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CHARACTERISTICS OF NEUTRAL PION PRODUCTION PROCESS IN π^-+ Xe NUCLEAR COLLISIONS AT 3.5 GeV/c MOMENTUM

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1. INTRODUCTION

The aim of this work has been to gain insight in the physics of the pion production process in hadron-nucleus collisions; first of all, the production of the neutral pions is studied here experimentally. In order to realize it, various characteristics of neutral pion production have been obtained experimentally, we present them here. Neutral pions, if registered with an efficiency of about 100%, as it is met often in experiments with some of the heavy liquid chambers - with the xenon bubble chambers, for example, can serve as effective probes for the particle production process study in hadron-nucleus and hadron-nucleon collisions. In fact, such pions are registered simply and effectively within the total value interval of their kinetic energies, including zero MeV, through total 4π solid emission angle; the kinetic energies and emission angles can be now estimated with accuracies high enough for the problems under investigations.

We prepared the characteristics of the pion production process in dependence on how much the target-nucleus in the hadron-nucleus collision is involved; the multiplicity n_p of the nucleons emitted from the target nucleus indicates it well enough[1]. The protons emitted plentifully in hadron-nucleus collisions from the target-nucleus are with kinetic energy values from about 20 up to about 400 MeV, and are known as the g-track leaving particles, if in emulsions. The n_p-dependences of the presented characteristics are of great importance, therefore.

This work closes a series of our works[2-4] in which results on characteristics of neutral pion production in $Pi^{\pm}$ + Xe nuclear collisions at 2.34 - 9 GeV/c are presented. The data here were obtained by means of the 180 litre xenon bubble chamber[5] exposed to 3.5 GeV/c momentum negatively charged pion beam from the accelerator of the Moscow Institute of Theoretical and Experimental Physics. In this chamber, neutral pions are registered with almost 100% efficiency within kinetic energy values total interval, including 0 MeV, through 4π emission angle.

2. EXPERIMENT

The xenon bubble chamber[5], used in this experiment, is built as the rectangular parallelepiped of 104x40x43 cm^3 volume, without magnetic field.

2.1. Beam and Exposure

The chamber was exposed to negatively charged pion beam of 3.5 GeV/c momentum. During the exposure time no more than five pions were introduced into the chamber, along its length perpendicularly to the front wall. The beam pion courses were parallel, widely spreaded within a distance limits of a few centimeters from the chamber axis. Such exposure conditions were of great convenience in studying the pion-xenon nucleus collision events, as we shall see later.

2.2. Scanning and Measurements

The photographs of the chamber were carefully scanned and rescanned for the pion-xenon nucleus collision events which could occur in a chosen parallelepipedal region of nearly 42x10x10 cm^3 volume situated coaxially and centered inside the chamber.

Any sharp change in the straight line track of any beam pion was considered as an indication that this pion undergoes the collision with the xenon nucleus. The end or deflection point of any beam pion track we accepted to be the pion-xenon nucleus collision location. In fact we were able to detect the collision events in which the beam pion track ends off or deflects at an angle of no less than 2 degrees, in accompaniment or not by any number of tracks outgoing from the interaction place.

The secondary neutral pions of any kinetic energy, including zero, are recorded and identified in our chamber by the simply visible tracks of the negaton-positon conversion pairs and by the observed electron-photon showers created by the gamma quanta appearing in the neutral pion decay process. The minimum energy value of the gamma quanta detected with the constant efficiency amounts nearly 5 MeV. The positive pions stopped within the chamber are identified simply by the characteristic track sequence left by the charged secondaries emerged in the decay process. We meet some difficulties in attempts to identify the negative pions stopping inside the chamber, namely - to distinct them from the stopping protons.

But, we estimate, as we shall see later, the content of the stopping pion tracks in the sample of tracks accepted as being left by the stopping protons. Stopping kaons are identified without difficulties as well. Similarly, we can identify hyperons if they decay inside the chamber. The neutrons which are emitted in the collision process interact with the xenon nuclei frequently, leaving characteristic "neutral stars".

Tracks of the lengths larger than nearly 5 mm are visible well and detectable with the constant efficiency which is close to 100%. To this minimum length there corresponds the minimum kinetic energy of the registered protons of nearly 20 MeV and of the registered charged pions of nearly 10 MeV. The tracks of smaller lengths are visible as well, but in this case the detection efficiency is not constant. The protons of energies from nearly 20 up to nearly 200 MeV, the secondary pions: the negatively charged of kinetic energy from nearly 10 up to nearly 100 MeV, positively charged of kinetic energy from 0 up to nearly 100 MeV, and the neutral pions of any kinetic energy, including 0 MeV, are recorded with the efficiency being near to 100% within the total 4π solid angle. The kinetic energy of protons emitted within the 60 degrees and stopping inside the chamber is no more than nearly 350 MeV.

The scanning efficiency for all pion-xenon nucleus collisions registered in our experiment was better than 99.5%. In nearly 6% of the events the tracks of stopped negatively charged pions were indistinguishable from those of the proton tracks; it amounts roughly 2% of all the proton tracks. This estimation follows from the analysis based on the experimental data from the studies of nuclear collisions in nuclear emulsions exposed to the negative pion beam/6/. The contamination of the sample of all the tracks considered to be left by protons with the tracks of deuterons, tritons, and alpha particles was estimated to be no larger than 10%. But, in the majority of cases, the tracks of such heavy particles are shorter than 5 mm; in this experiment we analyse the particles which leave tracks longer than 5 mm.

The accuracy of the proton energy measurement, using the range-energy relation, is 10% for the protons of 15 MeV kinetic energy and 1% for those of 200 MeV kinetic energy/7/. The proton emission angles were measured with an accuracy of 1 - 8 degrees. In most cases the average accuracy of the proton energy measurement is roughly 4 % and that of the emission angle estimation is nearly 3 degrees. The accuracy of the neutral pion energy estimation/8/ amounts nearly 12%, in average. The accuracy of the pion emission angle estimation, for the charged and neutral pions, is about 1 degree.

We have estimated that over 90% of all emitted protons are stopping inside the chamber.

Thus, the sample of all secondaries may be classified into following groups of particles: a) Charged secondaries stopping inside the chamber withowt interaction or decay; we consider them to be protons. b) Charged secondaries interacting within the chamber or having left it; we accept them to be charged pions. c) Positive pions stopping inside the chamber. d) Neutral pions or eta particles decaying into gamma quanta, converting inside the chamber for simply observed negaton-positon pairs or initiating well visible electron-photon showers.

