

# Correlation between X-rays and TeV gamma-rays in blazars

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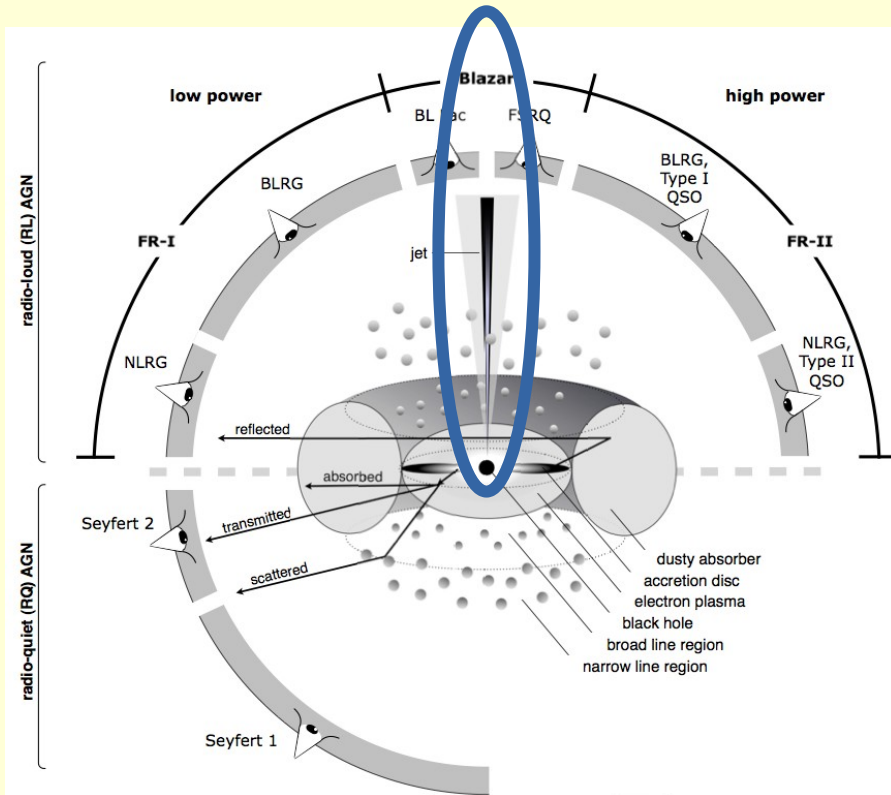
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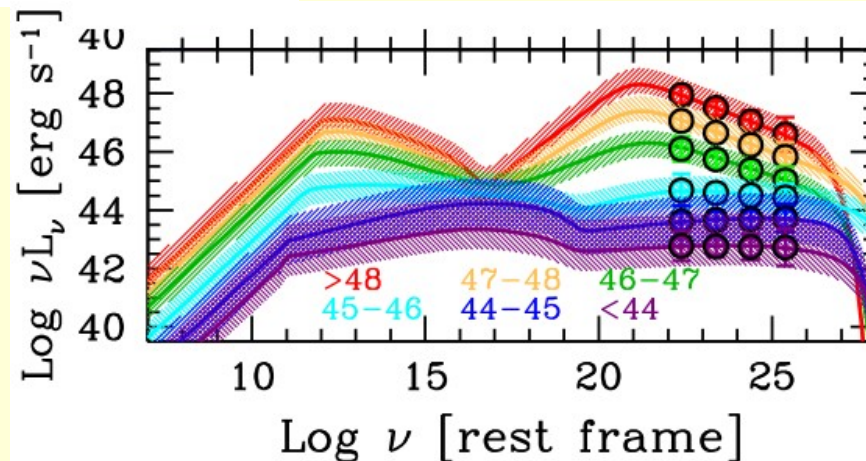
**Instituto de  
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# TeV Blazars



- AGN whose jet is pointed directly towards Earth.
- Highly variable broadband emission from radio to gamma-rays.
- Characterized by the double-humped spectrum.
- Classified according to the frequency of the synchrotron component. (HBL blazars and Extreme blazars have their peak component at frequencies  $>10^{15}$  Hz)

