Swift Observations of GRB 110715A

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1 Introduction

BAT triggered on GRB 110715A on 2011 July 15 at 13:13:50.0 UT (Trigger 457330) (Sonbas, *et al.*, 2011, *GCN Circ.* 12158). This was a bright double peaked burst with $T_{90} = 13.0 \pm 4$ *sec*. The BAT light curve showed a double-peaked structure with a duration of ∼15 sec. Swift slewed to this burst immediately and XRT began follow-up observations at $T + 90.9$ *sec*, and UVOT at $T + 99.0$ *sec*.

UVOT took a finding chart exposure of 150 seconds with white filter and found an afterglow candidate with ∼ 17.37 mag at

RA(J2000) = 15h 50m 44.09 s
DEC(J2000) = -46d 14′ 06.53″

with an estimated uncertainty of 0.56 arc sec.

GRB 110715A was also detected by INTEGRAL/SPI-ACS with the two brightest peaks at T+2 s an T+4 s (Beckmann, priv. comm.). Konus-Wind triggered the burst (Golonetskii et al. 2011) at 13:13:55.304 UT. Their light curve showed a bright pulse at T+2 s and a weaker pulse at T+11 s with a total duration of ∼20 s. Their time integrated spectrum was best fitted by Band model with α = -1.23 (-0.08, +0.09), β = -2.7 (-0.5, +0.2) and E_{peak}=120 (-11, +12) keV. Suzaku/WAM also observed the prompt emission of GRB 110715A (Ohmori et al. 2011). Their light curve showed a multi-peaked structure between T+0 s , T+4 s and a weaker emission at T+20 s within 8 seconds duration. Their preliminary spectrum was fitted well by a single power law model with α = 2.67 (-0.18, +0.19)

Spectroscopic observations of the GRB 110715A afterglow were also performed with the ESO VLT, X - Shooter spectrograph. They measured a redshift z=0.82 from CaII and CaI absorption lines (Piranomonte et al. 2011). de Ugarte Postigo et al. (2011) observed the burst using LABOCA/APEX in the 870 micrometer band. They detected a 11.0 ± 2.3 mjy flux at the position of afterglow. GRB 110715A was also observed simultaneously in g′r′i′z′JHK bands with GROND (Updike et al. 2011, Greiner et. al. 2008), and the AAVSO International High Energy Network observed in the optical band using the R filter (Nelson et al. 2011). A single unresolved radio source with 2.4 ± 0.1 mJy/beam flux at 44.00 GHz was found, consistent with UVOT position, with the observations of the Australian Telescope Compact Array (ATCA, Hancock et al. 2011).

Xu et al. (2011) determined spectral lags with Swift/BAT light curves binned at 64 ms using the CCF method. They found lags of 0.04 ± 0.01 s (1 σ) for 15-25 keV vs 25-50 keV and 0.04 ± 0.01 (1 σ) for 50-75 vs 75-350 keV. These results showed that GRB 110715A consistent with Liso - Lag relation for long GRBs.

2 BAT Observation and Analysis

Using the data set from $T - 60.0$ to $T + 963.0$ *sec*, further analysis of BAT GRB 110715A has been performed by Swift team (Ukwatta, *et al.*, *GCN Circ.* 12160). The BAT ground-calculated position is RA($J2000$) = 237.665° (15h50m39.7s), Dec(J2000) = -46.237° (-46d14′13.9″) ± 1.0 $arcmin$, (radius, systematic and statistical, 90% containment). The partial coding was 69%.

The mask-weighted light curve shows a bright first peak (Fig.1), which is composed of at least 2 overlapping peaks (at the lower energies), starting at ∼ $T - 10$ sec and peaking at ∼ T+2.5 sec. The

first peak never returns to basline before the second and much weaker peak goes from ∼ T+12 to T+17 sec. T_{90} (15-350 keV) is 13.0± 4.0 sec (estimated error including systematics).

The time-averaged spectrum from $T-3.1$ to $T+20.9$ sec is best fit by a power law with an exponential cutoff. This fit gives a photon index 1.25 ± 0.12, and Epeak of 120 ± 21 keV ($\chi^2 = 49.6$ for 56 d.o.f.). For this model the total fluence in the 15-150 keV band is $1.18 \pm 0.02 \times 10^{-5} erg\ cm^{-2}$ and the 1-sec peak flux measured from T+1.86 sec in the 15-150 keV band is $53.9 \pm 1.1\ ph\ cm^{-2}\ sec^{-1}$. To within the calibration limits, the Band model fits equally well. A fit to a simple power law gives a photon index of 1.63 ± 0.03 (χ^2 81.5 for 57 d.o.f.). All the quoted errors are at the 90% confidence level.

