Swift Observations of GRB 110915A

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1 Introduction

BAT triggered on GRB 110915A on 2011 Sep 15 at 13:20:44.4 UT (Trigger 503219) (Holland et al. 2011). This was a long burst with T_{90} = 78.76 s (Ukwatta et al. 2011). *Swift* slewed immediately to this burst and follow-up observations started with the XRT at 76.1 s and UVOT at 84 s. The best *Swift* position is the UVOT-enhanced XRT location, RA, Dec (J2000.0) = 310.°82447, −0.°72312, which corresponds to

$$\begin{aligned} \text{RA (J2000.0)} &= 20^{\rm h}43^{\rm m}17.^{\rm s}87 \\ \text{Dec (J2000.0)} &= -00^\circ 43' 23.''2 \end{aligned}$$

with an uncertainty of 1.″6 (radius, 90% containment, including systematics). No optical afterglow was detected by UVOT or by ground-based observatories. Deep optical and infrared upper limits on the afterglow, combined with the X-ray flux, suggest that this is a dark GRB (Malesani et al. 2011).

GRB 110915A was also detected by *Konus-Wind*. A joint spectrum, using both *Swift* and *Konus* data, was best fit with a power law with an exponential cutoff with $\alpha = 1.08^{+0.14}_{-0.19}$ and $E_{\rm peak} = 183^{+80}_{-48}$ keV (Pal'shin et al. 2011).

2 BAT Observation and Analysis

The BAT data set from $T - 240$ to $T + 962$ s was analysed to obtain the following information. The BAT ground-calculated position is RA, Dec (J2000.0) = 310.°830, −0.°713, which corresponds to

$$\begin{aligned} \text{RA (J2000.0)} &= 20^{\rm h}43^{\rm m}19.^{\rm s}2 \\ \text{Dec (J2000.0)} &= -00^\circ 42' 46'' \end{aligned}$$

with an uncertainty of 1.′2, (radius, systematic + statistical errors, 90% containment). The partial coding was 25%.

The mask-weighted light curves (Figure 1) consists of a group of multiple overlapping peaks lasting from $T - 5$ s to $T + 45$ s. This is followed by a second cluster from $T + 55$ s to $T + 85$ s containing the brightest peak at $\approx T + 70$ s. T_{90} (15–350 keV) is 78.76 ± 1.25 s (estimated error including systematics).

The time-averaged spectrum from $T - 2.74$ to $T + 92.1$ s is best fit by a simple power-law model with an exponential cutoff. This fit gives a photon index of 0.94 ± 0.23 and $E_{\rm peak}$ = 124.8 ± 41.4 keV. The fluence in the 15–150 keV band is (5.7 ± 0.2) × 10^{-6} erg cm^{-2}. The 1-s peak photon flux measured from $T + 68.04$ s in the 15–150 keV band is 3.3 ± 0.2 ph cm^{-2} s^{-1}. 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/503219/BA/.

3 XRT Observation and Analysis

The *Swift*/XRT began observing GRB 110915A at 13:22:00.5 UT, 76.1 s after the BAT trigger. Using 2062 s of Photon Counting (PC) mode data and four UVOT images the astrometrically corrected X-

