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Z.Strugalski

HADRON-NUCLEUS COLLISIONS.
II. NUCLEON EMISSION, AVERAGE PARTICLE MULTIPLICATION

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1. INTRODUCTION

The purpose of the present paper is to consider the nucleon emission and particle production processes accompanying high energy hadron-nucleus collisions.

The picture of a hadron-nucleus collision observed in experiments, in bubble chamber experiments for example, reflects the end stage of the collision process; tracks of emitted nucleons, in particular of the simply registered protons, tracks of generated particles and of the products of their decays are observed as a rule. This stage we call, as usually is practiced, the asymptotic state. The only data one can obtain in experiment are those on the asymptotic state produced. Some information about what happens in the early stages of the collision can be obtained indirectly, from a study of the data on this state. Data are usually given as various characteristics: multiplicity distributions, angular distributions, and energy spectra of various products, and many possible relations between these distributions and spectra.

In this article we try to derive formulas which are to be reproducing characteristics observed experimentally, show how are the characteristics determined by nuclear sizes and nucleon density distributions in nuclei, suggest how it is possible to account for corresponding experimental data in terms of our present knowledge of hadron-nucleon interaction.

We start this article, being the second part in the series of papers devoted to the hadron-nucleus collisions, with the classification of various characteristics.

2. MAIN GROUPS OF CHARACTERISTICS

Among a large variety of characteristics of hadron-nucleus collisions four main groups might be distinguished: a) The characteristics of emitted nucleons; b) The characteristics of the average multiplication of particles inside target nuclei; c) The characteristics of the created particles; c) The characteristics of the target-nucleus fragments.

Usually, in many works performed by means of the photonuclear emulsions /1/, to the first group belong characteristics of the so-called slow particles, distinguished as forming the "grey" tracks; to the third group belong characteristics of the so-called "shower" particles, distinguished as leaving "shower" tracks; to the fourth group belong characteristics of the target-nucleus fragments forming the so-called "black" tracks. This terminology has been used in investigations performed lately by means of the electronic arrangement [2]. In the bubble chamber experiments the emitted protons, generated pions, and ejected nuclear fragments can be identified; the proton tracks correspond roughly to the "grey", the pion tracks to the "shower", and the track leaved by nuclear fragments to the "black".

The subject matter in this paper has been restricted to the three first groups of characteristics.

3. NUCLEON EMISSION

An information about the nucleons emitted we have usually from the data on the emitted protons only, they are registered well and simply identified in experiments. In our experiments [3-6] these protons correspond to the so-called "fast protons", of energies from nearly 20 to 400 MeV; in other experiments [2,7,8] the particles leaving the so-called "grey" tracks are considered to be protons.

In this section characteristics of the "fast protons" will be discussed.

3.1. Nucleon Multiplicity Distribution

The most often discussed characteristic of the high energy hadron-nucleus collisions is the frequency $f(n_N, A, E_h)$ of events with definite number n_N of nucleons, when hadrons of energy E_h collide with atomic nuclei of the mass number A. In experiments the frequency $f(n_p, A, E_h)$ of events with definite number n_p of emitted protons is usually studied instead of $f(n_N, A, E_h)$; neutrons cannot be registered. The number n_N is called the nucleon multiplicity and, correspondingly, n_p is called the proton multiplicity. The formula for the frequency $f(n_p, A, E_h)$ has been derived in our former works, the frequencies given by it are comparable with the experimental ones [9-14].

The derivation is based on the information about the nucleon emission taken from experiment. The physical meaning of the formula, discussion about approximation involved, and its application limitations are given in our former papers [12-14]; it was not found necessary to repeat them here. We limit ourselves to the presentation of the most important results.

