The Epeak - Fluence Bimodality: A fundamental discriminator between long and short GRBs

Adam Goldstein
under the direction of
Rob Preece

BATSE

NSSTC

UAHuntsville
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

Fermi
Gamma-ray Space Telescope

BATSE 5B Spectral Catalog

2,106 GRBs

19,936 Spectra

9,971 2-Sec Peak Flux Spectra

- Band: 1429 (67.9%)
- Comp: 1858 (88.2%)
- Log$_{10}$ Gauss: 1739 (82.6%)
- Power Law: 856 (40.6%)
- SBPL: 1909 (90.6%)

9,965 3.5 Sigma Fluence Spectra

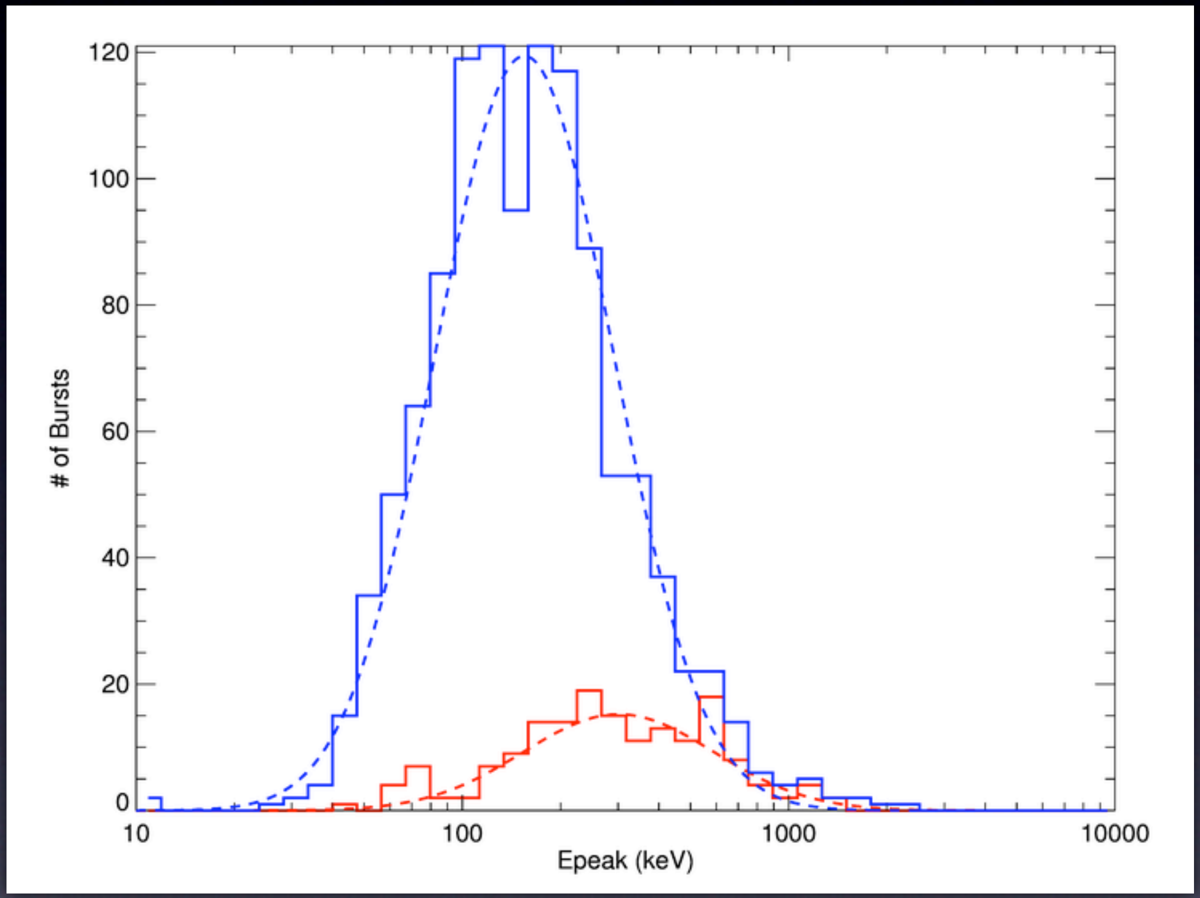
- Band: 1362 (64.7%)
- Comp: 1807 (85.8%)
- Log$_{10}$ Gauss: 1645 (78.1%)
- Power Law: 905 (43.0%)
- SBPL: 1872 (88.9%)

