Swift Observations of GRB 140206A

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1. Introduction

At 07:17:20 UT, the Swift Burst Alert Telescope (BAT) triggered and located GRB 140206A (trigger=585834) (Lien *et al*. GCN Circ. 15784). Swift slewed immediately to the burst. At the time of the trigger, the initial BAT position was 129° from the Sun (11.6 hours West) and 83° from the 45%-illuminated Moon. **Table 1** contains the best reported positions from Swift, and the latest XRT position can be viewed at http://www.swift.ac.uk/xrt_positions.

Oksanen (GCN Circ. 15786) reported the position for the optical afterglow of this GRB. Oates and Lien (GCN Circ. 15787) reported the detection with UVOT of an optical afterglow. Malesani *et al*. (GCN Circ. 15800) determined a redshift of 2.73 from NOT, and D'Elia *et al*. (GCN Circ. 15802) determined a redshift of 2.74 from TNG. **Table 2** is a summary of GCN Circulars about this GRB from observatories other than Swift.

Standard analysis products for this burst are available at http://gcn.gsfc.nasa.gov/swift_gnd_ana.html.

2. BAT Observations and Analysis

As reported by Sakamoto *et al*. (GCN Circ. 15805), the BAT ground-calculated position is RA, Dec = 145.321, 66.762 deg which is RA(J2000) = $09^h41^m16.9^s$ Dec(J2000) = +66°45'42.7" with an uncertainty of 1.0 arcmin, (radius, sys+stat, 90% containment). The partial coding was 100%.

The mask-weighted light curve (**Figure 1**) shows a multi-peaked structure with roughly three main pulse durations. The first pulse duration starts at ~T-15 s and ends at ~T+25 s, and consists of roughly three to four peaks. The second one starts at ~T+50 s, peaks at ~T+60 s, and ends at ~T+90 s. The third weaker pulse peaks at ~T+210 s, with a long low-level tail out to T+400 s. T_{90} (15-350 keV) is 93.6 ± 13.8 s (estimated error including systematics).

The time-averaged spectrum from T-37.2 to T+256.1 s is best fit by a power law with an exponential cutoff. This fit gives a photon index 1.04 ± 0.15, and E_{peak} of 100.9 ± 14.5 keV (χ^2 52.76 for 56 d.o.f.). For this model the total

fluence in the 15-150 keV band is $1.6 \pm 0.03 \times 10^{-5}$ erg cm^{-2} and the 1-s peak flux measured from T+60.80 s in the 15-150 keV band is 19.4 ± 0.5 ph cm^{-2} s^{-1}. This fluence is larger than that of 96.1% of the long GRBs in the Second BAT GRB Catalog (Sakamoto *et al*. 2011). A fit to a simple power law gives a photon index of 1.58 ± 0.03 (χ^2 91.21 for 57 d.o.f.). All the quoted errors are at the 90% confidence level.

The results of the batgrbproduct analysis are available at http://gcn.gsfc.nasa.gov/notices_s/585834/BA/.

3. XRT Observations and Analysis

Analysis of the initial XRT data was reported by Maselli *et al*. (GCN Circ. 15798). The XRT team has analysed 75 ks of XRT data for GRB 140206A, from 33 s to 760.9 ks after the BAT trigger. The data comprise 1.2 ks in Windowed Timing (WT) mode (the first 9 s were taken while Swift was slewing) with the remainder in Photon Counting (PC) mode. The enhanced XRT position for this burst was given by Osborne *et al*. (GCN Circ. 15793; see **Table 1**).

The late-time light curve (**Figure 2**) (from T0+885 s) can be modelled with an initial power-law decay with an index of α=0.75 (+0.04, -0.03), followed by a break at T+11.5 ks to an α of 1.352 (+0.027, -0.024).

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of 1.688 ± 0.022. The best-fitting absorption column is $1.06 \pm 0.10 \times 10^{22}$ cm^{-2}, at a redshift of 2.73, in addition to the Galactic value of 4.8×10^{20} cm^{-2} (Kalberla *et al*. 2005). The PC mode spectrum has a photon index of 1.88 ± 0.06 and a best-fitting absorption column of 1.01 (+0.24, -0.23) $\times 10^{22}$ cm^{-2}. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 3.8×10^{-11} (4.7×10^{-11}) erg cm^{-2} count^{-1}.

A summary of the PC-mode spectrum is thus:
Galactic foreground: 4.8×10^{20} cm^{-2}
Intrinsic column: 1.01 (+0.24, -0.23) $\times 10^{22}$ cm^{-2} at z=2.73
Photon index: 1.88 ±0.06

The results of the XRT team automatic analysis are available at http://www.swift.ac.uk/xrt_products/00585834.

