

Swift Observation of GRB 120804A

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1 Introduction

BAT triggered on GRB 120804A at 00:54:14 UT (Trigger 529686) (Lien, *et al.*, *GCN Circ.* 13573). This was a 0.064sec rate-trigger on a short length burst with $T_{90} = 0.81$ sec. Swift slewed to this burst immediately and XRT began follow-up observations at $T + 93.6$ sec, and UVOT at $T + 96$ sec with the White filter. Our best position is the XRT location

RA($J2000$) = 15h 35m 47.55s,

Dec($J2000$) = $-28^{\circ} 46' 56.9''$

with an uncertainty of 1.8 arcsec (radius, 90% confidence).

X-ray afterglows were also detected by Chandra (Troja, *et al.*, *GCN Circ.* 13640) 9.4 days after the BAT trigger and XMM-Newton (Margutti, *et al.*, *GCN Circ.* 13715) 18.8 days after the trigger. Additionally, a radio source was detected within the Swift-XRT error circle (Osborne, *et al.*, *GCN Circ.* 13577) 0.93 day after the trigger with the EVLA at 5.8 GHz (Fong *et al.*, *GCN Circ.* 13587).

Berger *et al.* (2012) reported a possible host galaxy that has a photometric redshift $z \sim 1.3$ within the Swift-XRT error circle (Osborne, *et al.*, *GCN Circ.* 13577). These authors also found a fading optical source in the galaxy with $m_i = 26.2$ and consider this be the optical afterglow of GRB120804A.

2 BAT Observation and Analysis

Using the data set from T-240 to T+962 sec from recent telemetry downlinks, we report further analysis of BAT GRB 120804A (trigger 529686) (Lien, *et al.*, *GCN Circ.* 13573). The BAT ground-calculated position is RA, Dec = 233.951, -28.768 deg, which is

RA($J2000$) = 15h 35m 48.1s

Dec($J2000$) = $-28^{\circ} 46' 06.1''$

with an uncertainty of 1.0 arcmin, (radius, sys+stat, 90% containment). The partial coding was 24%.

The mask-weighted light curve shows two overlapping peaks starting at T-0.2 sec, peaking at T+0.1 and T+0.5 sec, and ending at T+1.0 sec. T_{90} (15-350 keV) is 0.81 ± 0.08 sec (estimated error including systematics).

The time-averaged spectrum from T-0.16 to T+0.83 sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.34 ± 0.08 . The fluence in the 15-150 keV band is $8.8 \pm 0.5 \times 10^{-7}$ erg cm^{-2} . The 1-sec peak photon flux measured from T-0.16 sec in the 15-150 keV band is 10.8 ± 0.6 ph/cm²/sec. All the quoted errors are at the 90% confidence level.

To derive the broad-band parameters of this burst, joint spectral analysis of the Swift/BAT and Konus-Wind 3-channel data (obtained in the waiting mode from the detector S1) was performed, which covers the energy range from 24 keV to 1.4 MeV (Sakamoto & Pal'shin, *et al.*, *GCN Circ.* 13614).

The time intervals of the spectral data are chosen for the Konus-Wind from T0(BAT)-0.916 s to T0(BAT)+2.028 s (single KW bin which comprises the burst) and for the Swift/BAT from T0(BAT)-0.16 s to T0(BAT)+0.83 s (that is the BAT T100 interval), where T0(BAT) is the trigger time of BAT at 00:54:14.18 UTC. The energy ranges which we used in the joint spectral analysis are 24-1400 keV and 14-150 keV for the Konus-Wind and the Swift/BAT respectively. The spectral data of the two

instruments are fitted with the spectral model multiplied by a constant factor to take into account the systematic effective area uncertainties in the response matrices of each instrument and the difference in the chosen intervals.

The spectrum is well fitted with a power-law with exponential cutoff model: $dN/dE \sim E^\alpha \times \exp(-(2 + \alpha) \times E/E_{\text{peak}})$. No systematic residual from the best fit model is seen in the spectral data of each instrument. The best fit spectral parameters are: $\alpha = -0.89$ ($-0.28, +0.24$) and $E_{\text{peak}} = 135$ ($-29, +66$) keV ($\chi^2/\text{dof} = 56/58$).

The energy fluence and 16-ms peak flux in the 15-1000 keV band are 1.45 ($-0.31, +0.30$) $\times 10^{-6}$ erg cm^{-2} and $(6.0 \pm 2.7) \times 10^{-6}$ erg $\text{cm}^{-2} \text{ s}^{-1}$ respectively.

3 XRT Observations and Analysis

Using 797 s of XRT Photon Counting mode data and 1 UVOT images for GRB 120804A, we find an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue):

RA (J2000): 15h 35m 47.55s

Dec (J2000): -28d 46' 56.9"

with an uncertainty of 1.8 arcsec (radius, 90% confidence).

