Swift Observations of GRB 060929

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1. INTRODUCTION

BAT triggered on GRB 060929 at 19:55:01 UT (Trigger 231702) (Markwardt, et al., GCN Circ. 5654). This was a 4.096-sec rate-trigger on a long burst (T_90 of 554 sec) to which Swift slewed immediately. XRT began follow-up observations at T+92 sec, and UVOT at T+78 sec. Our best location is XRT position is RA,Dec(J2000) = 263.1208,+29.8358 deg with an error radius of 5.5 arcsec. This burst has a large flare starting at T+400 sec. Due to a 38-sec gap in the TDRSS telemetry coverage, the initial portion of the series of standard GCN Notices was not available (BAT_Position, FOM_Observe, SC_Slew, BAT_Lightcurve).

2. BAT OBSERVATION AND ANALYSIS

Using the data set from T-240 to T+1000 sec from recent telemetry downlinks, we report further analysis of BAT GRB 060929 (Markwardt, et al., GCN Circ. 5654). Using the first 14.5 sec of the burst, the BAT ground-calculated position is RA,Dec = 263.158, 29.846 deg {17h 32m 37.9s, 29d 50' 44.3"} (J2000) ± 1.9 arcmin, (radius, sys+stat, 90% containment). The partial coding was 84%.

The mask-weighted light curve (Fig 1) shows a roughly triangular shaped peak starting at T-5 sec, peaking at T+3 sec, and ending at T+9 sec. We note that there is highly significant emission in the mask-weighted light curve starting at T+400 sec and ending at T+600 sec. This emission is much softer than the initial emission at T_zero. This second episode of emission locates to the same RA,Dec values as the initial episode. For the first episode of emission, T_90 (15-350 keV) is 12.4 ± 0.2 sec (estimated error including systematics); including the second episode, T_90 is 554 ± 1 sec.

The time-averaged spectrum from T-5.5 to T+9.0 (the first episode of emission) is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.50 ± 0.25. The fluence in the 15-150 keV band is $2.8 \pm 0.4 \times 10^{-7}$ ergs cm^{-2}. The 1-sec peak photon flux measured from T+2.69 sec in the 15-150 keV band is 0.4 ± 0.1 ph/cm^2/sec. The second episode of emission (T+480 to T+600 sec) is softer. Fitting that interval with a simple power law, the index is 2.5 –0.6,+0.8. The fluence for both episodes is $8.5 \pm 0.2 \times 10^{-7}$ ergs cm^{-2}. All the quoted errors are at the 90% confidence level.

3. XRT OBSERVATION AND ANALYSIS

From 1.9ks of Photon Counting mode data, the refined XRT position is RA,Dec(J2000) = 17h 32m 29.0s,+29d 50' 08.9" with an error radius of 5.5 arcsec (90% confidence, including boresight uncertainties). This is within 0.4 arcsec of the initial XRT position, and 2.0 arcmin of the refined BAT position (Fenimore et al., GCN Circ 5660).

The XRT light curve (Fig 2) shows a giant flare from T+410s to T+1180s, which peaks at a count rate of ~70 count/s at T+535s. This flare is also seen in BAT data (Palmer et al., GCN Circ 5662) (Fig 1).

The average Windowed Timing mode spectrum during the flare (from T+476s to T+691s; count rate equal to 36.7 count/s) can be described by an absorbed power-law, with a column density of $1.85 \pm 0.15 \times 10^{21}$ cm^{-2} and a photon index of 1.86±0.05. The 0.3-10.0 keV observed (unabsorbed) flux during this interval is 1.61×10^{-9} (2.15×10^{-9}) ergs cm^{-2}s^{-1}.

The underlying non-flare emission is weak (0.07 count/s), and can be fit with a power-law of photon index 2.3+1.4-0.8 and an unconstrained column density less than 3.6×10^{21} cm^{-2}. The 0.3-10.0 keV observed

(unabsorbed) flux is 3.3 x 10^{-12} (5.3 x 10^{-12}) ergs cm^{-2}s^{-1}. The Galactic column in the direction of the source is 3.6 x 10^{20} cm^{-2}.

Using the first 9 orbits of XRT data obtained for GRB 060929, the X-ray afterglow fades with a decay slope of 0.79 ± 0.08 following the large flare between T+410s and T+1180s reported in GCN Circulars 5662 and 5663 (Palmer et al.; Beardmore et al.).

Using the spectral fit for the data after the flare (photon index = 2.5 ± 0.9) together with a total column density of 1.8e21 cm^{-2} (GCN Circ. 5663), this corresponds to an observed (unabsorbed) flux of 7.49 x 10^{-14} (1.41 x 10^{-13}) ergs cm^{-2}s^{-1}.

