A Multiwavelength Study of a Long-Duration VHE Flare from BL Lacertae with VERITAS

Claire E. Hinrichs, for the VERITAS Collaboration

Advisors: Wystan Benbow & Ryan Hickox

8th Heidelberg International Symposium on High-Energy Gamma-Ray Astronomy

September 2024 - Milan, Italy

CENTER FOR
ASTROPHYSICS
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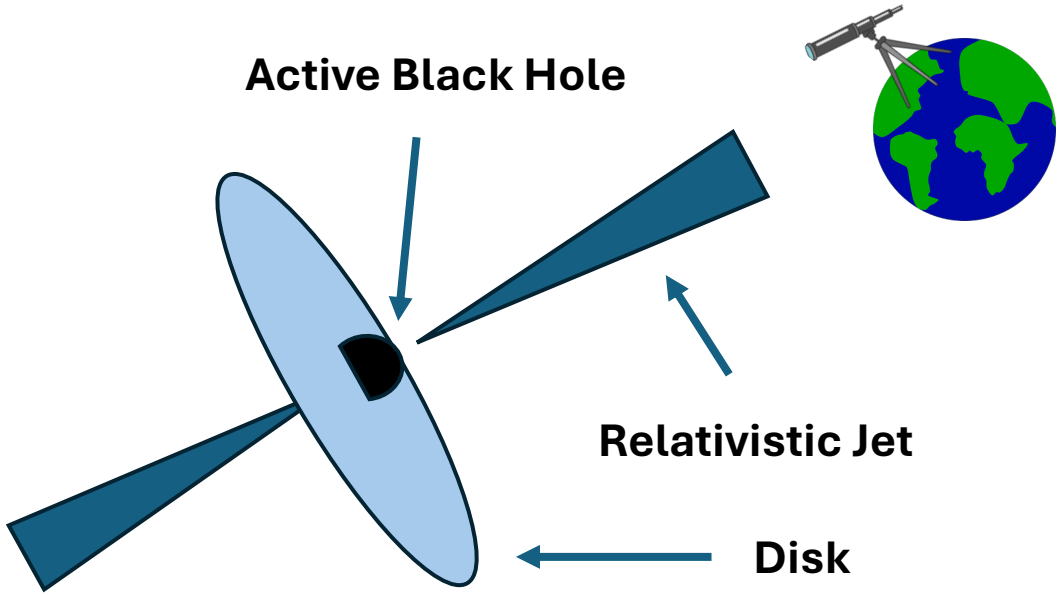
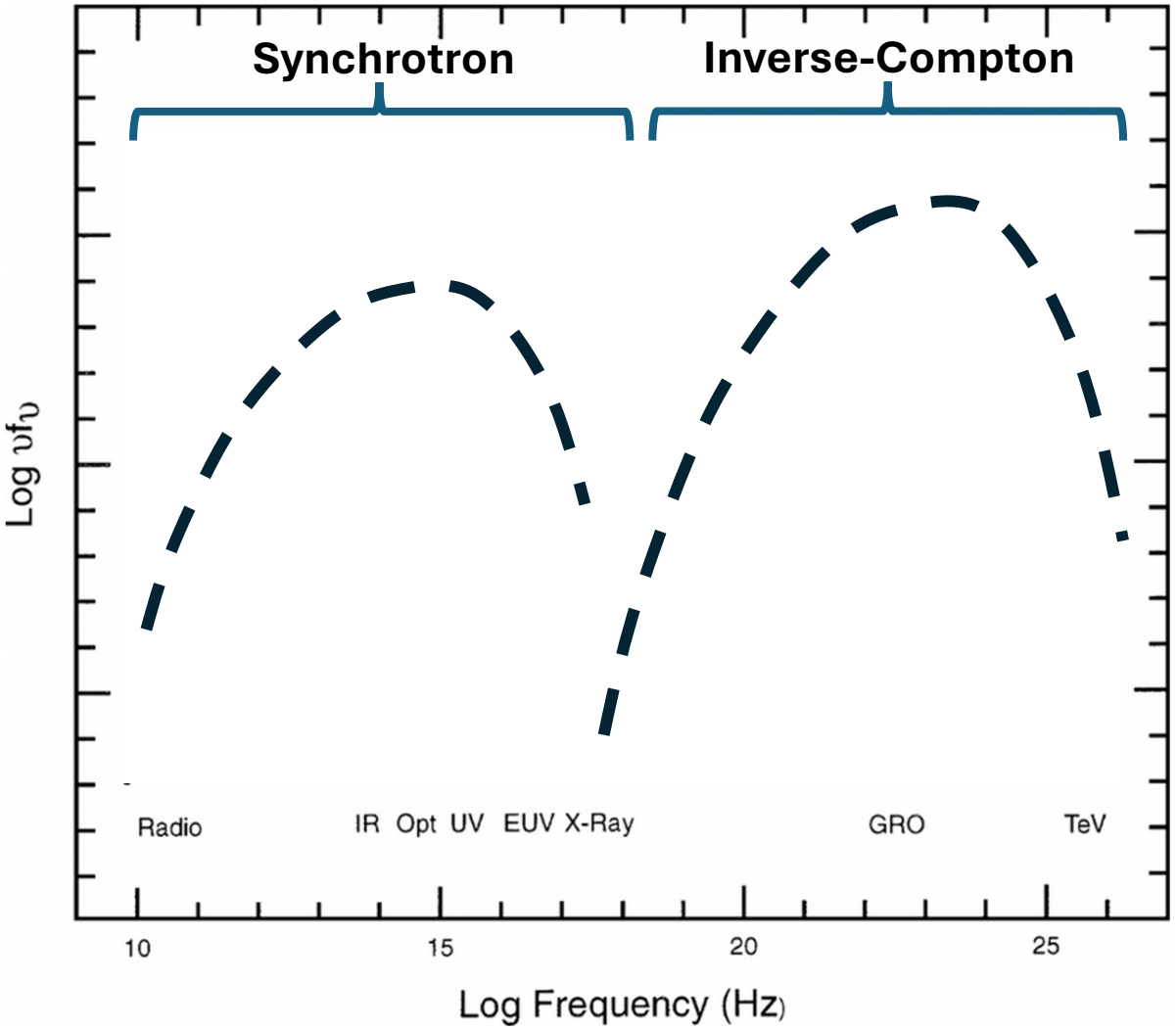
Courtesy of SAO

A Glance at Blazars

- Subclass of AGN
  - Jet along our line of sight
- Double-humped SED
  - Blazar Sequence:
    - LBL, IBL, HBL …



MODIFIED Sambruna et al. 1996



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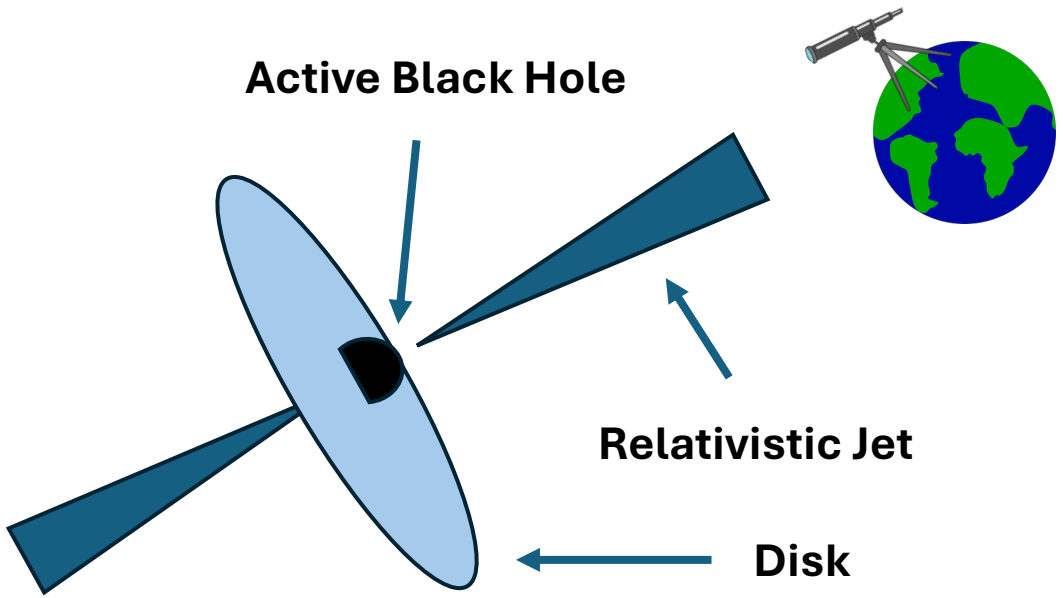

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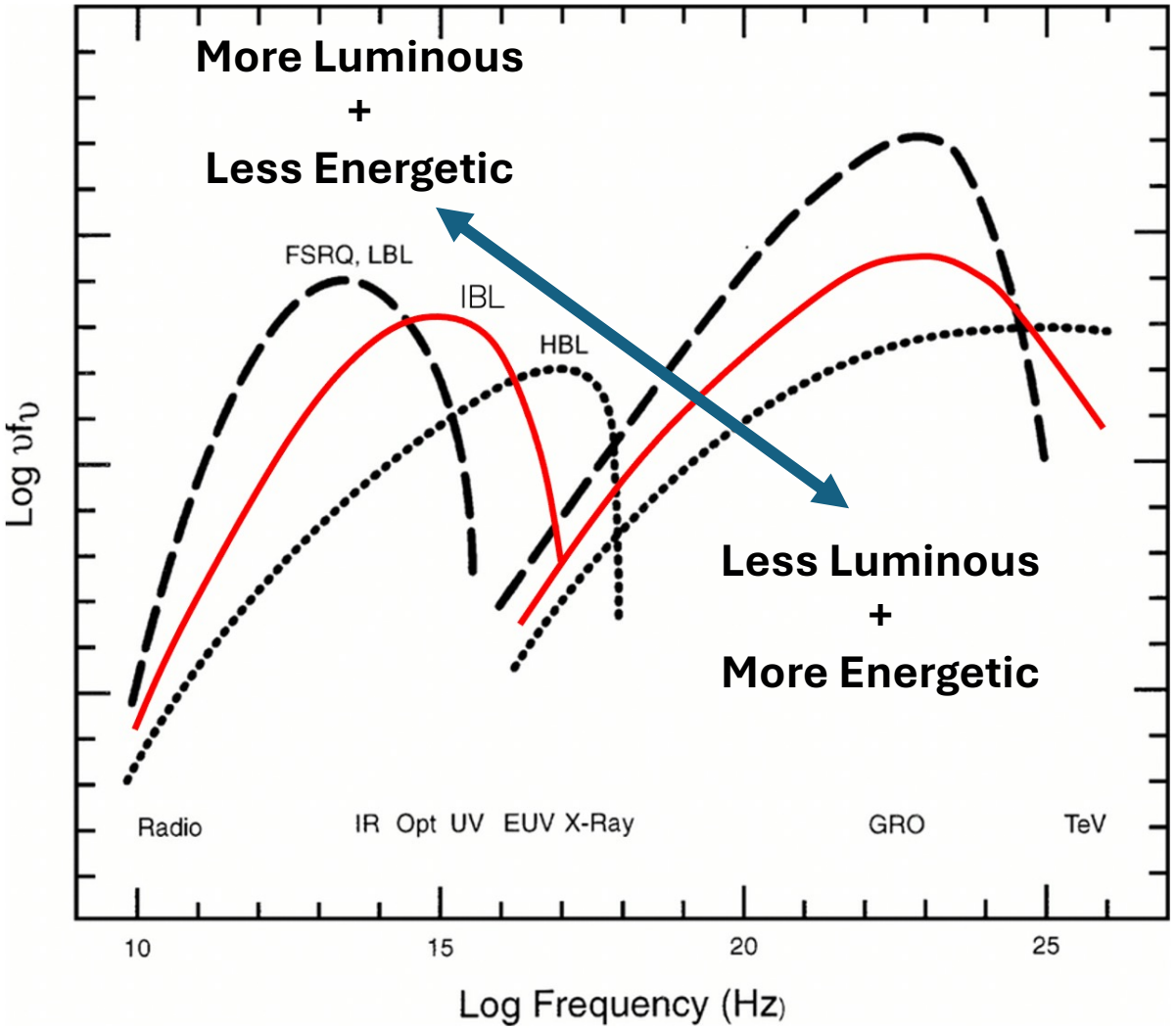

