PHENIX results on J/ψ production in Au+Au and Cu+Cu collisions at $\sqrt{S_{NN}}$=200 GeV

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Hugo Pereira Da Costa
CEA Saclay, for the PHENIX collaboration

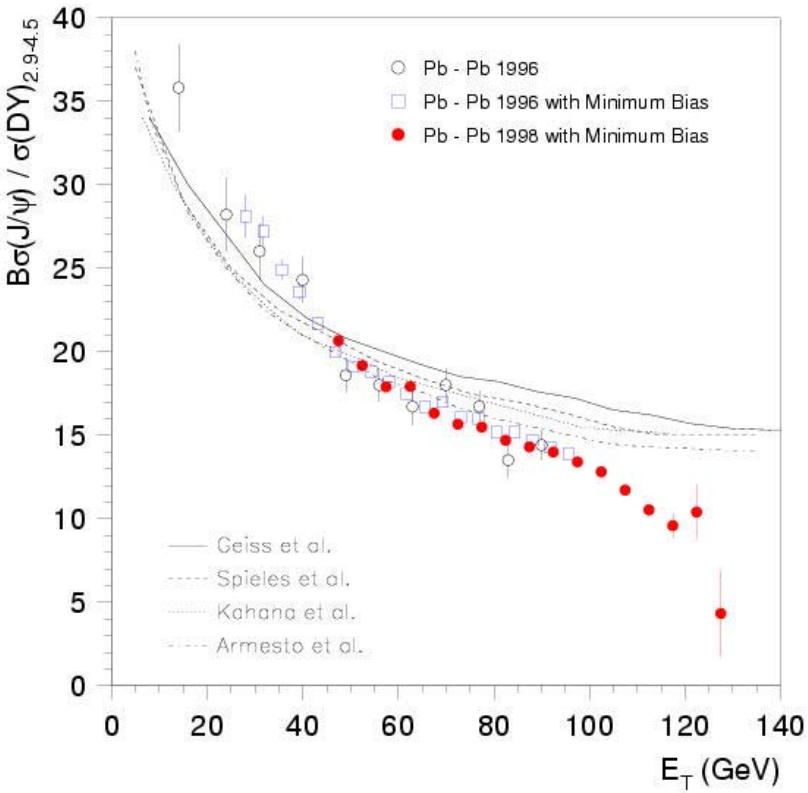
Outline

- Motivation
- Experimental setup
- Results and comparison to theory
- Highlights on additional J/ψ results

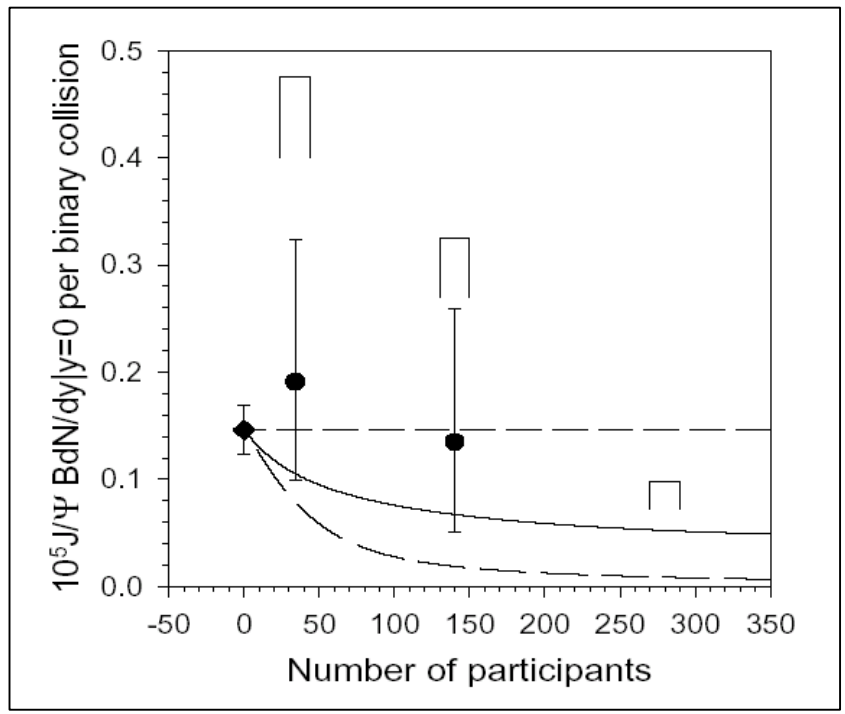
Motivations

- Predicted J/ψ suppression (Matsui and Satz, 1986, Phys. Lett. **B178,** 416.) via color screening
- Regeneration mechanisms at RHIC energy
- Comparison to CERN SPS results
- Poor statistics from PHENIX Run2 Au+Au collisions
- Available baseline from p+p and d+Au collisions @200 GeV (run3 data)

NA50, Phys. Lett. B477 (2000) 28.



PHENIX, Phys. Rev. C 69, 014901 (2004)



Experimental setup and J/Ψ signal

The PHENIX detector

Central arms:

hadrons, photons, electrons

$J/\Psi \rightarrow e^+e^-$

$p > 0.2$ GeV/c

$|y| < 0.35$

$\Delta\phi = \pi$

Muon arms:

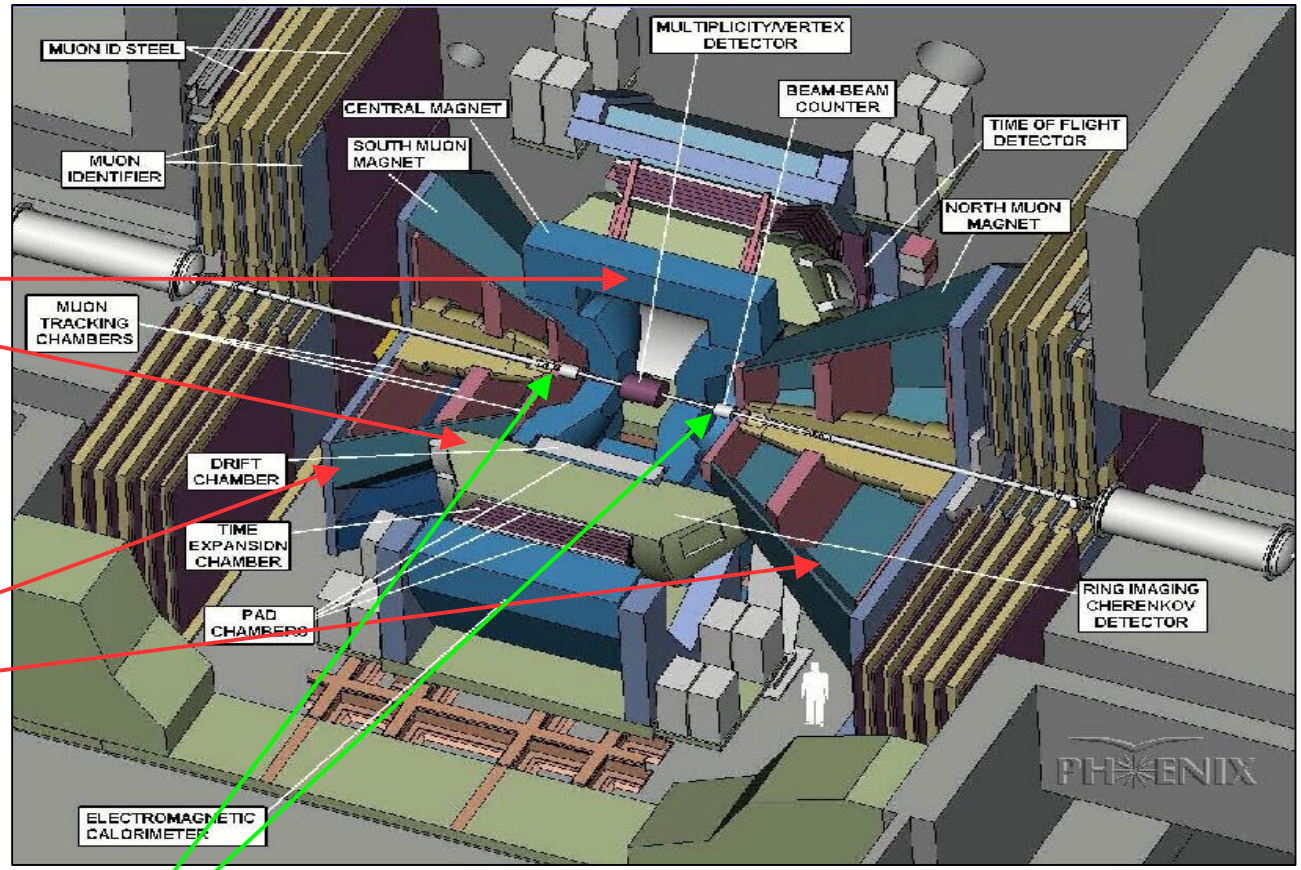
muons at forward rapidity

$J/\Psi \rightarrow \mu^+\mu^-$

$p > 2$GeV/c

$1.2 < |y| < 2.4$

$\Delta\phi = 2\pi$



Centrality measurement:

We use beam beam counters together with zero degree calorimeters

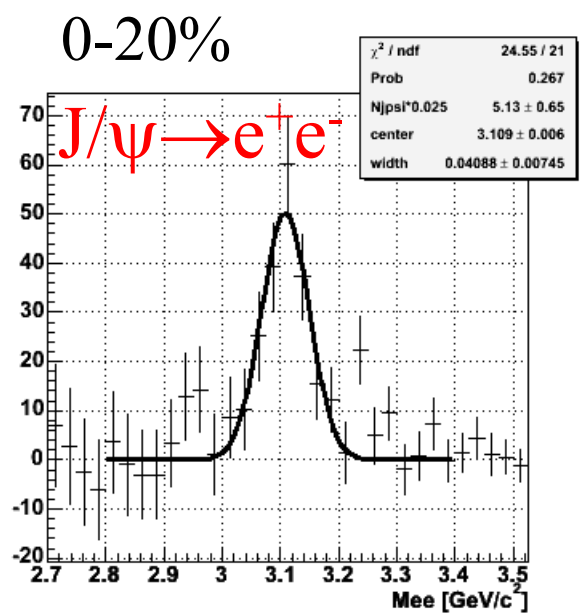
Centrality is mapped to N_{part} (N_{col}) using Glauber model

