The importance of Blazars in the cosmic magnetic field scenario

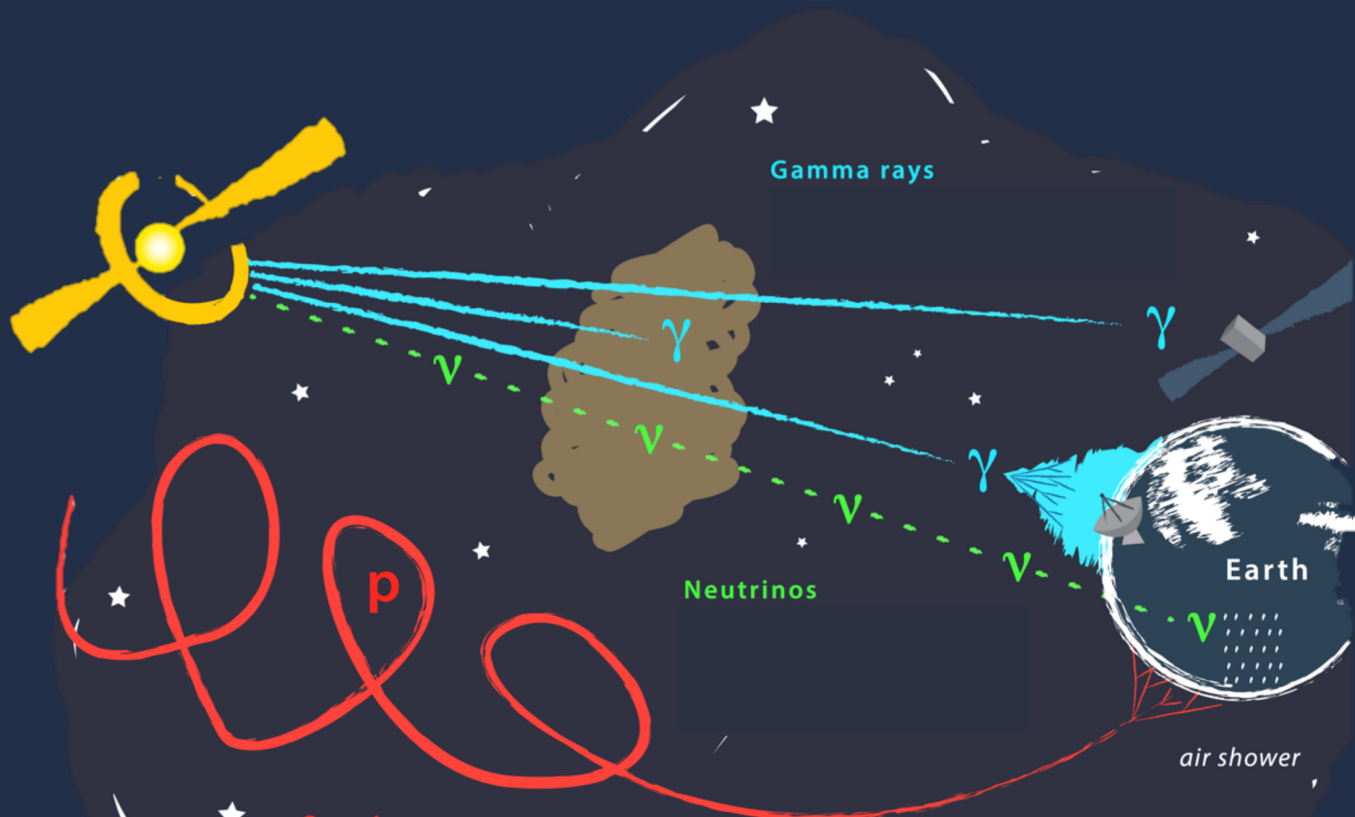
C. Righi

23-27 Jan 2023

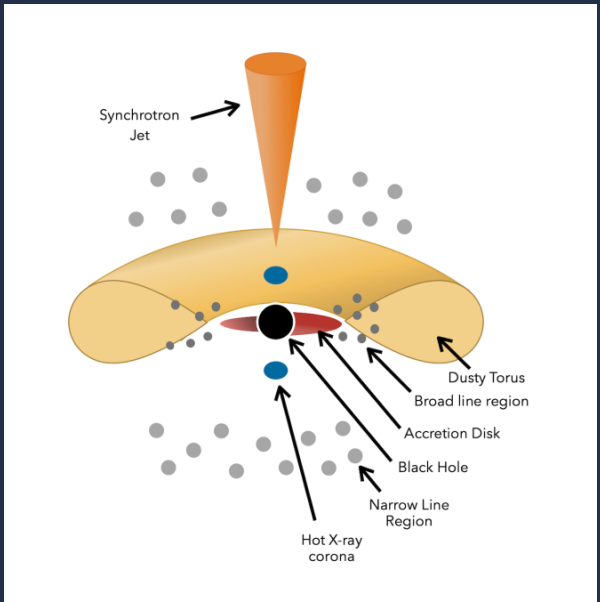
Cosmic Magnetism in Voids & Filaments - Bologna

Outline

- Introduction on AGN
- Blazars basic phenomenology
- Blazars and magnetic field
- Conclusions



Active Galactic Nuclei (AGN)



$M_{BH} > 10^7 M_{sun}$

Infalling gas forms an accretion disk around the black hole (optical through soft X-ray continuum).

AGN are ≈1-10% of all galaxies

The span of observed AGN bolometric luminosities is huge, $L \approx 10^{40}–10^{48}$ erg/s

AGN are the most luminous long-lived objects in the Universe

Large variety of properties -> sub-classes

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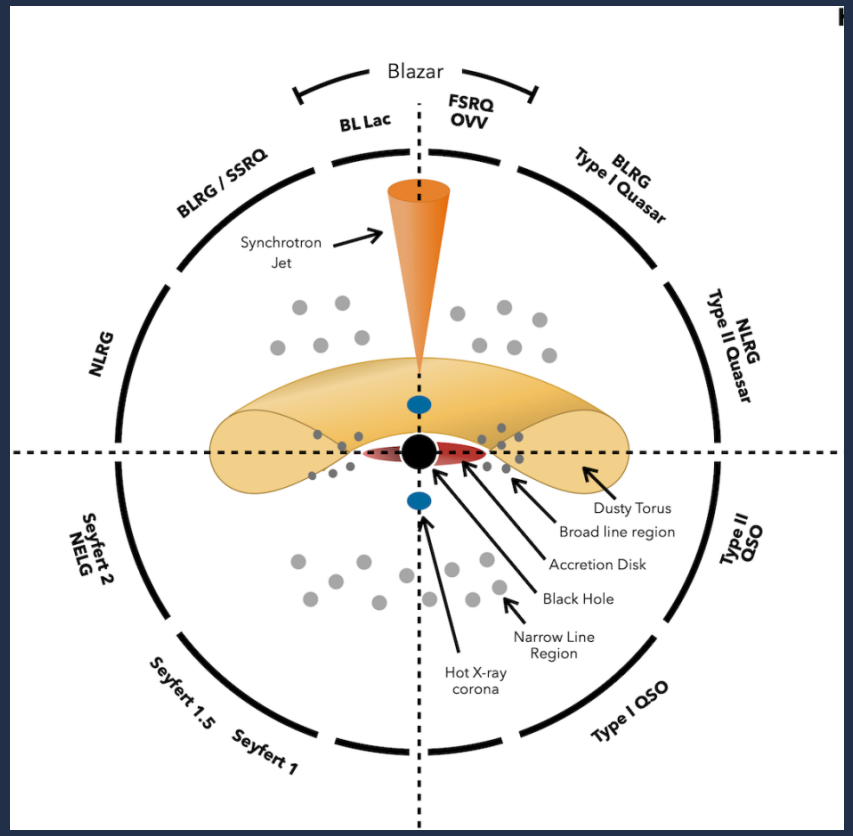

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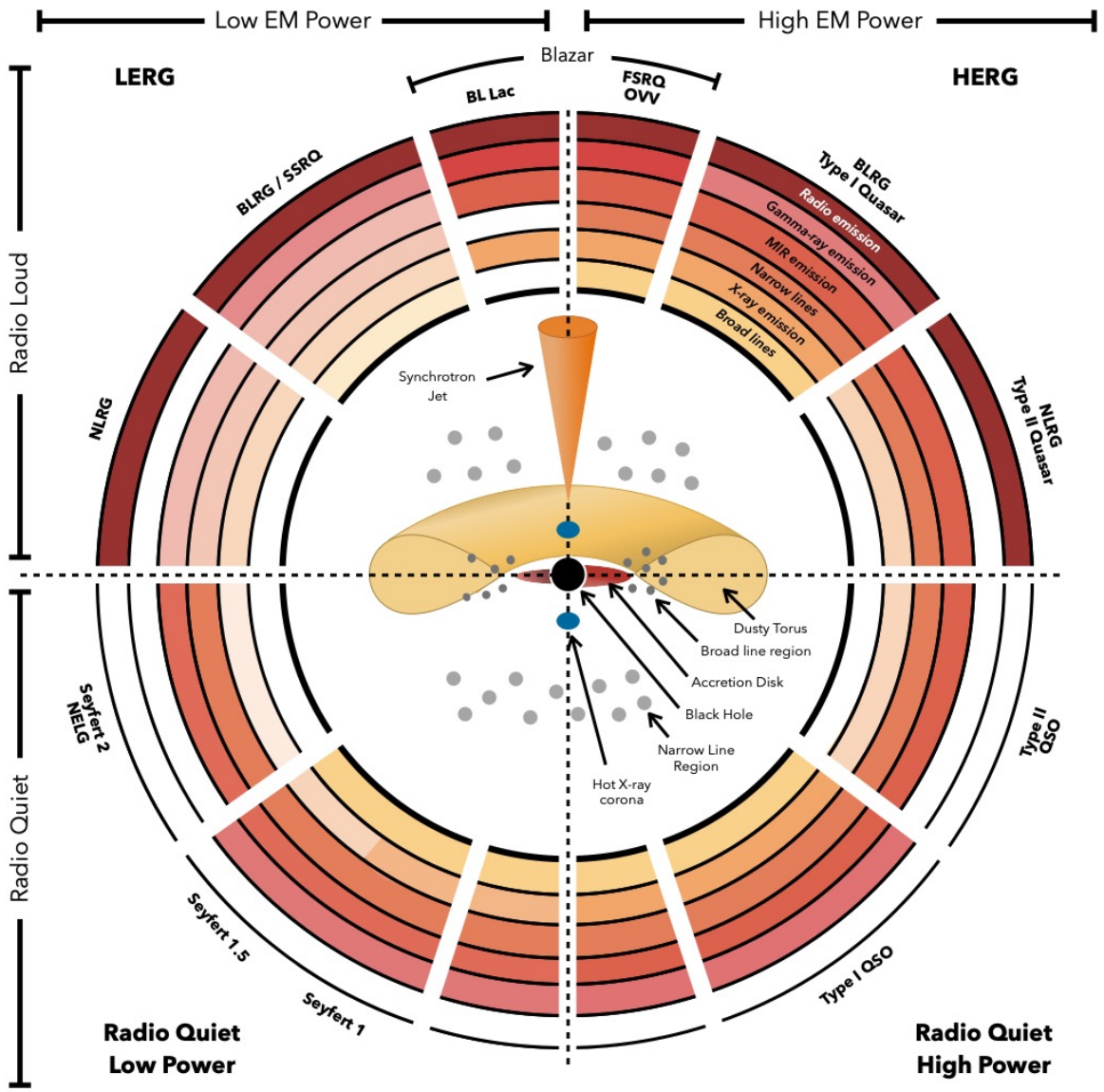