4. UVOT OBSERVATION AND ANALYSIS

The UVOT began observing the GRB 060929 field, 78 seconds after the BAT trigger (GCN Circ 5654, 5660). No new source was detected in the co-added UVOT observations down to the following 3-sigma magnitude upper limits within the refined XRT error circle (GCN Circ 5663):

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Filter          T_range (s)     Exposure (s)     3sigma UL
V               78 - 2356       950              20.71
B               678 - 2295      136              20.55
U               654 - 2271      156              20.25
W1              630 - 2247      156              19.60
M2              606 - 2223      156              19.83
W2              707 - 2333      156              19.98
White           95 - 2309       273              20.96
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T_range is calculated from the time of the burst. The upper limits are not corrected for Galactic extinction E(B-V) = 0.048 along the line of sight to the burst.
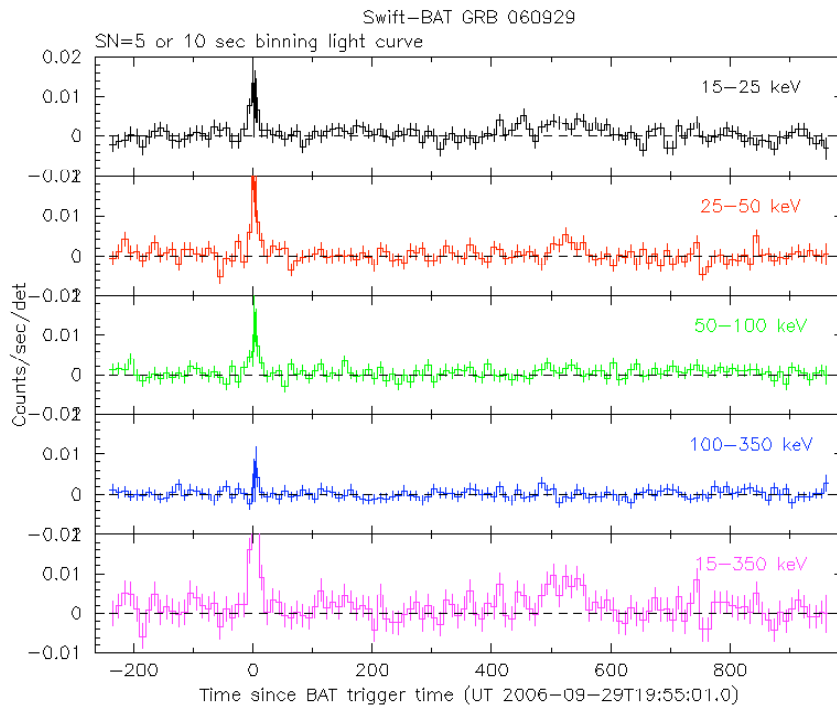

Fig.1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/sec/illuminated_detector (note illum_det = 0.16 cm^2) and T_zero is 14:07:35UT. The time binning is variable and is set to that which yields a signal-to-noise ratio of 5 or 10 sec max.
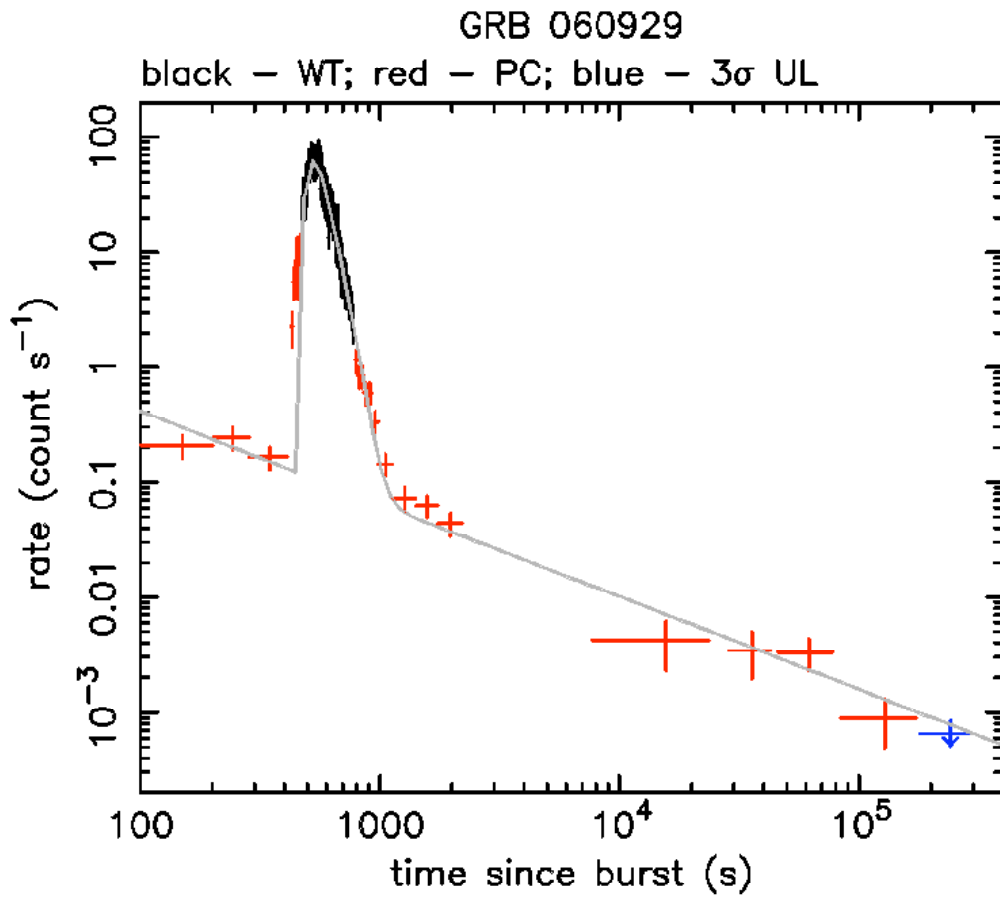
Fig. 2: XRT Lightcurve. A typical power-law decay with a giant flare from T+410s to T+1180s.