Femtoscopy of particles with strange quarks

using UrQMD and Therminator models

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Outline

- Main goals
- Motivation
- Femtoscopy
- Results from models
  - Charged kaons
  - Neutral kaons
- Conclusions

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- compare with the experimental results ($K^{\pm}K^{\pm}$, $K^0_S K^0_S$ and $K^0_S K^{\pm}$)

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Why do we analyse kaons?

Kaons can provide complementary information to pions:

- contain strange quarks
- less affected by the feed-down from resonance decays
- smaller cross section with the hadronic matter

Femtoscopy

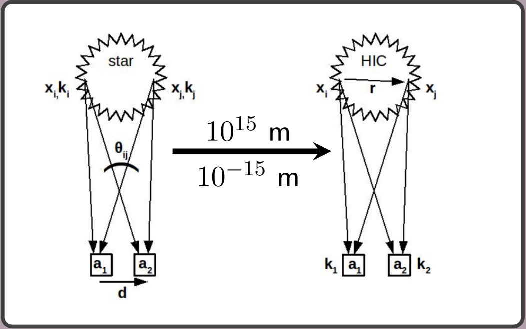
Hanbury Brown and Twiss interferometry

HBT

measure the angular size of astronomical objects through the use of Michelson interferometry

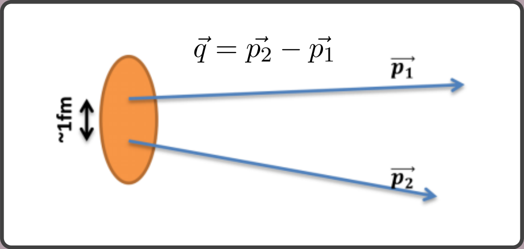
Femtoscopy

examine the particle-emitting source by measuring a momentum distribution



R.Lednicky, Nucl.Phys. A774 (2006) 189-198

Correlation function



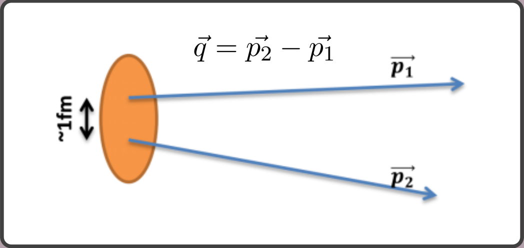
Theory

$$C_2(\vec{p_1}, \vec{p_2}) = \frac{P_2(\vec{p_1}, \vec{p_2})}{P_1(\vec{p_1})P_1(\vec{p_2})}$$

P_2 - the probability of finding two particles at the same place and time

P_1 - the probability of finding these particles separately

Correlation function



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Experiment

$$C(\vec{q}) = \frac{A(\vec{q})}{B(\vec{q})}$$

$A(\vec{q})$ - the measured distribution of pairs from the same event

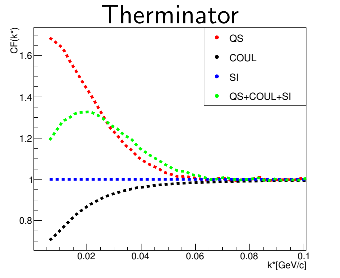
$B(\vec{q})$ - the reference distribution of pairs from mixed events

Correlation function

The shape of the kaon correlation function depends on:

Charged

- Quantum Statistical effects (QS)
- Final State Interactions (FSI)
  - Coulomb Interaction (COUL)
  - Strong Interaction (SI)



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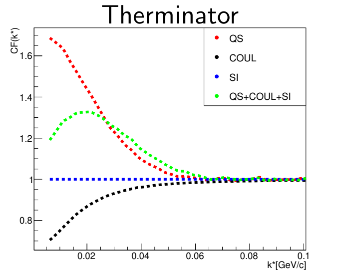
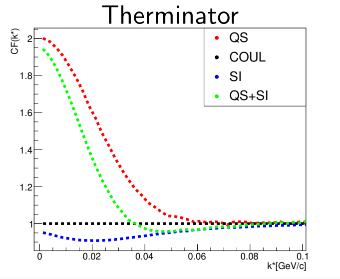


