LEPTON MEASUREMENT AT PHENIX

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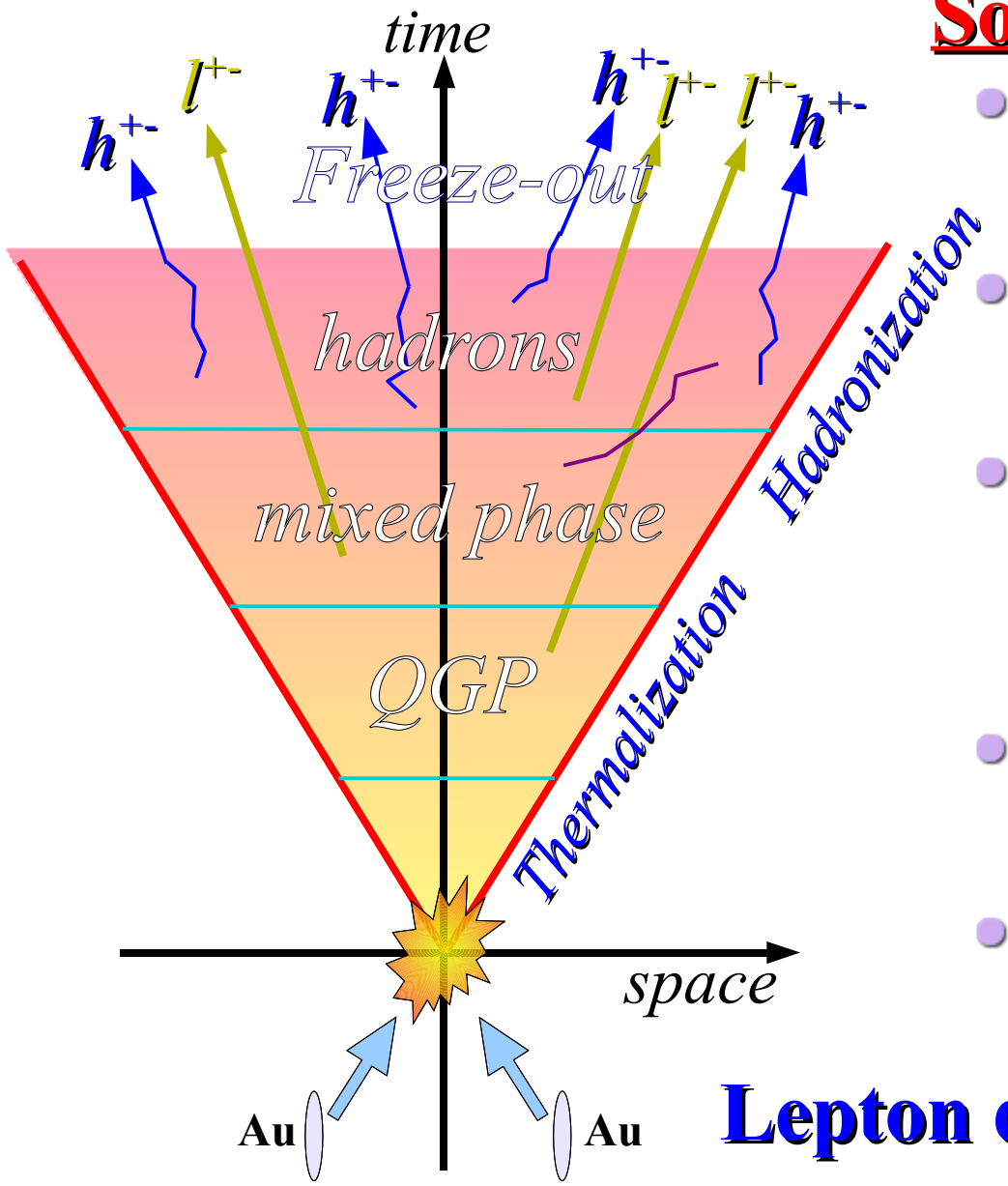
The matter we are investigating at RHIC has shown a behavior that has not been observed previously.

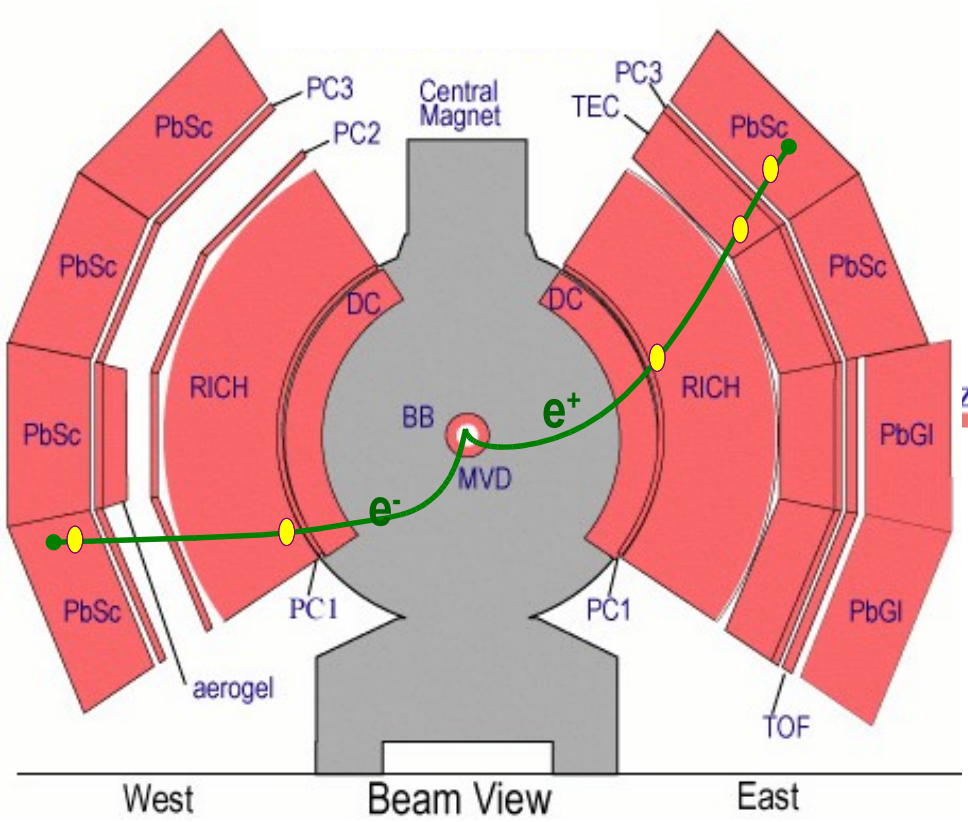


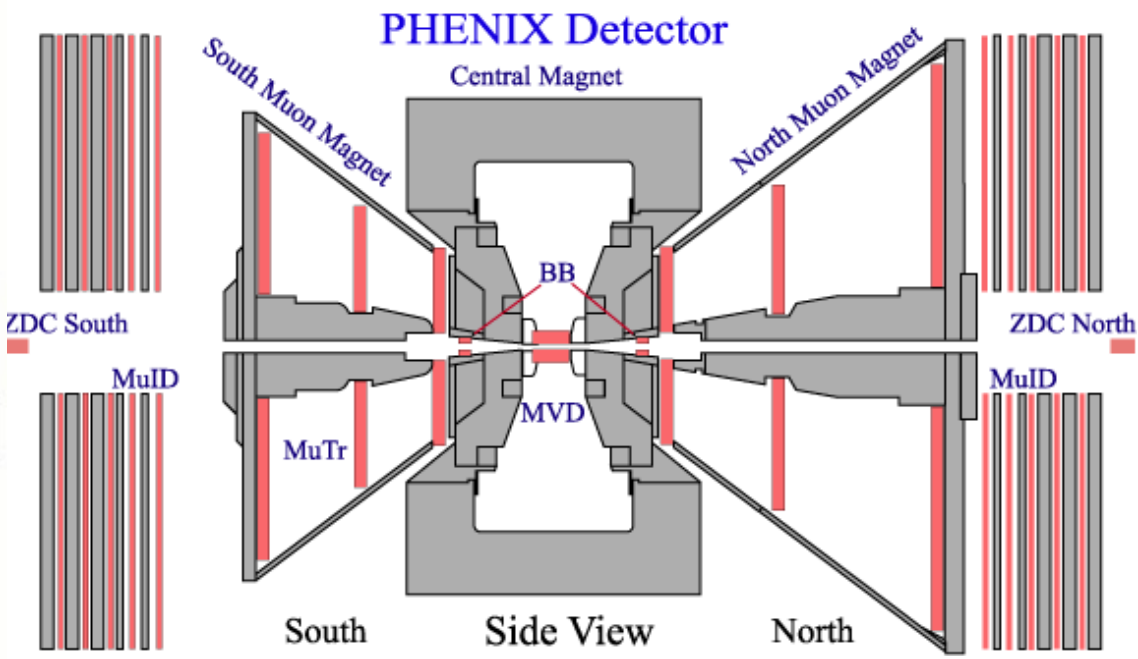
Some Questions

- can heavy quarks be treated by pQCD ?
- how does the medium look like ?
- is the deconfinement of quarks and gluons observed ?
- how is the thermal radiation at the initial stages ?
- does chiral symmetry restoration occur ?

Lepton decays are good probes to answer these questions.

PHENIX Measures Electrons and Muons





- $|\eta|<0.35$
- $\Delta\phi=2 \times \pi/2$
- amount of material = **0.4% X_0**
- 3 detectors for electron ID

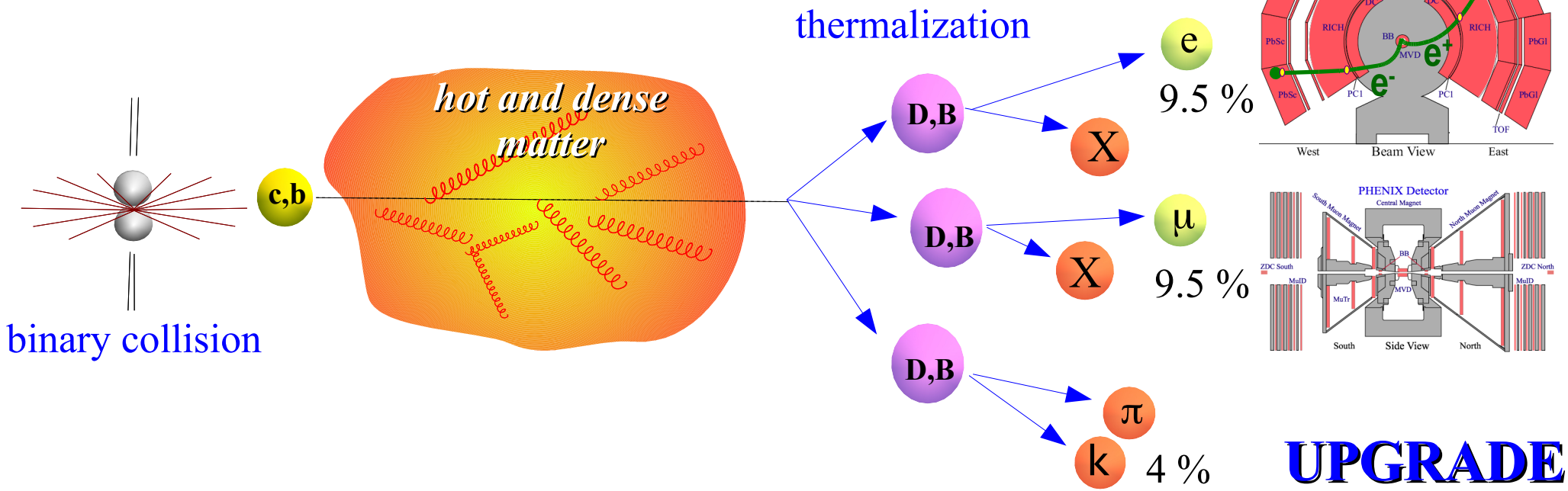
- $-1.2 > \eta > -2.0$ and $2.4 > \eta > 1.2$
- $\Delta\phi=2\pi$
- Muon $|p| > 2$ GeV/c
- 4 hadron absorbers in MuID

