Femtoscopic scales of particle-emitting source in small and large systems

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Outline

- **Correlation functions**
- **Azimuthally sensitive HBT in Cu+Au and Au+Au at 200 GeV**
  - Azimuthally sensitive HBT w.r.t. the event plane
  - Correlation functions and their fits
  - Cu+Au Vs. Au+Au@200 GeV
  - Tilt for Au+Au and Cu+Au
- **Femtoscopy in d+Au and ^{3}He+Au collisions at 200 GeV**
  - Correlation functions and their fits
  - Transverse momentum dependence of the pion femtoscopic radii
- **Summary**

Motivation for femtoscopic measurements

In high-energy collisions, the spatio-temporal size of the particle production region can be measured using the Bose-Einstein correlations of identical bosons at low relative momentum

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

C(q) – correlation function
A(q) – q distribution with weight = 1 + cos(ΔxΔp)
B(q) – q distribution with weight = 1

1-D fit

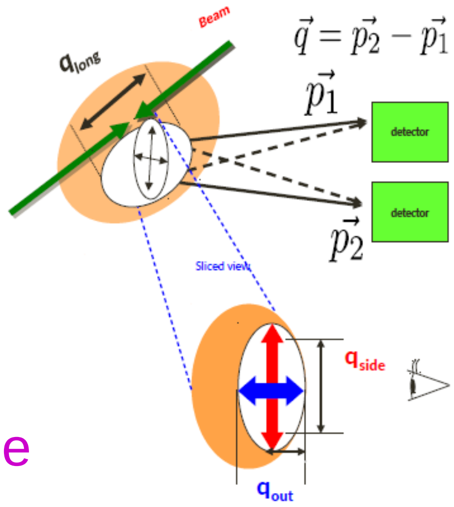
$$C(q_{inv})=1+\lambda e^{-q_{inv}^2 R_{inv}^2}$$

and

$$C(q_{inv})=1+\lambda e^{-q_{inv} R_{inv}}$$

3-D fit

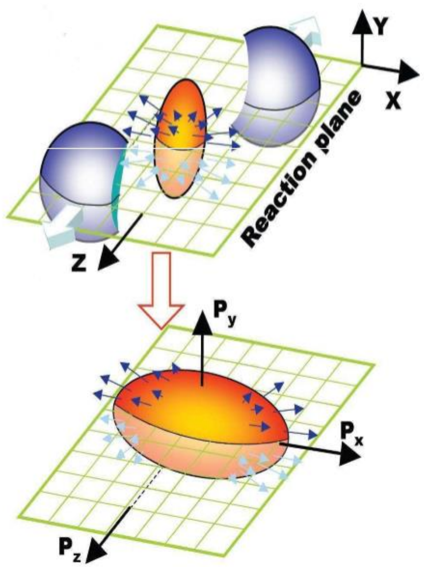
$$C(q_{out},q_{side},q_{long},\Delta\phi)=1+\lambda\exp(-R_{out}^2(\Delta\phi)q_{out}^2-R_{side}^2(\Delta\phi)q_{side}^2-$$
$$-R_{long}^2(\Delta\phi)q_{long}^2-2R_{os}^2(\Delta\phi)q_{out}q_{side}-2R_{sl}^2(\Delta\phi)q_{long}q_{side}-2R_{ol}^2(\Delta\phi)q_{out}q_{long})$$



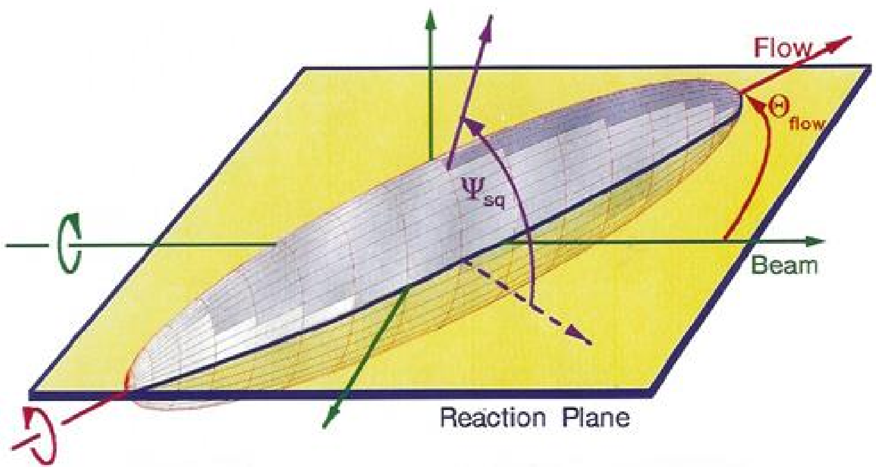
All results presented in this work are based on the UrQMD simulation

Azimuthally sensitive HBT in Cu+Au and Au+Au at 200 GeV

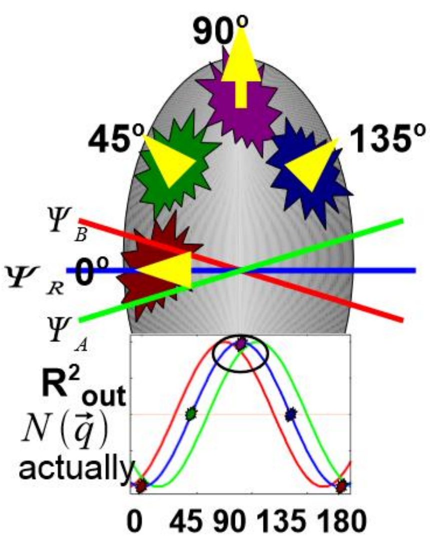
Azimuthally sensitive HBT w.r.t. the event plane

