Swift Observations of GRB 100704A

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1 Introduction

At 03:35:08 UT on 2010-07-04, the Swift Burst Alert Telescope (BAT) triggered and located GRB 100704A (trigger=426722). Swift slewed immediately to the burst and found an X-ray counterpart of the burst in the XRT (Grupe et al., *GCN Circ.* 10929)

The best *Swift* position of this burst is the XRT position given in Osborne et al. (*GCN Circ.* 10930) with RA-2000 = 08h 54m 33.92s, and Dec-2000 = -24° $12^{'}$ $09.7^{''}$ with an uncertainty of $1.7^{''}$.

The burst was also detected by the FERMI GBM (S. McBreen, *GCN Circ.* 10933), KONUS-WIND (Golenetskii et al., *GCN Circ.* 10937), and INTERGRAL SPI (V. Beckmann, priv. comm.). The spectrum measured by FERMI and KONUS-WIND can be described by a band function with a low-energy spectral slope 0.75 and an $E_{\rm peak} = 176^{+35}_{-24}$ keV.

2 BAT Observation and Analysis

At 03:35:08 UT on 2010-07-04, the Swift Burst Alert Telescope (BAT) triggered and located GRB 100704A (trigger=426722, Grupe et al., *GCN Circ.* 10929). Using the data set from T-240 to T+962 s, the BAT ground-calculated position is RA, Dec = 133.639, –24.202 deg which is

RA(J2000) = 08h 54m 33.3s

Dec(J2000) = -24° $12^{'}$ $08.0^{''}$

with an uncertainty of 1.0 arcmin, (radius, sys+stat, 90% containment). The partial coding was 85% (Cummings et al. *GCN Circ.* 10932).

The mask-weighted light curve (Figure 1) shows an initial very weak peak starting at T-70 s and peaking at T-60 s. Then comes the main peak starting at T-5 s, peaking at T+1.5 s, and ending at T+50 s. That is followed by a small peak at T+100 s, and then a larger peak from T+140 to T+210 s. This peak is also seen in the XRT (see below). T_{90} (15-350 keV) is 197.5±23.3 s (estimated error including systematics).

The time-averaged spectrum from T-62.3 to T+202.3 s is best fit by a single power law model. The power law index of the time-averaged spectrum is 1.73±0.06 ($\chi^2 = 57$ for 57 d.o.f.). For this model the total fluence in the 15-150 keV band is $6.0 \pm 0.2 \times 10^{-6}$ ergs cm^{-2}. The 1s peak photon flux measured from T+0.76 s in the 15-150 keV band is 4.3±0.2 photons s^{-1} cm^{-2}. 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/426722/BA/

3 XRT Observations and Analysis

The XRT began observing the field of GRB 100704A at 03:36:34.9 UT, 86.2 seconds after the BAT trigger. Using 3449 s of XRT Photon Counting mode data and 7 UVOT images for GRB 100704A, Osborne et al. (*GCN Circ.* 10930) found an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA, Dec = 133.64132, –24.20269 which is equivalent to:

RA (J2000): 08h 54m 33.92s

Dec (J2000): $-24^\circ\ 12'\ 09.7''$

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 (317s exposure) can be fitted with an absorbed single power-law model with a photon spectral index of 1.96±0.04 (Grupe, *GCN Circ.* 10935). The best-fitting absorption column is $3.23\pm0.14\times10^{21}$ cm^{-2}, in excess of the Galactic value of 1.0×10^{21} cm^{-2} (Kalberla et al. 2005). With an excess absorption column density of 2.32×10^{21} cm^{-2} the N_H-redshift relation by Grupe et al. (2007, AJ 133, 2216) suggests a redshift z<3.0. The PC mode spectrum has a photon index of $\Gamma = 2.6 \pm 0.3$ and a best-fitting absorption column of $3.1^{+0.9}_{-0.8} \times 10^{21}$ cm^{-2}. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 3.5×10^{-11} (8.3×10^{-11}) erg cm^{-2} count^{-1}.

