Two-pion correlations in Au+Au collisions at 10.8 GeV/c per nucleon

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We present here results of the correlation analysis of pions produced in central (10%) Au+Au collisions at 10.8 GeV/c per nucleon by the AGS experiment E877 [1, 2]. The correlation function $C(\mathbf{q})$ is defined as the number of pion pairs in a $\mathbf{q}$-bin (signal) divided by the number of such pairs obtained by event mixing (background). The background pairs were weighted with the Coulomb correction factor which had been evaluated taking into account the finite size of the source and the momentum resolution of the spectrometer. The three-dimensional correlation functions were fitted by

$$C(q_{\rm out}, q_{\rm side}, q_{\rm long}) = 1 + \lambda \exp(-{R_{\rm out}}^2 {q_{\rm out}}^2 - {R_{\rm side}}^2 {q_{\rm side}}^2 - {R_{\rm long}}^2 {q_{\rm long}}^2 - 2|R_{\rm ol}|R_{\rm ol} q_{\rm out} q_{\rm long}) \ . \qquad (1)$$

The variables $q_{\rm out}, q_{\rm side}$, and $q_{\rm long}$ are the components of $\mathbf{q}$ in the beam rapidity frame $y_{\rm anal} = y_{\rm beam} = 3.14$, with $q_{\rm long}$ being the component parallel to the beam, $q_{\rm side}$ perpendicular to the beam and to the total pair momentum, and $q_{\rm out}$ perpendicular to $q_{\rm long}$ and $q_{\rm side}$. The projections of the correlation and of the fit, obtained by averaging over the two other components of $\mathbf{q}$ in the range from -50 MeV/c to 50 MeV/c, are shown in Fig. 1. The fit results are given in Table 1.

The π^+ and π^- sources apparently differ in size. We attribute this to the distortion of the correlation function caused by the Coulomb interaction between each of the pions and the rest of the system [3].

It has been shown recently that the two-pion correlation function is related to the pion phase space density (defined as the number of pions per unit volume h^3) at freeze-out [4]. Using this result we obtained the following formula for the density of core pions (i.e. excluding pions from decays of long-lived resonances):

$$\langle f \rangle_{\mathbf{p}}^{\rm core} = \frac{d^3n}{d^3p} \, \frac{\sqrt{\pi}^3 \sqrt{\lambda}}{R_{\rm out} R_{\rm side} R_{\rm long}} \ , \qquad (2)$$

where $\langle f \rangle_{\mathbf{p}}$ is the phase space density of pions with momentum $\mathbf{p}$, averaged over the spatial coordinates, d^3n/d^3p is the differential pion multiplicity, and λ, $R_{\rm out}$, $R_{\rm side}$, and $R_{\rm long}$ are the parameters of the correlation function. In the absence of tranverse flow and neglecting spectral changes due to Δ decay, the phase space density of pions in thermal equilibrium would follow the Bose-Einstein distribution:

$$f^{\rm BE}(\mathbf{p}) = \frac{1}{\exp(m_t \cosh(y - y_S)/T) - 1} \qquad (3)$$

with the pion transverse mass m_t and rapidity y, and the source rapidity y_S. Thus we can test the thermalization of pions by comparing the experimental phase space density to that given by Eq. (3). The comparison is simplified by the fact that the experimental differential multiplicity can also be parametrized by the Bose-Einstein function:

$$\frac{d^3n}{d^3p} = \frac{A}{\exp(m_t/T_{\rm eff}) - 1} \qquad (4)$$

with two fit parameters: effective transverse temperature $T_{\rm eff}$ and normalization A. We assume that $T_{\rm eff} = T/\cosh(y - y_S)$. Consequently, the comparison between $\langle f \rangle_{\mathbf{p}}^{\rm core}$ and $f^{\rm BE}(\mathbf{p})$ is reduced to the comparison between the parameters of the two-pion correlation function and the normalization of the pion spectra A:

$$\frac{\langle f \rangle_{\mathbf{p}}^{\rm core}}{f^{\rm BE}(\mathbf{p})} = A \frac{\sqrt{\pi}^3 \sqrt{\lambda}}{R_{\rm out} R_{\rm side} R_{\rm long}} \ . \qquad (5)$$

Using A obtained from a fit to the entire measured transverse momentum spectra $0 < p_t < 0.6$ GeV/c in the rapidity range 3.0–3.3 [5] and the correlation parameters from Table 1, we evaluated the experimental-to-thermal density ratio of 0.97±0.23 and 1.02±0.18 for π^+ and π^-, respectively. Thus the experimental pion phase space density is consistent with the presence of local equilibrium.

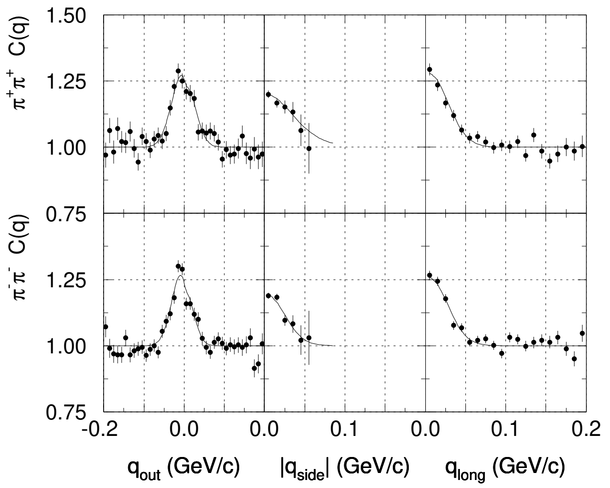

Figure 1: Projections of the 3-dim. $\pi^+\pi^+$ and $\pi^-\pi^-$ correlation functions. Solid lines are projections of the fit.

Table 1: Fit results (corrected for momentum resolution).

	λ	$R_{\rm out}$(fm)	$R_{\rm side}$(fm)	$R_{\rm long}$(fm)
$\pi^+\pi^+$	0.62±0.06	5.8±0.5	3.9±0.8	5.5±0.4
$\pi^-\pi^-$	0.62±0.05	6.5±0.5	5.6±0.7	5.8±0.4

References

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