

# Probing Conserved Charge Dynamics via HBT Interferometry in Relativistic Heavy-Ion Collisions

**Arkadip Mukherjee**

In collaboration with:

**Dr. Tribhuban Parida**

**Prof. Sandeep Chatterjee**



**IISER**  
BERHAMPUR

Hot **QCD** Matter 2025  
(Series 3)

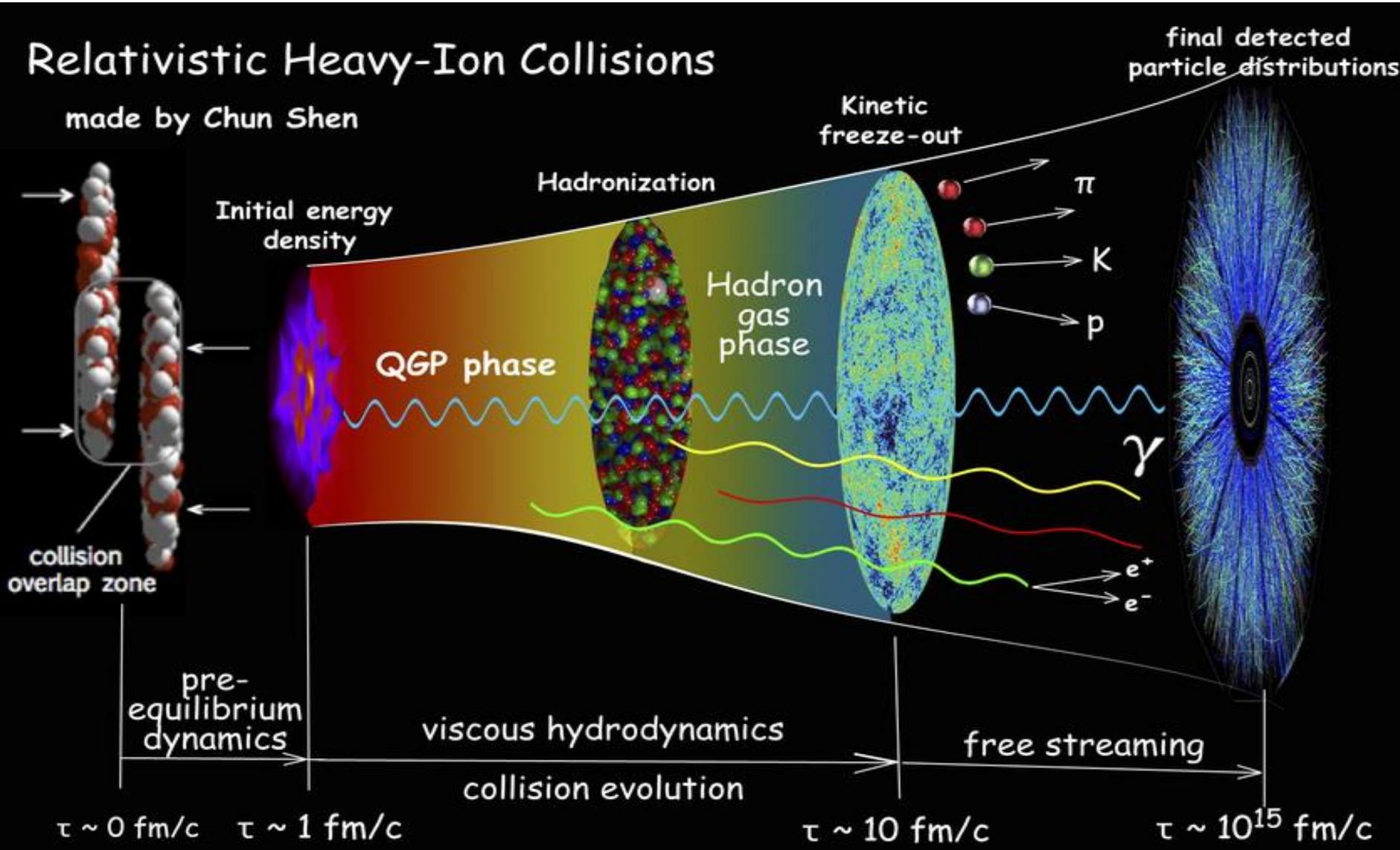
September 04, 2025



# Introduction

## Relativistic Heavy-Ion Collisions

made by Chun Shen



Brookhaven  
National Laboratory



GSI Helmholtzzentrum für  
Schwerionenforschung

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Richard Q. Twiss

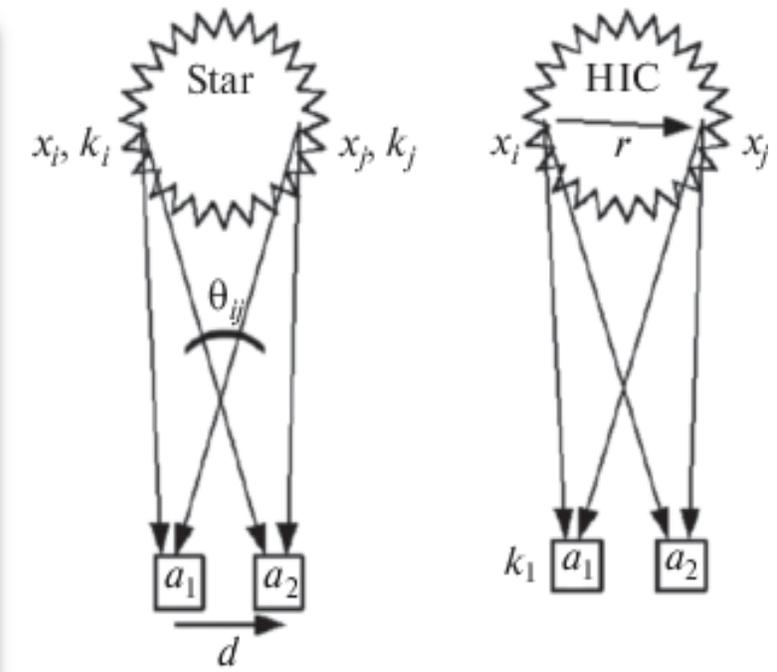
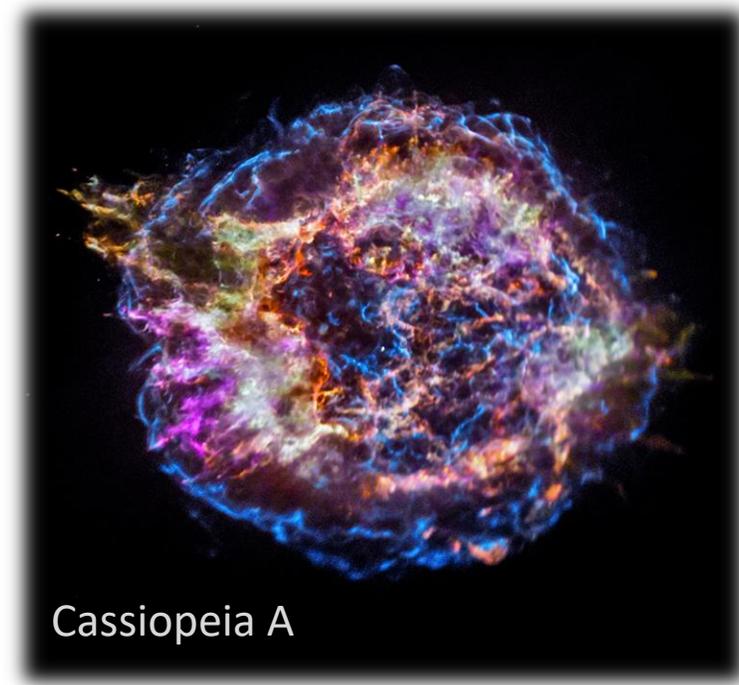
R. Hanbury Brown



Cassiopeia A

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- In 1960, HBT interferometry was applied to particle physics by **Goldhaber et. al.** [Physical Review 120.1 (1960): 300] to characterize source size using identical pion pairs in  $p - \bar{p}$  collisions.



