J/Ψ Measurements in $\sqrt{s_{NN}}$=200 GeV Au+Au Collisions

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for the PHENIX collaboration
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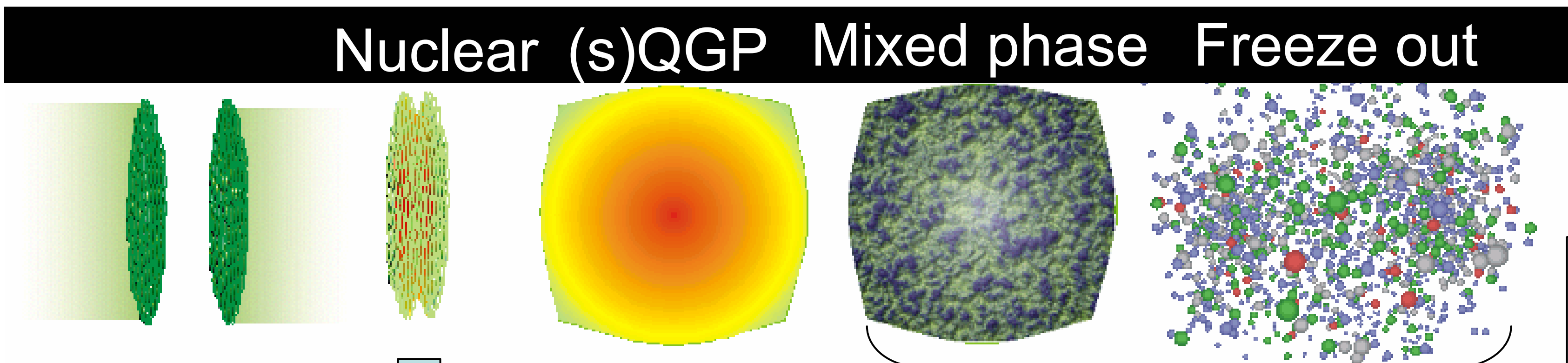
PHENIX

DNP 2006

J/Ψ Production

J/ψ's are produced in hard scatterings at the early stages of collision, and interact with the collision medium, thus providing information about the properties of this medium.



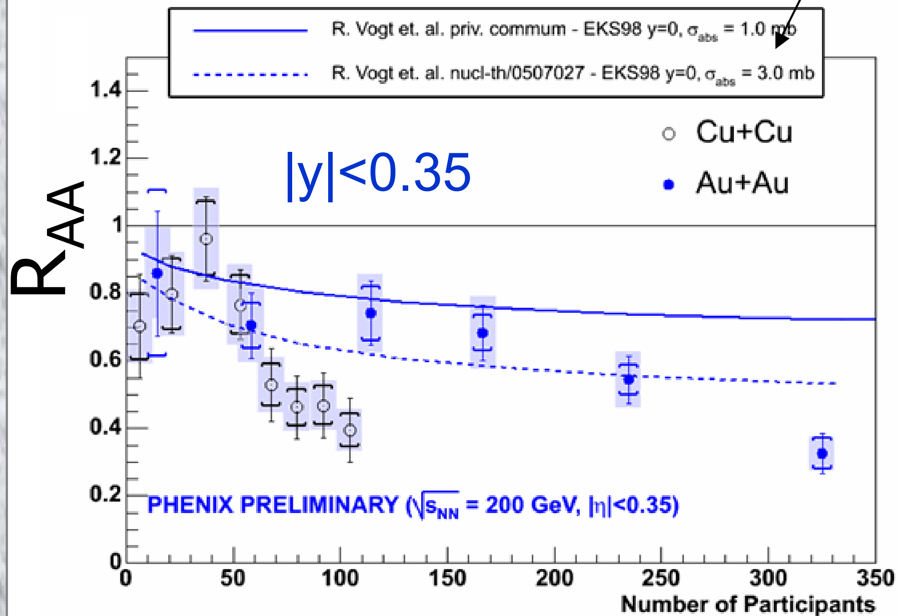
- Gluon Shadowing (Modification of PDF in nuclei)
- Nuclear absorption by the spectators
- Cronin effect
- Color screening (Dissociation by gluons)
- Formation of J/Ψ by $c\bar{c}$ coalescence
- Comover scattering

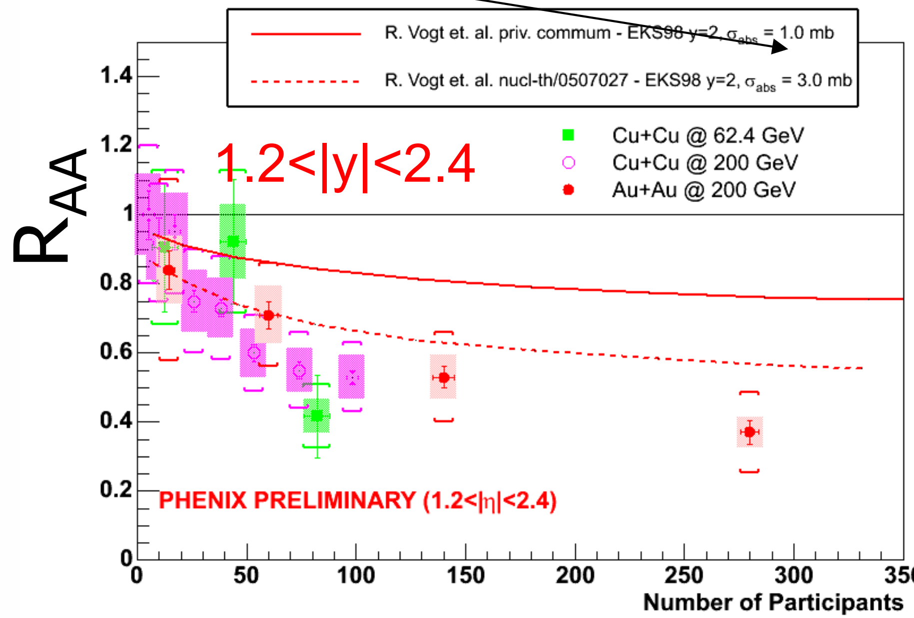
Feed down from χ_c and Ψ'

R_{AA} of J/Ψ in Au+Au

$$R_{AA} = \frac{d^3N_{J/\psi}^{AuAu}/dp^3}{d^3N_{J/\psi}^{pp}/dp^3 \times \langle N_{coll}\rangle}$$