The data accumulated allow us to measure some rare processes

Run	Species	$s^{1/2}$ [GeV]	∫Ldt
01	Au+Au	130	1 μb^{-1}
02	Au+Au	200	24 μb^{-1}
	p+p	200	0.15 pb^{-1}
03	d+Au	200	2.74 nb^{-1}
	p+p	200	0.35 pb^{-1}
04	Au+Au	200	241 μb^{-1}
	Au+Au	62	9 μb^{-1}
05	Cu+Cu	200	3 nb^{-1}
	Cu+Cu	62	0.19 nb^{-1}
	Cu+Cu	22.5	2.7 μb^{-1}
	p+p	200	3.8 pb^{-1}
06	p+p	200	10.7 pb^{-1}
	p+p	62	?

data used in this presentation

Heavy Quark Production

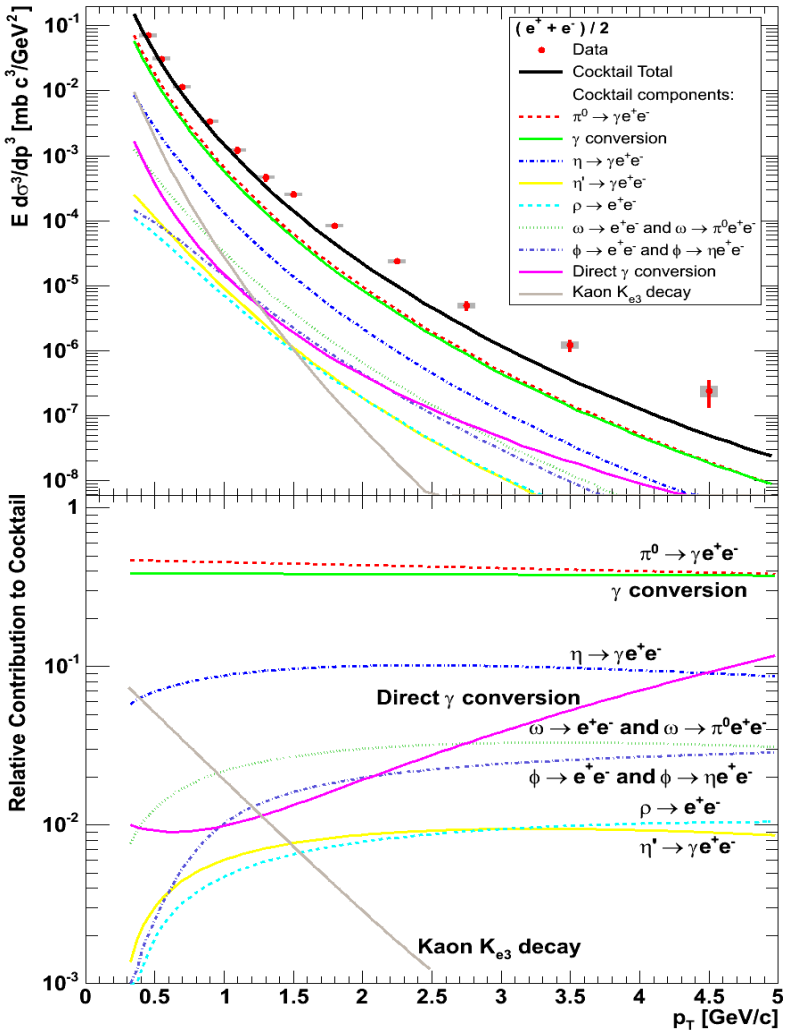


UPGRADE

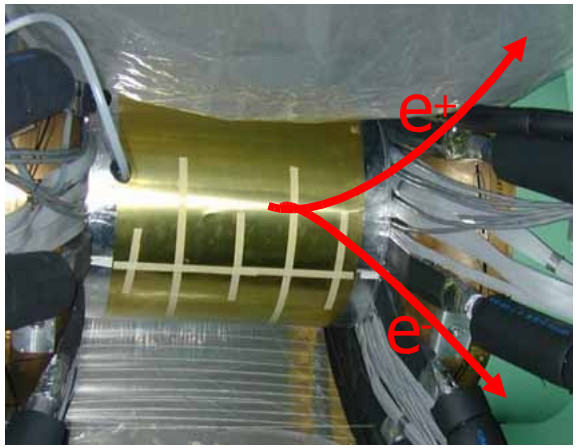
- Experimental challenge to remove "photonic" sources of electrons and hadron decays/contamination in muon arms
- Production in the early stages of collision with large momentum transfer. Good test for pQCD estimations.
- Loss of energy under the influence of medium environment.
- Anisotropy (v2) sensitive to collective motion in the first stages of collision.

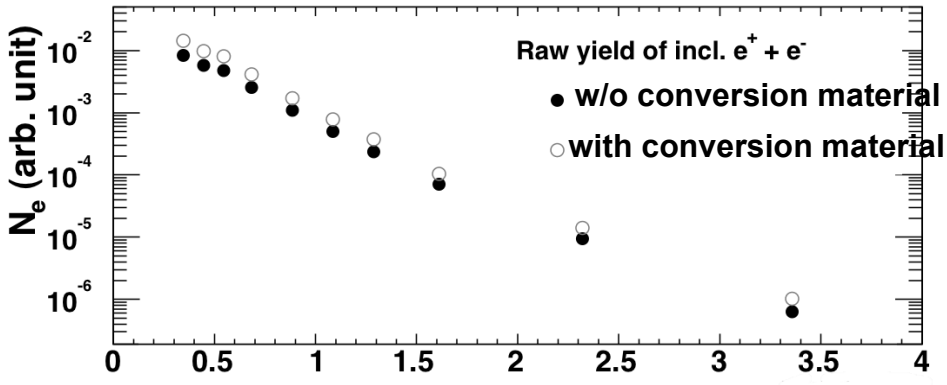
Photonic contribution to electron yield.

Subtraction of a "cocktail" of measured sources of electrons.



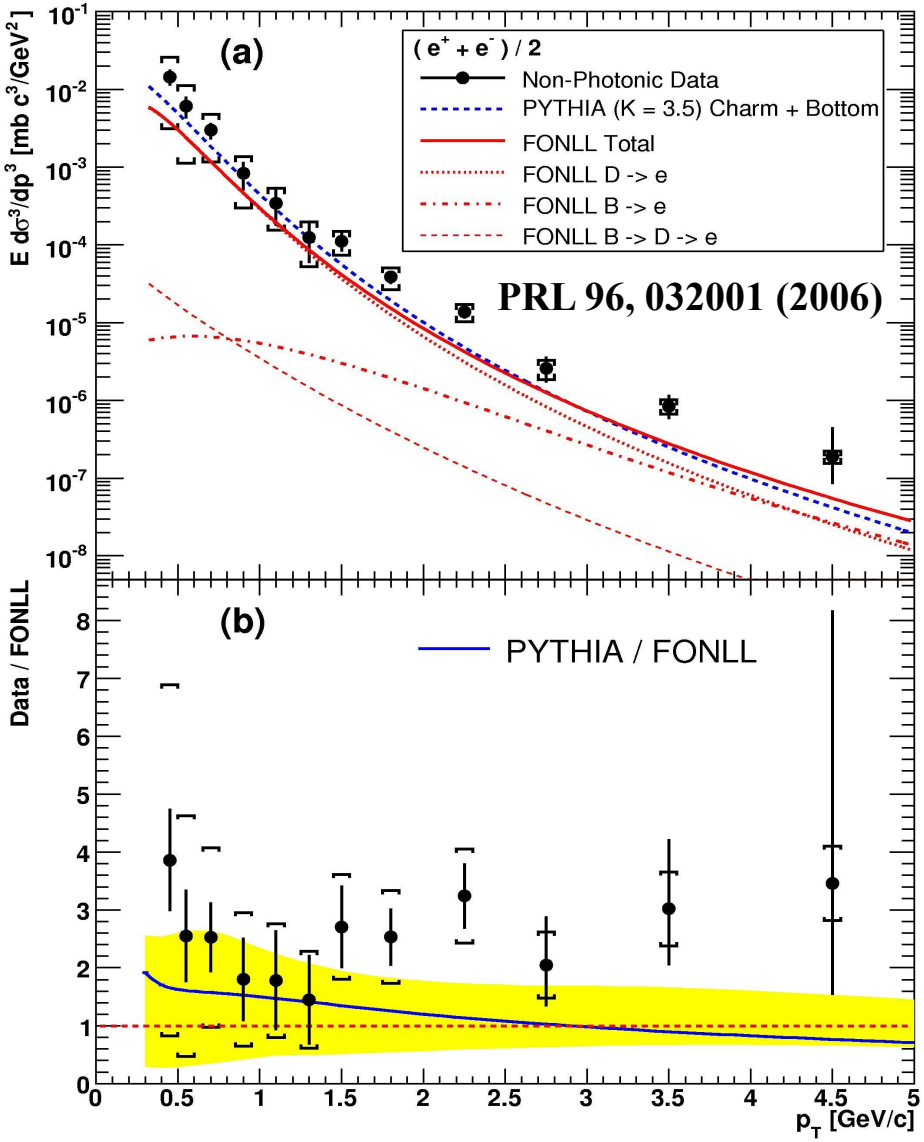
Estimation of photonic yield per X_0 by introducing a known amount of material.





Results from the two methods are in good agreement.
Non-photonic originated from heavy quarks.

p+p → D,B → e^{+-} + X



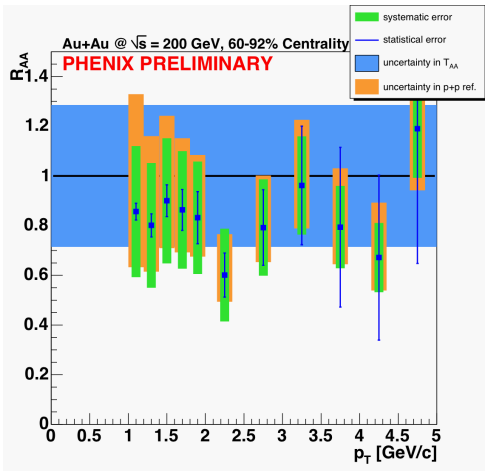
Non-photonic electron yield in p+p collisions consistent with FONLL pQCD calculation.

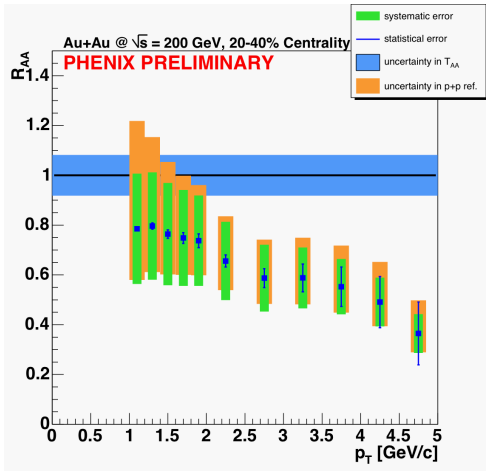
Brand new result with extended p_T from high luminosity Run5 p+p coming up.

