ϱ-DOMINANCE IN A MODEL FOR INELASTIC pp-COLLISIONS

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A model of inelastic proton-proton collisions is discussed in which only ϱ-mesons are produced, subsequently decaying into pions in the usual way.

In previous publication [1] we developed a model for the calculation of multiparticle distributions in high energy hadronic collisions. In these calculations isospin conservation was fully taken into account, but, apart from section four, no allowance was made for the production of other than pi-mesons. This omission will now be repaired by considering inelastic proton-proton collisions and assuming that the only particles which are produced are ϱ-mesons, which subsequently decay into pion in the usual way.

Our model contained two parameters, viz. a coupling g and a temperature T. It was shown in [1] that for high energies g^2 had to be a linear function of the average number of produced particles $\bar{n}$. The energy dependence of T, i.e., its dependence on $\bar{n}$ was chosen in such a way that the dispersion of the multiplicity distribution for charged particles was a linear function of the average number of charged particles $\bar{n}_c$.

For the present calculations we again know that a linear relation

$$g^2 = a\bar{n}_c + b, \tag{1}$$

should be obtained. For the parameters a and b we find the values

$$a = 0.103, \quad b = 0.074. \tag{2}$$

As in [1] we also take a linear dependence of T on $\bar{n}_c$

$$T = c\bar{n}_c + d. \tag{3}$$

The quantities c and d are the only parameters of our model and are chosen in such a way that the dispersion of the charged particle distributions at ISR energies 11×11 and 31×31 GeV are in agreement with our theoretical values. We find

$$c = 0.156, \quad d = -0.906. \tag{4}$$

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Now for any input value of $\bar{n}_c$, i.e., for any energy, we can determine with Eqs (1) and (3) the values of g and T and with these values all distributions, moments and correlations can be calculated.

The results of our calculations are as follows:

1. The calculated values of the average charge multiplicity agree within 0.4% with the input values of $\bar{n}_c$.

2. The dispersion of the charged particle distribution plotted as a function of $\bar{n}_c$ is a straight line going not only through the (fitted) experimental values [2] at 11 and

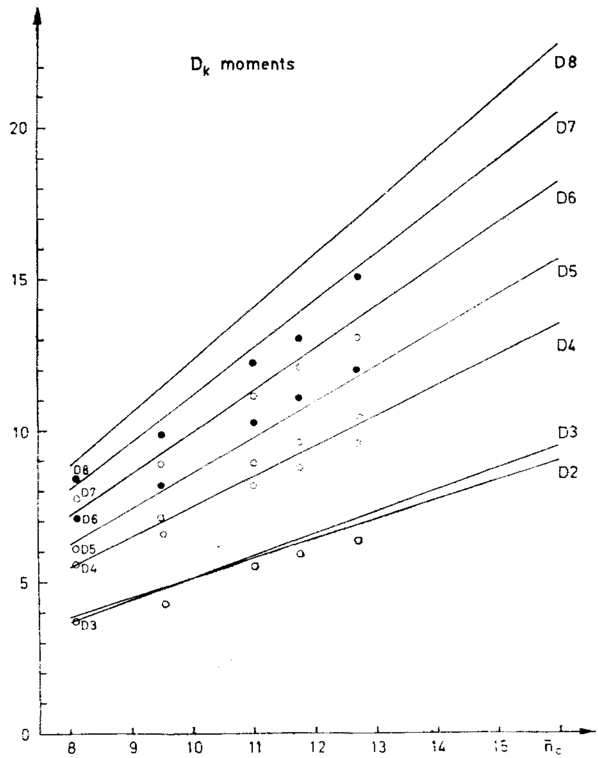

Fig. 1. Central moments of the distribution of charged particles as a function of the average number charged particles

31 GeV/c, but also through the experimental points [2] at the ISR energies of 15, 22 and 26 GeV/c.

3. The central moments D_3 till D_8 are linear functions of $\bar{n}_c$. This is shown in figure 1, together with the data [2]. The agreement is not very good, but two characteristic features common to the experimental and theoretical values should be mentioned.

a) Each central moment is a linear function of $\bar{n}_c$. For sufficiently high energies this implies KNO-scaling. In order to give an idea of how much the KNO-function is changing in the energy range from $\sqrt{s} = 23.6$ GeV till $\sqrt{s} = 101$ GeV, we have plotted it in figure 2.

b) The higher moments have a larger slope. It even appears that the extensions of the straight lines for the moments all intersect in a point for which $\bar{n}_c = 4$ and $D \simeq 1.7$.

