Quantification of the multi-frequency variability

David Paneque and Diego Tescaro

Update from presentation done on Meeting on April 9th

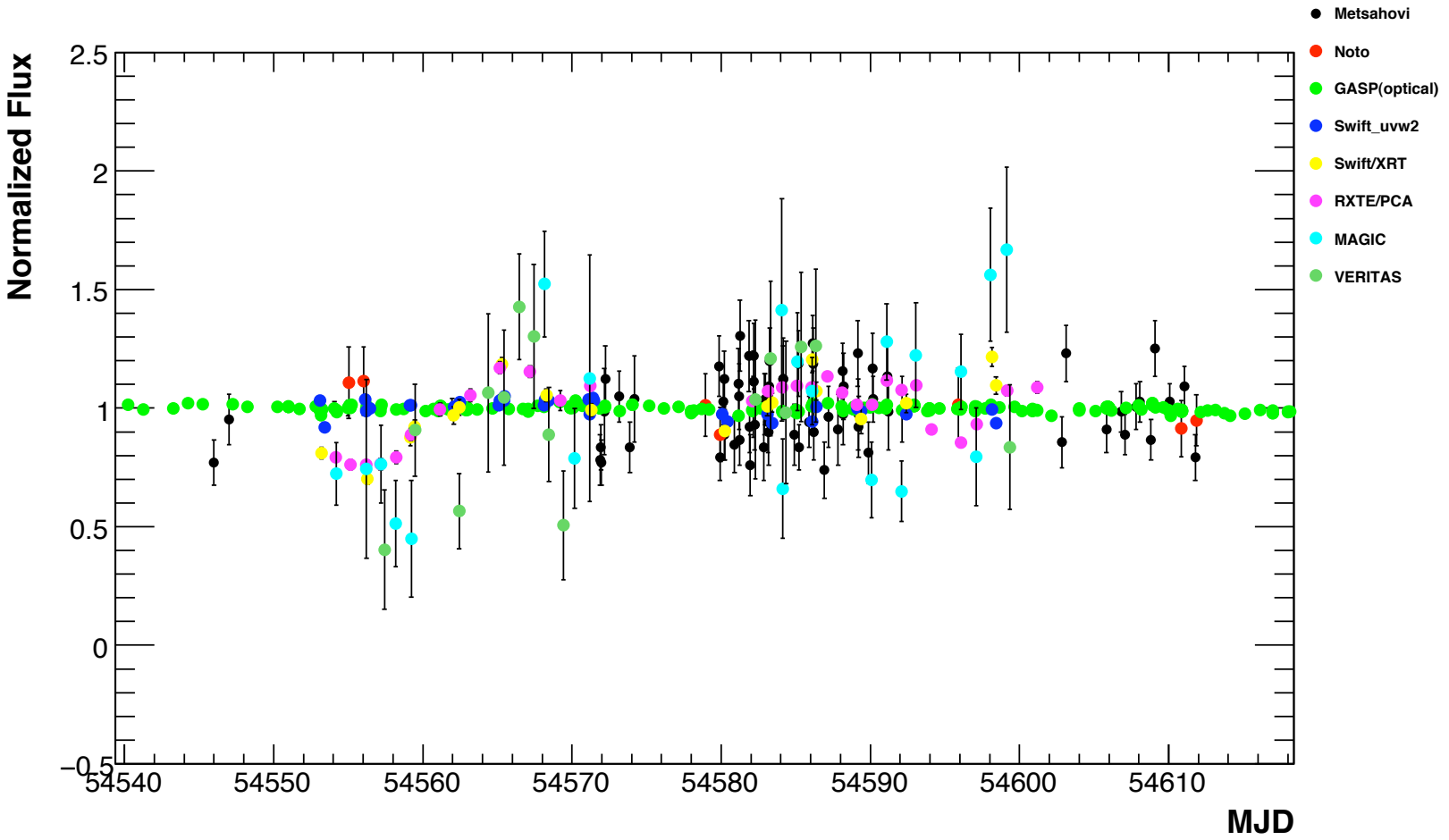
What's new:

Clarified the issue of Metsahovi data

Solved the problem with optical (GASP) data

Normalized Light Curves

Few instruments were removed



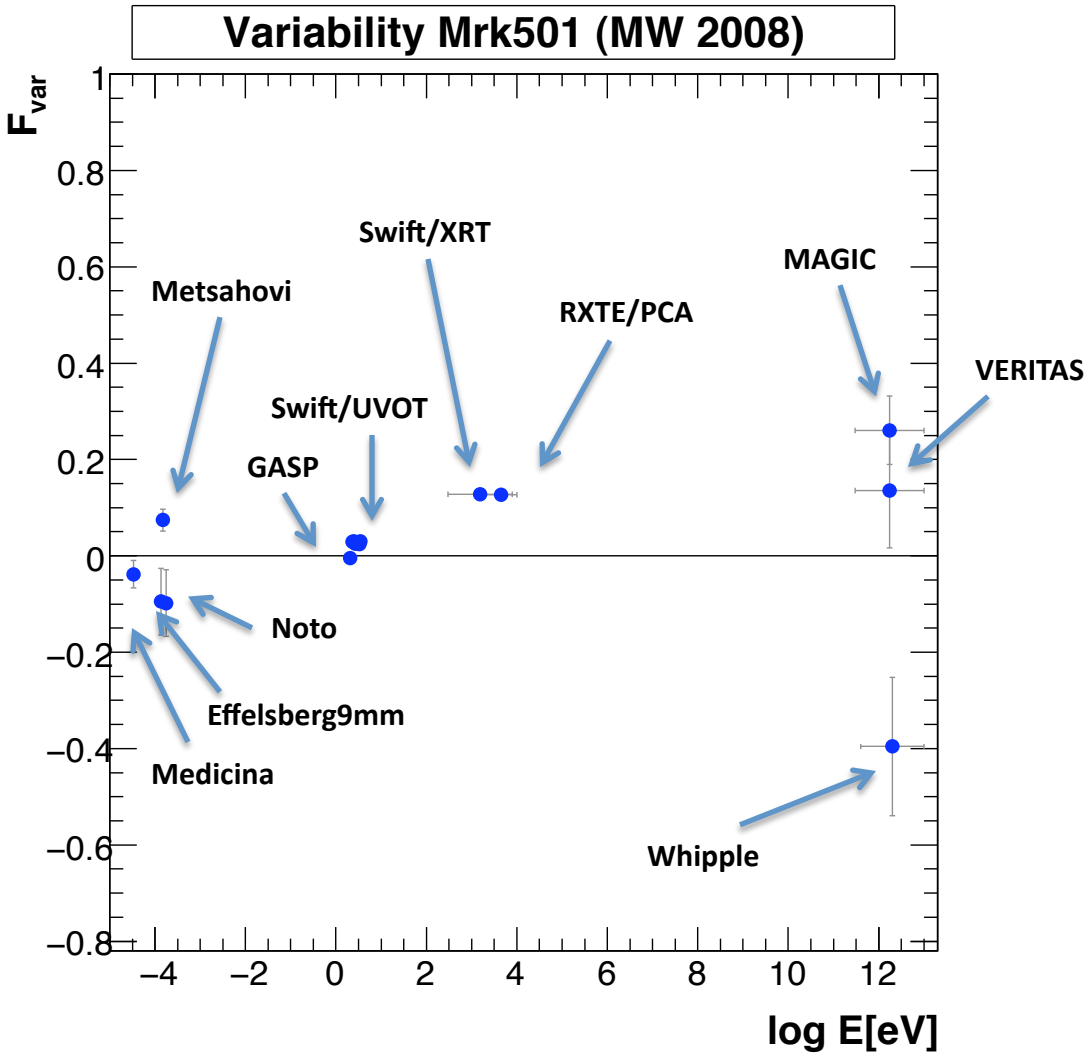
Measured fluxes at VHE were low (big relative errors)
In general No big flux variations (little variability)

Quantification of the Variability

Quantification following prescription given in *Vaughan et al. 2003*

Journal-ref: Mon. Not. Roy. Astron. Soc. 345 (2003) 1271
astro-ph/0307420 (July 2003)

