Swift Observations of GRB 080411

F.E. Marshall (NASA/GSFC), O. Godet (U. Leicester), S. R. Oates (MSSL), S.D. Barthelmy
(NASA/GSFC), D.N. Burrows (PSU), P. Roming (PSU), and N. Gehrels (NASA/GSFC) for the Swift
Team

1. INTRODUCTION

At 21:15:32 UT, the Swift Burst Alert Telescope (BAT) triggered and located GRB 080411 (trigger
309010; Marshall *et al*. GCN Circ. 7584). Swift slewed immediately to the burst. Because the satellite was
in the SAA, little XRT data and no UVOT data were taken during the first hour after the trigger.

Kruehler *et al.* (GCN Circ. 7586) found an optical afterglow candidate, and Thoene *et al.* (GCN Circ. 7587)
reported a redshift of 1.03 based on several strong absorption lines. Oates and Marshall (GCN Circ. 7592)
showed that the afterglow candidate was decaying and reported the most accurate Swift position of RA
(J2000) = 02h 31m 55.19s and Dec (J2000) = -71° 18' 07.3" with an estimated error of 0.5". The position
is consistent with that reported by Kruehler *et al.*

The burst was also detected with Konus-Wind (Golenetskii *et al.* GCN Circ. 7589) and the INTEGRAL
SPI-ACS. INTEGRAL light curves are available at
http://isdc.unige.ch/cgi-bin/cgiwrap/~beck/ibas/spiacs/ibas_acs_web.cgi?trigger=2008-04-11T21-15-
33.0698-22155-00007-0 and http://isdc.unige.ch/Soft/ibas/results/triggers/spiacs/2008-04/2008-04-11T21-
15-33.0698-22155-00007-0.png.

2) BAT OBSERVATION AND ANALYSIS

The BAT ground-calculated position is RA (J2000) = 02h 31m 50.6s and Dec (J2000) =-71° 17' 49.6" with
an uncertainty of 1.0'(90% containment radius including both statistical and systematic errors). The partial
coding was 86%.

The mask-weighted light curve (Figure 1) shows two clusters of overlapping peaks. The first starts at T+0.0
sec and rises to a peak in 1 sec. The second peak is at T+7 sec., the third is at T+10 sec., and the fourth is
at T+19 sec. at 25 counts-cm^{-2}-sec^{-1} (15-150 keV). The light curve returns to background before the
beginning of the second cluster of peaks. The fifth peak starts at ~T+39 sec., rises linearly, peaking at
~T+41 sec. at 43 counts-cm^{-2}-sec^{-1}. There are two more much smaller peaks at T+55 and T+64 sec. The
light curve returns to background by ~T+95 sec. T_{90} (15-350 keV) is 56 ± 1 sec. (estimated error including
systematics).

The time-averaged spectrum from T-0.0 to T+84.3 sec is best fit by a simple power-law model. The power
law index of the time-averaged spectrum is 1.75 ± 0.03. The fluence in the 15-150 keV band is 2.64 ±
0.01x10^{-5} erg-cm^{-2}. The 1-sec peak photon flux measured from T+40.45 sec in the 15-150 keV band is 43.2
± 0.9 photons-cm^{-2}-sec^{-1}. All the quoted errors are at the 90% confidence level.

3. XRT OBSERVATIONS AND ANALYSIS

The XRT began observing GRB 080411 at 21:16:42 UT, 71 seconds after the BAT trigger. The data consist
of 0.9 sec. in Windowed Timing (WT) mode and 348 ks in Photon Counting (PC) mode. Using 1122 sec. of
overlapping XRT Photon Counting mode and UVOT data for GRB 080411, we found an astrometrically
corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the
USNO-B1 catalogue) of RA (J2000) = 02h 31m 54.84s and Dec (J2000) = -71d 18' 06.8" with an
uncertainty of 1.5" (radius, 90% confidence).

The X-ray light-curve (Fig. 2) shows a broken power-law behavior with breaks at about 8 ks and 600 ks
and additional short-term features at late times (after 1.0 x10^6 sec.) that disturb the accurate estimation of

the second break time and the decay slope after 600 ks. The decay slope before 8 ks is 0.54 (+0.08/-0.13), and it is 1.24 (+0.03/-0.02) from 8 ks to 600 ks. The decay slope after 600 ks is about 1.59.

The WT spectrum contains only 20 counts and does not give any useful spectral information. The PC spectrum from 4.2 ks to 1.0 x10^6 sec. is fitted well by an absorbed power-law model with a photon index of 2.07 ± 0.04 and an intrinsic absorption column of 5.22 (+0.48/-0.46) x10^{21} cm^{-2} (using a redshift of 1.03), in excess of the Galactic value of 5.8 x10^{20} cm^{-2} (Kalberla *et al*. 2005). There is evidence for spectral hardening during the time when the short-term features are seen in the XRT light-curve.

