Medium formation in small systems?

Selected recent results from PHENIX in d+Au and ^{3}He+Au

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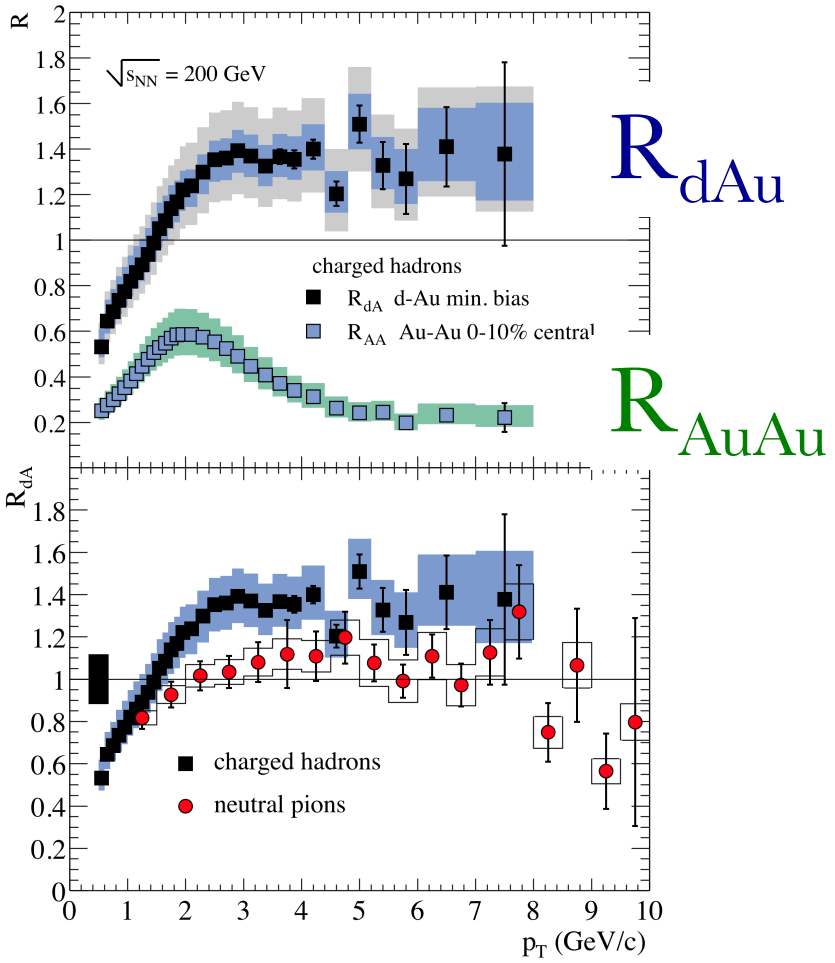
WWND 2015, Jan 26 Keystone CO

A funny thing happened…

…on the way to the control example.



R_{dAu}

R_{AuAu}

Idea: d+Au is just like N+N except for initial-state/ CNM effects on partons.

2003: d+Au does not show jet quenching! There was much rejoicing!

But: That simple picture is breaking down…

PRL 91, 072303 (2003)

"A search for possible evidence of a created medium being formed in small collision systems, e.g. H+A and He+A at RHIC and LHC energies"

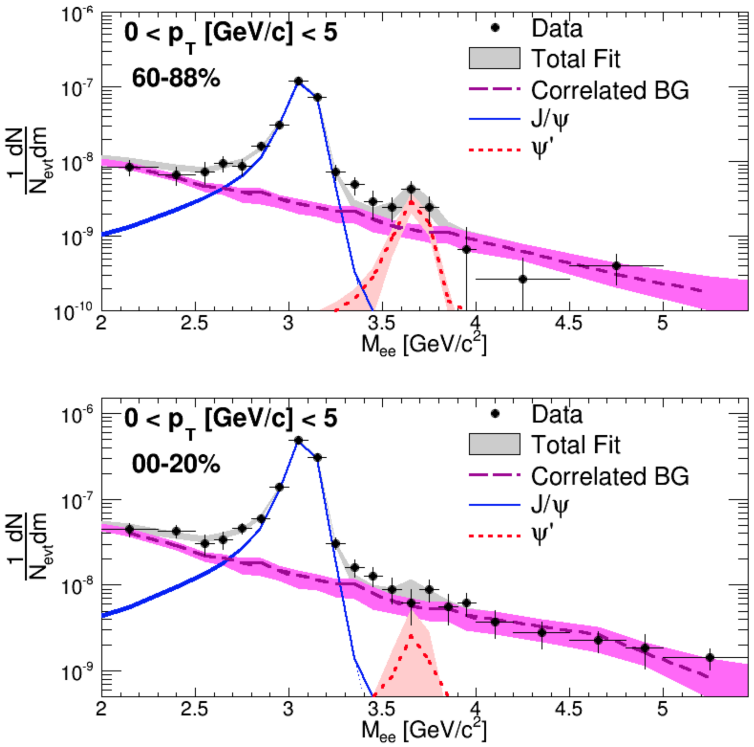
or

"A search for possible evidence of a created medium being formed in small collision systems, e.g. H+A and He+A at RHIC and LHC energies"

or

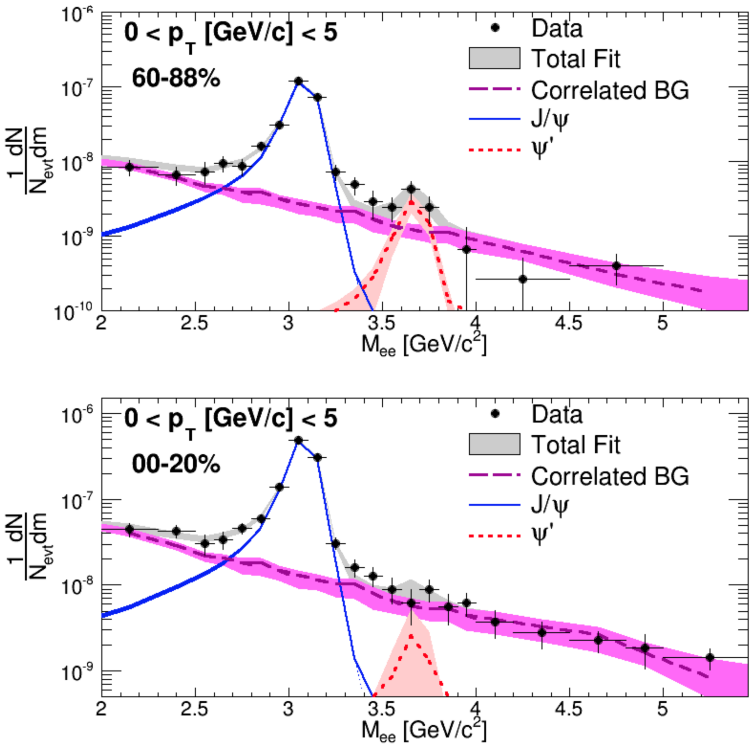
"Small Medium At Large"

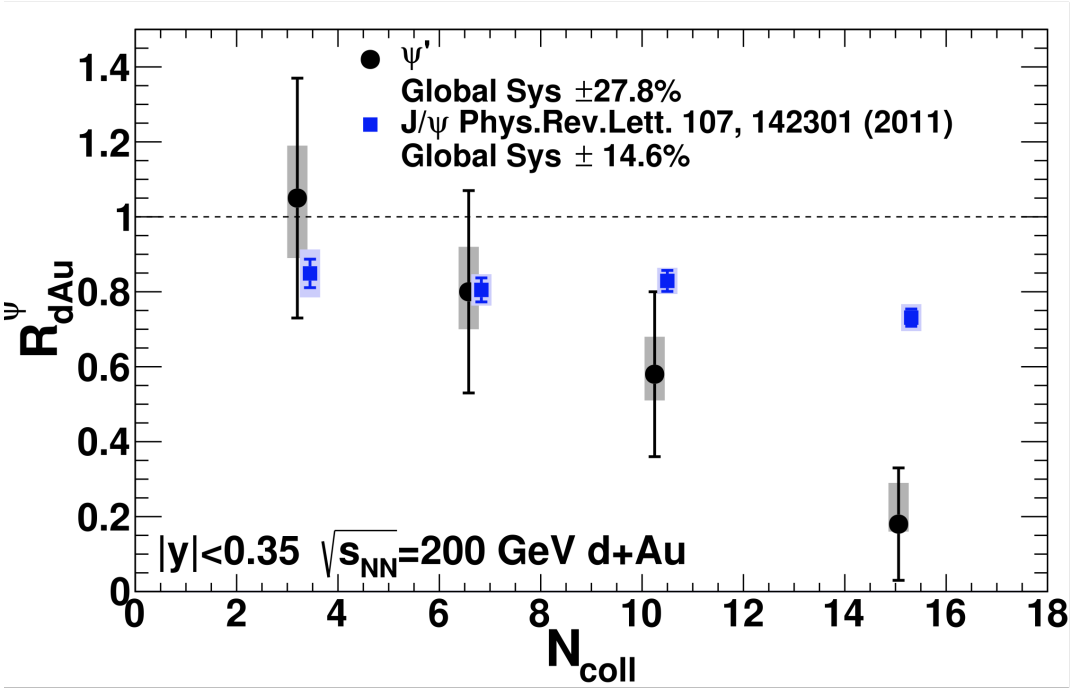
Psi' (over?) suppression in d+Au



PRL 111, 202301 (2013)

Psi' (over?) suppression in d+Au





Relative suppression of Psi' compared to J/Psi – is it a created medium effect?

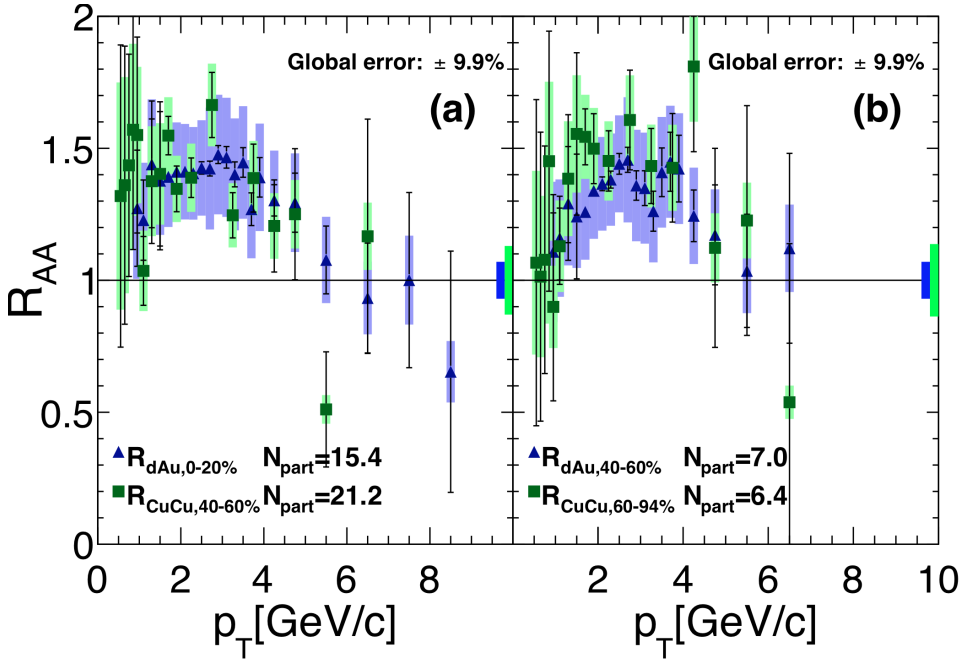
(Also seen by ALICE in p+Pb)

PRL 111, 202301 (2013)

Charm boost follows N_{Part}

Heavy-flavor electrons in three systems

d+Au meets Cu+Cu



arXiv:1310.8286

Charm boost follows N_{Part}

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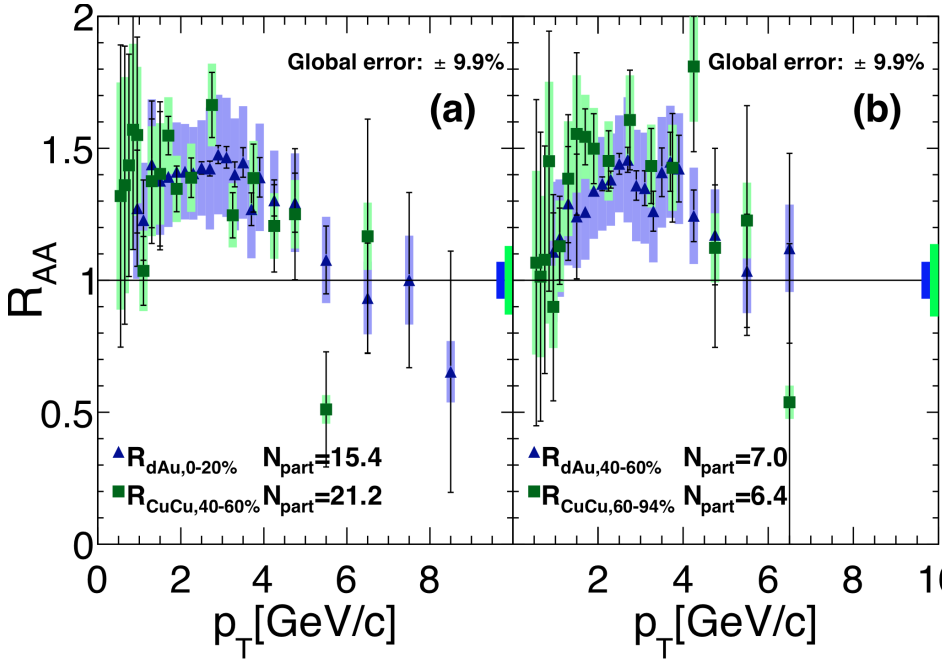
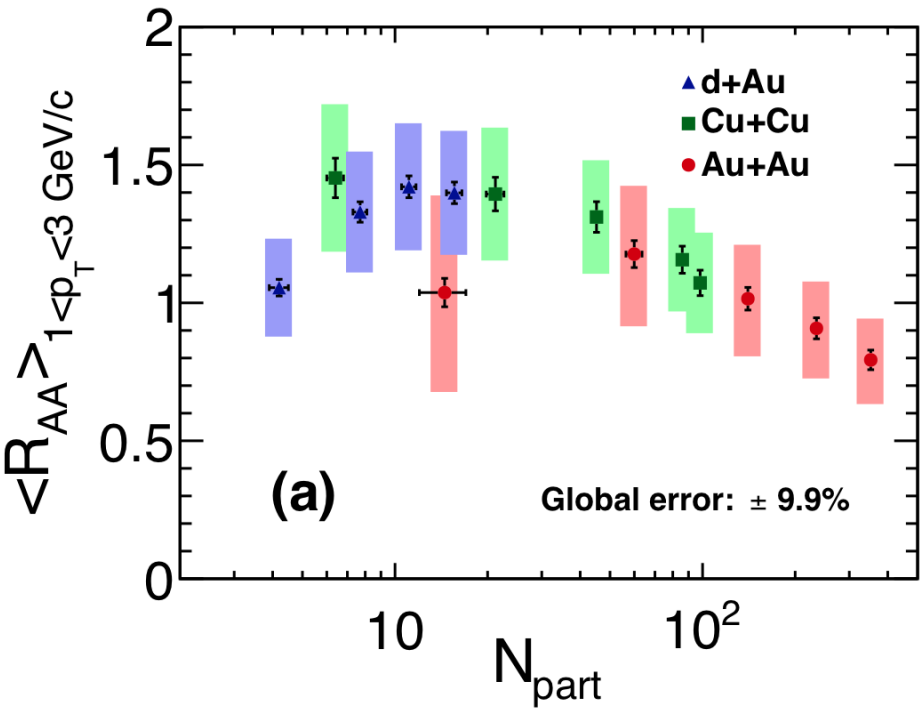
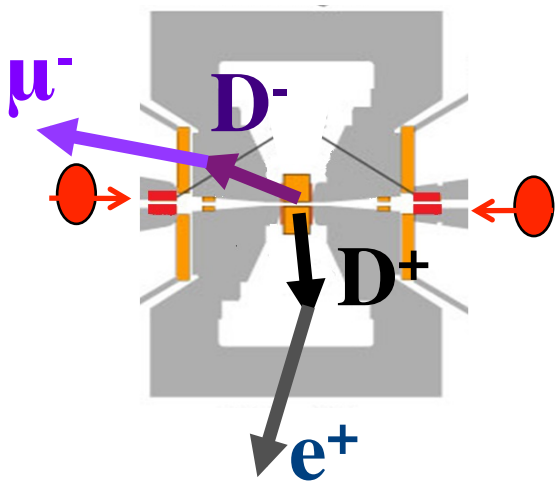




