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ANALYSIS OF THE ALIGNMENT OF MOMENTA IN $\bar{p}p$ -INTERACTIONS AT 22.4 GeV/c

Alma-Ata - Dubna - Helsinki - Moscow - Prague - Tbilisi Collaboration

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1. AZIMUTHAL CORRELATIONS IN INDIVIDUAL EVENTS

A study of the effects connected with the distribution of transverse momentum vectors is of interest to clarify the mechanism of multiparticle production.

For example, angular momentum conservation can lead to coplanar particle scattering in space (collinear in the transverse momentum plane). A similar effect can also arise from large transverse momenta of two produced centers of particle emission. In this case, in addition to azimuthal correlations which are due to conservation laws, azimuthal correlations of a dynamical nature can appear.

The expansion of the relative azimuthal distribution into a Fourier series was used to study azimuthal correlations[1,2].

The coefficients of the series can be determined for each event and can give information about correlations in two-particle distributions.

Let y_1 and y_2 be the rapidities of particles 1 and 2, $\vec{p}_{T_1}$ and $\vec{p}_{T_2}$ transverse momenta of these particles, ϕ the azimuthal angle between them, $\rho_2^{(n)} = \frac{1}{\sigma_n}\cdot\frac{d\sigma}{d^3p_1 d^3p_2}$, the density, and s, the total energy squared in the reaction $a + b \to 1 + 2 + \ldots + n$, where n is the total multiplicity. Then the integral distribution

$$f^{(n)}(\phi,s) = \frac{1}{n(n-1)}\int \rho_2^{(n)}(y_1, y_2, \vec{p}_{T_1}, \vec{p}_{T_2}, \phi)\, dy_1 dy_2\, d\vec{p}_{T_1}\, d\vec{p}_{T_2} \tag{1}$$

can be expanded to its partial waves

$$f^{(n)}(\phi,s) = \frac{1}{\pi}\sum_{k=0}^{\infty} C_k^n \cos k\phi\,, \tag{2}$$

where

$$C_k^n = \int_{-\pi}^{\pi} f^{(n)}(\phi,s)\cos k\phi\, d\phi = 2\langle\cos k\phi\rangle \tag{3}$$

and $C_0^n = 1$. The coefficients C_k^n are mathematical expectation values of the factors S_k^n calculated for each interaction

$$S_k^n = 2 \sum_{i \neq j} \frac{\cos k\phi_{ij}}{n(n-1)}\,, \quad k = 1,2,3\ldots \tag{4}$$

Studying the S_k^n distributions, one can find definite kinematic configurations, if they are available, in the transverse plane. Let us consider the following configurations in an event with multiplicity 4: a) All four particles go in the same direction in the transverse plane (one cluster), then $S_1^4 = 2$ and $S_2^4 = 2$. b) Three particles go in the same direction and one, collinearly in the opposite direction, then $S_1^4 = 0$, $S_2^4 = 2$. c) Two particles go in the same direction and the other two, collinearly in the opposite direction (two symmetric clusters), then $S_1^4 = -2/3$ and $S_2^4 = 2$. It can be seen from this example and from eq. (4) that S_k^n are sensitive to the relative configuration of k clusters.

Calculations of the coefficients C_1^n are simplified if we neglect energy conservation laws and take into account transverse momentum conservation only. An application of this approach is shown in paper /3/. In the framework of this model C_1^n can be calculated precisely /1/ for the case of Gaussian transverse momentum distributions of secondary particles.

For other types of transverse momentum distributions it is possible to use an approximate formula /1/

$$C_1^n = \frac{2\cdot[\int_0^\infty p_T\, d\sigma(p_T)]^2}{n(n-1)\cdot\sigma\cdot\int_0^\infty p_T^2\, d\sigma(p_T)}\,, \tag{5}$$

where $\sigma = 1/n \cdot \int_0^\infty d\sigma(p_T)$.

If $n = n_0 + n_{ch}$, where n_0 is the number of neutral and n_{ch} of charged particles, one can determine the mean number of neutrals, accompanying charged particles in a given topological channel, by comparing the experimental value of $\overline{S_1^{n_{ch}}}$ with the value of C_1^n calculated by (5). A discrepancy between this number and that of neutral determined by direct methods indicates a deviation from the model considered, i.e., the presence of correlations of a dynamical nature.

