Swift Observations of GRB 140502A

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1. Introduction

At 08:30:20 UT, the Swift Burst Alert Telescope (BAT) triggered and located GRB 140502A (trigger=597841) (Swenson *et al*. GCN Circ. 16202). Swift slewed immediately to the burst. **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.

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 Lien *et al*. (GCN Circ. 16208), the BAT ground-calculated position is RA, Dec = 319.172, 48.975 deg, which is RA(J2000) = $21^h16^m41.3^s$ Dec(J2000) = +48°58'28.2" with an uncertainty of 1.2 arcmin, (radius, sys+stat, 90% containment). The partial coding was 99%.

The mask-weighted light curve (**Figure 1**) shows a FRED-shaped peak starting at ~T-3 s, peaking at ~T+2 s, and ending at ~T+20 s. T_{90} (15-350 keV) is 16.9 ± 1.9 s (estimated error including systematics).

The time-averaged spectrum from T-1.66 to T+17.39 s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.22 ± 0.13. The fluence in the 15-150 keV band is 6.7 ± 0.5 x 10^{-7} erg cm^{-2}. This fluence is larger than that of 29% of the long GRBs in the Second BAT GRB Catalog (Sakamoto *et al*. 2011). The 1-s peak photon flux measured from T+1.44 s in the 15-150 keV band is 0.9 ± 0.1 ph cm^{-2} s^{-1}. 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/597841/BA/.

3. XRT Observations and Analysis

Analysis of the initial XRT data was reported by Burrows *et al*. (GCN Circ. 16207). We have analysed 6.3 ks of XRT data for GRB 140502A, from 84 s to 17.3 ks after the BAT trigger. The data are entirely in Photon Counting (PC) mode. The enhanced XRT position for this burst was given by Goad *et al*. (GCN Circ. 16206).

The light curve (**Figure 2**) can be modelled with a power-law decay with a decay index of α=0.85 (+0.23, -0.17).

A spectrum formed from the PC mode data can be fitted with an absorbed power-law with a photon spectral index of 1.7 (+0.8, -0.6). The best-fitting absorption column is 2.2 (+1.4, -1.1) x 10^{22} cm^{-2}, in excess of the Galactic value of 9.5 x 10^{21} cm^{-2} (Willingale *et al*. 2013). The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 7.0 x 10^{-11} (1.3 x 10^{-10}) erg cm^{-2} count^{-1}.

A summary of the PC-mode spectrum is thus:
Total column: 2.2 (+1.4, -1.1) x 10^{22} cm^{-2}
Galactic foreground: 9.5 x 10^{21} cm^{-2}
Excess significance: 1.8 σ
Photon index: 1.7 (+0.8, -0.6)

The results of the XRT team automatic analysis are available at http://www.swift.ac.uk/xrt_products/00597841.

