PROCEEDINGS OF SCIENCE

The spectral catalog of GRBs observed with INTEGRAL: IBIS/SPI joint spectral analysis

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We present the updated *INTEGRAL* catalog of gamma-ray bursts (GRBs) observed between November 2002 and February 2011. The catalog contains the spectral parameters for GRBs localized by the *INTEGRAL* Burst Alert System (*IBAS*). We used the data from the two main instruments on board the *INTEGRAL* satellite, the spectrometer *SPI* (SPectrometer on *INTEGRAL*), and the imager *IBIS* (the Imager on Board the *INTEGRAL* Satellite). The catalog contains the burst coordinates, positional errors, trigger times, durations and peak fluxes for 25 new GRBs obtained between September 2008 and February 2011. The spectral analysis was performed on the whole sample of GRBs observed by *IBIS*, including also the events occurring before September 2008. We applied a new data extraction technique developed in order to explore the energy regions of highest sensitivity for both instruments, *SPI* and *IBIS*, and compared the prompt emission properties of *INTEGRAL* GRB sample with *BATSE* and *Fermi* samples.

"An INTEGRAL view of the high-energy sky (the first 10 years)" 9th INTEGRAL Workshop and celebration of the 10th anniversary of the launch,
October 15-19, 2012
Bibliotheque Nationale de France, Paris, France

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PoS(INTEGRAL 2012)124

1. Introduction

During the past two decades gamma-ray bursts (GRBs) have been observed by several missions providing the wealth of spectral and temporal data. The most complete catalogs of spectral GRB properties comprise the events observed by BATSE (Burst And Transient Source Experiment) onboard the *Compton Gamma Ray Observatory* [1], and the *Swift* satellite launched in 2004 [2]. The *Fermi* satellite launched in 2008 [3] has provided significant discoveries in the high energy ($>$ 100 MeV) domain. In this paper we present the spectral catalog of the properties of gamma-ray bursts detected with *INTEGRAL* satellite [4]. We provide the general information of the previously unpublished events (25 GRBs observed after October 2008) in Table 1. In order to perform the spectral analysis, we combined the data from the two main instruments onboard *INTEGRAL*, the spectrometer *SPI* and the imager *IBIS*.

2. Method and Results

The joint spectral analysis, using the data from both instruments, allows to perform the consistent analysis of the spectrum and exploits fully the potential of each instrument. The *SPI* data can provide the spectral information at energies where *IBIS/ISGRI* (*INTEGRAL* Soft Gamma-Ray Imager) effective area becomes low ($\gtrsim$ 200 keV), and therefore are suitable to determine the GRB spectral peak energy (typically at $\sim$ a few 100 keV). For the *SPI* instrument, a spectrum for each of the 19 (where applicable) Ge detectors was computed. The net individual GRB spectra (i.e. on-burst – off-burst spectra) have the advantage (with respect to the global spectra produced by OSA software) to be more accurate since the background spectra were computed for each GRB and each detector, taking into account the local temporal background evolution. For each *SPI* detector an individual response function was calculated, taking into account the GRB direction (either as determined by *IBIS/ISGRI* or by more precise X-ray or optical follow-up observations). This response function takes into account the exposed fraction of each detector for the GRB direction. For the *IBIS/ISGRI* spectra, due to the large number of detectors, we did not compute individual pixel spectra. We selected only the pixels that were fully illuminated by the GRB, in order to compute the off-burst and on-burst spectra. A corresponding spectral response was computed, taking into account the reduced ($\sim$ 30%) area of the detector plane we used. For each GRB we computed and fitted the time-integrated spectrum, using all the available *SPI* spectra and 1 *ISGRI* spectrum (Fig 1). We performed the spectral analysis of the time-integrated spectra for 63 GRBs on the energy interval $\sim$ 40 keV - 1 MeV. The spectral parameters of the prompt gamma-ray burst spectrum were compared with the results of the BATSE and *Fermi* missions. As an example, the distributions of the spectral peak energies and the low energy power law indices are shown in Figure 2. The majority of *INTEGRAL* GRBs have lower peak energies than the *BATSE* GRBs in the same fluence range, whereas there is a good agreement with the distribution of the *Fermi* sample. The distribution of the low energy power law slopes obtained for *INTEGRAL* GRBs is consistent with both, *Fermi GBM* and *BATSE* GRB samples.

References

[1] Fishman, G.J. et al. *The first BATSE gamma-ray burst catalog*, *ApJSS* **92** (1994) 229

Table 1: Properties of *INTEGRAL* gamma–ray bursts detected between September 2008 and February 2011. Peak fluxes were measured in the energy band 20-200 keV.