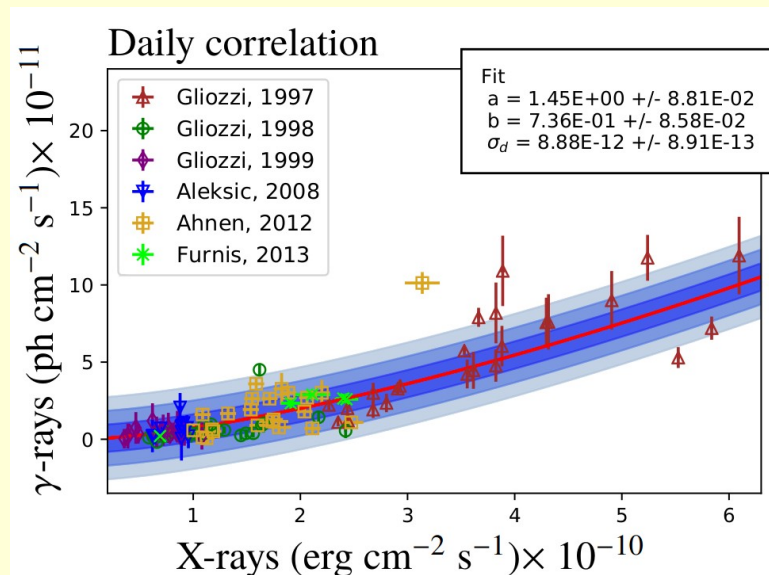
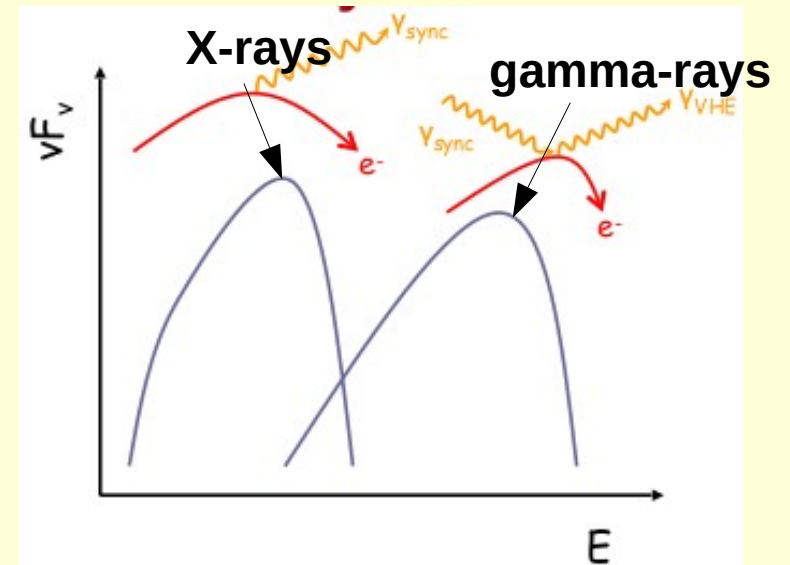
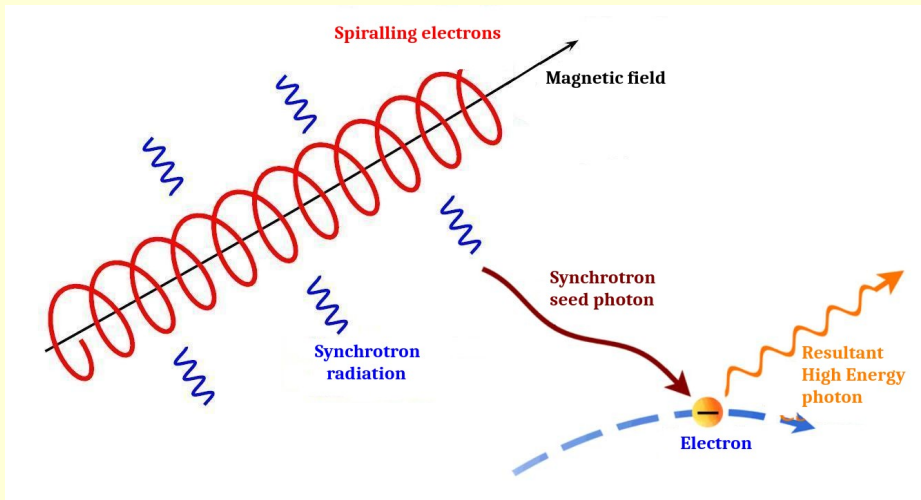
Unification scheme.  
Beckmann & Shrader, 2012



Blazar sequence.  
Ghisellini et al, 2017

# Radiation Emission models

- Synchrotron Self Compton (SSC)



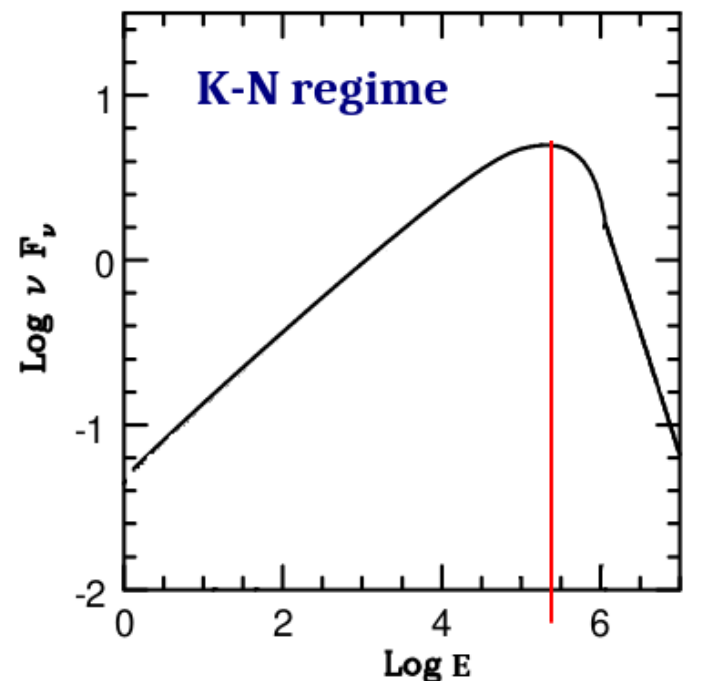
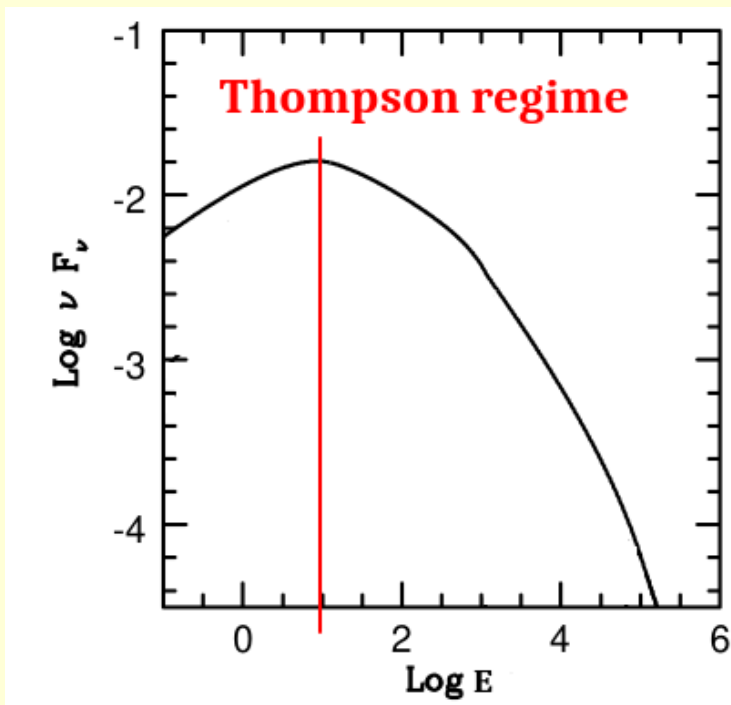
## - Thompson regime

