

## Swift Observations of GRB 111225A

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### 1 Introduction

At 03:50:37 UT on 25 December 2011, the Swift Burst Alert Telescope (BAT) triggered and located GRB 111225A (trigger=510341). Swift slewed immediately to the burst and identified an X-ray and optical afterglow (Siegel et al., *GCN Circ.* 12720). Optical and infrared observations by TAROT (Klotz et al., *GCN Circ.* 12721, 12722), Super-LOTUS (Updike et al., *GCN Circ.* 12723), TNT (Xin et al., *GCN Circ.* 12725) and CAHA (Gorosabel et al., *GCN Circ.* 12728) confirmed the fading afterglow. Later observations by MITSuME (Kuroda et al., *GCN Circ.* 12730), PAIRITEL (Morgan *GCN Circ.* 12731), Keck (Cenko et al., *GCN Circ.* 12733), Swift/UVOT (Siegel et al., *GCN Circ.* 12734), T100 (Sonbas et al., *GCN Circ.* 12740) and CrAO (Rumyantsev et al., *GCN Circ.* 12793) showed that the optical afterglow faded rapidly. The XRT afterglow was detected out to 430 ks after the burst.

The best *Swift* position for this burst is the UVOT position given in Siegel et al. (*GCN Circ.* 12734): RA, Dec (J2000) = 13.15510 (00h 52m 37.22s), 51.57208 (51° 34′ 19.5″) with an uncertainty of 0.67″.

### 2 BAT Observation and Analysis

At 03:50:37 UT on 25 December 2011, the Swift Burst Alert Telescope (BAT) triggered and located GRB 111225A. Using the data set from T-240 to T+963 sec for further analysis<sup>1</sup>, the BAT ground-calculated position is RA, Dec (J2000) = 13.158 (00h 52m 37.9s), 51.573 deg (51° 34′ 21.8″) with an uncertainty of 1.3 arcmin, (radius, sys+stat, 90% containment). The partial coding was 93% (Baumgartner et al., *GCN Circ.* 12726).

The mask-weighted light curve shows a FRED like structure with the emission starting at  $\sim$ T-15 sec, peaking at  $\sim$ T-5 sec and ending at  $\sim$ T+150 sec.  $T_{90}$  (15-350 keV) is  $106.8 \pm 26.7$  sec (estimated error including systematics).

The time-averaged spectrum from T-14.28 to T+111.24 sec is best fit by a simple power-law model. The power law index of the time-averaged spectrum is  $1.70 \pm 0.15$ . The fluence in the 15-150 keV band is  $1.3 \pm 0.1 \times 10^{-6}$  erg cm<sup>-2</sup>. The 1-sec peak photon flux measured from T-4.40 sec in the 15-150 keV band is  $0.7 \pm 0.1$  ph cm<sup>-2</sup> sec<sup>-1</sup>. All the quoted errors are at the 90% confidence level.

### 3 XRT Observations and Analysis

The XRT began observing the field at 03:52:05.9 UT, 88.1 seconds after the BAT trigger. Using promptly downlinked data we found a fading, uncatalogued X-ray source. Using 1857 s of XRT PC data and 2 UVOT image, we find an enhanced position of RA, Dec (J2000) = 13.15557 (00h 52m 37.34s), +51.57157 (+51° 34′ 17.6″) with an uncertainty of 2.2 arcseconds (radius, 90% containment),

<sup>1</sup>The results of the batgrbproduct analysis are available at [http://gcn.gsfc.nasa.gov/notices\\_s/510341/BA/](http://gcn.gsfc.nasa.gov/notices_s/510341/BA/)

