Swift Observations of GRB 090927

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1 Introduction

At 10:07:16 UT on 2009-09-27, the Swift Burst Alert Telescope (BAT) triggered and located GRB 090927 (trigger=370846). Due to an observing constraint, Swift could not observe the burst until about 34 minutes after the trigger (Grupe et al. *GCN Circ.* 9945).

The best *Swift* position of this burst is the UVOT position given in Gronwall & Grupe (*GCN Circ.* 9946) with RA-2000 = 22h 55m 53.41s, and Dec-2000 = -70° $58^{'}$ $49.3^{''}$ with an uncertainty of $0.63^{''}$.

The classification of this burst as short or long is not clear. The T_{90} (2.2 s) puts it right at the traditional boundary between long and short GRBs, and it could be in either population. On the other hand, the burst appears to have significant lag between energy bands (suggesting a long GRB), and moreover is not particularly hard.

A VLT spectroscopic redshift for this burst of z=1.37 was reported by Levan et al. (*GCN Circ.* 9958).

2 BAT Observation and Analysis

At 10:07:16 UT on 2009-09-27, the Swift Burst Alert Telescope (BAT) triggered and located GRB 090927 (trigger=370846). The BAT ground-calculated position is RA, Dec = 343.929, -70.973 deg which is

RA(J2000) = 22h 55m 42.9s

Dec(J2000) = -70° 58′ 24.2″

with an uncertainty of 1.6 arcmin, (radius, sys+stat, 90% containment). The partial coding was 55% (Stamatikos et al. *GCN Circ.* 9955).

The mask-weighted light curve shows a single irregular peak with an overall roughly FRED shape. T_{90} (15-350 keV) is 2.2±0.4 s (estimated error including systematics).

The time-averaged spectrum from T-0.0 to T+2.4 s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.80±0.20. ($\chi^2 = 79.0$ for 57 d.o.f.). The fluence in the 15-150 keV band is $2.0 \pm 0.3 \times 10^{-7}$ ergs cm^{-2}. The 1s peak photon flux measured from T-0.01 s in the 15-150 keV band is 2.0±0.2 photons s^{-1} cm^{-2}. 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/370846/BA/

3 XRT Observations and Analysis

Due to an observing constraint, the XRT began observing the field of GRB 090927 delayed at 10:43:03 UT, 2147 seconds after the BAT trigger and found a faint, fading, uncatalogued X-ray source (Grupe & Vetere *GCN Circ.* 9952).

Using 1424 s of XRT Photon Counting mode data and 3 UVOT images for GRB 090927, Evans et al. (*GCN Circ.* 9950) found an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA, Dec = 343.97291, -70.98032 which is equivalent to:

RA (J2000): 22h 55m 53.50s

Dec (J2000): -70° 58′ 49.2″

with an uncertainty of 2.0″ (radius, 90% confidence). The latest position can be viewed at http://www.swift.ac.uk/xrt_positions. Position enhancement is described by Goad et al. (2007, A&A, 476, 1401) and Evans et al. (2009, MNRAS, 397, 1177). This position is 24.8″ from the BAT onboard-calculated position given in Grupe et al. (*GCN Circ.* 9945) and 0.5″ from the UVOT position given in Gronwall & Grupe (*GCN Circ.* 9946).

The Photon Counting mode (pc) mode data can be fitted with a single absorbed power law model with $\Gamma = 1.89 \pm 0.14$ and an absorption column density consistent with the Galactic value of 2.92×10^{20} cm^{-2} (Kalberla et al. 2005).

The $0.3 - 10$ *keV* light curve given below (Fig.2) can be modelled with a broken power-law decay with an initial decay slope of $\alpha = 3.8 \pm 2.0$, followed by a break at T+2700^{+540}_{-230} s to an $\alpha = 0.1 \pm 0.2$. There is another break after the plateau phase at T+$10^{+2.7}_{-1.9}$ ks with a decay slope of $1.17^{+0.15}_{-0.09}$.

4 UVOT analysis

The Swift/UVOT began a delayed observing the field of GRB 090927 2121s after the trigger due to an observing constraint. A fading optical afterglow was initially detected in the white, v,b, and u filters (Kuin et al. *GCN Circ.* 9954), but was later detected in all filters.