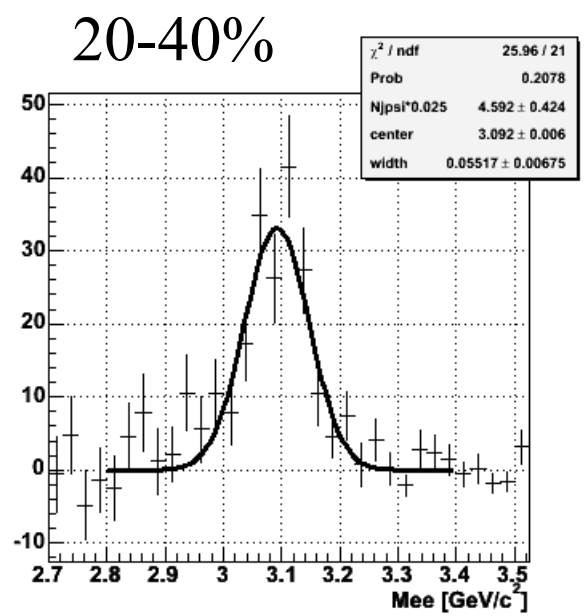
Data sets

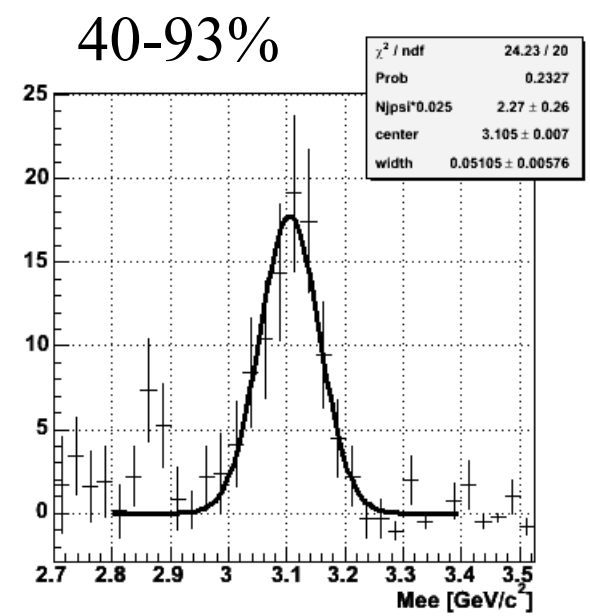
Year	Ions	Luminosity	#Events
2003	p+p @200GeV D+Au @200GeV	350 nb^{-1} 2.74 nb^{-1}	
2004	Au+Au @200GeV	241 μb^{-1}	$1.5\ 10^9$
2005	Cu+Cu @200GeV Cu+Cu @62GeV	3.06 nb^{-1} 190 μb^{-1}	$1.08\ 10^9$ $425\ 10^6$

- Run4 Au+Au data processed using offline level2 triggers
- Run5 Cu+Cu data processed using online level1and offline level2 triggers
- Run3 p+p data are used as reference for R_{AA} calculations
- Run3 d+Au gives baseline for comparison to heavier ions

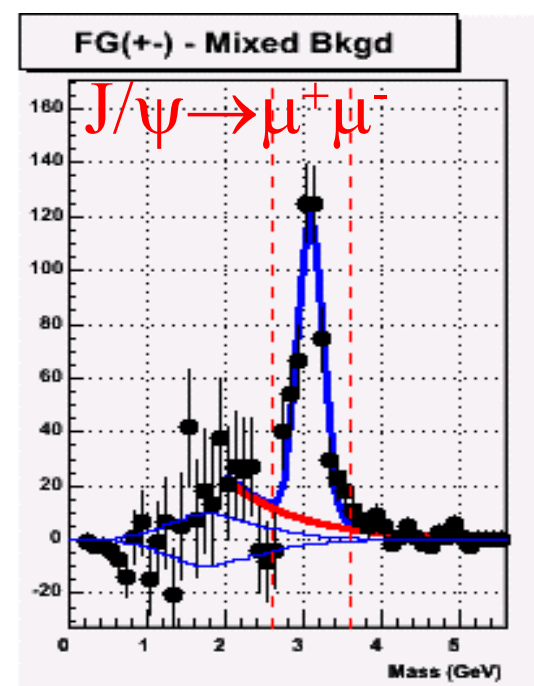
J/ψ signal in Au+Au





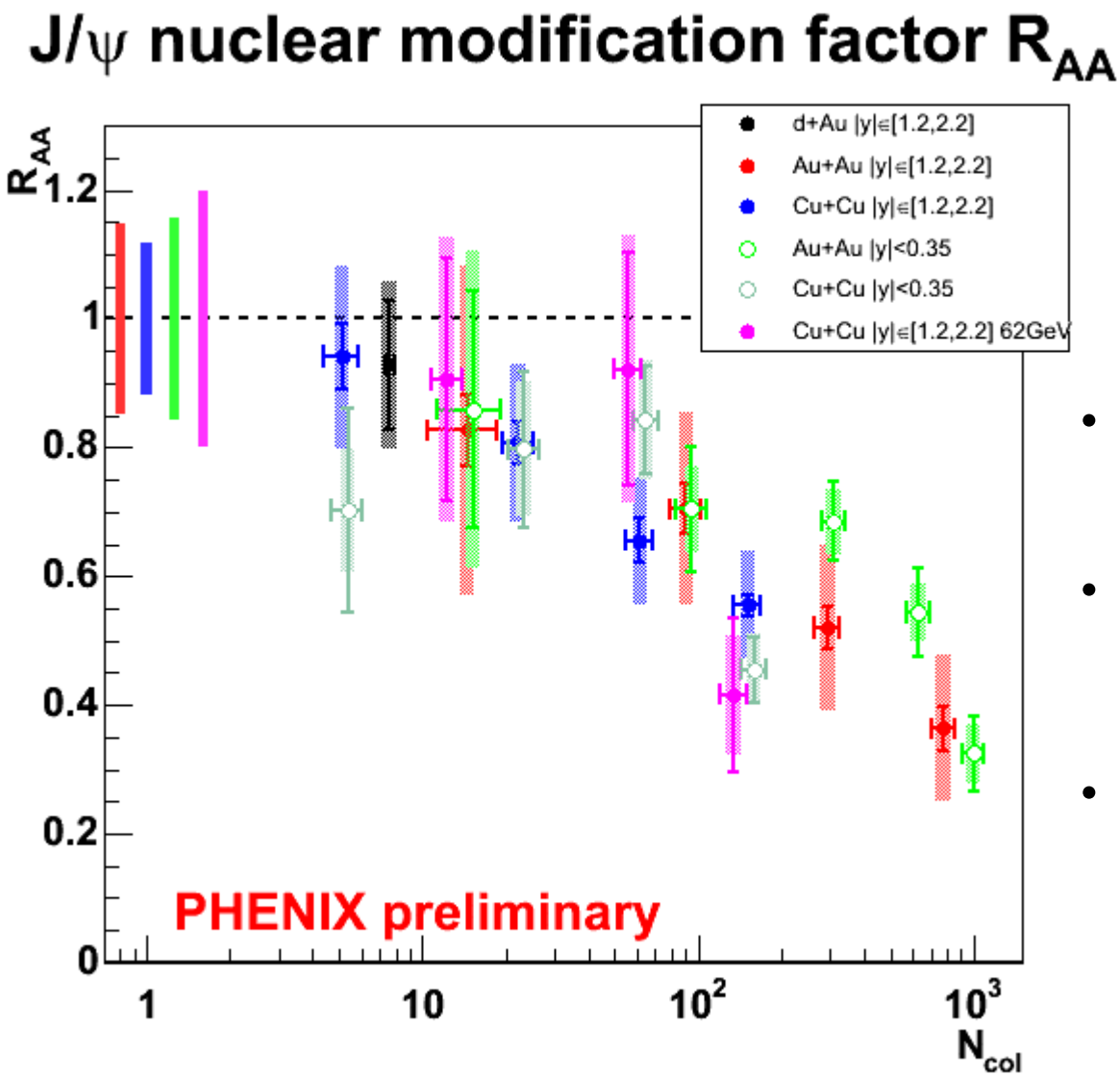


- Background subtracted using event mixing
- Number of J/ψ calculated by simple counting in mass window
- Fit used to estimate the systematics
- Cu+Cu signal is similar to Au+Au peripheral, with much larger statistics



Results

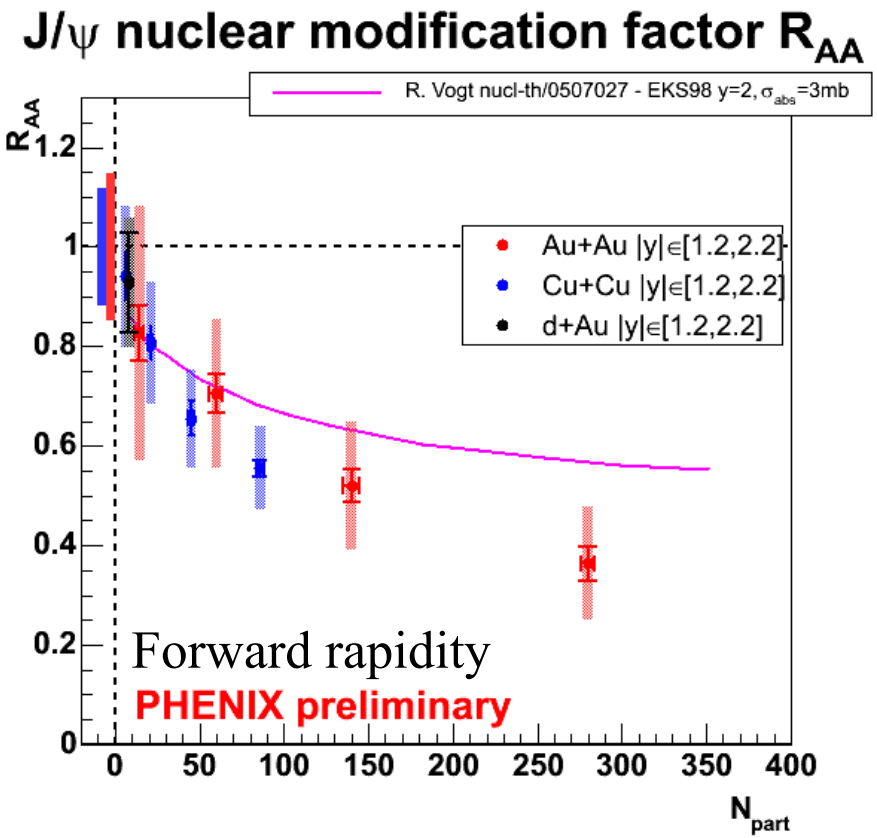
R_{AA} vs N_{col}

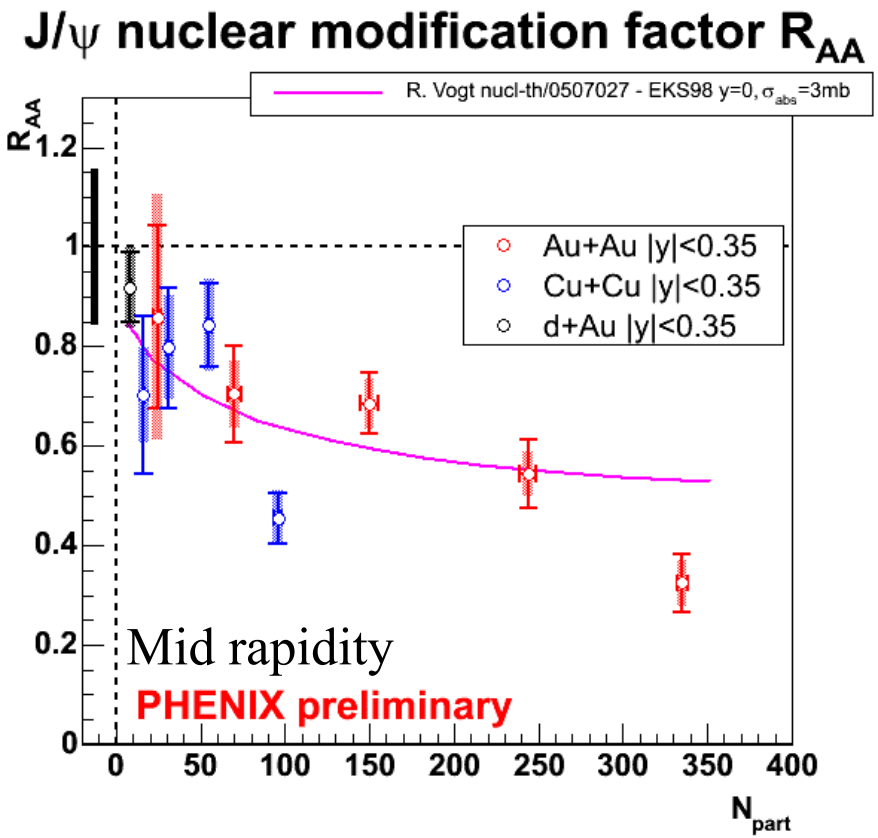


- Good agreement between muon datasets where they overlap
- Central arm points somewhat higher but the rapidity window differs
- Three additional points for Cu+Cu @62 GeV (forward rapidity)

