HEAO-1 OBSERVATIONS OF GAMMA RAY BURSTS

Geoffrey J. Hueter and James L. Matteson
Center for Astrophysics and Space Sciences
University of California, San Diego, La Jolla, CA 92093 U.S.A.

ABSTACT

A search of data from the High Energy X-Ray and Low Energy Gamma Ray Experiment on HEAO-1 uncovered 14 gamma ray bursts. Nine of these events are reported for the first time. Except for the faintest events, all of the bursts detected by this experiment have been measured above an MeV, thereby confirming the hard spectral character of gamma ray burst spectra reported by SMM. Our results give a burst rate of at least 105 per year above 6×10^{-7} ergs, which is consistent with previous measurements of burst frequency.

1. Instrumentation

The HEAO-1 mission lasted from August, 1977, to February, 1979. The UCSD/MIT High Energy X-Ray and Low Energy Gamma Ray Experiment consisted[1] of three sets of shielded NaI/CsI phoswich detectors with differing fields of view and effective energy ranges (Table I).

Table I. HEAO A4 Detectors

Number and Name	Area (cm^2)	Field of View (°FWHM)	Energy Range (Mev)	Spectral Integration
1 High Energy Detector (HED)	120	43	0.1-6.1	10.24 seconds 512 channels
4 Medium Energy Detector (MED)	42	16	0.03-2.	5.12 seconds 512 channels
2 Low Energy Detector (LED)	103	1.7x20	0.01-.2	0.64 seconds 64 channels

In order to provide temporal information on timescales shorter than the nominal integration times listed in Table I, the counts from the five higher energy detectors (HED and MED's) were summed and read out every 0.32 seconds. We searched for bursts in these data using an algorithm which triggered on significant 0.32 second excesses.

2. Observations

Table II lists the bursts discovered in a search of the entire 18 month mission. As indicated in the table, four of the bursts were detected by other spacecraft, two of which, GB771020 and GB771110, have already been discussed by Knight et al.[2] The March 25, 1978 event, which showed an absorption feature at 55 keV in its spectrum, has been discussed by Hueter et al.[3][4].

The time given for a burst is the Universal Time at which the burst reached its maximum intensity. Durations are the total time that the event was

seen above background. For the March 25, 1978 event and the bursts which have been observed by other spacecraft the fluences are well known.[5] The remaining bursts have not been completely analyzed with regard to spectral shape and aperture modulation, so that only approximate fluences can be given. These values, given in parentheses, may vary by a factor of three or more. The peak flux of a burst is the maximum rate in a 0.32 second interval and is subject to the same uncertainties as the fluence.

Table II. Bursts Detected by HEAO A4

Date			Time (UT)	T_d	Peak flux (ergs/cm^2-s)	Fluence (ergs/cm^2)
August	16,	1977	11:23:26	30	(1×10^{-6})	(8×10^{-6})
October	20		7:54:55	39	2×10^{-5}	2×10^{-4}
November	10		17:12:45	3	6×10^{-5}	7×10^{-5}
March	25,	1978	6:29:03	90	1.2×10^{-6}	1.5×10^{-5}
March	30		10:40:38	21	$> 5 \times 10^{-7}$	$> 3 \times 10^{-6}$
April	17		7:32:30	9	(3×10^{-6})	(1×10^{-5})
May	18		23:53:32	30	(2×10^{-7})	(1×10^{-6})
May	21		21:53:46	4	2×10^{-5}	5×10^{-5}
June	30		3:14:32	7	(2×10^{-7})	(6×10^{-7})
July	6		13:13:51	5	(6×10^{-7})	(1×10^{-6})
July	24		9:11:04	1	$> 5 \times 10^{-8}$	$> 1 \times 10^{-7}$
July	31		20:32:47	2	$> 5 \times 10^{-8}$	$> 1 \times 10^{-7}$
November	19		9:26:56	13	9×10^{-5}	3.2×10^{-4}
December	27		21:28:12	4	(6×10^{-7})	(4×10^{-6})

3. Discussion

Data from the SMM Gamma Ray Spectrometer have demonstrated that >MeV emission is a common feature of gamma ray bursts[6]. In our observations we find measurable >MeV emission in 9 of the 14 bursts. During two of the remaining five bursts the High Energy Detector was inactive, while the other three are sufficiently faint that we would not expect to detect the higher energy photons. In addition, by examining the instrument telemetry, we can reconstruct the >MeV time profiles down to 1.28 seconds. These profiles show no significant lag behind the lower energy emission. In fact the spectra of these bursts are generally hardest at the beginning of the bursts and in the August 16, 1977 burst (Figure 2) the >MeV rate increases in the 1.28 second interval before the rest of the emission appears. More study is needed, however, to determine to what extent burst hardness correlates with burst intensity, since the initial stages of most bursts are also the most intense.

