# Swift Observations of GRB 070129

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## 1   Introduction

BAT triggered on and located GRB 070129 at 23:35:10 UT (trigger=258408; Godet et al., GCN Circ. 6053) and slewed immediately. The trigger itself was an image trigger on a precursor. Thus the narrow field instruments were on target in time for the main burst, about 300 seconds later. This burst is quite long with a $T_{90} = 460$ s. The best Swift position is that determined from the XRT at RA(J2000) = 02h 28m 00.88s, Dec(J2000) = +11d 41' 03.2" with a 90% confidence interval of 2.4 arcsec. Swift collected 29ks of data so far (2 days after the trigger). Malesani et al. (GCN Circ. 6055) reported a possibly extended source with an R magnitude of 21.3 mag using the VLT at RA(J2000) = 02h 28m 00.94s, Dec(J2000) = +11d 41' 04.0" ± 0.2".

## 2   BAT Observation and Analysis

The BAT ground-calculated position is RA(J2000) = 37.001 deg (02h 28m 0.3s), Dec(J2000) = +11.730 deg (+11d 43' 46.7") ± 2.6 arcmin, (radius, sys+stat, 90% containment). The partial coding was 41%.

The mask-tagged light curve showed that the trigger was on a precursor to the main burst which started at approximately T+200s, coincident with the detections reported in the XRT (Godet et al, GCN Circ. 6056). Emission started at ∼T-180s, then continued through a series of peaks out to ∼T+160s, where there was a dip in the light curve preceding the main peak of the prompt emission which lasted until T+380 s. This was followed by some possible low level emission out to ∼T+600 s. $T_{90}$ (15-350 keV) is $460 \pm 20$ s (estimated error including systematics).

The time-averaged spectrum from T-125.0s to T+373.9s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is $2.05 \pm 0.16$. The fluence in the 15-150 keV band is $3.1 \pm 0.3 \times 10^{-6}$ erg/cm$^2$. The 1 s peak photon flux measured from T+361.46s in the 15-150 keV band is $0.6 \pm 0.1$ ph/cm$^2$/s. All the quoted errors are at the 90% confidence level.

## 3   XRT Observations and Analysis

The XRT began observing the burst 140 seconds after the initial trigger.

Using ∼ 21 ks of Photon Counting (PC) data from the first five orbits of data, we derive the best refined position of RA(J2000) = 02h 28m 00.88s, Dec(J2000) = +11d 41' 03.17", with an estimated error radius of 2.4 arcsec (90% confidence, using UVOT images for aspect correction of the XRT position). This position is included within the ground-calculated BAT error circle. The UVOT aspect-corrected XRT position is only 1.2" from the VLT position of a possibly extended source (RA(J2000) = 02h 28m 00.94s, Dec(J2000) = +11d 41' 04.0" ± 0.2", Malesani et al. GCN Circ. 6055).

The X-ray light curve (see Fig. 2) shows the main burst seen in the BAT from T+140s to T+700s, followed by a steep decay to T+1200s and then a flatter decay. This flatter decay can be fitted by a single power-law with a decay slope of $\alpha_1 = 0.34 \pm 0.08$. The light-curve shows a break at $t_b = 29538^{+5199}_{-4418}$ s followed by a steeper decay with a decay slope of $\alpha_2 = 1.64^{+0.40}_{-0.26}$.

The Windowed Timing (WT) data correspond to the main burst, which shows strong spectral evolution. An absorbed power-law fit of the WT data (first orbit) from T+140s to T+792s gives a photon index of $1.81 \pm 0.03$ and an absorption value of $(2.1 \pm 0.1) \times 10^{21}$ cm$^{-2}$ ($\chi^2/$dof $= 475/402$), compared to the Galactic value of $8.4 \times 10^{20}$ cm$^{-2}$ in the burst direction. The spectrum of the PC data from T+4000s to T+58000s (corresponding to the flat and steep decay part of the light-curve) can be fit by an absorbed power-law with $\Gamma = 2.32^{+0.22}_{-0.19}$ and an absorption value of $(2.2 \pm 0.4) \times 10^{21}$ cm$^{-2}$ ($\chi^2/$dof $= 36.6/48$).

All the quoted errors are at the 90% confidence level.

