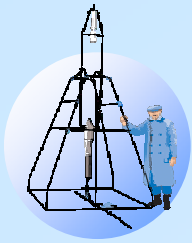


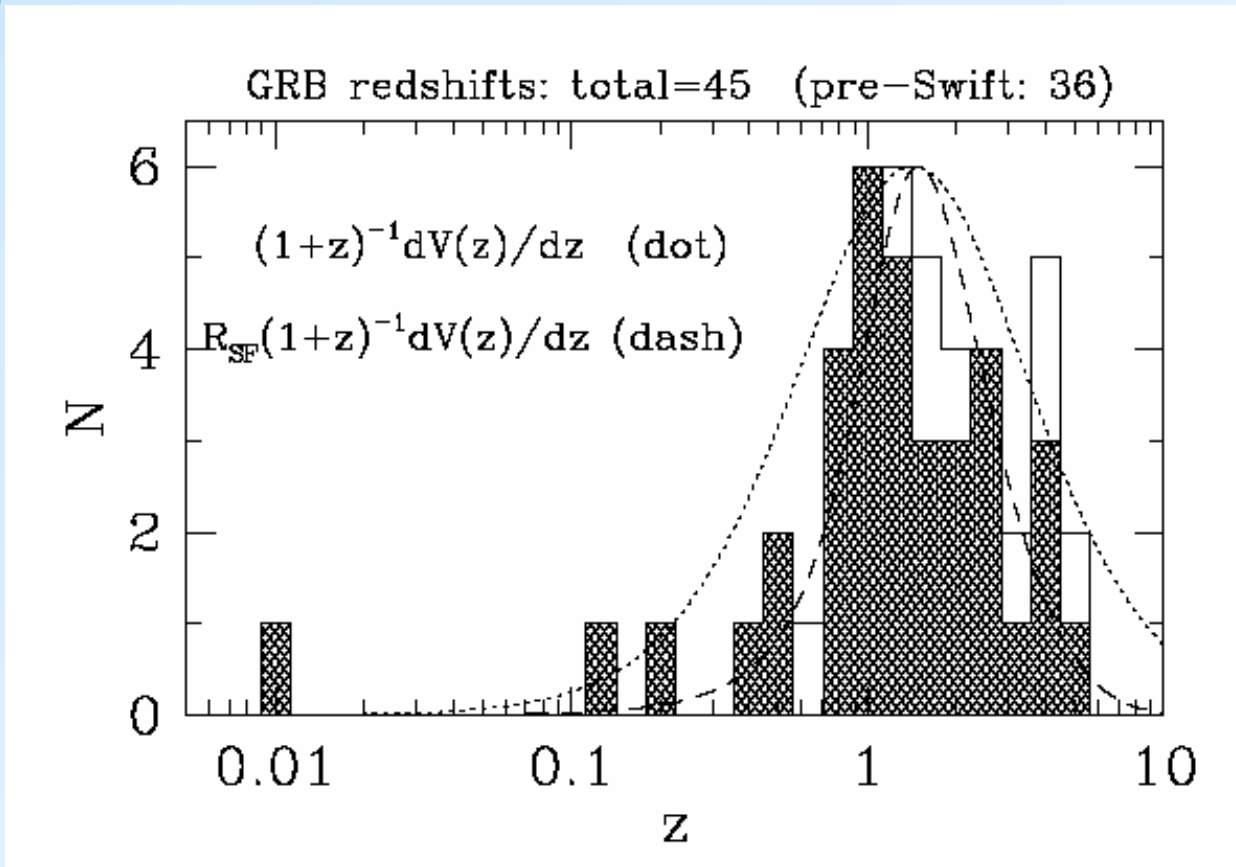
Recent GRB Results from Swift

**John Cannizzo/UMBC/Goddard
LSC Meeting, Hanford, WA
August 16, 2005**

LIGO-G050431-00-Z



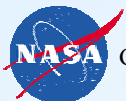
GRBs Trace Comoving Volume

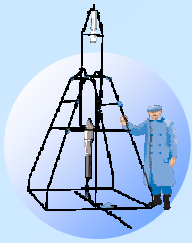


$$dV/dz = 4\pi D^2(z) dD(z)/dz$$

36 pre-Swift: $\langle z \rangle = 1.4$, $\sigma(z) = 1.0$

7 Swift + 2 other: $\langle z \rangle = 2.3$, $\sigma(z) = 1.3$





GRB Rate:

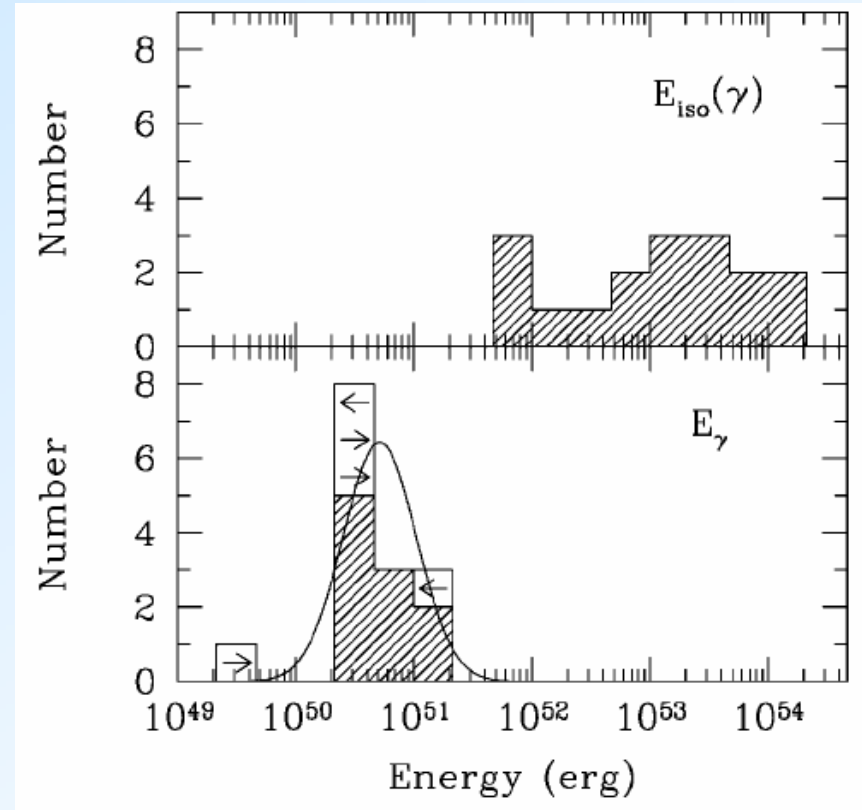
$$[1] V(z < 10) = 4 \times 10^3 \text{ Gpc}^3$$

$$[2] \text{Luminosity Density (V band)} = 2 \times 10^{17} L_{\odot} \text{ Gpc}^{-3}$$

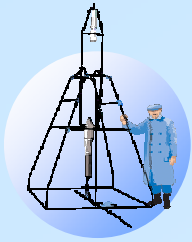
=> about 10^{10} galaxies

$$[3] \text{Rate(BATSE)} \sim 10^3 \text{ yr}^{-1}$$

So, rate per galaxy is about
1 in 10^7 yr.



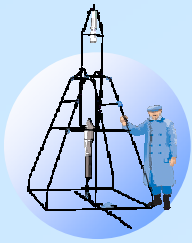
Frail et al. (2001)



Long GRBs: Jet from a Collapsar

(Weiqun Zhang - Stanford)

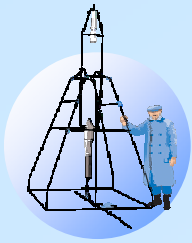
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Short GRBs: NS-NS Merger