arXiv:1310.8286

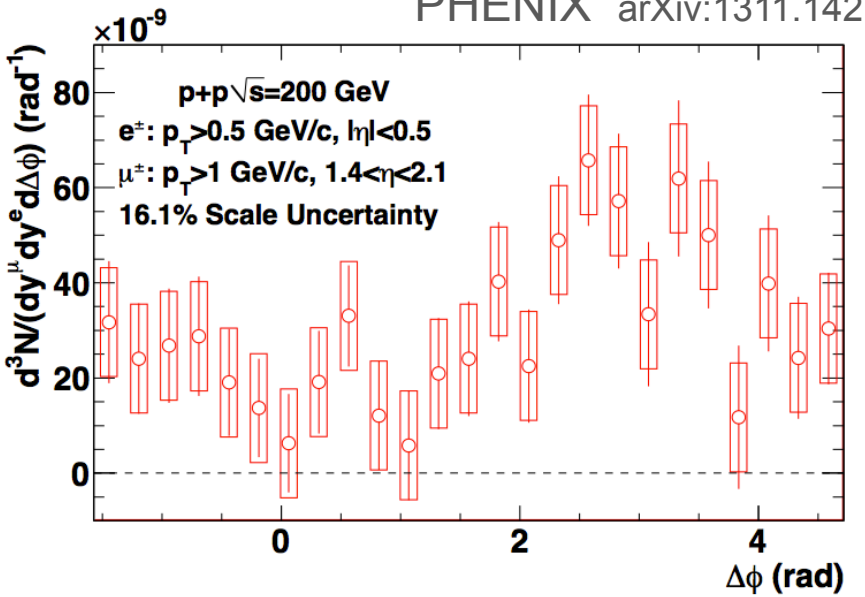
Single charm is pushed but never destroyed; is trend with N_{Part} indicative of medium effect?

Open charm de-correlation

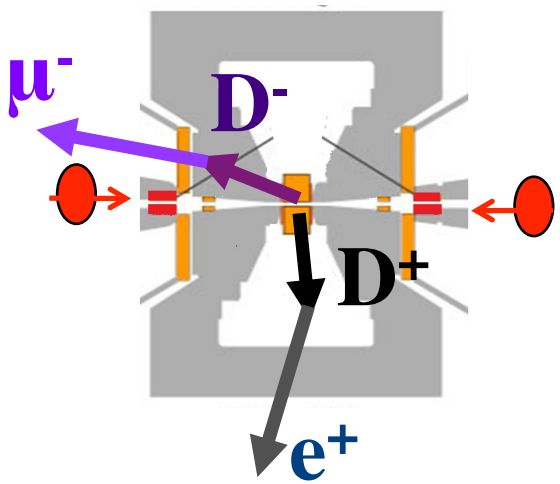


PHENIX arXiv:1311.1427

p+p



Open charm de-correlation



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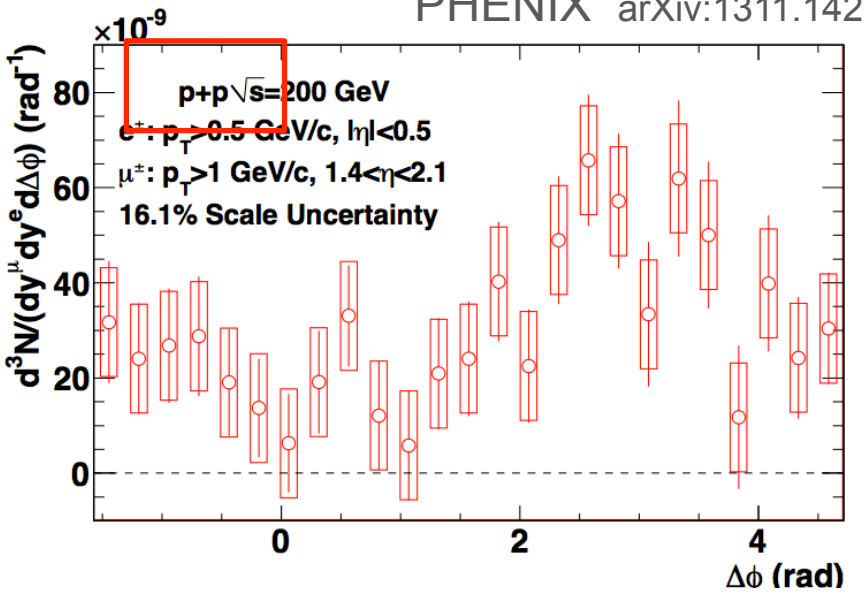
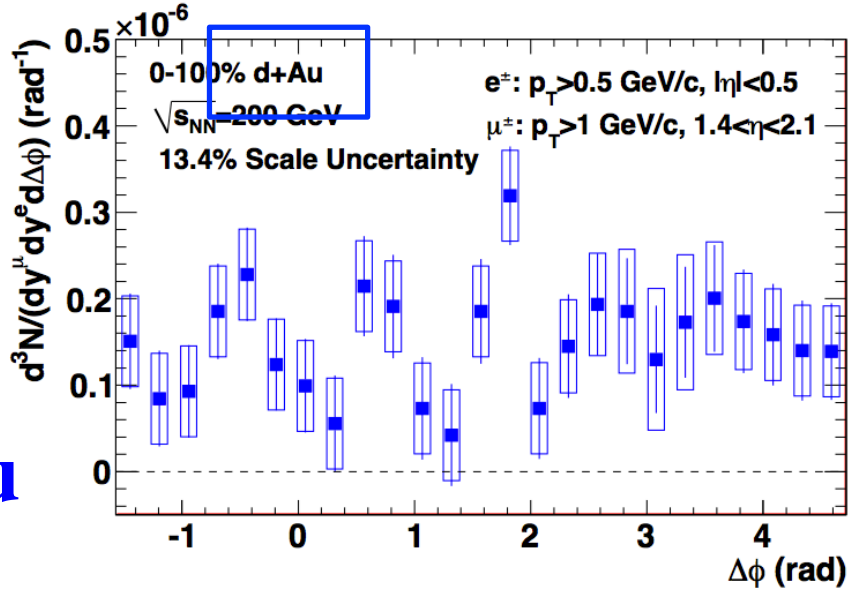
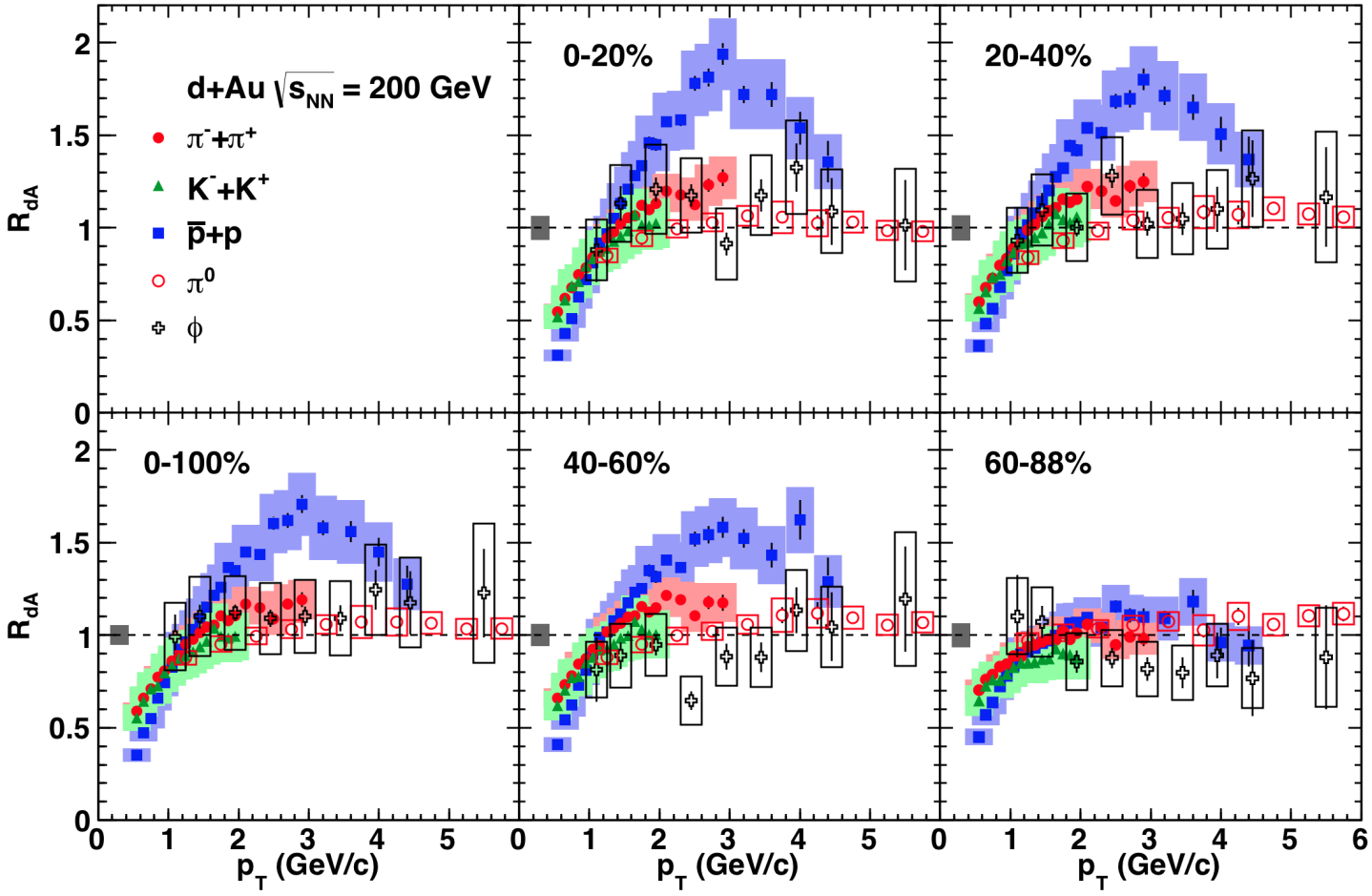


d+Au



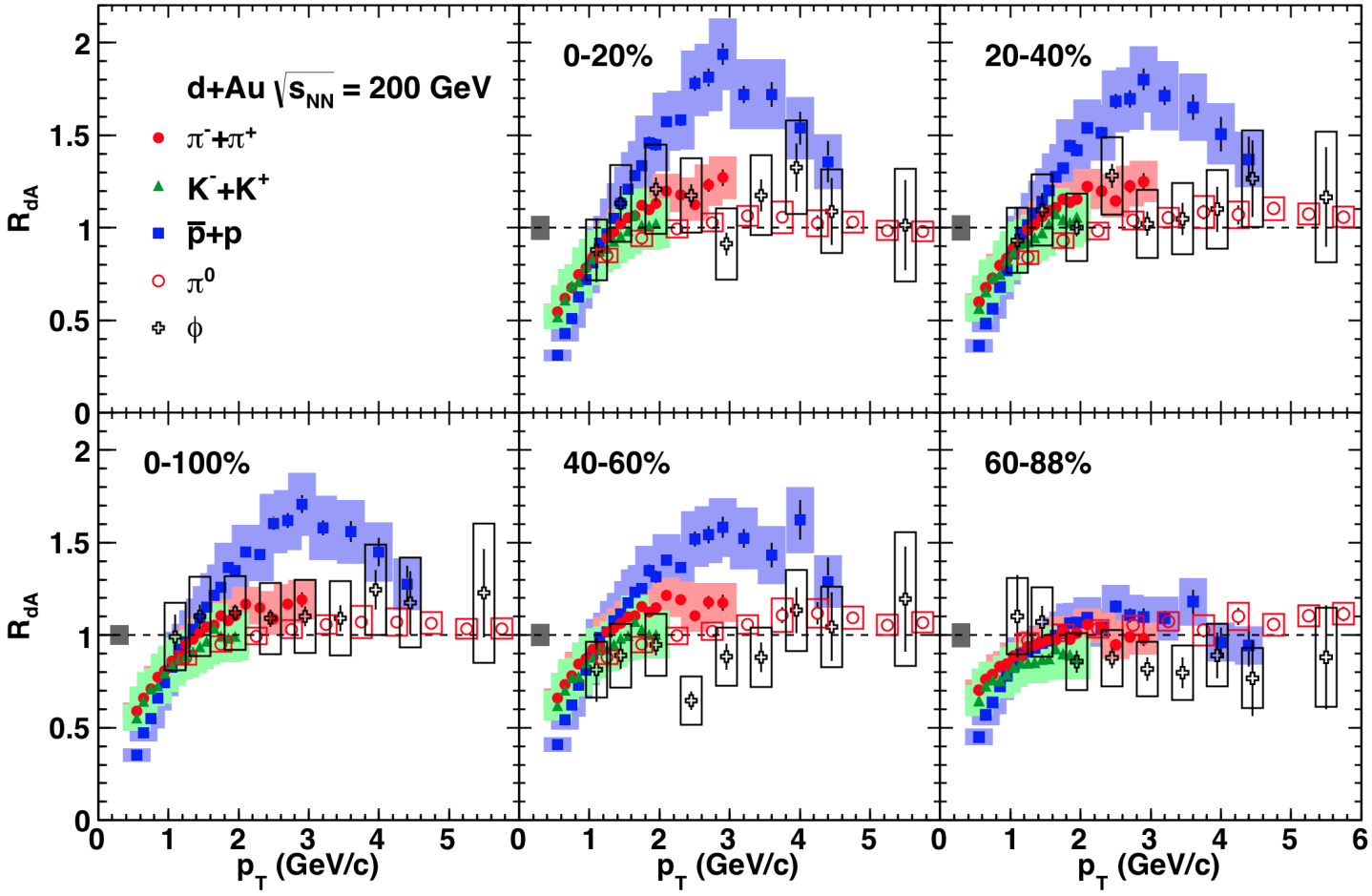
Back-to-back correlation of associated charm is decreased in d+Au; what is the site of any re-scattering?

