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E1 - 10909

INVESTIGATION OF TWO-PION CORRELATIONS IN $\bar{P}P$-INTERACTIONS AT 22.4 GeV/c

Alma-Ata-Dubna-Helsinki-Košice-Moscow-
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Боос Э.Г. и др. **E1 - 10909**

Исследование двухпионных корреляций в $\bar{p}p$ -взаимодействиях при 22,4 ГэВ/с

Изучается зависимость от быстрот двухчастичных полуинклюзивных корреляционных функций для пар π-мезонов, образованных в $\bar{p}p$ -взаимодействиях при 22,4 ГэВ/с. В частности, при $y_1 = -y_2 \cong \pm 1.5$ были обнаружены корреляции между π-мезонами с одинаковыми зарядами, что может указать на "периферическое" образование кластеров (резонансов). Работа выполнена на материалах, полученных на жидководородной камере "Людмила".

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна 1977

Boos E.G. et al. **E1 - 10909**

Investigation of Two-Pion Correlations in $\bar{p}p$ -Interactions at 22.4 GeV/c

Two particle semi-inclusive correlations have been studied for like and unlike pion pairs produced in $\bar{p}p$-interactions at 22.4 GeV/c. In particular, positive correlations in like pion pairs have been observed at $y_1 = y_2 = \pm 1.5$ which may indicate a "peripheral" resonance or cluster production.

The investigation has been performed at the Laboratory of High Energies, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna 1977

Despite the fact that a considerable body of data on two-particle correlations is available, particularly in rapidity space, the conclusions on the status of these correlations are still quite uncertain. However, the importance of presenting results in terms of semi-inclusive correlation functions and discriminating between particles of different charges is now well understood (see, e.g., refs. /1-7/). It should be pointed out that simple independent cluster emission models /5-7/ or multiperipheral cluster models "explain" only the most salient features of the data. Besides, the interpretation of the clusters is not clear. A remarkable resonance production in high energy collisions ($\pi_{res}/\pi_{all} \geq 0.5$) /9/ and quite a small charge multiplicity of the cluster decay($K \sim 2$) /10/ suggest the resonance interpretation of the clusters. On the other hand, in some cluster models $K \sim 4$ is obtained /6,11/ and, in addition, the cluster mass (1.5 to 3 GeV) estimated in the multiperipheral models is larger than all prominent boson resonance masses thus indicating that some heavier correlated pion groups can be created /12/.

We present data on the rapidity dependence of the two-particle correlation functions for like and unlike pairs of charged pions in $\bar{p}p$ -interactions at 22.4 GeV/c. Preliminary results have been already reported at the Stockholm and Tbilisi Conferences[13,14]. The data come from a study of 13500 events produced in the 2-m HBC "Ludmila" exposed to a RF-separated antiproton beam at the Serpukhov accelerator. The details of the experimental procedure and event selection can be found in ref.[15] For kinematic calculations all positive particles not identified as protons by ionization (up to a 1.4 GeV/c laboratory momentum) are assumed to be π^+s, and all negative particles, except a part of fast antiprotons with the Feynman variable $x > 0.66$, to be π^-'s. The latter criterion is based on the CP-symmetry, i.e., on a comparison of the reflected π^+ and proton spectra with the c.m.s. spectrum of negative particles. The proton, antiproton and kaon contamination of our pion spectra is estimated to be 5%, 12% and 2.5%, respectively.

For a semi-inclusive process with given numbers p and m of positive and negative pions we use the following popular definition of correlation function in rapidity space:

$$C^{ij}_{pm}(y_1 y_2) = \rho^{ij}_{pm}(y_1, y_2) - \frac{n^i (n^j - \delta_{ij})}{n^i n^j} \rho^i_{pm}(y_1) \rho^j_{pm}(y_2), \qquad (1)$$

where $i, j = \pi^\pm$, $n^i = p, m$ and $\rho^{ij}_{pm} = \frac{1}{\sigma_{pm}} \frac{d^2\sigma^{ij}_{pm}}{dy_1\, dy_2}$, $\rho^i_{pm} = \frac{1}{\sigma_{pm}} \cdot \frac{d\sigma^i_{pm}}{dy}$. The inclusive correlation function can be defined in a similar way and rewritten in terms of the components of semi-inclusive processes (see, e.g., ref.[4]),

