Submillimeter Variability and the γ-ray Connection in Fermi Blazars
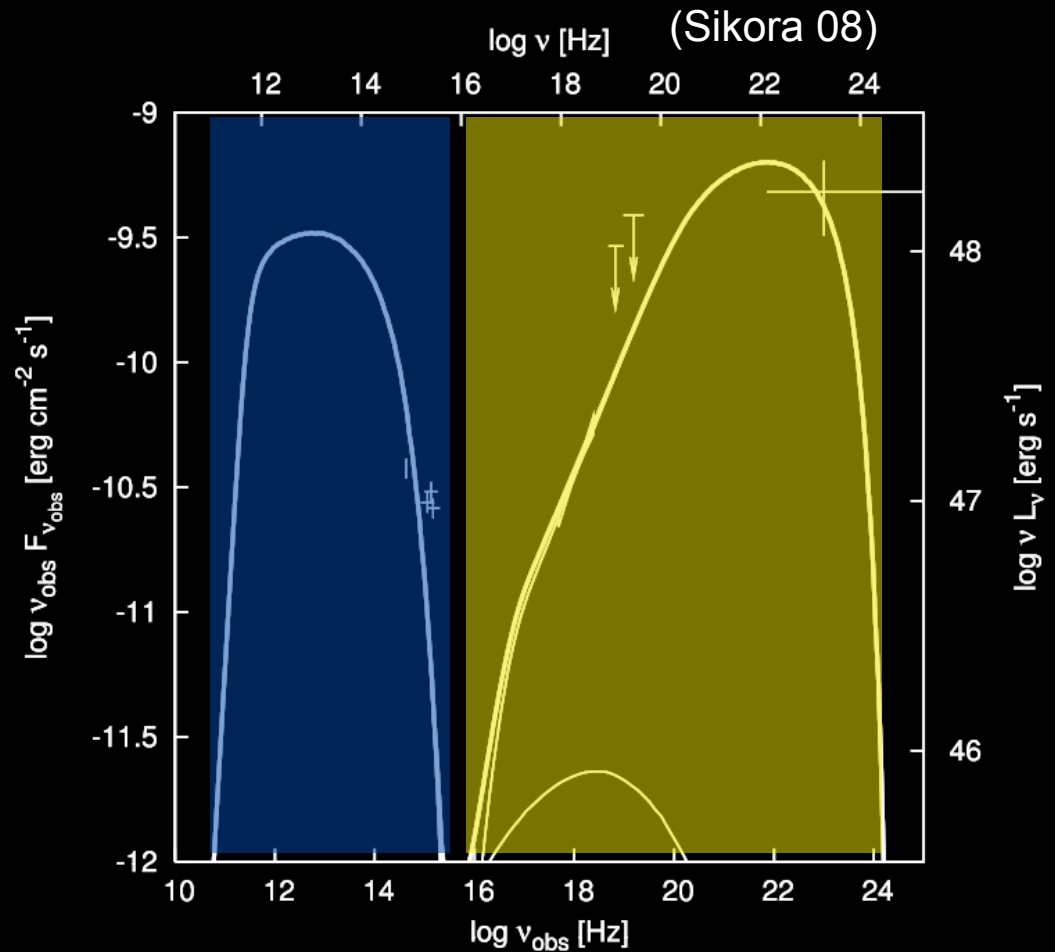
Allison Strom

University of Arizona

Aneta Siemiginowska (CfA), Mark Gurwell (CfA), Brandon Kelly (CfA)
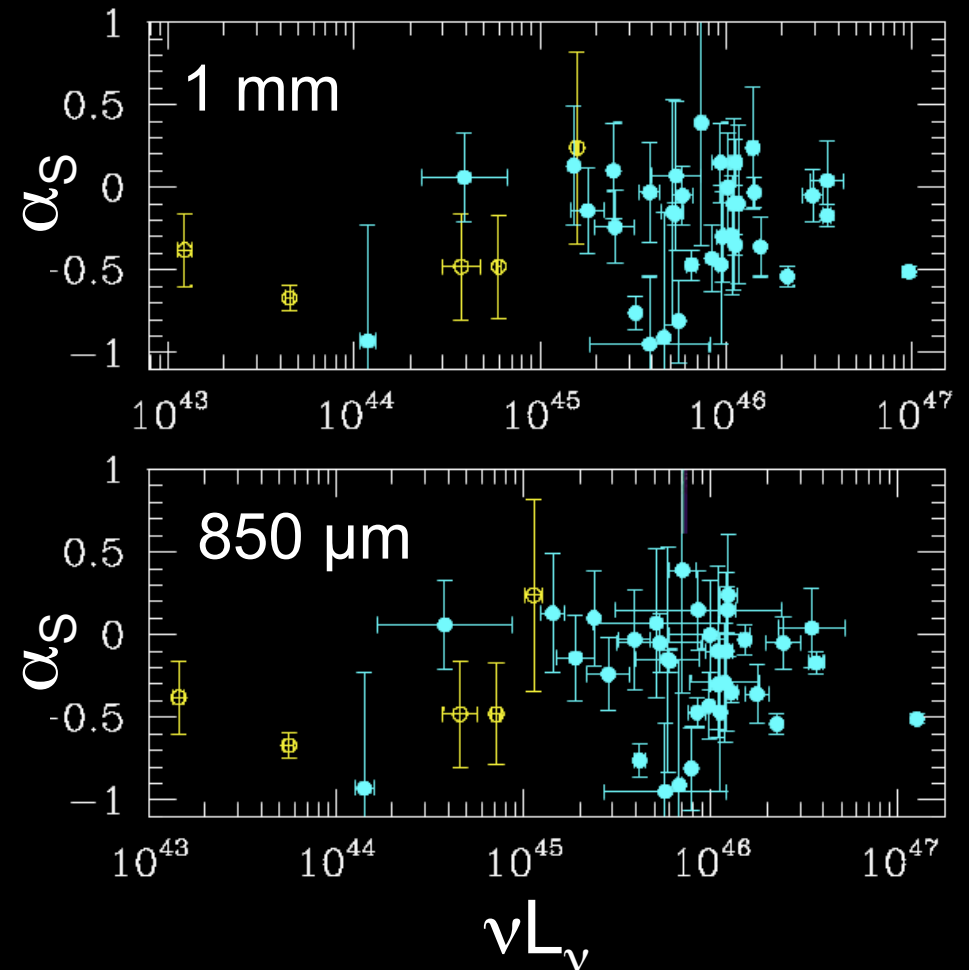
Jet Emission Processes

- ## Synchrotron

- ## Inverse Compton
  - ### Synchrotron-self-Compton
  - ### External-radiation-Compton
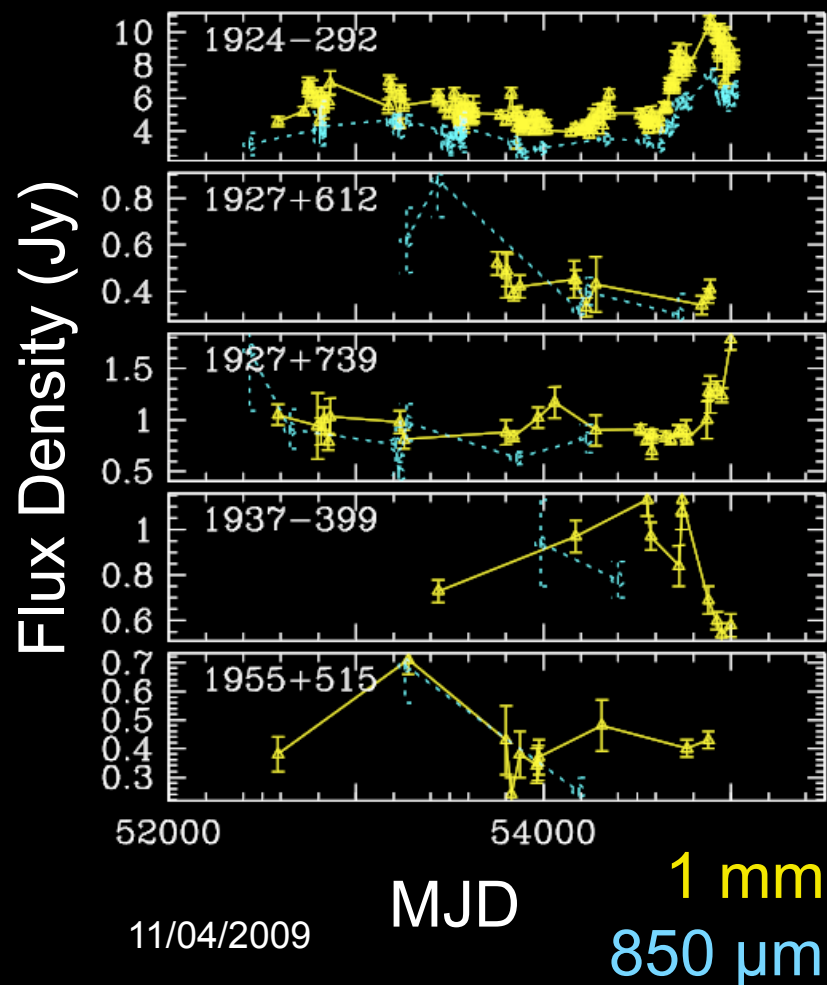
(Sikora 08)