About a factor 3 suppression for most central Au+Au points

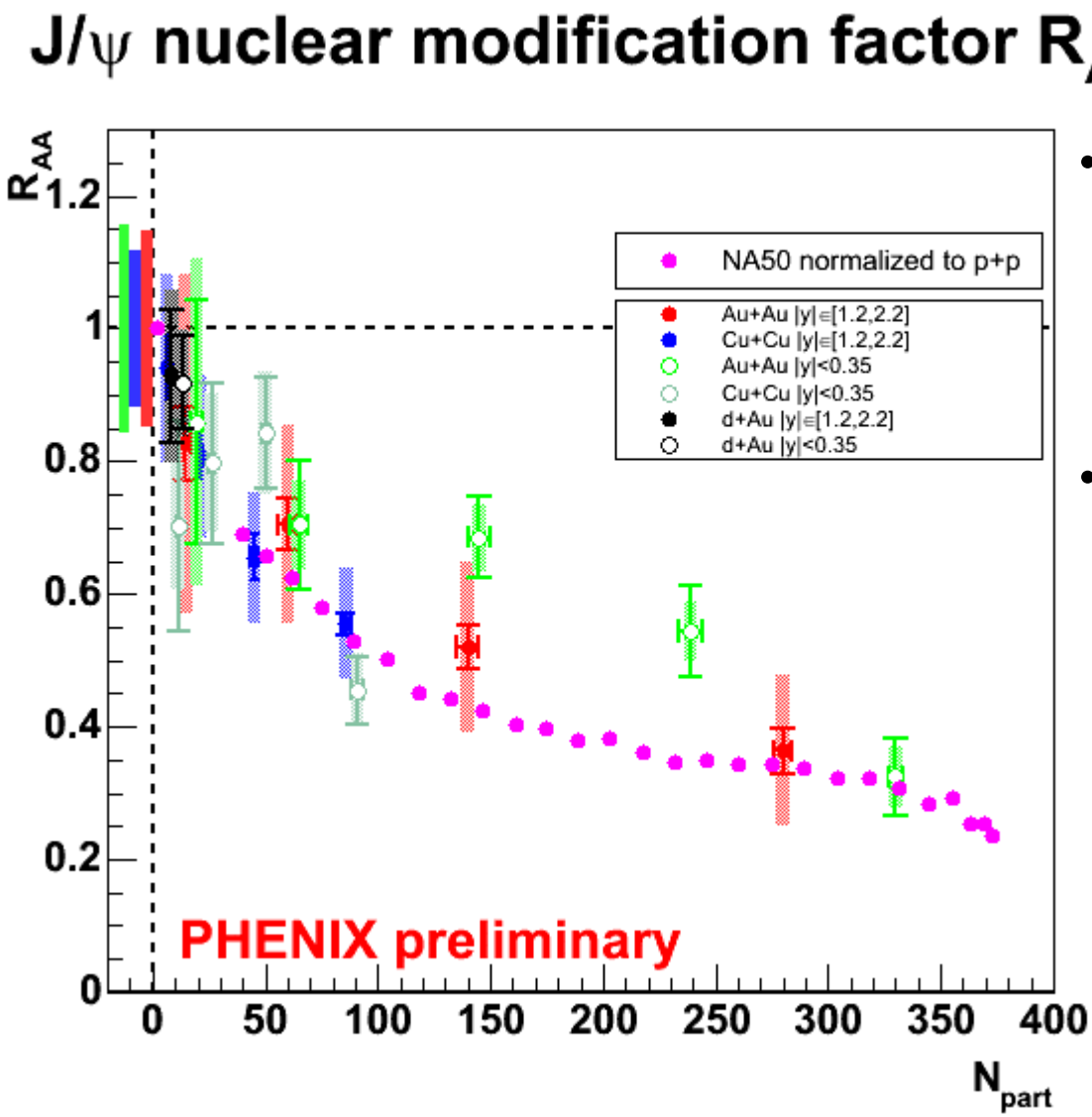
R_{AA} vs N_{part} (1/4)
comparison to cold nuclear effects





- Prediction is from pQCD calculations, including 3mb nuclear absorption and shadowing
- Seems to underestimate the suppression
- Note: σ_{abs} somewhat too high wrt d+Au data

R_{AA} vs N_{part} (2/4) comparison to NA50 data

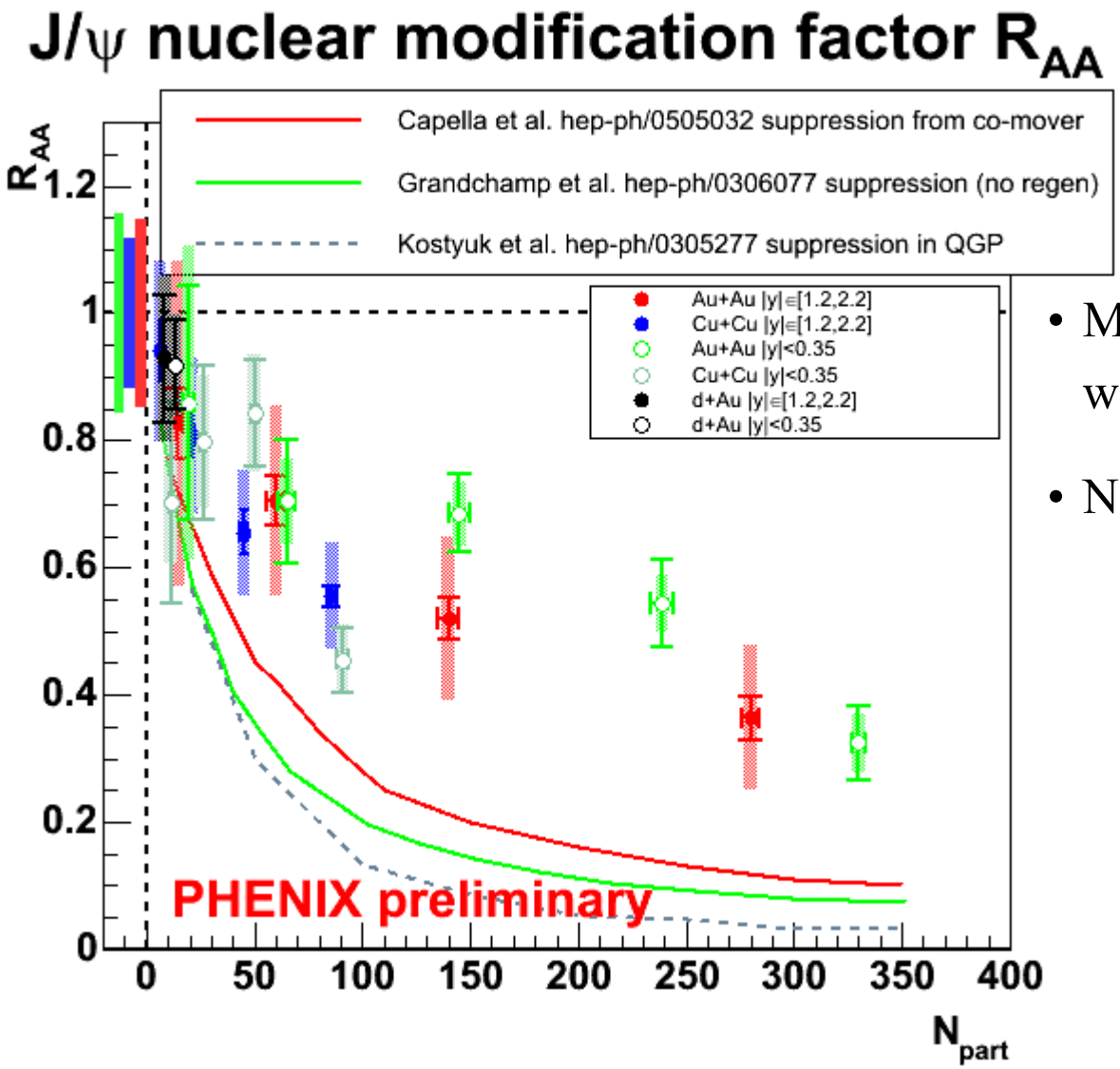


- Comparison with NA50 data presented wrt N_{part} and normalized to NA50 p+p point.

- Suppression level is similar between the two experiments, **but**
  1. the collision energy is 10 times higher (200GeV wrt 17GeV)
  2. the rapidity window for NA50 is $|y| \in [0,1]$

