Swift Observations of GRB 091221

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1 Introduction

BAT triggered on GRB 091221 at 20:52:52 UT (Trigger 380311) (Krimm *et al.*, *GCN Circ.* 10283). This was an 1.024-sec rate-trigger on a intermediate length burst with $T_{90} = 68.5 \pm 5.5$ sec. Swift slewed immediately to the burst. The best position is the UVOT position (de Pasquale & Krimm, *GCN Circ.* 10289): RA($J2000$) = 55.797500° (3h 43m 11.40s), Dec($J2000$) = +23.241194° (+23°14′28″.3) with an error of 0.6 arcsec (radius, systematic plus statistical, 90% containment).

The prompt emission from GRB 091221 was also detected by *Fermi*/GBM (Wilson-Hodge, *GCN Circ.* 10293) and INTEGRAL/SPI-ACS (V. Savchenko, private communication) .

2 BAT Observation and Analysis

Using the data set from T-240 to T+962 sec, further analysis of GRB 091221 was performed by the Swift/BAT team (Cummings et al., GCN 10291). The partial coding was 62%. The mask-weighted light curve (Figure 1) shows a weak peak from T-45 to T-20 sec and a stronger, slow-rise, complex peak from T-10 to T+42 sec. T_{90} (15-350 keV) is 68.5±5.5 sec (estimated error including systematics).

The time-averaged spectrum from T-43.6 to T+41.1 sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.59 ± 0.06. The fluence in the 15-150 keV band is $5.7 \pm 0.2 \times 10^{-6}$ $erg\ cm^{-2}$. The 1-sec peak photon flux measured from T+20.7 sec in the 15-150 keV band is 3.0 ± 0.2 $ph\ cm^{-2}\ s^{-1}$. All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

Using the 3.7 ks of XRT data of GRB 091221, the enhanced XRT position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue) is RA($J2000$) = 55.79749° (03h 43m 11.40s), Dec($J2000$) = +23.24119° (+23°14′28″.3) with an uncertainty of 1.7 arcsec (90% confidence, including boresight uncertainties). This is consistent with the UVOT position. The data comprise 332 s in Windowed Timing (WT) mode with the remainder in Photon Counting (PC) mode.

The $0.3 - 10$ keV light curve (Fig 2) shows a flare feature from T_0+90 s to T_0+200 s (Mao & Krimm *GCN Circ.* 10288), with a peak value of about 55 count/s at T_0+106 s. Starting from the second orbit (T_0+3.0 ks) the curve is well described by a power-law model with index $\alpha = -1.14 \pm 0.03$.

The X-ray spectrum during the power-law decay is well fit by an absorbed power-law model with a photon spectral index of $\Gamma = 1.68^{+0.45}_{-0.51}$. The best-fitting absorption column is about $n_H = 1.1 \times 10^{21}$ cm^{-2}, consistent with the Galactic value. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is $4.4(7.2) \times 10^{-11}$ $erg\ cm^{-2} count^{-1}$. A spectrum formed from the (early) WT mode data can be fitted with an absorbed power-law with a photon spectral index of 2.52 $\pm$ 0.17. Errors are given at the 1σ level.

4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB091221 80s after the BAT trigger with a 150s finding chart exposure in the White filter.

The optical afterglow is detected in the finding chart exposure, at a time corresponding to the bright X-ray flare. The afterglow is not detected at later times in single or summed exposures in all filters. Preliminary magnitudes and 3σ upper limits are reported below.

Filter	Start	Stop	Exposure (s)	Magnitude
white	80	230	149.8	20.19 ± 0.27
white	3657	11605	927.1	> 21.62
v	4068	5704	393.2	> 19.56
b	3452	11054	1278.4	> 21.11
u	4683	10142	1083.4	> 20.68
uvw1	4478	6075	354.4	> 19.96
uvm2	4273	5909	393.3	> 19.79
uvw2	3863	5499	393.3	> 20.07

Table 1: Magnitude limits from UVOT observations.

The quoted magnitudes and upper limits have not been corrected for the heavy Galactic extinction along the line of sight of $E_{B-V} = 0.22$ mag (Schlegel *et al.*, 1998, ApJS **500**, 525). All photometry is on the UVOT photometric system described in Poole *et al.*, (2008, MNRAS **383**, 627).