# 4   UVOT Observation and Analysis

The UVOT observed the field of GRB 070129 starting 124s after the BAT trigger (Godet et al., GCN Circ. 6053). We do not find any source, in any of the UVOT observations, inside the refined XRT error circle (Godet et al., 2007 GCN Circ. 6056). The 3-$\sigma$ upper limits for detecting a source inside the XRT error circle in the V-band settling image, the finding-chart exposures, and the co-added frames are summarized in Table 1.

| Filter | $T_{start}$ | $T_{stop}$ | Exposure (s) | Mag ($3 - \sigma$ UL) |
|---|---|---|---|---|
| V settling | 124 | 133 | 9 | 17.3 |
| V finding | 247 | 647 | 400 | 19.2 |
| V finding | 979 | 1379 | 400 | 19.8 |
| White finding | 142 | 242 | 100 | 19.7 |
| White finding | 873 | 973 | 100 | 20.0 |
| | | | | |
| V | 124 | 47339 | 3046 | 20.7 |
| B | 726 | 53670 | 3073 | 21.4 |
| U | 701 | 53414 | 5398 | 21.3 |
| UVW1 | 678 | 52501 | 4895 | 22.2 |
| UVM2 | 653 | 58021 | 3956 | 22.0 |
| UVW2 | 754 | 46426 | 2239 | 22.0 |
| White | 143 | 13183 | 1460 | 20.8 |

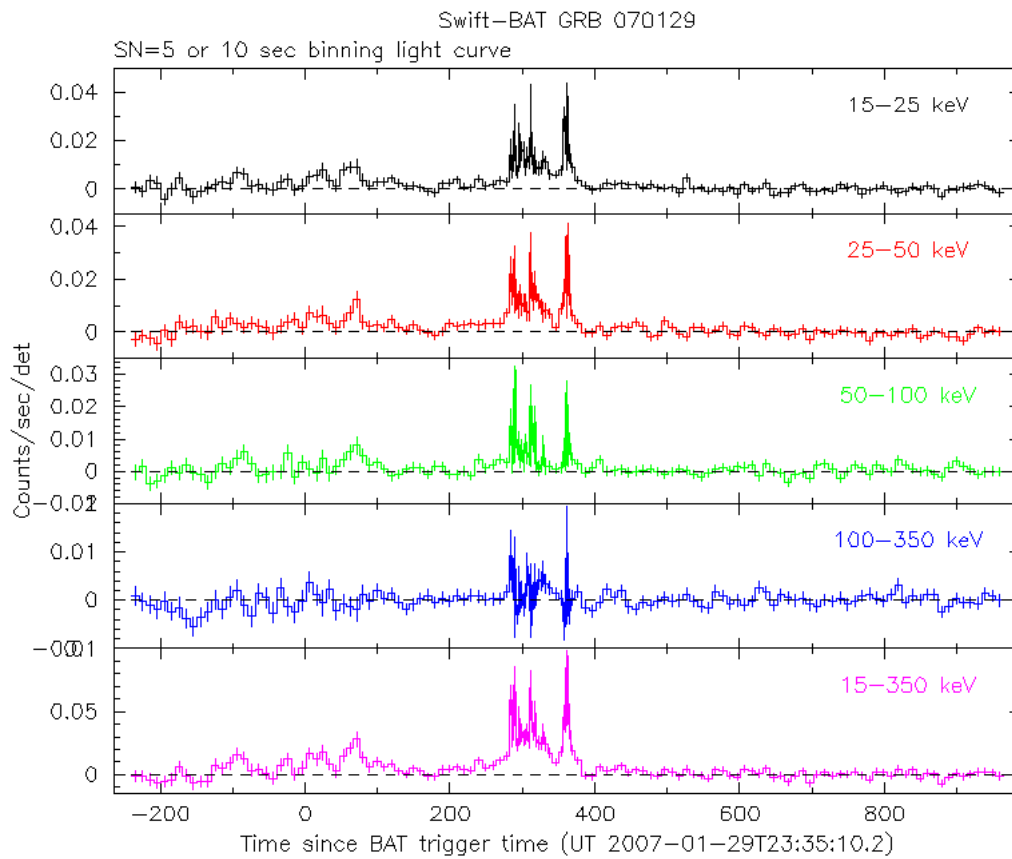Table 1: Magnitude limits from UVOT observations.

