Angular distributions of secondary particles in proton-nuclear interactions at 400 GeV/c

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We have obtained the angular distributions of the secondary charged particles produced in the interaction of 400 GeV/c protons with emulsion nuclei. A comparison of the obtained distributions with analysis data at proton and π-meson momenta 200 GeV/c shows that although the general character of the angular distribution remains the same as before, the average number of particles in the pionization region has increased appreciably.

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The experimental setup was fully identical with that used in the earlier and completed experiments on bombardment of emulsion stacks with protons[1] and negative pions[2] with momentum 200 GeV/c from the FNAL accelerator (Batavia, Ill.). The processing of the stacks bombarded with 400 GeV/c protons is continuing. The present communication, based on an analysis of 1151 events obtained over a total length 420 m of scanned primary tracks is preliminary. These events do not include the so called coherent-production events,[3] but do include events on free hydrogen and on quasi-free nucleons of nuclei.

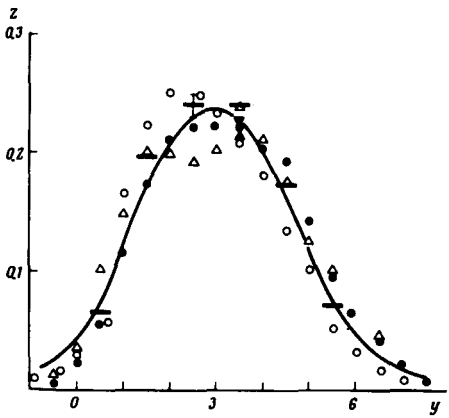

FIG. 1. Distribution of the secondary particles in the rapidity $y(Z = (1/\sigma)(d\sigma/dy))$. Explanations in the text.

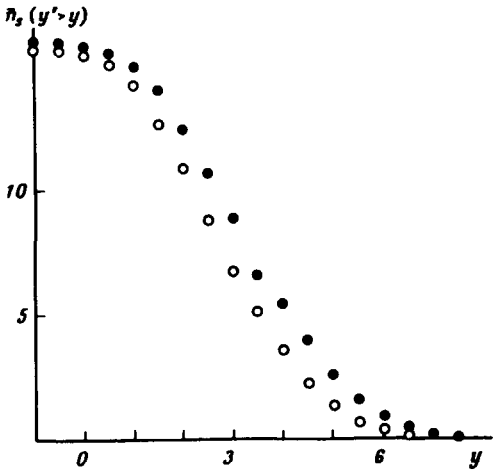

FIG. 2. Distribution of average multiplicities $n_s(y'>y)$. Explanation in the text.

Just as before, we used a function of the emission angle θ of the secondary particle, $y=-\ln\tan(\theta/2)$, which we call rapidity.

The main results of the present study is shown in Fig. 1. The ordinate is the quantity $Z=(1/N)(\Delta N/\Delta y)$, where N is the total number of tracks in all the events and ΔN is the number of tracks per rapidity interval Δy. The solid black circles correspond to the rapidity distribution of 18 thousand secondary particles emitted from the 1151 events due to the 400-GeV/c protons interacting with the emulsion nuclei ($\bar{n}_s=15.9\pm0.3$). The smooth curve corresponds to the hydrodynamic model of multiple production.[4] No quantitative agreement is found ($\chi^2_{89}=1640.3$), although there is a qualitative correspondence.

The solid black rectangles in Fig. 1 give an idea of the angular distribution of the events with large multiplicity ($n_s>16$). In these events the cross section for forward emission of particles (large y) is much lower than for all events. The errors of these distributions are of the same order, since the total number of tracks in the events with $n_s>16$ is of the order of 11 500.

For comparison, the light circles in the Fig. 1 denote the distribution of $\approx 20\,700$ particles in p-nuclear interactions with momentum 200 GeV/c, while the light triangles denote $\sim 63\,000$ particles from π^--nuclear interactions with the same momentum. The errors correspond approximately to the dimension

TABLE I.

Parameter	p—400	p—200	π^-—200
1. Average rapidity $\bar{y}$	3.25 ± 0.05	2.86 ± 0.04	2.99 ± 0.02
2. $\bar{n}_s$ ($y<2.00$)	3.84 ± 0.12	4.18 ± 0.10	3.62 ± 0.06
3. $\bar{n}_s$ ($2.0<y<4.65$)	8.90 ± 0.19	7.56 ± 0.13	6.13 ± 0.07
4. $\bar{n}_s$ ($y>4.65$)	3.19 ± 0.06	1.75 ± 0.03	1.89 ± 0.02
5. $\bar{n}_s$ ($y>5.3$)	1.70 ± 0.06	...	...

of the triangles. A qualitative agreement is observed between the angular distributions in the proton-nuclear interactions at 200 and 400 GeV, and an appreciable deviation from the angular distribution of the secondary particles in π^--nuclear interactions. In this case, an appreciable asymmetry is observed, and even some double hump regions.

The average multiplicity of events with rapidity y larger than a specified value is shown in Fig. 2. (Dark points—400 GeV, light points—proton interacting with Ag or Br nucleus, 200 GeV/c). The total multiplicities practically coincide, but in the rapidity interval from 1 to ≈ 5 the multiplicities at an energy 400 GeV for the entire aggregate of the emulsion nuclei are higher than for heavy emulsion nuclei only at 200 GeV.

The table lists certain characteristics of the angular distributions of the secondary particles for the interaction of 400- and 200-GeV protons and 200-GeV π^- mesons with emulsion nuclei.

It follows therefore that the increase of the multiplicity with increasing energy from 200 to 400 GeV was due mainly to the pionization region.

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[1]Struktura uglovykh raspredeleniĭ livnevykh chastits v proton-yadernykh vzaimodeĭstviyakh pri energii 200 GeV. (Structure of Angular Distributions of Shower Particles in Proton-Nuclear Interactions at 200 GeV Energy), Alma-Ata—Leningrad—Moscow—Tashkent Collaboration, Preprint IFVÉ 23-75, Alam-Ata, 1975.

[2]Mnozhestvennost' i uglovye raspredeleniya v pion-nuklonnykh i pion-yadernykh soudareniyakh pri impul'se 200 GeV/s (Multiplicity and Angular Distributions in Pion-Nucleon and Pion-Nuclear Collisions at a Momentum 200 GeV/sec), Alma-Ata—Gatchina—Moscow—Tashkent Collaboration, Preprint No. 29, FIAN, Moscow, 1976.

[3]Alma-Ata—Gatchina—Moscow—Tashkent Collaboration, Yad. Fiz. **19**, 322 (1974) [Sov. J. Nucl. Phys. **19**, 159 (1974)]; Preprint No. 29 FIAN, Moscow, 1976.

[4]P. Carruthers and Duong van Minh, Phys. Rev. **D8**, 859 (1973).