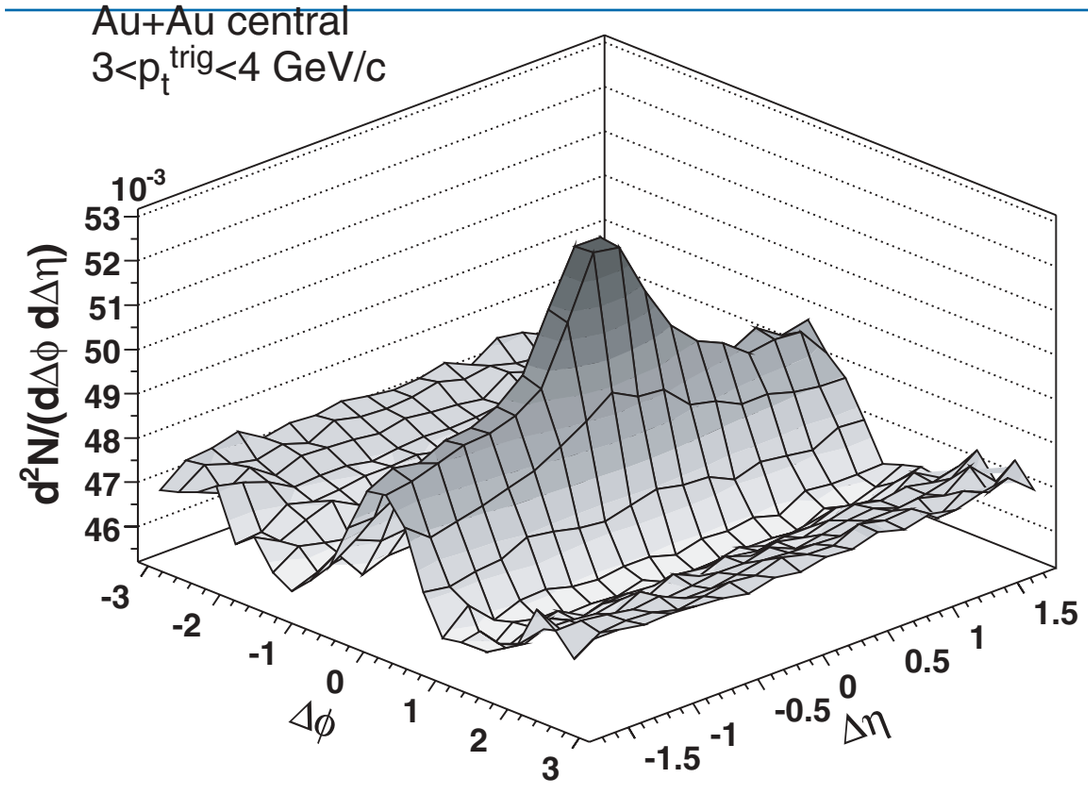
Light-Heavy Collisions at RHIC: d+Au & He3+Au

ILLINOIS

Anne M. Sickles

April 9, 2015

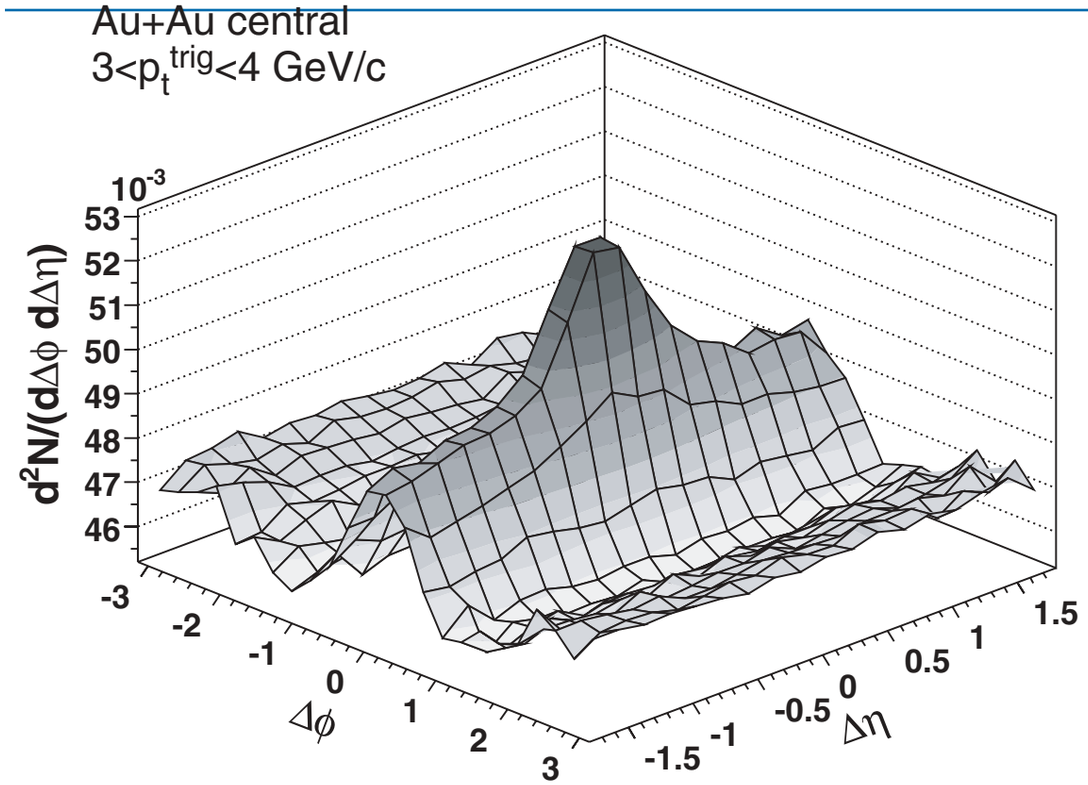
ridges & flow in AA collisions



the ridge: long range Δη correlation in heavy ion collisions
many theoretical explanations proposed...

STAR PRC80 064912
ALICE PLB708 249
Alver & Roland PRC81 054905

ridges & flow in AA collisions



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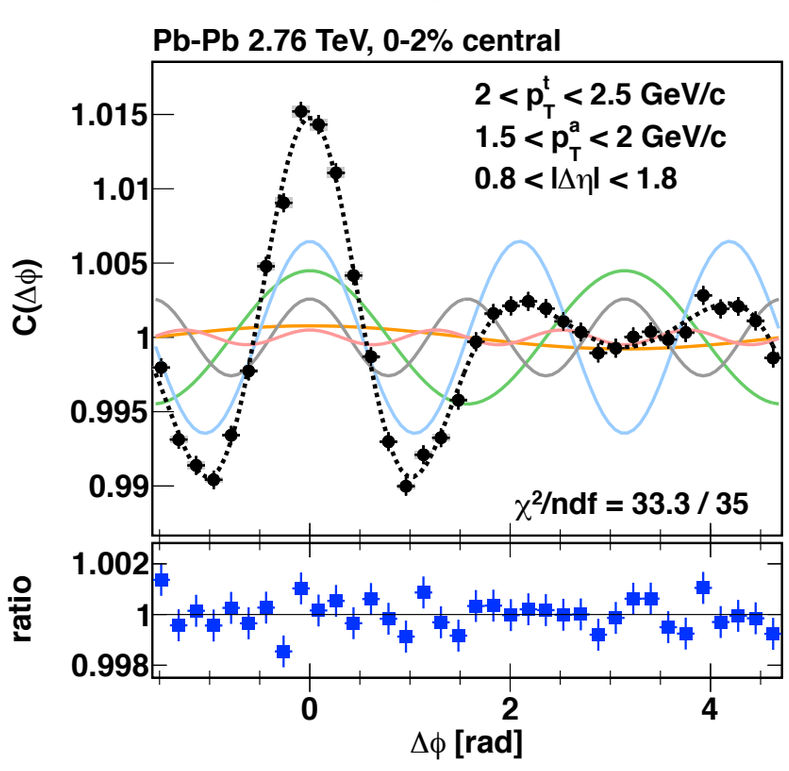

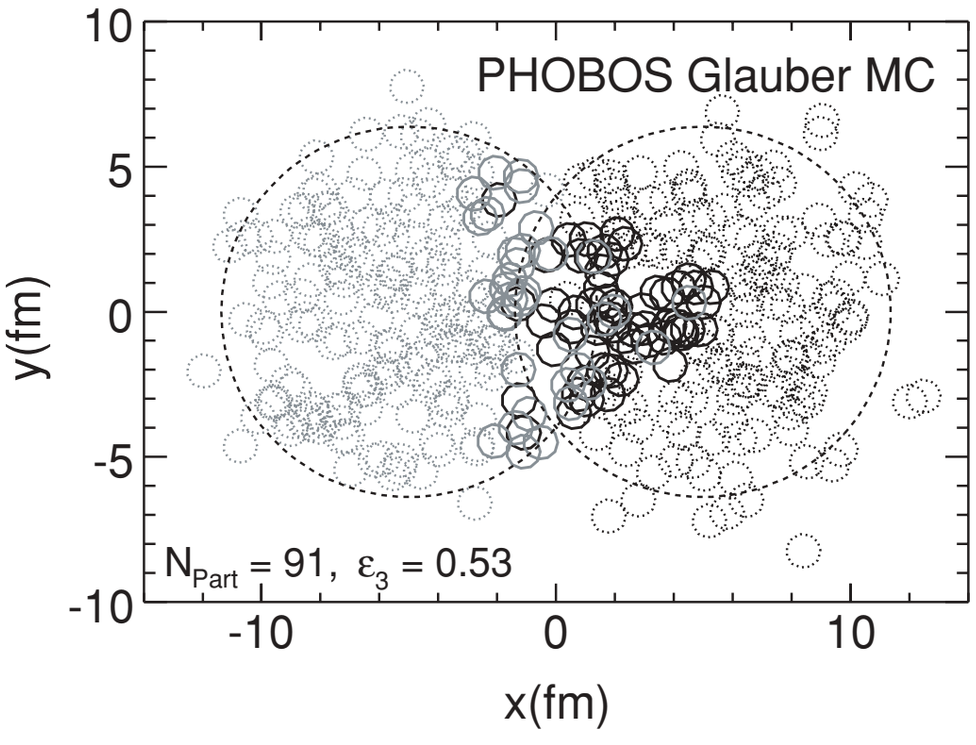

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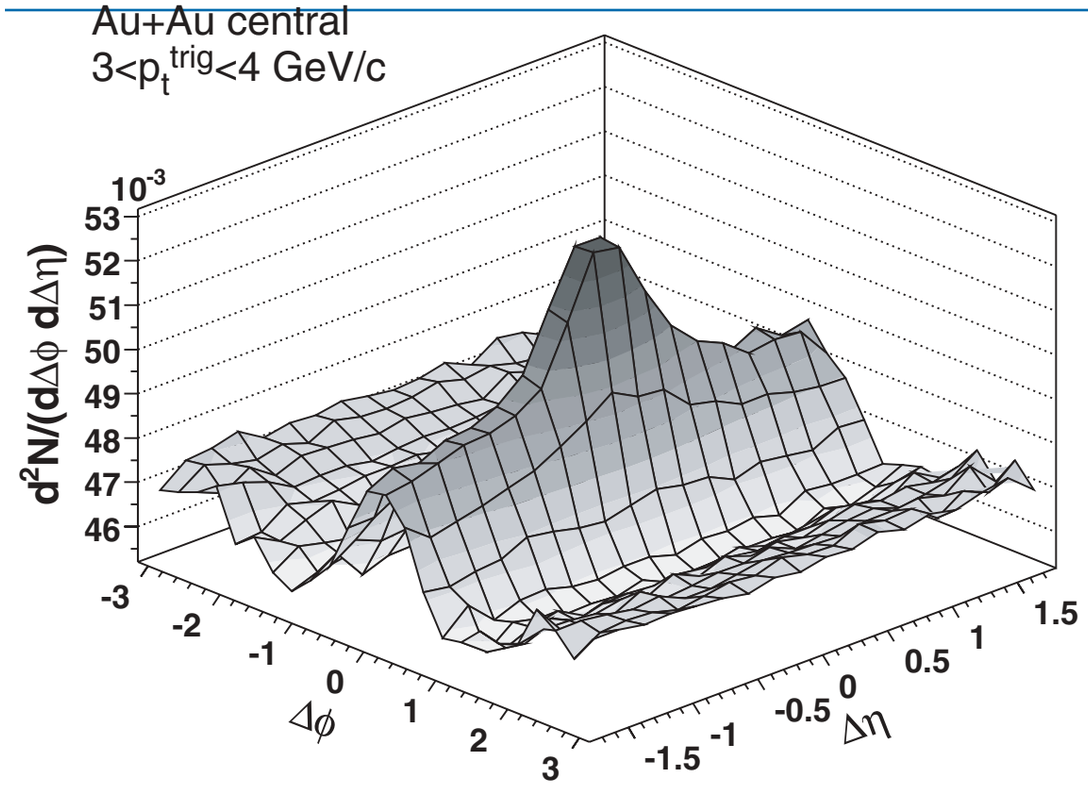

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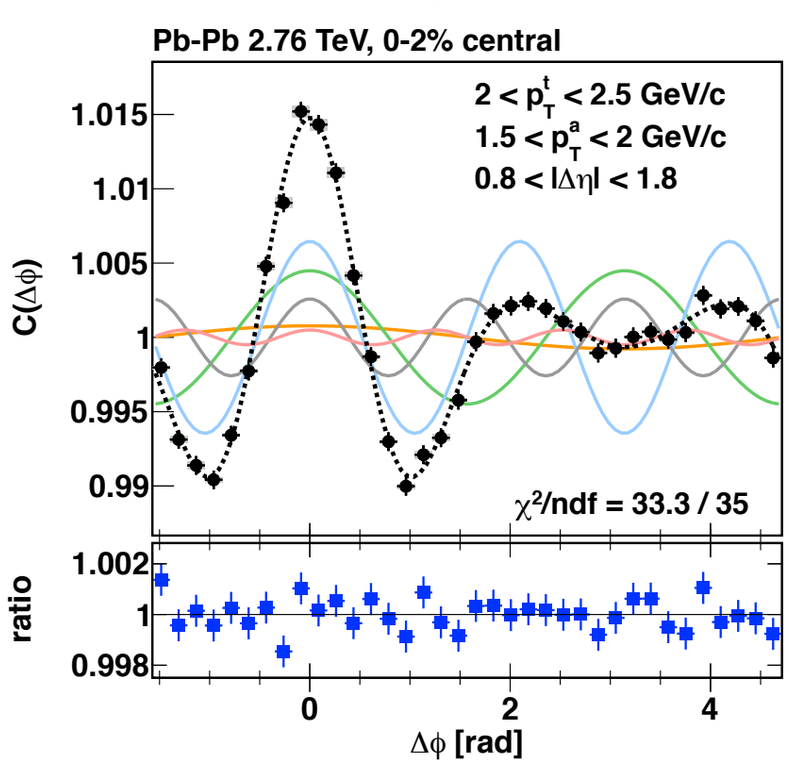

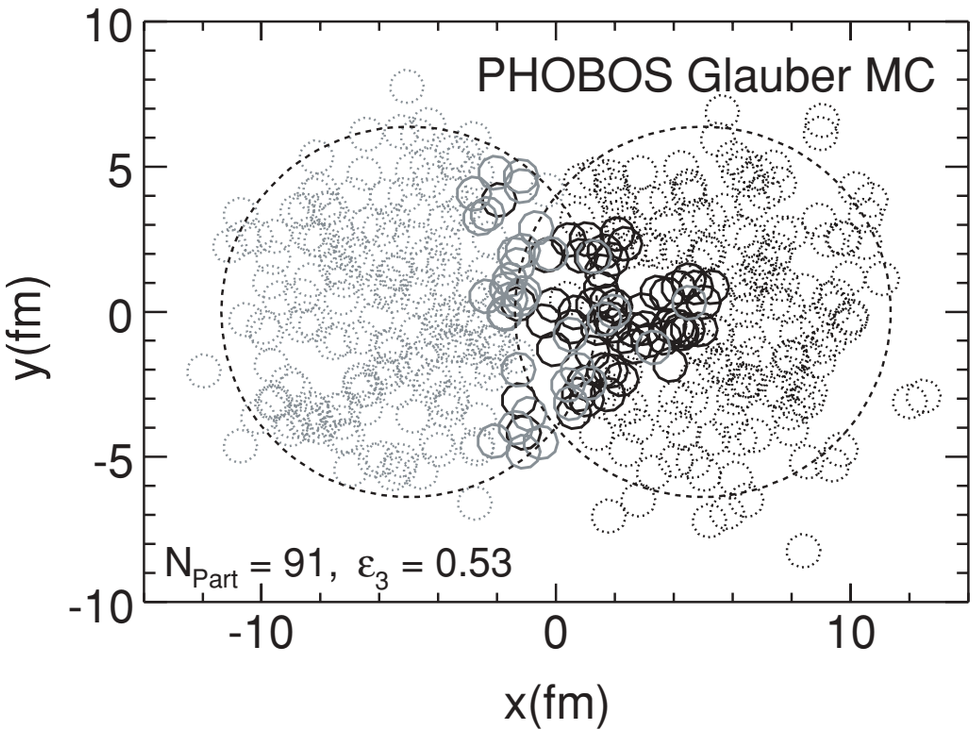

ridge: geometry + hydrodynamic evolution

STAR PRC80 064912
ALICE PLB708 249
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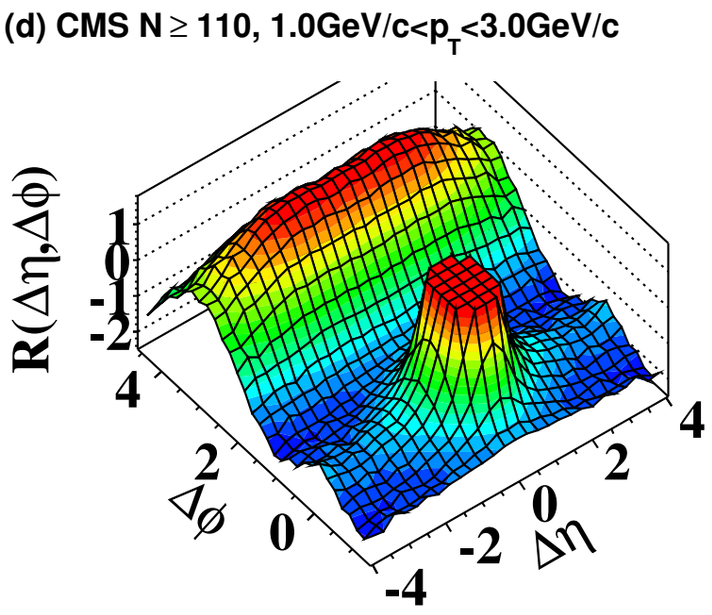
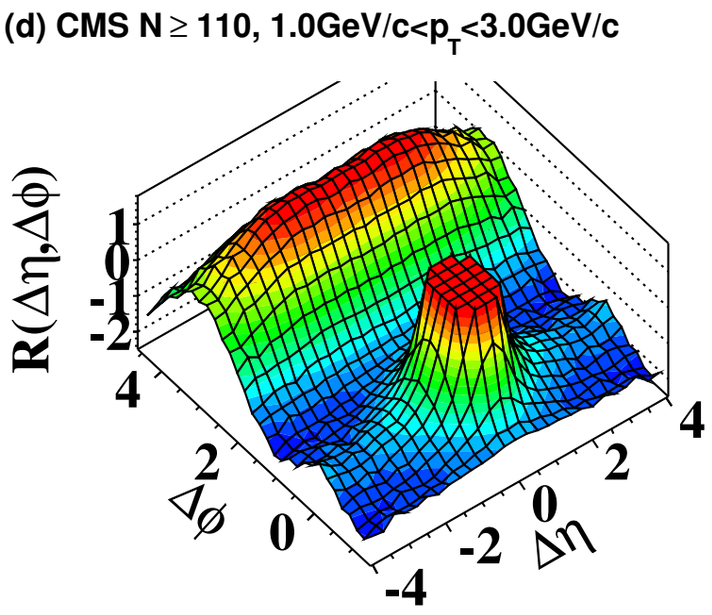
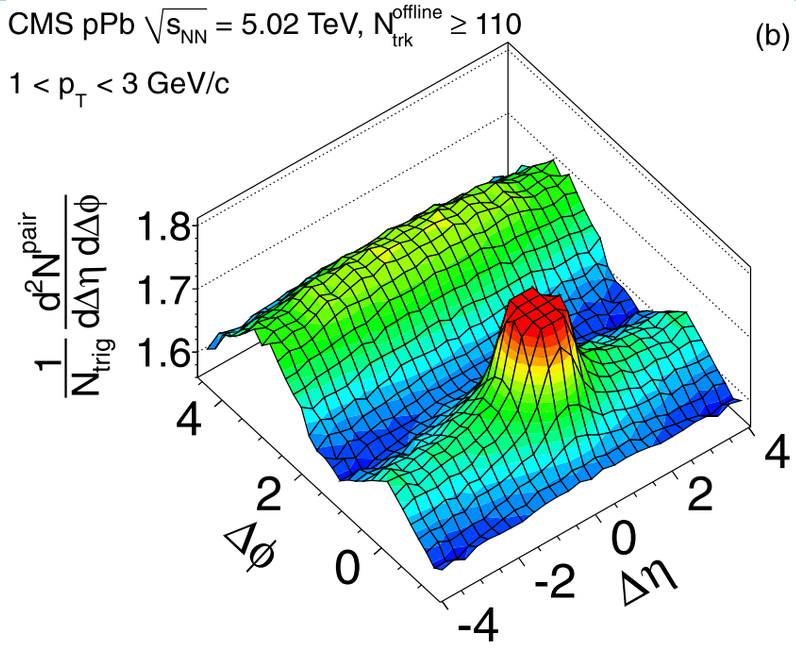
ridges in pA



CMS PLB 718 795 (2013)
ALICE PLB 719 29
ATLAS PRL 110 182302

ridges in pA





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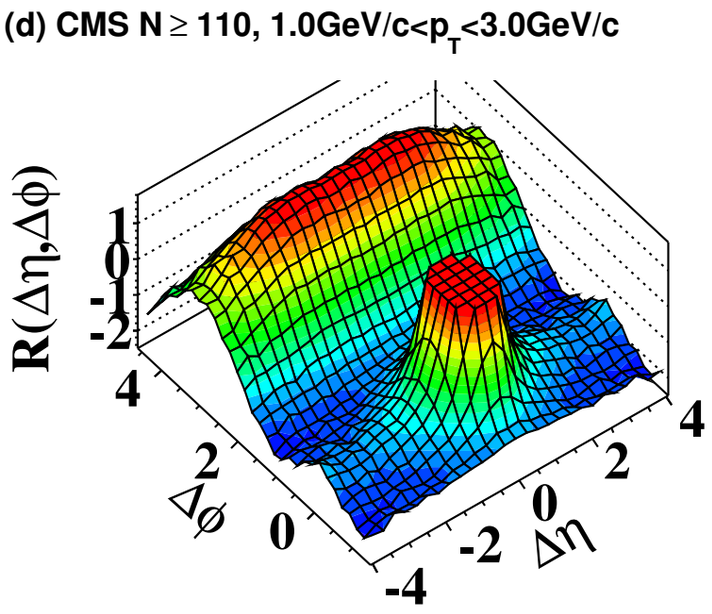

