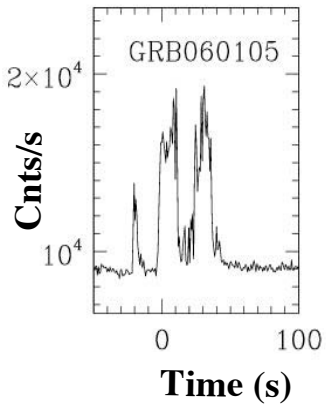
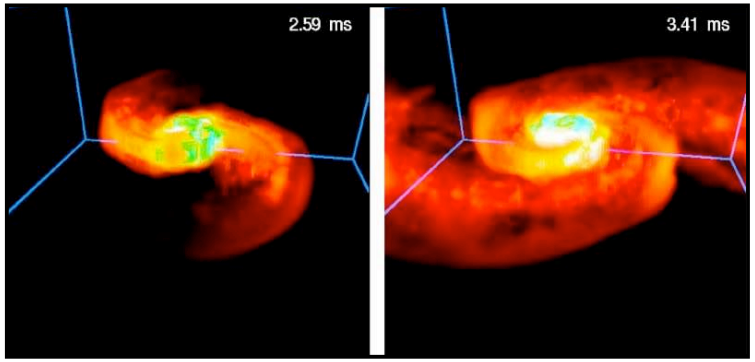




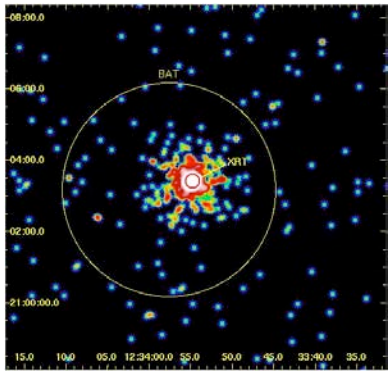
An Update on Swift GRB Observations

Neil Gehrels

NASA-GSFC

June 2, 2010

CCE Workshop

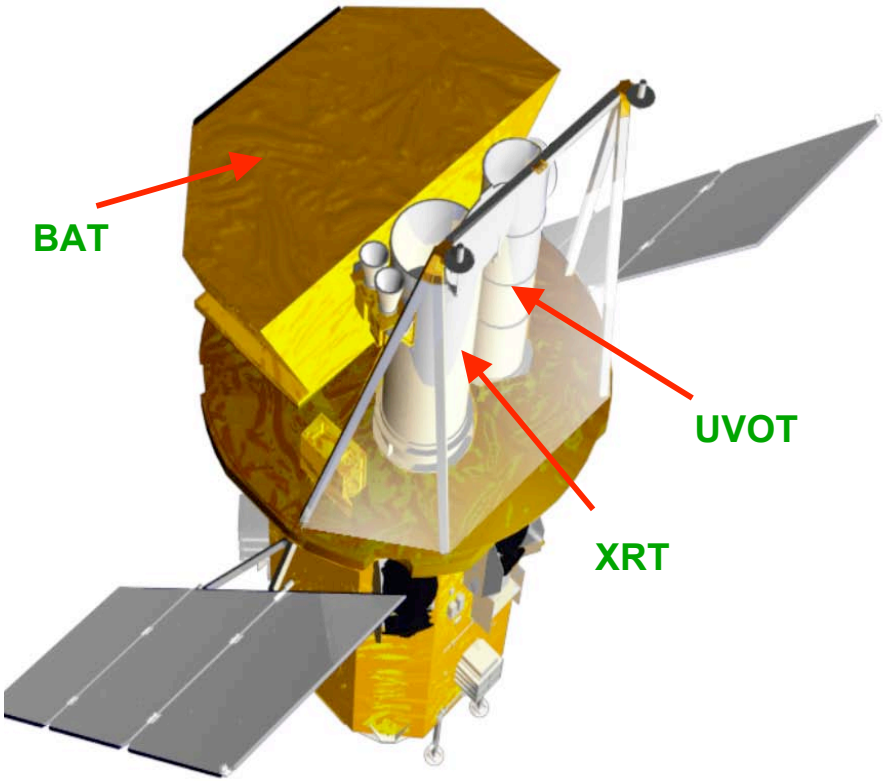


Highway 50

Placerville 46
South Lake Tahoe 107
Ocean City, MD 3073

San Francisco
New York
US
50

Swift Instruments



Burst Alert Telescope (BAT)

- 15 - 350 keV (15-150 keV imaging)
- 0.5 m^2 detector area (CdZnTe)
- 1.4 sr FoV

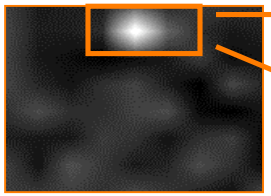
X-Ray Telescope (XRT)

- 0.2 - 10 keV
- 120 cm^2 effective area
- 18 arcsec PSF

UV/Optical Telescope (UVOT)

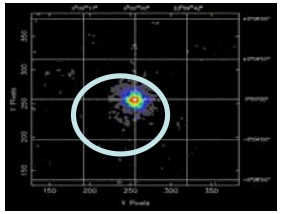
- 170-700 (white) nm
- 30 cm Ritchey-Chrétien folded optics
- 6 color filters, 2 GRISMs
- 1.9 arcsec PSF
- 17 arcmin FOV
- 22nd mag sensitivity (1000 sec)

