Swift Observations of GRB 110420A

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1 Introduction

BAT triggered on GRB 110420A at 11:02:24 UT, (trigger 451757, Mangano *et al.*, *GCN Circ.* 11941). This was a 1.024 s rate-trigger on a long burst with $T_{90} = 11.8 \pm 0.9$ s. Swift slewed immediately to the burst and found an X-ray counterpart to the burst in XRT. XRT began follow up observations at $T + 77$ s, and UVOT observations began at $T + 97$ s.

Our best position is the UVOT refined position RA($J2000$) = 2.16363 *deg* ($00^h\ 08^m\ 39.27^s$) Dec($J2000$) = -37.88664 *deg* ($-37^d\ 53^{'}\ 11.9^{"}$) with an uncertainty of 0.5 arcsec (radius, 90% confidence, Oates *et al.*, *GCN Circ.* 11948).

GRB 110420A has been detected also by Konus Wind (Golenetskii *et al.*, *GCN Circ.* 11951) at 11:02:30.543 UT, with a light curve duration of ∼18 s and a a time-integrated spectrum well fitted (in the 20−500 keV range) by a power law with exponential cutoff model with Photon index alpha = $-1.71^{+0.31}_{-0.26}$, and peak energy Ep = 43^{+17}_{-18} keV.

GRB 110420A has also been seen by INTEGRAL/SPI-ACS, confirming the bright peak reported in Mangano *et al.*, *GCN Circ.* 11941 (Volker Beckmann, private communication).

The field of GRB 110420A has been observed and the source detected in the Optical/NIR with GROND mounted at the 2.2 m MPI/ESO telescope at La Silla Observatory (Chile) 22.5 hours after the GRB trigger (Afonso *et al.*, *GCN Circ.* 11954).

2 BAT Observation and Analysis

Using the data set from T−61 to T+242 s from telemetry downlinks, the refined analysis of BAT GRB 110420A was performed by the Swift team and reported in Krimm *et al.*, *GCN Circ.* 11945.

The BAT ground-calculated position is RA($J2000$) = 2.164 *deg* ($00^h\ 08^m\ 39.3^s$) Dec($J2000$) = -37.877 *deg* ($-37^d\ 52^m\ 35.5^s$) with an uncertainty of 1.0 arcmin, (radius, sys+stat, 90% containment). The partial coding was 15%.

The mask-weighted light curve (Fig.1) shows a single peak with some structure starting at ∼T−15 s, peaking at ∼T+8 s, and ending at ∼T+35 s. T_{90} (15−350 keV) is 11.8±0.9 s (estimated error including systematics).

The time-averaged spectrum from T−0.1 to T+16.0 s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 2.30±0.07. The fluence in the 15−150 keV band is $(5.9\pm0.2)\times10^{-6}$ erg cm^{-2}. The 1−sec peak photon flux measured from T+8.04 s in the 15−150 keV band is 14.0±0.9 ph cm^{-2} s^{-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/451757/BA/

3 XRT Observations and Analysis

The whole Swift-XRT dataset for GRB 110420A (trigger 451757, Mangano *et al.*, *GCN Circ.* 11941), consists of 137.8 ks of data from 77 s to 1677.8 ks after the BAT trigger. The data comprise 10 s in Windowed Timing (WT) mode taken while Swift was slewing (from T+77 to T+87 s), 57 s in Windowed Timing (WT) mode (from T+93 to T+150 s), with the remainder in Photon Counting (PC) mode (from T+153 s). Using the initial 1599 s of PC mode data and 2 UVOT images, we find an enhanced XRT position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA($J2000$), Dec($J2000$) = 2.16355, -37.88627 which is equivalent to RA($J2000$) = 00^h 08^m 39.25^s Dec($J2000$) = -37^d $53^{'}$ $10.6^{"}$ with an uncertainty of 1.5 arcsec (radius, 90% confidence, Osborne *et al.*, *GCN Circ.* 11526).

Preliminary refined analysis has been reported in Mangano *et al.*, *GCN Circ.* 11943. The 0.3−10 keV XRT light curve (Fig.2) can be modelled with a broken power-law with five breaks, with the following best fit parameters:
α_1=$3.973^{+0.2862}_{-0.2805}$, T$_{break1}$=T+$185^{+14}_{-10}$ s, α_2=$0.06528^{+0.1424}_{-0.2057}$, T$_{break2}$=T+$979^{+252}_{-207}$ s,
α_3=$0.7272^{+0.197}_{-0.09162}$, T$_{break3}$=T+$13995^{+2025}_{-4293}$ s, α_4=$1.493^{+0.171}_{-0.1617}$, T$_{break4}$=T+73113^{+32373}_{-21863} s,
α_5=$0.6325^{+0.1981}_{-0.1713}$, T$_{break5}$=T+$393550^{+84870}_{-74234}$ s, α_6=$2.517^{+0.7207}_{-0.4687}$.