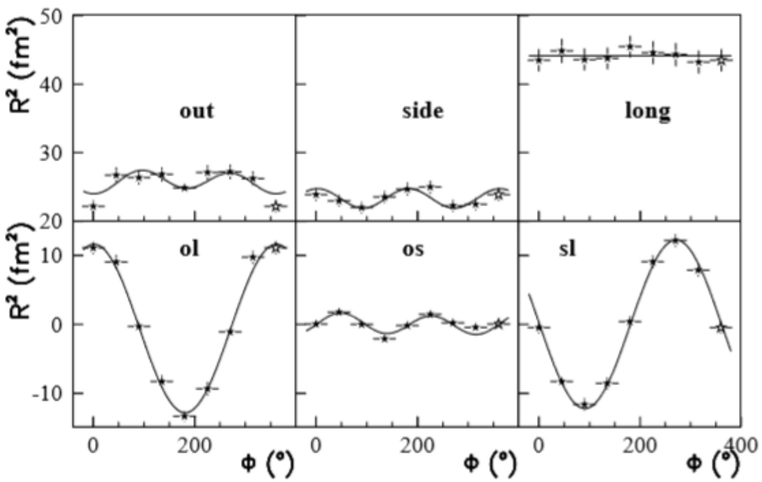


In heavy-ion collisions spatial anisotropy leads to momentum anisotropy. In non-central collisions created medium can be tilted in reaction plane



Azimuthally sensitive HBT measurements allow us to probe shape and orientation of emission source

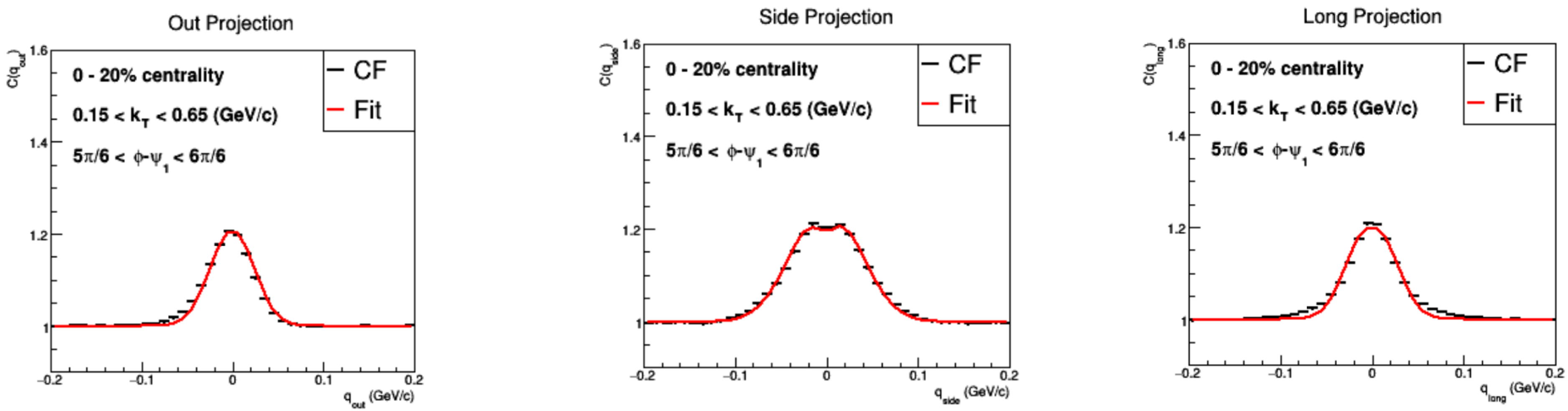




Correlation functions and their fits

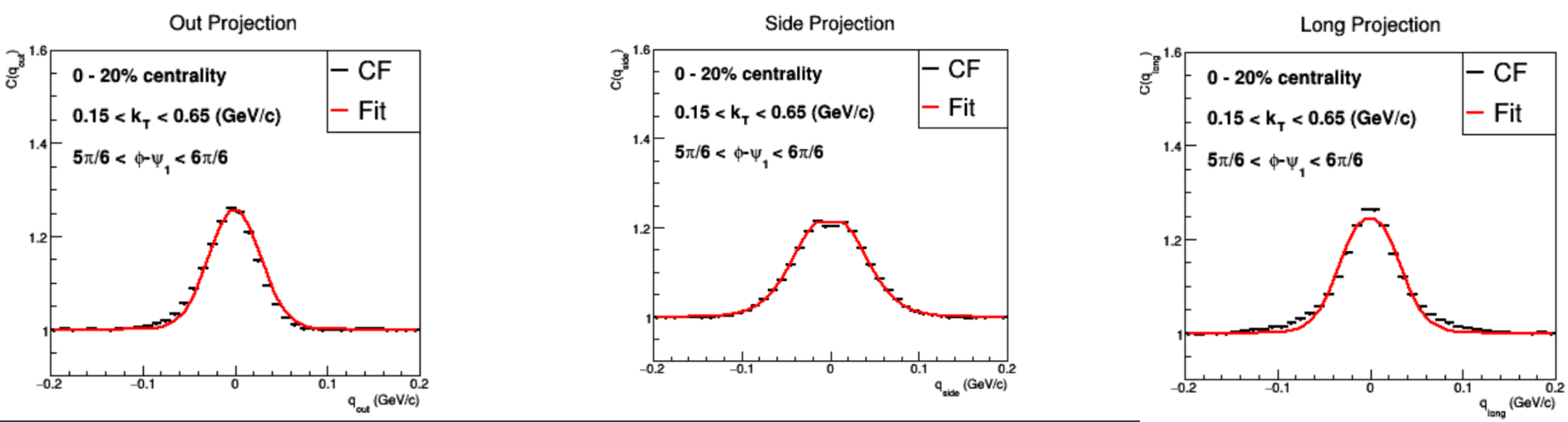
UrQMD, 10M events, $\pi^+\pi^+ + \pi^-\pi^-$