γ-ray Position - 2 arcmin



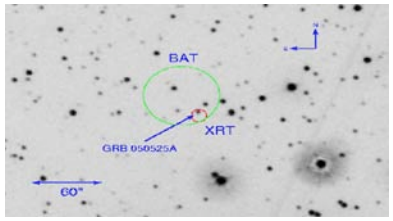
T<10 sec

X-ray Position - 2 arcsec

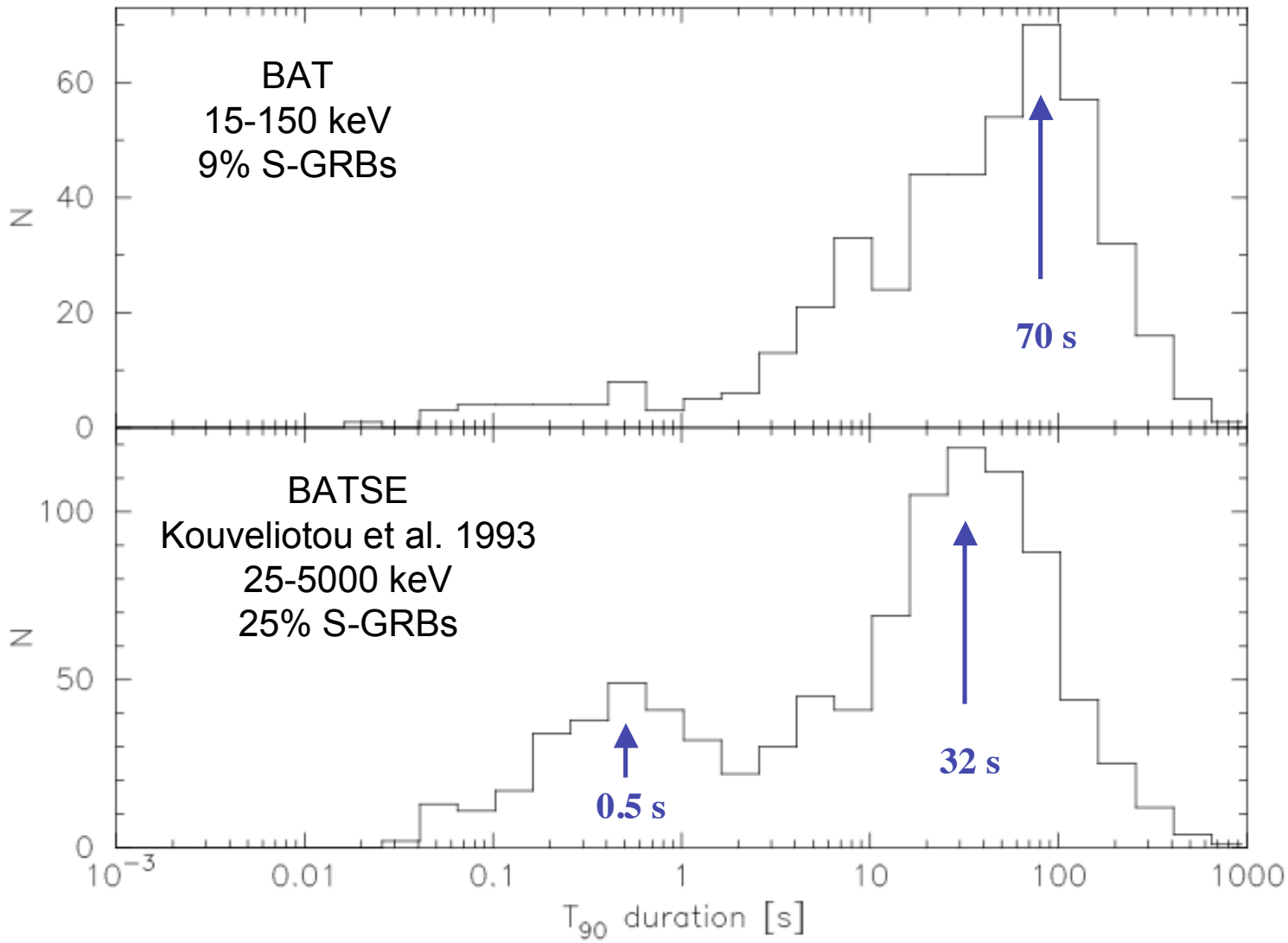


T<90 sec

Optical Position - < 1 arcsec

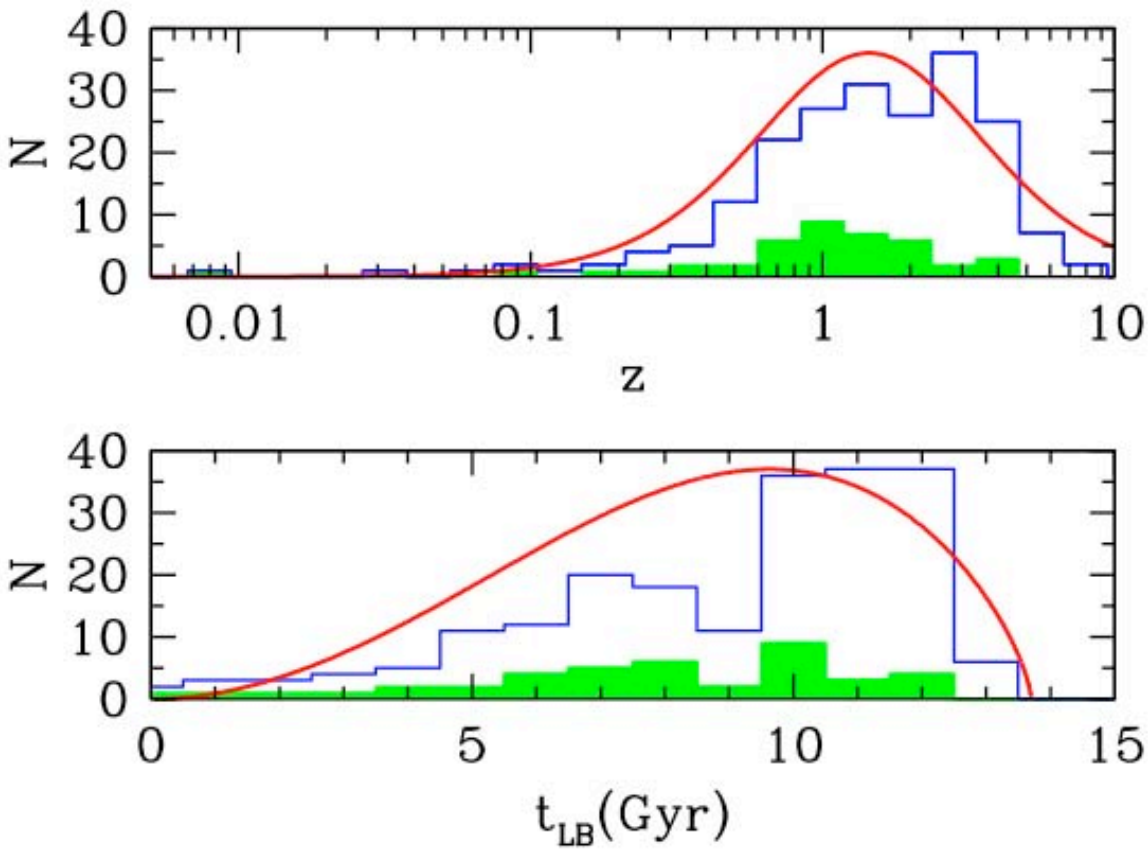


T<2 min



Sakamoto et al. 2010

513 GRBs 165 Redshifts



redshift

look-back time

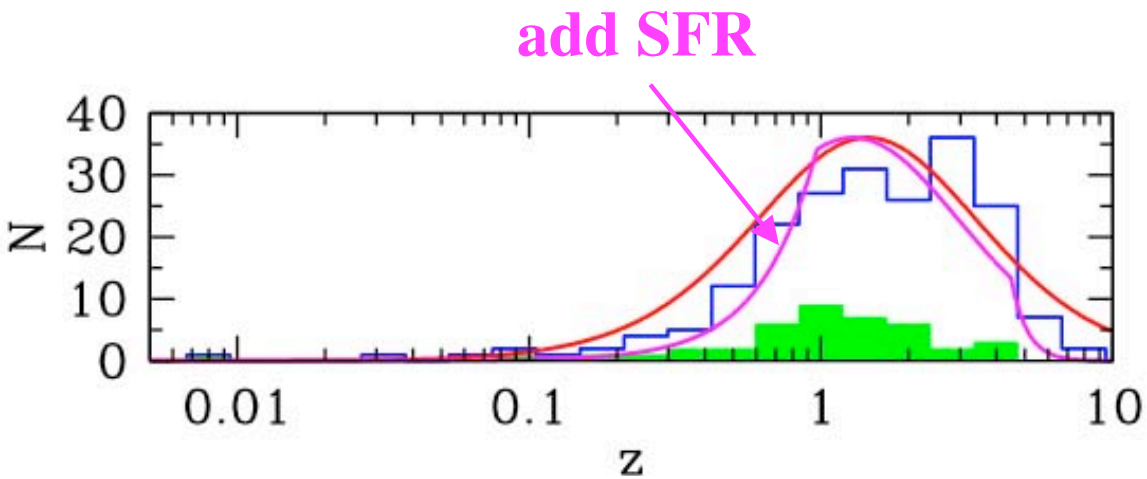
NG, Ramirez-Ruiz & Fox 2009

Swift

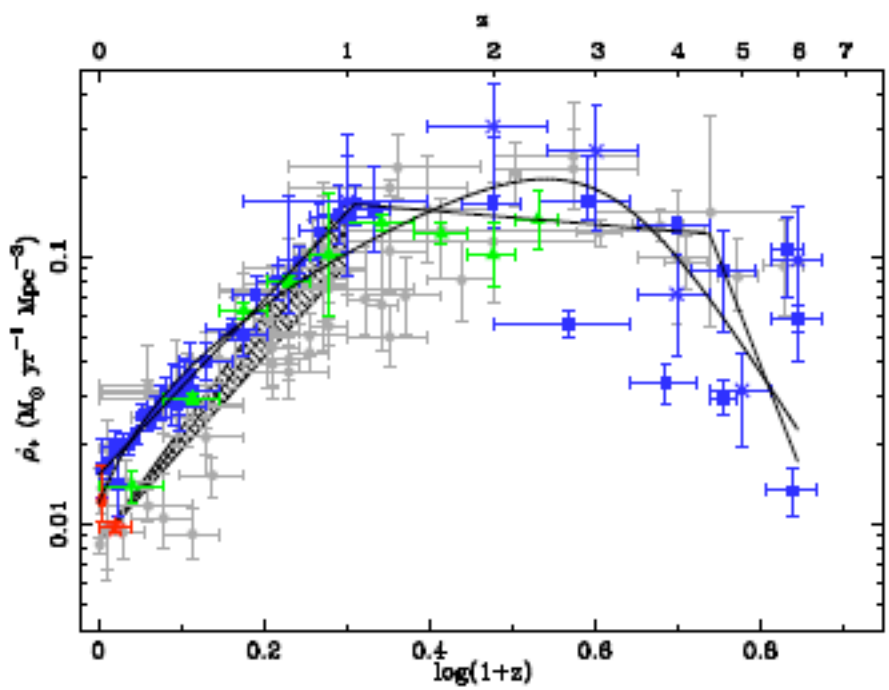
Pre-Swift

comoving volume

513 GRBs 165 Redshifts



redshift

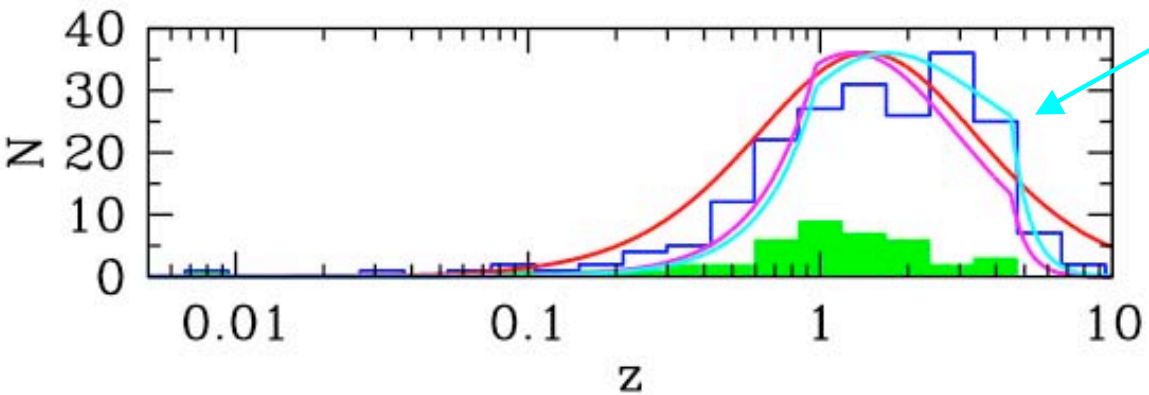


star formation rate

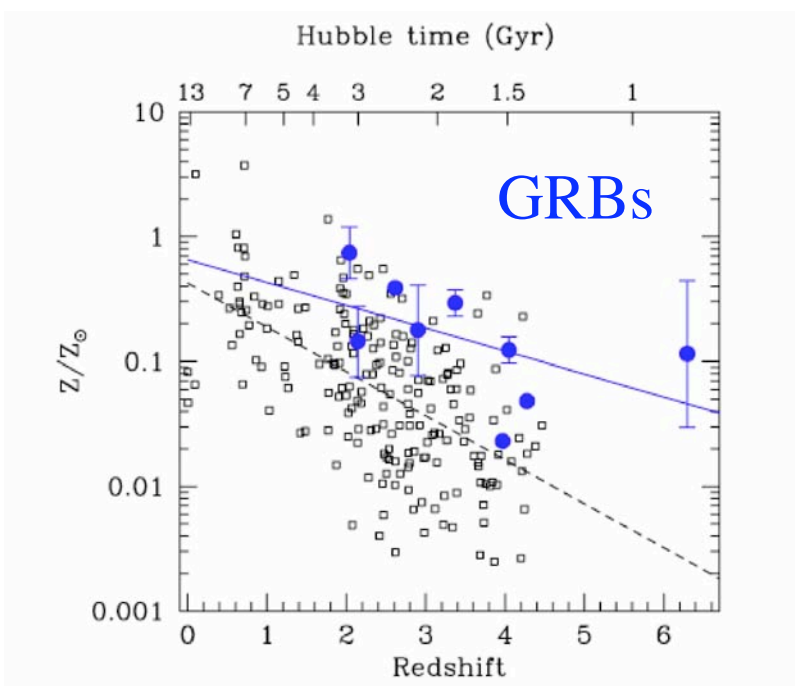
Hopkins 2006

513 GRBs 165 Redshifts

add metallicity ($1 / z^{0.5}$)

