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STUDY OF THE PARTICLE PRODUCTION PROCESS USING NUCLEAR TARGETS

I. Method, Experimental Indications, Working Hypothesis, Testing Procedure

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1. INTRODUCTION

The purpose of the present paper is to show that the particle creation in the hadron-nucleon collisions proceeds through an intermediate object decaying after some time into the commonly observed in experiments so-called "produced particles". Arguments furnished by experiments shall be put forward in witness of this statement. Massive nuclear targets have been used as detectors or indicators in studying the particle creation mechanism.

In the hadron-nucleon collisions, in particular in the hadron-proton collisions, the only directly observable data that one can obtain are that on the final state produced. Indirectly some information about what happens in the earlier stages after the collision can be obtained from a detailed study of the finally emerged particles. For example, by looking at correlations between the various particles, one can deduce if the particles are decay products of some systems, for example of resonances. This kind of analysis becomes more and more difficult as the energy of colliding hadrons and subsequent number of produced particles increases.

To obtain direct information about what happens in the early stages of the particle production process, it is necessary to interfere with the process just as it is taking place. An application of nuclear targets is the only tool available which allows the realization of such interference in experiments and the experimental study, in a direct way, of the space-time development of the particle production process.

Really, in collisions of hadrons with atomic nuclei at energies large enough for the pion production, we call them "high energies" later, to a good approximation the target-nucleus can be considered as a spherical collection of nucleons, of definite size and nucleon density distribution; such collection, existing in its natural form as atomic nucleus, we shall call "nuclear matter" later on.

The wave length of the incident high energy particle is much smaller than nuclear radii, and the characteristic times of hadronic interactions are much shorter than nuclear periods. The nuclear structure and correlations between nucleons can be ignored, therefore. Nuclear diameters D for many atoms are much larger as the hadron mean free path $<\lambda_0>$ in nuclear matter[1,2]. Atomic nuclei may be used thus conveniently for the particle production process development studies up to distances, from the collision "point", as long as the nuclear diameter $D \approx 15$ f.

The idea of using nuclei both as the targets and indicators of the properties of produced states in hadron-nucleon collisions has been discussed by many authors, for example in the works[3-14] and in works of many other authors referred to in the above. In one of my papers it has been shown how the target-nucleus may be used in experimental practice as an indicator of various properties of the hadron-nucleon and hadron-nucleus collision processes and of the particle creation mechanism in hadron-nucleon collisions[15].

This paper is arranged as follows: after the introduction in section 1, in section 2 the method of investigation of the particle creation mechanism using nuclear targets is presented; in section 3 appropriate experimental data are given; in section 4 the picture of the particle production mechanism in hadron-nucleon collisions is hypothesized; in section 5 it is proposed how this working hypothesis can be tested experimentally; the concluding section 6 contains a short project of the investigations of the particle production process which are to be described in the second part of the series of papers concerning the problem in question.

2. METHOD

Information about what happens in the early stages after a hadron collision with a nucleon in nuclear matter, resulting particle production, can be obtained from a detailed study of the finally emitted nucleons, in particular of the simply registered protons, and of produced particles observed in experiments, primarily of the copiously produced pions.

The existence of events in which incident hadron traversing the target-nucleus causes only intensive emission of "fast" nucleons, of energies from roughly 20 to 400 MeV, without particle production[16,17] furnishes experimental argumentation that both the two processes, the nucleon emission and the particle production, proceed independently one on another[18,19].

The intensity of the emitted nucleons, in collisions at incident hadron energies higher than a few GeV, in both the classes of collisions - with and without production, is proportional to the nuclear matter layer thickness λ expressed in nucleons/f^2. In particular, it has been shown[19-22] that the number n_p of emitted protons equals the number of protons contained inside the cylindrical volume $\pi \cdot D_0^2 \cdot \lambda$:

$$n_p = \pi \cdot D_0^2 \cdot \lambda \cdot \frac{Z}{A}, \tag{1}$$

where $D_0 = 1.81$ f is defined by the relation $D_0^3 \rho = 1/A$ between the nucleon density ρ nucleons/f^3 in the nucleus region where it is saturated and the mass number A of the target nucleus, for A>16 the experimental relation $A\rho = 0.168$ f^{-3} is known /1/; λ, in nucleons per f^2, is the path length of the high energy hadron in nuclear matter; Z is the atomic number of the target. The number n_p of observed emitted protons, called often the "proton multiplicity", might be applied, therefore, as a measure of the nuclear matter layer thickness, if measured in units of protons per the area πD_0^2, as we have used it already in our former work /15/.