Au+Au@200 GeV

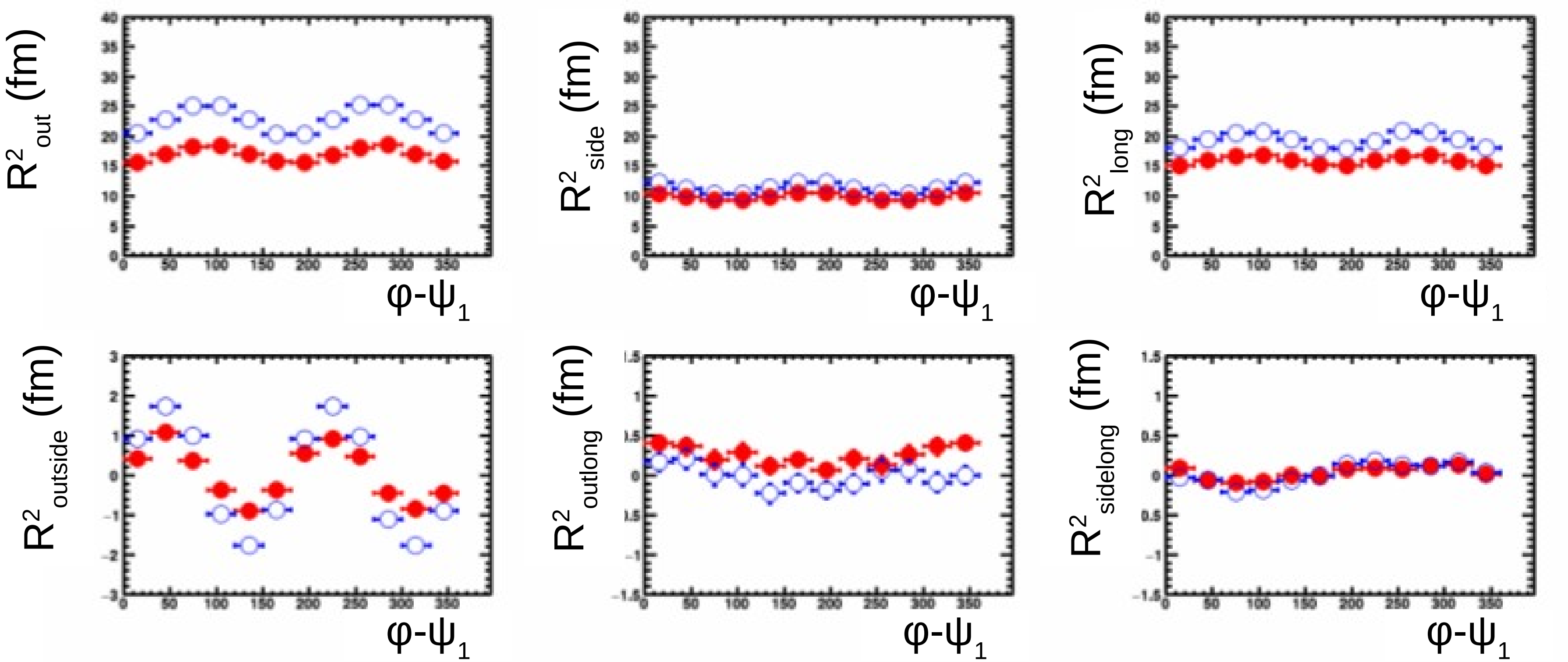


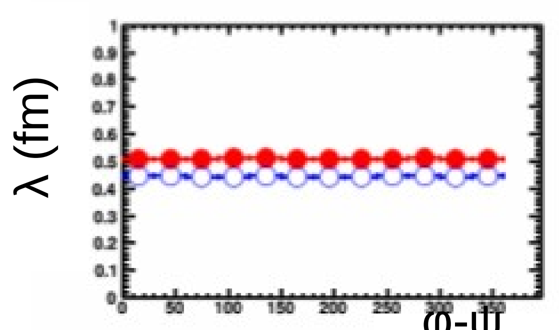
Cu+Au@200 GeV

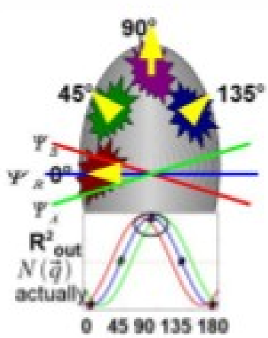
All fits of CFs look good



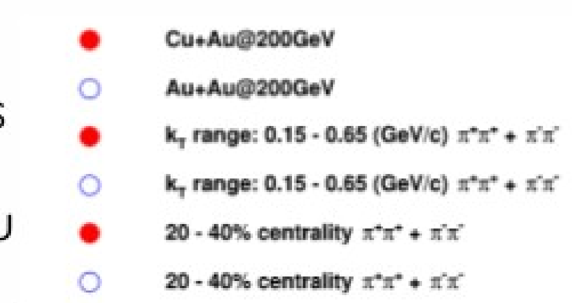
Cu+Au Vs. Au+Au@200 GeV





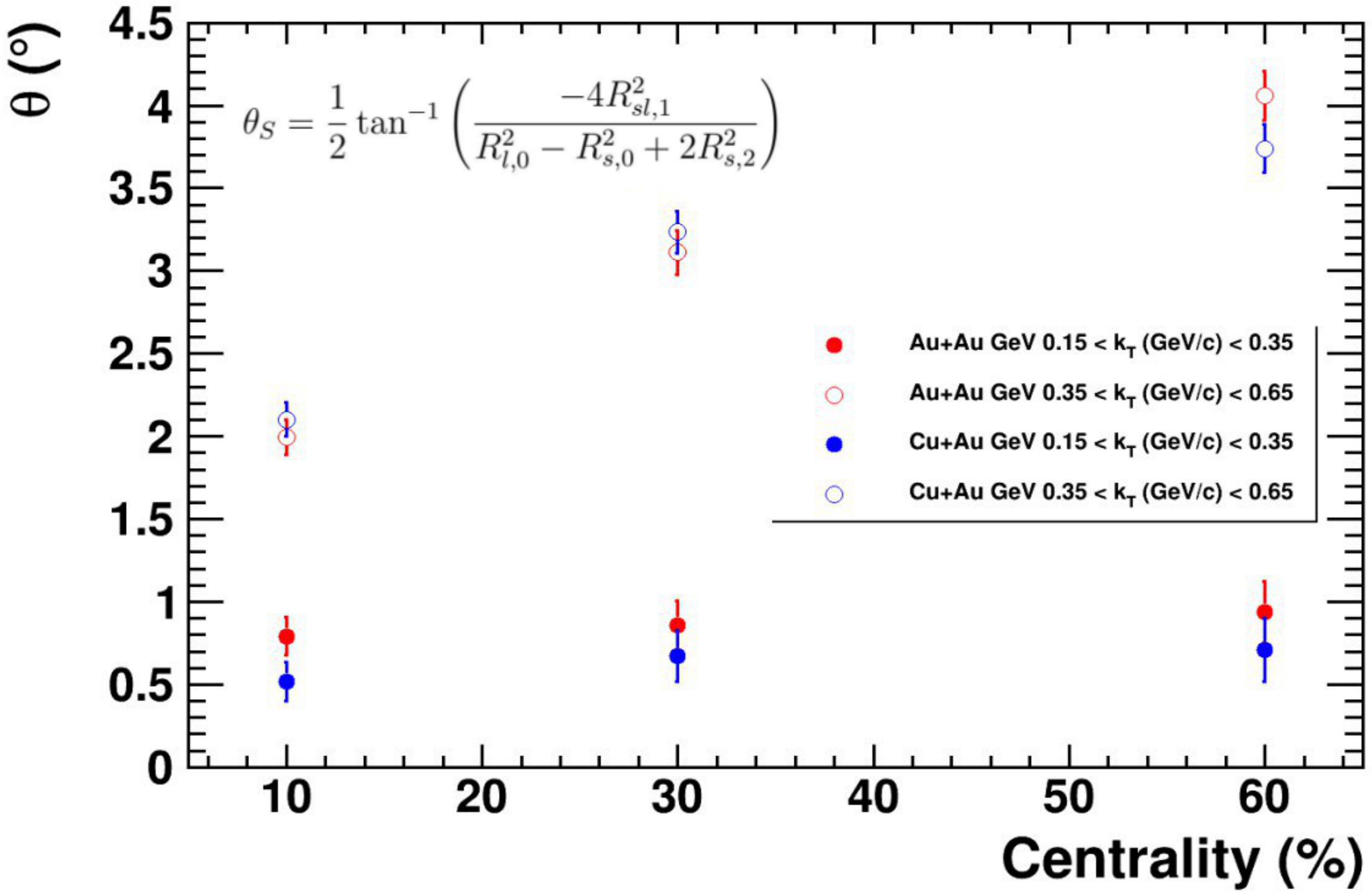


10M events for Au+Au and Cu+Au



Femtoscopic radii measured for Au+Au collisions are systematically larger those for Cu+Au

