

Swift Observations of GRB 091102

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1 Introduction

At 14:34:38 UT on 2 November 2009 BAT triggered on and located GRB 091102 (Hoversten, *et al.*, *GCN Circ.* 10117, Trigger #374598). Due to an observing constraint Swift did not slew to the GRB position until $T + 985$ s. Our best position is the UVOT enhanced XRT position at $\text{RA}(J2000) = 72.61610$ deg (04h50m27.87s), $\text{Dec}(J2000) = -72.51970$ deg ($-72d31'10.9''$) with an uncertainty of 2.2 arcsec (radius, 90% confidence).

GRB 091102 was also detected by Fermi GBM (Rau, *GCN Circ.* 10126). Photometric upper limits were reported by a number of ground based observatories including ROTSE-III (Schaefer, *et al.*, *GCN Circ.* 10119), GROND (Filgas, *et al.*, *GCN Circ.* 10123), Faulkes (Cano, *et al.*, *GCN Circ.* 10127), LABOCA/APEX (de Ugarte Postigo, *et al.*, *GCN Circ.* 10129), and MOA-II (Nishimoto, *et al.*, *GCN Circ.* 10132). A tentative low-signal source was reported from the Yock-Allen robotic telescope (de Ugarte Postigo, *et al.*, *GCN Circ.* 10122).

2 BAT Observation and Analysis

Using the data set from $T - 240$ to $T + 962$ s further analysis of the GRB 091102 has been performed by the Swift team (Baumgartner, *et al.*, *GCN Circ.* 10121). The BAT ground-calculated position is $\text{RA}(J2000) = 72.622$ deg (04h50m29.3s), $\text{Dec}(J2000) = -72.527$ deg ($-72d31'37.9''$) with an uncertainty of 1.2 arcmin, (radius, sys+stat, 90% containment). The partial coding was 80%.

Because the spacecraft slewed for an observing constraint, the burst location went out of the BAT FOV at $T + 160$ s, and then came back into the FOV at $T + 900$ s. The mask-weighted light curve shows two slightly overlapping peaks starting at $\sim T - 2$ s, and ending at $\sim T + 20$ s. Measurable flux was still detected at $T + 900$ s when the location came back into the BAT FOV. T_{90} (15-350 keV) is 6.6 ± 0.5 s (estimated error including systematics). The BAT light curve is shown in Figure 1.

The time-averaged spectrum from $T - 0.8$ to $T + 6.6$ s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.08 ± 0.12 . The fluence in the 15-150 keV band is $5.2 \pm 0.4 \times 10^{-7}$ erg cm^{-2} . The 1-second peak photon flux measured from $T - 0.26$ s in the 15-150 keV band is 1.4 ± 0.2 ph cm^{-2} s^{-1} . All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

XRT observations of GRB 091102 began 988 seconds after the trigger (Vetere & Hoversten, *GCN Circ.* 10125). The UVOT-enhanced XRT position of GRB 091102 is $\text{RA}(J2000) = 72.61610$ deg (04h50m27.87s), $\text{Dec}(J2000) = -72.51970$ deg ($-72d31'10.9''$) with an uncertainty of 2.2 arcsec (radius, 90% confidence).

X-ray analysis of GRB 091102 was performed using 1.4 ks of XRT data from 988 s to 19 ks after the BAT trigger. All data was taken in photon counting (PC) mode. The PC 0.3-10 keV light curve shows a steep drop at 1.3 ks after the BAT trigger with a decay index of $\alpha = 2.9 \pm 0.6$. The XRT light curve is shown in Figure 2.

A spectrum formed from the PC mode data can be fitted with an absorbed power-law with a photon spectral index of $2.0^{+0.8}_{-0.6}$. The best-fitting absorption column is $2.4^{+2.5}_{-1.3} \times 10^{21}$ cm^{-2} , consistent with the