Light hadrons Cronin rides again?



Phys. Rev. C 88, 024906 (2013)

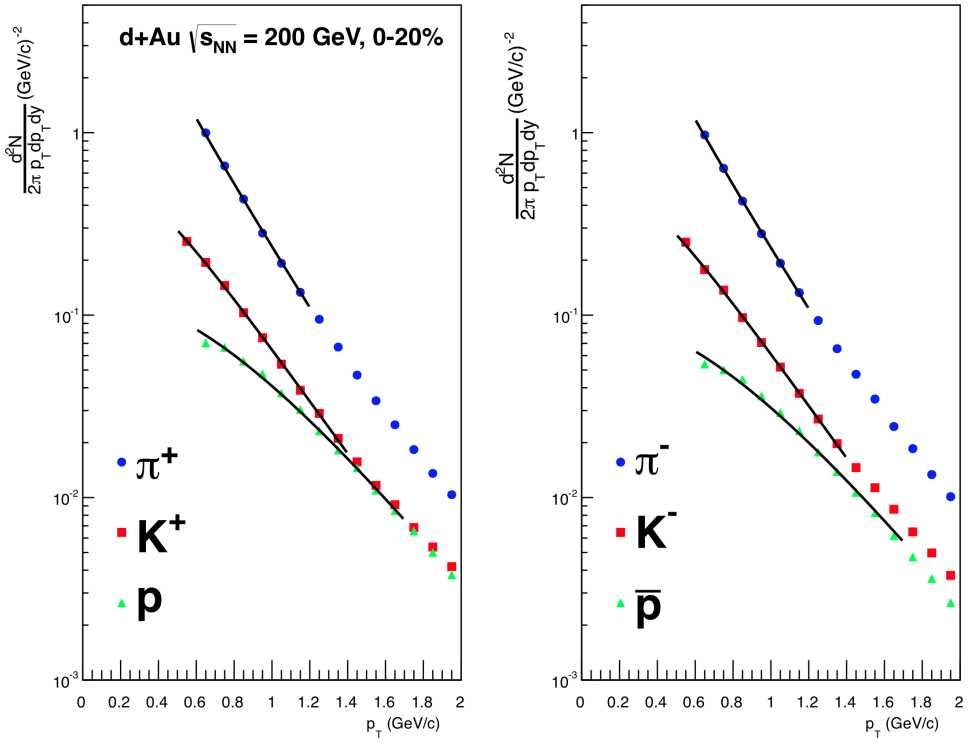
Light hadrons Cronin rides again?



Dramatic baryon enhancement: recombination from a medium?

Phys. Rev. C 88, 024906 (2013)

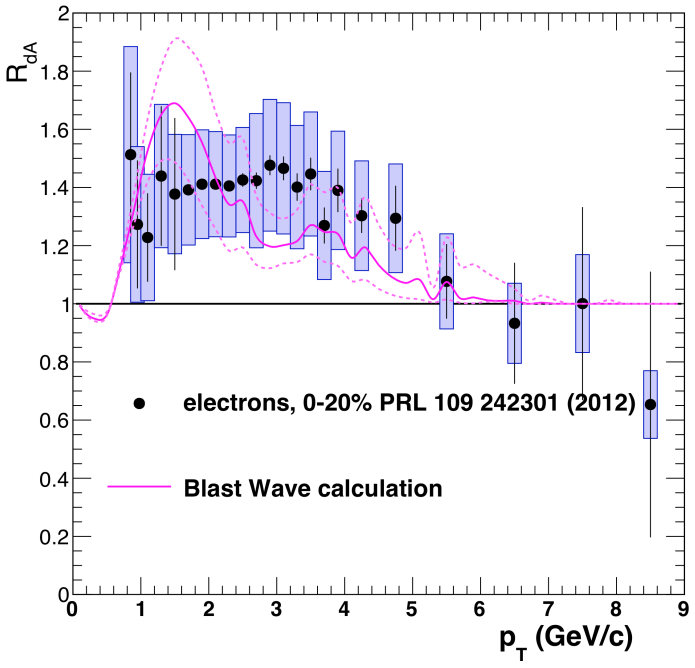
Radial flow in d+Au?



Blast-wave fits to identified light hadron spectra

A. Sickles, Phys. Lett. B731 51-56 (2014), "Possible Evidence for Radial Flow of Heavy Mesons in d+Au Collisions"

Was it the source of the Cronin effect?



Heavy-flavor (charm) electron R_{dAu}

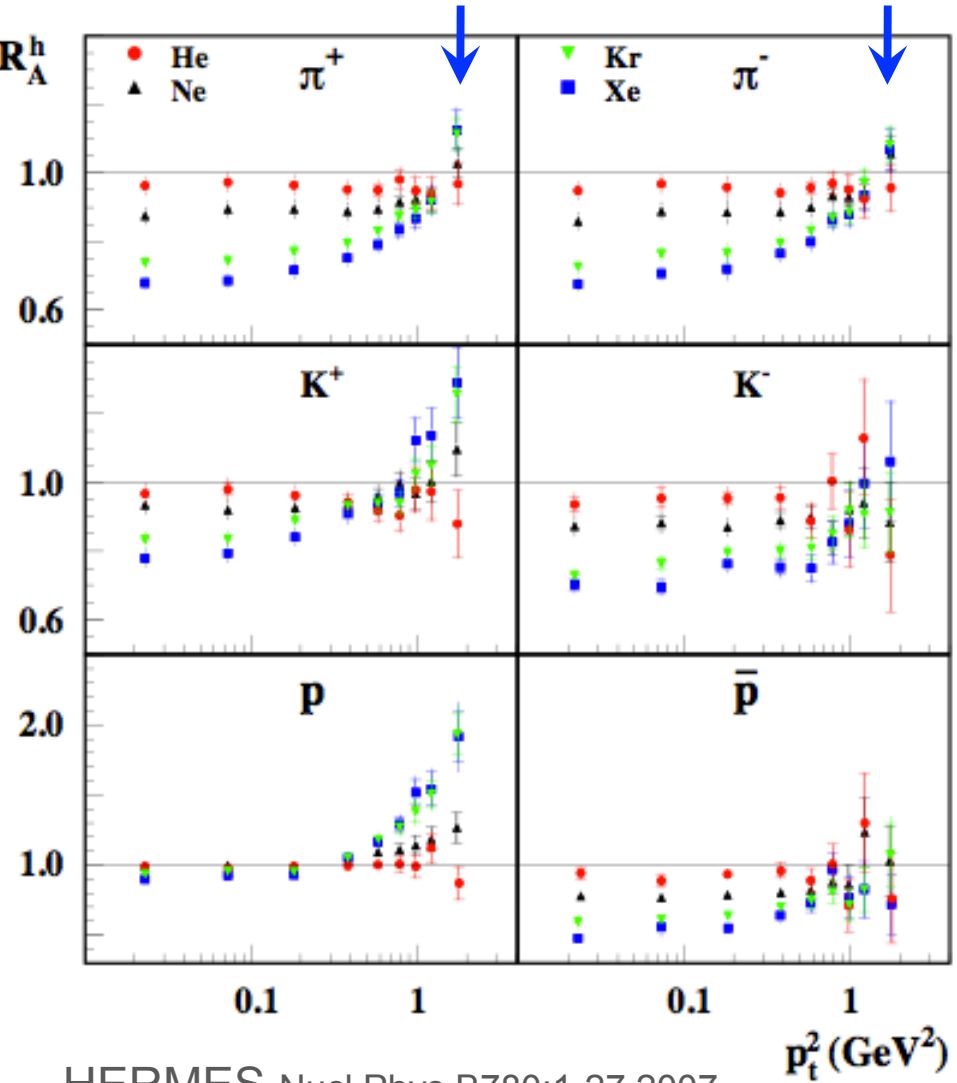
Caution: Cronin rides in *e*+A

Enhancement of (+) hadron yields at $p_T \sim$ 1-1.5 GeV/c is seen with increasing A in e+A.

Pattern is *sort of* like radial flow?

Moral: Need to look at small systems with full, proper models

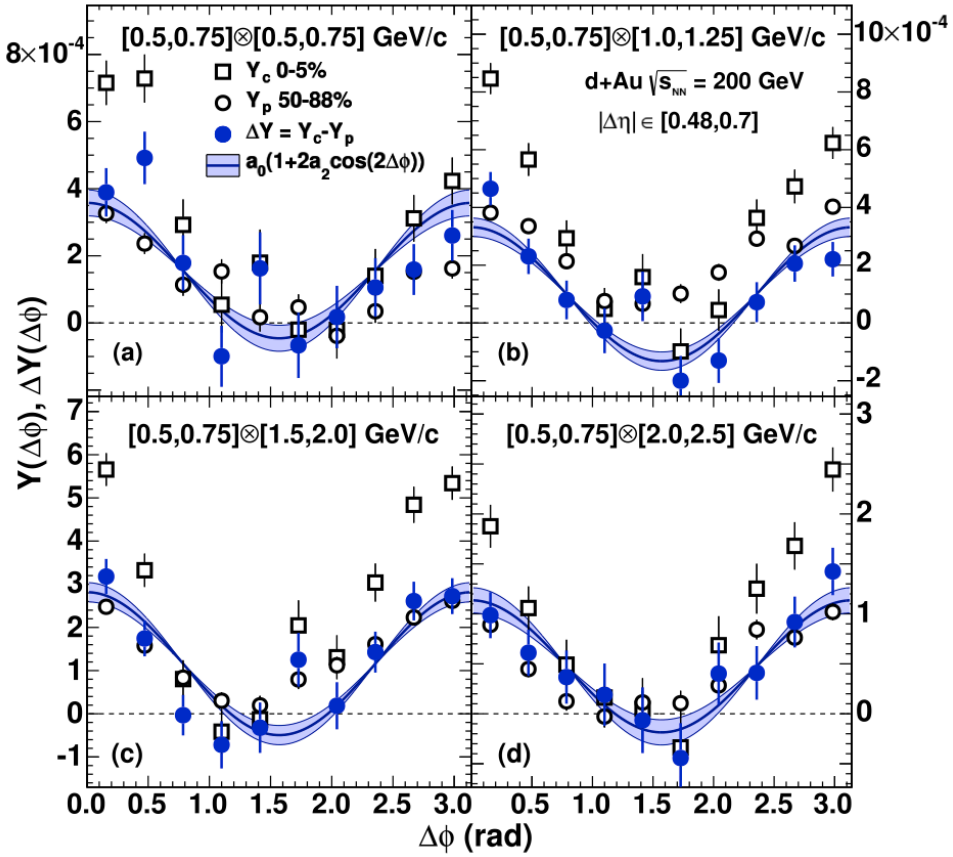
R_{eA}



HERMES Nucl.Phys.B780:1-27,2007

Elliptic flow in d+Au?

Charged pairs at mid-rapidity over $\Delta\phi$; central, peripheral and difference



PRL 11, 212301 (2013)

Elliptic flow in d+Au?

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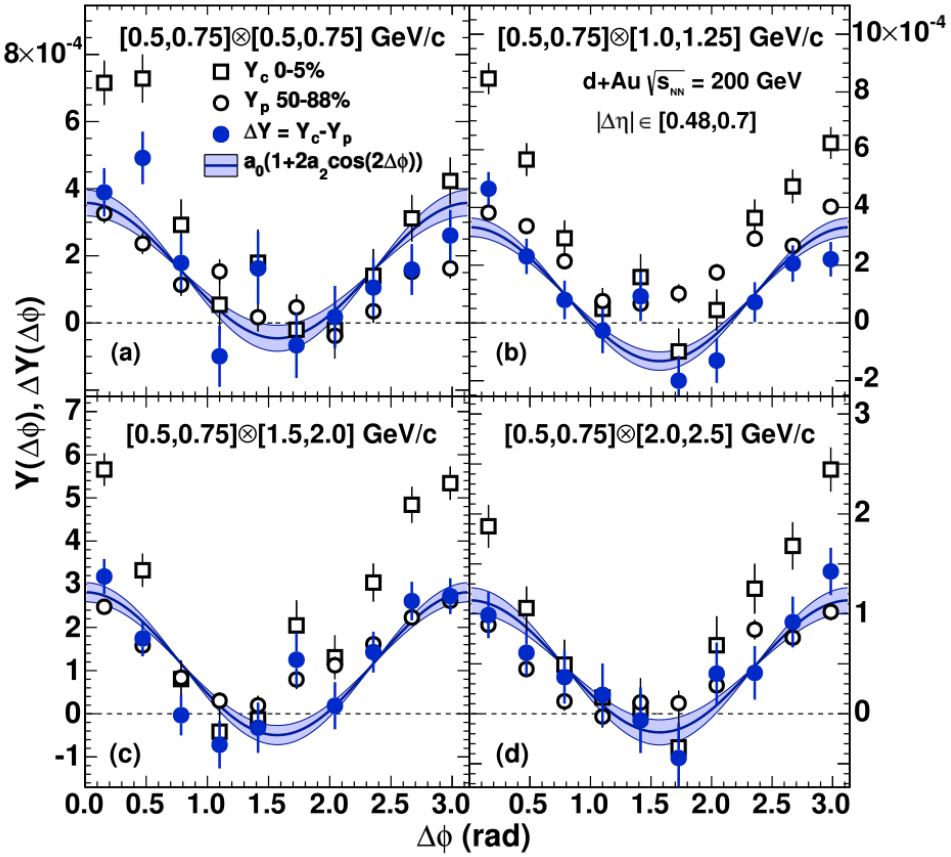
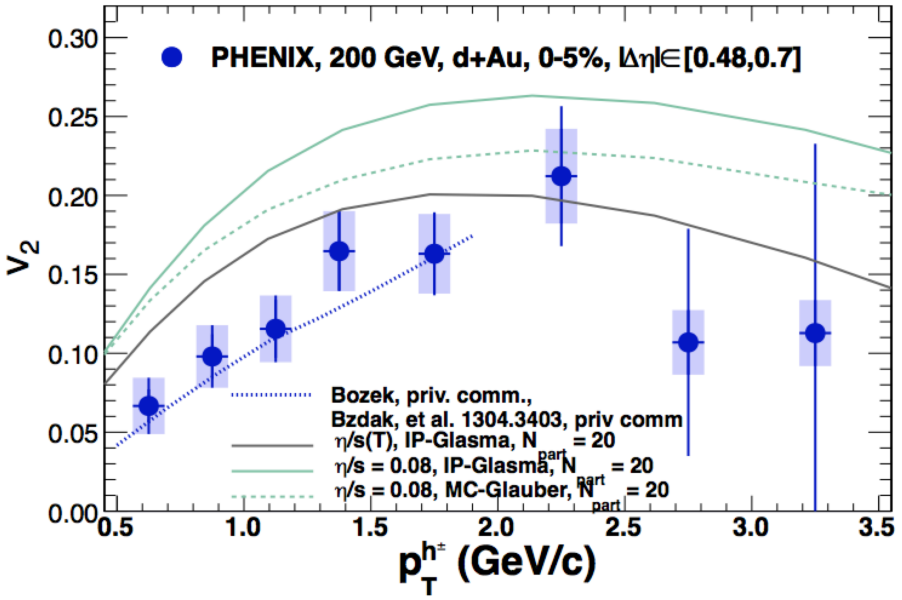