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The two-particle correlation function is defined as:

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where,

$$D_1(p) = \int d^4x E(x, p)$$

$$D_2(p_1, p_2) = \int d^4x_1 d^4x_2 E(x_1, x_2, p_1, p_2)$$

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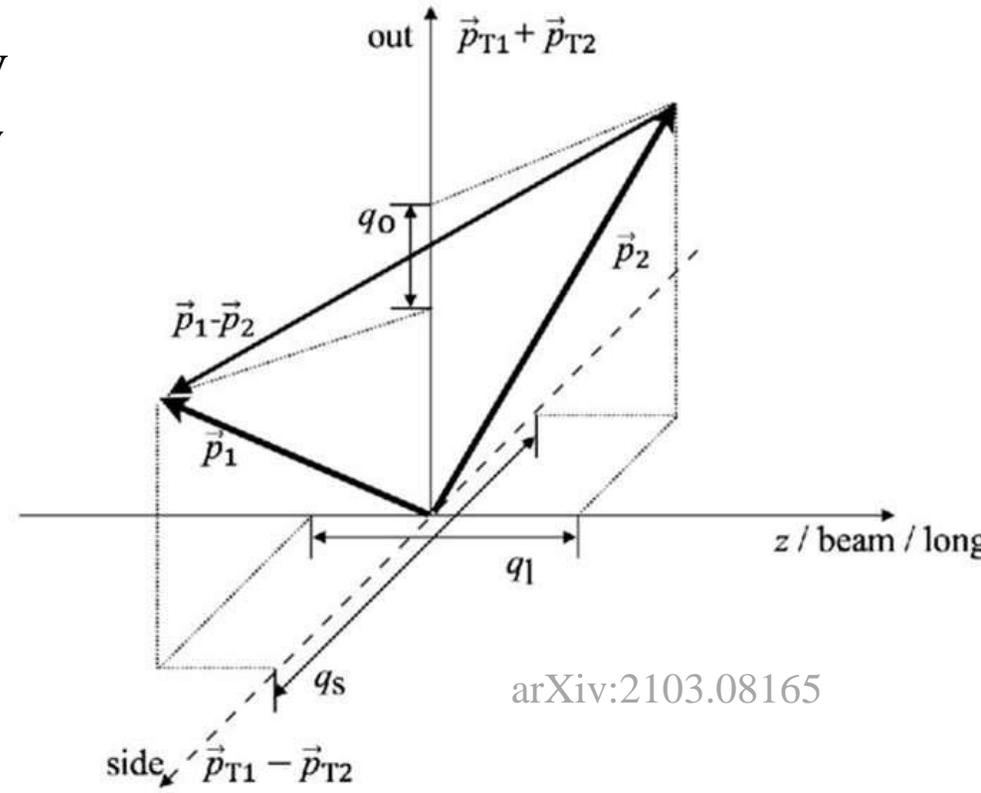
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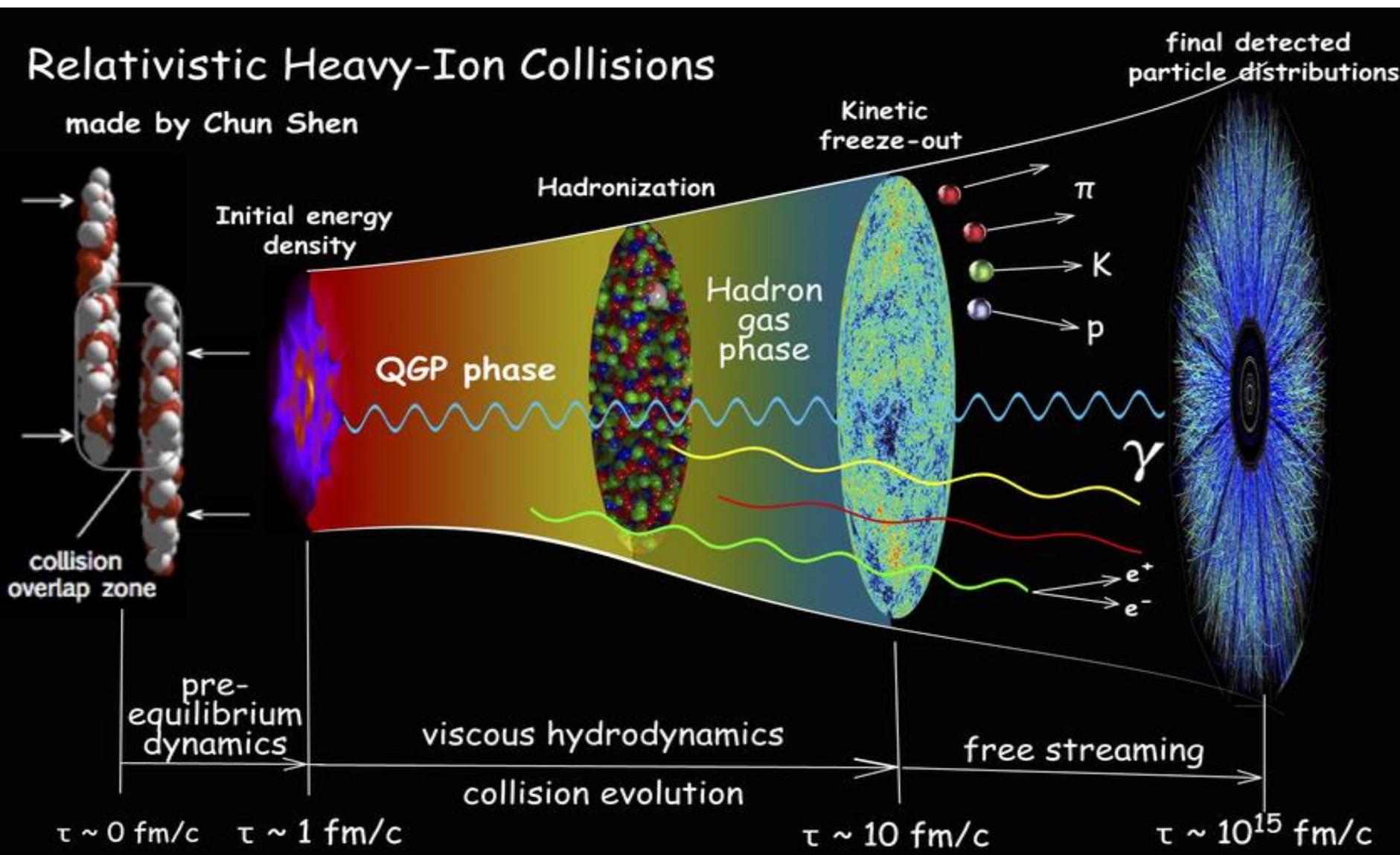


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- Bertsch-Pratt Parameterization: out-side-long axes. [Phys. Rev., C37 (1988) 1896-1900 ; Phys. Rev., D33 (1986) 1314-1327 ]

