Structure of inclusive distribution in the longitudinal rapidity in the 20–200 GeV region

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Equality of the normalized inclusive cross sections for the production of particles by hadrons on nucleons and nuclei is observed in the distribution in the longitudinal rapidity. The corresponding value of the rapidity increases like the logarithm of the primary-hadron energy.

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We have investigated the behavior of the ratio of the normalized differential cross sections with respect to the rapidity $y = \frac{1}{2}\ln[(E+P_p)/(E-P_p)]$ in inclusive processes of production of pions and fast protons in hadron-nucleus (hA) and hadron-nucleon (hN) interactions:

$$R(y) = \frac{\left(\frac{1}{\sigma_{in}}\frac{d\sigma}{dy}\right)_{hA}}{\left(\frac{1}{\sigma_{in}}\frac{d\sigma}{dy}\right)_{hN}} \tag{1}$$

We used in the analysis experimental data obtained with a propane bubble chamber bombarded by 40-GeV/c π^- mesons[1] as well as results obtained by an emulsion procedure.[2,3]

In the Kancheli multiperipheral Regge model[4] and in the parton two-phase model[5] it is predicted that the inclusive spectra of the high-energy particles produced in hA and hN collisions coincide; starting with a certain rapidity value y_{crit}, the ratio (1) becomes equal to unity at energies $\gtrsim 100$ GeV.

Figure 1 shows the distribution of the ratio (1) in rapidity in the laboratory

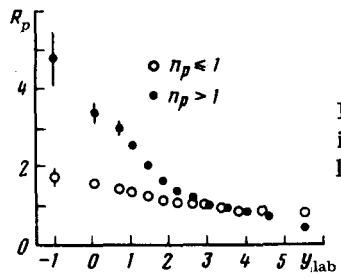

FIG. 1. Ratio of normalized inclusive cross sections in "π^-C" and π^-N interactions at 40 GeV/c vs. the longitudinal rapidity.

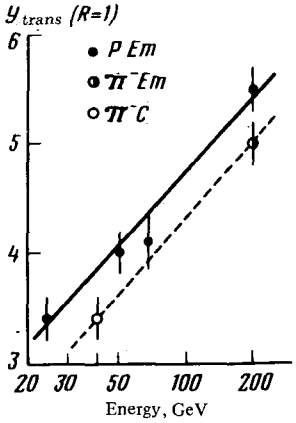

FIG. 2. Dependence of y_{trans} on the energy of the incident hadron in the laboratory frame.

frame of $\pi^{\pm}$ mesons in π^-C^{12} interactions at 40 GeV/c for events with different numbers of protons n_p. The inclusive cross sections were normalized to the cross section of the "πC" interaction with a given proton multiplicity. n_p could be regarded as a parameter that characterizes the number of collisions inside the nucleus. It is seen from Fig. 1 that with increasing y the ratios (1) for both groups decrease and become equal in the region y_{trans} on going through the straight line $R(y)=1$, i.e., the normalized inclusive cross sections are independent at the point y_{trans} of the number of nucleons that take part in the interaction.

The distribution of the ratios of the inclusive cross sections of the s particles in the quasirapidity $\eta=-\ln\tan(\theta/2)$ were obtained in[2,3] for the nuclei of emulsions bombarded by protons with momenta 21, 50, 67, and 200 GeV/c and by π^- mesons with a momentum 200 GeV/c. The distribution in the quasirapidity at small secondary-particle emission angles θ_{lab} practically coincides with the distribution in the longitudinal rapidity.[6] An analysis of the data of[2,3] shows that the normalized inclusive cross sections on a nucleon, a light nucleus, or a heavy nucleus, also become equal at the same value of y_{trans}. We note that according to the parton model[5] $R(y)$ has a dip before the regime $R(y>y_{crit})=1$ is reached, as is indeed observed in experiment at $y>y_{trans}$.

Figure 2 shows the obtained values of y_{trans} for PA and π^-A interactions. The abscissa axis is graduated in the energy of the incident particle in the laboratory frame. The solid and dashed lines are approximations of a straight line of the type $y_{trans}=\ln E+a$. It is seen from the figure that y_{trans} can be regarded as a linear function of $\ln E$ in first-order approximation. Since the maximum rapidity also varies with energy like $\ln E$, it follows therefore that the scale

$$L=y_{max}-y_{trans}, \tag{2}$$

which depends on the type of the incident particle, is constant, with $L_p<L_\pi$ and $L_\pi\sim 3$. It is interesting to note that in the multiperipheral model[7] the fragmentation region of the incident particle behaves similarly and has the same scale L as obtained by us.

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[1]Budapest—Bucharest—Dubna—Krakow—Sofia—Tbilisi—Tashkent—Ulan-Bator—Hanoi Collaboration; Preprint JINR R1-9792, 1976.
[2]Alma Ata—Gatchina—Moscow—Tashkent Collaboration, FIAN Preprint, 1977.
[3]S. A. Azimov *et al.*, Rep. No. A6-446 at Sixteenth Intern. Conf. on High Energy Physics, Tbilisi, 1976.
[4]O. V. Kancheli, Pis'ma Zh. Eksp. Teor. Fiz. **18**, 469 (1973) [JETP Lett. **18**, 277 (1973)].
[5]G. V. Davidenko and N. N. Nikolaev, Yad. Fiz. **24**, 772 (1976) [Sov. J. Nucl. Phys. **24**, 402 (1976)]
[6]V. P. Nikitin and I. L. Rozental', Teoriya mnozhestvennykh protsessov (Theory of Multiple Processes), Atomizdat, 1976.
[7]E. M. Levin and M. G. Ryskin, Materials, 8th Winter School of Leningrad Inst. of Nucl. Phys. on the Physics of Nuclei and of Elementary Particles, Leningrad, 1973, p. 94.