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MULTIPLICITIES AND FORWARD-BACKWARD CORRELATIONS IN $\bar{P}P$ INTERACTIONS AT 22.4 GEV/C

Alma – Ata – Dubna – Helsinki – Košice – Moscow – Prague Collaboration

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In this paper we report on the results obtained in a study of multiplicities and forward-backward multiplicity correlations in $\bar{p}p$ -interactions at 22.4 *GeV/c*. About 12000 inelastic events are analysed. Conventional charged particle multiplicity parameters have been published earlier /1/.

1. FORWARD-BACKWARD MULTIPLICITIES

The forward-backward multiplicity distribution is defined /2,3/ by

$$P(n_f, n_b) = \sigma(n_f, n_b) / \sigma_{inel} , \qquad (1)$$

where $\sigma(n_f, n_b)$ is the associated cross section for producing n_f charged particles in the forward and n_b in the backward CM-hemisphere. Dividing this two-dimensional discrete probability distribution into odd (n_f-, n_b-odd) and even (n_f-, n_b-even) parts

$$P(n_f, n_b) = P_{odd}(n_f, n_b) + P_{even}(n_f, n_b) \qquad (2)$$

one gets a rough estimate for diffractive production

$$\sigma_D / \sigma_{inel} \simeq P_{odd} - P_{even}. \qquad (3)$$

This follows from the assumption that diffraction mainly contributes to the odd component of the overall multiplicity distribution. At low energy there may be a significant overlapping between the hemisphere. Thus the diffractive cross section obtained through eq. (3) should be considered as a lower limit. We get the following estimate

$$\sigma_D / \sigma_{inel} = 0.09 \pm 0.02 .$$

The forward-backward multiplicity parameters are shown in *table 1* together with those for the even and odd components. The corresponding KNO-scaling plot [4] is shown in *fig. 1*. We observe that the forward and backward multiplicities lie, within errors, on the same curve which is different from the overall charged particle multiplicity distributions.

Table I

The multiplicity parameters for forward, backward, even and odd components

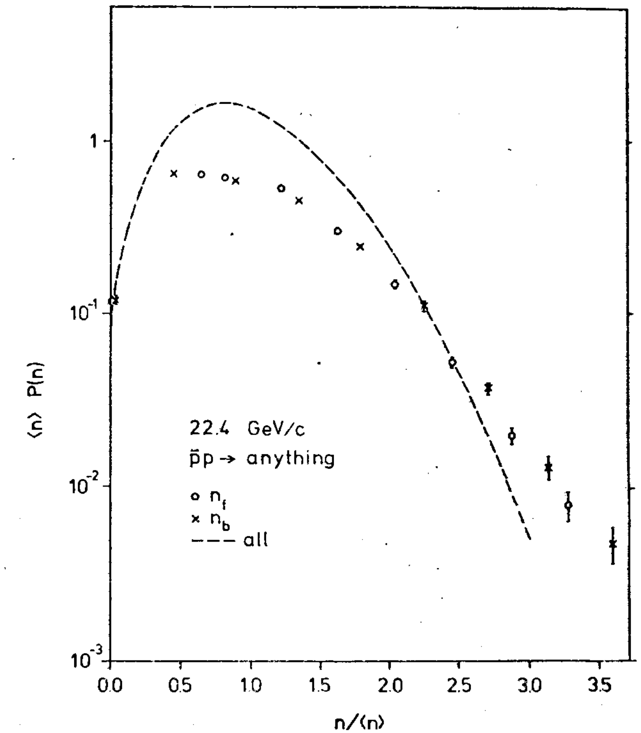
$\langle n_f \rangle$	$D[n_f]$	$\langle n_b \rangle$	$D[n_b]$
2.45±0.06	1.49±0.09	2.28±0.06	1.43±0.09

$\langle n \rangle_{even}$	D_{even}	$\langle n \rangle_{odd}$	D_{odd}
5.00±0.12	2.16±0.20	4.50±0.12	2.22±0.18

2. CORRELATION COEFFICIENTS

To study the forward-backward correlations, we define the coefficient r_i (i = even, odd)

$$r_i = \frac{\langle n_f n_b \rangle_i - \langle n_f \rangle_i \langle n_b \rangle_i}{D[n_f]_i \; D[n_b]_i}, \qquad (4)$$



Plot of $\langle n \rangle P(n)$ *versus* $n/\langle n \rangle$ *for the reaction* $\bar{p}p$ — *anything at 22.4 GeV/c. Shown are the forward* (n_f) *and backward* (n_b) *multiplicities together with the overall charged particle multiplicity distribution (dotted curve) from ref. 1.*

where $D[n_f]_i$ and $D[n_b]_i$ are the dispersions of the multiplicity distributions $P(n_f)$ and $P(n_b)$. The even and odd parts of the probability distribution $P(n_f, n_b)$ are considered separately to avoid trivial correlations arising from charge conservation.

