

Ulysses/BeppoSAX Observations of Cosmic Gamma-Ray Bursts

K. Hurley^{a*} T. Cline^b F. Frontera, D. Dal Fiume, M. Orlandini^c E. Costa, L. Piro, and M. Feroci^d

^aUC Berkeley Space Sciences Laboratory, Berkeley, CA 94720-7450

^bNASA Goddard Space Flight Center, Greenbelt, MD 20771

^cUniversity of Ferrara and I. Te.S.R.E./CNR, I-40129 Bologna, Italy

^dI.A.S./CNR, I-00044 Frascati, Italy

BeppoSAX has been added to the 3rd Interplanetary Network of gamma-ray burst detectors. Of the 8 events observed to date by Ulysses and the BeppoSAX Gamma Ray Burst Monitor (GRBM), four have been localized by triangulation, resulting in annuli whose 3σ widths are as small as $63''$. These data give error boxes whose sizes are sometimes smaller than those obtained with the SAX Wide Field Camera (WFC). They can be used to confirm the association between fading X-ray and optical sources and gamma-ray bursts.

1. INTRODUCTION

A preliminary search of the BeppoSAX GRBM data has revealed that eight events have been observed by the GRBM and Ulysses, among other spacecraft, since the launch of BeppoSAX. They are listed in Table 1. In addition, there are many more Ulysses/GRBM bursts which we have not yet analyzed.

The BeppoSAX GRBM utilizes four 1100 cm^2 anticoincidence shields to detect bursts, while Ulysses has two hemispherical detectors which present a cross-sectional area of 20 cm^2 in any direction. Thus we do not expect to detect all the GRBM bursts with Ulysses.

2. FOUR ULYSSES/WFC EVENTS

We present briefly the four events in Table 1 which were also observed by the Wide Field Camera (WFC) in order of increasing localization accuracy and interest in figures 1-4. The WFC error box sizes have been reduced with respect to their original determinations [4].

GRB970402 (figure 1) was observed as a weak

event by Ulysses; it did not trigger the detector, and the only data available were taken with 0.25 s resolution. The resulting annulus width is quite large (4.8°), but consistent with the MECS/LECS fading X-ray source [11].

GRB970508 (figure 2) was also observed only weakly by Ulysses. It too did not trigger the detector, but the resulting annulus width is smaller ($18'$). The annulus is consistent with the positions determined by the WFC [4], the MECS [12], and the optical transient [10].

GRB970111 (figure 3) was more intense, and triggered the Ulysses detector. A 32 ms resolution time history is available, leading to an annulus width of $3.5'$, which is consistent with the WFC error box. No optical transient was observed for this burst.

GRB970228 (figure 4) was the most intense of the three, and also triggered Ulysses, leading to 32 ms resolution data. The annulus width is only $63''$, and is consistent with the WFC and LECS/MECS error boxes, as well as with the optical transient. These results are particularly interesting for two other reasons. First, they allow a model-independent lower limit to the distance to be made. From wavefront curvature arguments, this is 11,000 AU, or a redshift $z > 10^{-11}$. Second, they provide a confirmation of the accuracy of the IPN. IPN uncertainties cannot exceed $\pm 3'$,

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Table 1
Gamma-ray bursts observed by SAX and Ulysses.

Date	Ulysses	GRBM	WFC	BATSE
960805	Trigger	Yes	No	No
961101	Trigger	Yes	No	No
970111	Trigger	Yes	Yes	# 5773
970117	Trigger	Yes	No	No
970228	Trigger	Yes	Yes	No
970402	RI*	Yes	Yes	# 6152
970508	RI*	Yes	Yes	# 6225
970627	Trigger	Yes	No	No

* Rate increase - this means that the burst was detected in a low time resolution mode (0.25 - 2 s)

the radius of the WFC error circle. Assuming that the fading X-ray source is associated with the GRB, the uncertainty becomes $\pm 1'$, and further assuming that the optical transient is associated with the GRB leads to a maximum uncertainty of $\pm 31.5''$.

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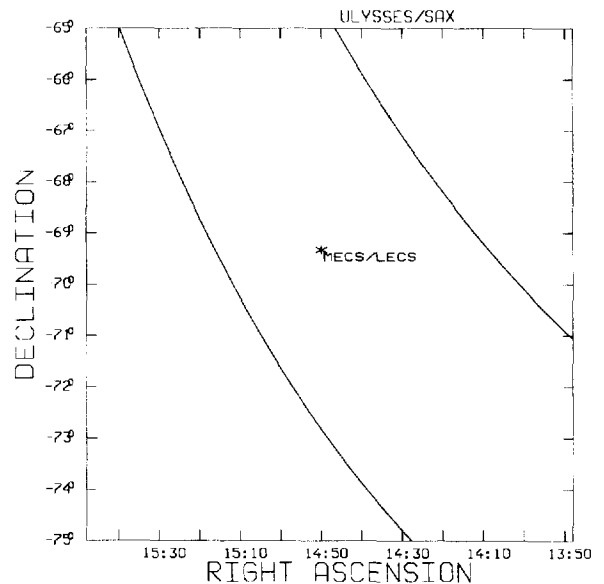


Figure 1. GRB970402 was observed only weakly by Ulysses. The Ulysses/SAX triangulation annulus has a total width of 4.8° (3σ). The annulus confirms, but does not improve upon, the source location derived from the observation of a fading X-ray source by the SAX MECS/LECS [10].

