

Swift Observations of GRB 081109A

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1. INTRODUCTION

BAT triggered on GRB 081109A at 07:02:06 UT (trigger 334112) (Cummings et al., GCN Circ. 8500). This was a 1.024 sec rate-trigger on a long burst with $T_{90} = 190 \pm 60$ sec. Swift slewed immediately to the burst. XRT observations began at 65.6 sec after the BAT trigger and discovered a bright and fading X-ray afterglow. UVOT began observing at $T + 150$ s and found no optical counterpart down to about 18 mag in the initial data products.

This burst has also been observed by Fermi GBM (von Kienlin et al., GCN Circ. 8505).

An optical source was seen by REM, starting about 52 s after the burst, at $H = 15.47 \pm 0.26$ and $K = 14.51 \pm 0.27$ (D'Avanzo et al., GCN Circ. 8501). The object subsequently brightened, reaching $K = 14.27 \pm 0.16$ on Nov 09.30612 UT.

Observation with GROND, starting at 00:08 UT on November 10th, 2008, 17.1 hr after the GRB trigger, gave a redshift limit of $z < 3.5$ and a best fit intrinsic extinction of A_V between 0.6 and 1.2 (Clemens et al., GCN Circ. 8515).

Continued observations with UVOT confirm a weak source close to the REM position and the refined XRT position, with a magnitude in the summed 54.4 ks image of white = 22.9 ± 0.1 mag (11.4 sigma detection) at RA = 22 03 09.579, Dec = -54 42 40.49 (J2000) (Kuin & Immler, et al., GCN Circ. 8523). The observations are interpreted as the detection of the host galaxy.

2. BAT OBSERVATION AND ANALYSIS

Using the data set from T-240 to T+962 sec, the BAT ground-calculated position is RA, Dec = 330.798, -54.711 deg, which is

$$\text{RA (J2000)} = 22\ 03\ 11.5$$

$$\text{Dec (J2000)} = -54\ 42\ 40.5$$

with an uncertainty of 1.0 arcmin, (radius, sys+stat, 90% containment). The partial coding was 73%.

The mask-weighted light curve shows a smooth rise to a single peak starting at $\sim T-90$ sec, peaking at $\sim T+5$ sec, and roughly exponentially decaying back to baseline at $\sim T+400$ sec. T_{90} (15-350 keV) is 190 ± 60 sec (estimated error including systematics).

The time-averaged spectrum from $T-15.9$ to $T+416.1$ sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.72 ± 0.09 . The fluence in the 15-150 keV band is $3.6 \pm 0.2 \times 10^{-6}$ erg/cm². The 1-sec peak photon flux measured from T+7.64 sec in the 15-150 keV band is 1.1 ± 0.0 ph/cm²/sec. All the quoted errors are at the 90% confidence level.

3. XRT OBSERVATION AND ANALYSIS

Using 10478 s of XRT Photon Counting mode data and 13 UVOT images, we find an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching to the USNO-B1 catalogue) of RA, Dec = 330.7905, -54.7118 which is equivalent to :

$$\text{RA (J2000)} = 22\ 03\ 9.72$$

$$\text{Dec (J2000)} = -54\ 42\ 42.4$$

with an uncertainty of 1.4 arcsec (90% confidence). D'Avanzo et al. (GCN Circ. 8501) report an updated REM position of

$$\text{RA (J2000)} = 22\ 03\ 09.46$$

$$\text{Dec (J2000)} = -54\ 42\ 41.2$$

with an uncertainty of 1 arcsec (68%). The REM pixel scale is 1.2 arcsec and the astrometry was performed with respect to the 2MASS catalogue.

The XRT and REM positions differ by 2.6 arcsec, which is 1.2 times the combined 90 percent error circle. The USNO/2MASS astrometric systems can differ by 0.5 arcsec which would bring the positions into agreement.