i.e.,

$$C^{ij}(y_1, y_2) = \sum_{pm} \omega_{pm} C^{ij}_{pm}(y_1, y_2) + \sum_{pm} \omega_{pm} (\rho^i(y_1) - \rho^i_{pm}(y_1))(\rho^j(y_2) - \rho^j_{pm}(y_2)), \qquad (2)$$

where $\omega_{pm} = \sigma_{pm} / \sum_{p'm'} \sigma_{p'm'}$. The second term here originates from the mixing of the semi-inclusive one-particle spectra and evidently contains no information about dynamical correlations between the produced particles. The first term in eq. (2) allows one to measure the upper limit of the overall correlation.

In $\bar{p}p$ -interactions it is convenient to define

$$\rho^{UNLIKE}(y_1, y_2) = \frac{1}{2}(\rho^{+-}(y_1, y_2) + \rho^{-+}(-y_2, -y_1))$$
$$(3)$$
$$\rho^{LIKE}(y_1, y_2) = \frac{1}{2}(\rho^{--}(y_1, y_2) + \rho^{++}(-y_1, -y_2))$$

and similar expressions for the products of the one-particle densities. According to the CP-symmetry, the terms in parentheses in both eqs. (3) should be equal, i.e., the corresponding correlation functions C^{UNLIKE} and C^{LIKE} should coincide with C^{+-} and C^{--}, respectively.

The inclusive correlation functions plotted in Fig. 1 vs $y_1 = y_2$ show pronounced peaks at $y_1 = y_2 = 0$. However, these peaks are mostly connected with the second terms of the decomposition (2). The semi-inclusive C-functions plotted in Figs. 2 and 3 for the

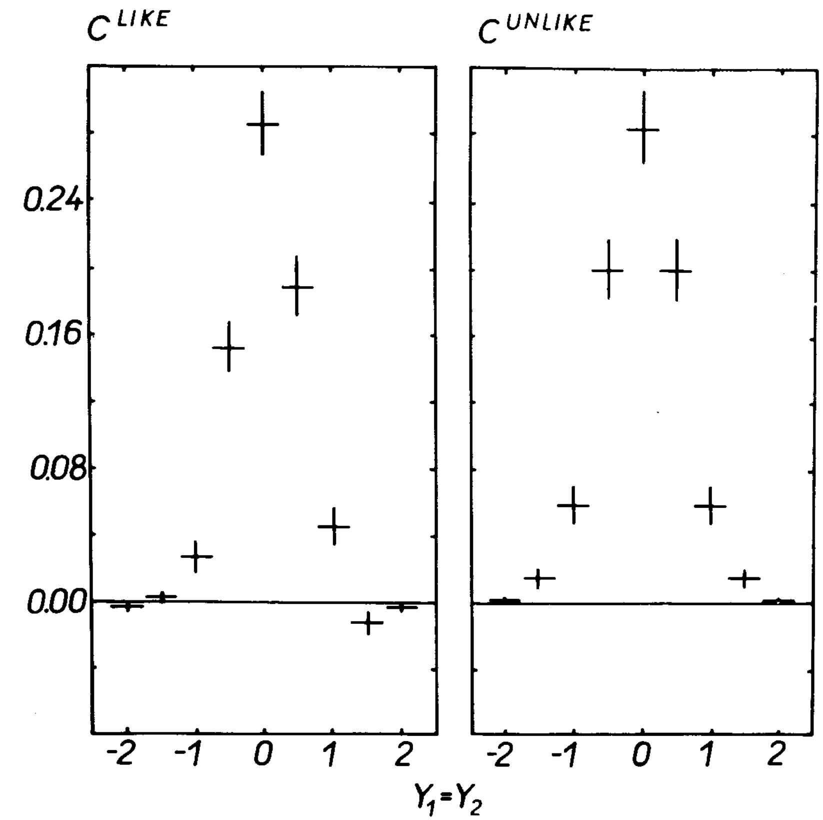

Fig. 1. The inclusive correlation functions $C(y_1, y_2)$ vs $y_1 = y_2$ for unlike and like pion pairs.

