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The Gamma Ray Burst experiment on the Indian SROSS C-2 satellite

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Abstract. The SROSS C-2 satellite launched by the ASLV carried aloft a CsI gamma ray burst detector. To date, 51 GRB events have been detected unambiguously with 22 being common with BATSE. The experiment with its 2 ms time resolution, provides good light curves in the 20 keV –1 MeV range. In addition, simultaneous light curves are also available in 3 broad energy bands. We present the current status and summary of GRB events from SROSS C-2.

1. Introduction

Since the discovery of gamma-ray bursts in 1972 (Klebesadel et al., 1973) GRBs have become one of the most intriguing areas of astrophysical research, encompassing a large number of observers and theorists at all frequencies, in the continuing effort to understand the origin of this phenomenon. With the launch of the BATSE experiment on CGRO in 1991, a large number of γ-ray events have been made available along with detailed temporal and spectral properties. With the remarkable detection of X-ray afterglow from GRB970228 by BeppoSax (van Paradijs et al, 1997), γ-ray burst studies exploded into multifrequencies yielding exciting new results on the basic afterglow mechanism and its connection with the burst itself. The measurement of redshifts using optical observations of the afterglow has firmly placed these events at cosmological distances. The Gamma Ray Burst (GRB) monitor onboard the Stretched Rohini Series Satellite (SROSS C-2) has detected 51 GRB events to date since its launch on 4th May 1994, the latest being GRB001207 on Dec 07, 2000.

2. Instrument description and capabilities

Kasturirangan et al. (1997) describes the details of the GRB experiment on the SROSS C-2 satellite. The following information on a GRB is available from the detector system. (a) The GRB time-history in three energy bands, viz. ch1 (20-100 keV), ch2 (100-1024 keV) with 256 ms integration and ch3 (1024-3000 keV) with 512 ms integration. In addition, high time resolution (2 ms) time-history in the 20-1024 keV band during the peak of the burst (data duration 2.048 secs). (b) The hardness ratio [(100-1024 keV)/(20-100keV)]. (c) The burst durations (T_{90} and T_{50}). (d) The GRB pulse height spectra in the 20 keV-3MeV band (512 ms time integration). (e) The GRB fluence in the 3 energy bands. (f) The peak flux in the 3 bands. The GRB monitor has a very wide FOV (2π steradian). Therefore, GRB location can be obtained only if triangulation can be done using other satellites. Since Aug, 2000 we have acquired the capability to send out global GRB notices through the GCN system. Efforts are on to reduce the response time to well below 24 hours. So far four GCN circulars were sent out giving information on three classical GRBs (GCN Nos. 772, 773, 768, 856). We also have the following limitations viz. (a) no anti-coincidence shield and this implies large number of charged particle induced triggers, (b) a maximum of seven triggers may be stored onboard at any given time, (c) only one readout pass per day is available along with limited duty cycle due to earth occultation, passage through SAA and high latitude regions.