The X-ray light curve is modeled with a doubly broken powerlaw. The parameters are :

$$\alpha_1 = 1.80 \pm 0.06,$$

$$t_{\text{break1}} = 380 +56 -32 \text{ s},$$

$$\alpha_2 = 0.79 +0.15 -0.20,$$

$$t_{\text{break2}} = 2.9 +2.2 -1.0 \text{ ks},$$

$$\alpha_3 = 1.34 \pm 0.04.$$

The spectrum of the WT data from orbit 1 (from $T+71.9$ sec to $T+318.4$ sec) can be well fit by an absorbed powerlaw with a photon index of 1.72 ± 0.08 and column density of $(1.84 \pm 0.22) \times 10^{21} \text{ cm}^{-2}$, compared with the Galactic column density of $1.6 \times 10^{20} \text{ cm}^{-2}$ in the direction of the burst. The observed 0.3-10 keV flux is $(7.4 \pm 0.4) \times 10^{-10} \text{ erg cm}^{-2} \text{ s}^{-1}$. The corresponding unabsorbed 0.3-10 keV flux is $(9.5 \pm 0.5) \times 10^{-10} \text{ erg cm}^{-2} \text{ s}^{-1}$.

A powerlaw fit to a spectrum obtained from PC mode data spanning orbits 2 to 3 ($T+4.76$ ks to $T+12.88$ ks) is best fit with a photon index of 2.20 ± 0.20 and column density $(3.1 \pm 0.7) \times 10^{21} \text{ cm}^{-2}$. The observed 0.3-10 keV flux over this interval is $(7.3 \pm 0.7) \times 10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$. The count-to-observed-flux conversion factor is $6.0 \times 10^{-11} \text{ erg cm}^{-2} \text{ count}^{-1}$.

4. UVOT OBSERVATION AND ANALYSIS

Continued observations by UVOT (Kuin and Immler, GCN Circ. 8504; Immler et al., GCN Circ. 8509) confirm that a weak source is present close to the REM position (D'Avanzo et al, GCN Circ. 8501) and also offset from the refined XRT position (Beardmore et al., GCN Circ. 8506).

We detect a constant source in images totaling 54.4 ks of exposure time over a period of 544 ks (~1 week) in the white filter at position:

$$\text{RA} = 22\ 03\ 09.579,$$

$$\text{Dec} = -54\ 42\ 40.49 \text{ (J2000)}$$

with an uncertainty of 0.84 arcsec (90% confidence). The source magnitude in the summed image is $wh = 22.9 \pm 0.1 \text{ mag}$ (11.4 sigma detection).

The magnitudes quoted above are on the UVOT Photometric System (Poole et al, 2008, MNRAS 383, 627). They are not corrected for the expected galactic reddening of $E(B-V) = 0.019$ in the direction of the burst (Schlegel et al. 1998).

We interpret this source found in the UVOT white filter as the possible host galaxy. In that case the REM position offset suggests that the GRB took place on the edge of the host galaxy. The source we detect is also just outside the XRT error circle.

