Pion femtoscopy in p+Au and Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV using transport approach

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INTRODUCTION

Correlation femtoscopy is one of the tools for studying properties of the hadronic matter at extremely high temperatures and energy densities. This technique allows extracting information about the spatiotemporal structure of the region of homogeneity (emission source of correlated particles) at freeze-out. In turn this information has an immediate connection with space-time evolution of the fireball created in ultrarelativistic proton-ion and ion-ion collisions.

In this work UrQMD model was chosen in order to simulate Au+Au and p+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The same energy for these colliding systems is reached at RHIC (Relativistic Heavy Ion Collider). The subject of the study is correlations of charged pions as they make a major contribution of the newly produced particles in mentioned collisions. Dependence of femtoscopic radii on the transverse pair momentum and charged particle multiplicity for these differing colliding systems are compared at the same multiplicities.

FEMTOSCOPY TECHNIQUE

In case of identical bosons are examined the femtoscopy technique is based on the Bose-Einstein statistics. That means the two-particle inclusive spectrum should have an enhancement at small relative momentum.

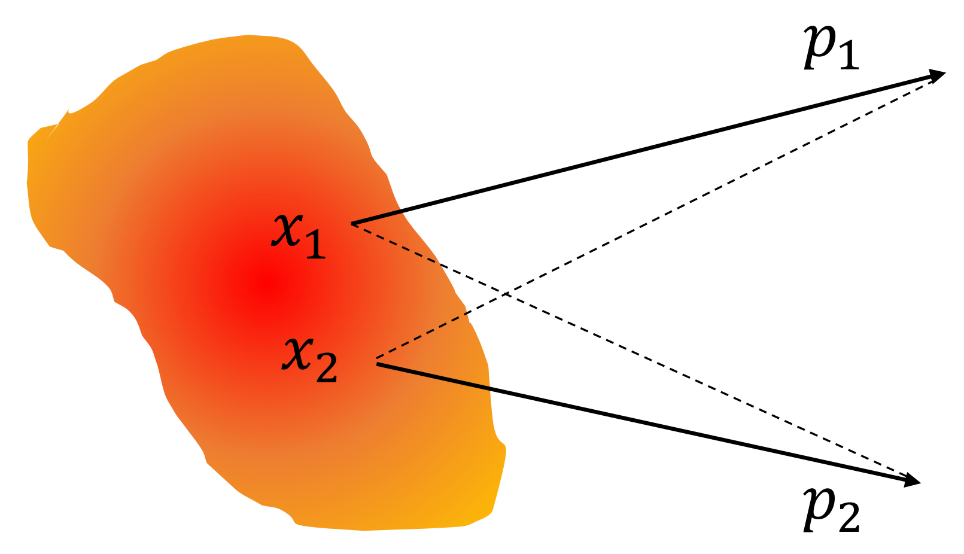
In practice two-particle correlation functions are constructed as the ratio of the measured two-particle inclusive and single-particle inclusive spectra [1]

$$C^{ab}(\boldsymbol{q},\boldsymbol{k}) = \frac{dN^{ab}/(d^3p_a * d^3p_b)}{(dN^a/d^3p_a)(dN^b/d^3p_b)},$$

where **q** is a relative pair momentum, **k** is an average pair momentum.

For Monte-Carlo simulated particles the correlation function usually constructed as the ratio of weighted two-particle distribution – in case of this study, each pair is introduced by $(1+\cos(q\Delta x))$ term, where $\Delta x = x_1 - x_2$, x_i is a space-time point of particle emission – and unweighted one.

Theoretical analysis connects measured correlation with the space-time structure of the particle emitting source [1]. A schematic representation of the basis for such linkage is shown.



One way to extract the femtoscopic radii is to analyze correlation function in terms of q-invariant parametrization, where $Q_{inv} = \sqrt{(\Delta\boldsymbol{p})^2 - (\Delta E)^2}$.