$$m_e c^2 > h \nu$$

## - Klein-Nishina (K-N) regime

$$m_e c^2 < h \nu$$

$$\frac{L_{IC}}{L_{syn}} \propto \frac{1}{B^2}$$





# Implications of the SSC model

- It is expected flux correlation between the synchrotron and the IC components
- The correlation shapes:
  - Thompson regime: quadratic correlation  $F_{IC} \propto F_{syn}^2$  <sup>(1)</sup>
  - K-N regime: linear correlation <sup>(2)</sup>
  - Jet with structure: correlation with indices  $> 1$  <sup>(3)</sup>
  - They depend on the chosen energy band <sup>(2)</sup> and on the time scale <sup>(3)</sup>

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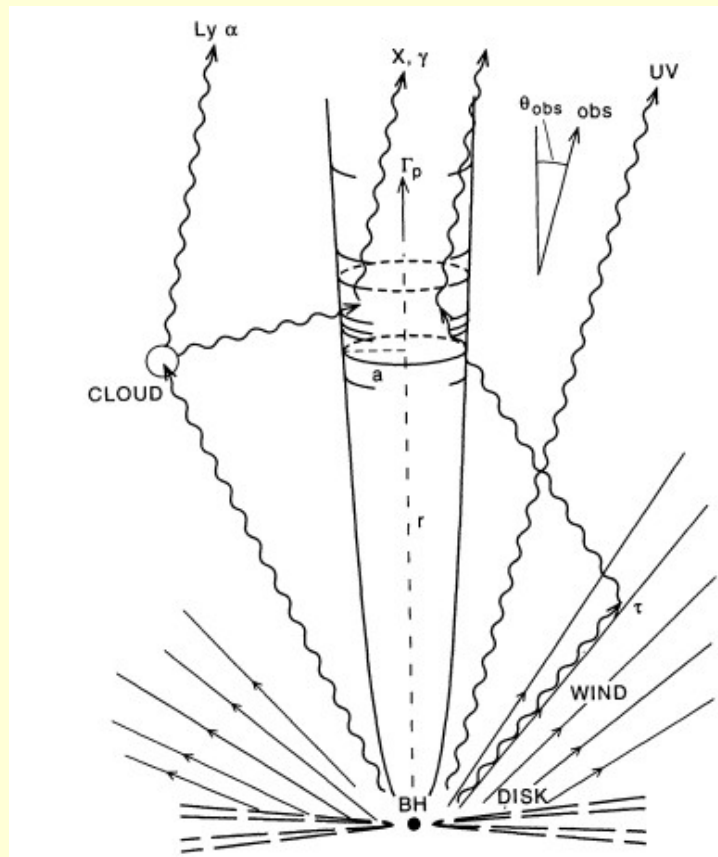
<sup>(1)</sup> M. Amenomori, et al. (2003)

<sup>(2)</sup> K. Katarzynski, et al. (2005)

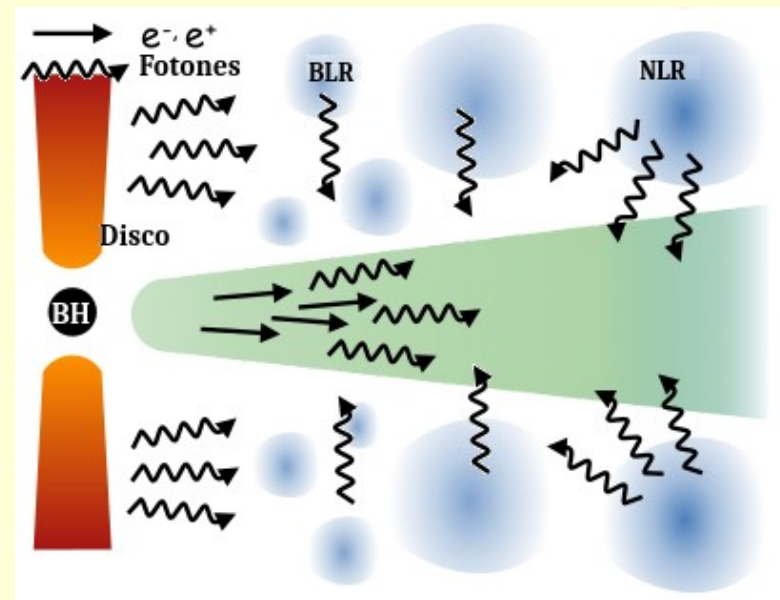
<sup>(3)</sup> K. Katarzynski & K. Walczewska (2010)