$$F_{var} = \sqrt{\frac{S^2 - < \sigma_{err}^2 >}{< F_\gamma >^2}}$$



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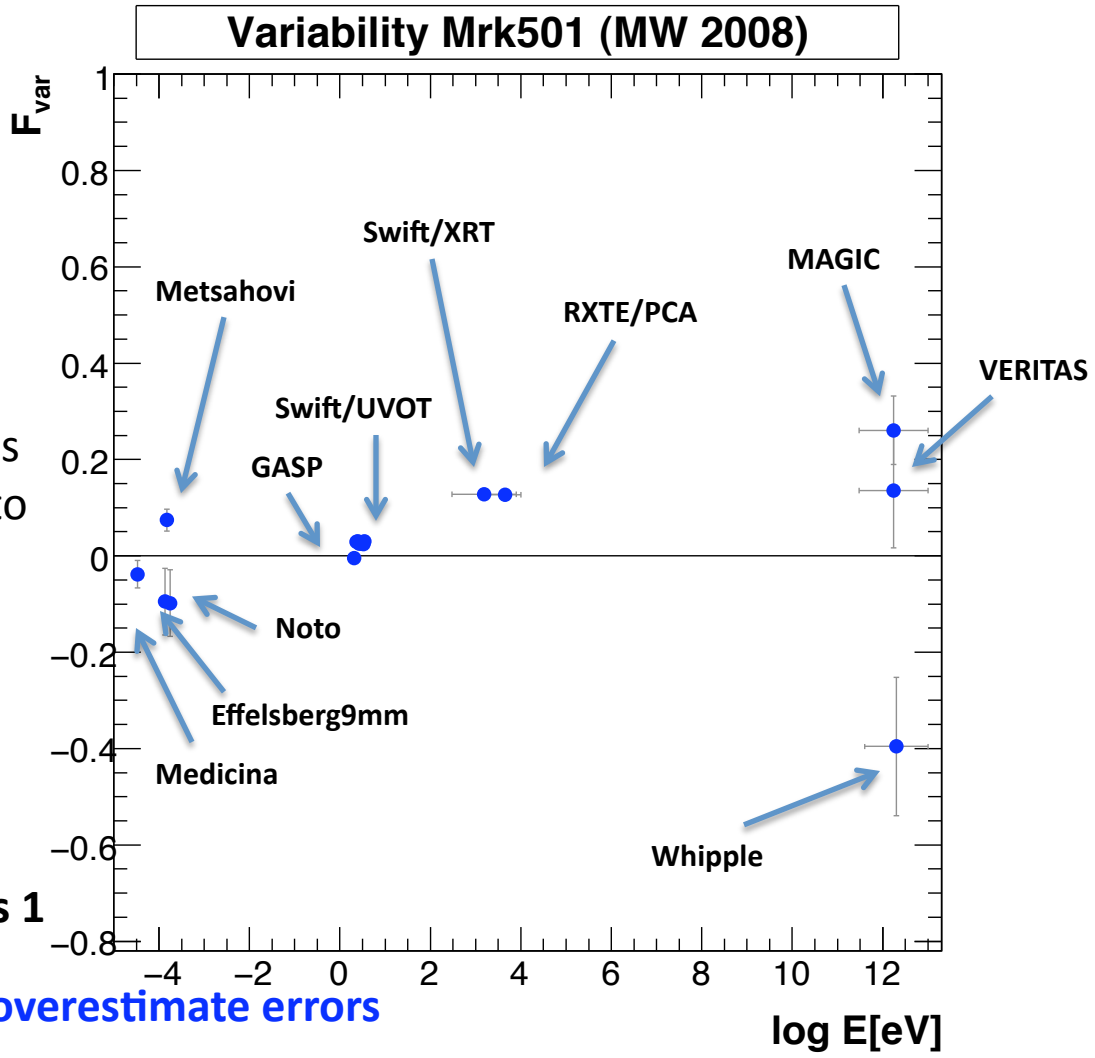
Negative fluxes produced when there is a "lack" of flux fluctuations according to errors.

This could happen:

1 – By chance. Specially if few points

2 – Errors over-dimensioned

All negative values compatible with zero… thus consistent with hypothesis 1



Yuri mentioned that typically people overestimate errors (conservative approach) in radio data

