Swift results on GRBs

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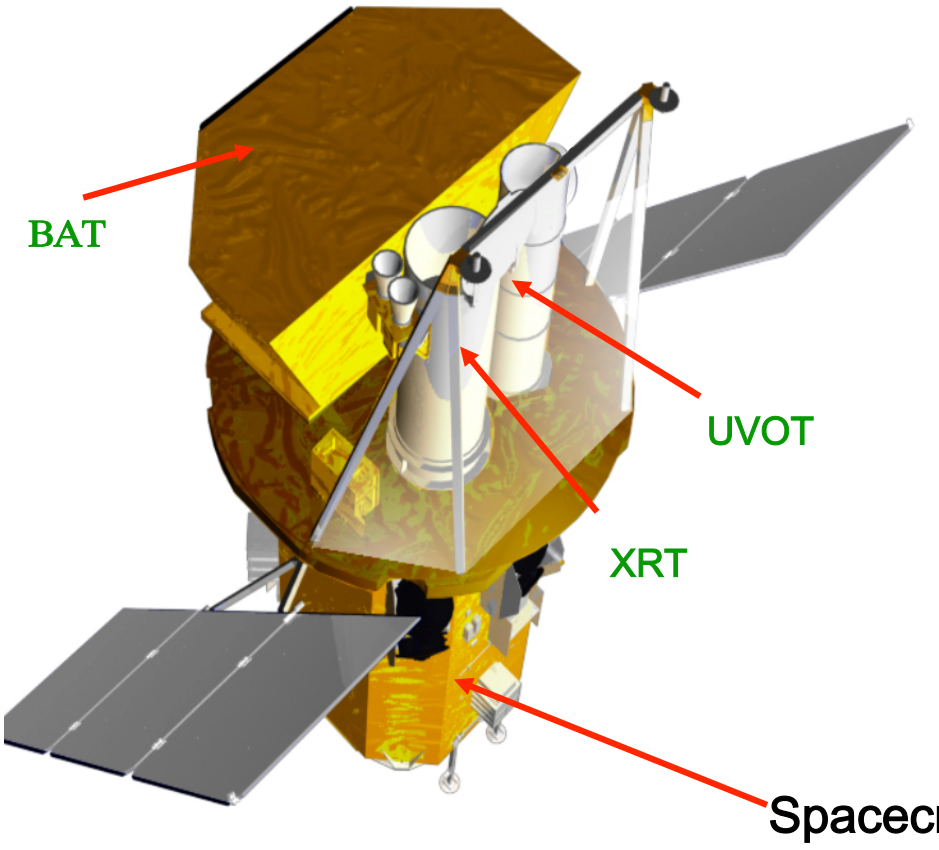
on behalf of the Swift Team

Outline

- Mission outline
- Goals and achievements
- Main breakthroughs in GRB science
- … and so on

The Swift mission payload



- Burst Alert Telescope (BAT)
  - CdZnTe detectors
  - Detect >100 GRBs per year depending on logN-logS
  - Most sensitive hard X-ray imager ever made
- X-Ray Telescope (XRT)
  - Arcsecond GRB positions
  - CCD spectroscopy
- (UVOT) UV/Optical Telescope
  - Sub-arcsec imaging
  - Grism spectroscopy
  - 24th mag sensitivity (1000 sec)
  - Finding chart for other observers
- Autonomous re-pointing, 60 - 100 s
- Onboard and ground triggers

Swift design and objectives

Gamma-ray monitor with Large FOV
(1/6 of the sky) and
localization capability with 3-4 arcmin error

Detection rate:
3 GRBs per week
100 GRBs per year

MORE AFTERGLOWS THAN EVER!

Fast automatic repointing with NFI (less than 2 min)

Early X-ray/optical afterglow detection

Quick localization with 3-5 arcsec error (or less)

MORE REDSHIFTS THAN EVER!

Sensitive to:
•Short GRBs
•High z GRBs

ABLE TO CATCH SHORT GRB AFTERGLOWS!

Follow up observations for days/weeks/months

WELL SAMPLED X-ray LCs

Goals and Achievements

Launched on 2004 November 21

Swift has fulfilled almost all its Scientific Objectives

(http://heasarc.nasa.gov/docs/swift/about_swift/objectives/)

All Swift data are immediately public since 2005 April 1

- The Swift science-up time is still ~ 98%
- The observatory status is still nominal, instruments are fully operational
- The observatory life time is above predictions (orbital life > 2026)
- The response of the Flight Operation Team is still excellent
- The response of the Science Operation Team is still excellent

The 2012 NASA Senior Review Committee selected Swift for full funding for 2013-14 and recommended full funding for 2015-16

Open Problems Before … and After Swift

Short GRBs	Afterglows?	→	Detected!
	Redshifts? Hosts?	→	Detected!
	Progenitors?	→	Binary mergers?
Long GRBs	Massive star progenitors?	→	More evidences
	Explosion mechanism?	→	Spinning magnetars?
	SN connection: universal?	→	New detections & insights
	Fe lines?	→	No confirmation
Early afterglows	What happens before 10^4 s?	→	Detected!
	Reverse shock signatures?	→	Evidences
Late X-ray afterglows	Jet breaks in X-rays?	→	Too late for XRT?
More redshifts	Luminosity function tracking star formation history	→	Detected!
Very high redshifts	Connection to first stars	→	Detected!

