Proton correlation function in Au + Au collisions at $\sqrt{s_{NN}}$ = 3.2 GeV

Yu Zeng (zengy@mails.ccnu.edu.cn) Central China Normal University,
for the STAR Collaboration

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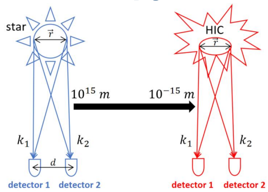
Abstract

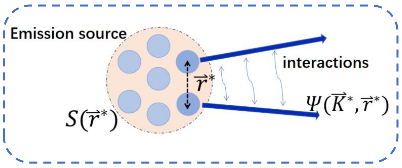
A correlation function contains information about the dynamics in the early stage of collisions. This allows the study of the geometry and dynamic properties of the particle emission region, which is important for understanding of the evolution of medium formed in heavy-ion collisions. In this poster, we present measurements of the proton correlation function in Au + Au collisions at $\sqrt{s_{NN}}$ = 3.2 GeV from the second phase of the beam energy scan (BES II) at STAR. The rapidity and centrality dependence of the correlation function are shown.

Femtoscopy



- In heavy-ion collisions, a two-particle correlation function can probe the space-time geometry of the particle emission source. This technique is called femtoscopy.
- Inspired by the Hanbury-Brown and Twiss interferometry method [1].
- The orders of magnitude differ significantly between astronomy and HIC. Astronomy focuses on measuring signal intensities, while HIC primarily measure the momenta of emitted particles.

Correlation function



Theory: $C(K^*) = \frac{P(p_1,p_2)}{P(p_1)P(p_2)}$

$= 1 + \int S(\vec{r}^*)\left[\left|\Psi(\vec{K}^*,\vec{r}^*)\right|^2 - 1\right] d^3\vec{r}^*$ [2]

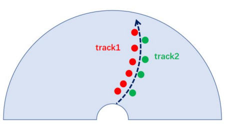
Experiment: $C(K^*) = N \times \frac{Same(K^*)}{Mixed(K^*)}$

$p^{\mu} = (\vec{p}, \frac{i}{c}E) \quad K^* = \frac{1}{2}\left|\Delta p^{\mu}\right| = \frac{1}{2} q_{inv}$

Same events: particles are correlated.
Mixed events: uncorrelated.
N : normalization constant.

$S(\vec{r}^*)$: emission source function.
$P(p_1, p_2)$: The probability of detecting two particles with momenta p_1 and p_2 simultaneously.
$P(p_1)$: The probability of detecting particles with momenta p_1 independently.
$\Psi(\vec{K}^*, \vec{r}^*)$: wave function of the pair.

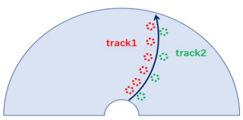
Track-splitting effect



One track in the detector is split into two (track 1, track 2).

- Track-splitting effect leads to an increase in productions of pairs at low relative momenta K*, arising from the accidental reconstruction of a single track as two different tracks with close momentum.
- The track-splitting effect is addressed by applying a cut on nhitsfit.

Track-merging effect



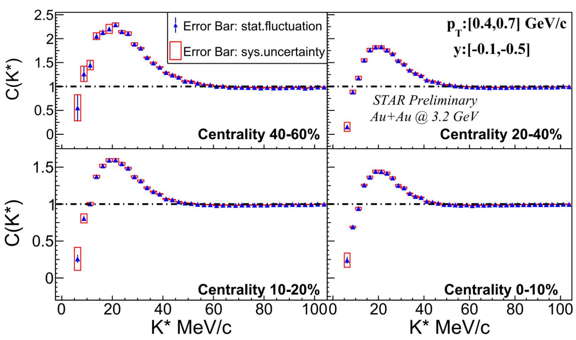
Two tracks (track 1 and track 2) are mistakenly reconstructed as a single track.

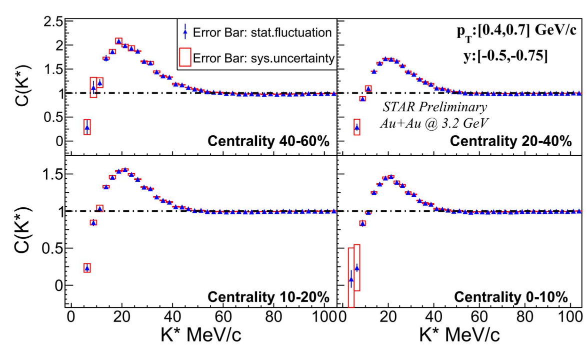
- Track-merging effect results in a reduction of pairs at low relative momentum K*, occurring when two separate tracks are mistakenly reconstructed as a single track.
- The track-merging effect is addressed by applying cuts on Δθ and Δϕ.

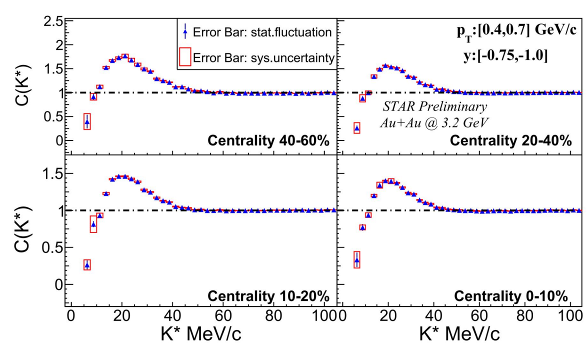
Momentum smearing effect

- Measured momentum is smeared by detector resolution.
- The correlation function is corrected by the smearing factors.

Results and summary







Summary

- Measurements of the proton correlation function in Au+Au collisions at 3.2 GeV.
- The centrality and rapidity dependence of the proton correlation function are presented.

To do

- Extract the source size.
- Extract effective range of the strong interaction (f_0) and scattering length (d_0) [3].

References

[1] R. Hanbury-Brown, R. Q. Twiss, Nature 178, 1046 (1956).
[2] M. Lisa, S. Pratt, R. Soltz, et al., Annu. Rev. Nucl. Part. Sci., 55: 357-402 (2005).
[3] R.Lednický, Sov. J.Nucl.Phys. 35, 770 (1982).

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https://drupal.star.bnl.gov/STAR/presentations

華中師範大學
CENTRAL CHINA NORMAL UNIVERSITY