

Probing Blazar Emission Processes with Optical/ γ -ray Flare Correlations

I. Liodakis

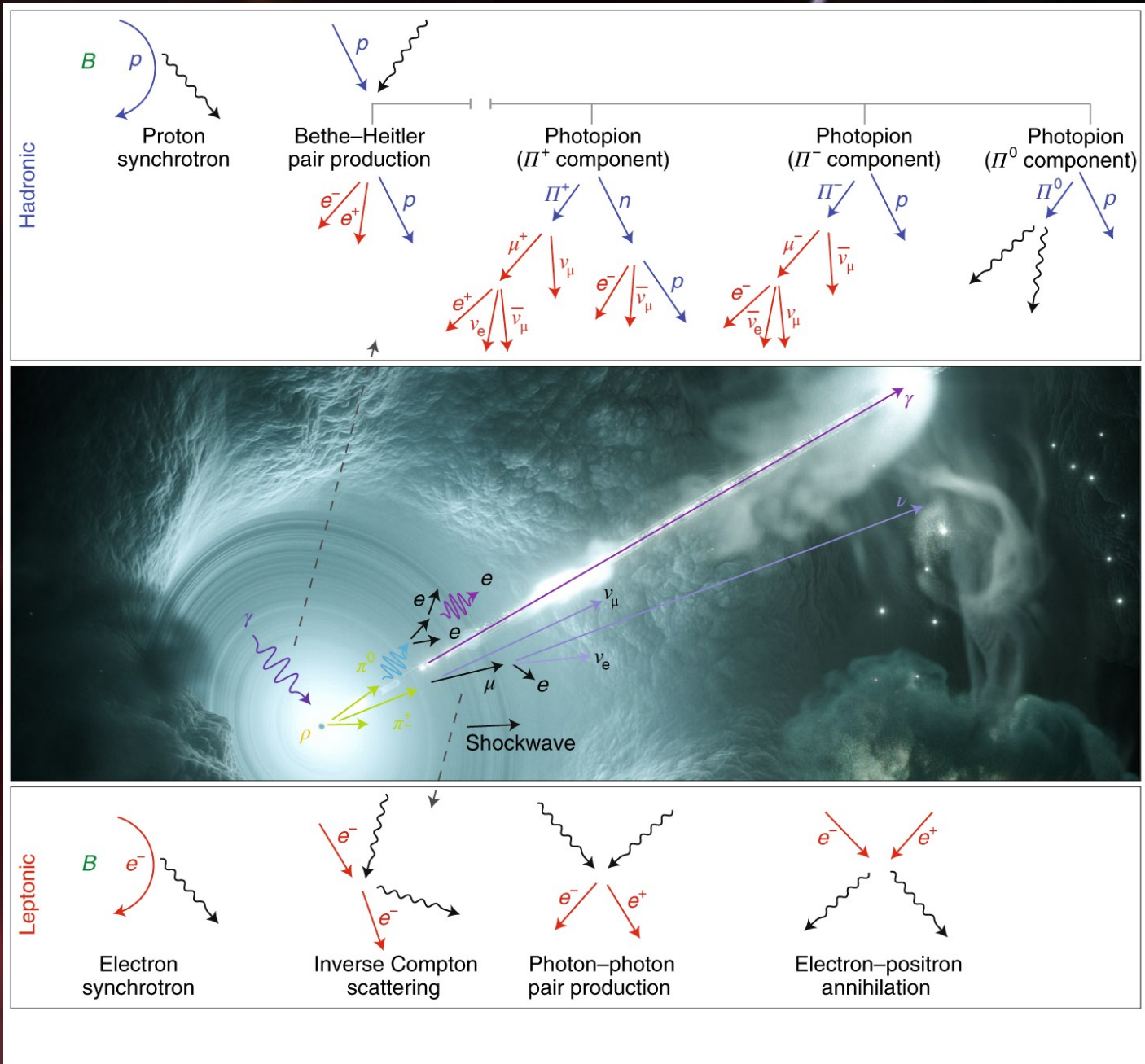
In collaboration with: R. W. Romani, D. Kocevski, A. V. Filippenko, and W. Zheng



*TeV Particle Astrophysics
Sydney – December 2019*



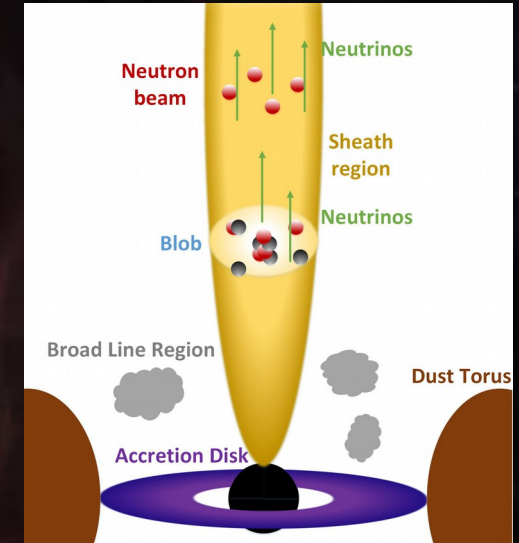
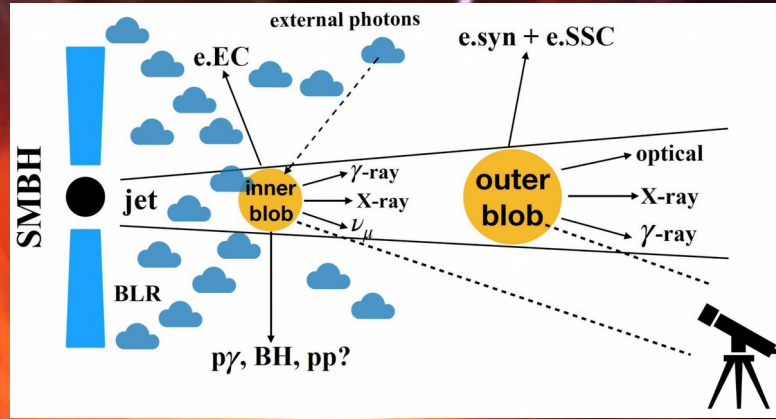
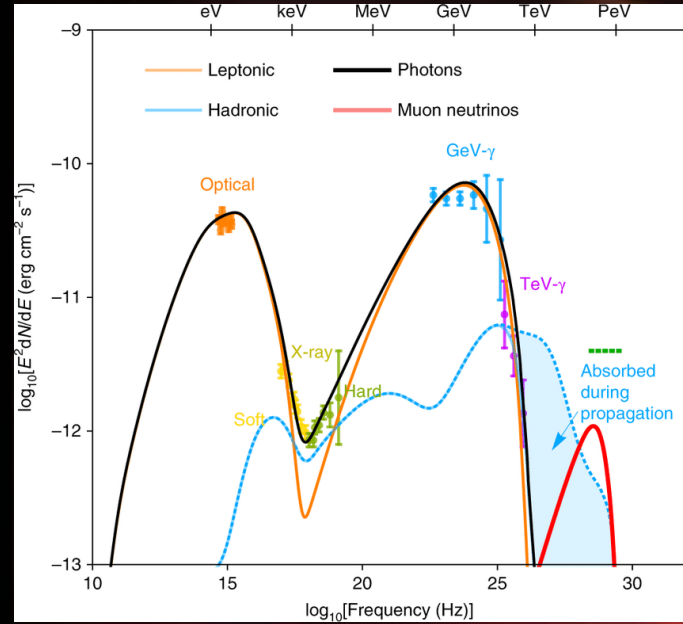
Where is the high-energy emission coming from?



