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The Spectral Index Distribution and the Spectral Shape of Unresolved Emission of GeV Blazars

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Outline

- Past Work
- Determination of ISIDs from Maximum Likelihood Studies
- Determination of the spectral shape (and uncertainties) of unresolved blazar emission
- Conclusions

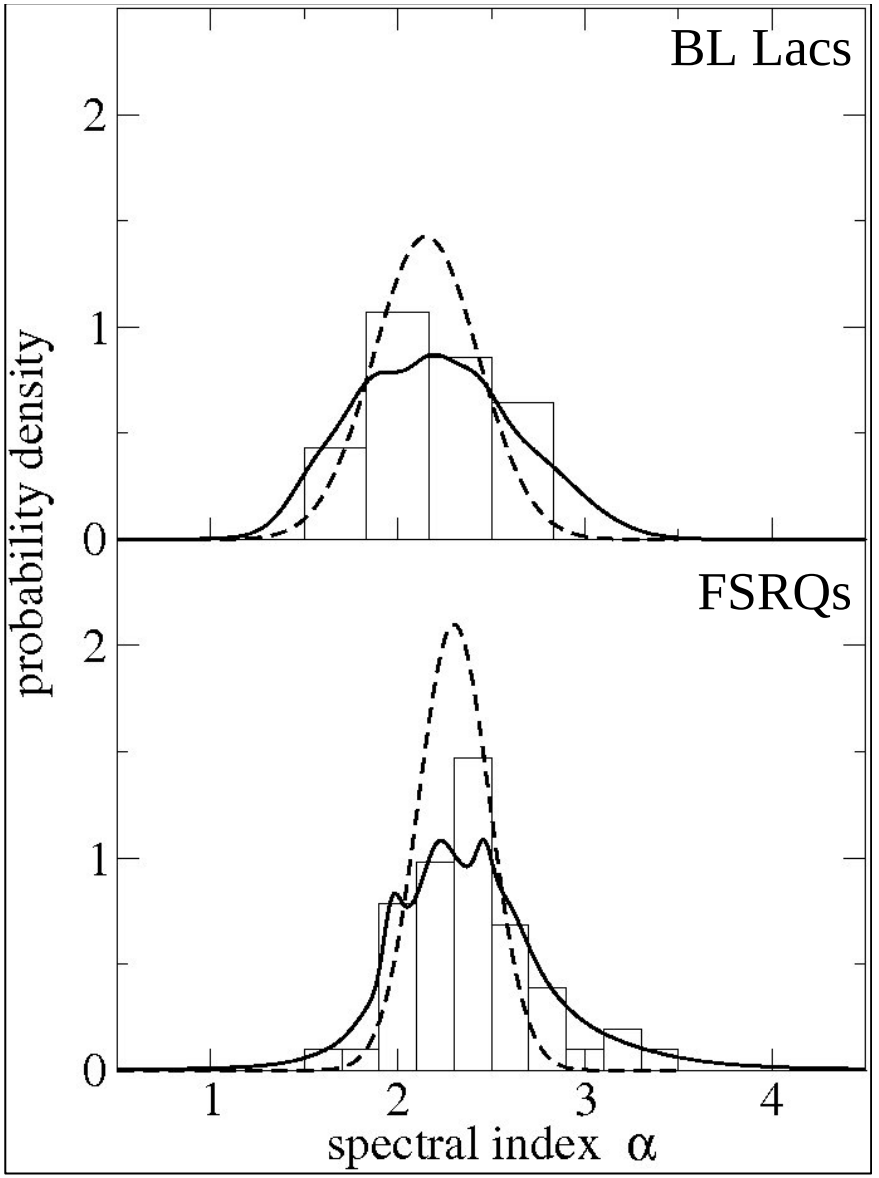
Past Work

Stecker and Salamon (1996)

⇨ importance of the SID

⇨ importance of accounting for measurement error

Affect the blazar contribution to the EGRB ☛concavity of the spectrum



$$p(\alpha) = \frac{1}{N}\sum_{i=1}^{N}\frac{1}{\sigma_i\sqrt{2\pi}}e^{-\frac{(\alpha-\alpha_i)^2}{2\sigma_i^2}}$$

