# The HETE-2 Burst Catalog

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**Abstract.** During its >2.5 years of operation, the High Energy Transient Explorer (HETE-2) has detected nearly 300 GRBs, over 800 XRBs, and ∼50 bursts from SGRs in on-orbit operations and sophisticated ground searches of archived data. In addition to these bursts, there have been over 1500 other triggers detected using on-board or ground algorithms, hundreds of which are as yet unidentified and may come from cosmic sources. We have developed the HETE Burst Catalog as a means of organizing and analyzing the data from these nearly 3000 triggers in a systematic way. We present preliminary results from the HETE burst catalog.

## INTRODUCTION

During its >2.5 years of operation, the High Energy Transient Explorer (HETE-2) has detected over 170 GRBs in on-orbit operations; over 100 additional bursts have been detected in more sensitive ground searches of survey data. In this same period, over 800 XRBs and ∼50 bursts from SGRs have been detected. In addition to these ∼1200 bursts, there have been over 1500 additional triggers detected by on-board software (hereafter "triggered" bursts) or ground algorithms (hereafter "untriggered" bursts), hundreds of which are as yet unidentified and may come from cosmic sources.

We have developed the HETE Burst Catalog as a means of organizing and analyzing the data from these nearly 3000 triggers in a systematic way. We apply the same analyses to all triggers, allowing us to identify patterns in the data that identify particular types of triggers. The output of these analyses are text files in a "keyword=value" format; these text files are reprocessed and put into the master HETE trigger database, aka the HETE Burst Catalog. Simple scripts can be used to extract data from the catalog to create tables and illuminative plots, such as the ones in Figure 1 and Table 2; in addition,

CP727, *Gamma-Ray Bursts: 30 Years of Discovery,* edited by E. E. Fenimore and M. Galassi

**TABLE 1.** Distribution of HETE Trigger Types

| Trigger Type | Triggered | Untriggered | Description |
|---|---|---|---|
| GRB | 104 | 101 | Bursts with significant band C emission |
| XRB | 281 | 561 | Bursts localized to known XRB sources. The initial classification of XRB is also given to unlocalized bursts detected near the Galactic Center if the burst is bright and FRED-like. |
| Collimator | 58 | 0 | Real GRBs which entered Fregate through the graded-shield collimator (incident angle $>70°$). The shield absorbs everything $<100$ keV, so collimator bursts have no band A or B emission. |
| XRF | 10 | 8 | Bursts with significant low-energy fluence, yet not consistent with an XRB source |
| SGR | 40 | 6 | Bursts from known SGR; also assigned to very short, soft bursts when the Galactic Center is in the Fregate FOV. |
| Particles | 298 | 4 | Particle events from either the Ecuador or South Atlantic Anomaly. |
| Emersion | 28 | 1 | Emersion of a bright X-ray source from behind the Earth's limb. |
| Immersion | 3 | 0 | Immersion of a bright X-ray source behind the Earth's limb. |
| Corruption | 13 | 0 | Data corruption |
| Error | 61 | 0 | Operational error |
| Poisson | 92 | 2 | False trigger due to statistical fluctuations |
| Sco X-1 | 56 | 0 | Trigger due to Sco X-1 fluctuation |
| Solar | 46 | 1 | Reflected solar X-rays |
| Spin | 180 | 0 | Trigger due to spacecraft spin |
| Other | 65 | 763 | Unclassified or unknown trigger sources |

intermediate data products can be extracted and further processed (e.g., color-color plots, $T_{50}$ distributions, etc.).

As more sophisticated analyses are developed, they are incorporated into the suite of analysis routines and modified to create standard output files; new database keywords are created as needed. The new analysis routines are run over the entire collection of triggers, and a new Burst Catalog is created.

One caveat to the Burst Catalog in general and to the results presented here: because the new analysis routines are developed and perfected using subsets of HETE data before they are added to the suite of routine analyses, the catalog sometimes does not have the most up-to-date results. At this point in the development of the catalog, these differences are typically small; some of the results from detailed spectral analyses of certain bursts, presented elsewhere in these proceedings, may differ slightly from what is in the catalog and presented here.

