Gamma Ray Burst Discoveries with the Swift Mission

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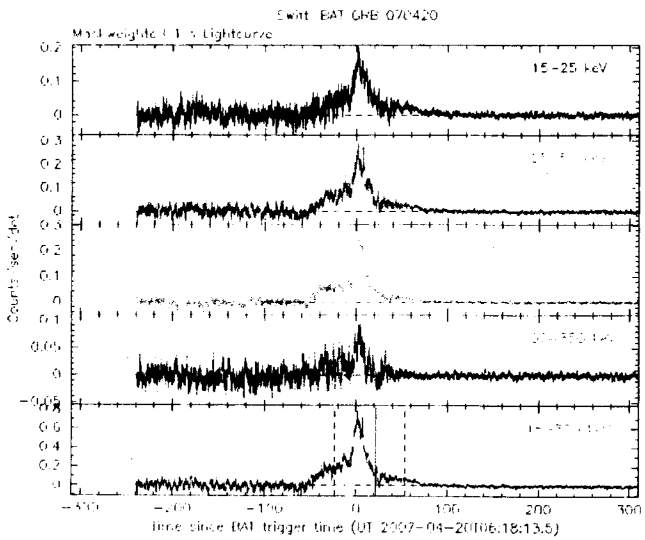
Gamma-ray bursts (GRBs) are among the most fascinating occurrences in the universe. They are powerful explosions, visible to high redshift, and thought to be the signature of black hole formation. The Swift Observatory has been detecting 100 bursts per year for 3 years and has greatly stimulated the field with new findings. Observations are made of the X-ray and optical afterglow from ~1 minute after the burst, continuing for days. Evidence is building that the long and short duration subcategories of GRBs have very different origins: massive star core collapse to a black hole for long bursts and binary neutron star coalescence to a black hole for short bursts. The similarity to Type II and Ia supernovae originating from young and old stellar progenitors is striking. Bursts are providing a new tool to study the high redshift universe. Swift has detected several events at z>5 and one at z=6.3 giving metallicity measurements and other data on galaxies at previously inaccessible distances. The talk will present the latest results from Swift in GRB astronomy.

# GRB Discoveries with

# *Swift* GRB 070420

## BAT prompt emission

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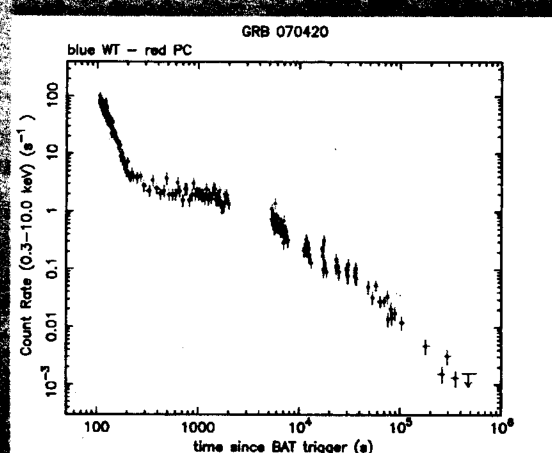
## XRT afterglow



# Long GRBs

| | |
|---|---|
| 6.29 | 050904 |
| 5.47 | 060927 |
| 5.3 | 050814 |
| 5.11 | 060522 |
| 4.9 | 060510B |
| 4.41 | 060223A |
| 4.27 | 050505 |
| 4.05 | 060206 |
| 3.97 | 050730 |
| 3.91 | 060210 |
| 3.71 | 060605 |
| 3.69 | 060906 |
| 3.62 | 070721B |
| 3.53 | 060115 |
| 3.44 | 061110B |
| 3.43 | 060707 |
| 3.36 | 061222B |
| 3.34 | 050908 |
| 3.24 | 050319 |
| 3.21 | 060926 |
| 3.21 | 060526 |
| 3.08 | 060607A |
| 2.95 | 070411 |
| [illegible] | 060401 |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |

