Swift Observations of GRB 110731A

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1 Introduction

BAT detected GRB 110731A at 11:09:37 UT on the 31^{st} July 2011 (Oates, *et al.*, *GCN Circ.* 12215). This GRB was detected with a rate trigger at a significance of 180.74σ. The $T_{90}(15-350$ keV) for this GRB is 38.8 ± 13.0 s (estimated error including systematics).

Swift BAT slewed immediately to this burst and XRT observations and settled UVOT observations began ~ 56 s and 75 s, respectively, after the BAT trigger (Target ID 458448). A source was detected by the XRT (Beardmore, *et al.*, *GCN Circ.* 12219; Littlejohns, *et al.*, *GCN Circ.* 12224) and by the UVOT (Oates, *et al.*, *GCN Circ.* 12222). Observations were also reported by multiple observatories: FTN+FTS (Bersier, *et al.*, *GCN Circ.* 12216), Fermi-LAT (Bregeon, *et al.*, *GCN Circ.* 12218), Fermi-GBM (Gruber, *et al.*, *GCN Circ.* 12221), NOT (Malesani, *et al.*, *GCN Circ.* 12220), Konus-Wind (Golenetskii, *et al.*, *GCN Circ.* 12223), INTEGRAL/SPI-ACS (private communication), Gemini-N (Tanivr, *et al.*, *GCN Circ.* 12225), EVLA (Zauderer, *et al.*, *GCN Circ.* 12227), MITSuME (Kuroda, *et al.*, *GCN Circ.* 12226), MOA (Tristram, *et al.*, *GCN Circ.* 12242), Suzaku WAM (Hanabata, *et al.*, *GCN Circ.* 12244) and SOA RAS and Terskol (Moskvitin, *et al.*, *GCN Circ.* 12333).

Our best position is the UVOT location RA($J2000$) = 280.50413 *deg* ($18h\ 42m\ 00.99s$), Dec($J2000$) = -28.537167 *deg* ($-28d\ 32'\ 13.8''$) with an error of 0.5 arcsec (radius, 90% confidence).

2 BAT Observation and Analysis

Using the data set from T-240 to T+402 sec, we report on the refined analysis of BAT GRB 110731A (trigger 458448) (Oates, *et al.*, *GCN Circ.* 12215). The BAT ground-calculated position is RA, Dec = 280.513, -28.536 *deg*, which is:

RA(J2000) = $18h\ 42m\ 03.1s$
Dec(J2000) = $-28d\ 32'\ 10.0$"

with an uncertainty of 1.0 arcmin, (radius, sys+stat, 90% containment). The partial coding was 98%.

The mask-weighted light curve, see Fig. 1, shows many overlapping peaks starting at ∼T-1.5 sec, peaking at T_{zero}, and ending at ∼T+8 sec with a long exponential decay lasting out to ∼T+80 sec. $T90(15-350$ keV) is 38.8 ± 13.0 sec (estimated error including systematics).

The time-averaged spectrum from T-1.3 to T+80.3 sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.15 ± 0.05. The fluence in the 15-150 keV band is $6.0 \pm 0.1 \times 10^{-6}$ erg cm^{-2}. The 1-sec peak photon flux measured from T-0.26 sec in the 15-150 keV band is 11.0 ± 0.3 ph cm^{-2} sec^{-1}. 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/458448/BA/`

3 XRT Observations and Analysis

The XRT began observations of GRB 110731A 56 s after the BAT trigger.

The XRT found a bright, uncatalogued X-ray source located at RA, Dec = 280.50433, −28.53715 *deg* which is equivalent to:

RA (J2000): $18h\ 42m\ 1.04s$
Dec (J2000): $-28d\ 32'\ 13.7$"

with an uncertainty of 1.4 arcsec (radius, 90% confidence).

We analyzed 8.1 ks of XRT data for GRB 110731A (Oates, *et al.*, *GCN Circ.* 12215), from 56 s to 36.0 ks after the BAT trigger. The data comprise 573 s in Windowed Timing (WT) mode (the first 8 s were taken while Swift was slewing) with the remainder in Photon Counting (PC) mode.

The light curve, see Fig. 2, can be modeled with a broken power-law decay. The initial decay index is $\alpha = 1.09 \pm 0.04$ and at ∼T+2800 s the decay steepens to an α of $1.30^{+0.07}_{-0.05}$.

