

Swift Observation of GRB 081121

S. R. Oates (MSSL-UCL), T. Sakamoto (GSFC/UMBC), O. Godet (U. Leicester) report for the Swift Team

1 Introduction

BAT triggered on GRB 081121 at 20:35:32 UT (Trigger 335105) (Oates, *et al.*, *GCN Circ.* 8537). This was a 4.096 s rate-trigger on a burst with $T_{90} = 14.2$ s. Due to an Earth limb constraint, Swift could not slew to this burst until ~ 45 minutes after the trigger after which, the XRT and UVOT began follow-up observations. Our best position is the UVOT location at $RA(J2000) = 89.275625deg$ (05h57m06.15s), $Dec(J2000) = -60.602778deg$ ($-60d36'10.0s''$) with an error of 0.6 arcsec (90% confidence).

This GRB was also observed by Fermi (Colleen, *et al.*, *GCN Circ.* 8546), Konus-Wind (Golenetskii, *et al.*, *GCN Circ.* 8548) and Integral/SPI-ACS (private communication). The optical/IR afterglow was detected 57.2s after the trigger by the ROTSE-III (Yuan, *et al.*, *GCN Circ.* 8536) and was also detected by GROND (Loew, *et al.*, *GCN Circ.* 8540) and SMARTS (Cobb, *GCN Circ.* 8547). A spectroscopic observation of the afterglow, taken with the Magellan telescope (Berger, *et al.*, *GCN Circ.* 8542), measured a redshift of $z = 2.512$ leading to an $E_{iso} = 2.7 \times 10^{53}$ erg (Golenetskii, *et al.*, *GCN Circ.* 8548).

2 BAT Observation and Analysis

Using the data set from T-119 to T+271 s, we report on the analysis of BAT GRB 081121 (Oates, *et al.*, *GCN Circ.* 8537). The BAT ground-calculated position is RA, Dec = 89.282, -60.612 deg, which is: $RA(J2000) = 05h 57m 07.7s$ $Dec(J2000) = -60d 36' 42.1''$ with an uncertainty of 1.4 arcmin, (radius, sys+stat, 90% containment). The partial coding was 5%.

The mask-weighted light curve, see Fig. 1, shows an approximately square-shaped pulse with a trailing spike. The pulse starts at $\sim T-10$ s and ends at $\sim T=15$ s. There is a hint of low-level precursor emission starting before T-119 sec (the beginning of the saved event-by-event data). The T90 (15-350 keV) is 14 ± 2 s (estimated error including systematics).

The time-averaged spectrum from T-2.8 to T+12.9 s is best fit by a power law with an exponential cutoff. This fit gives a photon index 0.43 ± 0.54 , and E_{peak} of 123 ± 69 keV ($\chi^2 = 44.9$ for 56 d.o.f.). For this model the total fluence in the 15-150 keV band is $4.1 \pm 0.3 \times 10^{-6}$ erg cm^{-2} and the 1-sec peak flux measured from T+6.94 sec in the 15-150 keV band is 4.4 ± 1.0 ph/cm²/sec. A fit to a simple power law gives a photon index of 1.21 ± 0.12 ($\chi^2 = 52.0$ for 57 d.o.f.). 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/335105/BA/

3 XRT Observations and Analysis

The Swift-XRT started observing the field of GRB 081121 (Oates, *et al.*, *GCN Circ.* 8537) at 2008-11-21 20:35:32 UT, 2.8 ks after the trigger. The best XRT position is the UVOT-enhanced position reported by Goad *et al.* (*GCN Circ.* 8541). This position is consistent with the optical positions reported by the Swift-UVOT and ROTSE III (Oates, *et al.*, *GCN Circ.* 8537, Yuan, *et al.*, *GCN Circ.* 8536).

The X-ray light curve, see Fig. 2, spans 19.7 ks of photon counting (PC) mode data from T+2.8 ks to T+800 ks. The light curve shows an initial decay with a slope of $1.11_{-0.05}^{+0.06}$ up to at least T+17 ks,

followed by a drop in count rate between T+17 ks and T+22 ks. There appears to be a rebrightening, peaking or flattening at T+2.8 × 10⁴s, which is followed by a power-law decay with a slope of 1.20^{+0.24}_{-0.25}. A break occurs in the lightcurve at T+71.2^{+11.3}_{-9.2} ks, after which, the decay continues with a slope of 1.63^{+0.12}_{-0.11}.

