

## Swift Observations of GRB 070318

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### 1. INTRODUCTION

At 07:28:56 UT, the Swift Burst Alert Telescope (BAT) triggered and located GRB 070318 (trigger=271019). Swift slewed immediately to the burst. This was a rate trigger with  $T_{90} = 63 \pm 3$  sec. Our best position is from the UVOT:

$$\begin{aligned} \text{RA(J2000)} &= 03:13:56.83 = 48.4868 \\ \text{DEC(J2000)} &= -42:56:46.3 = -42.9462 \end{aligned}$$

with a 1-sigma error radius of about 0.5 arc sec. The optical afterglow remained bright enough to observe with the UVOT for about 9 days. The redshift has been reported as  $z=0.836$  (Jaunsen *et al.* <sup>1</sup>).

### 2) BAT OBSERVATION AND ANALYSIS

The following analysis uses the BAT data set from T-120 to T+302 sec. The BAT ground-calculated position is RA, Dec = 48.486, -42.950 deg, which is

$$\begin{aligned} \text{RA(J2000)} &= 03\text{h } 13\text{m } 56.6\text{s} \\ \text{Dec(J2000)} &= -42^\circ 57' 1.1'' \end{aligned}$$

with an uncertainty of 0.8 arcmin, (radius, sys+stat, 90% containment). The partial coding was 80%.

The mask-weighted lightcurve (Figure 1) is a single FRED peak starting at  $\sim T-10$ sec, peaking at  $\sim T+2$  sec, and returning to background at around T+120 sec. There is the possibility of weak peaks at  $\sim T+140$  and T+170 sec at the  $\sim 3$ -sigma level. There is a low-significance positive value at T+280, at the time of the XRT flare.  $T_{90}$  (15-350 keV) is  $63 \pm 3$  sec (estimated error including systematics).

The time-averaged spectrum from T-1.0 to T+89.4 is best fit by a simple power-law model. The power law index of the time-averaged spectrum is  $1.44 \pm 0.08$ . The fluence in the 15-150 keV band is  $2.3 \pm 0.1 \times 10^{-6}$  erg/cm<sup>2</sup>. The 1-sec peak photon flux measured from T+1.94 sec in the 15-150 keV band is  $1.6 \pm 0.2$  ph/cm<sup>2</sup>/sec. All the quoted errors are at the 90% confidence level.

### 3. XRT OBSERVATION AND ANALYSIS

The first two orbits of Swift-XRT data on GRB 070318 with a total exposure of 427 s seconds in Window Timing (WT) mode and 33.4 ks seconds in Photon Counting (PC) mode provide a refined XRT position at RA, Dec=48.4870, -42.9454 which is:

$$\begin{aligned} \text{RA (J2000)} &= 03\text{h } 13\text{m } 56.9\text{s} \\ \text{Dec(J2000)} &= -42^\circ 56' 43.6'' \end{aligned}$$

with an estimated error radius of 3.5 arcseconds (90% confidence). This position is 16.8 arcseconds from the BAT refined position (Cummings, et al., GCN 6212), 6.2 arcseconds from the initial XRT position, and 2.9 arcseconds from the UVOT optical candidate.

The 0.3-10 keV X-ray light curve (Figure 2) presents a bright flare peaking at about 280 sec from the trigger and a second fainter peak at 200 sec. The underlying light curve between 70 sec and 7.5 ksec can be fit with a simple power-law with a decay slope of  $1.11 \pm 0.02$ . The hardness ratio (Figure 2a) shows a moderate spectral variation before and during/after the flare.

