Swift Observations of GRB 111121A

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1   Introduction

The Swift BAT triggered on and located GRB 111121A at 16:26:24 UT (trigger=508161) (D'Elia et al., GCN Circ. 12578). Swift slewed immediately to the burst and XRT and UVOT observations of the field started 66 and 86 seconds after the trigger, respectively. The best Swift position is the XRT localization at RA(J2000)= 154.76122 deg, Dec(J2000)= -46.67072 deg, RA(J2000)= $10^h19^m2.69^s$, Dec(J2000)= -46^d 40' 14.6", with an error radius of 1.4 arcsec (90% confidence).

GRB111121A has been also detectedb by Konus-Wind (Golenetskii et al., GCN Circ. 12585), Suzaku-WAM (Chuang et al., GCN Circ. 12607) and INTEGRAL/SPI-ACS.

The optical afterglow was not detected by UVOT, also due to the presence of a bright ($R \sim 12.4$) star close to the XRT position. A faint source at the southern edge of the XRT error circle has been reported by Fong et al. (GCN Circ. 12583).

2   BAT Observations and Analysis

Using the data set from T-60 to T+243 sec (Cummings et al., (GCN Circ. 12581), the BAT ground-calculated position is RA, Dec(J2000) = 154.746, -46.670 deg, which is RA(J2000) = $10^h18^m59.1^s$ Dec(J2000) = $-46^d40'10.7$" with an uncertainty of 1.1 arcmin, (radius, sys+stat, 90% containment). The partial coding was 64%.

The mask-weighted light curve (Figure 1) shows an inital strong pulse composed of two overlapping peaks, the first starting at $\sim T - 0.3$ sec and peaking at $\sim T + 0.17$ sec (at 2.6 cnts/det/sec). The second peaks at $\sim T + 0.3$ sec and is done by $\sim T + 0.6$ sec. This is followed by two episodes of extended emission. The first is roughly constant (~ 0.02 to 0.03 cnts/det/sec) out to $\sim T + 65$ sec. The second episode is ~ 0.006 cnts/det/sec out to $\sim T + 130$ sec. T90 ($15 - 350$ keV) is 119 ± 16 sec (estimated error including systematics). This T90 includes the extended emission.

The spectral lag is $10.2^{+2.6}_{-1.8}$ ms (for the $100 - 350$ to $25 - 50$ keV band) and $12.7^{+6.8}_{-8.7}$ ms (for the $50 - 100$ to $15 - 25$ keV band). This puts it on the long end of the distribution for spectral lag for short GRBs.

The time-averaged spectrum from T-0.34 to T+141.08 sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.66 ± 0.12. The fluence in the 15-150 keV band is $(2.2 \pm 0.2) \times 10^{-6}$ erg/cm2. The 1-sec peak photon flux measured from T-0.26 sec in the 15-150 keV band is 7.1 ± 0.3 ph/cm2/sec. 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/508161/BA/

3   XRT Observations and Analysis

Swift-XRT began observing the field of GRB 111121A at 09:54:57.8 UT, 136.5 seconds after the BAT trigger (D'Elia et al., GCN Circ. 12578, Sbarufatti et al., GCN Circ. 12582, Evans et al., GCN Circ. 12579).

Using 7570 s of XRT Photon Counting mode data and 12 UVOT images for GRB 111121A, the astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT

field sources to the USNO-B1 catalogue): RA(J2000)= 154.76122 deg, Dec(J2000)= −46.57072 deg, RA(J2000)= $10^h19^m2.69^s$, Dec(J2000)= −46^d 40' 14.6", with an uncertainty of 1.4 arcsec (radius, 90% confidence).

XRT data for GRB 111121A (D'Elia et al. GCN Circ. 12578), from 66 s to 64.5 ks after the BAT trigger, comprise 180 s in Windowed Timing (WT) mode (the first 9 s were taken while Swift was slewing) with the remainder in Photon Counting (PC) mode. The enhanced XRT position for this burst was given by Evans et al. (GCN. Circ. 12579).

Analyzing 17.4 ks of XRT data, the 0.3–10 keV light curve (Figure 2) can be modelled with a series of power-law decays. The initial decay index is $\alpha_1 = 1.85 \pm 0.09$. At T+213 s the decay steepens to $\alpha_2 = 3.4^{+1.2}_{-0.7}$. The light curve breaks again at T+411 s to a decay with $\alpha_3 = 0.91^{+0.09}_{-0.1}$, before a final break at T+8.9 ks after which the decay index is $\alpha_4 = 1.8 \pm 0.3$. At later times there are no more observations.

A spectrum formed from the 17.2 ks of PC mode data can be fitted with an absorbed power-law with a photon spectral index of $\Gamma = 1.88^{0.15}_{-0.17}$ and a best-fitting absorption column of $N_H = 3.4 \pm 0.7 \times 10^{21}$ cm^{-2}, in excess of the Galactic value of $N_H = 1.2 \times 10^{21}$ cm^{-2} (Kalberla et al. 2005). The counts to observed (unabsorbed) $0.3 - 10$ keV flux conversion factor deduced from the PC spectrum is 4.5×10^{-11} (7.0×10^{-11}) erg cm^{-2} count^{-1}.

All the quoted errors are at the 90% confidence level.

4   UVOT Observation and Analysis

The UVOT observed the field of GRB 110210A settling 86 s after the BAT trigger (Kuin et al., GCN Circ. 12584).