The *SMA-Fermi* Blazars

- 171 objects observed by *SMA*
  - 35 BL Lacs
  - 136 FSRQs
- 43 objects observed by *Fermi*
  - 14 BL Lacs
  - 29 FSRQs
- $0.03 \leq z \leq 2.19$

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SMA Light Curves

http://sma1.sma.hawaii.edu/callist/callist.html

- Beginning in 2003
  - irregular sampling
- Typically variable
  - diverse properties with large range of observed characteristics
- Quasi-simultaneous band measurements
  - 850 μm observed less frequently than 1mm
- Brighter objects observed more often
  - BL Lacs underrepresented

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Analyzing Blazar Variability

- Variability Index (Hovatta et al. 2007)
- First-order Structure Function (e.g. Simonetti 1985)
- Continuous First-order Autoregressive Process (Kelly et al. 2008)

Variability Index
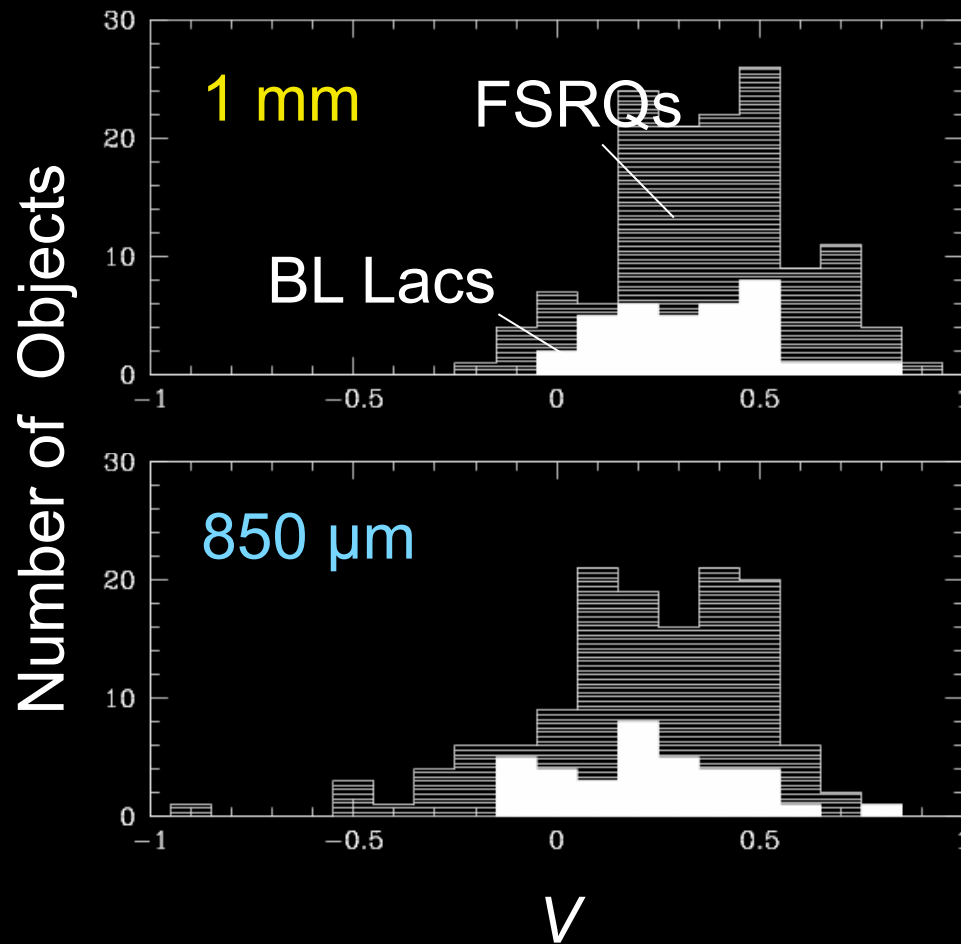
$$V = \frac{(F_{\max} - \sigma_{F_{\max}}) - (F_{\min} + \sigma_{F_{\min}})}{(F_{\max} - \sigma_{F_{\max}}) + (F_{\min} + \sigma_{F_{\min}})}$$

- No difference in BL Lac and FSRQ distributions
- V < 0 indicates measurement errors larger than intrinsic variability

Analyzing Blazar Variability

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CAR(1) Process

$$dS(t) = -\frac{1}{\tau}S(t)dt + \sigma\sqrt{dt}\epsilon(t) + bdt$$

τ relaxation timescale

$\mu = b/\tau$ mean level of the time series

σ dispersion in white noise perturbations

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CAR(1) Results
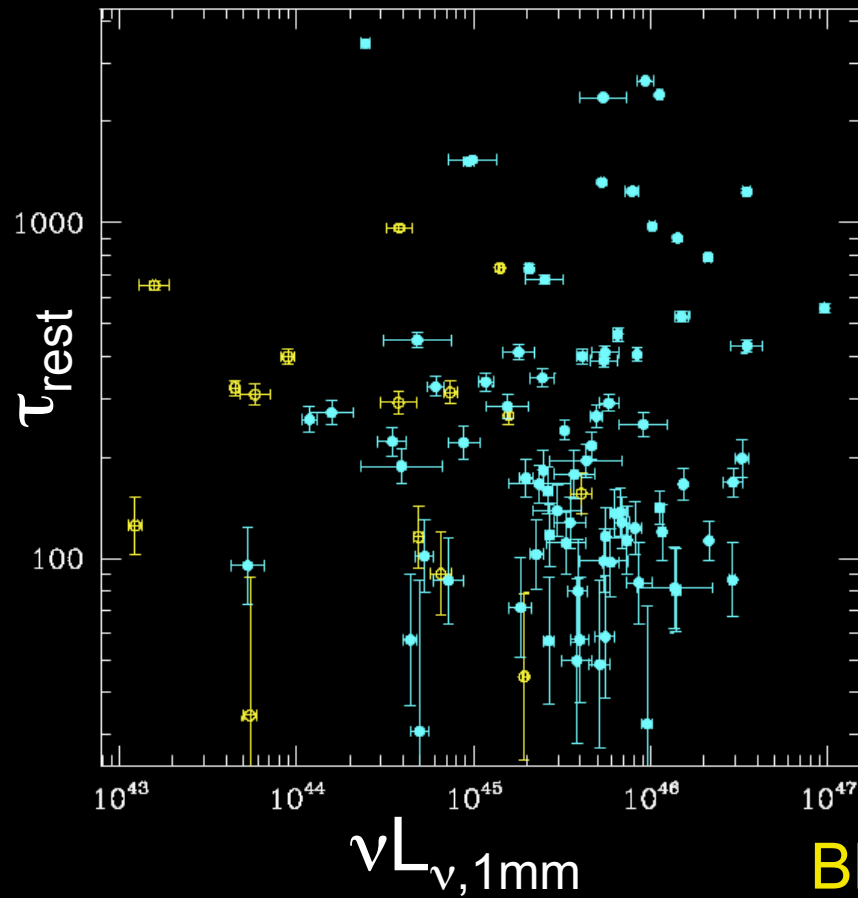
BL Lacs
FSRQs

