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A STUDY OF THE INTERFERENCE EFFECT IN IDENTICAL PARTICLE PAIRS FOR INCLUSIVE $\bar{p}p$-INTERACTIONS AT 22.4 GeV/c

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

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Submitted to ЯФ

Филиппова В.В. и др. **E1 - 11073**

Изучение эффекта интерференции в парах тождественных частиц в инклюзивных $\bar{p}p$-взаимодействиях при 22,4 ГэВ/с

На материалах с установки "Людмила" изучен эффект интерференции в парах тождественных пионов в $\bar{p}p$-взаимодействиях при 22,4 ГэВ/с со множественностью $N \geq 6$. Эффект наблюдался как на $\Delta\Delta$-диаграмме, так и в спектре эффективных масс $M_{\pi\pi}$ пар пионов. В рамках анализа $\Delta\Delta$-диаграммы определены средний размер и время жизни области рождения пионов: $\langle R \rangle = (3{,}0 \pm 0{,}5)$ fm и $\langle \tau \rangle = (3{,}1 \pm 1{,}6)$ fm/c. Измеренному соотношению поперечного ($\perp$) и продольного размеров ($R_\perp = (1{,}7+0{,}4)$ fm, $R_{||} = (4{,}4 \pm 1{,}4)$ fm) дано объяснение в рамках модели движущихся источников.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1977

Filippova V.V. et al. **E1 - 11073**

A Study of the Interference Effect in Identical Particle Pairs for Inclusive $\bar{p}p$-Interactions at 22.4 GeV/c

The interference effect (IE) in identical pion pairs has been investigated in $\bar{p}p$-interactions with charge multiplicities $N_{ch} \geq 6$ at 22.4 GeV/c using the data from the HBC "Ludmila". The effect was observed both on the $\Delta\Delta$-plot and in the effective mass ($M_{\pi\pi}$) spectra for pion pairs. The mean dimension and lifetime of the pion emission region were determined from the analysis of the $\Delta\Delta$-plot: $\langle R \rangle = (3.0 \pm 0.5)$ fm and $\langle \tau \rangle = (3.1 \pm 1.6)$ fm/c. The explanation for the observed relation between transverse ($\perp$) and longitudinal ($||$) dimensions ($R_\perp = (1.7 \pm 0.4)$ fm, $R_{||} = (4.4 \pm 1.4)$ fm) was offered in the framework of the model of moving sources.

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

Preprint of the Joint Institute for Nuclear Research. Dubna 1977

In this paper we present the data on the interference effect observed in the two-particle spectra of identical pions from inclusive $\bar{p}p$-interactions at 22.4 GeV/c *. The experimental material has been obtained using the 2m HBC "Ludmila" exposed to a RF-separated antiproton beam at the Serpukhov accelerator [1]. Details of the experimental procedure have been published elsewhere [1,2]. Results on the topological cross sections and single-particle inclusive spectra can be found in papers [2,3].

1. THE INTERFERENCE EFFECT IN MULTIPARTICLE PRODUCTION

The first evidence for a possible influence of the interference effect (IE) on the identical particle spectra has been obtained from the analysis of the angular correlations of secondary π-mesons in multiparticle reactions and is known as a GGLP-effect [4]. Recently this problem has been studied from a new point of view in Kopylov's and Podgoretsky's papers [5-8]. The authors have shown that the interference between two identical particles 1 and 2 with 4-momenta p_1 and p_2 appears only when $p_1 \simeq p_2$ and depends on the 4-momentum difference $q = p_1 - p_2$. For the case of bosons (e.g., π-mesons) the in-

*Preliminary results were reported at the XVIII International Conference on High Energy Physics, Tbilisi, 1976.

terference is constructive and the two-particle phase space density W for identical particles is of the form:

$$W(p_1,p_2) = [1 + f(q,p)]W_0(p_1,p_2), \tag{1}$$

where $p = p_1+p_2$ and W_0 is the phase space density in the case when the interference is absent. The form of the function $f(q,p)$ depends on the type of production mechanism. Nevertheless, $f(q,p)$ has the following general properties: a) $f(0,p) = 1$; b) $f(q,p)\to 0$ when the modulus of any component of the 4-momentum q tends to infinity. The velocity of this decrease depends on the space-time characteristics of the π-meson sources.

