GRB000615 in X-rays

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Abstract. GRB000615 was detected simultaneously by the *Beppo*SAX GRBM and WFC 1 with a localization uncertainty of $2'$ (error circle radius). X-ray emission was detected only in the 0.1–4 keV range during a NFI observation started $\simeq$ 10 hours after the trigger time. The positional and temporal analysis shows the presence of two sources, one of which may be related to the GRB.

1 Introduction

GRB000615 was detected on 15 June 2000, 06:17:44.91 UT [3] at coordinates (J2000) R.A. = $15^{\rm h}\,32^{\rm m}\,36\overset{\rm s}{.}9$, Dec = $+73^\circ\,49'\,07''$ ($2'$ error radius), which are revised with respect to those distributed in GCN 705 [1]. *Beppo*SAX NFI observation started the same day at 16:20:14 UT, i.e. $\simeq$ 10 hours after the trigger time, and lasted 1.44 days. The net exposure time was 44609 s for MECS and 31280 s for LECS. Two distinct uncatalogued X-ray sources are detected, one for each instrument. The source detected in the MECS has constant flux during the observation and its position is only marginally compatible with the WFC position of the GRB. The LECS source (0.1–4 keV), though detected at low statistical significance, is visible only in the first half of the observation; its position is fully compatible with the WFC one.

Optical/IR/radio searches did not detect any new source (see GCN circulars 706, 708, 709, 713, 719, 721, 727).

2 The burst

The GRBM (40–700 keV) light curve (lasting $\simeq$ **13** s) is shown in the top panel of Fig. 1. Spectral analysis shows a softening during the burst with a power-law spectral index ($\mathbf{N_E} \propto \mathbf{E}^{-\alpha}$) from 1.0 ± 0.4 (rise) to 2.4 ± 0.7 (last part of the decay) with an average of $\alpha = 1.71 \pm 0.46$. The average flux in the 40–700 keV band is $f_\gamma = (8.2 \pm 0.7) \times 10^{-8}$ erg cm^{-2} s^{-1}, the peak flux is $(1.0 \pm 0.2) \times 10^{-7}$ erg cm^{-2} s^{-1} and the total fluence $F_\gamma = (9.8 \pm 0.9) \times 10^{-7}$ erg cm^{-2}. The hardness ratio $f_{100-300/50-100} = 2.0 \pm 0.3$.

In the 2–28 keV WFC band, the burst behaviour is quite different. At the time of the GRB onset, the X-ray flux increases only slightly, while a major rise appears some 40 s later and lasts $\simeq$ 60 s. Splitting the WFC band in the ranges 2–10 and 10–28 keV we note that the prompt emission comes mainly from the hard band, while the delayed emission from the soft band. This effect, which is under study, can be attributed to scattering of gamma-rays to lower energies rather than to "clean" source photons. The 2–28 keV (delayed) flux is $(2.85 \pm 0.45) \times 10^{-8}$ erg cm^{-2} s^{-1}. In 2–10 keV it is $f_x = (1.74 \pm 0.10) \times 10^{-8}$ erg cm^{-2} s^{-1}.

3 *Beppo*SAX NFIs observation

The follow-up *Beppo*SAX NFIs observation showed, in the MECS energy range 1.6–4 keV, a soft and stable X-ray source ($\sim 5\sigma$ level). An optimized source counts extraction radius of $3'$ was used. Figure 2 shows the smoothed image of the entire observation. The source coordinates are: R.A. = $15^{\rm h}\,32^{\rm m}\,23\overset{\rm s}{.}3$, Dec = $+73^\circ\,47'\,30''$ (1SAX J1532.4+7349). To be *conservative*, we can set an error circle of $2'$ (see Fig. 2). This position (note it is $\simeq 1\overset{'}{.}5$ away from that reported in GCN 707 [2]) could then be compatible (offset = $1\overset{'}{.}8$) with the WFC GRB position. However its flux stability suggests it is not related to the GRB. The average flux is $f_x = (6.7 \pm 1.5) \times 10^{-14}$ erg cm^{-2} s^{-1} in 1.6–4 keV. No significant emission is detected above 4 keV.

In the LECS (0.1–4 keV) a source is detected at 2.5σ level, but *only in the first half* of the observation. The smoothed images of the two halves of the observation are shown in Fig. 3. The position of this source is: R.A. = $15^{\rm h}\,32^{\rm m}\,35$, Dec = $+73^\circ\,48'\,50''$ (1SAX J1532.6+7348), fully compatible with the WFC (GRB) position. The low significance of the detection cannot help in discriminating the source characteristics.

