Uncorrelated Multi-wavelength Variability of 3C279

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Short term variability of blazars

Correlated variability with or without lag in optical and γ-ray (e.g., Bonning et al. (2009,2012), Hayashida et al. 2012, Chatterjee et al. 2013)

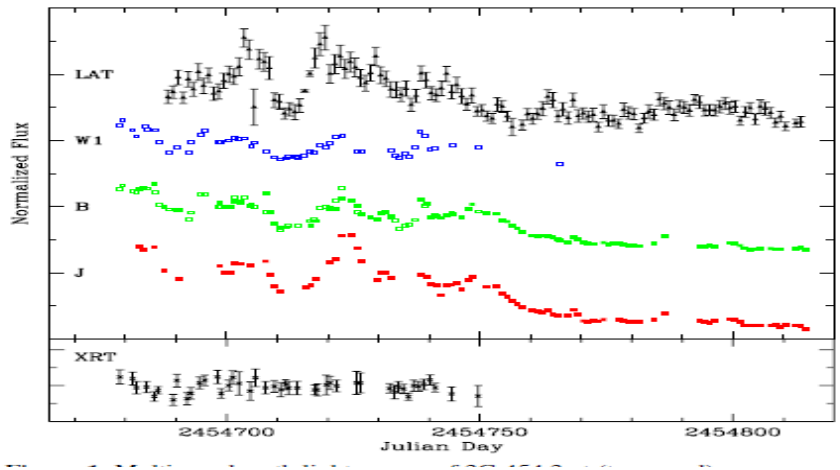


Figure : 3C 454.3 (Bonning et al. 2009)

- Correlated optical and γ-ray emission with zero lag.

Short term variability of blazars

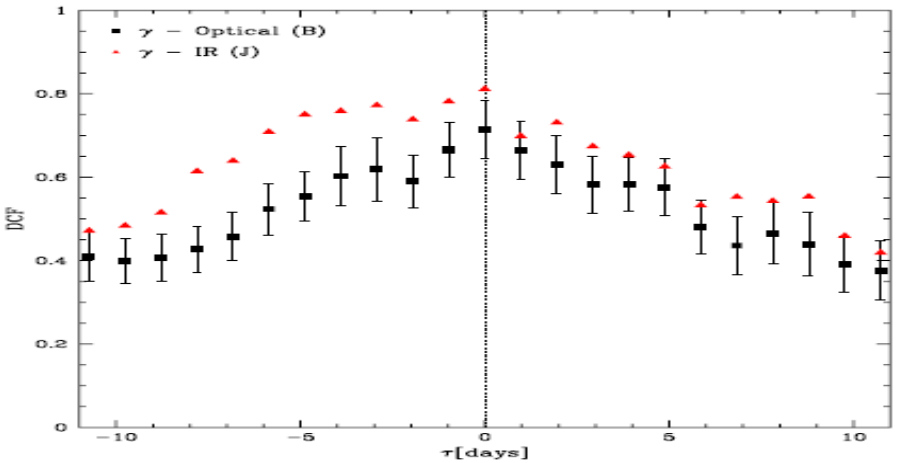


Figure : (Bonning et al. 2009)

Optical flare with no γ-ray counterpart PKS 0208-512 (Chatterjee et al. 2013), S4 1849+67 (Cohen et al. 2014)