PRL 11, 212301 (2013)

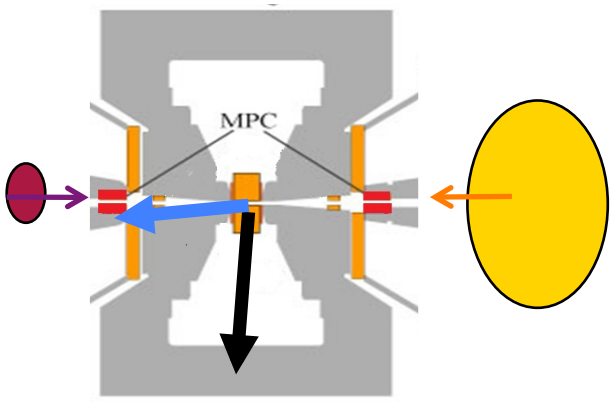


Quadrupole anisotropy allows extraction of singles v_2

Caution: C-P subtraction may not play well with jet modifications

Near-side "ridge" in d+Au?

Pair central arm tracks with MPC-S, $\Delta\eta \sim 3.4$



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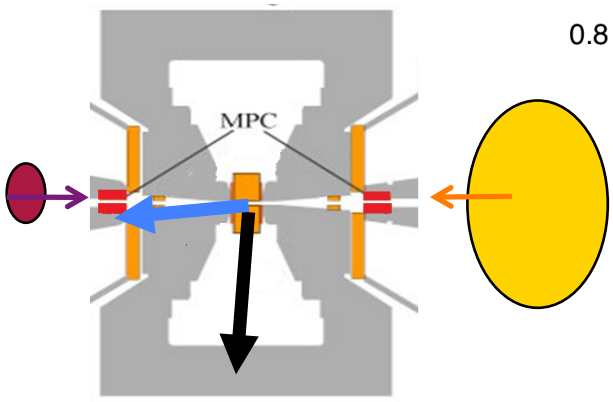
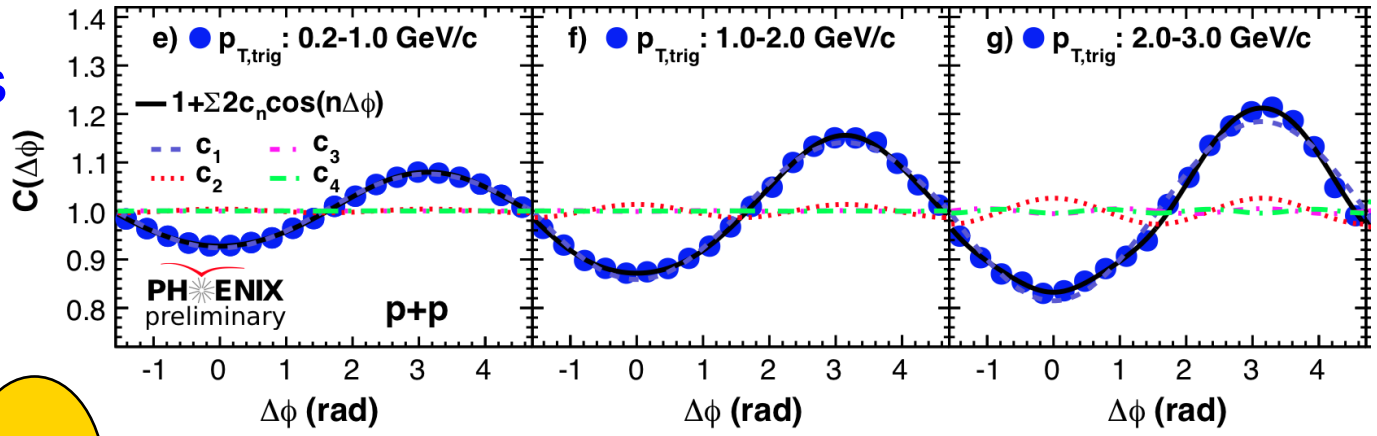
Pair central arm tracks with MPC-S, $\Delta\eta \sim 3.4$

p+p min-bias



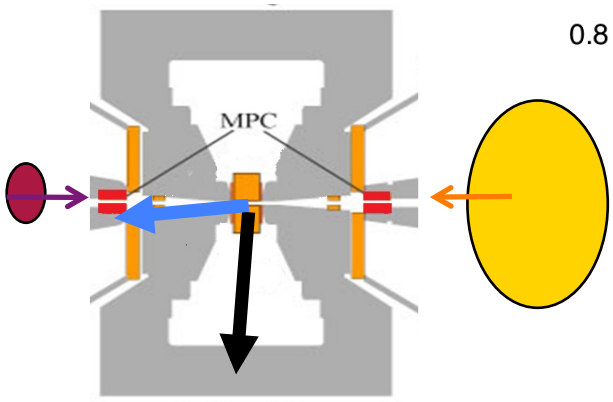


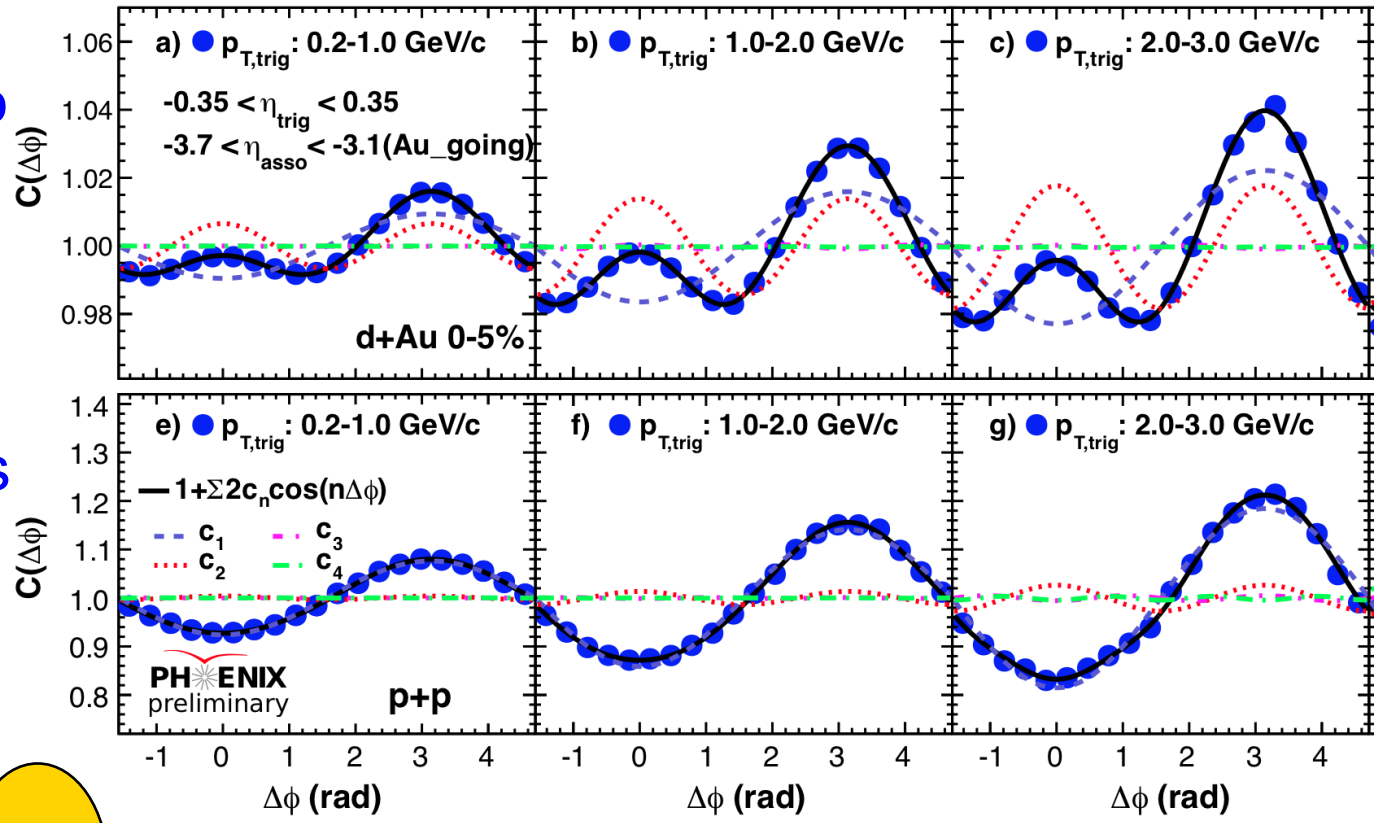
Near-side "ridge" in d+Au?

