Identical Pion Interferometry from Au+Au Collisions at $\sqrt{s_{NN}}$ = 3.0, 3.2, 3.5, and 3.9 GeV in the STAR Experiment at RHIC

Vinh Luong (for the STAR Collaboration)
Joint Institute for Nuclear Research

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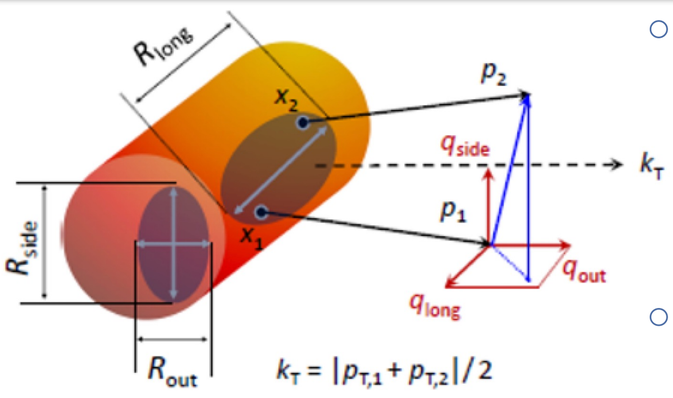
Abstract

Two-pion interferometry provides access to the spatial and temporal size, shape and evolution of their sources created in heavy ion collisions and hence offers strong constraints for the model calculations. In this work, we will report the measurement of correlation strength (λ) and femtoscopic radii (R_{out}, R_{side}, R_{long}, $R^2_{\text{out–long}}$) extracted from the two-pion correlation function in Au+Au collisions at $\sqrt{s_{NN}}$ = 3.0, 3.2, 3.5, and 3.9 GeV. The dependence of these parameters on pair transverse momentum, pair rapidity, collision centrality, and collision energy will be presented.

Introduction



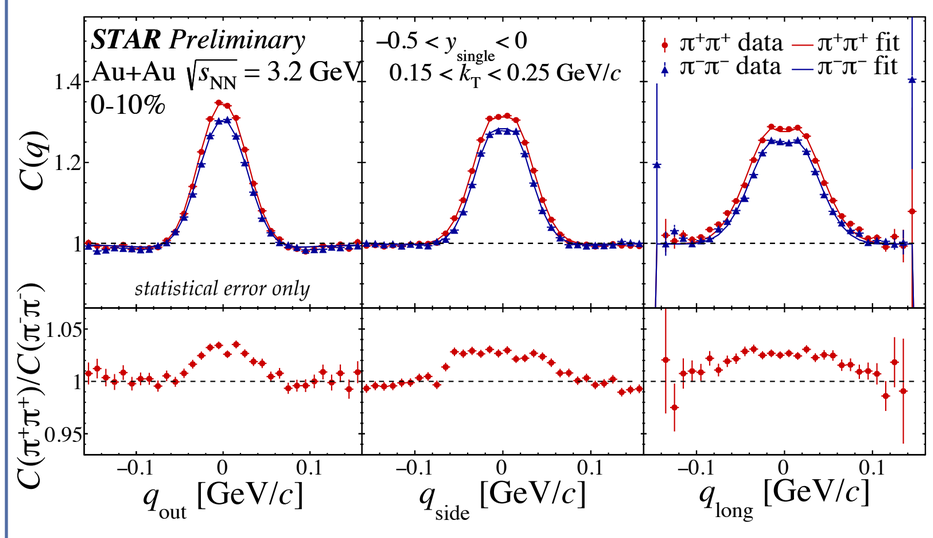
- Experimentally, two-particle correlation function is defined as $C(\vec{q}) = N(\vec{q})/D(\vec{q})$, where $\vec{q} = \vec{p}_2 - \vec{p}_1$ is the pair relative momentum, $N(\vec{q})$: distribution of pairs from the same event, $D(\vec{q})$: distribution of pairs from different events.
- $\vec{q}$ is boosted into the longitudinally comoving system and decomposed into Bertsch–Pratt [1,2] "out-side-long" orthogonal components.
- $C(\vec{q})$ is fitted using Bowler–Sinyukov [3,4] procedure:

$$C(\vec{q}) = N\left[(1-\lambda) + \lambda K_{\text{Coul}}(q_{\text{inv}})(1+G(\vec{q}))\right]$$

$$G(\vec{q}) = \exp(-q^2_{\text{out}}R^2_{\text{out}} - q^2_{\text{side}}R^2_{\text{side}} - q^2_{\text{long}}R^2_{\text{long}} - 2q_{\text{out}}q_{\text{long}}R^2_{\text{out–long}})$$

