Swift Observation of GRB 100606A

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1 Introduction

BAT detected GRB 100606A at 19:12:41 UT on the 6^{th} June 2010 (Oates, *et al.*, *GCN Circ.* 10824). Swift slewed immediately to the burst and XRT observations and UVOT settled observations began $\sim$ 85 s and 107 s respectively, after the BAT trigger (Target ID 424031). A source was detected by the XRT, but not by the UVOT (Oates, *et al.*, *GCN Circ.* 10824). Our best position is the UVOT-enhanced XRT location RA($J2000$) = 350.62688 *deg* ($23h$ $22m$ $30.45s$), Dec($J2000$) = -66.24122 *deg* ($-66d$ $14'$ $28.4''$) with an error of 1.4 arcsec (radius, 90% containment). Observations were also performed by Konus-Wind (Golenetskii, *et al.*, *GCN Circ.* 10833), Suzaku WAM (Sugita, *et al.*, *GCN Circ.* 10836), INTEGRAL/SPI/ACS (Beckmann, private communication), Gemini-South (Levan, *et al.*, *GCN Circ.* 10831), GROND (Nicuesa, *et al.*, *GCN Circ.* 10835) and the Australian National University's Wide-Field-Spectrograph (Rapoport, *et al.*, *GCN Circ.* 10869). Neither the UVOT, Gemini-South nor the Australian National University's Wide-Field-Spectrograph observe an afterglow, although Gemini-South observes an extended source at the location of the X-ray afterglow (Levan, *et al.*, *GCN Circ.* 10831).

2 BAT Observation and Analysis

Using the data set from T-240 to T+962 s, we report on the BAT refined analysis of BAT GRB 100606A (trigger 424031)(Krimm, *et al.*, *GCN Circ.* 10828). The BAT ground-calculated position is RA, Dec = 350.617, -66.234 deg, which is RA(J2000) = $23h$ $22m$ $28.1s$ Dec(J2000) = $-66d$ $14'$ $03.3''$ with an uncertainty of 1.1 arcmin, (radius, sys+stat, 90% containment). The partial coding was 25%.

The mask-weighted light curve, shown in Fig. 1, shows an initial FRED peak starting at T-0.2 sec, peaking at T+0.5 s. Then there are two peaks at T+12 and T+20 s followed by a roughly exponential decay out to T+180 s. Another, weak peak occurs at T+200 followed by some very weak emission out to T+370 s, and possibly out to T+500 s. T_{90} (15-350 keV) is 480$\pm$150 s (estimated error including systematics).

The time-averaged spectrum from T+0.3 to T+672.3 s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.35 ± 0.10. The fluence in the 15-150 keV band is $6.4 \pm 0.4 \times 10^{-6}$ erg cm^{-2}. The 1-sec peak photon flux measured from T+7.82 s in the 15-150 keV band is 1.6 ± 0.4 ph cm^{-2} s^{-1}. All the quoted errors are at the 90% confidence level.

The results of the batgrbproduct analysis are available at:
`http://gcn.gsfc.nasa.gov/notices_s/424031/BA/`

3 XRT Observations and Analysis

The XRT began observations of GRB 100606A 86 s after the BAT trigger. The XRT found a bright, uncatalogued X-ray source located at the refined position RA, Dec 350.62688, -66.24122 which is equivalent to: RA(J2000) = $23h$ $22m$ $30.45s$ Dec(J2000) = $-66d$ $14'$ $28.4''$ with an uncertainty of 1.4 arcseconds (radius, 90% containment).

We have analyzed 4.9 ks of XRT data from 86 s to 19.1 ks after the BAT trigger. The data comprise 313 s in Windowed Timing (WT) mode (the first 9 s were taken while Swift was slewing) with the

remainder in Photon Counting (PC) mode. The enhanced XRT position for this burst was given by Evans, *et al.*, (*GCN Circ.* 10825).

The light curve, shown in Fig. 2, can be modeled by a series of 4 broken power-laws. The light curve initially shows some flaring with an underlying decay index of $-0.45^{+0.38}_{-0.44}$ from T+86 s to T+154 s. The first break occurs at T+154 s to a decay with $\alpha = 1.80^{+0.12}_{-0.11}$. The second break occurs at T+459 s to a decay of $\alpha = 0.85^{+0.14}_{-0.22}$, flares may also be present in this interval up to the final break at T+1932 s after which the decay index is $2.20^{+5.82}_{-4.67}$.

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of 1.59 ± 0.08. The best-fitting absorption column is $1.76^{+0.29}_{-0.28} \times 10^{21}$ cm^{-2}, in excess of the Galactic value of 2.4×10^{20} cm^{-2} (Kalberla, *et al.*, 2005). The PC mode spectrum has a photon index of 1.94 ± 0.14 and a best-fitting absorption column of $2.0^{+0.45}_{-0.42} \times 10^{21}$ cm^{-2}. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 4.3×10^{-11} (6.2×10^{-11}) erg cm^{-2} count^{-1}.

The results of the XRT-team automatic analysis are available at:
`http://www.swift.ac.uk/xrt_products/00424031`

4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB 100606A 107 s after the BAT trigger (Oates *et al.*, *GCN Circ.* 10824). We do not detect any source at the enhanced Swift XRT position (Evans, *et al.*, *GCN Circ.* 10827).