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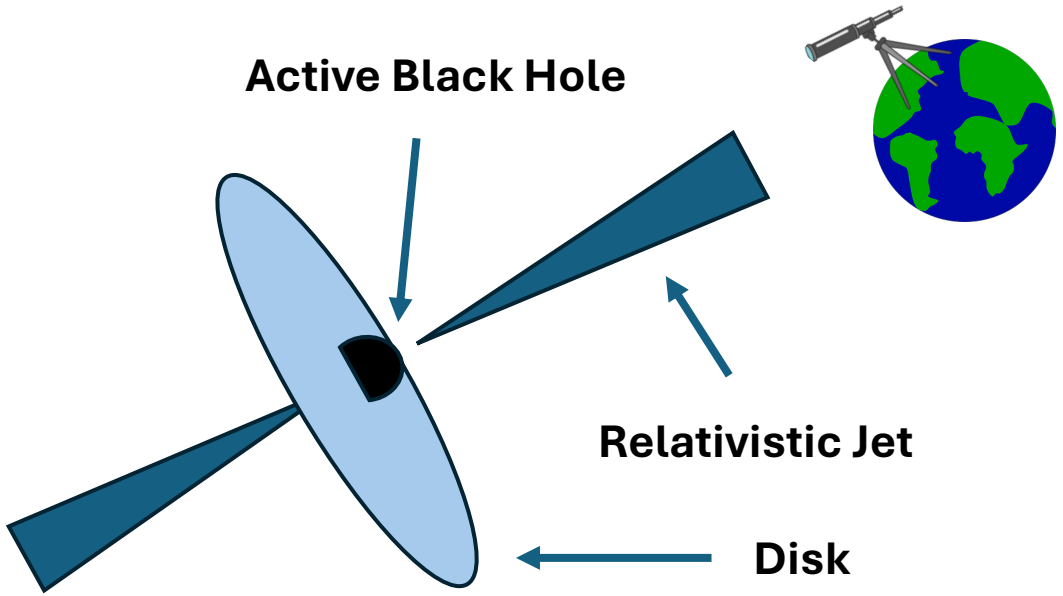

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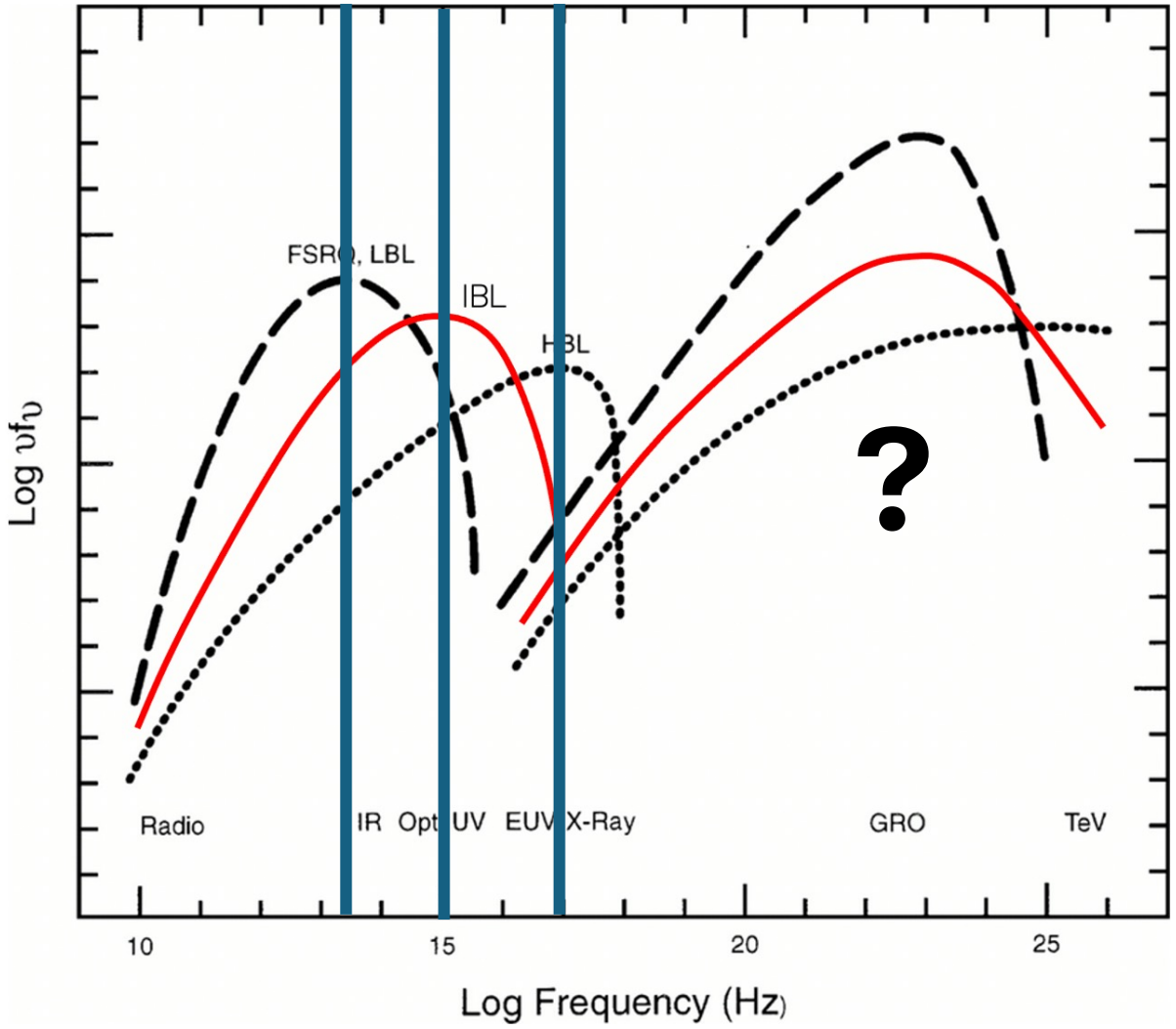

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  - LBL: EC
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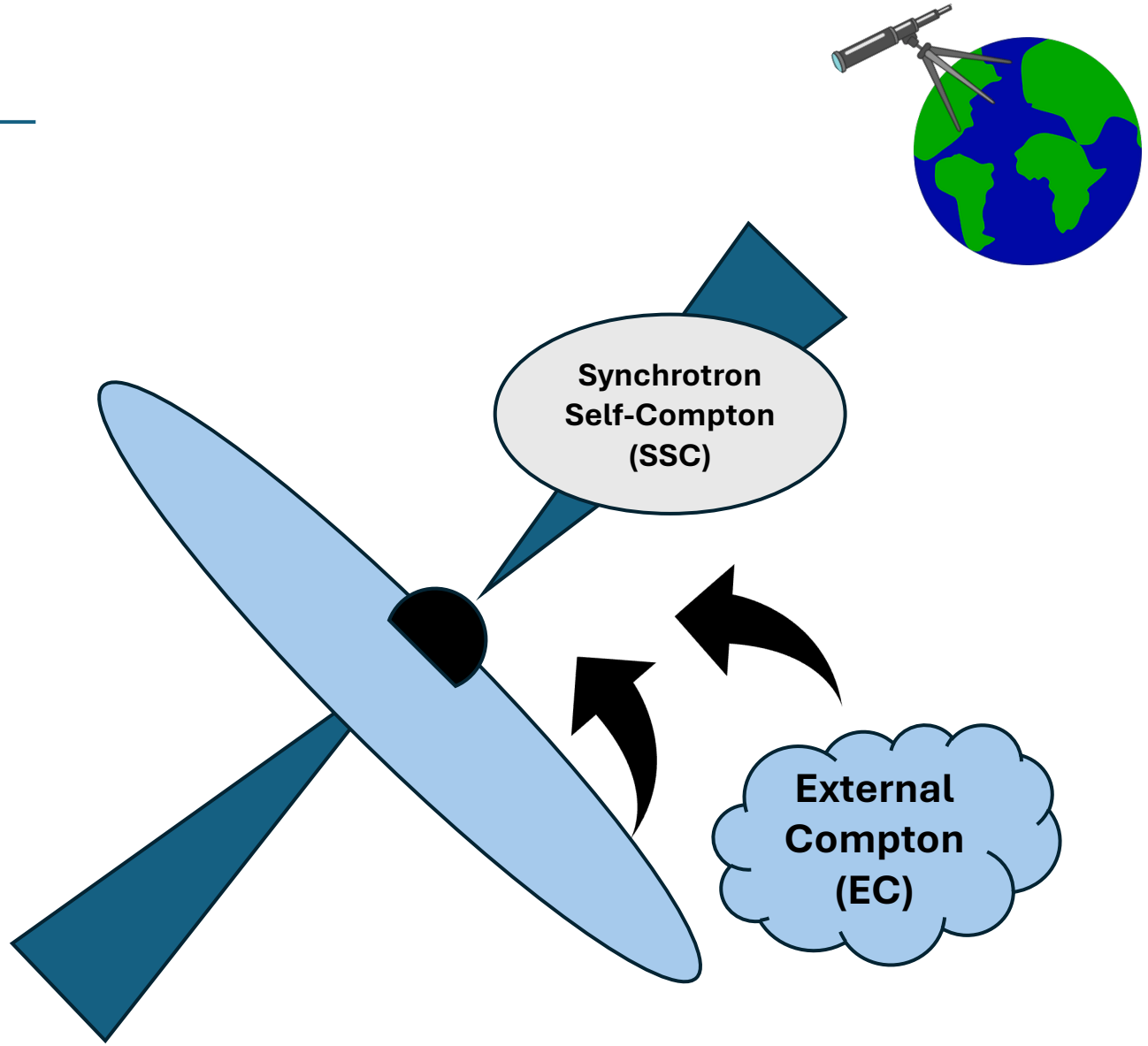

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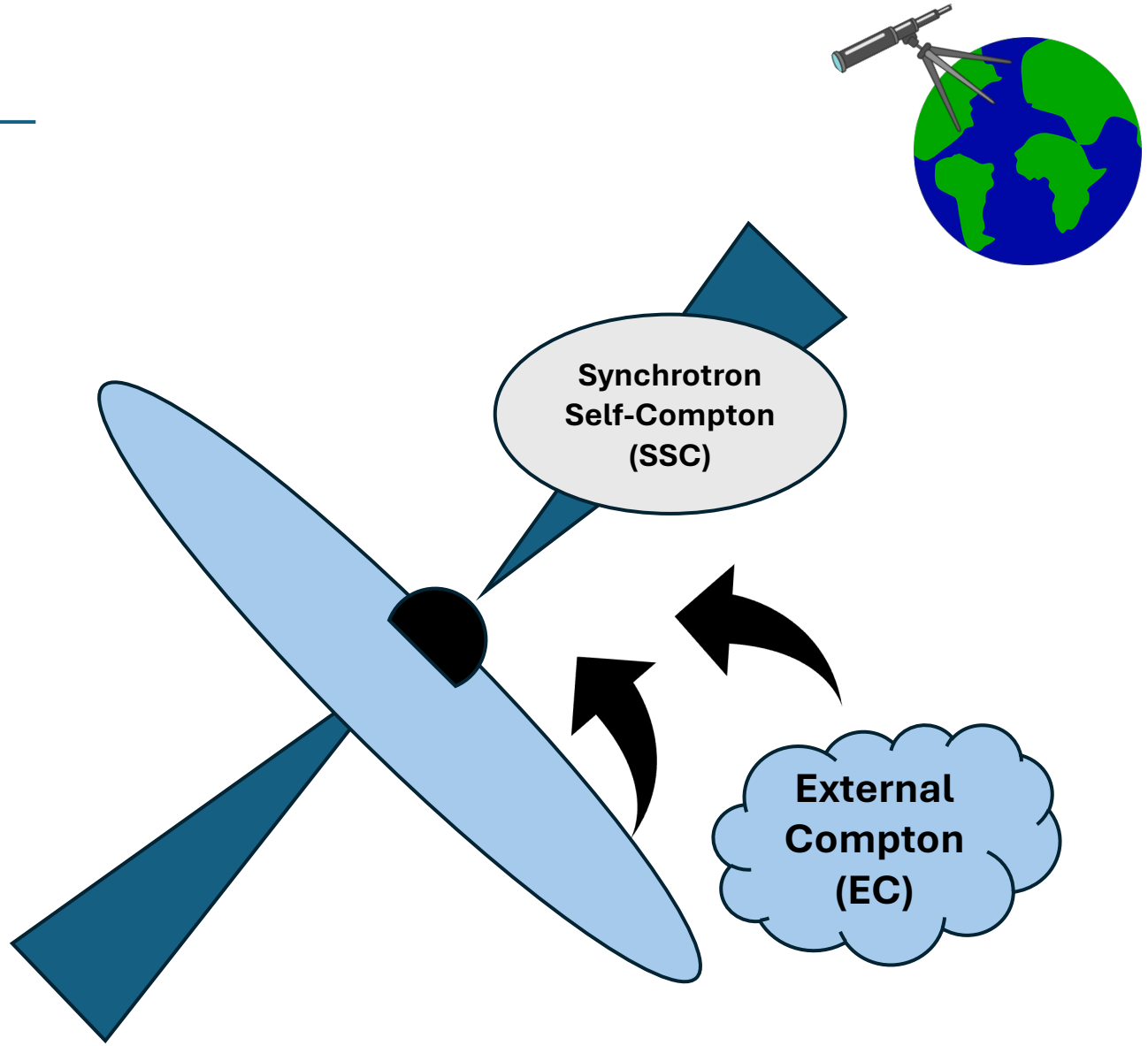