As is shown by Kopylov [8], for the IE study it is enough to analyze the two-dimensional (q_0, q_T^2)-distribution ($\Delta\Delta$-plot), if one uses the projections of vector $\vec{q}$ on the pair motion direction $\vec{n} = \frac{\vec{p}}{|\vec{p}|}$. Here $q_0 = |p_{01} - p_{02}|$ and $q_T^2 = \vec{q}^{\,2} - (\vec{q}\cdot\vec{n})^2$. If pions are independently emitted by the sphere surface of radius R, the function $f(q)$ takes the form:

$$f(q) = \left[\frac{2J_1(Rq_T)}{Rq_T}\right]^2 \frac{1}{1+(\tau q_0)^2}, \tag{2}$$

where τ is the lifetime of the sources and $J_1(x)$ is the first order Bessel function.

More precisely, formula (2) corresponds to the disk which uniformly emits π-mesons in the direction $\vec{n}$. If eq. (2) is taken in the exponential approximation

$$f(q) \approx \exp\left(-\frac{R^2 q_T^2}{4} - \tau^2 q_0^2\right), \tag{3}$$

replacement of τ^2 by $\tau^2 + \frac{R^2}{18v_0^2}$ (v_0 is the pion pair velocity) permits one to take into account the curvature of the emission surface [9].

It should be emphasized that in general the q_0-dependence of the function $f(q,p)$ is defined by three parameters: lifetime of the sources, dispersion of moments, when the sources are switched on, and "longitudinal" time" R_L/v_0 (R_L is the size of the pion source system along the observation direction $\vec{n}$) [6]. The behaviour of the q_T^2-dependence of $f(q,p)$ is determined by the source system dimension perpendicular to the direction $\vec{n}$. Thus, it is possible to obtain the longitudinal ($R_{||}$) and transverse ($R_\perp$) dimensions of the pion generation region by changing the observation direction $\vec{n}$ [13].

It is easy to show that the IE appears also in the effective mass ($M_{\pi\pi}$) spectrum of identical pion pairs or in the m^2-spectrum, where $m^2 = M_{\pi\pi}^2 - 4\mu^2 = q_0^2 - \vec{q}^{\,2}$ (μ is the π-meson mass). For the $M_{\pi\pi}$-spectra of like pions one can get the following relation

$$\frac{d\sigma/dM_{\pi\pi}}{d\sigma_0/dM_{\pi\pi}} = 1 + \exp\left(-\frac{B^2 m^2}{3}\right), \tag{4}$$

which is true for small m. The denominator in eq. (4) corresponds to the $M_{\pi\pi}$-spectrum when the interference is switched off. In the general case the slope B^2 depends on the source system dimensions, their lifetime, the direction of observation, and the pair velocity.

2. EXPERIMENTAL RESULTS

The interference effect was studied in the c.m.s. of the $\bar{p}p$-reaction for a sample of 3775 events with the number of prongs $N_{ch} \geq 6$. As a $W_0(p_1,p_2)$ distribution in eq. (1), the $(\pi^+\pi^-)$-pair distribution was taken. The $\Delta\Delta$-plot was analysed in the region $q_0 \leq 0.44$ GeV, $q_T^2 \leq 0.22$ (GeV/c)^2 and the $M_{\pi\pi}$-spectra for $M_{\pi\pi} \leq 0.54$ GeV.

As mentioned above, the expected effect should appear at $p_1 \simeq p_2$, i.e., for tracks which are situated very close in space. Due to some difficulties in a reconstruction procedure of such tracks, there can be a difference in geometric parameters for particles from (++, --) and (+-) pairs. However, the analysis of the pairs with $q_0 \leq 0.05$ GeV and $q_T^2 \leq 0.02$ (GeV/c)^2 shows that the accuracy of geometric reconstruction for tracks in this region is practically the same for (++, --) and (+-) pairs and does not differ from the mean accuracy for all tracks. The mean momentum error was $<\frac{\Delta p}{p}> \sim 1\%$ for pairs with $q_0 < 0.05$ GeV and $q_T^2 \leq 0.02$ (GeV/c)^2. The choice of a bin value for all distributions was determined by the condition $<\frac{2|p_1-p_2|}{p_1+p_2}> \gg \frac{\Delta p}{p}$ (here $p_{1,2}$ are the laboratory momenta of particles). Only some 7% of (++,--) pairs in the above intervals q_0 and q_T^2 satisfied the condition $\frac{2|p_1-p_2|}{p_1+p_2} < 1\%$. It should be noted that the estimation of particle ionization was made up to $p_{lab} = 1.5$ (GeV/c). The mean value of laboratory momentum for narrow pairs in the chosen region was found to be 0.9 GeV/c, and 86% of particles (with $p_{lab} \leq 1.5$ (GeV/c)) were unambiguously identified. Some contamination of protons among the particles with $p_{lab} > 1.5$ (GeV/c) can only decrease the visible interference effect. But this contamination is small enough which follows from the symmetry of the total p_L^*-distribution in the c.m.s. for pions in an interval of $q_0 \leq 0.05$ GeV and $q_T^2 \leq 0.02$ (GeV/c)^2. The latter was found to be symmetrical in agreement with CP-symmetry. It is also clear that a possible contamination of Dalitz-pairs in (+-) pairs can only decrease the observed effect.