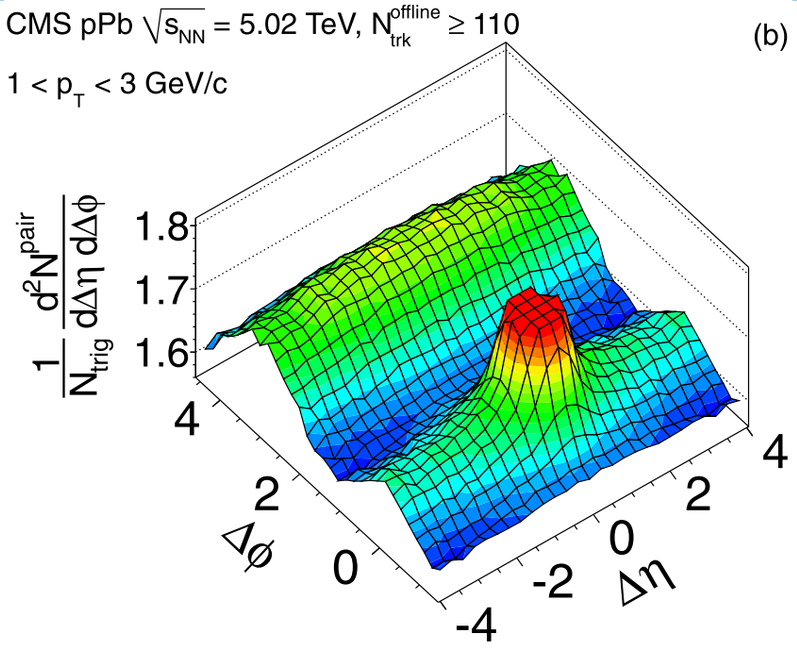

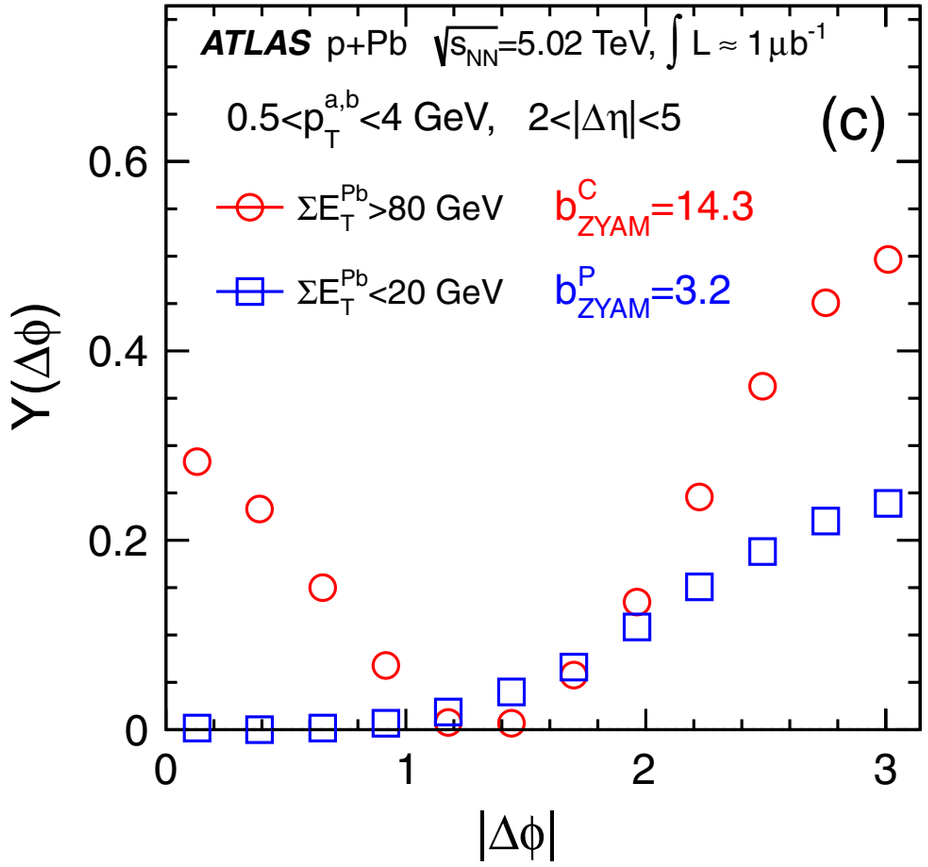

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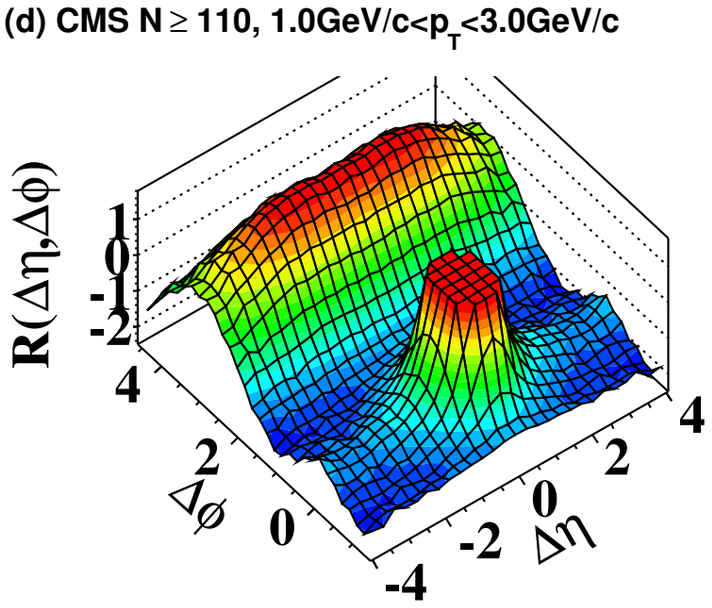

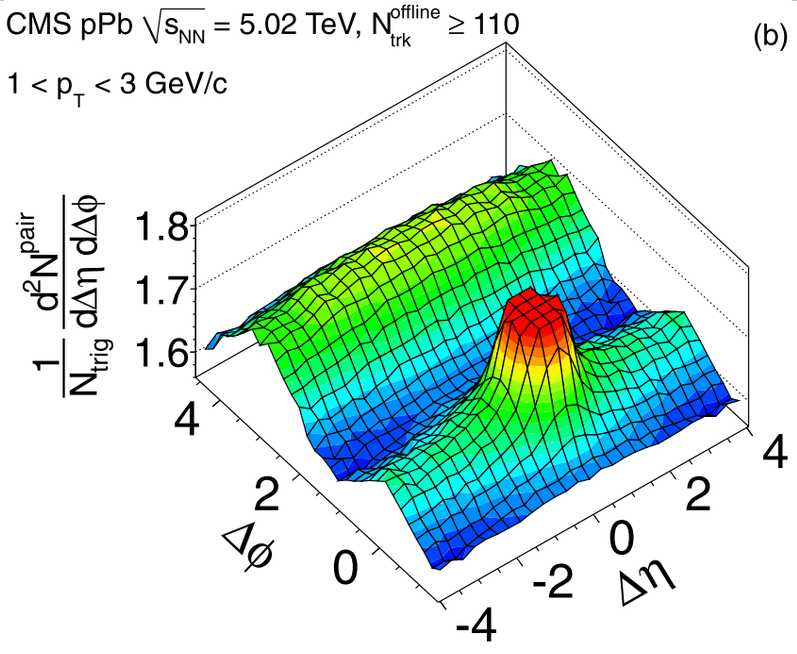

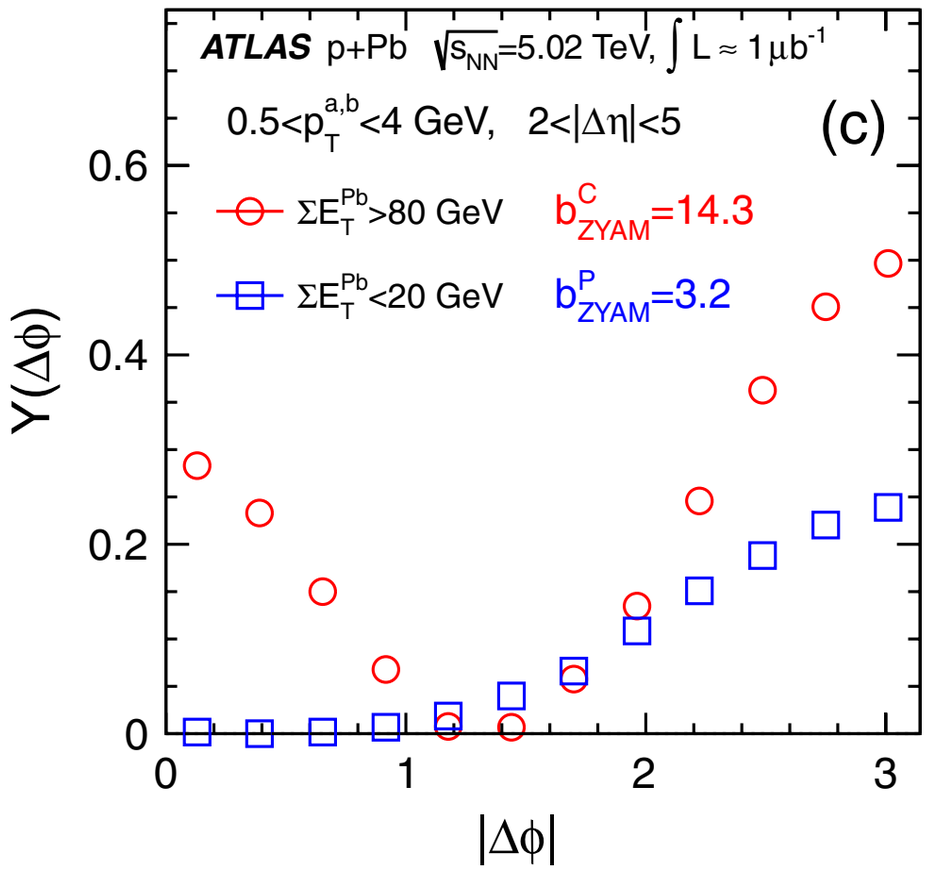

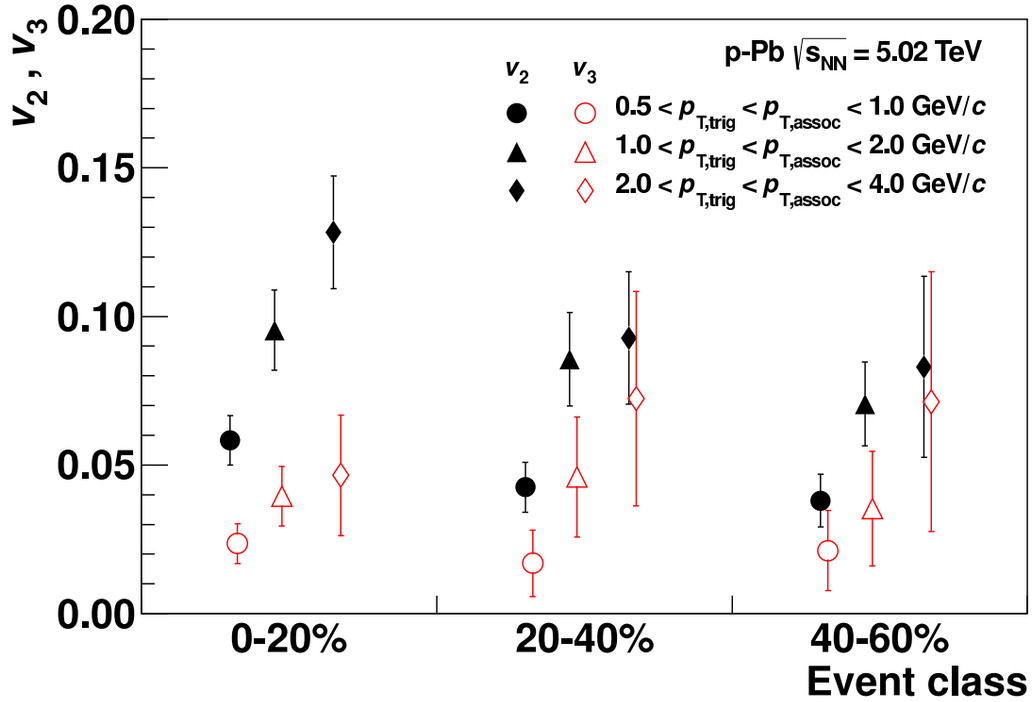

CMS PLB 718 795 (2013)
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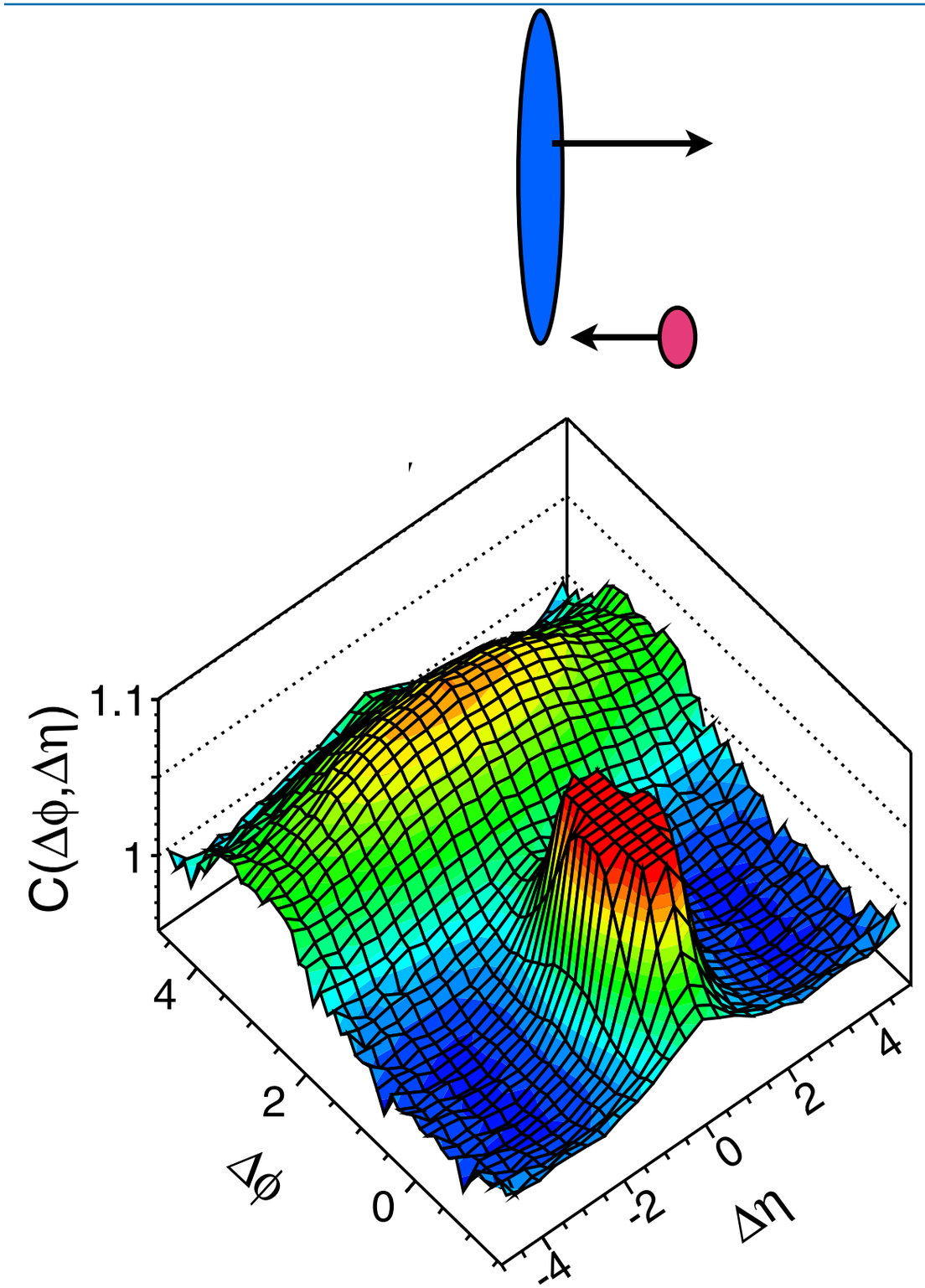
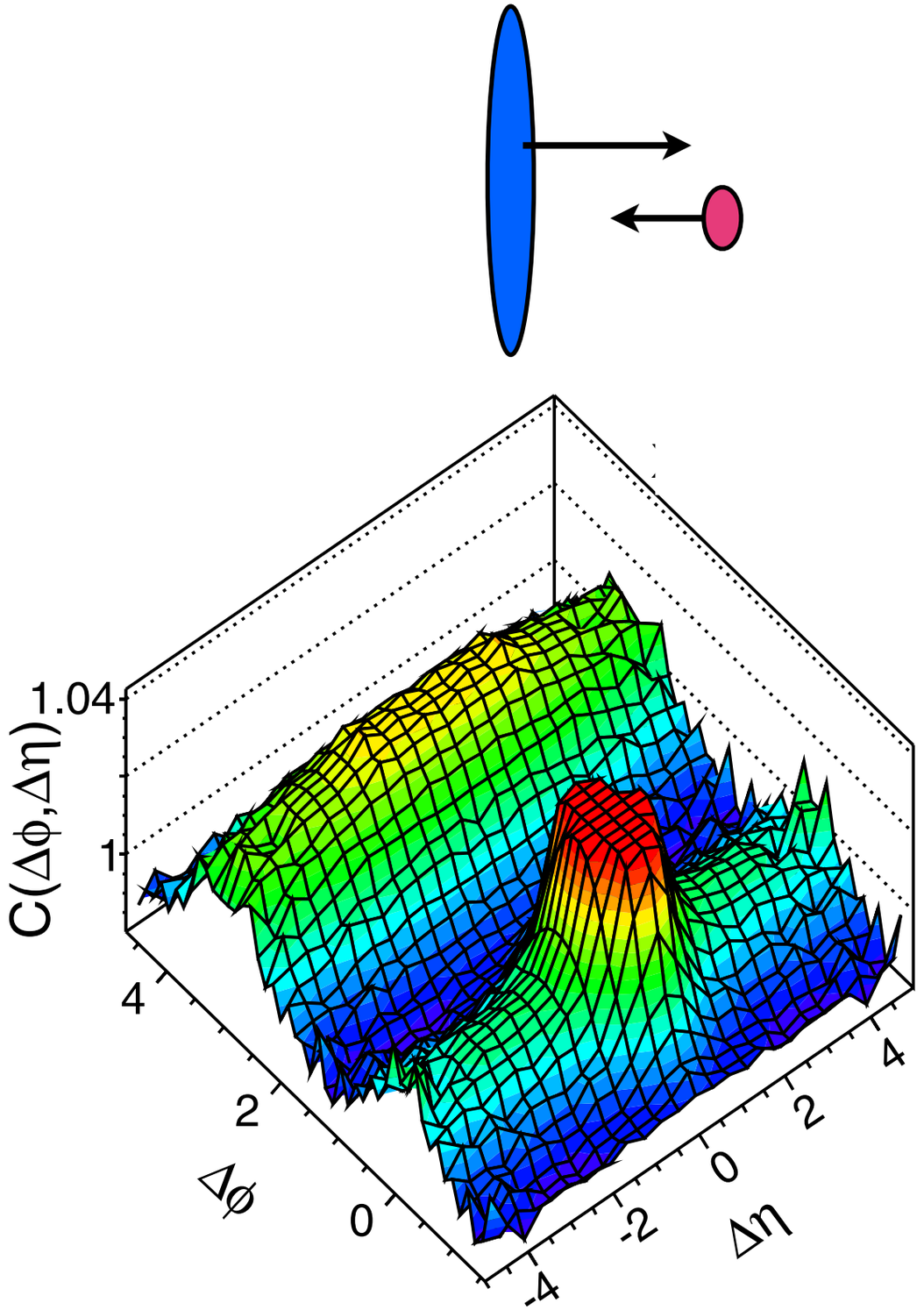
ATLAS PRL 110 182302

