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Results from a GRB monitor system on board of SZ-2 Spacecraft

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A GRB monitor system, including 3 detectors, had been designed and constructed. It was successfully operated on the SZ-2 Chinese spacecraft in 2001 for about 6 months. As it was just a period of Solar active time, hundreds burst-like events including gamma-ray bursts(GRB), solar flares(SF) and particle precipitation events(PPE) had been observed and provided a lot of information related to this Solar cycle. In this paper, we will give a brief introduction about the detector system, its on board performance, the data system and our analysis. The results on GRBs, SFs, and PPEs will be presented.

1. GRB monitor system on board of SZ-2

Since 1993, a small GRB monitor system had been designed and constructed in order to detect the burst-like events, such as, Gamma ray bursts (GRB) and Solar Flares (SF), which are especially for the set up of the on-orbit part of ShenZhou-2 (SZ-2) spacecraft. According to the results of BATSE observations at that time, the monitor system had been arranged as three sub-detectors to cover a wider energy band than BATSE[1] and to keep the similar time resolution as BATSE had. They are Soft X-ray detector (SXD), X-ray detector (XD) and γ-ray detector(GD). Their performances and working mode are listed in Table 1.

Table 1. GRB monitor system on board of SZ2

	SXD	XD	GD
Energy Range (keV)	0.2~2 keV	XD1: 20-200 keV XD2: 40-800 keN	200keV ~ 8MeV
sensor	Proportional counter 20 cm^2	NaI XD1: ϕ 125mm x 6mm XD2: ϕ 125mm x 15mm	BGO ϕ76 x 70 mm
Energy band	6 chs	64 chs	128 chs
Time resolution	40ms	40 ms	80 ms
Trigger timing		40ms, 200ms, 1000ms	
Trigger logic	SXD + XD1 + XD2	XD1 + XD2	GD + XD1 + XD2
Data collection	128 kB	512 kB (40s B+ 40ms/128s Bst)	128 kB (event by event)

The energy band of SXD was just set in the region of interstellar medium absorption line, so that, hopefully, it may provide roughly the distance information of a GRB from the combination of SXD and XD1 spectrum. But, it may less important after 1997 since BeppoSax discovered afterglow of GRBs[2]. XD was used to provide trigger signal for all the three detectors and played the main role in the GRB observation. GD had near isotropic response and overlap with XD2 at its low energy boundary, so that the direction information of the burst can be obtained by combining GD and XD2 spectrum together, and helpful for the spectrum analysis of XD data. The total weight of the monitor system is 30.7 kg and the total power consumption is 15.3 W.

Except the spectrum measurement with a time scale of 40ms for the burst mode and 1s for background mode (i.e. waiting mode), there were records of single channel integral counting rates for XD1 and XD2 respectively to measure the whole time profile of long duration burst events.

2. Observations and data analysis

SZ-2 was launched in 10 Jan 2001. The orbital module was separated with the recovery module on 16 Jan. and completed its mission on 25 June. During the total operation time of 160 days, 281 trigger events were obtained in 145 days of real time. Continuous counting rates, which covered most of the running time, were also measured and stored in a separate file. 600 peaks were found with further off-line analysis by searching excesses of >3 σ of background.

The three detectors are coaxial to point in anti-earth direction when the attitude of the spacecraft in the "pointing to the earth" mode, and to point to the sun when the attitude of the spacecraft in the "pointing to the Sun" mode. So, the working status of the whole monitor system is the same as XD, which had already been described in [3].

The spacecraft crossed the field of view of the Beijing ground base station, where the scientific data was downloaded, 5-6 times per day in time intervals of 90 minutes. During the other 2/3 of the duty cycle, more data was stored on board and in the XD DAQ system priority was always given to the burst event with highest significance. If no trigger between telemetries, the background spectra were recorded. As shown in Figure 1, the on-flight energy calibration performed with the 511 keV line from the background spectra indicates that the energy measurement is stable over the whole period.

