

## Swift Observations of GRB 071018

*H. A. Krimm (CRESST & NASA GSFC/USRA), A. Beardmore (U. Leicester), J. R. Cummings (CRESST & NASA GSFC/UMBC), S. D. Barthelmy (NASA GSFC), D. N. Burrows (PSU), N. Gehrels (GSFC), P. W. A. Roming (GSFC) for the Swift Team*

### 0 Changes

Modified the discussion to reflect that no XRT counterpart to this burst was found. Included new Figure 2 and updated Figure 3 (and added Figure 4) to show the light curves for all five candidate sources. Added a sentence to the BAT section to say that no source at this position has been seen before. Added a discussion of why the BAT position shifted from initial to final ground position.

### 1 Introduction

BAT triggered on GRB 071018 at 05:57:44.47 UT (trigger=294645) (Krimm, *et al.*, *GCN Circ.* 6932). This was a 320 sec image-trigger on a long burst with  $T_{90} = 376 \pm 20$  sec. Because the Swift operations team was still in the process of resuming normal operations, there were no automatic follow-up observations by the XRT or UVOT. Following a commanded slew, XRT began follow-up observations at  $T + 15.8$  hours. UVOT did not observe this burst. XRT detected five unidentified sources in its field of view, only one of which is within the refined BAT error circle. Our best position is the BAT location RA( $J2000$ ) =  $164.6848^\circ$  (10h 58m 44.35s), Dec( $J2000$ ) =  $+53.8217^\circ$  ( $+53^\circ 49' 18.1''$ ) with an error of 2.1 arcmin (90% confidence, including boresight uncertainties).

The field of GRB 071018 continued to be observed until 1001.2 ksec (11.5 days) and none of the possible sources showed any signs of fading. Therefore, we do not have a confirmed XRT counterpart to this burst.

### 2 BAT Observation and Analysis

Using the data set from  $T - 239$  to  $T + 844$  sec, further analysis of BAT GRB 071018 was performed by Swift-BAT team (Sato, *et al.*, *GCN Circ.* 6933). The best BAT ground-calculated position (Krimm, *et al.*, *GCN Circ.* 7009) is RA( $J2000$ ) =  $164.6848^\circ$  (10h 58m 44.35s), Dec( $J2000$ ) =  $+53.8217^\circ$  ( $+53^\circ 49' 18.1''$ )  $\pm 2.1$  arcmin, (radius, systematic and statistical, 90% containment). This is based on a time interval of  $T + 20$  to  $T + 470$  sec and an energy interval of 14 to 100 keV, which yields a higher significance detection than the trigger interval ( $10.6\sigma$  vs.  $6.2\sigma$ ). The partial coding was 97% (the bore sight angle was  $19.9^\circ$ ).

The mask-weighted light curve (Fig.1) shows an elongated multi-peaked structure. The burst location came into the BAT field of view at  $T - 70$  sec. and there was an initial peak at  $T - 50$  sec, followed by low-level emission from  $T + 20$  to  $T + 80$  sec, followed by the main emission in several peaks from  $T + 120$  sec to  $T + 420$  sec. There is also possible emission at later times ( $T + 600$  and  $T + 800$  sec), although statistics are poorer for this late time since the spacecraft slewed to a new target, moving the burst nearer the edge of the field of view.  $T_{90}(15 - 350\text{keV})$  is  $376 \pm 20$  sec (estimated error including systematics).

The time-averaged spectrum from  $T + 113.1$  to  $T + 417.7$  sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is  $1.63 \pm 0.26$ . The fluence in the 15-150 keV band is  $1.0 \pm 0.2 \times 10^{-6}$  erg  $\text{cm}^{-2}$ . The 1-sec peak photon flux measured from  $T + 124.18$  sec in the 15-150 keV band is  $0.2 \pm 0.1$  ph  $\text{cm}^{-2}$   $\text{sec}^{-1}$ . All the quoted errors are at the 90% confidence level.

