Swift Observation of GRB 070721A
H. Ziaeepour (UCL/MSSL), S. D. Barthelmy (GSFC), T. Sakamoto (GSFC/ORAU), P.A. Evans, K.L. Page, (U. Leicester), P. Schady (MSSL-UCL) for the Swift Team

0 Revisions
The detection of a faint afterglow by the UVOT and a non-varying source in the XRT error circle by ground observation are added. The break in the XRT light curve as well as revised estimation of slopes are reported.

1 Introduction
BAT triggered on GRB 070721A at 10:00:56.4 UT (Trigger 285653) (Ziaeepour, et al., GCN Circ. 6639). This was a 1.02 sec rate-trigger with significance of 6.1 on an intermediate length burst with $T_{90} = 3.868$ sec. Swift slewed to this burst immediately and XRT began follow-up observations at $T + 86$ sec, and UVOT at $T + 69$ sec. Our best position is the XRT location RA(J2000) = 3.16348 deg (00 h 12 m 39.24 s), Dec(J2000) = 28.55017 deg (28d22'00.6") with an error of 2.3 arcsec (90% confidence, including boresight uncertainties). However, in the UVOT reanalyzed data a faint afterglow was found (Marshall, et al., GCN Circ. 6676). Its coordinates are: RA(J2000) = 3.16343 deg (00 h 12 m 39.22 s), Dec(J2000) = 28.55020 deg (28d22'00.7") . The NOT and VLT observations (Malesani, et al., GCN Circ. 6674) detect a non-varying source in the XRT error circle at RA(J2000) = 00 h 12 m 39.13 s and Dec(J2000) = 28d22'00.9" with R $\sim$ 22.9 ± 0.1 mag. This source seems to be point-like. No other source is found in the XRT error circle.

2 BAT Observation and Analysis
Using the data set from $T − 119$ to $T + 183$ sec, further analysis of BAT GRB 070721A has been performed by Swift team (Palmer, et al., GCN Circ. 6643). The BAT ground-calculated position is RA(J2000) = 3.144 deg (00h12m34.5s), Dec(J2000) = 28.530 deg (28d31'47") ± 2.3 arcmin, (radius, systematic and statistical, 90% containment). The partial coding was 72% (the offset angle was 30.63 deg).

The masked-weighted light curves (Fig.1) starts at trigger time $T − 4$ sec with a single rapidly rising peak, and returns to background at about $T + 8$ sec. $T_{90}$ (15 − 350 keV) is 3.4 ± 0.2 (estimated error including systematics).

The time-averaged spectrum from $T − 0.1$ to $T + 3.7$ sec is best fitted by a simple power law model. This fit gives a photon index of 2.46 ± 0.41, ($\chi^2 = 52.84$ for 57 d.o.f.). For this model the total fluence in the 15 − 150 keV band is (7.1 ± 1.8) $\times$ 10$^{-8}$ergs cm$^{-2}$and the 1-sec peak flux measured from $T + 0.12$ sec in the 15 − 150 keV band is 0.7 ± 0.1 ph cm$^{-2}$ sec$^{-1}$. All the quoted errors are at the 90% confidence level.

We note that the fluence ratio in a simple power-law fit between the 25 − 50 keV band and the 50 − 100 keV band is 1.38. This fluence ratio is larger than 1.32 which can be achieved in the Band function of $\alpha = -1.0$, $\beta = -2.5$, and $E_{peak} = 30$ keV. Thus, preliminary analysis shows that $E_{peak}$ of the burst is very likely around or below 30 keV. Therefore the burst can be classified as an X-ray flash.
3 XRT Observations and Analysis

Using all the available data of the XRT for GRB 070721A the refined XRT position is RA(J2000) = 3.16348 deg (00h12m39.24s), Dec(J2000) = −28.55017 deg (−28d33′00.6″) ± 2.3 arcsec (90% confidence, including boresight uncertainties). This position is within 3.2 arcsec of the initial XRT position (Ziaeepour, et al. GCN Circ. 6639).

The 0.3 − 10 keV light curve (Fig.2) shows an initial steep decline with a slope of 2.98±0.51 until $T + 279^{+72}_{-53}$ sec, following by a shallow slope of 0.71±0.069 that lasts until $T + 114000^{+43600}_{-11200}$ and then breaks to a slope of 1.27±1.20.

The Photon-Counting X-ray data can be modeled with an absorbed power-law with spectral index of 2.30±0.42. The NH column density is $6.11^{+7.8}_{-5.2} \times 10^{20}$ cm$^{-2}$, consistent with the galactic column density, $6.01 \times 10^{20}$ cm$^{-2}$. The average observed (unabsorbed) flux over 0.3 − 10 keV for this spectrum (spanning a time from 86 sec to $3 \times 10^4$ sec after the trigger) is $6.53 \times 10^{-12}$ ergs cm$^{-2}$ sec$^{-1}$.

4 UVOT Observation and Analysis

The UVOT began observing the field of GRB 070721A at 10:02:05 UT, 69 sec after the initial BAT trigger (Schady et al., GCN Circ. 6648). No new source was detected within the XRT error circle in the White (156 sec) and V (453 sec) 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 $E(B-V) = 0.1$. A reanalysis of the UVOT data (Marshall, et al., GCN Circ. 6676) finds a fading afterglow in the exposures starting at $T + 88$ sec for 100 sec in White and at $T + 194$ sec for 400 sec in V. The corresponding magnitudes are respectively 21.4 mag (2.4σ detection) and 20.2 mag (3.4σ detection). The position of this source is: RA(J2000) = 3.16343 deg (00h12m39.22s), Dec(J2000) = −28.55020 deg (−28d22′00.7″).

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Table 1: Magnitude 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 10:00:56.3 UT.

Figure 2: XRT light curve in the 0.3 – 10 keV band: Window Timing mode (blue), Photon Counting mode (red). The approximate conversion factor to absorbed flux is 1 count/sec \( \sim 4.267 \times 10^{-11} \) ergs cm\(^{-2}\) sec\(^{-1}\) and to unabsorbed flux 1 count/sec \( \sim 5.450 \times 10^{-11} \) ergs cm\(^{-2}\) sec\(^{-1}\).