UNIVERSITÀ DEGLI STUDI DI PADOVA

INFN PADOVA

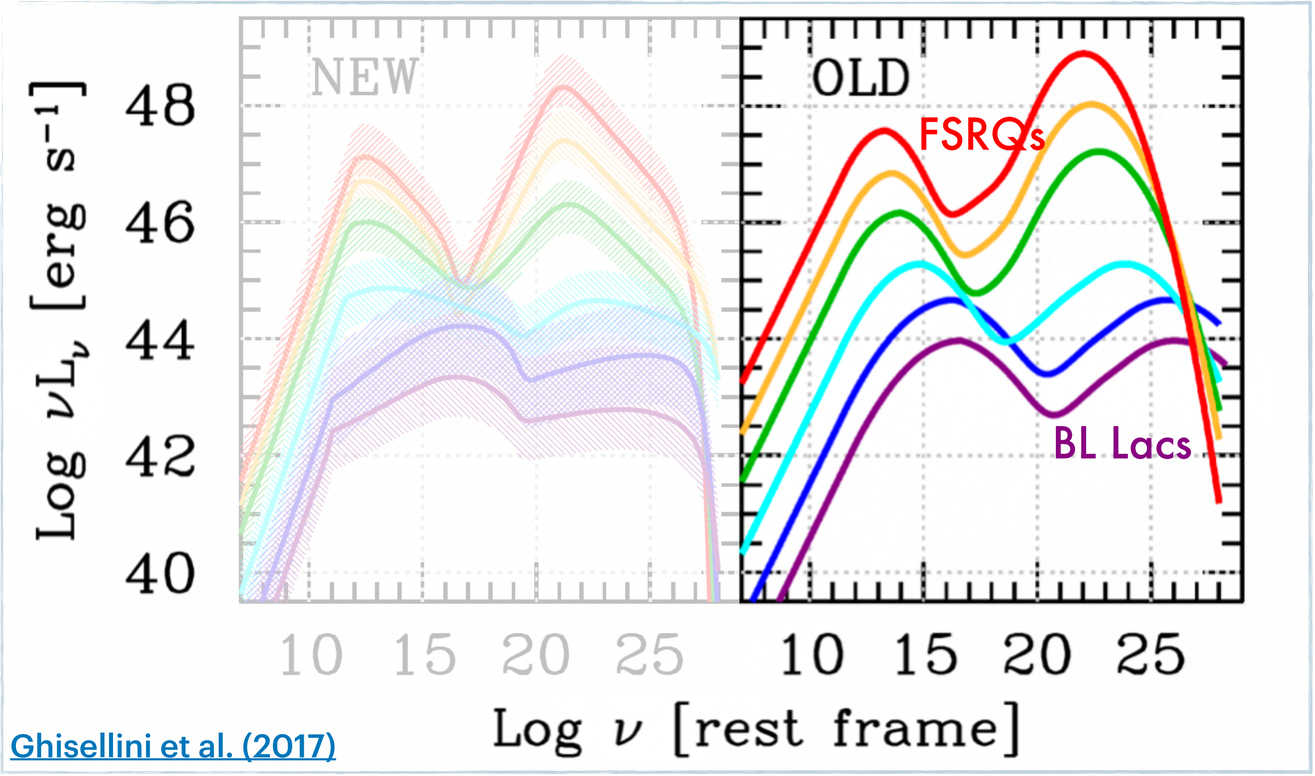
Towards a TeV blazar sequence and its physical interpretation

I. Viale, E. Prandini, C. Righi, F. Bovolon, N. Sahakyan

The blazar sequence

Original sequence: Fossati et al. (1998)

- 126 sources from X-ray and radio samples
- Radio luminosity bins



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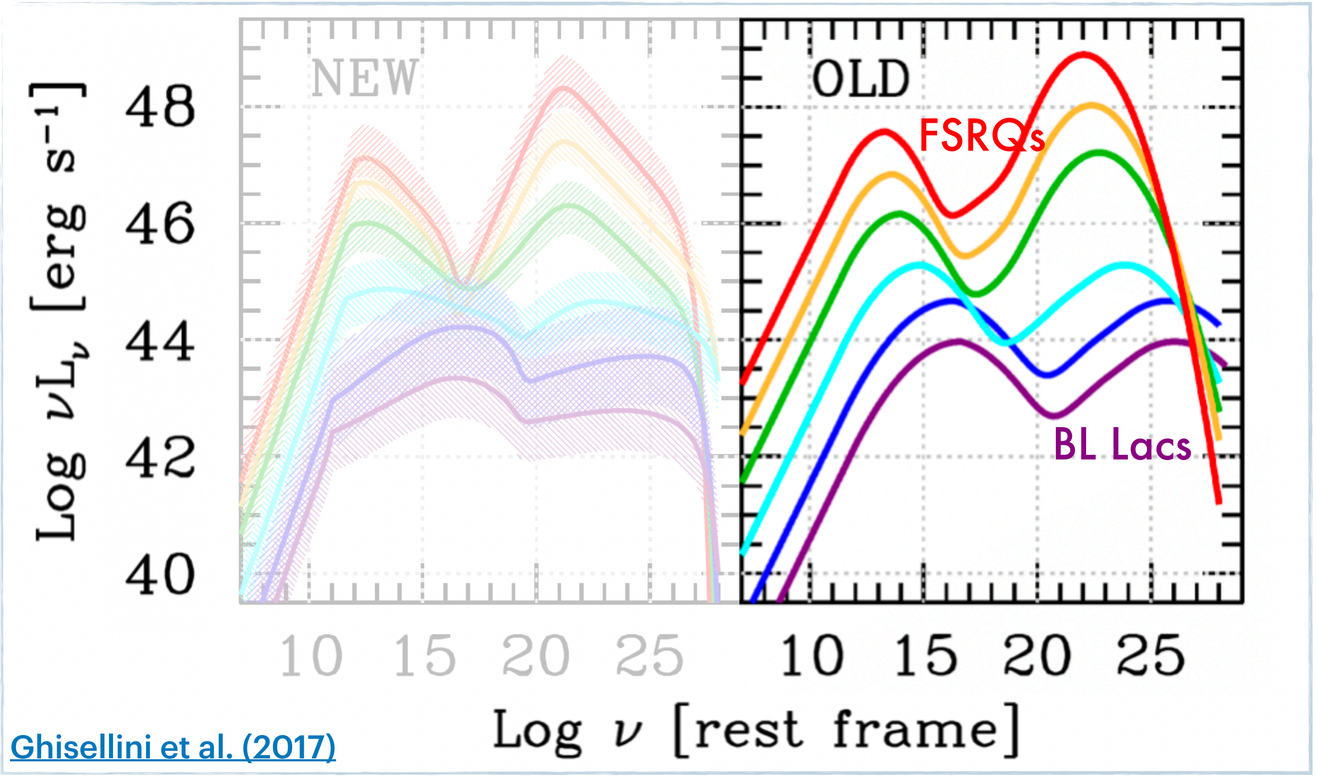

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Main results:

- Anti-correlation between total luminosity and peak frequencies
- Correlation between peak frequencies of bumps
- Increase of Compton dominance with total luminosity

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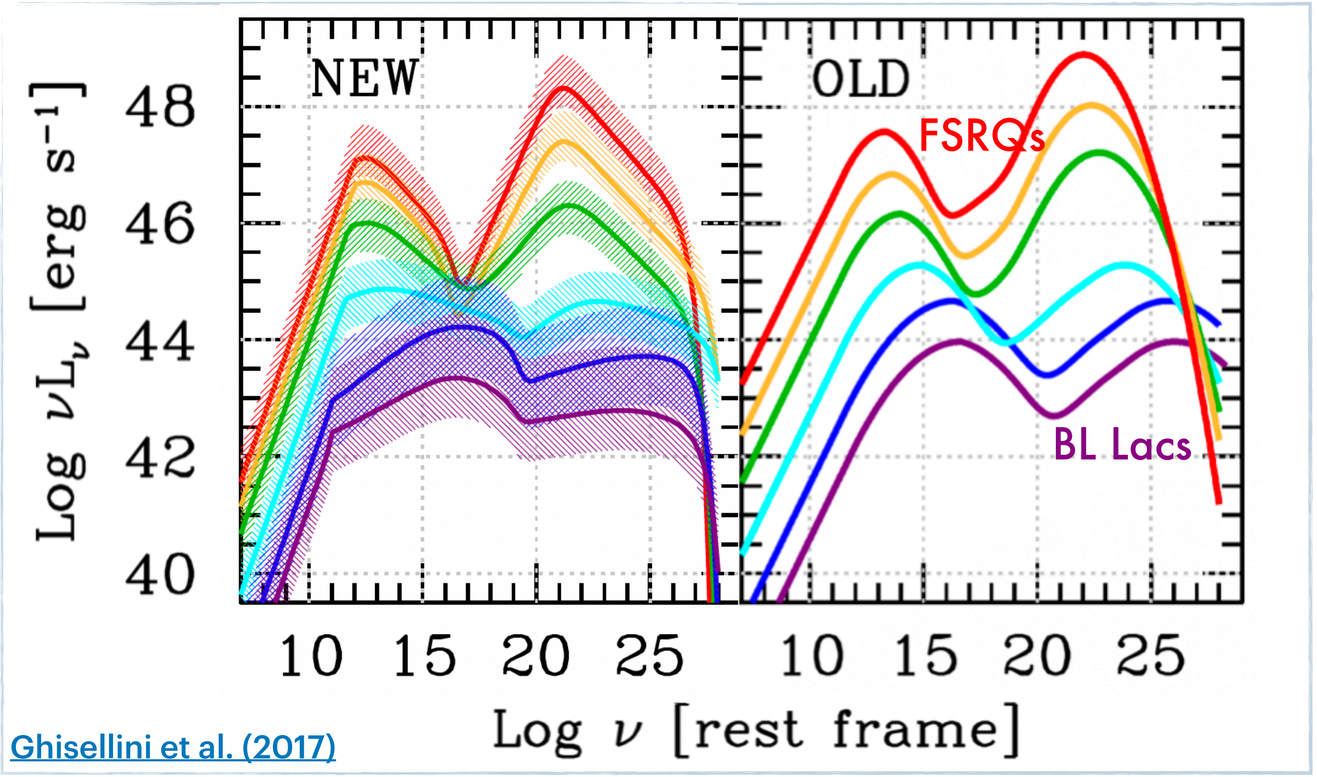
- 747 sources from 3LAC Fermi catalog
- γ-ray luminosity bins