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Gao et al., (2019, arXiv: 1807.04275)

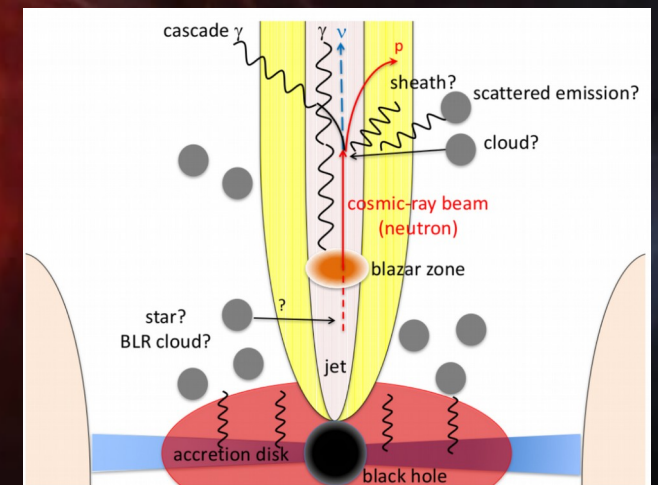
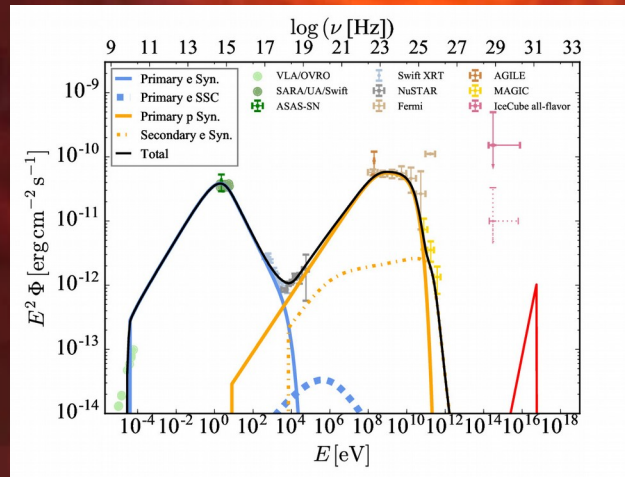
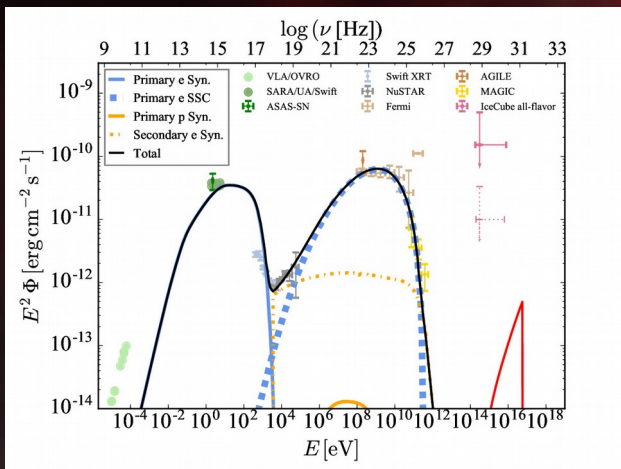
Zhang et al., (2019, arXiv:1910.11464)



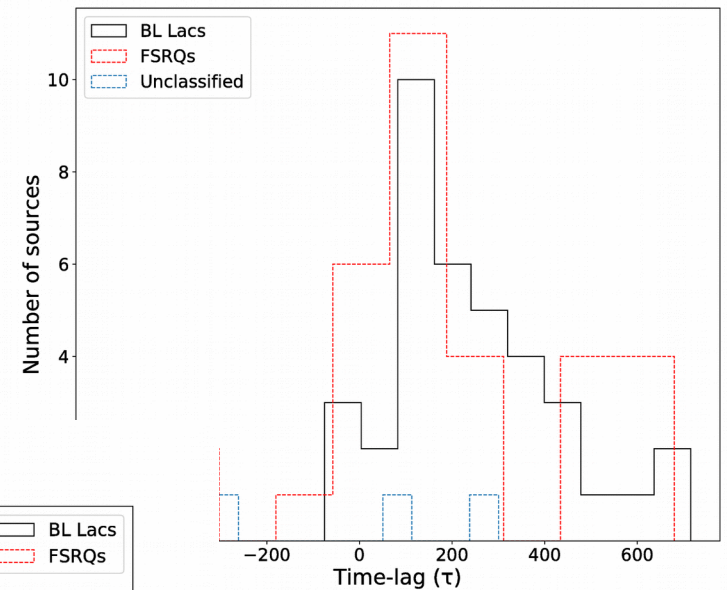
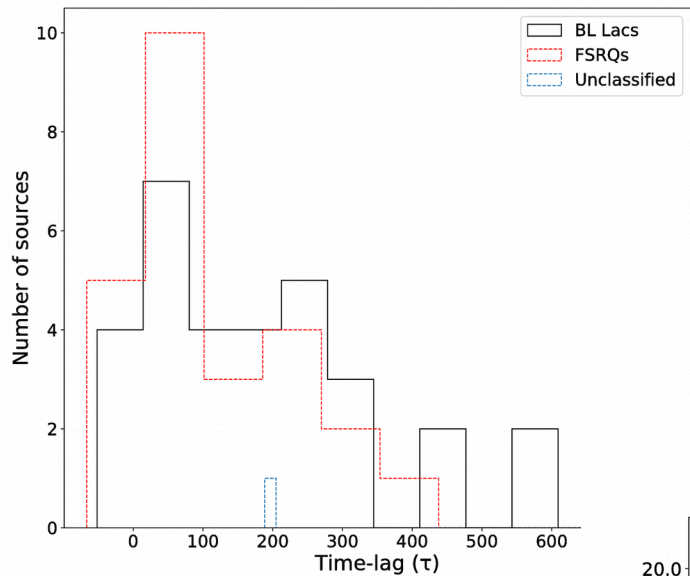
Xue et al., (2019, arXiv: arXiv:1908.10190)

Oikonomou et al. (2019, arXiv:1903.02006)

Zhang et al., (2018, arXiv:1807.11069)