The X-ray spectrum (figure 2d) from the XRT/WT data covering up to the beginning of the bright flare is well fit by an absorbed power-law with a photon index of  $1.4 \pm 0.1$  and column density of  $1.5 \pm 0.7 \times 10^{21}$  cm<sup>-2</sup>, higher than the Galactic column density in the direction of the source  $2.5 \times 10^{20}$  cm<sup>-2</sup>. The unabsorbed 0.3-10 keV flux for this spectrum is  $1.3 \times 10^{-9}$  erg/cm<sup>2</sup>/s. The XRT/WT spectrum of the bright flare and the XRT/PC spectrum are modelled by an absorbed power law with photon index of  $1.9 \pm 0.1$  and column density of  $1.3 \pm 0.3 \times 10^{21}$  cm<sup>-2</sup>. The unabsorbed 0.3-10 keV flux of the bright flare is  $8.2 \times 10^{10}$  erg/cm<sup>2</sup>/s and the one relative to the PC spectrum is  $1.0 \times 10^{-10}$  erg/cm<sup>2</sup>/s.

There was a small flare at about T+2 to T+4 days, otherwise the X-ray emission continued to decline at approximately the same rate until the end of the observations at about T+11 days.

A second transient source was seen about 30 arcsec from the afterglow. Its light curve (Figure 2c) peaked at about T+3 days with a flux comparable to the afterglow. It was consistent with a single point source at:

$$\begin{aligned} \text{RA (J2000)} &= 03\text{h } 13\text{m } 57.6\text{s} \\ \text{Dec (J2000)} &= -42\text{h } 56\text{m } 19.7\text{s} \end{aligned}$$

#### 4. UVOT OBSERVATION AND ANALYSIS

The bright optical afterglow of GRB 070318 had an approximately power-law decay, index 1.1, with some deviations (Figure 3). At 13,000 sec. after the trigger, the magnitude in the UVOT B filter was  $\sim 19.9$  with a best-fit decay index of 1.16. The decay leveled off at about T+1 day. There was a flare in the optical over about the same interval as that seen in the XRT. It returned to the power-law after about  $2.8 \times 10^5$  seconds. The afterglow was detected in all 7 UVOT filters. No optical source was seen at the position of the XRT second source.

The Swift/UVOT began taking data 88 sec after the BAT trigger. The photometry results are given for the 7 UVOT filters below. The refined position is

$$\begin{aligned} \text{RA (J2000)} &= 03\text{h } 13\text{m } 56.83\text{s}, \\ \text{Dec (J2000)} &= -42^\circ 56' 46.3'' \end{aligned}$$

with a 1-sigma error radius of about 0.5 arcseconds. The results are not corrected for extinction. The Galactic reddening in the direction of the UVOT position is  $E(B-V) = 0.017$  mag (Schlegel et al. 1998).

#### Reference

1) Jaunsen et al. GCN circular 6216. [http://gcn.gsfc.nasa.gov/gcn3\\_archive.html](http://gcn.gsfc.nasa.gov/gcn3_archive.html)