The values of $S_k^{n_{ch}}$ can be defined separately for like and unlike pairs of particles.

In the case of like charges

$$S_k^{n_{like}} = 2 \sum_{i \neq j} \frac{\cos k\phi_{ij}}{n_{ch}(n_{ch}/2-1)}\,. \tag{6}$$

For unlike charges

$$S_k^{n_{unlike}} = 2 \cdot \sum_{i,j} \frac{\cos k\phi_{ij}}{n_{ch}\, n_{ch}/2}\,. \tag{7}$$

The values of $S_k^{n_{like}}$ and $S_k^{n_{unlike}}$ should coincide if there are no dynamical correlations.

The asymmetry coefficient $A^{n_{ch}}$ defined as

$$A^{n_{ch}} = \left(\int_{\pi/2}^{\pi} f(\phi)d\phi - \int_0^{\pi/2} f(\phi)d\phi \right) / \int_0^{\pi} f(\phi)d\phi\,, \tag{8}$$

where $f(\phi)$ is the azimuthal angle distribution of all particle pairs, can be calculated by means of $S_k^{n_{ch}}$ as follows /2/:

$$A^{n_{ch}} = -\frac{2}{\pi}\left(\overline{S_1^{n_{ch}}} - \frac{\overline{S_3^{n_{ch}}}}{3} + \ldots\right). \tag{9}$$

And the collinearity coefficient defined as

$$B^{n_{ch}} = \left(\int_0^{\pi/4} f(\phi)d\phi + \int_{3\pi/4}^{\pi} f(\phi)d\phi - \int_{\pi/4}^{3\pi/4} f(\phi)d\phi \right) / \int_0^{\pi} f(\phi)d\phi \tag{10}$$

equals

$$B^{n_{ch}} = \frac{2}{\pi}\left(\overline{S_2^{n_{ch}}} - \frac{\overline{S_6^{n_{ch}}}}{3} + \ldots\right). \tag{11}$$

2. SPHERICITY AND PLANARITY IN INDIVIDUAL EVENTS

For each event an axis (principal) is determined with respect to which the sum of the transverse momenta squared $\sum_i p_{Ti}^2$ of all charged particles is minimal. With this aim a symmetric tensor T with elements /4/

$$T^{\alpha\beta} = \sum_i (\delta^{\alpha\beta}\, \vec{p}_i^{\,2} - p_i^\alpha p_i^\beta) \tag{12}$$

($\alpha, \beta = 1,2,3$ and p_i^α are the components of $\vec{p}_i$ for each event) is calculated and diagonalized. In this way we obtain three eigenvalues λ_1, λ_2, λ_3 with the corresponding eigenvectors $\vec{e}_1$, $\vec{e}_2$, $\vec{e}_3$.

The eigenvalues λ_i represent the sums of transverse momenta squared with respect to the three corresponding axes.

Let us consider an example, where $\lambda_3 < \lambda_2 < \lambda_1$. Then the axis $\vec{e}_3$ associated with λ_3 is the reconstructed principal axis, and the principal plane of the event is determined by the vectors $\vec{e}_3$ and $\vec{e}_2$ (see fig. 1). Sphericity S is defined by

$$S = \frac{3\lambda_3}{\lambda_1 + \lambda_2 + \lambda_3} = \frac{3 \cdot \sum_i p_{Ti}^2}{2 \cdot \sum_i p_i^2}\,. \tag{13}$$

