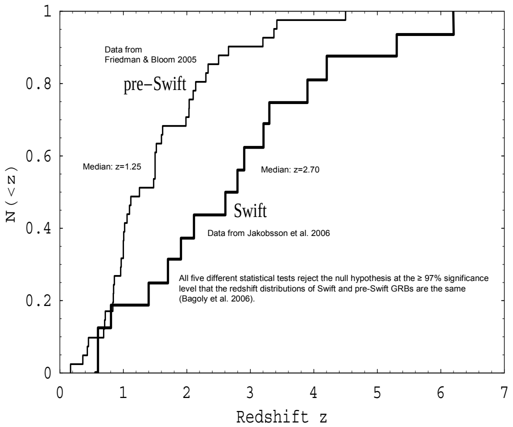
Gamma Ray Bursts in the Swift and GLAST Era

Truong Le (NRC/NRL) & Charles D. Dermer (NRL)

Why are the Swift and pre-Swift redshift distribution different?

• Different flux thresholds of GRB detectors, e.g.,

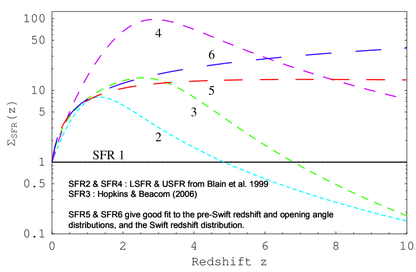


What assumptions do we impose to resolve the redshift discrepancy?

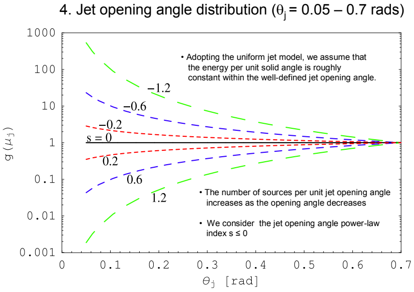
1. Different detector triggering properties $f_\varepsilon = 10^{-8}$ (10^{-7}) ergs cm^{-2} s^{-1} for Swift (pre-Swift)

2. Mean intrinsic duration (10 sec) and corrected emitted γ-ray energy (4×10^{51} ergs)

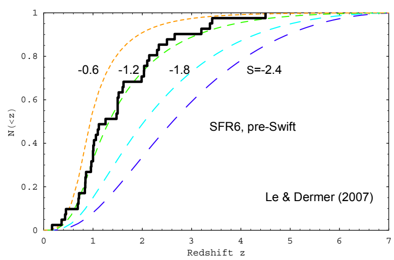
3. GRBs comoving rate density

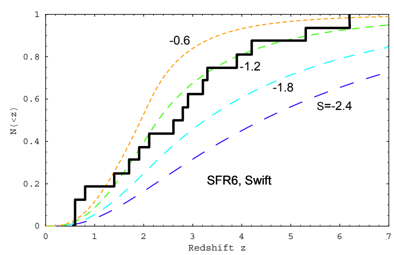


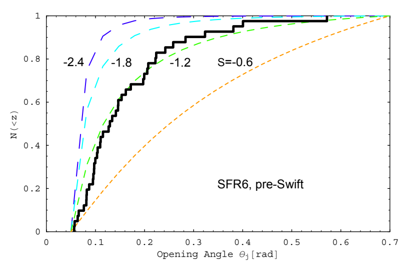
4. Jet opening angle distribution (θ_j = 0.05 – 0.7 rads)



In order to fit the pre-Swift and Swift data, the GRB formation rate must rise faster than the SFR





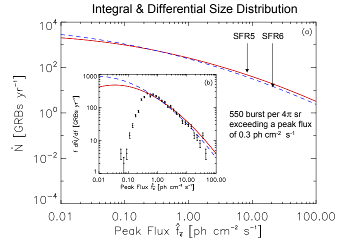


Results from the fit:

- We find that the comoving rate density of GRB sources exhibits positive evolution to z ≥ 3 -- 5, inconsistent with the shape of the star formation rate given from measurements of the blue and UV luminosity density (SFR2 & SFR4)
- The mean intrinsic beaming factor of GRBs is found to range from ≈ 34-42, with the Swift average opening half-angle $\langle\theta_j\rangle \sim 10^o$, compared to the pre-Swift average of $\langle\theta_j\rangle \sim 7^o$.
- The range of the jet opening angle is between 2.8° – 40°, with the corrected γ-ray mean energy release value of 4×10^{51} ergs.

