Swift Observation of GRB 091020

J. L. Racusin (NASA/GSFC), S. R. Oates (UCL/MSSL), A. Beardmore (U Leicester),
H. Krimm (NASA/GSFC/USRA) for the Swift Team

1 Introduction

BAT triggered on GRB 091020 at 21:36:44 UT (Trigger 373458) (Racusin, et al., GCN Circ. 10048). This was a rate-trigger on a intermediate length burst with $T_{90} = 34.6$ sec. Swift slewed to this burst immediately and XRT began follow-up observations at $T + 81$ sec, and UVOT at $T + 89$ sec. Our best position is the UVOT location RA($J2000$) = 175.760deg (11h42m55.2s), Dec($J2000$) = +50.97733deg (+50d58'42.0") with an error of 0.5 arcsec (radius, 90% confidence).

2 BAT Observation and Analysis

Using the data set from $T − 240$ to $T + 962$ sec, further analysis of BAT GRB 091020 has been performed by Swift BAT team (Palmer, et al., GCN Circ. 10051). The BAT ground-calculated position is RA($J2000$) = 175.727deg (11h42m54.4s), Dec($J2000$) = +50.977deg (+50d58'36.6") with an error of 1.0 arcmin, (radius, systematic and statistical, 90% containment).

The mask-weighted light curves (Fig.1) began with a small hump at $T − 10$ sec, rising sharply to a peak at $T + 2$ sec and decaying exponentially out to $T + 50$ sec, with a much smaller peak superimposed at $T + 33$ sec. $T_{90}$ (15 − 350 keV) is 39.0 ± 4.9 sec (estimated error including systematics).

The time-averaged spectrum from $T − 8.7$ to $T + 38.3$ sec is best fitted by a simple power law model. The power law index of the time-averaged spectrum is 1.53 ± 0.07. The fluence in the 15 − 150 keV band is 3.7 ± 0.1 × 10$^{-6}$ ergs/cm$^2$. The 1-sec peak photon flux measured from $T + 1.14$ sec in the 15 − 150 keV band is 4.2 ± 0.3 ph/cm$^2$/sec. All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

Using 1088 sec of XRT Photon Counting mode data and 1 UVOT image for GRB 091020, we find an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA($J2000$) = 175.73005deg (11h42m55.21s), Dec($J2000$) = +50.97839 (+50d58'42.2") with an error of 1.8 arcsec (radius, 90% confidence). This position is within 4.0 arcsec of the initial XRT position, and 0.2 arcsec from the optical afterglow candidate, reported by Oates et al., GCN Circ. 10054.

The 0.3 − 10 keV light curve (Fig.2) shows an initial steep decline with a slope of $3.5^{+0.7}_{−0.4}$, following by a shallower slope of $0.89 ± 0.04$, beginning at $T + 135 ± 20$ sec. At $(6.7_{−1.1}^{+0.9}) \times 10^3$ sec the light curve breaks with a slope of 1.38 ± 0.04. There is a small flare superimposed at $T + 190$ sec.

Three segments of the X-ray lightcurve can be modeled with an absorbed power-law with spectral indices of $2.34 ± 0.14$, $2.15 ± 0.13$, and $2.22_{−0.08}^{+0.07}$, respectively. The best fitted absorption column at a redshift of 1.7 (Xu, et al., GCN Circ. 10053) is $9.4_{−2.0}^{+2.1} \times 10^{21}$, $5.4_{−1.7}^{+1.8} \times 10^{21}$, and $6.4_{−1.0}^{+0.9} \times 10^{21}$ cm$^{-2}$, respectively in addition to the Galactic value ($1.4 \times 10^{20}$ cm$^{-2}$).

The average observed (unabsorbed) flux over 0.3−10 keV for the three spectral intervals corresponding to the light curve segments excluding the flare (spanning a time of $80 − 120$, $300 − 6500$, $6500 − 1 \times 10^6$ seconds after the trigger, respectively) is $1.1 \times 10^{-9}$, $5.0 \times 10^{-11}$, $9.8 \times 10^{-13}$ ($1.7 \times 10^{-9}$, $6.4 \times 10^{-11}$, $1.3 \times 10^{-12}$) ergs/cm$^2$/sec, respectively.
4 UVOT Observation and Analysis

The UVOT began observing the field of GRB 091020 at 21:38:13 UT, 89 sec after the initial BAT trigger (Racusin et al., GCN Circ. 10048). We detect the optical afterglow in all filters at the refined UVOT position RA(J2000) = 175.760deg (11h42m55.2s), Dec(J2000) = +50.97833deg (+50d58'42.0") with an error of 0.5 arcsec (radius, 90% confidence). This position is consistent with the enhanced XRT position (Beardmore et al., GCN Circ. 10050). The detection in the white, v, b and u filters and the weak detection in the uvw1 filter is consistent with a redshift $z \sim 1.7$, which is consistent with the redshift reported by NOT (Xu, et al., GCN Circ. 10053).

The multi-filter UVOT light curve (Figure 3) shows an initial rise followed by a power-law decay with similar shape to that of the XRT light curve. These magnitudes are not corrected for the Galactic extinction corresponding to a reddening of $E_{B-V} = 0.02$ mag (Schlegel et al., 1998, ApJS, 500, 525). The photometry is on the UVOT photometric system described in Poole et al. (2008, MNRAS, 383,627).

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 21:36:44 UT.
Figure 2: XRT Lightcurve. Counts/sec in the 0.3-10 keV band: Window Timing mode (blue), Photon Counting mode (red). The approximate observed (unabsorbed) conversion is 1 count/sec $\approx 3.4 \times 10^{-11}$ ($\approx 4.4 \times 10^{-11}$) ergs/cm$^2$/sec.

Figure 3: UVOT white filter light curve. The red points are detections, and the green points are 3-sigma upper limits.