3. Results and discussion

The GRB experiment has detected 51 classical GRBs, 42 of them being coincident with events detected by other spacecrafts. In order to make GRB location determination possible using the triangulation method with small enough error box sizes, very good absolute times are required. So far, we have been able to give an absolute GRB detection time that is $194 \pm 90 ms (3\sigma)$ away from the corresponding BATSE GRB detection time (K. Hurley, pvt. comm: 2000) when the maximum possible distance between the two spacecrafts can atmost be equal to 45 light ms. Attempts are underway to improve this absolute timing accuracy to well below 100 ms. We will briefly describe results below. (1) $(C_p/C_{lim})^{-1.5}$ distribution: C_p is the peak counting rate in the GRB time history (light curve) in a given integration time scale (in our case the integration time is 256 ms). C_{lim} is the limiting (threshold) counting rate in the same integration time scale. For a homogeneous source distribution in Euclidean space, this distribution should be uniform with average value equal to 0.5. The average value of this parameter for 35 SROSS C-2 GRBs is equal to 0.504 ± 0.05 and its distribution is uniform to a probability level of 0.18. The corresponding numbers for the BATSE distribution is equal to 0.321 ± 0.013 (Meegan et al. 1992). Our average sensitivity is worse by a factor of 19 than that of BATSE. When the BATSE sensitivity is reduced by a factor of 20 the number is 0.47 ± 0.05 which is consistent with our results (Meegan et al. 1993). (2) $\log(N > C_p) - \log C_p$ distribution : C_p has been defined earlier. The number of GRB events (cumulative) that have a peak counting rate larger than a given value C_p is denoted by $(N > C_p)$. It may be shown easily that if the sources are homogeneously distributed in Euclidean space, the $\log (N > C_p) - \log C_p$ distribution should have a slope equal to -1.5. The slope of this distribution (for 35 SROSS C-2 GRBs) is -1.38 ± 0.06 which is consistent with that expected for a homogeneous source distribution in Euclidean space. (3) The Hardness Ratio Distribution : Our GRB hardness ratio (*H-R*) is defined as the number of gamma rays detected in the (100-1024 keV) band divided by the number of gamma rays detected in the (20-100 keV) band during the same time interval. This parameter is a simple measure of the steepness or flatness of the GRB photons' energy distribution (spectrum). The *H-R* distribution for 49 GRBs is shown in Fig. 1. The mean of this distribution is equal to 0.92 ± 0.08. For 21 GRBs that have common BATSE triggers this value is equal to 0.97 ± 0.08. (4) The T_{90} distribution : T_{90} is a measure of the duration of a GRB. The T_{90} distribution for 49 GRBs is shown in Fig. 2. Previously reported (Kouveliotou et al. 1992) bimodality in T_{90} is visible. (5) Special GRBs : There are seven events that are somewhat special. All of these (except the 981107 event) have low hardness ratios $[< H\text{–}R > = 0.67]$, short duration $[< T_{90} > = 404$ ms$]$ and are relatively nearby $[< (C_p/C_{lim})^{-1.5} > = 0.33]$. It is not yet clear

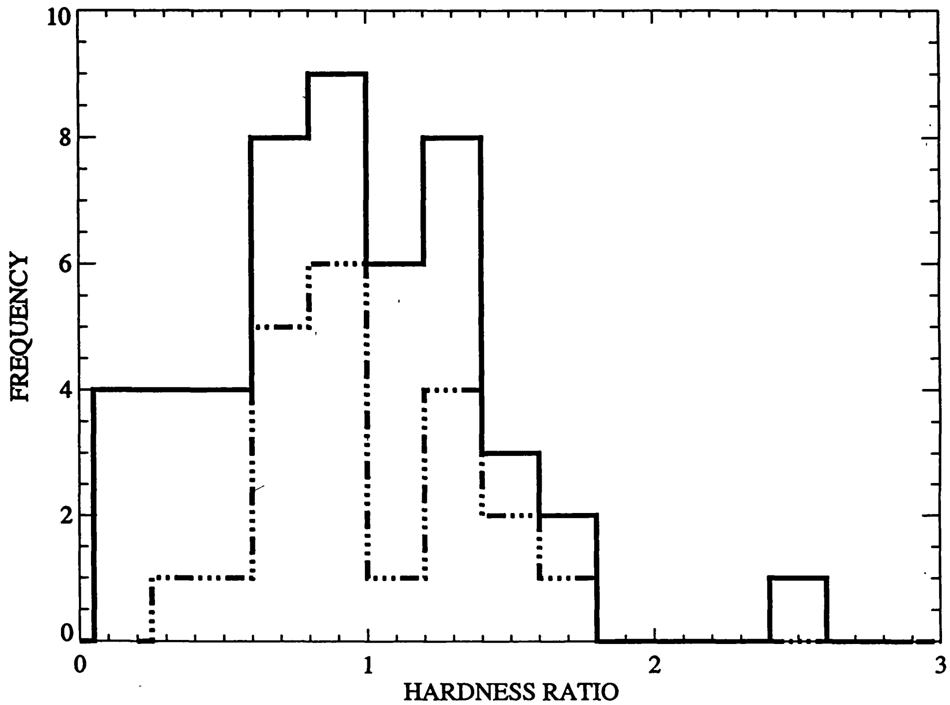

Figure 1. The distribution of T_{90} for 49 SROSS C-2 GRB events.