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of 1.98 ± 0.04. The best-fitting absorption column is $1.54^{+0.21}_{-0.20} \times 10^{22}$ cm^{-2}, in excess of the Galactic value of 1.0×10^{21} cm^{-2} (Kalberla et al. 2005). The PC mode spectrum has a photon index of 1.85 ± 0.10 and a best-fitting absorption column of $9.8^{+5.5}_{-5.0} \times 10^{21}$ cm^{-2}. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 4.0×10^{-11} (5.2×10^{-11}) erg cm^{-2} count^{-1}.

The results of the XRT-team automatic analysis are available at:
`http://www.swift.ac.uk/xrt_products/00458448`

4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB 110731A 75 s after the BAT trigger (Oates, *et al.*, *GCN Circ.* 11787). We detect a fading source, see Fig. 3, in the *white*, *v*, *b* and *u* filters at a refined position of RA, Dec = 280.50413, −28.537167 *deg* which is equivalent to:

RA (J2000): $18h\ 42m\ 00.99s$
Dec (J2000): $-28d\ 32'\ 13.8$"

with an uncertainty of 0.5 arcsec (radius, 90% confidence). This is consistent with the enhanced position of the X-ray afterglow. The non-detection in the ultra-violet filters suggests a redshift of between 2 and 3, consistent with the Gemini-N reported redshift z=2.83 (Tanvir, *et al.*, *GCN Circ.* 12225).

The results of the UVOT-team automatic analysis are available at:
`http://gcn.gsfc.nasa.gov/swift_gnd_ana.html`

The preliminary magnitudes for the optical filters and the 3-sigma upper limits for the summed ultra-violet images are provided in Table 1.

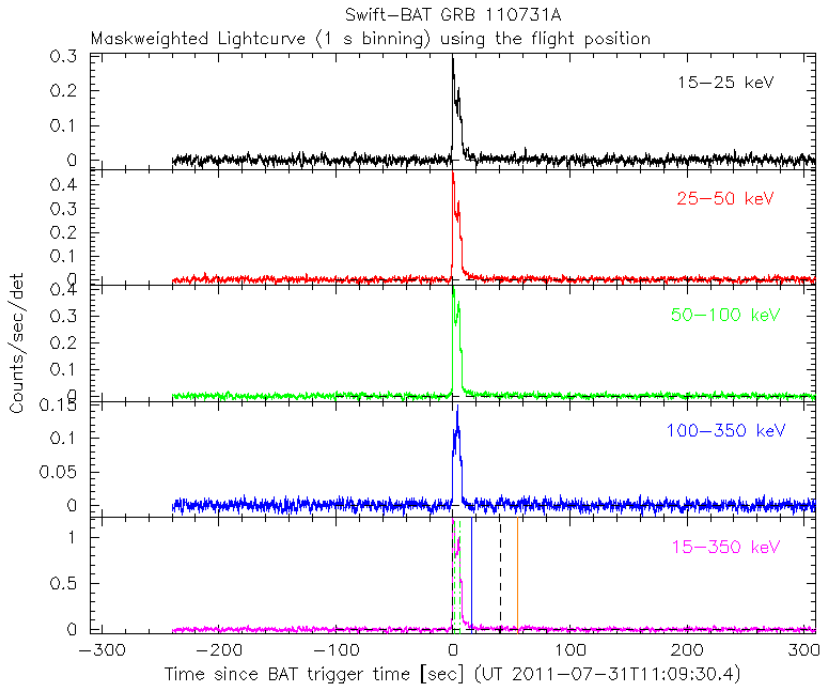

Figure 1: BAT light curve. The mask-weighted light curve in the 4 individual plus total energy bands: 15 - 25 keV (black), 25 - 50 keV (red), 50 - 100 keV (green), 100 - 350 keV (blue), 15 - 350 keV (magenta)