In result of our most accurate investigations of the function $f(n_p, A, E_h)$, described in our former papers [10,12-14], it has been shown [10,13] that it might be expressed for any target-nucleus by the formula [13,14]:

$$f(n_p,A,E_h) = W_0(n_p,A)\, e^{-\frac{\lambda(n_p)}{\langle\lambda_0\rangle_{el}}} + \sum_{i=0}^{i=n_p-1} w_{in_p} W_0(i,A)\left(1-e^{-\frac{\lambda(i)}{\langle\lambda_0\rangle_{el}}}\right) + O(n_p), \quad (1)$$

where $W_0(n_p,A)$ is the probability for a hadron collision with the target-nucleus of a mass number A in result of which n_p protons could be met by this hadron in its passing through the target-nucleus along initial course, it is expressed by the formula (3) in part I; $\lambda(n_p)$ is the hadron path inside the target-nucleus corresponding to these n_p protons; $\langle\lambda_0\rangle_{el} = \langle\lambda_0(E_h)\rangle_{el}$ is mean free path for such hadron-nucleon elastic collision inside the target-nucleus in result of which a recoil nucleon appears of kinetic energy large enough this nucleon to be able to cause monotonous nucleon emission [12,13] as the projectile-hadron does it; w_{in_p} are coefficients indicating the transition intensity of events which could be belonging to those with the proton multiplicity $i < n_p$ to those with the proton multiplicity n_p; the term $O(n_p)$ expresses the approximation involved.

The first term in the formula (1) reproduces the proton multiplicity distribution $f(n_p, A, E_h)$ in such hadron-nucleus collision events in which the pure monotonous nucleon emission [10,12,13] takes place only [10,13]; the second term, describing the content of events in which recoil nucleons causing monotonous nucleon emission are present, has been expressed in former papers [10,13] in various approximate manners.

In practice, a simplified formula, containing the first term only, describes well the proton multiplicity distribution in the case when n_p are no larger than 5, as it has been shown [12-14]. Explicitly, this simplified formula is:

$$f_1(n_p, A, E_h) = W_0(n_p, A, E_h)\, e^{-\frac{\lambda(n_p)}{\langle\lambda_0\rangle_{el}}} \quad . \quad (1')$$

Taking into account the particle creation mechanism, hypothesized in part I, it might be stated that this formula (1) should be valid for the total sample of collision events, both for those with particle creation and those without it. In particular, the formula (1′) should describe the sample of events with small proton multiplicities, $n_p \leqslant 5$. It has been shown that it is the case [12-14].

The comparison of the distributions given by formulas (1) and (1´) with appropriate experimental data, on pion-nucleus collisions registered in the xenon bubble chamber exposed to the negative pion beam of 3.5 GeV/c momentum /4,6/ and on pion- and proton-nucleus collisions at 3.6, 200, 400 GeV/c registered in photographic nuclear emulsions /15–17/, shows that these formulas describe satisfactorily the distributions observed in experiments /12–14/.

There are arguments /6/ that pure monotonous nucleon emission /12/ takes place in hadron-nucleus collisions without particle creation when the projectile hadrons are deflected through the angles $\theta_h \le 30°$. In fig.1 the proton multiplicity distribution in such events observed in the xenon bubble chamber, exposed to negative pion beam of 3.5 GeV/c momentum, is presented /6/; because the events in which $n_p=0$ are registered with the efficiency much smaller than 100%, the events with $n_p \ge 1$ are analysed only in preparing this distribution. For comparison, corresponding distribution $f_1(n_p, Xe, 3.5)$ calculated by using the formula (1´) is superimposed in this figure. In calculating, the value of the mean free path $\langle\lambda_0\rangle_{el}$ has been estimated from the relation $W_0(1,Xe)\, e^{-\lambda(1)/\langle\lambda_0\rangle_{el}} : W_0(2,Xe)\, e^{-\lambda(2)/\langle\lambda_0\rangle_{el}} = N(1)/N(2)$, where N(1) and N(2) are the numbers of events at $n_p=1$ and $n_p=2$ correspondingly. $W_0(n_p,Xe)$ are determined by nuclear size and nucleon density distribution in target-nucleus; the so-called Fermi distribution has been used /18,19/.

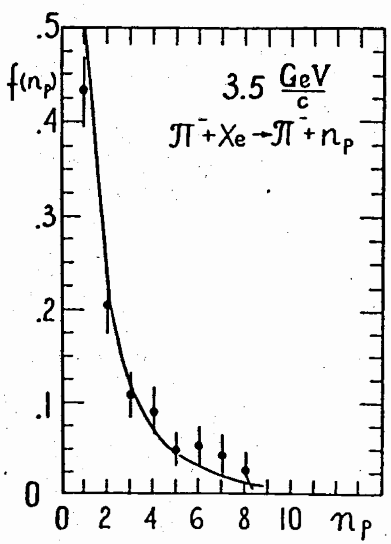

Fig.1. Proton multiplicity distribution in pion-xenon nucleus collision events without particle creation, at 3.5 GeV/c momentum, in which the projectile pions deflect through the deflection angle $\theta_h \le 30°$ /6/. Solid curve is given by formula (1´); normalization to the total number of events with $n_p \ge 1$.