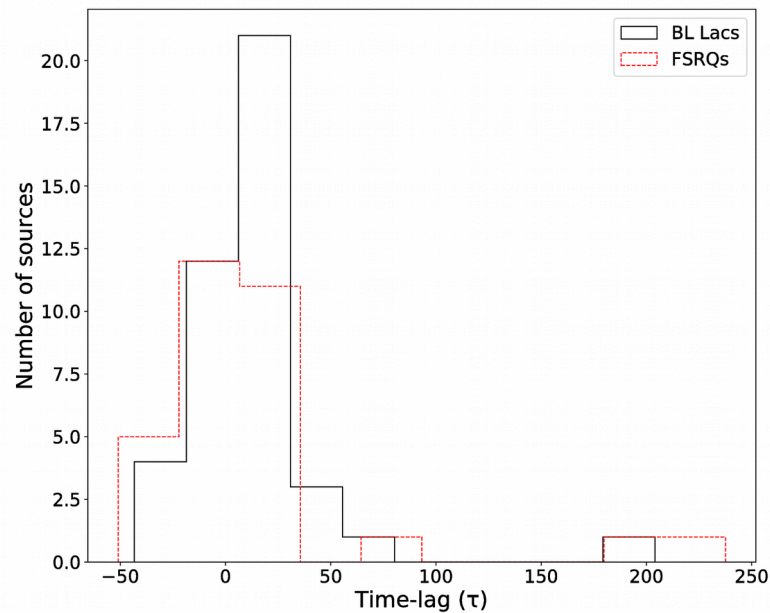
Multiwavelength cross-correlations



Optical-Radio

Optical-y-rays

~145 sources



y-rays-Radio

OVRO: <http://www.astro.caltech.edu/ovroblazars/>
KAIT: <http://herculesii.astro.berkeley.edu/kait/agn/>
Fermi: <https://fermi.gsfc.nasa.gov/ssc/data/access/>