It becomes to be evident, therefore, that in order to receive information about how the particle production process proceeds - are the many-particle-states generated directly inside the target-nucleus or the particle production goes through some intermediate objects decaying after having left the target nucleus, we should study the dependences of various characteristics of the produced particles, for example of the pions, on the nuclear matter layer thickness or, in other words, on the number n_p of emitted protons accompanying the hadron-nucleus collision process. The hadron-nucleus collisions should be studied first at such incident hadron energies at which the produced particles are widely spreaded. The generated particles should be registered with the efficiency being closed to 100% in the total interval of their kinetic energies, including zero. Such conditions exist for the neutral pion registration in large heavy liquid bubble chambers exposed to beam particles of some GeV momentum. The charged pions of energies larger than some MeV are registered in such chambers with the efficiency being roughly 100%, and practically may be considered as the secondaries fulfilling the desired conditions as well.

An experimental indication exists that this way the particle production process in hadron-nucleon collisions might be studied. In fact, the dispersions of the particle multiplicity distributions in hadron-nucleon collisions and in hadron-nucleus collisions both depend linearly and identically on the average multiplicities of produced charged particles /14,23/. It means, in my opinion, that in the hadron-nucleus collisions particles are created in quasielementary collisions of incident hadron with nucleons inside the target-nucleus.

Another way which allows one to receive information about what happens in the early stages of the production process may provide an application of the dependence of the average proton multiplicity n_p on the multiplicity of produced pions. We note that this information may be obtained in any case of the nucleon emission mechanism, because the number of emitted nucleons must obviously depend on the number of hadrons traversing the target-nucleus.

Suppose first that in hadron-nucleon collisions in nuclei the multiparticle final states are created inside target nuclei and the created particles are ejected at the angles being of values comparable with the observed in experiments. With this assumption what would be outcome of a hadron-nucleus collision? After approximately one mean free path $<\lambda_0>$ the incident hadron will interact with one of the nucleons in nuclear matter and produce hadrons, primarily pions. After another mean free path, $<\lambda'_0>\approx<\lambda_0>$, each of these produced hadrons interacts with the downstream nucleons in the target-nucleus and intranuclear hadronic cascade will develop. If the produced particles are broadly spreaded, what should take place at moderately high incident hadron energies - of a few GeV, then the multiplicity n_p of emitted protons should change with increasing the multiplicity n_π of finally emerged pions. This change can be predicted by the intranuclear cascade model/24/.

Suppose now that in the initial hadron-nucleon collisions the multiparticle final states are not produced until distances from the collision "point" much larger than nuclear sizes. The change of the average proton multiplicity n_p with the number of the pion produced may take place as well, but it should differ by much from the predicted in the case discussed above; this change can be predicted as well using formula (1), as it has been done /25/.

Clearly, the outcome of a hadron-nucleus collision in both these cases under consideration will differ by much. The particle production mechanism may be studied, therefore, effectively this way.

However, the information about what happens in the early stage after the hadron-nucleon collision will be first relatively poor. Distinction between the two a priori possible cases will be received only: a) the multiparticle final states appear indirectly inside the target-nucleus, or b) intermediate objects through which the finally observed particles are generated appear at first. The first case is of a limited interest for us, but the second one is highly interesting and of great importance, if takes place in the nature.

