OBSERVATION OF HIGH ENERGY GAMMA-RAYS FROM THE SUN WITH THE GAMMA-1 TELESCOPE (E>30 MEV)

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1. <u>Introduction.</u> Till now the highest photon energies ever registered from the Sun lay a little above 100 MeV. This unique result was obtained with the GRS spectrometer on the Solar Maximum Mission (SMM) observatory during the 1982 June 3 flare [1]. In our experiment we observed gamma-ray emission extending to energies greater than 1 GeV from two solar flares: on 1991 March 26 and 1991 June 15. Time histories and preliminary energy spectra of these distinct events are presented.

2. <u>Observation and results.</u> A separate report is devoted to the experiment performance in session OG-10 [2]. Details of the telescope design and its characteristics can be found in [3] and [4,5].

March 26 event. Our satellite entered the field of visibility of the Sun and the telescope was switched on in solar orientation at 20:25:02 UT. Fig.1 shows the total counting rate (1sec-bin) of gamma-rays with energies above the instrumental threshold.

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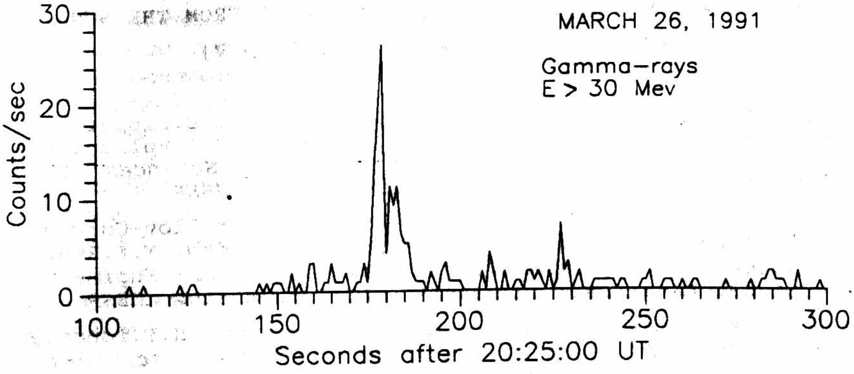

Fig.1. Counting rate of the gamma-telescope in 1-sec bins for the 1991 March 26 solar flare.

The main burst of hard gamma-rays started at 20:27:56 UT and lasted 11 seconds, exceeding the background by more than two orders of magnitude. It was led by a small increase in flux, and recovery time to the background level was about 3 min. The gamma-ray flux above 100 MeV reached at the very maximum of emission the value of 0.6 $cm^{-2} sec^{-1}$.

As can be seen the main peak is split in two sub-peaks of duration 5 and 6 sec. Comparison of energy distributions for two sub-peaks did not reveal any statistically significant distinction. Energy spectrum for the whole 11-sec peak is shown in Fig.3. A power law best fit trough the first four points gives an exponent of -2.4. The highest energy channel contains 2 photons when an expectation from the background counting rate equals to 0.12. If the power law was valid between 300 and 1000 MeV we could expect 8 photons in this range, but no one was registered. Probability of such realization is less than 0.1%.

This flare was attributed to a class 3B-X4.7 and had the heliographic coordinates S28, W23 [8].

June 15 event. During the Sun observations an orbital period (92 min in a low orbit) was shared between solar and anti-solar orientations separated by the intervals of satellite slew when the telescope was off. It so happened that a powerful class 3B-X12 flare (coordinates: N33, W69) started at 08:10 UT and reached its maximum at 08:21 UT (1-8 A X-rays, GOES-7 data [6]). At this time the telescope was pointed to anti-solar direction and screened by the Earth. Fig.2 shows the counting rate of photons with energies above 100 MeV. In order to suppress the latitude dependent background a strict selection criteria were applied (see [2]). The telescope was switched on in solar attitude at 08:37:22 UT (≈15.359 D) and registered a high gamma-ray flux up to $4*10^{-3} cm^{-2} sec^{-1}$ (>100 MeV). One can see that in the next orbit (later 15.423 D) solar gamma-ray flux was yet well above the background. From 15.377 D to

