Swift Observation of GRB 080212

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1   Introduction

BAT triggered on GRB 080212 at 17:34:33.46 UT (Trigger 303105) (Ziaeepour, et al., *GCN Circ.* 7296). This was a 4.096 sec rate-trigger with significance of 10.53 on a long multi-peak burst with $T_{90} = 122.788$ sec. Swift slewed to this burst immediately and XRT began follow-up observations at $T + 106$ sec, and UVOT began its finding chart exposure $T + 109$ sec. In the reanalyzed UVOT data a faint varying afterglow was found (De Pasquale and Ziaeepour, *GCN Circ.* 7307). This source is very close to a K-star (Berger *GCN Circ.* 7294, *GCN Circ.* 7304). Our best position is the UVOT location at RA($J2000$) = 231.147500 deg ($15h24m35.40s$), Dec($J2000$) $= -22.741528$ deg ($-22d44'29.50$") with an error of 1.0 arcsec (radius, 90% confidence).

The opt/IR afterglow was also found by Gualba Obs. telescope (Sànchez Caso, et al., *GCN Circ.* 7301) in V,R, and I REM in H band (D'Avanzo, et al., *GCN Circ.* 7302, *GCN Circ.* 7310), GROND in g,r,i,z,J,H, and K (Kuepcue Yoldas, et al., *GCN Circ.* 7303), MITSuME in g', Rc, and Ic (Yoshida, et al., *GCN Circ.* 7305), VLT (D'Avanzo, et al., *GCN Circ.* 7311), Mount Abu telescope (Lokesh, et al., *GCN Circ.* 7321). The observation of the afterglow up to g' band put an upper limit of $z < 3.5$ on the redshift of this burst (Kuepcue Yoldas, et al., *GCN Circ.* 7303). No radio afterglow was detected at $\sim T + 20h$ (Chandra, et al., *GCN Circ.* 7308).

2   BAT Observation and Analysis

Using the data set from $T - 239$ to $T + 963$ sec, further analysis of BAT GRB 080212 has been performed by Swift team (McLean, et al., *GCN Circ.* 7306). The BAT ground-calculated position is RA($J2000$) = 231.145 deg ($15h24m34.8s$), Dec($J2000$) $= -22.739$ deg ($-22d44'19$") ± 1.5 arcmin, (radius, systematic and statistical, 90% containment). The partial coding was 35% (the offset angle was 41.58 deg).

The mask-weighted 1-sec binned light curves (Fig.1) show the main burst activity starting at about $T - 60$ sec, the highest peak is at $\sim T + 5$ sec, and the main gamma-ray activity ends at about $T + 110$ sec. 10-sec binned light curves show a soft extended precursor detected only in $15 - 25$ keV and $25 - 50$ keV from about $T - 170$ sec to $T - 100$ sec. There is also a weak peak at $T + 250$ to $T + 350$ sec, which matches the flare in the XRT light curve peaking at about $T + 250$ sec. T_{90} ($15 - 350$ keV) is 123 ± 13 sec (estimated error including systematics).

The time-averaged spectrum from $T - 60.5$ to $T + 75.7$ sec is best fitted by a power law with an exponential cutoff model. This fit gives a photon index of 0.31 ± 0.64 and E_{peak} of 67.6 ± 13.1 keV ($\chi^2 = 52.75$ for 56 d.o.f.). For this model the total fluence in the $15 - 150$ keV band is $(2.9 \pm 0.3) \times 10^{-6}$ergs cm^{-2}and the 1-sec peak flux measured from $T + 3.75$ *sec* in the $15 - 150$ keV band is 1.2 ± 0.3 ph cm^{-2} sec^{-1}. A fit to a simple power law gives a photon index of 1.59 ± 0.12 ($\chi^2 = 68.06$ for 57 d.o.f.). All the quoted errors are at the 90% confidence level.

3   XRT Observations and Analysis

Using all the available data of the XRT for GRB 080212 the enhanced Swift-XRT position is RA($J2000$) = 231.14749 deg ($15h24m35.40s$), Dec($J2000$) =-22.74154 deg ($-22d44'29.5$")± 2.0 arcsec (90% confi-

dence) (Goad, et al., *GCN Circ.* 7300). This position is within 3.54 arcsec of the initial XRT position (Ziaeepour, et al.*GCN Circ.* 7296).