Suppose it is the case - from our experimental data follows that in hadron-nucleon collisions at a few GeV of the incident hadron energy intermediate objects are generated. Therefore, it is necessary firstly to look for experimental arguments that particles are produced through such states at any energy, and secondly to account for existing experimental data on the hadron-nucleus collisions in terms of our knowledge of the hadron-nucleon collisions.

The subject matter in the next sections 3 and 4 is to present how it is possible to realize this method in practice. In doing it, it should be remembered that the selection of appropriate sample of experimental hadron-nucleus data is of a principal importance. Let us start with the review of corresponding experimental facts.

3. EXPERIMENTAL DATA

In this section the collection of experimental data which can be used for the particle production mechanism elucidation is presented. It is selected from a large sample of experimental material used in many previous works /16,17,26-31/. It contains in the main the data on the neutral and electrically charged pions produced in collisions of negative charged pions with the xenon nuclei in the 180 litre xenon bubble chamber exposed to pion beam of 3.5 GeV/c momentum /27-31/. The registration and identification efficiencies of the neutral pions in this chamber correspond to the desired ones. The data furnished by the 26 litre xenon bubble chamber exposed to 2.34 GeV/c positive charged pions and to negative charged pions of 5 and 8 GeV/c momentum fulfill such conditions as well, and will be used too.

Among many various characteristics of the pion production the simplest one is the pion average multiplicity $\langle n_\pi \rangle$, in particular the neutral pion multiplicity $\langle n_{\pi^\circ} \rangle$, n_p- dependence. Let us start the presentation of the experimental data with it.

In figs. 1 and 2 the n_p-dependences of the neutral pion multiplicities are shown. In fig.1 the n_p -dependence of the produced neutral pion average multiplicity is presented, in the pion-xenon nucleus collisions at 3.5 GeV/c momentum. In fig.2 neutral pion multiplicity n_{π° distributions in the classes of pion-xenon nucleus collision events at 3.5 GeV/c momentum, with various proton multuplicities n_p, are shown.

In fig.3 the relation between the n_p -dependences of the neutral pion multiplicity n_{π° distributions and the n_p-depen-

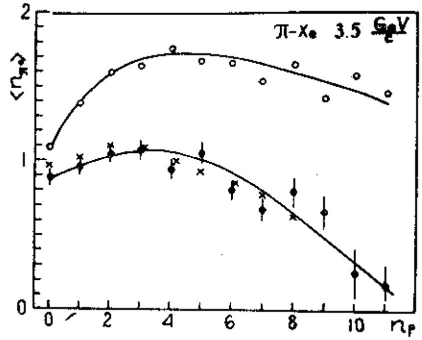

Fig.1. The n_p-dependence of the average number of produced neutral pions, $\langle n_{\pi^\circ} \rangle$, in pion-xenon collisions at 3.5 GeV/c momentum. ● - experimental data, o - predictions of the intranuclear cascade model[24], × - predictions given by our model[25] in which the particle production goes through intermediate objects. Lines are drawn to guide the eye.

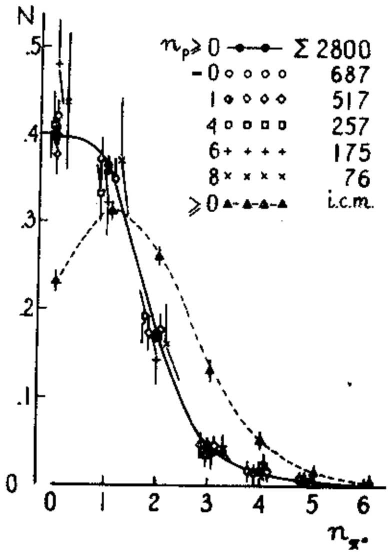

Fig.2. Neutral pion multiplicity, n_{π°, distribution in pion-xenon collision events with various proton multiplicities, n_p, at 3.5 GeV/c momentum. Solid line is drawn to guide the eye through the experimental points for $n_p = 0$; dotted line is drawn to guide the eye through the points predicted by the intranuclear cascade model[24]. In the right upper corner the numbers of events analysed in experiment are given[27].

dences of the any charge pion multiplicity n_π distributions is presented. In this fig. the ratios $\alpha = \frac{N_{\pi^\circ}}{N_\pi}$ between the numbers of produced neutral pions N_{π° and the numbers of any charge pions produced $N_\pi = N_{\pi^\circ} + N_{\pi^-} + N_{\pi^+}$ are distributed, in the classes of pion-xenon nucleus collision events with various proton multiplicities n_p, at 3.5 GeV/c momentum.