| | |
|---|---|
| 2.35 | 070110 |
| 2.31 | 070506 |
| 2.30 | 060124 |
| 2.20 | 050922C |
| 2.17 | 070810 |
| 2.04 | 070611 |
| 1.95 | 050315 |
| 1.71 | 050802 |
| 1.55 | 051111 |
| 1.51 | 060502A |
| 1.50 | 070306 |
| 1.49 | 060418 |
| 1.44 | 050318 |
| 1.31 | 061121 |
| 1.29 | 050126 |
| 1.26 | 061007 |
| 1.17 | 070208 |
| 0.97 | 070419A |
| 0.94 | 051016B |
| 0.84 | 070318 |
| 0.83 | 050824 |
| 0.76 | 061110A |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |

| z | GRB |
|---|---|
| 6.29 | [illegible] |
| 5.6 | [illegible] |
| 5.3 | [illegible] |
| 5.11 | [illegible] |

# GRB Host Spectr

GRB 050505

$z = 4.275$

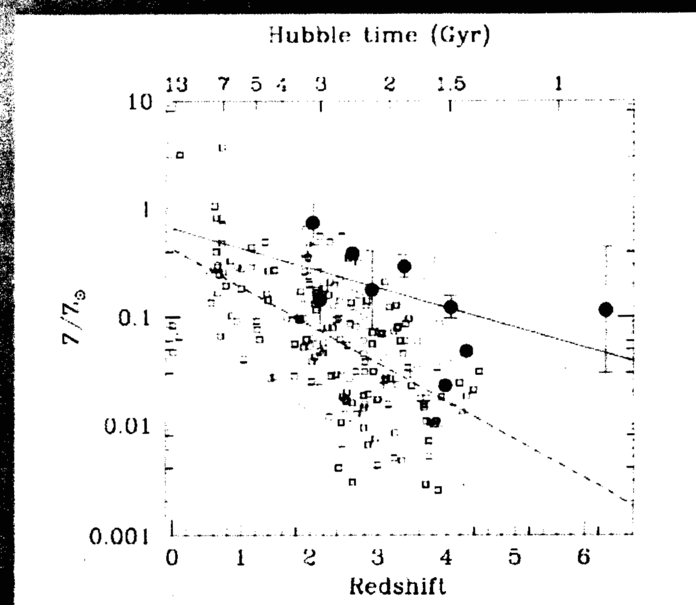
Damped Ly$\alpha$

N(HI)=$10^{22}$ cm$^{-2}$