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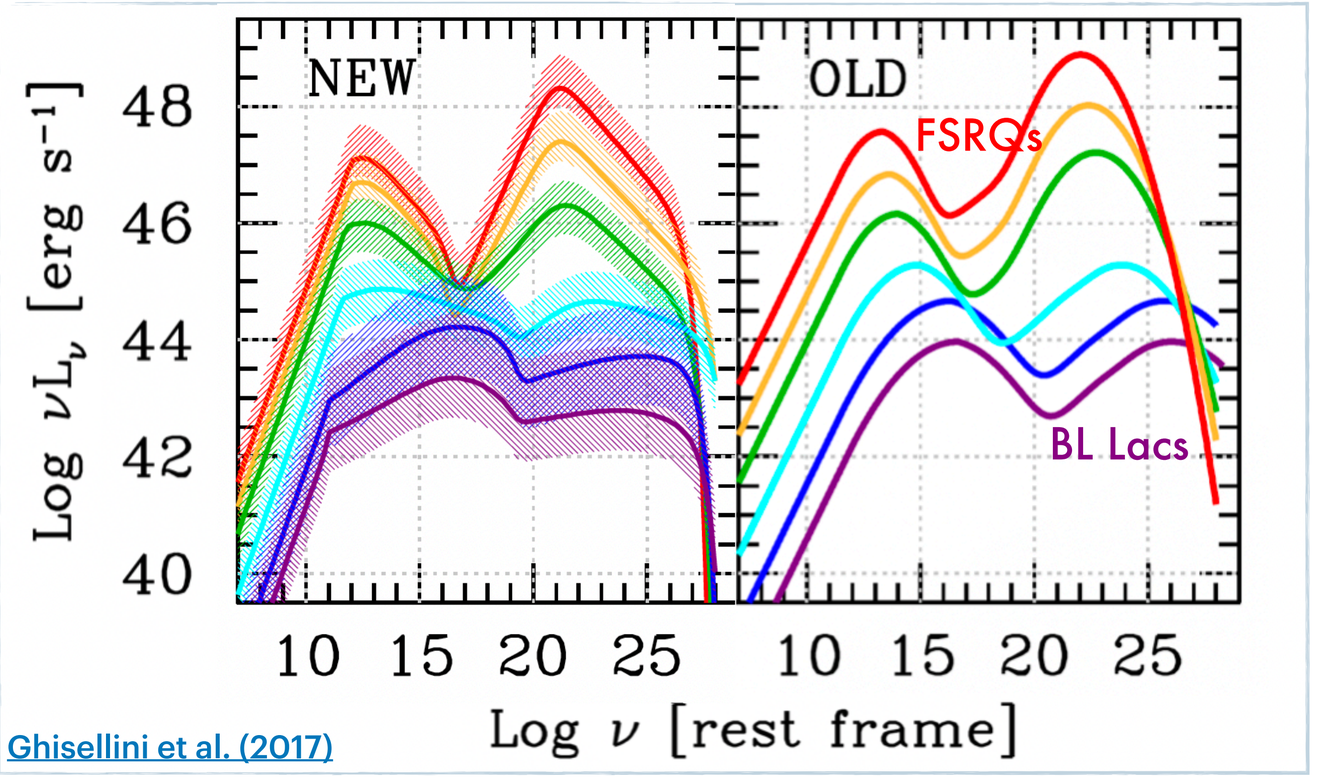

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- FSRQs: stable synchrotron peak frequency
- BL Lacs: peaks correlate with luminosity

First studies of a TeV blazar sequence

TeV-detected sources and the sequence:

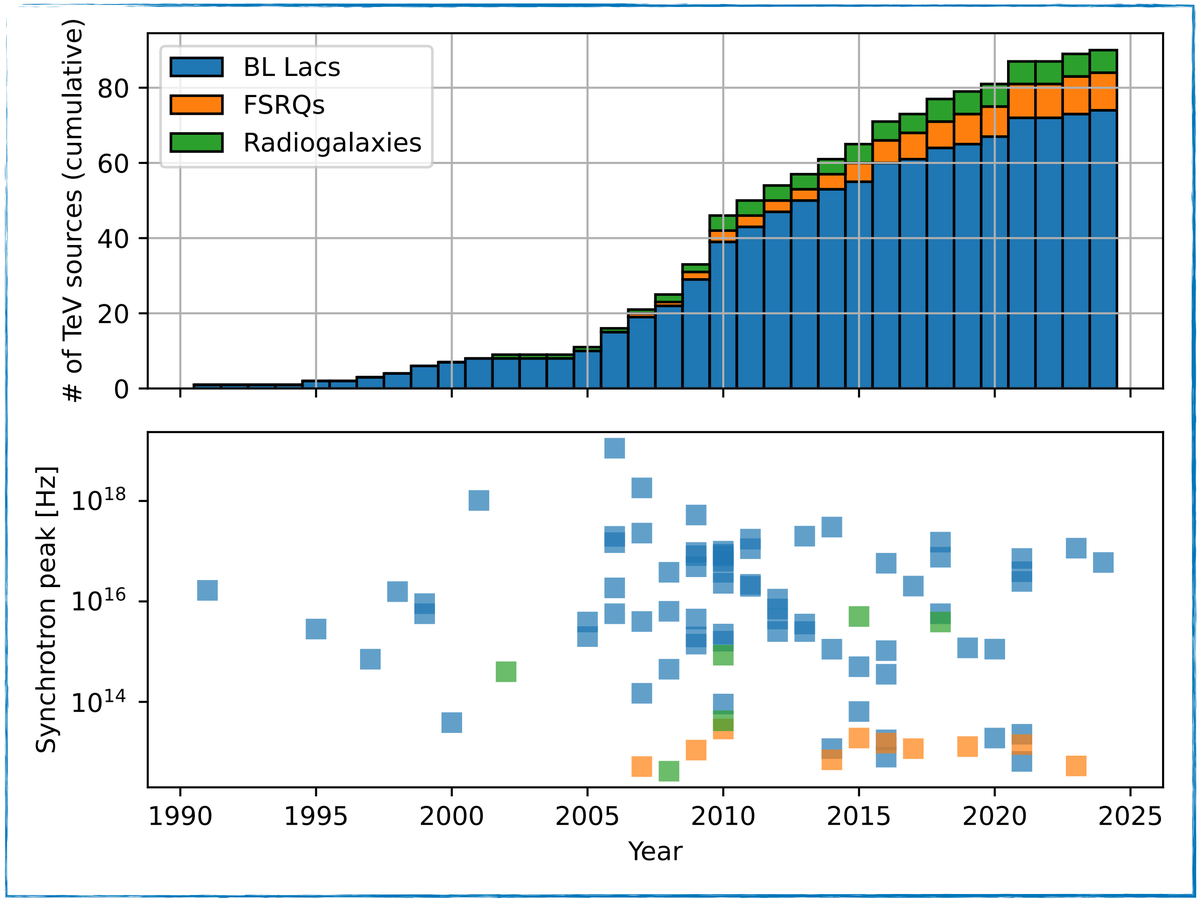
Prandini & Ghisellini (2022)

- 81 TeV blazars from TeVCat (at Jan 2022)
- Same luminosity bins as in 2017 sequence
- No strong differences in SED wrt Fermi blazars
- Larger X-ray luminosity than in Fermi blazars

Quiescent vs flaring activity in TeV blazars:

Ouyang et al. (2023)

- 48 sources in quiescent state, 21 in flaring state
- Anti-correlation between luminosity and ν_{syn} present only during flares



This work

Goal

Which is the role of TeV sources in the blazar sequence?

Is the blazar sequence physically driven?

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Is the blazar sequence physically driven?