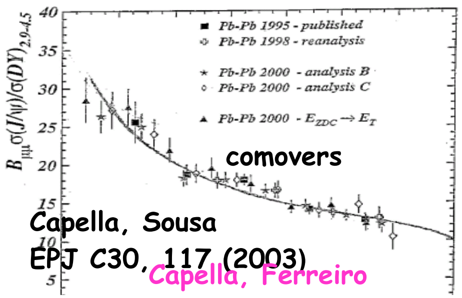
Constrained by d+Au

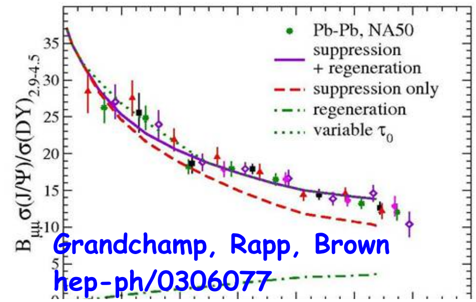


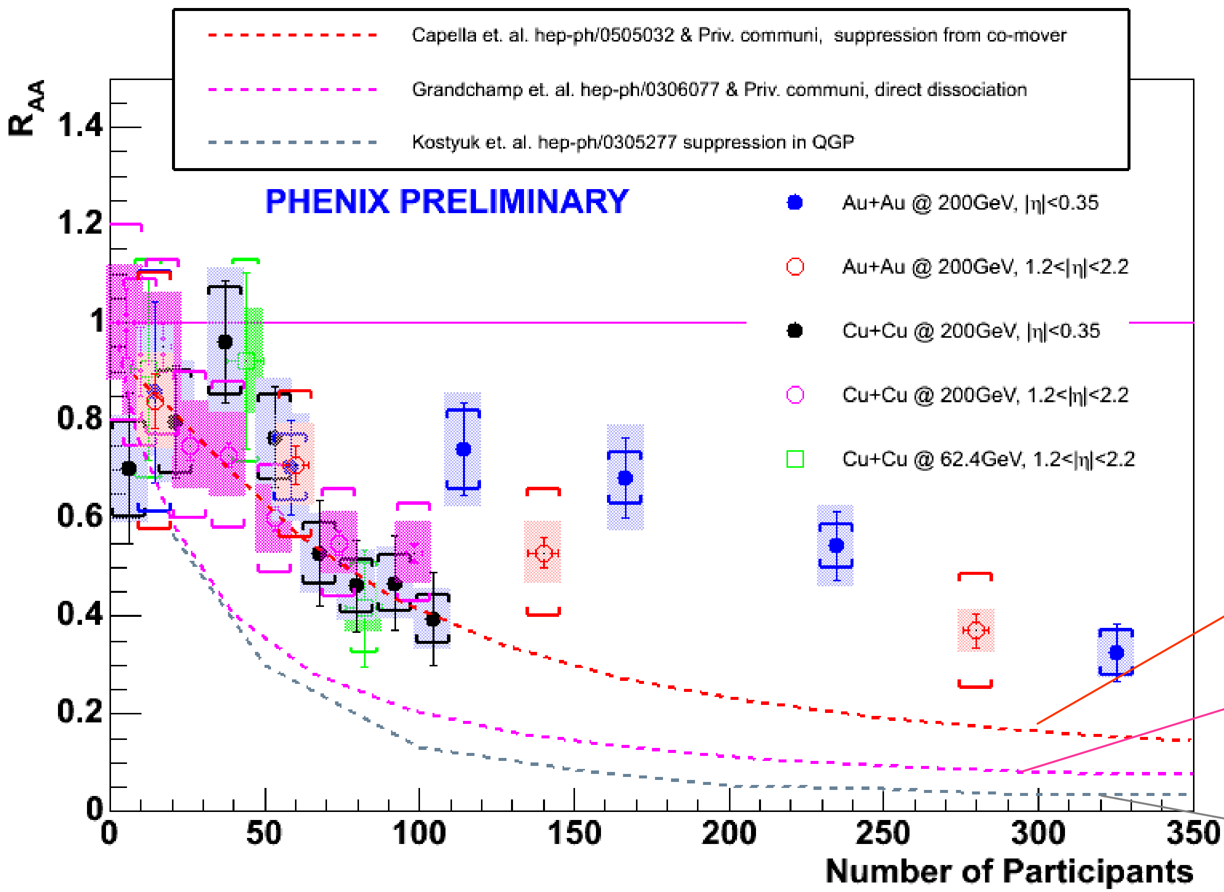


- Suppression increased toward the central collisions. Factor of 3 suppression at most central (Au+Au)
- Beyond the suppression from cold matter effect.

R_{AA} and Suppression Models







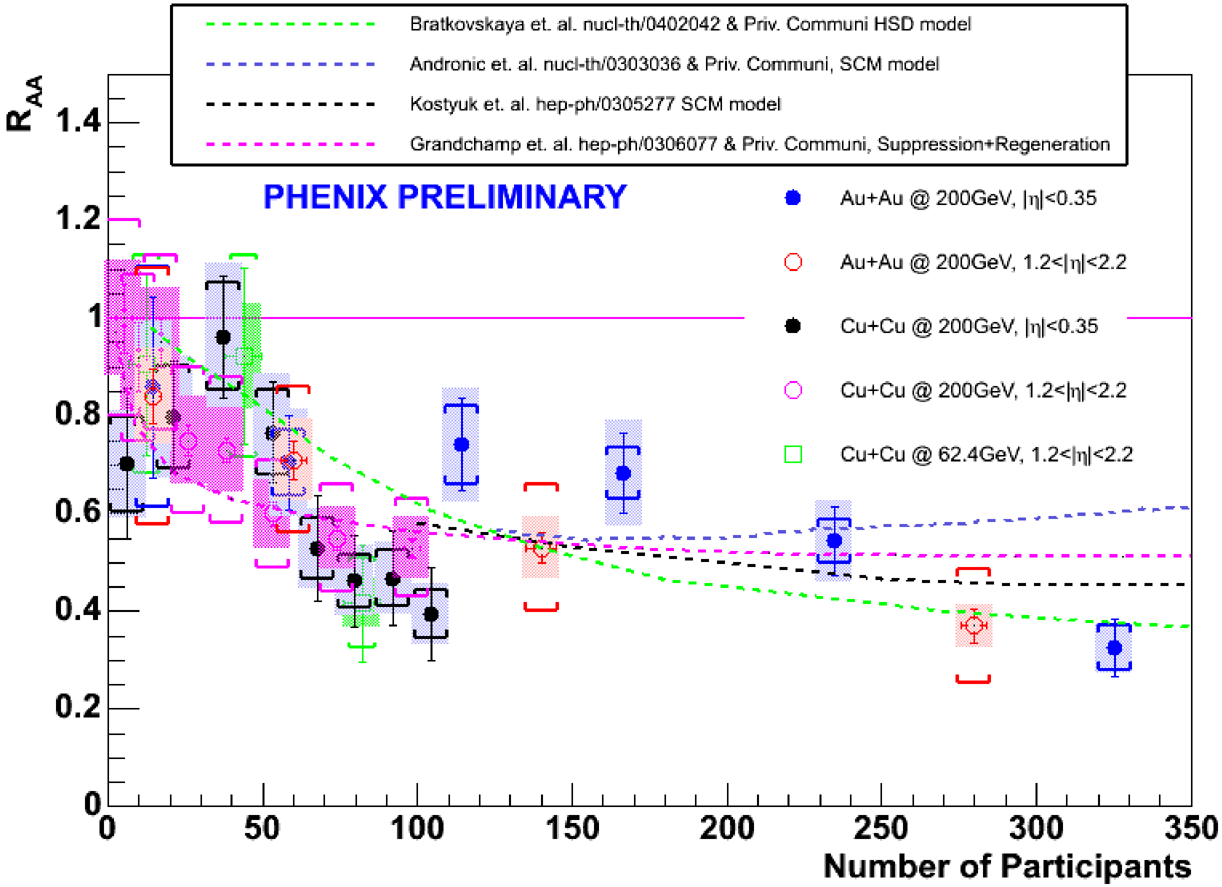
J/Ψ suppression at RHIC is over-predicted by the suppression models that described SPS data successfully.

