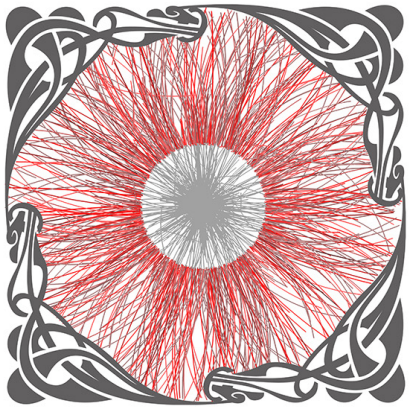
Measurement of single electrons from heavy flavor decays from p+p, d+Au, and Cu+Cu collisions in the PHENIX experiment

Sanghoon Lim

for the PHENIX collaboration

Yonsei University



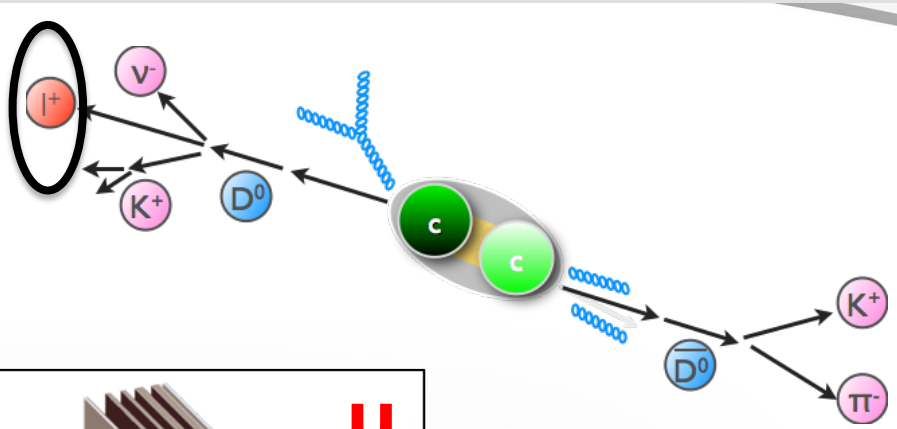
XXIV QUARK MATTER DARMSTADT 2014

PHENIX

YONSEI UNIVERSITY

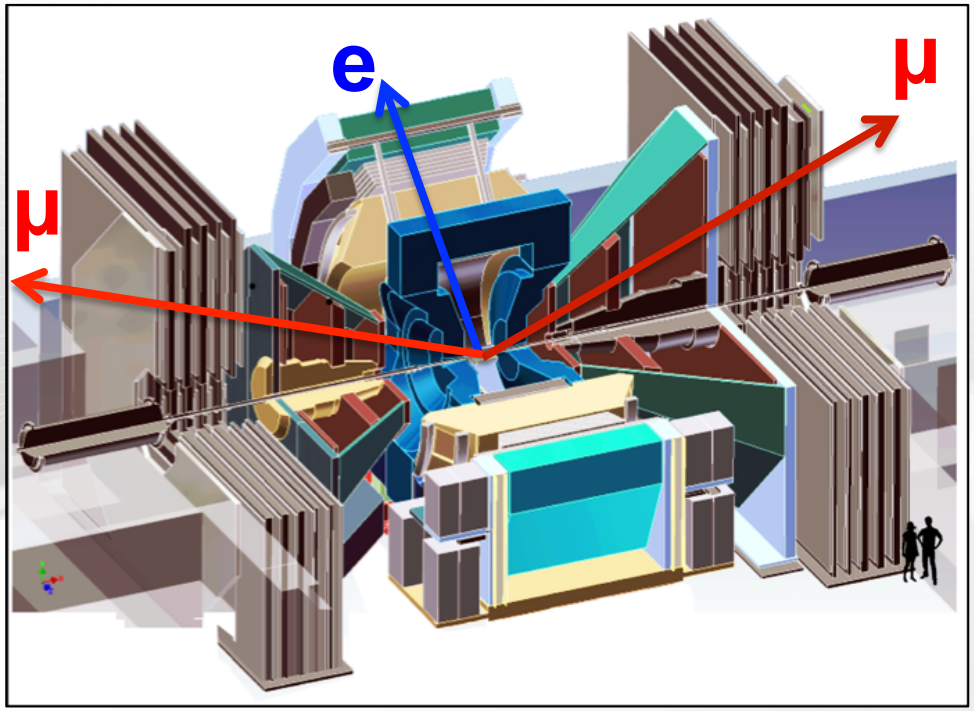
Heavy flavor in PHENIX

Measurement of leptons from semi-leptonic decays of D/B mesons



Electrons at Central arm

- $|\eta| < 0.35$
- $\Delta\phi = \pi$
- Tracking
  w/ DC, PC
- eID
  w/ RICH, EMCal

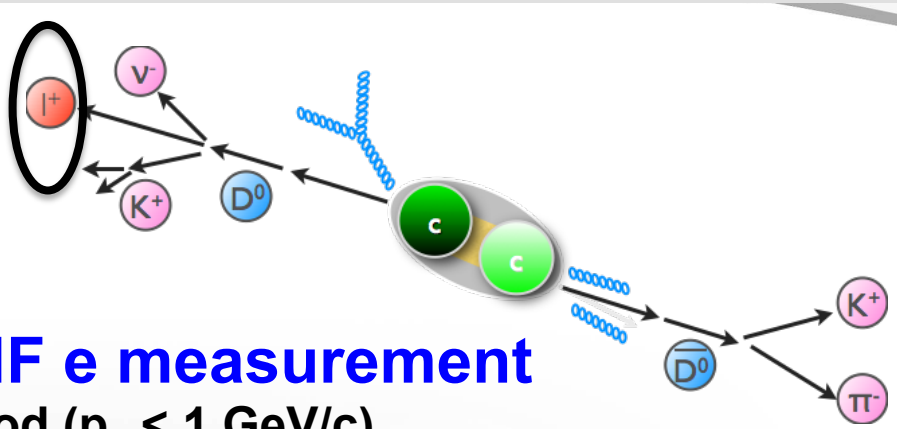


Muons at Muon arm

- $1.2 < |\eta| < 2.2$
- $\Delta\phi = 2\pi$
- ~10λ absorber
- Tracking
  w/ wire chamber
- muID
  w/ layers of steel
  and Iarocci tubes

Heavy flavor in PHENIX

Measurement of leptons from semi-leptonic decays of D/B mesons

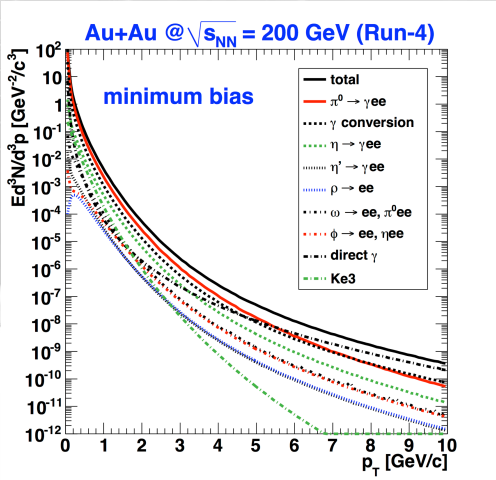


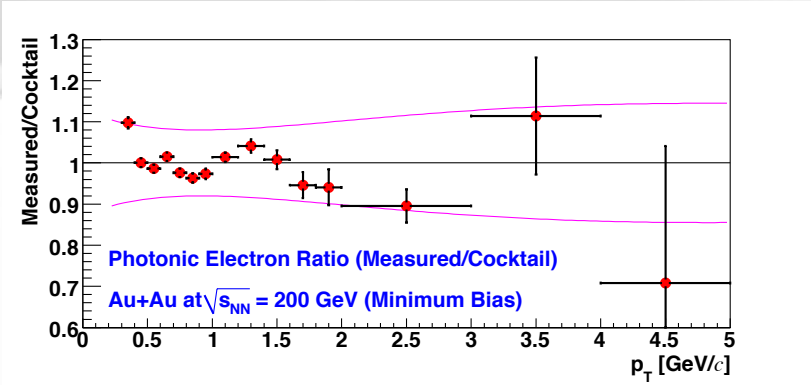
Electrons at Central arm

- $|\eta| < 0.35$
- $\Delta\phi = \pi$
- Tracking
  w/ DC, PC
- eID
  w/ RICH, EMCal

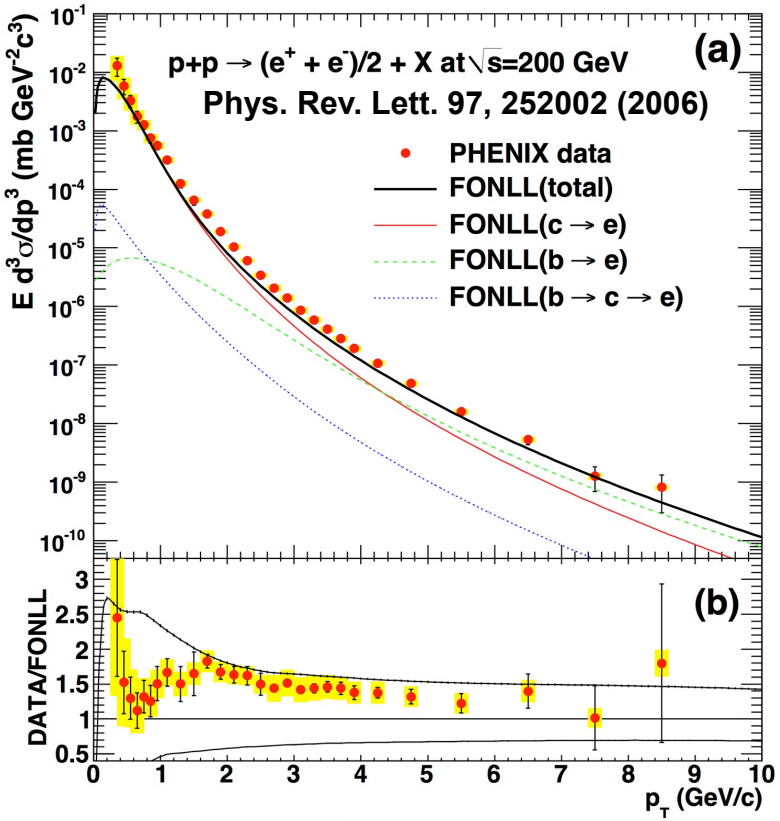
Methods for HF e measurement

- **Converter method (p_T < 1 GeV/c)**
  increase photonic electrons with a converter of 1.680% X_0
- **Cocktail method (p_T > 1 GeV/c)**
  statistically subtract background electrons based on measured sources



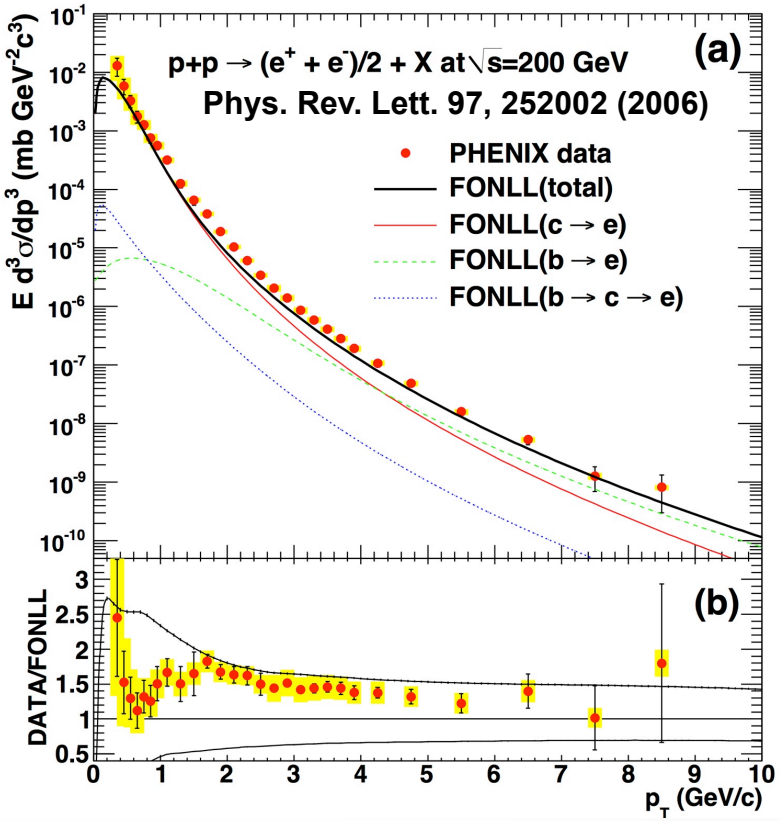


From N_{coll}=1 to N_{coll}=1000

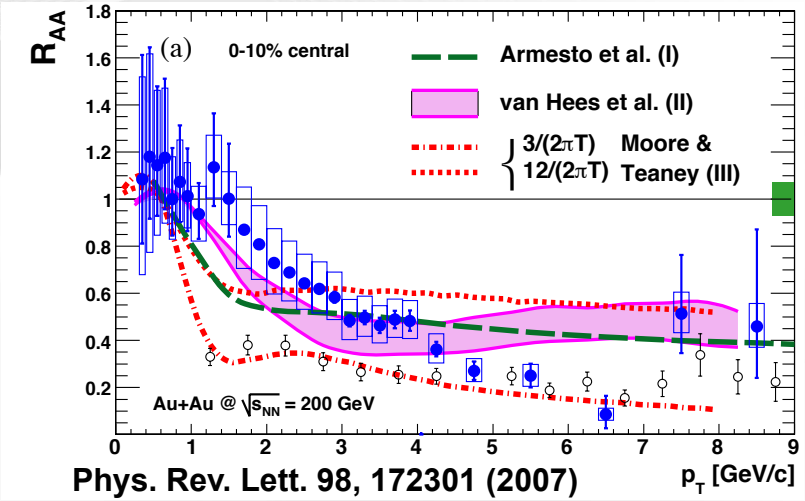


- In p+p collisions
  - consistent with the FONLL calculation
  - reference for other collision systems