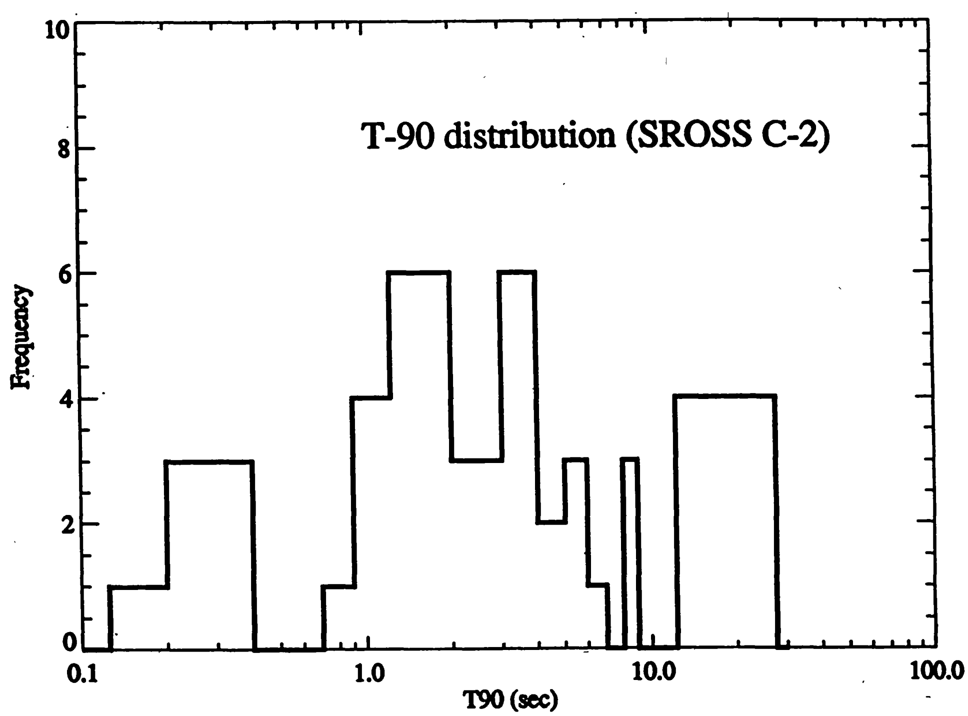

Figure 2. Hardness ratio distribution for 49 SROSS C-2 GRB events (solid histogram). Hardness ratio of SROSS C-2 events seen by BATSE are also shown (dotted line).

whether these events belong to a seperate class of GRBs. One possibility might be that some of these events may be SGR (Soft Gamma Ray Repeater) events. In the following table we list the parameters of these special (short duration) GRBs.

Parameters of Special GRBS

DATE	T_{90}(msec)	*H–RATIO*	$(C_p/C_{lim})^{-1.5}$	Sim. Detection
970202	91	1.02	0.38	U/K
970521	359	0.85	0.73	K
980706	303	0.82	0.09	B
981107	272	2.43	0.06	N
981226	804	0.67	0.45	B
990724	116	0.19	0.22	U/N/K
000407	751	0.47	0.10	K (?)

U (Ulysses), K (Konus(WIND)), N (NEAR), B (BATSE) The $< H\text{–}R > = 0.67$, $< T_{90} > = 404$ ms and $< (C_p/C_{lim})^{-1.5} > = 0.33$ if we exclude the GRB981107 event ($H - R = 2.43$).

4. Conclusion

The GRB detector onboard SROSS C-2 has detected 51 GRBs to date and it is expected to provide useful data for another 7-8 months. The combined $H - R$, T_{90} and $(C_p/C_{lim})^{-1.5}$ distribution suggest possible detection of a class of short, soft bursts at low redshifts, if these are not due to SGRs. Results obtained from more detailed and in-depth analysis on these data will be reported by us in a forthcoming paper.

Acknowledgements

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