Swift Observation of GRB 090929B

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1 Introduction

BAT triggered on the long GRB 090929B at 10:09:07.2 UT (Trigger 371050) (Pagani, *et al.*, *GCN Circ.* 9963), a burst with $T_{90} = 360 \pm 20$ *sec*. *Swift* slewed immediately to the burst. The XRT detected the afterglow in observations starting 84.1 *sec* after the trigger. The UVOT did not detect the optical afterglow (Curran, *et al.*, *GCN Circ.* 9969). The fading optical afterglow was detected in observations by the RAPTOR telescope (Wren, *et al.*, *GCN Circ.* 9967) but only upper limits were measured by Skynet/DSO (Haislip, *et al.*, *GCN Circ.* 9970) and Gemini-North (Cucchiara, *et al.*, *GCN Circ.* 9971). The burst was also deteced by *Konus-Wind* (Golenetskii, *et al.*, *GCN Circ.* 9975) that measured a peak energy of 282 (-78, +169) keV and by the *Suzaku* Wide-band All-sky Monitor (Ohmori, *et al.*, *GCN Circ.* 9993) and by the *INTEGRAL* SPI Anti-Coincidence System (Beckmann, private communication; all SPI-ACS events can be found under http://isdc.unige.ch/Soft/ibas/ibas_acs_web.cgi). The afterglow optical analysis is complicated by the contamination of a USNO catalogued star (R2=19.3) and a bright (R = 9.5), near-by star.

2 BAT Observation and Analysis

Using the data set from $T - 239$ to $T + 691$ *sec*, further analysis of BAT GRB 090929B has been performed by the *Swift* team (Krimm, *et al.*, *GCN Circ.* 9979). The BAT ground-calculated position is RA($J2000$) = $117.712 deg$ ($07h50m50.9s$), Dec($J2000$) = $-0.645 deg$ ($-00d38'41.2''$) $\pm$ 1.4 *arcmin*, (radius, systematic and statistical, 90% containment). The partial coding was 63%.

The mask-weighted light curve (Fig.1) shows many peaks interspersed with intervals with no detected flux, from T-10 to T+380 sec when the source left the coded field of view due to a observing constraint. There may have been small and/or low-energy peaks beyond this time. The largest peak was at about T+30 to T+40 sec. $T_{90}(15 - 350 keV)$ is 360 ± 20 *sec* (estimated error including systematics).

The time-averaged spectrum from $T - 9.8$ to $T + 371.0$ *sec* is best fitted by a simple power law model. The power law index of the time-averaged spectrum is 1.85 ± 0.08. For this model the total fluence in the $15 - 150$ *keV* band is $(5.9 \pm 0.3) \times 10^{-6} ergs/cm^2$, and the 1-sec peak flux measured from $T + 30.67$ *sec* in the $15 - 150$ *keV* band is 3.3 ± 0.2 $ph/cm^2/sec$. All the quoted errors are at the 90% confidence level considering the statistical and usual systematic effects.

The results of the batgrbproduct analysis are available at:
http://gcn.gsfc.nasa.gov/notices_s/371050/BA/

3 XRT Observation and Analysis

Using 2438 *sec* of overlapping XRT Photon Counting mode and UVOT data for GRB 090929B, we find an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA($J2000$) = $117.72015 deg$ ($07h50m52.84s$), Dec($J2000$) = -0.65764 *deg* ($-00d39'27.5''$) $\pm$ 1.8 *arcsec* (radius, 90% confidence) (Goad, *et al.*, *GCN Circ.* 9964).