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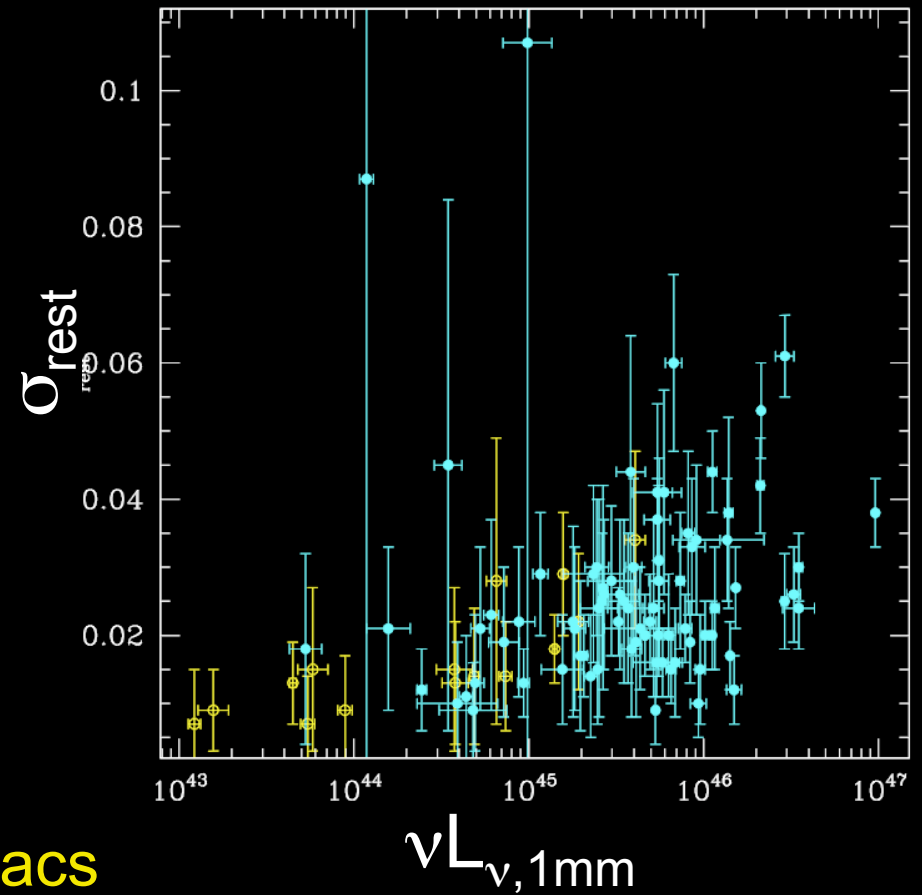
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Connections with *Fermi*
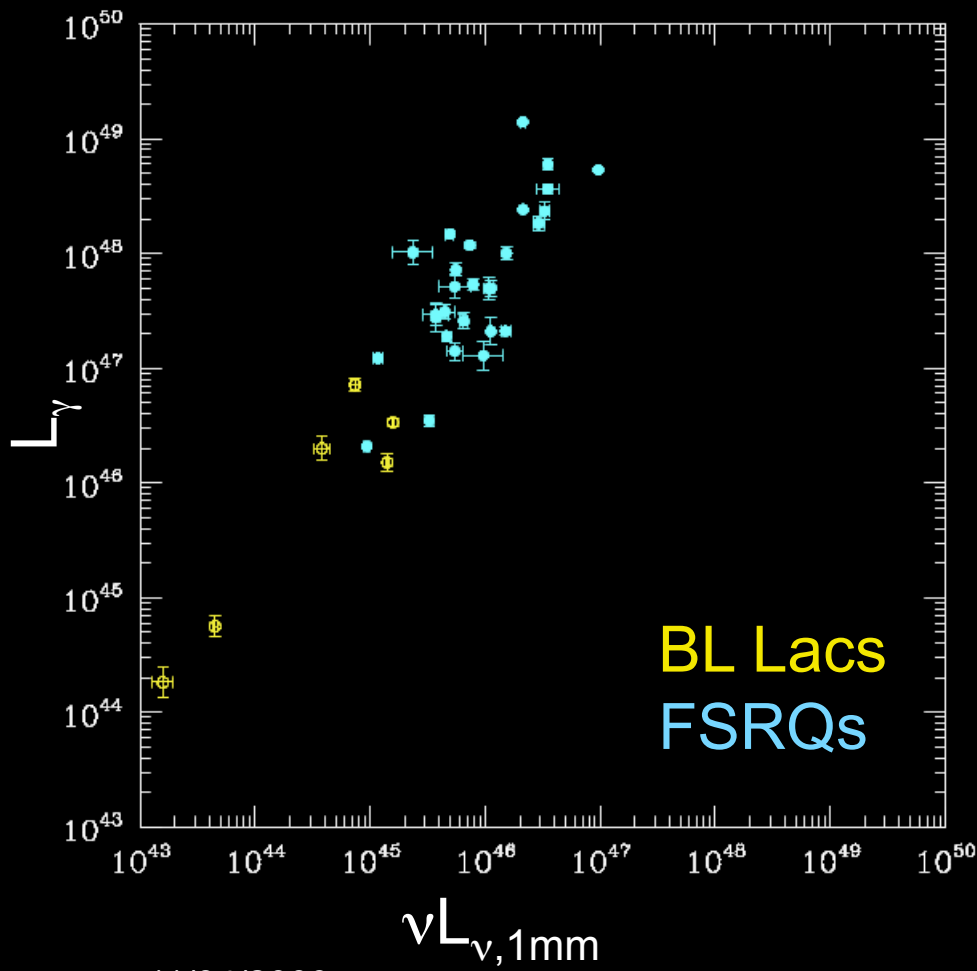
- Relationship between classes not based solely on luminosity
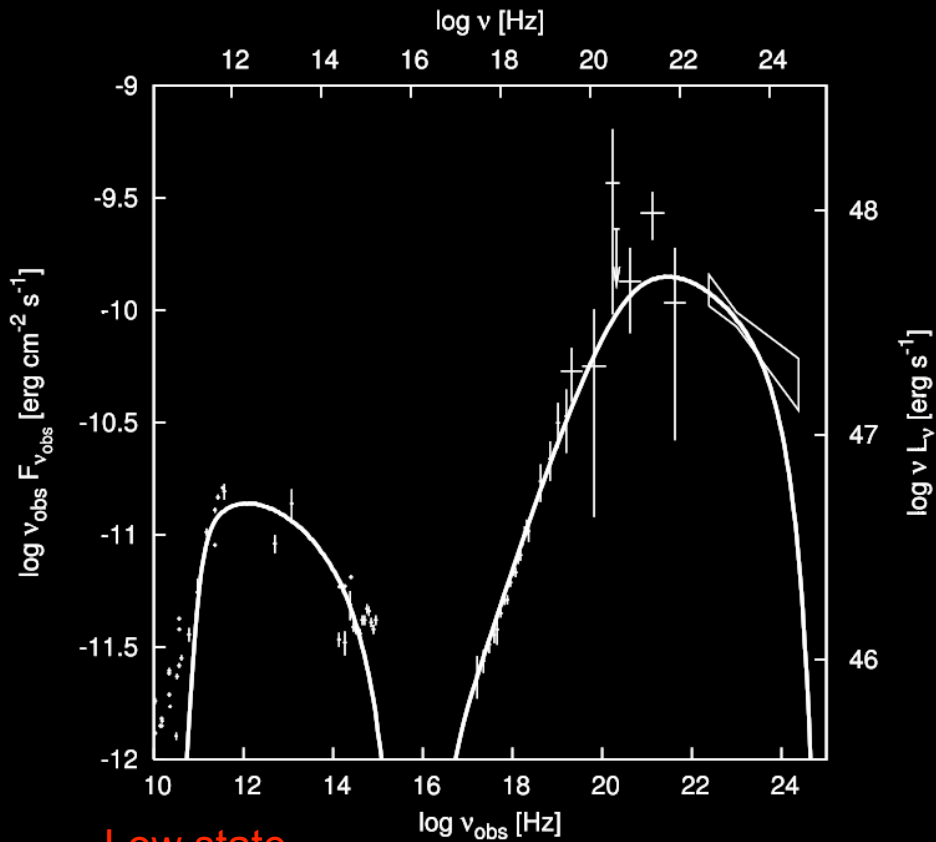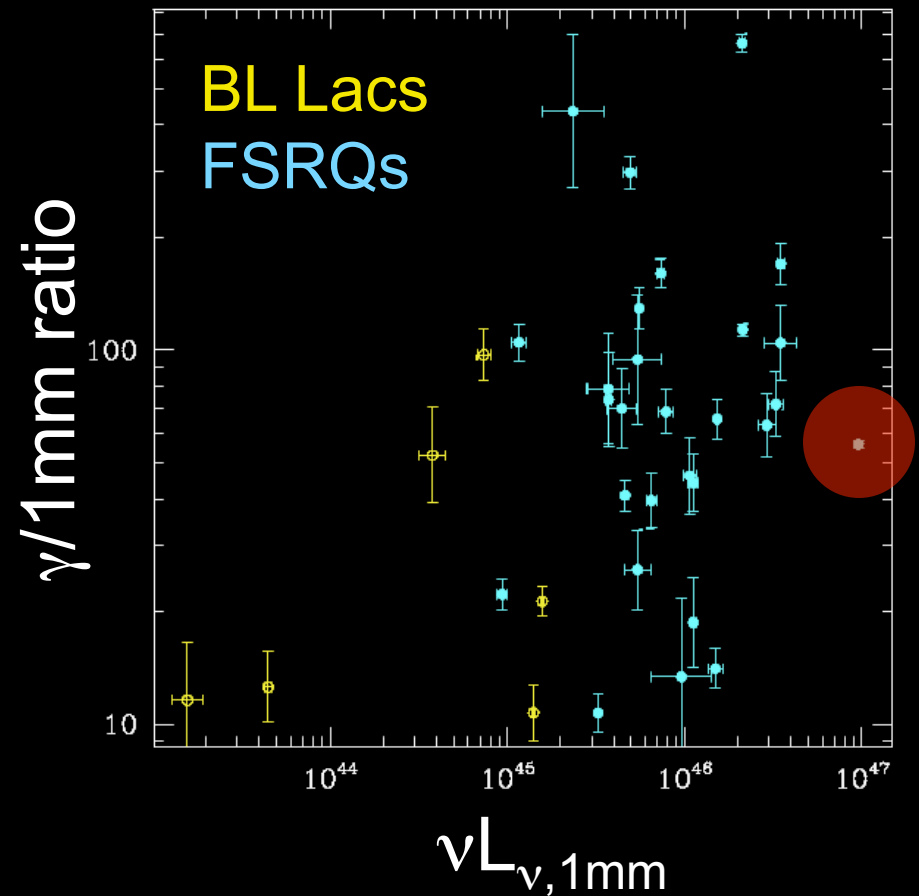- Provides constraints on particle populations and magnetic field strength

