Swift Observations of GRB 111210A

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1 Introduction

At 14:37:03 UT on 10 December 2011, the Swift Burst Alert Telescope (BAT) triggered and located GRB 111210A (trigger=509419). Swift slewed immediately to the burst and identified an X-ray afterglow (Siegel et al., *GCN Circ.* 12650). Optical and infrared observations by UVOT, MITSuMe (Yanagisawa et al., *GCN Circ.* 12655, Kuroda et al., *GCN Circ.* 12659) and TNT (Xin et al., *GCN Circ.* 12665) did not detect the afterglow. However, deep observations by Gemini-North and GROND detected a potential host galaxy (Tanvir et al., *GCN Circ.* 12657, *GCN Circ.* 12661, Kann et al., *GCN Circ.* 12662)

The best *Swift* position for this burst is the enhanced XRT position given in Goad et al. (*GCN Circ.* 12652): RA, Dec (J2000) = 191.47674 (12h 45m 54.42s), -7.16604 (-7° $09^{'}$ $57.7^{''}$) with an uncertainty of $1.9^{''}$.

2 BAT Observation and Analysis

At 14:37:03 UT on 10 December 2011, the Swift Burst Alert Telescope (BAT) triggered and located GRB 111210A. Using the data set from T-61 to T+178 sec for further analysis[1], the BAT ground-calculated position is RA, Dec (J2000) = 191.493 (12h 45m 58.3s), -7.173 deg (-7° $10^{'}$ $21.8^{''}$) with an uncertainty of 1.7 arcmin, (radius, sys+stat, 90% containment). The partial coding was 100% (Stamatikos et al., *GCN Circ.* 12651).

The mask-weighted light curve (Figure 1) shows two peaks; the first starting at ∼T-2.3 sec and ending at ∼T-1.6 sec, and the second starting at ∼T-0.2 sec, peaking at ∼T+0.1 sec, and ending at T+0.4 sec. T_{90} (15-350 keV) is 2.52±0.13 sec (estimated error including systematics).

The time-averaged spectrum from T-2.33 to T+0.36 sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.30±0.19. The fluence in the 15-150 keV band is $1.6\pm0.2 \times 10^{-7}$ erg cm^{-2}. The 1-sec peak photon flux measured from T-2.33 sec in the 15-150 keV band is 1.0±0.1 ph cm^{-2} sec^{-1}. All the quoted errors are at the 90% confidence level.

Using 16-ms binned light curves, the spectral lag for the 15-25 keV to 50-100 keV bands is 38 (+26, -33) msec, and 36 (+16, -18) msec for the 25-50 keV to 100-350 keV bands for both peaks combined (Barthelmy & Norris, *GCN Circ.* 12653. For just the second peak, the lag for 15-25 keV to 50-100 keV bands is 97 (+52, -40) msec. These lag values place this burst in the long burst category.

[1]The results of the batgrbproduct analysis are available at http://gcn.gsfc.nasa.gov/notices_s/509419/BA/

