The Spectral Energy Distribution of the Candidate Neutrino Source TXS 0506+056

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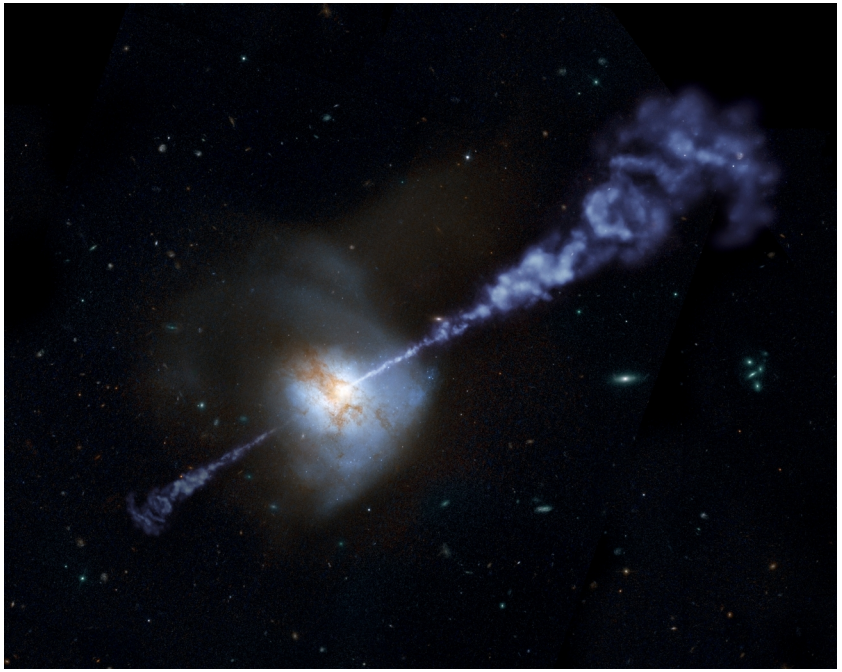
Active Galactic Nuclei

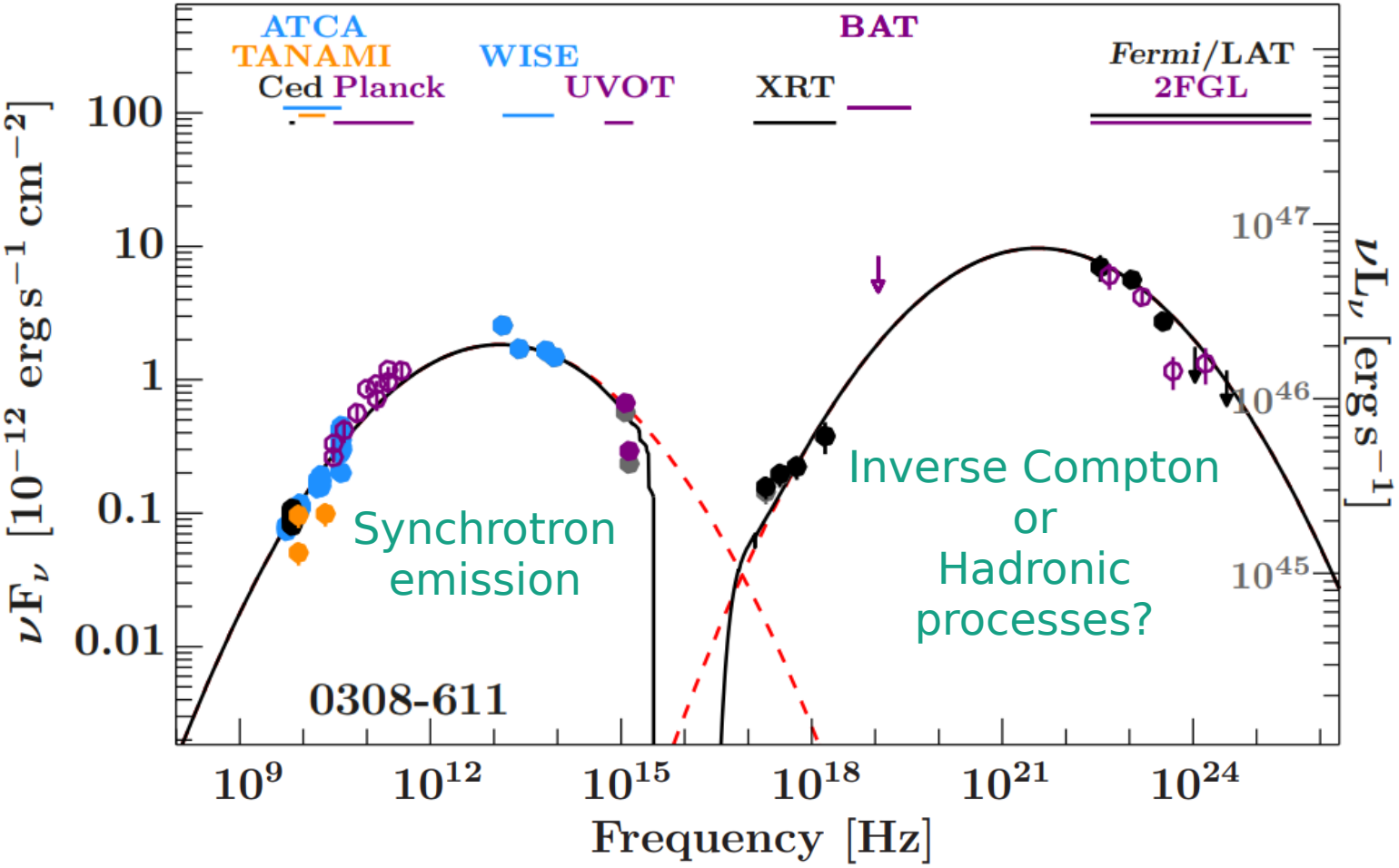
- **Classification into several subclasses depending on radio loudness, inclination angle and luminosity**
- **Blazar: jet pointed toward Earth**