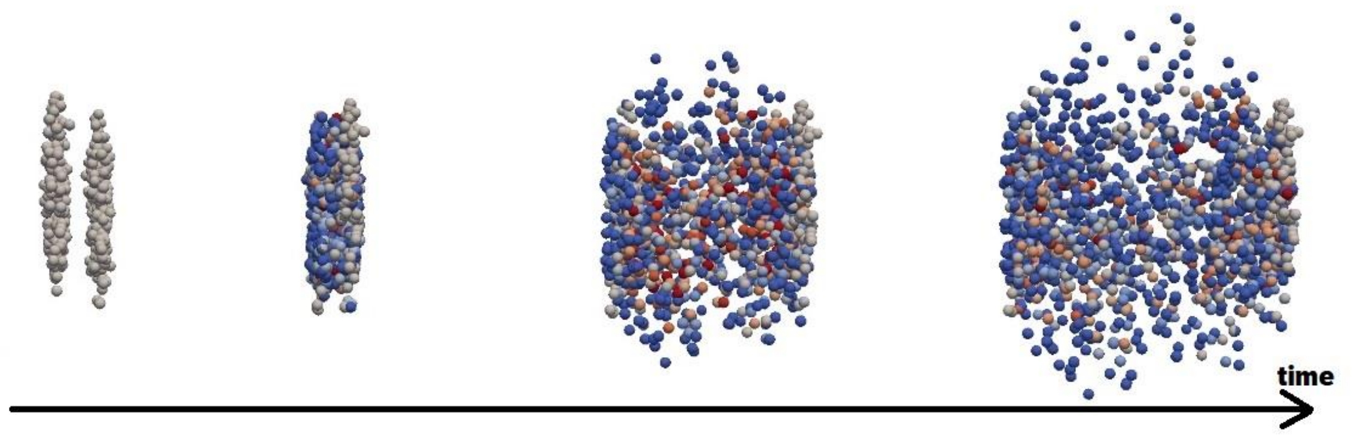
In such form all spatiotemporal information is concentrated in one parameter R_{inv} expressing one-dimensional Gaussian width. The correlation function follows the formula:

$$C(\boldsymbol{q},\boldsymbol{k}) = 1 + \lambda e^{-R_{inv}^2 Q_{inv}^2},$$

where λ is the correlation strength.

UrQMD MODEL

The transport theory of relativistic quantum many-body system is been successfully using for interpretation of experimental results extracting from heavy ion collision data. It can be applied for describing the non-equilibrium evolution, rapid time-dependence of the system, collective dynamics and suits for some other cases [2].



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One of such models is the Ultra-relativistic Quantum Molecular Dynamics model (UrQMD) [2,3] providing effective solution of relativistic Boltzmann equation:

$$p^{\mu}\partial_{\mu} f_i(x^{\nu}, p^{\nu}) = C_i\,.$$

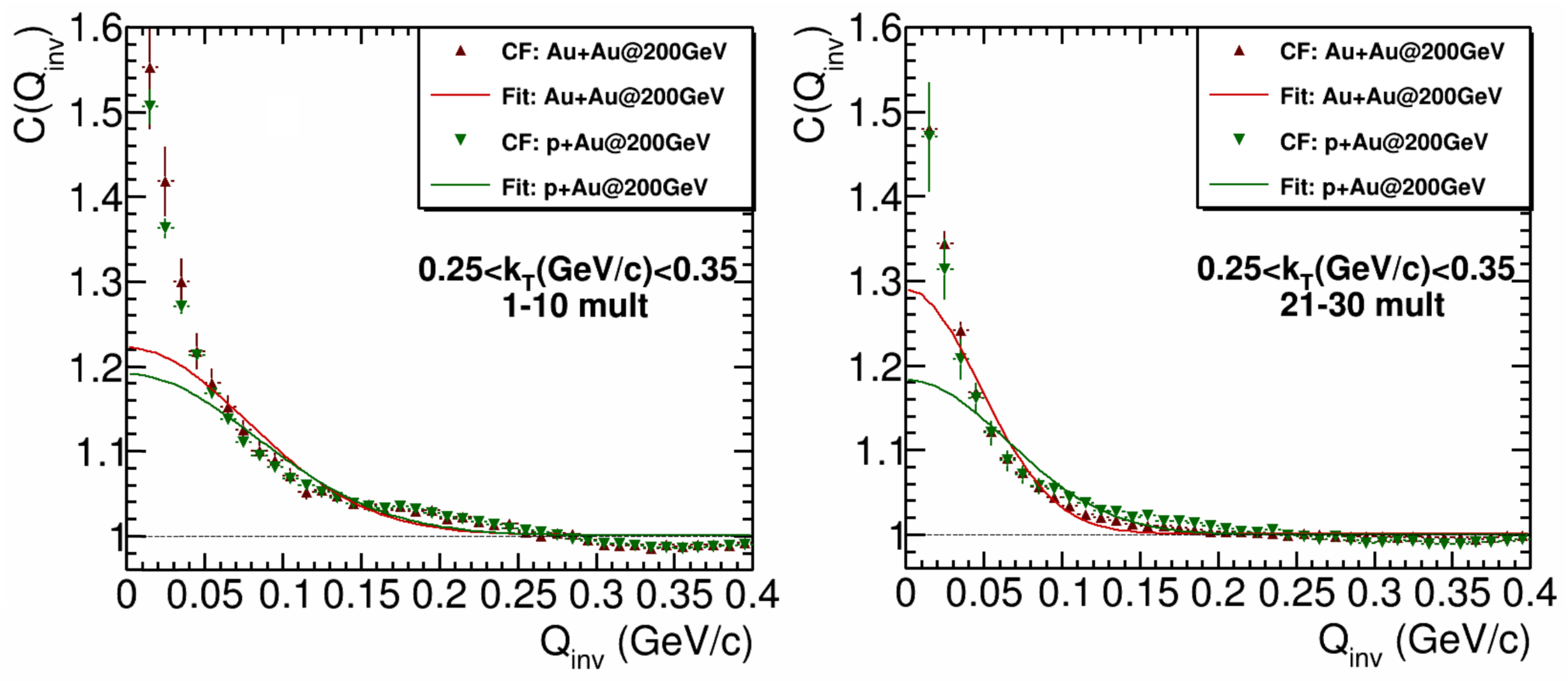
The time evolution of the distribution functions for different particle species *i* is described by this equation with the full collision term on the right-hand side.