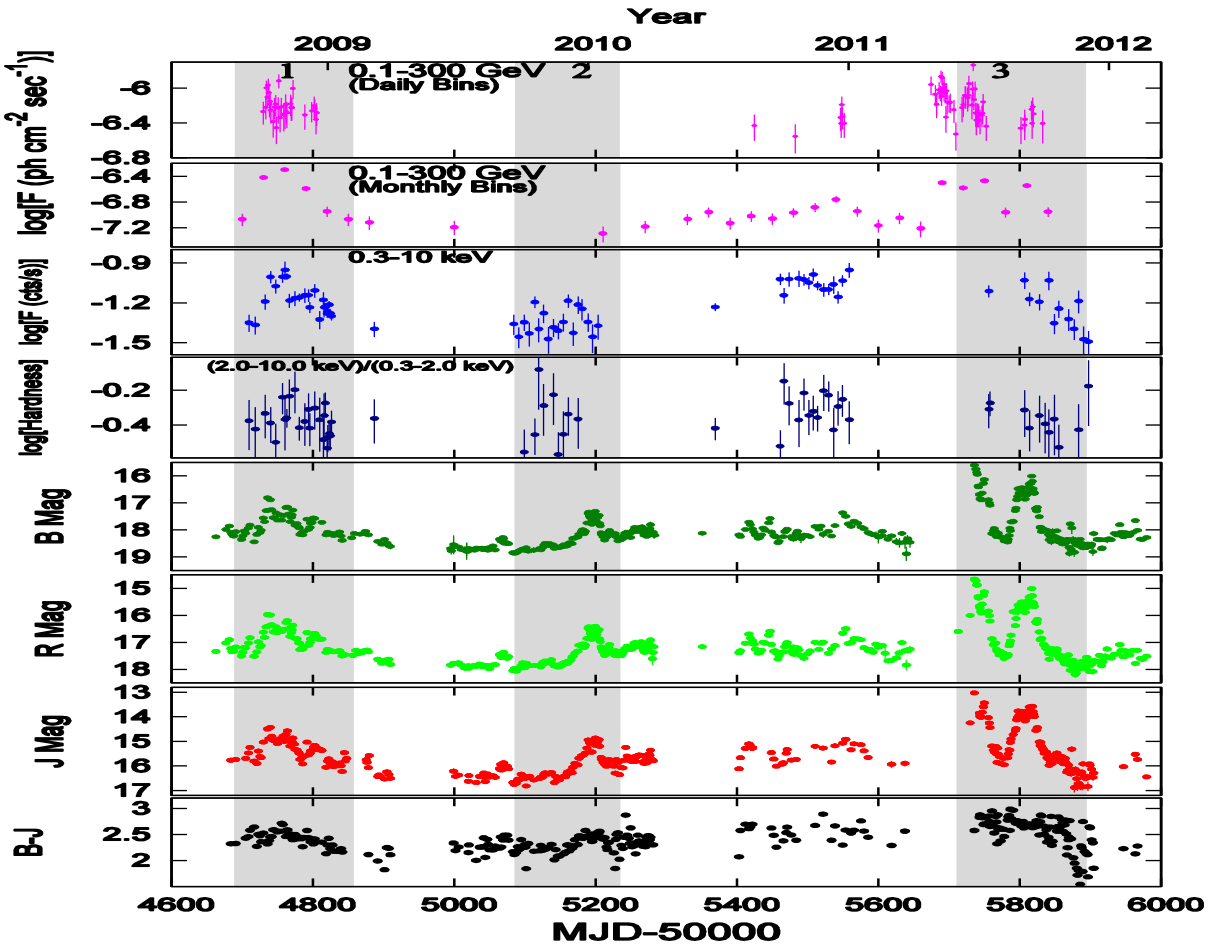


Figure : (Chatterjee et al. 2013)

PKS 0208-512

- Gamma-ray and optical fluxes are correlated with zero lag
- Orphan optical flare was observed (interval 2)
  Possible explanation:
  Source of optical emission: synchrotron emission, Depends on a) no. of emitting electrons (N), Doppler factor (δ), magnetic field (B)
- Source of γ-ray emission: external Compton emission,
  Depends on a) N, δ, total no. of seed photons
  So, change in B without any change in other parameters can produce the orphan optical flare.

γ-ray flare with no optical counterpart PKS 2142-75 (Dutka et al. 2013), PKS 1510-089 (MacDonald et al. 2015)

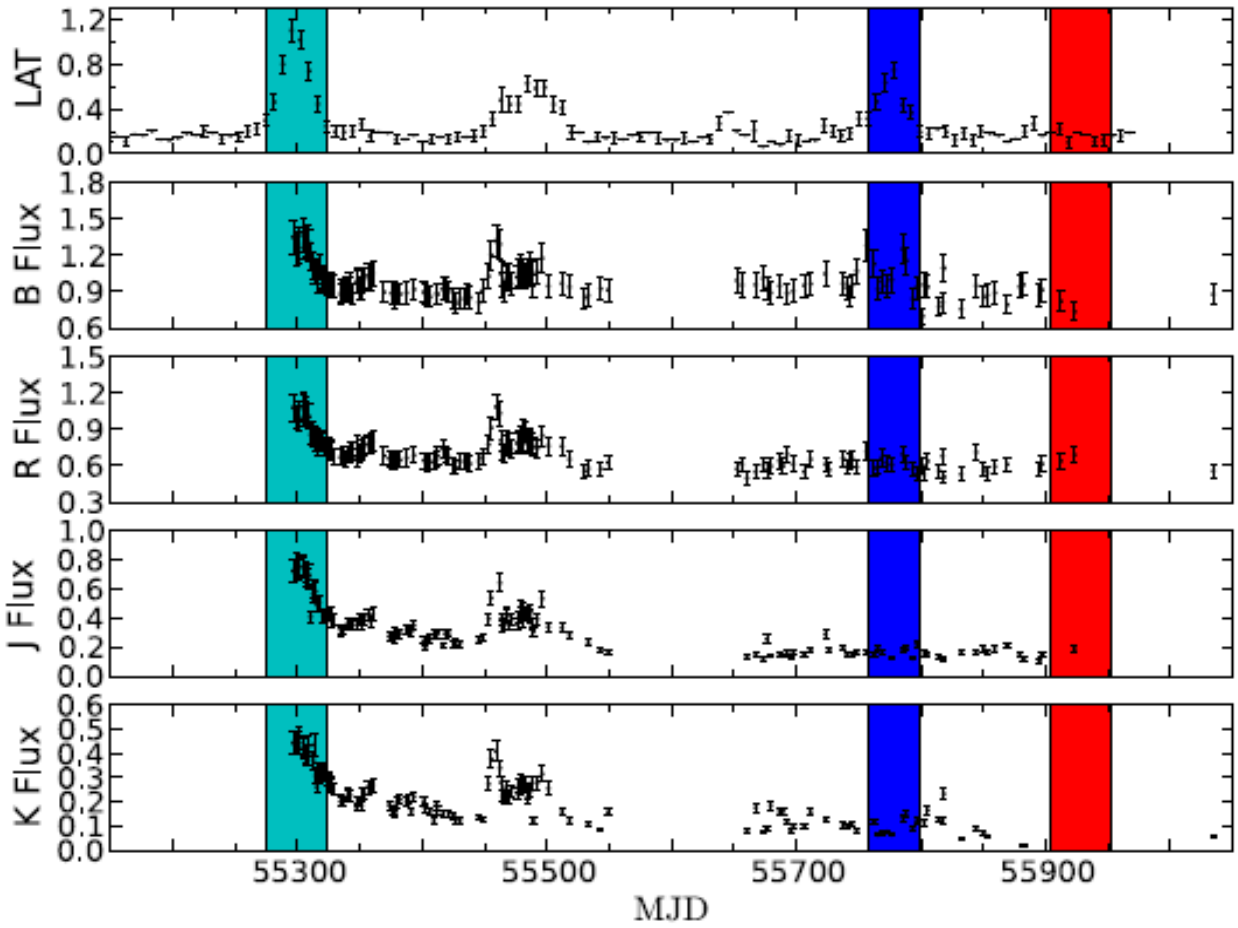


Figure : (Dutka et al. 2013)

Whether all these phenomena can be seen in a single source ?

