

INTERACTION OF 200 GeV PROTONS WITH HEAVY NUCLEI OF NUCLEAR EMULSION

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The general characteristics of the interaction of 200 GeV protons with emulsion nuclei are given in Refs. 1-3. In the present work the interaction of 200 GeV protons with heavy nuclei of nuclear emulsion has been studied. The mean number $\langle n_g \rangle$ of relativistic tracks and the mean number $\langle N_h \rangle$ of heavy tracks have been determined, as well as the angular distribution of relativistic particles. According to Ref. 4, 85% of relativistic particles are pions, and $\sim 10\%$ are kaons. Using the obtained value of $\langle n_g \rangle$ for the interaction on heavy (Ag, Br) emulsion nuclei, the dependence of $\langle n_g \rangle$ on the incident proton energy and on the atomic number of the target nucleus has been determined.

In this experiment use was made of stack of Ilford K-5 emulsion (a part of the stack belonging to the Barcelona-Batavia-et al. Collaboration) which was exposed to 200 GeV protons in September, 1972. at Batavia. By along-the-track scanning (89.94 m) 263 interactions were detected, from which the proton inelastic mean free path in emulsion was determined to be $\langle \lambda \rangle = (34.20 \pm 2.12) \text{ cm}^{\frac{5}{3}}$. In this work 179 interactions were analyzed (interactions which took place too close to the emulsion surface were not analyzed in order to eliminate the effect of chemical treatment of emulsion on the results of measurement).

According to the criterion given in Ref. 6, all interactions in emulsion may be classified into three groups:

1. Quasinucleon group comprises p-p, p-n and coherent inelastic interactions.

2. "Light" group consists of events with $1 \leq N_h \leq 6$ including black track of a length $R \leq 80\mu$.

3. "Heavy" group consists of events with $1 \leq N_h \leq 6$ having black tracks of a length $R > 80\mu$ ("Heavy T1") and of events with $N_h \geq 7$ ("Heavy T2").

The "Light" and "Heavy" groups comprise only a part of interactions on the C, N, O and Ag, Br nuclei respectively.

The remaining interactions on these nuclei are undefined and belong to the quasinucleon group. In order to derive the characteristics of interactions on heavy (Ag, Br) emulsion nuclei, the "Heavy" group (T1 and T2) should be supplemented by events from the quasinucleon group according to geometric cross-section (of the total number of interactions in emulsion, 5% of interactions take place on H, 25% on the C, N, O nuclei, and 70% on the Ag, Br nuclei). From Table I it may be seen that about 1/6 of the total number of interactions on heavy (Ag, Br) emulsion nuclei belong to the quasinucleon group. Distributions over n_s and N_h are given in Fig. 1.

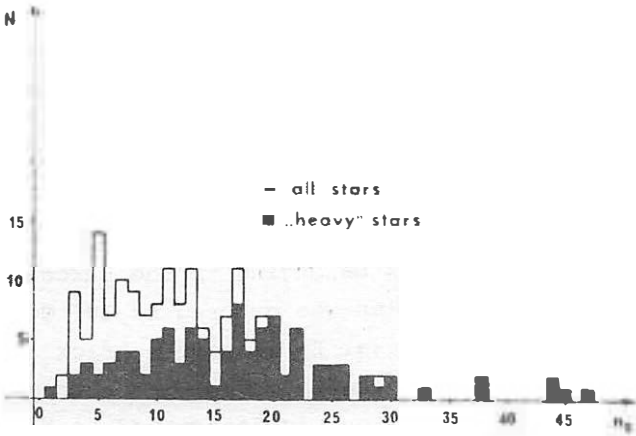


Fig.1.(a) The n_s distribution

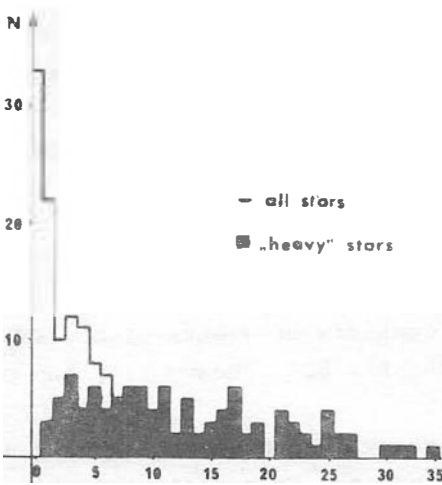


Fig.1.(b) The N_h distribution

TABLE I

Group of interactions	$\langle n_s \rangle$	$\langle N_h \rangle$	Number of interactions
Quasinucleon	8.5±0.6	0.31±0.07	46
"Light"	10.2±1.1	3.1 ±0.3	28
"Heavy T1"	11.7±1.0	3.6 ±0.3	29
"Heavy T2"	19.2±1.1	16.1 ±0.8	76
"Heavy T1 and T2"	17.1±0.9	12.6 ±0.8	105
Ag, Br	15.8±0.8	10.7 ±0.8	125
All interactions	13.8±0.7	7.9 ±0.6	179