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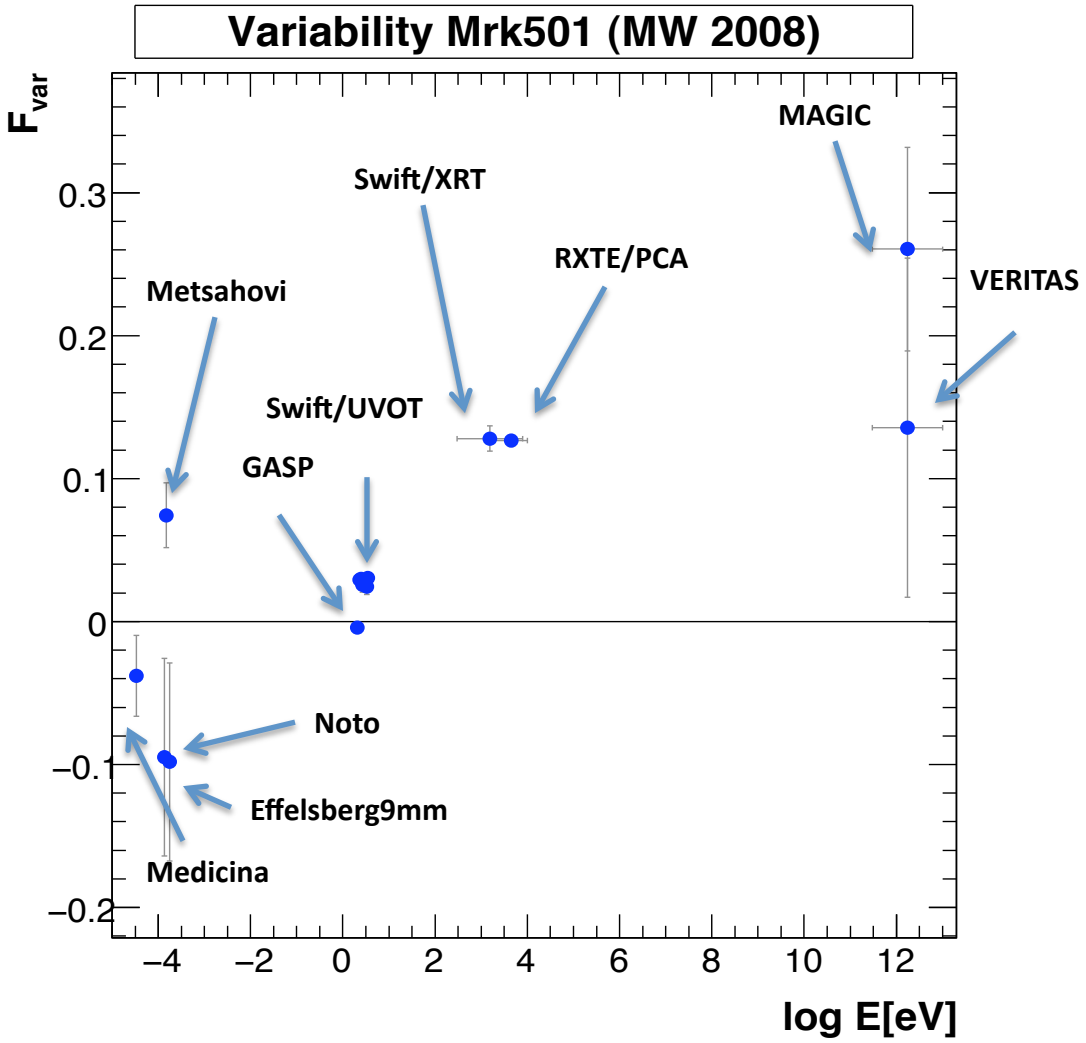
***F_{var}* increases with energy**

Metsahovi could be the exception.
Still … errors are large….

This could indicate that flux variations are produced by injection of fresh (high energy) electrons



I asked **Anne Lahtenmaki** (analyzer of Metsahovi data)

The errors are NOT underestimated. If at all, the errors are overestimated (as in the case of the other radio instruments)

The fluctuations we see in the data are REAL and NOT new (for her… I did not know that….). Literally she said:

“It is one of the annoying sources that don't do much anything except "flicker" around a bit -Mrk 421 is another one of those, but fainter. Many of the fainter (at radio) TeV sources seem to be like that, in contrast to the "truly variable" sources in which clear flares can be seen.”