Credit: NASA/JPL-Caltech

Spectral Energy Distribution

- **Broadband emission from Radio to Gamma-rays**



Credit: Krauss et al. 2014, A&A, 566, L7

How can neutrinos be linked to AGN?

- **Particle interactions induce cascades:**

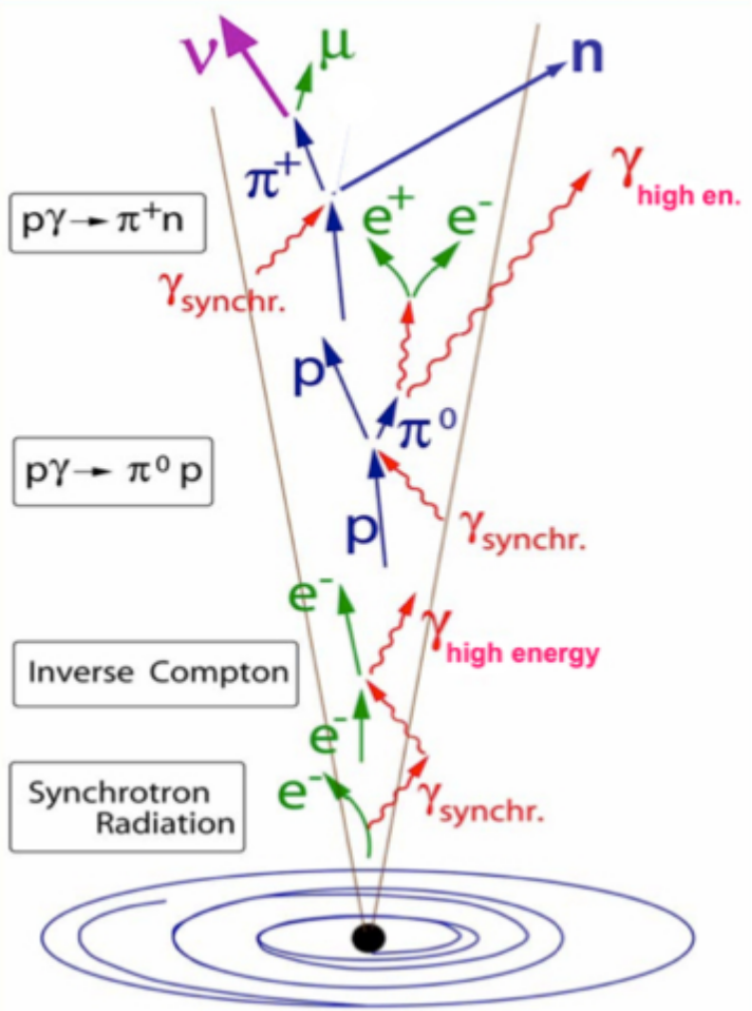
$$p + \gamma \rightarrow \Delta^{+} \rightarrow \begin{cases} \pi^0 + p \\ \pi^{+} + n \end{cases}$$

Further cascades:

$$\pi^0 \rightarrow \gamma + \gamma$$

&

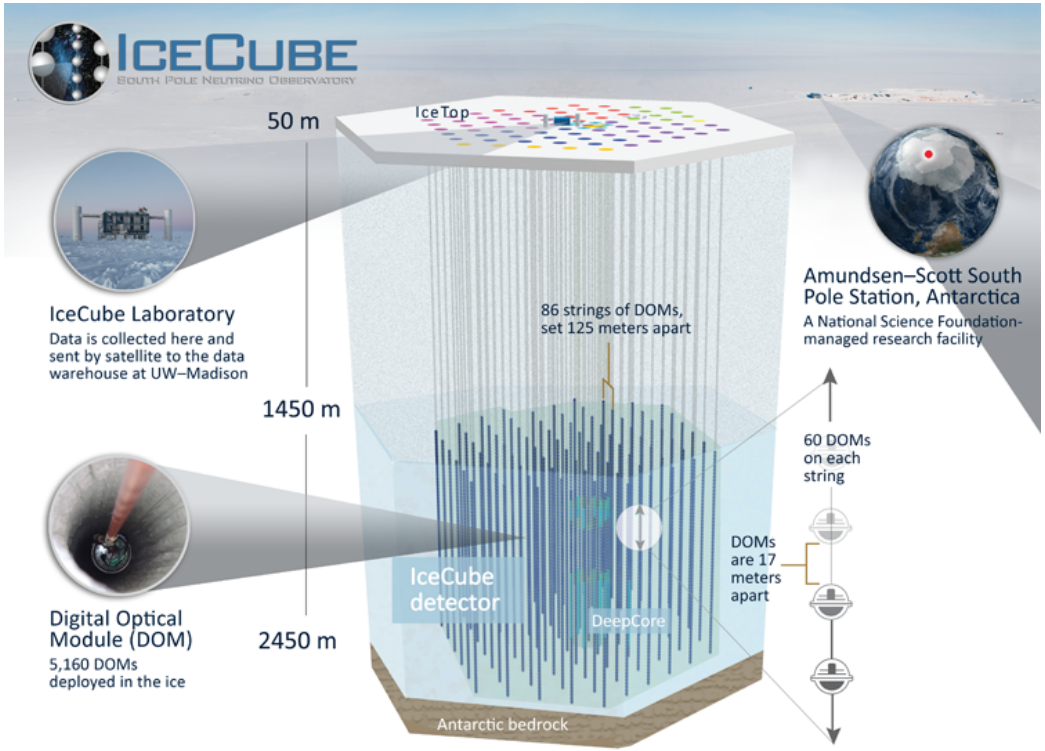
$$\pi^{+} \rightarrow \mu^{+} + \overline{\nu}_{\mu}$$
$$\mu^{+} \rightarrow e^{+} + \overline{\nu}_{\mu} + \nu_{e}$$



Credit: Katz & Spiering 2012

Neutrino detection with IceCube

- **Particle detector in the Antarctic Ice:**
  - Volume: 1km^3
  - Depth: ~2500m



https://icecube.wisc.edu/science/icecube/detector

So far, detection of

ν_e & ν_μ

Blob-like event

Track-like event

Sky position reconstruction possible

Neutrino event

- **First extragalactic neutrino event that is temporally and spatially coincident with detected gamma-ray flare**
- **Paper(s) yet to be published**

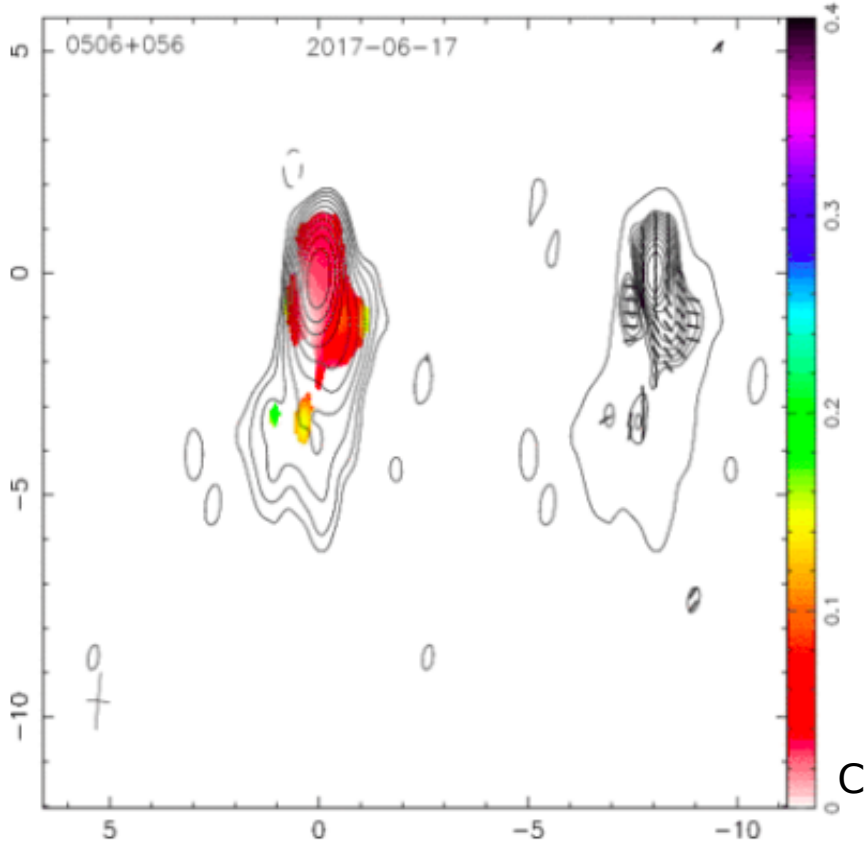
Fermi-LAT detection of increased gamma-ray activity of TXS 0506+056, located inside the IceCube-170922A error region.