From N_{coll}=1 to N_{coll}=1000



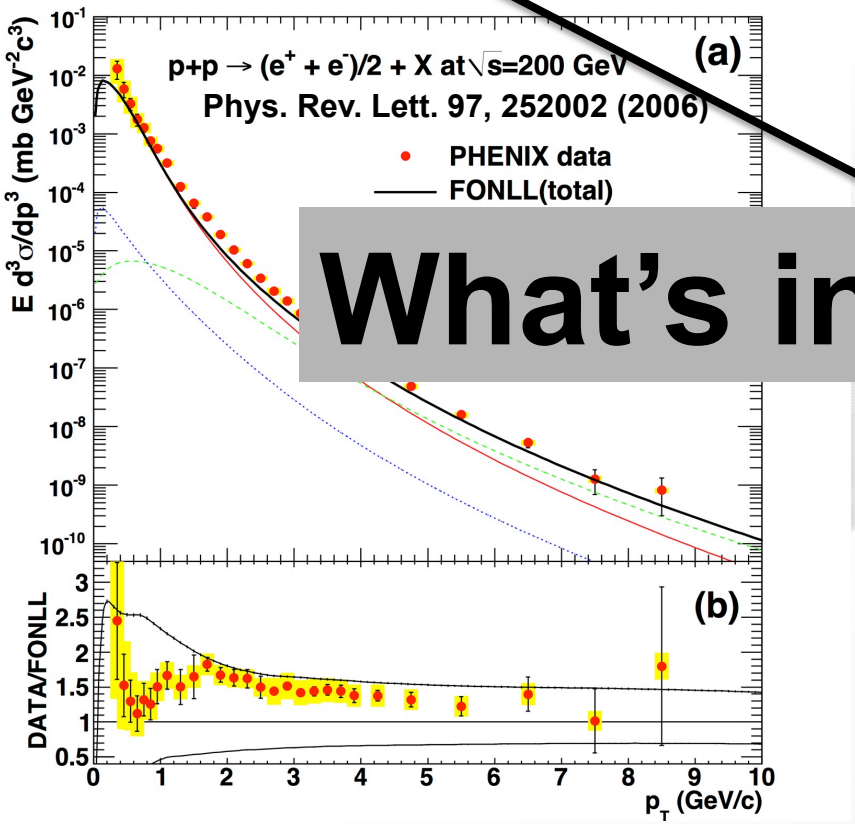
- In p+p collisions
  - consistent with the FONLL calculation
  - reference for other collision systems
- In central Au+Au collisions
  - large suppression of high p_T HF e

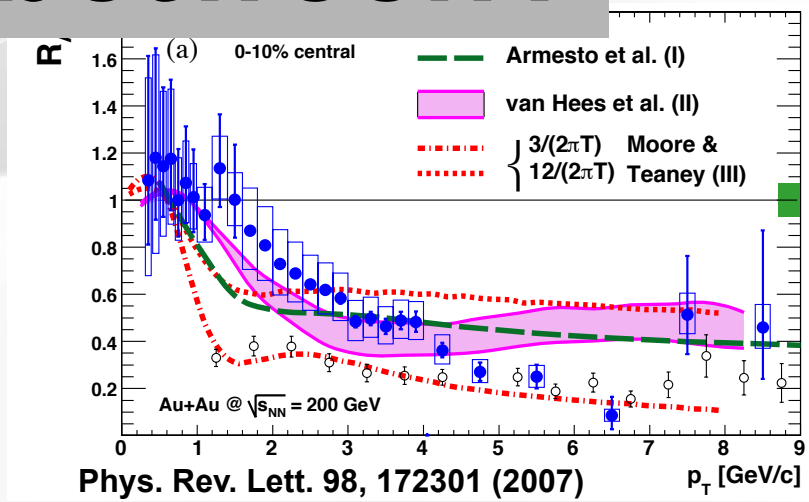


From N_{coll}=1 to N_{coll}=1000

- In p+p collisions
  - consistent with the FONLL calculation
  - reference for other collision systems
- In central Au+Au collisions
  - p_T HF e

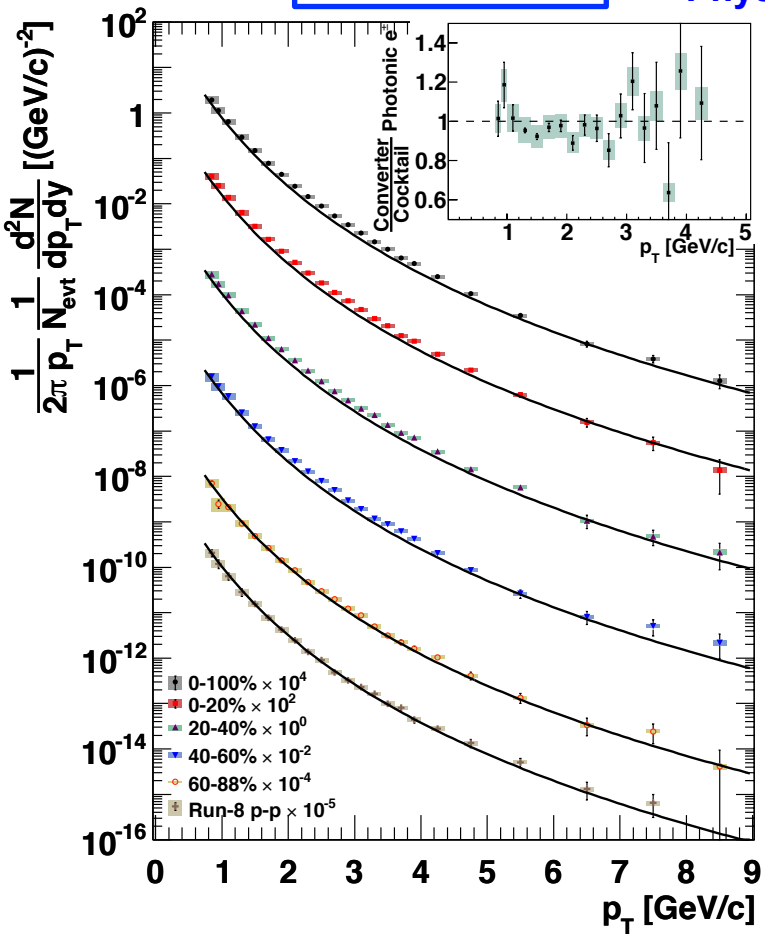
What's in between?





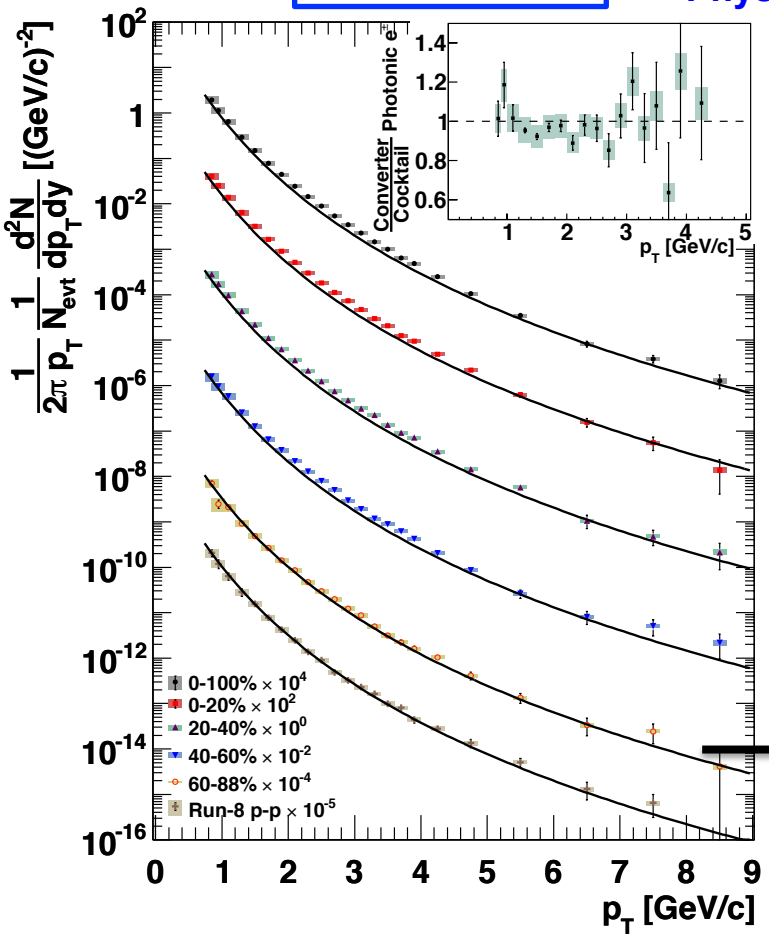
In d+Au collisions

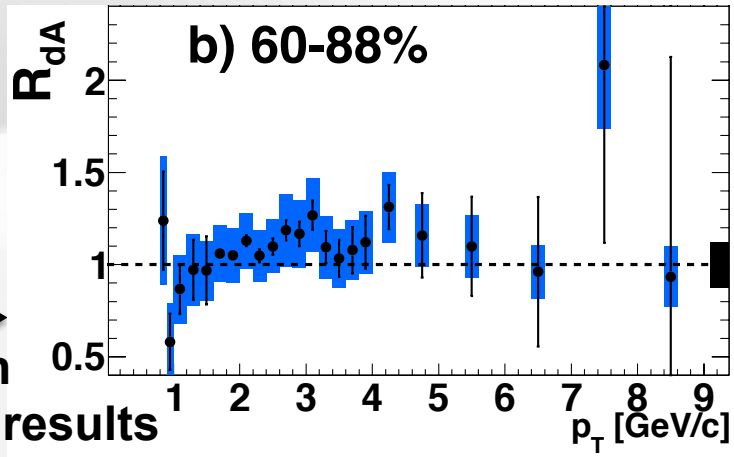
Phys. Rev. Lett. 109, 242301 (2012)



In d+Au collisions

Phys. Rev. Lett. 109, 242301 (2012)

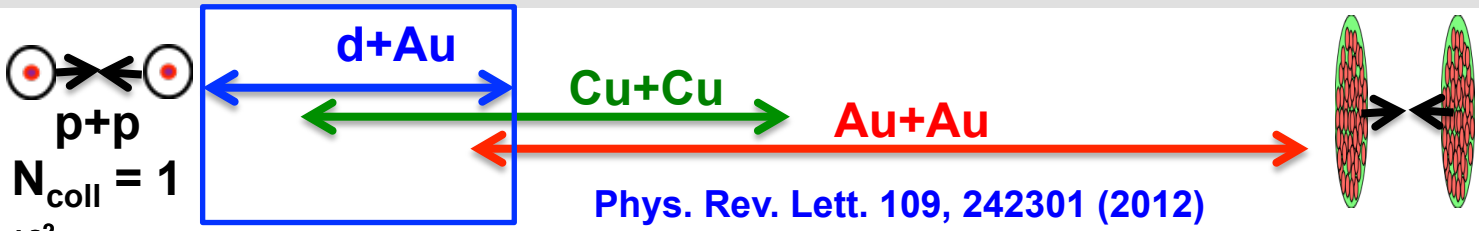




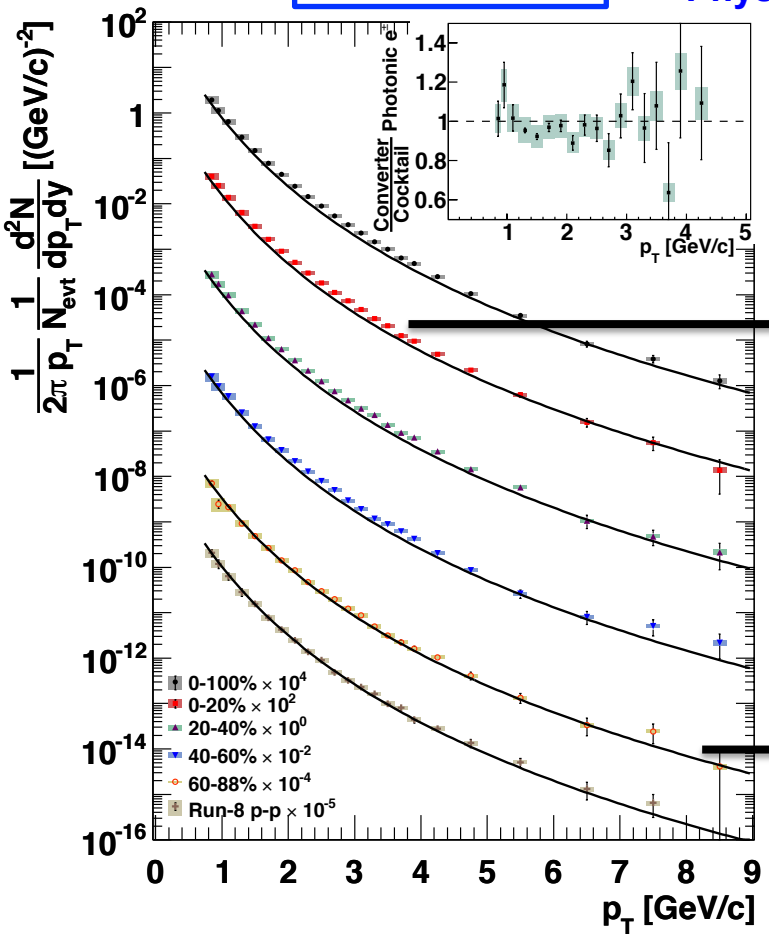
<Ncoll>≈3.2

Consistent with the scaled p+p results

In d+Au collisions



Phys. Rev. Lett. 109, 242301 (2012)