The particles from the groups a) - c) form the class of the charged secondaries the multiplicity of which we denote by N_{ch}. However, we should note that among the particles in the group a) there are (1 - 2)% admixture of the negatively charged pions and nearly 10% admixture of the heavier particles[9,10]. Similarly, in the group b) an admixture of nearly (10 - 20)% of protons may be found.

A sample of 6301 pion-xenon nucleus collision events with any number of secondaries were selected in scanning of about 80000 chamber photographs.

3. EXPERIMENTAL DATA

The sample of 6301 pion-xenon nucleus collision events with any number of secondaries forms experimental basis of this work.

The distribution, fig.1, of the multiplicities n_γ of the gamma-quanta which the Pi$^-$+ Xe nuclear collisions are accompanied by indicated that the gammas are ejected in even numbers $n_\gamma = 0,2,4,6,...$ predominantly; the distribution here is prepared without any corrections for the gamma-quanta registration efficiency. The distribution of the values $m_{\gamma\gamma}$ of the effective masses, fig.2, shows that the sources of the gammas are neutral pions, with a very small admixture[11] of the eta zero particles decaying into pairs of gamma-quanta, less than about 5%. The effective mass is defined as

$$m^2_{\gamma_i\gamma_j} = 2E_{\gamma_i}E_{\gamma_j}(1 - \cos\Theta_{\gamma_i\gamma_j}), \qquad (1)$$

where E_{γ_i}, E_{γ_j} are energies of an i-th and a j-th two gamma quanta, $i \neq j$; $\Theta_{\gamma_i\gamma_j}$ is the angle between the emission directions of the gammas.

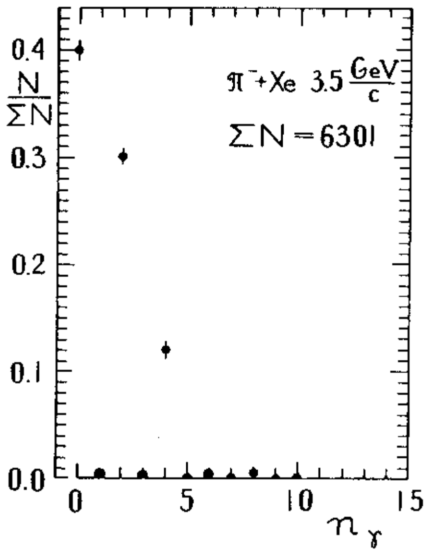


Fig.1. The distribution N/ΣN of the multiplicity n_γ of gamma quanta which the Pi+Xe collisions at 3.5 GeV/c are accompanied by, not any corrections for the quanta registration efficiency were involved.

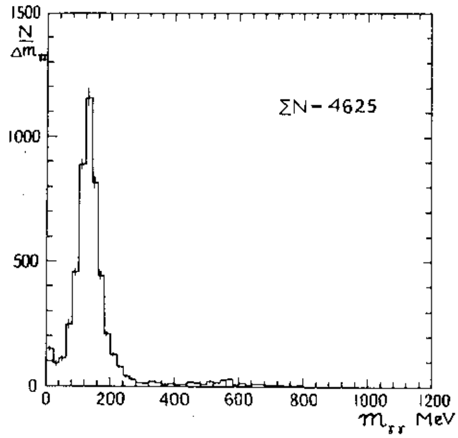


Fig.2. The distribution of the values $m_{\gamma\gamma}$ of the effective masses, Eq.1, from pairs of gamma quanta ejected in Pi+Xe nuclear collisions at 3.5 GeV/c.

In the experiment, 3584 neutral pions were registered; 2873 were emitted into forward hemisphere; 711, into the backward one. The number of the registered neutral pions amounts almost 1/3 of the total number of all the pions registered - of the positively and negatively charged, and of the neutral ones together.

The number of protons emitted in the total sample of events collected in the scanning is 18351 what makes, in average, $< n_p > = 2.94$ protons per collision event.

Below, the multiplicity n_{π^0}, or Pi0 production intensity distributions, kinetic energy $E_{k\pi^0}$ and momentum P_{π^0} spectra, and angular distributions of the neutral pions are presented. Additionally, information about production characteristics of charged pions produced in the collision events is given.

3.1. Production Intensity of the Neutral Pions

The histogram describing the production intensity n_{π^0} distribution of the neutral pions, $N(n_{\pi^0})/\Sigma N$, is shown in fig.3.

The mean value of the multiplicity, or intensity, $< n_{\pi^0} > = 0.92$, for the total sample of events under study, but

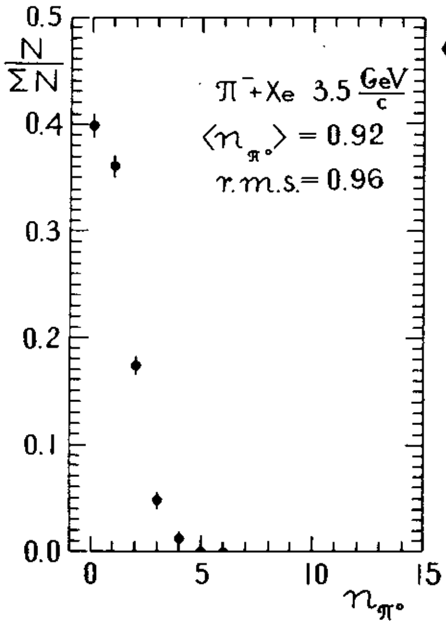


Fig.3. Neutral pion multiplicity n_{π^0}, or production intensity distribution $N/\Sigma N$ in Pi+Xe nuclear collisions at 3.5 GeV/c.

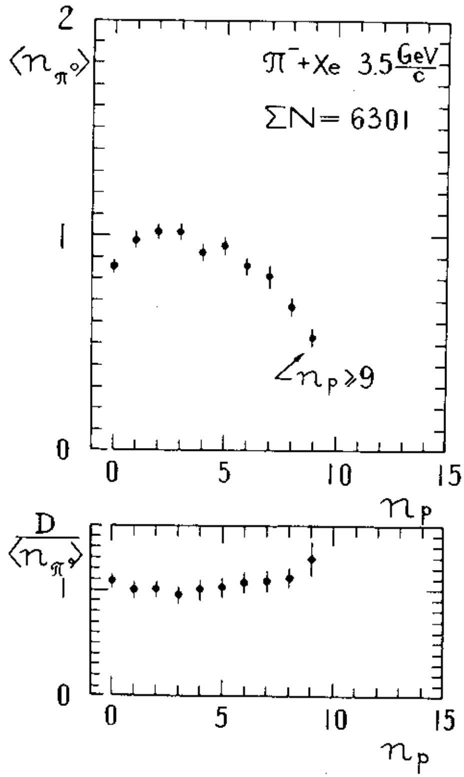


Fig.4. The proton multiplicity n_p dependence of the mean multiplicity $< n_{\pi^0} >$ of the produced pions, in the classes of events with $n_p = 0,1,2,\ldots$; $D/ < n_{\pi^0} >$ - the normalized dispersion in dependence on n_p.

