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Two-pion Femtoscopy in Au+Au Collisions at $\sqrt{s_{NN}} = 3$ GeV in the STAR Experiment

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Abstract

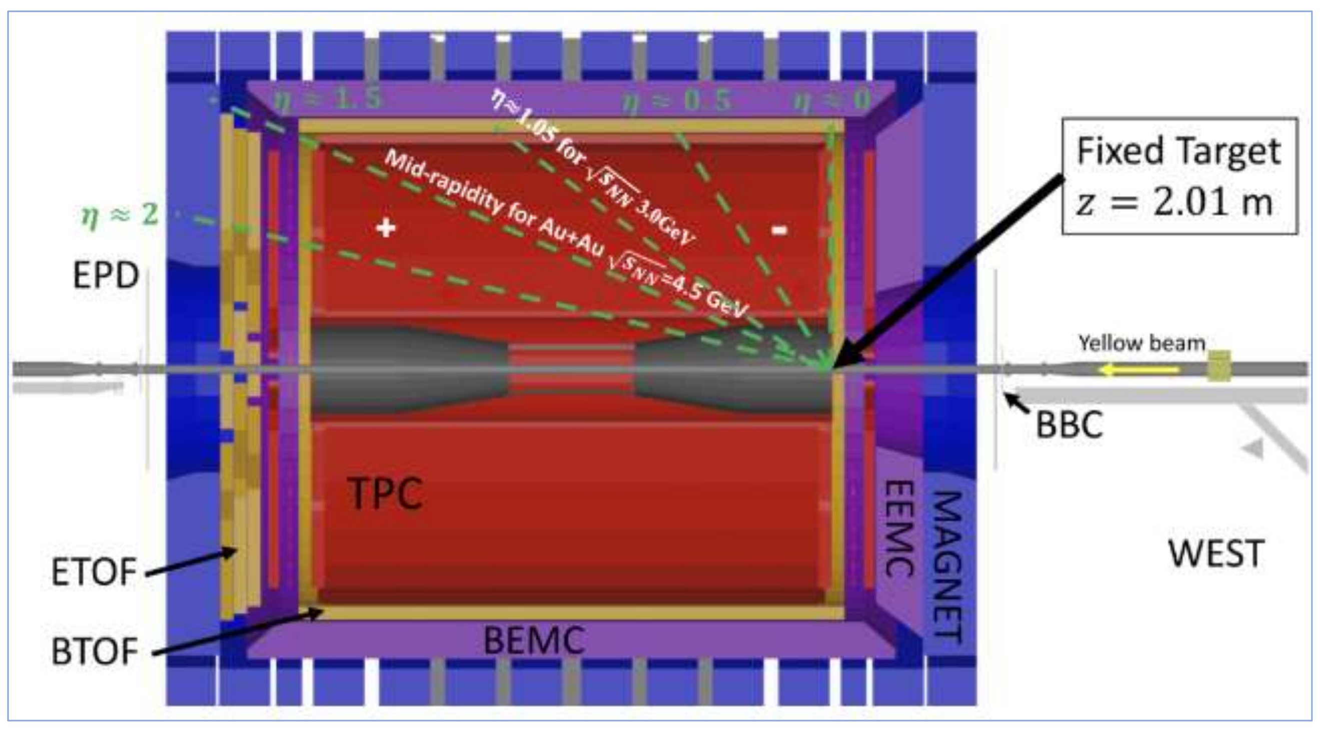
The correlation femtoscopy technique makes it possible to estimate the geometric dimensions and lifetime of the particle emission region after the collision of ions. Measurements of the emission region characteristics not only at midrapidity, but also at the backward (forward) rapidity can provide new information about the spatio-temporal structure of source and make it possible to impose constraints on heavy-ion collision models. This study is aimed to measure the femtoscopic parameters of identical-pion emission region in Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV by the STAR experiment. The extracted radii (R_{out}, R_{side}, R_{long}, $R^2_{out-long}$) and correlation strength (λ) are presented as a function of collision centrality, pair rapidity and transverse momentum.

