Femtoscopy in event by event hydrodynamics

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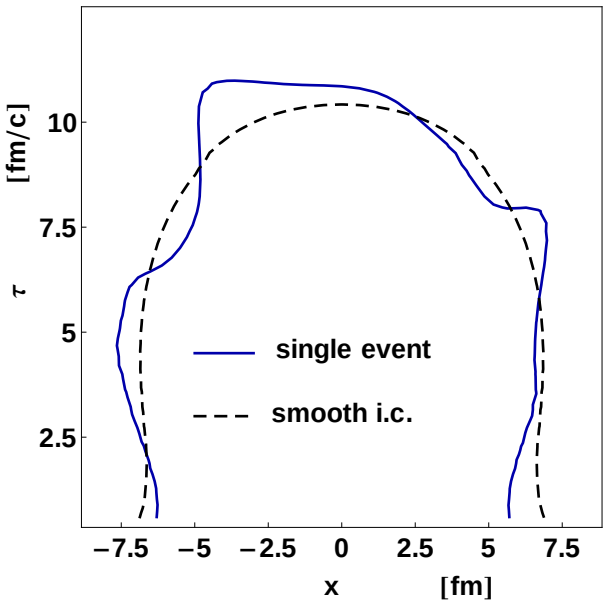
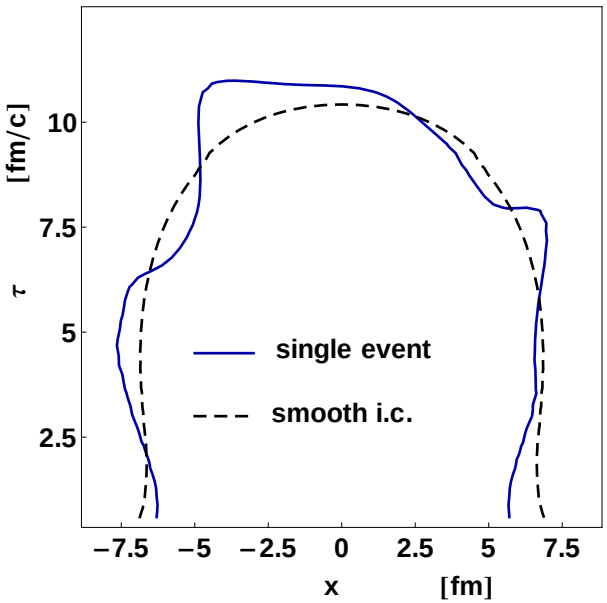
HBT of fluctuating fireballs



can the lumpy surface be observed?

NO (WPCF 2012, Frankfurt)

HBT of fluctuating fireballs



can the lumpy surface be observed?

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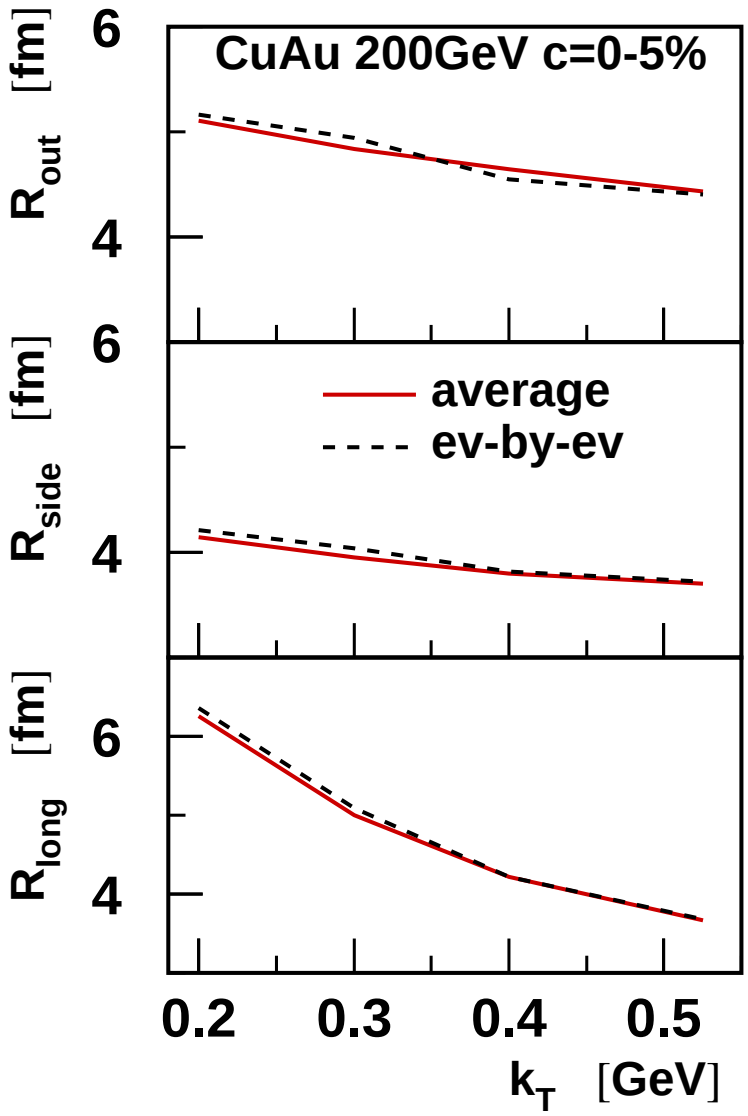