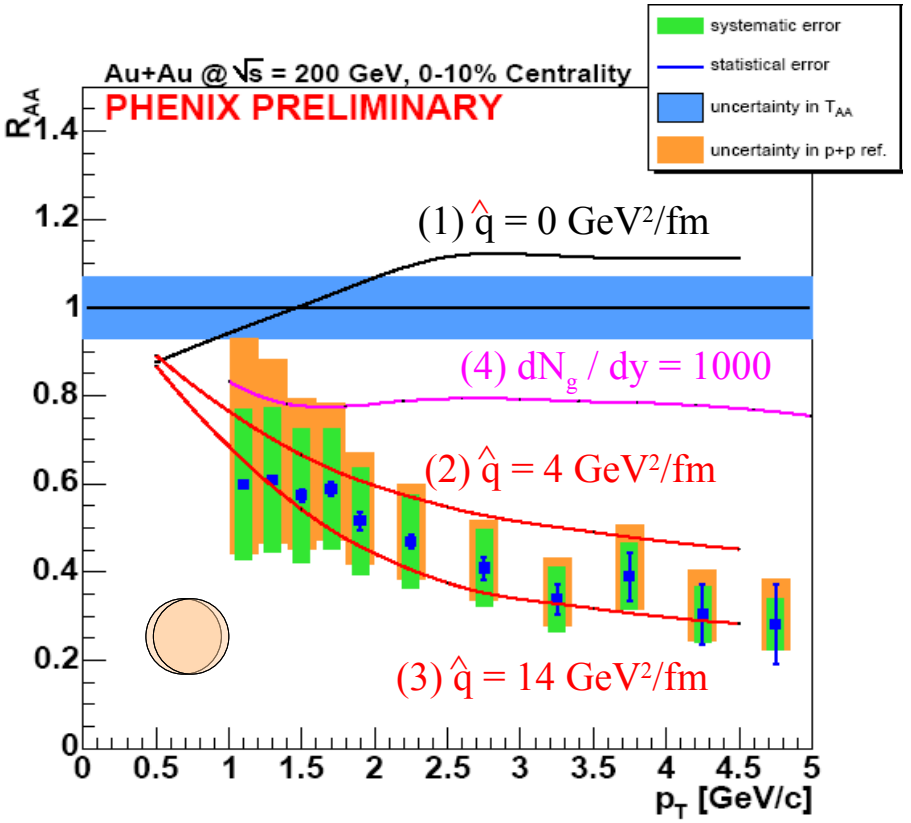
Suppression of Heavy Quarks in Au+Au Collisions

Nuclear modification factor

$$R_{AA} = \frac{dN_{Au+Au}}{\langle T_{AA} \rangle \times d\sigma_{p+p}}$$







Strong heavy quark energy loss.

Surprisingly consistent to light quark mesons.

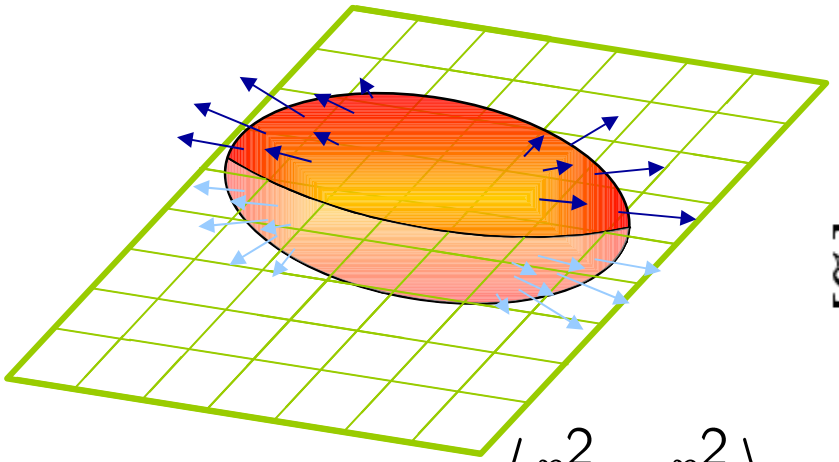
(1-3) charm contribution only : N. Armesto, *et al.*, PRD 71, 054027

(4) charm + bottom : M. Djordjevic, M. Gyulassy, S.Wicks, PRL 94, 112301

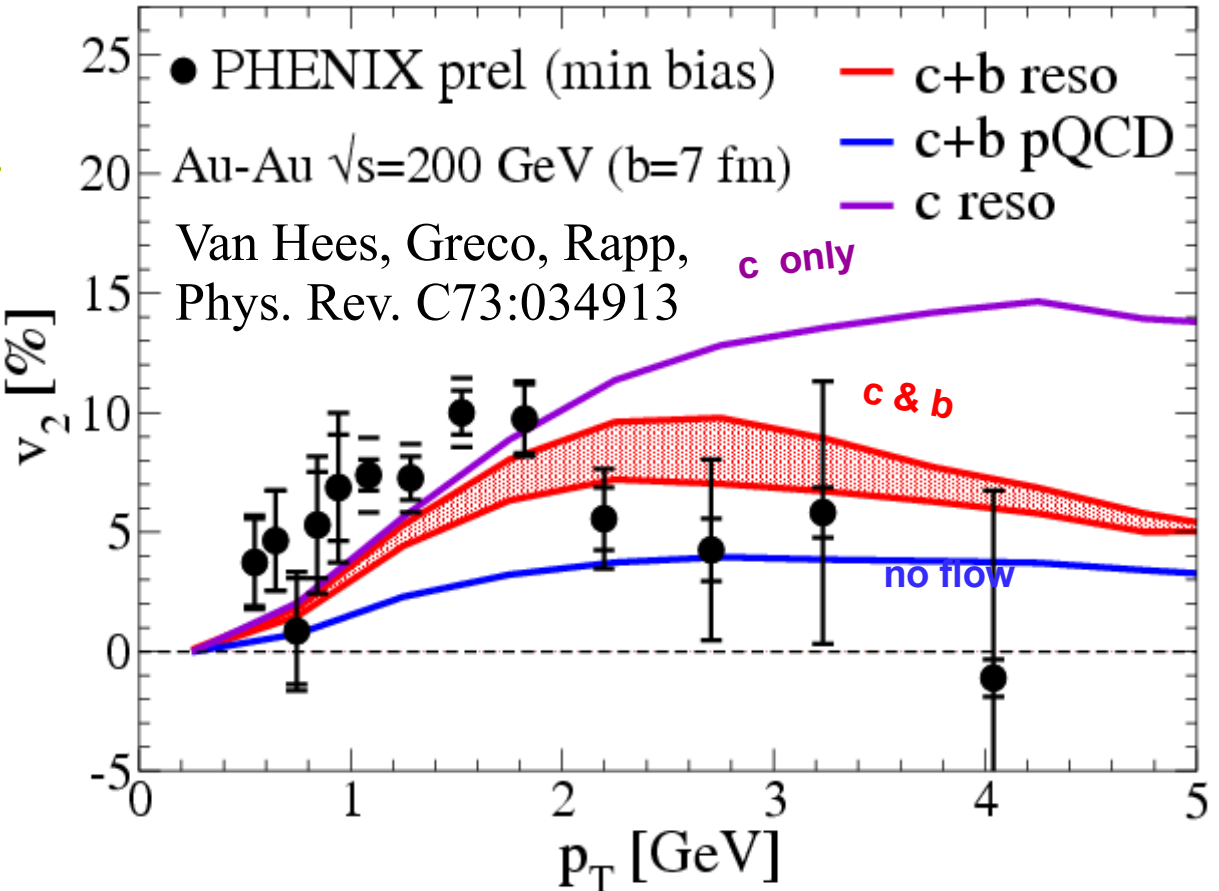
$\hat{q}$: transport coefficient
dN_g/dy initial gluon density

Anisotropy of Heavy Quarks in Au+Au Collisions

$$\frac{dN_e}{d\phi} \propto 1 + 2v_2 \cos\left[2(\phi - \Psi_{R.P})\right] + \ldots \qquad \Psi_{R.P}: \textit{reaction plane}$$



$$v_2 = \left\langle \frac{p_x^2 - p_y^2}{p_x^2 + p_y^2} \right\rangle$$

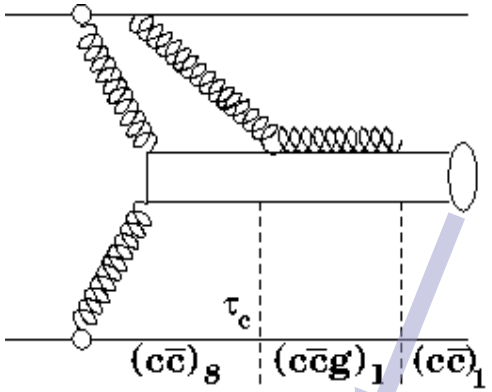


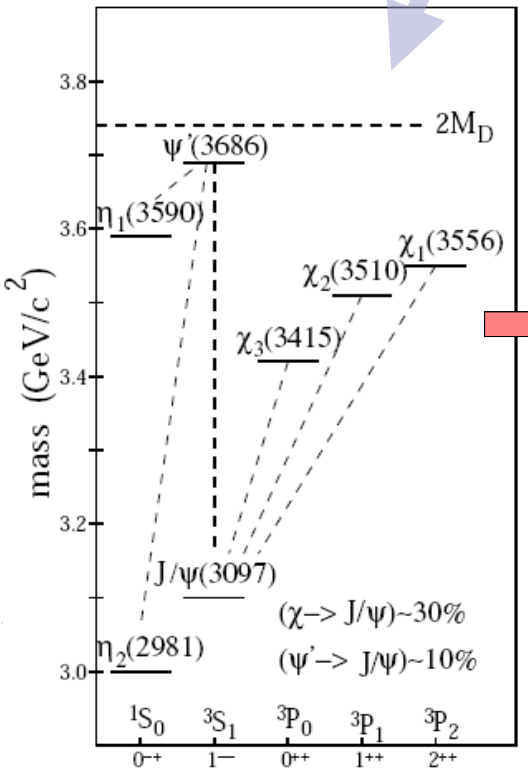
Flow (v_2>0) observed for p_T<2GeV/c where charm is dominant.

Consistent with thermalized and high density partonic matter.

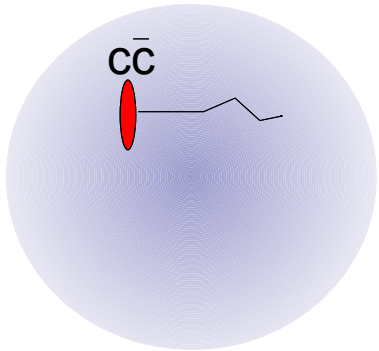
Drop of v_2 at high p_T : possibly bottom contribution.

