

***Swift* Observations of GRB 090807**  
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## 1 Introduction

BAT triggered on a long burst, GRB 090807, at 15:00:27 UT (Trigger 359378) (Cannizzo, et al., *GCN Circ.* 9746). *Swift* slewed immediately to the burst. The BAT on-board calculated location is RA, Dec = (273.744, +10.281), which is {18h 14m 59s; +10d 16' 51"} (J2000) with an uncertainty of 3 arcmin (radius, 90% containment).

The XRT began observing the field at 15:03:00.5 UT, at  $T + 153.5$  s. and found a bright, fading, uncatalogued X-ray source with an enhanced position: RA, Dec = (273.7438, +10.2665) deg, or {18h 14m 58.51s; +10d 15' 59.3"} (J2000) with  $\sigma = 2.4$  arcsec (radius, 90% containment). This location is 52 arcsec from the BAT position.

A power-law fit to a spectrum gives a column density in excess of the Galactic value ( $8.6 \times 10^{20} \text{ cm}^{-2}$ , Kalberla et al. 2005), with an excess column of  $2(+1.68/ - 1.50) \times 10^{21} \text{ cm}^{-2}$  (90% confidence).

The initial flux in the 2.5 s image was  $8.55 \times 10^{-9} \text{ erg cm}^{-2} \text{ s}^{-1}$  (0.2 – 10 keV).

UVOT took a finding chart exposure of nominal 150 s with the White filter starting at  $T + 163$  s. No credible afterglow candidate was found. The  $2.7' \times 2.7'$  sub-image covers 100% of the XRT error circle. The  $3\sigma$  U.L. is  $\sim 19.2$  mag. The  $8' \times 8'$  region for the list of sources generated on-board covers 100% of the XRT error circle. The list of sources is typically complete to about 18.0 mag. No correction has been made for the expected extinction corresponding to  $E(B - V) = 0.18$ .

There are two reports of upper limits on the prompt optical emission (RIMOTS at  $T+2.2$  min – Kono et al., *GCN Circ.* 9747; MITSuME at  $T+3$  min 8s – Yoshida et al., *GCN Circ.* 9752) and one report of an upper limit in the optical afterglow (2-m Liverpool Telescope at  $T+8.75$  h – Guidorzi et al., *GCN Circ.* 9753).

## 2 BAT Observation and Analysis

Using the data set from  $T - 239$  to  $T + 423$  s, further analysis of GRB 090807 was performed by the *Swift* team (Ukwatta, et al., *GCN Circ.* 9749). The BAT ground-calculated position is RA, Dec = (273.741, +10.279) deg, or {18h 14m 57.8s; +10d 16' 45.9"} (J2000) with  $\sigma = 1.8$  arcmin, (radius, sys+stat, 90% containment). The partial coding was 64%.

The mask-weighted light curve shows a complex structure lasting from  $T - 5$  to  $T + 150$  s with at least five peaks superimposed on a broad, soft and slowly varying background. There is an additional peak at  $T + 185$  s which corresponds to a large flare seen by XRT. There is also possible precursor activity from  $T - 200$  to  $T - 80$  s.  $T_{90}$  (15 – 350 keV) is  $140.8 \pm 13.1$  s (estimated error including systematics).

The time-averaged spectrum from  $T - 9.5$  to  $T + 151.5$  s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is  $2.25 \pm 0.14$ . The fluence in the 15 – 150 keV band is  $2.2(\pm 0.2) \times 10^{-6} \text{ erg cm}^{-2}$ . The 1 s peak photon flux measured from  $T + 41.96$  s in the

15 – 150 keV band is  $0.7 \pm 0.2$  ph cm<sup>-2</sup> s<sup>-1</sup>. All the quoted errors are at the 90% confidence level.

### 3 XRT Observation and Analysis

Using 1531 s of XRT Photon Counting mode data and 2 UVOT images for GRB 090807 (Beardmore et al., *GCN Circ.* 9748), we find an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA, Dec = (273.74377, +10.26583), or

{18h 14m 58.50s; +10d 15' 57.0"} (J2000)

with  $\sigma = 1.8$  arcsec (radius, 90% confidence).

Subsequent analysis was carried out with 149 s of Windowed Timing (WT) and 1.5 ks of Photon Counting (PC) mode data (Margutti et al. *GCN Circ.* 9750), respectively, between 154 s and 1.9 ks after the trigger.

The light curve shows a large flare peaking around 185 s which was also detected in 15 – 150 keV (BAT). The underlying light curve decays with a power-law index of  $5.0 \pm 0.5$ . Around  $T + 580$  s the decay flattens, to a slope of  $0.87 \pm 0.42$ .