Connections with *Fermi*
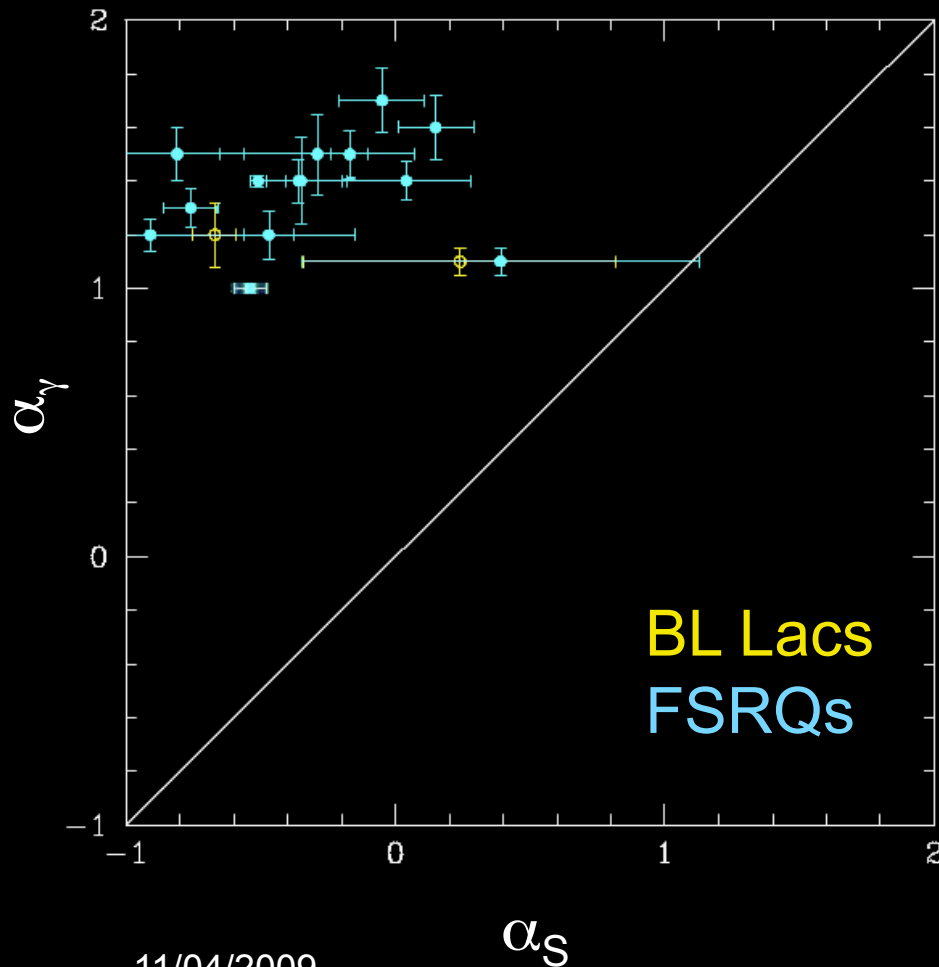
BL Lacs
FSRQs

- Relationship between classes not based solely on luminosity

- Provides constraints on particle populations and magnetic field strength

3C 454.3
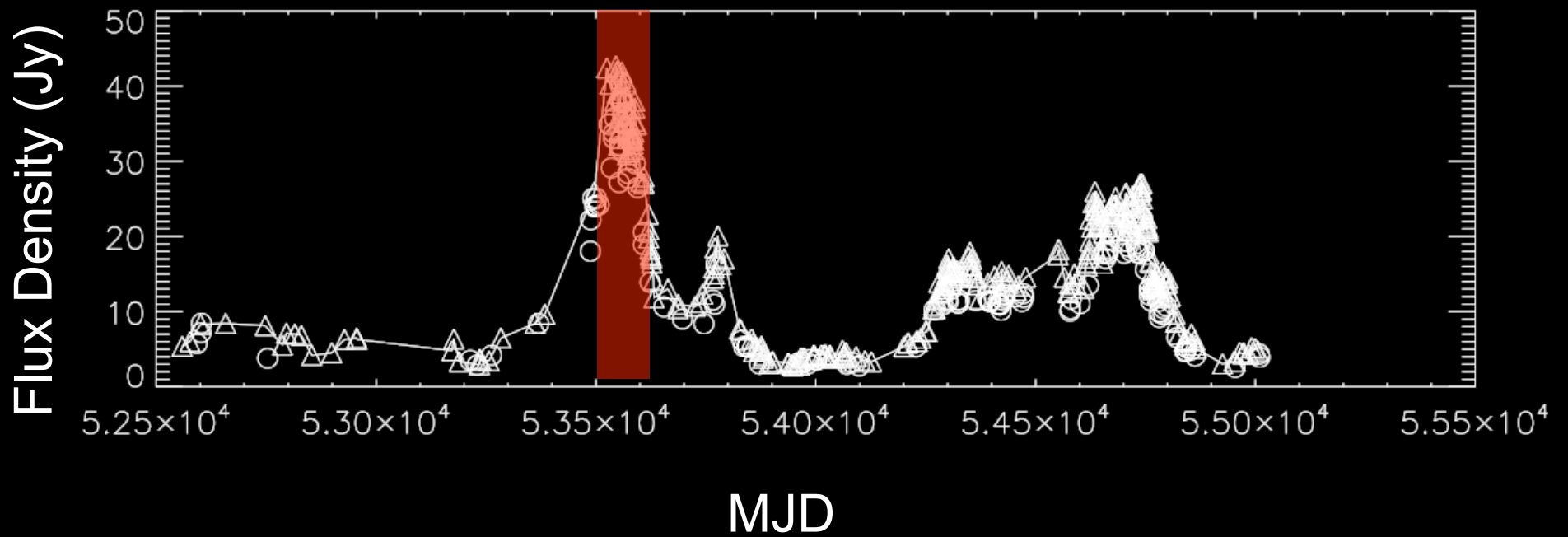
3C 454.3
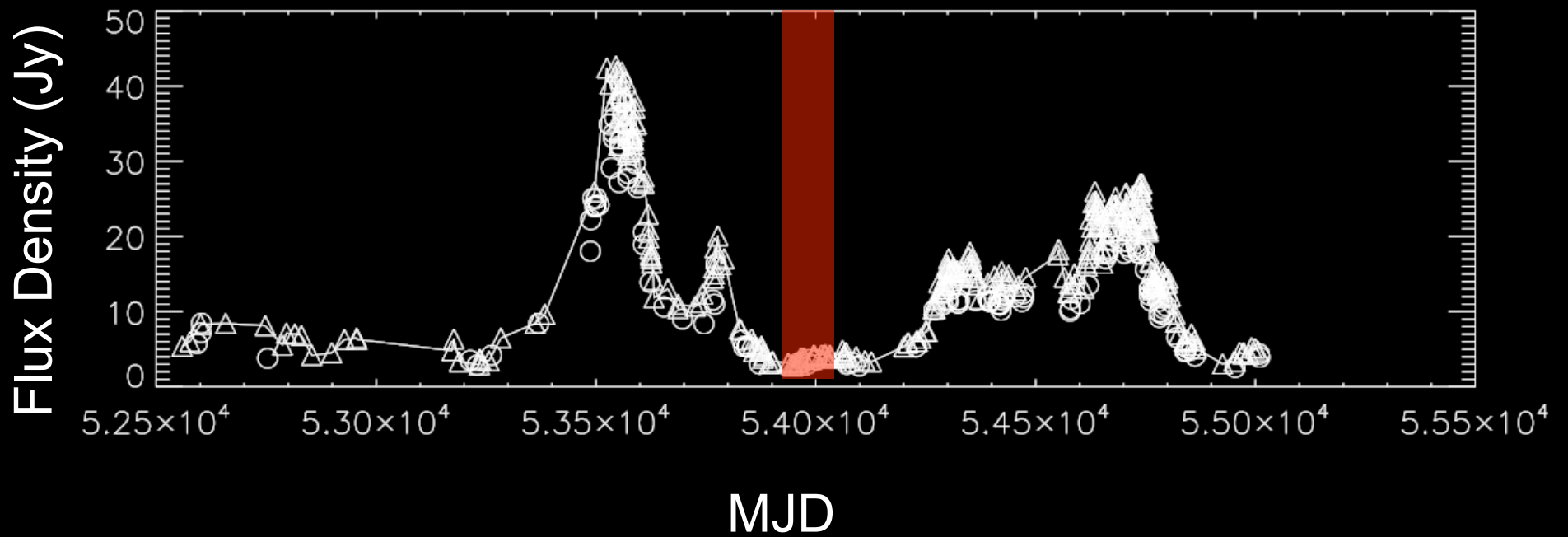