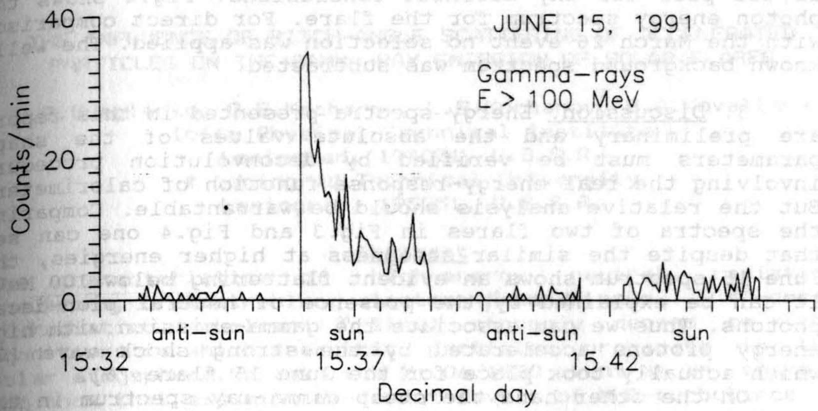

Fig.2. Counting rate of the gamma-telescope above 100 MeV by 1-min bins for the 1991 June 15 solar flare.

15.385 D (as well as from 15.438 D to 15.449 D) the satellite was traversing the South Atlantic Anomaly, therefore this interval was excluded from the later analysis.

No variations in the shape of energy spectrum were found from 15.359 D to 15.377 D. From 15.423 D statistics

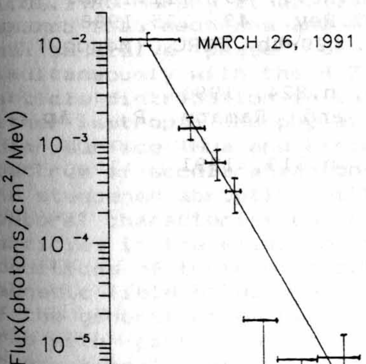

Fig.3. Gamma-ray energy spectrum for March 26 flare. Solid line - power law best fit with $\gamma=-2.4$.

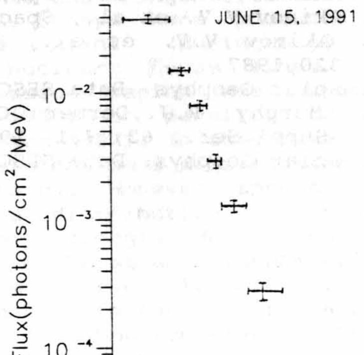

Fig.4. Gamma-ray energy spectrum for June 15 flare during the interval 08:37:22-09:02:22 UT

is too poor for any definite conclusions. Fig.4 shows the photon energy spectrum for the flare. For direct comparison with the March 26 event no selection was applied. The well known background spectrum was subtracted.

3. Discussion. Energy spectra presented in this report are preliminary and the absolute values of the shape parameters must be verified by deconvolution procedure involving the real energy-response function of calorimeter. But the relative analysis should be warrantable. Comparing the spectra of two flares in Fig.3 and Fig.4 one can see that despite the similar steepness at higher energies, the June 15 spectrum shows an evident flattering below 100 MeV. It can be explained by the presence of neutral pion-decay photons. Thus we can associate the gamma-emission with high energy protons accelerated by the strong shock wave [7] which actually took place for the June 15 flare [6].

On the other hand the steep gamma-ray spectrum in the impulsive March 26 flare implies that in this case photons originate as a bremsstrahlung of accelerated electrons. Some constraints on the model of interaction should be imposed by the fact that in this flare gamma-rays came from a site close to the solar center.

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