4. In figures 3–8 we have plotted our multiplicity distributions for charged particles, together with the data. The last bin shown in each picture, except Fig. 8, includes the contribution of the tail. In this we follow the experimental practice. For each of the

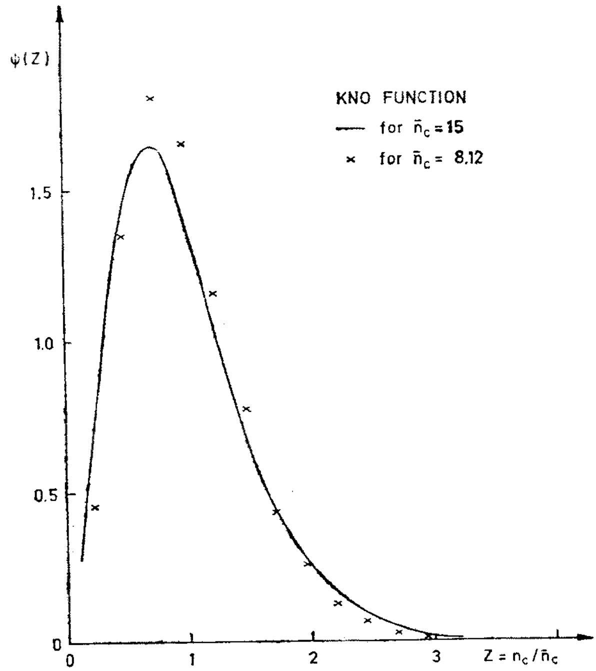

Fig. 2. KNO-function for $\bar{n}_c = 15$ (full curve corresponding to $\sqrt{s} = 101$ GeV) and for $\bar{n}_c = 8.12$ (crosses, corresponding to $\sqrt{s} = 23.6$ GeV)

five ISR-energies we have also calculated χ^2, using the full error matrix [3]. The value of χ^2 divided by the number of data points is indicated in each of the figures 3–7.

5. The distribution of the number of neutral pions consists of two branches, one for an even and one for an odd number of π^0's. In figure 9 we show the combined distribution for $\sqrt{s} = 62.8$ GeV, in which we have added the contributions from $2n_0$ and $2n_0+1$ neutral pions and plotted them in the point $2n_0$. We want to emphasize that the fact that the maximum occurs at $n_0 = 0$, is not in contradiction with the different form of the distribution for the total number of pions, which is shown in figure 10 for the same energy. The dispersion of both the neutral and total distribution is a linear function of $\bar{n}_c$. They are given by

$$D_0 = 0.38\bar{n}_c - 0.65, \quad \text{and} \quad D_{tot} = 0.8\bar{n}_c - 7.35. \tag{5}$$

Also the average number of neutral pions is a linear function of $\bar{n}_c$ and we find

