

Swift Observation of GRB 090401B

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report on behalf of the Swift Team:*

1 Introduction

BAT triggered on GRB 090401B at 08:35:25 UT (Trigger 348152) (Schady, et al., *GCN Circ.* 9066), and *Swift* slewed immediately to this burst. This was a 64 ms event trigger with a significance of 41.40. GRB 090401B was a long, multi-peaked burst, with $T_{90} = 183 \pm 29$ s. The best position is the UVOT position, RA($J2000$) = 95.08775 deg (06h20m21.11s), Dec($J2000$) = -8.97199 deg ($-08d58'19.5''$) with an estimated uncertainty of 0.5 arcsec (radius, 90% confidence).

GRB 090401B was also detected by INTEGRAL SPI/ACS, Konus-Wind (Golenetskii, et al., *GCN Circ.* 9083), Suzaku WAM (Suzuki, et al., *GCN Circ.* 9084), as well as by SuperAGILE and AGILE/ACS and MCAL, with a significant detection above 2.8 MeV (Moretti, et al., *GCN Circ.* 9069).

2 BAT Observation and Analysis

Using the data set from $T - 239$ to $T + 914$ s, the BAT ground-calculated position is RA($J2000$) = 95.095 deg (06h20m22.7s), Dec($J2000$) = 8.963 deg ($-08d57'47.1''$) ± 1.0 arcmin, (radius, systematic and statistical, 90% containment) (Stamatikos, et al., *GCN Circ.* 9068). The partial coding was 67%.

The masked-weighted light curve (Fig.1) shows several FRED-like peaks with the first starting at $\sim T - 0.4$ s. The brightest peak is at $\sim T + 7$ s with a long exponential tail out to $\sim T + 600$ s. T_{90} (15-350 keV) is 183 ± 29 s (estimated error including systematics) (Stamatikos, et al., *GCN Circ.* 9068).

The time-averaged spectrum from $T - 0.1$ to $T + 326.1$ s is best fitted by a simple power-law model. The power-law index of the time-averaged spectrum is 1.37 ± 0.05 . The fluence in the 15–150 keV band is $(1.0 \pm 0.0) \times 10^{-5}$ erg cm $^{-2}$ and the 1-s peak flux measured at $T + 6.49$ s in the 15–150 keV band is 23.1 ± 0.5 ph cm $^{-2}$ s $^{-1}$ (Stamatikos, et al., *GCN Circ.* 9068). All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

The XRT began observations of GRB 080401B 73.2 s after the BAT trigger and detected a bright, fading, uncatalogued X-ray source. Using 2409 s of overlapping XRT Photon Counting (PC) mode data and 5 UVOT images for GRB 090401B, the astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue) is RA($J2000$) = 95.08773 deg (06h20m21.06s), Dec($J2000$) = -8.97244 deg ($-08d58'20.8''$) ± 1.7 arcsec (radius, 90% confidence) (Osborne, et al., *GCN Circ.* 9070).

The 0.3–10 keV light curve (Fig.2) can be modelled with an initial power-law decay with a decay index of $\alpha_{X,1} = 1.16 \pm 0.03$ that breaks at $t_{break} = 574_{-92}^{+141}$ s to a steeper decay index of $\alpha_{X,2} = 1.47_{-0.01}^{+0.02}$.

The X-ray spectrum formed from the Window Timing (WT) mode data can be fitted with an absorbed power-law with a photon spectral index of $\Gamma = 1.74 \pm 0.03$, absorbed by a column of $(3.68 \pm 0.12) \times 10^{21}$ cm $^{-2}$ in excess of the Galactic value of 2.3×10^{21} cm $^{-2}$ (Kalberla, et al., 2005). The PC mode spectrum has a photon index of 2.13 ± 0.11 and a best-fitting absorption column of $(4.4_{-0.4}^{+0.5}) \times 10^{21}$ cm $^{-2}$ (Rowlinson, et al., *GCN Circ.* 9073). All errors are at the 90% confidence level.

4 UVOT Observation and Analysis

The UVOT observed the field of GRB 080401B 82 s after the BAT trigger, and detected a likely optical afterglow candidate in the early white and u -band finding chart observations, although there was some initial source confusion with a catalogued source ~ 3 arcsec north-west of the optical afterglow candidate. The transient nature of the uncatalogued source was promptly confirmed, and was localised at $RA(J2000) = 95.08775$ deg ($06h20m21.11s$), $Dec(J2000) = -8.97199$ deg ($-08d58'19.5''$) ± 0.5 arcsec (radius, 90% confidence) (Schady, et al., *GCN Circ.* 9067), consistent with the enhanced XRT error circle (Osborne, et al., *GCN Circ.* 9070). Analysis on the full data set revealed a source detection in the white, v , b and u -band filters, but not in any of the UV filters, placing an upper limit on the redshift of $z < 3$.

