

Swift Observations of GRB 110709A

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1 Introduction

BAT triggered on GRB 110709A on 2011 Jul 9 at 15:24:29 UT (Trigger 456939) (Holland et al. 2011). This was a long burst with $T_{90} = 44.7$ s (Sakamoto et al. 2010). *Swift* slewed immediately to this burst and follow-up observations started with the XRT at 65.6 s and UVOT at 73 s. The best *Swift* position is the UVOT-enhanced XRT location, RA, Dec (J2000.0) = 238°89144, +40°92427, which corresponds to

$$\begin{aligned} \text{RA (J2000.0)} &= 15^{\text{h}}55^{\text{m}}33^{\text{s}}.95 \\ \text{Dec (J2000.0)} &= +40^{\circ}55'27''.4 \end{aligned}$$

with an uncertainty of $1''.5$ (radius, 90% containment, including systematics). No optical afterglow was detected by UVOT or by ground-based observatories. The Konkoly Observatory detected a source with $R = 21.4$ mag inside the XRT error circle (Kelemen 2011).

GRB 110709A was detected by *Fermi*/GBM (Connaughton 2011). Their light curve had several bright peaks with a total duration of $T_{90} = 43.5$ s, and their spectrum was best fit with a power law with an exponential cutoff with $\alpha = -1.16 \pm 0.02$ and $E_{\text{peak}} = 533 \pm 37$ keV. *Konus-Wind* detected the burst (Golenetskii et al. 2011). Their light curve has several partially-overlapping pulses with a total duration of ≈ 60 s and their spectrum was a power law with an exponential cutoff with $\alpha = -1.03^{+0.07}_{-0.07}$ and $E_{\text{peak}} = 356^{+42}_{-34}$ keV. *Suzaku*/WAM also detected GRB 110709A (Hanabata et al. 2011). Their light curve showed multiple peaks with a duration of $T_{90} \approx 41.5$ s and their preliminary spectrum was a power law with an exponential cutoff with $\alpha = -1.37^{+0.61}_{-0.49}$ and $E_{\text{peak}} = 431^{+173}_{-113}$ keV. The burst was observed by *INTEGRAL*/SPI-ACS (Beckmann, priv. comm.). Their light curve had a multipeak structure with a duration of 50 s.

2 BAT Observation and Analysis

The BAT data set from $T - 239$ to $T + 963$ s was analysed to obtain the following information. The BAT ground-calculated position is RA, Dec (J2000.0) = 238°895, +40°918, which corresponds to

$$\begin{aligned} \text{RA (J2000.0)} &= 15^{\text{h}}55^{\text{m}}34^{\text{s}}.8 \\ \text{Dec (J2000.0)} &= +40^{\circ}55'06'' \end{aligned}$$

with an uncertainty of $1''.0$, (radius, systematic + statistical errors, 90% containment). The partial coding was 91%.

The mask-weighted light curves (Figure 1) shows at least eight peaks starting at $T - 5$ s with the brightest peak at $\approx T + 34$ s and returning to background at $\approx T + 100$ s. T_{90} (15–350 keV) is 44.7 ± 1.0 s (estimated error including systematics).

The time-averaged spectrum from $T - 4.3$ to $T + 65.5$ s is best fit by a simple power-law model. The power-law index of the time-averaged spectrum is -1.24 ± 0.03 . The fluence in the 15–150 keV band is $(1.00 \pm 0.02) \times 10^{-5}$ erg cm^{-2} . The 1-s peak photon flux measured from $T - 0.37$ s in the 15–150 keV band is 6.2 ± 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/456939/BA/.