Co-mover (σ_{abs} = 1mb)

Direct dissociation (+Comover)

QGP screening (+Comover, feed down)

Recombination Models

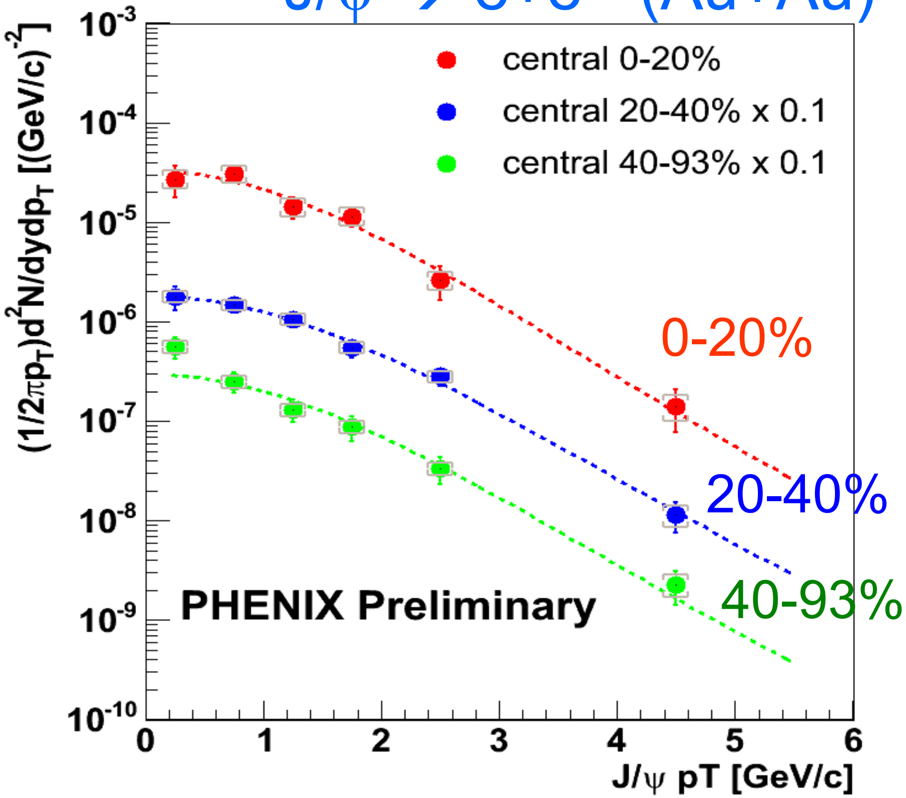


- Better matching with results compared to the suppression models.
- Don’t forget about free parameters.
- At RHIC (energy): Recombination compensates stronger suppression?

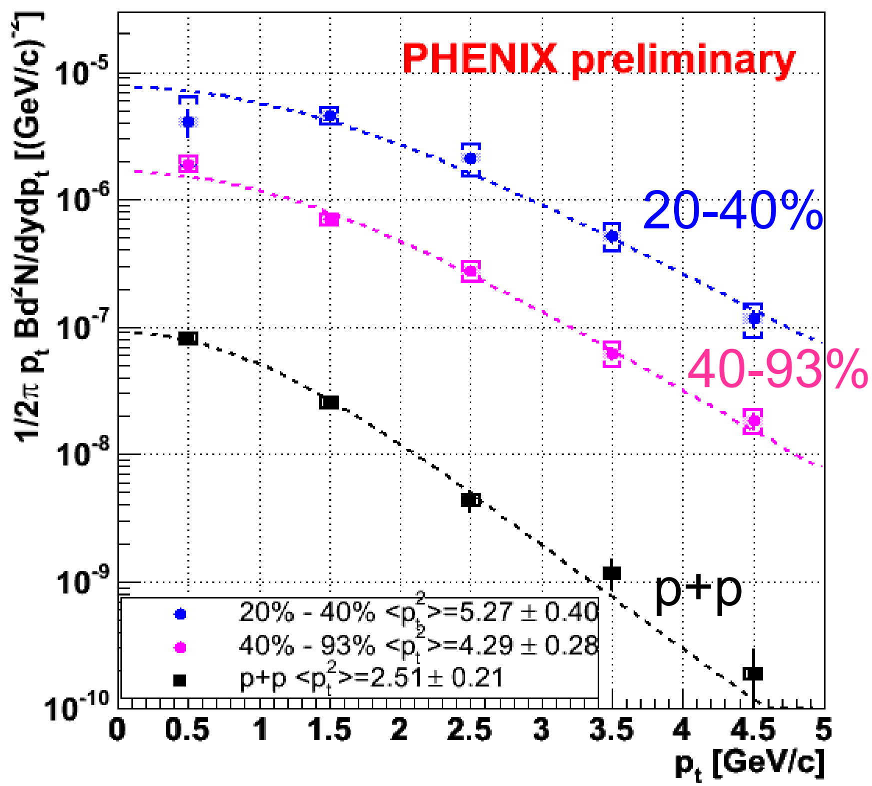
Invariant p_T distributions

We of course have other observables

J/ψ → e+e- (Au+Au)

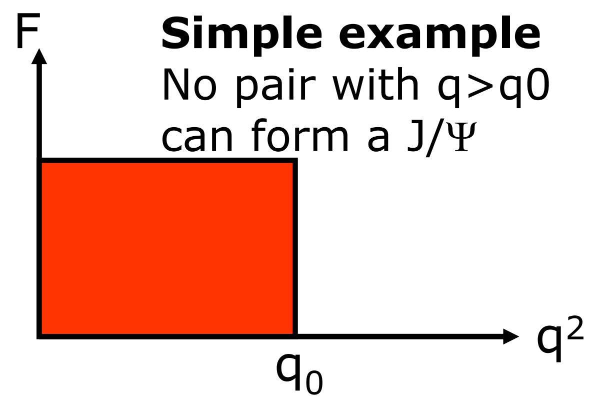


J/ψ → μ+μ- (Au+Au)



