SAMARKAND COMPLEX SETUP FOR INVESTIGATION OF COSMIC RAY VARIATION IN THE ENERGY RANGE OF $7\ \mathrm{IO}^{9} - \mathrm{IO}^{15}$ eV

Dorman L.I.
Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences, I42092 Troitsk, Moscow Region, USSR

Valikhodzhaev F., Makhmudov B.M., Sirodzhev N., Tashpulatov R.
Samarkand State University, Uz.RRS, Samarkand, USSR

I. Abstract. The Samarkand complex setup is aimed at the study of cosmic ray variations in a wide energy range from $7.\mathrm{IO}^{9}$ eV (which corresponds to the geomagnetic threshold in the region of Samarkand) up to $\sim \mathrm{IO}^{15}-\mathrm{IO}^{16}$ eV. The setup consists of four 6-counter sections of neutron supermonitor with counters SNM-I5 and 48 scintillator detectors (Im^2 each) placed under and above the supermonitor. The effective area of the setup for recording neutrons and muons is 24 m^2. The setup can register time variations of the following cosmic ray components: I) the total neutron counting rate, 2) counting rates for neutrons of different multiplicity, 3) soft-muon fluxes, 4) hard-muon fluxes at various zenith and azimuth angles, 5) electron-photon component, 6) extensive air showers (EAS) induced by primary particles in a wide energy range and accompanied or not accompanied by muons and neutrons.

2. Description of the setup. The complex setup consists of four 6-counter sections of neutron supermonitors which are compactly placed at a hight of I m. Under and above each section there are 6 scintillator detectors with an effective area of I m^2 each. The dimensions of each section are 3I5 x 222 x x 52 cm^3 and the weight is about I3 tons. The generator of neutrons is made of lead (an effective area in one section is -6.2I m^2), and the retarder and reflector of neutrons was made of polyethylene. Neutrons are detected by Soviet neutron counters SNM-I5 (effective length -200 cm, diameter-I5 cm, filled with a gas BF_3 up to a pressure of 20 cm Hg, the concentration of IO_B isotope in boron reaches 80 %, operating voltage - 2600-2800 B, proper radioactive background $\leq$ I %). Plastic scintillators with reflectors and photomultipliers placed at the top of reflectors are used as detectors of charged particles (electrons, muons, protons). After amplification, formation, and discrimination, pulses from detectors come to the general logic scheme in which different components are selected (neutron, electron-photon, muon, EAS with different accompanying). The results of the selection come into a multichannel recorder with a punch out on the paper tape and digitizer.

3. <u>Recording of single and multiple neutrons</u>. The developed electronics makes it possible to sort out events induced by single and multiple neutrons and to block pulses from electrons and muons in neutron counters /I/. Bearing in mind the coupling coefficients for single and multiple neutrons one can say that the Samarkand neutron supermonitor is sensitive to promary cosmic rays in the energy range from 7 to several tens of GeV, with an effective energy of about I5 GeV. The total counting rate for neutrons is expected to be about IO^6 pulses/hr, which corresponds to the rms statistical error σ = = 0.I%/hr; for 5-minute data this corresponds to $\sigma \sim$ 0.3-0.4 %/5 min., which is quite sufficient for statistical investigation of cosmic ray scintillations. The counting rate for neutrons of multiplicity m=2 is $\sim$ I.3 IO^5 pulses/hr, which provides $\sigma \sim$ 0.3%/hr; for m=3 the counting rate is $\sim$ 4 IO^4 pulses/ /hr, which gives $\sigma \sim$ 0.5%/hr; for the sum m=4 and 5 the counting rate is $\sim$ 2.IO^4 pulses/hr and $\sigma \sim$ 0.7 %/hr, and for m=6 the counting rate is $\sim$ 4.IO^3 pulses/hr and $\sigma \sim$ 2 %/hr. These accuracies show that the data on high multiplicities can be used only for the investigation of long-period variations and statistical analyses, and also of short-time variations with a large amplitude (powerful Forbush decreases, effects of solar flares).