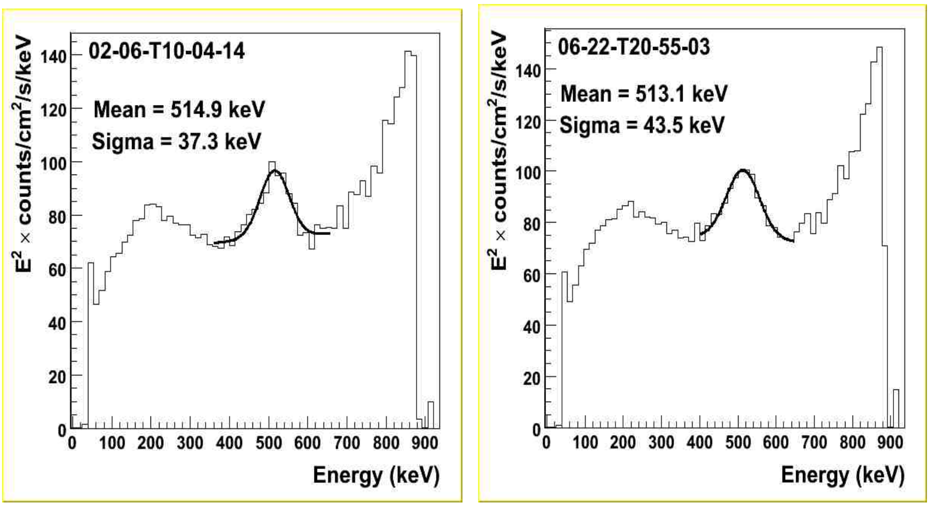

Figure 1. On-flight calibration by using the 511 keV line from XD2 background spectrum. The left one was obtained on 6 Feb, and the right one was on 22 June. Practically the energy measurement is stable over the whole period.

3. Results

According to different properties of GRBs, Solar Flares and Particle Precipitation Events, firstly those events having time coincidence with GOES-8 SF observations are picked up, 108 x-ray SF from the- counting rate data, and 42 SF from the trigger data, including ~27 M-class flares, 3 X-class flares (Figure3-5). Then 142 PPE events are identified with the slow gradient of the flux, mostly repeated occurred in the high latitude region (Figure6). Finally, the rest events are considered as GRB candidates or related to some unknown phenomena. ~30 GRBs were obtained and 11 of them had already been recognized by other observations, Figure2 is GRB010317 which are observed by many missions.

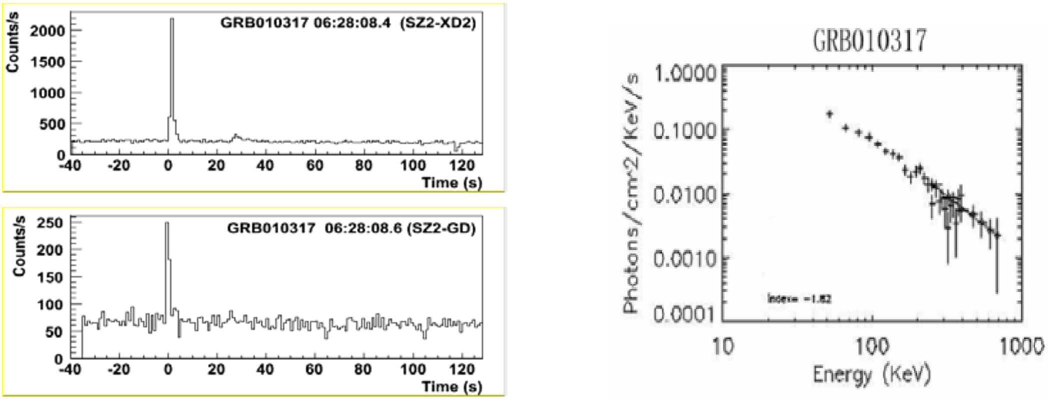

Figure2 GRB010317 observed by SZ2-XD & GD, which are also recorded by BeppoSax and Konus.

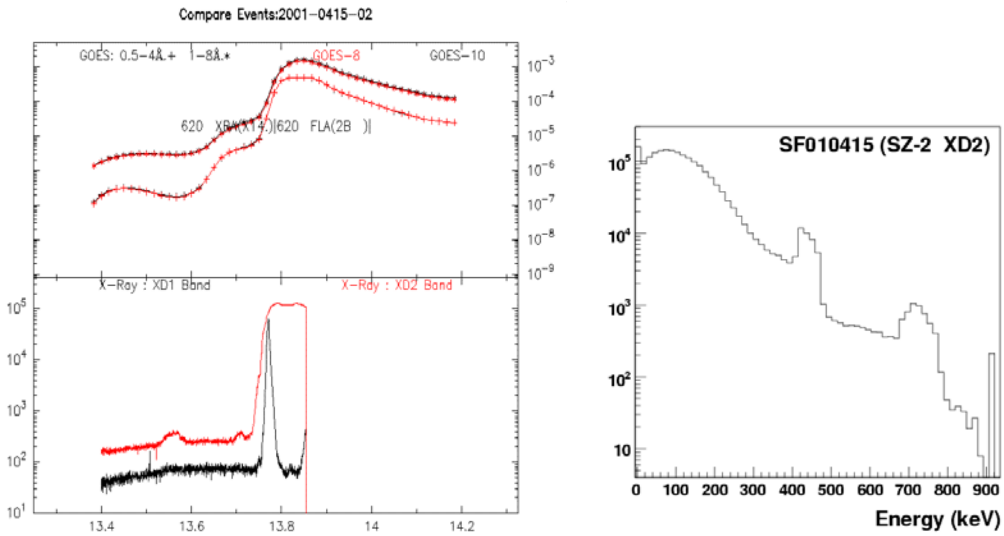

Figure3 SF010415, the biggest solar proton event in the 23rd solar cycle, X14.4 X-ray flare, also a CME event, a GLE event with neutron flux increase ~58% at the Oulu station. Two possible lines were observed by SZ2/XD2 around 420keV and 720keV, 15% red shift of the 511keV and 847 keV lines, which is only a line feature obtained during the detector observation. (Left: light curve, up: GOES-10 result, down: counting rate of XD1 and XD2, there are no data after ~13:52, because HV was swiched off. Right: XD2 spectrum).

