Multiwavelength variability and correlation studies of Mrk421 during historically low X-ray and γ-ray activity in 2015–2016

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Acciari et al. 2021, MNRAS, 504, 1427

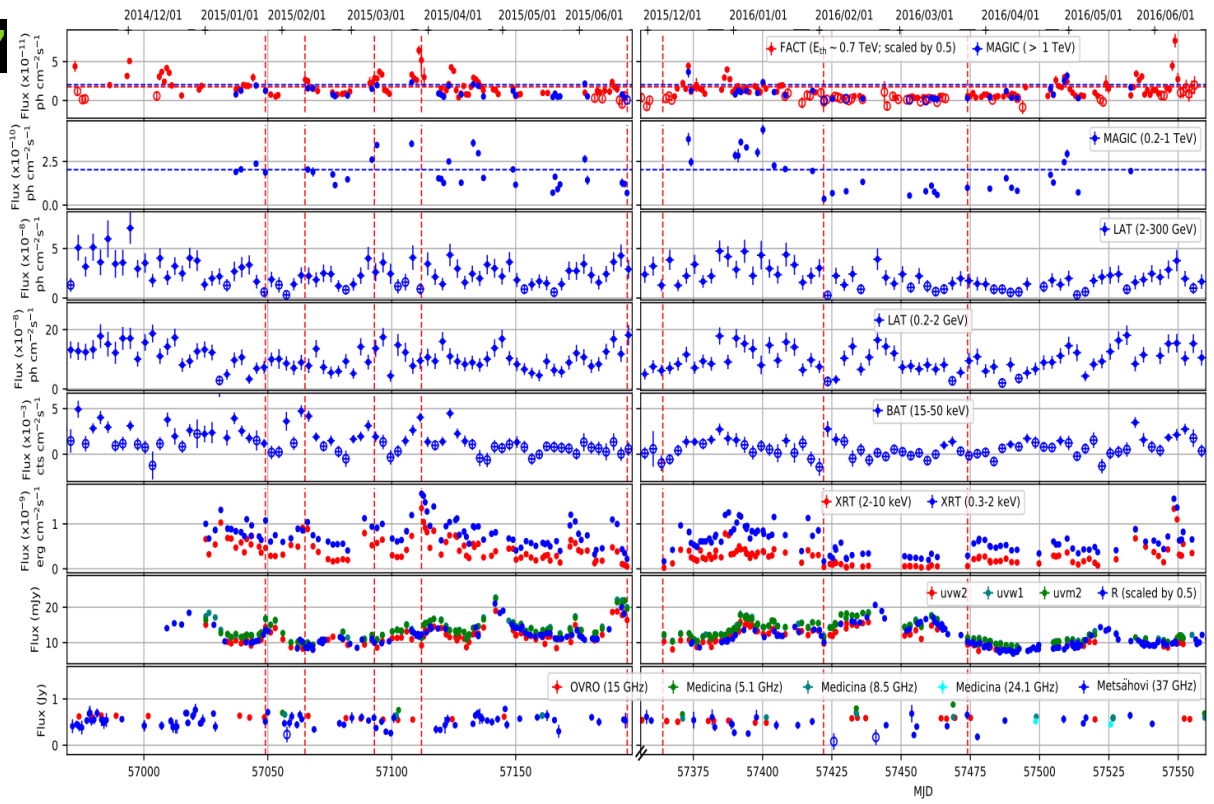
→ Mrk421 a BL Lac type object.

→ Most of the studies biased towards the high flux states.

→ Only a few studies during non-flaring episodes.

→ During 2015-2016, MAGIC observed the lowest flux state in the 0.2 − 1 TeV ($3.56 \pm 0.91 \times 10^{-11}$ ph cm $^{-2}$ s $^{-1}$) , on MJD 57422.

→ In X-rays, on MJD 57364, we observed lowest ever flux in the 2 − 10 keV band ($2.41 \pm 0.15 \times 10^{-11}$ erg cm $^{-2}$ s $^{-1}$).