Lioudakis et al., 2018
MNRAS, 480, 5517 arXiv:1808.05625

Focusing on Optical – γ -rays

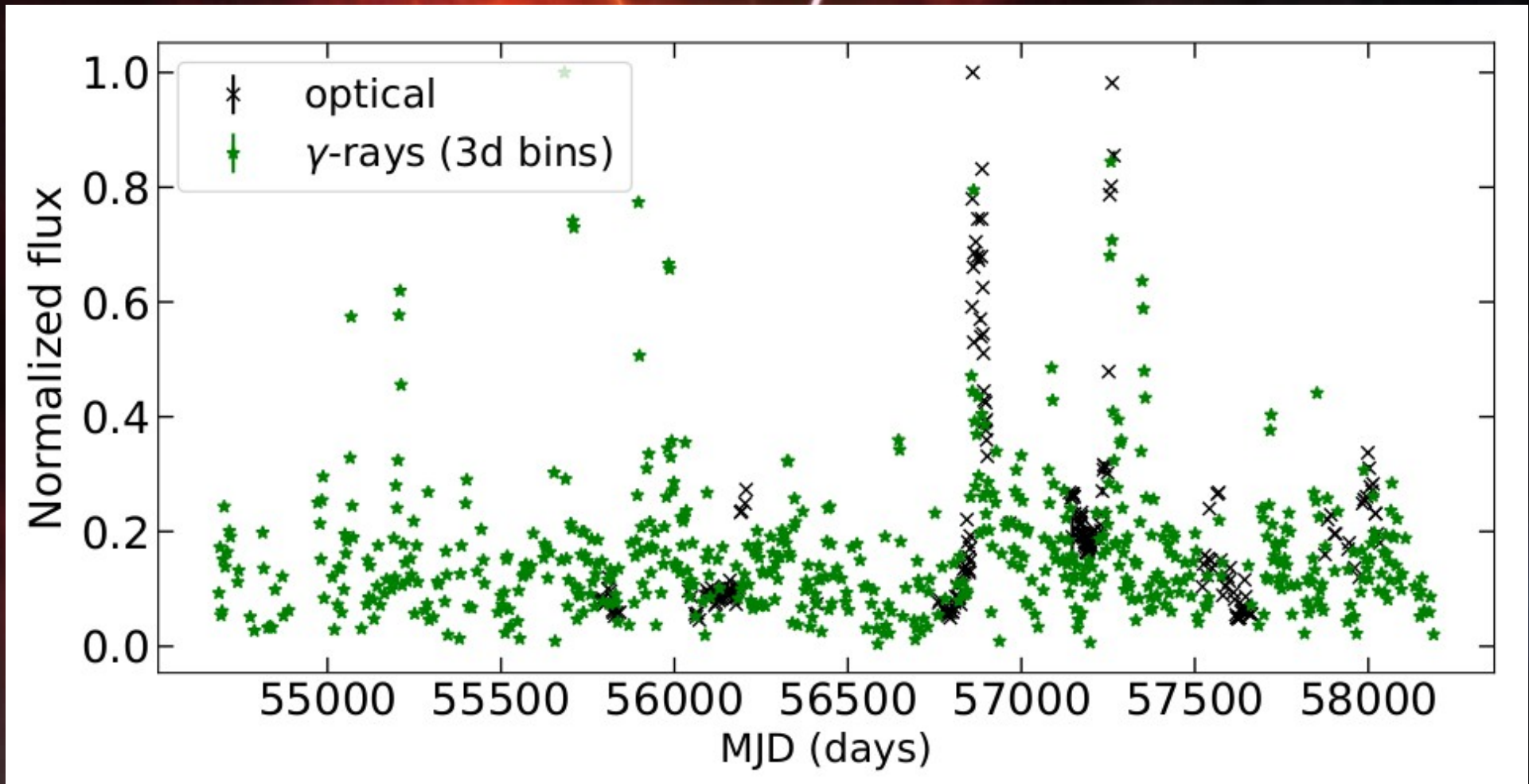
~8 year long light curves

+SMARTS

178 sources: 107 BL Lacs, 64 FSRQs, 4 Radio galaxies, 3 Unclassified

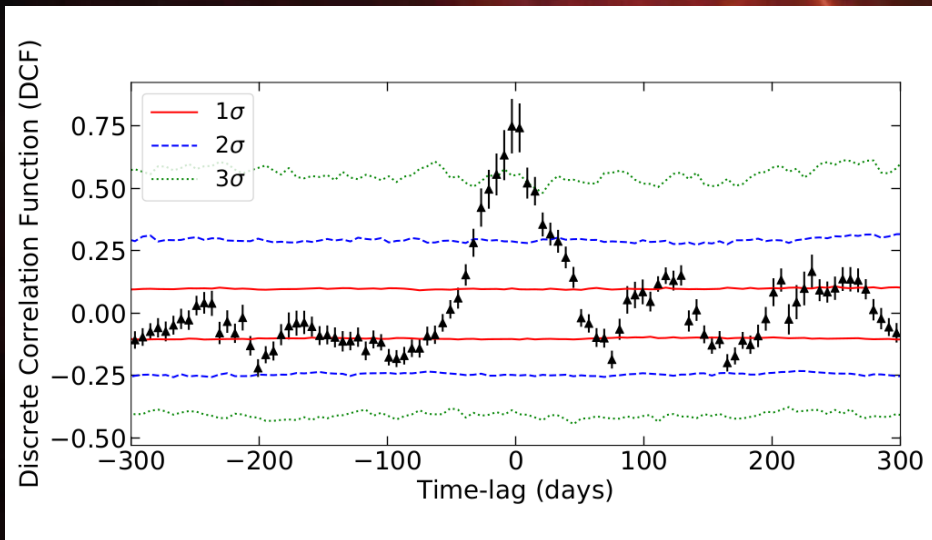
+Steward Observatory

80 LSPs, 27 ISPs, 35 HSPs, 36 No SED Info.



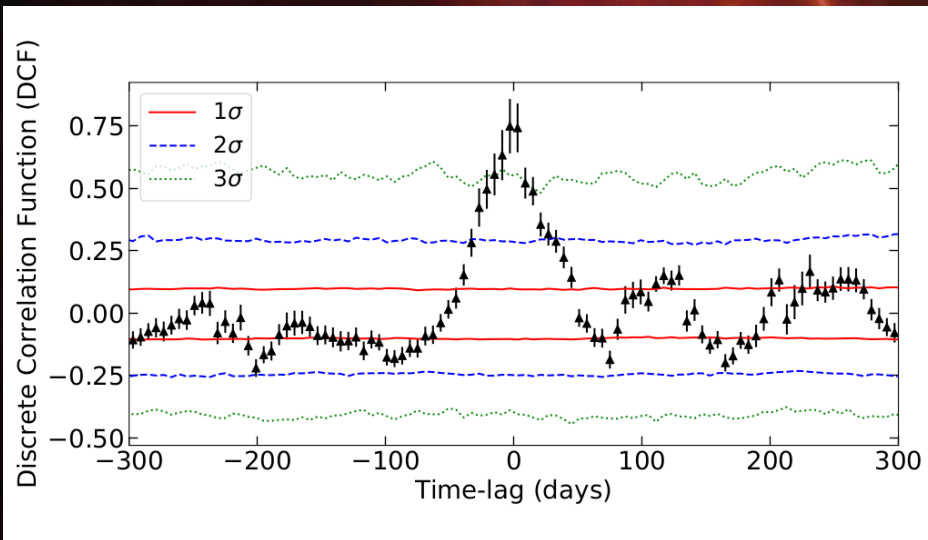
Estimating cross-correlations

Time-lags: Discrete correlation function
(Edelson & Krolic 1988)



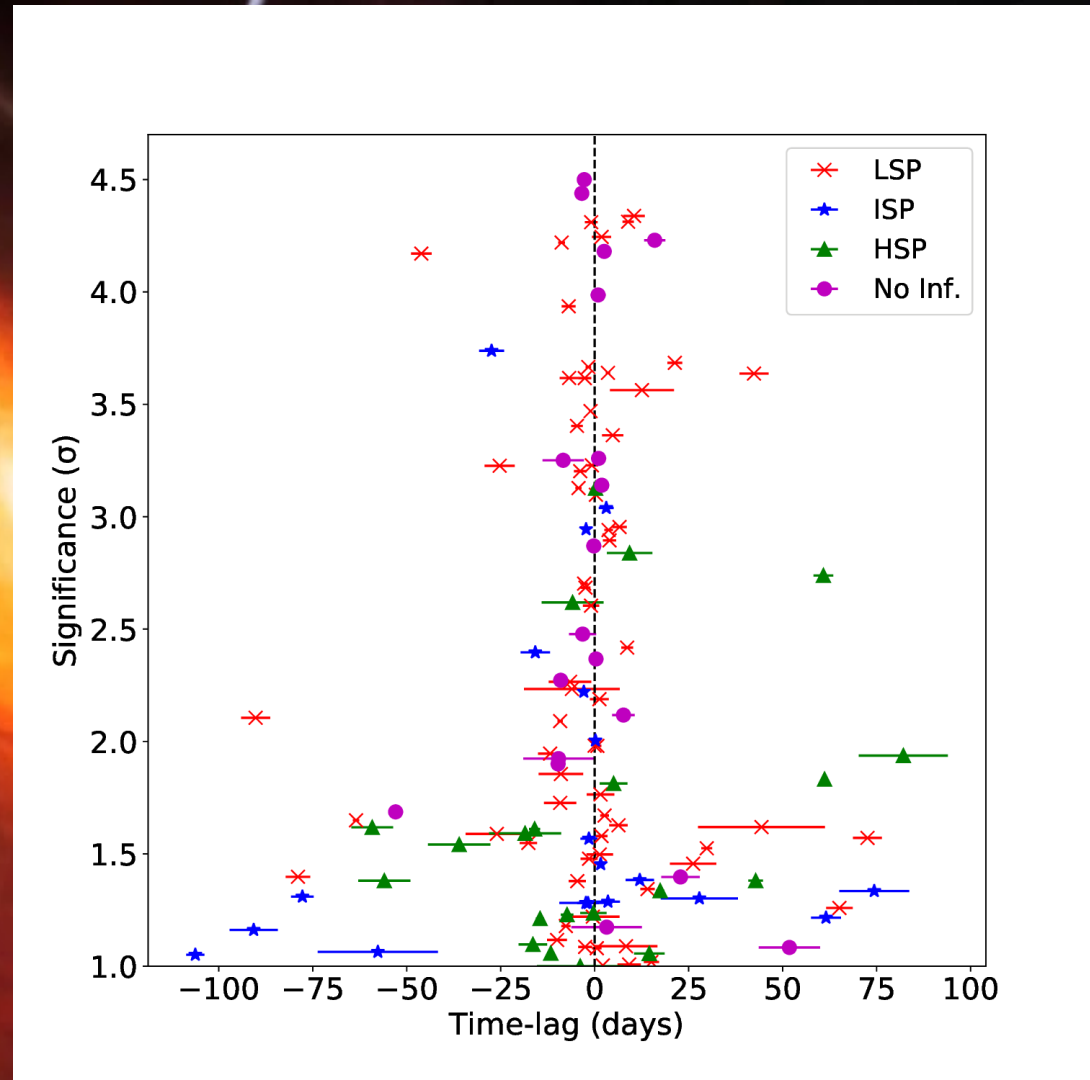
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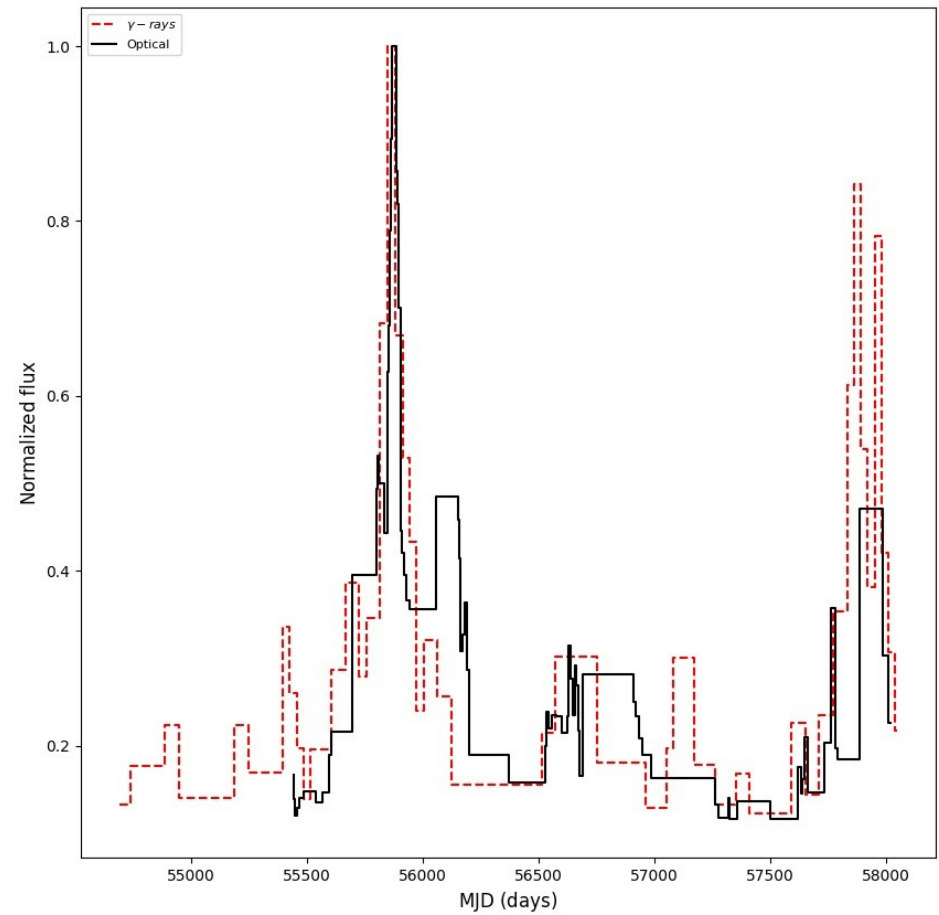
121/178 sources showed a $>1\sigma$ significant correlation.