The light curve (Fig.2) can be modelled with a power-law decay with a decay index of $\alpha=1.11(\pm 0.03)$.

A spectrum formed from the PC mode data can be fitted with an absorbed power-law with a photon spectral index of 1.98 ($+0.21, -0.20$). The best-fitting absorption column is 3.5 ($+0.9, -0.8$) $\times 10^{21} \text{ cm}^{-2}$, in excess of the Galactic value of $9.3 \times 10^{20} \text{ cm}^{-2}$ (Kalberla et al. 2005). The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 4.3×10^{-11} (7.0×10^{-11}) erg $\text{cm}^{-2} \text{ count}^{-1}$.

A summary of the PC-mode spectrum is thus:

Total column: $3.5(+0.9, -0.8) \times 10^{21} \text{ cm}^{-2}$

Galactic foreground: $9.3 \times 10^{20} \text{ cm}^{-2}$

Excess significance: 5.3 sigma

Photon index: 1.98 ($+0.21, -0.20$)

4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB 120804A 97 s after the BAT trigger (Lien, *et al.*, *GCN Circ.* 13573). No optical afterglow consistent with the XRT position (Osborne, *et al.*, *GCN Circ.* 13577) is detected in the initial UVOT exposures.

Preliminary 3-sigma upper limits using the UVOT photometric system (Breeveld et al. 2011, AIP Conf. Proc. 1358, 373) for the first finding chart (FC) exposures and subsequent exposures are given in Table 1.

The magnitudes in the table are not corrected for the Galactic extinction due to the reddening of $E(B-V) = 0.23$ in the direction of the burst (Schlegel et al. 1998).

Filter	Start	Stop	Exposure	Mag
white_FC	97	247	147	>21.4
u_FC	310	560	246	>20.7
white	97	5665	453	>22.0
v	640	6077	432	>20.6
b	566	6706	243	>20.9
u	310	6692	659	>21.3
w1	689	6487	413	>20.3
m2	4646	6282	393	>21.3
w2	4237	5872	393	>21.0

Table 1: Upper limits from UVOT observations

References

- [1] Berger, E., Zauderer, B. A., Levan, A., et al. 2012, arXiv:1209.5423
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- [8] X Schlegel, D. J., et al., 1998, ApJS, 500, 525
- [9] Troja et al., 2012, GCN Circ. 13640
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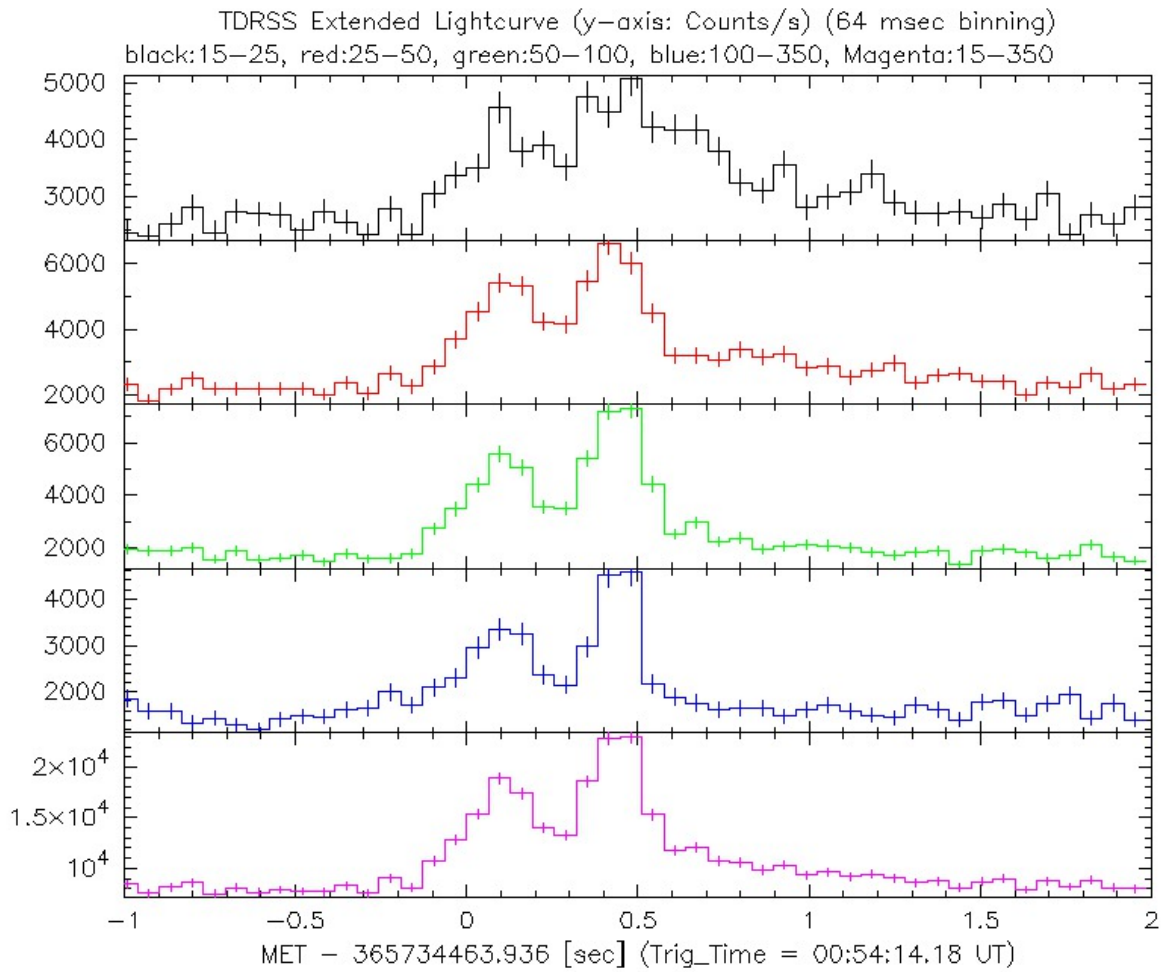