Quarkonia

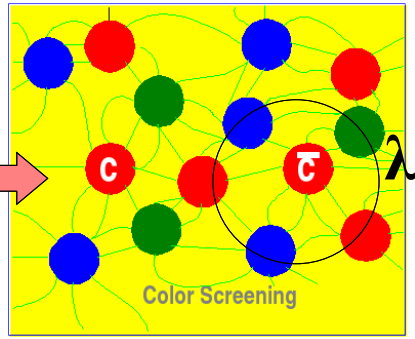


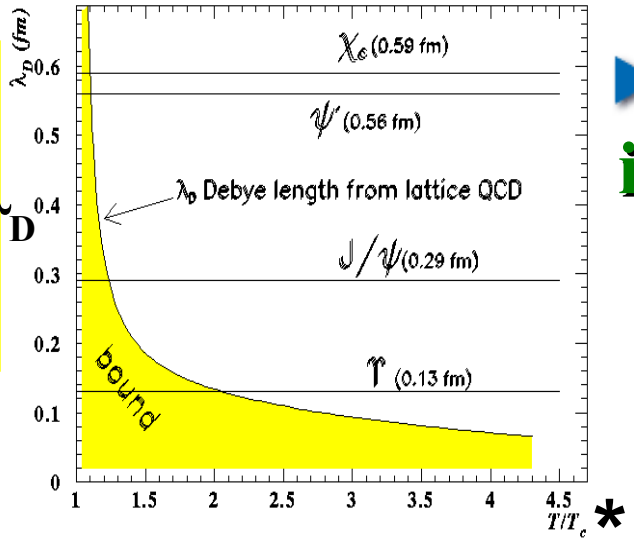


Production

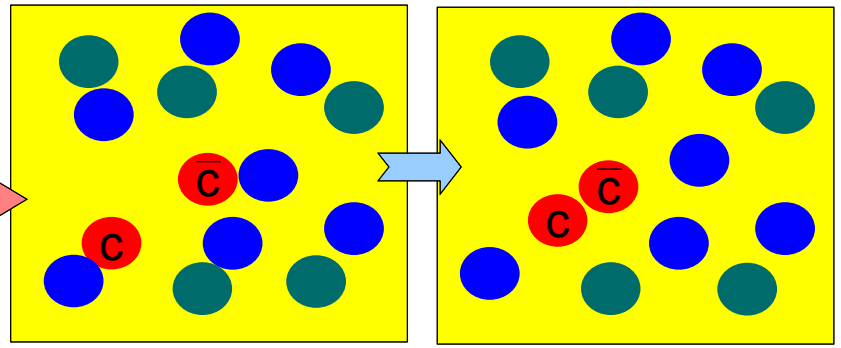


- Nuclear Absorbtion
- Shadowing
- pT broadening





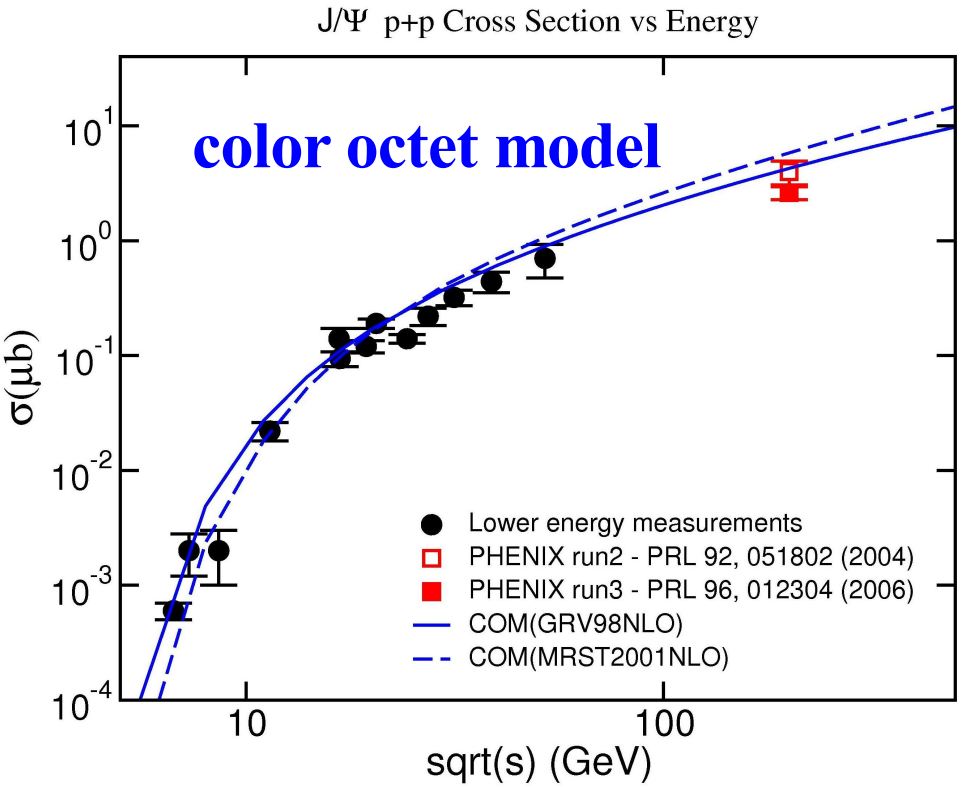
- Dissociation in deconfined quarks and gluons

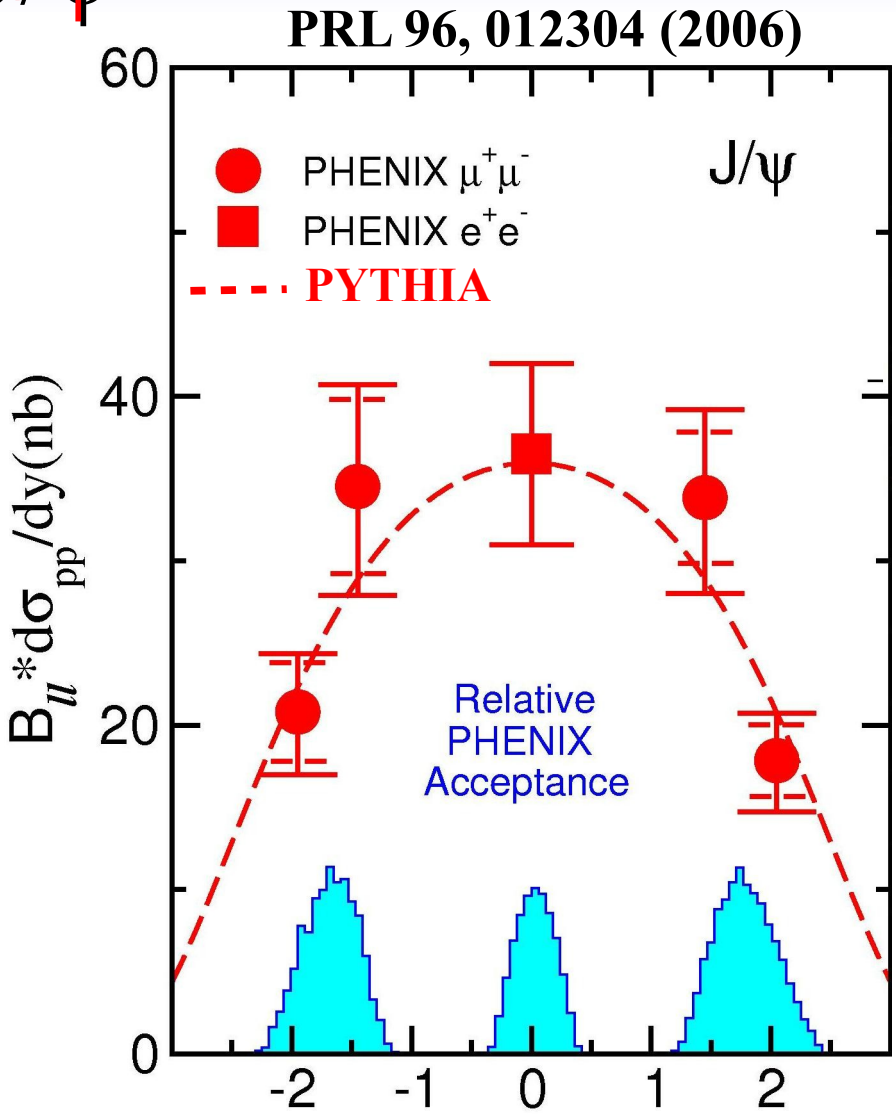


- Recombination
- Coalescence

* Recent lattice calculation has shown J/ψ wont dissociate until T>2Tc (Datta et. al., J.Phys. G30 (2004))

p+p → J/ψ



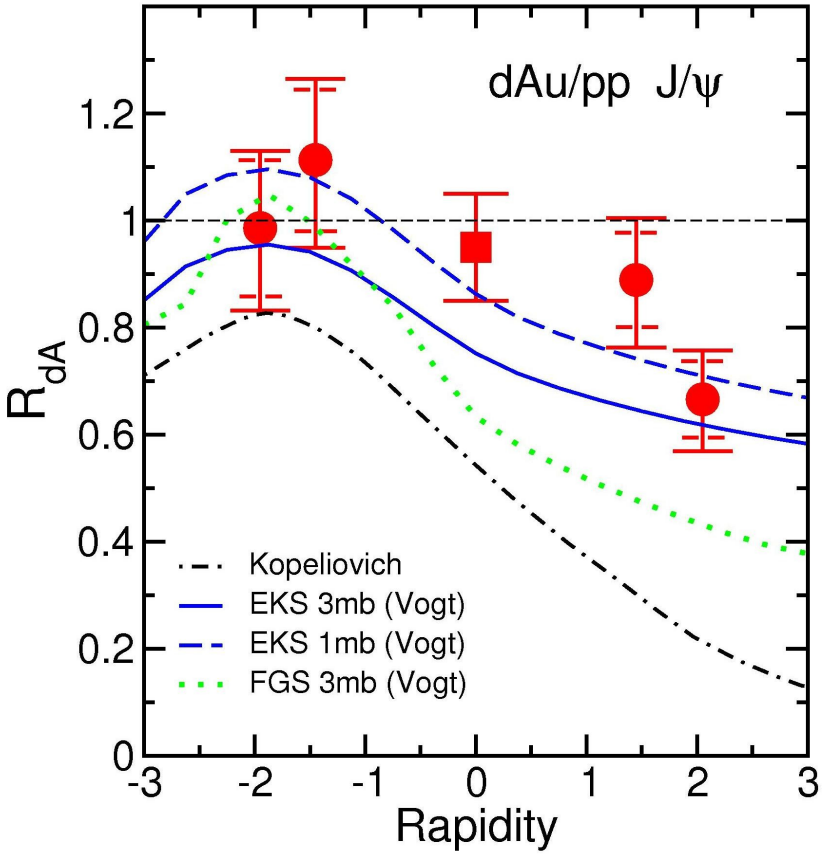


Consistent with color octet model and PYTHIA

10x more statistics from Run5 and 30x more statistics from Run6

d+Au → J/ψ

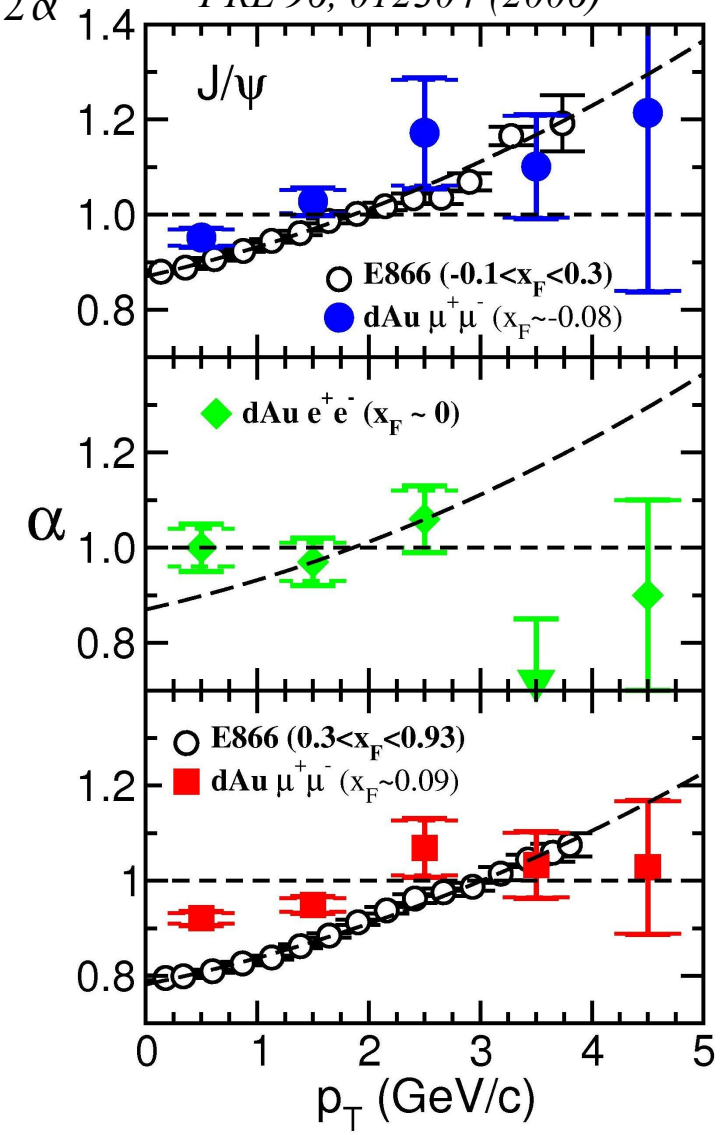
PRL 96, 012304 (2006)



Vogt, PRC71, 054902 (2005)
Kopeliovich, NP A696, 669 (2001)

$$\sigma_A = \sigma_{pp} A^{2\alpha}$$

PRL 96, 012304 (2006)