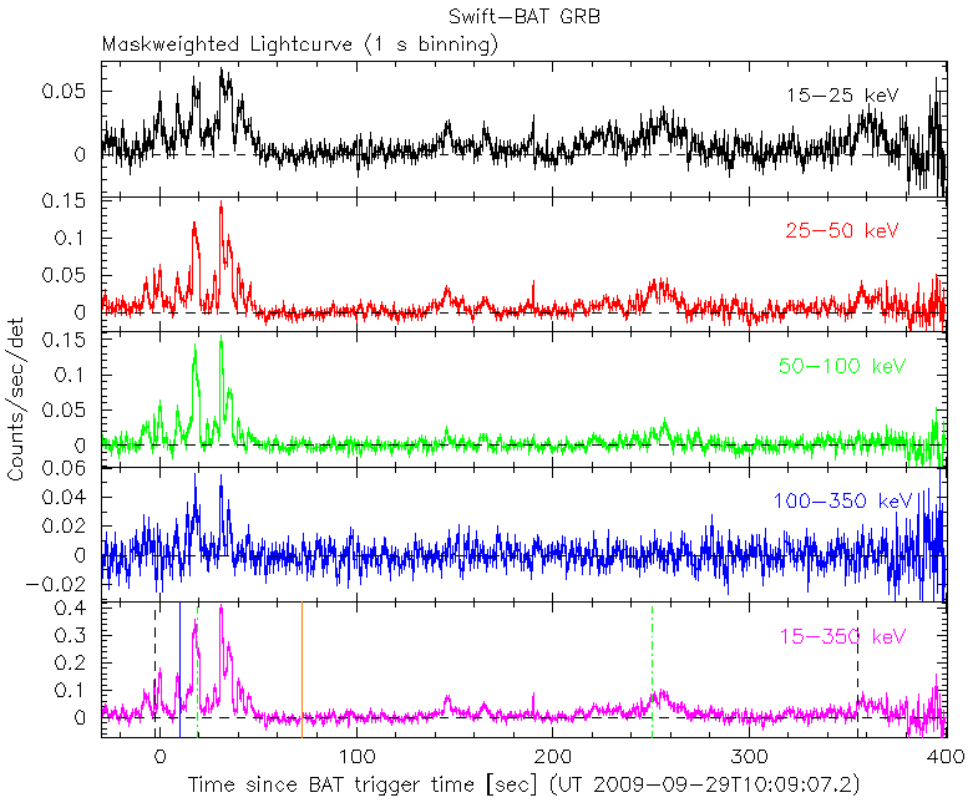

Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/sec/illuminated-detector and T_0 is 10:09:07.2 UT.

The $0.3-10$ keV light curve (Fig.2) shows intense flaring activity during the first orbit with the strongest emission of $\sim 7.0\times10^{-9} ergs/cm^2/sec$ at $T+150$ sec. The following orbits can be modeled with a broken power-law decay with an initial decay index of alpha=0.97 ± 0.05 and a jet break after $\sim$ 2.2×10^5 sec with decay index alpha=$2.5^{+1.1}_{-0.5}$.

The X-ray spectrum of the first orbit of Windowed Timing mode data from $T+90$ sec to $T+190$ sec can be well fitted by an absorbed power law with spectral index 1.55 ± 0.05. The best-fitting absorption column is $1.6\pm0.2\times10^{21} cm^{-2}$, in excess of the Galactic value of $5.4\times10^{20} cm^{-2}$ in that direction (Kalberla et al. 2005). The Photon Counting mode spectrum has a spectral index of 2.09 ± 0.14 and a best-fitting absorption column of $(1.32^{+0.40}_{-0.35})\times10^{21} cm^{-2}$ The average absorbed flux over $0.3-10$ keV for the WT spectrum is 4.09×10^{-10} $ergs/cm^2/sec$, which corresponds to an unabsorbed flux of 5.0×10^{-10} $ergs/cm^2/sec$.