A spectrum formed from the 57 s WT mode data can be fitted with an absorbed power-law with a photon spectral index of $4.2^{+0.5}_{-0.4}$. The best-fitting intrinsic absorption column is $1.9^{+0.6}_{-0.5} \times 10^{21}$ cm^{-2}, in excess of the Galactic value of 1.3×10^{20} cm^{-2} (Kalberla *et al.*, 2005). A spectrum formed from the initial 17.4 ks of PC mode data (from T+93 s to T+42.2 ks) can be fitted with an absorbed power-law with a photon spectral index of $2.053^{+0.080}_{-0.078}$. The best-fitting intrinsic absorption column is $1.35^{+0.21}_{-0.20} \times 10^{21}$ cm^{-2}. The counts to observed (unabsorbed) 0.3−10 keV flux conversion factor deduced from this spectrum is $3.6{\times}10^{-11}$ ($5.1{\times}10^{-11}$) erg cm^{-2} s^{-1}.

The results of the XRT-team automatic analysis are available at
http://www.swift.ac.uk/xrt_curves/00451757.

4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB 110420A approximately 97 s after the BAT detection (Mangano *et al.*, *GCN Circ.* 11941). A source is detected at the refined position of RA($J2000$) = 2.16363 *deg* (00^h 08^m 39.27^s) Dec($J2000$) = −37.88664 *deg* (-37^d $53^{'}$ $11.9^{"}$) with an estimated uncertainty of 0.5 arcsec (radius, 90% confidence).

This is consistent with the position of the X-ray afterglow (Osborne *et al.*, *GCN Circ.* 11526). The afterglow is detected in all filters providing a photometric redshift limit of z $\lesssim$ 1.6.

Preliminary magnitudes for the white, u, v, b, $uvw1$, $uvm2$ and $uvw2$ exposures are given in the following Table 1 where T_{start} and T_{stop} are the start and stop time of the observation (Oates *et al.*, *GCN Circ.* 11948).

The above magnitudes are not corrected for the Galactic extinction corresponding to a reddening of E(B-V) = 0.05 (Schlegel et al., 1998, ApJS, 500, 525). The photometry is on the UVOT photometric system described in Poole et al. (2008, MNRAS, 383, 627).

The final UVOT light curves normalized together are shown in figure 3.

Filter	T_{start}(s)	T_{stop}(s)	Exp(s)	Magnitude
white (FC)	97	247	147	17.81 ± 0.05
white	761	781	19	18.10 ± 0.17
u (FC)	309	559	246	17.46 ± 0.07
u	712	732	19	17.96 ± 0.36
v	811	831	19	18.20 ± 0.67
b	737	757	19	18.04 ± 0.28
uvw1	688	707	19	17.08 ± 0.24
uvm2	663	683	19	17.73 ± 0.41
uvw2	614	634	19	17.91 ± 0.35

Table 1: Magnitudes from UVOT observations. (FC) stands for Finding Chart.