3C 279: lightcurve

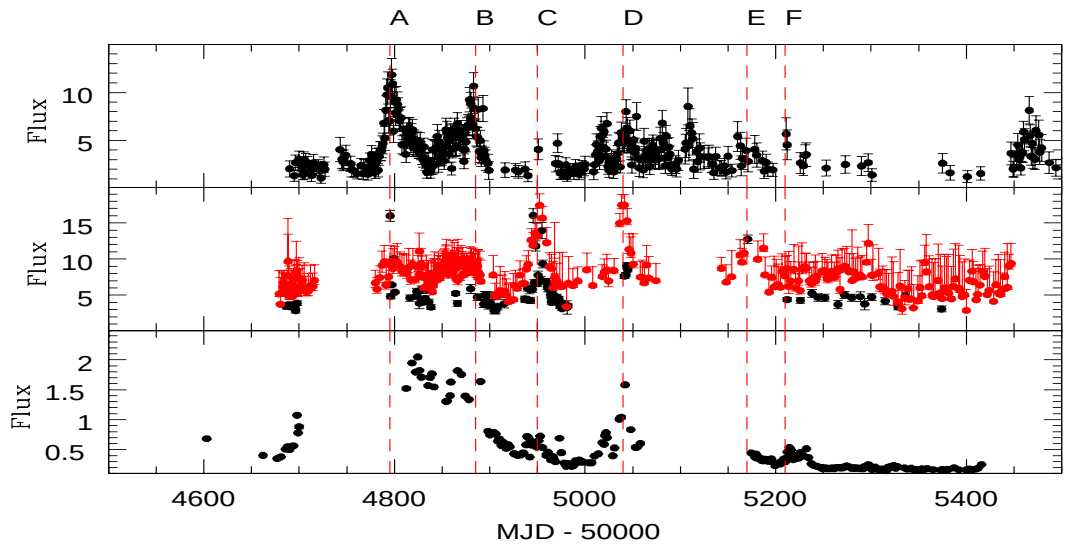


Figure : Optical (bottom panel), X-ray (middle panel) and γ-ray (top panel) lightcurves of 3C 279 during period 1 from MJD 54500 to MJD

3C 279: lightcurve

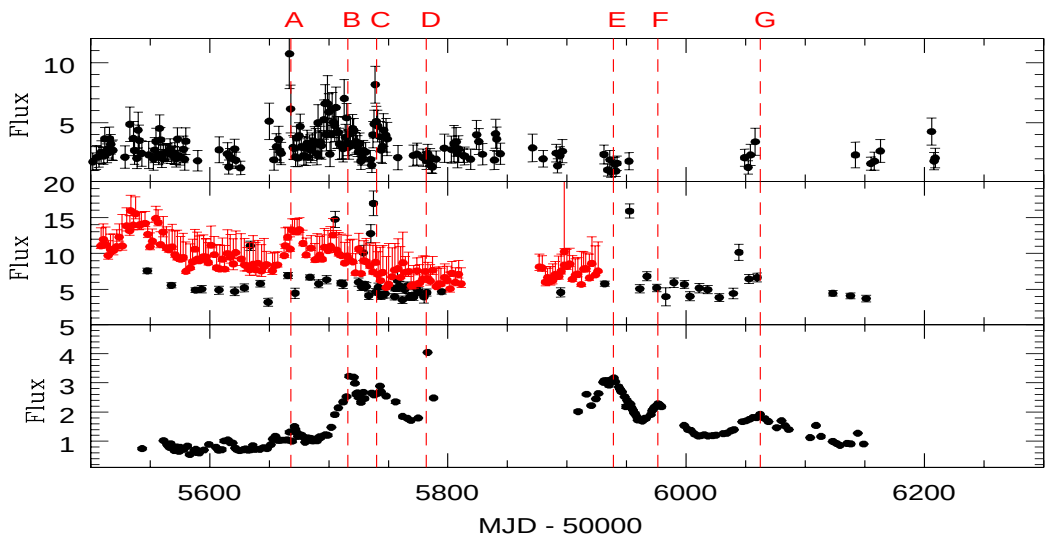


Figure : Optical (bottom panel), X-ray (middle panel) and γ-ray (top panel) lightcurves of 3C 279 during period 2 from MJD 55500 to MJD

3C 279: lightcurve

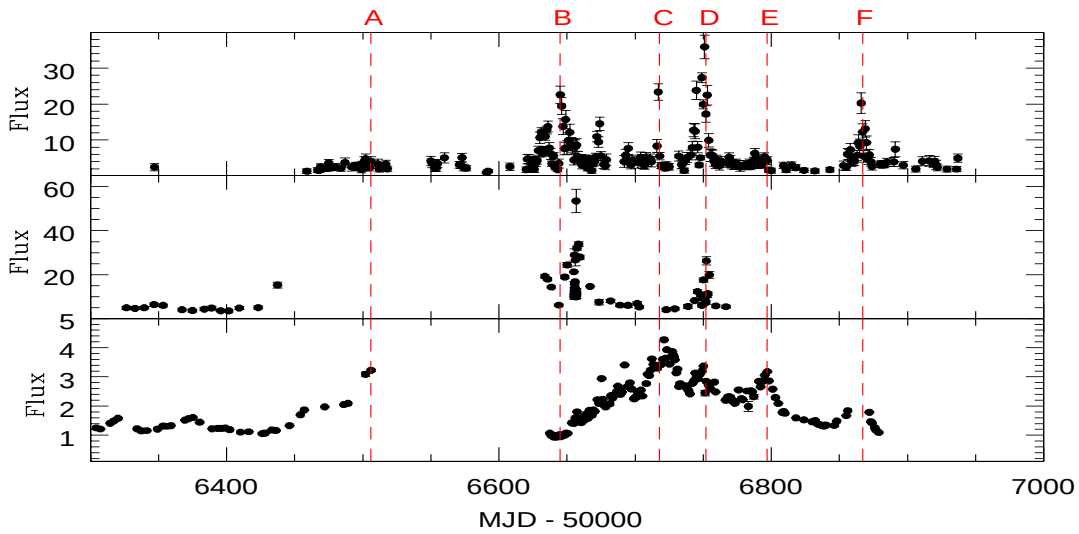


Figure : Optical (bottom panel), X-ray (middle panel) and γ-ray (top panel) lightcurves of 3C 279 during period 3 from MJD 56300 to MJD

Short term variability of blazars

- Same source exhibits correlated and orphan flares in different times.
- Required detailed campaigns of few selected blazars.
- Population study of complete source class.