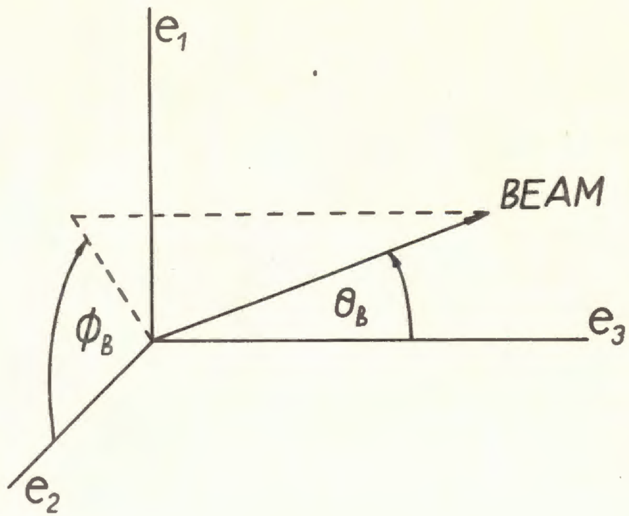

Fig. 1. System of "principal axes": $\vec{e}_3$ is the principal axis; axes $\vec{e}_3$ and $\vec{e}_2$ determine the principal plane.

The direction of the beam particle with respect to the system of the principal axis is determined by polar and azimuthal angles Θ_B and Φ_B (fig. 1).

The alignment of events in the plane of transverse momenta can be detected with the help of planarity P. The quantity P is defined, in a similar way as sphericity, in the space of transverse momenta:

$$P = \frac{2\lambda_2}{\lambda_1 + \lambda_2} \qquad (\lambda_2 < \lambda_1). \tag{14}$$

If $\lambda_1 \gg \lambda_2$, the alignment is present and $P \approx 0$. And when $\lambda_1 \sim \lambda_2$, there is no alignment and $P \sim 1$.

3. EXPERIMENTAL DATA ANALYSIS

The present analysis has been performed for ~ 25000 inelastic events of charged multiplicities 2,4,6,8 and 10 obtained in an $\bar{p}p$-experiment at 22.4 GeV/c using the HBC Ludmila.

The events were processed using geometrical reconstruction programs MDTHRESH and HYDRA geometry. Details of the data processing have been published earlier [5]. All particles unidentified by ionization were taken to be π-mesons.

3.1. Azimuthal Correlations

We have studied the distributions of $S_k^n (k=1,2,3)$ for charged multiplicities 2,4,6,8 and 10 for all charged particles and for like and unlike pairs of particles.

These distributions do not show any irregularities corresponding to the cluster production in the sense of the above discussion. Therefore, below we discuss only the mean values of $S_k^{n\,ch}$, $S_k^{n\,like}$ and $S_k^{n\,unlike}$ presented in Table 1. The mean values of $S_3^{n\,ch}$ do not practically differ from zero; later on $S_3^{n\,ch}$ will not be considered.

According to the kinematics of the process, $|S_1^{n\,like}|$ and $|S_1^{n\,unlike}|$ decrease with increasing multiplicity. However, $|S_1^{n\,like}|$ falls much slower, and the difference between $|S_1^{n\,like}|$ and $|S_1^{n\,unlike}|$ achieves $0{,}129 \pm 0{,}016$ for $n_{ch} = 10$ although it should be always equal to 0 if dynamical correlations are absent. The coefficients $S_2^{n\,like}$ and $S_2^{n\,unlike}$ are not very different from zero. In order to make sure that the observed difference between like and unlike distributions is not due to the presence of leading particles, we exclude events in which there is at least one particle with $|x| > 0.5 \, (x = 2p_{\parallel}^* / \sqrt{s})$. In order to eliminate the possible effect of identical particle interference [6], we also exclude the events with particle pairs from the region $q_T < 0.2$ GeV/c and $q_0 < 0.07$ GeV/c (where $q = (q_0, \vec{q}_T) = p_1 - p_2$ is the difference of the particle 4-momenta, and $\vec{q}_T$ is the component of $\vec{q}$ perpendicular to the particle pair momentum $\vec{p}_1 + \vec{p}_2$). The results are presented in Table 1. After excluding these events, the difference between $S_1^{n\,like}$ and $S_1^{n\,unlike}$ vanishes for multiplicity 10. However, the difference ΔS is not changed, within errors, for multiplicities 6 and 8. So it can be concluded that the interference effect is not the only mechanism responsible for the observed difference ΔS.

In fig. 2 we show the asymmetry and collinearity parameters $A^{n\,like}$, $A^{n\,unlike}$, $B^{n\,like}$, $B^{n\,unlike}$ calculated according to formulae (9) and (11) neglecting the terms $S_k^{n\,ch}$ $(k \geq 3)$ which are small.