$< n_{\pi^0} >$, depends on the intensity, or multiplicity, n_p, of the emitted protons, fig.4. Firstly, it grows with increasing of n_p from $< n_{\pi^0} > \approx 0.8$ at $n_p = 0$ to $< n_{\pi^0} > \approx 1$ at n_p values region 1 ÷ 3, and then is falling down up to $< n_{\pi^0} > \approx 0.5$ at $n_p \geqq 9$. It is not excluded that the lower value of $< n_{\pi^0} >$ at $n_p = 4$ is of a physical meaning - because of the regularity in the configuration of the experimental points - and it should be discussed in some of future works; may be, it indicates directly on the incident hadron mean free path in intranuclear matter.

About 20% of produced pions are ejected into backward hemisphere.

3.2. Kinetic Energies and Momenta of the Neutral Pions

The mean kinetic energy of the produced neutral pions is $< E_{k\pi^0} > = 332 \pm 10$ MeV; The mean energy value for pions directed into forward hemisphere is $< E_{k\pi^0} > = 387 \pm 12$ MeV and that for the pions into the backward is $< E_{k\pi^0 B} > = 116 \pm 7$ MeV.

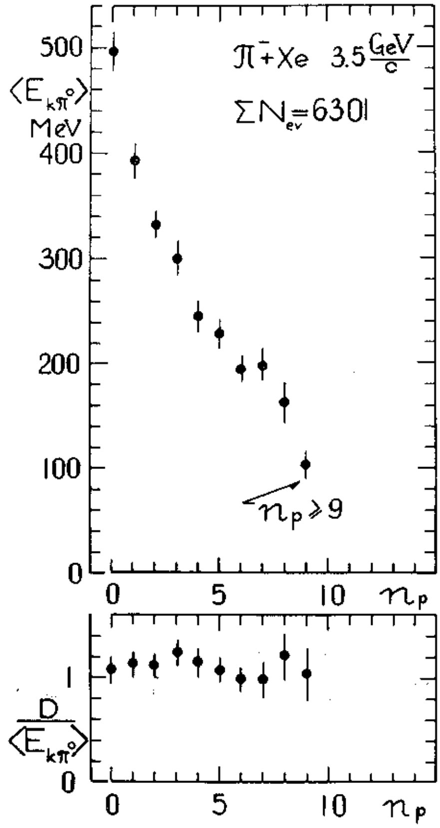


Fig.5. Mean kinetic energy $< E_{k\pi^0} >$ of the produced pions in dependence on the intensity n_p of the emitted protons, in the classes of pion-xenon nuclear collisions with various numbers $n_p = 0,1,\ldots$ at 3.5 GeV/c; $D/< E_{k\pi^0} >$ corresponding normalized dispersion.

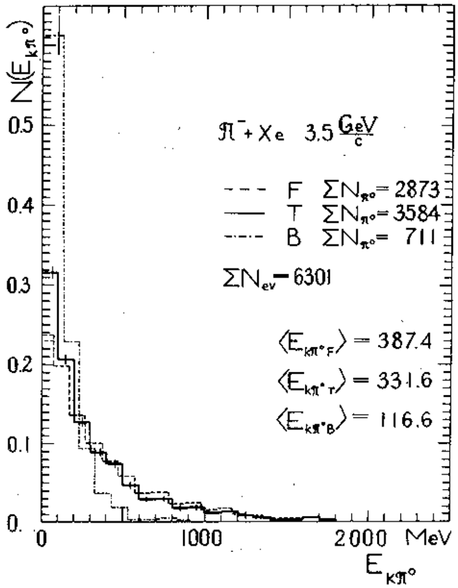


Fig.6. Energy $E_{k\pi^0}$ spectra $N(E_{k\pi^0})$ of neutral pions in three classes of pions: T - in the total sample of pions, F - in the sample of pions ejected into forward hemisphere, B - in the sample of pions ejected into backward hemisphere. ΣN_{ev} - total number of pion-xenon nuclear collisions events at 3.5 GeV/c; ΣN_{π^0} - total number of pions in the samples T,F,B.

The value of $< E_{k\pi^0} >$ depends on the number n_N of the nucleons emitted in the collision from the target nucleus, and of the number n_p of the emitted protons only; it decreases with n_p increase, fig.5.

The spectra $N(E_{k\pi^0})$ of kinetic energies $E_{k\pi^0}$ are presented in fig.6, for various classes of events: for the total sample of neutral pions - T, for the sample of pions emitted into forward hemisphere - F, for the sample of pions emitted into backward hemisphere - B. Fig.7 presents energy spectra of neutral pions in the classes of collisions with numbers $n_p = 0,1,2,..., \geq 9$ of the emitted protons.

