сообщения
объединенного
института
ядерных
исследований
дубна

E1-81-156

Z.Strugalski

HADRON-NUCLEUS COLLISIONS. III. PRODUCED PARTICLE MULTIPLICITIES, ENERGY AND ANGULAR SPECTRA, PSEUDORAPIDITY DISTRIBUTIONS

1981

1. INTRODUCTION

This article, being the third in the series, sets out to describe some of the progress in our research of particle production process in hadron-nucleus collisions. The purpose of our investigations was to look at all sides of the particle production process both in hadron-nucleus and hadron-nucleon using nuclear targets.

In a hadron-nucleon collisions the only directly observable information about this process, one can obtain, is that on the asymptotic state produced. Indirectly some information about what happens in the early stages after collision can be obtained from a detailed study of the finally produced particles, observed in experiments; for example, by looking at correlations between various particles, one can deduce if the particles are decay products of resonances. To obtain direct information about what happens in the early stages of the production process, it is necessary to interfere with the process as it is taking place. The only tool available which allows to realize such interference is an application of a massive target-nucleus, being a collection of many nucleons; such targets might serve as detectors of properties of the particle production process taking place when hadrons collide with the nucleons inside nuclei /1/.

Information about what happens in the early stages after hadron collision with nucleon in nuclear matter resulting particle production can be obtained from a detailed study of the finally emitted nucleons and produced particles, registered in experiments. Relations between the characteristics of produced particles in hadron-nucleon collisions and corresponding characteristics of produced particles in collisions of the same hadrons with various nuclei contain the information about the space-time evolution of the particle production process. When such relations will be found, the particle production process might be explained in terms of our knowledge of hadron-nucleon interaction.

It has been shown, in parts I and II, that such characteristics of the hadron-nucleus collision process as inelastic collision cross-section energy- and A -dependences, nucleor multiplicity distribution A -dependence, average particle multiplication energy- and A-dependences can be described in terms of our knowledge of nuclear sizes, nucleon density distribution in nuclei, and of elementary hadron-nucleon interaction. In the present article we intend to show how it is possible to reproduce in this way various characteristics of the particle production process in hadron-nucleus collisions.

2. PARTICLE PRODUCTION

One of the most important characteristics of the particle production process is the production intensity. Let us start, therefore, our considerations with this characteristic.

2.1. Particle Production Intensity

Particle production intensity is characterized usually as the frequency $f(n_s, A, E_h)$ of events versus the number n_s of produced particles, observed in experiments, when a hadron of energy E_h collides with a target-nucleus of the mass-number A; Usually n_s is referred to as observed fast particles produced, "s" is for "shower" /2-4/.

Within the frames of our picture, presented in part I, particles are produced through some "excited states" moving along incident hadron course and decaying into observed particles, after having left the target-nucleus. If a layer of nuclear matter, which a hadron has to overcome, is thick enough - of a thickness t, some quasi-unidimensional cascade of the "excited states" develops inside the target-nucleus; the average number $\langle m \rangle$ and multiplicity m distribution $P(m,t)$ of such "excited states" outcoming from the target are expressed by formulas (4) and (5) in part I.

The outcome, one can observe in hadron-nucleus collision experiments, is a result of the superposition of what one could observe when hadrons of energies $\frac{E_h}{m}$ collide with nucleons resting in the laboratory system; a detector, the bubble chamber for example, records the produced particles apparent to be outcoming from the interaction "point". This superposition might be expressed as the sum of m terms $P(m,t)p_m(n_s)$, $m = 1, 2, 3, \ldots$, where $p_m(n_s)$ is the probability to appear n_s produced particles if m "excited states" decay "simultaneously".

Therefore, using formulas (4), (5), (4″), and (5′), given in part I, the expression for the frequency $f(n_s, A, E_h)$ can be written as:

$$f(n_s, A, E_h) = e^{-\frac{\langle\lambda\rangle}{\langle\lambda_0\rangle}} \sum_{m=1}^{m=k} \left(1 - e^{-\frac{\langle\lambda\rangle}{\langle\lambda_0\rangle}}\right)^{m-1} p_m(n_s), \qquad (1)$$