a closer look at pPb



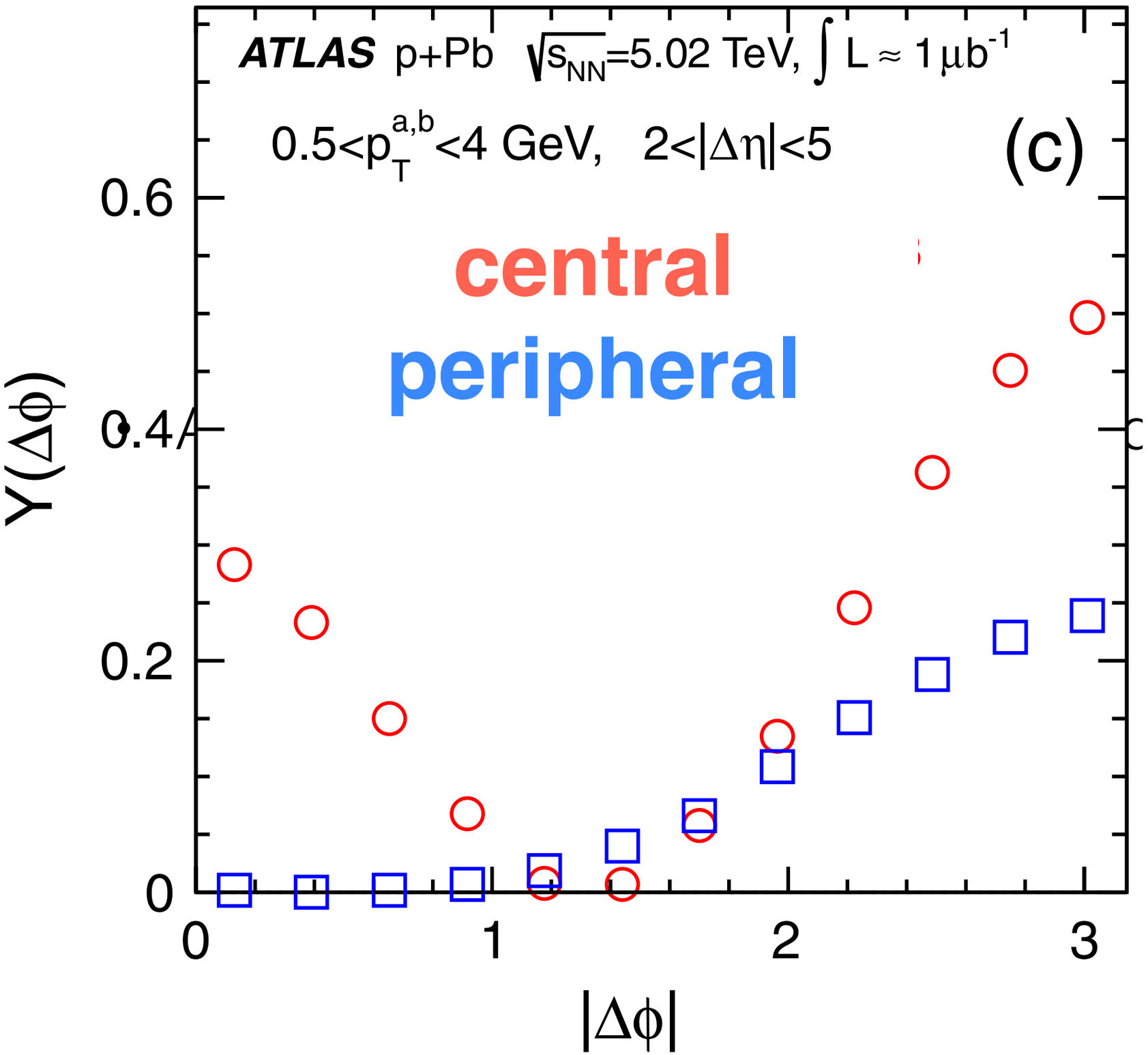
jets



jets + flow

ATLAS PRL 110 102303

a closer look at pPb

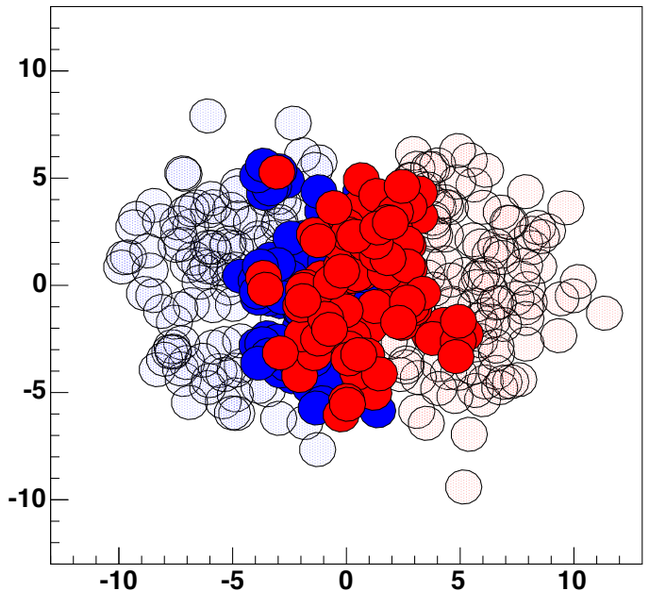


ATLAS PRL 110 102303

geometry in AA & pA

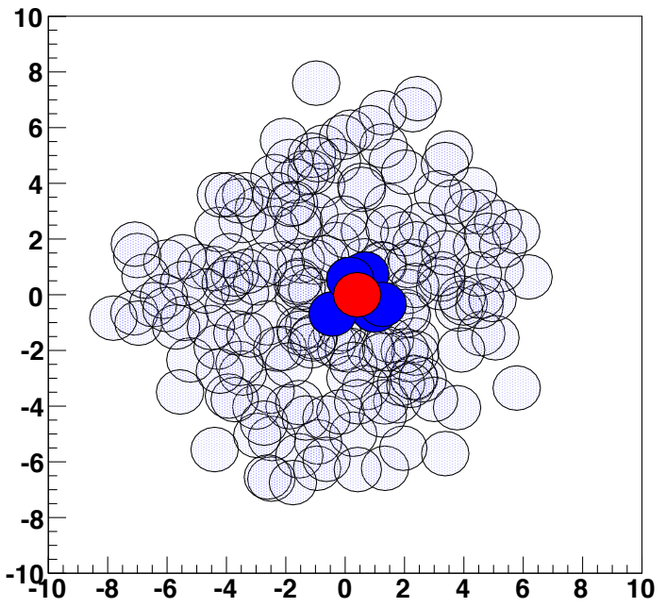
AA

impact parameter
+ fluctuations



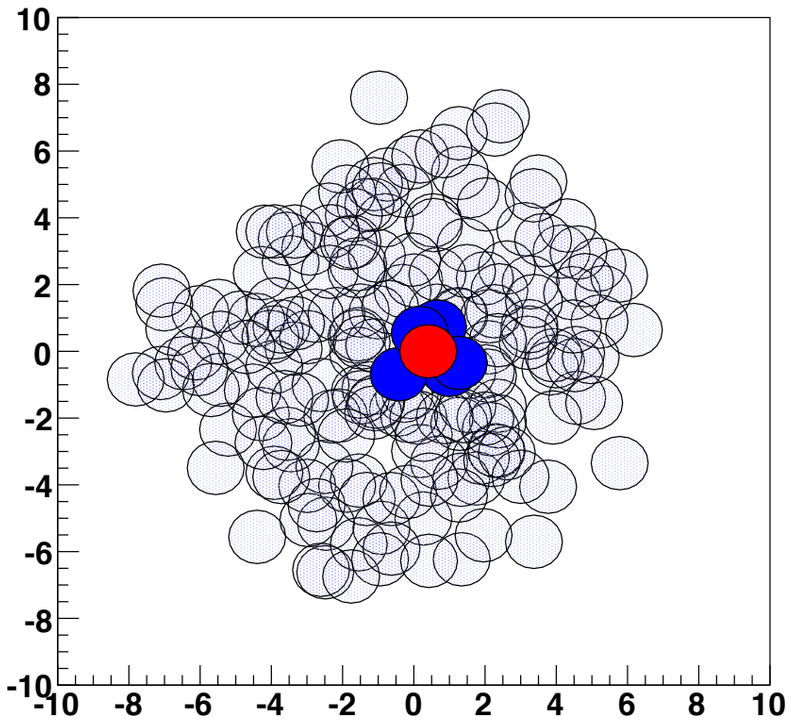
pA

fluctuations

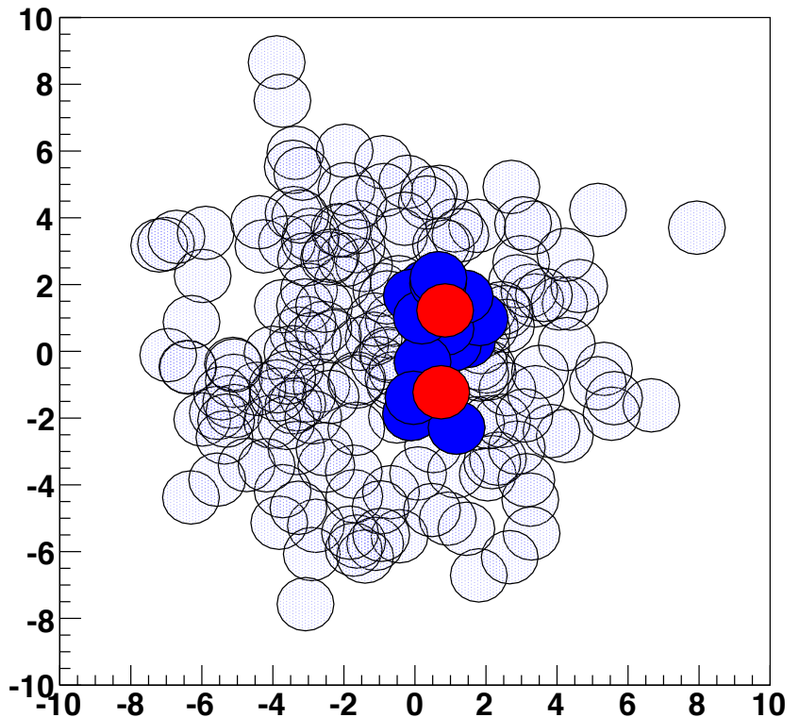


variation of the small nucleus

pA



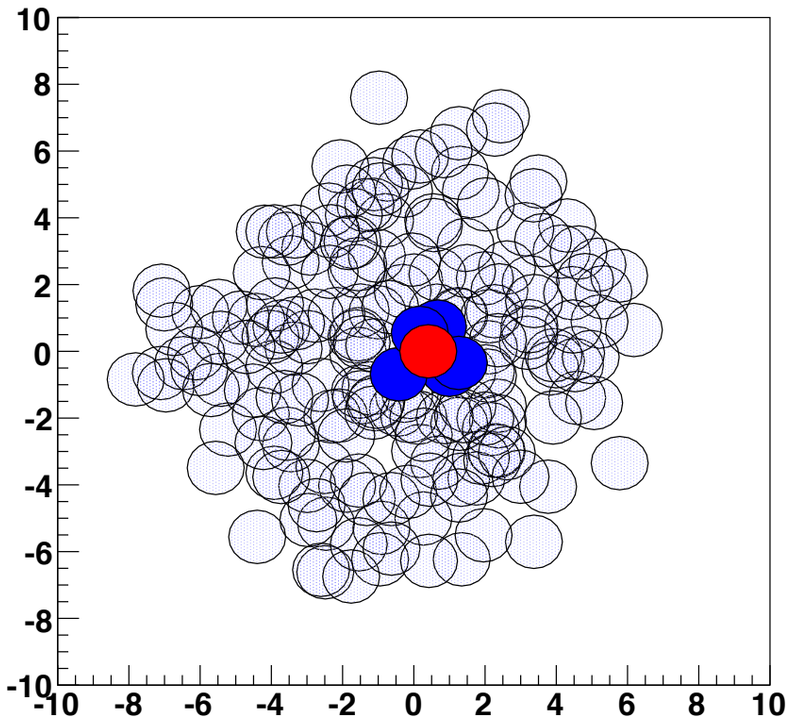
dA



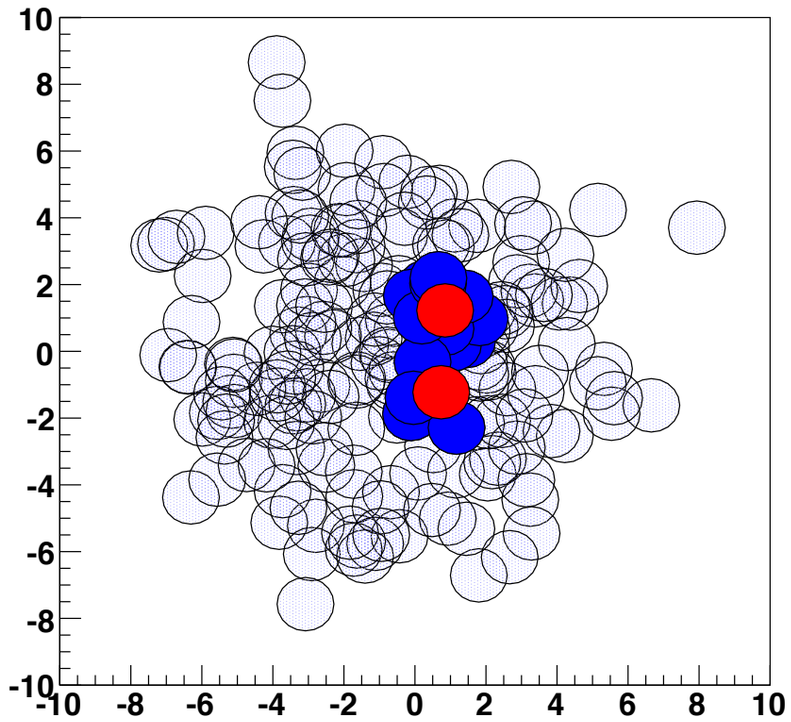
control the collision geometry by varying the small nucleus

variation of the small nucleus

pA



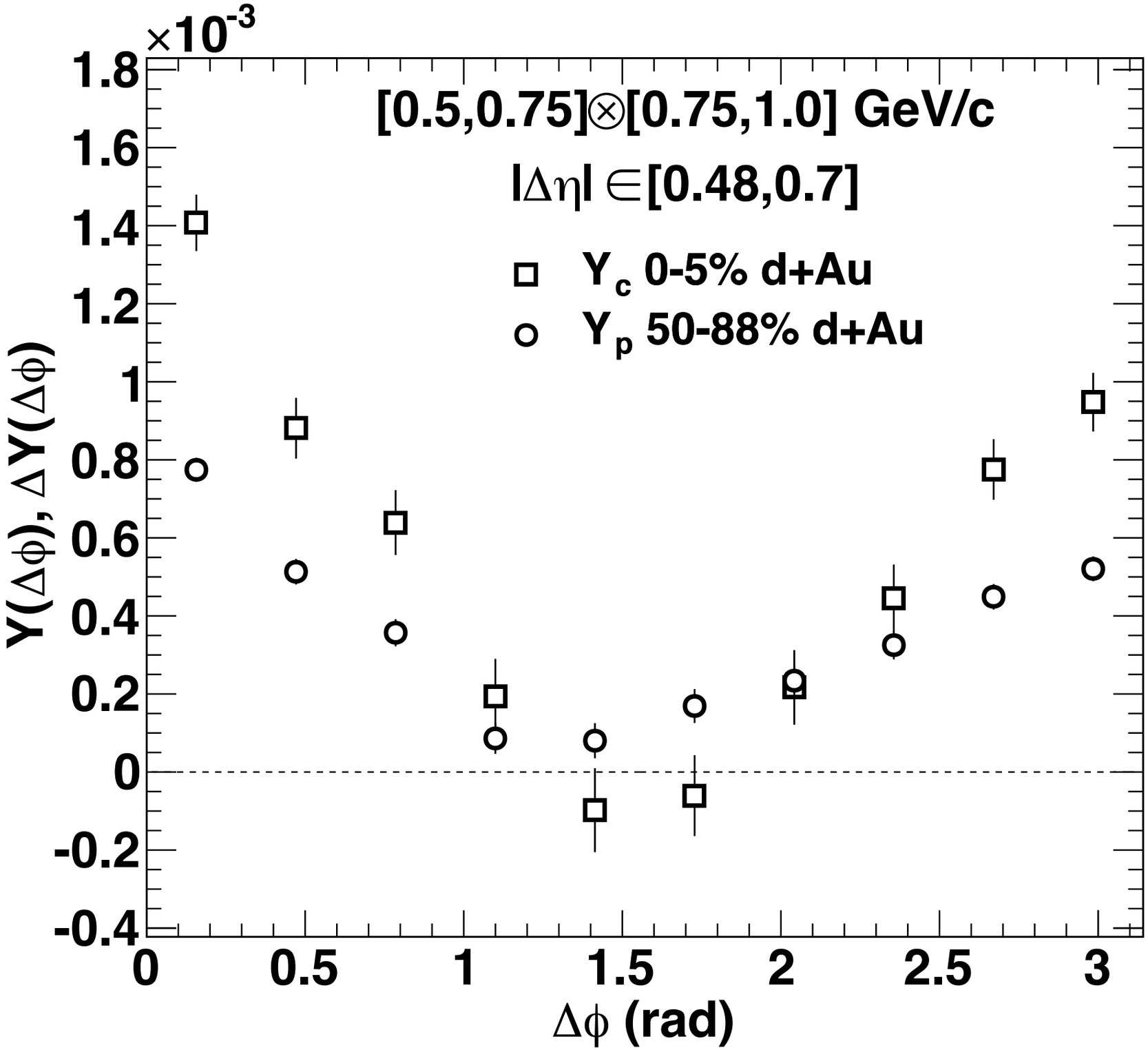
dA



control the collision geometry by varying the small nucleus

does v2 reflect the geometry of the initial state in p/d+A as in A+A?

two particle correlations in dAu

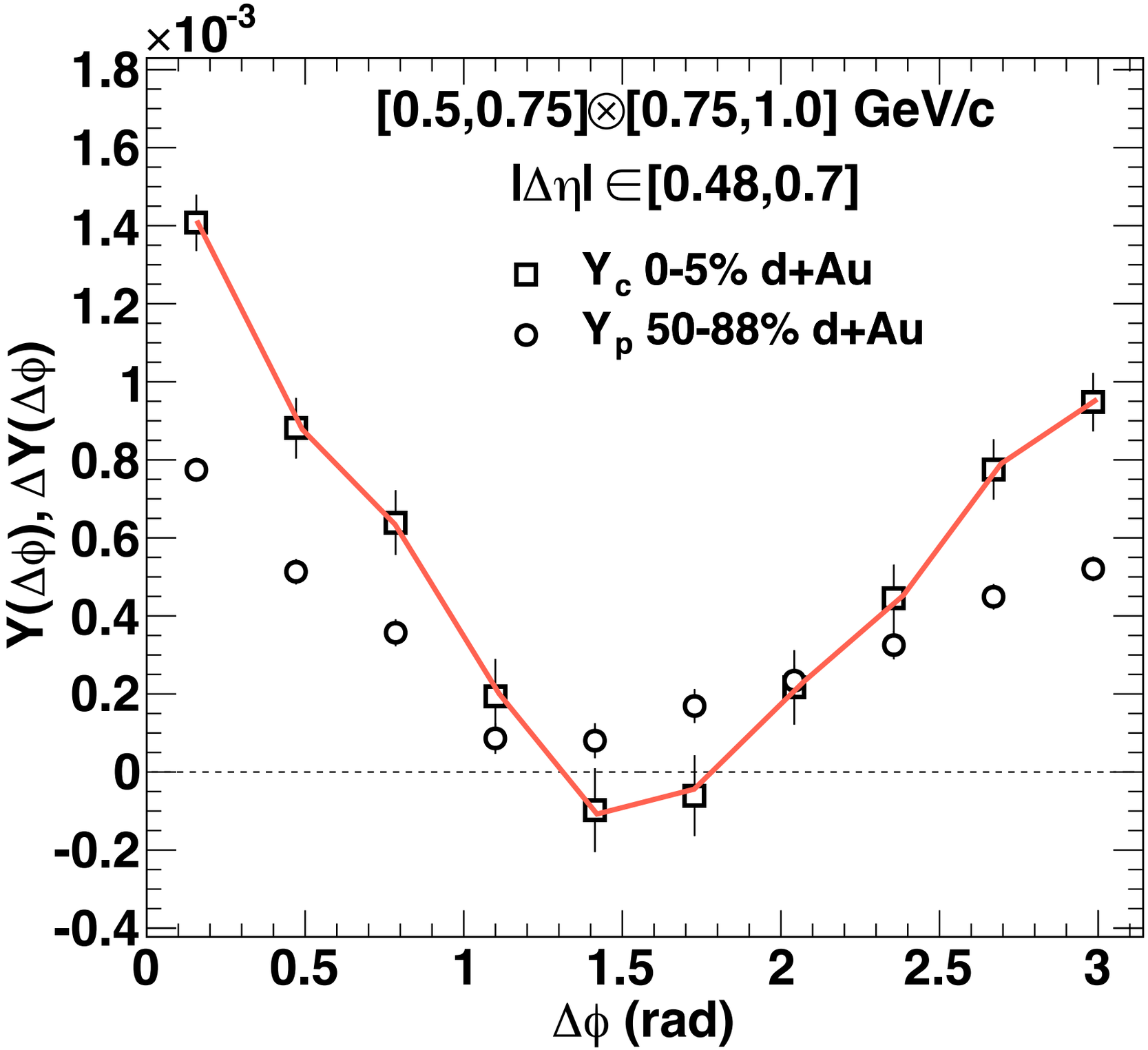


central

peripheral

PHENIX PRL 111 212301

two particle correlations in dAu



central

peripheral

PHENIX PRL 111 212301

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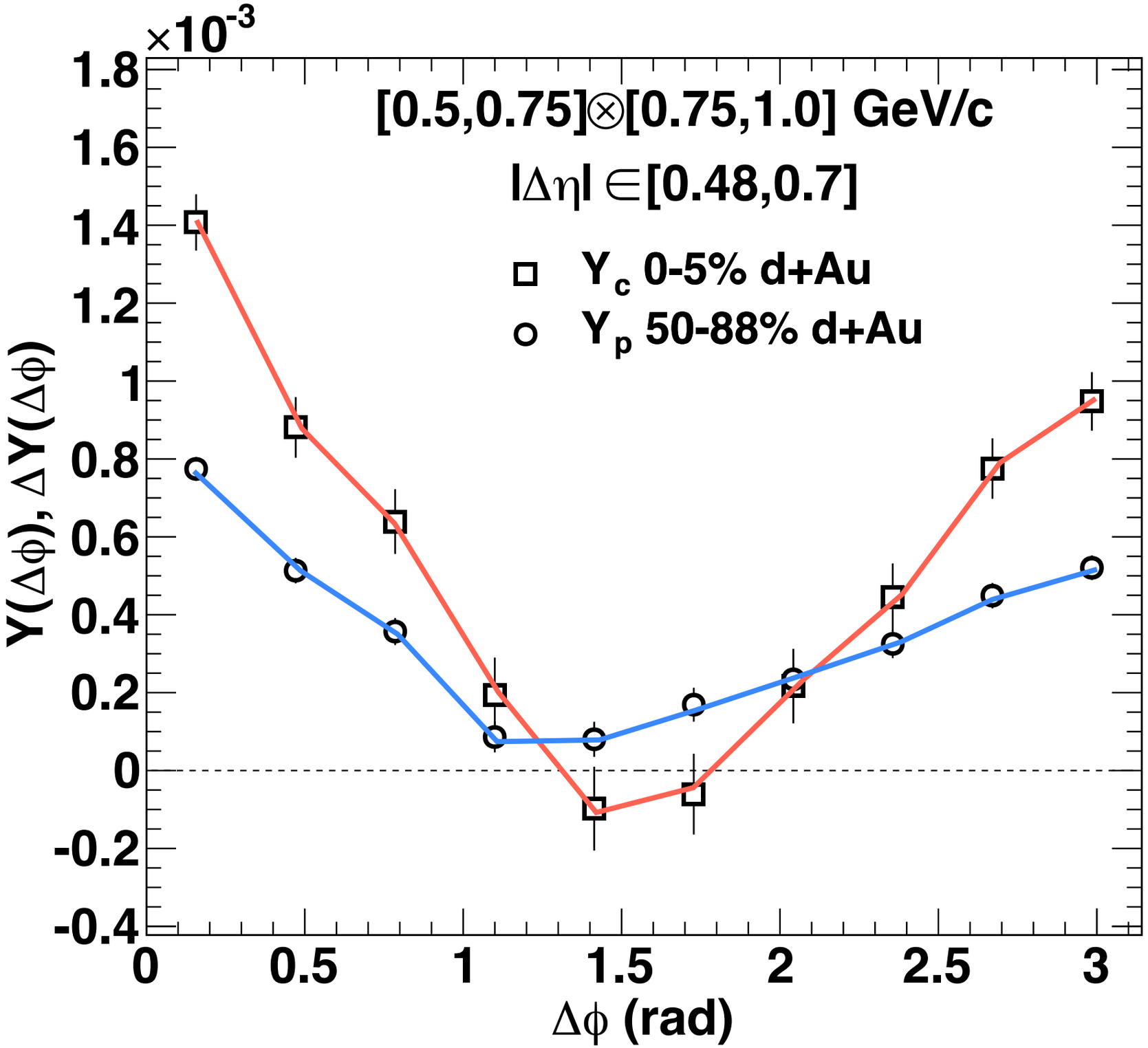
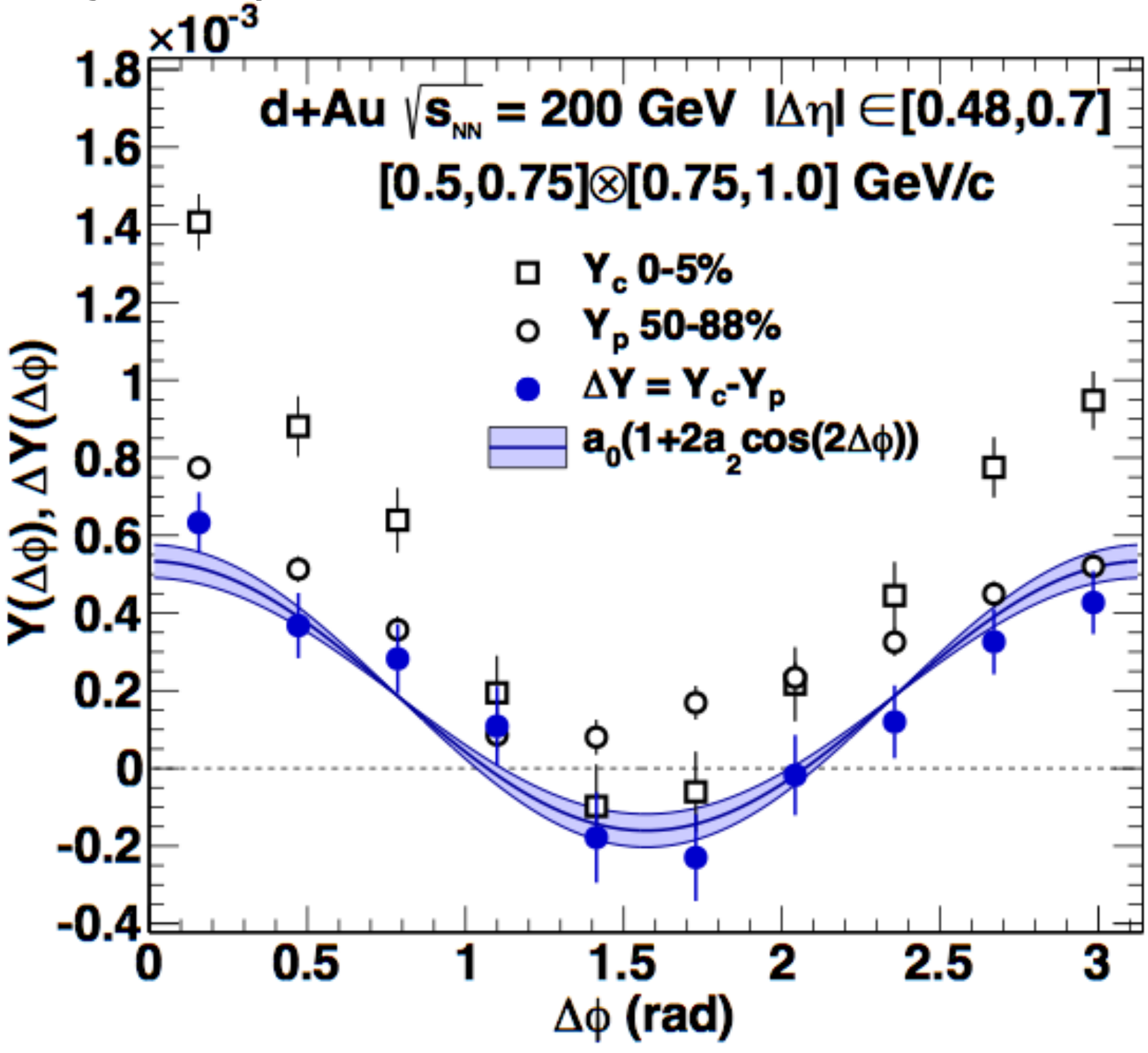


central

peripheral

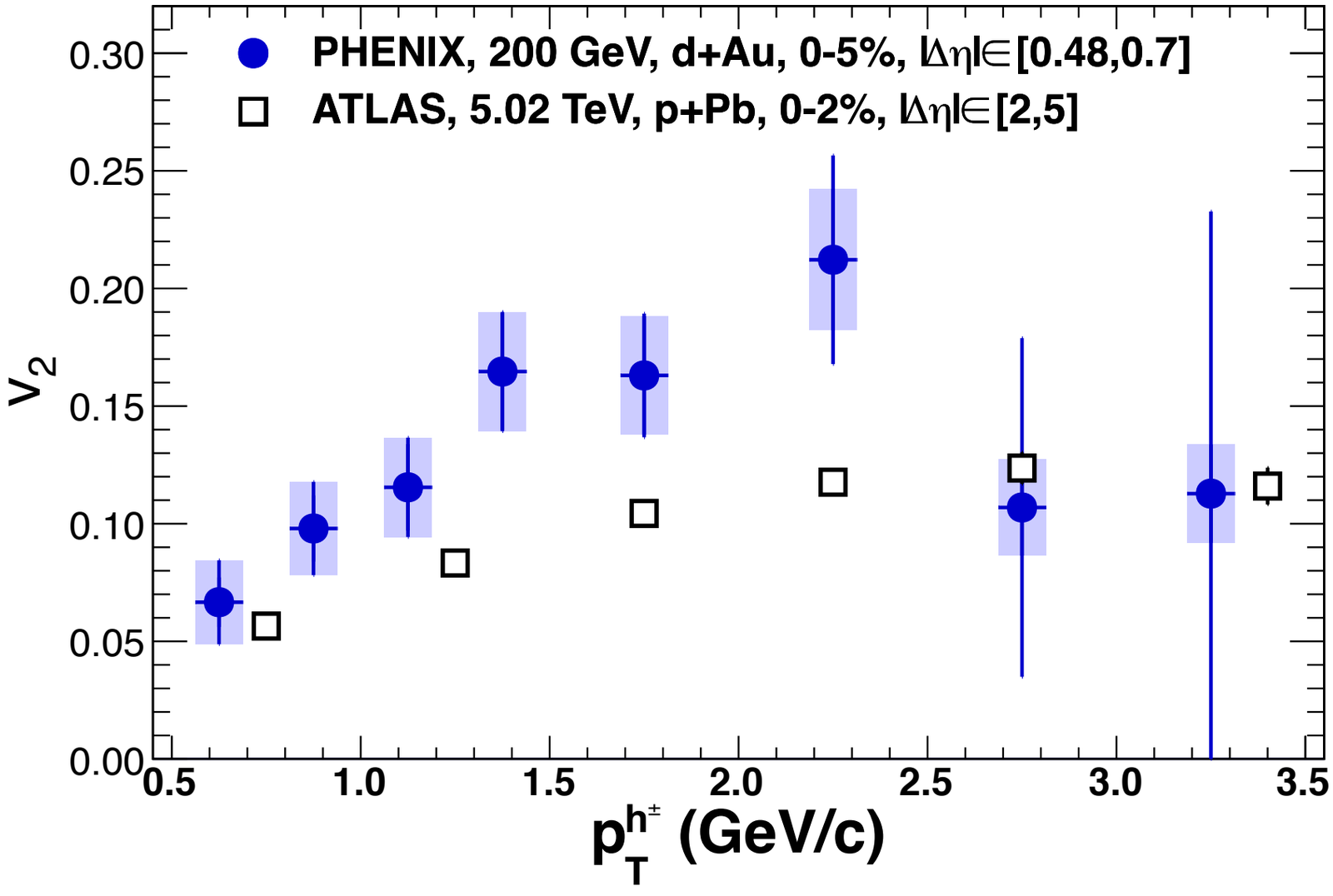
PHENIX PRL 111 212301

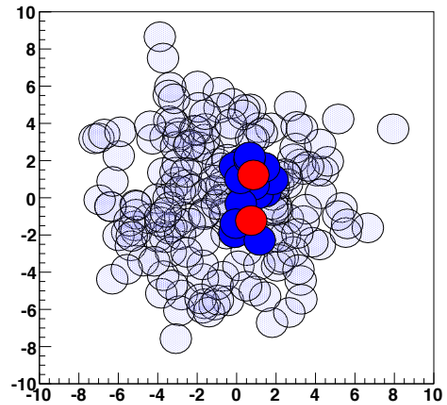
centrality dependence

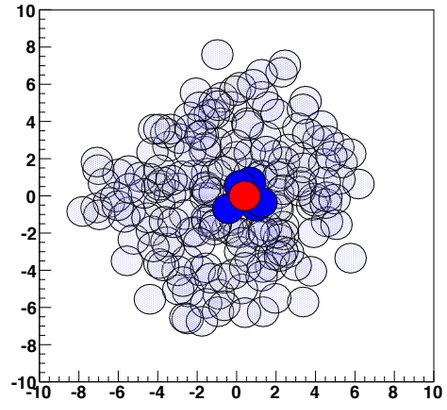


PHENIX PRL 111 212301

v2: pPb & dAu







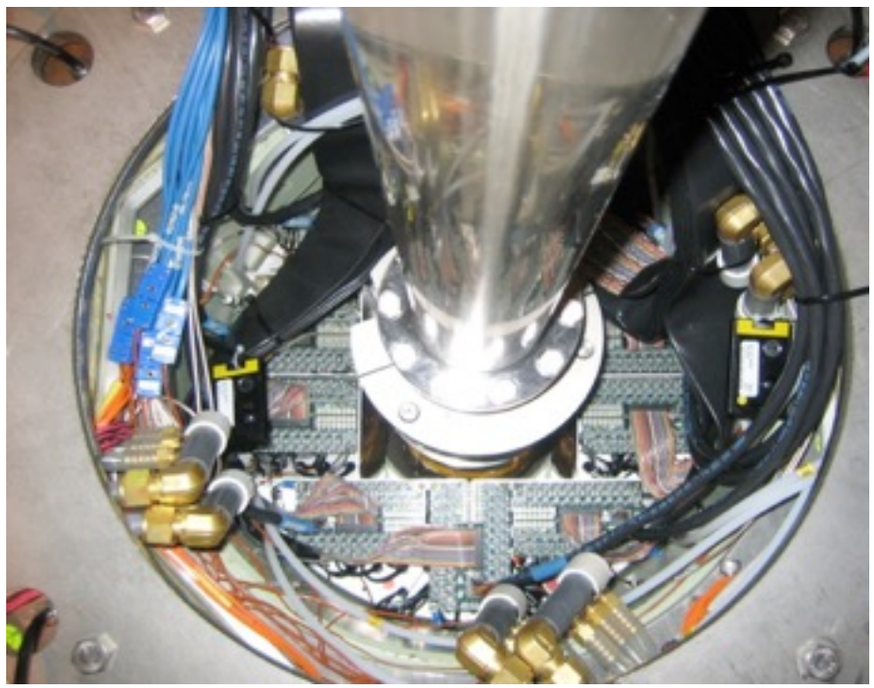
evidence for double ridges, but not a long range measurement