3.2. A-Dependence of the Nucleon Multiplicity Distribution

The expressions (1) and (1´) give the proton multiplicity distributions of hadron-nucleus collisions with definite target-nucleus, of a given mass number A. We would like now to derive a formula which will reproduce a set of frequencies $F(n_p,A,E_h)$ for hadron collisions with targets of various mass numbers A.

Before starting this derivation, let us take into account that the impact parameter $d(n_p)$ at which n_p protons could be met by a hadron traversing a target-nucleus depends on the size of this nucleus according to the formula (1) in part I; for a given value of n_p one definite "average" value of $d(n_p)$ from the $d(n_p)^{+\Delta_2}_{-\Delta_1}$ value interval corresponds for the target-nucleus of the mass number A, fig.1 in part I; for some other target-nucleus, of the mass number A_1, corresponds other "average" value $d_1(n_p)$, from the value interval being $d_1(n_p)^{+\Delta_{12}}_{-\Delta_{11}}$, for the same proton multiplicity n_p. The ratio between the number of the hadron-A collisions and the number of the hadron-A_1 collisions with the same proton multiplicity n_p, for any n_p, can be expressed as:

$$\kappa = \frac{|d(n_p)+\Delta_2|^2 - |d(n_p)-\Delta_1|^2}{|d_1(n_p)+\Delta_{12}|^2 - |d_1(n_p)-\Delta_{11}|^2} = \frac{\Delta_2^2-\Delta_1^2+2d(n_p)|\Delta_2+\Delta_1|}{\Delta_{12}^2-\Delta_{11}^2+2d_1(n_p)|\Delta_{22}+\Delta_{11}|}. \qquad (2)$$

From the analysis of the values of the intervals Δ_1, Δ_2, Δ_{11}, Δ_{12} it follows that they might be treated as being equal one to another and the ratio κ can be expressed simpler, with an accuracy being high enough for our considerations performed here, as:

$$\kappa' = \frac{2\pi\, d(n_p)}{2\pi\, d_1(n_p)} = \frac{d(n_p)}{d_1(n_p)} \qquad (2')$$

being the ratio of the "average" values of the impact parameters. These parameters $d(n_p)$ and $d_1(n_p)$, and the intervals Δ_1, Δ_2, Δ_{11}, Δ_{12} are determined by nuclear sizes and nucleon density distributions in nuclei. We write, therefore, for the $F(n_p,A,E_h)$:

$$F(n_p,A,E_h) = \kappa\, f(n_p,A,E_h) \qquad (3)$$

or

$$F_1(n_p,A,E_h) = \kappa' f(n_p,A,E_h), \qquad (3')$$

where $f(n_p, A, E_h)$ is expressed by formula (1). We will use later on the simpler formula (3´), in order to facilitate an interpretation of the results to be under discussion.

When the formula(3) or(3´)is used for expression of the series of $f(n_p, A, E_h)$ distributions for many various mass numbers A, any of $d(n_p)$ corresponding to any mass number of the target used can be applied as the quantity $d_1(n_p)$; it is convenient to use $d_1(n_p)$ corresponding to the uranium target.

For a test how the formulas (3) and (3´) are able to describe appropriate experimental data received in the paper of Faessler et al.[2] the functions $F_1(n_p, A, E_h)$ were calculated for C , Al , Cu , Ag , and Pb targets. In calculations the values for $\langle\lambda_0\rangle_{el}$ expressed in units of protons/S were estimated using the data on the proton multiplicity distribution in pion-carbonium nucleus collisions at 40 GeV/c registered in 2 m propane bubble chamber[20]. In estimating, the relation:

$$W_0(1,C)\, e^{-\frac{\lambda(1)}{\langle\lambda_0\rangle_{el}}} : W_0(2,C)\, e^{-\frac{\lambda(2)}{\langle\lambda_0\rangle_{el}}} = N(1) : N(2)$$

