Variability study of extreme Blazars with VERITAS

ICRC 2019

Orel Gueta
for the **VERITAS collaboration**

DESY

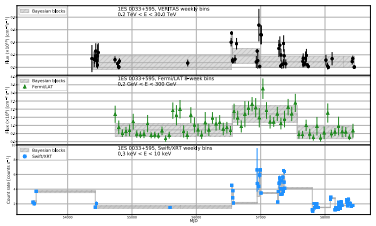
July 2019

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

Introduction

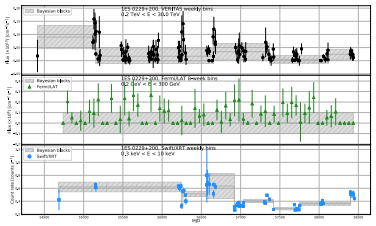
Why variability of xHBL?

1ES 0033+595



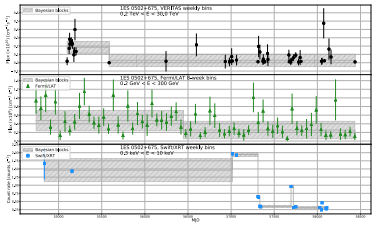
xHBL

1ES 0229+200



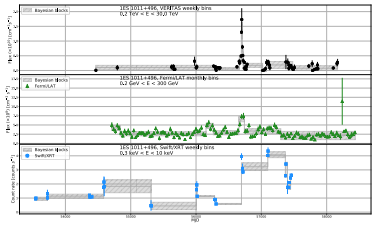
xHBL

1ES 0502+675



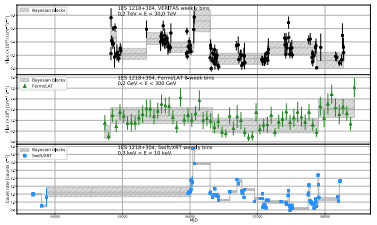
xHBL

1ES 1011+496



xHBL(?)

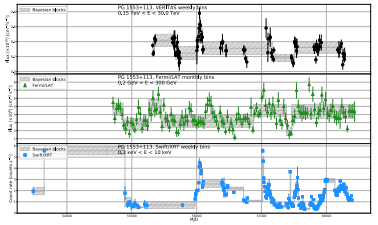
1ES 1218+200



xHBL

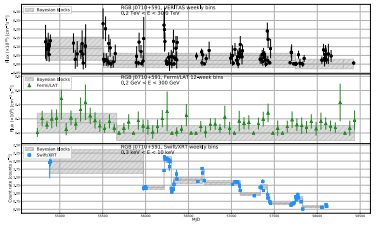
- xHBLs spectra challenge the single-zone SSC model.
- MWL correlation study could resolve the tension.
- First look at lightcurves with over 10 years of data.

PG 1553+113



HBL

RGB J0710+591



xHBL

Secondary photons

- Proposed solution to very hard EBL corrected spectra observed in some xHBLs.
- Explore VHE short-term variability as a function of energy to probe their contribution.

VERITAS

The basics

General:

- Energy range: 100 GeV to >30 TeV
- Energy resolution 15-25%
- Sensitivity: 1% Crab in ~25h
- Angular resolution: R_68% < 0.1 deg at 1 TeV
- Pointing accuracy: Error < 50 arcsec
- Field of View: 3.5º
- Effective area 100,000 m^2

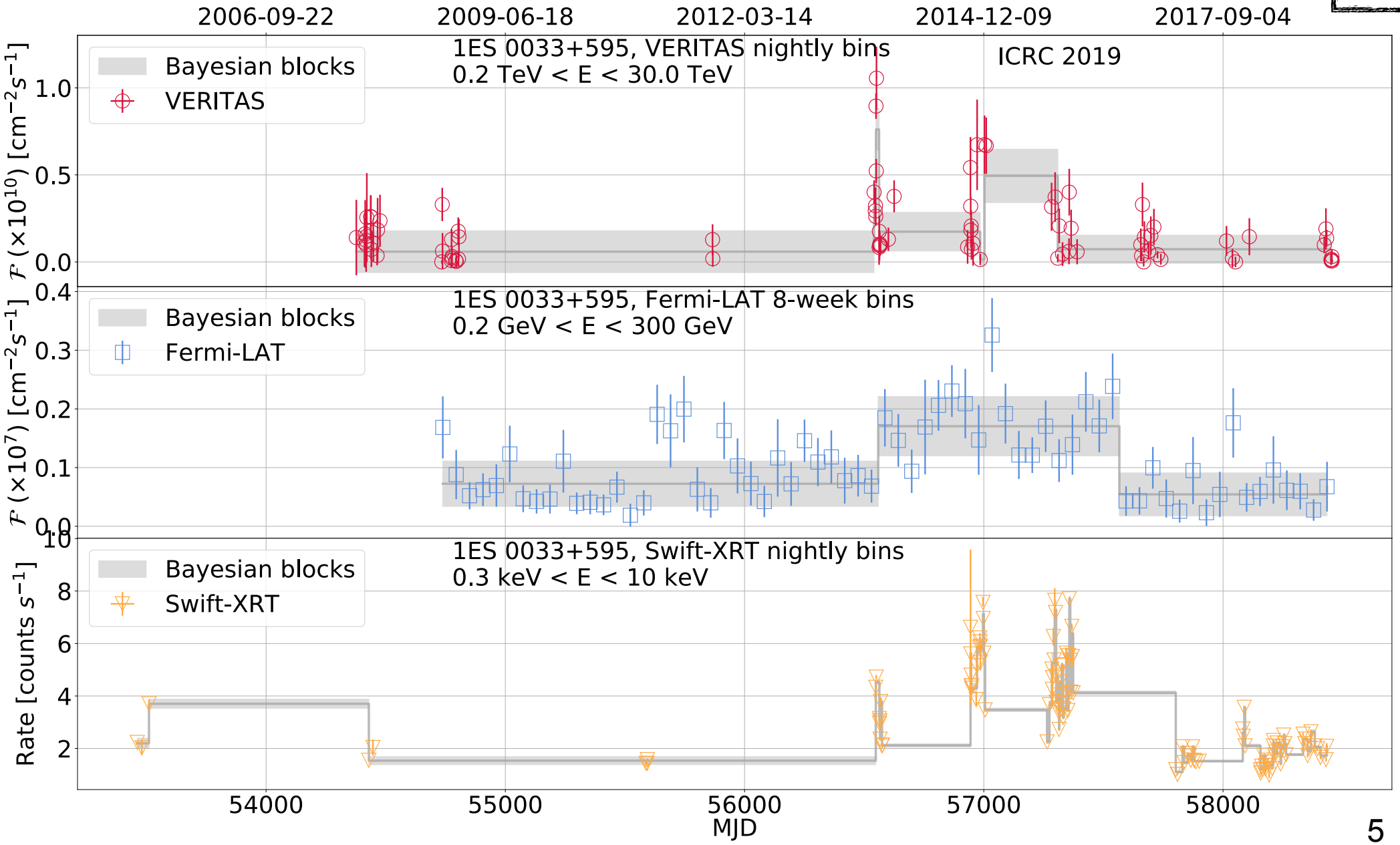
xHBL variability study:

- Min energy threshold: 150 GeV
- Stability of the Crab was checked
- FermiPy used for *Fermi*-LAT analysis
- Swift-XRT from Leicester online tool

1ES 0033+595

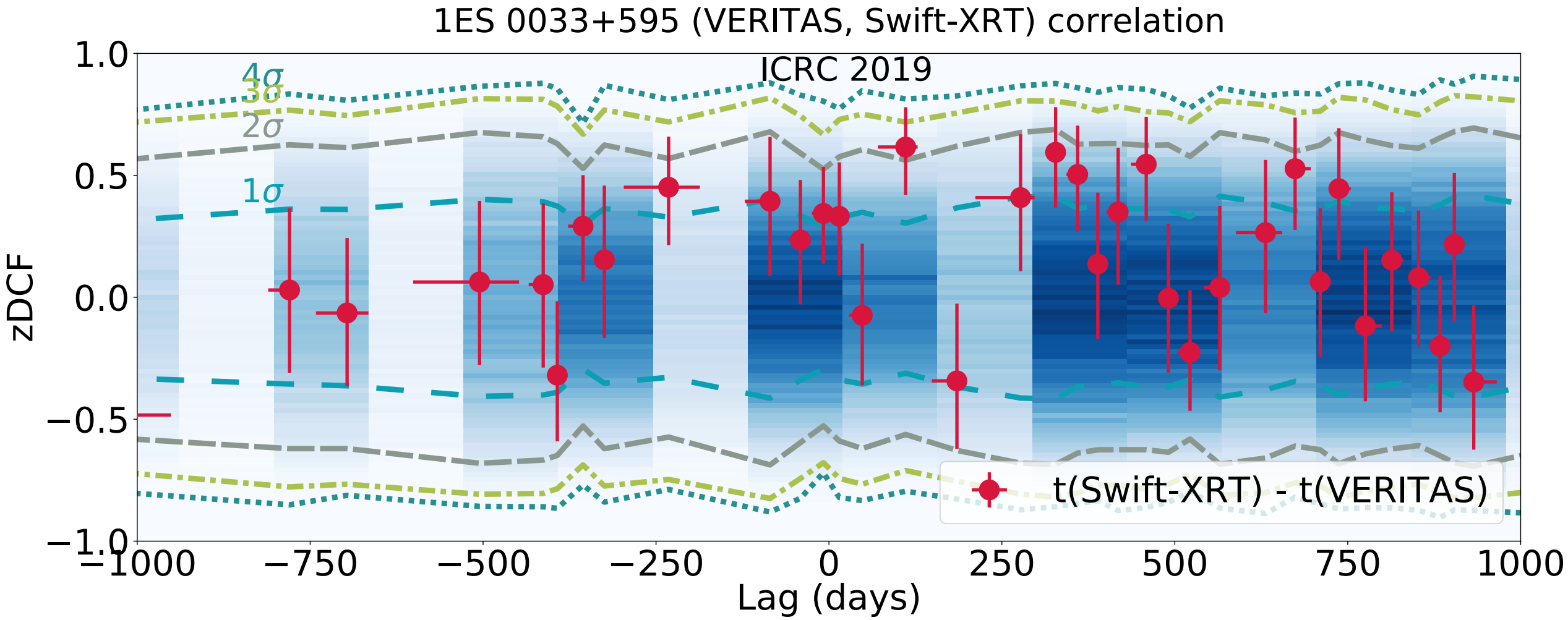
MWL long-term lightcurves 1ES 0033+595

z=0.467?



