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The interplanetary network supplements to the BATSE 5B and untriggered burst catalogs(*)

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Summary. — We describe Interplanetary Network (IPN) detection and localization information for 554 gamma-ray bursts (GRBs) observed as triggered and untriggered events by BATSE. For any given burst observed by BATSE and one other distant spacecraft, arrival time analysis (or "triangulation") results in an annulus of possible arrival directions whose half-width varies between 14 arcseconds and 5.6 degrees, depending on the intensity, time history, and arrival direction of the burst, as well as the distance between the spacecraft. This annulus generally intersects the BATSE error circle, resulting in a reduction of the area of up to a factor of ~ 650. When three widely separated spacecraft observed a burst, the result is an error box whose area is as much as 30000 times smaller than that of the BATSE error circle.

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1. – Introduction

This paper describes the 8th and 9th catalogs of gamma-ray burst localizations obtained by arrival time analysis, or "triangulation", between the missions in the 3rd interplanetary network (IPN), which began operations in 1990 and continues to operate today. Two of these catalogs [1, 2] were supplements to the BATSE 3B and 4Br (r for revised) burst catalogs [3, 4]. Five of them involved bursts observed by numerous other spacecraft [5-9]. The 8th one presented IPN data on 211 *luntriggered* bursts which occurred throughout the entire *lCompton Gamma-Ray Observatory (CGRO)* mission (1991 April through 2000 May) [10]. The 9th IPN supplement catalog, to the BATSE 5B catalog, is in preparation [11, 12]. Tables I and II summarize the 8th and 9th catalogs.

TABLE I. – *Two BATSE untriggered GRB catalogs and the IPN supplement to them.*

Authors	Stern *et al.* [13]	Kommers *et al.* [14]
Time period covered	December 1991–May 2000	December 1991–December 1997
Number of untriggered bursts	1838	873
Conclusions	$\log N$-$\log S$ increases	$\log N$-$logS$ flattens
Total number of bursts	≈ 2000	
IPN supplement paper	Hurley *et al.* [10]	
Number of IPN detections	211 (11%)	

TABLE II. – *The BATSE 5B GRB catalog and the IPN supplement to it.*

Authors	Briggs *et al.* [11]
Time period covered	August 1996–May 2000
Number of triggered bursts	≈ 1068
Number of IPN detections	343 ($\approx 32\%$)
IPN supplement paper	Hurley *et al.* [10]

2. – The BATSE and IPN supplement catalogs

The main objectives of the IPN supplement to the 5B catalog are to reduce the sizes of the BATSE error circles and enable the BATSE team to refine their model of localization uncertainties. The main objectives of the supplement to the untriggered catalog were slightly different; the first was to confirm that the events detected were really GRBs, the second was to validate the search procedures used, the third was to lend credibility to the number-intensity relation derived in the catalogs, and the last was to reduce the sizes of the error circles.

During BATSE's lifetime, the IPN consisted of 15 separate GRB experiments aboard 12 missions. The procedure used to identify IPN bursts corresponding to BATSE bursts was the following. For the near-Earth spacecraft, the data were searched for a detection at the same time as the BATSE burst. For the distant spacecraft (NEAR, Ulysses, and PVO), knowing the Earth-crossing time and approximate arrival direction for each BATSE burst, the crossing times at the spacecraft were calculated, and the data were searched around these times. In all cases, if an event was identified, its time history was cross-correlated with the BATSE one, and an IPN annulus or error box was obtained. In the end, detections came from the data of just 11 experiments: BeppoSAX, DMSP, Ginga, Konus-A, Konus-Wind, NEAR, PHEBUS, PVO, SROSS C-2, Ulysses, and WATCH-GRANAT.

3. – Results

Two hundred and sixty-four bursts in the 5B catalog were localized to annuli with widths $11''$ and above; the average reduction in area of the corresponding BATSE error circles was a factor of 20. Eighty bursts were localized to error boxes with areas 1 square arcminute and above, and the average reduction in area was a factor of 87. Figure 1 shows the Galactic distribution of the bursts.

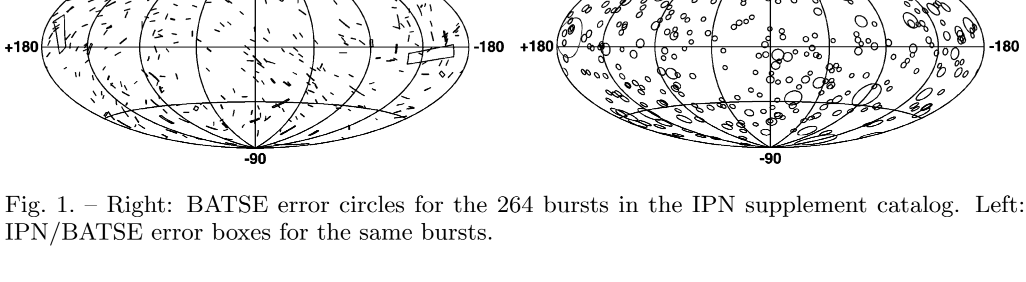

Fig. 1. – Right: BATSE error circles for the 264 bursts in the IPN supplement catalog. Left: IPN/BATSE error boxes for the same bursts.

A few anomalies were found in the course of this work. For example, some "untriggered" bursts actually turned out to be triggered events, because the trigger occurred for some reason other than the burst, such as a Cyg X-1 fluctuation. Also, 9 untriggered events were probably SGR bursts. But apart from these anomalies, the vast majority of the untriggered events detected by the IPN are real GRBs.

Stern *et al.* [13] and Kommers *et al.* [14] reached different conclusions about the shape of the number-intensity relation for weak bursts. Stern *et al.* found that it continued to increase for weak events, while Kommers *et al.* found evidence for flattening. This is probably due to different methods of classifying weak events. The untriggered BATSE bursts have peak fluxes between 0.06 and 25 photons cm^{-2} s^{-1}. However, IPN can only detect bursts down to 1 photon cm^{-2} s^{-1} with good efficiency. Thus although the untriggered supplement catalog does validate many of the search procedures used for untriggered BATSE bursts, it does not indicate what the shape of the number-intensity relation is for the weak events.

4. – Conclusions

The BATSE triggered and untriggered catalogs contain data on $\approx$ 4700 GRBs; the IPN supplements contain data on $\approx$ 900 of them. This type of catalog will not be duplicated, even by Swift, in the near future. Among the uses for these catalogs are searches for GRBs associated with peculiar SNe (97ef, 98ey, 99as, etc.), and searches for neutrinos associated with GRBs (AMANDA). The untriggered catalogs also present the possibility of studying correlations between burst properties such as hardness, intensity, and duration, without the selection effects introduced by the onboard trigger criteria. Thus they will remain valuable resources for many years to come.

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