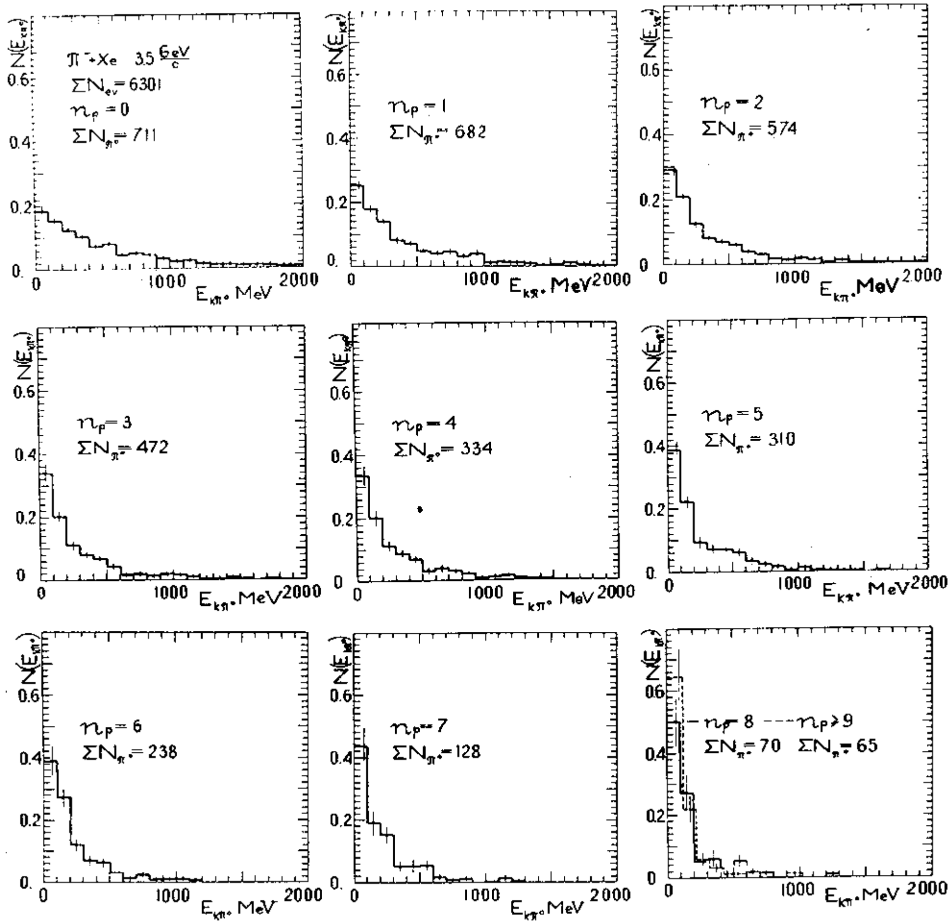


Fig.7. Energy $E_{k\pi^0}$ spectrum of neutral pions produced in pion-xenon nuclear collisions at 3.5 GeV/c, in events with $n_p = 0,1,..., \geq 9$ emitted protons; ΣN_{π^0} - number of pions in a histogram.

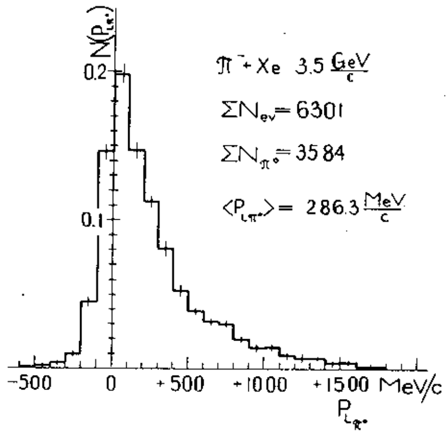


Fig.8. Longitudinal momentum $P_{L\pi^0}$ distribution $N(P_{L\pi^0})$ in pion-xenon nuclear collisions at 3.5 GeV/c. ΣN_{ev}, ΣN_{π^0} - total numbers of collision events and of the produced pions correspondingly.

The longitudinal component values $P_{L\pi^0}$ of the produced neutral pions momenta are from about -600 MeV/c up to about +1800 MeV/c, fig.8. The mean value $< P_{L\pi^0} > = 286 \pm 8$ MeV/c. Mean value $< P_{L\pi^0} >$ depends on the multiplicity n_p of the emitted protons and decreases from $< P_{L\pi^0} > = 465$ MeV/c up to $< P_{L\pi^0} > = 90$ MeV/c with n_p increase from $n_p = 0$ up to $n_p = 8$, fig.9. The longitudinal momentum distribution in the classes of collision events with various numbers $n_p = 0,1,2,\ldots,8, \geq 9$ of protons emitted from the target nucleus are shown in fig.10.

The transverse momentum $P_{T\pi^0}$ spectrum $N(P_{T\pi^0})$ of the neutral pions is shown in fig.11. The values of $P_{T\pi^0}$ are within

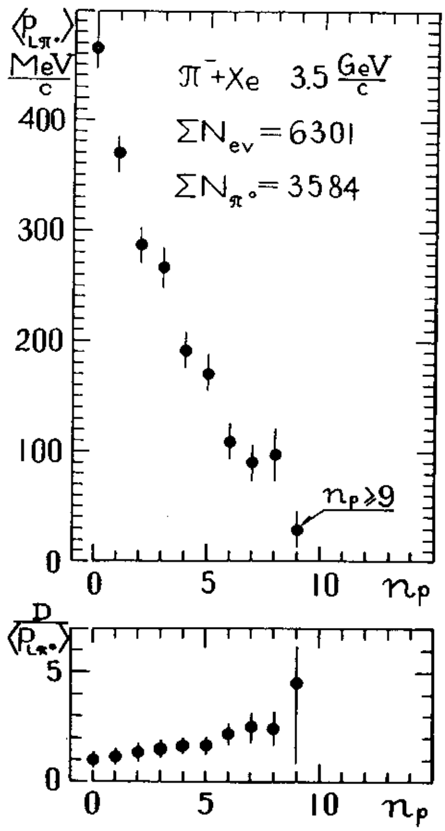
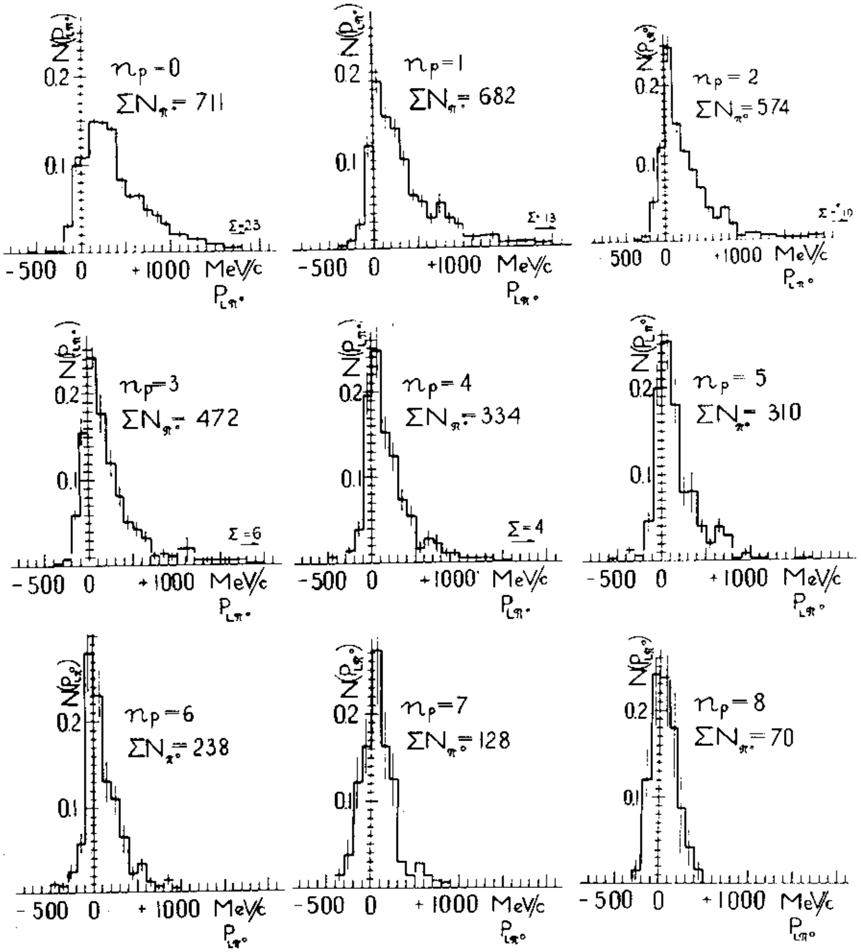
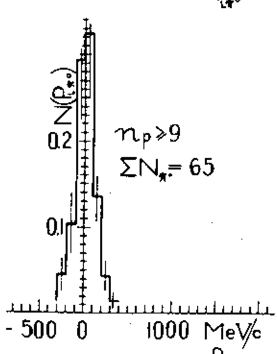


