



Kaon femtoscopy in STAR

Diana Pawłowska
for the STAR Collaboration

Beam Energy Scan program

Beam Energy Scan (BES) – a comprehensive program conducted by all experiments of the RHIC complex, launched in 2010 to study the Quantum Chromodynamics Phase Diagram at different chemical potential (μ_b) and temperature (T) values using collisions of Au ions at collision energies from 7.7 GeV to 200 GeV [1, 2].

The main goals:

- to study the QCD Phase Diagram at different collision energies and to find areas in which QGP signatures are turned off,
- to find a Critical Point between crossover and the first-order phase transition,
- to examine the area between the hadronic and Quark Gluon Plasma matter.

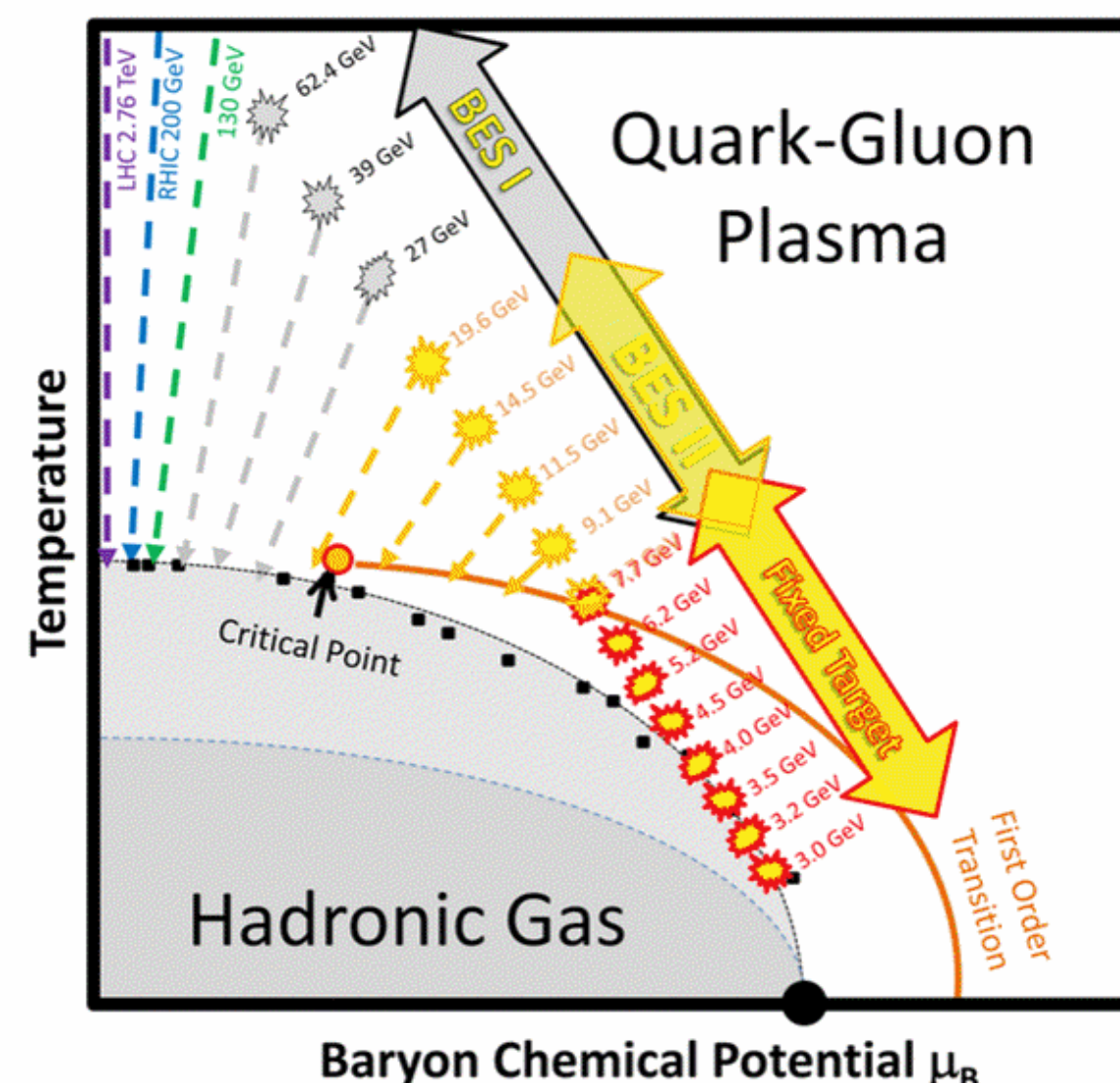


Fig. 1 The Quantum Chromodynamics Phase Diagram [3].

Femtoscopy

Femtoscopy - a method to examine the **particle emitting source** sizes (of the order of 10^{-15} m) by measurements of relative momentum characteristics [4].

The correlation function (CF) - the ratio of probability of observing two particles with specific momenta \vec{p}_1 and \vec{p}_2 at the same place and time to the product of probabilities to find them separately [5]:

$$CF(\vec{p}_1, \vec{p}_2) = \frac{P_2(\vec{p}_1, \vec{p}_2)}{P_1(\vec{p}_1)P_1(\vec{p}_2)}$$

The experimental correlation function:

$$CF(q_{inv}) = \frac{A(q_{inv})}{B(q_{inv})}$$

$A(q_{inv})$ - the signal distribution,

$B(q_{inv})$ - the background distribution.