MWL correlation 1ES 0033+595

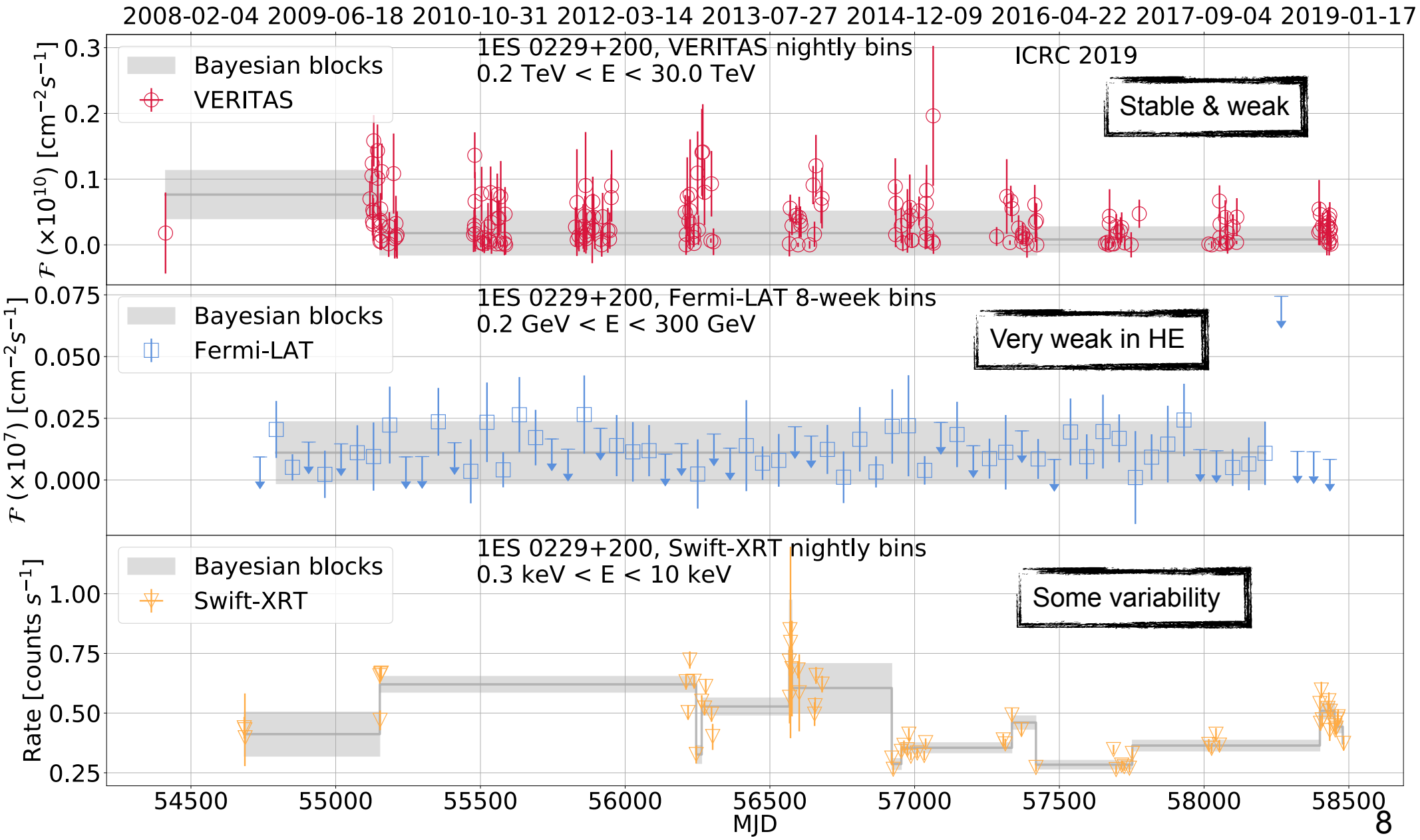
z=0.467?