Epeak and Fluence for Short and Long GRBs

$$\chi^2_\nu \leq 3\sigma \text{ confidence level}$$

$$\sigma_{E_p} \leq 0.4E_p, \quad \sigma_{F_\gamma} \leq 0.4F_\gamma$$

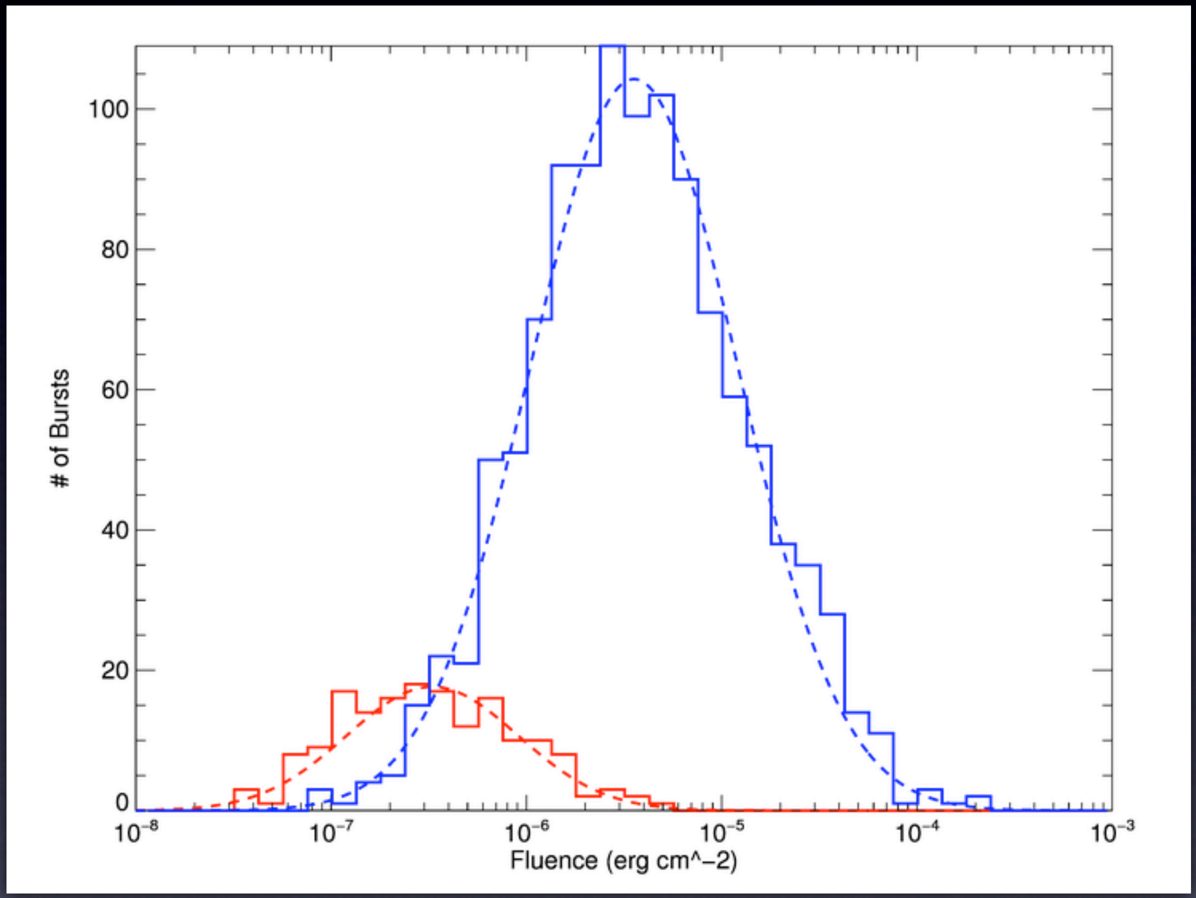
Epeak Distribution



$$\text{Long}: \quad E_{peak} = 155 \text{ keV}$$

$$\text{Short}: \quad E_{peak} = 301 \text{ keV}$$

