Multi-Timescale Variability in Gamma-ray Blazars

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for the Fermi-LAT collaboration

Blazars through Sharp Multi-Wavelength Eyes.
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Fermi-LAT and blazar variability

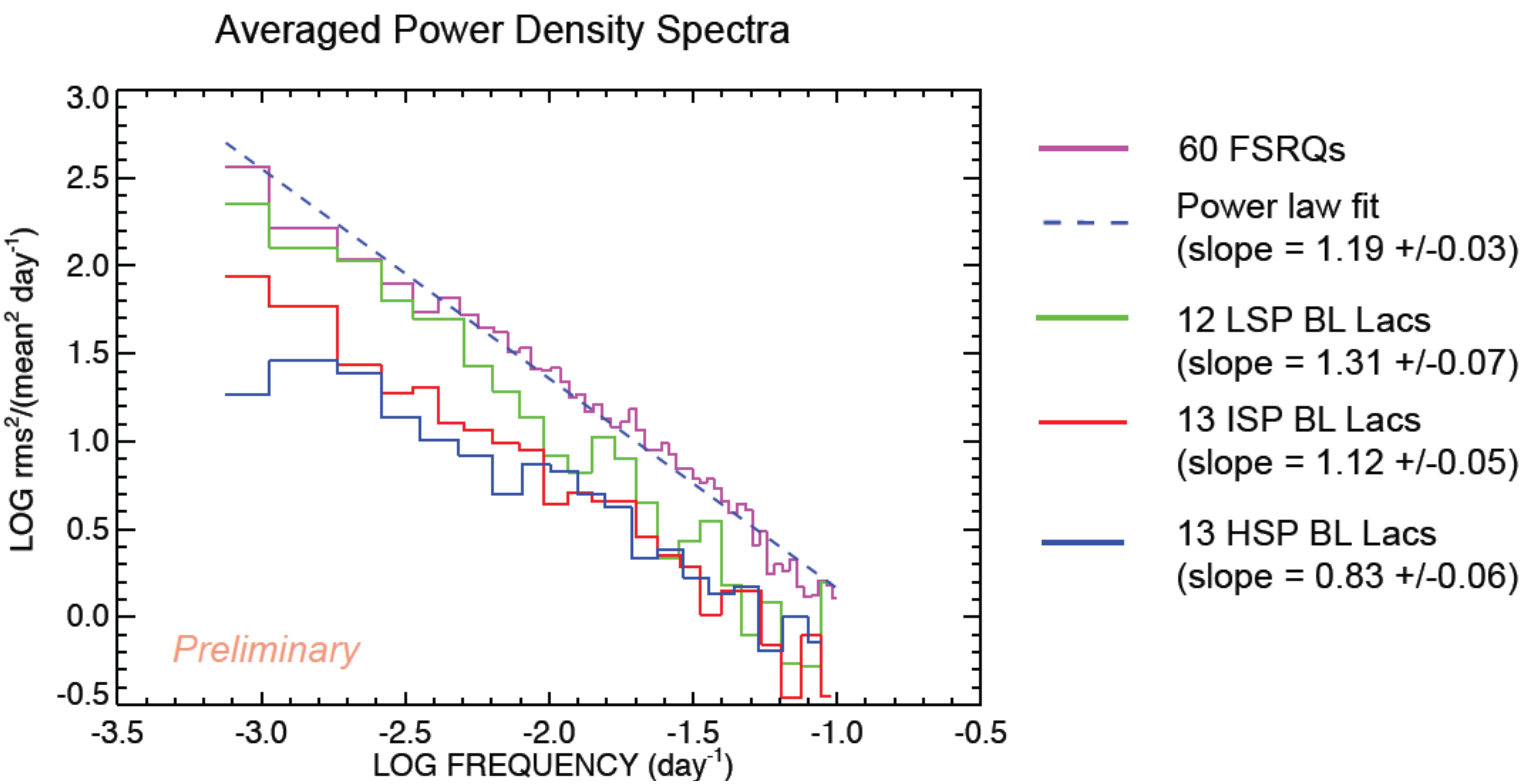
Variability

- How do we characterize blazar variability?
  Duty cycle, time asymmetry, power spectrum etc

MW Correlations

- How are gamma-ray and radio/optical/X-ray emission related?
- Where in the jet are the gamma-rays produced?

Fermi-LAT and blazar variability



No persistent breaks found in PDS of individual sources

Power Density Spectra in radio, optical, X-ray typically power-laws with index 1 to 2

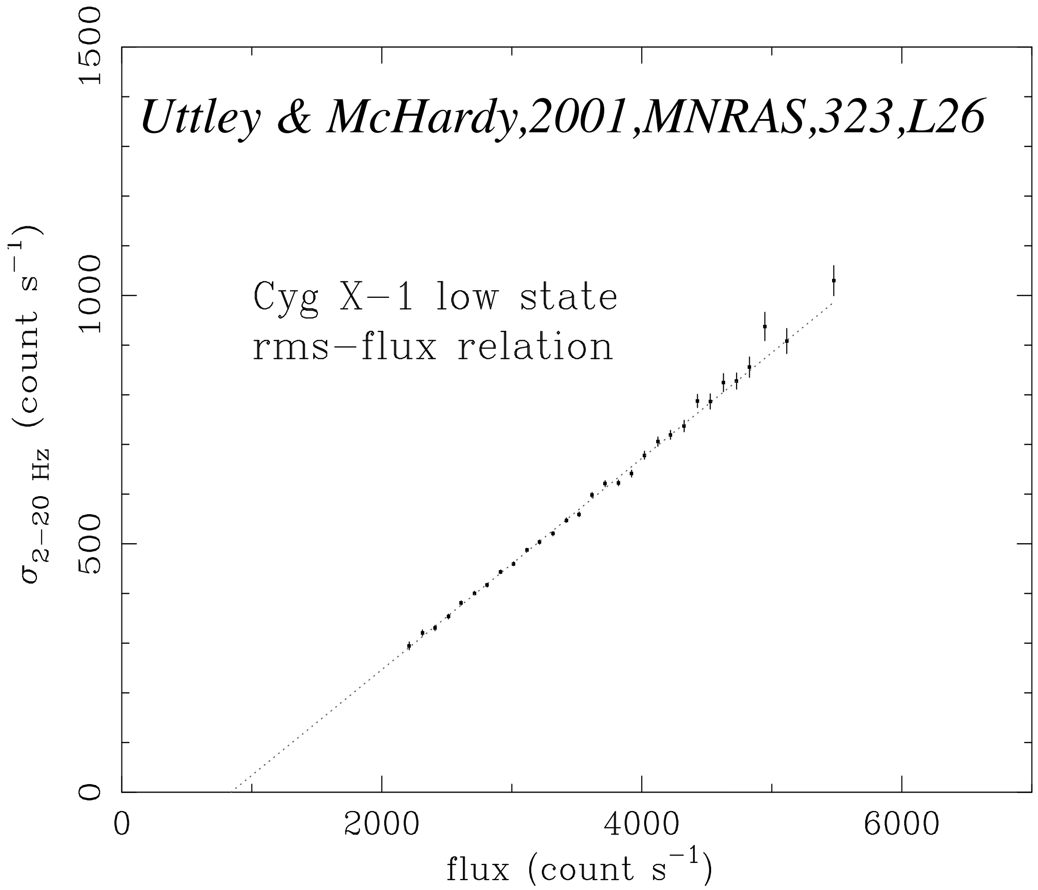
Fermi-LAT and blazar variability

Gamma-ray variability:

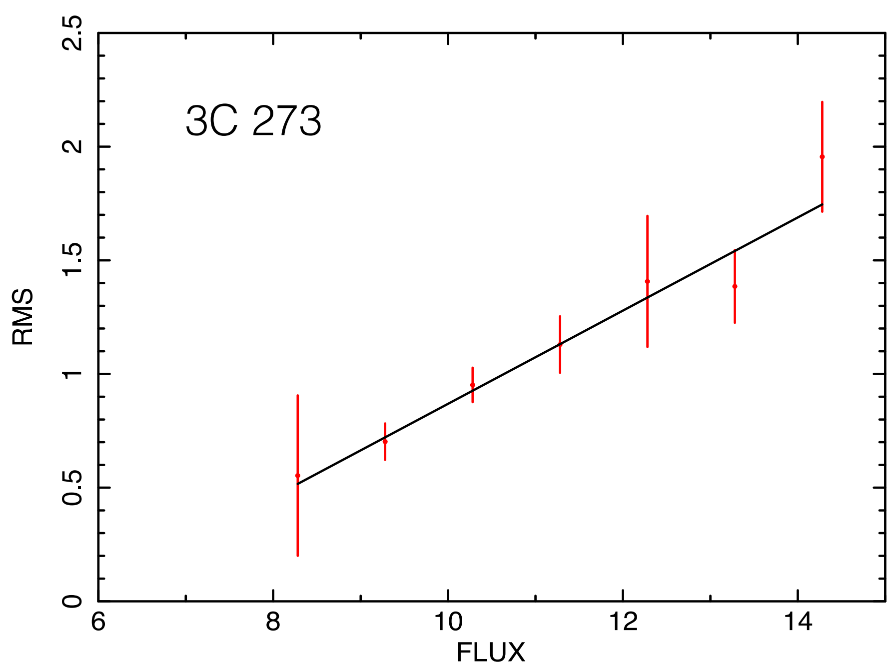
1. Spectral: Harder-when-brighter (FSRQs) mixed (BL Lacs)
2. Time asymmetry: No
3. PDS: Power law index ~ 0.8 - 1.3
   No persistent break (= characteristic time scale)

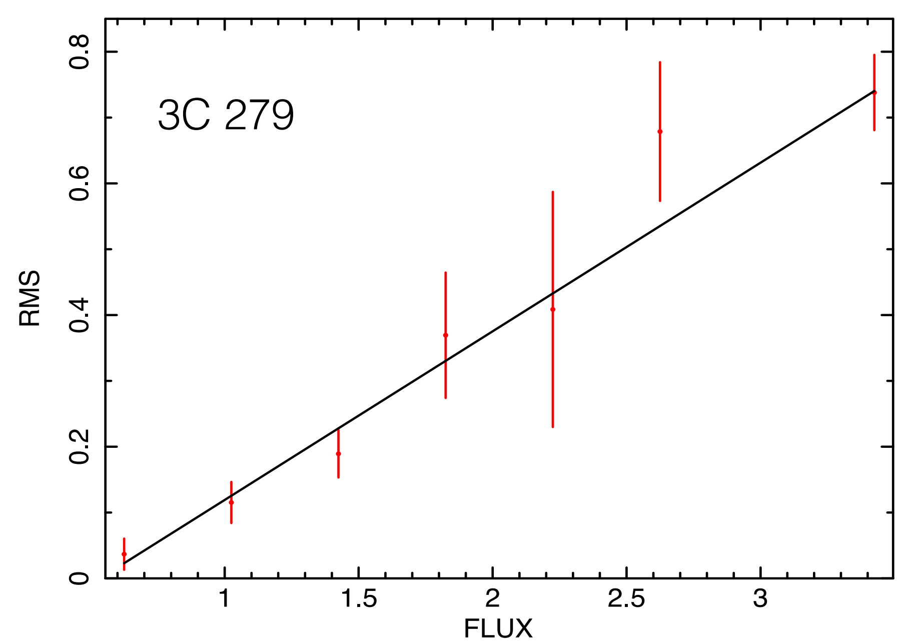
Next question: Stationary/Non-stationary?
Linear/Non-linear?

RMS - Flux relation



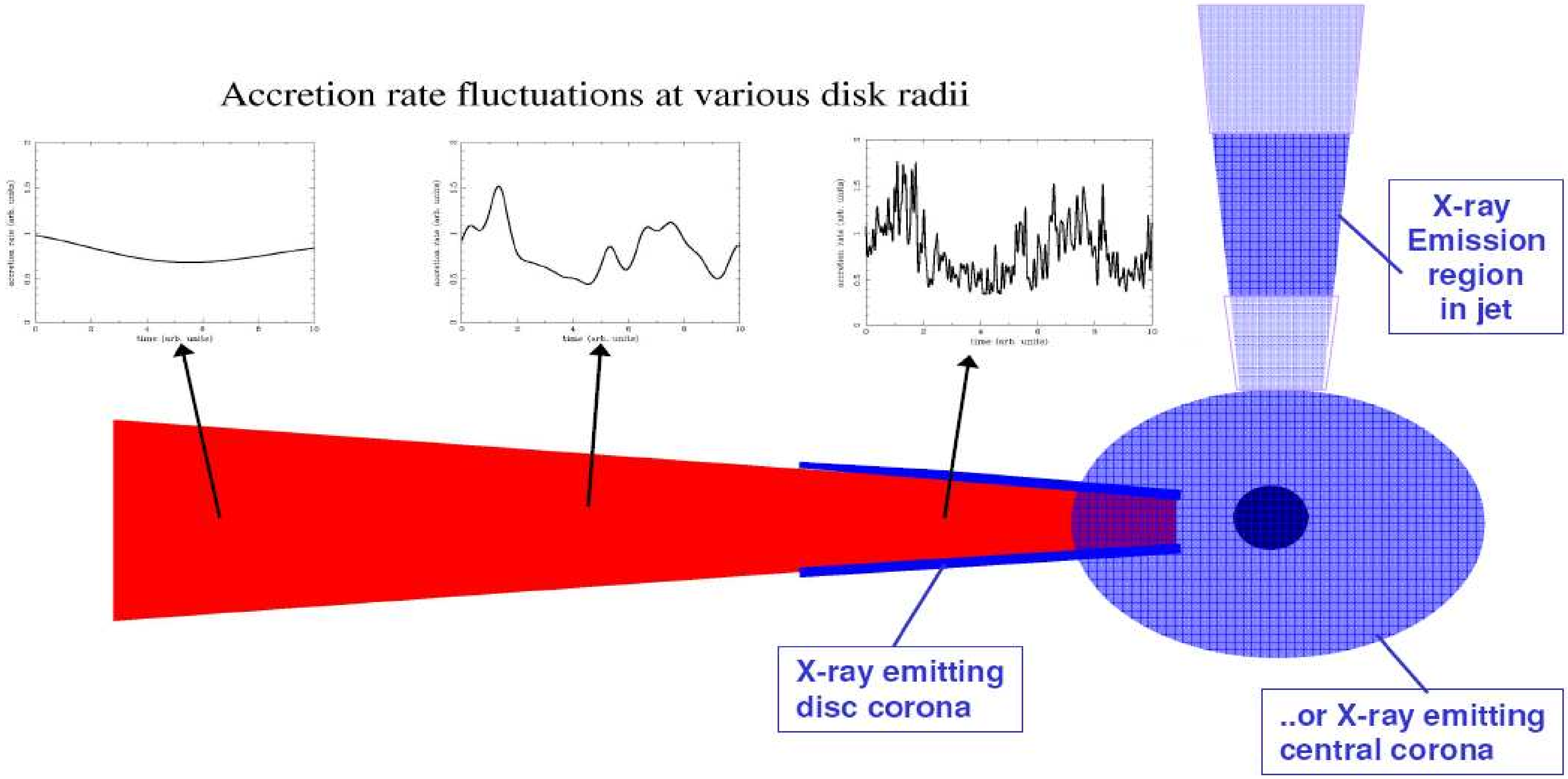
McHardy (2008)