multiplicities $N = 6$ and $N = 8, 10, 12$ vs $y_1 = \pm y_2$ also show peaks at $y_1 = y_2 = 0$. but much smaller in magnitude if multiplied by the weights ω_N. We limit the semi-inclusive analysis to charge multiplicities $N \gtrsim \langle N \rangle$ in order to avoid complications due to diffraction and also due to a relatively large proton and antiproton contamination of the pion

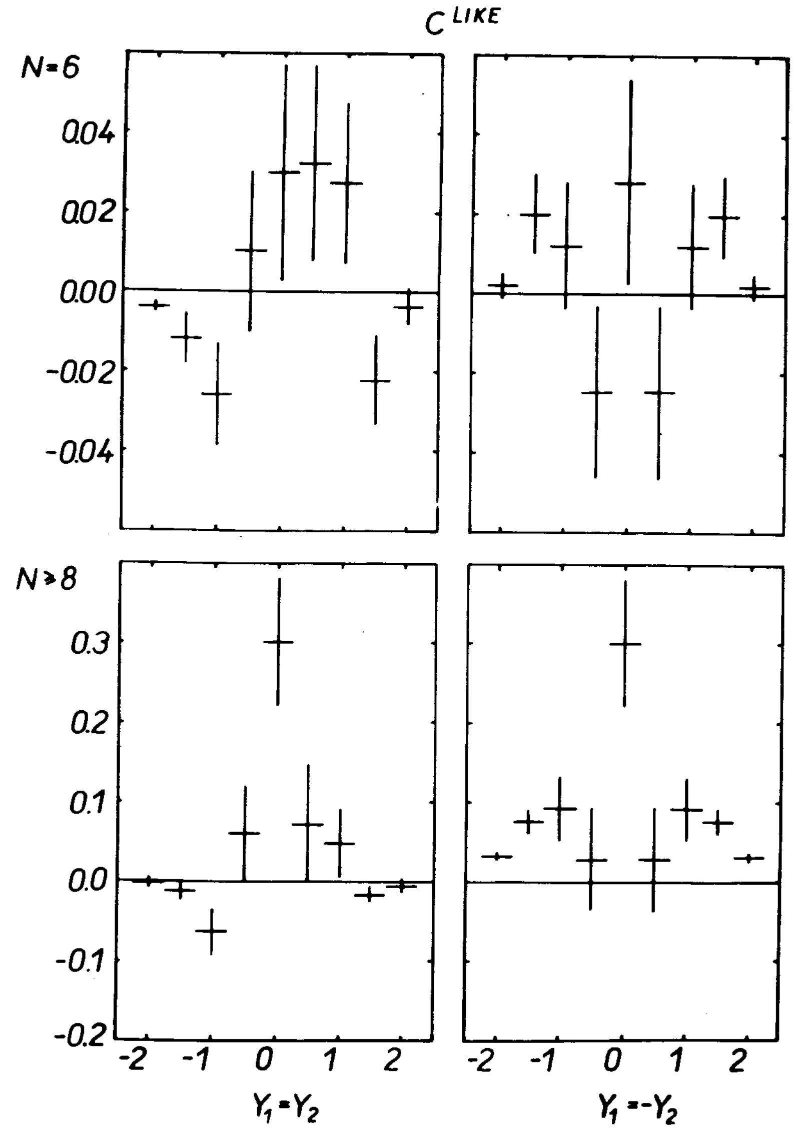

Fig. 2. The semi-inclusive correlation functions $C_N^{LIKE}(y_1, y_2)$ vs $y_1 = \pm y_2$.

