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Rapidity Space Distribution of Multiparticle Production by Proton–Nucleon Collisions at 70 GeV/*c*

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Abstract

Statistical analyses of the rapidity space distribution for 70 GeV/*c* p–p collisions in photoemulsion plates lend support to the view that multiparticle production due to hadron–hadron interactions proceeds via an intermediate cluster state.

Studies of multiparticle production induced by p–p collisions in photoemulsion have recently attained some importance, for they have strengthened the conviction that high energy hadron–hadron interactions pass through an intermediate state, called a cluster (Burdett *et al.* 1972; Agnese and Watighan 1973; Hanlon *et al.* 1973; Pokorski and Van Hove 1974; Daftari and Roy 1976). Apparent clustering has also been observed at intermediate energies ($P_{\mathrm{lab}} \leqslant 30$ GeV). However, before a framework can be established for clustering in multiparticle production, more experimental information is needed.

The presence of clustering in an inelastic collision is conveniently analysed in terms of the distribution of the rapidity Y of each charged particle of the multiparticle event, where

$$Y = -\ln(\tan\tfrac{1}{2}\theta),$$

with θ the emission angle of the particle measured in the laboratory frame. A group of particles will appear to form a cluster if its extension along the rapidity axis is small compared with the total range of rapidity for all of the constituent particles.

In this note we describe a study of clustering based on the rapidity space distribution obtained from photoemulsion plates exposed to a 70 GeV/*c* proton beam from the Serpukhov accelerator. Two sets of plates were examined, each with dimensions 10 cm square by 600 μm deep. Individual inelastic events were selected, and rapidity measurements were made for each constituent particle. This was done by taking along-the-track scans with a travelling microscope (a Leitz–Wetzler with a Brower travelling stage, using an oil immersion $53 \cdot 1\times$ objective lens and $16 \cdot 8\times$ oculars), starting close to the entrance of the proton beam in the emulsion.

Two hundred showers were examined, comprising clean events only, with no blobs at the point of production. These events did not have electron–positron pairs on the beam track. To ensure that only p–p collisions were examined, we selected events with no more than 3 black and grey tracks in the interaction and with no more than 10 light tracks (Roy and Daftari 1972). Angular measurements were made on all secondary tracks having a grain density $g^* < 1 \cdot 4\, g_{\mathrm{min}}$.

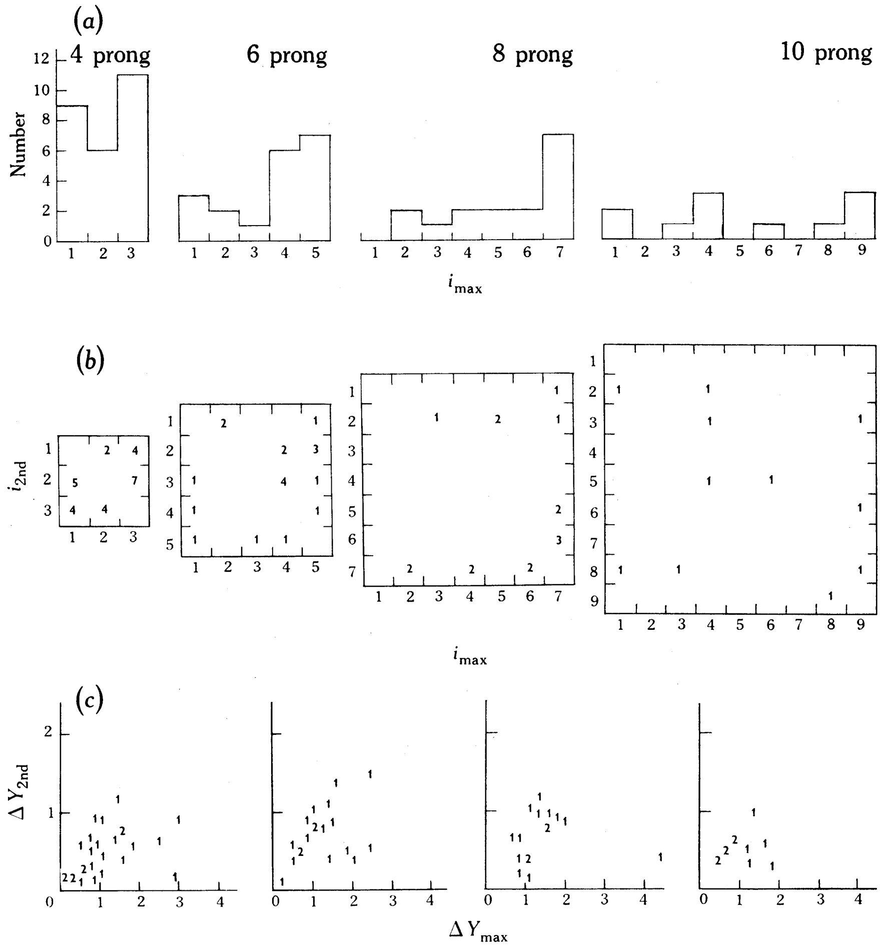

Fig. 1. Distributions for charge multiplicity $n_c = 4$, 6, 8 and 10 (as indicated) of:
(*a*) maximum gap number i_{max},
(*b*) i_{2nd} as a function of i_{max},
(*c*) ΔY_{2nd} as a function of ΔY_{max}.

By ordering the rapidities of each charged particle in an event as

$$Y_1 < Y_2 < \ldots < Y_i < \ldots < Y_{n_c}, \tag{1}$$

where n_c is the charge multiplicity, we obtain a description of the event in rapidity space. We can then examine the first differences, or gaps,

$$\Delta Y_i = Y_{i+1} - Y_i,$$

and select the maximum and second-maximum gaps ΔY_{max} and ΔY_{2nd} and their corresponding ordinal positions (gap numbers) i_{max} and i_{2nd} within the rapidity space distribution.

Fig. 1*a* shows the distribution of i_{max}, Fig. 1*b* shows the correlation between i_{max} and i_{2nd}, and Fig. 1*c* shows the correlation between ΔY_{max} and ΔY_{2nd}, in each case for 4, 6, 8 and 10 prong events. From Fig. 1*a* it is seen that i_{max} is likely to be either 1 or $n_c - 1$, a tendency which holds even for the high multiplicity events. These results are in agreement with those of Homma *et al.* (1976). In addition, the correlation plots of Figs 1*b* and 1*c* are in agreement with the results of Adamovich *et al.* (1975) and Homma *et al.* (1976). They do not support the prediction of multiparticle production based on the multiperipheral model, according to which the spacing among rapidities is expected to be nearly equal, that is, $\Delta Y_{\max} \approx \Delta Y_{2\mathrm{nd}}$. On the other hand, the present results can very well be understood in terms of cluster formation, and they further lend support to the view that multiparticle production in nucleon–nucleon interactions proceeds via this process.

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