Kaon correlation function

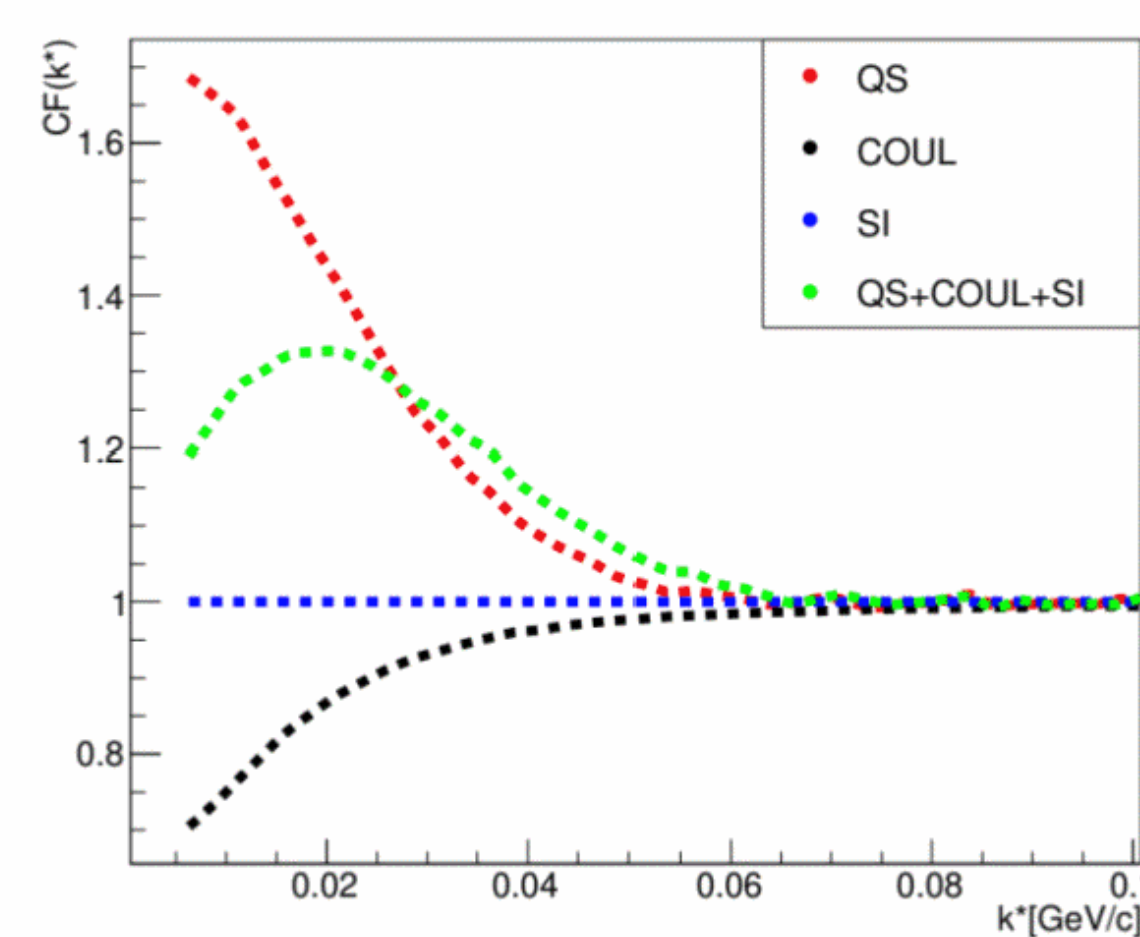


Fig. 2 CF of the like-sign charged kaons from the Thermanator model for central Au+Au collisions at $v_{s,NN} = 200$ GeV.

The correlation function depends on:

- **Quantum statistics (QS)**
- **Final state interactions (FSI):**
 - Coulomb interaction (COUL)
 - Strong interaction (SI)

Like-sign charged kaons -> dominant quantum statistical effects together with Coulomb interaction

Neutral kaons -> absent Coulomb interaction but strong interaction need to be taken into account together with quantum statistical effects