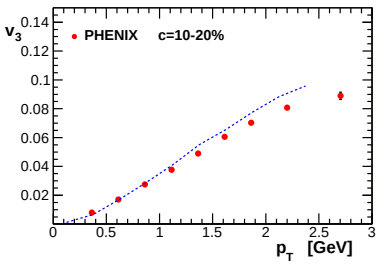
correlations in event by event hydrodynamics

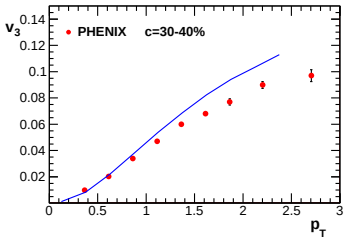
- combine several (many) events (A. Kisiel)

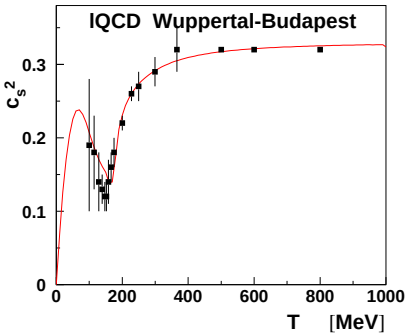
$$C(q_a, k_b) = \frac{\frac{1}{N_{pairs,num}} \sum_{j=1}^{N_h} \sum_{m,l=1}^{N_e} \sum_{s=1}^{M_l} \sum_{f=1}^{M_m} \delta_{q_a} \delta_{k_b} \Psi(q, x_1 - x_2)}{\frac{1}{N_{pairs,den}} \sum_{i \neq j=1}^{N_h} \sum_{l,m=1}^{N_e} \sum_{s=1}^{M_l} \sum_{f=1}^{M_m} \delta_{q_a} \delta_{k_b}}$$

  numerator - sum over different hydro events
  denominator - sum over different hydro event pairs
  increases the effective number of pairs (d-Au 5000$\times$)
- azimuthally sensitive HBT possible with reasonable cost
- perfect event plane resolution

