Swift Observation of GRB 081222

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1 Introduction

At 04:53:59 UT on 2008 December 22, the Swift Burst Alert Telescope (BAT) triggered on GRB 081222 (Grupe et al. *GCN Circ.* 8691). *Swift* slewed promptly and the *Swift* XRT and UVOT began observing the field of GRB 081222 52 s after the burst. The best *Swift* position of the afterglow is from the UVOT at RA (J2000) $=$01h 30m 57.59s, Dec (J2000) $= -34°05'41.49"$

There were several ground-based followup observations of this burst. Most importantly, Gemini South and North independently measured a redshift of the burst at z=2.77 (Cucchiara et al. *GCN Circ.* 8713 and Graham et al. *GCN Circ.* 8718, respectively), confirming the redshift z=2.7 measured by the *Swift*-UVOT (Breeveld et al. *GCN Circ.* 8712). The burst was also detected at high energies by the FERMI GBM and Konus-Wind which measured an E_{peak} of 134±9 and 165^{+47}_{-29} keV, respectively (Bissaldi & McBreen *GCN Circ.* 8715 and Golenetskii et al. *GCN Circ.* 8721). In addition it was also detected by the INTEGRAL SPI-ACS (Beckmann priv. comm.).

2 BAT Observation and Analysis

At 04:53:59 UT on 2008 December 22, the Swift BAT triggered on GRB 081222 (trigger #337914). The BAT ground-calculated position is RA, Dec = 22.748, −34.095 deg (Fenimore et al. *GCN Circ.* 8709), which is

RA(J2000) = 01h 30m 59.5s

Dec(J2000) = $-34°05'41.4"$

with an uncertainty of $1.0'$ (radius, 90% containment, including systematic uncertainty). The burst was in the fully-coded field of view. The mask-weighted light curve shows a main peak with several subpeaks from T+0 to T+20s and an exponential tail visible to about T+70s. T_{90} (15-350 keV) is 24±3 s (estimated error including systematics).

The time-averaged spectrum from T-0.9 to T+38 s is best fit by a power-law with exponential cutoff model. The photon index of the time-averaged spectrum is Γ=1.08±0.15 and $E_{\text{peak}} = 131 \pm 31$ keV. (χ^2/ν=46/56). This E_{peak} is consistent with those found by the FERMI GBM and Konus-Wind (Bissaldi & McBreen *GCN Circ.* 8715 and Golenetskii et al. *GCN Circ.* 8721). The fluence in the 15-150 keV band is $(4.8\pm0.1)\times10^{-6}$ ergs cm^{-2}. The 1s peak photon flux measured from T+3.45 s in the 15-150 keV band is (7.7±0.2) photons cm^{-2} s^{-1}. A fit with a simple power law model gives a photon index Γ=1.48±0.03 (χ^2/ν=68/57). 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/337914/BA/

3 XRT Observations and Analysis

The XRT began observing the field of GRB 081222 at 04:54:51.7 UT, 51.8 seconds after the BAT trigger. Using promptly down-linked data XRT found a fading, uncatalogued X-ray source. The *Swift*-XRT position as reported by Grupe al. (*GCN Circ.* 8691) is RA (J2000) = 22.74067, Dec (J2000) = −34.09556 which is equivalent to:

RA (J2000): 01h 30m 57.76s

Dec (J2000): −34° 05′ 44.0″

with an uncertainty of 3.6″ (radius, 90% confidence). This position is 120″ away from the onboard BAT position and within the BAT error circle.

The $0.3 - 10$ keV light curve (Fig.2) follows the canonical light curves as given in Nousek et al. (2006) and Zhang et al. (2006) with the following decay slopes and break times: $\alpha_1 = 2.00 \pm 0.40$, $T_{\mathrm{break,1}} = 80 \pm 20$s, $\alpha_2 = 0.89 \pm 0.05$, $T_{\mathrm{break,2}} = 1240 \pm 100$s, $\alpha_3 = 1.10 \pm 0.05$, $T_{\mathrm{break,3}} = 81 \pm 5$ks, and $\alpha_4 = 1.90 \pm 0.10$. The last break is most likely a jet break.

As reported by Grupe (*GCN Circ.* 8705), the XRT Windowed Timing mode data can be modeled by an absorbed single power-law with photon index $\Gamma = 2.01 \pm 0.20$ and an absorbing column density $N_{\mathrm{H}} = (4.61 \pm 0.80) \times 10^{20}$ cm^{-2} which is in excess of the Galactic column density at the position of the burst of $N_{\mathrm{H,gal}} = 2.24 \times 10^{20}$ cm^{-2} (Kalberla et al. 2005). The spectrum of the Photon Counting mode data are consistent with this result.