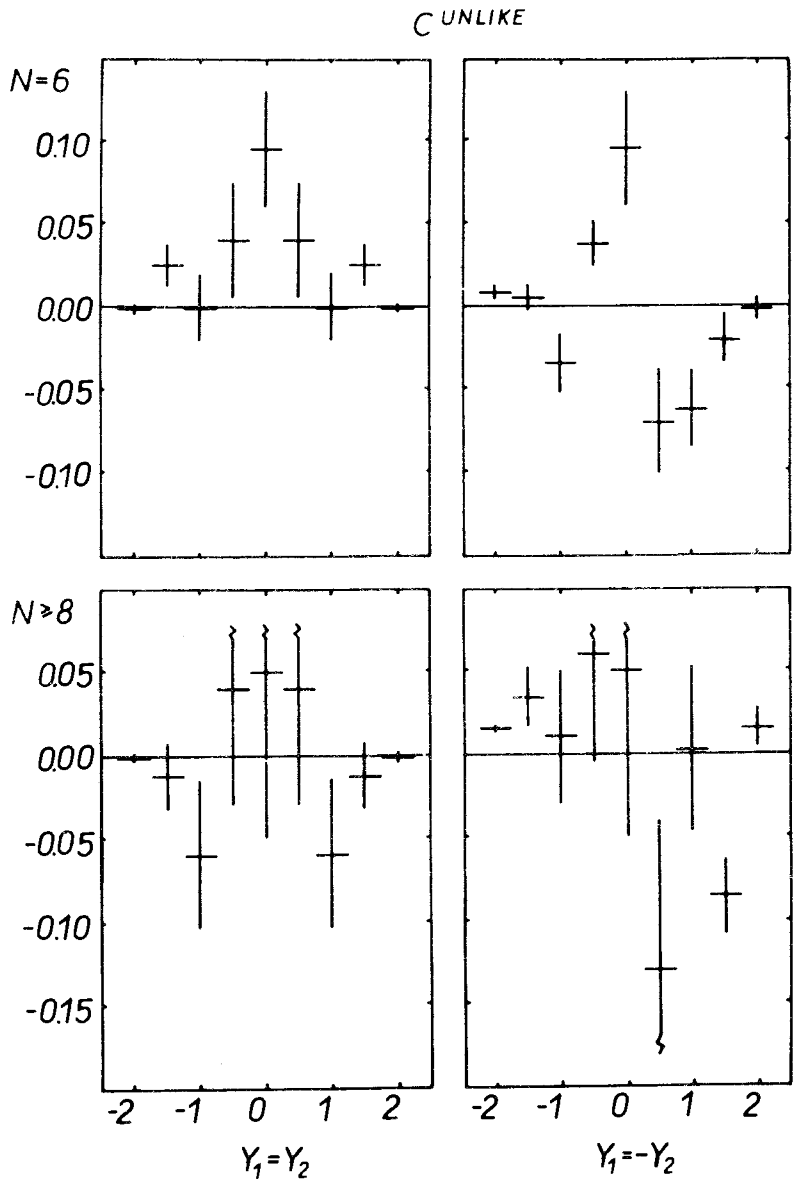

Fig. 3. The semi-inclusive correlation functions $C_N^{UNLIKE}(y_2, y_2)$ vs $y_1 = \pm y_2$.

spectra in low multiplicity events. The contributions of the processes with different numbers p,m of pions to the semi-inclusive channels with $N=6$ and $N \geq 8$ are taken into account by the following replacements in eq. (1): $n^i n^j \to \langle n^i \rangle \langle n^j \rangle$ and $n^i(n^j - \delta_{ij}) \to \langle n^i (n^j - \delta_{ij}) \rangle$. This ensures vanishing the C-function integrated over phase space. For unlike pion pairs a positive peak in the C -function is observed at $y_1 = y_2 = 0$ only in 6-prong events while for like pion pairs such a peak is the most pronounced for multiplicities $N \geq 8$. Moreover, the positive correlations are seen in $C_N^{LIKE}(y_1, y_2)$ at $y_1 = -y_2 \simeq \pm 1.5$ for both $N=6$ and $N \geq 8$. These peaks become more pronounced in terms of the known R-functions (see Fig. 4) which represent the C-functions divided by the second term in eq. (1). Note that we see no evidence for positive correlations at $y_1 = y_2 \simeq \pm 1$ which have been observed in pp -interactions at 69 GeV/c [14] and confirmed for $\pi^-\pi^-$ combinations at 205 GeV/c [15].

1. The positive peaks in the C_N-functions at $y_1 = y_2 = 0$ indicate presence of short-range correlations in our data. These peaks cannot be explained by kinematic effects in the simple models of pion uncorrelated production due to a remarkable difference between the C_N-functions for like and unlike pion pairs. Besides, the central peaks in C_N^{LIKE} are evidently not due to the Bose-Einstein statistics. The latter effect is responsible for positive correlations only in quite a small phase-space region at $p_1 \simeq p_2$ [13].