The PC X-ray spectrum from T+2.8ks to T+16ks can be well fit by an absorbed power-law with a photon index of 1.99^{+0.10}_{-0.09} and a column density of 9.7^{+2.2}_{-2.0} × 10²⁰ cm⁻² (the Galactic value is 4.0 × 10²⁰ cm⁻² in the direction of the burst).

The observed 0.3-10.0 keV flux is 7.1 ± 0.4 × 10⁻¹¹ erg cm⁻² s⁻¹ which corresponds to an unabsorbed flux of 9.0^{+0.2}_{-0.5} × 10⁻¹¹ erg cm⁻² s⁻¹.

The X-ray spectrum from T+20ks to T+60ks can be well fit by an absorbed power-law with a photon index of 2.15 ± 0.14 and a column density fixed at 9.7 × 10²⁰ cm⁻².

The X-ray spectrum after T+60ks can be well fit by absorbed power-law with a photon index of 1.91 ± 0.14 and a column density fixed at 9.7 × 10²⁰ cm⁻².

4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB 081121, 2816s after the BAT trigger (Oates et al., GCN Circ. 8537). The optical afterglow was detected in the white, v, b, u filters and marginally in the uvw1 filter at the position:

$$\text{RA(J2000.0)} = 5:57:06.15$$

$$\text{DEC(J2000.0)} = -60:36:10.0$$

with an estimated uncertainty of 0.6 arcsec (radius, 90% confidence). This position is consistent with the UVOT-enhanced XRT position (Goad, *et al.*, GCN Circ. 8541) and the position reported by ROTSE-III (Yuan, *et al.*, GCN Circ. 8536).

The marginal detection of the optical afterglow in uvw1, and the lack of a detection in the uvm2 and uvw2 filters is consistent with a redshift of z=2.512 reported by Magellan (Berger & Rauch, GCN Circ. 8542).

The magnitudes and 3σ upper limits are given in Table 1. These values have not corrected for the Galactic extinction corresponding to a reddening of E_{B-V} = 0.05 mag (Schlegel et al., 1998, ApJS, 500, 525). The photometry is based on the UVOT flight system described in Poole et al. (2008, MNRAS, 383,627). The white filter UVOT lightcurve is shown in Fig. 3.

Filter	Start (sec)	Stop (sec)	Exposure (sec)	Magnitudes/3σ Upper Limits
white	2816	2965	147	17.93 ± 0.04
v	2972	3172	197	17.58 ± 0.08
b	3792	3992	197	18.26 ± 0.07
u	3587	3787	197	17.62 ± 0.06
uvw1	3383	3582	197	20.60 ± 0.48
uvm2	3177	4813	393	> 20.09
uvw2	4203	11200	790	> 20.78