4 UVOT analysis

UVOT took a finding chart exposure of 147s in White starting 60 s after the BAT trigger (Breeveld & Grupe, *GCN Circ.* 8696). The analysis of the full UVOT data set (Breeveld et al, *GCN Circ.* 8712) shows an the optical afterglow detected in the UVOT White, v, b, and u filters. The position of this source in the White and u filters is

RA (J2000) = 01h 30m 57.59s

Dec (J2000) = −34° 05′ 41.49″

corresponding to RA-2000=22.73996, Dec-2000=–34.09486 with an estimated 90% confidence radius of 0.5″. This position is consistent with the position of the X-ray afterglow and the optical positions reported by REM and GROND (Covino et al. *GCN Circ.* 8692 and Updike et al. *GCN Circ.* 8693, respectively). A 49s UV grism spectrum was obtained beginning 216s after the trigger. The very low S/N quicklook spectrum shows a continuum of about 3×10^{-15} ergs s^{-1} cm^{-2} Å^{-1} longward of 3400 Å. No flux is detected shortward of 3400 Å, even though the grism sensitivity increases toward shorter wavelengths. If this is the wavelength of the Lyman edge, then the redshift of GRB081222 is 2.7. The detection of GRB081222 in the u filter and the non-detection in UVW1 filter are consistent with this redshift. This redshift was later confirmed by optical spectroscopy at the Gemini South and North (Cucchiara et al. *GCN Circ.* 8713 and Graham et al. *GCN Circ.* 8718, respectively) with z=2.77.

The magnitudes and 3σ upper limits in the UVOT photometric system (Poole et al. 2008, MNRAS, 383, 627) for detecting the source are listed in Table 1. No correction has been made for the expected

extinction corresponding to E(B-V) of 0.021 (Schlegel et al., 1998).

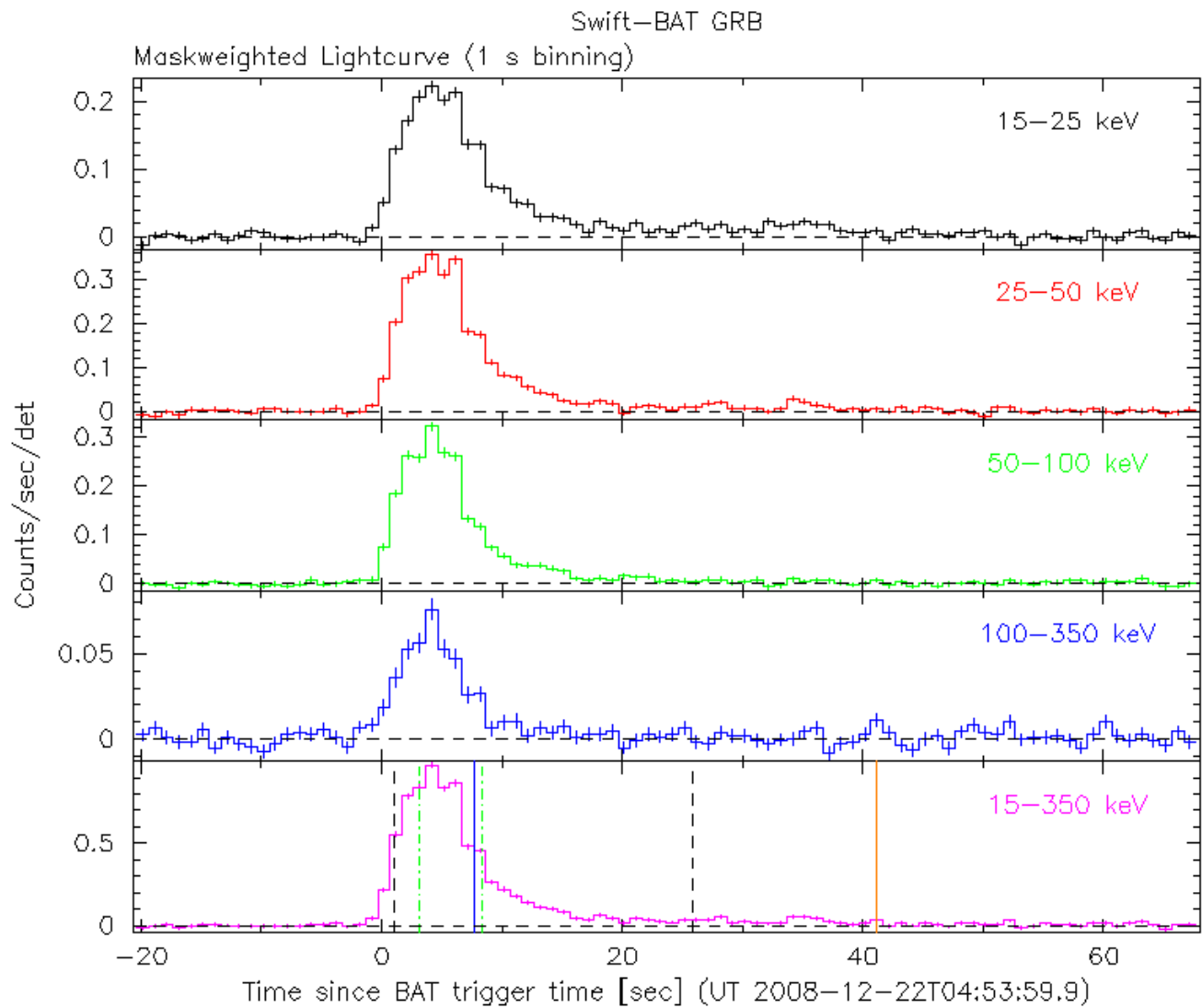| Filter	T_{Start}	T_{stop}	Exposure	Mag
white	60	210	147	14.84±0.02
white	873	1023	147	17.36±0.03
v	602	622	20	16.20±0.02
b	528	548	20	16.86±0.02
u	272	522	246	16.32±0.03
uvw1	652	1815	142	>20.9 (3σ UL)
uvm2	627	1790	127	>21.0 (3σ UL)
uvw2	577	1914	124	>21.1 (3σ UL)