Neutral

- Quantum Statistical effects (QS)
- Final State Interactions (FSI)
  - ~~Coulomb Interaction (COUL)~~
  - Strong Interaction (SI)



Fitting procedure

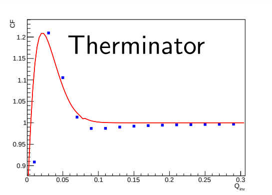
- **Bowler-Sinyukov formula:**

  M. Bowler, Phys. Lett. B270 (1991) 69

  Y. Sinyukow, Phys. Lett. B432 (1998) 248

  *charged kaons

$$C(q_{inv}) = 1 - \lambda + \lambda K(q_{inv})(1 + \exp[R_{inv}^2 q_{inv}^2])$$



λ - the correlation strength

$K(q_{inv})$ - Coulomb factor (the two-particle Coulomb wavefunction integrated over a static spherical Gaussian source)

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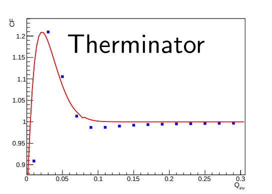


- **Final State Interaction Lednicky&Lyuboshitz model**

R.lednicky and V.L. Lyuboshitz, Sov.J.Nucl.Phys. 35, 770 (1982)
*neutral kaons

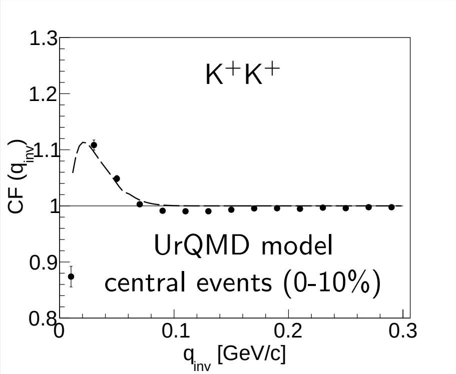
$$C(q_{inv}) = 1 + \lambda \left[\exp[-R_{inv}^2 q_{inv}^2] + \frac{1}{2} \left(\left| \frac{f(k^*)}{R_{inv}} \right|^2 + \frac{4 \Re f(k^*)}{\sqrt{\pi} R_{inv}} F_1(q_{inv} R_{inv}) - \frac{2 \Im f(k^*)}{R_{inv}} F_2(q_{inv} R_{inv}) \right) \right]$$

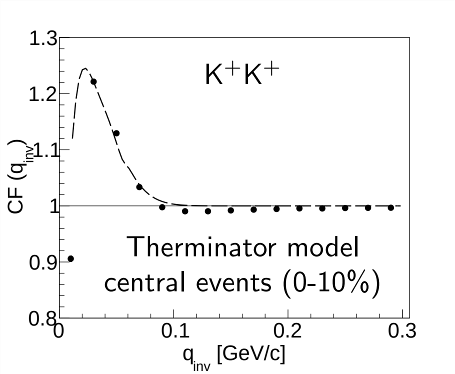
λ - the correlation strength
$K(q_{inv})$ - Coulomb factor (the two-particle Coulomb wavefunction integrated over a static spherical Gaussian source)
$f(k^*)$ - scattering amplitude, which is dominated by the near threshold s-wave isoscalar and isovector resonances $f_0(980)$ and $a_0(980)$

