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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

S.R.GEVORKYAN, G.R.GULKANYAN,

Ar.M.KOTZINIAN, V.M.ZHAMKOCHYAN

INCLUSIVE SPECTRA OF HADRONS IN COLLISION OF Π -AND K-MESONS WITH NUCLEI

ЦНИИатоминформ

ЕРЕВАН-1985

Experimental study of inclusive spectra of different hadrons produced in hadron-nuclei collisions at high energies [1] has initiated a number of theoretical works [2,3], wherein it has been made an attempt as to describe the inclusive spectra of hadrons in proton-nuclei collisions both qualitatively and quantitatively.

In Ref. [3] we have proposed a version of multiple-scattering model that has allowed a quantitative description of inclusive hadron spectra in proton-nuclei collisions in the incident proton fragmentation region.

The model was based on the following assumptions:

a) a hadron striking a nucleus (M meson) already in the first act of inelastic interaction turns into excited H_M system whose valent composition coincides with that of the initial hadron;

b) the H_M system undergoes in the nucleus a series of multiple collisions with no change in valent composition (the interaction occurs owing to sea gluons [4]). The H_M decay into real hadrons takes place outside the nucleus (the Lorentz-factor $E/m \gg 1$).

The present work deals with a comparison carried out between the model predictions [3] and the experimental data on inclusive hadron spectra produced under collision of π - and K -mesons with nuclei. According to [3], the inclusive spectra of $M+A\to h+X$ processes, integrated over transverse momentum, can be presented as the following series:

$$\frac{d\sigma}{dx} = \sum_{n=1}^{A} N_n(\sigma)\,\Phi_n(x) \tag{1}$$

where $N_n(\sigma)=\frac{1}{\sigma n!}\int(\sigma T)^n e^{-\sigma T} d^2 b$ are "effective nucleon numbers", $T(b)=\int\rho(b,z)\,dz$ is a projection of one-particle nuclear density on the impact parameter plane, $\Phi_n(x)$ is inclusive spectrum of final hadron h provided that the leading system H_M in the nucleus underwent n-1 inelastic collisions:

$$\Phi_n(x)=\int_{x}^{x_{max}}\cdots\int_{x/x_1\cdots x_{n-1}}^{x_{max}}\frac{1}{\sigma}\frac{d\sigma}{dx_1}(MN\to H_M X)\,\frac{1}{\sigma}\frac{d\sigma}{dx_2}(H_M N\to H_M X)\ldots\times$$

$$\times\,\frac{d\sigma}{dx_n}(H_M N\to hX)\,\delta(x-x_1\cdot x_2\cdots x_n)\,dx_1\cdots dx_n \tag{2}$$

(where $M\equiv\pi$ or K).

So long as the inclusive hadron spectrum of the given type in the fragmentation region of the incident particle is determined only by its valent composition, then according to a) and b)

$$\frac{d\sigma}{dx}(H_M N\to hX)=\frac{d\sigma}{dx}(MN\to hX) \tag{3}$$

In the experiment [1] , the region $x\leqslant 0.88$ was measured, in which the contribution from the diffractive dissociation processes is inessential. Energy losses in the diffractive dissociation process are small [5] ($\lesssim 3\%$), therefore expression (1) contains inclusive cross sections of non-diffractive processes for which the following relation takes place:

$$\int_{X_{min}}^{X_{max}} \frac{d\sigma}{dx}(MN \to H_M X) = \int_{X_{min}}^{X_{max}} \frac{d\sigma}{dx}(H_M N \to H_M X) = \tag{4}$$

$$= \sigma^{in}(MN) - \sigma_{diff}(MN) \equiv \sigma$$

where $X_{min} = \frac{m}{\sqrt{s}}$ is a minimum value of variable X in the lab system; X_{max} is a maximum value of variable X at which non-diffractive inelasti interactions take place.

