Dramatic Changes in the Multiwavelength Emission of TeV BL Lac 1ES 1215+303

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Introduction

A blazar is a jetted active galaxy with one jet pointed towards Earth. BL Lac objects tend to have higher frequency electron synchrotron peaks, with the high-energy spectral bump attributed to synchrotron self-Compton (SSC) in the leptonic framework.

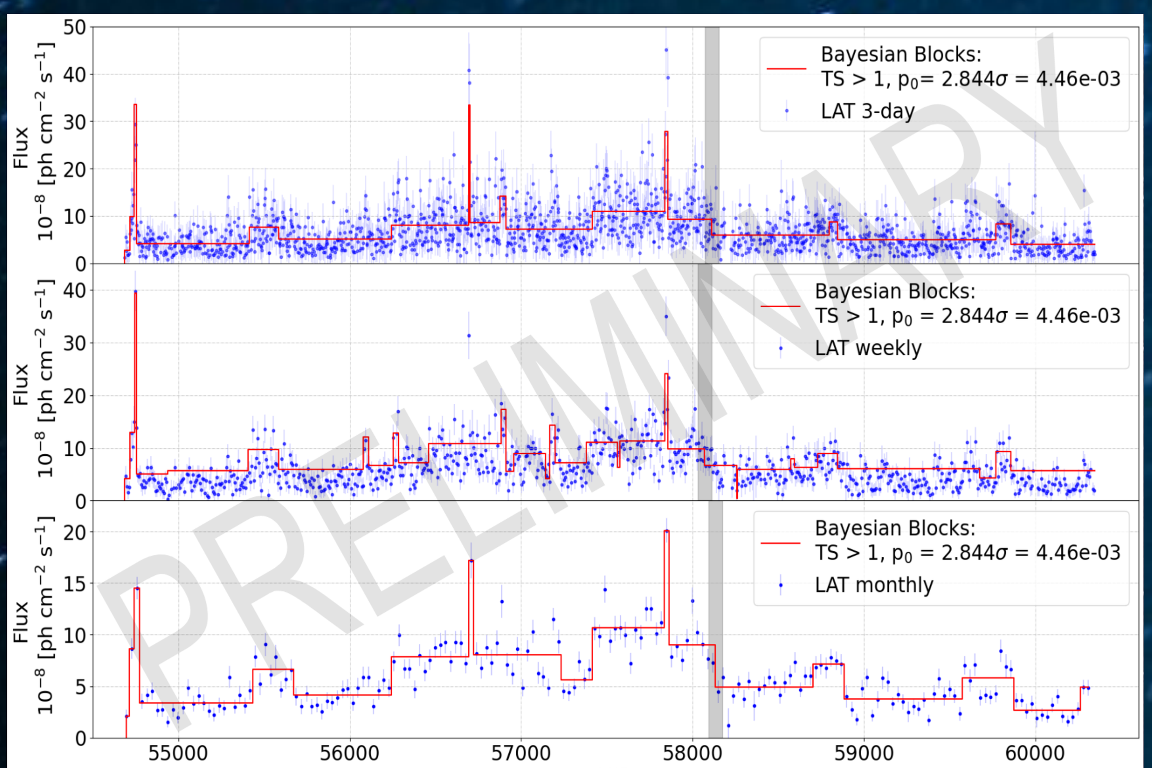
Valverde et al. (2020) completed a decade long multiwavelength campaign of the BL Lac object 1215+303. This work extends that observing campaign and presents new theoretical analyses of the observations.

1ES 1215+303

- BL Lac. Redshift z=0.131.
- First discovered by MAGIC (>200 GeV) in 2011.
- Largest IR – X-ray frequency shift in a BL Lac object when going from a low to a high flux state (Valverde et al. 2020).
- Long-term flux correlation between the optical and GeV gamma-rays with that correlation having a slope that was very close to 1 (Valverde et al. 2020).

Newer Low-State spectral energy distribution (SED) data was recorded in a 2021-2022 multi-wavelength campaign led by our team with VERITAS, MAGIC, *Fermi*-LAT, *Swift*, Tuorla, ATLAS, NOT, VLBA, SARAO observatories.

Figure 1. The Bayesian Blocks method (Scargle et al. 2013) indicate that the low state started around Dec 2017, after 7 years of continuous brightening.



