Swift Observation of GRB 120116A

A. Melandri (INAF-OAB), D. M. Palmer (LANL), N. P. M. Kuin (MSSL-UCL), M. H. Siegel (PSU), D. N. Burrows (PSU) and N. Gehrels (GSFC), for the Swift Team

1 Introduction

At 18:06:28 UT, the *Swift* Burst Alert Telescope (BAT) triggered and located GRB 120116A (Trigger = 511866; Melandri, *et al.*, *GCN Circ.* 12834). *Swift* slewed immediately to the burst. The BAT on-board calculated location is RA, Dec = (16.248, +33.929) deg, which is

RA(J2000) = $01^h\ 05^m\ 00^s$
Dec(J2000) = $+33^\circ\ 55'\ 44''$

with an uncertainty of 3 arcmin (radius, 90% containment, including systematic uncertainty). The BAT light curve shows at least two precursor peaks followed by a complex FRED peak with a total duration of at least 50 s. The peak count rate was ~ 4000 counts s^{-1} (15-350 keV), at ~ 1 s after the trigger.

The XRT began observing the field at 18:07:42.5 UT, $T+74.4$ s after the BAT trigger. Using promptly downlinked data we find a bright, uncatalogued X-ray source located at RA, Dec = (16.241, 33.930) deg, which is equivalent to:

RA (J2000) = $01^h\ 04^m\ 58.04^s$
Dec (J2000) = $+33^\circ\ 55'\ 49.2''$

with an uncertainty of $4.0''$ (radius, 90% containment). This location is $19''$ from the BAT onboard position, within the BAT error circle.

UVOT took a finding chart exposure of 150 s with the White filter starting $T + 83$ s after the BAT trigger. No credible afterglow candidate has been found in the initial data products. The $2.7' \times 2.7'$ sub-image covers 100% of the XRT error circle. The typical 3σ upper limit has been about 19.6 mag. The $8' \times 8'$ region for the list of sources generated on-board covers 100% of the XRT error circle. The list of sources is typically complete to about 18 mag. No correction has been made for the expected extinction corresponding to $E_{(B-V)}$ of 0.05.

2 BAT Observation and Analysis

Using the data set from $T-61$ to $T+242$ s further analysis of BAT GRB 120116A has been performed by *Swift* team (Palmer, *et al.*, *GCN Circ.* 12839). The BAT ground-calculated position is RA(J2000) = 16.240 deg ($01^h\ 04^m\ 57.7^s$), Dec(J2000) = +33.927 deg ($+33^\circ\ 55'\ 36.3'' \pm 1.0'$ (radius, sys+stat, 90% containment). The partial coding was 85%.

The mask-weighted light curve (Fig.1) shows a couple of small precursor peaks starting at $\sim T-30$ s. The main peak has a fast rise starting around $T-2$ s, peaking at $\sim T+0$ s, and a roughly linear decay ending around $T+30$ s. T_{90}(15-350 keV) is 41.0 ± 5.0 s (estimated error including systematics).

The time-averaged spectrum from $T-33.44$ to $T+26.57$ s is best fit by a power law with an exponential cutoff. This fit gives a photon index 1.31 ± 0.41, and E_{peak} of 19.4 ± 6.3 keV (chi squared 55.4 for 56 d.o.f.). For this model the total fluence in the 15-150 keV band is $(2.9 \pm 0.1) \times 10^{-6}$ $ergs/cm^2$ and the 1-sec peak flux measured from $T + 0.00$ s in the 15-150 keV band is 4.1 ± 0.3 $ph/cm^2/sec$. A fit to a simple power law gives a photon index of 2.70 ± 0.07 (chi squared 101.2 for 57 d.o.f.). All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

We have analysed 11.5 ks of XRT data for GRB 120116A (Melandri, *et al.*, *GCN Circ.* 12834), from 64 s to 144.5 ks after the BAT trigger. The data comprise 92 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 Goad, *et al.*, *GCN Circ.* 12846. The astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue) is RA, Dec = 16.24134, +33.93057 which is equivalent to:

RA (J2000) = $01^h\ 04^m\ 57.92^s$
Dec (J2000) = $+33^\circ\ 55'\ 50.0''$

with an uncertainty of $1.7''$ (radius, 90% containment) (Goad, *et al.*, *GCN Circ.* 12846).

The light curve (Fig.2) can be modelled with a series of power-law decays. The initial decay index is $\alpha_1 = 3.9^{+0.9}_{-0.8}$. Centred at $T + 114$ s there is a small flare. The light curve breaks again at $T + 205$ s to a decay with $\alpha_2 = 0.42^{+0.09}_{-0.07}$, before a final break at $T + 8394$ s after which the decay index is $\alpha_3 = 1.24^{+0.69}_{-0.24}$.