No statistically significant difference is found between different populations



Associated and orphan events.

~63% of all optical and ~26% of all γ -ray flares appear orphan.

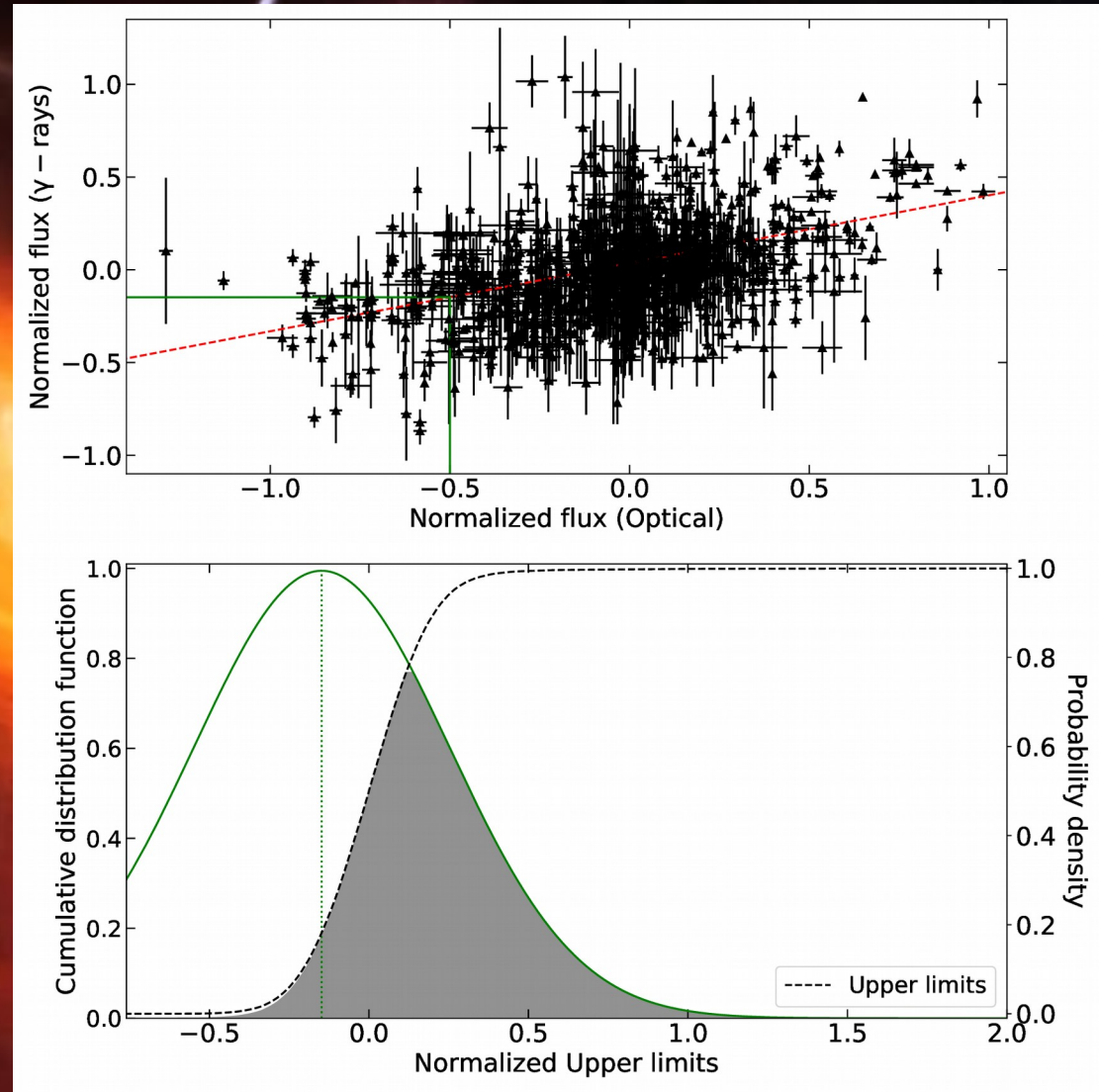


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56% of the optical and 21% of γ -ray events are truly orphan!



