ENERGY SPECTRA OF PROTON AND NUCLEI OF PRIMARY COSMIC RAYS IN ENERGY REGION > 10 TeV/PARTICLE

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To investigate the chemical composition of primary cosmic rays, several emulsion chambers were exposed at a 10.8 g/cm^2 depth in the stratosphere. Each chamber has the area of 0.92×0.46 m^2 and the depth of 14 c.u. The exposure time of chambers processed by now is 260 hours. The detecting layers were X-ray films and nuclear emulsions, which allowed to measure an energy of cascade and a type of primary particle. Previous results and technique were described in /1,2/

Results. The obtained results are listed in Table 1. All cascades were devided into six groups, according to the type of a primary. He and Z denote here the cascades produced in a chamber by He nuclei and nuclei with $Z \geqslant 3$. SH denotes the cascades produced in the chamber cover, these cascades were observed as a shower in the emulsion layer just below the cover. A fraction of cascades was induced by secondaries generated in the residual atmosphere (A-cascades). The cascades observed as groups of two or more members with the same zenith and azimuth angles are called A_F cascades. The events belonging to none of the above numerated types were attributed to p-cascades. This group consists of proton cascades with a small addition of single A-cascades. A small number of cascades were failure to identify due to technique causes (?-cascades). The third line in Table 1 lists the value of exposure factor $\langle S \Omega \varphi \eta \rangle \cdot T$, were S is the chamber area, Ω is the solid angle, φ is the efficiency of registration of given-type particles in a chamber, η being the coefficient of intensity attenuation in the residual atmosphere, T - exposure time. The angular intervals for which the processing was made also presented here.

Table 1.

primary	p		He		Z > 3		SH		A_F		?	
θ°	25-60	10-72	25-60	10-72	25-60	10-72	25-60	10-72	25-60	10-72	25-60	10-72
G·T, $m^2 hr\ sr$	43.4	62.5	50	70.5	M 45 H 37 VH 31	63 51 43						
ε, TeV > 1.6	292		39		58		68		60		39	
> 2	170		35		41		44		49		23	
> 2.5	115		23		30		30		40		13	
> 3	80	99	18	23	27	30	25	34	36	40	10	17
> 4	43	53	13	14	25	27	15	22	25	27	3	6
> 5	26	31	10	11	17	19	11	12	18	18	1	4
> 10	6	9	6	6	3	4	6	6	3	3		1
> 20	1	2	1	1			2	2				
> 40			1	1								

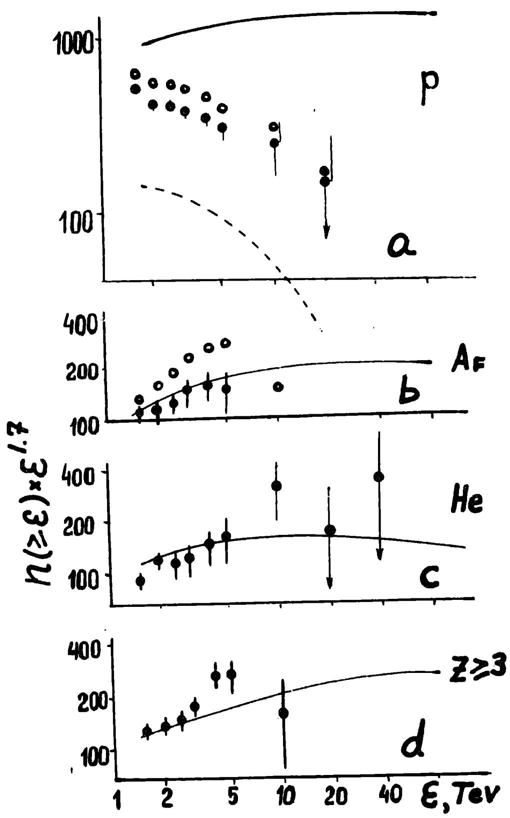
In Fig.1 the data for p, He and Z - cascades are shown along with the expected dependencies calculated for a primary composition model implying all spectra can be described by power-low dependences of the form $i_j = i_{oj} E^{-\beta_j}$, were E is the particle energy in TeV, and the values of parameters i_{oj} and β_j for various groups are given below:

Group	p	He	M	H	VH
i_{oj}, $m^{-2} hr^{-1} sr^{-1}$	240	90	75	107	67
β_j	1.7	1.8	1.7	1.7	1.7

These parameters were chosen when analysing experimental data obtained in /4-7/.