3C 454.3
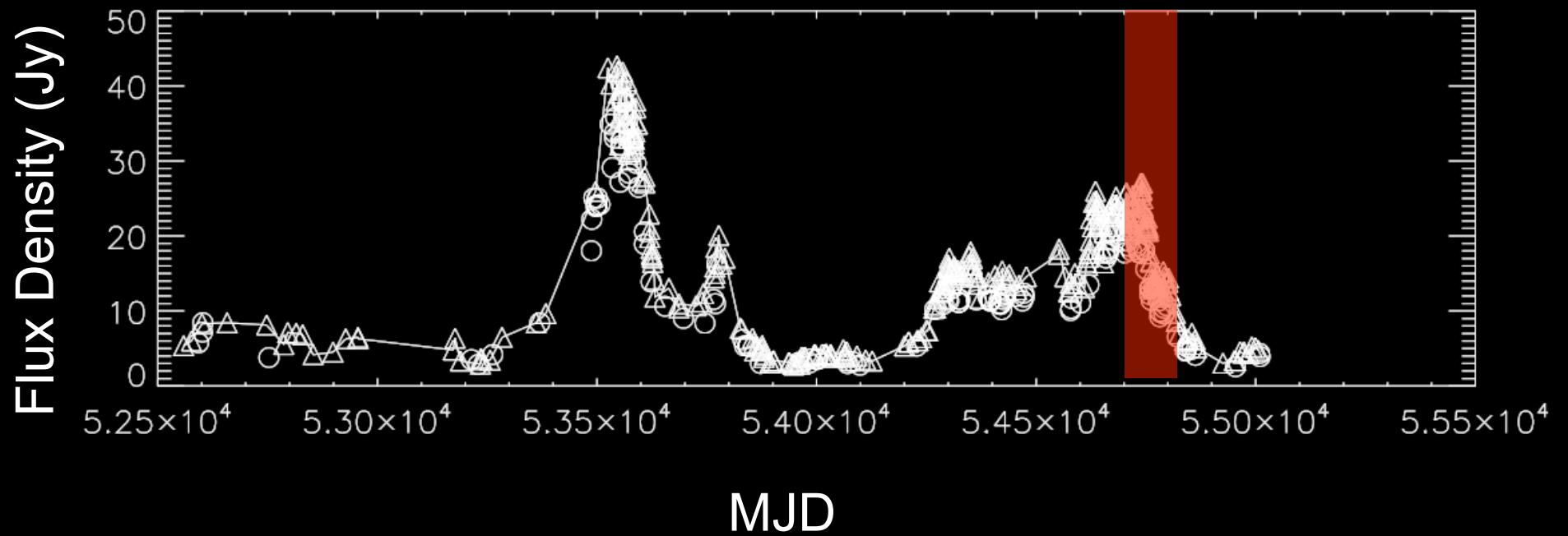
3C 454.3

Low state
(Sikora 08)

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BL Lacs
FSRQs

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3C 454.3

SSC
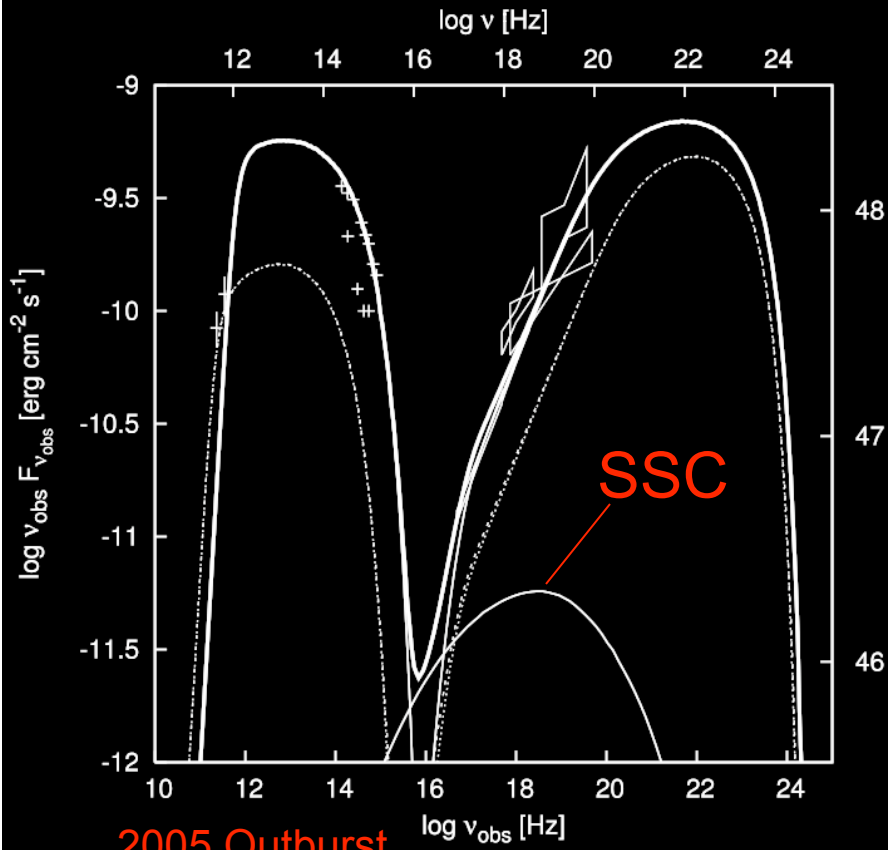
2005 Outburst
(Sikora 08)