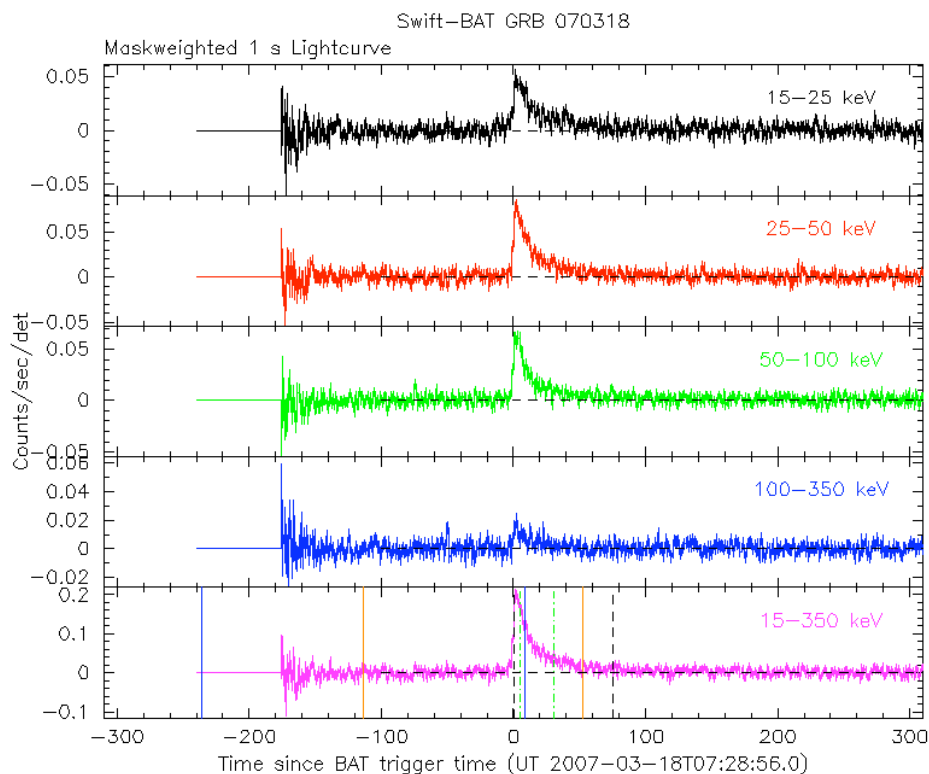


Fig.1: BAT Lightcurve. The light curve in 4 individual plus total energy bands. The vertical lines indicate: Blue, slew start; Orange, slew end (second slew end is approximate start of XRT and UVOT observations); Green, T50; Black, T90.

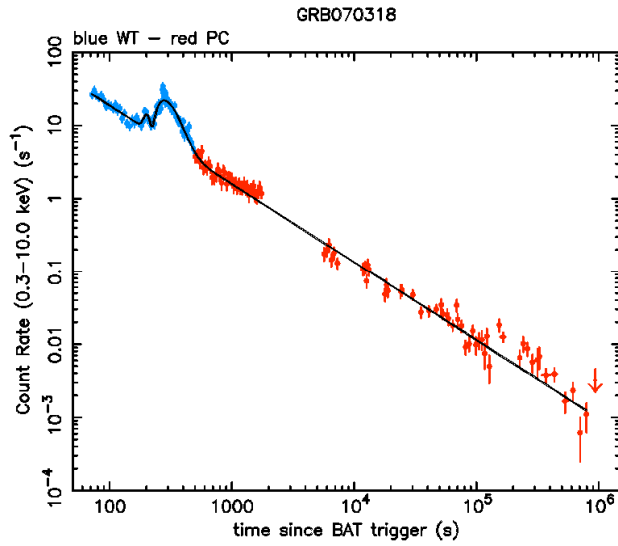


Fig. 2: XRT Lightcurve Blue is Window Timing Mode and Red is Photon Counting Mode. The conversion factor 0.3-10 keV counts -- 0.3-10 keV flux is  $7.6 \times 10^{-11}$ .

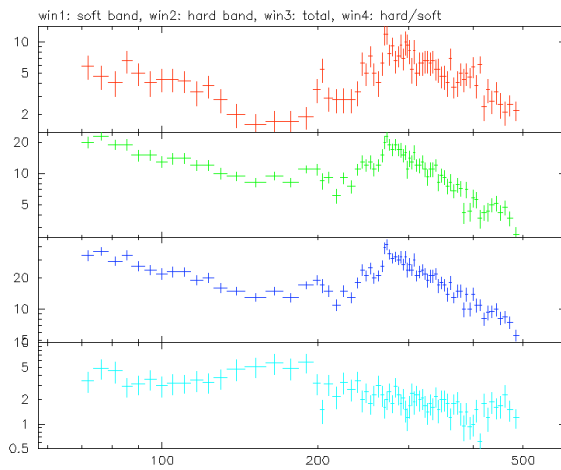


Fig 2b: XRT lightcurve in two energy bands, total, and ratio.