Theory (Model) Example

- Inspired by [1] which used **coherent** scattering to describe SPS suppression (but gave no p_T information), we [2] implemented a Monte Carlo model of **incoherent** scattering similar to calculations in [3] to study the effects on p_T.
- Glauber model → binary collision geometry
  PYTHIA → $c\bar{c}$ kinematics.
- Random kicks in the transverse plane are given from a distribution with a width set by the parameter $\langle k_T^2 \rangle$.
  - kicks before $c\bar{c}$ production change the pair p_T **but not** the q^2.
  - kicks after $c\bar{c}$ production change the pair p_T **and** the q^2.
- The survival probability is given by $F(q^2)$

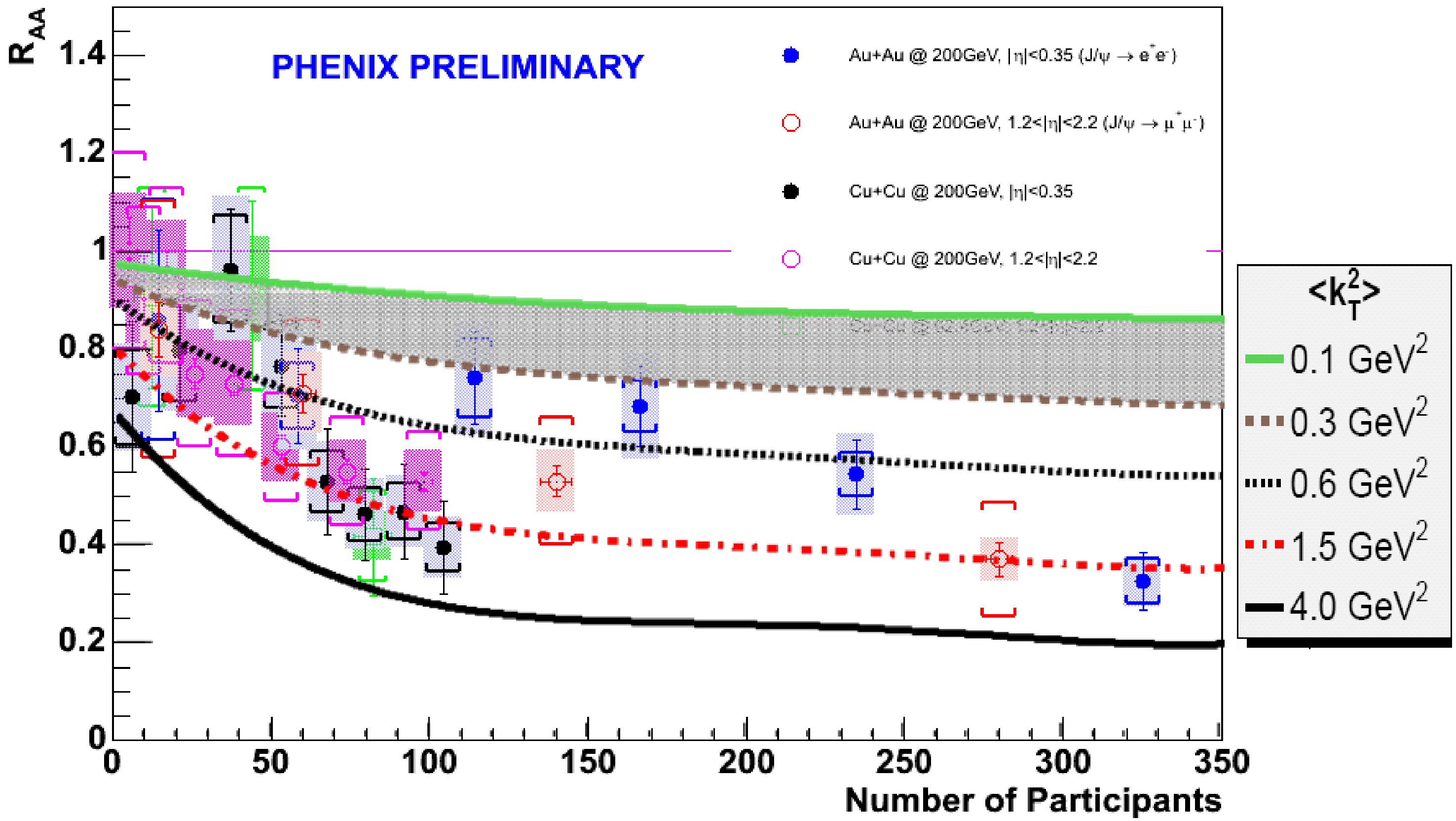


Simple example
No pair with q>q0 can form a J/Ψ

[1] J. Qiu, J. P. Vary and X. Zhang, Phys. Rev. Lett. 88, 232301 (2002).
[2] A.M. Glenn, Denes Molnar, J.L. Nagle nucl-th/0602068
[3] H. Fujii, Phys. Rev. C 67, 031901 (2003).