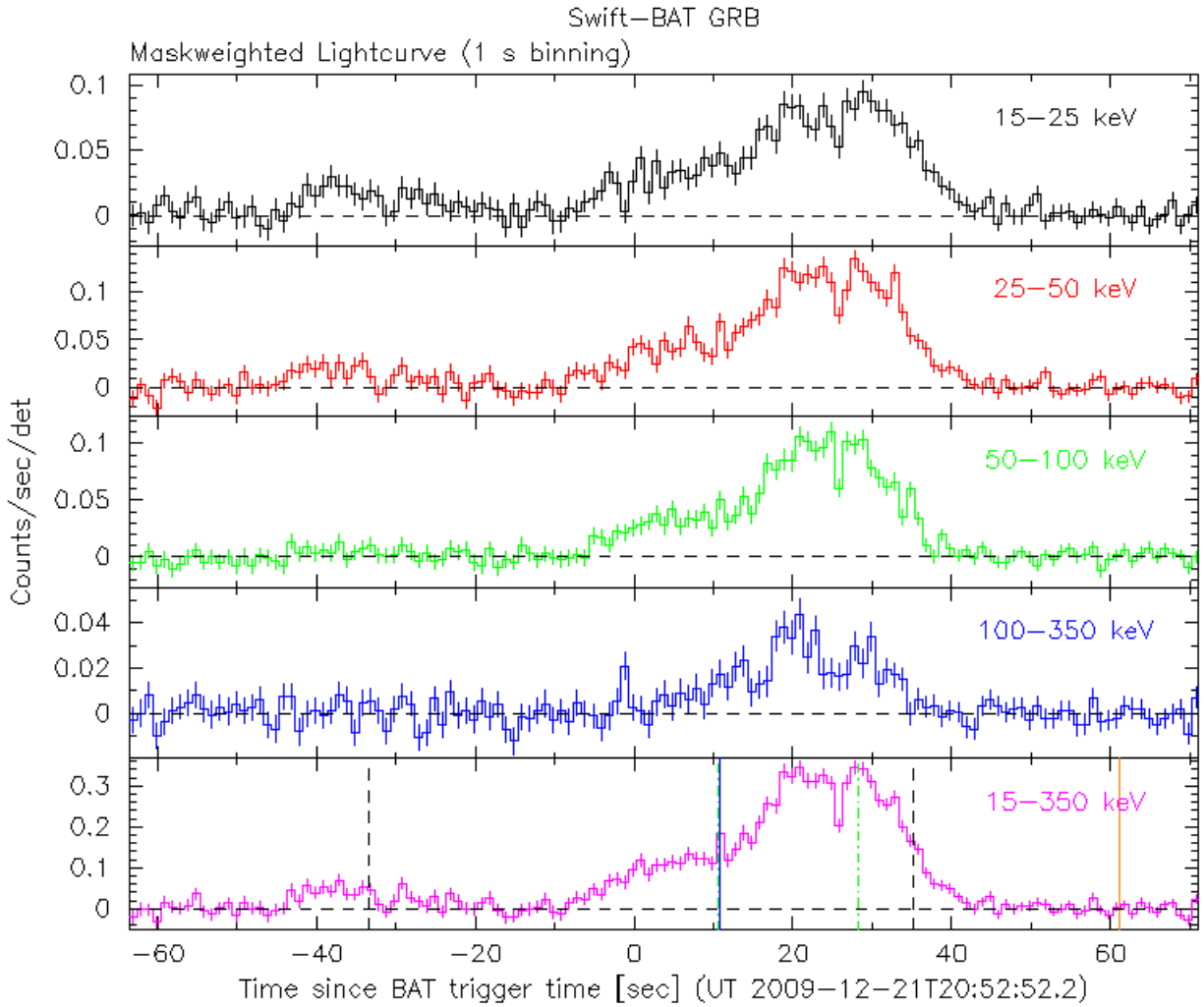

Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/sec/illuminated-detector (note illum-det = 0.16 cm^2).