GRB	t_{start} (UTC)	R.A. (deg)	Dec. (deg)	Pos.error (arcmin)	Afterglow X	O	z	T_{90} (s)	Peak flux (ph cm^{-2} s^{-1})
081003	13:46:01	262.3750	16.5661	2.0	Y	-	-	25	-
081003B	20:48:08	285.0250	16.6914	2.0	-	-	-	24	3.13
081016	06:51:32	255.5708	-23.3300	1.5	Y	-	-	32	7.34
081204	16:44:56	349.7750	-60.2214	2.3	Y	-	-	13	0.75
081226B	12:13:11	25.495	-47.4389	2.5	-	-	-	0.55	-
090107B	16:20:38	284.8075	59.5925	1.5	Y	-	-	20	1.47
090625B	13:26:21	2.2625	-65.7817	1.7	Y	-	-	10	1.93
090702	10:40:35	175.9	11.5	2.5	Y	-	-	19	0.06
090704	05:47:50	208.2042	22.79	2.5	-	-	-	76	1.31
090814B	01:21:14	64.775	60.5828	2.9	Y	-	-	51	0.65
090817	00:51:25	63.9708	44.1244	2.6	Y	-	-	225	1.69
091015	22:58:53	306.1292	-6.17	2.9	-	-	-	229	0.12
091111	15:21:14	137.8125	-45.9092	2.9	-	-	-	354	0.03
091202	23:10:08	138.8292	62.5439	2.5	Y	?	-	40	0.08
091230	06:26:53	132.8875	-53.8925	2.5	Y	Y	-	225	0.15
100103A	17:42:38	112.3667	-34.4825	1.6	Y	-	-	35	2.17
100331A	00:30:23	261.0625	-58.9353	2.5	-	-	-	20	0.42
100518A	11:33:38	304.8000	-24.5608	1.6	Y	Y	4	39	0.36
100703A	17:43:37.37	9.5208	-25.7097	2.8	-	-	-	0.08	-
100713A	14:35:52	255.2083	28.3900	2.5	Y	-	-	25	0.16
100909A	09:04:06	73.9500	54.6544	2.0	Y	Y	-	66	0.26
100915B	05:49:36.4	85.3958	25.0950	2.0	-	-	-	5.5	-
101112A	22:10:14	292.2167	39.3589	1.3	Y	Y	-	24	7.60
110112B	22:24:54.7	10.6000	64.4064	2.6	-	-	-	0.29	-
110206A	18:07:55	92.3417	-58.8106	2.0	Y	Y	-	35	-

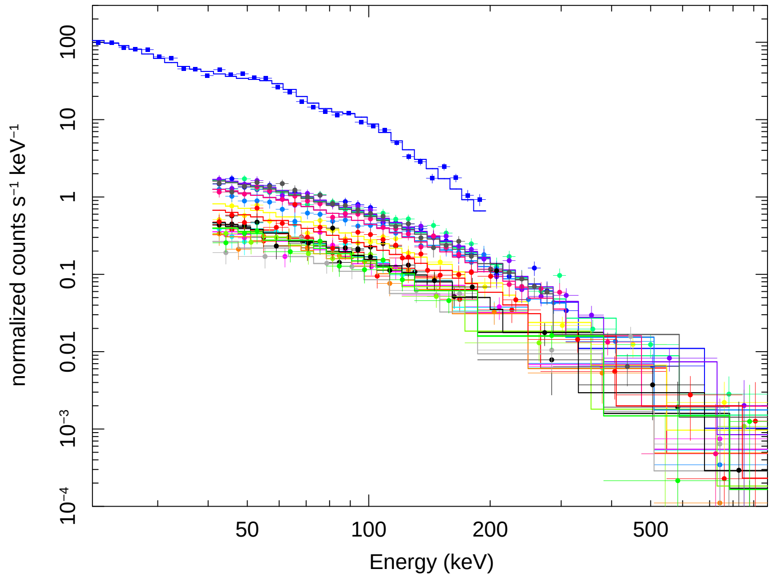

Figure 1: Spectral model and the data for GRB 061122. The dark blue squares are *ISGRI* data; the data on energy interval 20-200 keV were used for the fit. The coloured points are the data from 19 *SPI* detectors; the data covering the energies 40-1000 keV were used in fitting procedure. The data were fitted with the cutoff-powerlaw model in this example.

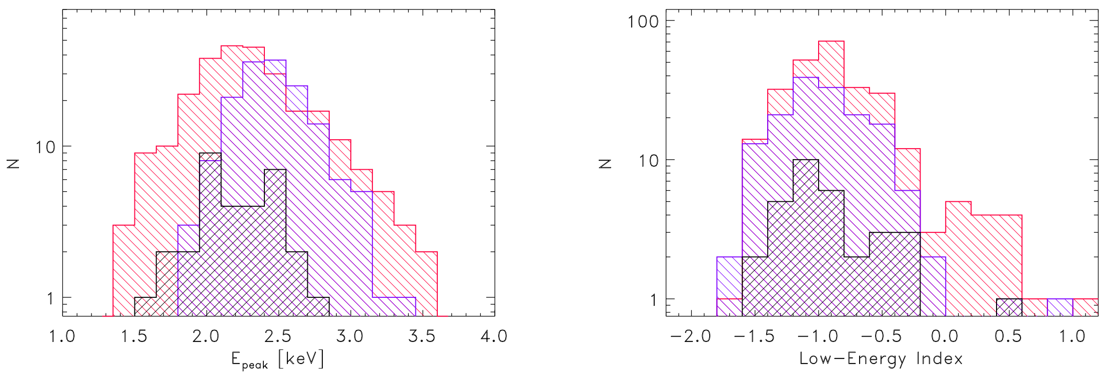

Figure 2: Distribution of the spectral peak energies and the low energy spectral powerlaw indices. The sample of *INTEGRAL* GRBs is shown in black; *BATSE* results (violet) and *Fermi GBM* results (red) of the time-integrated spectral analysis were used. For the comparison with the *INTEGRAL* sample of GRBs, only long events were selected fitted with the Band or cutoff powerlaw model, having the fluence in the same range as *INTEGRAL* GRBs.

[2] Gehrels, N. et al. *The Swift Gamma-Ray Burst Mission*, *ApJ* **611** (2004) 1005

[3] Atwood, W. B. et al. *The Large Area Telescope on the Fermi Gamma-Ray Space Telescope Mission*, *ApJ* **697** (2009) 1071

[4] Winkler et al. *The INTEGRAL mission A&A* **411** (2003) L1