SENSITIVITY OF SINGLE AND MULTIPLE COSMIC RAY NEUTRONS TO THE SURROUNDING MEDIUM IN A LEAD-FREE MONITOR

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In I98I-I985 the neutron component of cosmic rays was recorded, the effect of cosmic ray multiplication in lead being disregarded /I-2/. The recording device consisted of neutron counters placed in a polyethylene retarder (polyethylene tubes with wall thickness of 2 cm). The device registered neutrons formed directly on the surface or not deep underground; the intensity of neutrons depended on the chemical composition of the substance.

The neutron component was measured by a lead-free monitor in an expedition in the Moscow Canal, Belomor-Baltic Canal and in the Atlantic Ocean. Figure I presents the time variation of 5-minute data of the intensity obtained in the Belomor-Baltic Canal and in the Atlantic Ocean relative to the mean value in the open sea (in %, Fig.I b). The intensity is seen to increase considerably when cosmic rays pass through locks and ports. In different locks the amplitudes of the effect are different which is due to the difference in the depth, in the geometry of the locks, and in the chemical composition of the shore substance.

The observed intensity increases due to recording of additional neutrons formed in nuclear interactions in the shore substance. These neutrons leave the nucleus at the evaporation stage, and the larger the mass number of the nucleus, the more the amount of evaporating neutrons for a given energy of an incident particle. Thus, it seems possible to use the method of recording multiplicities for the determination of substance composition since these neutrons can be considered as multiple. The possibility of their recording is much smaller than in local-generation detectors because of a large distance from the place of their formation to the place of recording. For this reason the counting level for multiplicity $k = 2$ is not high relative to the total count and is negligibly small for higher multiplicities. Nonetheless, since the increase in the count is just due to multiple neutrons, it is reasonable to record multiplicities.

Besides the total intensity, the multiplicities were also recorded in the Belomor-Baltic Canal. Along with intensity variations δI, Fig.I demonstrates the $\delta I_{>2}$ time dependence of δI, which is the multiple neutron intensity variation for multiplicity k = 2 and the mean multiplicity k for the time of passing through the Canal (from 5-minute data). The results of these measurements show a synchronous variation in the level of count of I and $I_{>2}$. But if the increase of the intensity I in locks makes up on the average 20-30 %, for multiplicities $k \geqslant 2$ the increase reaches 2000-3000 %. This difference confirms the fact that the intensity increase in locks is due to recording of neutrons formed in interactions between cosmic rays and lock-wall or shore substance nuclei. (In the open see this effect is relatively small - the rate of counting of $I_{>2}$ is about 3 pulses per 5 minutes). Thus, the data on the multiplicities are many times more sensitive to the influence of the environment than the data on the total intensity, the rate of counting multiple neutrons formed in CR - air interactions being negligibly small. Standard deviations in locks for δI and $\delta I_{>2}$ make up 2 and 300 %, which in the relative units make up about 8 and II %, respectively. Therefore, in spite of the small rate of $I_{>2}$ count, the accuracy in determining the variation $\delta I_{>2}$ is comparable with the accuracy of determining the intensity variations. Thus, the information on the surrounding medium is more complete if neutrons are recorded by both methods. Because of its smallness, the mean multiplicity does not react to the surrounding medium since statistic fluctuations overlap possible variations.

The influence of the chemical composition of the surrounding medium on multiplicity distribution is of considerable interest. Within the statistical error of measurements the multiplicity distribution for a lead-free neutron monitor is exponential, $I_K \sim \exp(\alpha k)$ (Fig.2), the parameter α depending on the position of the neutron monitor; in locks with rocky shores (Fig.2, curve I) $\alpha = 3.70 \quad 0.08$; in locks with ordinary ground (curve 2) $\alpha = 4.00 \quad 0.IO$; between locks with a distance to the shores of 4-8 m, $\alpha = 4.II \quad 0.II$ (curve 3); in the open see $\alpha = 7.0 \quad 0.6$ (curve 4). In locks with rocky shores (Fig.I, locks N 6-9) α decreases, in locks with ordinary groung such a decrease is not observed. In the open see the intensity $I_{>2}$ makes up only 0.I % of the total intensity which is responsible for a corresponding maximum value of α. (It should be noted that the riverside effect on the intensity makes up IO-20 % if the distance to the banks is IO-I5 m. As the distance increases to IOO m, the riverside effect vanishes and the data on the intensity correspond to those obtained in the open see).

