A Tale of Two Faint Bursts: GRB 050223 and GRB 050911

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Abstract.
GRBs 050223 and 050911 are examples of *Swift* bursts with two of the faintest X-ray afterglows at (relatively) early times. While a faint, fading X-ray afterglow was located for GRB 050223, GRB 050911 was not detected, making any X-ray afterglow extremely faint. The faintness of the afterglow of GRB 050223 could be explained by a large opening or viewing angle, or by the burst being at high redshift. The non-detection of GRB 050911 may indicate the burst occurred in a low-density environment, or, alternatively, was due to a compact object merger, in spite of the apparent long duration of the burst.

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INTRODUCTION

During its first 18 months of operation *Swift* triggered on 147 bursts, 135 of which were followed up by the X-ray Telescope (XRT). In almost all cases after a prompt slew, and often even after a substantial delay, an X-ray afterglow has been detected, adding substantially to the details known about GRBs in the first few minutes and hours following the initial burst.

Not all bursts are easily detectable by the XRT, though, with some being very much fainter; however, these sources are in the minority. Up until the start of June 2006, there were only three complete non-detections (besides GRB 050911) following a prompt slew. These were GRB 050925 (although this trigger may have been due to a new SGR; [1-2]), together with GRB 050906 [3] and GRB 051105A[4], both of which were short

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TABLE 1. γ- and X-ray parameters for GRBs 050223 and 050911. The times over which the X-ray fluxes were calculated are given in the last row of the table.

Burst	GRB 050223	GRB 050911	*Swift* mean
T_{90} (s)	23	16	46
15–150 keV T_{90} fluence (erg cm^{-2})	4.8×10^{-8}	3.0×10^{-7}	2.3×10^{-6}
0.3–10 keV unabs. flux (erg cm^{-2} s^{-1})	8.2×10^{-13}	UL: 1.7×10^{-14}	5.2×10^{-10}
time range post-burst (ks)	2.8–4.0	16–716	large range

bursts. (In general, the afterglows of short bursts tend to be fainter and drop below the XRT detection threshold quite rapidly; e.g., [5-6].)

This poster presented the analysis of GRBs 050223 and 050911 - two faint bursts initially triggered on by *Swift*. The X-ray afterglow of GRB 050223 was detected by the XRT after $\sim$ 47 minutes, whereas GRB 050911 remained undetected in an observation starting $\sim$ 4.6 hours after the burst.

DATA ANALYSIS

GRBs 050223 and 050911 were faint in both prompt and afterglow emission, as demonstrated by Table 1 and Figures 1 & 2. In the case of GRB 050223, the X-ray flux at 11 hours ($\sim 1 \times 10^{-13}$ erg cm^{-2} s^{-1} over 0.3–10 keV) was below all those detected by BeppoSAX [7]. The flux upper limit of 1.7×10^{-14} erg cm^{-2} s^{-1} for GRB 050911 shows that, at $\sim 10^4$ s, any X-ray afterglow emission was at least an order of magnitude fainter than all of the other long bursts detected by *Swift*, with the possible exception of GRB 050421 (Figure 1; [8-9]).

GRB 050223 - a large opening/viewing angle or high redshift?

The data for GRB 050223 were found to be inconsistent with post-jet-break evolution (from the standard GRB afterglow models; [10]). A large opening angle could explain both a late jet-break and the faintness of the afterglow, as well as the BAT fluence being relatively low. Alternatively, the low afterglow flux and prompt fluence could be caused by the burst being at high redshift; *Swift* GRBs are at a mean redshift of $\sim$ 2.1, while pre-*Swift*, the mean was $\sim$ 1.2. More details on the analysis of GRB 050223 can be found in Page et al. [11].

GRB 050911 - a naked GRB or a short burst?

