Swift Observations of GRB 070107

M. Stamatikos (GSFC/ORAU), T. Mineo (INAF-IASF Pa), B. Sbarufatti (INAF-IASF Pa), J. Kennea (PSU), M. Chester (PSU), P. Boyd (GSFC), S.D. Barthelmy (GSFC), D.N. Burrows (PSU), P. Roming (PSU) and N. Gehrels (GSFC) for the Swift Team

1 Introduction

At 12:05:18 UT, on January 7, 2007, BAT triggered on GRB 070107 (trigger #255029) (Stamatikos et al., GCN Circ. 5999). Prompt emission began while the burst was outside of BAT's FOV, during a pre-planned slew, which brought the burst within the FOV and resulted in a 96 second image trigger on the tail end of the last of 2 (or potentially more) peaks in the burst. Computer network issues delayed the discovery of both XRT (Kennea et al., GCN Circ. 6000) and UVOT (Boyd et al., GCN Circ. 6002) afterglow counterparts until the full data set was processed on the ground. Our best position is the UVOT optical afterglow candidate located at RA, DEC (J2000) = 10h 37m 36.35s, -53d 12′ 47.5″) with a with a 1-sigma error radius of about ∼1 arcsec, as given in Boyd et al., GCN Circ. 6002.

2 BAT Observations and Analysis

Using the data set from T-239 to T+963 sec telemetry down links, further analysis of BAT GRB 070107 has been performed by the Swift team (Barthelmy et al., GCN Circ. 6001). The BAT ground-calculated position is RA, Dec (J2000) = 159.422 (10h 37m 41.4s), -53.202 deg (-53d 12′ 08.4″) with an uncertainty of 1.1 arcmin, (radius, sys+stat, 90% containment). The partial coding was 53%.

The mask-weighted light curve (Figure 1), starts at ∼T-32 sec with a rising flux, peaking at ∼T-7 sec, and then returning to almost background levels at ∼T+80 sec. There is a FRED-like peak starting at ∼T+310 sec, peaking at ∼T+320 sec, and returning to background levels at ∼T+400 sec. As previously mentioned, the analysis of this burst is complicated by the fact that the burst started before it was in the BAT FOV. For these reasons, we are not quoting a T90 value because the burst data was truncated at the beginning of the burst.

For the partial amount of time covered, the time-averaged spectrum from T-19.7 to T+404.2 is best fit by a simple power-law model, with an index of 1.34 ± 0.10. The lower limit of the fluence in the 15-150 keV band is $5.2 \pm 0.3 \times 10^{-6}$ ergs/cm^2. The 1-sec peak photon flux measured (for the portion of the burst BAT observed) from T-7.24 sec in the 15-150 keV band is 1.9 ± 0.2 photons/cm^2/s. All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

The XRT began observing the field at 12:08:17.02 UT, 179 seconds after the BAT trigger. Although no X-ray counterpart was found by the on-board software, analysis of downlinked data revealed a bright, flaring, uncatalogued point source at RA, DEC (J2000) = 10h 37m 36.1s, -53d 12′ 46.9″, with an uncertainty of 10 arcseconds (90% confidence), as given in Kennea et al., GCN Circ. 6000. This position lies 24 arcseconds from the BAT on-board (flight) position reported in Stamatikos et al., GCN Circ. 5999.

Using the data from the first ten orbits of Swift-XRT data on GRB 070107, with a total exposure of 420 seconds in Window Timing (WT) mode and 15.8 ks seconds in Photon Counting (PC) mode, the refined XRT position is RA, DEC (J2000) = 159.4016 deg (10h 37m 36.4s), -53.2131 deg (-53d 12′ 47.3″), with an estimated error radius of 3.7 arcsec (90% confidence), as given in Mineo et al., GCN

Circ. 6003. This position is 59.4 arcseconds from the BAT ground position (Barthelmy et al., GCN Circ. 6001), 2.6 arcseconds from the initial XRT position (Kennea et al., GCN Circ. 6000), and 0.4 arcseconds from the UVOT optical candidate (Boyd et al., GCN Circ. 6002).