7 years of GRB observations

Swift	GRBs	673
INTEGRAL	GRBs	38
HETE	GRBs	5
IPN	GRBs	10
AGILE	GRBs	16
Fermi	GRBs	10
Total	GRBs	752

Short GRBs 57

GRBs with redshift 201
(+41 prior to Swift)

GRB detection rate: ~ 90-100/year roughly constant

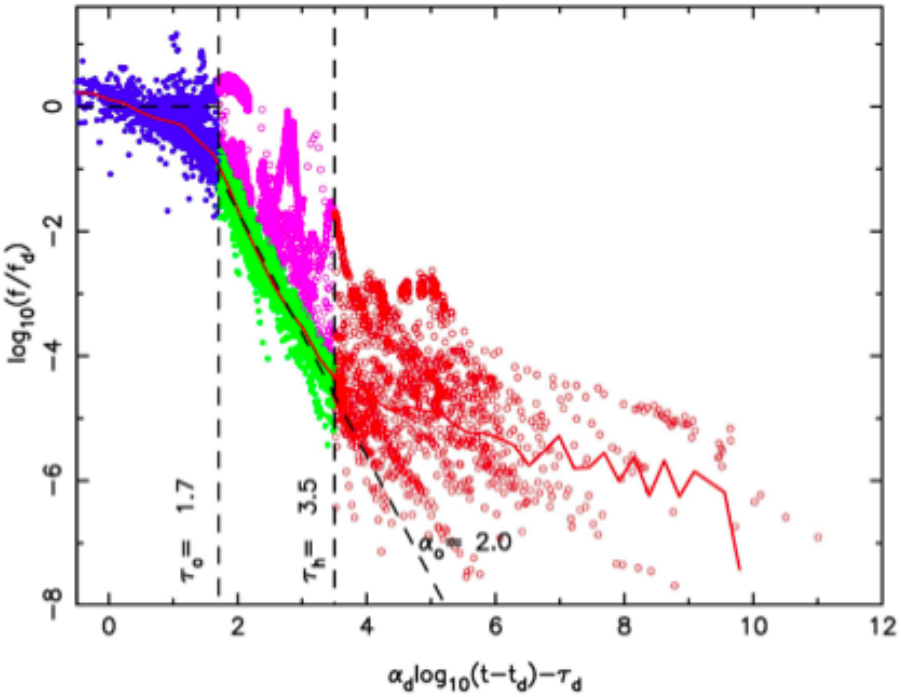
Time dedicated to GRBs	decreased from 46% (2005) to 17% (2011)
Time dedicated to ToOs	increased from 6% (2005) to 30% (2011)
Time dedicated to GI obs	increased from 13% (2005) to 35% (2011)

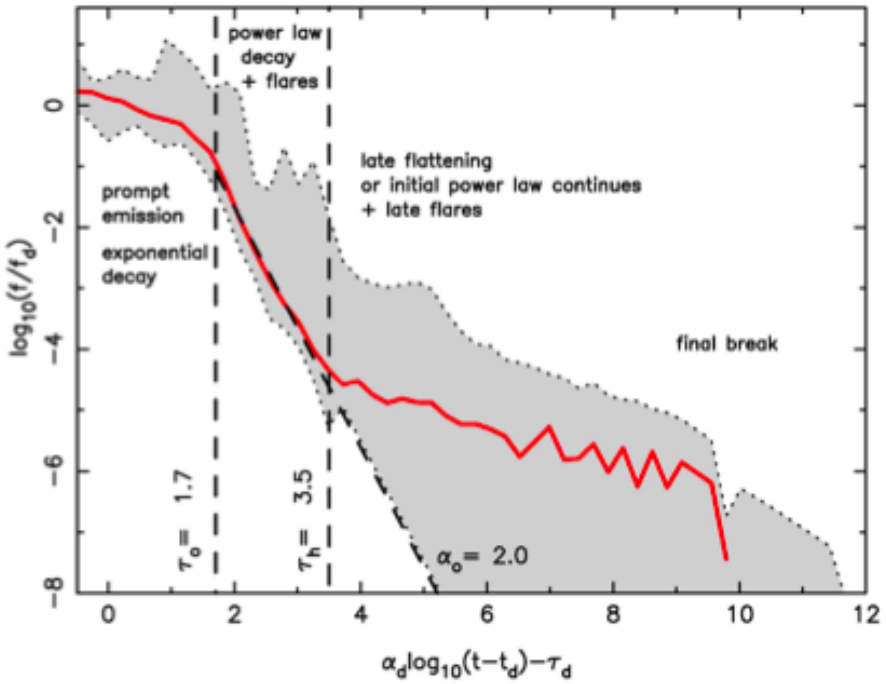
Swift results in GRB Science

(flashcard-like view)