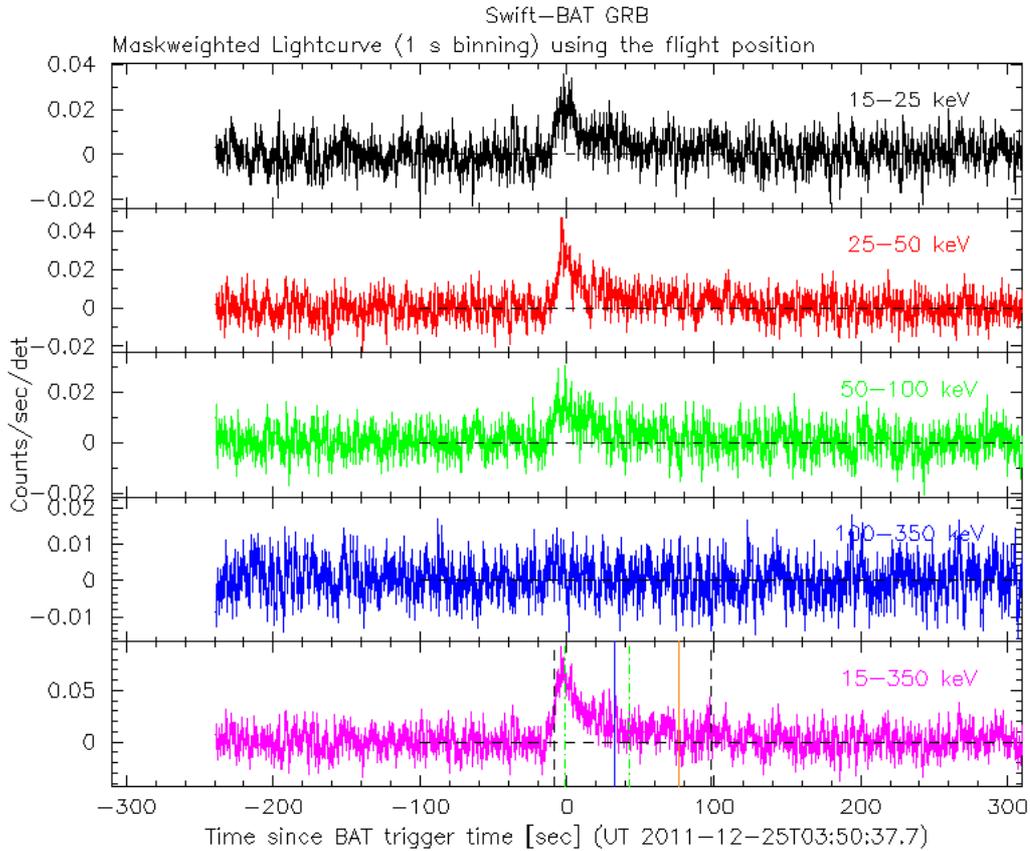


Figure 1: BAT Light curve of GRB 111225A.

using the methods describe by Goad et al. (2007, A&A, 476, 1401) and Evans et al. (2009, MNRAS, 397, 1177).

We collected 83 ks of XRT data from 88 s to 432 ks after the BAT trigger. The data comprised 556 s in Windowed Timing (WT) mode with the remainder in Photon Counting (PC) mode (Zhang et al., *GCN Circ.* 12727).

The light curve (Figure 2) can be modelled with a series of power-law decays. The initial decay index is  $\alpha=0.6$  (+0.4, -0.3). At T+114 s the decay steepens to an  $\alpha$  of 1.87 (+0.10, -0.09). The light curve breaks again at T+344 s to a decay with  $\alpha=2.6$  (+.22, -0.19), before a final break at T+1030 s, after which the decay index is  $\alpha=1.03$  (+0.16, -0.15). An early time flare (from T+214.6 to T+321.8 s) and a possible late time flare (from T+20000s) are excluded from the fit.

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of 2.43 ( $\pm 0.07$ ). The best-fitting absorption column is  $2.09$  (+0.16, -0.15) $\times 10^{21}$  cm $^{-2}$ , in excess of the Galactic value of  $1.7 \times 10^{21}$  cm $^{-2}$  (Kalberla et al. 2005). The PC mode spectrum

has a photon index of 1.71 (+0.17, -0.15) and a best-fitting absorption column consistent with the Galactic value. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is  $4.5 \times 10^{-11}$  ( $5.7 \times 10^{-11}$ )  $\text{erg cm}^{-2} \text{count}^{-1}$ .

