

## Swift Observations of GRB 110411A

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### 1 Introduction

At 19:34:11 UT on 2011-04-11, the Swift Burst Alert Telescope (BAT) triggered and located GRB 110411A (trigger=451165). Swift slewed immediately to the burst and found an X-ray counterpart in the XRT (Grupe et al., *GCN Circ.* 11918)

The best *Swift* position of this burst is the XRT position given in Goad et al. (*GCN Circ.* 11920) with RA-2000 = 19h 25m 46.13s, and Dec-2000 = +67° 42' 42.0" with an uncertainty of 1.8".

### 2 BAT Observation and Analysis

At 19:34:11 UT on 2011-04-11, the Swift Burst Alert Telescope (BAT) triggered and located GRB 110411A (trigger=451165, Grupe et al., *GCN Circ.* 11918). Using the data set from T-61 to T+242 s, the BAT ground-calculated position is RA, Dec = 291.427, +67.706 deg which is

RA(J2000) = 19h 25m 42.5s

Dec(J2000) = +67° 42' 21.0"

with an uncertainty of 1.0 arcmin, (radius, sys+stat, 90% containment). The partial coding was 71% (Cummings et al. *GCN Circ.* 11921).

The burst had multiple peaks with gradual rise and fall. The two largest peaks were centered around T+5 and T+60s (Figure 1).  $T_{90}$  (15-350 keV) is  $80.3 \pm 5.2$  s (estimated error including systematics).

The time-averaged spectrum from T-11.9 to T+86.3 s is best fit by a single power law model with exponential cutoff. This gives a photon index  $\Gamma = 1.51 \pm 0.31$  and  $E_{\text{peak}} = 41.0 \pm 8.1$  keV ( $\chi^2 = 49.7$  for 56 d.o.f.). For this model the total fluence in the 15-150 keV band is  $3.3 \pm 0.2 \times 10^{-6}$  ergs  $\text{cm}^{-2}$ . The 1s peak photon flux measured from T+4.73 s in the 15-150 keV band is  $1.3 \pm 0.2$  photons  $\text{s}^{-1} \text{cm}^{-2}$ . A fit with a single power law model gives a photon index of  $\Gamma = 2.05 \pm 0.07$  ( $\chi^2/\nu = 59.7$  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/451165/BA/](http://gcn.gsfc.nasa.gov/notices_s/451165/BA/)

### 3 XRT Observations and Analysis

The XRT began observing the field of GRB 110411A at 19:36:18.2 UT, 126.4 seconds after the BAT trigger. Using 2358 s of XRT Photon Counting mode data and 2 UVOT images for GRB 110411A, Goad et al. (*GCN Circ.* 11920) found an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA, Dec = 291.44219, +67.71167 which is equivalent to:

RA (J2000): 19h 25m 46.13s

Dec (J2000): +67° 42' 42.0''

with an uncertainty of 1.8'' (radius, 90% confidence). The latest position can be viewed at [http://www.swift.ac.uk/xrt\\_positions](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 PC mode data (11 ks exposure) can be fitted with an absorbed single power-law model with a photon spectral index of  $2.93^{+0.21}_{-0.23}$  (Grupe, *GCN Circ.* 11927). The best-fitting absorption column is  $1.02^{+0.14}_{-0.12} \times 10^{22} \text{ cm}^{-2}$  which is in excess of the Galactic value of  $6.9 \times 10^{20} \text{ cm}^{-2}$  (Kalberla et al. 2005). The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is  $4.0 \times 10^{-11} (2.3 \times 10^{-10}) \text{ erg cm}^{-2} \text{ count}^{-1}$ .

With an excess absorption column density of  $9.5 \times 10^{21} \text{ cm}^{-2}$  following the relation in Grupe et al. (2007, AJ, 133, 2216) the estimated maximum redshift of the afterglow is  $z < 1.0$ .

The 0.3 – 10 keV light curve given below (Fig.2) displays the standard canonical shape (Nousek et al. 2006) with

$$\alpha_1 = 6.03^{+0.58}_{-0.02}$$

$$T_{\text{break},1} = 230^{+20}_{-13} \text{ s}$$

$$\alpha_2 = 0.58^{+0.11}_{-0.16}$$

$$T_{\text{break},2} = 3640 \pm 2000 \text{ s}$$

$$\alpha_3 = 1.21^{+0.19}_{-0.20}$$

## 4 UVOT analysis

The Swift/UVOT began settled observations of the field of GRB 110411A 135 s after the BAT trigger (Grupe et al., *GCN Circ.* 11918) with the finding chart in the white filter. Kuin & Grupe (*GCN Circ.* 11925) reported that no optical counterpart was found within the uncertainties of the XRT position as given by Goad et al. (*GCN Circ.* 11920).