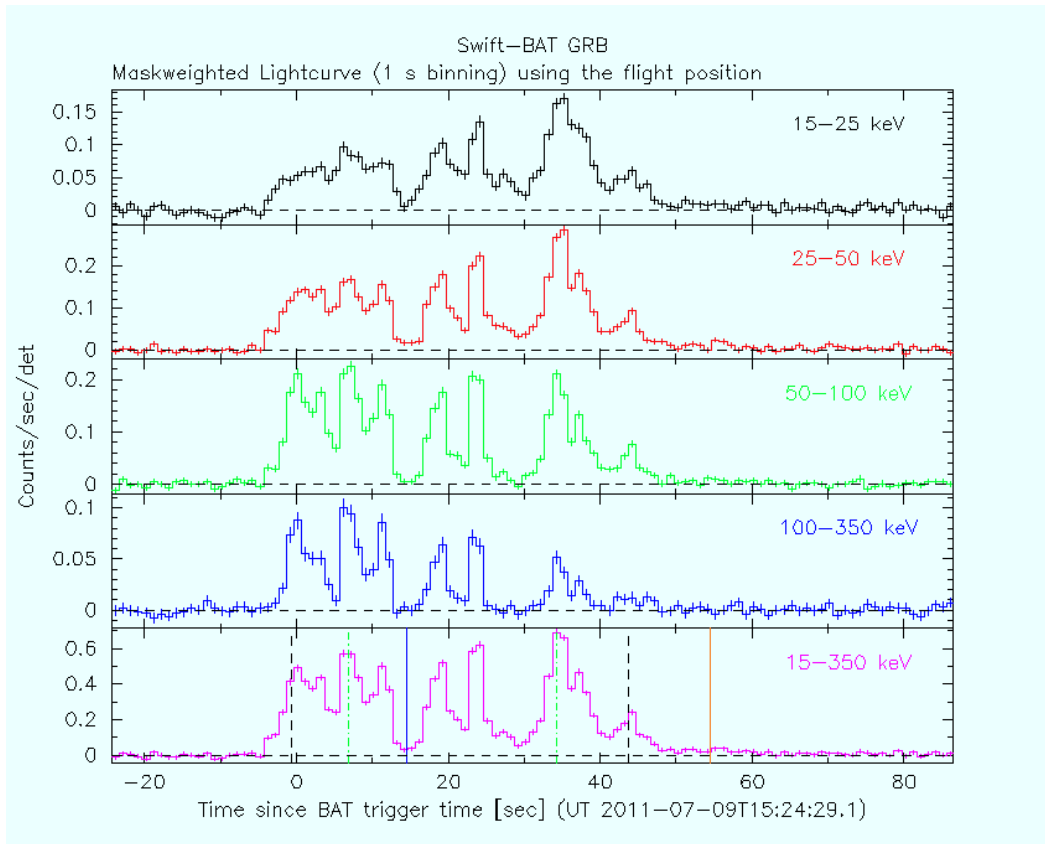


Figure 1: BAT light curves. The mask-weighted 1 s light curves in the four individual plus total energy bands. The units are count s^{-1} illuminated-detector $^{-1}$ and T_0 is 15:24:29.1 UT.

3 XRT Observation and Analysis

The *Swift*/XRT began observing GRB 110709A at 15:25:34.7 UT, 65.6 s after the BAT trigger. Using 3951 s of Photon Counting (PC) mode data and seven UVOT image the astrometrically corrected *X*-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1.0 catalogue) is RA, Dec (J2000.0) = 238°89144, +40°92427, which corresponds to

$$\begin{aligned} \text{RA (J2000.0)} &= 15^{\text{h}}55^{\text{m}}33^{\text{s}}.95 \\ \text{Dec (J2000.0)} &= +40^{\circ}55'12''.4 \end{aligned}$$

with an uncertainty of $1''.5$, (radius, 90% containment).

The *X*-ray light curve (Figure 2) has an initial decay index of ≈ -3 until $T + 100$ s with a small flare at $\approx T + 90$ s. This was followed by a short plateau to $\approx T + 300$ s. After the plateau the decay index is -0.80 ± 0.03 . At $T + 64000$ s the light curve breaks to a final decay index of -1.72 ± 0.10 . A spectrum formed from the WT mode data can be fit with an absorbed power-law with a photon spectral index of $-2.21^{+0.08}_{-0.09}$. The best-fitting absorption column is $7.5^{+0.6}_{-0.5} \times 10^{21} \text{ cm}^{-2}$ in excess of the Galactic value of $1.5 \times 10^{20} \text{ cm}^{-2}$ (Kalberla et al. 2005). The results of the XRT team's automated analysis are available at http://www.swift.ac.uk/xrt_products/00456939.

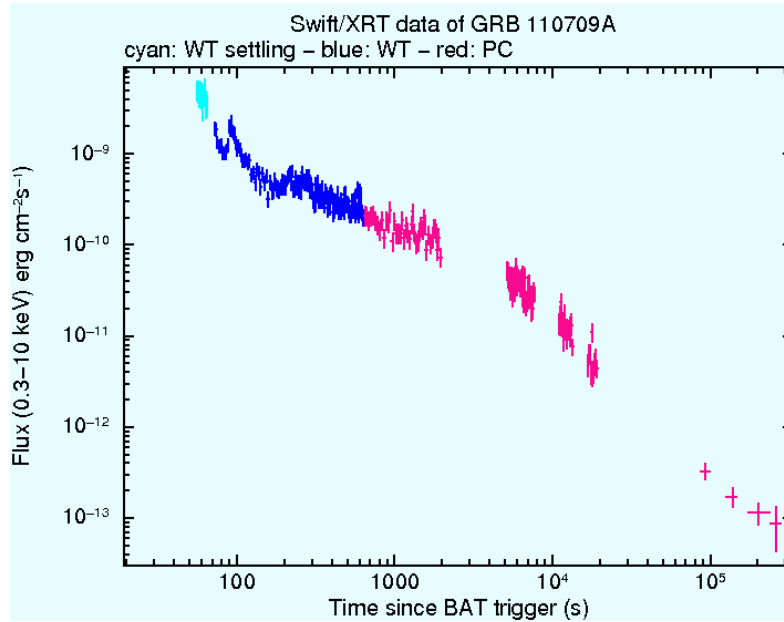


Figure 2: XRT flux light curves in $\text{erg cm}^{-2} \text{s}^{-1}$ in the 0.3–10 keV band: Window Timing settling mode (cyan), Window Timing mode (blue), Photon Counting mode (red). The conversion factor to observed (unabsorbed) flux is 5.0×10^{-11} (1.0×10^{-10}) $\text{erg cm}^{-2} \text{count}^{-1}$.