The SWIFT GRB light curve

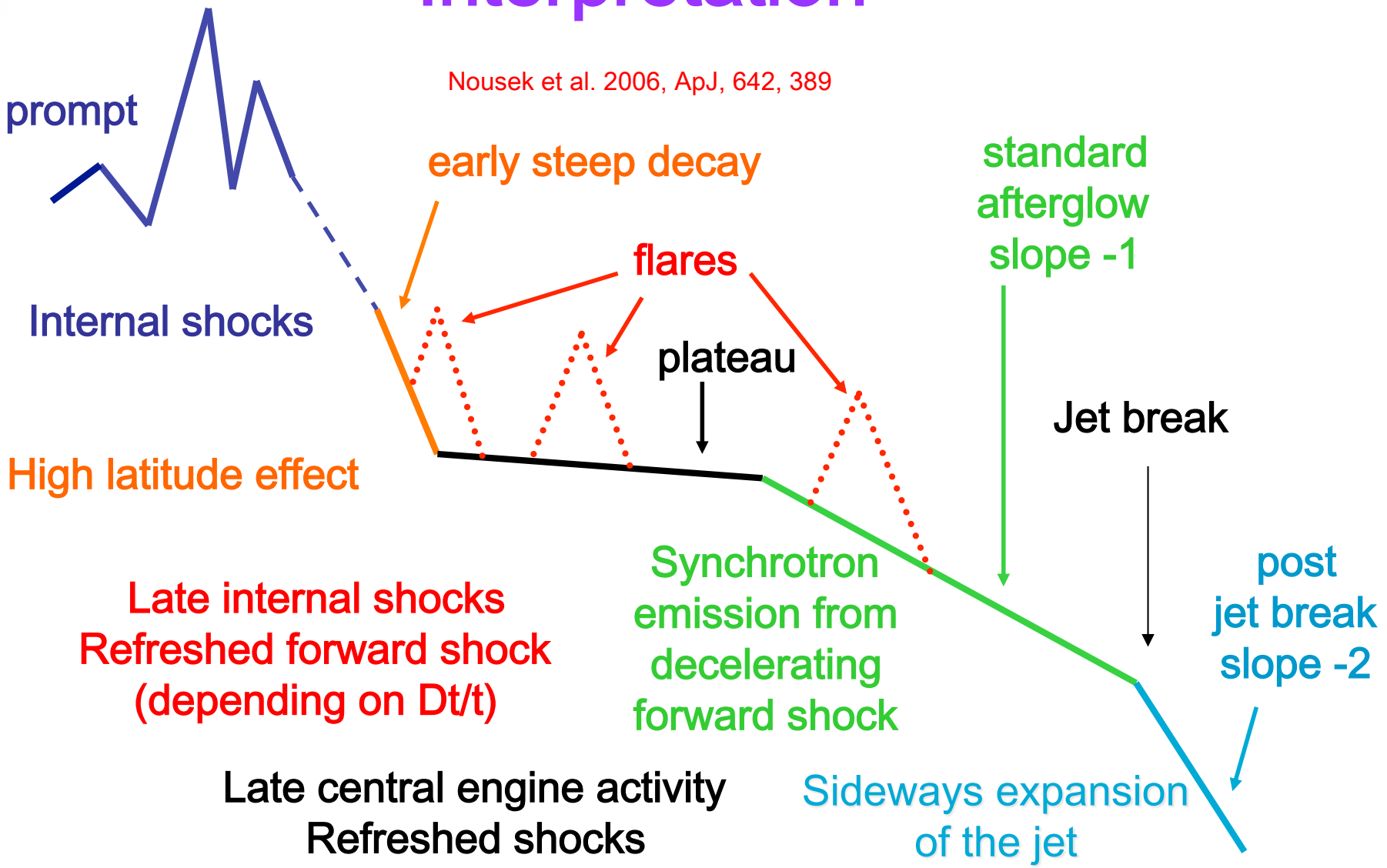
Composite light curve of the Swift X-ray afterglows (rescaled)





Nousek et al. 2005, ApJ 642, 389
O'Brien et al. 2006, ApJ 647, 1213
Chincarini et al. 2007, ApJ 671, 1903