Pair central arm tracks with MPC-S, $\Delta\eta \sim 3.4$

d+Au 0-5%

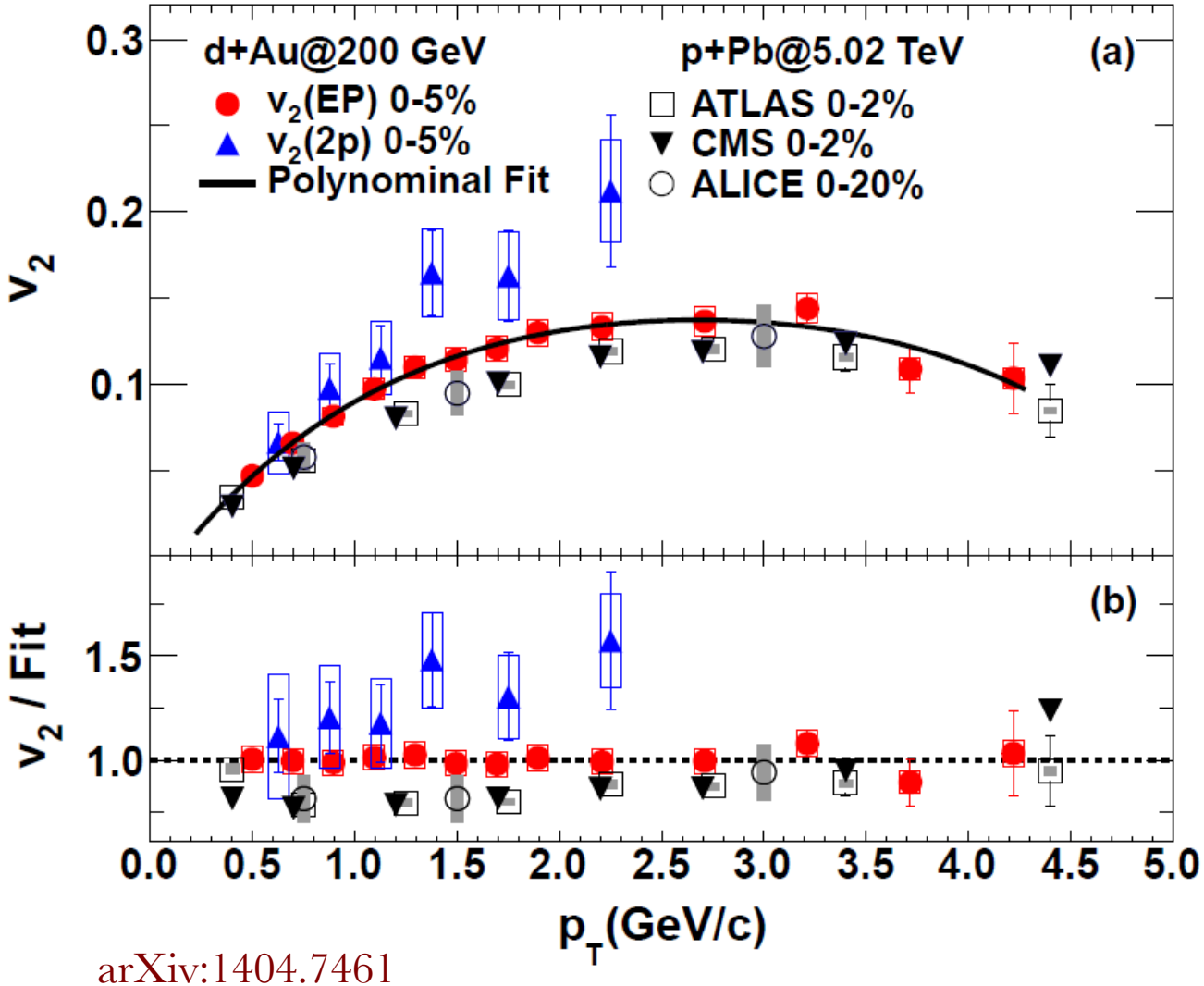
p+p min-bias





arXiv:1404.7461

v_2(EP) of charged hadron in 0-5% d+Au

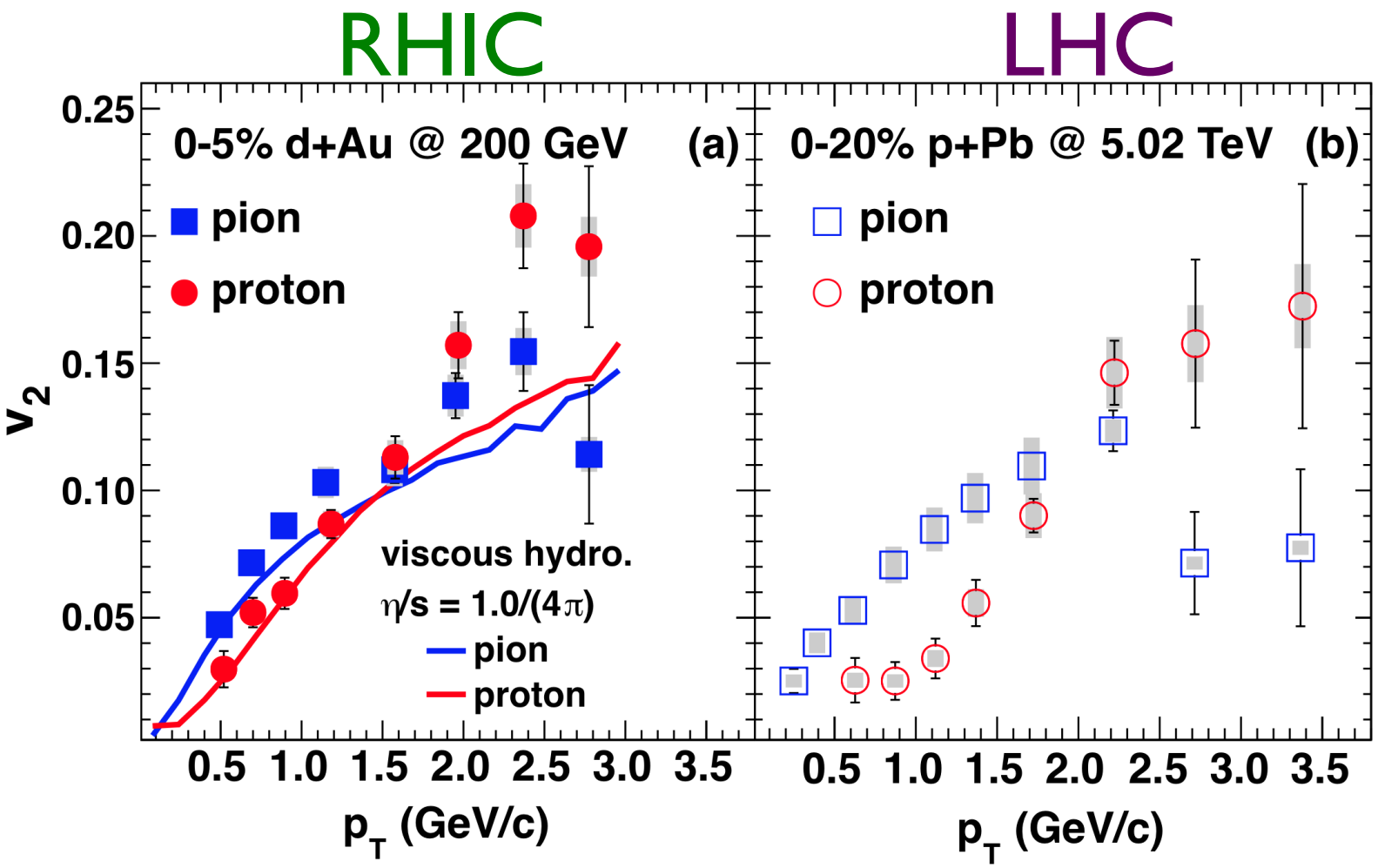


arXiv:1404.7461

Hydro-like shape in $v_2(p_T)$?

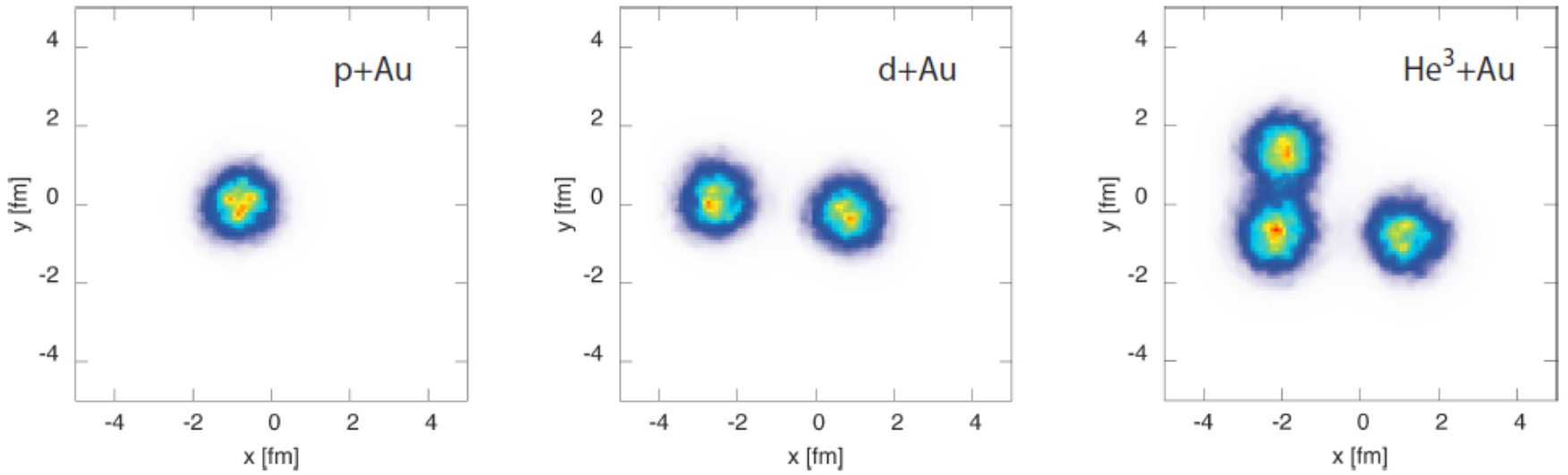
No visible v_3 over long range, unlike LHC p+Pb.

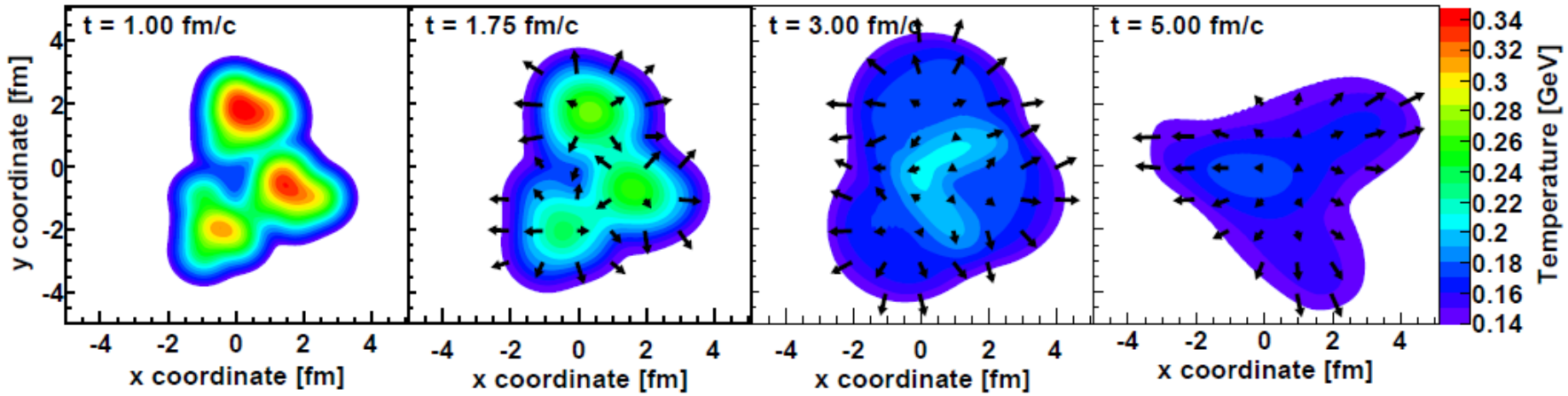
Mass splitting of v_2(EP)