Table 1: Magnitudes from UVOT observations of GRB 081222
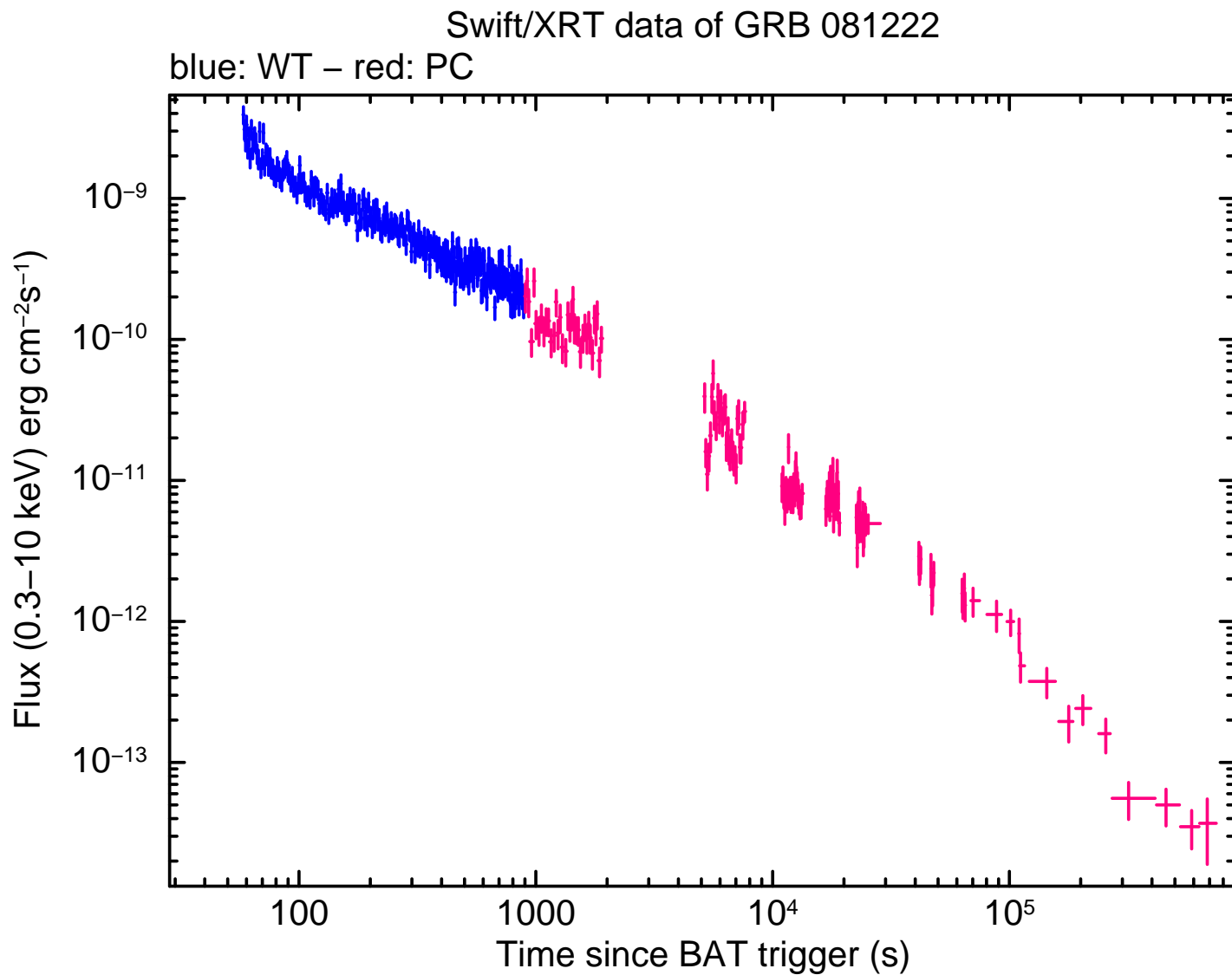
Figure 1: BAT Light curves of GRB 081222.

Figure 2: XRT flux light curve in the 0.3-10 keV band. The approximate conversion is 1 count s^{-1} = $\sim 3.32 \times 10^{-11}$ $ergs$ $s^{-1}cm^{-2}$ for an observed flux.