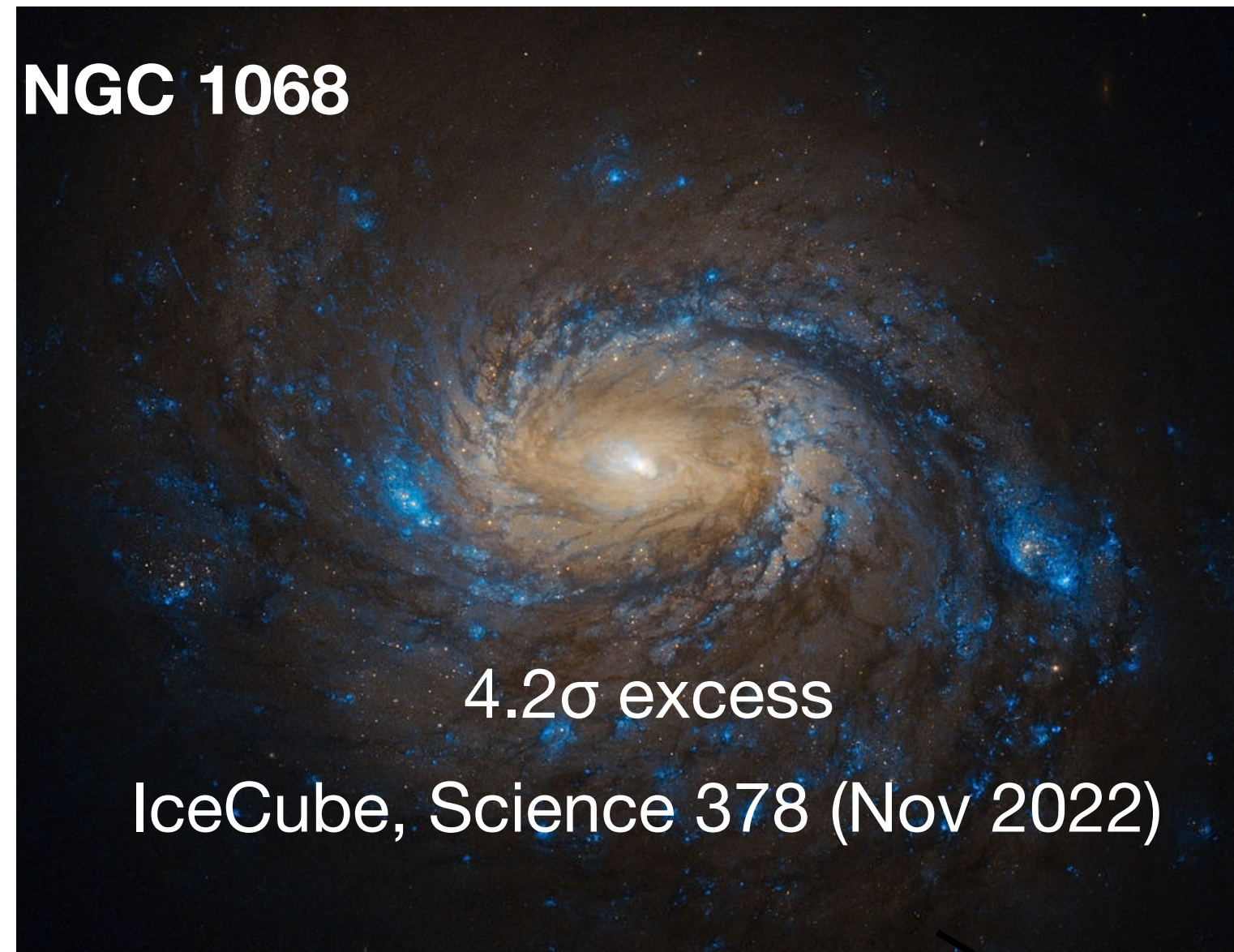November 15 **2022**

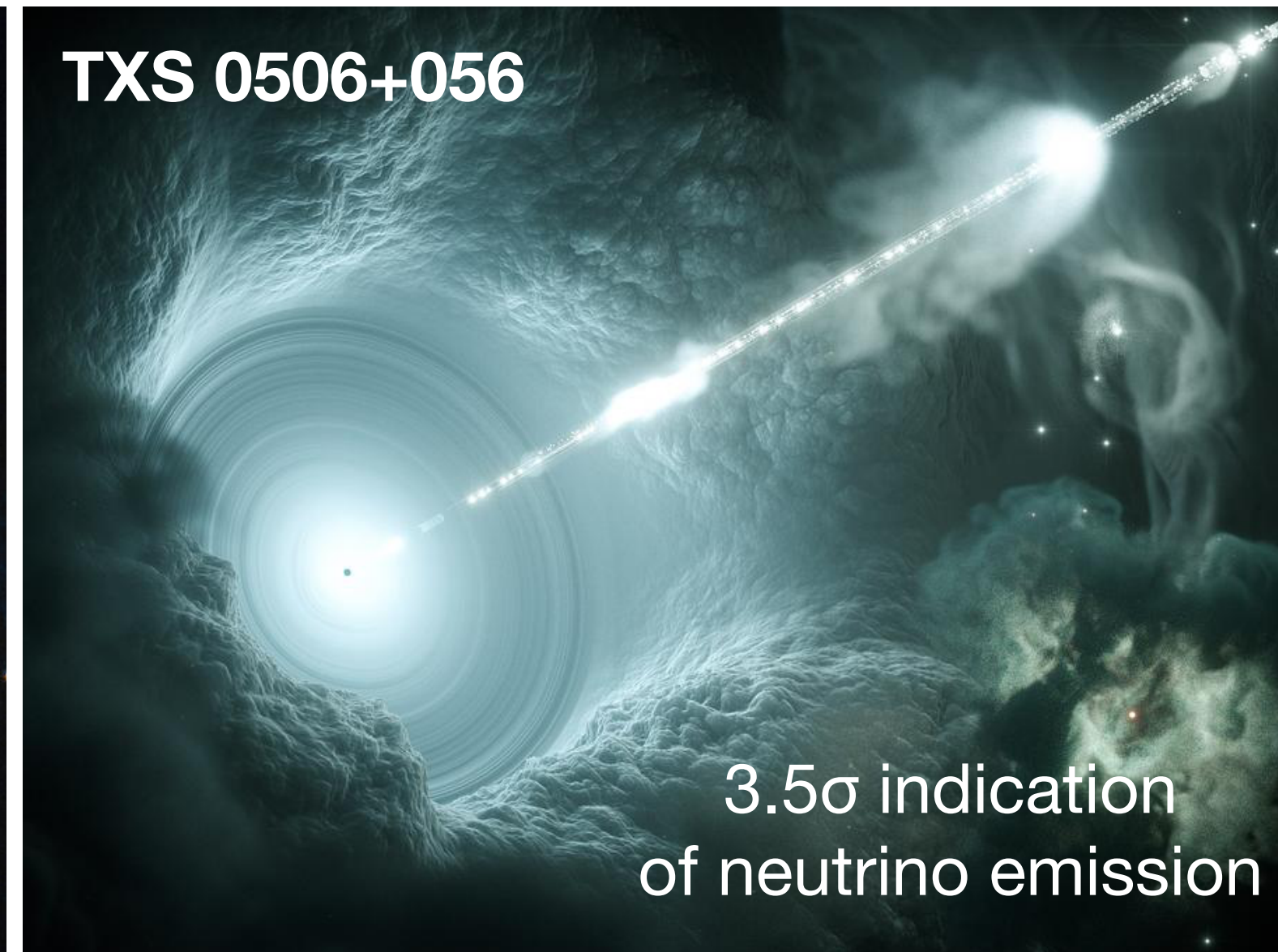**RU**B DESY.

The origin of the IceCube neutrinos

IceCube collaboration, Science 378 (2022)

The origin of the IceCube neutrinos

NGC 1068

4.2σ excess

IceCube, Science 378 (Nov 2022)

IceCube collaboration, Science 378 (2022)

The origin of the IceCube neutrinos
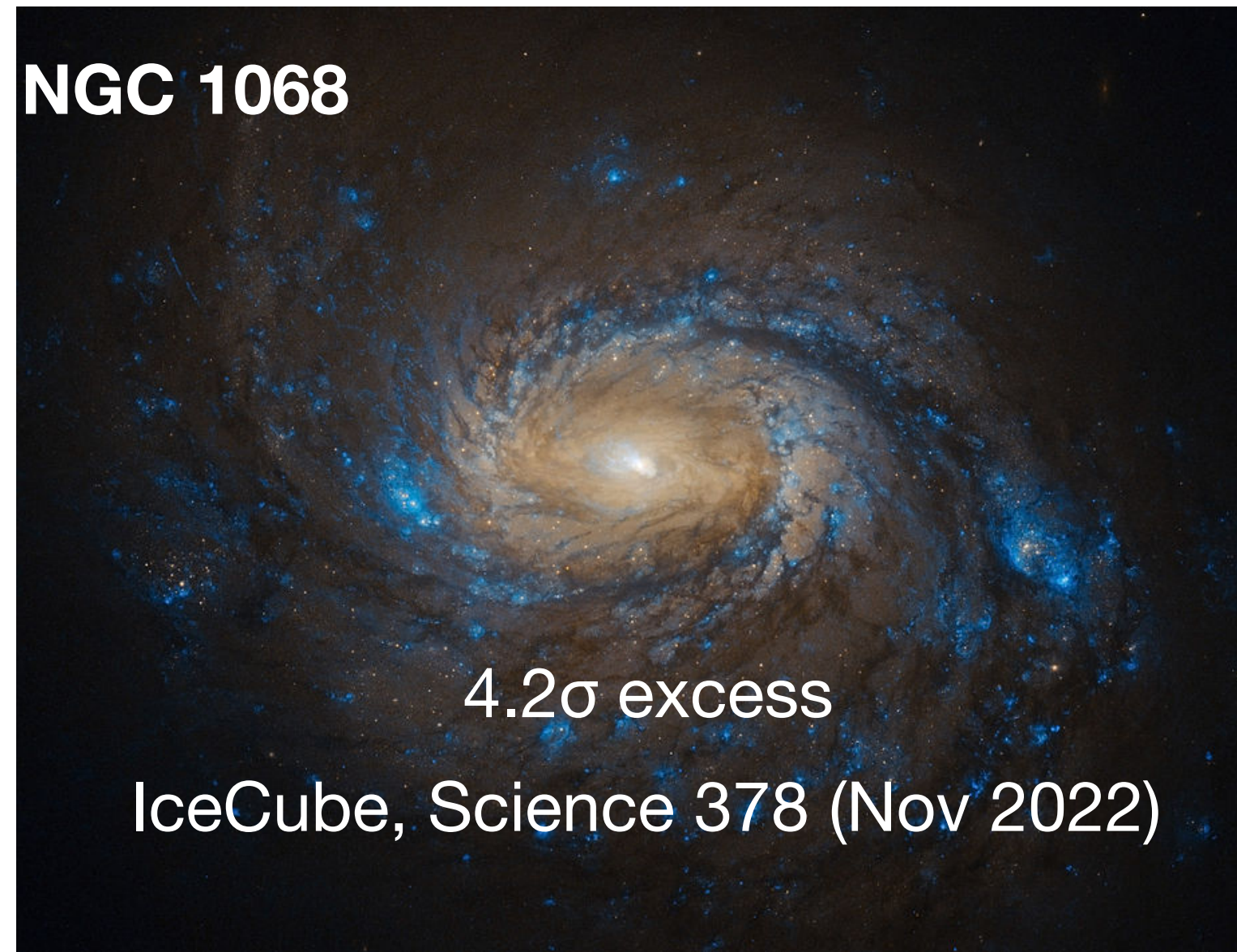
Once during a quiescent state in GeV gammas, the other time during a flare (???)

NGC 1068

4.2σ excess

IceCube, Science 378 (Nov 2022)
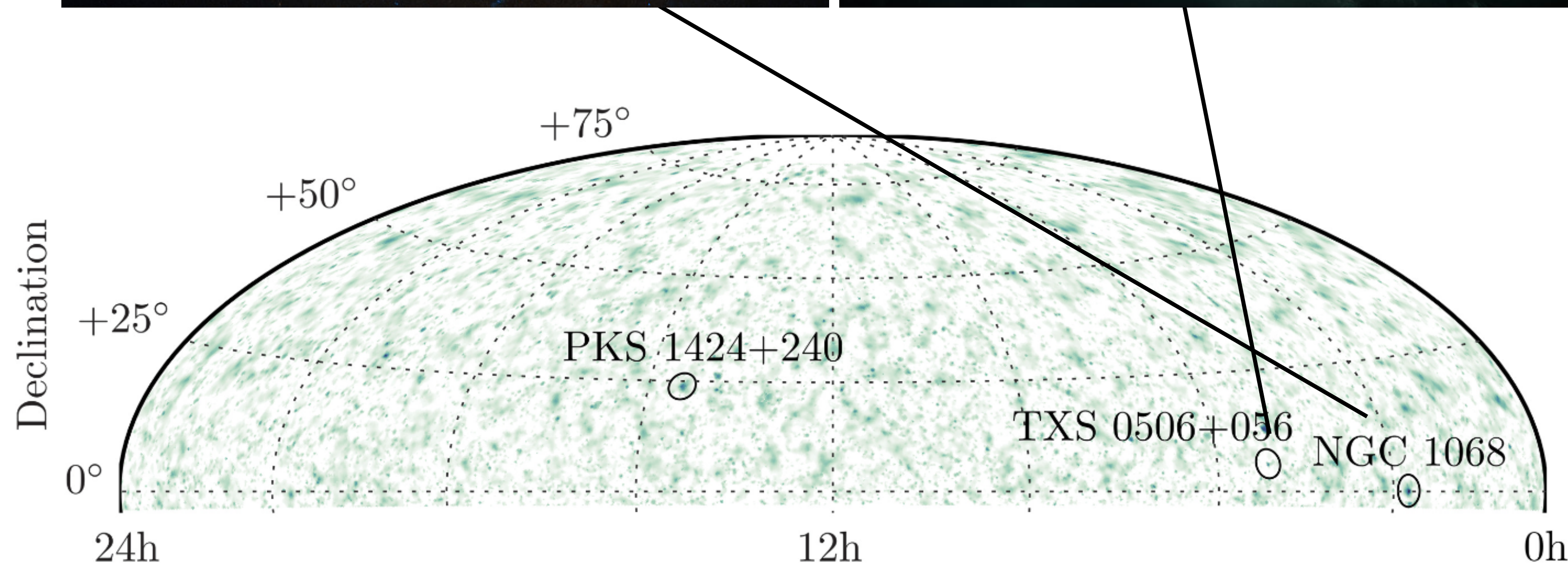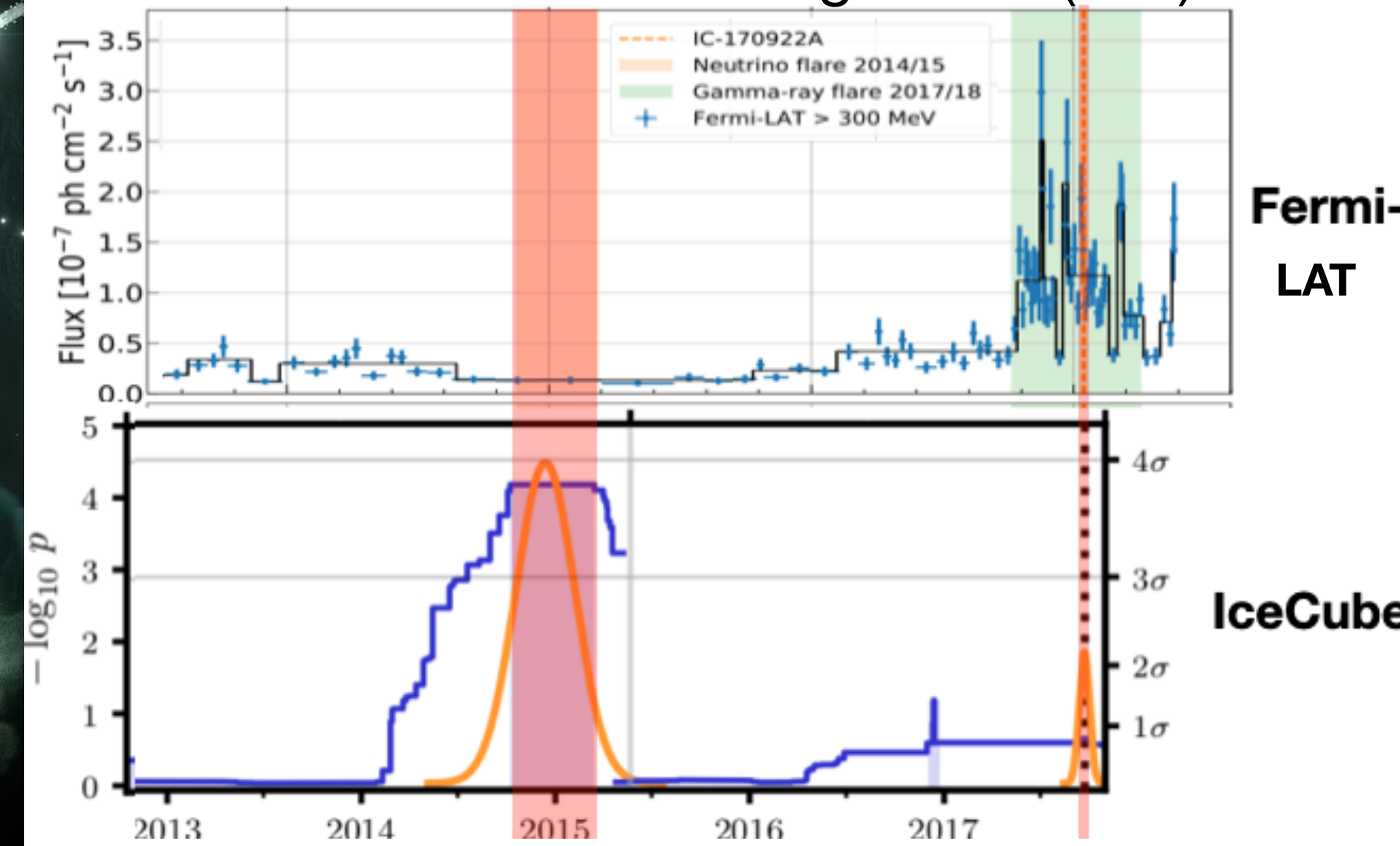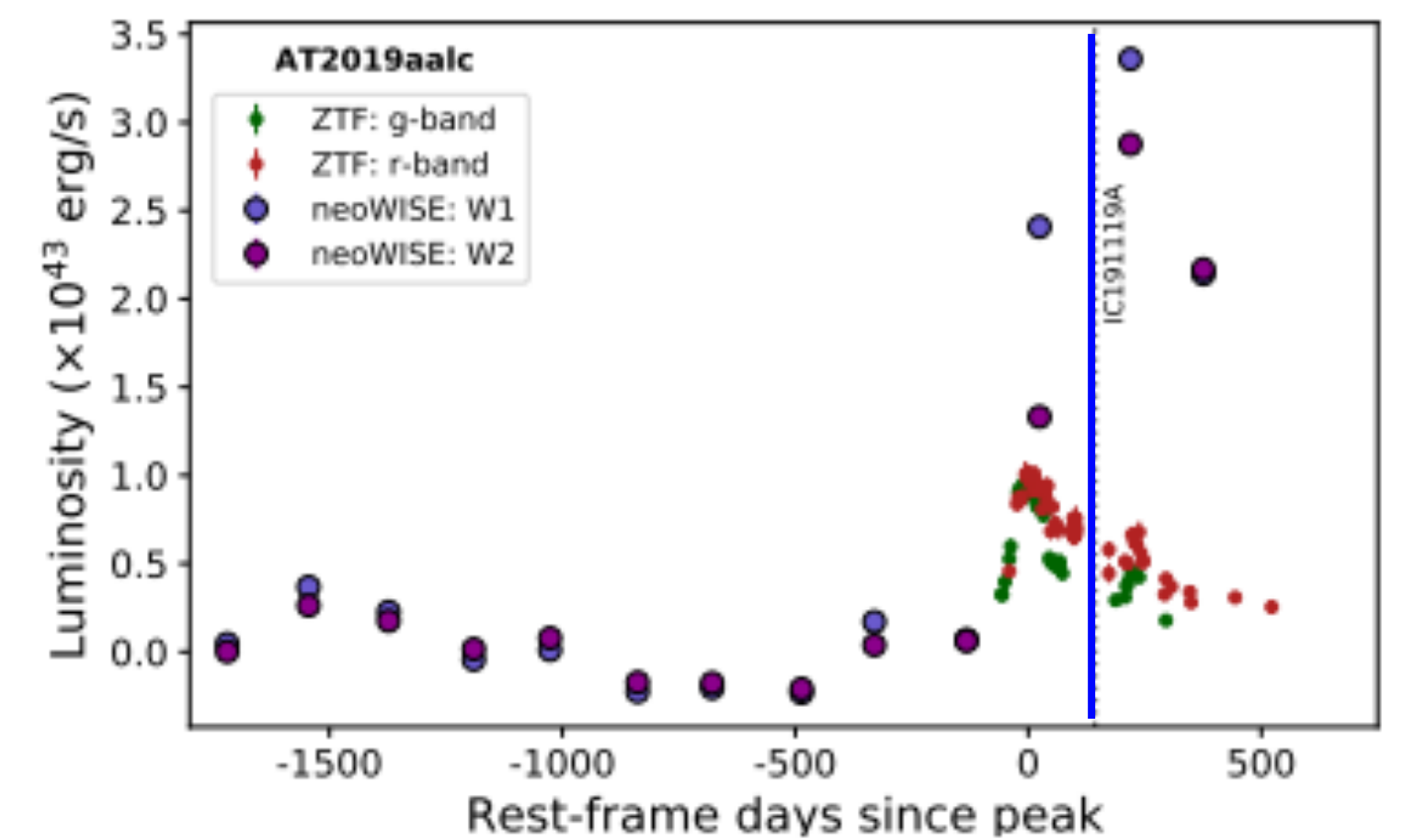
TXS 0506+056