1ES 0229+200

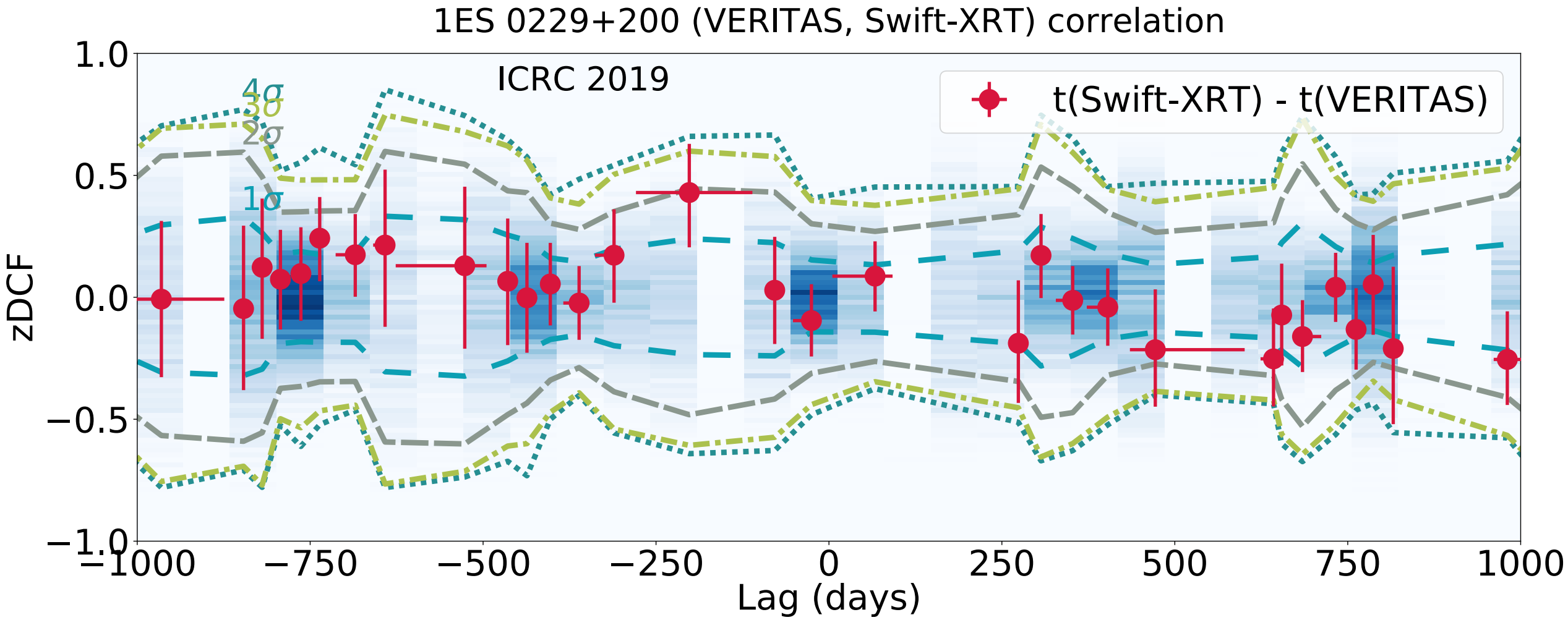
MWL long-term lightcurves 1ES 0229+200

z=0.14



MWL correlation 1ES 0229+200

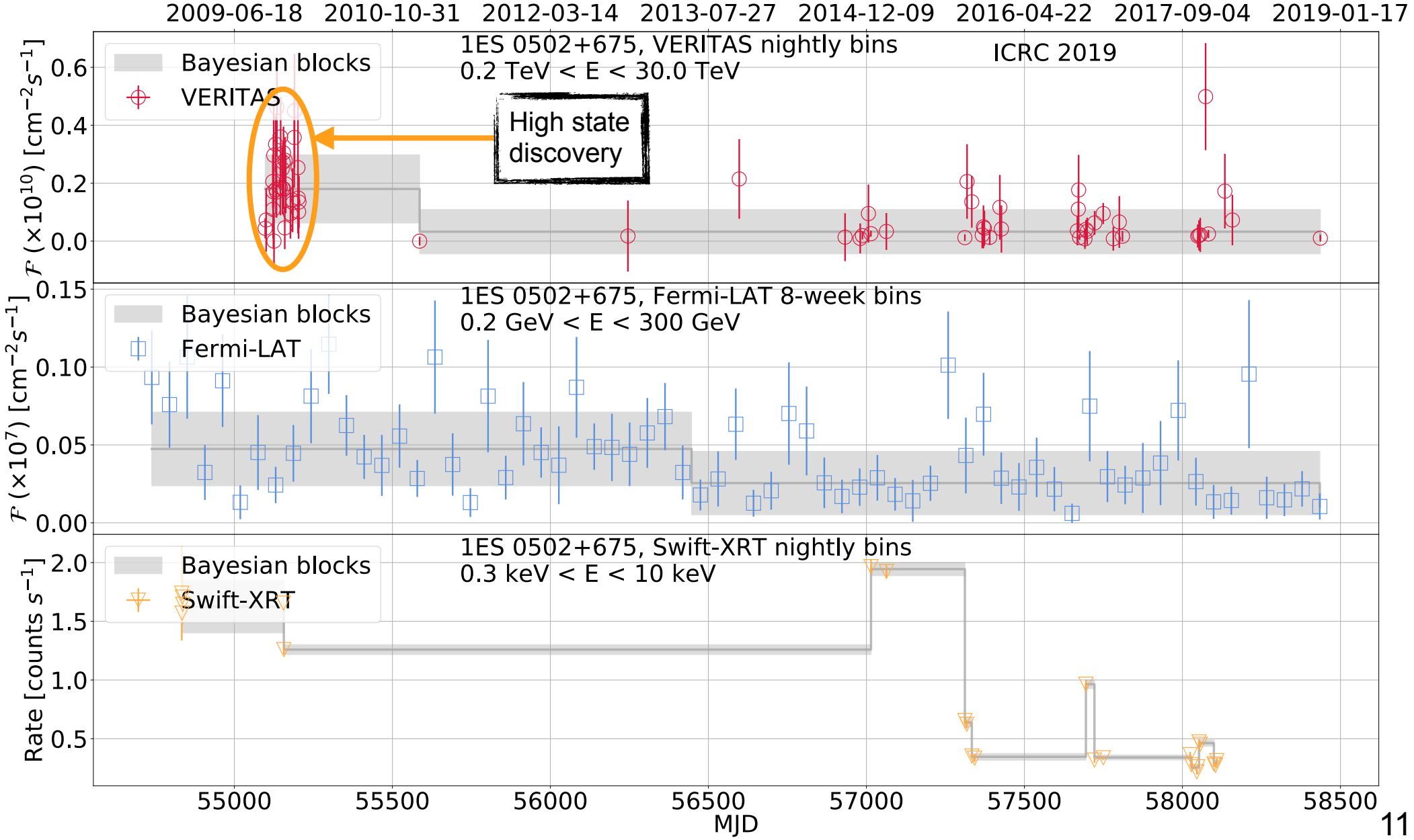
z=0.14



1ES 0502+675

MWL long-term lightcurves 1ES 0502+675

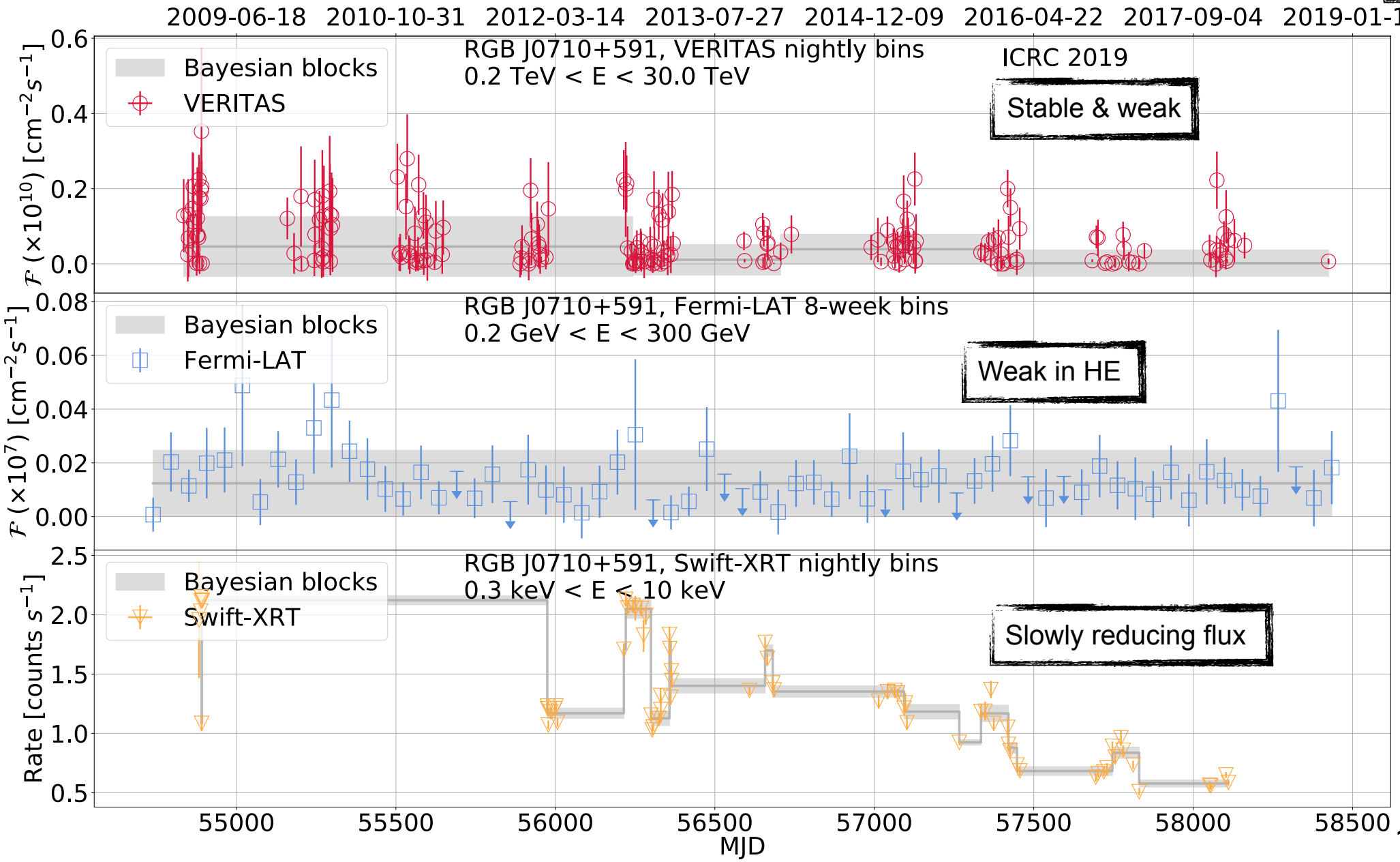
z=0.341



RGB J0710+591

MWL long-term lightcurves RGB J0710+591

