

## Swift Observation of GRB 061222A

*D. Grupe (PSU), J. Cummings (GSFC), L. Barbier (GSFC), S. D. Barthelmy (GSFC), S.R Oates(UCL-MSSL), M. Chester (PSU), D.N. Burrows (PSU), P. Roming (PSU), and N. Gehrels (GSFC) for the Swift Team*

### 1 Introduction

BAT triggered on GRB 061222A at 03:28:52 UT (Trigger 252588) (Grupe, *et al.*, *GCN Circ.* 5954). This burst is a long burst with an observed  $T_{90} = 72 \pm 3$  s. Swift slewed to this burst immediately and XRT began follow-up observations at  $T + 101$  s, and UVOT at  $T + 92$  s. Our best position is the XRT location  $RA(J2000) = 358.263708$  deg (23h53m03.29s),  $Dec(J2000) = +46.53297$  deg (+46d31'58.7") with an error of 3.5 arcsec (90% confidence, including boresight uncertainties) as reported in Grupe *GCN Circ.* 5966.

### 2 BAT Observation and Analysis

Using the data set from  $T - 240$  s to  $T + 302$ s, further analysis of BAT GRB 061222A has been performed by Swift team (Tueller, *et al.*, *GCN Circ.* 5964). The BAT ground-calculated position is  $RA(J2000) = 358.258$ deg (23h53m01.9s),  $Dec(J2000) = +46.527$  deg (+46d31'37.3")  $\pm 1.2$  arcmin, (radius, systematic and statistical, 90% containment). The partial coding was 70%.

The masked-weighted light curves (Fig.1) show the emission starting at  $T - 100$  s with a small peak at  $T_0$ , and then a 10-s FRED peak starting at  $T + 25$  s. It is followed by two 10-s peaks at  $T + 50$  and  $T + 65$  s; then a large peak at  $T + 88$  s with a FWHM of 12 s and the emission returns to background at  $T + 115$  s.  $T_{90}(15 - 350$ keV) is  $72 \pm 3$  (estimated error including systematics).

The time-averaged spectrum from  $T - 2.5$ s to  $T + 117.7$ s is best fitted by a simple power law model. This fit gives an energy spectral index of  $\beta_\gamma = 0.39 \pm 0.04$ , ( $\chi^2 = 44.4$  for 57 d.o.f.). For this model the total fluence in the 15 – 150 keV band is  $(8.3 \pm 0.3) \times 10^{-6}$  ergs cm $^{-2}$  and the 1-s peak flux measured from  $T + 86.54$ s in the 15 – 150 keV band is  $9.2 \pm 0.3$  photons cm $^{-2}$  s $^{-1}$ . All the quoted errors are at the 90% confidence level.

### 3 XRT Observations and Analysis

Using the data from the first seven orbits of XRT data of GRB 061222A (13.7 ks in Photon Counting mode, 117 s in Windowed Timing mode), the refined XRT position is  $RA(J2000) = 358.263708$  deg (23h53m03.29s),  $Dec(J2000) = +46.53297$  deg (+46d31'58.7")  $\pm 3.5$  arcsec (90% confidence, including boresight uncertainties) as reported by Grupe *GCN Circ.* 5966. This position is within 1.8 arcsec of the initial XRT position reported by Grupe *et al.*, *GCN Circ.* 5954.

The 0.3 – 10 keV light curve (Fig.2) shows an initial steep decline with a slope of  $\alpha_1 = 5.38 \pm 0.13$ , following by a shallow slope of  $\alpha_2 = 0.26 \pm 0.03$ , beginning at  $T + 250 \pm 50$ s. At  $(5.8 \pm 1.0)$  ks the light curve breaks with a slope of  $\alpha_3 = 1.15 \pm 0.11$ .

The initial Windowed Timing mode spectrum can be fitted by an absorbed single power law with an absorption column density  $N_H = (4.7 \pm 0.3) \times 10^{21}$  cm $^{-2}$  and an energy spectral index  $\beta_X = 1.34 \pm 0.08$  with  $\chi^2 = 164$  with 163 dof. The free-fit absorption column density is significantly in excess of the

Galactic value of  $N_{\text{H,gal}} = 1.0 \times 10^{21}$  (Dickey & Lockman 1990). Following the relation given in Grupe et al. 2006 (AJ submitted, astro-ph/0612104) the high excess absorption column density suggests that this burst is at a redshift  $z < 3.0$ . Note that the hardness ratios of the WT data suggest a dramatic change in the spectrum within minutes. The later PC mode data can also be fitted by an absorbed power law spectrum with a free-fit absorption column density  $N_{\text{H}} = (4.1 \pm 0.3) \times 10^{21} \text{ cm}^{-2}$  and an energy spectral index  $\beta_{\text{X}} = 1.15 \pm 0.08$ .

