

## Swift Observations of GRB 071122

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### 1 Introduction

At 01:23:25 UT, on November 22, 2007, BAT triggered on GRB 071122 (trigger #297114) (Stamatikos et al., GCN Circ. 7121). This was a long GRB with a  $T_{90}$  of  $\sim 70$  seconds in BAT. Swift slewed immediately allowing for XRT and UVOT follow-up observations at T+146 and T+145 seconds, respectively, resulting in the detection of an afterglow candidate in XRT and UVOT. Our best localization is from the XRT afterglow position of RA, DEC (J2000) = 18h 26m 25.31s, 47d 04' 30.1" (Evans et al., GCN Circ. 7126), with an uncertainty of 1.7" (radius, 90% confidence), which was corroborated by subsequent UVOT detection at RA, DEC (J2000) = 18h 26m 25.38s, 47d 04' 30.8" (Brown et al., GCN Circ. 7131). Both localizations are consistent with ground based optical observations of a source at coordinates RA, DEC (J2000) = 18h 26m 25.23s, 47d 04' 31.3" (Cenko et al., GCN Circ. 7125), which lead to an absorption redshift of 1.14 (Cucchiara et al., GCN Circ. 7124). The proximity of this GRB to the sun precluded further Swift observation.

### 2 BAT Observations and Analysis

Using the data set from T-239 to T+723 sec from recent telemetry downlinks, further analysis of BAT GRB 071122 was performed by the Swift team (Sakamoto et al., GCN Circ. 7128). The BAT ground-calculated position is RA, Dec (J2000) = 276.576 deg (18h 26m 18.2s), 47.102 deg (47d 06' 06") with an uncertainty of 2.3 arcmin (radius, sys+stat, 90% containment). The partial coding was 69%.

The mask-weighted light curve (Figure 1) shows a single, roughly symmetrical peak starting at  $\sim T-30$  sec, peaking at  $\sim T+5$  sec, and ending at  $\sim T+60$  sec. The  $T_{90}$  (15-350 keV) is  $68.7 \pm 14.4$  sec (estimated error including systematics).

The time-averaged spectrum from T-29.4 to T+47.3 sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is  $1.77 \pm 0.31$ . The fluence in the 15-150 keV band is  $5.8 \pm 1.1 \times 10^{-5}$  ergs/cm<sup>2</sup> and the 1-sec peak photon flux measured from T+3.00 sec in the 15-150 keV band is  $0.4 \pm 0.2$  photons/cm<sup>2</sup>/sec. All the quoted errors are at the 90% confidence level.

Under a  $\Lambda$ CDM cosmological model<sup>1</sup>, with  $H_o \sim 73^{+3.1}_{-3.2}$  km/Mpc/s,  $\Omega_M \sim 0.241 \pm 0.034$ , and  $\Omega_\Lambda \sim 0.759 \pm 0.034$ , the absorption redshift of  $z=1.14$  (Cucchiara et al., GCN Circ. 7124) translates into a luminosity distance of  $d_L \sim 7745 \pm 1946$  Mpc  $\sim 2.39 \pm 0.60 \times 10^{28}$  cm. When coupled with the BAT fluence reported above, this results in a preliminary isotropic energy emission estimate of  $\sim 1.95 \pm 1.05 \times 10^{51}$  ergs in the 15-150 keV observed ( $\sim 32-321$  keV GRB rest frame) band pass.

### 3 XRT Observations and Analysis

The XRT began observing the field at T+146 seconds and found an uncatalogued fading X-ray source based upon the analysis of 1.4 ksec of data, comprised of 125 sec in Windowed Timing (WT) mode and 1.3 ksec in Photon Counting (PC) mode (Evans et al., GCN Circ. 7126). Using 778 sec of overlapping XRT PC mode and UVOT V-band data, an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue) was found at RA, DEC (J2000) = 276.60547 deg (18h 26m 25.21s), 47.07504 deg (47d 04' 30.1"), with an error radius of

<sup>1</sup>Spergel et al., ApJSS 170:377-408 (2007).

1.7 arcsec (90% confidence). This position is 1.5 arcsec from the optical afterglow reported by Cenko et al., GCN Circ. 7125, 74 arcsec from the initial BAT position, within the BAT error circle, and 7.1 arcsec from the initial XRT position (Stamatikos et al., GCN Circ. 7121).

