

Swift Observations of GRB 110407A

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1 Introduction

At 14:06:41 UT on 2011-04-07, the Swift Burst Alert Telescope (BAT) triggered and located GRB 110407A (trigger=450884). Swift slewed immediately to the burst and found an X-ray counterpart in the XRT (Wolf et al., *GCN Circ.* 11894)

The best *Swift* position of this burst is the XRT position given in Evans et al. (*GCN Circ.* 11903) with RA-2000 = 12h 24m 7.47s, and Dec-2000 = +15° 42' 42.1" with an uncertainty of 1.7".

2 BAT Observation and Analysis

At 14:06:41 UT on 2011-04-07, the Swift Burst Alert Telescope (BAT) triggered and located GRB 110407A (trigger=450884, Wolf et al., *GCN Circ.* 11894). Using the data set from T-239 to T+800 s, the BAT ground-calculated position is RA, Dec = 186.022, +15.726 deg which is

$$\text{RA(J2000)} = 12\text{h } 24\text{m } 05.3\text{s}$$

$$\text{Dec(J2000)} = +15^\circ 43' 33.2''$$

with an uncertainty of 1.5 arcmin, (radius, sys+stat, 90% containment). The partial coding was 77% (Barthelmy et al. *GCN Circ.* 11902).

The mask-weighted light curve (Figure 1) shows several overlapping peaks starting at T-10 s, with the brightest peak at T+15 s, and ending at T+275 s. T_{90} (15-350 keV) is 145 ± 15 s (estimated error including systematics).

The time-averaged spectrum from T-2.9 to T+158.8 s is best fit by a power law with an exponential cutoff. This fit gives a photon index of 0.73 ± 0.64 and E_{peak} of 57.9 ± 15.1 keV ($\chi^2 = 46.5$ for 56 d.o.f.). For this model the total fluence in the 15-150 keV band is $1.7 \pm 0.2 \times 10^{-6}$ erg cm^{-2} and the 1s peak flux measured from T+27.64 s in the 15-150 keV band is 0.5 ± 0.1 photons $\text{cm}^{-2} \text{s}^{-1}$. A fit to a simple power law gives a photon index of 1.73 ± 0.12 ($\chi^2 = 55.6$ for 57 d.o.f.). 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/450884/BA/

3 XRT Observations and Analysis

The XRT began observing the field of GRB 110407A at 14:09:20.4 UT, 159.3 seconds after the BAT trigger. Using 2767 s of XRT Photon Counting mode data and 6 UVOT images for GRB 110407A, Evans et al. (*GCN Circ.* 11903) found an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA, Dec

= 186.03111, +15.71170 which is equivalent to:

RA (J2000): 12h 24m 7.47s

Dec (J2000): +15° 42' 42.1"

with an uncertainty of 1.7" (radius, 90% confidence). The latest position can be viewed at http://www.swift.ac.uk/xrt_positions. Position enhancement is described by Goad et al. (2007, A&A, 476, 1401) and Evans et al. (2009, MNRAS, 397, 1177).

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of $\Gamma = 1.80 \pm 0.05$. The best-fitting absorption column is $1.00 \pm 0.13 \times 10^{21} \text{ cm}^{-2}$, in excess of the Galactic value of $2.0 \times 10^{20} \text{ cm}^{-2}$ (Kalberla et al. 2005). The PC mode spectrum has a photon index of $\Gamma = 1.87_{-0.11}^{+0.21}$ and a best-fitting absorption column density of $N_{\text{H}} = 8.4_{-2.7}^{+5.1} \times 10^{20} \text{ cm}^{-2}$. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 4.1×10^{-11} (5.0×10^{-11}) $\text{erg cm}^{-2} \text{ count}^{-1}$.

The 0.3 – 10 keV light curve given below (Fig.2) displays a canonical light curve (as described by Nousek et al. 2006, ApJ, 642, 389). After initial flaring (T_0 0.9 ks), the light curve can be modeled by a broken power-law model, with an initial decay slope $\alpha = 2.19_{-0.11}^{+0.12}$ with a break at $T + 13.6 \pm 2$ ks followed by a flattening of the decay slope to $\alpha = 0.4_{-0.7}^{+0.5}$.

The results of the XRT-team automatic analysis are available at http://www.swift.ac.uk/xrt_products/00450884.