If we consider only the seven bursts for which it is certain that the burst fell within the field of view of at least the HED, then the net observation time of .57 years in the search combined with the 12% coverage of the sky by the HED gives a burst rate of 105 yr^{-1} greater than 6×10^{-7} ergs/cm^2, which agrees with the uncorrected rate obtained by Mazets et al.[7] for the KONUS experiment. This is not surprising, since the triggering criteria used here is similar to that used by KONUS. This burst rate is most certainly a lower limit on the true rate because the 0.32 second burst trigger is inefficient for bursts which vary in intensity on timescales much longer than the trigger time.
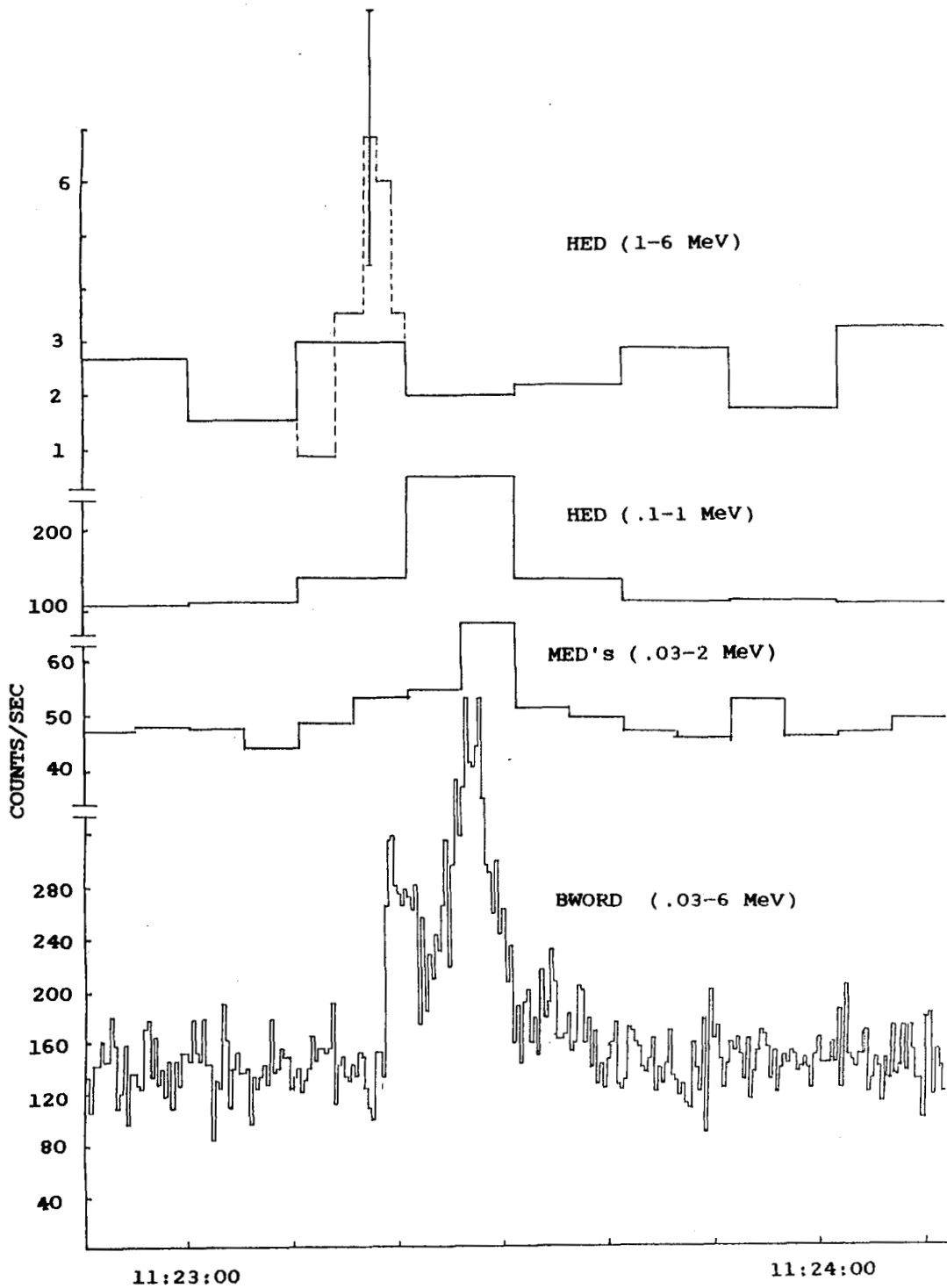
Figure 1. GB770816 detector rates. The dashed line indicates the >MeV rates infered from telemetry. The >MeV emission peaks before the burst appears in the 0.32 second rates.

Subsequent searches of the data with longer integration times should yield more low luminosity, slow rising bursts. Other effects which must be considered in future searches before a sensible size-frequency distribution can be constructed are the decrease in effective sky coverage for faint bursts and the variations in the instrument background. (For a more detailed discussion of these effects, see Higdon and Lingenfelter[8] elsewhere in these Proceedings.)

5. Acknowledgements

References

1. J.L. Matteson, Proc. A.I.A.A., 78-35.
2. F.K. Knight, *et al.*, Astrophys. Sp. Sci. <u>75</u>, 21 (1981).
3. G.J. Hueter and D.E. Gruber, Accreting Neutron Stars (MPI, 1982), p.213.
4. G.J. Hueter *et al.*, 18th ICRC Papers (Bangalore) <u>1</u>, 54 (1983).
5. W.A. Baity *et al.*, High Energy Transients in Astrophysics (AIP, 1984), p.434.
6. S.M. Matz *et al.*, Ap. J. (Letters) <u>288</u>, L37 (1985).
7. E.P. Mazets *et al.*, Sov. Astron. Letters <u>6</u>, 318 (1980).
8. J.C. Higdon and R.E. Lingenfelter, these proceedings.