The 0.3 – 10 keV X-ray light curve (Figure 2) follows a power-law decay with  $\alpha = 2.52_{-0.09}^{+0.10}$ , with a small flare at approximately T+400 sec. The WT mode spectrum can be fitted with an absorbed power-law, with the absorption column fixed at the Galactic value of  $4.75 \times 10^{20} \text{ cm}^{-2}$ . Adding a redshifted absorber at  $z=1.14$  (Cucchiara et al., GCN Circ. 7124) improved the fit marginally, with  $\chi^2$  decreasing from 36.14 for 39 degrees of freedom, to 32.83 for 38 degrees of freedom. An f-test indicates that the probability of this being a chance improvement is  $\sim 5\%$ . The redshifted absorber has a column density of  $9.9_{-9.0}^{+10.0} \times 10^{20} \text{ cm}^{-2}$ , and a power-law index, gamma of  $2.00_{-0.13}^{+0.14}$ . The observed (unabsorbed) 0.3-10 keV flux is  $2.52 \times 10^{-10}$  ( $3.04 \times 10^{-10}$ )  $\text{ergs/cm}^{-2}/\text{s}$ .

## 4 UVOT Observations and Analysis

UVOT took a finding chart exposure of 100 seconds with the White (160-650 nm) filter starting at T+145 seconds. Initially, no afterglow candidate was found in the  $2.7' \times 2.7'$  sub-image covering 100% of the XRT error circle, resulting in a  $3\sigma$  upper limit of 19.4 mag. No correction was made for the expected extinction corresponding to E(B-V) of 0.05.

However, subsequent analysis (Brown et al., GCN Circ. 7131) resulted in the detection of a faint source (Figure 3) within the first white exposure at a position of RA, DEC (J2000) = 18h 26m 25.38s, 47d 04' 30.8'', consistent with the optical afterglow (Cenko et al., GCN Circ. 7125) and the revised XRT position (Evans et al., GCN Circ. 7126). The afterglow is detected at a level of  $4\sigma$  and has a magnitude of white =  $20.8 \pm 0.3$  at a midpoint time of T+196 seconds. It is not detected in subsequent exposures in white or the other 6 filters. The detection and  $3\sigma$  upper limits in the coadded frames are summarized in Table 1.

Filter	T <sub>Start</sub> (sec)	T <sub>Stop</sub> (sec)	Exposure Time (sec)	Magnitude (or $3\sigma$ U.L.)
White	145	245	100	$20.8 \pm 0.3$
White	748	1483	119	> 21.3
V	252	1517	823	> 21.2
B	733	1469	30	> 19.6
U	708	1444	40	> 19.4
UVW1	684	703	20	> 19.2
UVM2	658	1395	59	> 18.7
UVW2	763	1508	40	> 18.8

Table 1: Optical afterglow magnitude detection and  $3\sigma$  upper limits from UVOT observations of GRB 071122 (Brown et al., GCN Circ. 7131). N.B. - The values quoted above are not corrected for the expected Galactic extinction corresponding to a reddening of E(B-V) = 0.048 mag towards the direction of the burst (Schlegel et al. ApJ 500: 525-553, 1998).

