# Two-pion and two-kaon femtoscopic correlations in Au+Au collisions at $\sqrt{s_{NN}}$=200 GeV from STAR

Grigory Nigmatkulov for the STAR collaboration
National Research Nuclear University MEPhI

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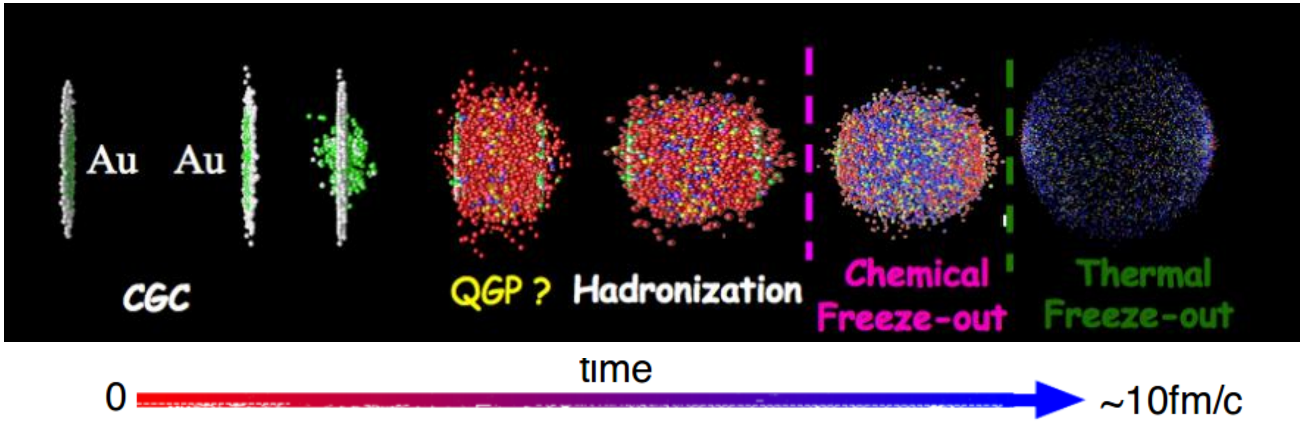
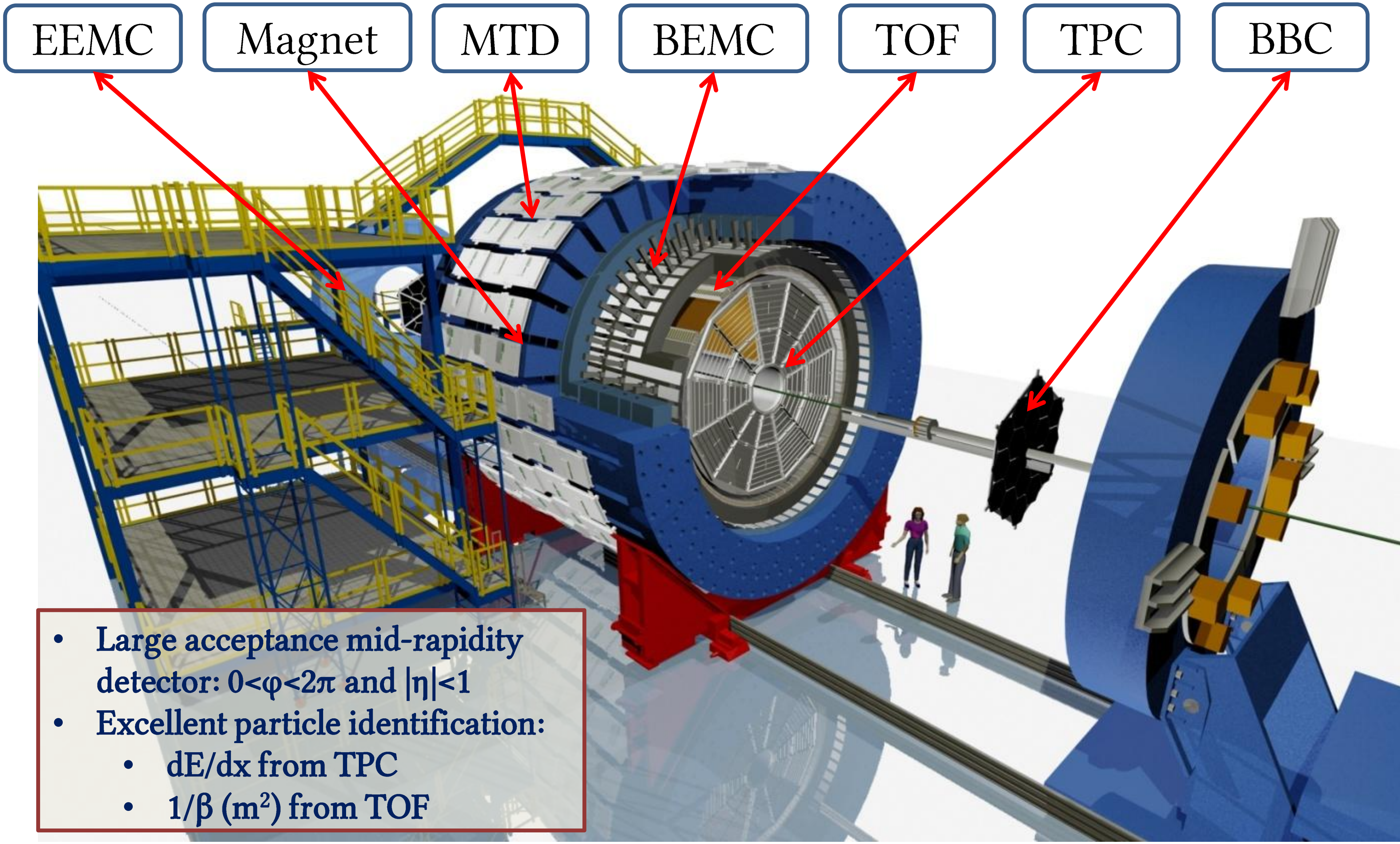
# Motivations