3.5σ indication
of neutrino emission

IceCube collaboration, Science 378 (2022)
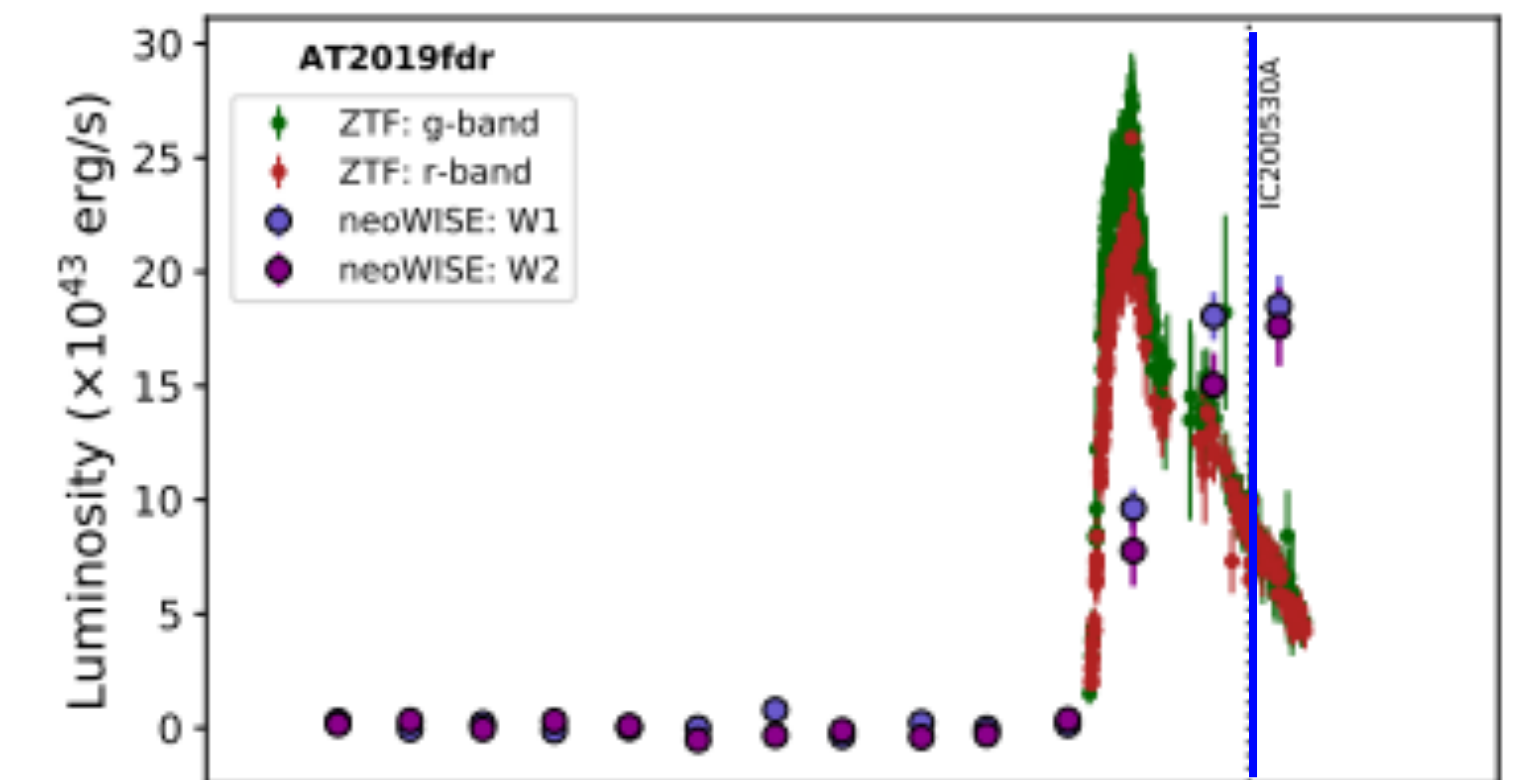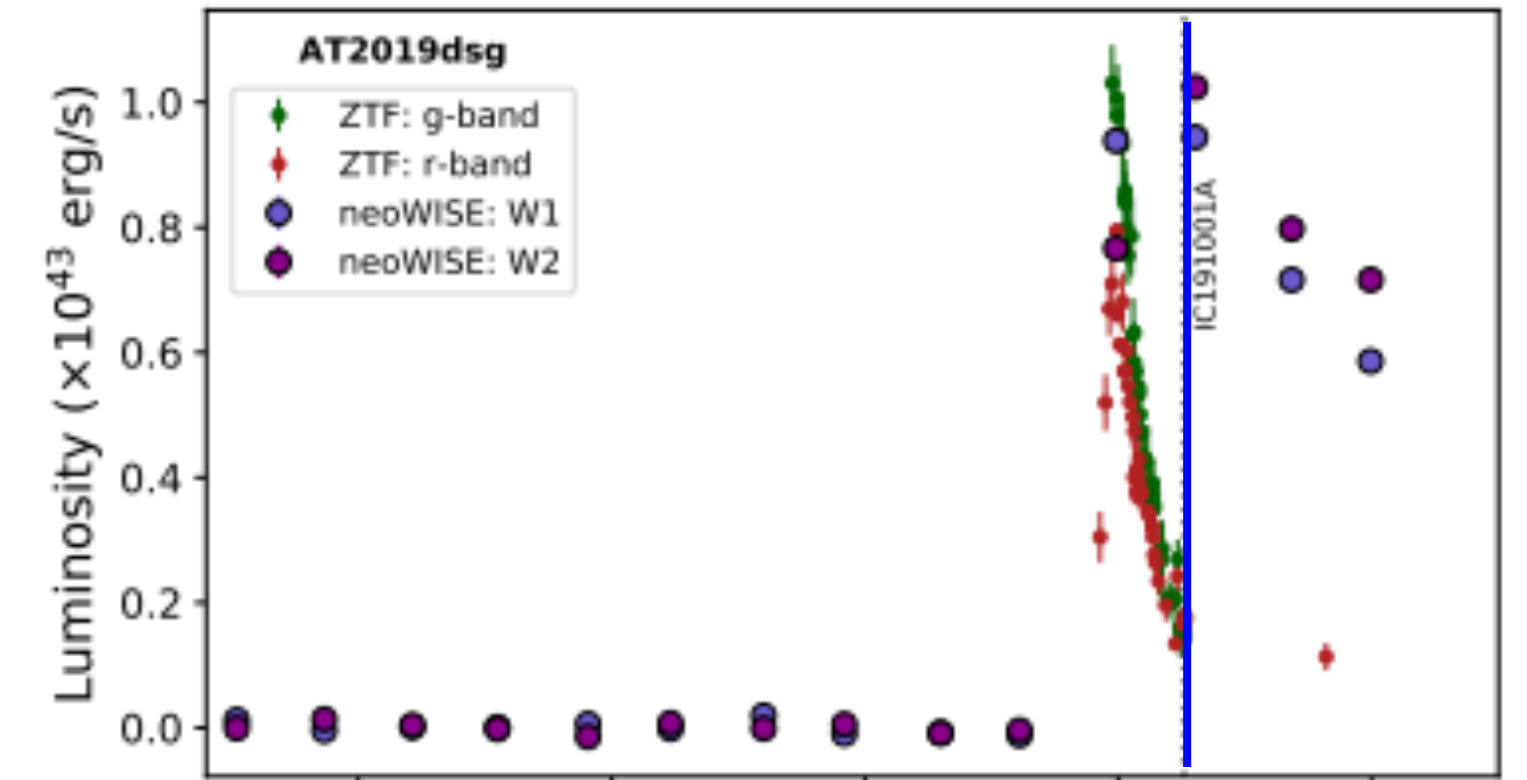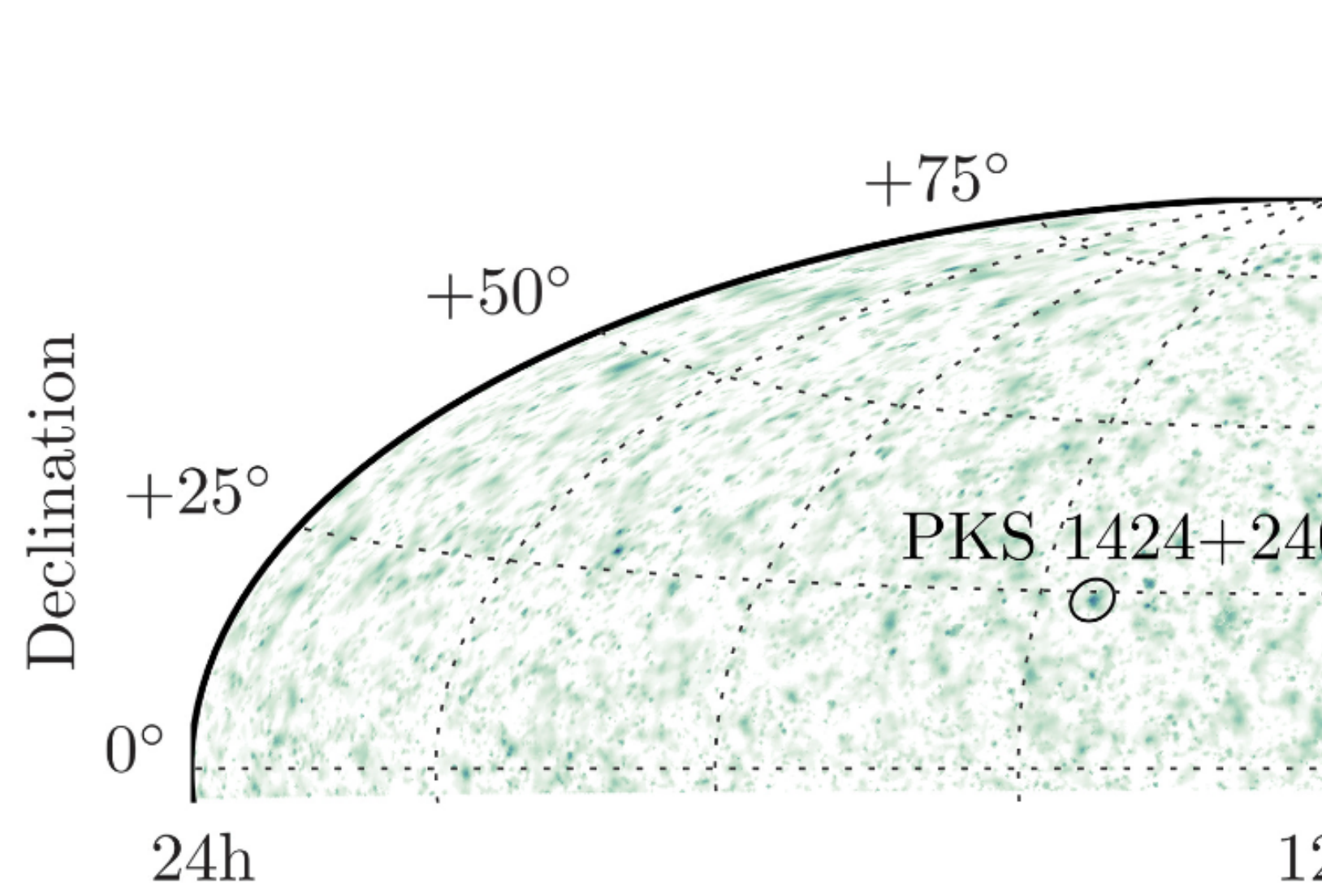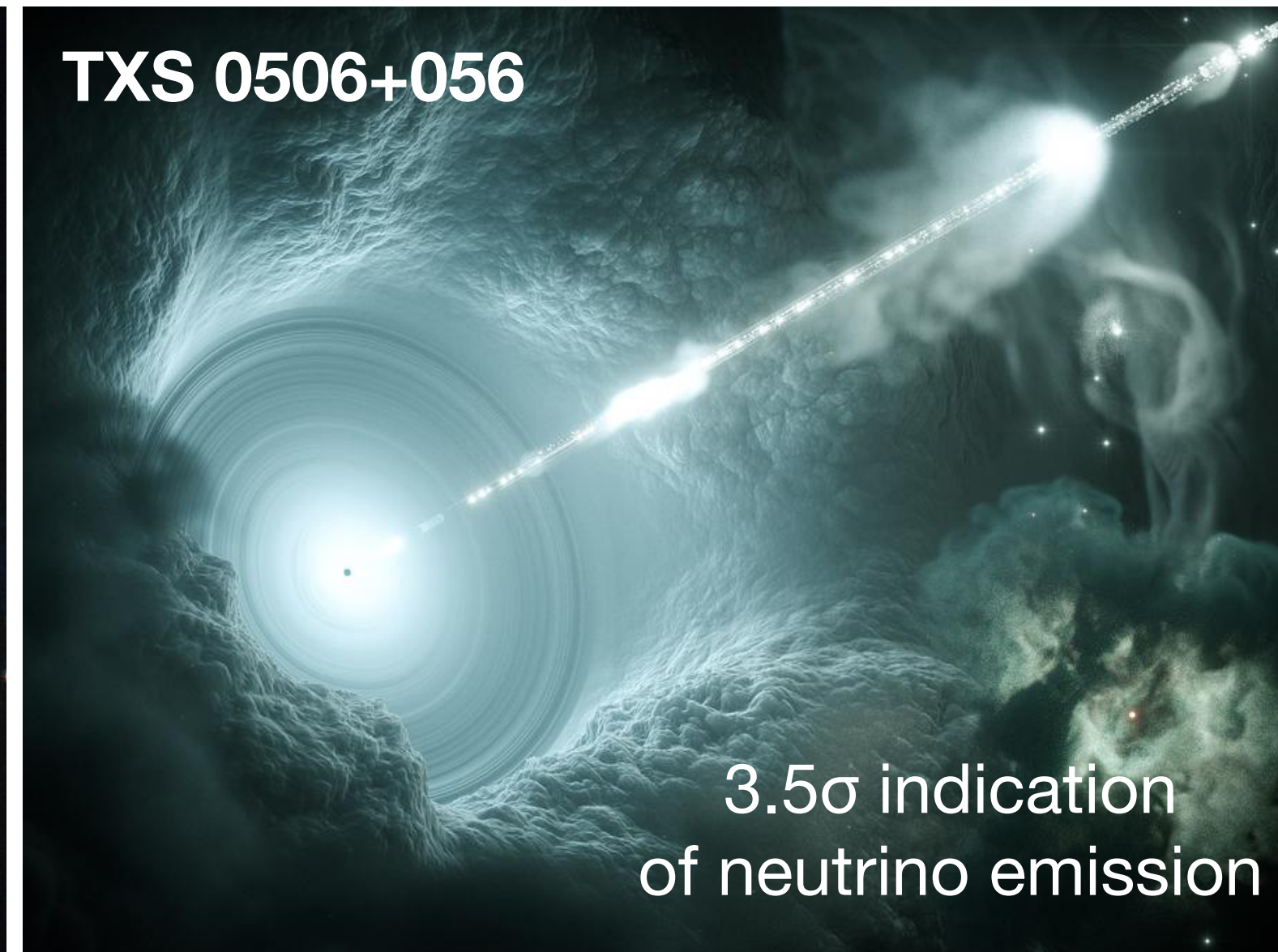
The origin of the IceCube neutrinos