4. UVOT Observations and Analysis

The Swift/UVOT began settled observations of the field of GRB 140206A 52 s after the BAT trigger (Oates and Lien GCN Circ. 15795). A source consistent with the XRT position (Osborne *et al*. GCN Circ. 15793) and the optical positions reported by Oksanen *et al*. (GCN Circ. 15786) and Yurkov *et al*. (GCN Circ. 15788) is detected in the initial UVOT exposures. **Table 3** gives preliminary magnitudes using the UVOT photometric system (Breeveld *et al*. 2011, AIP Conf. Proc., 1358, 373). No correction has been made for the expected extinction in the Milky Way corresponding to a reddening of E_{B-V} of 0.14 mag. in the direction of the GRB (Schlegel *et al*. 1998).

The UVOT light curve is plotted in Figure 3. The light curve shows a break at 240 ks, followed by a power-law decay with a slope of 1.56.

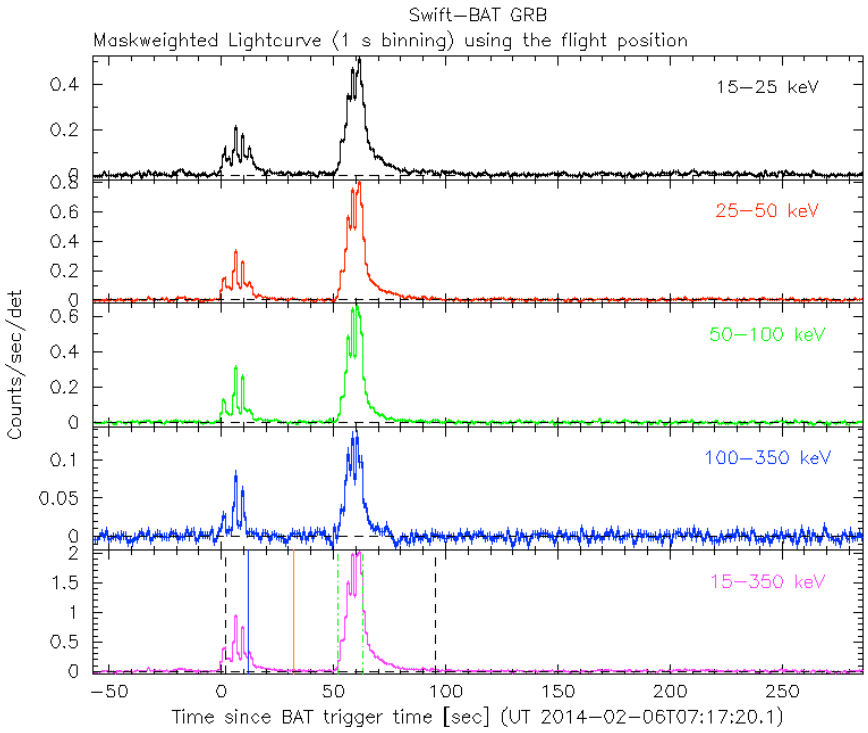

Figure 1. The BAT mask-weighted light curve in the four individual and total energy bands. The units are counts s^{-1} illuminated-detector^{-1}.

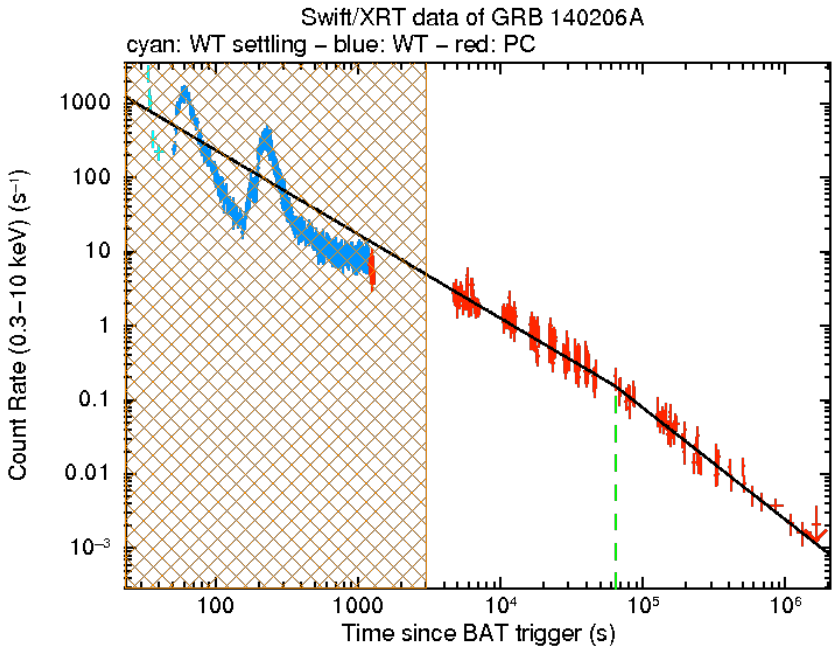

Figure 2. The XRT light curve. Any data from a cross-hatched region are not included in the fit.