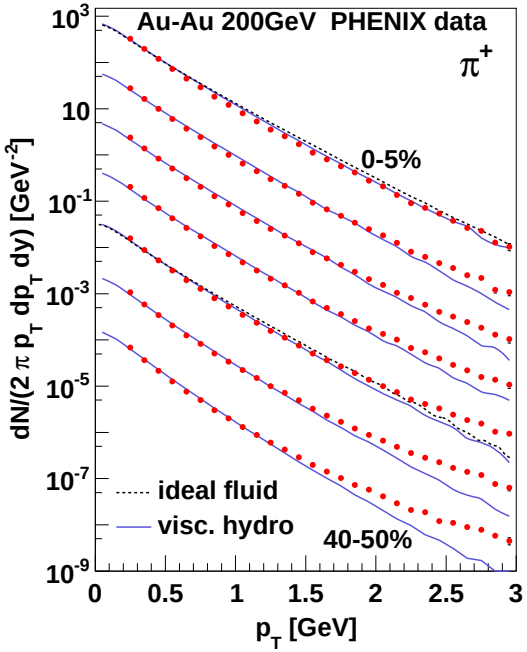
3+1D hydrodynamics

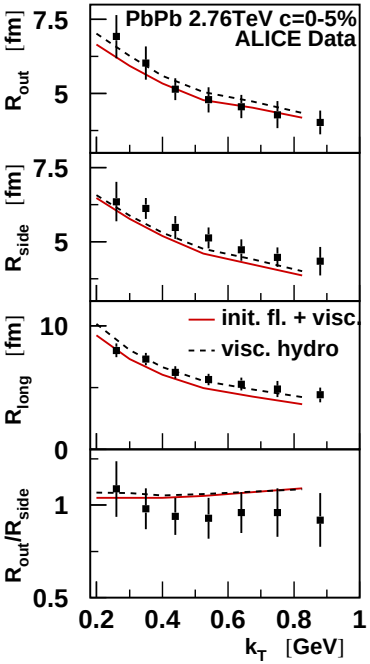


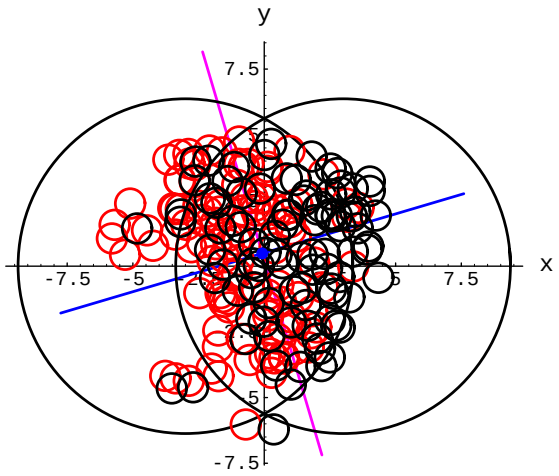




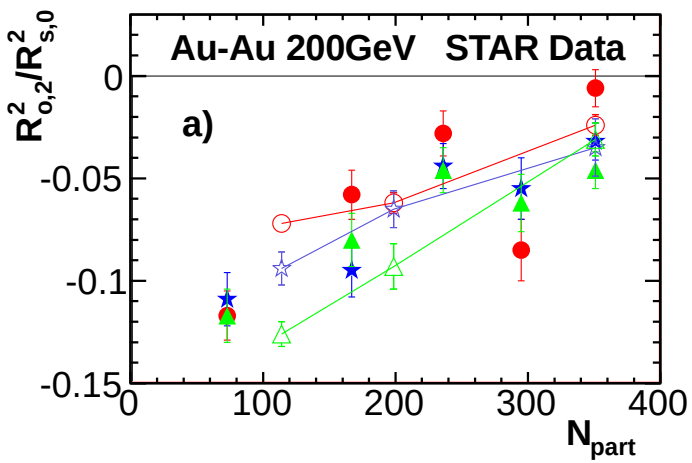
IQCD + Hadron Gas

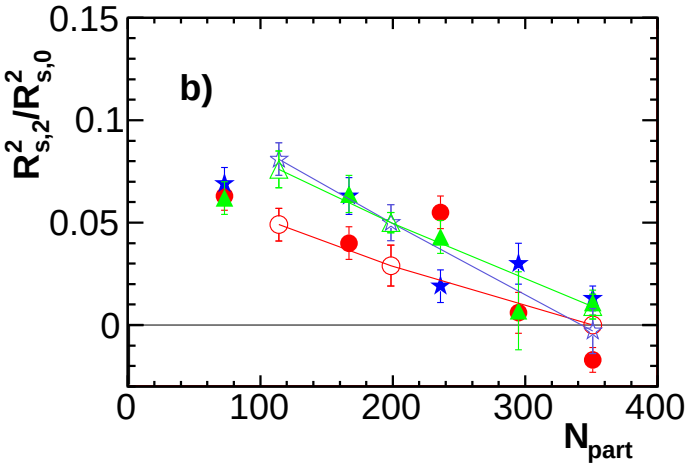


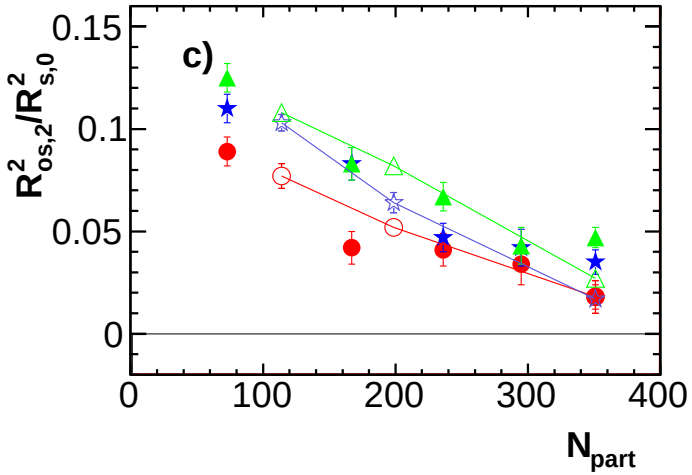




azHBT in Au-Au at 200GeV (second order reaction plane)