# Heavy-Ion Collisions

## Relativistic Heavy-Ion Collisions

made by Chun Shen



GICG

MUSIC

iISS

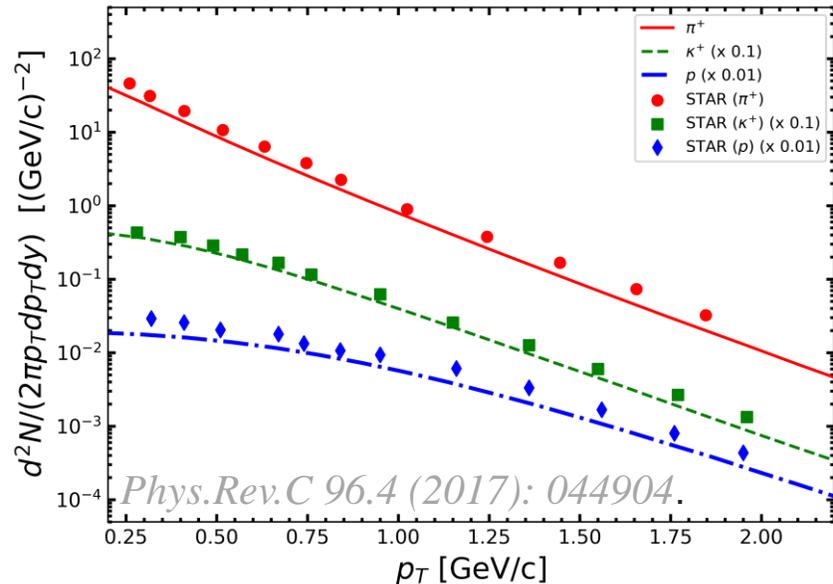
UrQMD

# Bulk Observables

Hybrid Framework successful in reproducing several bulk observables:

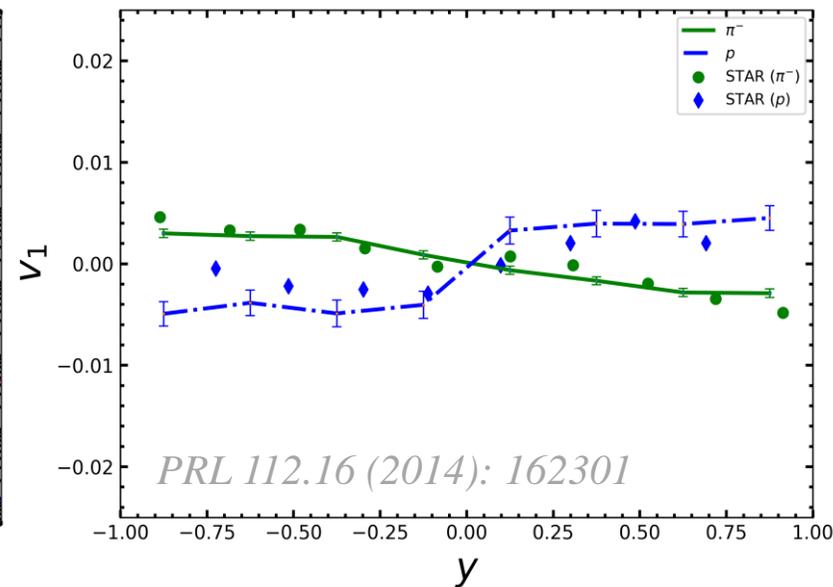
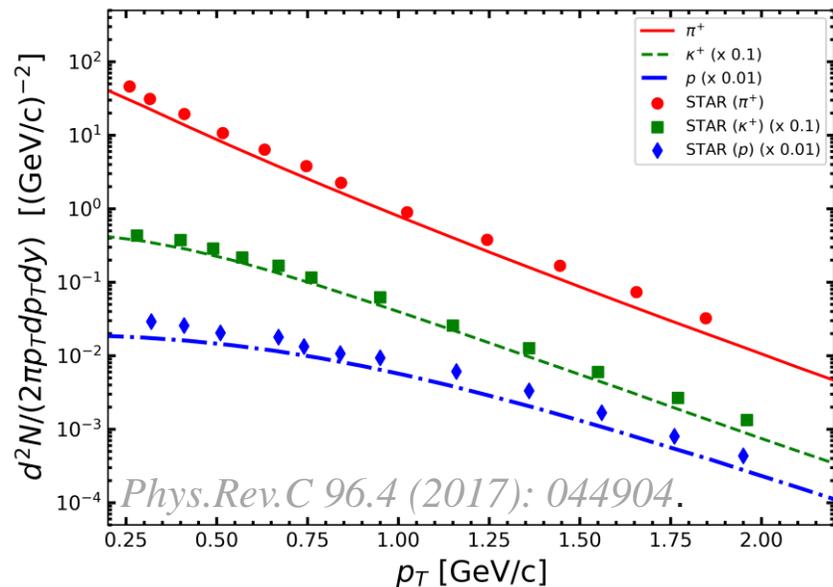
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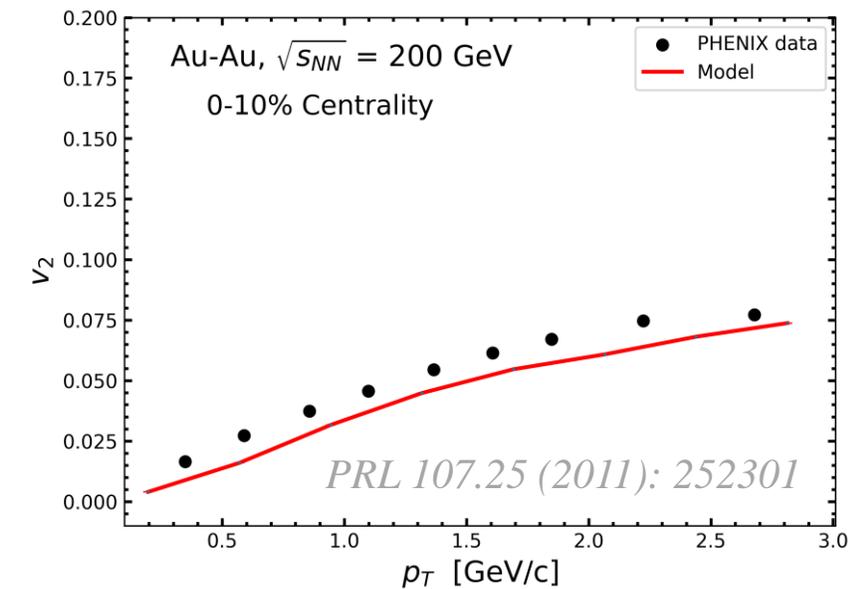
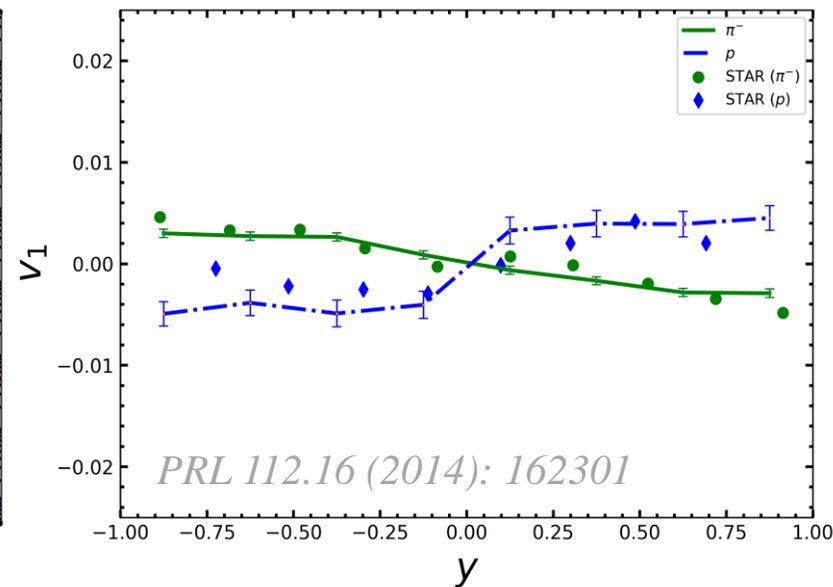
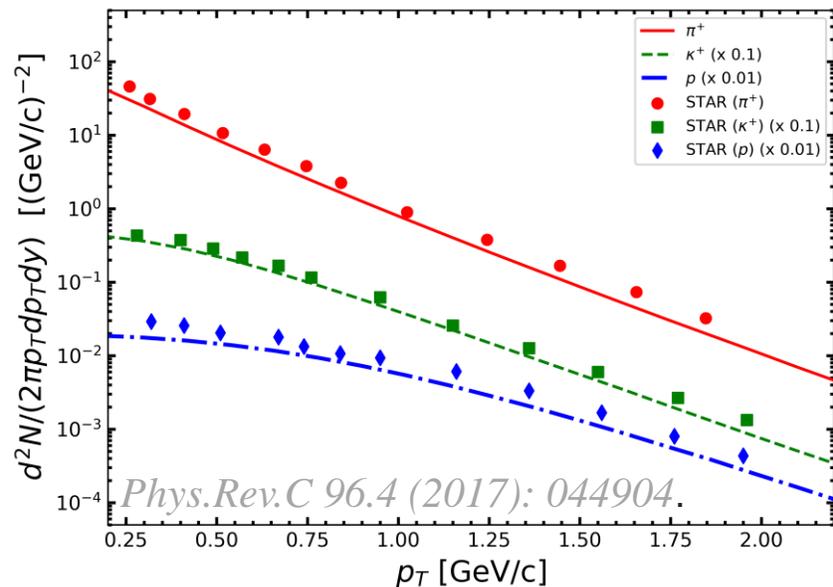
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- Directed Flow ( $v_1$ )



