Swift Observations of GRB 100619A

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1   Introduction

BAT triggered on a long burst, GRB 100619A, at 00:21:07 UT (trigger=424998) (Cannizzo, et al., *GCN Circ.* 10863). *Swift* slewed immediately to the burst. The BAT on-board calculated location is RA, Dec = (84.615, −27.001) deg, which is {05h 38m 28s; -27d 00' 02"} (J2000) with an uncertainty of 3 arcmin (radius, 90% containment). The BAT light curve showed two well-separated peaks about 90 s apart with an overall duration of about 120 s. The peak count rate was ∼4000 c s^{-1} (15 − 350 keV), at ∼ T for the first peak, and 5000 c s^{-1} (15 − 350 keV) at ∼ $T + 95$s for the second peak.

The XRT began observing the field at 00:22:23.7 UT, at $T + 76.4$ s, and found a bright, fading, uncatalogued X-ray source with an enhanced position: RA, Dec = (84.6227, −27.0049) deg, or {05h 38m 29.46s; -27d 00' 17.8"} (J2000) with $\sigma = 2.1$ arcsec (radius, 90% containment). This location is 27 arcsec from the BAT position. A power-law fit to a spectrum gives a column density in excess of the Galactic value (2×10^{20} cm^{-2}, Kalberla et al. 2005), with an excess column of $3.8(+1.95/-1.69) \times 10^{21}$ cm^{-2} (90% confidence). The initial flux in the 0.1 s image was 5.61×10^{-8} erg cm^{-2} s^{-1} (0.2 − 10 keV).

UVOT took a finding chart exposure of 150 s with the White filter starting at $T + 87$ s. No credible afterglow candidate was found. The $2.7' \times 2.7'$ sub-image covers 100% of the XRT error circle. The typical 3σ U.L. has been ∼19.6 mag. The $8' \times 8'$ region for the list of sources generated on-board covers 100% of the XRT error circle. The list of sources is typically complete to about 18 mag. No correction has been made for the expected extinction corresponding to $E(B - V) = 0.03$.

The burst was also detected by *Fermi* GBM (Bhat, et al., *GCN Circ.* 10868). The trigger time was incorrectly given initially, and later corrected (Bhat, et al., *GCN Circ.* 10879). The GBM on-ground location was consistent with the *Swift* position. The GBM light curve shows two well separated pulses with $T_{90} \simeq 96.8$ s (50 − 300 keV). The event fluence (8 − 1000 keV) in this time interval is $(1.71 \pm 0.1) \times 10^{-5}$ erg cm^{-2}. The 1 s peak photon flux measured starting from $T + 83$ s in the 10 − 1000 keV band is 1.88 ± 0.04 ph s^{-1} cm^{-2}.

2   BAT Observation and Analysis

Using the data set from $T - 239$ to $T + 963$ s, further analysis of BAT GRB 100619A was performed (Stamatikos, et al., GCN Circ. 10864). The BAT ground-calculated position is RA, Dec = (84.618, −27.012) deg, or {05h 38m 28.3s −27d 00' 42.2"} (J2000) with $\sigma = 1.0$ arcmin, (radius, sys+stat, 90% containment). The partial coding was 75%.

The mask-weighted light curve shows two well separated peaks. The first was composed of several overlapping pulses starting at ∼ $T − 3$ s, peaking at ∼ $T + 10$ s, and returning to background at ∼ $T + 20$ s. The second peak starts at ∼ $T + 55$ s, peaks at ∼ $T + 85$ s, and ends at ∼ $T + 120$ s. T_{90} (15 − 350 keV) is 97.5 ± 3 s (estimated error including systematics).

The time-averaged spectrum from $T - 2.9$ s to $T + 105.7$ s is best fit by a simple power-law model.[2] The power law index of the time-averaged spectrum is 1.83 ± 0.06. The fluence in the $15 - 150$ keV band is $4.5 \pm 0.1 \times 10^{-6}$ erg cm^{-2}. The 1 s peak photon flux measured from $T + 87.22$ s in the $15 - 150$ keV band is $4.8 + -0.2$ ph cm^{-2} s^{-1}. All the quoted errors are at the 90% confidence level.

3   XRT Observation and Analysis

Using 4927 s of XRT Photon Counting mode data and 8 UVOT images (Beardmore, et al., GCN Circ. 10865), an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA, Dec = (84.62214, −27.00534), or {05h 38m 29.31s −27d 00' 19.2"} (J2000) with $\sigma = 1.5$ arcsec (radius, 90% confidence).