To do it we …

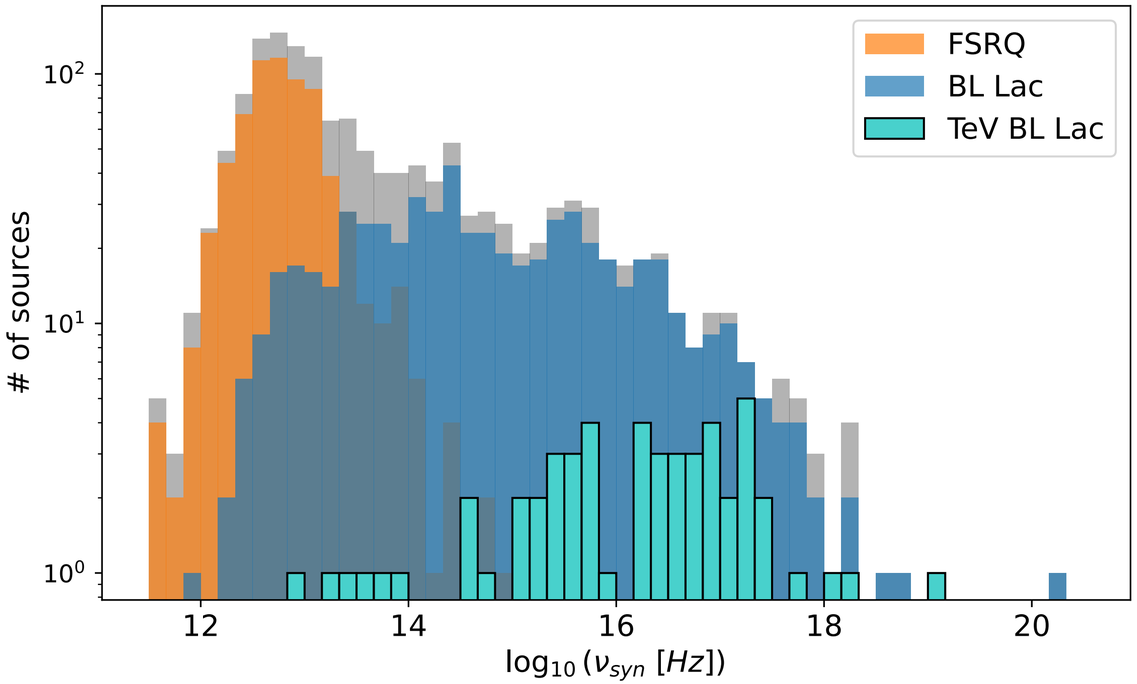
Concentrated only on TeV BL Lac sources

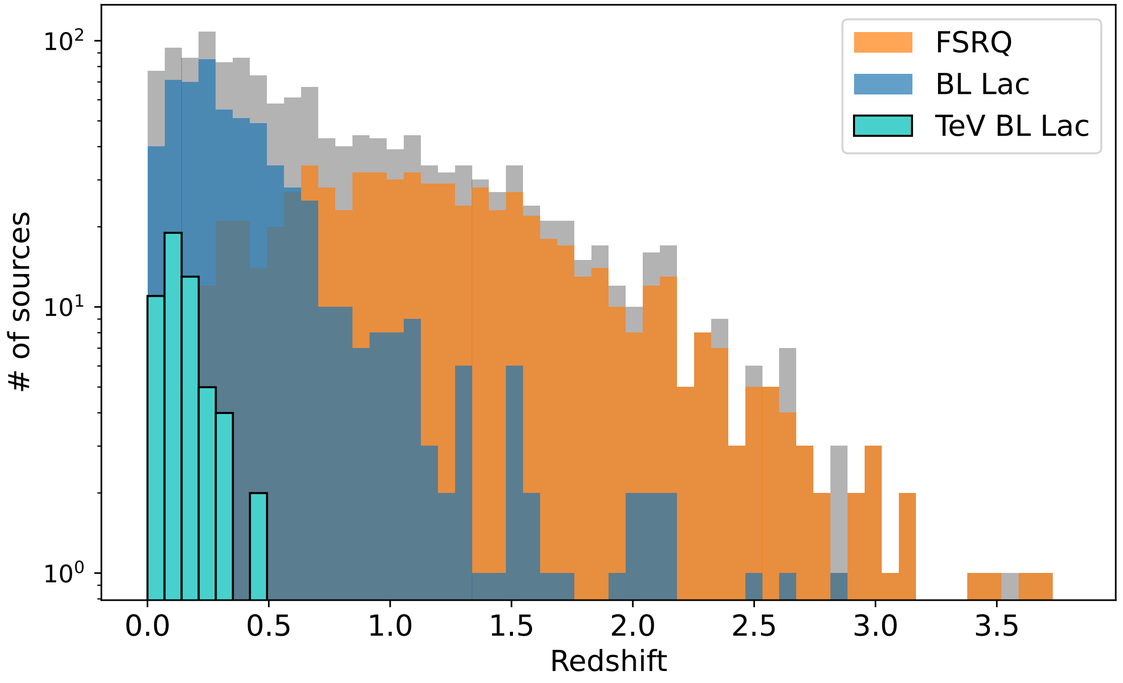
Modeled their emission in framework of Synchrotron Self Compton model

Is there a trend in the model parameters?

Our sample

- 84 TeV-detected blazars at TeVCat to date, data from 4LAC-DR2
- Concentrate only on BL Lacs with known redshift → total of 56 sources
- ν_{syn} bins used instead of luminosity bins
- Selection of one representative source for each bin





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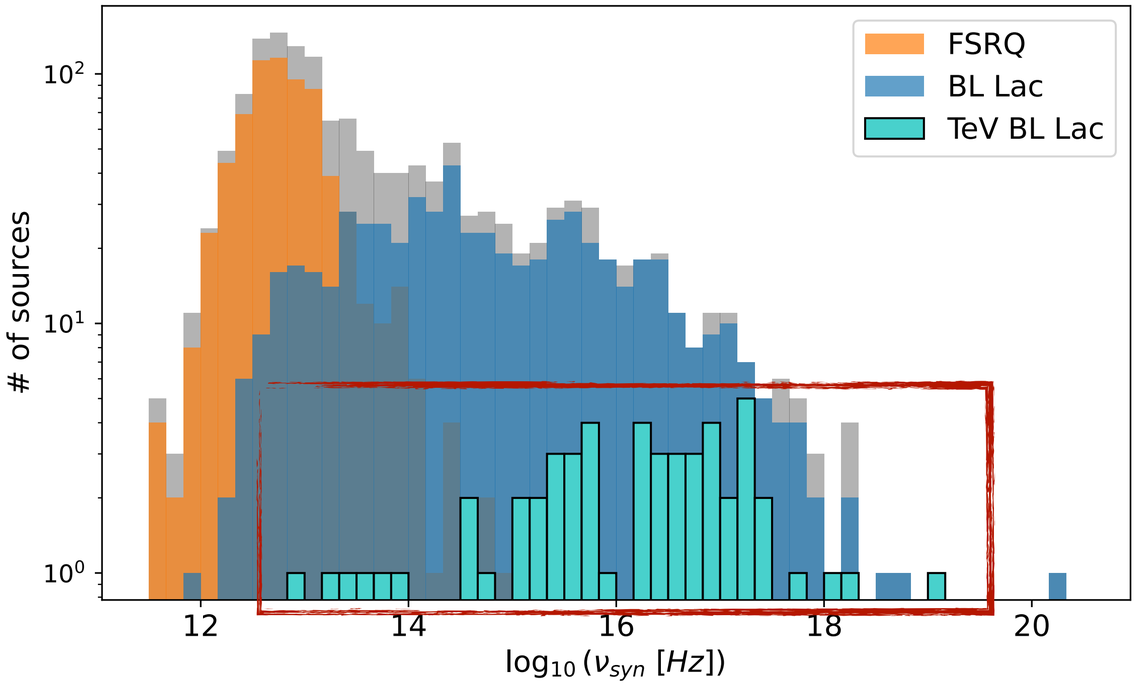
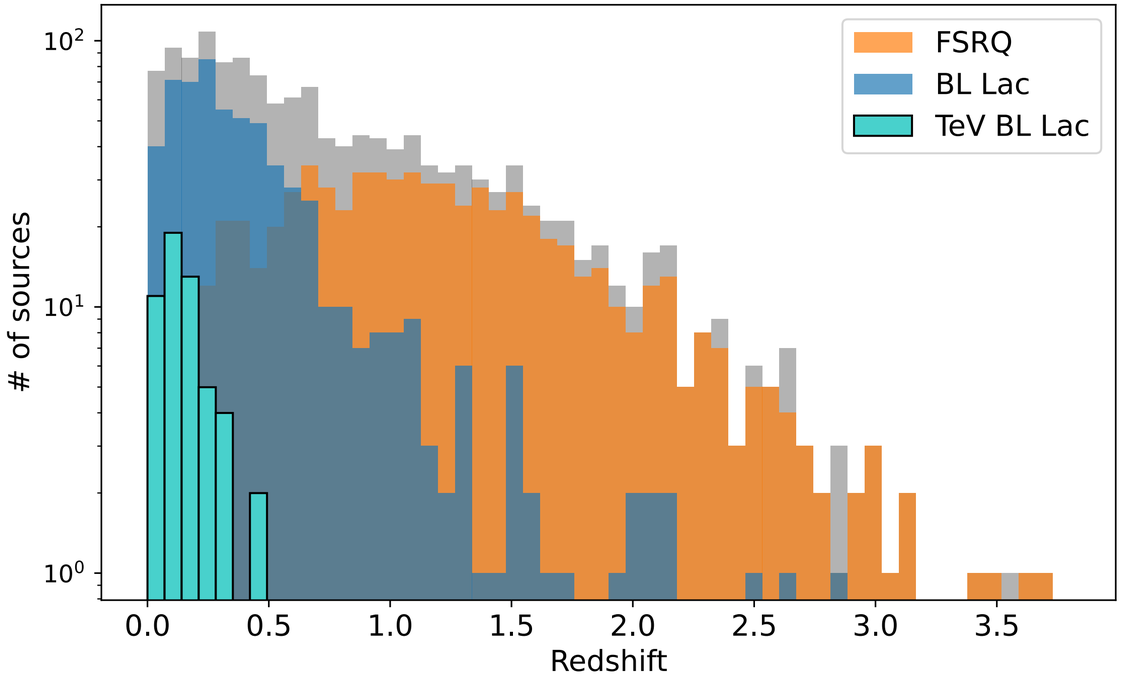
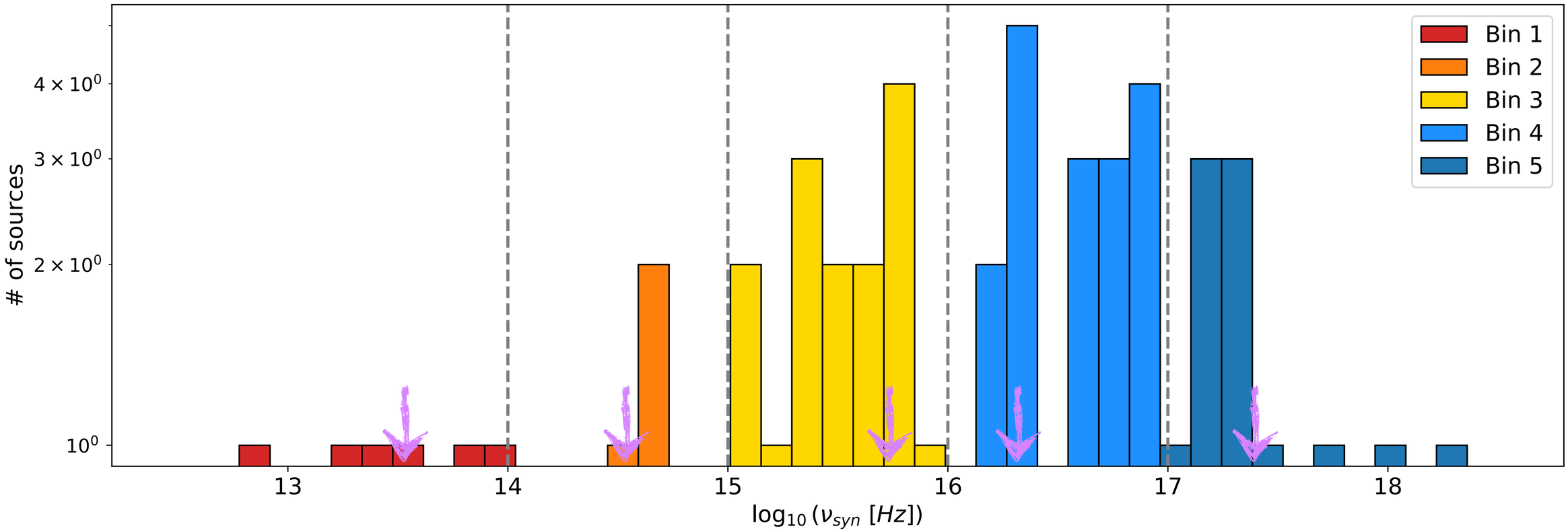




