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 first observed in TeV by Whipple IACT [7].
- Mrk 501 SED is well described by one-zone SSC leptonic model [5], but during flares two-zone model is needed to explain all the features [1]. Hadronic models are also considered [9].
- We use 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).

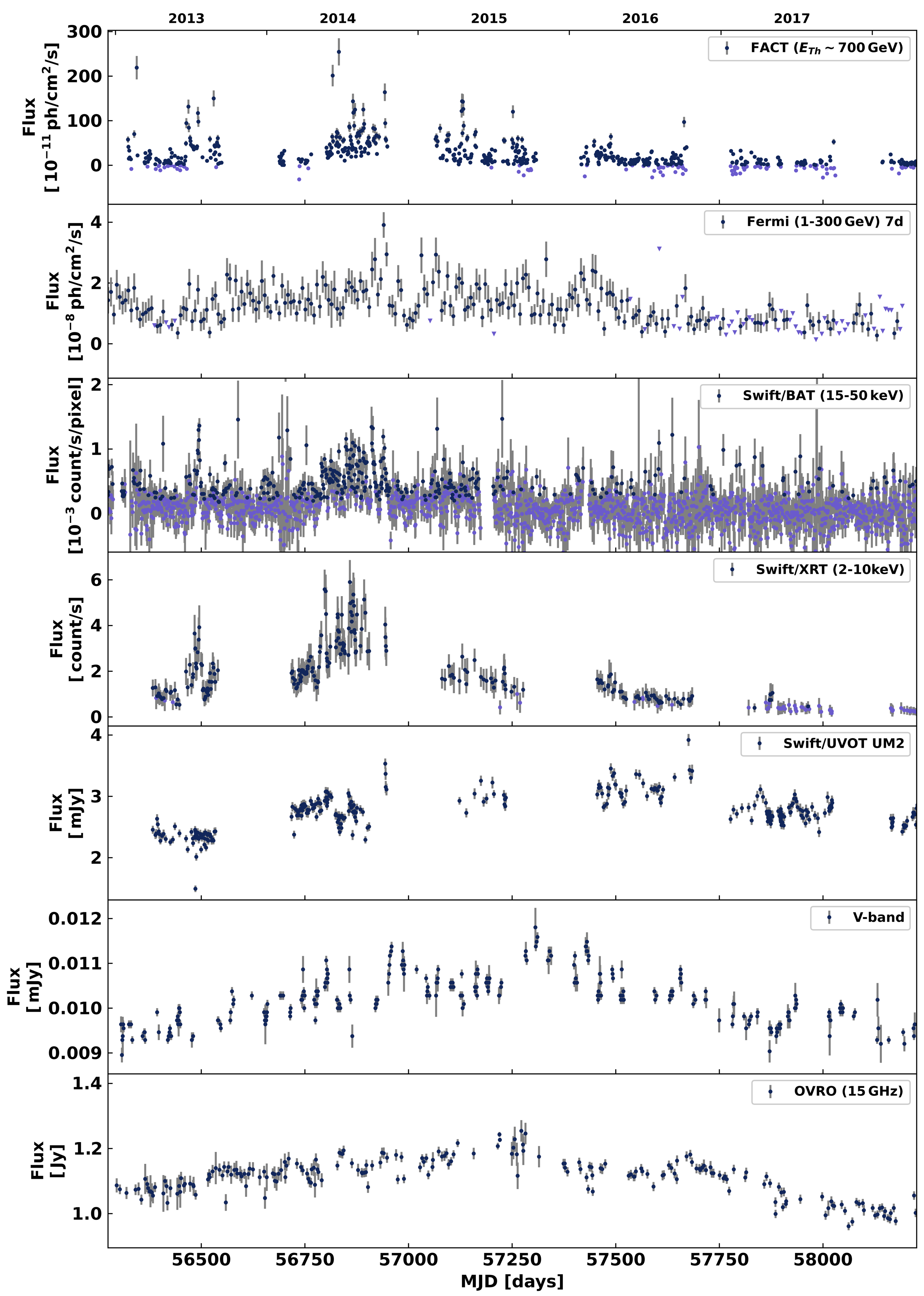

Fig. 1: Long-term light curves of Mrk 501. Top to bottom: FACT (E_{Th} ~700 GeV), Fermi 1–300 GeV, Swift/BAT 15–50 keV, Swift/XRT 2–10 keV, Swift/UVOT, V-band and 15 GHz OVRO.

Variability timing analysis

- Fractional variability $F_{var}(\nu)$ has two-bump shape, with peaks in Swift/XRT 2-10 keV X-rays and TeVs with F_{var} of 0.55 and 1.08.
- TeV and X-rays are strongly correlated without significant time lag, combined lag between the two is (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 Bayesian Block algorithm we identified 37 TeV flares, all flares are coincident with flares or mild flare activity in X-rays.
- The time delays distribution between TeV flares peaks between 5 and 25 days, which is compatible with Lense-Thirring precession of 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 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 fast-rise-slow-decay profile: $t_{fall} = 126.6$ and $t_{delay} = 217$ days. Goodness of fit of the obtained synthetic light curve using best-fit profile is $\chi^2/\nu = 222/98$.