- eccentricity and elliptic flow give azimuthal angle dependence
- good agreement with data and with smooth hydro (Kisiel et al. 2009)
- expected centrality dependence

HBT of fluctuating fireballs II

- event by event emission function

$$C(q,k) = \frac{\int d^4x_1 d^4x_2 \langle S(x_1,p_1)S(x_2,p_2)\rangle |\Psi(k,(x_1-x_2))|^2}{\int d^4x_1 \langle S(x_1,p_1)\rangle \int d^4x_2 \langle S(x_2,p_2)\rangle}$$

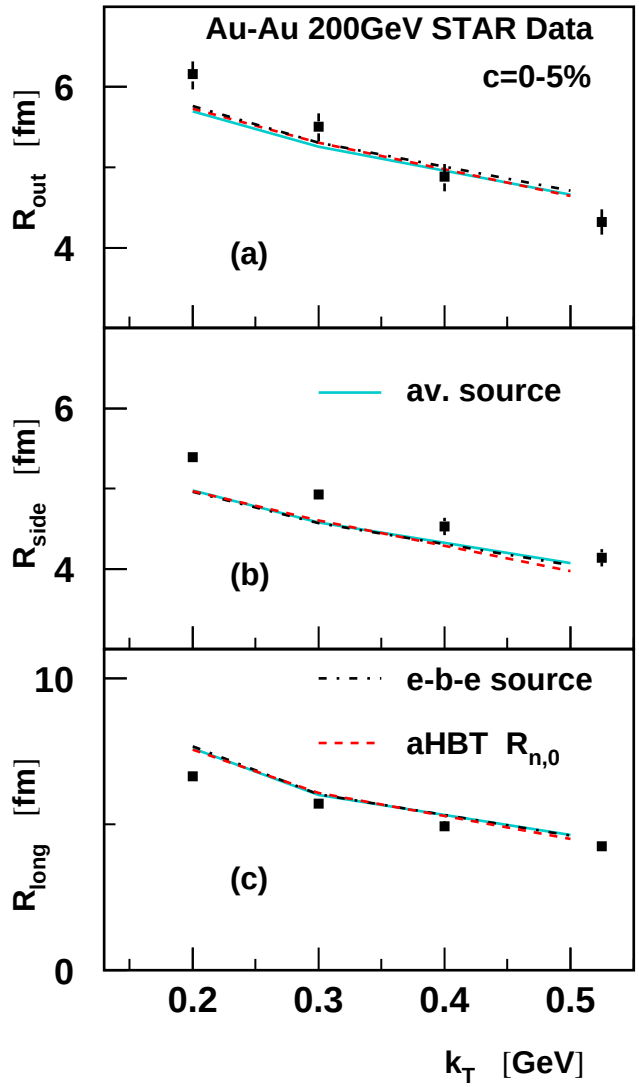
- average emission function

$$C_{av}(q,k) = \frac{\int d^4x_1 d^4x_2 \langle S(x_1,p_1)\rangle\langle S(x_2,p_2)\rangle |\Psi(k,(x_1-x_2))|^2}{\int d^4x_1 \langle S(x_1,p_1)\rangle \int d^4x_2 \langle S(x_2,p_2)\rangle}$$