The $(\pi^+\pi^+)$- and $(\pi^-\pi^-)$-spectra were combined, and the spectra of like and unlike pions were normalized according to the definition (1) so that the ratios of the spectra shown in figs. 1-5 should be equal to 1 outside the interference effect region ($q_0 >$ 0.12 GeV, $q_T^2 > 0.06$ (GeV/c)^2, $M_{\pi\pi} > 0.34$ GeV). Later on the ratio of the normalized x-spectra will be called the x-distribution and be denoted by $g(x)$.

The q_0-distributions for different intervals of q_T are shown in fig. 1, where one can see a distinct peak at small values of q_0 for an interval of $0 < q_T \leq 0.2$ GeV/c. A clear peak in the q_T^2-distribution is seen in fig. 2 at small q_T^2 for an interval of $0 < q_0 \leq 0.05$ GeV. The observed effect is in agreement with the theoretical predictions /5-8/ discussed above. A similar effect is observed in other reactions as well (see Table 1).

The mean dimension R of the emission region was determined by fitting the q_T^2-distribution presented in fig. 2a by the formula

$$g(q_T^2) = b\{1 + a[\frac{2J_1(Rq_T)}{Rq_T}]^2\}. \quad (5)$$

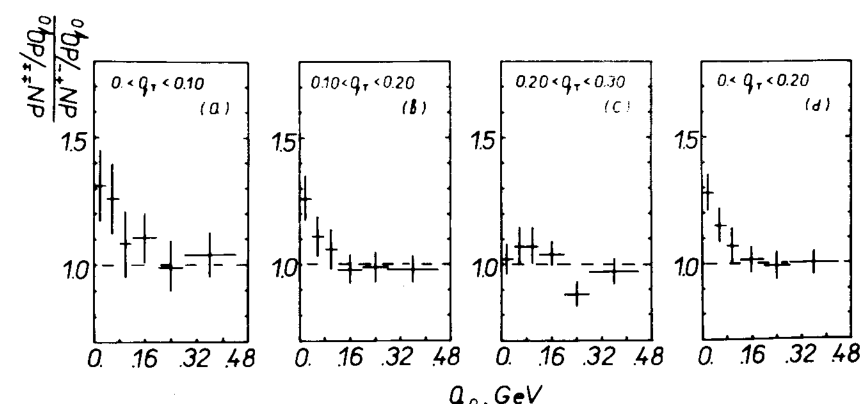

Fig. 1. The q_0-distribution for different q_T-intervals.

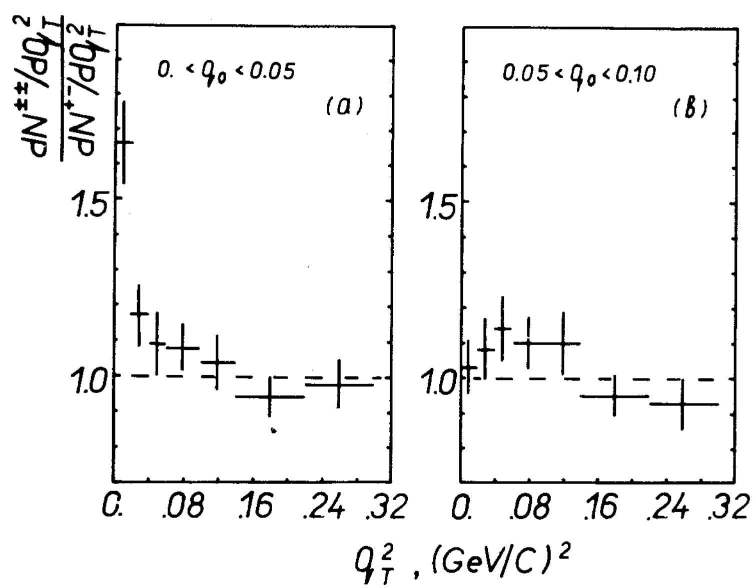

Fig. 2. The q_T^2-distributions for different q_0-intervals.

