

## Swift Observation of GRB 070520A

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### 1 Revisions

- Updated XRT light curve using data out to  $T + 1.9 \times 10^6$ s.
- Revised UVOT data.
- Possible IR afterglow candidate.

### 2 Introduction

At 13:05:10 UT, the Swift Burst Alert Telescope (BAT) triggered and located GRB 070520A (trigger=279817, Romano et al., GCN Circ. 6423). This is an 88-s image trigger, and as such the TDRSS lightcurve does not show anything significant above background, as is typical for image triggers. The BAT light curve showed a single peak with a long tail. T90 (15–350 keV) is  $18 \pm 3$  s (estimated error including systematics). Swift slewed immediately, and the narrow field instruments were on target 159 seconds later. The best Swift position is that determined from the XRT detection of the afterglow at RA(J2000)= 193.36131 deg, Dec(J2000)= +74.99038 deg, RA(J2000)=  $12^{\text{h}}53^{\text{m}}26.72^{\text{s}}$ , Dec(J2000)=  $+74^{\text{d}}59'25.4''$ , with a 90% confidence interval of 4.1 arcsec (Romano et al., GCN Circ. 6427).

No high-significance detection from ground-based facilities has been reported. However, Hattori et al. (GCN Circ. 6441) report that in the XRT error circle they find a possible afterglow candidate as a low-significance source (1.5 sigma) at RA(J2000)=  $12^{\text{h}}53^{\text{m}}26.52^{\text{s}}$ , Dec(J2000)=  $+74^{\text{d}}59'26.6''$ , with a positional uncertainty of  $0.4''$ , and a rough estimation of the magnitude  $z' \sim 24$  mag (FOCAS on the Subaru Telescope, 06:32 to 07:27 May 21 with a total exposure of 1920 s).

### 3 BAT Observation and Analysis

Using the data set from T–239 to T+963 s the BAT team reported further analysis of GRB 070520A (Markwardt et al., GCN Circ. 6428). The BAT ground-calculated position is RA(J2000)= 193.255 deg, Dec(J2000)= +75.005 deg, RA(J2000)=  $12^{\text{h}}53^{\text{m}}1.1^{\text{s}}$ , Dec(J2000)=  $+75^{\text{d}}0'16.6''$ , with an uncertainty of 2.2 arcmin, (radius, sys+stat, 90% containment). The partial coding was 67%.

The mask-weighted light curve (Figure 1) shows a single peak with a long tail. The peak starts at  $\sim T+10$  s, peaks at T+35 s, and ends at  $\sim T+105$  s. The long tail appears to extend out to  $T+370 \pm 30$  s at the  $0.02 \pm 0.01$  ph cm<sup>-2</sup> s<sup>-1</sup> level. T90 (15–350 keV) is  $18 \pm 3$  s (estimated error including systematics).

The time-averaged spectrum from T+25.5 to T+45.4 is best fit by a simple power-law model. The power law index of the time-averaged spectrum is  $1.60 \pm 0.33$ . The fluence in the 15–150 keV band is  $2.5 \pm 0.5 \times 10^{-7}$  erg cm<sup>-2</sup>. The 1-s peak photon flux measured from T+35.80 s in the 15–150 keV band is  $0.4 \pm 0.1$  ph cm<sup>-2</sup> s<sup>-1</sup>. All the quoted errors are at the 90% confidence level.

## 4 XRT Observations and Analysis

Using the data from the first four orbits of XRT data of GRB 070520 (6.5 ks in Photon Counting mode), the refined XRT position is RA(J2000)= 193.36131deg, Dec(J2000)= +74.99038deg, RA(J2000)= 12<sup>h</sup>53<sup>m</sup>26.72<sup>s</sup>, Dec(J2000)= +74<sup>d</sup> 59' 25.4", with a 90% confidence interval of 4 arcsec (Romano et al., GCN Circ. 6427). This is 2.6 arcsec away from the initial XRT position quoted in Romano et al. (GCN Circ. 6423).

The final XRT light curve (Figure 2) was derived from a 203.8 ks total net exposure, up to  $T+1.9 \times 10^6$  s. The XRT light curve exhibits an initial flaring behaviour throughout the first orbit (in the WT data, i.e., up to T+244 s) with an underlying power law with slope  $4.3 \pm 0.5$ . The PC data start at T+3565 s, when the count rate had decreased by three orders of magnitude. The PC data power-law slope is  $0.68 \pm 0.07$ . The last point is a  $3\text{-}\sigma$  upper limit, based on 86 ks of data, is not included in the fit. The light curve, therefore, probably presented a break after  $\sim T + 7 \times 10^5$  s.

The mean WT spectrum, extracted during the flaring activity, can be fit with an absorbed power law with a photon index of  $3.1 \pm 0.2$  and a column density of  $(2.2 \pm 0.4) \times 10^{21} \text{ cm}^{-2}$  significantly in excess of the Galactic value ( $2.3 \times 10^{20} \text{ cm}^{-2}$ ; Dickey & Lockman, 1990). The absorbed (unabsorbed) 0.3–10.0 keV flux for the WT spectrum is  $5.2 \times 10^{-10}$  ( $1.5 \times 10^{-9}$ )  $\text{ergs cm}^{-2} \text{ s}^{-1}$ .

Detailed light curves are available in both graphical and ASCII formats at [http://www.swift.ac.uk/xrt\\_curves/](http://www.swift.ac.uk/xrt_curves/).

