Two-pion Interferometry Measurements for Au+Au and Cu+Cu Systems at RHIC-PHENIX

Alex M. Mwaï for the PHENIX Collaboration

Nuclear Chemistry Group, Stony Brook University, Stony Brook, New York

1. Abstract

HBT measurements are presented as a function of collision centrality and the mean transverse momentum of pion pairs, for different collision systems and beam collision energies. They provide new insights on reaction dynamics at RHIC, as well as a detailed model independent mapping of the evolution of the space-time extent of the emitting source, from RHIC to LHC.

2. HBT Method

Two-particle correlations encode information about the space-time extent of pion-emitting sources.

\[ C(q) = \int dr |\Phi(r,q)|^2 S(r,q) \quad \text{Eq. 1} \]

\( r \) is the pair separation; \( q \) is the relative momentum; \( S(r,q) \) is the emission function; \( \Phi(r,q) \) is a correction for Final State Interactions (FSI).

In experiment, we fit \( C(q) \) in 3-D with the form:

\[ C(q) = 1 + \lambda \exp \left( -R_{\text{in}}^2 q_{\text{in}}^2 - R_{\text{side}}^2 q_{\text{side}}^2 - R_{\text{long}}^2 q_{\text{long}}^2 \right) \quad \text{Eq. 2} \]

\( q_{\text{out}} \parallel \) parallel to pair transverse momentum

\( q_{\text{in}} \perp \) perpendicular to beam direction

\( q_{\text{side}} \) or parallel to beam direction gives \( R_{\text{out}} \), which gives source emission duration (\( \Delta \tau \))

\( R_{\text{side}} \) that provides source geometrical size, \( R_{\text{geom}} \)

\( R_{\text{long}} \) that carries information on source lifetime (\( \tau \))

3. Experiment

4. \( \bar{R} \) Scaling of HBT Radii

\( \bar{R} \) is the transverse size of the system

\[ 1/\bar{R} = \sqrt{1/\sigma^2 + 1/\sigma^2} \quad \text{Eq. 3} \]

\( \sigma_{x}, \sigma_{y} \) : RMS widths of density distributions

5. \( m_{T} \) Scaling of HBT Radii

[Diagram showing \( R_{\text{out}}, R_{\text{side}}, R_{\text{long}} \) for different collision energies and beam collision momenta]

6. \( (R_{\text{out}})^2 - (R_{\text{side}})^2 \) and \( (R_{\text{out}} - \sqrt{2}\bar{R})/R_{\text{long}} \)

7. Summary and Conclusion

[Diagram showing % dependence of \( (R_{\text{out}})^2 - (R_{\text{side}})^2 \) on \( \sqrt{s_{NN}} \)]

\( (R_{\text{out}})^2 - (R_{\text{side}})^2 \) is proportional to \( \Delta \tau^2 \)

\( (R_{\text{out}} - \sqrt{2}\bar{R})/R_{\text{long}} \) is expansion rate in the transverse as compared to the longitudinal

\( (R_{\text{out}})^2 - (R_{\text{side}})^2 \) dependence on \( \sqrt{s_{NN}} \) shows a maximum with a compliment minimum in \( (R_{\text{side}} - \sqrt{2}\bar{R})/R_{\text{long}} \)

This pattern is suggestive of decay trajectories in vicinity of critical end point (CEP)

References


L. Adamczyk et al. (STAR Collaboration) (2014), 1403.4972

Acknowledgments

• Nuclear Chemistry Group, Stony Brook University
• PHENIX collaboration

Very good PID attained from EMC and TOF East

Fig. 2

Fig. 3

Fig. 4 (a), (b), (c) \( \bar{R} \) dependence of \( R_{\text{out}}, R_{\text{side}}, R_{\text{long}} \). Curves are linear fits to data. (d) \( 1/m_{T} \) dependence of slopes from linear fits in (a), (b), (c).

Au+Au and Cu+Cu similar at same \( m_{T} \) and \( \bar{R} \)

• Strong linear dependence of HBT radii on \( \bar{R} \)

• Decrease of slope in scaling curves for HBT radii with \( m_{T} \), indicative of strong influence of space-momentum correlations

Fig. 5 PHENIX and STAR \( R_{\text{out}}, R_{\text{side}}, R_{\text{long}} \) dependence on \( 1/m_{T} \) for \( v_{NN} = 200 \text{ GeV} \) (a), (b), (c); 62 GeV (d), (e), (f); 39 GeV (g), (h), (i). Curves are linear fits to data.

PHENIX and STAR results show a very good comparison for all HBT radii at the three energies

• HBT radii in all systems and energies studied scale with \( 1/m_{T} \),

Fig. 6 (a) \( (R_{\text{out}})^2 - (R_{\text{side}})^2 \) and (b) \( (R_{\text{side}} - \sqrt{2}\bar{R})/R_{\text{long}} \) dependence on \( v_{NN} \).

\( (R_{\text{out}})^2 - (R_{\text{side}})^2 \) is proportional to \( \Delta \tau^2 \)

\( (R_{\text{side}} - \sqrt{2}\bar{R})/R_{\text{long}} \) is expansion rate in the transverse as compared to the longitudinal

\( (R_{\text{out}})^2 - (R_{\text{side}})^2 \) dependence on \( v_{NN} \) shows a maximum with a complimentary minimum in \( (R_{\text{side}} - \sqrt{2}\bar{R})/R_{\text{long}} \)

This pattern is suggestive of decay trajectories in vicinity of critical end point (CEP)

More measurements needed in future RHIC beam energy scan to help locate CEP

5 - alexmwai@bnl.gov