NGC 1068

4.2σ excess

IceCube, Science 378 (Nov 2022)

TXS 0506+056

3.5σ indication
of neutrino emission

Three tidal disruption events

PKS 1424+240

IceCube collaboration, Science 378 (2022)

van Velzen et al 2011

2

The origin of the IceCube neutrinos

NGC 1068

TXS 0506+056

IceCube, Science 378 (Nov 2022)

3.5σ indication
of neutrino emission

IceCube event directions statistically associated with a **blazar catalog** with chance prob. **1.6e-5 (!)** (Buson et al 2022, ApJ Lett. 933)
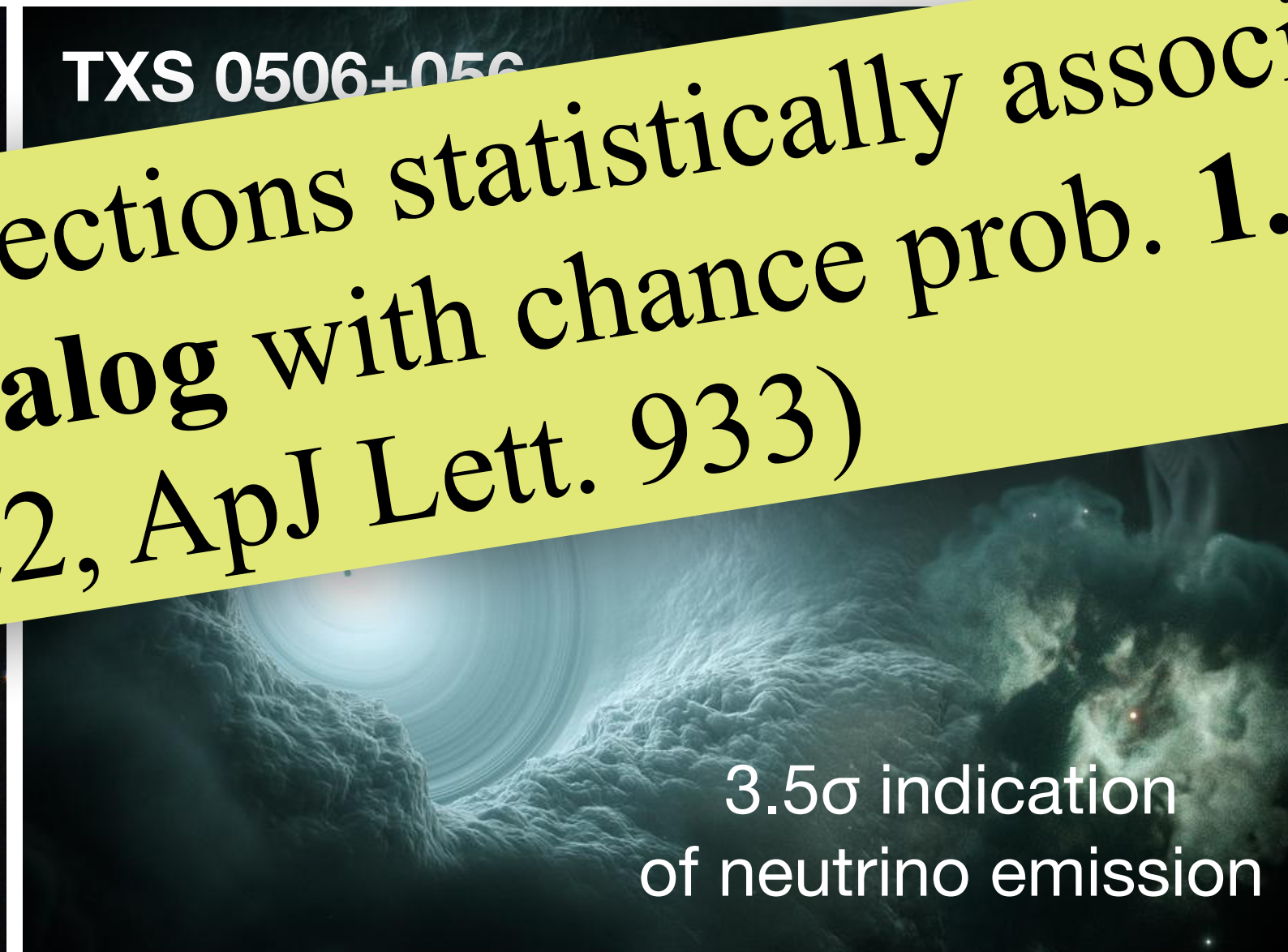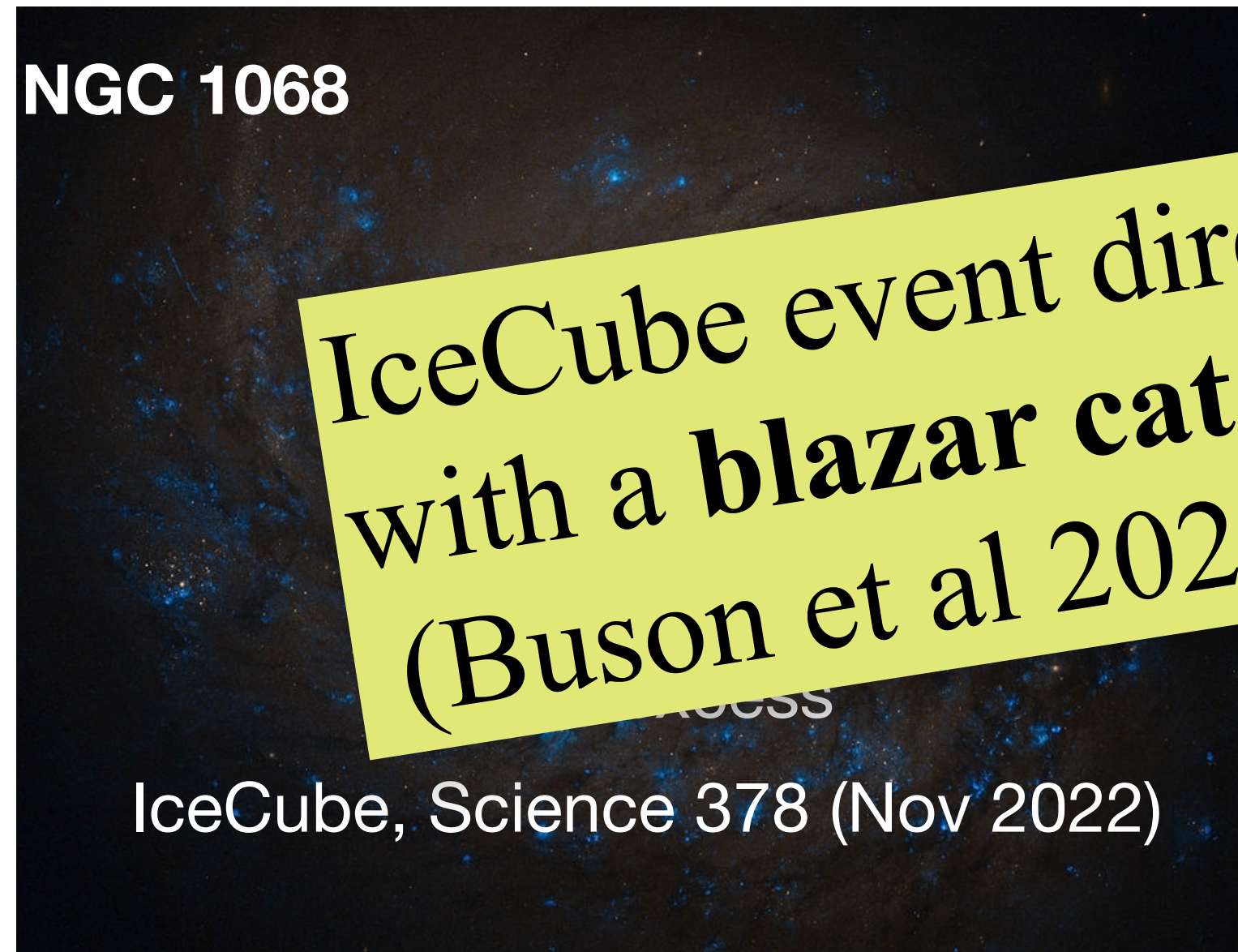
Three tidal disruption events

PKS 1424+240

IceCube collaboration, Science 378 (2022)

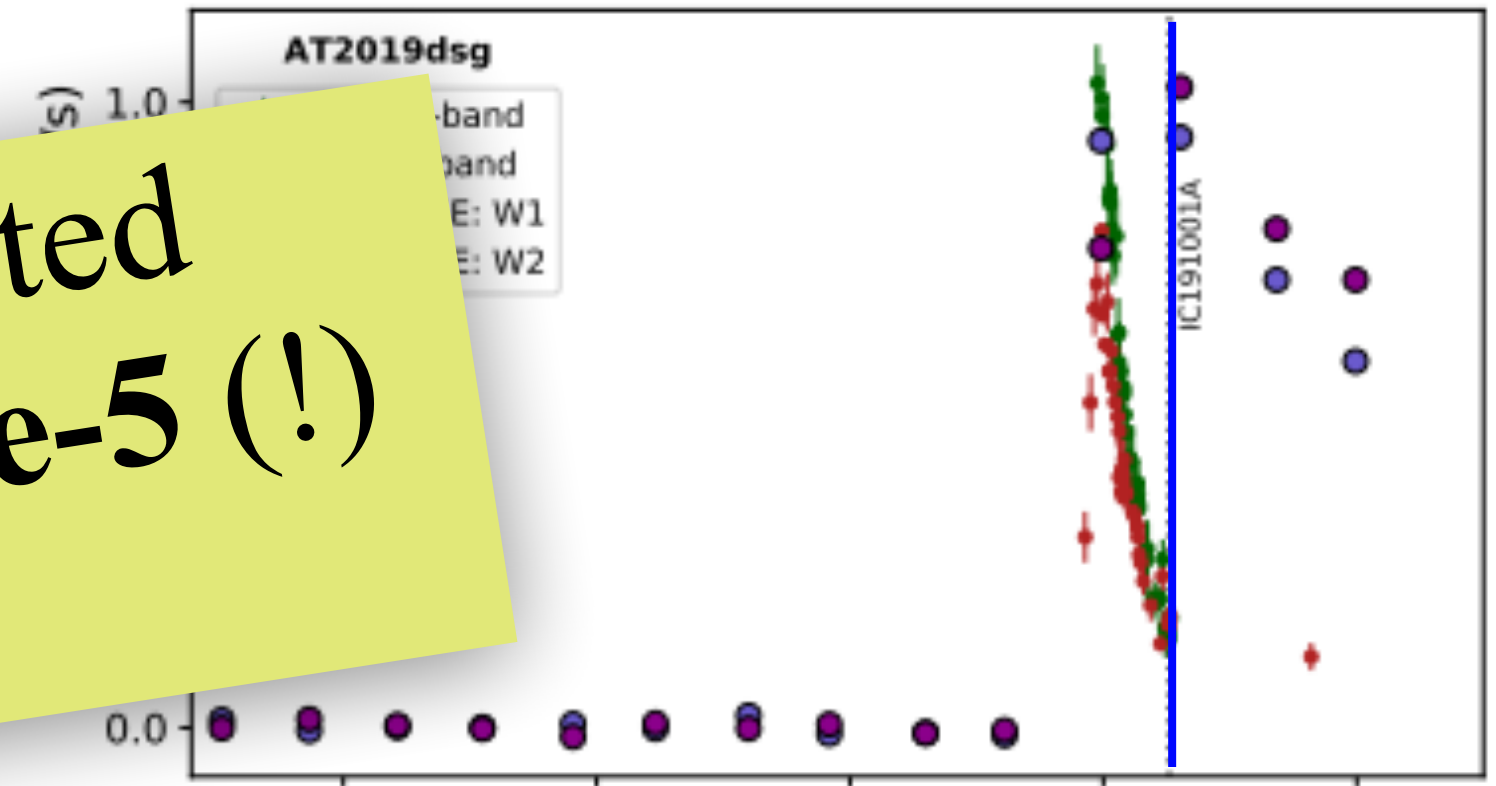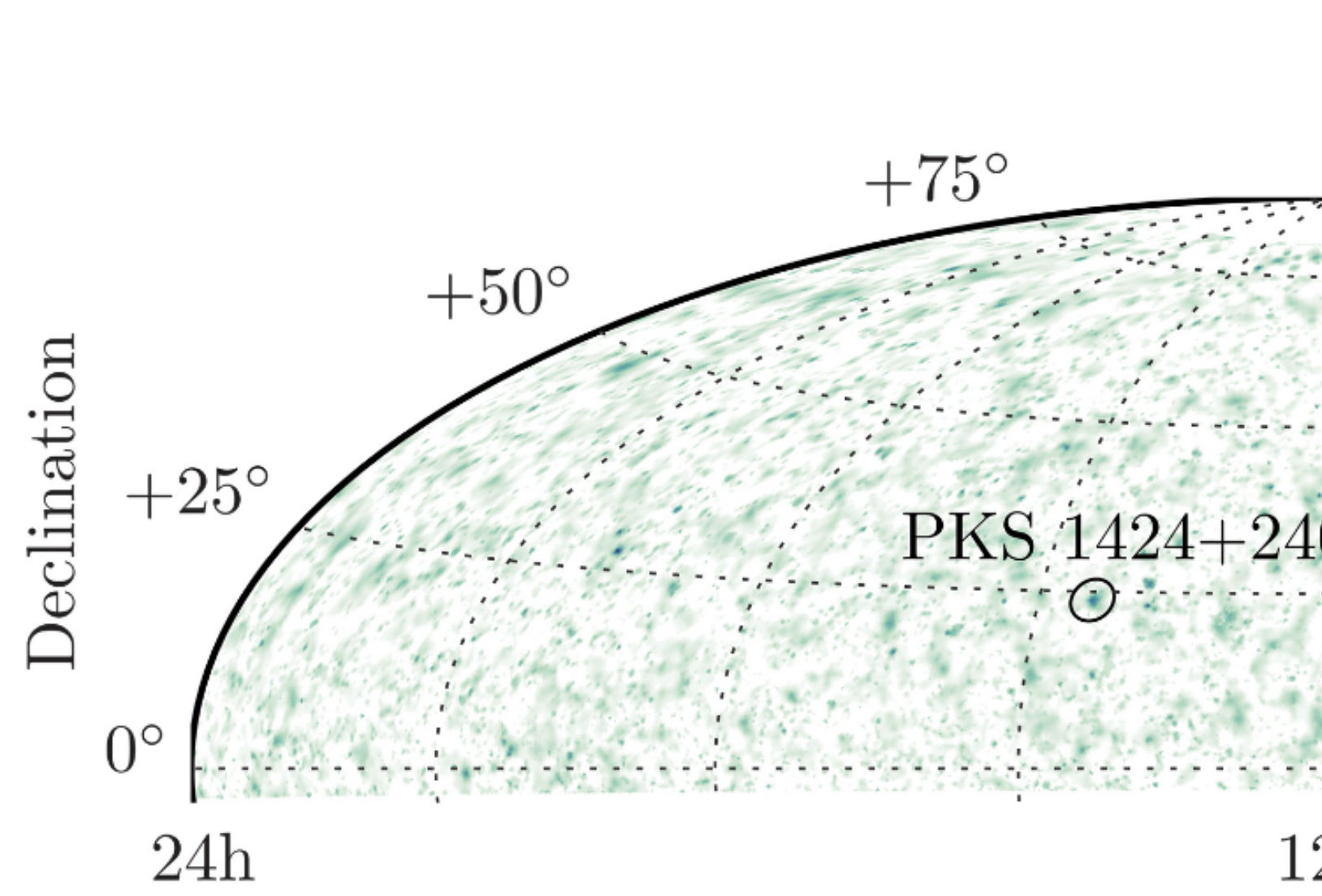van Velzen et al 2011