$\sigma_{diff}(\pi(K)N)$ = 3.3 (3) mb are the diffractive dissociation cross sections [5] in the 100 GeV energy range.

$$\sigma^{in}(\pi N) = 20 \text{ mb}; \qquad \sigma^{in}(K^+N) = 16.3 \text{ mb}; \qquad \sigma^{in}(K^-N) = 18 \text{ mb}$$

Like in Ref. [3] we assume the spectrum of $MN \to H_M X$ reaction to be independent of X, namely

$$\frac{d\sigma}{dx}(\pi(K)N \to H_M X) = \sigma = 17\,(14)\ mb$$

The spectra $\frac{d\sigma}{dx}(H_M N \to H_M X)$ in all the subsequent acts of inelastic collision of excited H_M hadronic state with nucleus nucleons were chosen in an analogous way, i.e. scaling is assumed valid in elementary processes. Below we shall show that the calculated inclusive hadron spectra on nuclei are low-sensitive to the choice of the form of elementary spectra entering to (4).

The calculations of the "effective nucleon numbers" were performed in the Fermi model for one-particle nuclear density with the use of parameters from Ref.[6]. To compare the calculated spectra (integrated over $P_\perp$) with the experimental ones (at fixed $P_\perp$ = 0.3 GeV/c) we present the inclusive spectrum on nucleus in a factorized form:

$$\frac{d\sigma}{dx\,d^2p_\perp} = \frac{e^{-\frac{p_\perp^2}{\langle p_\perp^2\rangle}}}{\pi\langle p_\perp^2\rangle}\,\frac{d\sigma}{dx} \qquad (5)$$

where the proportionality factor $C = \frac{e^{-\frac{p_\perp^2}{\langle p_\perp^2\rangle}}}{\pi\langle p_\perp^2\rangle}$ is independent of both the target atomic number and x.

Figs 1-10 present the inclusive spectra on nuclei as calculated according to expressions (1)-(4) with the use of (5); here the value of coefficient for all $M \rightarrow h$ processes considered lies within the limits $C = 1 \pm 0.2$. which does not contradict the values of mean-square transverse momenta of registered hadrons.

To estimate the sensitivity of calculated spectra to the choice of the form of elementary spectra (4), we have carried out also calculations using a parametrization

$$\frac{d\sigma}{dx}(\pi(K)N \rightarrow H_M X) = \frac{d\sigma}{dx}(H_M N \rightarrow H_M N) = 12x^2(1-x) \qquad (6)$$

Fig.11 illustrates the inclusive spectra of $\pi + Ag \rightarrow \pi^+ X$ and $\pi^+ Al \rightarrow \pi^+ X$ reactions using the constant spectrum (solid curve) and (6) (dotted line).

As is shown in Figs 1-10, the proposed model [3] allows, like in case with $pA \rightarrow hX$ reactions, to describe satisfactorily the experimental data in meson-nucleus interaction.

