

Gamma-ray observations of solar flares from August 2001 to November 2003: SONG experiment onboard CORONAS-F satellite results.

Irina N. Myagkova¹, S. N. Kuznetsov¹, V. G. Kurt¹, E.A. Murav'eva¹,
B. Yu. Yushkov¹ and K. Kudela²

¹ Skobel'syn Institute of Nuclear Physics, Moscow State University, Moscow, Russia
email: irina@srd.sinp.msu.ru

² Institute of Experimental Physics, Slovak Academia of Science, Kosice, Slovakia
email: kkudela@upjs.kosice.sk.ru

Abstract. We present the catalog of data for 27 gamma-ray flares detected above 500 keV by the gamma-ray spectrometer SONG (Solar Neutrons and Gamma-Rays) onboard the Russian CORONAS-F satellite. These gamma-ray flares were collected during the period from August 14, 2001 till November 31, 2003 covering the latter half of the 23rd solar sunspot cycle.

1. Introduction

The observations of solar flare gamma-emission provide the most direct information about the charged particle acceleration in solar flares (e.g. Ramaty, Kozlovsky & Suri 1977). During last four solar cycles some hundreds of solar flares generated gamma-emission were detected in different experiments, but the statistics of gamma-ray flares obtained during the 23 cycle was significantly poorer than in earlier cycles (especially before the extreme intensive solar flares in October - November, 2003). So new experimental data about solar gamma-emission of solar flares are important.

2. SONG experiment and its results

The CORONAS-F satellite was launched on July 31, 2001. It has a circular orbit with altitude about 500 km and 82.5 degree inclination. The detector part of SONG consists of CsI(Tl) crystal of diameter 20 cm and height 10 cm surrounded by the active anticoincidence plastic shielding 2 cm thickness (Kuznetsov et al. 2003). In this work we use data about gamma-emission with the energies 0.5-200 MeV. Temporal resolution for gamma-emission is 4 s. The background, caused by the local gamma-rays produced by the interactions of CR either with the instrument, satellite body or with the atmosphere and bremsstrahlung of relativistic electrons of radiation belts), was carefully subtracted before the flare emission analysis.

During the first 2.5 years CORONAS-F fly more than fifty flares with HXR- emission (more than 50 keV) were detected by SONG-instrument. In 27 flares the gamma- emission with the energy more than 500 keV was detected (see Table 1). Gamma- emission with energies higher than 60 MeV was detected in the flares 25/08/2001, 28/10/2003 and 04/11/2003. During the maximum and the decay phase of 23 solar cycle solar gamma-emission are measured in the experiments on board RHESSI (Lin et al. 2002) and CORONAS-F satellites (Kuznetsov et al. 2003). In the Table 1 we show whether

N	dd/mm/yy	UT	Class/Ball	Coordinates	RHESSY	E, MeV	p	e
1	25/08/01	16:29-16:38	X5.3/3'	S17E34	-	60-100	No enh.	no enh.
2	05/09/01	14:27-14:29	M6.0/2'	N15W31	-	1.3-4	No data	No data
3	09/09/01	15:11-15:13	M3.4/1N	S17E03	-	.5-1.3	No enh.	No enh.
4	19/10/01	16:23-ERB	X1.6/2B	N15W29	-	1.3-4.	3	17
5	11/12/01	08:04-08:08	X2.8/SF	N16E41	-	7-15	40	33
6	20/02/02	06:08-06:11	M5.1/1N	N12W72	No	4-7	140	7
7	20/05/02	15:25-15:29	X2.1/2N	S21E65	No	7-15	No data	No data
8	17/07/02	07:10-07:13	M8.5/1B	N22W17	No	1.3-4	1200	2000
9	20/07/02	21:08-21:29	X3.3/-	-	Yes	0.5-1.3	20	700
10	20/08/02	08:24-08:26	M3.4/1B	S10W38	Yes	4-7	60	600
11	21/08/02	01:38-01:42	M1.4/SF	S10W36	Yes	0.5-1.3	No enh.	No enh.
12	21/08/02	05:31-05:33	X1.0/1B	S12W51	No	4-7	No enh.	No enh.
13	24/08/02	00:58-01:03	X3.4/1F	S12W51	Partly	4-7	200	700
14	30/08/02	13:27-13:29	X1.5/SN	N15E74	Yes	4-7	No enh.	No enh.
15	26/04/03	03:03-03:04	?2.1/SN	S25W34	Yes	1.3-4.0	No enh.	No enh.
16	26/04/03	08:05-08:07	M2.0/-	-	Yes	4-7	No enh.	No enh.
17	27/05/03	23:02-23:09	X1.3/2B	S07W17	Yes	4-7	No data	No data
18	28/05/03	00:21-00:29	X3.6/3B	S07W17	Yes	4-7	No data	No data
19	29/05/03	00:59-01:07	X1.2/-	-	Yes	4-7	No data	No data
20	23/10/03	08:17-08:43	X5.4/1B	S21E88	No	4-7	100	150
21	28/10/03	11:02-11:13	17.2/4B	S16E08	Partly	60-100	8000	15000
22	29/10/03	20:38-20:55	X10/2B	S15W02	Yes	4-7	500	13000
23	03/11/03	01:17-01:29	X2.7/2B	N10W83	Yes	0.5-1.3	No data	No data
24	04/11/03	19:32-19:57	X28/3B	S19W83	Partly	100-200	1000	1800
25	17/11/03	08:59- 09:05	M4.2/1N	S01E33	Partly	1.3-4	No enh.	No enh.
27	20/11/03	08:04- 08:18	M9.5/-	-	Yes	0.5-1.3	45	100

Table 1. Solar flares detected by SONG instrument (CORONAS-F)

RHESSY data available or not during flare detected by SONG. We can see that the most of flares were detected in both experiments. This gives us the opportunity to compare obtained data for better understanding of processes during solar flares. Besides usual solar flare parameters we show the value of solar proton (1-5 MeV) and electron (300-600 keV) flux enhancements in $1/(\text{cm}^2 \text{ s sr})$ detected on board CORONAS-F by after each flare. This information is important for the Earth's radiation environment and space weather studies.

First two and a half years SONG experiment on board CORONAS-F not only illustrated its capability of detection of solar gamma-emissions, but gave us the valuable information for studying of flare processes. Obtained SONG gamma-flares catalog should be very useful for future statistical and correlative studies of solar flare intrinsic properties and solar particle events probability.

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