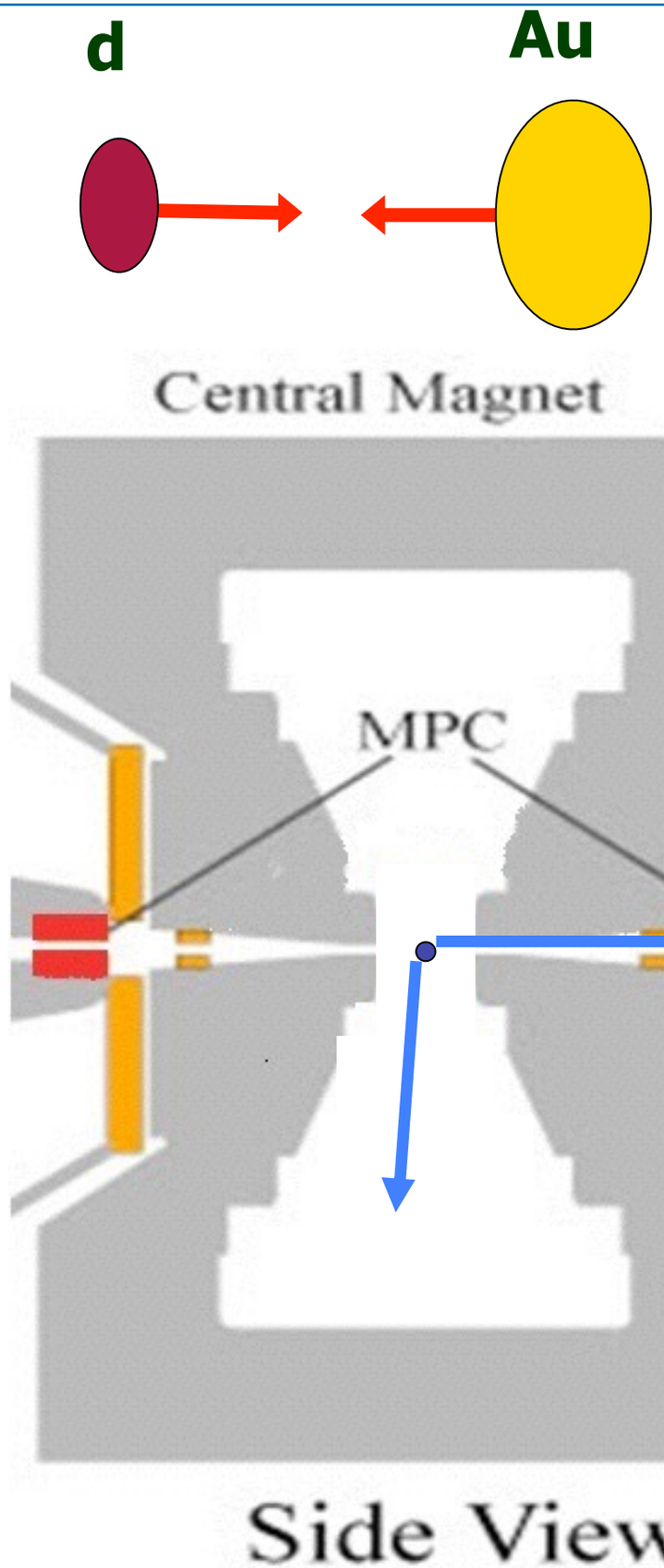
PHENIX PRL 111 212301 (2013)
ATLAS PRL 110 182302 (2013)

rapidity separated correlations

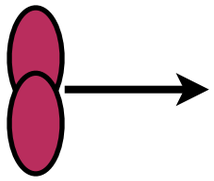
Muon Piston Calorimeters

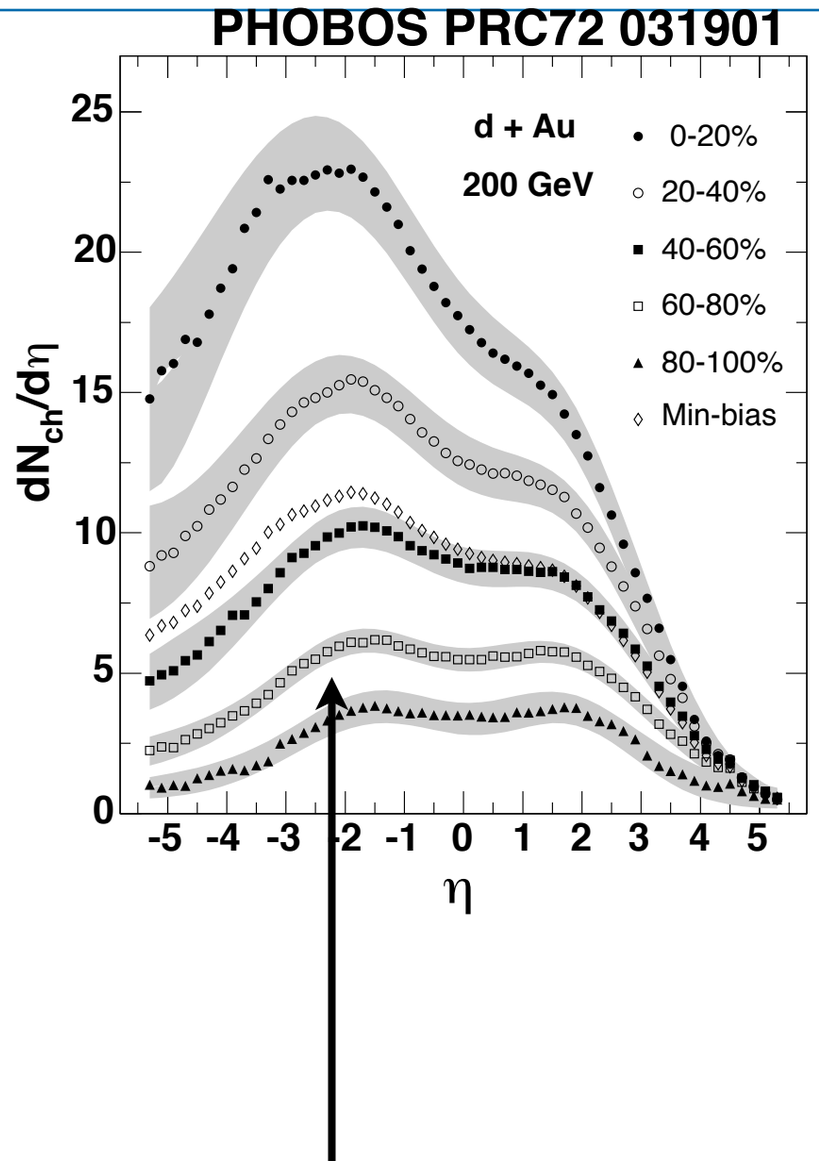
both d-going & Au-going directions
$3 < |\eta| < 4$

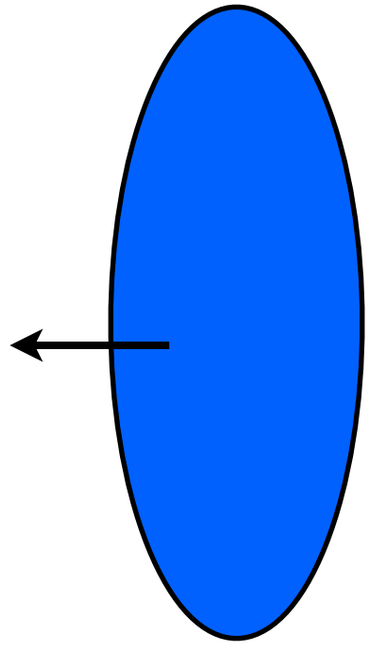




long range correlations in dAu

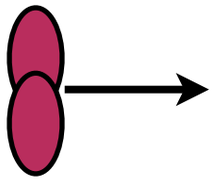


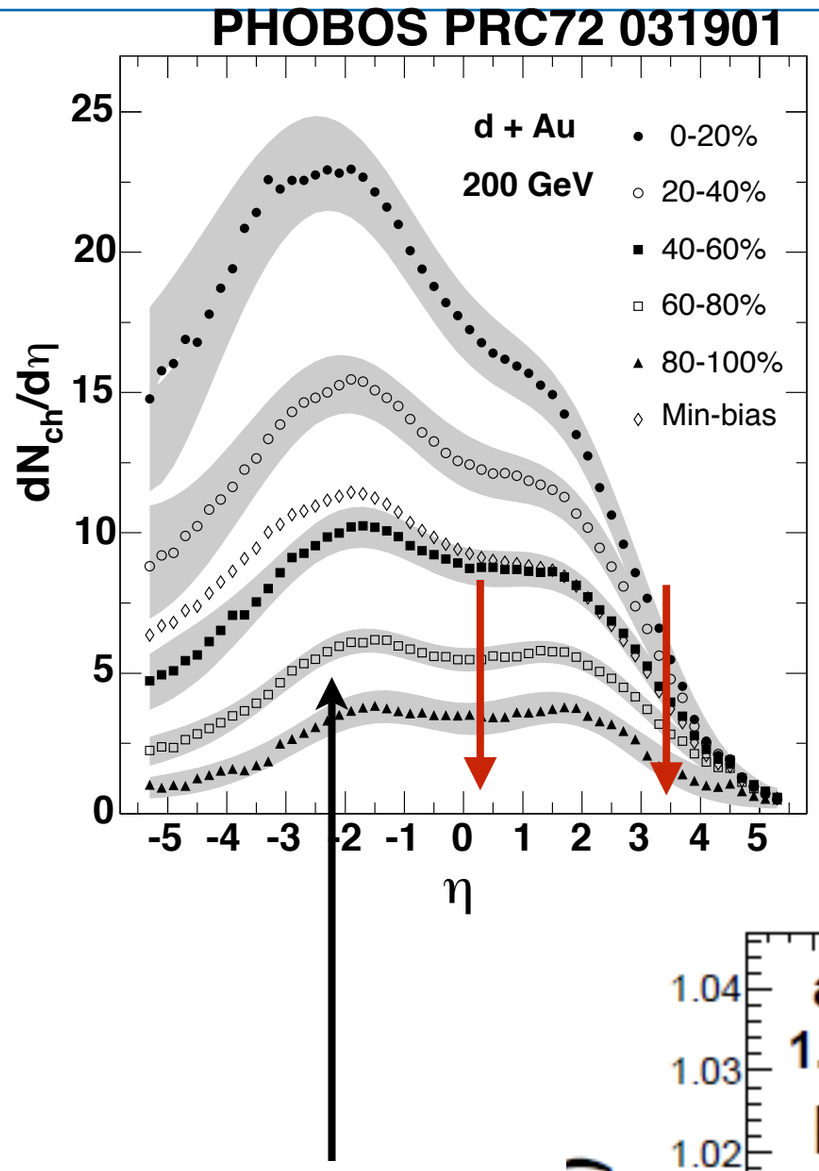


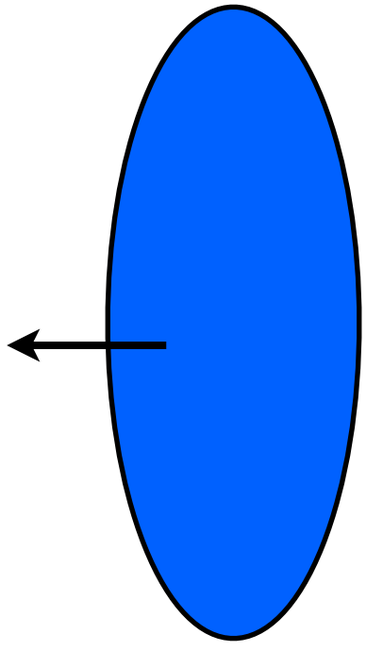


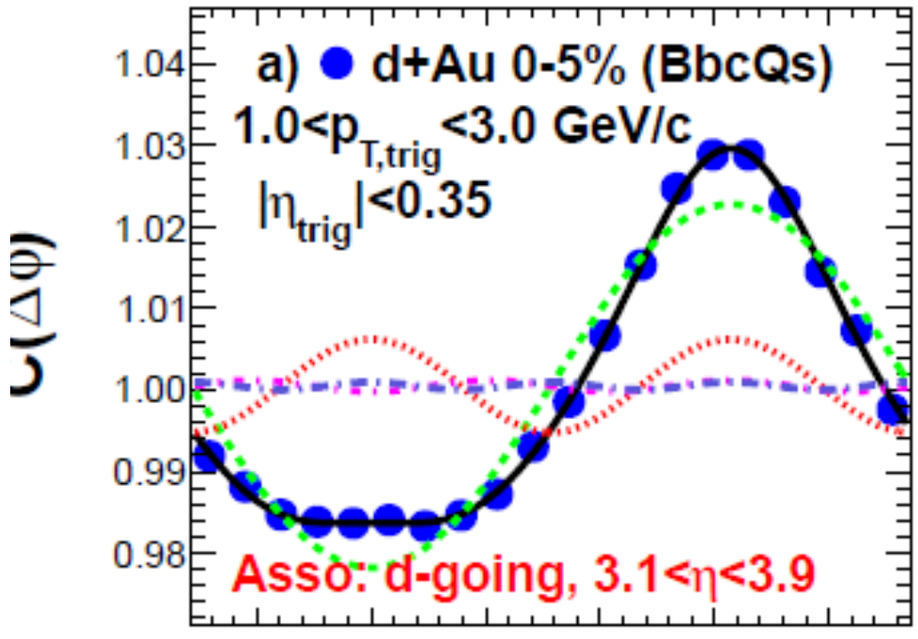
PHENIX: 1404.7461

long range correlations in dAu









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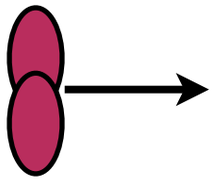
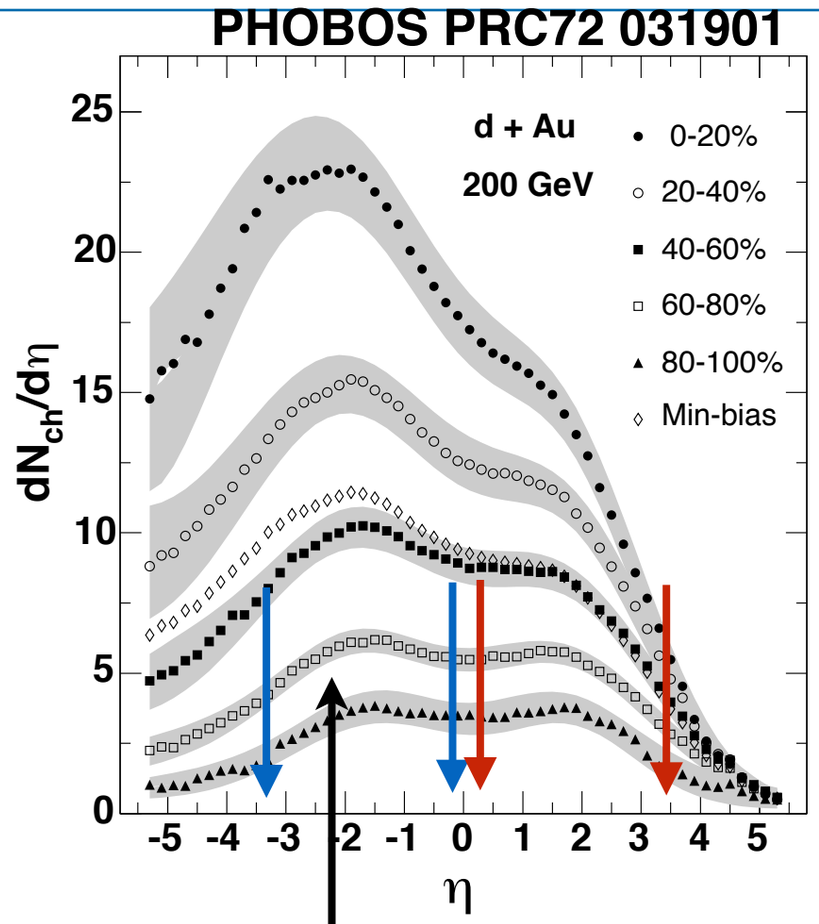
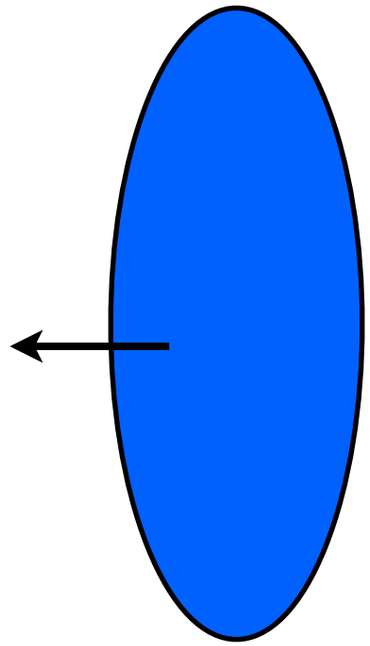
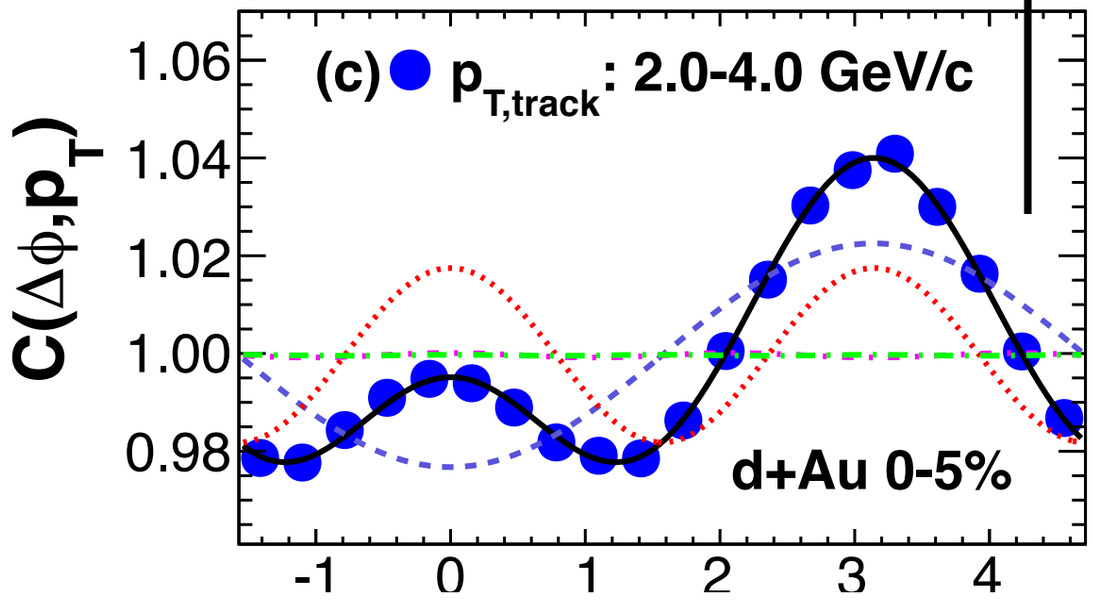
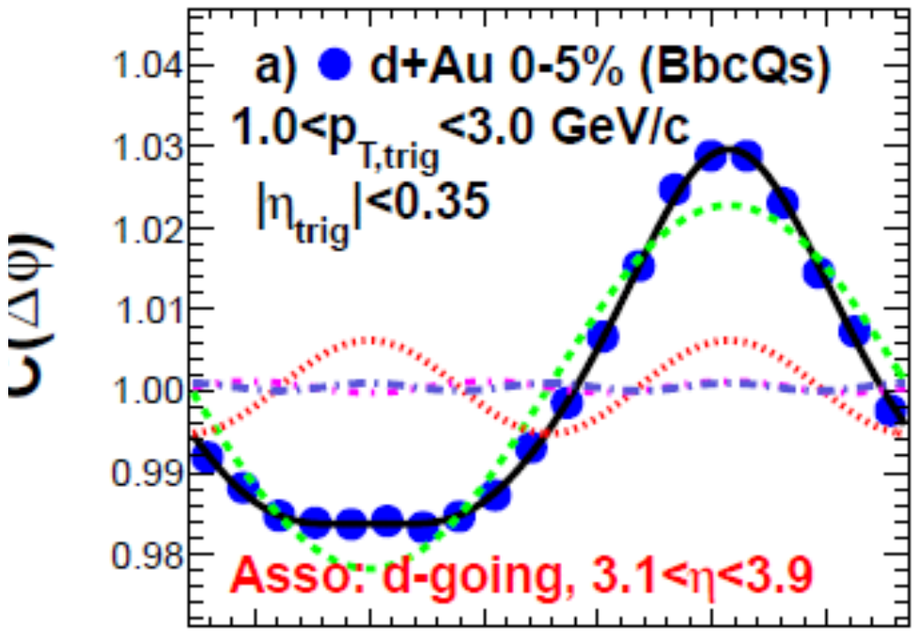
long range correlations in dAu