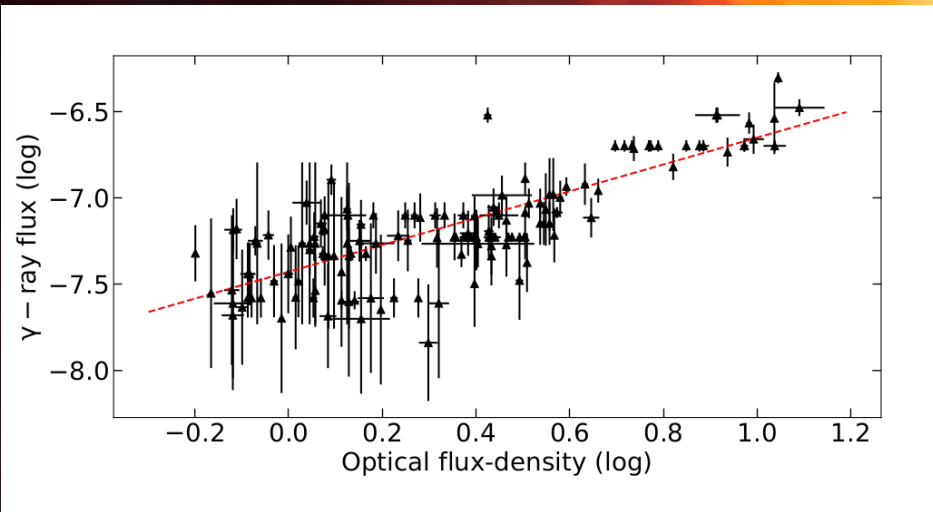
γ -ray orphan flare rate: 0.3 flares/source/yr

Flux-Flux correlation: Linear or quadratic?

Compare the simultaneous flux variations throughout the entire light curve.

Linear variations : *External Compton*

Quadratic variations: *Synchrotron Self-Compton*

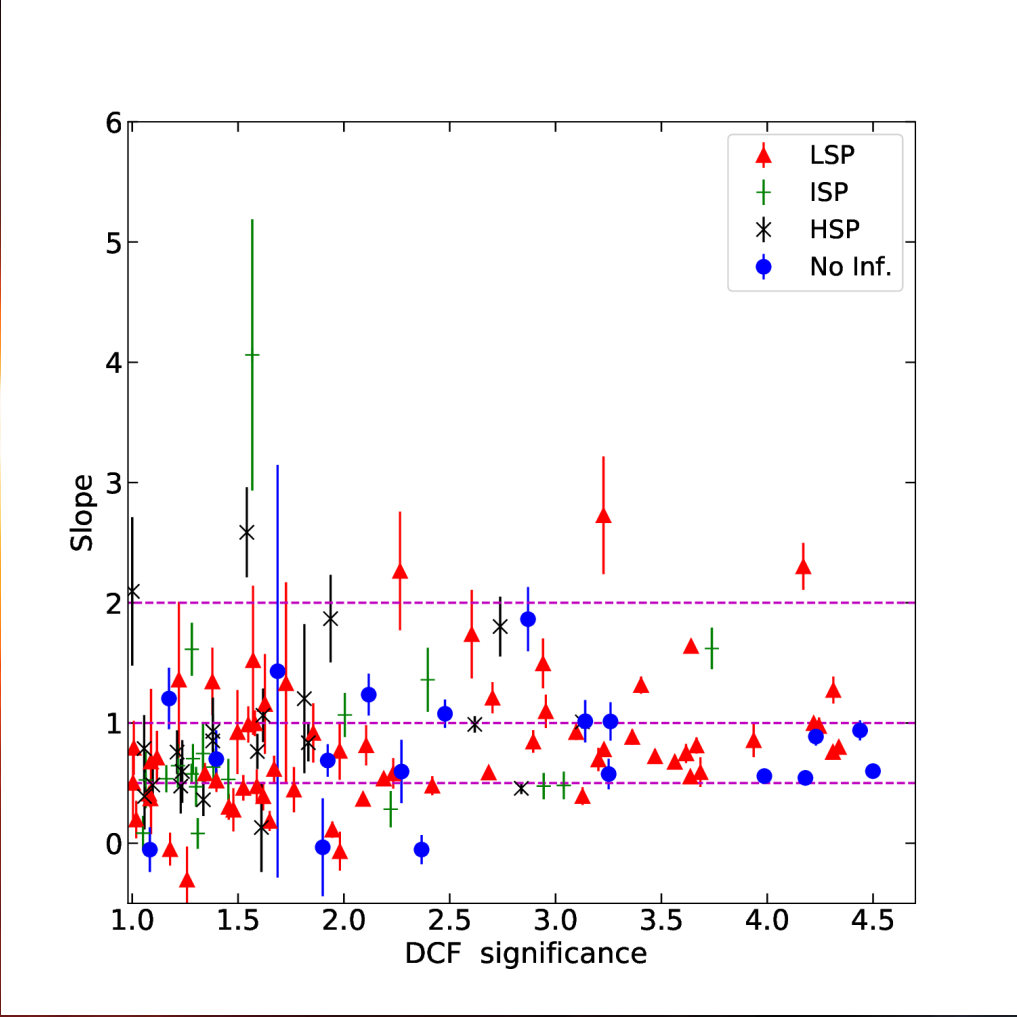
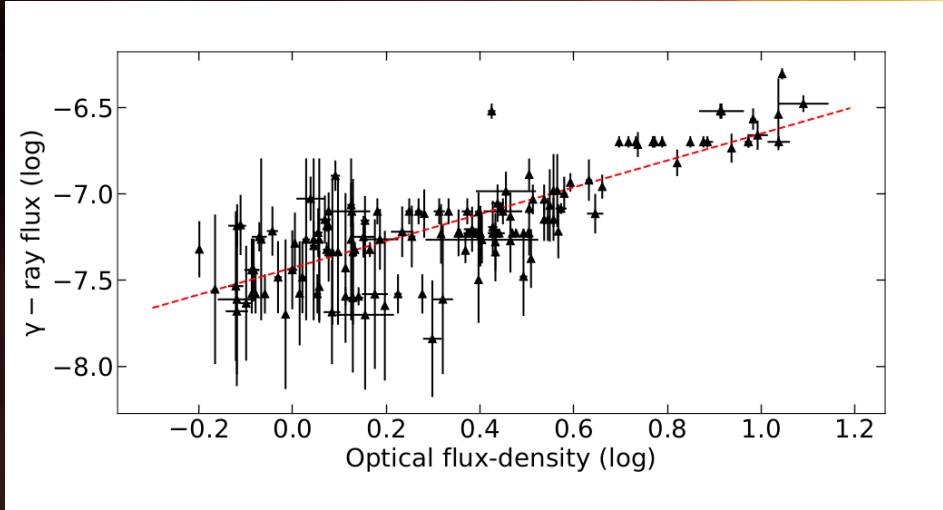