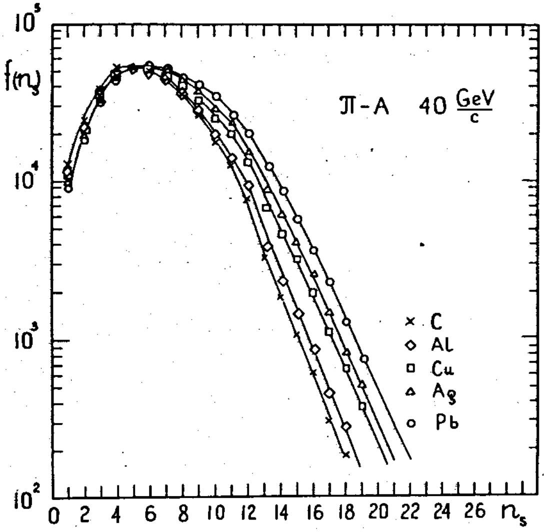
where $\langle\lambda\rangle$ is the target-nucleus average thickness /5/ $\langle\lambda_0\rangle = \langle\lambda_0(E_h)\rangle$ is mean free path for hadron of energy E_h collision with nucleon in nuclear matter /5/, given by formula (6) in part I; the probability $p_m(n_s)$ is determined by probabilities $p(u), p(v), p(w), \ldots, p(z)$ for appearance of u, v, w, ..., z particles in decaying each of the m "excited states" created in hadron-nucleus collision; $u + v + w + \ldots + z = n_s$. Any of $p(u), p(v), p(w), \ldots, p(z)$ can be taken from a hadron-nucleon experiment at $\frac{E_h}{m}$ energy. For example, if $m = 2$, $p_2(n_s) = p_2(u+v)$ is expressed simply by the formula:

$$p_2(n_s) = p(u+v) = \sum_{u=0}^{u=n_s} p(n_s - u)\, p(u), \qquad (2)$$

where $p(n_s - u) = p(v)$ and $p(u)$ can be taken from a hadron-nucleon collision experiment at $\frac{E_h}{m}$ energy.

In order to test formula (1) by experiment, a series of frequencies $f(n_s, A, E_h)$ has been calculated, for C, Al, Cu, Ag, and Pb nuclei at E_h 40 GeV/c momentum; experimental data exist for 37.5 GeV/c momentum /4/. In calculations only $k = 3$ terms in formula (1) have been taken into account. The probabilities $p(u)$, $p(v)$, and $p(w)$, which the probability $p_3(n_s) = p_3(u+v+w)$ is depending on, have been evaluated using the data on pion-proton collisions at 40, 16, and 11.2 GeV/c momenta /6/ It has been supposed the particle multiplicity distributions in hadron-nucleon collisions to be the same as in the hadron-proton collisions - the multiplicities of n_s being 1, 3, 5, ... charged secondaries are interpolated or extrapolated ones. The quantity $\langle\lambda\rangle$ in units of protons/S for various nuclei has been estimated from nuclear sizes and nucleon density distributions in nuclei /5,7/; the quantity $\langle\lambda_0(E_h)\rangle$ in units of protons/S has been estimated from corresponding hadron-nucleon inelastic collision cross-sections /5,6/, using formula (6) from part I.

Results are presented in fig. 1. It can be concluded that formula (1) reproduces well qualitatively the series of corresponding frequencies received in the Faessler et al. experiment, shown in fig. 3b in their work /4/; the quantitative prediction given by this formula does not differ by much from th experimental data, especially at $n_s < 10$. But, we must remember that not all terms in formula (1) have been taken into account



in calculations and the values of energies $\frac{E_h}{m}$ applied have been taken from the existing ones, not accurately as those needed.

Fig.1. Frequency of events $f(n_s)=f(n_s,A,E_h)$ versus produced particle multiplicity n_s, calculated using formula (1).

2.2. Proton Multiplicity Dependence of the Particle Production Intensity

The number of emitted protons n_p, or the proton multiplicity in an event, indicates, within the frames of our picture of the nucleon emission process/8/, how thickness λ had to overcome a hadron in collision with the target-nucleus/5/; also - formula (2) in part I. It should be noted that the relation $n_p \approx \lambda$ in units of protons/S takes place with an accuracy being high enough in our considerations when $n_p \leq \lambda_{max}$ where λ_{max} is maximal thickness of the target-nucleus.

