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III-6-13. Some Problems of Generation of Strange Particles*

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The results of investigation of generation of strange particles registered in penetrating showers of cosmic rays are given. The energy distribution of strange baryons, generated at nuclear interactions with energy about several tens BeV and the distribution of transverse momentum of strange particles are considered.

The results are based on the statistics consisting of 49 Λ°, 42 θ° and 18 $\Sigma^\pm$-particles registered in a cloud chamber, at an altitude of 1800 m above sea-level.

1. In earlier works by Ballam Gayther James it was noticed that energy distributions of Λ° and θ° particles generated under the same conditions differ greatly from each other. While the energy distributions of Λ° have the spectrum which increasses sharply with the decrease of energy to $E_k \sim$ 100 Mev, the distribution of θ°-mesons is more smooth and extends to much higher energies. In this respect the spectrum of θ°-particles resembles that of π-mesons generated under the same conditions, while the distribution of Λ°-hyperons apparently repeats the behaviour of the spectrum of secondary nucleons. In connection with the above mentioned, there arises a question whether the resemblance of the spectra of θ° and π particles is a general property of meson generation and if the energy distributions of baryons have the same general property.

To investigate this problem we have plotted the energy spectrum of $\Sigma^\pm$-hyperons selected on the basis of sufficiently strict criterion from all the charged unstable particles registered in a cloud chamber. As it is seen in Figs. 1 and 2 the spectrum of $\Sigma^\pm$-hyperons repeats the distribution of Λ°-particles so obviously that in spite of small statistics of $\Sigma^\pm$ we think it possible to make the following conclusion: apparently the process of multiple generation of particles at the energy about tens Bev is characterized by the resemblance of energy distributions of baryons. The spectrum of θ°-mesons registered at the same experiment is given in Fig. 3 for comparison. (event 3)

The observed spectra of Λ°, θ° and $\Sigma^\pm$-particles permit to draw up some idea about the angular distribution of strange particles in the center-of-mass system of colliding par-

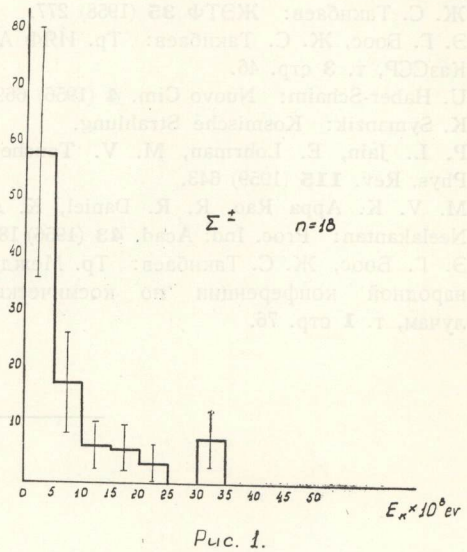

Рис. 1.

Fig. 1. Spectrum of kinetic energy of $\Sigma^\pm$ hyperons.

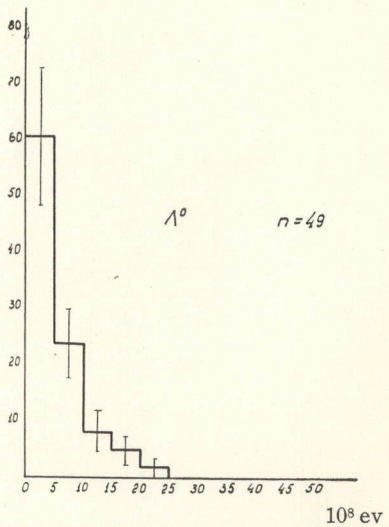

Fig. 2. Spectrum of kinetic energy of Λ° hyperons.

* This paper was read by G. E. Chikovani.

ticles. Indeed if one assumes that internuclear cascade processes have approximately the same influence in the picture of Λ°, θ° and $\Sigma^\pm$ generation one may conclude that both Λ° and $\Sigma^\pm$ have significantly bigger anisotropic distribution than θ°-mesons.

It should be noted that recently work has been performed with the help of a propane chamber irradiated by a flux of 8 Bev π-mesons (in JINR) in Dubna. It has completely confirmed our results both on the resemblance of the spectra of Λ° and $\Sigma^\pm$-hyperons and on the angular distribution of strange particles.

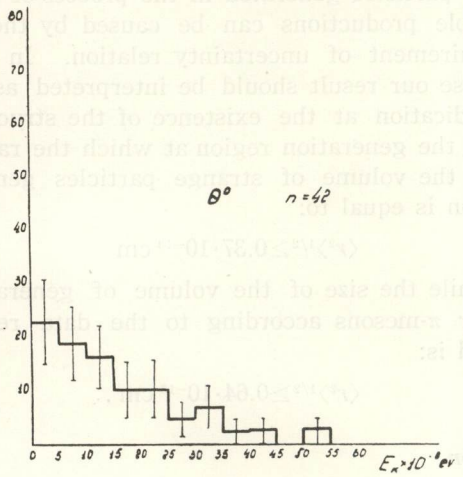

Рис. 3.

Fig. 3. Spectrum of kinetic energy of Θ° mesons.