Fig.9. Longitudinal momentum of the produced neutral pions mean values $<P_{L\pi^0}>$ in dependence on the multiplicity n_p of the protons emitted in the pion-xenon nuclear collisions at 3.5 GeV/c; $D/< P_{L\pi^0}>$ normalized dispersions. ΣN_{ev} and ΣN_{π^0} - the numbers of the collision events and the numbers of the produced pions correspondingly.





3.5 GeV/c

$\pi^- + Xe \longrightarrow n_{\pi} + n_p + f$

$n_{\pi} \geq 0$ $\qquad n_p = 0, 1, 2, \ldots, 8, \geq 9$

$N_{ev} = 6301$

Fig.10. Longitudinal momentum $P_{L\pi^0}$ distribution $N(P_{L\pi^0})$ for the neutral pions produced in pion-xenon nuclear collisions at 3.5 GeV/c, in the classes of events with various numbers $n_p = 0,1\ldots\ldots,8, \geq 9$ of the emitted protons. ΣN_{π^0} - number of pions in a histogram, ΣN_{ev} - total number of collision events.

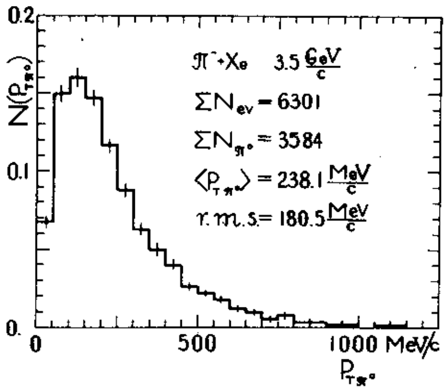


Fig.11. Transverse momentum $P_{T\pi^0}$ spectrum $N(P_{T\pi^0})$ of neutral pions produced in pion-xenon nuclear collisions at 3.5 GeV/c; symbols are as in other figures.

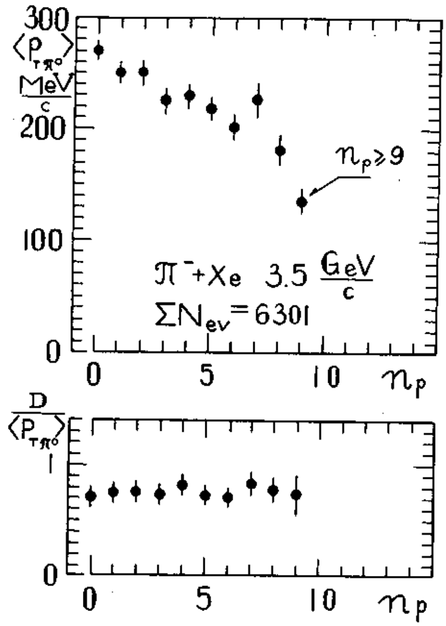
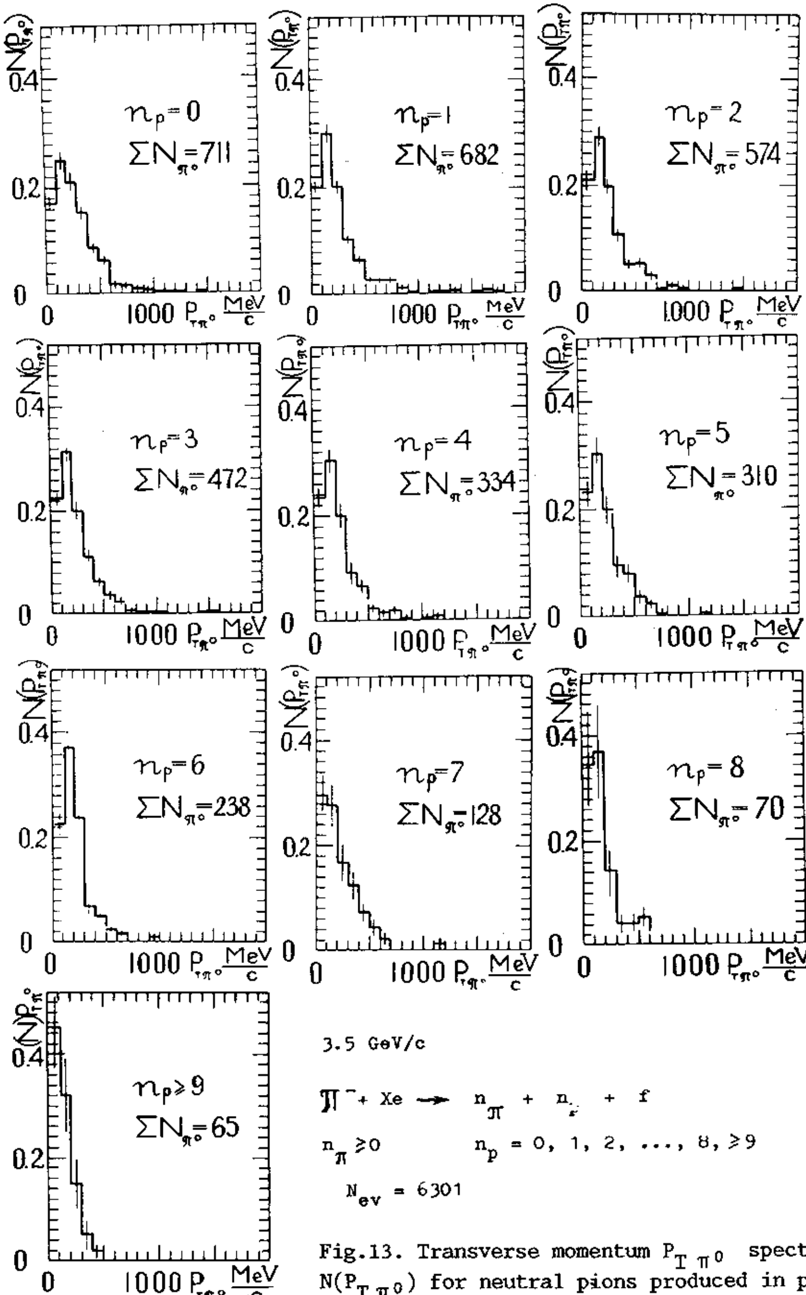


Fig.12. The n_p-dependence of the transverse momentum mean values $\langle P_{T\pi^0} \rangle$ for neutral pions ejected in pion-xenon nuclear collision reactions at 3.5 GeV/c, in classes of events with numbers n_p = = 0,1,..., ≧ 9 emitted protons; $D/\langle P_{T\pi^0} \rangle$ - normalized dispersion.