Therefore, the n_p-dependence of the particle production intensity might be received simply from formula (1), substituting $\lambda = n_p$ instead of the quantity $<\lambda>$ and putting in the coefficient $W_0(n_p,A)$, which expresses the probability for an incident hadron to collide with the target-nucleus at the impact parameter corresponding to n_p emitted protons /9/:

$$f(n_s,n_p,A,E_h) \approx W_0(n_p,A)\, e^{-\frac{n_p}{<\lambda_0>}} \sum_{m=1}^{m=k} \left(1-e^{-\frac{n_p}{<\lambda_0>}}\right)^{m-1} p_m(n_s). \qquad (3)$$

The A-dependence in this formula is expressed through the coefficient $W_0(n_p,A)$ and the quantity $<\lambda_0>$ which depends on the ratio $\frac{Z}{A}$ when is expressed in units of protons/S /8,9/.

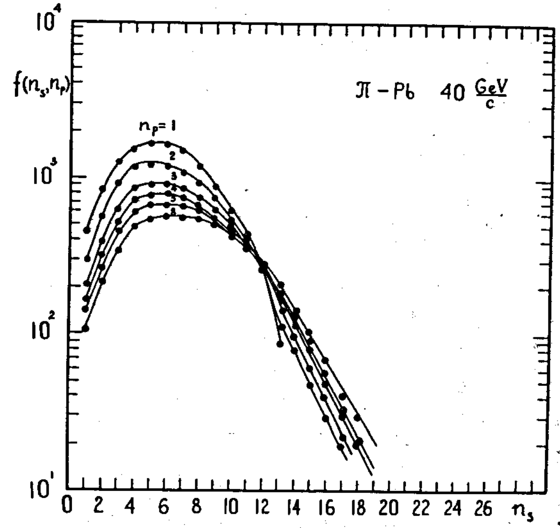


Fig.2. Frequency distributions $f(n_s) = f(n_s,n_p,A,E_h)$ versus produced particle multiplicity n_s, calculated for various proton multiplicities n_p using formula (3).

Using input data as used in calculating the series of $f(n_s,A,E_h)$ distributions, formula (1), the n_p-dependence (3) has been calculated for Pb target-nucleus. Result is shown in fig. 2. The calculated distribution reproduces qualitatively corresponding experimental data, presented in fig. 9 in the Faessler et al. work/4/, when $n_p \leq 5$; at higher values of n_p an expected disturbance, caused by the disturbance of the monotonous nucleon emission process /8,9/, is observed.

2.3. Proton Multiplicity Dependence of the Produced Particle Average Multiplicity

Within the frames of our picture of the particle production process in hadron-nucleus collisions, in result of collisions of a hadron of energy E_h with a given target-nucleus, of the mass number A, at an impact parameter corresponding to the nuclear matter thickness being $n_p = \lambda(n_p')$ in units of protons/S, $<m>$ "excited states" emerge in average. Each of the "states" corresponds to the "state" produced in collision of the same hadron with a nucleon at the kinetic energy $\frac{E_h}{<m>}$, each decays into $<n_s(\frac{E_h}{<m>})>_{hN}$ particles in average. It takes place for any n_p. The observed average multiplicity $<n_s(E_h,n_p)>_{hA}$ of particles produced in hadron-nucleus collisions should be expressed, therefore, as the product $n_s(E_h,n_p)_{hA} = <m> <n_s(\frac{E_h}{<m>})>_{hN}$, or, using formula for the quantity $<m>$, formula (5) in part I, as:

$$<n_s(E_h,n_p)>_{hA} = e^{\frac{\lambda(n_p)}{<\lambda_0>}} <n_s(\frac{E_h}{<m>})>_{hN}. \qquad (4)$$

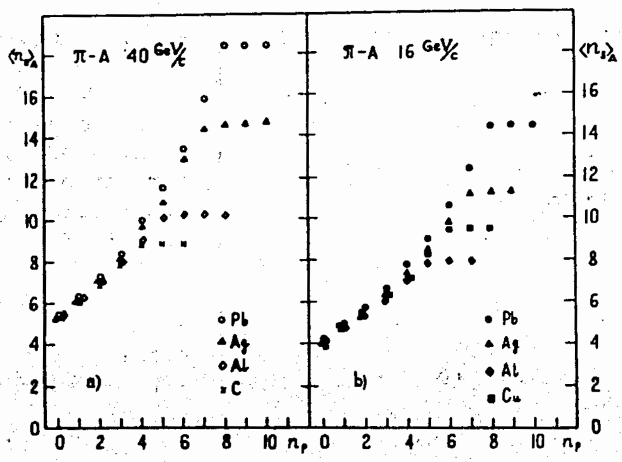


Fig.3. Dependence of the mean number of produced particles $\langle n_s \rangle_{hA}$ in pion-nucleus collisions on the number n_p of emitted protons, calculated using formula (4).