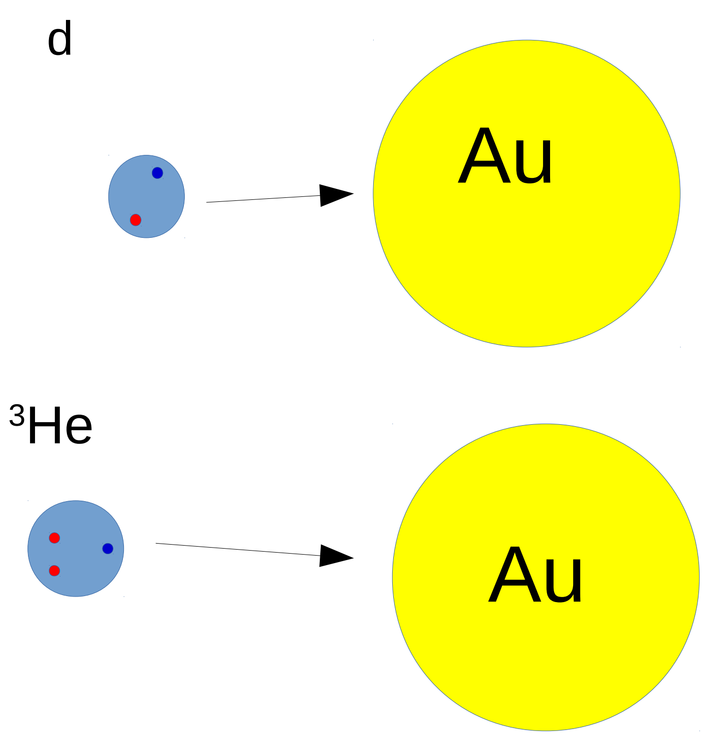
Tilt for Au+Au and Cu+Au

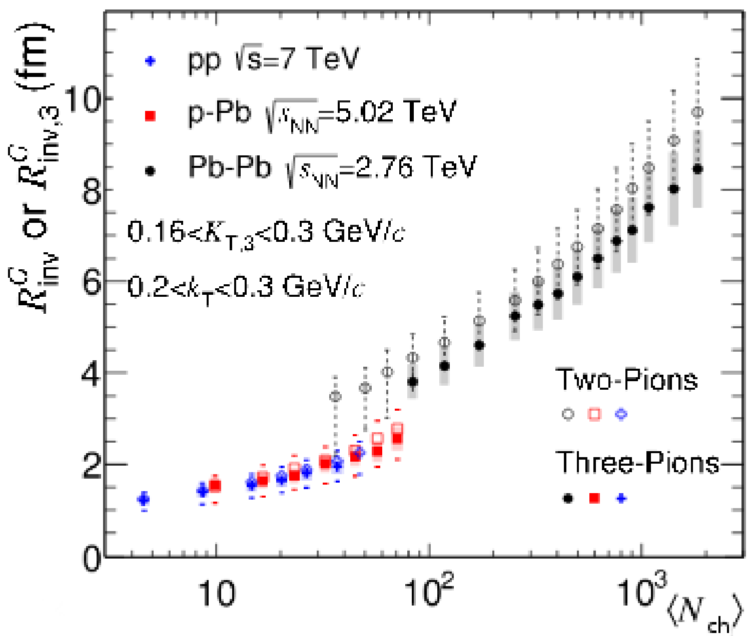


Tilts extracted from the asHBT analysis for Cu+Au and Au+Au analysis are consistent within the uncertainties, and increase with increasing k_T