We have calculated the number of neutral particles according to formula (5). In this case we use the approximation of the experimental transverse momentum distribution

Table 1

n_{ch}	number of events	$\overline{S_1^{n_{ch}}}$	$\overline{S_1^{n}}$ like	$\overline{S_1^{n}}$ unlike	$\overline{S_2^{n_{ch}}}$	$\overline{S_2^{n}}$ like	$\overline{S_2^{n}}$ unlike
2	2183	−0.54± 0.02		−0.54 ± 0.02			
4	11709	−0.284±0.004	−0.263±0.009	−0.295± 0.006	0.040±0.006	0.052±0.010	0.034±0.008
6	7672	−0.182±0.003	−0.133±0.005	−0.215± 0.005	0.011±0.005	0.014±0.007	0.010±0.006
8	3261	−0.140±0.003	−0.088±0.007	−0.179± 0.006	0.010±0.005	0.008±0.008	0.010±0.007
10	942	−0.100±0.004	−0.028±0.011	−0.157± 0.011	0.007±0.009	0.053±0.010	−0.035±0.010

n_{ch}	number of*) events	$\overline{S_1^{n}}$ like*)	$\overline{S_1^{n}}$ unlike*)	number of**) events	$\overline{S_1^{n}}$ like**)	$\overline{S_1^{n}}$ unlike**)
4	11008	−0.275±0.010	−0.314±0.006	4968	−0.180±0.012	−0.256±0.009
6	5966	−0.154±0.007	−0.234±0.007	4048	−0.133±0.009	−0.221±0.007
8	1769	−0.122±0.010	−0.199±0.007	1505	−0.119±0.010	−0.197±0.007
10	212	−0.133±0.020	−0.136±0.011	194	−0.137±0.020	−0.135±0.011

$\Delta S = \overline{S_1^{n\,like}} - \overline{S_1^{n\,unlike}}$

n_{ch}	All events	*)	**)
4	0.032±0.011	0.039±0.012	0.076±0.015
6	0.082±0.007	0.080±0.008	0.088±0.011
8	0.091±0.009	0.077±0.012	0.078±0.012
10	0.129±0.016	0.003±0.023	−0.002±0.023

*) events with pairs with $q_T < 0.2$ GeV/c and $q_0 < 0.07$ GeV/c^2 are excluded.

**) events with pairs with $q_T < 0.2$ GeV/c and $q_0 < 0.07$ GeV/c^2 and events with leading particles are excluded.

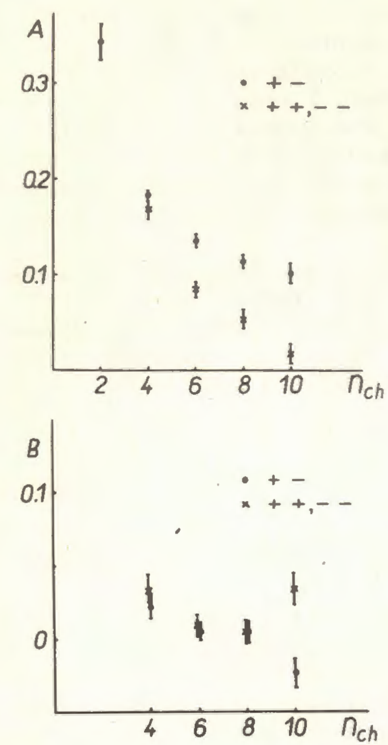

Fig. 2. a) Asymmetry coefficient A versus multiplicity for like and unlike particle pairs. b) Collinearity coefficient B versus multiplicity for like and unlike particle pairs.

from ref. [5].

$$\frac{dN}{dp_T^2} = \frac{a}{I_1}\exp(-b_1 p_T^2) + \frac{1-a}{I_2}\exp(-b_2 p_T^2). \qquad (15)$$

Taking values of a, b_1 and b_2 from ref. [5], we obtain the following numerical relation from eq. (5)

$$n_0 = \frac{-1.538 \pm 0.002}{\overline{S_1^{n_{ch}}}} - n_{ch} + 1. \qquad (16)$$