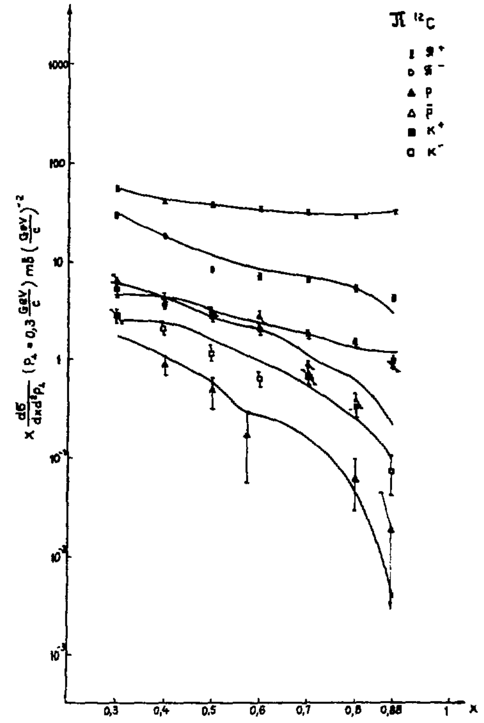
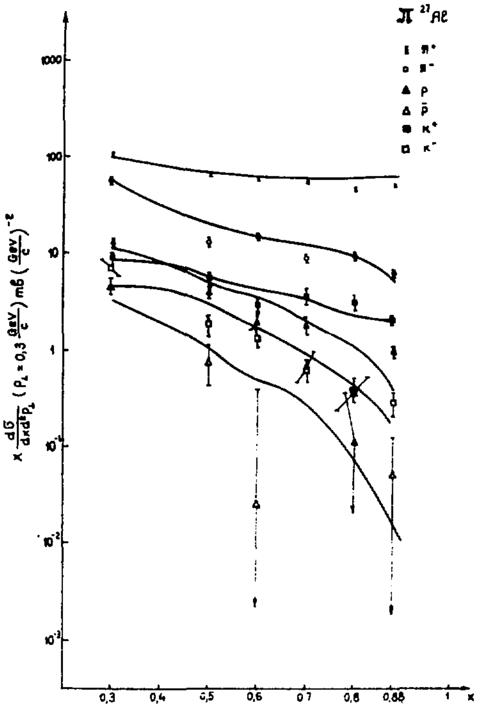
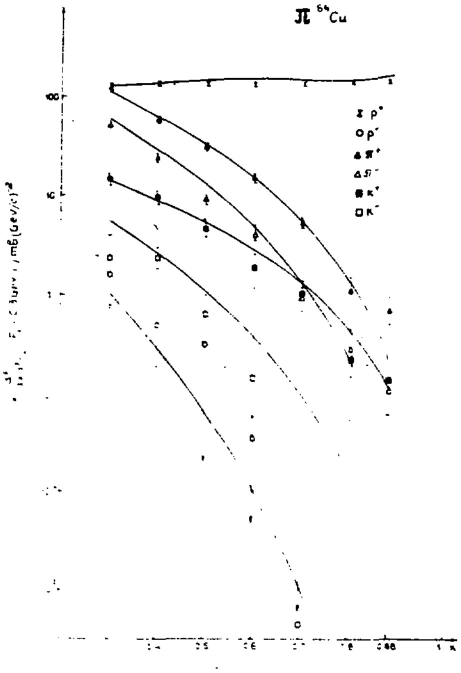

π ¹²C
π⁺
π⁻
p
p̄
K⁺
K⁻
1000
100
10
1
10⁻¹
10⁻²
10⁻³
x dσ/dxd²p⊥ (p⊥ = 0,3 GeV/c) mb (GeV/c)⁻²
0,3
0,4
0,5
0,6
0,7
0,8
0,88
1
x

Fig.1



π 27Al
π+
π−
p
p̄
K+
K−
x dσ/dxd²p⊥ (p⊥ = 0,3 GeV/c) mb (GeV/c)^−2
1000
100
10
1
10^−1
10^−2
10^−3
0,3
0,4
0,5
0,6
0,7
0,8
0,88
1
x

