Swift Observation of GRB 070721B

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1 Introduction

BAT triggered on GRB 070721B at 10:33:48 UT (Trigger 285654) (Ziaeepour, et al., *GCN Circ.* 6640). This was a 2.048 sec rate-trigger with significance of 12 on very long burst with $T_{90} \gtrsim 340 \pm 10$ sec. Swift slewed to this burst immediately and XRT began follow-up observations at $T + 92.2$ sec, and UVOT at $\sim T + 88$ sec. Our best position is the UVOT location RA($J2000$) = 33.1373 deg ($02h12m32.95s$), Dec($J2000$) = -2.1946 deg ($-02d11'40.6''$) with an error of 0.9 arcsec. The initial optical magnitude of the afterglow was 16.82 ± 0.1 in White filter ($160 - 650$ nm). Ground follow-up of this burst at $\sim T + 5.45$ hours (Melandri, et al., *GCN Circ.* 6647) did not find any new source in the refined XRT error circle. The magnitude limits are $R > 19.3$ and $I > 17.8$ at 6.4 and 6.2 hours after the trigger, respectively. A deep VLT observation at $\sim T + 21.6$ hours (Malesani, et al., *GCN Circ.* 6651) finds two sources close to the UVOT position with R magnitudes 23.8 and 24.3. The spectrum of the second source shows a DLA and several metallic lines inferring a redshift of $z = 3.626$ for this source. This redshift is consistent with the non-detection of the afterglow in filters bluer than V (De Pasquale & Ziaeepour, *GCN Circ.* 6650). Further observations are planned to test the variability of both objects.

2 BAT Observation and Analysis

Using the data set from $T - 239$ to $T + 903$ sec, further analysis of BAT GRB 070721B has been performed by Swift team (Sakamoto, et al., *GCN Circ.* 6642, Barthelmy, et al., *GCN Circ.* 6649). The BAT ground-calculated position is RA($J2000$) = 33.128 deg ($02h12m30.8s$), Dec($J2000$) = -2.198 deg ($-02d11'54''$) $\pm$ 1.2 arcmin, (radius, systematic and statistical, 90% containment). The partial coding was 23% (the offset angle was 26.67 deg).

The masked-weighted light curves (Fig.1) starts at trigger time $\sim T - 20$ sec a mildly FRED peak with substructures that returns to background at about $T + 20$ sec, following by a small peak lasting until $\sim T + 40$ sec. Another episode of activity begins at $\sim T + 230$ sec to $T + 380$ sec with multiple peak emission observed in all BAT bands. Gaps in the later data do not permit to know if the activity of the source continues further. T_{90} ($15 - 350$ keV) is 340 ± 10 sec (estimated error including systematics).

The time-averaged spectrum from $T - 6.7$ to $T + 359.9$ sec is best fitted by a simple power law model. This fit gives a photon index of 1.34 ± 0.11, ($\chi^2 = 50.05$ for 57 d.o.f.). For this model the total fluence in the $15 - 150$ keV band is $(3.6 \pm 0.2) \times 10^6$ergs cm^{-2}and the 1-sec peak flux measured from $T - 0.19$ *sec* in the $15 - 150$ keV band is 1.5 ± 0.3 ph cm^{-2} sec^{-1}. All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

Using all the available data of the XRT for GRB 070721B ($\sim$ 5.78 ksec in Photon Counting mode), the refined XRT position RA($J2000$) = 33.13710 deg ($02h12m32.90s$), Dec($J2000$) = -2.19462 deg ($-02d11'40.6''$) $\pm$ 3.5 arcsec (90% confidence, including boresight uncertainties)(Beardmore, et al., *GCN Circ.* 6646). This position is within 8.9 arcsec of the initial XRT position (Ziaeepour, et al.*GCN Circ.* 6640) and 0.7 arcsec from the UVOT position (Schady *GCN Circ.* 6641).

The $0.3 - 10$ keV light curve (Fig.2) shows an initial steep decay from $T + 100$ sec to $T + 144$ sec, followed by a number of flares from $T + 255$ sec to $T + 800$ sec which reached a maximum count rate

of 50 count/s at $T + 315$ sec. They coincide with peaks observed in the BAT bands. The underlying decay is a power-law with a slope of approximately -0.9, though it is difficult to be precise because of the flaring activity. There is break at $\sim T + 6000$ sec where the slope decreases to ~ -2.

The X-ray spectrum from the Windowed Timing mode data obtained during the non-flare intervals from the 1st orbit ($T + 144$ sec to $T + 220$ sec and $T + 400$sec to $T + 475$ sec) can be fit with an absorbed power-law to give a photon index of $1.48^{+0.18}_{-0.16}$ and a column density of $1.9^{+1.8}_{-1.9} \times 10^{20}$ cm^{-2}, consistent with the Galactic value of 2.3×10^{20} cm^{-2} in this direction (Kalberla, et al., 2005). The observed $0.3 - 10$ keV flux is $2.37 \pm 0.25 \times 10^{-10}$ ergs cm^{-2} sec^{-1}which corresponds to an unabsorbed flux of $2.45 \pm 0.25 \times 10^{-10}$ ergs cm^{-2} sec^{-1}.

4 UVOT Observation and Analysis

The UVOT began observing the field of GRB 070721B at 10 : 35 : 10 UT, 88.3 sec after the initial BAT trigger (Schady, *GCN Circ.* 6641, De Pasquale et al., *GCN Circ.* 6650). The optical afterglow is detected by Swift/UVOT in White filter and V filter finding chart exposures, taken from ~ 100 sec to 200 sec and from 207 sec to 607 sec after the BAT trigger. It is not detected at $3 - \sigma$ level in other filters and in the same filters after $\sim T + 700$ sec. Table 1 summarizes the magnitudes/magnitude limits of the afterglow.

