Swift Observations of GRB 100316C

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1 Introduction

At T_0 = 08:57:59 UT, on March 16, 2010, the BAT triggered on GRB 100316C (trigger #416115) (Stamatikos *et al.*, *GCN Circ.* 10491). This was a long GRB with a duration of ∼14 sec in BAT. Swift slewed immediately allowing for XRT and UVOT follow-up observations at T+78.3 and T+81 sec, respectively, which resulted in the detection of an afterglow candidate in the former and upper limits in the latter. Our best localization, based upon 1879 sec of XRT Photon Counting mode data and 2 UVOT images for GRB 100316C (Evans *et al.*, *GCN Circ.* 10506), is an astrometrically corrected X-ray position[1] (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue) of RA, Dec (J2000) = 32.28660°(2h 9m 8.78s), -67.99098° (-67d 59′ 27.5″), with an uncertainty of 1.8 arcsec (radius, 90% confidence).

2 BAT Observations and Analysis

Using the data set from T-239 to T+303 sec from telemetry downlinks, further analysis[2] of BAT GRB 100316C was performed beyond what was reported in Palmer, et al., GCN Circ. 10509. The BAT ground-calculated position is RA, Dec (J2000) = 32.273° (2h 9m 5.4s), -67.990° (-67d 59′ 23.5″), with an uncertainty of 2.0 arcmin, (radius, sys+stat, 90% containment). The partial coding was 100%.

The mask-weighted light curve (Figure 1) shows a roughly symmetric peak starting at ∼T-3 sec, peaking at ∼T+3 sec, and ending at ∼T+12 sec. The T_{90} (15-350 keV) is 14.1 ± 4.3 sec (estimated error including systematics).

The time-averaged spectrum from T-3.0 to T+13.6 sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.72 ± 0.29. The fluence in the 15-150 keV band is $(2.1 \pm 0.4) \times 10^{-7}$ erg/cm^2. The 1-sec peak photon flux measured from T+2.12 sec in the 15-150 keV band is 0.4 ± 0.1 ph/cm^2/sec. All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

The XRT began observing the field at 08:59:17.9 UT, 78.3 sec after the BAT trigger and found an uncatalogued X-ray source. Using 5.7 ksec of XRT data for GRB 100316C, from 87 sec to 13.5 ksec after the BAT trigger, further analysis[3] was performed using Photon Counting (PC) mode (Page and Stamatikos, GCN Circ. 10507). The enhanced XRT position for this burst was given by Evans et al. (GCN Circ. 10506).

The XRT light curve (Figure 2) can be modeled by a broken power-law, with $\alpha_1 = 1.96^{+0.46}_{-0.53}$, $T_{Break} \sim$ 445 sec after the trigger, $\alpha_2 = 0.83^{+0.21}_{-0.22}$, and a flare at $T_{Flare} \sim 212$ sec. A spectrum formed from the PC mode data can be fitted with an absorbed power-law with a photon spectral index of $1.6^{+0.5}_{-0.4}$. The best-fitting absorption column is $(1.8^{+1.6}_{-1.3}) \times 10^{21}$ cm^{-2}, in excess of the Galactic value of 3.9×10^{20}

[1]The latest position can be viewed at `http://www.swift.ac.uk/xrt_positions`. Position enhancement is described by Goad et al. (2007, A&A, 476, 1401) and Evans et al. (2009, MNRAS, 397, 1177).

[2]The results of the batgrbproduct analysis are available at `http://gcn.gsfc.nasa.gov/notices_s/416115/BA/`.

[3]The results of the XRT-team automatic analysis are available at `http://www.swift.ac.uk/xrt_products/00416115`.

cm^{-2} (Kalberla et al. 2005). The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 5.1×10^{-11} (6.2×10^{-11}) erg/cm^2/count.

4 UVOT Observations and Analysis

UVOT took a finding chart exposure of ∼150 sec with the White filter starting 81 sec after the BAT trigger. No credible afterglow candidate was found within the enhanced Swift XRT position (Evans et al. GCN Circ. 10506). The (3σ) upper limits for the finding chart (FC) exposures and summed images are given in Table 1 (Oates and Stamatikos, *GCN Circ.* 10510). The standard UVOT products are available at `http://gcn.gsfc.nasa.gov/swift_gnd_ana.html`.