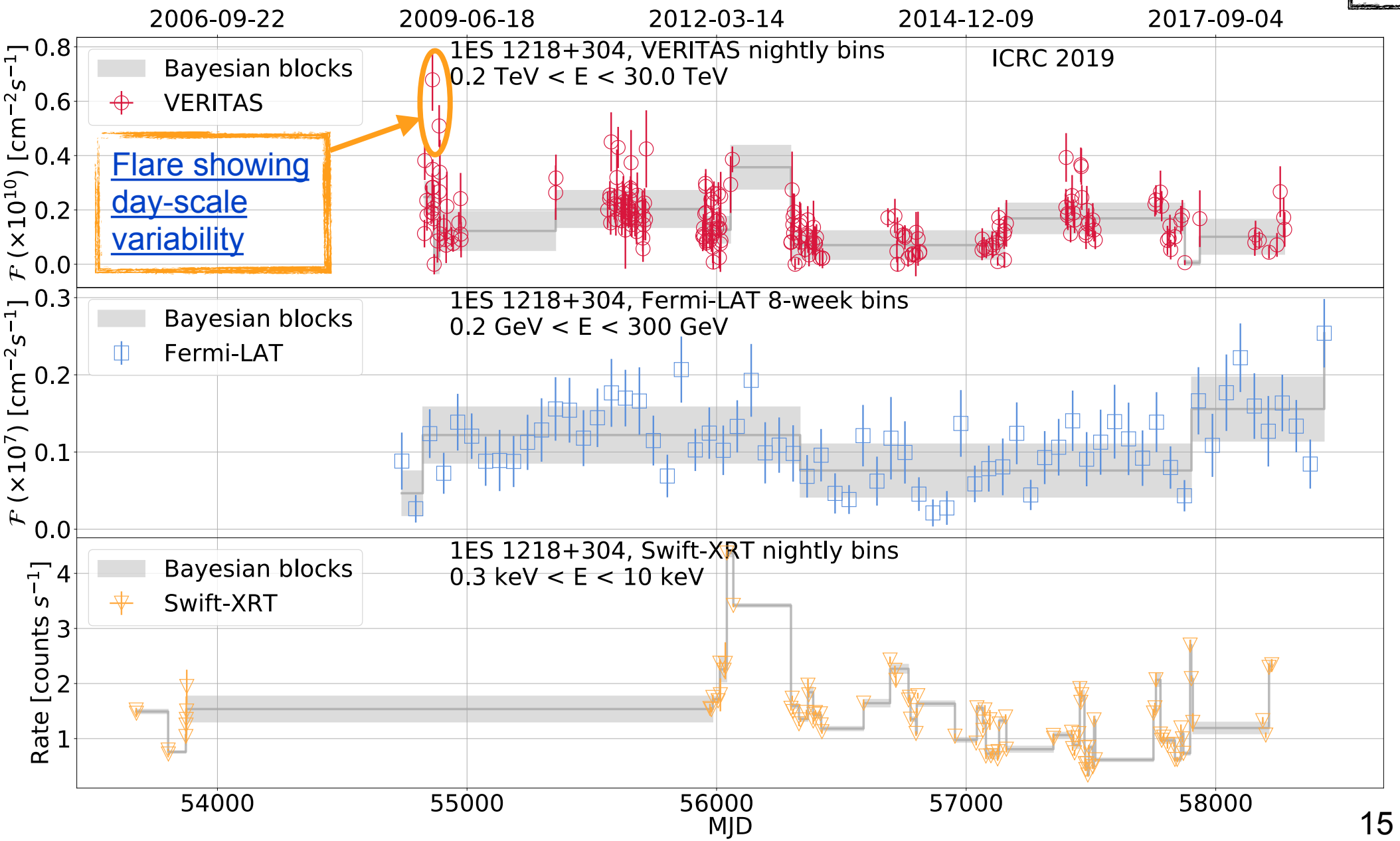
z=0.125



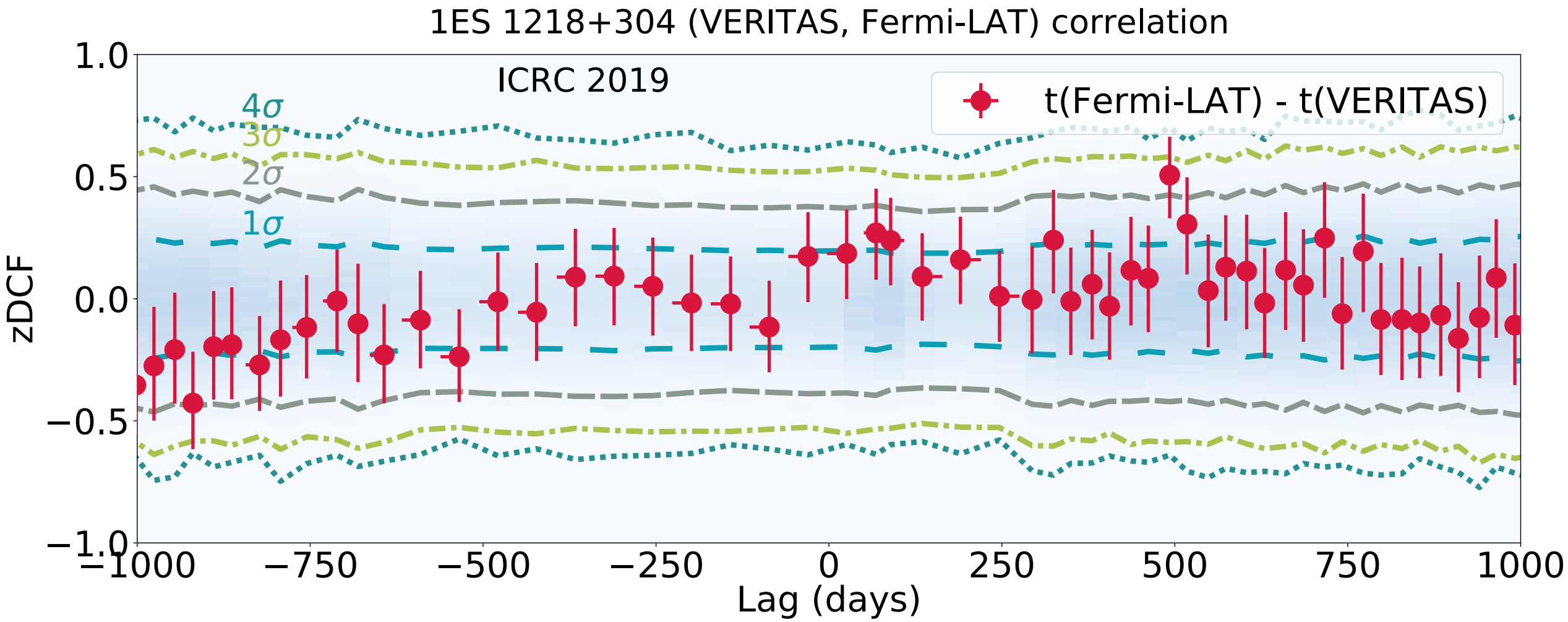
1ES 1218+304

MWL long-term lightcurves 1ES 1218+304

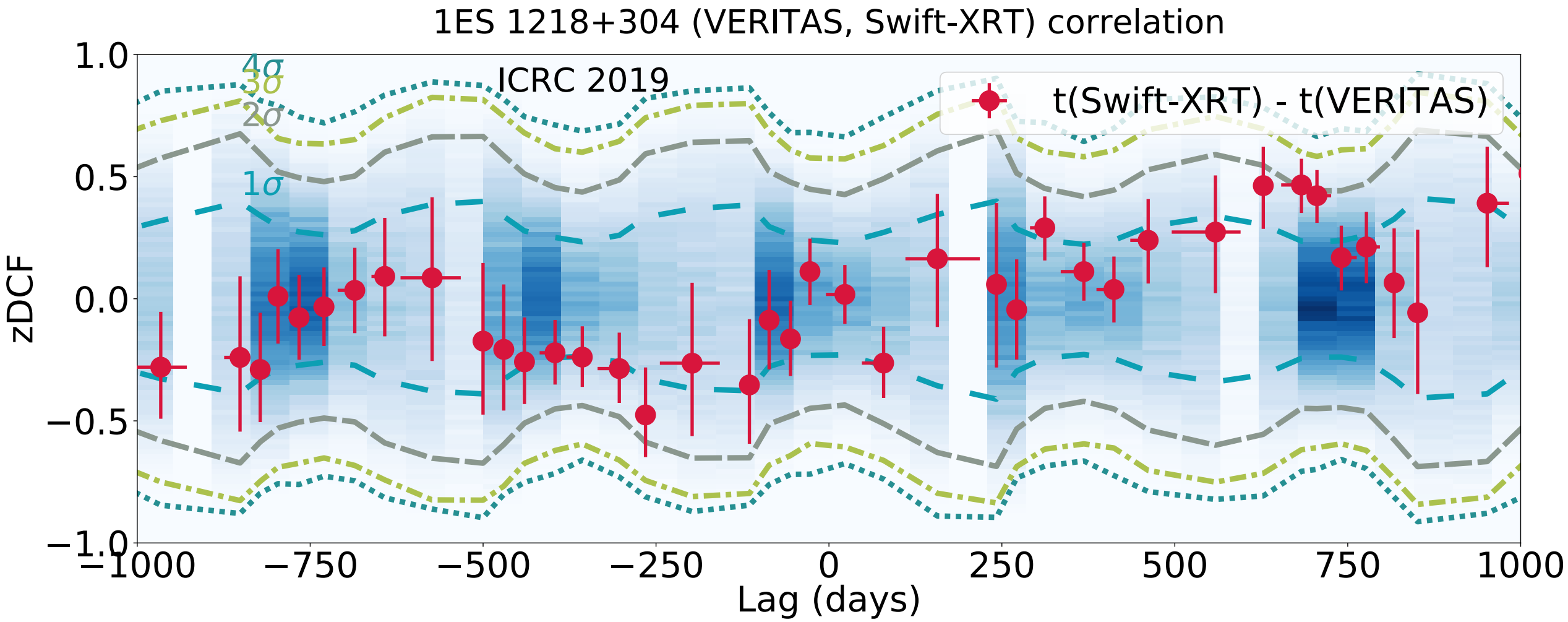
z=0.182



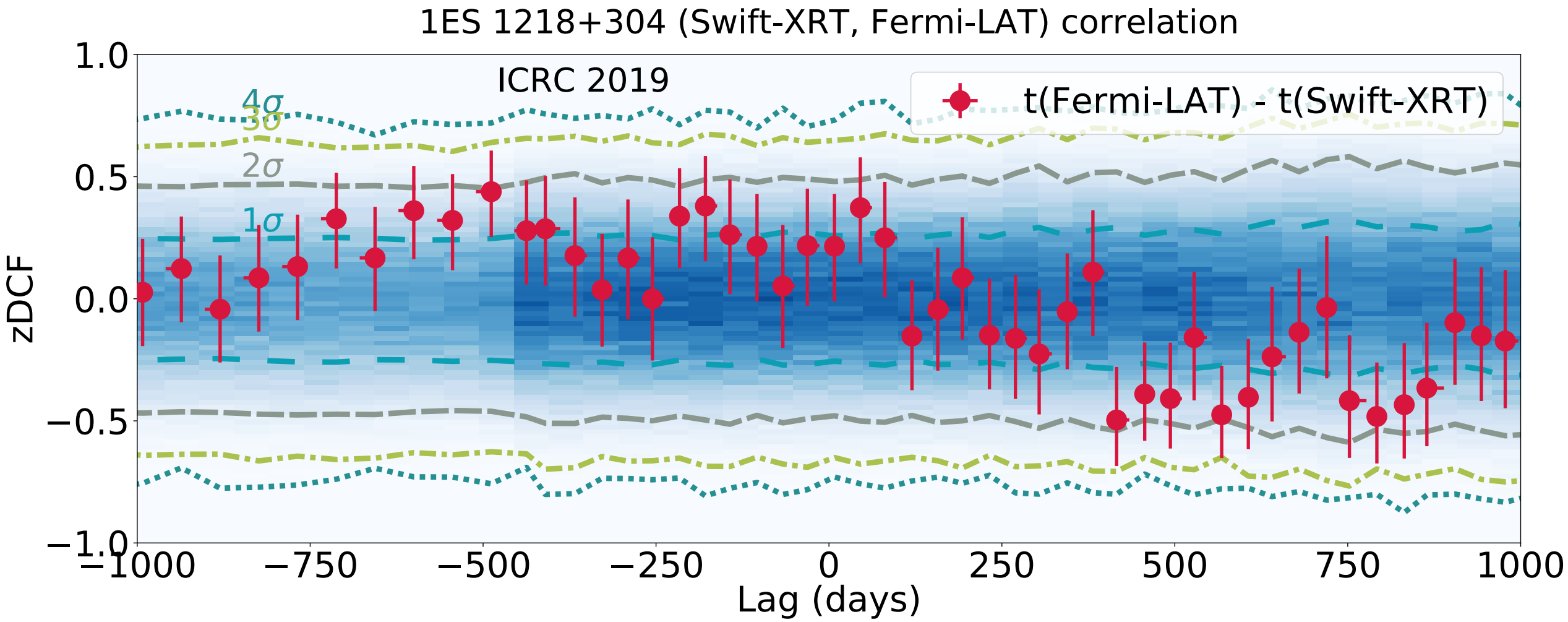
MWL correlations 1ES 1218+304



MWL correlations 1ES 1218+304



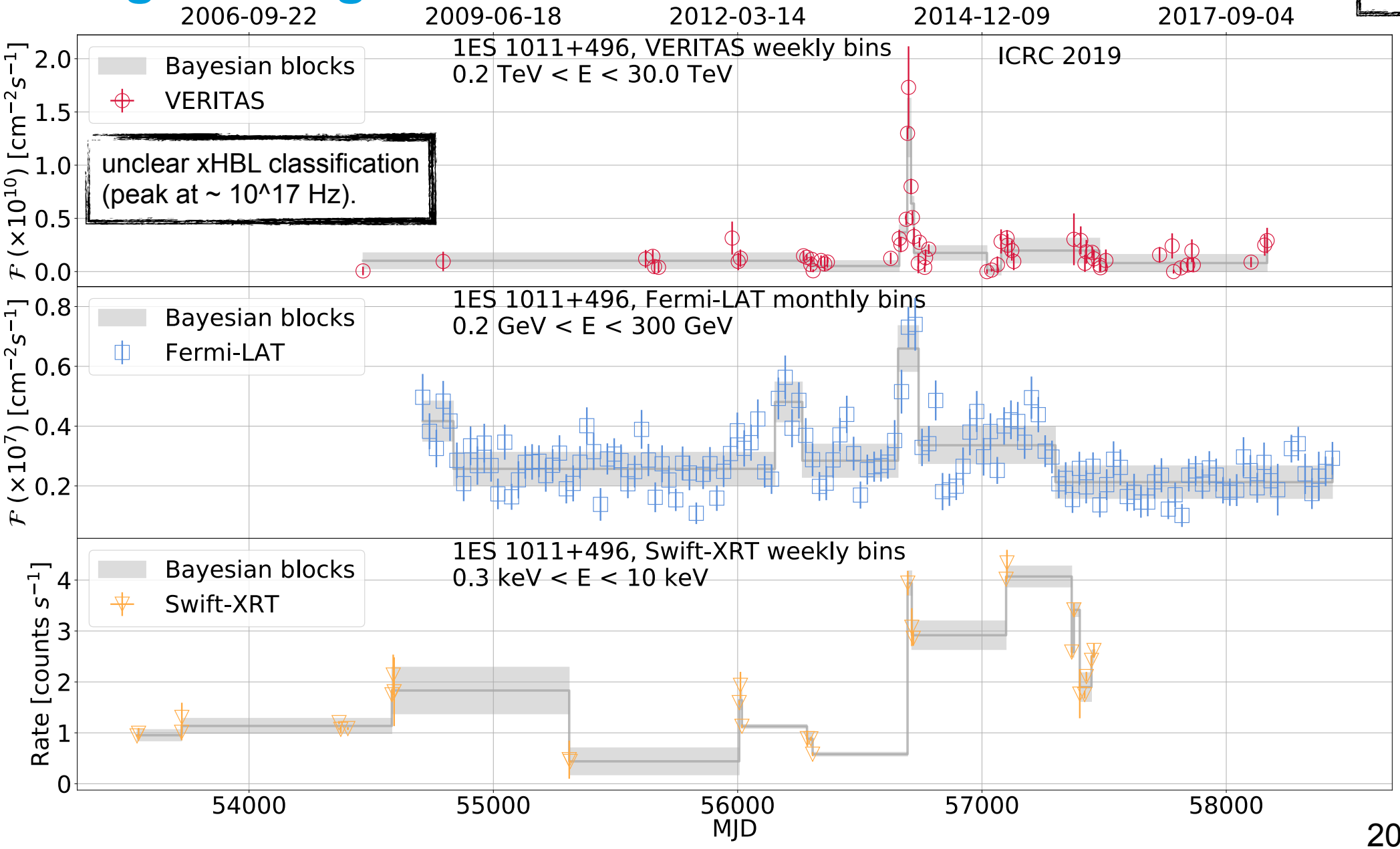