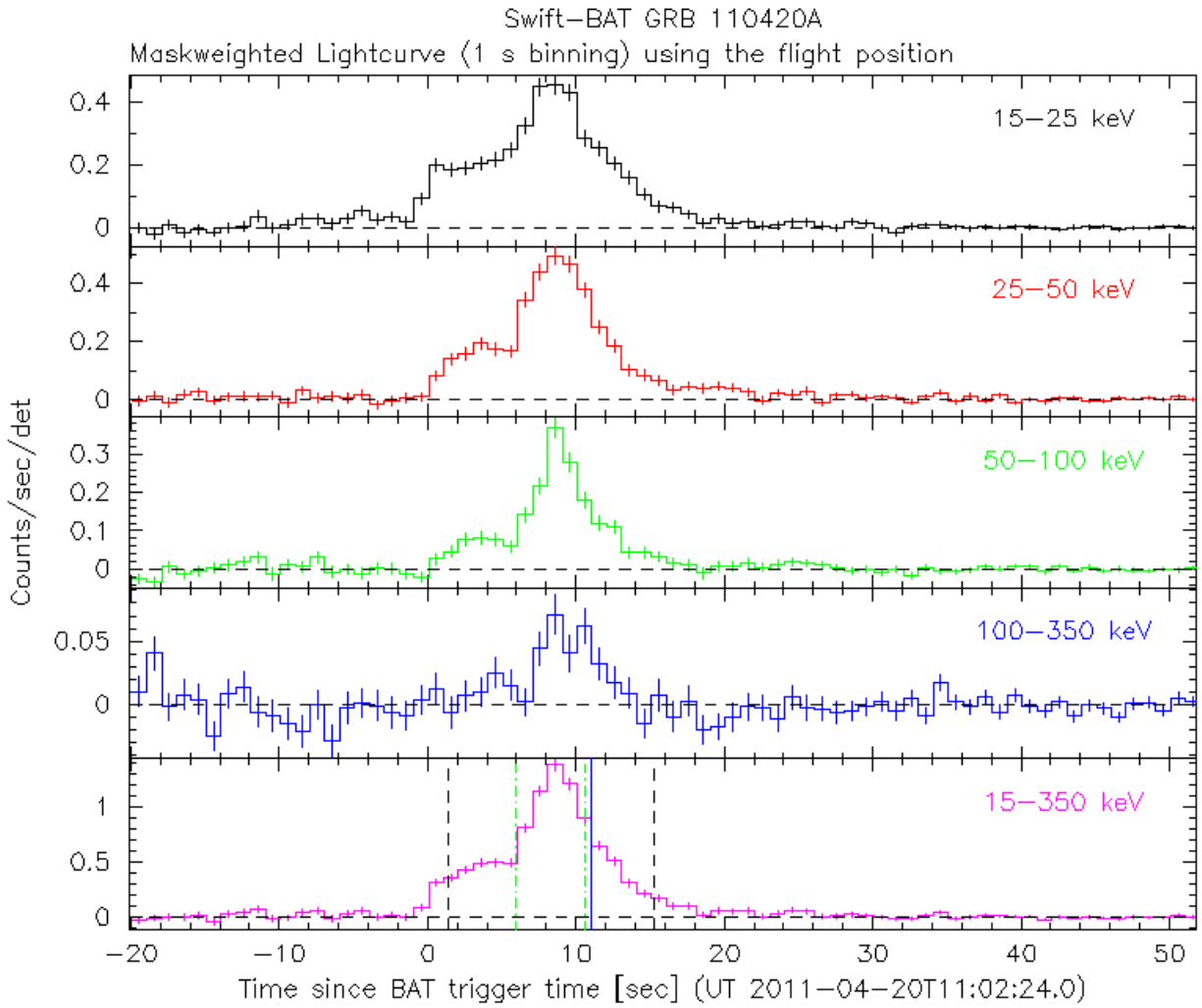

Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts s^{-1} illuminated-detector^{-1} (note illum-det = 0.16 cm^2) and T_0 is 2011 Apr 20 11:02:24 UT.