The mean values of neutral particle numbers determined separately by $S_1^{n_{ch}}$, $S_1^{n\,like}$ and $S_1^{n\,unlike}$ are presented in Table 2*. This table also shows the numbers of neutrals determined as a sum of the mean number of π°, K°, $\bar{K}^\circ$, Λ° and $\bar{\Lambda}^\circ$ in this experiment[8]. The calculated values of n_0 are close to the values of n_0 from ref.[8] only in the case when they are determined by $S_1^{n\,unlike}$. The number n_0, determined by $S_1^{n\,like}$, is too large to be explained by the $n,\bar{n}$ contribution to n_0. Therefore the mean angle between the transverse momenta of like secondaries turns out to be smaller than the value C_1^n in eq. (5).

An evidence for a similar effect has been also obtained in pp interactions at 28.5 GeV/c [3] (note that in ref.[3] $\langle n_{\pi^\circ}\rangle$ was taken from the $\pi^- p$ experiment at 25 GeV/c [16]). However, as we can see from Table 2, the difference observed in our reaction is more significant.

3.2. Planarity and Sphericity

The mean values of planarity $P^{n_{ch}}$ and sphericity $S^{n_{ch}}$ versus multiplicity are shown in fig. 3.

It is seen that both values increase with increasing multiplicity.

The $dN/dP^{n_{ch}}$ distributions for different multiplicities are presented in fig.4. The $P^{n_{ch}}$ distributions in events generated by cylindrical phase space[9] with $\langle p_T^2\rangle$ from our experiment are presented for comparison in the same figure.

As the contributions of different channels are unknown, the $P^{n_{ch}}$ distributions were generated for different channels in each multiplicity**, and $P^{n_{ch}}$ was found to be slightly dependent on the type of reaction (except, perhaps, events with 4 charged particles). The dashed regions in fig 4 show the limits of the changes for the $dN/dP^{n_{ch}}$ distributions for different generated channels in fig. 3. From figs. 3

* It should be noted that formula (5) is slightly sensitive to the p_T^2 spectrum shape. For one exponent in (15), we get the coefficient $\pi/2$ instead of 1.538 in (16). To check formula (16), the $dN/dS_1^{n_{ch}}$ distributions were generated by FOWL[7] for multiplicities 6 and 8 with the number of neutrals $n_0 = 2$. The mean values of S_1^6 and S_1^8 obtained for generated events ($S^6_{1\,FOWL}$, $S^8_{1\,FOWL}$) do not disagree with those calculated for the same value n_0 by (16) ($S^6_{1\,MODEL}$, $S^8_{1\,MODEL}$). ($S^6_{1\,FOWL} = -0.205 \pm 0.007$, $S^6_{1\,MODEL} = -0.219$, $S^8_{1\,FOWL} = -0.163 \pm 0.010$, $S^8_{1\,MODEL} = -0.171$).

** For example, for $n_{ch} = 8$ the channels $\bar{p}p \to 8\pi\, 4\pi^\circ$, $8\pi 3\pi^\circ$, $8\pi 2\pi^\circ$, 8π, $\bar{p}p\ 6\pi 4\pi^\circ$, $8\pi 2\pi^\circ n\bar{n}$, $\bar{p}p\ 6\pi$, $\bar{p}\, n 7\pi\pi^\circ$ were generated.