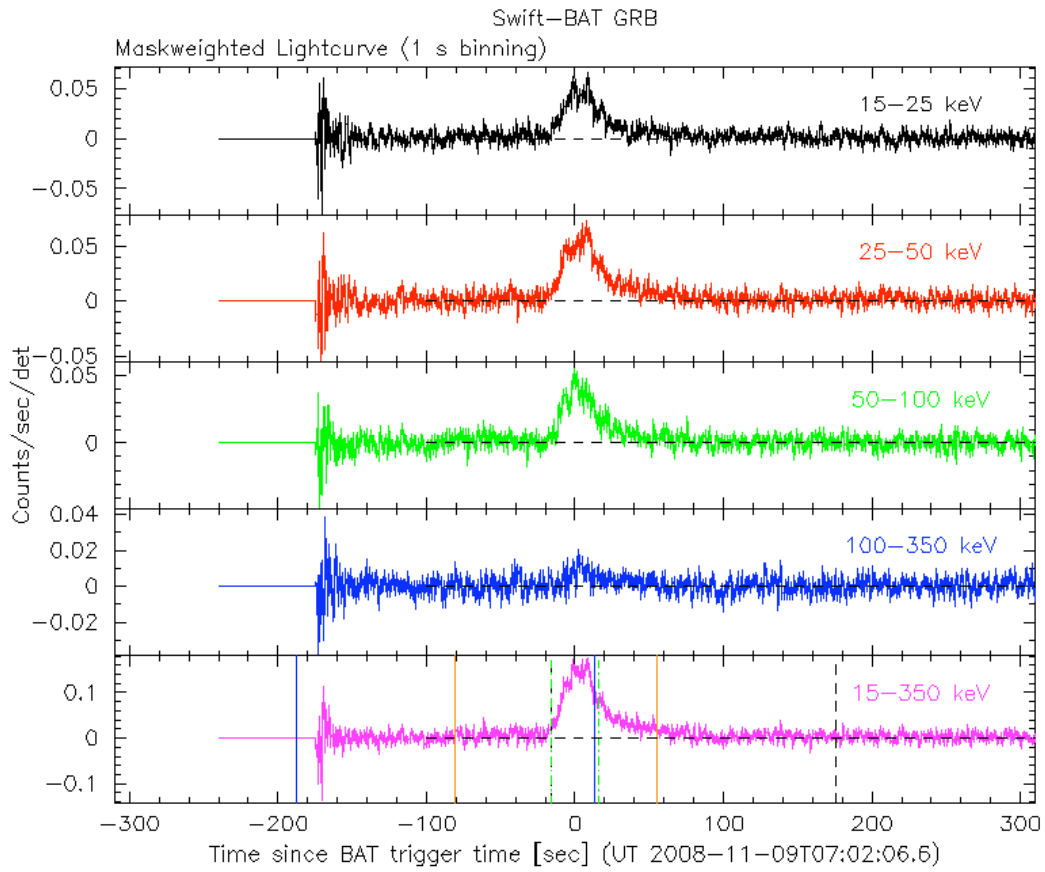


Fig.1: BAT Lightcurve. The light curve is given in the 4 individual plus total energy bands (bottom).

