Kaons femtoscopy at 200GeV in AuAu collisions at STAR

Martin Girard*
for STAR Collaboration

*Warsaw University of Technology
Faculty of Physics

Outline

- Introduction
- Results
  - Source shape analysis
  - m_T-dependence analysis
- Summary

Femtoscopy

- Emitting source for identical Bosons
  Symmetric wave function

$$N_1(k_1) = \int S(x_1, k_1)|\Psi_1|^2 dx_1$$

$$N_2(k_1, k_2) = \int S(x_1, k_1)S(x_2, k_2)|\Psi_{1,2}|^2 dx_1 dx_2$$

  Bose-Einstein Correlation

- Correlation functions

$$C_2(k1, k2) = \frac{N_2(k1, k2)}{N_1(k1)N_1(k2)} \simeq 1+|\frac{\tilde{S}(q, K)}{\tilde{S}(0, K)}|$$

$$\tilde{S}(q, K) = \int dx S(x, k) e^{iqx}$$

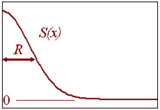
$$q = k_1 - k_2, K = \frac{1}{2}(k_1 + k_2)$$

- Final State Interaction
  - Strong
  - Coulomb

Gausian source approximation

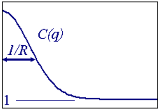
- Gaussian source approximation

$$S(x) \sim exp(-\frac{r_x^2}{2R_x^2} - \frac{r_y^2}{2R_y^2} - \frac{r_z^2}{2R_z^2})$$



- $\Rightarrow$ Correlation function Gaussian

$$R(q) = C(q) - 1 \sim exp(-q_x^2 R_x^2 - q_y^2 R_y^2 - q_z^2 R_z^2)$$



R_x, R_y, R_z so called HBT radii
LCMS system is often used with out,side and long

$$C(q) = 1 + \lambda exp(-q_o^2 R_o^2 - q_s^2 R_s^2 - q_l^2 R_l^2)$$

3D Source shapes

Expansion in harmonic basis:

$$R(\mathbf{q}) = \sum_{l} \sum_{\alpha_1 \ldots \alpha_l} R^l_{\alpha_1 \ldots \alpha_l}(q) A^l_{\alpha_1 \alpha_l}(\Omega_q)$$

$$S(\mathbf{q}) = \sum_{l} \sum_{\alpha_1 \ldots \alpha_l} S^l_{\alpha_1 \ldots \alpha_l}(q) A^l_{\alpha_1 \alpha_l}(\Omega_q)$$

Inverting

$\Downarrow$

$$R^l_{\alpha_1 \ldots \alpha l}(q) = \frac{(2l+1)!!}{l!} \int \frac{d\Omega_q}{4\pi} A^l_{\alpha_1 \ldots \alpha_l}(\Omega_q) R(\mathbf{q})$$

$$S^l_{\alpha_1 \ldots \alpha l}(q) = \frac{(2l+1)!!}{l!} \int \frac{d\Omega_q}{4\pi} A^l_{\alpha_1 \ldots \alpha_l}(\Omega_q) S(\mathbf{q})$$

Kaon femtoscopy analysis

Analysis with TPC only

Au-Au at $\sqrt{s_{NN}}$ 200GeV

|y|<0.5

Source shape

20% most central
4.6M Events (Run4) 16M Events (Run7)
0.2 < kT < 0.36 GeV/c

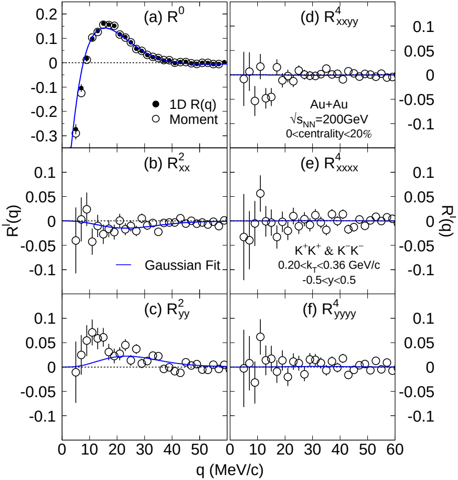
dE/dx: |nσ(K)|<2.0, |n$\sigma(\pi)$|>3.0, |nσ(e)|>2.0

m_T-dependence

30% most central
6.6M Events (Run4)
2 kT bins: kT $\in$ [0.2,0.36], [0.36,0.48] GeV/c

dE/dx: -1.5 < nσ(K) < 2.0

Correlation moments



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- (a): Agreement between 1D R(q) and R^0(q) obtained from the 3-D function
- (b),(c): Small second moments
- (d)-(f): Fourth moments insignificant and without any visible trend
- Trial function for S(r):

$$S^G(x,y,z) \sim \frac{\lambda}{(2\sqrt{\pi})^3 r_x r_y r_z} exp[-(\frac{x^2}{4R_x^2} + \frac{y^2}{4R_y^2} + \frac{z^2}{4R_z^2})]$$