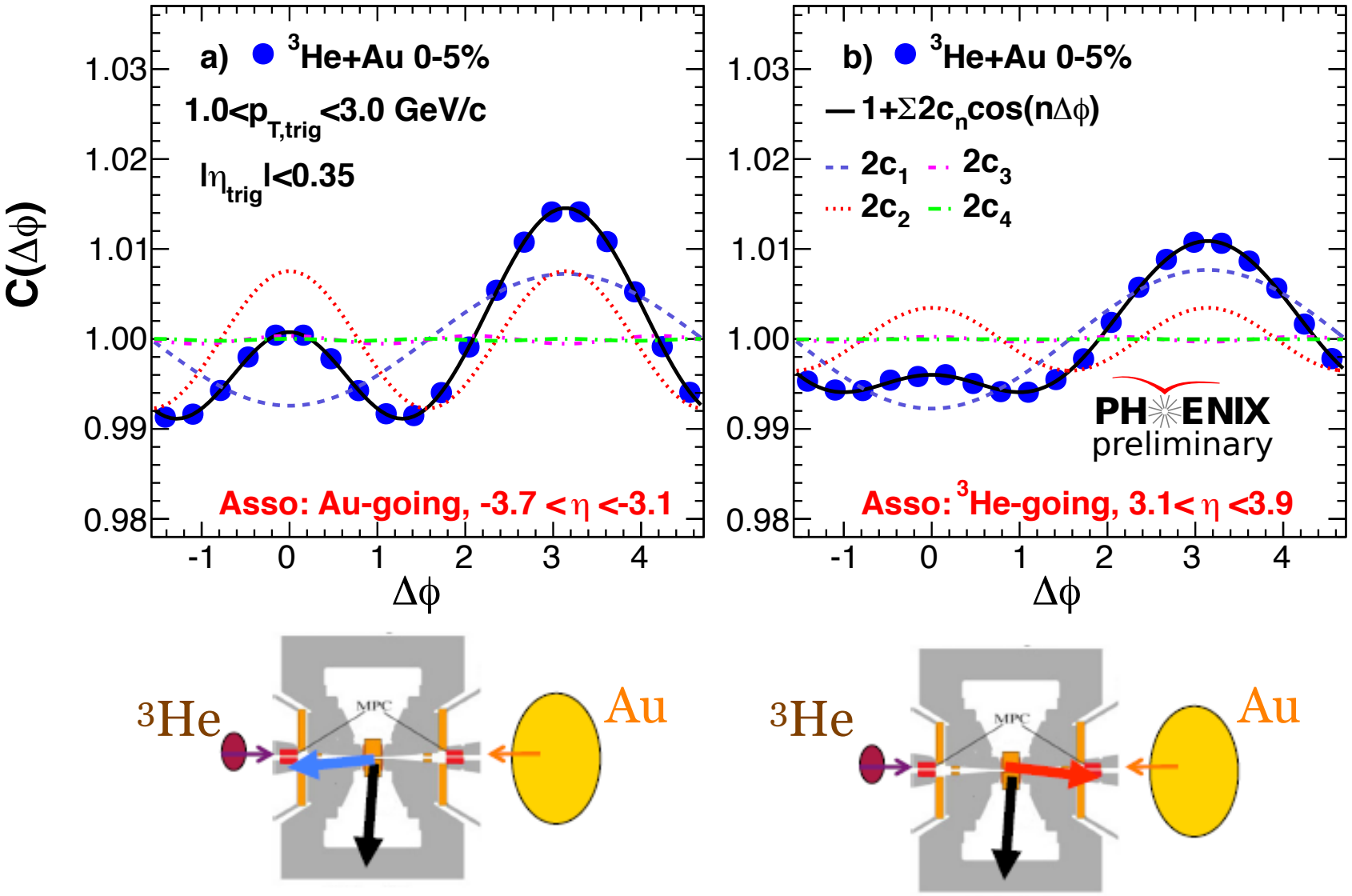
arXiv:1404.7461

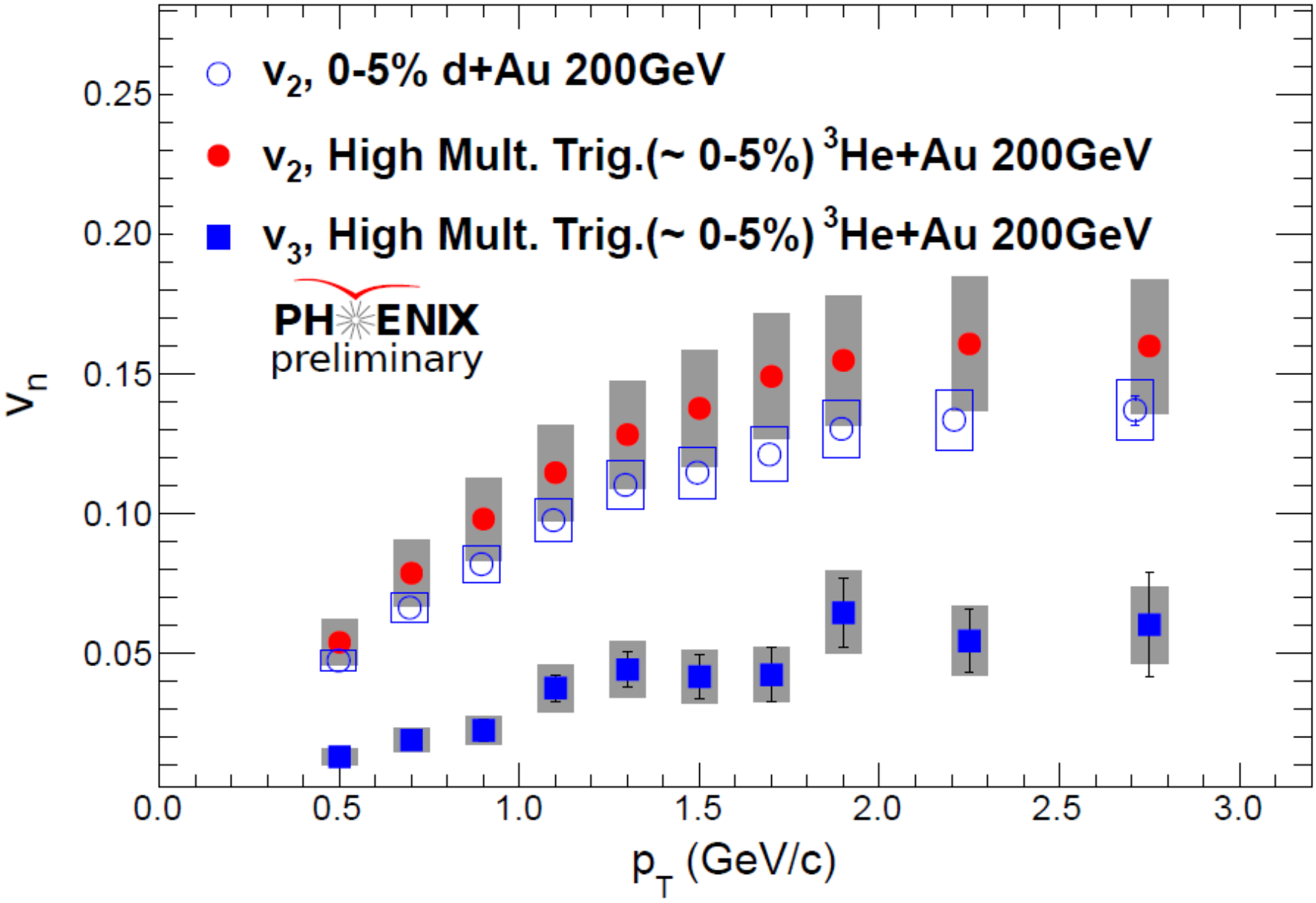
Geometry in small systems

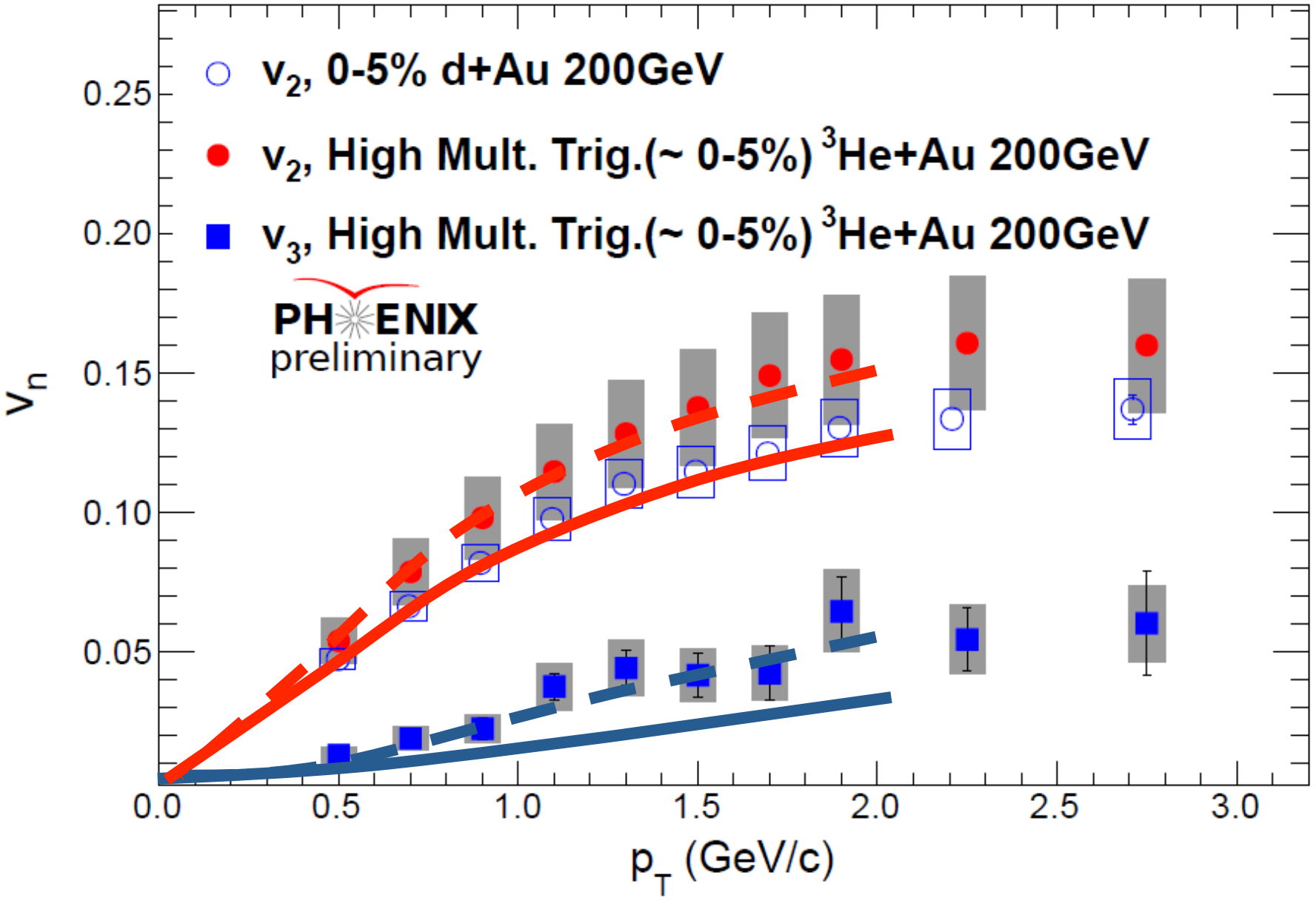




Long-range correlation in ^{3}He+Au




v2, 0-5% d+Au 200GeV
v2, High Mult. Trig.(~ 0-5%) 3He+Au 200GeV
v3, High Mult. Trig.(~ 0-5%) 3He+Au 200GeV
PHENIX
preliminary
vn
pT (GeV/c)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0.05
0.10
0.15
0.20
0.25


v2, 0-5% d+Au 200GeV
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PHENIX
preliminary
vn
pT (GeV/c)
0.25
0.20
0.15
0.10
0.05
0.0
0.5
1.0
1.5
2.0
2.5
3.0

Summary: Hints and Allegations

Small systems at RHIC and LHC have interesting physics beyond CNM effects – some observables are highly suggestive of a created medium being formed.

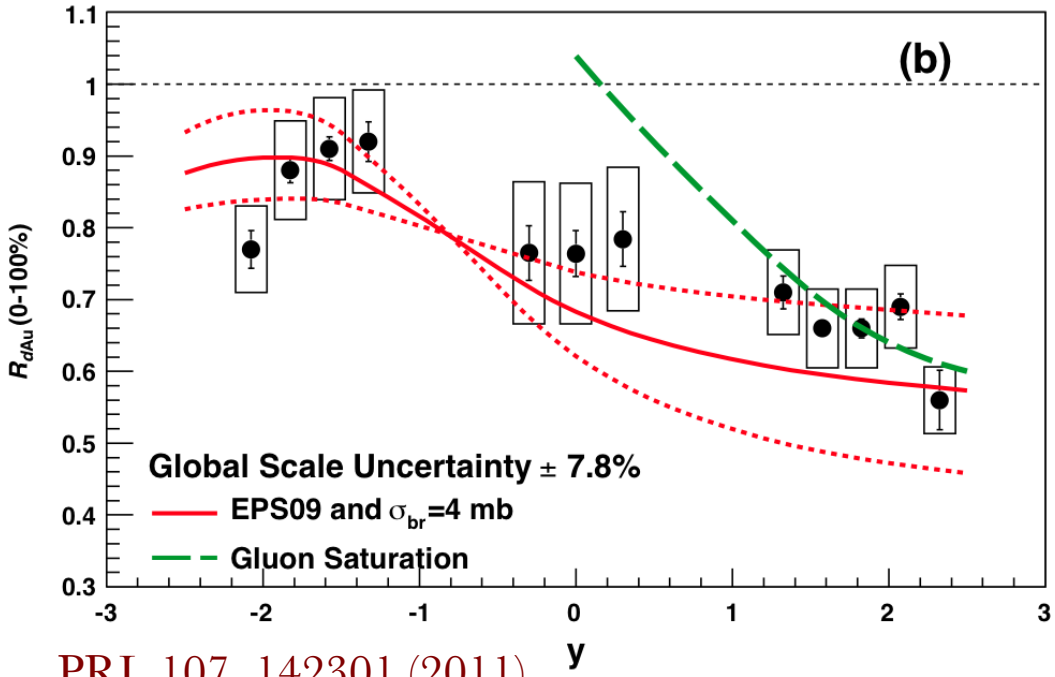
Selected observations from PHENIX:

- Ψ' relative suppression
- Single charm radial boost
- Associated charm de-correlation
- Ridge/flow-like correlations across $\Delta\eta$~3.7, see v_2 in d+Au and v_3 in ^{3}He+Au
- Not mentioned here: HBT, γ^{Dir}, LVM, high-p_{T}

Moral: Need to address *all* observables within a complete "standard-ish" model (all effects, as much as possible)

Backup material

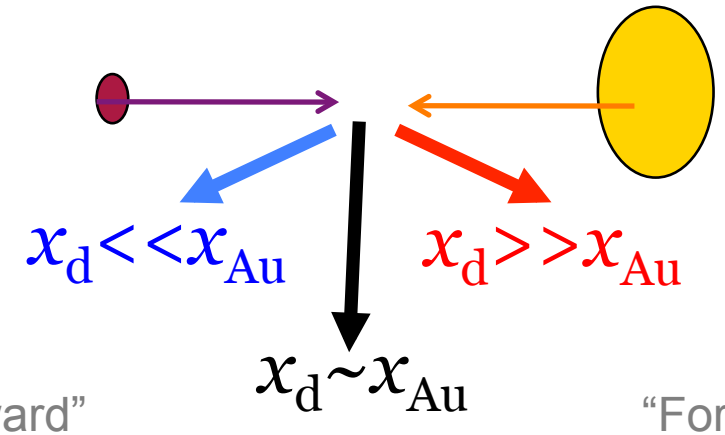
d+Au to forward/backward J/Psi



PRL 107, 142301 (2011)

R_{dAu} for J/Psi in min-bias d+Au

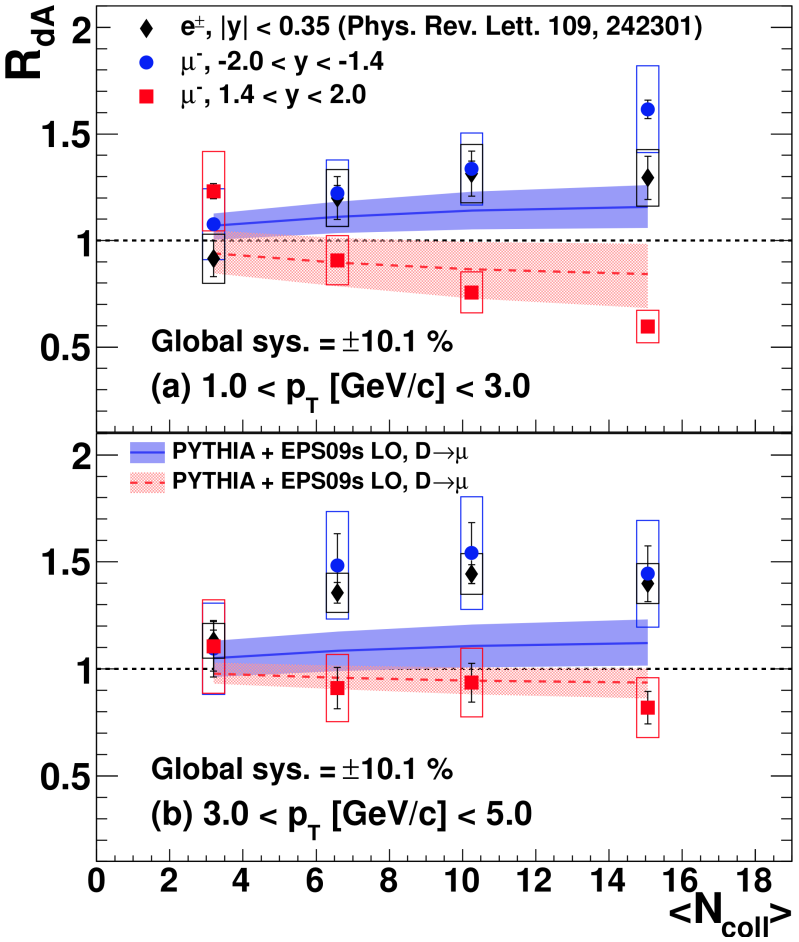
For inclusive d+Au, CNM modifications capture forward/ backward difference (but geometry dependence is harder).



South "Backward"

North "Forward"

