Quarkonia results from

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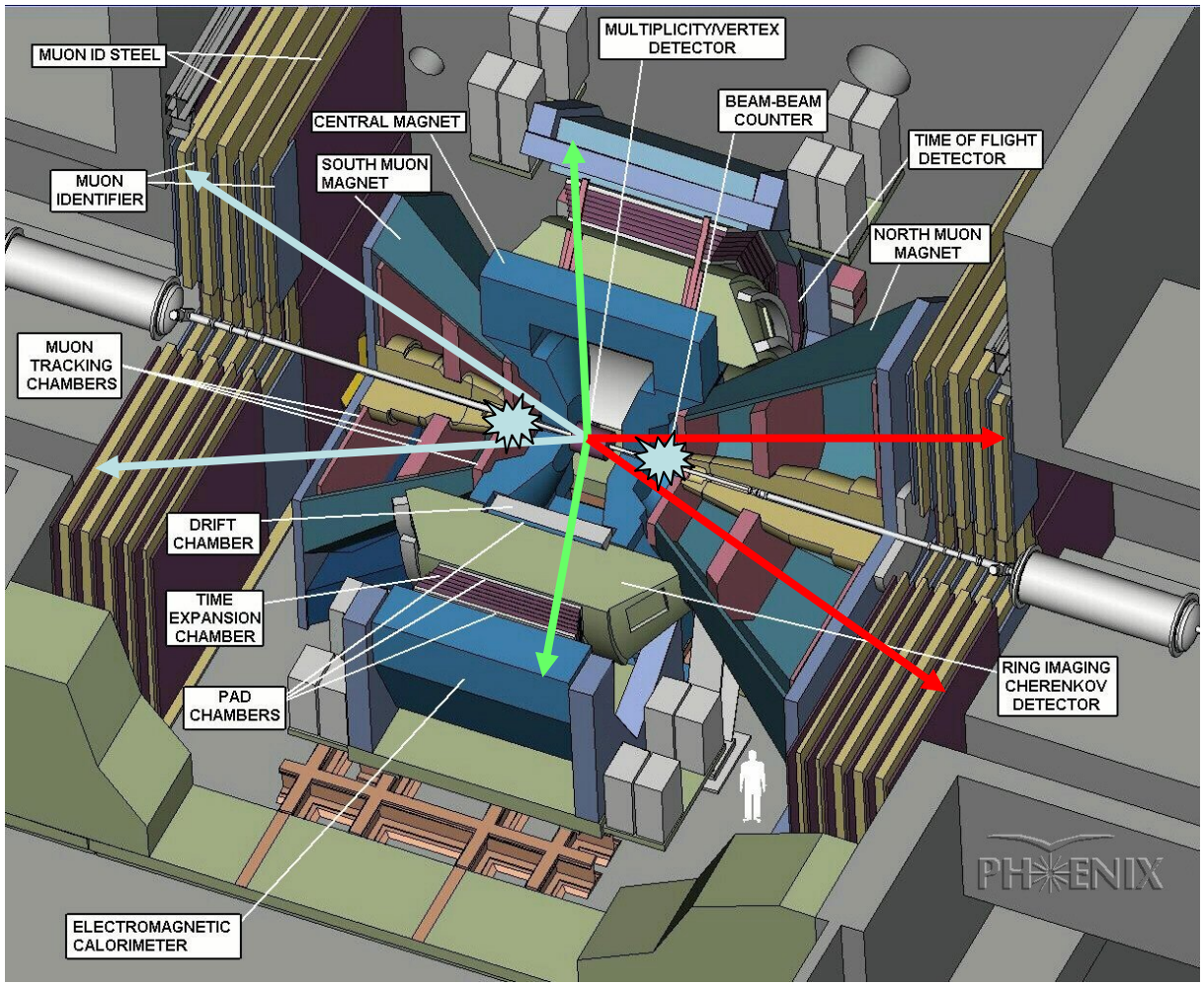
Outline and interests

- J/ψ in proton-proton
  - Production mechanisms, reference for dA, AA
- J/ψ in deuteron-gold
  - Cold nuclear matter effects, reference for AA
- From deuteron-gold to nucleus-nucleus
  - (a personal toy model)
- J/ψ in nucleus-nucleus
  - Deconfined quark gluon plasma ?
  - Still preliminary data from QM05 !
- A flash of other quarkonia in proton-proton

How does PHENIX see the J/ψ ?