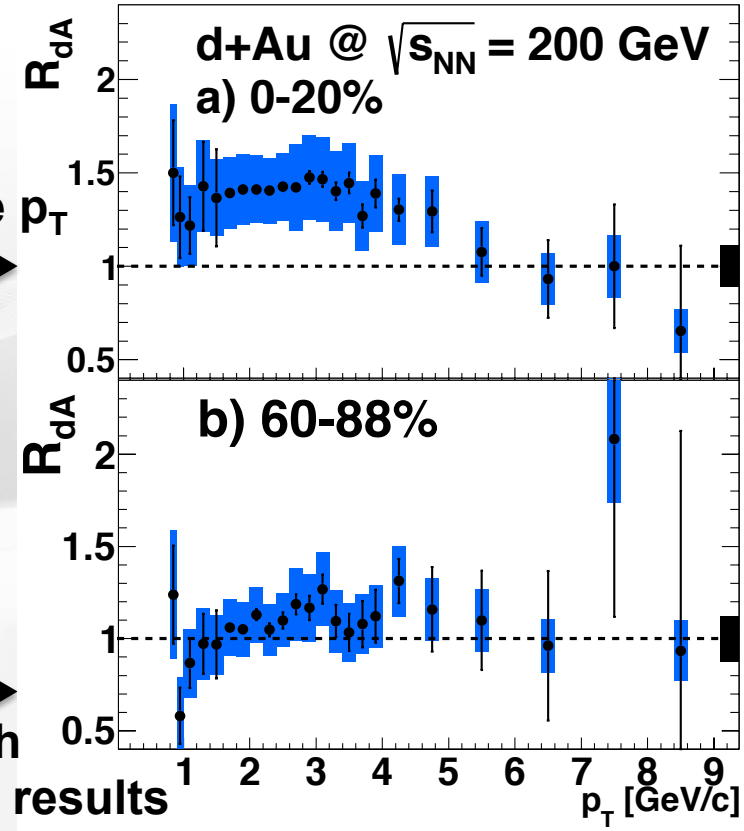


Enhancement at intermediate p_T

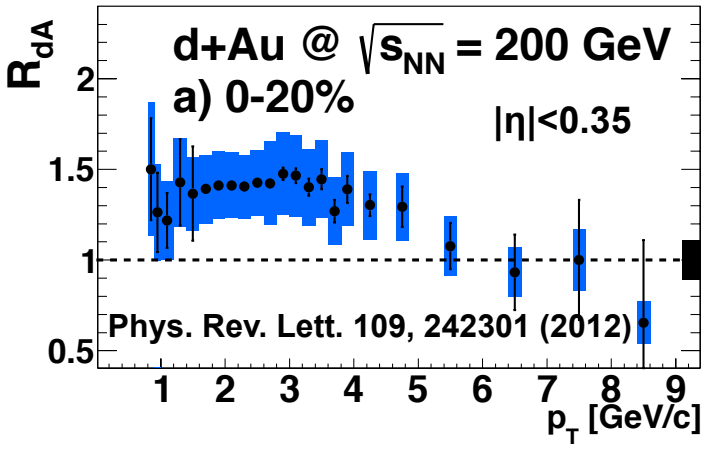
<Ncoll>≈15.1

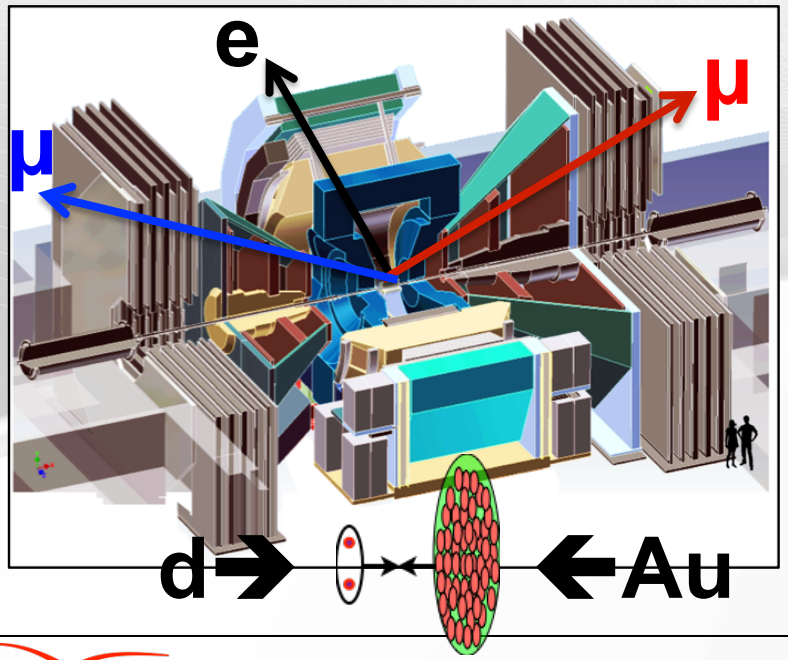
<Ncoll>≈3.2

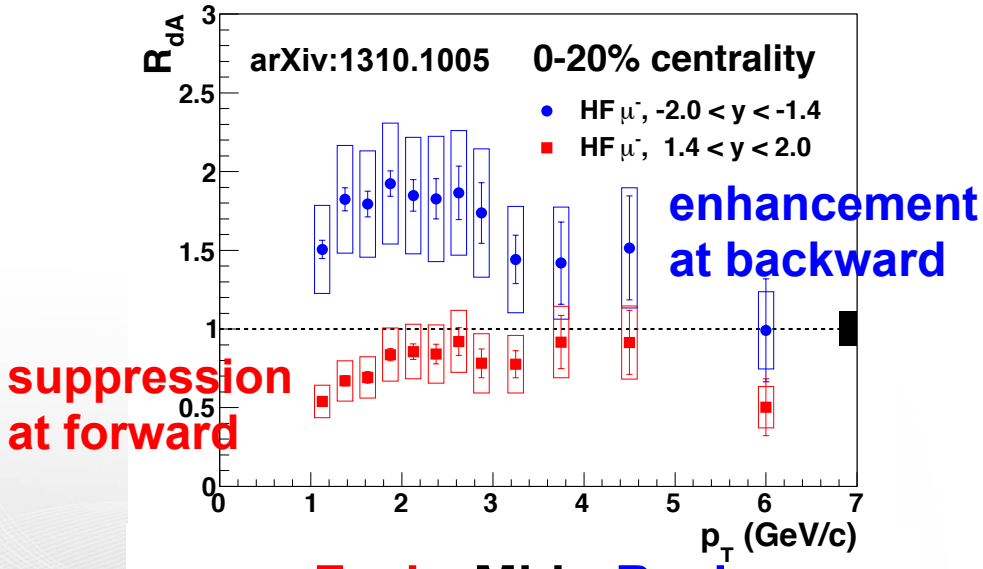
Consistent with the scaled p+p results

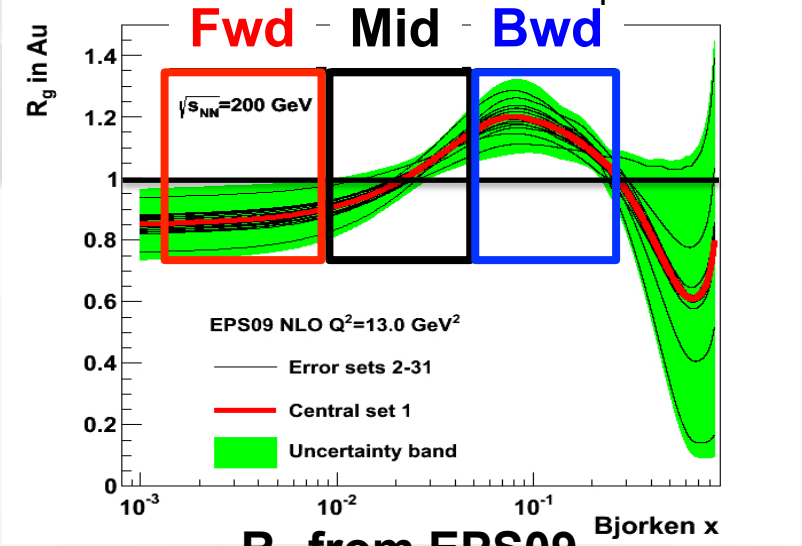


Rapidity expansion in d+Au



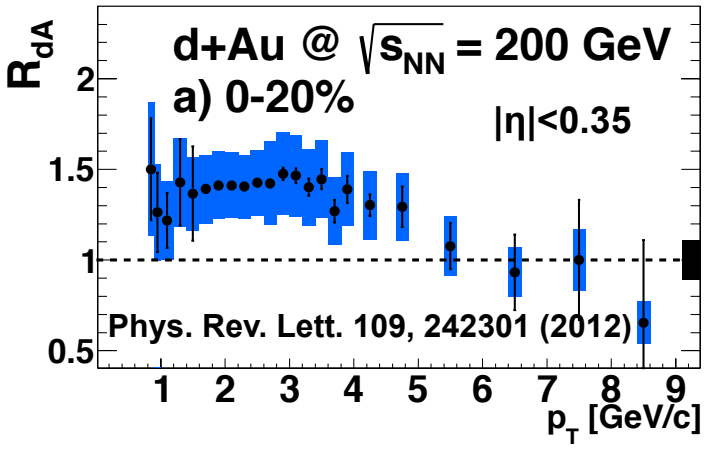


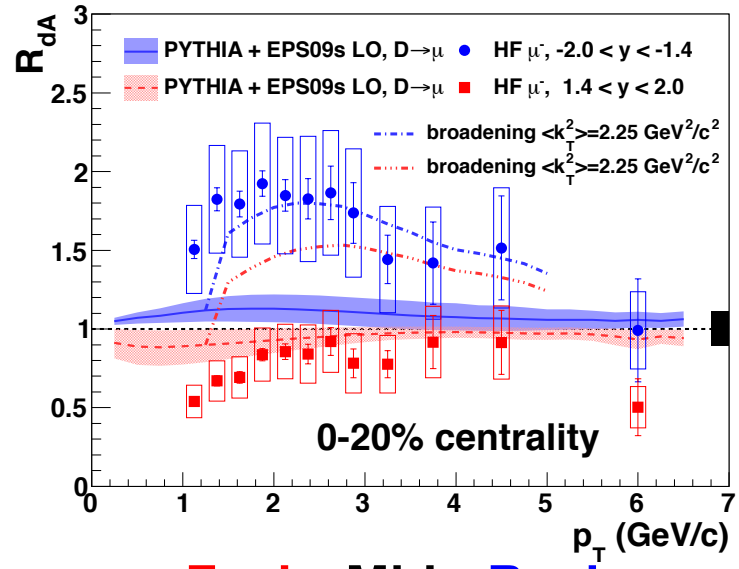


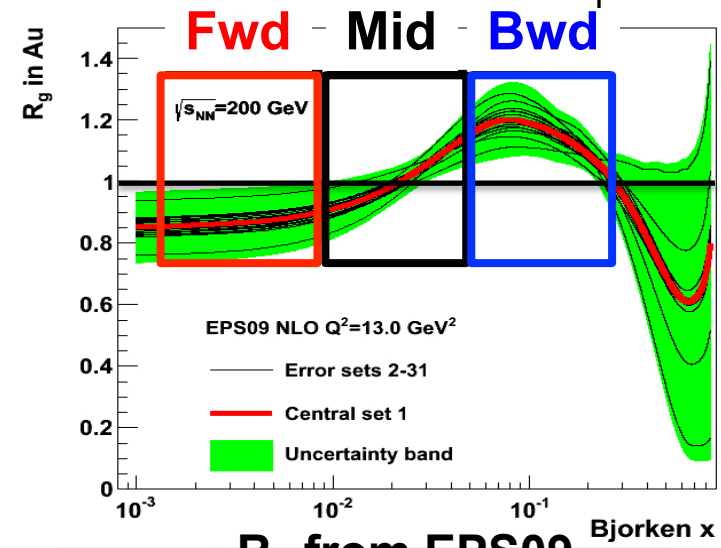


R_g from EPS09

Rapidity expansion in d+Au





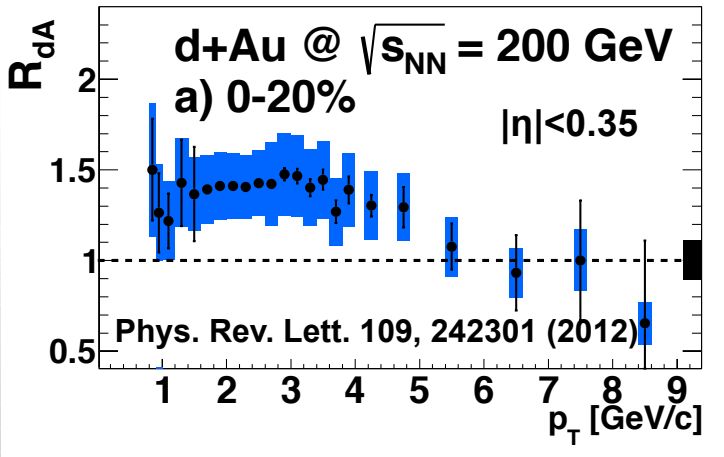


R_g from EPS09

Fail to reproduce the data at both rapidity simultaneously w/ combinations of initial-state effects!