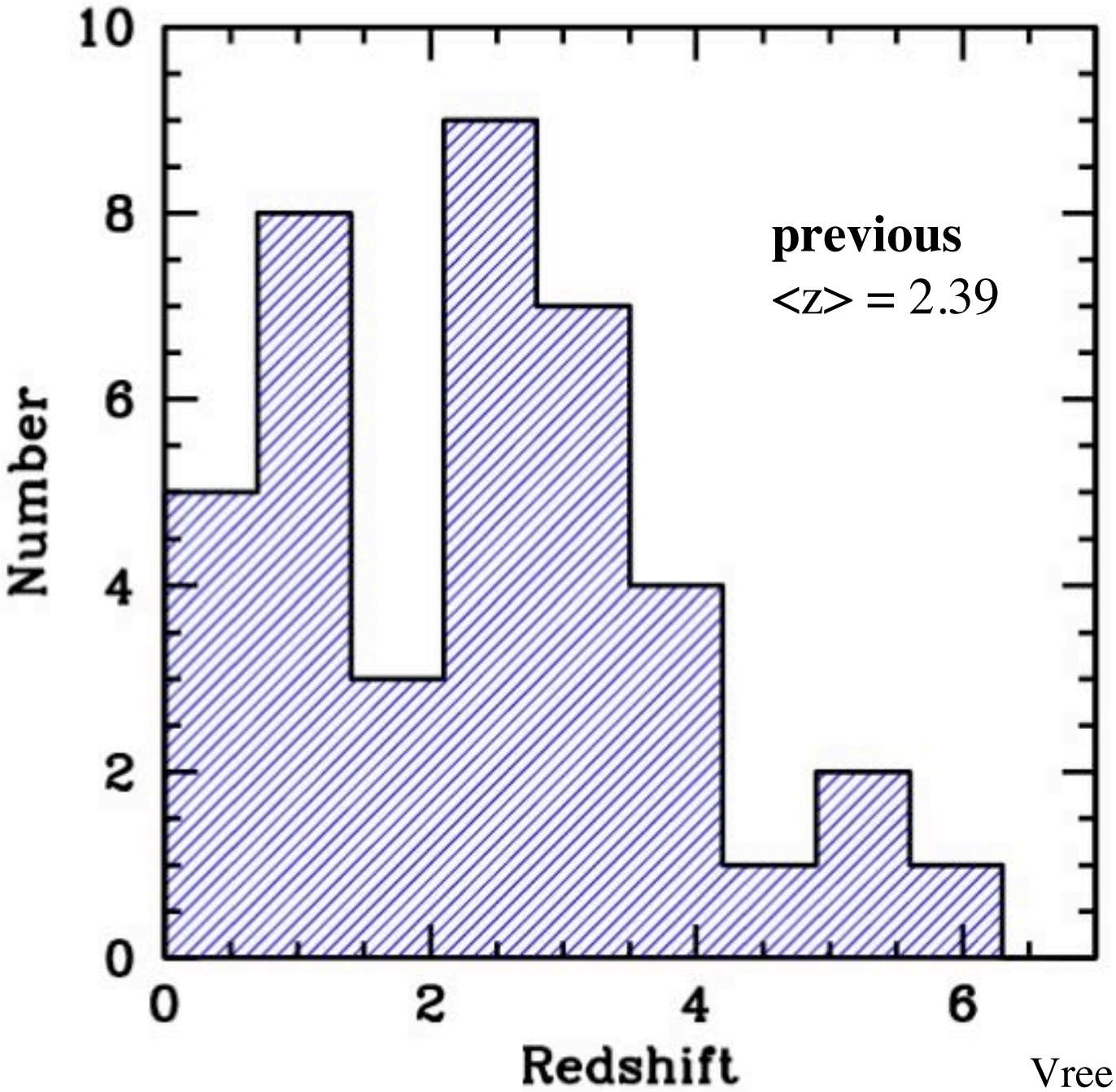


redshift



metallicity

Savaglio 2006



Danish Group Host Galaxy Study

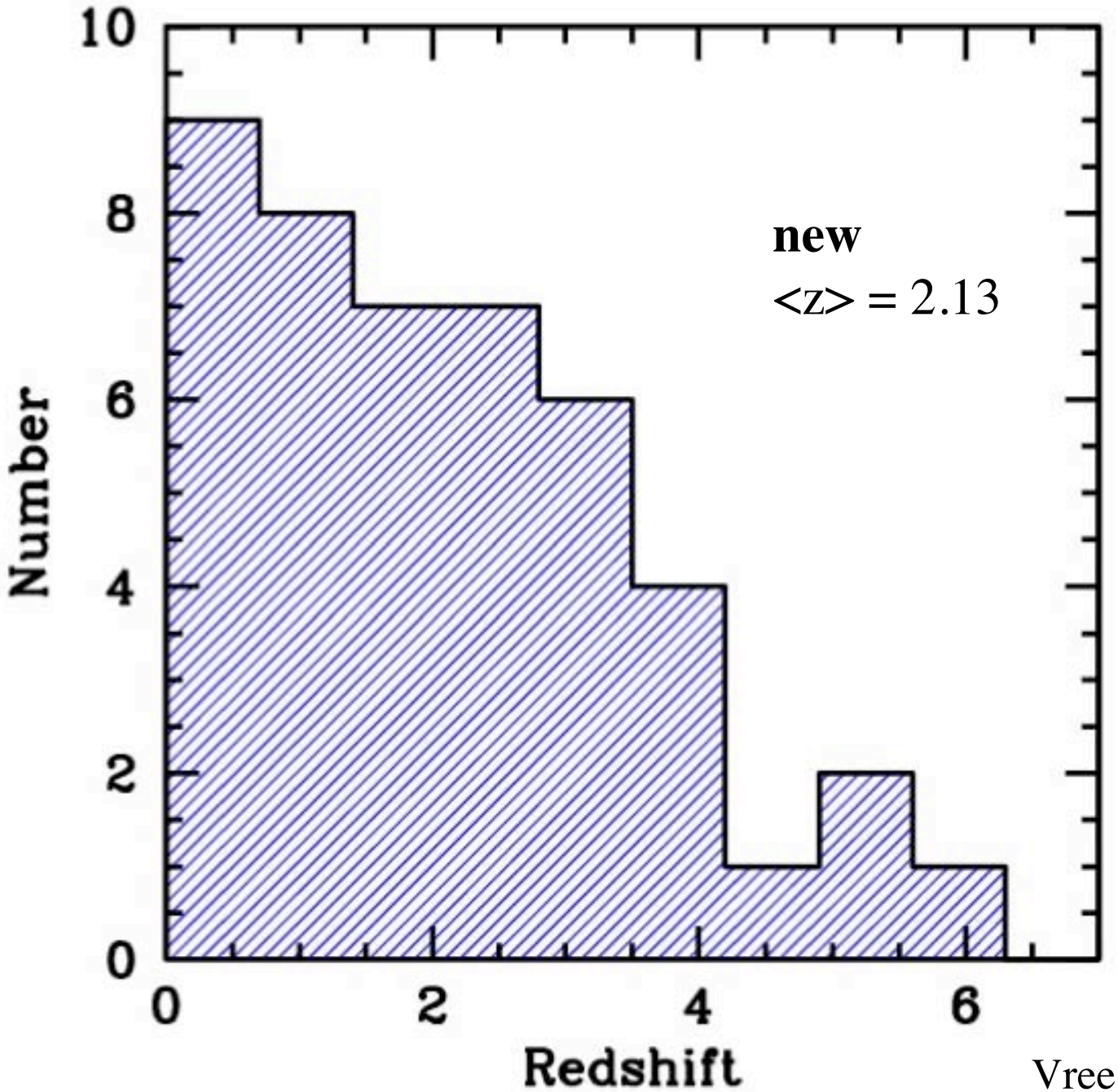
Large program

68 GRBs

VLT time
(PI: J. Horth)

Fynbo et al.
sample

Vreeswijk - Venice talk



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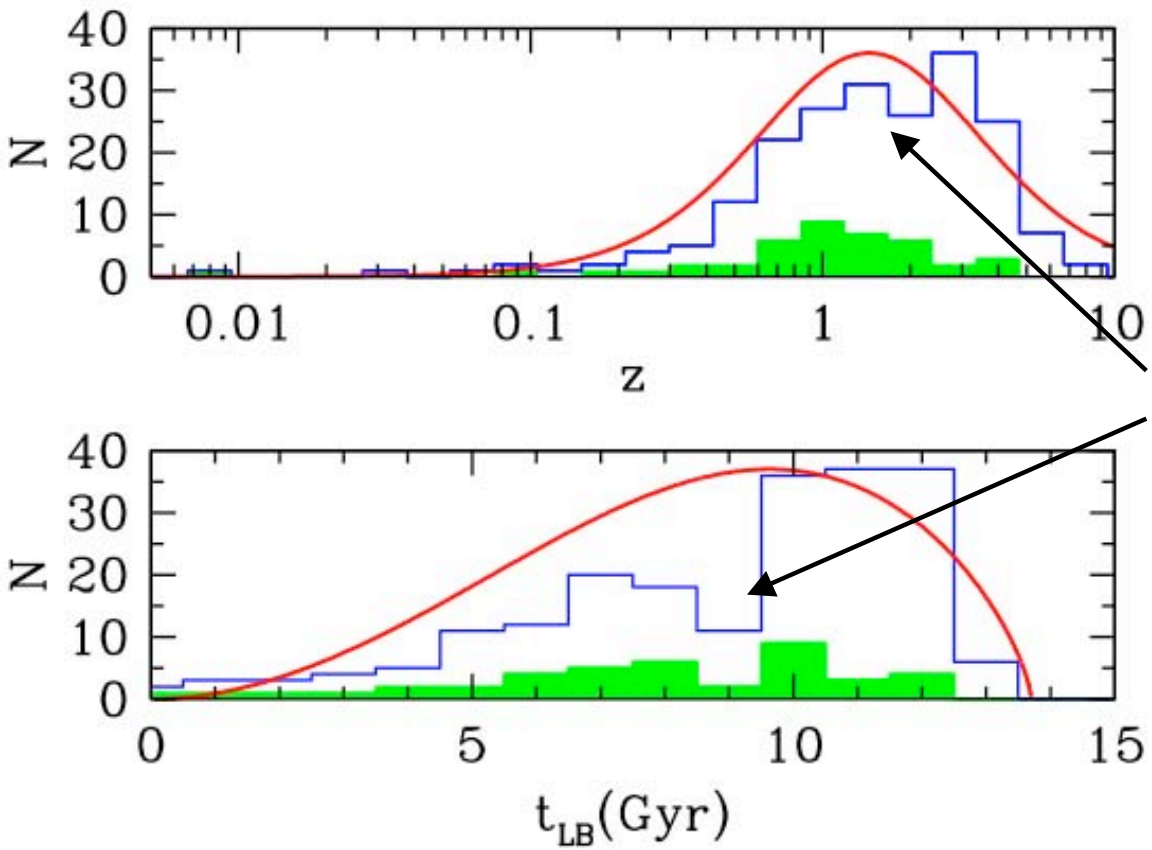


