

## Swift Observations of GRB 110128A

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### 1 Introduction

At 01:44:33 UT on 2011-01-28, the Swift Burst Alert Telescope (BAT) triggered and located GRB 110128A (trigger=443861). Swift slewed immediately to the burst and found an X-ray counterpart in the XRT (Grupe et al., *GCN Circ.* 11603)

The best *Swift* position of this burst is the UVOT position given in Oates & Grupe. (*GCN Circ.* 11612) with RA-2000 = 12h 55m 35.10s, and Dec-2000 = +28° 03' 54.1'' with an uncertainty of 1.3''.

There were several ground-based optical/NIR follow-up observation reported on this burst. Most notably are the VLT/X-shooter spectroscopic redshift measurement of  $z=2.339$  by Sparre et al. (*GCN Circ.* 11607) and the redshift measurements of two galaxies in the line of sight at  $z=0.639$  and  $z=0.109$  which might have caused absorption in the afterglow as reported by Tanvir et al. (*GCN Circ.* 11608). The burst was also detected by the FERMI GBM (Chaplin, *GCN Circ.* 11628). Due to the faintness of this burst only a single power law model with  $\Gamma = 1.5 \pm 0.1$  could be fitted to the GBM spectrum.

### 2 BAT Observation and Analysis

At 01:44:33 UT on 2011-01-28, the Swift Burst Alert Telescope (BAT) triggered and located GRB 110128A (trigger=443861, Grupe et al., *GCN Circ.* 11603). Using the data set from T-240 to T+962 s, the BAT ground-calculated position is RA, Dec = 193.871, +28.108 deg which is

RA(J2000) = 12h 55m 29.0s

Dec(J2000) = +28° 06' 28.7''

with an uncertainty of 2.3 arcmin, (radius, sys+stat, 90% containment). The partial coding was 37% (Cummings et al. *GCN Circ.* 11614).

The mask-weighted light curve (Figure 1) shows a single broad peak starting at T-3 s to T+40 s.  $T_{90}$  (15-350 keV) is  $30.7 \pm 18.1$  s (estimated error including systematics).

The time-averaged spectrum from T-1.4 to T+48.3 s is best fit by a single power law model. The power law index of the time-averaged spectrum is  $1.31 \pm 0.30$  ( $\chi^2 = 61.8$  for 57 d.o.f.). For this model the total fluence in the 15-150 keV band is  $7.2 \pm 1.4 \times 10^{-7}$  ergs  $\text{cm}^{-2}$ . The 1s peak photon flux measured from T+3.58 s in the 15-150 keV band is  $0.8 \pm 0.2$  photons  $\text{s}^{-1} \text{cm}^{-2}$ . 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/443681/BA/](http://gcn.gsfc.nasa.gov/notices_s/443681/BA/)

### 3 XRT Observations and Analysis

The XRT began observing the field of GRB 110128A at 01:46:53.5 UT, 140.5 seconds after the BAT trigger. Using 920 s of XRT Photon Counting mode data and 1 UVOT image for GRB 110128A, Osborne et al. (*GCN Circ.* 11606) found an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA, Dec = 193.89661, +28.06511 which is equivalent to:

RA (J2000): 12h 55m 35.19s

Dec (J2000): +28° 03' 54.4''

with an uncertainty of 1.9'' (radius, 90% confidence). The latest position can be viewed at [http://www.swift.ac.uk/xrt\\_positions](http://www.swift.ac.uk/xrt_positions). Position enhancement is described by Goad et al. (2007, *A&A*, 476, 1401) and Evans et al. (2009, *MNRAS*, 397, 1177).

A spectrum formed from the PC mode data (11 ks exposure) can be fitted with an absorbed single power-law model with a photon spectral index of  $1.64 \pm 0.22$  (Grupe, *GCN Circ.* 11610). The best-fitting absorption column is consistent with the Galactic value of  $9.0 \times 10^{19} \text{ cm}^{-2}$  (Kalberla et al. 2005). The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is  $4.0 \times 10^{-11}$  ( $4.1 \times 10^{-11}$ )  $\text{erg cm}^{-2} \text{ count}^{-1}$ .

The 0.3 – 10 keV light curve given below (Fig.2) displays an initial steep decay slope after the initial flare of  $2.3 \pm 0.5$ . The light curve of the X-ray afterglow breaks at  $T+700_{-200}^{+600}$  s followed by a flatter decay slope of  $0.69_{-0.12}^{+0.09}$ . This decay slope continued until the end of the observations on 2011-02-07.

