

## Swift Observation of GRB 070724

*H. Ziaeeepour (UCL/MSSL), S. D. Barthelmy (GSFC), A. Parsons (GSFC), K.L. Page (U. Leicester), M. De Pasquale, P. Schady (MSSL-UCL) for the Swift Team*

### 1 Introduction

BAT triggered on GRB 070724 at 10:53:50 UT (Trigger 285948) (Ziaeeepour, et al., *GCN Circ.* 6654). This was a 0.512 sec rate trigger with 13.03 significance on a short burst with  $T_{90} = 0.4 \pm 0.04$  sec (Parsons, et al., *GCN Circ.* 6656). Swift slewed to this burst immediately and XRT began follow-up observations at  $T + 72.1$  sec, and UVOT at  $T + 75$  sec. Our best position is the XRT location  $RA(J2000) = 27.80815$  deg (01h51m13.96s),  $Dec(J2000) = -18.59448$  deg ( $-18d35'40.1''$ ) with an error of 2.2 arcsec (Page, et al. *GCN Circ.* 6659). No optical/UV counterpart was found for this burst up to a  $3\sigma$  magnitude limit of 20.4 in White filter (160 – 650 nm) at  $\sim T + 100$  sec (De Pasquale, et al., *GCN Circ.* 6660). In the Digital Sky Survey (DSS) images it was found that a faint blue source partially overlaps the error circle of the refined XRT position (Bloom, *GCN Circ.* 6658, Bloom & Butler, *GCN Circ.* 6661). The same source has been detected in some of the UVOT filters. An IR observation of this burst by UKIRT (Levan, et al., *GCN Circ.* 6662), P60, and Gemini (Cenko, et al., *GCN Circ.* 6664, Cucchiara, et al., *GCN Circ.* 6665) confirms the presence of this source, its classification as a galaxy and its redshift  $z = 0.457$ . These observations do not find any other source in the XRT error circle, increasing the possibility that this source is the host galaxy of the short GRB 070724.

### 2 BAT Observation and Analysis

Using the data set from  $T - 310$  to  $T + 310$  sec, further analysis of BAT GRB 070724 has been performed by the Swift team (Parsons, et al., *GCN Circ.* 6656). The BAT ground-calculated position is  $RA(J2000) = 27.824$  deg (01h51m17.9s),  $Dec(J2000) = -18.610$  deg ( $-18d36'35''$ )  $\pm 1.2$  arcmin, (radius, systematic and statistical, 90% containment). The partial coding was 91% (the offset angle was 16.44 deg).

In the masked-weighted light curves (Fig.1) a peak with substructures starts at  $\sim T - 0.1$  sec and returns to background at about  $\sim T + 0.3$  sec. The maximum is at  $\sim 0.2$  sec. No extended emission was observed later.  $T_{90}$  (15 – 350 keV) is  $0.4 \pm 0.04$  sec (estimated error including systematics).

The time-averaged spectrum from  $T - 0.0$  to  $T + 0.4$  sec is best fitted by a simple power law model. This fit gives a photon index of  $1.81 \pm 0.33$ , ( $\chi^2 = 51.99$  for 57 d.o.f.). For this model the total fluence in the 15 – 150 keV band is  $(3.0 \pm 0.7) \times 10^{-8}$  ergs  $\text{cm}^{-2}$  and the 1-sec peak flux measured from  $T - 0.3$  sec in the 15 – 150 keV band is  $1.0 \pm 0.2$  ph  $\text{cm}^{-2} \text{sec}^{-1}$ . All the quoted errors are at the 90% confidence level.

### 3 XRT Observations and Analysis

The first three orbits of the Swift-XRT data obtained for GRB 070724 are used for refined analysis of the X-ray emission of this burst (Page, et al., *GCN Circ.* 6659). The data includes  $\sim 60$  sec of Windowed Timing (WT) mode and  $\sim 5.2$  ksec of Photon Counting (PC) data. Using 399 sec of overlapping XRT PC mode and UVOT V-band data, the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue the astrometrically corrected XRT position of GRB 070724 is:  $RA(J2000) = 27.80815$  deg (01h51m13.96s),  $Dec(J2000) = -18.59448$  deg ( $-18d35'40.1''$ )  $\pm 2.2$  arcsec (90% confidence). This position is within 2.7 arcsec of the initial XRT position (Ziaeeepour, et al. *GCN*

*Circ.* 6654) and 77.8 arcsec from the ground-calculated BAT position (Parsons, et al., *GCN Circ.* 6656).

The 0.3 – 10 keV light curve (Fig.2) shows an initial extended emission/flare that arrives to its maximum at around  $\sim T+127$  sec, followed by a very steep decline and a flare peaked at  $\sim T+200$  sec and fading with a slope of  $\sim 2.2$ . From  $\sim T+400$  sec a shallow regime begins with a slope of  $0.69 \pm 0.1$ . No break was observed up to the last available data point at  $\sim T + 4 \times 10^4$  sec.

In order to avoid any spectral evolution during the flares, Photon Counting (PC) mode data from the second and third,  $\sim T + 4$  to 12 ksec, were used to fit the X-ray spectrum. It can be modelled by a power-law of  $\Gamma = 1.3^{+0.8}_{-0.6}$ , absorbed by the Galactic column in this direction of  $1.43 \times 10^{20} \text{ cm}^{-2}$  (Kalberla, et al., 2005). The average observed flux in 0.3 – 10 keV during this time is  $5.18 \times 10^{-13} \text{ ergs cm}^{-2} \text{ sec}^{-1}$  corresponding to an unabsorbed flux of  $(5.27 \times 10^{-13}) \text{ ergs cm}^{-2} \text{ sec}^{-1}$ .