Table 1

Reaction	Reference	Beam momentum (GeV/c)	R (fm)	$c\tau$ (fm)
$\pi^- p \to 2\pi + X$	/10/	40.	1.7 ± 0.3	0.8 ± 0.5
$K^+ p \to K^+ p 2\pi^+ 2\pi^-$	/11/	8.25	~ 0.8	$0.9 \div 1.2$
$pp \to p 2\pi + X$	/12/	28.5	1.3 ± 0.1	0.4 ± 0.2
$\pi^\pm p \to p(5 \div 7)\pi$	/13/	from 4. to 25.	$1.0^{+0.4}_{-0.2}$	$0.7^{+0.6}_{-0.3}$
$\pi^- p \to p 2\pi^+ 3\pi^- X^0$	/14/	11.2	1.04 ± 0.1	0.41 ± 0.15
$\bar{p}n \to 3\pi^- 2\pi^+$	/15/	$1. \div 1.6$	1.23 ± 0.09	$1.44^{+0.26}_{-0.22}$
$\pi^- p \to 2\pi + X$	/16/	200.	1.41 ± 0.35	-
$\pi^- C^{12} \to 2\pi^- \pi^+(p) + X$	/17/	3.7	2.6 ± 1.2	0.8 ± 0.5
$\bar{p}p \to 2\pi + X$	our data	22.4	3.0 ± 0.5	3.1 ± 1.6

which follows from eqs. (1) and (2). Here b and α are free parameters, the parameter b being introduced to make a correction for normaluzation.

The τ-parameter was determined by fitting the q_0-distribution presented in fig. 1d by the formula

$$g(q_0) = b\left[1 + \frac{\beta}{1 + (\tau q_0)^2}\right], \tag{6}$$

where b and β are free parameters.

The fitted values of R and $c\tau$ (c is the light velocity) are given in Table 1 together with the results of some other experiments.

The value of R remains practically the same after replacing the term $2J_1(x)/x$ in eq. (5) by $\exp(-x^2/8)$. As is seen from Table 1, the dimension and lifetime of the pion emission region in $\bar{p}p$-interactions are larger than in other reactions.

To estimate the longitudinal and transverse dimensions of the pion emission region, the dependence of the interference effect on the pair orientation with respect to collision axis has been investigated. As is mentioned above, the like particle pairs moving in a definite direction $\vec{n}$ permit one to estimate the dimension of the system situated in the pair coplanarity plane and perpendicular to vector $\vec{n}$ /5-8,12/. The pair orientation in the c.m.s. can be defined by angles θ and ϕ: θ is the angle between direction $\vec{n}$ and collision axis $\hat{x}$, ϕ is the angle between vector $\vec{q}_T$ and plane $(\vec{n}, \hat{x})$. It is evident that the selection of pairs with $|\cos\theta|=1$ gives us the value of $R_\perp$ (due to the azimuthal symmetry, there is only one dimension in the transversal plane). In order to measure $R_{||}$, it is necessary to select pairs with $\cos\theta=0$ and $|\cos\phi|=1$. Note that the selection criteria for pair orientations are the same for $(\pi^\pm\pi^\pm)$-and $(\pi^+\pi^-)$-pairs in all the distributions discussed later.

The q_T^2-distributions for pairs emitted along the collision axis ($|\cos\theta| \geq 0.5$) and perpendicular to it are shown in fig. 3. From the fact that the peak in the q_T^2-distribution for pairs emitted in the longitudinal

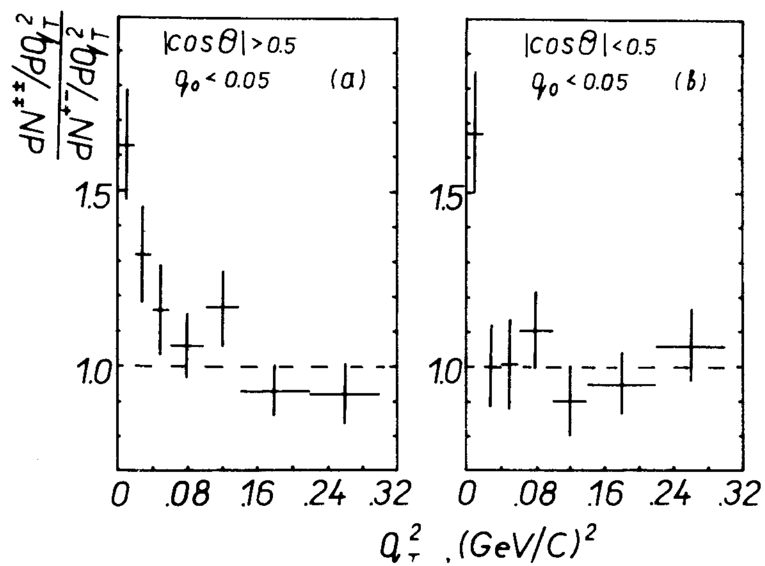

Fig. 3. The q_T^2-distributions for the pairs emitted with $0 \le q_0 \le 0.05$ GeV in the longitudinal and transverse directions in the c.m.s.: a) $|\cos\theta| \ge 0.5$, b) $|\cos\theta| < 0.5$.