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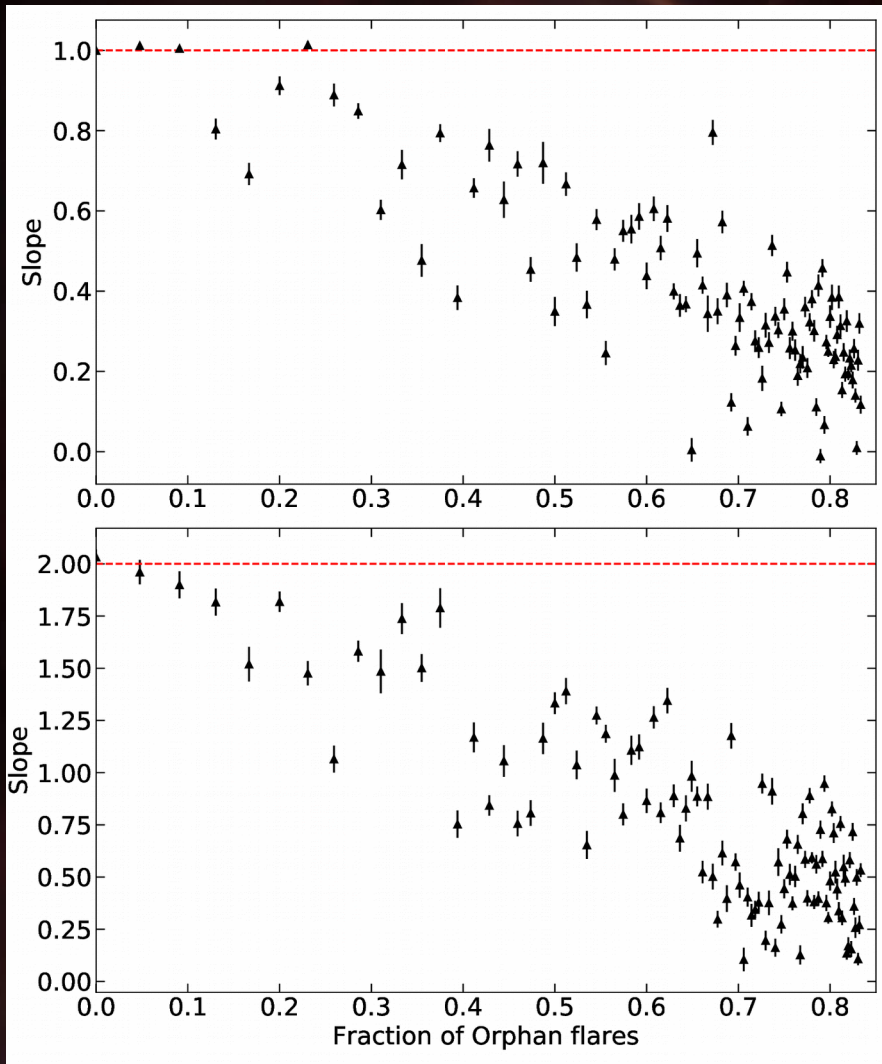
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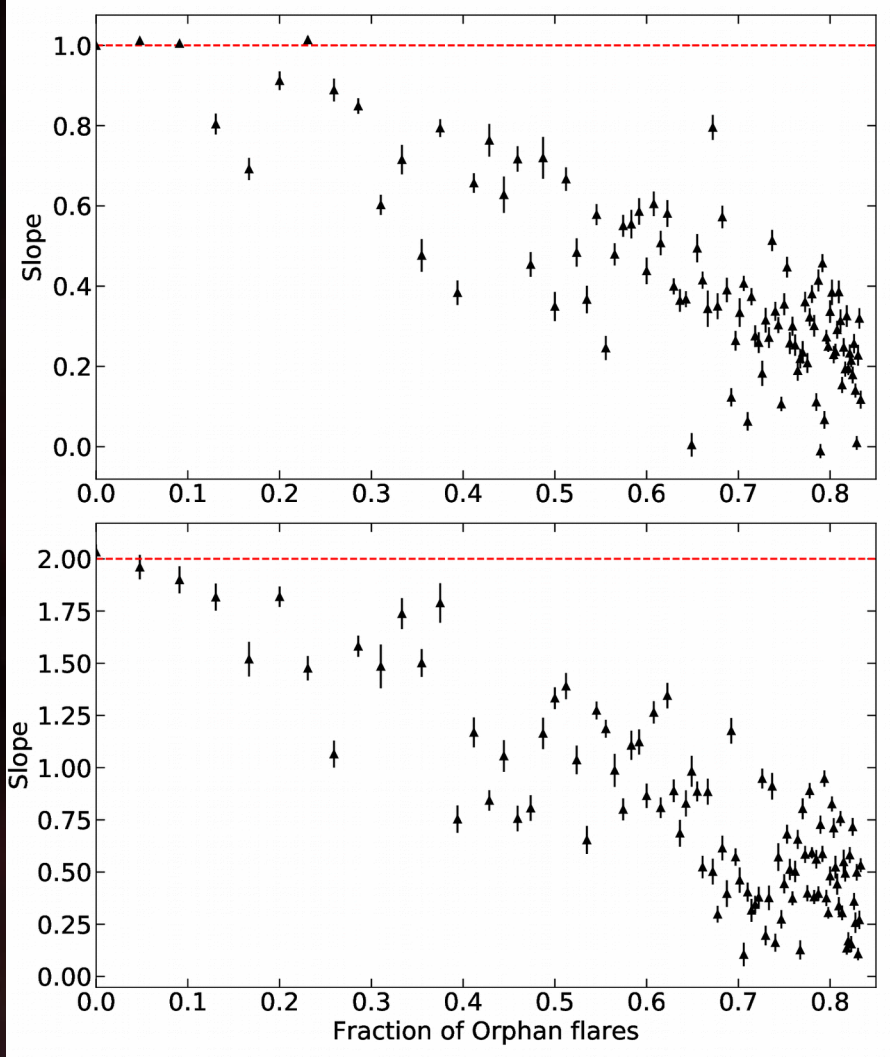


Intrinsic Flux-Flux scaling.

