Swift Observation of GRB 070330

D. Grupe (PSU), C. Markwardt (U.Md. & NASA/GSFC), Hans Krimm (GSFC), S. D. Barthelmy (GSFC), Paul Kuin (UCL-MSSL), Patricia Schady (UCL-MSSL), Peter Brown (PSU), M. Chester (PSU), Jamie Kennea (PSU, D.N. Burrows (PSU), P. Roming (PSU), and N. Gehrels (GSFC) for the Swift Team

1 Introduction

BAT triggered on GRB 070330 at 22:51:31 UT (Trigger 273180) (Grupe, *et al.*, *GCN Circ.* 6232). This burst is a long burst with an observed $T_{90} = 9\pm1$ s. Swift slewed to this burst immediately and XRT began follow-up observations at $T+68$ s, and UVOT at $T+54$ s. Our best position is the UVOT V-Filter location RA($J2000$) $= 269.5426$ deg ($17h58m09.94s$), Dec($J2000$) $= -63.7930$ deg ($-63d47'36.1''$) as reported in Kuin et al. *GCN Circ.* 6238.

2 BAT Observation and Analysis

Using the data set from $T-240$ s to $T+963$s, further analysis of BAT GRB 07330 has been performed by the Swift team (Fenimore, *et al.*, *GCN Circ.* 6237). The BAT ground-calculated position is RA($J2000$) $= 269.533deg$ ($17h58m07.9s$), Dec($J2000$) $= -63.799$ deg ($-63d47'54.7''$) ± 1.9 $arcmin$, (radius, systematic and statistical, 90% containment). The partial coding was 80%.

The masked-weighted light curves (Fig.1) shows a single FRED-like peak. $T_{90}(15 - 350keV)$ is 9 ± 1 s (estimated error including systematics).

The time-averaged spectrum from $T - 1.1$s to $T + 8.9$s is best fitted by a power law model with exponential cutoff. This fit gives a photon spectral index of $\Gamma = -0.33 \pm 1.76$ and $E_{peak} = 36.3 \pm 6.1$ keV, ($\chi^2 = 56.1$ for 56 d.o.f.). For this model the total fluence in the $15 - 150$ keV band is $(1.8 \pm 0.3) \times 10^{-7}$ ergs cm^{-2} and the 1-s peak flux measured from $T - 0.06$s in the $15 - 150$ keV band is 0.9 ± 0.1 photons cm^{-2} s^{-1}. A fit to a simple power law gives a photon index of $\Gamma = 2.06 \pm 0.22$ (χ^2 66.7 for 57 d.o.f.). All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

Using the data from the first 127 ks after the burst of XRT data of GRB 070330 (34.5 ks in Photon Counting mode), the refined XRT position is RA($J2000$) $= 269.5407$ deg ($17h58m09.8s$), Dec($J2000$) $= -63.7934$ deg ($-63d47'36.1''$) ($3.6''$ error circle ,90% confidence, including boresight uncertainties) as reported by Grupe *GCN Circ.* 6234. This position is within 0.4 $arcsec$ of the initial XRT position reported by Grupe *et al.*, *GCN Circ.* 6232.

The $0.3 - 10$ keV light curve (Fig.2) shows a flare with a peak at about 210s after the burst and an initial decline after the peak with a slope of $\alpha_1 = 3.49 \pm 0.26$, following by a shallow slope of $\alpha_2 = 0.53 \pm 0.20$, beginning at $T + 1000 \pm 200$s. After a third break at about 20ks after the burst the decay steepens again with a decay slope $\alpha_3 = 1.37 \pm 0.16$.

The initial Photon Counting mode spectrum can be fitted by an absorbed single power law with an absorption column density consistent with the Galactic value ($N_{H,gal} = 7.14 \times 10^{20}$; Dickey & Lockman 1990) and a photon spectral index $\Gamma = 1.91 \pm 0.14$. Following the relation given in Grupe

et al. 2007 (AJ in press, astro-ph/0612104) the consistency of the absorption parameter with the Galactic absorption column density suggest a burst possibly at high redshift.