4. <u>Recording of soft muons</u>. It is well known (see the review /I/) that in a neutron supermonitor about 7 % of pulses are induced by soft negative muons which form on lead nuclei the mesonic atoms with a subsequent capture of muons and a formation of several neutrons. Such events can be discriminated by pulse anticoincidence in the upper and lower scintillators and by retarding pulse coincidence in a neutron supermonitor. The expected counting rate for soft muons is about I.3 IO^5 pulses/hr, which corresponds to $\sigma \sim$ 0.3 %/hr. This will make it possible to study in detail the meteorological variations of soft muons which are of great theoretical and practical interest.

5. <u>Recording of the electron-photon and muon components</u>. Summation of the counting rates of upper scintillators provides information on time variations of the total ionizing component with a high statistical accuracy ($\sigma \sim$ 0.02% for a 5-minute interval). Subtraction from this counting rate of the flux of hard and soft muons gives data on variations of the electron-photon component. Further, the use of a scintillator system for selecting the respective double coincidences between individual upper and lower scintillator detectors gives exclusively valuable information about time variations of hard muon fluxes which arrive at different zenith and azimuth angles. After the quality of the work is analized, analogous

channels of coincidences which correspond to one and the same zenith and azimuth angles are summed up. The large effective area of the setup allows us to obtain observational data with so small statistical errors (smaller than I % for 5-minute data) that we can very reliably use the recording even at large zenith angles which correspond to primary cosmic rays with an energy $\gtrsim IO^{2}$ GeV. The data on time variations of hard muon fluxes from different directions yield much information about variations of atmospheric, geomagnetic and extraterrestrial origin with an energy of IO^{IO} - IO^{I2} eV.

6. Recording of different types of extensive air showers. Pulses from each of the 48 upper and lower scintillators, as well as from 24 neutron SNM-I5 counters come to a logic system which sorts out the following events: a) various combinations of coincidences only of upper scintillators - recording of counting rate for EAS of different power which correspond to primary particles of energies IO^{I3} - IO^{I6} eV; b) recording of EAS of different power accompanied by muons; c) recording of EAS of different power accompanied by neutrons.

7. Meteorological and coupling coefficients. With an account of the geometry of the setup and its geographical position, each of the components mensioned above in 3-6 is characterized by the following coefficients: β_i, a barometric coefficient for the i-th component of a setup; $\alpha_i(h)$, the density of temperature coefficient, where h is pressure at a corresponding isobaric level; $W_i(R)$, the coupling coefficient depending on the rigidity R of primary particles (see /I/, /2/, /3/).

8. Application of generalized spectrographic method for the analysis of observational data. A continuous recording of fluxes of single and multiple neutrons, soft muons, electron-photon component, fluxes of hard muons from different directions and frequencies of different types of EAS with essentially different meteorological coefficients and different coupling coefficients makes it possible to use the generalized spectrographic method /4/ for obtaining separate information about variations of atmospheric, geomagnetic, and extraterrestrial origin. The method consists in the fact that for each i-th component recorded by a complex setup for each time moment t one derives an equation for an observed variation of the counting rate

$$\frac{\delta I_i(t)}{I_{io}} = \beta_i \delta h_o(t) + \int_0^{h_o} \alpha_i(h) \delta T(h,t)\, dh - \delta R_c W_i(R_c) + \int \frac{\delta D(R,t)}{D_i(R)} W_i\, dR \qquad (I)$$

where the intensity variation $\delta I_i(t) = I_i(t) - I_{ic}$, variation of the air column mass above the setup may differ considerably from the pressure $\delta h_o(t) = h_o(t) - h_o$, temperature variation $\delta T(h,t) = T(h,t) - T_o(h)$, variation of geomagnetic cutoff rigidity $\delta R_c(t) = R_c(t) - R_c$ and variation of the primary spectrum $\delta D(R,t) = D(R,t) - D_o(R)$. Here the first two terms on the right imply variations of atmospheric origin, the third term determines variations of geomagnetic origin, and the fourth term - variations of extraterrestrial origin. The solution of a system of equations of the type (I) by the method described in /4/ for the above-mentioned set of components of a complex setup allows us to obtain continuously the information about $\delta h_o(t)$, $\delta T(h,t)$, $\delta R_c(t)$ and $\delta D(R,t)/D_o(R)$, i.e. in the end, about the processes in the atmosphere /2/ and magnetosphere /5/ of the Earth and in cosmic space /6/; the information of space-time variations of the energy spectrum of primary CR_s will be obtained in a wide energy range from $7\ IO^9$ eV to $IO^{I5} - IO^{I6}$ eV.

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