actual distributions would fill in here

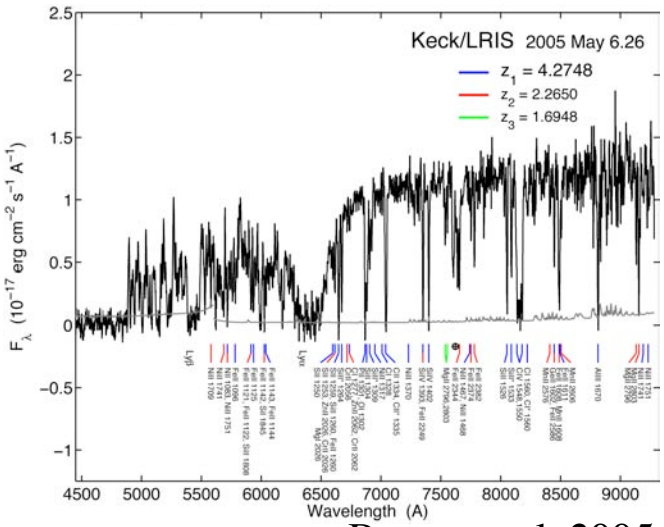
Swift

Pre-Swift

comoving volume

Swift High-z GRBs

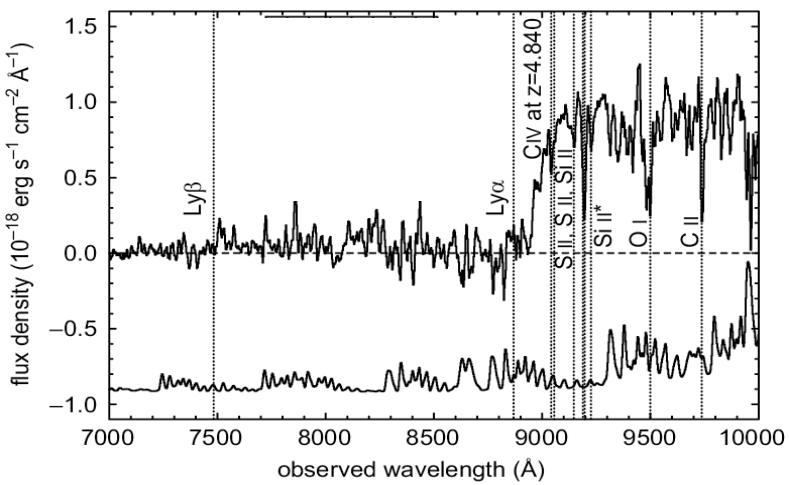
GRB 050505 z=4.3



Berger et al. 2005

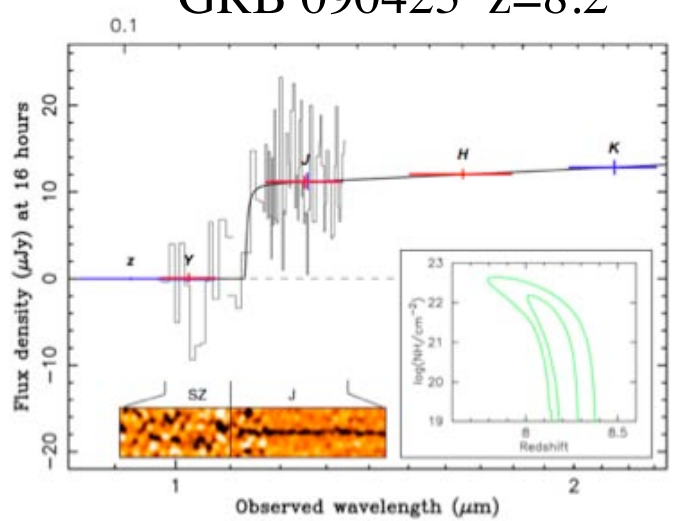
z	GRB	Optical Brightness
~9	090429B	K = 19 @ 3 hrs
8.2	090423	K = 20 @ 20 min
6.7	080813	K = 19 @ 10 min
6.29	050904	J = 18 @ 3 hrs
5.6	060927	I = 16 @ 2 min
5.3	050814	K = 18 @ 23 hrs
5.11	060522	R = 21 @ 1.5 hrs

GRB 050904 z=6.3



Kawai et al. 2005

GRB 090423 z=8.2



Tanvir et al. 2009, Salvatera et al. 2009

High-z Fraction Predictions

Bromm & Loeb (2006)

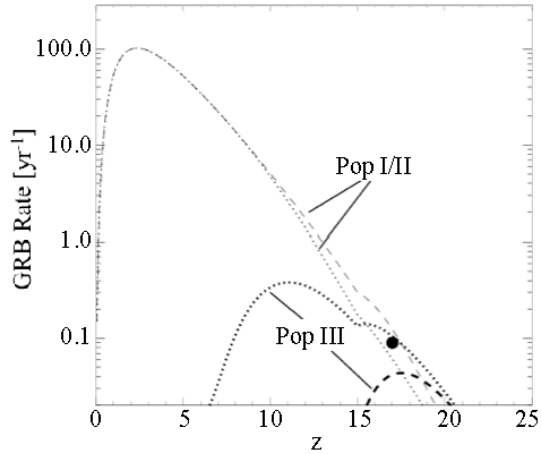
z > 5 ~7%

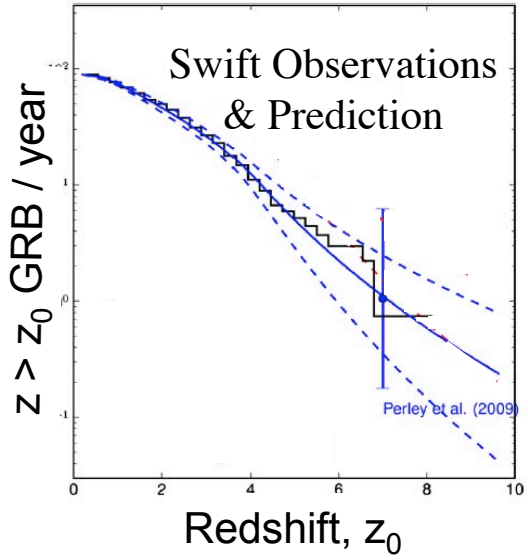
Butler, Bloom & Poznanski (2010)

z > 5 3% - 10%

Perley et al. (2010)

z > 7 0.2% - 7%



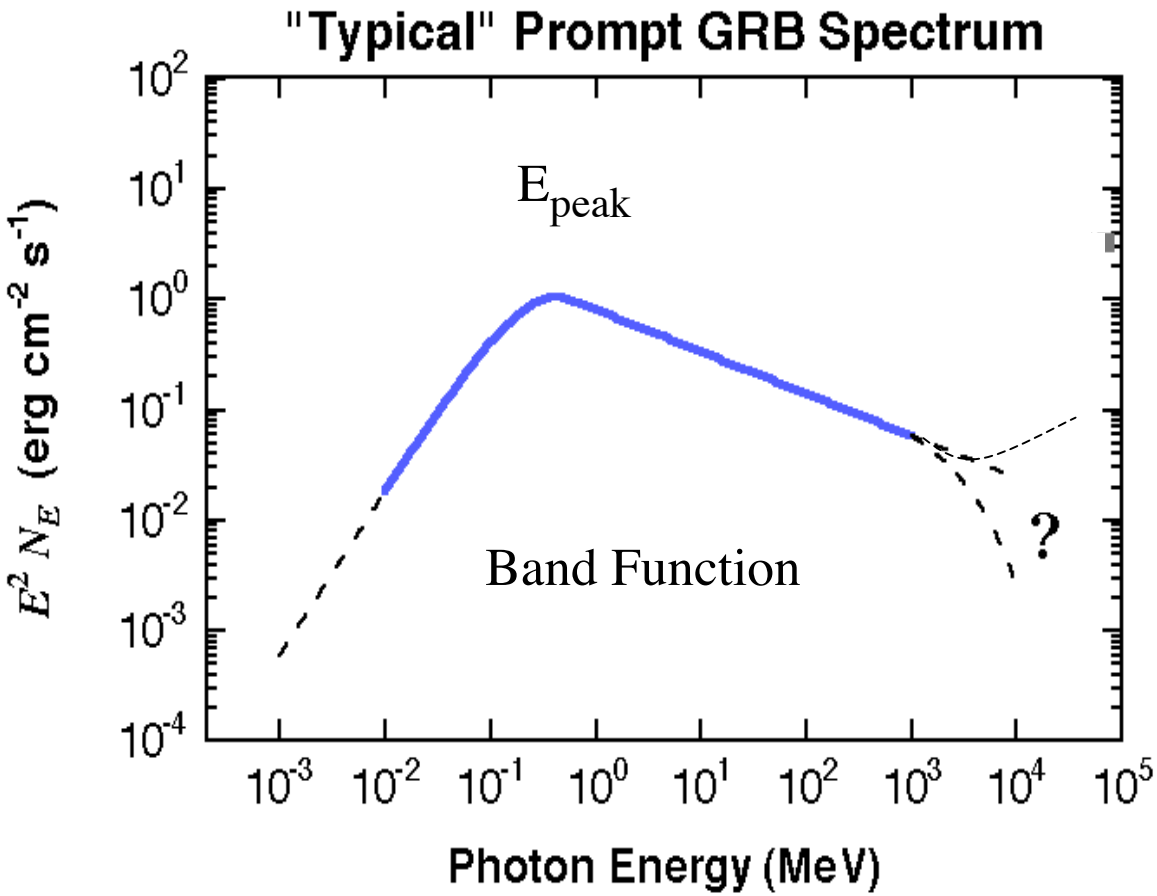


Measured:

z > 5 4% (7 out of 165)
z > 7 1% (2 out of 165)