- modification of nPDF
- initial k_T broadening

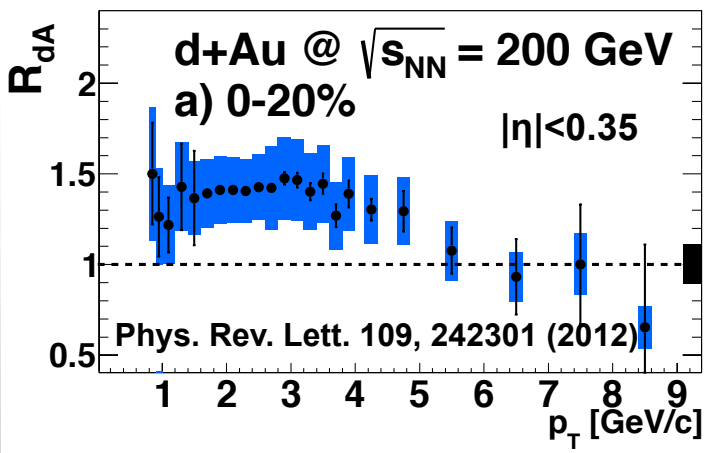
Enhancement in central d+Au

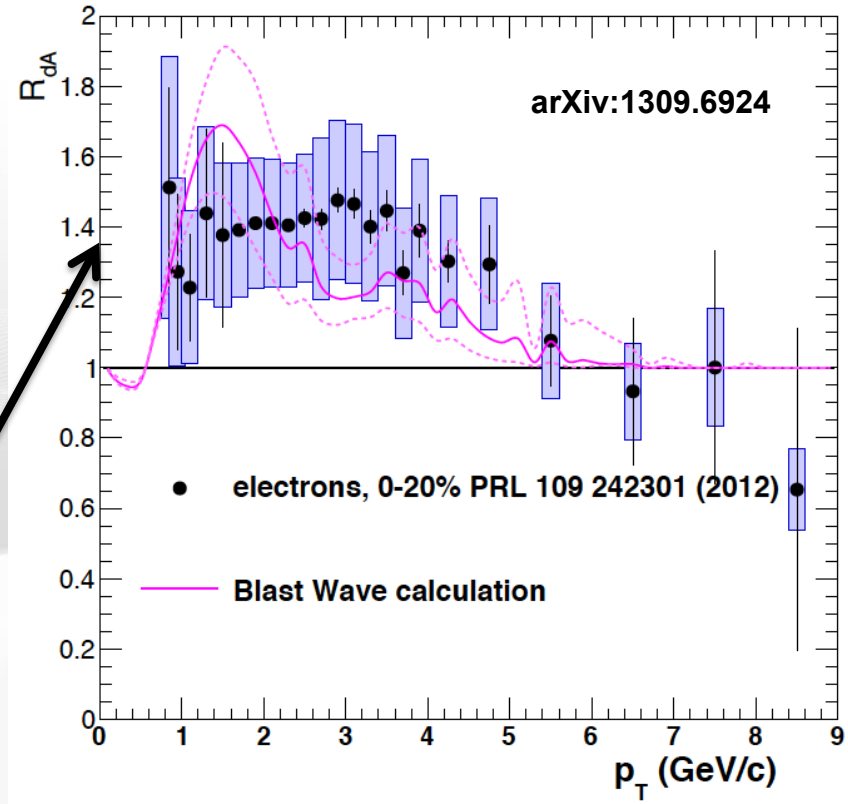


Cronin enhancement?

→initial p_T component due to multiple scattering of incoming partons

Enhancement in central d+Au

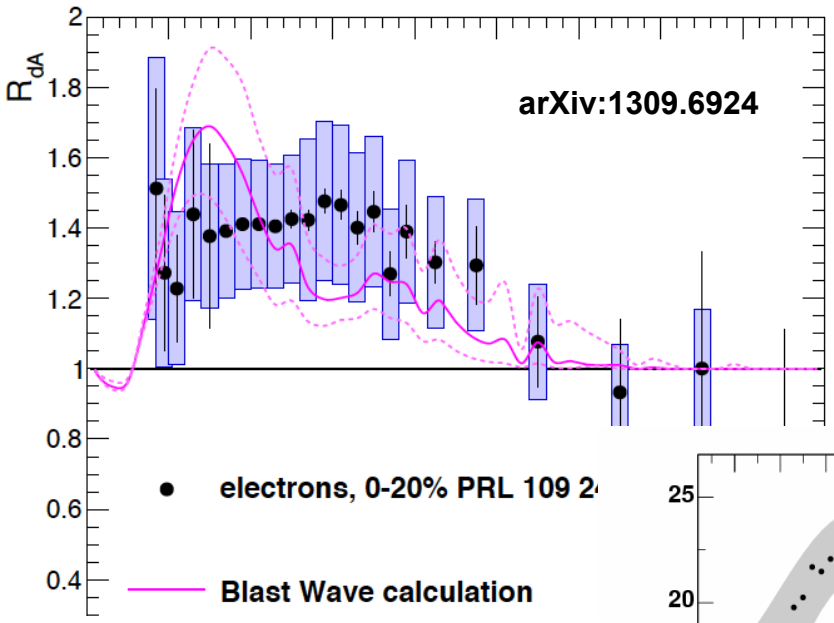


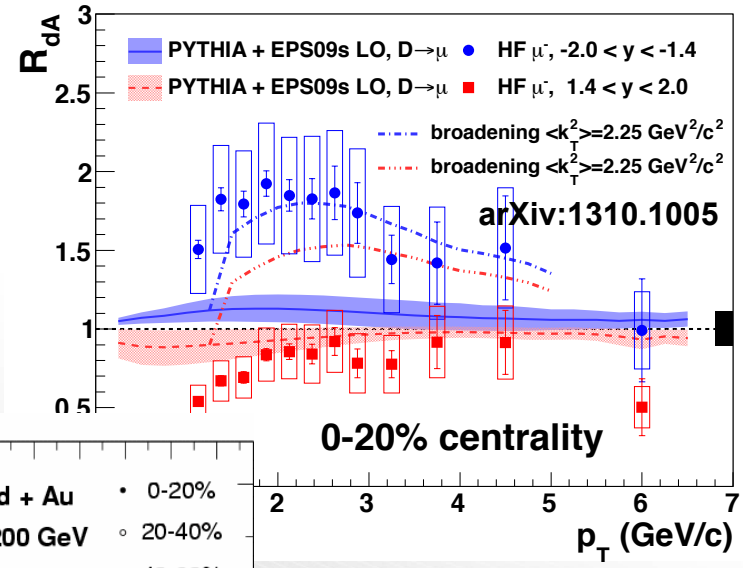


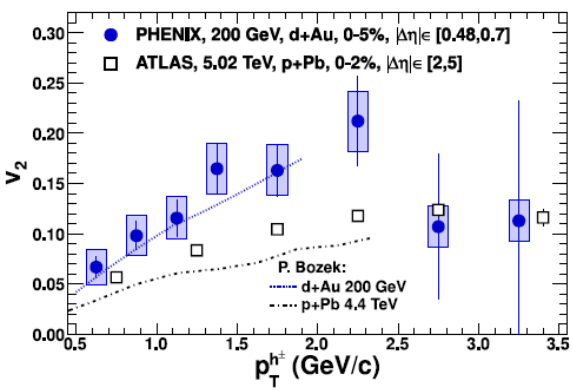
Cronin enhancement?
→initial p_T component due to multiple scattering of incoming partons

Radial flow qualitatively reproduces the data!!

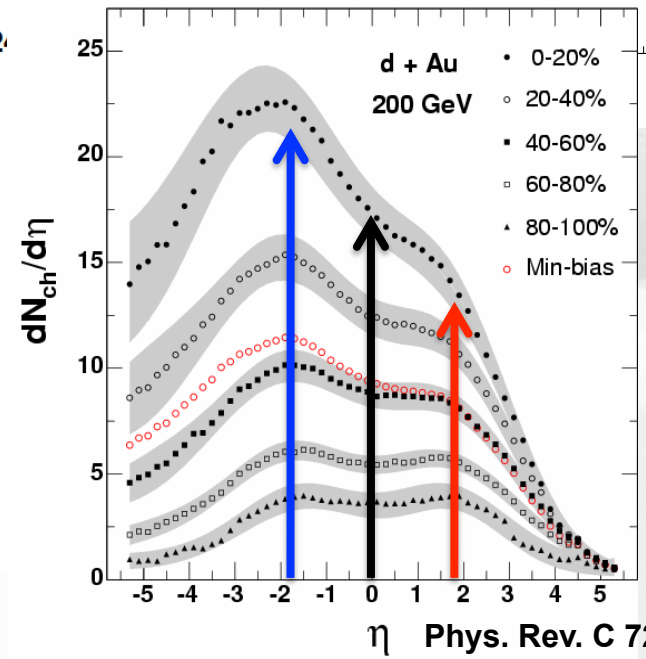
Hydrodynamic behavior?







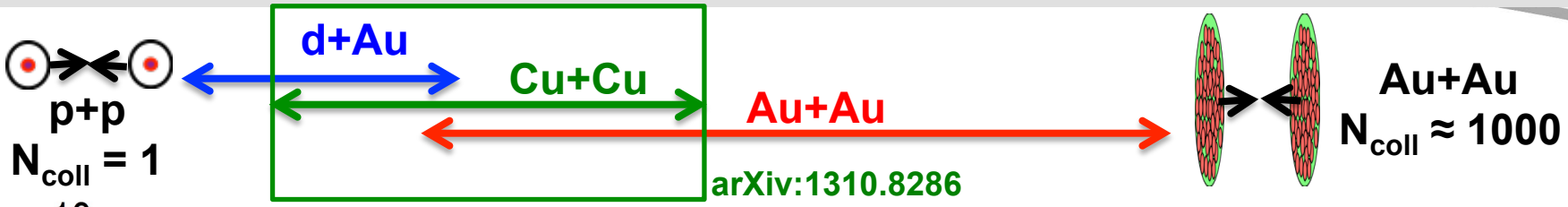
Phys. Rev. Lett. 111, 212301 (2013)

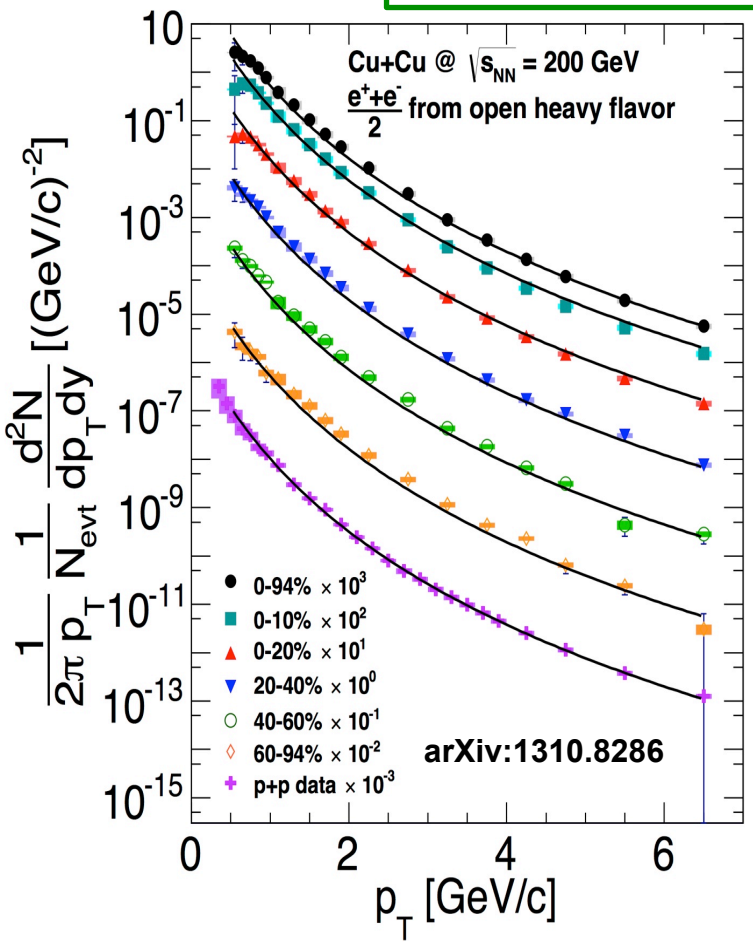


Phys. Rev. C 72, 031901 (2005)

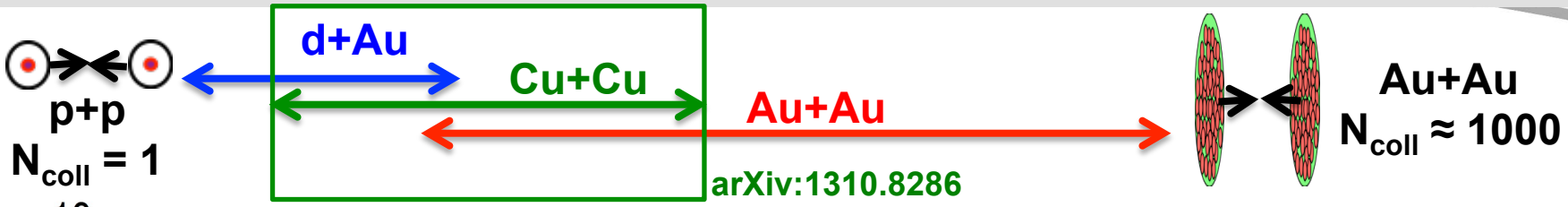
Enhancement at mid- and backward rapidity possibly due to <u>final-state interaction?</u>