Detailed light-curves in both count rate and flux units are available in both graphical and ASCII formats at http://www.swift.ac.uk/xrt_curves/. For GRB 080411, the approximate flux conversion is 1 count-s^{-1} = 5.9 x10^{-11} erg-cm^{-2}-s^{-1} (absorbed) in the 0.3-10 keV band.

4. UVOT OBSERVATIONS AND ANALYSIS

The Swift/UVOT observed the field of GRB 080411 starting at 4202 sec. after the BAT trigger. The afterglow is detected in all 7 filters at the position given in Section 1. The measured magnitudes are presented in Table 1, and the light curve in the white filter is shown in Fig 3. No corrections have been made for the expected extinction in the Milky Way corresponding to E_{B-V} of 0.04 (Schlegel *et al*. 1998). The photometry uses the UVOT flight system described in Poole *et al*. (MNRAS 383, 627 (2008)).
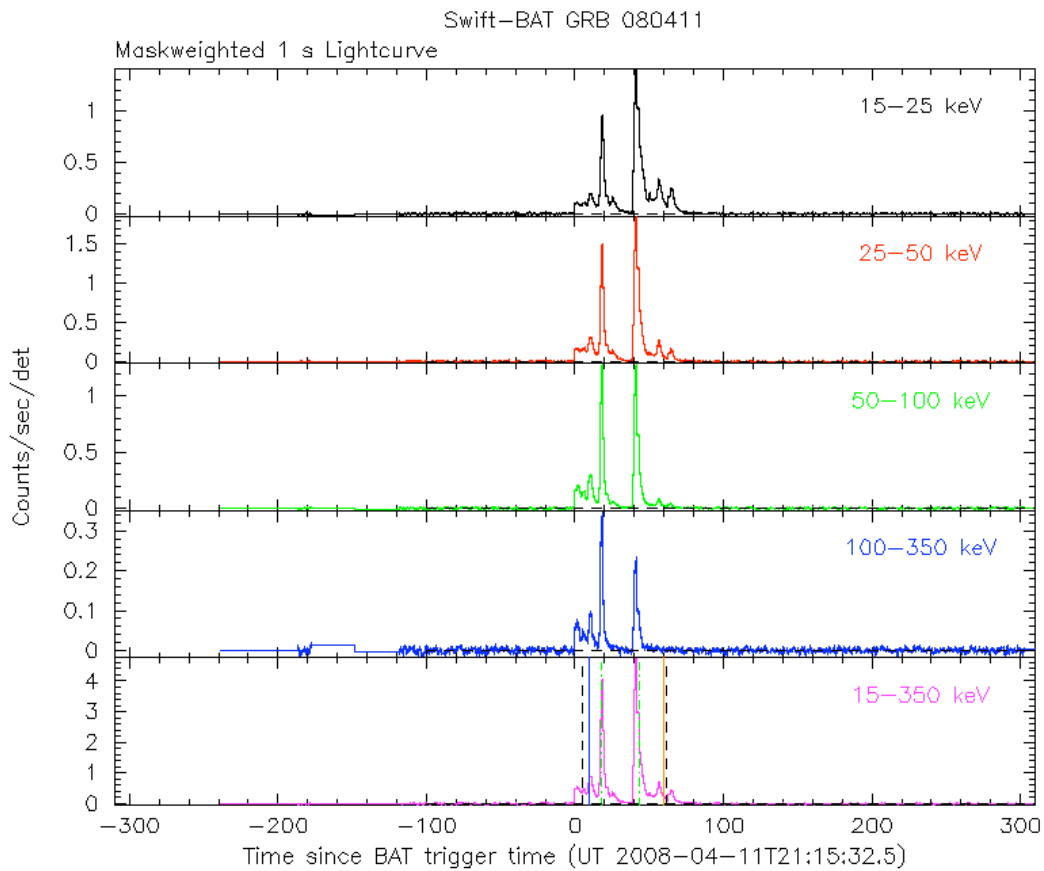
Fig.1: The BAT mask-weighted light curve in the 4 individual plus total energy bands. The units are counts s[-1] illuminated-detector[-1]. Each illuminated detector has an area of 0.16 cm[2].
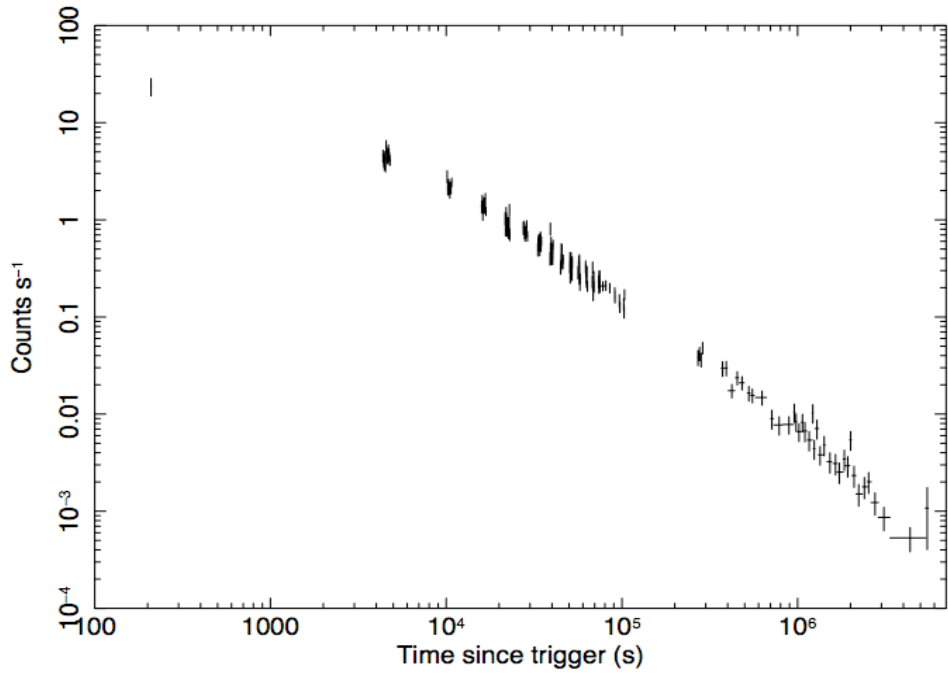
Fig.2: The XRT light curve plotted as a function of the time since the BAT trigger. One count-s^{-1} is about 5.9 x10^{-11} erg-cm^{-2}-s^{-1} (absorbed) in the 0.3-10 keV band.