Our sample

6 sources	3 sources	15 sources	18 sources	13 sources
BL Lac	TXS 0506+056	PKS 2155-304	PG 1218+304	PKS 0548-322

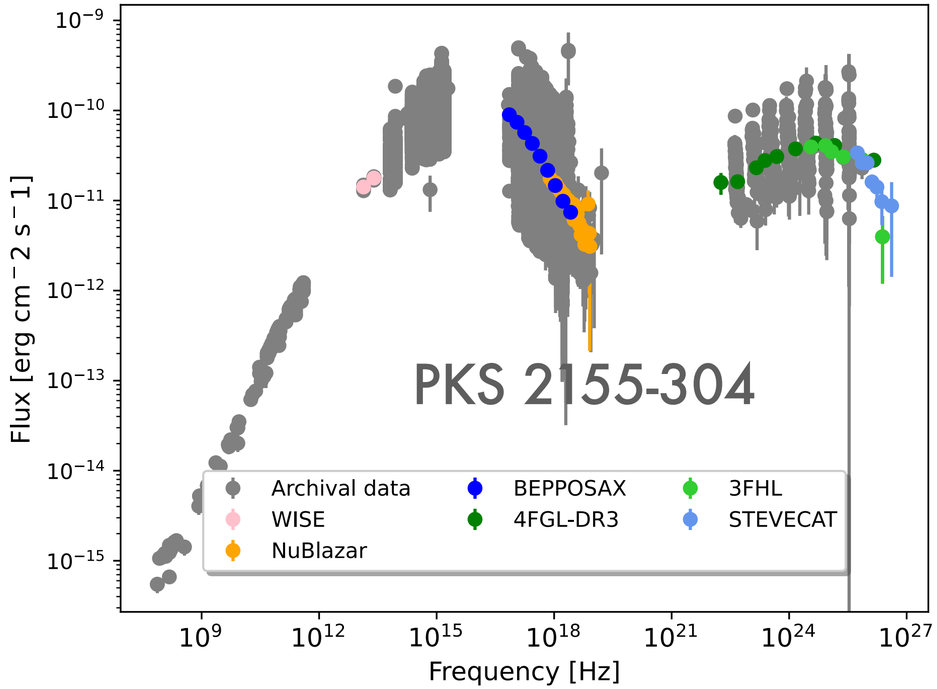


Data selection

Selection done source-wise

For each selected source:

- Data retrieved from MMDC + STeVECat
  Sahakyan et al. (2024), in prep. Grèaux et al. (2023)
- Average state of activity



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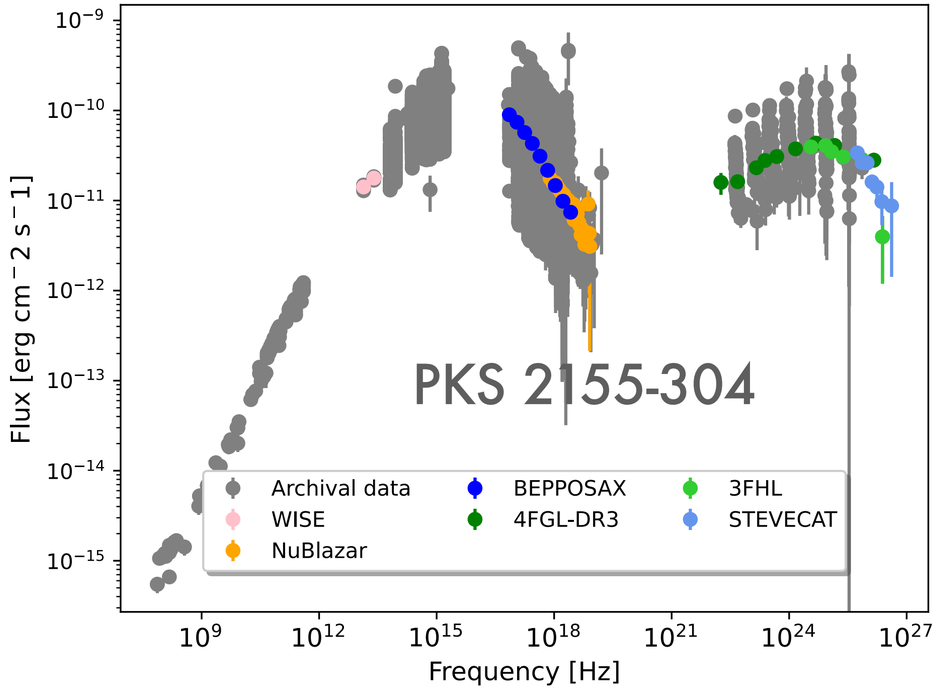
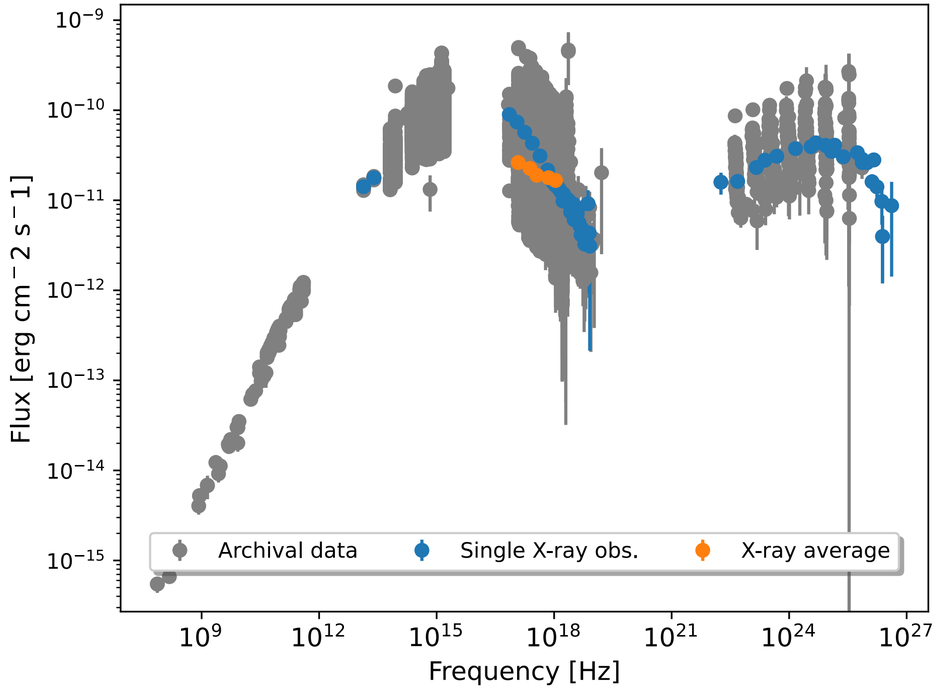
- Large spread in X-ray data
- Two selections:
  - Single observations
  - Average data from catalog OUSXB
    Giommi et al. (2019)