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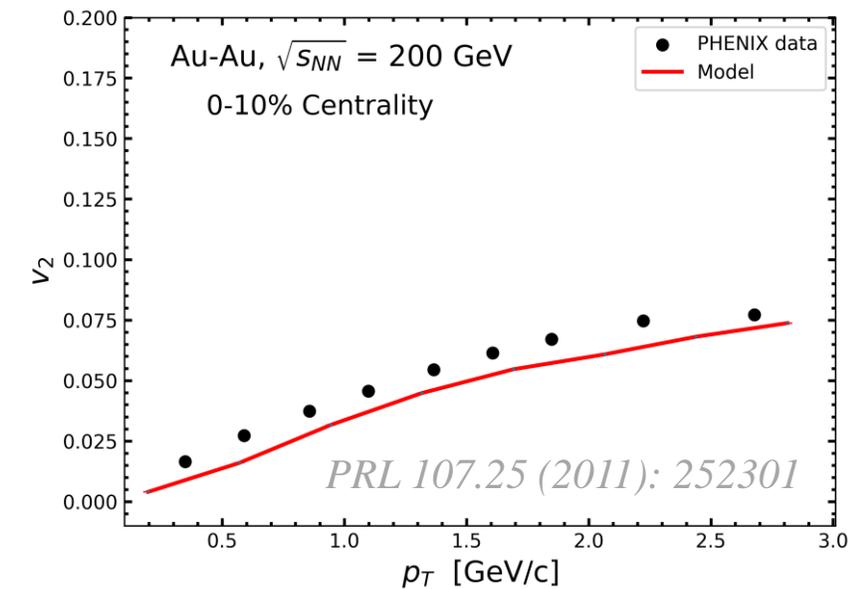
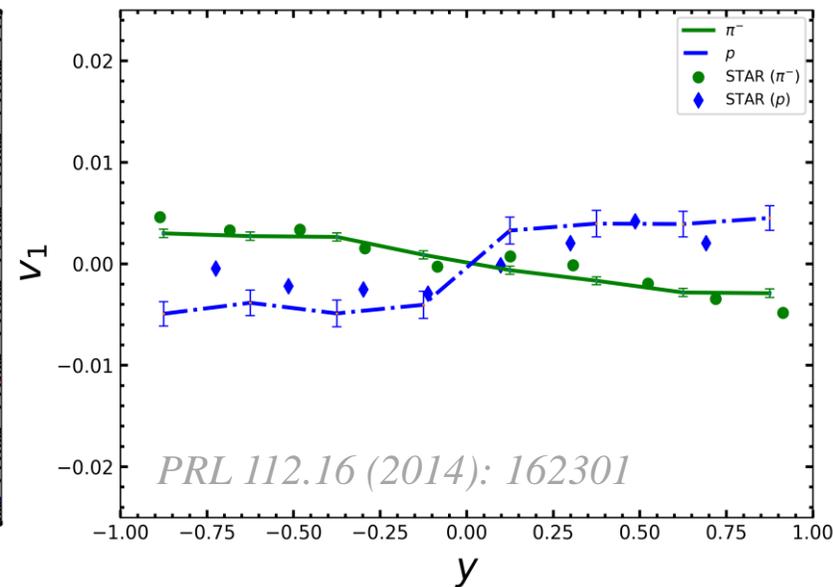
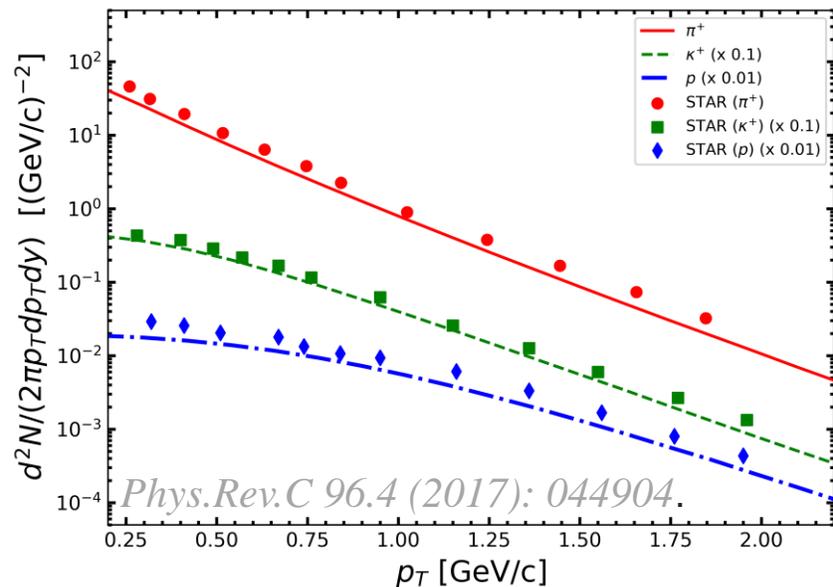
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- Invariant Yield Spectra
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## HBT Radii



# Extracting the HBT Radii

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$$C(\mathbf{Q}, k_T) = 1 + \lambda \exp \left[ -R_{out}^2(k_T) q_{out}^2 - R_{side}^2(k_T) q_{side}^2 - R_{long}^2(k_T) q_{long}^2 \right]$$

# Correlation Function Plots for Pions

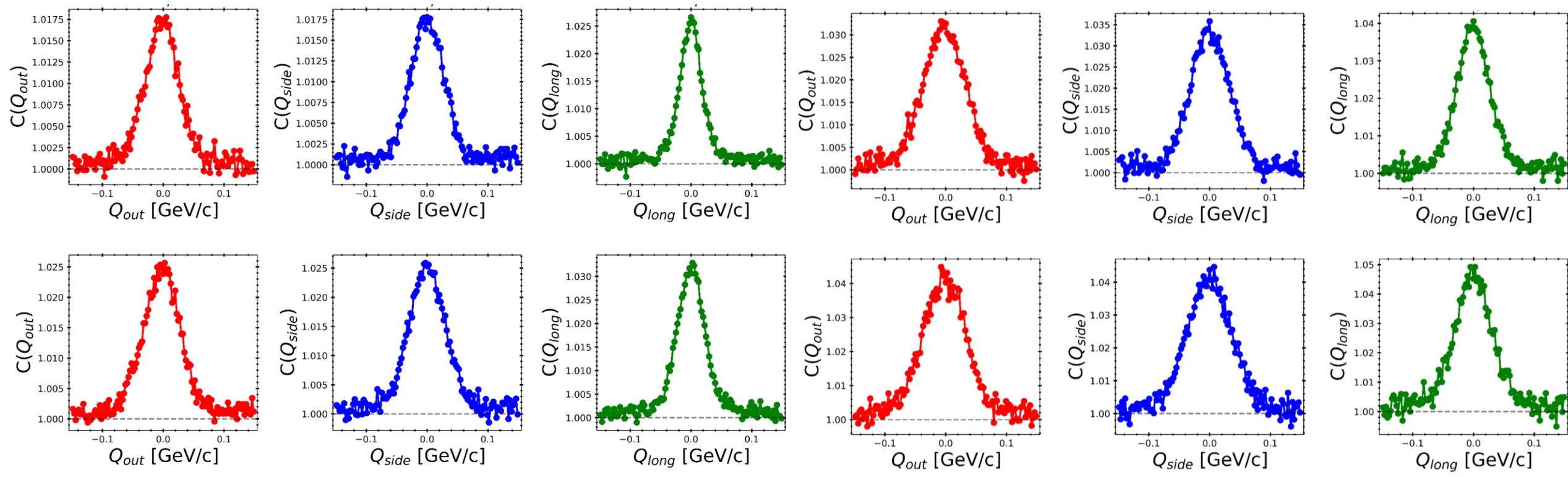


Fig: The 3-D  $C(Q)$  vs  $Q$  plots for 0-10% central Au-Au collisions at  $\sqrt{s_{NN}} = 200$  GeV.  $|y| < 1.0$