Since no clear counterpart was found, the BAT archival data was searched to see if there had been any

Table 1: Possible X-Ray counterparts to GRB 071018 (Counts and rates for all observations)

source	RA	declination	Err (arcsec) <sup>a</sup>	Src cts <sup>b</sup>	Bgd cts <sup>c</sup>	Rate ( $10^{-3}$ ct/sec) <sup>d</sup>	Dist (arcmin) <sup>e</sup>
1	164.51217	53.82256	4.15	74	5.45	$2.53 \pm 0.33$	6.1
2	164.57976	53.82489	5.02	24	5.40	$0.69 \pm 0.20$	3.7
3	164.56757	53.86905	4.82	21	5.38	$0.58 \pm 0.19$	5.0
4	164.50757	53.81064	4.28	51	5.43	$1.68 \pm 0.28$	6.3
5	164.72200	53.81441	4.35	47	5.43	$1.53 \pm 0.37$	1.4

<sup>a</sup> Err is the 90 percent error radius, which includes a 4 arcsec systematic error added in quadrature.

<sup>b</sup> Src is counts in a 10 pixel radius circle.

<sup>c</sup> Bgd is the estimated background counts in the source region (where the estimated background level was 0.01729 count/pixel).

<sup>d</sup> Rate is the  $1\sigma$  count rate range estimated from the Bayesian limits method of Kraft et al. These are not corrected for PSF losses (a factor of 1.24).

<sup>e</sup> Dist is the distance from the refined BAT position.

other detections from this location in the past (which would have indicated that this was a galactic transient instead of a GRB). Nothing was found back to February 2005 to a limiting flux of  $\approx 50$  mcraab.

### 3 XRT Observations and Analysis

Based on analysis of all observing segments, there is a total exposure of 27.1 ksec. In addition to the original 2 sources reported in (Beardmore, *et al.*, *GCN Circ.* 6943), there is one other source in the refined BAT error circle plus two more outside detected with a  $\text{snr} > 3$  in the tool ximage/detect (see Table 1). The sources and the BAT error circles are shown in Figure 2. Only Source 5 is within the revised BAT error circle.

The count rates for the five sources are shown in Figures 3 and 4. None of these sources shows signs of fading.

### 4 UVOT Observation and Analysis

Since the UVOT was not operating at the time of this burst, there are no UVOT observations.