• •

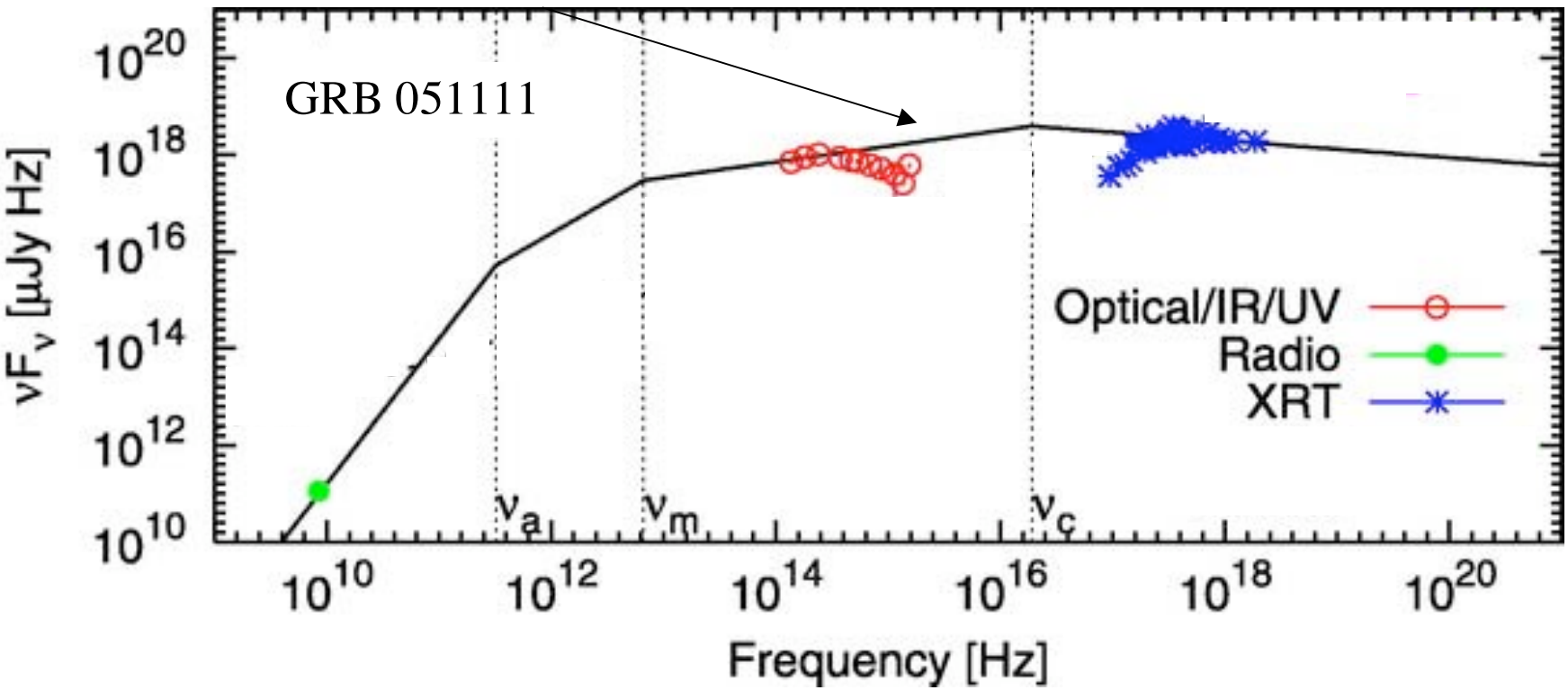
GRB Prompt Spectra



X-Ray Flashes (XRFs): $E_{peak} < 25$ keV

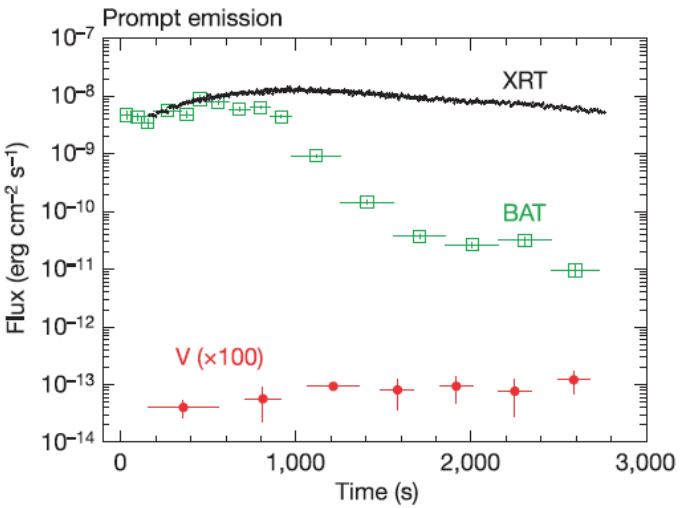
GRB Afterglow Spectrum

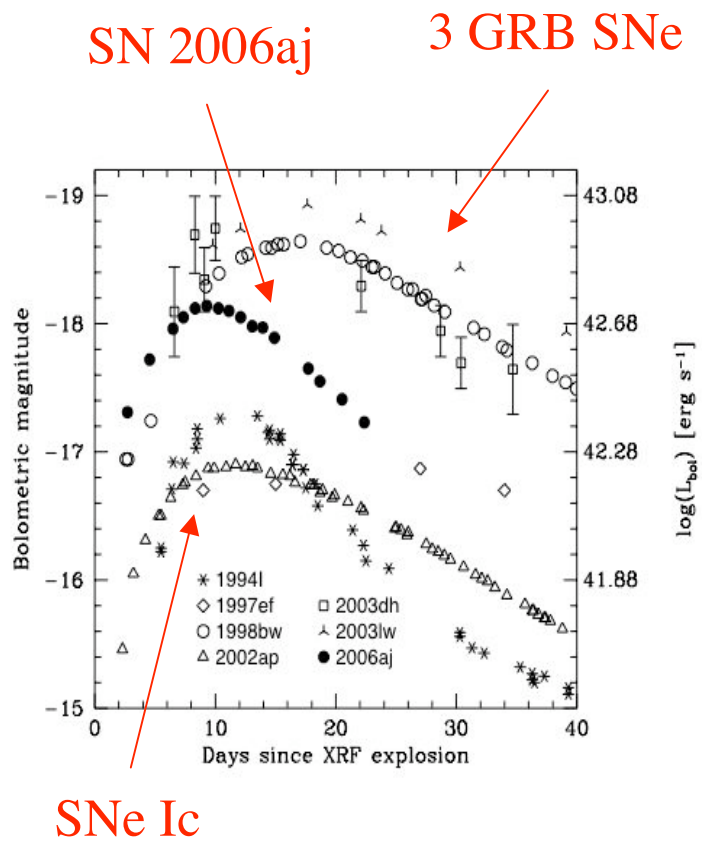
afterglow with
synchrotron fit



Butler et al. 2006

GRB 060218: GRB + Hypernova





Super-long GRB - ~35 minutes

BAT, XRT, UVOT during GRB

z = 0.033 (450 M yrs)

SN 2006aj SN Ib/c

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

Campana et al., Mazzali et al., Pian et al., Soderberg et al.

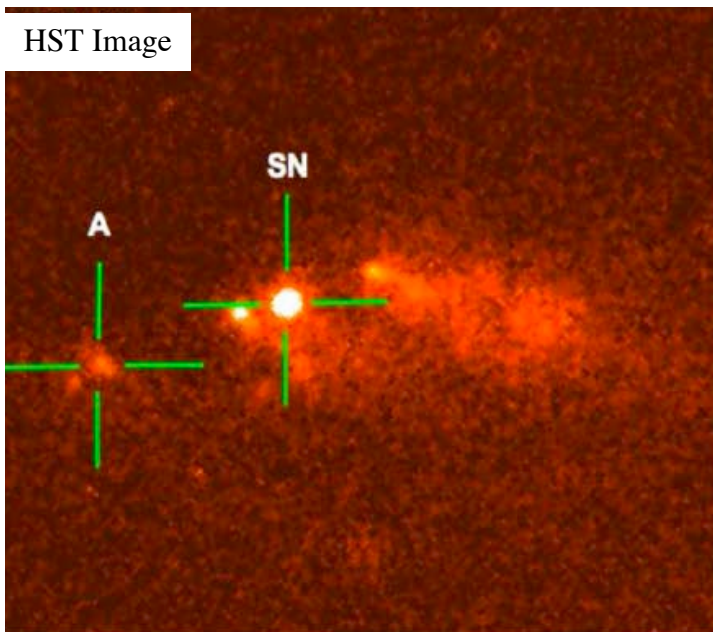
GRB 100316D: GRB + Hypernova

GRB duration > 12 minutes

z = 0.059

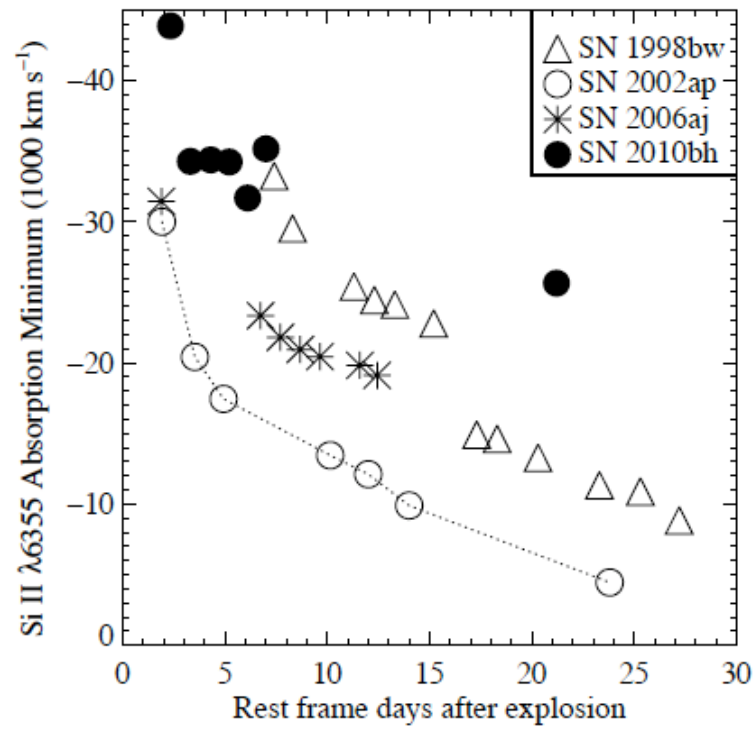
SN 2010bh SN Ib/c

$E_{iso} = 6 \times 10^{49}$ erg **underluminous**



Starling et al. 2010

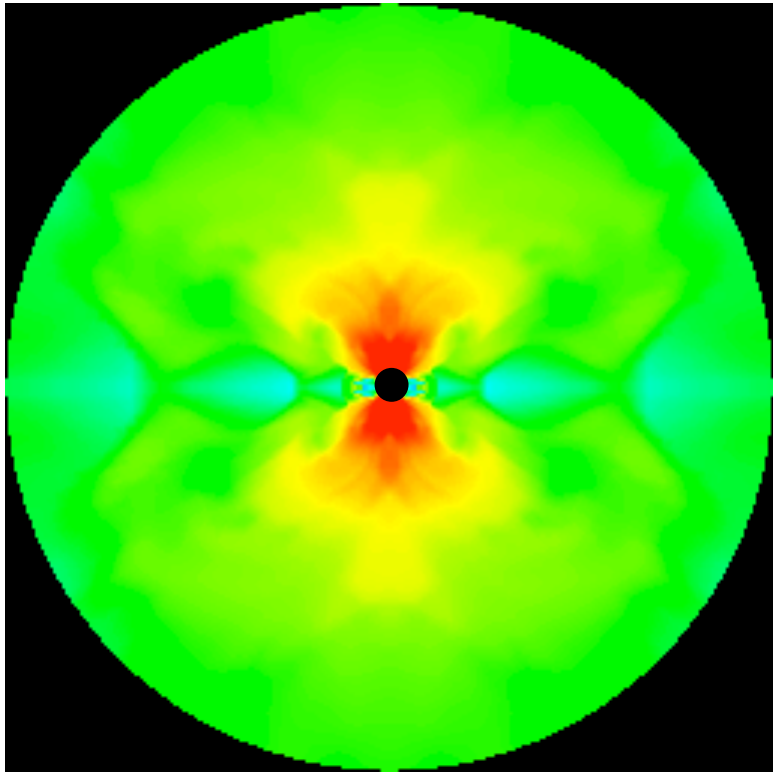
Highest velocity SN Ibc



Chornock et al. 2010

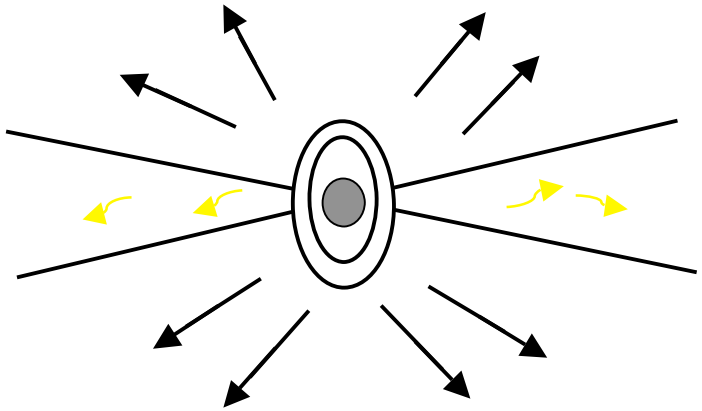
New paper on
GRB 091127 / SN2009nz
Cobb et al. 2010

