

United System of the Neutron Monitors and Muon Telescopes for the Cosmic Ray Registration in Wide Range of Energy

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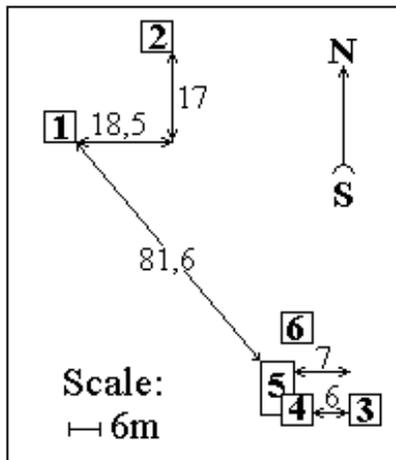
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Abstract

In the present paper the registration of cosmic radiation muons and neutrons is considered as united system by means of two neutron monitors and two muon supertelescopes with plastic scintillators. The possibility of the solar neutron registration by the neutron monitors at the Earth surface is considered also.

1 Introduction:

The cosmic ray station at the Kazakh State National University consists of two neutron monitors of MGG-57 and 6NM-64 types situated at the altitude of 810 m above the sea level at the distance of 6 m one from each other, two muon telescopes with effective area 20m^2 , godoscope telescope with effective area 1m^2 and the reception-register center for the reception and processing of the stratosphere probe data (see fig.1).



- 1- the narrow-solid muon telescope
- 2- the godoscope installation
- 3- the neutron monitor MGG-57
- 4- the neutron supermonitor 6NM-64
- 5- the muon supertelescope
- 6- the reception-register center of the stratosphere probe data

Figure 1: Scheme of the automatic installation disposition at the cosmic ray station of the Kazakh State National University.

Installations are intended mainly for solving problems such as:

- 1) Investigations of the cosmophysical problems.
- 2) Study of the particle interactions in wide range of the energy to 10^{12} eV.
- 3) Investigations of the cascade properties and shower properties.

Cosmophysical problems include the definition of the cosmic radiation variation characteristics, its anisotropy, problem of the neutron production in the Sun. Simultaneously with Galaxy cosmic ray (GCR) variations it is possible to make solar cosmic ray (SCR) investigations including the temporal structure of the particle acceleration process in the Sun, the energetic parameters of the SCR production in the flares. Besides it is possible to investigate the GCR properties; the GCR modulation in the heliomagnetosphere; the GCR anisotropy in the solar and sidereal time; the space-time and energy characteristics of the GCR density gradients and their change in time and dependence on energy.

2 The work regime “on line” of the neutron monitors and muon telescopes:

The radial network scheme of the installation cooperation is used for solving of the present problems. Each of the installations has connection with the central registering point (CRP). If the particle hit to the detecting part the event is digitized, the time and the impulse amplitude code are recorded by electronic logic and the information about this event is broadcast to the CRP. Usually two master-impulse levels are used: "soft" and "hard". The first level is caused by total energy release in the detectors of the installations and allows to choose events according to energy threshold, at the second level the space-time structure of the energy release is taken into account. Other conditions can be taken into account using choice of the events from the data bank. Reception and final processing of the variable information; the information sequencing of cascades and showers, the formation of the data banks; the testing of the capacity for a work of the system on the whole are made in the CRP.

The principle of the flexible reorganized microprocessor system connected with the analysis computer on the modem channel is put to the basis of the most installations of automation (Stupin Yu.V. et al., 1983, Kolomeets E.V. et al., 1986). The microprocessor complete set provides the automation of the cosmic ray registration processes and supports the capacity for a work of the installation in the set regime. The basis of any installation registering cosmic rays is the detector module (DM). The software of the control by the DM is intended for support of the normal capacity for a work of the DM by means of the regulation of the signal discrimination thresholds and high voltage levels of the DM feed. The regulation is necessary for the compensation of the DM physical parameter changes for example such as “fatigue” of the scintillators, the change of the converse efficiency of the photomultipliers (“fatigue” of the photomultiplier), the signal analog processing block parameter change in the time with the aim of the signal amplitude invariability preservation from the most probable of the particle energy loses in the detector.