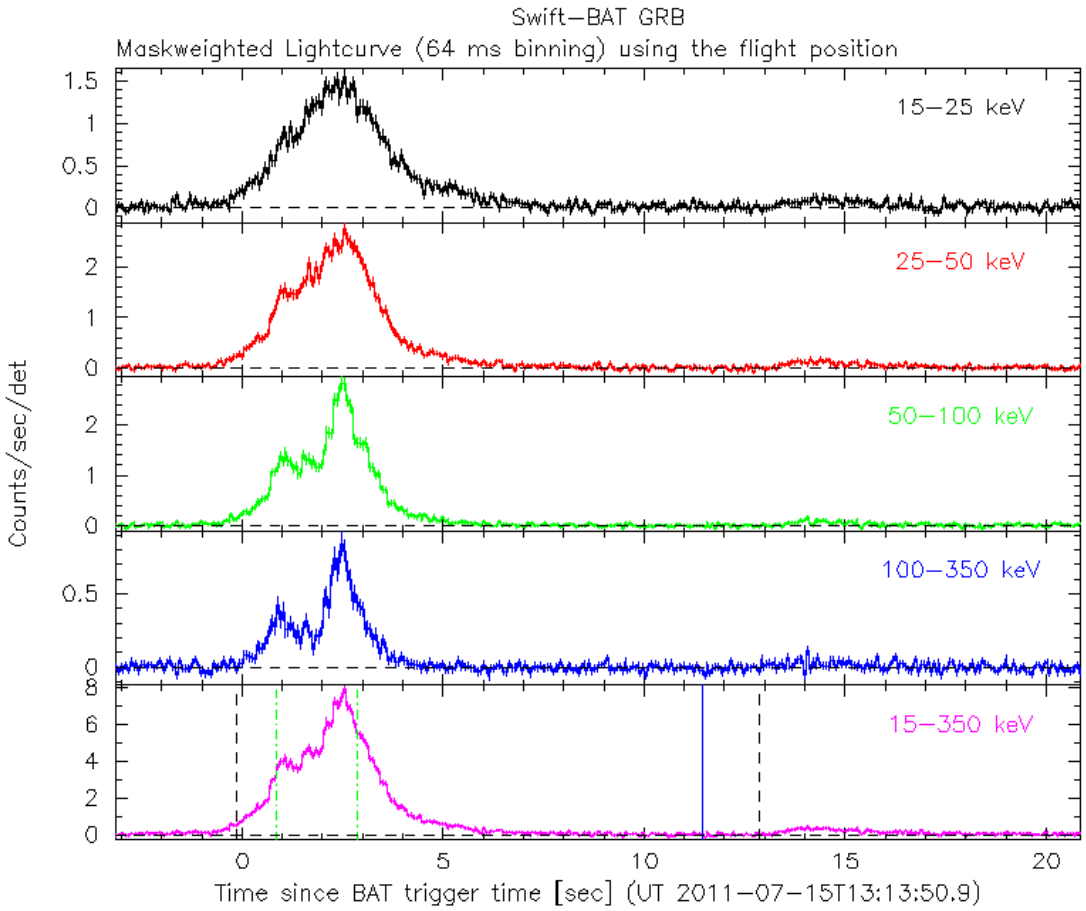

Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts $\sec^{-1}$illuminated-detector^{-1} and T_0 is 13:13:50.9 UT.

3 XRT Observations and Analysis

Over 59.11 ks of PC data were collected in total, as well as 400 s in Windowed Timing (WT) mode (the first 10 s were taken while Swift was slewing). The XRT data of GRB 110715A run from 79 s to 8.5×10^5 s after the BAT trigger. The data comprise 400 s in Windowed Timing (WT) mode (the first 10 s were taken while Swift was slewing) with the remainder in Photon Counting (PC) mode (Evans et al. 2011). The enhanced XRT position is RA($J2000$) = $15h50m44.0s$, Dec(J2000) = -46d14′07.5″) ±1.4 $arcsec$ (90% confidence).

The $0.3 - 10$ keV light curve (Fig.2) can be modelled with an initial power-law decay with an index of $\alpha = 0.57(\pm 0.05)$, followed by a break at T+2415 s to an $\alpha = 1.78(\pm 0.13)$.