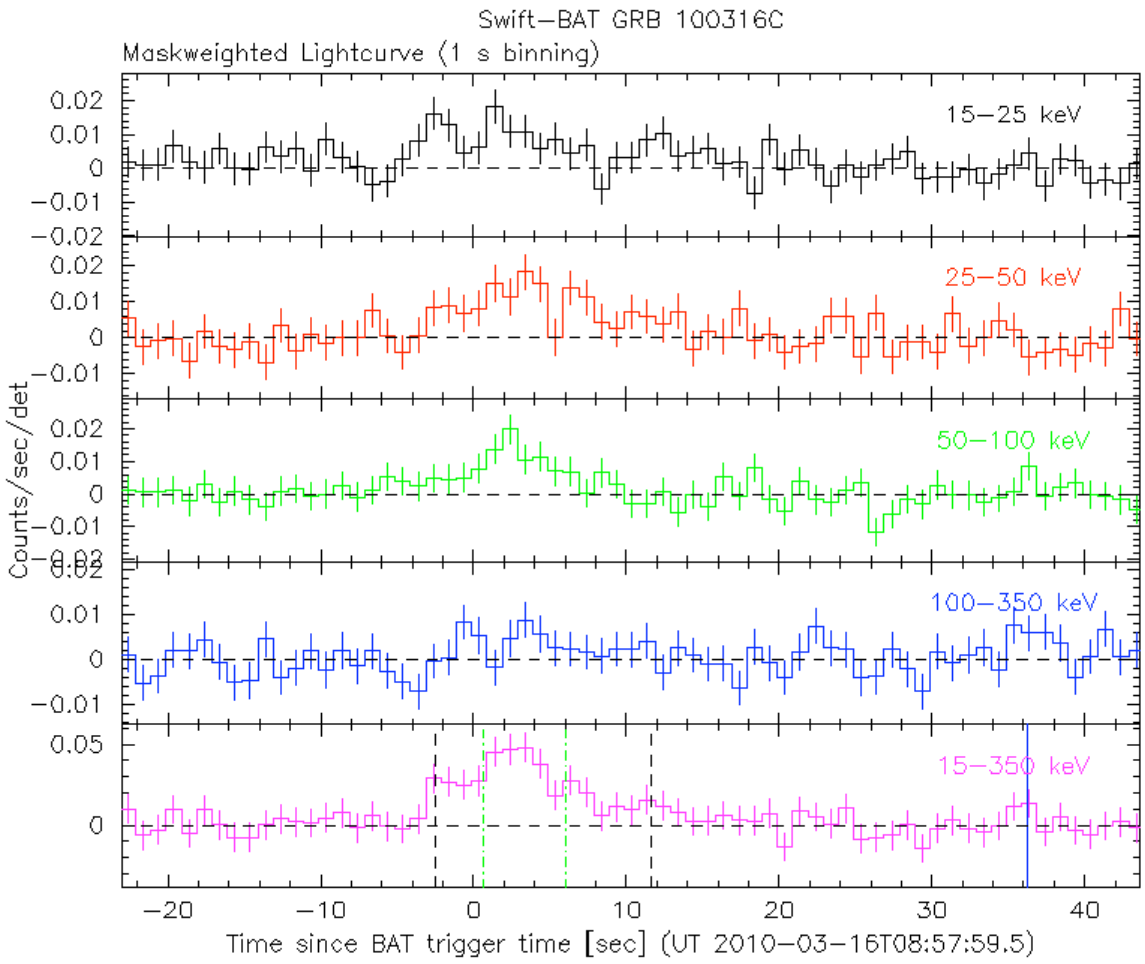

Figure 1: BAT Light curve for GRB 100316C. The mask-weighted light curve in the 4 individual plus total energy bands. The green and black dotted lines bracket the T_{50} and T_{90} intervals, respectively, while the blue solid line indicates the start of the slew. The time of each bin is in the middle of the bin. The units are counts/sec/illuminated-detector and T_0 is 08:57:59 UT.