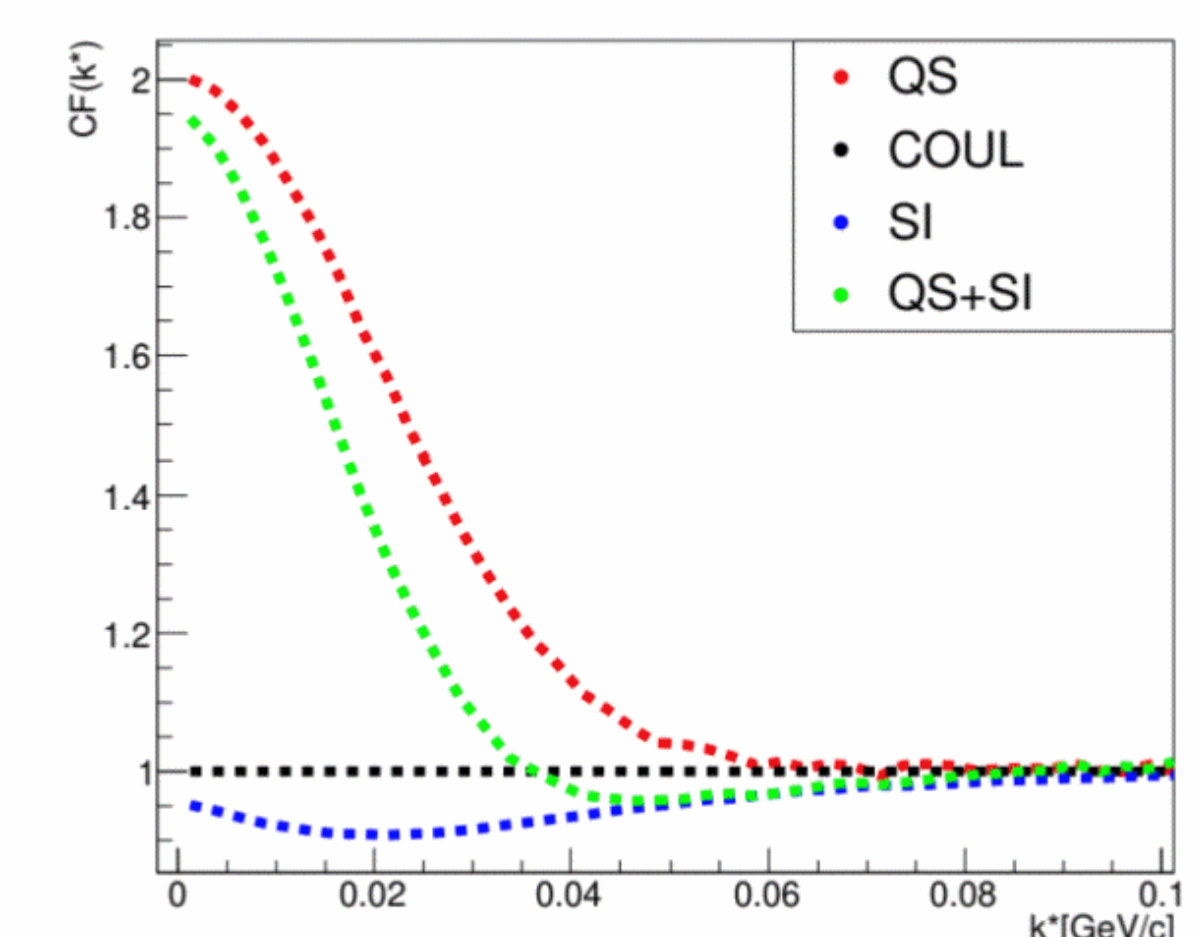


Fig. 3 CF of the neutral kaon pairs from the Thermanator model for central Au+Au collisions at $v_{s,NN} = 200$ GeV.

Parametrization

Gaussian density distribution (includes only QS effects):

$$CF(q_{inv}) = 1 + \lambda \exp(-R_{inv} q_{inv})$$

λ – the correlation strength

R_{inv} – the size of the particle-emitting source

Lednický and Lyuboshitz model includes strong FSI was also using to fit the K^0K^0 correlation functions [6].

Neutral kaon results

p_T [GeV/c]	0.2-1.5
$ \eta $	< 0.5
DCA V^0 to the PV [cm]	< 0.3
DCA of daughter [cm]	< 0.3
decay length [cm]	> 2
mass range [GeV/c ²]	0.488 – 0.51