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of $2.93^{+0.33}_{-0.28}$. The best-fitting absorption column is $(2.5 \pm 0.6) \times 10^{21}\ cm^{-2}$, in excess of the Galactic value of $4.6 \times 10^{20}\ cm^{-2}$ (Kalberla et al. 2005). The PC mode spectrum has a photon index of $2.19^{+0.19}_{-0.18}$ and a best-fitting absorption column of $(1.9 \pm 0.5) \times 10^{21}\ cm^{-2}$. The counts to observed (unabsorbed) $0.3 - 10\ keV$ flux conversion factor deduced from this spectrum is $3.5 \times 10^{-11} (5.5 \times 10^{-11})\ erg\ cm^{-2}\ count^{-1}$.

4 UVOT Observation and Analysis

The *Swift*/UVOT began settled observations of the field of GRB 120116A $T + 83$ s after the BAT trigger (Melandri, *et al.*, *GCN Circ.* 12834). No optical afterglow consistent with the enhanced XRT position (Goad, *et al.*, *GCN Circ.* 12846) is detected in the initial UVOT exposures. Preliminary 3σ 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	Start	Stop	Exposure	3σ UL
white_{FC}	83	233	147	> 21.0
u_{FC}	296	546	246	> 20.1
white	83	919	192	> 21.1
v	4479	4679	197	> 19.1
u	296	5173	324	> 20.4
w1	4889	5089	197	> 20.2
m2	4684	4884	197	> 19.8
w2	4274	4474	197	> 20.5

Table 1: 3σ upper limits from UVOT observations. The values quoted above are not corrected for the Galactic extinction due to the reddening of $E_{(B-V)} = 0.05$ in the direction of the burst (Schlegel et al. 1998)