Long term variability of blazars

Source selection criteria

Catalog used:

- 3rd EGRET point source catalogue (Hartman et al. 1999)
- Sowards-Emmerd et al. (2003, 2004)
- The γ-ray fluxes averaged over all the cycles of EGRET observations (P1234) were used for our calculations. The P1234 flux has been calculated from the counts map over four cycles.
- Only FSRQs that have a cumulative source detection significance > 4 for sources above the Galactic plane ($|b| > 10^{\circ}$) and > 5 for those in the Galactic plane ($-10^{\circ} \leq b \leq 10^{\circ}$) are included.

Fermi observation of EGRET detected FSRQs

- 38 EGRET detected FSRQs have been detected by Fermi
- 18 EGRET detected FSRQs are not in 2nd Fermi catalog

Flux variation of FSRQs during EGRET and Fermi era

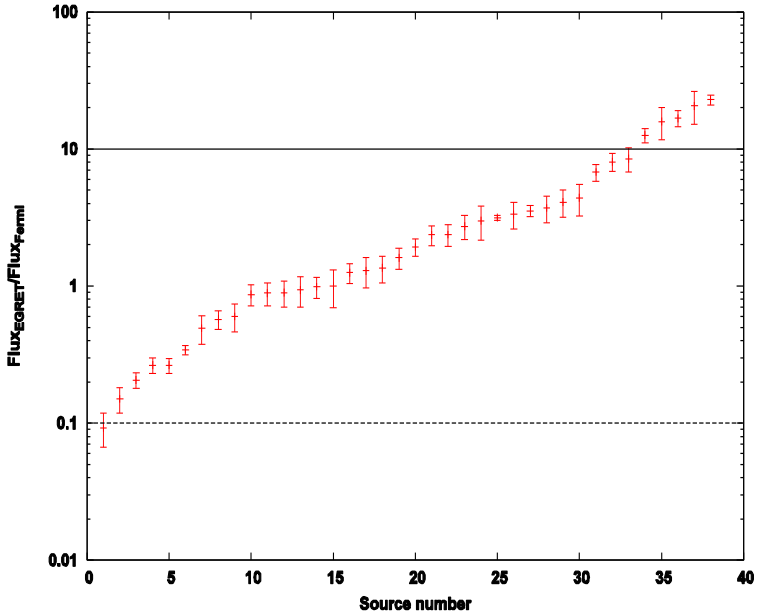


TABLE 1
DETAILS OF HIGHLY VARIABLE BLAZARS

Source Name	F_{EGRET}[a]	F_{Fermi}[a]	R[a]
PKS 0208-512	86.7 ± 4.6	3.79 ± 0.24	22.9 ± 1.9
3EGJ 1614+3424	10.1 ± 1.5	0.49 ± 0.11	20.6 ± 5.5
PKS 1622-29	40.1 ± 3.1	2.40 ± 0.26	16.7 ± 2.2
PKS 0336-01	21.4 ± 5.0	1.35 ± 0.17	15.9 ± 4.2
PKS 0528+134	32.4 ± 1.2	2.57 ± 0.29	12.6 ± 1.5
PKS 1454-354	1.1 ± 0.3	11.9 ± 0.42	0.09 ± 0.02

[a] γ-ray (> 1 GeV) flux during EGRET and Fermi observations in 10^{-9} photon cm^{-2} s^{-1}. R is the ratio of the EGRET to Fermi flux.

Figure : Bhattacharya et al. (2013)

EGRET lightcurve

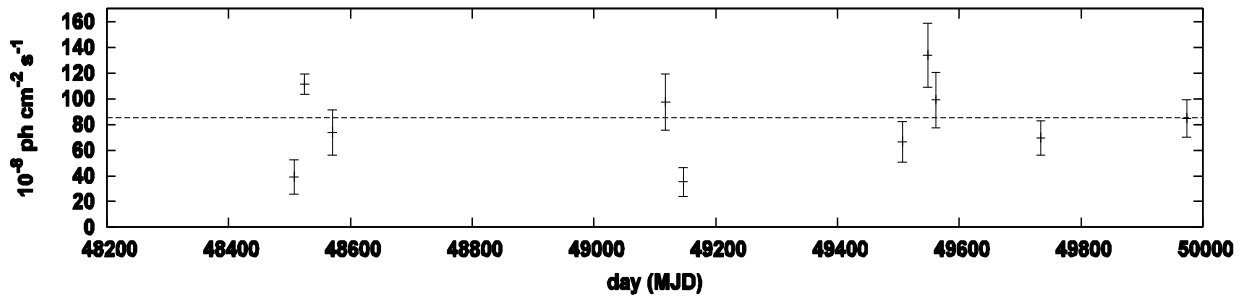


Figure : PKS 0208-512 (Bhattacharya et al. (2013))

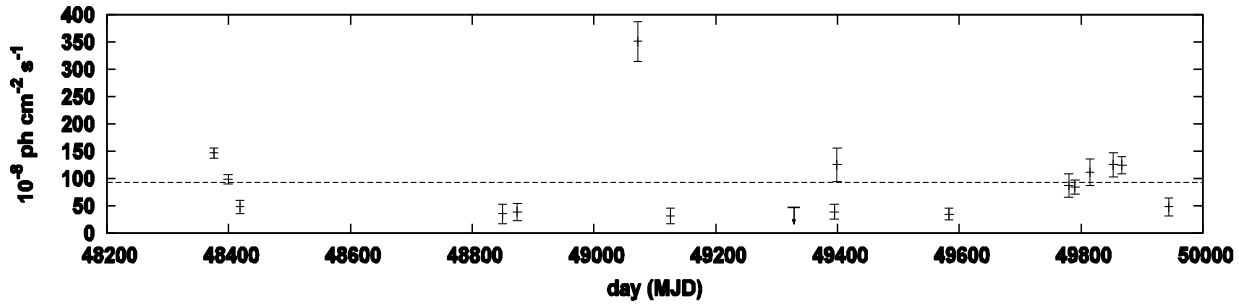


Figure : PKS 0528+134 (Bhattacharya et al. (2013))

X-ray observations

- It is also important to study long term variability of these sources in X-rays.
- There was no continuous monitoring in X-rays. ASM onboard RXTE could not detect these sources (marginal detection for PKS 1622-29)
- Over the 20 years PKS 0208-512 and PKS 0528+134 were observed by different X-ray satellites (ROSAT, ASCA, RXTE, BeppoSAX, Suzaku, XMM-Newton, SWIFT).