Table 1: Magnitude and 3σ upper limits from UVOT observations

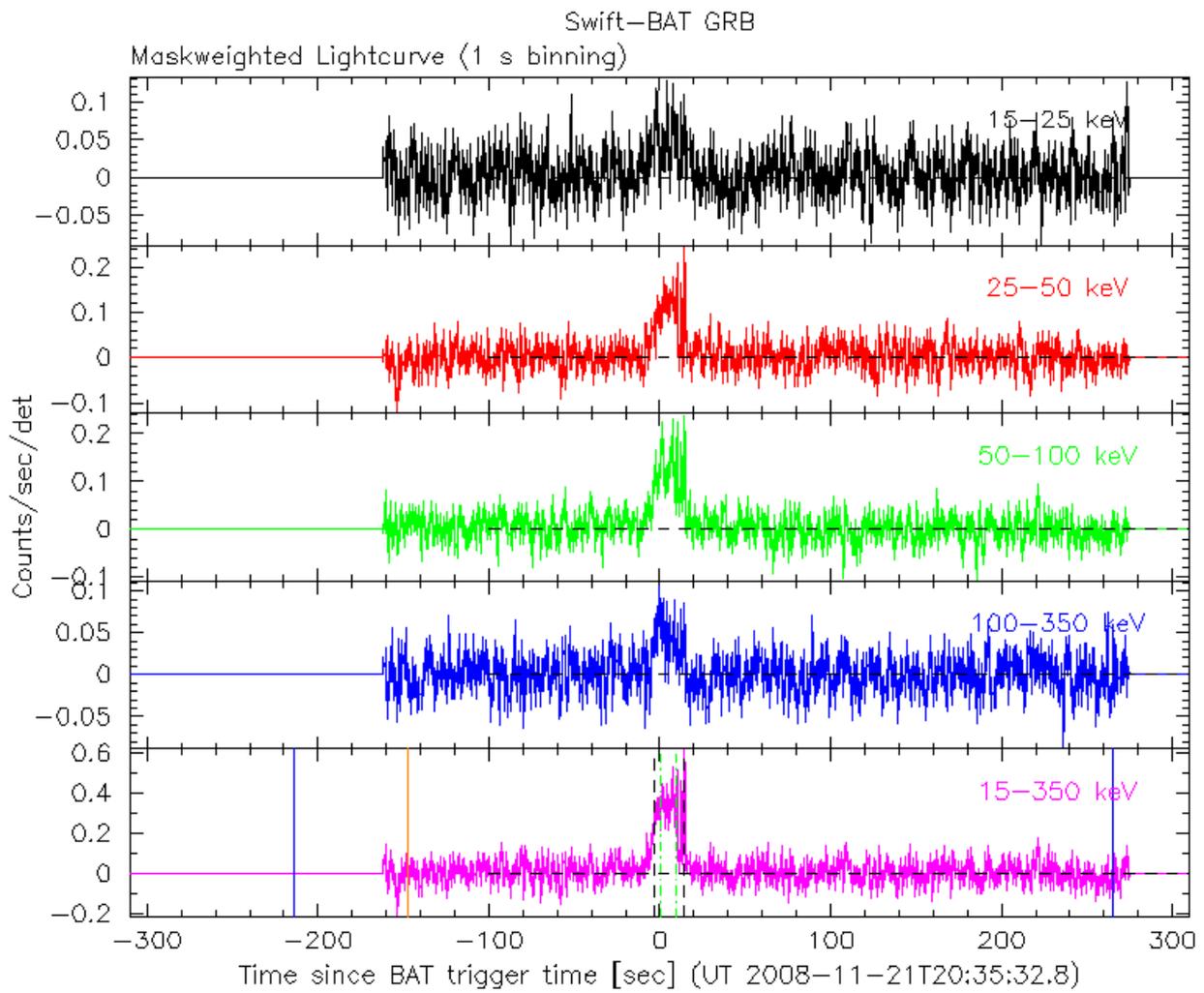


Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/sec/illuminated-detector

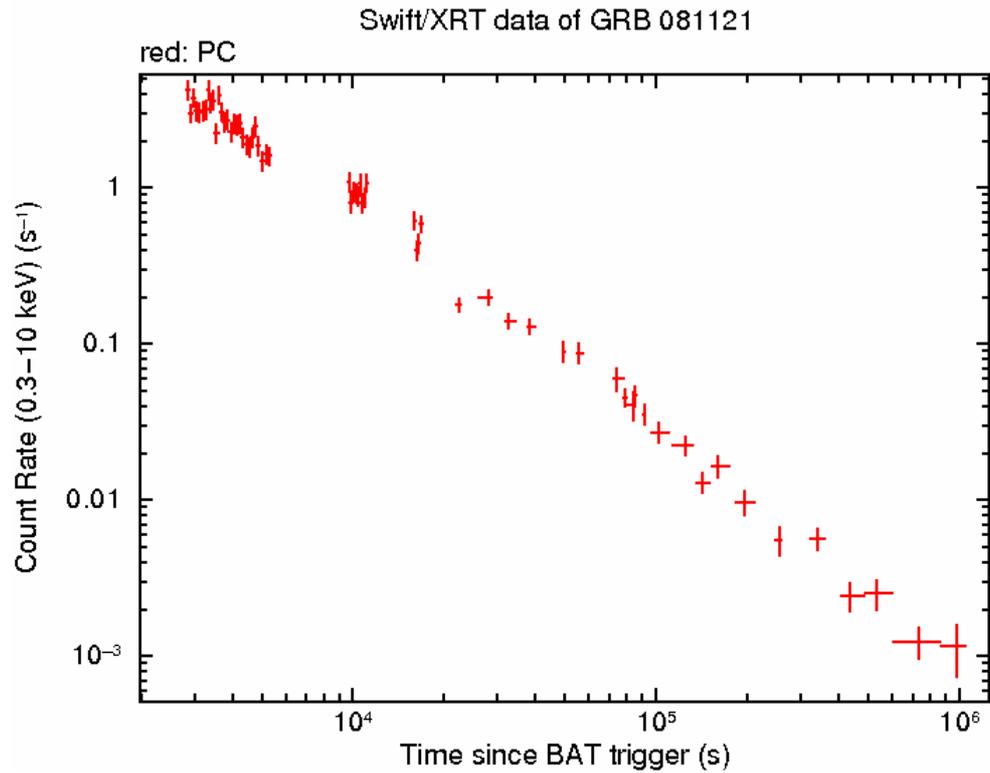


Figure 2: XRT Lightcurve. Counts/sec in the 0.3-10 keV band. The conversion factor from count rate to absorbed