Needs more detailed comparison to cope with energy difference

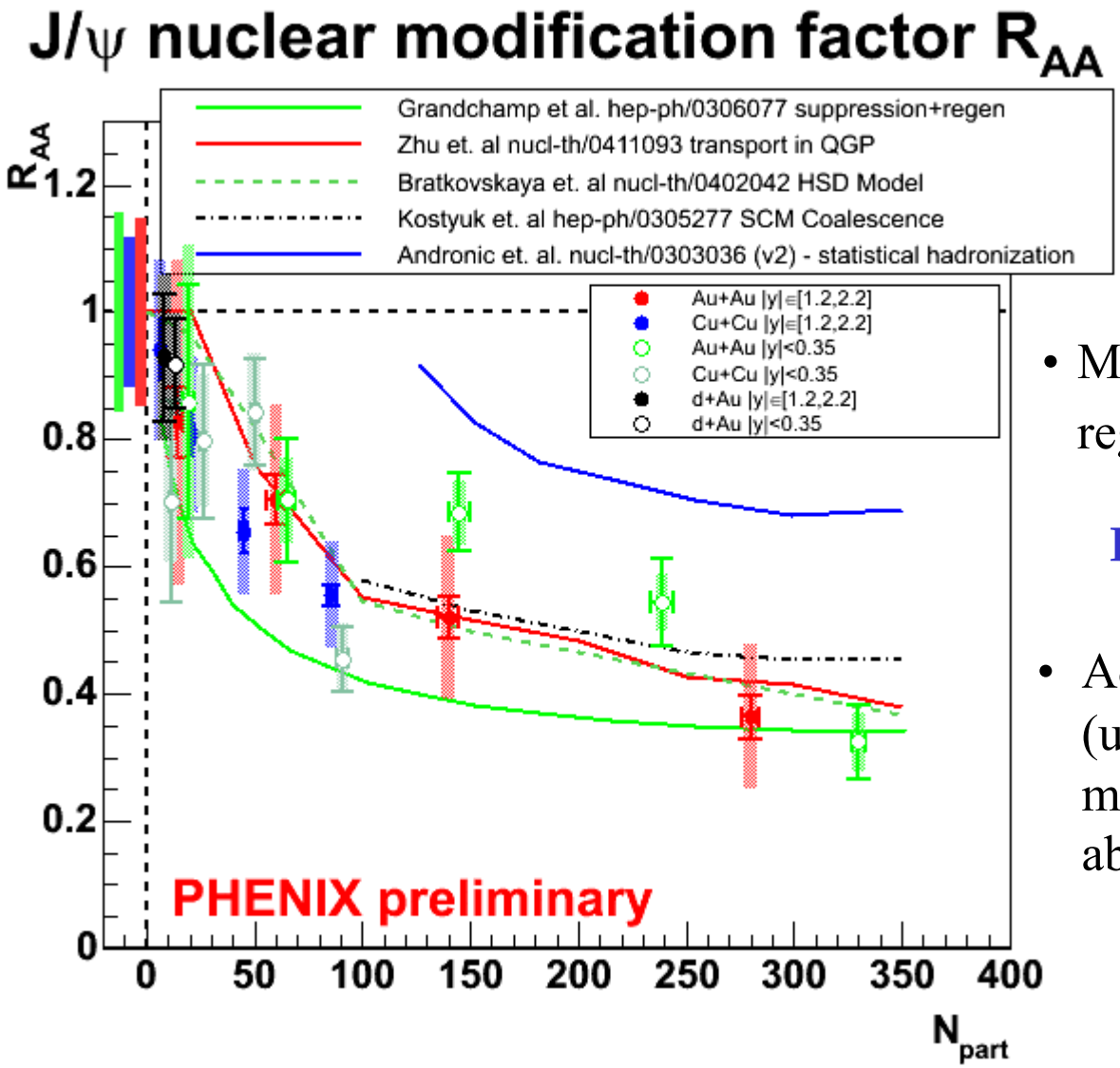
R_{AA} vs N_{part} (3/4)
Comparison to theoretical predictions



- Models which reproduce NA50 data, with J/ψ suppression only.
- No regeneration mechanism.

J/psi suppression is over-estimated

R_{AA} vs N_{part} (4/4)
Comparison to theoretical predictions

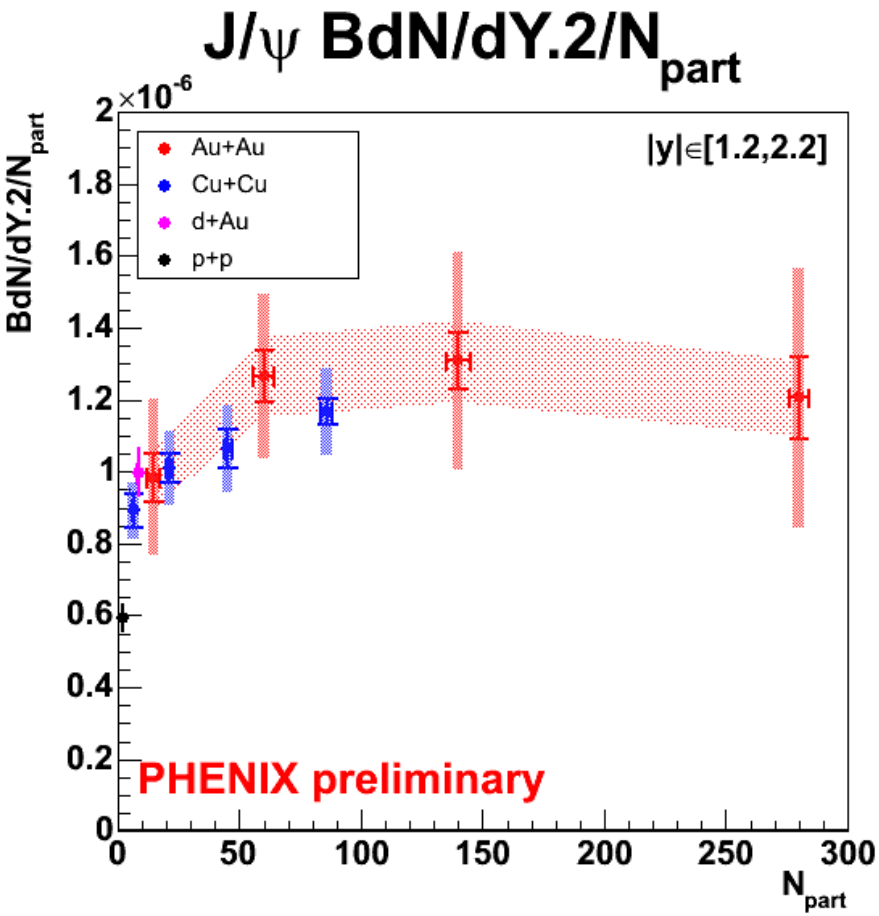


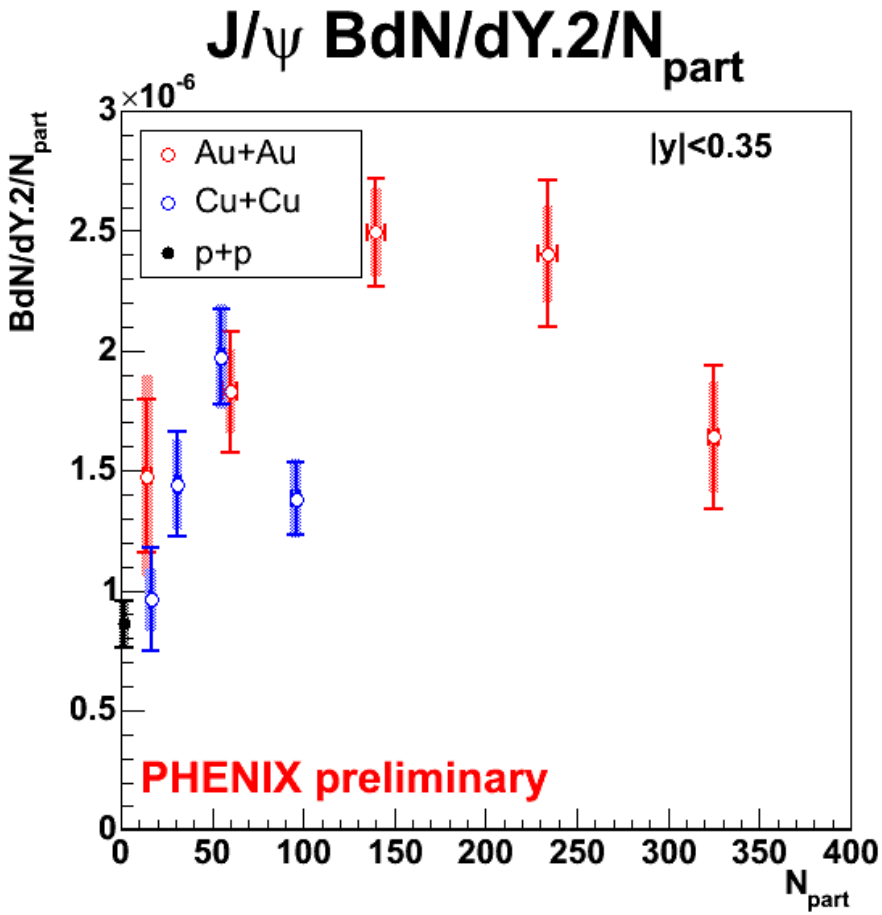
- Models using suppression + various regeneration mechanisms;

  Better matching with data points

- Added statistical recombination model (using 390μb for open charm σ, total melting of direct J/Ψ and no co-mover absorption)

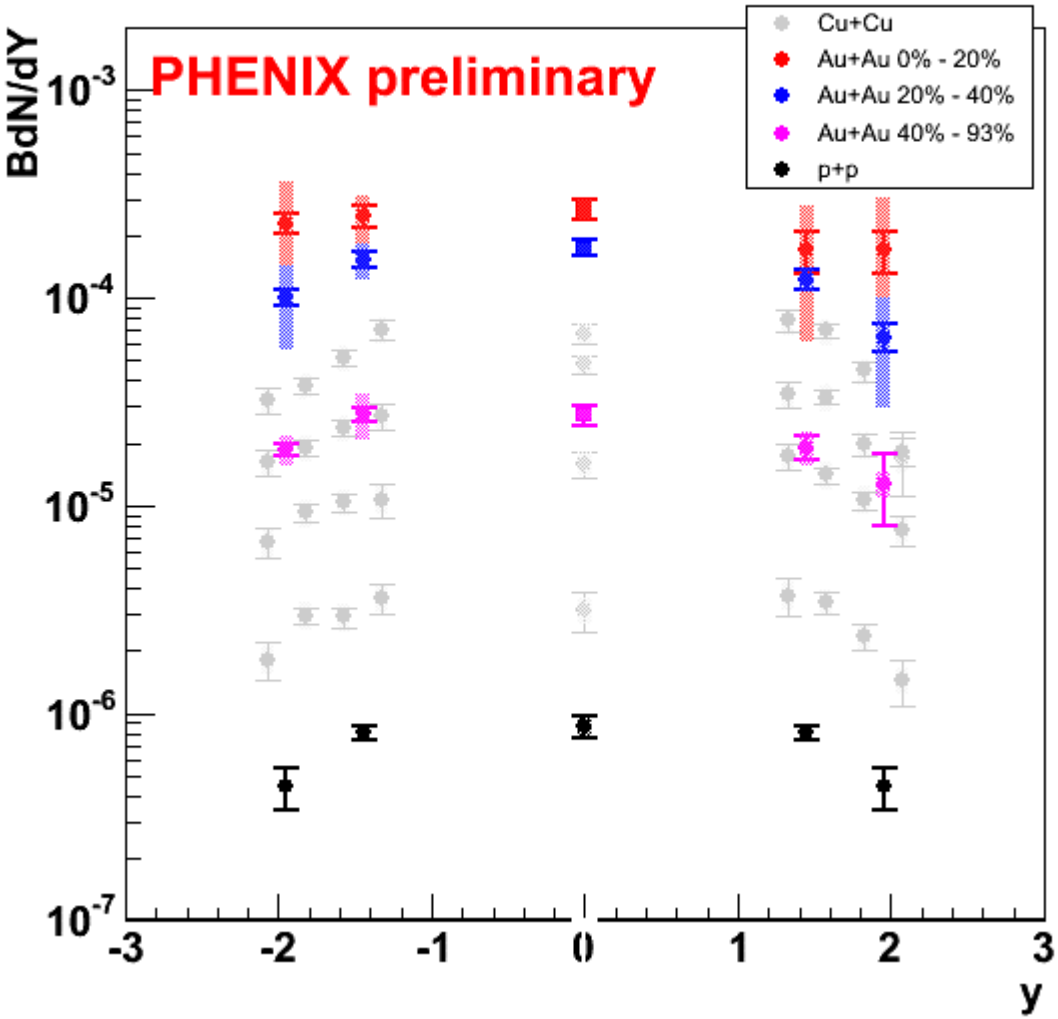
Test of N_{part} scaling





Rapidity and p_t spectrum

BdN/dy vs rapidity (1/2)