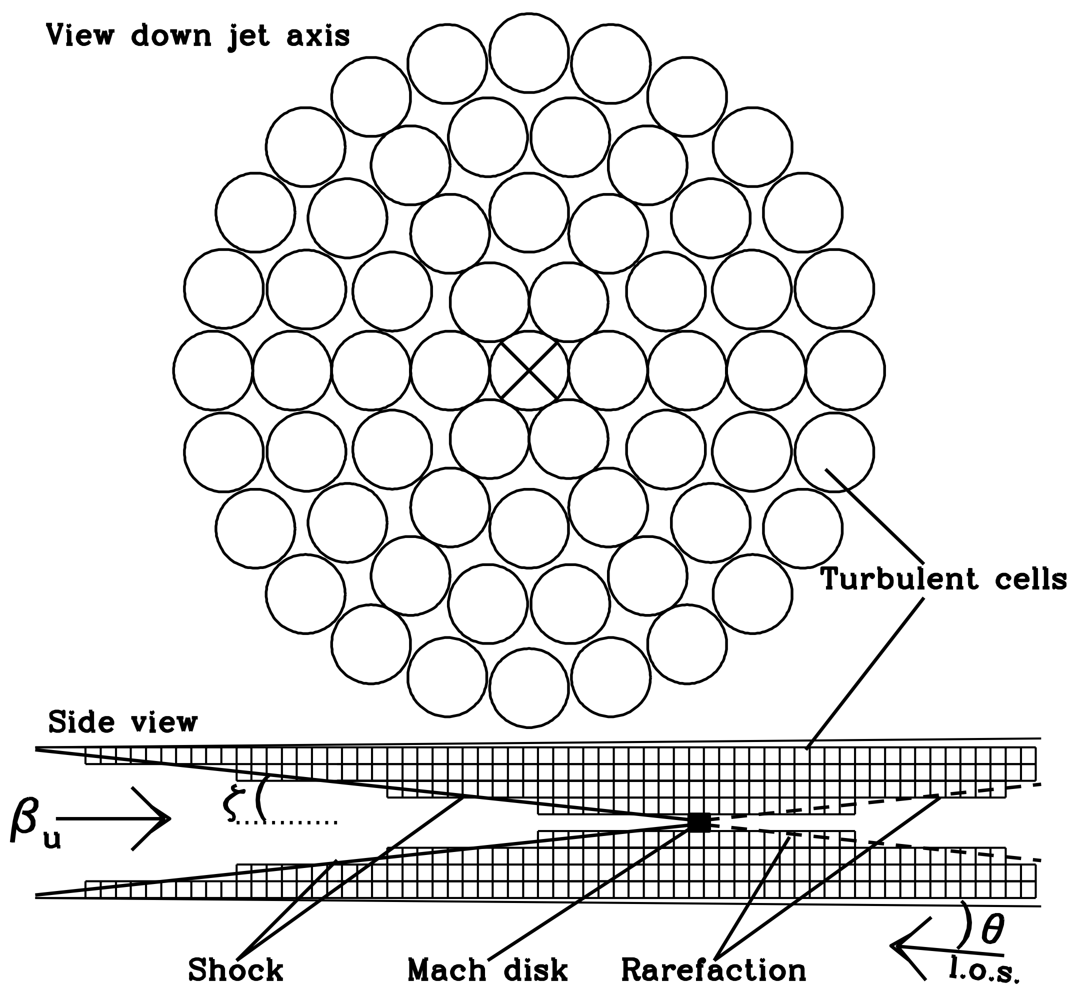


Fermi-LAT and blazar variability

Illustration from McHardy (2008):



In addition to power spectra, the RMS-Flux relation is should also be used as a test of models



Marscher (2014)

The RMS-Flux relation at gamma-ray energies

Full sample: 127 high significance AGN (3FGL)

This analysis: 16 FSRQs, 6 year light curves (6 day binning) for 2 (3C 279 and PKS 1510-089) also 7 year, 1 day binned light curves.

Method: Compute RMS directly from light curve using 20 or 72 day segments (sampling time scales: 2-20 days and 12-72 days respectively)

Analysis: RMS vs Flux (and RMS/Flux vs Flux)

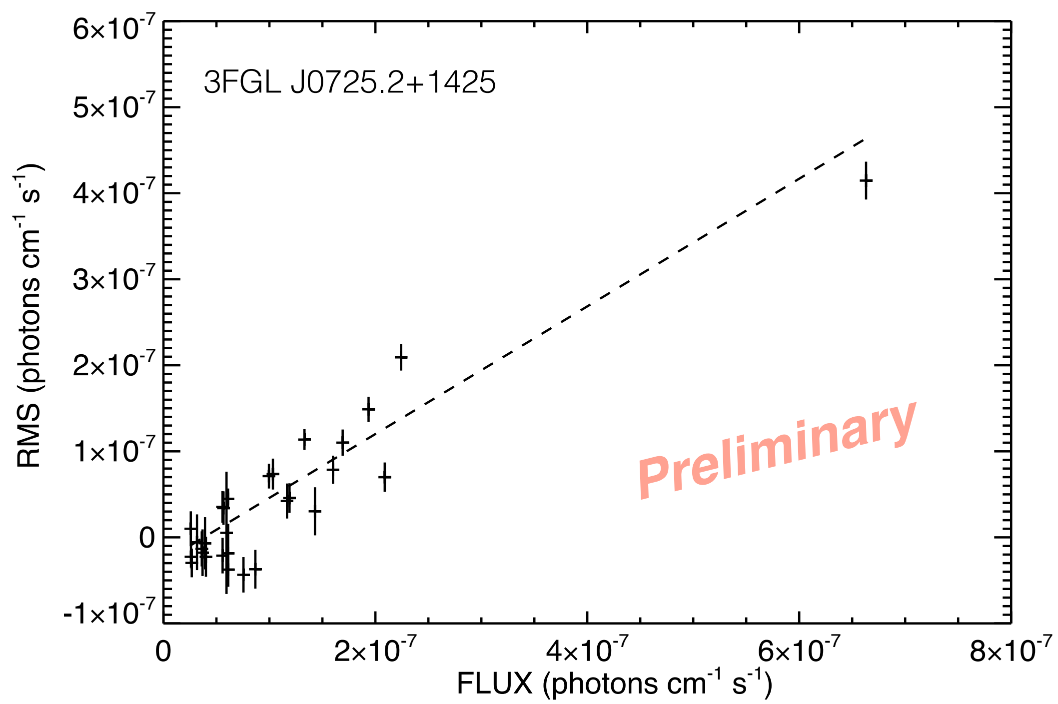
Questions: Is the RMS-Flux relation linear?

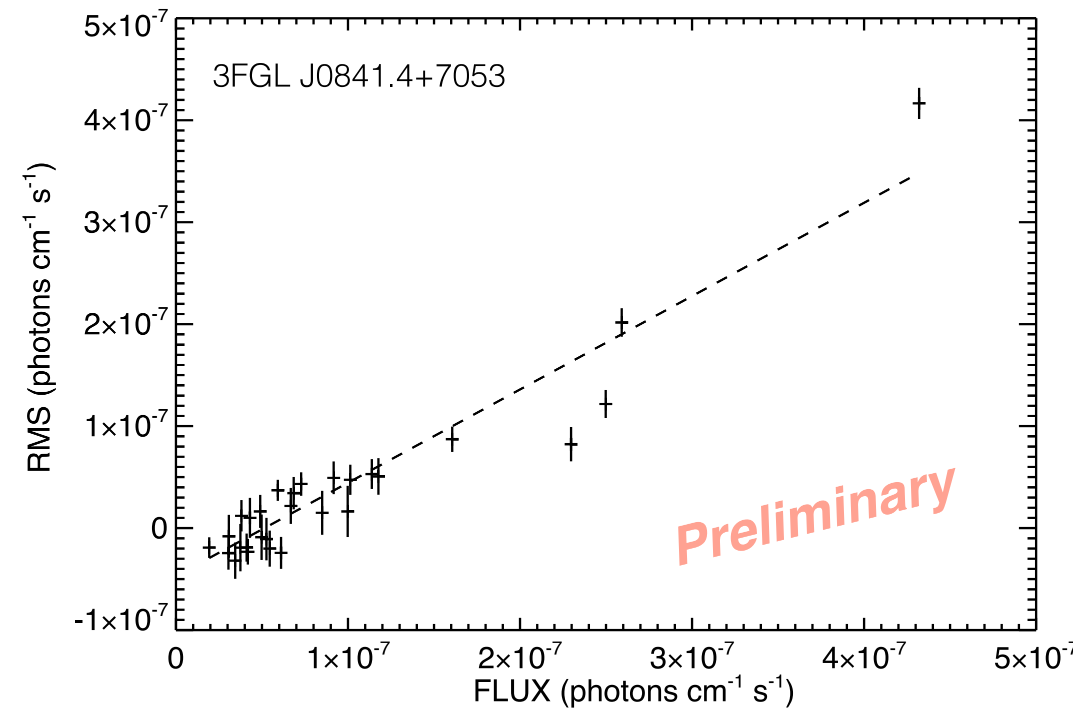
Is it the same over time?