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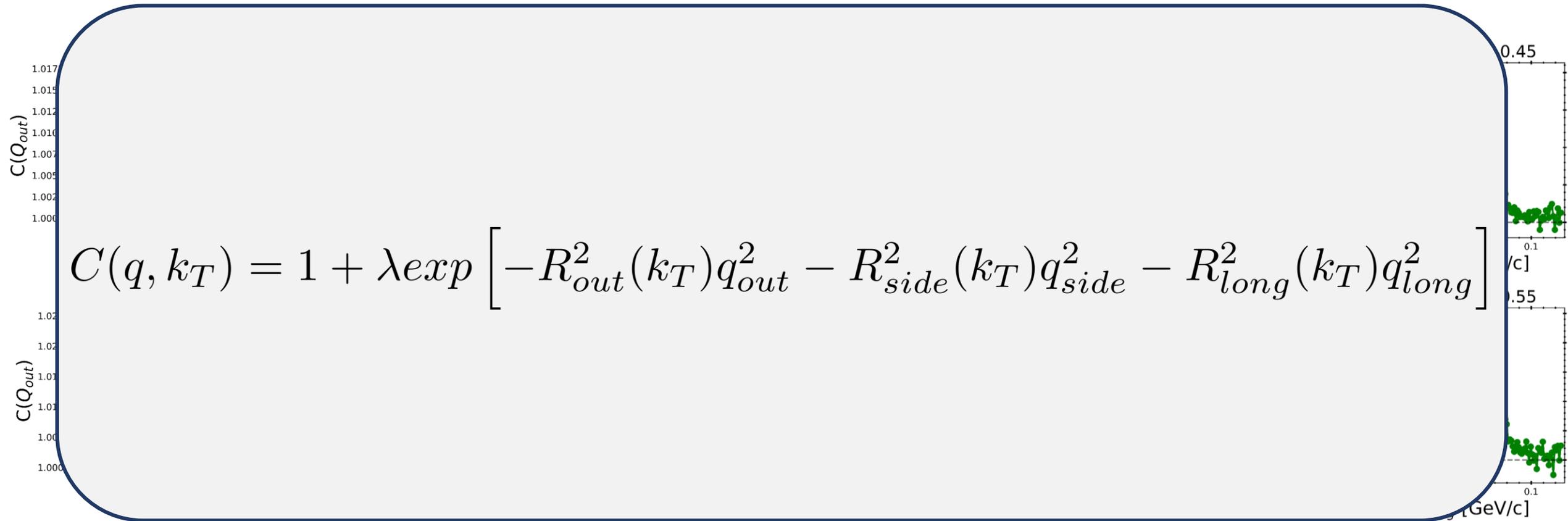


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# HBT Radii Distributions

200 GeV

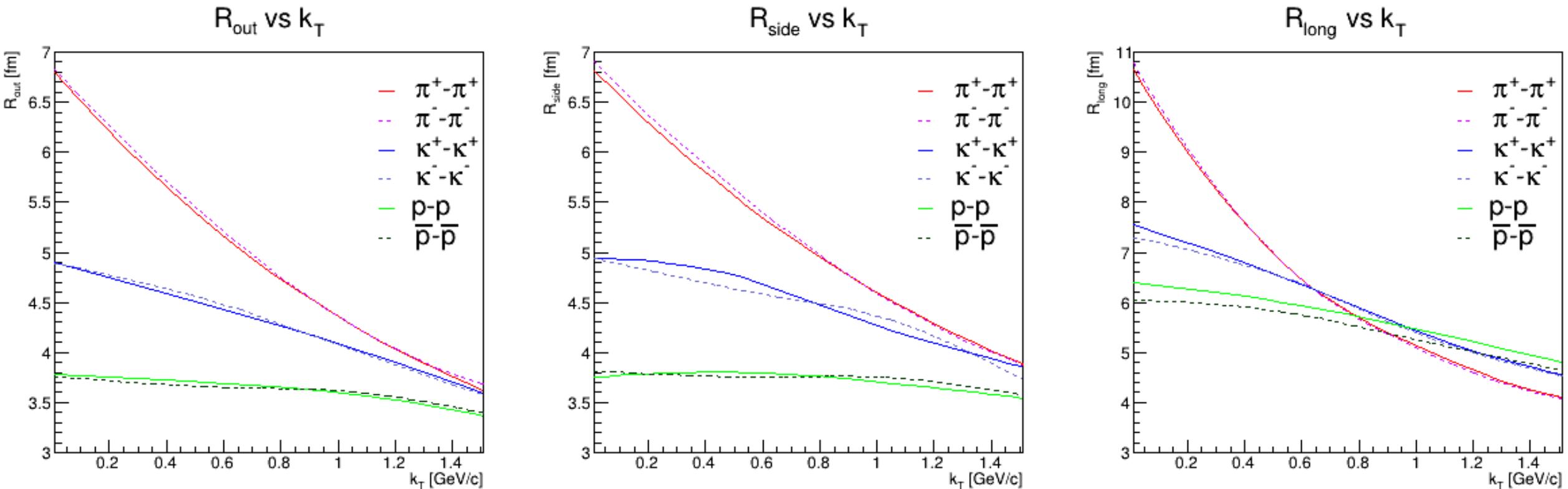


Fig: The three HBT Radii vs  $k_T$  plots for 0-10% centrality Au-Au collisions at  $\sqrt{s_{NN}} = 200$  GeV.