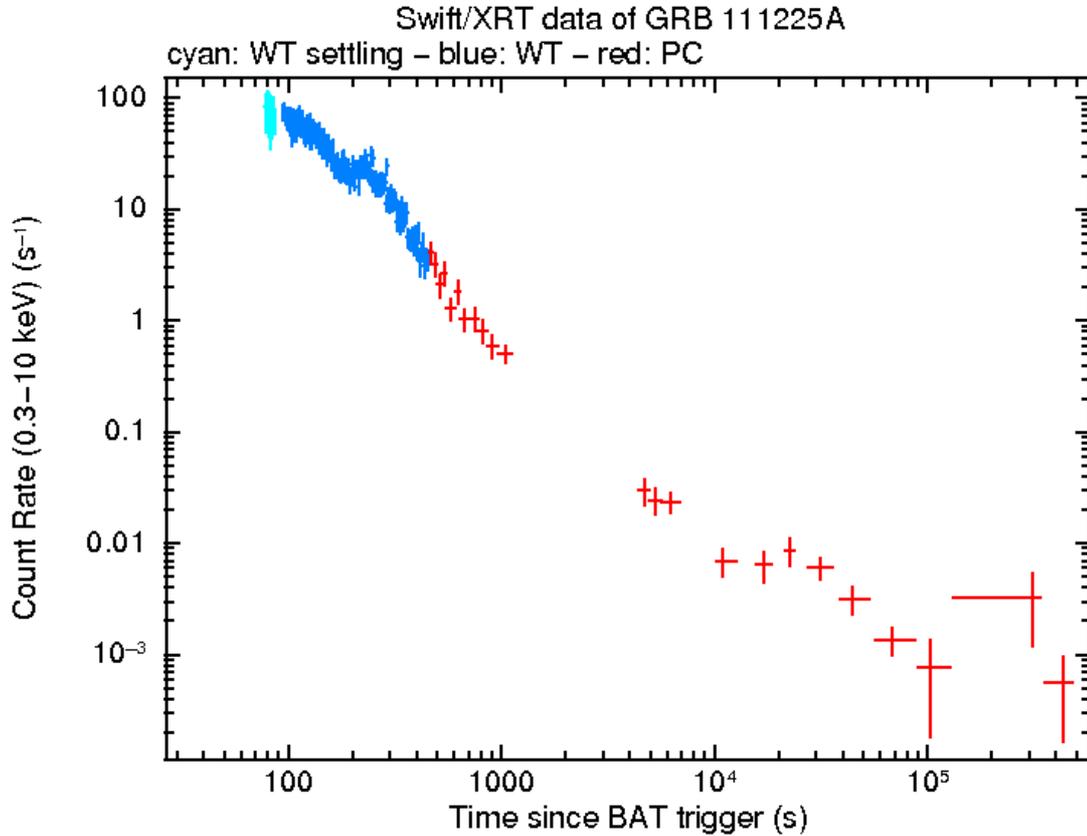


Figure 2: XRT flux light curve of GRB 111225A in the 0.3-10 keV band. The approximate conversion is  $1 \text{ count s}^{-1} = \sim 4.5 \times 10^{-11} \text{ ergs s}^{-1} \text{ cm}^{-2}$ .

## 4 UVOT analysis

The Swift/UVOT began settled observations of the field of GRB 111225A 95 s after the BAT trigger (Siegel, *GCN Circ.* 12735). A source consistent with the XRT position was detected in the initial UVOT exposures at the position RA, Dec (J2000) = 13.15510 (00h 52m 37.22s), +51.57208 (+51° 34' 19.5'')

The afterglow was not been detected after the first orbit. Detections and 3-sigma upper limits using the UVOT photometric system (Breeveld et al. 2011, AIP Conf. Proc. 1358, 373) for the early exposures are: listed in Table 1 with light curves shown in Figure 3.