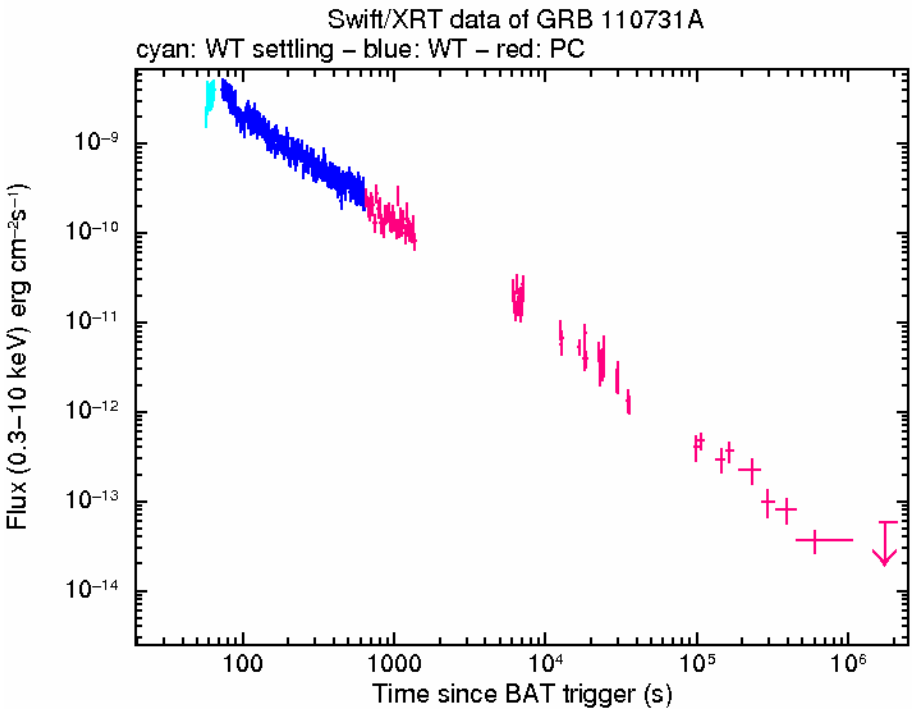

Figure 2: XRT light curve in the 0.3-10 keV band. The counts-to-observed-flux conversion factor is 1 count $= 4.0 \times 10^{-11}$ erg cm^{-2}.

Filter	Start (s)	Stop (s)	Exposure (s)	Magnitude/3σ UL
$wh(FC)$	75	225	147	15.85±0.02
wh	567	587	19	17.64±0.11
v	790	810	19	16.90±0.23
b	542	562	19	17.87±0.23
$u(FC)$	287	537	246	17.71±0.08
u	1118	1138	19	18.37±0.44
$uvw1$	666	1286	78	18.88
$uvm2$	642	1261	78	18.77
$uvw2$	592	1385	97	19.24

Table 1: Magnitudes for finding chart (FC), single images, and summed images from UVOT observations. The values quoted above are not corrected for the expected non-negelible Galactic extinction corresponding to a reddening of E(B-V) = 0.18 mag in the direction of the burst (Schlegel, Finkbeiner & Davis, 1998).

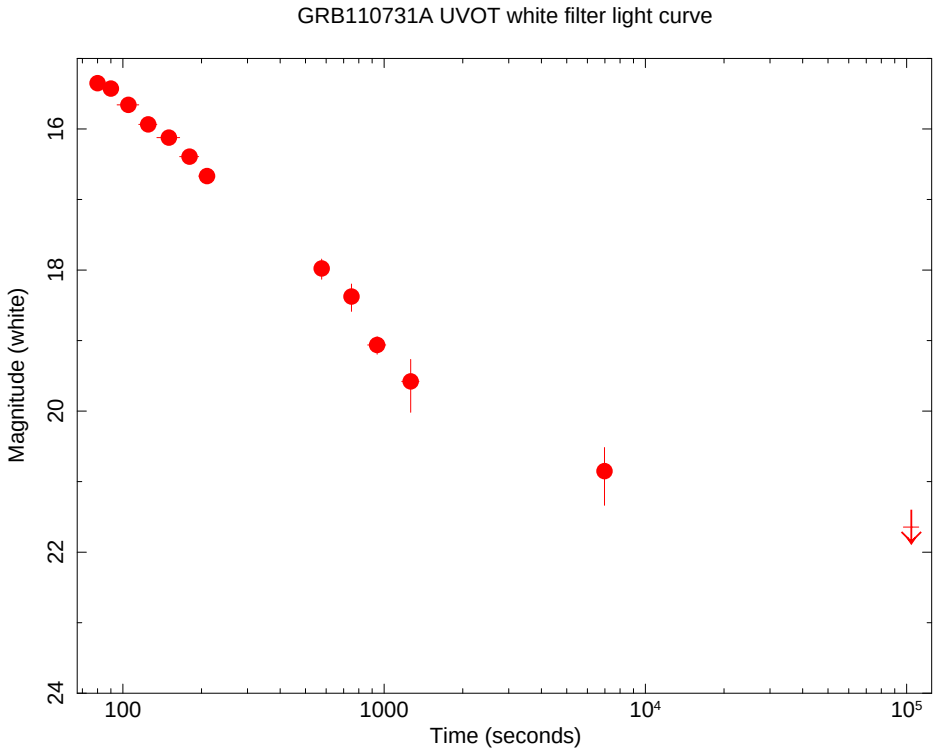

Figure 3: UVOT *white* filter light curve of GRB110731A. The arrow is a 3σ upper limit.