has been used, where N(1) and N(2) are the numbers of events with the proton multiplicities $n_p=1$ and $n_p=2$ correspondingly. The value of $\langle\lambda_0\rangle_{el}$ received this way is $\langle\lambda_0\rangle_{in}$ = =4.68 nucleons/S, which gives for the $\langle\lambda_0\rangle_{el}$ for Pb, Ag, Cu , Al,and C the values in units of protons/S correspondingly: 1.85, 2.04, 2.12, 2.25 and 2.34. $W_0(n_p, A)$ were estimated from the data on nuclear sizes and nucleon density distributions in nuclei, as it has been presented in previous papers[13,21] and in part I of the series of present works. Result is shown in fig.2.

The distributions presented in this figure can be compared with the data given in the Faessler et al. work[2]. It should be taken into account, although, that not all events with $n_p=0$ are usually detected in experiments and appropriate correction must be performed; this correction has been realized using the relation $F(0,A)/F(1,A) = X(0)/N(1,A)$, where X(0) is the corrected number of events at $n_p=0$, N(1,A) is the number of events at $n_p=1$ registered in collisions of a hadron with a target of the mass number A.

In fig.3 calculated distributions of the proton multiplicities n_p in collisions of pions with C , Al, Cu, Ag, and Pb nuclei are compared with appropriate distributions observed in experiment[2].

It might be stated that formula (3´) gives the series of the proton multiplicity distributions corresponding qualitatively to the series received in experiment, fig.2 in this

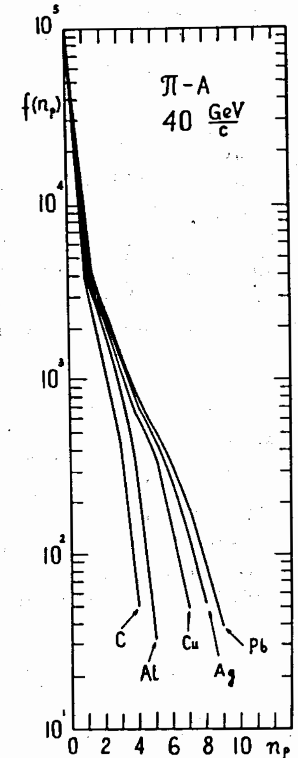

Fig.2. Proton multiplicity distributions $f(n_p)=F_1(n_p, A, E_h)$, formulas (1´) and (3´), calculated for collisions of pions with C , Al , Cu , Ag, and Pb nuclei at 40 GeV/c momentum. These distributions correspond to those presented in fig.3a of the Faessler et al. paper[2].

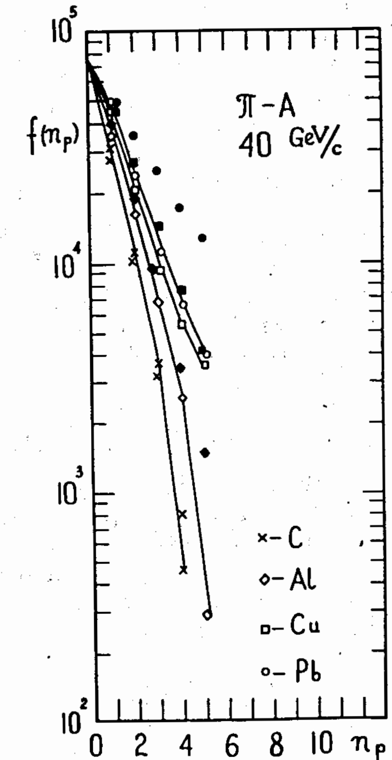

Fig.3.Proton multiplicity distributions $f(n_p)=F_1(n_p, A, E_h)$ in collisions of pions with C , Al, Cu, Pb nuclei calculated using formulas (1´) and (3´) for the projectile momentum 40 GeV/c - open figures; black figures - appropriate data from the Faessler et al. paper[2]. The curves are eye fits to the calculated points.

paper and fig.2a in the paper of Faessler et al.[2]. Quantitative reproduction is not as satisfactory as the qualitative one (fig.3). Formula (3´) reproduces quantitatively the data on pion-carbonium collisions. The predictions for the collisions of pions with Al and Cu nuclei might be considered to be satisfactory, as well, at $n_p \leq 4$. But, predictions for collisions of pions with Ag and Pb nuclei differ by much from the data at $n_p \geq 3$; it is, firstly, because of the simplification involved in deriving the formulas (1´) and (3´) and, secondly, due to disturbances of the monotonous nucleon emission which appear at small n_p as well, when heavy targets are used. However, agreement between the predictions and the experimental data can be achieved, if formula containing the second term, formula (1), is applied, as it has been shown for the pion-xenon nucleus collisions at 3.5 GeV/c and for pion-nucleus and proton-nucleus collisions registered in nuclear emulsions exposed to beams of particles of various energies, from nearly 3 to 400 GeV [13].