γ-ray and X-ray observations

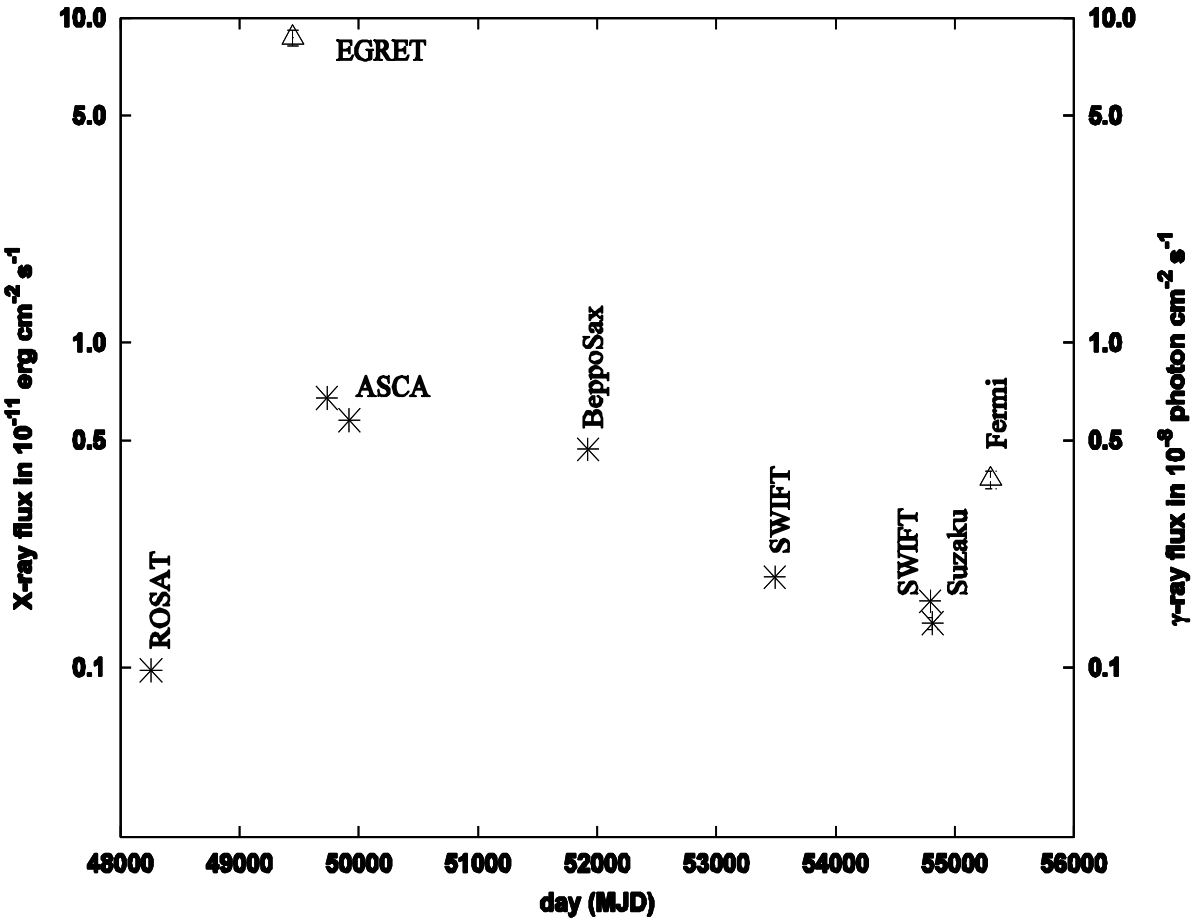


Figure : PKS 0208-512 (Bhattacharya et al. (2013))