Fig.2



π 64Cu
p+
p−
π+
π−
K+
K−
mb (GeV/c)^−2
100
10
1
0,4
0,5
0,6
0,7
0,8
0,88
1
x

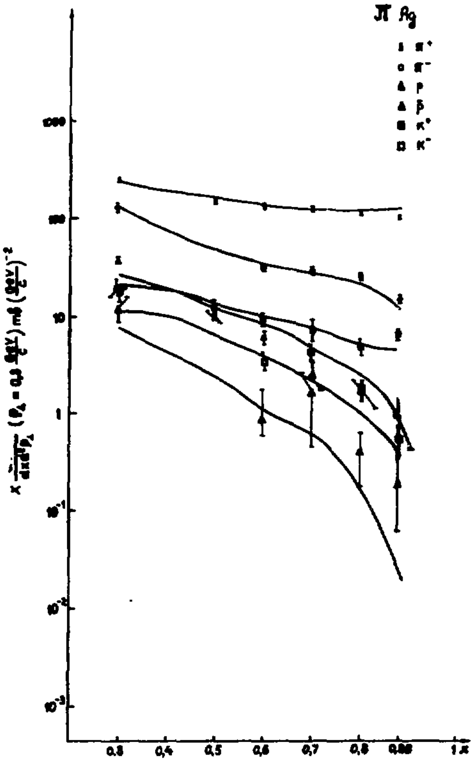

π Ag
π+
π−
p
p̄
K+
K−
1000
100
10
1
10^{-1}
10^{-2}
10^{-3}
$x \frac{d\sigma}{dx\,d^2p_\perp}$ ($p_\perp$ = 0,3 GeV/c) mb $(\frac{GeV}{c})^{-2}$
0,3
0,4
0,5
0,6
0,7
0,8
0,88
1 x

Fig.4

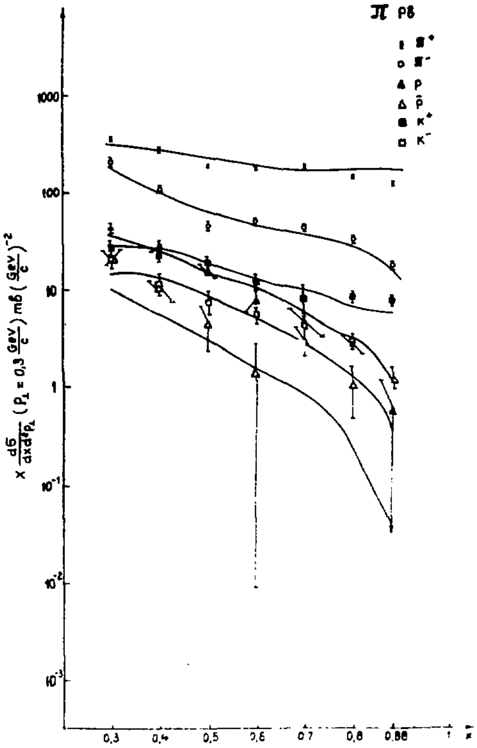

π Pb
π⁺
π⁻
p
p̄
K⁺
K⁻
$x \frac{d\sigma}{dx\,d^2p_\perp}$ ($p_\perp$ = 0,3 $\frac{GeV}{c}$) mb $\left(\frac{GeV}{c}\right)^{-2}$
1000
100
10
1
10^{-1}
10^{-2}
10^{-3}
0,3
0,4
0,5
0,6
0,7
0,8
0,88
1
x