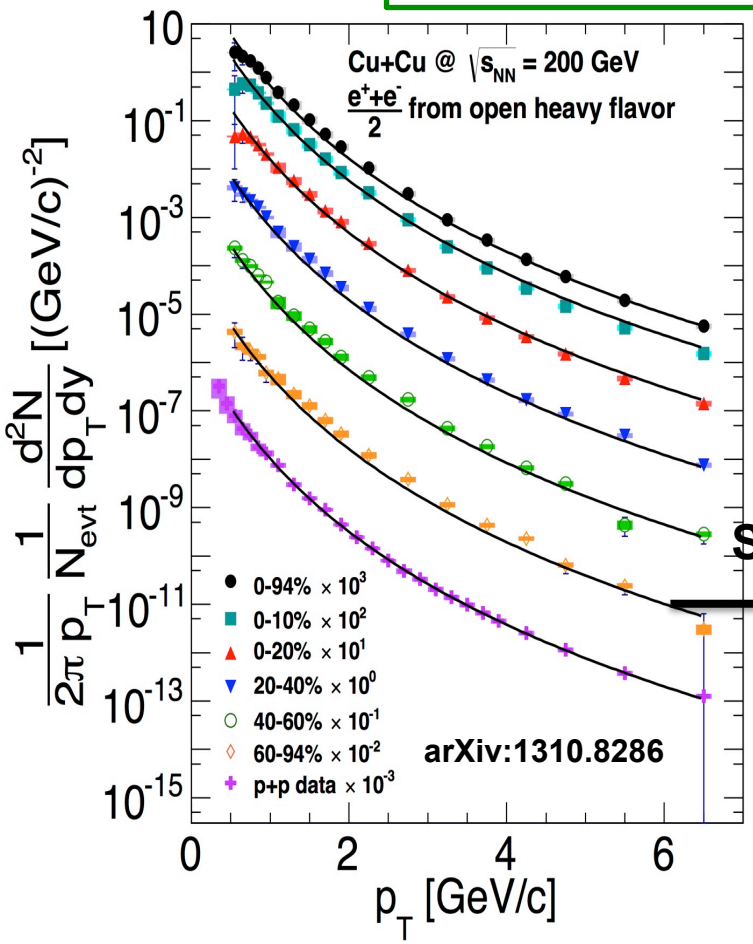
In Cu+Cu collisions





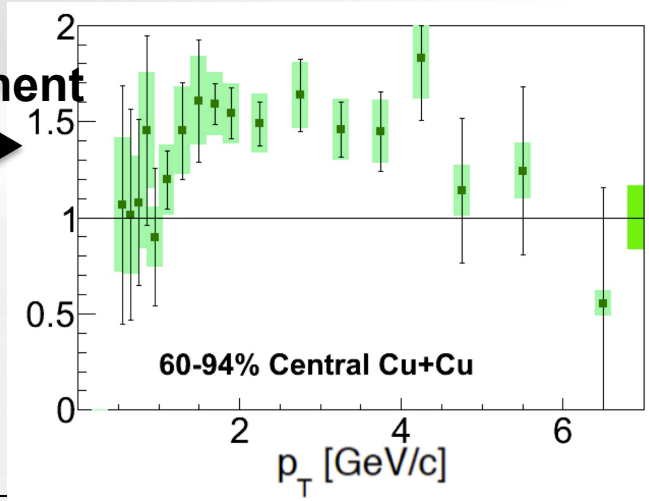
In Cu+Cu collisions



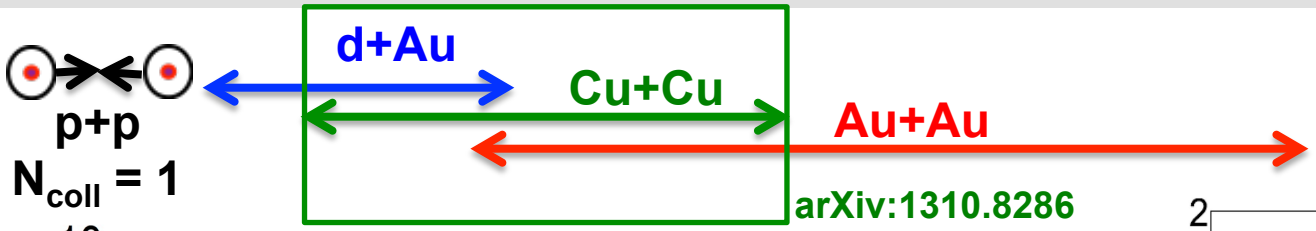


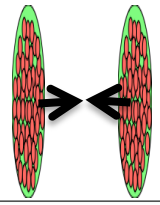
Significant enhancement

<Ncoll>≈5.1

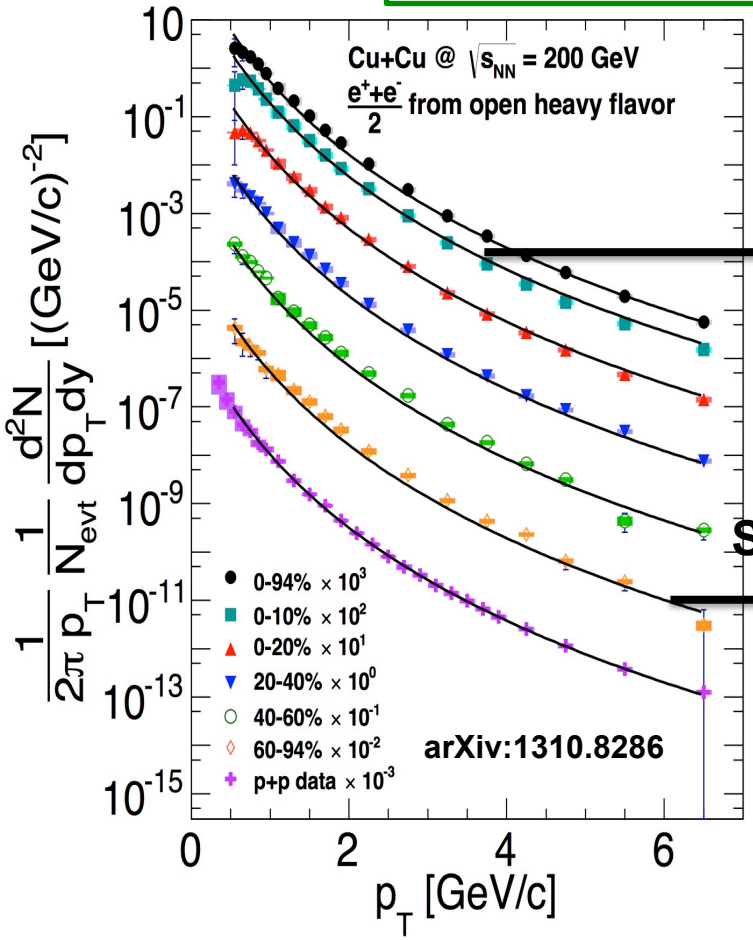


In Cu+Cu collisions



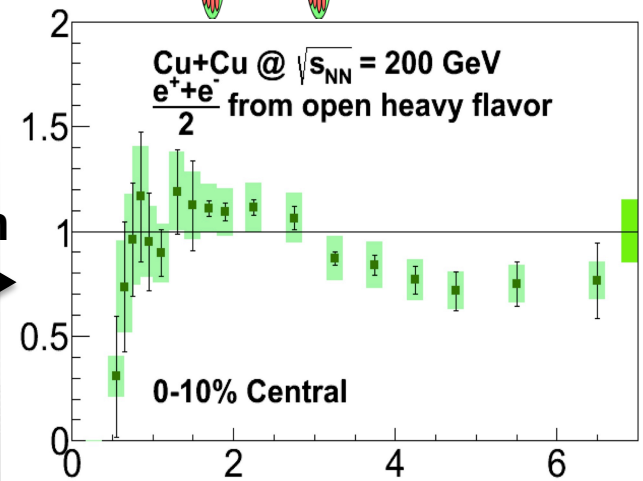


Au+Au
$N_{coll} \approx 1000$



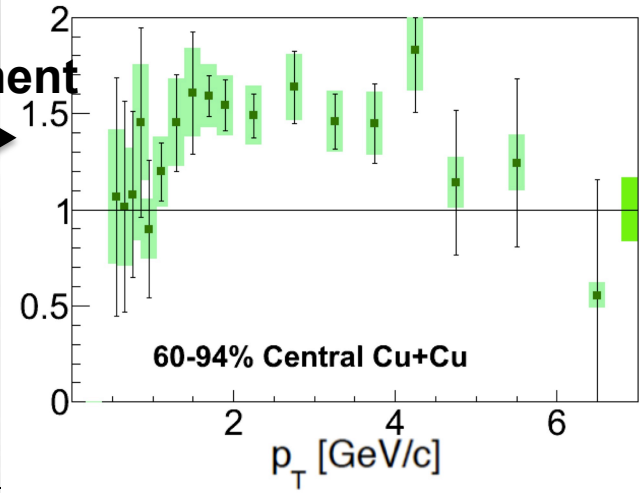
Slight suppression

<Ncoll>≈182.7

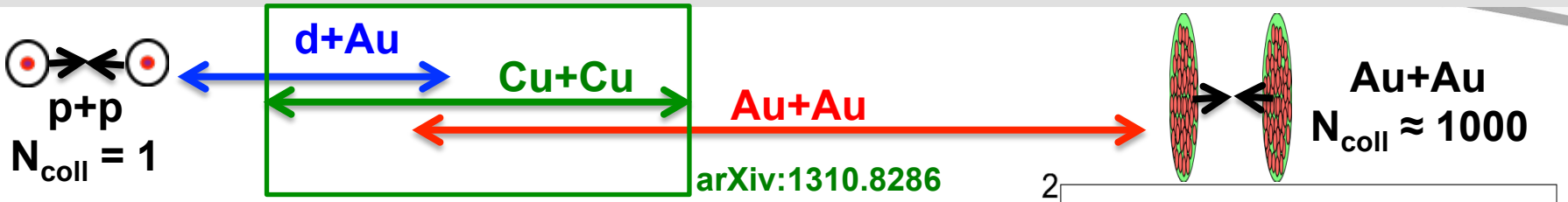


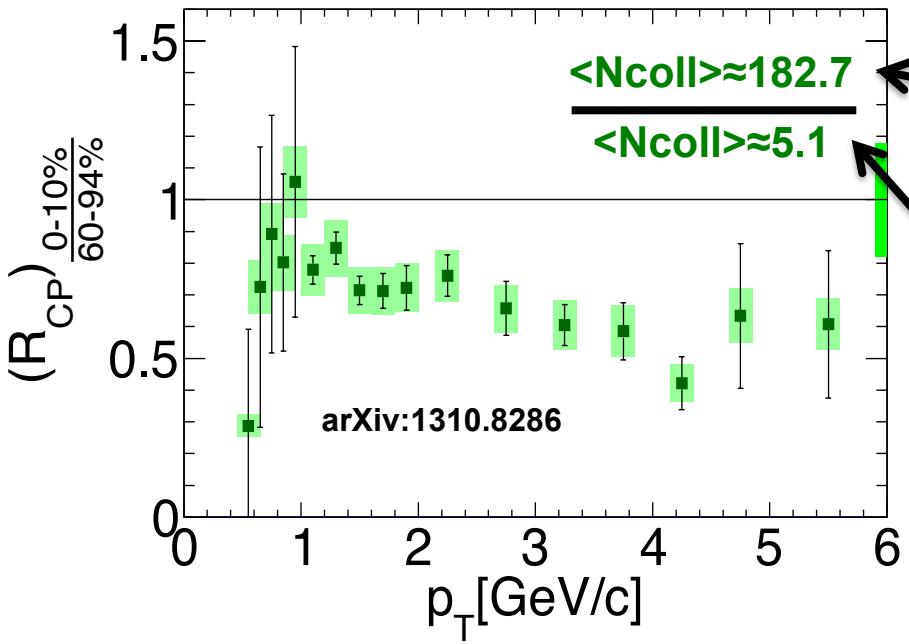
Significant enhancement

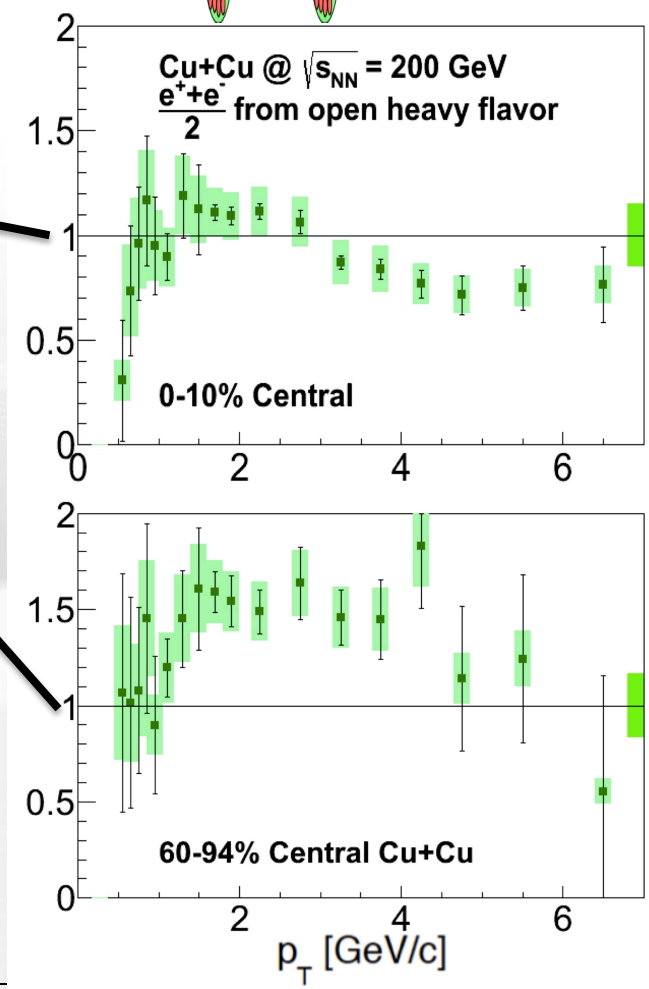
<Ncoll>≈5.1



In Cu+Cu collisions

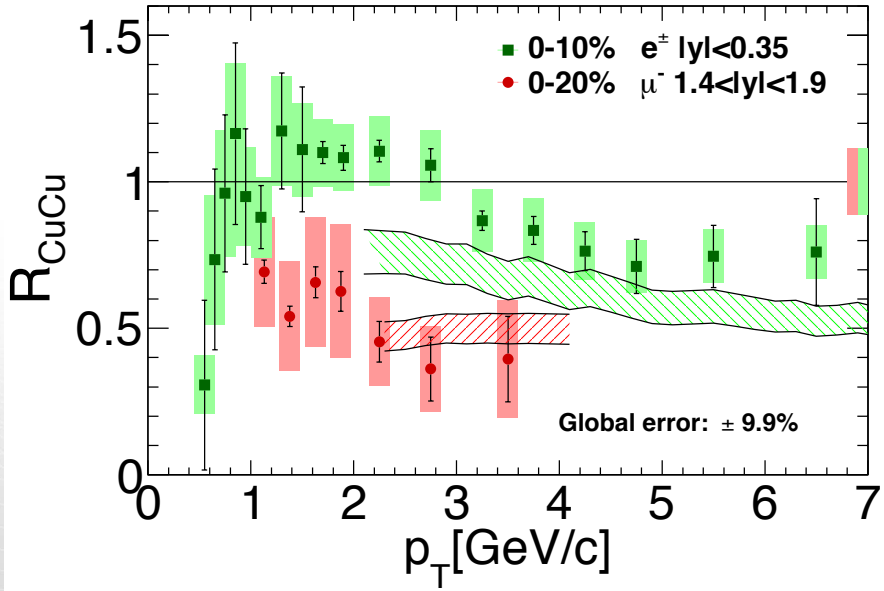






R_{CP} shows a significant suppression
→ hot nuclear matter effects are dominating in central Cu+Cu collisions