# Other emission models

- **Leptonic External Compton**

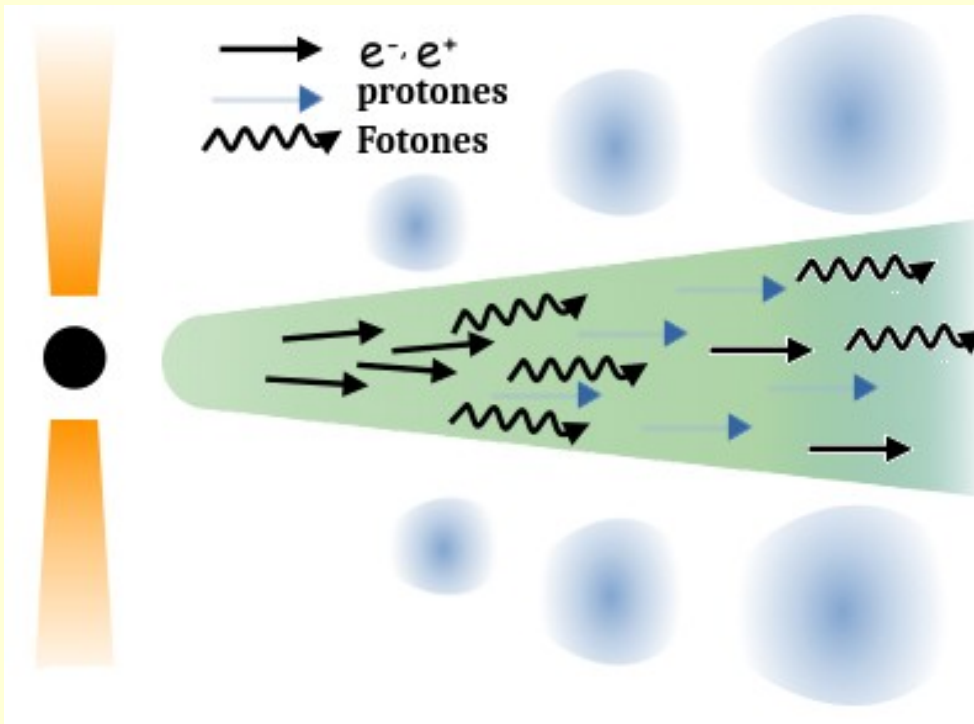


Sikora et al, 1994



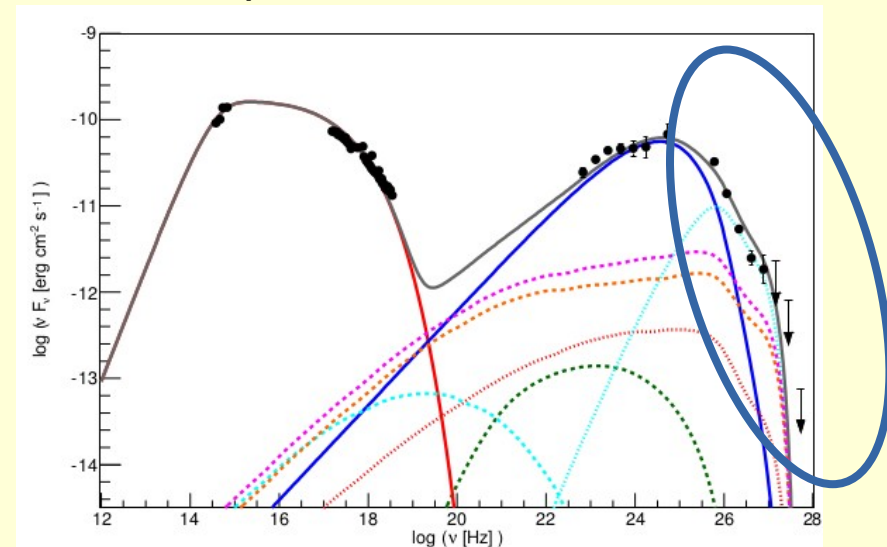
Manel Errando. Fermi summer school 2021

# • Hadronic model



Manel Errando. Fermi summer school 2021

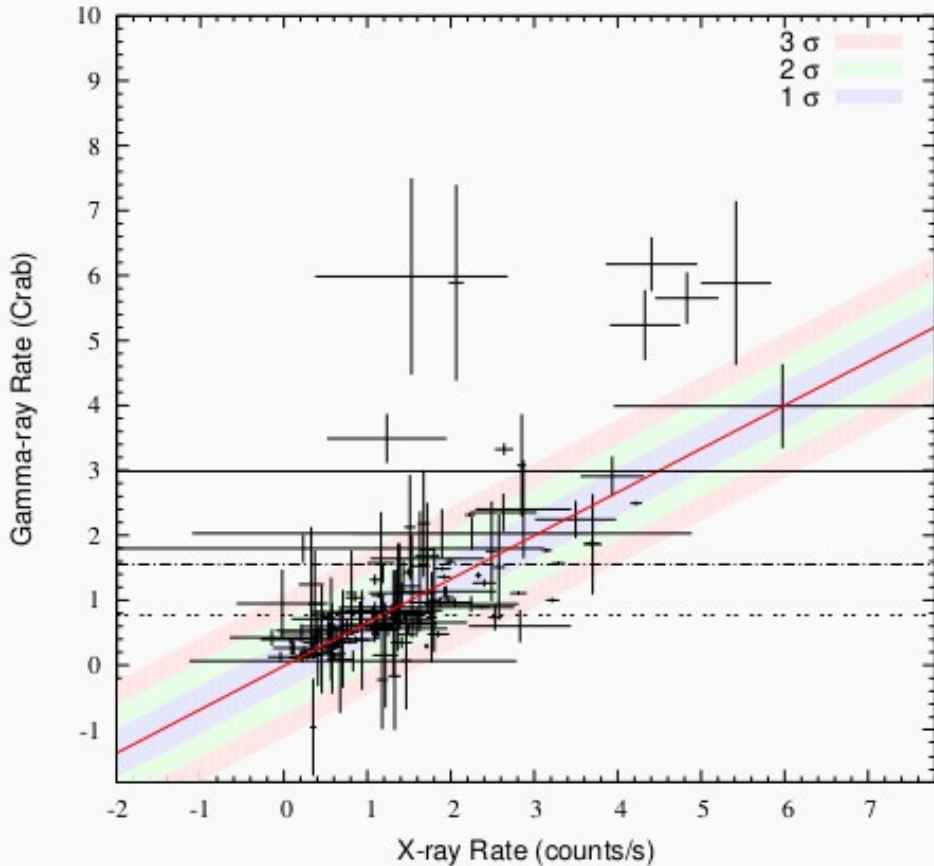
PKS 2155-304 hadronic component, the “cascade bump”.



M. Zech, et al, 2017

# Main motivation

**Reconciliation of VHE gamma-ray/X-ray correlation studies in Mrk 421 and break-down at high fluxes – M. M. González et al, 2019**



- They got a linear correlation.