4. UVOT Observations and Analysis

The Swift/UVOT began settled observations of the field of GRB 140502A 75 s after the BAT trigger (Oates and Swenson GCN Circ. 16210). Two bright USNO-B1 sources lie close to the XRT location, with R magnitudes of 13.48 and 13.61, lie within 3 and 9 arcseconds, respectively of the XRT position (Goad *et al*., GCN Circ. 16206). **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 2.97 mag. in the direction of the GRB (Schlegel *et al*. 1998).
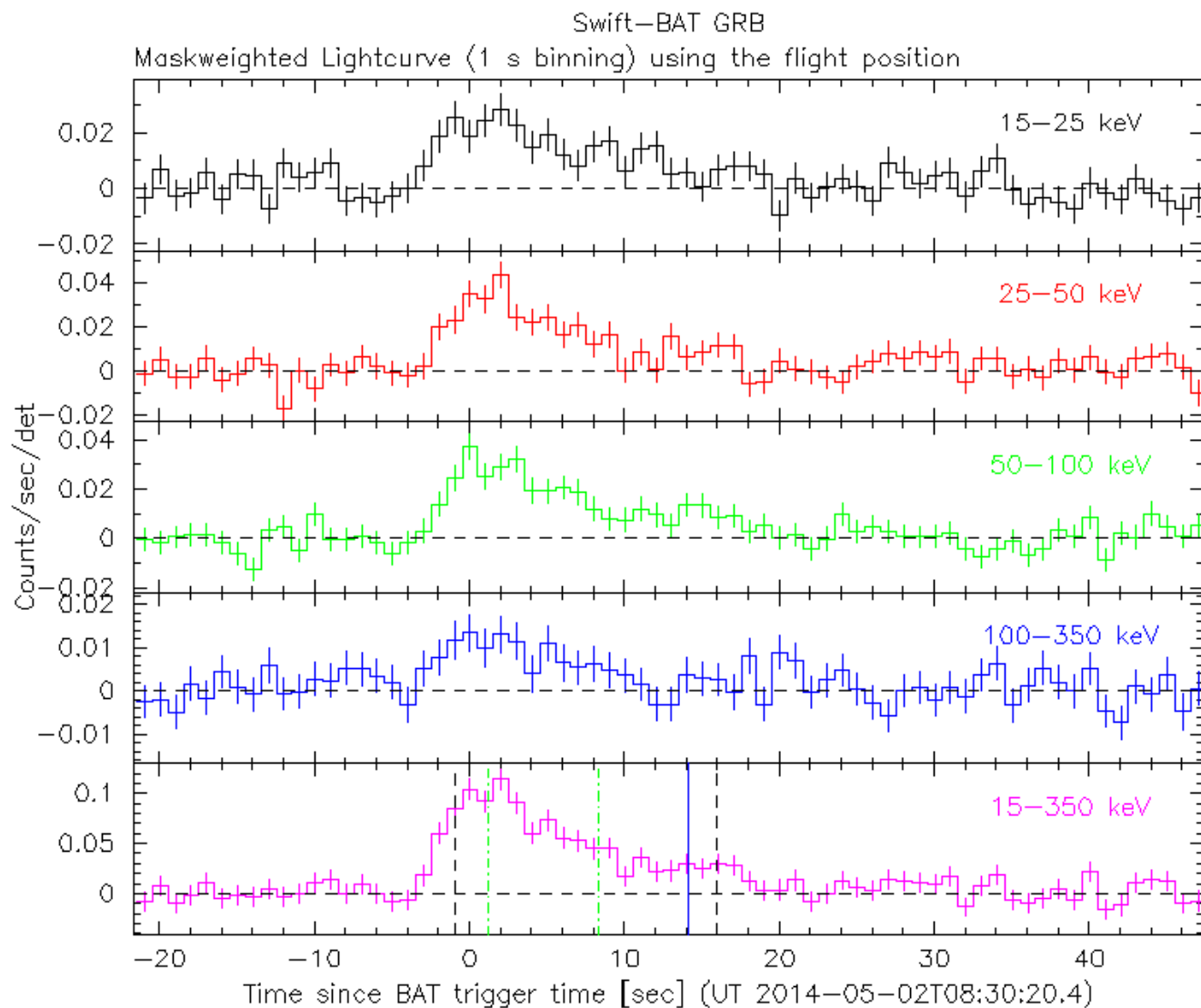
Figure 1. The BAT mask-weighted light curve in the four individual and total energy bands. The units are counts s[-1] illuminated-detector[-1].
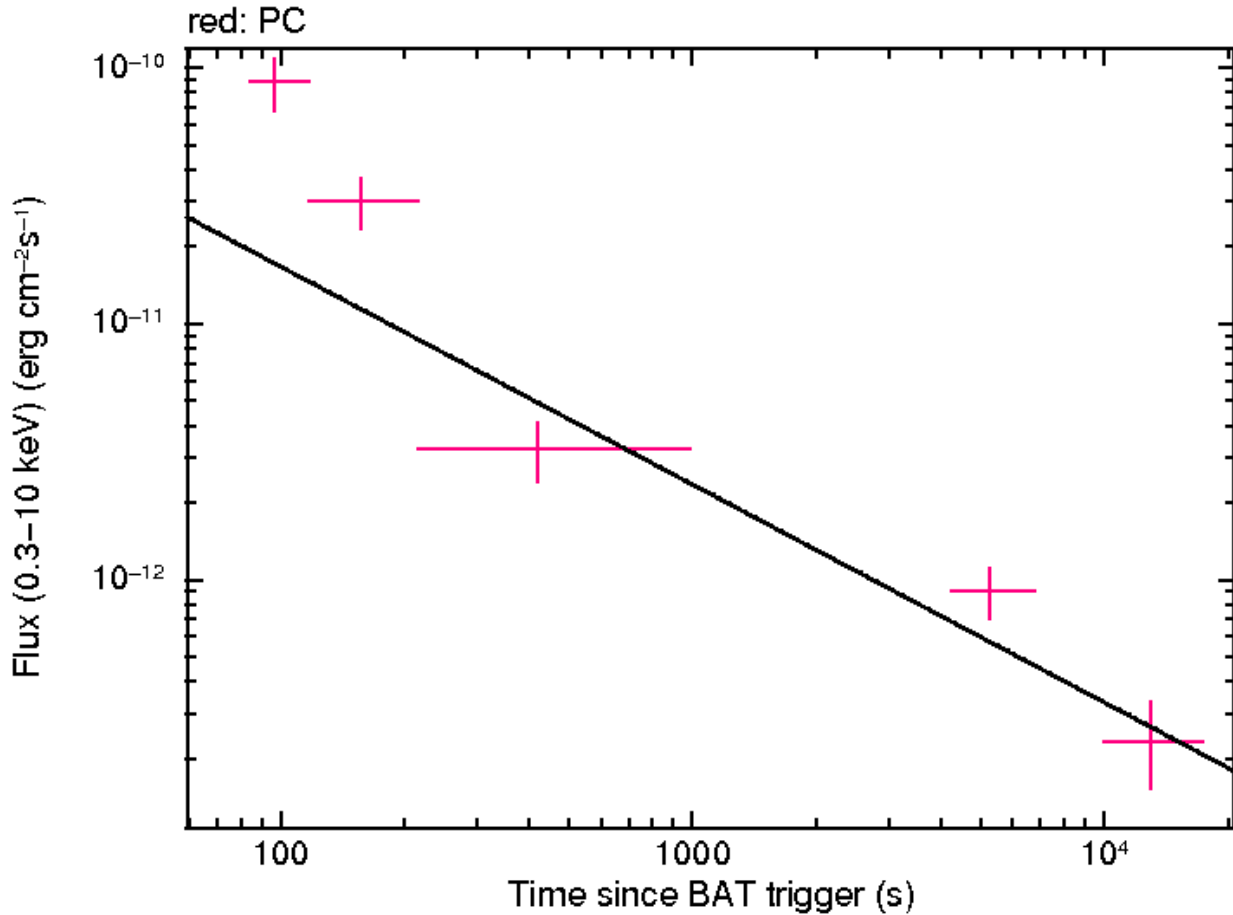
Swift/XRT data of GRB 140502A