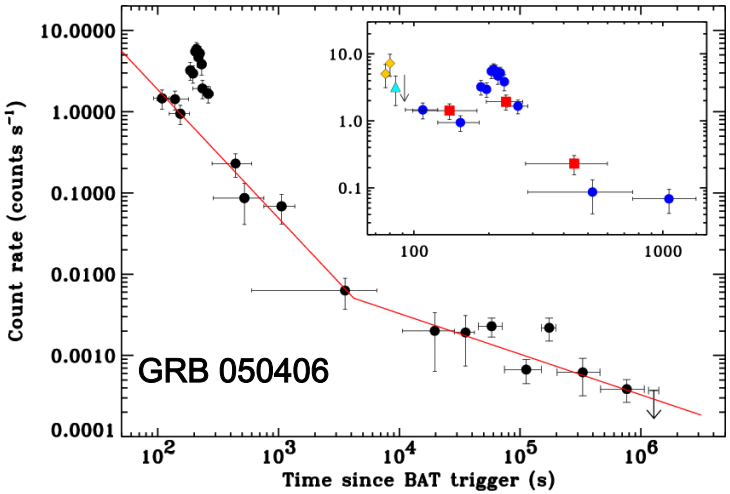
Interpretation



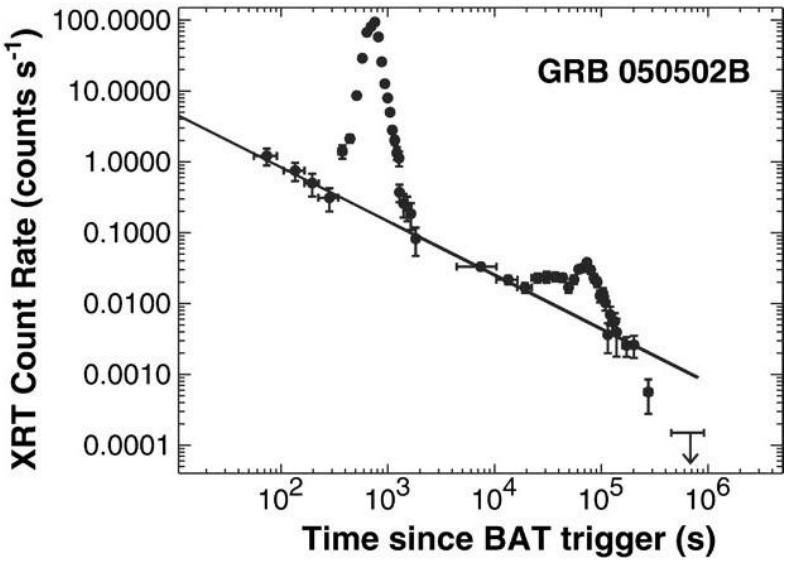
X-ray Flares

Observed in 1/3 of the Swift GRBs…

Falcone et al. 2005, ApJ, 641, 1010



Romano et al. 2005, A&A, 450,59

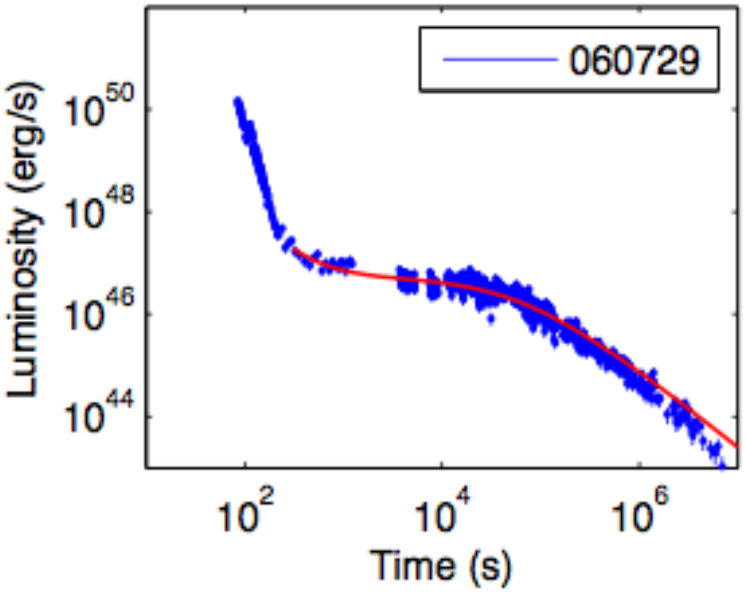


Chincarini et al. 2010, APJ, 671, 1903

Chincarini et al. 2010, MNRAS, 406, 2113

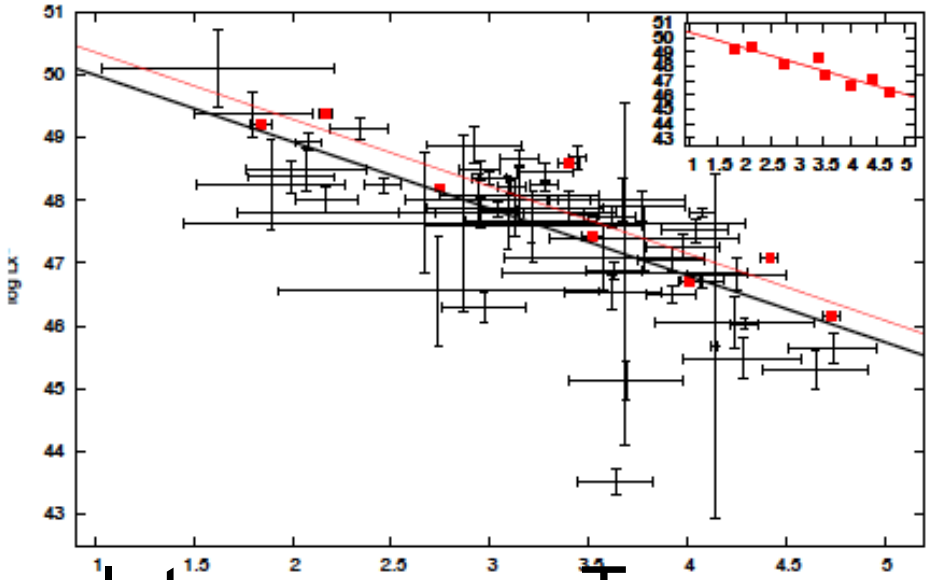
Plateau Phase

Another very common feature of X-ray afterglows…



