

## Swift Observations of GRB 120326A

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### 1 Introduction

At 01:20:29 UT on 26 March 2012, the Swift Burst Alert Telescope (BAT) triggered and located GRB 120326A (trigger=518626). Swift slewed immediately to the burst and identified an X-ray afterglow (Siegel et al., *GCN Circ.* 13105).

The burst was followed up extensively in the optical and IR by TAROT (Klotz et al., *GCN Circ.* 13107, 13108), Liverpool (Guidorzi, *GCN Circ.* 13111), IAC80 (Walker et al., *GCN Circ.* 13112), Crni Vrh (Dintinjana & Mikuz, *GCN Circ.* 13113), Swift (Kuin et al., *GCN Circ.* 13114), McDonald Observatory (Myungshin et al., *GCN Circ.* 13117), AstroCamp (Hentunen et al., *GCN Circ.* 13119), LOT (Urata et al., *GCN Circ.* 13121), GMG (Zhao et al., *GCN Circ.* 13122), Maisoncelles (Souler, *GCN Circ.* 13126), TNT (Xin, et al., *GCN Circ.* 13131, 13150), LOAO (Jang et al., *GCN Circ.* 13139), Bassano (Quadri et al., *GCN Circ.* 13142, 13160, 13172, 13178, 13189, 13192), PAIRITEL (Morgan, *GCN Circ.* 13143), MITSuME (Kuroda et al., *GCN Circ.* 13155, 13170, 13177), CARMA (Perley et al., *GCN Circ.* 13175) and HCT (Sahu et al., *GCN Circ.* 13185).

A radio counterpart was also identified by SMA (Urata et al., *GCN Circ.* 13136) and the EVLA (Laskar et al., *GCN Circ.* 13181) and the burst was detected by both Fermi (Collazi, *GCN Circ.* 13145) and Suzaku WAM (Iwakiri et al., *GCN Circ.* 13176). Spectroscopic observations measured a redshift of 1.78 (Tello et al., *GCN Circ.* 13118)

The best *Swift* position for this burst is the UVOT position given in Kuin et al. (*GCN Circ.* 13114): RA, Dec (J2000) = 273.90471 (18h 15m 37.13s), 69.259822 (69° 15' 35.4") with an uncertainty of 0.50".

### 2 BAT Observation and Analysis

At 01:20:29 UT on 26 March 2012, the Swift Burst Alert Telescope (BAT) triggered and located GRB 120326A. Using the data set from T-239 to T+963 sec for further analysis<sup>1</sup>, the BAT ground-calculated position is RA, Dec (J2000) = 273.906 (18h 15m 37.3s), 69.248 deg (69° 14' 54.4") with an uncertainty of 1.0 arcmin, (radius, sys+stat, 90% containment). The partial coding was 91% (Barthelmy et al., *GCN Circ.* 13120).

The mask-weighted light curve shows a possible ( $2\sigma$ ) precursor peak at  $\sim$ T-105 sec, and two definite precursor peaks ( $\sim$ 30 sec wide each) at  $\sim$ T-60 sec and  $\sim$ T-25 sec. The main FRED peak starts  $T_0$ , peaks at  $\sim$ T+4 sec, and returns to background at  $\sim$ T+20 sec.  $T_{90}$  (15-350 keV) is  $69.6\pm 8.3$  sec (estimated error including systematics).

The time-averaged spectrum from T-67.90 to T+22.56 sec is best fit by a power law with an exponential

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<sup>1</sup>The results of the batgrbproduct analysis are available at [http://gcn.gsfc.nasa.gov/notices\\_s/518626/BA/](http://gcn.gsfc.nasa.gov/notices_s/518626/BA/)

cutoff. This fit gives a photon index  $1.41 \pm 0.34$ , and  $E_{\text{peak}}$  of  $41.1 \pm 6.9$  keV ( $\chi^2$  55.8 for 56 d.o.f.). For this model the total fluence in the 15-150 keV band is  $2.6 \pm 0.3 \times 10^{-6}$  erg  $\text{cm}^{-2}$ . and the 1-sec peak flux measured from T+3.59 sec in the 15-150 keV band is  $4.6 \pm 0.2$  ph  $\text{cm}^{-2} \text{sec}^{-1}$ . A fit to a simple power law gives a photon index of  $2.06 \pm 0.07$  ( $\chi^2$  68.4 for 57 d.o.f.). All the quoted errors are at the 90% confidence level.