$J/\psi \rightarrow e^+e^-$ identified in RICH and EMCal

- $|\eta| < 0.35$
- $p_e > 0.2$ GeV/c

$J/\psi \rightarrow \mu^+\mu^-$ identified in 2 fwd spectrometers

- $1.2 < |\eta| < 2.4$
- $p_\mu > 2$ GeV/c

Centrality and vertex given by BBC in $3<|\eta|<3.9$ and ZDC

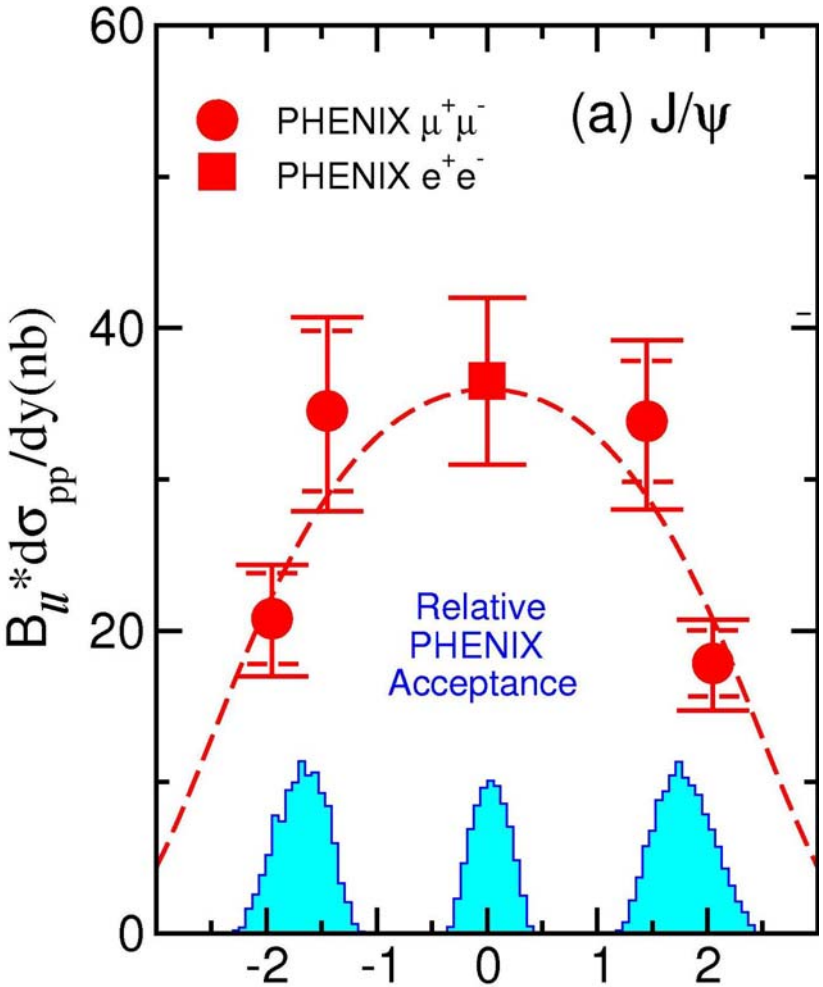
J/ψ in PHENIX

[1] PRL92 (2004) 051802
[2] PRC69 (2004) 014901
[3] PRL96 (2006) 012304
[4] QM05, nucl-ex/0510051