- emission function fluctuations

HBT of fluctuating fireballs II

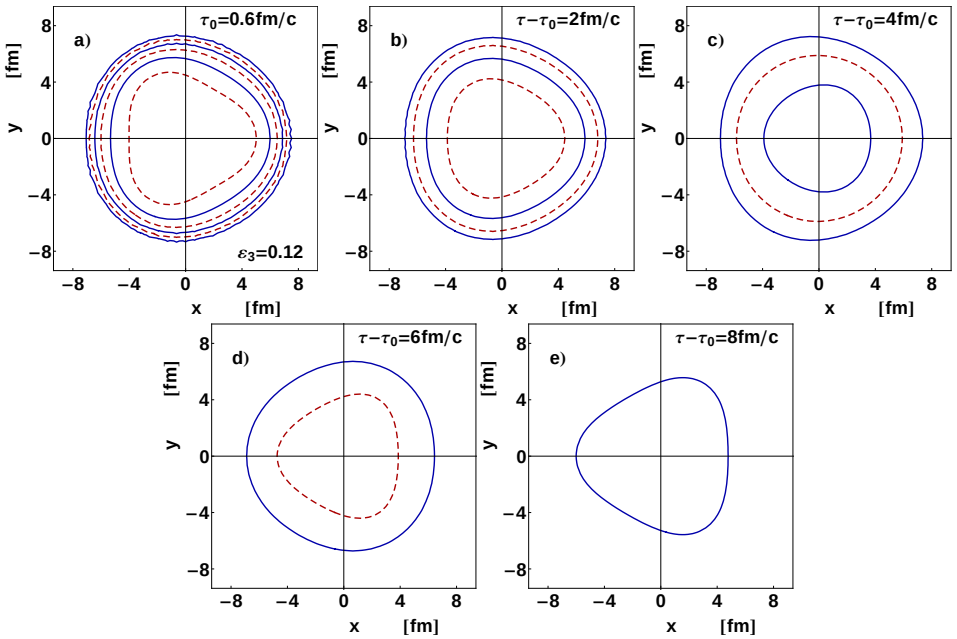
- event by event emission function similar to average emission function
- small source fluctuations
- spectra do not fluctuate event by event much



azHBT in Au-Au at 200GeV (third order event plane)

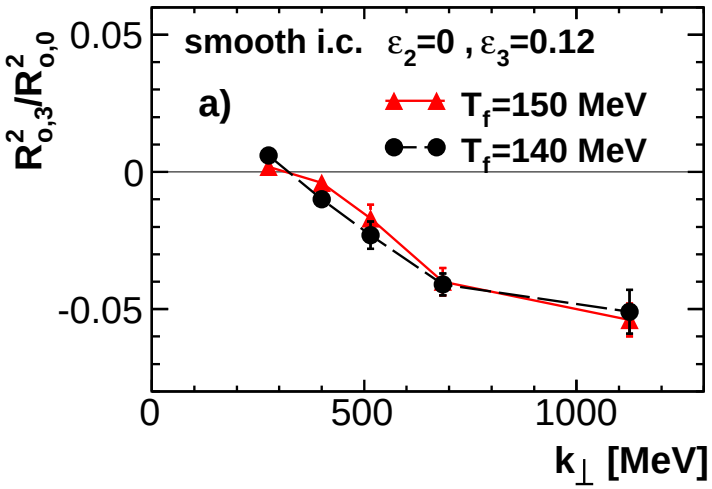
what is the origin of the $cos(3\Phi)$ angular dependence (Plumberg, Shen, Heinz, 2013)

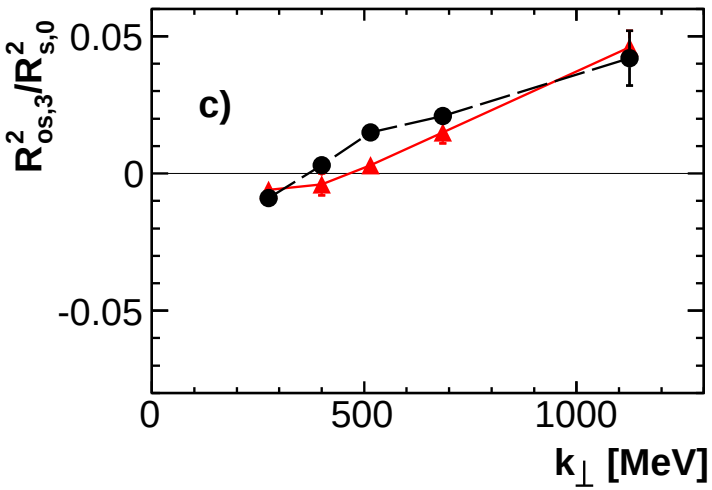
- deformed geometry + radial flow
- triangular flow