3.3. Energy Dependence of the Proton-Multiplicity Distribution

The distribution $f(n_p, A, E_h)$, formula (1), is energy dependent through the energy dependence of the mean free path $\langle\lambda_0\rangle_{el} = \langle\lambda_0(E_h)\rangle_{el}$. For any two samples of hadron collisions with a given nucleus of the mass number A, at two different energies E_1 and E_2, this dependence of the proton multiplicity distribution might be expressed as:

$$R(n_p, A, \frac{E_1}{E_2}) = \frac{f(n_p, A, E_1)}{f(n_p, A, E_2)}. \qquad (4)$$

Let us consider the simplest case, when the proton emission can be described by means of the simpler formula (1´). Then, using formulas (1´) and (4):

$$R(n_p, A, \frac{E_1}{E_2}) = e^{-\lambda(n_p)\frac{\langle\lambda_0(E_2)\rangle_{el} - \langle\lambda_0(E_1)\rangle_{el}}{\langle\lambda_0(E_1)\rangle_{el} \cdot \langle\lambda_0(E_2)\rangle_{el}}}. \qquad (4´)$$

If $\langle\lambda_0(E_1)\rangle_{el} \approx \langle\lambda_0(E_2)\rangle_{el}$, then $R(n_p, A, \frac{E_1}{E_2}) \approx 1$, which takes place when E_1 and E_2 do not differ by much.

For example, the values of the quantity $\langle\lambda_0\rangle_{el}$ for pion-nucleon elastic collisions at 37.5 and at 20 GeV/C momentum do not differ by much one from another, then we have for $R(n_p, A, \frac{E_1}{E_2}) \approx R(n_p, A, \frac{37.5}{20}) \approx 1$, as it is shown in fig.4. This result corresponds well to the experimental one received in the Faessler et al. work [2]; fig.4a in it.

Other characteristics of the nucleon emission accompanying high energy hadron-nucleus collisions, being of great importance for an elucidation the nature of the nucleon emission process, are the energy spectra and angular distributions of emitted protons. The mechanism of the nucleon emission has an effect on these characteristics.

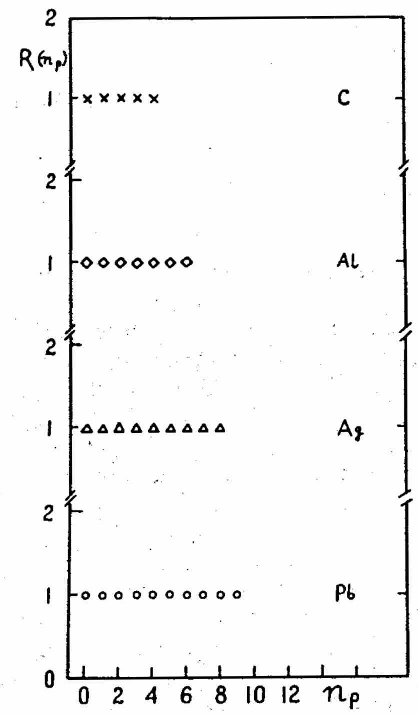

Fig.4. Dependence of the relation $R(n_p) = R(n_p, A, \frac{E_1}{E_2})$, defined by formula (4), on the proton multiplicity n_p in collisions of pions of energies $E_1 = 40$ GeV and $E_2 = 20$ GeV with C, Al, Ag and Pb nuclei. These distributions fit to those presented in the Faessler et al. work [2], where E_1=37.5 GeV/c and E_2=20 GeV/c, fig.4a in that work.