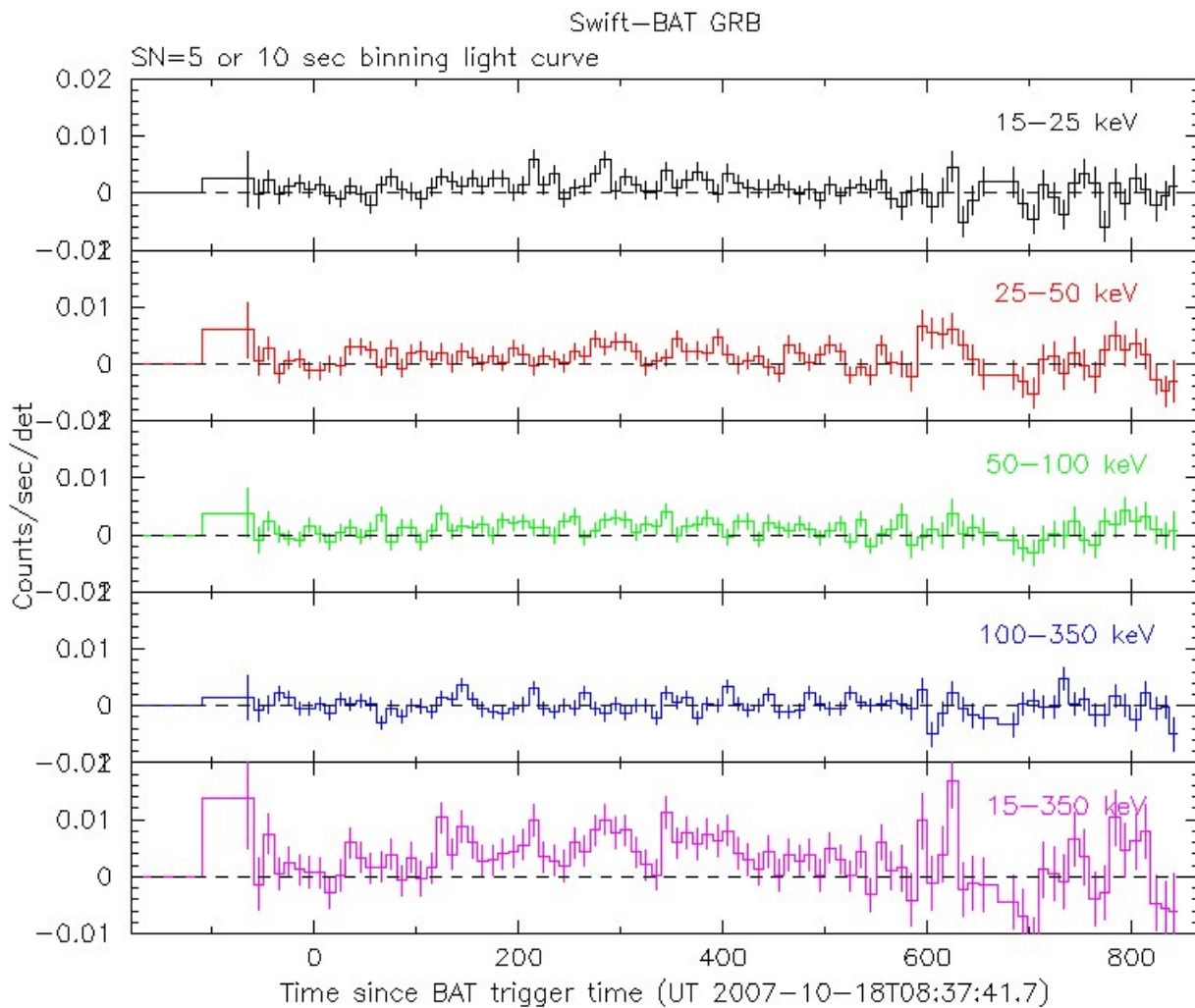


Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/sec/illuminated-detector (note illum-det =  $0.16\text{cm}^2$ ).