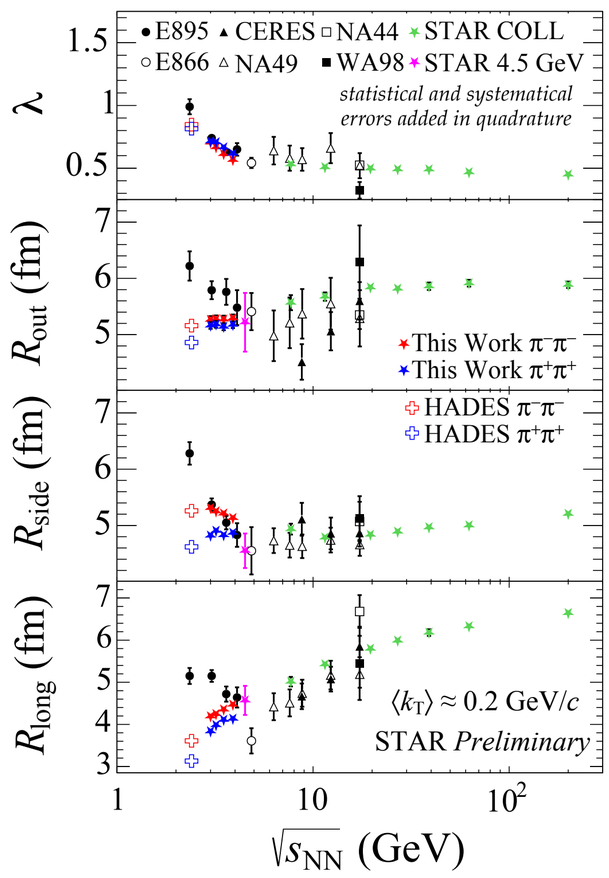
  where N: normalization constant, λ: correlation strength, K_{Coul}: Coulomb correction factor.
- R_{out}, R_{side}, and R_{long} reflect geometrical size + emission duration, geometrical size, and evolution time, respectively.
- For azimuthal integrated analysis: $R^2_{\text{out-side}} = R^2_{\text{side-long}} = 0$ due to symmetry, $R^2_{\text{out-long}}$ is non-vanishing for non-boost invariant sources [5].

Two-pion correlation functions



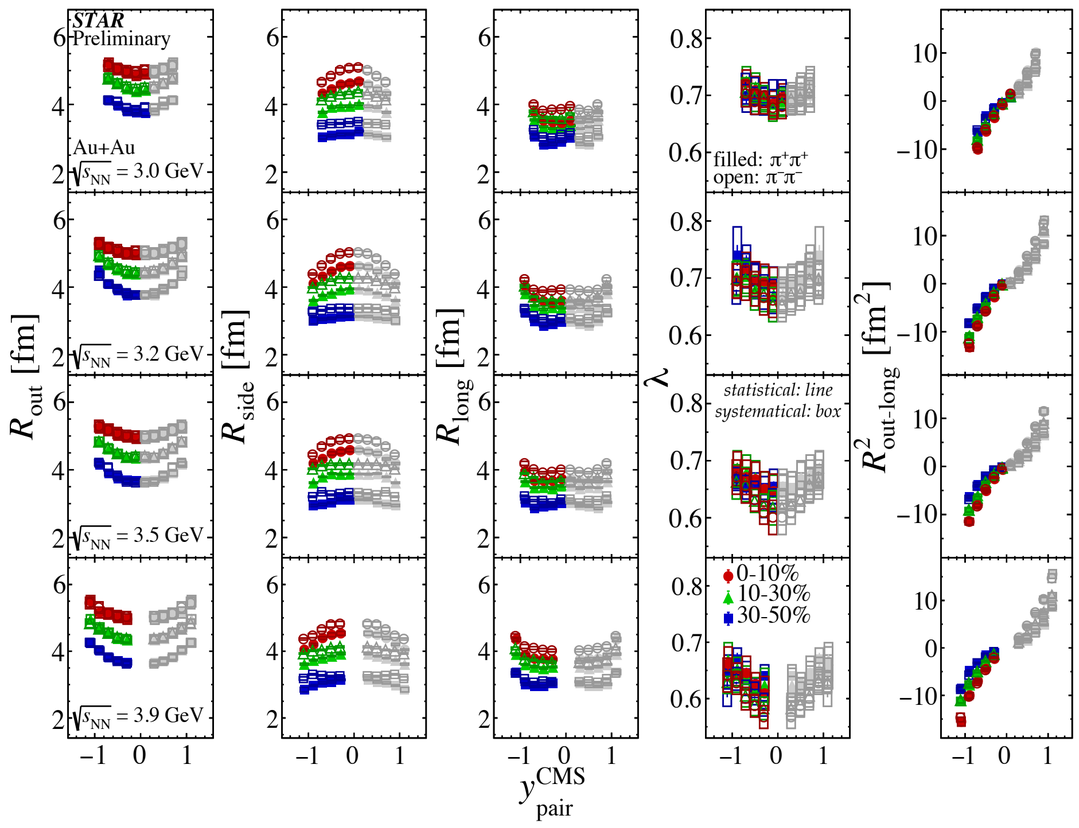
- Slight difference between measured correlation functions of positively and negatively charged pions for $0.15 < k_T < 0.25$ GeV/c in 0–10% most central collisions.
  - This observation may be attributed to residual electric charge.