Using a 2.5 arcsec aperture, the measured magnitudes in the UVOT photometric system (Poole, et al., 2008) and 3σ upper limits for detecting a source in co-added frames are given in Table 1. The combined light curve (Fig.3) can be modelled with by a power-law with a decay index of $\alpha_{opt} = 1.37 \pm 0.04$ ($\chi^2/dof = 83.8/30$). The fit is marginally improved by a broken power-law fit with an initial decay index of $\alpha_{opt,1} = 1.44^{+0.04}_{-0.02}$ that breaks at $t_{break} = 645^{+98}_{-32}$ s to a shallower decay index of $\alpha_{opt,2} = 0.82^{+0.05}_{-0.07}$ ($\chi^2/dof = 57.7/28$), although an f-test indicates that this is not a significant improvement to the fit.

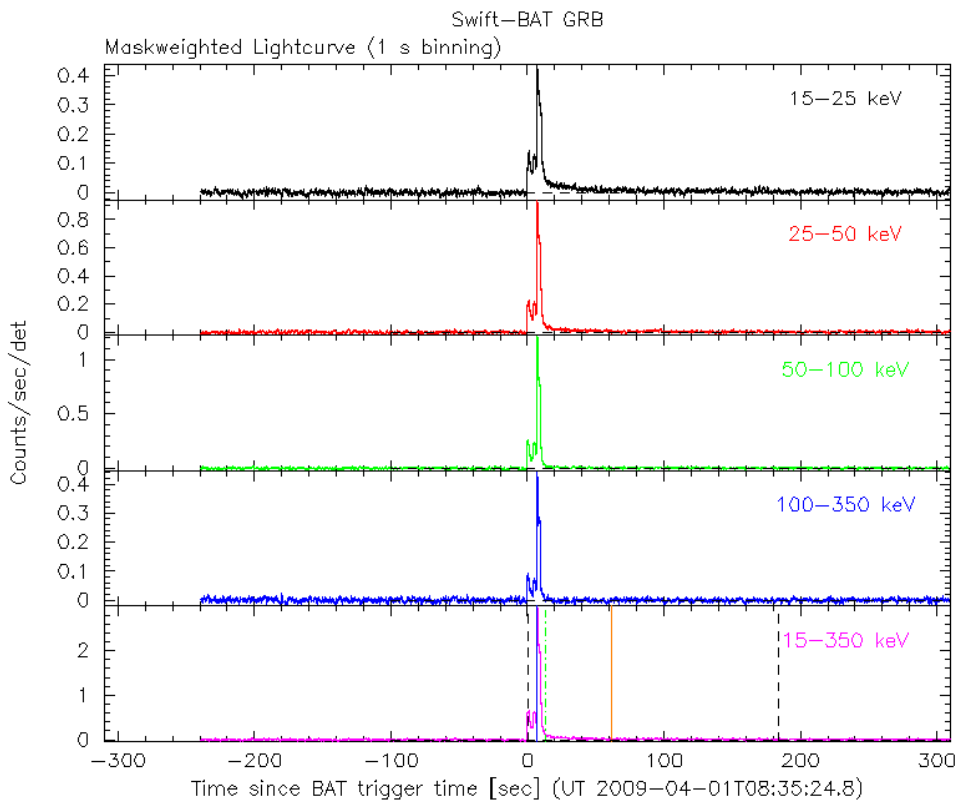


Figure 1: BAT Light curve. The mask-weighted 1-s light curve in the 4 individual plus total energy bands. The units are counts/s/illuminated-detector and T is 08:35:25 UT.