Table 2

Pair orientation	R (fm)	τ (fm/c)	B (fm/c)
All θ and φ	3.0± 0.5	2.3 ± 0.8	2.4 ± 0.3
$/\cos\theta/ \geqslant 0.5$	1.7± 0.4	3.1 ± 1.6	1.8 ± 0.4
$/\cos\theta/ < 0.5$	3.8± 1.0	2.2 ± 1.0	3.5 ± 0.7
$/\cos\theta/ < 0.5$ and $/\cos\varphi/ > \frac{1}{\sqrt{2}}$	4.4± 1.4	1.4 ± 0.5	3.4 ± 1.0

direction is wider than for transverse ones it follows that $R_\perp < R_{||}$. The values of the parameter R obtained by fitting the q_T^2-distribution by formula (5) for different pair orientations are given in Table 2. Use was made of the q_T^2-distributions with q_0 cut: $0 < q_0 \le 0.05$ GeV. As is seen from the table, $R_{||}$ is much larger than $R_\perp$.

It has been found that the slope for the q_0-distribution also depends on the pair orientation. For convenience in further discussion, the values of the τ-parameter given in Table 2 were obtained by fitting the q_0-distributions for $q_T \le 0.2$ GeV/c by the formula

$$g(q_0) = b[1 + a e^{-(\tau q_0)^2}]. \tag{7}$$

The data from Table 2 indicate that $\tau_{||} < \tau_\perp$.

It is evident that the lifetime of the π-meson source cannot depend on the pair emission direction. Consequently, the dependence of the τ-parameter on the pair motion direction indicates that in our experiment the slope of the q_0-distribution is determined not only by the lifetime of the π-meson source. It is possible that the longitudinal dimension of the pion source system (along the observation direction) affects the parameter τ.

A systematic excess of the relative number of like pion pairs over unlike ones was observed near the threshold of the $M_{\pi\pi}$-effective mass spectrum in different reactions /18-20/. The analysis of the $M_{\pi\pi}$-distributions (ratios $g(M_{\pi\pi}) = \frac{dN^{\pm\pm}/dM_{\pi\pi}}{dN^{+-}/dM_{\pi\pi}}$ is a sensitive method for studies of this phenomenon.

Our $M_{\pi\pi}$-distributions show a sharp peak near the threshold (see fig. 4). The width of the peak is ~ 60 MeV. As is pointed out above, this peak is due to the interference of identical pions. In order to obtain the parameter B in eq. (4) we have fitted the $M_{\pi\pi}$-distributions by the formula:

$$g(M_{\pi\pi}) = b[1 + a e^{-B^2 m^2/3}], \qquad (8)$$

where b and a are free parameters.

Having fitted the distribution shown in fig. 4a by eq. (8), we obtain the value $B=(2.4 \pm 0.3)$ fm/c.

Figure 5 shows the dependence of the $M_{\pi\pi}$-distributions on the pair emission direction. It is seen that the peak is wider for pairs emitted along the collision axis. The corresponding values of the B-parameter obtained by eq. (8) for different pair orientations are also given in Table 2. The data in figs. 4b and 4c indicate that the threshold peak becomes broader with increasing multiplicity. Finally it should be noted that the normalization parameter b was found to be close to 1 for the fits of all discussed distributions which is in accordance with our definition of normalization.

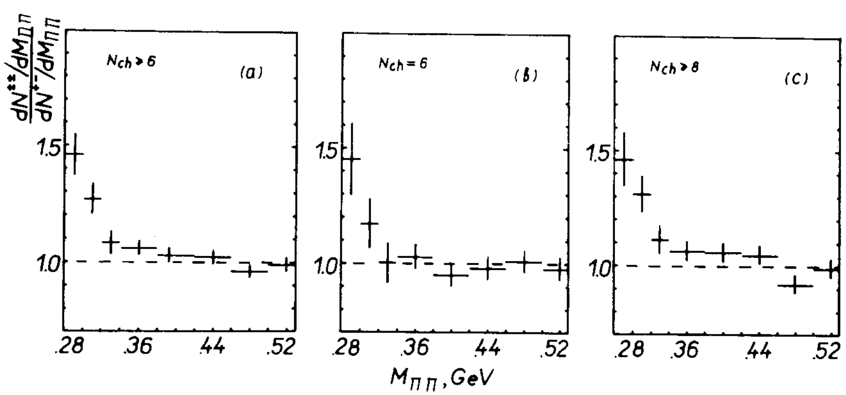

Fig. 4. The $M_{\pi\pi}$-distribution for different charge multiplicities: a) $N_{ch} \geq 6$, b) $N_{ch} = 6$, c) $N_{ch} \geq 8$.