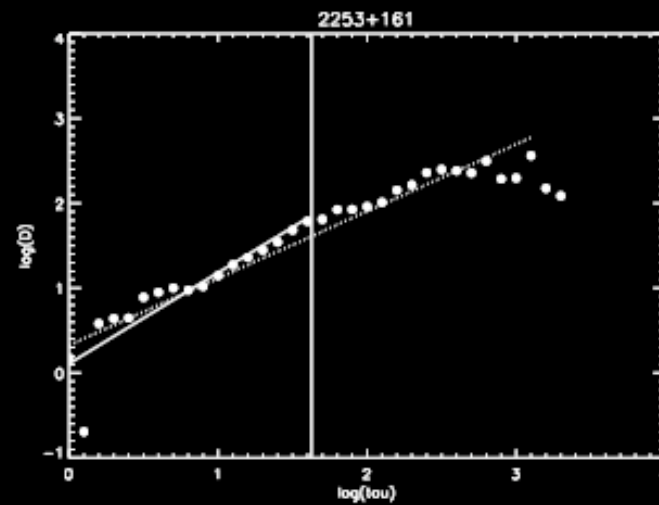11/04/2009

BL Lacs
FSRQs

γ/1mm ratio

$\nu L_{\nu,1mm}$
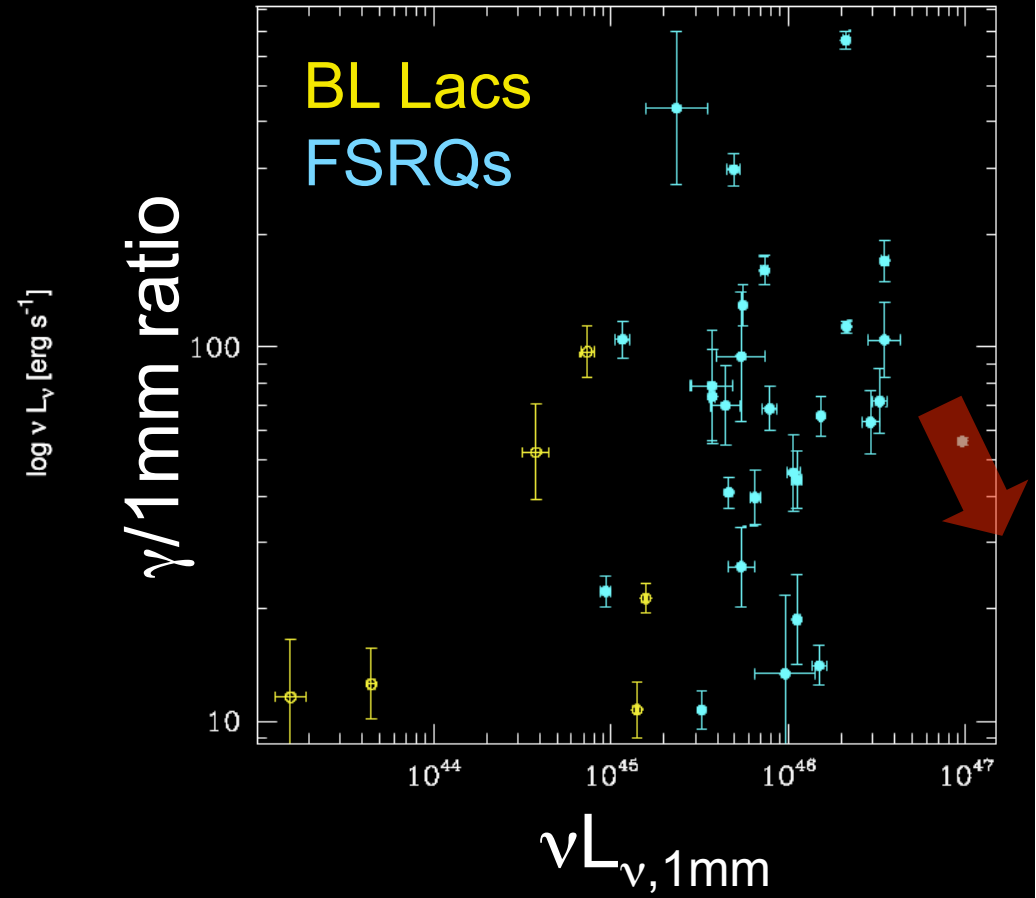
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Summary

- Submm luminosities and energy spectral indexes support the spectral sequence

- BL Lacs and FSRQs do not show differences in variability amplitude or characteristic timescale

- All of our blazar light curves are consistent with being produced by a single process

- *Fermi*-detected sources have synchrotron peaks at overall higher frequencies, regardless of luminosity