Figure 1: BAT light-curve. The mask-weighted light-curve in the 4 individual plus total energy bands. The units are counts/s/illuminated-detector (note illum-det = 0.16 cm$^2$) and T is 23:35:10 UT.
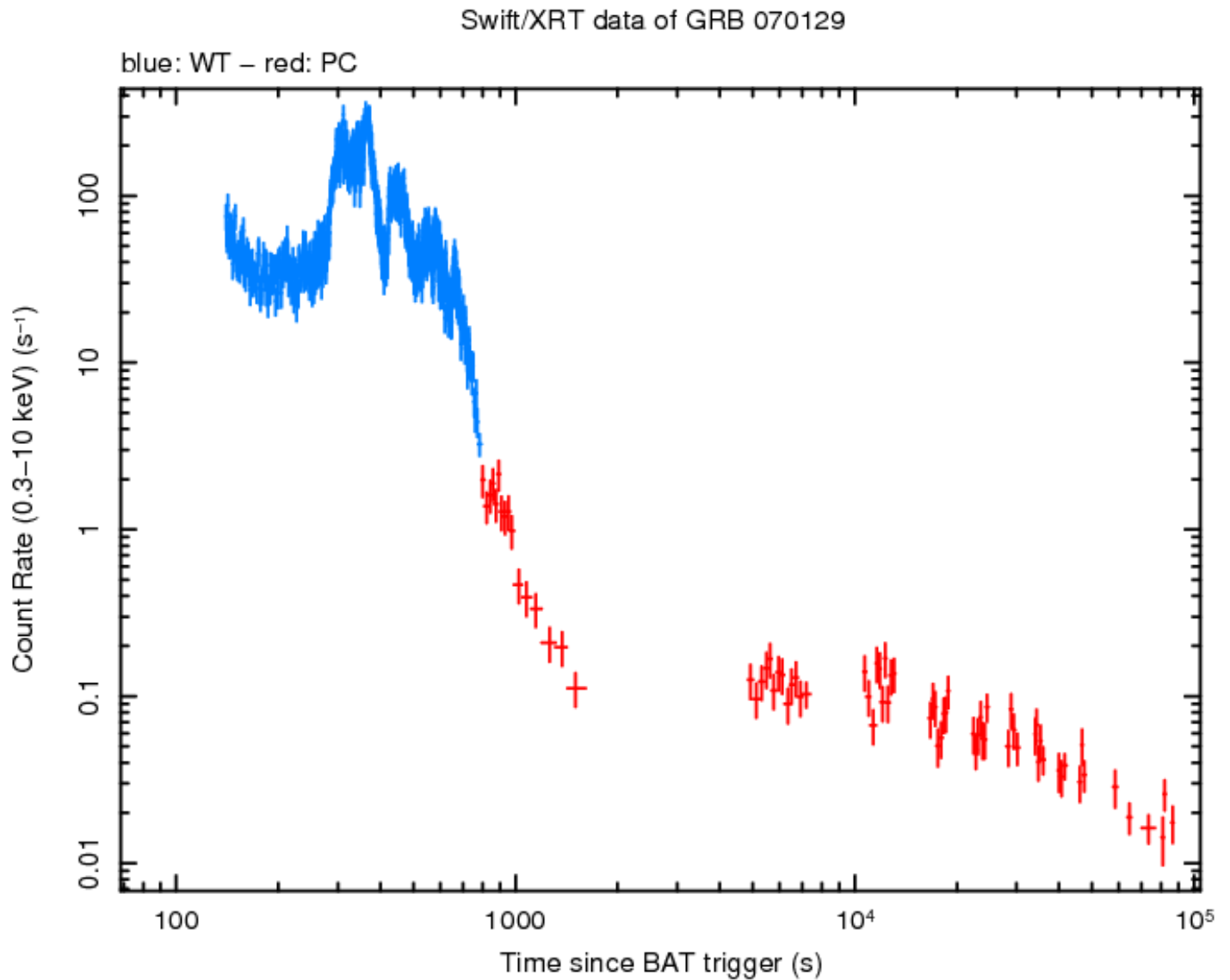
Figure 2: XRT light-curve. Count rate light-curve in the 0.3-10 keV band: Windowed Timing mode is shown in blue, Photon Counting mode in red. Fitting from 1200 s onwards, the decay slope, $\alpha_1 = 0.34 \pm 0.08$, until about $29.5^{+5.2}_{-4.4}$ ks after the trigger, when it steepens to $\alpha_2 = 1.64^{+0.40}_{-0.26}$. The approximate counts to flux conversion is 1 count $\mathrm{s}^{-1} = 4.2 \times 10^{-11}$ erg $\mathrm{cm}^{-2}$ $\mathrm{s}^{-1}$.