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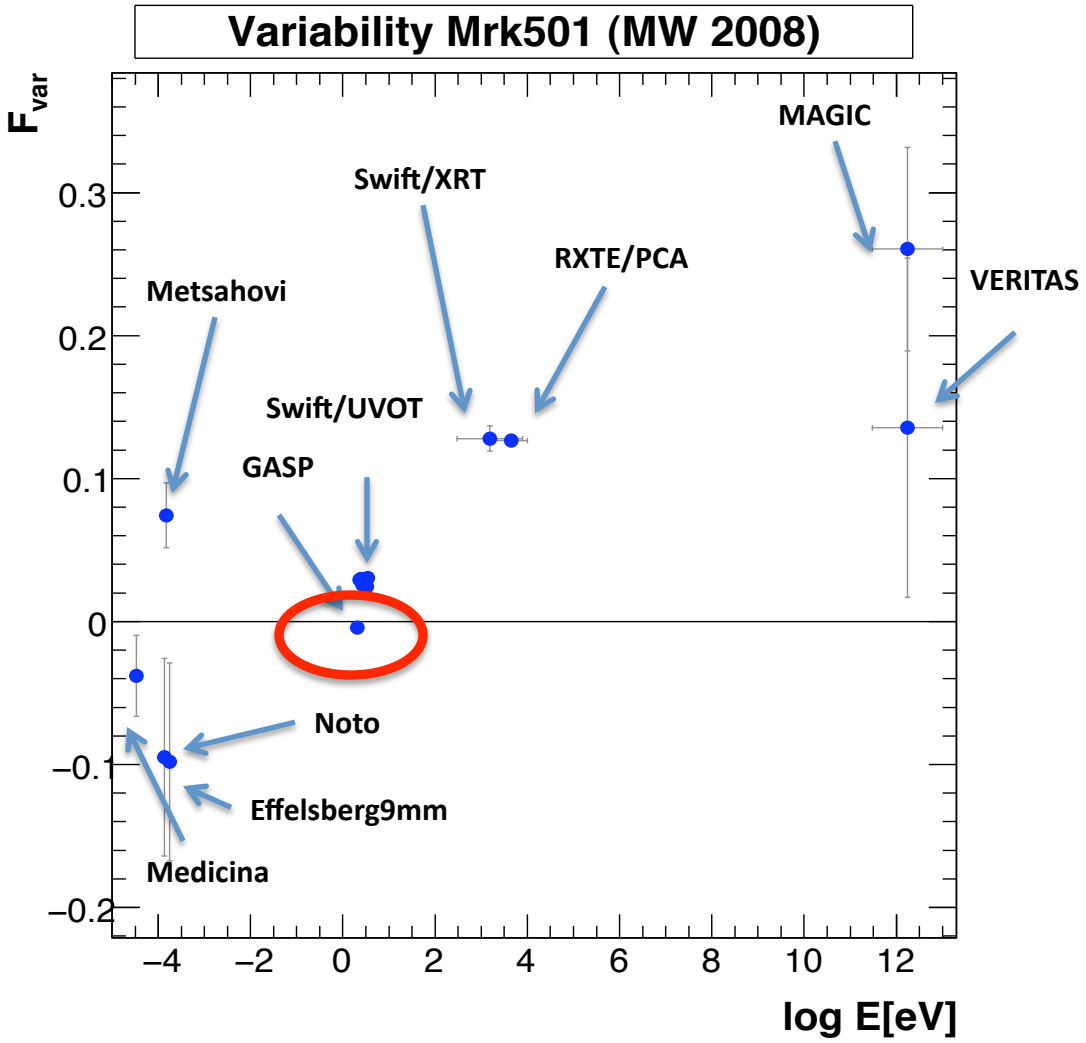
Big difference of GASP (R band) with the Swift UVOT data points.



The GASP data is a collection of optical (R band) data from various instruments.

In order to reduce systematics, we focused ONLY in one instrument (the one with larger amount of observations): KVA (at El Roque, MAGIC site)

We also noticed these data has systematic errors included. We subtract them so that only statistical errors are there. We did not subtract the host galaxy.

Index of /exp/glast/MW/Mrk501_2008/DetailedAnalysis/Data/GASP/KVA_Data

Name	Last modified	Size	Description
Parent Directory		-	
GASP Optical R Band Roque galaxy nosyst reformatted.txt	22-Apr-2009 16:19	63K	
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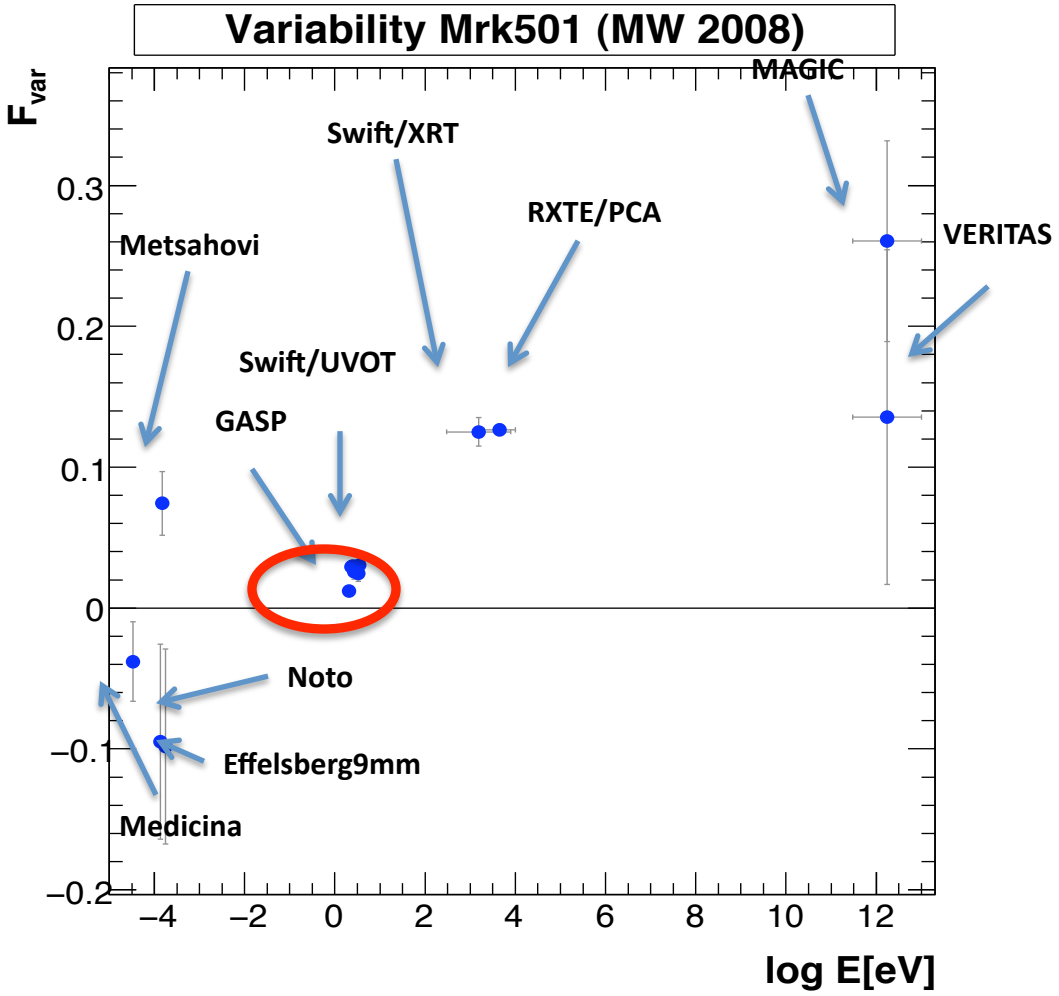
Now the R band and Swift UVOT frequencies show similar variability.



