THE SCR FLARE OF 16 FEBRUARY 1984 AS RECORDED BY THE SAYAN SPECTROGRAPH

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ABSTRACT. The Sayan cosmic ray (CR) spectrograph recorded an SCR flare that occurred on 16 February 1984. We present data from both 1-hour and 10-minute duration measurements in 10 channels with different energy sensitivity (of neutron monitors HM-64 located at different depths in the atmosphere, and of a neutron, multiple neutron and rigid mumeson component lead-less detector). The parameters of the SCR variation spectrum are evaluated and it is shown that the recording of multiple neutrons at the same geographic point and at the same level in the atmosphere provides information similar to that from a spectrographic complex of instruments.

INTRODUCTION. The Sayan CR spectrograph /1/ is designed to provide data on the CR variations in different portions of the primary spectrum. This is achieved through: recording two components of secondary cosmic radiation (nucleon and muon), spacing the detectors in the depth of the atmosphere and the different geometry of neutron detectors. The CR geomagnetic cut-off rigidity at the site where the detectors are located is 3.9 GV.

A complex treatment of spectrographic measurements makes it possible to separate the CR variations into the components of interplanetary, magnetospheric and atmospheric origin and to determine the parameters of a primary spectrum ($\Delta D/D$), the variations of geomagnetic cut-off rigidity ($\Delta \gamma$) and the variations of atmospheric temperature (ΔT_c) /2/.

Since 1983 the spectrograph incorporates the 6HM-64-selector instrument that provides multiple neutron records according to two discrimination criteria "$\geq m$" and "$= m$" (m - neutron multiplicity) /3/.

RESULTS OF THE RECORDING OF THE SCR FLARE. In February 1984, there occurred an SCR flare that was recorded by all the detectors of the complex.

The CR intensity increase according to five-minute measurements lasted for the first 10 minutes 10:00 UT on 16 February 1984 and almost immediately afterwards there was the onset of a decrease which, within 25 minutes, reached 1/2 its maximum value.

Table 1 summarizes the results of measurements of SCR flare amplitudes.

In order to intercompare the values of the amplitudes recorded, these are also plotted in Fig. 1. Straight line "A" indicates the values of flare amplitudes with five-minute intervals of averaging. These are recorded data on the neutron component obtained by three detectors HM-64 located at 3000, 2000 and 435 m above sea level and results of measurements of multiple neutrons at 3000 m according to the discrimination criterion of $m \geq 1$ and $m \geq 2$. The values of amplitudes for one-hour intervals of the neutron component measurements as recorded by the lead-less detector and HM-64 instruments at different depths of the atmosphere, the values of multiple neutrons according to the discrimination criteria of $m \geq 1$, $m \geq 2$, $m = 1$, $m = 2$, and $m = 3$ and of the values of the rigid mu-meson component are indicated on straight line "B".

Table I

Instrument (component)	Height above sea level of detector, m	Flare amplitude (in %) at different times of data averaging: 5 minutes	10 minutes	1 hour
Lead-less detector	3000	-	-	3.3±0.2
6HM-64	3000	5.2±0.4	4.8±0.3	2.6±0.1
12HM-64	2000	4.7±0.4	4.5±0.3	2.4±0.1
18HM-64	435	4.0±0.5	4.0±0.4	2.2±0.2
Rigid mu-meson	435	-	-	0.0±0.2
6HM-64	3000	-	-	2.6±0.1
$m \geq 1$	3000	5.0±0.4	4.8±0.3	2.5±0.1
$m \geq 2$	3000	4.6±1.0	4.6±0.7	2.2±0.3
$m = 1$	3000	-	-	2.6±0.1
$m = 2$	3000	-	-	2.5±0.3
$m = 3$	3000	-	-	1.5±0.8

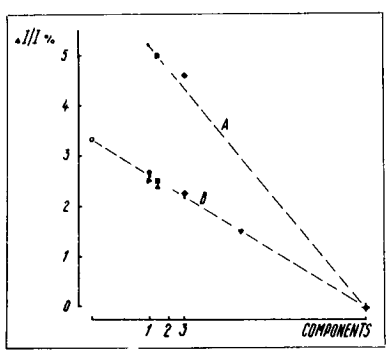

Fig. 1. Dependence of the recorded amplitudes of the SCR flare for five-minute (A) and one-hour (B) data of averagings. • - flare amplitude in the neutron component, as recorded by standard instruments at different depths in the atmosphere: 1 - 3000 m, 2 - 2000 m, 3 - 435 m; o - amplitude in the neutron component, as recorded by the lead-less detector; ● - amplitude in the total count rate of neutrons, as measured by the instrument 6HM-64-selector; flare amplitudes in multiple neutrons:

■ - m ≥ 1, ● - m ≥ 2, ▶ - m = 1, ▲ - m = 2, ◀ - m = 3; ✚ - flare amplitude, as measured in the rigid mu-meson component).

