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Large solar flares of October - November, 2003 - development in Soft X-ray, Hard X-ray and gamma-ray emissions.

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Abstract. The description of two major flares detected by SONG spectrometer on board the CORONAS-F mission during famous period of solar activity in October- November 2003 and their comparison with soft X-ray measured by GOES-12 is given.

Unexpected flare activity was observed on the Sun from October 23 till November 04, 2003. During this period several major flares were being observed in high energy X-ray and gamma-emission by CORONAS-F observatory. The duty cycle for the detection of solar flares was about 40 percents as a result of the circular CORONAS-F orbit with an altitude about 500 km and an inclination of 82.5 degrees. Several powerful flares were lost, but four events from active region NOAA 0486 - October 23 (08:17- 08:43 UT, X1.2/3B), October 28 (11:02-11:13 UT, 17.2/4B), October 29 (20:38-20:55 UT, X10/2B) and November 4 (19:32-19:57 UT, X28/3B) were detected during the impulsive phase of the flares by SONG (Solar Neutrons and Gamma-rays) spectrometer.

The SONG detector consists of CsI(Tl) crystal (diameter 20 cm and height 10 cm surrounded by the active anticoincidence plastic shielding 2 cm thick) described by Kuznetsov et al. (2003). The basic SONG data consist of the counting rate recorded every 4 sec in 11 gamma emission intervals covering an energy range 50 keV - 200 MeV and in 5 neutron channels with energy release 7-100 MeV. This short report deals with two the most intensive flares occurred on October, 28 and November, 4 in which solar gamma-emission with the energy 100 MeV and solar neutrons were detected by SONG experiment (see Figure 1).We should notice that the enhancement of count rate in 40-60 MeV gamma-channel after 2500 sec during November, 4, connected with the coming of neutrons produced at the Sun during the flare. Presented flares exhibited the similar time history of the gamma-ray emission above 10 MeV as was detected in earlier flares by SMM GRS presented in Dunphy P.P. & Chupp E.L. (1994) and by Gamma satellite Gamma-1 experiment shown in Akimov V.V., et al. (1994a) and Akimov V.V., et al. (1994b). For all flares in which high energy emission attributed to neutral pion- decay gamma-rays most of the neutral pions and high-energy neutrons were produced after the "main" impulsive phase. The time history of the gamma-ray emission above 30-40 MeV during this "extended" phase is also strikingly similar from flare to flare. Similar time histories have been also seen by EGRET (Schneid et al. (1994)) and COMPTEL (Ryan et al. (1994)) on CGRO and GRANAT on PHEBUS (Trottet G. (1994)). This may mean that acceleration of protons to high energy in an "extended" or "delayed" phase may be a common feature of flares with significant production of pions and high-energy neutrons.

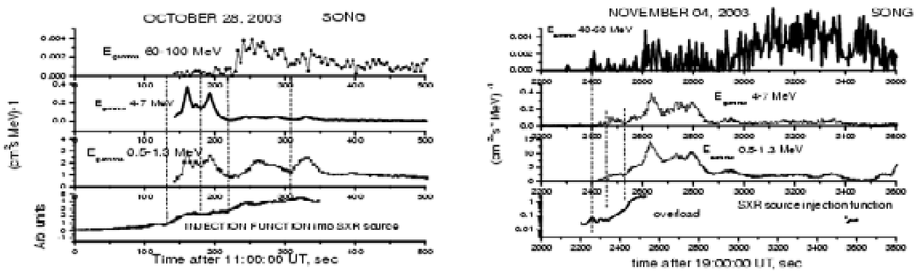

Figure 1. Time profiles of HXR and gamma-ray emission obtained by SONG on board CORONAS-F during October, 28 and November, 04, 2003 and calculated energy injection function - energy input in SXR emitting volume. Dashed vertical lines mark sequence of acceleration acts and energy input in SXR source.

Comparison of the hard X-ray and gamma-ray emission time behaviour with the main SXR source characteristic such an energy injection function was made for these two major flares. Calculating the energy injection function from the GOES data with different values of density one can find the minimal density for which the injection function does not become negative during all the analyzed time interval. In difference of Neupert's derivative (Neupert (1968)), which gives physically senseless negative values of energy input in the cases of short pion decay, our method described by Kurt V.G. et al. (1996) permits to avoid these difficulties and to estimate the mean matter density in flaring loops. We compared the calculated energy injection function with the flux of the 500 keV X-rays, detected by SONG spectrometer to define how the very intense high energy electron beams deposit their energy into SXR source. From obtained pictures we can see that time behaviour of injection function follows the hard X-ray time profile. Additional significant energy input into SXR source coincides with neutral pion-decay gamma-rays appearance during October, 28 event.

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