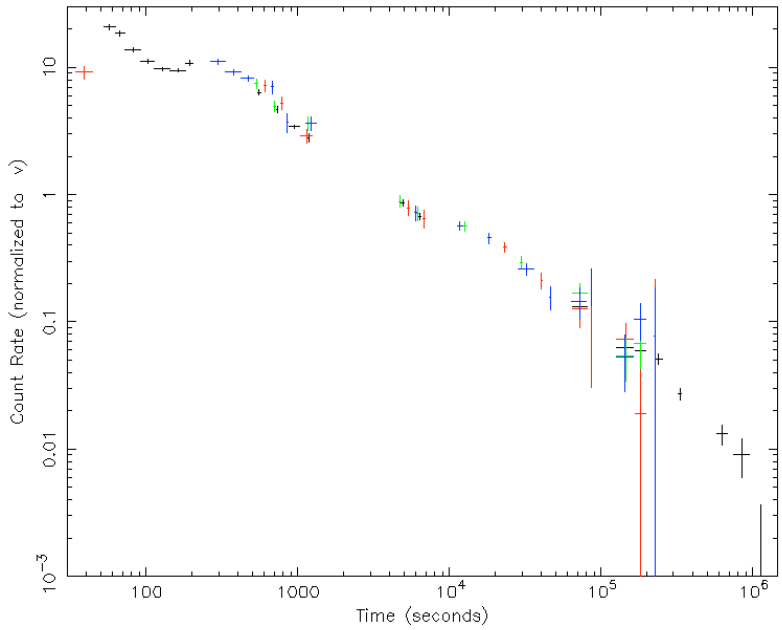

Figure 3. The UVOT light curve, normalized to the v band. Different colors represent light curves in different bands: black=white, red=v, green=b, blue=u.

RA (J2000)	Dec (J2000)	Error	Note	Reference
$09^h41^m20.26^s$	+66°45'38.6"	0.50"	UVOT-refined	Oates and Lien GCN Circ. 15795
$09^h41^m20.24^s$	+66°45'38.5"	1.4"	XRT-final	UKSSDC
$09^h41^m20.29^s$	+66°45'39.6"	1.4"	XRT-enhanced	Osborne *et al*. GCN Circ. 15793
$09^h41^m16.9^s$	+66°45'42.7"	1.0'	BAT-refined	Sakamoto *et al*. GCN Circ. 15805

Table 1. Positions from the Swift instruments.

Band	Authors	GCN Circ.	Subject	Observatory	Notes
Optical	Oksanen	15786	Optical afterglow candidate		detection
Optical	Yurkov *et al*.	15788	MASTER OT detection	MASTER	detection
Optical	Xu *et al*.	15789	Nanshan optical observations	Xinjiang Astro.Obs.	detection
Optical	Volnova *et al*.	15792	ISON-Ussuriysk optical observations	ISON-Ussuriysk	detection
Optical	Sonbas *et al*.	15797	T100 observations	T100	detection
Optical	D'Avanzo *et al*.	15799	TNG optical observations	TNG	detection
Optical	Malesani *et al*.	15800	NOT redshift	NOT	redshift
Optical	Masi and Nocentini	15801	Optical Observations via Virtual Telescope	Virtual Telescope	
Optical	D'Elia *et*	15802	TNG redshift	TNG	redshift

	al.		confirmation		
Optical	Saito *et al*.	15803	MITSuME Akeno detection of the optical counterpart	MITSuME Akeno	detection
Optical	Kopac *et al*.	15806	Liverpool Telescope optical afterglow observations	Liverpool Telescope	detection
Optical	Volnova *et al*.	15807	Mondy optical observations	Mondy	detection
Optical	Quadri	15813	Bassano Bresciano Observatory optical upper limit	Bassano Bresciano Obs.	upper limits
Optical	Toy *et al*.	15835	Discovery Channel Telescope Optical Detection	Discovery Channel	detection
Gamma-ray	Gotz *et al*.	15785	a long GRB detected by INTEGRAL	INTEGRAL	
Gamma-ray	von Kienlin and Bhat	15796	Fermi GBM detection	Fermi GBM	E_{peak}=120±6 keV Fluence=1.47±0.03x 10^{-5}erg cm^{-2} (82^{nd} percentile for long GRBs)

Table 2. Summary of GCN Circulars from other observatories sorted by band and then circular number.

Filter	**T_{start}(s)**	**T_{stop}(s)**	**Exp(s)**	**Mag**

white	52	202	147	15.88 ± 0.02
v	596	616	20	15.75 ± 0.11
b	522	542	20	16.51 ± 0.09
u	264	514	246	16.18 ± 0.04
w1	645	17944	963	>20.9
m2	16137	24450	1607	>21.2
w2	21898	22798	886	>21.0

Table 3. UVOT observations reported by Oates and Lien (GCN Circ. 15795). The start and stop times of the exposures are given in seconds since the BAT trigger. The preliminary detections and 3-σ upper limits are given. No correction has been made for extinction in the Milky Way.

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