The $0.3 - 10$ keV light curve (Fig.2) shows an initial steep decline with a slope of $\sim 3.8 \pm 0.3$ until $\sim T + 160$ sec when a significant flare begins. Its maximum occurs at about $T + 250$ sec and it breaks to a shallow slope regime after $\sim T + 450$ sec. From $\sim T + 3.5$ ksec until the last XRT observation at about 2×10^5 sec the XRT light curve can be fit by a power-law with $\alpha = 1.16 \pm 0.04$ (Page, et al., *GCN Circ.* 7299). Nonetheless, the light curve includes many small flares and the fit is only a representation of the average decline.

There is strong spectral evolution during the main flare. A spectrum formed from the subsequent Photon Counting (PC) mode data can be modelled with an absorbed power-law, with $\Gamma = 2.3 \pm 0.2$ and $nH = (2.1 \pm 0.4) \times 10^{21}$ cm^{-2}, significantly in excess of the Galactic value of 7.26×10^{20} cm^{-2}. The $0.3 - 10$ keV observed (unabsorbed) flux during this time ($\sim 3.5 - 12$ ksec after the trigger) is 8.4×10^{-12} (1.5×10^{-11}) ergs cm^{-2} sec^{-1}(Page, et al., *GCN Circ.* 7299).

4   UVOT Observation and Analysis

The UVOT began observing the field of GRB 080212 about 109 sec after the initial BAT trigger (De Pasquale & Ziaeepour, *GCN Circ.* 7307). A source is detected in the enhanced XRT error circle (Goad, et al., *GCN Circ.* 7300), blended with the K-type star (Berger, *GCN Circ.* 7294, *GCN Circ.* 7304). Its position is RA($J2000$) = 231.147500 deg ($15h24m35.40s$), Dec($J2000$) = -22.741528 deg ($-22d44'29.50$") with an error of 1.0 arcsec (radius, 90% confidence). The detection is only in the early V band exposures. There is no other 3-sigma detection of the afterglow in any exposure in other UVOT filters. The photometry for this burst has been carried out in very difficult conditions due to the blending with the K-star. Moreover, no correction has been made for the non-negligible Galactic extinction towards the burst, which amounts to E(B-V) = 0.16.

The detections and 3-sigma upper limits in the UVOT photometric system (Poole, et al., MNRAS, 383 (2008) 627) are summarized in the following table:

Filter	T_{start} (sec)	T_{stop} (sec)	Exposure (sec)	Mag/3-Sigma UL
V	110	510	393	18.6 ± 0.1
V	4734	6166	393	> 19.7
V	21968	22876	893	> 20.2
B	4323	4522	393	> 20.8
B	11320	40999	1774	> 21.2
U	4119	5548	393	> 20.3
U	10408	40703	3400	> 21.5
UVW1	3919	5344	393	> 20.0
UVW1	9502	50920	4309	> 21.2
UVM2	3741	6300	323	> 19.3
UVM2	15290	45066	3413	> 20.6
UVW2	4529	5961	393	> 19.4
UVW2	21062	21961	893	> 20.7

