Swift Observation of GRB 070306

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This final version of the report updates the continued XRT and UVOT observations of the burst. Afterglow decay nature and other available information are also included in the respective sections.

1   Introduction

BAT triggered on GRB 060306 at 16:44:28.0 UT (Trigger 263361) (Pandey, *et al.*, *GCN Circ.* 6169). This was a 12.1 sec rate-trigger on a fairly long duration burst with $T_{90} = 210.0$ *sec*. Swift slewed to this burst immediately and XRT began follow-up observations at $T + 153$ *sec*, and UVOT at $T + 162$ *sec*. Our best position is the XRT location RA($J2000$) $= 148.0968deg$ ($09h52m23.24s$), Dec($J2000$) $= 10.4821deg$ ($10d28'55.5''$) with an error of 1.22 arcsec (90% confidence), corrected by matching the UVOT images with the USNO-B1 catalogue, and is consistent with IR afterglow candidate (Rol *et al.*, *GCN Circ.* 6174) within 1.1 *arcsec* error radius. Further optical monitoring (Levan *et al.GCN Circ.* 6176, Malesani *et al.GCN Circ.* 6178) do not reveal considerable decay of the source brightness. Also, the afterglow candidate matches with the SDSS source (Cool *et al.GCN Circ.* 6170) within error-bars and considered as the red host galaxy of the burst. Spectroscopic observations of the probable host with the ESO-VLT (Jaunsen *et al.GCN Circ.* 6202) starting on March 08.11 UT (34 hours after the burst) show featureless continuum with the exception of an apparent emission line, give rise to a redshift value of z=1.497.

2   BAT Observation and Analysis

Using the data set from $T - 240.0$ to $T + 962.0$ *sec*, further analysis of BAT GRB 070306 has been performed by Swift team (Barthelmy, *et al.*, *GCN Circ.* 6173). The BAT ground-calculated position is RA($J2000$) $= 148.097deg$ ($09h52m23.3s$), Dec($J2000$) $= 10.477deg$ ($10d28'37.2''$) ± 2.4 *arcmin*, (radius, systematic and statistical, 90% containment). The partial coding was 28%

The masked-weighted light curves (Fig.1) starts at trigger time T with a single mildly rapid rise, and returns to background at about $T + 50$ *sec*. $T_{90}(15 - 350keV)$ is 210 ± 10 (estimated error including systematics).

The time-averaged spectrum from $T + 118.8$ to $T + 186.5$ *sec* is best fitted by a simple power law model. This fit gives a photon index of 1.72 ± 0.10, ($\chi^2 = 61.49$ for 57 d.o.f.). For this model the total fluence in the $15 - 150$ *keV* band is $(5.5 \pm 0.3) \times 10^{-06} ergs/cm^2$ and the 1-sec peak flux measured from $T + 98.27$ *sec* in the $15 - 150$ *keV* band is 4.2 ± 0.2 $ph/cm^2/sec$. All the quoted errors are at the 90% confidence level.

3   XRT Observations and Analysis

Using the data from the first three orbits of XRT data of GRB 070306 (3.3 *ksec* in Photon Counting mode), the refined XRT astrometry-corrected position (by matching the UVOT images with the USNO-B1 catalogue) is RA($J2000$) $= 148.0972deg$ ($09h52m23.24s$), Dec($J2000$) $= 10.4822$ *deg* ($10d28'55.5''$)$\pm$ 1.22 *arcsec* (90% confidence). This position is within 3.6 *arcsec* of the initial XRT position, and 1.1 *arcsec* from the IR afterglow candidate, reported by Rol *et al.*, *GCN Circ.* 6174.