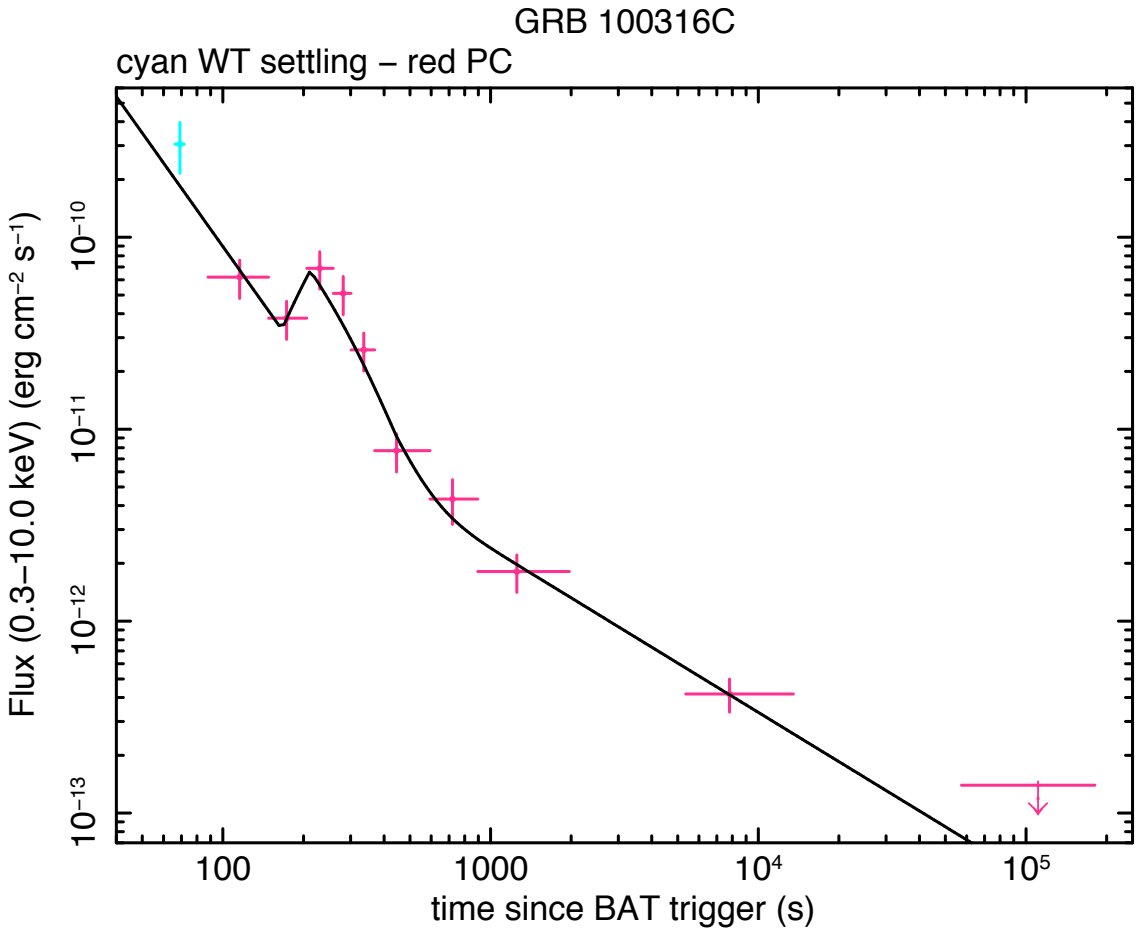

Figure 2: XRT light curve of GRB 100316C, in the $0.3 - 10$ keV energy band, for Windowed Timing settling (cyan) and Photon Counting (red) modes. The counts to observed ($0.3 - 10$ keV) flux conversion factor deduced from this spectrum is 5.1×10^{-11} erg/cm^2/count. Times are with respect to BAT trigger time (T_0 = 08:57:59 UT).

Filter	T_{Start} (sec)	T_{Stop} (sec)	Exposure Time (sec)	Magnitude (3σ U.L.)
White (FC)	81	231	147	> 20.52
White	521	7450	677	> 21.63
U (FC)	239	489	246	> 19.87
U	644	7039	529	> 20.22
V	570	12991	1326	> 20.45
B	495	7245	549	> 20.72
UVW1	620	6834	333	> 20.24
UVM2	595	13530	741	> 20.60
UVW2	546	7656	471	> 20.57

Table 1: Optical afterglow magnitude (3σ) upper limits from UVOT observations of GRB 100316C (Oates and Stamatikos, *GCN Circ.* 10510). N.B. - The quoted upper limits have not been corrected for the expected Galactic extinction along the line of sight, which corresponds to a reddening of E(B-V) = 0.04 mag (Schlegel et al. ApJ 500: 525-553, 1998). All photometry is on the UVOT photometric system described in Poole et al. (2008, MNRAS, 383, 627). N.B. T_{Start} and T_{Stop} are with respect to BAT trigger time (T_0 = 08:57:59 UT).