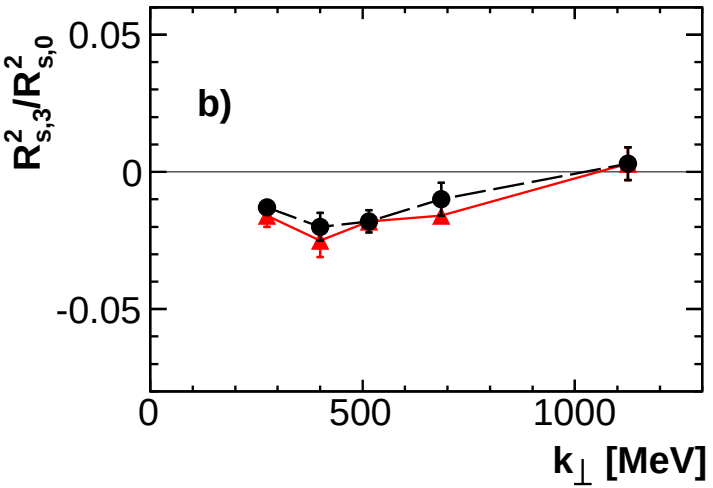


- OR both flow and geometry
- OR both flow and inverted geometry (example)

HBT third order reaction plane, smooth density (example)

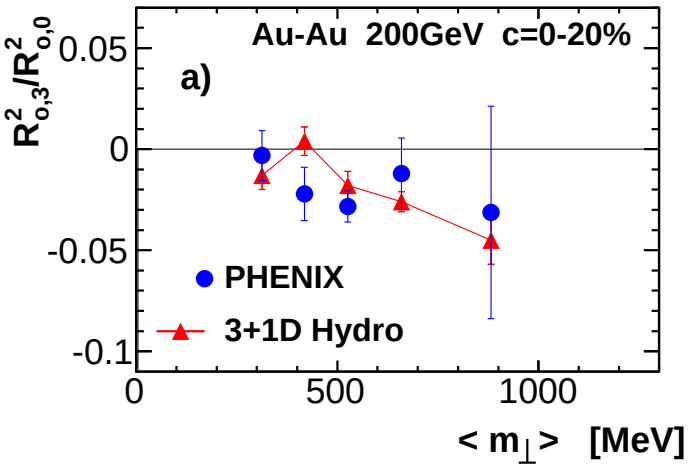


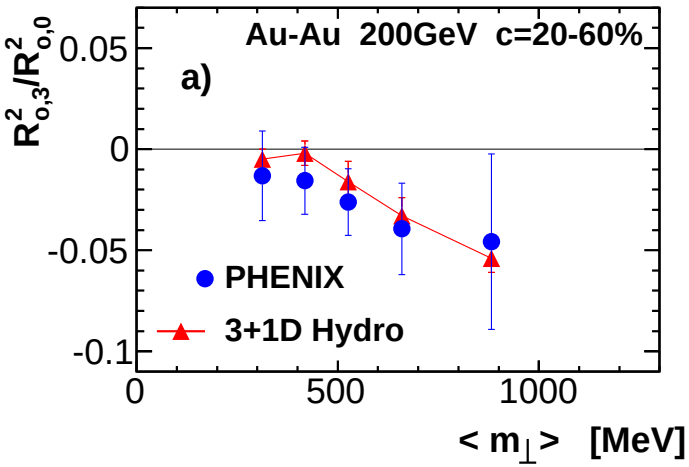




- negative, $k_\perp$ depend. $R^2_{o,3}$
- positive, $k_\perp$ depend. $R^2_{os,3}$
- small, negative $R^2_{s,3}$

