Swift Observation of GRB 130604A

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1 Introduction

At 06:54:26 UT, the *Swift* Burst Alert Telescope (BAT) triggered and located GRB 130604A (trigger=557354). *Swift* slewed immediately to the burst. The best *Swift* position is the enhanced, astrometrically corrected X-ray position reported in Goad *et al.*, *GCN Circ.* 14763.

2 BAT Observation and Analysis

Using the data set from $T - 240$ to $T + 962$ s further analysis of BAT GRB 130604A has been performed by *Swift* team (Barthelmy , *et al.*, *GCN Circ.* 14779). The BAT ground-calculated position is RA(J2000) = 250.166 deg ($16^h\ 40^m\ 39.9^s$), Dec(J2000) = +68.225 deg (+68° 13′ 28.4″) ± 1.1 arcmin, (radius, sys+stat, 90% containment). The partial coding was 81%.

The mask-weighted light curve (Fig.1) shows a FRED-like peak starting at $\sim T - 1$ s, peaking at $\sim T + 10$ s, and ending at $\sim T + 90$ s. T_{90} (15-350 keV) is 37.7 ± 4.6 s (estimated error including systematics).

The time-averaged spectrum from $T - 0.44$ to $T + 43.58$ s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.51 ± 0.12. The fluence in the 15-150 keV band is $1.4 \pm 0.1 \times 10^{-6}\ ergs/cm^2$. The 1-sec peak photon flux measured from $T + 14.39$ s in the 15-150 keV band is $0.8 \pm 0.2\ ph/cm^2/sec$. All the quoted errors are at the 90% confidence level.

3 XRT Observation and Analysis

We have analysed 5.7 ks of XRT data for GRB 130604A (Melandri, *et al.*, *GCN Circ.* 14752), from 105 s to 21.8 ks after the BAT trigger. The data comprise 146 s in Windowed Timing (WT) mode with the remainder in Photon Counting (PC) mode. The enhanced, astrometrically corrected X-ray position (Goad *et al.*, *GCN Circ.* 14763) for this burst is RA, Dec (J2000) = 250.188, +68.226 which is equivalent to:

RA (J2000) = $16^h\ 40^m\ 45.18^s$
Dec(J2000) = +68° 13′ 35.4″

with an uncertainty of 2.1 arcsec (radius, 90% confidence).

The light curve can be modelled with a broken power-law decay (Fig.2) with a initial decay index of $\alpha_1 = 2.06 \pm 0.09$, followed by a break at $t_b = 5.2^{+3.1}_{-0.9} \times 10^3$ s and a final decay index $\alpha_2 = 0.3^{+0.5}_{-1.3}$.

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of $2.10^{+0.13}_{-0.12}$. The best-fitting absorption column is $(2.8 \pm 0.4) \times 10^{21}\ cm^{-2}$, in excess of the Galactic value of $4.7 \times 10^{20}\ cm^{-2}$ (Kalberla et al. 2005). The PC mode spectrum has a photon index of 2.1 ± 0.3 and a best-fitting absorption column of $2.2^{+1.0}_{-0.9} \times 10^{21}\ cm^{-2}$. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 3.8×10^{-11} (5.9×10^{-11}) erg cm^{-2} count^{-1}.

4 UVOT Observation and Analysis

The UVOT began settled observations of the field of GRB 130604A $\sim$109 s after the BAT trigger (Melandri, *et al.*, *GCN Circ.* 14752). No optical afterglow consistent with the optical position (Perley, *et al.*, *GCN Circ.* 14753) is detected in the initial UVOT exposures. Preliminary 3-σ upper limits using the UVOT photometric system (Breeveld et al. 2011, AIP Conf. Proc. 1358, 373) for the first finding chart (FC) exposure and subsequent exposures are:

Filter	T_{start} (s)	T_{stop} (s)	Exp (s)	Mag
white$_{FC}$	109	258	147	>20.4
white	109	17767	1345	>21.8
v	5004	11999	1055	>20.3
b	4388	16933	1278	>21.5
u	267	5818	378	>20.0
w1	5414	5613	197	>20.0
m2	5208	5408	197	>19.7
w2	4798	11112	1082	>21.3