The complete non-detection of an X-ray afterglow is very unusual for *Swift* bursts, as mentioned above. Because of a combination of the Earth-limb observing constraint and

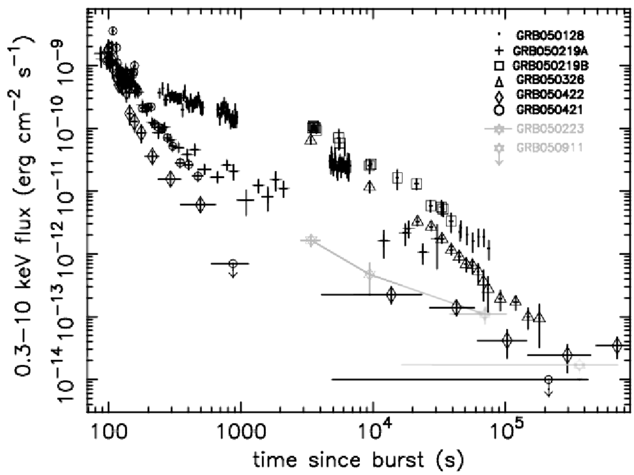

FIGURE 1. Flux light-curves for a selection of *Swift* GRBs, showing the faintness of the X-ray afterglows of GRB 050223 (grey stars joined by thick line) and GRB 050911 (grey starred upper limit).

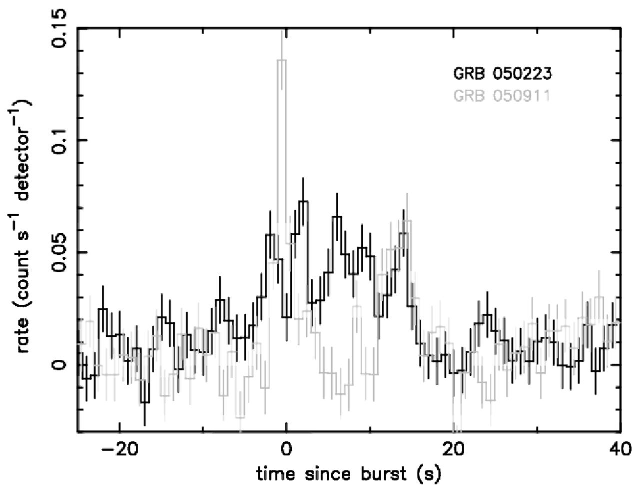

FIGURE 2. BAT light-curves (1-s bins) showing the count-rate per fully illuminated detector for each of the bursts.

a temporary problem with the star trackers, the first X-ray observation of GRB 050911 took place only $\sim$ 4.6 hours after the trigger. At this point, it was completely undetected, indicating that any afterglow corresponding to the burst must have faded very rapidly and/or been extremely faint. One possible explanation is the ‘naked GRB’ model, whereby the burst occurs in a low density environment, with the lack of surrounding material leading to a weak, or non-existent, forward shock. This may be the cause of the faintness of GRB 050421, as discussed by Godet et al. [8].

Short bursts ($T_{90} < 2$ s; thought to be formed through compact object mergers) tend to show weaker afterglows then their longer counterparts, typically fading below the XRT detection threshold within a few thousand seconds. Although its T_{90} makes GRB 050911 conventionally a long burst, there are two initial short (~ 0.5 s) spikes in the γ-ray light-curve. Thus, GRB 050911 is similar to some short bursts in showing an initial short peak followed by longer, softer faint high energy emission [12-14]. Simulations show that the later peak would not have been detected by BATSE at greater than the 1σ level; thus, if BATSE had triggered on this weak burst at all, it is likely that it would have been classified as short. A possibility, therefore, is that GRB 050911 could have been caused by a merger event: if one of the compact objects were a black hole, rather than a neutron star, the large mass ratio could lead to delayed accretion and, hence, high energy emission after 2 s [15]. See Page et al. [16] for more details.

CONCLUSIONS

The X-ray afterglows of both GRB 050223 and GRB 050911 are among the faintest observed at early times. Although *Swift* has the ability to measure faint X-ray emission out to many days after the burst, some afterglows are still too weak to be detected, indicating a difference in environment and/or formation mechanism.

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