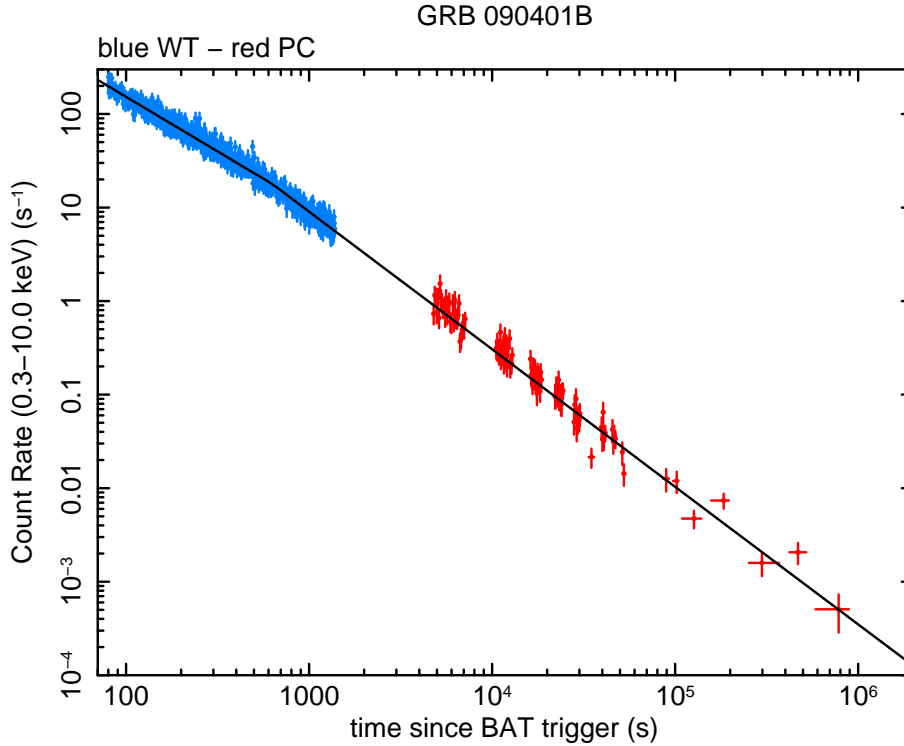


Figure 2: XRT Light curve. Counts/s in the 0.3 – 10 keV band taken in Window Timing mode (blue) and Photon Counting mode (red). The broken power-law fit is shown in black. The approximate conversion of the absorbed flux is 1 count/s = 4.5×10^{-11} erg cm $^{-2}$ s $^{-1}$.

Filter	T_{start} (s)	T_{stop} (s)	Exposure (s)	Mag/ 3σ UL
white	80	5469	294.0	16.83 ± 0.02
white	11355	12221	844.3	19.14 ± 0.08
v	623	1248	78	18.31 ± 0.20
v	4753	4953	197	19.10 ± 0.25
b	549	1346	58	19.48 ± 0.26
b	5573	5773	197	20.39 ± 0.28
u	293	543	246	17.99 ± 0.07
u	698	1312	58	18.67 ± 0.22
uvw1	672	1297	78	> 19.42
uvm2	647	1272	78	> 18.99
uvw2	599	1387	78	> 19.39

Table 1: Magnitudes from UVOT observations. The values quoted are not corrected for the expected Galactic extinction corresponding to a reddening of $E(B-V)=0.67$ mag in the direction of the burst (Schlegel, Finkbeiner & Davis, 1998).

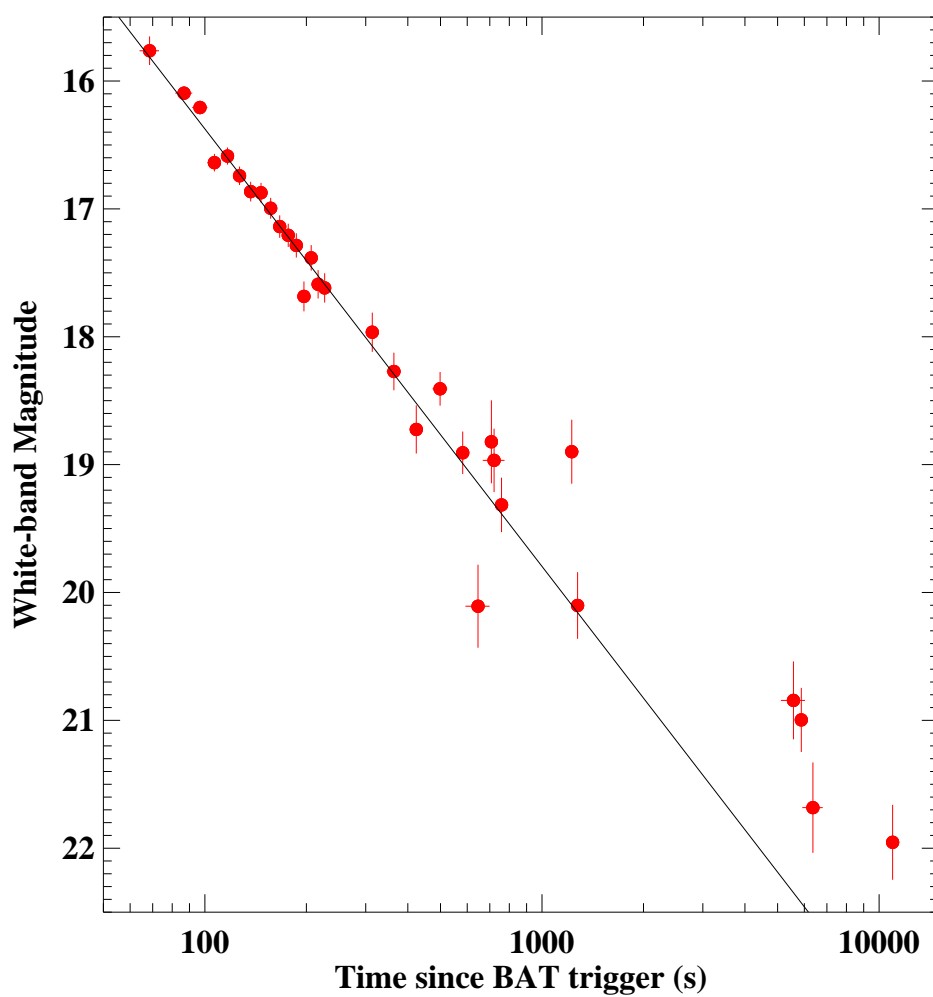


Figure 3: UVOT multiband light curve normalized to the white band filter in observed magnitude, containing all *white*, *v*, *b* and *u* band data points detected with at least 3σ significance. The power-law fit is shown in black.