- Measurement of space-time parameters of the particle emitting source at kinetic freeze-out
- Different particle species are sensitive to various effects (Final State Interactions (FSI), transport properties, asymmetries, etc…)
- Extending transverse mass region (up to 1 GeV/$c^2$) using particle identification from the Time-Of-Flight detector
- Kaon femtoscopy: provides complementary information because they are less affected by resonance decays, contain strange quark, heavier than pions

# STAR ☆ The Solenoidal Tracker At RHIC




- Large acceptance mid-rapidity detector: $0<\varphi<2\pi$ and $|\eta|<1$
- Excellent particle identification:
  - $dE/dx$ from TPC
  - $1/\beta$ ($m^2$) from TOF

# STAR ☆ Correlation function

- Two-particle correlation function:

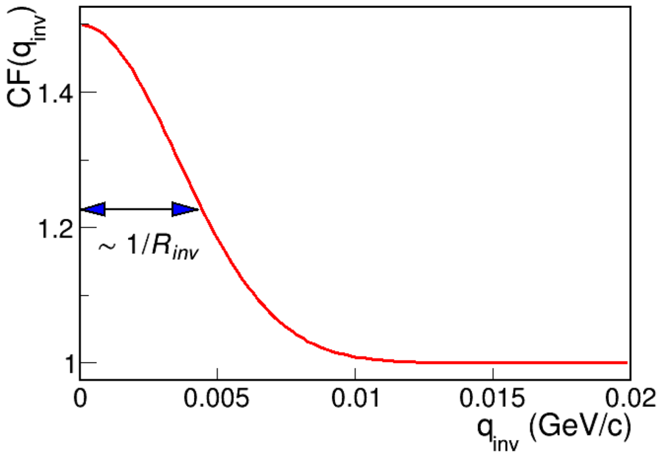
$$CF(p_1, p_2)=\int d^3r\, S(r, k)\, |\Psi_{1,2}(r, k)|^2$$