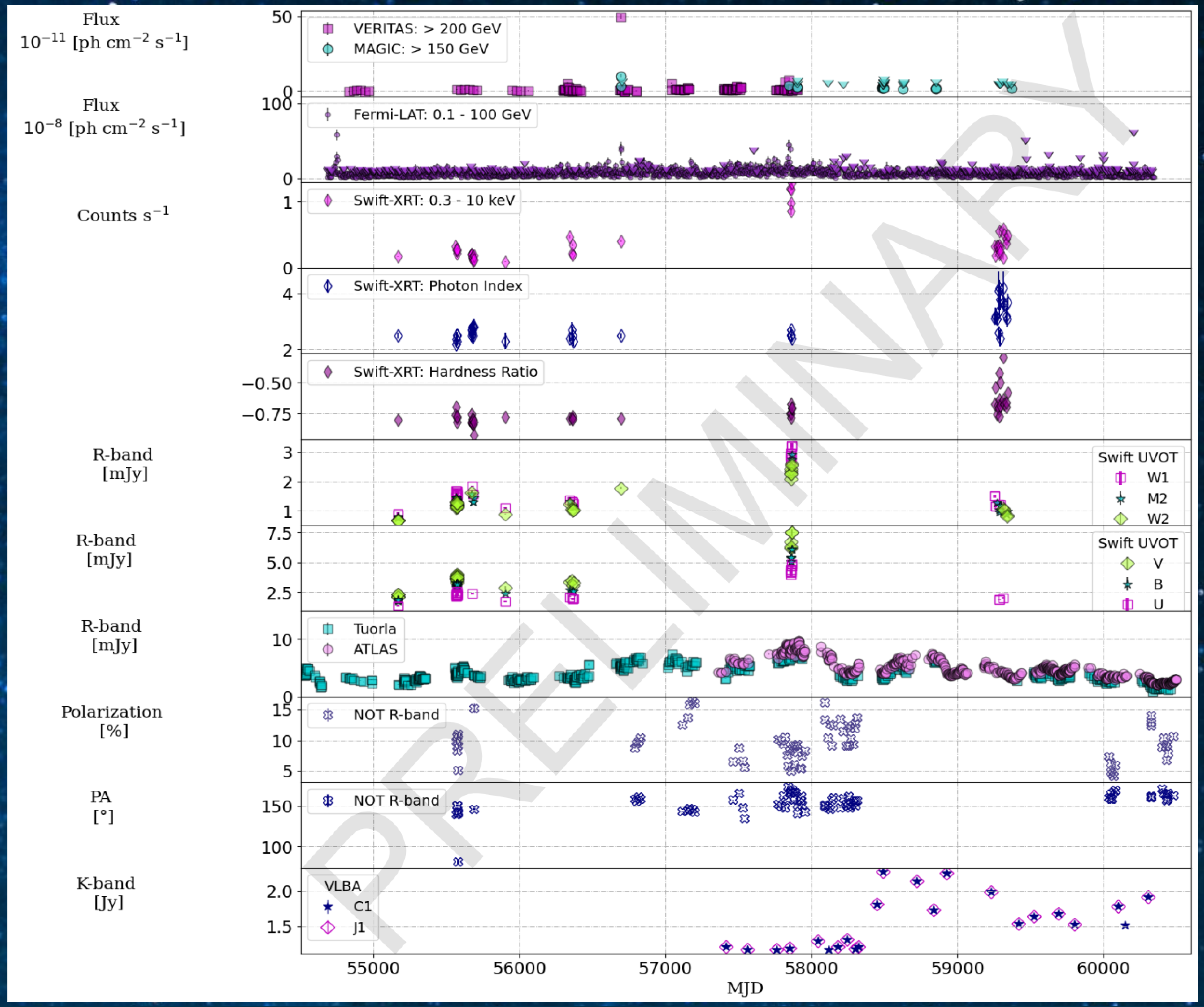
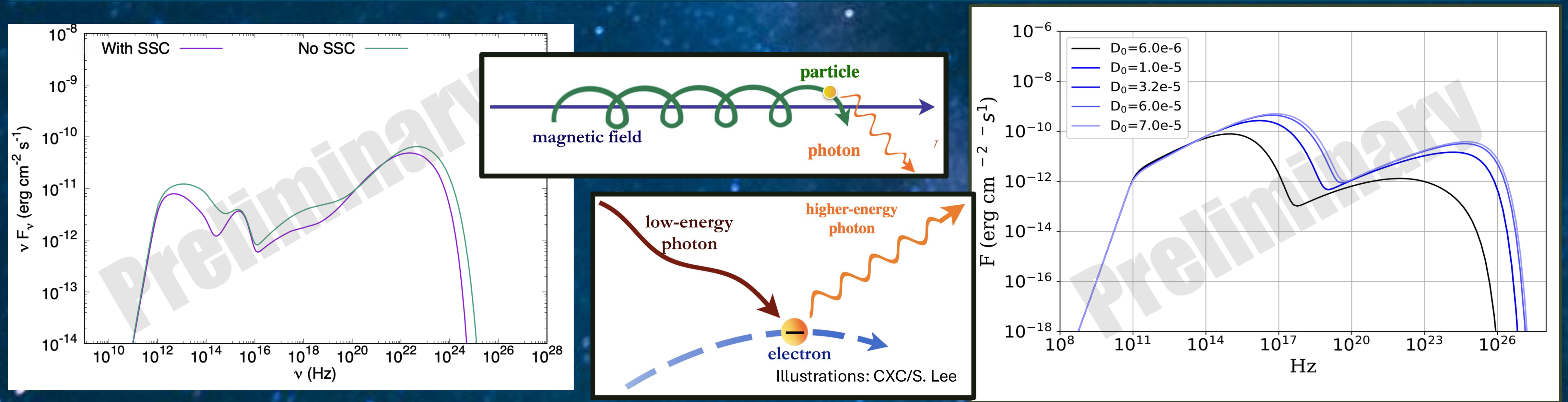