Fig.5

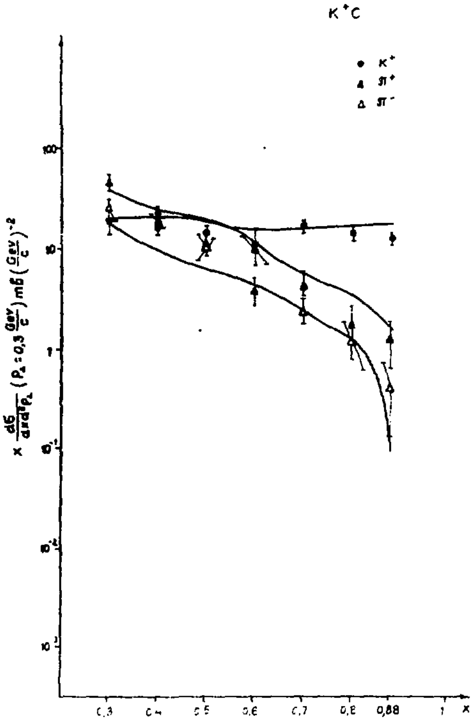
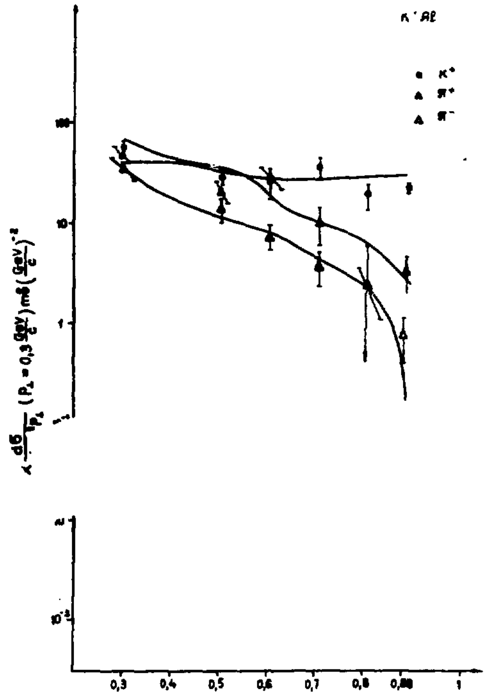
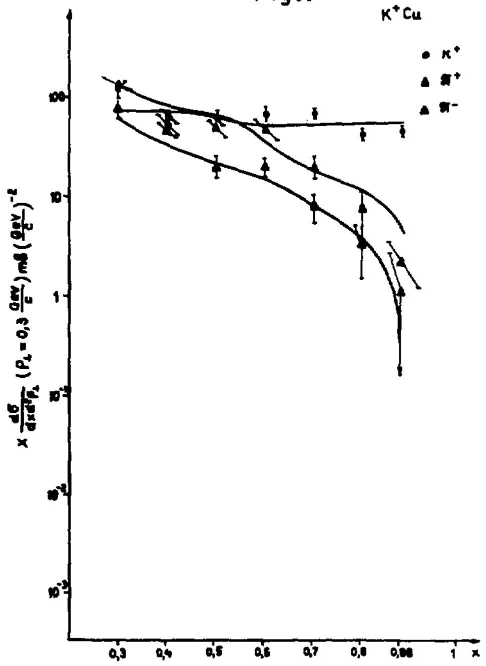

K^+C
● K^+
▲ π^+
△ π^-
$x \frac{d\sigma}{dx\,d^2P_\perp}\left(P_\perp = 0{,}3\,\frac{GeV}{c}\right)\,mb\left(\frac{GeV}{c}\right)^{-2}$
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0,3
0,4
0,5
0,6
0,7
0,8
0,88
1
x

Fig.6



K^+Al
● K^+
▲ π^+
△ π^-
$x\frac{d\sigma}{d^2p_\perp}\left(p_\perp = 0{,}3\ \frac{GeV}{c}\right) mb\left(\frac{GeV}{c}\right)^{-2}$
100
10
1
10^{-3}
0,3
0,4
0,5
0,6
0,7
0,8
0,88
1

Fig.7



K^+Cu
● K^+
▲ π^+
△ π^-
$x\frac{d\sigma}{dx\,d^2p_\perp}\left(p_\perp = 0{,}3\ \frac{GeV}{c}\right) mb\left(\frac{GeV}{c}\right)^{-2}$
100
10
1
10^{-1}
10^{-2}
10^{-3}
0,3
0,4
0,5
0,6
0,7
0,8
0,88
1
x