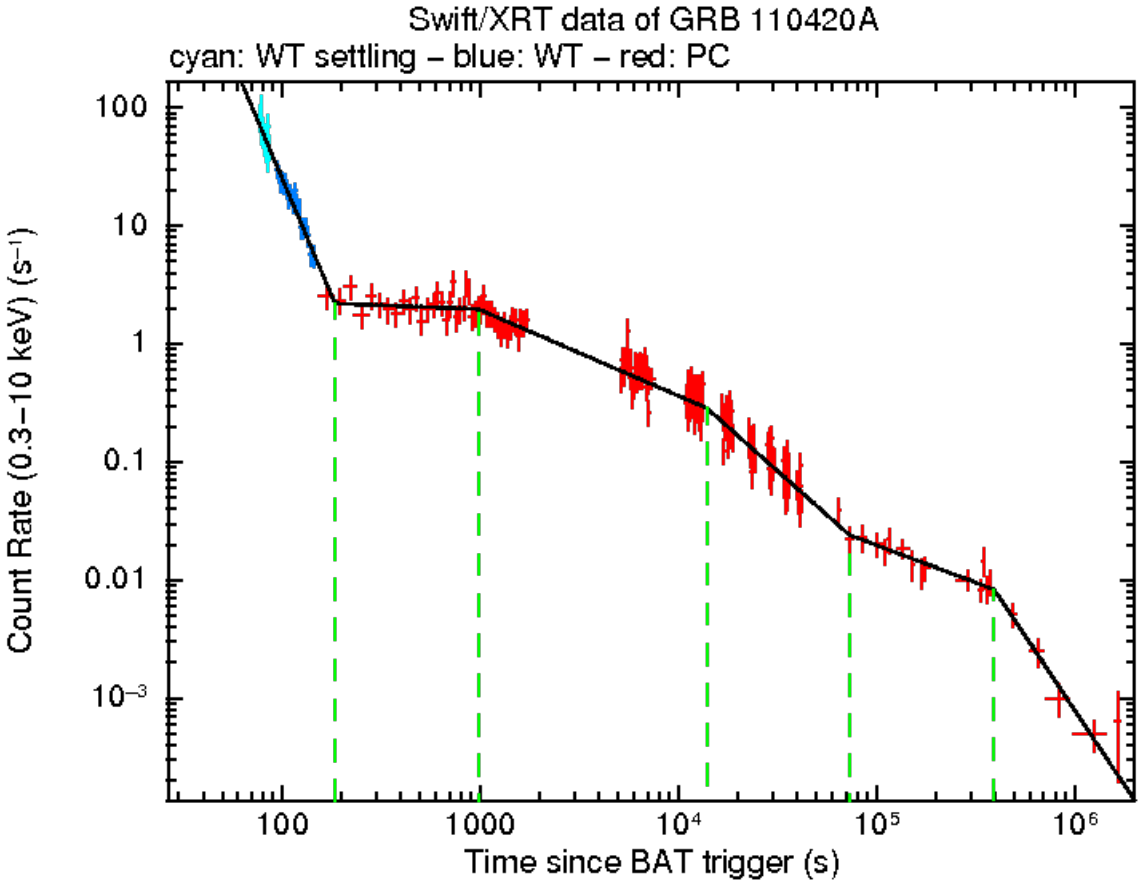

Figure 2: XRT Light curve. Counts/s in the 0.3−10 keV band: Windowed Timing mode (cyan for settling and blue for settled observation), and Photon Counting mode (red). The approximate conversion is 1 count/s = $\sim 5.1 \times 10^{-11}$ erg cm^{-2} s^{-1}.

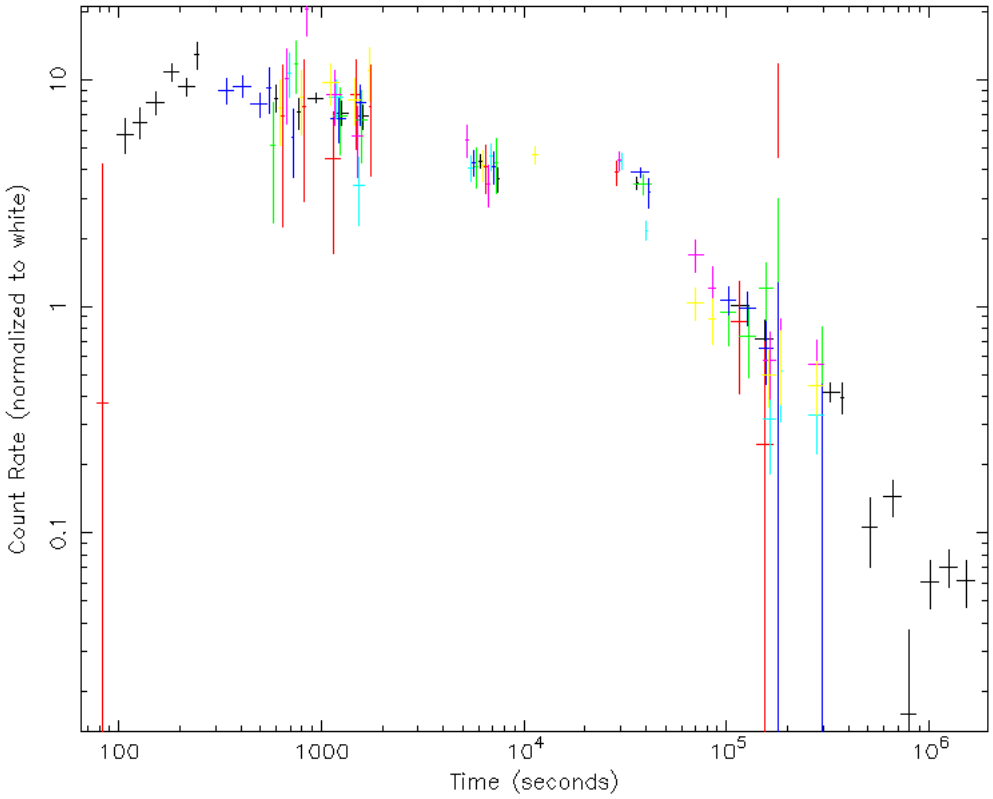

Figure 3: Final UVOT light curves normalized to v, each filter binned with Δt/t=0.2. Color coding: Black = *white*, Red = v, Green = b, Blue = u, Light Blue = $uvw1$, Magenta = $uvm2$ and Yellow = $uvw2$.