$$\bar{n}_0 = 0.45\bar{n}_c - 0.9. \tag{6}$$

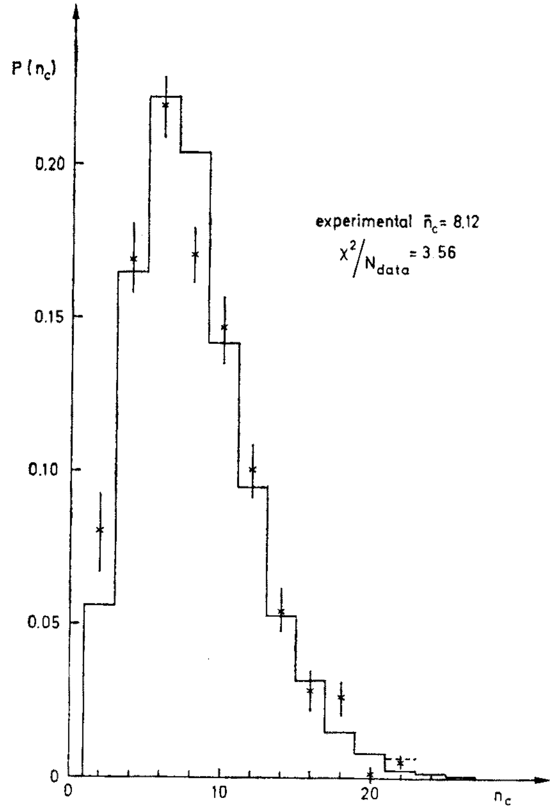

Fig. 3

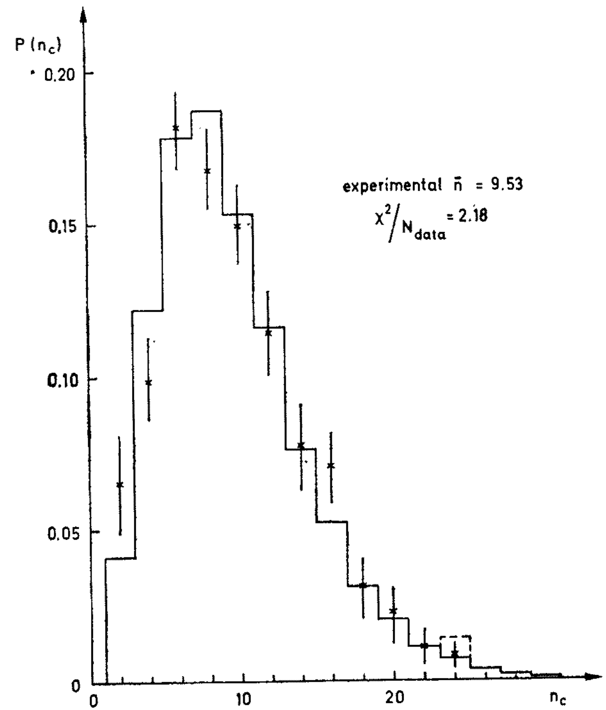

Fig. 4

Fig. 3. Distribution of charged particles. The contribution of the tail is indicated by a dotted line and can therefore be compared with the last experimental point