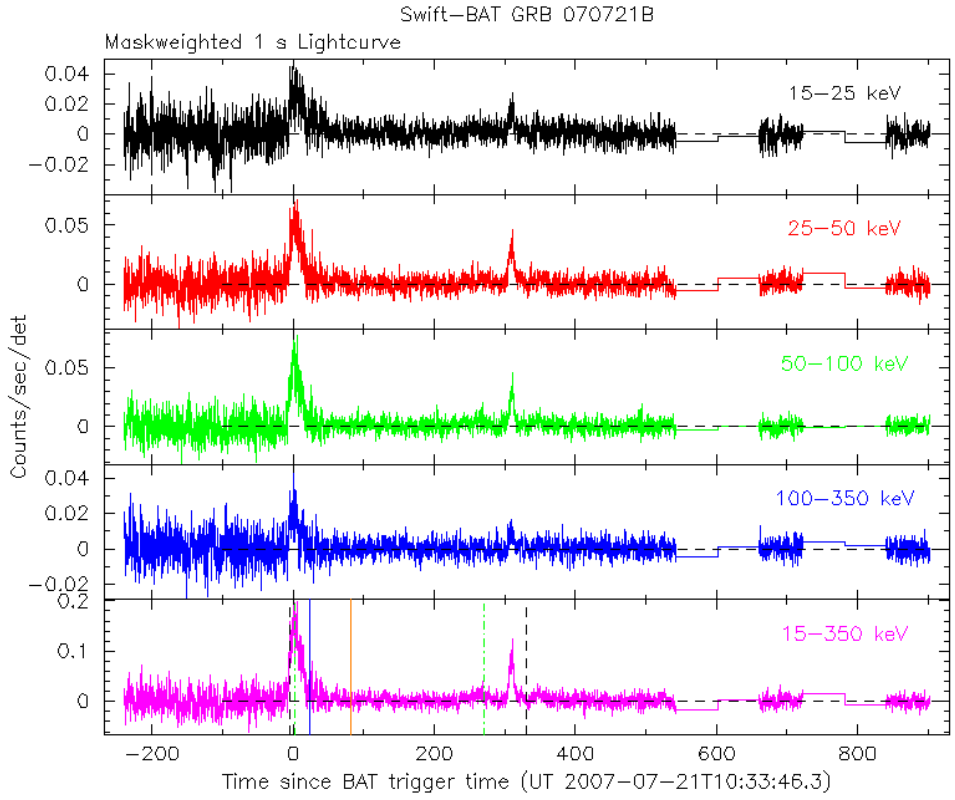

Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/sec/illuminated-detector and T is 10 : 33 : 46.3 UT.

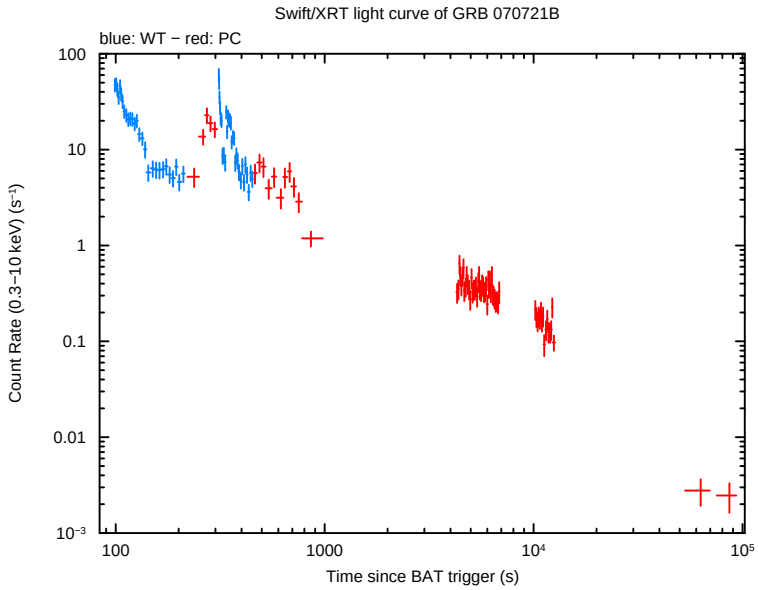

Figure 2: XRT Lightcurve. Counts/sec in the $0.3 - 10$ keV band: Window Timing mode (black), Photon Counting mode (red). The approximate conversion of the absorbed flux is 1 count/sec 5.4×10^{-11} ergs cm^{-2} sec^{-1}.

Filter	T_{mid} sec	Exposure (sec)	Mag/3σ UL
White	$100 - 200$	99	16.82 ± 0.1
White	$701 - 711$	10	> 18.8
White	$855 - 955$	99	> 19.9
White	$5089 - 6716$	393	> 20.9
V	$207 - 453$	399	16.7 ± 0.1
V	$621 - 641$	19	> 17.5
V	$961 - 1116$	154	> 18.3
V	$5500 - 5699$	199	> 18.7
B	$687 - 850$	19	> 18.4
B	$4884 - 6519$	393	> 20.4
U	$662 - 835$	39	> 18.5
U	$4679 - 6314$	393	> 20.1
UW1	$638 - 658$	39	> 18.8
UW1	$638 - 6109$	432	> 20.2
UM2	$613 - 786$	39	> 18.9
UM2	$613 - 5904$	432	> 20.6
UW2	$780 - 800$	19	> 18.8
UW2	$780 - 6902$	385	> 20.3

Table 1: Magnitudes from UVOT observations