

Swift Observation of GRB 090618

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report on behalf of the Swift Team:

1 Introduction

BAT triggered on GRB 090618 at 08:28:29 UT (Trigger 355083) (Schady, et al., *GCN Circ.* 9512), and *Swift* slewed immediately to this burst. This was a 1.024 s event trigger with a significance of 85.83. GRB 090618 was a bright, long, multi-peaked burst, with $T_{90} = 113.2 \pm 6$ s. The best *Swift* position is the UVOT position, RA(*J*2000) = 293.99465 deg (19h35m58.715s), Dec(*J*2000) = +78.35677 deg (+78d21'24.35") with an estimated uncertainty of 0.74 arcsec (radius, 90% confidence).

GRB 090618 has a spectroscopic redshift measurement of $z = 0.54$ (Cenko, et al., *GCN Circ.* 9518; Fatkhullin, et al., *GCN Circ.* 9542), and it was also detected by INTEGRAL SPI/ACS, Konus-Wind (Golenetskii, et al., *GCN Circ.* 9553), Suzaku WAM (Kono, et al., *GCN Circ.* 9568), as well as by SuperAGILE (Longo, et al., *GCN Circ.* 9524).

2 BAT Observation and Analysis

Using the data set from $T - 5$ to $T + 320$ s, the BAT ground-calculated position is RA(*J*2000) = 294.008 deg (19h36m01.8s), Dec(*J*2000) = +78.352 deg (+78d21'07.1") ± 0.46 arcmin, (radius, systematic and statistical, 90% containment) (Baumgartner, et al., *GCN Circ.* 9530). The partial coding was 62.5%.

The masked-weighted light curve (Fig.1) shows two episodes with four prominent peaks. The first episode is a smooth 50 s peak starting at $T - 5$ s, and ends at $T + 45$ s. The second episode starts at $\sim T + 45$ s and is about 275 s long, consisting of three overlapping peaks. The first peak is at $\sim T + 62$ s, the second peak is at $\sim T + 80$ s, and the third is at $\sim T + 112$ s, finally ending at $T + 320$ s. T_{90} (15-350 keV) is 113.2 ± 0.6 s (estimated error including systematics) (Baumgartner, et al., *GCN Circ.* 9530).

The time-averaged spectrum from $T - 4.4$ to $T + 213.6$ s is best fit by a power-law with an exponential cutoff. This fit gives a photon index 1.42 ± 0.08 , and $E_{peak} = 134 \pm 19$ keV ($\chi^2 = 14.6$ for 56 d.o.f.). For this model the total fluence in the 15–150 keV band is $(1.05 \pm 0.01) \times 10^{-4}$ erg cm $^{-2}$ and the 1-s peak flux measured at $T + 65.38$ s in the 15–150 keV band is 38.8 ± 0.8 ph cm $^{-2}$ s $^{-1}$ (Sakamoto, et al., *GCN Circ.* 9534). A simple power law fit gives a photon index of 1.72 ± 0.02 (χ^2 55.8 for 57 d.o.f.). All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

The XRT began observations of GRB 090618 120.9 s after the BAT trigger and detected a bright, fading, uncatalogued X-ray source. Using 2422 s of XRT Photon Counting (PC) mode data and 5 UVOT images for GRB 090618, the astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue) is RA(*J*2000) = 293.99304 deg (19h35m58.33s), Dec(*J*2000) = +78.35702 deg (+78d21'25.3") ± 1.7 arcsec (radius, 90% confidence) (Evans, et al., *GCN Circ.* 9521).

The burst was initially very bright in X-rays, observed at a rate of ~ 8000 count/s, and decayed rapidly with a slope of ~ 6 before breaking at $T + 310$ s to a shallower decay slope. The 0.3 – 10 keV light curve (Fig.2) after $T + 400$ s can be modelled with a double broken power-law model with an initial decay index of $\alpha_{X,1} = 0.71 \pm 0.02$ that breaks at $t_{break,1} = 5500 \pm 440$ s to a steeper decay index

of $\alpha_{X,2} = 1.36 \pm 0.02$, and then at $t_{break,2} = (3.1 \pm 0.8) \times 10^5$ s the light curve breaks again to a decay index of $\alpha_{X,3} = 1.90 \pm 0.17$.