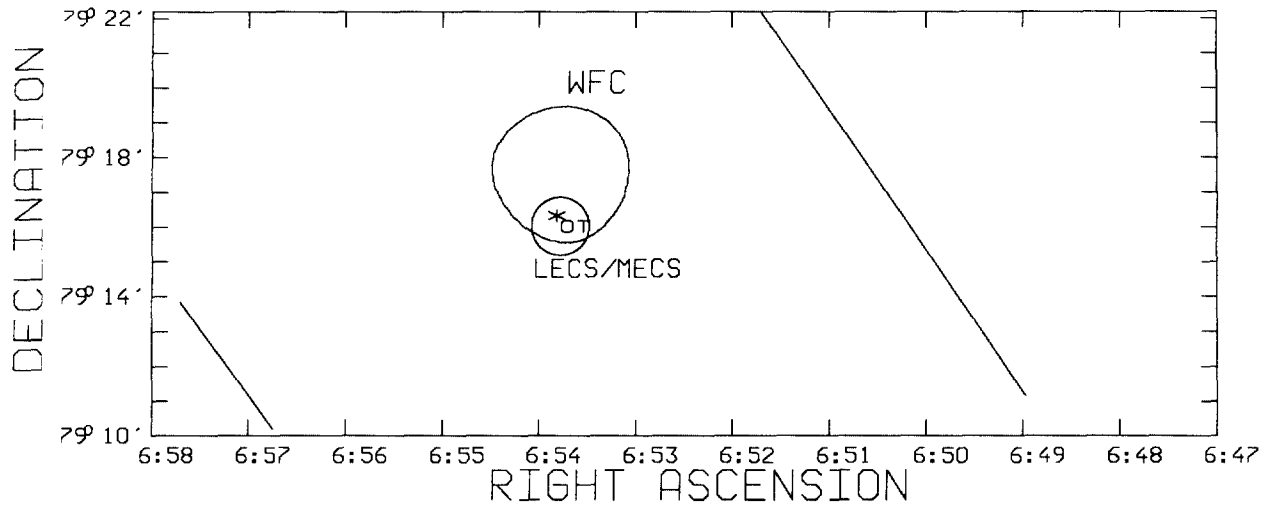


Figure 2. GRB970508 was also observed weakly by Ulysses. The Ulysses/SAX triangulation annulus has a total width of $18'$ (3σ) and confirms, but does not improve upon, the source locations derived from the WFC [3], the observation of a fading X-ray source by the SAX LECS [11], and the optical transient (OT) [9].

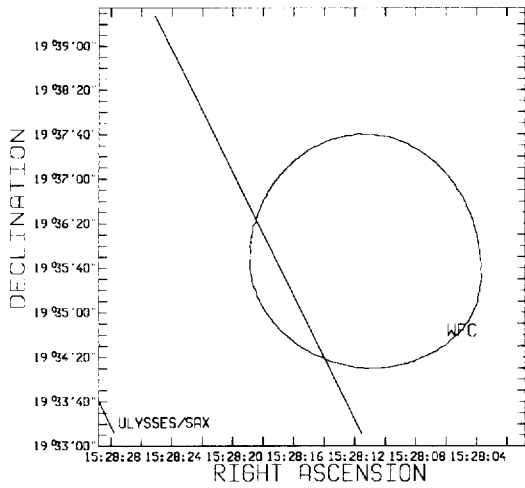


Figure 3. GRB970111 was intense enough to trigger Ulysses [2,4,5]. The Ulysses/SAX annulus has a total width of 3.5' (3σ), and reduces the size of the SAX WFC [3] error circle. No fading X-ray source or optical transient was observed.

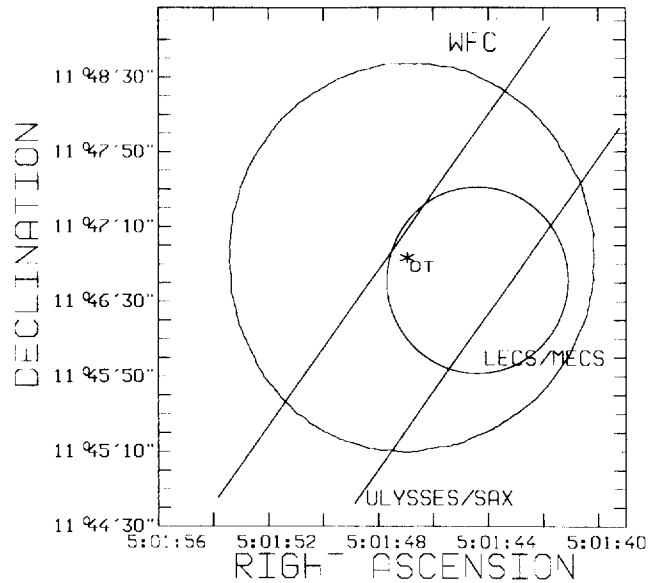


Figure 4. GRB970228 [6-8] was intense enough, and had a structured enough time history, to obtain a triangulation annulus 63" wide (3σ). This annulus reduces the size of the WFC error circle [3] substantially, and also that of the LECS/MECS [1] error circle, resulting in an error region with an area 0.76 square arcminutes. The region contains the optical transient [12].