γ-ray and X-ray observations

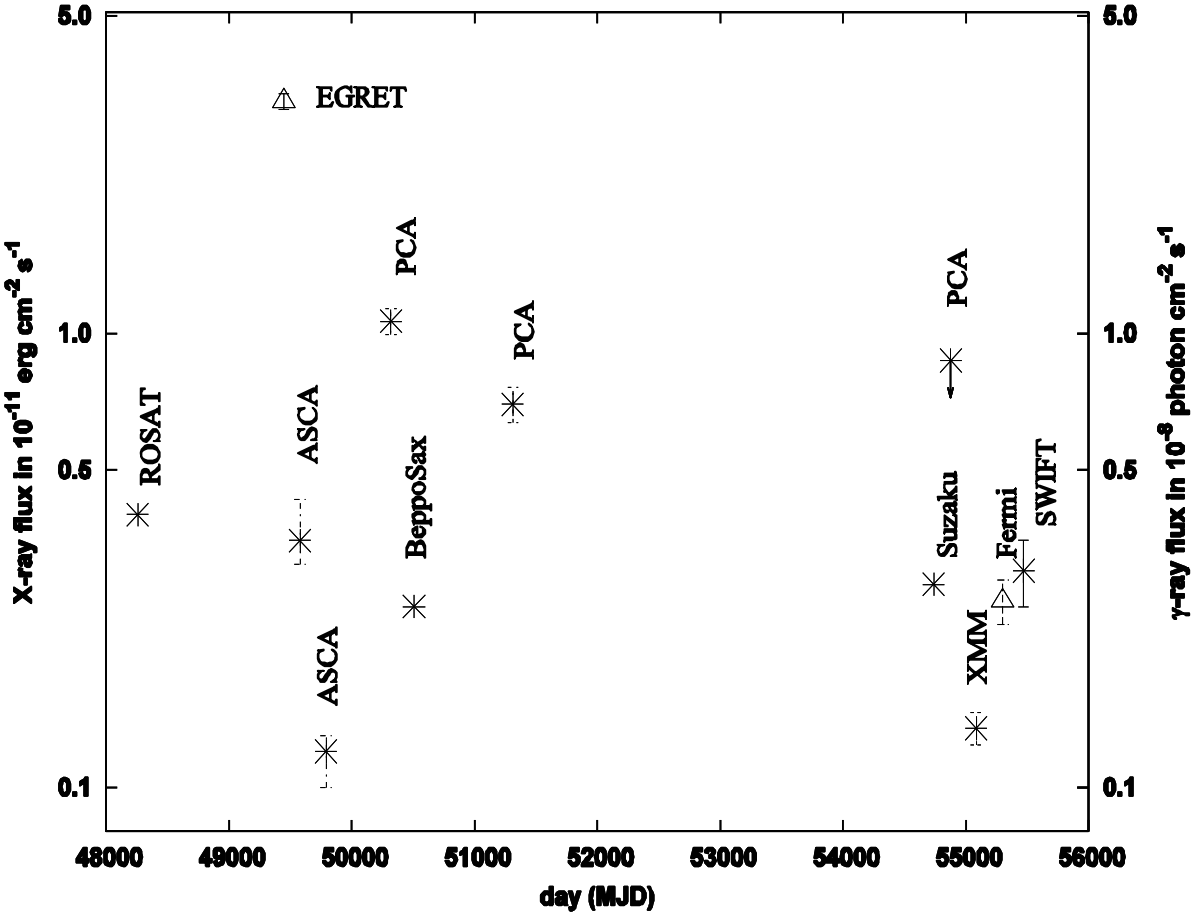


Figure : PKS 0528+134 (Bhattacharya et al. (2013))

Long term variability of blazars

- X-ray emission did not change much though γ-ray emission decreased by more than a factor of 10

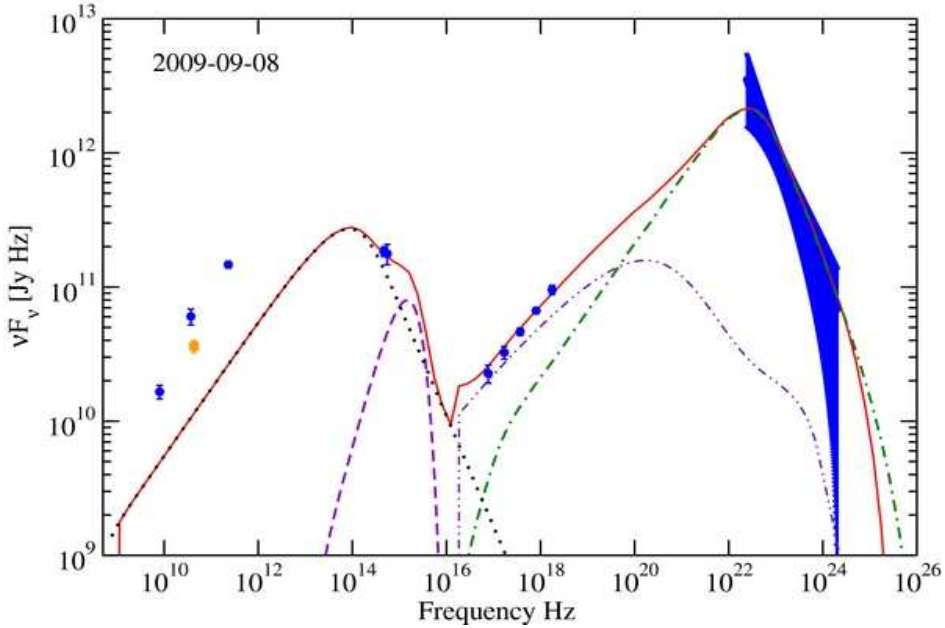


Figure : PKS 0528+134 (Palma et al. (2011))

- Origin of X-ray: Synchrotron self Compton (SSC) emission
- Origin of γ-ray: external Compton of accretion disk and/or BLR photons (EC emission)

Possible explanation:

- If the seed photons (the accretion disk and/or BLR photons) for external Compton (EC) emission was a factor of 10 more during EGRET time then, the EC emission and hence the γ-ray flux would have been a factor of 10 more during EGRET time.
- The SSC emission and hence, X-ray flux would not have been affected by the increase of these seed photons.

Possible explanation:

- If the seed photons (the accretion disk and/or BLR photons) for external Compton (EC) emission was a factor of 10 more during EGRET time then, the EC emission and hence the γ-ray flux would have been a factor of 10 more during EGRET time.
- The SSC emission and hence, X-ray flux would not have been affected by the increase of these seed photons.
- If the flux from the disk or BLR, which is connected to the accretion process can change by an order of magnitude but the average intrinsic properties of the jet are not affected, it implies very weak or no coupling between the accretion and jet emission processes. (Bhattacharya et al. 2013).