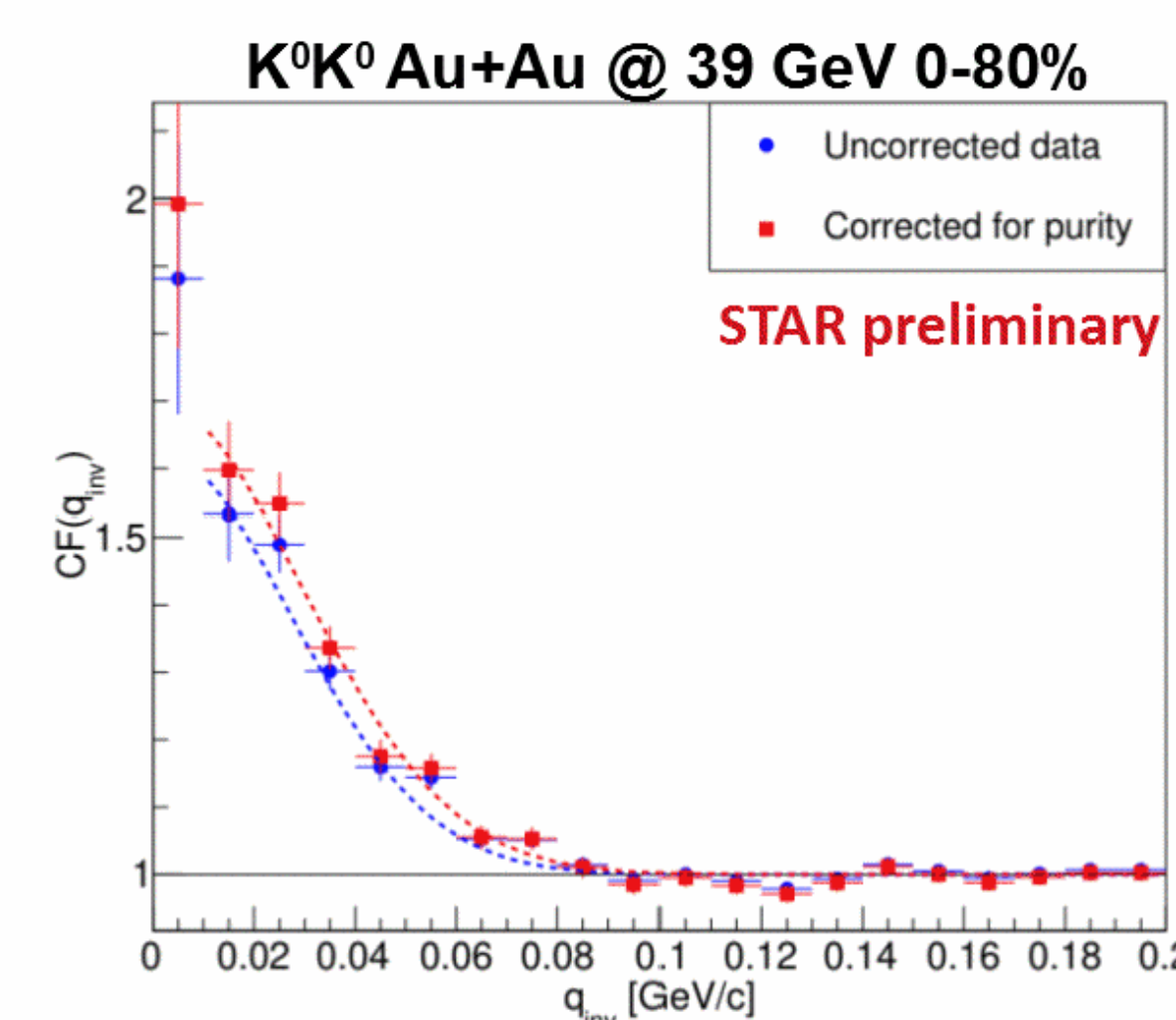


Fig. 6 Neutral kaons CF with Gaussian fit.

Before purity correction:

$$R = 5.08 \pm 0.19 \text{ fm}$$

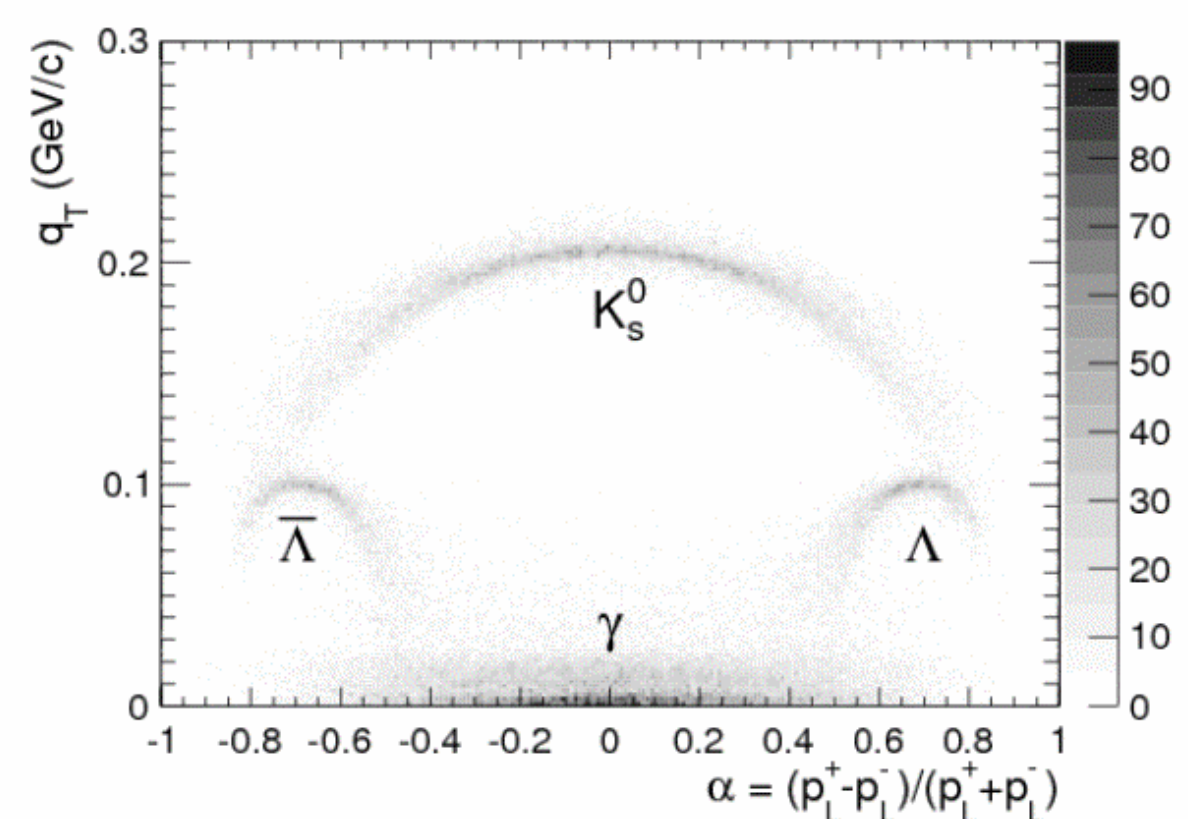
$$\lambda = 0.630 \pm 0.051$$

After purity correction:

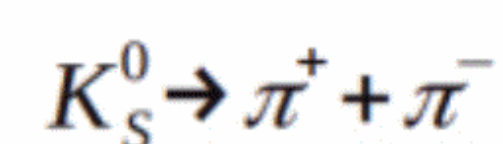
$$R = 4.72 \pm 0.20 \text{ fm}$$

$$\lambda = 0.701 \pm 0.056$$

Armenteros-Podolanski plot



The kinematic properties of the V^0 candidates.



π^+ and π^- have the same mass and their momenta are distributed symmetrically on average