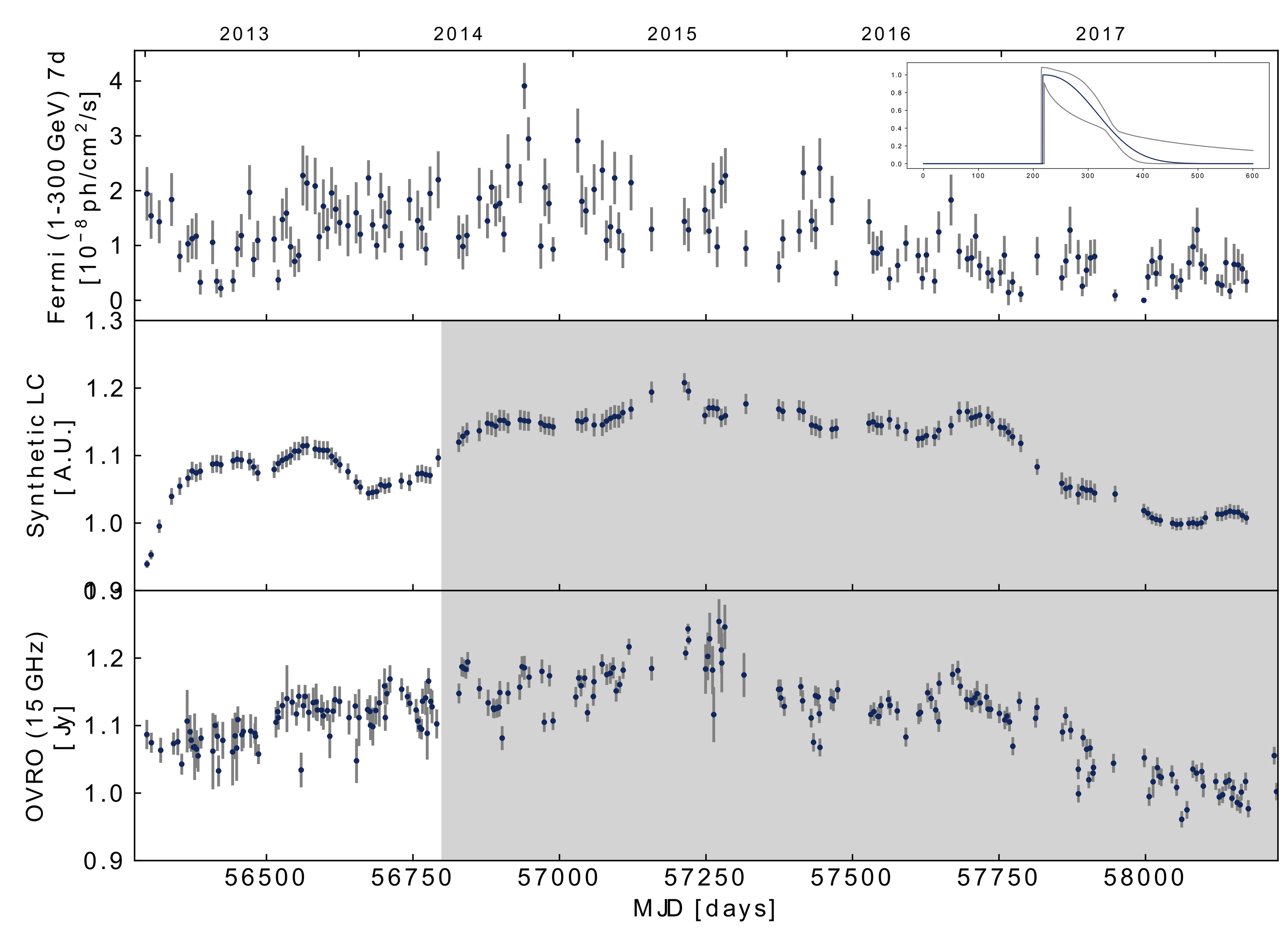

Fig. 3: Synthetic radio light curve (top) derived from Fermi LAT light curve and OVRO 15 GHz radio light curve (bottom). Best-fit response profile on grey-highlighted time range (top right).

Conclusions

- The strongest variations were found in TeV and X-rays. 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. The lag between the TeV and X-ray variations could be estimated as < 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.
- The characteristic time interval between TeV flares is comparable with the expectation if these flares are triggered by a Lense-Thirring precession of the accretion disk around the SMBH.

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Acknowledgements

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