0 and 1300 MeV/c, with a maximum at about 200÷300 MeV/c; the mean value $\langle P_{T\pi^0} \rangle$ = 238 ± 10 MeV/c. The mean $\langle P_{T\pi^0} \rangle$ depends evidently on the number n_p of the protons emitted from the target nucleus in a sample of the pion-xenon nucleus collisions. For the collisions at 3.5 GeV/c, the dependence is presented in fig.12. The mean values are from $\langle P_{T\pi^0} \rangle$ = 270 ± ± 8 MeV/c at n_p = 0 up to $\langle P_{T\pi^0} \rangle$ = 170 ± 9 MeV/C at n_p = 8. Fig.13 presents the $P_{T\pi^0}$ distributions in the classes of collision events with the numbers n_p = 0,1,2,...,8, ≧ 9 of protons emitted from the target xenon nucleus.

3.3. Angular Distributions of the Neutral Pions

The mean value of the cosine of the produced neutral pion emission angle θ_{π^0} is $\langle \cos\theta_{\pi^0} \rangle$ = 0.4527 ± 0.0100; about 20% of the neutral pions are ejected into forward hemisphere.



3.5 GeV/c

$\pi^- + Xe \rightarrow n_\pi + n_p + f$

$n_\pi \geq 0$ $n_p = 0, 1, 2, \ldots, 8, \geq 9$

$N_{ev} = 6301$

Fig.13. Transverse momentum $P_{T\,\pi^0}$ spectrum $N(P_{T\,\pi^0})$ for neutral pions produced in pion-xenon nuclear reactions at 3.5 GeV/c, in classes of events with $n_p = 0, 1, \ldots, 8, \geq 9$ emitted protons. Symbols are as in previous figures.

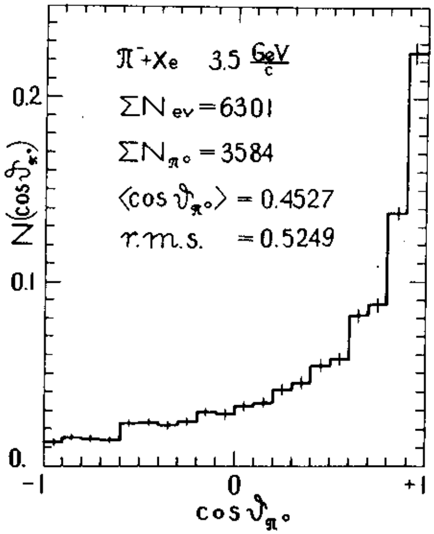


Fig.14. Angular distributions $N(\cos\theta_{\pi^0})$ of neutral pions produced in pion-xenon nuclear collisions at 3.5 GeV/c; symbols as in previous figures.

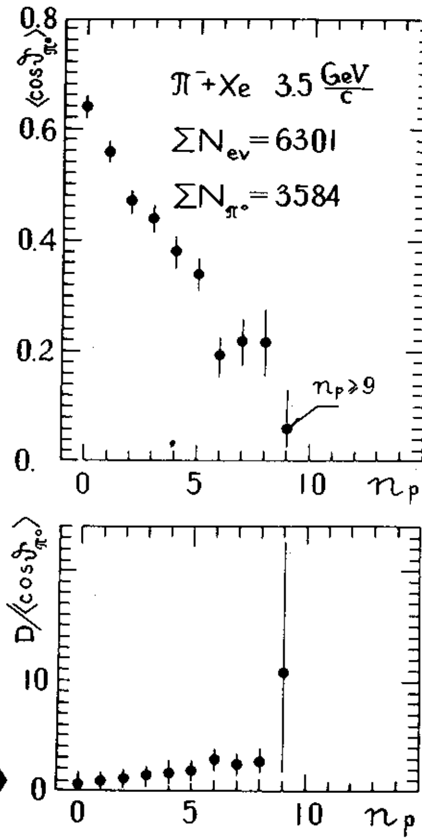


Fig.15. Proton multiplicity n_p dependence of $< \cos\theta_{\pi^0} >$ for neutral pions produced in pion-xenon nuclear collisions at 3.5 GeV/c, in classes of events with various numbers n_p of the emitted protons; symbols as in previous figures.

The $\cos\theta_\pi$ distribution is shown in fig.14. The mean value $< \cos\theta_{\pi^0} >$ depends on the multiplicity n_p of the protons emitted from the target nucleus, fig.15: at $n_p = 0$ $< \cos\theta_{\pi^0} > = 0.64$, at $n_p = 8$ $< \cos\theta_{\pi^0} > = 0.20$. The distribution $N(\cos\theta_{\pi^0})$ of $\cos\theta_{\pi^0}$ for the classes of events with various multiplicities $n_p = 0,1,\ldots,8$ and $n_p \geqq 0$ of the protons are shown in fig.16.

