

## Swift Observations of GRB 100823A

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### 1 Introduction

BAT triggered on GRB 100823A at 17:25:35 UT, (trigger 432420, Mangano *et al.*, *GCN Circ.* 11135). This was a 1.024 s rate-trigger on a long burst with  $T_{90} = 16.9 \pm 3.5$  s. Swift slewed immediately to the burst and found an X-ray counterpart to the burst in XRT. XRT began follow up observations at  $T + 59$  s, and UVOT observations began at  $T + 78$  s.

Our best position is the UVOT position determined from co-adding all of the later images (after  $T = 56215$  s) RA( $J2000$ ) = 20.70429 deg (01<sup>h</sup> 22<sup>m</sup> 49.03<sup>s</sup>), Dec( $J2000$ ) = +5.83511 deg (+05<sup>d</sup> 50' 06.4'') with an estimated uncertainty of 0.9 arcsec (radius, 90% confidence, statistical+systematic).

The field of GRB 100823A have been observed by some ground based optical telescopes: the William Herschel Telescope on La Palma with the ACAM instrument (Levan *et al.*, *GCN Circ.* 11138), with the UKIRT Wide Field Camera (Levan *et al.*, *GCN Circ.* 11142), and with the LIRIS (Levan *et al.*, *GCN Circ.* 11145); the 1.5m telescope at Observatorio de Sierra Nevada (Guziy *et al.*, *GCN Circ.* 11140); the TNG in the Canary Islands (D'Avanzo *et al.*, *GCN Circ.* 11141); the ESO VLT equipped with the X-shooter spectrograph (D'Avanzo *et al.*, *GCN Circ.* 11143); the MOA-II 1.8m telescope at Mt. John observatory in New Zealand (Suzuki *et al.*, *GCN Circ.* 11146); the AZT-22 telescope of Maidanak observatory (Pozanenko *et al.*, *GCN Circ.* 11152).

A bright X-ray source at a position consistent with GRB 100823A has also been detected by the Gas Slit Camera (GSC) of MAXI (Serino *et al.*, *GCN Circ.* 11151).

### 2 BAT Observation and Analysis

Using the data set from  $T - 240$  to  $T + 962$  s refined analysis of BAT GRB 090628 was performed by the Swift team and reported in Palmer *et al.*, *GCN Circ.* 11137.

The BAT ground-calculated position is RA( $J2000$ ) = 20.706 deg (01<sup>h</sup> 22<sup>m</sup> 49.4<sup>s</sup>), Dec( $J2000$ ) = +5.848 deg (+05<sup>d</sup> 50' 52.6'') with an uncertainty of 1.4 arcmin, (radius, sys+stat, 90% containment). The partial coding was 92%.

The mask-weighted light curve (Fig.1) shows a single FRED peak starting at  $\sim T - 2$  s, peaking at  $\sim T + 1$  s, and ending at  $T + 150$  s.  $T_{90}$  (15–350 keV) is  $16.9 \pm 3.5$  s (estimated error including systematics).

The time-averaged spectrum from  $T - 1.2$  to  $T + 18.2$  s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is  $2.19 \pm 0.18$ . The fluence in the 15–150 keV band is  $4.1 \pm 0.4 \times 10^{-7}$  erg cm<sup>-2</sup>. The 1-sec peak photon flux measured from  $T + 0.14$  s in the 15–150 keV band is  $1.0 \pm 0.1$  ph cm<sup>-2</sup> s<sup>-1</sup>. 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/432420/BA/](http://gcn.gsfc.nasa.gov/notices_s/432420/BA/)

### 3 XRT Observations and Analysis

Swift-XRT began follow-up observations of the field of GRB 100823A (trigger 432420, Mangano *et al.*, *GCN Circ.* 11135) 59 s after the BAT trigger.