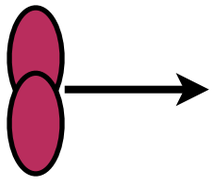


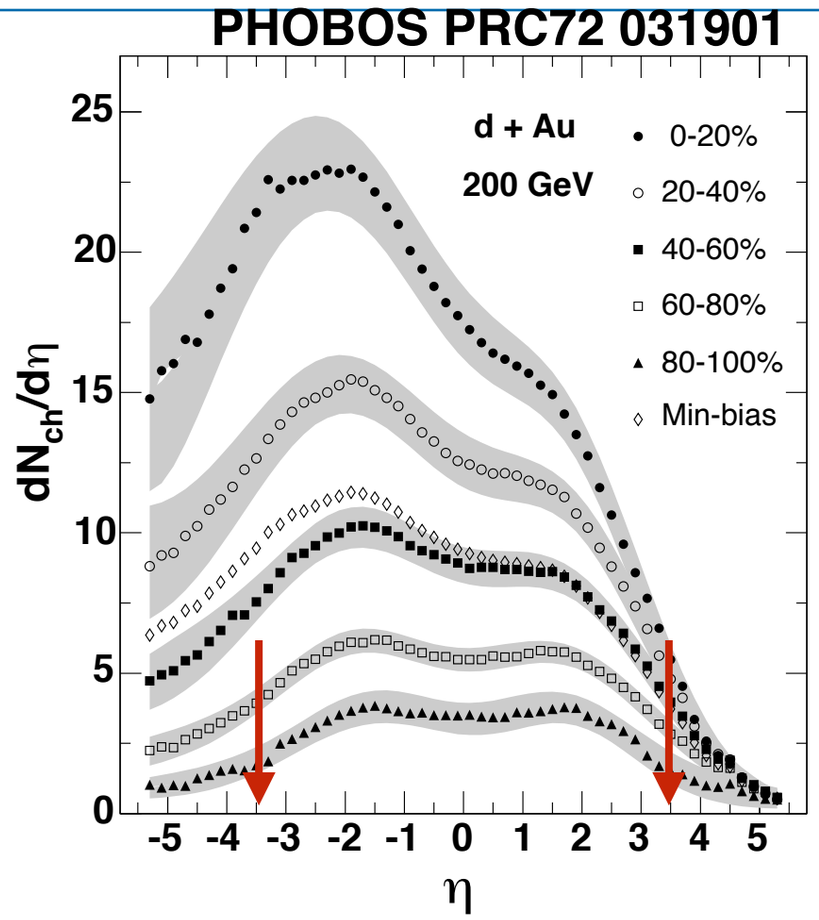


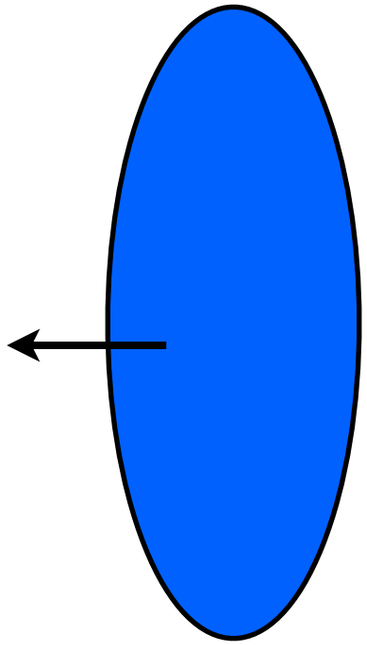


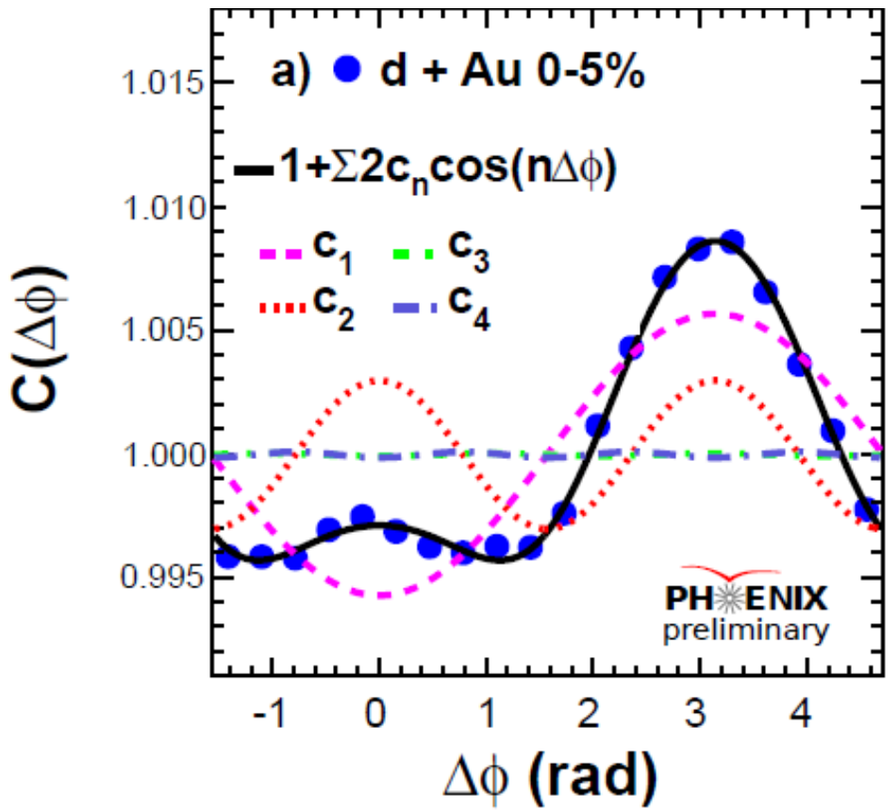
PHENIX: 1404.7461

long range correlations in dAu

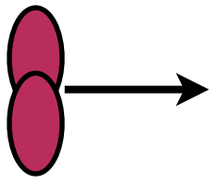


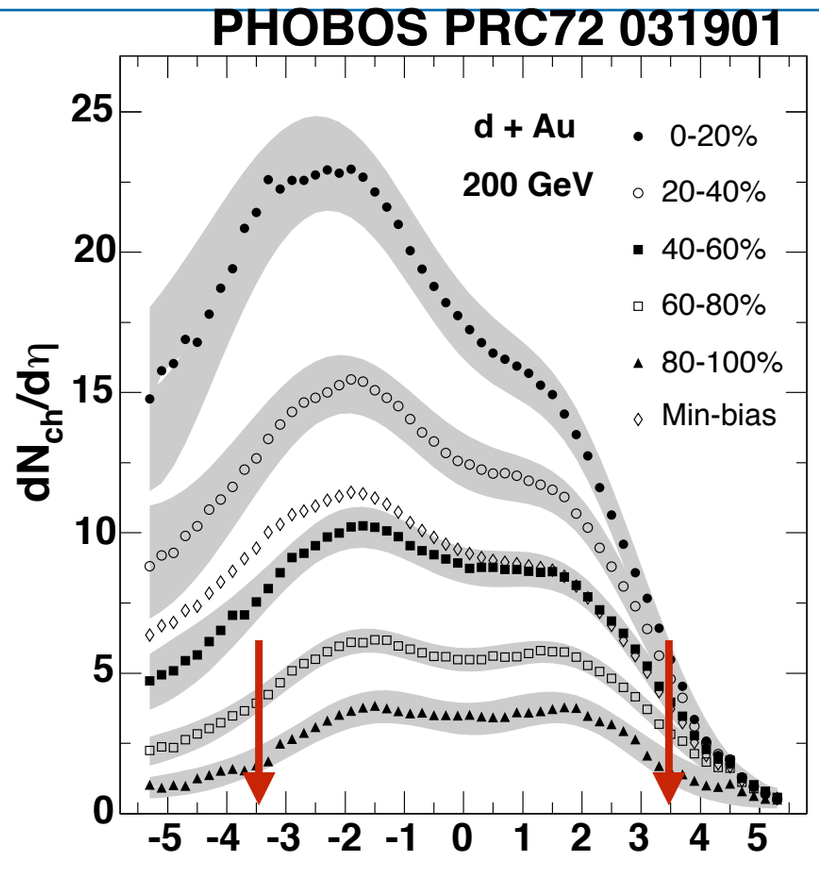


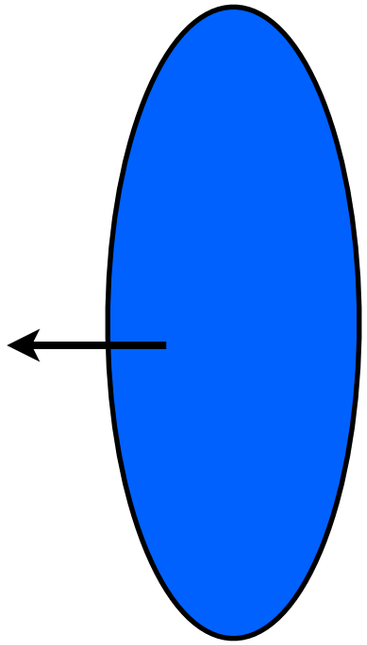




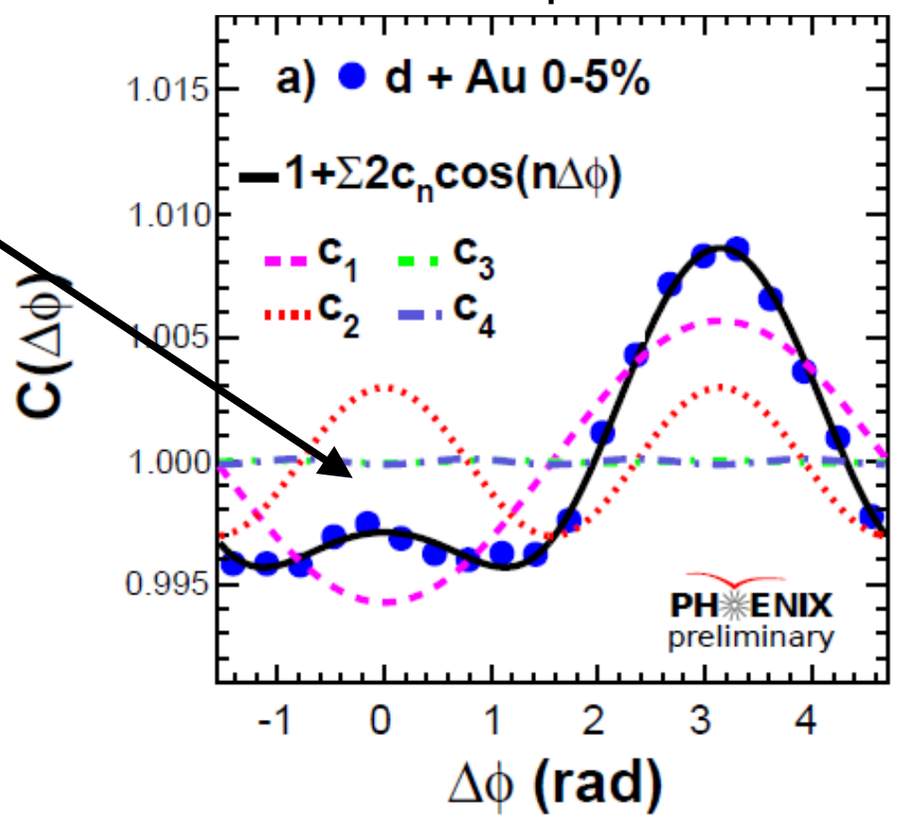
long range correlations in dAu



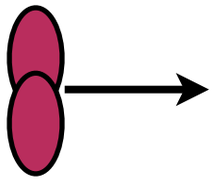


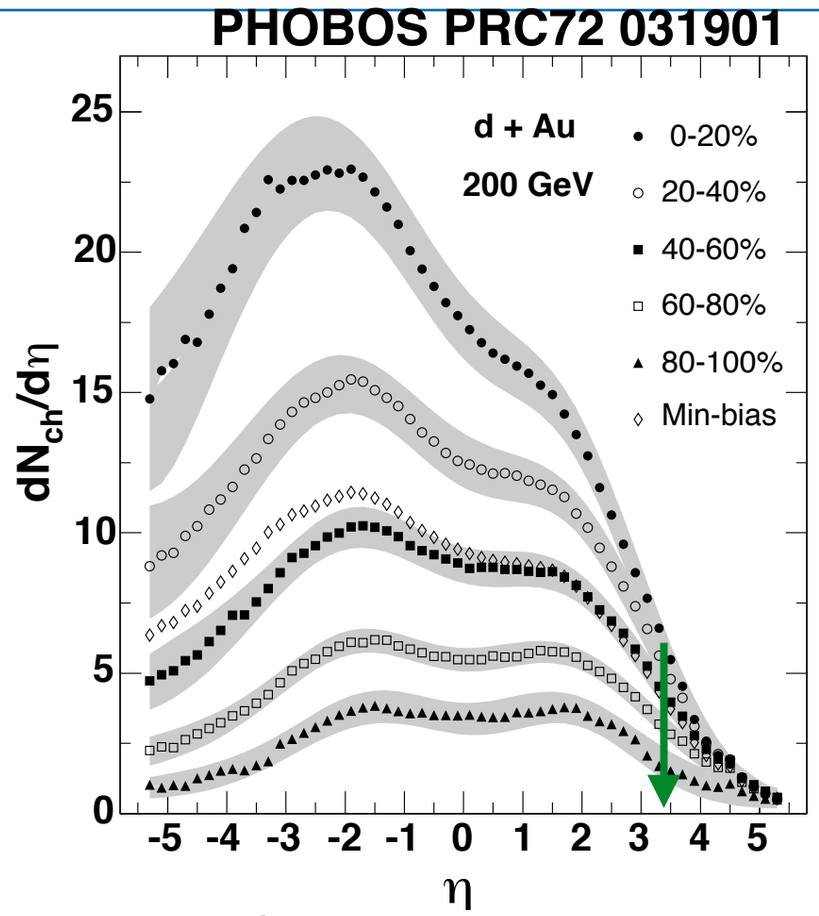


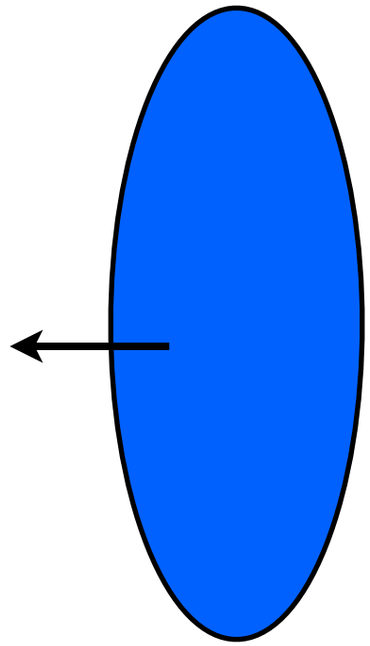
ridge correlation for |η| > 6!

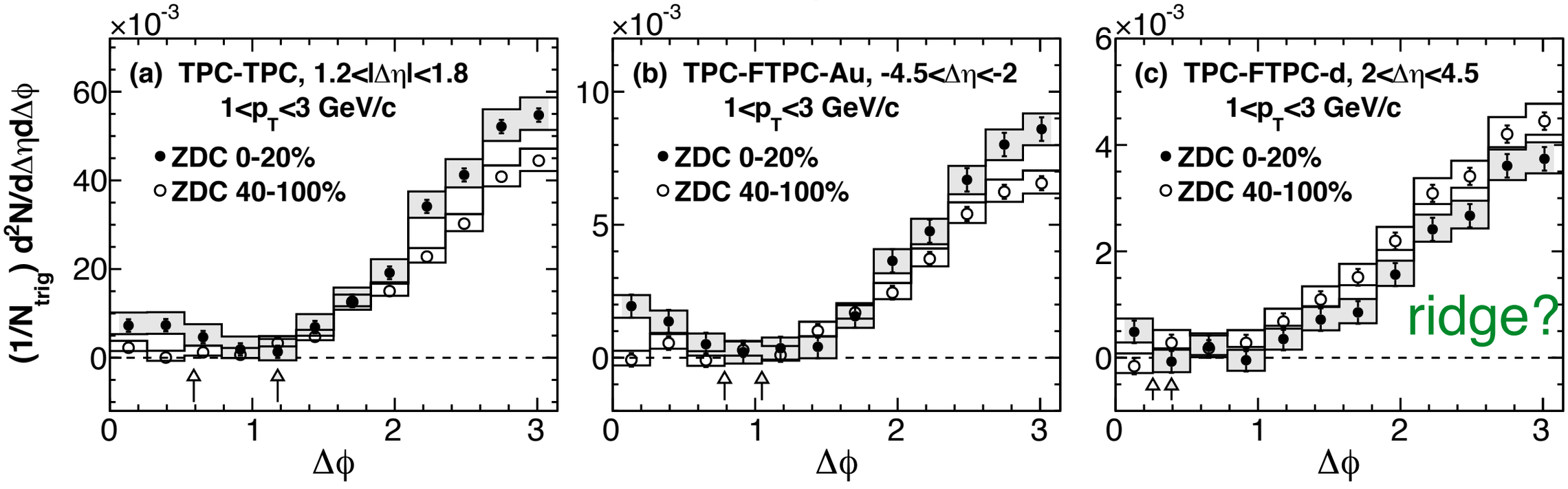


long range correlations in dAu



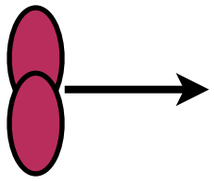


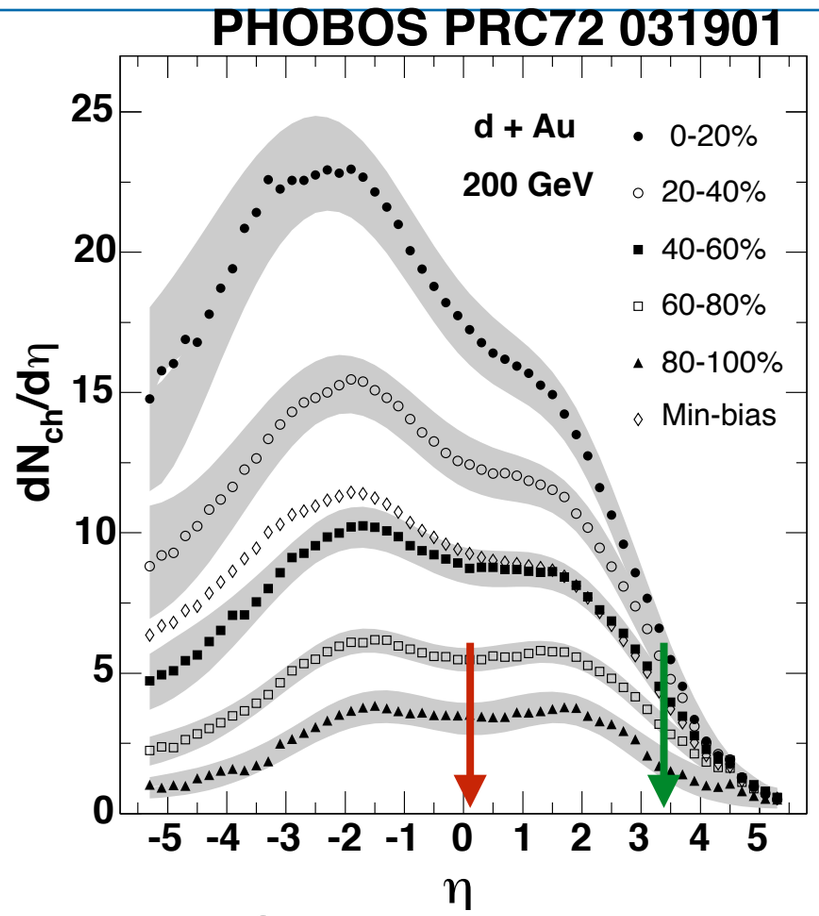


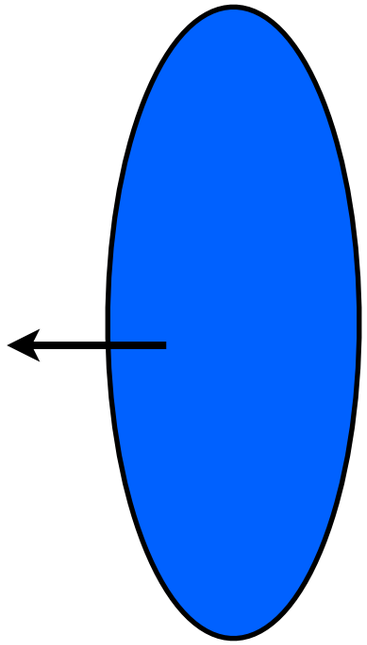


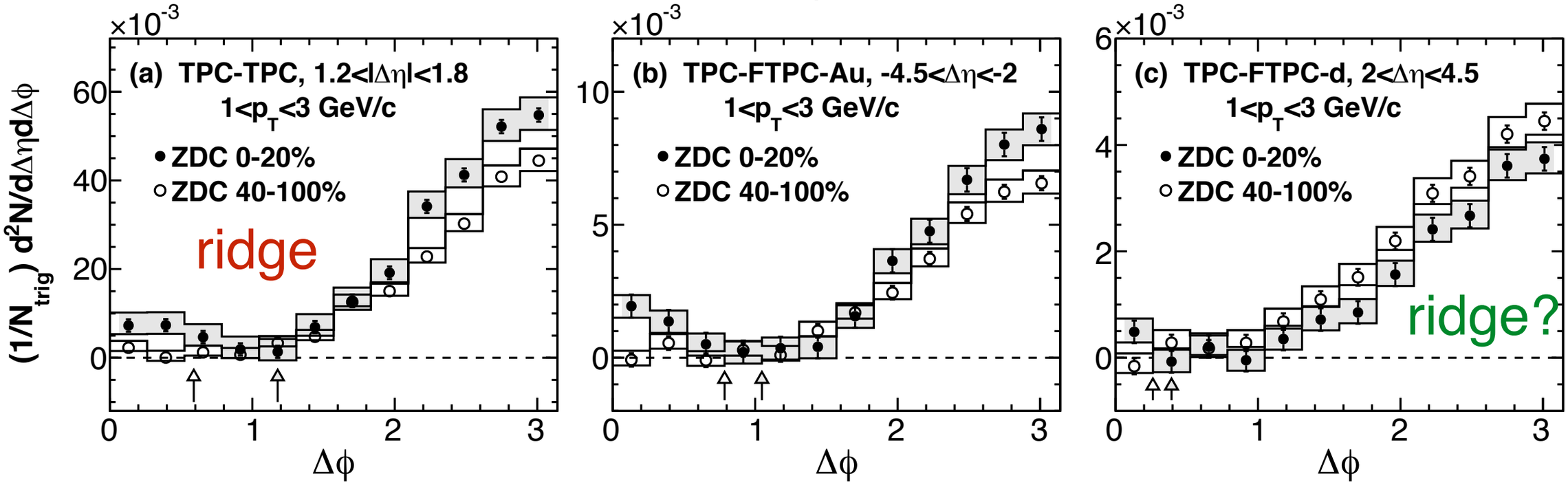
STAR: 1502.07652

long range correlations in dAu









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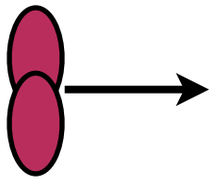
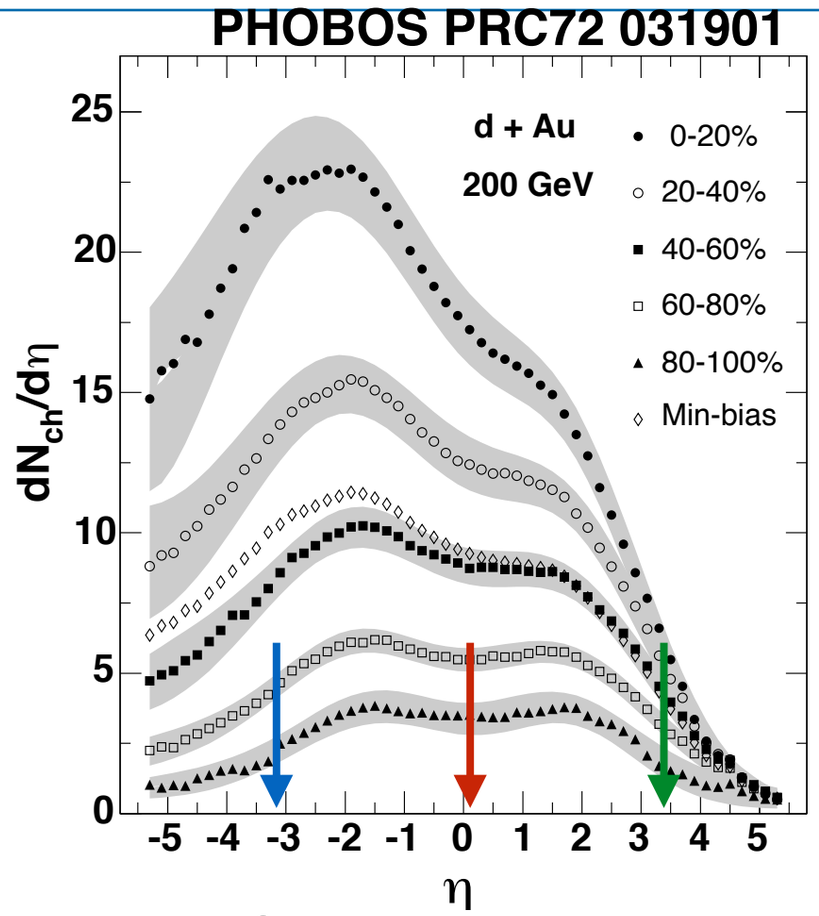
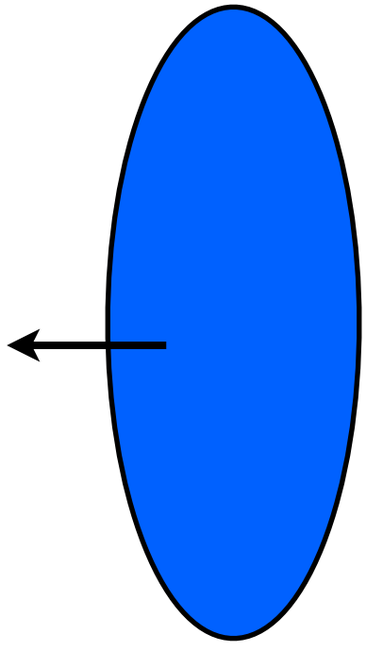
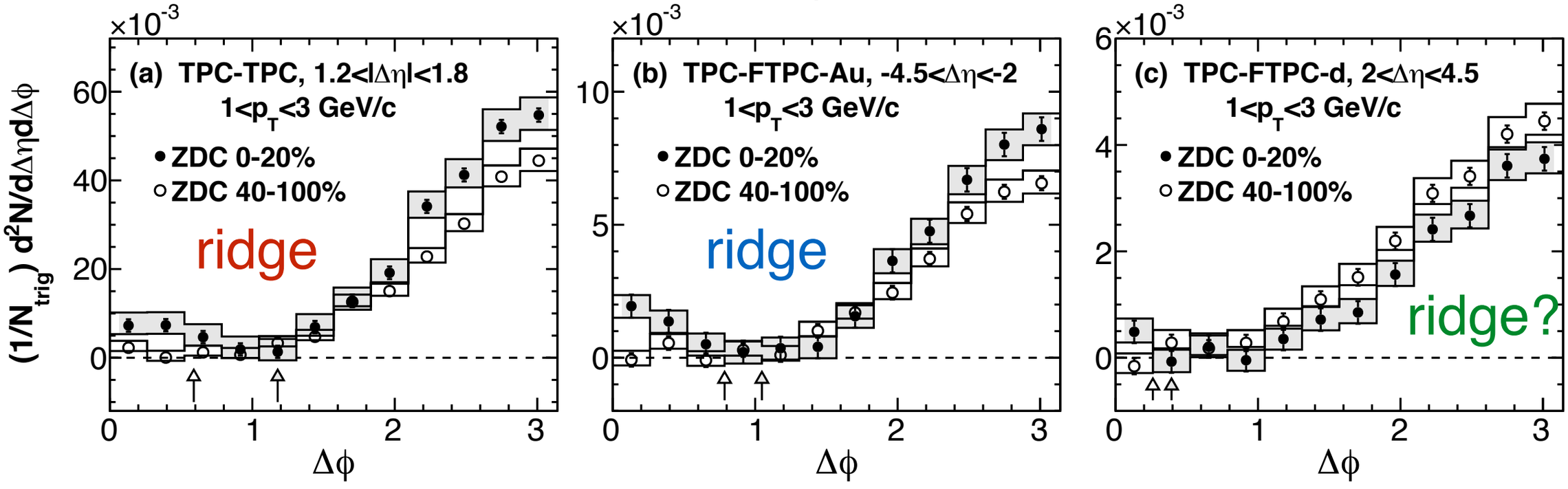
long range correlations in dAu





