

## Swift Observations of GRB 091010

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### 1 Introduction

SuperAGILE detected GRB 091010 at 02:43:09 UT (Donnarumma *et al.*, *GCN Circ.* 10004; Feroci *GCN Circ.* 10005). The event had a duration of about 10 s in the 17-60 keV energy range, with a highly structured shape. The burst position was reconstructed as RA(J2000)=298.669 deg (19<sup>h</sup>54<sup>m</sup>40.51<sup>s</sup>), Dec(J2000)=-22.538 deg (-22<sup>d</sup>32'17.36'') with an uncertainty of 3' radius (statistical plus systematic). Assuming a Crab-like energy spectrum, the peak flux on 1-s timescale was about  $6.2 \times 10^{-7}$  erg cm<sup>-2</sup> s<sup>-1</sup>.

This GRB triggered also the MCAL instrument onboard AGILE sensitive in the energy range 330 keV - 100 MeV (Marisaldi *et al.*, *GCN Circ.* 10022): the time integrated spectrum from T0-1.5 s to T0+2.0 s in the energy range 400 keV - 2 MeV is well described by a single powerlaw with best fit photon index  $-3.0_{-0.6}^{+0.8}$  ( $\chi^2/\text{dof} = 9.81/9$ ). No significant emission is detected by AGILE GRID.

GRB 091010 was also detected by Konus-Wind (Golenetskii *et al.*, *GCN Circ.* 10013): the time-integrated spectrum of the burst (from T0 to T0+8.448 s) is well fitted in the 20 keV - 2 MeV range by a Band model with a low energy photon index  $\alpha = -1.20_{-0.28}^{+0.35}$ ; a high energy photon index  $\beta \sim -2.9$  and a peak energy  $E_{\text{peak}} = 119_{-17}^{+19}$  keV ( $\chi^2/\text{dof} = 55/59$ ).

The Fermi/GBM detected and localized GRB 091010 (von Kienlin *et al.*, *GCN Circ.* 10018) (trigger 276835391 / 091010113): the GBM light curve consists of multiple peaks with a duration of about 8 s in the 8-1000 keV energy band. The time-averaged spectrum from T0-0.128 s to T0+8.064 s is best fit by a power law function with an exponential high energy cutoff with  $E_{\text{peak}} = 150_{-5}^{+6}$  keV. Flux and fluence upper limits based on the non-detection of GRB 091010 by Fermi/LAT are presented in Kocevski *et al.*, *GCN Circ.* 10128.

The Rossi X-ray Timing Explorer (RXTE) also recorded the event (Watts *et al.*, *GCN Circ.* 10014). This burst was also independently detected by INTEGRAL SPI-ACS (von Kienlin *et al.*, *GCN Circ.* 10018) and by Suzaku Wide-band All-sky Monitor (WAM) (Vasquez *et al.*, *GCN Circ.* 10023).

A candidate optical afterglow was proposed by Rossi *et al.*, *GCN Circ.* 10008 and Rumyantsev *GCN Circ.* 10030 and then rejected by Guidorzi *et al.*, *GCN Circ.* 10027 on the basis of the lack of fading. Optical upper limits are provided by Oksanen & Southgate *GCN Circ.* 10011.

### 2 BAT Observations and Analysis

No BAT data were taken for this burst.

### 3 XRT Observations and Analysis

The XRT began observing on 2009 Oct 10 at 14:48:26 UT, about 43 ks after the SuperAGILE trigger. A single, uncatalogued X-ray source was found within the SuperAGILE error box (Margutti & Guidorzi *GCN Circ.* 10006). Using 4 ks of overlapping XRT and UVOT data, the UVOT-enhanced XRT position was found to be (Evans & Goad *GCN Circ.* 10012) RA(J2000)=298.6655 deg (19<sup>h</sup>54<sup>m</sup>39.72<sup>s</sup>), Dec(J2000)= -22.5182 deg (-22<sup>d</sup>31'05.7''), with an uncertainty of 1.9 arcsec (radius, 90% confidence).