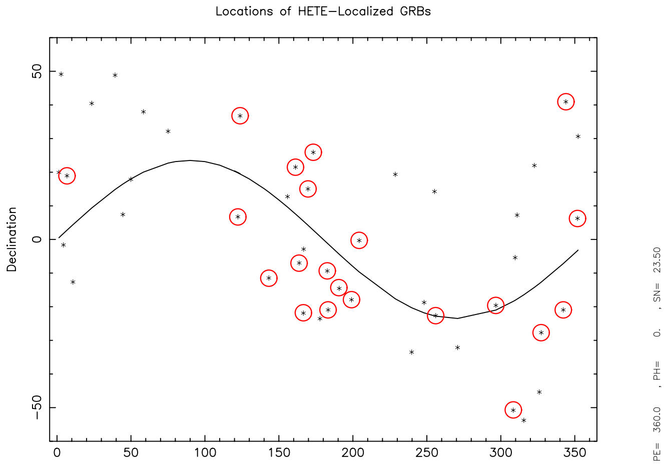


**FIGURE 1.** Plotted are the celestial coordinates of all GRBs localized by HETE; the sinusoid is the Ecliptic, the nominal (antisolar) pointing direction of the HETE instrument complement during the year. The circled localizations are those with detected afterglows, either optical, radio, infrared, or X-ray. The localized GRBs are distributed relatively randomly in a band $<50^\circ$ from the Ecliptic, as expected. The apparent clustering of the detected afterglows is curious, but likely not statistically significant.

## TRIGGER CLASSIFICATIONS

Table 1 gives a list of the major classifications of HETE triggers and their frequency in triggered and untriggered searches. The classification is assigned usually within 1–2 hours of the burst trigger; when the burst is reviewed later on, the classification can change.

Some classifications require significant analysis to confirm. For example, "collimator" events are those which propagated through the Fregate graded shield (which absorbs the lower-energy photons) and are typically hard and quite often short: The primary way to distinguish "collimator" events from "short, hard GRBs" is to examine the distribution of counts in the four Fregate detectors: any significant asymmetry is a sign that the burst came in through the collimator. The precise definition of the "classical GRB" category vs. "X-ray Flash" or the recently-added "X-ray Rich" categories depends on spectral analyses of the burst data; as more sophisticated analyses are performed, the designation can change.

The "other" category contains hundreds of weak triggers of the ground trigger software. Many of these may be weak bursts; further analyses are required to confirm them as cosmic events.

A tabular summary of those bursts localized by the WXM and/or SXC by 2003 September 1 is shown in Table 2. A summary of their locations on the celestial sphere is shown in Figure 1.