The whole dataset consists of about 25.5 ks of data from 59 s to 76.9 ks after the BAT trigger. The data comprise 68 s in Windowed Timing (WT) mode (the first 8 s were taken while Swift was slewing) with the remainder in Photon Counting (PC) mode (Mangano *et al.* GCN Circ. 11135).

Using 251 s of XRT Photon Counting mode data and 1 UVOT image for GRB 100823A, we find an astrometrically corrected X-ray position (using the XRT–UVOT alignment and matching UVOT field sources to the USNO–B1 catalogue):  $\text{RA}(J2000)$ ,  $\text{Dec}(J2000) = 20.70428, +5.83510$  which is equivalent to:

$$\begin{aligned}\text{RA}(J2000) &= 01^h 22^m 49.03^s \\ \text{Dec}(J2000) &= +05^d 50' 06.4''\end{aligned}$$

with an uncertainty of 2.1 arcsec (radius, 90% confidence; Goad *et al.*, GCN Circ. 11136).

This position is within 5.6 arcsec of the initial XRT position reported by Mangano *et al.*, GCN Circ. 11135.

The 0.3–10 keV XRT light curve (Fig.2) is well fitted by a broken power-law with an initial decay index of  $2.9 \pm 0.2$ , a break at  $T + (163 \pm 11)$  s and a final decay index of  $1.19 \pm 0.03$ .

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of  $3.6_{-0.6}^{+0.8}$ . The best-fitting absorption column is  $2.8_{-0.9}^{+1.2} \times 10^{21} \text{ cm}^{-2}$ , in excess of the Galactic value of  $3.7 \times 10^{20} \text{ cm}^{-2}$  (Kalberla *et al.*, 2005). The PC mode spectrum (extracted from  $T + 137.5$  s to  $T + 22.3$  ks, 8.65 ks exposure) has a photon index of  $2.2_{-0.2}^{+0.3}$  and a best-fitting absorption column of  $2.1_{-0.5}^{+0.6} \times 10^{21} \text{ cm}^{-2}$ . The counts to observed (unabsorbed) 0.3–10 keV flux conversion factor deduced from this spectrum is  $4.0 \times 10^{-11} (6.6 \times 10^{-11}) \text{ erg cm}^{-2} \text{ s}^{-1}$ .

The results of the XRT-team automatic analysis are available at [http://www.swift.ac.uk/xrt\\_products/00432420](http://www.swift.ac.uk/xrt_products/00432420).

## 4 UVOT Observation and Analysis

The UVOT began settled observations of the field of GRB 100823A 78 s after the BAT trigger (Mangano *et al.*, GCN Circ. 11135). No optical afterglow consistent with the enhanced XRT position (Goad *et al.*, GCN Circ. 11136) is detected in the initial UVOT exposures (Chester *et al.*, GCN Circ. 11139).

Further examination of Swift/UVOT observations of GRB 100823A show that a source detected in the white finding chart exposure, initially thought to correspond to the DSS2 source mentioned in Levan *et al.*, GCN Circ. 11138, faded in subsequent exposures to an apparently steady level. The source was marginally detected in the u finding chart exposure. The position of the source in both the finding chart and later images is consistent with the enhanced XRT position (Goad *et al.*, GCN Circ. 11136). We propose this result as further evidence that Source C in Levan *et al.*, GCN Circ. 11145, and referenced in Suzuki *et al.*, GCN Circ. 11146, is the afterglow of GRB 100823A.

Magnitudes for the white and u finding charts (FC) and white optimally co-added exposures are given in the following Table 1 where  $T_{start}$  and  $T_{stop}$  are the start and stop time of the observation.

The above magnitudes are not corrected for the Galactic extinction corresponding to a reddening of  $E(B-V) = 0.05$  (Schlegel *et al.*, 1998, ApJS, 500, 525). The photometry is on the UVOT photometric system described in Poole *et al.* (2008, MNRAS, 383, 627).