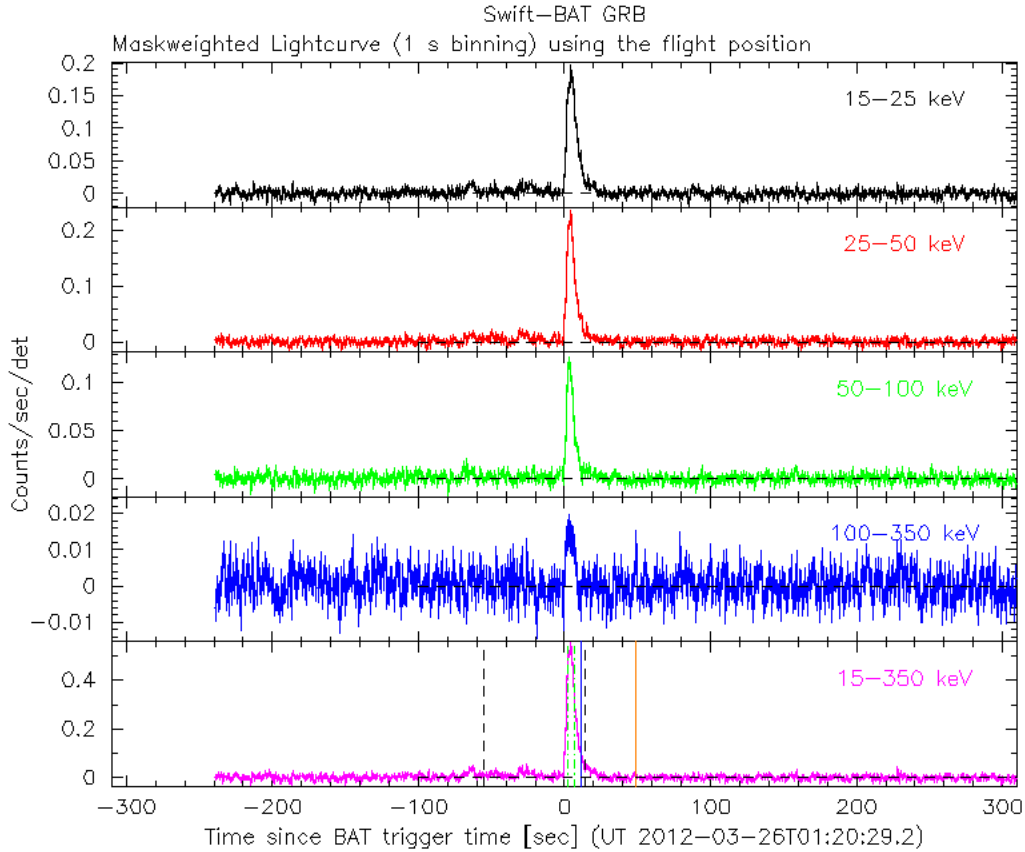


Figure 1: BAT Light curve of GRB 120326A.

### 3 XRT Observations and Analysis

The XRT began observing the field at 01:21:28.8 UT, 59.5 seconds after the BAT trigger. Using promptly downlinked data we found a fading, uncatalogued X-ray source. Using 1040 s of XRT PC data and 4 UVOT image, we find an enhanced position of RA, Dec (J2000) = 273.90451 (18h 15m 37.08s), +69.25998 (+69° 15' 35.9'') with an uncertainty of 1.8 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 57.6 ks of XRT data from 60 s to 449 ks after the BAT trigger. The data comprised 100 s in Windowed Timing (WT) mode with the remainder in Photon Counting (PC) mode (Kennea et al., *GCN Circ.* 13115).

The light curve (Figure 2) can be modelled with a series of power-law decays. The initial decay index is  $\alpha=3.6$  ( $\pm 0.11$ ). At  $T+295$  s the decay plateaus to an  $\alpha$  of 0.22 ( $+0.11$ ,  $-0.12$ ). The light curve breaks again at  $T+7\times 10^4$  s to a decay with  $\alpha=2.0$  ( $+1.7$ ,  $-0.9$ ). A notable feature of the XRT light curve, however, is the significant brightening between 20 and 70 ks, which corresponds to a similar re-brightening in the UVOT light curve.

