

Open Charm and Charmonium Production at RHIC

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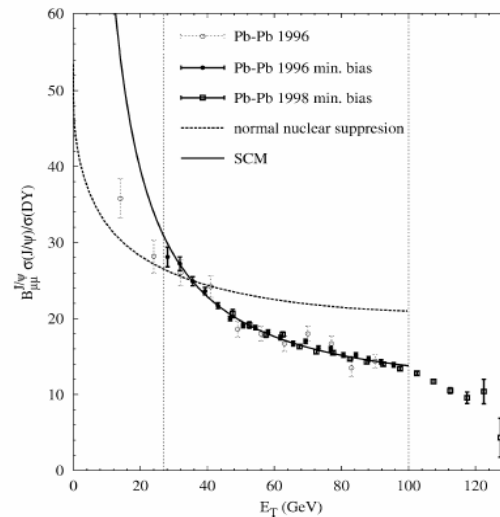
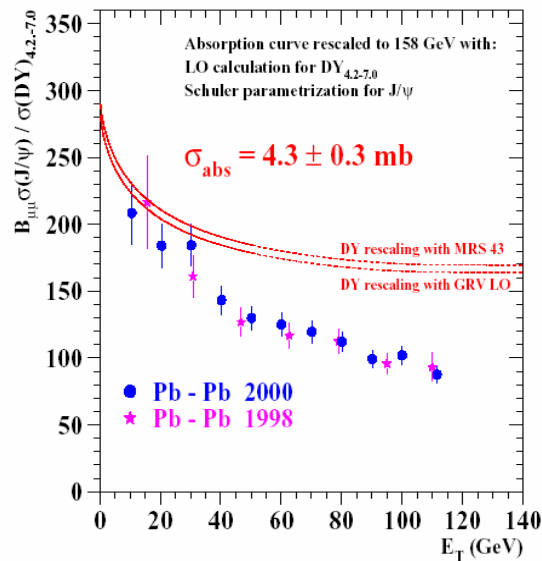
(PHENIX Collaboration)

- p+p (polarized)
- d+Au
- Au+Au

$$\sqrt{s_{NN}} = 200 \text{ GeV}$$

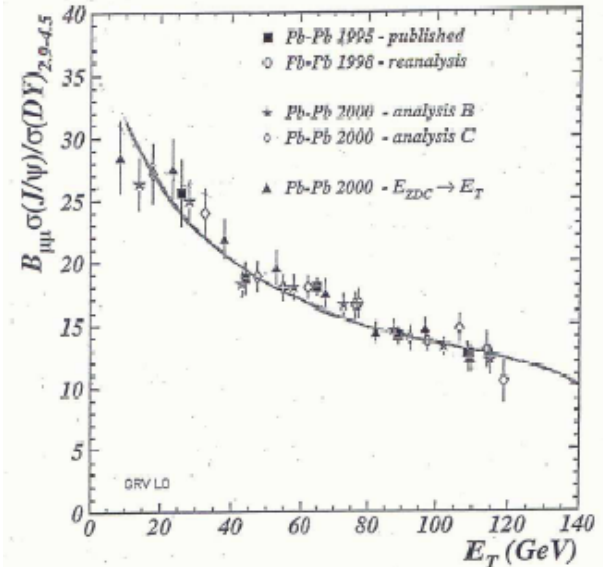
QGP and J/Psi Suppression in Pb-Pb at NA50

H. Santos, "Psi' production in nucleus-nucleus collisions at the CERN/SPS". QM04

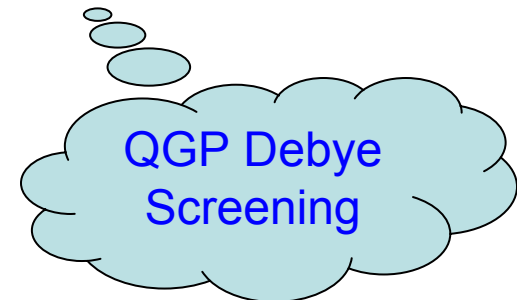


A.P.Kostyuk, M.I. Gorenstein, H. Stocker, W. Greiner, Phys. Lett B 531, 195-202

A. Capella, D. Sousa, nucl-th/0303055



- Suppression with respect to normal nuclear suppression expectations
- Alternative models:
 - Statistical coalescence model (enhanced open charm)
 - Hadron gas comovers
- RHIC data on J/Ψ and Open Charm from pp, dAu to AuAu
 - “cold” & “hot” medium



Charm Production – Probing QGP

- J/Psi production

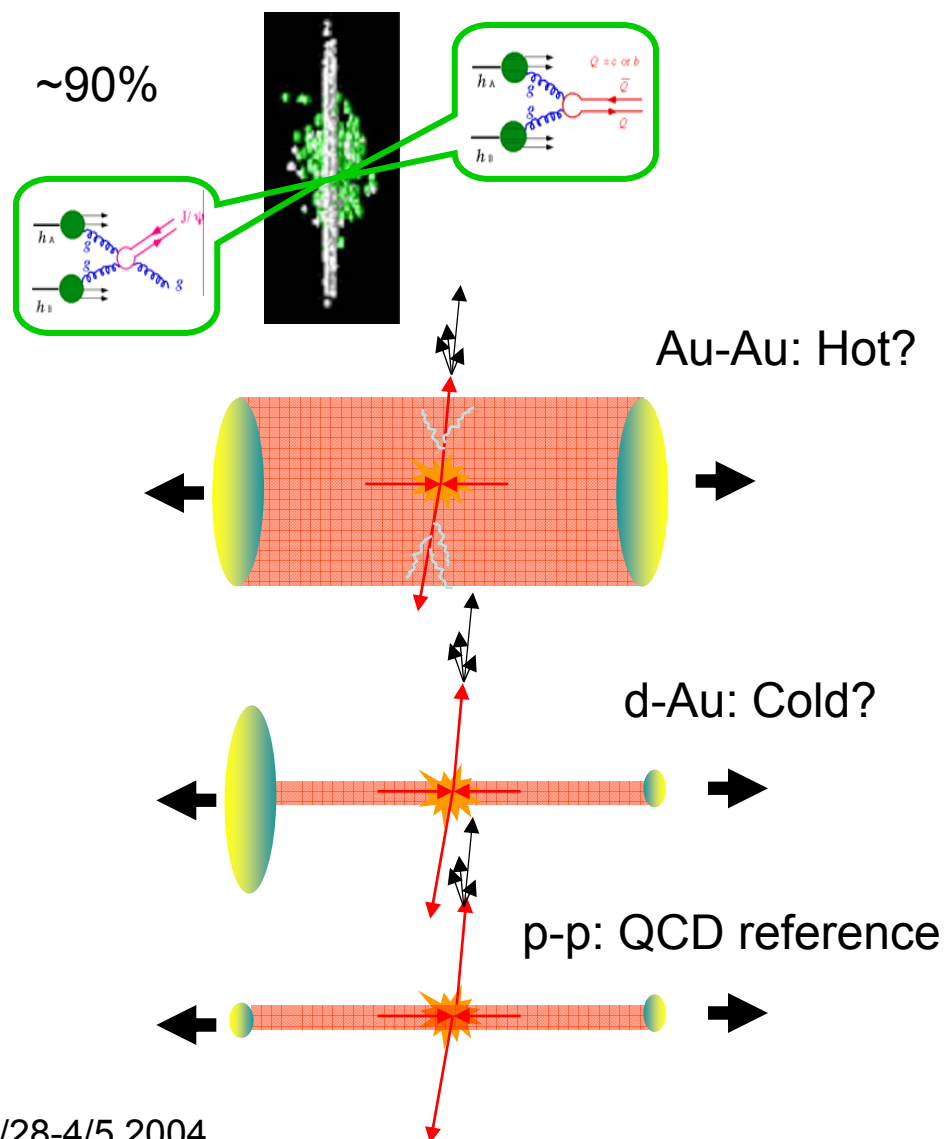
- QGP Debye Screening & J/Psi suppression

$$d\sigma^{J/\Psi} \propto f(x_1) \otimes f(x_2) \otimes d\hat{\sigma}_{x_1+x_2 \rightarrow c\bar{c}} \otimes D_{c\bar{c} \rightarrow J/\Psi + X}$$

- Thermal production
- Coalescence models
- Initial & final state interactions
- Production mechanism
 - CSM, COM, CEM
 - Polarization

