BATSE/OSSE RAPID BURST RESPONSE

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Abstract. The BATSE and OSSE instrument teams have modified flight software to promptly (within 2 min of trigger) slew the OSSE detectors to burst locations determined on-board by BATSE. This enables OSSE to make sensitive searches for prompt and delayed post-burst line and continuum emission above 50 keV. In the best cases our sensitivity will be more than an order of magnitude better than any other search in this energy range. We expect to slew to 1–2 bursts per month, based on the OSSE FOV and BATSE event rate. Detections or limits from continued operation of this system may provide significant constraints on burst models. As an example of the observations made using this system, we present preliminary limits for post-burst emission from GRB 950223 on several time scales.

Key words: Gamma-ray bursts – Counterparts – Instrumentation

1. Introduction

The search for counterparts is an important part of gamma-ray burst investigations. The burst source itself might produce fading emission after the event, while persistent DC flux might come from the burst source or an associated object, e.g., the parent galaxy. A true counterpart, if found, might indicate the nature of the burst source or the distance scale to bursts. Programs exist to observe burst locations promptly at optical [8], radio [2], and other wavelengths [3] using positions calculated on the ground and rapidly disseminated [1, 7]. To date, though, pre- and post-burst emission has only been seen at energies where bursts themselves are observed: by Ginga in soft X-rays [11, 9] and by EGRET in high-energy gamma-rays [10, 5].

2. BATSE/OSSE Rapid Burst Response System

In order to make the most prompt possible post-burst source observations, the BATSE and OSSE instrument teams have developed a system where BATSE calculates burst locations on-board GRO and sends the positions to OSSE, which then points at the designated position. OSSE [6] consists of 4 large ($\sim$ 500 cm^2 area each) cylindrical NaI/CsI phoswich detectors, each with a collimated field of view (FOV) of $3.8° \times 11.4°$ (FWHM). The detectors can be rotated through 192° about an axis parallel to the long

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direction of the collimator. This gives the OSSE instrument access to about 10% of the sky for any particular orientation of GRO.

In the BATSE position calculation, counts from each detector are accumulated from the trigger to trigger + 4.096 s. Six different ratios of these counts, from different subsets of the 8 detectors, are used to determine whether the burst is near the scan plane and within the OSSE slewing range. An intensity threshold of 40 counts/64 ms eliminates events which are too weak to position accurately. For events which meet the position and intensity selection criteria, the on-board BATSE-calculated position is sent to OSSE encoded as the length of the burst trigger signal.

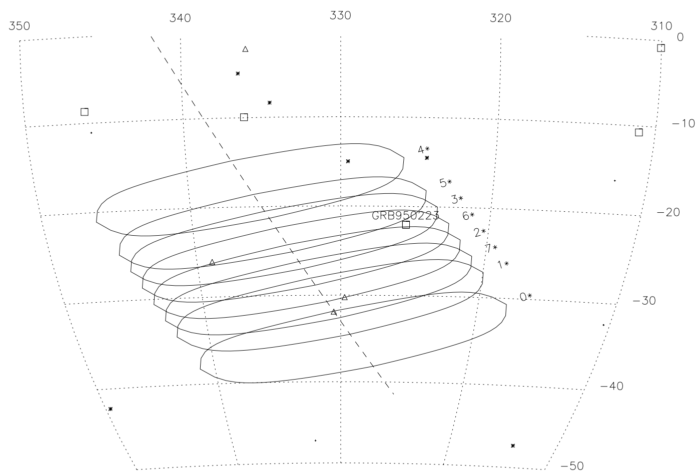

Fig. 1. The observation pointing strategy for GRB 950223. Coordinates are RA and Dec, in degrees.

OSSE tests the length of each burst trigger signal received to determine if the implied angle falls within the allowed scan range. If it does, a look-up table is used to convert the trigger signal length to a scan angle. That target location is used as the center of a detector pointing strategy table that views multiple positions spanning the probable error circle (±10°). Once the new pointing table is set up, the detectors slew to the target position and begin observations. The time from the trigger to the start of observations is less than 2 min. Post-burst observations normally last 12 hr, after which the detectors return to the scheduled target.

As an illustration of the burst source observation strategy, Figure 1 shows the OSSE FWHM fields of view for the 8 pointing positions of detector 1 used in the observation of GRB 950223. The numbers from 0 to 7 indicate the sequence of pointings (2-min per position, repeated throughout the observation). The other 3 detectors observed the same positions in a different sequence to give more uniform time coverage of the entire error box.