Fig. 4. Same as Fig. 3

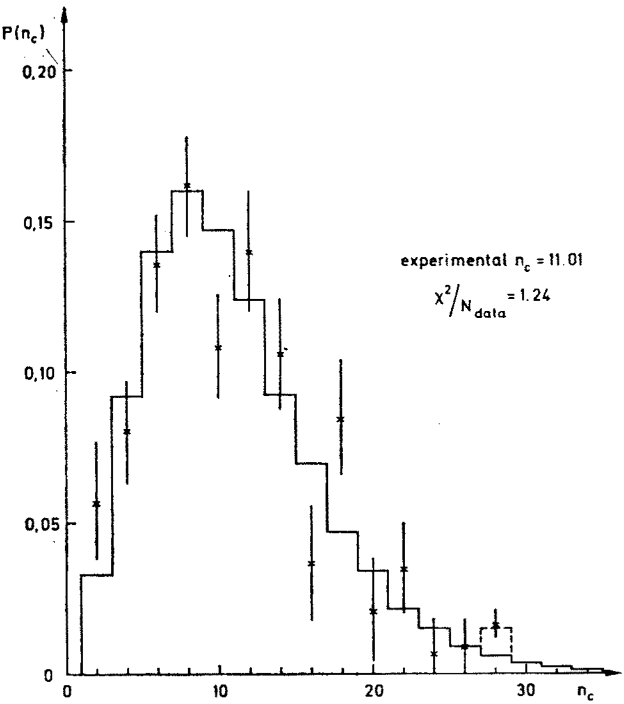

Fig. 5. Same as Fig. 3

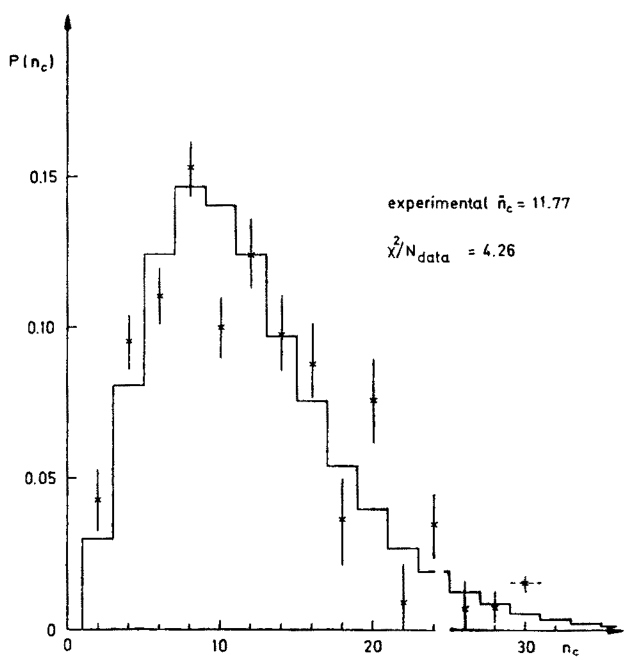

Fig. 6. Same as Fig. 3

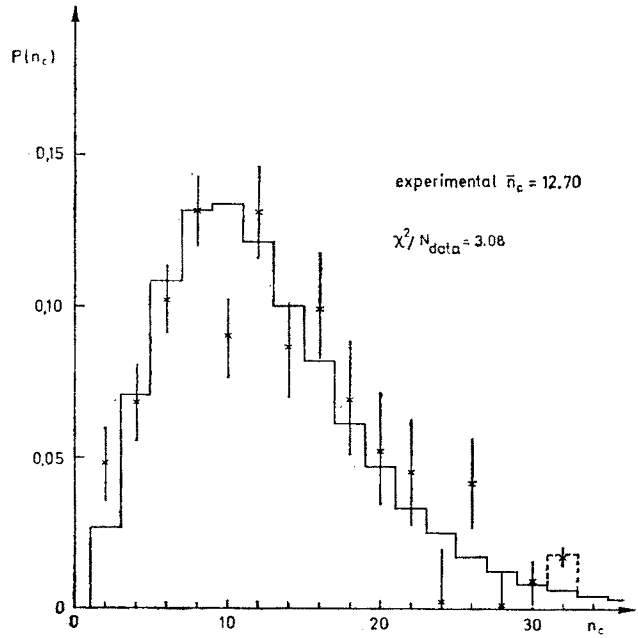

Fig. 7. Same as Fig. 4

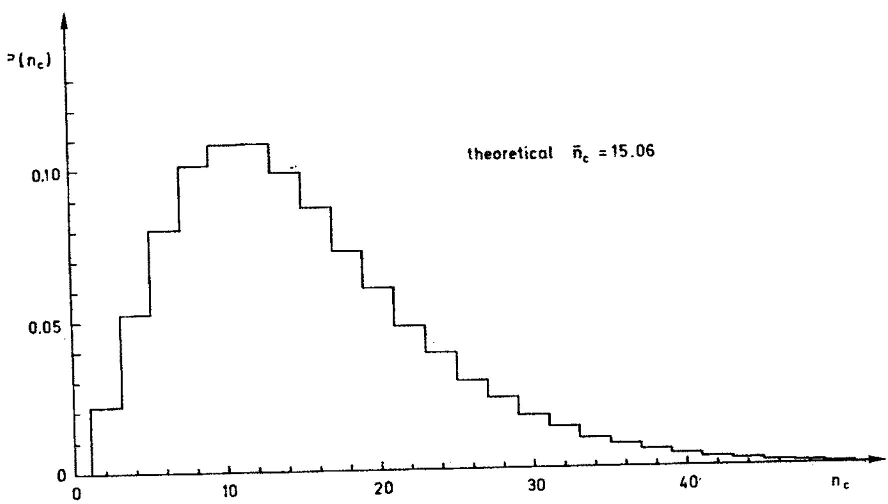

Fig. 8. Distribution of charged particles for $\bar{n}_c = 15.06$ which according to Ref. [4] corresponds to $\sqrt{s} = 101$ GeV