Year	Ions	$\sqrt{s_{NN}}$	Luminosity	Status	J/ψ (ee + μμ)
2000	Au-Au	130 GeV	1 μb^{-1}	Central (electrons)	0
2001	Au-Au	200 GeV	24 μb^{-1}	Central	13 + 0 [1]
2002	p-p	200 GeV	0.15 pb^{-1}	+ 1 muon arm	46 + 66 [2]
2002	d-Au	200 GeV	2.74 nb^{-1}	Central	360 + 1660 [3]
2003	p-p	200 GeV	0.35 pb^{-1}	+ 2 muon arms	130 + 450 [3]
	Au-Au	200 GeV	241 μb^{-1}	preliminary	~ 1000 + 5000 [4]
2004	Au-Au	63 GeV	9 μb^{-1}	analysis	~ 13
	p-p	200 GeV	350 nb^{-1}		
	Cu-Cu	200 GeV	3 nb^{-1}	preliminary	~ 1000 + 10000 [4]
2005	Cu-Cu	63 GeV	190 mb^{-1}	analysis	~ 10 + 200
	p-p	200 GeV	3.8 pb^{-1}		~ 1500 + 10000
2006	p-p	200 GeV	10.7 pb^{-1}	Analysis…	> 2000 + 27000

J/ψ in proton-proton

Cross section vs rapidity



Total cross section

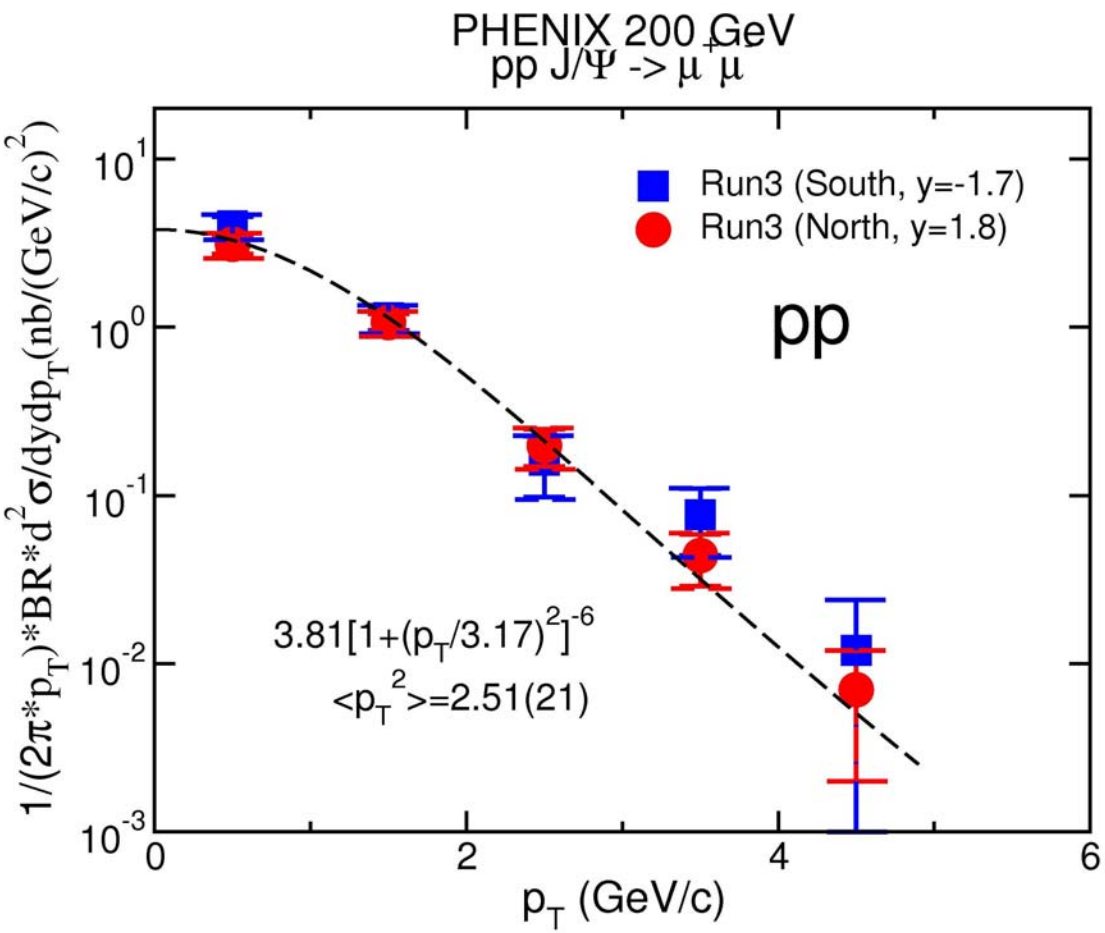
σ (pp $\rightarrow$ J/ψ)