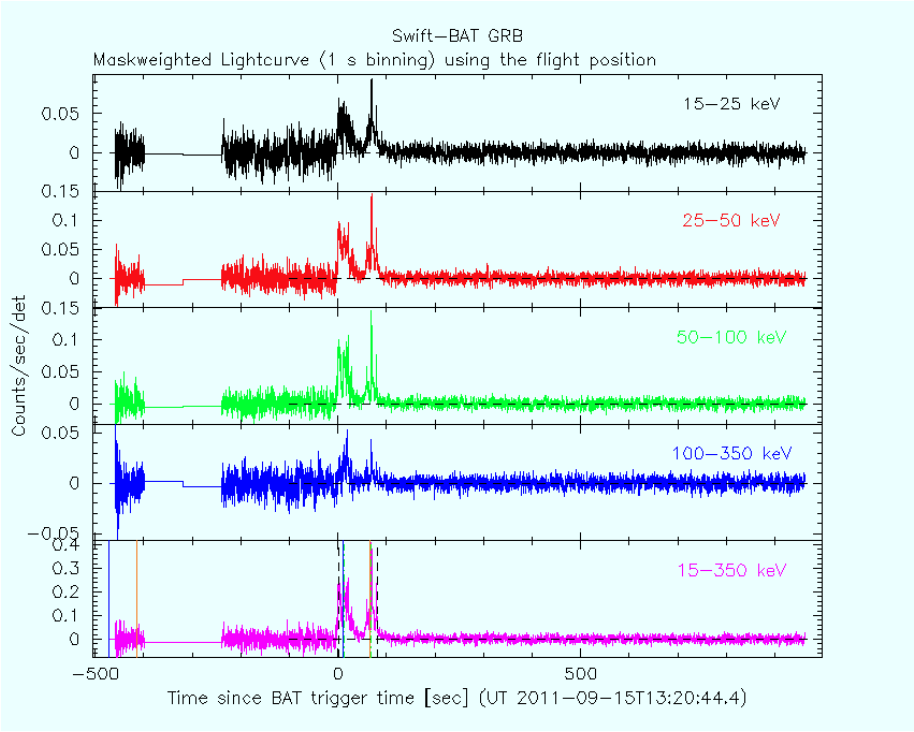

Figure 1: BAT light curves. The mask-weighted 1 s light curves in the four individual plus total energy bands. The units are count s^{-1} illuminated-detector^{-1} and T_0 is 13:20:44.4 UT.

ray position (using the XRT–UVOT alignment and matching UVOT field sources to the USNO-B1.0 catalogue) is RA, Dec (J2000.0) = 310.°82447, −0.°72312, which corresponds to

$$\begin{aligned} \text{RA (J2000.0)} &= 20^{\rm h}43^{\rm m}17.^{\rm s}87 \\ \text{Dec (J2000.0)} &= -00^\circ 43' 23.''2 \end{aligned}$$

with an uncertainty of 1.″6 (radius, 90% containment).

The X-ray light curve (Figure 2) can be modelled with a series of power-law decays and a flare. The initial decay index is $\alpha_1 = 6.1 \pm 0.6$ with a break at $T + 114.0 \pm 0.2$ s followed by a decay with $\alpha_2 = 0.76 \pm 0.30$. There is a flare at $T + 120$ s with a decay constant of $\tau = 25 \pm 9$ s. The decay breaks at $T + 4700 \pm 1000$ s to a final decay index of $\alpha_3 = 1.50 \pm 0.05$. A spectrum formed from the WT mode data can be fit with an absorbed power-law with a photon spectral index of 1.98 ± 0.05. The best-fitting absorption column is $2.69^{+0.18}_{-0.17} \times 10^{21}$ cm^{-2} in excess of the Galactic value of 5.3×10^{20} cm^{-2} (Kalberla et al. 2005). The PC mode spectrum has a photon spectral index of $2.04^{+0.21}_{-0.20}$. The results of the XRT team's automated analysis are available at http://www.swift.ac.uk/xrt_products/00503219.

4 UVOT Observation and Analysis

The *Swift*/UVOT began settled observations of the field of GRB 110915A at $T + 84$ s. No optical afterglow consistent with the UVOT-enhanced (Goad et al. 2008) XRT position (Evans et al. 2011) is detected in any of the UVOT exposures (see Figure 3). Preliminary 3-σ upper limits using the UVOT photometric system (Poole et al. 2008) for the finding chart (FC) exposures and the coadded