The $0.3 - 10$ *keV* light curve given below (Fig.2) displays a standard X-ray light curve (Nousek et al. 2006, Zhang et al. 2006) with several episodes of flaring. The burst showed a strong flare starting about 140s after the trigger, peaking at T+190 s. This flare was also seen in the BAT. The light curve is followed be a second, much weaker flare at about T+1000 s. After these initial flares, the X-ray afterglow light curve can be modeled with a multiple broken power-law model with the following decay slopes and break times:

$\alpha_2 = 0.75 \pm 0.04$

$T_{\rm break1} = 21.9^{+9.1}_{-7.5}$ ks

$\alpha_3 = 1.19\pm0.10$

$T_{\rm break2} = 300^{+55}_{-17}$ ks

$\alpha_4 = 1.90^{+0.25}_{-0.20}$

4 UVOT analysis

The Swift/UVOT began settled observations of the field of GRB 100425A 96 s after the BAT trigger (Grupe et al., GCN Circ. 10929) with the finding chart in white filter. Kuin & Grupe (*GCN Circ.* 10934) reported that no optical afterglow was detected within the enhanced XRT error circle position (Osborne et al., *GCN Circ.* 10930).

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

Filter	$T_{\rm Start}$	$T_{\rm stop}$	Exposure	Mag
white_FC	96	246	147	>21.0
u_FC	308	558	246	>20.2
white	96	6544	746	>21.8
v	638	6955	471	>20.0
b	564	6339	452	>21.1
u	308	6132	678	>21.1
w1	688	5927	255	>21.1
m2	662	7075	387	>20.2
w2	613	6750	471	>20.7

Table 1: Magnitudes from UVOT observations of GRB 100704A. The quoted upper limits have not been corrected for the expected Galactic extinction along the line of sight of $E_{\rm B-V} = 0.17$ mag. All photometry is on the UVOT photometric system described in Poole et al. (2008, MNRAS, 383, 627).