Model

Selected sources modeled with Synchrotron Self Compton model

- Aim of finding trend in model parameters describing the sequence

Concentrated only on HBL as starting point, $\nu_{syn} > 1 \times 10^{15}$ Hz

- Difficult to describe sources with lower ν_{syn} with pure SSC

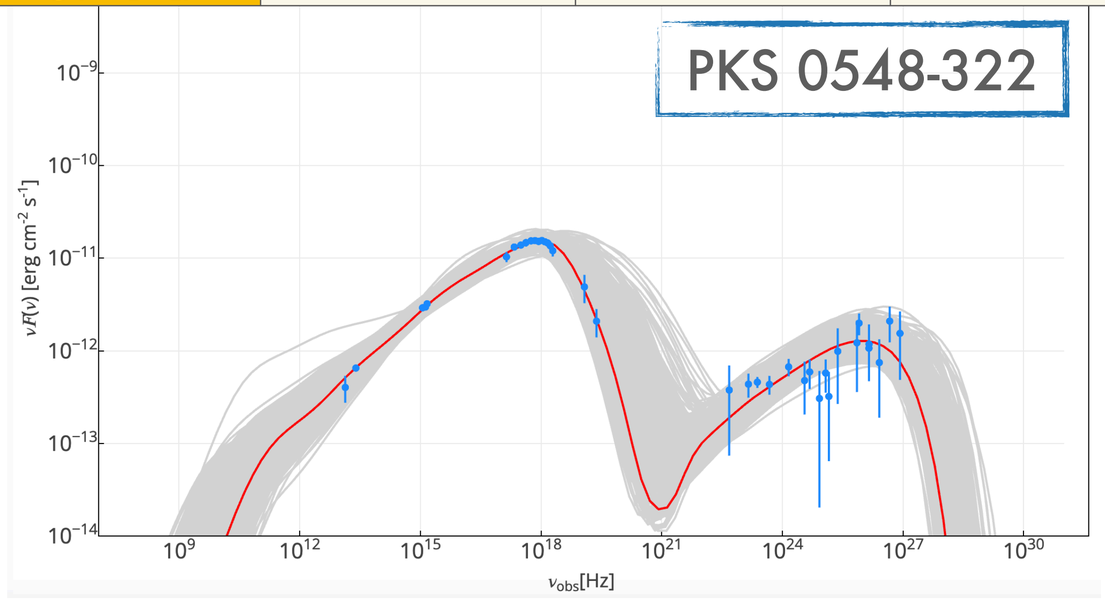
Modeling software based on Convolutional Neural Network: Bégué et al. (2023)

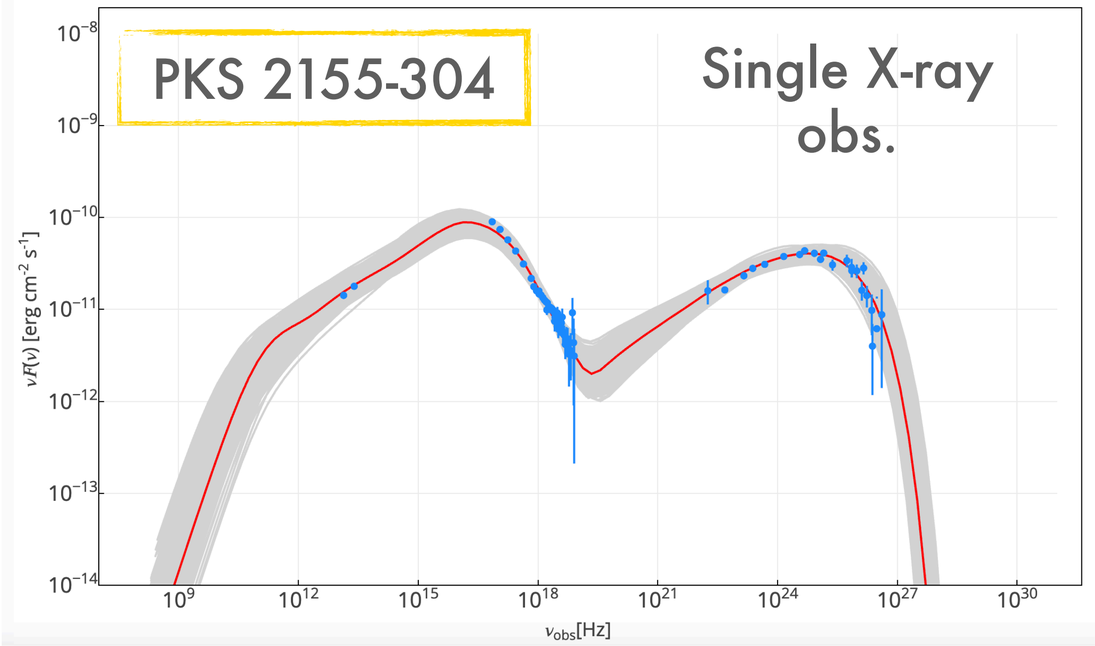
- Allows to scan the whole parameter space
- Available through MMDC platform

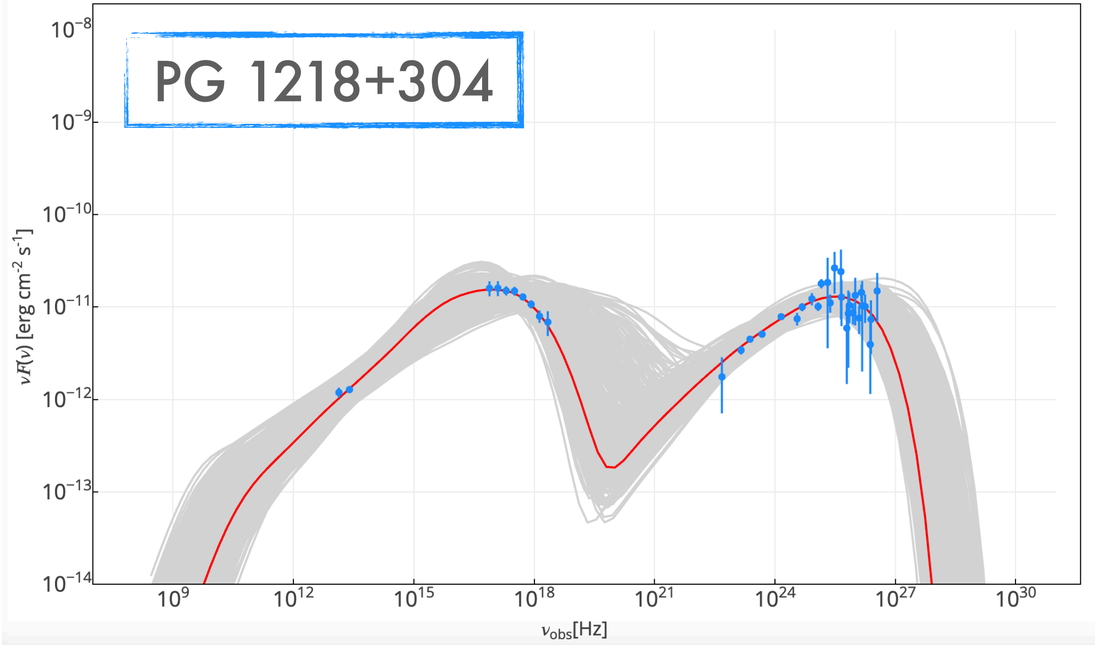
Results

Preliminary

	PKS 2155-304	PG 1218+304	PKS 0548-322
t_var [s]	4.86E+04	8.57E+04	1.05E+04
p1	2.34	2.1	2.16
log(L_e [erg/s])	44.77	44.48	43.39
log(γ_max)	5.28	5.66	5.79
δ	43.06	29.71	49.25
log(B [G])	-1.51	-1.61	-1.6







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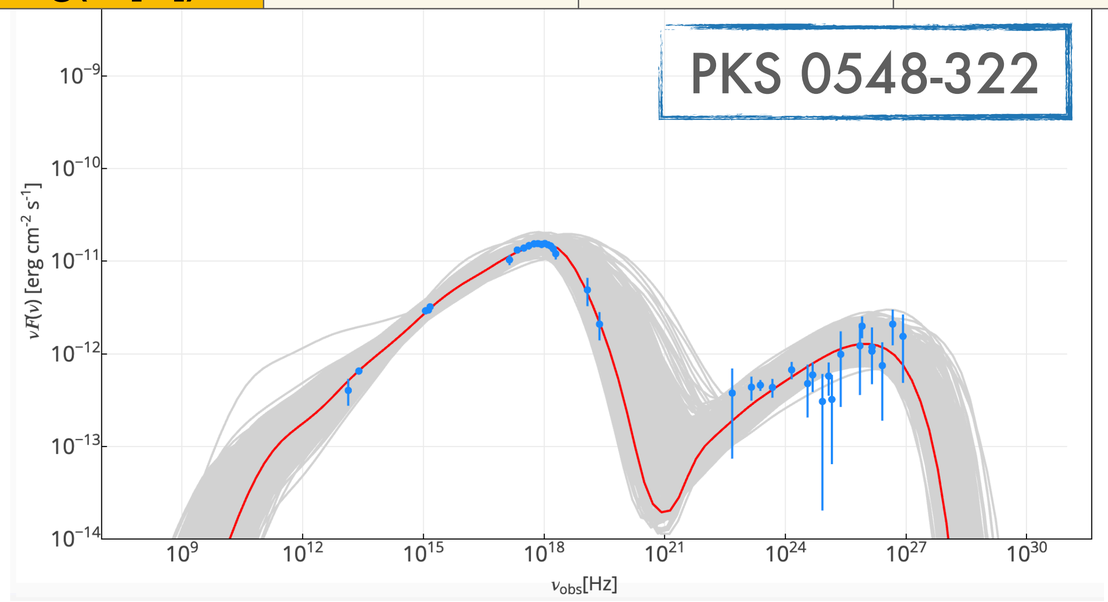