Filter	Midpoint (sec.)	Exposure (sec.)	Magnitude	Uncertainty (mag.)
white (FC)	4,251	98	17.01	0.03
white	22,869	295	18.09	0.03
v	16,808	177	18.05	0.12
b	4,615	197	17.43	0.05
u	4,410	197	16.46	0.04
uvw1	39,334	886	18.53	0.08
uvm2	34,470	870	18.64	0.09
uvw2	16,260	886	18.41	0.07

Table 1: UVOT Observations. The midpoints of the exposures are given in seconds since the BAT trigger. No corrections have been made for the expected extinction in the Milky Way corresponding to E_{B-V} of 0.04 (Schlegel *et al.* 1998)
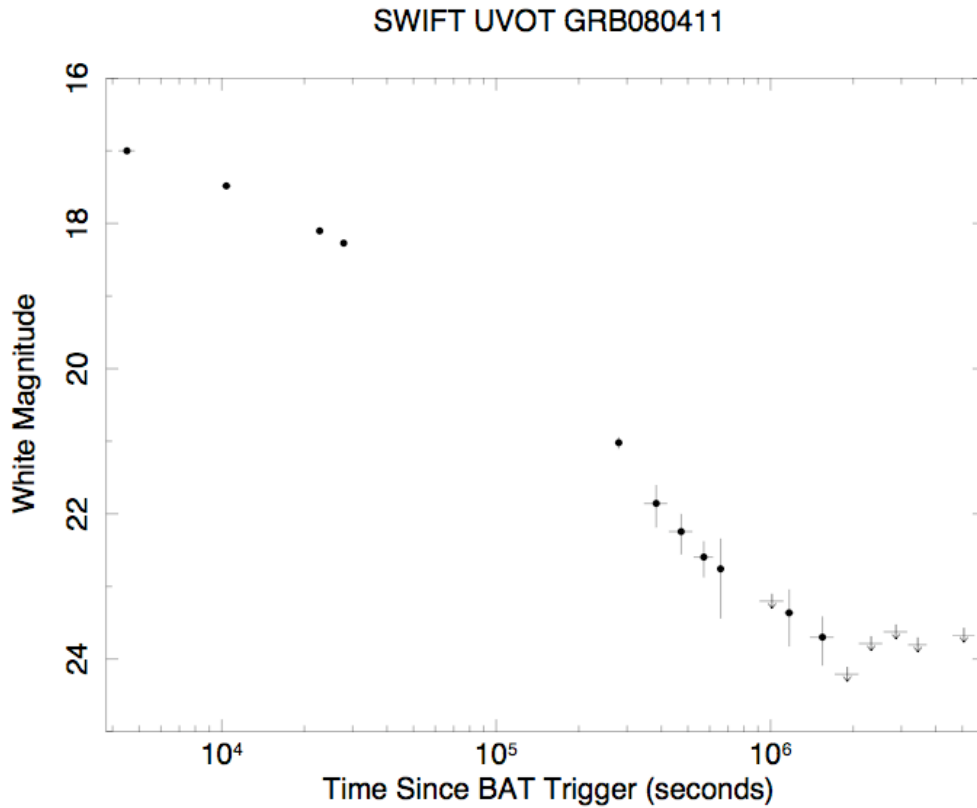

Fig.3: The light curve in the UVOT white filter.