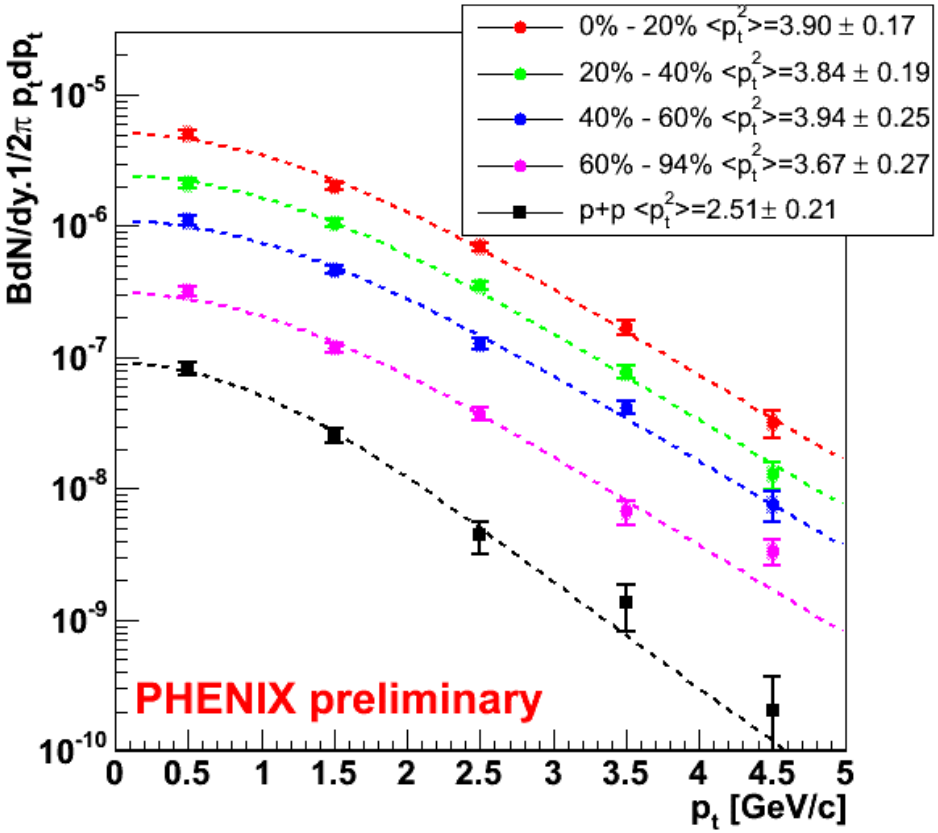
- For Cu+Cu, no significant change in shape, except in most central bin
- Adding Au+Au points on top of CuCu. Same conclusion.
- Recombination model (Thews et. al. nucl-th/0505055) expect rapidity shape to become narrower for increasing N_{part}

  but

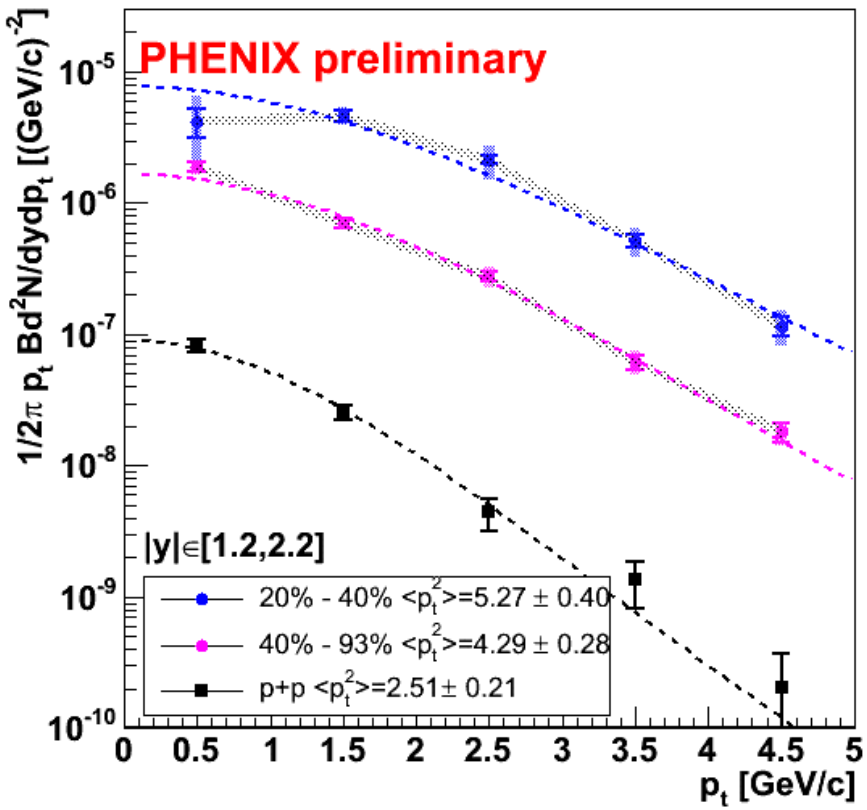
  - No available combination of suppression + recombination.
  - Rely on charm σ wrt rapidity

Invariant yield vs p_t

Cu+Cu (|y|∈[1.2,2.2])

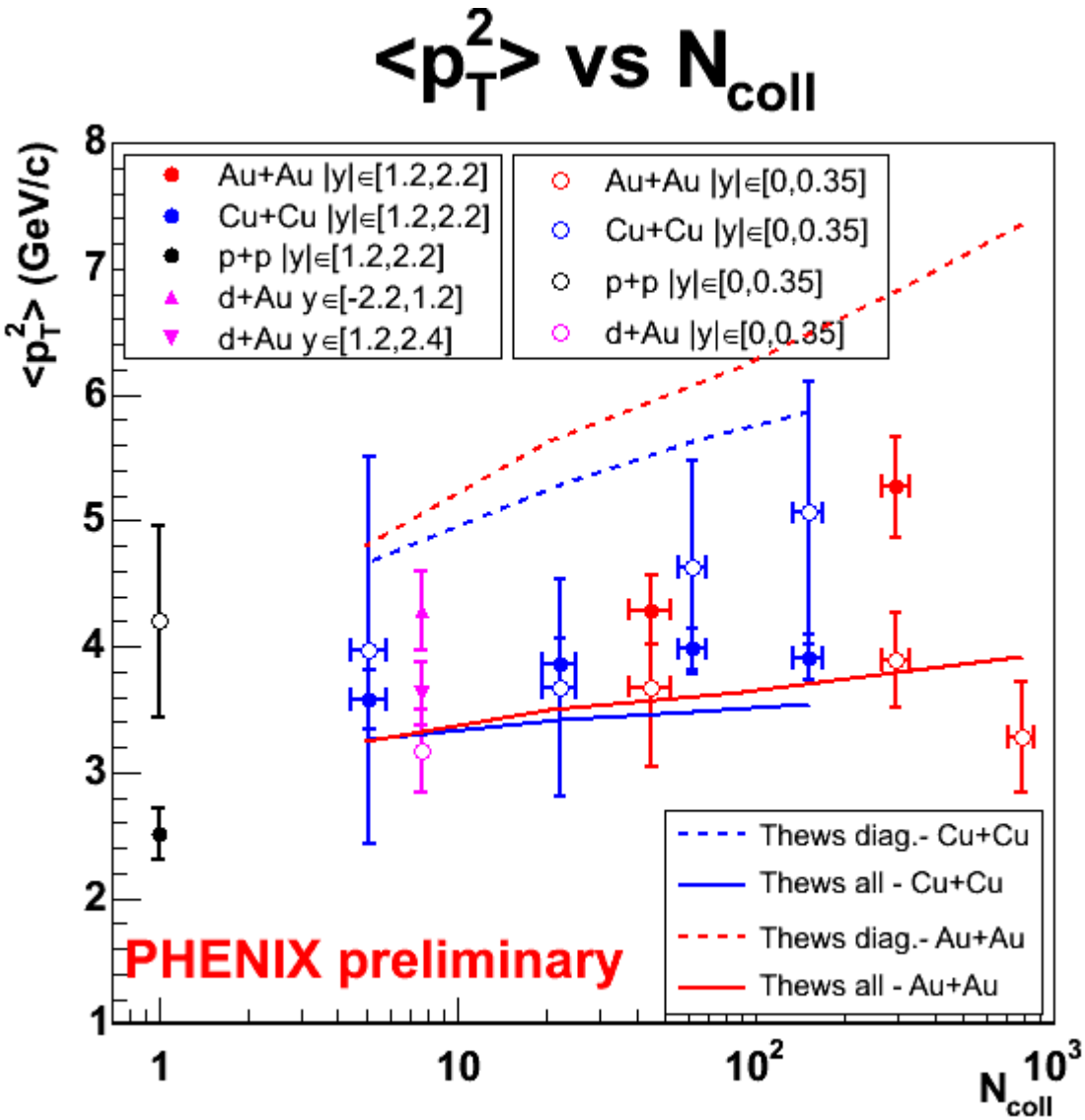


Au+Au (|y|∈[1.2,2.2])



we fit the p_t spectrum using $A[1+(p_t/B)^2]^{-6}$ to extract $\langle p_t^2 \rangle$

Mean transverse momentum vs N_{col}



- all PHENIX J/Ψ data
- Added Thews predictions for **Au+Au** and **Cu+Cu** collisions @200GeV. Solid (dashed) is with (without) regeneration.