ATel #10791; ***Yasuyuki T. Tanaka (Hiroshima University), Sara Buson (NASA/GSFC), Daniel Kocevski (NASA/MSFC) on behalf of the Fermi-LAT collaboration***
*on **28 Sep 2017; 10:10 UT***
Credential Certification: David J. Thompson (David.J.Thompson@nasa.gov)

Subjects: Gamma Ray, Neutrinos, AGN

Referred to by ATel #: 10792, 10794, 10799, 10801, 10817, 10830, 10831, 10833, 10838, 10840, 10844, 10845, 10861, 10890, 10942, 11419, 11430, 11489

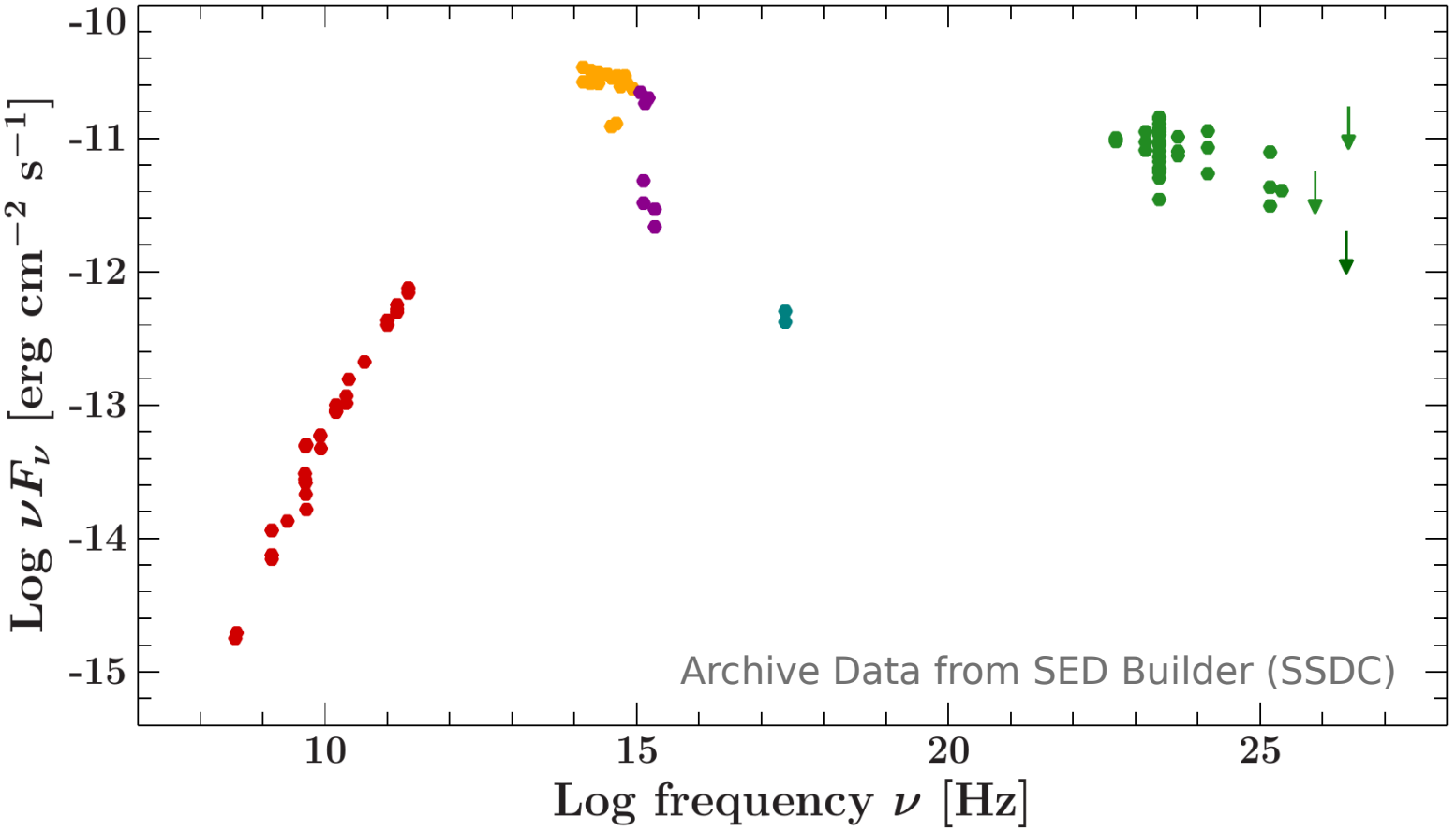
TXS0506+056



Credit: MOJAVE

- **Source type: unclear yet (BL Lac or FSRQ)**
- **Redshift: z = 0.3365 ± 0.001 (Paiano et al. 2018)**

Spectral Energy Distribution (SED)