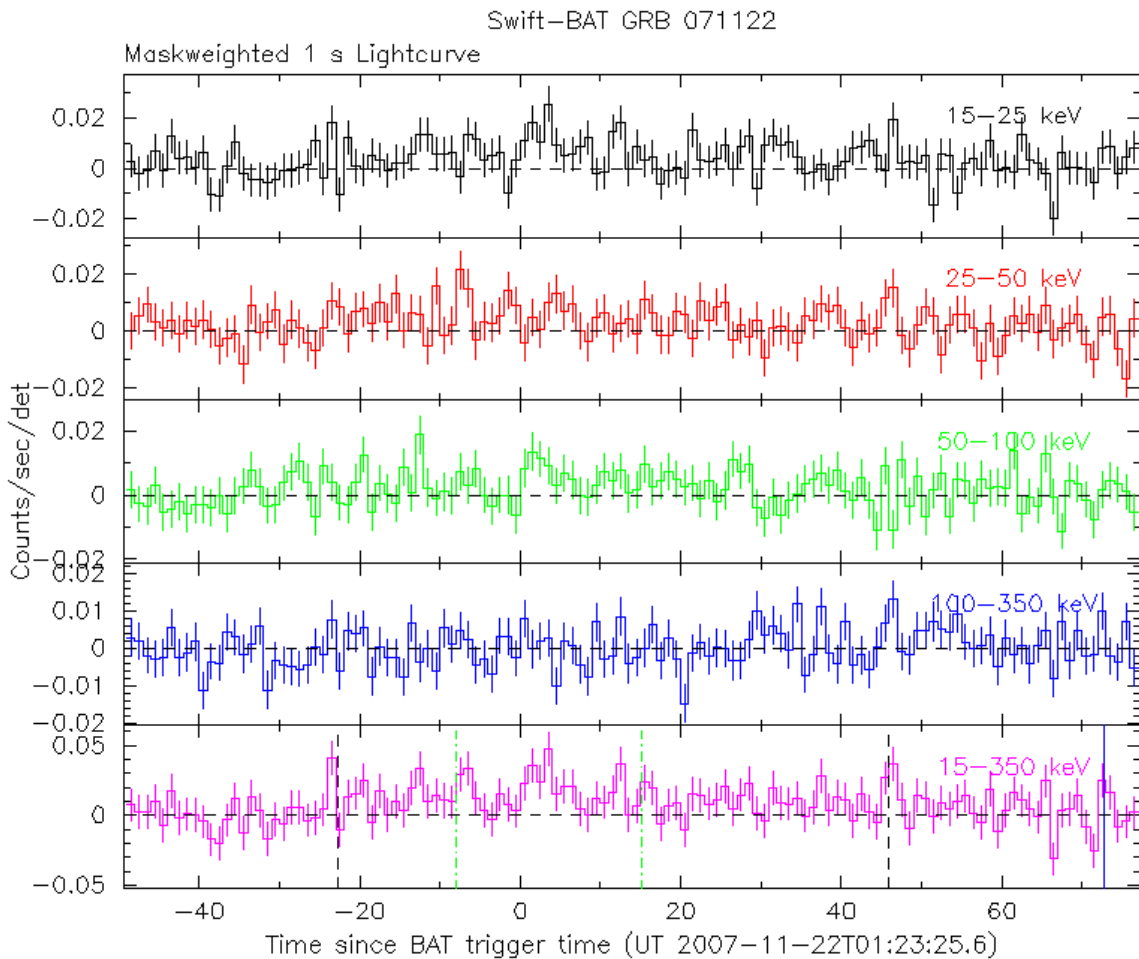


Figure 1: BAT Light curve for GRB 071122. The mask-weighted light curve in the 4 individual plus total energy bands. The green and black dotted lines bracket the  $T_{50}$  and  $T_{90}$  intervals, respectively, while the blue solid line indicates the start of the slew. The time of each bin is in the middle of the bin. The units are counts/sec/illuminated-detector and  $T_0$  is 01:23:25 UT.