Femtoscopy in d+Au and ^{3}He+Au collisions at 200 GeV

How will the radii change with changing the initial size collision system?





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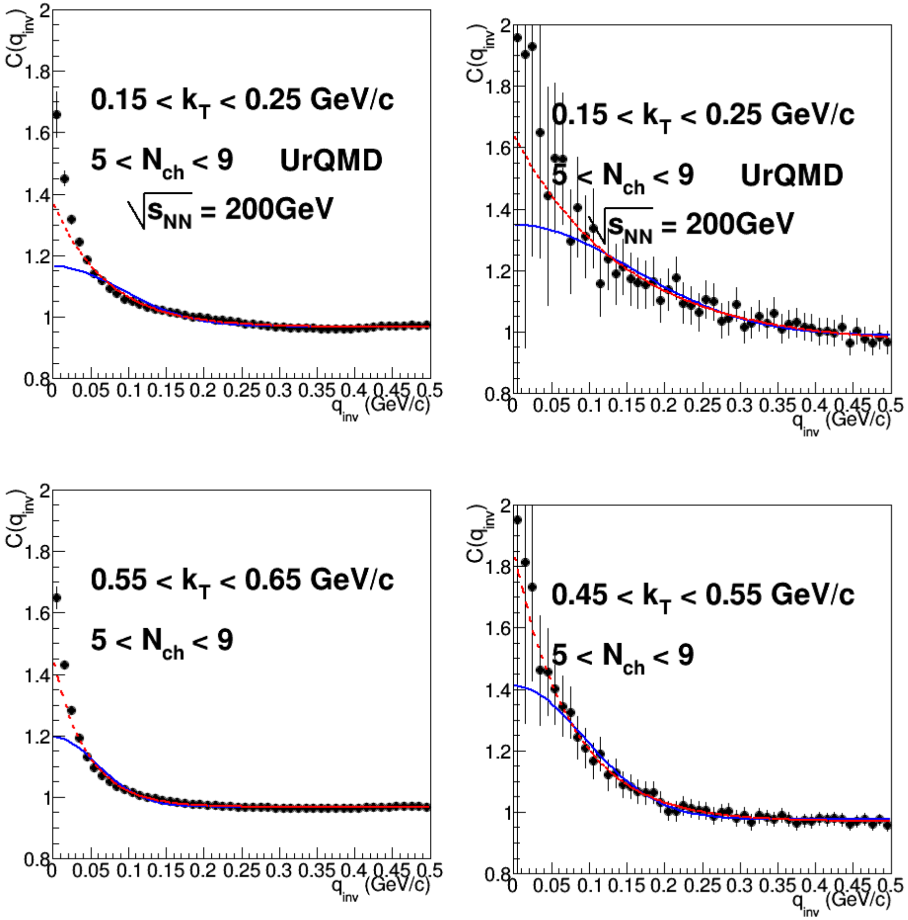
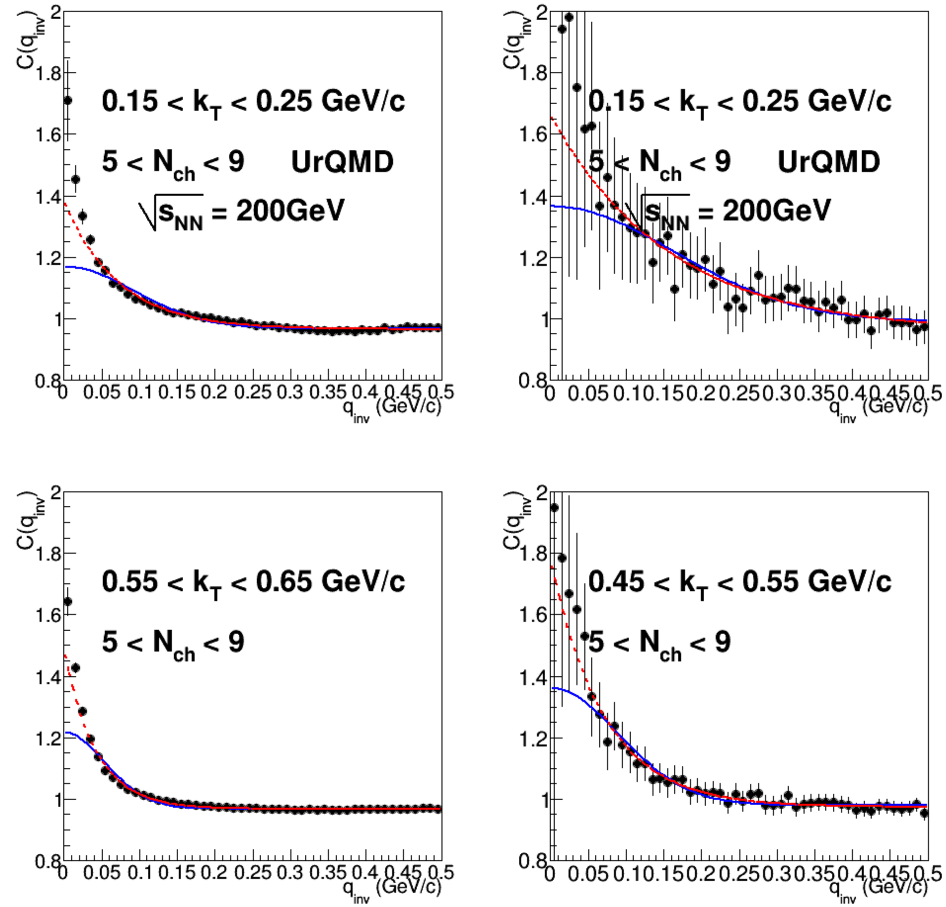
Correlation functions and fits