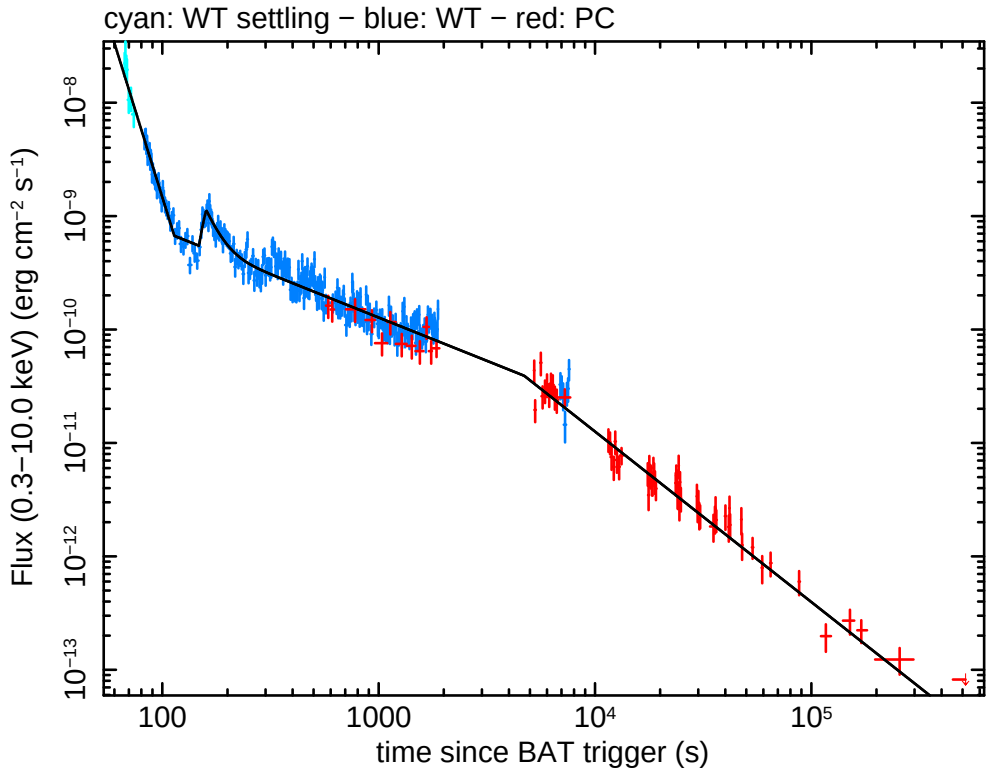

Figure 2: XRT flux light curves in erg cm^{-2} s^{-1} in the 0.3–10 keV band: Window Timing settling mode (cyan), Window Timing mode (blue), Photon Counting mode (red). The conversion factor to observed (unabsorbed) flux is 3.6×10^{-11} (5.7×10^{-11})erg cm^{-2} count^{-1}.

exposures are given in Table 1. These upper limits are not corrected for the Galactic extinction due to the reddening of $E_{B-V} = 0.06$ mag in the direction of the burst (Schlegel et al. 1998).

References

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Kalberla, P. M. W., et al., 2005, A&A, 440, 775

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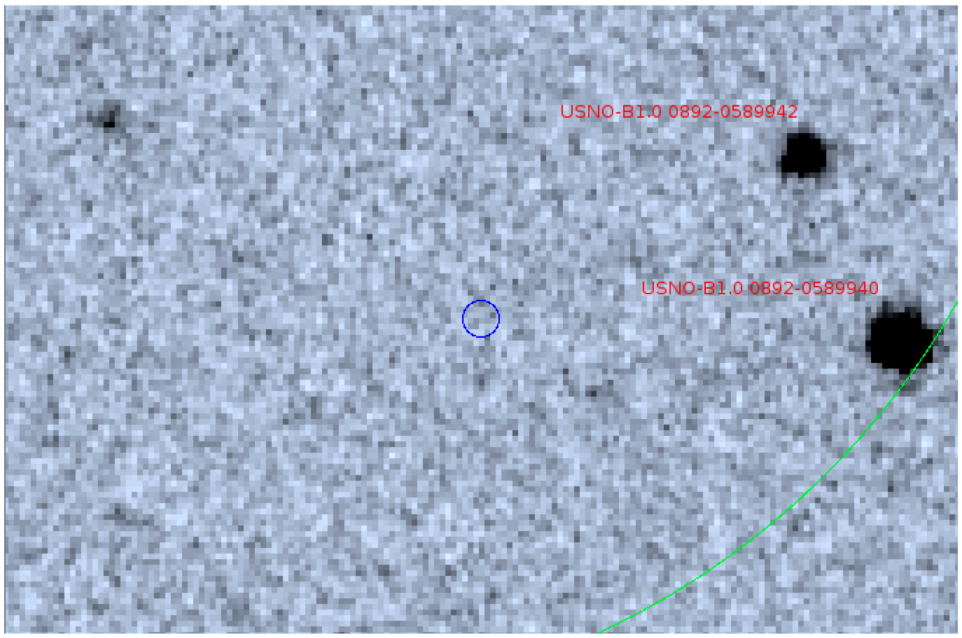

Figure 3: UVOT white finding chart for GRB 110915A. The green circle indicates the refined BAT error circle and the blue circle indicates the UVOT-enhanced XRT error circle. North is up and east is to the left.

Filter	$T_{\rm start}$	$T_{\rm stop}$	Exp(s)	Mag	
white (FC)	84	232	146	> 20.8	3-σ UL
v	616	5316	203	> 19.4	3-σ UL
b	540	1858	136	> 20.1	3-σ UL
u	284	1834	362	> 20.4	3-σ UL
uvw1	665	1809	136	> 19.6	3-σ UL
uvm2	641	1784	136	> 19.5	3-σ UL
uvw2	592	1897	144	> 19.8	3-σ UL
white	84	1884	429	> 21.5	3-σ UL

Table 1: UVOT 3-σ upper limits for GRB 110915A. $T_{\rm start}$ and $T_{\rm stop}$ are the times, in seconds since the BAT trigger, of the start and stop of the observations. Exp is the total exposure time. FC indicates a finding chart image.