- Next: correlate sources in updated Fermi catalog with submillimeter observations
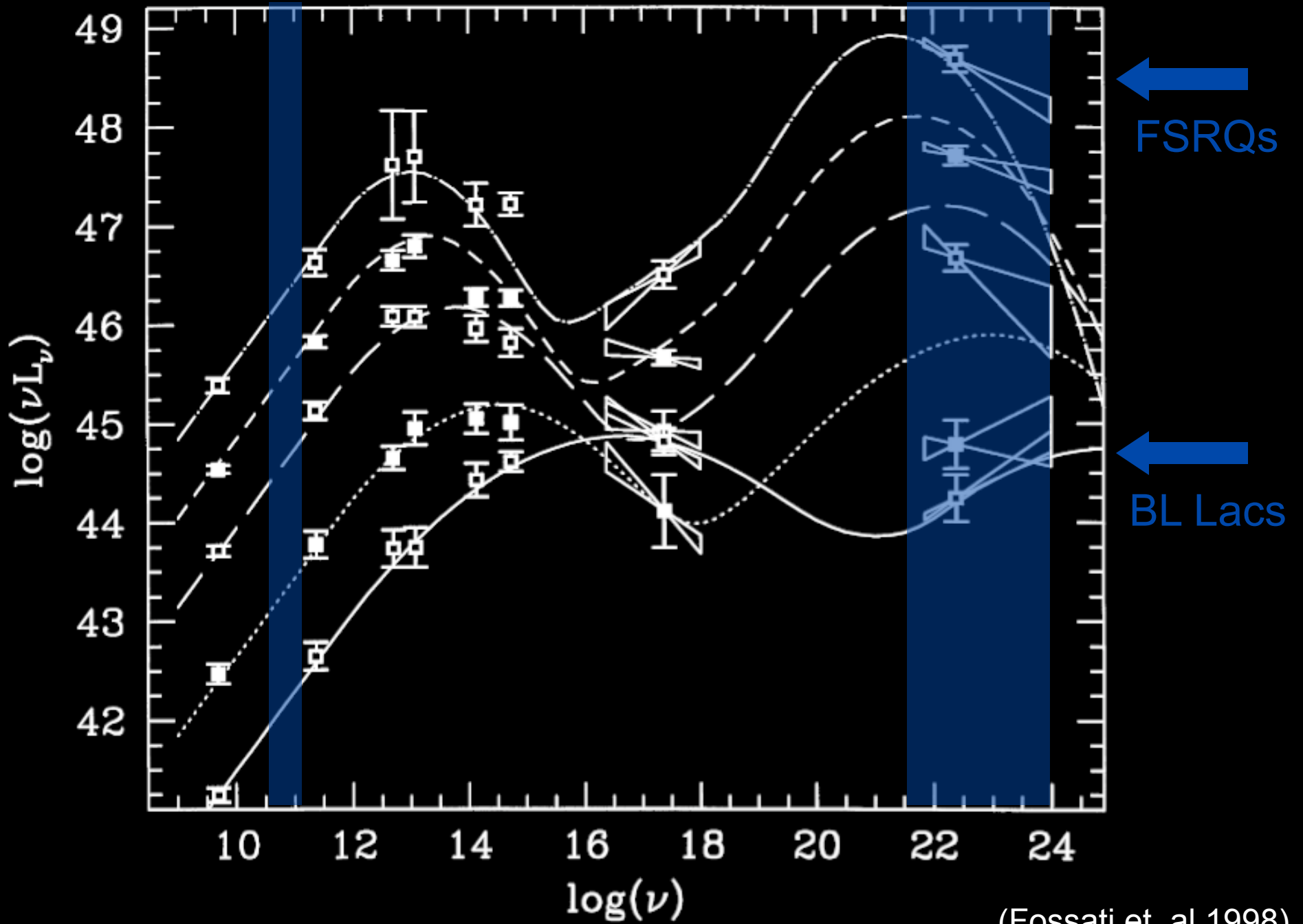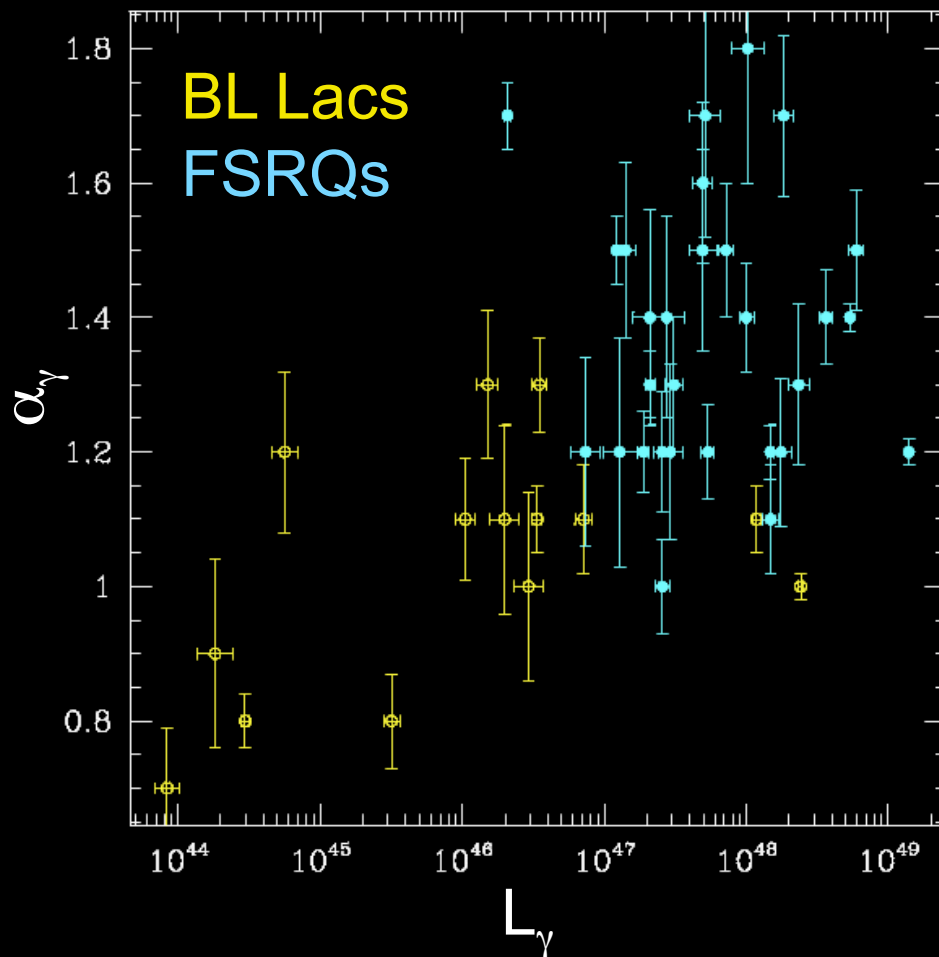
Light curve

Residuals

log(log(τ))