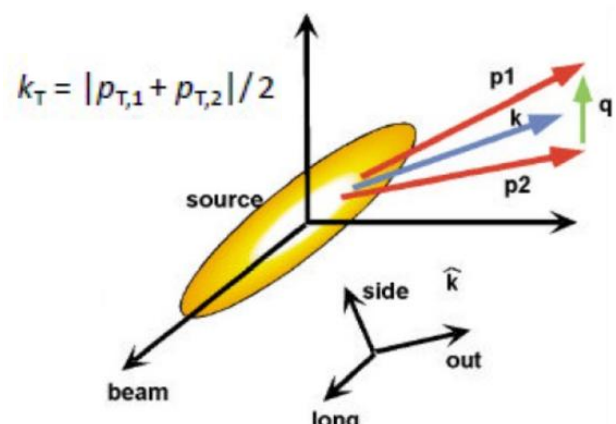
$$r=x_1-x_2 \text{ and } q\equiv q_{inv}= p_1 - p_2$$

- Experimentally:

$$CF(q) = A(q)/B(q)$$

  - A(q) – contain quantum statistical (QS) correlations and final state interactions (FSI)
  - B(q) – obtained via mixing technique (does not contain QS and FSI)




S. Pratt. Phys. Rev. D 33 (1986) 1314
G. Bertsch. Phys. Rev. C 37 (1988) 1896

The relative pair momentum can be projected onto the Bertsch-Pratt, out-side-long system:
$q_{long}$ – along the beam direction
$q_{out}$ – along the transverse momentum of the pair
$q_{side}$ – perpendicular to longitudinal and outward directions

Correlation functions are constructed in Longitudinally Co-Moving System (LCMS), where $p_{1z}+p_{2z}=0$

# Fitting procedure

- Femtoscopic radii are extracted by fitting C(**q**) with (Bowler-Sinyukov procedure):

$$C_2(q_{out}, q_{side}, q_{long}) = N\left(1 - \lambda + \lambda K(q_{inv})\left(1 + \exp\left(-R_{out}^2 q_{out}^2 - R_{side}^2 q_{side}^2 - R_{long}^2 q_{long}^2\right)\right)\right)$$

M. Bowler. Phys. Lett. B 270 (1991) 69
Yu. Sinyukov et al. Phys. Lett. B 432 (1998) 248

*N* – normalization factor   λ – correlation strength

$K(q_{inv})$ – Coulomb correction

$R_{side}$ ~geometrical size of the system

$R_{out}$ ~ geometrical size + particle emission duration

$R_{long}$ ~ medium lifetime

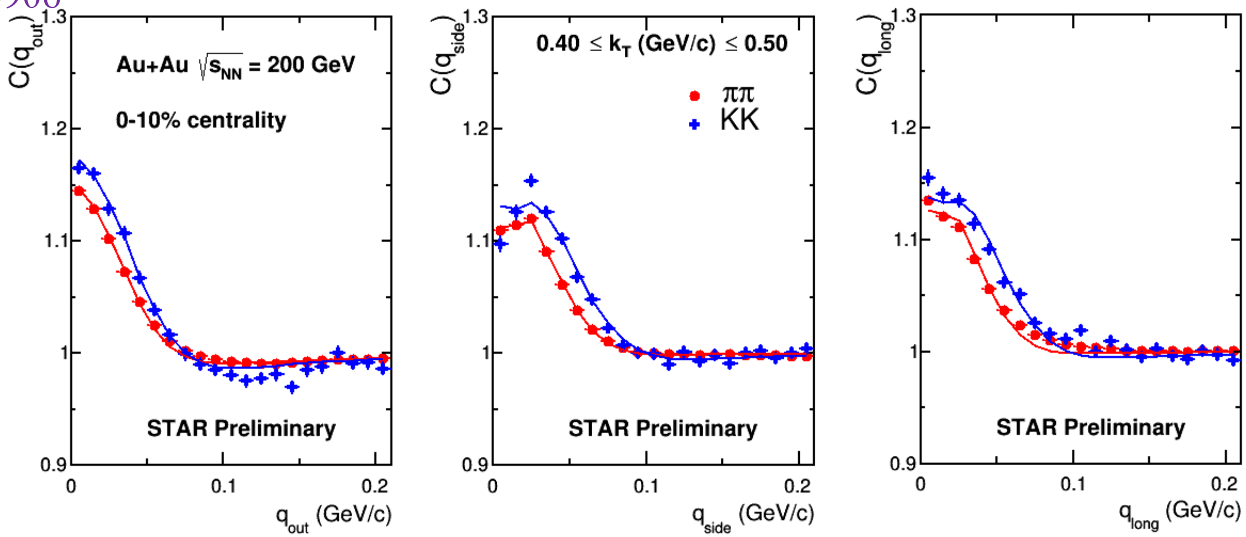
- Fit using Log-likelihood method:
  E-802. Phys. Rev. C 66 (2002) 054906