In fig.4 and 5 n_π-dependences of the emitted proton average multiplicity $\langle n_p \rangle$ are shown, in fig.4 the n_{π°-dependence of the $\langle n_p \rangle$ is shown, in fig.5 the $n_{\pi^{\pm}}$-dependence of the $\langle n_p \rangle$ is presented.

Let us analyse the above presented data in an aspect of the information about the particle production process. In

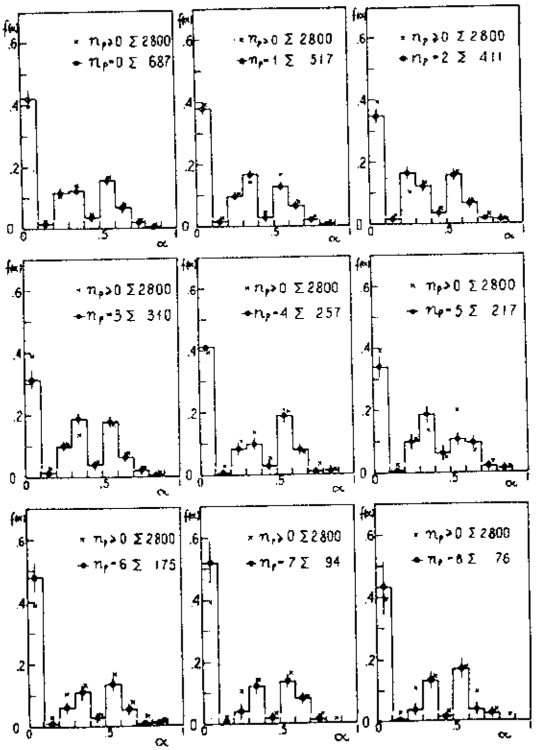

Fig.3. Distribution of the ratio $\alpha = N_{\pi^\circ} / (N_{\pi^\circ} + N_{\pi^-} + N_{\pi^+})$ between the numbers N_{π° of the neutral pion produced and the number $N_{\pi^\circ} + N_{\pi^-} + N_{\pi^+}$ of any charge pion produced, in the pion-xenon nucleus collisions at 3.5 GeV/c momentum in which various proton multiplicities n_p are observed. In the right upper corners the numbers of events with definite n_p are given /27/.

doing it the comparison of these data with corresponding predictions given by the intranuclear cascade model/24/ shall be applied. Calculations within the frames of this model, based on the programmes existing in JINR/24/ adapted to experimental conditions in the xenon bubble chamber used in experiment, have been done by W.Peryt /26/.

It follows from fig.1 that the neutral pion average multiplicity $\langle n_{\pi^\circ} \rangle$ does not increase markedly with increasing the nuclear matter layer thickness, or with increasing the proton multiplicity n_p; at n_p values from 0 to 2 the $\langle n_{\pi^\circ} \rangle$ increases from about 0.9 to about 1.05 and starts to decrease at $n_p \approx 3$. On the contrary, the neutral pion average multiplicity predicted by the intranuclear cascade model increases markedly with n_p, from $\langle n_{\pi^\circ} \rangle \approx 1.1$ at $n_p = 0$ to roughly 1.8 at $n_p \approx 5$, where it starts to decrease slowly to $n_{\pi^\circ} \approx 1.5$ at $n_p = 10$. Prediction given by the intranuclear cascade model for the neutral pion multiplicity n_{π° distribution in pion-xenon nucleus collision events with any number of emitted protons, $n_p \geq 0$, differs by