Long term variability of blazars

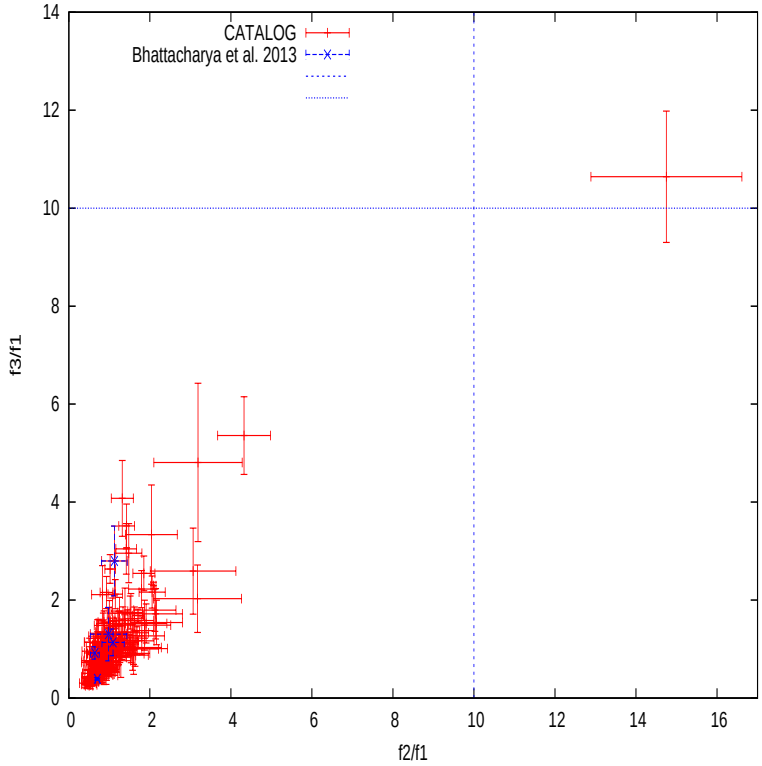


Figure : γ-ray flux ratio from Fermi catalogs

PKS 0208-512 lightcurve

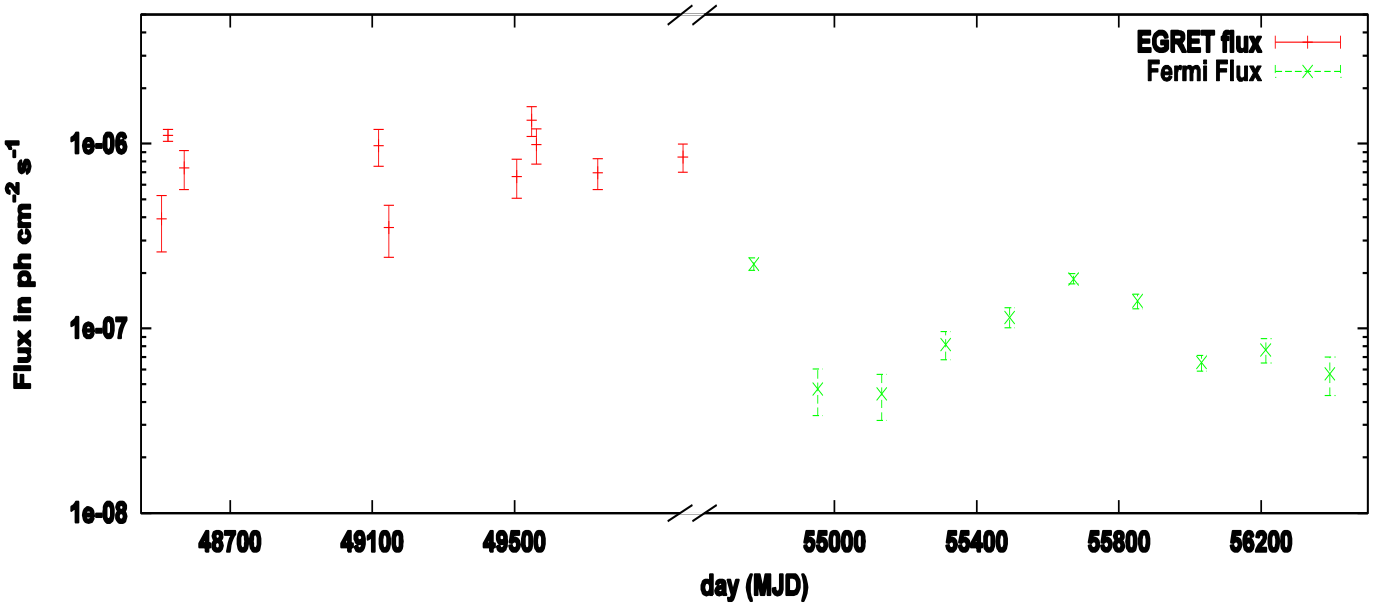


Figure : γ-ray lightcurve

PKS 1622-29 lightcurve

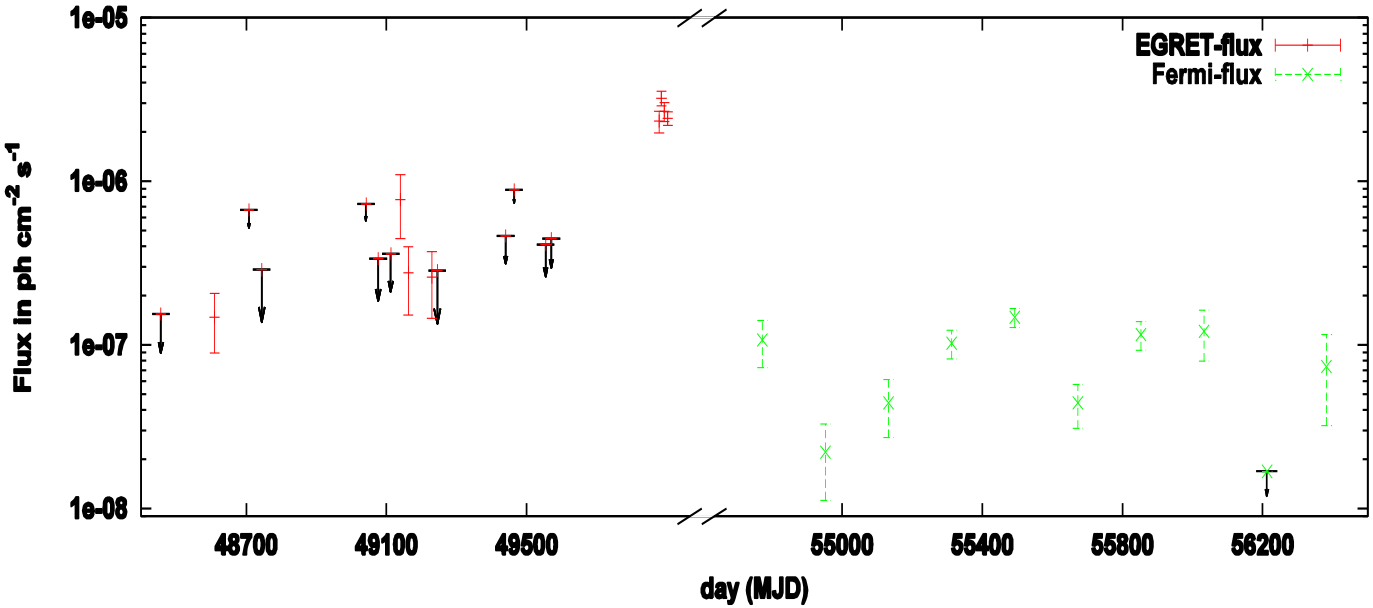


Figure : γ-ray lightcurve

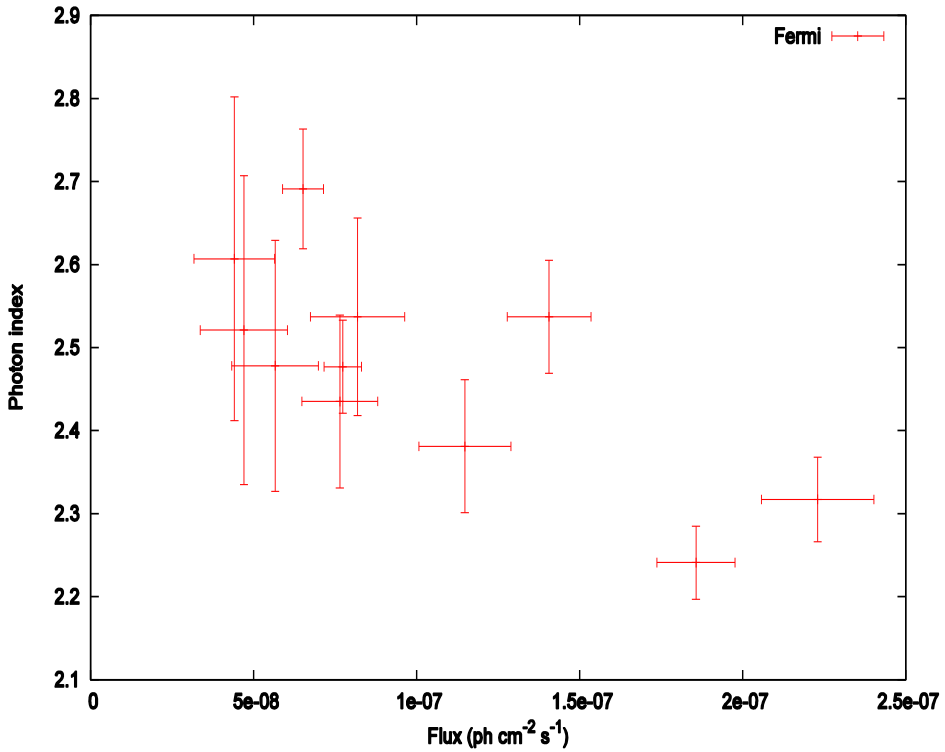
Long term variability of blazars

- Clearly two distinct activity states.