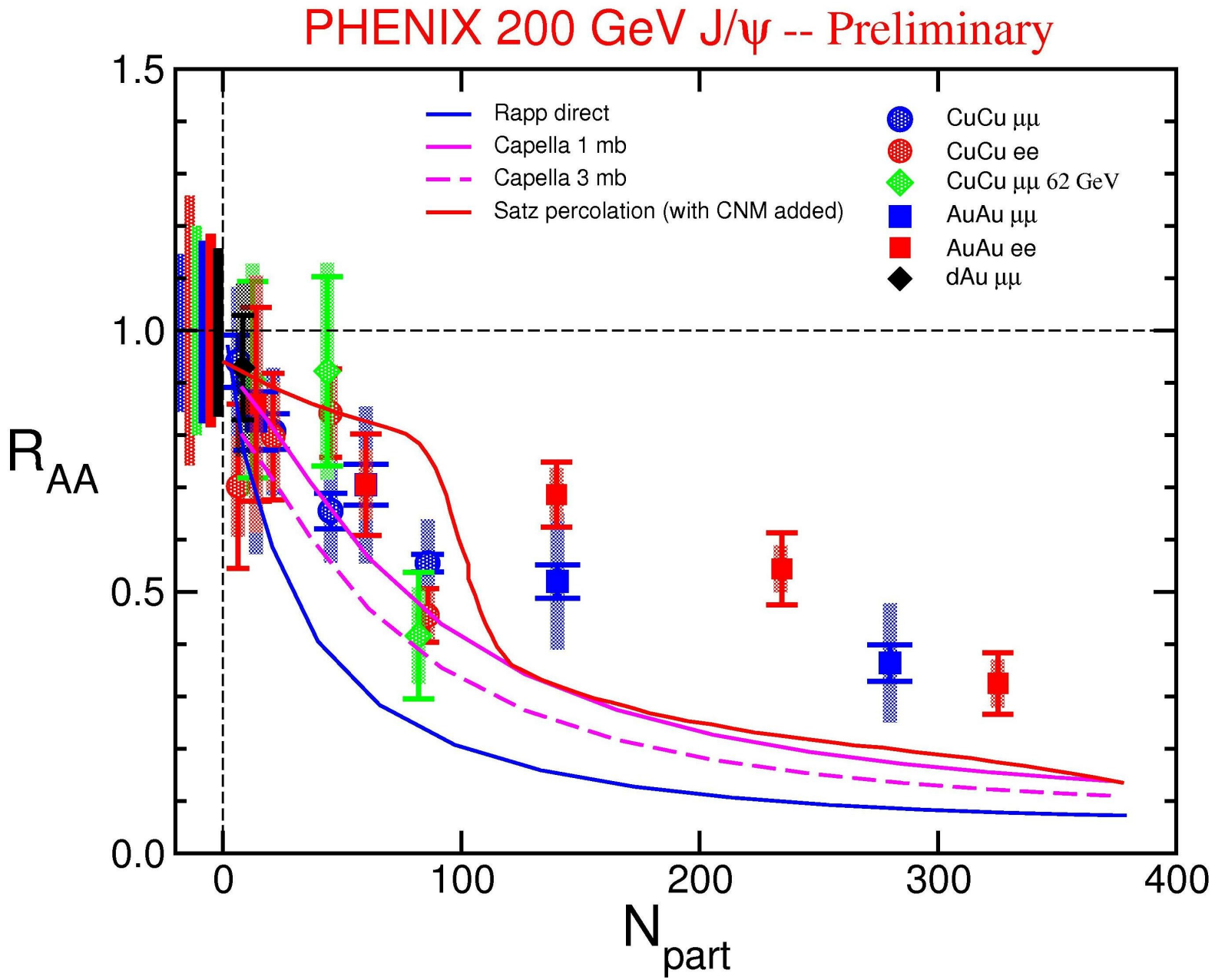


Weak gluon shadowing and nuclear absorbtion

More d+Au data is needed to constrain models

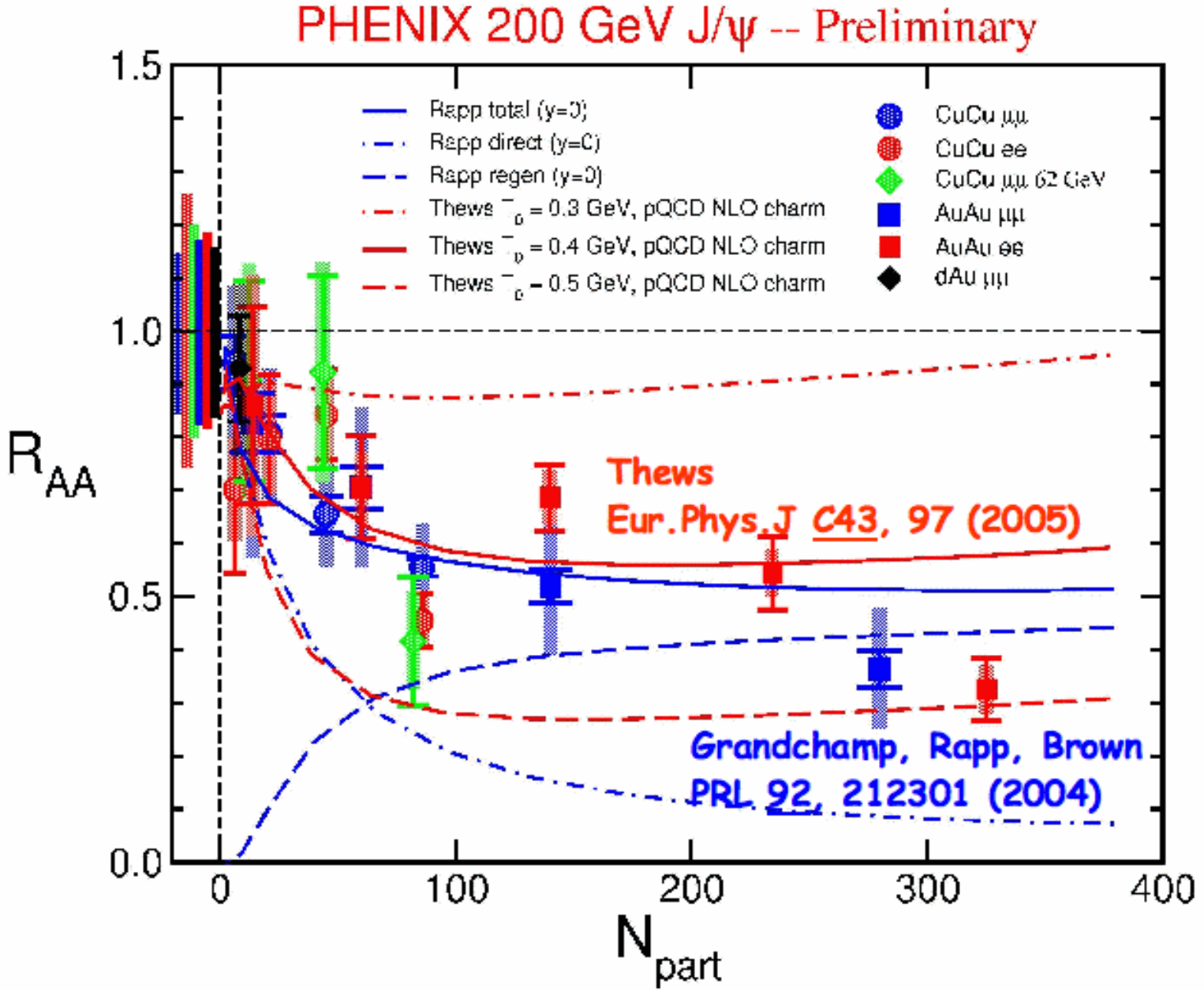
Au+Au and Cu+Cu → J/ψ

Nuclear absorption + color screening scenarios



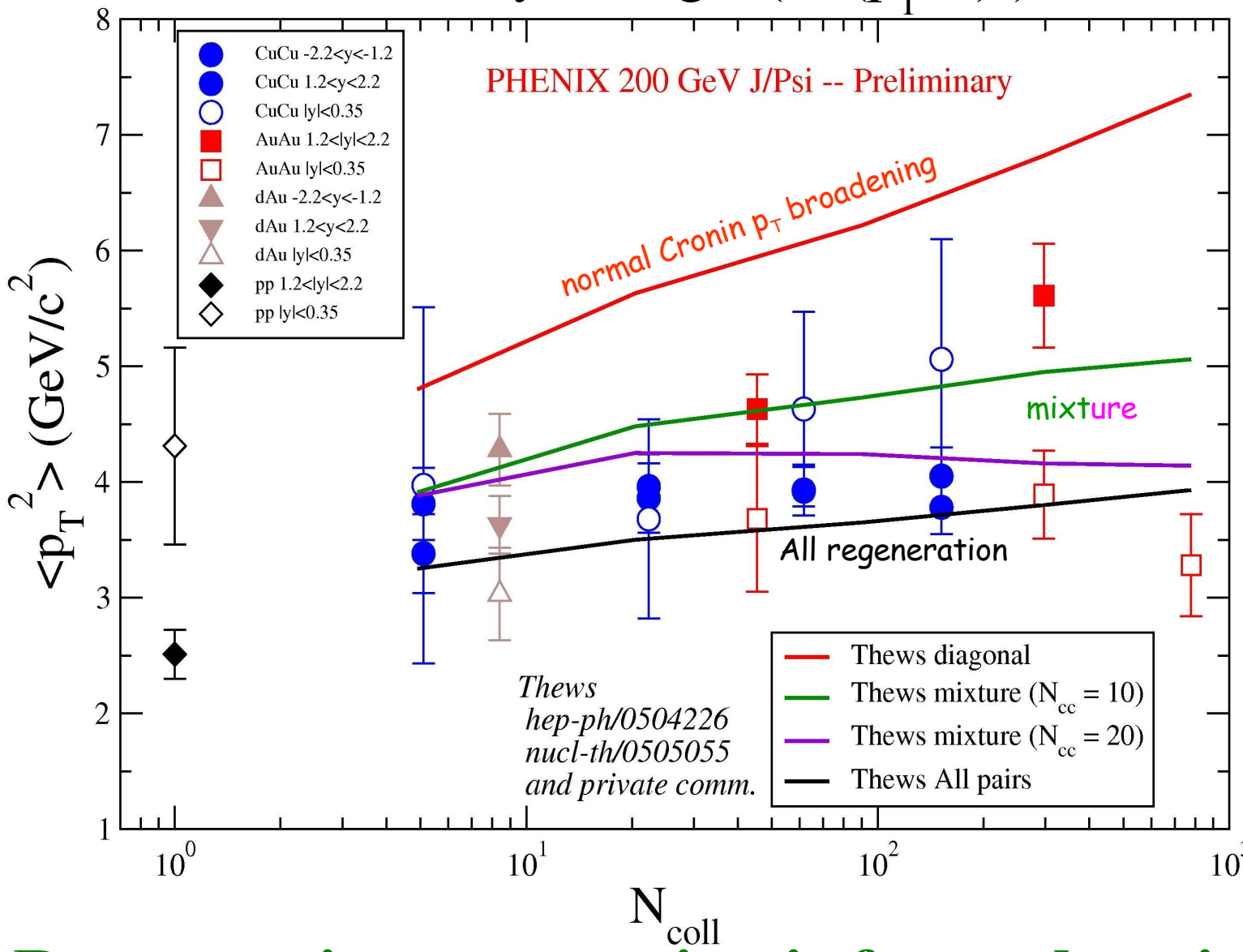
Au+Au and Cu+Cu → J/ψ

Nuclear abs. + color screening + recombination scenarios



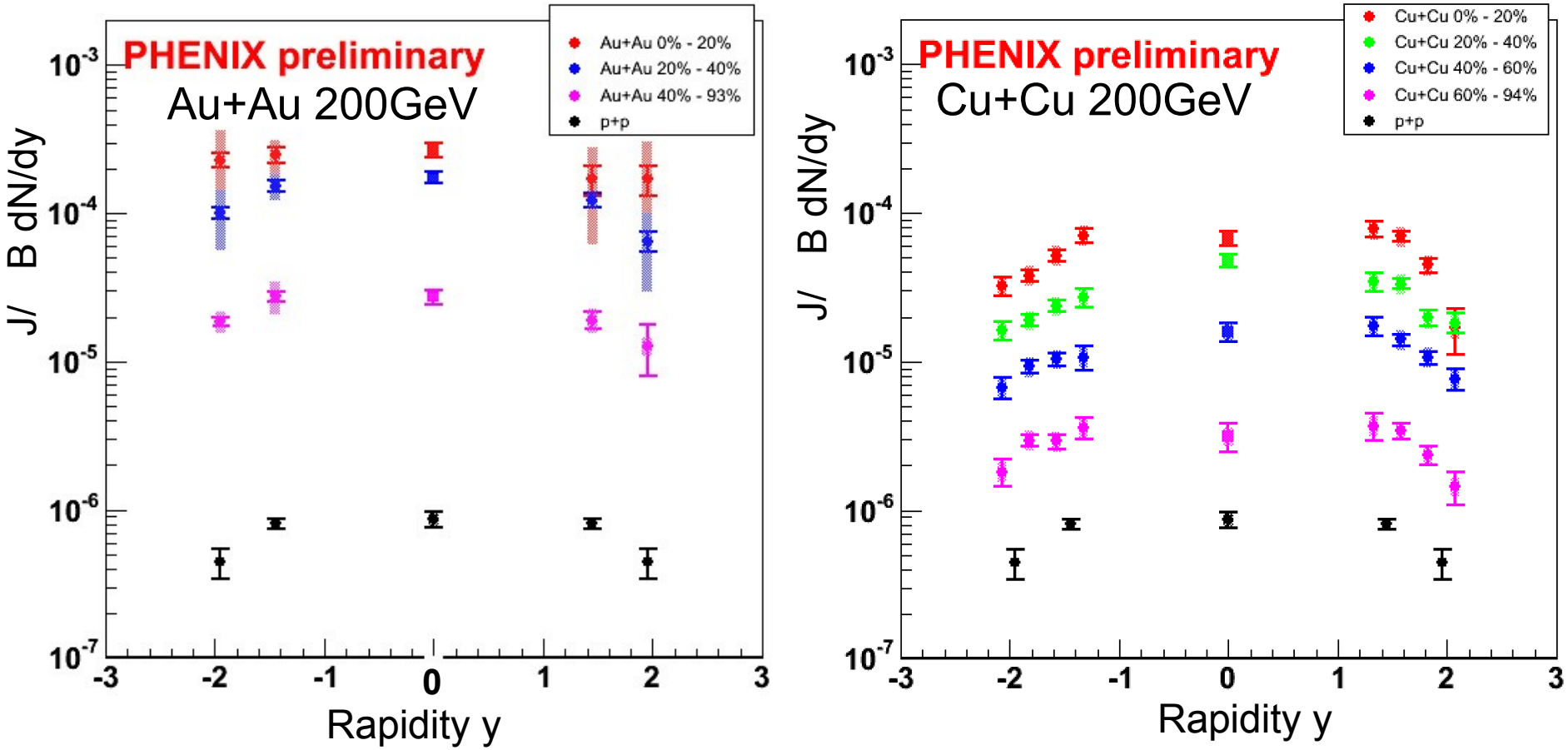
J/ψ $\langle p^2_T \rangle$

Obtained by fitting $A(1+(p_T/B)^2)^{-6}$