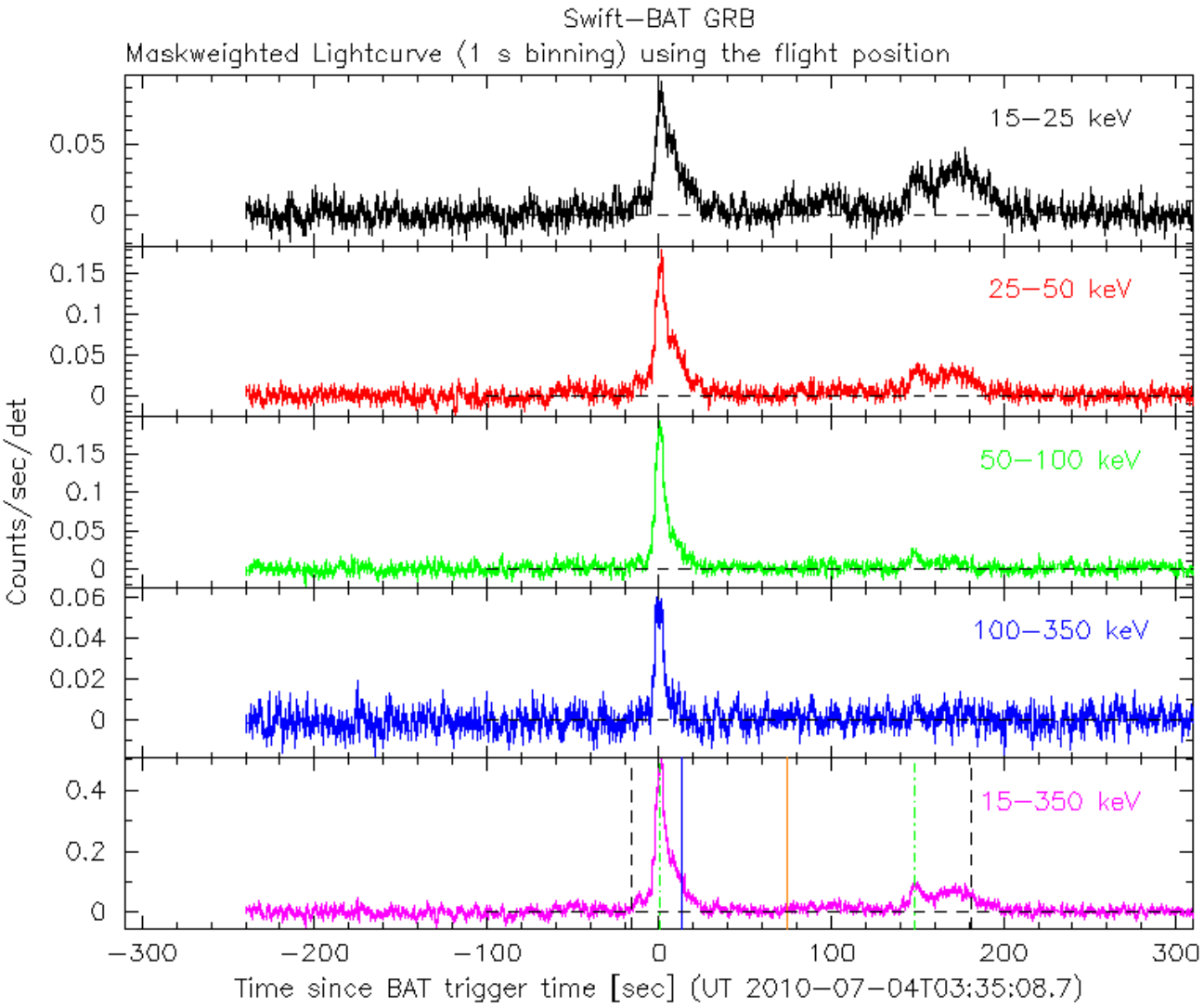

Figure 1: BAT Light curve of GRB 100704A.

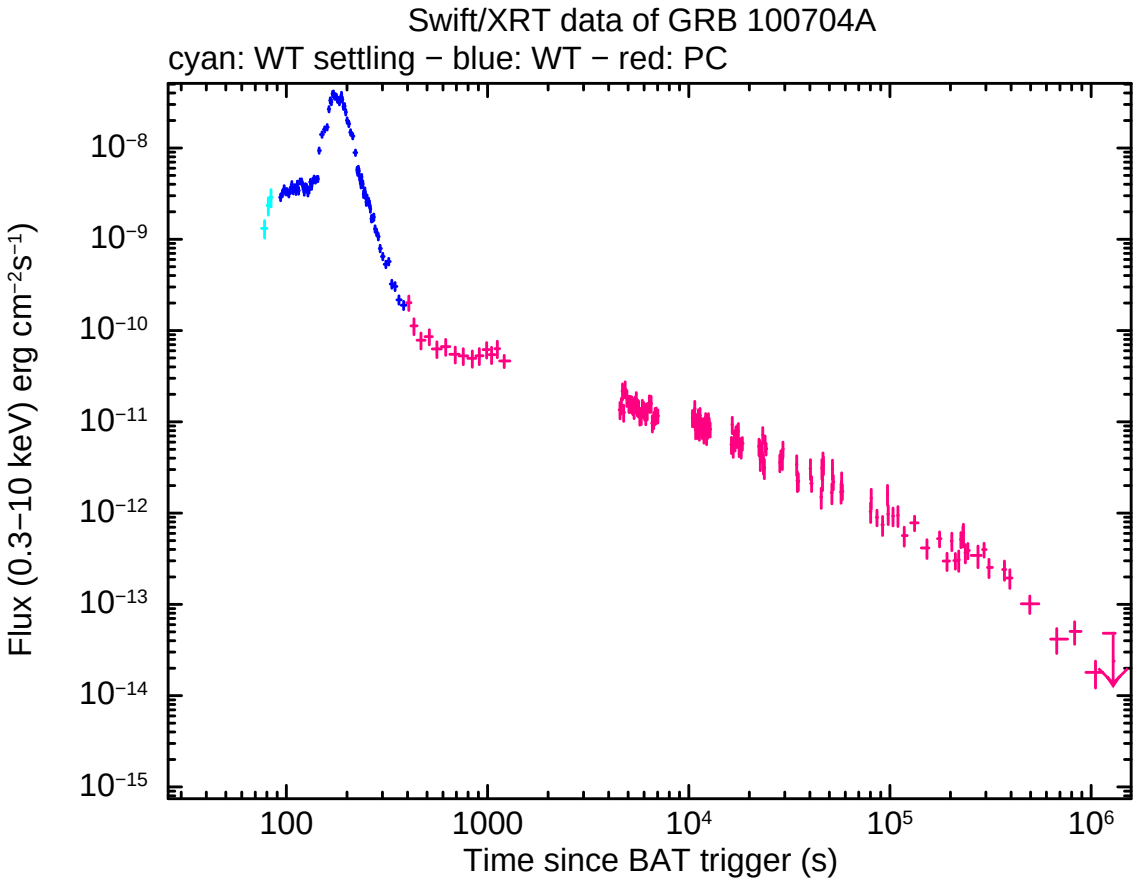

Figure 2: XRT flux light curve of GRB 100704A in the 0.3-10 keV band. The approximate conversion is 1 count $s^{-1} = \sim 3.5 \times 10^{-11}$ergs s^{-1} cm^{-2}.