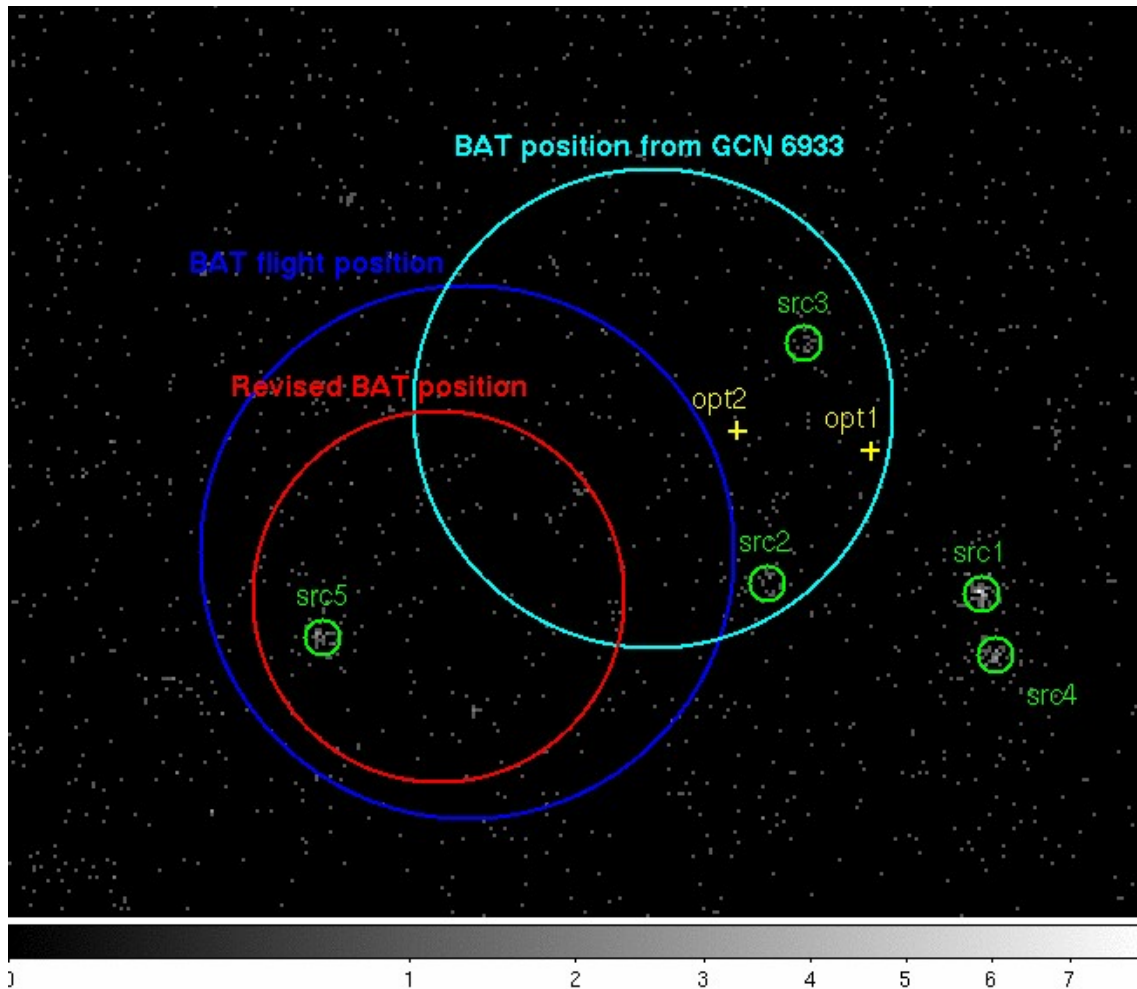


Figure 2: Sky image showing the five possible XRT counterparts in Table 1 and the BAT error circles reported in Krimm *et al.*, *GCN Circ.* 6932 (flight position), Sato *et al.*, *GCN Circ.* 6933 (ground) and Krimm *et al.*, *GCN Circ.* 7009 (revised ground position). The position reported in *GCN Circ.* 6933 was incorrect because the automatic script used to process the data used part of the burst time interval as background, thus subtracting part of the burst and skewing the localization. This error was found and corrected in *GCN Circ.* 7009. It is now seen the only source 5 is consistent with the best BAT position. Also shown are the locations of the two possible optical counterparts reported by Xin, *et al.*, *GCN Circ.* 6936.