- Open charm

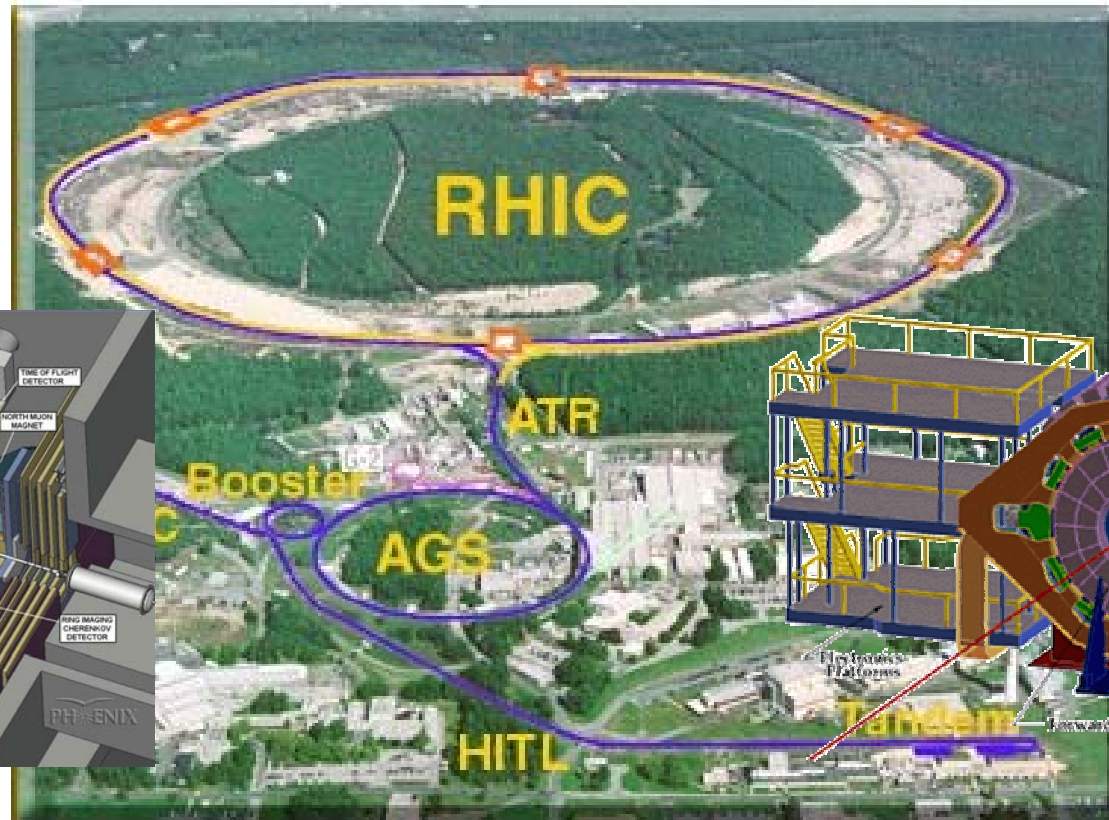
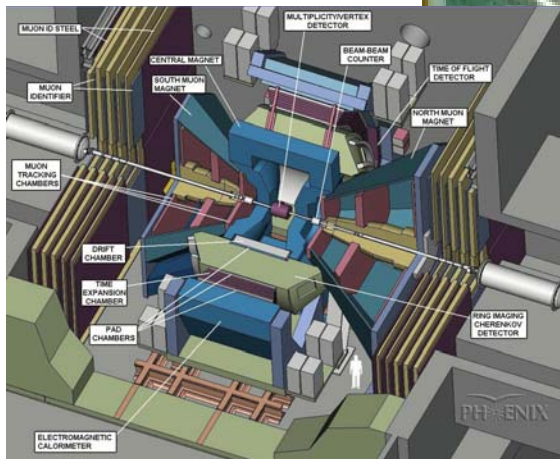
- Baseline for J/Psi
- Gluon structure function
- Nuclear medium effects
 - Light vs Heavy
 - Binary scaling in dAu, AuAu
- QGP signal: open charm enhancement?



$e^{\pm} : |\eta| < 0.35$

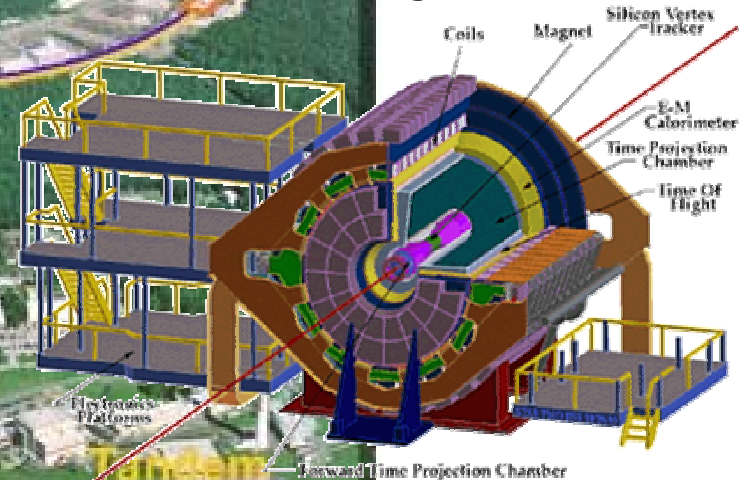
$\mu^{\pm} : 1.2 < |\eta| < 2.4$

PHENIX



$e, \pi, K, p : |\eta| < 1$

STAR



Run I, 2001 Au-Au beams at $\sqrt{s}=130$ GeV

- Open charm from PHENIX

Run II, 2002 Au-Au beams and p-p at $\sqrt{s}=200$ GeV

- Open charm and J/Ψ from PHENIX

Run III, 2003 d-Au, p-p at $\sqrt{s}=200$ GeV

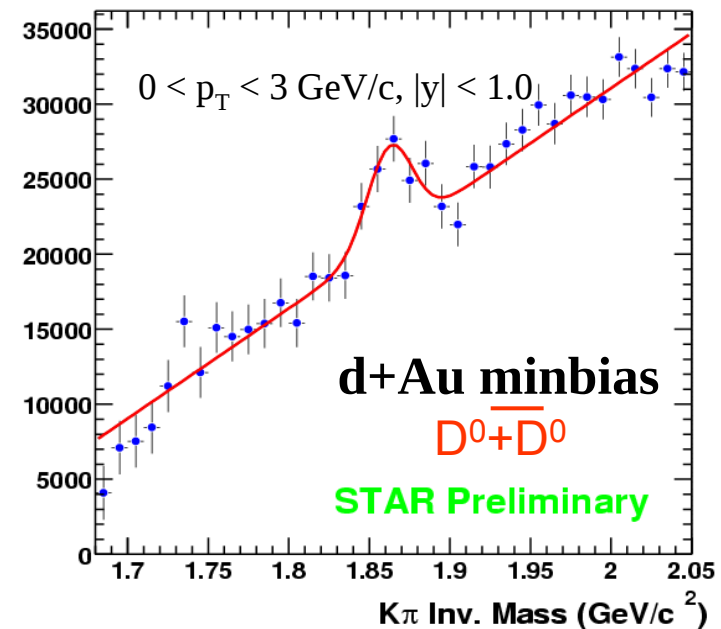
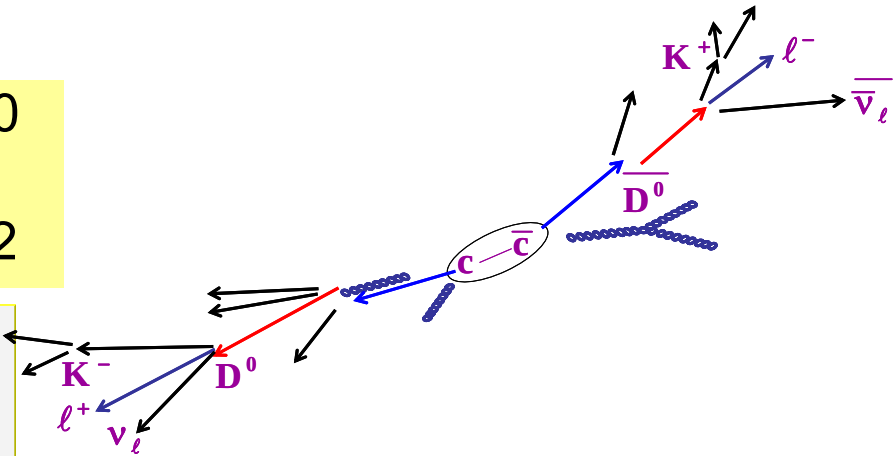
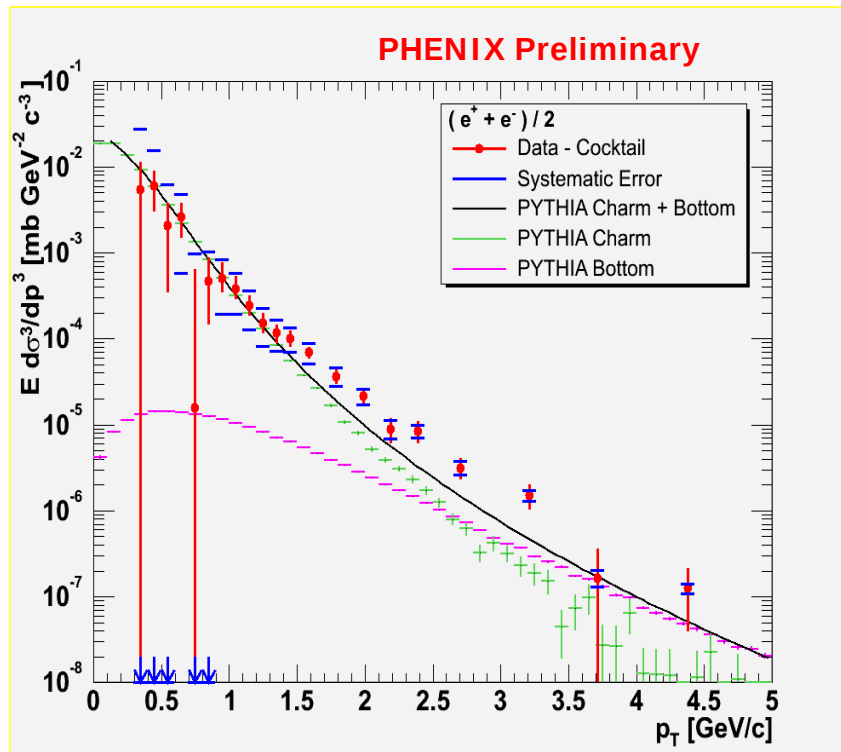
- Open charm from PHENIX and STAR, J/Ψ from PHENIX