2.61 ± 0.20 ± 0.26 μb

- Error from fit (incl. syst and stat)
- Error on absolute normalization

PHENIX, PRL96 (2006) 012304

Cross section versus p_T



Fit the function

$$\frac{A}{(1+(p_T/B)^2)^6}$$

$\langle p_T^2 \rangle = 2.51 \pm 0.21$ @ y=1.7

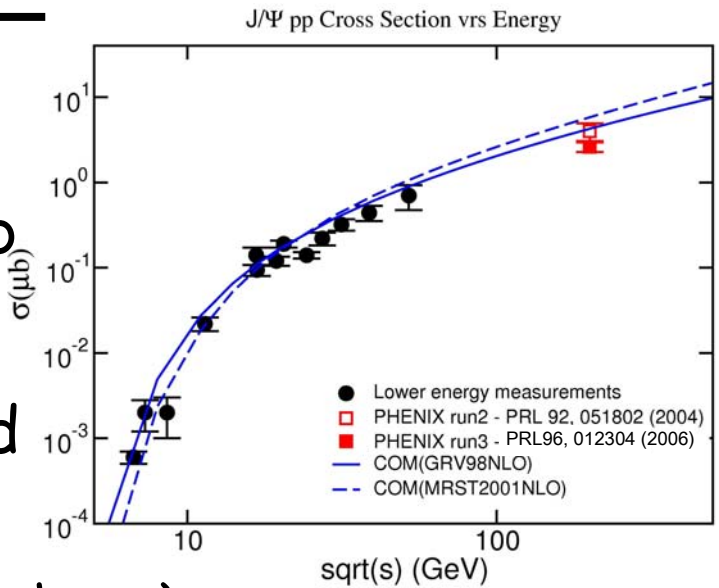
$\langle p_T^2 \rangle = 4.31 \pm 0.85$ @ y=0

[in $(GeV/c)^2$]

PHENIX, PRL96 (2006) 012304

p+p perspectives

- Production mechanism
  - Color Octet Model does the job
- In AA (or dA) we have
  - Large combinatorial background
  - Low physics backgrounds
    - (Drell-Yan or dileptons from open charm)
- Run 3 p+p is our baseline
  - Nuclear modification factor
- Run 5 & 6 pp analyses going on
  - Much more statistics, 40 times the luminosity !