## 4 UVOT Observation and Analysis

The UVOT began observing the field of GRB 070724 at 10 : 35 : 10 UT, 75 sec after the initial BAT trigger (De Pasquale et al., *GCN Circ.* 6660). No optical afterglow is detected by Swift/UVOT in the XRT error circle in the white (98 sec) and V (393 sec) finding exposures, or in the co-added images in any filter down to  $3\sigma$  magnitude limit. Upper limits are summarized in Table 1. These upper limits are not corrected for Galactic extinction  $E(B - V) = 0.01$ . The candidate host galaxy (Bloom, *GCN Circ.* 6658, Bloom & Butler, *GCN Circ.* 6661, Levan, et al., *GCN Circ.* 6662, Cenko, et al., *GCN Circ.* 6664, Cucchiara, et al., *GCN Circ.* 6665) is also detected by the UVOT in White and UWM2 filters.

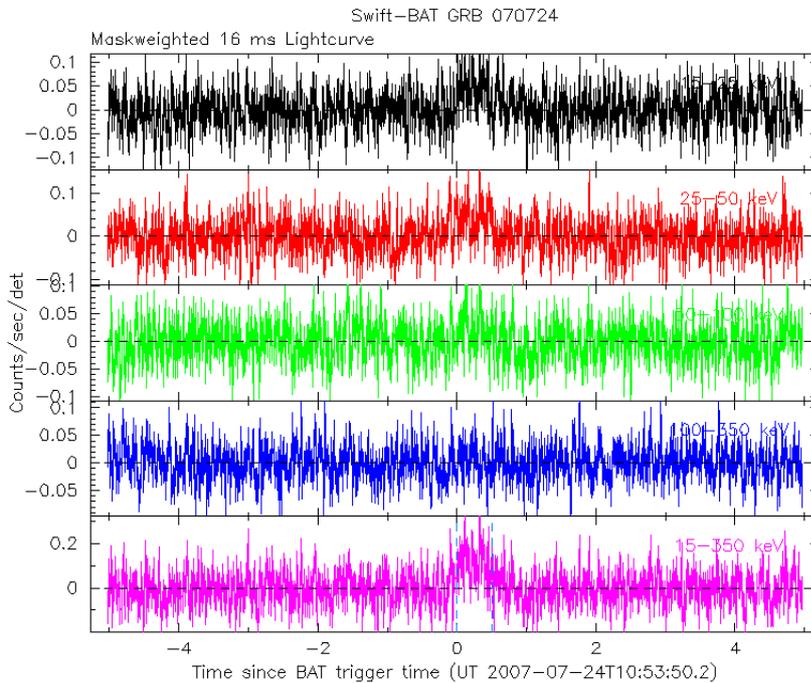


Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/sec/illuminated-detector and  $T$  is 10 : 53 : 50.2 UT.

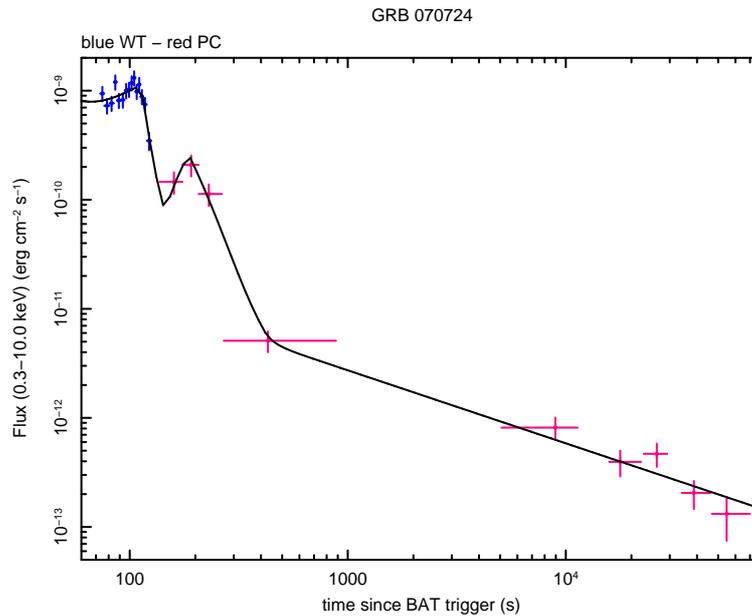


Figure 2: XRT Lightcurve. Counts/sec in the 0.3 – 10 keV band: Window Timing mode (blue), Photon Counting mode (red). The conversion of the absorbed flux is 1 count/sec  $\iff$   $5.99 \times 10^{-11}$  ergs cm $^{-2}$  sec $^{-1}$ .

Filter	$T_{mid}$ sec	Exposure (sec)	$3\sigma$ Mag.UL
White	76 – 176	98	20.4
V	182 – 581	393	19.5
White	76 – 5531	380	21.1
V	182 – 5941	806	20.0
B	662 – 5325	216	20.3
U	636 – 6456	332	20.0
UVW1	612 – 6352	432	20.4
UVM2	587 – 6146	432	20.4
UVW2	692 – 5736	432	20.7

Table 1: Magnitude limits from UVOT observations