HBT third order reaction plane $R^2_{O,3}$

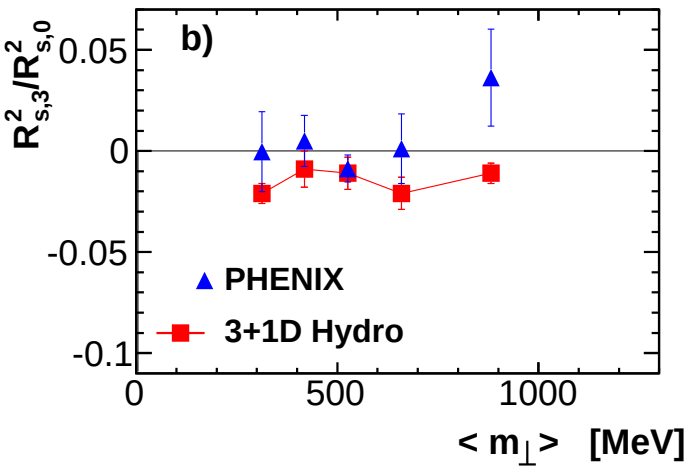




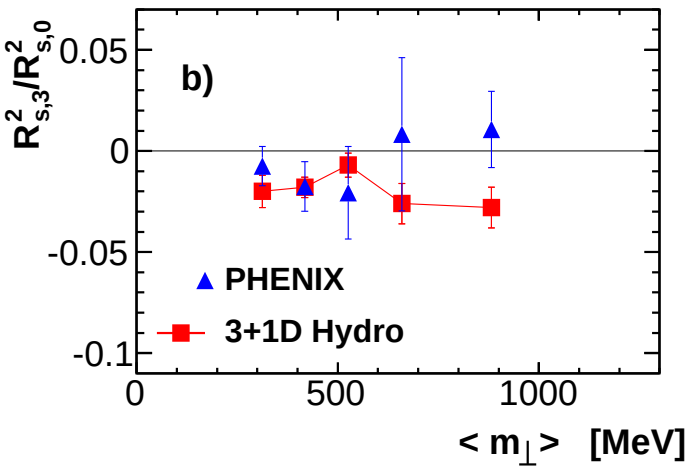
fair agreement with PHENIX

HBT third order reaction plane $R^2_{s,3}$

0-20%

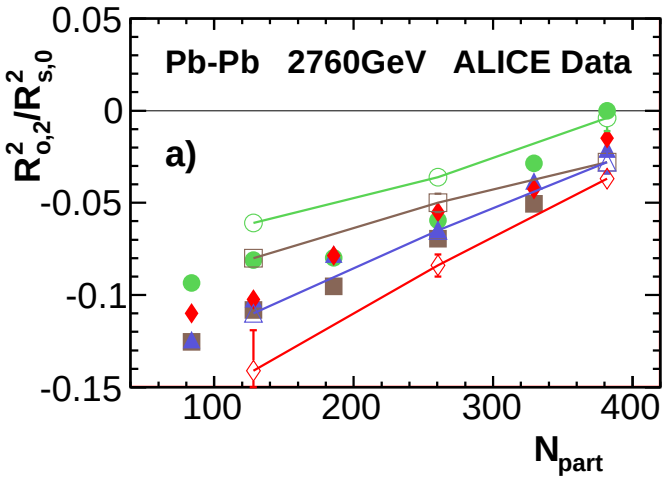


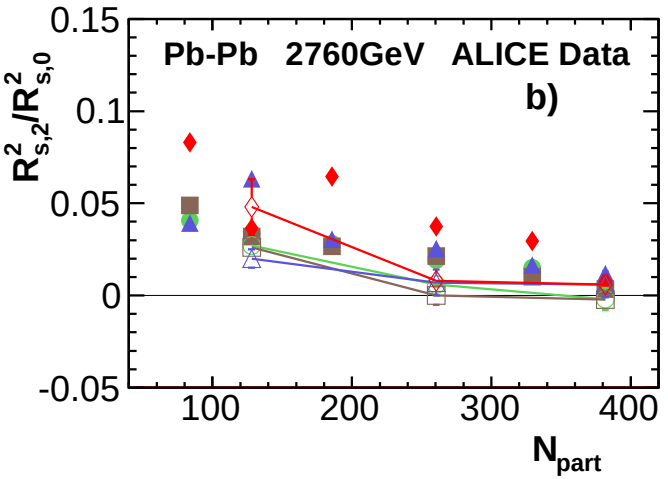
20-60%

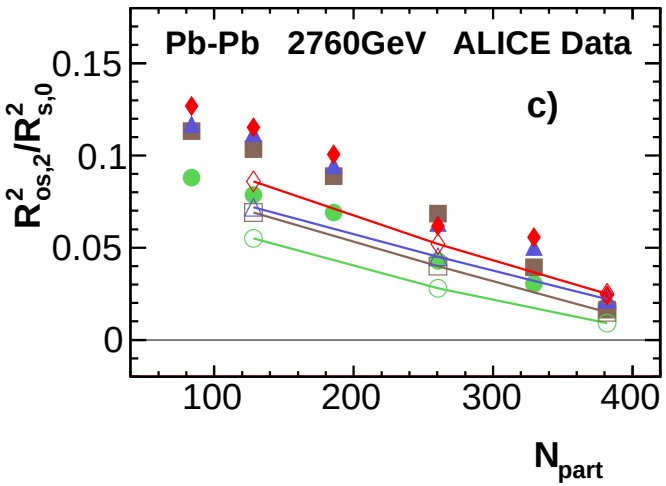


compatible with PHENIX data for 20-60%, tension for 0-20%

azHBT in Pb-Pb at 2.76TeV (second order reaction plane)