J. E. Thorne

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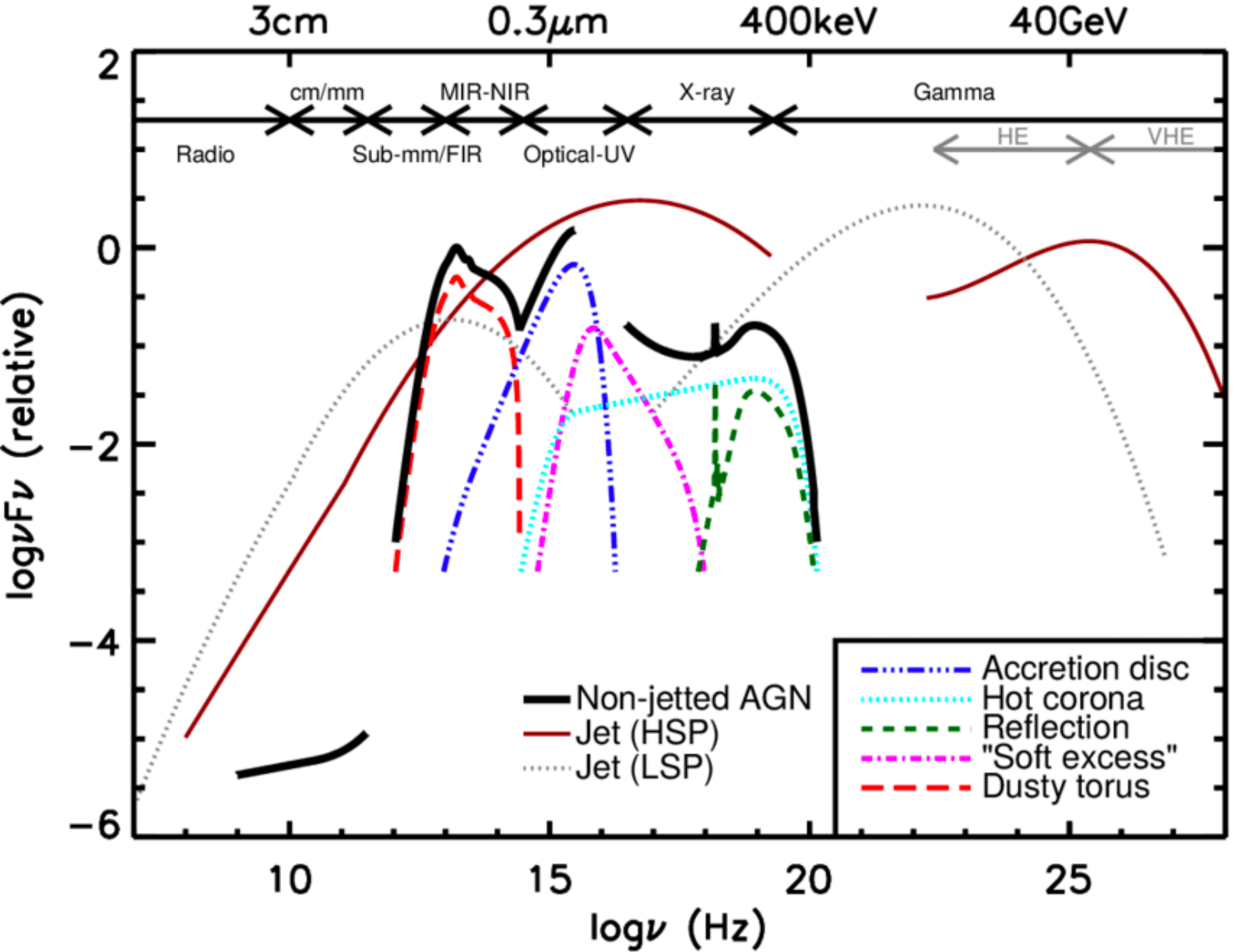
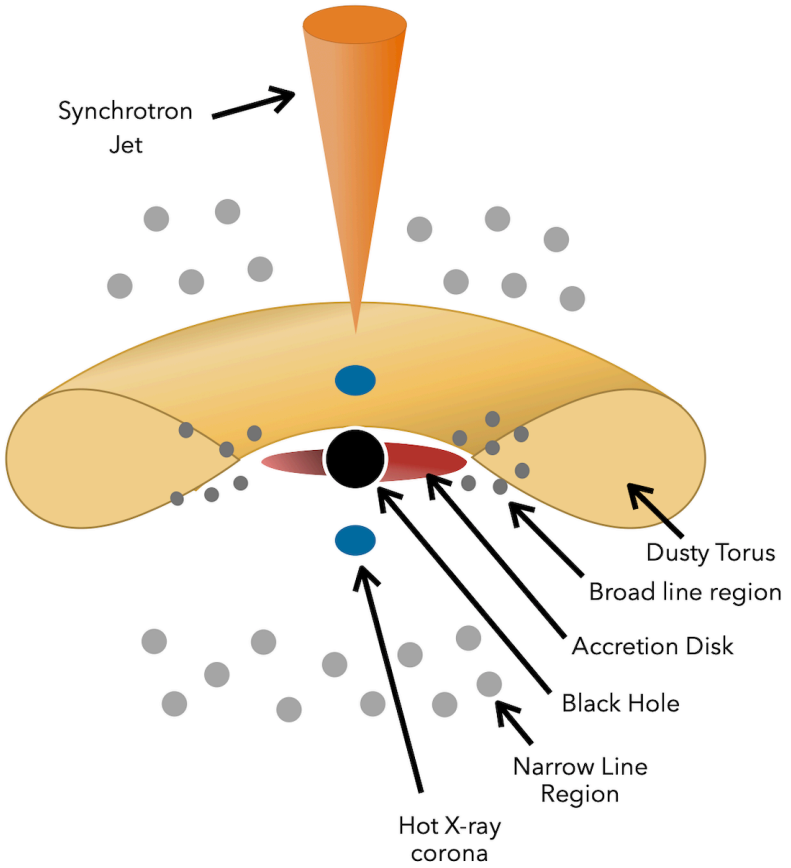
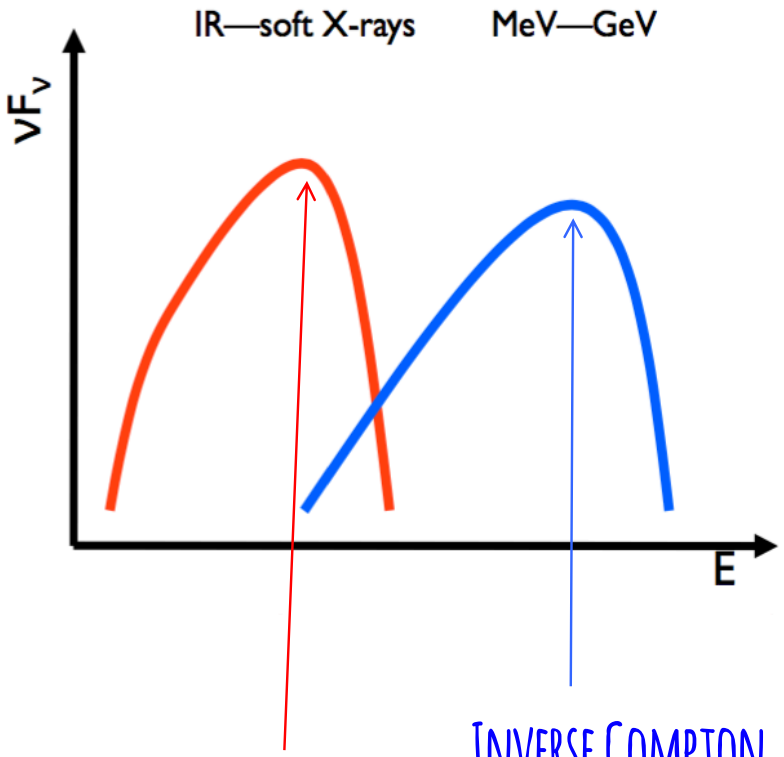