Conclusion

- PHENIX has measured J/ψ at mid (|y|<0.35) and forward (|y|∈[1.2,2.2]) rapidity in Au+Au and Cu+Cu collisions @ $\sqrt{S_{NN}} = 200$ GeV
- Different data sets are consistent where they overlap
- Data exhibits a **factor 3 suppression** for most central events in Au+Au collisions
- First comparison to models suggests that
  - cold nuclear absorption is not enough to reproduce the suppression
  - recombination/regeneration is needed in order not to overestimate the suppression when extrapolating from CERN experiments
- The rapidity dependence of the J/ψ yield shows no dramatic change in shape with increasing N_{part}
- Mean p_t squared is consistent with flat, but large error bars

Related posters (1/2)

Au+Au @200GeV		
130	M. L. Brooks	Finding and reconstructing J/psi ->mu+mu- in AuAu collisions at sqrt(sNN) = 200 GeV
145	M. Kweon	pT dependence of J/psi production at forward rapidity in sqrt(sNN) = 200 GeV Au-Au collisions in PHENIX experiment
148	A. Lebedev	Study of J/psi polarization via dielectron channel in sqrt(sNN) = 200 GeV Au+Au collisions by the PHENIX experiment
171	V. N. Tram	Forward rapidity J/psi production in Au+Au collisions at sqrt(sNN) = 200 GeV.
178	D. d'Enterria	Photoproduction of J/Psi and high mass e+e- pairs in ultra-peripheral AuAu collisions at sqrt(sNN) = 200 GeV in PHENIX
187	T. Gunji	J/psi -> e+e- measurements in sqrt(sNN) = 200 GeV Au+Au collisions by PHENIX at RHIC

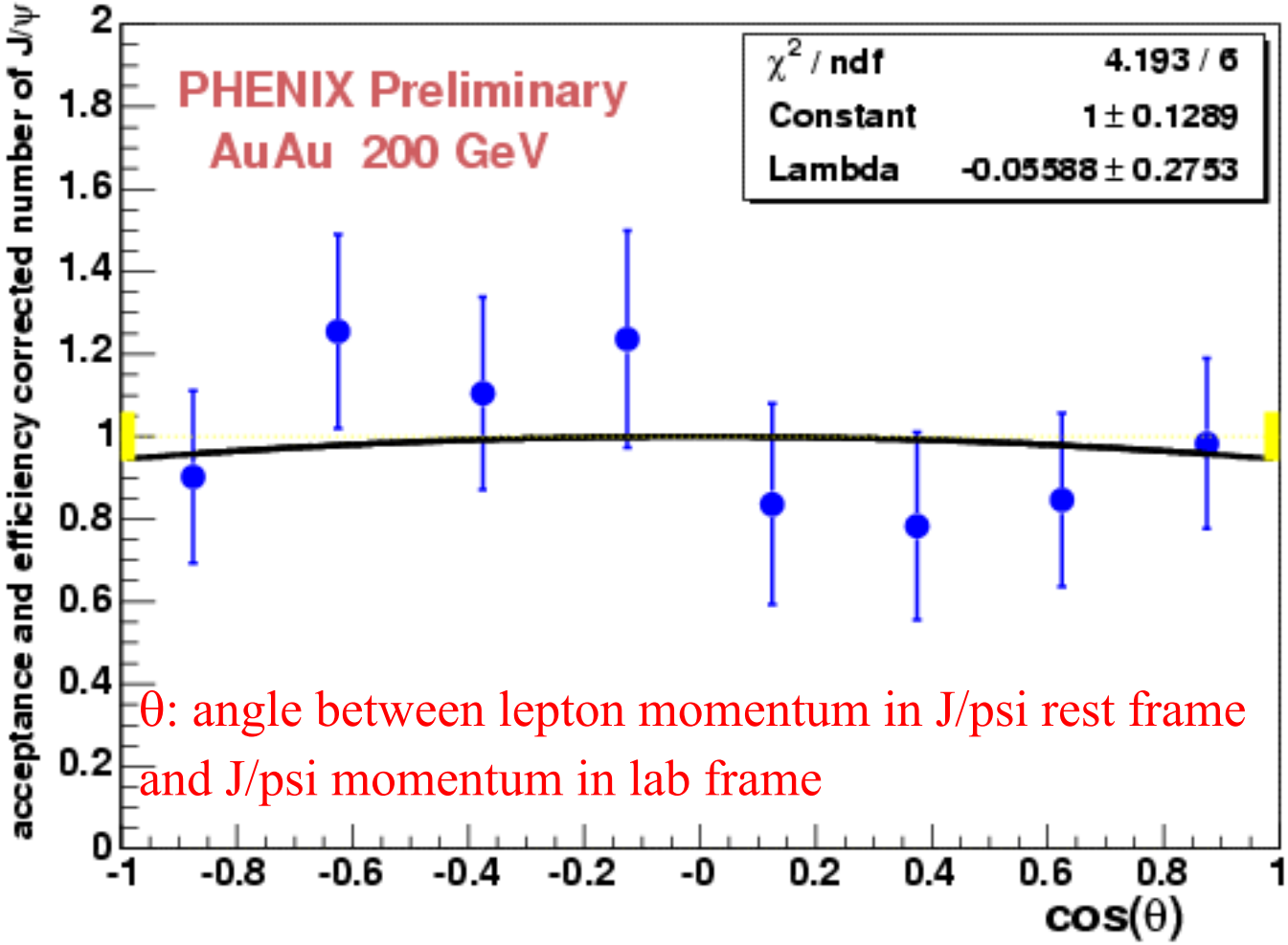
Related posters (2/2)

	Cu+Cu @200GeV	
7	X. He	J/psi polarization measurement via the dimuon decay channel from Cu+Cu collisions at sqrt(sNN) =200GeV at RHIC
181	K. Das	J/psi -> e+e- production at mid-rapidity in Cu+Cu collisions at sqrt(sNN) = 200 GeV from the Phenix experiment
184	A. M. Glenn	Transverse momentum dependence of J/psi production at forward rapidity in sqrt(sNN) = 200 GeV Cu+Cu collisions
201	A. Rakotozafindrabe	J/psi->mu+mu- measurement in Cu+Cu collisions at sqrt(sNN) = 200 GeV
204	D. Silvermyr	Centrality dependence of forward rapidity J/psi->mumu production in Cu+Cu collisions at sqrt(sNN) = 200 GeV
	Cu+Cu @62GeV	
129	A. A. Bickley	J/psi->mu+mu- production in Cu+Cu collisions at sqrt(sNN) = 62 GeV as observed in the Phenix muon arms
	p+p/d+Au @200GeV	
3	S. A. Butsyk	J/psi->mumu from the 2005 p+p RHIC run at sqrt(sNN) = 200 GeV
14	M. J. Leitch	J/Psi production and nuclear effects for d+Au collisions at sqrt(sNN) = 200 GeV
149	M. X. Liu	Open charm and J/Psi production at large rapidities in dAu collisions at RHIC

Highlights on additional results

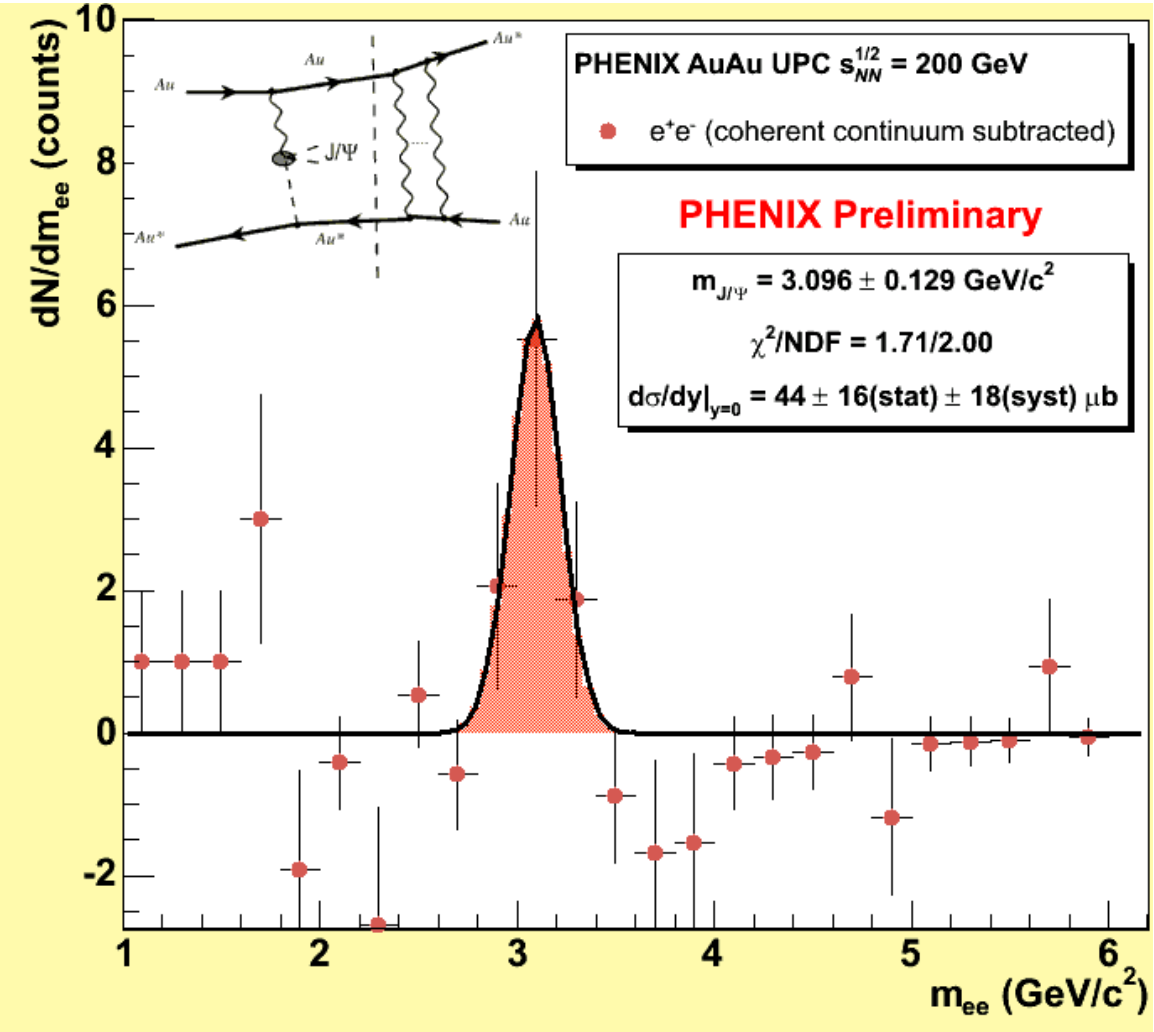
J/ψ polarization in Au+Au @200 GeV

Polarisation measurement: $N(\theta) = A[1+\lambda.\cos^2\theta]$



- J/ψ polarization helps discriminate between production mechanisms
- measured in central arm (|y|<0.35) in Au+Au @200GeV
- polarization is consistent with 0 within error bars

J/ψ photo-production in Au+Au ultra-peripheral collisions



- Measure coherent J/ψ photo-production at impact parameter 2xnuclei radius
- 1.7 10^6 events collected using dedicated trigger
- Clear J/ψ signal, consistent with theoretical predictions.