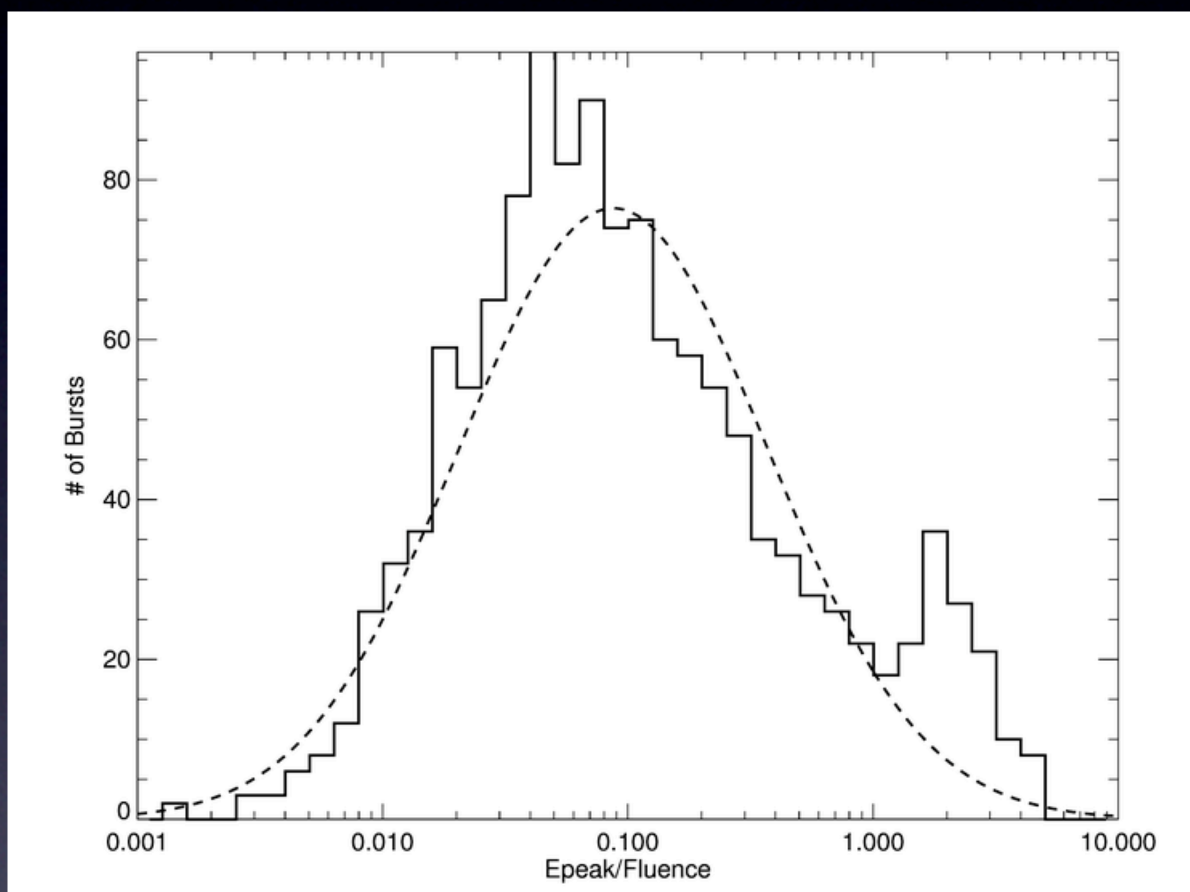
Fluence Distribution

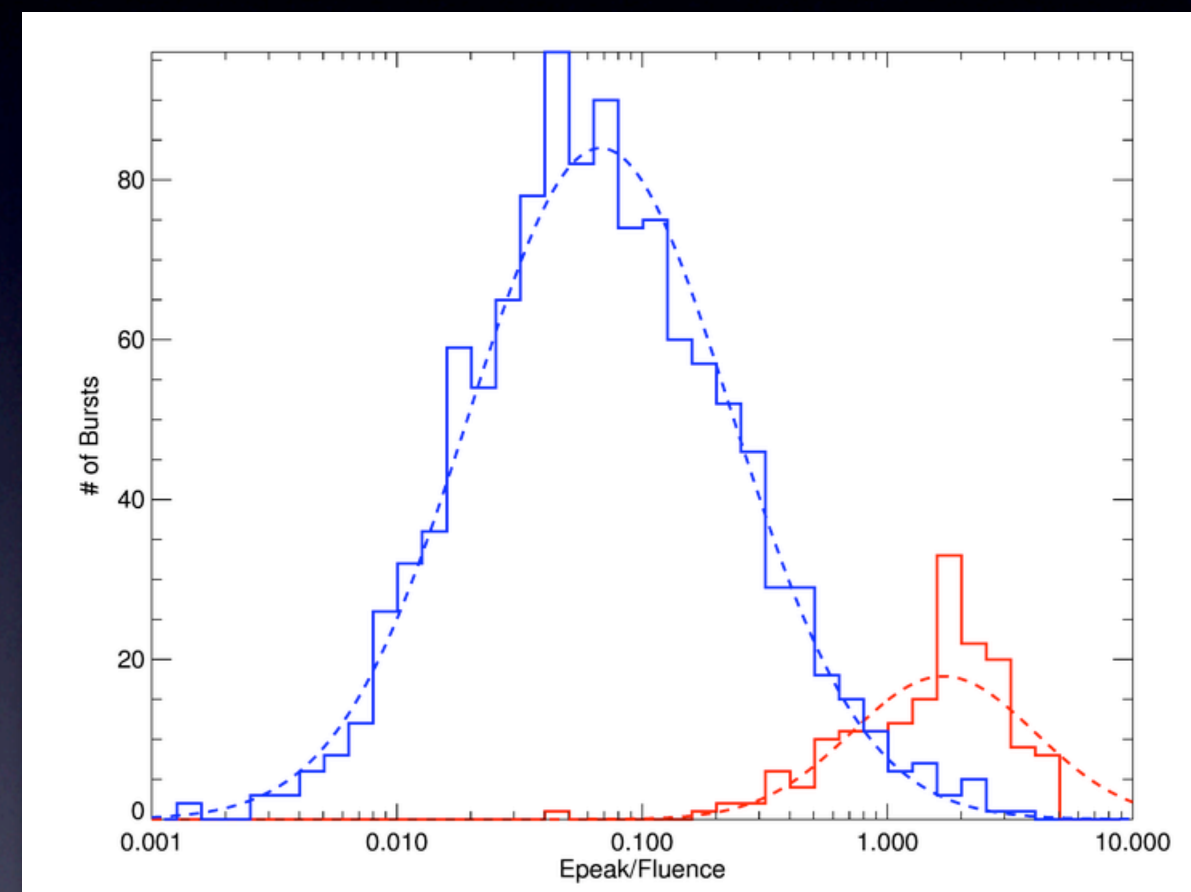


$$\text{Long}: \quad \overline{S_\gamma} = 3.56 \times 10^{-6} \text{ erg/cm}^2$$

$$\text{Short}: \quad \overline{S_\gamma} = 3.30 \times 10^{-7} \text{ erg/cm}^2$$

Epeak/Fluence Ratio for Short and Long GRBs