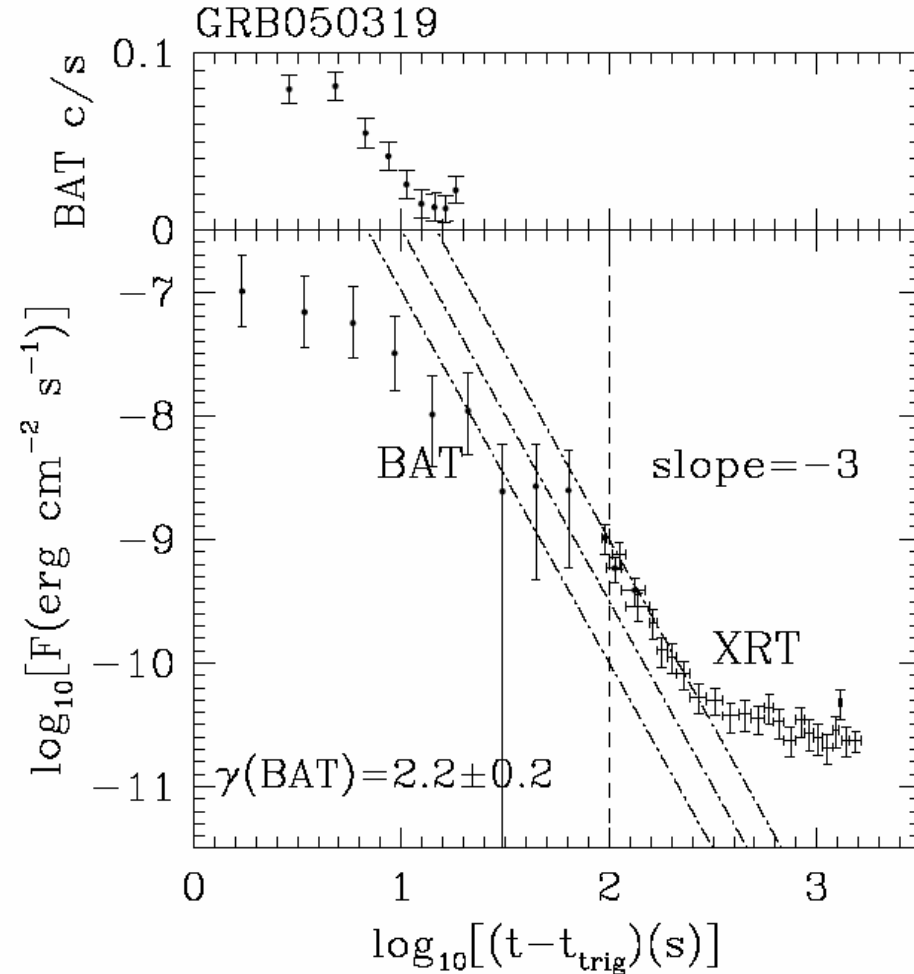
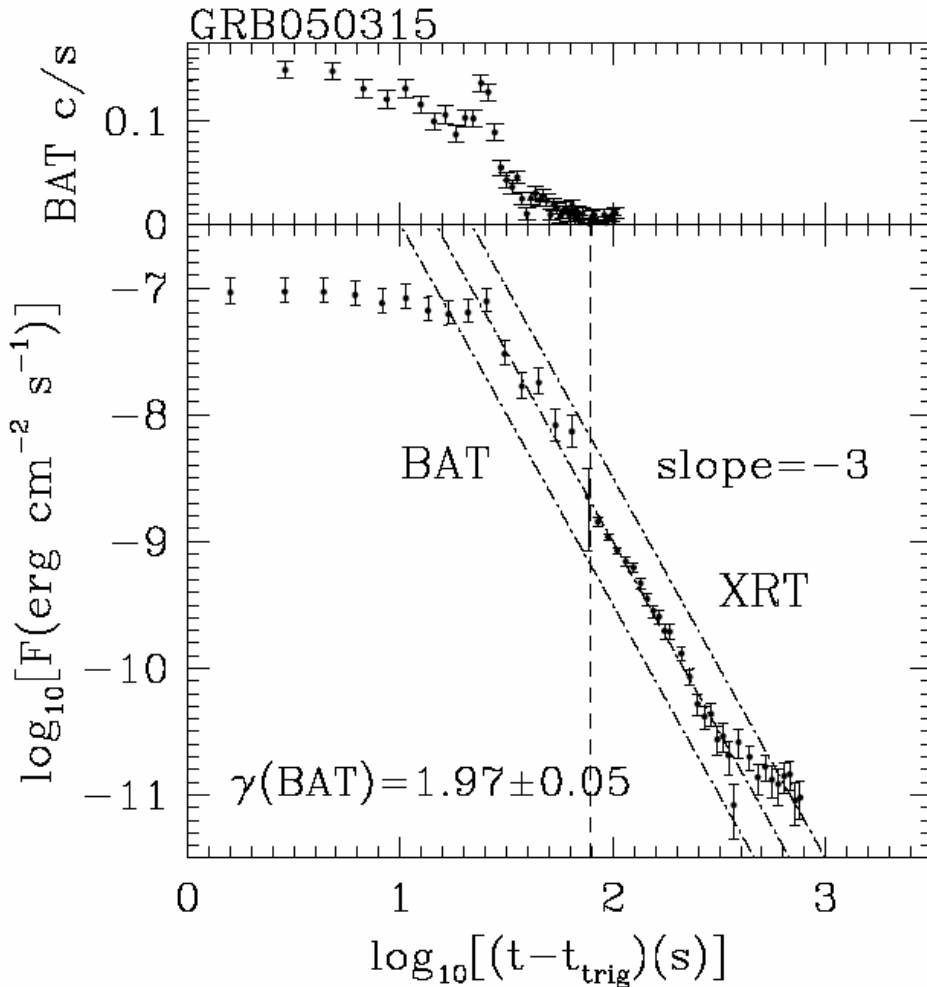
(Max Ruffert - University of Edinburgh)

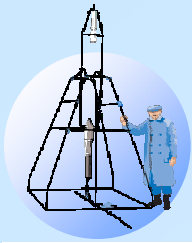
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BAT+XRT 2-10 keV Decay; $f=f_0t^{-\alpha}$

Barthelmy et al. (2005)





Interpretation: “Curvature Effect”

Kumar & Panaitescu (2000):

$$f_\nu(t) = \frac{1}{4\pi D^2} \int d^3r \frac{\epsilon'_{\nu'}(\mathbf{r}, t + r \cos \theta)}{\Gamma^2(1 - v \cos \theta)^2}$$

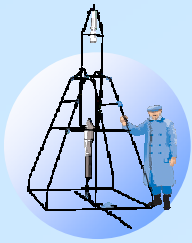
where $\nu' = \nu\Gamma(1 - v \cos \theta)$ and $\epsilon'_{\nu'}$ are frequency and emissivity in the shell rest frame.