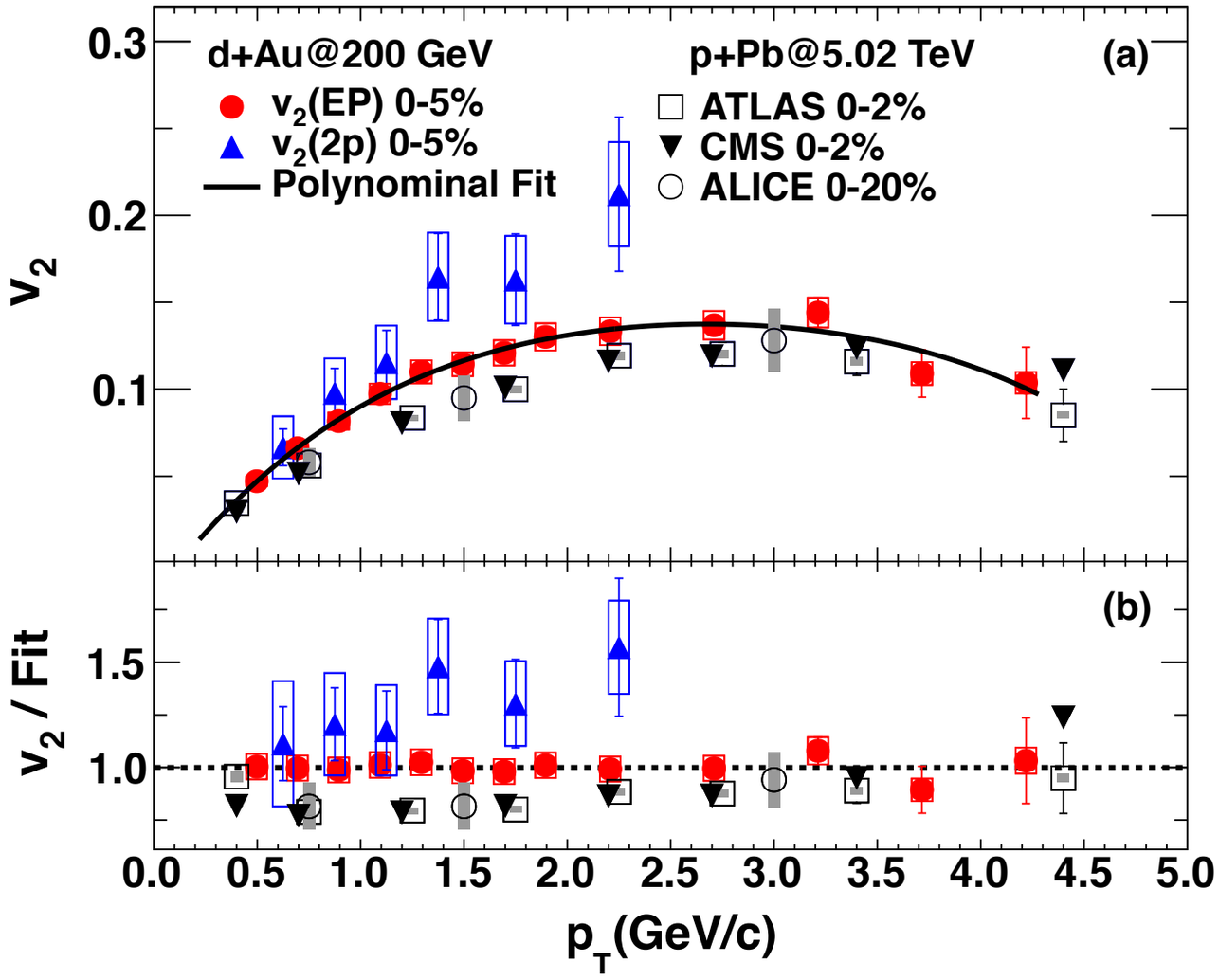




STAR: 1502.07652

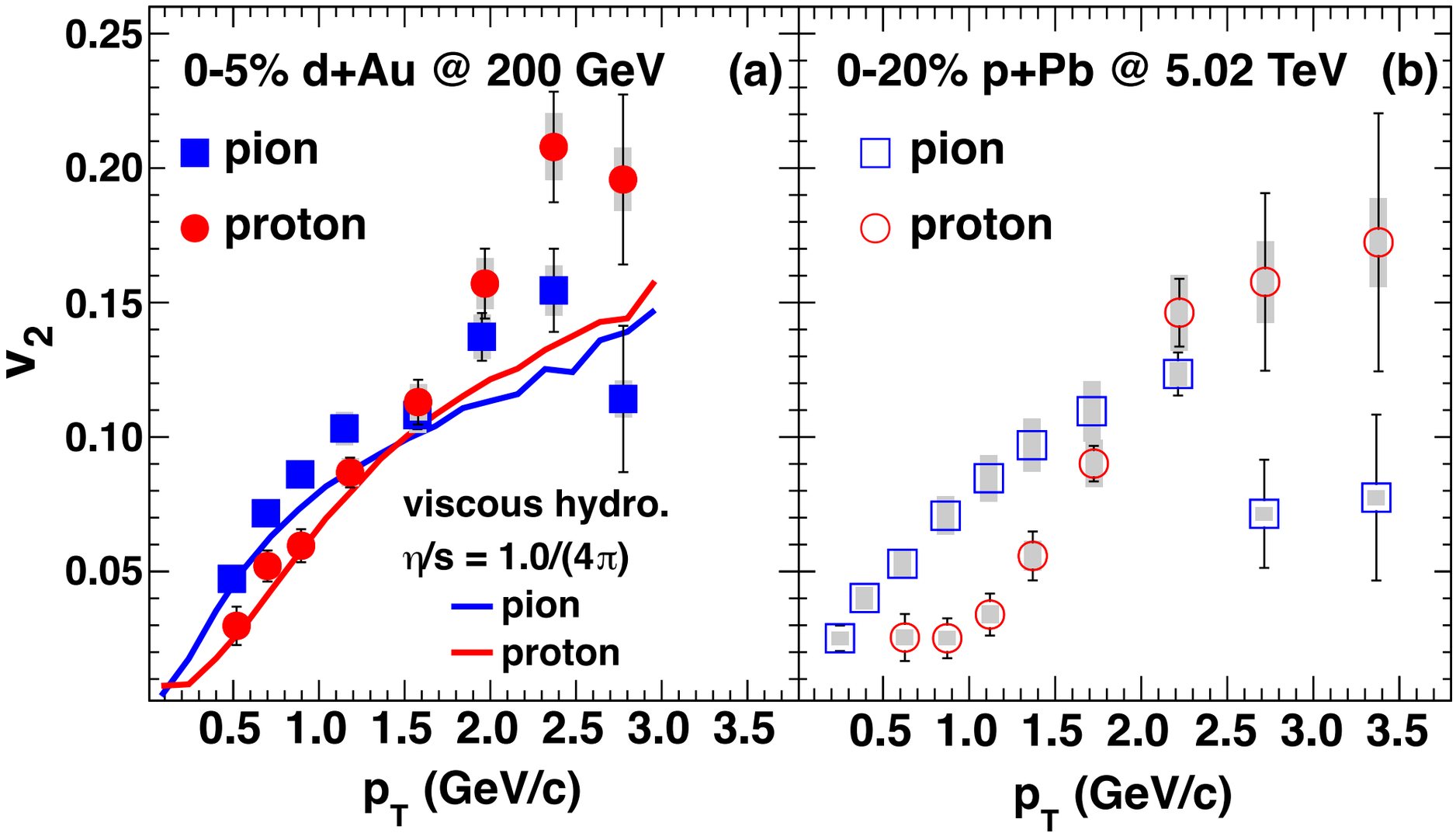
long range d+Au v_2

- event plane reconstructed @ η = 3-4, v_2 of particles @ |η| < 0.35
- true long range correlations
- v_2 slightly reduced from 2PC method, event plane method much less sensitive to any jet contributions



PHENIX: 1404.7461, accepted by PRL

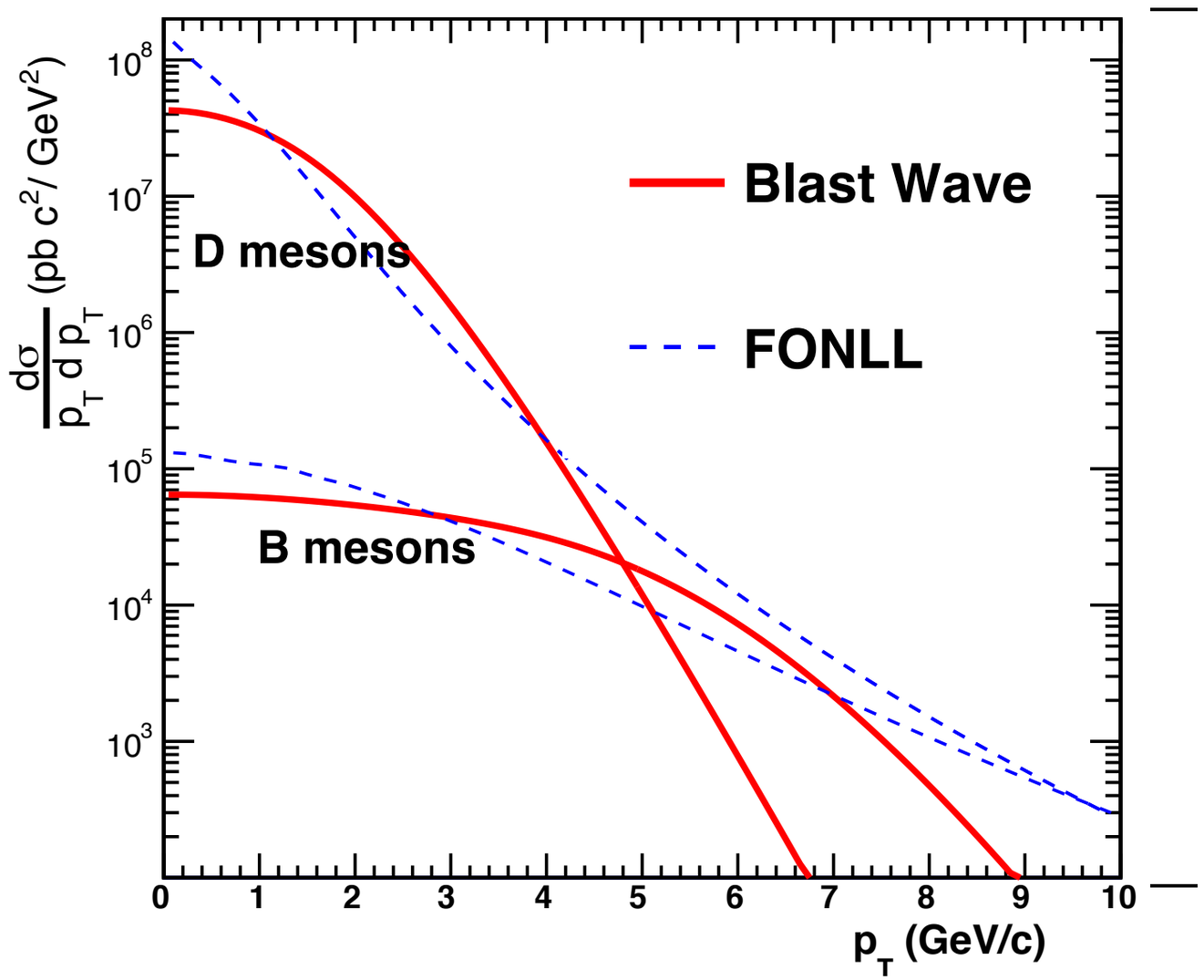
particle mass dependence

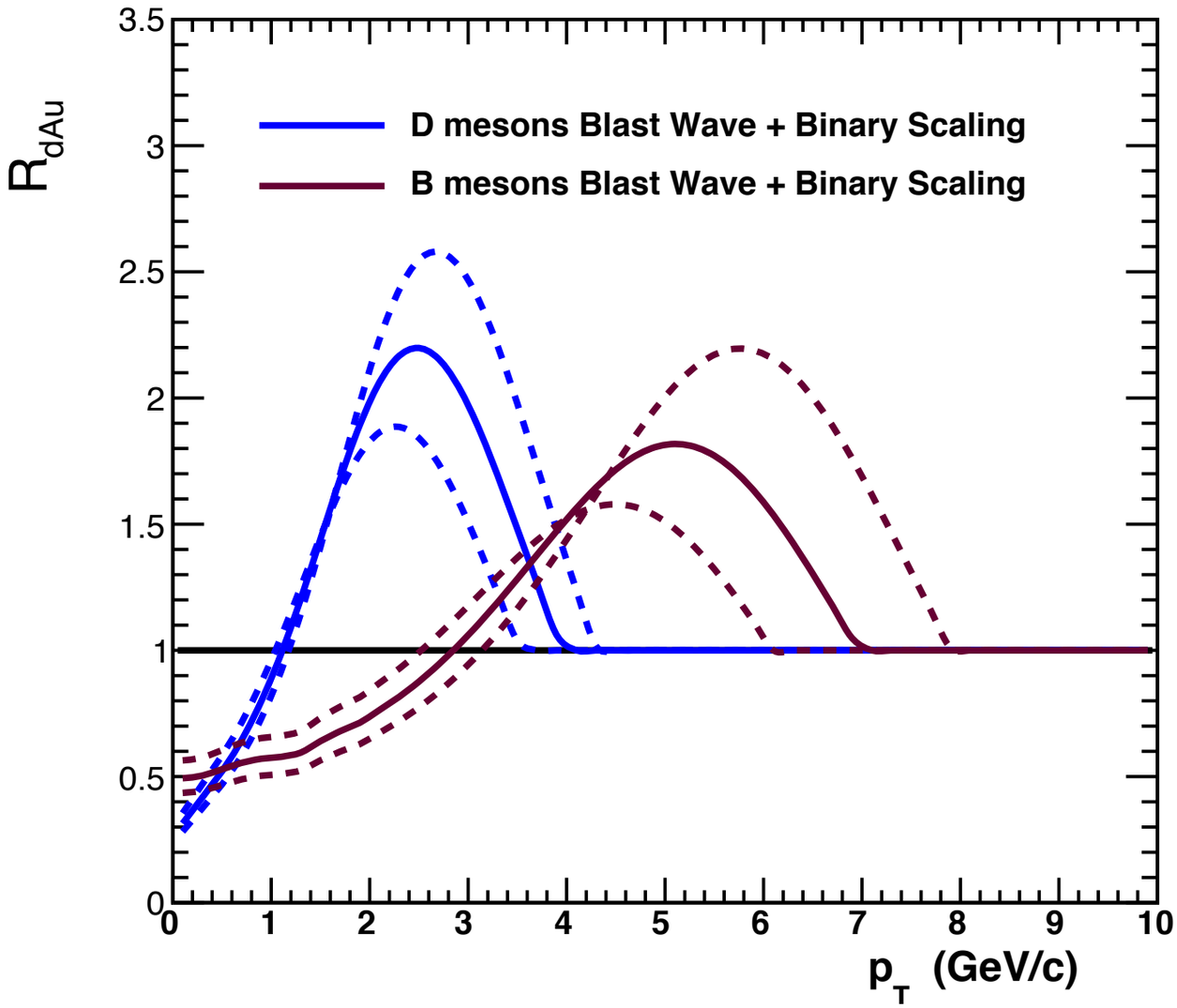


- event plane method
- characteristic flow particle mass dependence
  - stronger radial flow at the LHC

PHENIX: 1404.7461

heavy flavor?





AMS: PLB 731 51 (2014)

heavy flavor?

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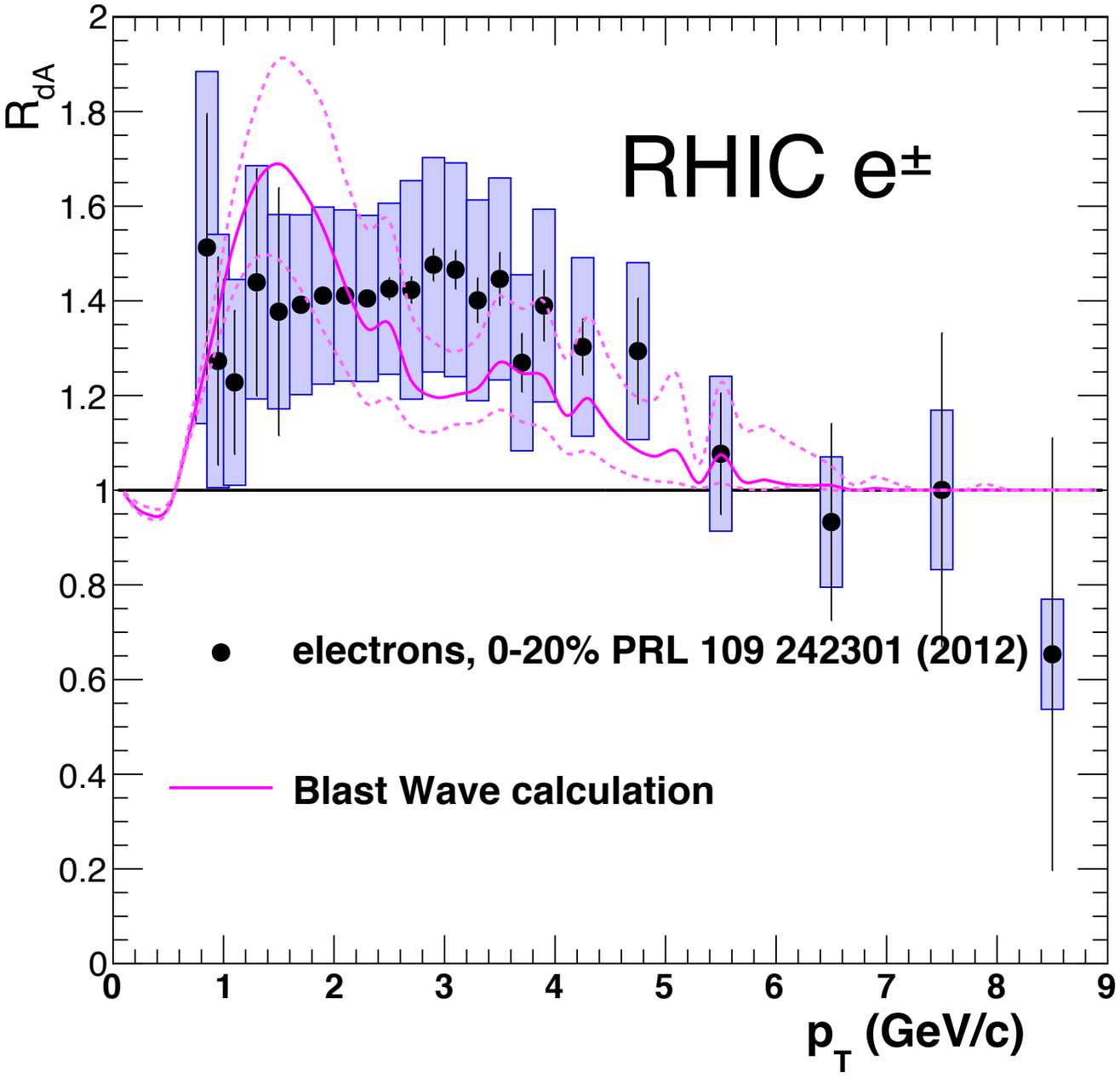
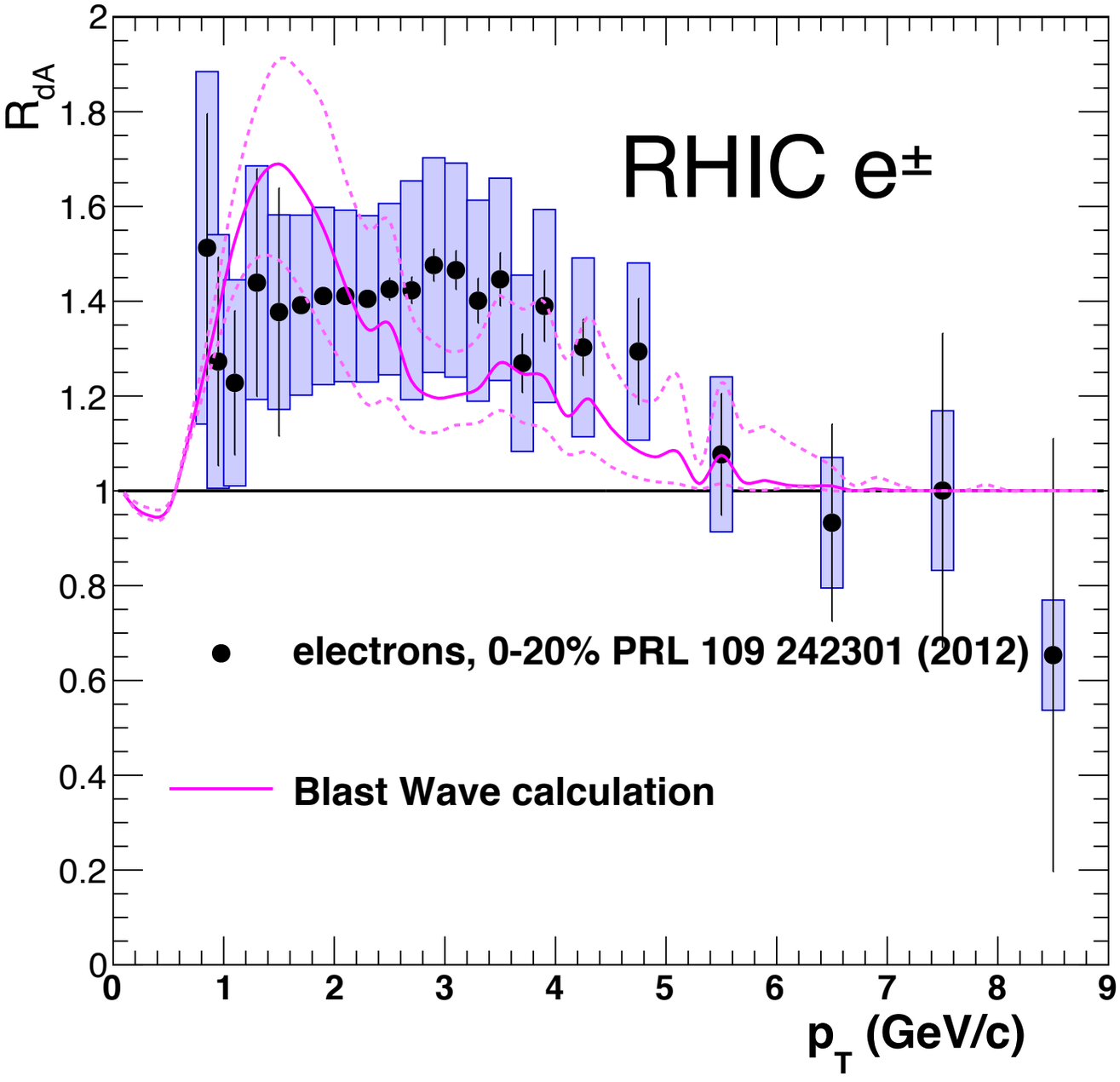
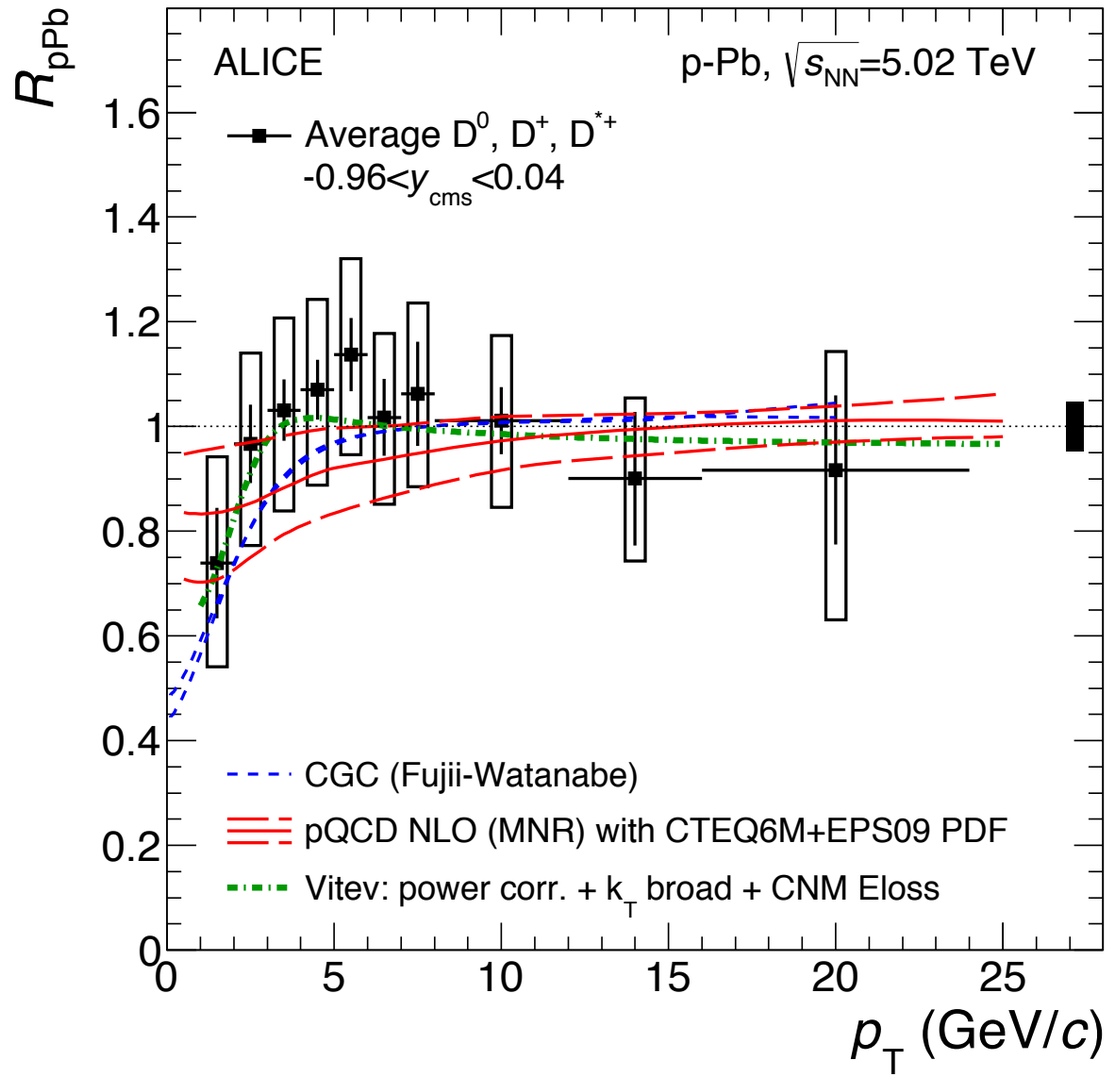