The origin of the IceCube neutrinos

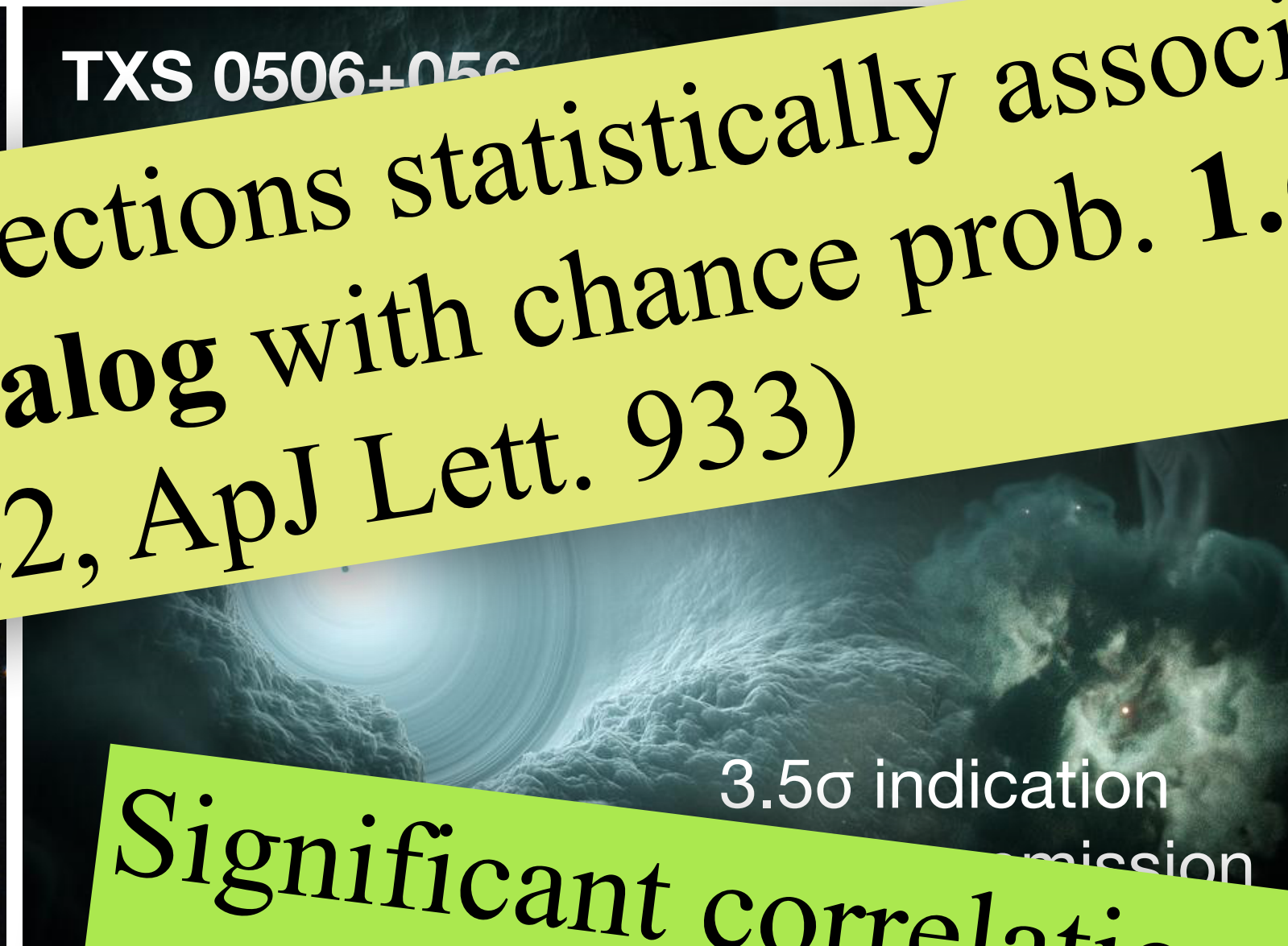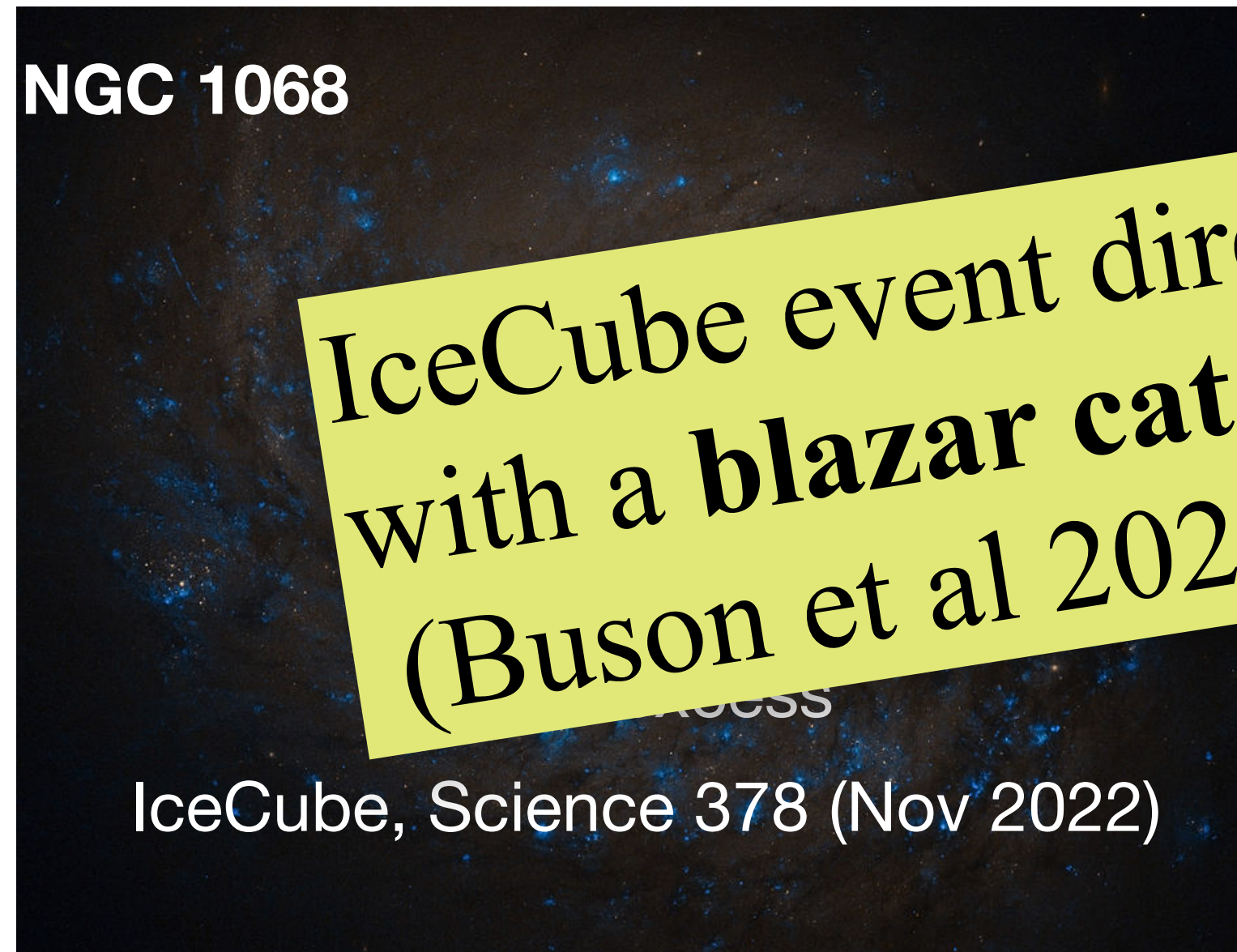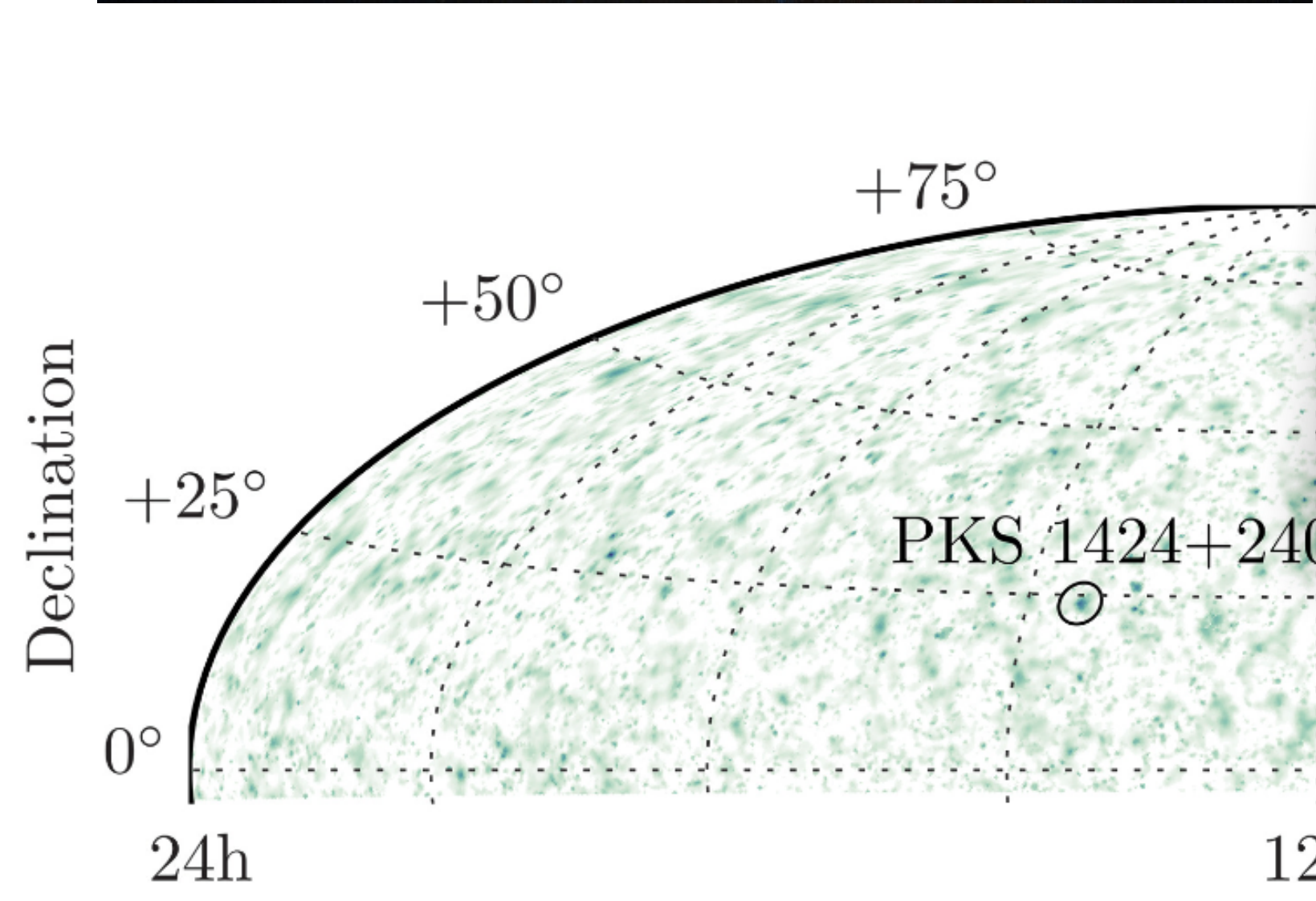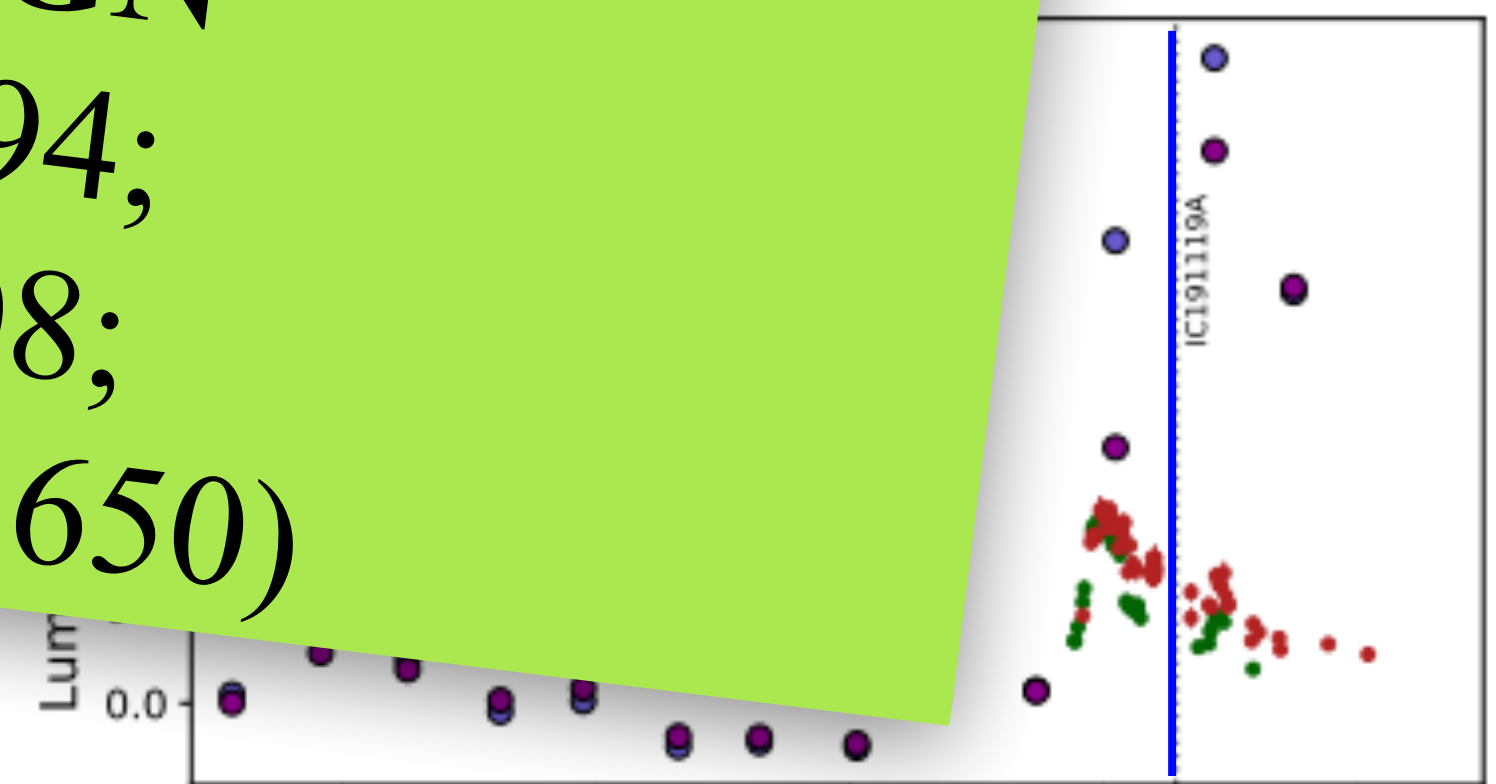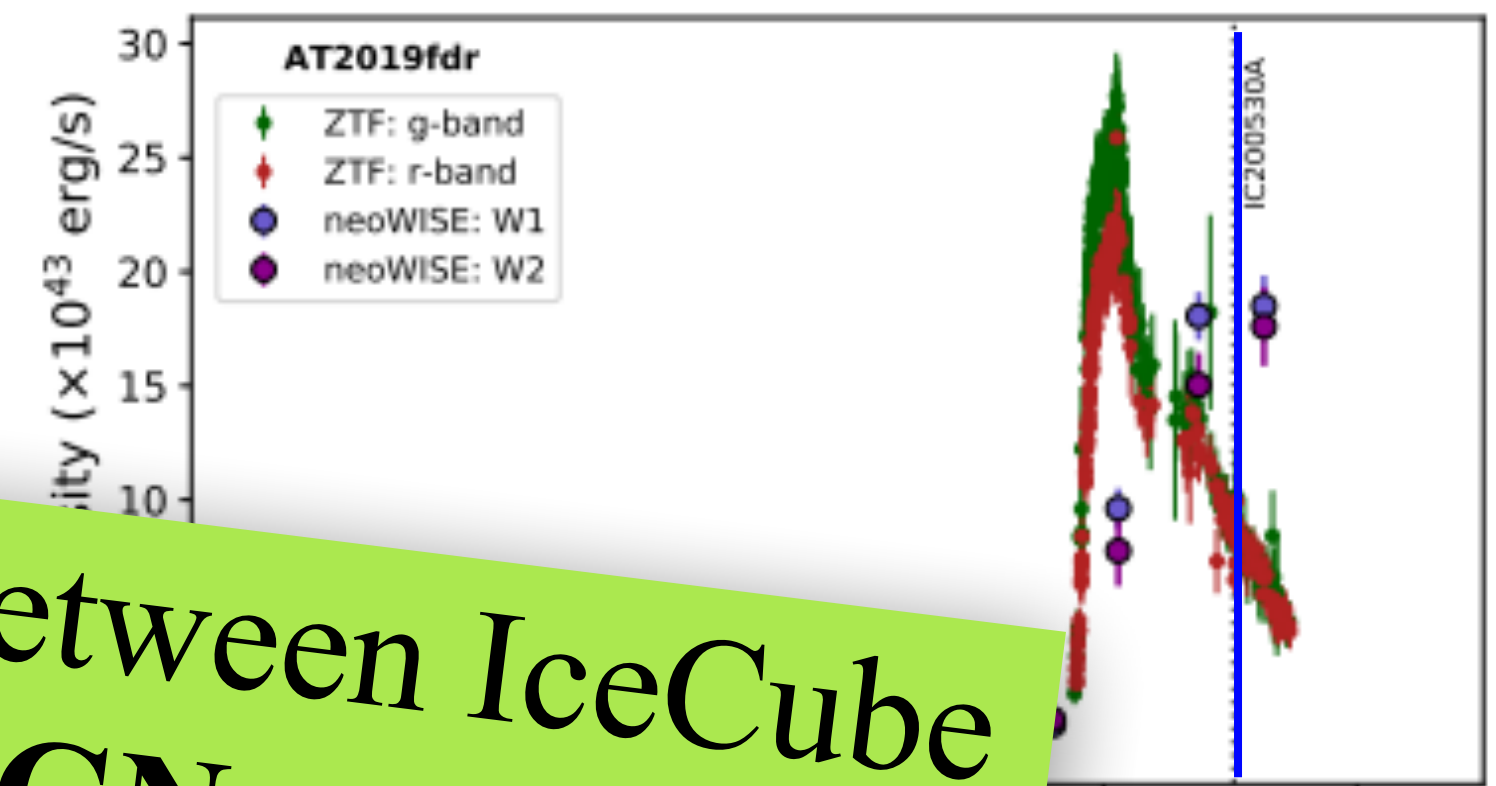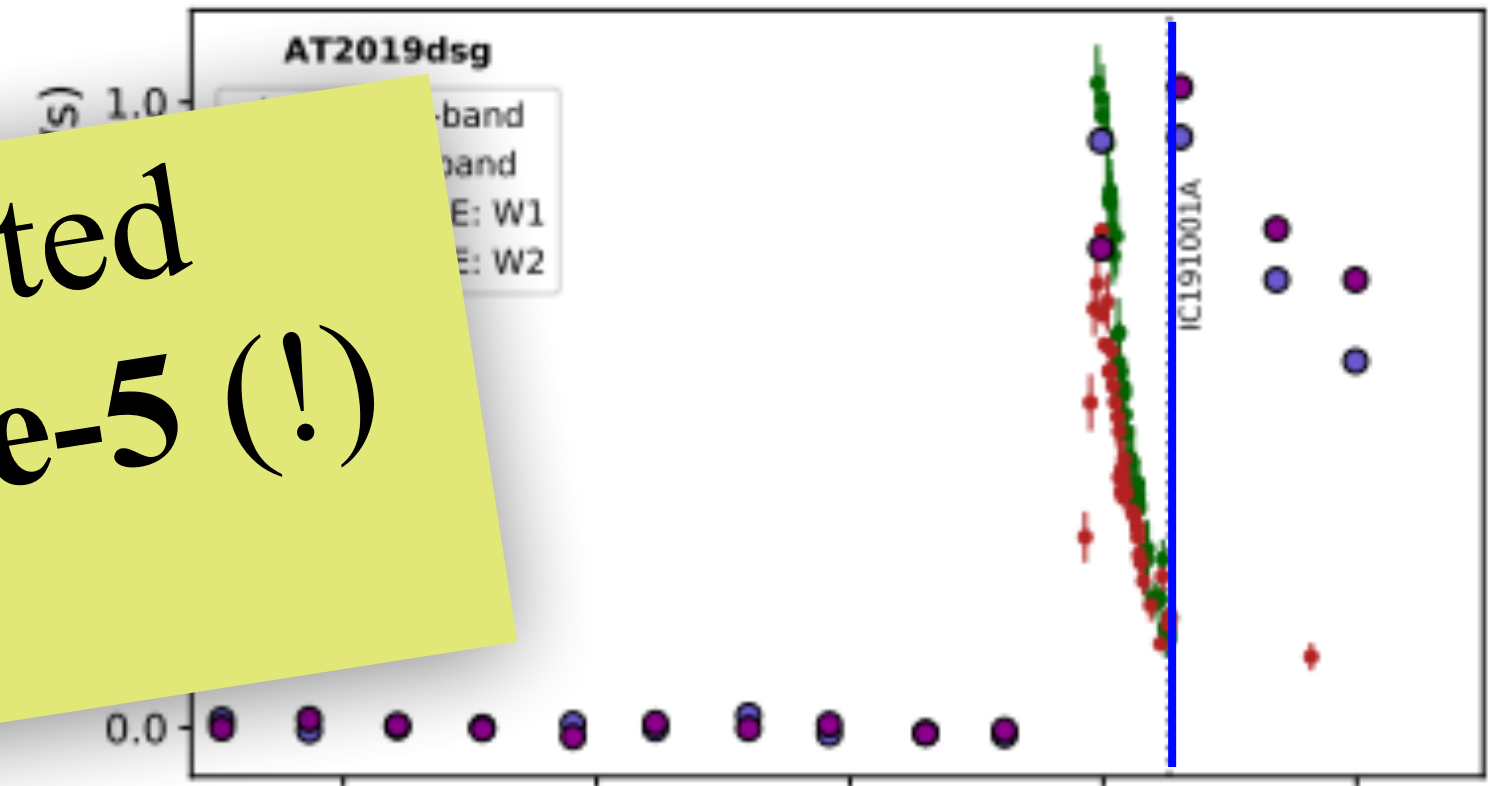**NGC 1068**