**TABLE 2.** Table of WXM/SXC localized bursts before 2003 September 1.

| GRB | Class* | Loc† | AG** | Z | $\alpha$ | $\beta$ | Error‡ | IPN§ |
|---|---|---|---|---|---|---|---|---|
| 010110 | GRB | Y/n | | | | | | K,U |
| 010213 | XRF | Y/n | | | | | | |
| 010225 | XRF | Y/n | | | | | | |
| 010326B | XRF | Y/n | | | $11^h\,50^m\,59^s$ | –23° 32′ 44.0″ | 10.0 | K,U |
| 010612 | GRB | Y/n | | | $18^h\,03^m\,18^s$ | –32° 08′ 02.0″ | 36.0 | K,S,U |
| 010613 | GRB | Y/n | | | $17^h\,00^m\,40^s$ | +14° 16′ 05.0″ | 36.0 | K,U |
| 010629B | GRB | Y/n | | | $16^h\,32^m\,38^s$ | –18° 43′ 23.0″ | 15.0 | K,S,U |
| 010921 | GRB | 1D/n | O | 0.451 | $23^h\,00^m\,00^s$ | +44° 00′ 00.0″ | 300.0 | K,S,U |
| 010928 | GRB | 1D/n | | | $23^h\,29^m\,00^s$ | +30° 39′ 90.0″ | 480.0 | D |
| 011019 | XRF | Y/n | | | $00^h\,43^m\,11^s$ | –12° 38′ 56.0″ | 12.0 | |
| 011103¶ | XRF | Y/n | | | $03^h\,19^m\,49^s$ | +17° 52′ 05.0″ | 840.0 | |
| 011130 | XRF | Y/n | | | $02^h\,58^m\,09^s$ | +07° 24′ 40.0″ | 60.0 | |
| 011212 | XRF | Y/n | | | $05^h\,00^m\,23^s$ | +32° 09′ 58.0″ | 10.0 | |
| 020124 | GRB | Y/n | O | 3.20 | $09^h\,32^m\,49^s$ | –11° 27′ 35.0″ | 12.0 | K,U |
| 020127 | GRB | Y/n | X | | $8^h\,15^m\,06^s$ | +36° 44′ 31.0″ | 7.8 | K,U |
| 020305 | GRB | Y/n | O | | $12^h\,43^m\,03^s$ | –14° 33′ 06.0″ | 25.0 | M,S,U |
| 020317 | XRF | Y/n | | | $10^h\,23^m\,21^s$ | +12° 44′ 38.0″ | 18.0 | |
| 020331 | GRB | Y/n | O | | $13^h\,16^m\,23^s$ | –17° 55′ 23.0″ | 7.8 | K,U |
| 020531 | GRB | Y/n | | | $15^h\,14^m\,45^s$ | +19° 21′ 30.0″ | 36.0 | M,U |
| 020625 | XRF | Y/n | | | $20^h\,44^m\,03^s$ | +07° 14′ 28.0″ | 14.0 | |
| 020801 | GRB | Y/n | | | $21^h\,2^m\,14^s$ | –53° 46′ 14.0″ | 13.9 | U |
| 020812 | GRB | Y/n | | | $20^h\,38^m\,48^s$ | –05° 23′ 34.0″ | 12.6 | |
| 020813 | GRB | Y/Y | OX | 1.254 | $19^h\,46^m\,38^s$ | –19° 35′ 16.0″ | 1.0 | K,M,U |
| 020819 | GRB | Y/Y | R | | $23^h\,27^m\,25^s$ | +06° 16′ 46.0″ | 1.1 | H,K,U |
| 020903 | XRF | Y/1D | OR | 0.25 | $22^h\,49^m\,01^s$ | –20° 55′ 47.0″ | 15.0 | |
| 021004 | GRB | Y/Y | OIRX | 2.328 | $00^h\,26^m\,57^s$ | +18° 55′ 44.0″ | 2.0 | K |
| 021016 | GRB | 1D/n | | | $00^h\,11^m\,04^s$ | +49° 08′ 20.0″ | 330.0 | K,M,U |
| 021021 | XRF | Y/n | | | $00^h\,17^m\,23^s$ | –01° 37′ 01.0″ | 20.0 | |
| 021104 | XRF | Y/n | | | $3^h\,53^m\,48^s$ | +37° 57′ 12.0″ | 25.9 | U |
| 021112 | XRF | Y/n | | | $02^h\,36^m\,52^s$ | +48° 50′ 56.0″ | 20.0 | U |
| 021113 | GRB | Y/n | | | $01^h\,33^m\,53^s$ | +40° 27′ 45.0″ | 13.6 | U,K,I |
| 021211 | GRB | Y/Y | O | 1.006 | $08^h\,09^m\,00^s$ | +06° 44′ 20.0″ | 2.0 | U,K |
| 030115 | GRB | Y/Y | OIR | | $11^h\,18^m\,30^s$ | +15° 2′ 17.0″ | 2.0 | |
| 030226 | GRB | Y/Y | OX | $> 1.986$ | $11^h\,33^m\,01^s$ | +25° 53′ 56.0″ | 2.0 | |
| 030323 | GRB | Y/1D | O | 3.3 | $11^h\,06^m\,06^s$ | –21° 54′ 20.0″ | 12.0 | |
| 030324 | GRB | Y/n | O | | $13^h\,37^m\,11^s$ | +00° 19′ 22.0″ | 7.2 | |
| 030328 | GRB | Y/Y | OX | 1.52 | $12^h\,10^m\,51^s$ | –09° 21′ 05.0″ | 0.8 | |
| 030329 | GRB | 1D/Y | ORX | 0.1685 | $10^h\,44^m\,50^s$ | +21° 30′ 54.0″ | 1.8 | |
| 030416 | XRF | Y/n | | | $11^h\,06^m\,51^s$ | –02° 52′ 58.0″ | 7.2 | |
| 030418 | GRB | Y/n | O | | $10^h\,54^m\,53^s$ | –06° 59′ 22.0″ | 9.0 | |
| 030429 | XRF | Y/Y | O | 2.656 | $12^h\,13^m\,06^s$ | –20° 56′ 00.0″ | 2.0 | |
| 030519 | GRB | 1D/n | | | $15^h\,59^m\,02^s$ | –33° 29′ 19.0″ | 136.6 | |
| 030528 | XRF | Y/Y | IX | | $17^h\,04^m\,02^s$ | –22° 39′ 00.0″ | 2.0 | |
| 030723 | XRF | Y/Y | OX | | $21^h\,49^m\,30^s$ | –27° 42′ 07.0″ | 2.0 | |
| 030725 | GRB | Y/1D | O | | $20^h\,33^m\,47^s$ | –50° 45′ 50.0″ | 14.4 | |
| 030821 | GRB | 1D/n | | | $21^h\,44^m\,08^s$ | –45° 21′ 25.0″ | 49.8 | K,I,M |
| 030823 | GRB | Y/n | | | $21^h\,30^m\,47^s$ | +21° 59′ 46.0″ | 5.4 | |
| 030824 | XRF | Y/n | | | $00^h\,05^m\,02^s$ | +19° 55′ 37.0″ | 11.2 | |

* Classification at the time of the conference; some designations may have changed (see text)

† WXM/SXC Localization

** Afterglow: O=optical, I=infrared, R=radio, X=X-ray

‡ radius of circumscribing circle in arcminutes

§ M=Mars Observer; H=RHESSI; U=Ulysses; I=INTEGRAL; S=SAX; D=DMS

¶ The correct burst localization was discovered in reprocessing archival burst data: no GCN Notice was issued for this burst