Bimodal Distribution!

Detector selection effects?

The Ghirlanda & Amati Relations

$$\mathrm{Amati:}\quad \mathrm{E_p} \propto \mathrm{E_{iso}^{\eta_A}}$$

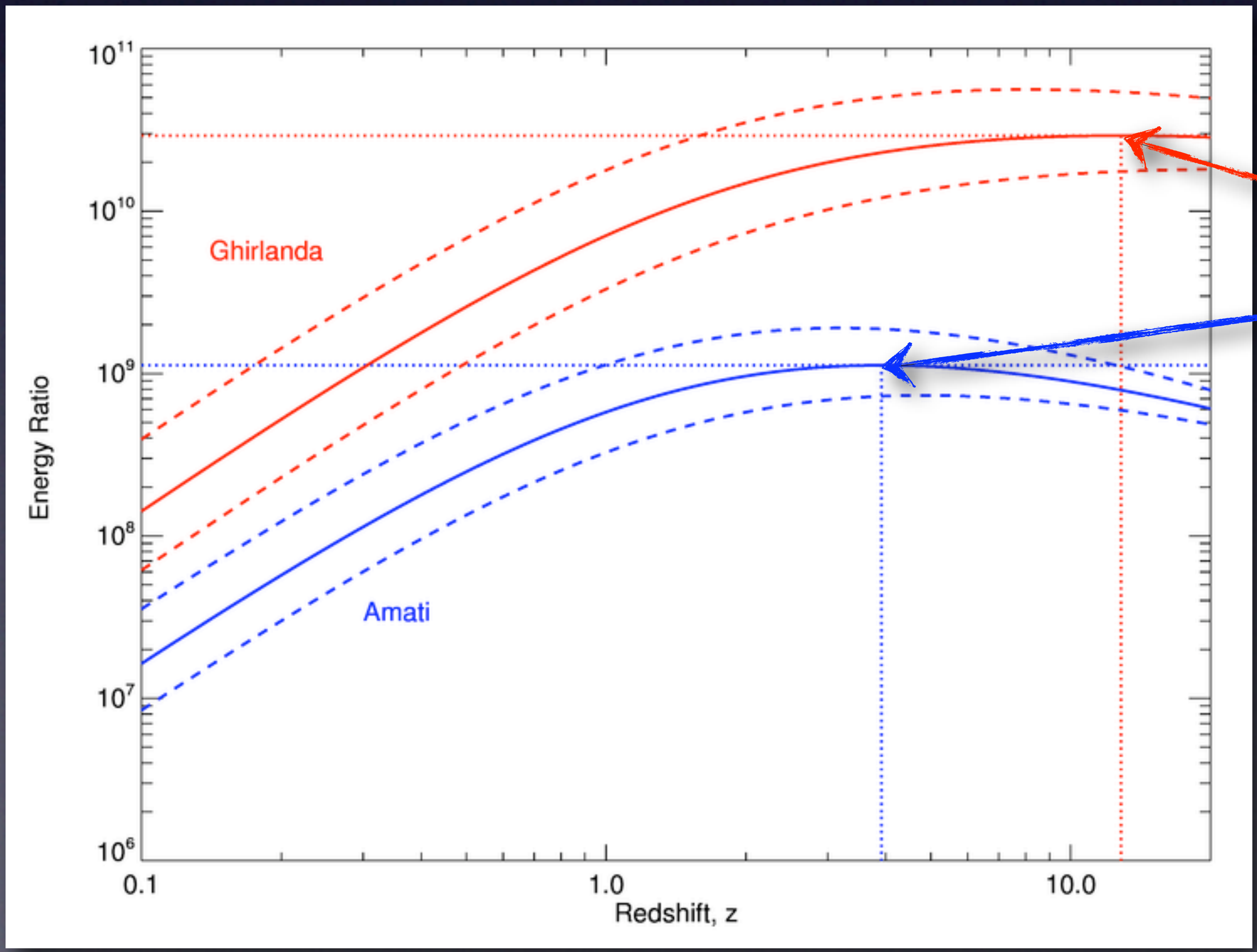
$$\mathrm{Ghirlanda:}\quad \mathrm{E_p} \propto \left(\mathrm{E_{iso}\, f_B}\right)^{\eta_G}$$