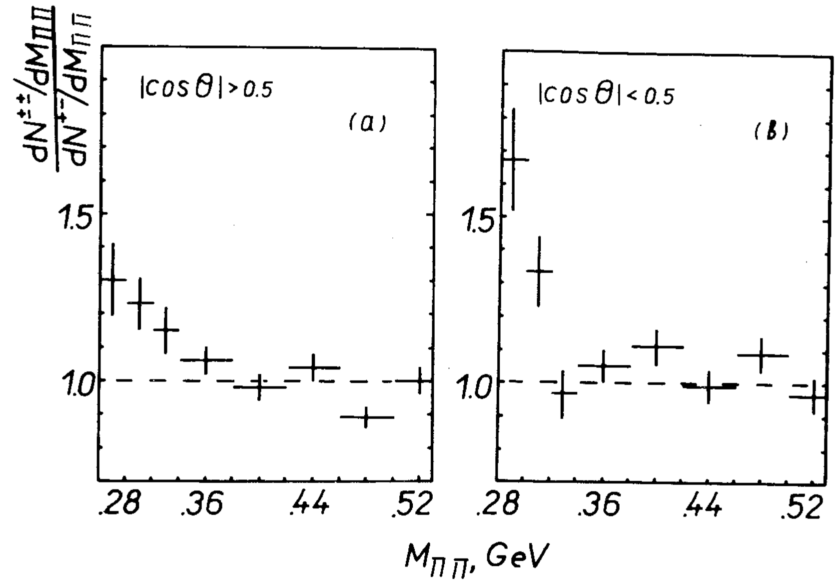

Fig. 5. The $M_{\pi\pi}$-distribution for the pairs emitted in the longitudinal and transverse directions in the c.m.s.: a) $|\cos\theta| \geq 0.5$, b) $|\cos\theta| < 0.5$.

3. DISCUSSION AND CONCLUSIONS

The above results on the interference effect have been obtained using the $(\pi^+\pi^-)$-spectra as a background. It is impossible a priori to exclude some dynamic correlations for $(\pi^+\pi^-)$-pairs with $q_0 \sim q_T \sim 0$. To eliminate such correlations, we used a special procedure of background construction based on mixing the 3-momentum components for particles in each real event (see paper [9]). It is important that this method does not violate the law of momentum conservation for each event in contrast to the method of mixing particles from different events.

Using the background constructed by the above procedure, we have obtained that the q_0-, q_T^2-,

$M_{\pi\pi}$ -distributions are not changed in the studied region. This is in additional evidence for the concentration of the observed effect in the pairs of identical particles.

Going on the interpretation of our results, let us note that the observed anisotropy of the R and τ parameters points to a cigar-like form of the π -meson emission volume, i.e., $R_{||} > R_{\perp}$. The obtained opposite relation between the parameters $\tau_{||} < \tau_{\perp}$ (see Table 2) is in good agreement with this conclusion because the parameters $\tau^2_{||}$ ($\tau^2_{\perp}$) contain a term proportional to $R^2_{\perp}$ ($R^2_{||}$),respectively.

On the other hand, the measured values of the parameters R and $c\tau$ (~ 3 fm) seem to be too large for the space-time characteristics of the interaction region. This is the reason why we decided to use the moving source model (MSM)/21,22/ in which it is possible to get in natural way a stretch of the π -meson emission region by $\vec{r} = \vec{v}\tau$ ($\vec{v}$ is the source velocity). For two like sources such as clusters with radius R moving with velocities $\vec{v}_1$ and $\vec{v}_2$, eq. (35) from paper /21/ can be written as

$$\frac{d^4\sigma}{d^4q} = \{1 + \frac{e^{-R^2\vec{q}^2}}{2}[(1-\alpha)(\frac{1}{1+y_1^2} + \frac{1}{1+y_2^2}) + \frac{2\alpha(1+y_1y_2)}{(1+y_1^2)(1+y_2^2)}]\}\frac{d^4\sigma_0}{d^4q}, \quad (9)$$

where $y_{1,2} = (q_0 - \vec{q}\cdot\vec{v}_{1,2})\tau_{1,2}$, $\tau_{1,2}$ is the lifetime of the sources in the observation system (assume that $\hbar = c = 1$). Here α is a relative contribution of the cross-interference term ($0 \le \alpha \le 1$). The spatial distribution for the sources inside the cluster is assumed to be gaussian-like in order to take into account the recoil effect. For the case $\vec{v}_1 = -\vec{v}_2 = \vec{v}$ ($\tau_1 = \tau_2 = \tau$) and small $y_{1,2}$ and $R|\vec{q}|$ eq. (9) can be rewritten in the following exponentional approximation