- The model integral size distribution of GRBs predicted by our best fit model suggests that ~ 340-350 GRBs per year should be detected with a BATSE-type detector over the full sky, and ~ 130-150 GRBs per year for the BAT instrument.
- Our model also gives a good presentation of the differential size distribution of the BATSE GRB distribution within the statistical error bars.
- The size distribution of the Swift GRBs will extend to much lower values, ~ 0.0625 ph/cm*s, and we can use our model to predict the peak flux size distribution to fit the Swift data.

Integral & Differential Size Distribution



The plots above normalized to the current total number of observed GRBs per year from BATSE in the ΔE = 50- 300 keV band for the Δt = 1.024 s trigger time.

Estimate of the number of GRBs per year GLAST will see based on measured EGRET/BATSE fluence ratios

- We use the fluence ratio between EGRET (100 MeV – 5 GeV) and BATSE (>20 keV) from the 5 bursts detected by EGRET spark chamber (Dingus 1995) and BATSE to determine the typical ratio of fluences in the BATSE/GBM band (>20 keV) and the EGRET/GLAST band (>100 MeV).

1. GRB 910503: ρ = 1.7%
2. GRB 910601: ρ = 2.8%
3. GRB 930131: ρ = 15%
4. GRB 940217: ρ = 0.8-2%
5. GRB 940301: ρ = 3.4%

Average: $\langle\rho\rangle \approx 5\%$

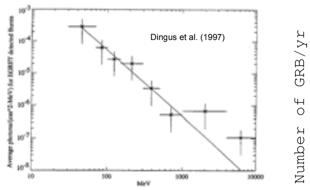
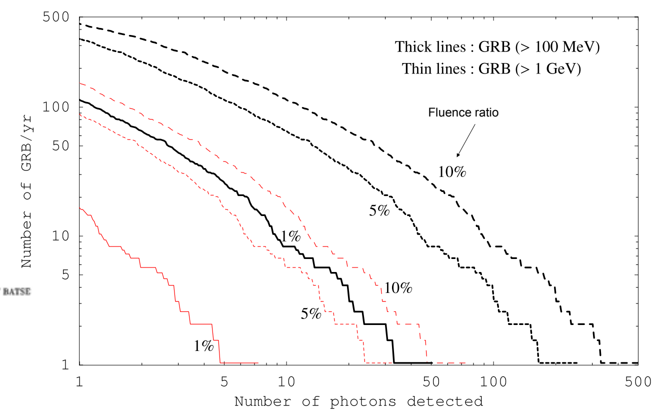
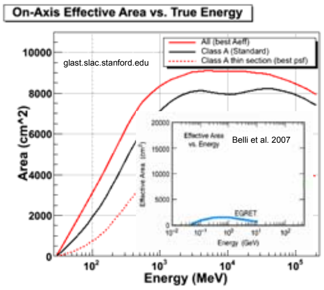
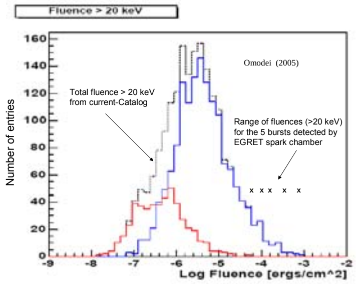


FIGURE 1. Average spectrum of 4 bursts over 200 sec time interval from start of BATSE emission. The differential photon spectral index for the fit line is 1.95±0.25.

- We use BATSE 4B fluence distribution (Omodei 2005), –2 photon spectrum in EGRET/GLAST range (Dingus and Catelli 1997), and the effective area of both the EGRET and GLAST to estimate the number of GRBs GLAST should observe per year for different values of the fluence ratio ρ = 10%, 5%, 1%







More Results!

- **Our model predicts that for a fluence ratio ρ = 5%, there will be ≈ 130 (≈ 35) GRBs/yr full-sky from which the GLAST LAT would detect at least 5 photons with energy > 100 MeV (> 1 GeV).**
- **Our analysis shows that GRBs give very little (<< 1%) contribution to the diffusive extragalactic γ-ray background.**