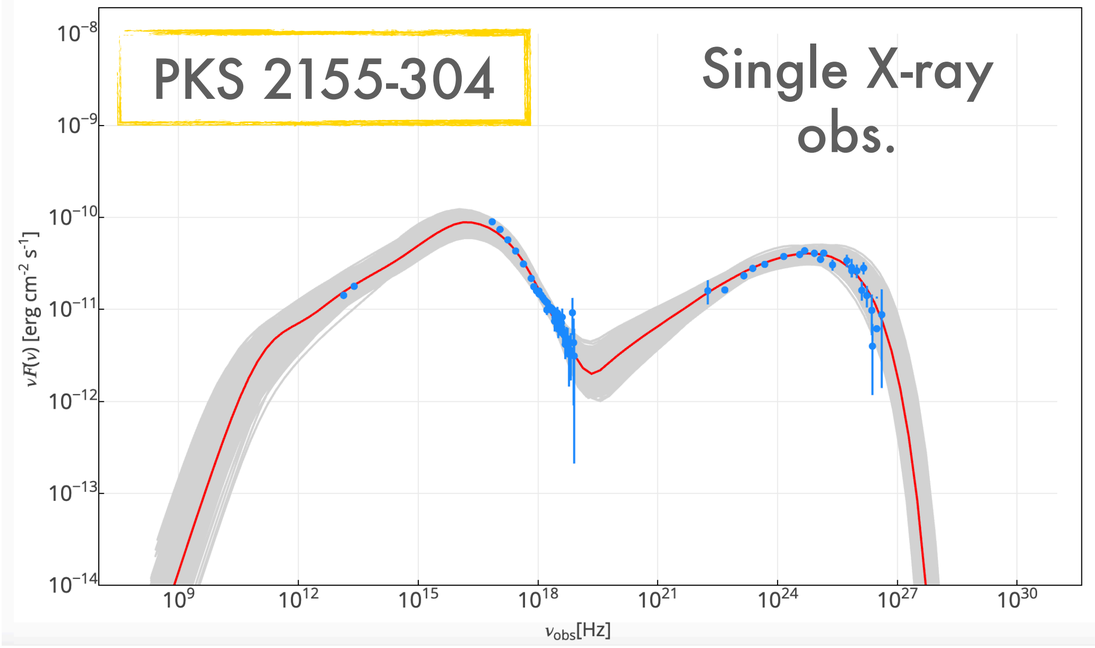

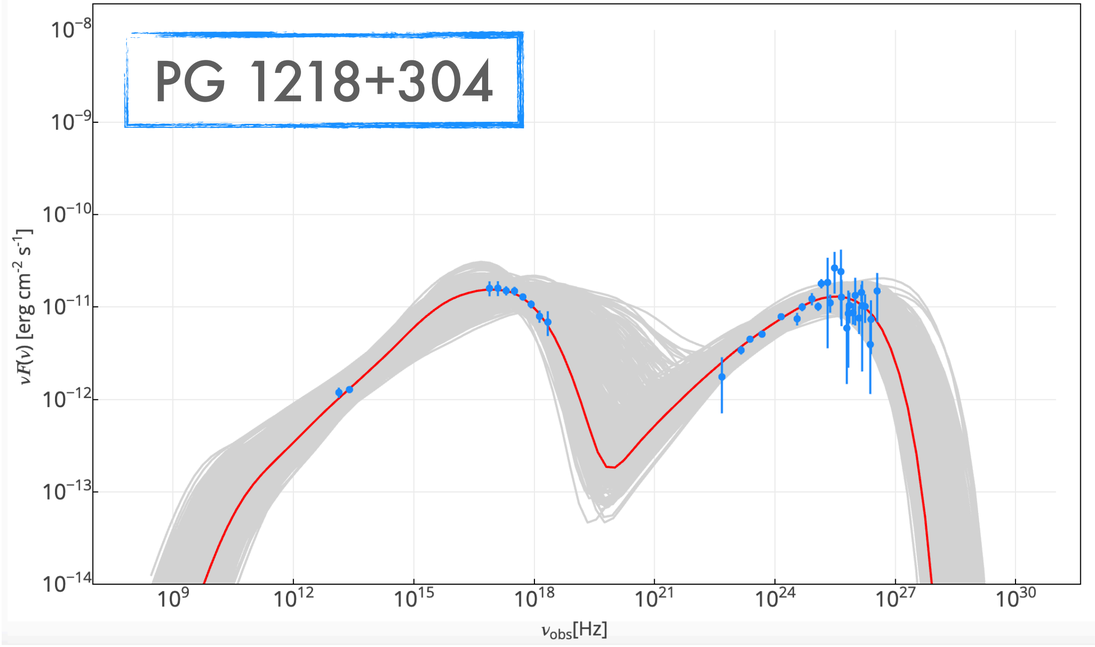

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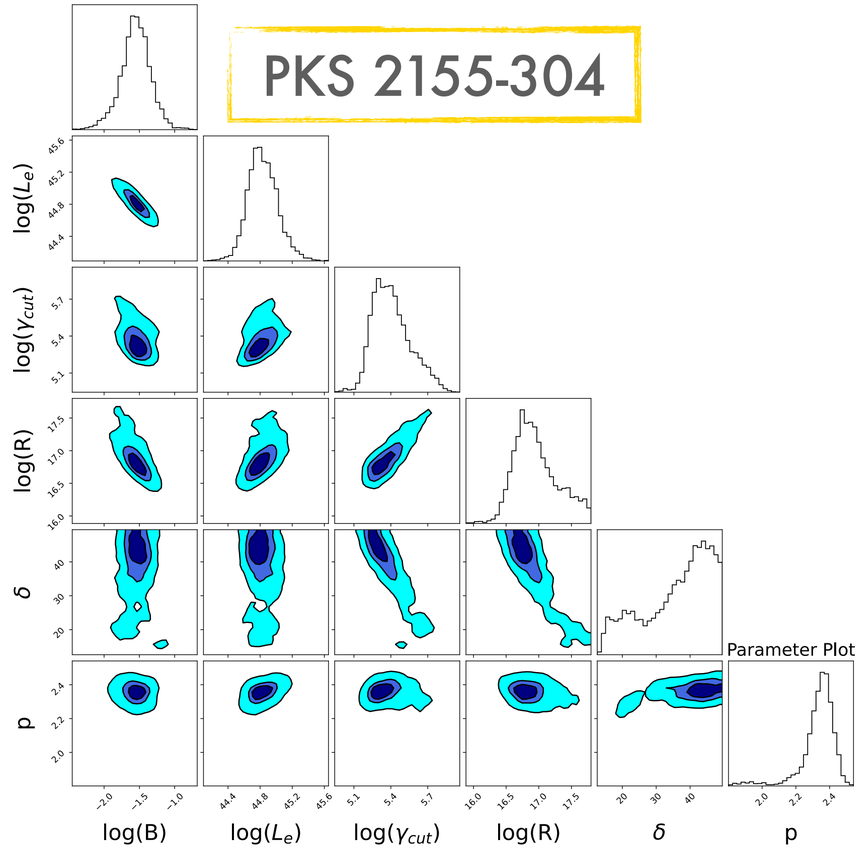