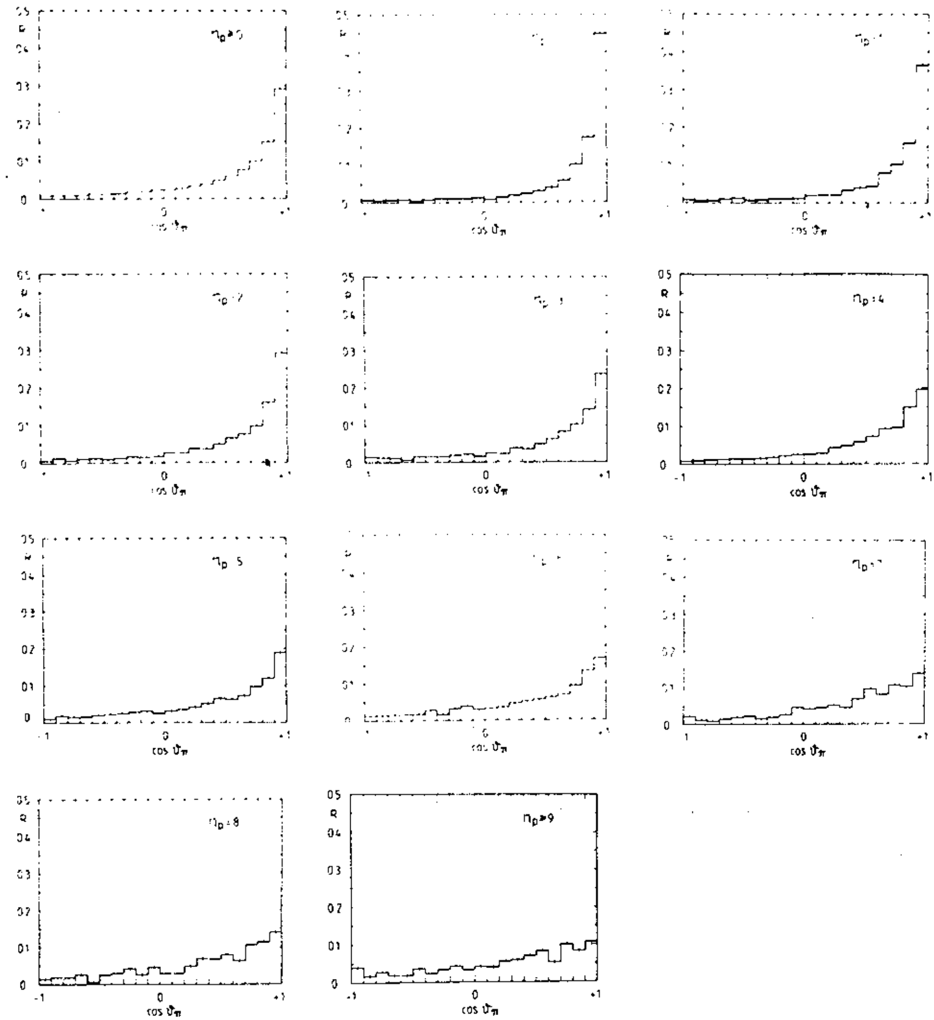


Fig.16. Angular distribution R = N(cos θ_{π^0}) for neutral pions produced in pion-xenon nuclear collisions at 3.5 GeV/c, in classes of events with various multiplicities n_p = 0,1,2,...,8, ≧ 9, ≧ 0 of the emitted protons; symbols as in previous figures.

4. THE PICTURE OF THE PION PRODUCTION PROCESS, INSPIRED BY EXPERIMENTAL DATA

The data presented in previous section 3 inspire some picture of the pion production process; neutral pion production is analysed predominantly, but it is known - from our former experiments - that main characteristics of pion production, the angular distributions and momentum spectra, are practically the same for the charged pions and for the neutral ones.

In spite of what has just been said, it is useful firstly to put together some predictions of the intranuclear cascade model[2,9], frequently in use now by many physicists,for comparison with corresponding experimental data on Pi0 meson production obtained in this work, although. The characteristic of the neutral pion production intensity n_{π^0} in dependence on the number n_N of nucleons emitted from the target nucleus is the most convenient one, for such a comparison; the nucleon emission intensity n_N, or multiplicity, is the measure how thick layer of intranuclear matter is involved in a nuclear collision; instead of n_N the proton multiplicity n_p can be used[12].

Figure 17 shows evident and conclusive disagreement between the intranuclear cascade model predictions and corresponding experimental data; for the case, when Pi0 mesons are considered, nobody has performed never "corrections" of the model in order to obtain the agreement being in want. Similarly, disagreement is evident from fig.18, where experimental dependence of the mean number $< n_p >$ of protons emitted from the target nucleus on the multiplicity n_π of all produced pions - electrically charged and neutral together - is confronted with the predictions of the intranuclear cascade model[2,9]. From the facts presented above, it can be concluded that the picture of the hadron-nucleus collision process commonly used as a basis in the model[2,9] cannot be accepted as the truth.

We are sure that true picture of this process may be infered by reasoning from the experimental facts presented above, although; at least the mechanism of the hadron-nucleus collision process may be depicted qualitatively, in the light

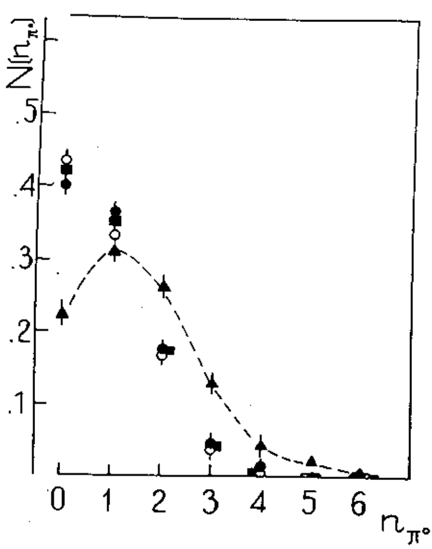


Fig.17. Neutral pion multiplicity n_{π^0} distributions in the classes of pion-xenon nuclear collision events with various multiplicities n_p of protons emitted from the targed nucleus. Experimental data: ⧫ - when $n_p \geq 0$, o - when $n_p = 0$, ▪ - when $n_p = 6$; predictions of the intranuclear cascade model ▲ are for events with $n_p \geq 0$.

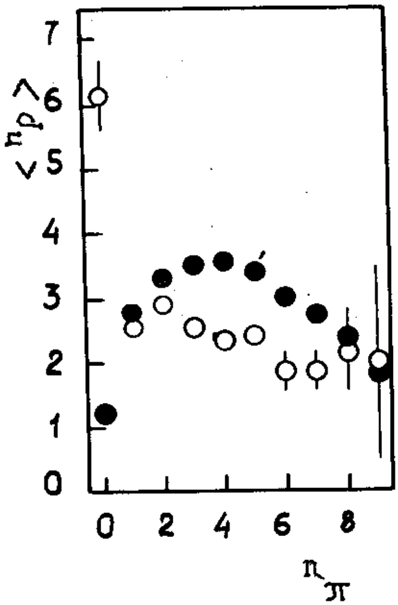


Fig.18. The dependence of the mean number $< n_p >$ of protons emitted from the target nucleus on the multiplicity $n_{\pi^{\pm}_{0}}$ of the produced pions; ● - intranuclear cascade model /2,9/, o - experimental data.

of the data. Some of the facts should attract our special attention now, first of all. Let us sum up the facts of corresponding informative value, therefore; these facts are:

1. As concerns the pion production intensity. a) The distributions of the neutral pion production intensities n_{π^0} do not depend on the intranuclear matter layer thickness involved in the collisions - on the proton emission intensity n_p, in other words; it is true within about (5÷15)% statistical error. At 3.5 GeV/c momentum in π^-+ Xe nuclear collisions there are represented the values of $0 \leqq n_{\pi^0} \leqq 6$; practically $n_{\pi^0} \geqq 5$ are in no more than 0.2% of events, $n_{\pi^0} \geqq 4$ are in 1.5%, fig.17 and the table.