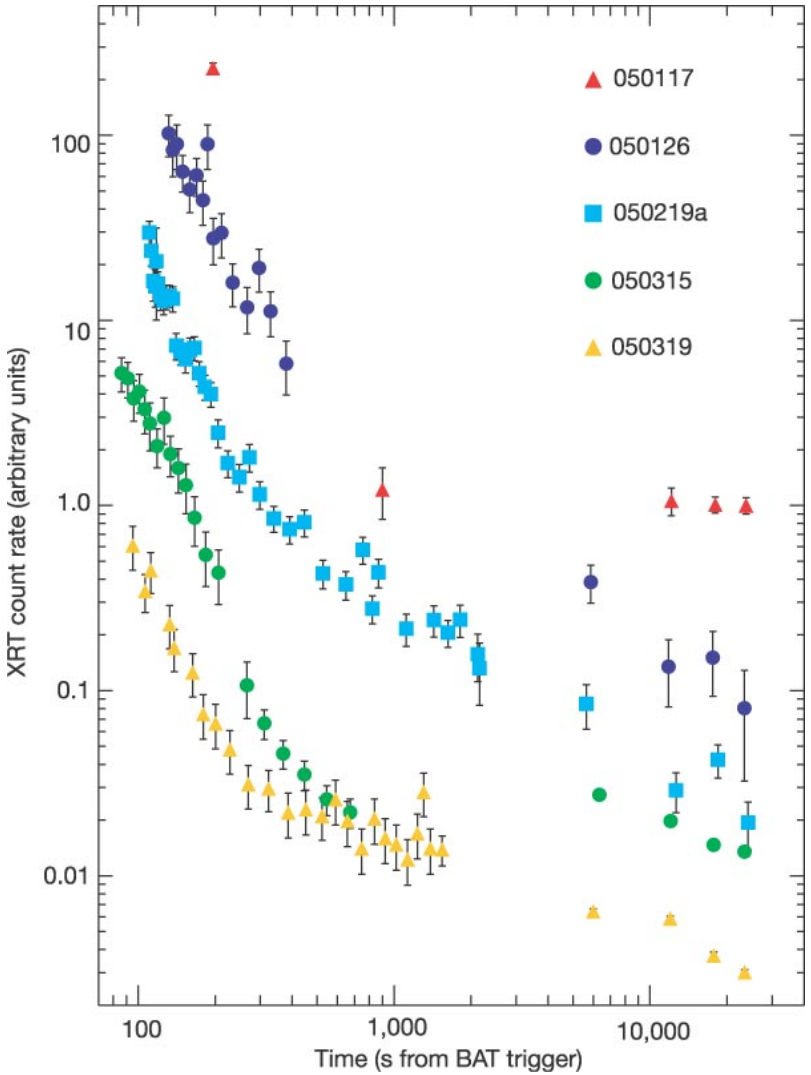
Dall'Osso et al. 2011, A&A, 526, 121

Dainotti et al. 2010, 2011



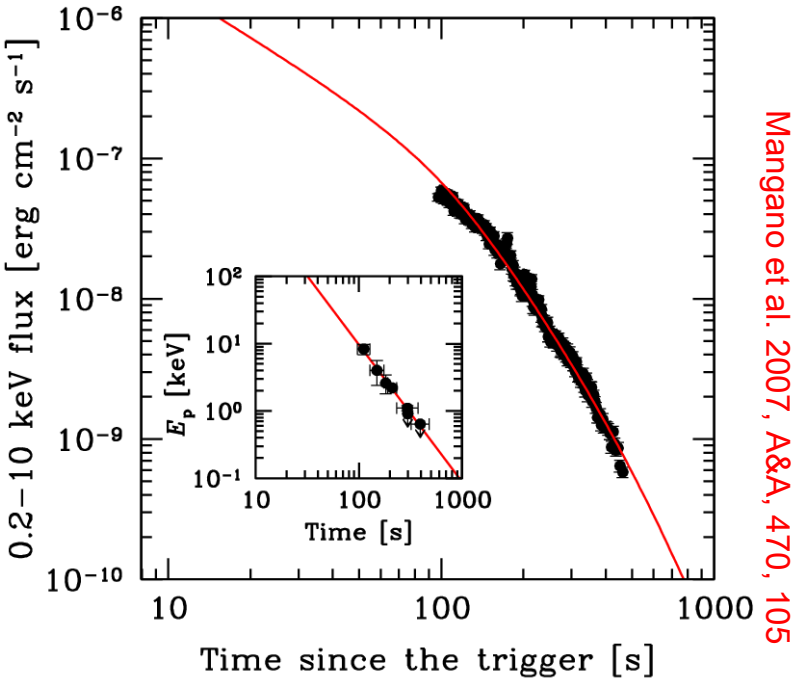
Swift GRBs with redhsift and plateau:
luminosity at the end of the plateau versus T_{break}

Early decay/High latitude effect



Tagliaferri et al 2005, Nature, 436, 985

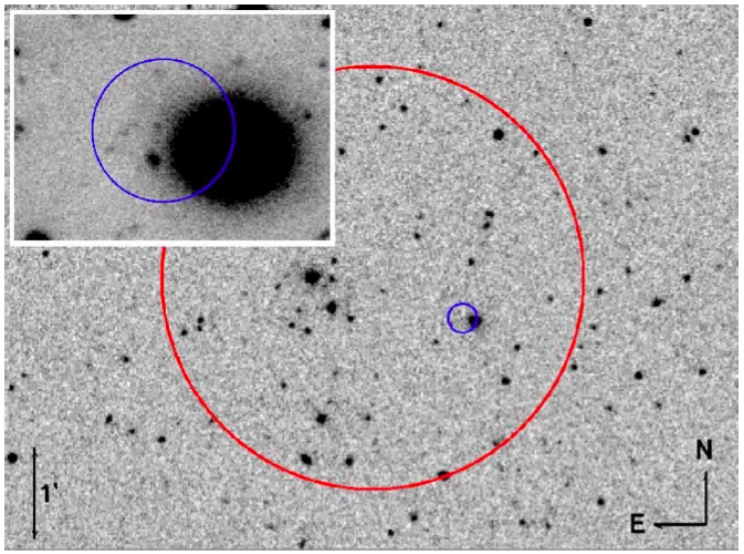
Early XRT light curve of GRB 060614
and decay of the peak energy
of the spectrum across the XRT band