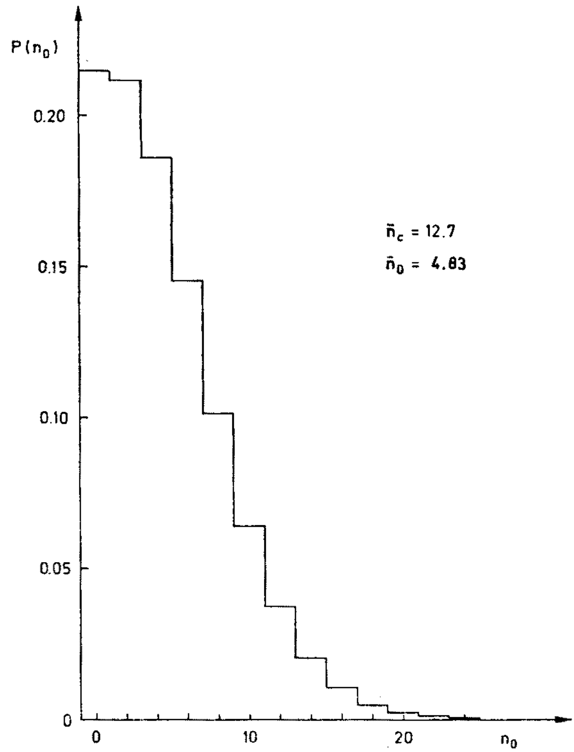

Fig. 9. Combined distribution (see text) of neutral pions for $\sqrt{s} = 62.8$ GeV

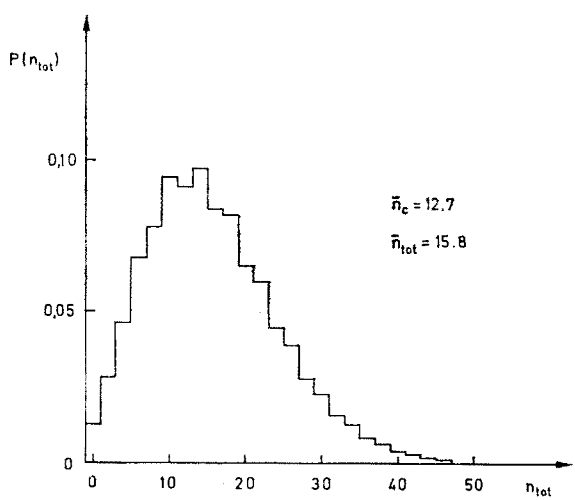

Fig. 10. Distribution of the total number of pions for $\sqrt{s} = 62.8$ GeV

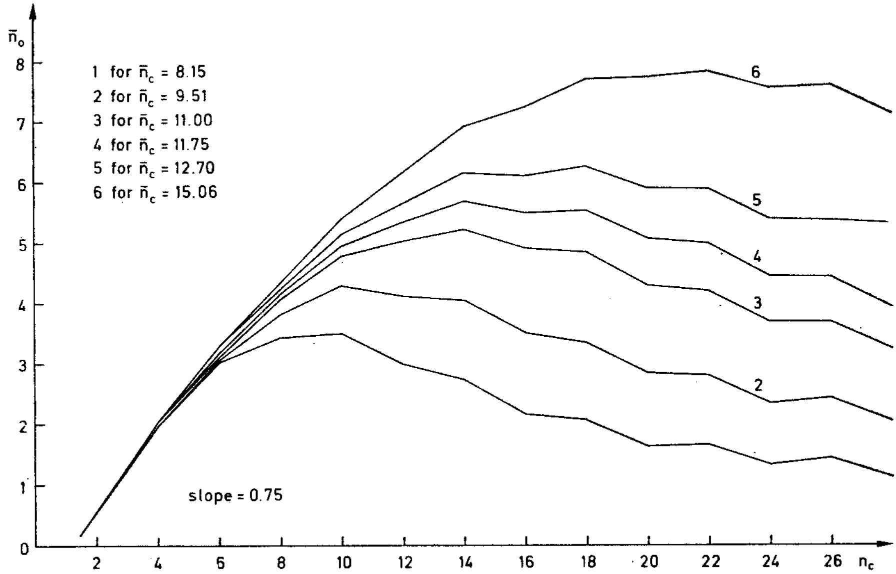

Fig. 11. The average number of neutral pions as a function of the number of charged particles