As we have reported [22] it is some indication that a structure exists in the proton spectra [22] which prompts that nucleons might be emitted not directly but through two- or more-nucleon systems decaying after having left the target nucleus, outside it, into the observed nucleons, in particular, into protons [12]; it has been hypothesized in our former papers, on the basis of the analysis of the average energy values of emitted nucleons, as well [3].

Angular distributions of emitted protons, especially the azimuthal ones, indicate that the nucleon emission starts from some relatively small cylindrical area inside the target-nucleus, localized around the projectile hadron course [4,12].

A possible mechanism of the nucleon emission was considered shortly and qualitatively in one of previous works [12], we find not necessary, therefore, to repeat these considerations here.

In efforts to describe quantitatively the energy and angular spectra of emitted protons additional experimental data and some new hypotheses based on these data, concerning the emission mechanism, are needed and we are not able to discuss this question here now.

4. AVERAGE MULTIPLICATION OF PARTICLES INSIDE THE TARGET-NUCLEUS

A measure of the average multiplication of particles inside target-nucleus is usually given by the ratio:

$$R_A = \frac{\langle n_s \rangle_{hA}}{\langle n_s \rangle_{hp}}, \qquad (5)$$

where $\langle n_s \rangle_{hA}$ is defined as the average number of charged relativistic particles ($\beta \gtrsim 0.7$) produced in an inelastic collision of the hadron h with the nucleus of the mass number A; $\langle n_s \rangle_{hp}$ is defined as the average number of charged relativistic particles produced in an inelastic collision of the same hadron with a proton. In emulsion experiments the average number of relativistic particles is referred to as $\langle n_s \rangle$, the "s" for "shower" particles. In this article the quantity $\langle n_s \rangle_{hA}$ will be treated as the number of particles produced in hadron-nucleus collisions and $\langle n_s \rangle_{hp}$ as the number of particles produced in collisions of this hadron with proton; these average numbers of particles are, in practice, the numbers of pions produced.

Let us derive the energy-dependent quantity R_A, within the frames of our hadron-nucleus collision process picture presented in the first paper of this series.

What $\langle n_s \rangle_{hA}$ will be outcome of the collision? The particle generation process goes through an "excited state", part I. Average number of generated particles in elementary hadron-nucleon collision at any E_h we denote as $\langle n_s(E_h) \rangle_{hN}$, because it is energy dependent. In hadron-nucleus collisions the cascade of the "excited states" develops according the working hypothesis formulated in part I. The outcome of the collision will be, therefore, some number m of such "excited states". The average number $\langle m \rangle$ is given by formula (5´) in part I, for a given nuclear matter layer thickness $\langle \lambda \rangle$ expressed in units of nucleons/S. In decaying of any of these "excited states" the number $\langle n_s(\frac{E_h}{\langle m \rangle}) \rangle_{hN}$ emerge in average; hN is for a hadron-nucleon collision. Then, it can be written for the quantity $\langle n_s(E_h) \rangle_{hA}$:

$$\langle n_s(E_h) \rangle_{hA} = \langle m \rangle \cdot \langle n_s(\frac{E_h}{\langle m \rangle}) \rangle_{hN} = e^{\frac{\langle \lambda \rangle}{\langle \lambda_0 \rangle}} \langle n_s(\frac{E_h}{e^{\frac{\langle \lambda \rangle}{\langle \lambda_0 \rangle}}}) \rangle_{hN}, \qquad (6)$$

where $\langle m \rangle = e^{\frac{\langle \lambda \rangle}{\langle \lambda_0 \rangle}}$, according to formula (5´) in part I, $\langle \lambda_0 \rangle$ is the mean free path for hadron-nucleon inelastic collision in nuclear matter[21] at projectile hadron energy , $\langle \lambda \rangle$ is the average thickness of the nuclear matter "slab"[21].