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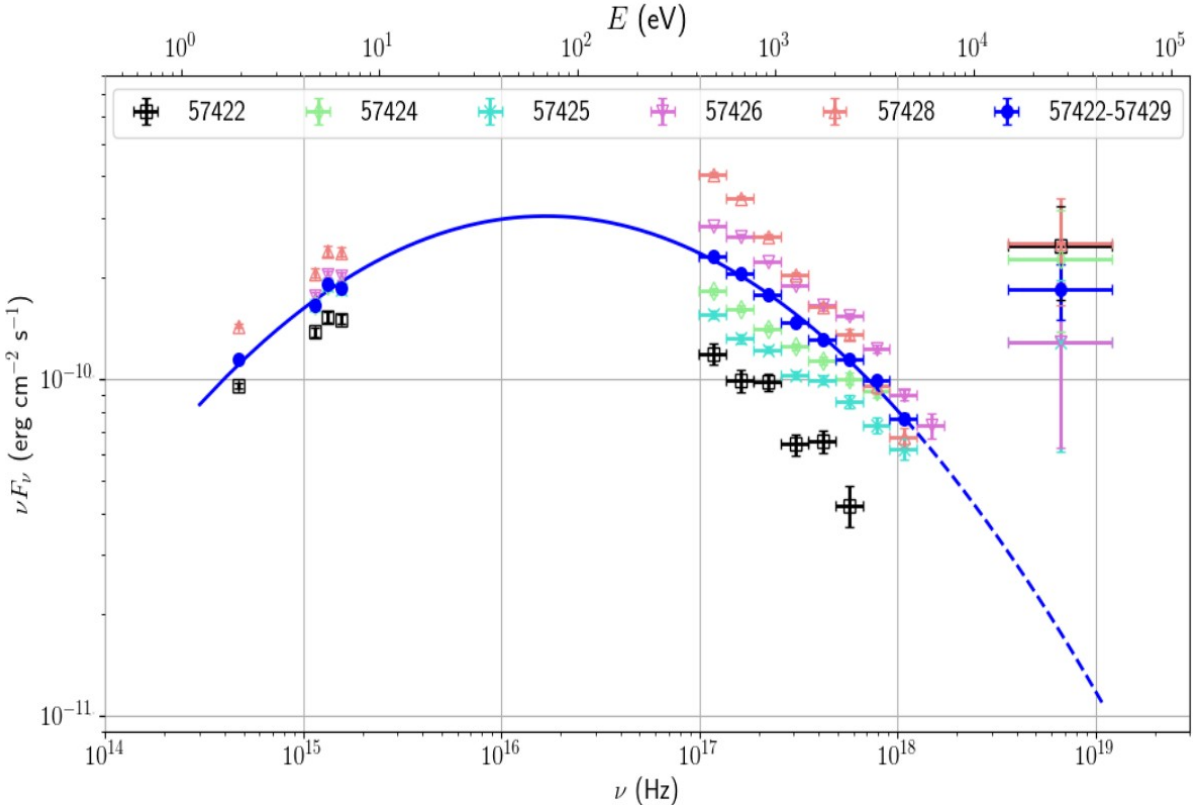
→ Synchrotron bump of Mrk421 (consisting of optical, UV, and X-ray) fitted with a log-parabola.

→ Flux measurements by Swift-BAT are significantly higher than the extrapolated XRT spectra during MJD 57422–57429.

→ Possible origin:

→ occasionally appearing narrow spectral component (as seen in Mrk 501; Acciari et al., 2020).

→ onset of the SSC component (Kataoka & Stawarz, 2016).



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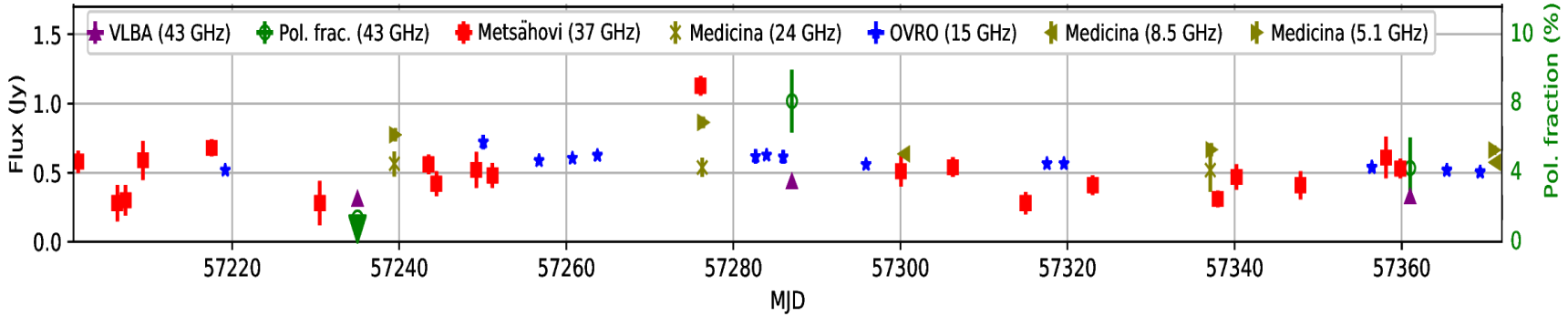