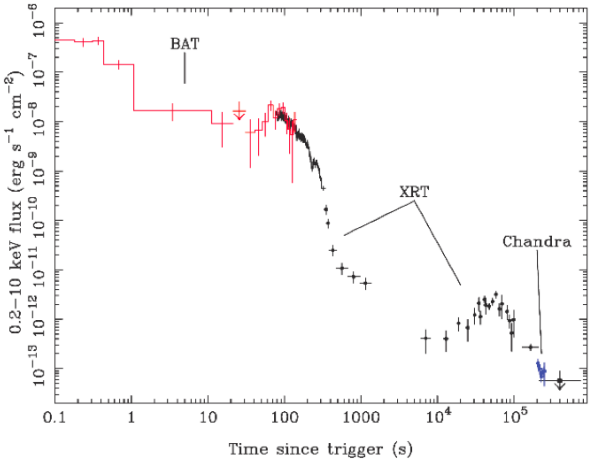
Mangano et al. 2007, A&A, 470, 105

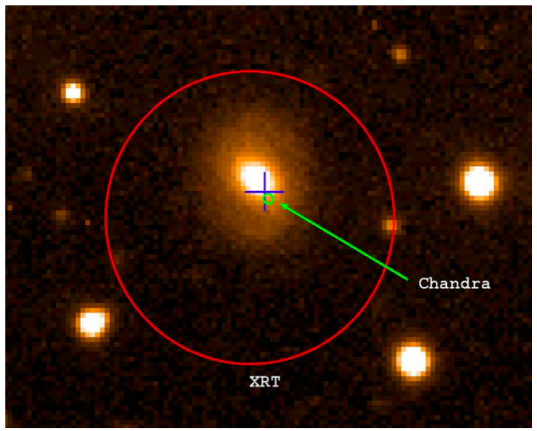
Short GRBs Afterglows and Hosts

GRB 050509B @ z=0.2251
Gehrels et al. 2005, Nature



GRB 0507245 @ z=0.258





Barthelmy at al. 2005, Nature

GRB 050709 @ z=0.16
Villasenor et al., 2005, Nature
(HETEII detection)

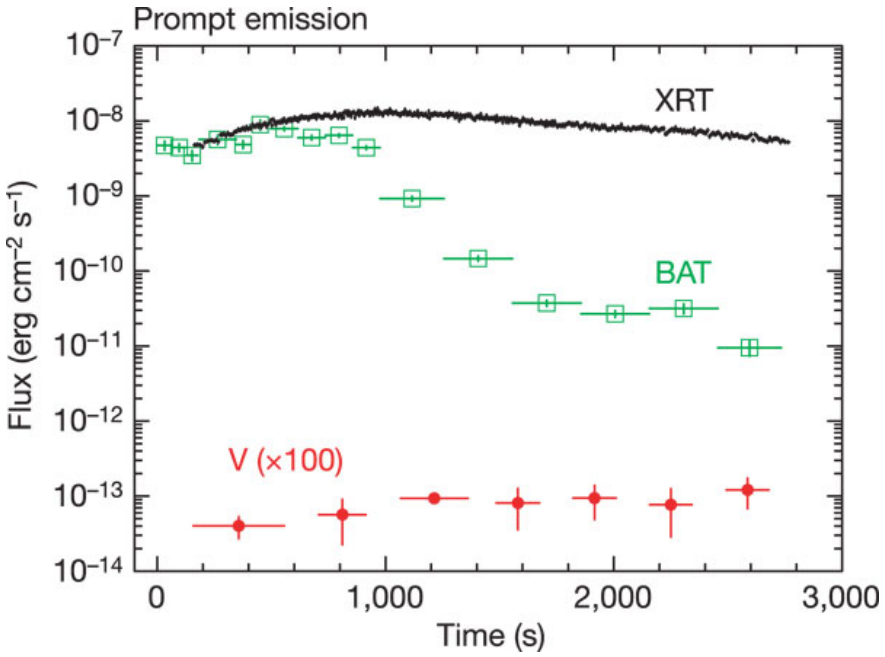
GRBs with SN associations

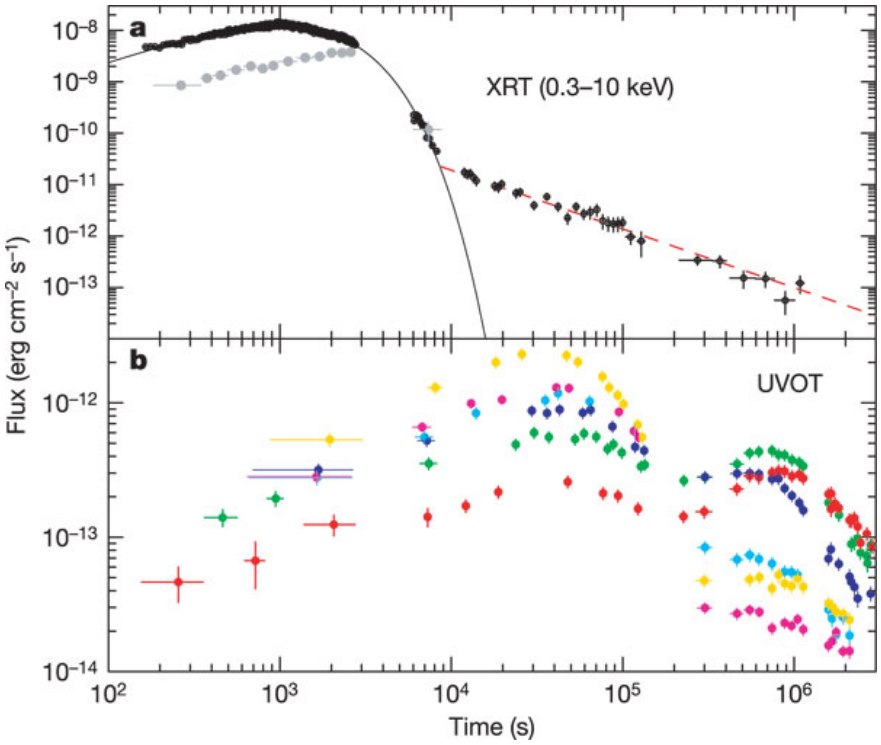
GRB 060218: the first SN shock break out