TXS 0506+056

IceCube, Science 378 (Nov 2022)

IceCube event directions statistically associated with a **blazar catalog** with chance prob. **1.6e-5** (!) (Buson et al 2022, ApJ Lett. 933)

3.5σ indication

Significant correlation between IceCube events and **radio-loud AGN** (Plavin et al 2020, ApJ 894; Plavin et al 2021, ApJ 908; Hovatta et al 2021, A&A 650)

PKS 1424+240
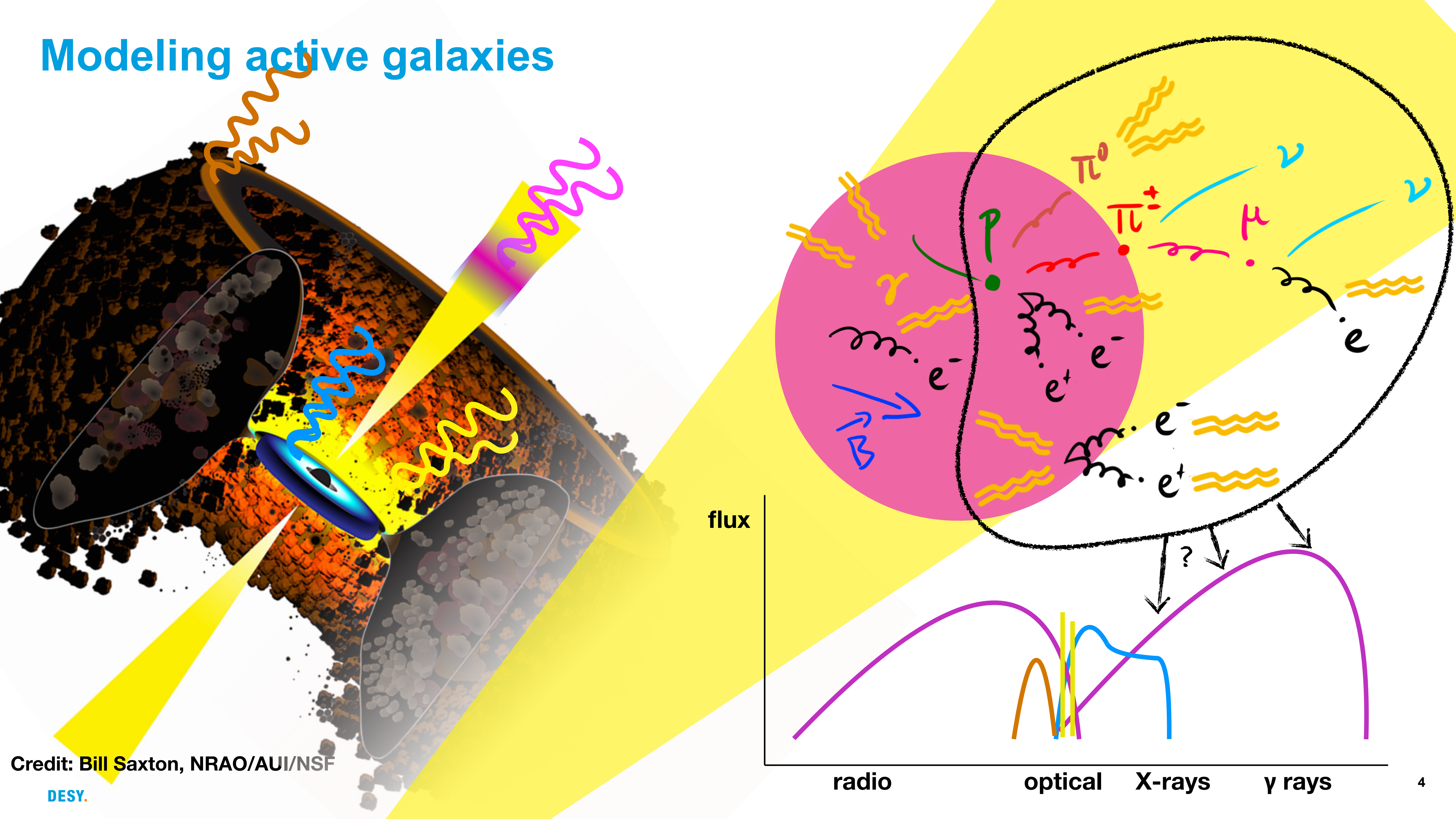
+75°
+50°
+25°
0°
24h
Declination

IceCube collaboration, Science 378 (2022)

AT2019dsg
AT2019fdr
ZTF: g-band
ZTF: r-band
neoWISE: W1
neoWISE: W2

Rest-frame days since peak
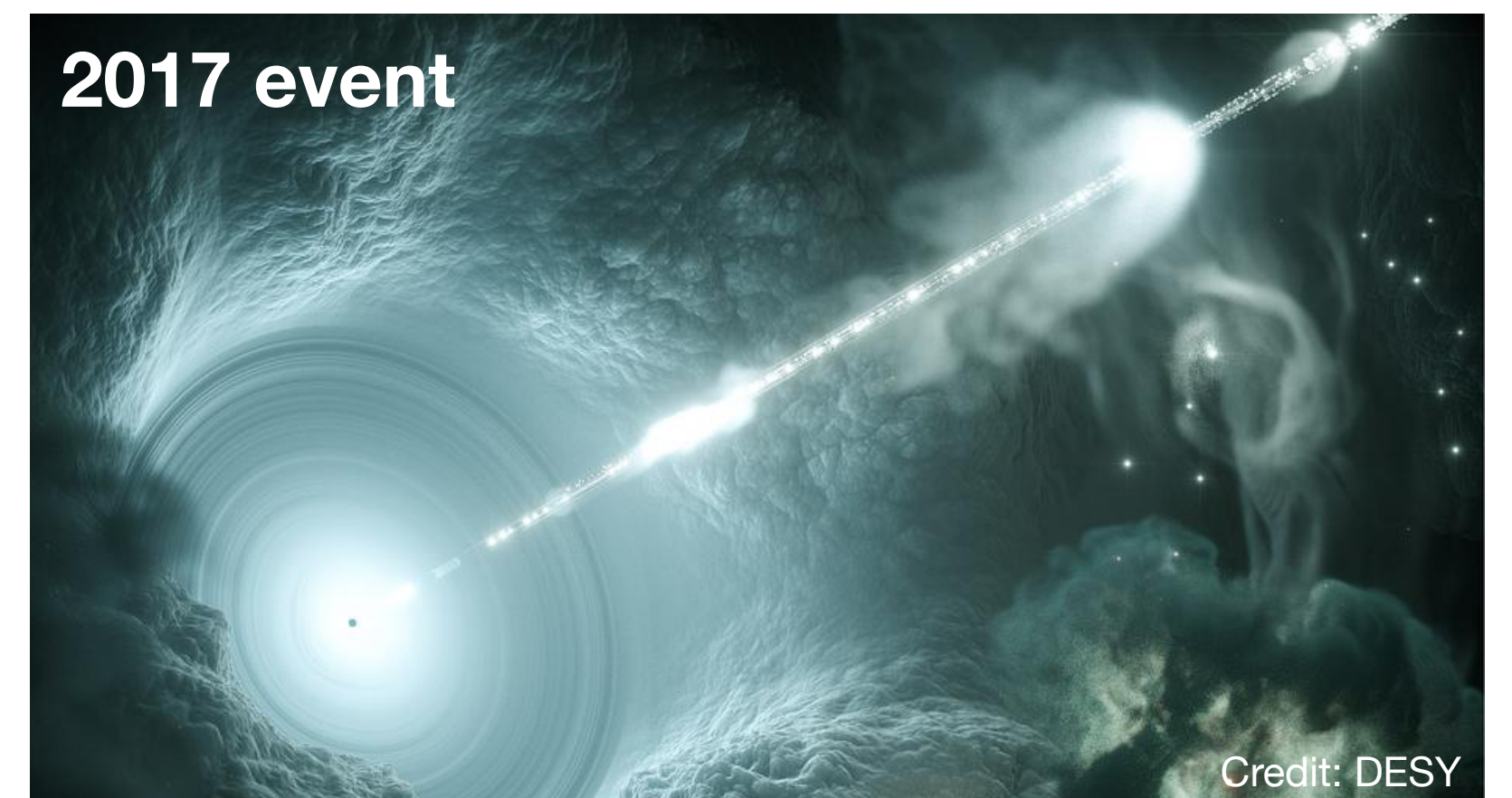-1500   -1000   -500   0   500

van Velzen et al 2011

DESY.