The $0.3-10$ keV X-ray light curve (Figure 2) exhibits a bright flare starting at about T+300 s, which is coincident with the peak detected in the BAT light curve (Figure 1). A second fainter peak is also present at T+1300 s and the light curve between 3 ks and 59 ks can be fit with a simple power-law with a decay slope of 1.05 ± 0.05.

The X-ray spectrum from the XRT/WT data, mainly covering the first bright flare, is well fit by an absorbed power-law with a photon index of 2.07 ± 0.07 and column density of $3.8 \pm 0.2 \times 10^{21}$ cm^{-2}, consistent with the Galactic column density in the direction of the source (3.6×10^{21} cm^{-2}). The unabsorbed $0.3-10$ keV flux for this spectrum is 1.3×10^{-9}ergs/cm^2/sec. The XRT/PC data is modeled by an absorbed power law with a photon index of 2.2 ± 0.1 and column density of $4.3\pm0.4\times10^{21}$ cm^{-2} while the unabsorbed $0.3-10$ keV flux is 2.48×10^{-11} ergs/cm^2/sec.

Assuming the X-ray emission continues to decline at the same rate, we predict a $0.3-10$ keV XRT count rate of 1×10^{-2} count/s at T+48hr, which corresponds to an observed $0.3-10$ keV flux of 1.4×10^{-12} ergs/cm^2/sec.

4 UVOT Observations and Analysis

UVOT took a 100-s finding chart exposure with the White filter (160-650 nm) starting 183 seconds after the BAT trigger, followed by a 400-s V finding chart exposure. A second set of finding chart exposures was obtained starting 868s post-trigger. A new variable source (Figure 3) was detected inside the XRT error region reported by Kennea et al., GCN Circ. 6000 in the first exposure at RA, DEC (J2000) = 10h 37m 36.35s, -53d 12′ 47.5″ with a 1-sigma error radius of about 1 arcsec (Boyd et al., GCN Circ. 6002). A caveat is that this source lies within a crowded region at low galactic latitude, and only 4.1 arcsec from a bright V = 15.9 cataloged star, which causes the afterglow and the star to be blended in the UVOT image, and complicates the position, magnitude, and significance estimates. We estimate a White magnitude of ∼19.5 for the new source. The source is detected at a ∼4-sigma significance level. The same source is detected at a level of 2.7 sigma in the subsequent 400-s V finding chart. The new source is not significant in later White and V exposures. We note that the extinction estimate in this region (whose galactic latitude is 4.56 degrees) is large, and uncertain.