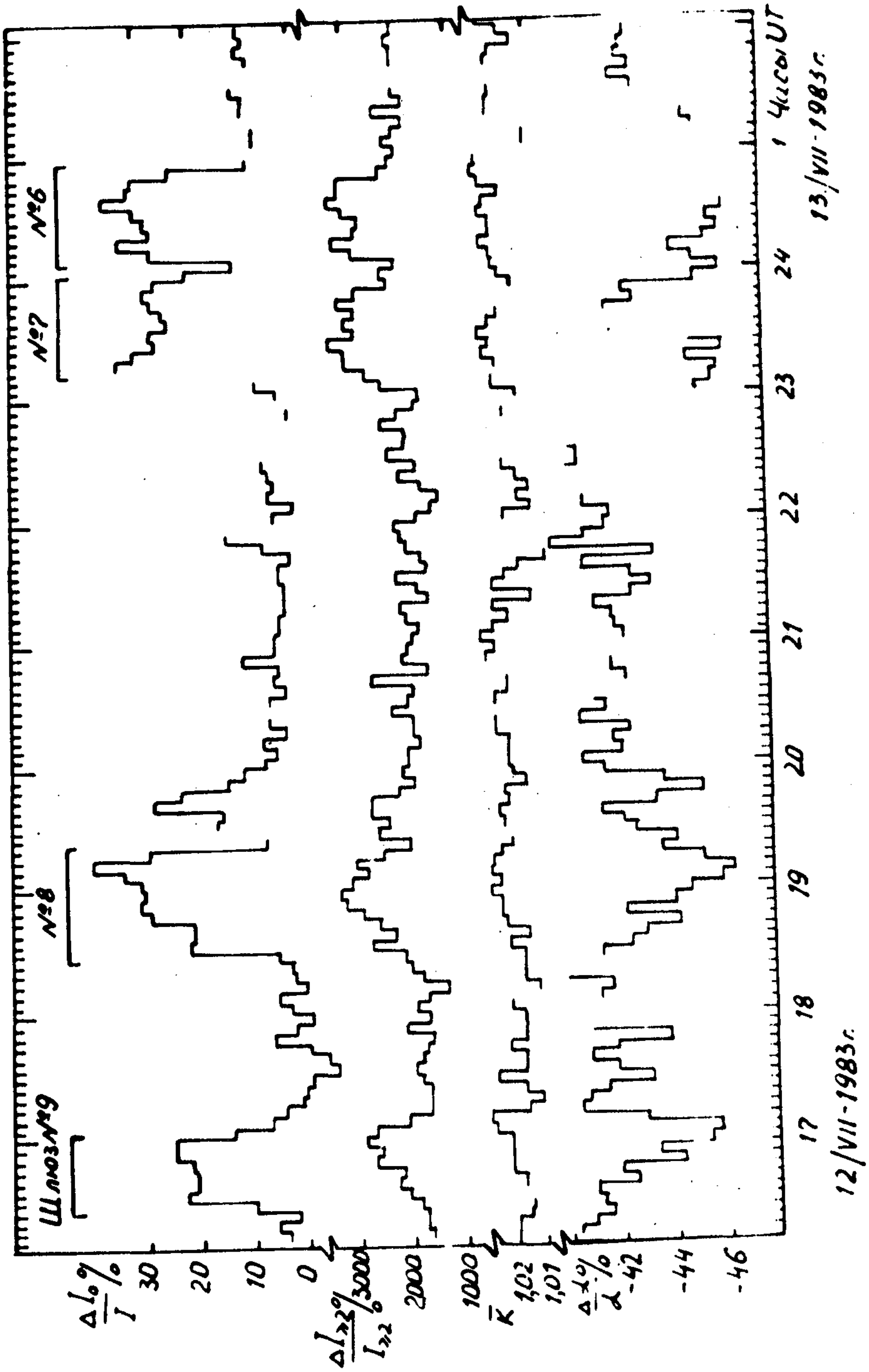

Fig. 1

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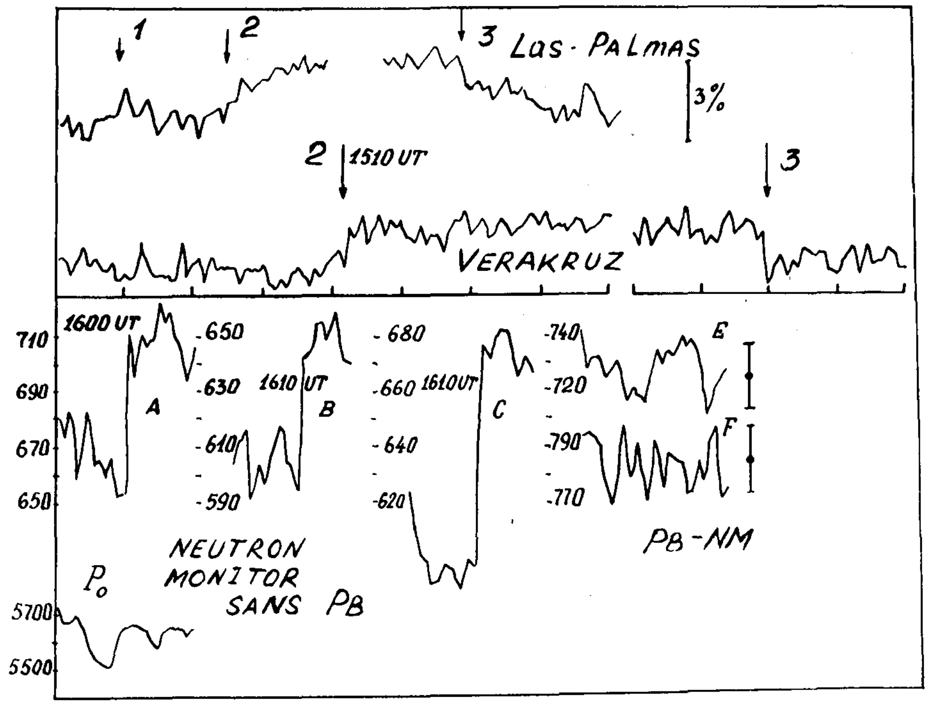
1
2
3
Las-PALmAS
3%
2
1510 UT
3
VERAKRUZ
1600 UT
710
690
670
650