Rapidity expansion in Cu+Cu

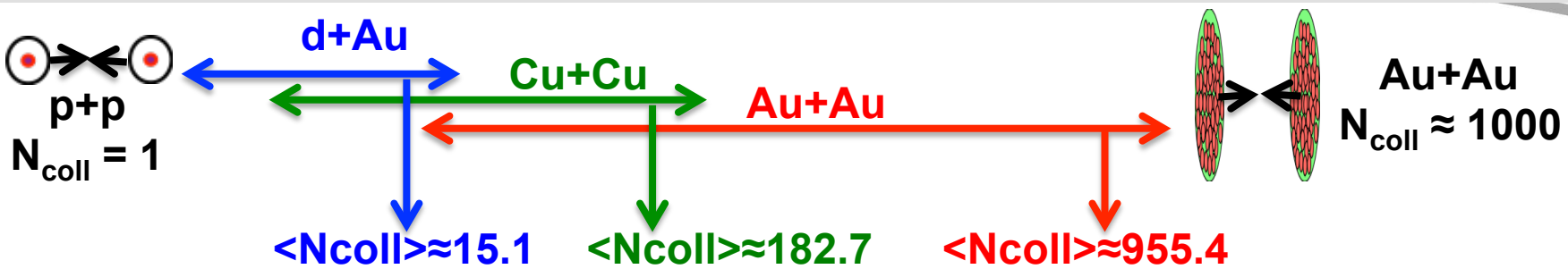


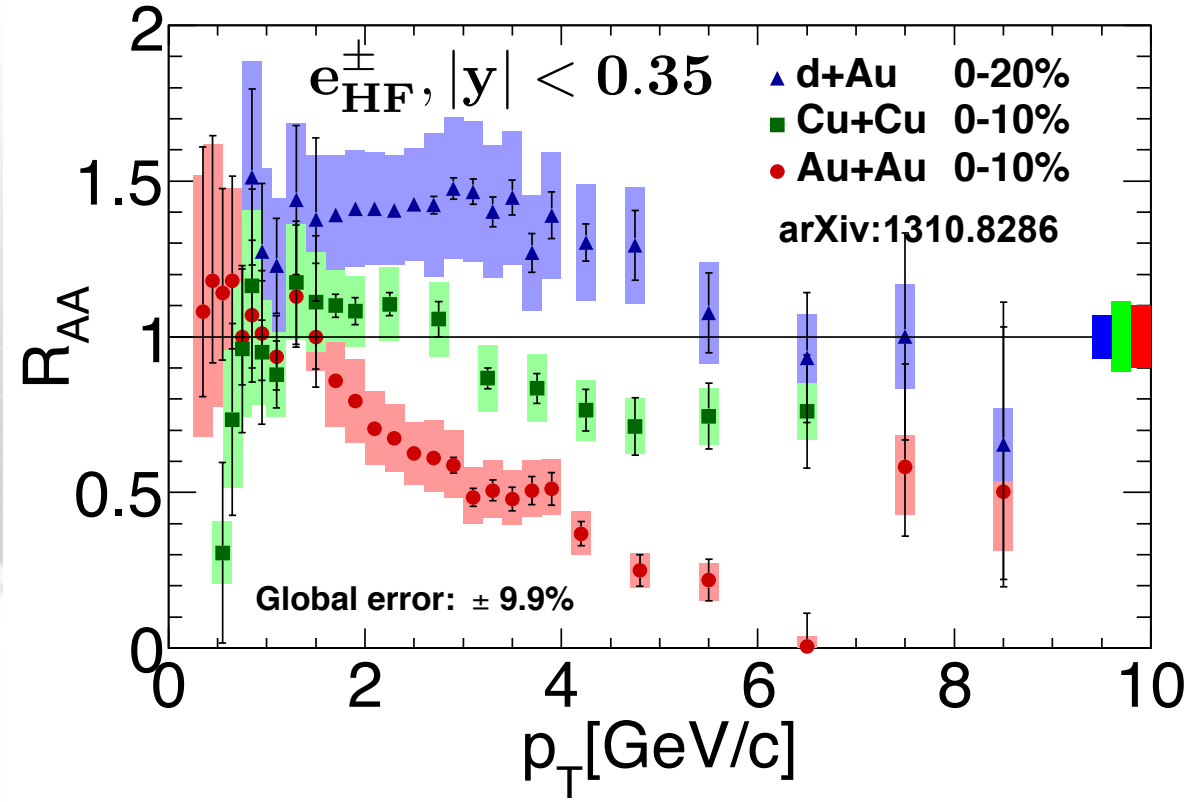
e : arXiv:1310.8286
μ : Phys. Rev. C 86, 024909 (2012)

theoretical calculation :
R. Sharma, I. Vitev, B.-W, Zhang
Phys. Rev. C 80, 054902 (2009)

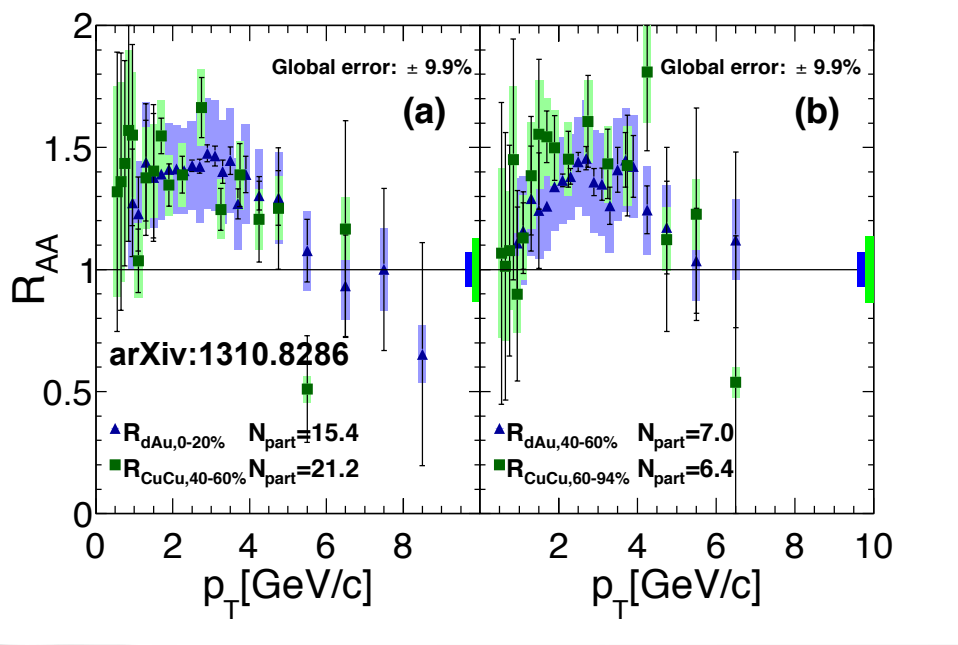
- larger suppression at forward rapidity
  - may need additional CNM effects (shadowing) at forward rapidity
  - theoretical calculations considering both hot and cold nuclear matter effects
    →consistent with the data at forward rapidity
    →slightly overestimate the suppression at p_T>3 GeV/c,
    but does not match at p_T<3 GeV/c at mid-rapidity