Blazars - SED



MODELS

LEPTONIC

HADRONIC

SYNCHROTRON

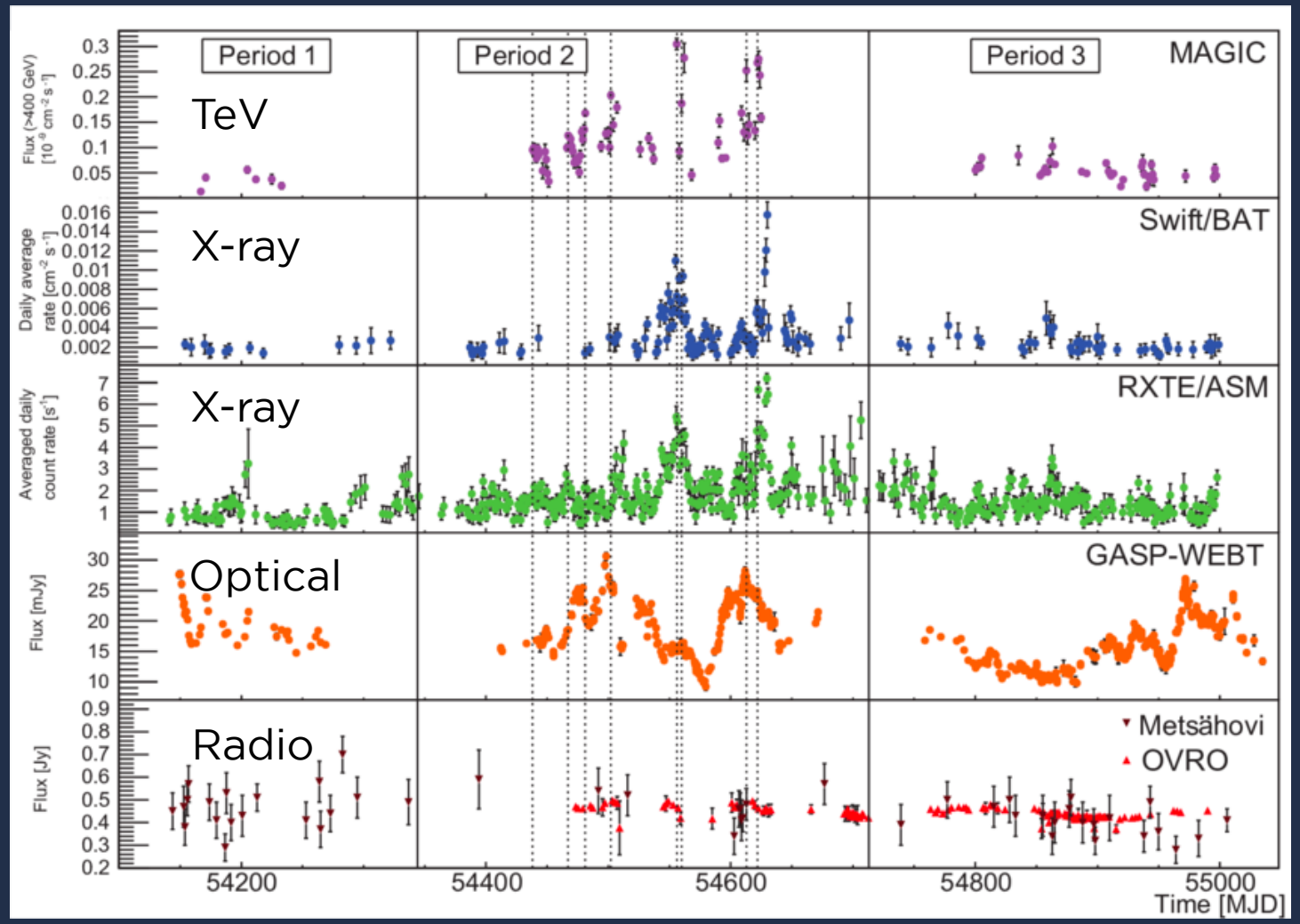
INVERSE COMPTON

REPROCESSED PHOTO-MESON PRODUCTS OR SYNCHROTRON (PROTONS)

Spectral Energy Distribution

Dominated by the relativistically boosted non-thermal continuum emission of the jet

Blazars - Variability

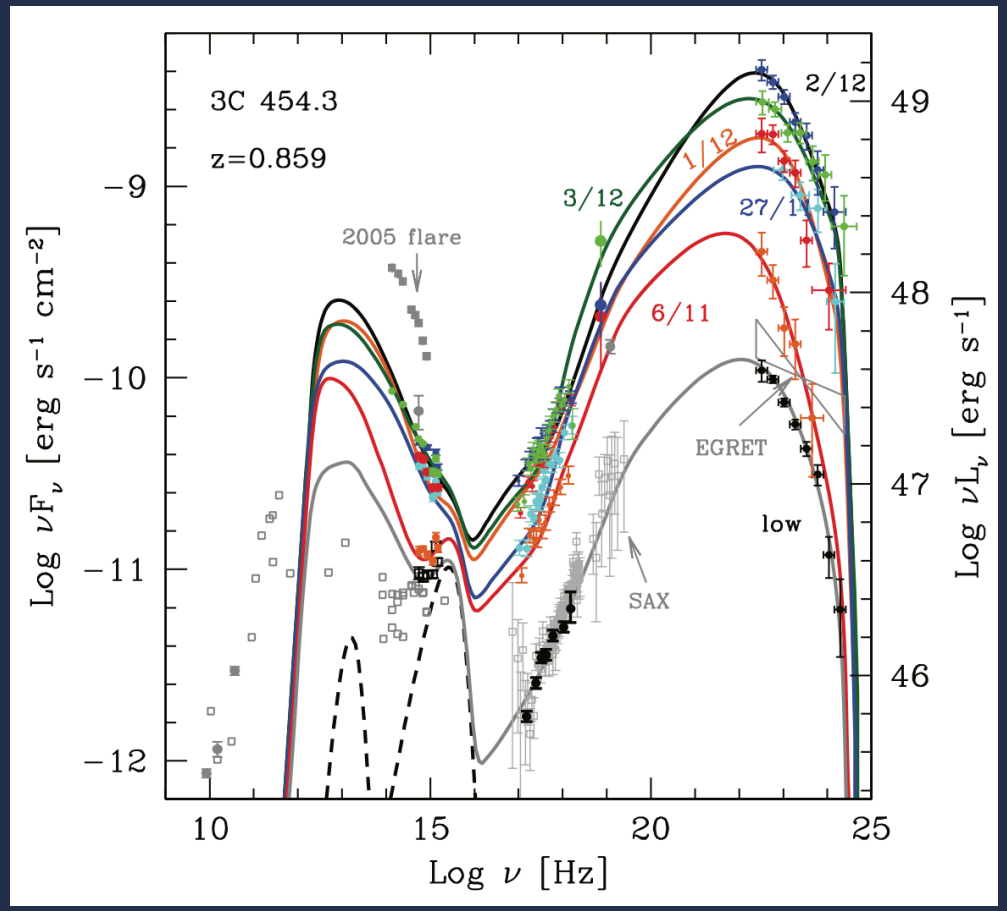


Multiwavelength Lightcurve

- Variability at all wavelengths
- Indication of physical properties of the jet.