Charged kaons results

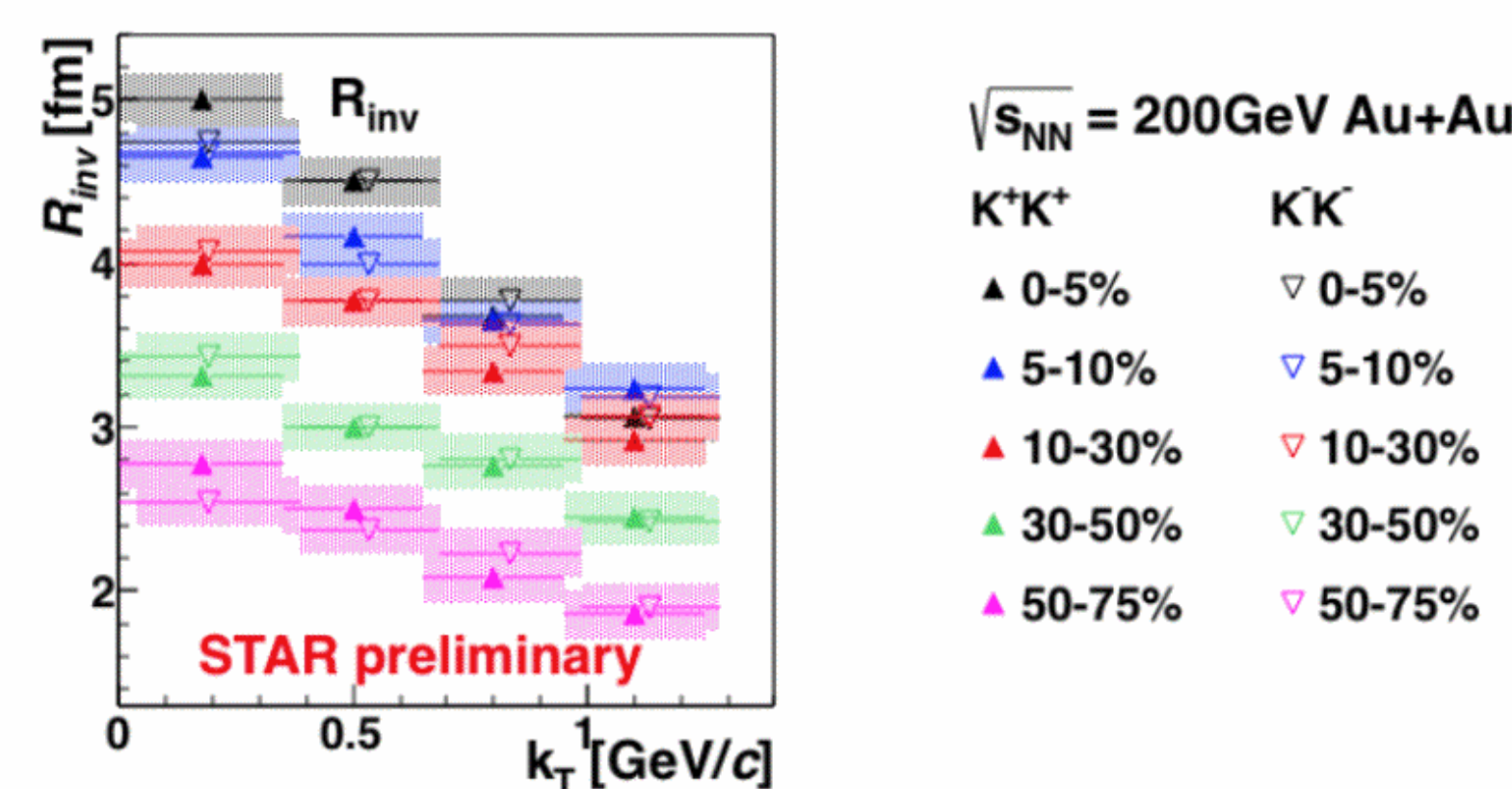


Fig. 5 Radii of the source from K^+K^+ and K^+K^- correlation function in different k_T ranges [8].

- k_T and centrality dependence of HBT radii observed
- source sizes increase with the centrality and decrease with the pair transverse momentum