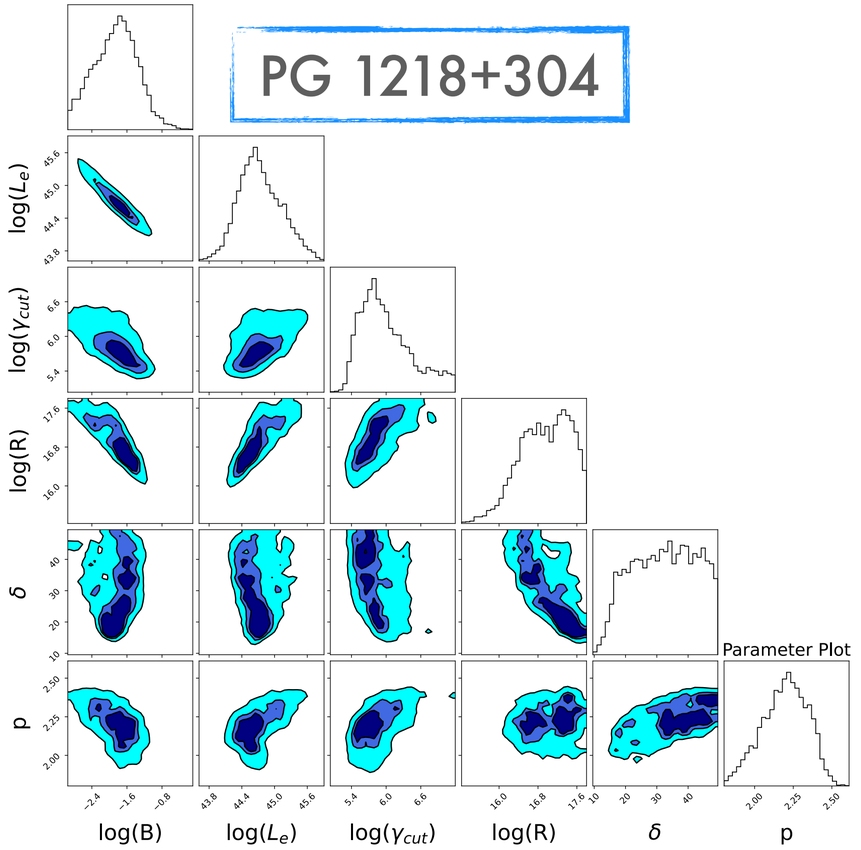

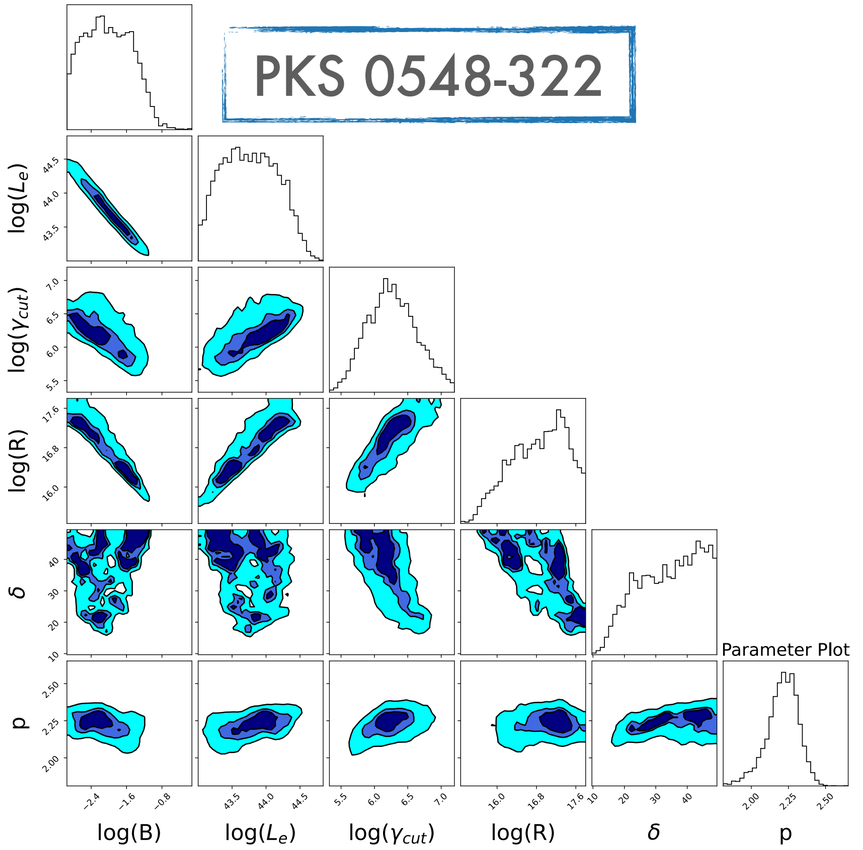

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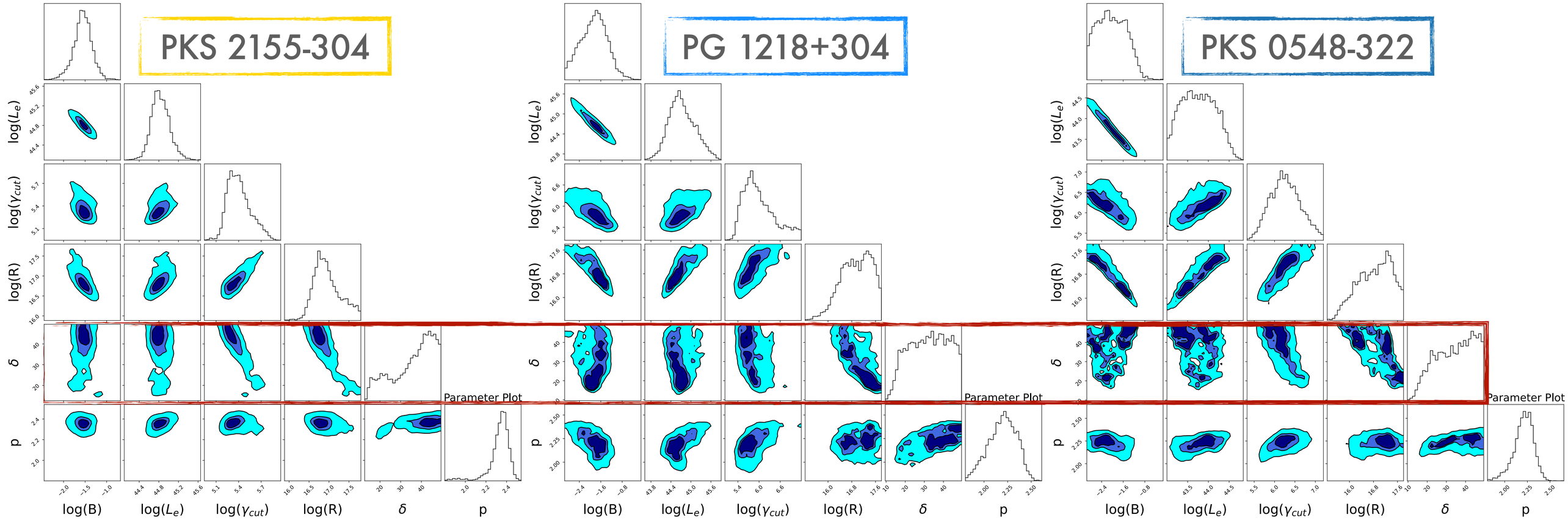

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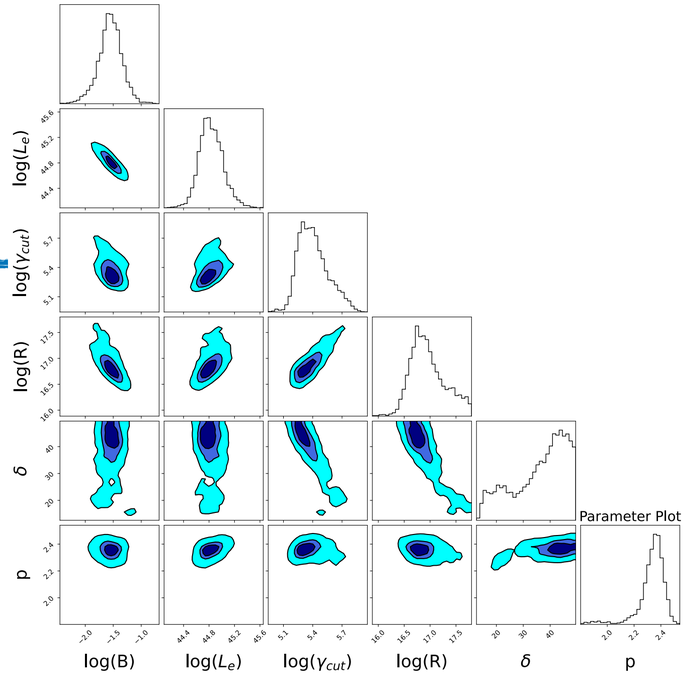