squelched jet

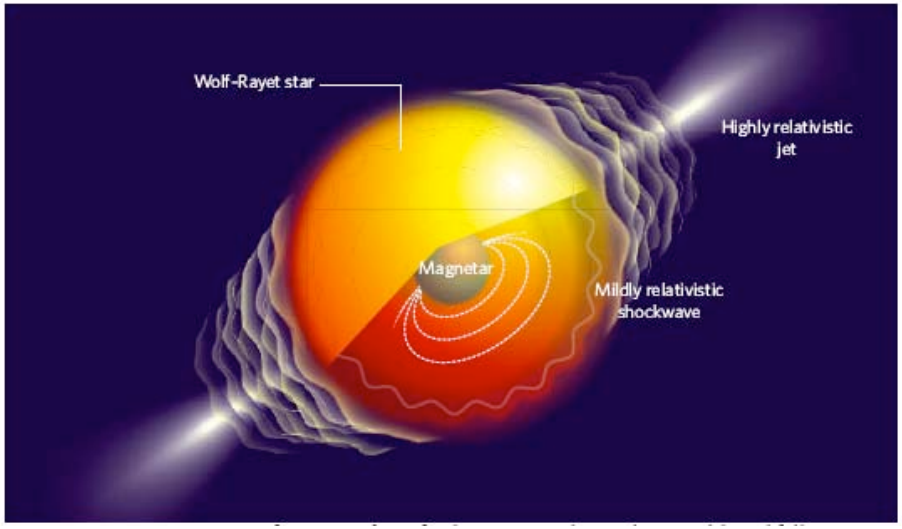


MacFadyen & Woosley

off-axis view



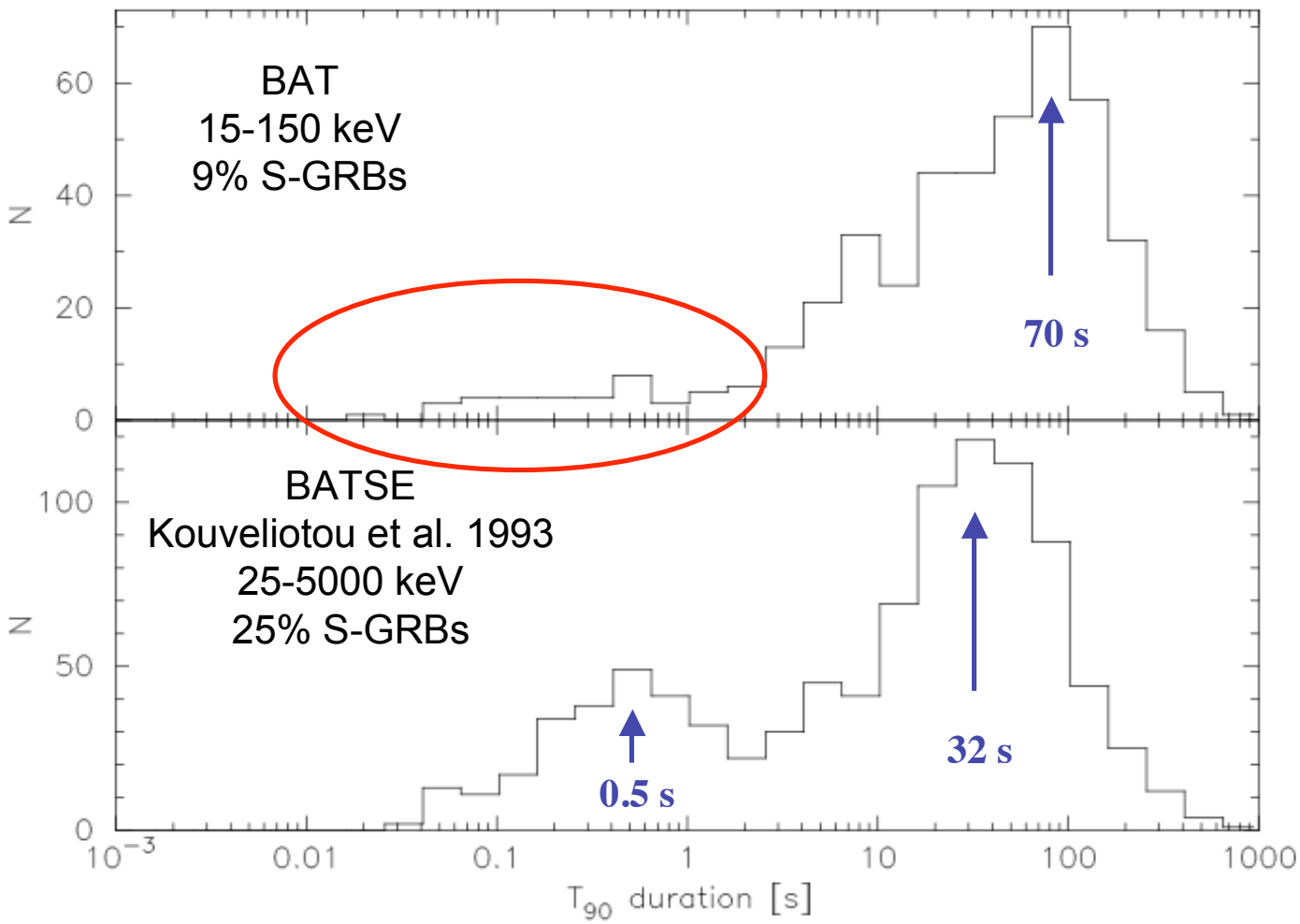
magnetar engine



Soderberg et al.