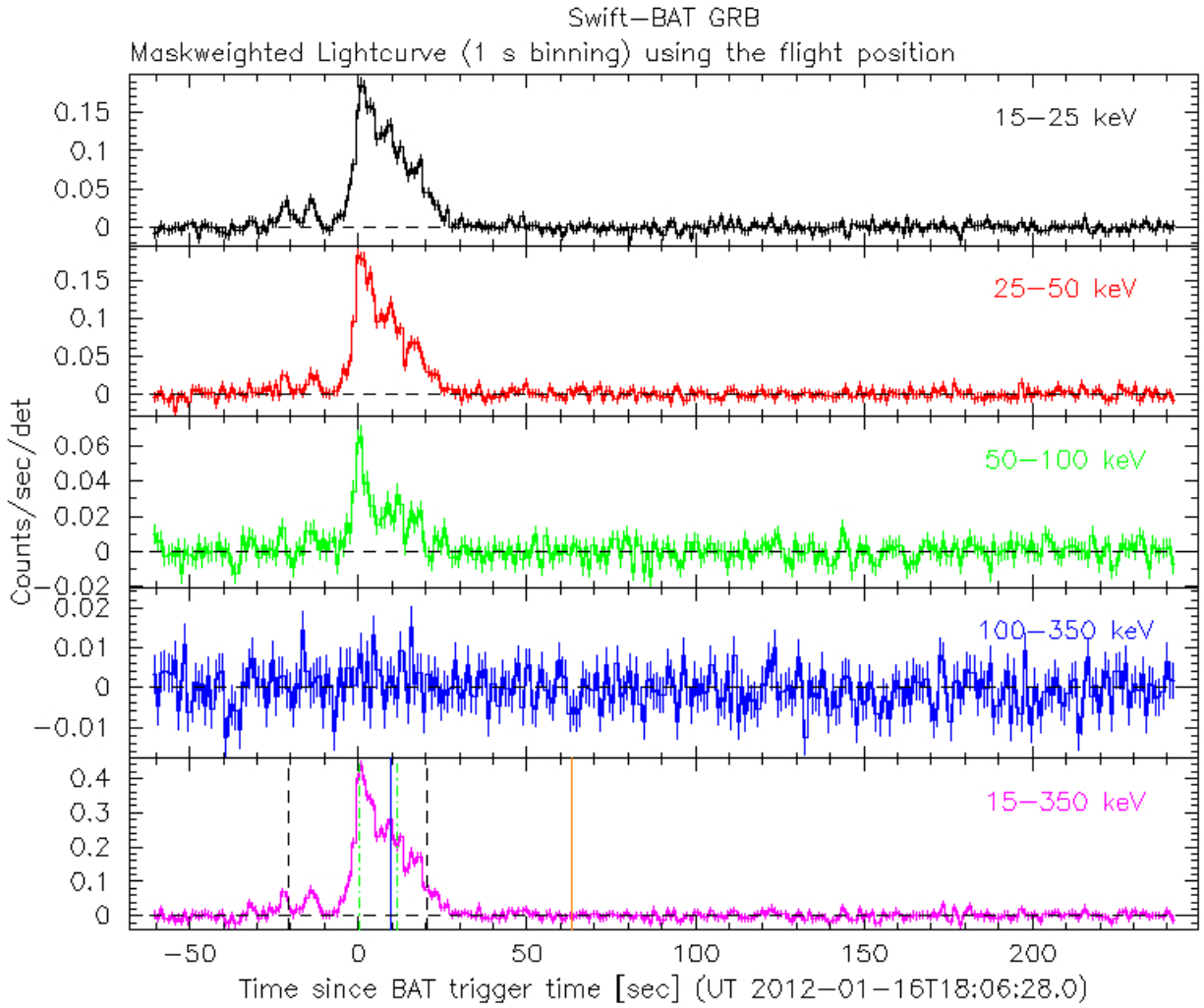

Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands (15 - 25, 25 - 50, 50 - 100, 100 - 350 and 15 - 350 keV).

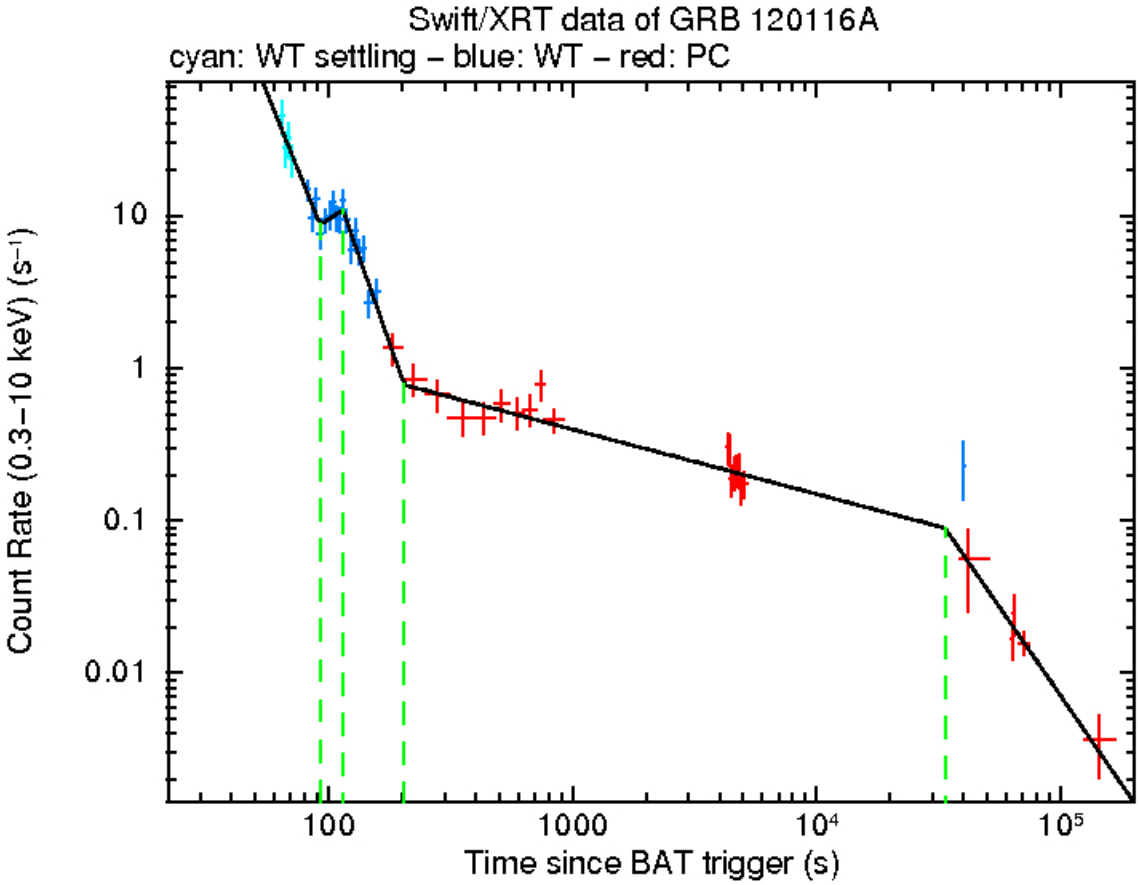

Figure 2: XRT Lightcurve. It can be modelled by a series of power-laws. Data are from WT mode (blue, slewing data in cyan) and PC mode (red); green vertical lines mark the times where the power-law decay changes.