Results for RHIC

Suppression due to multiple scattering in cold nuclear matter



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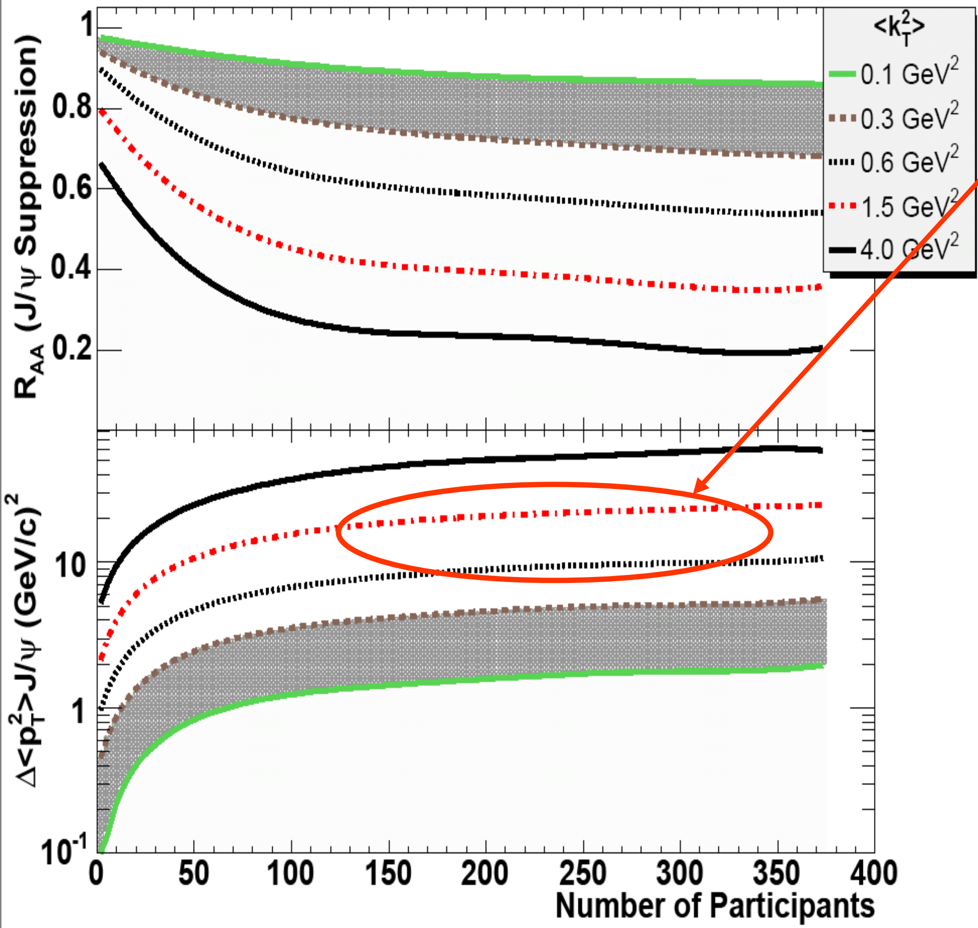
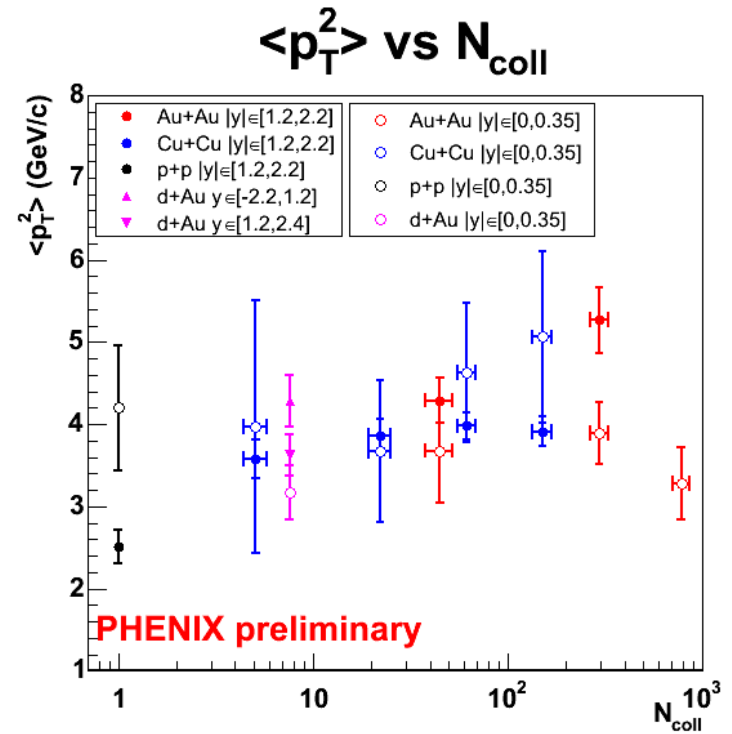
Connected Observables



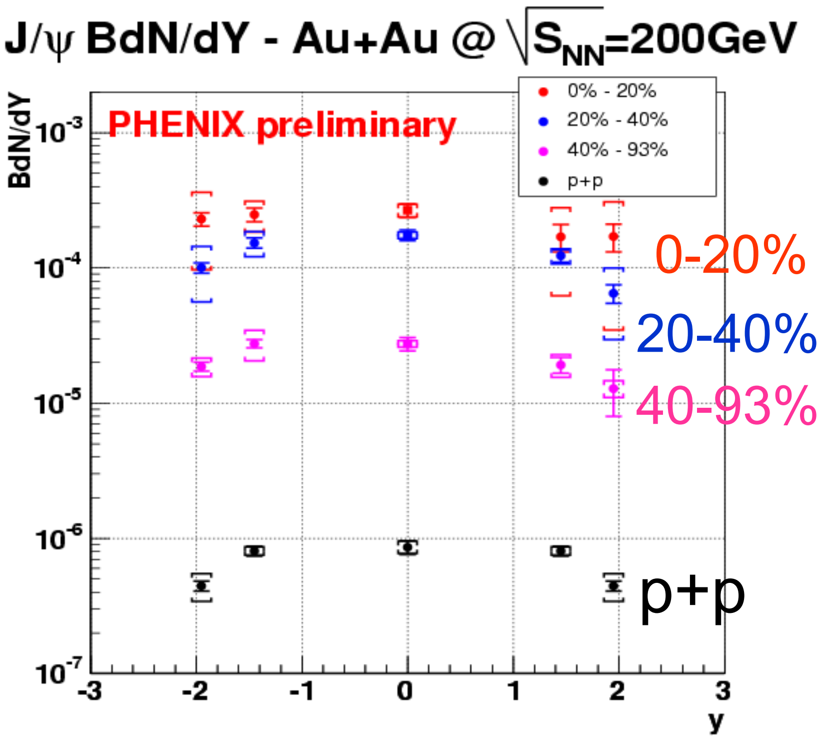
Matching the suppression from data would imply an increase in $<p_T^2>$ of ~ 10 (GeV/c)^2 from p+p to mid-central Au+Au

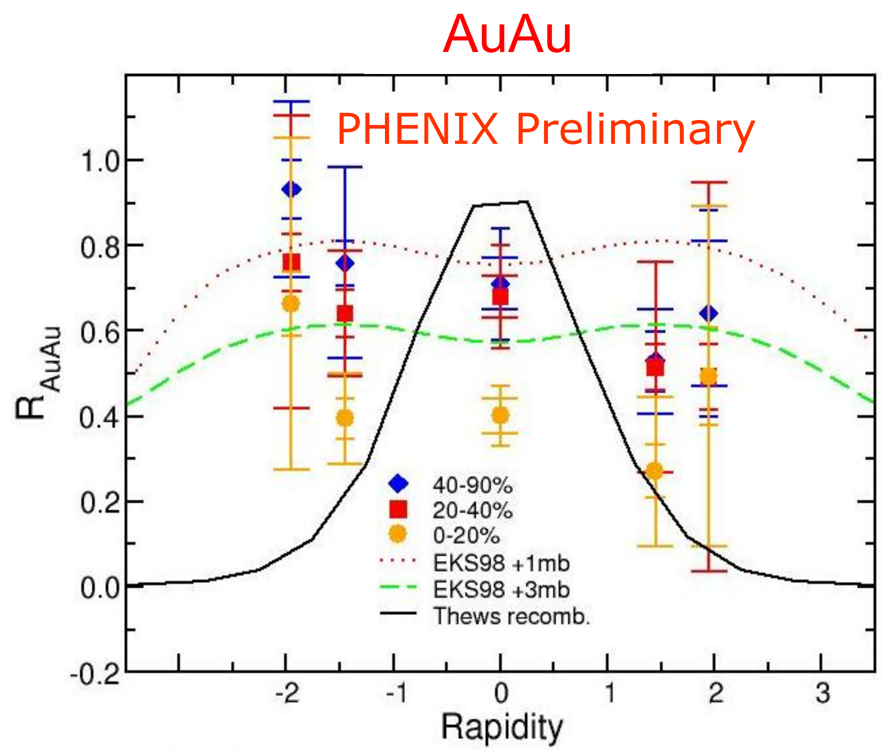


The increase is still too large if initial collisions (which do not change suppression) are turned off.