Regeneration assumption is favored again.

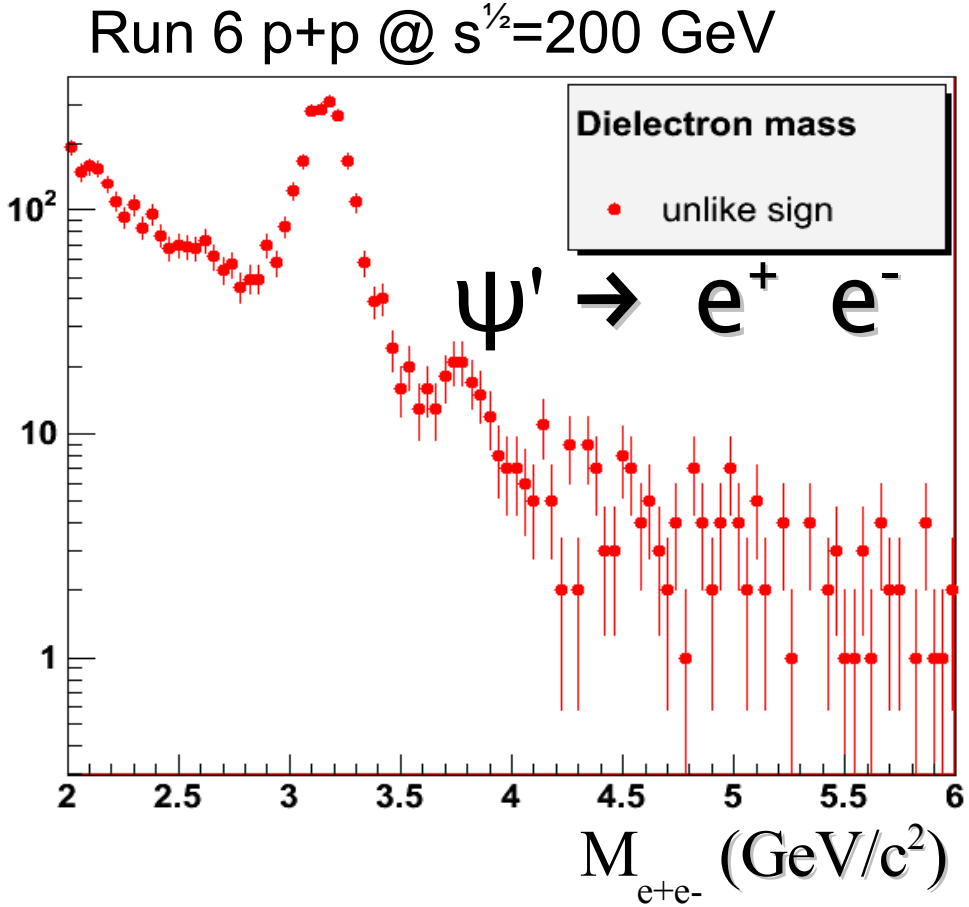
J/ψ rapidity dependence



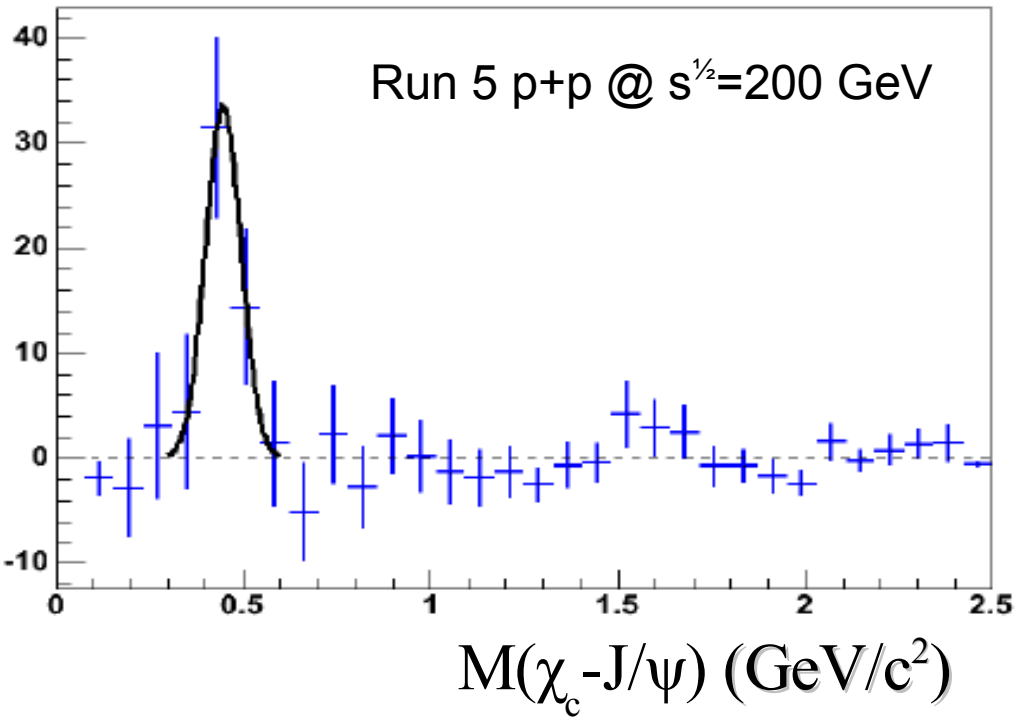
Flatter shapes than expected in regeneration models*.

* Thews & Mangano, Phys.Rev. C73 (2006) 014904.

Other states of charmonium



$\chi_c \rightarrow J/\psi+\gamma \rightarrow e^+ + e^- + \gamma$



Important to account feed-down contribution in J/ψ suppression.

Need much more statistics to see them in heavy ion collisions.