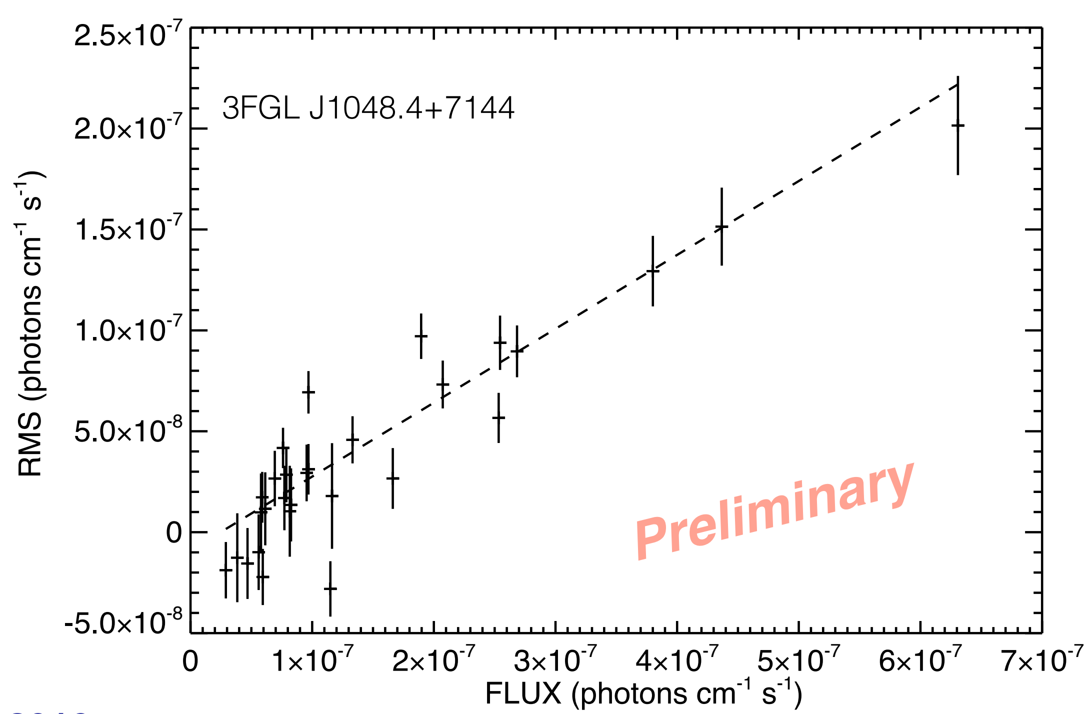
Implications for variability models?

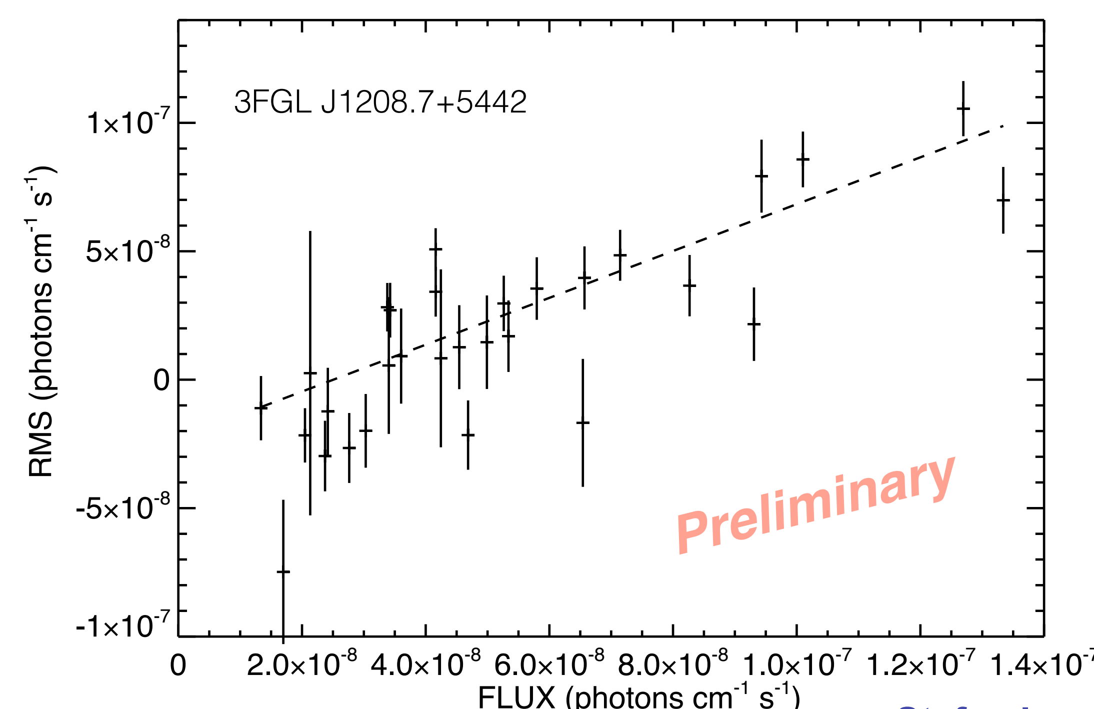
The RMS-Flux relation at gamma-ray energies

RMS-Flux for 6 year LAT light curves (with 6-day binning)
Points are for individual segments (error bars include measurement noise but not red noise)