MWL correlations 1ES 1218+304



1ES 1011+496

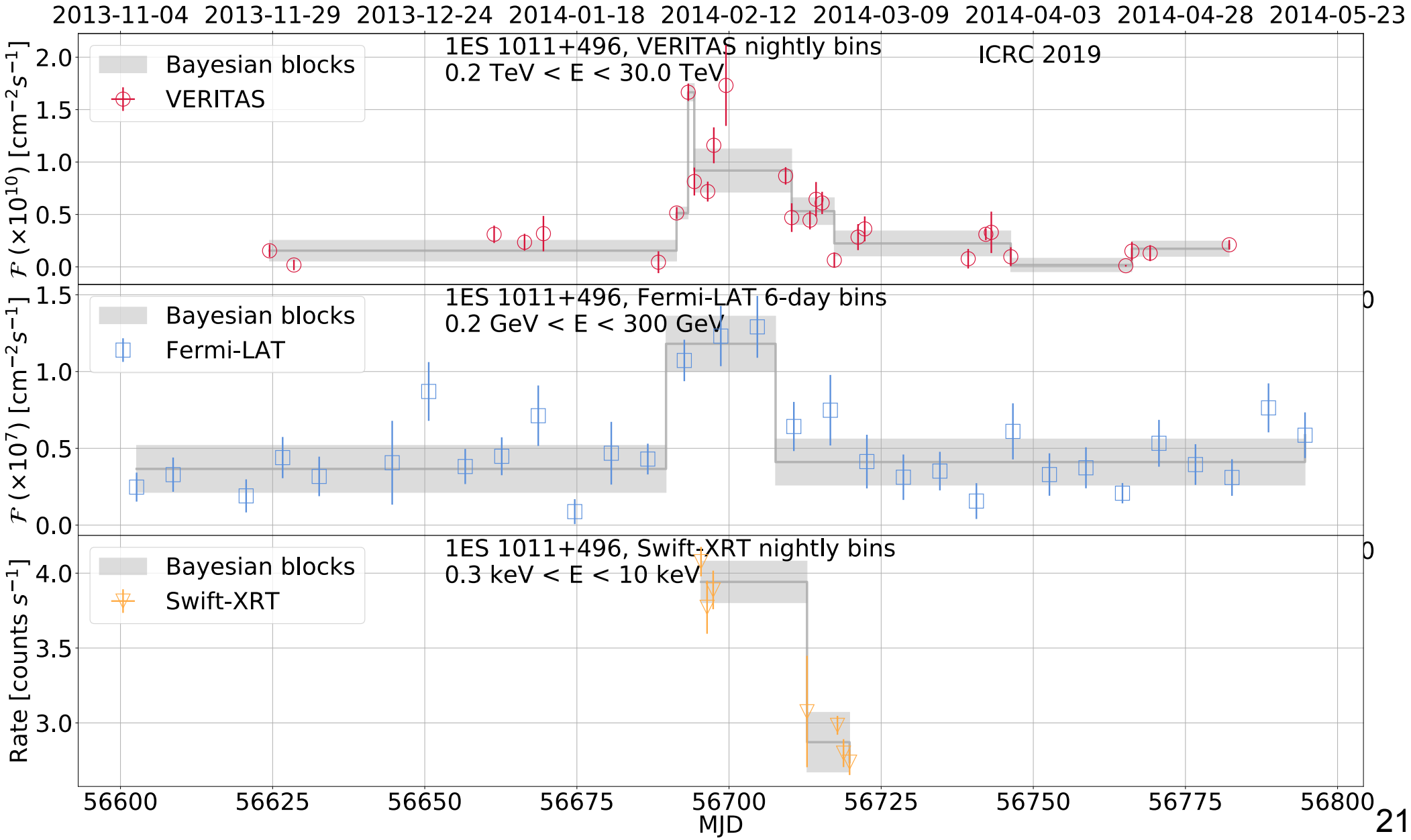
MWL long-term lightcurves 1ES 1011+496

z=0.212

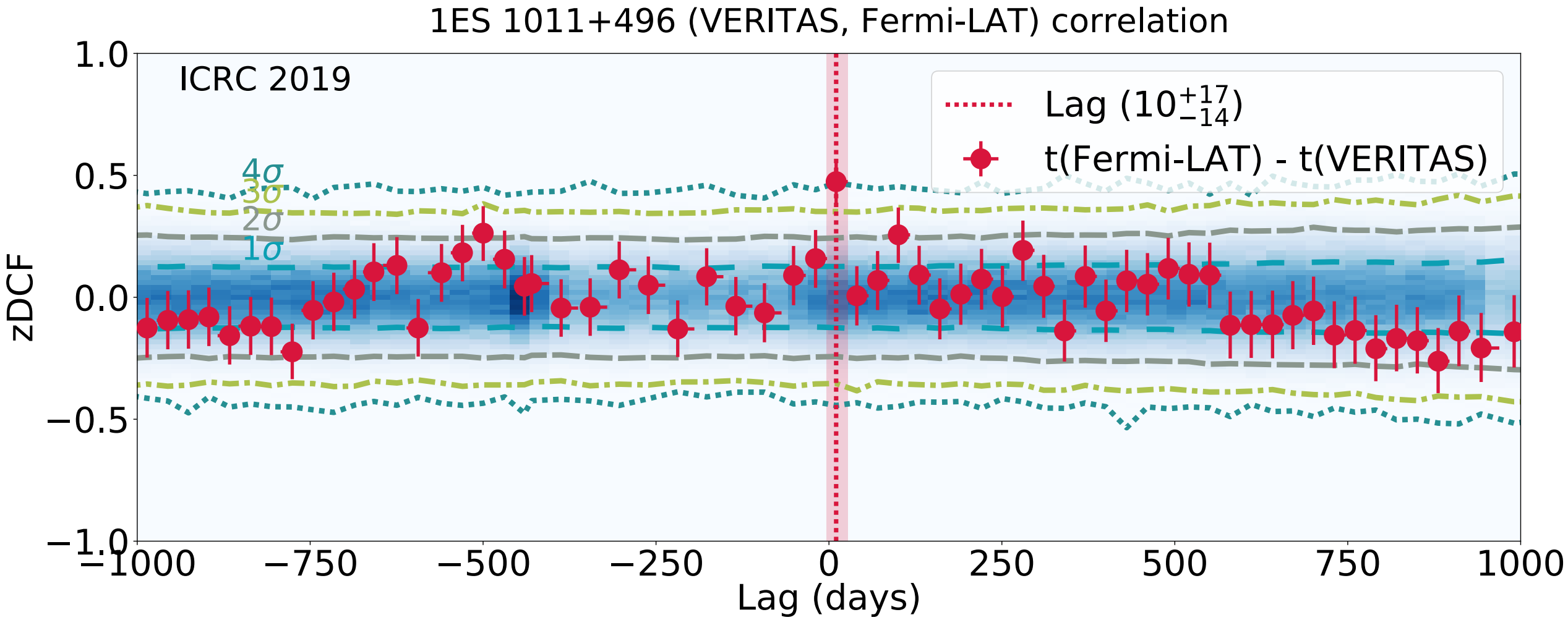


MWL flare lightcurve 1ES 1011+496

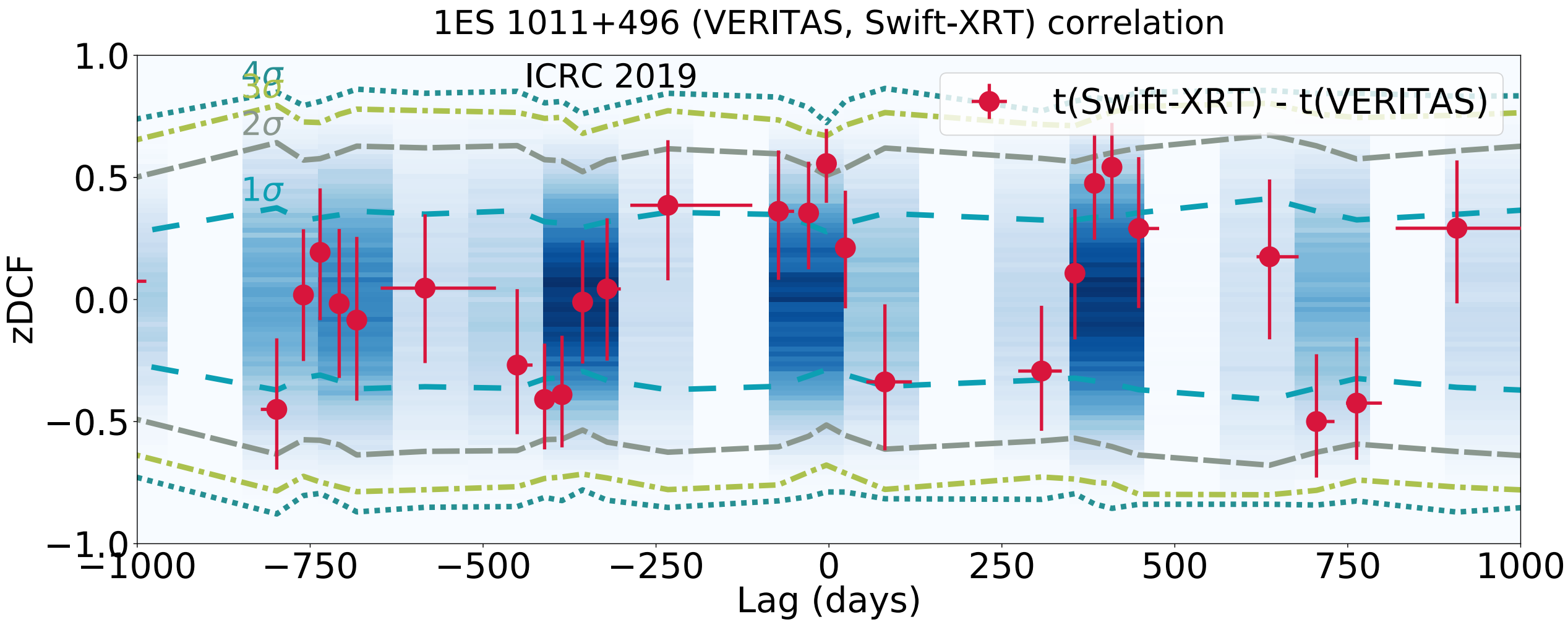
z=0.212



MWL correlations 1ES 1011+496



