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NUCLEAR INTERACTIONS OF HIGH ENERGY PROTONS IN NUCLEAR EMULSION

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Inelastic nuclear interactions in nuclear emulsions exposed to 200, 300 and 400 GeV proton beams are investigated. Dependence of inelastic cross sections on A is discussed. It seems to have been generally accepted that N_h-distribution has little dependence on incident energies, but it is shown that the fraction of events without heavily ionizing tracks (N_h=o) increases appreciably with increasing primary energies. Classifying events by number of heavily ionizing particles, the pseudo-rapidity distributions are studied, and the number of shower particles at higher rapidity region is less in central collisions with heavy nuclei compared to that in collisions with small N_h.

1. Introduction. Inelastic interactions of protons with nuclei are studied in Ilford K-5 nuclear emulsion stacks exposed to 200, 300 and 400 GeV proton beams at Fermilab. Some results are already published[1,2,3]. Mainly data are obtained by the along-the-track scanning to avoid selection biases. The number of shower(thin) particles are represented by n_s and the number of heavily ionizing tracks by N_h. Heavily ionizing tracks are those which have grain density more than 1.4 times of plateau ionization particles.

For measurements of emission angles, events within 50μm

from the top or bottom of emulsion plates are excluded.

Followed track lengths, number of obtained events and related quantities are summarized in Table 1.

Proton Momentum (GeV/c)	205	303	400
Track Length (m)	1060	526	1126
No of Inelastic Events	2963	1577	3267
Inelastic MFP (cm)	35.8±0.7	33.4±0.8	34.5±0.6
Fraction of (N_h=0) Events (%)	14.5±0.7	17.8±1.0	19.5±0.8
MFP for (N_h=0) Events (m)	2.47±0.12	1.88±0.11	1.69±0.07

Table 1

2 Mass number dependence of inelastic cross sections. Mean free paths of protons at 200, 300 and 400 GeV with nuclei of nuclear emulsions are shown in Table 1. The ratios of these cross sections to those of p-p inelastic interactions do not depend on primary energies. If, as customarily used, the inelastic cross section is expressed by the form of A^{α}, where A is mass number of target nuclei, α is 0.77±0.01. This approximation seems to fit fairly well and this value is very close to that predicted by Teranaka and Ogata[4]. But, as pointed out by Fukushima[5], data are not on a straight line for wide range of A and convex upward, as shown in Fig. 1. Data are from Belletini et al.[6] and the curve is the predicted one from Fukushima's model. Open circles are total cross sections, closed circles are absorption cross sections and crosses are elastic cross sections. The data

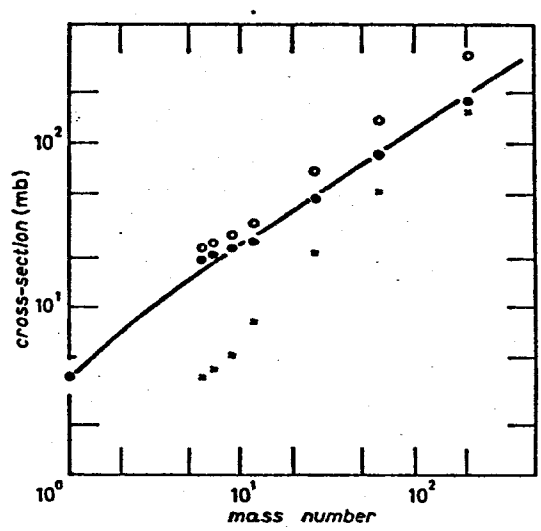

Fig.1

for π-nucleus cross sections also show similar results at 50 GeV[7], 100 and 175 GeV[8].

3 Energy dependence of the fraction of interactions without heavily ionizing tracks. As shown in Table 1, the fraction of events of $N_h=0$ increases markedly from 200 to 400 GeV. Fig. 2 shows the energy dependence of this fraction from much lower energies. Data are from references 9, 10, 11. The number of heavily ionizing tracks has been considered mainly due to residual nuclei, and N_h-distribution has been thought almost independent of incident energy. Usually this distribution is compared in integral form, taking N_h^2 as abscissa and logarithm of fraction as ordinate. This representation is not sensitive for smaller N_h and the energy dependence of this fraction seems to have been overlooked.