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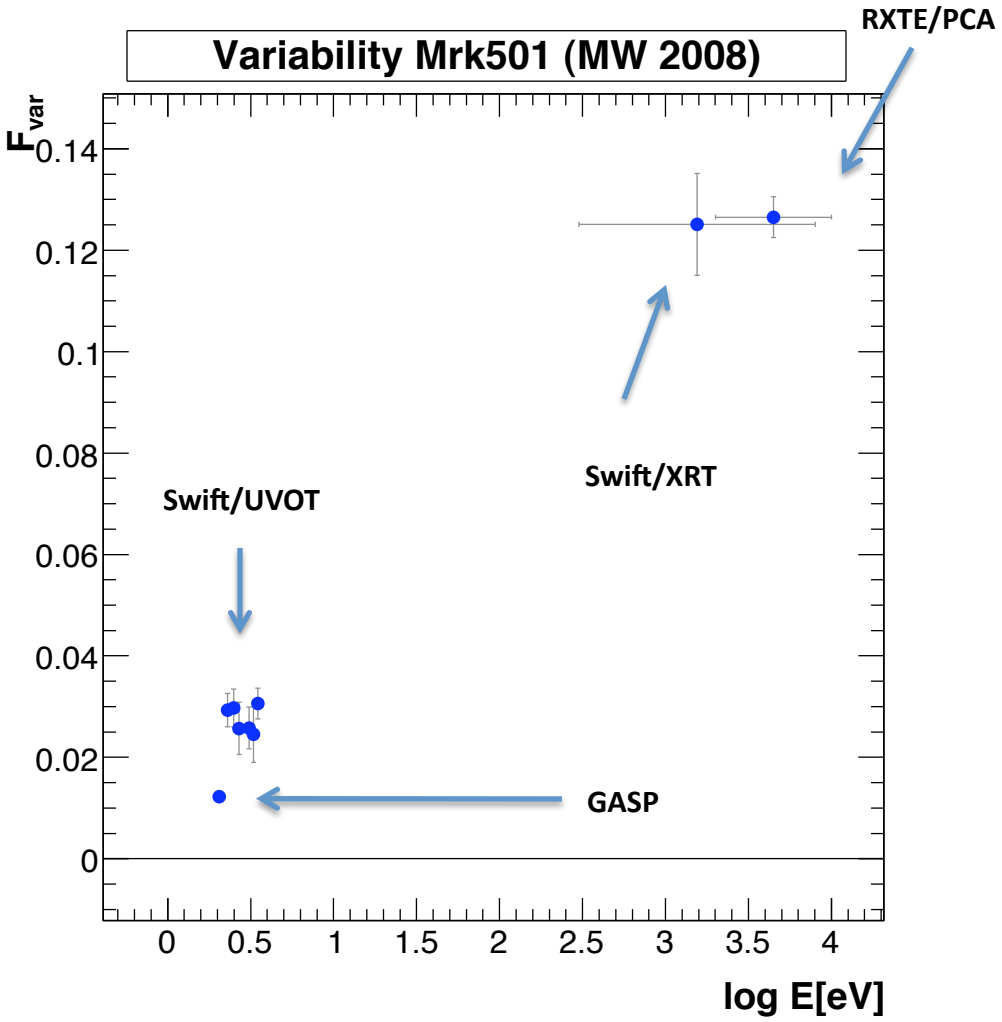