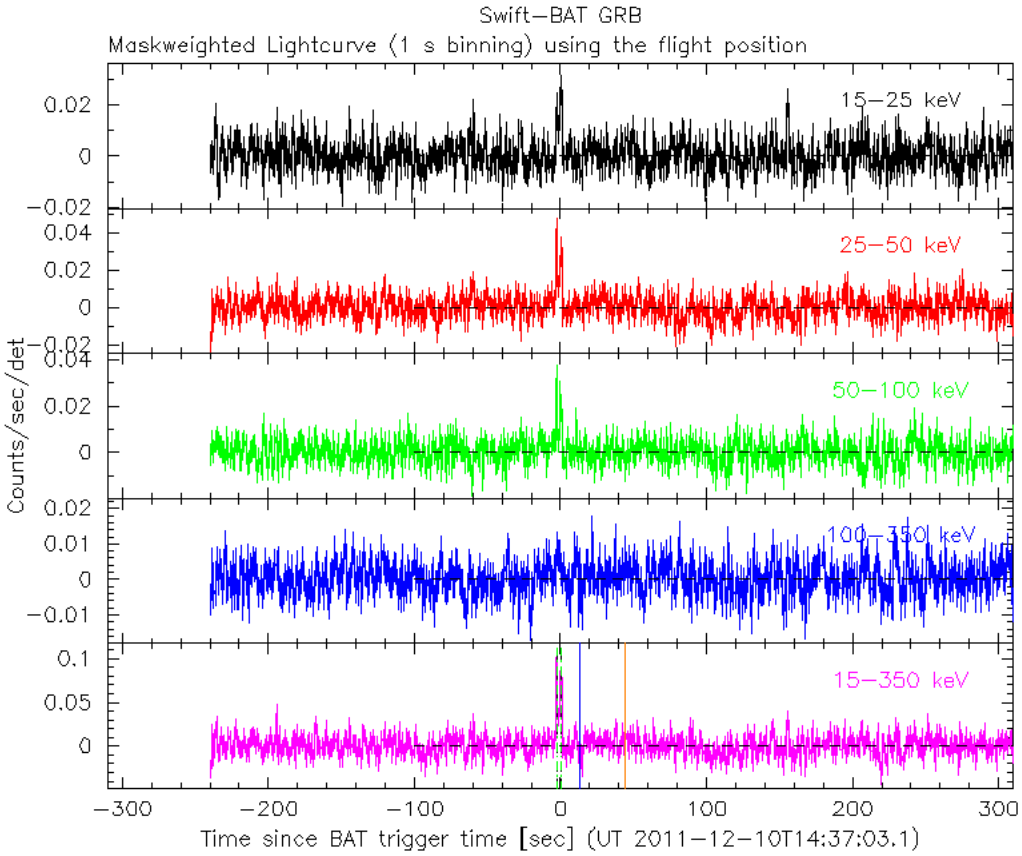

Figure 1: BAT Light curve of GRB 111210A.

3 XRT Observations and Analysis

The XRT began observing the field at 14:38:04.0 UT, 60.8 seconds after the BAT trigger. Using promptly downlinked data we found a fading, uncatalogued X-ray source. Using 466 s of XRT PC data and 1 UVOT image, we find an enhanced position of RA, Dec (J2000) = 191.47674 (12h 45m 54.42s), -7.16604 (-7° $09'$ $57.7''$) with an uncertainty of 1.9 arcseconds (radius, 90% containment), using the methods describe by Goad et al. (2007, A&A, 476, 1401) and Evans et al. (2009, MNRAS, 397, 1177).

We collected 8.4 ks of XRT data from 69 s to 30.5 ks after the BAT trigger. The data were entirely in Photon Counting (PC) mode (Burrows et al., *GCN Circ.* 12660). The light curve (Figure 2) can be modelled with a power-law decay with a decay index of α=3.7±0.4. It was not detected after the first orbit.

A spectrum formed from the PC mode data can be fitted with an absorbed power-law with a photon

spectral index of 1.6 (+0.6, -0.3). The best-fitting absorption column is consistent with the Galactic value of 1.9 $\times 10^{20}$ cm^{-2} (Kalberla et al. 2005). The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is 4.7 $\times 10^{-11}$(4.9 $\times$ 10^{-11}) erg cm^{-2} count^{-1}.