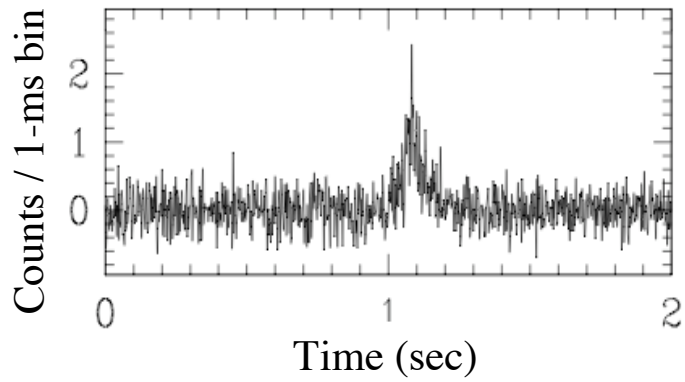
Short GRB Statistics with Swift

* 52 detected by BAT
* 41 X-ray, 17 optical
* 11 firm redshifts

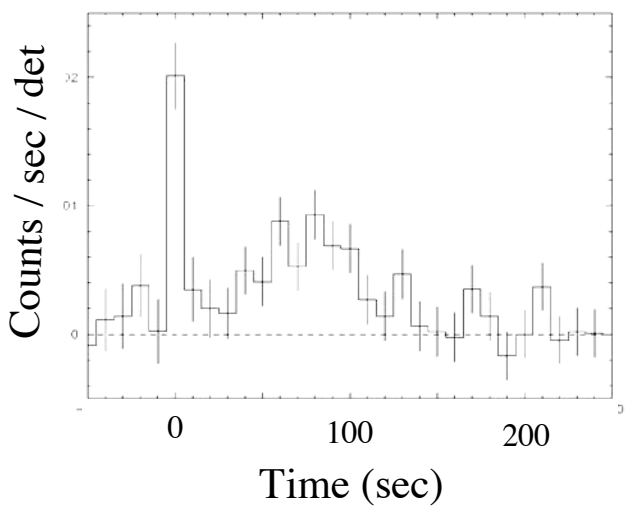


Types of S-GRB Lightcurves

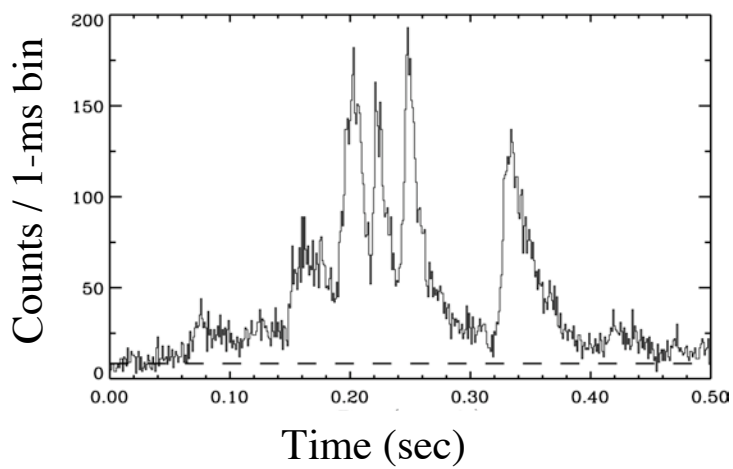
Single Spike - 15%
GRB 090621B



Extended Emission - 25%
GRB 050724

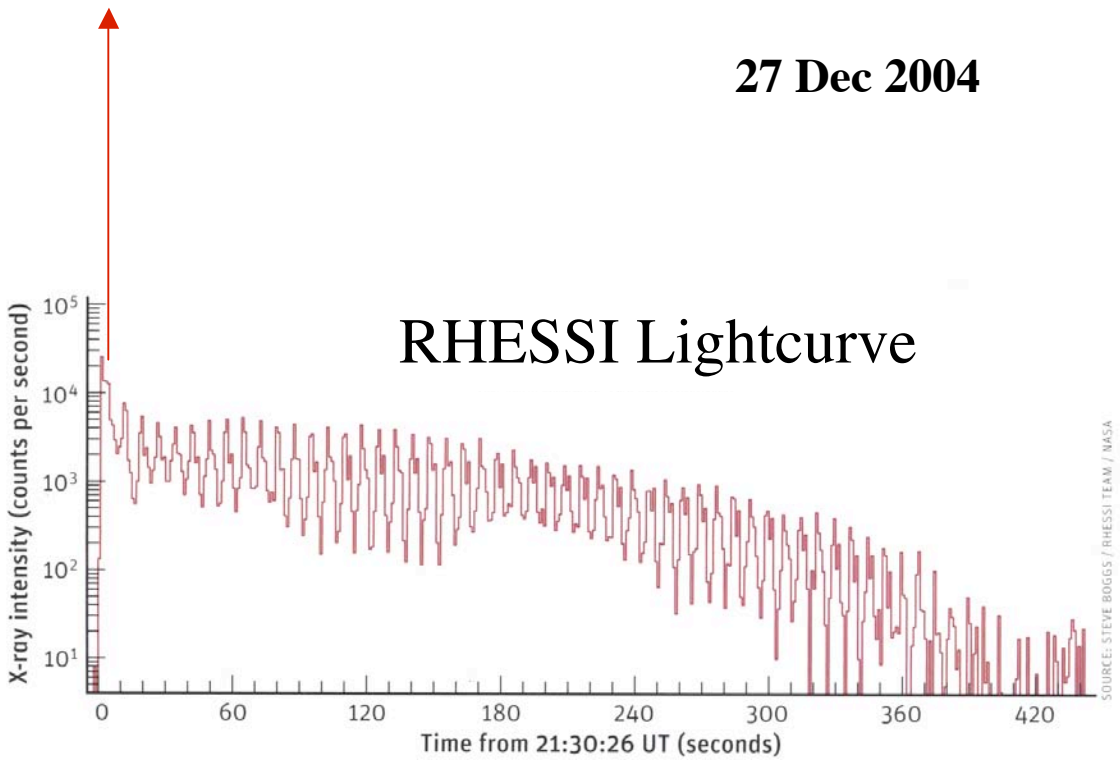


Complex - 25%
GRB 051221A

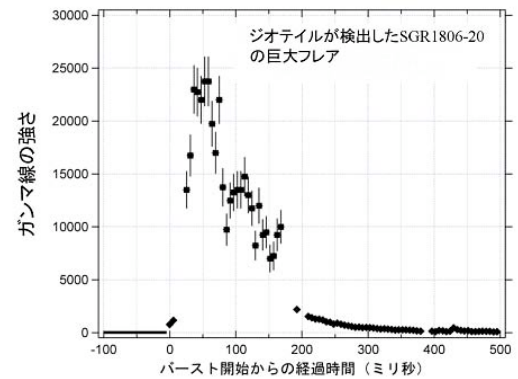


SGR 1806-20 Giant Flare

27 Dec 2004



GEOTAIL - Main Pulse

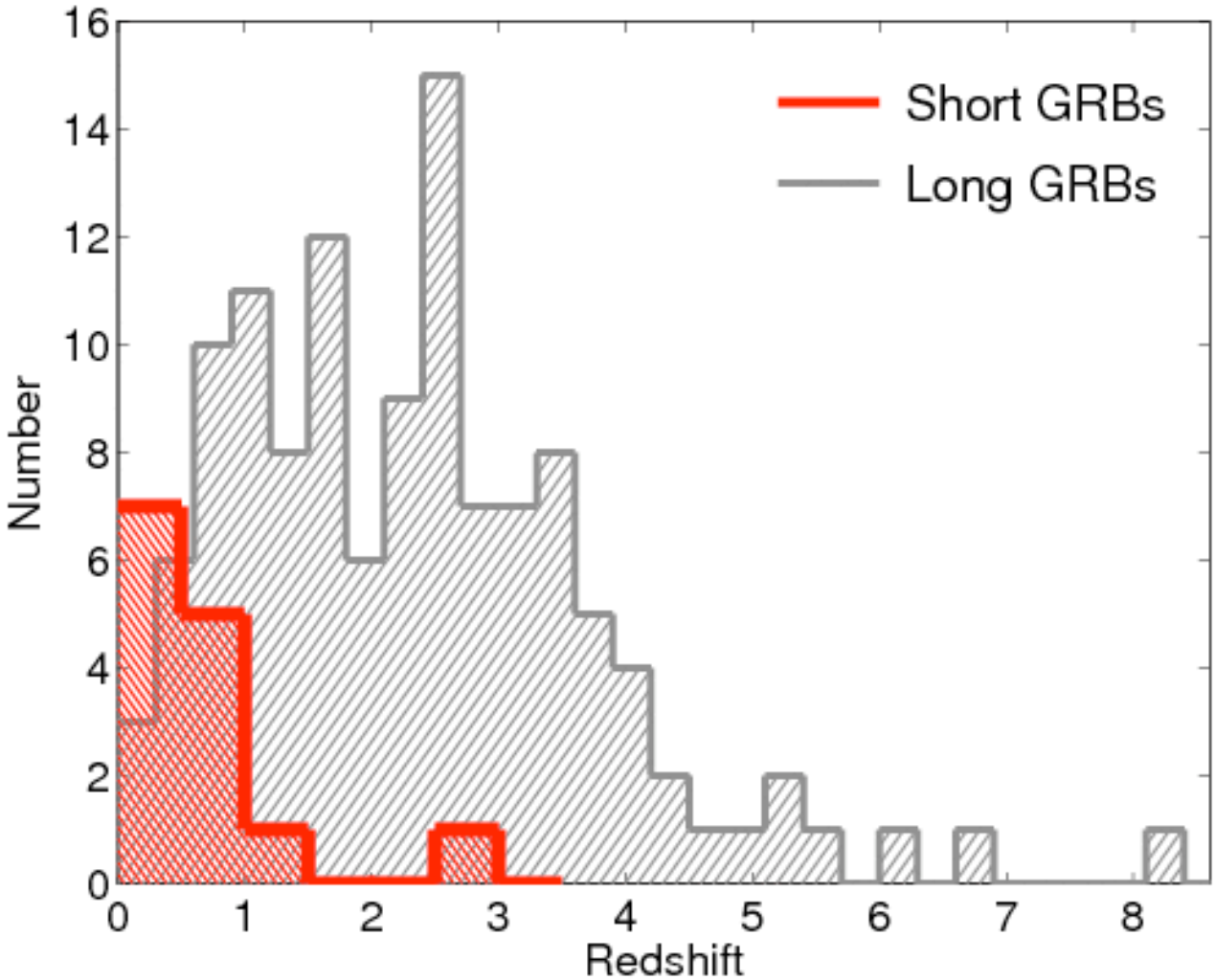


Palmer et al. 2005
Hurley et al. 2005

Could appear as short burst from an external galaxy to ~30 Mpc

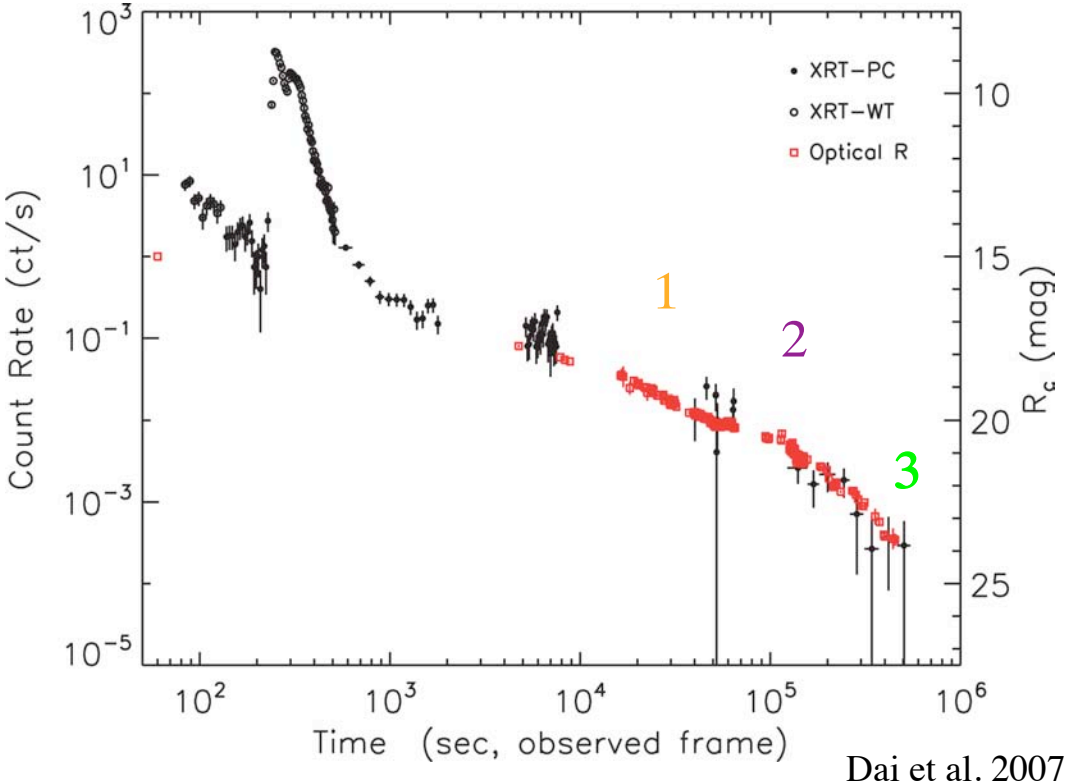
No nearby galaxy in ~40 well-localized burst error boxes implies
< ~2% short burst population