Radio: ATCA (Tingay et al., 2003), CGRaBS (Healey et al., 2008), CLASSCAT (Myers et al., 2003), CRATES (Healey et al., 2007), the Green Bank Telescope (Becker et al., 1991; Bennett et al., 1986; Gregory et al., 1996; White & Becker, 1992), the NRAO VLA Sky Survey (Condon et al., 1998), the Parkes-MIT-NRAO Survey (Griffith et al., 1995; Wright et al., 1994), OVRO (Ackermann et al., 2011; Richards et al., 2011), Planck (Planck Collaboration et al., 2014, 2015, 2011), the Texas Interferometer (Douglas et al., 1996), VERA (Petrov et al., 2007), VLBA (Lanyi et al., 2010; Lister et al., 2011) and the VLBI Space Observatory Program (Dodson et al., 2008; Horiuchi et al., 2004).
Optical and nearinfrared: Kitt Peak National Observatory (Meisner & Romani, 2010), the Swift Satellite (Rau et al., 2012) and 2MASS (Chen et al., 2005).
UV: GALEX (Seibert et al., 2012) and Swift (Rau et al., 2012).
X-rays: ROSAT (Boller et al., 2016; Voges et al., 1999)
γ-rays: Fermi/LAT (Abdo et al., 2010; Acero et al., 2015; Nolan et al., 2012) and ARGO2LAC (Bartoli et al., 2013)

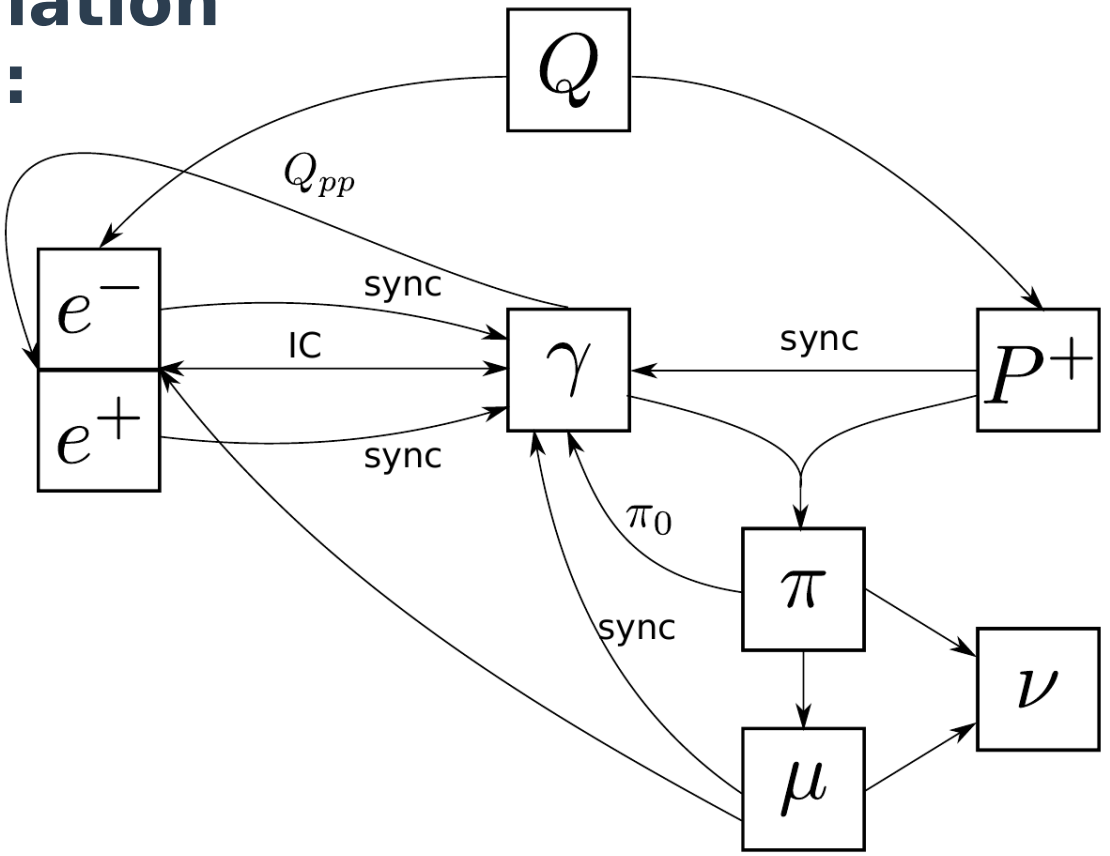
Modelling the SED with unicorn-0d

- **Unicorn-0d = Numerical model of acceleration and radiation processes of Blazars:**
  - Time-dependent
  - Hybrid:

Synchrotron-Self Compton

+

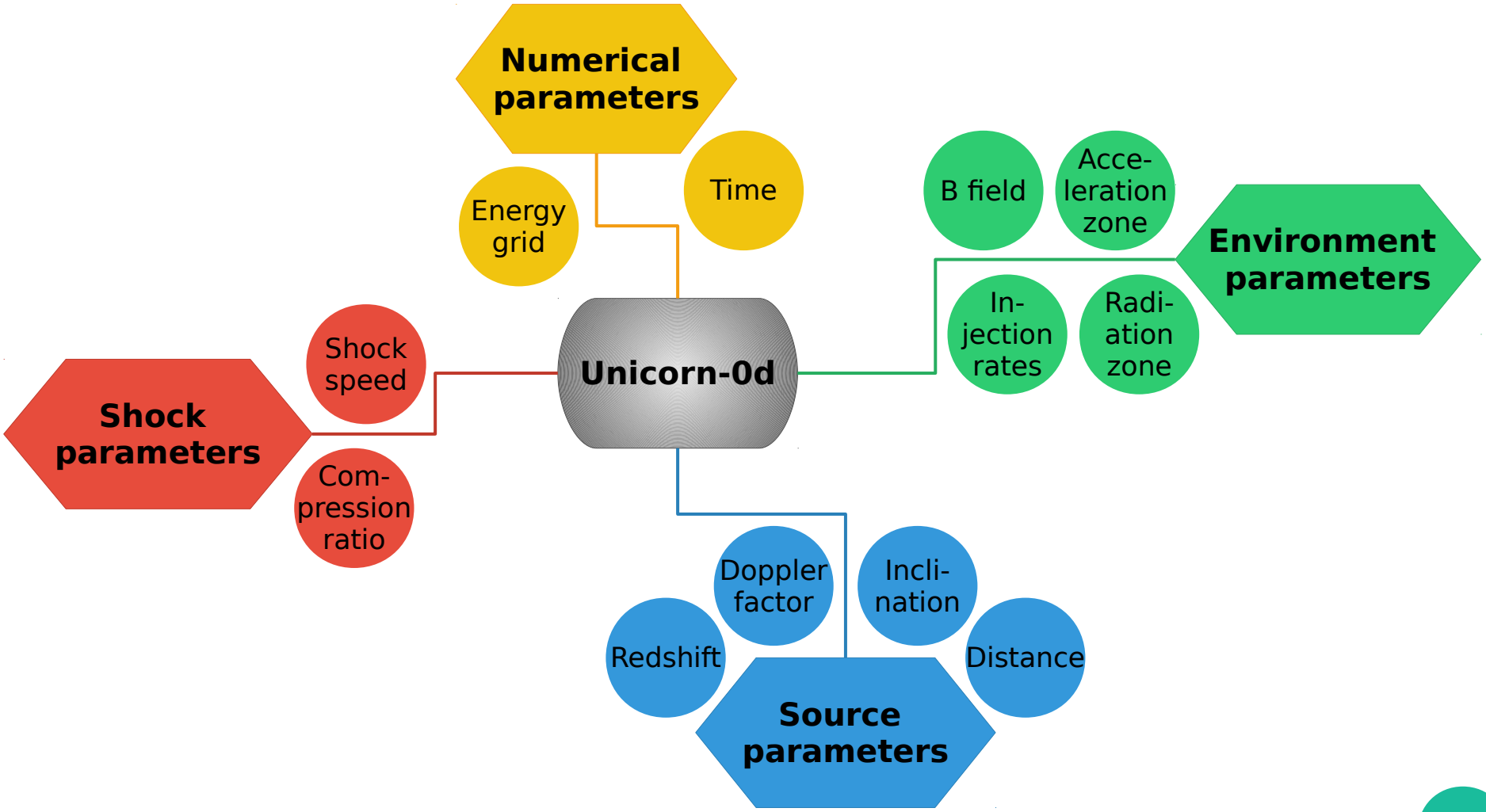
Photohadronic processes



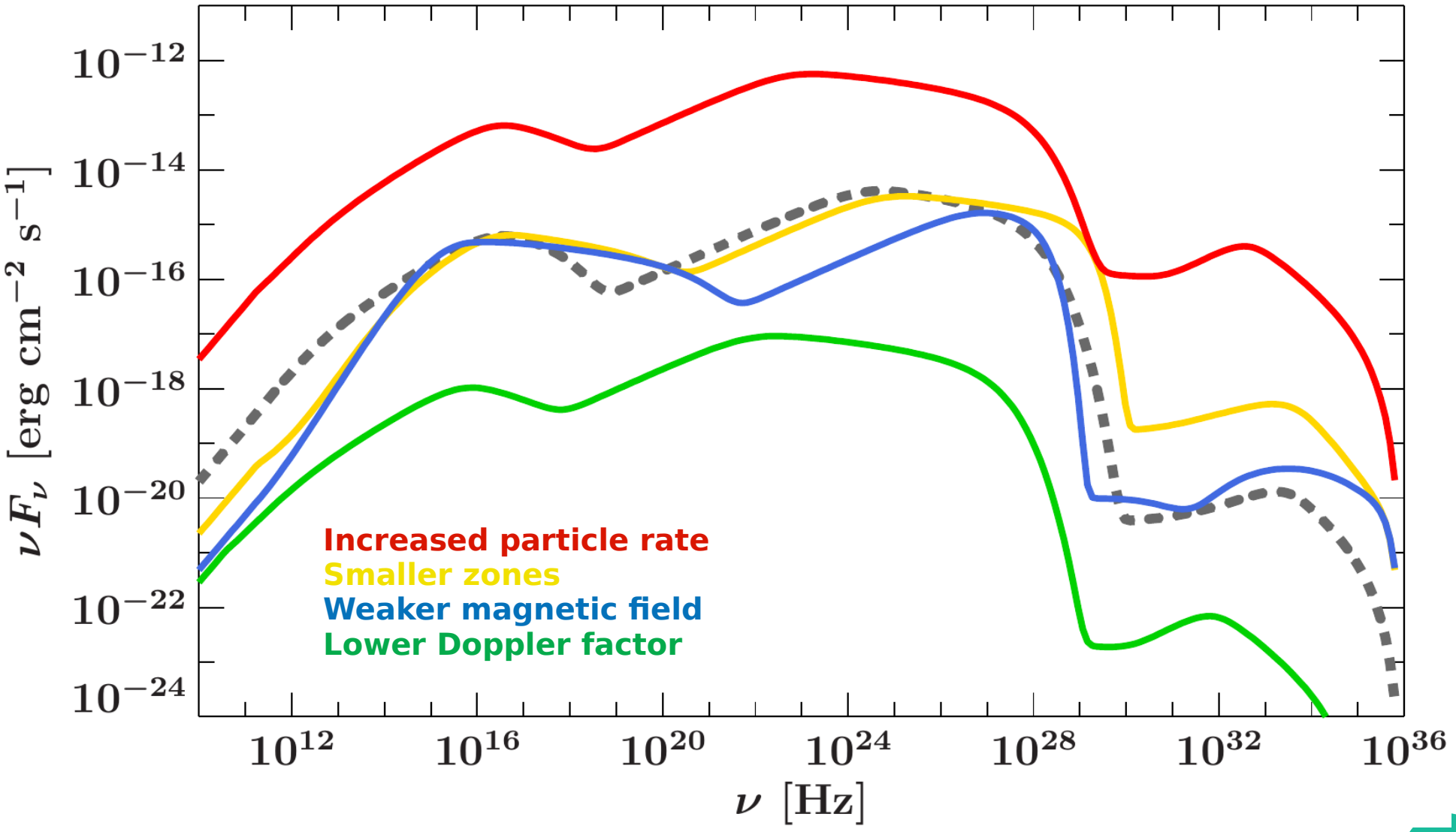
Credit: Stephan Richter, Dissertation 2014