Run IV, 2004 Au-Au, $\sqrt{s}=200$ GeV

- More measurements to come

Open Charm at RHIC

- Single electrons measured at $y \sim 0$
- D mesons (STAR) $|y| < 1.0$
- High Pt muons (PHENIX) $|y| \sim 1-2$



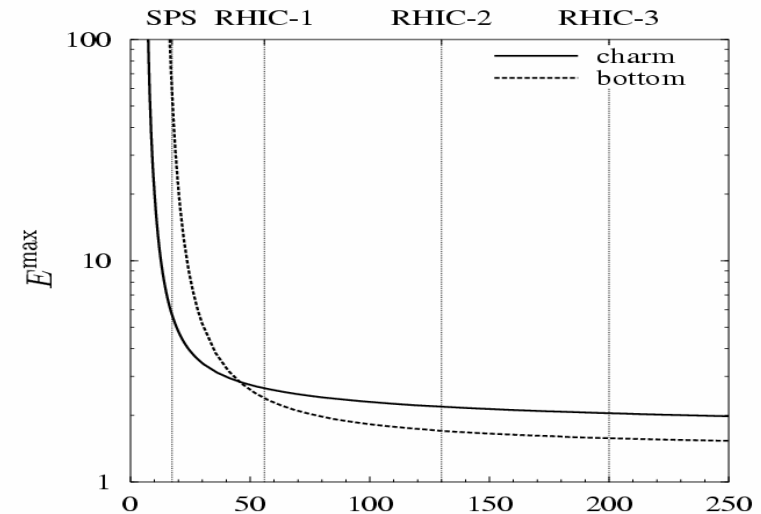
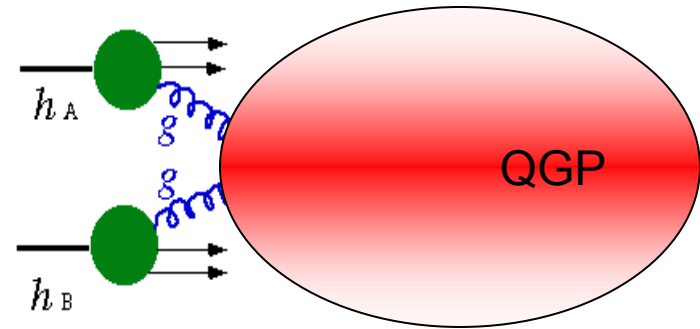
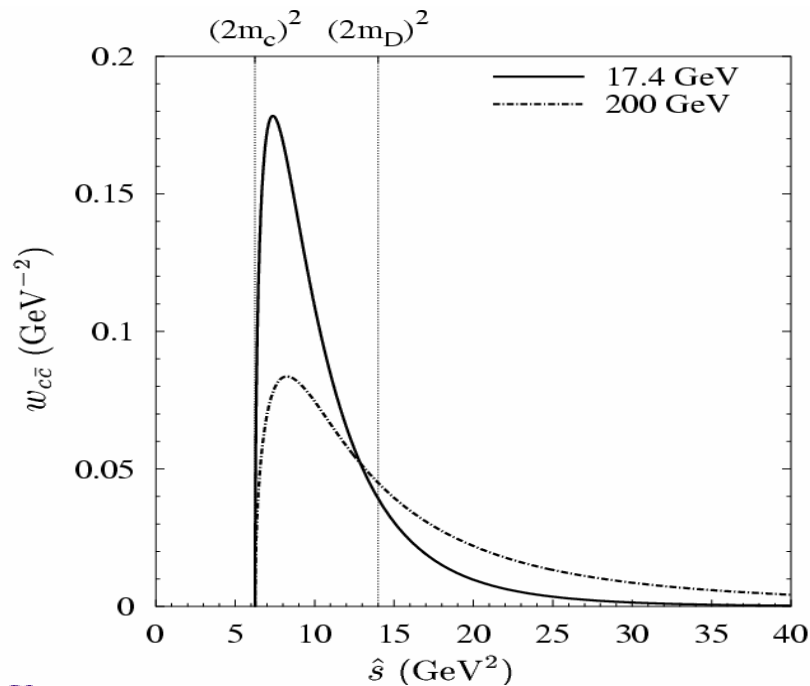
Open Charm Production in QGP

- Threshold effect

$$d\sigma^D \propto f(x_1) \otimes f(x_2) \otimes d\hat{\sigma}_{x_1+x_2 \rightarrow c\bar{c}} \otimes D_{c\bar{c} \rightarrow D+X}$$