Source shape: pions vs kaons

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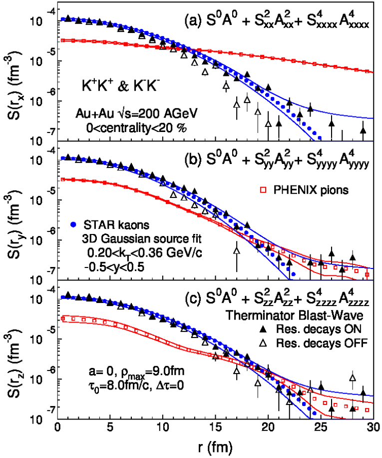

Therminator: Kisiel, Taluc, Broniowski, Florkowski, Comput. Phys. Commun. 174 (2006) 669.

Longer tail for pion:

- Caused by resonances?
- Different freeze-out dynamics?

Source shape: model comparison

Therminator

- Blast-wave model (STAR tune)
- Kaons: Instant freeze-out
- Resonances are needed for proper description

HKM (HydroKinetic Model)

- Hybrid model
- Consistent in side
- Slightly more tail (r>15fm) in out and long

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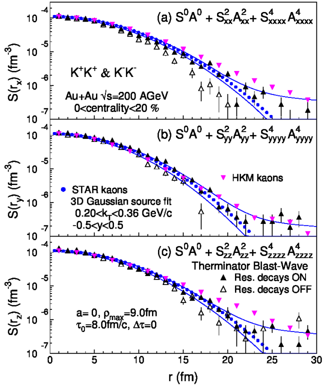

Therminator: Kisiel, Taluc, Broniowski, Florkowski, Comput. Phys. Commun. 174 (2006) 669.

HKM: PRC81, 054903 (2010) data from Shapoval, Sinyukov, arXiv:1308.6272

m_T-dependence

- Radii: rising trend at low m_T
  -Strongest in long
- Buda-Lund model
  - Perfect hydrodynamics, inherent m_T-scaling
  - Works perfectly for pions
  - Deviates from kaons in the long direction in the lowest m_T bin
- HKM
  - Describes all trends

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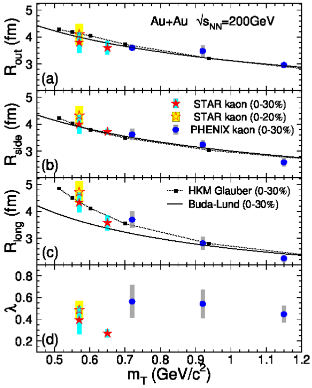


Buda-Lund: M. Csanád, 10.1140/epja/i2008-10605-7
HKM: PRC81, 054903 (2010)

Summary

Non-Gaussian tail not observed in kaon 3D source shape

Could indicate different dynamics for pions and for kaons

m_T-dependence of R_{out}, R_{side} and R_{long} rising at low m_T and consistent with HKM

Plans for future

Analysis of new data set with higher statistics:

- More precise results for low K_t
- Higher K_t extension

THANK YOU FOR YOUR ATTENTION!!

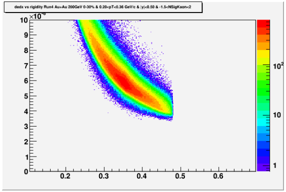
BACK UP

PID cut applied for TPC only analysis

1. Source shape analysis
   - dE/dx: $|n\sigma(\text{Kaon})| < 2.0$, $|n\sigma(\text{Pion})| > 3.0$ and $|n\sigma(\text{electron})| > 2.0$
   - $0.2 < pT < 0.4$ GeV/c

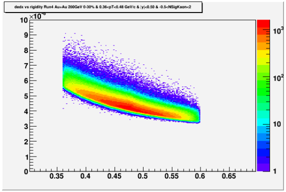
2. m_T-dependant analysis

$0.2 < kT < 0.36$ GeV/c



$-1.5 < n\sigma(\text{Kaon}) < 2.0$

$0.36 < kT < 0.48$ GeV/c



$-1.5 < n\sigma(\text{Kaon}) < 2.0$