The Interaction of 16.3 GeV $\pi^-$-Mesons with Complex Nuclei.

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Summary. — The interactions of 16.3 GeV negative pions with emulsion nuclei have been examined to test the Castagnoli and Duller-Walker formulae for the determination of the energy of a primary particle from the angular distribution of the secondary particles. It is found that these formulae may be applied with confidence to collisions in which the produced mesons do not interact within the nucleus.

1. — Introduction.

The secondary particles produced in a high-energy interaction have characteristic distributions in momenta and angles in the centre-of-mass system such that on transformation to the laboratory system they are collimated to an extent which depends upon the velocity of the centre of mass. The degree of collimation increases with the velocity of the centre of mass and hence an angle such as the mean angle of emission of the mesons can be used to estimate the velocity of the centre of mass and hence the energy of the primary particle. The Castagnoli formula and the Duller-Walker plot, which are described later, are methods for the study of very-high-energy interactions based on this type of analysis. With the production of high-energy beams of particles by the accelerating machines it has become possible to perform experiments with known primary energies in order to test these methods.

Several attempts have been made to verify the Castagnoli (*) and Duller and Walker (†) formulae by studying the interactions of protons and $\pi$-mesons

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with the complex nuclei of nuclear emulsion. Experiments with protons have been made by Winzeler et al. (2) at 6.2 GeV, by Ciulli et al. (4) at 9 GeV and by Barbaro Galli et al. (5) at 29 GeV. In each case it has been found that the formulae predict the correct value of the velocity for the centre-of-mass system only for events where star sizes are restricted to \( n_s < 4 \) and \( n_s > 4 \). The predicted value of the velocity also decreases with increasing \( n_s \). Pions at 7.3 GeV have been studied by Friedlander et al. (6). The validity of the formula was assumed and the apparent variation of the value of the velocity of the centre of mass was interpreted as a consequence of the interactions of primary mesons with targets in the nucleus whose masses were multiplets of the pion or nucleon masses.

In general, the interpretation of the interactions in the complex nuclei of emulsion is difficult because both the primary particle and its secondary products may interact again in the same nucleus. Thus to observe the pion-nucleon or the proton-nucleon collision it is necessary to devise methods whereby those interactions involving only one collision can be selected. Then the characteristics of meson production can be investigated.

In this paper the results are presented of the observation on the interactions of 16.3 GeV negative pions with complex nuclei. It has been possible to divide the interactions into two groups, according to whether the primary interaction of the pion and a target nucleon is, or is not, followed by the interactions of the secondary mesons. In the group of events where there is an interaction with a single nucleon the Castagnoli and Duller-Walker formulae are found to hold for all star sizes without any restrictions on \( n_s \) or \( n_b \) subject only to a correction allowing for the misclassification of the continuing primary as a secondary meson. The observations of Friedlander et al. are not confirmed.

2. Summary of the Castagnoli and the Duller-Walker formulae.

2'1. The Castagnoli formula. – This formula is based on three assumptions, namely,

i) the interaction is a nucleon-nucleon collision,