The X-ray spectrum formed from the Window Timing (WT) mode data from $T + 250$ s to $T + 1065$ s can be fit with an absorbed power-law with a photon index of $\Gamma_X = 2.11 \pm 0.03$ and an intrinsic absorption of $(1.78 \pm 0.14) \times 10^{21}$ cm $^{-2}$ (at $z = 0.54$, Cenko, et al., *GCN Circ.* 9518), in addition to the Galactic column of 5.8×10^{20} cm $^{-2}$ (Kalberla, et al., 2005) (Beardmore, et al., *GCN Circ.* 9528). All errors are at the 90% confidence level.

4 UVOT Observation and Analysis

The UVOT began settled observations of the field of GRB 080618 129 s after the BAT trigger and detected a decaying source in all UVOT filters at RA($J2000$) = 293.99456 deg (19h35m58.69s), Dec($J2000$) = +78.35676 deg (+78d21'24.3'') ± 0.74 arcsec (radius, 90% confidence) (Schady, et al., *GCN Circ.* 9512), consistent with the enhanced XRT error circle (Evans, et al., *GCN Circ.* 9521), as well as the optical afterglow position reported in a number of other GCNs (e.g. Cenko, et al., *GCN Circ.* 9513; Perley, et al., *GCN Circ.* 9514; Rujopakarn, et al., *GCN Circ.* 9515). The detection of the afterglow of GRB 090618 in all UVOT filters puts an upper limit on the redshift of $z < 1.7$, consistent with the redshift constraints reported by Cenko et al. (*GCN Circ.* 9518).

The measured magnitudes in the UVOT photometric system (Poole, et al., 2008) for the first UVOT observations of GRB 090618 in each filter are given in Table 1. The combined light curve (Fig.3) can be fit by a double broken power-law with an initial decay index of $\alpha_{opt,1} = 0.739 \pm 0.004$ that breaks at $t_{break,1} = 9294_{-841}^{+805}$ s to a steeper decay index of $\alpha_{opt,2} = 1.07 \pm 0.03$, with a second break at $t_{break,2} = 64323_{-5777}^{+6914}$ s, breaking to a decay index of $\alpha_{opt,3} = 1.63 \pm 0.05$ ($\chi^2/\text{d.o.f.} = 350/171$).