$$\frac{d^4\sigma}{d^4q} \approx \{1 + \exp[-R^2\vec{q}^2 - \tau^2 q_0^2 - \tau^2 k(v_{||}^2 q_{||}^2 + \frac{1}{2}v_{\perp}^2 q_{\perp}^2)]\}\frac{d^4\sigma_0}{d^4q},$$

where $V_{||}$($V_{\perp}$)is the longitudinal (transverse) velocity component) with respect to the collision axis and $k = 1 + 2\alpha$. For the pairs observed along or across the reaction axis, the last expression is a function of two variables only, and it is easy to get the equations:

$$R^2_{\perp} = 4R^2 + 2k\tau^2 v^2_{\perp}, \quad (10a)$$

$$\tau^2_{\perp} = \tau^2 + \frac{R^2_{||}}{4}\langle\frac{1}{v_0^2}\rangle, \quad (10b)$$

$$R^2_{||} = 4R^2 + 4k\tau^2 v^2_{||}, \quad (10c)$$

$$\tau^2_{||} = \tau^2 + \frac{R^2_{\perp}}{4}\langle\frac{1}{v_0^2}\rangle, \quad (10d)$$

where the mean value $\langle 1/v_0^2 \rangle \simeq 2$ in our experiment. The approximate formulae (10) are true in the region of the maximum of the interference, where they can be used for qualitative estimations. It should be emphasized that eqs. (10b) and (10d) are also valid in the case of motionless sources (for emission from the ellipsoid surface the factor 1/4 must be replaced by 1/18/9/). Note that if two like sources are moving in opposite directions and if only the cross-interference is essential ($k = 3$), one can get from eq. (10) the parameters $R^2_{||,\perp}$ 3 times (at $R \approx 0$) as large as those for the sources moving in the same direction ($k = 1$).Anisotropy of the parameters $\tau^2_{||,\perp}$ increases accordingly. In the case when the source 1 is fixed and the source 2 is moving (assuming $\tau_1 \ll \tau_2$), one needs to put $k = \frac{1+\alpha}{2}$ in eqs. (10) and replace $R^2 = \frac{R_1^2 + R_2^2}{2}$ and $\tau^2 = k\tau_2^2$ in eqs. (10b,d). The case of one moving source is described by eq. (10) at $k = 1$.

From eqs. (10) it follows that in all cases our results ($R_{\perp} < R_{||}$ and $\tau_{\perp} > \tau_{||}$) can be explained in the MSM by peripheral ($v^2_{||} > \frac{v^2_{\perp}}{2}$) generation of the π-meson sources. It is evident that the relation $R < 0.5R_\perp$ is true for the source dimension.

Using eq. (10) in our experiment, one can find an estimation of $\tau \leq 0.7$ fm/c. If one assumes $v_\perp \sim 0$ then $R \sim (0.8\text{-}0.9)$fm and $v_{||} \sim 1$ as it follows from eqs. (10). If R is small in comparison to dynamic terms in eqs. (10), then $v_{||}/v_\perp \sim 1.8$.

Eqs. (10), found for moving sources with fixed velocities, can be changed after integration over the source momentum spectrum. To illustrate this, let us neglect in eq. (9) the source radius and leave only the cross-interference term ($a=1$). After this one can integrate eqs. (9) and (10) over the momenta of the sources, which emit π-mesons with momentum $\sim \frac{\vec{p}}{2}$. We consider the interference between two pions one of which is produced directly from the interaction region and the second one is a resonance decay product (and $y_1 \ll y_2$ in (9)). We have considered this model in [22] discussing our preliminary results. A detailed study of such a model for the m^2-distribution only has been recently performed by Thomas [23] and Grassberger [24]. By averaging (10) over the inclusive spectra of π- and ρ°-mesons in our reaction [3,25], we obtain the following estimates for the parameters: $R_\perp \approx 1.3$ fm, $R_{||} \approx 2.9$ fm, $\tau_\perp \approx \tau_{||} \approx 2.4$ fm/c. In this approximation it is possible to find for the slope B^2 of the m^2-distribution some result which is independent of the observation direction (see also ref. [24]):

$$B^2 \simeq \left(\frac{\gamma^* v^*}{\Gamma}\right)^2 ,$$

where γ^* and v^* are the π-meson γ-factor and velocity in the resonance rest frame; Γ is the resonance width. For ρ-meson B is equal to ≈ 3.3(fm/c). In the case considered the dèpendence of the B-parameter on the observation direction can be related to superposition of different resonance contributions.