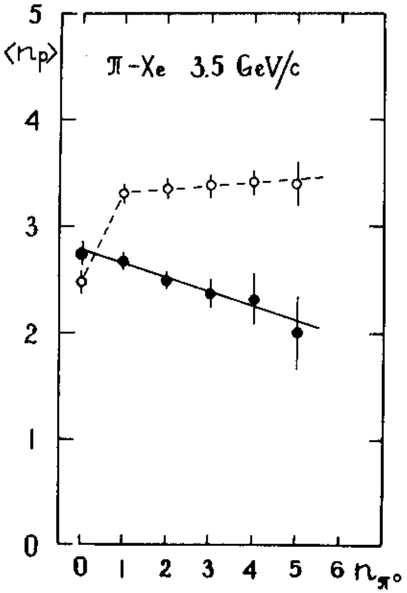

Fig.4. Emitted proton average multiplicity $\langle n_p \rangle$ in dependence on the produced neutral pion multiplicity n_{π^0}, in pion-xenon nucleus collision events at 3.5 GeV/c momentum. ● - experiment, o - predictions given by the intranuclear cascade model [24].

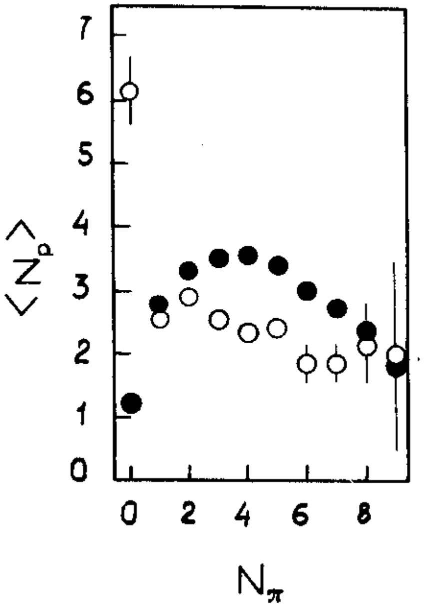

Fig.5. Emitted proton average multiplicity $\langle n_p \rangle$ n_π-dependence, in the pion-xenon nucleus collision events at 3.5 GeV/c momentum. ● - experiment [16], o - predictions given by the intranuclear cascade model [26].

much from corresponding experimental distribution, fig.2. The experimental neutral pion multiplicity, n_{π^0}, distributions in pion-xenon nucleus collision events with various numbers n_p of emitted protons do not depend on n_p, fig.2.

It can be concluded, from fig.3, that above presented, in figs.1 and 2, properties of the neutral pion multiplicity distribution n_p -dependences discovered experimentally are peculiar for all the pions, charged and neutral, as well.

It was found to be expedient, therefore, to analyse the emitted proton average multiplicity $\langle n_p \rangle$ n_{π^0}- and $n_{\pi^{\pm}_{0}}$-dependences. It is simply to see, from figs.4 and 5, that the values of $\langle n_p \rangle$ do not increase when n_{π^0} or $n_{\pi^{\pm}_{0}}$ grow. The predicted dependences are of totally different shapes.

The above presented results, fig.1-5, allow us to conclude that the intranuclear cascade model, in which the multiparticle final states produced in hadron-nucleon collisions inside the target-nucleus are supposed to be appearing inside this target-nucleus, cannot describe reasonably the experimental data.

Taking into account the experimentally discovered relations between the emitted proton multiplicities n_p and the produced pion multiplicities $n_{\pi^{\pm}_{0}}$, and the evident disagreement between the experimental results and the intranuclear cascade model predictions, we are inclined to conjecture that in the hadron-nucleon collisions, at least in the pion-nucleon collisions at a few GeV energy, the particle production goes through some intermediate object. But, it is known experimentally that at the incident hadron energy high enough, a few GeV and more, the number of finally produced particles in hadron-nucleus collisions is, in average, larger than the number of produced particles in collisions of the same hadron with the nucleon. It should be supposed, therefore, that in the hadron-nucleus collisions more than one intermediate object might be emerged as well.