Taking shell thickness $\Delta r \ll r$ and $\epsilon'_{\nu'} = \epsilon' \nu'^{-\beta}$, gives

$$f_\nu(t) = \frac{\nu^{-\beta}}{2D^2} \int dr \frac{\Delta r \epsilon' r^{3+\beta}}{[\Gamma(t + r/v - (t + r \cos \theta))]^{2+\beta}}$$

Assume impulsive injection at $r = r_c$, of duration δt , then:

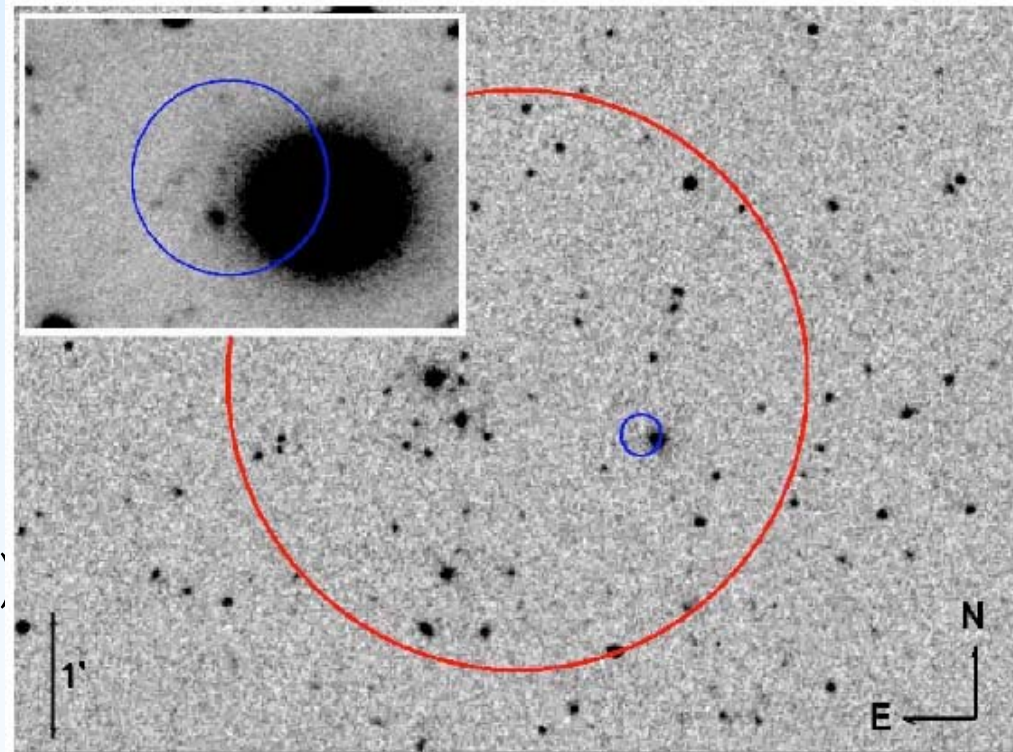
$$f_\nu(t) = f_{\nu_{p,c}} \left(\frac{\delta t}{t} \right)^{2+\beta} \left(\frac{\nu_{p,c}}{\nu} \right)^\beta$$

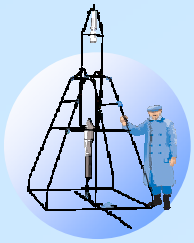


First Localization of a Short GRB

Gehrels et al. (2005)

- GRB050509b: 40 ms duration (BAT), soft part of the short/hard population
- XRT: 11 photons (10σ sig.)
- $z=0.225$ elliptical galaxy
- chance probability $\sim 10^{-4}$
- $E_{\text{iso}} = 1.1 \times 10^{48}$ erg (15-150 keV)
- $\sim 10^2$ E(2004 Dec 27 SGR flare)
- --> supports NS-NS merger





Summary

- GRBs trace comoving volume of the Universe, which exhibits a maximum at $z \sim 1-2$.
- In two cases, the prompt emission seen in BAT+XRT forms a continuous decay with $t^{-\alpha}$, where $\alpha \sim 3$, consistent with “curvature radiation” effect.
- Localization of one short GRB appears to be in a luminous, non-star forming elliptical galaxy, consistent with NS-NS merger theory.