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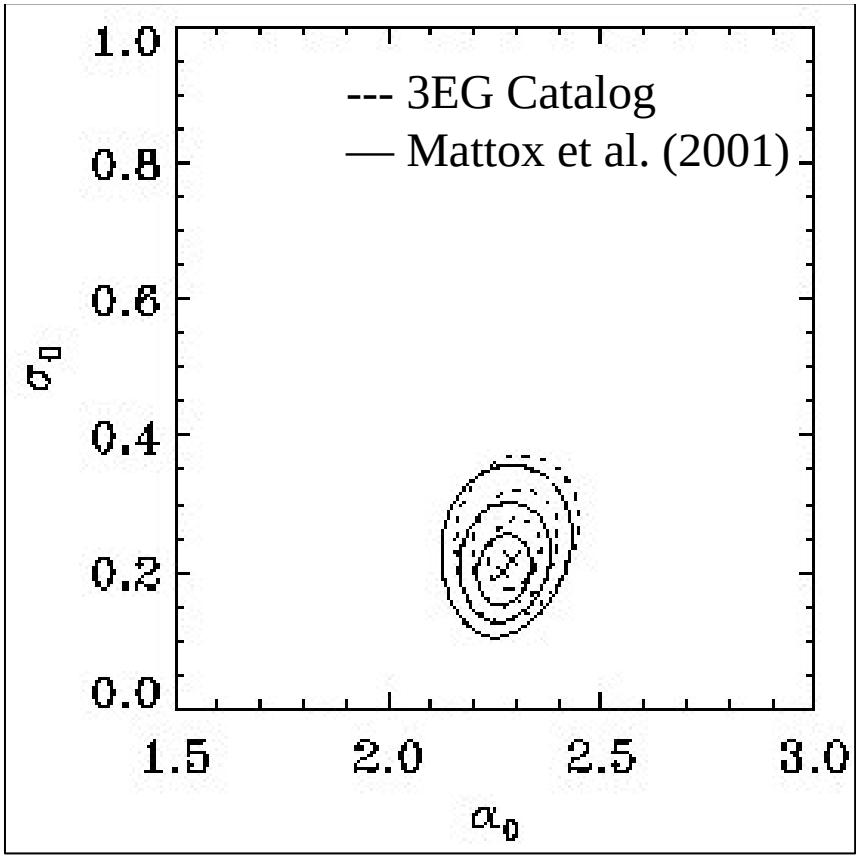
The Maximum Likelihood Approach