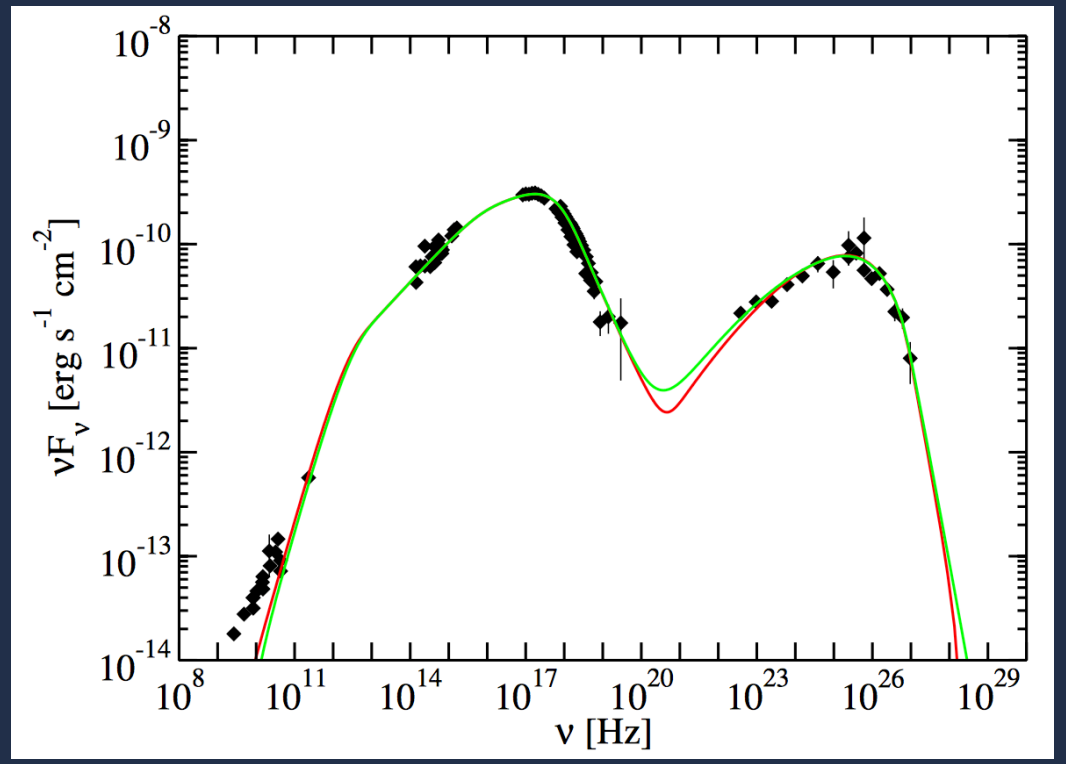
Blazars

FLAT SPECTRUM RADIO QUASAR



Bonnoli et al. 2011

BL LAC OBJECT



Abdo et al. 2011

Blazars

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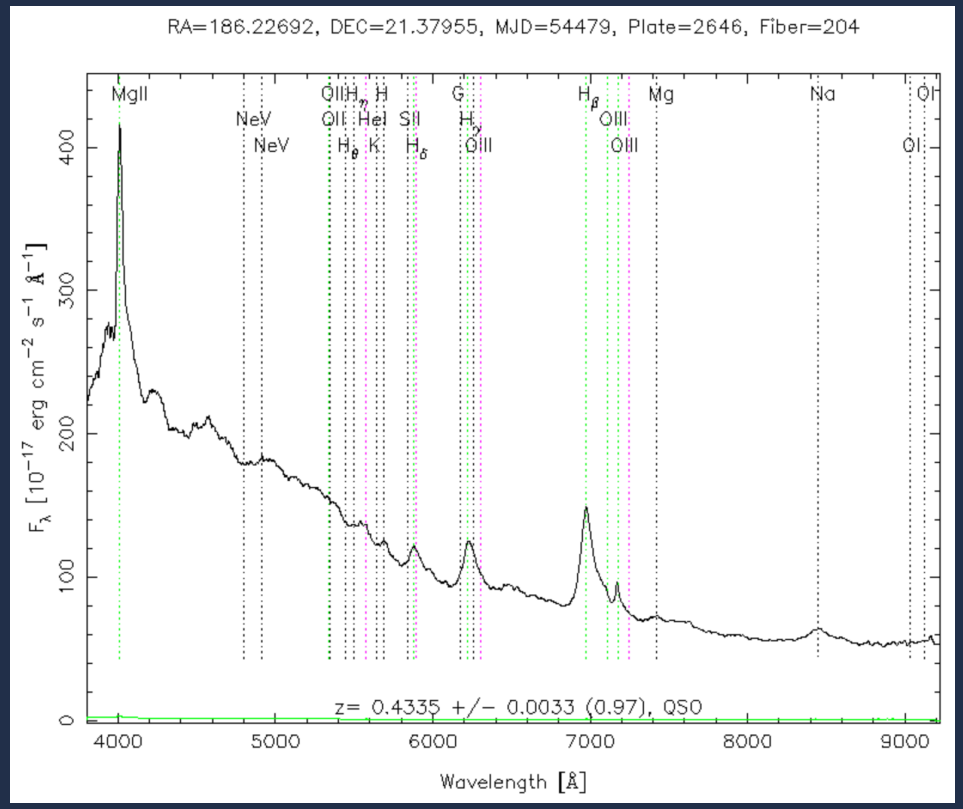
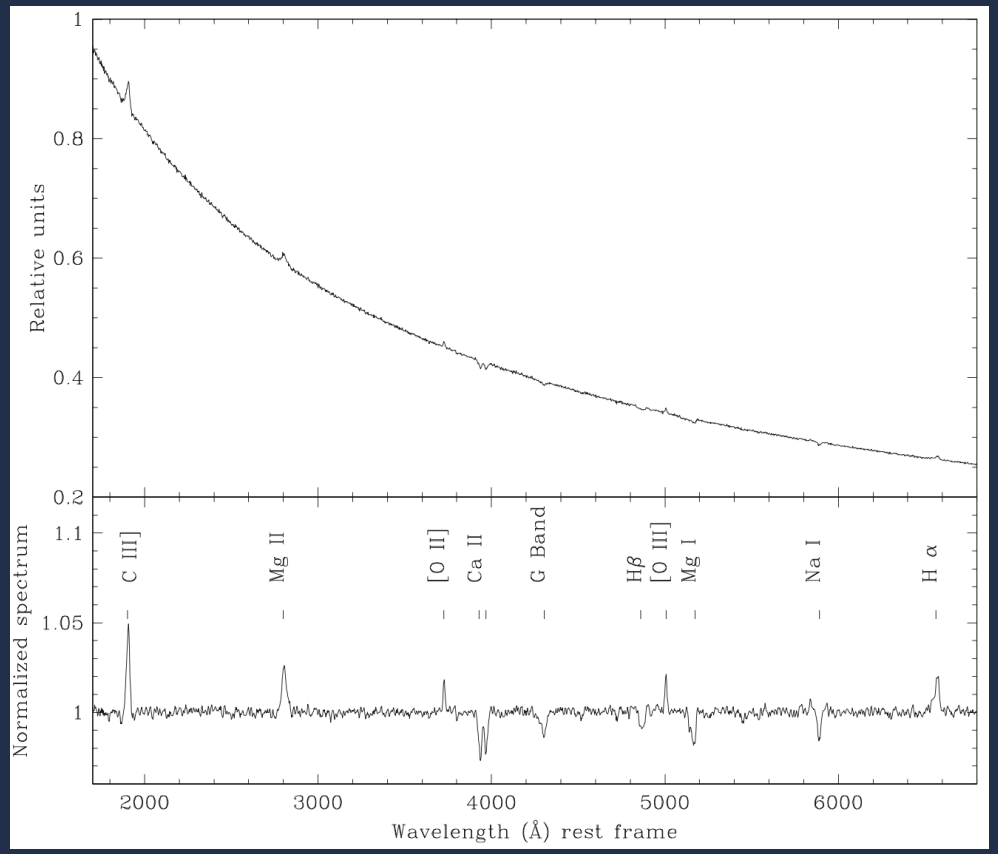


SDSS 2008

BL LAC OBJECT



Landoni et al. 2015

Blazars

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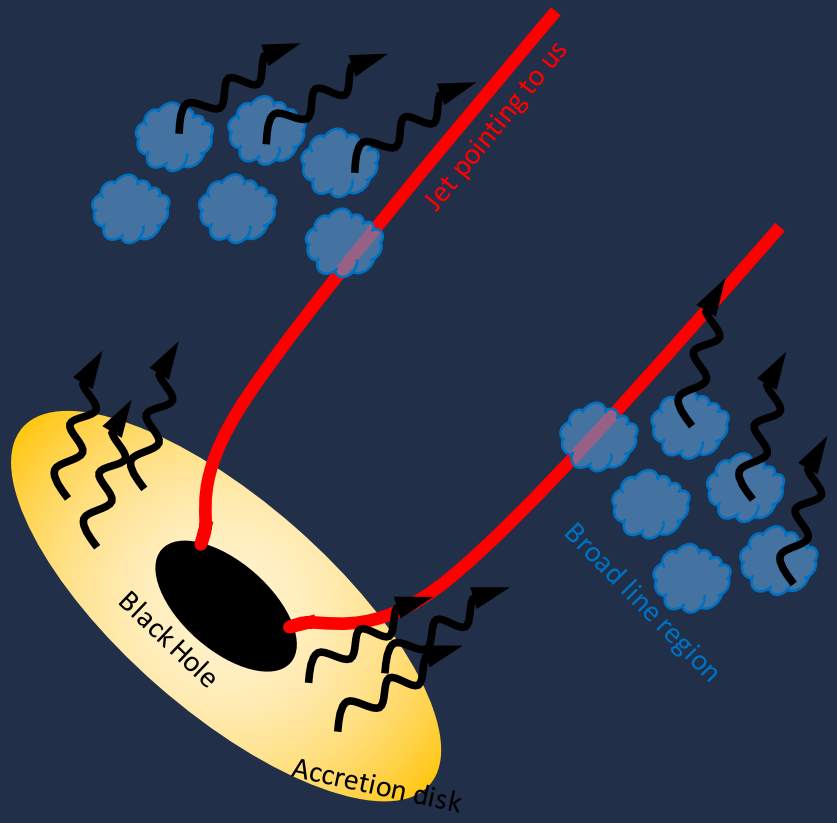

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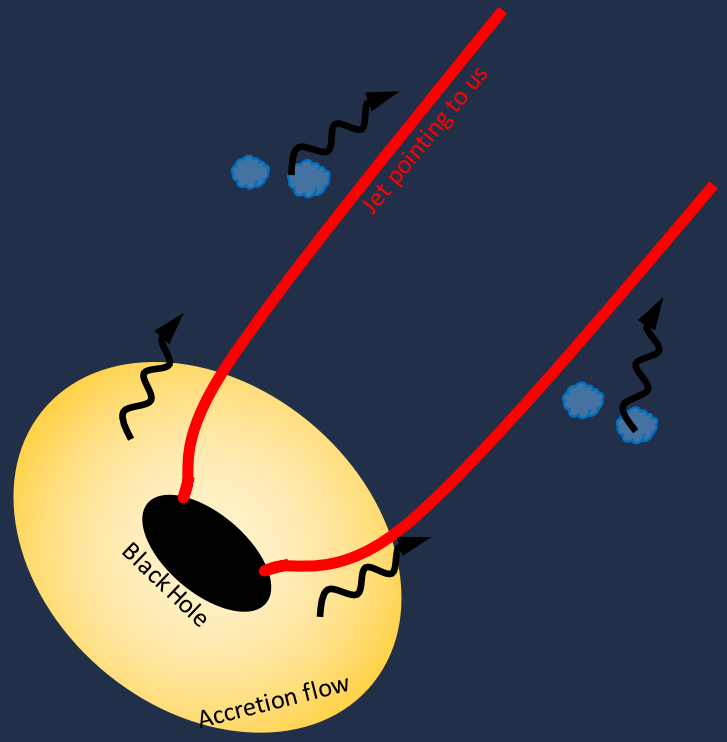
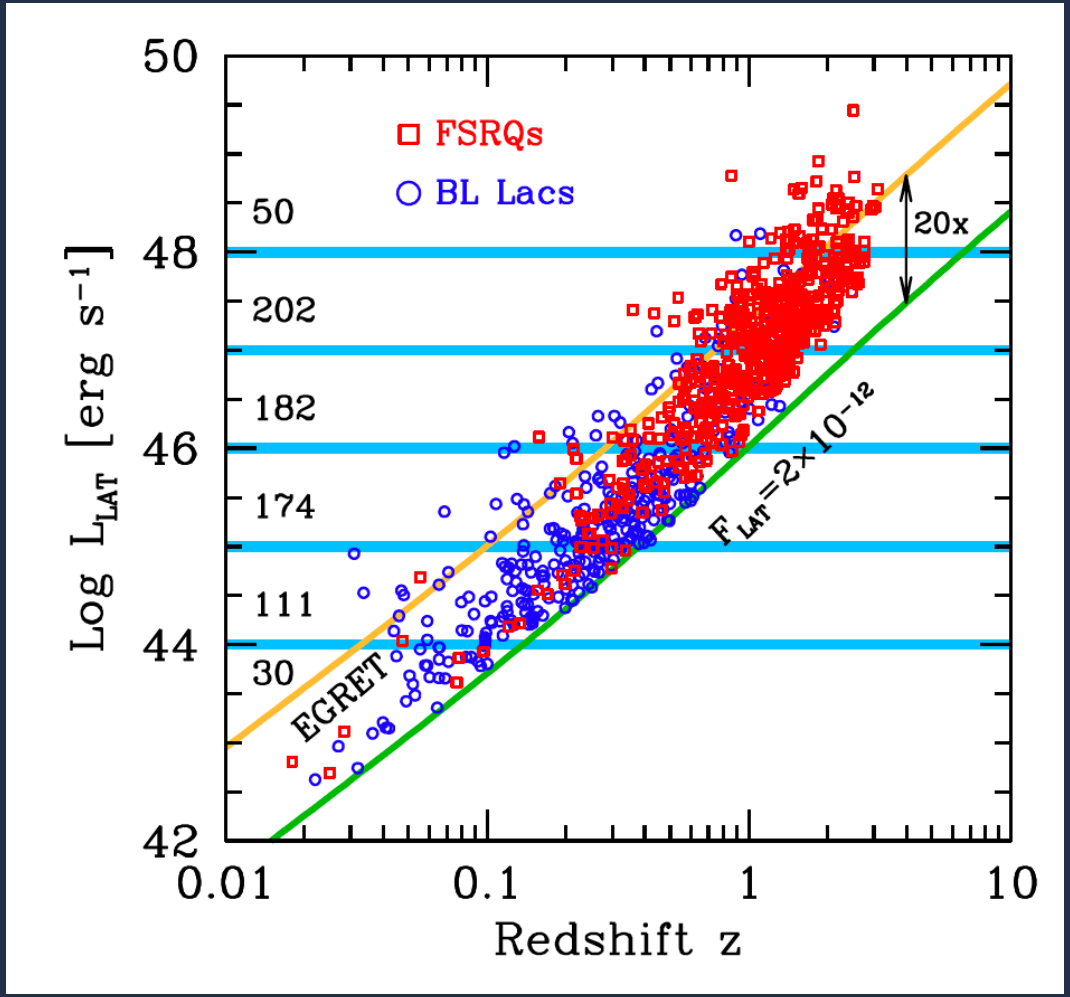