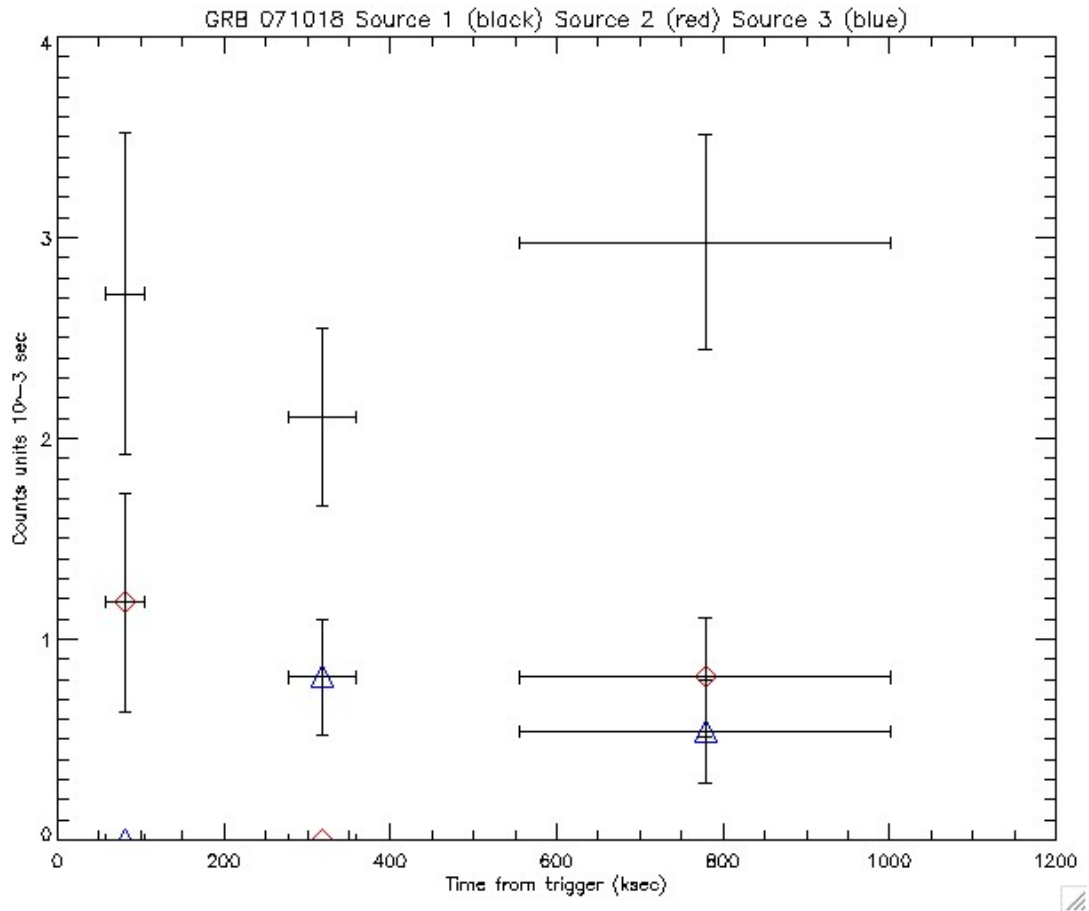


Figure 3: XRT Lightcurve. Counts/sec in the 0.3-10 keV band in the Photon Counting mode for possible XRT sources 1, 2, 3 (Table 1). All of these points are constant in flux to within errors.

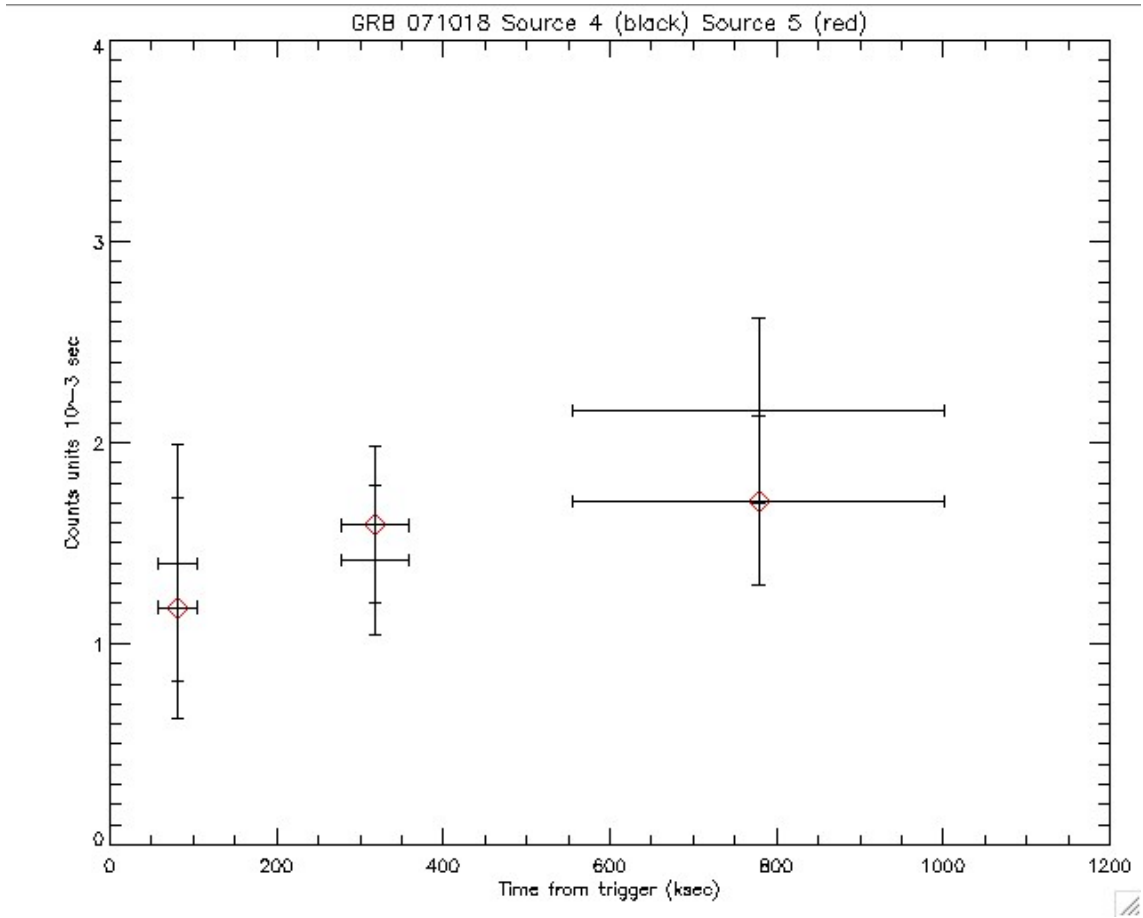


Figure 4: XRT Lightcurve. Counts/sec in the 0.3-10 keV band in the Photon Counting mode for possible XRT sources 4,5 (Table 1). All of these points (including point 5 inside the revised BAT error circle) are constant in flux to within errors.