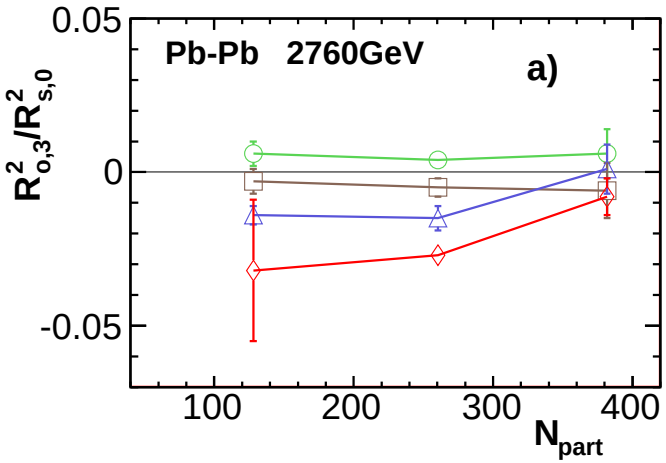


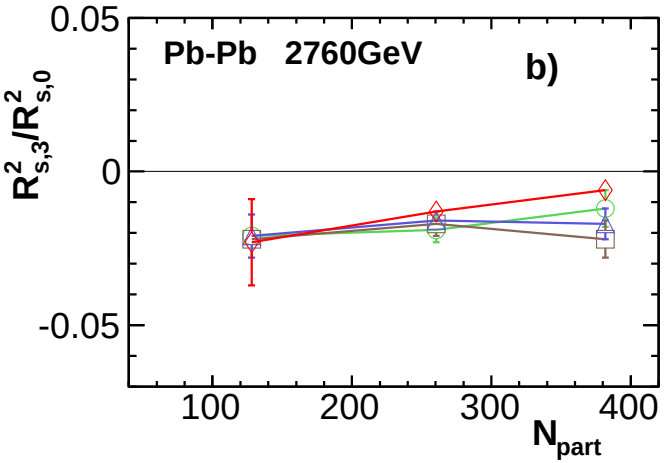


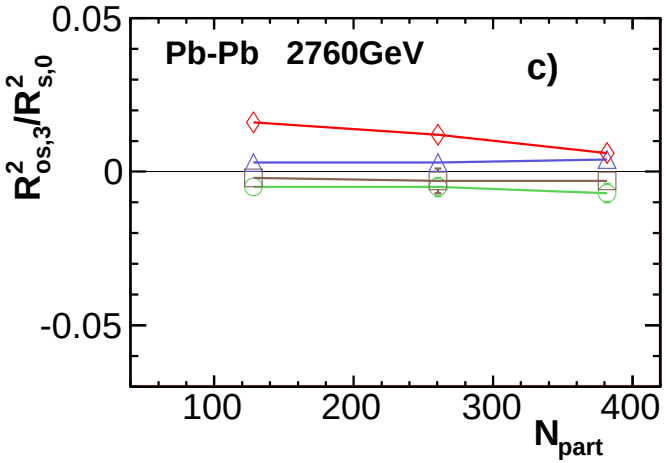


- eccentricity and elliptic flow give azimuthal angle dependence
- fair agreement with data

azHBT in Pb-Pb at 2.76TeV (third order reaction plane)







- similar as Au-Au at RHIC
- small negative $R^2_{s,3}$
- negative, $k_\perp$ depend. $R^2_{o,3}$

Summary

- HBT with event by event hydrodynamics
- angle averaged radii - small effect of fluctuations
  small emission function fluctuations
- azHBT (second order reaction plane) fair agreement with data
  - Au-Au (200GeV), Pb-Pb (2.76TeV)
- azHBT (third order reaction plane)
  fair agreement for $R^2_{out,3}$ - Au-Au (200GeV)
  deviation for $R^2_{side,3}$ (0-20%)