Blazar sequence

747 blazars detected in gamma-rays with a reported redshift.



Fossati et al. 1997, Ghisellini et al. 2017

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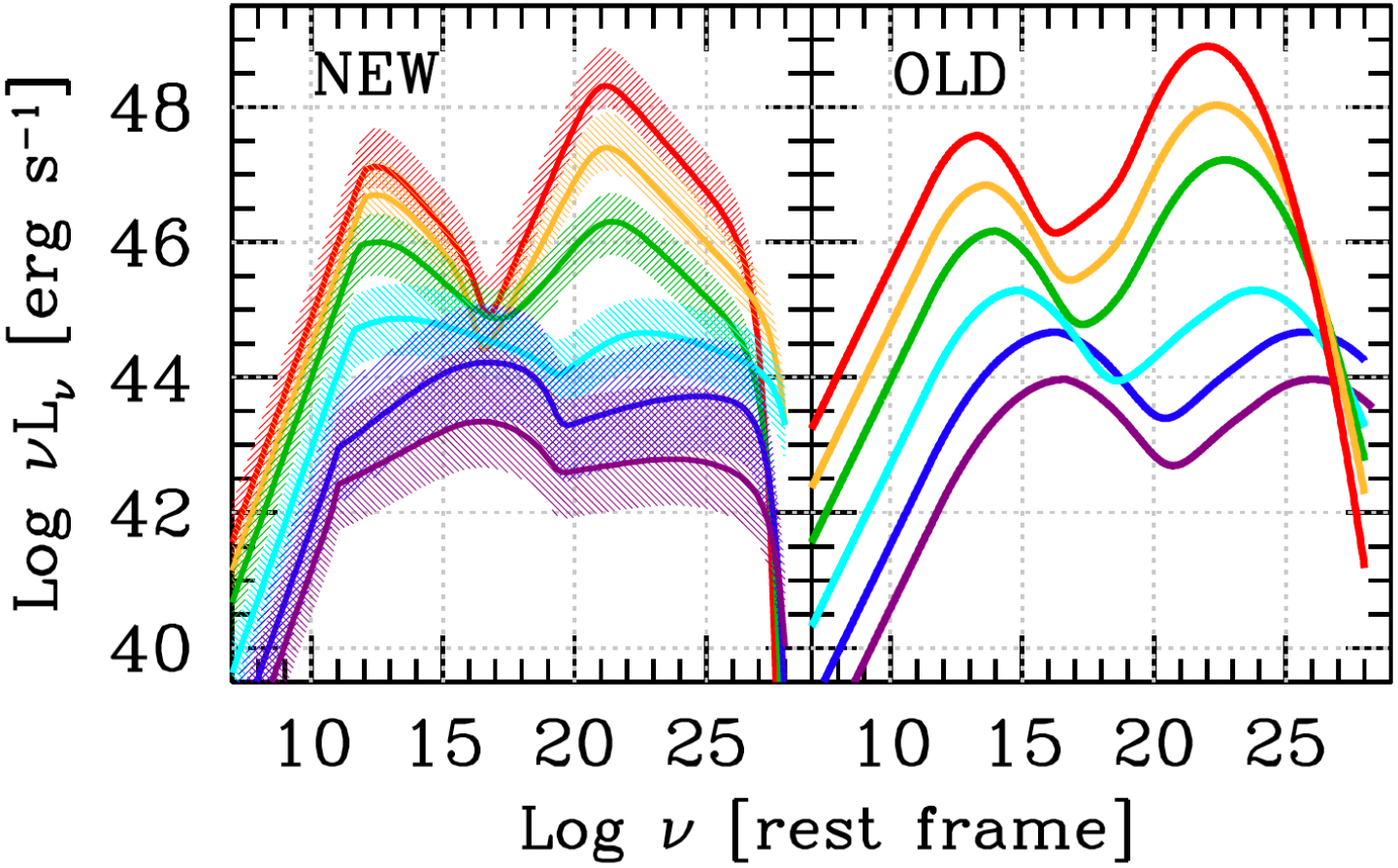
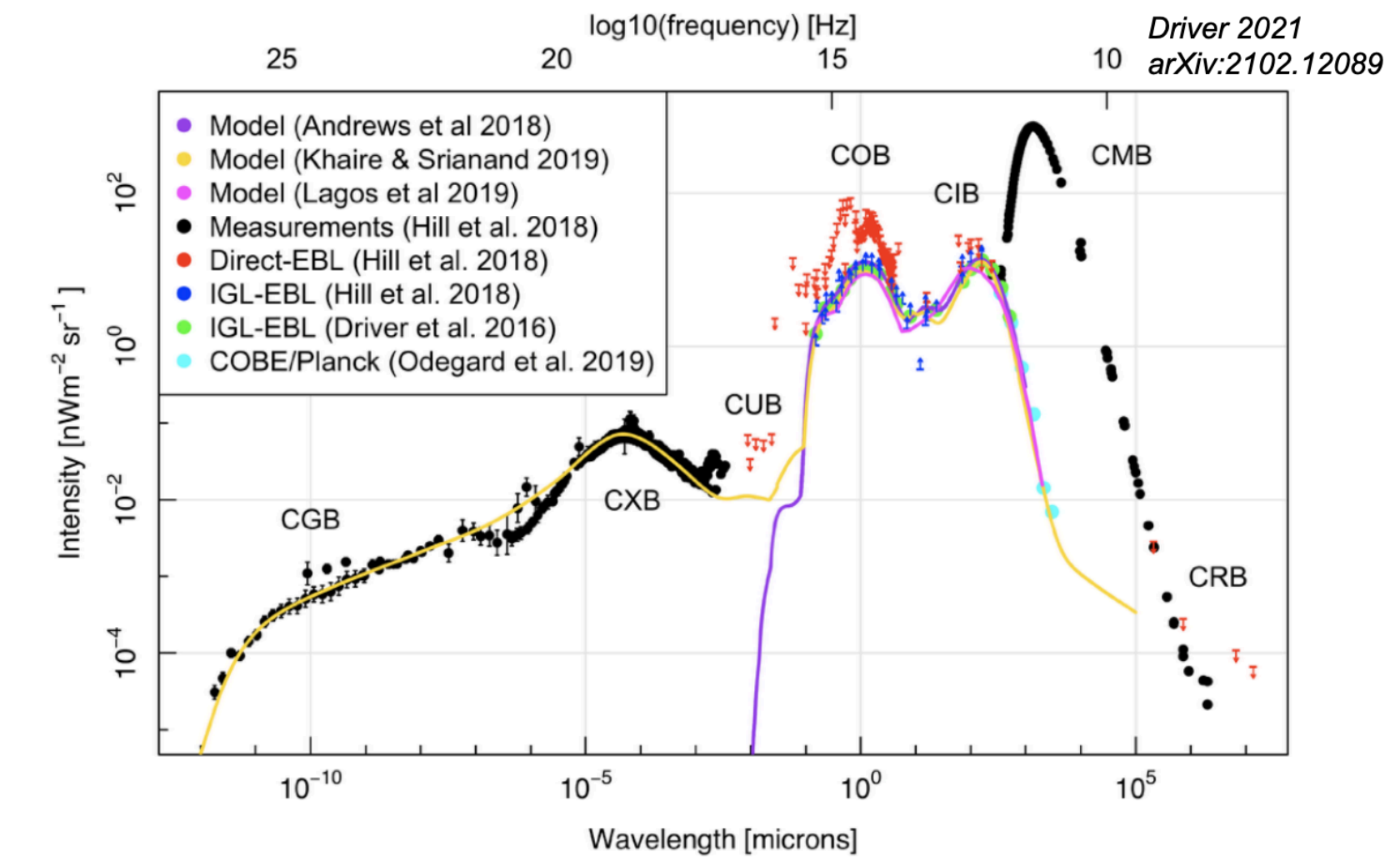


- blazars become "redder" with increasing L_{bol}, peak frequencies become smaller;
- the "Compton dominance" increases,
- the gamma-ray slope become softer with increasing L_{bol};
- (iv) the X-ray slope becomes harder with increasing L_{bol}.