The most central collisions



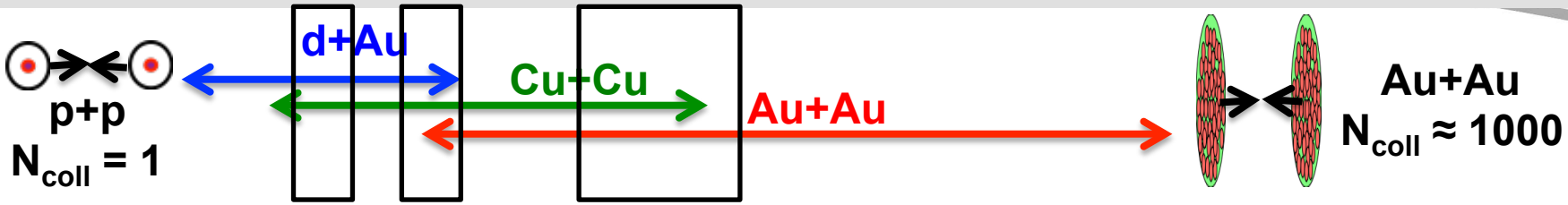


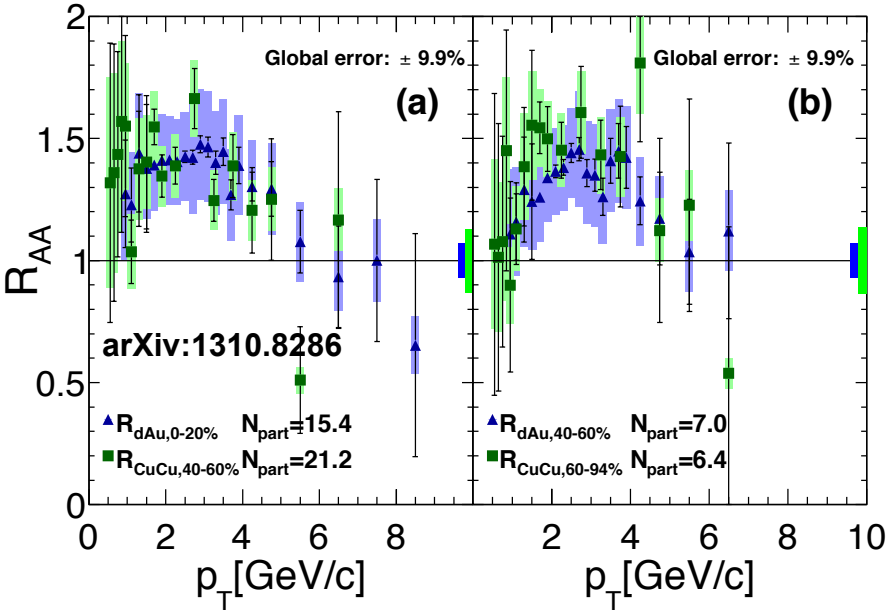
Similar system size

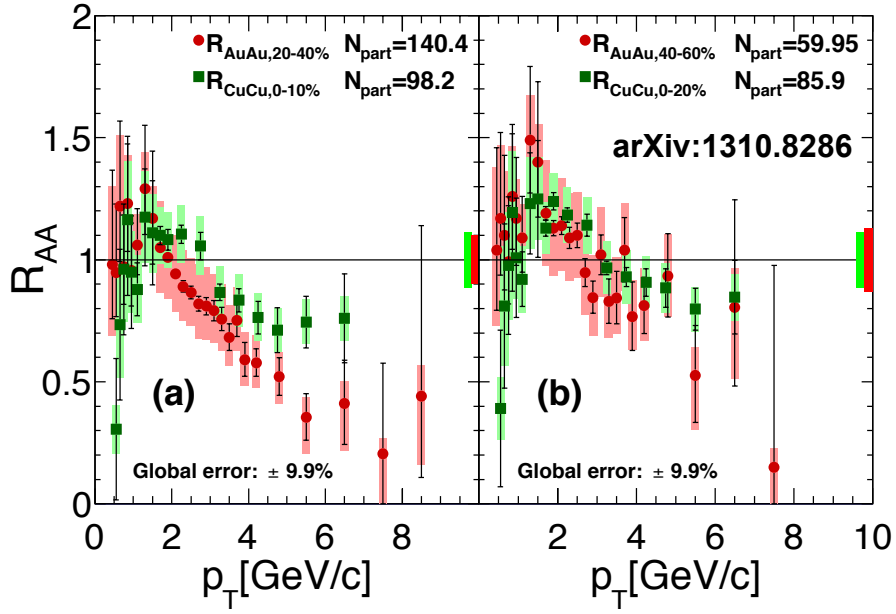


CENTRAL d+Au ≈ PERIPHERAL Cu+Cu

Similar system size



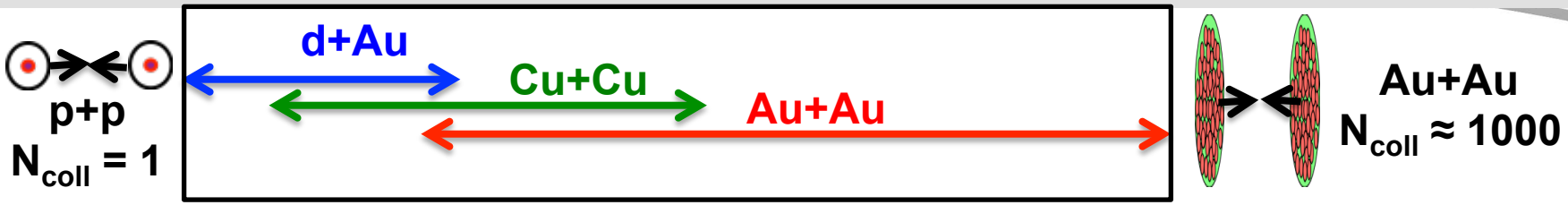


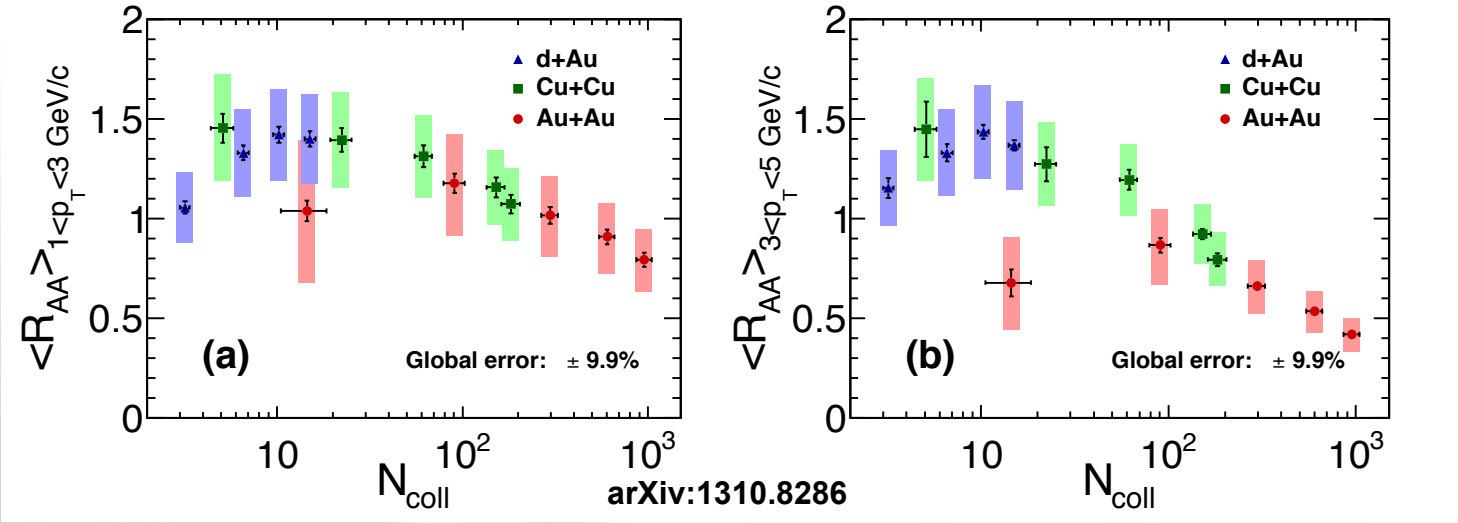


CENTRAL d+Au ≈ PERIPHERAL Cu+Cu

CENTRAL Cu+Cu ≈ MID Au+Au

System size dependence

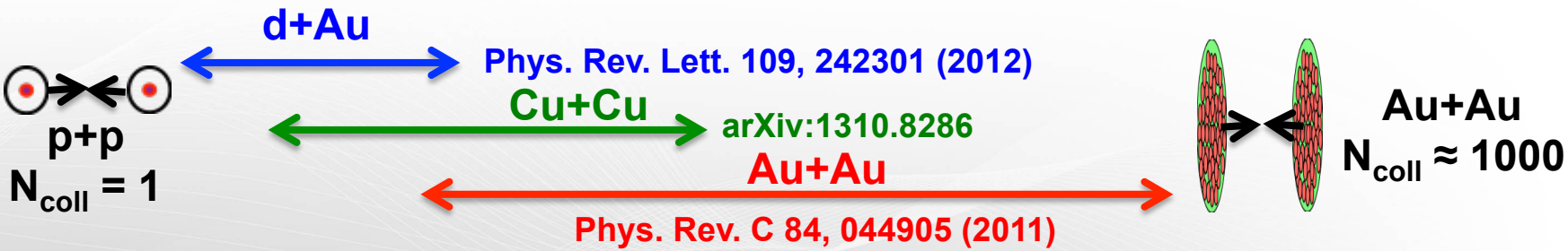


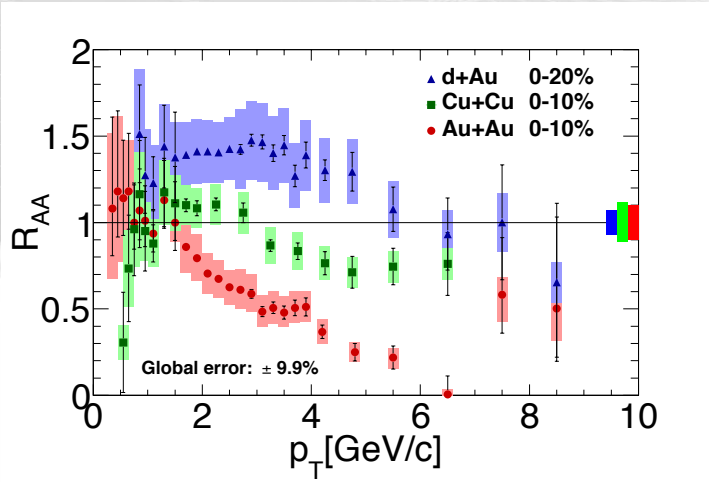


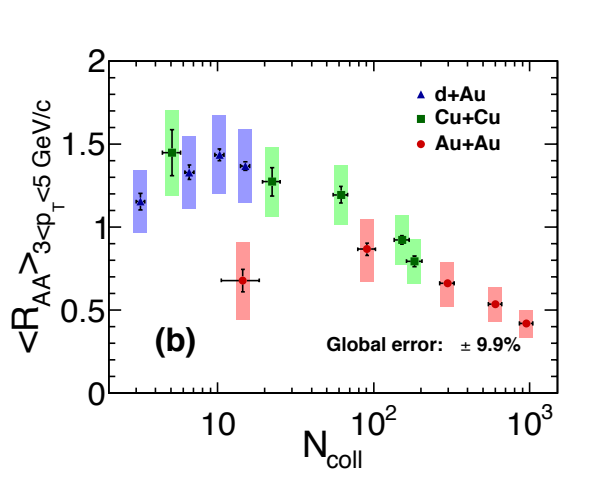
TREND FROM d+Au and peripheral Cu+Cu collisions
where enhancement effects are dominating
TO central Cu+Cu and Au+Au collisions
where suppression effects take over

Summary

- PHENIX has measured heavy-flavor electrons in various collision systems
  - **Showing the trend of decreasing R_{AA} with increasing system size after the enhancement in d+Au and peripheral Cu+Cu collisions**



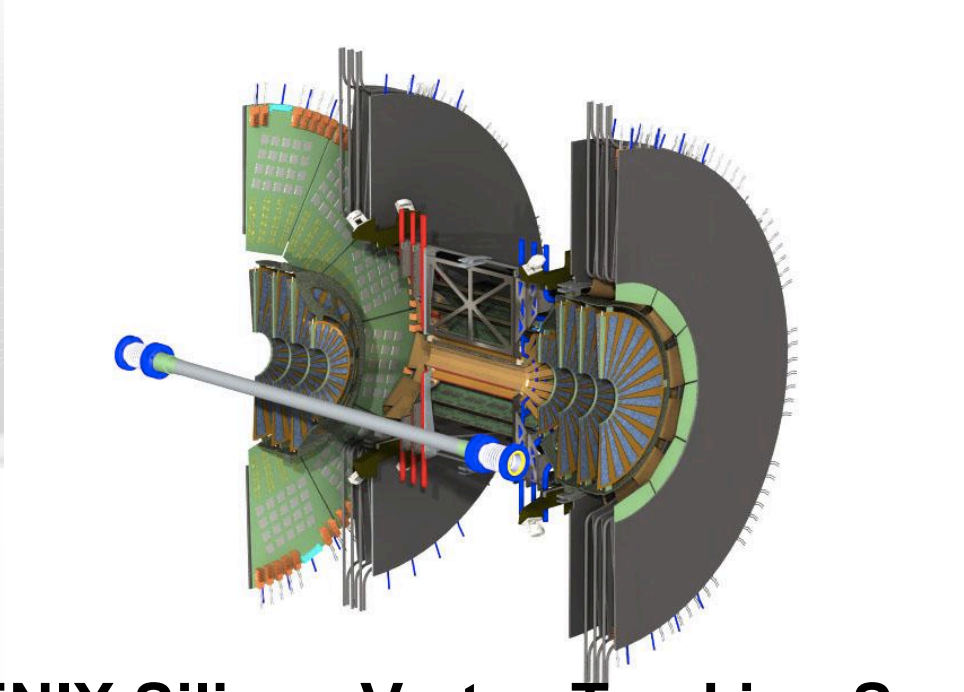




Next measurement!

- Silicon vertex tracking system VTX and FVTX are successfully taking Au+Au collision data now!
  - Separation of D and B meson based on precise vertex measurement

$$R_{AA}^{charm} \; ? \; R_{AA}^{bottom}$$



PHENIX Silicon Vertex Tracking System

BACK UP

Study of heavy quark production

- Produced in the early stage of collisions
  - experience evolution of medium
  - dominantly by gluon fusion at RHIC energy
- PHENIX can study effects on heavy quark production from various collision systems