AMS: PLB 731 51 (2014)

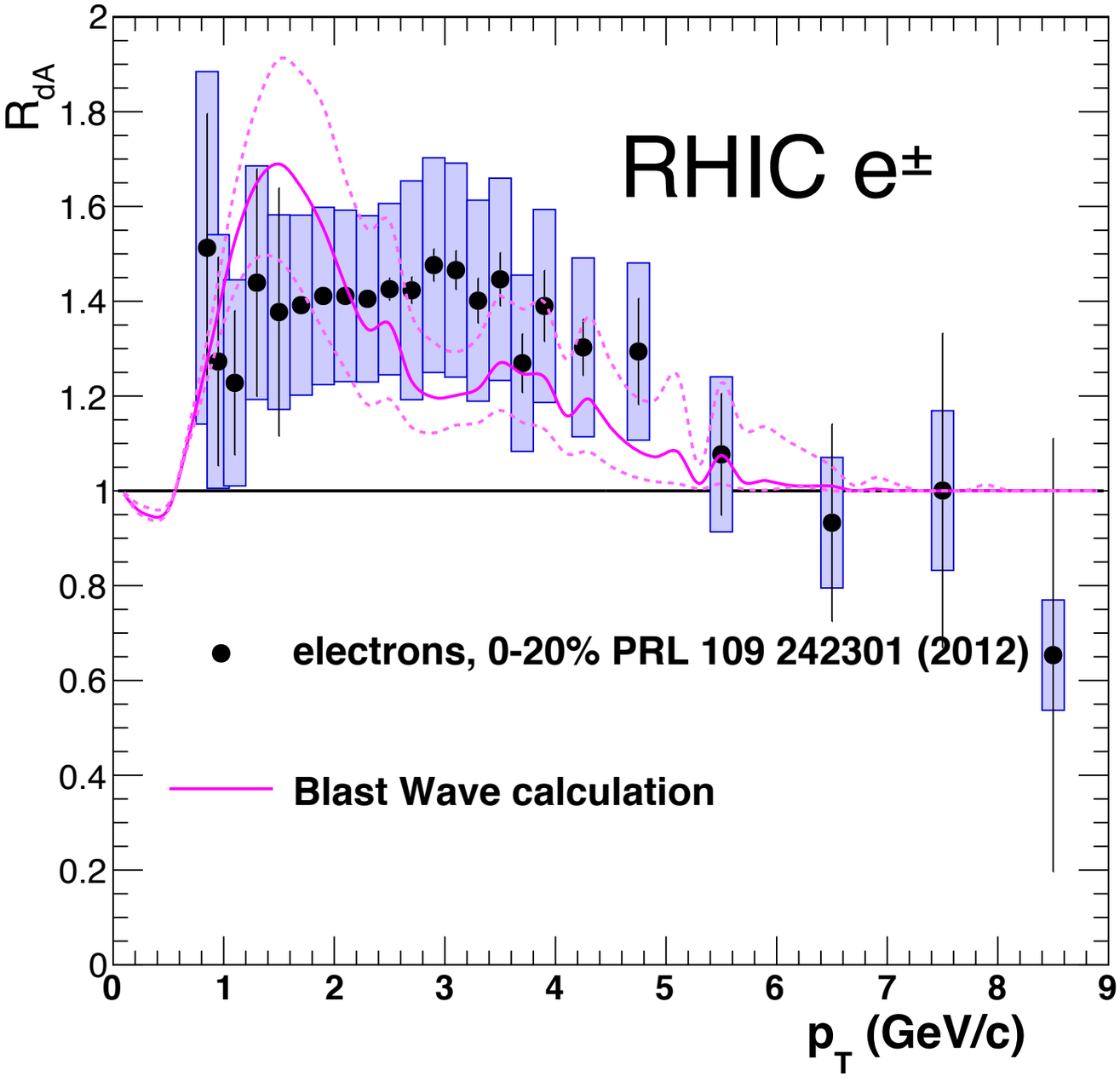
heavy flavor?

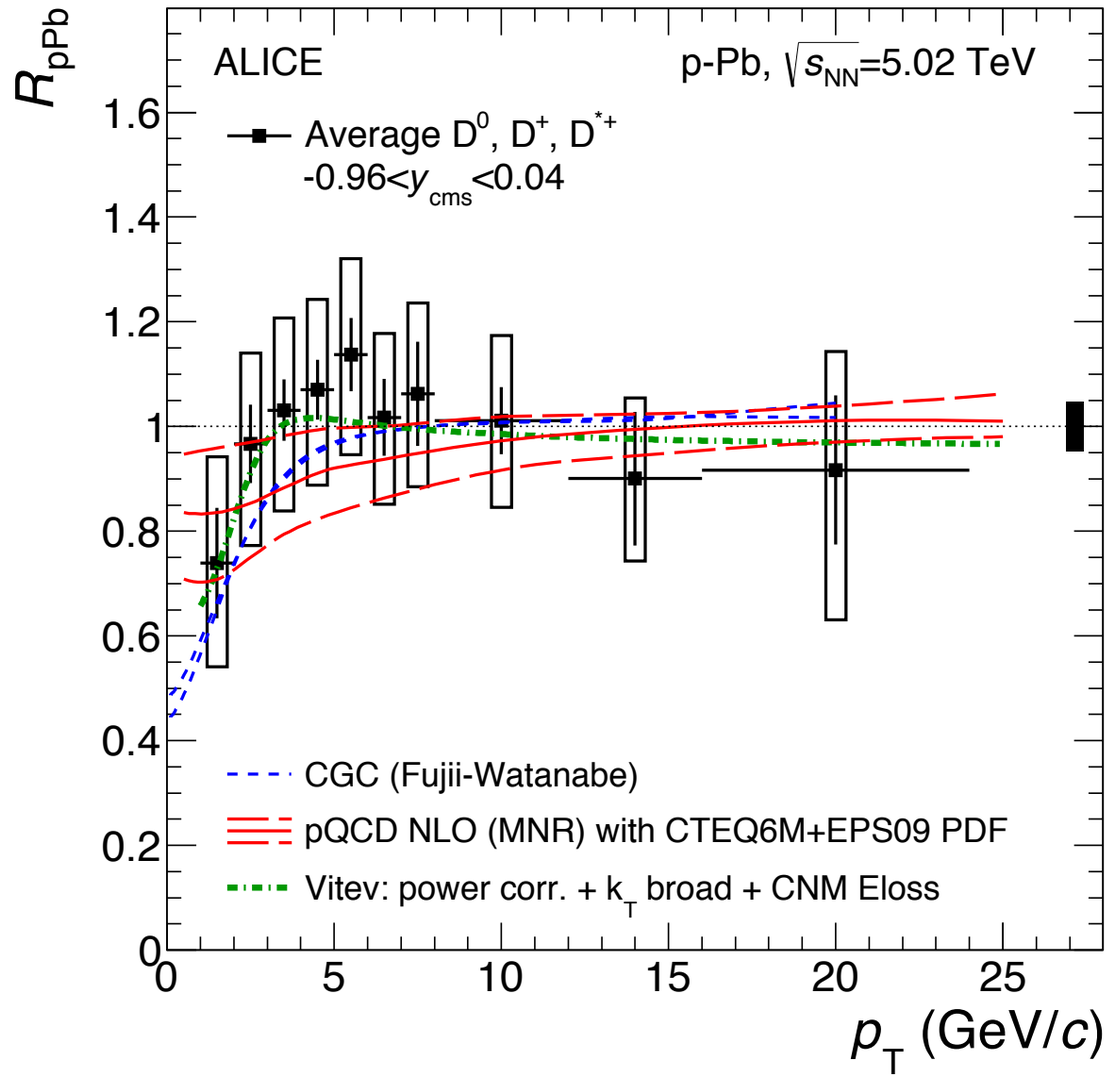




AMS: PLB 731 51 (2014)

heavy flavor?



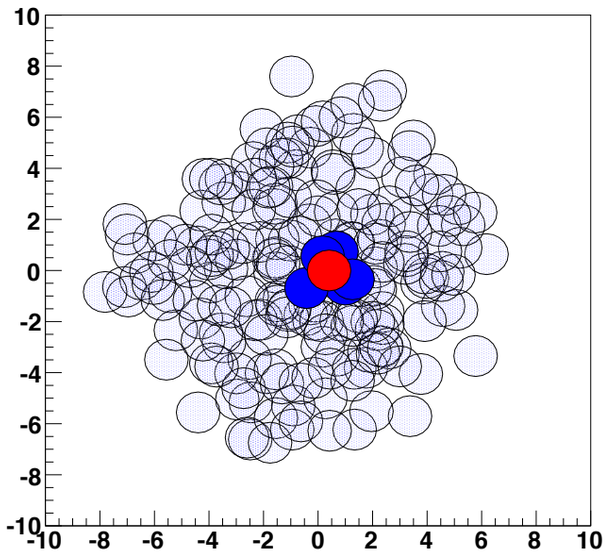


a smaller effect at the LHC could be due to the harder initial spectrum

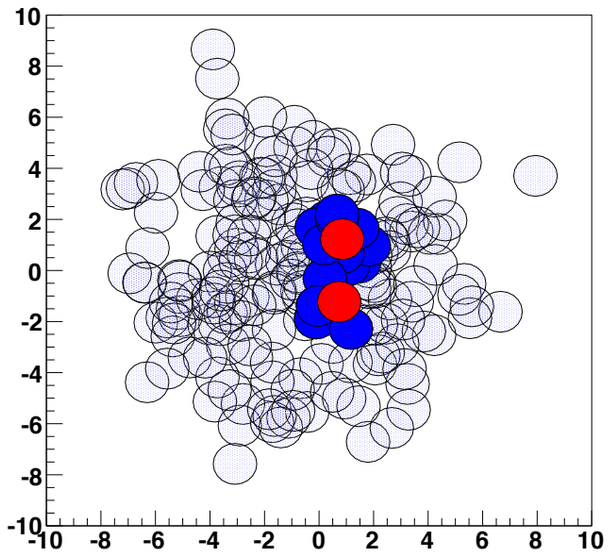
AMS: PLB 731 51 (2014)

variation of the small nucleus

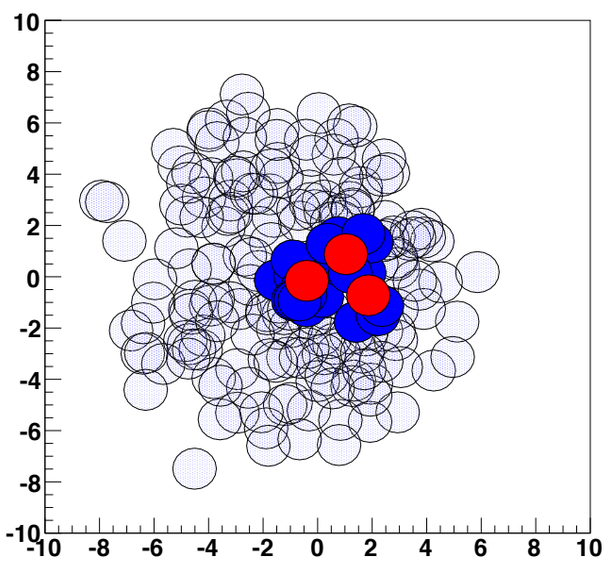
pA



dA



^{3}HeA

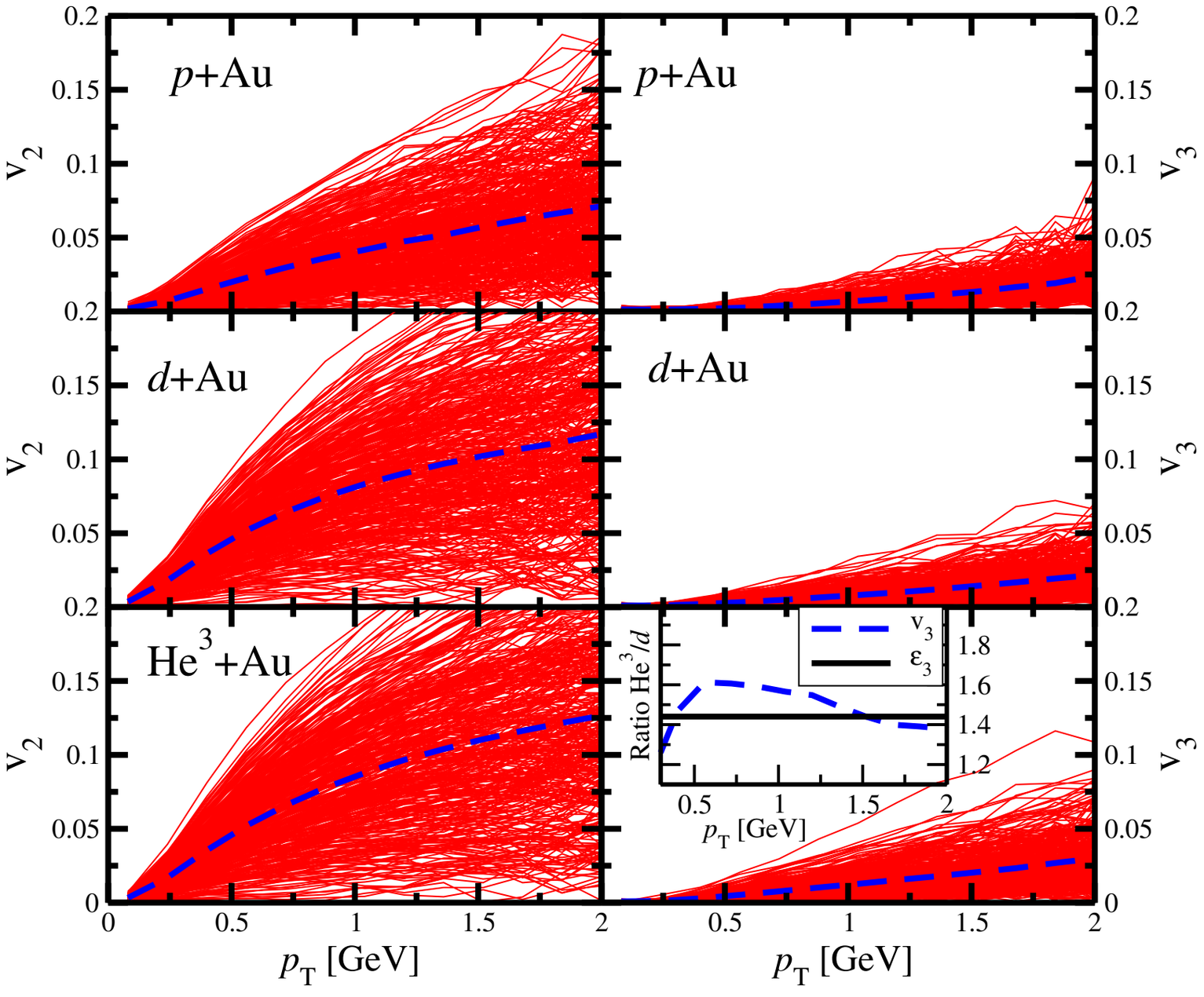


systematic variation of small nucleus ongoing at RHIC!

what can be learned from these small systems?

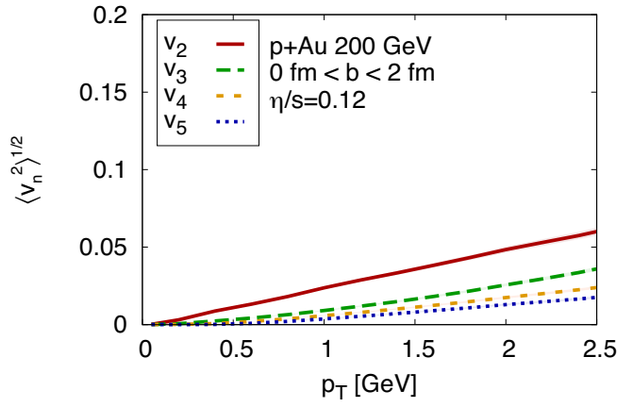
theory calculations, b<2fm

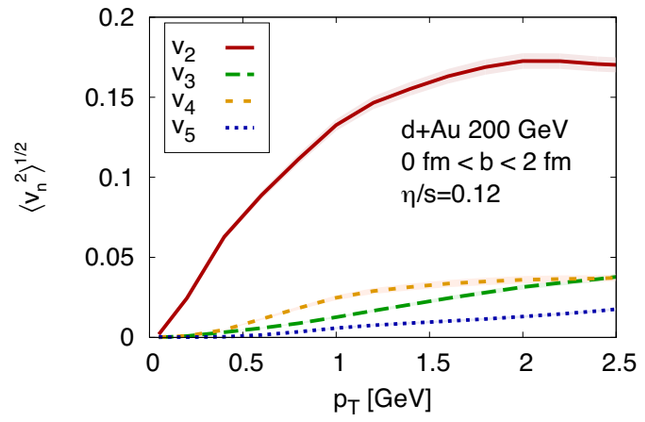
nucleons: Gaussians, σ = 0.7fm

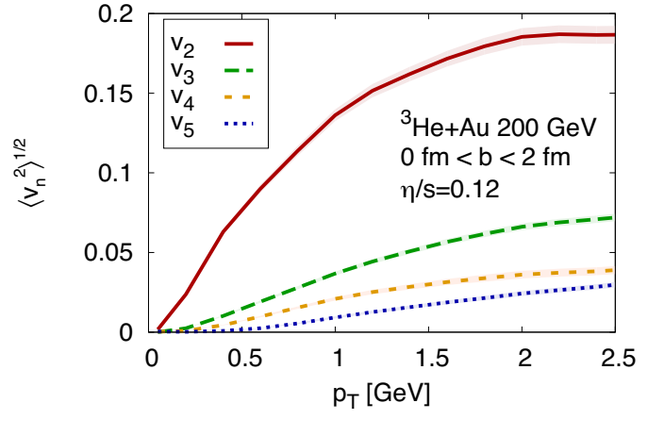


J.L. Nagle, et al PRL 113 112301

IP-Glasma + MUSIC (2+1d)



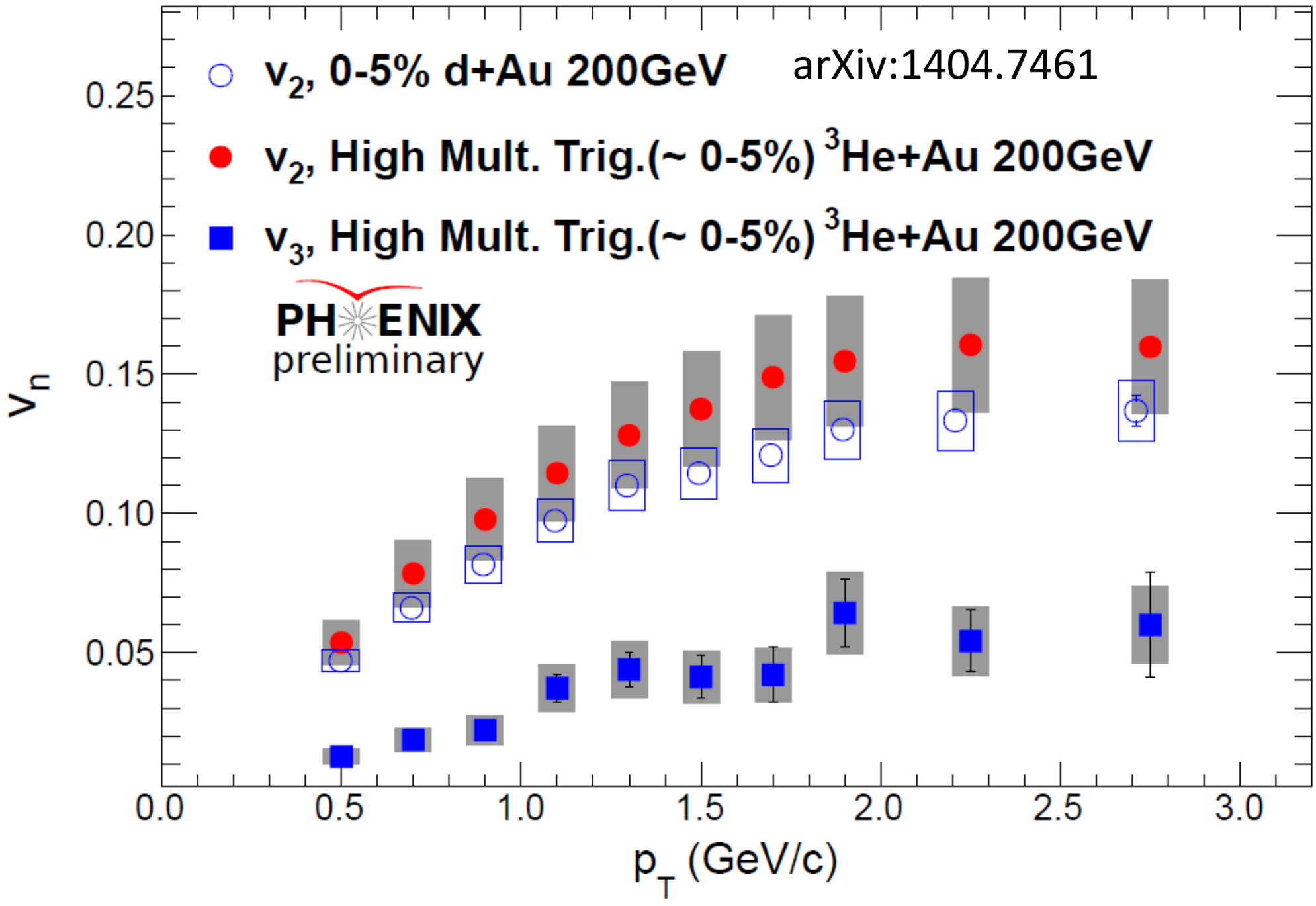




Schenke & Venugopalan: 1407.7557

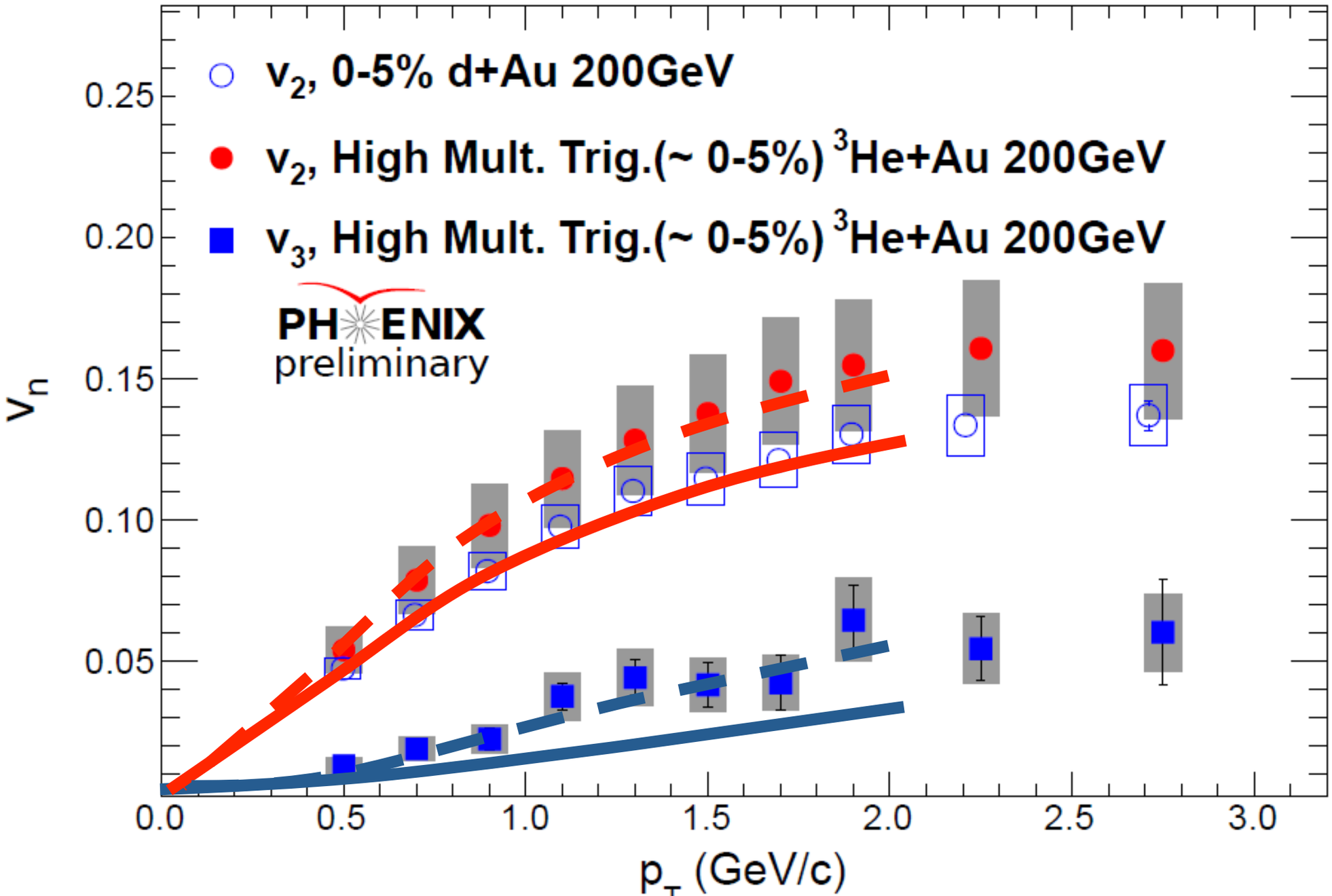
He3+Au: first data!