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of 4.4 ( $+0.4$ ,  $-0.3$ ). The best-fitting absorption column is  $3.4$  ( $\pm 0.5$ ) $\times 10^{21}$   $\text{cm}^{-2}$ , in excess of the Galactic value of  $5.2 \times 10^{20}$   $\text{cm}^{-2}$  (Kalberla et al. 2005). The PC mode spectrum has a photon index of 1.89 ( $\pm 0.10$ ) and a best-fitting absorption column of  $9.1$  ( $+2.3$ ,  $-2.2$ ) $\times 10^{20}$   $\text{cm}^{-2}$ . The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is  $3.8 \times 10^{-11}$  ( $4.6 \times 10^{-11}$ )  $\text{erg cm}^{-2} \text{ count}^{-1}$ .

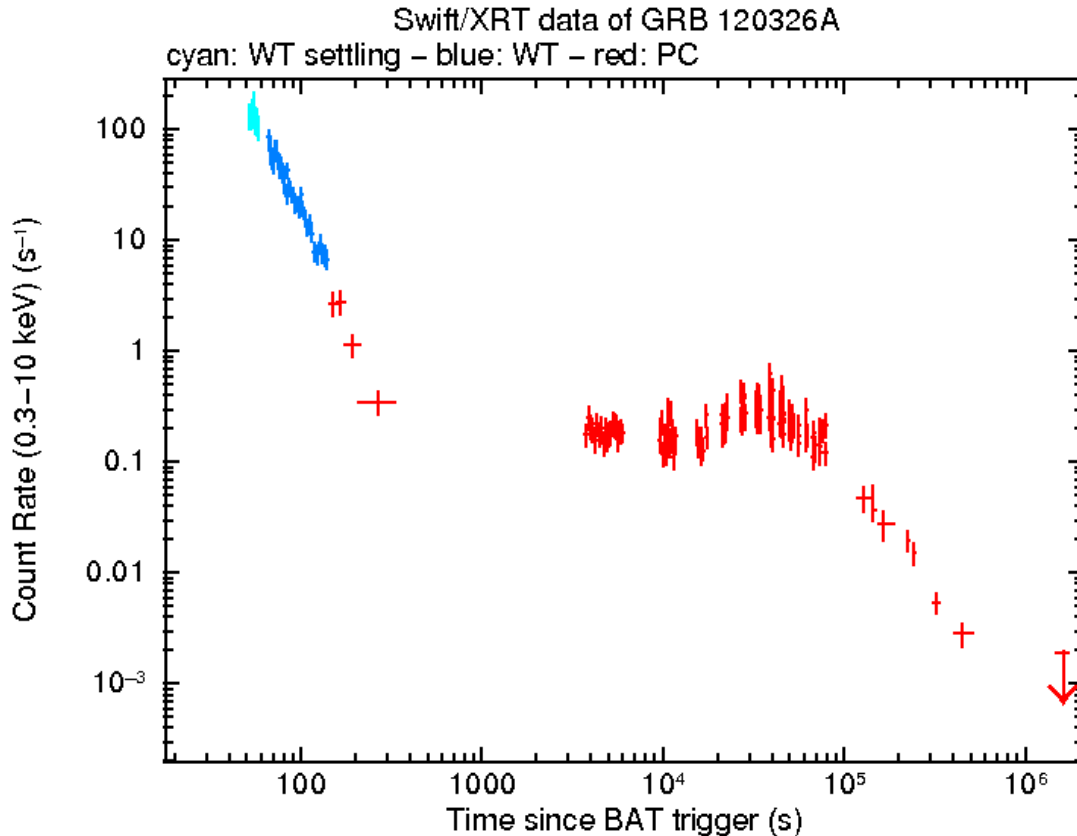


Figure 2: XRT flux light curve of GRB 120326A in the 0.3-10 keV band. The approximate conversion is  $1 \text{ count s}^{-1} = \sim 3.8 \times 10^{-11} \text{ ergs s}^{-1} \text{ cm}^{-2}$ .