Corresponding experimental data exist on pion collisions with Pb , Ag , Cu , Al , and C nuclei at 37.5 and 20 GeV/c momentum [4]. Therefore, in order to test this formula (4) by experiment, n -dependences of the quantities $\langle n_s(E_h, n_p) \rangle_{hA}$ have been calculated for corresponding pion-nucleus collisions at 40 and 16 GeV/c momenta; at those momenta corresponding data can be used on $\langle n_s(\frac{E_h}{\langle m \rangle}) \rangle_{hN}$ from the HERA tables [6]; the data are on hadron-proton collisions only, but it can be accepted the average multiplicities $\langle n_s \rangle_{hp}$, $\langle n_s \rangle_{hn}$, $\langle n_s \rangle_{hN}$ to be equal one to another. In calculations values $\langle n_s(E_h) \rangle_{hN}$ have been used instead of the $\langle n_s(\frac{E_h}{\langle m \rangle}) \rangle_{hN}$ for a simplification; it does not distort by much the predictions given by formula (4). The mean free paths $\langle \lambda_0 \rangle = \langle \lambda_0(E_h) \rangle$ for the hadron-nucleon inelastic collisions in nuclear matter were calculated using corresponding cross-sections for the elementary hadron-nucleon collisions [5,6].

Results are shown in fig. 3. It should be concluded that, in spite of the simplifications involved, distributions presented in this figure correspond qualitatively to the experimental ones, shown in fig. 11 in the Faessler et al. work [4]; quantitatively the distributions calculated in this work do not differ by much from the experimental ones as well.

2.4. Proton Multiplicity Dependence of Normalized Dispersion of the Produced Particle Multiplicity.

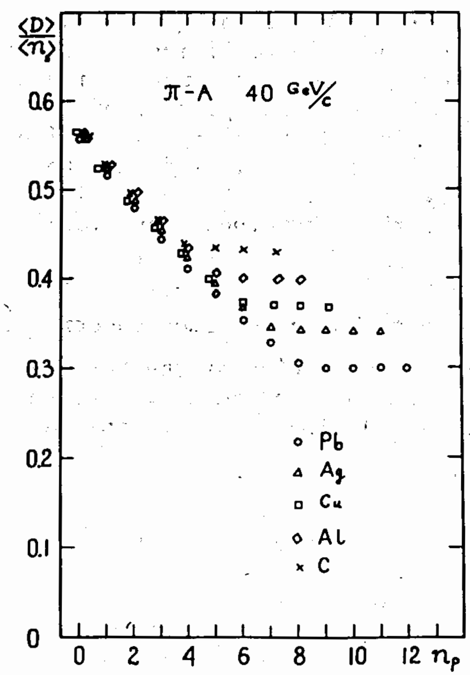
In order to characterize the proton multiplicity dependence of the normalized dispersion of the produced particle multiplicity, let us consider the quantity:

$$Z = \frac{\langle D(n_s) \rangle}{\langle n_s \rangle} = \frac{\langle n_s^2 \rangle - \langle n_s \rangle^2}{\langle n_s \rangle}, \qquad (5)$$

where n_s is the produced particle multiplicity.

Using formulas for the mean value and the dispersion of an accidental quantity being a sum of some number of accidental quantities, taking into account our picture of the particle generation process in hadron-nucleus collisions, and using formulas (4) and (5) we can write

$$Z_{hA}(E_h) = Z_{hN}\left(\frac{E_h}{\langle m \rangle}\right) \frac{1}{\sqrt{e^{\frac{\lambda(n_p)}{\lambda_0}}}} = Z_{hN}\left(\frac{E_h}{\langle m \rangle}\right) \frac{1}{\sqrt{\langle m \rangle}}, \qquad (6)$$



where $Z_{hA}(E_h)$ expresses the quantity Z, formula (5), for the hadron-nucleus collisions at E_h energy and $Z_{hN}(\frac{E_h}{\langle m \rangle})$ is the quantity Z for the hadron-nucleon collisions at $\frac{E_h}{\langle m \rangle}$ energy; $\langle m \rangle$ is the average number of the "intermediate states" produced, formula (5) in part I; $\langle \lambda_0 \rangle = \langle \lambda_0(E_h) \rangle$.