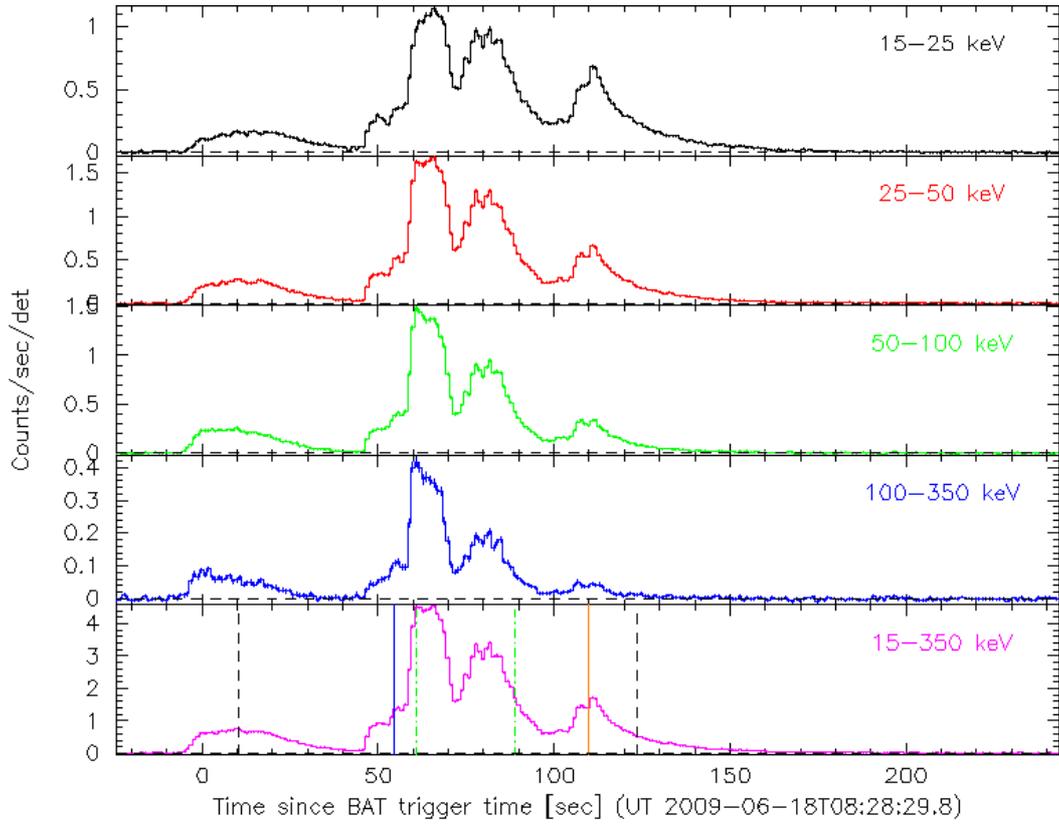


Figure 1: BAT Light curve. The mask-weighted 1-s light curve in the 4 individual plus total energy bands. The units are counts/s/illuminated-detector and T is 08:28:29.8 UT.

Filter	T_{start} (s)	T_{stop} (s)	Exposure (s)	Magnitude
white	129	279	147	14.27 ± 0.01
v	671	691	19	15.60 ± 0.09
b	596	616	19	15.92 ± 0.06
u	340	590	246	14.62 ± 0.01
uvw1	720	740	19	15.09 ± 0.08
uvm2	695	715	19	15.23 ± 0.12
uvw2	647	667	19	15.27 ± 0.10

Table 1: Magnitudes from initial UVOT observations. The values quoted are not corrected for the expected Galactic extinction corresponding to a reddening of $E(B-V)=0.09$ mag in the direction of the burst (Schlegel, Finkbeiner & Davis, 1998).