UVOT took a finding chart exposure of 150 seconds with the White filter starting 2141 seconds after the BAT trigger (Gronwall & Grupe *GCN Circ.* 9946). A candidate afterglow was found in the rapidly available 2.7'x2.7' sub-image at RA, Dec= 343.97255, -70.98037 which is equivalent to

RA(J2000) = 22h 55m 53.41s

DEC(J2000) = $-70°58'49.3''$

with a 90%-confidence error radius of about 0.63″.

The magnitudes and 3σ upper limits for the finding charts (FC) and summed images are listed in Table 1.

Observations continued over the following days, and the GRB was detected by the UVOT for more than 83 hours after the trigger. The UVOT light curve is shown in Figure 3. The magnitudes in the different filters have not been normalized to a common value. Because the Lyman break for the

Filter	$T_{\rm Start}$	$T_{\rm stop}$	Exposure	Mag
white(FC)	2141	2291	147.4	19.13±0.09
white	2372	2920	235.6	19.40±0.09
v	2121	2617	48.6	19.00±0.37
v	3131	3331	196.6	19.37±0.25
b	2348	2542	38.9	19.50±0.31
b	2696	2716	19.5	19.09±0.34
u	2323	2517	38.9	18.77±0.26
u	2671	2691	19.5	>18.89
uvw1	2299	3576	92.8	>19.63
uvm2	2446	3536	235.6	>19.89
uvw2	2397	2592	38.9	>18.84

Table 1: Magnitudes from UVOT observations of GRB 090927. The quoted upper limits have not been corrected for the expected Galactic extinction along the line of sight of $E_{\rm B-V} = 0.03$ mag. All photometry is on the UVOT photometric system described in Poole et al. (2008, MNRAS, 383, 627).

reported redshift of 1.37 falls in the uvw2 filter band, that band is of reduced brightness. After an initial decay, a plateau phase continued until about 15,000s after the trigger, followed by a faster decay. The light curve is similar to the one seen by XRT as can be seen by comparing Figure 3 to Figure 2.