Formulas (5) and (6) lead to a simple formula for R_A:

$$R_A = \langle m \rangle \frac{\langle n_s(\frac{E_h}{\langle m \rangle}) \rangle_{hN}}{\langle n_s(E_h) \rangle_{hp}} = e^{\frac{\langle \lambda \rangle}{\langle \lambda_0 \rangle}} \frac{\langle n_s(\frac{E_h}{e^{\langle \lambda \rangle / \langle \lambda_0 \rangle}}) \rangle_{hN}}{\langle n_s(E_h) \rangle_{hp}}. \qquad (7)$$

The average particle multiplicity $\langle n_s(E_h) \rangle_{hp}$ changes not by much with the projectile energy E_h; if E_h increases 1000 times, $\langle n_s(E_h) \rangle_{pp}$ increases proportionally 5 times only[23]. Therefore, $\langle n_s(E_h) \rangle_{hp}$ and $\langle n_s(\frac{E_h}{\langle m \rangle}) \rangle_{hN}$ can be treated practically as being equal one to another at any energy E_h. It might be written, therefore, approximate formula for the quantity R_A:

$$R_A \approx e^{\frac{\langle \lambda \rangle}{\langle \lambda_0 \rangle}}. \qquad (7')$$

From the equality (7) it follows that formula (7´) should reproduce well the values predicted by formula (7) when $\langle \lambda \rangle \ll \langle \lambda_0 \rangle$. As follows from the shape of the average charged multiplicity dependence on the incident hadron energy, in the proton-proton collisions, the values of the quantity R_A predicted by formula (7´) should approach corresponding values predicted by formula (7) with increasing of the projectile energy.

Let us compare the existing experimental data with the predictions given by formulas (7) and (7´) for R_A.

In comparing the experimental data, presented in Busza´s reviews[7,8], we shall use the approximate expression (7´) only. The quantities $\langle \lambda \rangle$ and $\langle \lambda_0(E_h) \rangle$ are defined in our previous work[21]. The quantity $\langle \lambda \rangle$ is determined by the target-nucleus size and nucleon density distribution in it, $\langle \lambda_0(E_h) \rangle$ is determined by the cross-section for inelastic hadron-nucleon collisions at any energy E_h, according to formula (6) in part I.

In fig.5 predicted energy dependence of the average multiplication of particles R_A in pion and proton collisions with nuclei in the standard nuclear emulsion are presented. Corresponding experimental data are superimposed on the predicted curves, an agreement is seen at projectile energy range from some tens to roughly 1000 GeV. For comparison of the data at smaller energies with predicted ones, the exact formula (7) should be used.

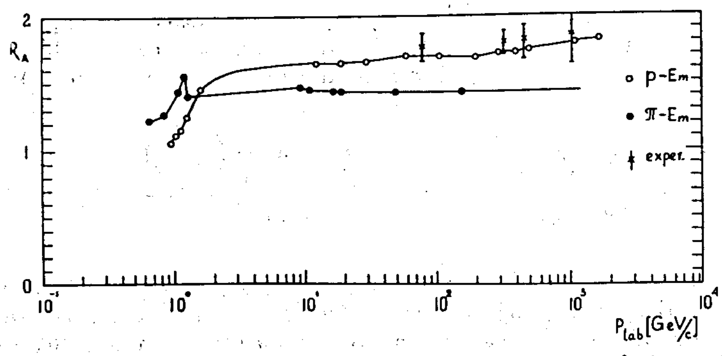

Fig.5. Energy dependence of the average particle multiplication in target-nuclei, R_A, calculated using formula (7′) for pion and proton collisions with nuclei in a standard nuclear emulsion.

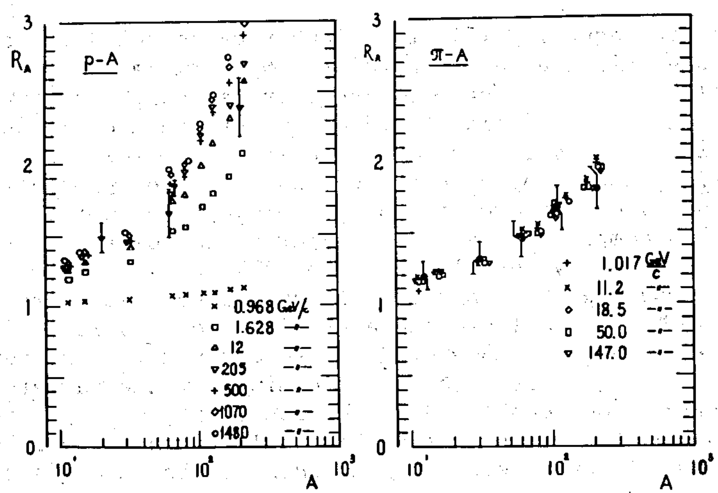

Fig.6. A-dependences of the average particle multiplication, R_A, in target-nuclei in pion-nucleus and proton-nucleus collision, calculated using formula (7′) for projectile momenta indicated in the figures; at such momenta corresponding data for the pion-proton and proton-proton inelastic collision cross-sections exist. Open figures and crosses - calculated points; corresponding black figures - experimental data [7,8].