Motivation

Experiments show that a flat rapidity plateau was observed at high energies at midrapidity. At lower collision energies the rapidity distribution of single particle has a Gaussian shape and the flat plateau disappears at midrapidity, while the distribution for particle pairs has not been studied at high statistics.

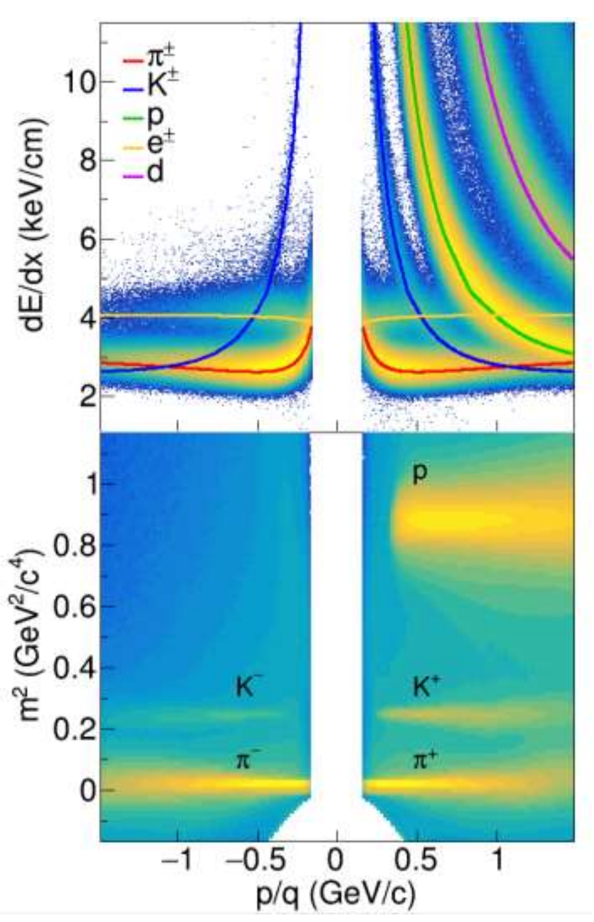
This work is aiming to measure the rapidity dependence of femtoscopic parameters of identical pion pairs in Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV.

Fixed-target Program (FXT) at STAR



- Gold target of thickness 1.93 g/cm^2 (0.25 mm)
- Located 2.01 m from the center of the Time Projection Chamber (TPC)
- The FXT setup provides a full rapidity coverage for identified charged pions from the $\sqrt{s_{NN}} = 3$ GeV Au+Au collisions.

Particle Identification

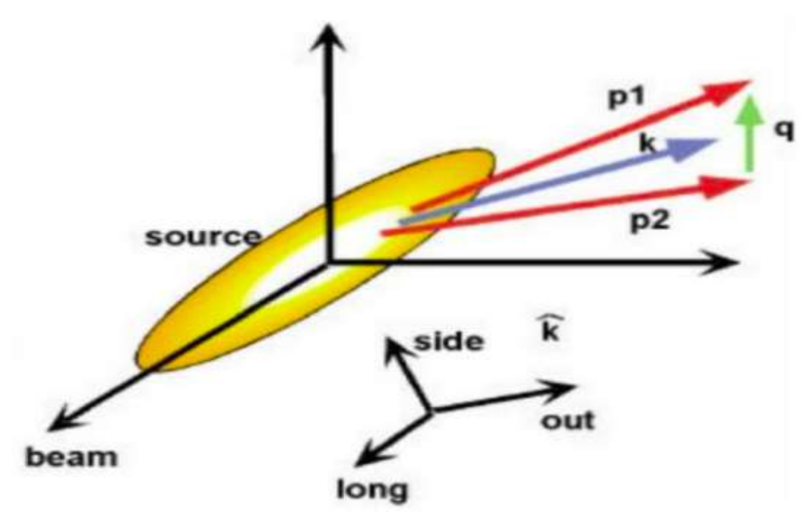


- Tracks used in the analysis were taken in the pseudorapidity (η) range of $-2 < \eta < 0$ in the laboratory frame
- Good particle identification using Time Projection Chamber (TPC) and Time-Of-Flight (TOF)

Correlation Femtoscopy Technique

Two-particle correlation function (CF) experimentally is defined as $C(q) = \frac{A(q)}{B(q)}$

- $q = p_1 - p_2$ is the relative momentum of the first and second particle from a pair;
- $A(q)$ formed using pairs, where both tracks are taken from the same event. It contains correlations due to quantum-statistics and final state interactions;
- $B(q)$ obtained via mixing technique, where pairs are formed of tracks from different events. Femtoscopic correlations are absent.