$$\frac{E_{p,obs}^{1/\eta_A}}{S_\gamma} \propto F(z)$$

$$f_B = 1 - \cos\theta_j$$

$$\frac{E_{p,obs}^{1/\eta_G}}{S_\gamma} \propto G(z) \times f_B$$

$f_B = 1.0$

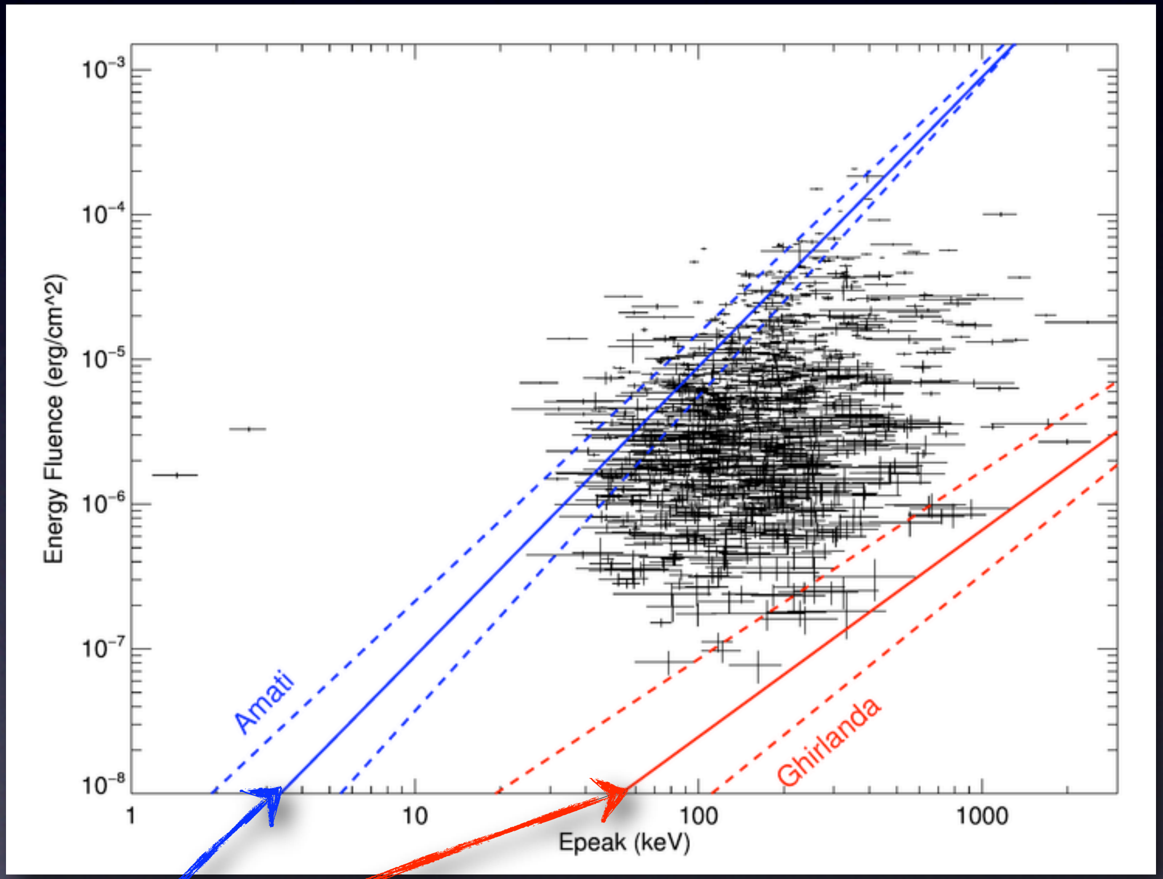