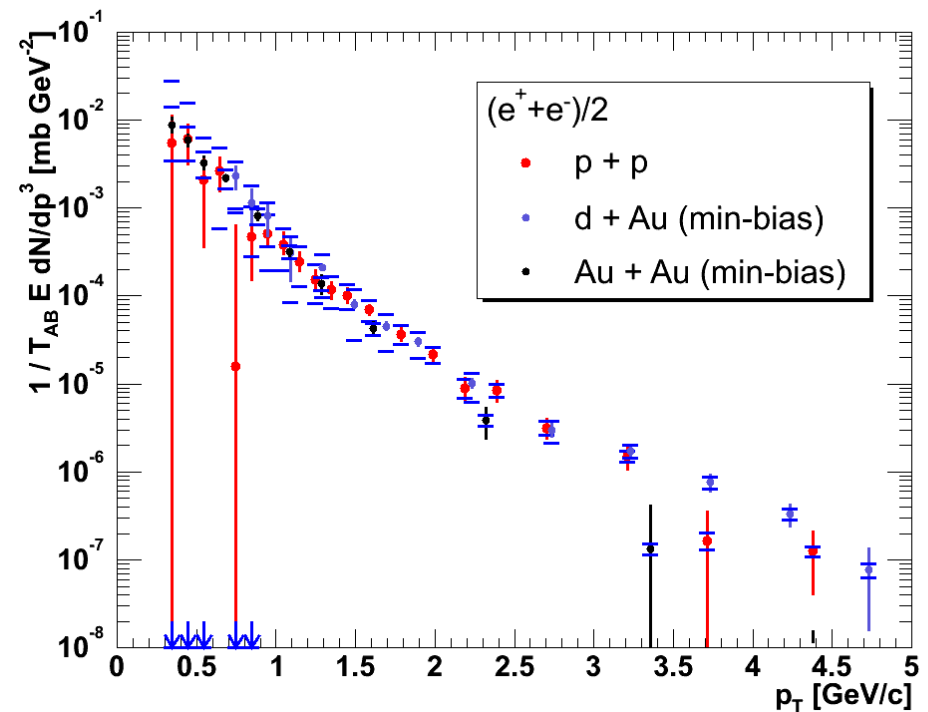
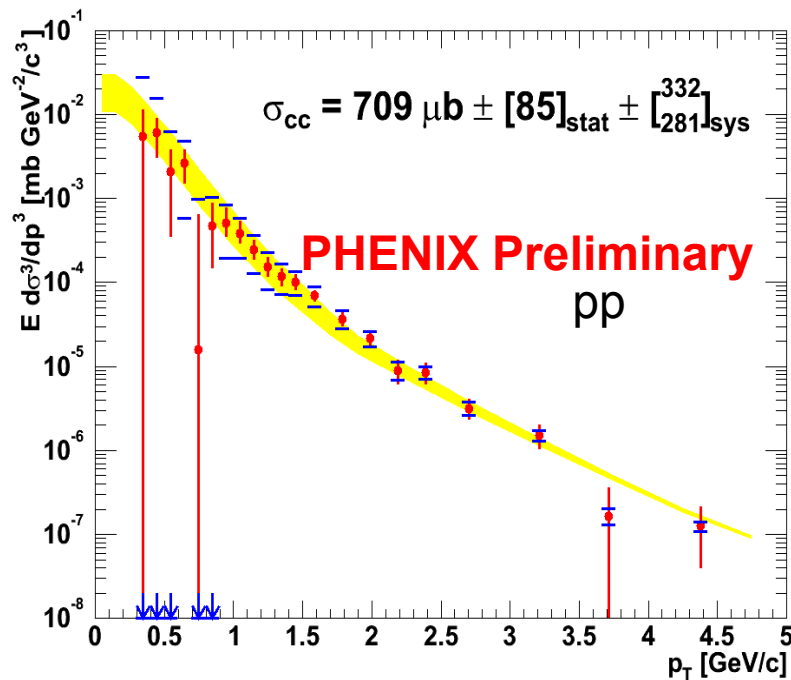
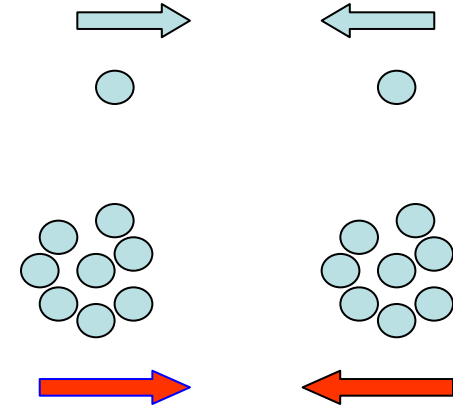
- Thermal production

A. Kostyuk, M. Gorenstien, W. Greiner. hep-ph/0103057



Nucleon Binary Scaling

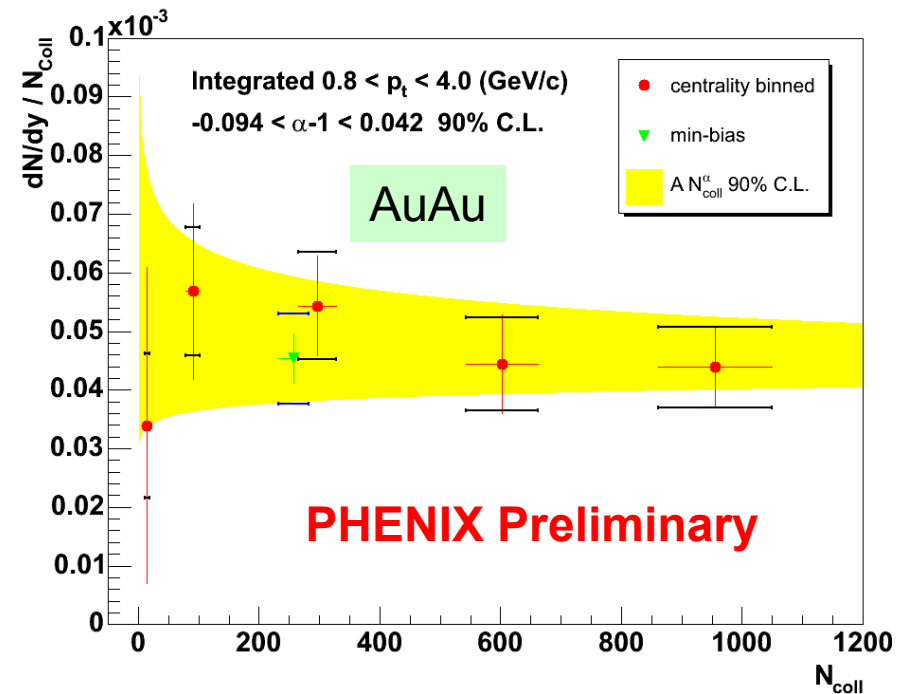
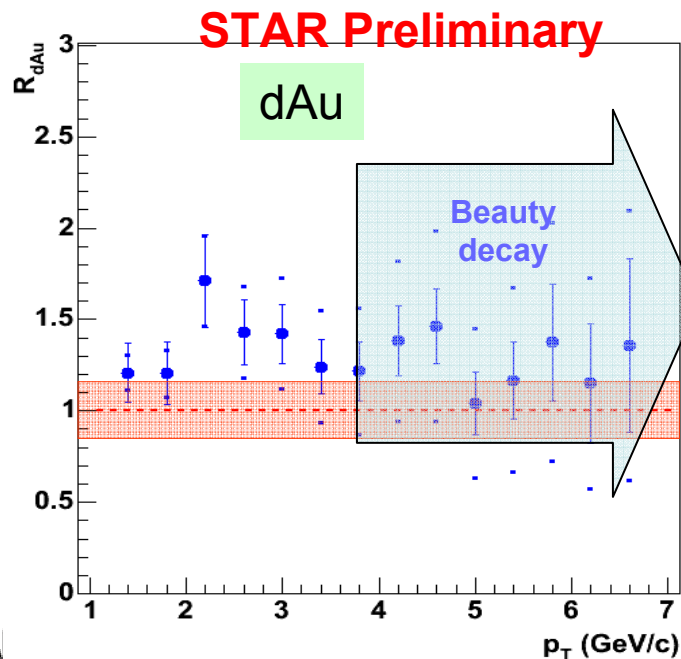
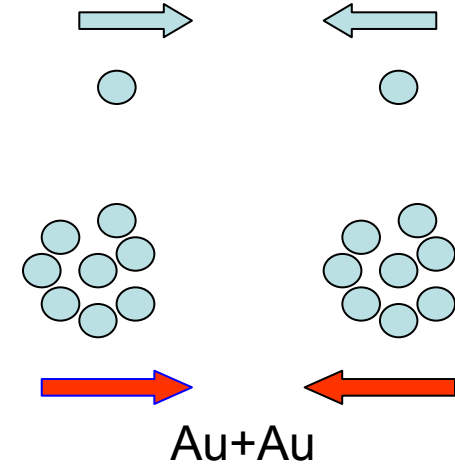
- pp, dAu, AuAu MinBias



Open Charm @ $y \sim 0$

- Scales with number of nucleon binary collisions in d+Au & Au+Au @ $y \sim 0$

$$R_{AB} = \frac{d^2 \sigma^{AB} / dp_T dy}{\langle N_{coll} \rangle d^2 \sigma^{pp} / dp_T dy}$$