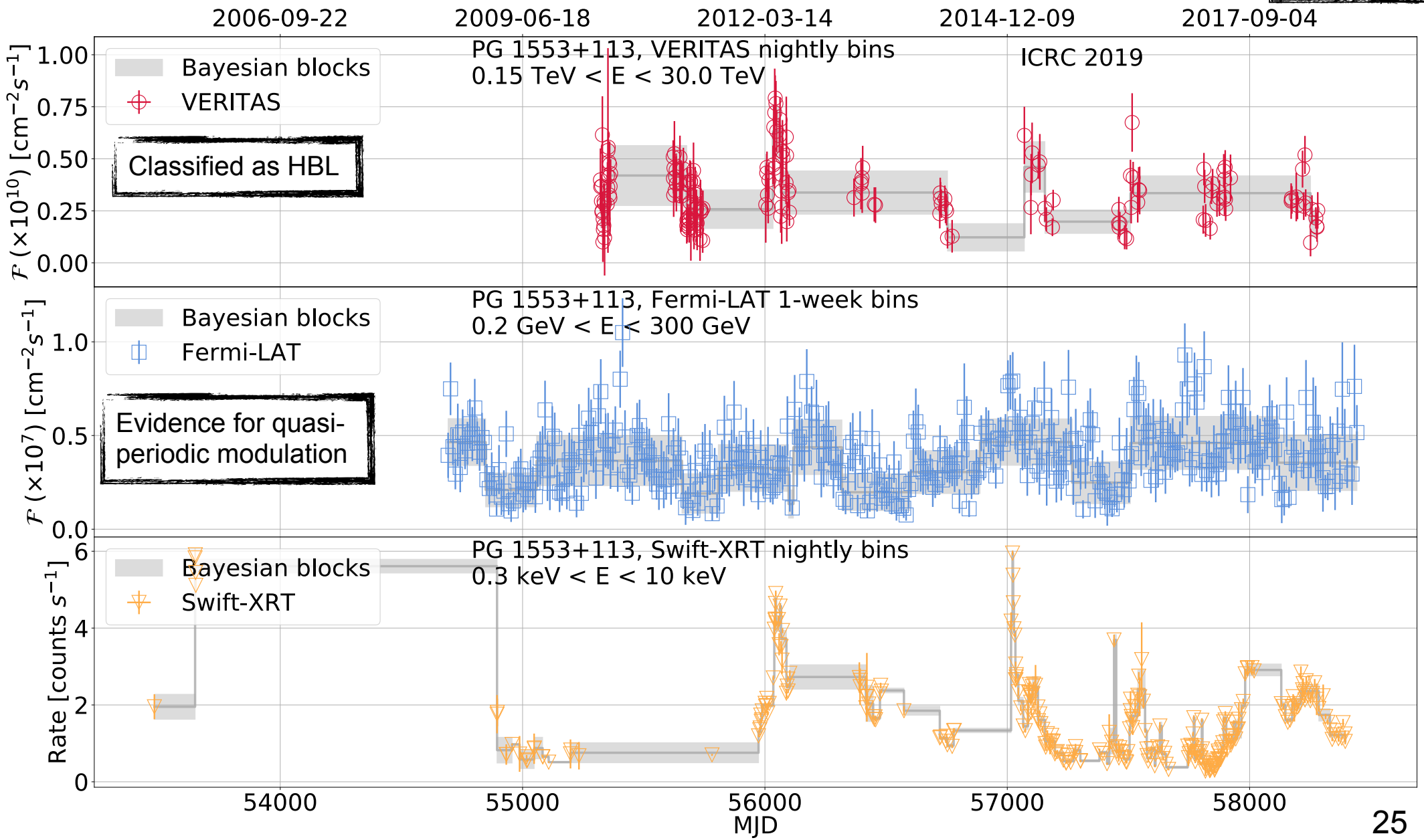
MWL correlations 1ES 1011+496



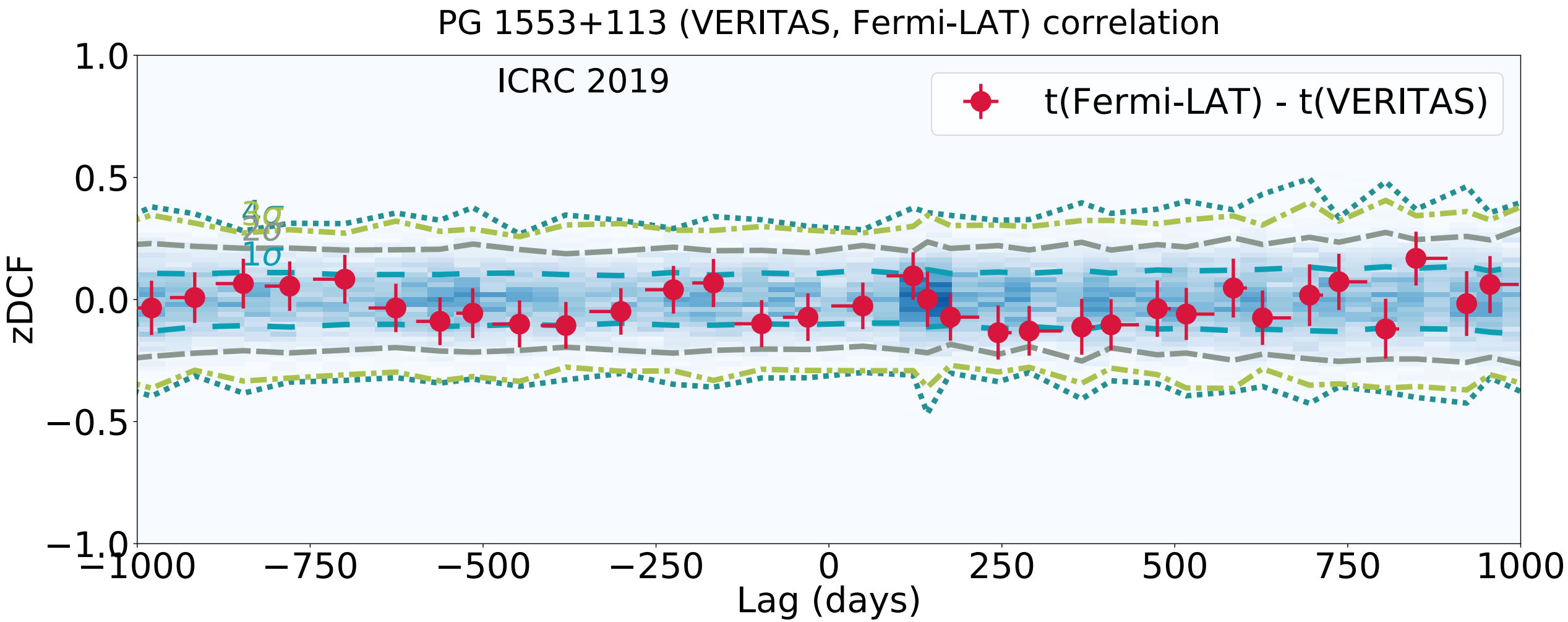
PG 1553+113

MWL long-term lightcurves PG 1553+113

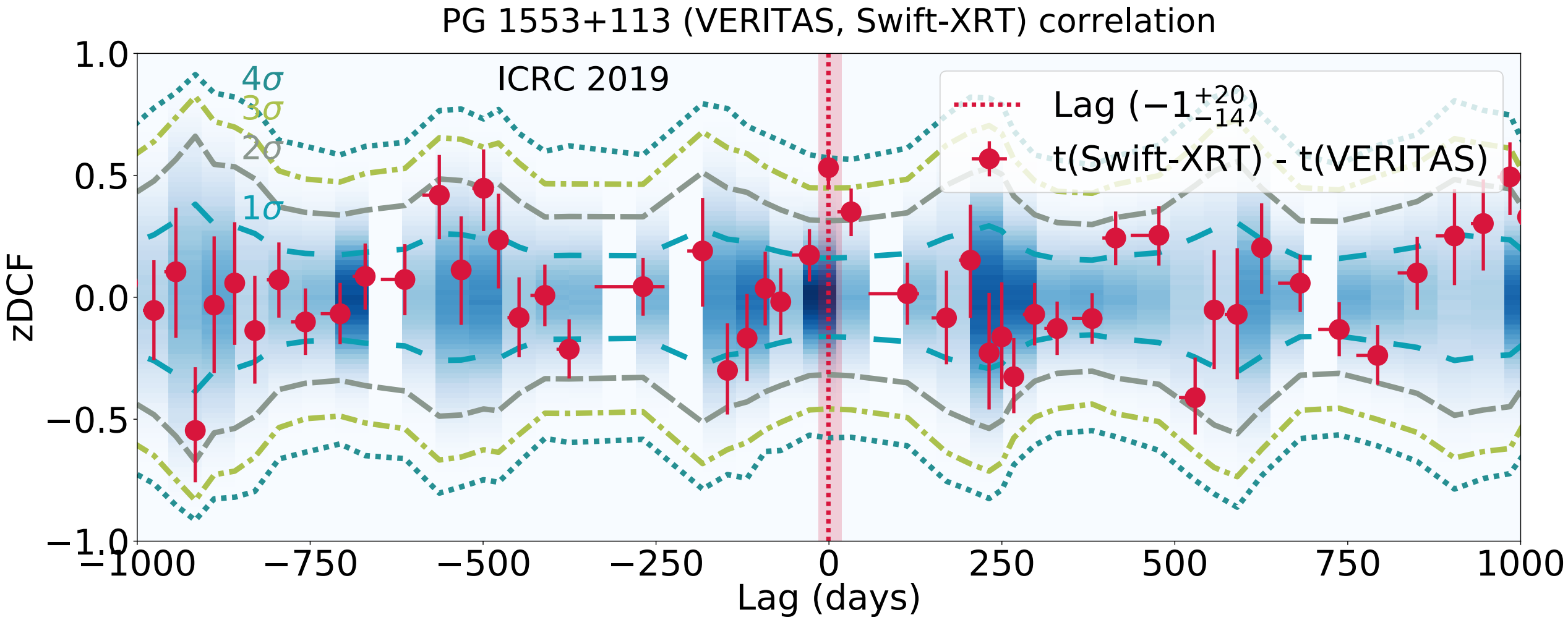
z=0.43 - 0.58



MWL correlations PG 1553+113



MWL correlations PG 1553+113

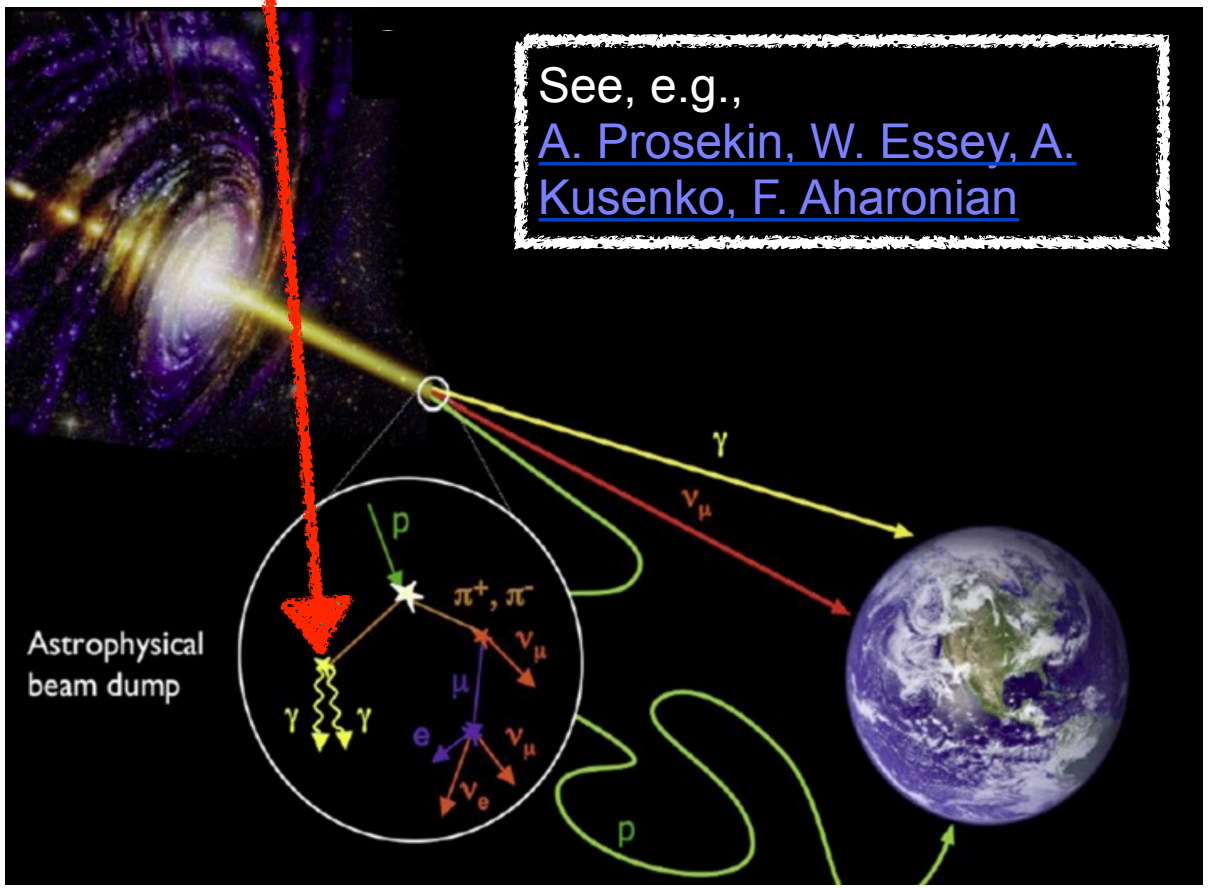


Contribution from secondary photons