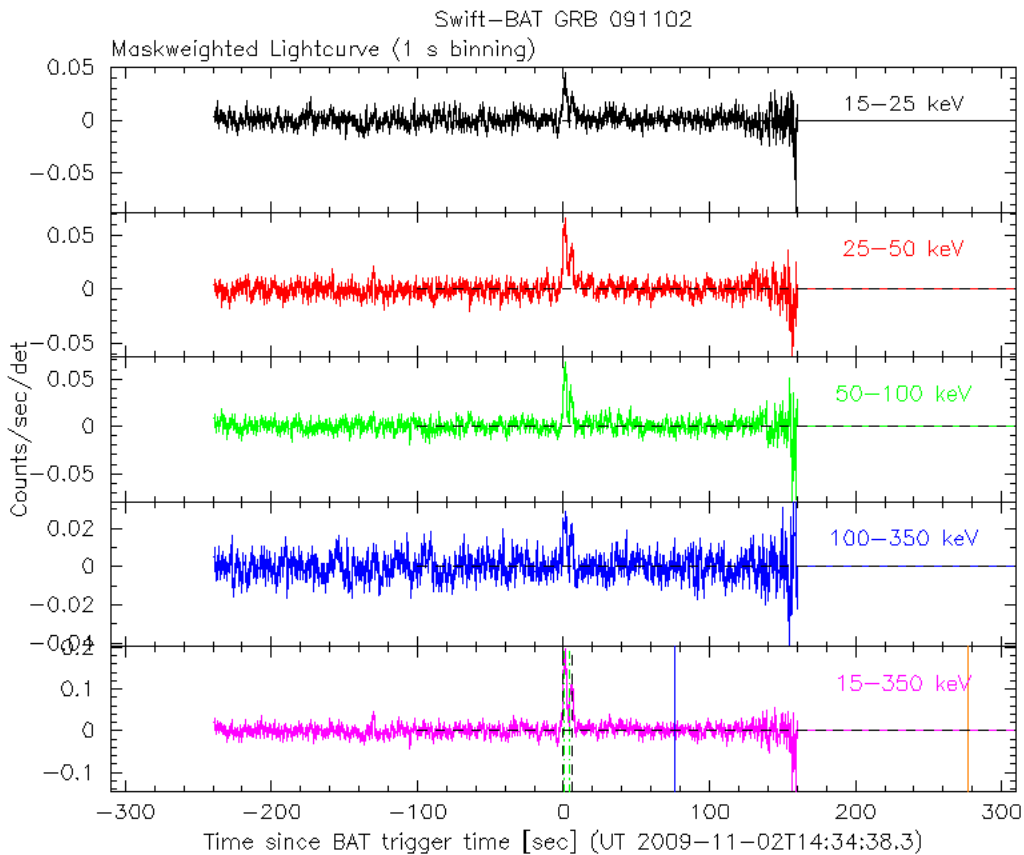


Figure 1: BAT Light curve. The mask-weighted light curve over all energy bands. The units are counts/s/illuminated-detector (note illum-det = 0.16cm^2) and T_0 is 14:34:38.3 UT.

Galactic value of $1.1 \times 10^{21}\text{cm}^{-2}$ (Kalberla et al. 2005). The counts to observed flux conversion factor in the 0.3-10 keV band deduced from this spectrum is $4.2 \times 10^{-11}\text{ erg cm}^{-2}\text{s}^{-1}$ for the absorption corrected spectrum and $6.3 \times 10^{-11}\text{ erg cm}^{-2}\text{s}^{-1}$ in the unabsorbed case for a count rate of 1 count s^{-1} .

4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB 091102 986s after the BAT trigger (Hoversten, *GCN Circ.* 10124). No source was detected at the enhanced Swift XRT position (Kennea, *et al.*, *GCN Circ.* 10120). UVOT magnitude 3-sigma upper limits are reported in Table 1. The values quoted in the table are on the UVOT Photometric System (Poole, et al, 2008). They are not corrected for the expected Galactic reddening of $E(B - V) = 0.07$ in the direction of the burst (Schlegel, Finkbeiner, & Davis, 1998).