4   UVOT Observation and Analysis

The UVOT began observing the field of GRB 070330 54 s after the initial BAT trigger (Kuin *et al.*, *GCN Circ.* 5973). The afterglow is clearly detected in V with V =18.69$\pm$0.24 mag in the first exposure, but was not detected in the following V exposures or in any of the other UVOT filters. Due to a 7th mag bright star no observations were obtained in White and UVW2. The non-detection in all following V exposures suggests a decay slope α_V >0.8. The V detection and upper limits are summarized in Table 1. These magnitudes are not corrected for Galactic extinction E(B-V) = 0.063 (Schlegel et al. 1998).
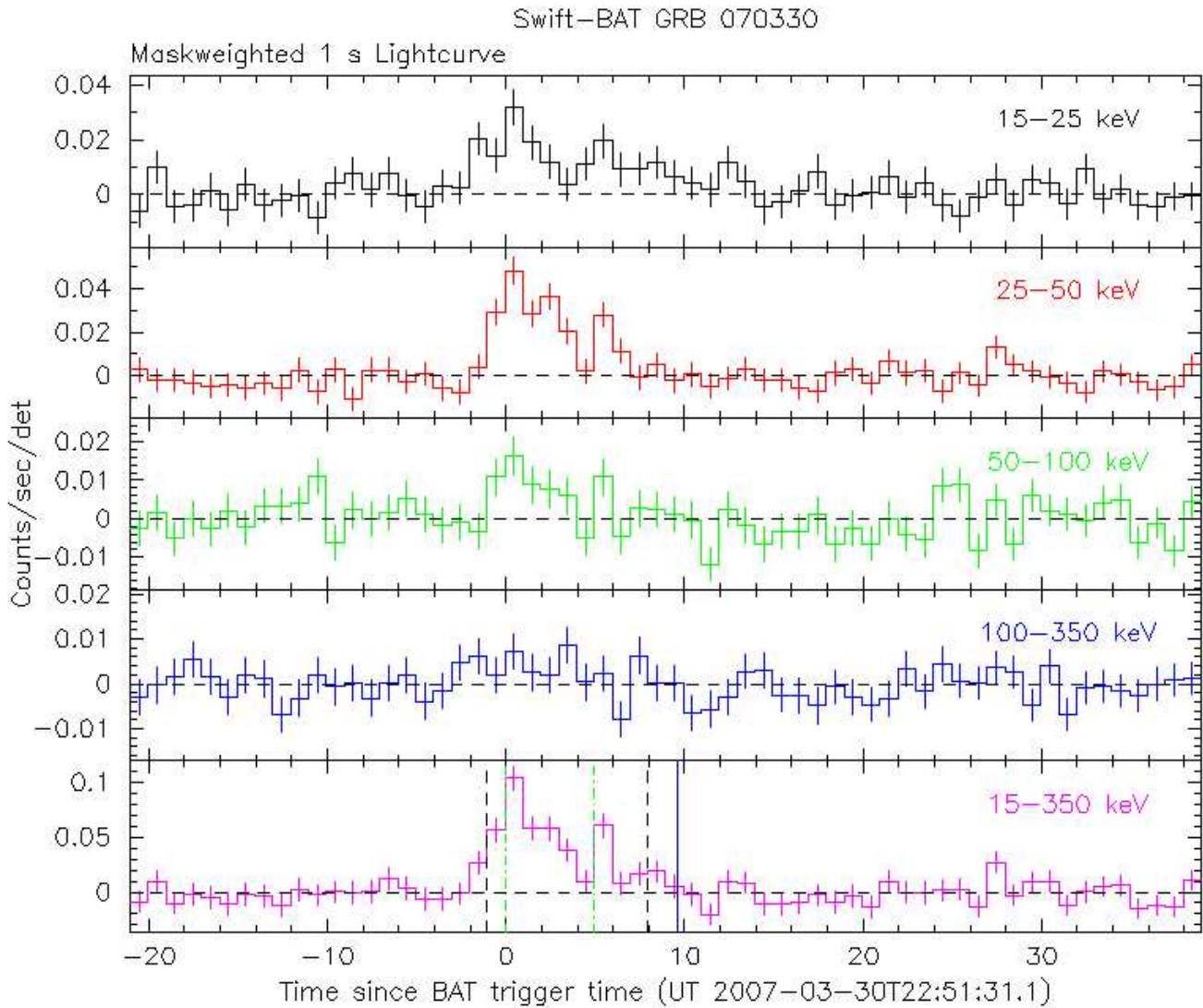
Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts s^{-1} illuminated-detector^{-1} and T_0 is 2007-March-30 22:51:31 UT.

