THE ME$\overset{h}{T}$OD OF X -RAY EMULSION CHAMBER AS APPLIED TO DETERMINATION OF THE CHEMICAL COMPOSITION OF PRIMARY COSMIC RAYS IN THE ENERGY RANGE OF IO -IOO TEV PER NUCLEUS.

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ABSTRACT.

An attempt were made to identify a primary particle in thin (50 μ) layers of nuclear emulsion forming the emulsion chambers together with the X- ray film. The idea was to trase the primary particle trajectory in all the layers of many-layer nuclear-emulsion chamber. The characteristics of the spatial -angle resolution are: $\sigma x = \sigma y = 350\mu$, $\sigma\phi = \mathrm{I}^{\circ}$, $\sigma\theta = 0.3^{\circ}$. 52 cascades in the X-ray emulsion chamber exposed at a I4 g/cm^2 depth for 70 hours have been trased. The primary is a nucleus with $z > 2$ on four of the trased cascades. Preliminary analysis of the obtained data is indicative of the normalcomposition of primary cosmic rays in the $\geqslant$ IO TeV/nucleus energy range.

INTRODUCTION.

Grigorov et al (I970) found a steepening of the proton spectrum at energies > I GeV. Other workers (Smith et al I973, Juli$\overset{u}{s}$son,E I973, W.R.Webber et al I973, R.L.Golden et al I973, V.K.Balasubramanyan I973, K.Atallah et al I973) have reported an increase of the portion of the nuclei (especially iron nuclei) at energies > 30 GeV/ nucleon. The muon, γ -quantum and hadron spectra measured by us using the technique of X-ray emulsion chambers (T.P.Amineva et al I976, T.P.Amineva et al I975)were also in agreement with the concept of the proton component steepening of the primary spectrum, or the entire primary cosmic ray spectrum in terms of energy per nucleon at > IO TeV. This information is of extreme importance in understanding the nuclear-physical and cosmophysical problems of the cosmic ray physics. The degree of reliability of this information is however still insufficient and reguires new studies.

THE EXPERIMENTAL PROCEDURE.

The measurements described below were carried out using a I6 - layer X-ray emulsion chamber of 0.5 x I.0 ^{2} size. Each layer consisted of a lead plate of 0.87 - cascade unit thickness and three sensitive layers: a 50 μ thick BR-2 nuclear emulsion and two layers of RT-6 X- ray film. All the sensitive layers were placed in an envelope made of 200 μ thick black paper and of 200 μ thick polyethylene. The chamber was exposed at a I4g/cm^{2} depth in the stratosphere for 70 hours in I975.

We made an attempt to classify the detected events according to Z and trace each event along its trajectory. The sensitive layeers were referred using the label of the X- ray gun. The obtained accuracy of the X- ray film reference was fairly good. The particle trajectory was reconstituted from single event spots employing the least square method, with the resultand coordinates diflection of $\sigma x = \sigma y = 100 \mu$. The accuracy of the reference of the nuclear layers is, however, worse because nuclear emulsion has been cut before the development. Therefore, the nuclear emulsion layers were referred according to the cascades and multiply-charged ions. The multiply-charged ions reference was carried out only for some upper layers where the number of cascades was smoll. The achieved accuracy in predicting the spatial-angular coordinates of a primary in each layer is characterized by $\sigma x = \sigma y = 350 \mu$ $\sigma\phi = I^{o}$, $\sigma\ell = 0.2$ l, where x and y are the spatial coordinates ϕ is the azimutal angle, $\ell = h \cdot tg\theta$ is the projection lenght of the primary particle track. The poor accuracy for ℓ is due to the instrumental scutter of the initial thickness, h , of the nuclear emulsion. The zenith angle determinating accuracy lie as ap to 0.3^{o}. These accuracies are quite sufficient to exclude not only the random nuclei but also the random low-energy α-particles. For example, the number of random α-particles on a I mm^{2} site for 70 hours at $\sigma\phi = I^{o}$, $\sigma\ell = 0.2\ell$, and a geomagnetic cut-off rijidity of 4 GV is $\leqslant I0^{-2}$.

RESULTS

52 events have been traced. In 28 cases a narrow cascade generated in the matter above the installation entered the chamber. Table I presents the distribution of the rest events.

Table I.

P	α	$3 \leq Z \leq 20$	$Z > 20$	cascades from outside
I7	3	3	I	28

DISCUSSION

The following two corrections should be made to understand the obtained results:

I. The measurements are to be reduced to the same energy per nucleon

2. The measurements are to be reduced to the atmosphere boundary.

The results are presented in table 2.

Table 2.

I	2	3	4	A	$\Lambda_{abs.}$	$e^{20/\Lambda_{abs.}}$	%	normal component %, $\gamma = 2.7$
P	I7	0.7/	0.7I	I	II0	I.2	30	33
α	3	0.I25	0.4	4	45	I.56	22	24
L+M+H	3	0.I25	0.4	I7	27	2.I	29	32
VH	I	0.04	0.I3	5I	I4	4.2	I9	II

The first column of table 2 lists the types of particles producing the event in the X-ray emulsion chamber. The second column shows the number of the events produced by given particles. The third column presents the relative frequency (the direct observation data at the I4g/cm^2 depth). Shown in the forth column are the observatio on data recalculated to the same energy per nucleus assuming that a half of the nucleon of a nucleus are on the average involved in the collisions. The fifth column shows the mean atomic number A. The sixth column presents the values of Λ in g/cm^2 used for the reduction to the atmospheric boundary. The seventh column shows the factors by which the data of column 4 are multiplied to be reduced to the atmospheric boundary. The eight column lists the relative intensities at the atmospheric boundary in percent. The ninth column shows the normal chemical composition calculated for $\gamma = 2.7$ it follows from the data of table 2. that the observations do not contradict the standart chemical composition of primary cosmic rays in the range of $>$ IO TeV per nucleus. However, the primary electrons and the secondary electromagnetic component may be found together with protons among the events in which the nucleus with $z > 2$ were not observed. The expected impurity of such particles can not be accurately calculated because of inaccurate knowledge of the absolute value of the threshold energy. The estimate shows however, that the impurity may constitute a marked portion of all such events. Therefore, the posibility cannot be as yet excluded that at the energies of $>$ IO TeV per nucleus the proton portion is smaller and the nucleus portion is greather then at low energies. The above analysis will be specified and detalized when the statistic is increased.

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