Associated to type Ib SN 2006 aj
@ z = 0.0331

Campana et al. 2006, Nature, 442, 1008

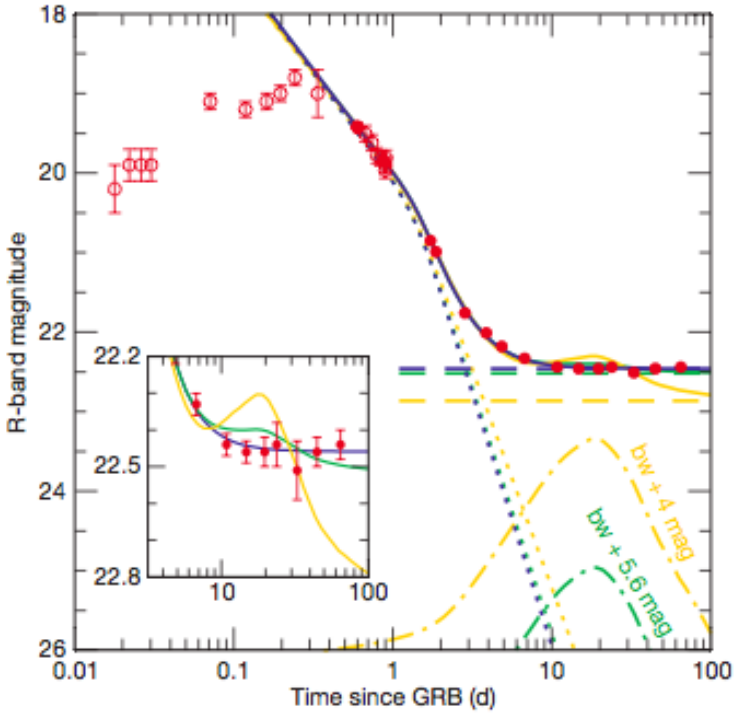
Softening black body detected by XRT and UVOT



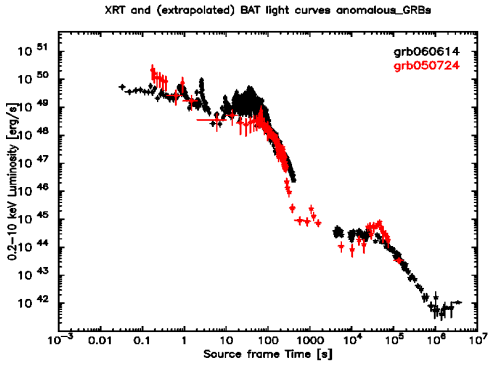


Similar case: GRB 100316d/SN 2010bh
@ z=0.059, Starling et al. 2011, MNRAS, 411, 2792

GRBs lacking SN association



GRB 060614
@ z = 0.125



Della Valle et al. 2006, Nature
Gal-Yam et al. 2006, Nature
Fynbo et al 2006, Nature
Gehrels at al 2006, Nature

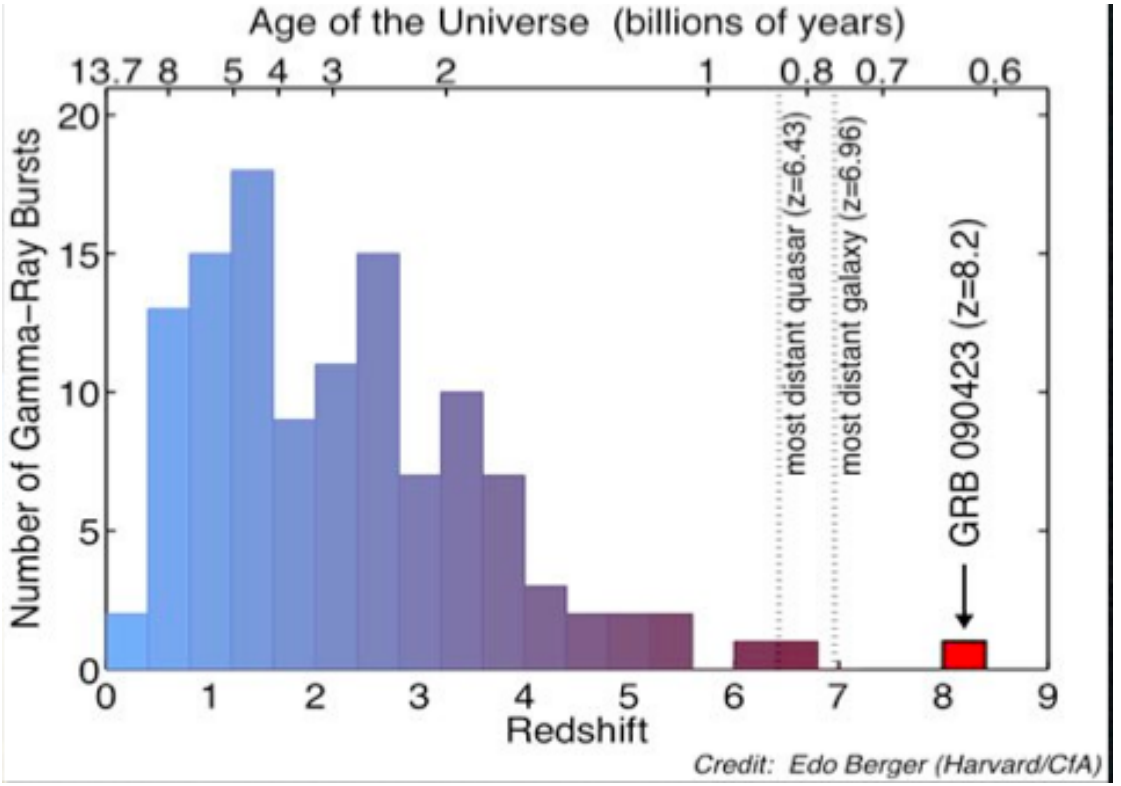
(and also GRB 060505 @ z = 0.089)