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of $1.91(\pm 0.07)$. The best-fitting absorption column is $4.7(+0.4, -0.3) \times 10^{21} cm^{-2}$, in excess of the Galactic value of $2.9 \times 10^{21} cm^{-2}$ (Kalberla et al. 2005). The PC mode spectrum has a photon index of 1.85 (± 0.13) and a best-fitting absorption column of 6.0 (± 0.8) $\times 10^{21} cm^{-2}$. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is $5.3 \times 10^{-11} (8.7 \times 10^{-11}) erg\ cm^{-2}\ count^{-1}$.

A summary of the PC-mode spectrum is thus:
Total column: 6.0 (± 0.8) $\times 10^{21} cm^{-2}$
Galactic foreground: $2.9 \times 10^{21} cm^{-2}$
Excess significance: 12.6 σ
Photon index: 1.85 ($\pm$ 0.13)

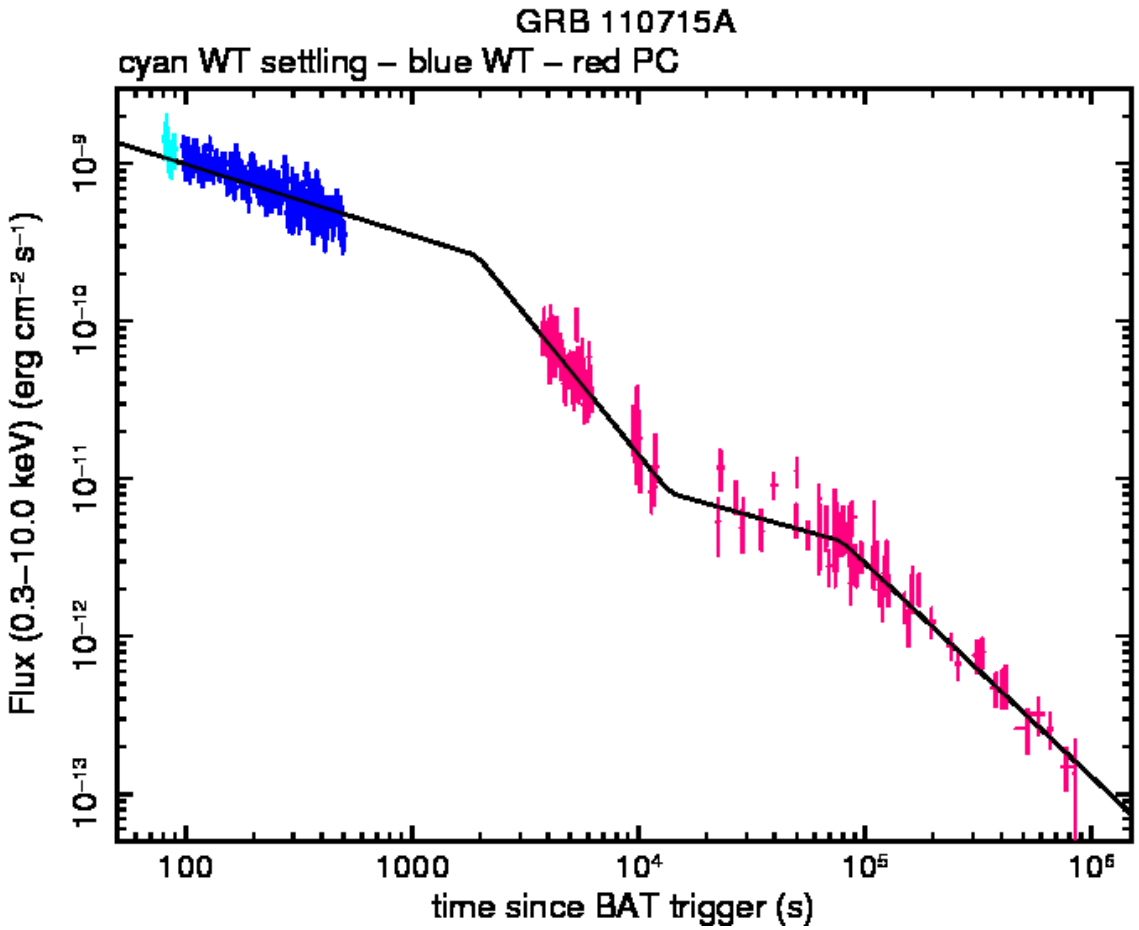

Figure 2: XRT Lightcurve. Counts/sec in the 0.3-10 keV band: Window Timing mode (blue), Photon Counting mode (red). The conversion factor for this burst is 1 count $= 5.3 \times 10^{-11}$ $erg\ cm^{-2}$.