Results

Charged kaons CF

200 GeV

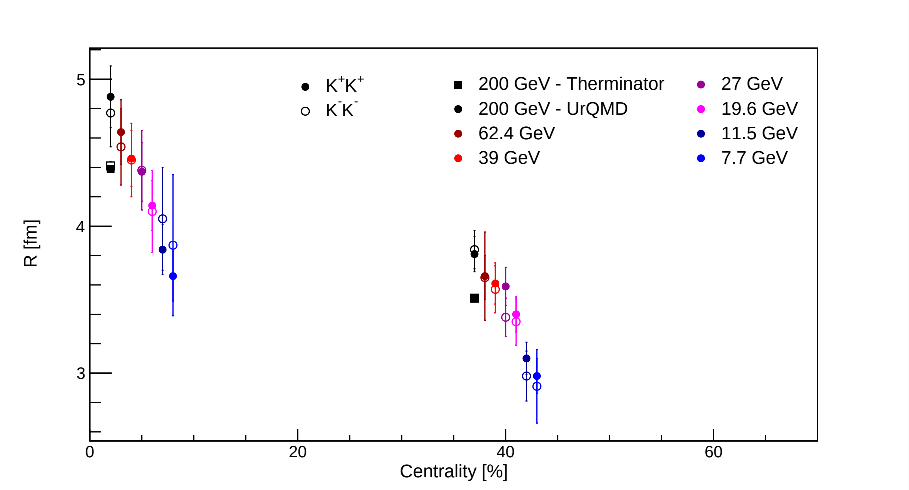




	UrQMD		Therminator	
	Radius [fm]	λ	Radius [fm]	λ
K^+K^+	4.88 ± 0.21	0.207 ± 0.024	4.39 ± 0.02	0.429 ± 0.006
K^-K^-	4.77 ± 0.23	0.201 ± 0.026	4.41 ± 0.03	0.428 ± 0.007

