Swift Observations of GRB 110521A

S. R. Oates (MSSL-UCL), C. Markwardt (GSFC), T. Sakamoto (GSFC/UMBC), O. M. Littlejohns (U. Leicester), S.D. Barthelmy (GSFC), D.N. Burrows (PSU), M. H. Siegel (PSU) and N. Gehrels (NASA/GSFC) report for the Swift Team

1 Introduction

BAT detected GRB 110521A at 15:51:32 UT on the 21^{st} May 2011 (Oates, *et al.*, *GCN Circ.* 12031). BAT detected GRB 110521A with a rate trigger at a significance of 17.88σ. The main emission was detected from ∼T+0 s to ∼T+18 s, and a low significance tail was observed untill ∼T+60 s. The $T_{90}(15-350$ keV) is 13.8 ± 3.3 s (estimated error including systematics).

Swift BAT slewed immediately to this burst, XRT observations and UVOT settled observations began ∼ 87 s and 105 s respectively, after the BAT trigger (Target ID 453788). A source was detected by the XRT, but not by the UVOT (Beardmore, *et al.*, *GCN Circ.* 12034; Oates, *et al.*, *GCN Circ.* 12039). Our best position is the XRT location RA($J2000$) = 120.13290 *deg* ($08h\ 00m\ 31.90s$), Dec($J2000$) = +45.82648 *deg* ($+45d\ 49'\ 35.3''$) with an error of 1.8 arcsec (radius, 90% containment). Observations were also performed by MASTER (Gres, *GCN Circ.* 12033; Gorbovskoy, *GCN Circ.* 12040), INTEGRAL/SPI-ACS (Beckmann, private communication) and NOT (Schulze, *et al.*, *GCN Circ.* 12036).

2 BAT Observation and Analysis

Using the data set from T-239 to T+529 sec, we report on the BAT refined analysis of GRB 110521A (trigger 453788) (Oates, *et al.*, *GCN Circ.* 12031). The BAT ground-calculated position is RA, Dec = 120.132, 45.818 *deg*, which is:

RA(J2000) = $08h\ 00m\ 31.7s$
Dec(J2000) = $+45d\ 49'\ 05.3$”

with an uncertainty of 1.8 arcmin, (radius, sys+stat, 90% containment). The partial coding was 100%.

The mask-weighted light curve, see Fig. 1, shows several overlapping peaks starting at ∼T+0 s, with the maximum peak at ∼T+8 s, and ending at ∼T+18 s. There is a low significance tail out to around T+60 s. The $T_{90}(15-350$ keV) is 13.8 ± 3.3 s (estimated error including systematics).

The time-averaged spectrum from T+0.2 to T+18.8 s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 0.90±0.22. The fluence in the 15-150 keV band is $(4.4 \pm 0.5) \times 10^{-7}$ erg cm^{-2}. The 1-sec peak photon flux measured from T+7.88 s in the 15-150 keV band is 0.5 ± 0.1 ph cm^{-2} s^{-1}. 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/453788/BA/`

3 XRT Observations and Analysis

The XRT began observations of GRB 110521A 87 s after the BAT trigger.

The XRT found a bright, fading, uncatalogued X-ray source located at RA, Dec = 120.13290, +45.82648 *deg* which is equivalent to:

RA (J2000): $08h\ 00m\ 31.90s$
Dec (J2000): $+45d\ 49'\ 35.3$"

with an uncertainty of 1.8 arcsec (radius, 90% confidence).

We analyzed 21 ks of XRT data for GRB 110521A, from 87 s to 47.7 ks after the BAT trigger. The data comprise 61 s in Windowed Timing (WT) mode (the first 8 s were taken while Swift was slewing) and the remainder in Photon Counting (PC) mode.

The light curve can be modelled with a series of power-law decays. The initial decay index is $\alpha = 1.5^{+0.4}_{-0.3}$. At T+299 s the decay steepens to an α of $7.1^{+2.9}_{-1.3}$ before breaking again at T+529 s to a final decay with index $\alpha = 1.0^{+0.5}_{-1.9}$.

A spectrum formed from the PC mode data can be fitted with an absorbed power-law with a photon spectral index of $2.0^{+0.3}_{-0.6}$. The best-fitting absorption column is $4.3^{+1.5}_{-2.6} \times 10^{20}\mathrm{cm}^{-21}$, in excess of the Galactic value of $4.5 \times 10^{20}\mathrm{cm}^{-2}$ (Kalberla et al. 2005). The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is $4.7 \times 10^{-11}(7.9 \times 10^{-11})$ erg cm^{-2} count^{-1}.

The results of the XRT-team automatic analysis are available at:
`http://www.swift.ac.uk/xrt_products/00453788`

4 UVOT Observation and Analysis

The Swift/UVOT began settled observations of the field of GRB 110521A 105 s after the BAT trigger (Oates, *et al.*, *GCN Circ.* 12039). No optical afterglow consistent with the XRT position (Beardmore,*et al.*, *GCN Circ.* 12034) is detected in the UVOT exposures.

The results of the UVOT-team automatic analysis are available at:
`http://gcn.gsfc.nasa.gov/swift_gnd_ana.html`

The 3-sigma upper limits for the finding chart exposures (FC) and summed images provided in Table 1.