The $0.3 - 10$ *keV* light curve (Fig.2) shows an initial steep decline with a slope of 6.4 ± 0.2, following by a shallow slope of 0.18 ± 0.04, beginning at $T + 417 \pm 12$ *sec*. At $(3.2^{+0.2}_{-0.3}) \times 10^4$ *sec* the light curve
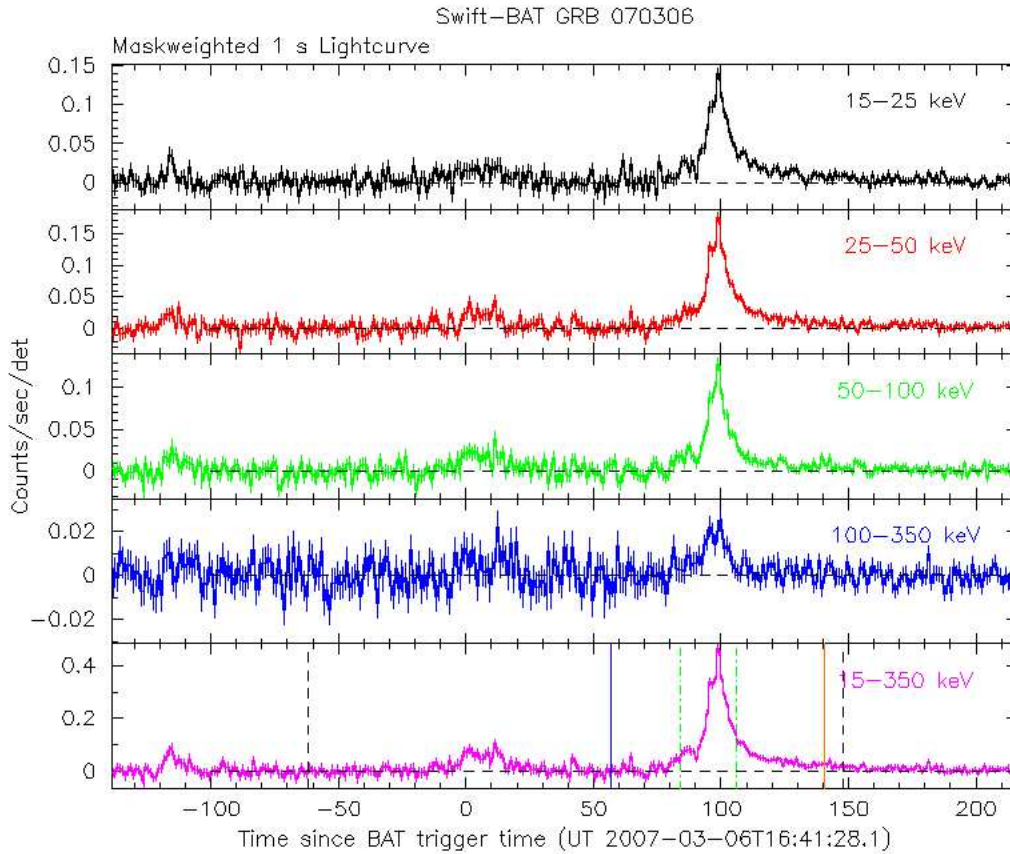
Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/sec/illuminated-detector (note illum-det $= 0.16 cm^2$) and T_0 is 16:41:28.0 UT.

breaks with a slope of 1.86 ± 0.07 till the end of the observations. Note that T0 has been taken to be the trigger time i.e. that corresponding to the precursor, not the main burst.

Three segments of the X-ray light curve can be modelled with an absorbed power-law with spectral indices of 2.30 ± 0.04, 2.30 ± 0.43, and 2.22 ± 0.12, respectively for the WT, PC pre-break and PC plateau phase. There is spectral evolution during the initial steep decay, but no considerable spectral evolution was observed starting the PC plateau phase and onwards (Fig.3) The fitted NH column density for the spectra is significantly in excess $(4.2 \times 10^{21} cm^{-2})$ of the Galactic one in the direction of burst. The average observed (unabsorbed) flux over $0.3 - 10\ keV$ for this spectrum (spanning a time of 153-309 seconds after the trigger) is 1.73×10^{-09} (3.48×10^{-09}) $ergs/cm^2/sec$.