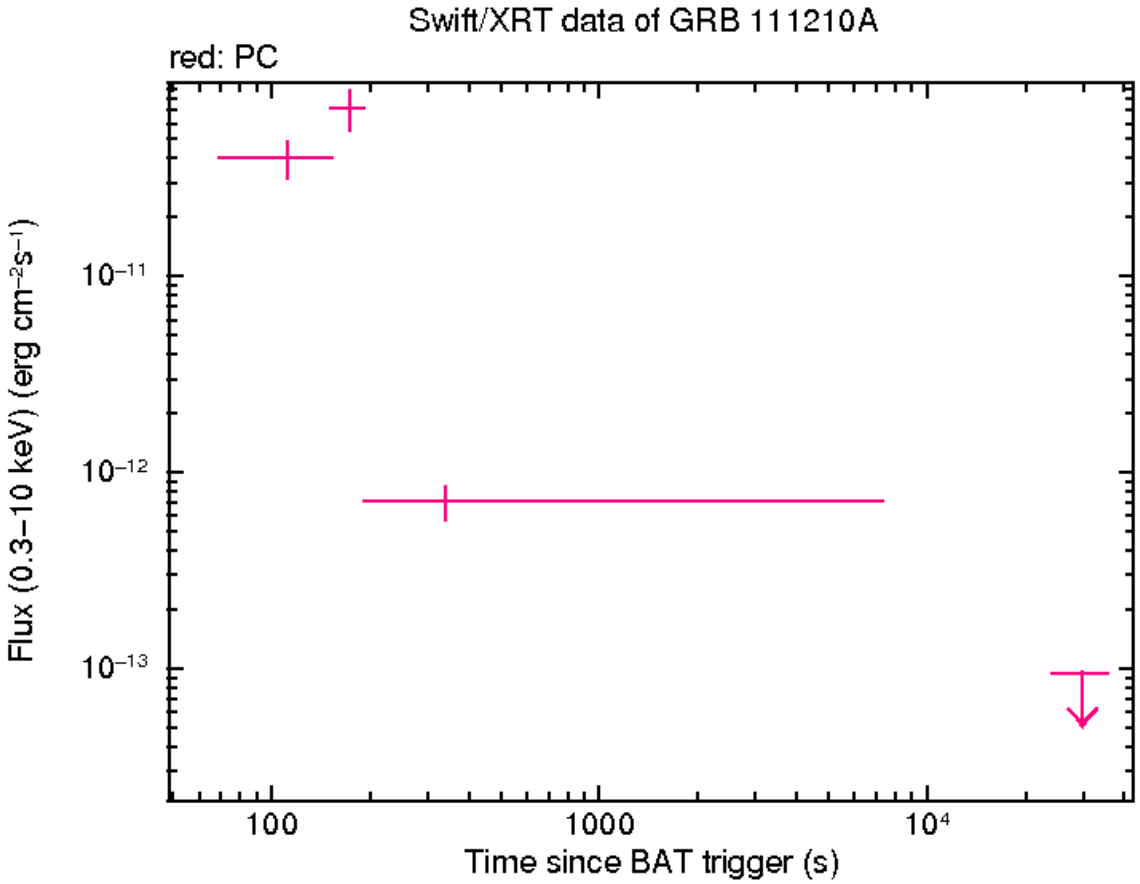

Figure 2: XRT flux light curve of GRB 111210A in the 0.3-10 keV band. The approximate conversion is 1 count s^{-1} = $\sim 4.7 \times 10^{-11}$ergs s^{-1} cm^{-2}.

4 UVOT analysis

The Swift/UVOT began settled observations of the field of GRB 111210A 65 s after the BAT trigger (Siegel, *GCN Circ.* 12654). No optical afterglow consistent with the XRT position was detected in the initial UVOT exposures. Three-sigma 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 listed in Table 1.

Filter	$T_{\rm Start}$	$T_{\rm stop}$	Exposure	Mag
white (FC)	65	214	147	>20.3
u (FC)	276	526	246	>19.5
white	65	6160	569	>20.5
v	606	6570	471	>19.3
b	532	7315	397	>20.0
u	276	7185	659	>19.9
uvw1	657	6980	471	>20.1
uvm2	1062	1082	19	>18.1
uvw2	582	6365	216	>20.5

Table 1: Magnitudes from UVOT observations of GRB 110201A. The quoted upper limits have not been corrected for the expected Galactic extinction along the line of sight of $E_{\rm B-V} = 0.03$ mag. All photometry is on the UVOT photometric system described in Breeveld et al. (2011, AIP Conf. Proc. 1358, 373).