4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB 110715A 100 s after the BAT trigger (Sonbas *et al.*, *GCN Circ.* 12158).

Detections and 3-σ upper limits using the UVOT photometric system (Poole et al. 2008, MNRAS, 383, 627) for the early exposures are reported in Tab.1 (Kuin et al. 2011). The UVOT light curve is shown in Fig.3. The light curve for white filter was extracted after subtracting all background sources that appear in the background region of the summed white image.

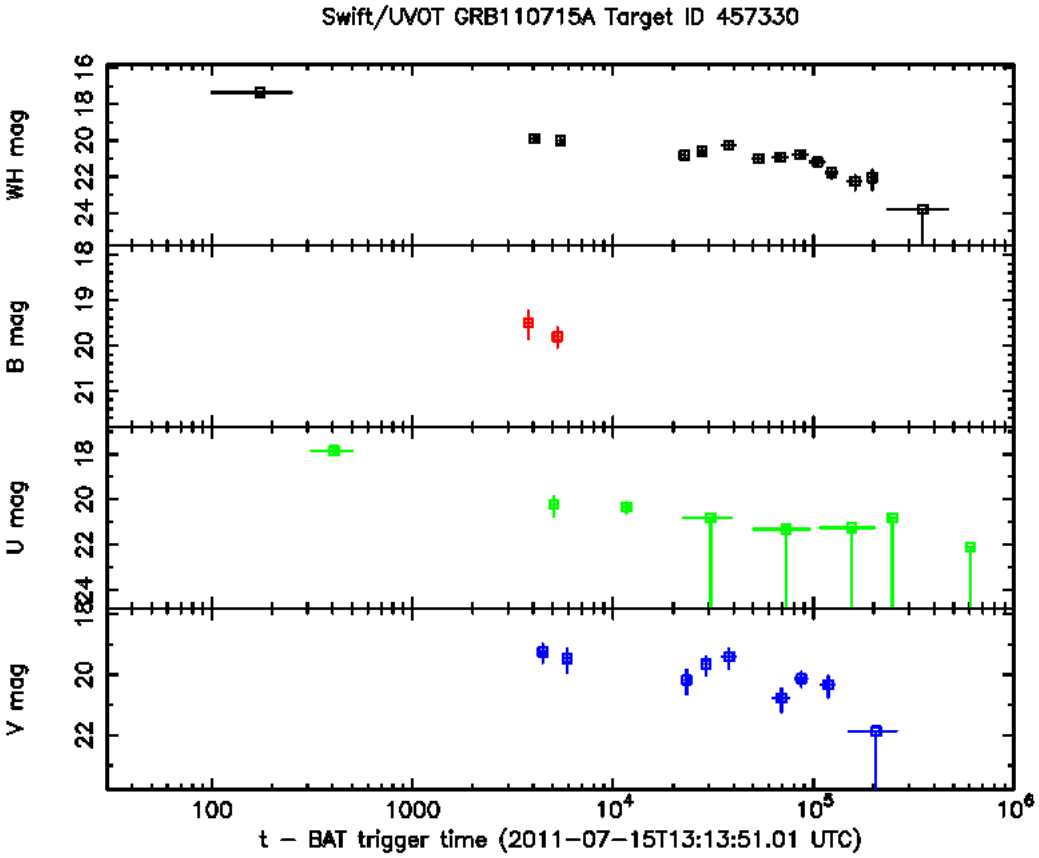

Figure 3: UVOT light curves

References

[1] Beckmann priv. comm.

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[15] Updike, A. C. et al. 2011, GCN Circ. 12169

[16] Xu, D. et al. 2011, GCN Circ. 12185

Filter	T_{Start}	T_{Stop}	Exposure (s)	Mag.
WHITE	100	249	147	17.37 ± 0.06
U	312	501	187	17.86 ± 0.09
B	3734	3857	121	19.5 ±0.3
WHITE	3960	4160	197	19.92 ± 0.16
UVW2	4166	4366	197	> 20.1
V	4371	4571	197	19.3 ± 0.3
UVM2	4576	6211	393	> 20.3
UVW1	4781	6280	259	>20.1
U	4986	5186	197	20.1 ± 0.4
B	5192	5391	197	19.9 ± 0.2

Table 1: Magnitude limits from UVOT observations