

Swift Observation of GRB 070616

R.L.C. Starling (Leicester), G. Sato (GSFC), M. De Pasquale (MSSL), O. Godet, K.L. Page, A.P. Beardmore, P.A. Evans (Leicester), D.N. Burrows, P. Roming (PSU), S. Barthelmy and N. Gehrels (GSFC) for the Swift Team

1 Introduction

BAT triggered on GRB 070616 at 16:29:33 UT (Trigger 282445) (Starling, *et al.*, *GCN Circ.* 6542). This was an image-trigger on a long burst with $T_{90} \geq 175$ sec. Swift slewed to this burst immediately and XRT began follow-up observations at $T + 131$ sec, and UVOT at $T + 142$ sec. Our best position is the astrometrically refined XRT location $RA(J2000) = 02h08m36.70s$, $Dec(J2000) = +56d56'43.9''$ with an error of 2.3 arcsec (90% confidence).

2 BAT Observation and Analysis

Using the data set from $T - 239$ to $T + 497$ sec, further analysis of BAT GRB 070616 has been performed by the Swift BAT team (Stamatikos, *et al.*, *GCN Circ.* 6543). The BAT ground-calculated position is $RA(J2000) = 32.096deg$ ($02h08m23.0s$), $Dec(J2000) = +56.946deg$ ($+56d56'45''$) ± 2.6 arcmin, (radius, systematic and statistical, 90% containment). The partial coding was 60%.

The mask-weighted light curve (Fig.1) shows many peaks. The burst started with a low-level smooth emission at $\sim T - 55$ sec continuing smoothly and increasing slowly until $\sim T + 100$ sec when the main emission started. The main peak is at $T + 120$ sec. Smaller overlapping peaks continue out past $T + 500$ sec (the limit of the downloaded data so far). T_{90} is at least 175 sec.

3 XRT Observations and Analysis

We have analysed the first eight orbits of Swift XRT data (18.6 ks of data out to $T_0 + 5.8E4s$) for GRB 070616.

Using 1.1 ks of overlapping XRT PC mode data and UVOT V-band data, we obtain an astrometrically corrected X-ray position (using the USNO-B1 catalogue) of

$$RA(J2000) = 02h08m36.70s$$

$$Dec(J2000) = +56d56'43.9''$$

with an error of 2.3 arcseconds (radius, 90% containment). This is 3.7 arcsec from the initially reported XRT position and 6.4 arcsec from the BAT position (Starling, *et al.*, *GCN Circ.* 6542), and 6.3 arcsec from the possible optical transient reported in De Ugarte Postigo, *et al.*, *GCN Circ.* 6548. The error circle overlaps with the USNO-B1.0 source noted in *GCN Circ.* 6542.

The lightcurve (Fig.2) began with a constant flux up to $T_0 + 536s$, and then decayed with $\alpha = -4.6$ until about $T_0 + 1000s$. A steep decay follows this, though there are not enough data to accurately measure its slope. After $T_0 + 1400s$ the decay continues with a shallower slope of $\alpha = -1.2$. Several small flares appear on top of the continuum emission up to $T_0 + 1000s$, some of which may be simultaneous with BAT peaks.

The PC mode spectrum including 14.6 ks of data from the second orbit onwards is well fit with a power law of photon index $\Gamma = 2.4^{+0.2}_{-0.1}$ (90%) absorbed only by the large Galactic column of $3.4 \times 10^{21} \text{ cm}^{-2}$ (Dickey & Lockman 1990). The 0.3-10 keV observed (unabsorbed) flux is 2.2×10^{-12} (4.0×10^{-12}) $\text{erg cm}^{-2} \text{ s}^{-1}$, corresponding to a count rate of $4.9 \times 10^{-2} \text{ count s}^{-1}$.

