Impact Parameter Analysis of Coherent and Incoherent Pion Productions on Nuclei by 11.7 GeV/c $\pi^+$ (*).

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Summary. — Using our complete momentum measurements for 2-, 3-, 4- and 5-pion final states, we have studied the impact parameter structure with the following principal results: 1) evidence is presented for an empirical method that can help in the separation of coherent events on nuclei; 2) incoherent nuclear production exhibits lower-bound impact parameters which systematically decrease with increasing number of produced pions; 3) the experimental $b$-distributions can be very well fitted by a single simple scaled functional form $d\sigma_N(b)/db \propto F(N/f(b))$; this $N$-distribution yields a dispersion divided by an average, at any impact parameter $b$, of about 0.35.

1. – Introduction.

The significance of studying general aspects of high-energy hadronic-collision processes in configuration space has recently become better appreciated. One wants to know whether the intuitive notion that more particles tend to be produced, on the average, the smaller the impact parameter between the initial colliding hadrons is, is true. A further general question concerns the fact that diffraction dissociation of the beam, whatever its detailed dynamical origin be, is essentially a peripheral phenomenon, as one would intuitively expect from a process that is coherent on all the small pieces of matter that compose a nucleon target. Probing more deeply, one may inquire into the nature of the multi-

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Impact parameter analysis as a function of the initial impact parameter. In order to approach these questions empirically, one needs a quantity which provides a consistent (going from one reaction to another) estimate of the relative initial impact parameter, in terms of readily measured quantities in the final multiparticle states. It has been suggested (1,2) that the following simple but approximate expression provides an approximate lower bound for the mean square impact parameter and that its behaviour, in going from one exclusive reaction (with \( n \) pions) to another, may be a reliable guide to the behaviour of the actual mean square impact parameter.

\[
\langle b^2(n) \rangle \geq \left( \sum_{i} (x^2_i - k^2_i/2p^2) \right)^{\frac{1}{2}} \left( \sum_{i,j} x_i x_j \right).
\]

Here the initial centre-of-mass momentum is \( p^0 \), \( k_i \) is the transverse momentum of the \( i \)-th final-state pion, and \( x_i = \frac{2 \cdot p_i}{p} \), where \( p_i \) is the total momentum of the \( i \)-th pion. For a given set of \( x_i \), this formula and the more precise formula (in terms of determinants) given by Webber (1) reduce to the same limit, if the transverse momenta of the \( n \) pions are uncorrelated with each other and with their longitudinal momenta (and thus overall momentum conservation provides the only correlation). We have also utilized the formula in eq. (1) with the sums taken over all \((n - 1)\) final-state particles (2) (using momentum conservation to determine the final momentum of the nuclear target). This results in somewhat larger individual bounds, but the empirical regularities among the bounds described in the next three sections do not depend upon the approximation used. The averages (denoted by \( \langle \cdots \rangle \)) in eq. (1) are taken over all the events for any exclusive reaction, and this formula has been recently applied (2) to \( K^-p \) and \( \pi^-p \) interactions at 10 and 16 GeV/c with the general conclusions (2) that increasingly central collisions involve increasing average multiplicity and that inelastic diffractive scattering occurs near the edge of the proton's interaction region. In this paper we present three new results based upon an impact parameter analysis of our experiments on coherent and incoherent pion productions on nuclei by 11.7 GeV/c \( \pi^- \) and also by 10 GeV/c K. The first result concerns a possible empirical method helping to separate coherent events on nuclei; another result answers the initial general