7.7 GeV

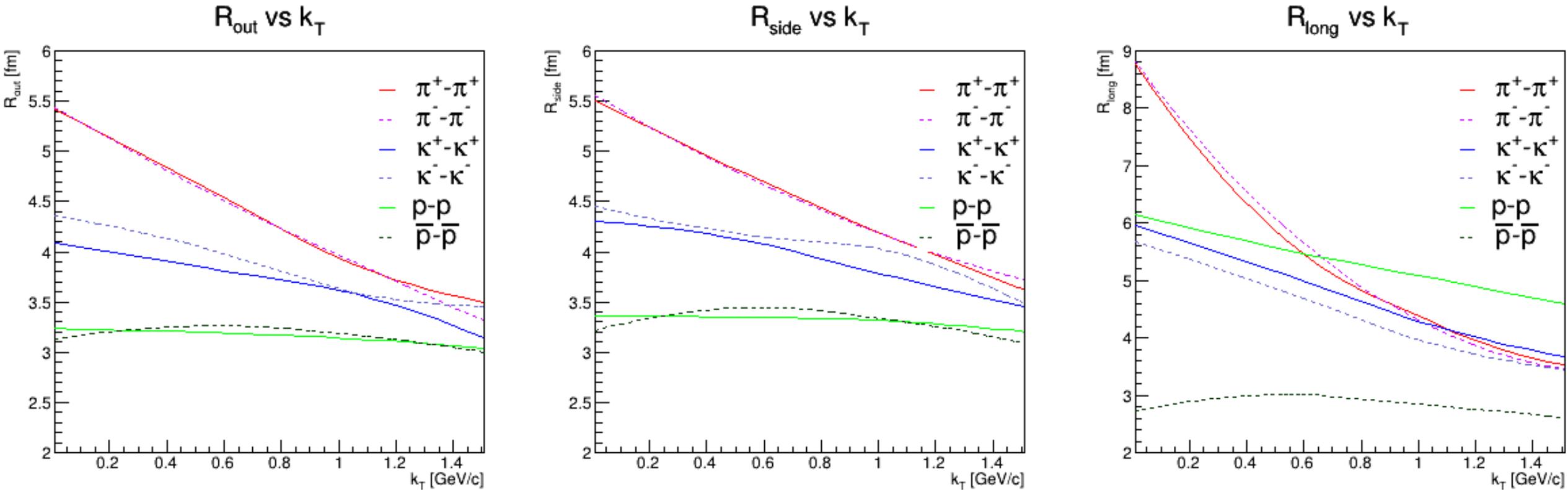


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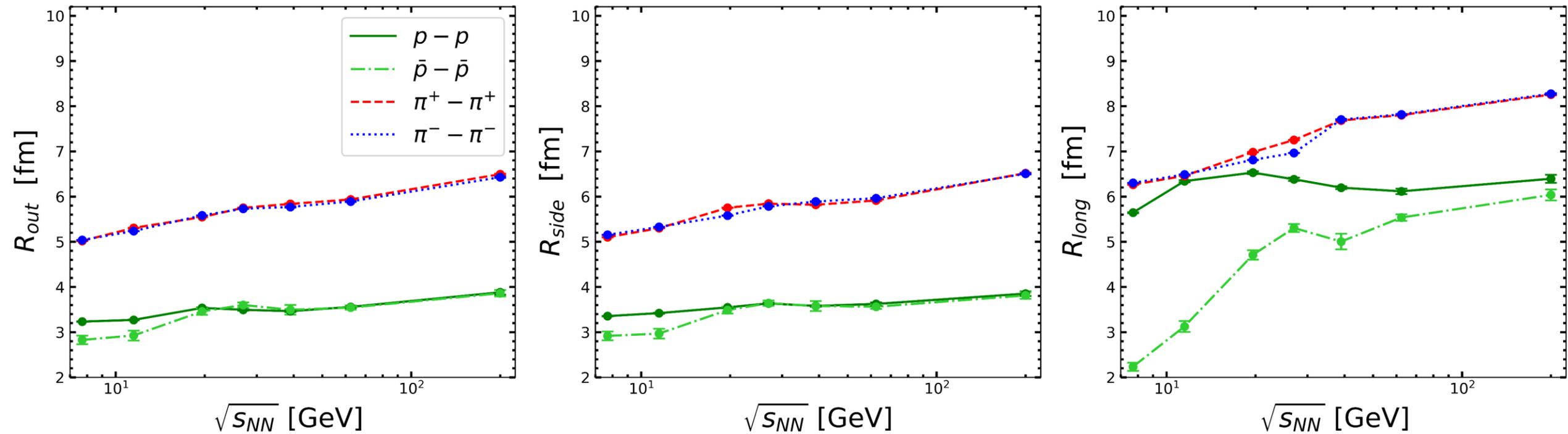


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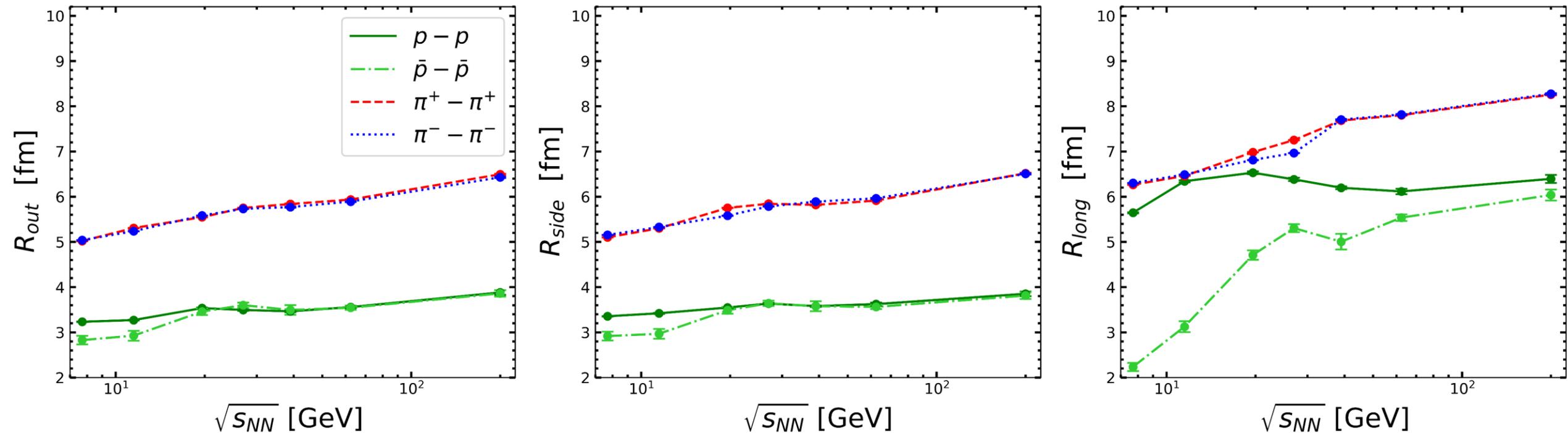


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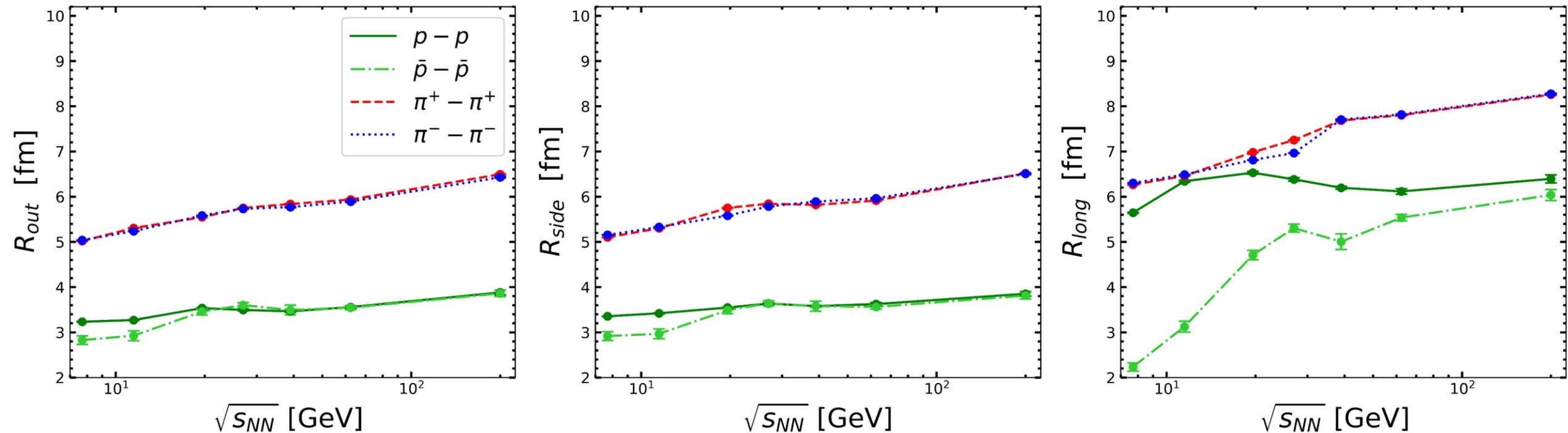