Fossati et al. 1997, Ghisellini et al. 2017

Blazar, EBL and Magnetic field



Second most intense diffuse photon field (after CMB)

Imprint from reionization, star formation, galaxy evolution, emission by AGN

Cosmic Optical Background: light from stars/galaxies,

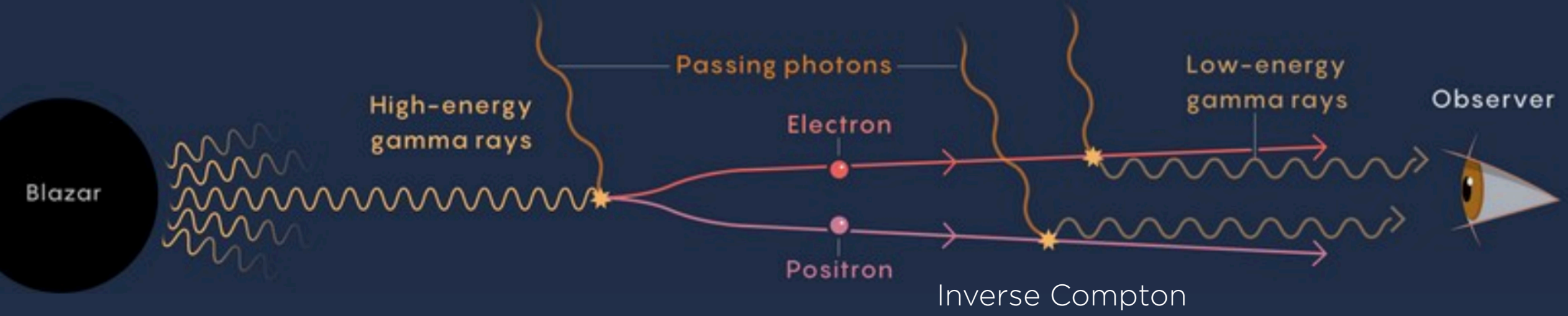
Cosmic Infrared Background: light re-radiated after absorption by dust

Driver et al. 2021

Propagation

Without IGMF

Pair production with EBL

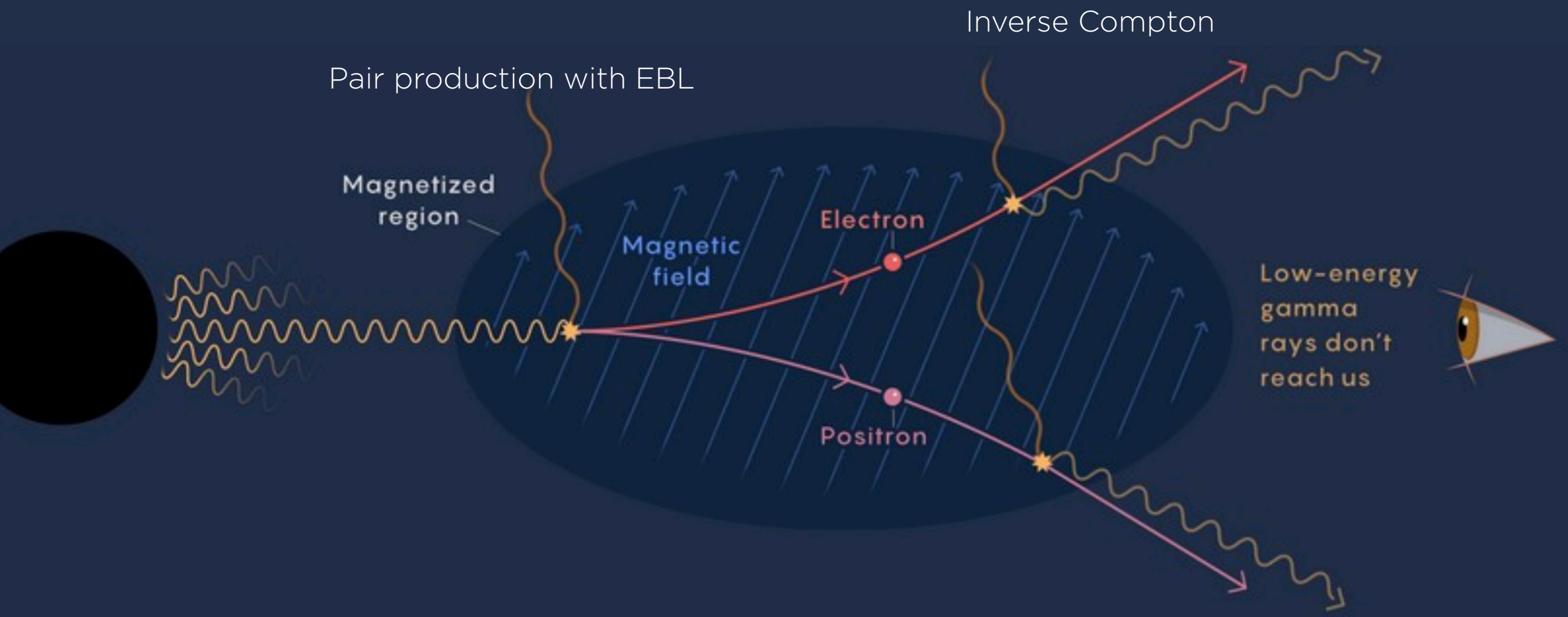


Inverse Compton

Credits: https://www.quantamagazine.org/the-hidden-magnetic-universe-begins-to-come-into-view-20200702/

Propagation

With IGMF



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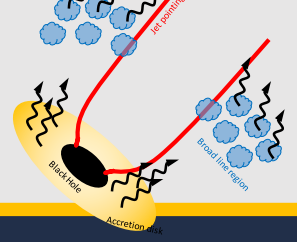
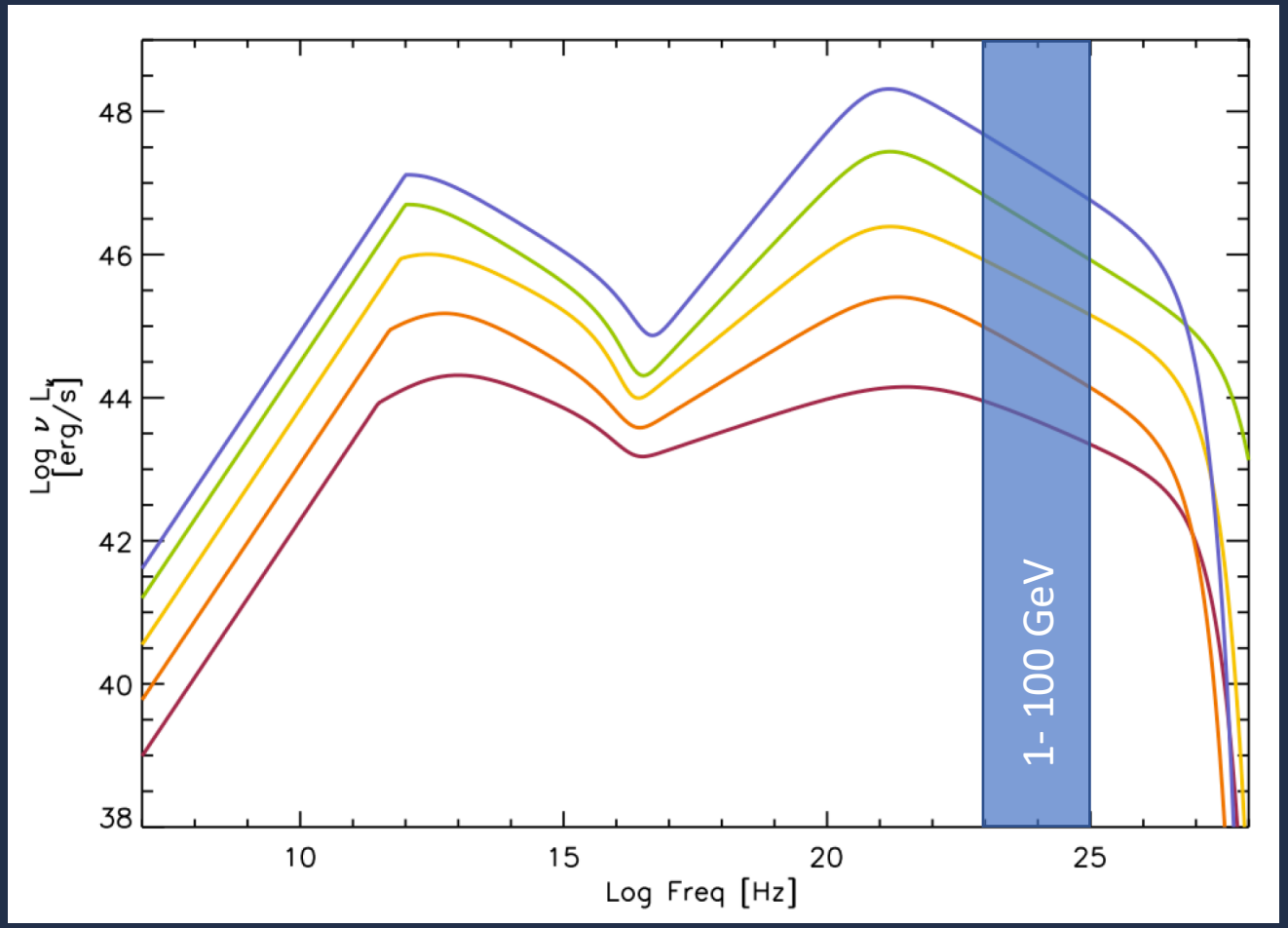
Recipe of a source

- HE primary spectrum must extend up to very high energies
- HE emission from the source cannot outshine the secondary emission
- Variability of the source cannot interfere with the IGMF measure
- Distance of the source is an important parameter