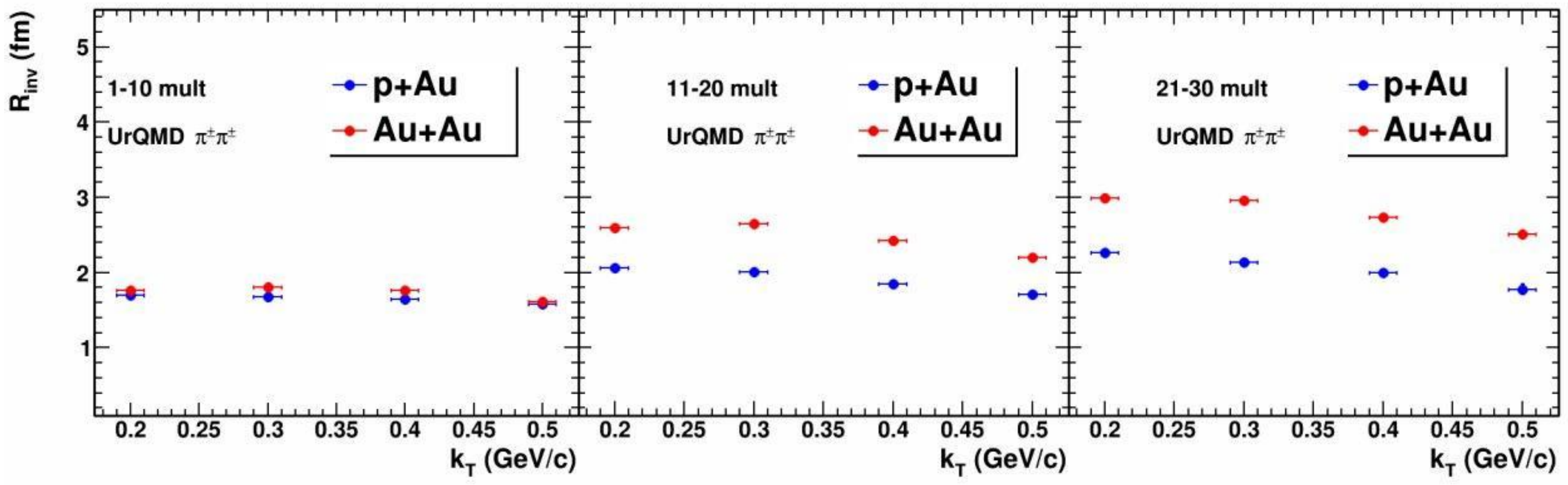
The UrQMD model is a microscopic many-body approach based on the covariant propagation of color strings, constituent quarks and diquarks (as string ends) [4]. 55 baryonic and 40 mesonic degrees of freedom are introduced. As a collision criterion geometrical one is employed.

In the present study UrQMD v.3.4 transport model was used.

R_{inv} vs. k_T (SYSTEMS COMPARISON)

Correlation functions of charged pions were constructed in four k_T bins (0.15-0.25 GeV/c, 0.25-0.35 GeV/c, 0.35-0.45 GeV/c, 0.45-0.55 GeV/c) for three charged multiplicity ranges: 1-10, 11-20, and 21-30. Due to same forms of correlation functions for $\pi^+\pi^+$ and $\pi^-\pi^-$ they were summed.





CONCLUSION

- ✓ one-dimensional source radii for charged pions in both colliding systems (p+Au and Au+Au) increase with the multiplicity increasing;
- ✓ invariant radii decrease as k_T values increase;
- ✓ femtoscopic radii for p+Au and Au+Au collision systems are similar for each k_T bin for 1-10 charged multiplicity range;
- ✓ radii values depend on colliding system and the dependence grows with the charged multiplicity of collision.

REFERENCES

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