EVALUATION OF PRIMARY SPECTRUM PARAMETERS DURING THE FLARE. The analysis of the ratio of increase amplitudes averaged over a one-hour interval to those recorded by different detectors of the complex reveals that the energy spectrum of the variations for particles incident on the atmospheric boundary over Irkutsk cannot be represented by a simple exponential function. Thus, from the ratio of the amplitudes recorded by the neutron exponent of the exponential spectrum γ must be ~ 0.35 while for detectors 6HM-64 (3000 m) and 18HM-64 (435 m), $\gamma \sim 0.7$. With such values of γ, the effect of CR intensity increase was to be observed in the rigid mu-meson component. However, no such effect was recorded. It is interesting to note that according to the ratio of the amplitudes in 6HM-64 (3000 m) and 18HM64 (435 m) averaged over the five-minute interval for a maximum SCR flux, the exponent of the spectrum was found to be ~ 1.7.

The observed peculiarities of the variation spectrum seem to be due to a significant anisotropy of the SCR flux density. In this case, because the particles of various energies have different asymptotic directions, the energy spectra of the particles arriving at the boundary of the atmosphere will depend on the location of the recording point, on local time and on SCR anisotropy characteristics. Within these considerations it is possible to explain both the anomalies in the spectrum of particles at some or another point of the Earth's surface and their dependence on the time interval of data averaging (on account of the anisotropy dynamics).

COMPARATIVE ANALYSIS OF THE MEASUREMENTS FROM THE SAYAN SPECTROGRAPH AND THE INSTRUMENT 6HM-64-SELECTOR. The instrument 6HM-64-selector is designed to record multiple neutrons of up to m ≥ 6 and m = 6.

An increase in CR intensity in the channels recording multiple neutrons during the flare was observed up to m = 3 (channel m ≥ 3 was not operative during this period).

A comparison of the amplitudes recorded during the flare by the Sayan spectrograph and the instrument 6HM-64-selector reveals that the amplitude measured by a standard neutron monitor 18 HM-64 at 435 m is equal to the value of the intensity increase of secondary multiplicity neutrons as measured by the instrument 6HM-64-selector at 3000 m (m ≥ 2, see Fig. 1). Temporal profiles of these components are also quite similar (see Fig. 2).

For the recording of third-multiplicity neutrons, the amplitude value is 1.5 % which is significantly smaller than that measured by a standard neutron monitor ($\Delta J/J = 2.6\%$). This indicates a shift of the energy sensitivity of channel "m = 3" towards the region of larger energies of primary particles.

CONCLUSIONS. The SCR flare of 16 February 1984 showed a significant CR anisotropy which makes it difficult to represent the primary CR variation spectrum using a simple exponential function.

The SCR amplitude as measured at 3000 m and by recording multiple neutrons according to the discrimination criteria of $m \geq 1$, $m \geq 2$, $m = 1$, and $m = 2$, correspond to those recorded by standard neutron monitors at 3000, 2000 and 435 m.

The energy sensitivity of third-multiplicity neutrons (as compared with measurements of the neutron component by standard detectors HM-64) is shifted towards the region of larger energies of primary CR.

The recording of multiple neutrons at 3000 m provides information about CR variations similar to that from the Sayan CR spectrograph.

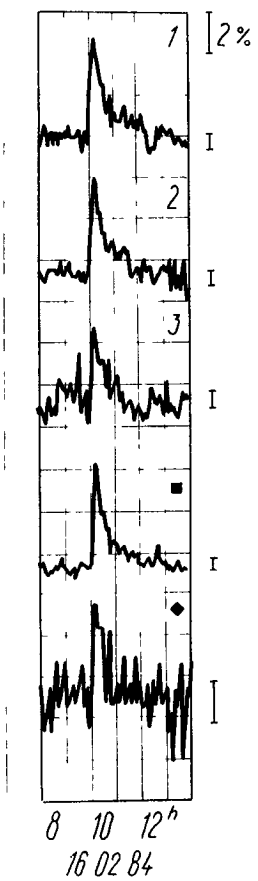

Fig.2. Results of recording the 16 February 1984 SCR flare from five-minute duration measurements with the Sayan spectrograph and the instrument 6HM-64-selector. 1, 2, 3 - neutron component as measured by standard neutron monitors at 3000, 2000 and 435 m, respectively; ■ ◆ - multiple neutrons as measured at 3000 m according to the discrimination criterion of $m \geq 1$ and $m \geq 2$, respectively (measurement errors are shown at right).

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