$$P(x_i \mid y_j) \propto P(x_i) \times \mathcal{L}(y_j \mid x_i)$$

$$\mathcal{L} = \prod_{j=1}^{N} l_j$$

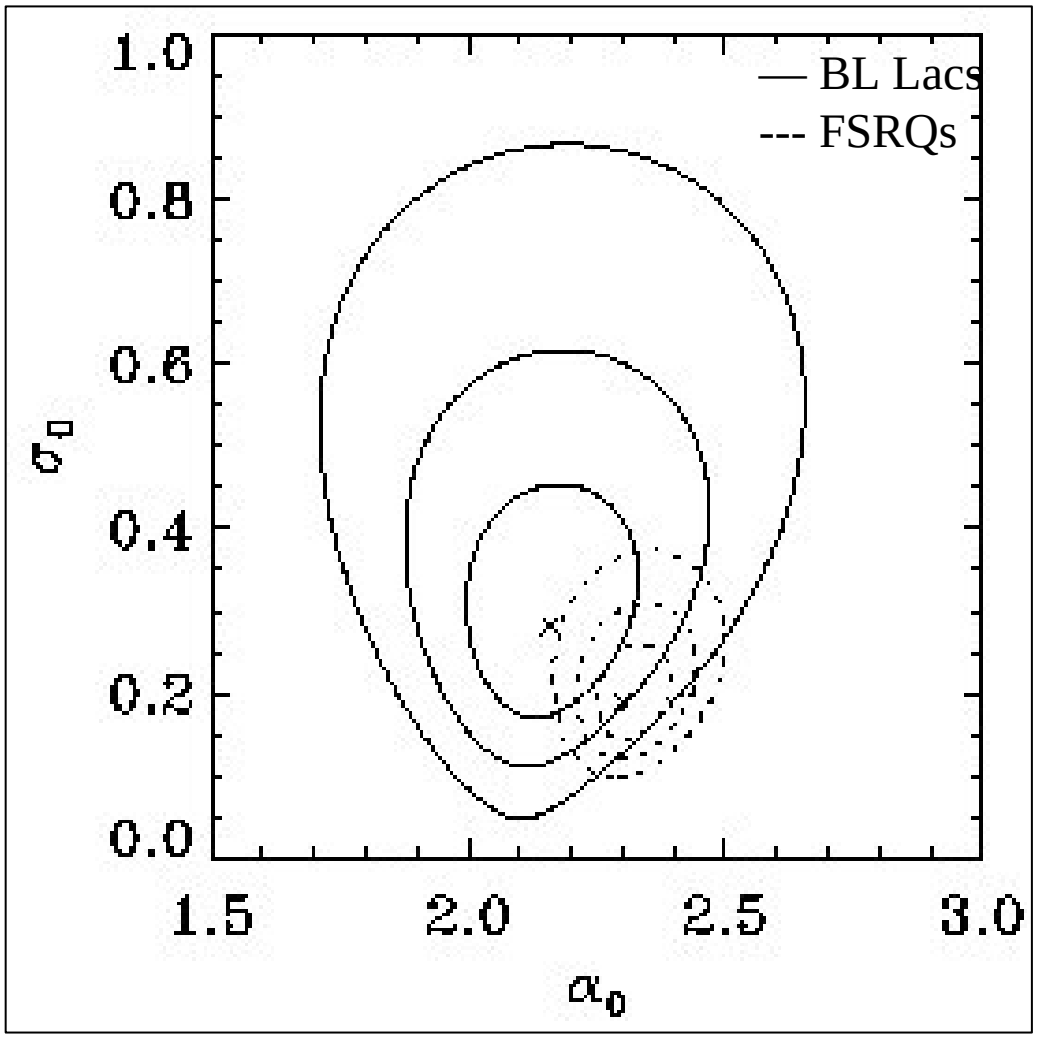


$$l_j = \int d\alpha \frac{\exp[-(\alpha-\alpha_j)^2/(2\sigma_j{}^2)]}{\sqrt{2\pi}\sigma_j} \frac{\exp[-(\alpha-\alpha_0)^2/(2\sigma_0{}^2)]}{\sqrt{2\pi}\sigma_0}$$

$$\mathcal{L} = \left(\prod_{j=1}^{N} \frac{1}{\sqrt{\sigma_0{}^2 + \sigma_j{}^2}} \right) \exp\left[-\frac{1}{2} \sum_{j=1}^{N} \frac{(\alpha_j - \alpha_0)^2}{\sigma_0{}^2 + \sigma_j{}^2} \right]$$