Bertsch-Pratt coordinate system [1,2]

Femtoscopic radii are extracted by fitting $C(q)$ with the following [3-5]:

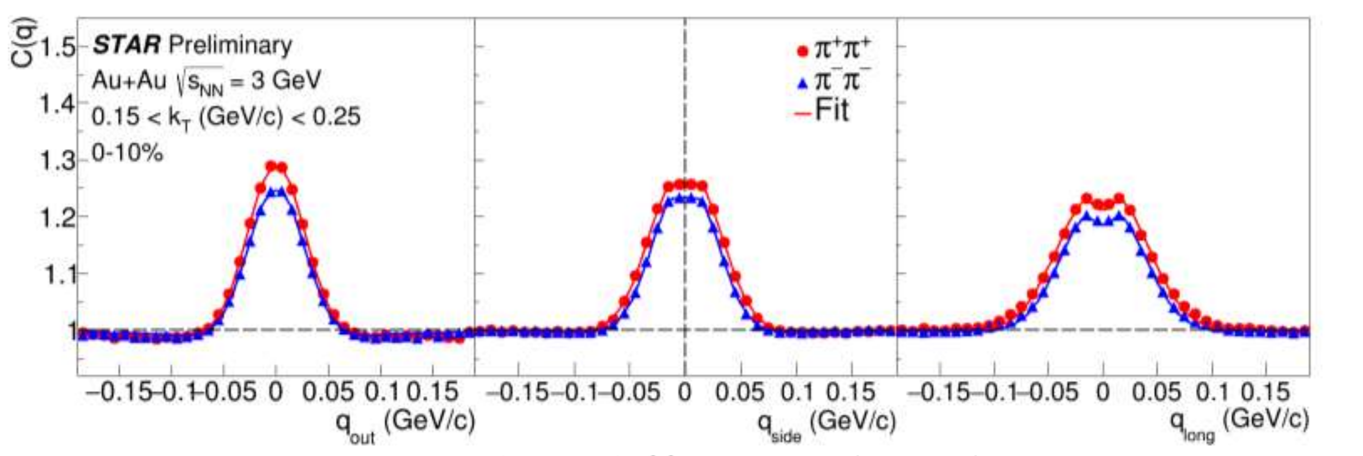
$$C(q) = N\left[(1-\lambda) + \lambda K(q)\left(1 + G(q)\right)\right],$$