Figure 1: The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/sec/illuminated-detector and T_0 is 00:54:14 UT.

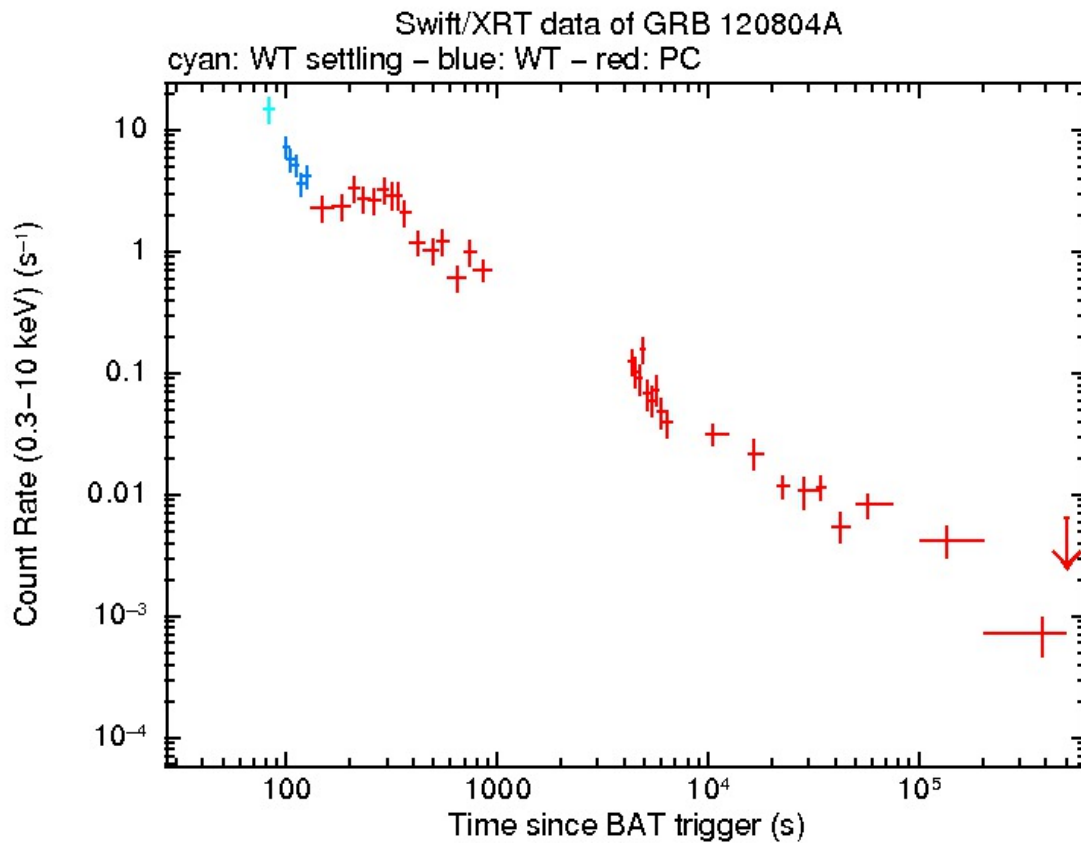


Figure 2: XRT light curve. Counts/sec in the 0.3–10 keV band: Window Timing settling mode (cyan), Window Timing mode (blue), Photon Counting mode (red). The counts to observed (unabsorbed) flux conversion is 4.3×10^{-11} (7.0×10^{-11}) $\text{erg cm}^{-2} \text{ count}^{-1}$.