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MEAN FREE PATH OF 4,3 BEV NEGATIVE PIONS IN NUCLEAR EMULSIONS

by

Alfredo Marques, Neusa Margem and G. A. B. Garnier

Centro Brasileiro de Pesquisas Físicas

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I. INTRODUCTION

In the present work we have measured the interaction mean free path of 4,3 Bev π-mesons in nuclear emulsions, and a value of 33,7 $\pm$ 4,7 cm was obtained. This result was compared with those obtained by other others workers in different energy regions; each measured value of the mean free path was converted into an average interaction cross-section for the emulsion nuclei and then plotted as a function of the pion kinetic energy (fig. 1). Within the statistical fluctuations of the observations one can conclude that in the energy range from 750 MeV to about 100 BeV, the average interaction cross-section of the emulsion is roughly constant and is significantly smaller than the one obtained by calculating the geometrical cross-section with a nuclear radius equal to

$\hbar / (M_\pi c) . A^{1/3}$ cm. Agreement with experiment can be obtained by

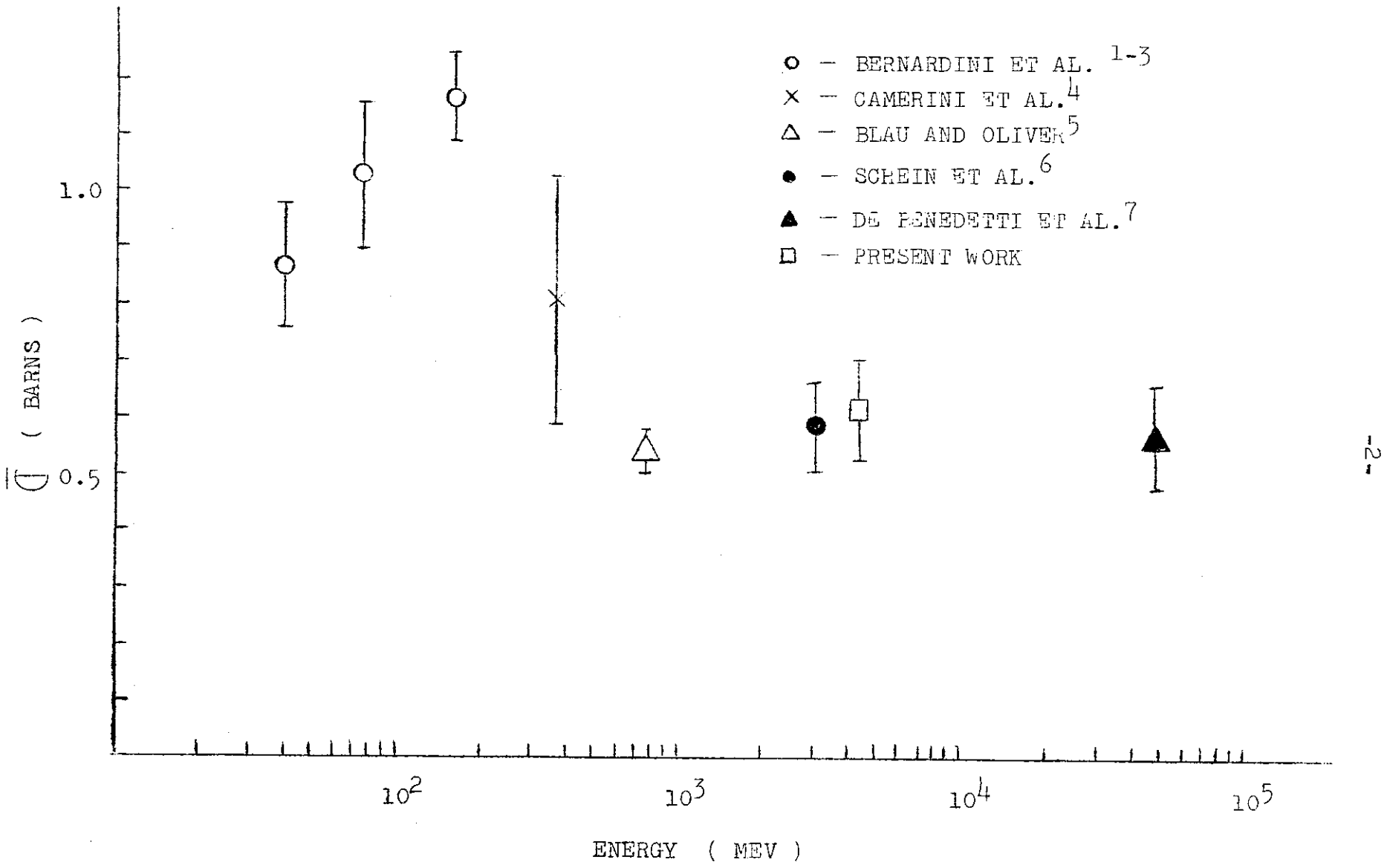
○ — BERNARDINI ET AL. [1-3]
× — CAMERINI ET AL. [4]
△ — BLAU AND OLIVER [5]
● — SCHEIN ET AL. [6]
▲ — DE BENEDETTI ET AL. [7]
□ — PRESENT WORK
1.0
0.5
$\bar{\sigma}$ (BARNS)
10^2
10^3
10^4
10^5
ENERGY (MEV)