4 UVOT analysis

The Swift/UVOT began settled observations of the field of GRB 110407A 168 s after the BAT trigger (Wolf et al., GCN Circ. 11894) with the finding chart in white filter. Oates (*GCN Circ.* 11907) reported that no optical counter part was found at the XRT position (Evans et al, *GCN Circ.* 11903).

The 3σ upper limits for the summed images are listed in Table 1.

Filter	T_{Start}	T_{stop}	Exposure	Mag
white_FC	168	317	147	>20.82
white	607	6514	580	>21.59
u_FC	327	577	246	>20.11
u	732	6104	413	>20.41
v	658	6873	382	>19.74
b	583	6309	432	>20.75
w1	709	5899	413	>20.34
m2	5493	5693	197	>19.75
w2	808	6719	413	>20.68

Table 1: 3σ upper limits from UVOT observations of GRB 110407A. The quoted values have not been corrected for the expected Galactic extinction along the line of sight of $E_{\text{B-V}} = 0.03$ mag. All photometry is on the UVOT photometric system described in Poole et al. (2008, MNRAS, 383, 627) and Breeveld et al. (2011, AIP Conf. Proc., Vol. 1358, 373)

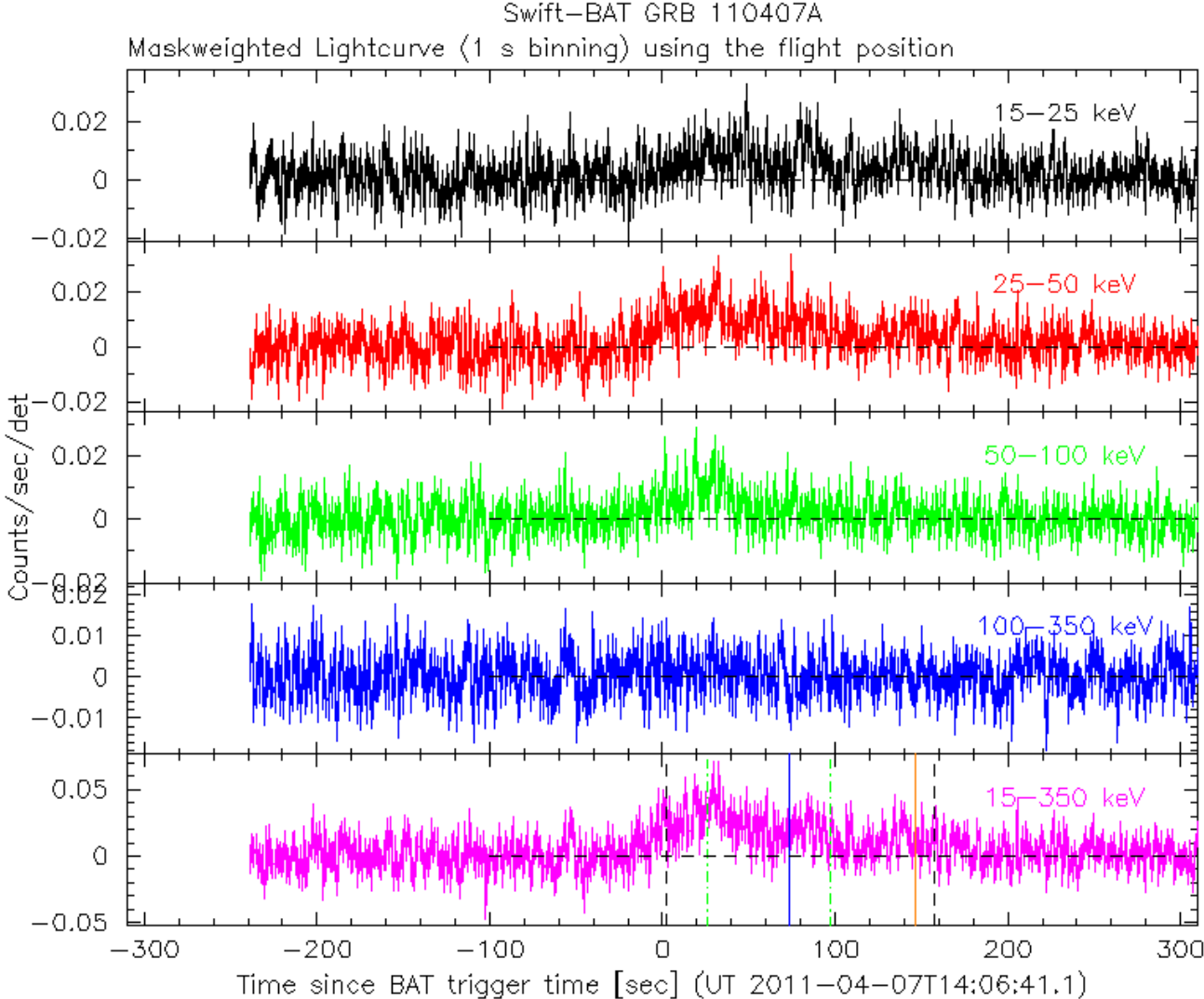


Figure 1: BAT Light curve of GRB 110407A.

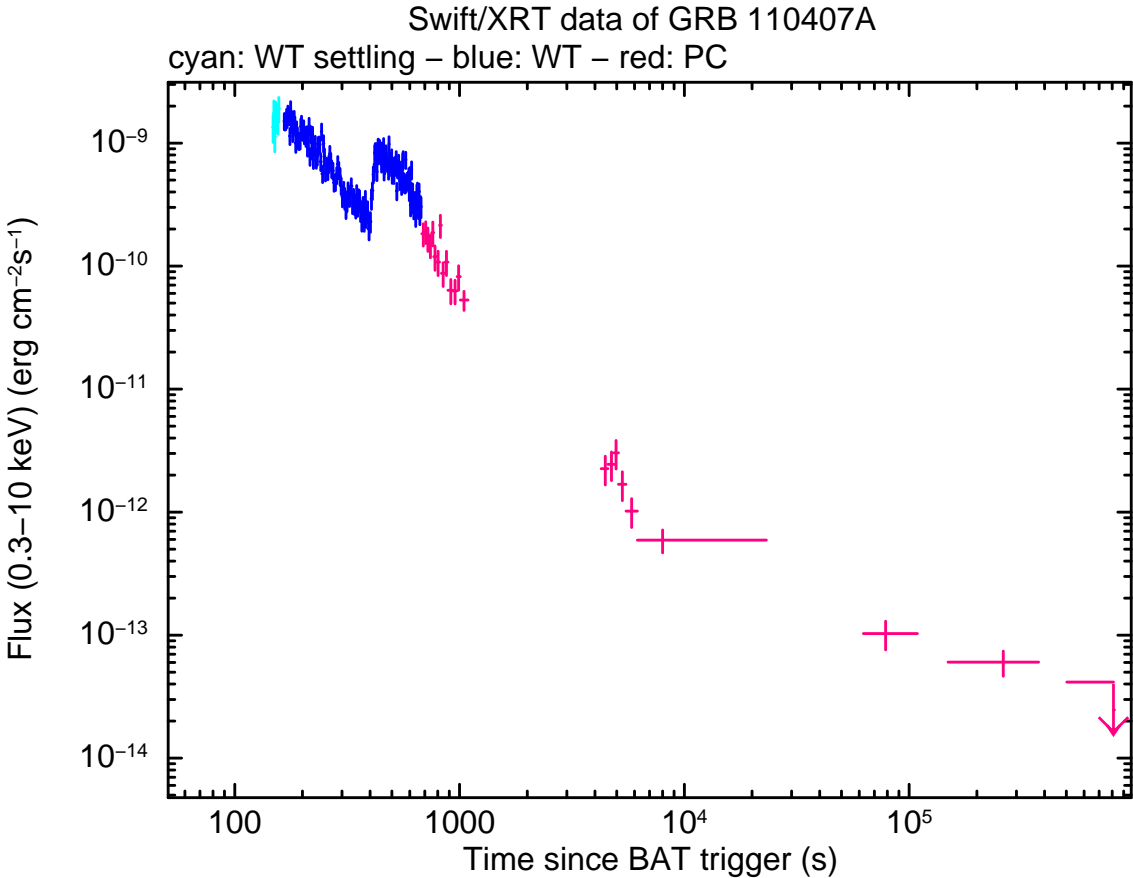


Figure 2: XRT flux light curve of GRB 110407A in the 0.3-10 keV band. The approximate conversion is $1 \text{ count s}^{-1} = \sim 4.1 \times 10^{-11} \text{ erg s}^{-1} \text{ cm}^{-2}$.