Long-term multi-band photometric monitoring of Mrk 501

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Introduction and the MWL campaign

- Mrk 501 is a bright and close ($z = 0.0034$) blazar variable from radio to TeV. It was discovered in the TeVs by Whipple IACT [7].
- Mrk 501 SEDs can be fitted with a one-zone SSC model [5], during some flares addition of a second smaller zone is required to explain all features in the high-energy hump [1]. Hadronic models are also considered [9].
- We use a long-term (5.5 years) and unbiased TeV light curve, obtained by FACT, a 3.8 m IACT located at La Palma, Canary Islands [2].
- The multi-wavelength light curves for eight instruments span from December 14, 2012, to April 18, 2018 (from MJD 56275 to 58226).

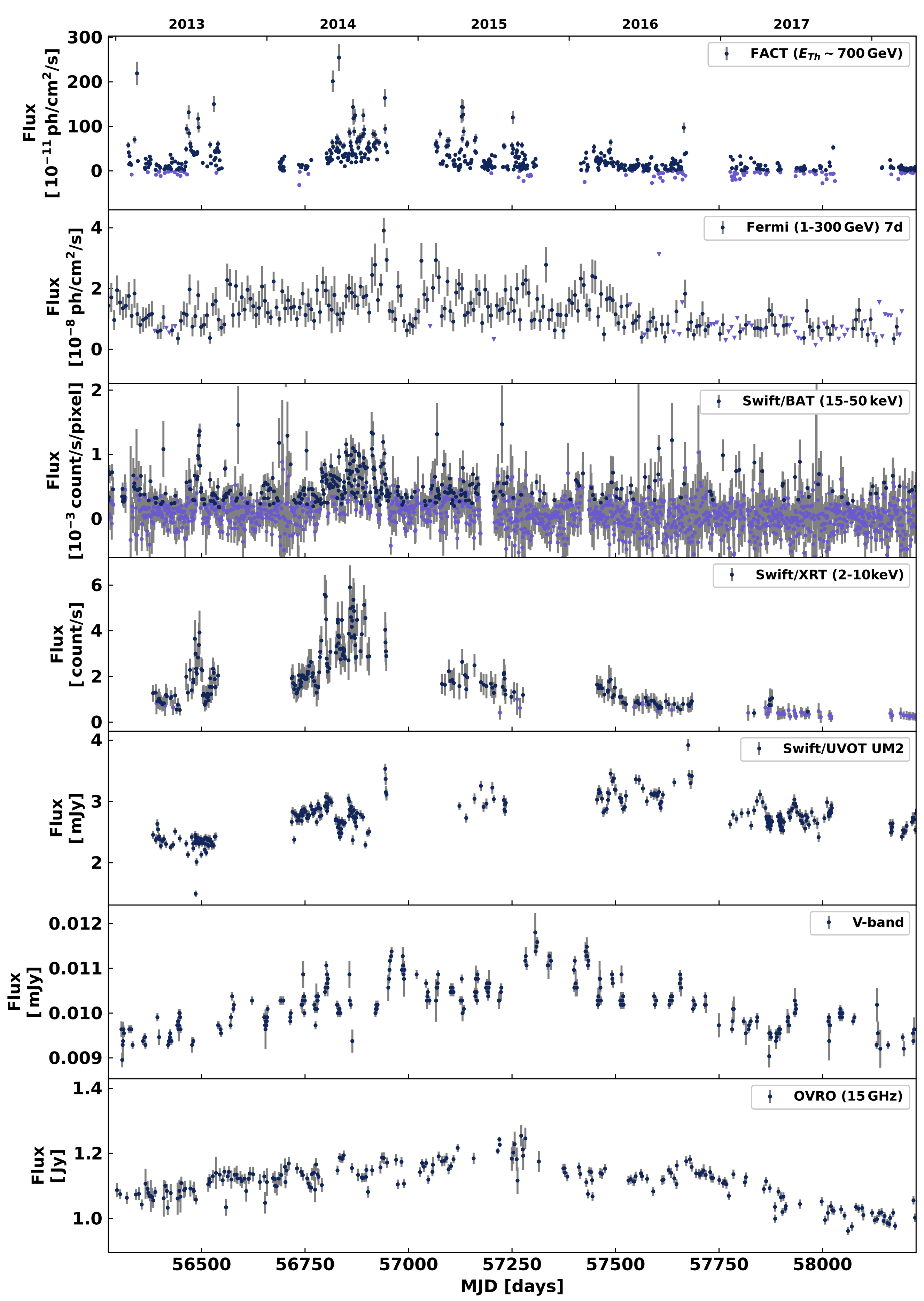

Fig. 1: Long-term light curves of Mrk 501. Top to bottom: FACT (E_{Th} ~700 GeV), *Fermi*-LAT 1–300 GeV, *Swift*/BAT 15–50 keV, *Swift*/XRT 2–10 keV, *Swift*/UVOT, V-band and 15 GHz OVRO.

Variability and timing analysis

- Fractional variability vs frequency dependency has a two-hump shape, peaking in the X-rays and TeVs, with F_{var} of 0.55 and 1.08.
- The TeV and X-ray light curves are strongly correlated without a significant time lag of (0.3 ± 0.4) days.
- Relation between the X-ray and γ-ray spectral breaks indicates that the cut-off energies of both spectral components are related.
- GeV is correlated with *Swift*/XRT (0.3-2 keV) and not with harder X-rays. Correlation between TeV and GeV was not found.
- Using the Bayesian Block algorithm, we identified 37 TeV flares, all coincident with flares or mild flare activity in the X-rays.
- The time delays distribution between the TeV flares peaks between 17 and 25 days, which is compatible with predictions of Lense-Thirring precession of an inclined accretion disk [3] for a SMBH of $0.9 - 3.4 \times 10^9 M_\odot$ [4].