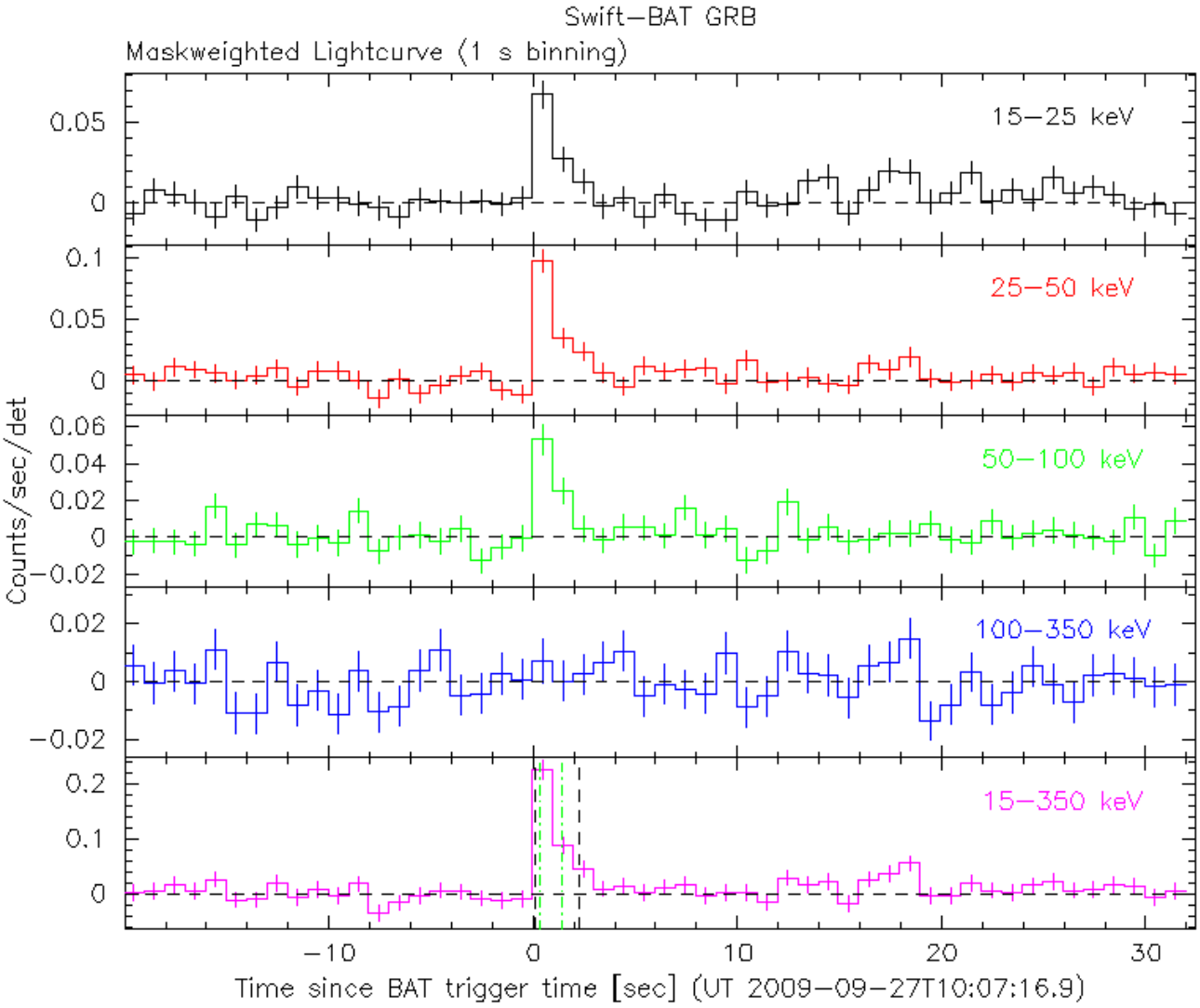

Figure 1: BAT Light curve of GRB 090927.