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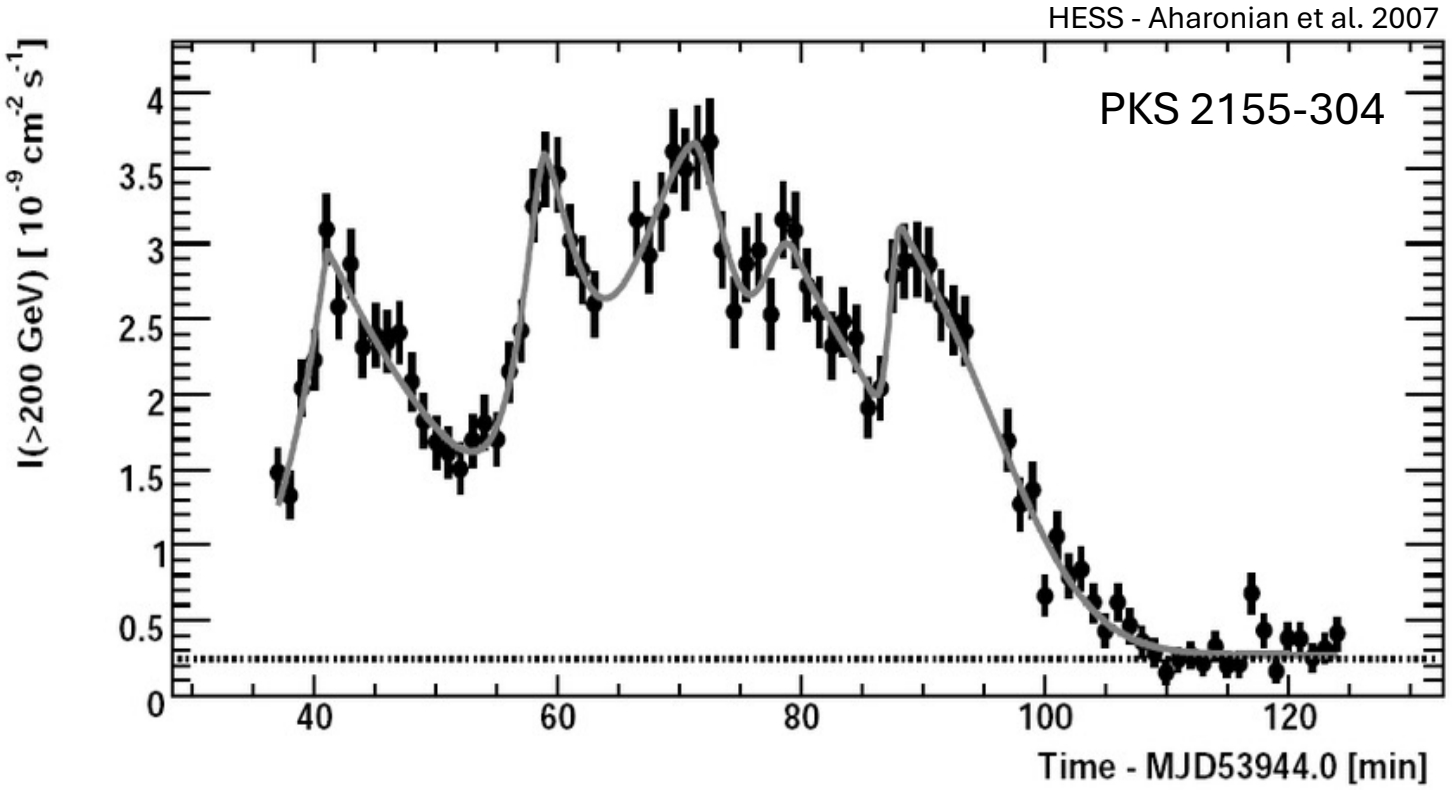

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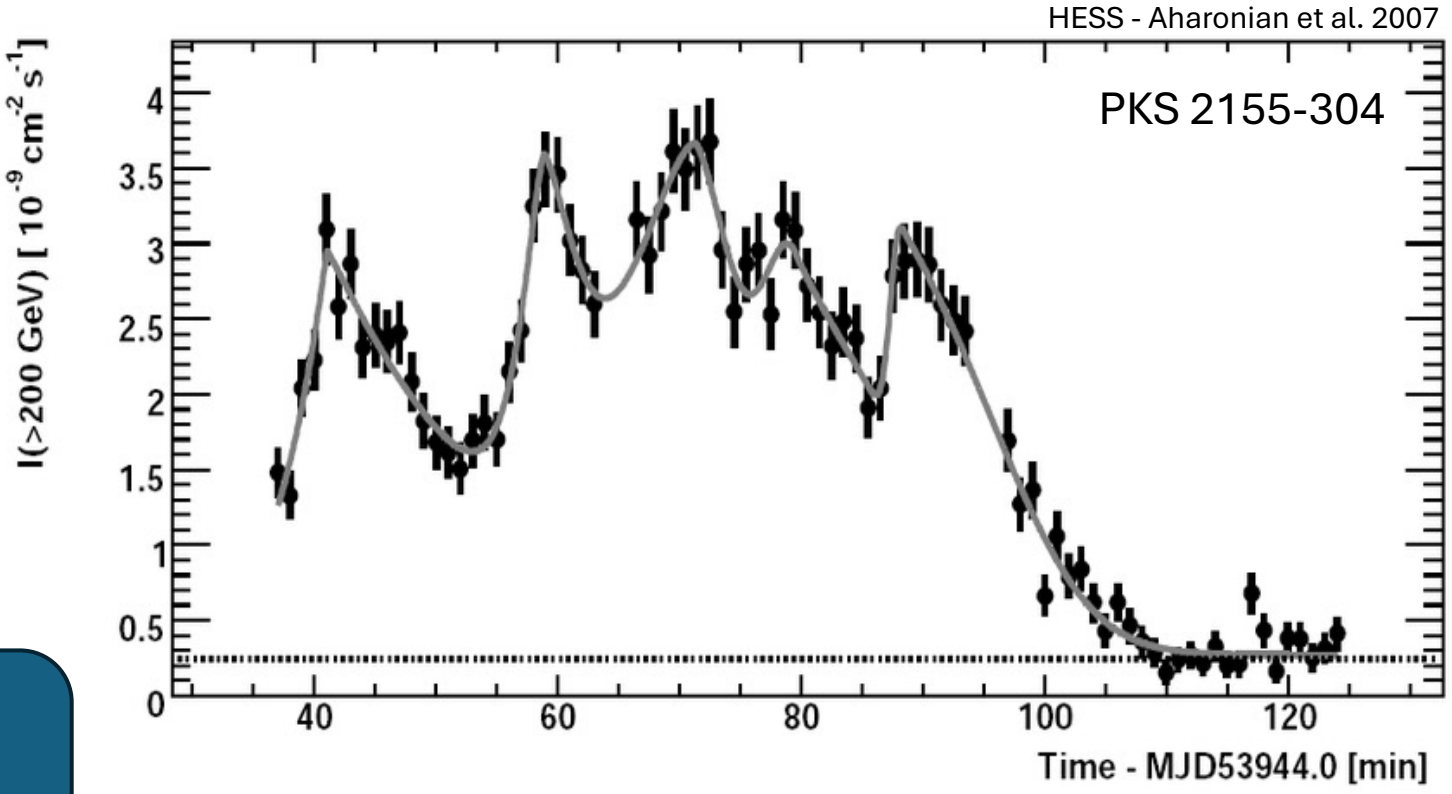

<u>Open Question #2:</u>
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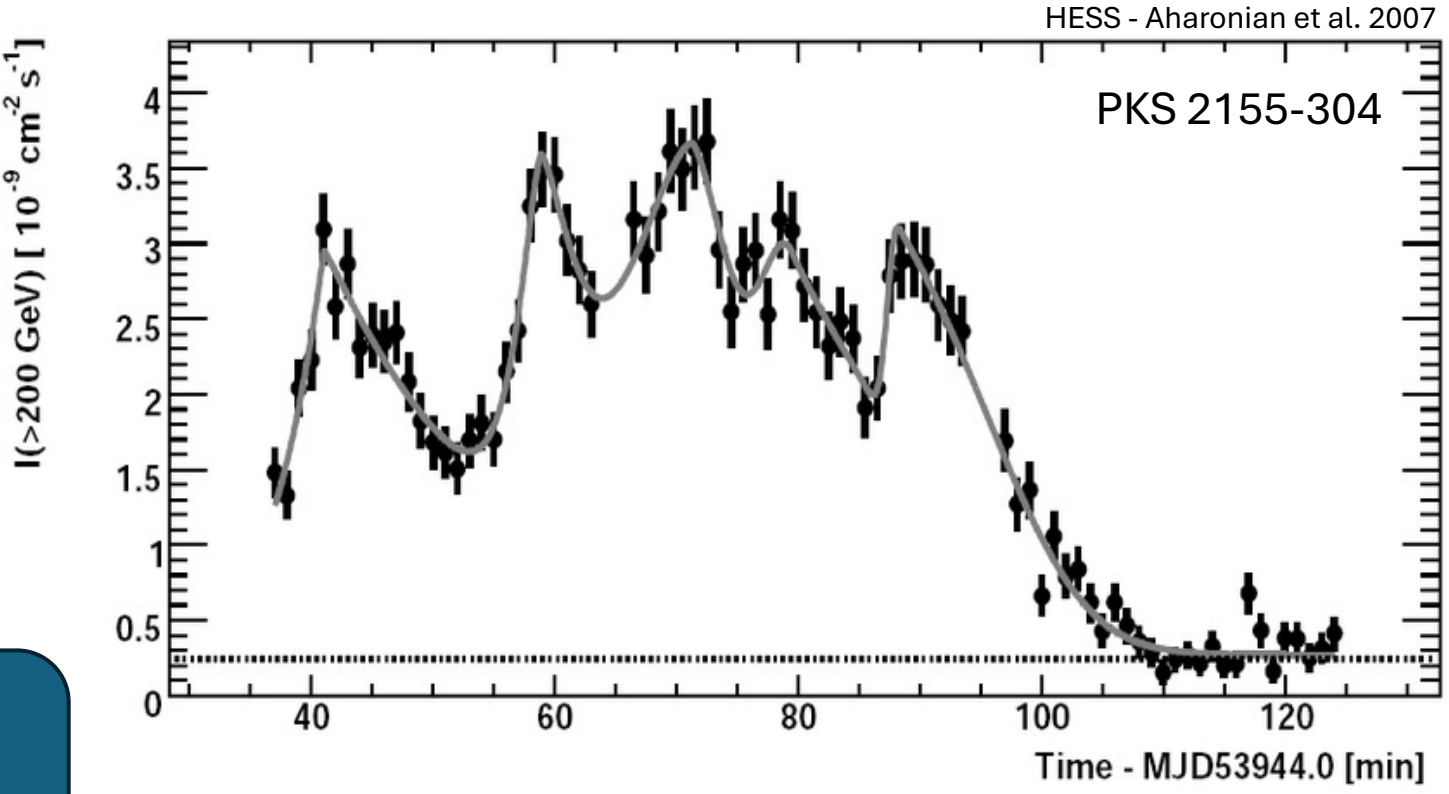

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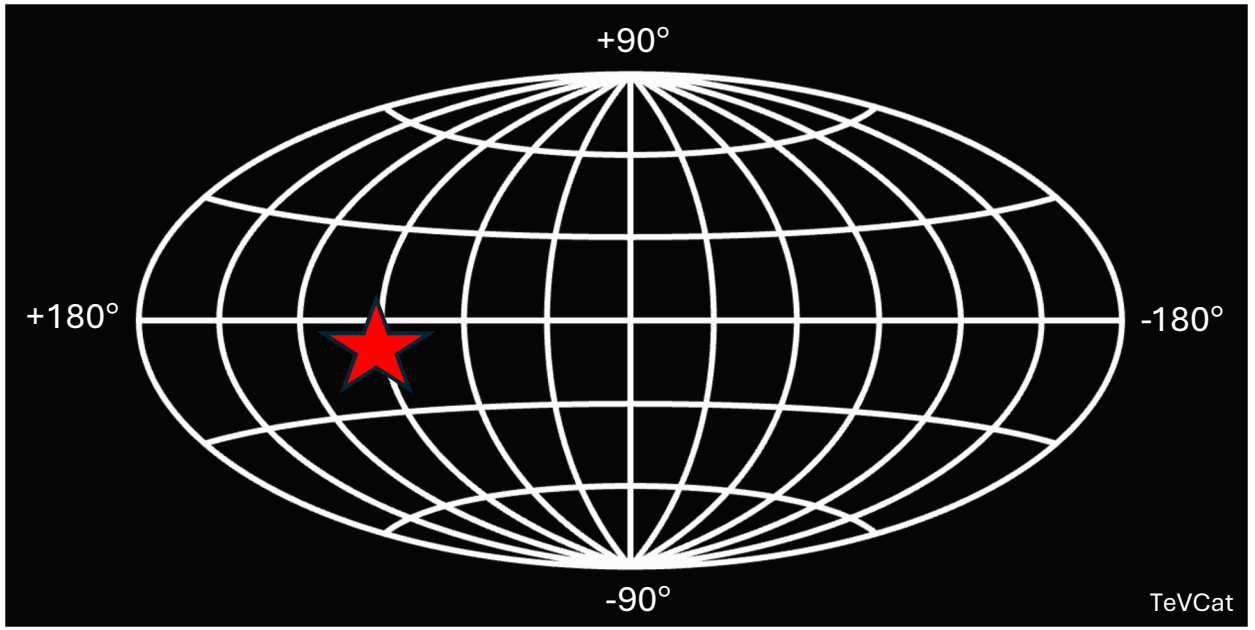
STUDY AND MODEL IBLs DURING BOTH FLARING AND NON-FLARING STATES!