4 UVOT Observation and Analysis

The UVOT began observing the field of GRB 090929B 94 sec after the BAT trigger (Curran *et al.*, *GCN Circ.* 9969). No optical afterglow is detected in the b, u or uvw2 UVOT exposures. There is

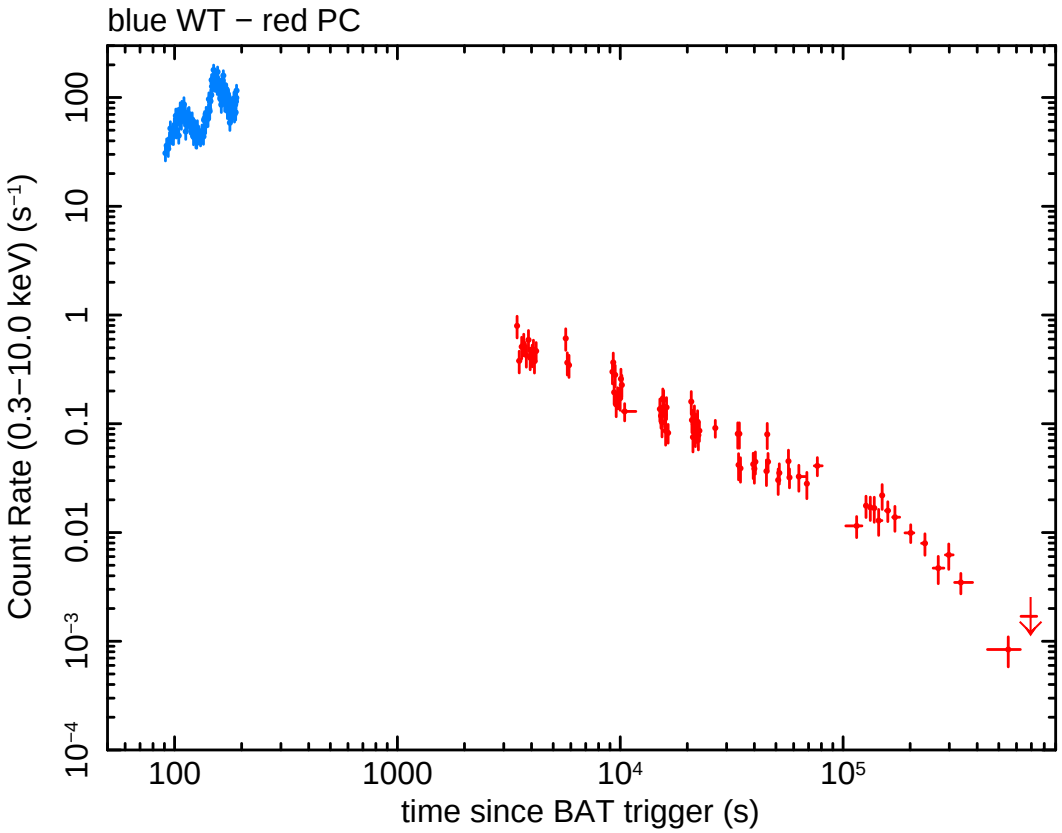

Figure 2: XRT Lightcurve. Counts/sec in the 0.3-10 keV band: Window Timing mode (blue), Photon Counting mode (red). The approximate conversion is 1 count/sec = $\sim 3.9 \times 10^{-11}$ $ergs/cm^2/sec$.

a detection in the white filter, consistent with the enhanced XRT position (Page, *et al.*, *GCN Circ.* 9965), the proposed optical counterpart (Wren, *et al.*, *GCN Circ.* 9967) and a USNO catalogued star (R2=19.3). Since the photometry is contaminated by a bright (R = 9.5), near-by star, we cannot determine the nature of the source. Preliminary magnitudes and 3σ upper limits for detecting a source are in Table 1. These values are on the UVOT Photometric System described in Poole et al. (2008, *MNRAS*, 383,627). These values are not corrected for the Galactic extinction in the direction of the burst corresponding to a reddening of $E_{B-V} = 0.073$ *mag* (Schlegel *et al.*, *ApJ.* 500:525-553, 1998).

Filter	T_{start}	T_{stop}	Exposure	Mag
White	94	4032	292	18.7 ± 0.5
B	3627	3827	197	> 20.5
U	3422	3622	197	> 20.3
UVW2	4038	4224	183	> 20.3

Table 1: Magnitudes and upper limits from UVOT observations