- The break in the correlation due to the highest gamma-ray fluxes constrains the magnetic field value of the jet.
- The blazar emission could be a combination of different models.



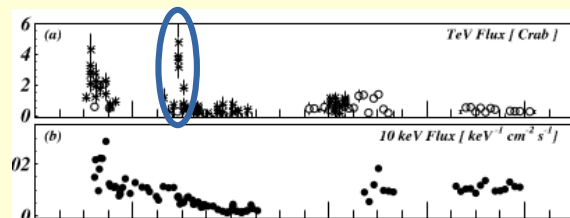
# Sample

The sources were obtained from the gamma-ray catalog TeVCat\*:

Source	redshift
Mrk 501	0.038
1ES 1959+650	0.048
PKS 2155-304	0.116
1ES 2344+514	0.044

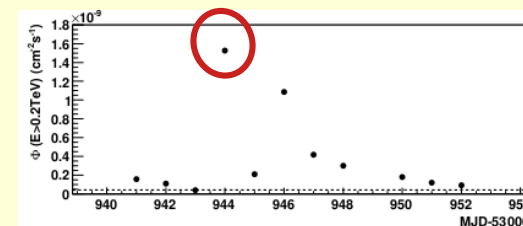
- HBL Blazars
- Sources with energy detection > 200 GeV
- Redshift  $z < 0.15$