According to Gottfried's energy flux cascade (EFC)-model⁷⁾ the ratio

$$R = \frac{\langle n_s \rangle_{pA}}{\langle n_s \rangle_{pp}}$$

(where $\langle n_s \rangle_{pA}$ and $\langle n_s \rangle_{pp}$ are the mean multiplicity in the p-nucleus and p-p interactions respectively) is independent of energy. Using the mean multiplicity determined in a hydrogen bubble chamber, $\langle n_s \rangle_{pp} = 7.65 \pm 0.17^{\beta)}$, it is found that $R_{AgBr} \approx 2.6 \pm 0.15$. If the dependence of the mean multiplicity in p-nucleus interaction on the atomic number of the target nucleus is expressed as $\langle n_s \rangle_{pA} = \langle n_s \rangle_{pp} A^\alpha$, then it is found that for heavy (Ag, Br) emulsion nuclei $\alpha_{AgBr} = 0.159 \pm 0.016$ ($\langle A \rangle_{AgBr} = 94$).

The energy dependence of mean multiplicity in p-nucleus interaction, $\langle n_s(E) \rangle_{pA}$, is logarithmic and may be expressed by a relation of the form¹⁰⁾

$$\langle n_s(E) \rangle_{pA} = a + k \log E$$

where a and K are constants, and E is the energy of the incident proton in GeV. Using experimental data from Ref. 9 and from the present work, we find that for heavy (Ag, Br) emulsion nuclei and at energies $E > 25$ GeV.

$$\langle n_s(E) \rangle_{AgBr} = -4.98 + 8.92 \log E \quad (\text{Fig. 3})$$

From measurement of the angle θ between the direction of the incident protons and secondary relativistic particles the mean value of the variable $U_L = \log|\operatorname{tg}\theta|$ has been calculated for all the groups of interactions ($-\langle U_L \rangle = \log\gamma_C$, where γ_C is the Lorentz factor for transition from the laboratory to the center-of-mass system).

The results obtained are presented in Table II. Figure 2 shows the distribution of $\log|\operatorname{tg}\theta|$, $\theta < 90^\circ$. It may be stated that in the "Heavy" group a larger fraction of relativistic particles in the center-of-mass system are emitted backward, which means that secondary processes are predominant.

TABLE II

Group of interactions	$\langle \log \operatorname{tg}\theta \rangle$	σ
Quasinucleon	-1.07 ± 0.03	0.59
"Light"	-0.88 ± 0.04	0.60
"Heavy T1"	-0.87 ± 0.03	0.62
"Heavy T2"	-0.75 ± 0.02	0.60
"Heavy T1 and T2"	-0.77 ± 0.01	0.60
All interactions	-0.83 ± 0.01	0.61

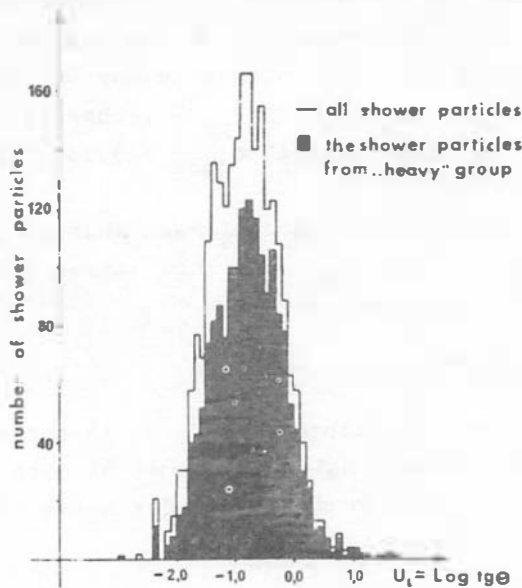


Fig.2. The angular distribution of shower particles

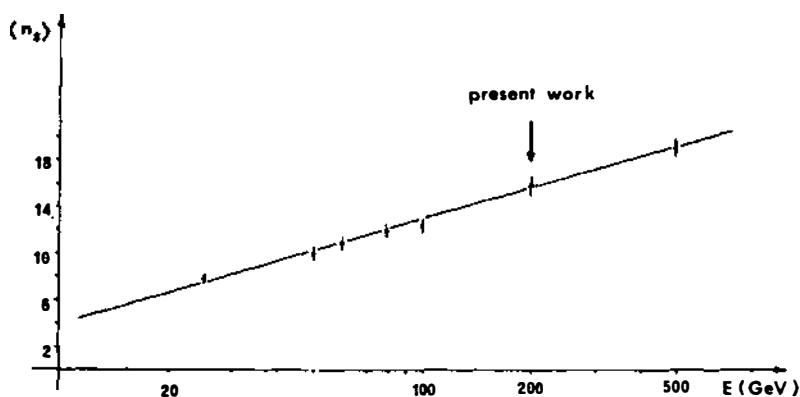


Fig.3. Energy dependence of the $\langle n_s \rangle$ for heavy emulsion nuclei

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