The most probable mechanisms of the production of leading neutral pions

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Abstract: Over a long period of time at Tien Shan high-altitude cosmic rays station, located at the height of 3340 m above the sea level, an experiment of studying cosmic radiation hadrons in the field of energy $E \geq 10^{13}$ eV has been carried out. The experimental data were received from complex units «Hadron-9» and «Hadron-44», consisting of ionizing calorimeters, X-ray emulsion chambers and targets of carbon and iron. This work analyzes the most probable mechanisms of the production of leading π^0- mesons. It was shown that major contribution to the generation of leading neutral mesons is made by the process of non-elastic recharging of an incident pion.

Keywords: Tien Shan high-altitude cosmic rays station, ionizing calorimeters, X-ray emulsion chambers, π^0- mesons

During the generation of families of γ-rays the essential role is played by the interaction of primary pions with atomic target nuclei [1]. It has been found out that the share of energy, transferred into the neutral component - K_π^0 during the pions collisions is higher than during the interaction of nucleons. Further, experiments on accelerators show that p-p interactions unlike π^-p ones lead to practical absence of γ-rays with energy $U = \frac{E_\gamma}{E_0} \geq 0{,}2$. It is known that in the mountains the flow of hadrons consists of nucleons and pions. At the same time the share of pions takes up, by different estimates, from 30 to 50%. Thus, it may be suggested that the advent of leading π^0-mesions in the mountains, generating the family of γ-rays, occurs, mostly, in the interaction of attacking pions with atomic nuclei of the matter.

In our opinion, major mechanisms, responsible for the generation of leading π^0- mesions are non-elastic recharge and diffraction dissociation of pions [2]. This point of view on the generation of energy-prominent or leading π^0- mesions is based on the results of the experiment [3].

We have analysed 1157 interactions in the carbonic target (x~0,15 $\lambda_{вз}$) and 1209 interactions that occurred in iron target (x~0,18 $\lambda_{вз}$), recorded on complex units «Hardon-9» and « Hardon-44». The analysis results show that the share of the interactions, generating the leading neutral pions with the relative energy $U_{\pi^0} = \frac{E_{\pi^0}}{E_0}$ in collisions of hardons with nuclei, of both carbon and iron, does not depend on the primary energy and the atomic number of the target nucleus.

Experimental data on the probability of non-elastic recharge of charged pions into neutral during their interaction with carbon nuclei in the range of primary energies E = 10- 50 TeV and with the iron nuclei in the range of primary energies E = 10-70 TeV, expressed in the share of the leading π^0-mesions with different relative energies $U_{\pi 0}$ are shown in tables 1,2.

Table 1 – Relative number of π^0-mesions depending on E_0 and U_π^0 for carbon target

U_π^0	E_0, TeV		
	10-15	15-30	30-50
≥ 0,2	0,22±0,04	0,20±0,05	0,20±0,06
≥ 0,3	0,14±0,03	0,09±0,05	0,11±0,07
≥ 0,4	0,09±0,03	0,10±0,05	0,08±0,06
≥ 0,5	0,06±0,02	0,06±0,03	0,05±0,06

From the data, given in tables 1,2 it may be concluded that the share of interactions with the generation of leading π^0-mesions with different relative energies U_π^0 does not change within experiment errors with the growth of E_0 and for the meanings of $U_\pi^0 \geq 0{,}2$ is $\eta = 0{,}23 \pm 0{,}02$.

Table 2 - Relative number of π^0-mesions depending on E_0 and U_{π}^0 for iron target

U_{π}^0	E_0, TeV		
	10-15	15-30	30-50
≥ 0,2	0,22±0,04	0,23±0,04	0,25±0,05
≥ 0,3	0,17±0,03	0,17±0,03	0,14±0,04
≥ 0,4	0,13±0,03	0,10±0,03	0,13±0,04
≥ 0,5	0,07±0,03	0,13±0,04	0,08±0,04

Taking into consideration the fact that the contribution of diffraction dissociation protons and pions into the generation of leading π^0-mesions with $U_{\pi}^0 \geq$ 0,2 does not exceed 4%, and the share of interactions generating π^0 with U ≥ 0,2, recorded in our experiment, is 23% we come to the conclusion that the prevailing part of the leading π^0-mesions are logically explained by the processes of non-elastic recharge of a charged pion into a neutral one.

Basing on the above results it is possible to assess the probability of non-elastic recharge - W, giving the share of pions in the flow of hadrons in the mountains. Complying with global data worldwide, this share is 40%, and the probability of recharge $\pi^{\pm} \rightarrow \pi^0$ under relative energy U ≥ 0,2 equals W(U > 0,2) = 0,47±0,08. The found value of the probability of non-elastic recharge under the interaction with the nuclei of iron in fact coincides with the W value for the carbon target, mean probability value of the non-elastic recharge for interactions with carbon and iron target is W = 0,46 ± 0,05.

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