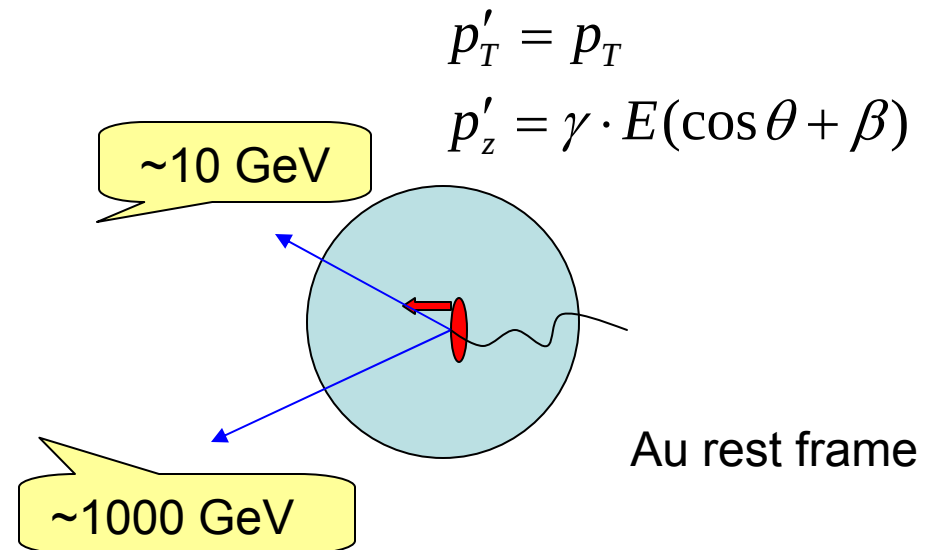
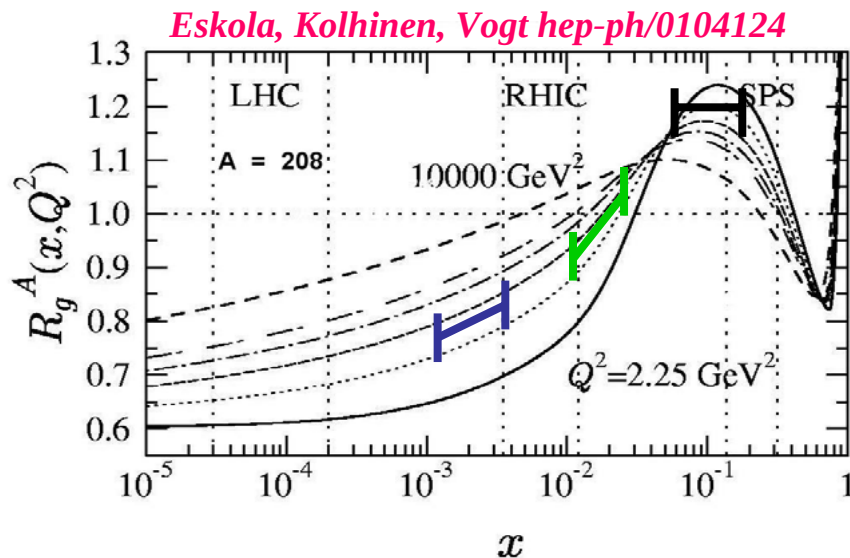
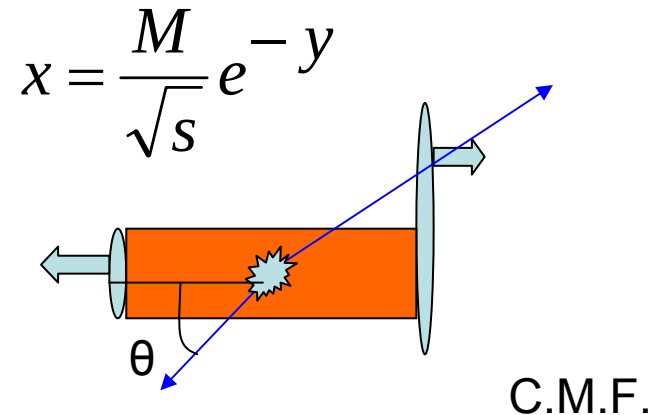


4 3/28-4/5 2004

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Physics @ large rapidity

- Different “x” range:
initial state
 - (anti)shadowing/CGC
- Final state scattering:
energy dependent



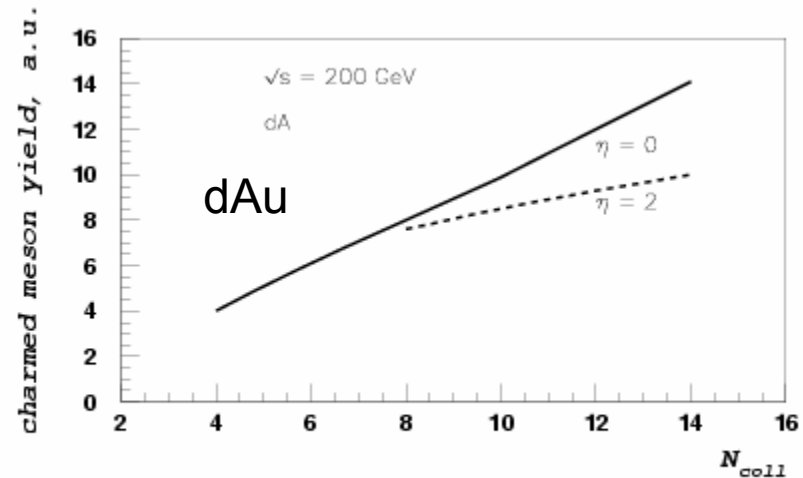
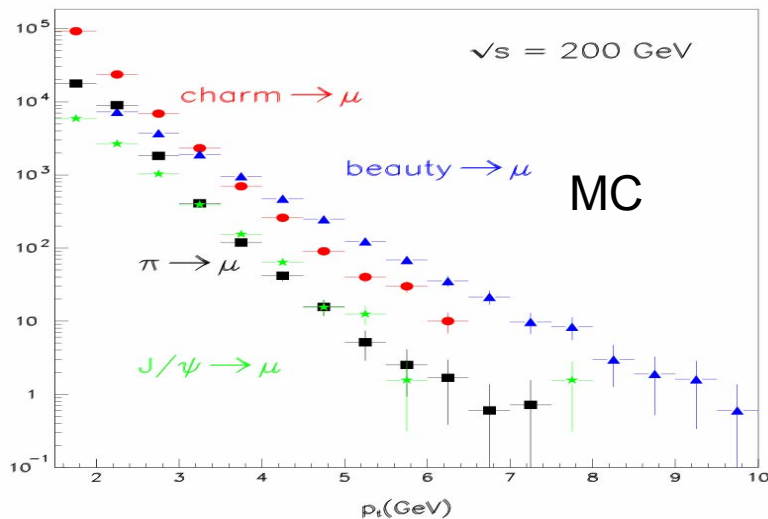
Open charm at large rapidity