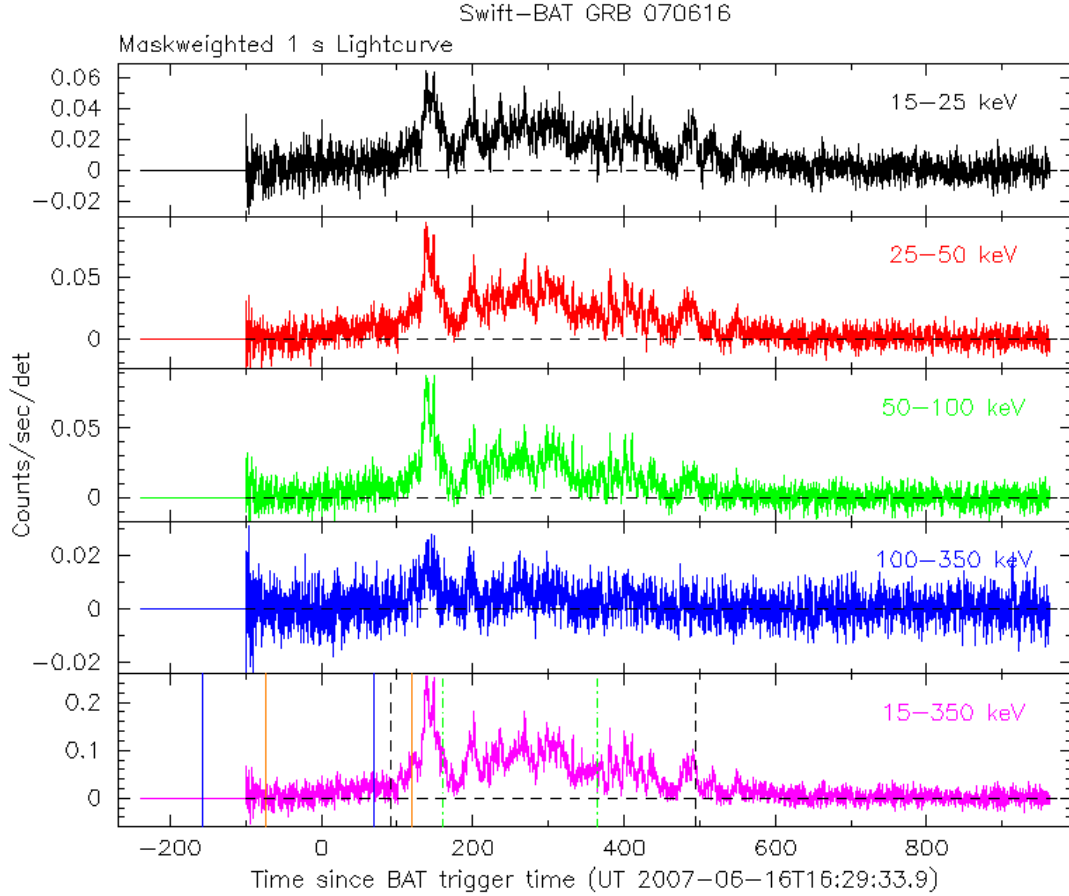


Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/sec/illuminated-detector and T_0 is 16:29:33 UT.

The predicted fluxes at $T_0+24\text{h}$ and $T_0+48\text{h}$ are 2.3×10^{-13} and 9.9×10^{-14} erg cm $^{-2}$ s $^{-1}$ respectively, assuming the decay continues with $\alpha=-1.2$.

4 UVOT Observation and Analysis

The Swift UVOT telescope began its White filter finding chart exposure of GRB 070616 144 seconds after the trigger. The XRT position lies on a bright object, listed in the USNO-B1.0 catalogue, therefore we caution that this source strongly affects the photometry. In the XRT error circle we do not detect any optical afterglow. We derive the 3 sigma upper limits listed in 1.

No correction has been made for the high Galactic reddening of $E(B-V) = 0.4$ (Schlegel et al. 1998). We note that this value should be taken with caution, the burst having occurred at low Galactic latitude.