d+Au: $\pi^+\pi^+ + \pi^-\pi^-$ $K^+K^+ + K^-K^-$



82M events

^{3}He+Au: $\pi^+\pi^+ + \pi^-\pi^-$ $K^+K^+ + K^-K^-$

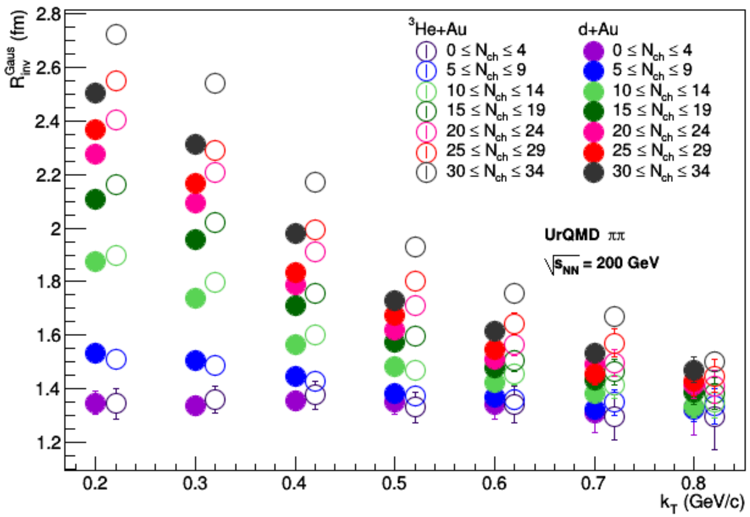


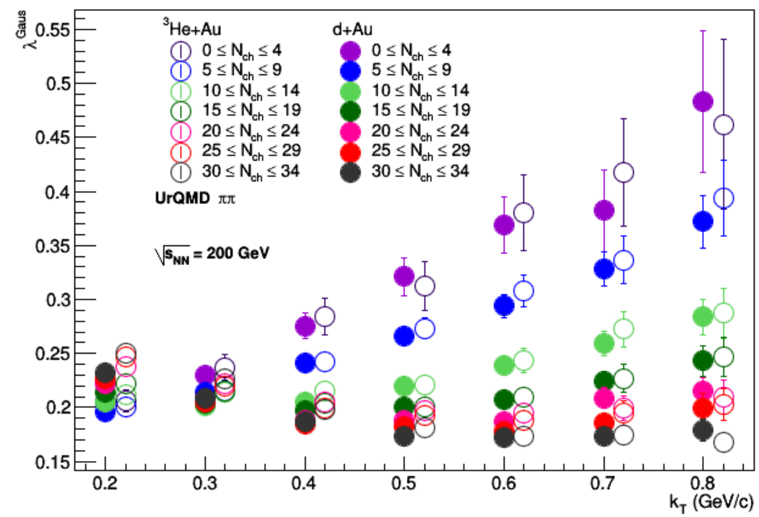
51M events

Exponential fits have a better description of the data as compared to the Gaussian ones