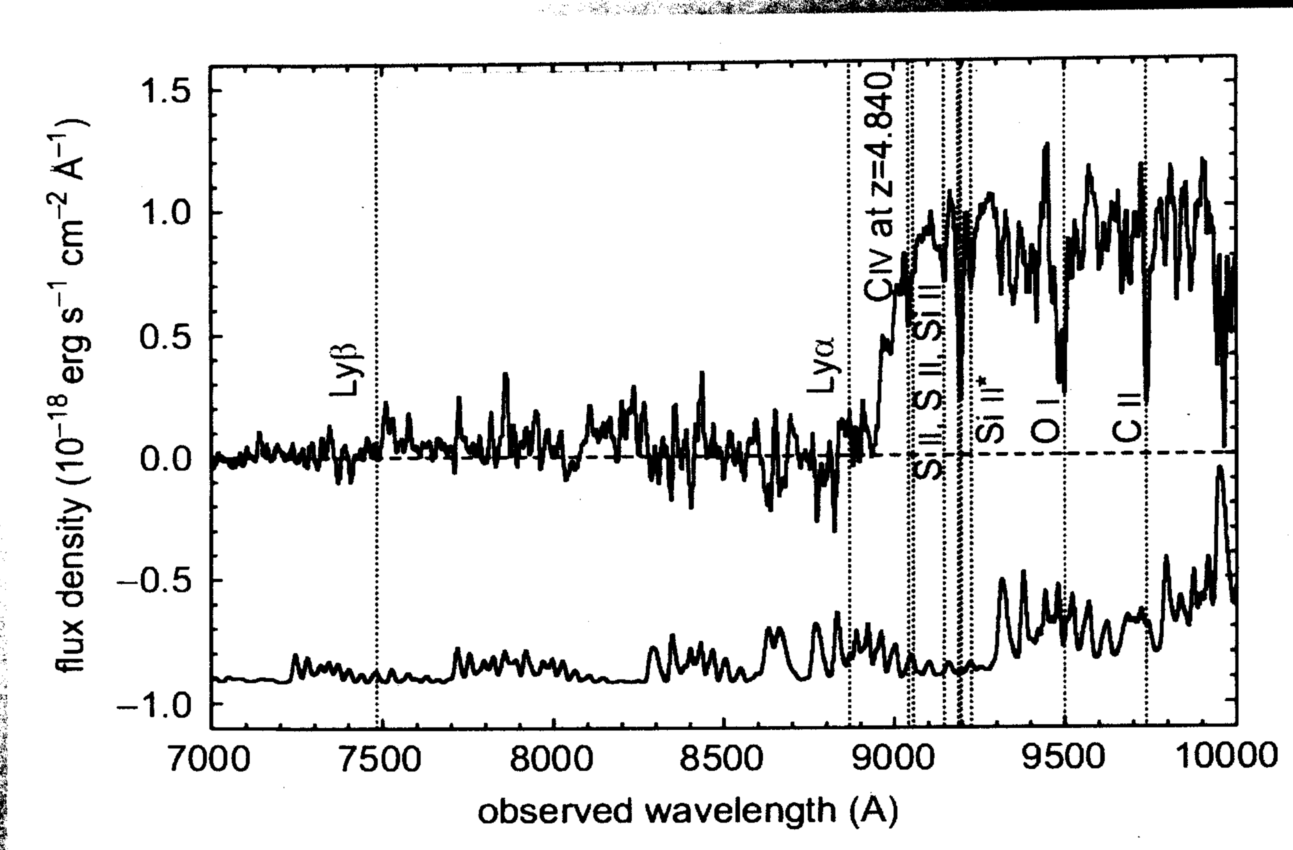
$n \sim 10^2$ cm$^{-3}$

$Z = 0.06\ Z_O$

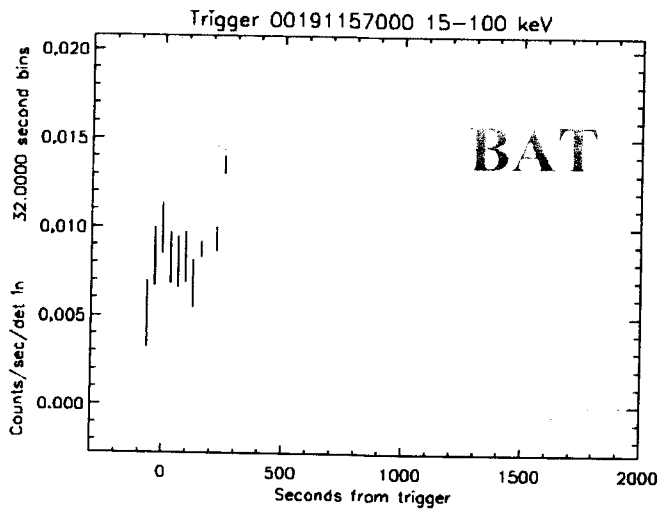
$M_{progenitor} < 25\ M_O$



# GRB 050904 $z=6.29$



# GRB 060218: GRB + Su



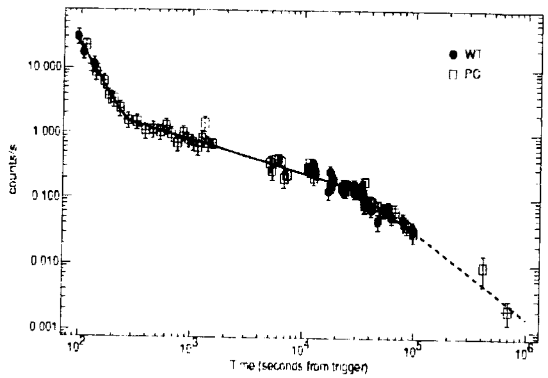

Super-long GRB

BAT, XRT, UVOT

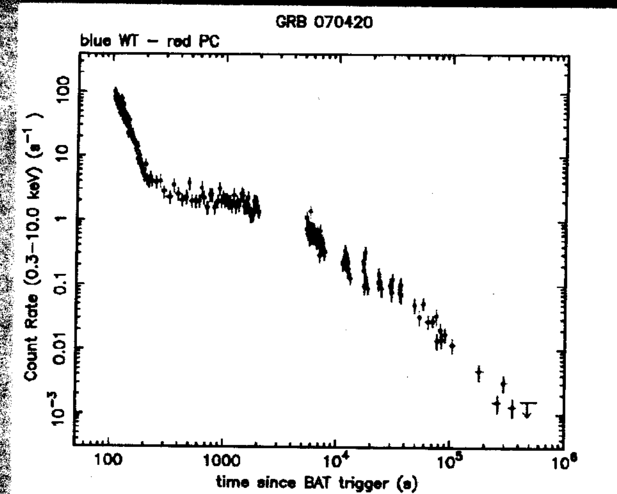
d = 145 Mpc

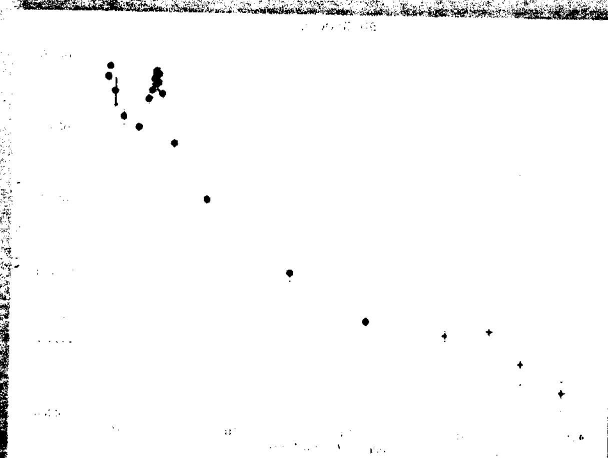