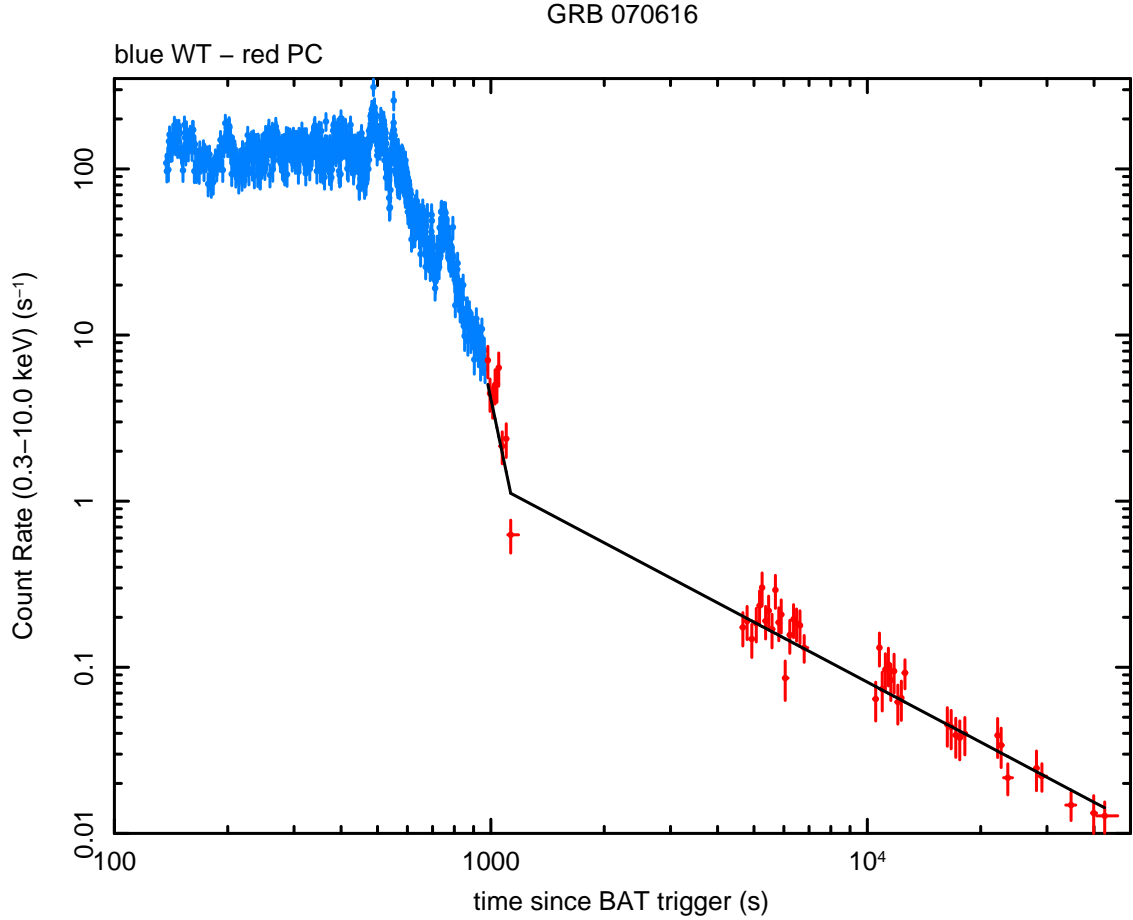


Figure 2: XRT Lightcurve. Count s^{-1} in the 0.3-10 keV band: Window Timing mode (blue), Photon Counting mode (red) and possible model to the PC mode data overlaid in black. The approximate count rate to flux conversion is $1 \text{ count s}^{-1} = 4.5 \times 10^{-13} \text{ erg cm}^{-2} \text{ s}^{-1}$.

Filter	Time after trigger (s)	Exposure (s)	3-Sigma UL
WHITE	144-243	98	18.3
V	250-649	390	18.1
WHITE	144-979	209	18.6
V	250-1122	547	18.3
B	729-738	10	17.1
U	707-874	39	17.2
UVW1	680-850	39	17.1
UVM2	655-825	39	17.3
UVW2	758-777	20	17.0

Table 1: Magnitude limits from UVOT observations