$$\chi^2 = -2\left[A\ln\left(\frac{C(A+B)}{A(C+1)}\right) + B\ln\left(\frac{A+B}{B(C+1)}\right)\right], C = \frac{A}{B}$$

- Fit example →

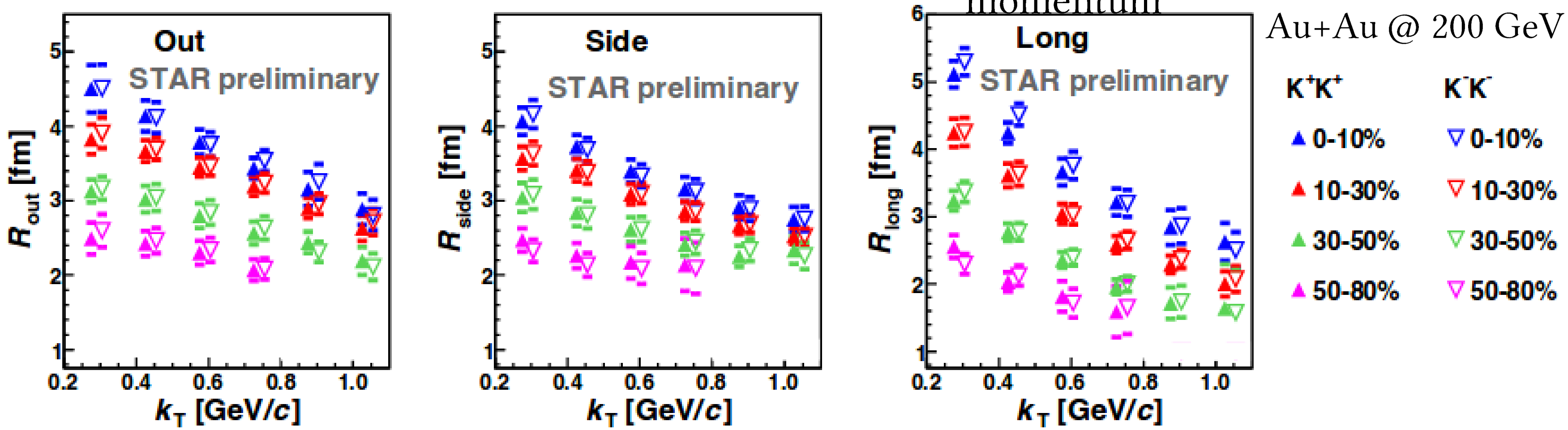
Out, side and long projections of 3D ππ and KK correlation functions

