

Swift Observation of GRB 070721A

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0 Revisions

The detection of a faint afterglow by the UVOT and a non-varying source in the XRT error circle by ground observation are added. The break in the XRT light curve as well as revised estimation of slopes are reported.

1 Introduction

BAT triggered on GRB 070721A at 10:00:56.4 UT (Trigger 285653) (Ziaeeppour, et al., *GCN Circ.* 6639). This was a 1.02 sec rate-trigger with significance of 6.1 on an intermediate length burst with $T_{90} = 3.868$ sec. Swift slewed to this burst immediately and XRT began follow-up observations at $T + 86$ sec, and UVOT at $T + 69$ sec. Our best position is the XRT location RA($J2000$) = 3.16348 deg (00h12m39.24s), Dec($J2000$) = -28.55017 deg ($-28d22'00.6''$) with an error of 2.3 arcsec (90% confidence, including boresight uncertainties). However, in the UVOT reanalyzed data a faint afterglow was found (Marshall, et al., *GCN Circ.* 6676). Its coordinates are: RA($J2000$) = 3.16343 deg (00h12m39.22s), Dec($J2000$) = -28.55020 deg ($-28d22'00.7''$). The NOT and VLT observations (Malesani, et al., *GCN Circ.* 6674) detect a non-varying source in the XRT error circle at RA($J2000$) = 00h12m39.13s and Dec($J2000$) = $-28d22'00.9''$ with $R \sim 22.9 \pm 0.1$ mag. This source seems to be point-like. No other source is found in the XRT error circle.

2 BAT Observation and Analysis

Using the data set from $T - 119$ to $T + 183$ sec, further analysis of BAT GRB 070721A has been performed by Swift team (Palmer, et al., *GCN Circ.* 6643). The BAT ground-calculated position is RA($J2000$) = 3.144 deg (00h12m34.5s), Dec($J2000$) = -28.530 deg ($-28d31'47''$) ± 2.3 arcmin, (radius, systematic and statistical, 90% containment). The partial coding was 72% (the offset angle was 30.63 deg).

The masked-weighted light curves (Fig.1) starts at trigger time $T - 4$ sec with a single rapidly rising peak, and returns to background at about $T + 8$ sec. T_{90} (15 – 350 keV) is 3.4 ± 0.2 (estimated error including systematics).

The time-averaged spectrum from $T - 0.1$ to $T + 3.7$ sec is best fitted by a simple power law model. This fit gives a photon index of 2.46 ± 0.41 , ($\chi^2 = 52.84$ for 57 d.o.f.). For this model the total fluence in the 15 – 150 keV band is $(7.1 \pm 1.8) \times 10^{-8}$ ergs cm^{-2} and the 1-sec peak flux measured from $T + 0.12$ sec in the 15 – 150 keV band is 0.7 ± 0.1 ph $\text{cm}^{-2} \text{sec}^{-1}$. All the quoted errors are at the 90% confidence level.

We note that the fluence ratio in a simple power-law fit between the 25 – 50 keV band and the 50 – 100 keV band is 1.38. This fluence ratio is larger than 1.32 which can be achieved in the Band function of $\alpha = -1.0$, $\beta = -2.5$, and $E_{peak} = 30$ keV. Thus, preliminary analysis shows that E_{peak} of the burst is very likely around or below 30 keV. Therefore the burst can be classified as an X-ray flash.

3 XRT Observations and Analysis

Using all the available data of the XRT for GRB 070721A the refined XRT position is $\text{RA}(J2000) = 3.16348 \text{ deg } (00h12m39.24s)$, $\text{Dec}(J2000) = -28.55017 \text{ deg } (-28d33'00.6'') \pm 2.3 \text{ arcsec}$ (90% confidence, including boresight uncertainties). This position is within 3.2 arcsec of the initial XRT position (Ziaepour, et al. *GCN Circ.* 6639).

The 0.3 – 10 keV light curve (Fig.2) shows an initial steep decline with a slope of $2.98^{+0.51}_{-0.30}$ until $T + 279^{+72}_{-53}$ sec, following by a shallow slope of $0.71^{+0.069}_{-0.070}$ that lasts until $\sim T + 114000^{+43600}_{-11200}$ and then breaks to a slope of $1.27^{+1.20}_{-0.46}$.

The Photon-Counting X-ray data can be modeled with an absorbed power-law with spectral index of $2.30^{+0.42}_{-0.32}$. The NH column density is $6.11^{+7.8}_{-5.2} \times 10^{20} \text{ cm}^{-2}$, consistent with the galactic column density, $6.01 \times 10^{20} \text{ cm}^{-2}$. The average observed (unabsorbed) flux over 0.3 – 10 keV for this spectrum (spanning a time from 86 sec to 3×10^4 sec after the trigger) is $6.53 \times 10^{-12} \text{ ergs cm}^{-2} \text{ sec}^{-1}$.