From the above discussion it follows that our data can be explained in the framework of the MSM by peripheral movement of sources. They may be resonances, clusters or fireballs. Different values of interference parameters in various reactions may be connected with various dynamics of pion production: directly from the interaction region (or from the sources fixed in the c.m.s.) or from the decay of moving sources: clusters, resonances or fireballs.

In order to make a choice between models with fixed and moving sources, it is necessary to investigate the dependence of the interference effect not only on the observation direction but also on the pair velocity.

Let us summarize the main results of this paper.

1. The interference effect of identical pions predicted by Kopylov and Podgoretsky has been observed in inclusive $\bar{p}p$-interactions at 22.4 GeV/c. The interference was observed both on the $\Delta\Delta$-plot and in the effective mass spectrum for identical pion pairs.

2. The mean dimension and lifetime of the pion generation region were determined from the $\Delta\Delta$-plot analysis: $\langle R \rangle = (3.0 \pm 0.5)$fm and $\langle \tau \rangle = (3.1 \pm 1.6)$fm/c.

3. From the $\Delta\Delta$-plot analysis some evidence has been obtained for the opposite dependence of the parameters R and τ on the observation direction: $R_\perp = (1.7 \pm 0.4)$ fm, $R_{||} = (4.4 \pm 1.4)$ fm, $\tau_\perp = (3.1 \pm 1.6)$ fm/c, $\tau_{||} = (1.4 \pm 0.5)$ fm/c. It is shown that these parameters not only describe the space-time characteristics of the interaction region but also can be connected with the motion of pion sources.

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REFERENCES

1. Alferov V.N. et al. Preprint IHEP, OP 74-53, OP 74-54, Serpukhov, 1974; Gubrienko K.I. et al. Preprint IHEP, OP 74-55, Serpukhov, 1974.
2. Abesalashvili L.N. et al. Phys.Lett., 1974, 52B, p.236.
3. Boos E.G. et al. Nucl.Phys., 1977, B121, p.381; Boos E.G. et al. JINR, E1-9781, Dubna, 1976.
4. Goldhaber G. et al. Phys.Rev., 1960, 120, p.300.
5. Kopylov G.I., Podgoretsky M.I. Soviet Nucl. Phys., 1972, 15, p.392; 1973, 18, p.656; 1974, 19, p.434.
6. Kopylov G.I., Podgoretsky M.I. JETP, 1975, 69, p.414.
7. Kopylov G.I. Phys.Lett., 1974, 50B, p.472.
8. Kopylov G.I. JINR, E2-8549, Dubna, 1975.
9. Kopylov G.I., Podgoretsky M.I. JINR, E2-9285, Dubna, 1975.
10. Angelov N. et al. JINR, P1-10502, Dubna, 1977.
11. Grard F. et al. Mons-Brussels-CERN Collaboration. Nucl.Phys., 1976, B102, p.221.
12. Cantor J. et al. Preprint BNL-20516, Brookhaven, 1976.
13. Deutschmann M. et al. Aachen - Berlin - Bonn - CERN - Cracow - Heidelberg - Warsaw Collaboration. Nucl.Phys., 1976, B103, p.198.
14. Calligarich E. et al. Lett. al Nuovo Cim., 1976, v.16, p.129.
15. Borreani G. et al. Report 112-A2-66 at the XVIII Int. Conf. on High Energy Phys., Tbilisi, 1976.
16. Biswas N.N. et al. Phys.Rev.Lett., 1976, 37, p.175.
17. Bayukov Yu.D. et al. Preprint ITEP-70, Moscow, 1976.

18. Clayton J. et al. Topical Conf. on High Energy Collisions of Hadrons. CERN 68-7, v.1, 595 (1968).
19. Eskreys A. et al. Brussels - CERN - Cracow Collaboration. Nucl.Phys., 1972, B42, p.44.
20. Aniola L., Bartke J., Toghen T. Nucl.Phys., 1973, B60, p.338.
21. Kopylov G.I., Podgoretsky M.I. Soviet Nucl. Phys., 1973, 18, p.656.
22. Lednicky R. Alma-Ata - Dubna - Helsinki - Kosice - Moscow - Prague Collaboration. Antinucleon-Nucleon Interactions. Proc. of the 3d European Symposium, p.447, Stockholm, July 9-13, 1976.
23. Thomas G. Argonne Preprint ANL-HEP-PR-76-33, 1976.
24. Grassberger P. Nucl.Phys., 1977, B120, p.231.
25. Boos E.G. et al. Inclusive ρ^0 Production in $\bar{p}p$-Interactions at 22.4 GeV/c, paper submitted to the European Conf. on Particle Physics, Budapest, 4-9 July, 1977.

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