The  $3\sigma$  upper limits for the summed images are listed in Table 1.

Filter	$T_{\text{Start}}$	$T_{\text{stop}}$	Exposure	Mag
white_FC	135	285	147	>21.3
u_FC	347	597	246	>20.4
white	135	7753	883	>22.2
v	677	8164	607	>19.9
b	603	7548	586	>21.1
u	347	7343	637	>20.4
w1	726	7139	391	>20.2
m2	701	8326	508	>20.1
w2	653	7959	607	>20.9

Table 1:  $3\sigma$  upper limits from UVOT observations of GRB 110411A. The quoted values have not been corrected for the expected Galactic extinction along the line of sight of  $E_{B-V} = 0.10$  mag. All photometry is on the UVOT photometric system described in Poole et al. (2008, MNRAS, 383, 627).

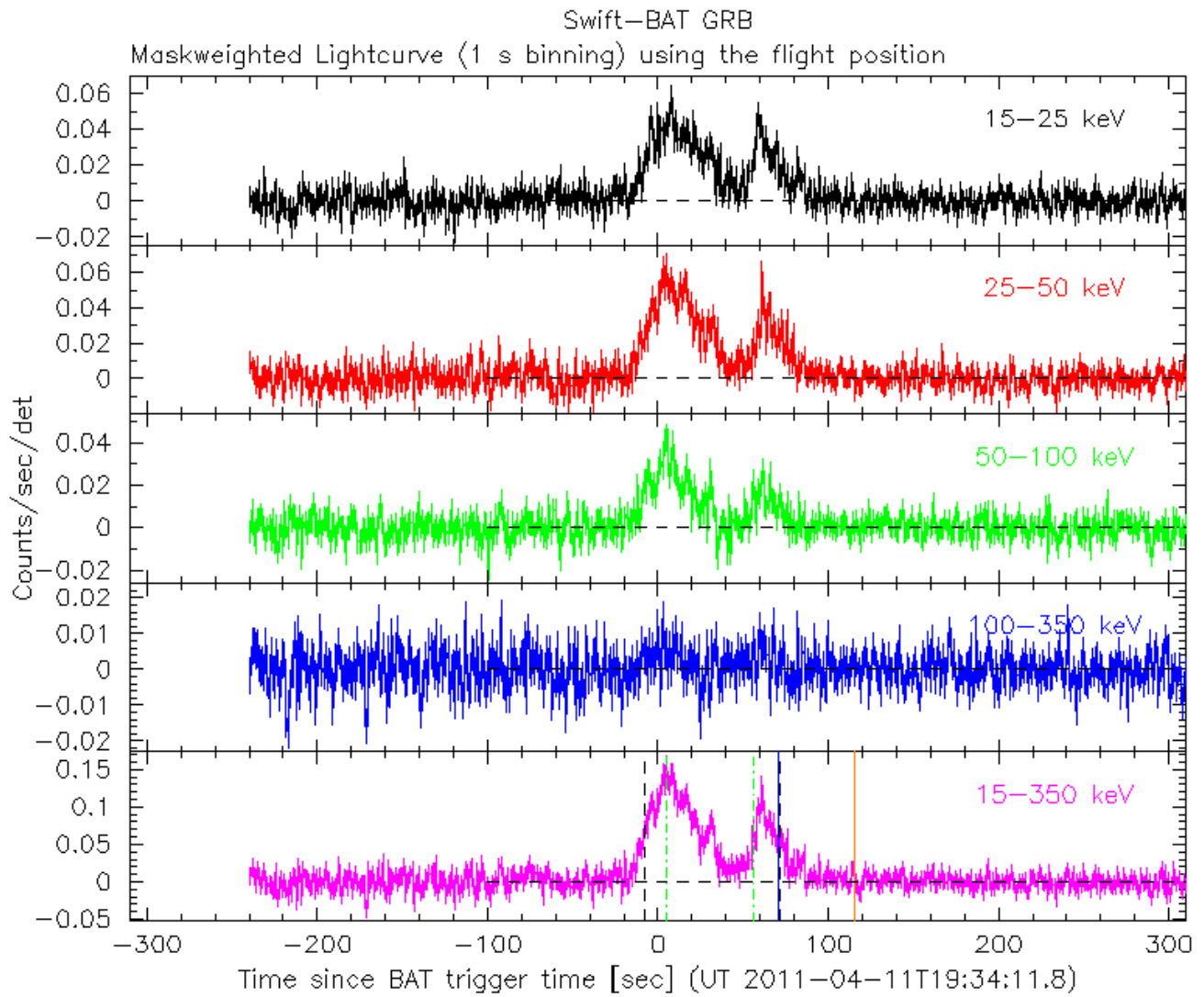


Figure 1: BAT Light curve of GRB 110411A.

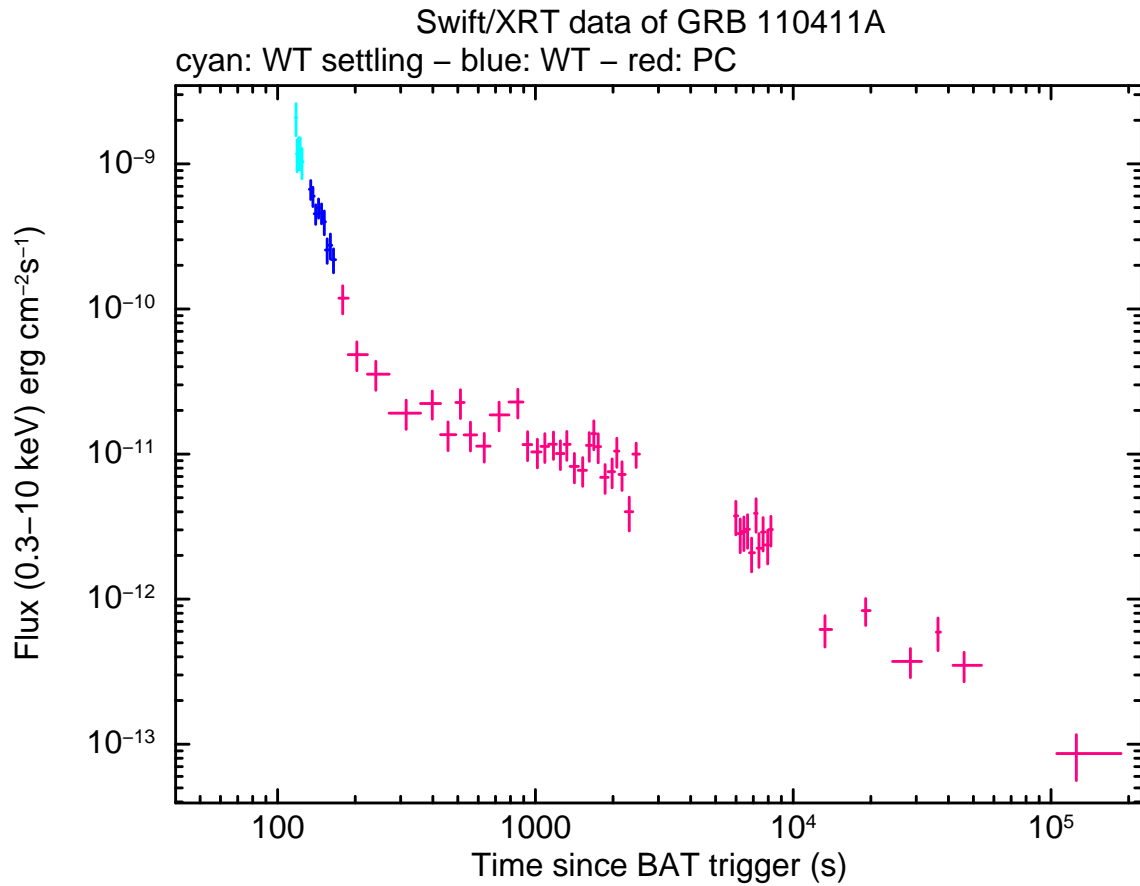


Figure 2: XRT flux light curve of GRB 110411A in the 0.3-10 keV band. The approximate conversion is  $1 \text{ count s}^{-1} = \sim 4.0 \times 10^{-11} \text{ ergs s}^{-1} \text{ cm}^{-2}$ .