The light curve (Fig. 1) can be modelled by a simple power-law with best fit power law index  $\alpha =$

$-1.4 \pm 0.6$  (90% c.l.). The spectrum extracted in the time interval 43-50 ks contains about 170 photons and can be fitted using an absorbed power law model. The best fit photon index is found to be  $2.3 \pm 0.4$ . The spectrum shows evidence of neutral hydrogen absorption corresponding to a column density of  $(1.9 \pm 0.1) \times 10^{21} \text{ cm}^{-2}$ , in excess of the Galactic value in the direction of the burst which is  $8.1 \times 10^{20} \text{ cm}^{-2}$ , Kalberla et al. 2005. The observed (unabsorbed) flux over this time interval is  $1.5 \times 10^{-12} (2.8 \times 10^{-12}) \text{ erg cm}^{-2} \text{ s}^{-1}$ . The counts to observed (unabsorbed) 0.3–10 keV flux conversion factor deduced from this spectrum is  $3.6 \times 10^{-11} (6.6 \times 10^{-11}) \text{ erg cm}^{-2} \text{ count}^{-1}$  (Margutti *GCN Circ.* 10024).

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/](http://www.swift.ac.uk/xrt_curves/).

## 4 UVOT Observations and Analysis

The UVOT observed the field of GRB 091010 starting 43 ks after the SuperAGILE trigger. No optical afterglow consistent with the Swift XRT position is detected in the UVOT exposures. The  $3\text{-}\sigma$  upper limits, using the UVOT photometric system described in Poole *et al.* (2008, MNRAS, 383, 627) are listed in Table 1:

Filter	$T_{\text{mid}}$ (s)	Exposure (s)	Mag ( $3\text{-}\sigma$ )
White	$4.41 \times 10^4$	498	$> 21.36$
v	$4.47 \times 10^4$	609	$> 19.86$
u	$4.35 \times 10^4$	567	$> 20.48$

Table 1: Magnitudes from UVOT observations.

The values quoted above are not corrected for the Galactic extinction corresponding to a reddening of  $E_{B-V} = 0.010 \text{ mag}$  (Schlegel *et al.*, 1998).

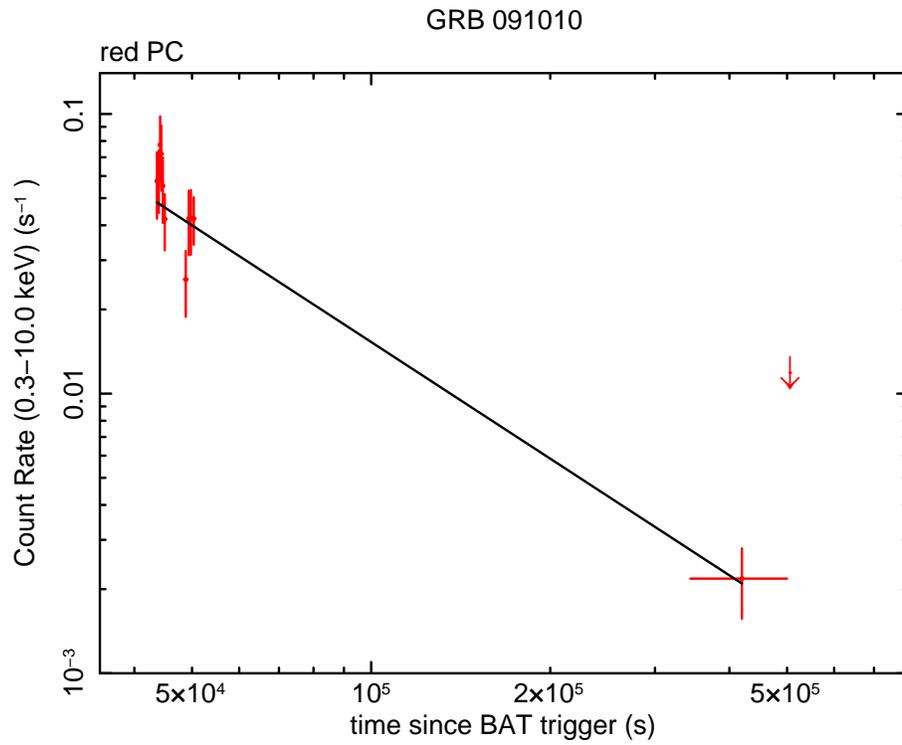


Figure 1: XRT Lightcurve in the 0.3-10 keV band. The count to observed 0.3-10 keV flux conversion factor is  $\sim 3.6 \times 10^{-11} \text{ erg cm}^{-2} \text{ s}^{-1}$ .