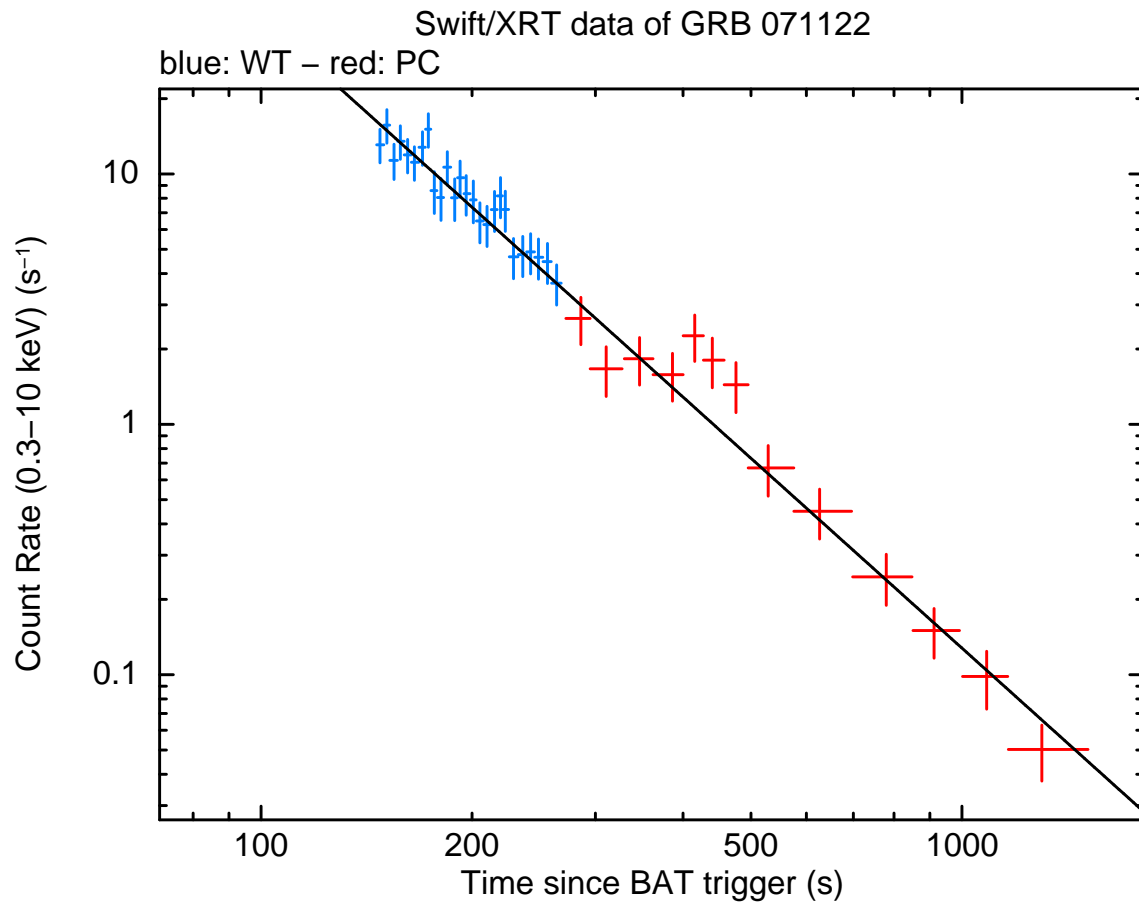


Figure 2: XRT light curve of GRB 071122, in the 0.3–10 keV energy band, for windowed timing (blue) and photon counting (red) modes. The counts to (observed) flux conversion factor is  $\sim 3.6 \times 10^{-11}$  erg/cm<sup>2</sup>/s/count.

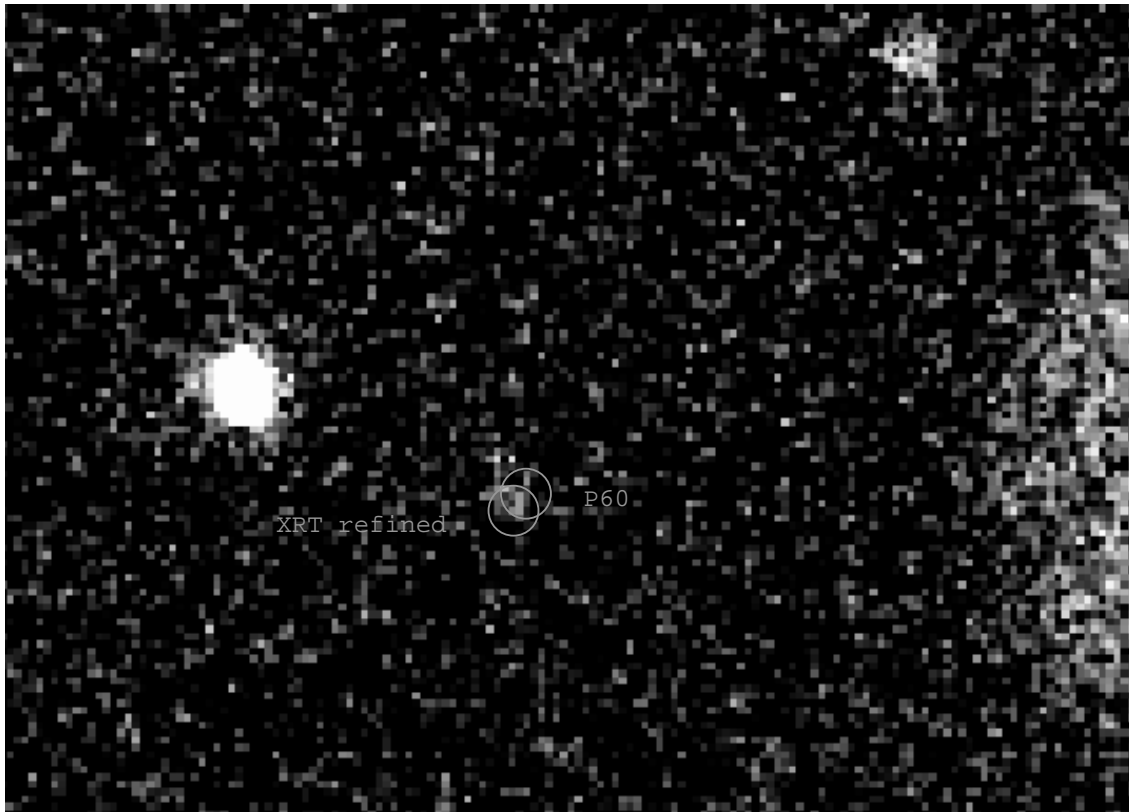


Figure 3: UVOT finding chart for GRB 071122, based upon an exposure of 100 sec with the White (160-650 nm) filter starting at T+145 sec, with XRT refined (Evans et al., GCN Circ. 7126) and P60 optical afterglow (Cenko et al., GCN Circ. 7125) error radii.