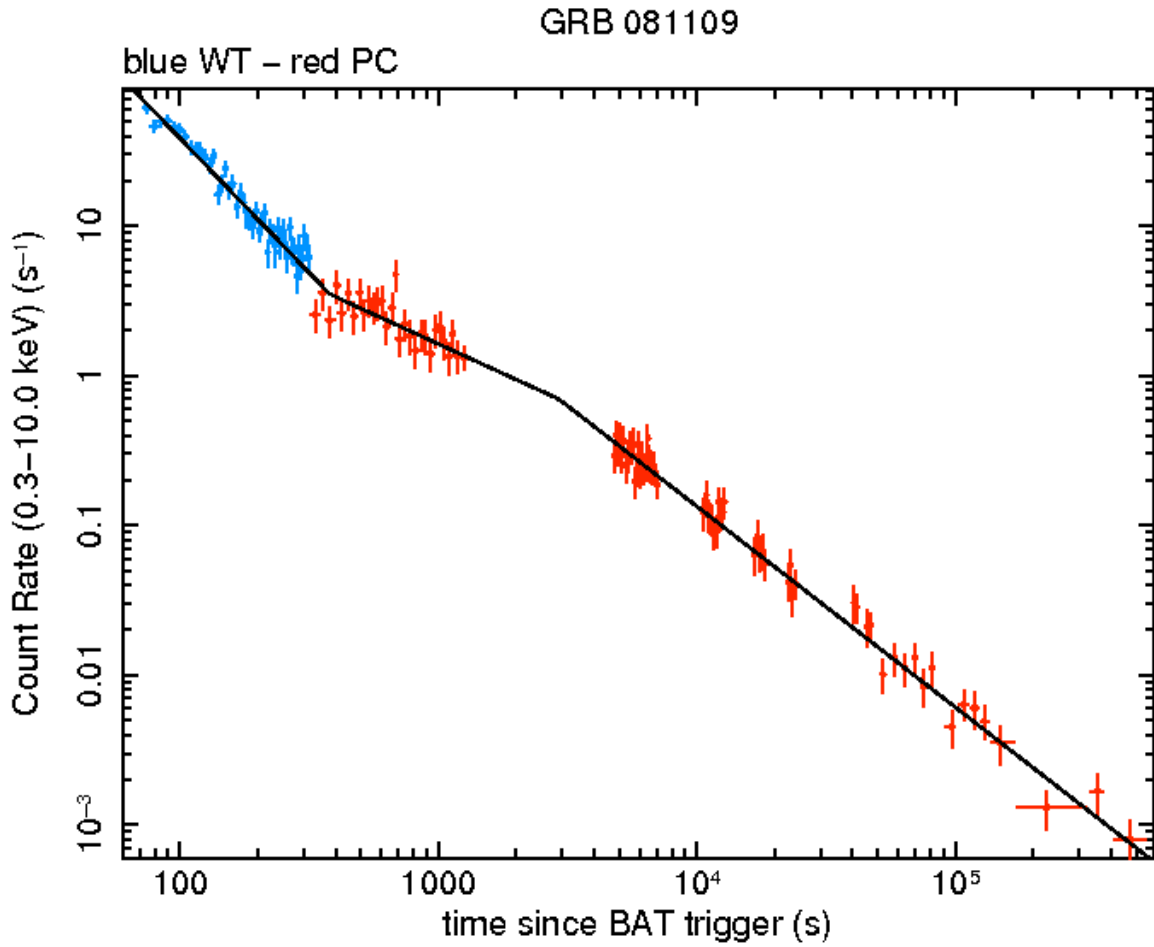


Fig. 2: XRT light curve. Window Timing mode is given in blue, Photon Counting mode in red.

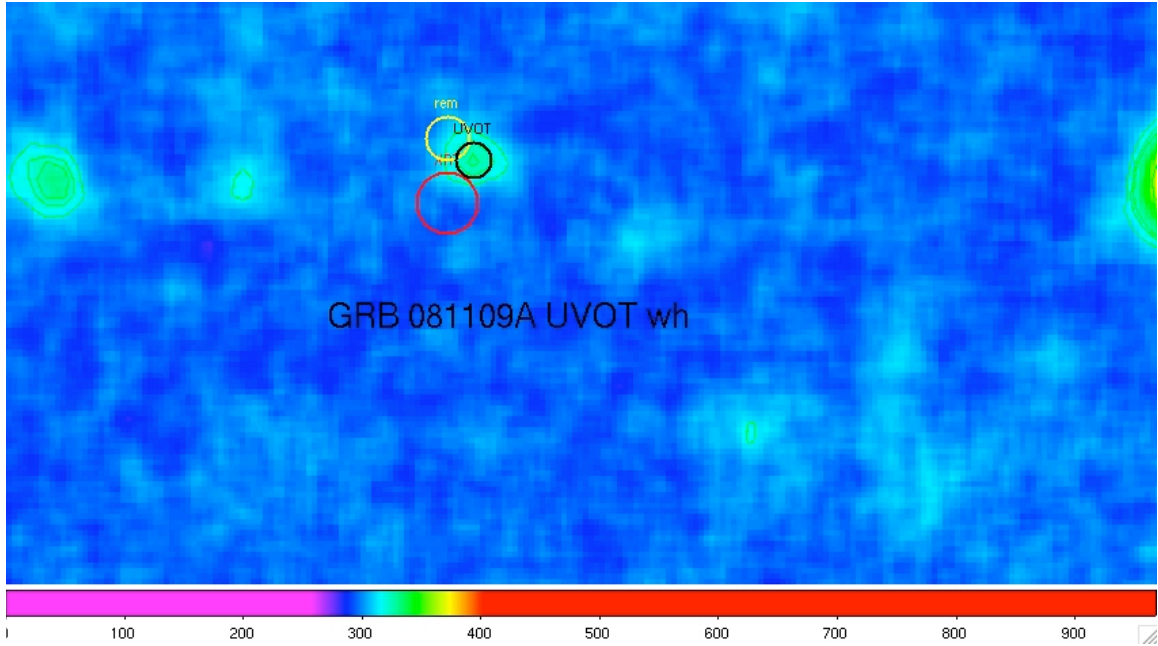


Fig. 3: Co-added 54.4 ks UVOT white image. The REM position is given in yellow, the XRT refined position in red, and the best position from this image in black. The size of the error circles is REM: 1.0", XRT: 1.4", UVOT-white: 0.84".