3EG Catalog
α_0=2.29, σ_0=0.22

The ISIDs—Maximum Likelihood in Action



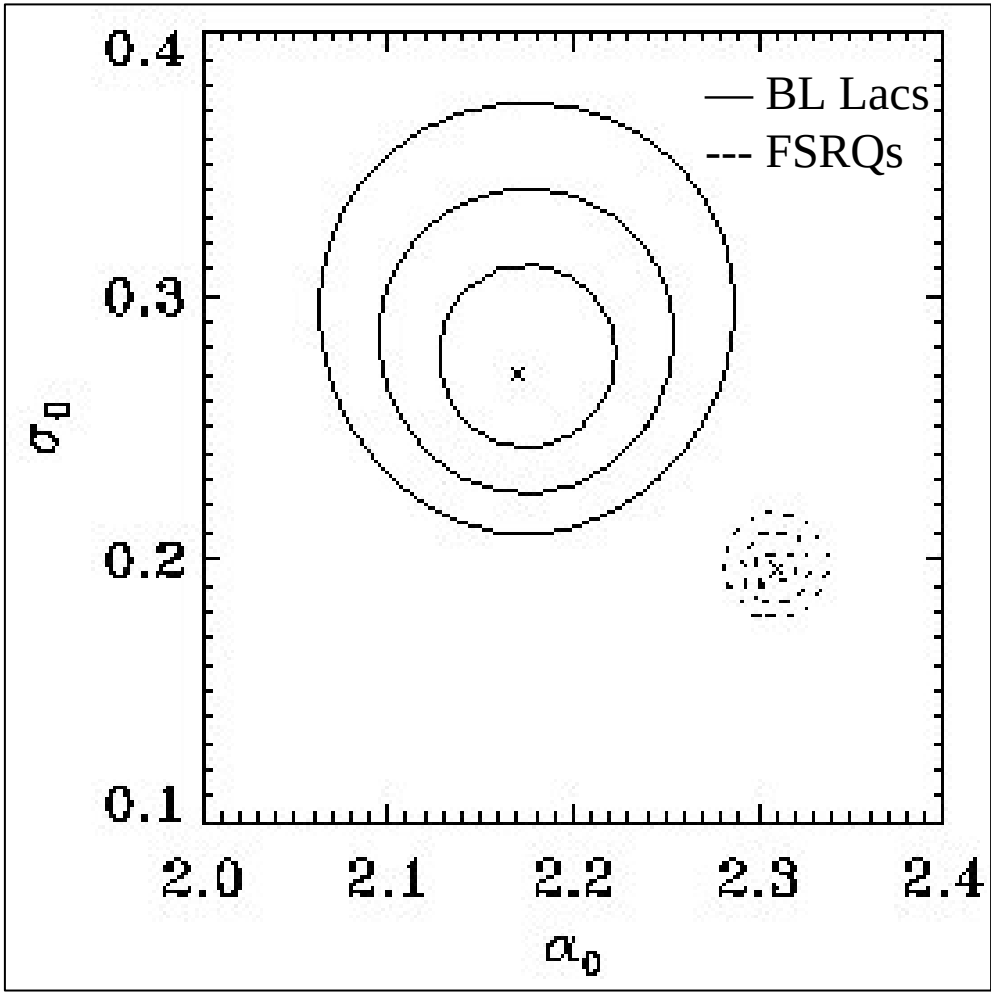
Separate Populations?

Blazar ISIDs—According to GLAST

- Simulate GLAST data using the number distributions in Dermer (2007)
- Draw true spectral indices from EGRET ISIDs
- Uncertainty determined from the number of detectable photons:

$$N_{\text{photon}} = F\Delta tA$$
$$\sigma = 7.0 \times N_{\text{photon}}^{-0.7}$$

- Draw measured spectral index from Gaussian with mean being the true spectral index and sigma the uncertainty