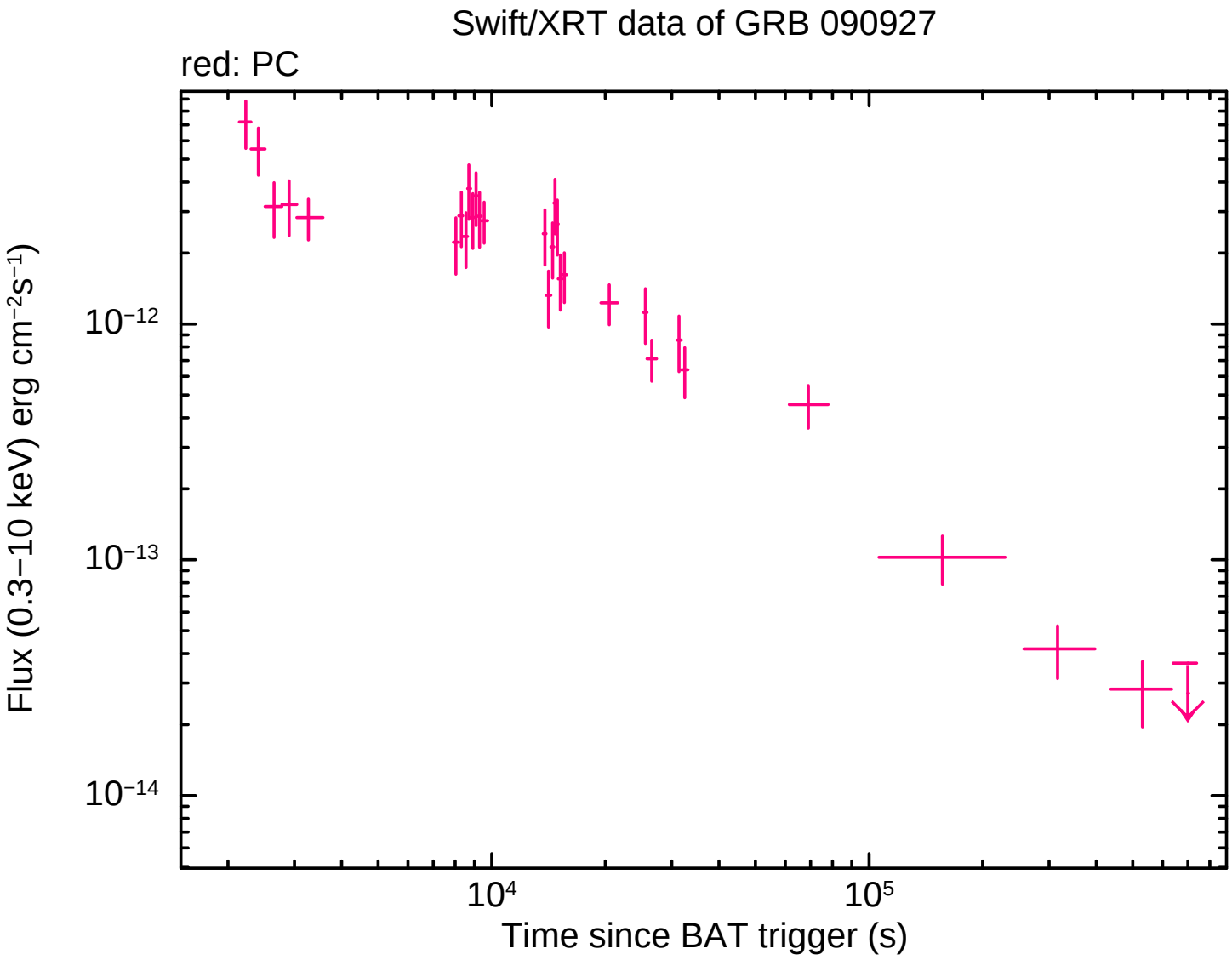

Figure 2: XRT flux light curve of GRB 090927 in the 0.3-10 keV band. The approximate conversion is 1 count $s^{-1} = \sim 3.5 \times 10^{-11}$ $ergs\ s^{-1}cm^{-2}$ for an observed flux assuming a standard X-ray afterglow spectrum.

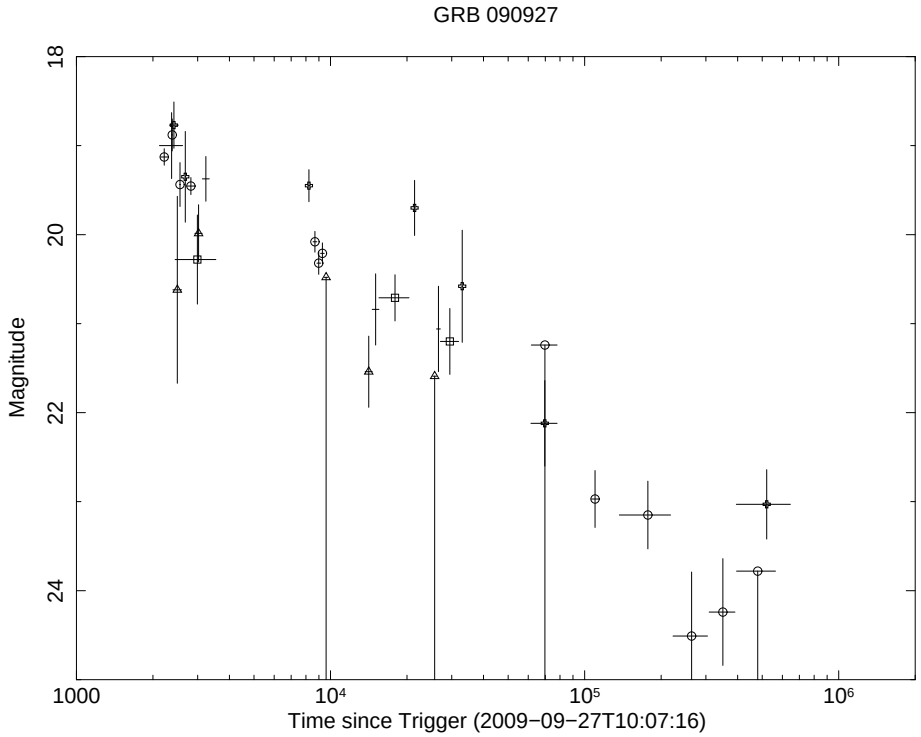

Figure 3: Observed UVOT light curve of GRB 090927 in the following selected uvot filters: white (circles), V (cross), U(crossed boxes), uvm2 (square box), uvw2(triangles). Upper limits are 3σ.