The first thing to do now is see how are the created states moving inside nuclear matter. In connection with this question, let us review our experimental general information about the[16,17] pion-xenon nucleus collision events. It has been discovered that in the total sample of these collisions two classes of events might be distinguished: a) the class of events without particle production - with one or zero secondary charged or neutral pion emerged, and with any number of emitted protons; b) the class of events with particle production and with any number of emitted protons. In the class of events with one secondary pion and any number of accompanying emitted protons, i.e., without particle production when the incident pion undergoes the deflection only in passing through the target-nucleus, the pion deflection angles θ_h are no larger than about 150 degrees[32]. It enables us to suppose that the intermediate states produced in the hadron-nucleon collisions inside the target-nucleus move along the incident hadron course in nuclear matter, as being products of the almost central collisions.

But, what happens there, inside the target-nucleus, we do not know now immediately from experiment; we may put forward some conjectures only, as it currently is practiced. In particular, we do not know how are the intermediate objects behaving themselves in passing through nuclear matter, and how are a few such onjects appearing in the hadron-nucleus collision. We shall try, therefore, to put forward one of possible and mostly evident for us and adequate to existing experimental data [15-23,31,32] working hypothesis. The justification for this hypothesis depends, apart from internal consistency, on the agreement of the predictions given by some model based on it with the existing experimental data. We show later that it should be possible within frames of such a model to account for these data in terms of our knowledge of the elementary hadron-nucleon collisions and experimental information about nuclear sizes and nucleon density distribution in them.

4. WORKING HYPOTHESIS

Taking into account the total sample of the existing experimental facts [25] it is reasonable to put forward following working hypothesis: a) The particle production in hadron-nucleon collisions proceeds through intermediate objects which turn into the commonly observed "produced particles" after some time. b) Such an intermediate object produced in a hadron-nucleon collision moves in the laboratory system along the incident hadron course, approximately, if of kinetic energy larger than zero. c) When hadrons collide with atomic nuclei such objects are produced in quasielementary hadron-nucleon collisions inside the target-nuclei. d) The intermediate objects behave themselves in traversing the parent nuclei as the incident hadrons do it. e) If the nuclear matter layer thickness λ, which the intermediate object has to overcome, is large enough, $\lambda \gg \langle\lambda_0\rangle$, where $\langle\lambda_0\rangle$ is mean free path of a hadron in the nuclear matter before the intermediate object to produce, some unidimensional intranuclear cascade of the intermediate objects develops along the incident hadron course inside the target-nucleus: an intermediate object generated in the first inelastic quasielementary collision of the incident hadron with the nucleon inside the target-nucleus collides in one's turn with the next nucleon lying on its course resulting the appearance of two intermediate objects which both can produce new such objects, etc... f) In result of such cascading some number $m = 1, 2, 3, \ldots$ of intermediate objects can emerge outside the target nucleus and decay into finally observed "generated particles". g) The observable multiparticle final state that one registers in experiment when an incident hadron of energy E_h collides with the nucleus is the composition of that one could observe in average in any of the m final states when the same hadron of the average energy E_h/m collides with a free nucleon. h) The mean lifetime of the intermediate objects is long enough them to be possible to leave the parent nuclei before turning into multiparticle final state.

Our aim is to test the above formulated hypothesis and to characterize the intermediate objects using existing hadron-nucleus collision data.

5. HOW CAN BE THE WORKING HYPOTHESIS TESTED?

If our working hypothesis corresponds to the reality, simple relation between the average number $\langle n_\pi(E_h)\rangle_{hA}$ of produced pions in hadron-nucleus collisions at a hadron energy E_h and the average number $\langle n_\pi(E_h/\langle m\rangle)\rangle_{hN}$ of produced pions in collisions of the same hadron at energy $E_h/\langle m\rangle$ should take place, where $\langle m\rangle$ is the average number of intermediate objects emerged from the target-nucleus. Similarly, simple relation should exist between the normalized dispersion $Z = (\langle n^2\rangle - \langle n\rangle^2)^{1/2}/\langle n\rangle$ for the hadron-nucleus collisions at a hadron energy E_h and for the hadron-nucleon collisions at the hadron energy $E_h/\langle m\rangle$.