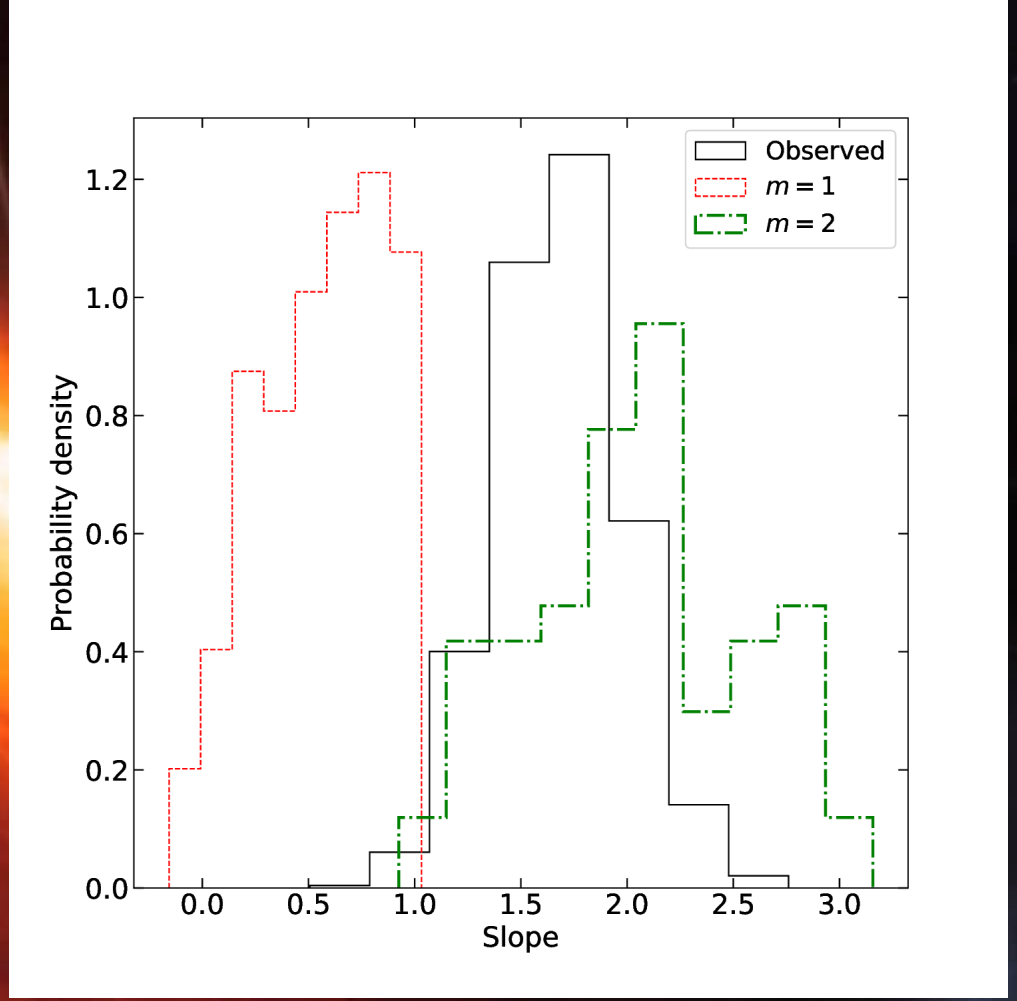


Uncorrelated variations can significantly impact the scaling of the intraband relation.

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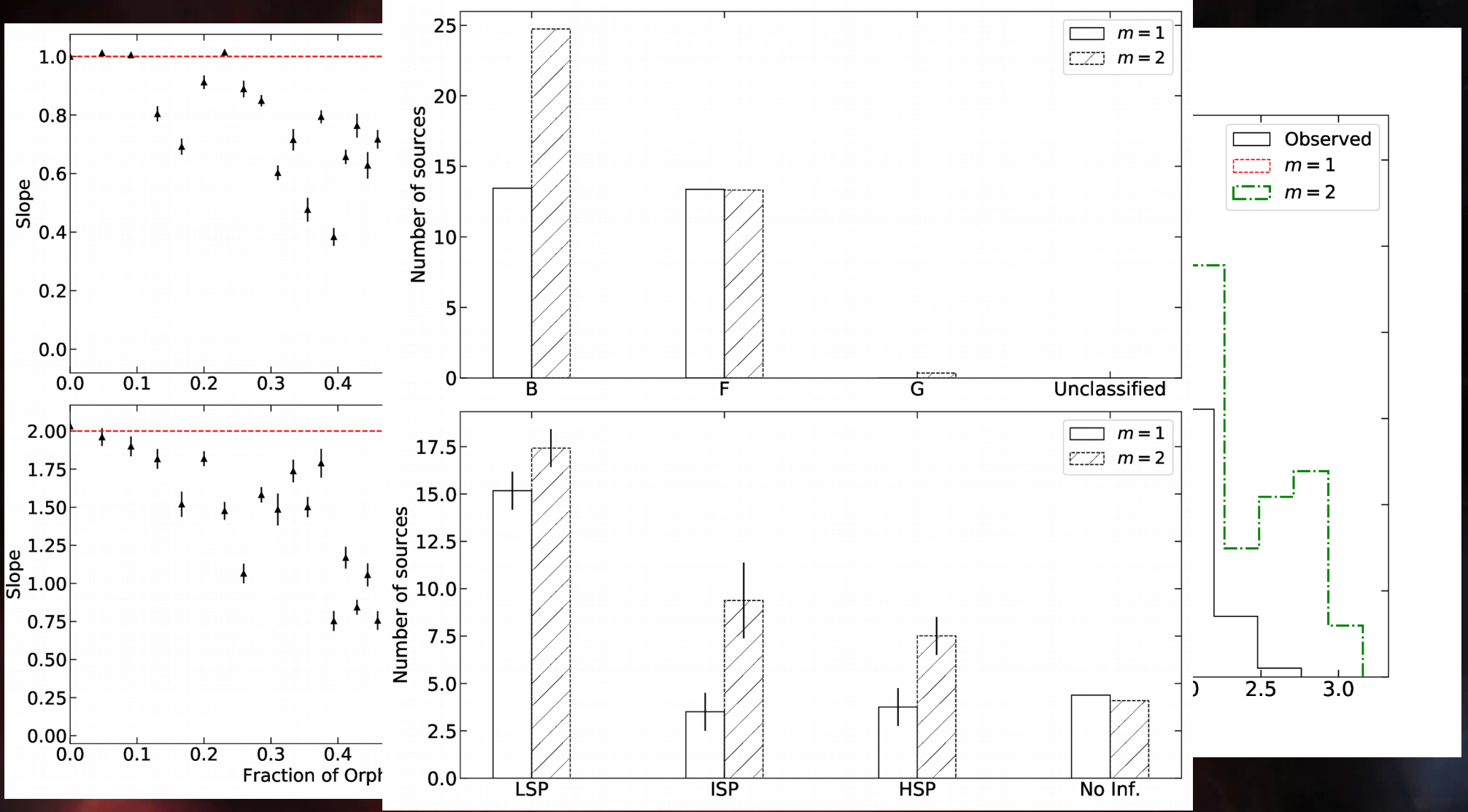


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Comparing observed to simulated distributions can be used to statistically associate sources with either EC or SSC!

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Summary.

Liodakis et al., 2019
APJ, 880, 32, arXiv:1905.11418

Explored the time-lags between optical and γ -rays for the largest number of sources.

The majority of sources show a strong correlation between optical and γ -rays. If your model can not produce simultaneous variations with a small number of orphan flares, its not a good model!

21% of γ -ray flares are truly orphan events.
Translation: only about 1 flare per 3 years is orphan!

BL Lacs favor SSC for the production of γ -rays,
FSRQs do not favor either EC or SSC!