Fall 2022 BL Lacertae Flare

BL Lacertae

- Blazar - IBL
  - z = 0.07
- Typically >>10 hr to detect in VHE (5**σ**)



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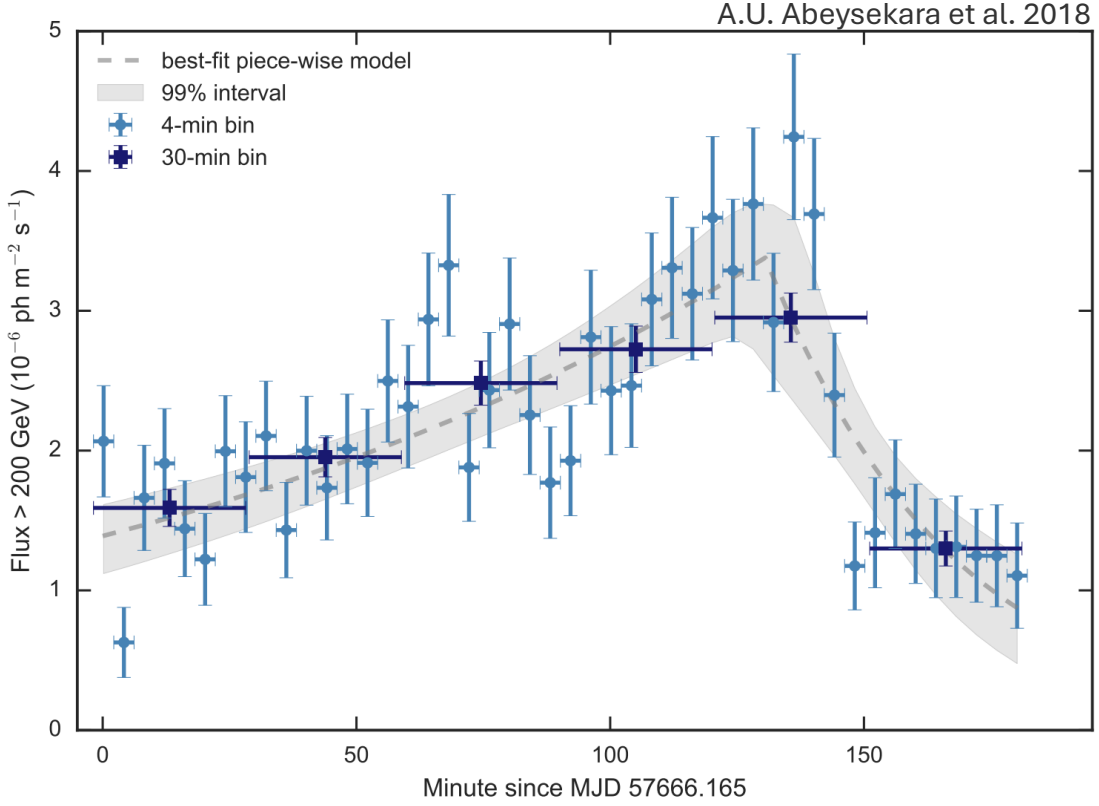
  - May 2019 flare
  - **2020-2022 active state**

A.U. Abeysekara et al. 2018



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Previous flaring activity has only shown rapid variability (minutes to day timescales)!

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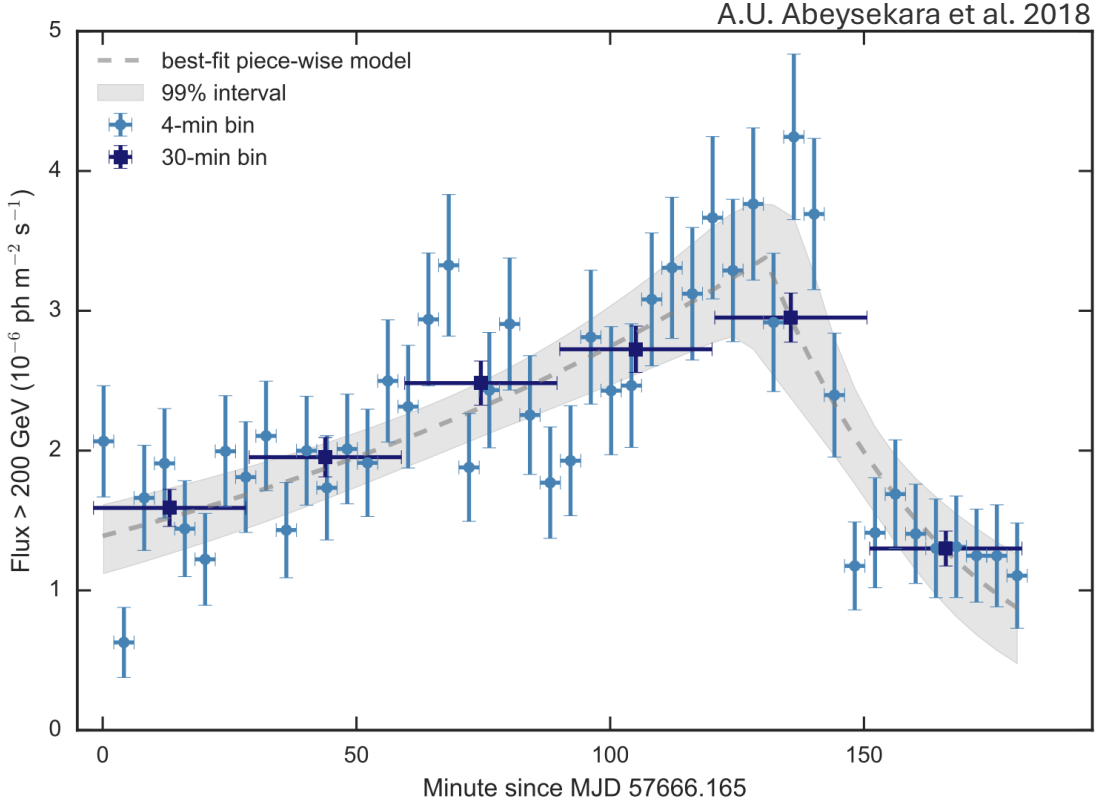

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Fall 2022 BL Lacertae Flare Timeline

2020-2021

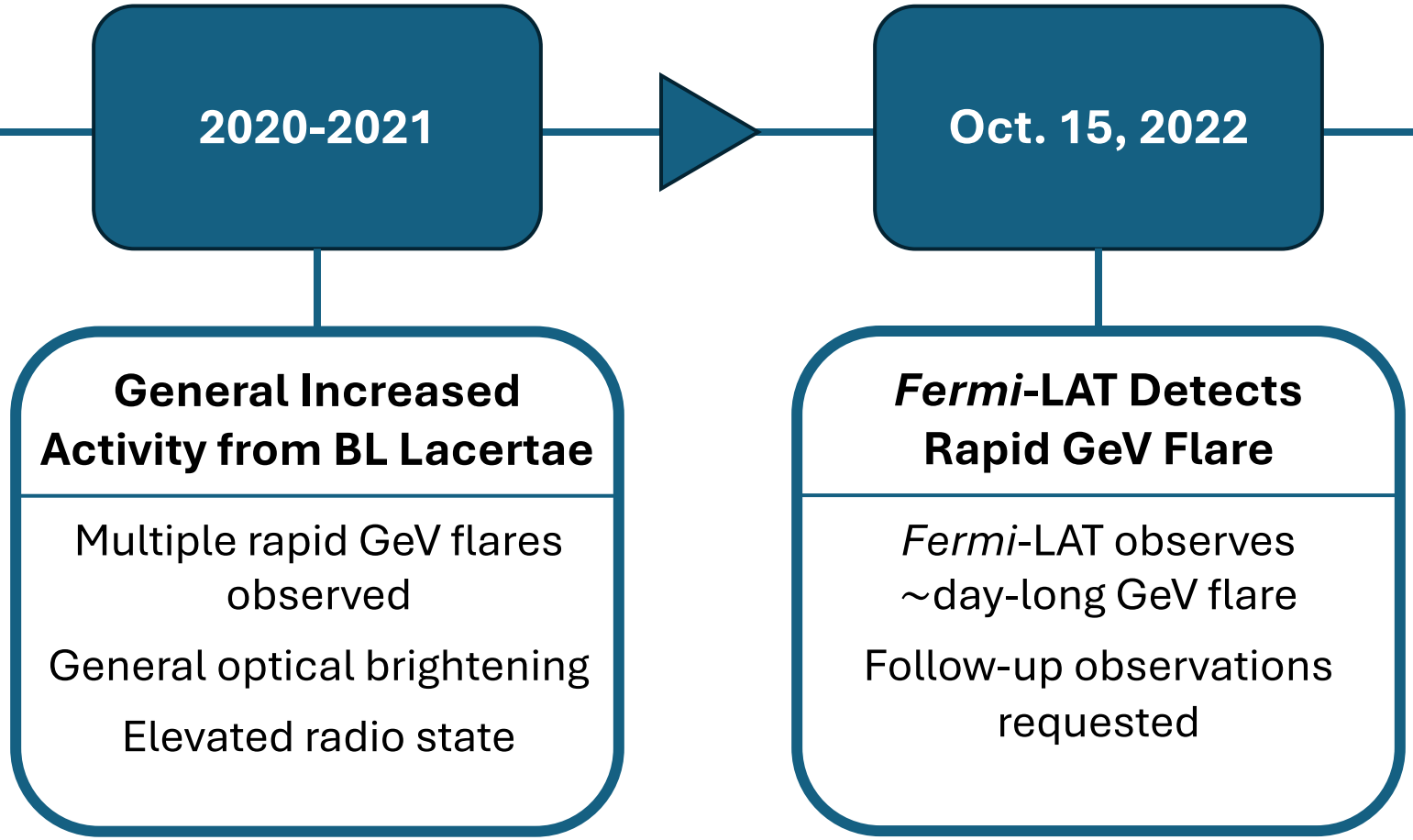
General Increased Activity from BL Lacertae

Multiple rapid GeV flares observed

General optical brightening

Elevated radio state

Fall 2022 BL Lacertae Flare Timeline



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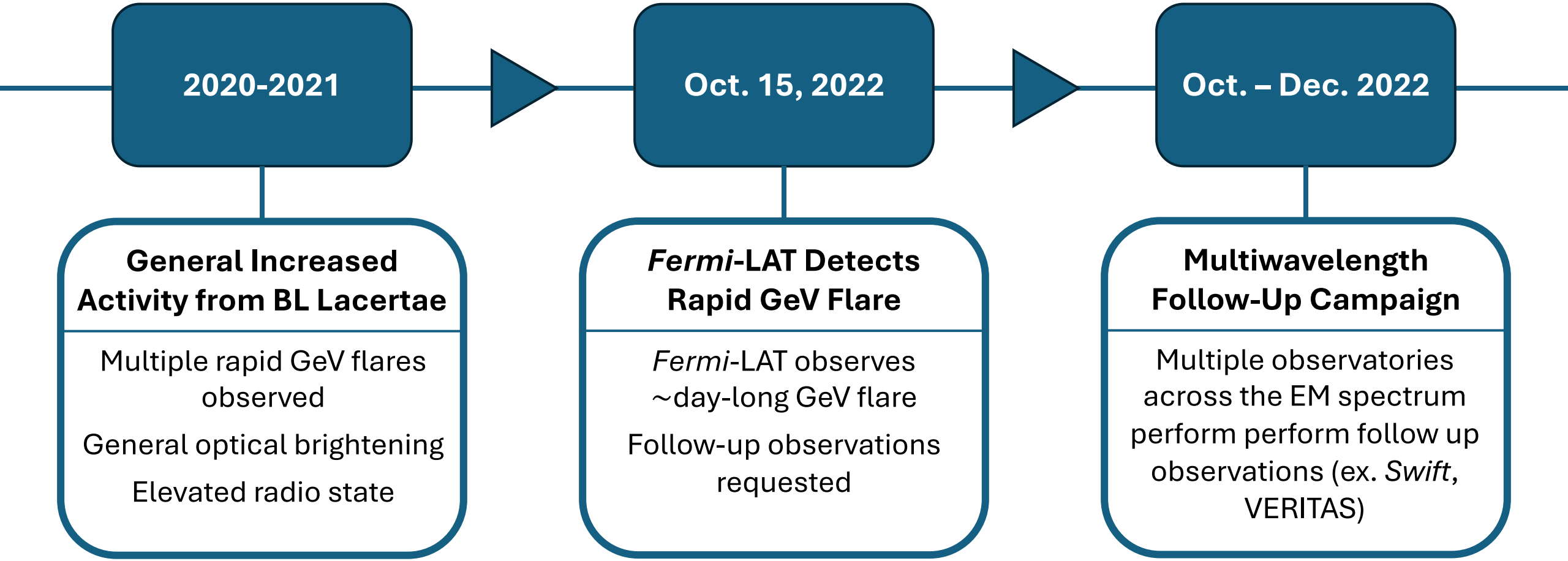