Correlations at longer wavelengths

- Strong and wide correlation was found between GeV and V-band, GeV and radio (only after MJD 56800).
- Radio light curve can be obtained from GeV variability by convolving with a fast-rise-slow-decay profile: $t_{fall} = 126.6$ and $t_{delay} = 217$ days. Goodness of fit for the obtained synthetic light curve using best-fit profile is $\chi^2/\nu = 222/98$.

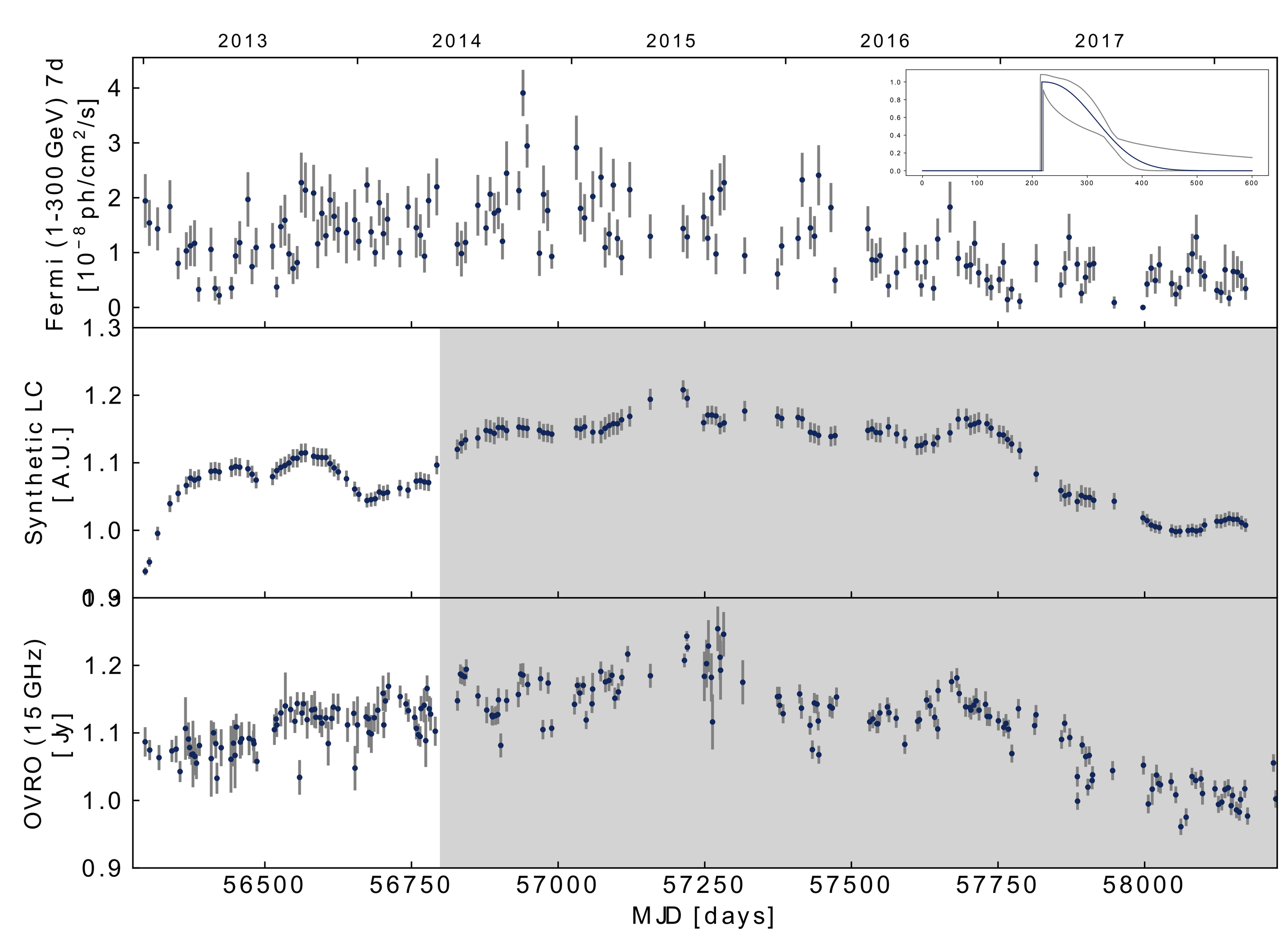

Fig. 3: A synthetic radio light curve (middle) derived from the *Fermi*-LAT light curve (top). The best-fit GeV to radio response profile (top right) was obtained for the time raneg highlighted in grey by comparing the synthetic and original radio light curve (bottom).

Conclusions

- The strongest variations were found in TeV and X-rays bands. The TeV and X-ray fluxes, measured simultaneously (within 24 hours), are correlated as well as the X-ray and gamma-ray spectral breaks, as expected by SSC models. Using 5.5 years of observational data the lag between the TeV and X-ray variations could be constrained to < 0.4 days (1σ).
- Long-term radio variability can be reproduced by a convolution of the GeV light curve with a fast-rise-slow-decay response profile with a 217 days delay.
- The characteristic time interval between TeV flares of 17-20 days observed in Mrk 501 is comparable with the theoretical prediction of these flares being triggered by the Lense-Thirring precession of the accretion disk around the SMBH.

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Acknowledgements

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