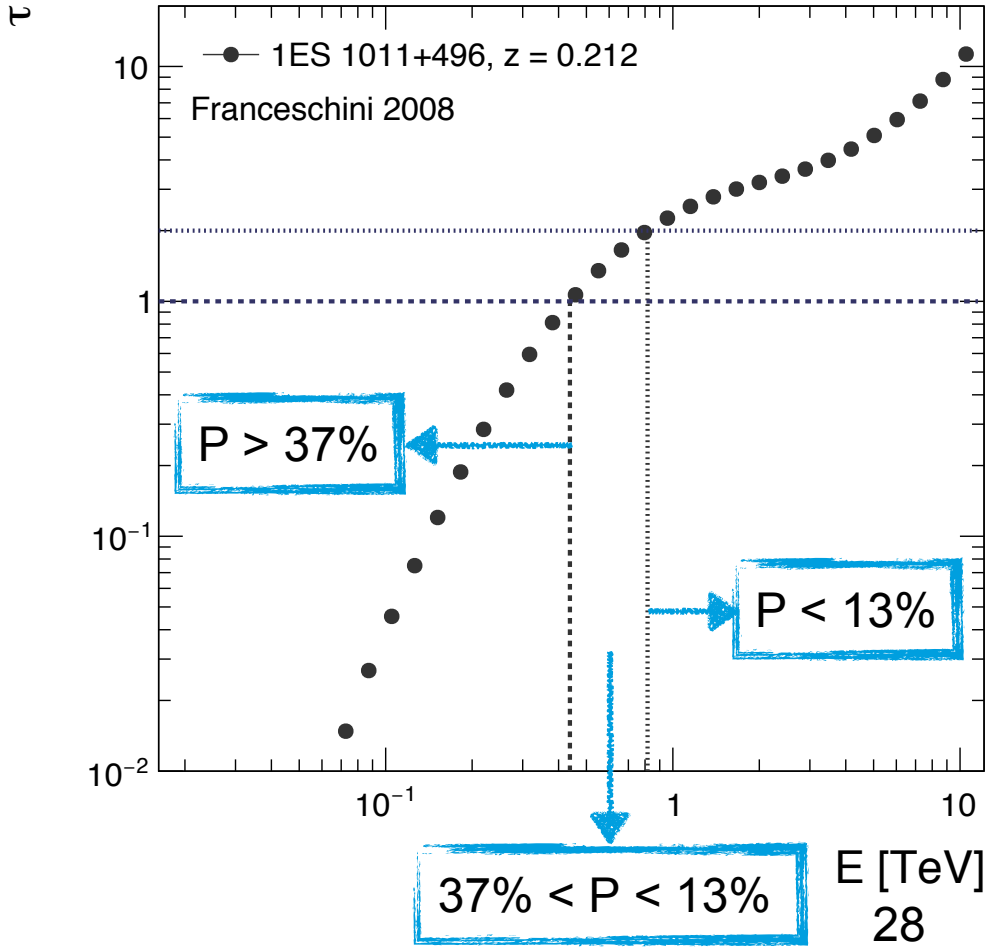
Search for short-term correlations in VHE

High energy photons come from secondary photons.

Should smear out short-term variability of the source (0.1 year).



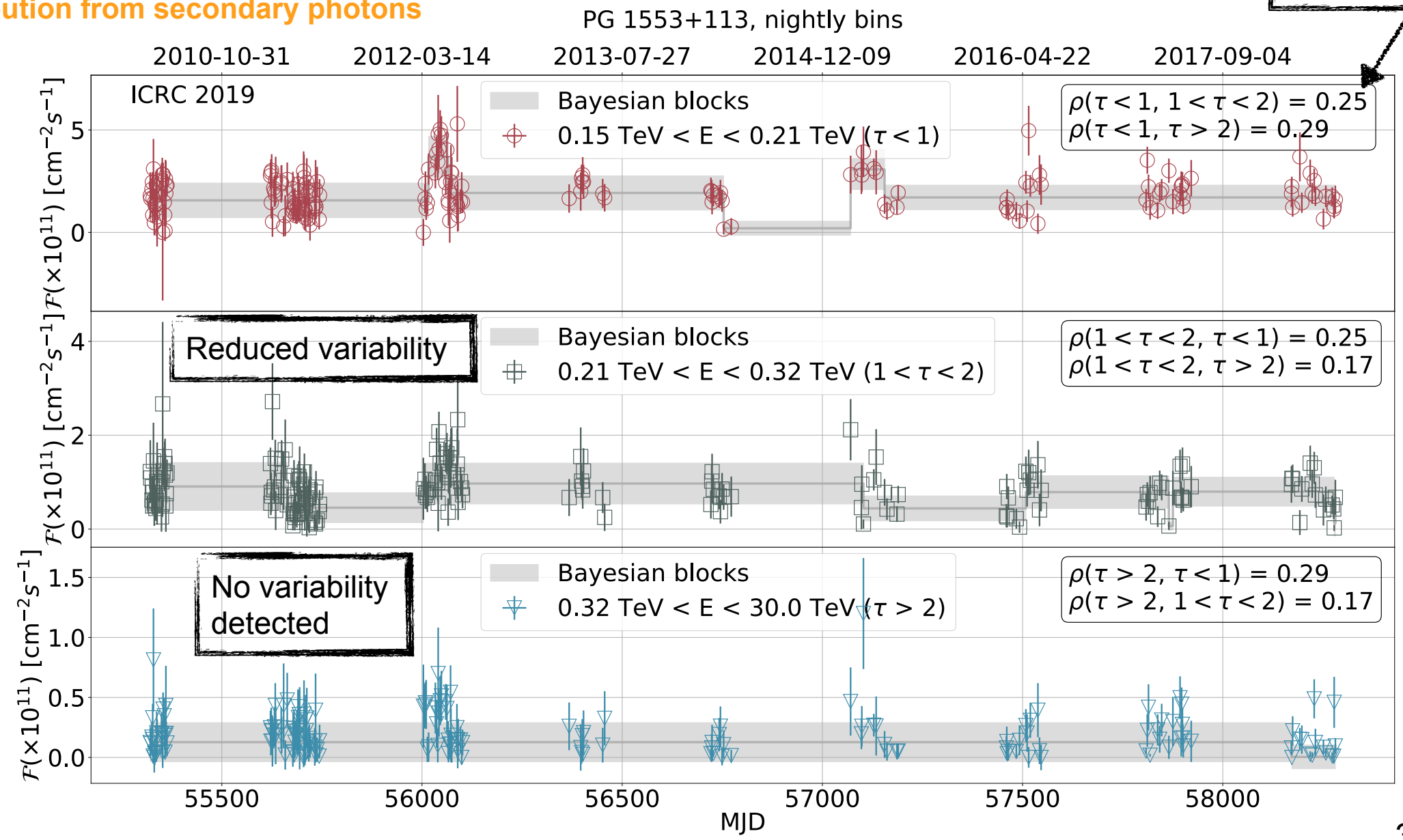
Derive energy thresholds based on photon survival probability for each source.