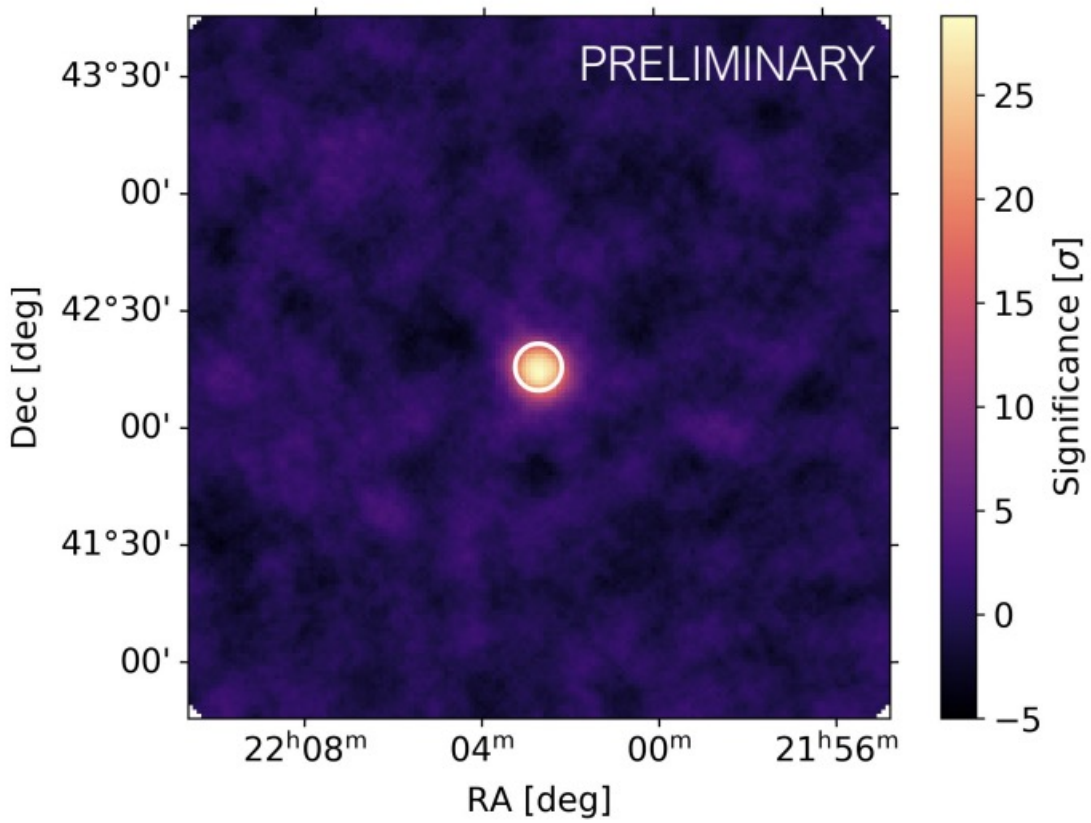
VERITAS

- Fred Lawrence Whipple Observatory, Tucson, AZ, USA
- Array of four 12-m Atmospheric-Cherenkov Telescopes
- Energy range: ~ 100 GeV to ~ 30 TeV
- One of the most sensitive ground-based TeV observatories

VERITAS Results

- Total Exposure: ~10 hr
  - Sept. - Dec. 2022
- ~10% Crab Nebula Flux; **28σ**
  - F (>350 GeV): $(1.1 \pm 0.1) \times 10^{-11}$ cm^{-2}s^{-1}

VERITAS Significance Map



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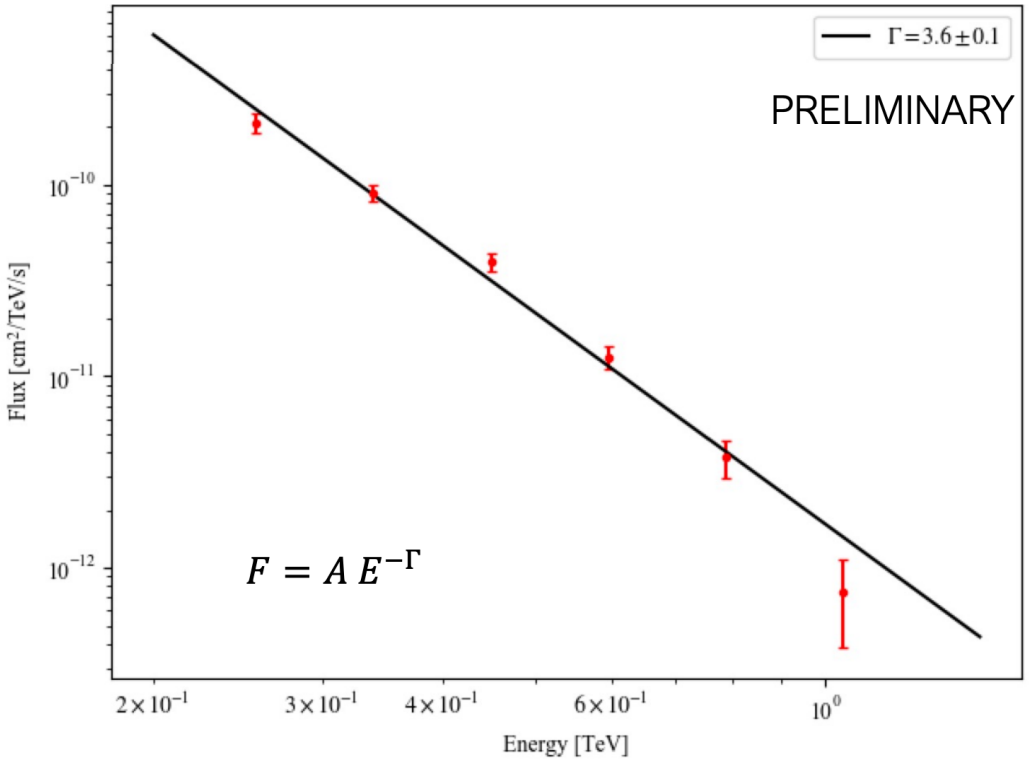
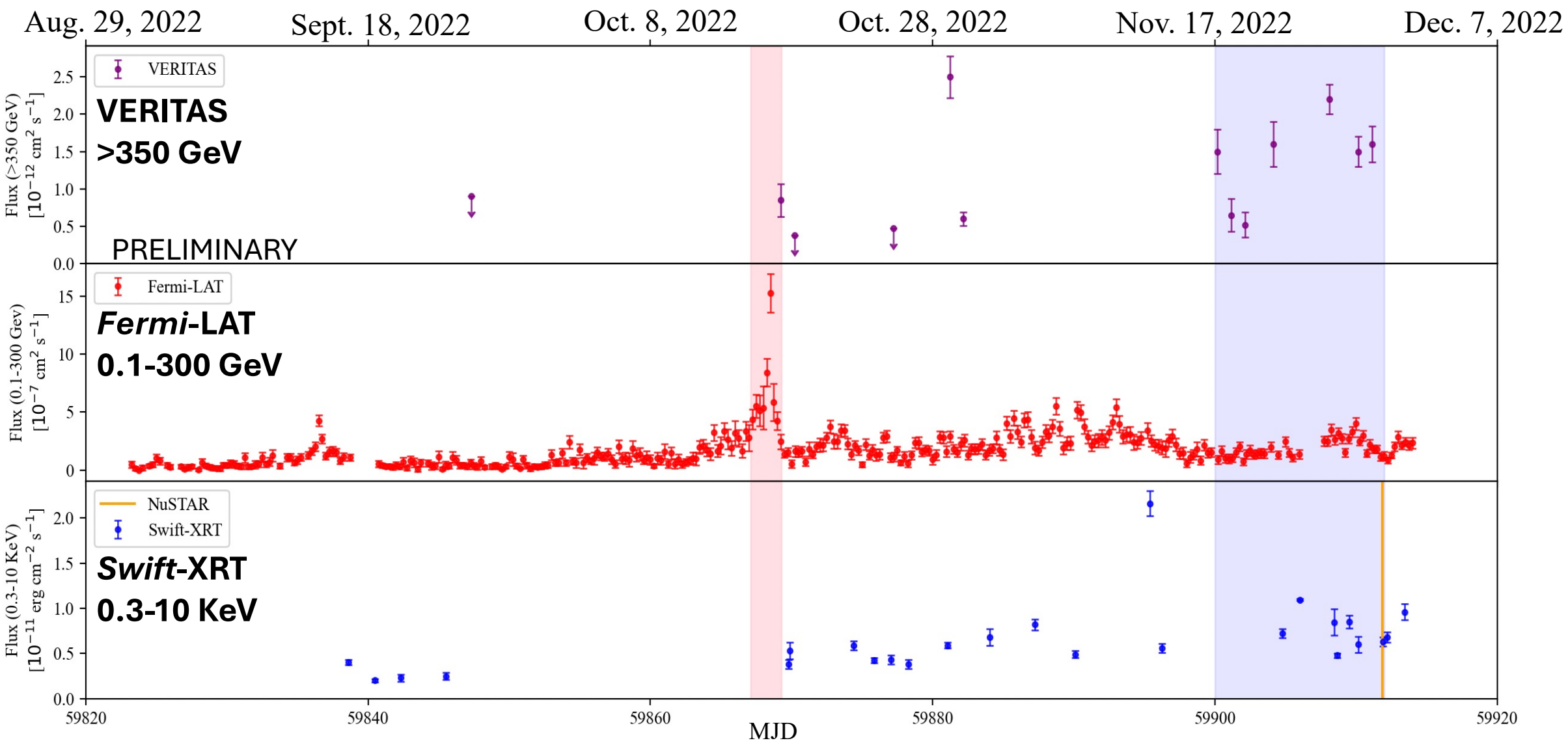
- Photon Index: 3.6 ± 0.1
  - Power Law Fit: χ^2/DOF ≅ 10.2/4 ≅ 2.6
  - Soft spectrum consistent with previous flares

VERITAS Photon Spectrum



High-Energy Multiwavelength Lightcurve



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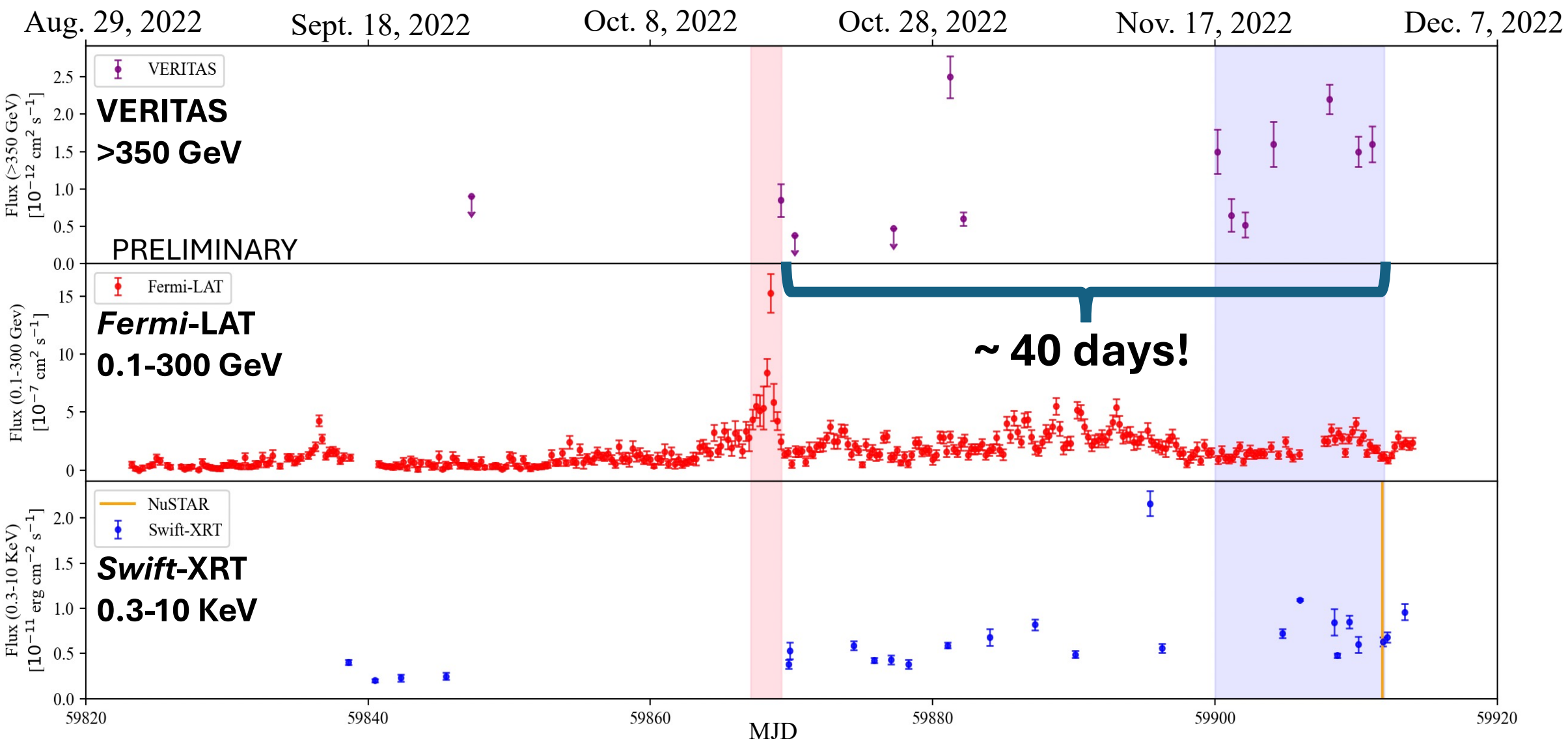


