We present a systematic analysis of two-pion interferometry for the central Au+Au collisions at √s_{NN} = 3, 5, 7, 11, 17, 27, 39, 62, 130 and 200 GeV/c with the help of a multiphase transport (AMPT) model. Emission source-size radius parameters R_{long}, R_{out}, R_{side} and the chaotic parameter \lambda are extracted and compared with the experimental data. Transverse momentum and azimuthal angle dependencies of the HBT radii are also discussed for central Au+Au collisions at 200 GeV/c. The results show that the HBT radii in central collisions do not change much above 7 GeV/c. For central collisions at 200GeV/c, the radii decrease with the increasing of transverse momentum p_T but not sensitive to the azimuthal angle. These results provide a theoretical reference for the energy scan program of the RHIC-STAR experiment.

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clude additional reaction channels which are very important at high energies. In the present work we use the AMPT version with the string melting scenario.

Hanbury Brown-Twiss interferometry of two identical pions can directly access the space-time structure of the emitting source formed in heavy-ion collisions, providing a probe of the system evolution dynamics. To measure multi-dimension source sizes, relative momentum \((k)\) is decomposed into standard side-out-long axis \([32]:\) where \(k_{long}(k)\) represents for a component parallel to the beam-axis, \(k_{out}(k)\) for the one parallel to the transverse momentum of the pair \((K_T = (p + q)/2)\), and \(k_{side}(k)\) for the one orthogonal to both \(k_{long}\) and \(k_{out}\). The “HBT puzzle” from hydrodynamical models might arise because the combination of several effects: mainly prethermalized acceleration, using a stiffer equation of state, and adding viscosity as claimed in Ref. [34]. Knowledge or reasonable assumption of duration and freeze-out shape of source can improve to understand the “HBT puzzle”, which need more works in both experiments and theories.

The two-boson correlation function is given by

\[
C_2(p, q) - 1 = \frac{\int d^4xS(x, K) \int d^4yS(y, K) \exp(2ik \cdot (x - y))}{\int d^4xS(x, p) \int d^4yS(y, q)} \approx \frac{\int d^4xS(x, K) \int d^4yS(y, K) \exp(2ik \cdot (x - y))}{\int d^4xS(x, K)}^2
\]

where \(K = (p + q)/2\) and \(k = (p - q)/2\). We calculate the correlation parameters by performing a \(\chi^2\) fit of the three-dimensional correlation function \(C_2(k_o, k_s, k_t)\) to a Gaussian \([33]\) as,

\[
C_2(k_o, k_s, k_t) = 1 + \lambda \exp(-k_o^2 R_o^2 - k_s^2 R_s^2 - k_t^2 R_t^2). \tag{3}
\]

Here, \(\lambda\) is often referred to as an incoherence factor \([2]\). The parameter \(\lambda\) can represent the correlation strength. Theoretically it can be less than unity due to partial coherence of strong interaction, long-lived resonance decays and the non-Gaussian form of the correlation function \([2, 4]\).

The correlation functions are calculated from the phase space distributions of pions at freeze-out using the CRAB (the CoRrelation After Burner) \([36]\). Given a model for a chaotic source described by \(S(x, K)\), such as the transport model described above, Eq. (3) \([37]\) can be employed to compute the correlation function.

Here we present results of a systematic study of two-pion interferometry in central Au+Au collisions. As pion is one of the main production particles in relativistic nucleus-nucleus collisions, we use \(\pi^+\) and \(\pi^+\) as correlation particles. In this calculation, we use the similar event selection method in experiment \([4]\) for centrality cuts, where the centrality was characterized according to the multiplicity of charged hadrons. In transport model, Glauber model \([38]\) is always employed to calculate the number of participants to define centrality, which is discussed in detail in our previous work \([38]\).

The kinetic variable of pseudorapidity \((\eta = \frac{1}{2} \ln \left( \frac{p_T + |p_z|}{p_T - |p_z|} \right))\) is limited to (-1,1) for investigating mid-pseudorapidity physics. With no special statement, we selected the collision centrality of 0 to 10% and pseudorapidity region of \(|\eta| < 1\). Figure 1 shows the two pions \((\pi^+ + \pi^+)\) HBT correlation functions in three-dimension for 0-10% centrality Au + Au collisions at 200 GeV/c in the AMPT model with the help of CRAB. And the correlation functions are fitted by Eq. (3) for the three-dimension. It presents nice quality of the fitting in the algorithm of CRAB and Eq. (3) based on a Gaussian ansatz.

Figure 2 shows the HBT radii, the chaotic parameter \(\lambda\) and the ratio \(R_o/R_s\) from the AMPT model and their comparisons with the experimental results. The chaotic parameter and the ratio from the AMPT model are consistent with the experimental results \([3, 4, 10, 17]\), but the HBT radii from the AMPT model seems larger than those from the experimental results. Moreover, the radii do not show much dependence on the beam energy from 7 GeV to 200 GeV.

Figure 3 shows azimuthal angle dependence of HBT radii in 0-10% centrality at 200 GeV/c with the AMPT model. \(R_o\), \(R_s\) and \(R_l\) are not so sensitive to the azimuthal angle \(\phi\). Considering that we only select 0-10% centrality, it is reasonable not to see a strong dependence on \(\phi\). These results are consistent with those from STAR for the same system \([4]\).

Figure 4 shows the \(K_T\) dependence of the HBT radii for 0-10% centrality by the AMPT model, and 0-5%, 5%-10% centrality for STAR results at \(\sqrt{s_{NN}} = 200\) GeV. It can be seen from Figure 4 that the HBT radii and the ratio from AMPT model decrease with the increasing of transverse momentum and the ratio \(R_o/R_s\) is around 1.0-1.2. Qualitatively speaking, high transverse momentum mesons are ejected from the emission source earlier, while the low transverse momentum meson emits lately, therefore we can see the expansion of the emission source by
the $K_T$ dependence of HBT radii.

In conclusion, we calculated $\pi^+ + \pi^+$ correlation function and extract the emission radius parameters for central Au+Au collisions in wide RHIC energies. It shows that the chaotic parameter and the ratio $R_o/R_s$ from the AMPT model are consistent with the experimental data, but the HBT radii from the AMPT model are larger than experimental results. We also present an analysis of the transverse momentum and azimuthal angle dependencies of the HBT radii in central Au+Au collisions at 200 GeV/c. The results show that HBT radii are not sensitive to the azimuthal angle and it decreases with the increasing of transverse momentum $p_T$ in central collisions.

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FIG. 3: (Color online) The HBT radii relative to the reaction plane angle for 0-10% centrality for AMPT model at 200GeV/c.

FIG. 4: (Color online) The $K_T$ dependence of the HBT radii for 0-10% centrality by the AMPT model, comparing with the STAR data at 0-5% and 5%-10% centrality at 200GeV/c.