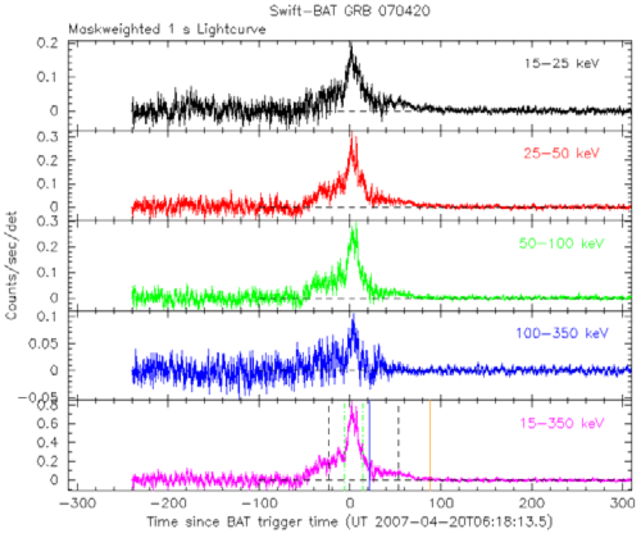
GRB Discoveries with Swift

Neil Gehrels

NASA-GSFC

Swift GRB 070420

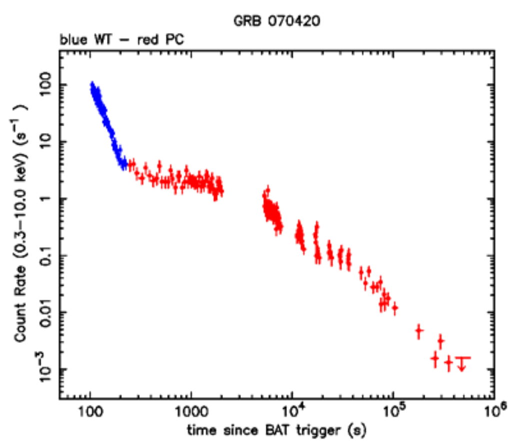
BAT prompt emission



3 instruments, each with:

- **lightcurves**
- **images**
- **spectra**

XRT afterglow



Long GRBs

63 *Swift* Long GRB Redshifts

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
2.90	050401
2.82	050603
2.71	060714
2.68	060604
2.61	050820A
2.50	070529
2.45	070802
2.43	060908
2.35	051109A

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
0.70	060904B
0.65	050416A
0.62	070612A
0.61	050525A
0.54	060729
0.44	060512
0.125	060614
0.089	060505
0.033	060218

z	GRB	Optical/IR Brightness
6.29	050904	J = 18 @ 3 hrs
5.6	060927	I = 16 @ 2 min
5.3	050814	K = 18 @ 23 hrs
5.11	060522	R = 21 @ 1.5 hrs