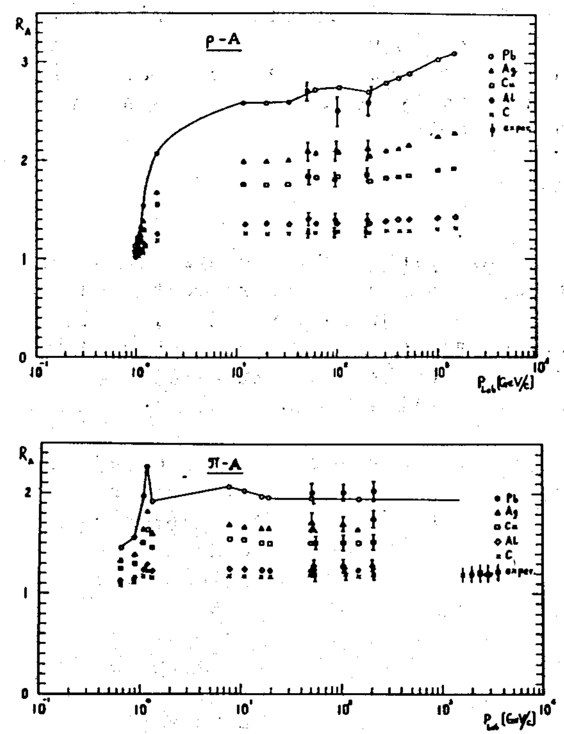

Fig.7. Energy dependence of the average particle multiplication, R_A, in collisions of protons and pions with C, Al, Cu, Ag, and Pb target-nuclei; open figures and crosses - points calculated using formula (7′), solid lines connected to some points are eye fitted; black figures and crosses with errors - corresponding experimental data [7,8].

The A-dependence and energy dependence of R_A for proton-nucleus and pion-nucleus collisions are presented in fig.6 and fig.7, where corresponding existing experimental data are superimposed on the predicted ones. It can be stated that simple formula (7′) reproduces quantitatively the experimental data within the total energy interval at which these data are available [7,8], from nearly 20 to 200 GeV for the proton-nucleus and from roughly 10 to 150 GeV for the pion-nucleus collisions. The experimental data received in emulsion experiments at roughly 1000 GeV correspond to the predicted as well, fig.6; the average mass number for the "average" nucleus in standard emulsion is nearly 67.

It can be concluded, therefore, that the energy dependence of the average particle multiplication R_A is determined by the energy dependence of the cross-section σ_{hN} for the elementary hadron-nucleon inelastic collisions; the mean free path $\langle\lambda_0\rangle = \langle\lambda_0(E_h)\rangle$ in formulas for R_A depends on σ_{hN} according to formula (6) in part I. The A-dependence of R_A is determined by the A-dependence of the average thicknesses of target-nuclei $\langle\lambda\rangle$, as it is shown in our previous work [21]; if the quantity $\langle\lambda\rangle$ is expressed in units of protons/S its value depends on the ratio Z/A as well, where Z is the atomic number. Because the quantity $<\lambda>$ is determined by nuclear sizes and nucleon density distribution in nuclei, it can be concluded that the A-dependence of the average particle multiplication in nuclei is determined simply by nuclear sizes and nucleon density distribution in nuclei.

5. CONCLUSION

As it has been shown in this paper, the picture of the hadron-nucleus collision process observed in experiments and the working hypothesis which has been put forward in part I, on the basis of this picture, allow to work out simple method for a reproduction the data on the proton multiplicity distributions and on the average multiplication of particles in hadron-nucleus collisions.

It should be emphasized that, in describing the data, information about nuclear sizes and nucleon density distributions in nuclei, and data on cross-sections for appropriate elementary hadron-nucleon collisions have been used only. This remarkable property of the method of hadron-nucleus collision description, worked out in part I of this series,enables us to expect that various characteristics of the particle production process in hadron-nucleus collisions might be described satisfactorily this way as well. We will try to realize such description in the next, third, part of this series of papers.

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