FSRQ and Magnetic field





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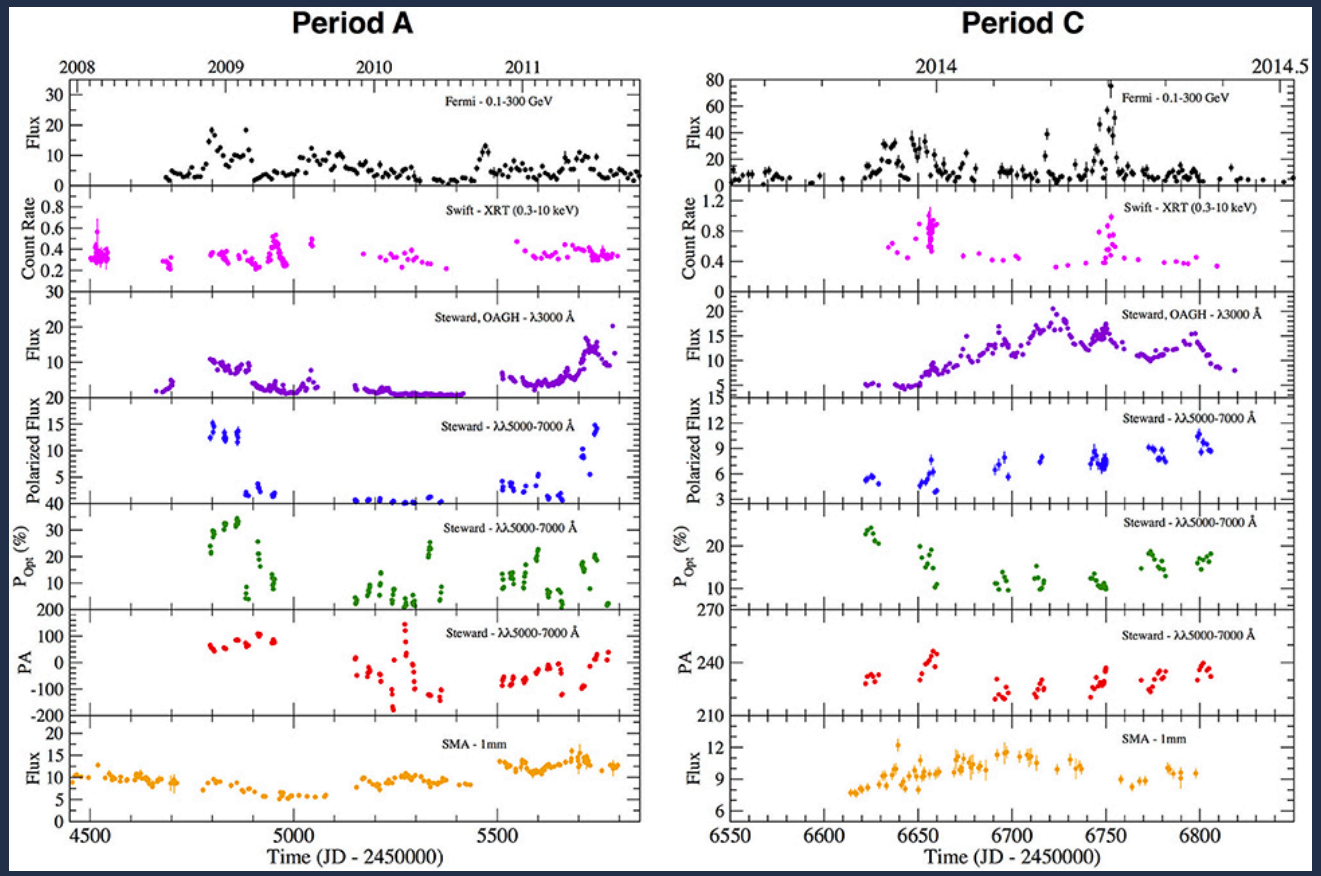
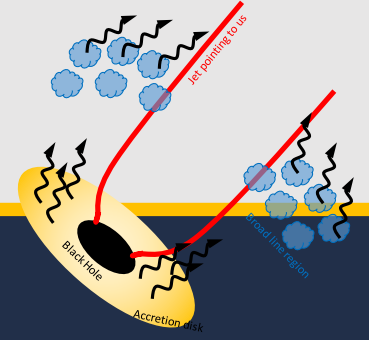


3c 279 MWL LC - Alvarez et al 2017



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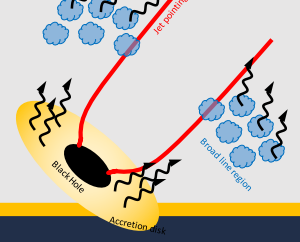

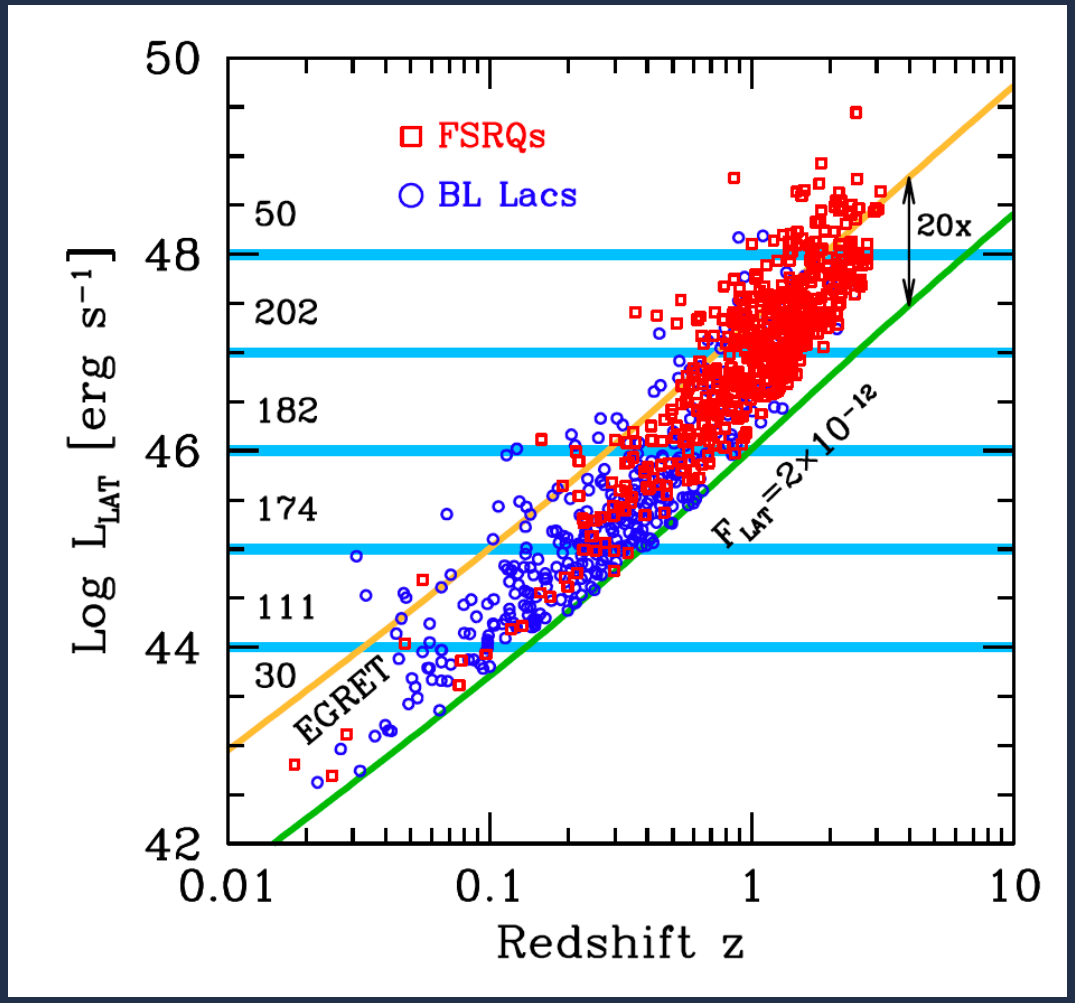

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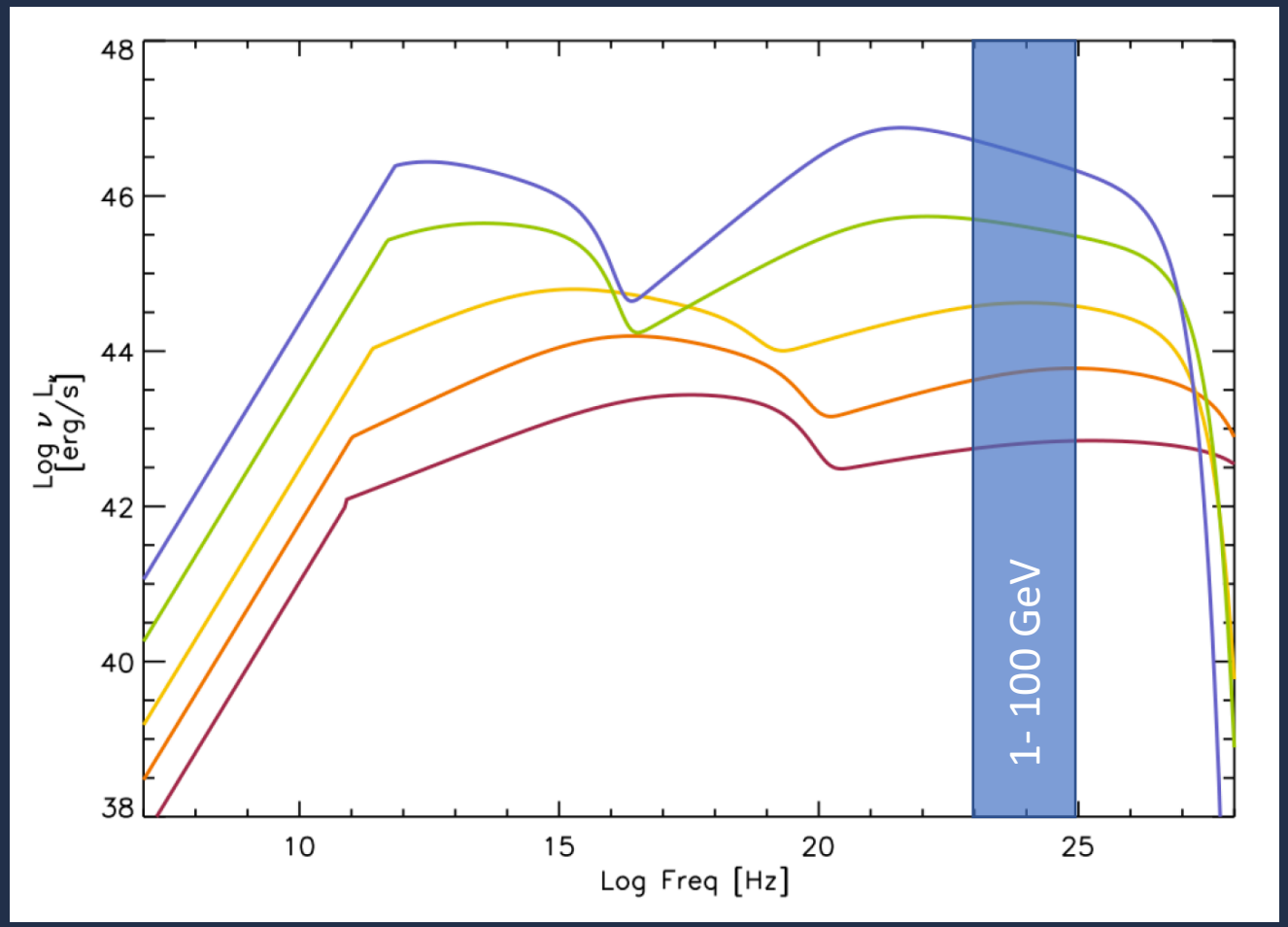
BL Lac and Magnetic field