2253+161

0136+478
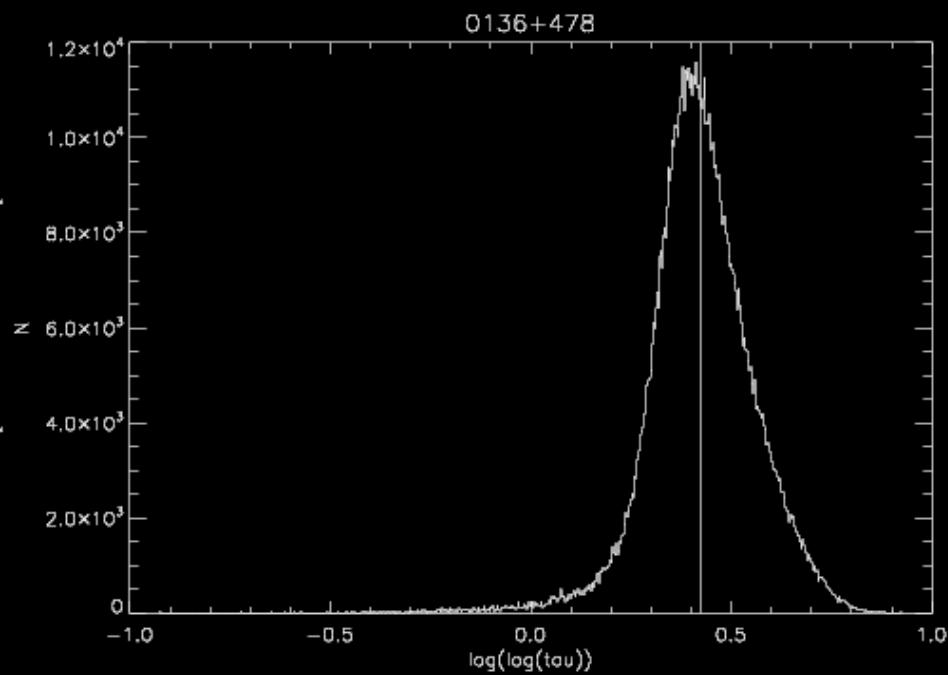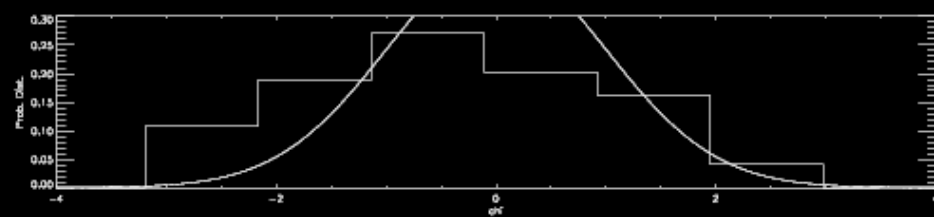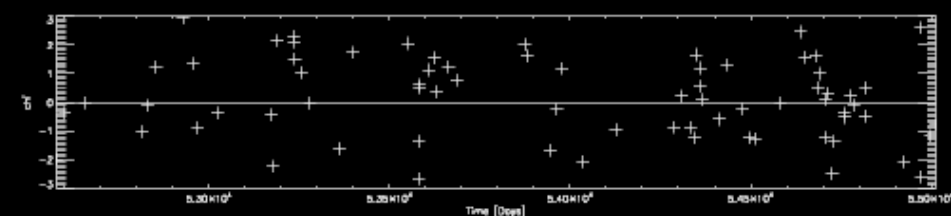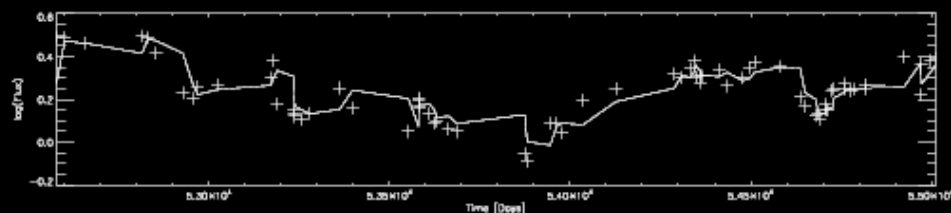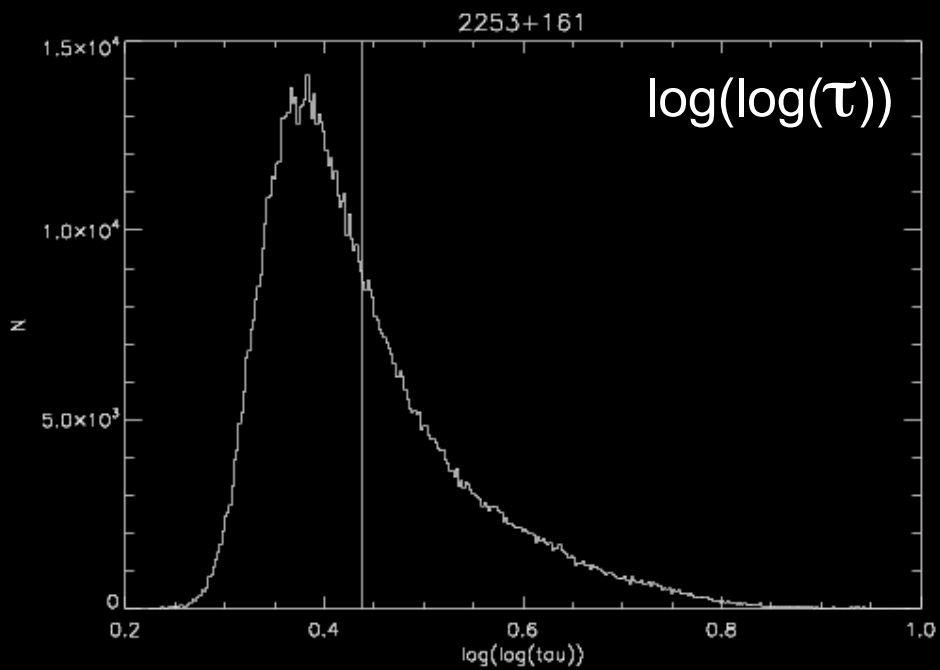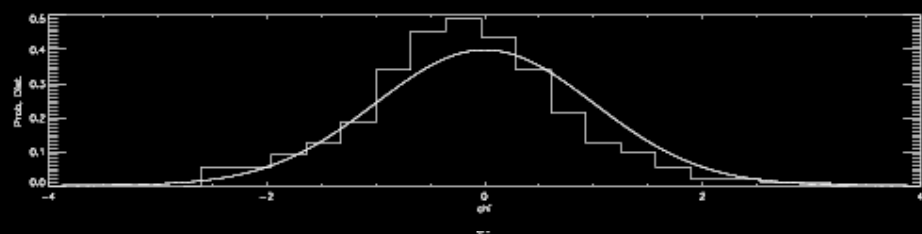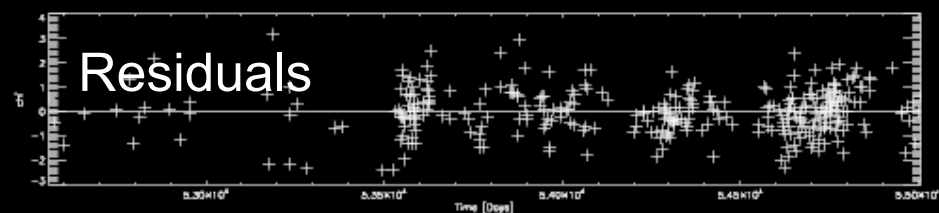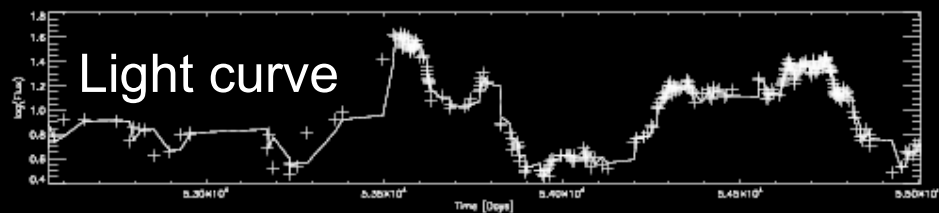
The Structure Function
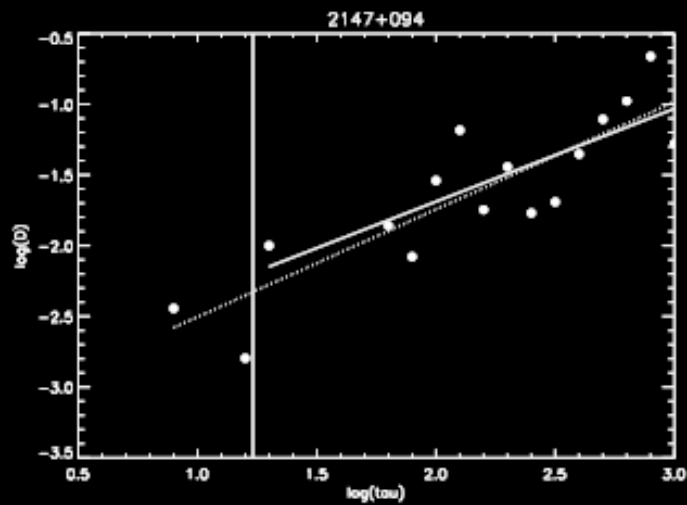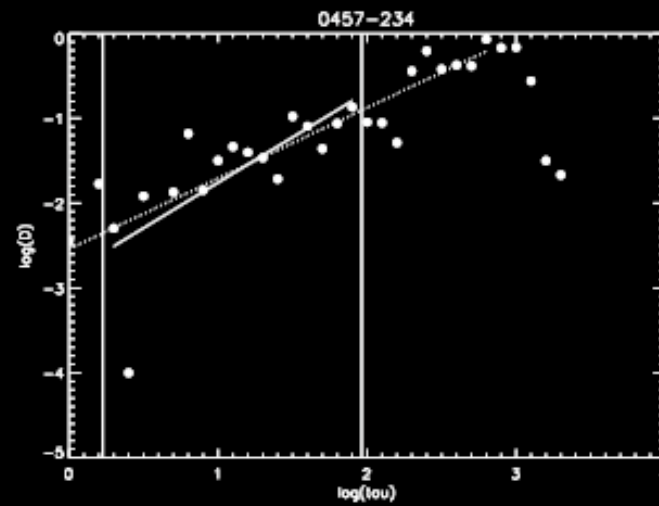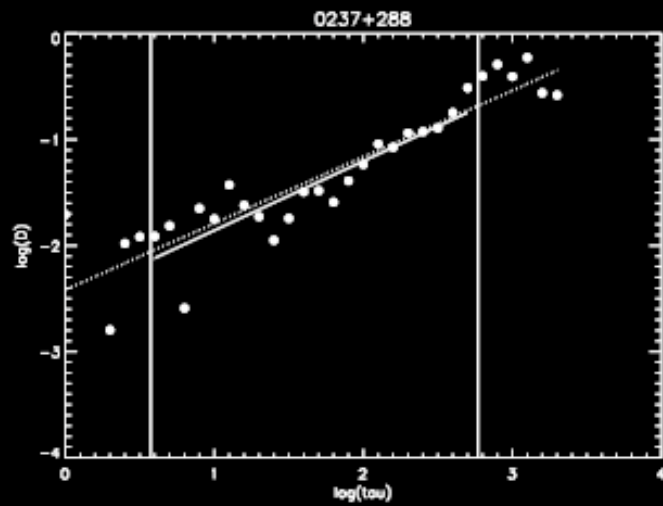
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FSRQs

BL Lacs

(Fossati et. al 1998)

Connections with *Fermi*

- BL Lacs with steeper gamma-ray spectra unlikely

- Relationship between classes not based solely on luminosity