Filter	$T_{\text{Start}}$	$T_{\text{stop}}$	Exposure	Mag
u (FC)	95	345	246	$19.46 \pm 0.17$
v	610	18443	2140	$> 21.1$
u	4385	16744	1475	$> 20.7$
uvw1	659	12668	1212	$> 20.4$
uvm2	634	11879	1337	$> 20.5$
uvw2	354	17652	1780	$21.36 \pm 0.31$

Table 1: Magnitudes from UVOT observations of GRB 111225A. The quoted upper limits have not been corrected for the expected Galactic extinction along the line of sight of  $E_{B-V} = 0.26$  mag. All photometry is on the UVOT photometric system described in Breeveld et al. (2011, AIP Conf. Proc. 1358, 373).

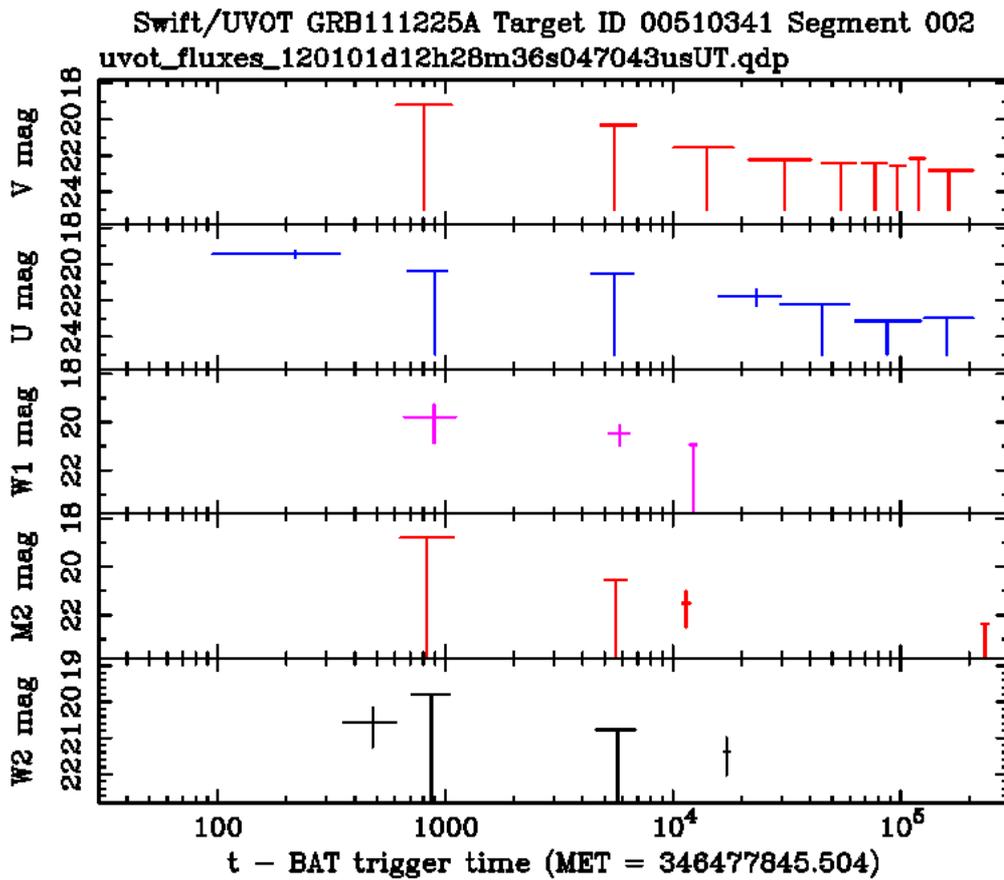


Figure 3: UVOT light curves of GRB 111225A.