Charged kaons CF

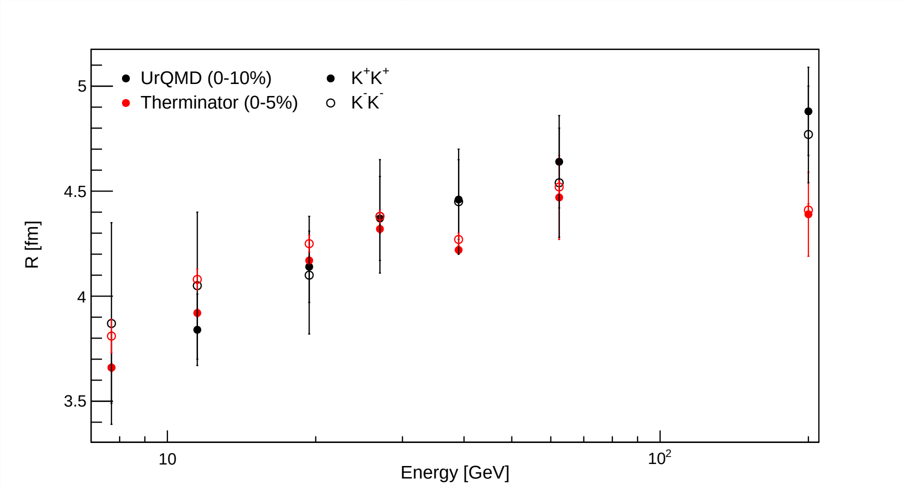
centrality dependence



Clear centrality dependence

Charged kaons CF

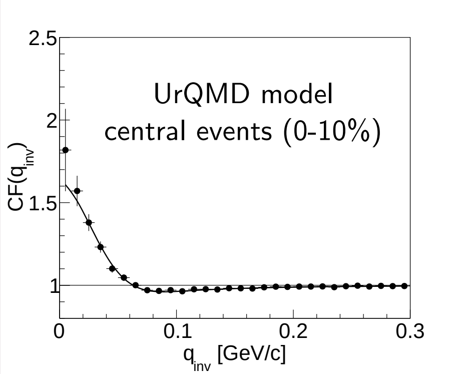
energy dependence

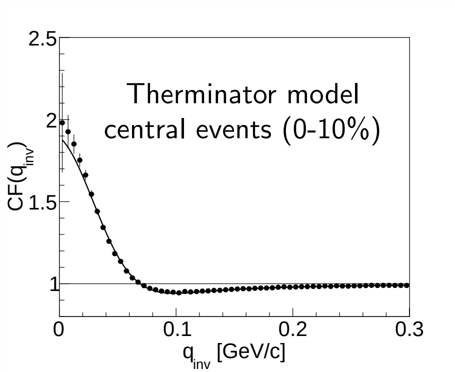


Clear energy dependence

Neutral kaons CF

200 GeV

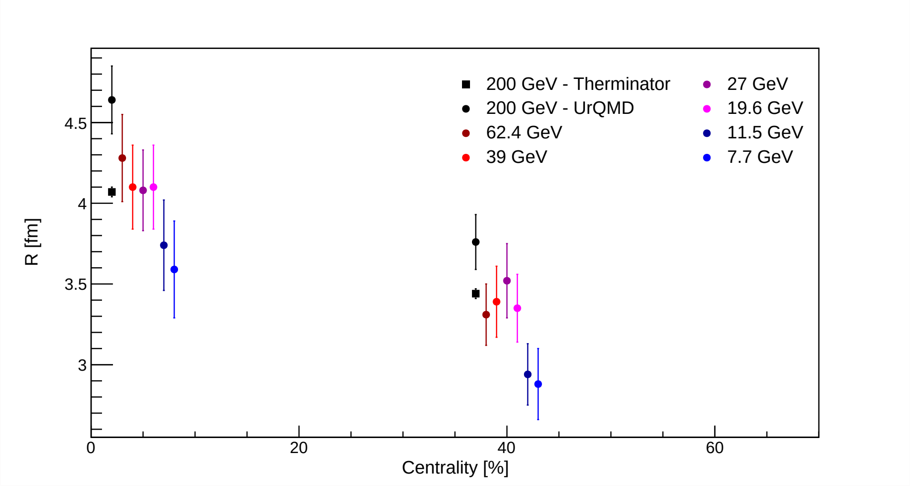




	UrQMD		Therminator	
	Radius [fm]	λ	Radius [fm]	λ
$K_s^0 K_s^0$	4.64 ± 0.21	0.636 ± 0.059	4.07 ± 0.03	0.884 ± 0.013

Neutral kaons CF

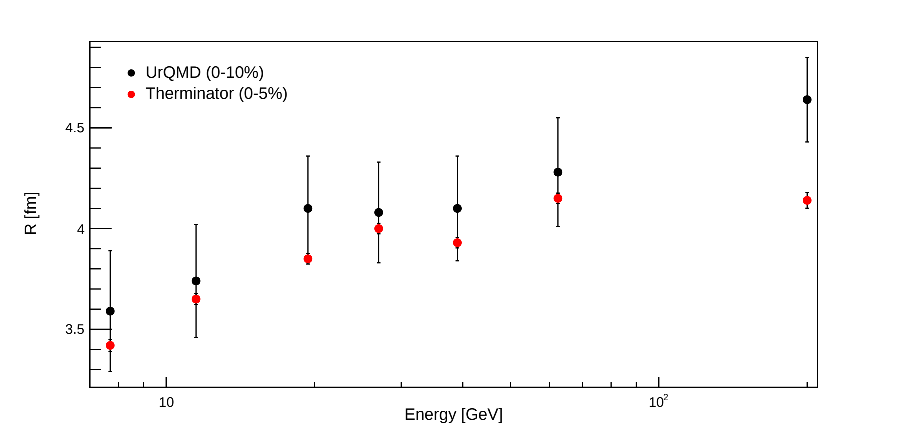
centrality dependence



Clear centrality dependence

Neutral kaons CF

energy dependence



Clear energy dependence

Similar radii values for 19.6, 27, and 39 GeV in UrQMD

Conclusions

Charged kaons

- differences in CF from models for 200 GeV
  - **UrQMD:** $R_{K^+K^+} = 4.77$ fm, $R_{K^-K^-} = 4.88$ fm
  - **Therminator:** $R_{K^+K^+} = 4.39$ fm, $R_{K^-K^-} = 4.41$ fm
  - λ parameter 2 times greater for Therminator
- centrality dependence is clear
  - the difference between CF for positive and negative kaons - all within the error limit
- energy dependence is visible
  - **UrQMD:** larger source size for higher energy
  - **Therminator:** smaller than expected size for 39 GeV

Conclusions

Neutral kaons

- differences in CF from models for 200 GeV
  - **UrQMD:** $R_{K^0_s K^0_s} = 4.64$ fm
  - **Therminator:** $R_{K^0_s K^0_s} = 4.07$ fm
- centrality dependence is clear
  - central collisions have larger size of the source
- energy dependence is visible
  - **UrQMD:** similar sizes of source for energies 19.6, 27 and 39 GeV
  - **Therminator:** smaller than expected size for 39 GeV

Thank you for your attention!