- Gluon saturation/CGC

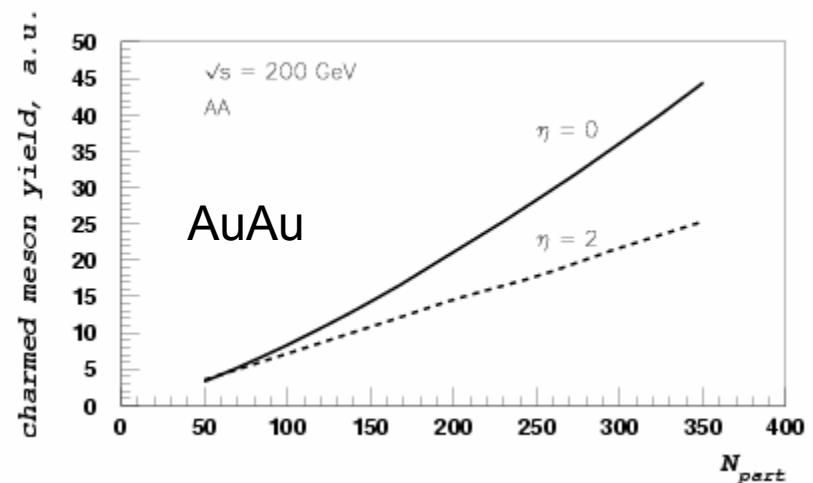
$$y \sim 0: d\sigma \propto N_{coll}$$

$$y \sim 2: d\sigma \propto N_{part}$$

- PHENIX forward muons $1.2 < |y| < 2.4$

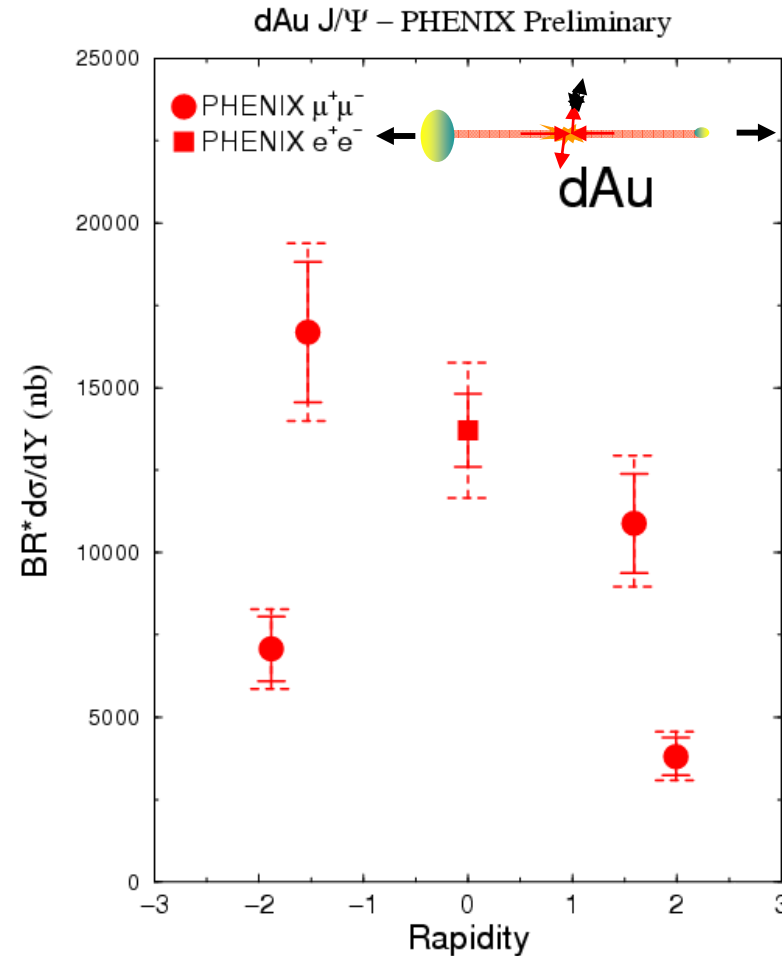
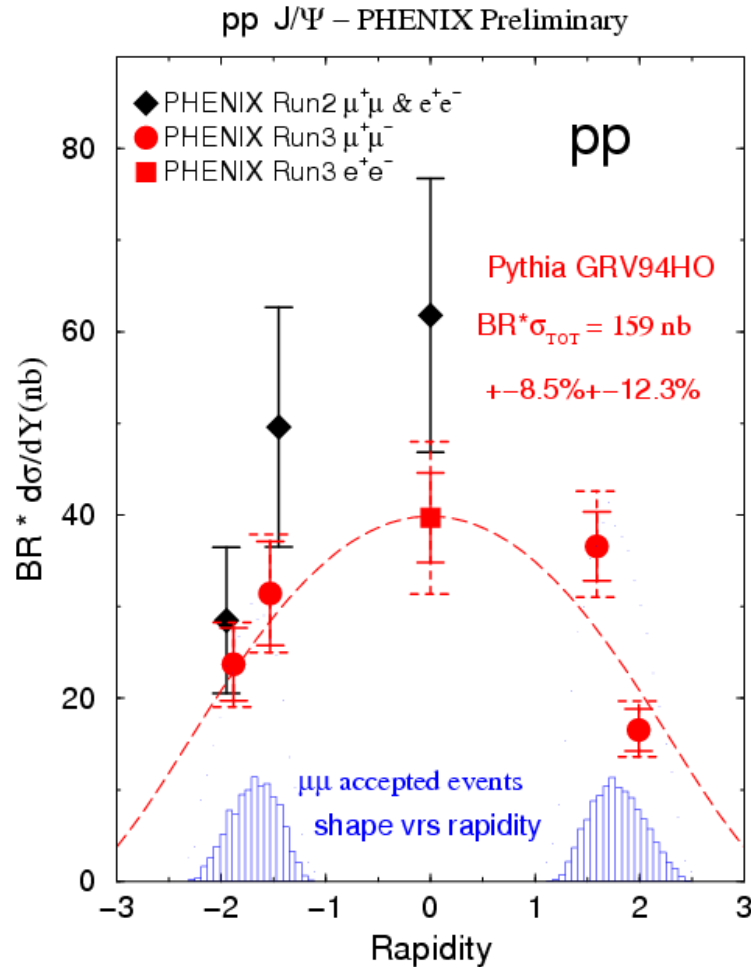


D. Kharzeev & K. Tuchin
hep-ph/0310358



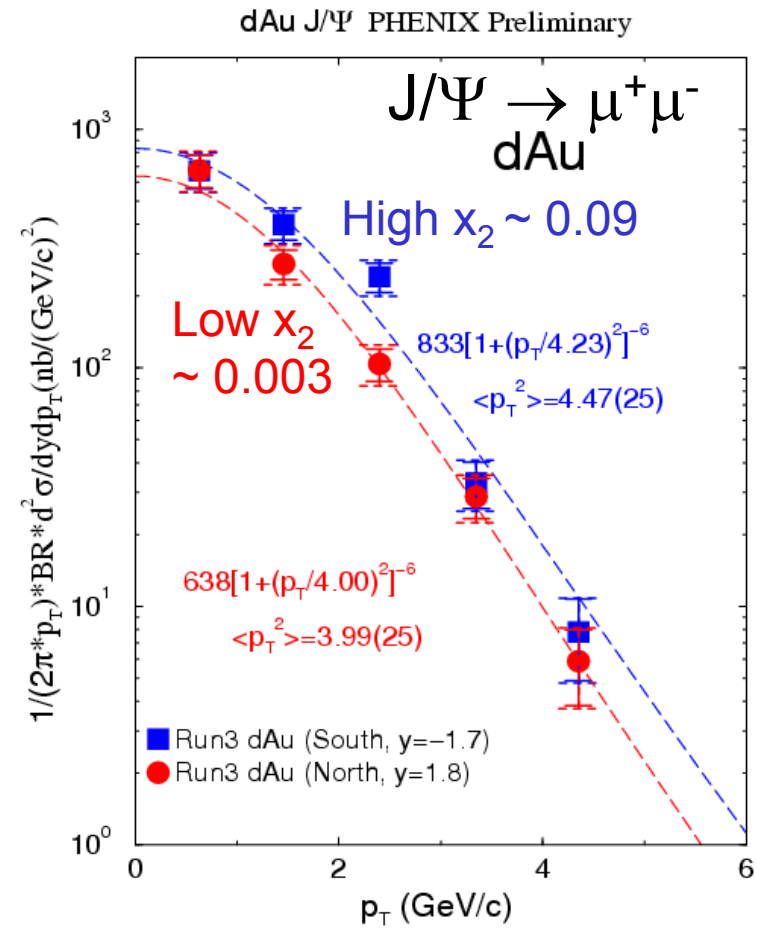
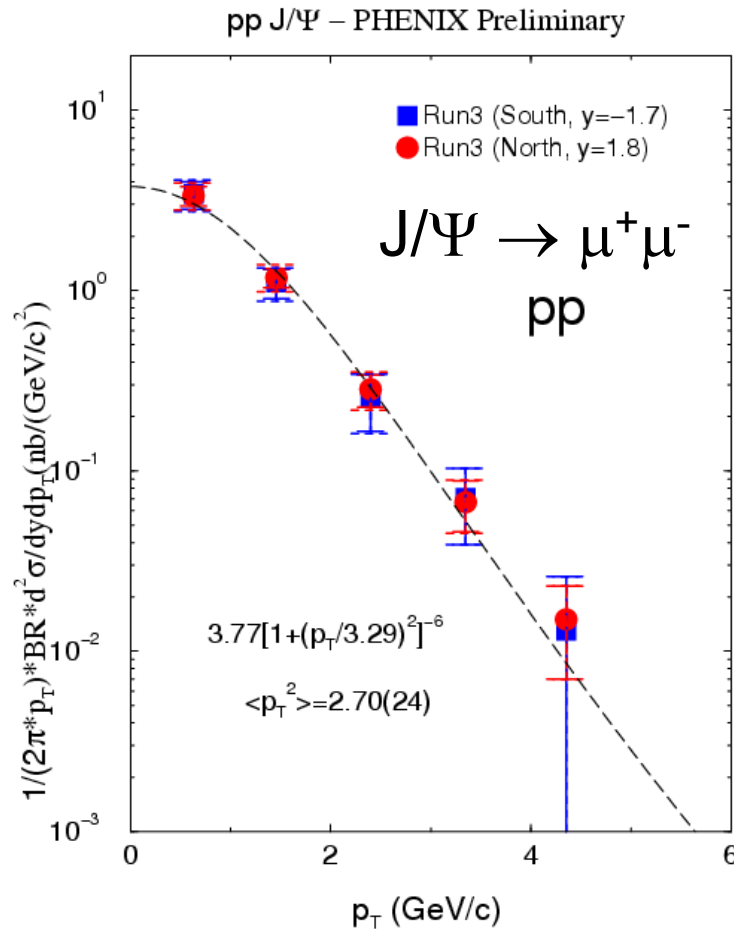
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J/Psi production at RHIC: pp & dAu



$$BR \times \sigma_{pp} = 159 \text{ nb} \pm 8.5 \% (\text{fit}) \pm 12.3\% (\text{abs})$$