A
650
630
610
590
1610 UT
B
680
660
640
620
1610 UT
C
740
720
790
770
E
F
PB-NM
NEUTRON
MONITOR
SANS PB
P_o
5700
5500

Fig. 2

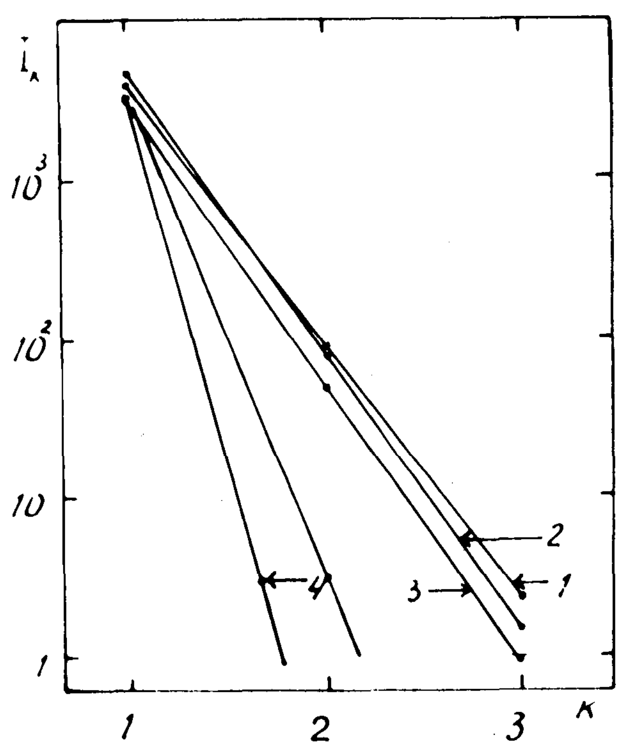
I_A
10^3
10^2
10
1
2
1
3
4
1
2
3
K

Fig. 3