Neutral kaon femtoscopy in Au+Au collisions measured at STAR experiment

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Abstract
The Solenoidal Tracker at RHIC (STAR) enables the possibility of exploring the properties of strongly interacting nuclear matter using the method of femtoscopy. By studying the quantum statistical effects and final state interactions between two particles, one can extract emission source parameters, which describe geometrical and dynamical properties of the homogeneity region. We use the high statistics data of Au+Au collisions recorded by the STAR experiment to study the correlations between strange particles. The lightest strange particles are kaons. Kaons are less affected by resonances decays and provide a cleaner signal of two-particle correlations. Neutral kaons, $K^0_S$, can be measured through their decay products to the pair of charged pions.

The Solenoidal Tracker at RHIC

![Diagram of the STAR detector](image)

Fig. 1. Diagram of the STAR detector [1].

Kaon identification was performed using information from two detectors:
- **Time Projection Chamber (TPC)** – identification was done via specific ionization energy loss (dE/dx);
- **Time-Of-Flight (TOF)** – measurement of velocity of a particle based on its time of passage through the length of the detector.

**Femtoscopy**

Femtoscopy – a method to examine the particle emitting source sizes (of the order of $10^{-18}$ m) by measurements of relative momentum characteristics [2].

**The correlation function (CF)** – the ratio of probability of observing two particles with specific momenta $p_1$ and $p_2$ at the same place and time ($P_2$) to the product of probabilities to find them separately ($P_1$) [3]:

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

**The experimental correlation function:**

$$A(q_{mn}) = \frac{A(q_{mn})}{B(q_{mn})}$$

$A(q_{mn})$ – the signal distribution,

$B(q_{mn})$ – the background distribution,

$$q_{mn} = \sqrt{(\vec{p}_1-\vec{p}_2)^2 - (E_1- E_2)^2}$$

**Neutral kaon results**

<table>
<thead>
<tr>
<th>$p_{K^-}$ [GeV/c]</th>
<th>0.2 - 1.5</th>
<th>DCA of daughter [cm]</th>
<th>&lt; 0.3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Decay length [cm]</td>
<td>&gt; 2</td>
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<tr>
<td></td>
<td></td>
<td>DCA $\pi^0$ to the PV [cm]</td>
<td>&lt; 0.3</td>
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<td>Mass range [GeV/c]</td>
<td>0.488 – 0.51</td>
</tr>
</tbody>
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**Before purity correction:**

$R = 5.08 \pm 0.19$ fm

$\lambda = 0.630 \pm 0.051$

**After purity correction:**

$R = 4.72 \pm 0.20$ fm

$\lambda = 0.701 \pm 0.056$

**Summary**

- Kaon femtoscopy – a complementary method to pion femtoscopy
- Allows one to learn about the final state interaction
- Neutral kaon source size ~5 fm for the minimum bias collisions
- Purity correction slightly reduces the extracted size of the particle-emitting source

**References**

[1] Maria and Alex Schmah

The STAR Collaboration

[Link to STAR website]