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III-6-9. A Comparison of Pion and Nuclear interactions in Emulsion at Energies between 10^{11} and 10^{13} ev*

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Using a 10 litre stack of pure emulsion flown to 126,000 ft over Texas in the fall of 1959[1], together with the previously published results of the Bristol group[2] and the Chicago 22 litre stack[3] it has been possible to show

1) that the interaction mean free path of jet secondaries is $\frac{4558}{121}=37.7\begin{smallmatrix}+3.7\\-3.2\end{smallmatrix}$ cms which corresponds to a cross section per nucleon of about 20 mb.

2) that the average number of shower particles ($\langle n_s \rangle$) in secondary jets is 12.3±.3 and changes (if at all) only slowly with energy in the energy interval studied.

3) that the average number of shower particles in primary jets produced by minimum ionising particles is 22.5±.4 and in similar energy intervals is about twice that of the secondary jets.

4) that the two distributions in n_s are very different and that for primary jets is in good agreement with the predictions of the Tunnel Theory[4]. These distributions are shown in Figs. 1 and 2.

5) that, for secondary jets the average

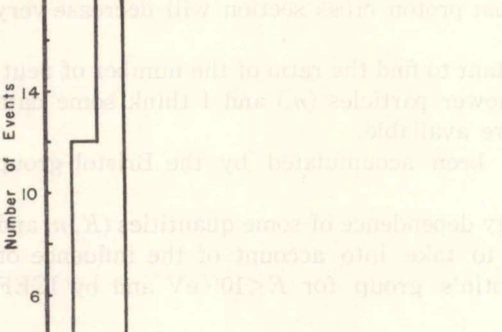

Fig. 1.

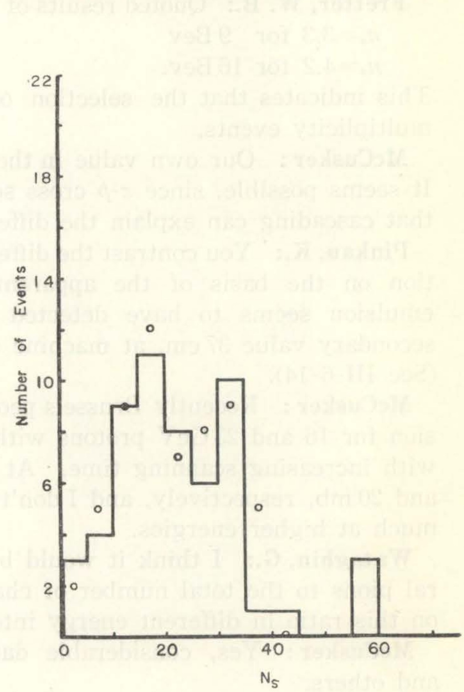

Fig. 2.

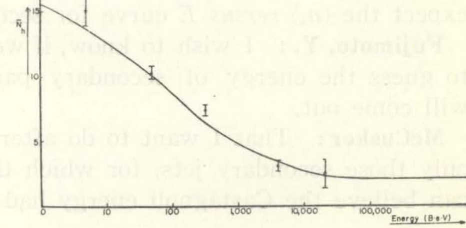

Fig. 3.

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number of heavy prongs ($\langle N_h \rangle$) *decreases* with increasing energy as shown in Fig. 3. A possible explanation of the effect is the decay of a 'fireball' inside the nucleus at low energies and outside at high energies. The solid line in Fig. 3 is the effect computed assuming a single fireball of lifetime, in its own system, of 3×10^{-24} sec. Other explanations however are not ruled out.

References

1) Brisbout, Gauld, McCusker, Malos, Nishikawa, Peak and van Loon: Nuclear Physics (in the press).
2) Edwards, Losty, Pinkau, Perkins, and Reynolds: Phil. Mag. **3** 237.
3) Barkow, Charary, Haskin, Jain, Lohrman, Teucher and Schein: Phys. Rev. **122** 617.
4) Rossler and McCusker: Nuovo Cimento **10** 127.

Discussion

Koshiba, M.: Although you selected the events with $n_s \geq 7$, why didn't you make the correction for $\langle n_s \rangle$?

McCusker, C. B. A.: The correction factors for higher energies are not certain, but this correction will not change appreciably the general tendency.

Fretter, W. B.: Quoted results of multiplicity in π^--p interactions at Dubna and CERN

$n_s=3.3$ for 9 Bev

$n_s=4.2$ for 16 Bev.

This indicates that the selection of secondary events is highly biased toward large multiplicity events.

McCusker: Our own value in the 0-10 Bev range is 8.9 ± 1.0. This is for emulsion. It seems possible, since π-p cross sections around 1 Bev are much higher than 20 mb that cascading can explain the difference.

Pinkau, K.: You contrast the difference between pion interaction and nucleon interaction on the basis of the apparent difference in cross section. As far as I know, emulsion seems to have detected the same effective m.f.p. for proton with your secondary value 37 cm, at machine energy in Geneve and at energy $\sim10^{13}$ eV in Bristol (See III-6-14).

McCusker: Recently Brussels people got the value of 27∼28 cm for m.f.p. in emulsion for 16 and 23 GeV protons with CERN machine. I heard that m.f.p. decreased with increasing scanning time. At machine energy p-p and π-p cross sections are 40 and 20 mb, respectively, and I don't think that proton cross section will decrease very much at higher energies.

Wataghin, G.: I think it would be important to find the ratio of the number of neutral pions to the total number of charged shower particles (n_s) and I think some data on this ratio in different energy intervals are available.

McCusker: Yes, considerable data have been accumulated by the Bristol group and others.

Zhdanov, G. B.: When you study the energy dependence of some quantities (K, n_s and others), I suppose it would be worth while to take into account of the influence of asymmetry effect observed by Prof. Dobrotin's group for $E \leq 10^{12}$ eV and by ICEF group for higher energies.

McCusker: I agree with this and we have already started to do this, but I do not expect the (n_s) *versus* E curve for secondary jets to be greatly affected.

Fujimoto, Y.: I wish to know, if we assume constant transverse momentum and try to guess the energy of secondary particles just measuring the angle, what results will come out.

McCusker: That I want to do after coming back to Sydney is this. I will take only those secondary jets, for which the p_t lies between 0.1 and 1 Bev/c, where you can believe the Castagnoli energy had been correct, and do this.