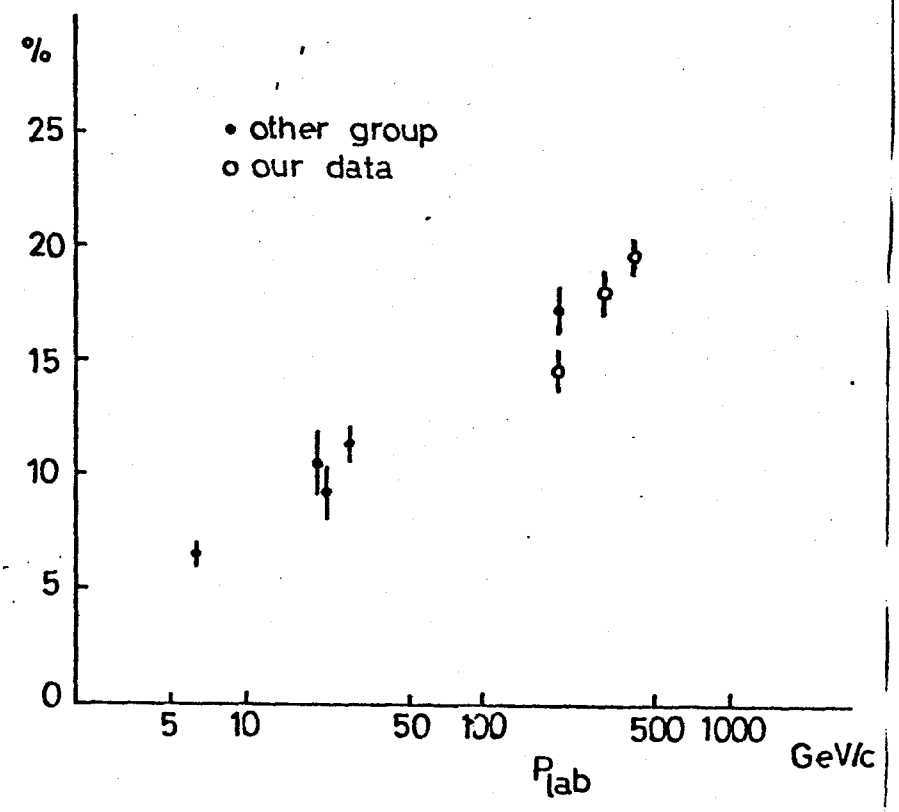

Fig. 2

When the incident energy comes higher, residual nuclei get more kinetic energy and particles which were grey at lower primary energies might become thin particles. This effect may cause some energy dependence at lower primary energies, but increase over 100 GeV is difficult to be attributed to such effect. Any existing model can not explain this energy dependence and new kinds of models on hadron-nucleus collisions are required.

4 Pseudo-rapidity distribution in small angle region. It is often stated that the rapidity distribution of p-nucleus interactions is same as that of p-p interactions in the very forward region(projectile fragmentation region). Many investigations show, however, that in p-nucleus interactions particles in small angle

region are less than those in p-p interactions[12]. The case of 200 GeV is shown in Fig. 3 as an example. Here distributions of pseudorapidity($\eta=-\log(\tan\frac{\theta}{2})$) of p-nucleus interactions subtracted by that of p-p ones are shown. Fig. 3a is for $1\leq N_h\leq 8$ and 3b is for $N_h\geq 9$. This fact is understood intuitively, if we assume that particles produced in the first collision in high rapidity regions have chance to suffer secondary interactions and are lost from these regions. This consideration is supported qualitatively by the observation that for larger N_h the loss is larger, because for larger N_h the number of nucleons participated in multiple-production is expected to be larger. These points require more quantitative investigation.

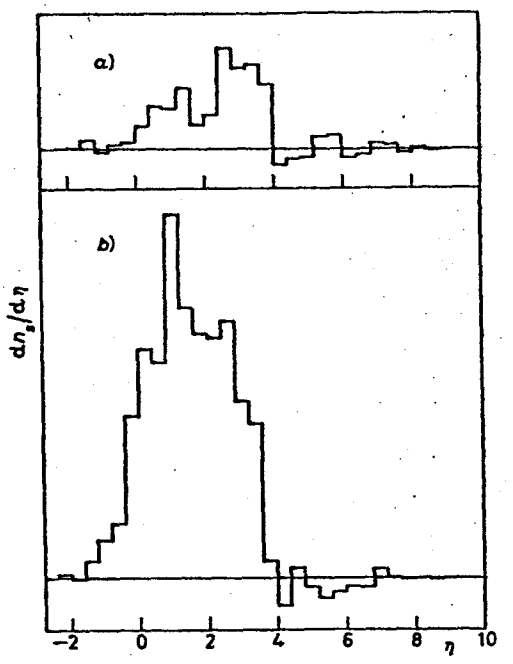

Fig. 3

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