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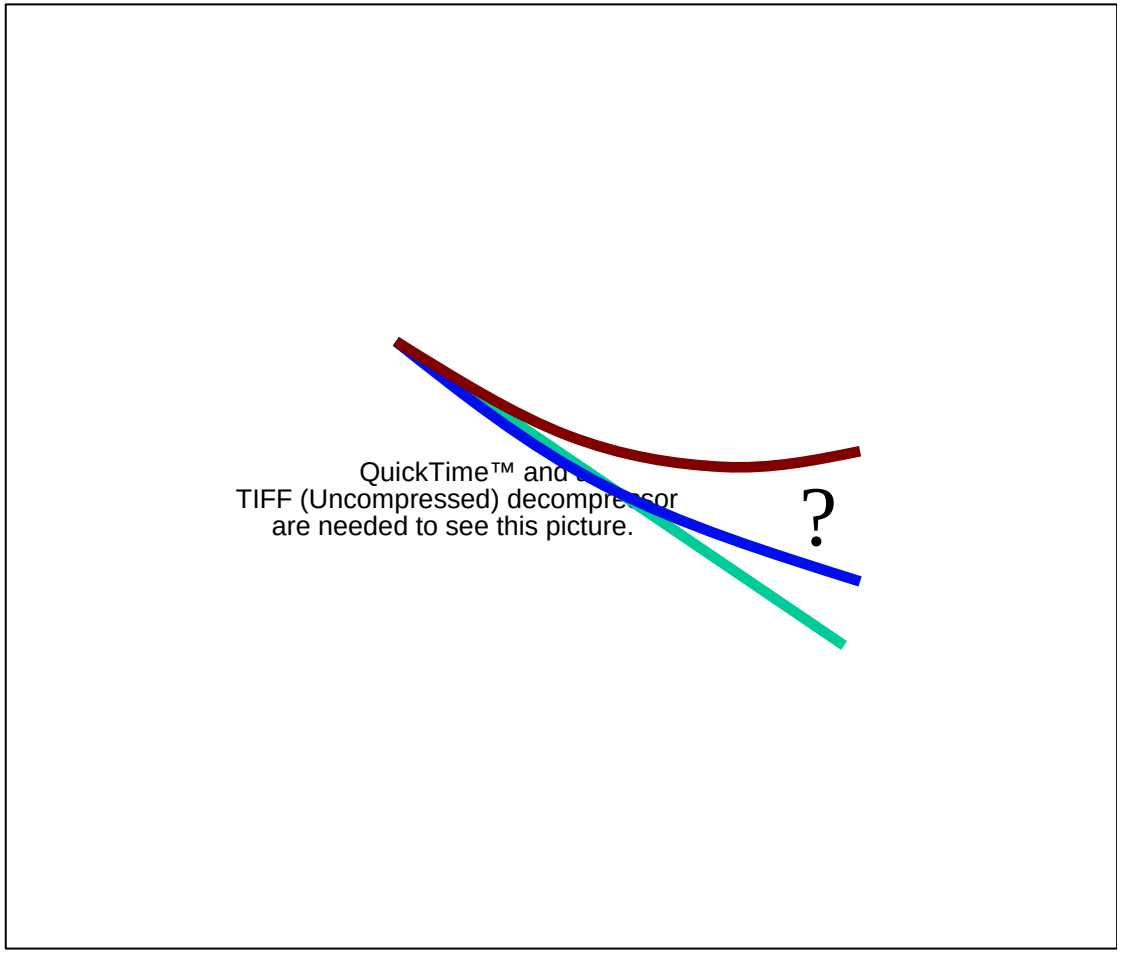
The SID and the Spectral Shape

WARNING!!!

The question of the blazar contribution to the EGRB is not just a question of magnitude, but also of shape!!!



Data taken from Strong et al. (2004)

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The Separation of Magnitude and Shape

Three important assumptions:

- Blazar spectra can be described as power-laws
- Flux distribution of blazars is independent of spectral index
- Spectral index does not evolve with time and does not depend on luminosity

$$F_E(E) = F_{E,0}\left(\frac{E}{E_0}\right)^{-\alpha}$$

$$F = F(>E_0) = F_{E,0}\frac{E_0}{\alpha - 1}$$

$$I_1 = (\alpha - 1)\frac{F}{4\pi E_0}\left(\frac{E}{E_0}\right)^{-\alpha}$$

$$I_{EGRB}(E) = \int_{\alpha=-\infty}^{\infty} d\alpha \int_{F=0}^{F_{\min}} dF g(F) I_1 p(\alpha)$$

Magnitude and Shape Decouple!!!

$$I_{EGRB}(E) = I_0 \int_{\alpha=-\infty}^{\infty} d\alpha (\alpha - 1)\left(\frac{E}{E_0}\right)^{-\alpha} p(\alpha)$$

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The Spectral Shape of Blazars

○Sreekumar et al. (1998)
▲Strong et al. (2004)

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

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Spectral Shapes of Separate Blazar Populations

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Conclusions

- Maximum Likelihood ISID of the blazar population is a Gaussian with $\alpha_0 = 2.29$ and $\sigma_0 = 0.22$ ☛ spectral shape of unresolved blazar emission may be smaller than previously suspected
- Some indication that BL Lacs and FSRQ are spectrally distinct.
- Spectral index independent of redshift and luminosity + flux distribution independent of spectral index ☛ magnitude of spectrum of unresolved blazar emission decouples from the shape ☛ shape gives information about whether blazars can dominate the EGRB at all energies if it does dominate at low energies.
- Spectral shapes also have uncertainties ☛ not very well constrained by EGRET, but will be very well constrained by GLAST

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