flux is $1 \text{ count/sec} \sim 7.1 \times 10^{-11} \text{ ergs cm}^{-2} \text{ sec}^{-1}$ and to unabsorbed flux $1 \text{ count/sec} \sim 9.0 \times 10^{-11} \text{ ergs cm}^{-2} \text{ sec}^{-1}$.

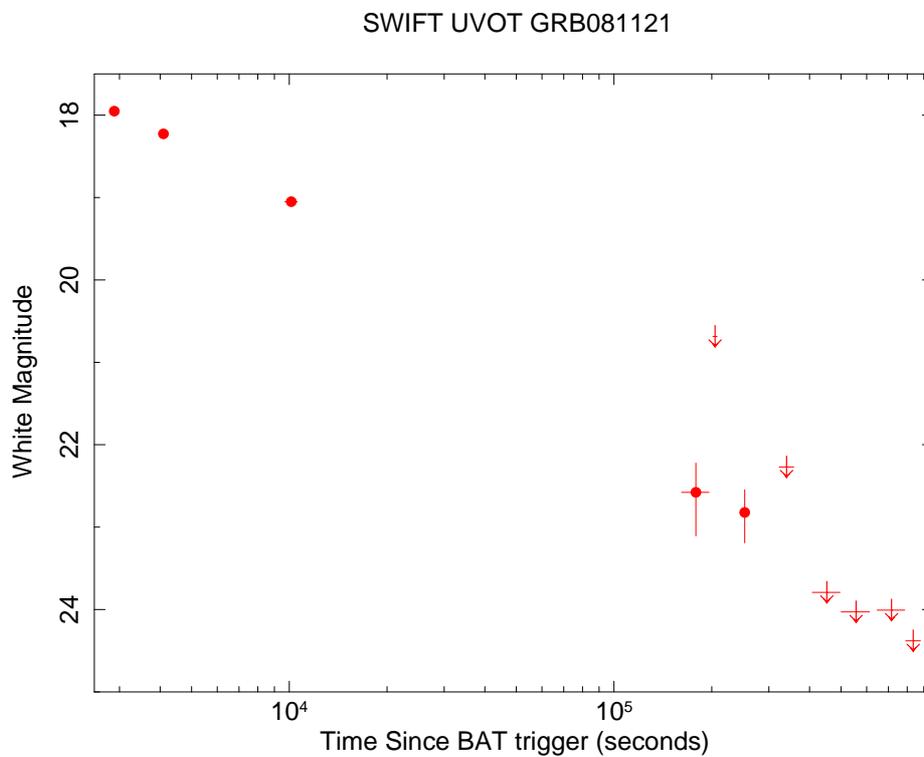


Figure 3: UVOT Lightcurve in the white filter. The arrows pointing down are 3σ upper limits.