In *table II* we compare our results with those obtained from $\pi^+ p$ – interactions [3]. From this table one can see that the coefficient r_{odd} is systematically bigger than r_{even}. This is naturally

Table II

The forward-backward correlation coefficients. ($\pi^+ p$ data/3/ are included for comparison)

Correlation coefficients	$\bar{p}p$ 22.4 GeV/c	$\pi^+ p$ 8 GeV/c	$\pi^+ p$ 16 GeV/c	$\pi^+ p$ 23 GeV/c
$r_{odd} \times 10^2$	20.0 ± 7.0	-1.0 ± 0.08	3.0 ± 0.4	9.3 ± 0.7
$r_{even} \times 10^2$	6.3 ± 7.9	0.1 ± 1.1	1.8 ± 0.4	5.8 ± 0.9
$(r_{odd} - r_{even}) \times 10^2$	13.7 ± 10.6	-0.9 ± 1.1	1.2 ± 0.6	3.5 ± 1.1

$r^{\bar{p}p}_{odd}$ (22.4 GeV/c) $- r^{\pi^+ p}_{odd}$ (23 GeV/c) $= (10.7 \pm 7.0) \times 10^{-2}$

$r^{\bar{p}p}_{even}$ (22.4 GeV/c) $- r^{\pi^+ p}_{even}$ (23 GeV/c) $= (0.5 \pm 7.9) \times 10^{-2}$.

attributed to the diffractive type of production. When comparing our data with those on $\pi^+ p$ - collisions at nearby incident CM-energy, we observe further that the correlation coefficients $r^{\bar{p}p}_{even}$ and $r^{\pi^+ p}_{even}$ are of the same magnitude while the difference $\Delta r = r_{odd} - r_{even}$ turns out to be bigger in $\bar{p}p$ - interactions (see *table II*). This may reflect a larger contribution of diffraction dissociation in $\bar{p}p$- than in $\pi^+ p$ -interactions, where G -parity conservation forces the incident pion to dissociate into an odd number of pions only.

3. *SIMPLE TWO-COMPONENT PICTURE*

Considering a simple two-component picture /5/ , where one assumes two independent production mechanisms a and b one can deduce the following relations

$$\sigma = \sigma_a + \sigma_b \, , \tag{5}$$

$$\langle n \rangle = \alpha \langle n \rangle_a + \beta \langle n \rangle_b \, , \tag{6}$$

$$D^2 = \alpha D_a^2 + \beta D_b^2 + \alpha\beta (n_a - n_b)^2 \, , \tag{7}$$

where $\alpha + \beta = 1$, $\alpha = \sigma_a / \sigma$, and $\beta = \sigma_b / \sigma$. The linear Malhotra-Wroblewski relation/6/

$$D = A \langle n \rangle - B \tag{8}$$

is easily obtained supposing that one of the components is related to markedly smaller multiplicities than the other one, and the dispersions D_a and D_b are not too large.

If the mechanism b is associated with the component of lower multiplicity, one gets asymptotically

$$A = [\beta / \alpha]^{1/2} \, . \tag{9}$$

E. de Wolf et al./7/ have fitted the data on $\bar{p}p$ - interactions as a function of average charged multiplicity and obtained

$A = 0.42 \pm 0.01$.

It is natural to identify the lower multiplicity class with diffraction dissociation (D) which leads to the asymptotic estimate

$\sigma_D / \sigma_{inel.} = 0.15 \pm 0.01$.

We write for the dispersion of the lower multiplicity class

$$D_D^2 = 6 \langle n \rangle_D - \langle n \rangle_D^2 - 8 \, , \tag{10}$$

where only two and four prongs are considered. Using eqs. (6), (7) and (10), we get

$$\sigma_D / \sigma_{inel.} = \beta P_{odd} \, . \tag{11}$$

The results are given in *table III*. It should be noted that the value of the ratio $\sigma_D / \sigma_{inel.}$ = 0.11 ± 0.03 is of the same magnitude as obtained from eq. (3) whereas the "asymptotic" limit (eq. (9)) turns out to lie higher.

Table III

Estimates of the ratio of the diffractive to the total inelastic cross section and the mean diffractive charged multiplicity

Reaction beam momentum	σ_D / σ_{inel}	$\langle n \rangle_D$
$\bar{p}p$ 22.4 GeV/c	0.11 ± 0.03	2.4 ± 0.9

The following features in $\bar{p}p$ -interactions at 22.4 *GeV/c* have been demonstrated. The magnitude of the correlation coefficients suggests that diffractive production is more abundant in $\bar{p}p$ than in $\pi^+ p$ - collisions. The absolute difference between the correlation parameters does not indicate additional long-range correlations present only in $\bar{p}p$ - collisions. Our data do not support the idea that the KNO-multiplicity scaling could be extended to separate phase space regions giving the same behavious with the overall multiplicity distribution.

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