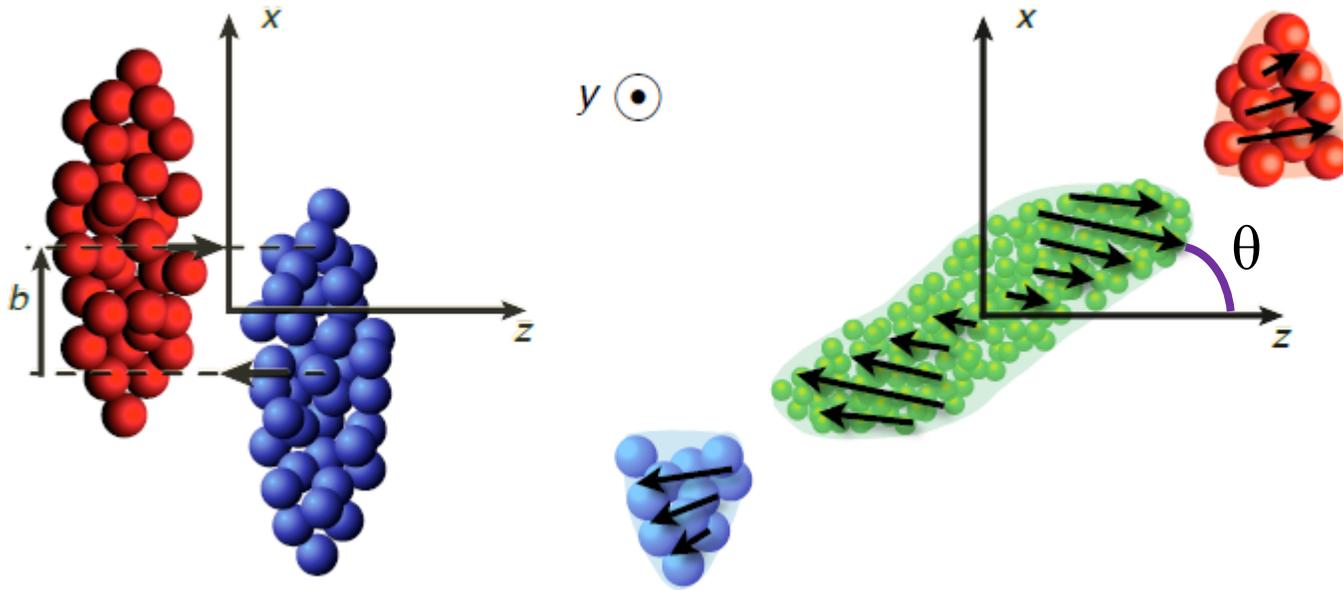
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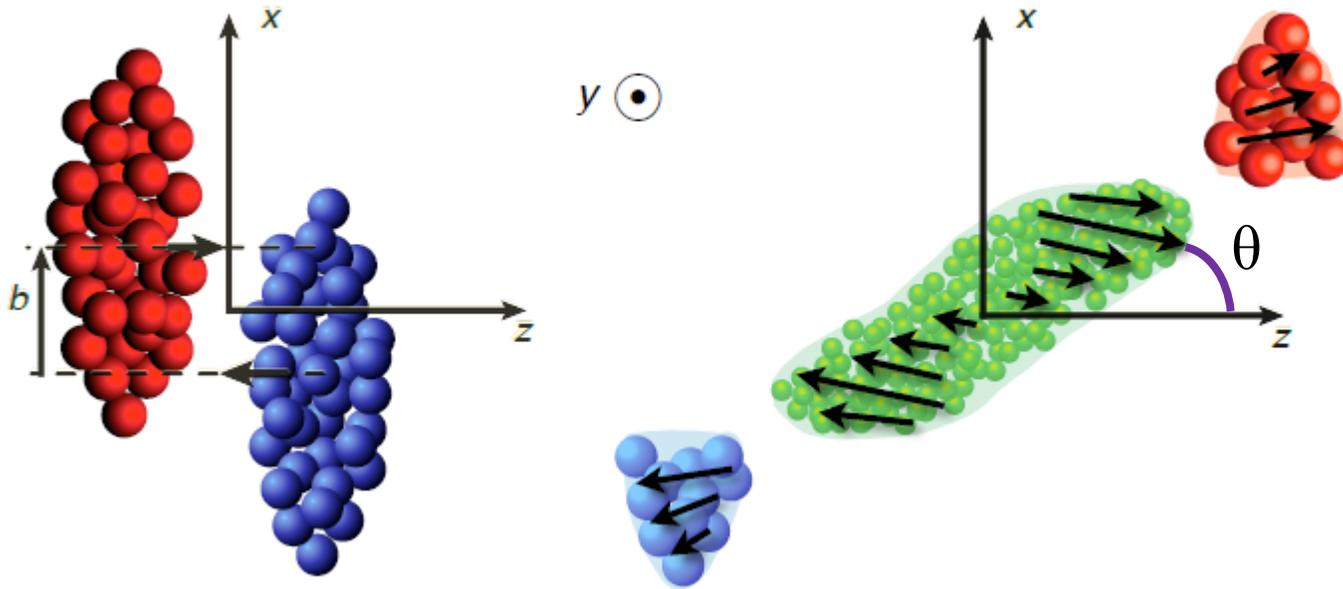
**Baryon Stopping**

# Tilted Emission Source

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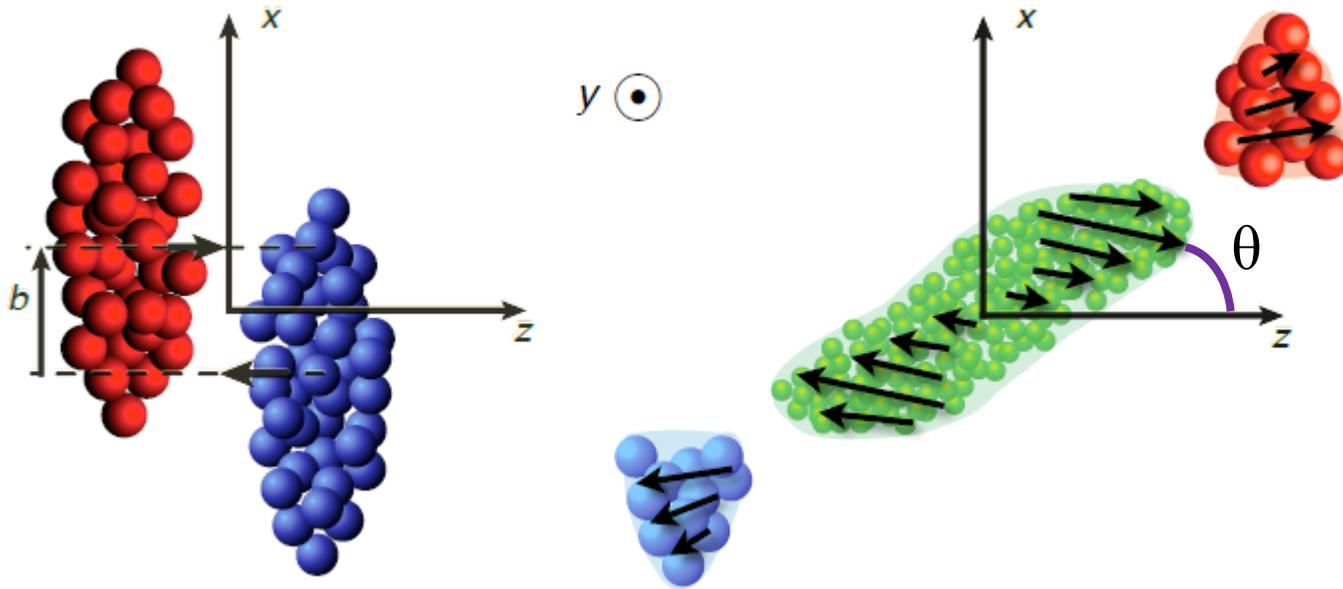
arXiv:2410.15134v1