2

Modeling active galaxies

Credit: Bill Saxton, NRAO/AUI/NSF
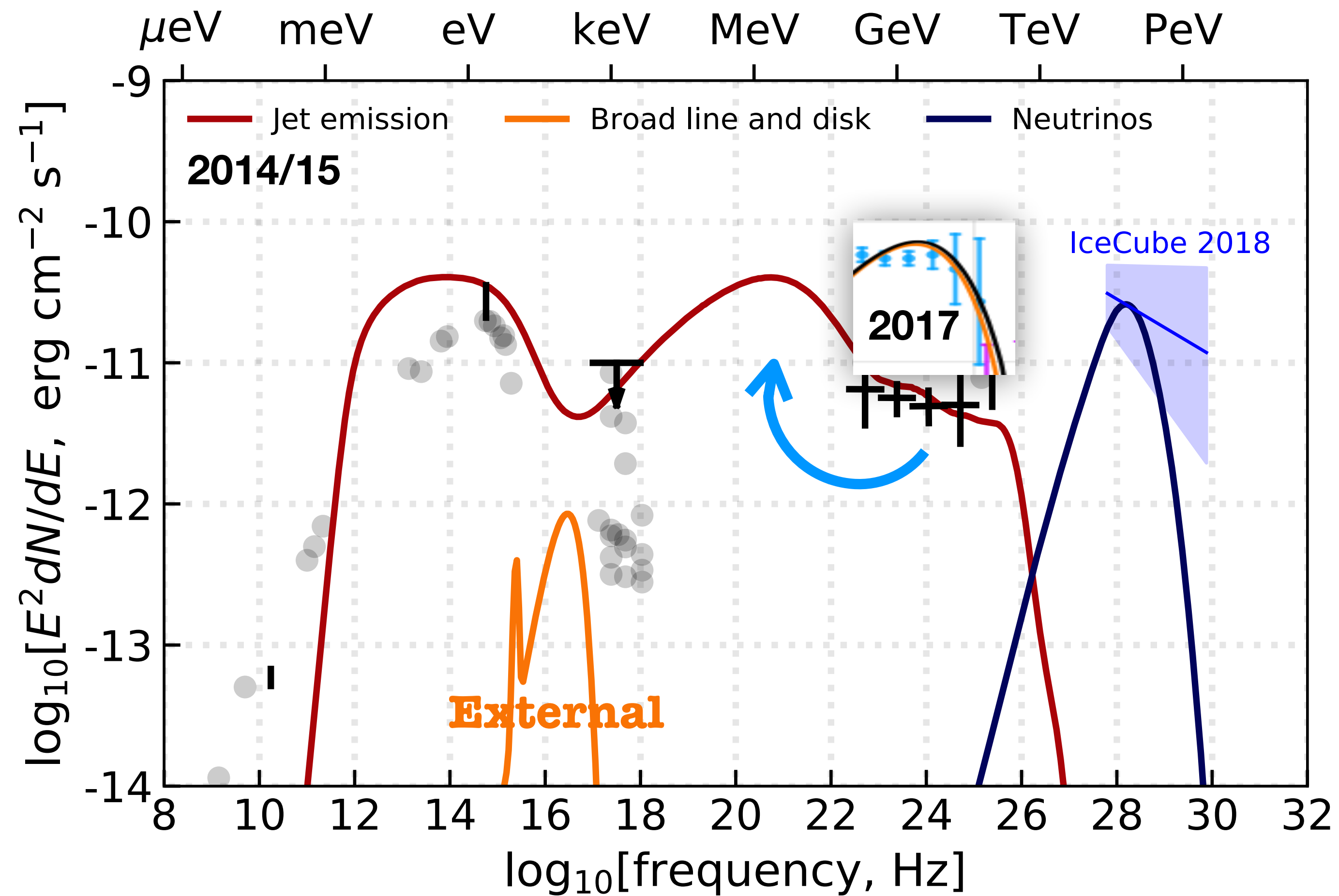
DESY.

flux

radio   optical   X-rays   γ rays

What we've learned: blazar TXS 0506+056

2017 flare
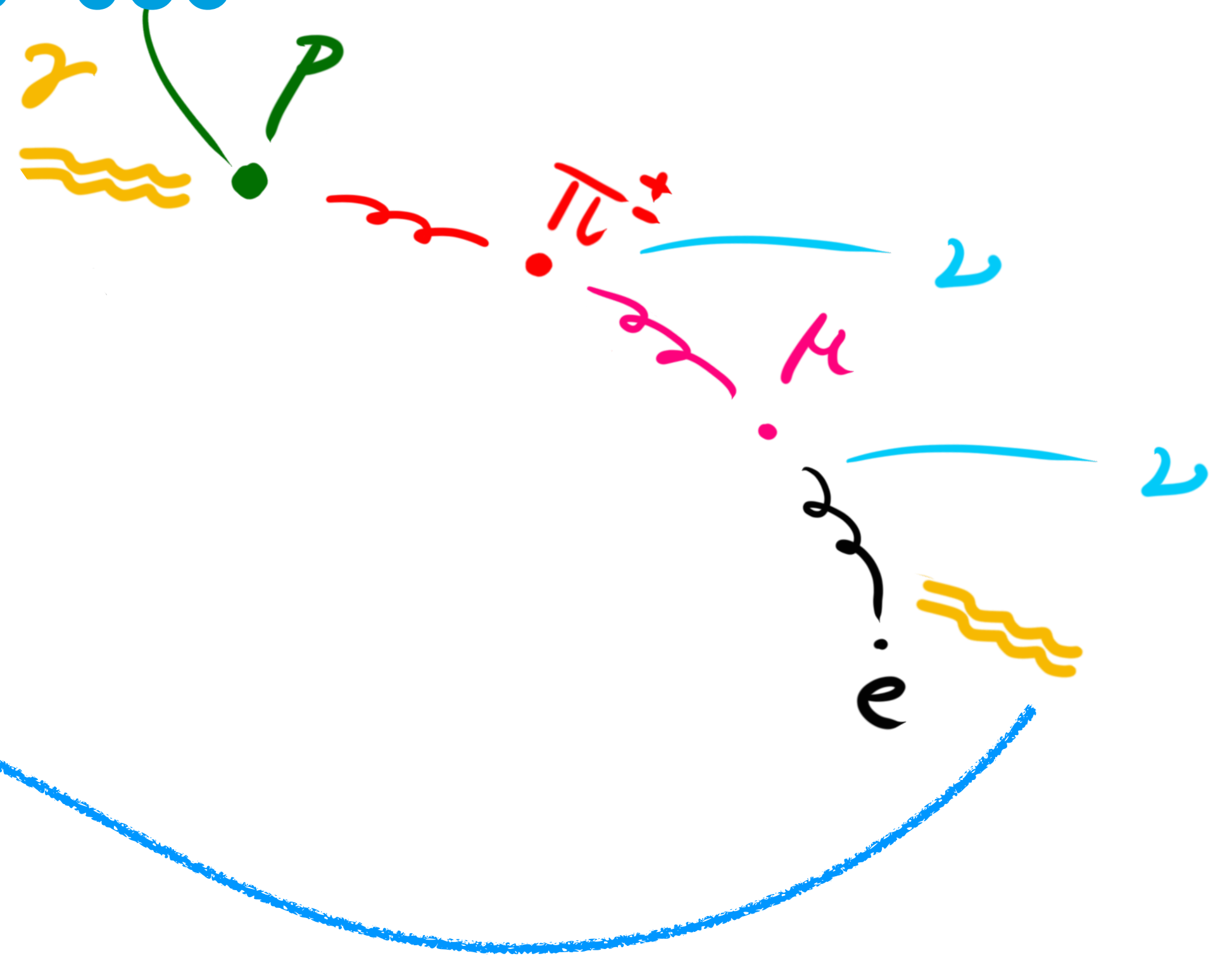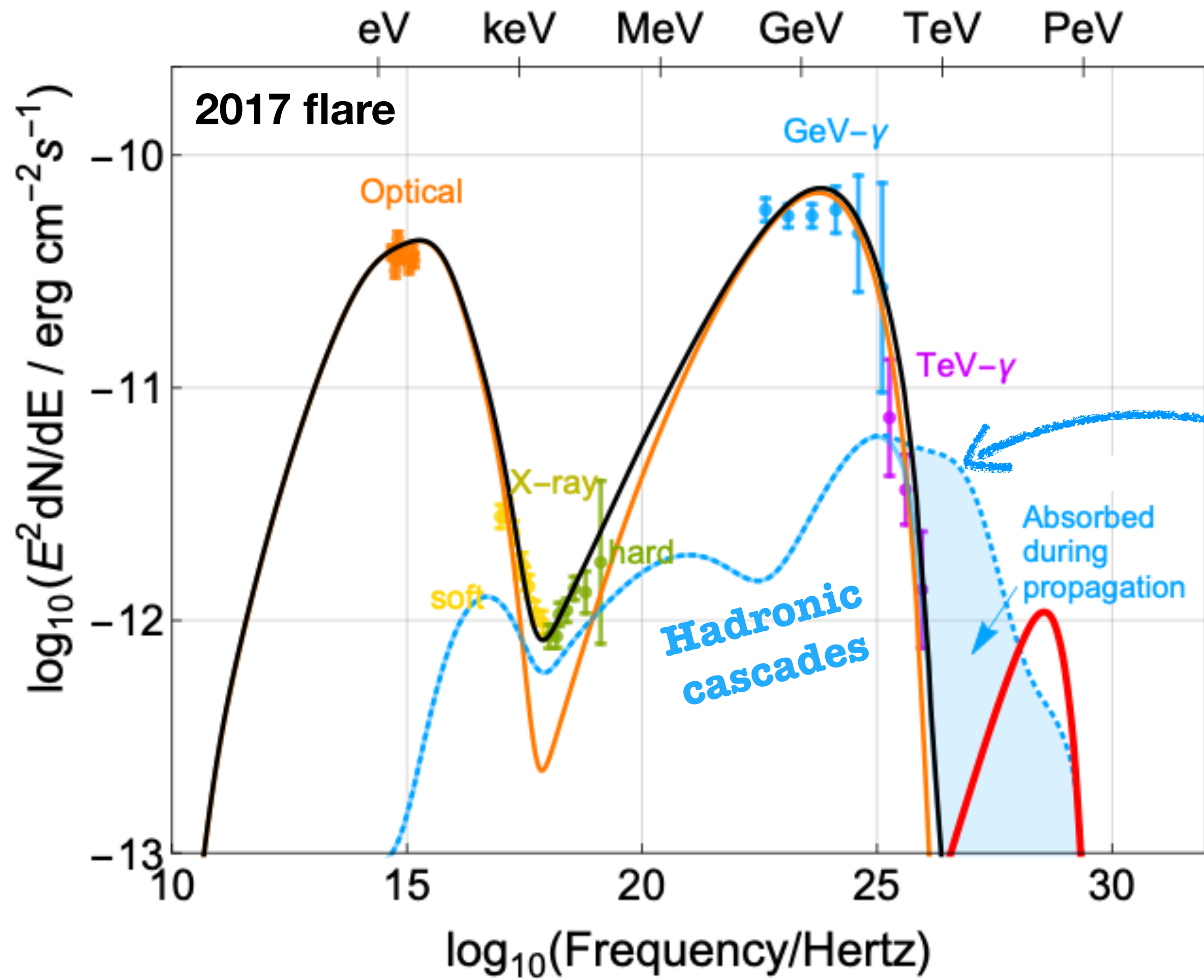
Gao, Fedynitch, Winter, Pohl, Nat.Astron. 3 (2019)

SED total

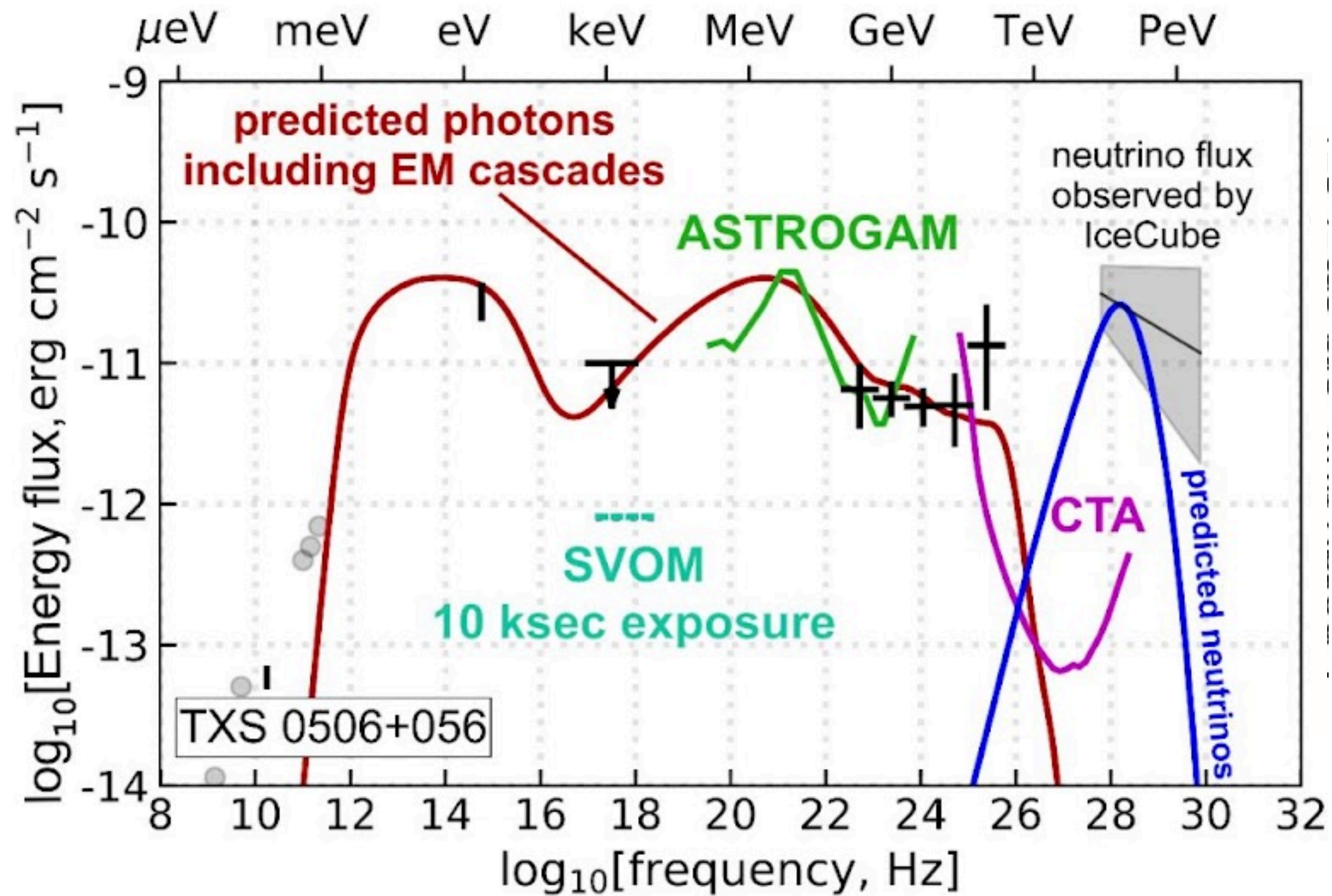**2017 event**

Credit: DESY

What we've learned: blazar TXS 0506+056

Rodrigues, Gao, Fedynitch, Palladino, Winter, ApJ L874 (2019)

What we've learned: blazar TXS 0506+056

Rodrigues, Gao, Fedynitch, Palladino, Winter, ApJ L874 (2019)

2014/15 orphan flare

Credit: DESY

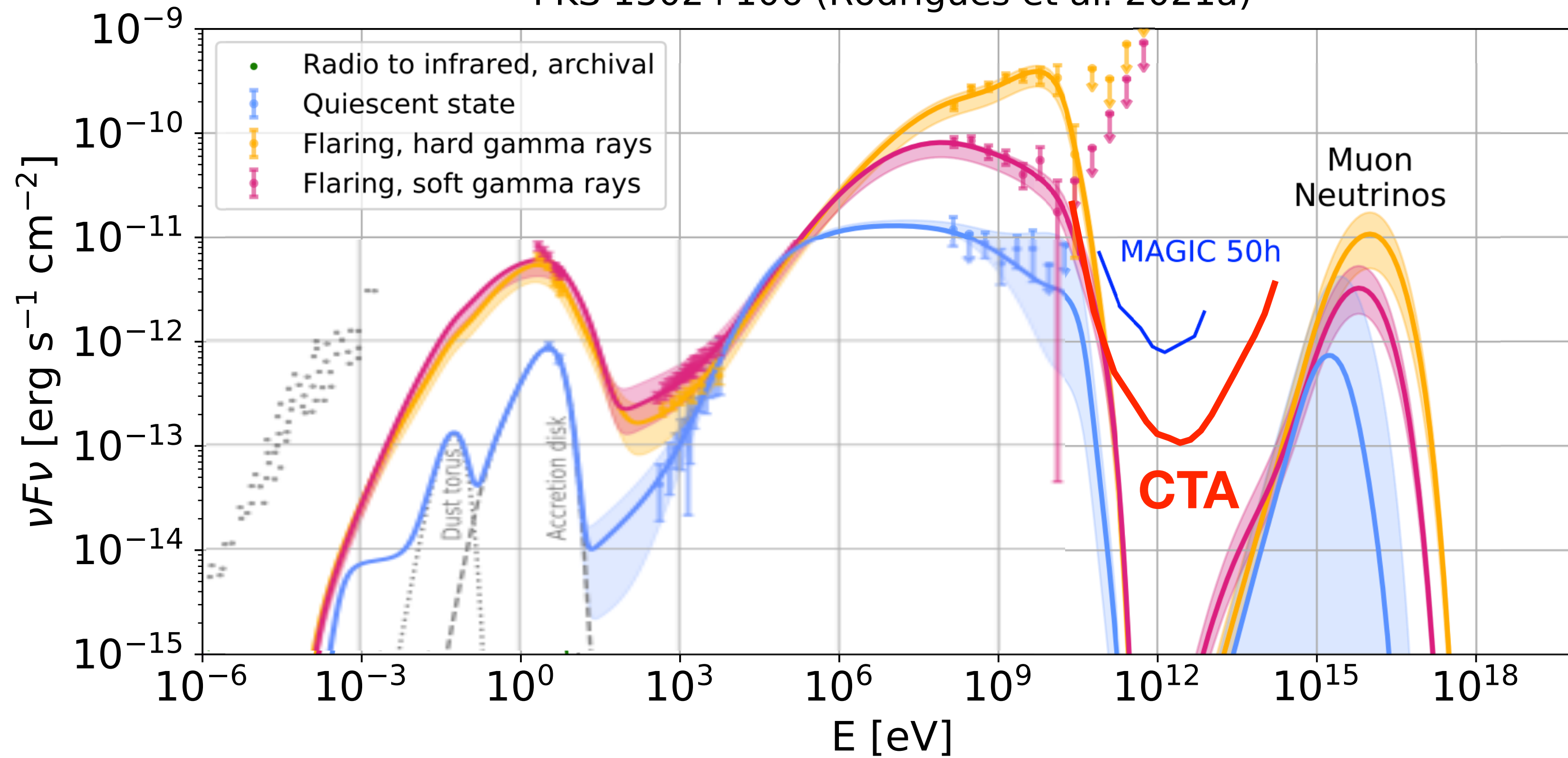# What we can still learn: blazar PKS 1502+106