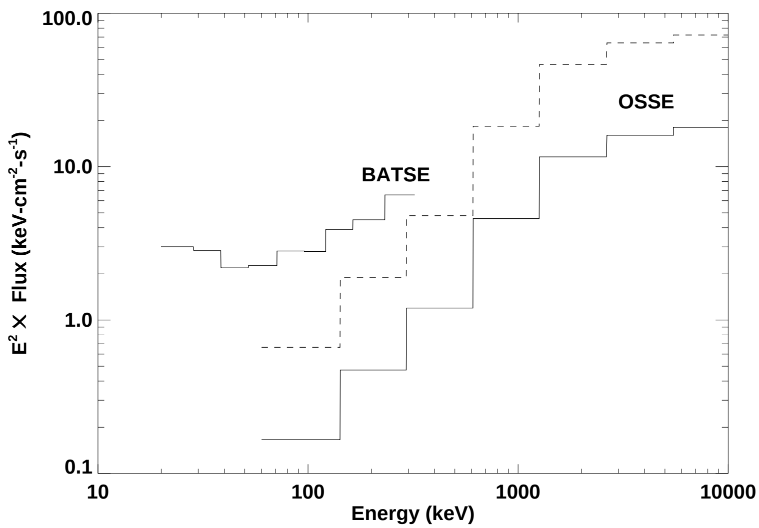

Fig. 2. A comparison of the BATSE and OSSE sensitivities for persistent burst emission. See text for description.

Figure 2 is a comparison of the BATSE one-orbit occultation sensitivity [4] to the sensitivity for slewing observations by OSSE, also for one orbit. The solid line represents the best-case OSSE sensitivity, while the dashed line is a typical value for a broad scan pattern and the burst offset from the scan plane. In addition to better sensitivity for bursts near the scan plane, OSSE provides more complete time coverage since occultation observations are limited to a few minutes per orbit.

3. Accuracy of Burst Angle Signals

Since we began operations on August 8, 1994, BATSE has generated position signals for 13 gamma-ray bursts. To evaluate the accuracy of the on-board locations, we compare them with the final BATSE positions. For reasons not currently understood, four of the positions were outliers, with differences between the on-board and final positions of greater than 30° in elevation or azimuth. The other 9 have a mean difference of 0.2° in elevation and 3° in azimuth, and an RMS difference of 10°. Seven of the 9 are within the 11 degree azimuth range acceptable to OSSE, with the others at 16° and 22°. The preliminary evaluation, based on the current, limited, sample of events, indicates that the system is accurate to within the expected 5–10°. We will continue to monitor the on-board positioning accuracy.

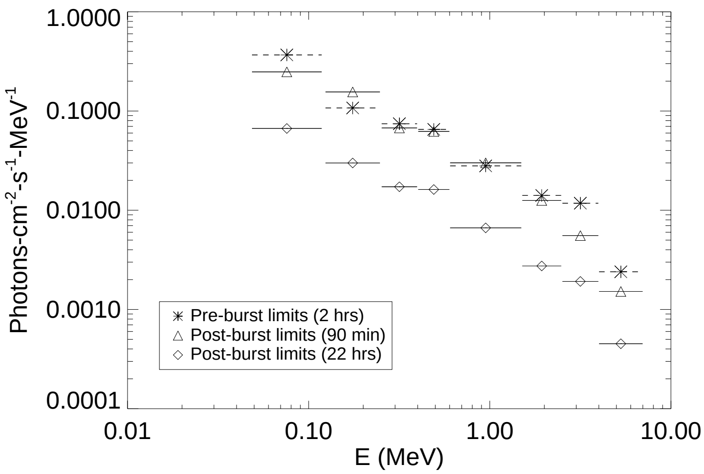

Fig. 3. Upper limits (3σ) on the average flux from GRB 950223 both before and after the event.

4. Prompt OSSE Observations of GRB 950223

As an example of the observations made with the rapid slewing system we present preliminary results from a relatively weak burst, GRB 950223 (BATSE trigger 3439). OSSE began observations of the burst location provided by BATSE about 100 s after the trigger. Since the scheduled OSSE target was near the burst position, we also have data before the trigger.

Figure 3 shows the 3σ upper limits derived for *average* flux from the nominal position of GRB 950223, integrated over three time scales: 2 hrs before the burst, the 90 min (1 orbit) immediately following the burst, and 22 hrs after the burst. The limits shown are only statistical; there is a substantial additional uncertainty in the derived flux limits since they depend on the assumed position of the source.

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