Transverse momentum dependence of the pion femtoscopic radii

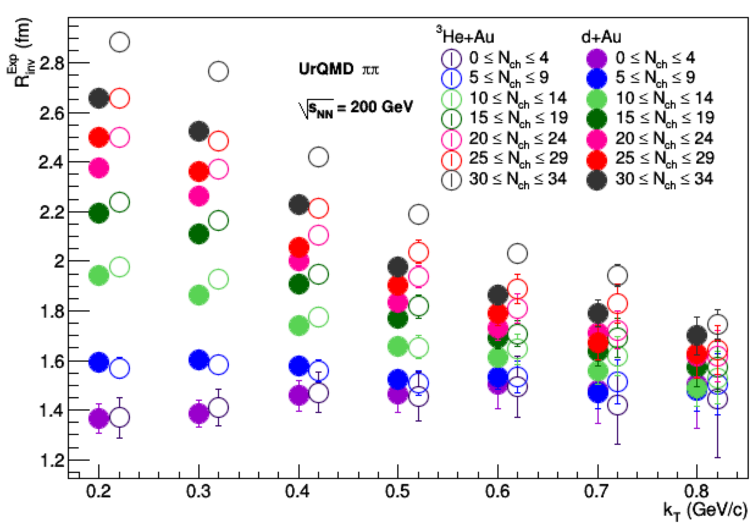
Gaussian

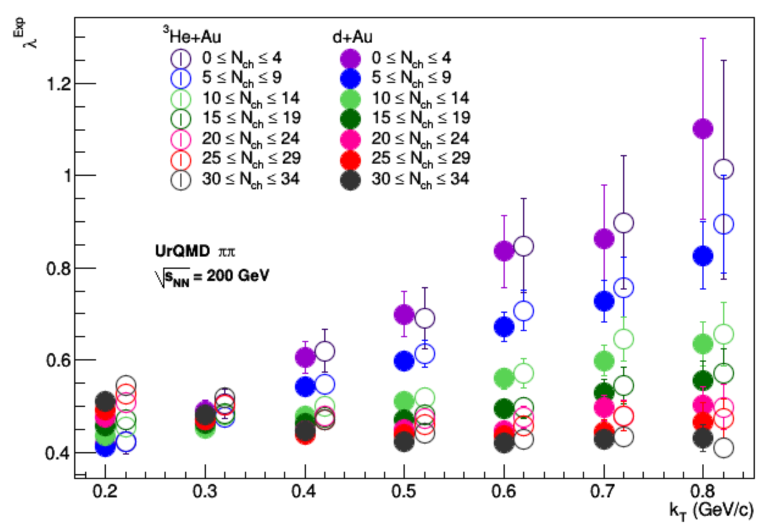




Femtoscopic radii extracted for d+Au and He3+Au collisions are similar for multiplicities below 20 (for the given k_T).

Exponent





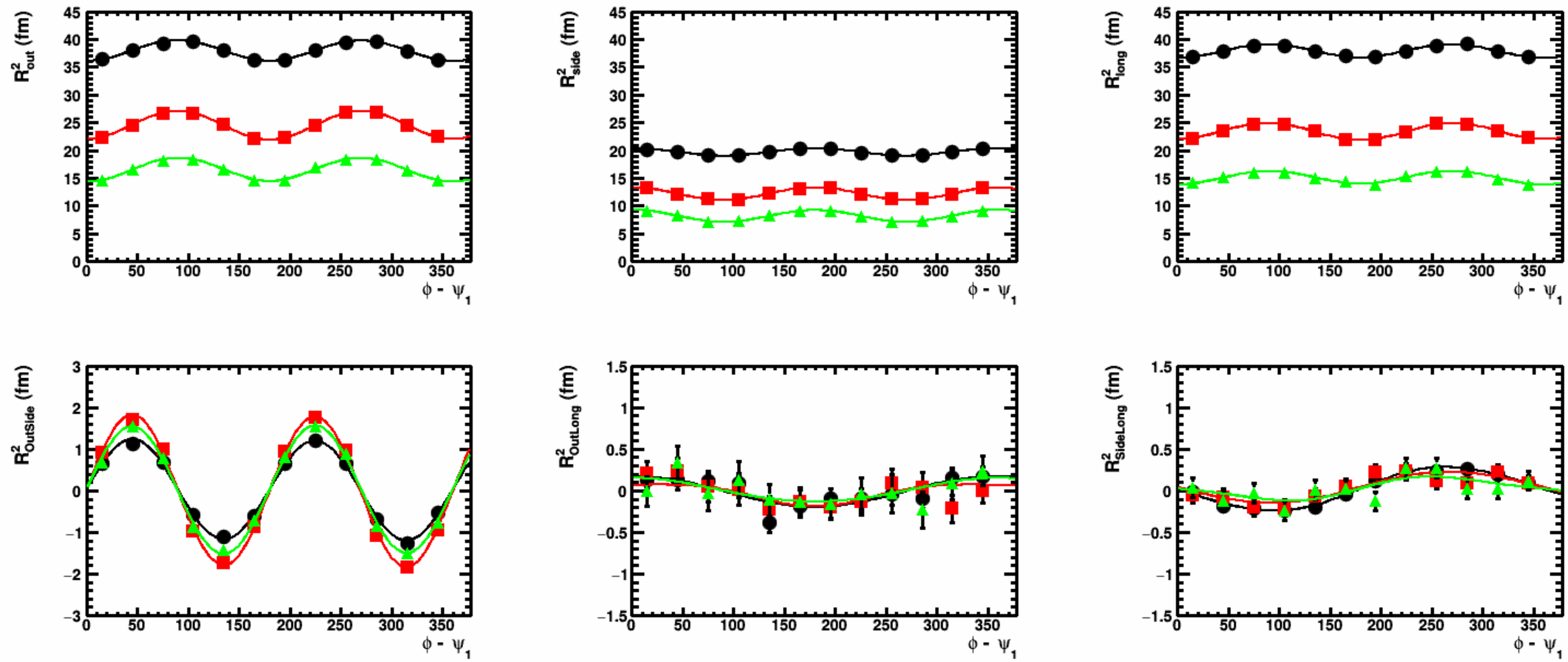
For higher multiplicities femtoscopic radii measured for He3+Au collisions are systematically larger than those for d+Au

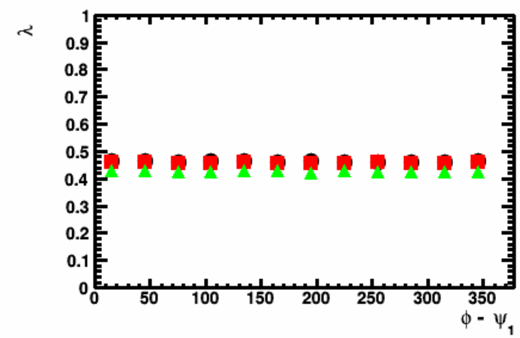
Summary

- **Azimuthally sensitive HBT in Cu+Au and Au+Au at 200 GeV in UrQMD**
  - In 3D analysis with respect to the first-order event plane the oscillations of the radii were observed as the function of azimuthal angle
  - The extracted radii for Au+Au collisions are systematically larger than those for Cu+Au at the same centrality and pair transverse momentum
  - Tilts extracted from the asHBT analysis for Cu+Au and Au+Au analysis are consistent within the uncertainties, and increase with increasing k_T
- **Femtoscopy in d + Au and ^{3}He + Au collisions at 200 GeV**
  - Femtoscopic radii extracted for d+Au and He3+Au collisions are similar for multiplicities below 20 (for the given k_T).
  - For higher multiplicities femtoscopic radii measured for He3+Au collisions are systematically larger than those for d+Au