Table 2

n_{ch}	Configuration	n_0	$n^{/8/}_{\pi^\circ K^\circ \Lambda \bar{\Lambda}}$	Configuration	$n_0^{/3/}$	$n_{\pi^\circ}^{/16/}$
2	all	1.8 ± 0.1	2.03± 0.25	all	1.3 ± 0.2	1.9 ± 0.4
4	all	2.4 ± 0.1	1.97± 0.13	all	2.3 ± 0.2	1.9 ± 0.1
	+ −	2.2 ± 0.1		+ −	2.6 ± 0.2	
	++, −−	2.8 ± 0.2		+ +	2.0 ± 0.2	
6	all	3.5 ± 0.1	2.23 ± 0.1	all	3.4 ± 0.2	2.6 ± 0.3
	+ −	2.2 ± 0.2		+ −	3.1 ± 0.3	
				++	3.2 ± 0.3	
	++, −−	6.6 ± 0.4		−−	6.8 ± 2.0	
8	all	4.0 ± 0.2	2.11 ± 0.29	all	4.4 ± 0.5	3.2 ± 0.3
	+ −	1.6 ± 0.3		+ −	3.2 ± 0.4	
	++, −−	10.5 ± 1.4		+ +	4.3 ± 0.8	
				− −	27 ± 20	
10	all	6.4 ± 0.6	1.48 + 0.47	all	3.9 ± 1.3	3.1 ± 0.5
	+ −	0.8 ± 0.7		+ −	2.0 ± 1.3	
	++, −−	45.9 ± 21.6		+ +	3.3 ± 1.5	
				− −	103 ± 358	

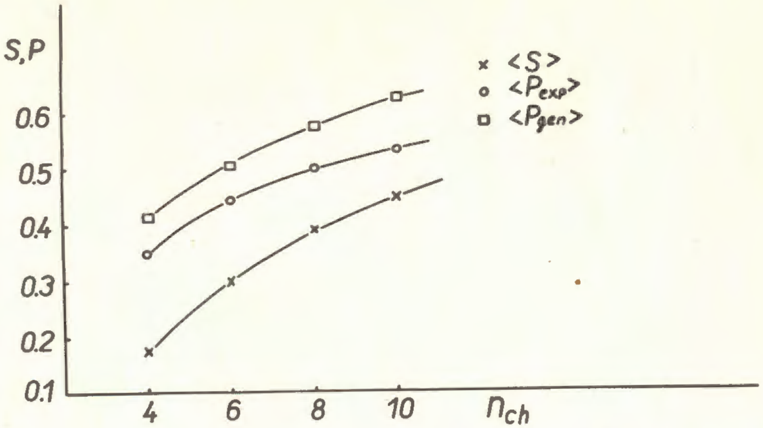

Fig. 3. Mean values of sphericity S, planarity P and planarity of generated events versus multiplicity. The curves are drawn by hand.

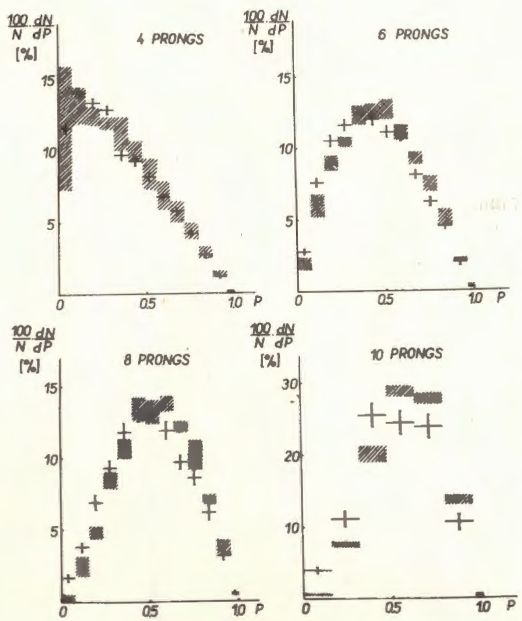

Fig. 4. Planarity distribution for multiplicities 4,6,8 and 10. The shaded region shows the boundaries inside which the value of planarity generated for various channels is changed. Each channel is normalized to the total number of events of a given topology.

and 4 one can see that the experimental distributions do not coincide with the distributions of generated events.

Table 3 presents the mean values $<P^{n_{ch}}_{exp}>$, $<P^{n_{ch}}_{gen}>$* and their difference

$$\Delta P = <P^{n_{ch}}_{gen}> - <P^{n_{ch}}_{exp}> . \qquad (17)$$

Note that a positive value of ΔP may indicate a tendency to the alignment of particles in the transverse plane. We also note that ΔP depends on multiplicity very weakly.

In order to eliminate the influence of leading protons and antiprotons, we exclude the events with protons and negative particles with $x > 0.66$ because the latter are mostly antiprotons. We also exclude the events with particle pairs with near momenta where the Bose-Einstein interference effect becomes apparent /6/ ($q_0 < 0.1$ GeV/c and $q_T < 0.2$ GeV/c)**.