- Long term variation may be due to changes in the accretion disk (?)

Thanks for your attention

Long term variability of blazars: Additional Slide

PKS 0208-512 Flux vs. Sp. Index



- hint of flattening of spectra with increasing flux

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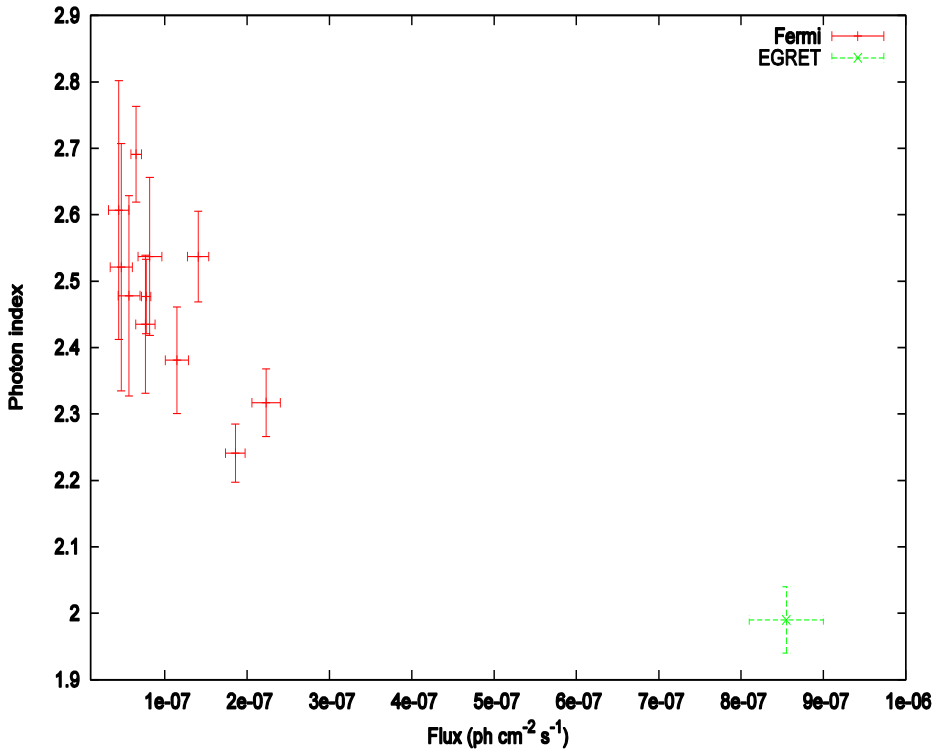

- Clear hint of flattening of spectra with increasing flux

Six month averaged light