VERITAS

***Fermi*-LAT**

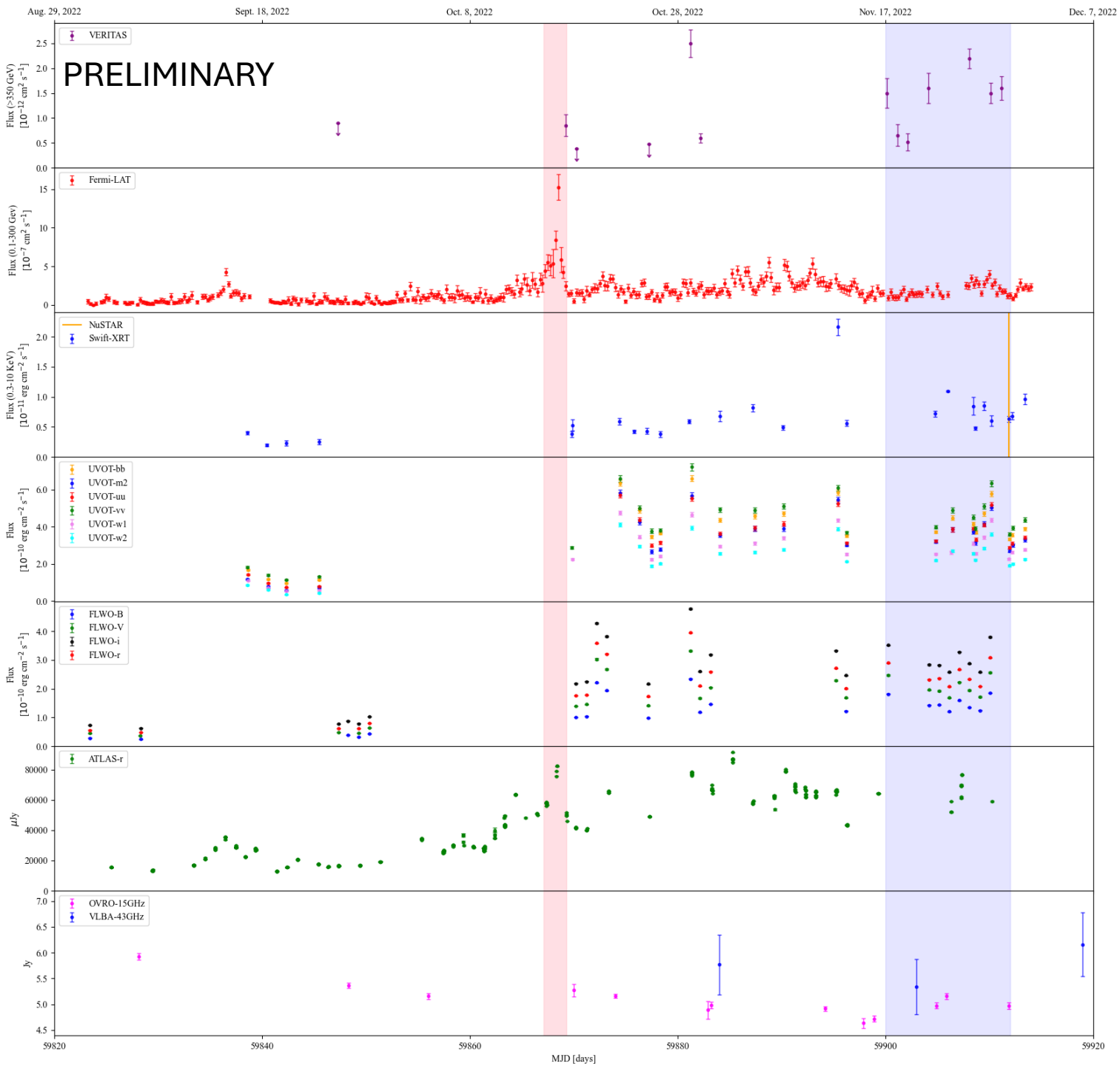
***Swift*-XRT**

***Swift*-UVOT**

FLWO – Optical

ATLAS – Optical (r)

OVRO + VLBA (radio)



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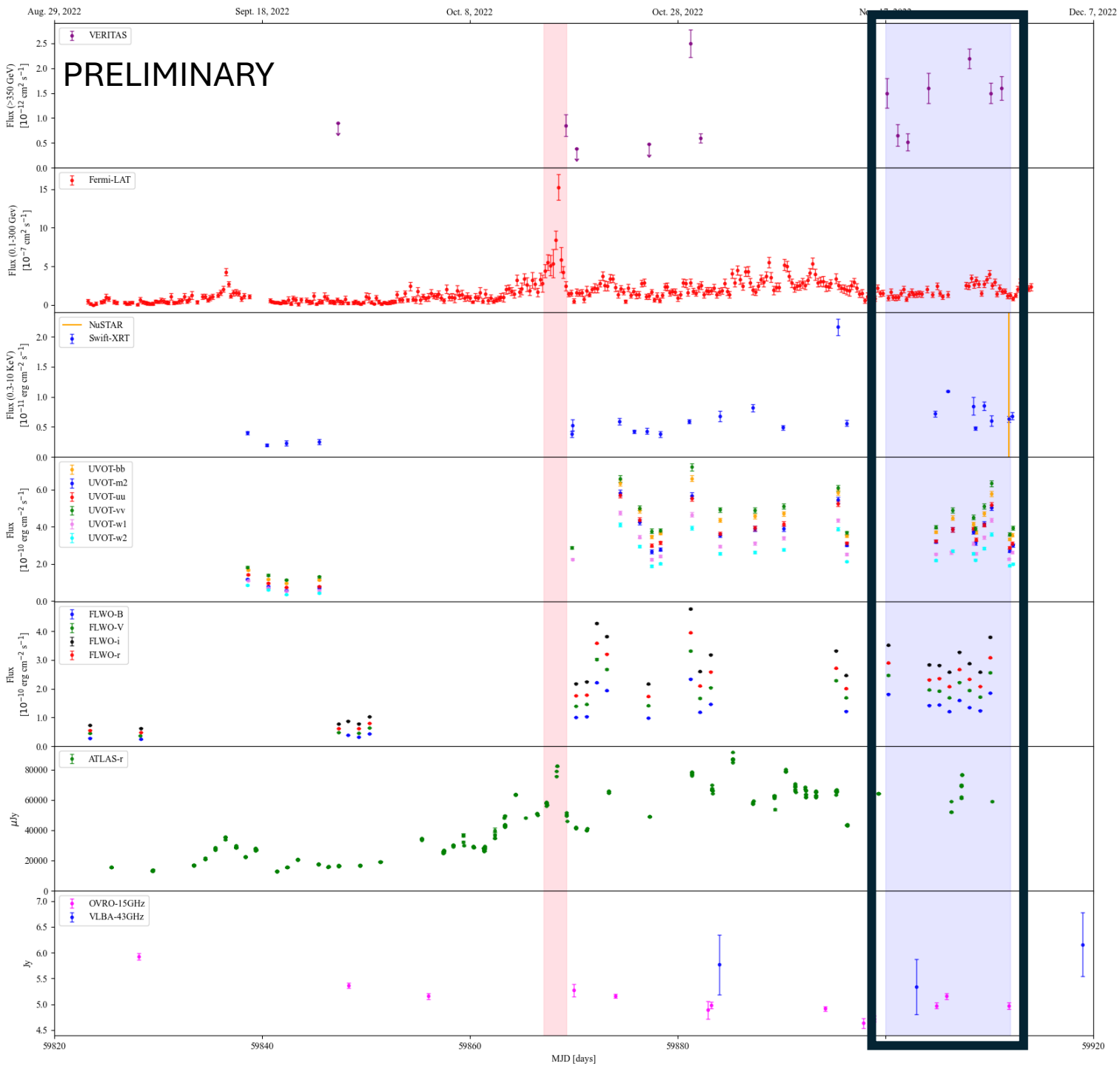
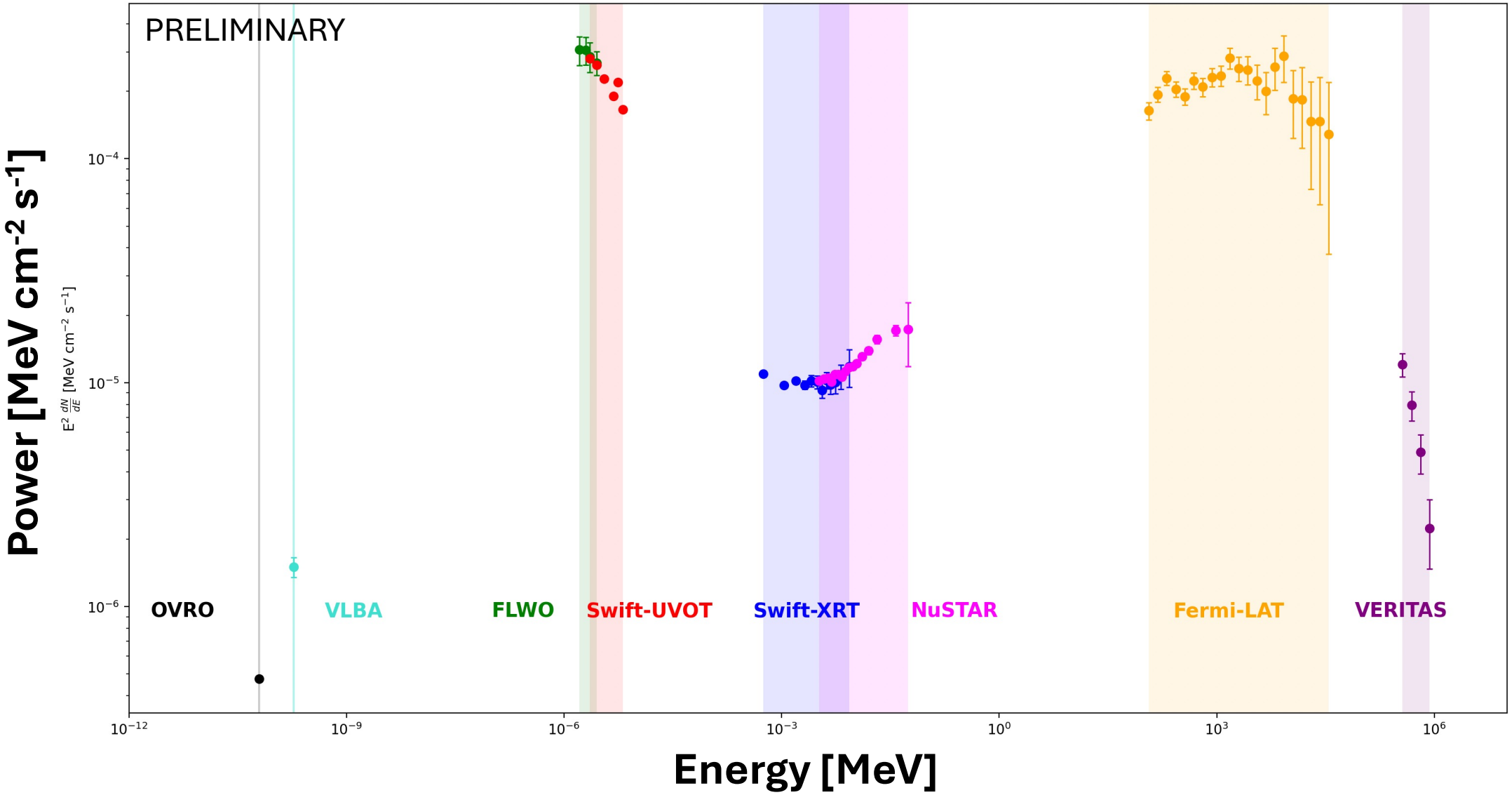
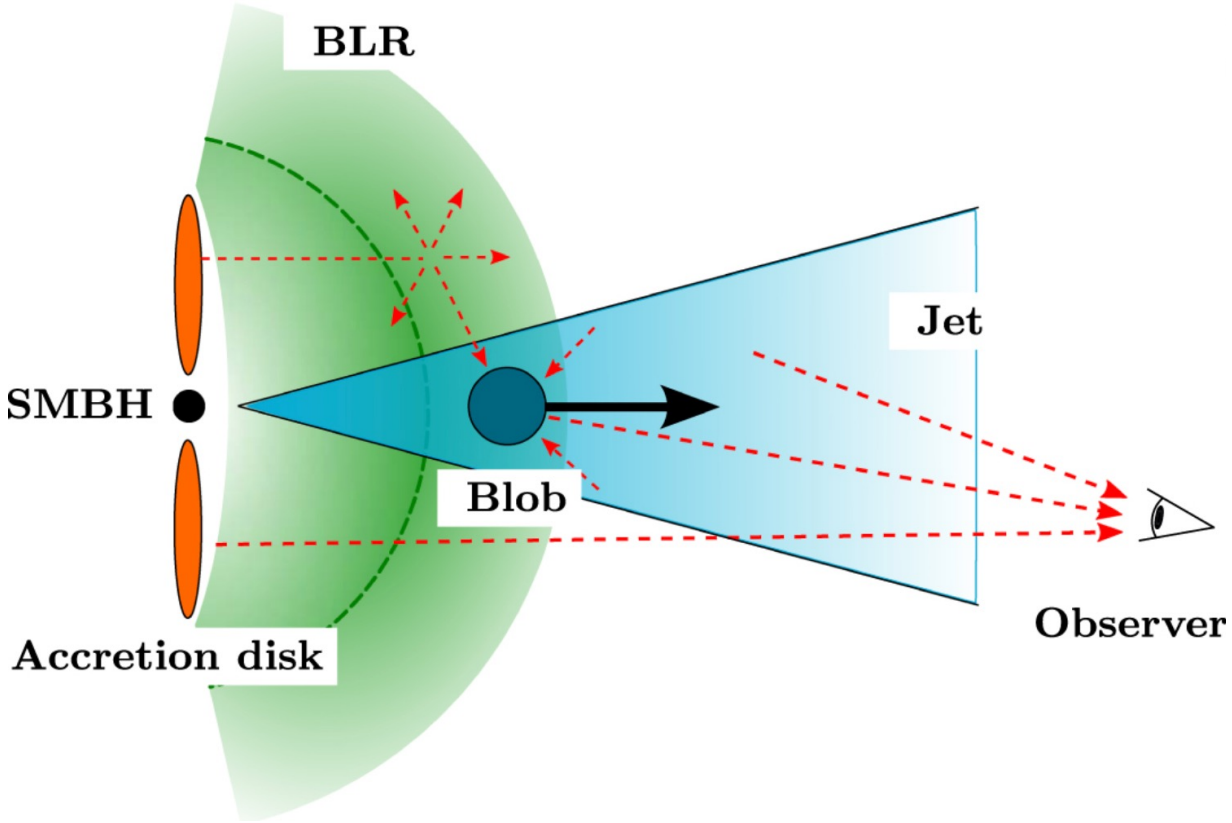