Much more physics from J/ψ

Polarization measurement

$N(\theta) = A[1+\tilde{\lambda}\cos^2\theta]$

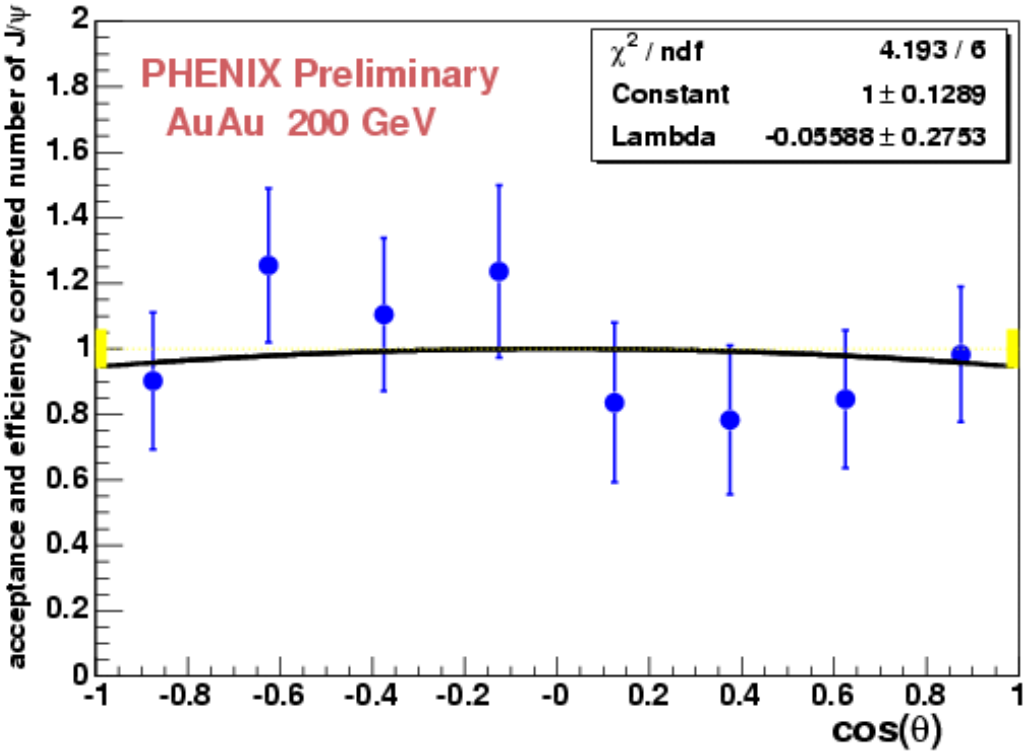
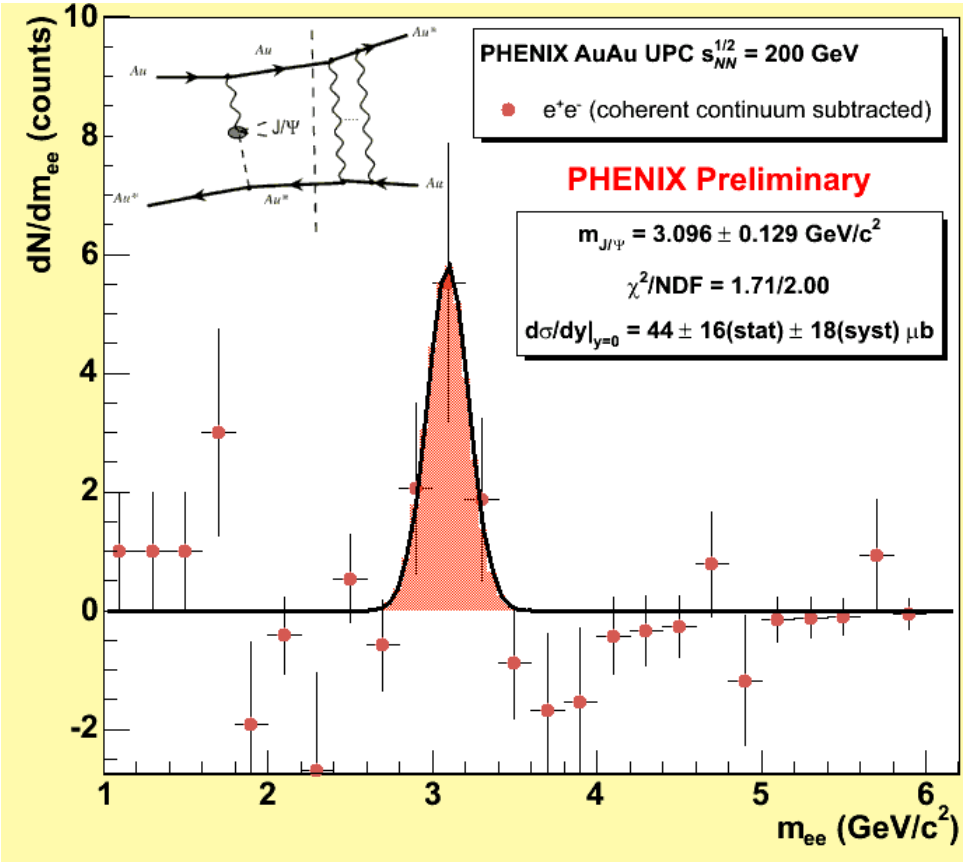
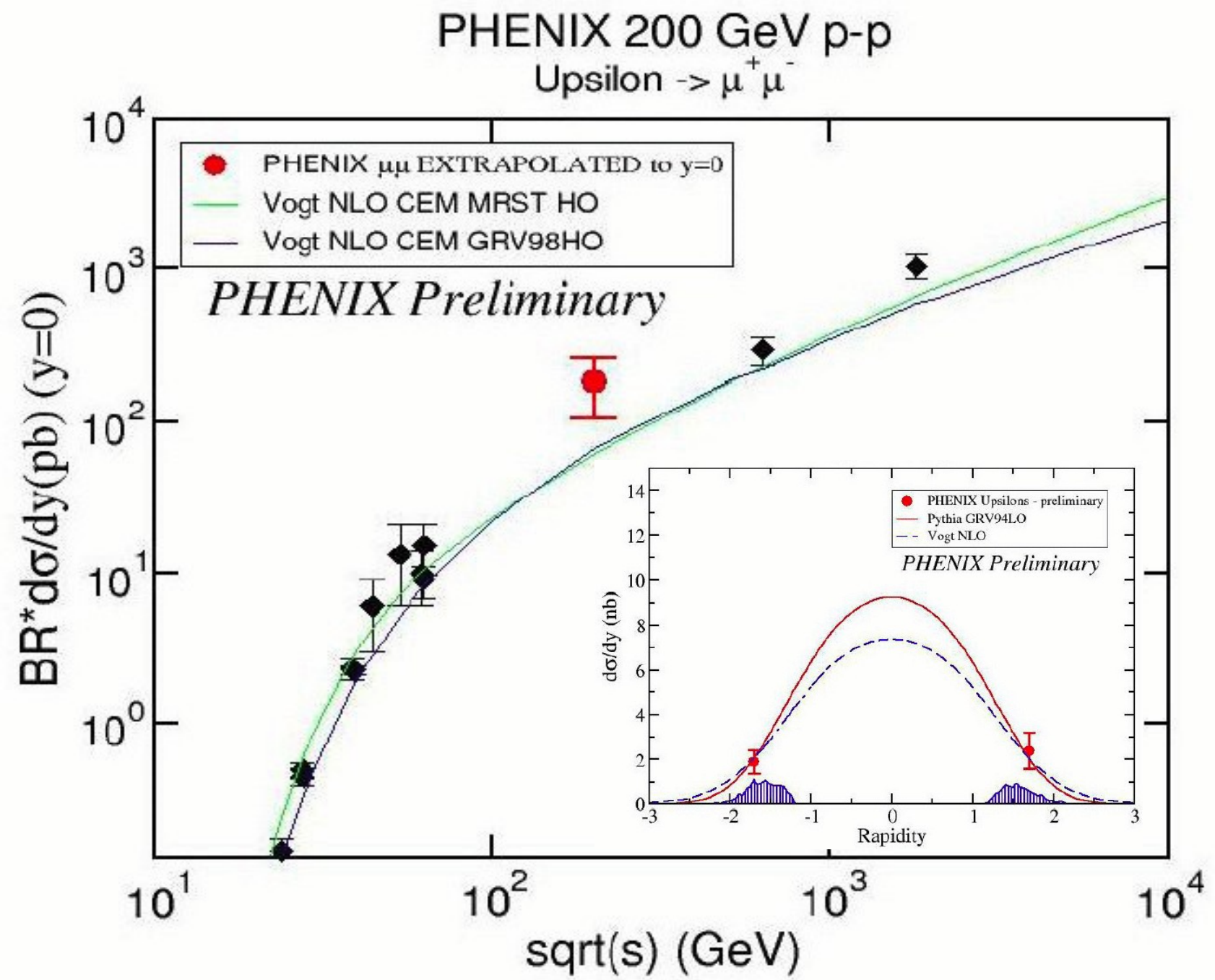


Photo-production in ultra peripheral collisions

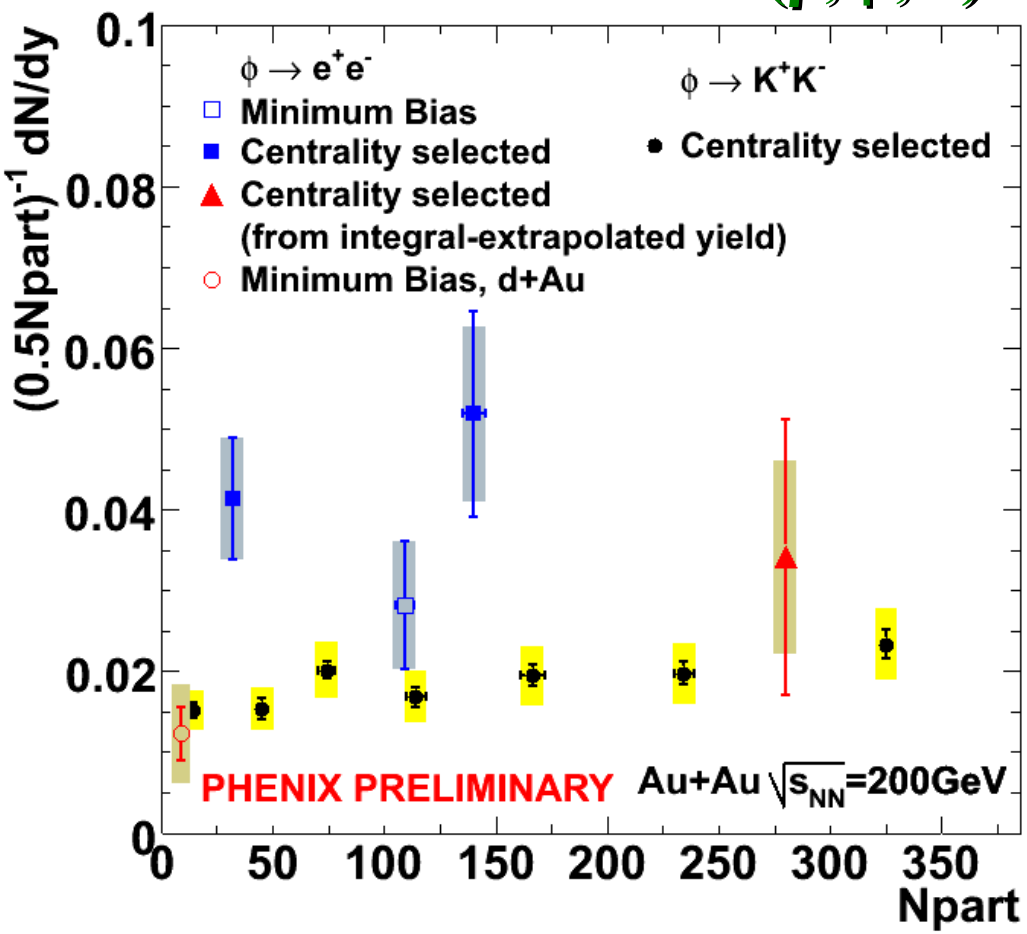


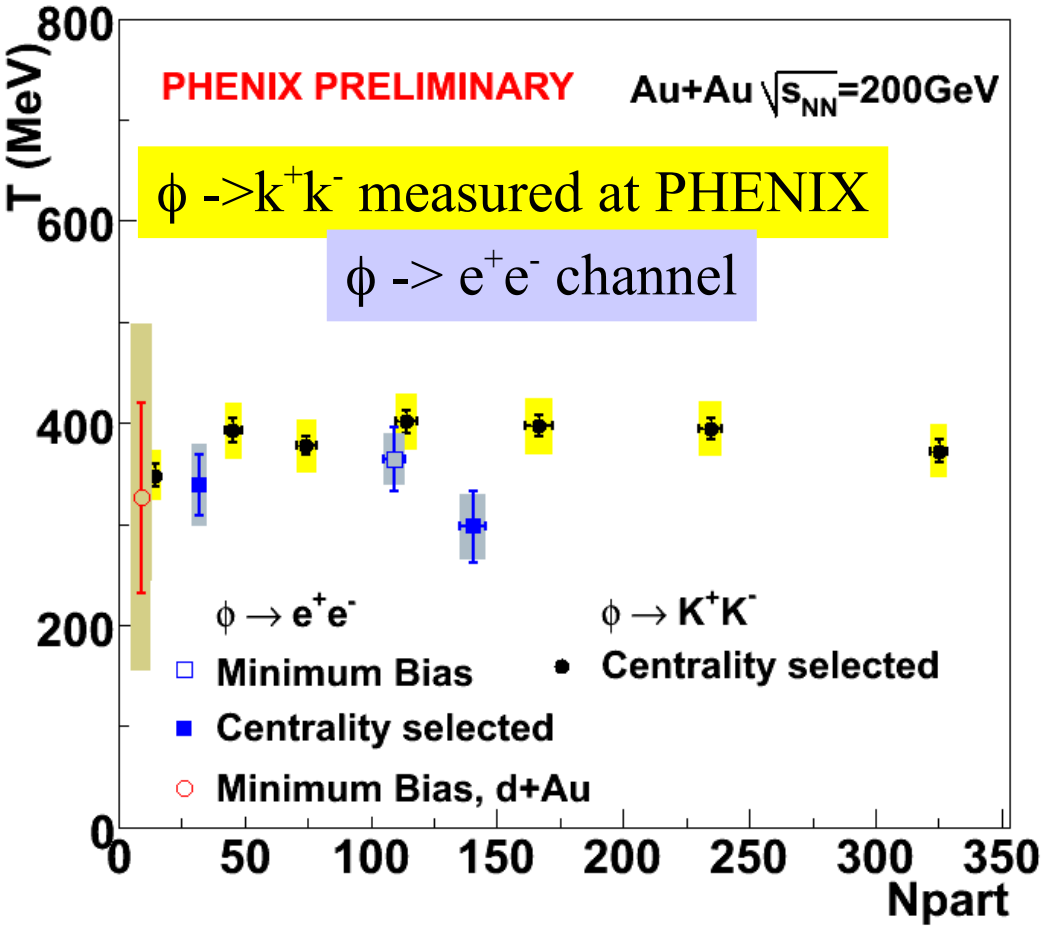
First observation of Bottonium at RHIC



Low Mass Vector Mesons

Chiral symmetry restoration changes the peak position and width of low mass vector mesons (ρ,ϕ,ω).