### 4 UVOT analysis

The Swift/UVOT began settled observations of the field of GRB 110128A 144 s after the BAT trigger (Grupe et al., *GCN Circ.* 11603) with the finding chart in white filter. Oates & Grupe (*GCN Circ.* 11612) reported that the afterglow was detected in the first white and u exposures. The refined UVOT position is RA(J2000)= 193.89625 deg, DEC(J2000) = 28.06503, which is:

RA (J2000): 12h 55m 35.10s

Dec (J2000): +28° 03' 54.1''

with an estimated uncertainty of 1.3 arcsec (radius, 90% confidence). This position is consistent with the optical afterglow detection by NOT (de Ugarte Postigo. et al, *GCN Circ.* 11605) and the enhanced XRT position (Osborne et al., *GCN Circ.* 11606).

The white and u magnitudes and the  $3\sigma$  upper limits for the summed images are listed in Table 1.

Filter	$T_{\text{Start}}$	$T_{\text{stop}}$	Exposure	Mag
white_FC	144	294	147	$20.98 \pm 0.29$
u_FC	302	552	246	$20.32 \pm 0.35$
white	582	6352	580	$> 21.89$
v	632	6763	432	$> 20.09$
b	707	5943	412	$> 20.95$
u	558	6148	432	$> 21.32$
w1	682	5738	221	$> 20.34$
m2	658	6874	340	$> 20.43$
w2	608	6558	393	$> 20.88$

Table 1: Magnitudes from UVOT observations of GRB 110128A. The quoted values have not been corrected for the expected Galactic extinction along the line of sight of  $E_{B-V} = 0.01$  mag. All photometry is on the UVOT photometric system described in Poole et al. (2008, MNRAS, 383, 627).