Figure 2. 1ES 1215+303 multi-wavelength light curves from 2008-2024. From top to bottom: VERITAS & MAGIC, *Fermi*-LAT, *Swift*-XRT, -UVOT, Tuorla & ATLAS, NOT, and VLBA.

Spectral Modeling with SSC

The theoretical spectral analysis uses a particle transport-based method to self-consistently account for the acceleration and cooling in the blazar zone. It includes synchrotron, SSC, and external Comptons processes in addition to Fermi I and Fermi II acceleration in situ.

Figure 3. The SSC process cools the particle distribution, which reduces the particle energies and spectral peaks compared to a case where it is not considered in the particle calculation (below, left). Increasing Fermi II acceleration (D_0) tends to compensate for that energy loss (below, right).



Multiwavelength Spectrum

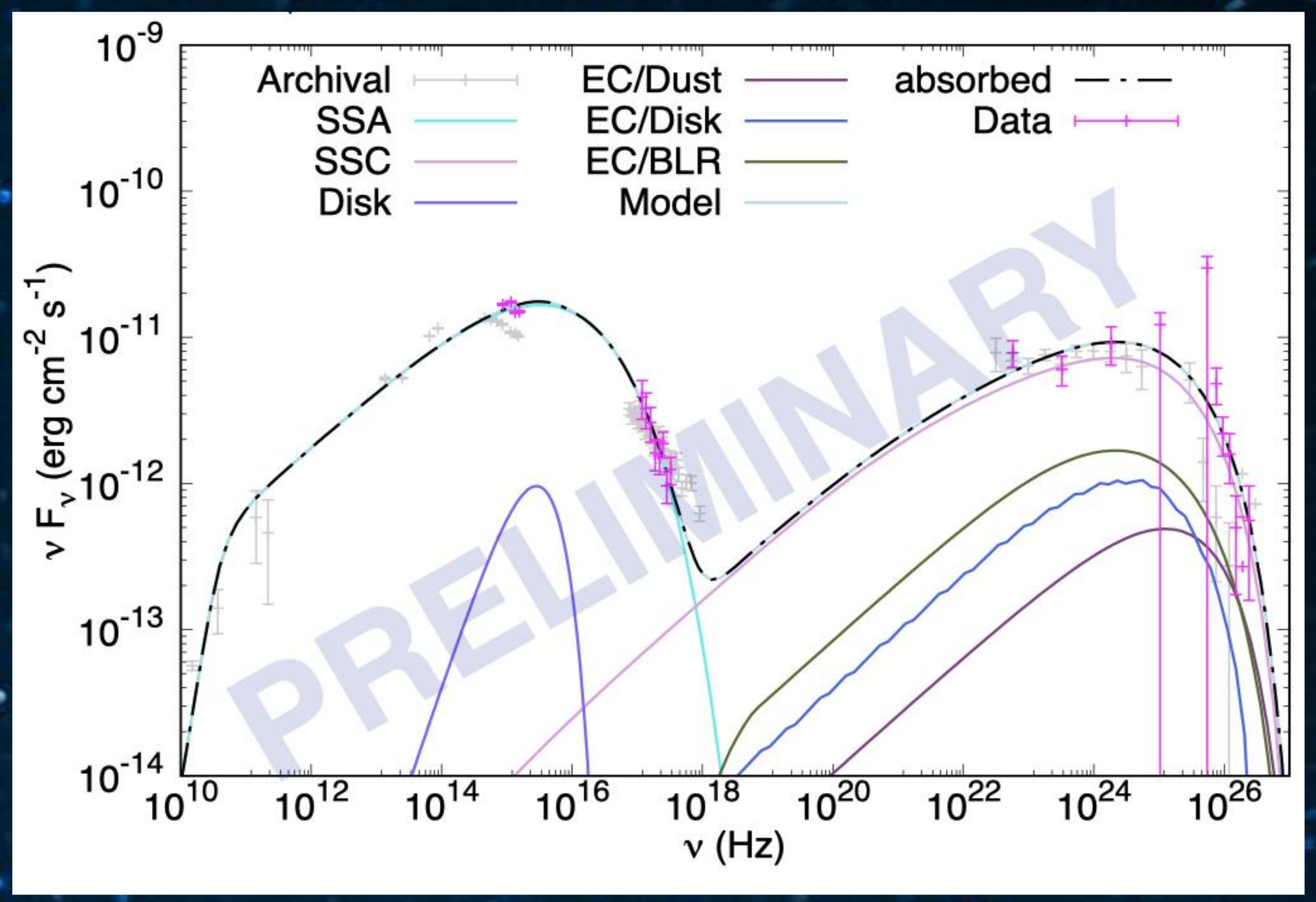


Figure 4. 1ES1215+303 Low-State SED: VERITAS (2018-2024), *Fermi*-LAT and *Swift*-XRT & -UVOT (2021). The current fit uses a magnetic field ~0.02G, consistent with the previous campaign. The acceleration is strongly associated with Fermi-II (turbulence) and the jet power is particle dominated.

Flux distributions

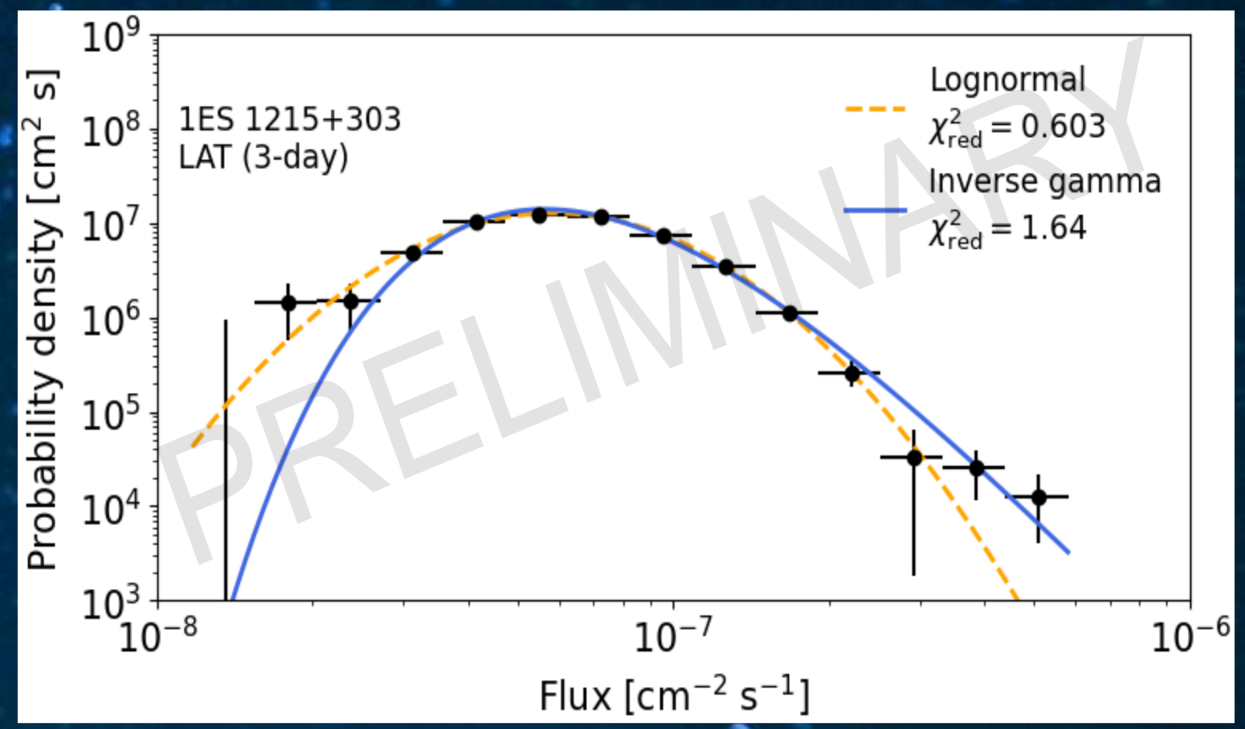


Figure 5. *Fermi*-LAT flux distribution of mission-long 3-day light curve from the Light Curve Repository. Inverse gamma fit parameters can be interpreted in terms of processes in the accretion disk (Brill 2022). With LAT data up to 2024, this corresponds to a ~3 day timescale of magnetic flux accumulation and a ~7 day timescale of stochastic variability.

References

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