- 15th brightest Fermi-LAT source

- z = 1.8

- Huge radio flare during neutrino detection

- No associated GeV flare
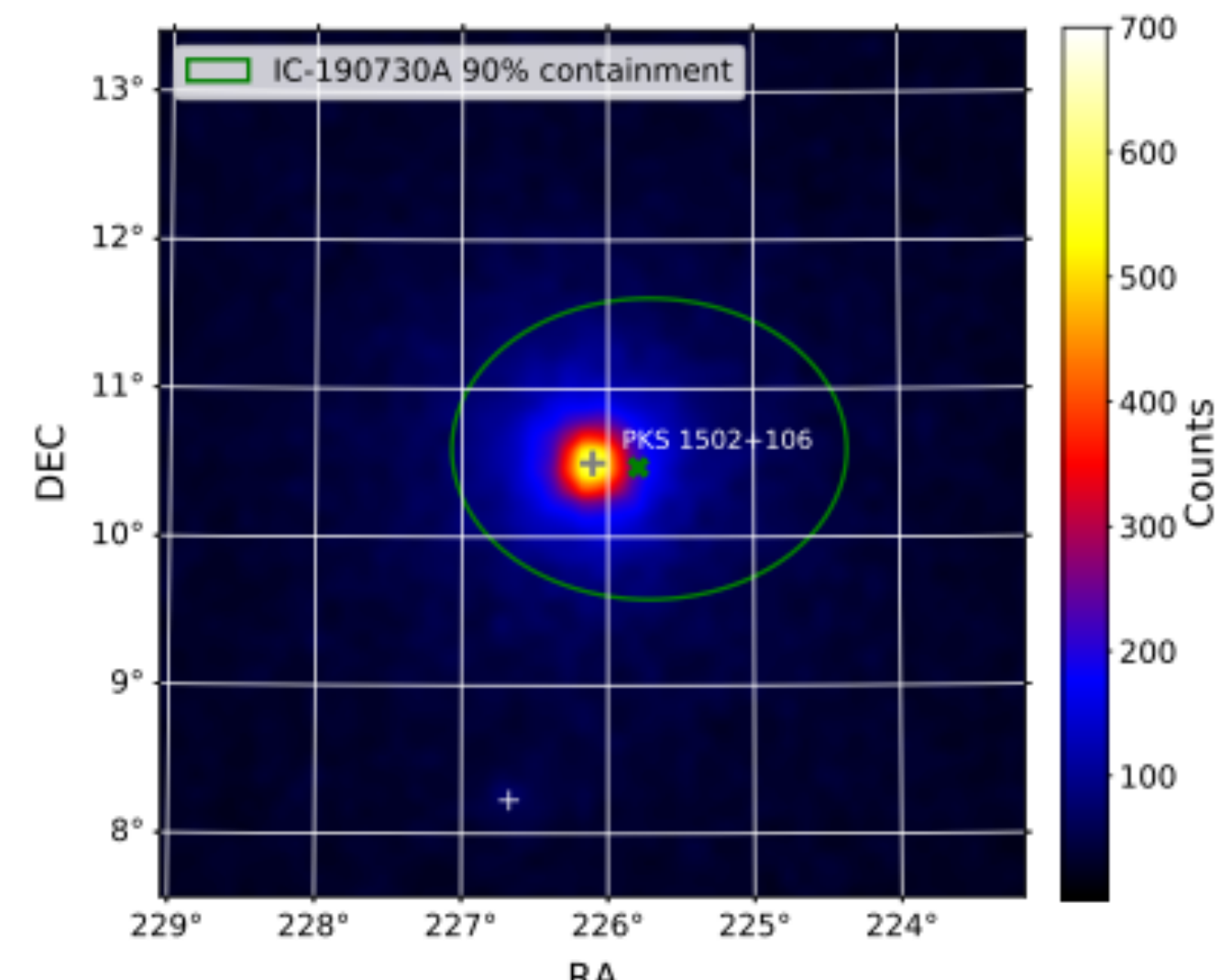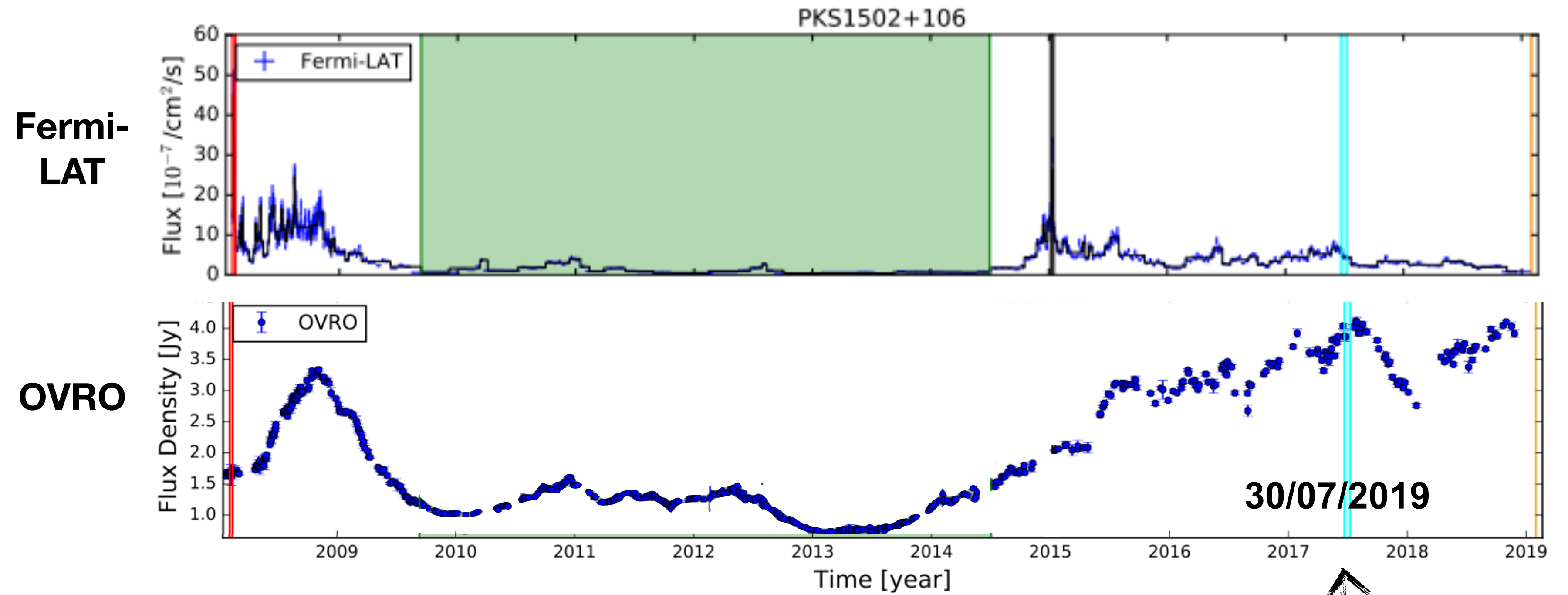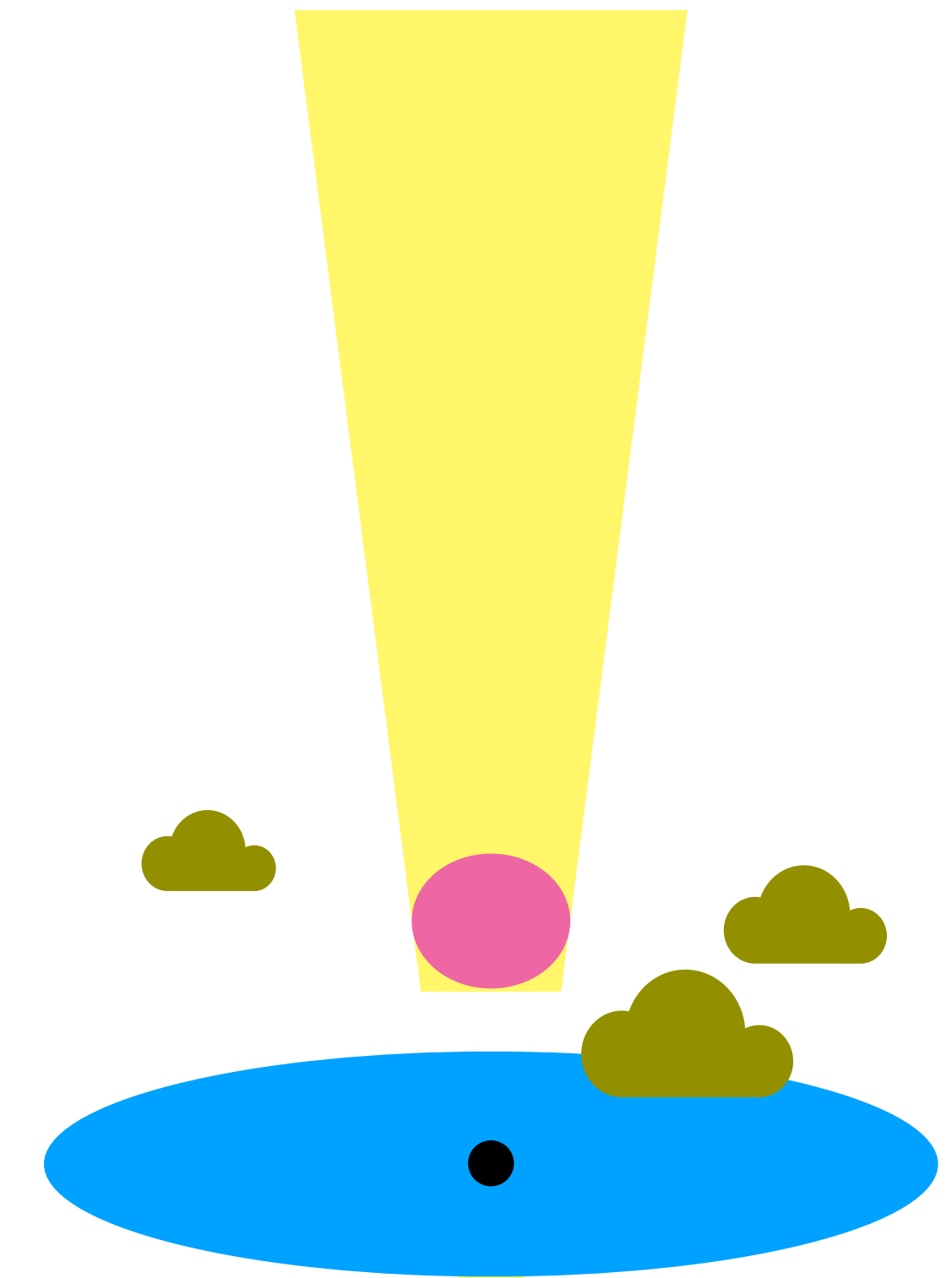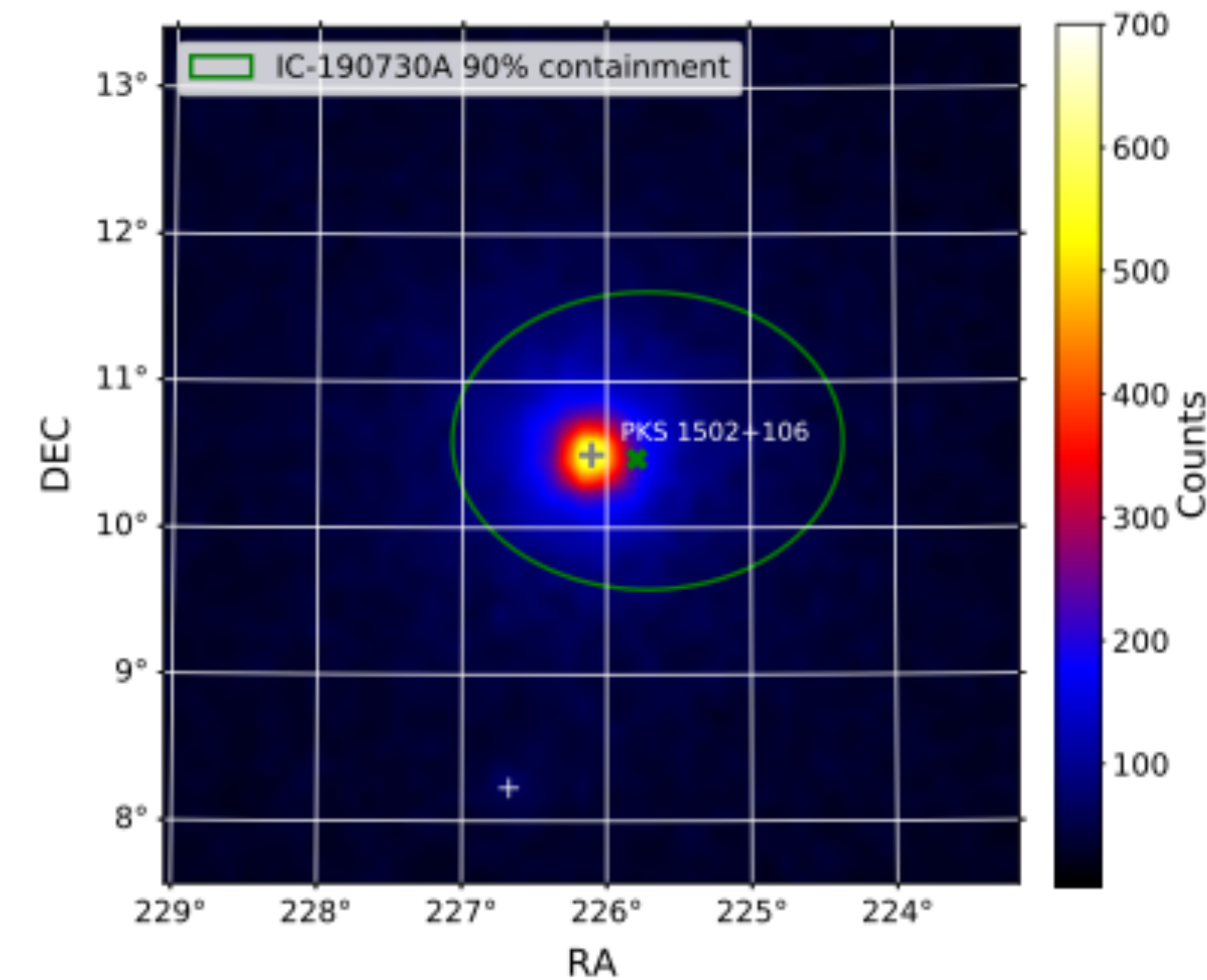
Franckowiak, Garrappa, et al, ApJ 893 (2020)

30/07/2019

DESY.