GRB Host Spectroscopy

GRB 050505

$z = 4.275$

Damped Lyα

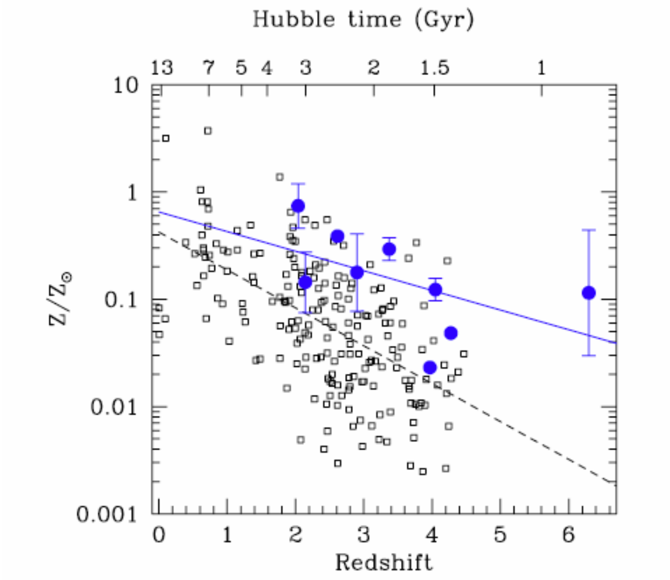
$N(HI)=10^{22}\ cm^{-2}$

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

$Z = 0.06\ Z_O$

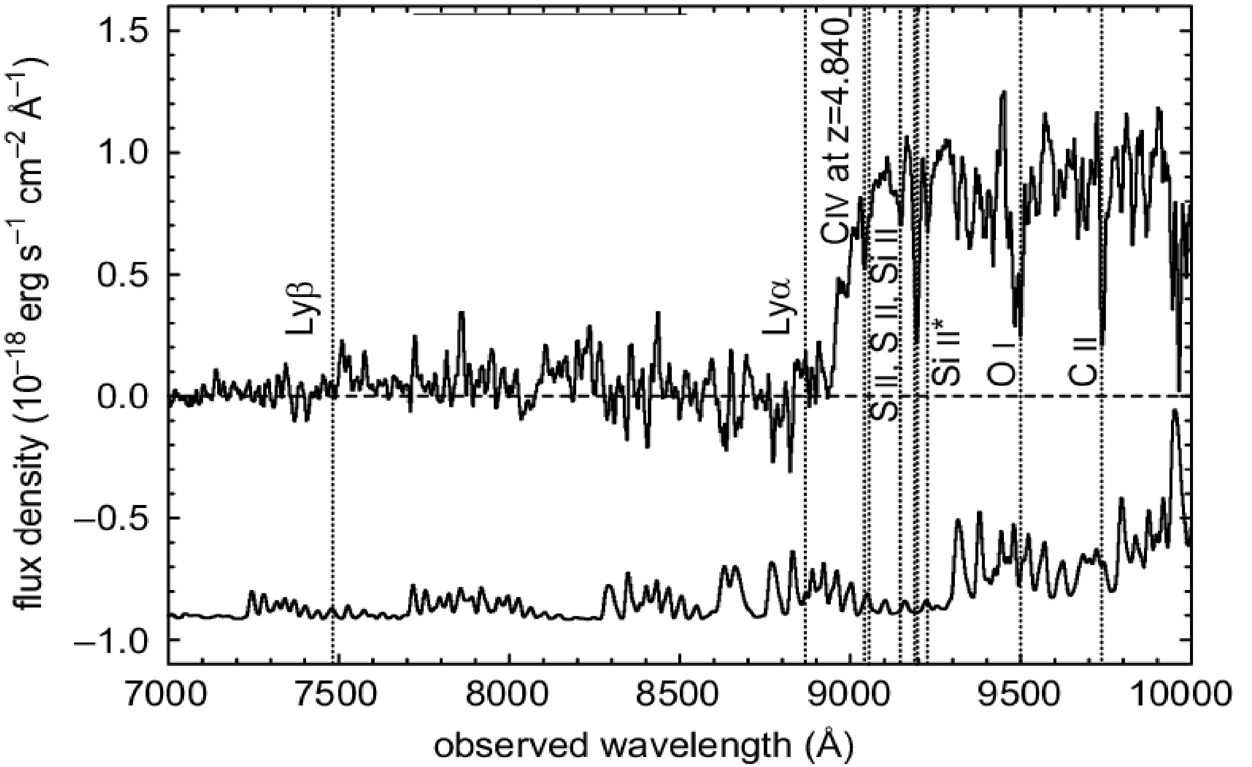
$M_{progenitor} < 25\ M_O$

Metallicity vs Redshift



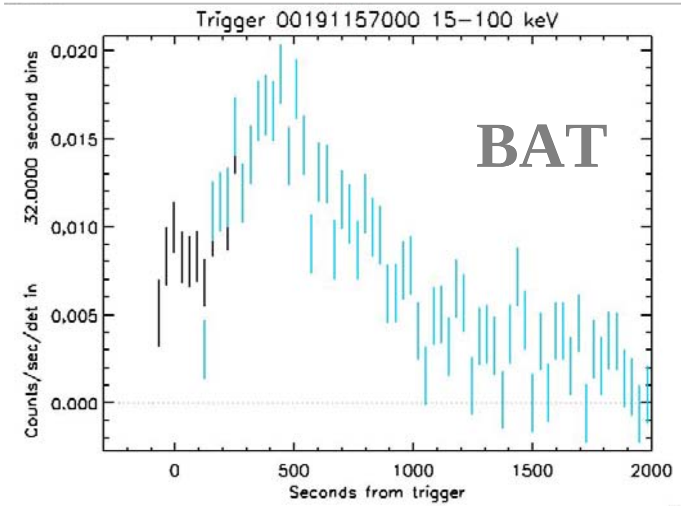
Savaglio 2006

GRB 050904 z=6.29



Subaru Telescope
Kowai et al. 2006

GRB 060218: GRB + Supernova