4 UVOT Observation and Analysis

The UVOT began observing the field of GRB 070721A at 10 : 02 : 05 UT, 69 sec after the initial BAT trigger (Schady et al., *GCN Circ.* 6648). No new source was detected within the XRT error circle in the White (156 sec) and V (453 sec) finding exposures, or in the co-added images in any filter down to 3-sigma magnitude. Upper limits are summarized in Table 1. These upper limits are not corrected for Galactic extinction $E(B-V) = 0.1$. A reanalysis of the UVOT data (Marshall, et al., *GCN Circ.* 6676) finds a fading afterglow in the exposures starting at $T + 88$ sec for 100 sec in White and at $T + 194$ sec for 400 sec in V. The corresponding magnitudes are respectively 21.4 mag (2.4σ detection) and 20.2 mag (3.4σ detection). The position of this source is: $\text{RA}(J2000) = 3.16343 \text{ deg } (00h12m39.22s)$, $\text{Dec}(J2000) = -28.55020 \text{ deg } (-28d22'00.7'')$.

Filter	T_{mid} sec	Exposure (sec)	3-Sigma UL
White	1088	156	> 21.7
V	1194	453	> 20.9
B	1509	97	> 19.5
U	1359	117	> 20.0
UVW1	1334	117	> 19.6
UVM2	1309	117	> 19.2
UVW2	1530	97	> 19.4

Table 1: Magnitude limits from UVOT observations

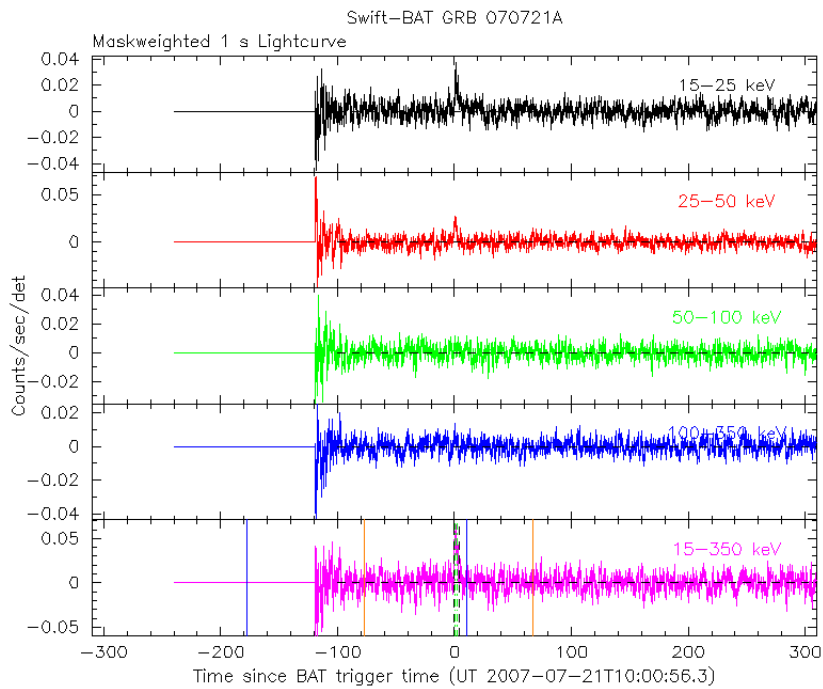


Figure 1: BAT light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/sec/illuminated-detector and T_0 is 10 : 00 : 56.3 UT.

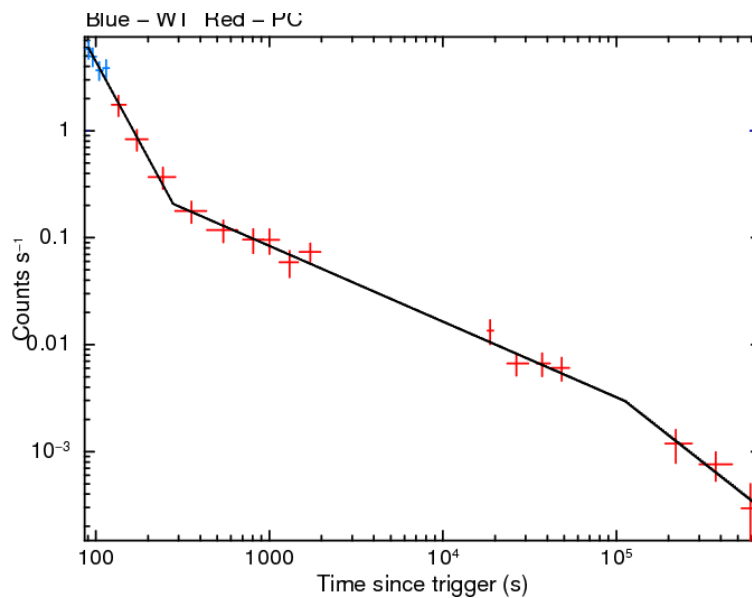


Figure 2: XRT light curve in the 0.3 – 10 keV band: Window Timing mode (blue), Photon Counting mode (red). The approximate conversion factor to absorbed flux is 1 count/sec $\sim 4.267 \times 10^{-11}$ ergs cm^{-2} sec^{-1} and to unabsorbed flux 1 count/sec $\sim 5.450 \times 10^{-11}$ ergs cm^{-2} sec^{-1} .