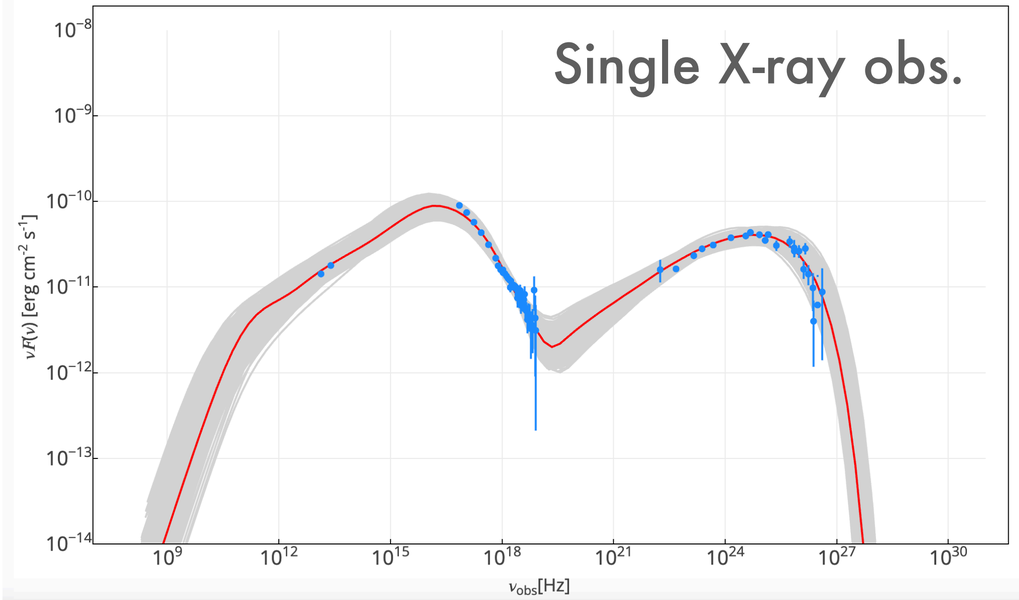

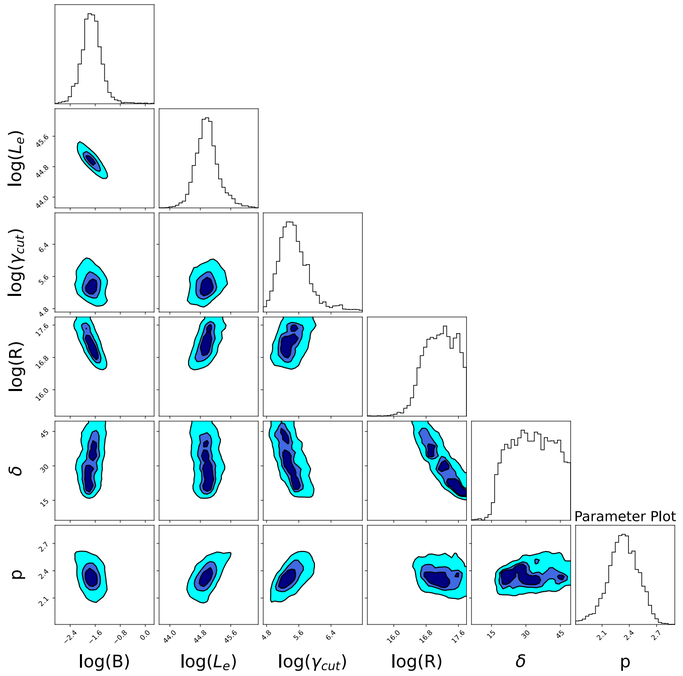

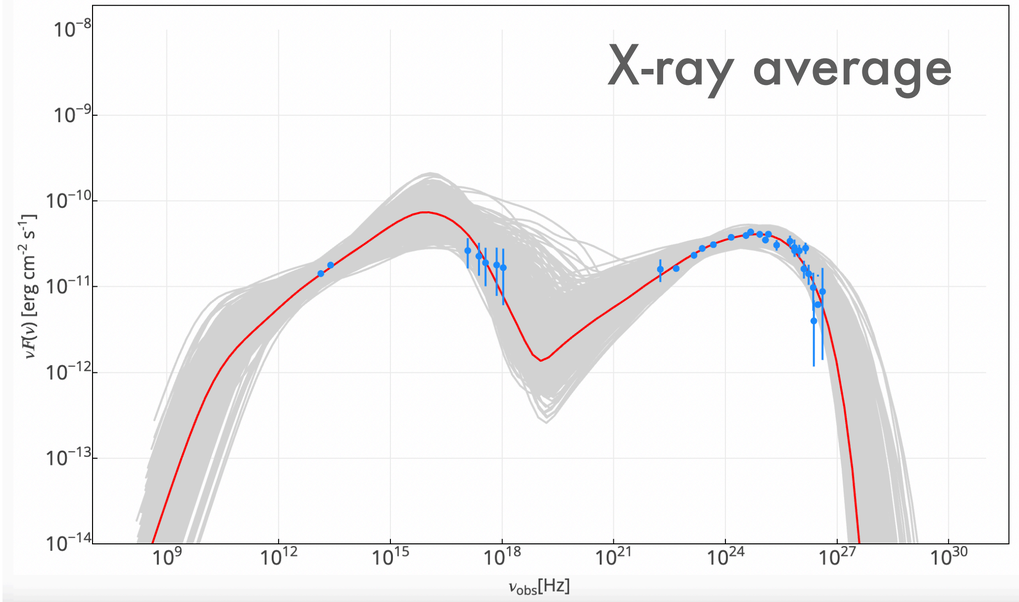

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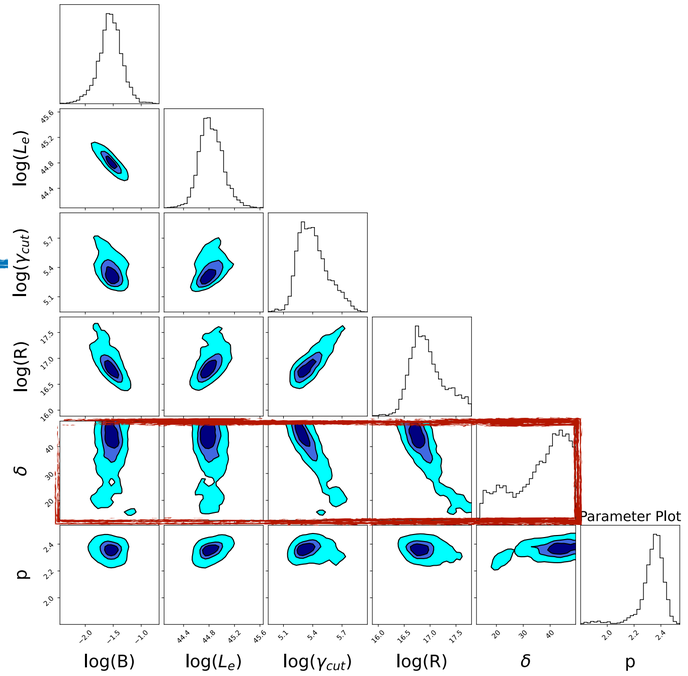

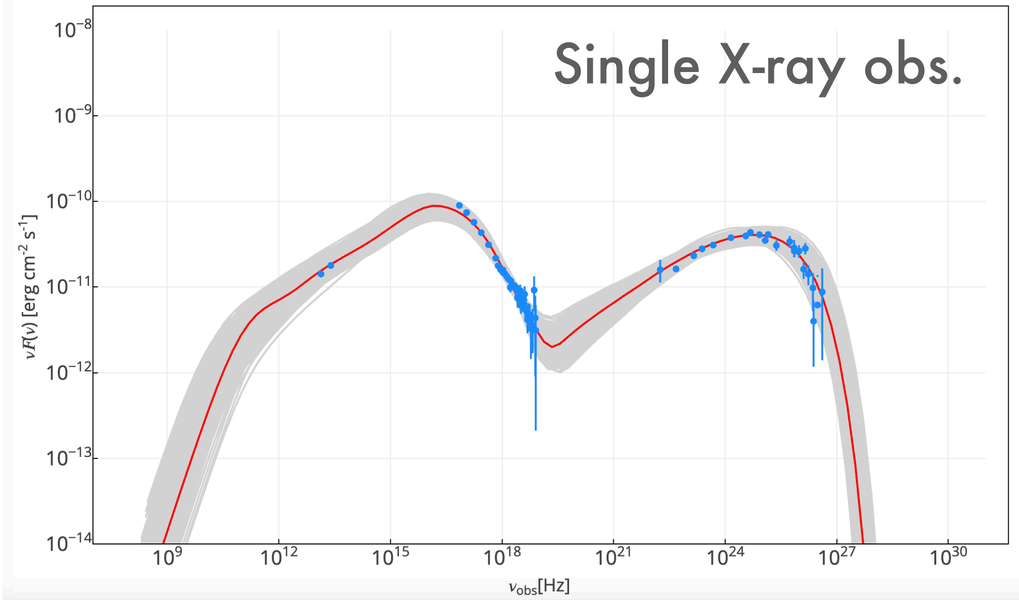

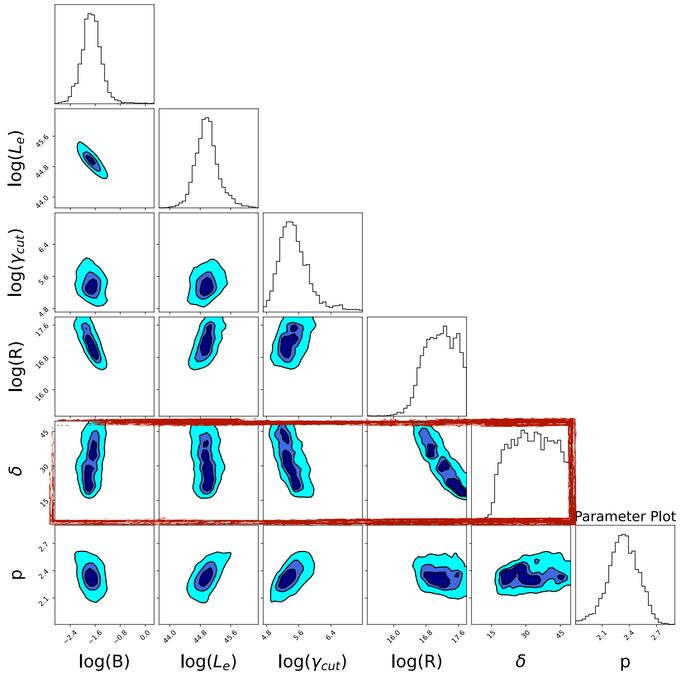

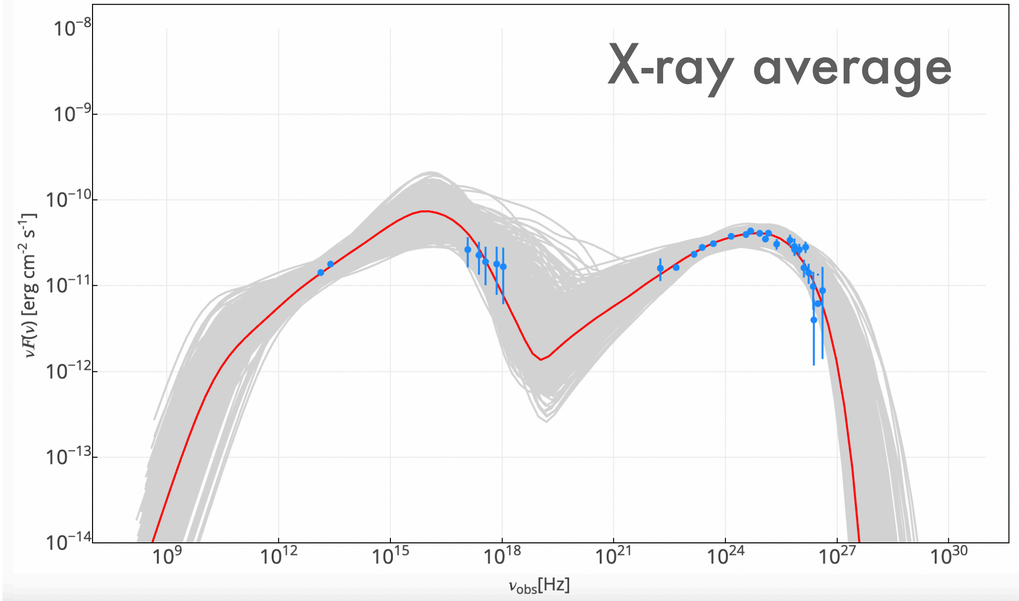

Take home messages and outlook

- Investigation of role of TeV sources in the blazar sequence
- Non-trivial data selection, especially in X-rays:
  - Useful in the future…
    - Continuous monitoring of sources in X-rays
    - Obs. strategy of simultaneous X-ray and γ-ray data
    - Online tools filtering observations based on the obs. Period
- Doppler factor not well constrained in tested models
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Stay tuned for new results!

Thank you!