Energy spectrum of cosmic rays at energies of $5\cdot10^{15}$-$5\cdot10^{17}$eV.

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New data of the EAS MSU array are used to obtain information on energy spectrum and anisotropy of primary cosmic rays.

The data on the spectrum of cosmic rays have been obtained by analyzing the EAS size spectrum. Up to date the EAS size spectrum near sea level is not strictly determined. In particular the discrepancy both the absolute intensity and the shape of the size spectrum exists between the results of MSU [1] and Akeno [2] arrays although the both spectra have a knee at $Ne\simeq4\cdot10^5-10^6$.

As it was shown by the analysis of the MSU data [3] the shape of the size spectrum and its absolute intensity depend on the supposed lateral distribution function (LDF) used for the determining of Ne at the observation level. So the main source of discrepancy between the MSU and Akeno size spectra might be the difference in used LDF. Unfortunately it is difficult to establish what LDF was used at Akeno, but it dependence on Ne has not evidently taken into account. It is also noticed that the registration of charge particles flux in EAS was realized at Akeno by scintillation counters in which the transition effect is necessary to take into account. At the same time at MSU array the Geiger counters are used and the transition effect is practically absent for them.

We have analyzed experimental data on LDF in a wide region of $Ne=10^5-10^8$. All showers were divided on groups with narrow intervals of Ne ($\Delta Lg(Ne)=0.2$). Obtained lateral distributions permit various approximations in limits of experimental errors. It is caused by that circumstance that the central region and the periphery is unsufficiently studied for large and small showers respectively. Similar lack is peculiar to all currently operating EAS arrays. Fig.1 presents obtained by us differential EAS size spectra for various assumptions on LDF.Full circles corresponds to the spectrum obtained with modified function more gently sloping at large core distances compare with the NKG LDF. This function properly describes the experimental data of the MSU EAS array [4] and may be presented independently of Ne in form:

$$f(r)\sim(r/r_0)^{s-2}\cdot(1+r/r_0)^{s-3.9}\ ,\ r_0=80\ m \qquad (1)$$

Crosses in Fig.1 relate to the spectrum obtained with taking into account the dependence of LDF on Ne. In this case we used as LDF the function in form similar [5]:

$$f(r)\sim(r/r_0)^{s-2}\cdot(1+r/r_0)^{s-3.9}\cdot(1+C_2\cdot r/r_0) \qquad (2)$$

but introducing the dependence of the parameters s and C_2 on Ne:

$$s(Ne)=1.65-0.12Lg(Ne)$$

$$C_2(Ne)=0.16Lg(Ne)-0.63 \qquad (3)$$

As it is seen from Fig.1 the spectrum became more gently sloping and the absolute intensity is increased especially for large Ne.

It should be noted that the mentioned above LDF's don't contradict to the existing set of experimental data.The Akeno size spectrum for vertical direction [2] recalculated to the sea level is presented (dashed line) for comparison in Fig.1. For this purpose we take into account the absorption of Ne from Akeno level (X_A=920 $g\cdot cm^{-2}$) according to ~$\exp[-(X_0-X_A)/185]$ [6]. As it is seen from Fig.1 the best agreement of our and Akeno data is reached for LDF in form (2) with parameters s and C_2 depending on Ne (3).

This version of the EAS size spectrum was used for transformation to the energy spectrum of primary cosmic rays. The size Ne was scaled to the primary energy E_0 according to the QGS model (with Δ=0.12) [7], taking into account the quasicalorimetric measurements at the Samarcand EAS array [8] and supposing the gradually heaving with increasing of E_0 primary composition (diffusion model) [9]. Obtained energy spectrum is presented in Fig.2. together with the Akeno energy spectrum [2]. Evidently we may consider that both spectra are in a satisfactory agreement.* But the question stays what LDF was used in the Akeno group.

To obtain the information on the anisotropy of the primary cosmic rays we analyzed our data for period from January 1,1985 to October 4,1988. For analysis all showers were divided on two groups in accordance with the used triggering systems. One group has $2.7\cdot10^5$ showers with the average energy $\bar{E}_0=5.8\cdot10^{15}$ eV and the other group - $1.5\cdot10^5$ showers with $\bar{E}_0=2.8\cdot10^{16}$ eV.

Amplitudes A and phases φ of the first and second harmonics of variation of intensity in sidereal time for these groups of showers are presented in Table. (Analysis was made taking into account the barometric and temperature effects.)

Table.

$\bar{E}$,eV	A_1,%	φ_1,degr	A_2,%	φ_2,degr
$5.8\cdot10^{15}$	0.27±0.27	133±58	0.64±0.27	8±12
$2.8\cdot10^{16}$	0.90±0.36	196±23	0.49±0.36	112±21

Fig 3(a.b) presents current data on amplitudes and phases of the first harmonic [11]. It is noted that the phase at $\bar{E}_0=2.8\cdot10^{16}$ eV is near to the phase at $E_0=10^{17}$ eV (Haverah Park). Unfortunately the world data at $E_0>10^{14}$ eV is impossible to consider as reliable. The values of the first and second harmonic obtained by us don't contradict to world data. Showers with $\bar{E}_0=5.8\cdot10^{15}$ eV were used for obtaining their distribution on celestial sphere. Observed part of celestial sphere (declination $\delta>18^0$) was divided on bins with angular area ~10^{-2} sr in accordance with accuracy of the finding shower arrival directions.

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* It is noticed that new assumptions on LDF may change the dependence of muon number on Ne [10].