Super-long GRB - ~35 minutes

BAT, XRT, UVOT during GRB

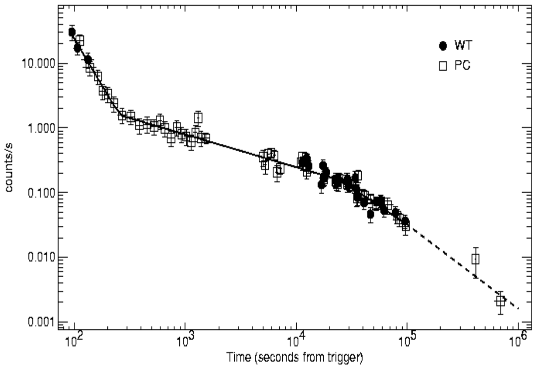
z = 0.033 d = 145 Mpc

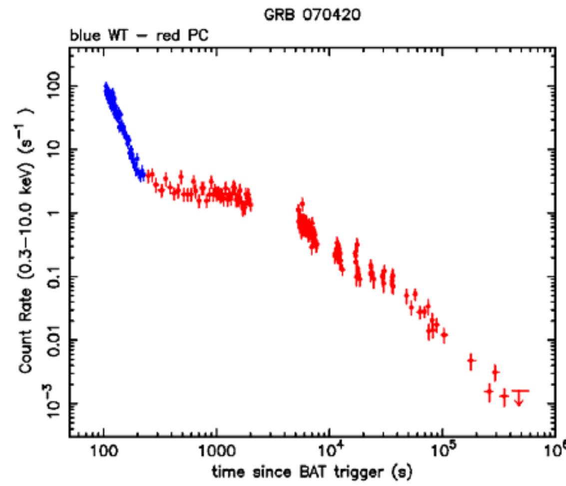
SN 2006aj SN Ib/c

E_{iso} = few x 10^{49} erg - **underluminous**

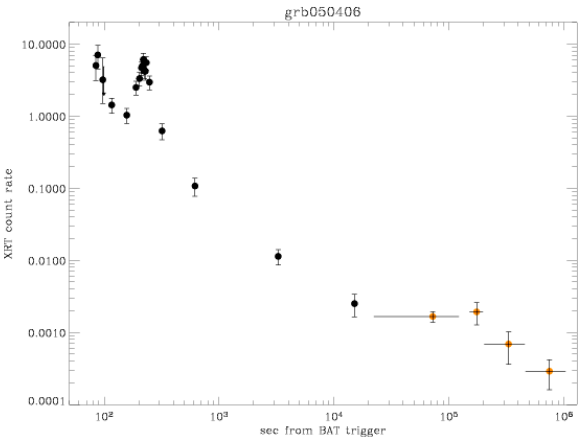
Afterglows

Typical *Swift* X-ray Lightcurves

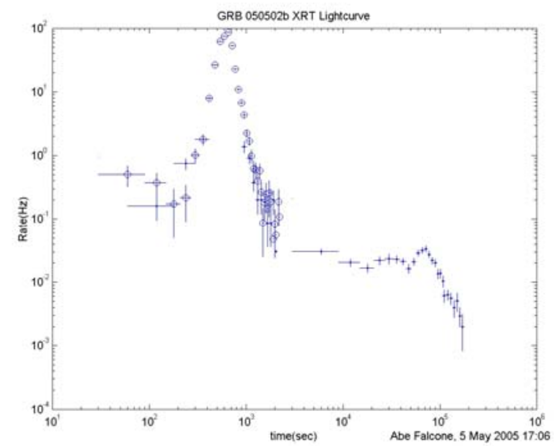




50% with bright early component

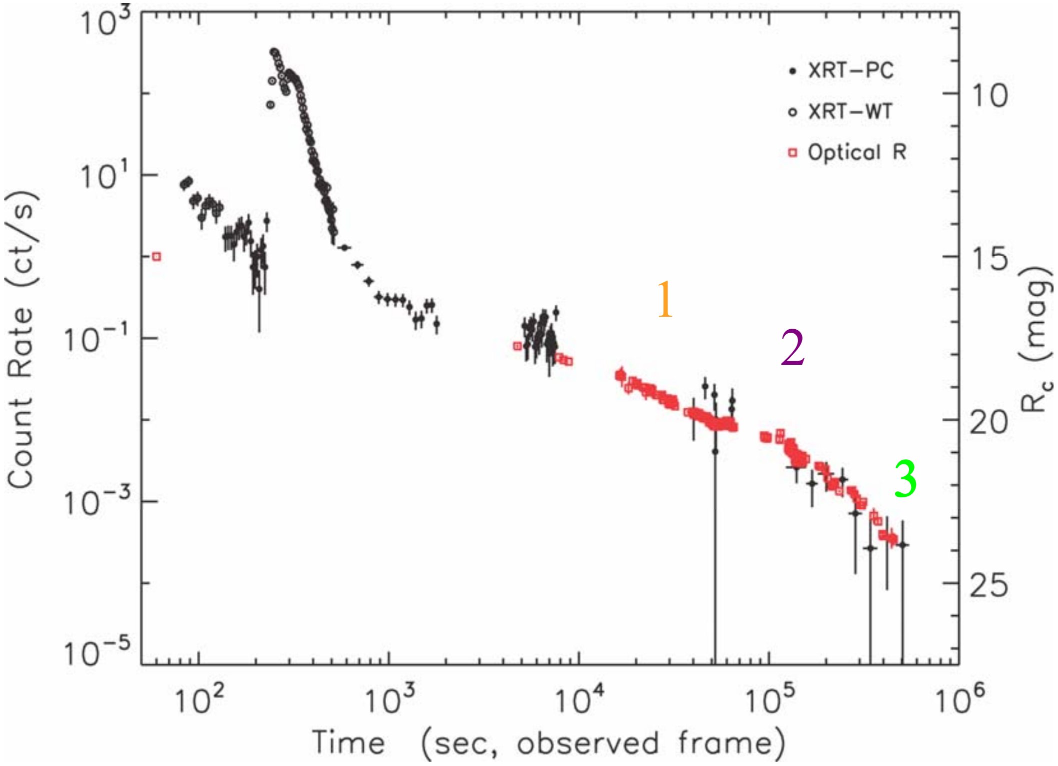


>30% with flares