Modelling the SED with unicorn-0d

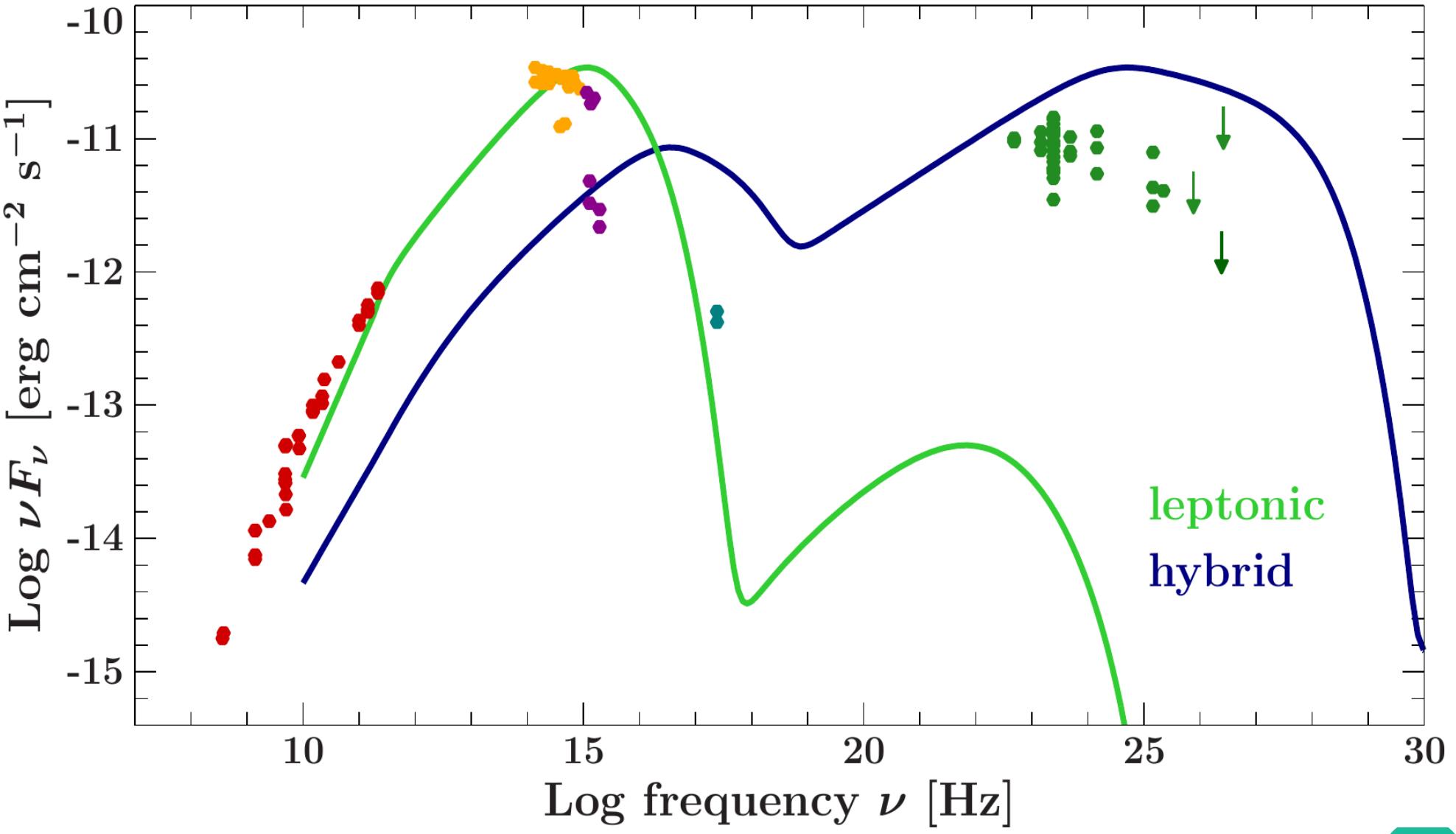
- **Parameter space:**



SEDs with different parameters



Model vs. Data



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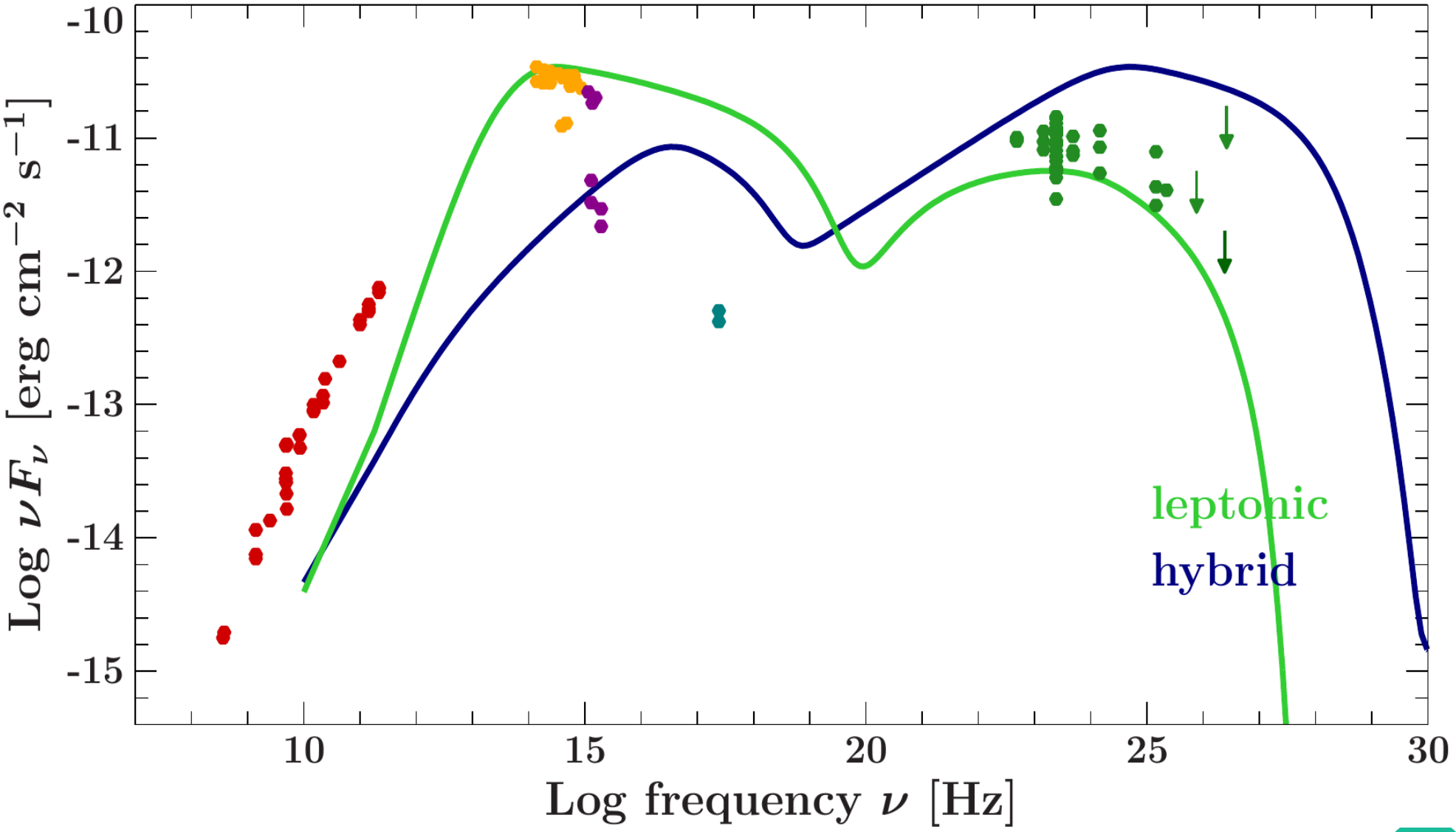

Summary

- **Possible link between extragalactic neutrino event and the blazar TXS0506+056 by gamma-ray flare**
- **Important to study for understanding the physical processes in AGN jets**
- **Physical model unicorn-0d provides both a calculation for a SSC as well as a hybrid scenario**
- **Work in progress: more parameter space needs to be covered for finding a fit to TXS0506+056 data**
- **Data from various instruments during flare in September not public yet**