Filter	Start (s)	Stop (s)	Exposure (s)	Magnitude/3σ UL
white (FC)	105	255	147	>20.4
u (FC)	263	513	246	>20.0
white	105	6615	766	>21.0
v	594	41254	2261	>20.5
b	519	30377	1766	>21.1
u	263	36155	3624	>21.7
*uvw*1	644	35466	3860	>22.0
*uvm*2	618	41934	3564	>22.3
*uvw*2	570	40340	2262	>22.3

Table 1: Magnitude limit from UVOT observations. The values quoted above are not corrected for the expected Galactic extinction corresponding to a reddening of E(B-V) = 0.09 mag in the direction of the burst (Schlegel, Finkbeiner & Davis, 1998).

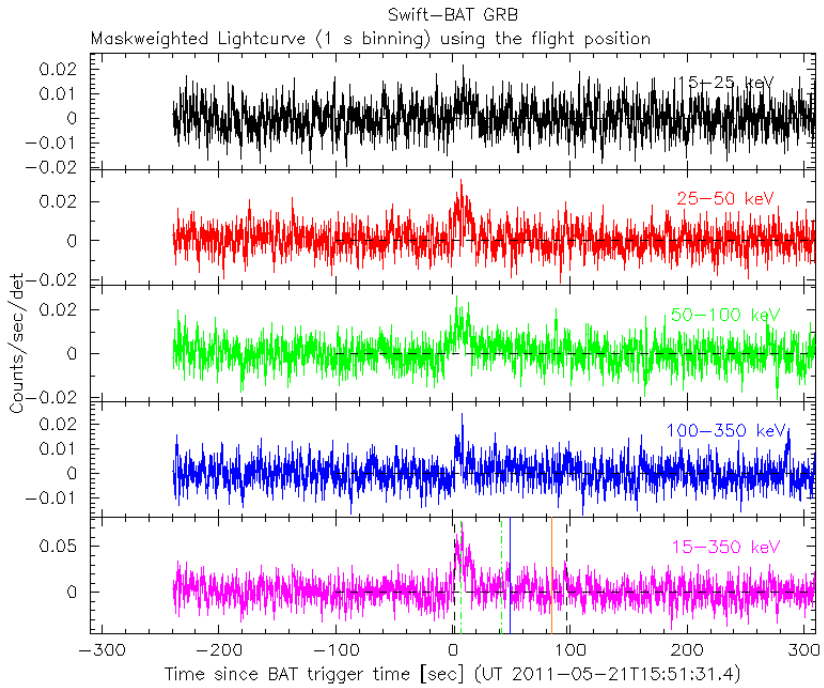

Figure 1: BAT light curve. The mask-weighted light curve in the 4 individual plus total energy bands: 15 - 25 keV (black), 25 - 50 keV (red), 50 - 100 keV (green), 100 - 350 keV (blue), 15 - 350 keV (magenta)

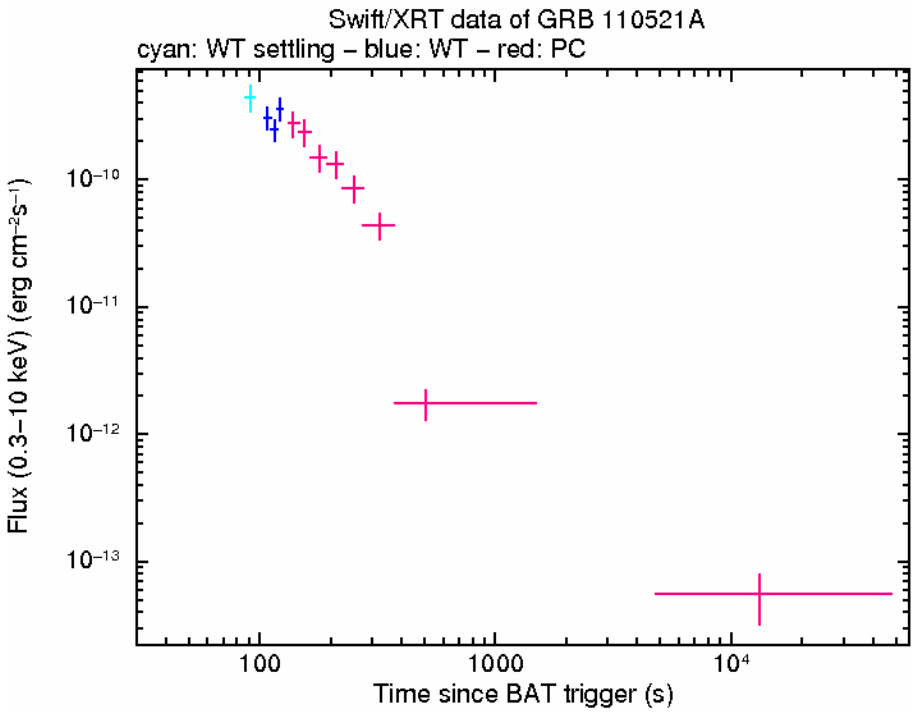

Figure 2: XRT light curve in the 0.3-10 keV band. The counts-to-observed-flux conversion factor is 1 count $= 4.7 \times 10^{-11}$ erg cm^{-2}.