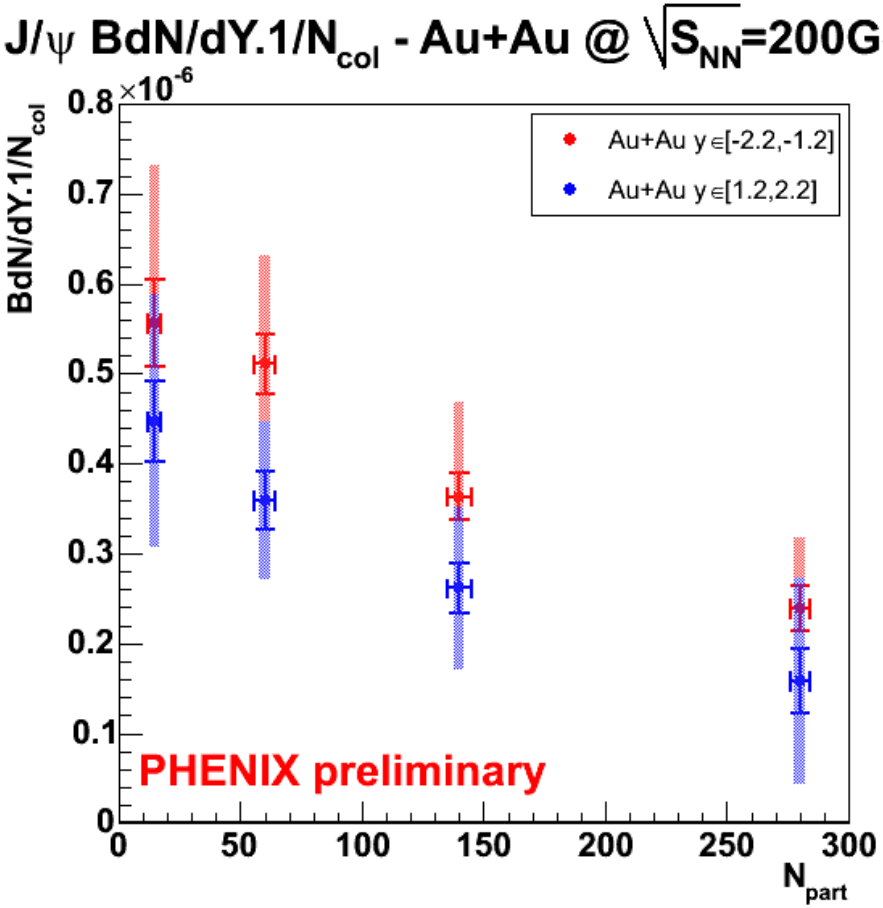
Backup slides

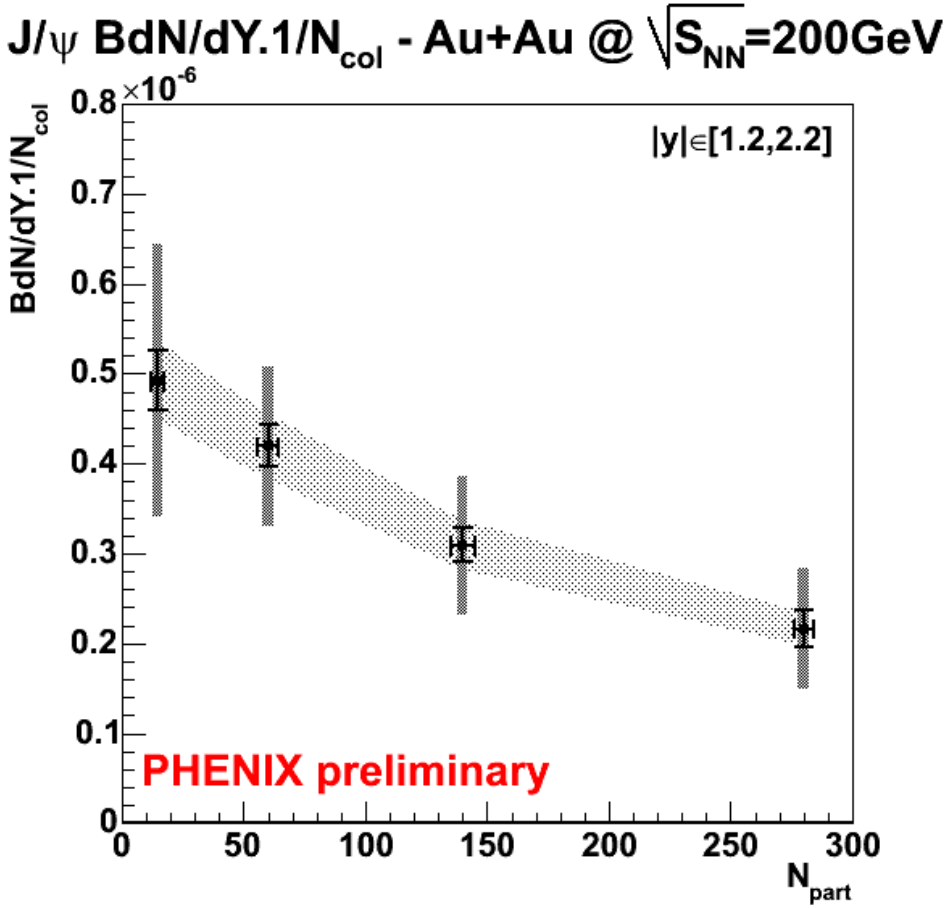
J/ψ measurement

Central arms: $J/\psi \rightarrow e^+e^-$ BR (%) = 5.93 ± 0.10
using RICH and EMCal for electron identification,
drift/pad chambers for tracking

Muon arms: $J/\psi \rightarrow \mu^+\mu^-$ BR (%) = 5.88 ± 0.10
using Iarocci tubes + absorber layers for muon identification
cathode strip chambers for tracking

North/South arm discrepancy in Au+Au @200 GeV



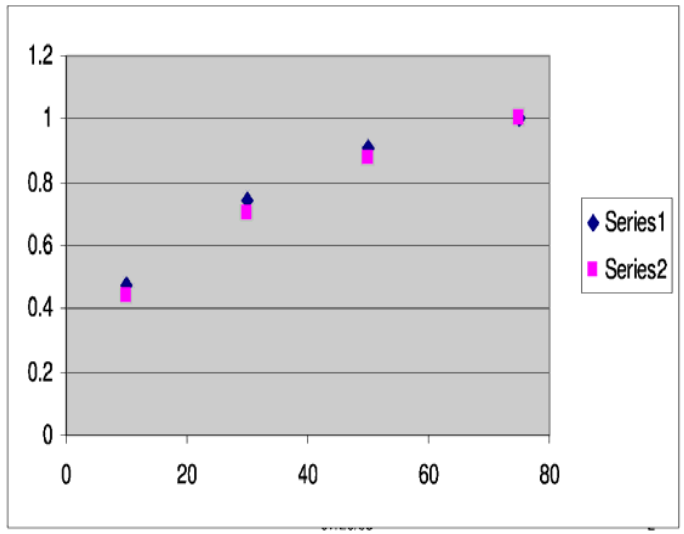


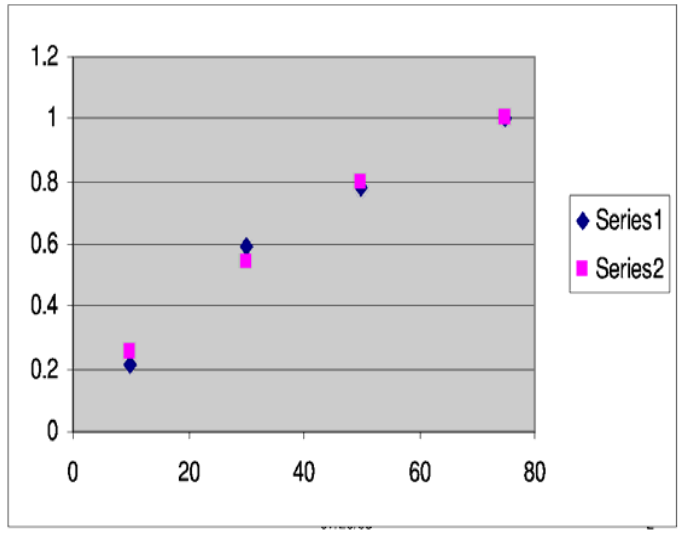
We believe the discrepancy is a global normalization problem.
We assign an additional $30/\sqrt{12}$ % global systematic error to account for it.
For RAA calculations, it is added quadratically to the p+p error.
This *problem* affects only the Au+Au muon data.

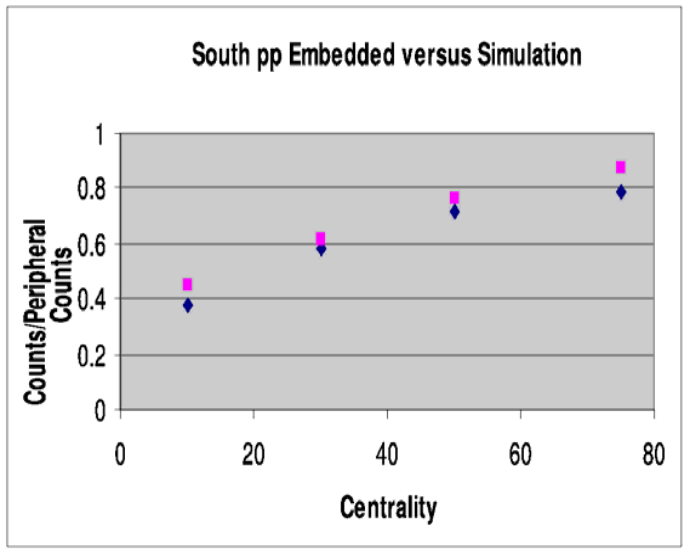
Acceptance x efficiency corrections for Au+Au @200 GeV

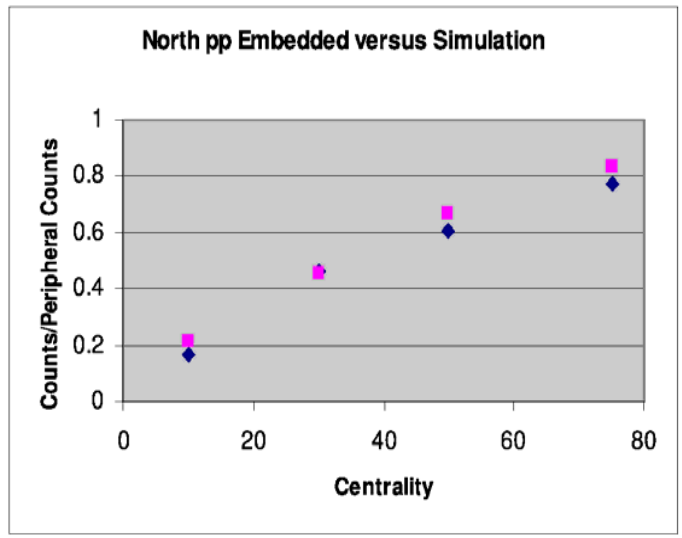
- Blue is MC embedded in Au+Au real data
- Purple is pp embedded in Au+Au real data

- Top plots are normalized to periph efficiency
- Bottom plots are normalized tp unmixed eff
- Good matching. 8% systematics added to account for residual disagreement