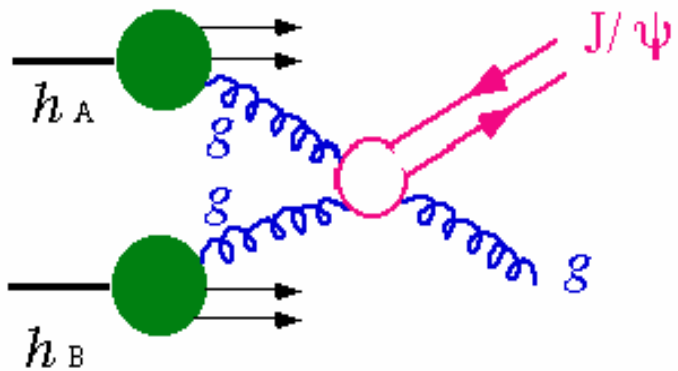


$$R_{AB} = \frac{N_{\psi}^{AB}}{N_{\psi}^{PP} \times \langle N_{coll} \rangle}$$

J/ψ in deuteron-gold

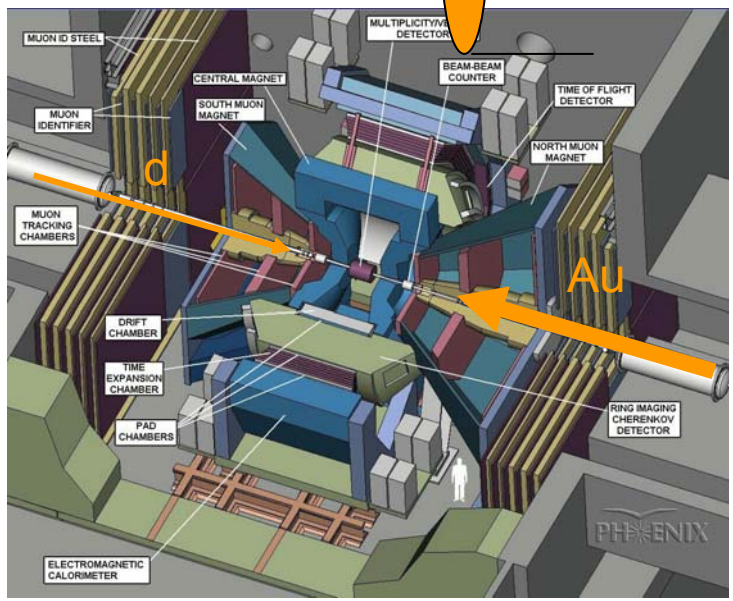
d+Au physics motivation

- Goal: disentangle normal "cold" nuclear effects
  - Antishadowing & Shadowing (gluon saturation, color glass ?)
  - Energy loss of initial parton
  - p_T broadening (Cronin effect)
  - J/ψ (or $c\bar{c}$) absorption
  - Something else ?
- Tools: d+Au collisions
  - over a broad range of p_T, rapidity and centrality
- Interests:
  - Intrinsically probes interesting nuclear effects
  - Baseline for Au+Au: Why do J/ψ disappear / appear ?