Table 3 presents the mean values of planarity for the remaining ~ 10000 events. Within errors, these values for charged multiplicities 8 and 10 coincide with those obtained for our total statistics. For charged multiplicities 4 and 6 they are slightly smaller.

To decide whether the alignment is due to the presence of one particle with large transverse momentum, we have determined the mean values of $p_{T\,max}$ (maximum transverse momentum in the event) and the mean value of $<p_T>$ (average transverse momentum in the event) for two types of events: with $P^{n_{ch}} \le 0.24$ and $P^{n_{ch}} > 0.8$. The results presented in Table 4 show that the presence of one particle with large transverse momentum is not responsible for the alignment although the average transverse momentum for events with $P^{n_{ch}} \le 0.24$ is larger than $<\overline{p_T}>$ for those with $P^{n_{ch}} > 0.8$.

Figure 5 presents the $\cos\Theta_B$ distributions for 4- and 6-prong events. As is seen, the distribution becomes wider with increasing multiplicity***. The $\cos\Theta_B$ distribution for 4- and 6-charged particles is well described by the distribution

$$\frac{dN}{d\cos\Theta_B} = \frac{a}{I_1}\exp[-a_1(1-\cos\Theta_B)] + \frac{1-a}{I_2}\exp[-a_2(1-\cos\Theta_B)], \qquad (18)$$

where I_1 and I_2 are normalization integrals.

---

* In order to determine the mean value of $<P^4_{gen}>$, we take into account our preliminary data on exclusive channels /10/.

** These effects are not considered in the used Monte Carlo calculations /9/.

*** Distributions for 8- and 10-prong events are not presented because of poor statistics.

Table 3

n_{ch}	No of events	$\langle P^{n_{ch}}_{exp} \rangle$	$\langle P^{n_{ch}}_{gen} \rangle$	ΔP	No of events	$\langle P^{n_{ch}}_{exp} \rangle$ *)	ΔP
4	11709	0.350 ±0.002	0.415±0.002	0.065±0.003	4823	0.372±0.003	0.043±0.004
6	7672	0.445 ±0.003	0.510±0.002	0.065±0.004	3740	0.466±0.004	0.044±0.004
8	3261	0.504 ±0.004	0.580±0.003	0.076±0.005	1167	0.515±0.007	0.065±0.008
10	942	0.538 ±0.007	0.630±0.003	0.092±0.008	133	0.533±0.017	0.097±0.017

Table 4

	$\langle p_{T\,max} \rangle$		$\langle \overline{p_T} \rangle$	
n_{ch}	$p^{nch} \leq 0.24$	$p^{nch} > 0.8$	$p^{nch} \leq 0.24$	$p^{nch} > 0.8$
4	0.448 ± 0.003	0.451±0.007	0.438± 0.002	0.406 ± 0.005
6	0.483 ± 0.005	0.485±0.007	0.434± 0.004	0.403 ± 0.004
8	0.53 ± 0.01	0.506 ±0.007	0.428± 0.008	0.379 ± 0.004
10	0.32 ± 0.04	0.33 ± 0.02	0.40 ± 0.02	0.316 ± 0.005

Table 5

n_{ch}	Interval	a_1	a_2	α	χ^2/NF
4	1. - 0.965	141.6 ± 27.2	27.0 ± 12.6	0.34 ±0.18	0.88
6	1. - 0.94	131.1 ± 46.8	20.8 ± 5.0	0.14 +0.06	0.52

*) events with pairs from the interference region and events with leading particles are excluded.