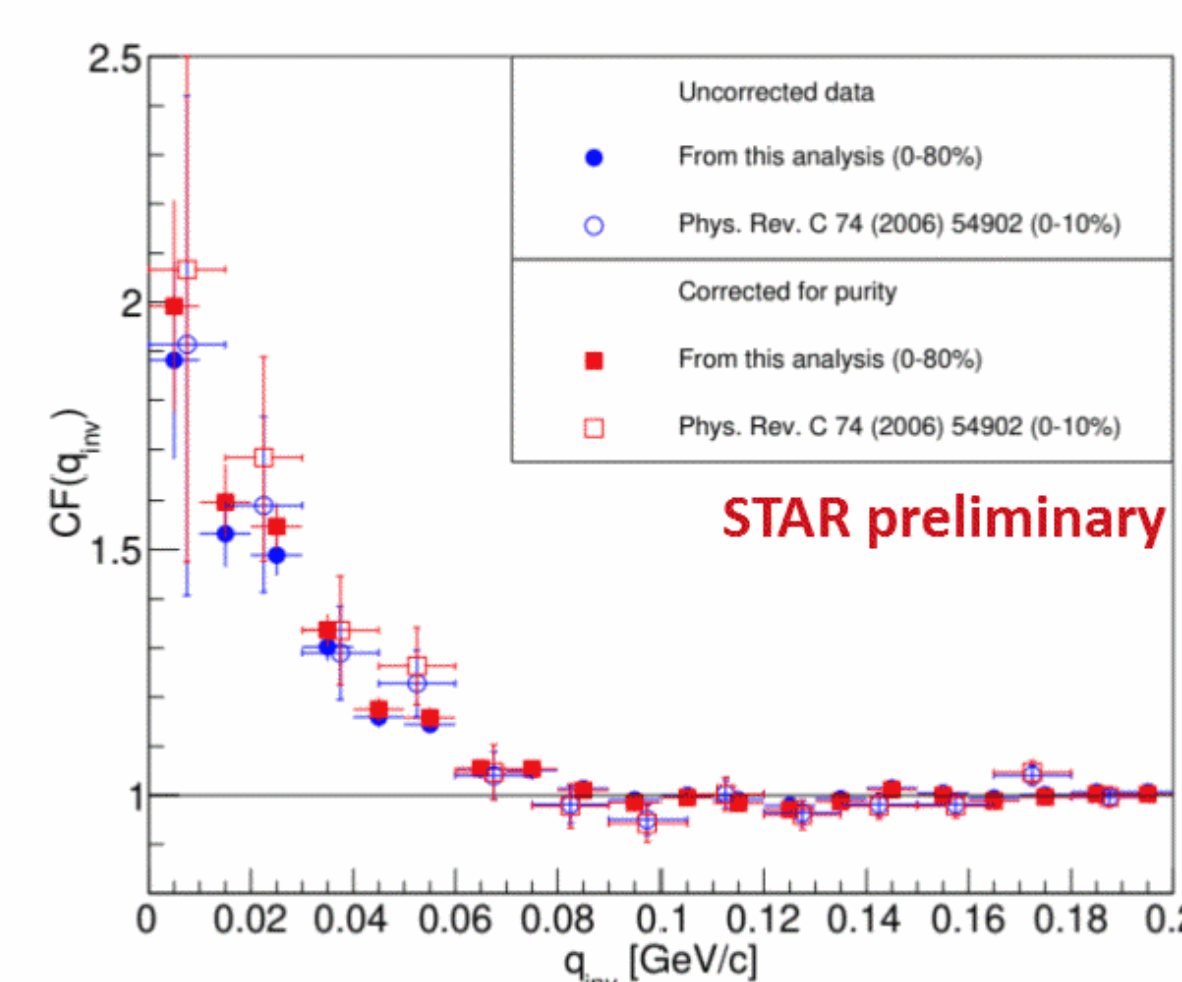


Fig. 7 Comparison with previous STAR result.

References

- [1] Odniewicz, G., "Future of the Beam Energy Scan program at RHIC," EPJ Web Conf. (2015).
- [2] Adams, J., et al., "Studying the Phase Diagram of QCD matter at RHIC," (March 2014).
- [3] Meehan, K., "STAR Results from Au+Au Fixed-Target Collisions at $\sqrt{s_{NN}} = 4.5$ GeV," Nucl.Phys. A (2017).
- [4] Hanbury Brown, R. and Twiss, R., "A new type of interferometer for use in radio astronomy," Phil. Mag. (1954).
- [5] Zbroszczyk, H., "Studies of baryon-baryon correlations in relativistic nuclear collisions registered at the STAR experiment," (2008). Ph.D thesis.
- [6] Lednický, R. and Lyuboshitz, V., "Final-state interaction effect on pairing correlations between particles with small relative momenta," Sov.J.Nucl.Phys (1982).
- [7] Aamodt, K., et al., "Strange particle production in proton-proton collisions at $\sqrt{s_{NN}} = 0.9$ TeV with ALICE at the LHC," Eur. Phys. J. C (2011)
- [8] Lidrych, J., "Kaon femtoscopy at the STAR experiment," presentation on Hot Quarks conference (2016)

Summary

- Kaon femtoscopy – a complementary method to pion femtoscopy
- Less affected by resonance decays than pions
- Allows one to learn about the final state interaction
- Source size ~ 5 fm for the most central collisions