References

- [1] Baumgartner, W. H., et al. 2009, *GCN Circ.* 10121

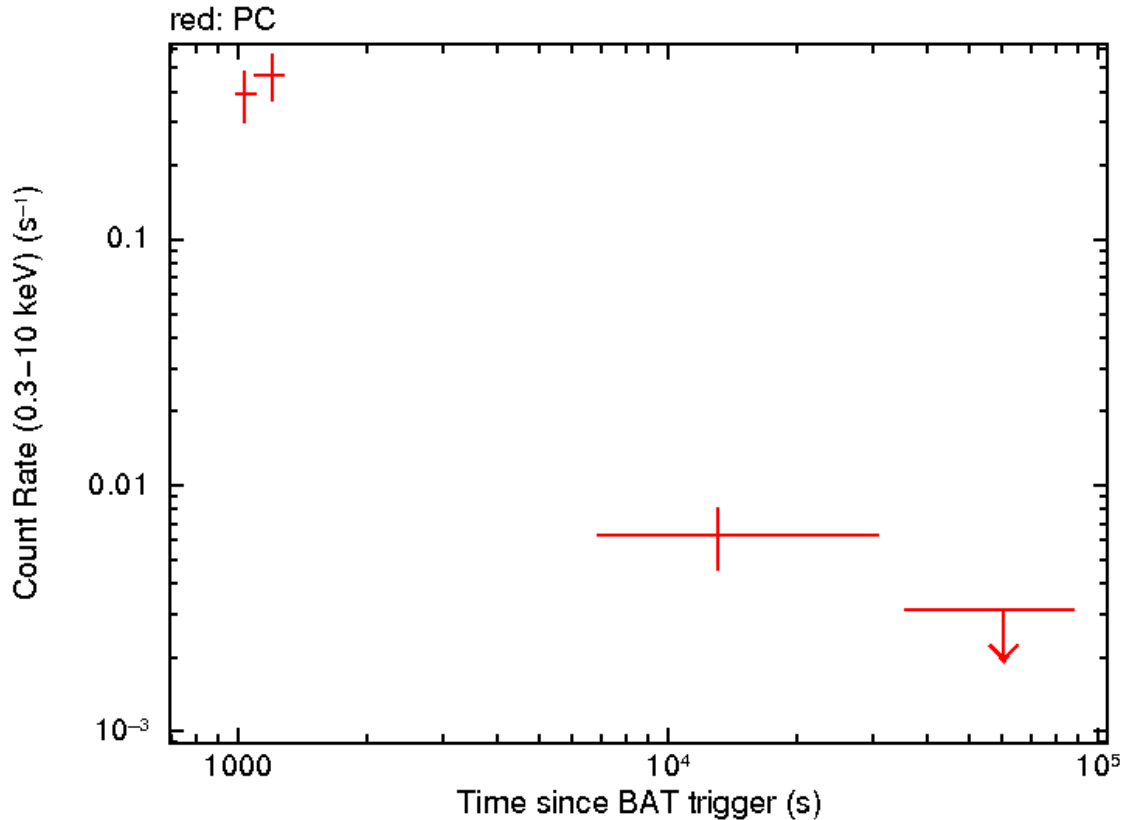


Figure 2: XRT Light curve. Flux in the 0.3-10 keV band: Photon Counting mode (red). Due to the low count rate at the time of the late slew there were no data taken in Window Timing. The approximate conversion is $1 \text{ count } s^{-1} \simeq 4.2 \times 10^{-11} \text{ ergs cm}^{-2} s^{-1}$.

- [2] Cano, Z., et al. 2009, *GCN Circ.* 10127
- [3] Filgas, R., et al. 2009, *GCN Circ.* 10123
- [4] Hoversten, E. A. 2009, *GCN Circ.* 10124
- [5] Hoversten, E. A., et al. 2009, *GCN Circ.* 10117
- [6] Kaberla, P. M. W., et al. 2005, *A. & A.*, 440, 775
- [7] Kennea, J. A., et al. 2009, *GCN Circ.* 10120
- [8] Nishimoto, K., et al. 2009, *GCN Circ.* 10132
- [9] Poole, T. S., et al. 2008, *MNRAS*, 383, 627
- [10] Rau, A. 2009, *GCN Circ.* 10126
- [11] Schaefer, B. E., et al. 2009, *GCN Circ.* 10119
- [12] Schlegel, D. J., Finkbeiner, D., & Davis, M. 1998, *ApJ.*, 500, 525
- [13] de Ugarte Postigo, A., et al. 2009, *GCN Circ.* 10122
- [14] de Ugarte Postigo, A., et al. 2009, *GCN Circ.* 10129
- [15] Vetere, L. & Hoversten, E. A. 2009, *GCN Circ.* 10125

Filter	Start	Stop	Exposure	Magnitude
WHITE	986	1136	147	> 20.05
v	1267	1287	19	> 17.18
b	1193	1213	19	> 18.09
u	1168	1188	19	> 17.70
uvw1	1144	1164	19	> 17.70
uvm2	1292	1301	9	> 16.61
uvw2	1243	1263	19	> 17.79

Table 1: UVOT observations