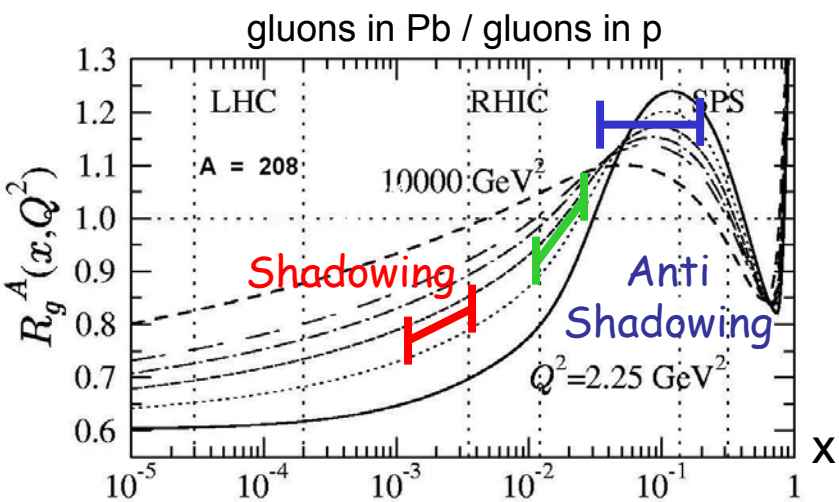
Deuteron → ← Gold

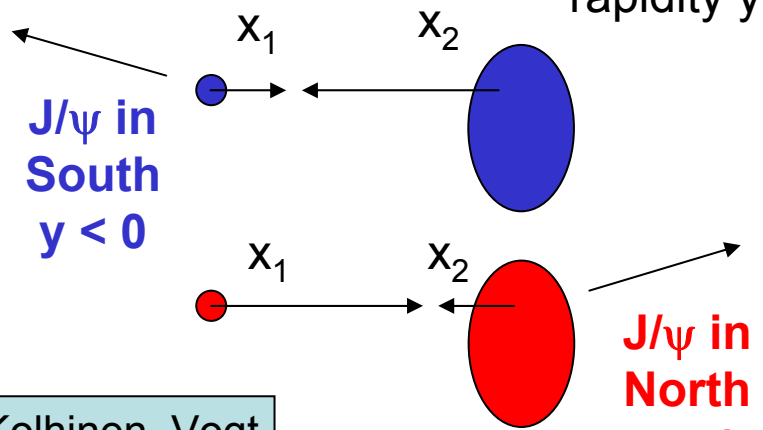
- In PHENIX, J/ψ mostly produced by gluon fusion, and thus sensitive to gluon pdf
- Three rapidity ranges probe different momentum fraction of Au partons
  - South (y < -1.2) : large x_2 (in gold) ~ 0.090
  - Central (y ~ 0) : intermediate x_2 ~ 0.020
  - North (y > 1.2) : small x_2 (in gold) ~ 0.003