NB: We can find $<k_T^2>$ values which reproduce SPS suppression or $<p_T^2>$, but not both simultaneously.

Rapidity dependence





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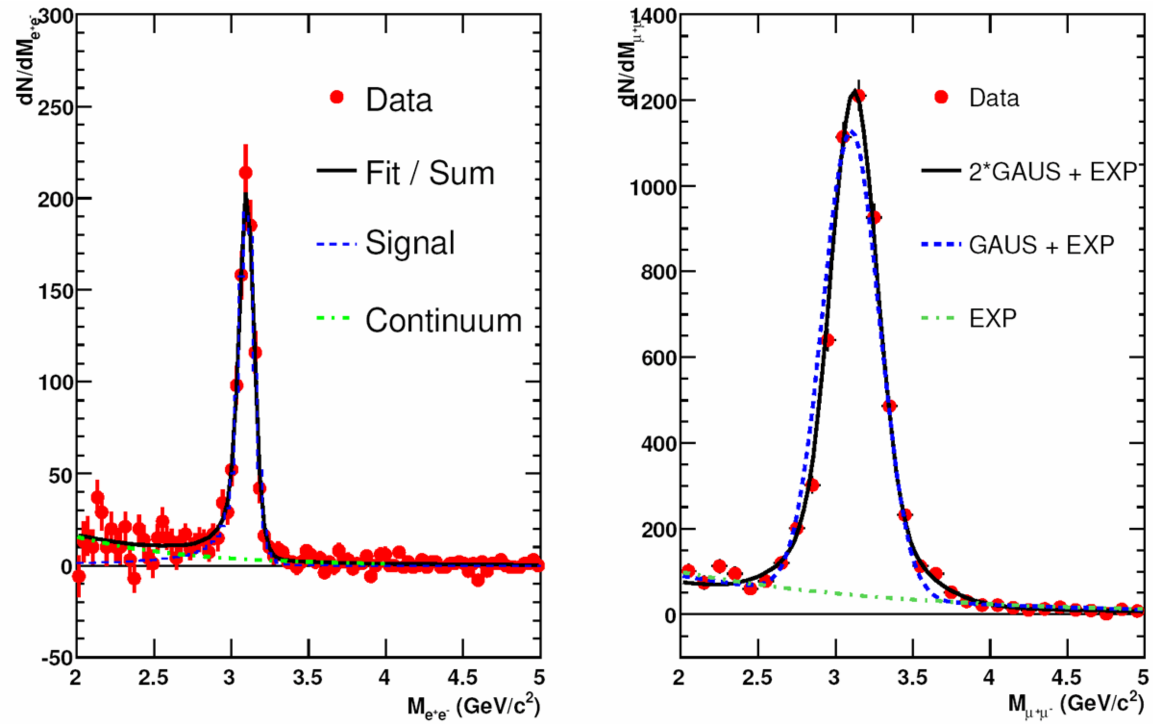
- Recombination models have implications for rapidity
- Errors still too large, theory still under-developed

Outlook

- Analysis of Run5 p+p nearly complete



~1.5K $J/\psi \rightarrow e^+e^-$
~8k $J/\psi \rightarrow \mu^+\mu^-$

~Ten times the statistics of current Reference data

- Will provide much better reference
- Final results for Au+Au and p+p (i.e. publications) should be ready soon

Summary

- Factor of 3 suppression in most central Au+Au collisions
- Beyond the suppression from cold matter effects.
- Over-predicted by the suppression models effective for SPS.
- Recombination seems promising.
- Reference statistics increased 10x and final results with smaller error bars coming soon.

BONUS SLIDES

PHENIX

12 Countries; 58 Institutions; 480 Participants*

Brazil University of São Paulo, São Paulo

China Academia Sinica, Taipei, Taiwan
China Institute of Atomic Energy, Beijing
Peking University, Beijing

France LPC, University de Clermont-Ferrand, Clermont-Ferrand
Dapnia, CEA Saclay, Gif-sur-Yvette
IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, Orsay
LLR, Ecòle Polytechnique, CNRS-IN2P3, Palaiseau
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Debrecen University, Debrecen
Eötvös Loránd University (ELTE), Budapest

India Banaras Hindu University, Banaras
Bhabha Atomic Research Centre, Bombay

Israel Weizmann Institute, Rehovot

Japan Center for Nuclear Study, University of Tokyo, Tokyo
Hiroshima University, Higashi-Hiroshima
KEK, Institute for High Energy Physics, Tsukuba
Kyoto University, Kyoto
Nagasaki Institute of Applied Science, Nagasaki
RIKEN, Institute for Physical and Chemical Research, Wako
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Columbia University, Nevis Laboratories, Irvington, NY
Florida State University, Tallahassee, FL
Florida Technical University, Melbourne, FL
Georgia State University, Atlanta, GA
University of Illinois Urbana Champaign, Urbana-Champaign, IL
Iowa State University and Ames Laboratory, Ames, IA
Los Alamos National Laboratory, Los Alamos, NM
Lawrence Livermore National Laboratory, Livermore, CA
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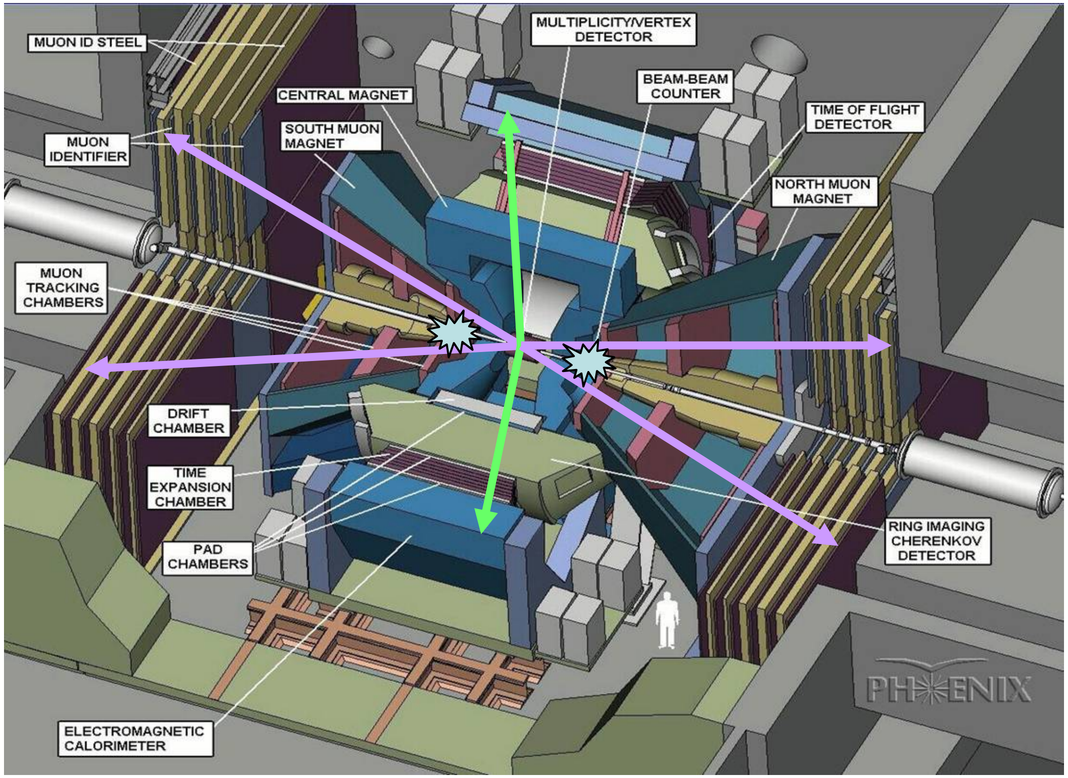
*as of January 2004