# Afterglows

# Typical *Swift* X-ray Ligh

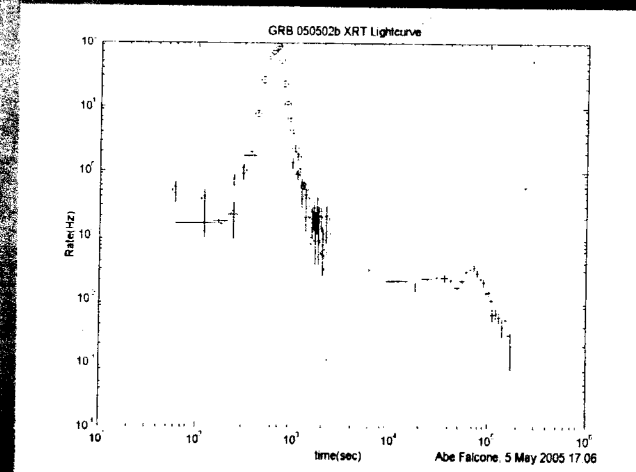



**50% with bright early component**

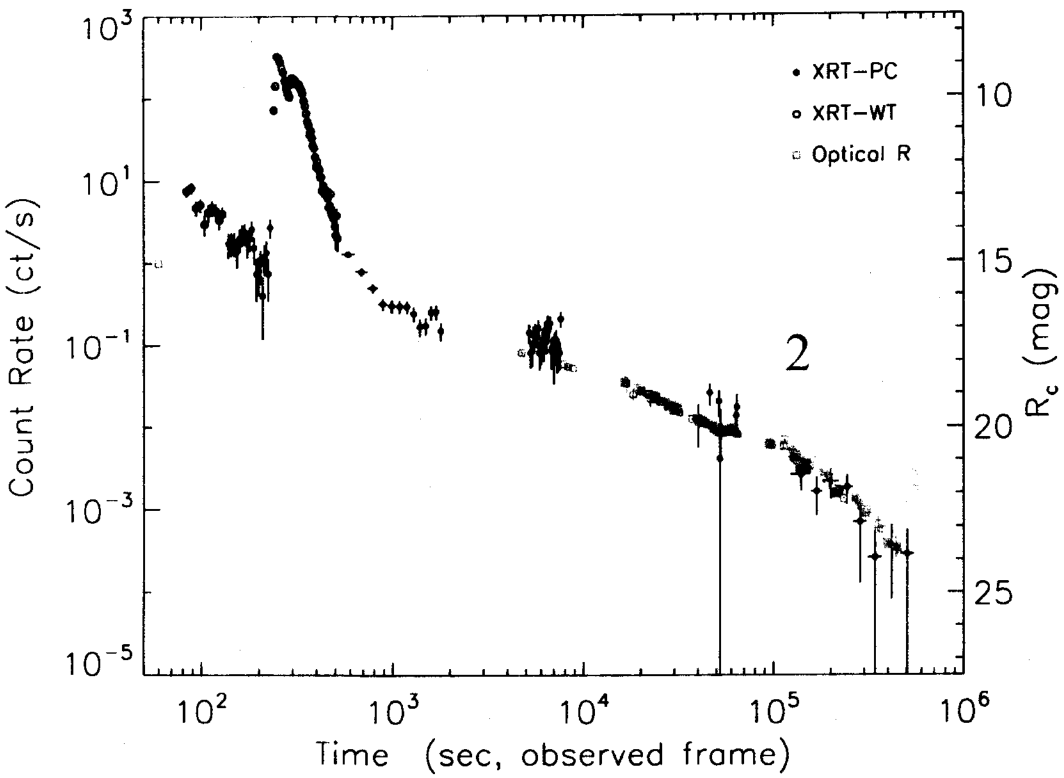


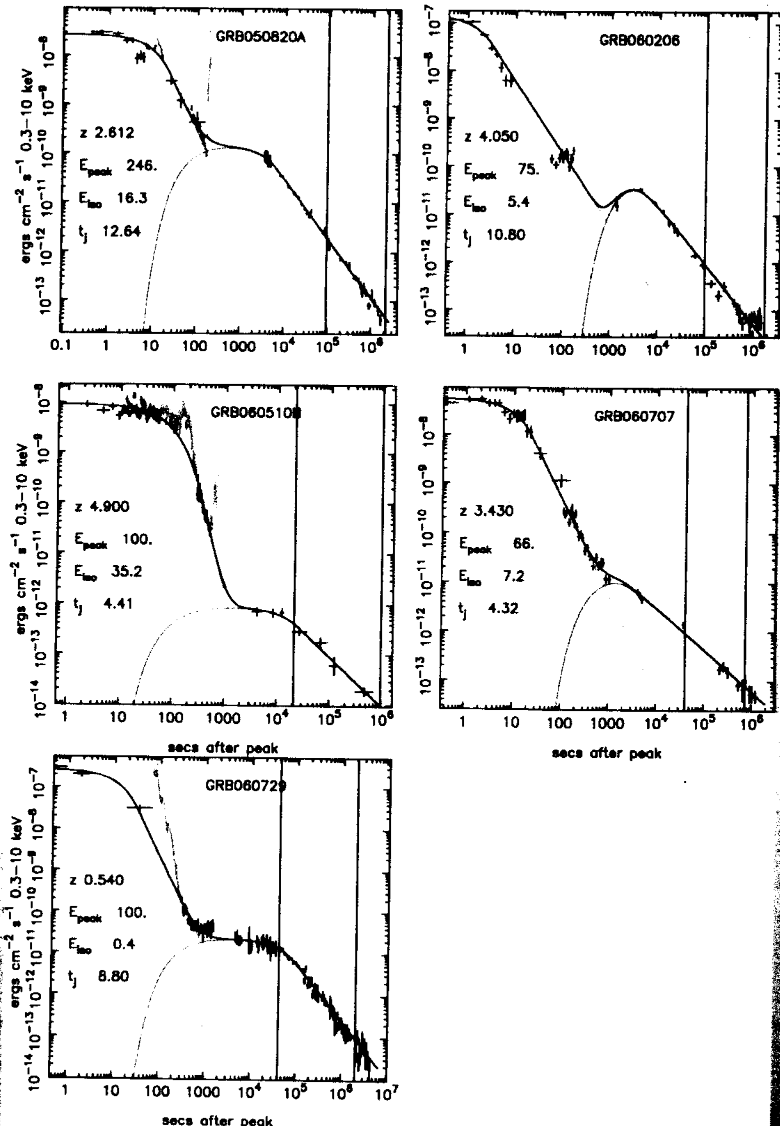



**>30% with**



# Achromatic Jet Break - G





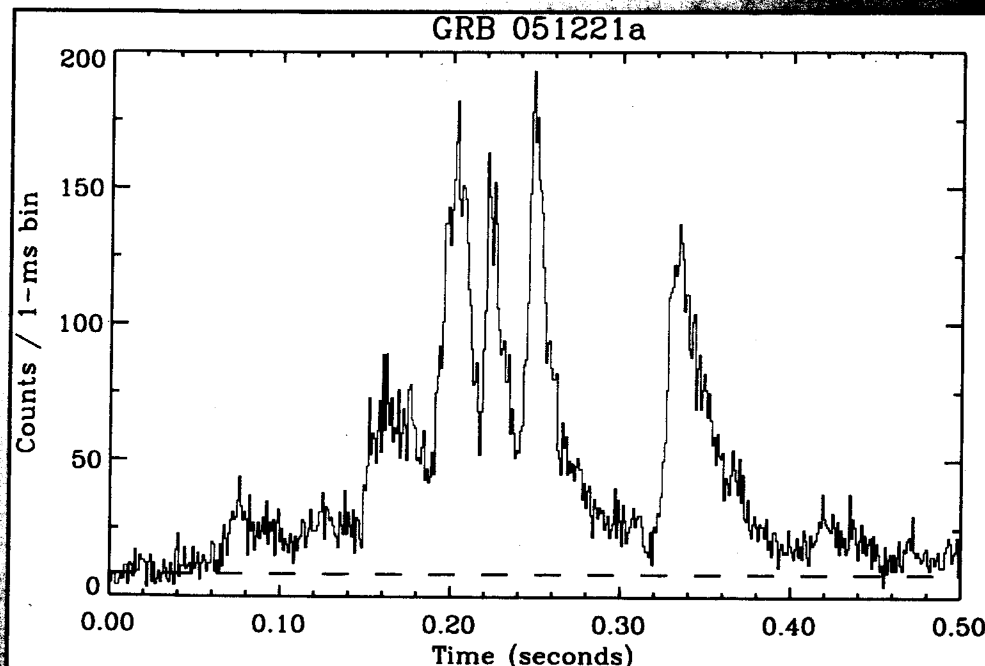

# Puzzl

- Many GRBs d
- In other cases, breaks are not
- Complex shape of makes jet breaks

Other new papers

# Short GRBs

# Short GRB Time Structure



# Short GRB - Curr[illegible]

*Swift* short GRB observations

- 23 short bursts detected (+ 2 from HETE, +1 from [illegible]
- 78% with X-ray afterglow detected by XRT (96% [illegible]
- 28% with optical detection (58% [illegible]
- ~50% with host IDs