Figure 1

taking $1,2.10^{-13}.A^{1/3}$ cm for the nuclear radius.

II. METHOD

Ilford G-5 Nuclear Emulsions, 1000 microns thick, were exposed to the π^- beam of the Berkeley bevatron. The beam was obtained through bombardment of a Be target with 6,2 BeV protons and then magnetically analysed and focussed; the pions kinetic energy impinging on the emulsion was 4,2 BeV.

Tracks with an angular deviation within 5° with the average direction were selected for measurement and their trajectories were followed. Each track was followed back, from the selection point to the point of entrance in the emulsion, in order to ensure that it was not a secondary particle. The number of tracks selected and followed was 885, corresponding to a 18.482 mm track length.

III. EVENTS

57 interactions were observed and they are classified as follows:

a) a pion makes a small angular deviation (smaller than 10°) with the initial direction without any apparent change in ionization; no associated tracks or blobs are observed (4 events);

b) the pion stops in flight without any change in ionization, production of visible secondaries or recoils (1 event).

c) a pion interacts with an emulsion nucleus producing

typical evaporation tracks and lightly ionizating ones (46 events)

d) a pion interacts with an emulsion nucleus and only lightily ionizing secondaries (minimum or gray tracks) are observed (6 events).

The four events found in class (a) were considered to be shadow or, possibly, coulomb scatterings. Collisions with neutrons in the edge of the nucleus, however, could have the appearance of class (a) events.

Four out the six class (d) events had only two lightly ionizing secondaries; only two of these could be analysed, and were shown not to correspond to π^-- p scatterings. In the two remaining class (d) events 3 and 5 minimum ionization secondaries were observed. These events could not be analysed, but they are certainly processes where meson production has occurred; as the number of charged secondaries is odd the collisions involved bound neutrons.

Out of the total of 57 events observed, only 3 could be due to interactions with free protons in the emulsion, i.e., the two not analysed class (d) cases and, possibly, class (b) event. This number is consistent with the expected number of such collisions if we assume that the mean free path for π^-- p interactions of 4,3 BeV pions does not differ sensibly from that at 1,5 BeV[8] (8,7 m). Events of the same nature as class (b) event have, however, been interpreted, at lower energies, as stars where only neutral particles have been emitted [1-3,9]. For the purpose of calculating the average interaction cross-section of the emulsion nuclei (hydrogen excluded) we have taken class (b), class (c) and four out of the six classes (d) events.

The star's distribution in number of prongs is shown in fig. 2 (ordinates in logarithmic scale). For the sake of comparison, events observed at 1,5 BeV[10], normalized to the same total number, have been included. The stars show the same general characteristics; it can be seen that at 4,3 BeV stars with a greater number of visible prongs are more frequent.

IV. RESULTS

A total 18.482 mm pion track length has been observed. The correction for muon contamination in the beam reduced that lenght to 17.873 mm. The resulting interaction mean free path is 33,7 ± 4,7 cm. This result as well as those obtained by other workers in other energy regions are found in fig.1, converted into an average cross-section. This cross-section is related to the interaction mean free path through $\bar{\sigma}_{barns} = 21/\lambda_{cm}$, approximately. The point plotted with pions from cosmic radiation at intermediate energies[4] corresponds to an average energy of 350 MeV, calculated from the measured spectrum of the particles. The point at 40 - 45 BeV was obtained by the Torino group[7] and is related to a jet of particles having momenta between 1 and 200 BeV/c; the mean free path of the pions in the jet was 37 ± 6 cm. The result of this work has been checked against the value which one can compute starting from counter measurements. From the cross-sections of Be, C, Al and Cu for 4,2 BeV pions[11] we have computed the average interaction cross-section of the emulsion and found the value 599 ± 20mb, which is in a good agreement with the experiment.