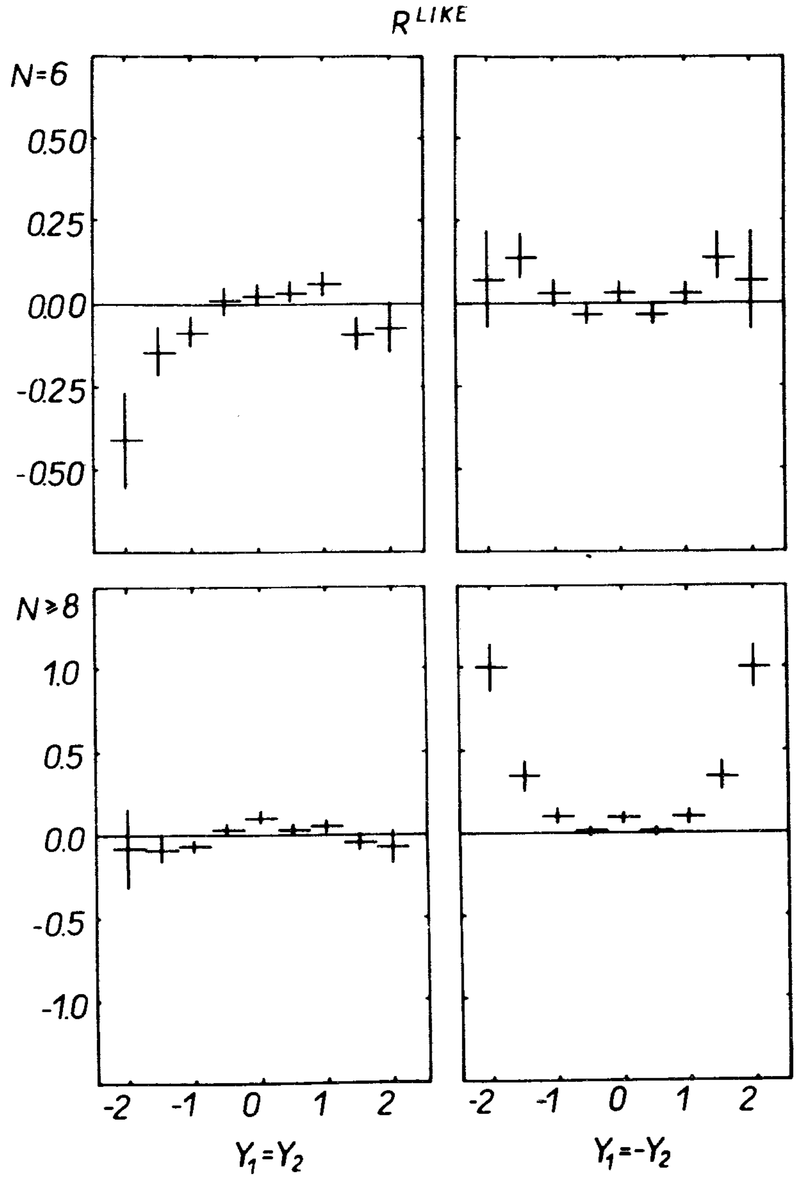

Fig. 4. The semi-inclusive correlation R_N-functions vs $y_1 = \pm y_2$ for like pion pairs.

2. We see no indication for positive correlations at $y_1 = y_2 = \pm 1$ observed in pp -interactions at 69 and 205 GeV/c [16,17] for $\pi^- \pi^-$ pairs.

3. We observe positive peaks in C_N^{LIKE} at $y_1 = -y_2 \simeq \pm 1.5$. Such peaks can be connected with long-range correlations arising from the "peripheral" resonance production in our reaction. In fact, in ref. [13] we have assumed the "peripheral" resonance (or cluster) production to explain a cigar form of the pion production region ($R_{\parallel} / R_{\perp} \sim 2.5$) measured with the help of the second order interference effect by the method of Kopylov and Podgoretsky. It should be noted, however, that the absence of similar correlations for unlike pion pairs in our data is a problem in such a picture.

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