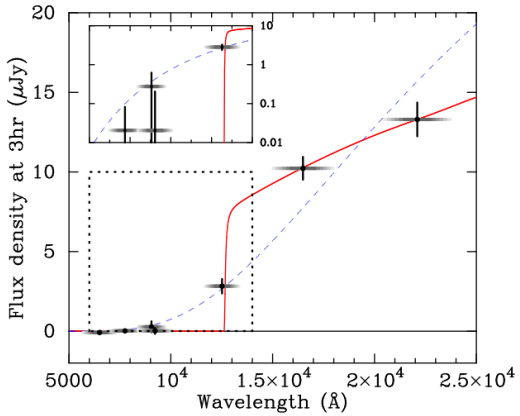
Very High redshift GRBs

GRB 050904 @ z = 6.29
Cusumano et al, 2006, Nature
Kawai et al., 2006, Nature

GRB 080913 @ z = 6.7
Greiner et al., 2009, ApJ

GRB 090423 @ z = 8.2
Salvaterra et al., 2010, Nature
Tanvir et al., 2010, Nature





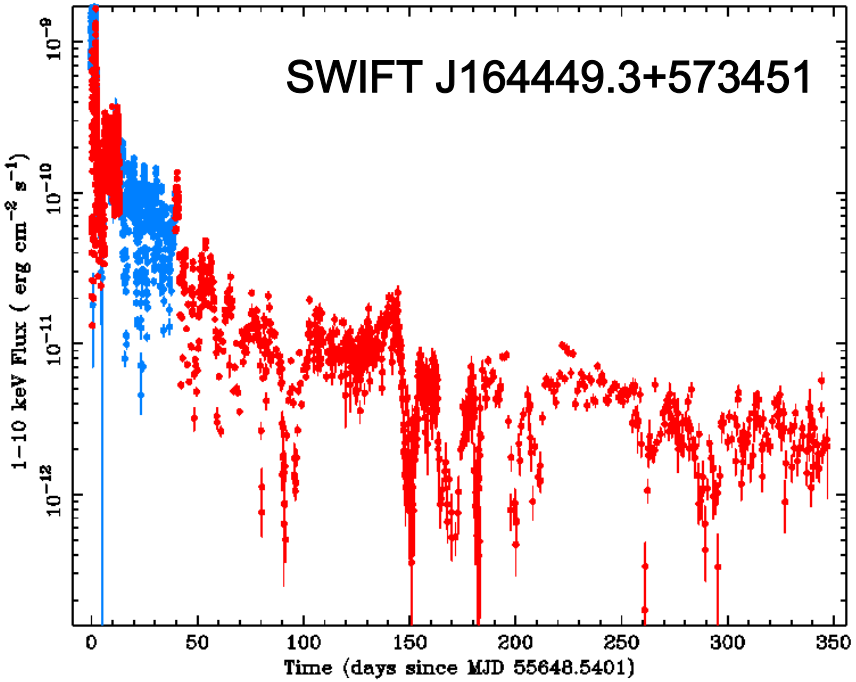
GRB 090429B @ z = 9.4
Cucchiara et al., 2011, ApJ

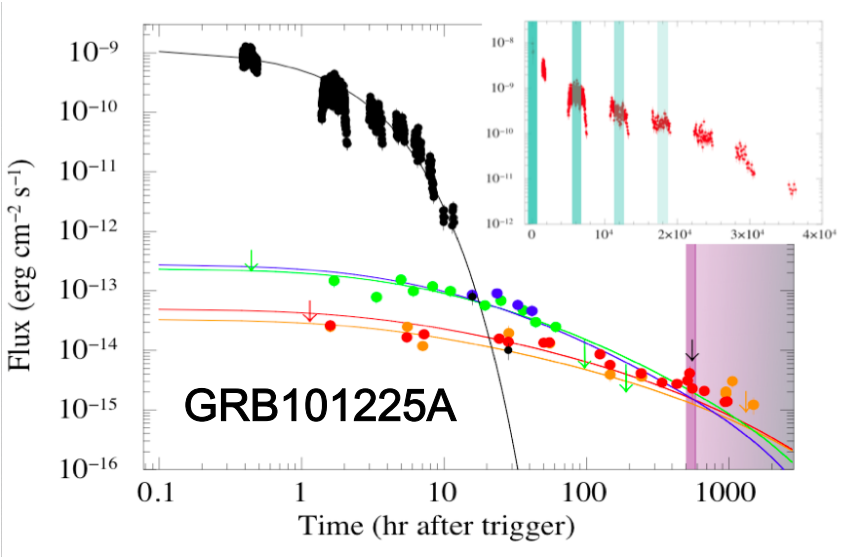
…not only GRBs

Swift is great in catching many kinds of X-ray transients

Novae
LMXBs/HMXBs
SGRs/AXPs
SFXTs
BHCs….
and weird sources

Burrows et al. 2011, Nature





Campana et al. 2011, Nature
Thone et al. 2011, Nature

Swift

is an on going successful mission