Spectral Energy Distribution - VERITAS Epoch



SED Modeling



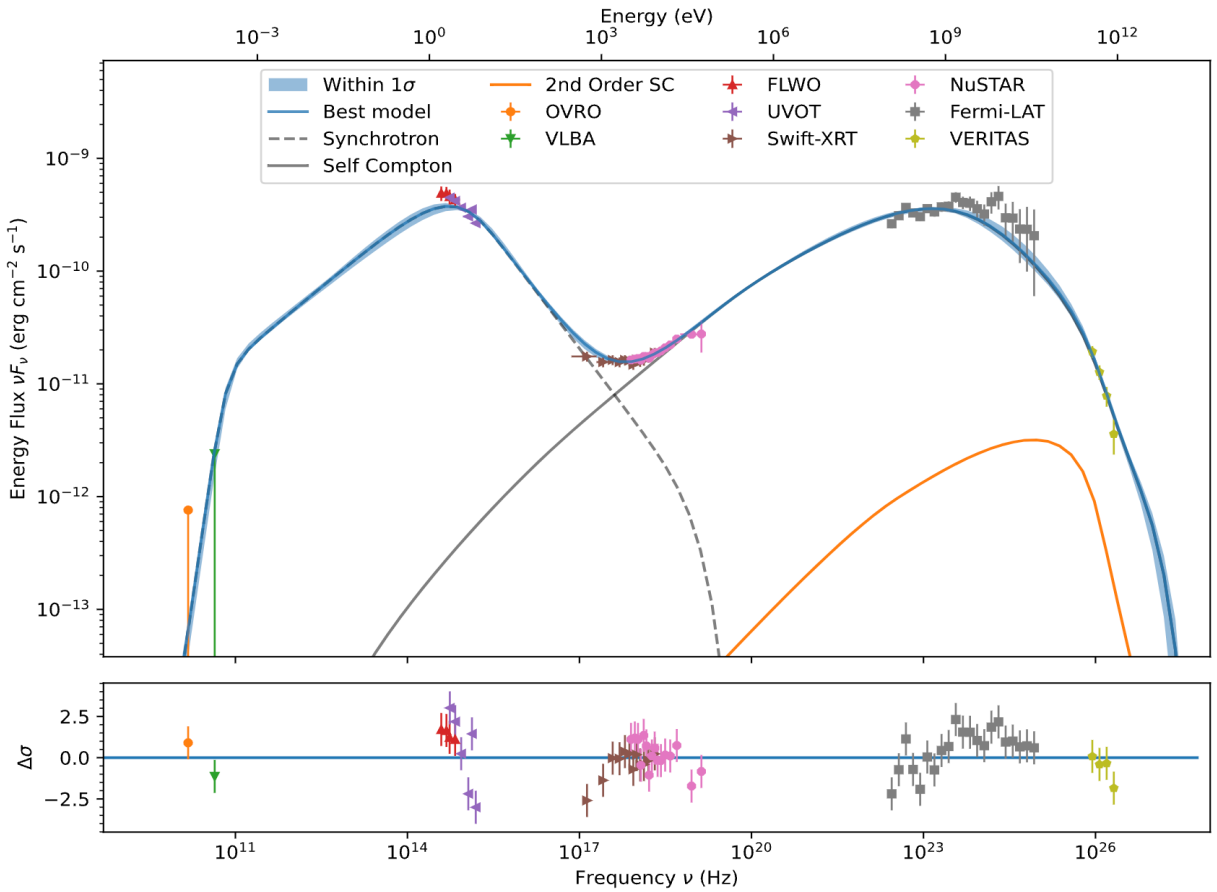
- One-zone SSC vs. SSC+EIC modeling
- Nested model
  - Allows for direct comparison
- Publicly available blazar SED modeling tool
  - https://github.com/Ohervet/Bjet_MCMC

O. Hervet et al. 2024

BJET_MCMC

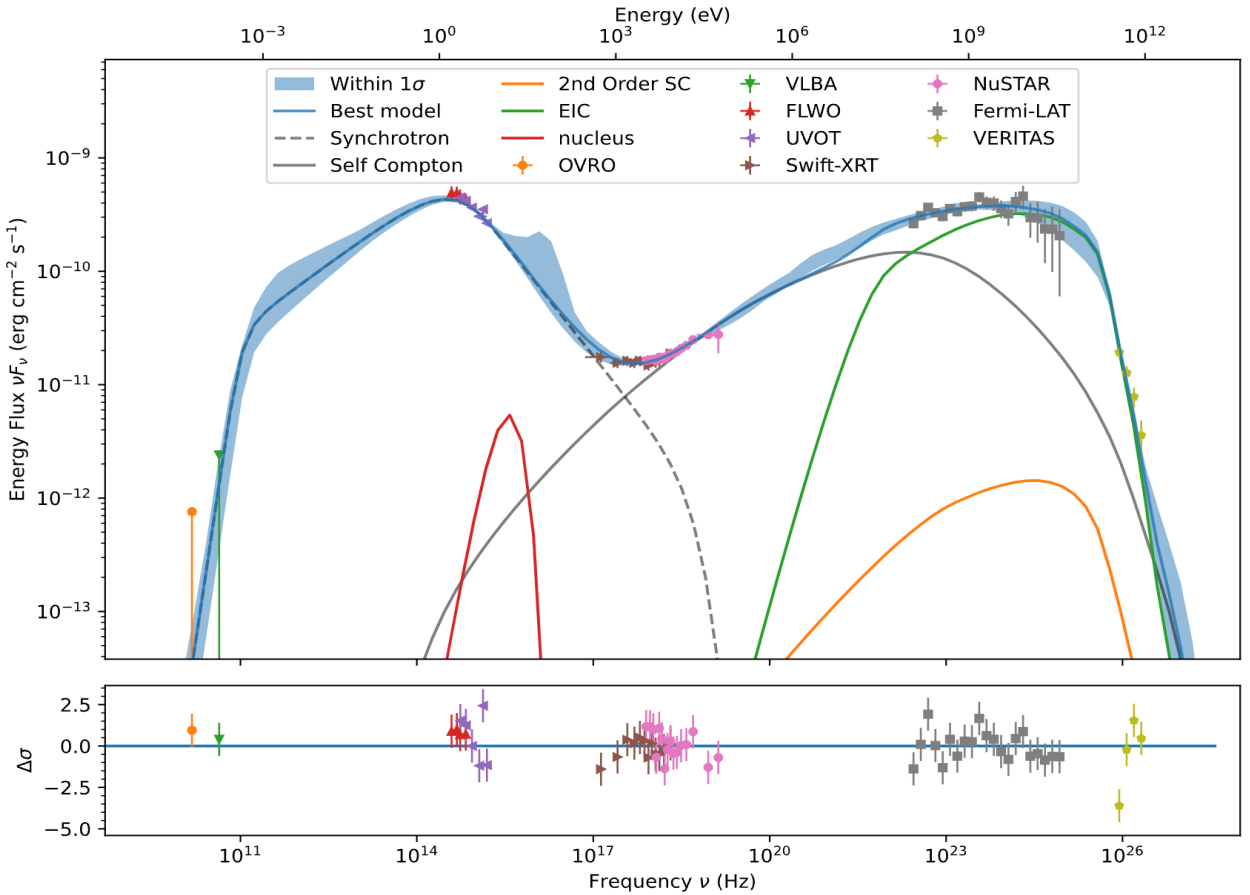
SED Modeling Results

SSC Model



Reduced Chi Square: 97.8 / 56 = 1.75

SSC+EIC Model

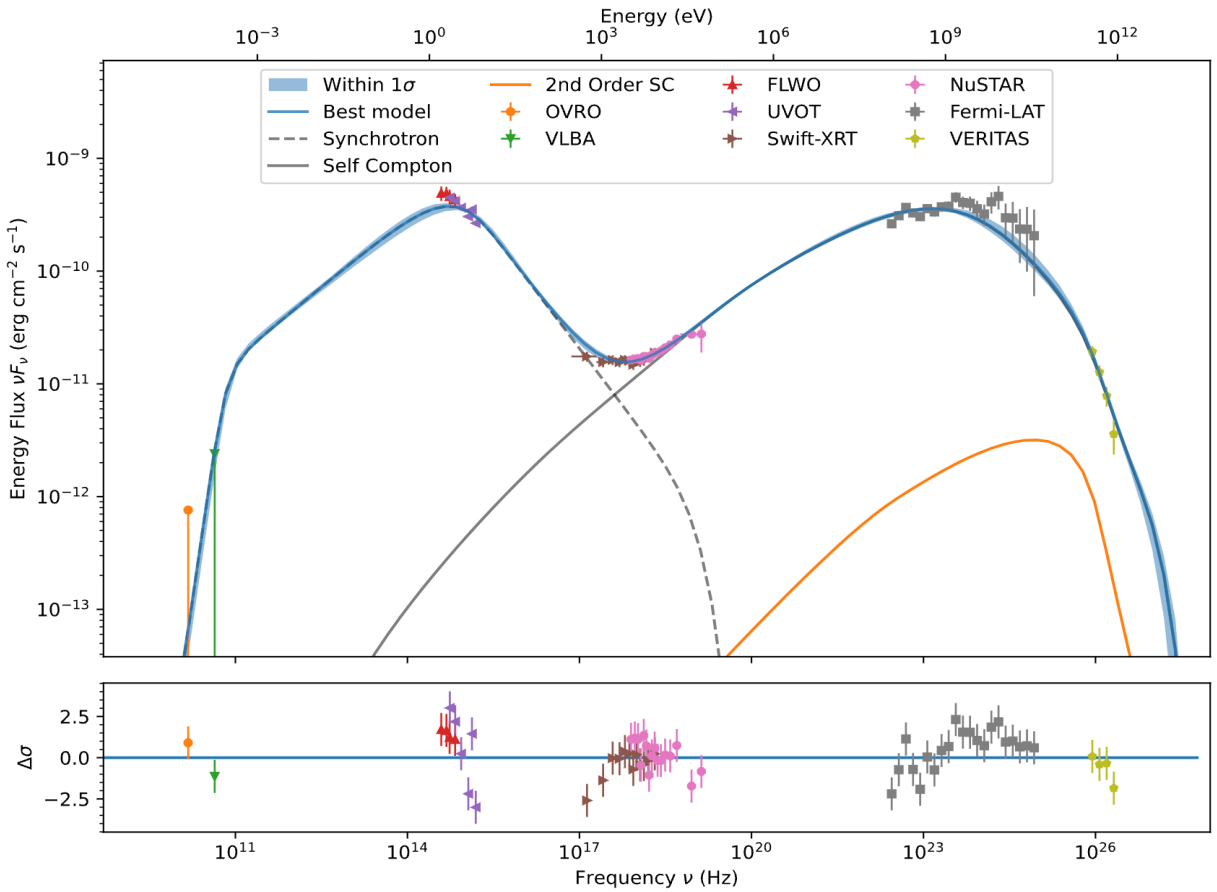


Reduced Chi Square: 54.4 / 52 = 1.05

SED Modeling Results

7σ preference for SSC+EIC model over pure one-zone SSC model!

