COSMIC RAY SPECTRA MEASUREMENTS AT THE YAKUTSK EAS ARRAY

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1. Introduction. The EAS spectra on ρ_{600} obtained at the Yakutsk array for 38000 operation hours in 1974-1982 are presented. The refined value of the conversion factor from ρ_{600} to E_0 is given and based on it the primary energy spectrum is obtained.

2. Methods. At the Yakutsk EAS array the showers are classified on parameters which are well measured in real showers: in the central part - on ρ_{300} and on the whole array - on ρ_{600}. The shower spectra are constructed first on these parameters, then - a single spectrum on ρ_{600}.

The ρ_{300} and ρ_{600} values are determined on the particle lateral distribution function (LDF) obtained in Yakutsk (for instance,[1]) and on approximation $\rho \sim R^{-n}$ using the experimental points closest to R^* (300 and 600 m) [2]. In [1] and [2] somewhat different methods of selection of showers for a construction of spectra are also used.

3. Results. The differential spectra on ρ_{600} from the Yakutsk EAS array data for 38000 operation hours from January 1974 to April 1982 are given in Fig.1. They are presented the physical and instrumental errors of ρ_{600} uncorrected since the conversion factor will be further used for transformation of ρ_{600} to E_0 uncorrected as well.

From Fig.1 it is seen that the spectra obtained by two somewhat different methods do not contradict each other on the whole. However, at $\rho_{600} \leq 10\ m^{-2}$ the spectrum according to [2] is ~ 1.5 times higher than one in [1].

The spectrum ρ_{600} (HP) (Haverah Park) is presented with the recount to ρ_{600} (Y) (Yakutsk) using the dependence $\rho_{600}(Y) = (1,72\pm0,25)\cdot\rho_{600}(HP)^{1,06\pm0,03}$. Such a dependence is obtained from the comparison of the detector responses at these arrays [1].

From Fig.1 the irregular change of spectra, in particular, "bump" at $\rho_{600} > 20$ is evident. However, there is no a common opinion in estimation of such "bump" confidence. To our point of view it is necessary to find out the possible methodical details before concluding the existence of any irregularities of the spectrum, the more so that in this region the insufficient statistics is available and the EAS characteristics at $E_0 > 10^{19}$ eV are investigated not enough.

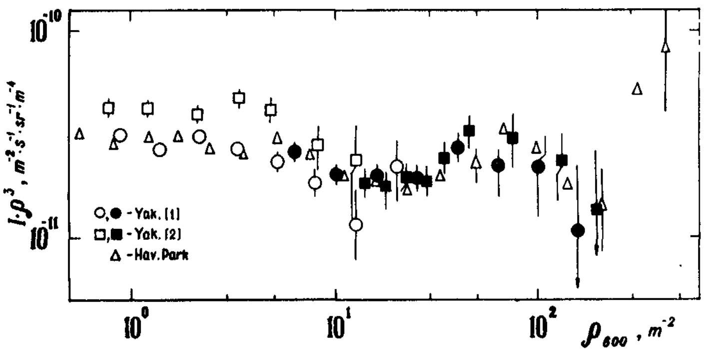

Fig.1

The parameter ρ_{600} for the Yakutsk EAS array is reliably measured and besides it is proportional to E_o. The relationship between ρ_{600} and E_o in [1] is found by the calorimetric method and in [2] - either by the same method or only on the Cerenkov light method (on Q_{400}).

In the total balance of E_o the portion E_i (energy dissipated by electromagnetic component in the atmosphere) is $\sim$ 80%. It is found as $E_i = K\cdot\Phi$, where Φ is the total EAS Cerenkov light flux in the atmosphere. The value K depends weekly on the shower development model and is $K\approx$ $3{,}8\cdot10^4$ eV/photon$\cdot$eV^{-1} (photon number is expressed per unit of energy range; for photomultipliers used in Yakutsk the frequency range energy is 2,6 eV).

The conversion factors from ρ_{600} to E_o obtained in [1] and [2] by a calorimetric method differ by 1,4-1,5 times. It is associated mainly with the different estimation of the light absorption in the atmosphere and with the different values of the average energy of muons.

In [1] the light absorption is taken to be (27sec Θ)%, in [2] it is 40% for all the zenith angles Θ . The average energy of muons with $E_\mu \geqslant 1$ GeV is taken to be 7 GeV [1] and it is 16 GeV in [2].

If to suppose that the light absorption occurs only in near the ground atmosphere layer as in [2] and it increases as sec Θ (i.e. the absorption is 33 sec Θ,%), and if the average energy of muons is taken to be 9 GeV (such a refined estimation seems to be proper), then we obtain:

$$E_o = (5{,}0\pm1{,}4)\cdot10^{17}\cdot \rho_{600}(0^\circ)^{0{,}96\pm0{,}04} .$$

From here we obtain on the Yakutsk EAS array data at sea level the following dependences of charged particle number N_s and of muon number N_μ ($\geqslant$1 GeV) on E_o:

$$E_o = (7{,}8\pm2{,}1)\cdot10^{17}(N_s/10^8)^{0{,}86\pm0{,}06} ,$$

$$E_o = (1{,}8\pm0{,}5)\cdot10^{17}(N_\mu/10^6)^{1{,}15\pm0{,}04} .$$

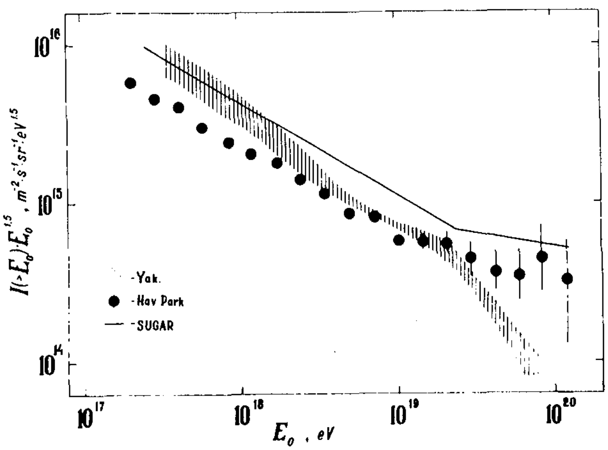

Fig.2

4. Discussion. The integral energy spectrum on the Yakutsk EAS array data by the above conversion factor is presented in Fig.2. The shaded region corresponds to data of [1] and [2]. Note that the achieved at present accuracy of the energy calibration allows to determine the absolute intensity in the range 10^{18} eV with the accuracy to 1,8. The spectrum of the SUGAR array data is presented on [3] using the obtained dependence between N_μ and E_0 and taking into account the difference in thresholds E_μ.

The discrepancy from the Haverah Park spectrum at the extremely high energies is that at the Haverah Park EAS array were registered 4 showers with very high values of ρ_{600} (two last points in Fig.1). At the Yakutsk EAS array such showers were not detected and the experimental data do not contradict the possibility of the existence of cutoff spectrum.

The reasons of the discrepancy of the Yakutsk and Haverah Park ρ_{600} spectra are not completely revealed. It is without exception that there are differences in the geometry of arrays, types of detectors and analysis method.

5. Conclusion. We think that it is necessary to analyze all the details of registration, treatment and analysis of showers based on the common methods to find out the nature of the observed irregularities of spectra.

References

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