1ES 1959+650



Krawczynski, et al, 2004

PKS 2155-304

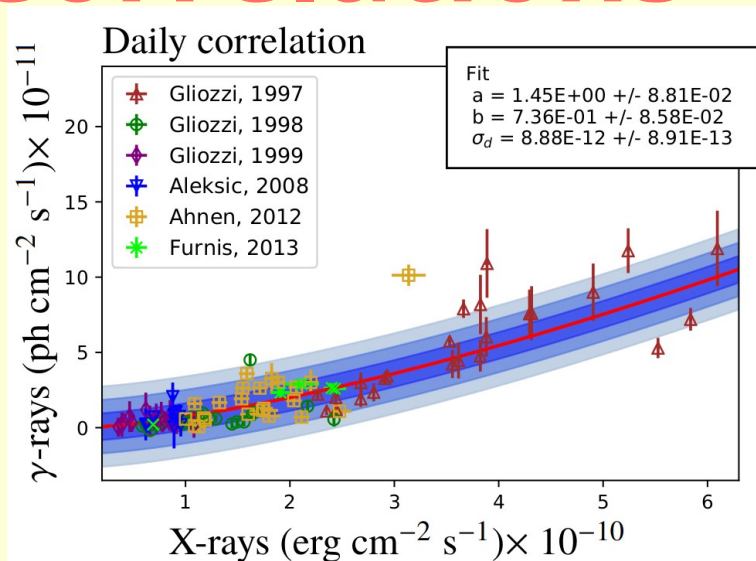


Abramowski, et al, 2010

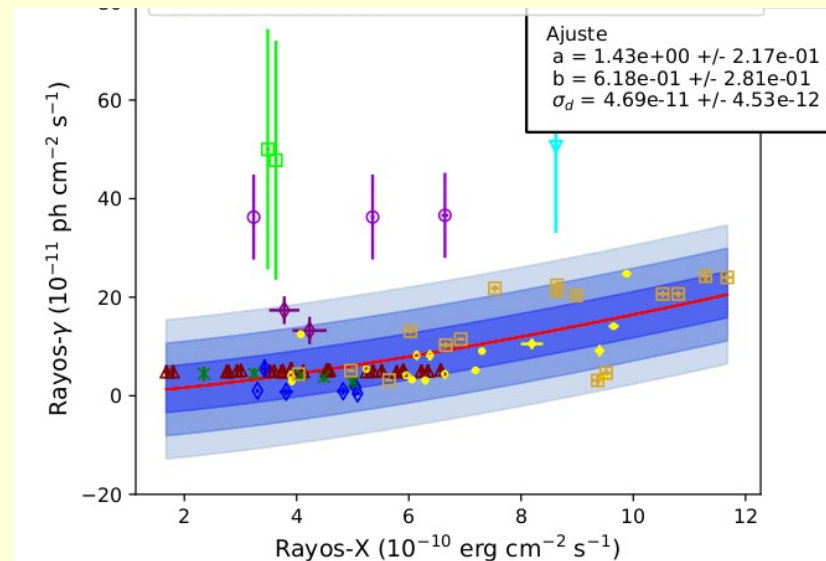
\*<http://tevcat.uchicago.edu/>

# Results:

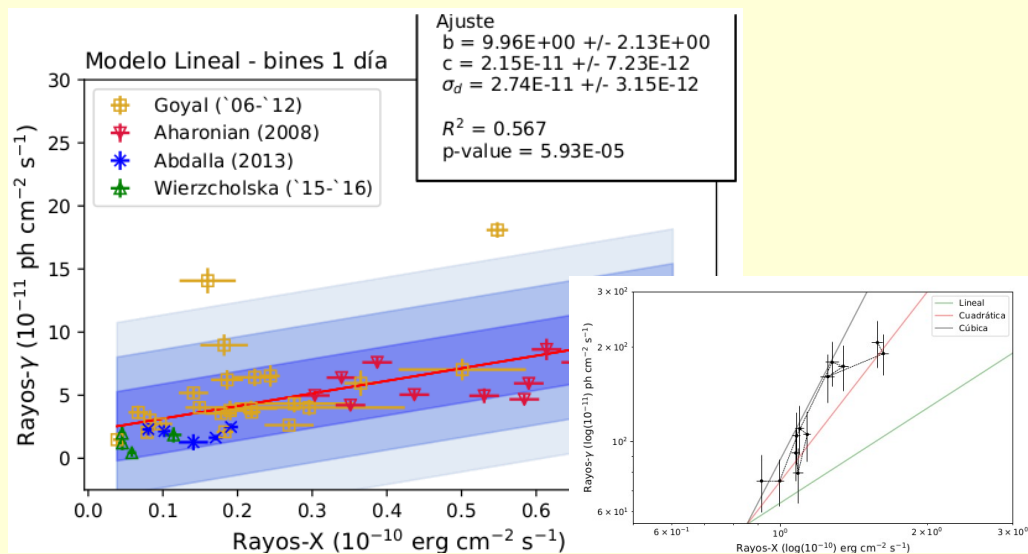
## Correlations



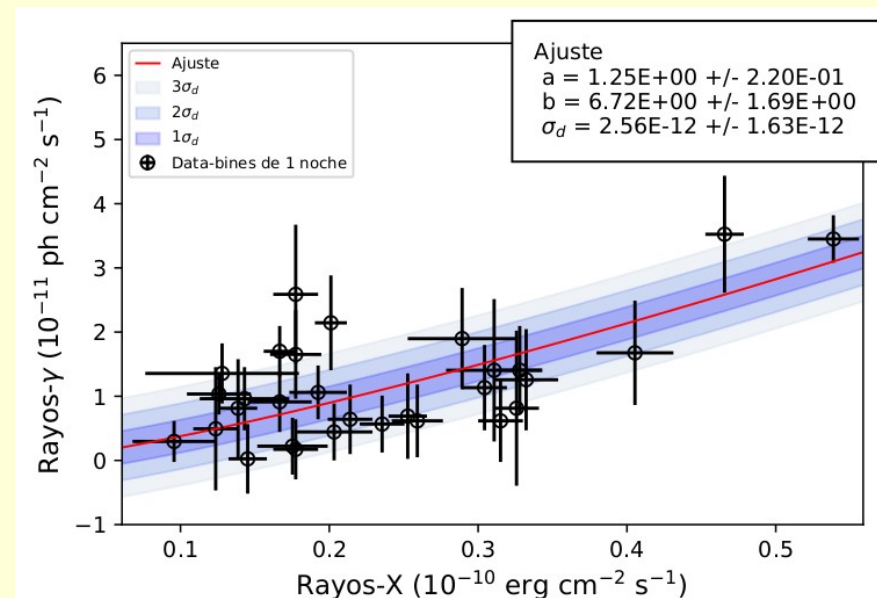
Mrk 501



1ES 1959+650

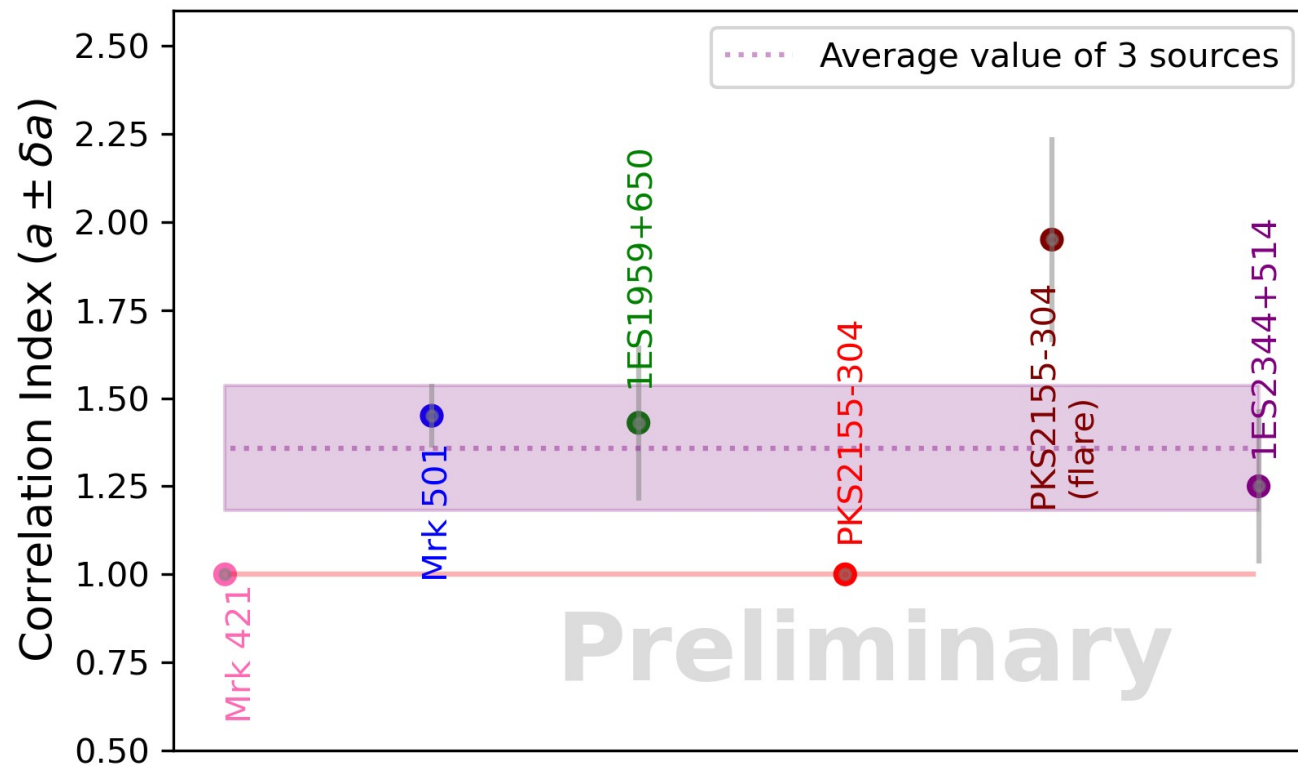


PKS 2155-304



1ES 2344+514

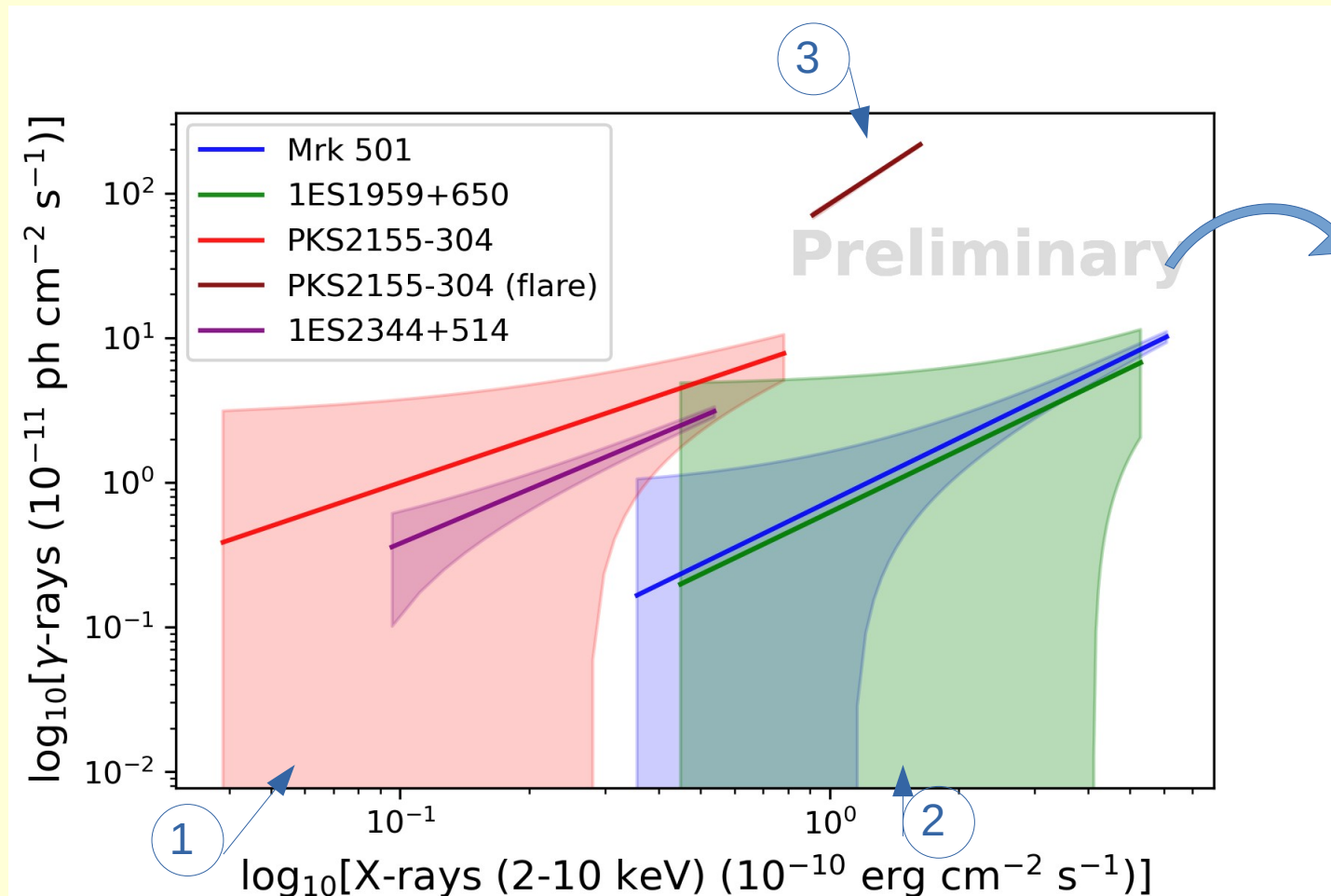
# Correlation index



Multiple emission zones disagreement