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Phys. Rev. C 84, 014908 (2011)



$$\theta_{\text{out-long}} = \frac{1}{2} \tan^{-1} \left( \frac{2R_{\text{out-long}}^2}{R_{\text{long}}^2 - R_{\text{out}}^2} \right)$$

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arXiv:2410.15134v1

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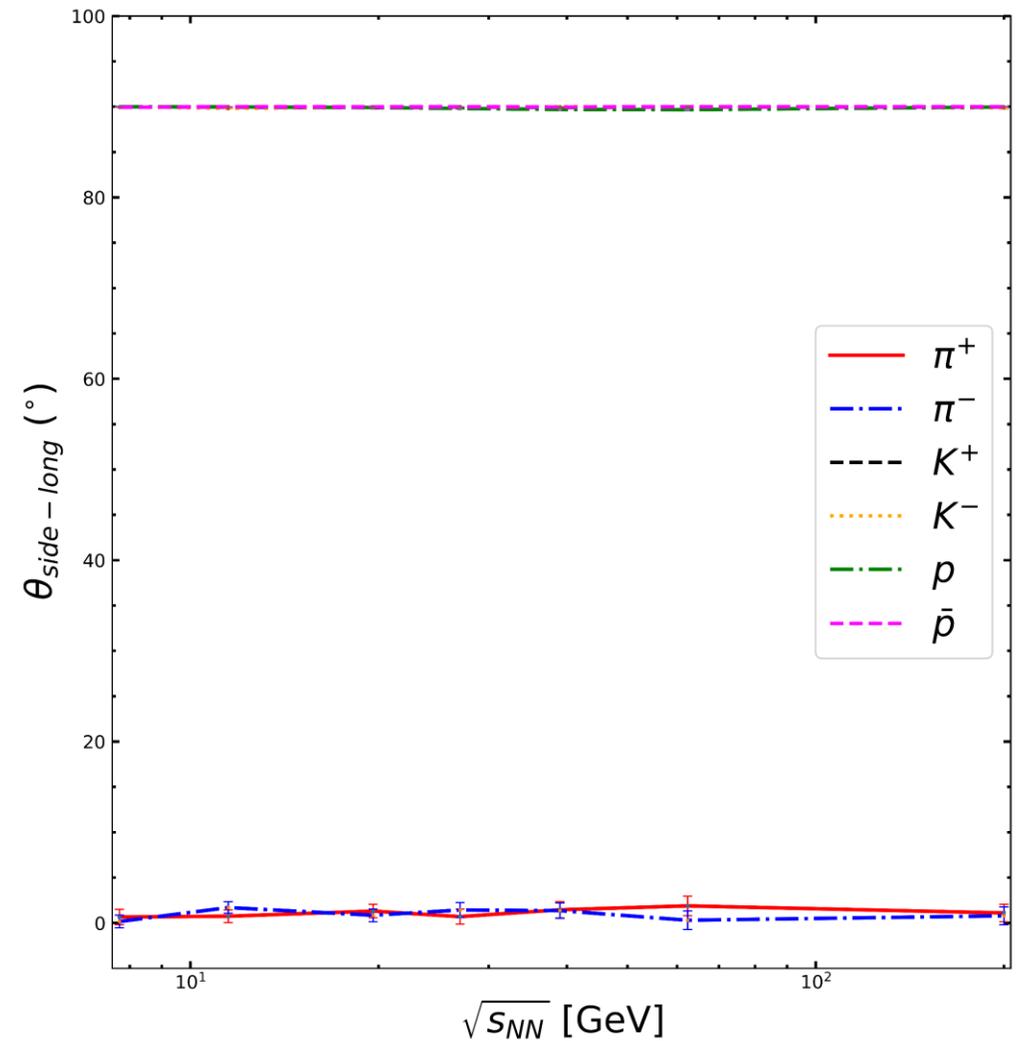
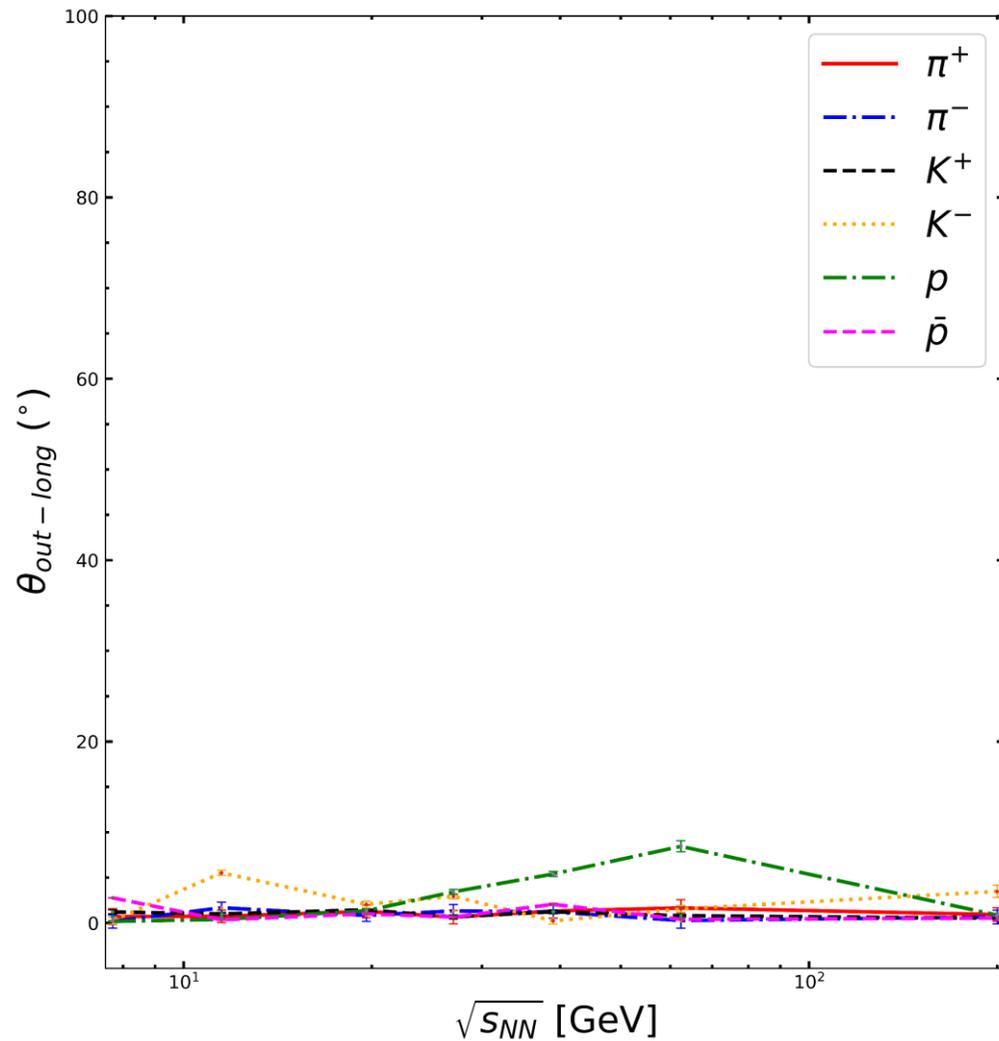


Fig:  $\theta_{ol}$  &  $\theta_{sl}$  vs.  $\sqrt{s_{NN}}$  for 0-10% central Au-Au collisions;  $|y| < 1.0$

# Summary

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## Upcoming Work:

- Exact cause of splitting only in  $R_{\text{long}}$ , and very less or no splitting in  $R_{\text{out}}$  &  $R_{\text{side}}$ .
- Study centrality dependence of HBT Radii.
- Effect of peripheral collisions in  $\theta_{\text{out-long}}$  &  $\theta_{\text{side-long}}$ .

# Thank You

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