The XRT enhanced position falls within the PSF wings of a $B \sim 13.6$ magnitude star. No optical afterglow consistent with the enhanced XRT position (Evans et al, GCN Circ. 12579) is detected in the initial UVOT exposures or in the summed ones. Preliminary 3-sigma upper limits for detecting a source in the finding charts and in the following exposures are listed in Table 1. The quoted upper limits have not been corrected for the expected Galactic extinction along the line of sight corresponding to a reddening of $E_{(B-V)} = 0.26$ mag (Schlegel, et al., 1998, ApJS, 500, 525). All photometry is on the UVOT photometric system described in Breeveld et al. (2011, AIP Conf. Proc. 1358, 373).

Filter	T_start (s)	T_stop (s)	Exp (s)	Mag
white (fc)	86	235	147	> 14.8
u (fc)	298	552	246	> 15.5
white	86	990	296	> 14.7
v	629	882	39	> 13.1
b	554	748	39	> 14.2
u	298	723	265	> 15.5
uvw1	678	873	39	> 16.5
uvm2	653	847	39	> 18.5
uvw2	604	797	39	> 17.9

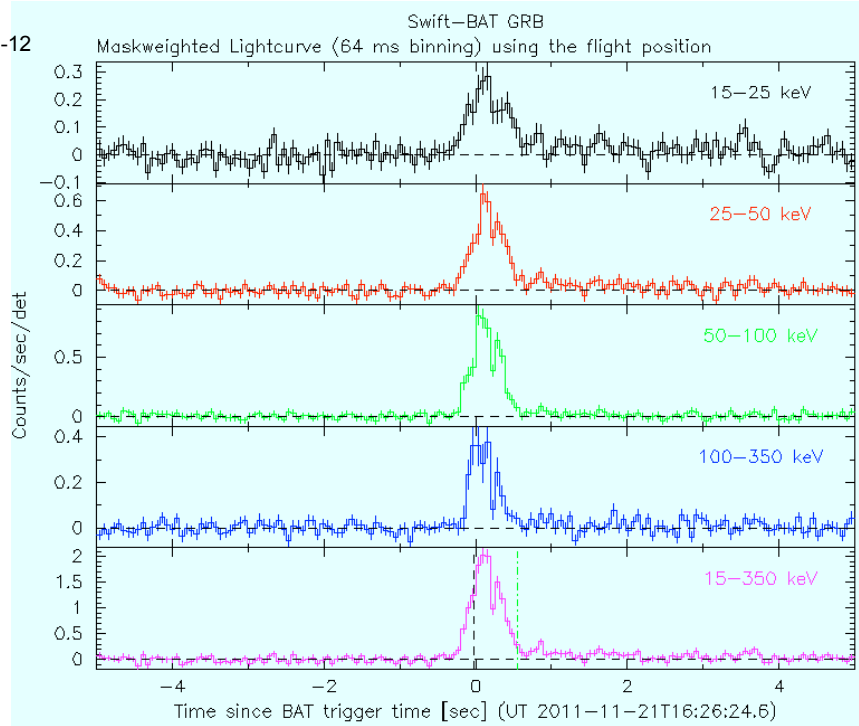Table 1: 3-sigma upper limits from UVOT observations.

Figure 1: BAT light-curve. The mask-weighted light curve in the 4 individual plus total energy bands. Green dashed line: T_{90}. Black: Slew start. The units are counts s^{-1} illuminated-detector^{-1} (note illum-det = 0.16 cm^2).
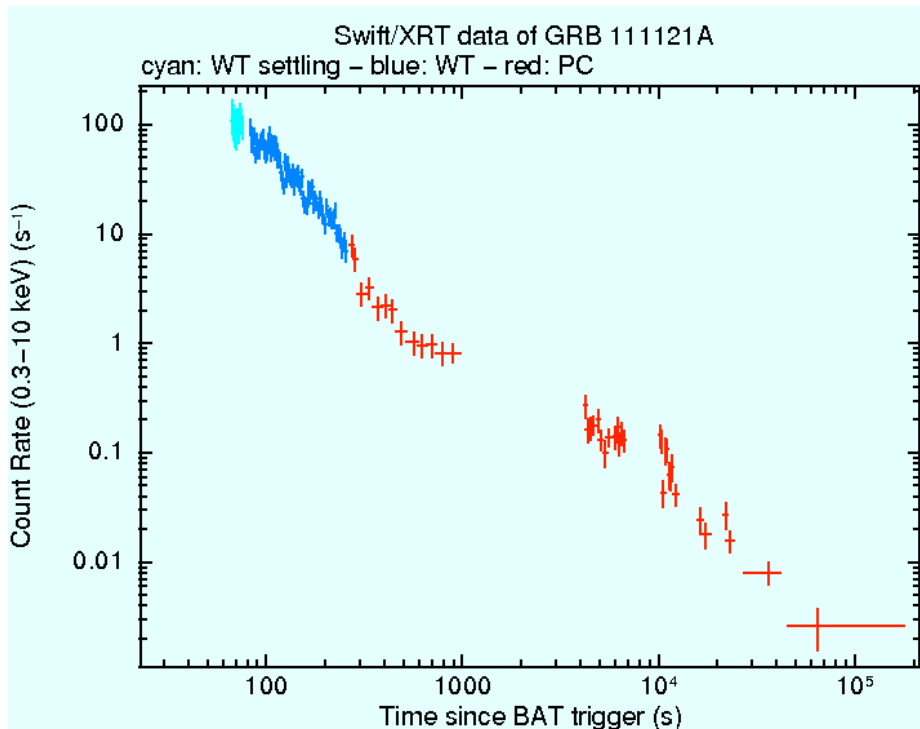

Figure 2: XRT light-curve. Count rates in the 0.3–10 keV band taken in Windowed Timing (WT) and Photon Counting (PC) mode are plotted. The approximate conversion of the 0.3–10 keV observed flux is 1 count/s $\sim 4.5 \times 10^{-11}$ erg cm^{-2} s^{-1}.