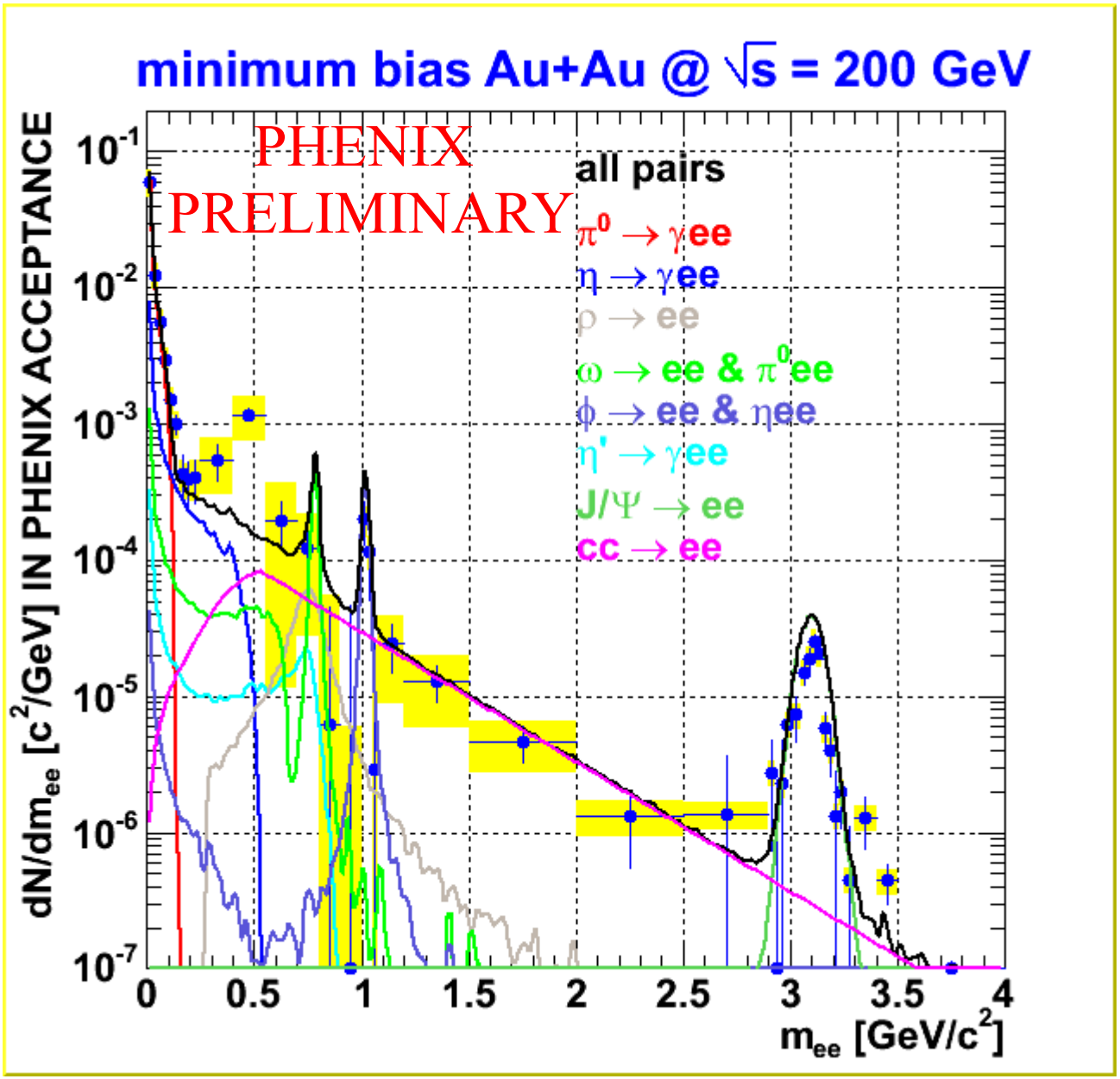




Temperatures (obtained from transverse mass spectra) are consistent for kaon and electron decays.

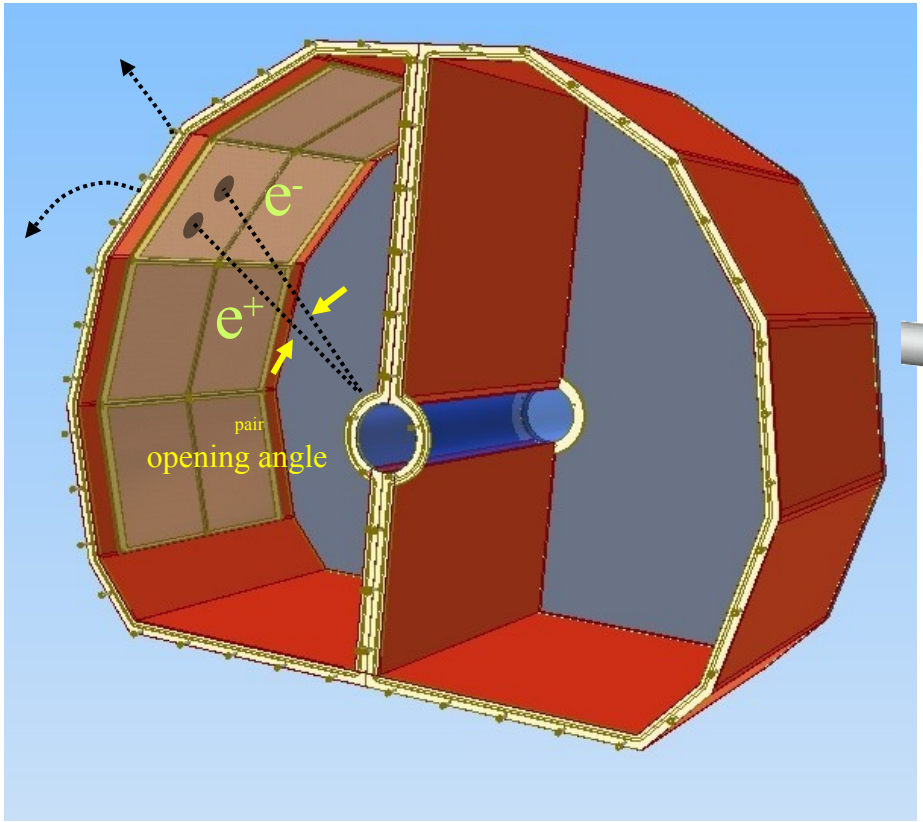
Errors too large to make statements about changes in electron branching ratio.

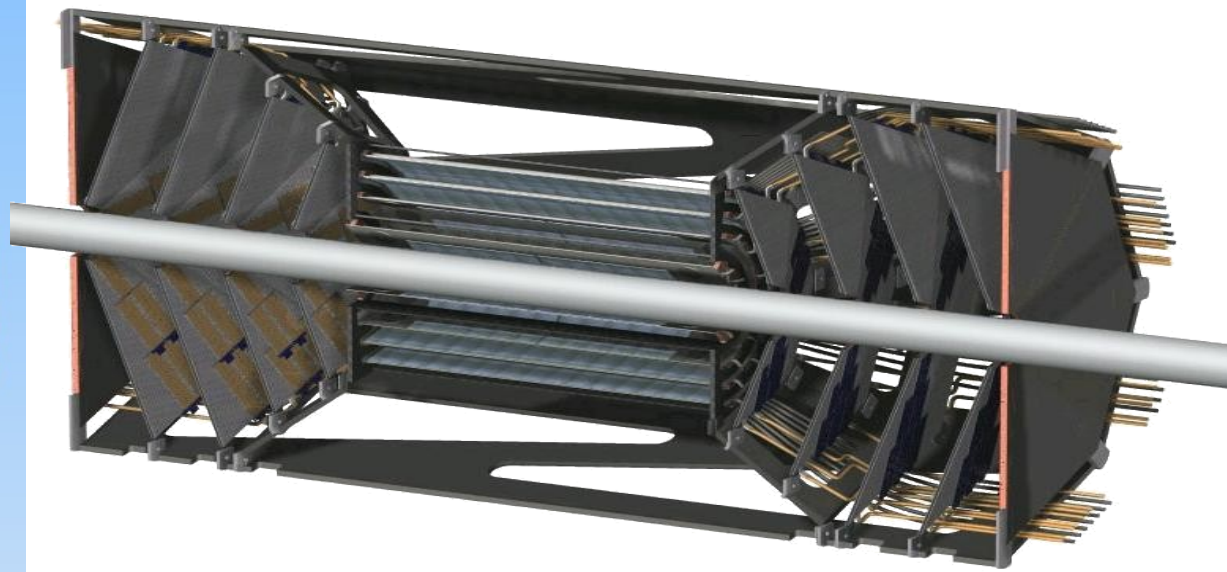
Dielectron Continuum



Errors too large to distinguish thermal radiation scenario.

Upgrades





Hadron Blind Detector

- Improve S/B for low mass di-electrons
- Select $e^+ + e^-$ from their opening angle

Silicon Vertex Detector

- better S/B non-photonic electron
- disentangle D from B production

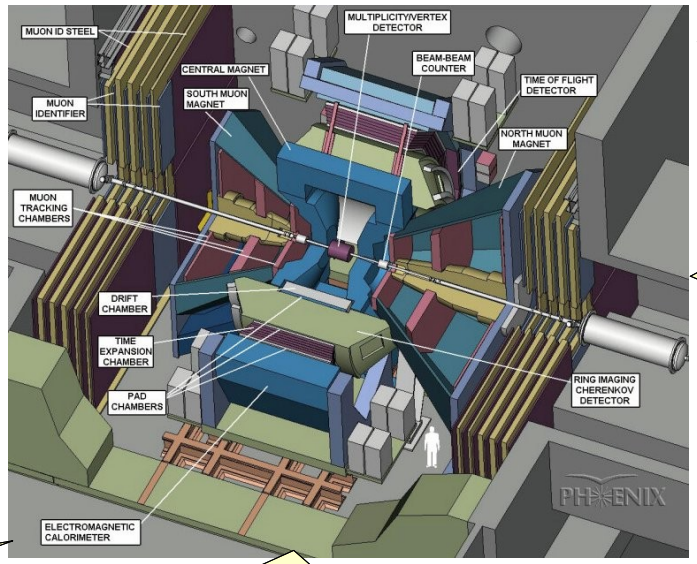
Summary

PHENIX obtained plenty of information from lepton decays, which are related to the early stages of RHIC collisions.

Heavy flavor consistent with pQCD

Heavy quarks strongly suppressed like light mesons

Charm flows. Therefore, the matter seen is partonic and thermalized



Absorption of J/ψ in nuclear matter is about 1-3mb

Low mass di-electrons waiting for HBD

ψ', χ_c, Υ are feasible measurements with higher luminosities

Color screening and regeneration describe well J/ψ suppression in Au+Au collisions

Coming up :

- **results from high luminosity p+p runs**
- **~x4 Au+Au data in 2007**
- **detector upgrades**

Heavy Quark Paper for the next week(s)

Title: Measurement of high-p_T Single Electrons from Heavy-Flavor Decays in *p*+*p* Collisions at $s^{1/2}$

Abstract:
The momentum distribution of electrons from decays of heavy flavor (charm and beauty) at mid-rapidity in *p*+*p* collisions at $s^{1/2}$=200 GeV has been measured by the PHENIX experiment at the Relativistic Heavy Ion Collider (RHIC) over the transverse momentum range $0.3 < p_T < 9$ GeV/c.

Two independent methods have been used to determine the heavy flavor yields, and the results are in good agreement with each other. A Fixed Order plus Next to Leading Log pQCD calculation agrees with the data within the theoretical and experimental uncertainties, with the data/theory ratio ~ 1.7 over the entire measured range of transverse momentum. The total charm production cross section at this energy has also been deduced.

ϕ Transverse mass spectra.