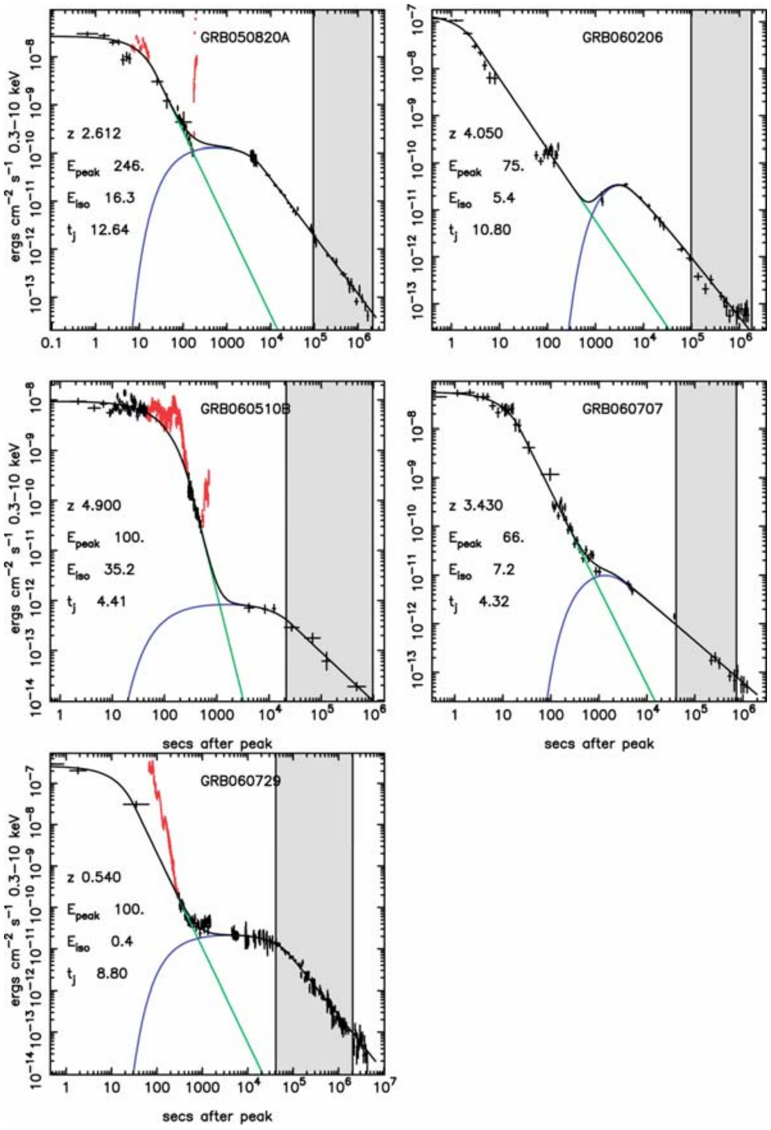
Burrows et al. 2005

Achromatic Jet Break - GRB 060526



z=3.21
jet angle = 7°

Dai et al. 2007



Willingale et al. 2007

Puzzling Data

- Many GRBs do not show jet breaks
- In other cases, optical and X-ray breaks are not coincident.
- Complex shape of afterglow lightcurves makes jet breaks hard to find

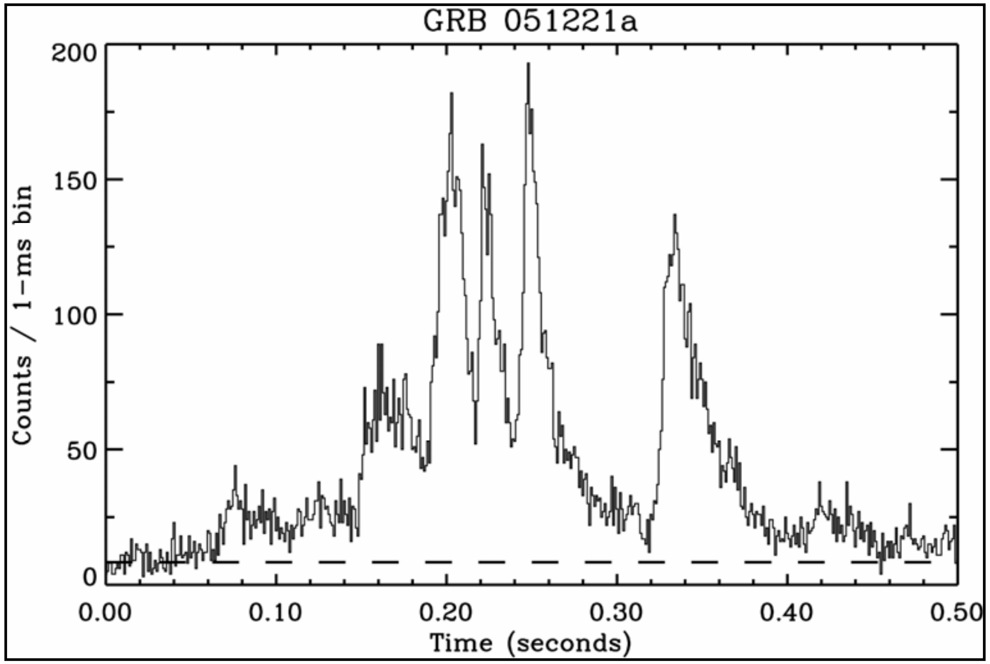
Other new papers:

Curran et al. (astro-ph 0706.1188) - evidence for achromatic breaks in several Swift GRBs

Oates et al. (astro-ph 0706.0669) - GRB 050802 case with X-ray break clearly seen but no optical break

Short GRBs

Short GRB Time Structure



Short GRB - Current Status

Swift short GRB observations

- 23 short bursts detected (+ 2 from HETE, +1 from INTEGRAL)
- 78% with X-ray afterglow detected by XRT (95% long GRBs)
- 28% with optical detection (58% long GRBs)
- ~50% with host IDs