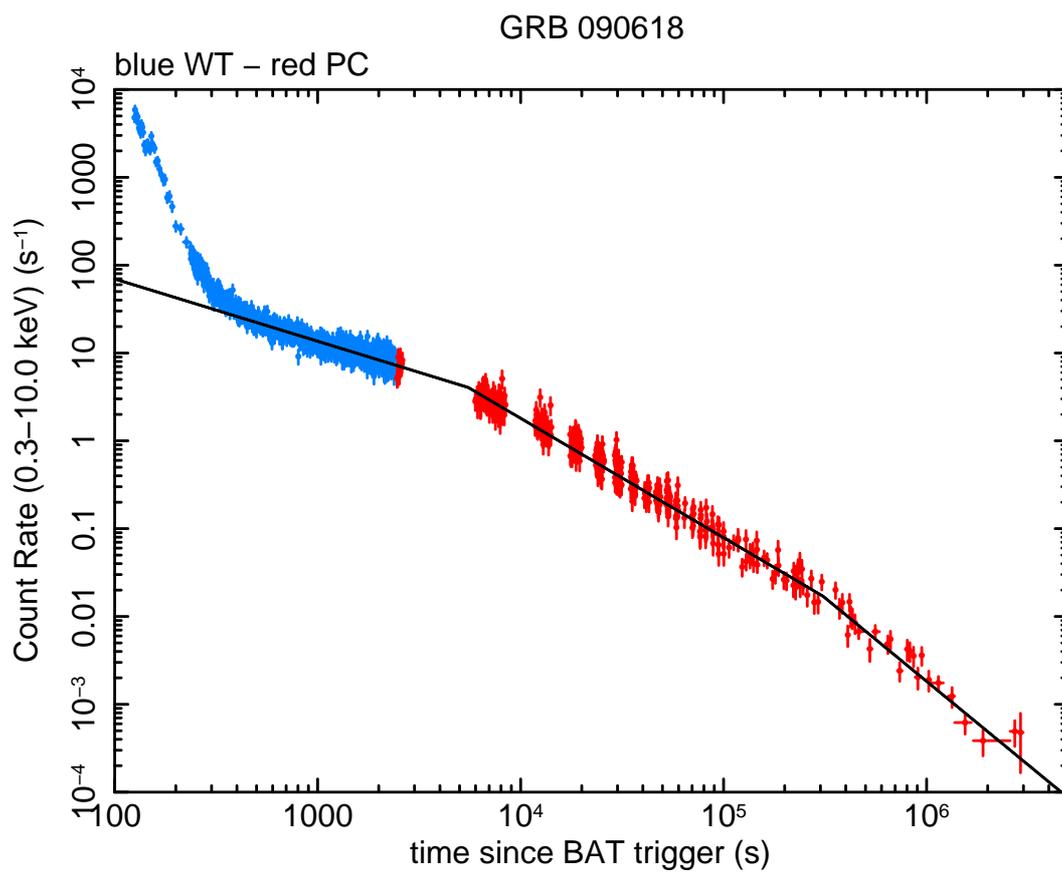


Figure 2: XRT Light curve. Counts/s in the 0.3 – 10 keV band taken in Window Timing mode (blue) and Photon Counting mode (red). The broken power-law fit is shown in black. The approximate conversion of the absorbed flux is 1 count/s = 4.0×10^{-11} erg cm⁻² s⁻¹.

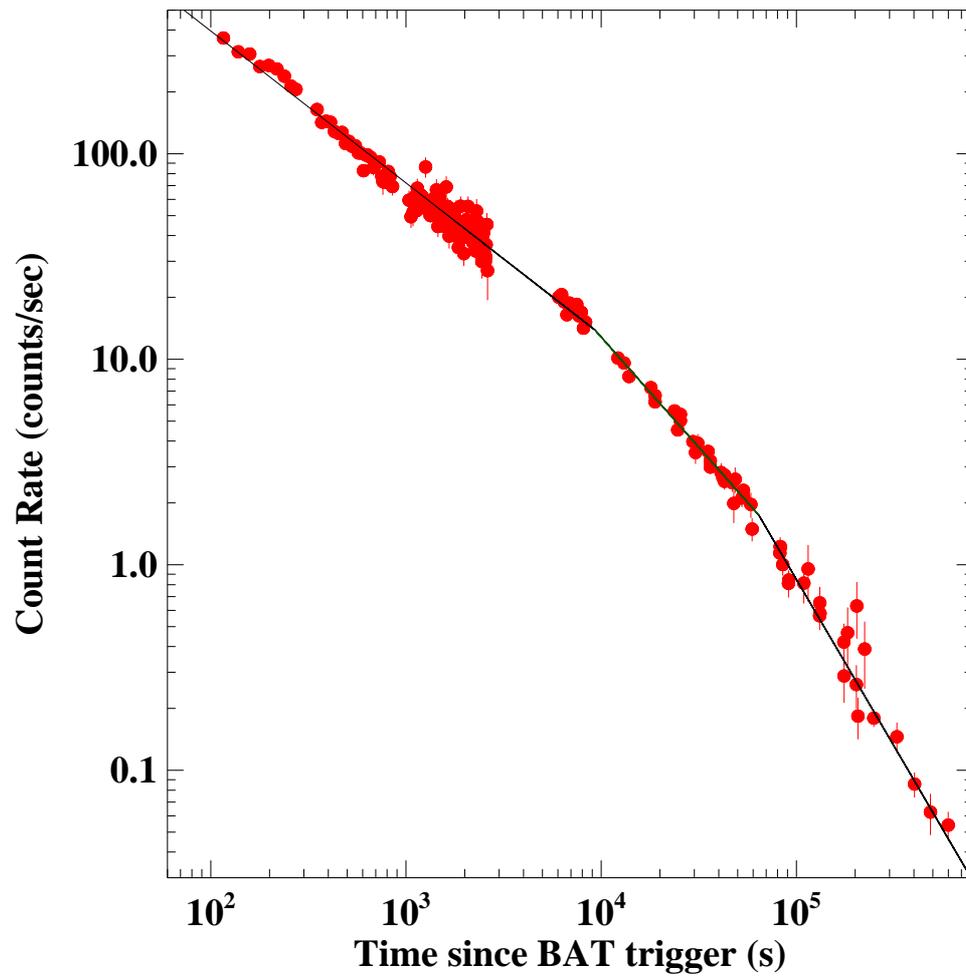


Figure 3: UVOT multiband light curve normalized to the white band filter in observed magnitude, containing all UVOT filter data points detected with at least 3σ significance. The double broken power-law fit is shown in black.