Comparison of the correlation indexes with Mrk 421. The horizontal purple stripe is the average value with  $1.36 \pm 0.18$ , within which lie the correlation indexes of 3 of the sources.

# Comparison of the correlation models

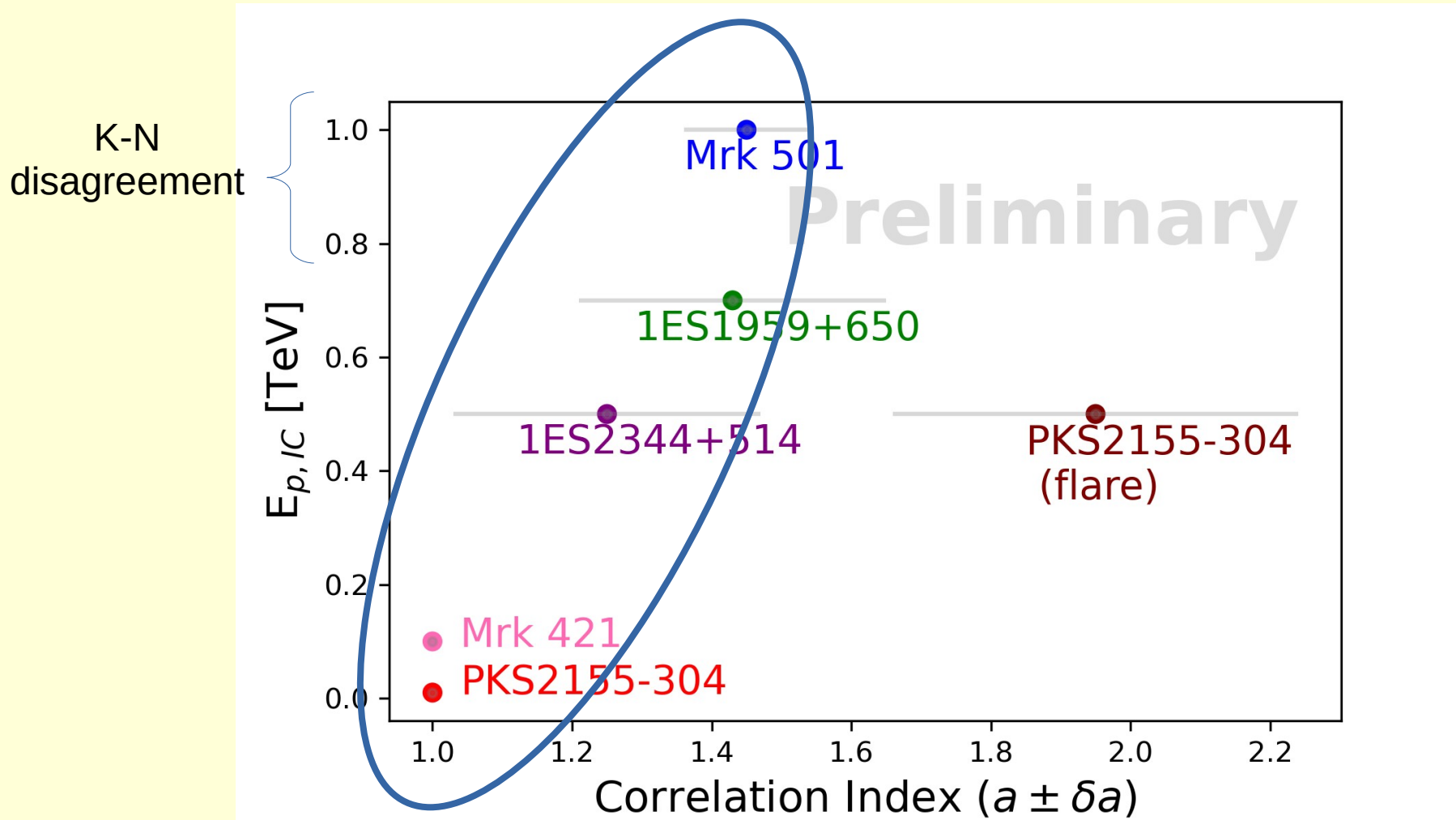


- Less efficient in generating gamm-rays.
- Lower value of the magnetic field.

$$\frac{L_{IC}}{L_{syn}} \propto \frac{1}{B^2}$$

Comparison of the correlation descriptions. 3 different groups are distinguished.

# Relation between peak energy and correlation index



The higher the energy peak, the higher the correlation index.



# Summary

- Individual correlations showed a break at high TeV gamma-ray fluxes, same as Mrk 421 reported in M. M González et al, 2019.
- There are three distinctive groups when comparing the correlation descriptions.
- We found a preliminary tendency between the peak energy at TeV and the correlation indices.
- The exceptional flare of PKS 2155-304 observed in July 2006, shows a different behavior in all our results.

Thank you!