Swift Observations of GRB 110731A

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1 Introduction

BAT detected GRB 110731A at 11:09:37 UT on the 31st July 2011 (Oates, et al., GCN Circ. 12215). This GRB was detected with a rate trigger at a significance of 18.0.74σ. The T90 (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 SOAR 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 03.1 s
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 Tzero, 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 ± 0.1 × 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 $\sim T+2800$ s the decay steepens to an $\alpha$ 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 $1.98 \pm 0.04$. The best-fitting absorption column is $1.54^{+0.31}_{-0.20} \times 10^{22}$ cm$^{-2}$, in excess of the Galactic value of $1.0 \times 10^{21}$ cm$^{-2}$ (Kalberla et al. 2005). The PC mode spectrum has a photon index of $1.85 \pm 0.10$ 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 $4.0 \times 10^{-11}$ ($5.2 \times 10^{-11}$) 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$^{-2}$. 
<table>
<thead>
<tr>
<th>Filter</th>
<th>Start (s)</th>
<th>Stop (s)</th>
<th>Exposure (s)</th>
<th>Magnitude/3σ UL</th>
</tr>
</thead>
<tbody>
<tr>
<td>$wh(FC)$</td>
<td>75</td>
<td>225</td>
<td>147</td>
<td>15.85±0.02</td>
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<tr>
<td>$wh$</td>
<td>567</td>
<td>587</td>
<td>19</td>
<td>17.64±0.11</td>
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<td>$v$</td>
<td>790</td>
<td>810</td>
<td>19</td>
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<tr>
<td>$b$</td>
<td>542</td>
<td>562</td>
<td>19</td>
<td>17.87±0.23</td>
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<tr>
<td>$u(FC)$</td>
<td>287</td>
<td>537</td>
<td>246</td>
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<td>1138</td>
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<td>592</td>
<td>1385</td>
<td>97</td>
<td>19.24</td>
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</tbody>
</table>

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-negligible 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.