4 UVOT Observation and Analysis

The *Swift*/UVOT began settled observations of the field of GRB 110709A at $T + 74$ s. No optical afterglow consistent with the UVOT-enhanced (Goad et al. 2008) XRT position (Osborne et al. 2011) is detected in any of the UVOT exposures (see Figure 3). Preliminary $3\text{-}\sigma$ upper limits using the UVOT photometric system (Poole et al. 2008) for the finding chart (FC) exposures and the coadded exposures are given in Table 1. These upper limits are not corrected for the Galactic extinction due to the reddening of $E_{B-V} = 0.02$ mag in the direction of the burst (Schlegel et al. 1998).

Filter	T_{start}	T_{stop}	Exp(s)	Mag	
white _{FC}	74	224	147	> 21.7	$3\text{-}\sigma$ UL
u_{FC}	287	536	246	> 21.0	$3\text{-}\sigma$ UL
white _{FC}	865	1014	147	> 21.8	$3\text{-}\sigma$ UL
v	616	7409	549	> 20.9	$3\text{-}\sigma$ UL
b	542	19 323	2148	> 22.5	$3\text{-}\sigma$ UL
u	287	18 560	2337	> 22.2	$3\text{-}\sigma$ UL
uvw1	666	17 646	1383	> 21.7	$3\text{-}\sigma$ UL
uvm2	5978	7614	393	> 20.7	$3\text{-}\sigma$ UL
uvw2	591	7204	490	> 21.2	$3\text{-}\sigma$ UL
white	74	13 546	1538	> 23.1	$3\text{-}\sigma$ UL

Table 1: UVOT $3\text{-}\sigma$ upper limits for GRB 110709A. T_{start} and T_{stop} are the times, in seconds since the BAT trigger, of the start and stop of the observations. Exp is the total exposure time.

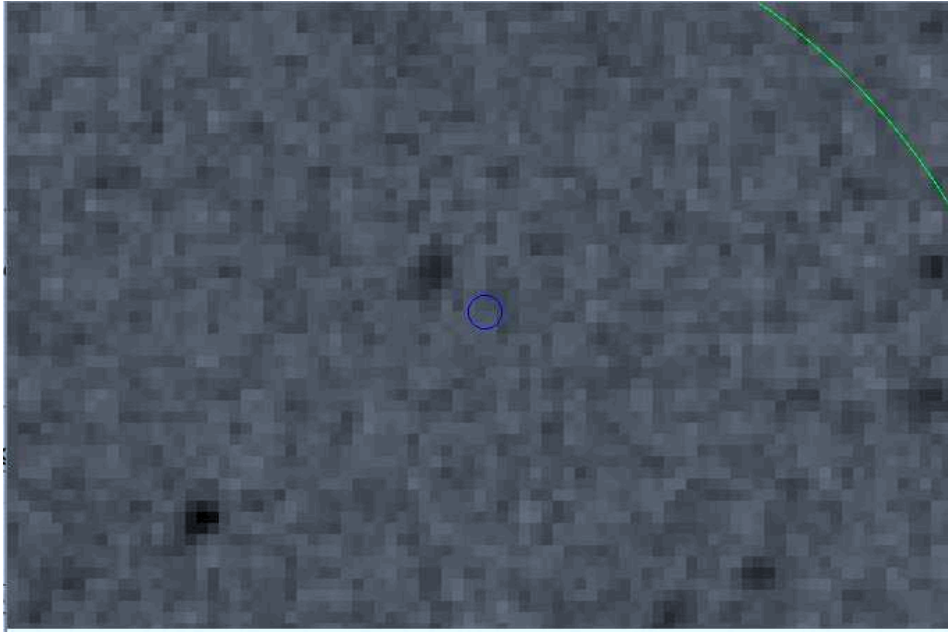


Figure 3: UVOT finding chart for GRB 110709A. The green circle indicates the refined BAT error circle and the blue circle indicates the UVOT-enhanced XRT error circle.

References

- Connaughton, V., 2011, GCN Circ. 12133
- Goad, M. R., et al., 2008, A&A, 492, 873
- Golenetskii, S., et al., 2011, GCN Circ. 12138
- Hanabata, Y., et al., 2011, GCN Circ. 12152
- Holland, S. T., et al., 2011, GCN Circ. 12118
- Kalberla, P. M. W., et al., 2005, A&A, 440, 775
- Kelemen, J., 2011, GCN Circ. 12146
- Osborne, J. P., et al., GCN Circ. 12123
- Sakamoto, T., et al., 2011, GCN Circ. 12127
- Schlegel, D. J., et al., 1998, ApJS, 500, 525