## 5 UVOT Observation and Analysis

The Swift/UVOT observed the field of GRB 070520A starting 152 s after the BAT trigger (Immler et al. CGN Circ. 6439). No new source is detected within the XRT refined position in any of the UVOT observations. The 3-sigma upper limits for detecting a source inside the XRT error circle in the co-added frames are reported in Table 1. The reported upper limits are uncorrected for the estimated Galactic reddening of  $E(B - V) = 0.02$  mag towards the direction of the burst (Schlegel et al. 1998).

Filter	T_start (s)	T_stop (s)	Exp (s)	3-sigma UL mag
White	168	4793	273	20.2
V	152	11162	1288	19.6
B	4389	6021	393	20.0
U	4184	16822	1142	20.3
UVW1	3979	16047	1279	20.1
UWM2	3774	11805	1021	20.4
UVW2	4799	10249	1082	20.5

Table 1: Magnitude limits from UVOT observations.

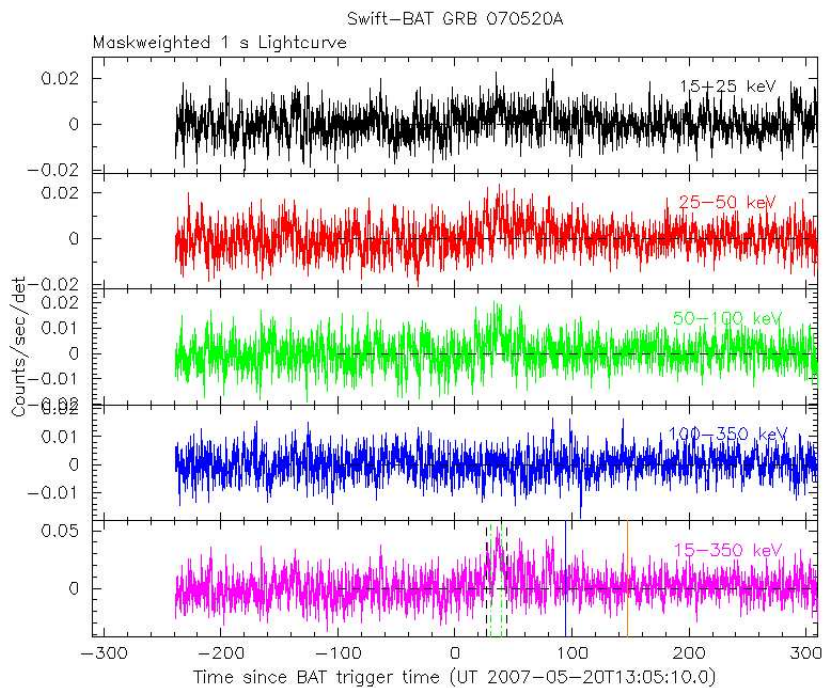


Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. Green dotted line: T50, Black dotted line: T90, Blue: Slew start, Orange: Slew end Time of each bin is in the middle of the bin. The units are counts  $\text{s}^{-1}$  illuminated-detector $^{-1}$  (note illum-det =  $0.16 \text{ cm}^2$ ) and  $T_0$  is 2007-05-20 13:05:10.0 UT.

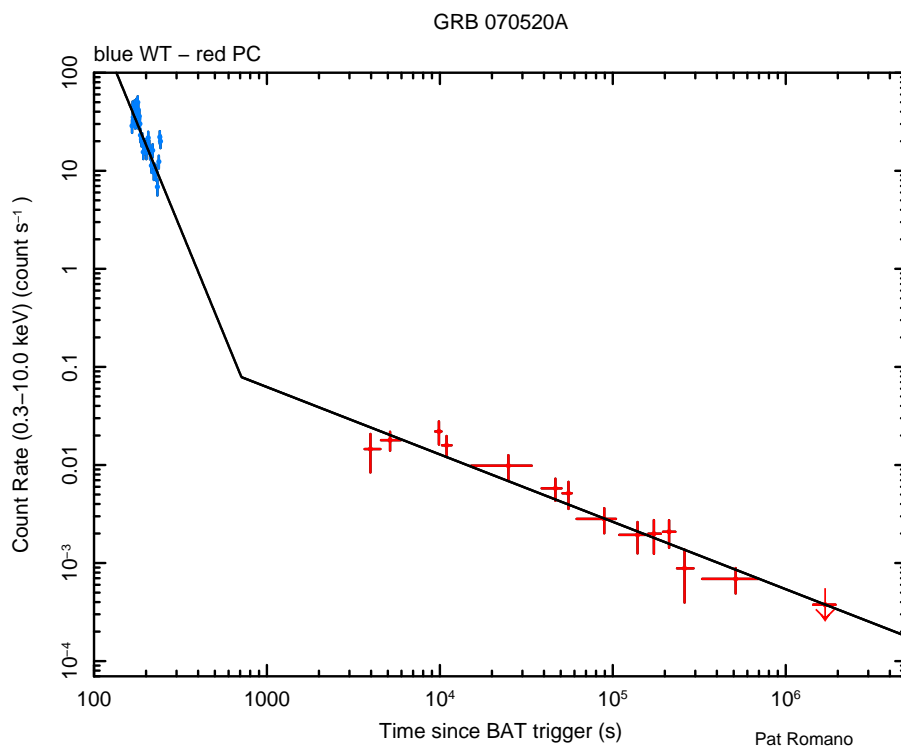


Figure 2: XRT Lightcurve. Counts  $\text{s}^{-1}$  in the 0.3–10 keV band: Window Timing mode (blue), Photon Counting mode (red). The approximate conversion is  $1 \text{ count s}^{-1} \sim 5.5 \times 10^{-11} \text{ erg cm}^{-2} \text{ s}^{-1}$ .