Systematics on J/ψ counts in Au+Au muon channel

J/ψ counts systematics estimated

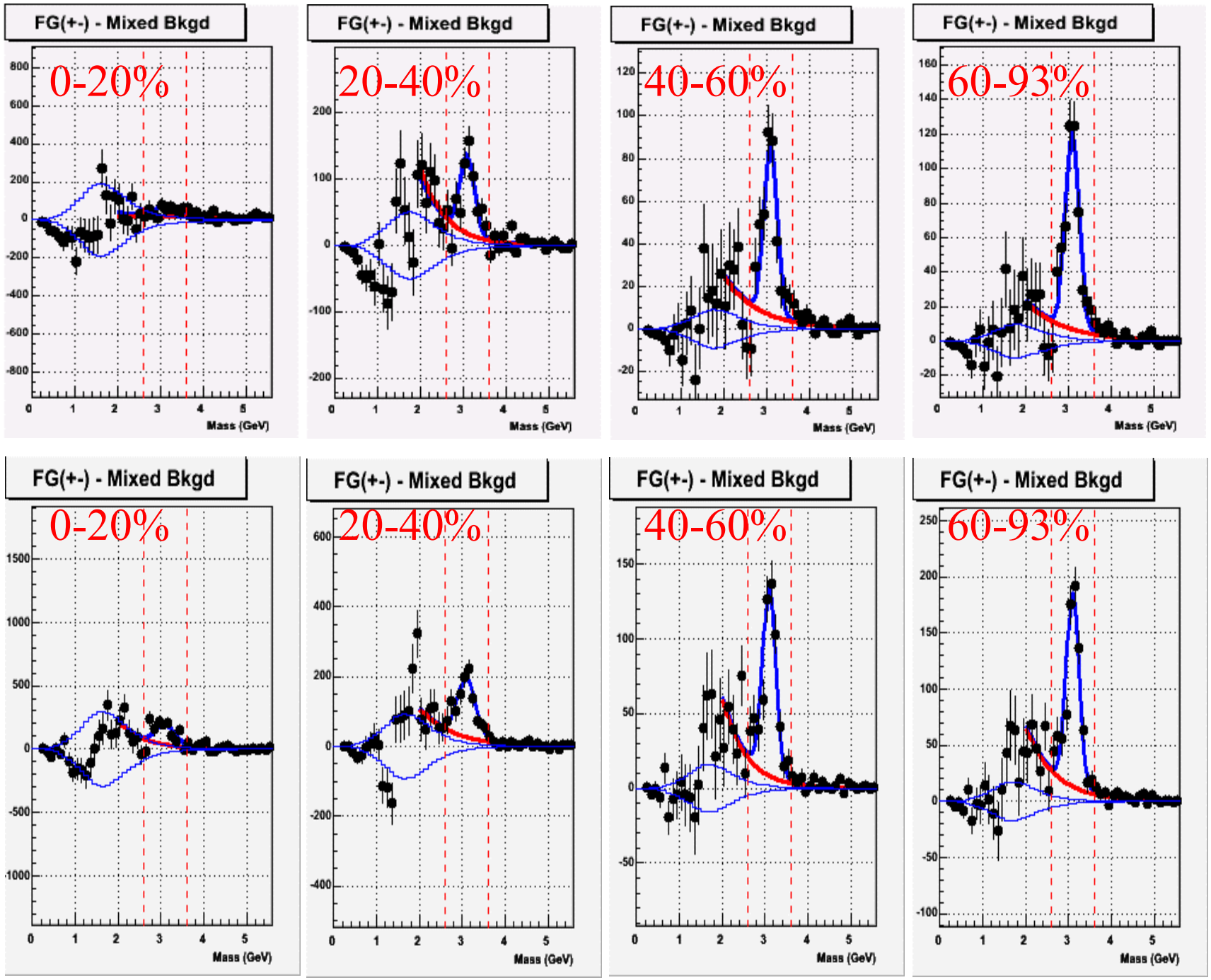
- using gaussian + exponential fit
- varying mixed background normalization (+/- 2%)
- using like-sign counts in mass window

we use the largest of the errors above

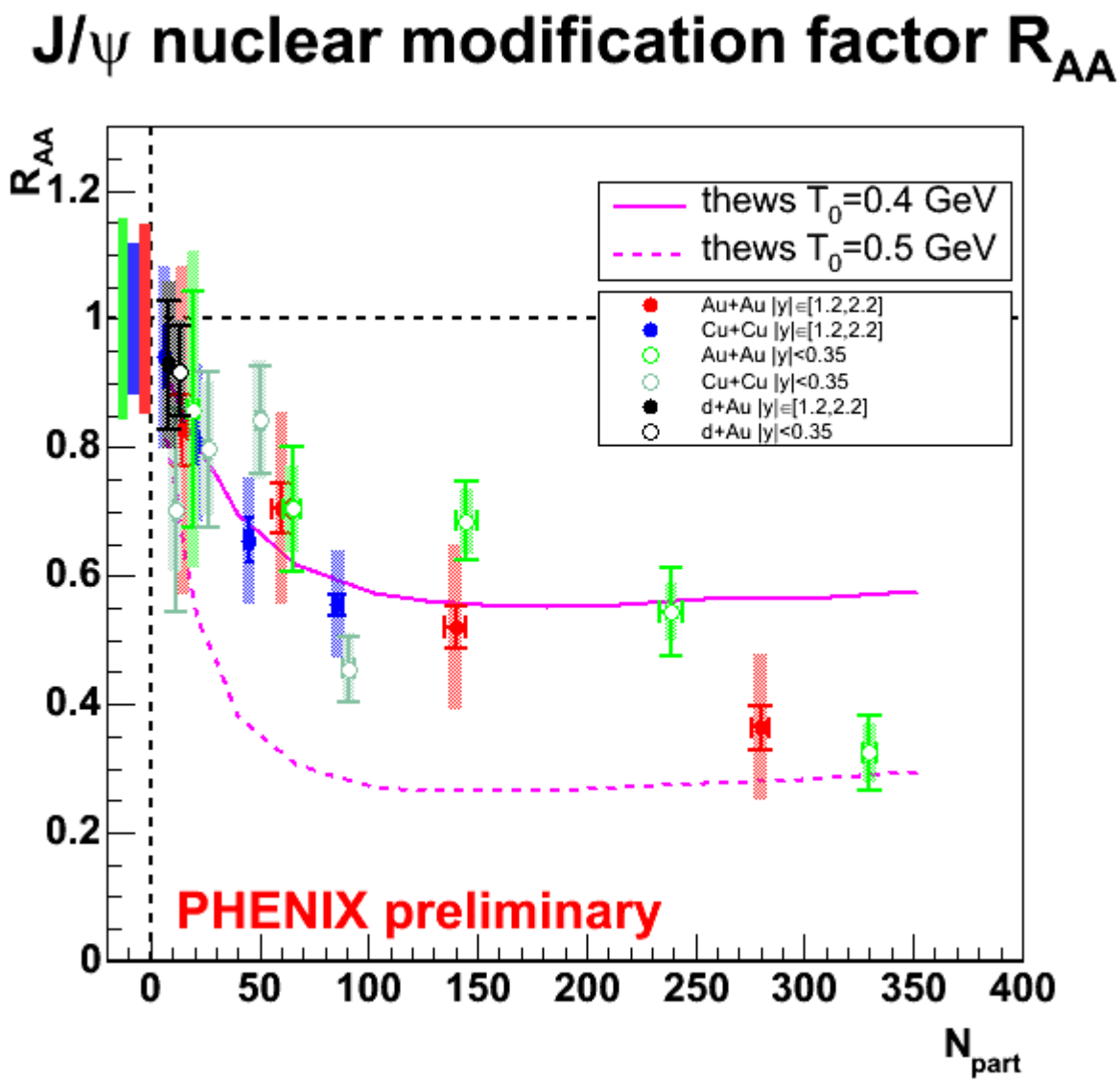
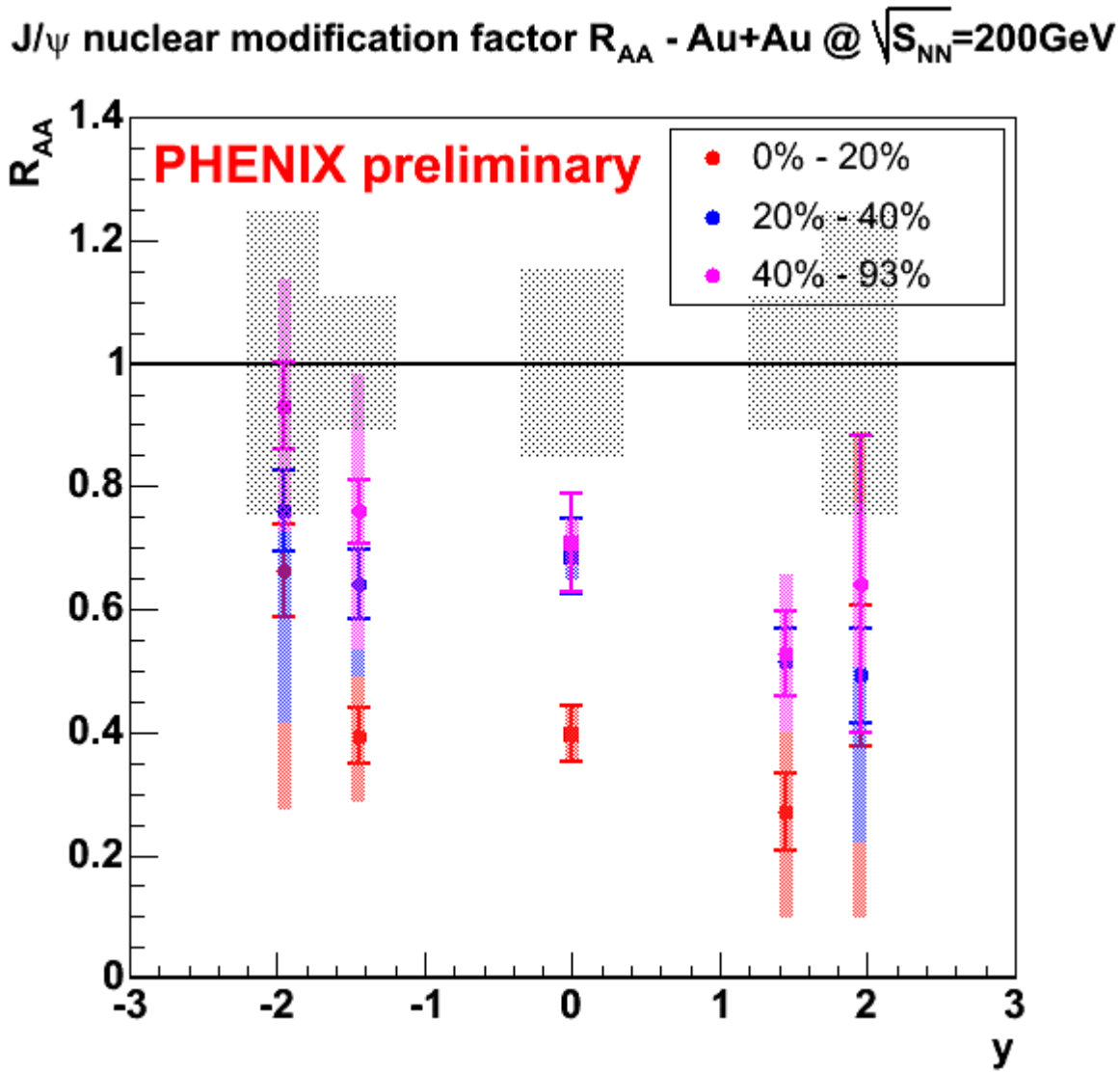
J/ψ signal - Au+Au muon arms

North arm

South arm



R_{AA} vs N_{part}


J/ψ nuclear modification factor R_AA
R_AA
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
400
N_part
thews T_0=0.4 GeV
thews T_0=0.5 GeV
Au+Au |y|∈[1.2,2.2]
Cu+Cu |y|∈[1.2,2.2]
Au+Au |y|<0.35
Cu+Cu |y|<0.35
d+Au |y|∈[1.2,2.2]
d+Au |y|<0.35
PHENIX preliminary

R_{AA} vs rapidity