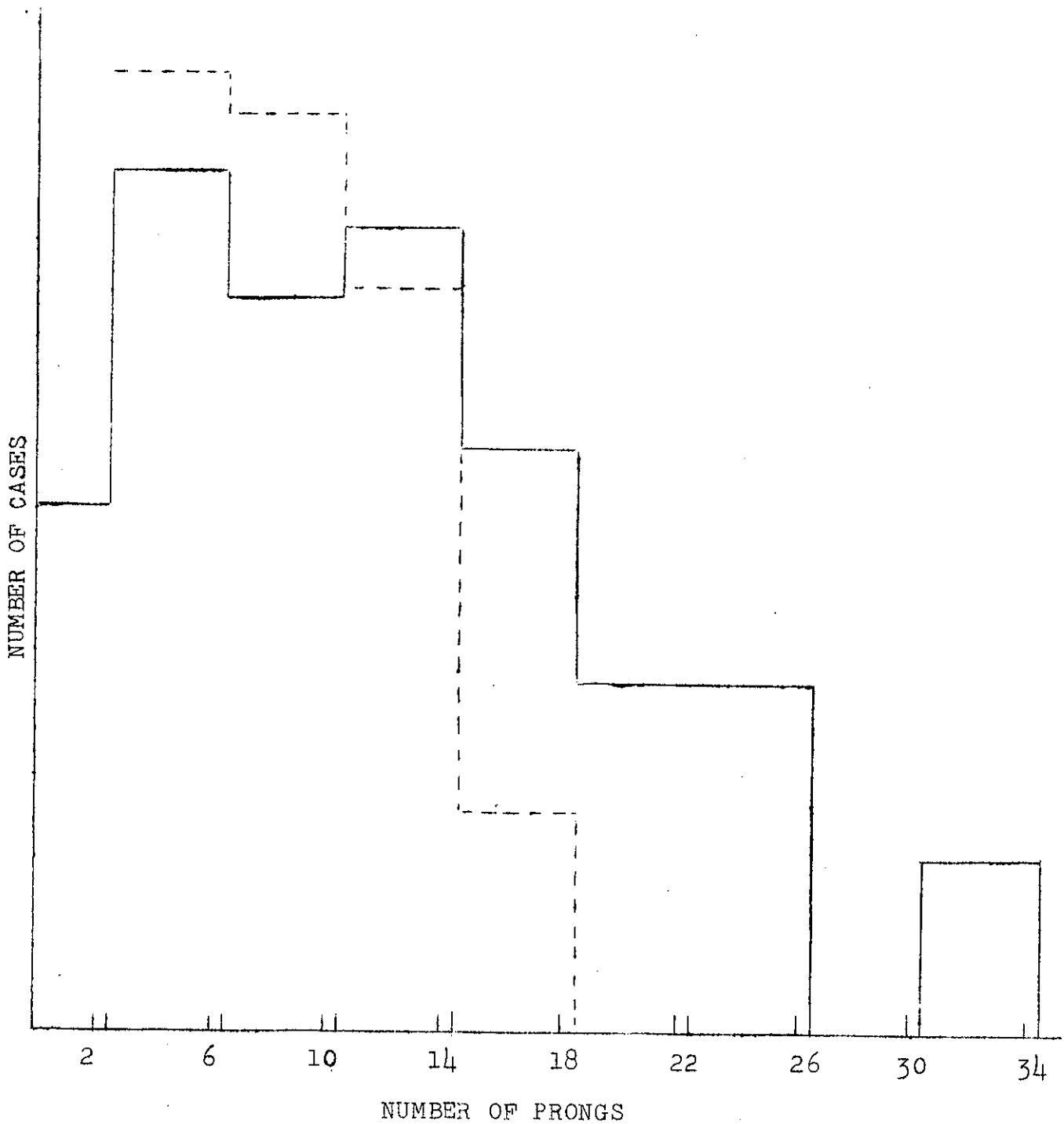

Figure 2

V. ACKNOWLEDMENTS

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