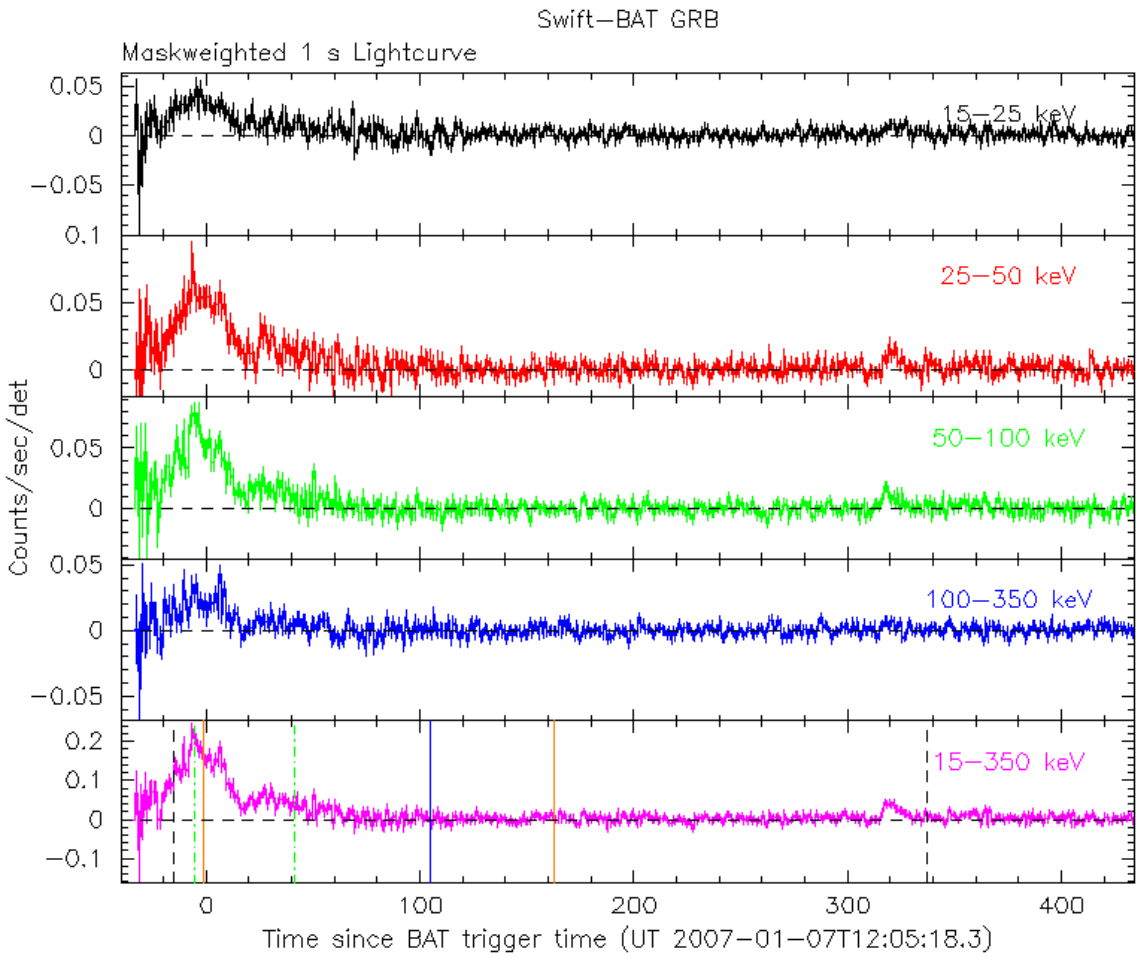

Figure 1: BAT Light curve for GRB 070107. The mask-weighted light curve in the 4 individual plus total energy bands. The green and black dotted lines bracket the T50 and T90 intervals, respectively, while the blue and orange solid lines bracket the start and end of the slew, respectively. The time of each bin is in the middle of the bin. The units are counts/sec/illuminated-detector and T_0 is 12:05:18 UT.