Fig.4. Normalized dispersion $\frac{\langle D \rangle}{\langle n_s \rangle}$ of produced particle average multiplicites $\langle n_s \rangle$ as a function of the number n_p of emitted protons, calculated using formula (6).

In order to test the formula (6), the n_p -dependence of Z_{hA} has been calculated for pion collisions with Pb, Ag, Cu, Al, C nuclei at 40 GeV/c; corresponding experimental data exist for pion collisions with Pb, Ag, and Al nuclei at 37.5 GeV/c momentum, in the Faessler et al. work/4/. The value for Z_{hN} (40) has been estimated on the basis of the data from the HERA tables/6/, it equals to 0.635 at 40 GeV/c; instead of it the value 0.558 has been used which corresponds to the Z_{hN} quantity at 37.5 GeV/c momentum in the Faessler et al. work/4/, at n_p =0. The incident hadron energy dissipation $\frac{E_h}{\langle m \rangle}$ has not been taken into account.

Result of calculations is shown in fig. 4. The calculated distributions reproduce well qualitatively the experimental ones, presented in fig. 10 b) in the Faessler et al. work/4/; quantitatively the calculated distributions do not differ by much from the experimental ones as well. It should be expected that exact calculations will give predictions reproducing precise experimental data.

3. ENERGY SPECTRA OF PRODUCED PARTICLES

The number of particles $N(E_h, E+dE, A)$ of energies within energy value interval $(E, E+dE)$ produced in collisions of a hadron of energy E_h with a nucleus of the mass number A might be expressed simply, within the frames of our picture of the hadron-nucleus collision process. Indeed, the E -distribution of the quantity $N(E_h, E+dE, A)$ for energy E values from 0 to its maximal value E_{max}, the energy spectrum, in hadron-nucleus collisions is, according to our working hypothesis put forward in part I, the superposition of some number m=1, 2, 3, ..., k of energy spectra for hadron-nucleon collisions at $\frac{E_h}{m}$ incident hadron energy. The distribution of such spectra is expressed by the formula for the distribution of the "excited states" generated in nuclear matter when hadron traverses the target-nucleus, formula (4) in part I. Therefore, it can be written:

$$N(E_h, E+dE, A) = e^{-\frac{\langle\lambda\rangle}{\langle\lambda_0\rangle}} \sum_{m=1}^{m=k} \left(1-e^{-\frac{\langle\lambda\rangle}{\langle\lambda_0\rangle}}\right)^{m-1} N_0\left(\frac{E_h}{m}, E+dE, N\right), \qquad (7)$$

where $\langle\lambda\rangle$ is the average thickness of the target-nucleus/5/ expressed in units of protons/S; $\langle\lambda_0\rangle = \langle\lambda_0(E_h)\rangle$ is mean free path for hadron-nucleon interactions in nuclear matter/5/ expressed in units of protons/S; $N_0(\frac{E_h}{m}, E+dE, N)$ is number of particles of energy $(E, E+dE)$ produced in hadron-nucleon collions at energy of $\frac{E_h}{m}$.

The n_p -dependence of the energy spectra $N(E_h, E+dE, A, n_p)$ might be written simply, by analogy, as:

$$N(E_h, E+dE, A, n_p) = e^{-\frac{\lambda(n_p)}{\langle\lambda_0\rangle}} \sum_{m=1}^{m=k} \left(1-e^{-\frac{\lambda(n_p)}{\langle\lambda_0\rangle}}\right)^{m-1} N_0\left(\frac{E_h}{m}\right), \qquad (8)$$

where $N_0(\frac{E_h}{m}) = N_0(\frac{E_h}{m}, E+dE, N)$, $\lambda(n_p) = n_p$ protons/S is the thickness of a nuclear matter "slab", along the incident hadron course.

There are not available at present corresponding experimental data which could be used for testing formulas (7) and (8).

4. ANGULAR SPECTRA OF PRODUCED PARTICLES

After the analogy of the energy spectra, the angular spectra of produced particles might be expressed simply as:

$$N(E_h, \theta+d\theta, A) = e^{-\frac{\langle\lambda\rangle}{\langle\lambda_0\rangle}} \sum_{m=1}^{m=k} \left(1-e^{-\frac{\langle\lambda\rangle}{\langle\lambda_0\rangle}}\right)^{m-1} N_0\left(\frac{E_h}{m}, \theta+d\theta, N\right), \qquad (9)$$

where $N(E_h, \theta+d\theta, A)$ is the number of particles produced in collisions of a hadron of energy E_h with a target-nucleus of the mass number A and ejected at angles of values within an interval $(\theta, \theta+d\theta)$; the quantity $N_0(\frac{E_h}{m}, \theta+d\theta, N)$ is the number of particles produced in collisions of the same hadron of energy $\frac{E_h}{m}$ with a nucleon and ejected at angles within the value interval $(\theta, \theta+d\theta)$.