→ Radio flare @37 GHz (Metsähovi) on 2015 September 11, with flux doubling timescale < 21 days.

→ No change in the flux observed at 24 GHz; enhanced activity at 5 GHz, both observed with Medicina.

→ Increase in the polarization fraction with VLBA on September 22.

→ Possible origin a momentary disruption of the ordering of the magnetic field followed by a particle-acceleration via a kink instability.

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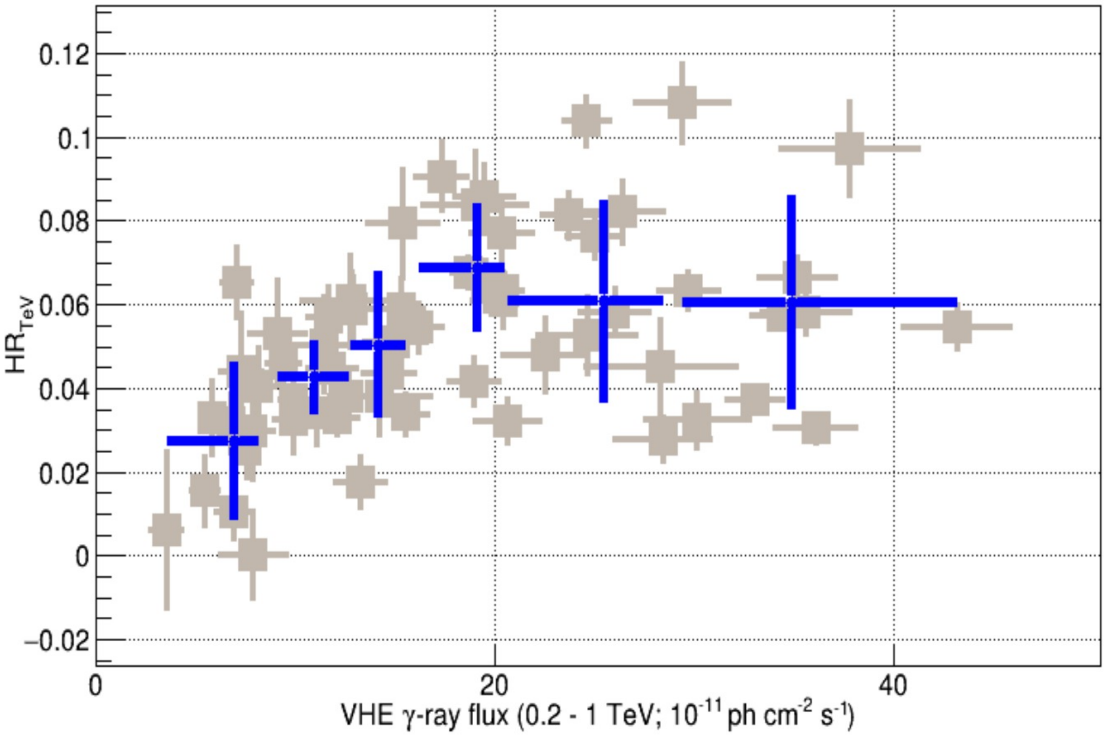
→ Variability quantified with fractional variability and hardness ratio (HR=hard band flux/ soft band flux).

→ Flattening of HR vs. flux in the VHE γ−rays, pronounced in the soft VHE band.

→ Similar phenomena for Mrk421 reported in the high (and low) X-ray fluxes (Baloković et al. 2016).



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→ Correlation between MWL LCs quantified using Pearson and Discrete Correlation Coefficient.

→ The correlation results involving radio, optical and GeV bands substantiated with data from 2007–2014.