The spectrum extracted from WT data can be modelled with an absorbed simple power-law, with  $\Gamma = 2.2 \pm 0.1$  and  $N_H = (3.0 \pm 0.2) \times 10^{21}$  cm<sup>-2</sup> in excess of the Galactic column in this direction which is  $8.6 \times 10^{20}$  cm<sup>-2</sup> (Kalberla et al. 2005). A spectrum extracted from PC data in the time interval from  $T + 310$  s to  $T + 1840$  s has a best-fitting photon index of  $2.6 \pm 0.4$  and a best-fitting absorption column of  $N_H = (3.3 \pm 0.1) \times 10^{21}$  cm<sup>-2</sup> in excess of the Galactic value. The counts to observed (unabsorbed) 0.3–10 keV flux conversion factor deduced from this spectrum is  $3.1 \times 10^{-11}$  ( $8.4 \times 10^{-11}$ ) erg cm<sup>-2</sup> count<sup>-1</sup>.

### 4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB 090807 at  $T + 164$  s (Swenson et al., *GCN Circ.* 9751) No optical afterglow consistent with the XRT position is detected in the initial UVOT exposures. Preliminary  $3\sigma$  UL's using the UVOT photometric system (Poole et al. 2008, *MNRAS*, 383, 627) for the first finding chart (FC) exposure and subsequent exposures are:

Filter	T_start(s)	T_stop(s)	Exp(s)	Mag
white_FC	164	313	147	>21.2
u_FC	322	571	246	>20.1
white	164	1026	295	>21.1
u	322	571	246	>20.1

The values quoted above are not corrected for the Galactic extinction due to the reddening of  $E(B - V) = 0.18$  in the direction of the burst (Schlegel et al. 1998).

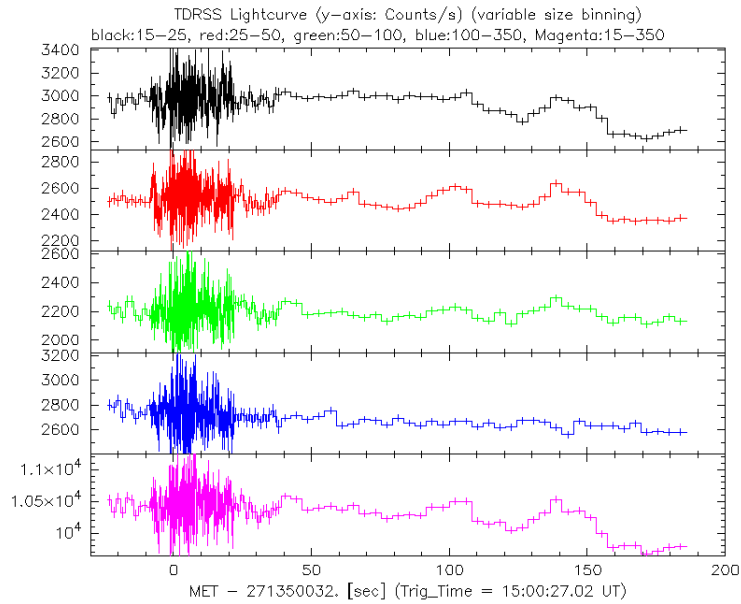


Figure 1: BAT Lightcurve. The light curve in the 4 individual plus total energy bands (15 – 25 keV, 25 – 50, 50 – 100, 100 – 350, and 15 – 350).

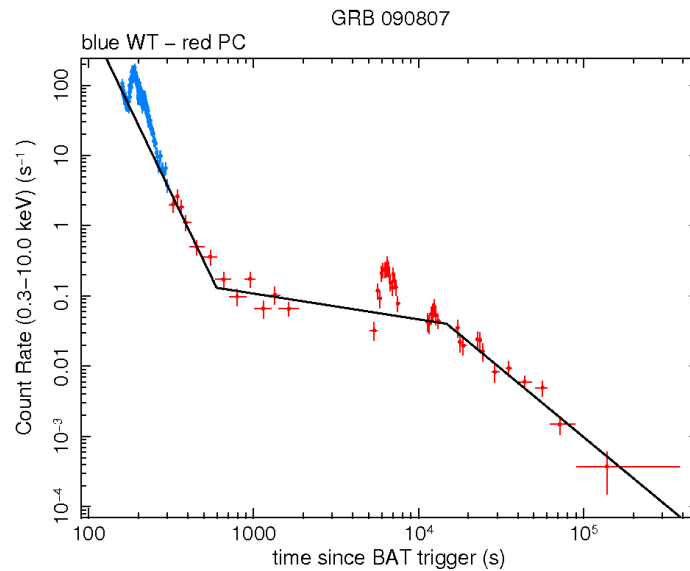


Figure 2: XRT Lightcurve. A broken powerlaw fit gives:  $\alpha_1 = -4.9 \pm 0.2$ ,  $t_{\text{break}, 1} = 600$  s,  $\alpha_2 = -0.37 \pm 0.05$ ,  $t_{\text{break}, 2} = 15 \pm 1$  ks,  $\alpha_3 = -1.9 \pm 0.2$ . A large flare is seen, peaking around 185 s (detected by BAT as well); there is also late time (7 ks) flaring activity. The broken power law fit excludes the time intervals 176 – 271 s and 5390 – 7500 s which are dominated by flaring activity.