Table 1: 3σ upper limits from UVOT observations (Breeveld & Melandri, *GCN Circ.* 14768). The values quoted above are not corrected for the Galactic extinction due to the reddening of $E_{(B-V)} = 0.03$ in the direction of the burst (Schlegel et al. 1998).
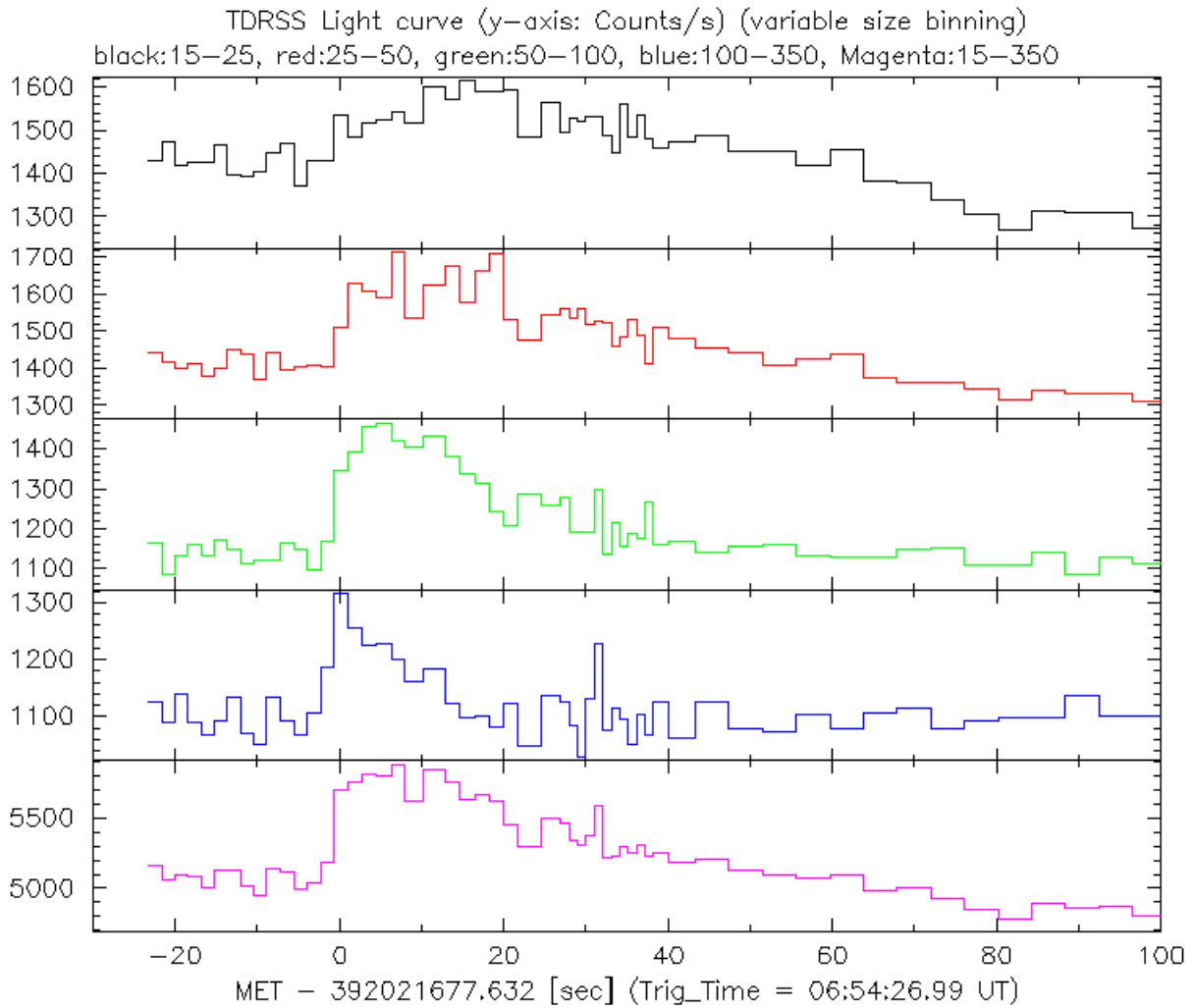
Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands (15 - 25, 25 - 50, 50 - 100, 100 - 350 and 15 - 350 keV).

Figure 2: XRT Lightcurve. It can be modelled by a broken power-law.