p_T Broadening

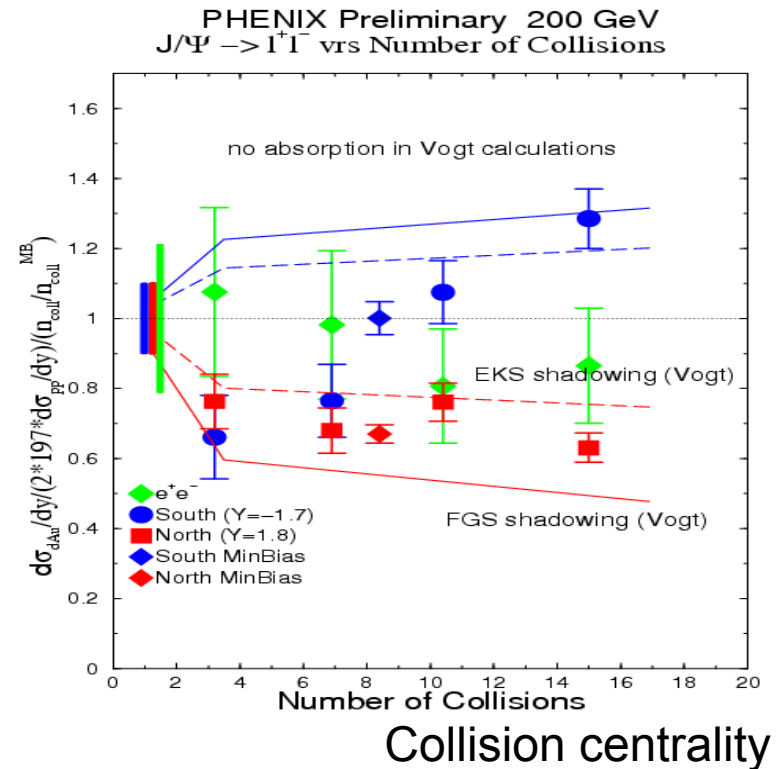
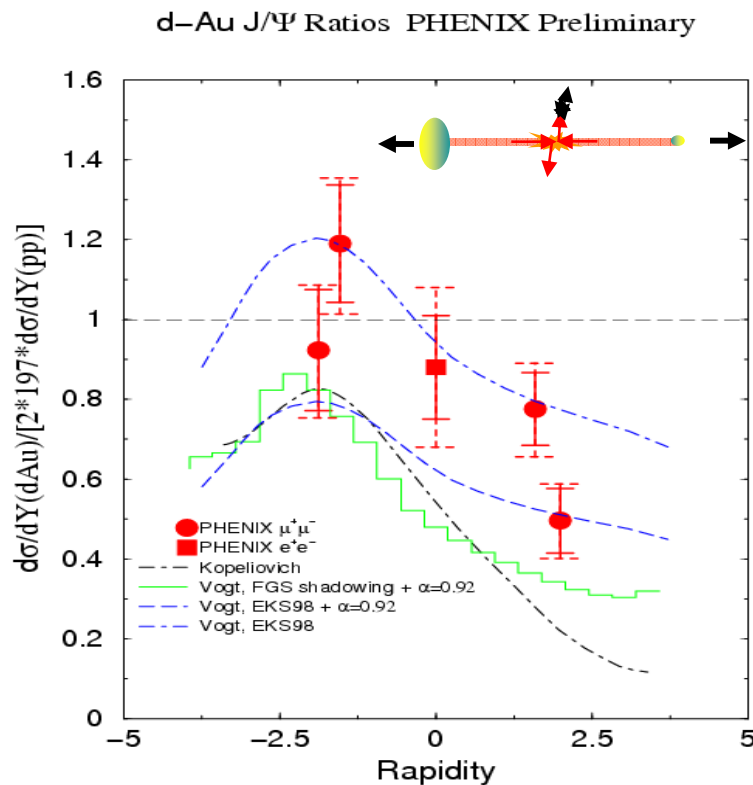


$$\Delta \langle p_T^2 \rangle = \langle p_T^2 \rangle_{\text{dAu}} - \langle p_T^2 \rangle_{\text{pp}} = 1.77 \pm 0.35 \text{ GeV} \text{ (} 1.29 \pm 0.35 \text{ GeV)}$$

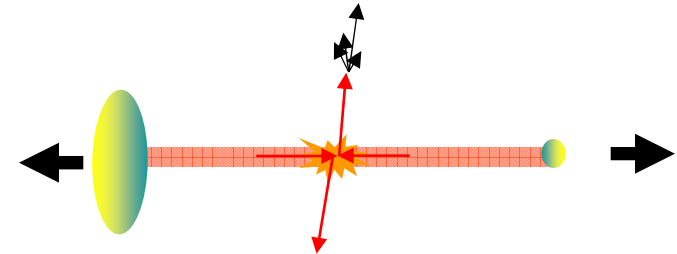
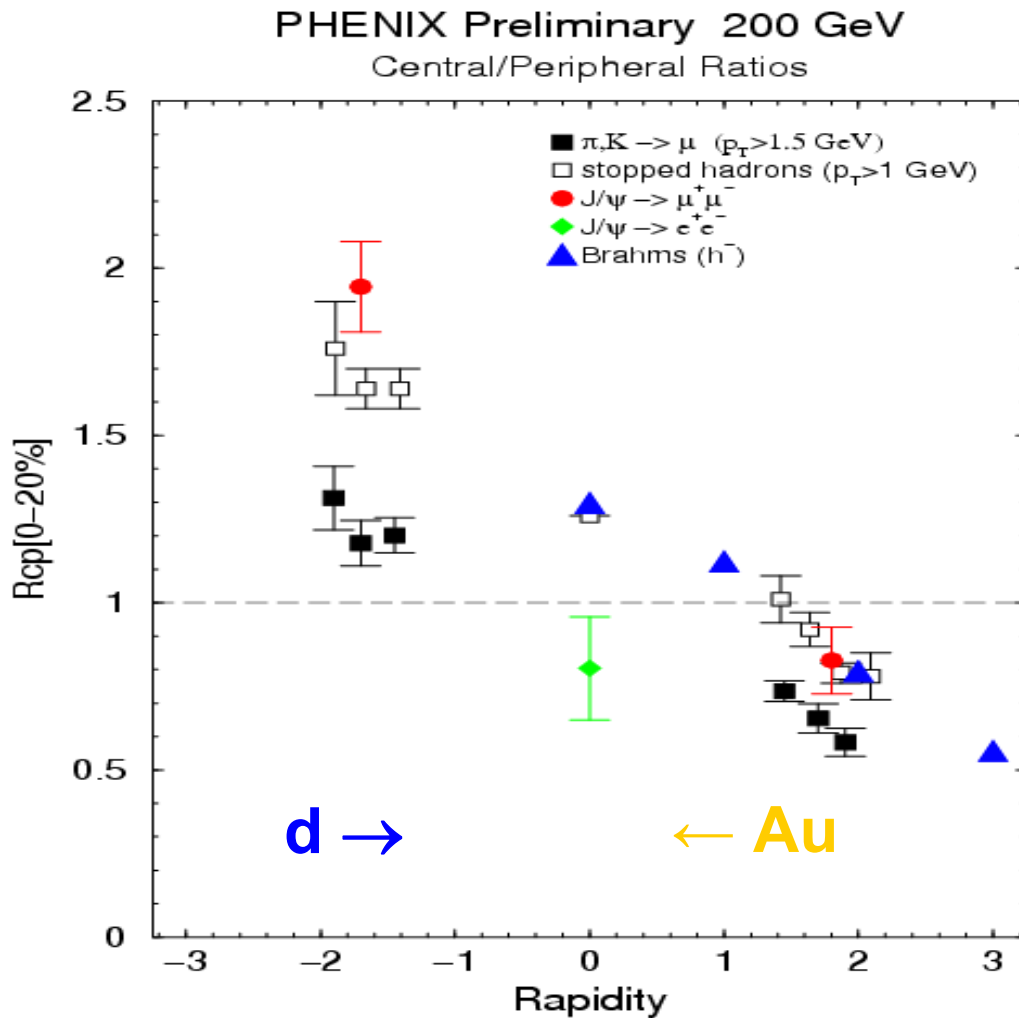
J/Psi @ large rapidity in dAu

- Gluon (anti)shadowing
- Final state interactions

$$R_{dA} = \frac{d^2\sigma^{dA} / dp_T dy}{\langle N_{coll} \rangle d^2\sigma^{pp} / dp_T dy}$$