Fit shows a good description of the data



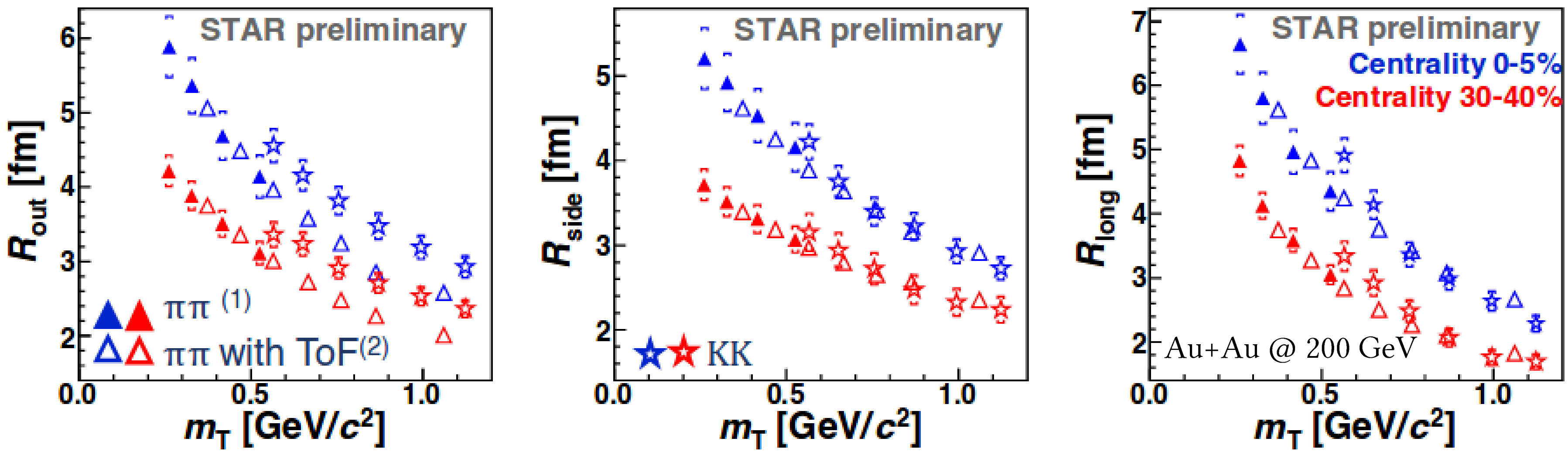
# Like-sign kaon femtoscopy

$k_T = |\mathbf{p}_{T,1} + \mathbf{p}_{T,2}|/2$ Pair transverse momentum




- Positively and negatively charged kaon emitting source radii are consistent within uncertainties
- Systematic uncertainties are obtained by varying the fit range, Coulomb source radii and PID cuts
- Extracted source radii decrease with increasing pair transverse momentum and increase with increasing collision centrality
- The more central collisions correspond to the larger size of the emitting region

# STAR ☆ Source radii: pions vs. kaons




$$m_T = \sqrt{k_T^2 + m^2}$$

- Extending transverse mass region (up to 1 GeV/$c^2$) using particle identification from the Time-of-Flight detector
- Pion results are consistent with the previous analysis (1)
- $R_{side}$ trend for kaons is similar to that of pions
- $R_{out}$ and $R_{long}$ of pion and kaon source radii follow different $m_T$ dependences
- Kaons freeze-out later the pions (3)

(1) STAR, Phys. Rev. C 92 (2015) 014904
(2) This analysis: STAR Preliminary
(3) STAR, Phys. Rev. Lett. 91 (2003) 262302

STAR ☆ Summary

- Charged kaon and pion emitting source radii $R_{out}$, $R_{side}$ and $R_{long}$ are extracted
- Using the TOF detector pion source radii measurements were extended to the higher transverse mass region (up to 1 GeV/$c^2$)
- Positively and negatively charged kaon radii are consistent within the uncertainties
  - The more central collisions correspond to the larger size of the emitting region
- Comparison of KK and ππ source radii:
  - Kaons freeze-out later than pions
  - Most prominent difference between pions and kaons is in $R_{out}$