Unfortunately the low statistics leaves open several interpretations. In particular it is not clear if the MECS and LECS sources are really distinct and which (if any) is related to GRB000615. More sensitive observations of the field may help investigating the two detected sources. Nevertheless, one can speculate that a soft prompt (actually *delayed*) X-ray event could lead to a soft afterglow. In brief, our refined data analysis shows that:

- a stable (probably unrelated to the GRB) source is detected in the MECS. Its spectrum can be fit by a power-law of index $\alpha = 3.2 \pm 0.5$ ($\chi^2_n = 1.1$).
- after $\sim$ 20 hours from the gamma-ray event the X-ray afterglow is not detected to the limit of the MECS sensitivity suggesting a power-law temporal decay index $\lesssim -1.7$ (respect to the WFC mean flux and $T_{start} = T_{burst}$).
- a source is detected in the LECS band 0.1–4 keV; some hint of decay is present.

References

1. G. Gandolfi et al.: GCN circ. 705 (2000)

2. G. Gandolfi et al.: GCN circ. 707 (2000)
3. L. Piro et al.: GCN circ. 703 (2000)

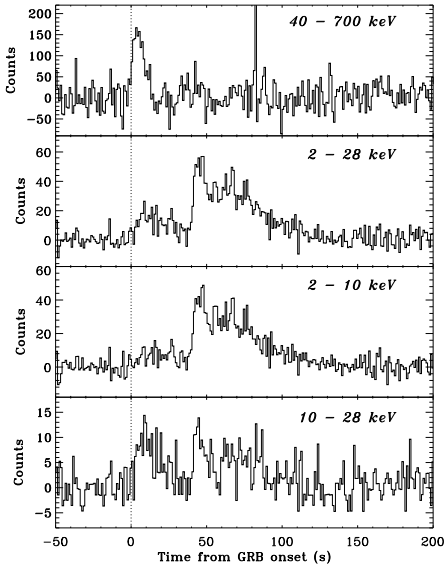

Fig. 1. The 1 s GRBM (*top*) and WFC light curves. A hard X-ray component is visible in the 10–28 keV band at the GRB onset. The soft emission starts after $\simeq$ 40 s from the trigger

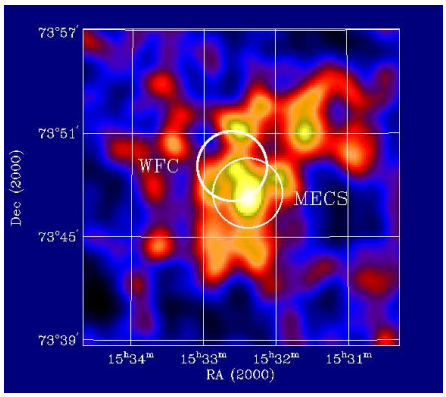

Fig. 2. MECS 1.6–4 keV smoothed image. The 2′ error circle is shown together with the WFC one (also 2′). The main source is stable during the observation

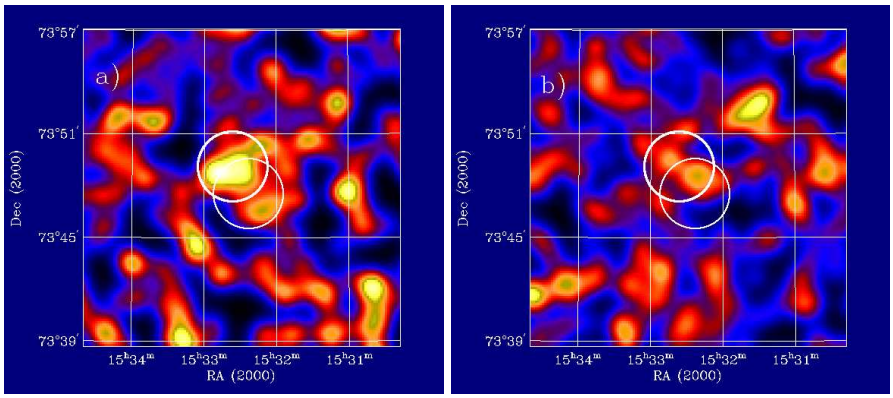

Fig. 3. LECS (0.1–4 keV) images for the first (**a**) and second (**b**) half of the observation. The WFC and MECS source error circles are shown