Upper Limits

Testing the Lower Limits with BATSE

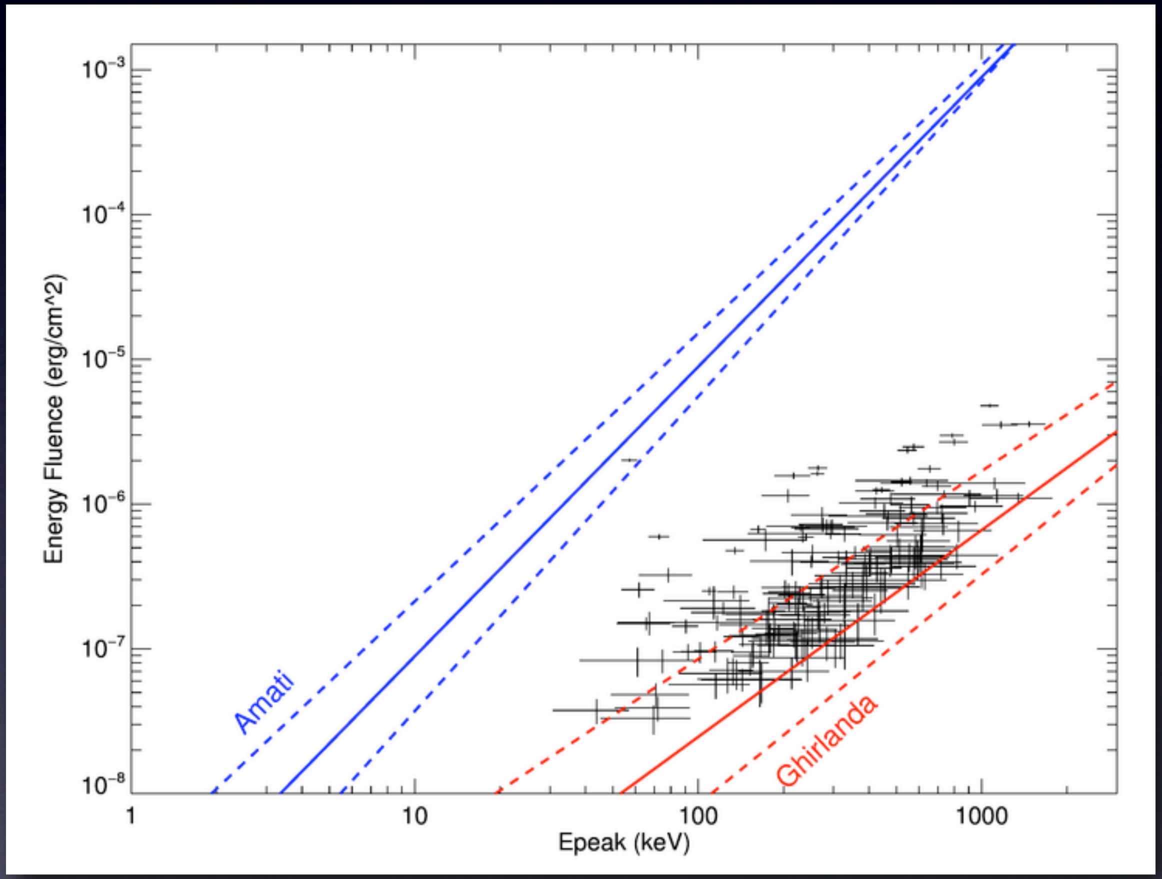
$$H_0 = 74 \text{ km Mpc}^{-1} \text{ s}^{-1} \quad \Omega_m = 0.3 \quad \Omega_\Lambda = 0.7$$