As it is known the maximum positions of the differential spectrum are determined by the impulse corresponding amplitude values that is by values of the most probable loses. The change of the DM characteristics in the process of the exploitation leads to the change of the maximum positions. At the practice the maximum positions are corrected by means of the changes of the radiation detector intensification coefficients and discrimination thresholds. General algorithm of the control by the DM consists of the chain steps:

- 1) The differential spectrum of the impulse amplitudes is taken during set temporal interval, the duration of the interval is determined by the necessary statistical accuracy.
- 2) The smoothing of the obtained spectrum is made for the removal of the high-frequency fluctuations.
- 3) The maximum in the distribution of A_{max} is found.
- 4) The found value of A_{max} are compared with the standard A_{st} , which is held in the memory for every of the DM.

In dependence on the sign of their difference one of the 3 decision is taken:

- a) $A_{max} - A_{st} = 0$ - the return to the point 1,
- b) $A_{max} > A_{st}$ - the decrease of the voltage code on 1 and the passage to the point 1,
- c) $A_{max} < A_{st}$ - the increase of the voltage code on 1 and the passage to the point 1.

3 The registration of neutrons and muons:

The neutron supermonitor is intended for registration of neutrons evaporating from the nuclei of the monitor target which are excited in the result of the interaction of the neutrons with them generated at the interaction of cosmic radiation with the nuclei of the Earth atmosphere atoms (Simpson J.A., 1990). The block of the neutron monitor detection is under the roof (12g/cm^2) and includes 6 boric proportional counters. Electronic block of the monitor includes analog and microprocessor parts providing the work of the monitor in the automatic regime and also stabilized sources of the high-volt and low-volt feed and sensor of the atmospheric pressure measurements.

The impulses from the exits of the preliminary amplifiers enter to the integral discriminators forming the standard impulses then through the high-frequency cable enter to the storage of the primary information consisting of the frequency dividers of the input signals and summing counters of the impulses. On expiration of the every 10 minutes the reading of the impulse counters and also the reading of the pressure sensors are recorded to the buffer.

The fundamental investigations of the muon component are important for obtaining of the information about the cosmic ray modulation in the region of the relatively high energies. The muon telescope consists of 20 blocks of the detection situated in two rows each above other. The detector consists of the plastic scintillator by thickness of 50mm and area of 1m^2 and photomultiplier. The feed of the photomultiplier are realized from the block of high voltage sources (HVS) controlled by computer. The control computer sets the regime of the work: the operative control of the detector regimes, the automatic setting of the nominal voltage of the photomultiplier feed of the each detector, the correction of the operation thresholds of the discriminators and exposure.

The program of the muon telescope work is put down to the EEPROM with ultraviolet erasure that permits to reprogram the control. The structural scheme of the detector work stabilization is shown in fig.2. From the discriminator 1 (working) the impulses enter to the storage. The operation threshold FF corresponds to minimum of the threshold

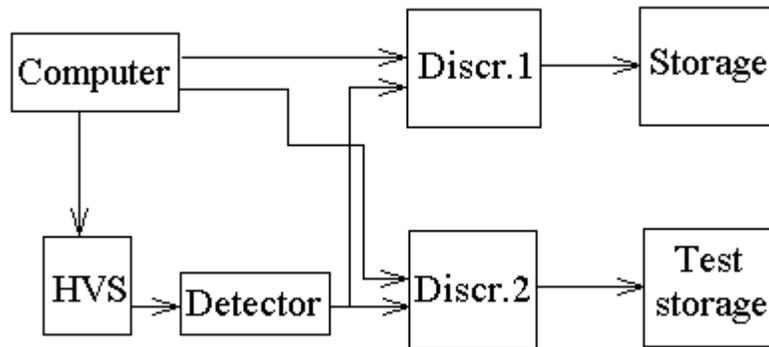


Figure 2: Structural scheme of the detector work stabilization.

characteristic. The discriminator 2 is used for control of the detector parameters (fatigue of the scintillator counter, photomultiplier and so on), for taking the calculating characteristic of the detectors, for the receiving of the cosmic radiation frequency spectrum, for the stabilization of the detector work in the regime of the real time. In the certain intervals of time which is necessary to discriminator 2 for taking the differential threshold characteristic the operation threshold FF is set on the part with the maximum steepness. The ratio of the calculating speeds I_1/I_2 is stabilized. Due to the great steepness of the characteristic in the region FF the stability is considerably improved. The readings of the test and working storage are compared with each other and in case of need the computer changes the operation threshold of the discriminator 1 and high voltage of the detector feed. The relative error of the registration don't exceed 0.01%. The directions of the muon telescope registration (the channels) are formed by the logic selection of the 2-multiple coincidences of the each detector with each one through the vertical direction north-south, east-west. The 5-minute data are analyzed and if the standard deviation exceeds of 5σ with increasing of the intensity the exposure time decreases up to 1 min automatically. The account of the atmosphere temperature change influence on the muon component are conducted by means of using of the neutron component observed data and the theory of the atmospheric processes.