Let us note that the pion multiplicity distribution corresponding to any of m intermediate objects are statistically independent. For such the case simple relations exist between the average values and dispersions characterizing these statistically independent distributions and the average value and dispersion characterizing the distribution composed of the statistically independent components. Using them for the finally produced pion multiplicity distributions in the hadron-nucleus collisions, following formulas can be written:

$$\langle n_\pi(E_h)\rangle_{hA} = \langle m\rangle \cdot \langle n_\pi(E_h/\langle m\rangle)\rangle_{hN}. \tag{2}$$

$$Z_{hA}(E_h) = \frac{1}{\sqrt{\langle m\rangle}} Z_{hN}(E_h/\langle m\rangle), \tag{3}$$

where hA is for hadron-nucleus and hN for hadron-nucleon collisions.

In order to determine the average number $\langle m\rangle$ of the intermediate objects emitted when a hadron of the energy E_h collides with a given target-nucleus, let us apply following procedure. We shall consider any target-nucleus as a "slab" of nuclear matter which remains undemolished after any collision. In fact in any collision the target-nucleus is destroyed, but in any of collisions in the sample of collision events identical projectile hadron and target-nucleus are always involved. It is possible, therefore, to treate any sample of collision events as the interaction of the homogeneous monoenergetic beam of parallelly moving hadrons with a "slab" of nuclear matter.
In order to do it, let us characterize the hadron by the mean free path $\langle\lambda_0\rangle = \langle\lambda_0(E_h)\rangle$ in units of nucleons per some area S,

and the target-nucleus by its maximal thickness λ_{max}, average thickness $\langle\lambda\rangle$, and the thickness $\lambda(b)$ of nuclear matter layer at a given impact parameter b; these quantities have been defined accurately in our previous papers [2,33], it is convenient to express them in units of nucleons per the area S.

It has been shown [2] that $\langle\lambda_0(E_h)\rangle$ is determined simply by the cross-section $\sigma_{hN}(E_h)$ for hadron-nucleon collisions by the relation $\langle\lambda_0(E_h)\rangle = 1/k \cdot \sigma_{hN}(E_h)$, where $k \simeq 0.3333$. The characteristics of the target-nuclei as nuclear matter "slabs" are determined by the nuclear sizes and nucleon density distribution in nuclei; we have determined them for various nuclei [33].

We can start now to determine the number of intermediate objects which may be produced, if a hadron of energy E_h traverses the nuclear matter "slab" of a given thickness; let us consider any thickness λ. We would like to determine the distribution $P(m,t)$ of the numbers m of the intermediate objects as the function of the nuclear matter layer thickness measured in $\langle\lambda_0\rangle$, $t = \lambda/\langle\lambda_0\rangle$. We will determine, this way, the most probable and average numbers of the objects emerging, as well.

When a hadron h of the energy E_h passes through a massive target-nucleus, it may produce first intermediate object in colliding with the nucleon at any depth $t = \lambda/\langle\lambda_0\rangle$, where λ, in nucleons/S, is the hadron path length inside the target-nucleus. This depth t can vary from $t_{min} = 0/\langle\lambda_0\rangle = 0$ to $t_{max} = \lambda_{max}/\langle\lambda_0\rangle$, where t_{max} corresponds to the maximum thickness of the target-nucleus. Such t-fluctuation complicates the calculation of the $P(m,t)$ distribution. We solve, therefore, a decidedly oversimplified problem, which nevertheless serves to indicate the essential nature of the desired distribution: we suppose, namely, first intermediate object to be generated in any of collisions just at the nuclear surface on which incident hadron is falling, and this object starts to pass through nuclear matter along projectile course. The probability that in traversing thickness dt one intermediate object is converted into two is just dt. If one object enters a sheet of thickness t, what is the probability $P(m,t)$ that m objects will emerge? The distribution in question has been derived in the Furry's paper [34]. It has been established in his work that

$$P(m, t) = e^{-t} (1 - e^{-t})^{m-1}. \qquad (4)$$

The most probable number of the intermediate objects emerged is one, the mean number is:

$$\langle m\rangle = e^{t} = e^{\lambda/\langle\lambda_0\rangle} = e^{n_N/\langle\lambda_0\rangle} = e^{n_p/\langle\lambda_0\rangle}. \qquad (5)$$