Table

Neutral pion production intensity n_{π^0} in dependence on the number n_p of protons emitted from the target nucleus, in pion-xenon nucleus collision reactions at 3.5 GeV/c

n_p \ n_{π^0}	0	1	2	3	4	5	6
0	572±24	437±21	226±15	58±8	14±4	2±1	0±0
1	421±21	412±20	207±14	55±7	20±4	5±2	0±0
2	327±18	327±18	173±13	56±7	15±4	3±2	1±1
3	239±15	304±17	130±11	48±6	9±3	1±1	0±0
4	234±15	218±14	119±10	18±4	7±3	2±1	0±0
5	209±14	203±14	81±9	36±6	8±3	1±1	0±0
6	177±13	149±12	71±8	13±4	6±2	1±1	0±0
7	123±11	87±9	50±7	9±3	1±1	0±0	0±0
≥8	221±14	148±12	41±6	6±2	0±0	0±0	0±0
≥0	2523±50	2285±48	1098±33	299±17	80±8	15±3	1±1

b) The mean intensity $< n_p >$ of the protons emitted from the target nucleus is practically independent of the intensity n_{π^0} of the pion production, at $n_p > 0$, fig.18. c) The mean intensity $< n_{\pi^0}>$ of the PiO production depends on the number n_N of the nucleons, or on the number n_p of the emitted protons, fig.4; it means that $< n_{\pi^0}>$ depends on the thickness of the intranuclear matter layer ivolved in the collision. The value of $< n_{\pi^0}>$ increases firstly slowly, $0.85 \leqq n_{\pi^0} \leqq 1.05$ at n_p values from 0 up to 3, and then it is falling down, $1.05 \leqq$ $\leqq n_{\pi^0} \leqq 0.5$ at n_p values larger than 4.

From 1 a) and 1 b), it follows that the pion production takes place in nuclear collisions with any impact parameter, from nearly 0 up to nuclear radius R, and it goes with the same intensity n_{π^0} distribution, fig.17. The mean intensity $< n_p >$ of the protons emitted from the target nucleus does not depend on the number n_π of produced pions, what may indicate that the pions, as such entities, appear outside the target nucleus; probably, some intermediate object is produced firstly which moves along the incident hadron course and decays into observed pions after having left the parent nucleus. But, because $< n_{\pi^0}>$ increases firstly with n_p increase and then it is falling down with n_p increase, it may indicate that such intermediate objects may behave themselves as the incident hadron does it and can come into collisions inside the nucleus and produce new intermediate objects; some cascade of the objects develops linearly along incident hadron course. These objects may lose their kinetic energies within the nucleus, and then the mean multiplicity $< n_{\pi^0}>$ of the produced neutral pions is falling down.

2. As concerns the energy and momentum spectra of neutral pions. a) Kinetic energy of PiO, $E_{k\pi^0}$, and longitudinal momentum, $P_{L\pi^0}$, decrease with increase of the number n_p of protons emitted from the target nucleus, or with increase of the thickness of the intranuclear matter layer involved in the collision, fig.5 and fig.6. It is shown evidently in fig.7 and 10. b) Transverse momentum, $P_{T\pi^0}$, decreases with increase of the number n_p of emitted nucleons, fig.12 and 13.

Such a behaviour of the energies and momenta may indicate that, in fact, the observed neutral pions produced in the collisions are from decaying of some intermediate objects generated at first. The objects lose kinetic energies in passing through layers of intranuclear matter.

3. As it concerns angular distributions of pions produced in the collisions. a) Many neutral pions are ejected into backward hemisphere, fig.14; the larger is the thickness of the intranuclear matter layer involved in collisions the larger is the percentage of pions ejected into backward hemisphere, fig.16. The distributions presented in fig.16 should be considered in correlation with the distributions of longitudinal momenta of the pions presented in fig.10. b) The mean values of the emission angles of the neutral pions produced in the collisions increase with increase of the thickness of the intranuclear matter layer involved in the collisions, fig.15 and 16. This fact should be considered in connection with multiplicity n_{π^0} distributions at various thicknesses of the intranuclear matter layer involved in the collisions, fig.17.

The facts may indicate that the pions in fact are produced through some intermediate objects. The objects are formed in reactions of the incident hadron just after hitting the target nucleus and lose kinetic energies in passing through intranuclear matter, and decay into observed pions after having left the parent nucleus. At 3.5 GeV/c momentum of the incident pions in Pi^- + Xe nuclear collisions, these objects leave the nucleus with kinetic energy mean values near to 100 MeV only, fig.7, and with corresponding longitudinal momentum mean values near to 0 MeV/c, fig.10.

These facts, listed above, do not contradict the picture of the hadron-nucleus collision process obtained experimentally, when massive target nucleus was employed as the detector of properties of the nuclear collision processes[13-15].

Shortly, according to this picture, a hadron, when hitted a massive atomic nucleus, may undergo various reactions in intranuclear matter. In general, it can traverse the target nucleus without causing particle production; in passing through layers of intranuclear matter it loses monotonously kinetic energy - by causing emission of nucleons from the target nucleus. Sometimes, on the background of this passage, the incident hadron - for example the proton - can come into reaction with one of the downstream nucleons leading to the particle production. The particle-producing collisions are endoergic reactions of the type 2 → 2 leading to apperance of two intermediate objects; the objects are ejected predominantly colinearly with the incident hadron course and behave themselves in intranuclear matter as usual hadrons do, and decay after some time $\tau \gtrsim 10^{-23}$ s into commonly observed resonances and particles produced. Some of the objects can produce new objects, and linear cascade of the intermediate objects may develop in intranuclear matter, when incident hadron energy is high enough and the nucleus is large. The intermediate objects we called the "generons" in one of the previous works[14].

On the basis of such picture, prompted experimentally, the free-parameterless model of the hadron-nucleus collision process has been proposed[15]. THe quantitative predictions of the model are testable experimentally, and we are testing them, consequently.

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