## 4 UVOT Observation and Analysis

The UVOT began observing the field of GRB 061222A at 03:30:24 UT, 92 s after the initial BAT trigger (Oates *et al.*, *GCN Circ.* 5973). No new source was detected within the XRT error circle in the white (209 s) and V (615 s) finding exposures, or in the co-added images in any filter down to 3-sigma magnitude. Upper limits are summarized in Table 1. These upper limits are not corrected for Galactic extinction  $E(\text{B-V}) = 0.099$  (Schlegel et al. 1998).

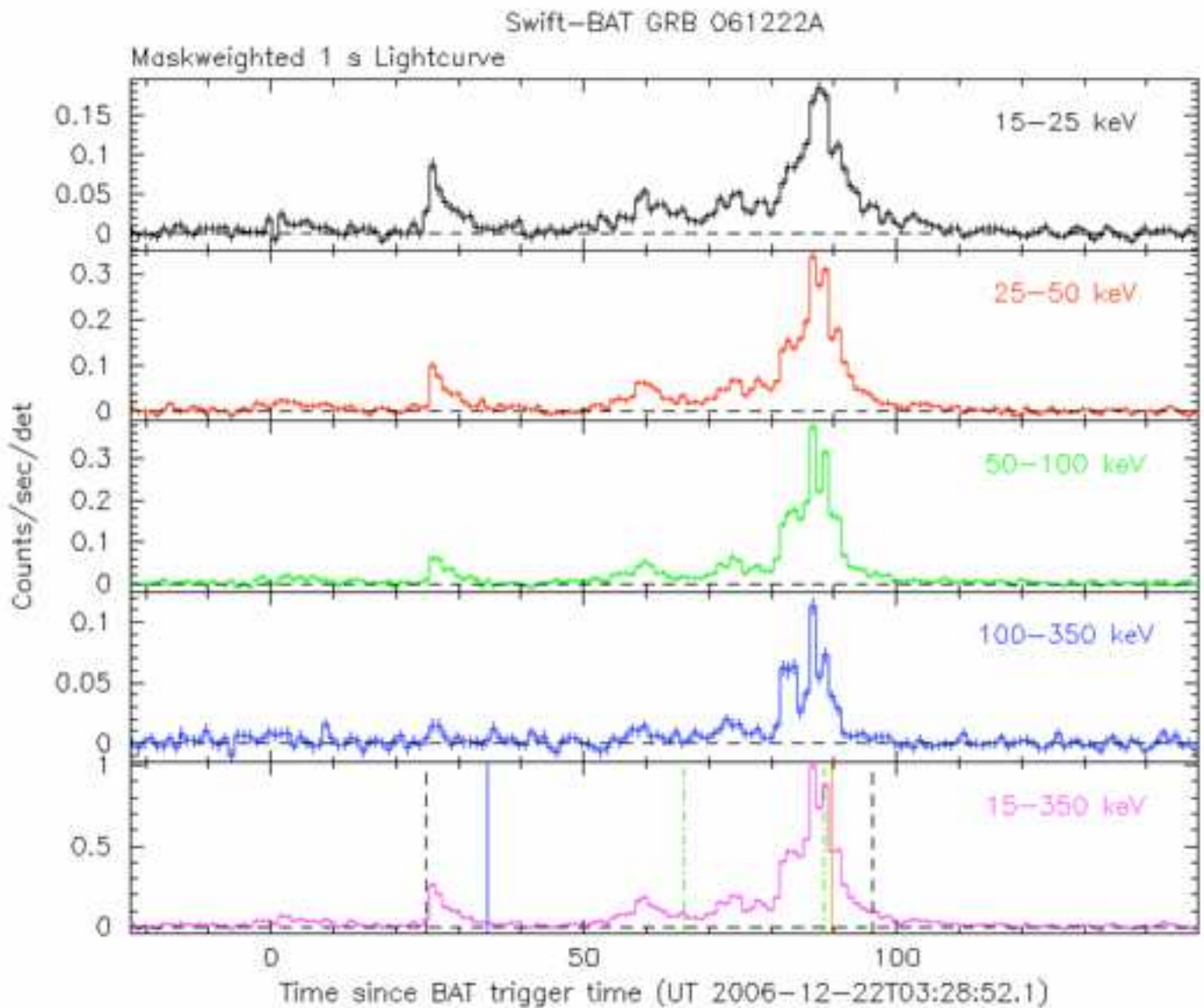


Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts  $s^{-1}$  illuminated-detector $^{-1}$  and  $T_0$  is 03:28:52 UT.