<Npart$_{He3Au}$> ~ 25



strong v2; v3 ~ hydrodynamic expectations

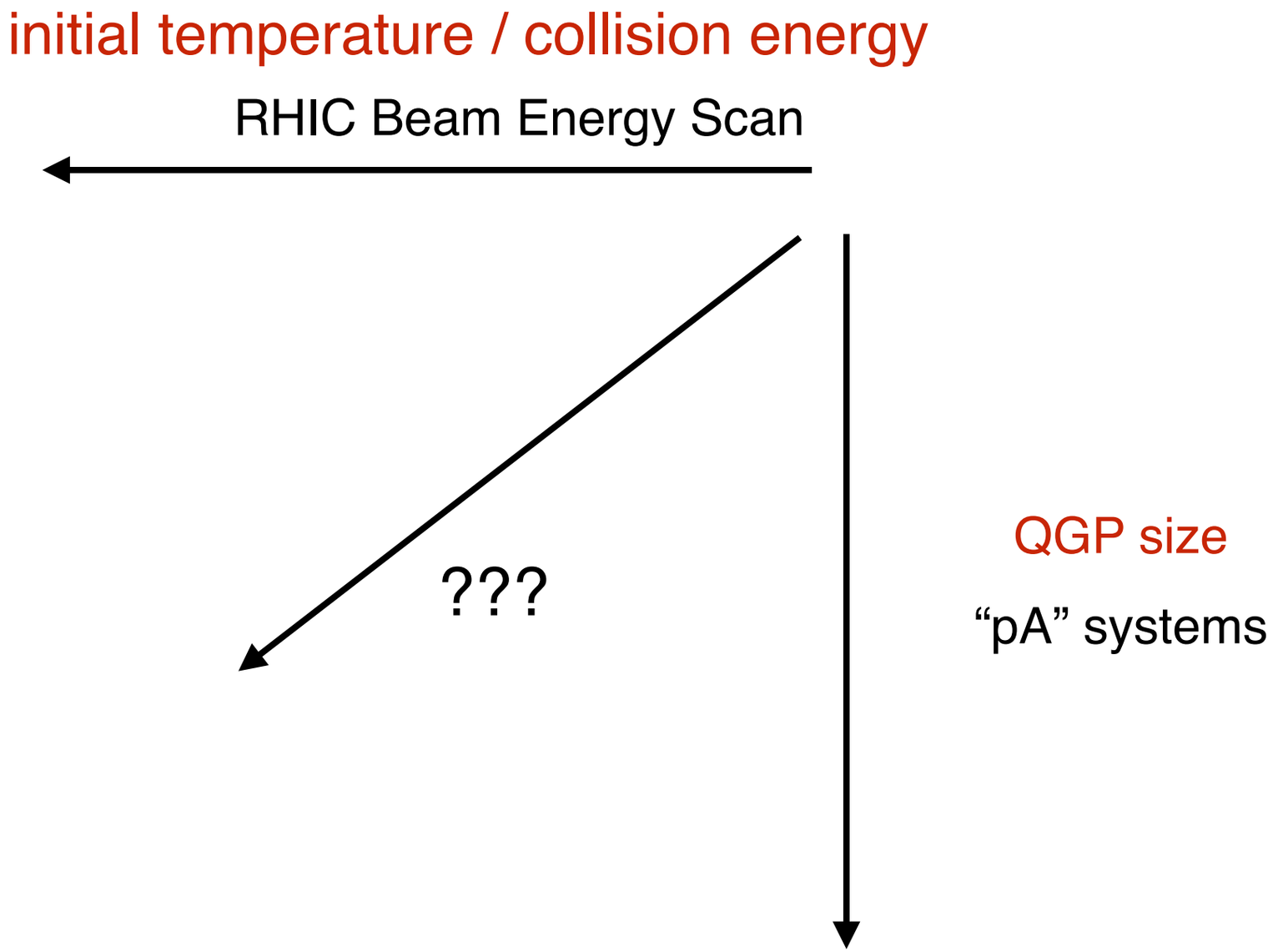
He3+Au: first data!



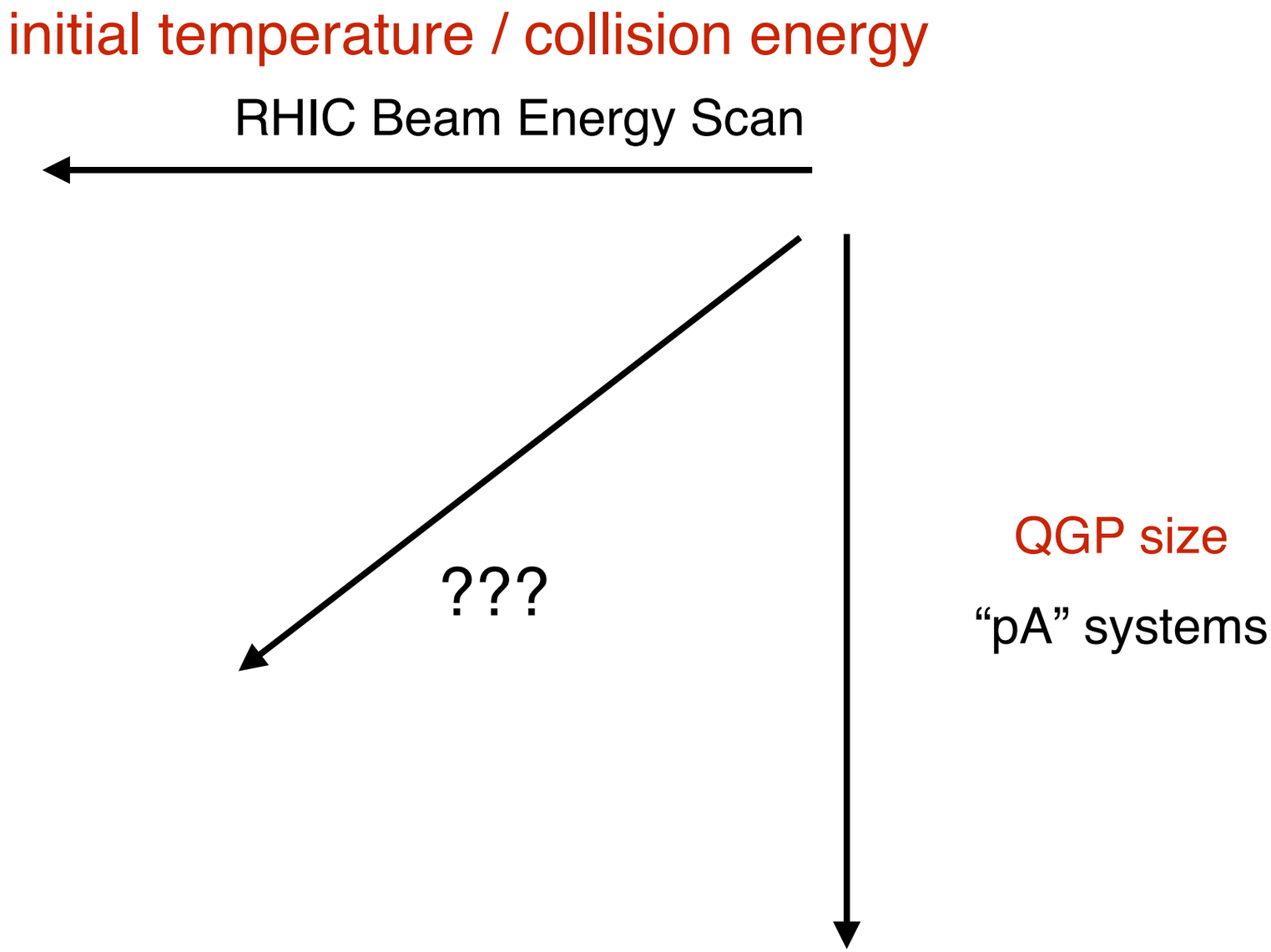
Glauber IS + Hydo + Cascade
PRL 113, 112301 (2014)

Same + Pre-flow
Romatschke, QM14

smaller and cooler?

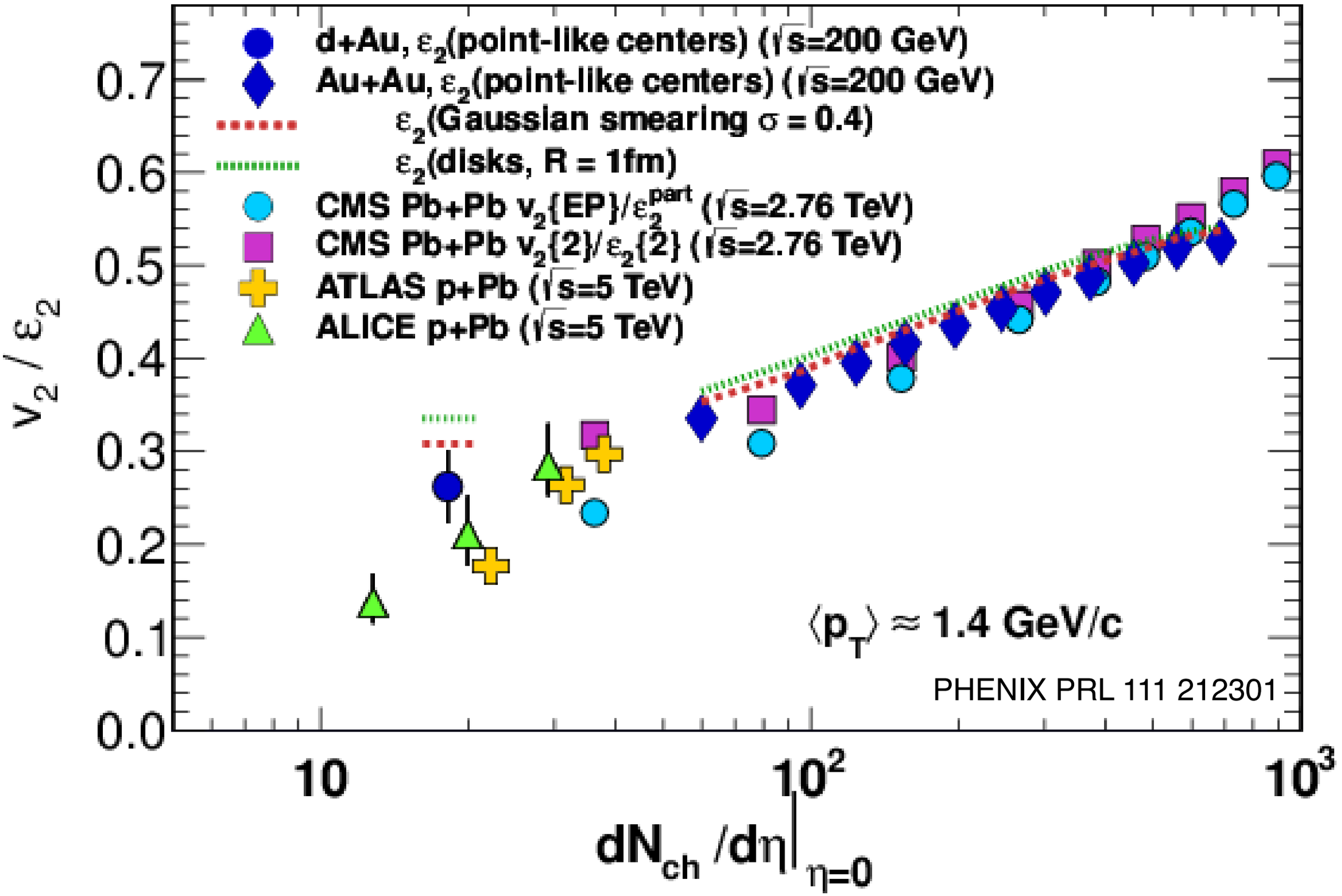


smaller and cooler?



pA collisions: how is the QGP formed, how does it thermalize, what is the initial energy density distribution?

dAu, pPb, AuAu & PbPb



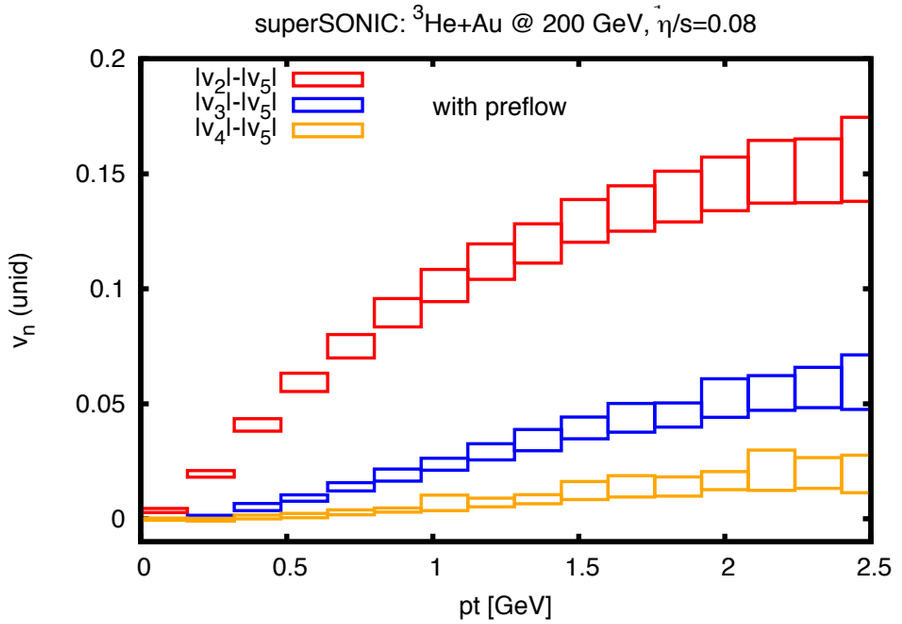
single trend, AA data understood as initial geometry + hydrodynamics

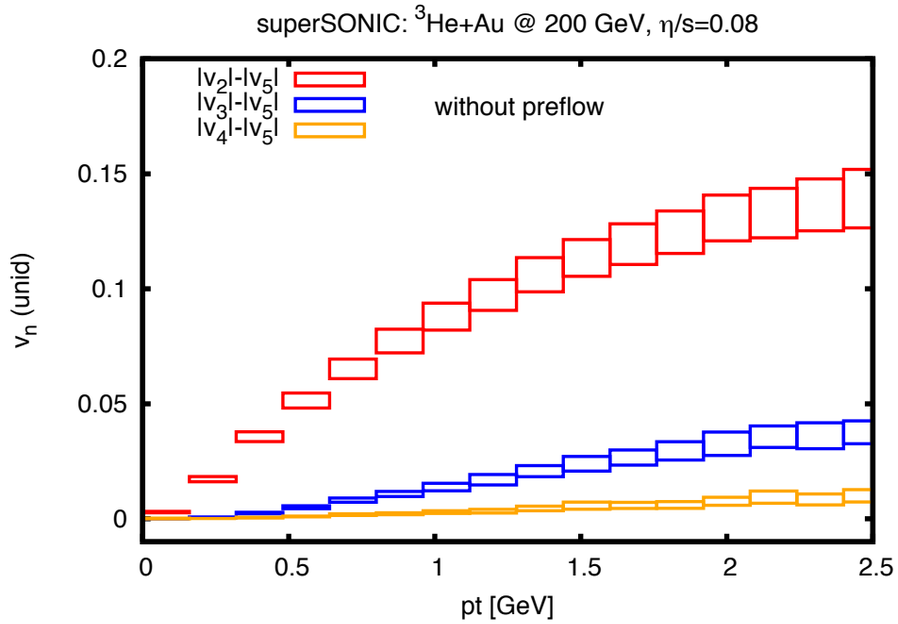
pre-equilibrium

Light-Heavy Ion Collisions: A window into pre-equilibrium QCD dynamics?

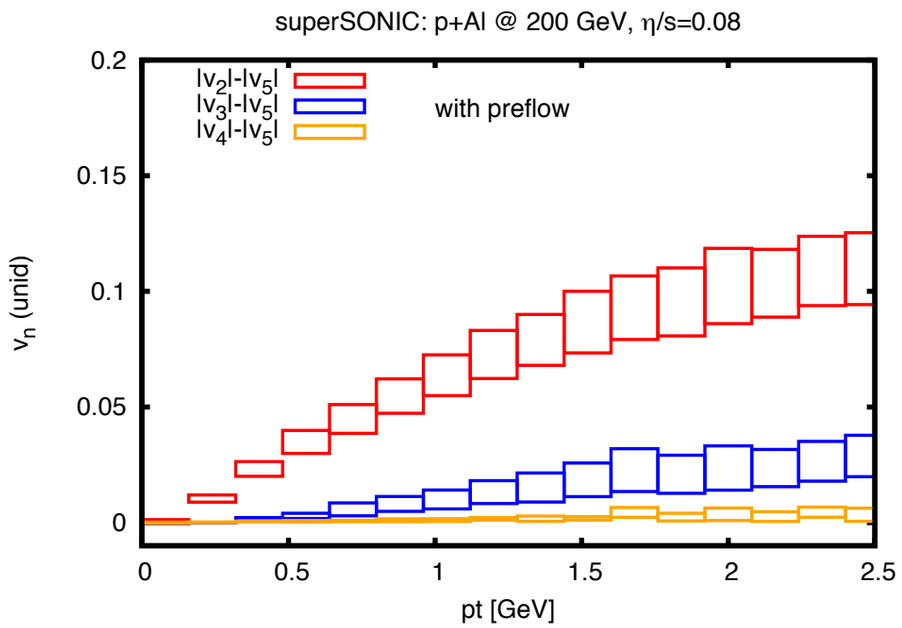
P. Romatschke[1]

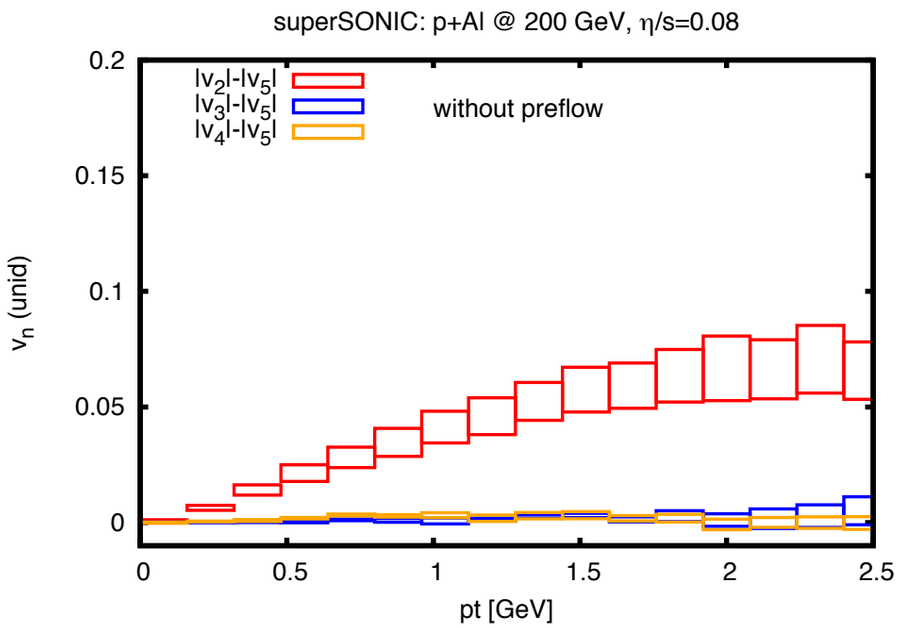
He3+Au





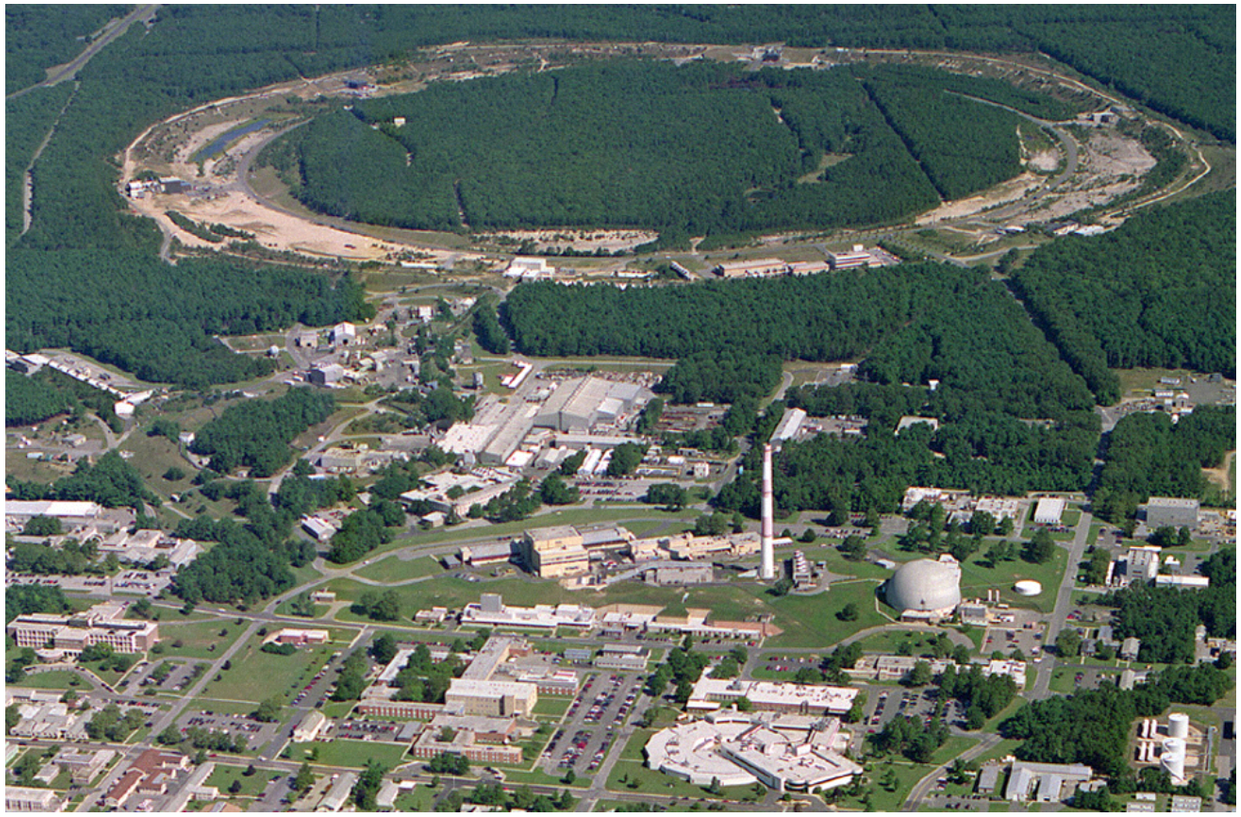
p+Al

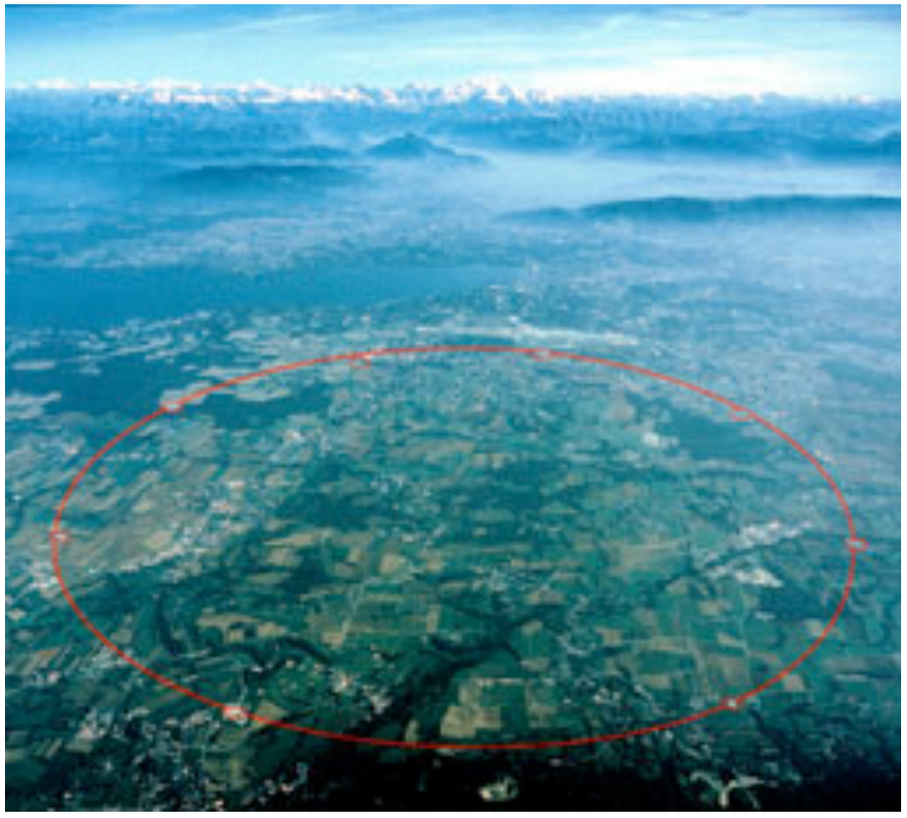




smaller systems, higher harmonics, lower energies: more sensitive to earliest times

Heavy Ion Programs at RHIC and LHC





the pA physics story is made possible by the simultaneous strong programs at both RHIC & the LHC

conclusions

- wealth of low pT measurements at both RHIC and LHC
  - from surprises to systematic measurements
- on track to understand more about the very young QGP with pA systems at RHIC
- data & theoretical developments at the same time drive progress
- eA: pA lessons drive interest in eA collisions with the EIC!

extras