## 4 UVOT analysis

The Swift/UVOT began settled observations of the field of GRB 120326A 67 s after the BAT trigger (Kuin et al., *GCN Circ.* 13114). A source consistent with the XRT position was detected in the initial UVOT exposures at the position RA, Dec (J2000) = 273.90471 (18h 15m 37.13s), +v (+69° 15' 35.36") with an uncertainty of 0.5" (90% confidence).

The light curve showed a late re-brightening between 20 and 70 ks (Figure 3). This rebrightening was confirmed by numerous ground-based studies. Initial 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.

Filter	$T_{\text{Start}}$	$T_{\text{stop}}$	Exposure	Mag
white (FC)	67	217	147	>20.0
white	3903	4103	197	$20.16 \pm 0.12$
v	4314	5949	393	>19.3
b	3697	5334	393	$20.23 \pm 0.16$
u	4929	5128	197	$19.66 \pm 0.20$
m2	4518	16222	1228	>21.2
w2	4109	5744	393	>21.0
w1	9527	10427	886	$20.21 \pm 0.18$
v	21959	22259	295	$18.67 \pm 0.12$
w2	21052	21952	886	$21.26 \pm 0.32$

Table 1: Magnitudes from UVOT observations of GRB 120326A. The quoted upper limits have not been corrected for the expected Galactic extinction along the line of sight of  $E_{B-V} = 0.05$  mag. All photometry is on the UVOT photometric system described in Breeveld et al. (2011, AIP Conf. Proc. 1358, 373).

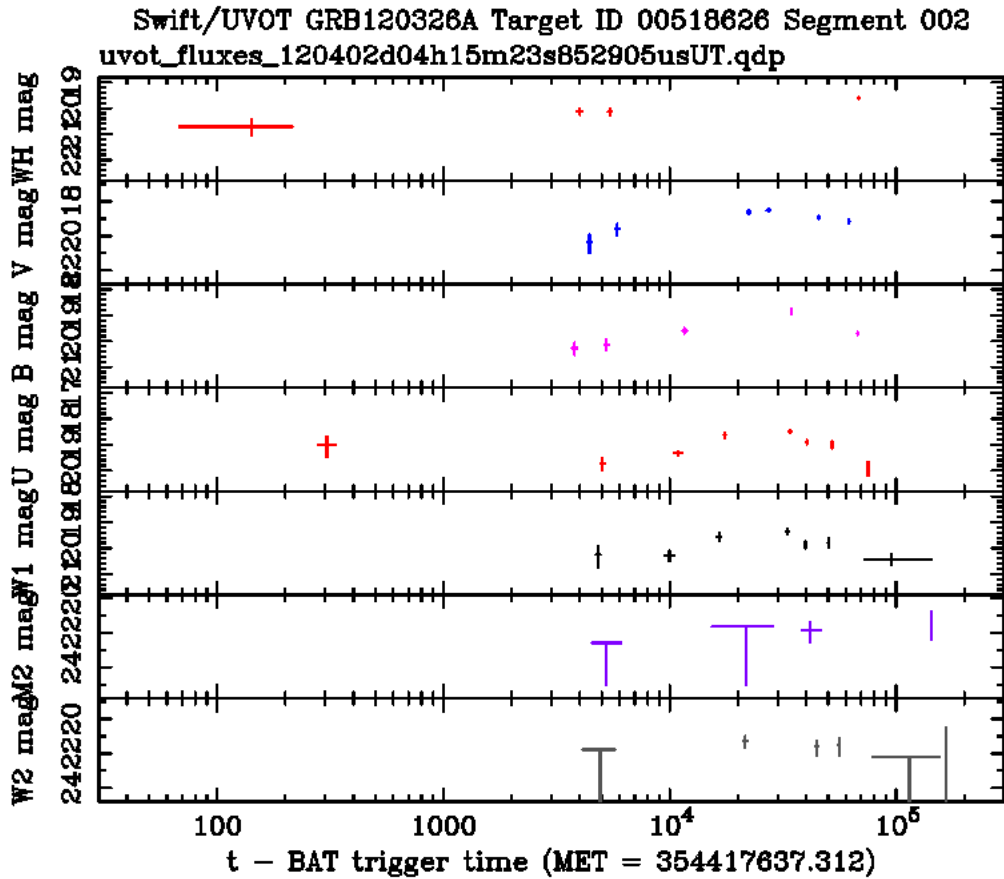


Figure 3: UVOT light curves of GRB 120326A.