red: PC

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

RA (J2000)	Dec (J2000)	Error	Note	Reference
21^{h}16^{m}45.16^s	+48°58'12.7"	2.0"	XRT-final	UKSSDC
21^{h}16^{m}45.16^s	+48°58'12.7"	2.0"	XRT-enhanced	Goad *et al*. GCN Circ. 16206
21^{h}16^{m}41.3^s	+48°58'28.2"	1.2'	BAT-refined	Lien *et al*. GCN Circ. 16208

Table 1. Positions from the Swift instruments.

Band	Authors	GCN Circ.	Subject	Observatory	Notes
Optical	Kuroda *et al*.	16209	MITSuME Okayama upper limits	MITSuME Okayama	upper limits
Optical	Elenin *et al*.	16221	ISON-NM early optical limit	ISON-NM	upper limits
Gamma-ray	Yu	16203	Fermi GBM observation	Fermi GBM	E_{peak}=298±71 keV T_{90}=20 seconds Fluence=1.6±0.2x10^{-6}erg cm^{-2} (24th 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$_{FC}$	75	225	147	>16.0
u$_{FC}$	287	537	246	>16.3
white	75	5702	525	>16.0
v	616	6113	432	>15.0
b	543	11919	337	>16.0
u	287	11811	1347	>16.3
w1	666	17270	1642	>17.9
m2	4681	16734	1262	>20.0
w2	593	5908	432	>18.9

Table 3. UVOT observations reported by Oates and Swenson (GCN Circ. 16210). The start and stop times of the exposures are given in seconds since the BAT trigger. The preliminary 3-σ upper limits are given. No correction has been made for extinction in the Milky Way.

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