The expected number of cascades with energy $> \varepsilon$ was calculated by the formula: $n_j(>\varepsilon) = i_j(>E(\varepsilon)) \cdot \langle S\Omega\varphi\eta\rangle T \zeta$, where ζ =1.25 is the factor allowing for overestimation of the measured intensity due to fluctuations. A relationship between the measured energy ε and the total particle energy regarding fluctuations of the interacting nucleons number, fluctuations of K_γ and diversity of a nucleon cascade from an electromagnetic one has been considered in /1,3/.

Fig.1 shows a good agreement between the observed and expected spectra of He and Z-cascades and the difference between the observed and expected p-cascade spectrum being small at low energies and rapidly increasing with energy.



As note above, p-cascades include some fraction of single A-cascades. To estimate this fraction we performed simulations,which results are shown in Fig.1. The simulation was made by the program /8/, where interaction was assumed to quasi-scaling type, and a superposition model was used for nucleus-nucleus interaction. The expected number of single A-cascades is shown in Fig.1a by dashed line, the black circles denoting the corrected spectrum of proton cascades. Thus made correction is not quite reliable that follows from Fig. 1b, where the expected and observed numbers of A_F-cascades are shown (solid line and open circles). The observed number of A_F-cascades can be seen to somewhat exceed the calculated number. It must be note that the number of A_F-cascades is the strongly fluctuating magnitude. For instance, if one of 31 observed families is exclude from the A_F-cascades, the calculated and observed (black circles) spectra would coincide. However, it is desirable to have a reliable experimental identification procedure, that is our aim in the nearest future.

<u>Discussion.</u> Fig.2 summarizes the data available on the p and He-components. One can see that there is a discrepancy between our and JACEE proton data. Unfortunately, JACEE spectrum in various energy ranges was obtained over different exposures, that makes it difficult to analyse the

origin of discrepancy.

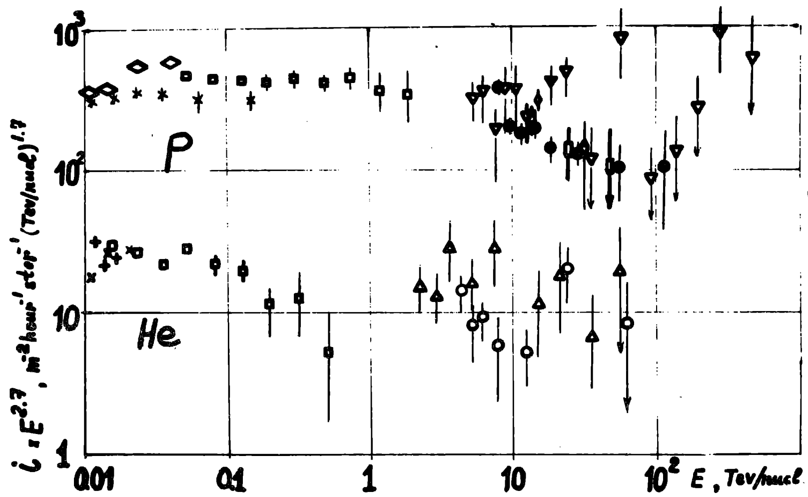


Fig.2. The differential energy spectra of protons and He at the atmospheric boundary.

□ - /4/
◇,+ - /6/
× - /7/
▽,△ - /9/
◇- /10/, ▯- /11/
●,○ -present work.

Furthermore the steepening of the proton spectrum measured in our experiment shows that the proton spectrum problem in the range 10^{12} - 10^{14} eV is still unsolved and requies further explorations. The proton spectrum being steep in the range 10^{12}- 10^{14} eV and the normal amount of protons being present at $E > 10^{15}$ eV may indicate the existence of two proton components of different origin /2/.

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