4   UVOT Observation and Analysis

The UVOT began observing the field of GRB 070306 at 16:44:10 UT, 162 sec after the initial BAT trigger (Pandey *et al.*, *GCN Circ.* 6169). No new source was detected within the XRT error circle in the white (98 *sec*) finding chart exposure, or in the co-added images in any filter. 3-sigma Upper limits are summarised in Table 1. These upper limits are not corrected for extinction corresponding to a reddening of E(B-V) = 0.03 mag.
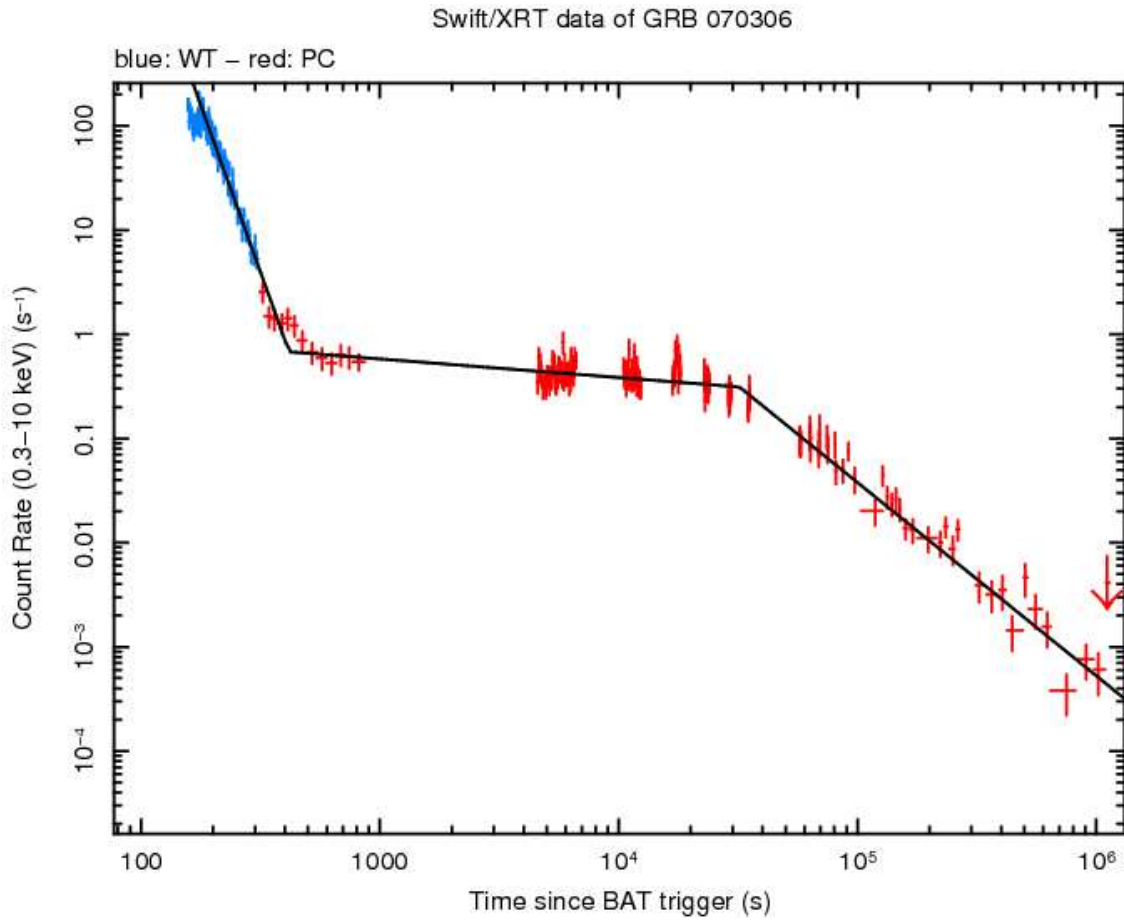
Figure 2: XRT Light curve. Counts/sec in the 0.3-10 keV band: Window Timing mode (blue), Photon Counting mode (red). The approximate conversion is 1 count/sec $= \sim 4.3 \times 10^{-11}$ $ergs/cm^2/sec$.