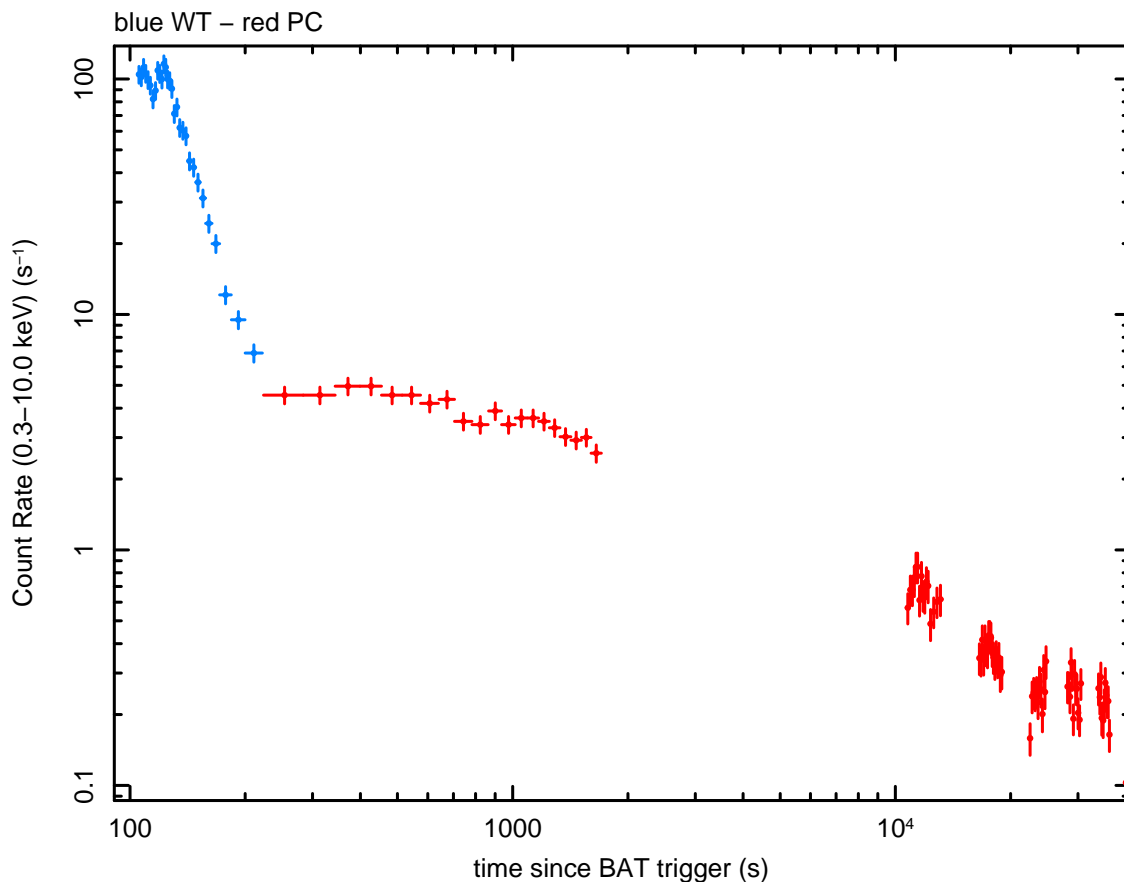


Figure 2: XRT Lightcurve. Counts  $s^{-1}$  in the 0.3-10 keV band: Window Timing mode (blue), Photon Counting mode (red). The approximate conversion is  $1 \text{ count } s^{-1} = \sim 1 \times 10^{-11} \text{ ergs } s^{-1} \text{ cm}^{-2} \text{ counts}^{-1} s$ .

Filter	Start	Stop	Exposure	3-Sigma UL
WHITE (finding)	215	615	393	19.6
V (finding)	111	209	97	20.0
V	745	24842	5310	20.4
B	693	24112	2713	20.8
U	669	1591	78	19.4
UVW1	645	1711	83	19.2
UVM2	621	1701	97	19.3
UVW2	721	1653	58	19.3
WHITE	110	1629	322	20.6

Table 1: Magnitude limits from UVOT observations