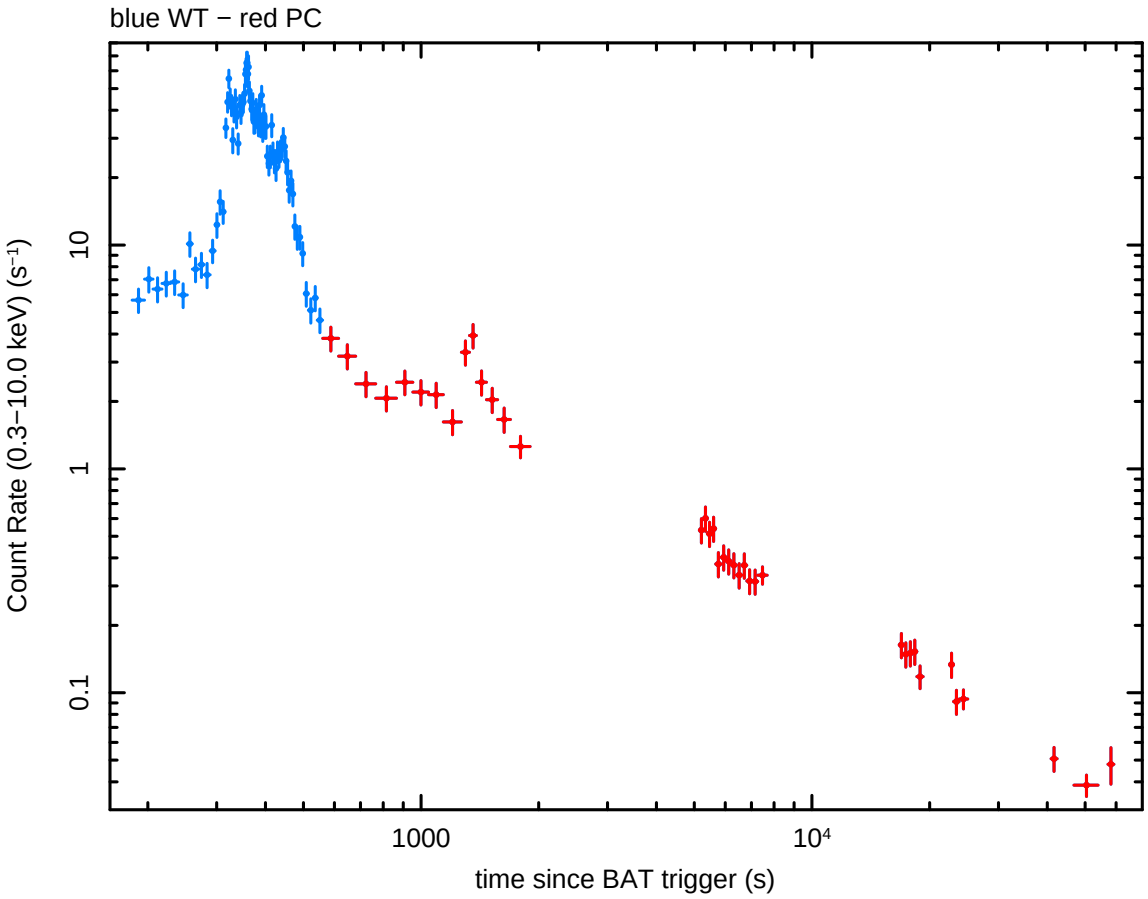

Figure 2: XRT Lightcurve for GRB 070107. Counts/sec in the 0.3-10 keV band. Window Timing mode (blue), Photon Counting mode (red). The approximate conversion is 1 count/sec = $\sim 8 \times 10^{-11}$ ergs/cm^2/sec.

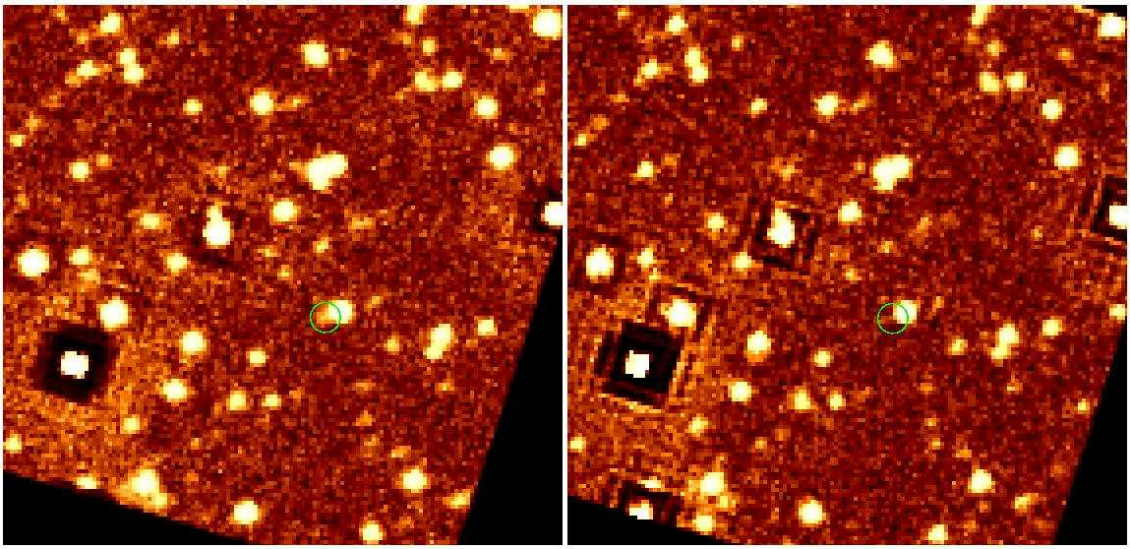

Figure 3: UVOT finding charts for GRB 070107. Left panel - Initial 100 s White filter (160-650 nm) exposure taken at T+183 s. Right Panel - Subsequent 100 a White filter exposure taken at T+868 s. The afterglow candidate has been identified within the green circle. Note that the source lies within a crowded field only 4.1 arcsec away from a bright V = 15.9 cataloged star.