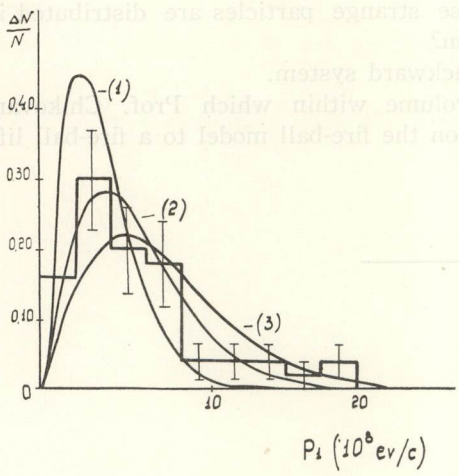

Fig. 4. Distribution of strange particles' p_t. Curves correspond to one-dimensional variant of hydrodynamical theory for various values of critical temperature.
1—$KT=0.5m_\pi c^2$
2—$KT=1.5m_\pi c^2$
3—KT—$1.5m_\pi c^2$

2. It is known that for some past years great attention has been paid to investigations of transverse momentum distributions of particles generated in nuclear interactions. The general character of p_t-momentum of π-mesons, its independence of the generating particle energy and of properties of the terget's nucleus as well as its narrow distribution near the mean value p_t-300 Mev/c have been well determined.

But so far the results of the measurements of transverse momentum of non-π-meson nature particles disagree seriously with each other. These disagreements may have some physical grounds.

By the time we started our investigation of transverse momentum distribution for strange particles, the only available data were the indirect measurements by Takibaev and Edwards for nucleons that indicated at the wide distribution of their p_t, extending to several Bev/c.

In our work we have shown that within our statistical possibilities p_t spectra of Λ°, $\Sigma^\pm$ and θ° particles do not differ. This spectra repeats in general features the forms of p_t-distribution of π-mesons.

Fig. 4 is shown the p_t-distribution for all strange particles. The mean value of p_t is equal to 0.53 ± 0.06 Bev/c.

And finally, thanks to the peculiarities of our device we have managed, in rather a simple way, to separate the cases into two according to the intervals of primay energy, one of which is two or three times larger than the other. It has been found that p_t-distribution of strange particles as well as that of π-mesons is not sensitive to the change in the energy of the generating particle in the interval from 10 till 100 Bev.

In conclusion a few words about the possible theoretical interpretation of the p_t-spectrum which we have observed.

During the last year several works were published dealing with the investigation of p_t-distribution of heavy particles.

Awunor-Renner *et al*[9] obtained the mean value $p_t=0.59$ Bev/c for 14 decays of V°-particles. The similar result $p_t=0.56$ Bev/c was

obtained by the Bartke group (CERN) for 48 $\Sigma^{\pm}$-hyperons generated by 16 Bev π-mesons in the propane chamber.

On the other hand the Dubna materials for $\pi-p$, $p-p$ and p-nuclear interactions at the energies 7-9 Bev lead to the conclusion that $P_{\perp}$ for Λ°, θ°, $\Sigma^{\pm}$ and protons is of the order 0.4 Bev/c. For a group of particles most of which are apparently protons. Hansen obtained the value $P_{\perp}=0.308$ Bev/c.

Perhaps, the differences in p_t mean values for particles other than π-mesons are caused by the physical conditions of the experiment, namely by a slight increase of $\bar{p}_t$ with the energy in the energy region of genereting particles from the threshold to 10 BeV. A similar increase can be observed for π-mesons as well.

If we assume as in the one-dimensional variant of hydrodynamic theory, that the existence of p_t spectra is accounted for by thermal motion of the elements of liquid, then the p_t spectrum of the mixture of the particles observed by us determines the temperature of separation

$$kT=\left(1.1^{+0.6}_{-0.1}\right)M_{\pi}c^2$$

This value is in good agreement with the temperature of separation for π-mesons

$$kT=\left(0.96^{+0.14}_{-0.01}\right)M_{\pi}c^2$$

which is derived from their mean p_t value. On the other hand, according to Heisenberg, the existence of the transverse momentum of particles generated in the process of multiple productions can be caused by the requirement of uncertainty relation. In this case our result should be interpreted as an indication at the existence of the structure of the generation region at which the radius of the volume of strange particles generation is equal to:

$$\langle r^2\rangle^{1/2}\geq 0.37\cdot 10^{-13}\ \text{cm}$$

while the size of the volume of generation for π-mesons according to the data reported is:

$$\langle r^2\rangle^{1/2}\geq 0.64\cdot 10^{-13}\ \text{cm}\,.$$

Discussion

Fretter, W. B.: What was the average energy of the events in which the strange particle were produced?

Chikovani, G. E.: 3.10^{10} ev$\sim 8.10^{10}$ ev.

Wataghin, G.: Can you tell me how these strange particles are distributed in forward and backward directions in CM system?

Chikovani: All these measured are from backward system.

McCusker, C. B. A.: I think that the volume within which Prof. Chikovani believes π-mesons to be produced corresponds on the fire-ball model to a fire-ball life time of $\sim 10^{-24}$ seconds.