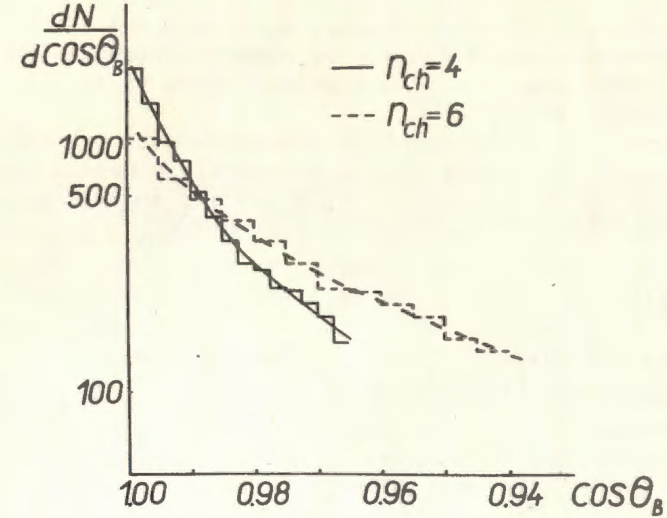

Fig. 5. $dN/d\cos\Theta_B$ distribution for topologies 4 and 6. The curves are fitted by formula (18).

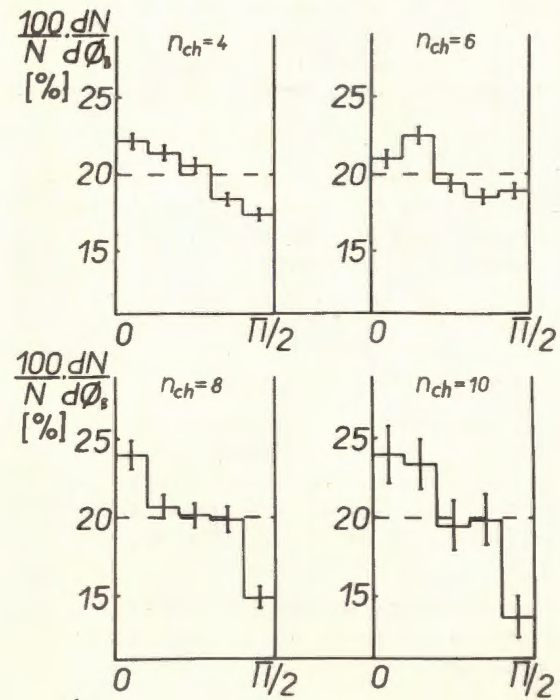

Fig. 6. Φ_B distribution for topologies 4,6,8 and 10.

The values of the fitted parameters are given in Table 5.

The Φ_B-distributions for multiplicities 4,6,8 and 10 (fig. 6) show anisotropy increasing with multiplicity. The anisotropy means that the beam particle tends to lie in the principal plane (see fig.1).

The presence of such alignment disagrees with the results obtained from simple models for particle generation by cylindrical phase space only /9/. A similar anisotropy has been observed in K^+p reactions at 32 GeV/c /11/.

CONCLUSIONS

The following conclusions can be made:

1. Azimuthal correlations in $\bar{p}p$ interactions at 22.4 GeV/c have been observed, and they have been found to be due neither to conservation laws nor to the presence of leading particles. The interference effect of identical particles is responsible only for a small part of the observed difference between like and unlike distributions.

The difference between the model values from eq. (5) and the experimental data turned out to be larger for like particles than for unlike ones. This fact means that the observed correlations are not connected with the presence of resonances. A similar effect has been found in $\bar{p}p$ collisions at 9.1 GeV/c /12/.

2. There is an indication of particle alignment in the transverse momentum plane.This alignment is practically independent of multiplicity.Decrease of the alignment with multiplicity has been observed in K^-p collisions at 8.25 GeV/c /13/ and in πp collisions in a momentum range from 4 to 25 GeV/c /14/. The alignment in pp interactions at 205 GeV/c /15/ has not been observed at all. The alignment in our experiment is connected neither with leading particles nor with the interference effect caused by Bose-Einstein statistics.

3. The $\cos\Theta_B$ distribution is fitted by two exponents.This can be explained by the presence of two different types of mechanisms: nonannihilation (exponent with large slope) /11/ and annihilation (exponent with smaller slope) ones. The part of processes with smaller slope is larger for $n_{ch}=6$ than for $n_{ch}=4$.

4. Disagreements with the isotropy are found in the distributions of the beam azimuthal angle Φ_B.Such anisotropy can appear, e.g., in the case when a large total angular momentum is built up from relatively small (i.e., almost parallel) angular momenta of secondary particles.

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