rapidity y

An example of gluon shadowing prediction

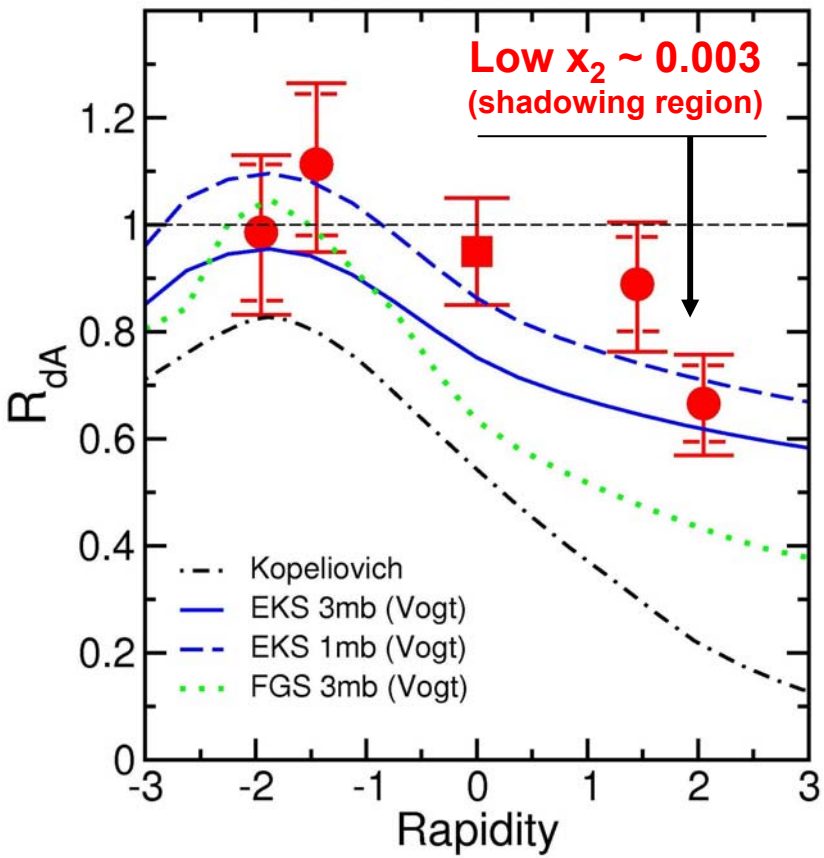




Eskola, Kolhinen, Vogt NPA696 (2001) 729

R_{dAu} versus rapidity

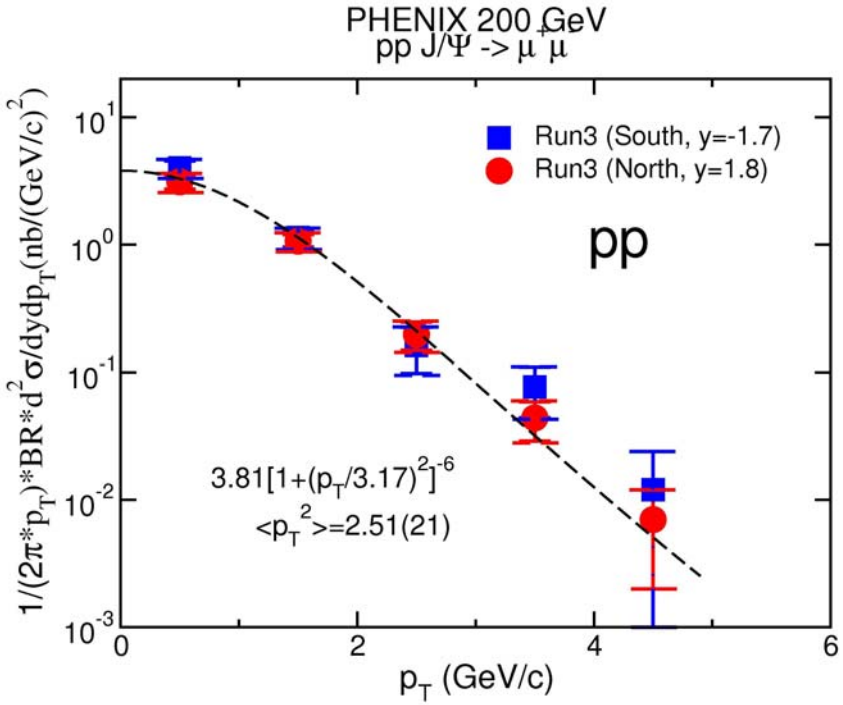
R_{dA}

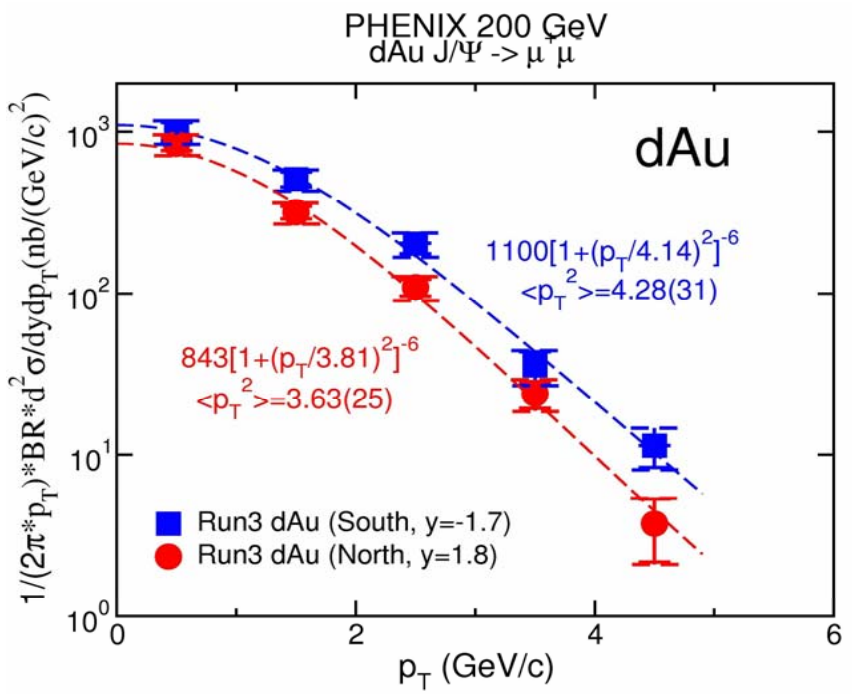


- Data favours
  - (weak) shadowing
    Eskola, Kolhinen, Salgado prescription matches better
  - (weak) absorption
    σ_{abs} ~ 1 to 3 mb