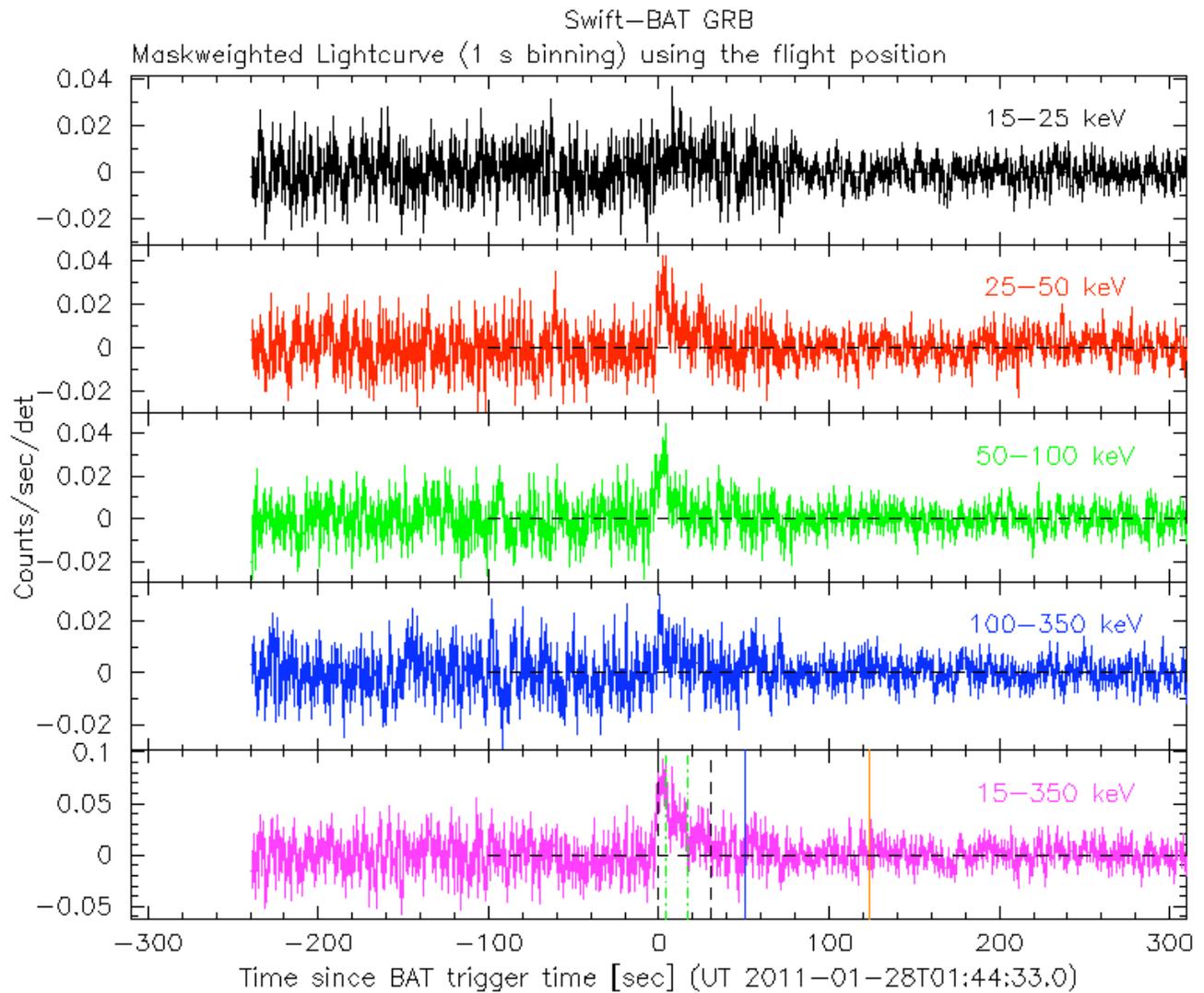


Figure 1: BAT Light curve of GRB 110128A.

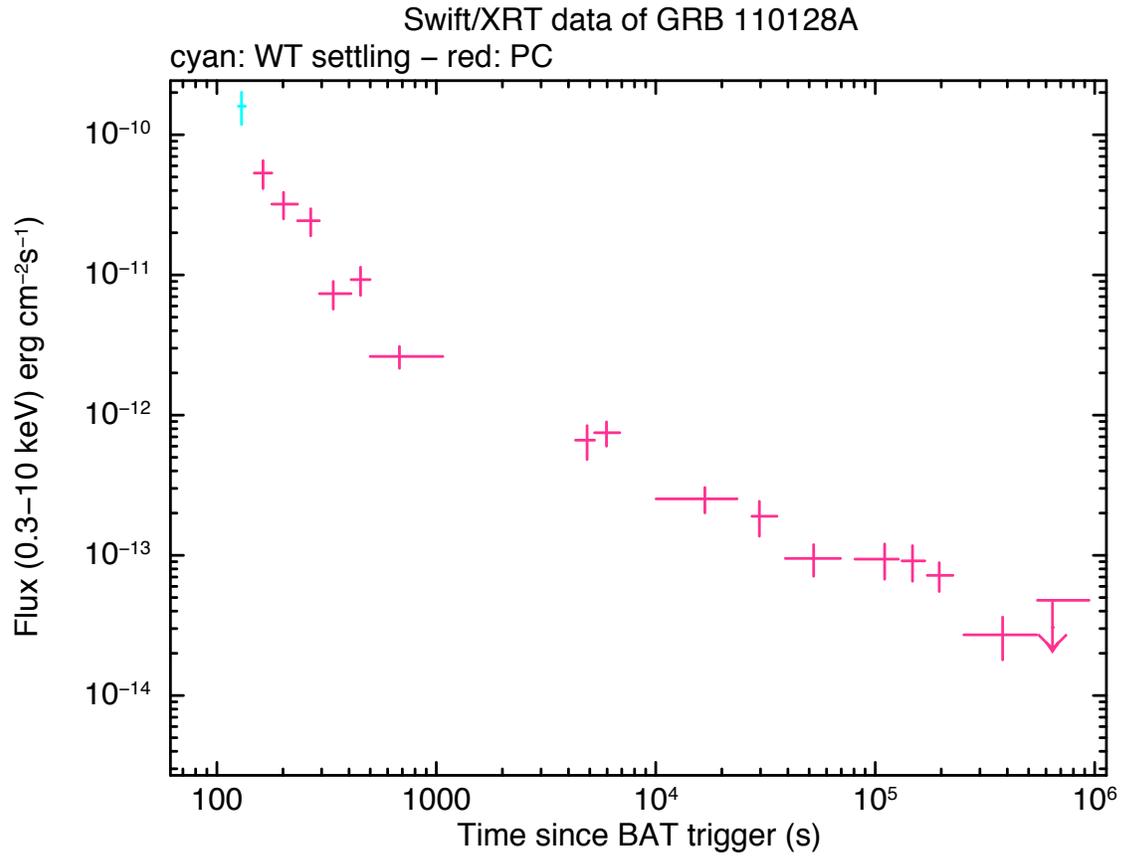


Figure 2: XRT flux light curve of GRB 110128A in the 0.3-10 keV band. The approximate conversion is  $1 \text{ count s}^{-1} = \sim 4.1 \times 10^{-11} \text{ ergs s}^{-1} \text{ cm}^{-2}$ .