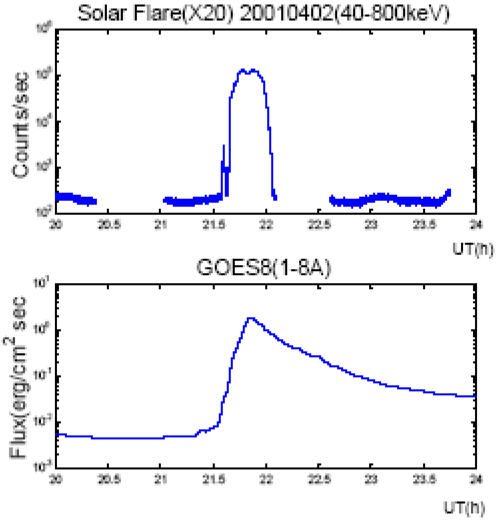

Figure4 The brightest solar flare in the 23rd cycle. SF 010402 by SZ2/XD2 and GOES(down)

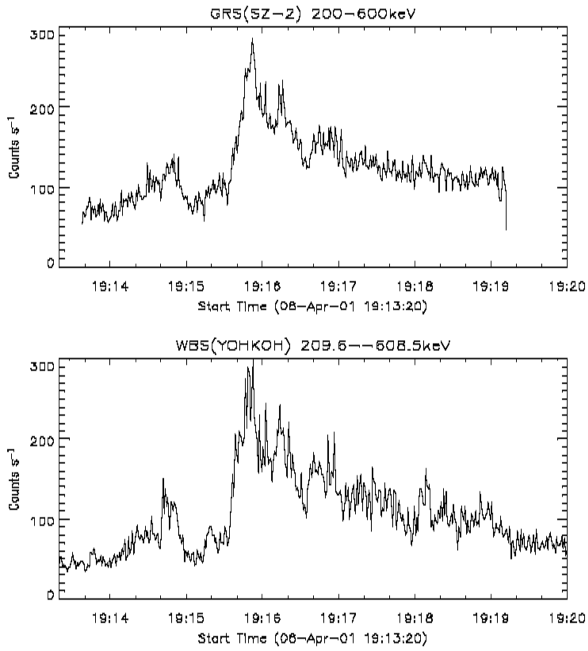

Figure5 light curve of SF010406, SZ2/GD(top), and Yohkoh (down) observation, X5.6 flare

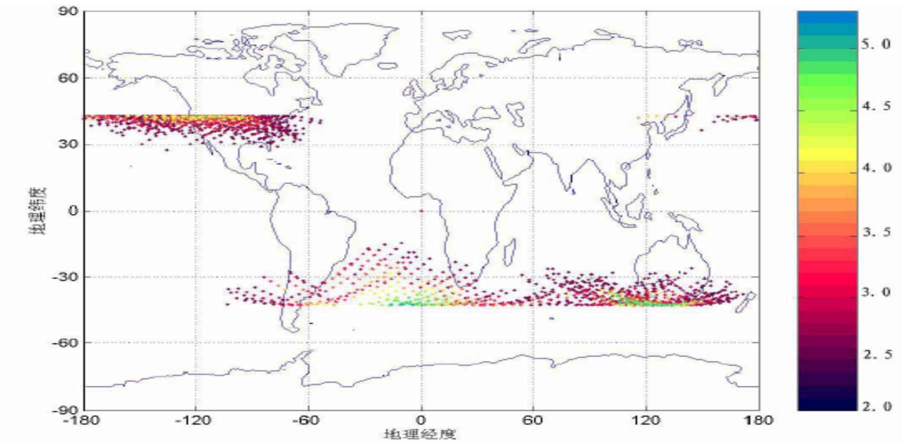

Figure6 Burst-like electron events(PPE) measured in Jan-Jun. The SAA regions were mostly excluded by switching off the HV of PMT. The flux shown on SAA regions was ~~in~~ from the first several days when the HV control program did not work.

References

[1] http://www.batse.msfc.nasa.gov/batse

[2] van Paradijs J. et al., Nature, 386, 686, (1997)

[3] Y.Q.Ma et al., pp 2765-2768, OG2.4, Proceedings of 28th ICRC, 2003, Tsukuba , Japan