Swift Observation of GRB 120404A

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1   Introduction

At 12:51:02 UT, the Swift Burst Alert Telescope (BAT) triggered and located the long GRB 120404A (trigger=519380, Stratta et al., GCN Circ. 13208). The BAT mask-weighted light curve shows several overlapping peaks with a total duration of about 40 sec.

Swift slewed immediately, and the narrow field instruments were on target 130 seconds later. The X-ray telescope XRT detected a bright X-ray afterglow. UVOT took a finding chart exposure of 150 seconds with the White filter starting 139 seconds after the BAT trigger. The afterglow was detected already in the rapidly available sub-image at RA(J2000) = 15^h 40^m 02.29^s = 235.00956 deg and Dec(J2000) = $+12^d 53' 06.3$" = 12.88508 deg, with a 90%-confidence error radius of about 0.65 arcseconds (GCN Circ. 13208).

Several detections from ground-based facilities have been reported. The redshift of this GRB was measured at z=2.876 using GMOS Spectrograph on the Gemini-North 8-m telescope (Cucchiara et al., GCN Circ. 13217).

2   BAT Observation and Analysis

Using the data set from $T - 239$ to $T + 963$ sec from prompt telemetry downlinks, the BAT ground-calculated position is RA, Dec = 235.002, 12.883 deg which is RA(J2000) = 15^h 40^m 00.4^s and Dec(J2000) = $+12^d$ $52'$ 57.3" with an uncertainty of 1.2 arcmin, (radius, sys+stat, 90% containment). The partial coding was 49% (Ukwatta et al. GCN Circ. 13220)

The mask-weighted light curve shows several overlapping peaks starting at $\sim T - 20$ sec, peaking at $\sim T + 4$ sec, and ending at $\sim T + 80$ sec. $T_{90}(15 - 350$ keV) is (38.7 ± 4.1) sec (estimated error including systematics).

The time-averaged spectrum from $T - 7.31$ to $T + 38.45$ sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.85 ± 0.13. The fluence in the $15 - 150$ keV band is $(1.6 \pm 0.1) \times 10^{-6}$ erg cm^{-2}. The 1-sec peak photon flux measured from $T + 3.29$ sec in the $15 - 150$ keV band is 1.2 ± 0.2 ph cm^{-2} sec^{-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/519380/BA/

3   XRT Observations and Analysis

The XRT data comprise 109 s in Windowed Timing (WT) mode (the first 9 s were taken while Swift was slewing) with the remainder in Photon Counting (PC) mode (Evans et al. GCN Circ. 13222). The enhanced Swift/XRT position RA (J2000)= 15^h 40^m 02.28^s and Dec (J2000)= $+12^d$ $53'$ 04.9" with an uncertainty of 1.6 arcsec (radius, 90% confidence) was given by Osborne *et al.* (GCN Circ. 13218).

The X-ray (0.3-10 keV) light curve can be modelled with a series of power-law decays. The initial decay index is $\alpha_1 = (2.15 \pm 0.18)$. A temporal break is observed around $T + 544$ s when the decay flattens to a second decay index of $\alpha_2 = 0.1^{+0.4}_{-0.6}$ before breaking again at $T + 2930$ s to a final decay with index of $\alpha_3 = 1.83^{+0.21}_{-0.19}$.

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of $1.72^{+0.14}_{-0.13}$. The best-fitting absorption column is $(2.3^{+4.7}_{-2.3}) \times 10^{21} \text{cm}^{-2}$ at a redshift of 2.87, in addition to the Galactic value of 3.4×10^{20} cm^{-2} (Kalberla et al. 2005). The PC mode spectrum has a photon index of 1.90 ± 0.12 and a best-fitting absorption column of $(4.5^{+4.3}_{-4.0}) \times 10^{21}$ cm^{-2}. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 3.7×10^{-11} (4.3×10^{-11}) erg cm^{-2} count^{-1}.

Detailed light curves in both count rate and flux units are available in both graphical and ASCII formats at http://www.swift.ac.uk/xrt_curves/00519380.

4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field 139 s after the BAT trigger. A source at a position consistent with the enhanced XRT position (Osborne et al., GCN Circ. 13218), is detected in the initial UVOT exposures. The source is only seen in the optical filters and rises initially and then fades. The fact that the source is not detected in the UV filters is consistent with the redshift of z=2.876 reported by Cucchiara et al., GCN Circ. 13217. Preliminary detections and 3-sigma upper limits, using the UVOT photometric system (Breeveld et al. 2011, AIP Conf. Proc. 1358, 373), for the early exposures are reported in Table 1. The quoted magnitudes have not been corrected for the expected Galactic extinction along the line of sight corresponding to a reddening of $E_{B-V} = 0.05$ mag (Schlegel, et al., 1998, ApJS, 500, 525).
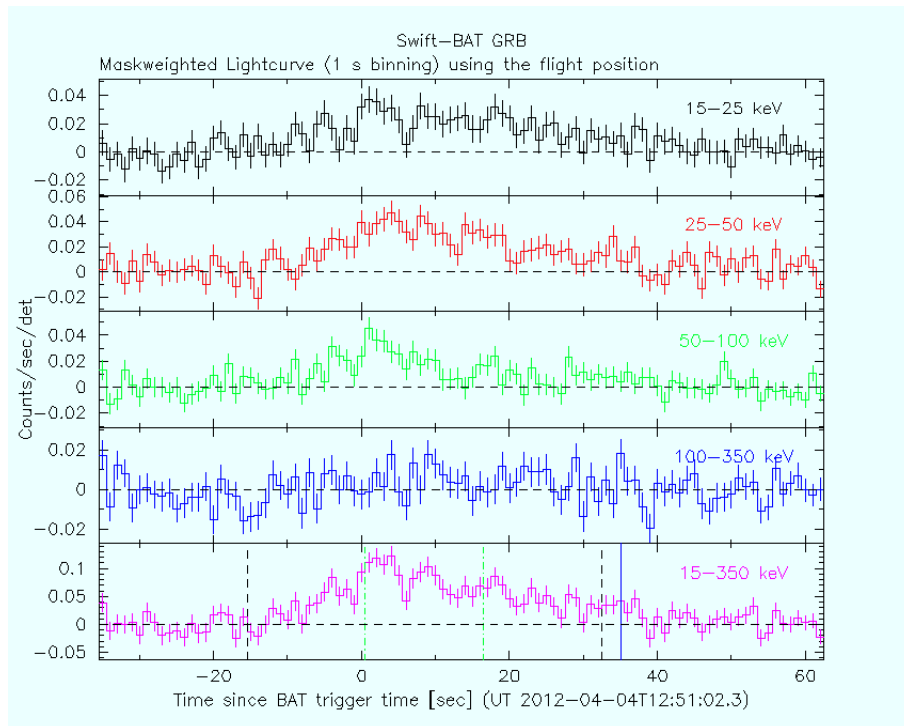

Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The verticle lines correspond to following: green dotted lines are T50 interval, black dotted lines are T90 interval, blue solid line(s) is a spacecraft slew start time. The units are counts s^{-1} illuminated-detector^{-1} (note illum-det = 0.16 cm^2).

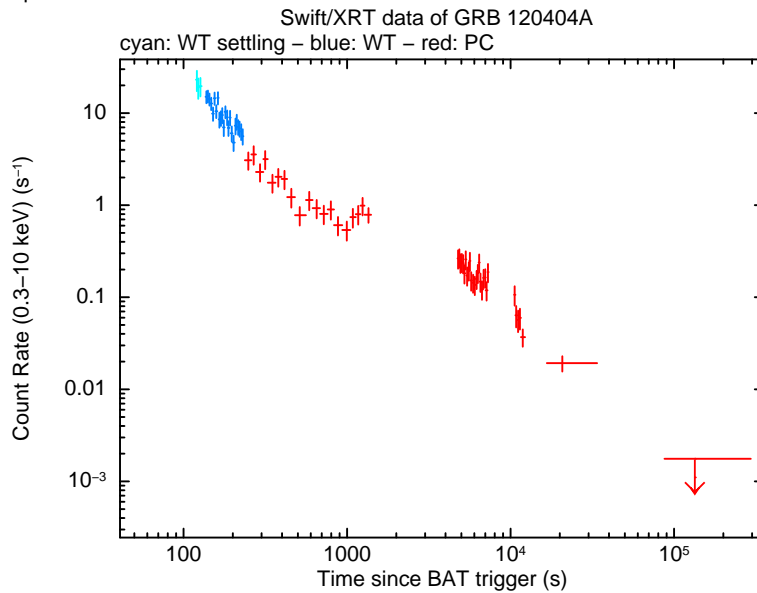Swift/XRT data of GRB 120404A
cyan: WT settling – blue: WT – red: PC

Figure 2: XRT Lightcurve. Counts s^{-1} in the 0.3-10 keV band: Windowed Timing (WT) settling mode data (cyan), WT mode data (blue), Photon Counting mode data (red). The approximate conversion to observed (unabsorbed) flux is 1 count s^{-1} ~ 3.7(4.3) × 10^{-11} erg cm^{-2} s^{-1}.

Filter	T_start (s)	T_stop (s)	Exp (s)	mag
white	139	288	147	19.43 ± 0.12
v	4734	4934	197	17.69 ± 0.10
b	606	1178	58	19.22 ± 0.28
u	351	1327	304	19.90 ± 0.19
uvw1	729	6779	452	> 20.3
uvm2	704	6574	432	> 21.5
uvw2	656	11408	1179	> 22.1

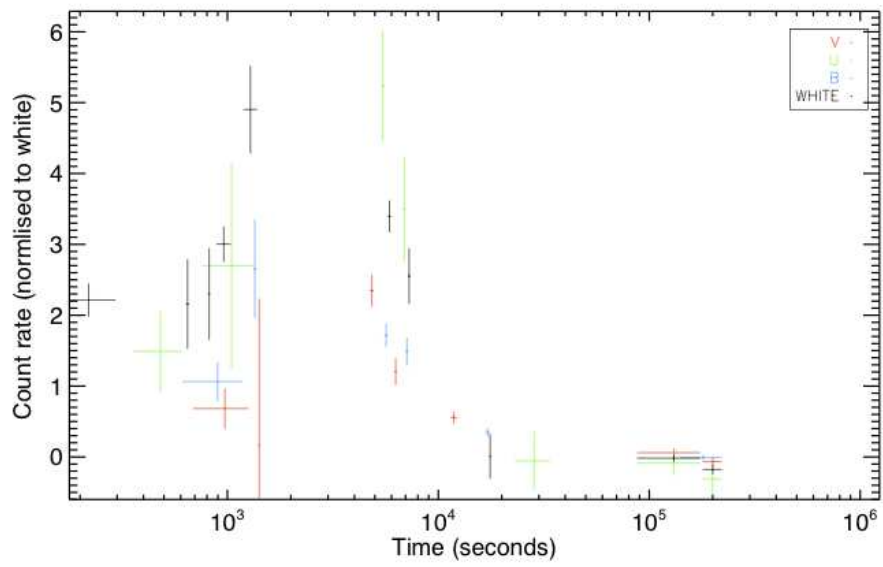Table 1: Magnitudes and 3-sigma upper limits from UVOT observations.

Figure 3: UVOT optical light curves normalised to white.