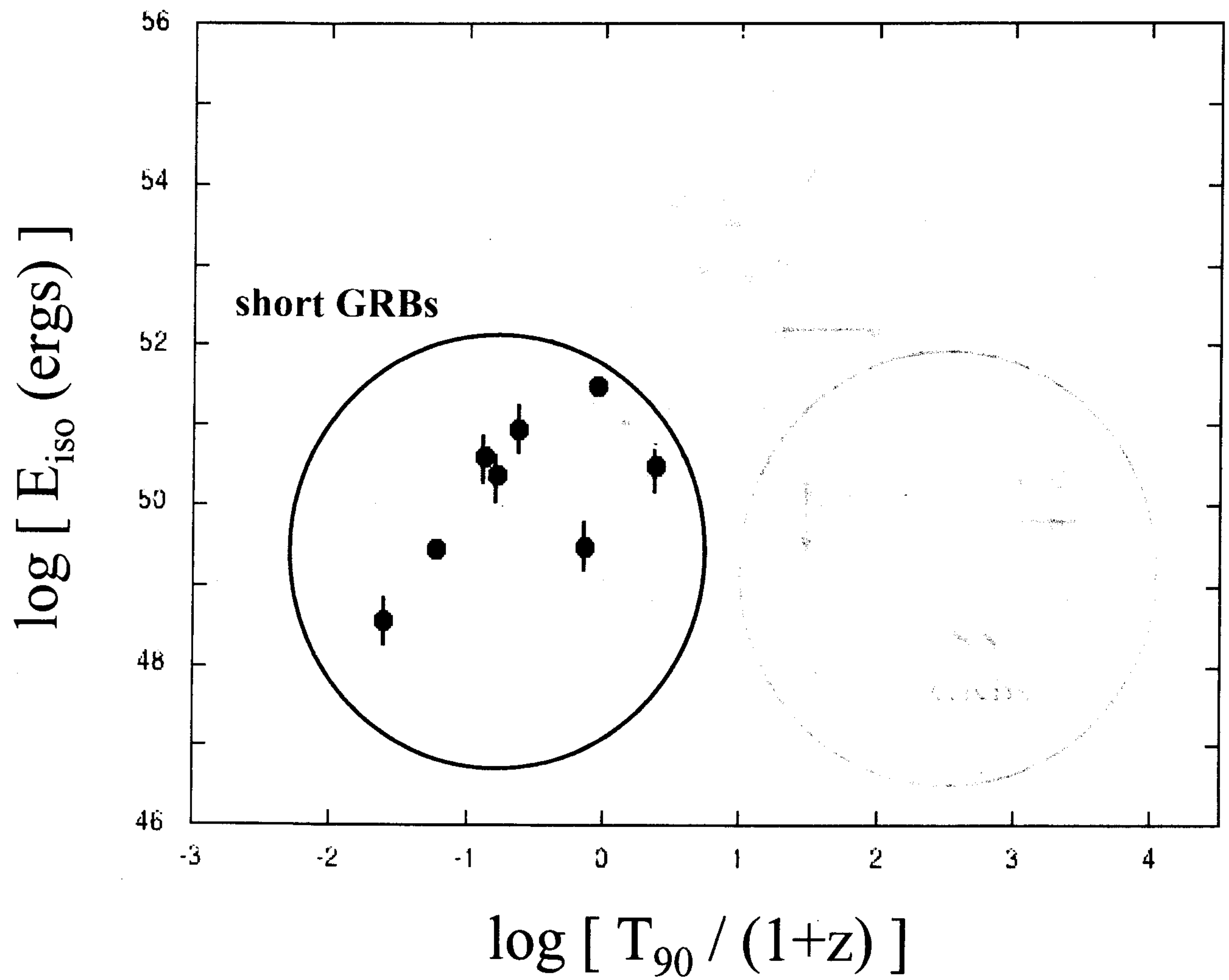
~1/2 shorts accompanied by soft extended emission up to 100 sec

Redshift range from z = 0.2 to 1 [illegible]

- $\langle z \rangle$ [illegible] = 0.6
- [illegible]

# 3 Types of GRBs

*Swift* GRBs (mostly)



# Implications for Grav. Wa

Assuming all short GRBs are due to **NS-NS** mergers, merger rate is ~300 $Gpc^{-3}$ $yr^{-1}$

[Concsistent with NS-NS population **synthesis** modeling O'Shaughnessy, Kalogera, & Belczynski (2005)]

**⇒ Advanced LIGO detection rate of ~30 $yr^{-1}$**

**Nakar et al.:**

**Possible much higher rates of**

**Swift will be in orbit until > 2020**