The n_p -dependence of the angular spectra might be written, by analogy, as:

$$N(E_h, \theta+d\theta, A, n_p) = e^{-\frac{\lambda(n_p)}{\langle\lambda_0\rangle}} \sum_{m=1}^{m=k} \left(1-e^{-\frac{\lambda(n_p)}{\langle\lambda_0\rangle}}\right)^{m-1} N_0\left(\frac{E_h}{m}\right), \qquad (10)$$

where $N(E_h, \theta+d\theta, A, n_p)$ is the number of particles ejected at angles from the value interval $(\theta, \theta+d\theta)$ in such hadron-nucleus collisions in which n_p protons are emitted from the target nucleus of the mass number A; $N_0(\frac{E_h}{m}) = N_0(\frac{E_h}{m}; \theta+d\theta, N)$ is the number of produced particles in collisions of the same hadron of energy $\frac{E_h}{m}$ with a nucleon ejected at angles within value interval $(\theta, \theta+d\theta)$; other quantities used in the expression (10) are of the same meaning as those in the foregoing sections.

The energy (8) and angular (10) spectra can differ from the experimental ones at $n_p > 5$, because of possible disturbance of the monotonous nucleon emission caused by single hadron-nucleon elastic scattering through relatively large angles, when recoil nucleons appear of energies high enough to be able to cause monotonous nucleon emission /8,9/.

There are not available corresponding experimental angular spectra of the produced particles which could be used for testing the predictions given by formulas (9) and (10).

5. PSEUDORAPIDITY DISTRIBUTION OF PRODUCED PARTICLE AVERAGE MULTIPLICITIES

The pseudorapidity, $\eta = -\ln \mathrm{tg}\frac{1}{2}\theta_{lab}$, distribution, denoted as $P_r(E_h, \frac{\Delta\langle n_s\rangle}{\Delta\eta}; A)$, of produced particle average multiplicity $\langle n_s\rangle$ in collisions of a hadron of energy E_h with a nucleus of the mass number A can be expressed simply, after the analogy of the formula (4) for the produced particle average multiplicity, as:

$$P_r(E_h, \frac{\Delta\langle n_s\rangle}{\Delta\eta}; A) = e^{\frac{\langle\lambda\rangle}{\langle\lambda_0\rangle}} P_r(\frac{E_h}{\langle m\rangle}; \frac{\Delta\langle n_s\rangle}{\Delta\eta}; N), \qquad (11)$$

where $P_r(\frac{E_h}{\langle m\rangle}; \frac{\Delta\langle n_s\rangle}{\Delta\eta}; N)$ is the pseudorapidity distribution of the average multiplicities of particles produced in hadron-nucleon collisions at $\frac{E_h}{\langle m\rangle}$ energy, "N" is for "nucleon".

The pseudorapidity distribution n_p -dependence can be expressed simply as well:

$$P_r(E_h, \frac{\Delta\langle n_s\rangle}{\Delta\eta}, A, n_p) = e^{\frac{\lambda(n_p)}{\langle\lambda_0\rangle}} P_r(\frac{E_h}{\langle m\rangle}; \frac{\Delta\langle n_s\rangle}{\Delta\eta}, N), \qquad (12)$$

where the meaning of the quantities used in this expression is the same as in formulas written in the foregoing sections.