Cold Nuclear Matter effects

shadowing

pT broadening

initial-state energy loss

nuclear break-up

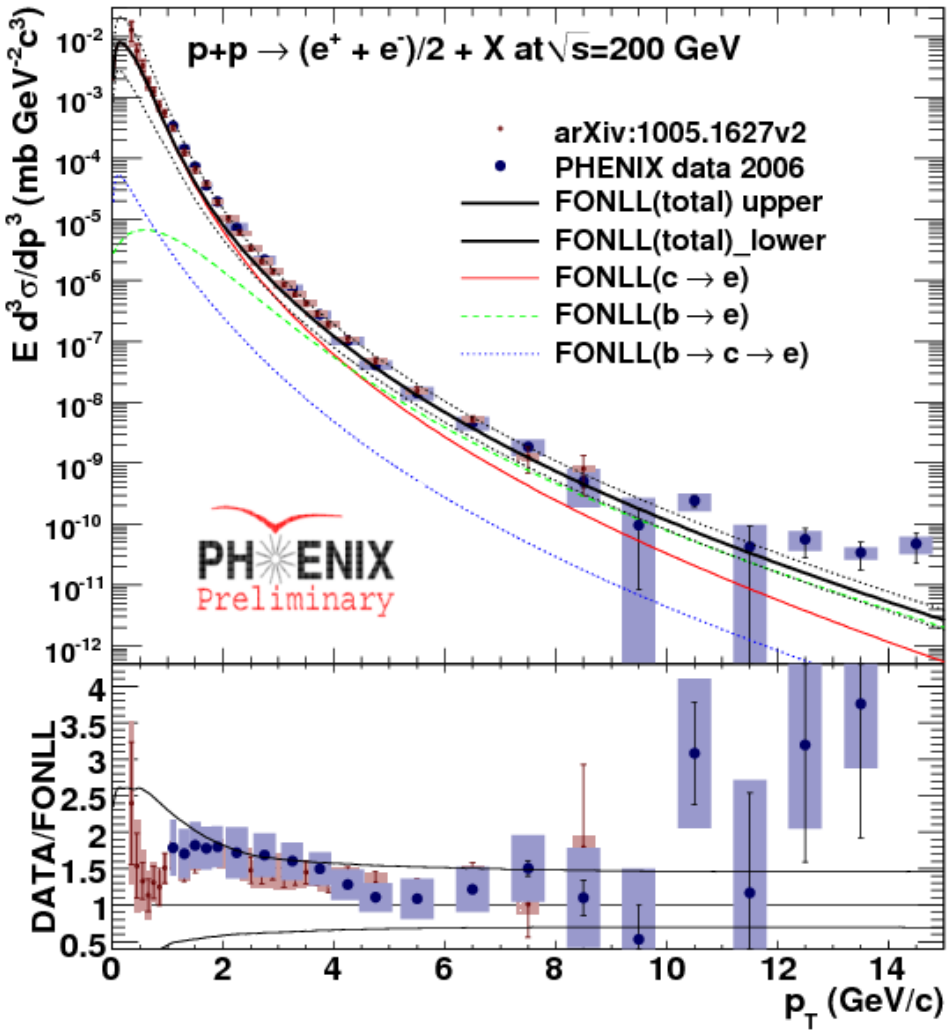
Hot Nuclear Matter effects

energy loss mechanism

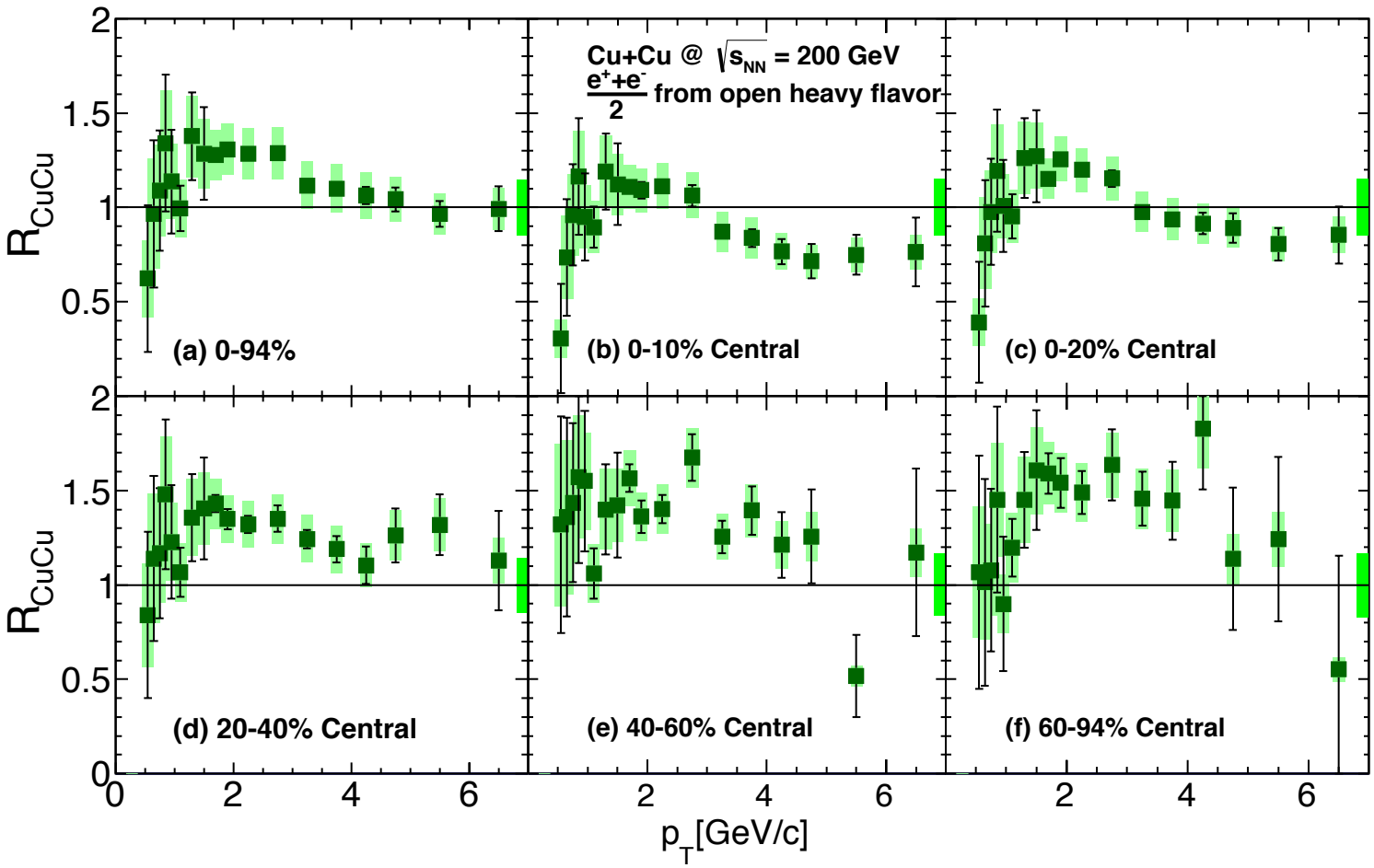
dead cone effect

$$\Delta E_g > \Delta E_{u,d} > \Delta E_c > \Delta E_b$$

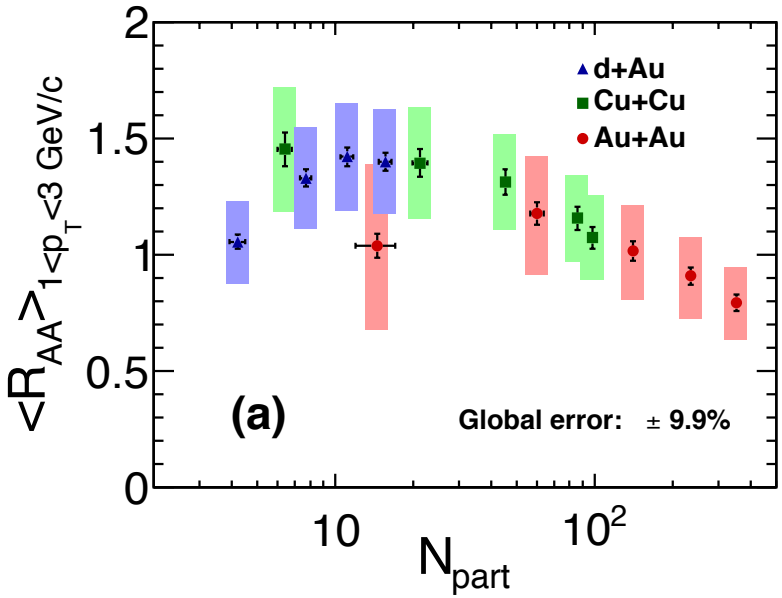
Improved p+p baseline

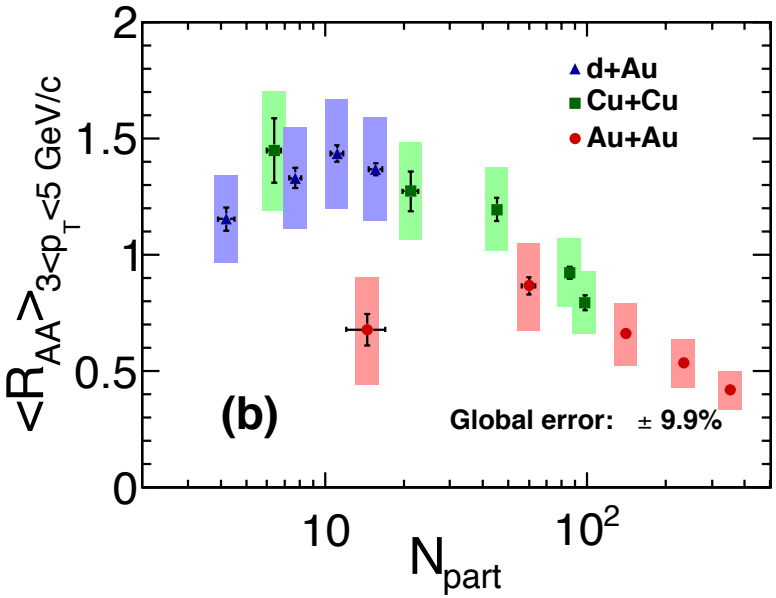


R_{AA} in Cu+Cu collisions

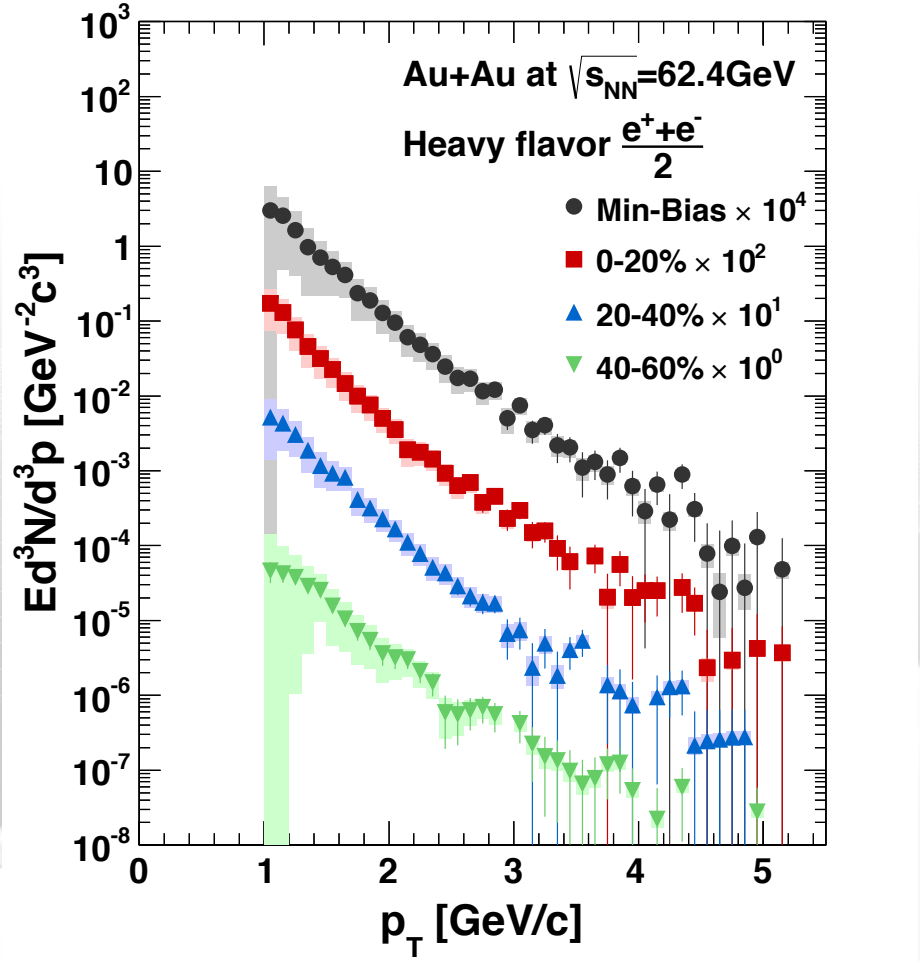


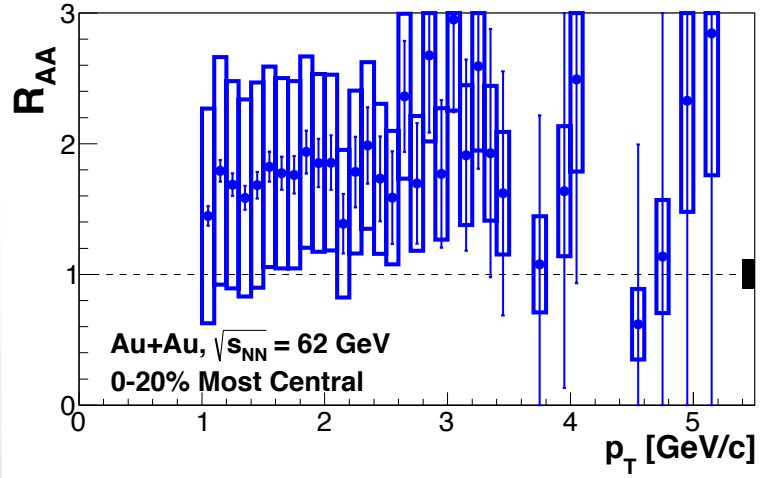
R_{AA} vs. N_{part}

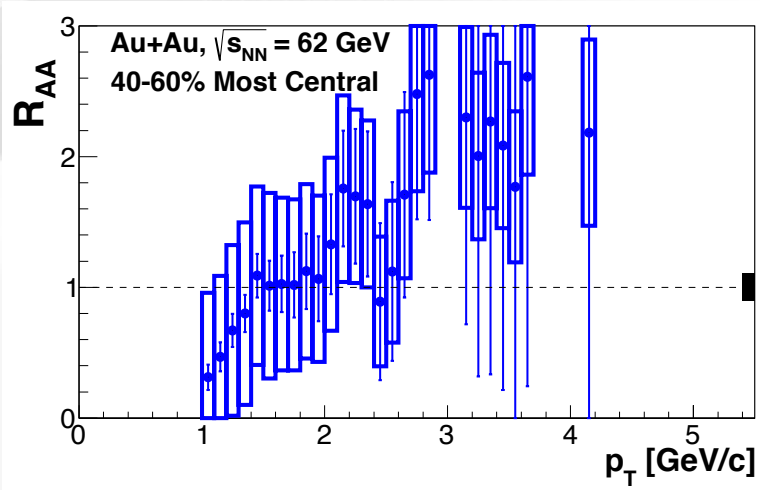
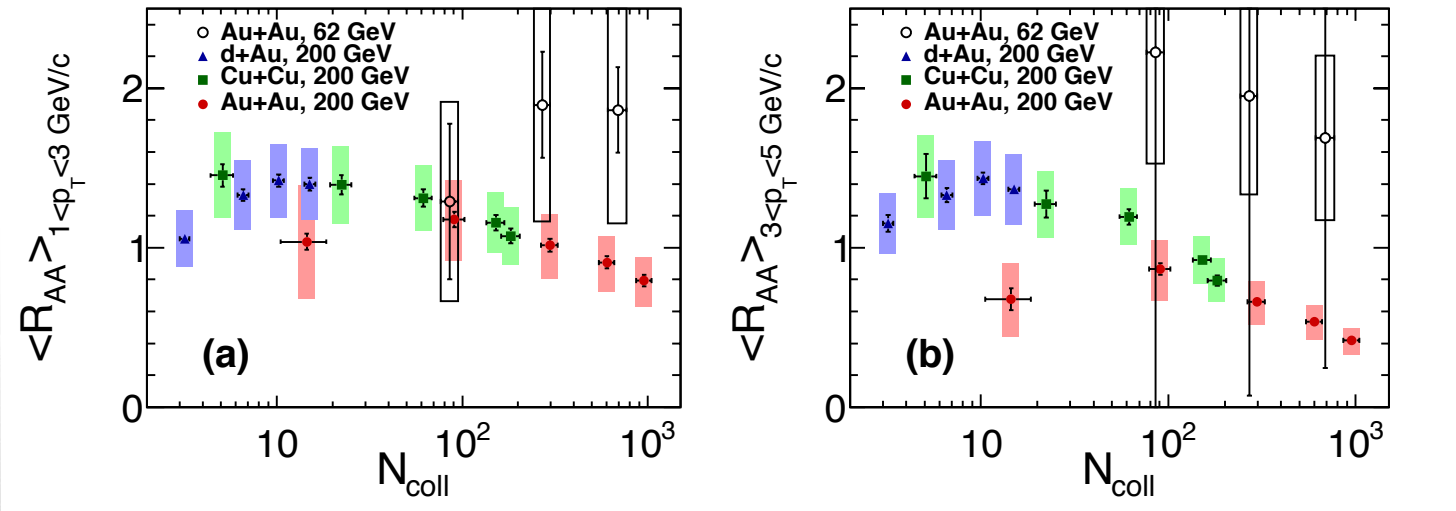
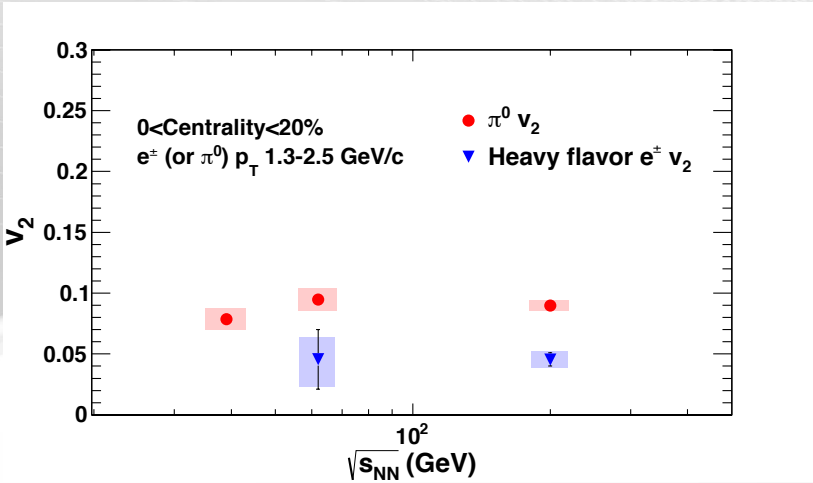
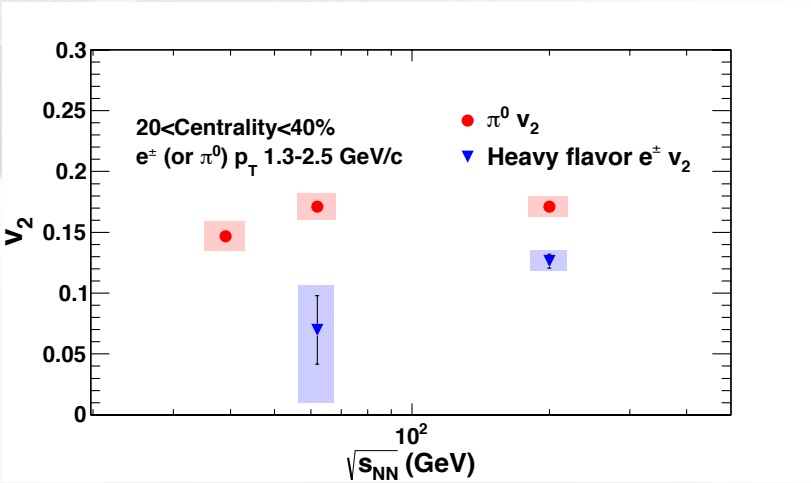

d+Au
Cu+Cu
Au+Au
(a)
Global error: ± 9.9%
$\langle R_{AA} \rangle_{1<p_T<3\ GeV/c}$
N_{part}


d+Au
Cu+Cu
Au+Au
(b)
Global error: ± 9.9%
$\langle R_{AA} \rangle_{3<p_T<5\ GeV/c}$
N_{part}

Au+Au collisions @ 62.4 GeV







Au+Au collisions @ 62.4 GeV