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

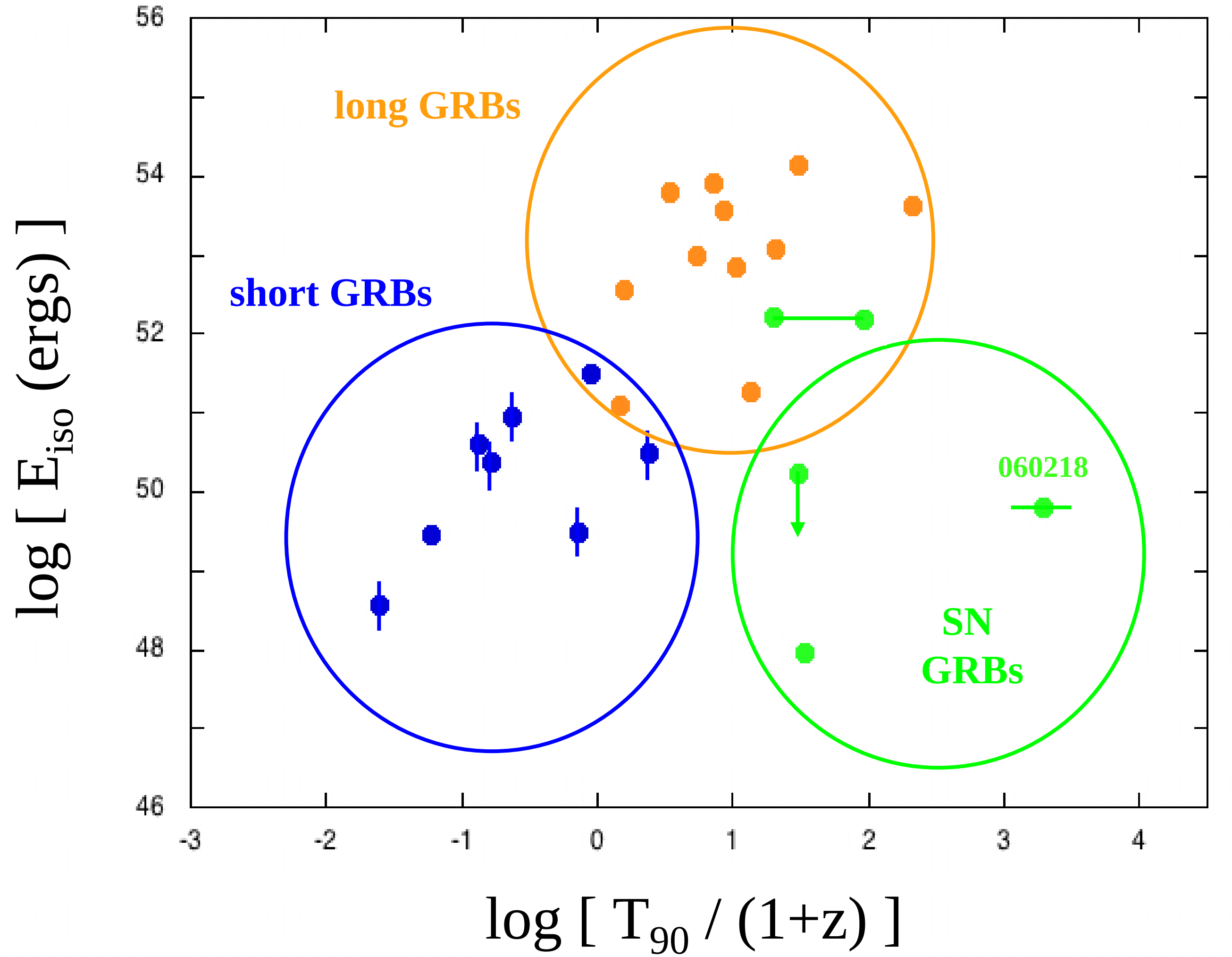
Redshift range from z = 0.2 to 1

- $<z>_{short} = 0.6$
- $<z>_{long} = 2.3$

GRB 070714B z = 0.92
(Graham et al. 2007)

3 Types of GRBs

Swift GRBs (mostly)



Implications for Grav. Wave Detections

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)]

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

Nakar et al.:

Possible much higher rates of $10^5\ Gpc^{-3}\ yr^{-1}$.

$\Rightarrow$ Detection with enhance LIGO

Swift will be in orbit until > 2020