Short GRB Redshifts



Berger 2010

Achromatic Jet Break - GRB 060526

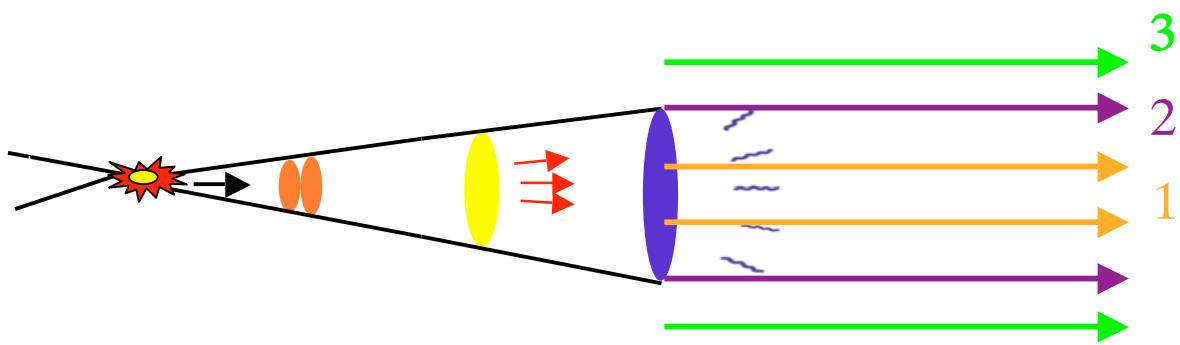


Dai et al. 2007

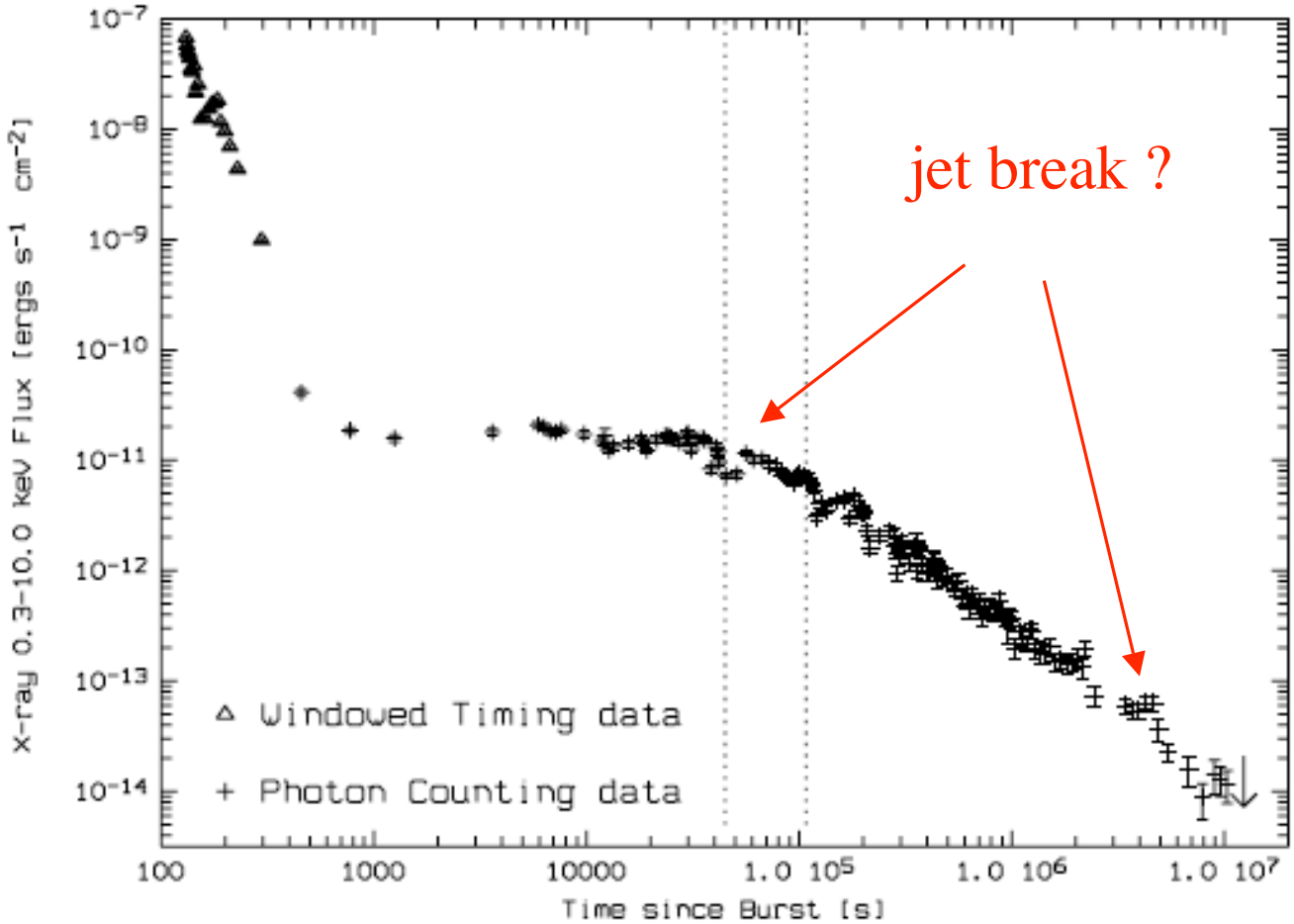
z=3.21
jet angle = 7°

With beaming:
$E_\gamma \sim 10^{51}$ ergs

Without beaming
$E_\gamma \sim 10^{53}$ ergs

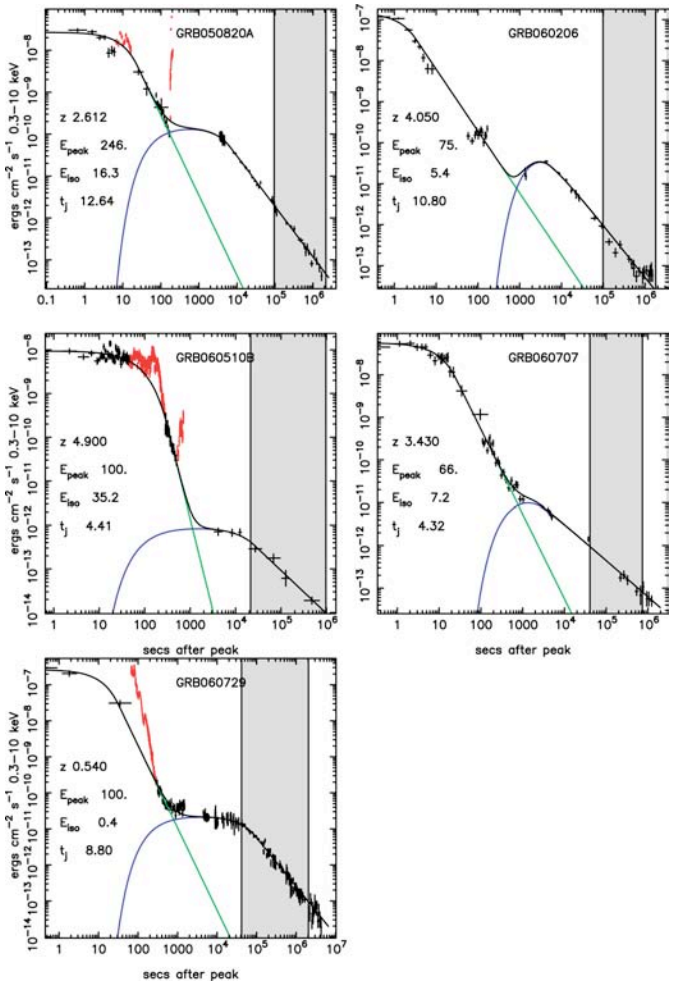


GRB 060729



Grupe et al. 2007

Jet Breaks in Swift Era



Willingale et al. 2007

- Many GRBs do not show jet breaks
- Other cases have optical and X-ray breaks not coincident.
- Complex shape of afterglow lightcurves makes jet break hard to find

Other papers:

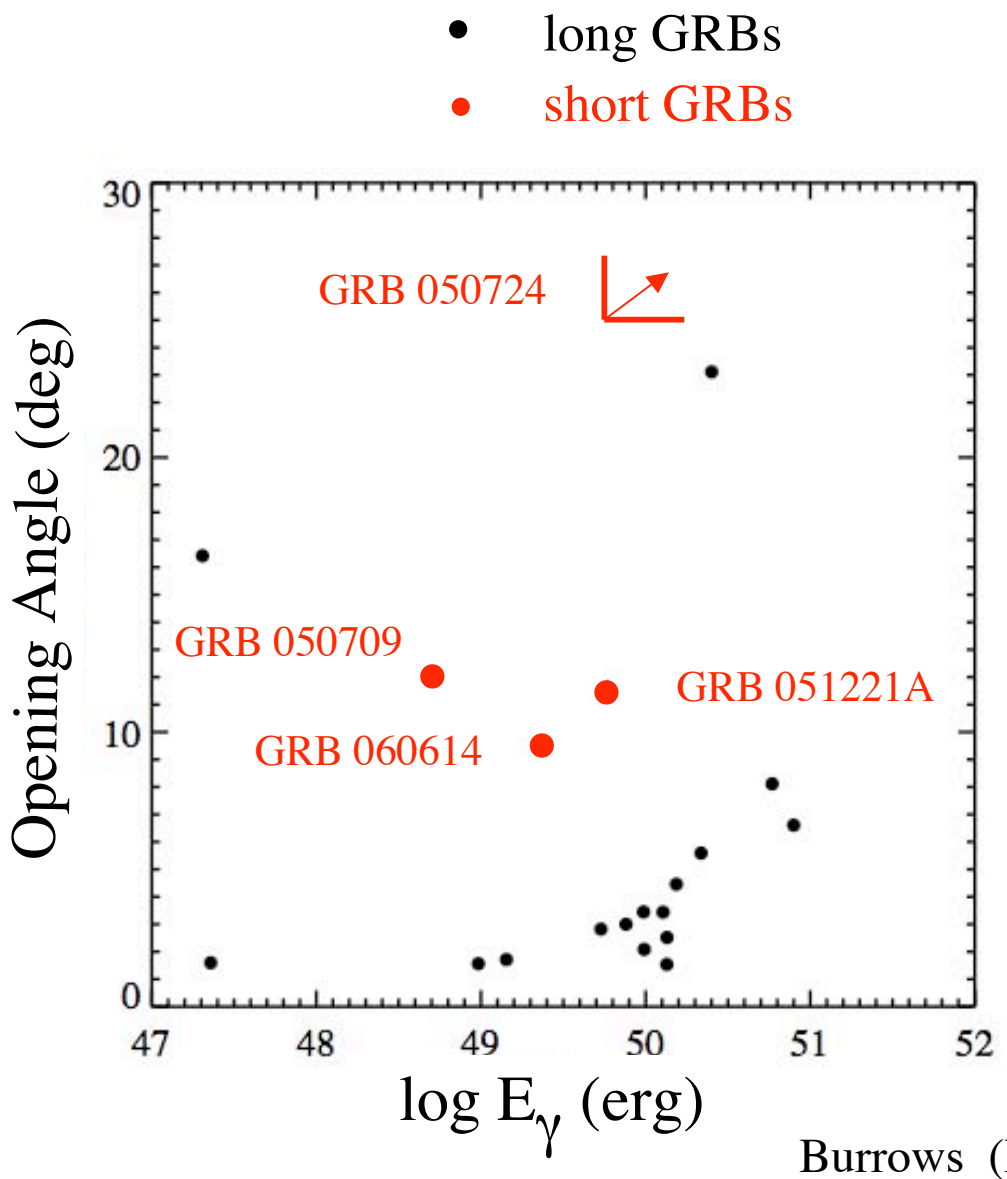
Curran et al. (2007) - evidence for achromatic breaks

Oates et al. (2007) - GRB 050802 with X-ray break clearly seen but no optical break

Panaitescu (2007) - study of X-ray jet break

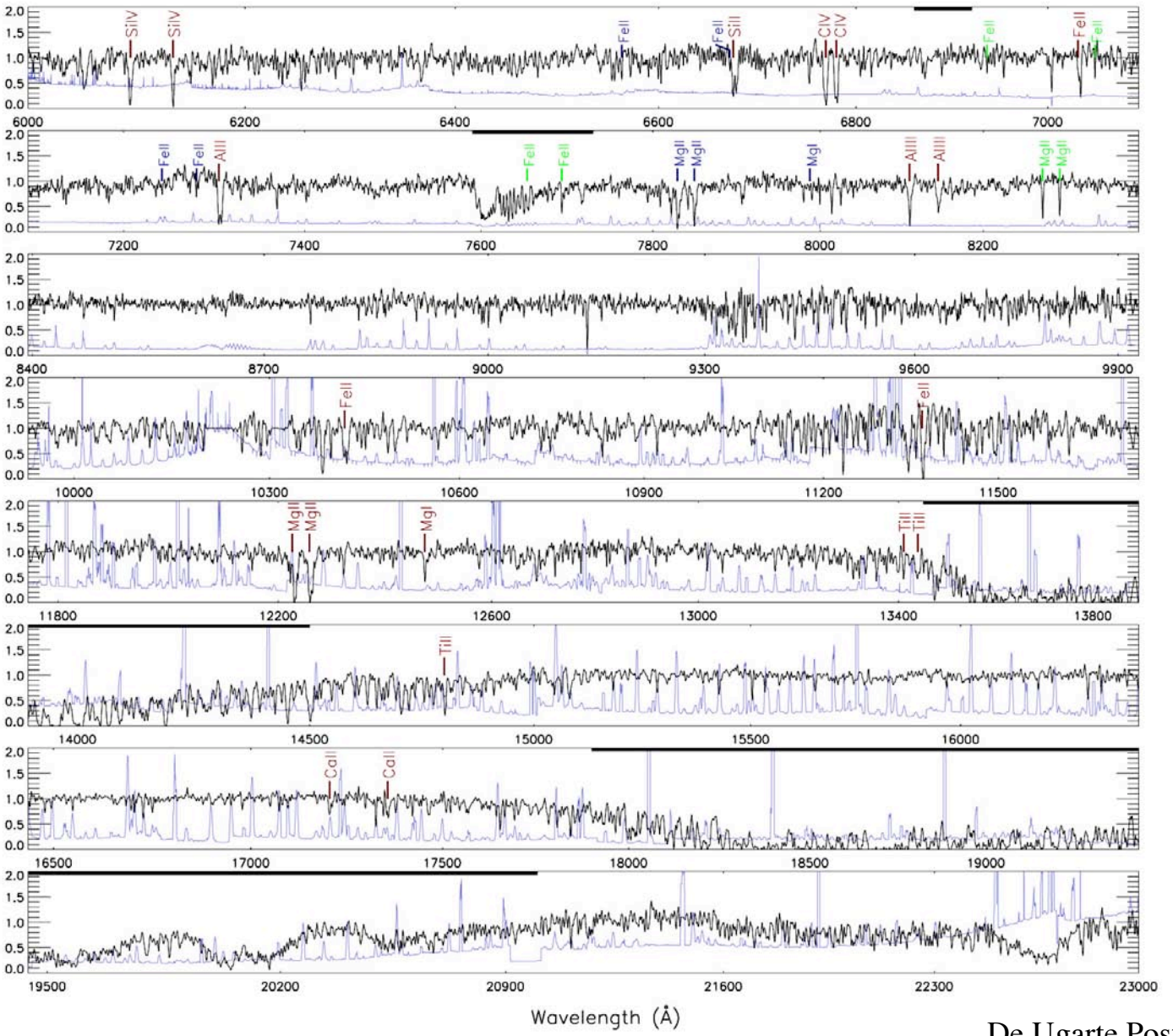
Kocevski & Butler (2008) - difficult to determine jet breaks in Swift era

GRB Opening Angle



Burrows (Racusin, Panaitescu)

VLT / **X-Shooter** GRB 090313 300 - 2500 nm R = 4000 - 14000



De Ugarte Postigo et al. 2009