Filter	T_{mid}	Exposure	Mag
V	462	393	18.69±0.24
V	33978	1632	> 21.45 (3-σ upper limit)
UVM2	25521	2814	> 18.35 (3-σ upper limit)
' UVW1	20282	1998	> 18.36 (3-σ upper limit)
U	25521	2814	> 21.60 (3-σ upper limit)
B	30318	3305	> 18.15 (3-σ upper limit)

Table 1: Magnitude from UVOT observations

Swift/XRT data of GRB 070330

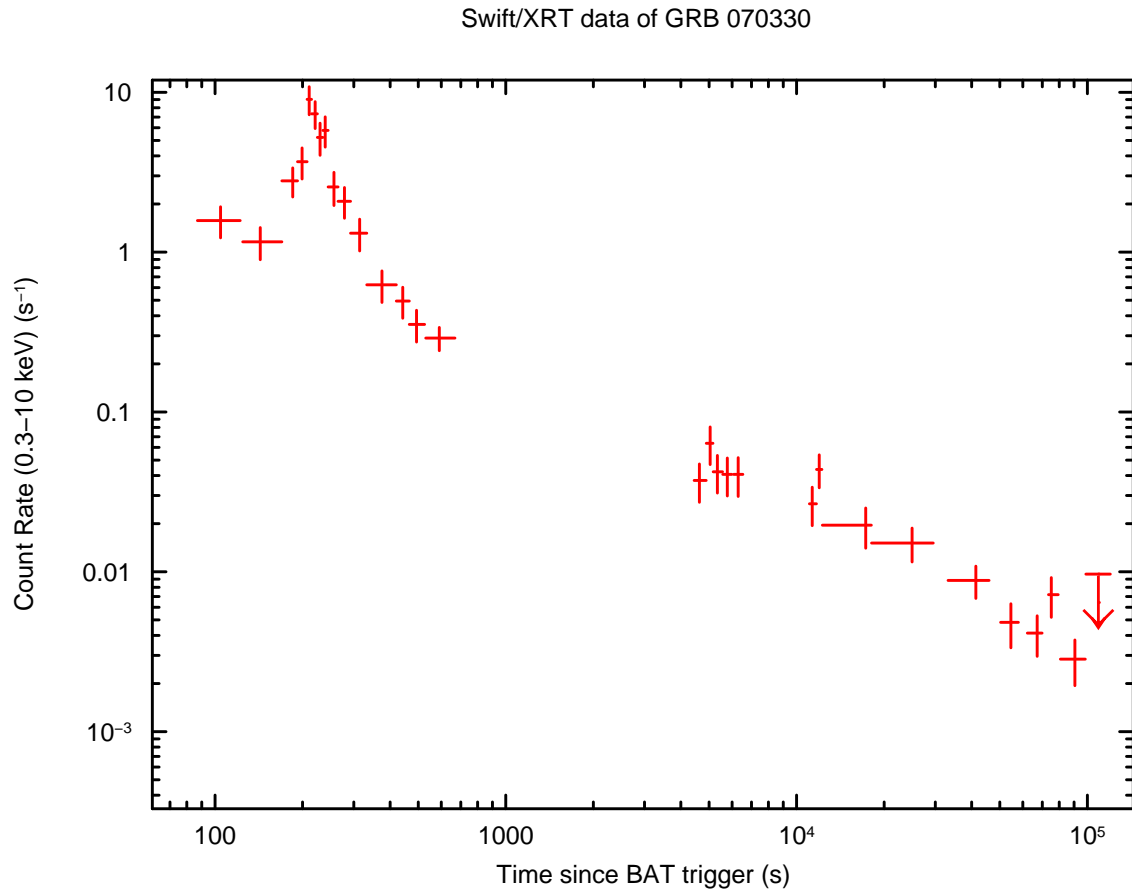Figure 2: XRT Lightcurve. Counts s^{-1} in the 0.3-10 keV band: Photon Counting mode (red). The approximate conversion is 1 count $s^{-1} = \sim 1.2 \times 10^{-10}$ $ergs\ s^{-1}cm^{-2}$ for an unabsorbed flux corrected for photon pileup.