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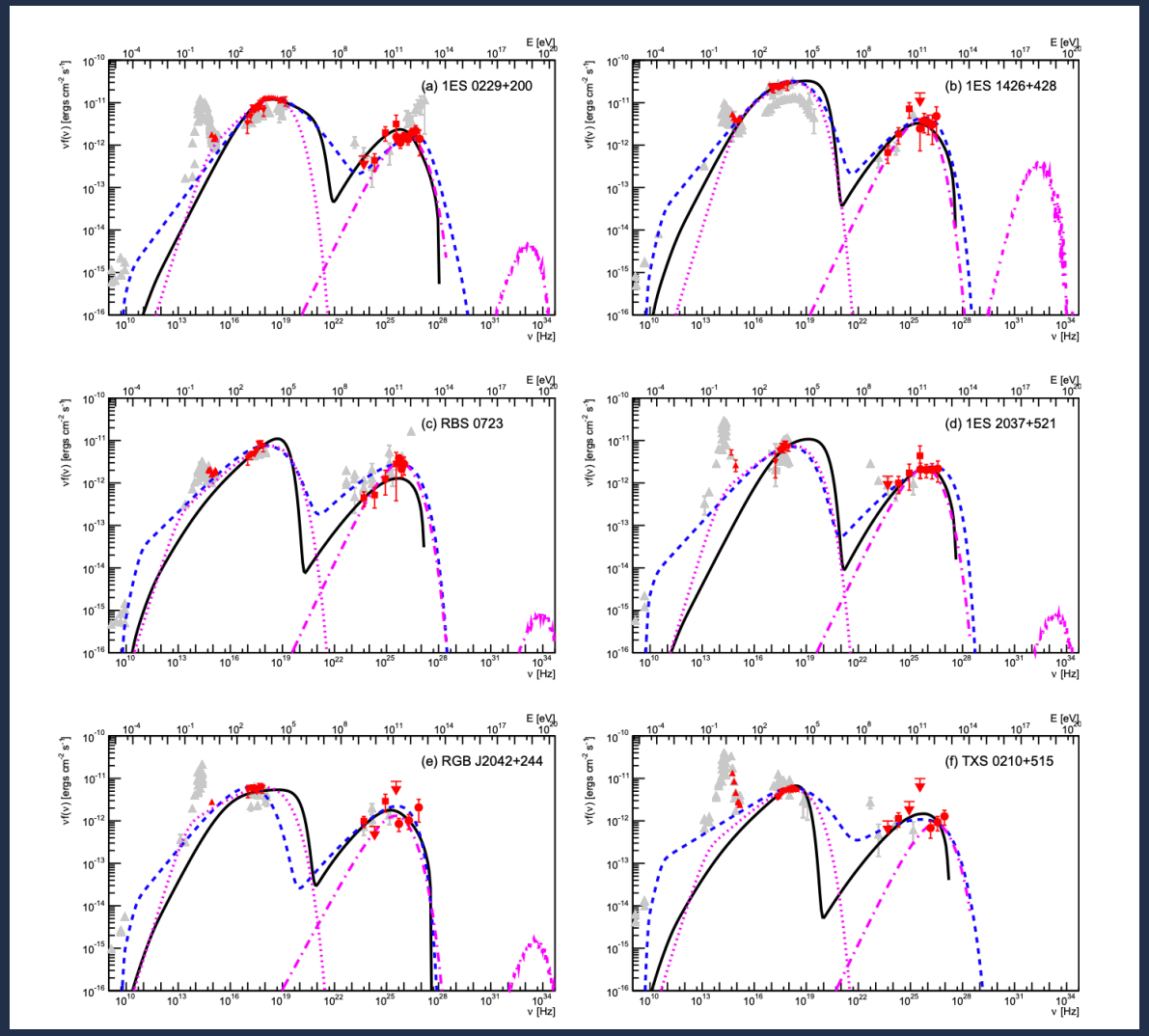
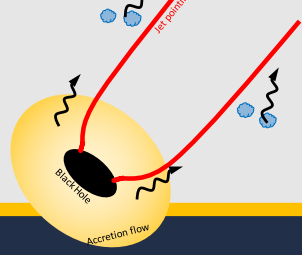
Extreme BL Lac

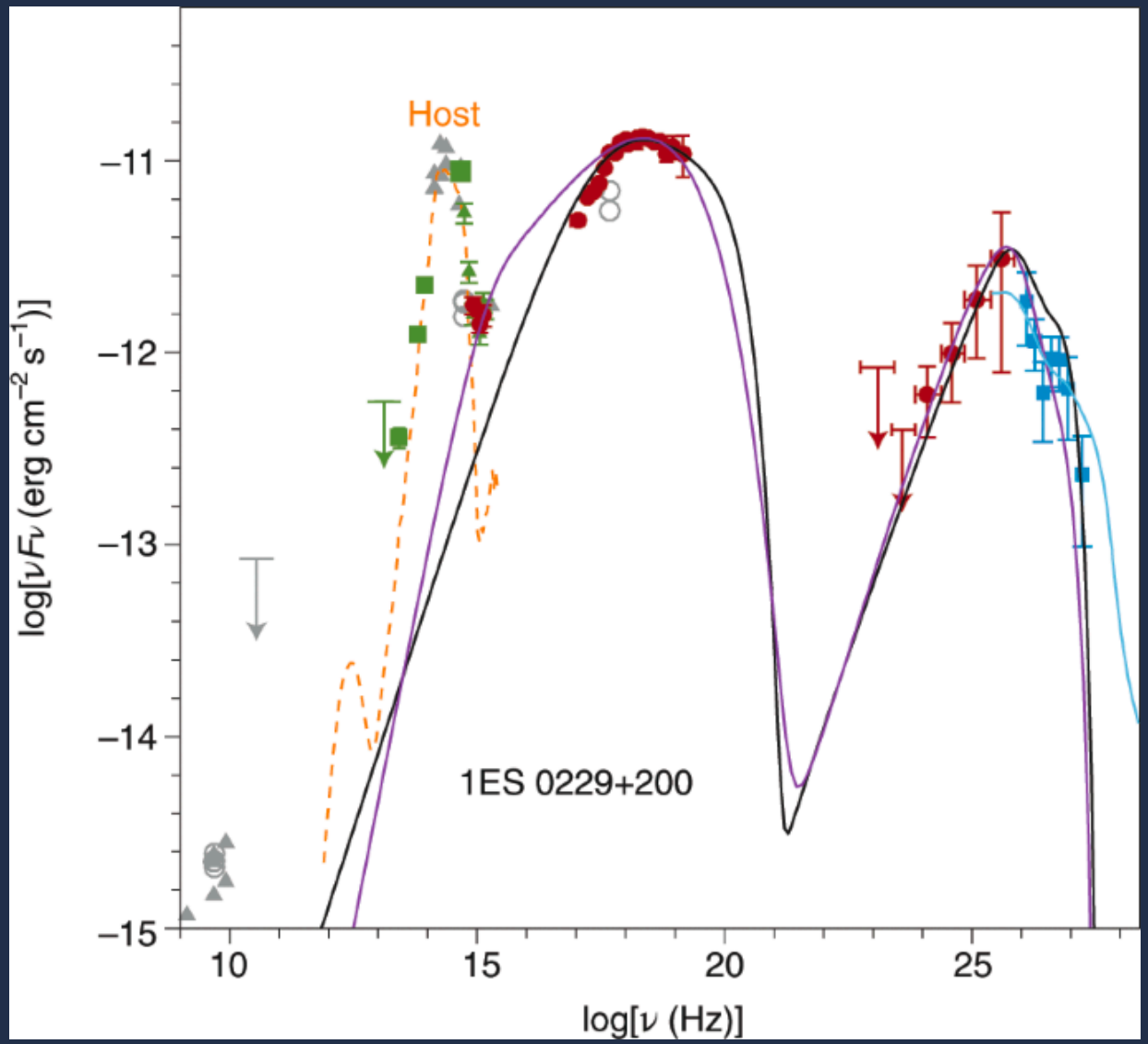


MAGIC coll. 2019

- Sample of ~15 EHBL detected in the TeV band
- Strong X-ray emission
- No signal of strong variability



Extreme BL Lac and Magnetic field



Biteau et al. 2020

- Best candidate to IGMF lower limit

See Da Vela's talk

Take home message

- Blazar are the most powerful and persistent objects in the Universe
- A better understanding of the structure and the composition of the blazar jet plays a key role on the study of the Universe environment
- HBL and EHBL are the best sources to limit the IGMF
- The observation of HE and VHE bands will show new sources for the IGMF study