$f_B = 1.0$



Lower Limits

1141 Long GRBs
Amati fails for 86.8%
Ghirlanda fails for 0.0%



167 short GRBs
Amati fails for 99.4%
Ghirlanda fails for 0.0%

21 GBM Redshift GRBs

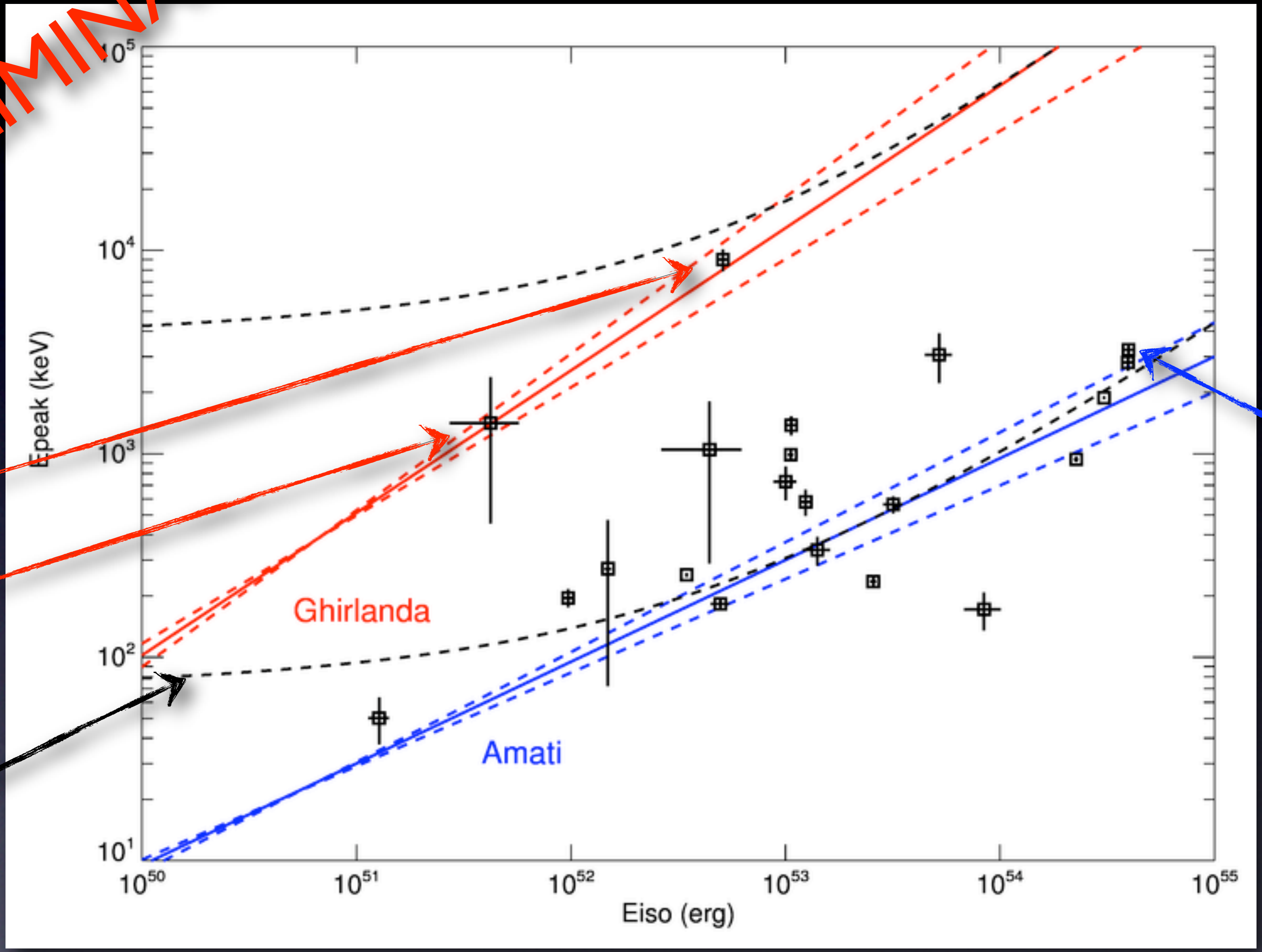
PRELIMINARY

$f_B = 1.0$

090510

090927

Upper Limit

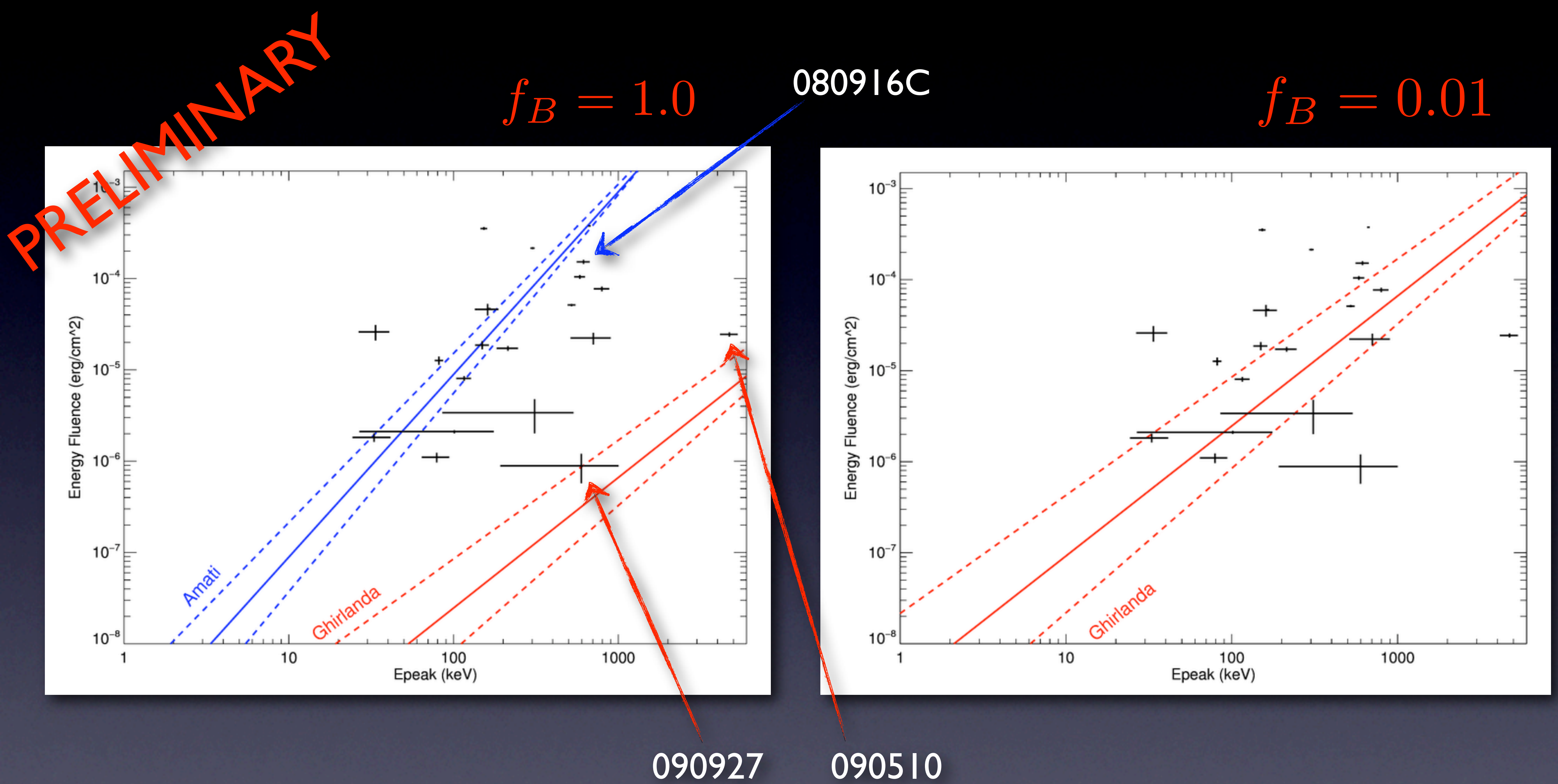


080916C

Short GRBs 090510 & 090927 are consistent with the Ghirlanda relation

6/19 Long GRBs consistent with the Amati relation

Testing the Lower Limits with GBM



Initial GBM results are consistent with BATSE results

Concluding Thoughts

- The Epeak/fluence ratio is a discriminator between long and short bursts and does not rely on the full T_{90} of the burst.
- Short bursts are harder than long bursts and are possibly uncollimated (or very near so) if the Ghirlanda relation is to be believed.
- Preliminary results from Fermi/GBM appear to confirm the uncollimation of short bursts.
- Only 6 of the 19 long GBM redshift bursts are consistent with the Amati relation, but both short bursts are fully consistent with the Ghirlanda relation.
- The Ghirlanda relation appears to be a global lower limit in the E_{peak}-fluence plane and an upper limit in the E_{peak}-E_{iso} plane.
- Fermi should be able to complete the energy ratio distribution by detecting high-Epeak short GRBs

Questions?