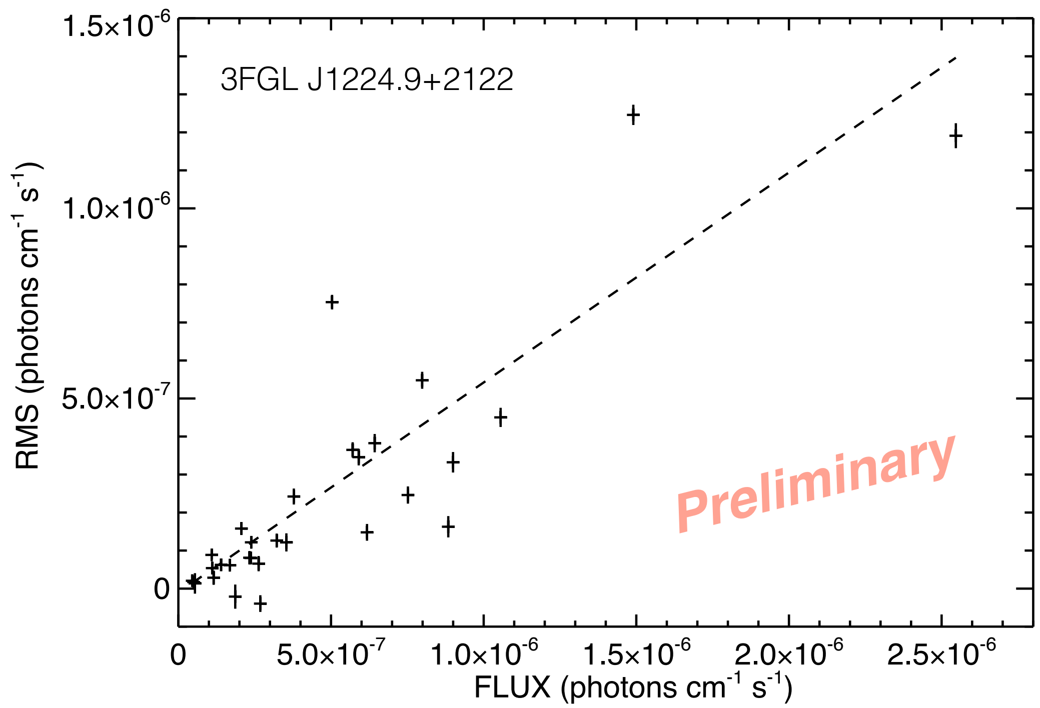


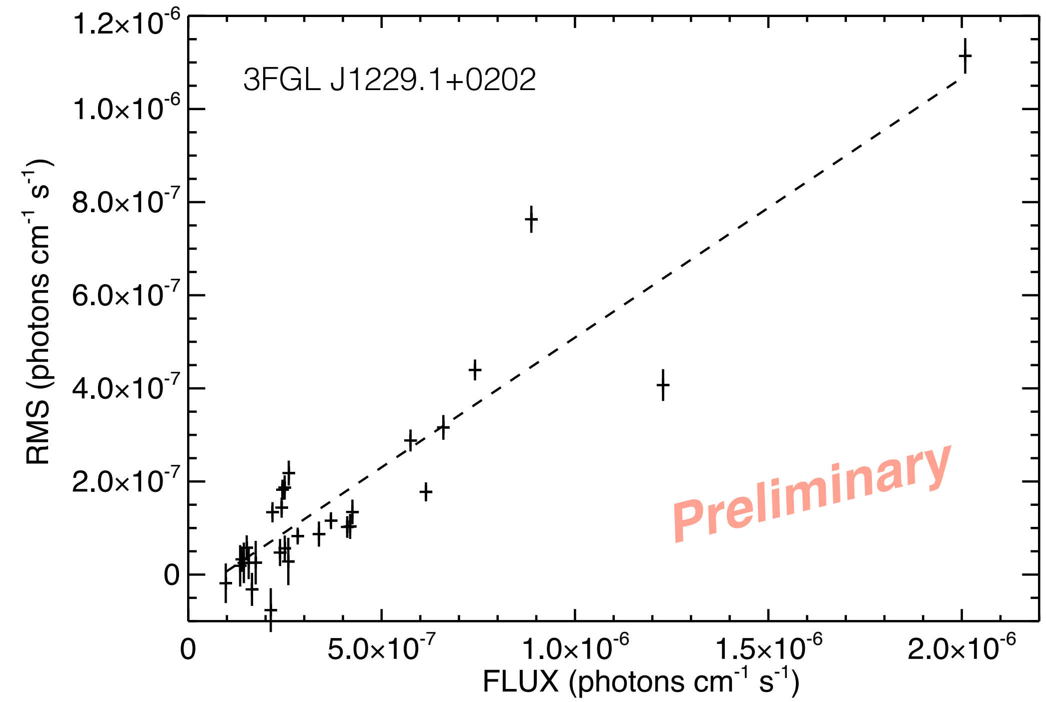


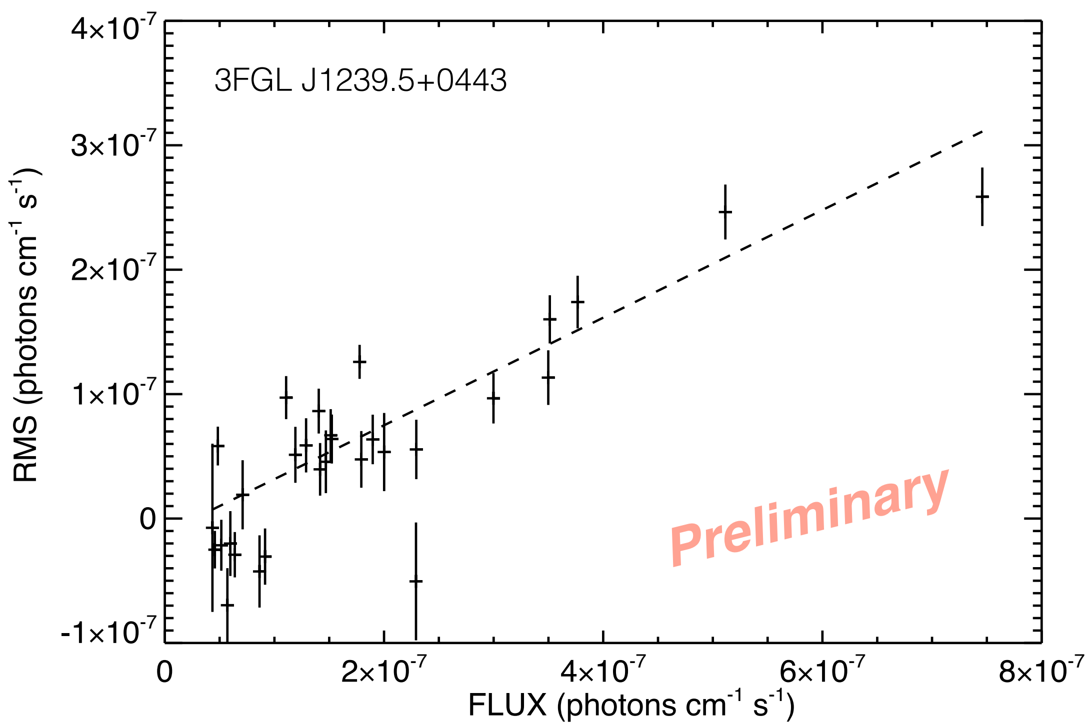


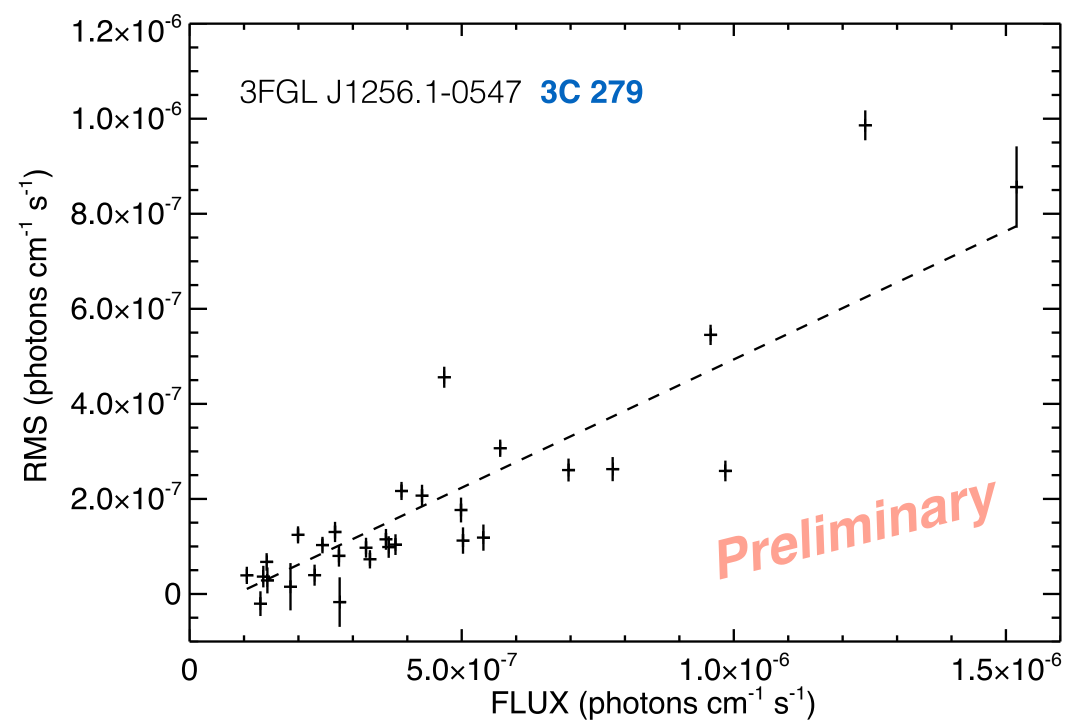


The RMS-Flux relation at gamma-ray energies

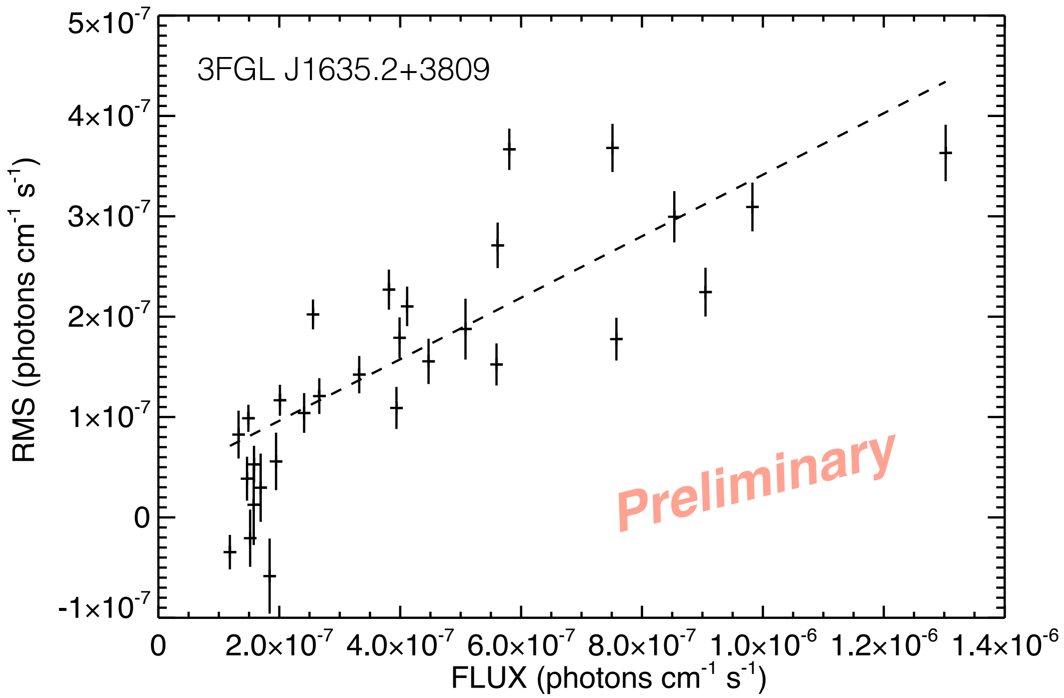