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

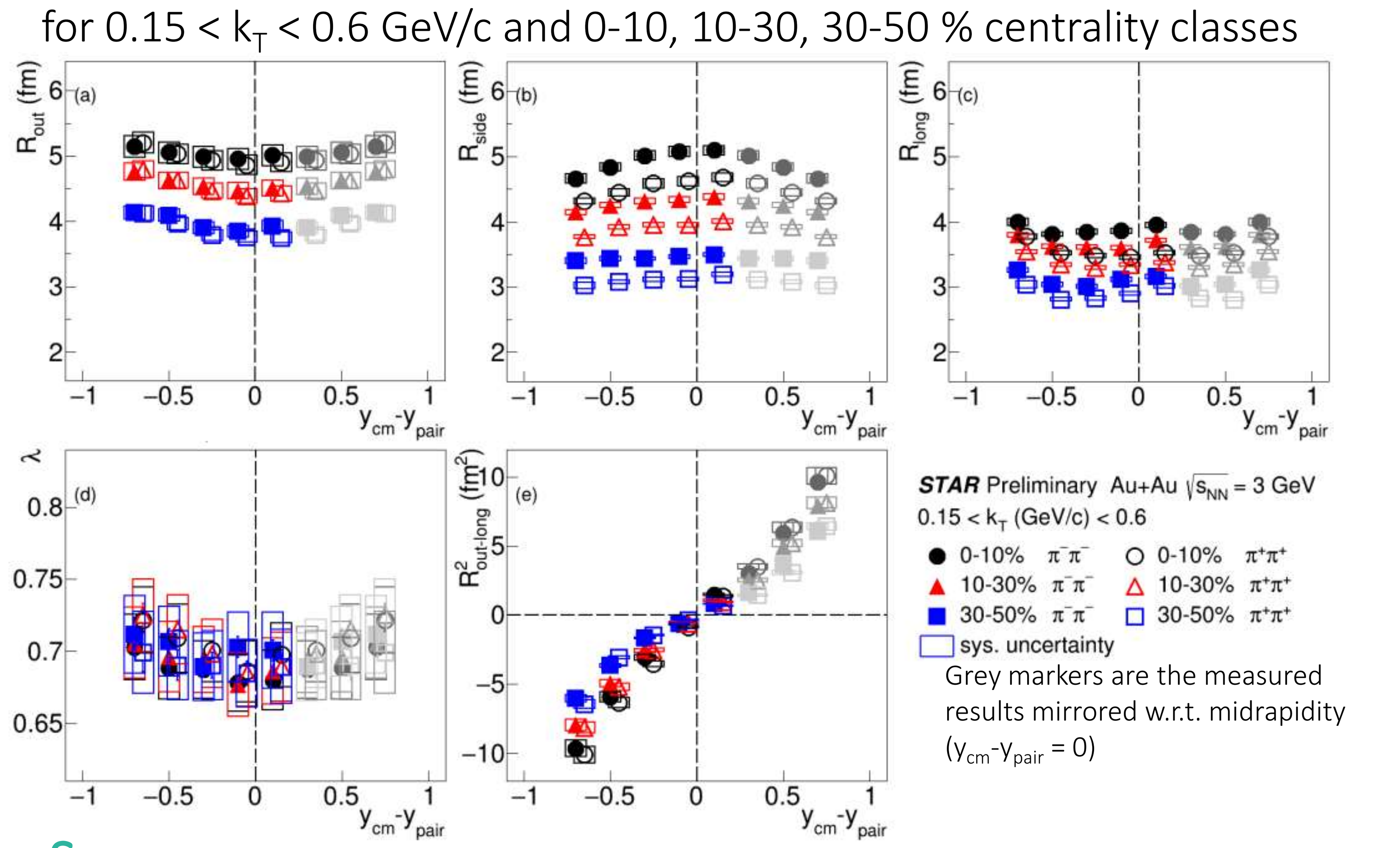
N - normalization factor, K(q) - Coulomb correction factor, $R^2_{out-long}$ has a non-zero value and corresponds to the tilt of the CF in the $q_{out} - q_{long}$ plane.

Results

CFs for $\pi^+\pi^+$ and $\pi^-\pi^-$ in rapidity-integrated analysis for 0-10% centrality class and $0.15 < k_T < 0.25$ GeV/c



Femtoscopic parameters in rapidity-differential analysis for $0.15 < k_T < 0.6$ GeV/c and 0-10, 10-30, 30-50 % centrality classes



Summary

The dependence of the λ, R_{out}, R_{side}, R_{long}, $R^2_{out-long}$ on the pair rapidity and collision centrality was presented:

- The difference between the extracted femtoscopic parameters for positive and negative pion pairs is most visible for R_{side} and R_{long} that may be due to the influence of residual electric charge and different resonance decay contributions;
- Rapidity dependence of $R^2_{out-long}$ is due to symmetry in longitudinal direction;
- The decrease of R_{side} with increasing pair rapidity as well as the behavior of $R^2_{out-long}$ show a hint of boost-invariance breaking.

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[1] G. Bertsch, G. Brown, V. Koch and B. Li, Nucl. Phys. A. 490, 3 (1988)
[2] S. Pratt, Phys. Rev. Lett. 53, 1219 (1984)
[3] Yu. Sinyukov et al. Phys. Lett. B 432, 248 (1998)
[4] M. Bowler Phys. Lett. B 270, 69 (1991)
[5] R. Lednicky and V. Lyuboshitz, Sov. J. Nucl. Phys. 35, 770 (1982)