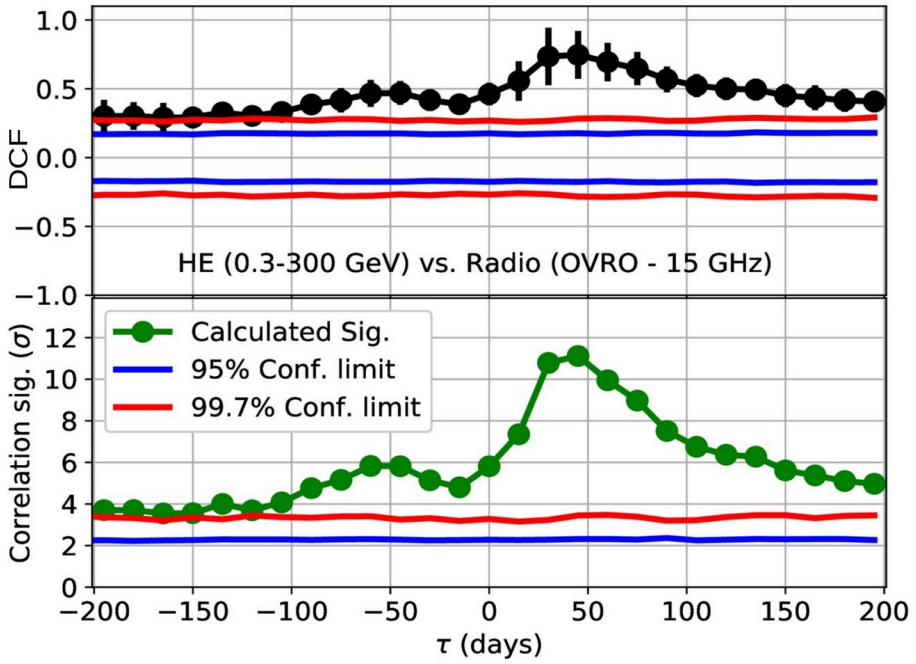
→ Three distinct observations emerging from this study:

Correlation between:

a) X-ray and VHE γ-ray LCs at time-lag τ =0, above 5σ;

b) Optical and HE γ-rays at τ =0, with a significance ∼11σ

c) Radio and HE (and optical) LCs at τ ~ 45-d.
Consistent with a separation of about 0.2 pc between the regions emitting the HE (optical) and the radio



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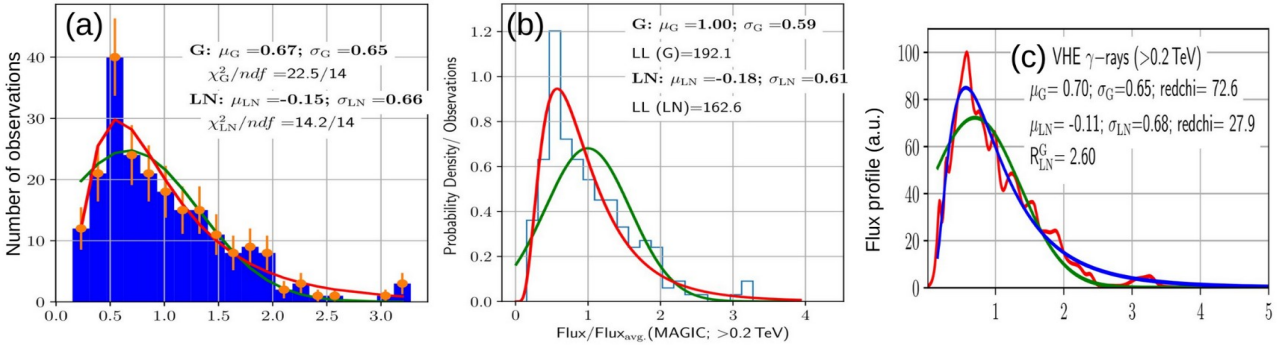
→ Crucial drawbacks of flux-histograms (panel a) using χ2 minimization:

a) Highly dependent on the choice of the binning, and

b) Flux uncertainty not considered.



→ Two newly devised methods that considers flux uncertainties, and no binning required: “Flux-profile” (panel b) & ”Unbinned likelihood” (panel c) methods.

→ The flux distributions in radio and soft X-rays better described with Gaussian, while the rest are better described with LogNormal.

→ A LogNormal distribution hints to multiplicative process responsible for variability (fluctuations in the accretion disk; McHardy, 2010).

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