What we can still learn: blazar PKS 1502+106

PKS 1502+106 (Rodrigues et al. 2021a)

Rodrigues, Garrappa, Gao, Paliya, Franckowiak and Winter, ApJ 912 (2021)

What we can still learn: blazar PKS 1502+106

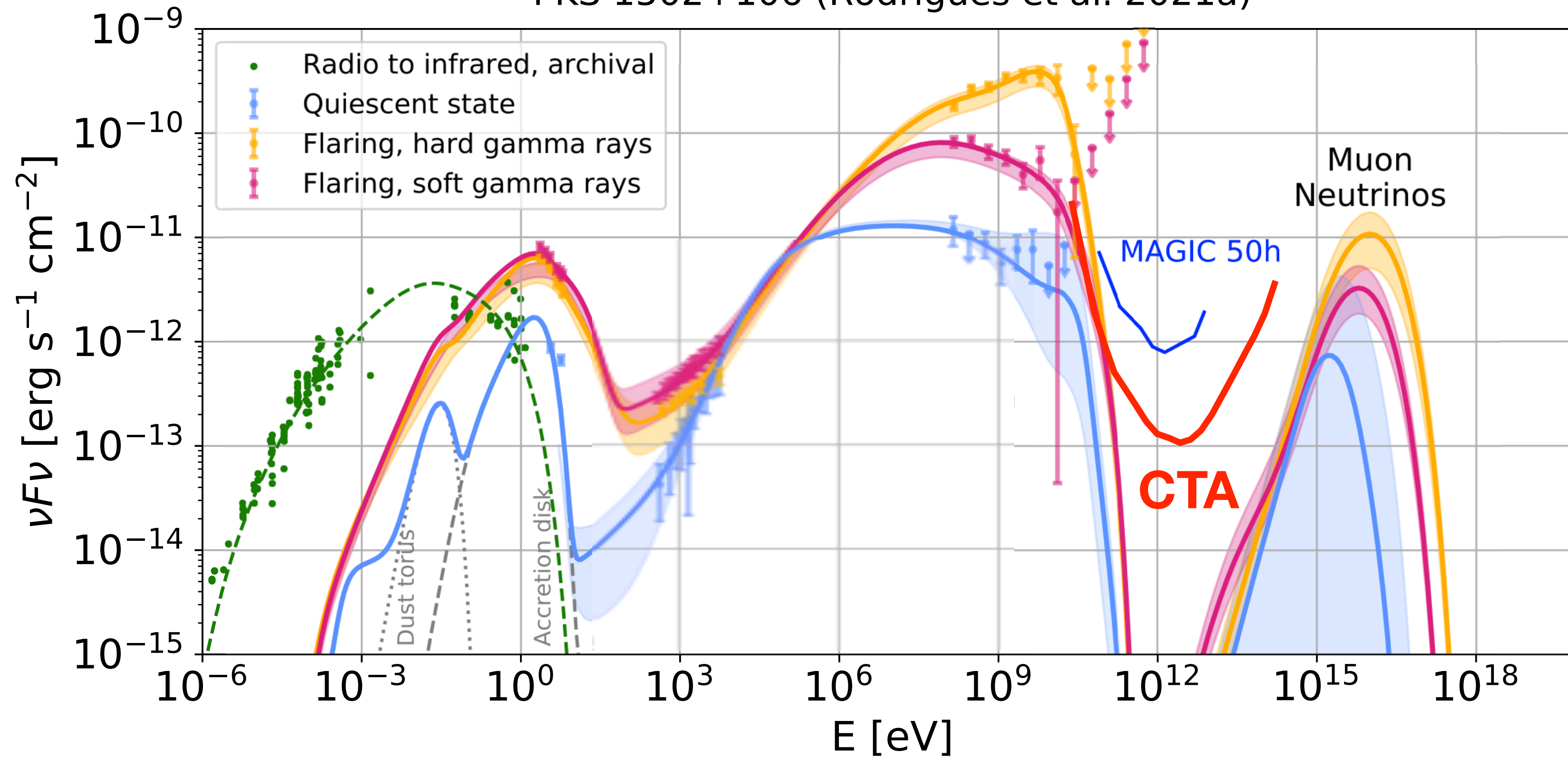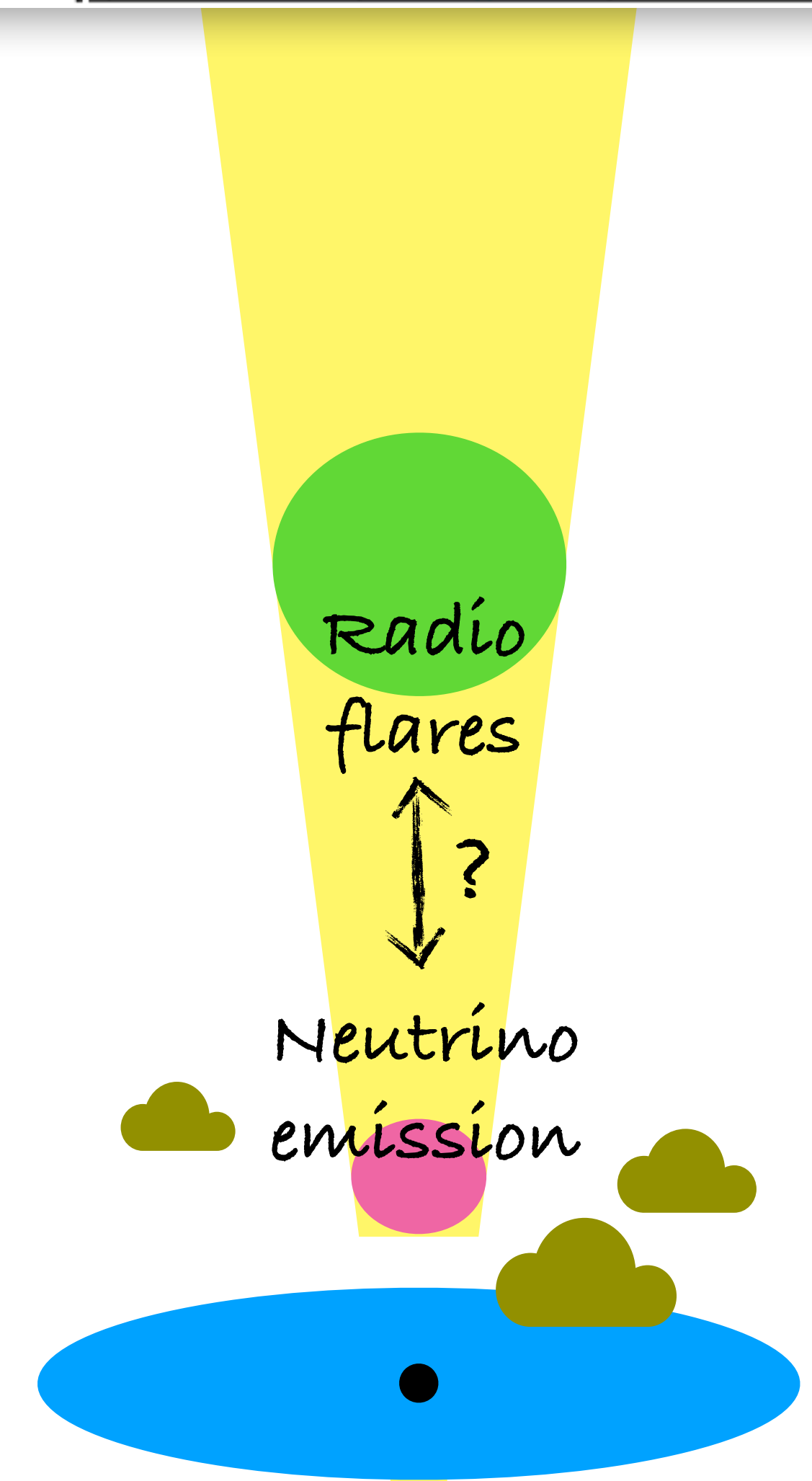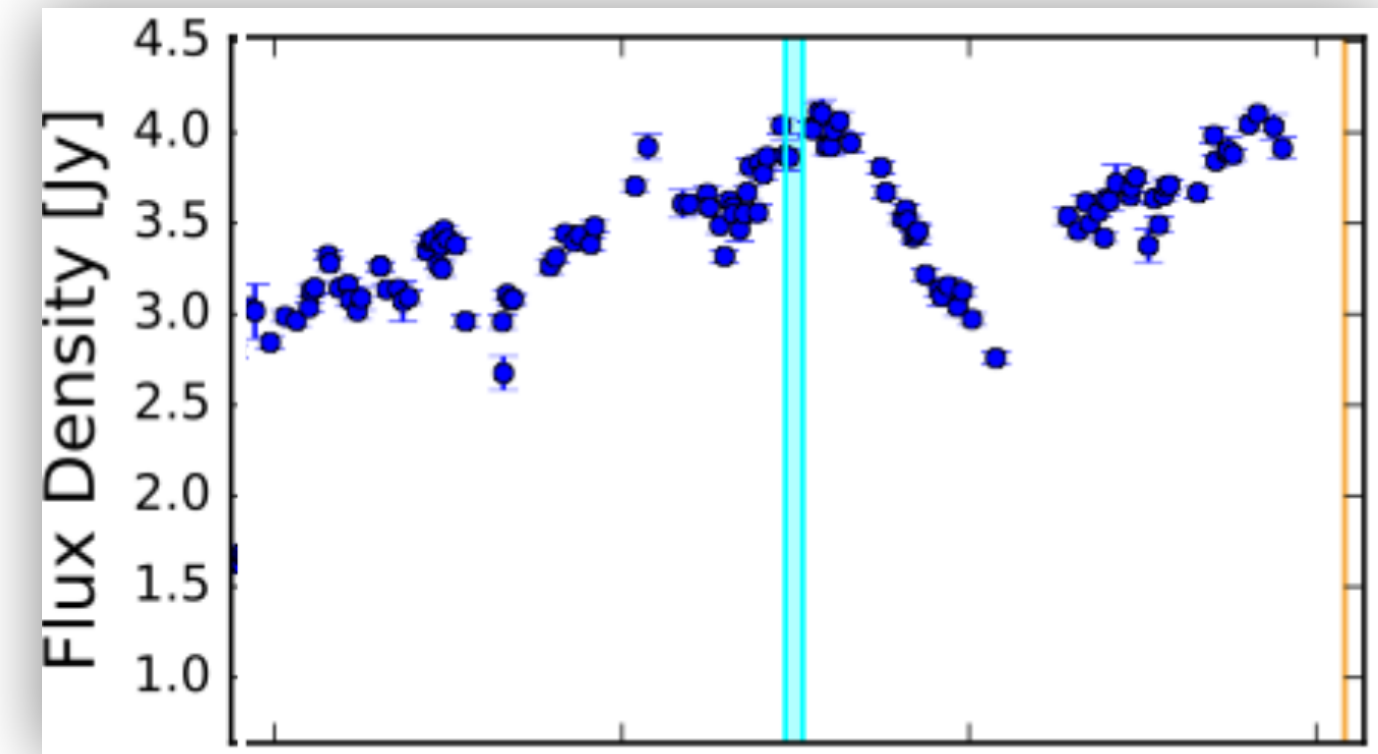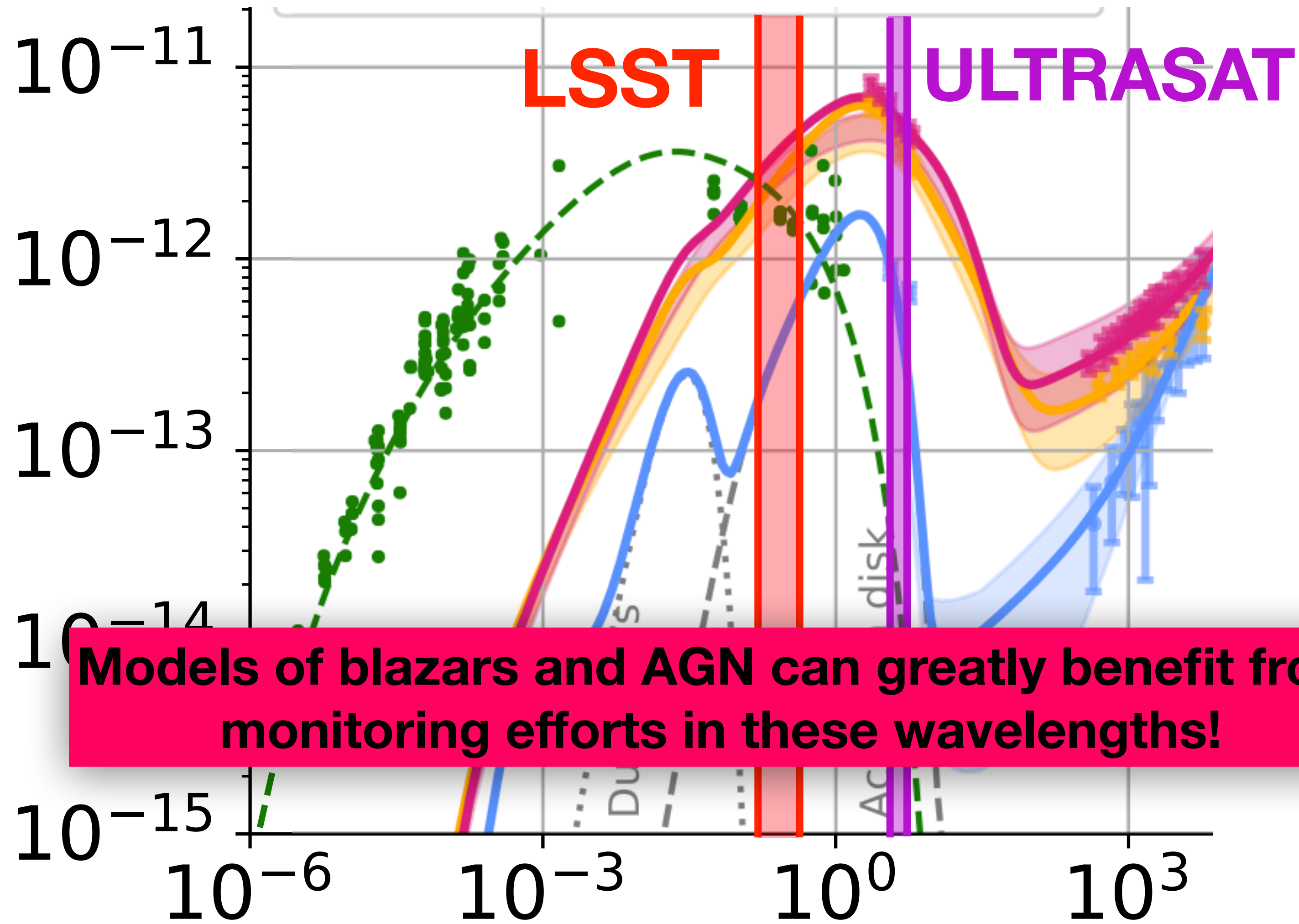PKS 1502+106 (Rodrigues et al. 2021a)

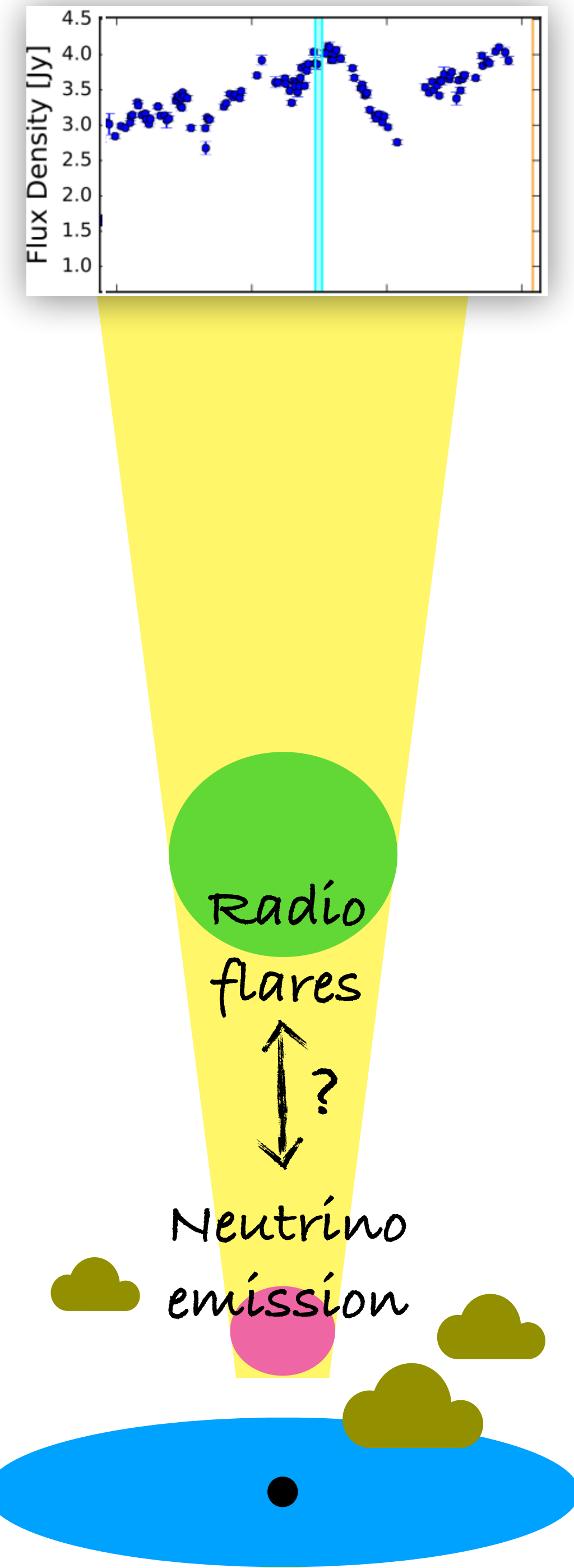**Rodrigues, Garrappa, Gao, Paliya, Franckowiak and Winter, ApJ 912 (2021)**

What we can still learn: blazar PKS 1502+106

LSST

ULTRASAT

Models of blazars and AGN can greatly benefit from monitoring efforts in these wavelengths!

Radio flares

?

Neutrino emission

Rodrigues, Garrappa, Gao, Paliya, Franckowiak and Winter, ApJ 912 (2021)

DESY.

Summary

Synergies between **neutrino and MWL experiments** have resulted in an unprecedented wealth of information

Through **theoretical modeling** we are starting to constrain the **physics of multi-messenger sources** like AGN and TDEs

Future experiments will be crucial to **complete our MWL picture** and constrain the source populations

DESY.

9