SSC Model



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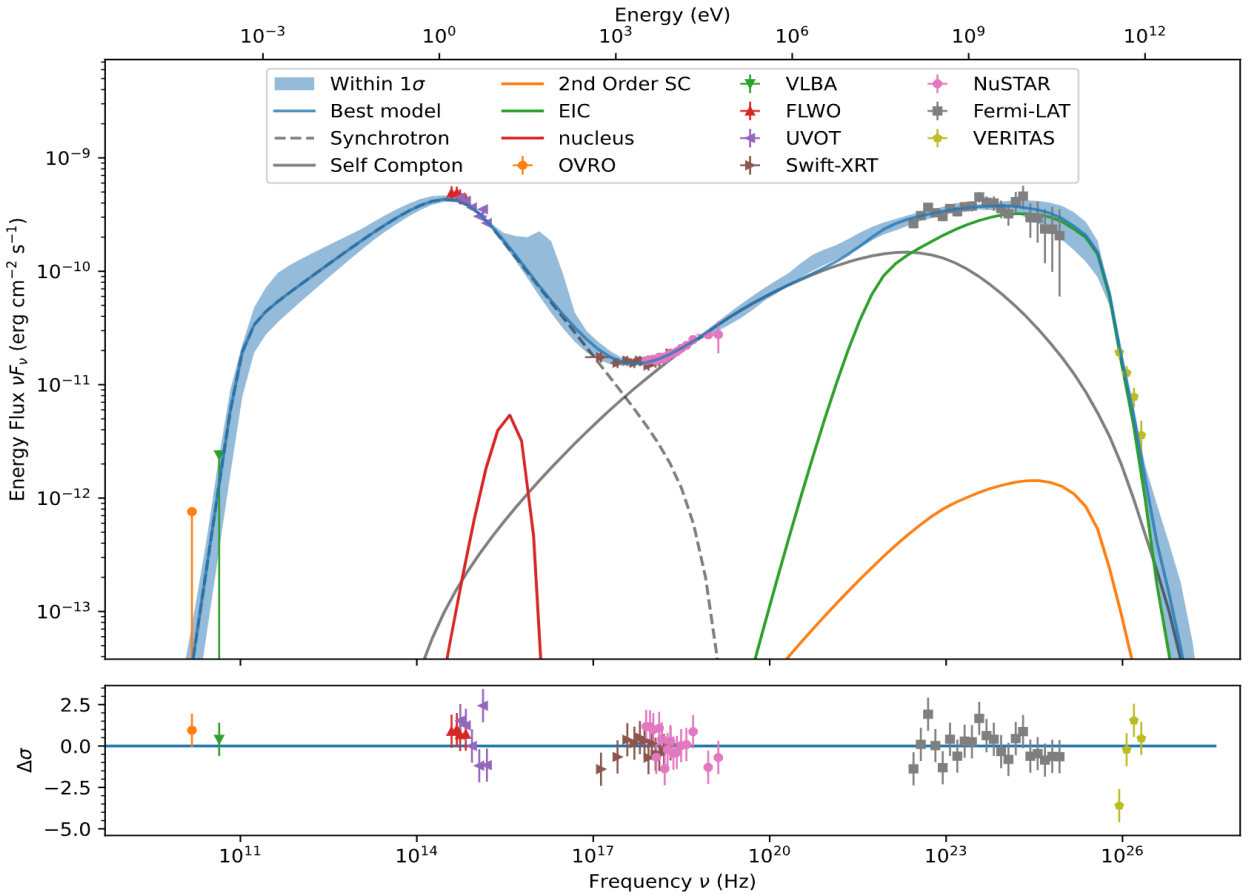

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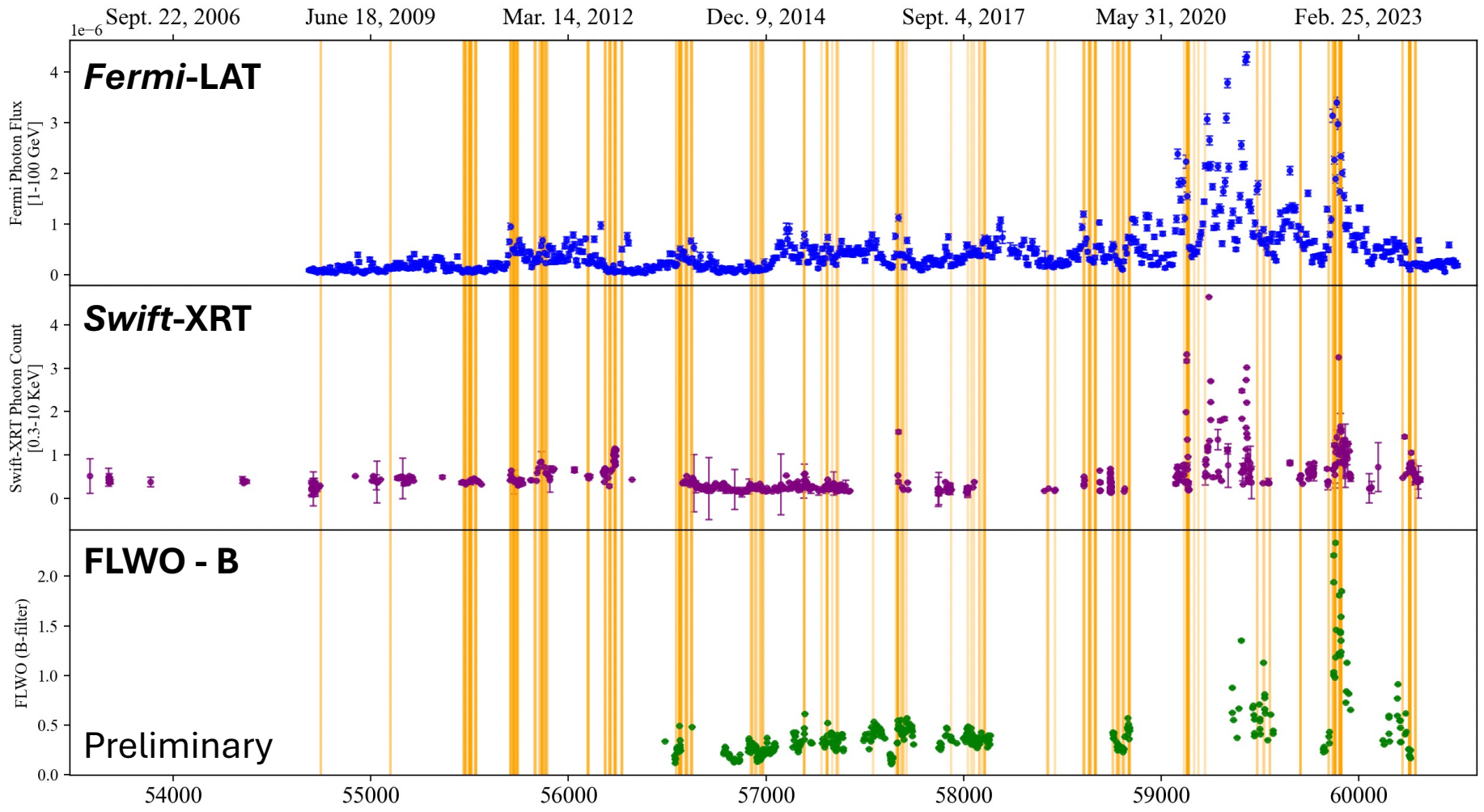
→ First long-duration ($\sim$ 40 days) VHE flare observed – needs further study during different flaring states!

Long-Term Lightcurve of BL Lacertae

- Publish this work (in the final paper committee stages)
- Long term study of BL Lacertae
- Long term study of other selected IBLs



Future Work

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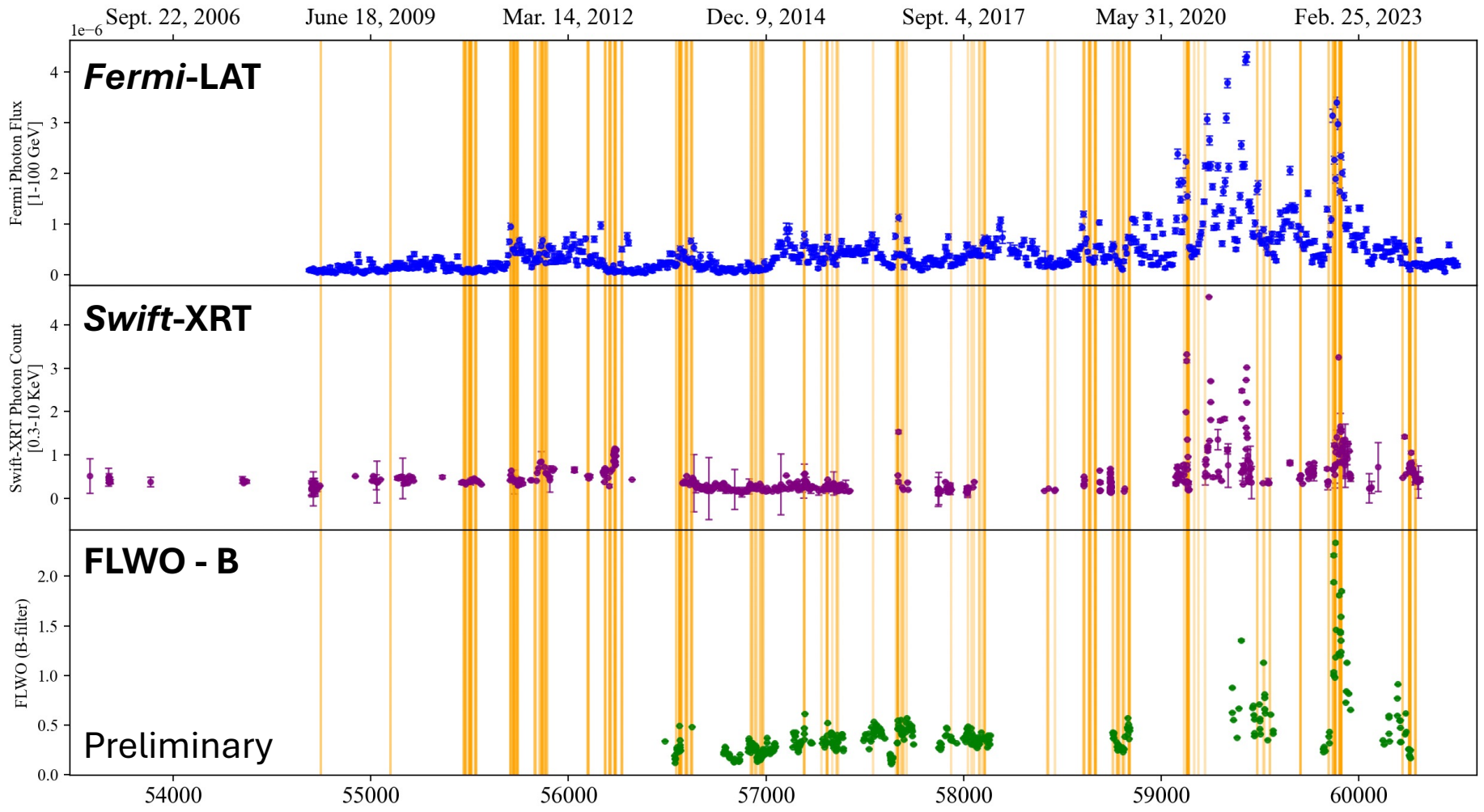

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Thank you! QUESTIONS?

Email: claire.hinrichs@cfa.harvard.edu

References and Acknowledgements

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VERITAS Collaboration Webpage: https://veritas.sao.arizona.edu/

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