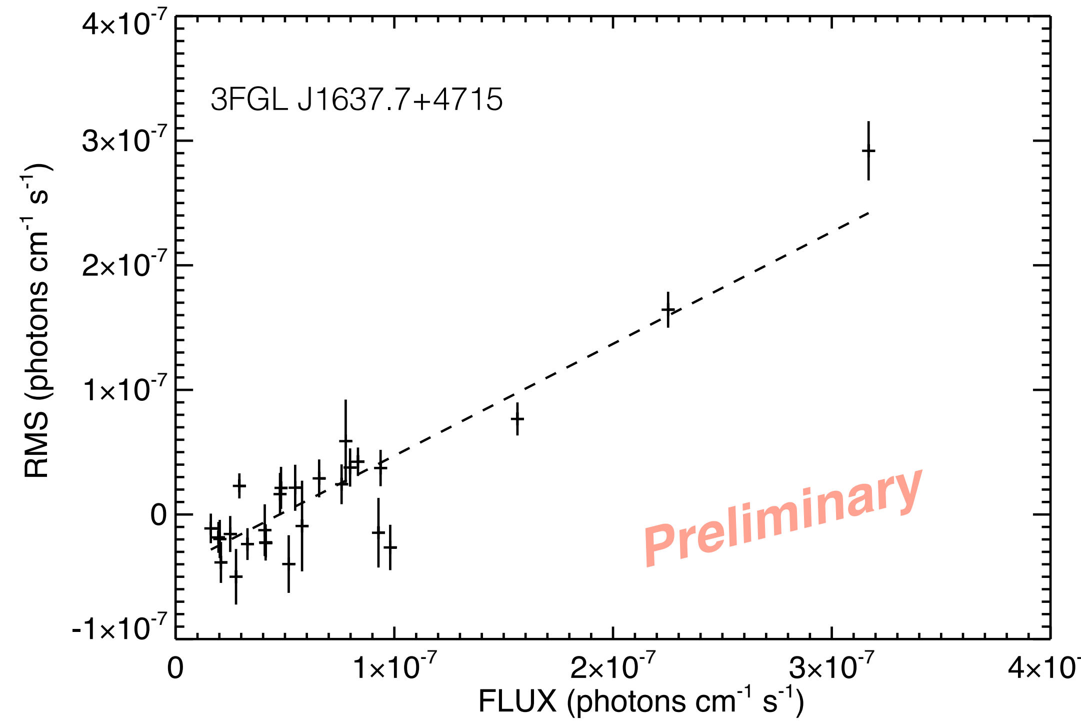


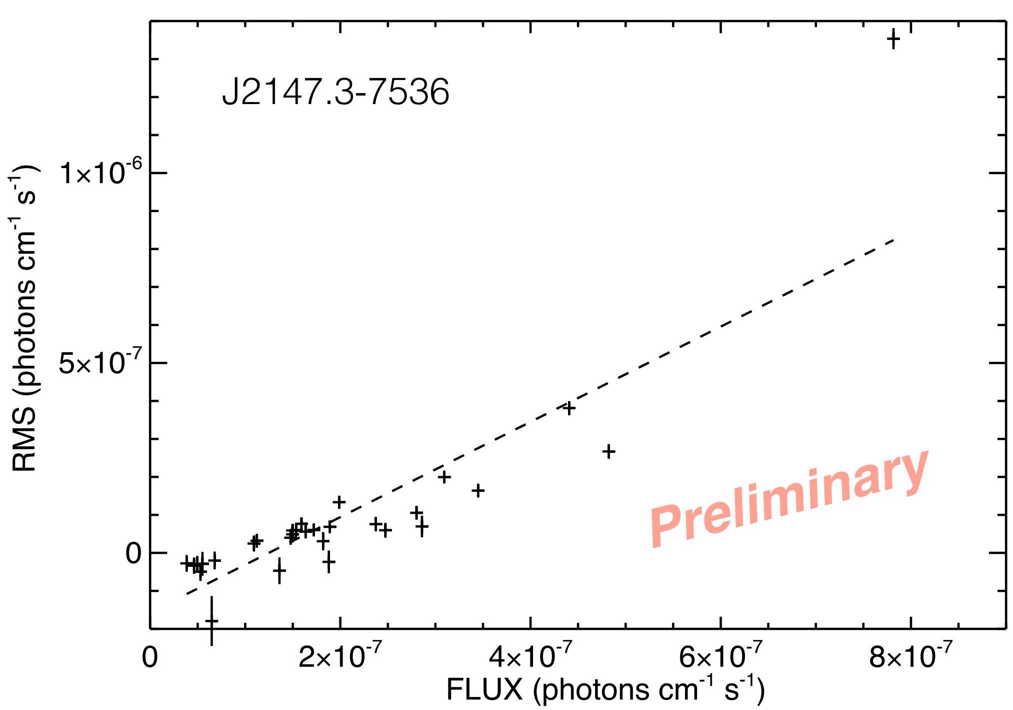


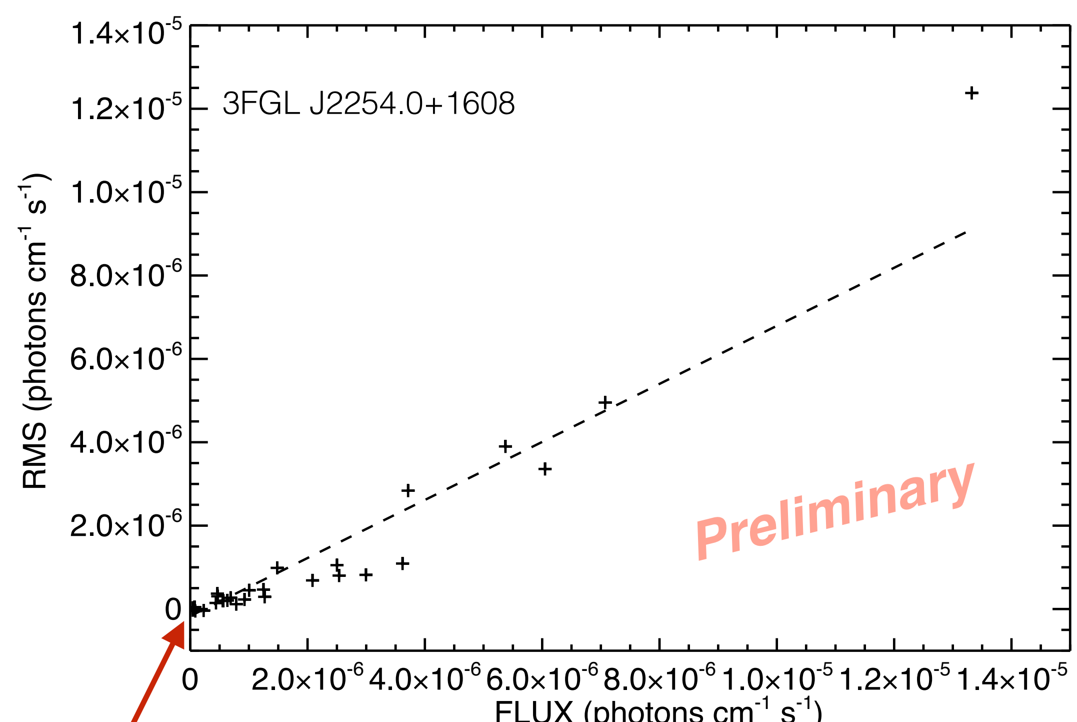


The RMS-Flux relation at gamma-ray energies







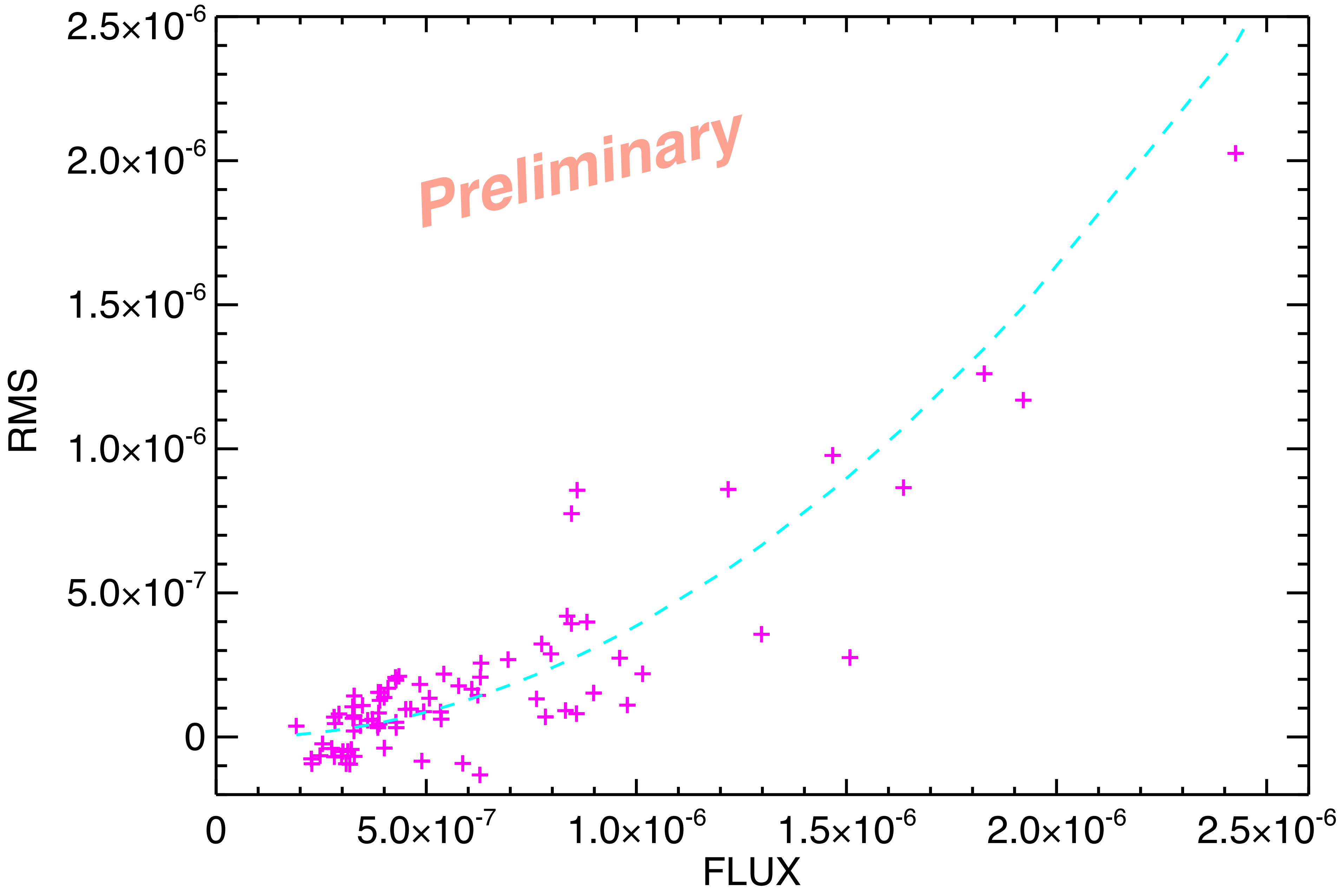


No evidence for a non-variable component