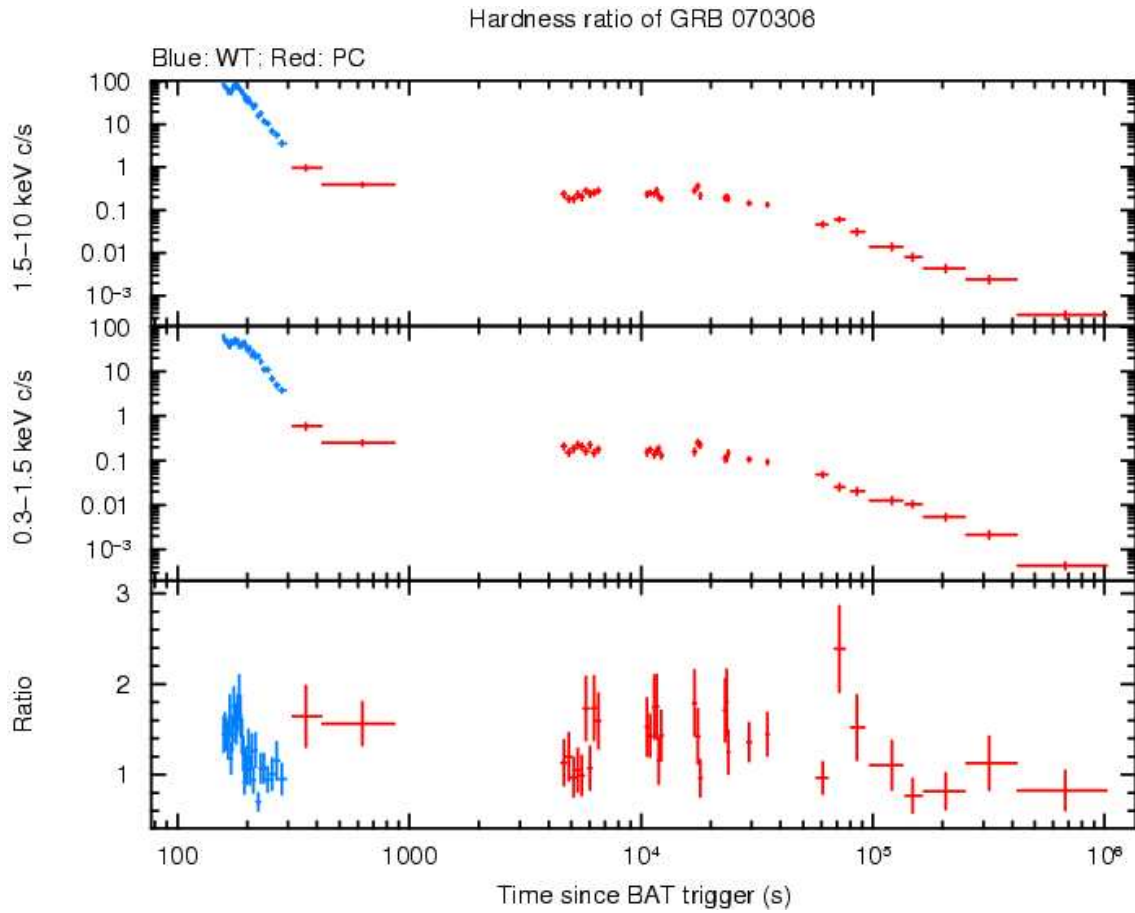| Filter	Start	Stop	Exposure	3-Sigma UL
WHITE (finding)	162	262	98	19.8
V	267	11158	1259	20.5
B	745	6257	403	21.5
U	721	6053	413	21.0
UVW1	697	5848	236	19.0
UVM2	673	5633	236	18.7
UVW2	773	6651	397	19.5
WHITE	162	6462	512	20.7

Table 1: Magnitude limits from UVOT observations

Figure 3: XRT Hardness Ratio and light curve in two energy bands. The hardness ratio is the counts ratio: C(0.3-1.5 keV)/C(1.5-10 keV).