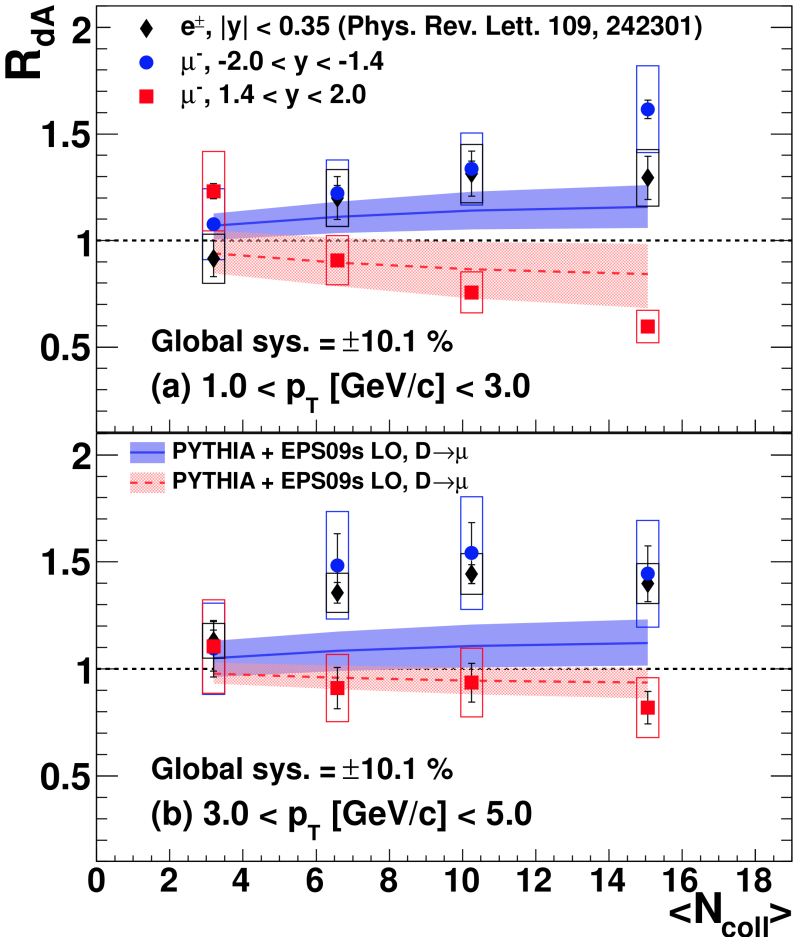
Heavy flavor leptons, forward/back

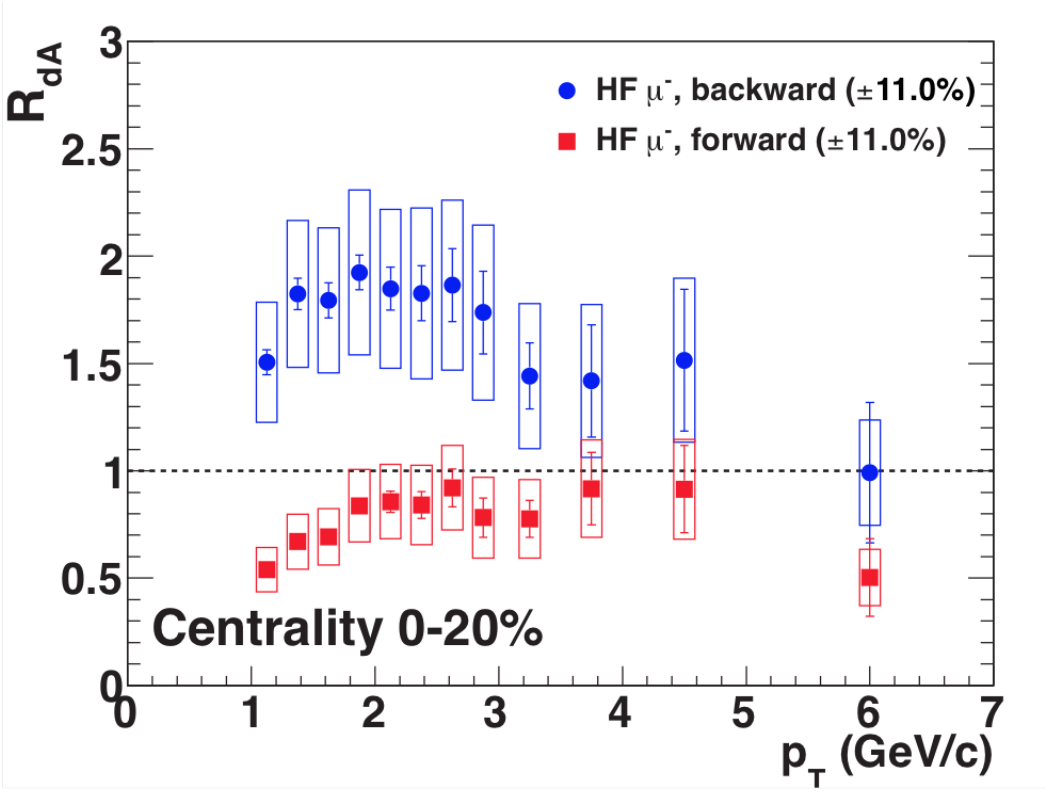


Forward-backward difference seen, but larger than from EPS09

arXiv:1310.1005

Heavy flavor leptons, forward/back





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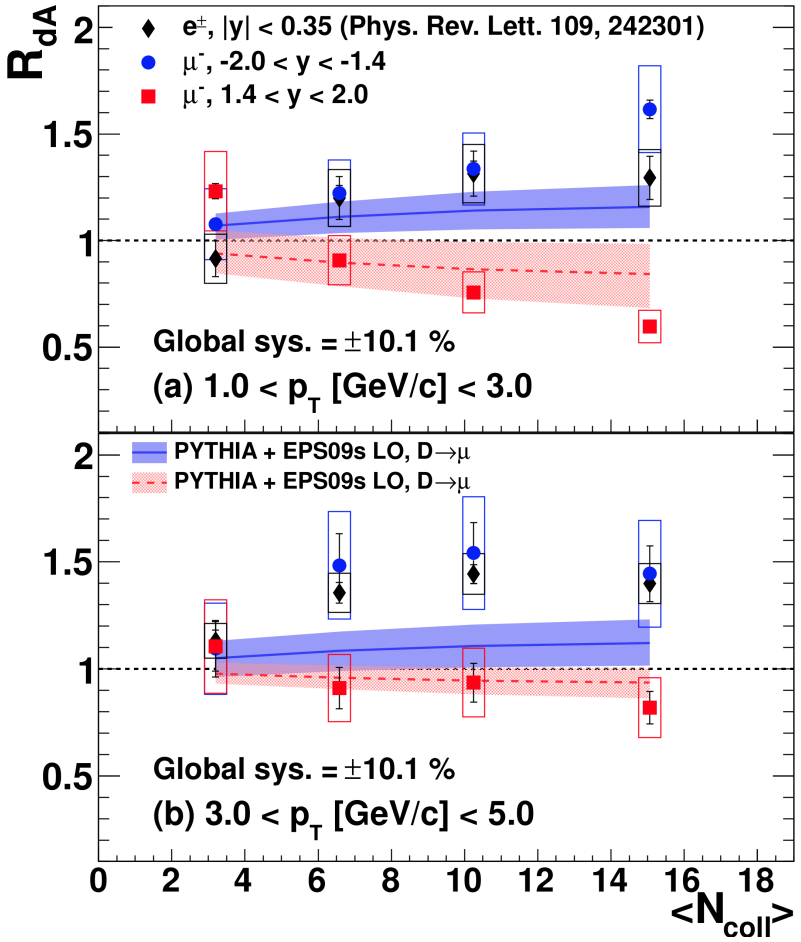
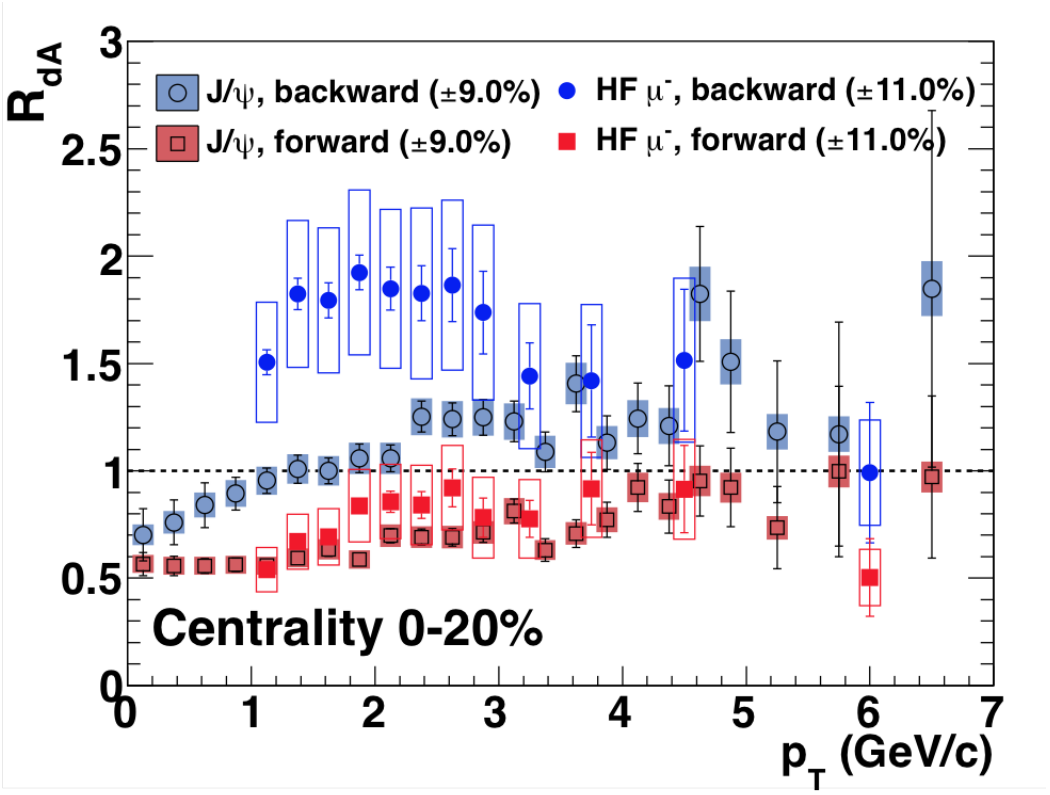




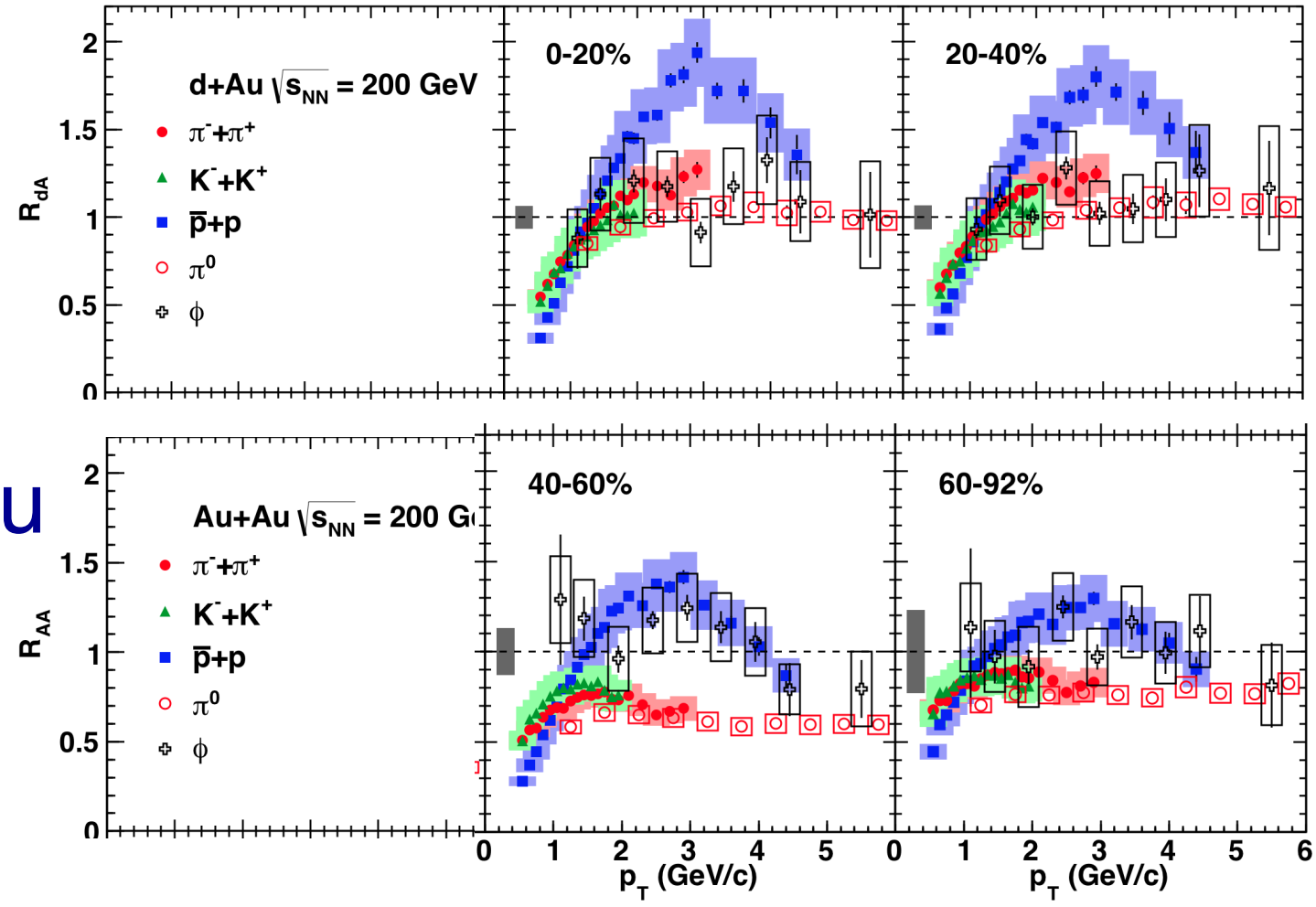
Backward, Au-going effect larger for HF than for J/Psi

arXiv:1310.1005

Central d+Au *vs* Periph Au+Au

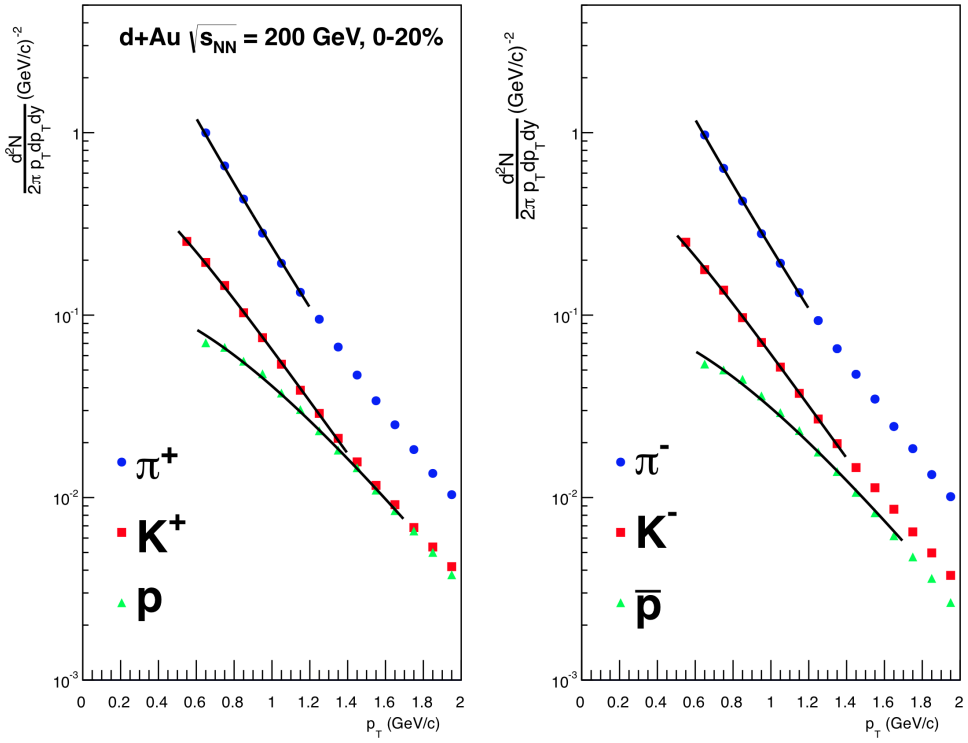
d+Au

Au+Au

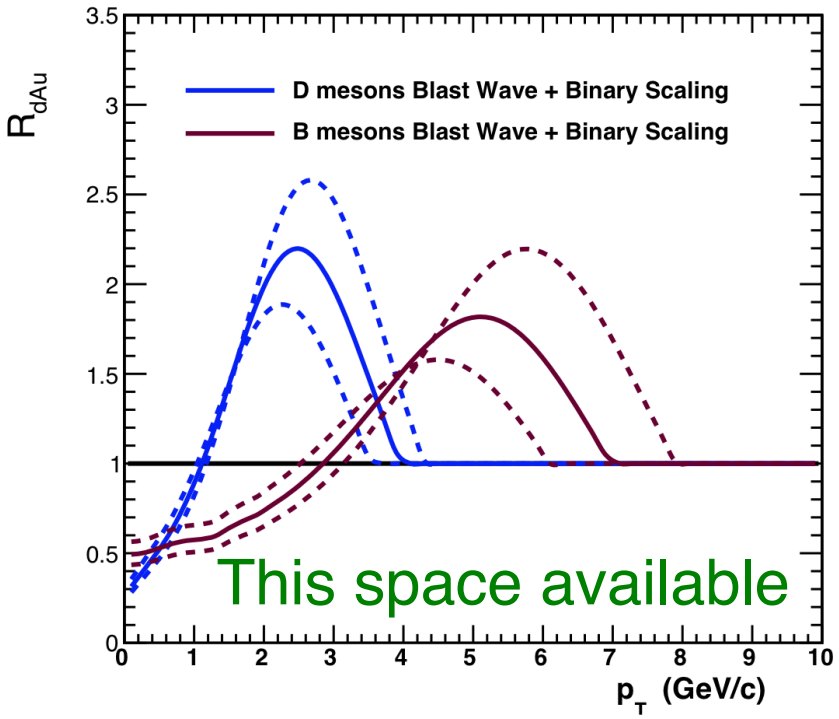


Phys. Rev. C 88, 024906 (2013)

Radial flow in d+Au?