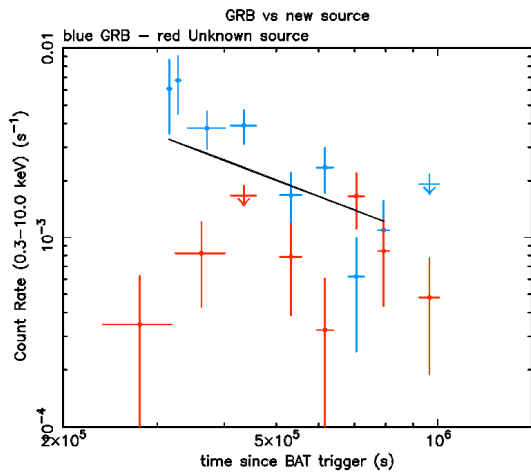


Fig 2c: XRT lightcurve of afterglow (blue points) and second source (red points).

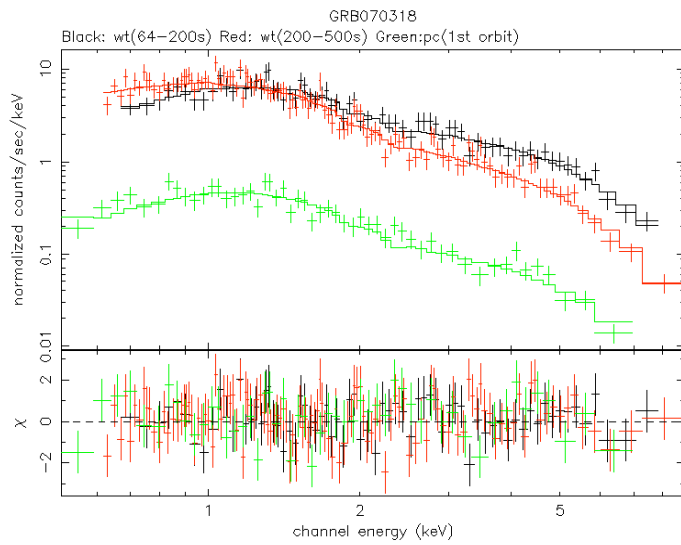


Fig 2d: XRT Spectrum

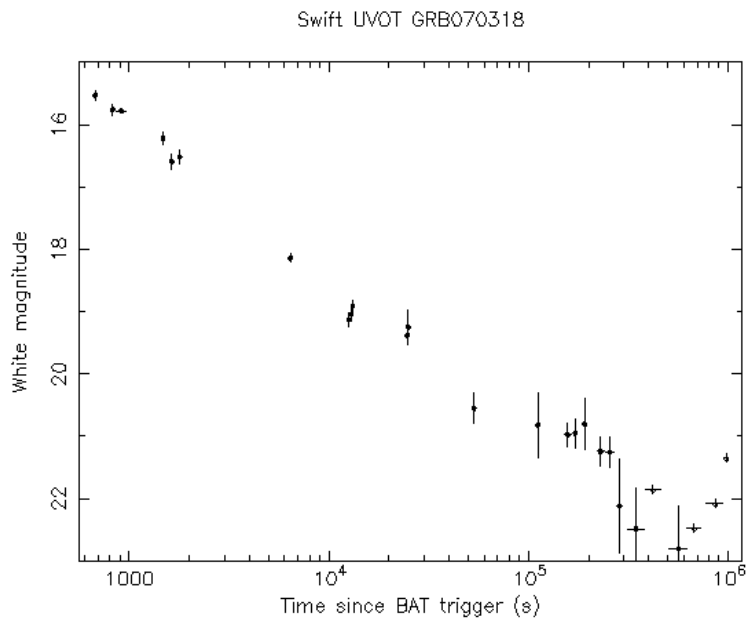


Fig. 3: UVOT Lightcurve. A powerlaw decay model is shown, but there are clear deviations.

UVOT Afterglow observations:

Filter	T range(s)	Exp(s)	Mag	Significance
White	672-682	10	15.53±0.08	17 sigma
V	180-580	400	15.43±0.02	54 sigma
B	658-668	10	16.25±0.12	10 sigma
U	634-644	19	15.89±0.09	13 sigma
UVW1	610-620	19	16.89±0.18	6 sigma
UVM2	586-596	19	17.97±0.37	3 sigma
UVW2	837-847	19	18.03±0.30	4 sigma