The results of the UVOT-team automatic analysis are available at:
`http://gcn.gsfc.nasa.gov/swift_gnd_ana.html`

The 3-sigma upper limits for the finding chart exposures (FC) and summed images provided in Table 1.

Filter	Start (s)	Stop (s)	Exposure (s)	3σ UL
white (FC)	107	256	147	> 21.08
u (FC)	319	568	246	> 20.35
white	598	6542	461	> 21.70
v	648	6952	333	> 19.86
b	574	6337	312	> 20.76
u	722	7567	487	> 20.47
uvw1	698	7362	490	> 20.54
uvm2	673	7157	274	> 19.93
uvw2	1030	6748	255	> 20.27

Table 1: Magnitude limit from UVOT observations. The values quoted above are not corrected for the expected Galactic extinction corresponding to a reddening of E(B-V) = 0.03 mag in the direction of the burst (Schlegel, Finkbeiner & Davis, 1998).

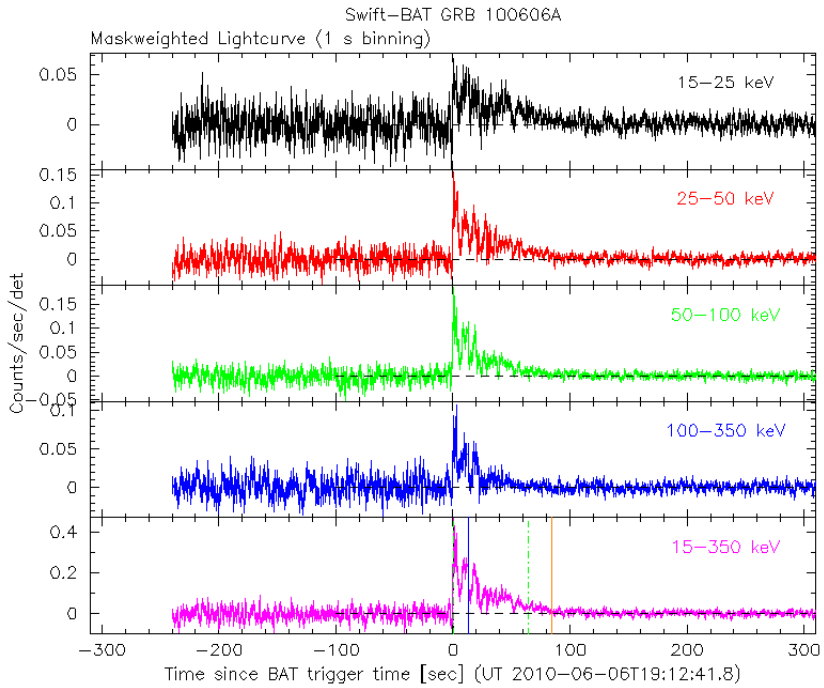

Figure 1: BAT light curve. The mask-weighted light curve in the 4 individual plus total energy bands: 15 - 25 keV (black), 25 - 50 keV (red), 50 - 100 keV (green), 100 - 350 keV (blue), 15 - 350 keV (magenta)

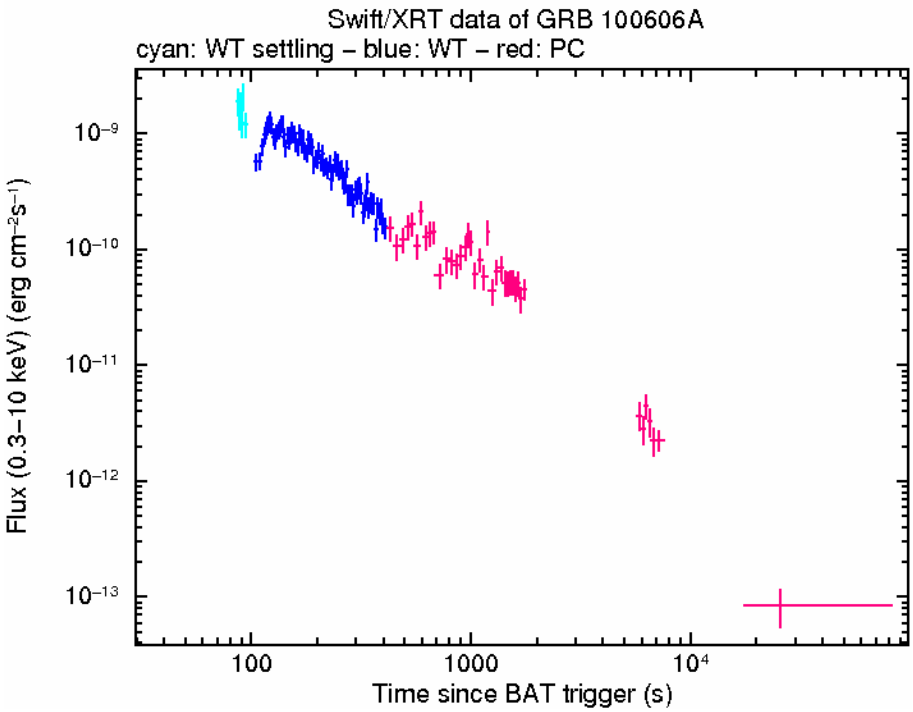

Figure 2: XRT light curve in the 0.3-10 keV band. The counts-to-observed-flux conversion factor is 1 count $= 4.3 \times 10^{-11}$ erg cm^{-2}.