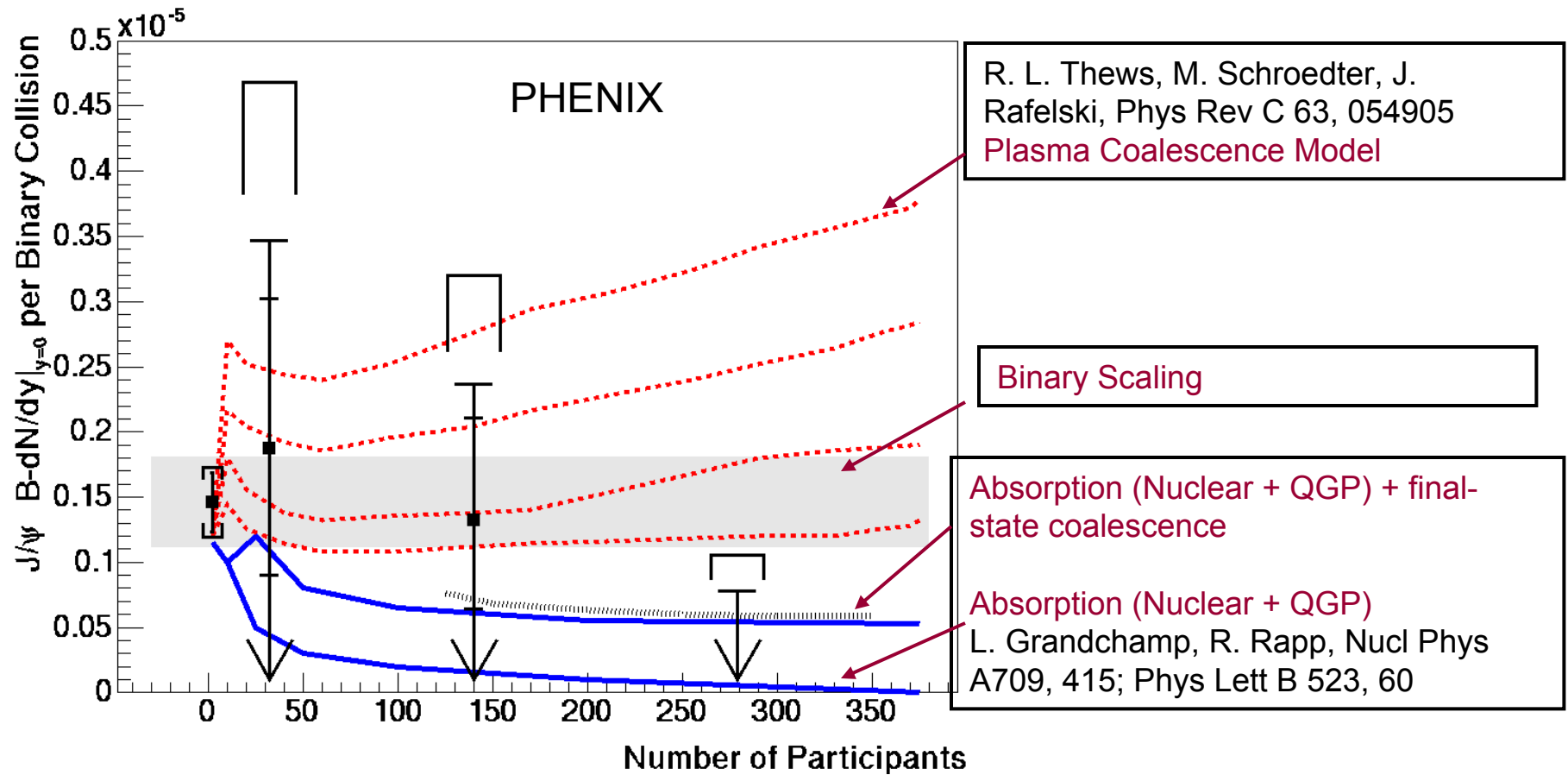
More on Nuclear medium effects



$$R_{CP} = \frac{dN^{central} / dy dp_T / \langle N_{coll} \rangle}{dN^{60-88\%} / dy dp_T / \langle N_{coll} \rangle}$$

(00-20%)/(60-88%)

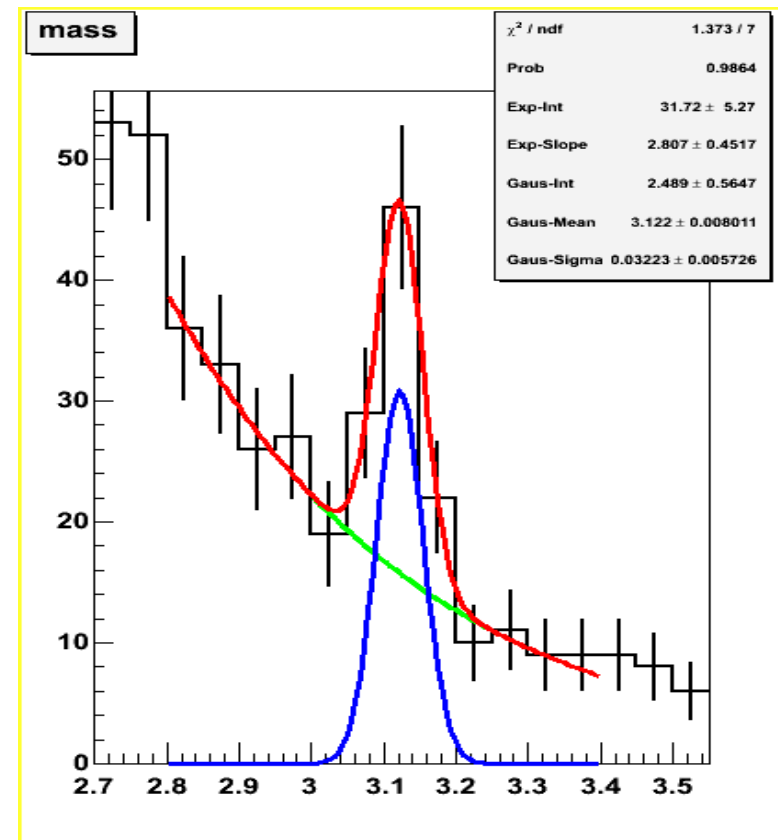
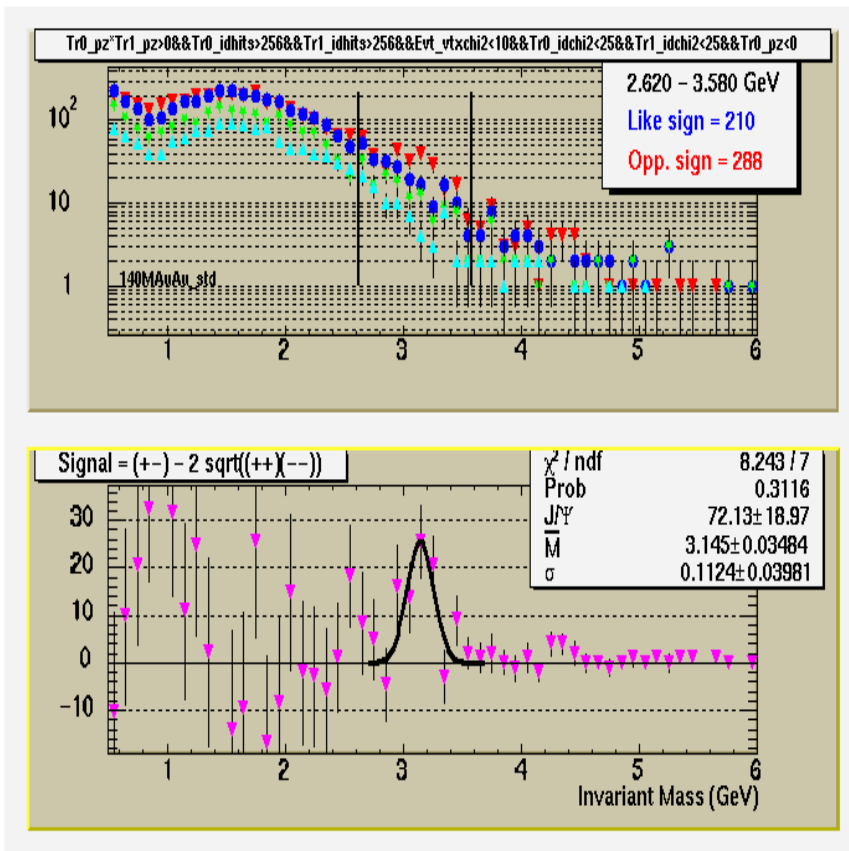
J/Psi in AuAu (2002 Run)



J/Psi from 2004 run (AuAu)

$1.2 < |y| < 2.4: J/\Psi \rightarrow \mu^+ \mu^-$

$|y| < 0.35: J/\Psi \rightarrow e^+ e^-$



Summary and Outlook

- Open charms
 - pp, dAu, AuAu @y=0
 - Follows binary scaling at high Pt
 - Large rapidity – work in progress
- J/Psi
 - pp, dAu, AuAu
 - Observed cold nuclear medium effect
 - Rapidity
 - Centrality
- High statistics AuAu data available soon
 - Open charm and J/Psi
 - Central and forward rapidity