Analysis of 6.6 ks of XRT data (Mao & Cannizzo, GCN Circ. 10866), from $T + 80$ s to $T + 13.2$ ks was carried out. The data comprise 492 s in Windowed Timing (WT) mode with the remainder in Photon Counting (PC) mode. The light curve initially shows a flare feature at the time $T + 90$s, then it has a power-law decay with an index 0.88, after that, the light curve shows a clear flare feature with the peak at 1000s. Then, the light cure has a power-law decay with an index of $\alpha = 0.85 \pm 0.02$.

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of 1.41 ± 0.03. The best-fitting absorption column is $3.4(\pm 0.1) \times 10^{21}$ cm^{-2}, in excess of the Galactic value of 2.0×10^{20} cm^{-2} (Kalberla et al. 2005). The PC mode spectrum has a photon index of $2.16(+0.20, -0.19)$ and a best-fitting absorption column of $3.7(\pm 0.6) \times 10^{21}$ cm^{-2}. The counts to observed (unabsorbed) $0.3 - 10$ keV flux conversion factor deduced from this spectrum is 6.7×10^{-11} (9.6×10^{-11}) erg cm^{-2} ct^{-1}.

4   UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB 100619A at $T + 87$ s (Curran & Cannizzo, GCN Circ. 10867). No optical afterglow consistent with the enhanced XRT position (Beardmore et al., GCN Circ. 10865) is detected in the initial UVOT exposures. Preliminary 3σ UL's using the UVOT photometric system (Poole et al. 2008, MNRAS, 383, 627) for the first finding chart (FC) and subsequent exposures are:

Filter	T_start(s)	T_stop(s)	Exp(s)	Mag
white	87	6773	785	>22.0
v	630	7184	510	>20.2
b	556	13220	1161	>21.5
u	300	19002	2089	>21.6
w1	679	18300	2128	>21.7
m2	654	17394	1396	>21.4
w2	606	6978	510	>20.9

The values quoted above are not corrected for the Galactic extinction due to the reddening of $E(B - V) = 0.03$ in the direction of the burst (Schlegel et al. 1998).
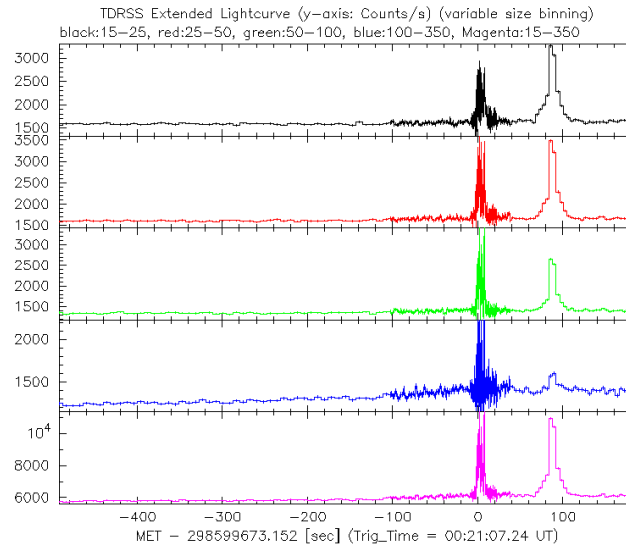
Figure 1: BAT Lightcurve. The light curve in the 4 individual plus total energy bands ($15 - 25$ keV, $25 - 50$, $50 - 100$, $100 - 350$, and $15 - 350$).
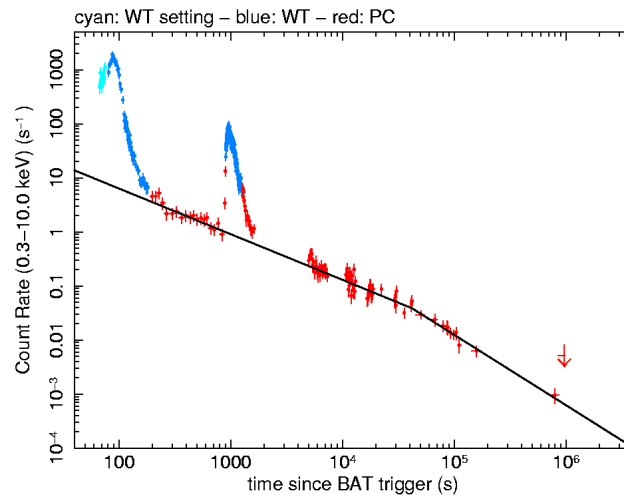

Figure 2: XRT Lightcurve. A broken powerlaw fit gives: $\alpha_1 = -0.85 \pm 0.02$, $t_{\text{break, 1}} \simeq 42$ ks, $\alpha_2 = -1.30 \pm 0.12$. A large flare is seen, peaking around 1000 s (detected by BAT as well).