PG 1553+113

VHE lightcurves, PG 1553+113

Contribution from secondary photons

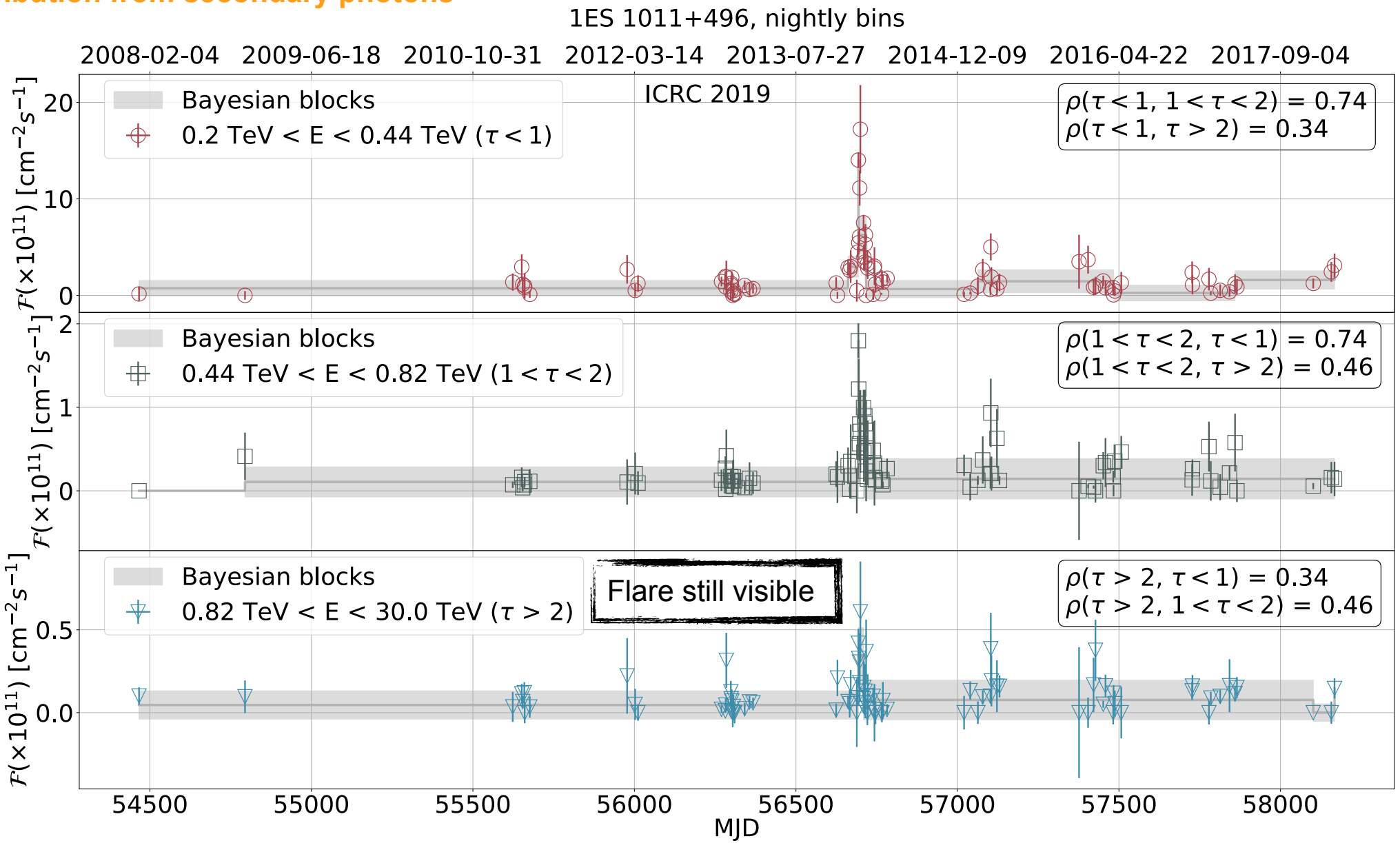


Simple Pearson correlation factors

1ES 1011+496

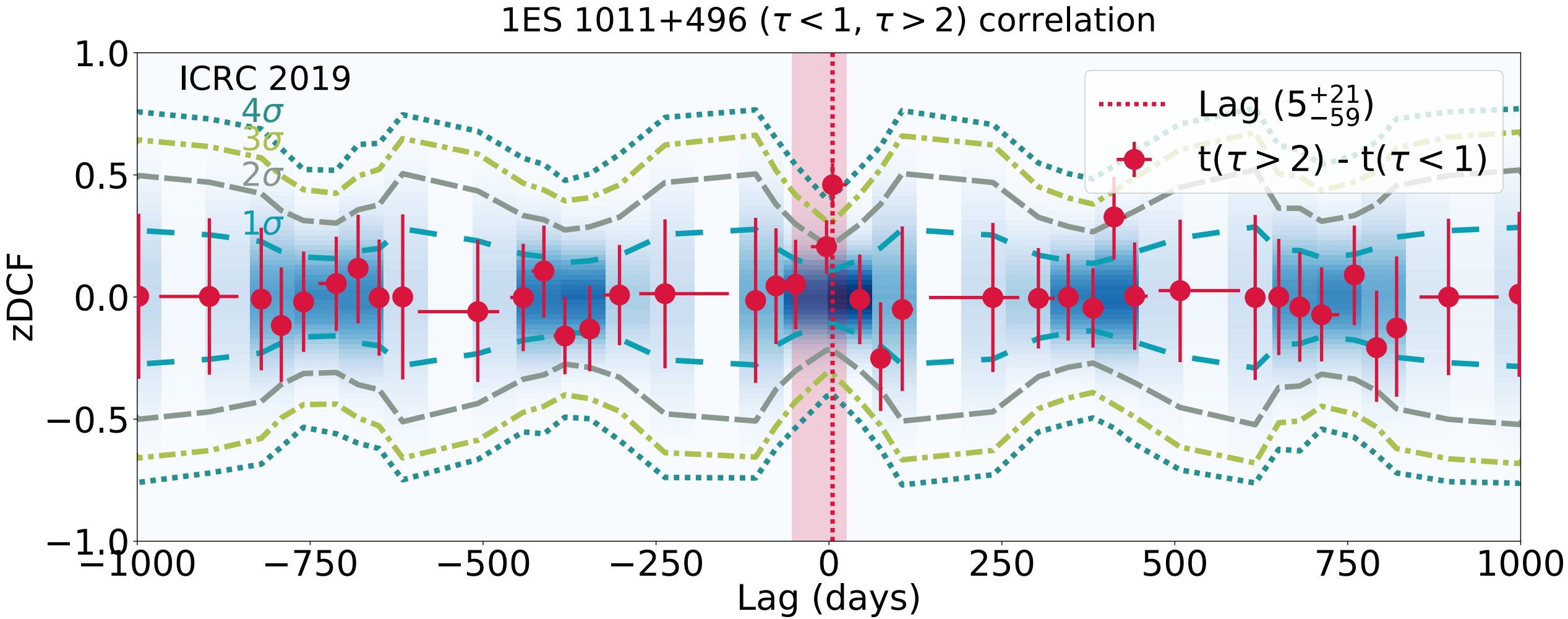
VHE lightcurves, 1ES 1011+496

Contribution from secondary photons



Correlation VHE lightcurves 1ES 1011+496

Contribution from secondary photons



Toy MC study: ~3σ correlation observed for primary photons contributing only 13% to the $\tau > 2$ lightcurve

Summary and outlook

Multiwavelength lightcurves

- Studied long-term lightcurves of various HBLs/xHBLs, spanning a decade of VERITAS data.
- No fast VHE/HE variability observed for (X-ray variable, too weak in gamma-rays?)
  - **1ES 0229+200**,
  - **1ES 0502+675**,
  - **RGB J0710+591**.
- MWL correlation study:
  - **1ES 0033+595**, **1ES 1218+304**: no correlation observed, short time-scale variability in VHE/X-Ray.
  - **1ES 1011+496** (flare): 4σ VHE/HE correlation, no lag, suggesting one source.
  - **PG 1553+113**: 3.8σ correlation VHE/X-Ray observed, no lag. No correlation seen with HE despite observed variability. Implications for one-zone SSC model?

Secondary photons

- Current dataset cannot rule out line-of-sight secondary photon model.
- Short time-scale variability/correlation in the $\tau > 3$ is necessary for that.

Outlook

- Explore SED variations for high/low states.

Backup slides

Correlation VHE lightcurves 1ES 1011+496

Contribution from secondary photons