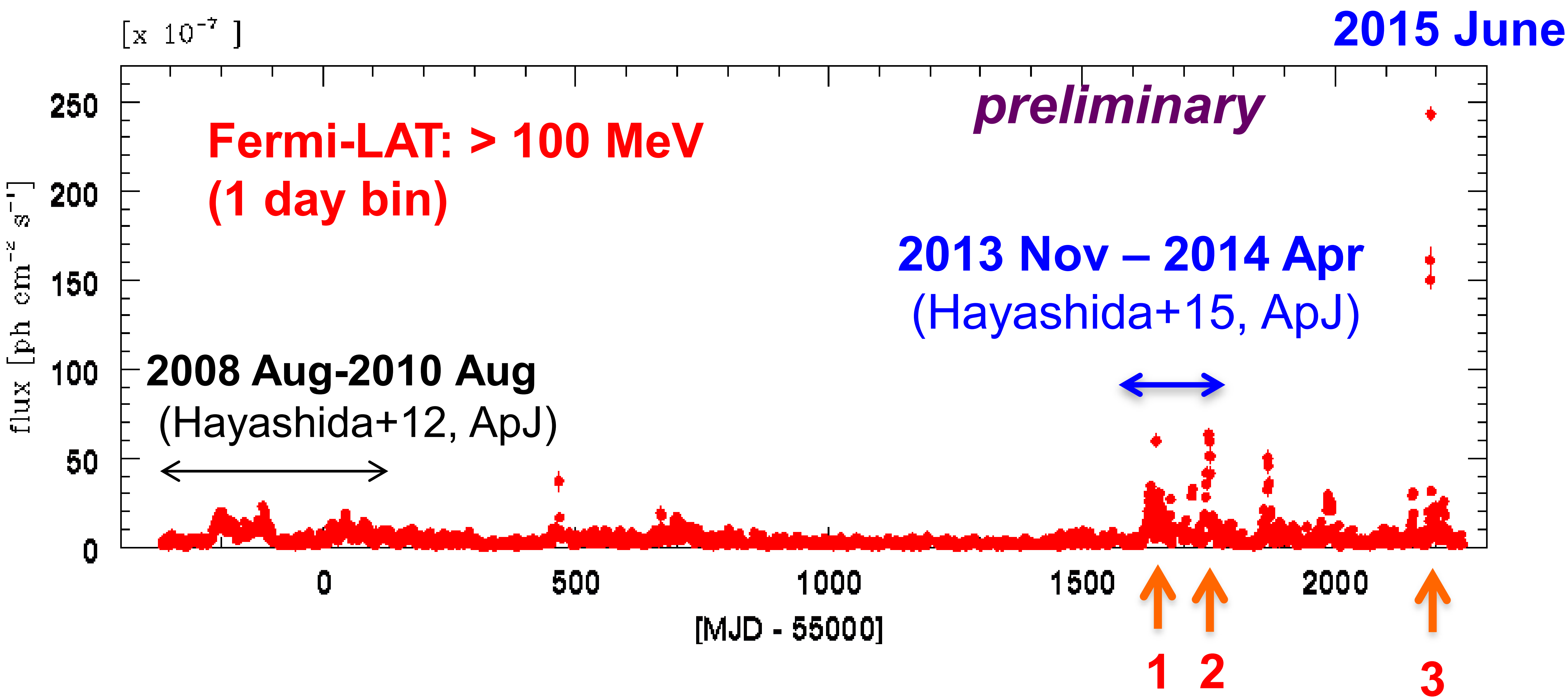
The RMS-Flux relation at gamma-ray energies

3C 279 RMS-Flux based on 1 day binned Fermi LAT light curve (7 years of data)

A second order polynomial provides a better fit than a linear relation when all data is used