In the next to last and in the last terms in expression (5) the relations $\lambda = n_N$ and $\lambda = n_p$ have been used, where n_N is the multiplicity of emitted nucleons and $n_p = \frac{Z}{A} n_N$ is the multiplicity of emitted protons; it is possible to use them firstly due to relation (1) and secondly - owing to almost constant ratio Z/A within the target nucleus [1,35], if $\langle\lambda_0\rangle$ is expressed in the number of nucleons or, correspondingly, in the number of protons per the area $S = \pi D_0^2 f^2$.

Using formulas (2) and (3) in which the quantity $\langle m\rangle$ is determined by formula (5), the produced particle, in particular the produced pion, average multiplicity and normalized dispersion n_p -dependences in hadron-nucleus collisions [36] can be determined by the produced particle average multiplicity energy-dependence and normalized dispersion in the hadron-nucleon collisions. Such information about the elementary pion-proton and proton-proton collisions is known well [37]. It has been proved, in addition, that instead of the $\langle n_\pi\rangle_{hN}$ values for elementary hadron-nucleon collisions the values $\langle n_\pi\rangle_{hA}$ from hadron-nucleus collisions with $n_p = 0$ may be used, at the same incident hadron energy. For example, using formula (2) and the quantity $\langle\lambda_0\rangle$ for the pion-xenon nucleus collisions at 3.5 GeV/c momentum, which is determined by the inelastic effective cross-section for the pion-nucleon collisions, and the information about the xenon-nucleus size and nucleon distribution in it, the produced neutral pion average multiplicity n_p -dependence has been calculated for the pion-xenon nucleus collisions at 3.5 GeV/c momentum; in calculation values $1/3 \langle n_\pi\rangle_{hN}$ instead of the $\langle n_{\pi^0}\rangle_{hN}$ for elementary hadron-nucleon collisions have been used at $E_h/\langle m\rangle$ incident hadron energy, where E_h corresponds to the 3.5 GeV/c momentum. Result is presented in fig.1.

6. CONCLUSIONS

In analysing the correlations between the multiplicities of the emitted protons and the multiplicities of the produced pions in the pion-xenon nucleus collisions at 3.5 GeV/c momentum new picture of the particle creation process in the hadron-nuclei collisions emerged. This picture has been presented already in our former papers [25]. The main property of the process is that particles are created through some intermediate objects decaying into commonly observed "produced particles" after having left the target-nuclei; these objects are produced in quasielementary hadron-nucleon collisions inside the target nuclei. It is reasonable to accept that the particle creation in elementary hadron-nucleon collisions goes through such relatively long-lived intermediate objects as well.

Because this property of the particle production process has been discovered at one definite incident hadron energy, in collisions of the pions with one definite target nucleus, the picture of the particle creation process in hadron-nucleon collisions prompted by experiment we will treate as the working hypothesis which should be tested: a) on the basis of the existing hadron-nucleus experimental data at energy interval as wide as it is possible now, when various target nuclei are used; b) on the basis of the existing experimental data on particle-nucleon collisions at various possible incident particle energies. We expect that many properties of the intermediate objects shall be discovered this way as well.

We would like to know whether these objects are some new kind of microobjects through which all the well known particles and resonances are produced in general. Maybe we have to do with a new class of microobjects or particles being some kind of excited nucleon of excited hadronic matter or, in general, of excited matter. Such objects generate the observed "produced particles".

In the second part of the series of papers we limit ourselves to the working hypothesis testing using mainly the existing hadron-nucleus collision data at various incident hadron energy. In doing it we will describe general properties of the intermediate object.

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