Back up slides

Au+Au@200 GeV: azimuthally differential femtoscopic measurements





(0.15 < kT (GeV/c)< 0.35)

Fit

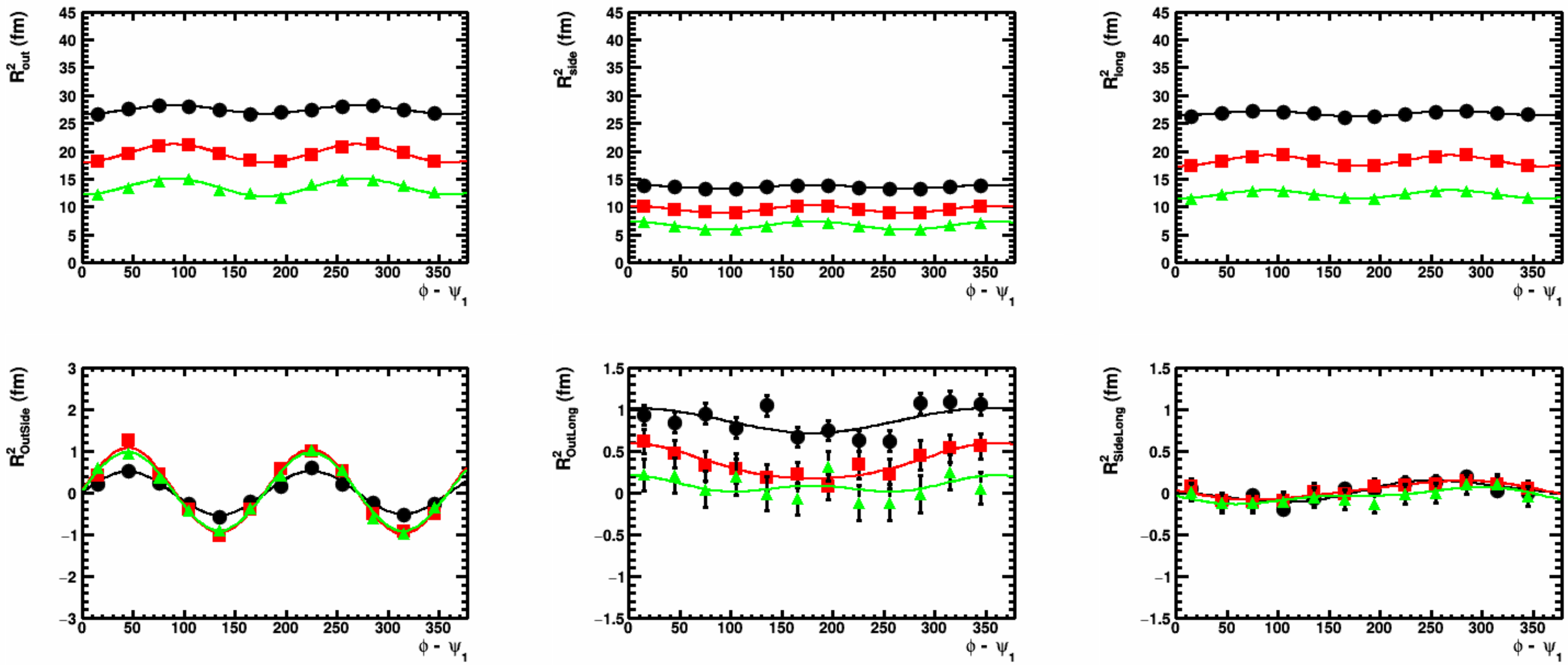
$$R^2_\mu(\varphi) = R^2_{\mu,0} + 2R^2_{\mu,1}\cos(\varphi) + 2R^2_{\mu,2}\cos(2\varphi),$$
$$for\ out, side, long, outLong$$
$$R^2_\mu(\varphi) = R^2_{\mu,0} + 2R^2_{\mu,1}\sin(\varphi) + R^2_{\mu,2}\sin(2\varphi),$$
$$for\ outSide, sideLong$$

● 0 - 20% centrality $\pi^+\pi^+ + \pi^-\pi^-$

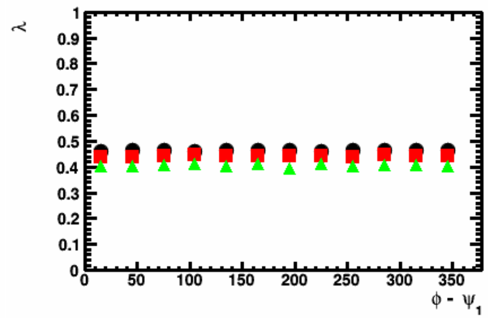
■ 20 - 40% centrality $\pi^+\pi^+ + \pi^-\pi^-$

▲ 40 - 80% centrality $\pi^+\pi^+ + \pi^-\pi^-$

Cu+Au@200 GeV: azimuthally differential femtoscopic mesurements



(0.15 < kT (GeV/c)< 0.35)



Fit

$$R^2_\mu(\varphi) = R^2_{\mu,0} + 2R^2_{\mu,1}\cos(\varphi) + 2R^2_{\mu,2}\cos(2\varphi),$$
$$for\ out, side, long, outLong$$
$$R^2_\mu(\varphi) = R^2_{\mu,0} + 2R^2_{\mu,1}\sin(\varphi) + R^2_{\mu,2}\sin(2\varphi),$$
$$for\ outSide, sideLong$$

- ● 0 - 20% centrality $\pi^+\pi^+ + \pi^-\pi^-$
- ■ 20 - 40% centrality $\pi^+\pi^+ + \pi^-\pi^-$
- ▲ 40 - 80% centrality $\pi^+\pi^+ + \pi^-\pi^-$