Collision energy dependence



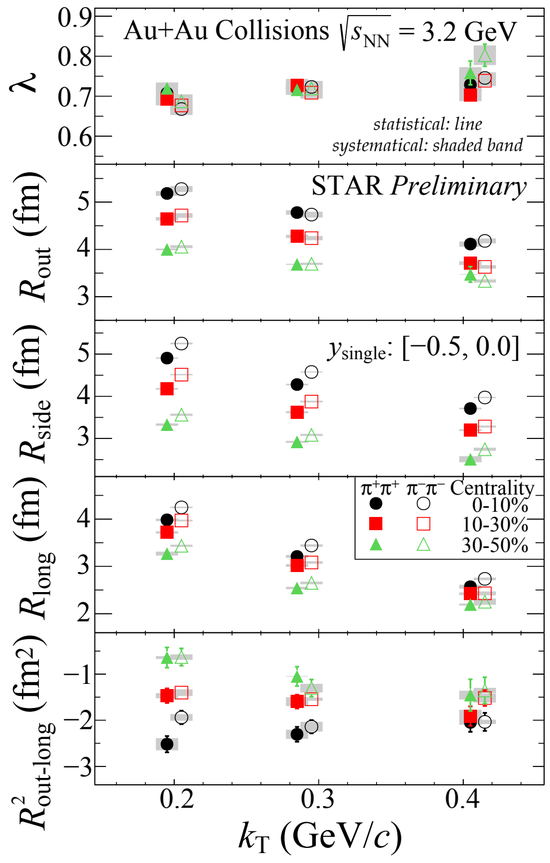
- R_{side} slightly decreases and R_{long} increases with increasing collision energy.
- Extracted femtoscopic parameters follow the trend of HADES [6] and STAR's collider mode [7] results.

y_{pair}-dependence



- R_{side}, R_{long} are different for $\pi^-\pi^-$ and $\pi^+\pi^+$. The difference decreases with increasing collision energy.
  - This may be attributed to residual electric charge.
- R_{side} decreases and $|R^2_{\text{out–long}}|$ increases with increasing magnitude of pair rapidity in the center-of-mass system ($|y^{\text{CMS}}_{\text{pair}}|$).
  - Hint of boost-invariance breaking.

k_T-dependence



- R_{out}, R_{side}, R_{long} decrease with increasing k_T and from central to peripheral collisions
  - due to radial flow and collision geometry, respectively.
- $R^2_{\text{out–long}}$ is non-zero due to asymmetric pion acceptance w.r.t. midrapidity.

Summary

- Two-pion femtoscopic measurements in Au+Au collisions at $\sqrt{s_{NN}}$ = 3.0, 3.2, 3.5, 3.9 GeV measured by the STAR experiment are reported.
- The difference between positively and negatively charged pions in correlation functions and, subsequently, in R_{side} and R_{long}, most prominent at $\sqrt{s_{NN}}$ = 3 GeV, may be due to Coulomb interaction between pion source and the fireball.
- Hint of boost-invariance breaking is given by the decrease of R_{side} with increasing pair rapidity magnitude and by the clear pair rapidity dependence of $R^2_{\text{out–long}}$.

References

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