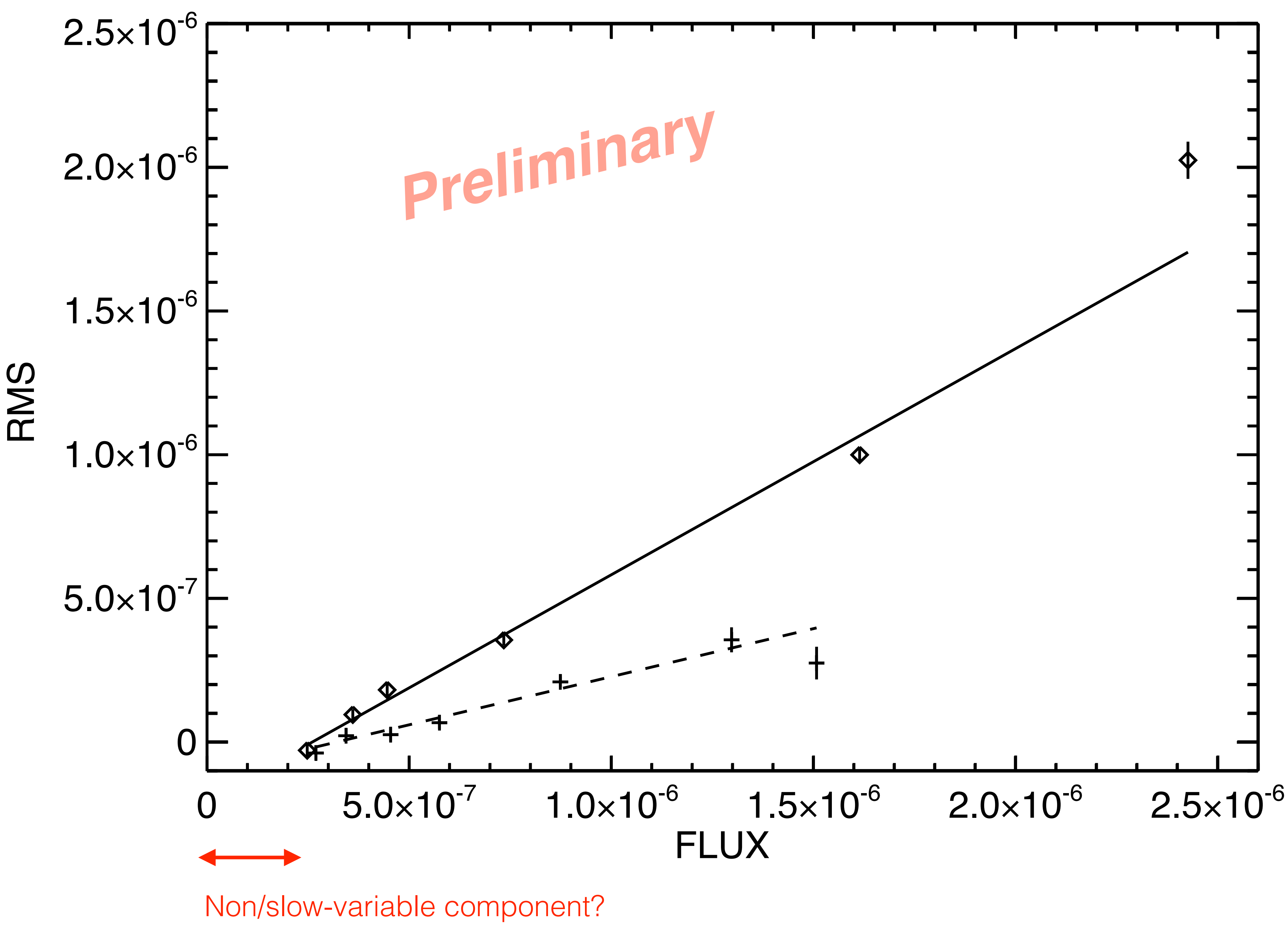


The RMS-Flux relation at gamma-ray energies



The RMS-Flux relation at gamma-ray energies

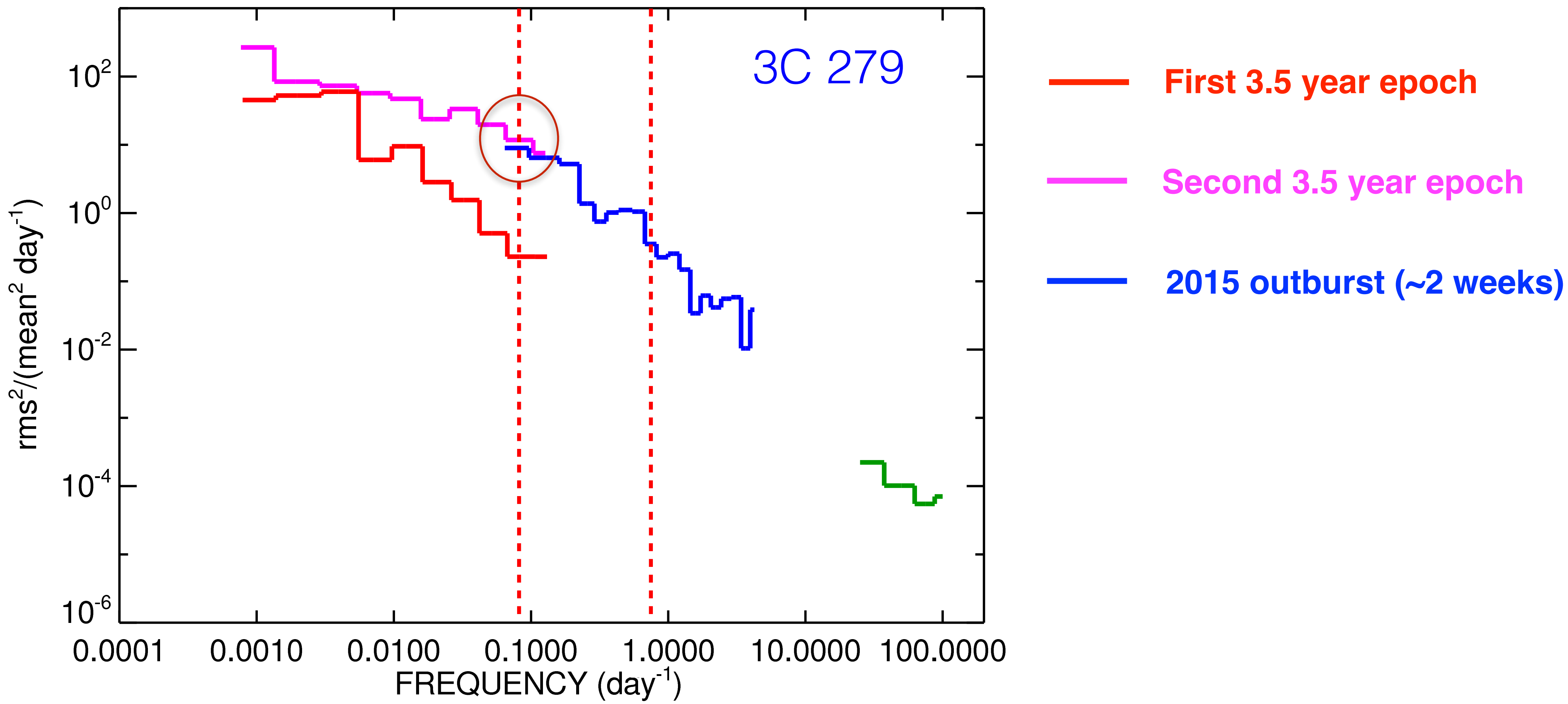
3C 279 RMS-Flux for the first (+) and second (diamonds) 3.5 years of Fermi-LAT observations (flux binned)



3C 279 Power Density Spectrum

Also the Power Density Spectrum differ between the two epochs (from Ackermann et al 2016, http://arxiv.org/abs/1605.05324)

Talk by Masaaki Hayashida yesterday



Overlapping PDS is consistent with constant RMS/Flux

(but for a linear RMS-Flux relation, RMS/Flux will be constant only if the RMS-Flux line goes thorough origo)

Summary

- We have investigated the RMS-Flux relation at gamma-ray energies for 16 FSRQs
- The preliminary analysis suggests that the relation is typically linear but with a slope that may change with time
- A more weakly variable components might be present in som sources but their contribution is typically small.
- The RMS-Flux should be considered in models of blazar variability.