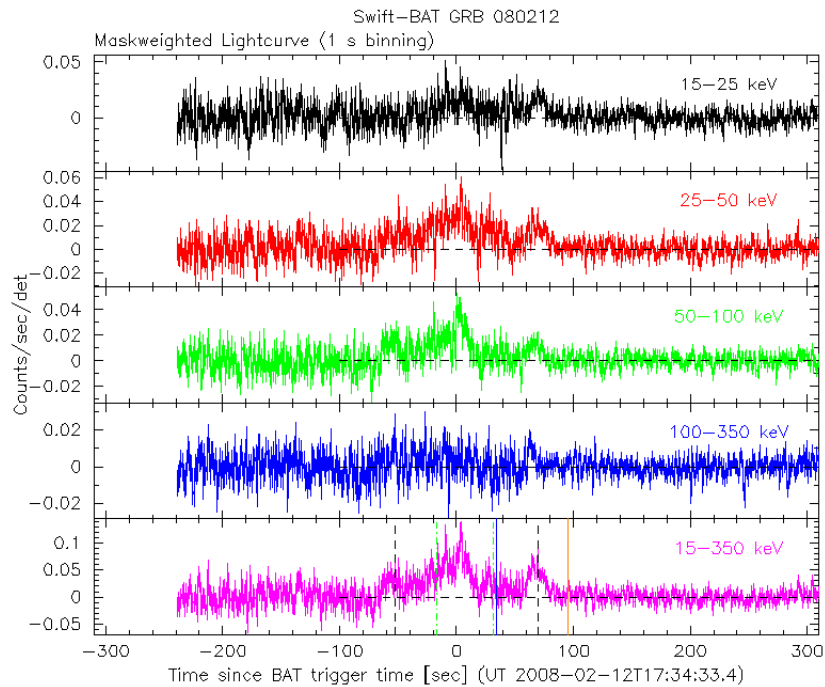Table 1: Magnitudes and upper limits from UVOT observations

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 and T_0 is $17 : 34 : 33.46$ UT.
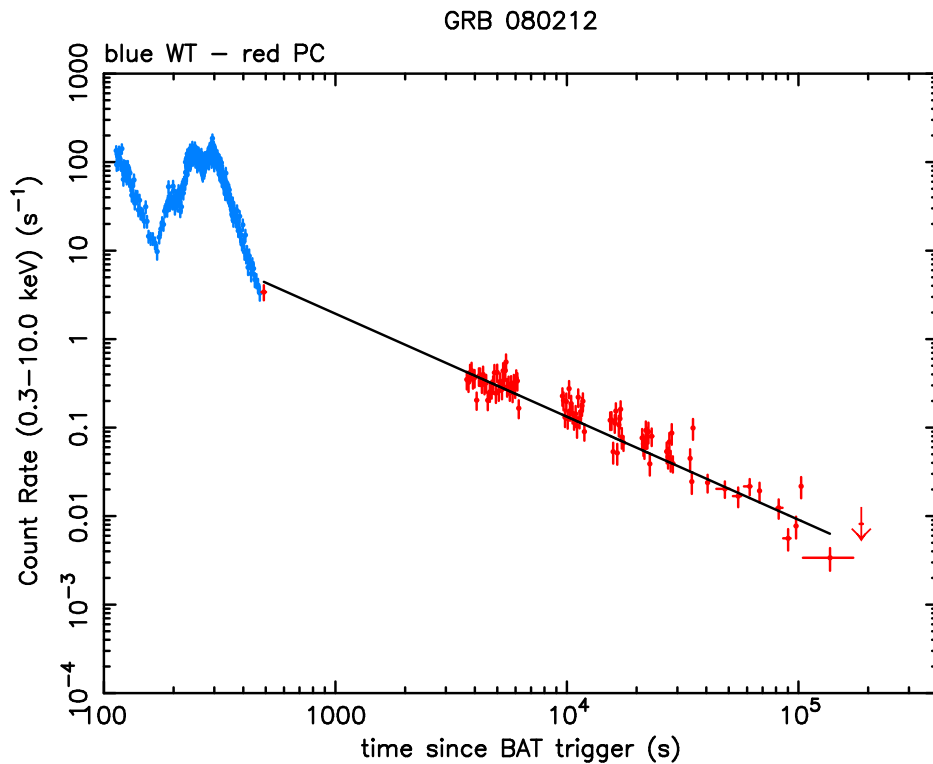

Figure 2: XRT light curve in the $0.3 - 10$ keV band: Windowed Timing (WT) mode (blue), Photon Counting (PC) mode (red). The approximate conversion factor to absorbed flux is 1 count/sec $\sim 4.0 \times 10^{-11}$ ergs cm^{-2} sec^{-1} and to unabsorbed flux 1 count/sec $\sim 7.14 \times 10^{-11}$ ergs cm^{-2} sec^{-1}.