Filter	$T_{start}(s)$	$T_{stop}(s)$	Exp(s)	Magnitude	S/N
white_FC	78	227	147	$20.7 \pm 0.3$	2.9
u_FC	290	539	246	$20.4 \pm 0.4$	2.1
white	576	57266	3157	$23.4 \pm 0.8$	2.3
white	61907	63386	1453	$22.9 \pm 0.7$	2.4
white	67668	73670	2674	$23.3 \pm 0.8$	2.1
white	73673	75876	2168	$23.0 \pm 0.7$	2.5

Table 1: Magnitudes from UVOT observations

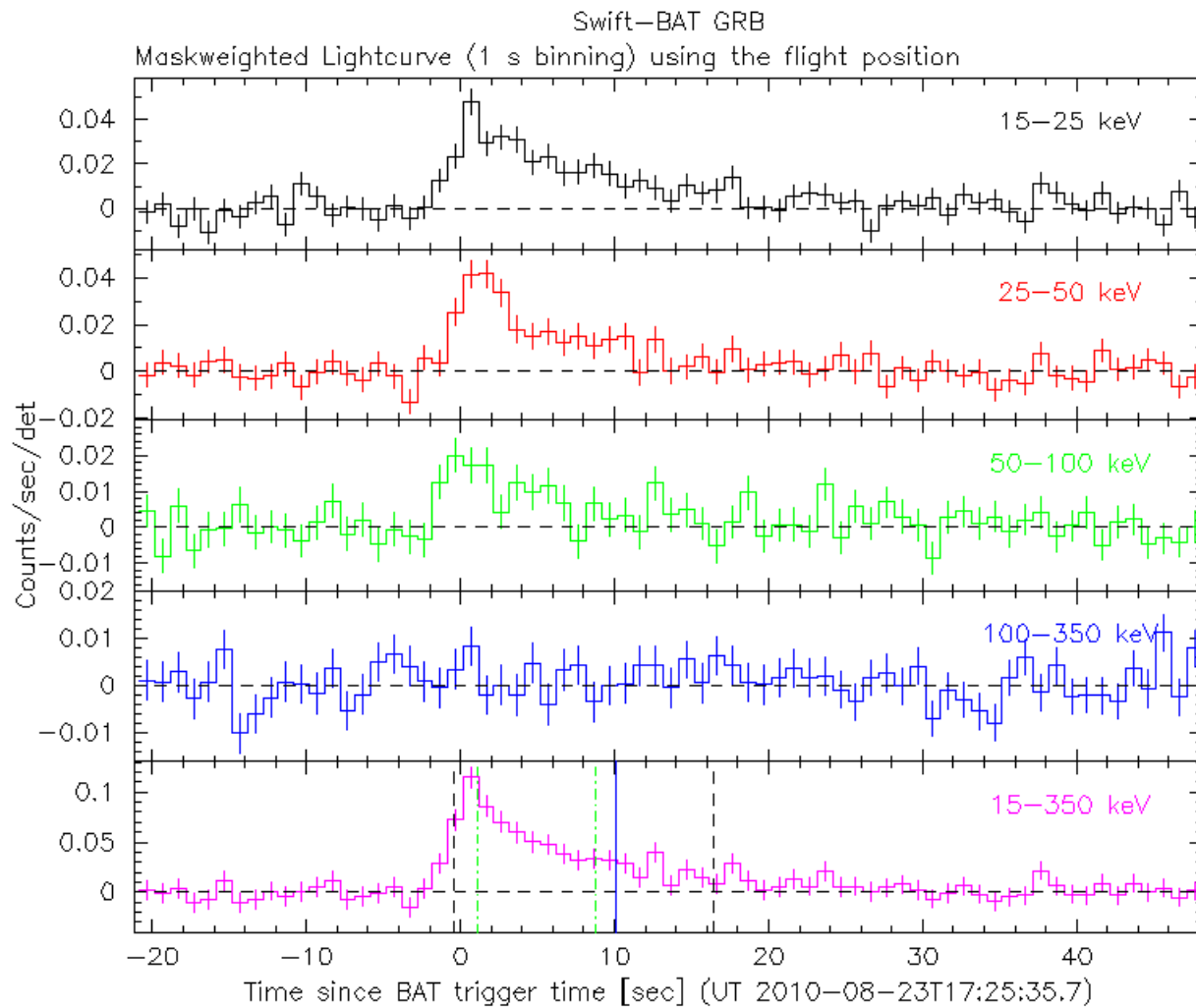


Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts  $s^{-1}$  illuminated-detector $^{-1}$  (note illum-det =  $0.16 \text{ cm}^2$ ) and  $T_0$  is 2010 Aug 23 17:25:35 UT.

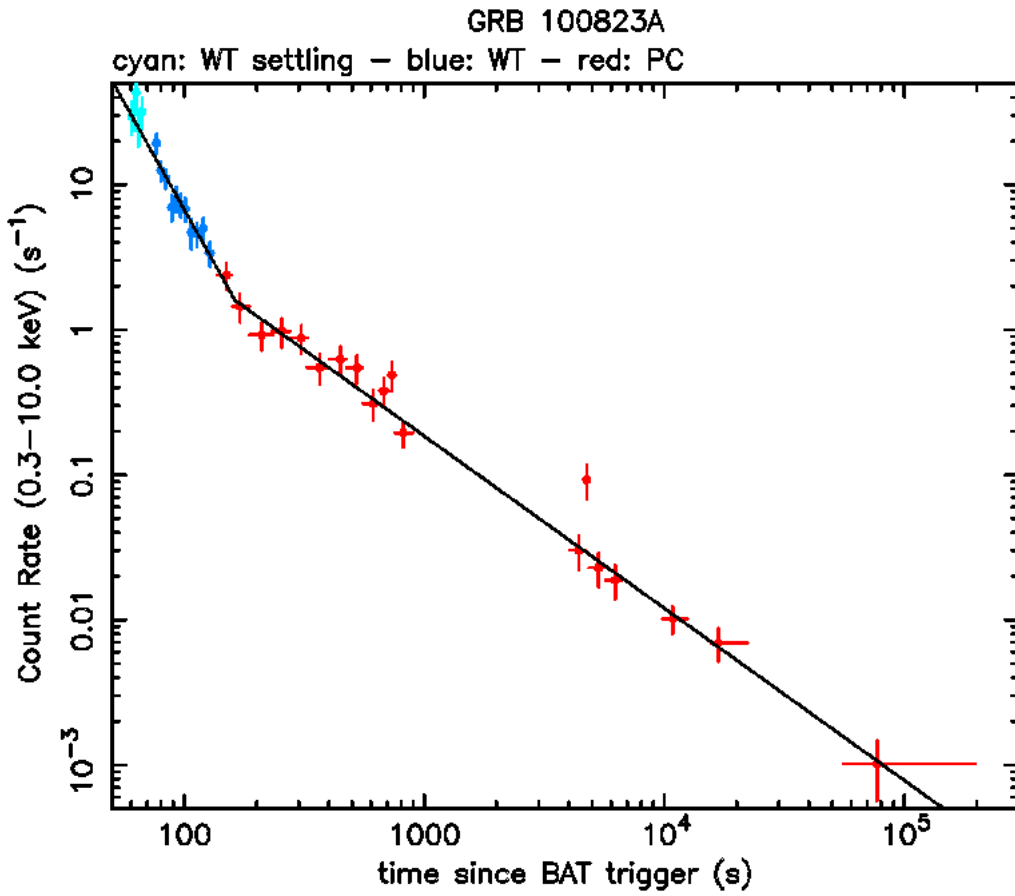


Figure 2: XRT Light curve. Counts/s in the 0.3–10 keV band: Window Timing mode (cyan for settling and blue for settled observation), Photon Counting mode (red). The approximate conversion is 1 count/s =  $\sim 6.6 \times 10^{-11}$  erg cm<sup>-2</sup> s<sup>-1</sup>.