PHENIX experiment



Central Arms:
Hadrons, photons, electrons
- $J/\psi \rightarrow e^+e^-$
- $|\eta|<0.35$
- $P_e > 0.2$ GeV/c
- $\Delta\phi = \pi$ (2 arms x $\pi/2$)

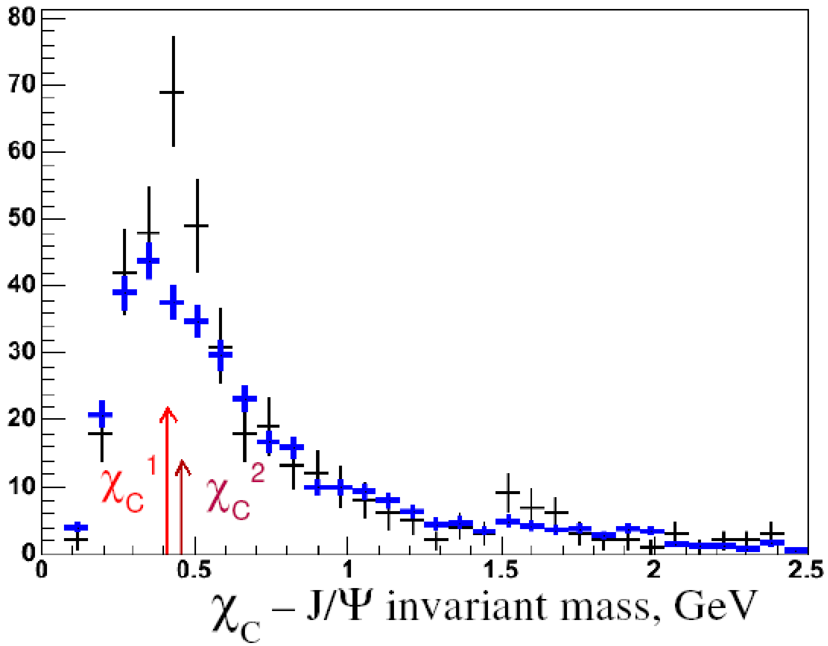
Muon Arms:
Muons at forward rapidity
- $J/\psi \rightarrow \mu^+\mu^-$
- $1.2< |\eta| < 2.4$
- $P\mu > 2$ GeV/c
- $\Delta\phi = 2\pi$

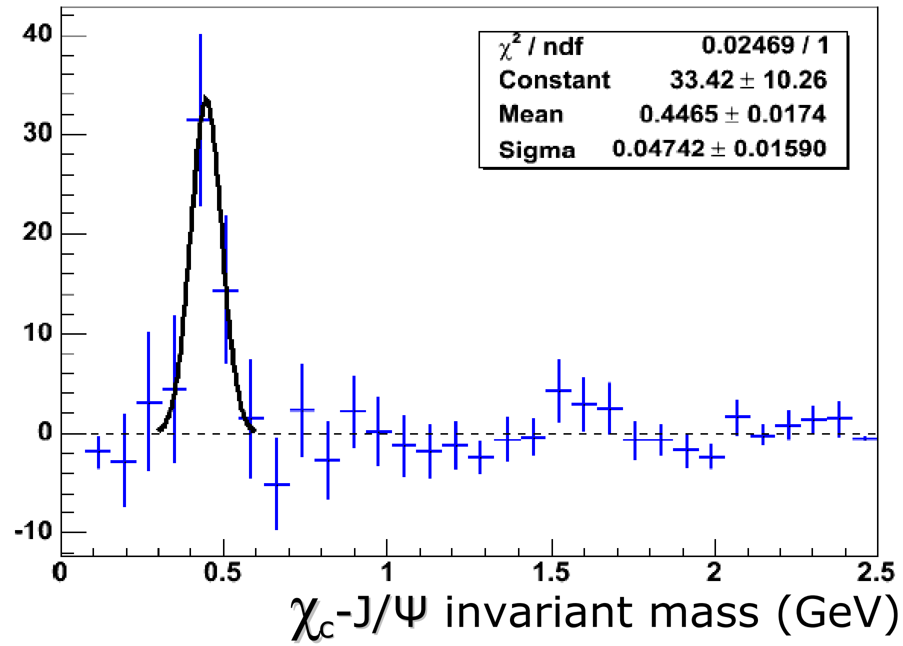
Centrality measurement:

Beam Beam Counters together with Zero degree calorimeters

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

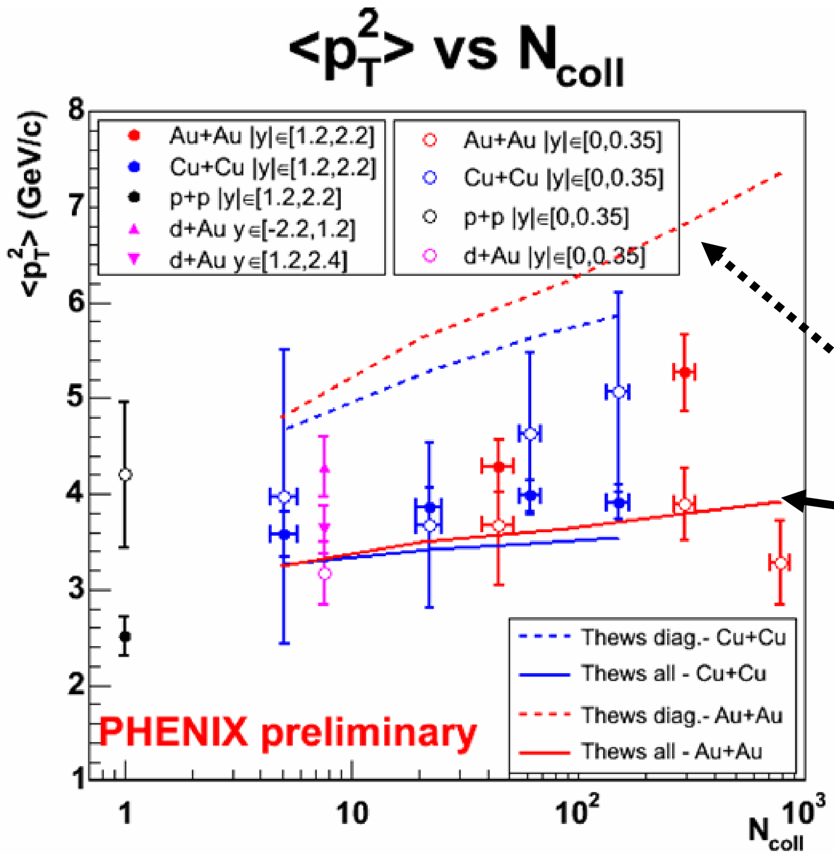
$\chi_c \rightarrow J/\Psi + \gamma$





Clear χ_c signal

$<p_T^2>$ as a function of N_{col}



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Au+Au = RED

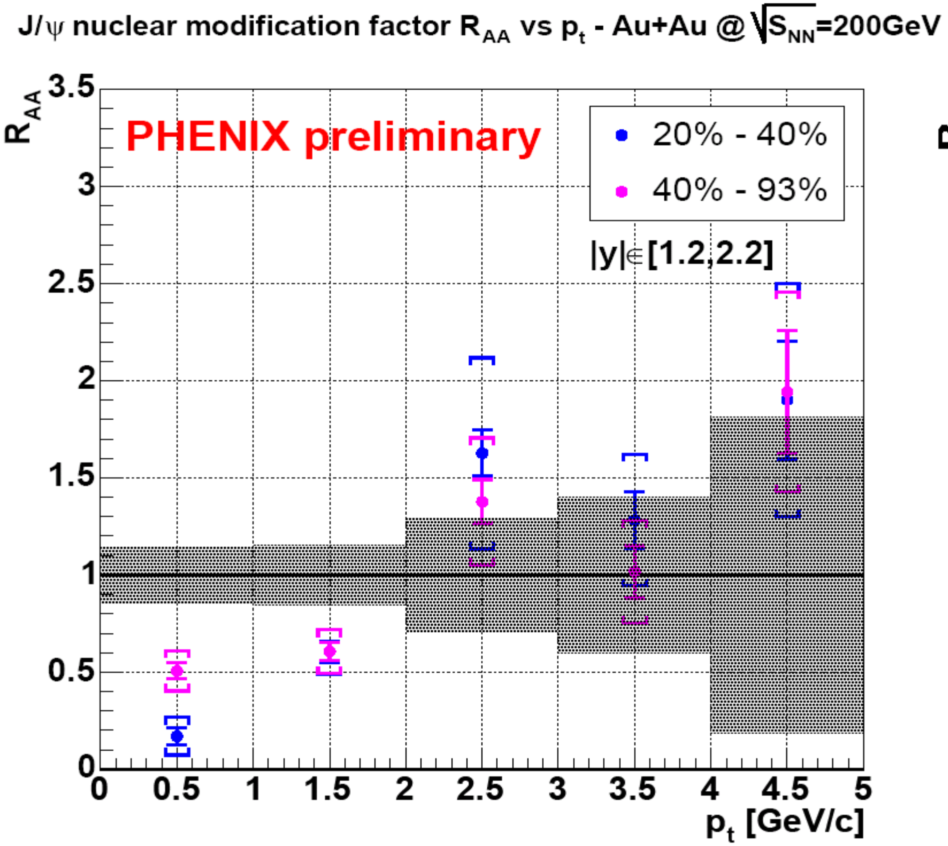
Cu+Cu = BLUE

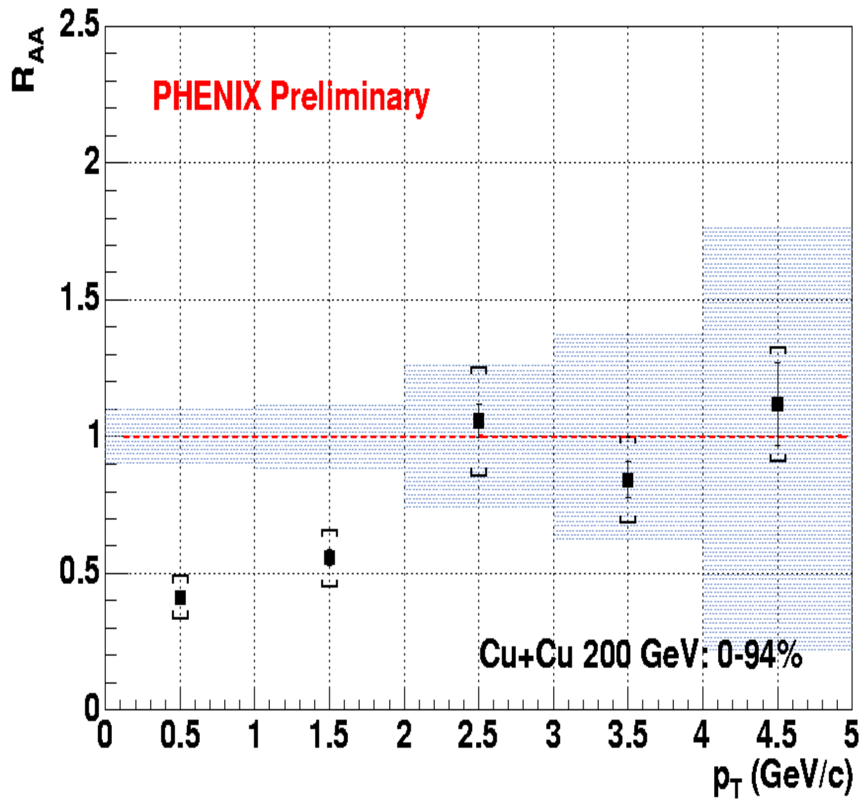
Dashed: without recombination

Solid: includes recombination

Recombination model matches better to the data… But don't forget the error bars

R_{AA} vs. p_T in Au+Au/Cu+Cu





- Suppression of J/Ψ yield at low p_T in both Au+Au and Cu+Cu.
- Might one expect “pile up” at low pT for recombination+energy loss?