Following to [12] the deviation of observed number of shower n from expected ones N for every bin expresses in standard errors is determined as

$$I=\sqrt{2[nLn(n/N)+N-n]}$$

The distribution of deviations for all bins agrees with Gaussian distribution ($P(\chi^2)=0.9$). In Fig.4 the bins with $|I|>2$ are marked. The marked bins don't correlate with known sources with the exception of the bin ($\Delta\delta=36^0-42^0$, $\Delta\alpha=306^0-315^0$) which includes Cyg X-3. It is noted, that the excess from the bin with Cyg X-3 is more than 3σ, if showers with $n_\mu<\bar{n}_\mu$ are selected (n_μ and $\bar{n}_\mu$ are observed and average numbers of muons in the bin correspondingly).

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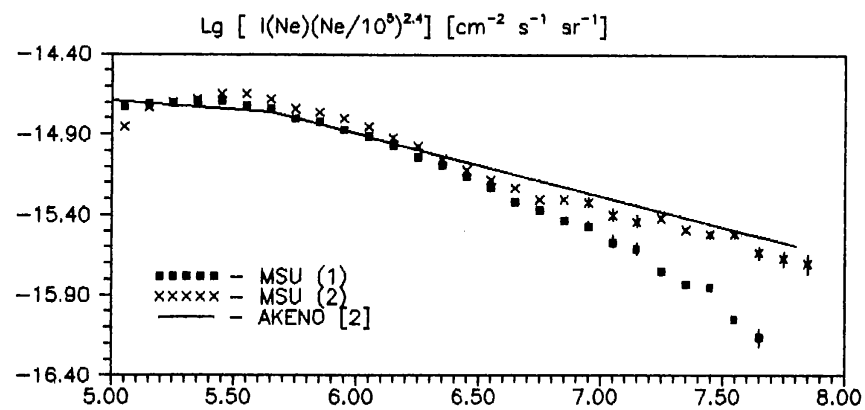

Figure 1. Lg (Ne)

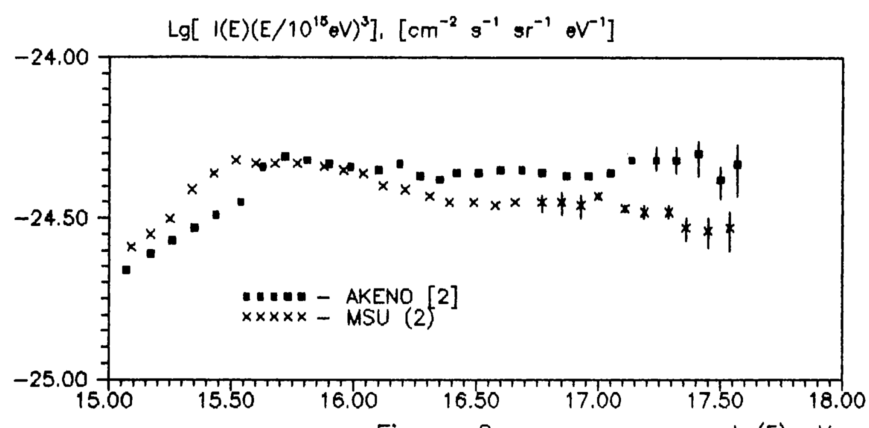

Figure 2. Lg(E), eV

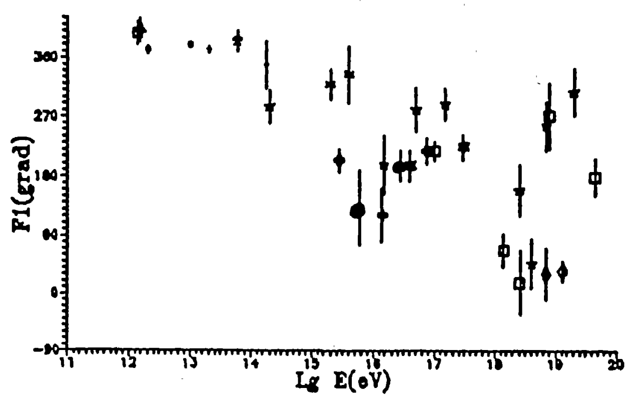

Figure 3(a).

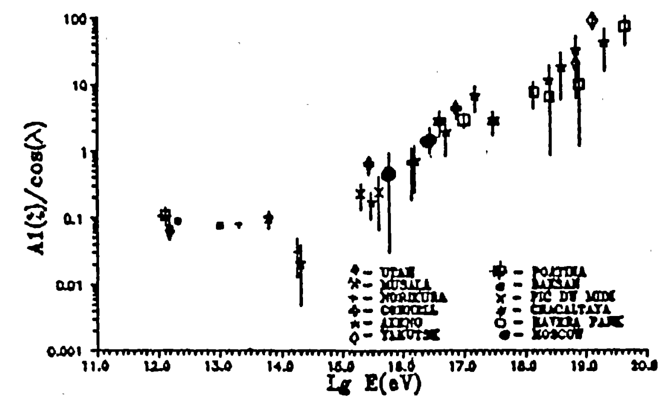

Figure 3(b).

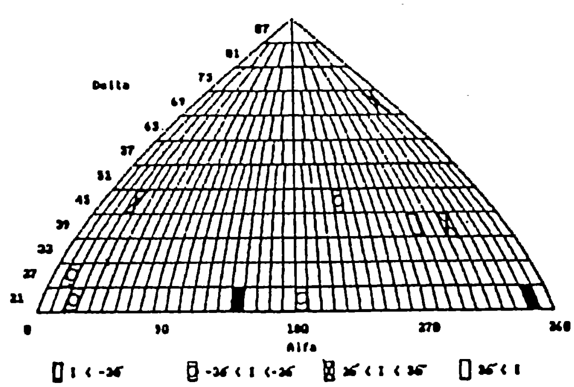

Figure 4.