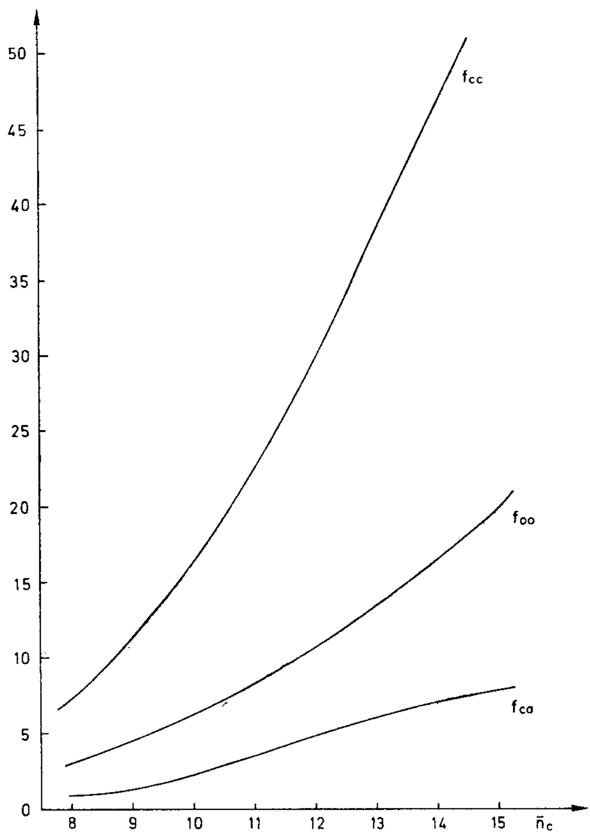

Fig. 12. Correlations as functions of $\bar{n}_c$

From the energy independent value of 1.73 for the average number of protons we obtain furthermore

$$\bar{n}_+ = \tfrac{1}{2}\bar{n}_c - 0.73 \tag{7}$$

together with the trivial relation

$$\bar{n}_- = \tfrac{1}{2}\bar{n}_c - 1 \tag{8}$$

for the average number of positive and negative pions.

6. For six different energies we have calculated and plotted in figure 11 the average number of neutral pions as a function of the number of charged particles. For low n_c-values the curves coincide and are given by the straight line

$$\langle n_0(n_c)\rangle = 0.75n_c - 0.9. \tag{9}$$

7. Figure 12 shows

$$f_{cc} = \overline{n_c(n_c-1)} - (\bar{n}_c)^2, \tag{10}$$

$$f_{00} = \overline{n_0(n_0-1)} - (\bar{n}_0)^2, \tag{11}$$

$$f_{c0} = \overline{n_c n_0} - \bar{n}_c \cdot \bar{n}_0 \tag{12}$$

as functions of $\bar{n}_c$. For f_{cc} also some data are given [2]. For f_{00} and f_{c0} new data will be forthcoming soon from the ISR measurements of neutral pions.

We want to conclude with the remark that in comparing our results with experiment it must be borne in mind that we have considered two extreme cases. In [1] we assumed that only pions were produced, whereas in the present paper we considered the case in which the isovector particles were ϱ-mesons. We expect the truth to lie in between.

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REFERENCES

[1] Z. Gołąb-Meyer, Th. W. Ruijgrok, *Acta Phys. Pol.* **B8**, 1105 (1977).

[2] These data are preliminary results of an ISR experiment. We thank Drs I. Derado and H. Preissner for showing us their data before publication.

[3] We are grateful Dr. H. Preissner for giving us the necessary information on this point, as well as for stimulating discussions.

[4] I. Derado, R. Meinke, H. Preissner, S. Uhlig, HE20: Contribution to XV International Cosmic Ray Conference, Plovdiv, Bulgaria 1977.