The energy dependence of the pseudorapidity distribution (11) we determine as:

$$P_r(\frac{E_{1h}}{E_{2h}}, \frac{\Delta\langle n_s\rangle}{\Delta\eta}, A) = \frac{P_r(E_{1h}, \frac{\Delta\langle n_s\rangle}{\Delta\eta}; A)}{P_r(E_{2h}, \frac{\Delta\langle n_s\rangle}{\Delta\eta}; A)} = R(\frac{\Delta\langle n_s\rangle}{\Delta\eta}, A, \frac{E_{1h}}{E_{2h}}). \qquad (13)$$

Using formula (11) the relation (13) might be written as:

$$R(\frac{\Delta\langle n_s\rangle}{\Delta\eta}, A, \frac{E_{1h}}{E_{2h}}) = e^{\lambda(n_p)\left[\frac{1}{\langle\lambda_0(E_{1h}, A)\rangle} - \frac{1}{\langle\lambda_0(E_{2h}, A)\rangle}\right]} \frac{P_r(\frac{E_{1h}}{m}; \frac{\langle n_s\rangle}{\Delta\eta}, N)}{P_r(\frac{E_{2h}}{m}; \frac{\Delta\langle n_s\rangle}{\Delta\eta}; N)}; \qquad (14)$$

where E_{1h} and E_{2h} are two different incident hadron energies; the meaning of other quantities is the same as in many formulas presented above.

In order to test the formulas expressing the pseudorapidity distributions of produced particle average multiplicities, calculations are performed for such input data at which results comparable with the existing data will be received. Therefore, the distribution (11) has been calculated for pion collisions with Pb, Ag, and C nuclei, using for $P_r(\frac{E_h}{m}, \frac{\Delta\langle n_s\rangle}{\Delta\eta}; N)$ values taken from figs. 12a) and 12b) in the Faessler et al. work /4/ at $N_g = 0$, because there are not available other, more accurate, data. Using the same input data, energy dependence of the pseudorapidity distribution, expressed by formula (14), has been calculated as well. Results are shown in fig. 5a) and 5b) correspondingly. The calculated distributions reproduce qualitatively the experimental ones, shown in fig. 6a) and 6b) in the Faessler et al. work. Quantitatively, the calculated distributions do not differ by much from the experimental ones as well.

The n_p -dependence of the pseudorapidity distribution, expressed by formula (12), has been calculated for pion-nucleus collisions at nearly 40 GeV/c momentum, using for the distribution $P_r(\frac{E_h}{m}; \frac{\Delta\langle n_s\rangle}{\Delta\eta}; N)$ data read out from fig. 12 in the Faessler et al. work /4/ at $N_g = 0$, for $\frac{E_h}{m} = 37.5$ and 20 GeV/c momentum; as data for this distribution at momenta

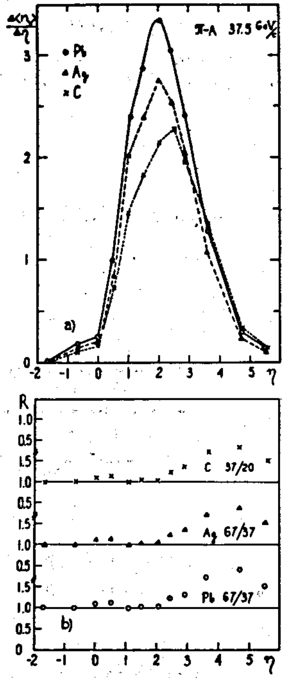


Fig.5. a) Average pseudorapidity $\frac{\Delta<n_s>}{\Delta\eta}$ distribution of produced particle for different targets at 37.5 GeV/c, calculated using formula (11); b) Energy dependence η of pseudorapidity distributions for different targets, calculated using formula (14).

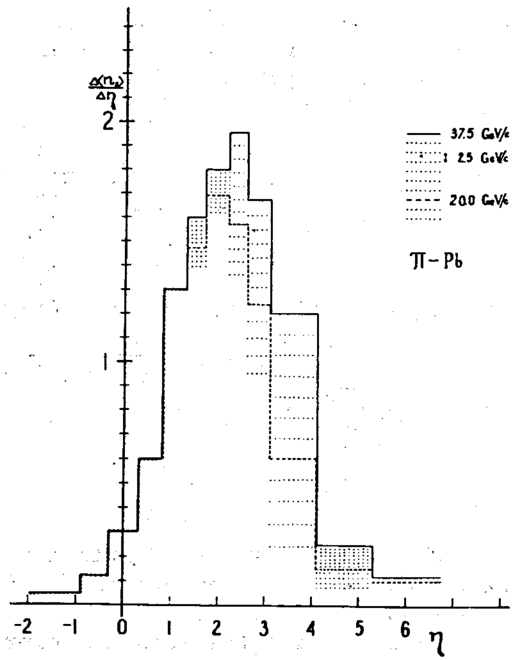


Fig.6. Pseudorapidity η dependence on incident hadron momentum constructed for pion-nucleon collisions on the basis of data from fig. 12 in the Faessler et al work /4/ at $N_g = 0$; the point lines represent the linear inter- and extrapolations for incident hadron momenta not available.