Conclusions

Variability quantified for all frequencies (instruments)

Instruments with variable flux

- **Metsahovi (flickering)**
- **GASP (KVA)**
- **Swift/UVOT**
- **Swift/XRT and RXTE/PCA**
- **MAGIC and VERITAS**

Flux variations during this campaign are substantially lower than in past campaigns

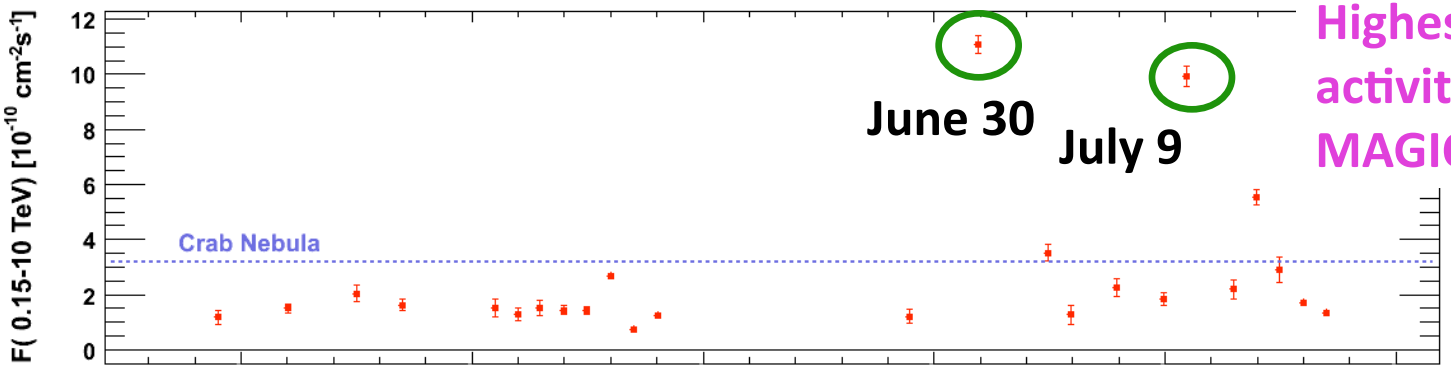
Variability seems to increase with energy; largest flux variations observed at the highest energies. This would be consistent with flux variations being produced by injection of fresh (high energy) electrons.

Backup slides

Quantification of the Variability

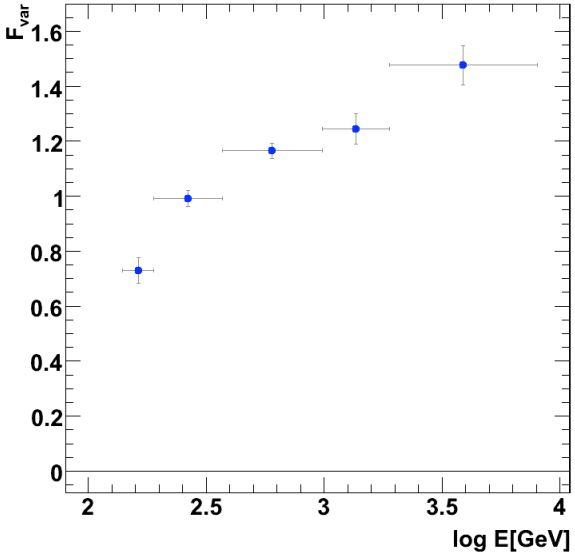
Comparison of variability at gamma-ray energies with previous campaigns

Mrk501 observations with MAGIC during 2005 (J. Albert et al., ApJ 669 (2007) 862)

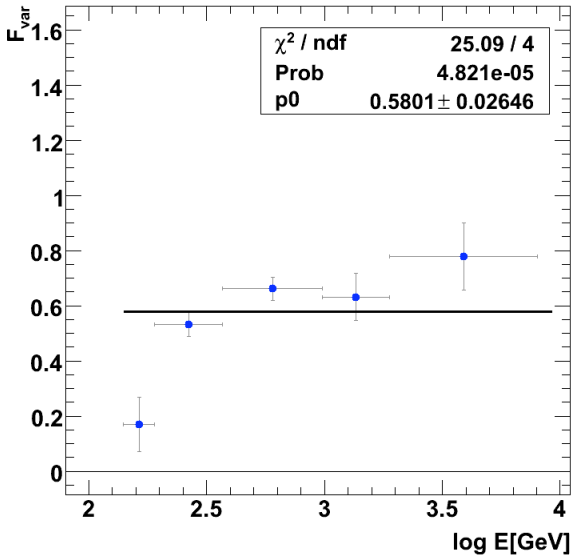


Highest VHE activity during MAGIC obs.