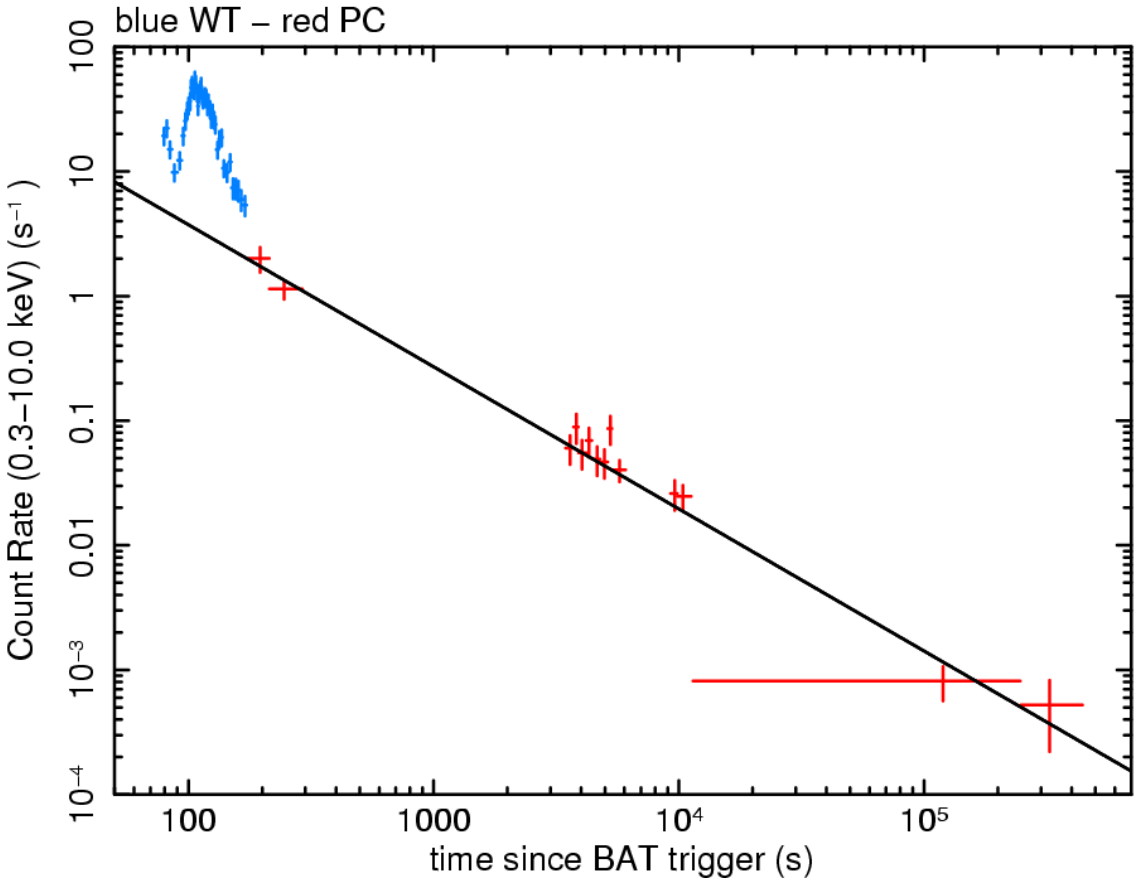

Figure 2: XRT light-curve. Counts s^{-1} in the 0.3-10 keV band for the Windowed Timing mode (blue) and Photon Counting mode (red). The approximate conversion of the 0.3 – 10 keV observed flux is 1 count $s^{-1} \sim 4.4 \times 10^{-11} erg\ cm^{-2} s^{-1}$.

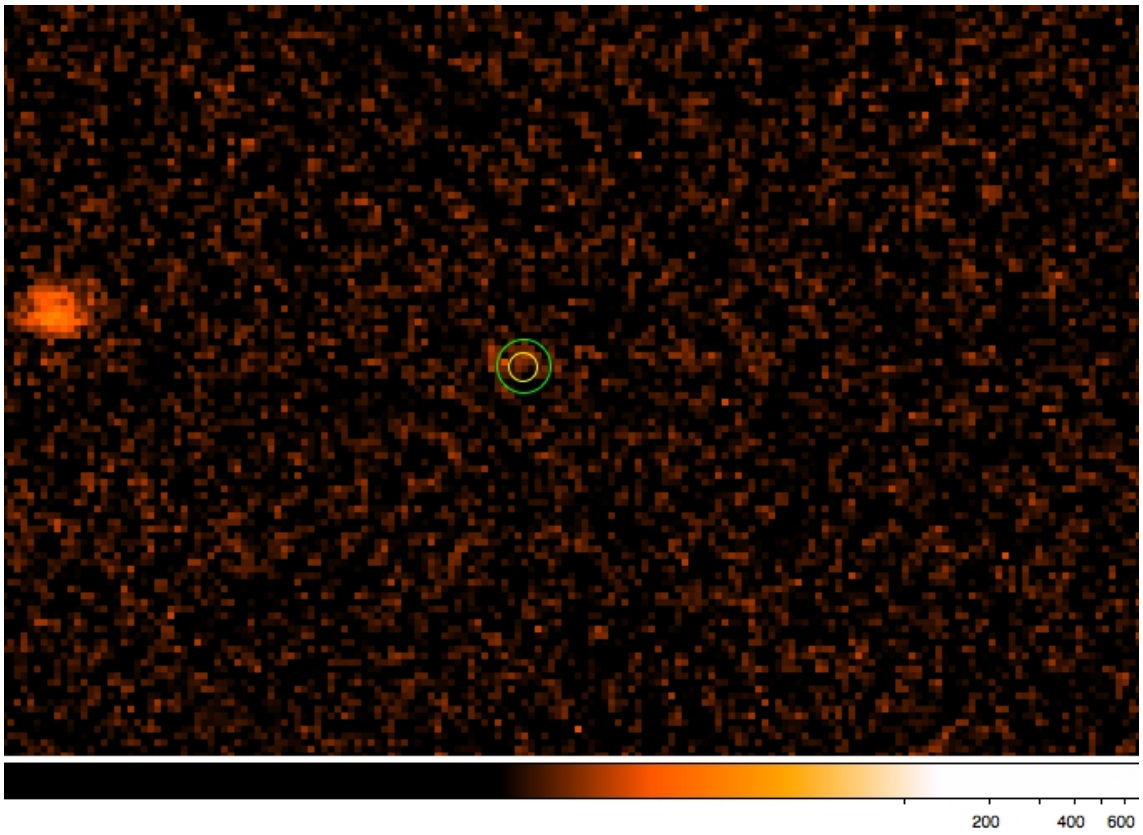

Figure 3: UVOT finding chart image. The green circle is the error circle of the enhanced XRT position. The UVOT error circle is indicated with a yellow circle.