lying between 37.5 and 20 GeV/c the interpolated values have been used, as data at momenta being smaller than 20 GeV/c the extrapolated values have been used, as it is shown in fig. 6. Such extrapolation and interpolation give a rough approximation, but it should allow to receive characteristics of the n_p -dependence of the pseudorapidity distribution which might show the same behaviour as the experimental ones. Result is

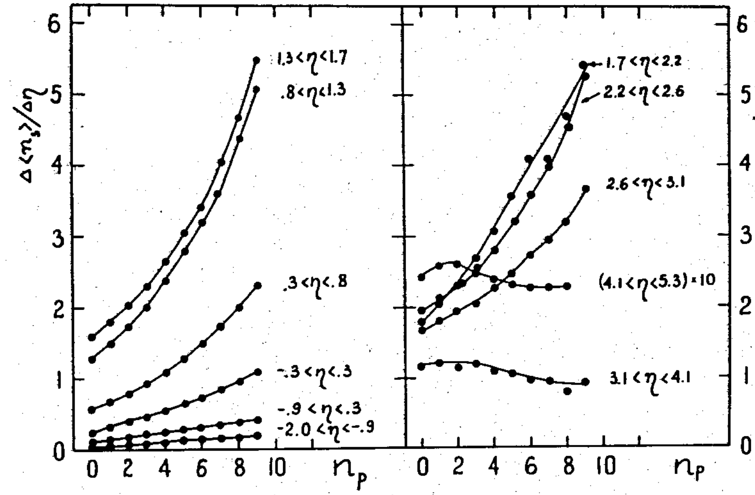


Fig.7. The pseudorapidity $\frac{\Delta<n_s>}{\Delta\eta}$ distribution as a function of the number n_p of emitted protons, calculated using formula (12), for pion-Pb nucleus collisions at nearly 40 GeV/c momentum.

shown in fig. 7. The distributions presented in this figure correspond to those shown in the Faessler et al. work/4/.It is easy to see that the calculated distributions correspond qualitatively to the experimental ones.It can be concluded that characteristic change in behaviour of the distributions at $3.1<\eta<4.1$ and $4.1<\eta<5.3$ is caused by the energy dissipation of the incident hadron in its passing through nuclear matter.Really,the produced particle average multiplicities correspond,as we have pointed out, to smaller hadron energies, being of $\frac{E_h}{m}$ instead of E ,but the values of $\frac{\Delta<n_s>}{\Delta\eta}$ at $\eta>1.3$ decrease with hadron momentum decrease, as it might be seen in fig. 6; it is mostly evident at η values lying between 3.1 and 4.1.

6. CONCLUSIONS

It has been shown, in the series of the present three articles, that our model and description procedure of the hadron-nucleus collision process can account for hadron-nucleus data in terms of our knowledge of hadron-nucleon interaction, of nuclear sizes, and of nucleon density distributions in nuclei.

The interrelation between characteristics of the hadron-nucleon collisions and corresponding characteristics of collisions of the same hadron with a target-nucleus can be expressed by means of simple formulas.

It enables us to think our picture of the hadron-nucleus collision process and our working hypothesis, put forward in part I of this series of articles, to be near to the reality.

REFERENCES

1. Strugalski Z. JINR, E1-80-548, Dubna, 1980.
2. Powell C.F., Fowler P.H., Perkins D.H. The Study of Elementary Particles by the Photographic Method. Pergamon Press, London-New York-Paris-Los Angeles, 1959.
3. Busza W. In: High Energy Physics and Nuclear Structure. 1975, Santa-Fe and Los Almos, AIP Conference Proceedings No. 26, p. 211; Acta Physics Polonica, 1977, B8, p. 333.
4. Faessler M.A. et al. Nucl.Phys., 1979, B157, p.1.
5. Strugalski Z. JINR, E1-80-799, Dubna, 1980.
6. Famino V. et al. CERN-HERA, 79-01, 79-02, 79-03, 1979.
7. Elton L.R.B. Nuclear Sizes, Oxford University Press, 1961.
8. Strugalski Z. JINR, E1-80-215, Dubna, 1980.
9. Strugalski Z. JINR, E1-80-216, Dubna, 1980.

Received by Publishing Department
on March 3 1981.