Fig.8

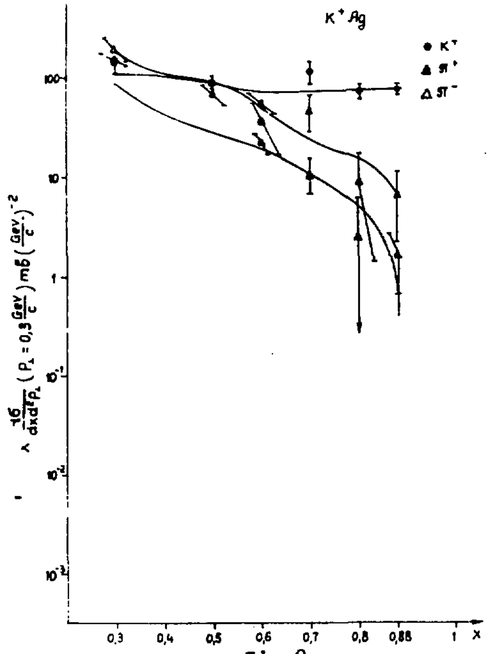

K⁺Ag
● K⁺
▲ π⁺
△ π⁻
x dσ/dx d²p⊥ (p⊥ = 0,3 GeV/c) mb (GeV/c)⁻²
100
10
1
10⁻¹
10⁻²
10⁻³
0,3
0,4
0,5
0,6
0,7
0,8
0,88
1
x

Fig.9

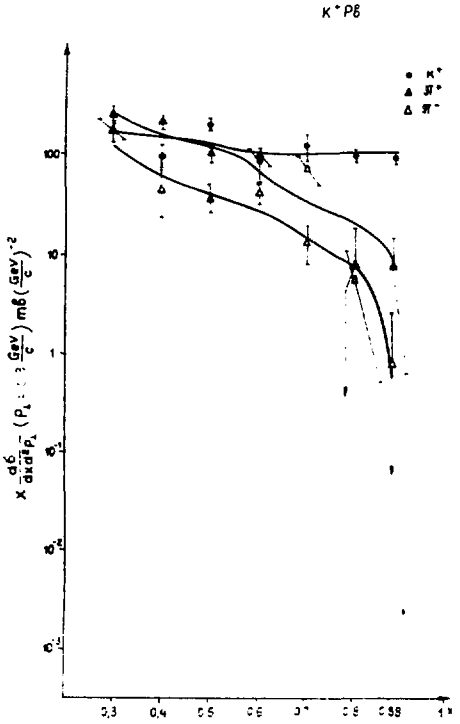

K⁺Pb
● K⁺
▲ π⁺
△ π⁻
x dσ/dx d²p⊥ (p⊥ = 0,3 GeV/c) mb (GeV/c)⁻²
100
10
1
10⁻¹
10⁻²
10⁻³
0,3
0,4
0,5
0,6
0,7
0,8
0,88
1
x

Fig.10

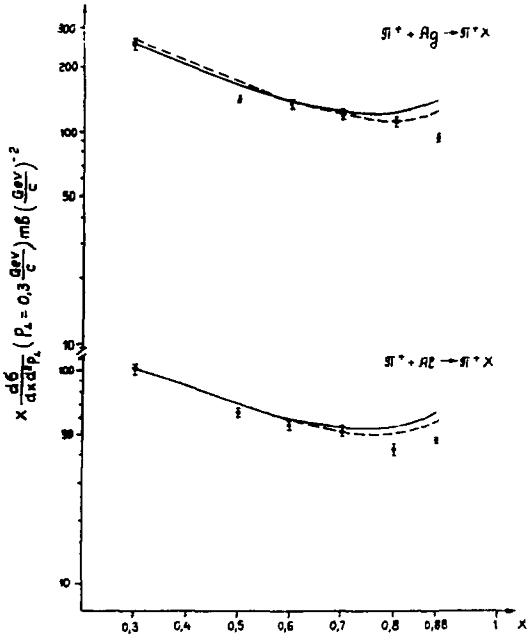

$x\frac{d\sigma}{dx\,d^2p_\perp}\left(p_\perp = 0{,}3\,\frac{GeV}{c}\right) mb\left(\frac{GeV}{c}\right)^{-2}$
$\pi^+ + Ag \rightarrow \pi^+ X$
$\pi^+ + Al \rightarrow \pi^+ X$
300
200
100
50
10
100
50
10
0,3
0,4
0,5
0,6
0,7
0,8
0,88
1
x

Fig.11

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С.Р.ГЕВОРКЯН,Г.Р.ГУЛКАНЯН,Ар.М.КОЦИНЯН,
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ИНКЛЮЗИВНЫЕ СПЕКТРЫ АДРОНОВ ПРИ СТОЛКНОВЕНИИ
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