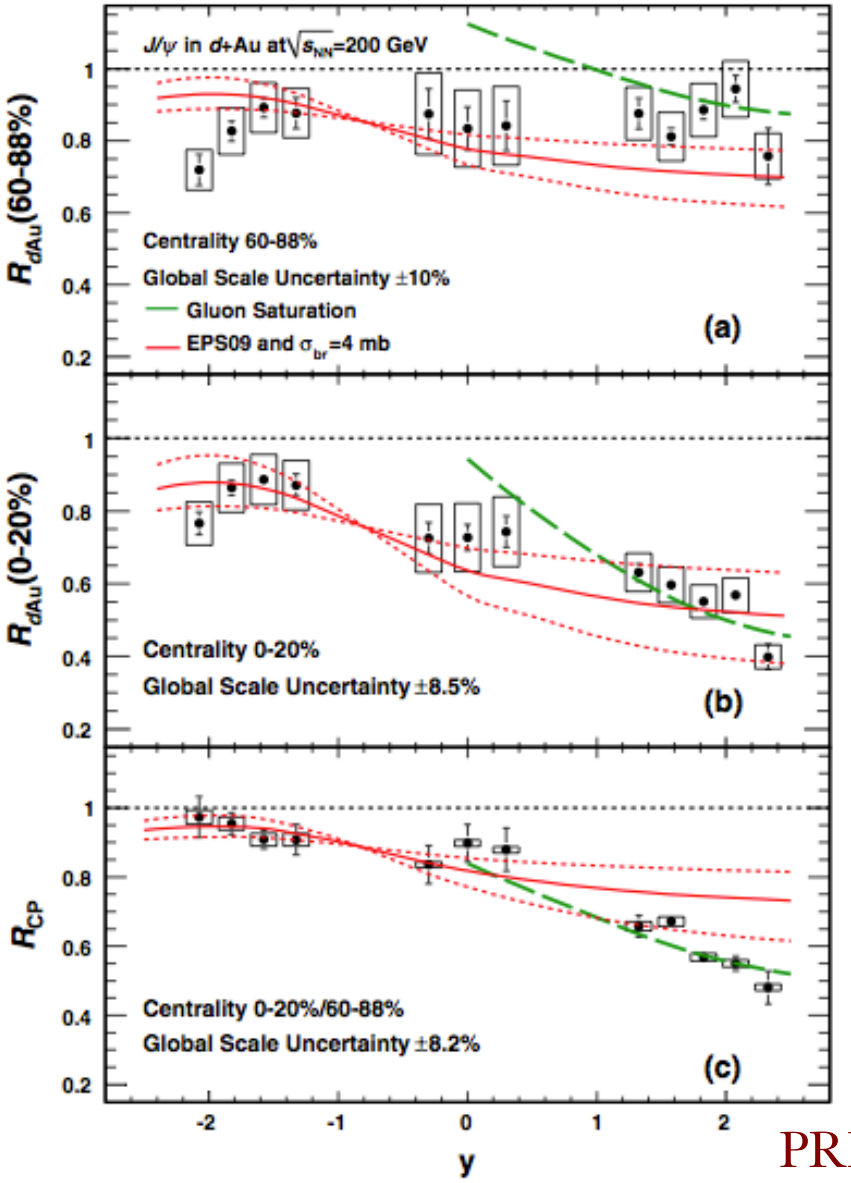
Blast-wave fits to identified light hadron spectra



Heavy-flavor meson predicted R_{dAu}

A. Sickles, Phys. Lett. B731 51-56 (2014), "Possible Evidence for Radial Flow of Heavy Mesons in d+Au Collisions"

Geometry of CNM effects?



Peripheral

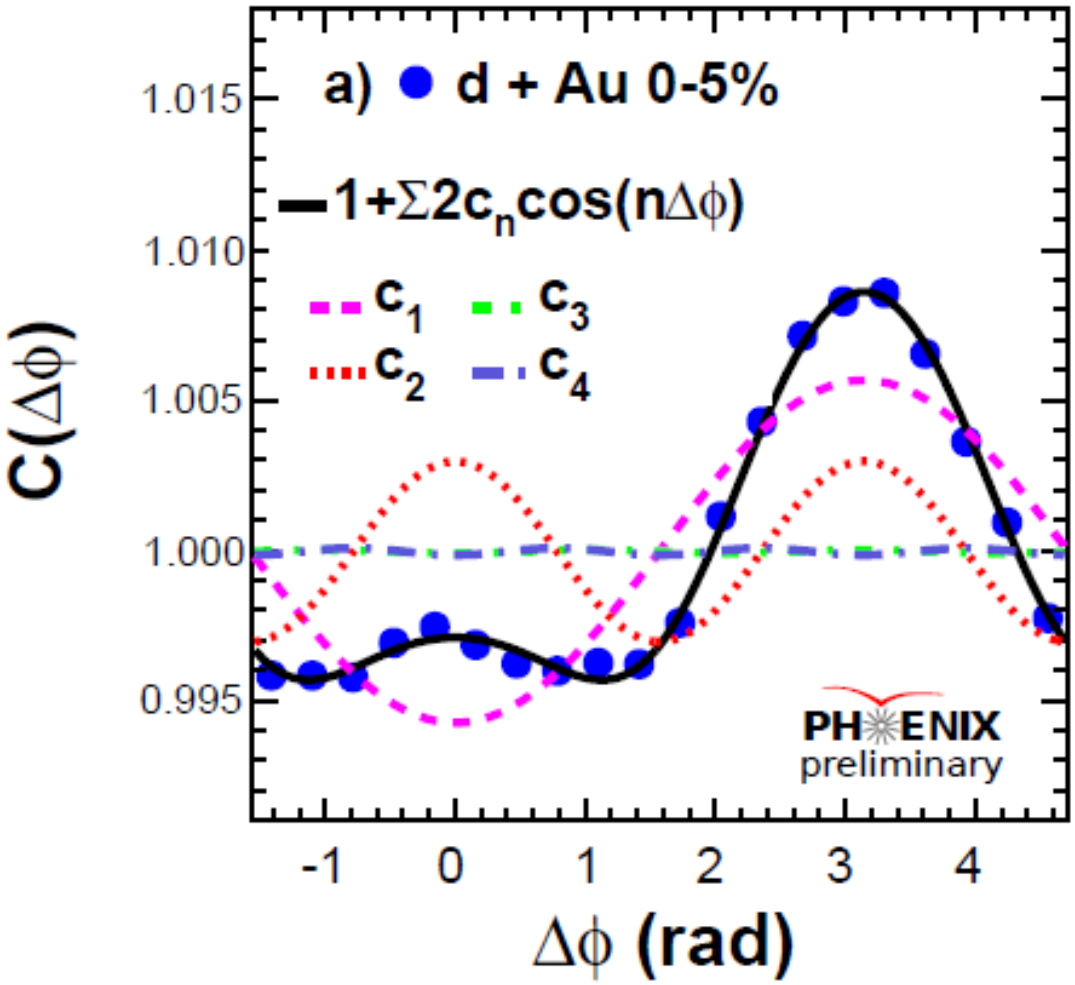
Central

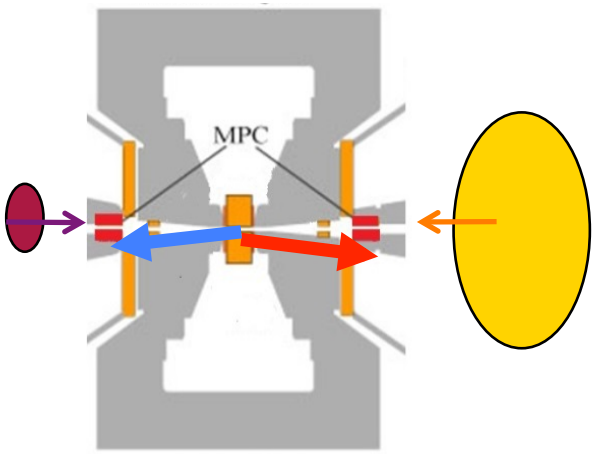
R_{CP}

CNM modification does *not* reproduce centrality/geometry dependence.

PRL 107, 142301 (2011)

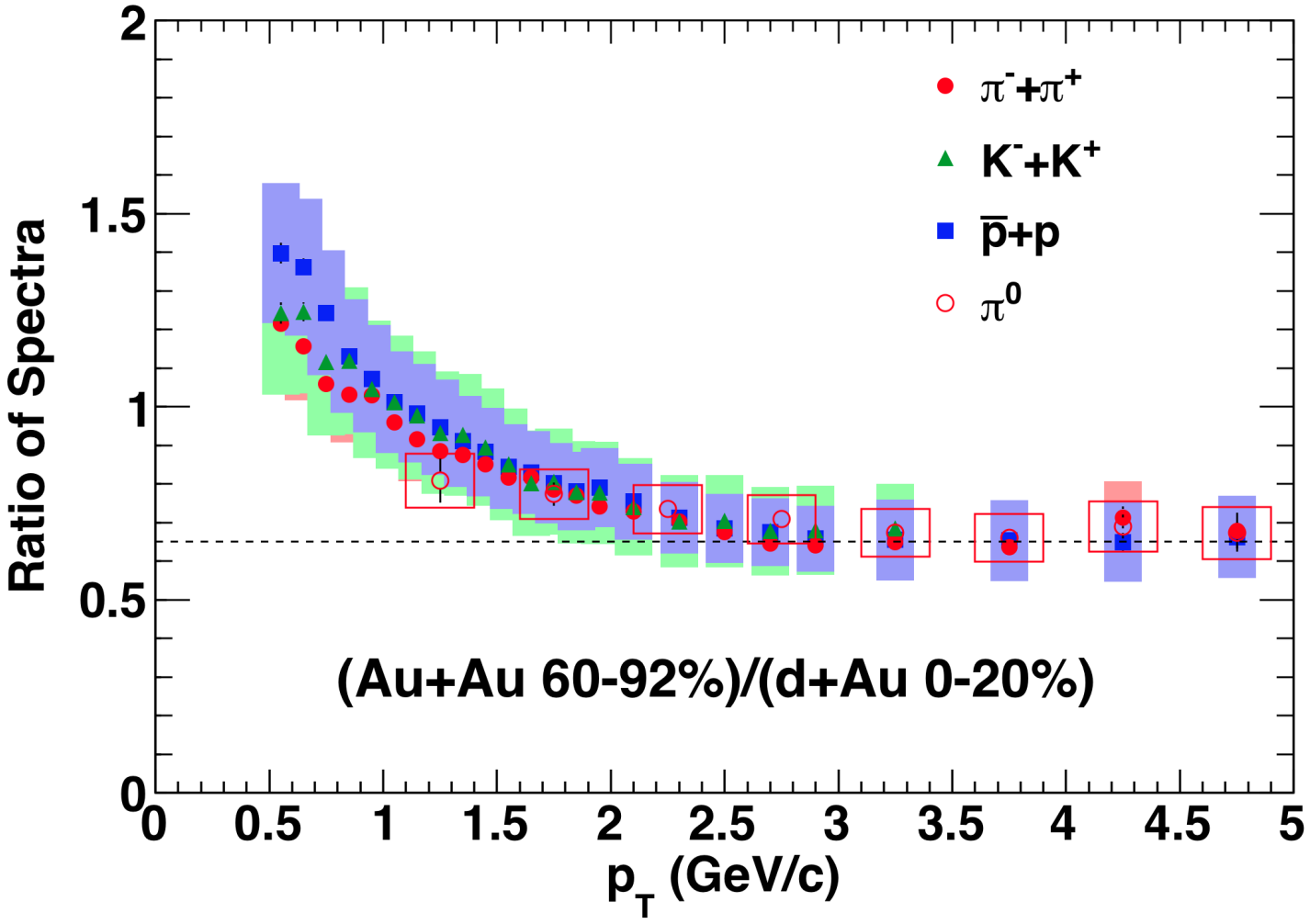
Near-side "ridge" over $\Delta\eta \sim 7$





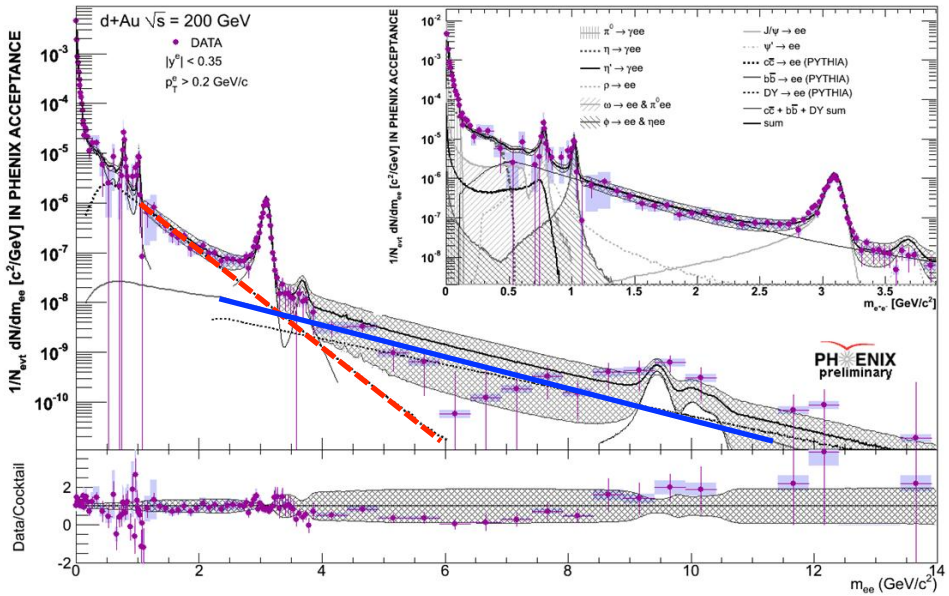
Correlation between Au-going and d-going MPC towers

Periph Au+Au/Central d+Au



Phys. Rev. C 88, 024906 (2013)

More news…



cc vs bb separation via dielectrons in d+Au across mass and p_T