All nights included

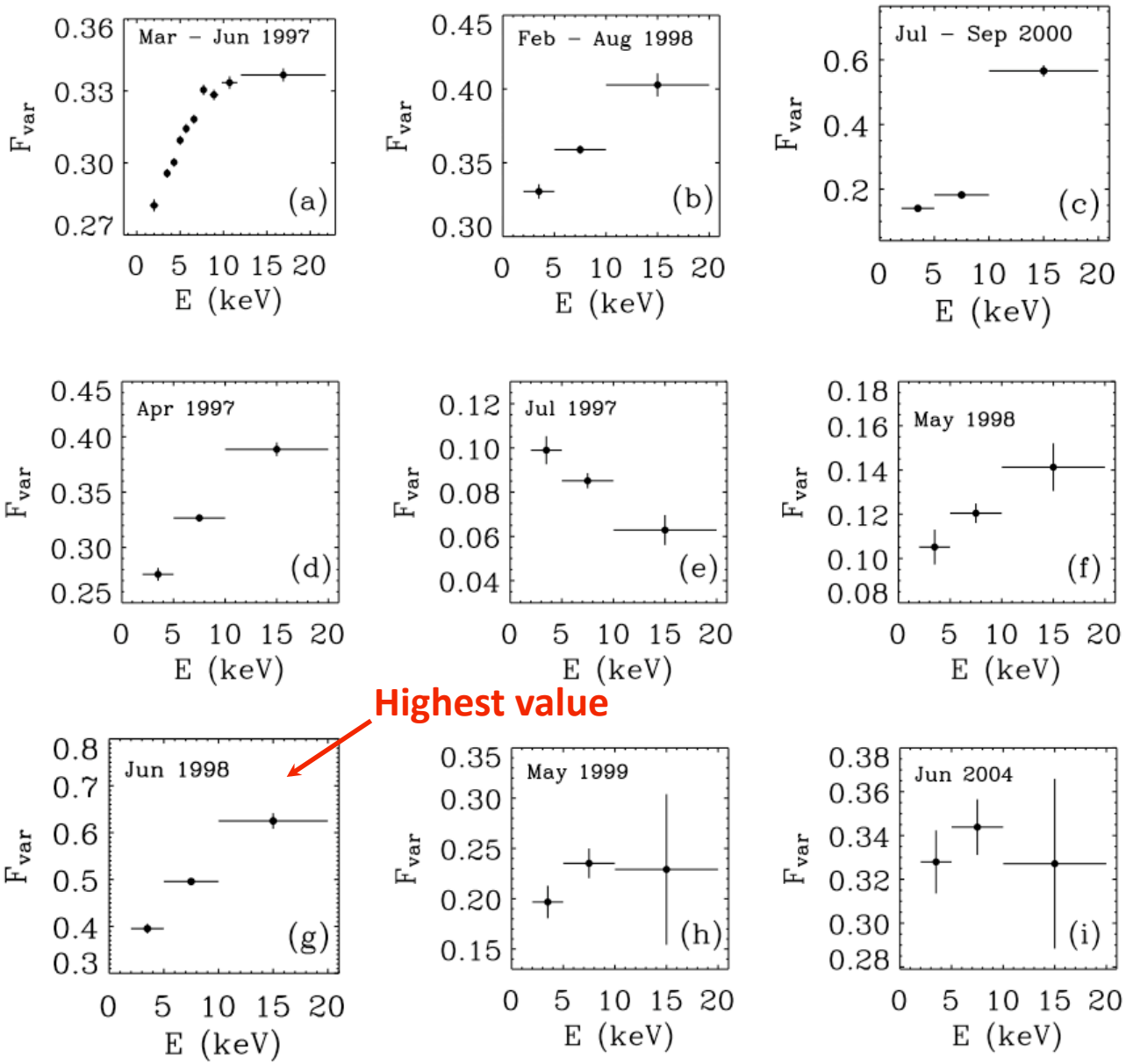


Flare nights excluded



In 2008 the Fvar value at VHE (E>0.3 TeV) is ~ 0.2

Comparison with Fvar at X-rays (Gliozzi et al. 2006, ApJ, 646)



In general, F_{var} increases with energy

Highest F_{var} value was not obtained in 2007, when X-ray (and gamma) flux was highest

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