4 Production and propagation of the solar neutrons:

We'll consider the possibility of solar neuron registration by ground level neutron monitors (see scheme in fig.3). Chemical composition of the solar atmosphere is supposed as protons $>90\%$, α -particles $\sim 9\%$, nuclei with $Z>2 \sim 1\%$. Angular distribution of particles accelerated in the flare is considered from direction of Sun-Earth $\pm\pi/2$, in other words we except the sphere-symmetry case and take the most optimum one - half of sphere. The primary spectrum of the accelerated protons in the flare is accepted as a power function $f(E)=A \cdot E^{-\gamma}$ with the exponent of

spectrum $\gamma=3$. The number of neutrons of the total quantity of accelerated protons with energy $E>1\text{GeV}$ form extremely small part (Belov A.V. et al., 1989 and Lingenfelter R.E. and Ramaty R., 1967), in the case of thin target even. The neutron energy spectrum at the exit of the solar corona is approximated by power function with the exponent of spectrum γ from 1 to 3 in dependence on angular distribution of the neutrons. The angular distribution at the calculation of the energy spectrum and integral flux of the neutrons is taken up in the range of $0 < \pm \cos\Theta < 1$, i.e. the change is from 0° to 180° . The integral flux of the solar neutrons with $E>250\text{MeV}$ reaching the Earth orbit in the dependence on the angular distribution near by the flare region is expected for the flares 23.02.1956 and 29.09.1989 types in the limits of some tens of the neutrons per sm^2 (Lingenfelter R.E. and Ramaty R, 1967 and Kocharov G.E., 1983). At the passage of the solar neutron through the Earth atmosphere the energy losses take place only due to the elastic collisions, because of their relatively low energies. Taking into account the above mentioned it follows that the registration of the solar neutrons by the neutron monitor at the Earth surface is so unlikely and to distinguish the intensity increase of the neutron monitor during the large flares even, through the solar neutrons only, is practically impossible. Existent experimental data of the intensity increase may take place at the taking into account of the solar proton contribution.

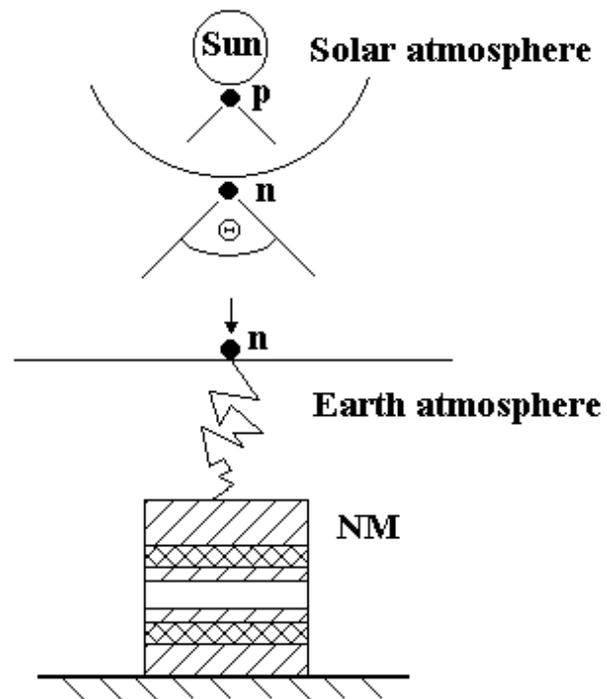


Figure 3: Scheme of the neutron production during solar flares and their registration at the Earth surface by the neutron monitor (NM).

5 Conclusion:

In conclusion we want to note that considered network of the installations gives possibility to register muon and neutron components of the secondary cosmic radiation and besides allow to distinguish exactly secondary neutrons produced in the Earth atmosphere and solar neutrons. Analysis of the results cosmic radiation registration by our station and also other stations of neutron component registration shows that the picked out neutrons generated during solar flares is unlikely .

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