- But with limited statistics difficult to disentangle nuclear effects !

PHENIX, PRL96 (2006) 012304
Klein,Vogt, PRL91 (2003) 142301
Kopeliovich, NPA696 (2001) 669

Cross section versus p_T





$\Delta\langle p_T^2\rangle = \langle p_T^2\rangle_{dAu} - \langle p_T^2\rangle_{pp}$

Backward: 1.77 ± 0.37 $(GeV/c)^2$

Mid: [-1.28 ± 0.94 $(GeV/c)^2$]

Forward: 1.12 ± 0.35 $(GeV/c)^2$

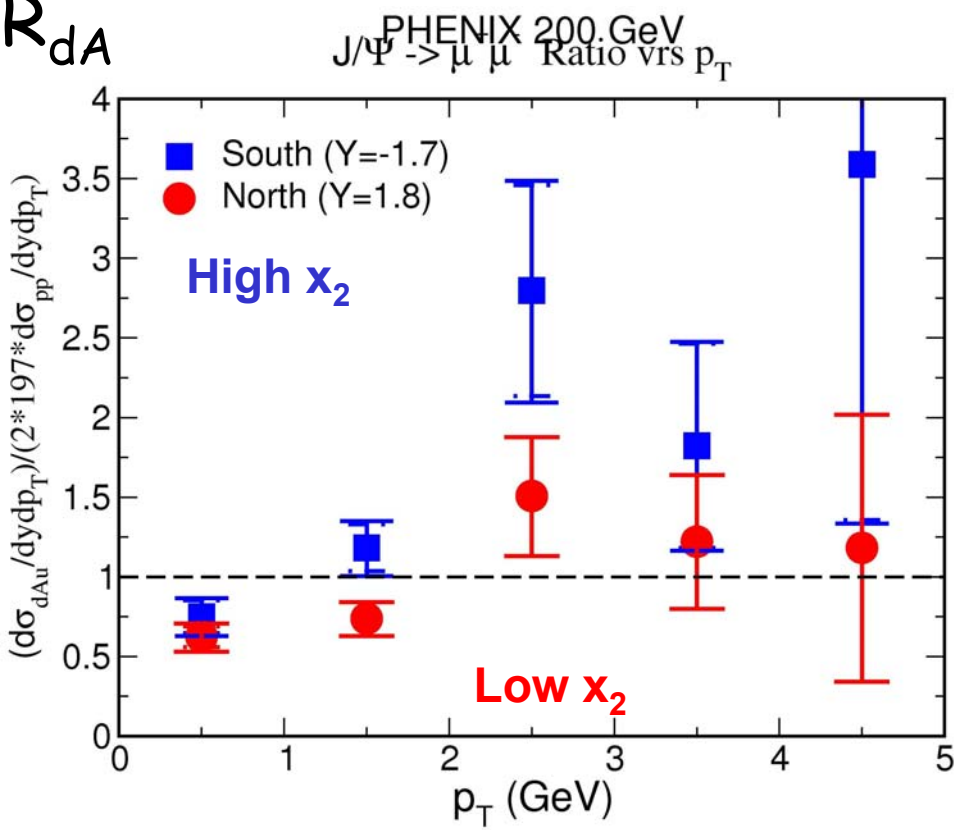
PHENIX, PRL96 (2006) 012304

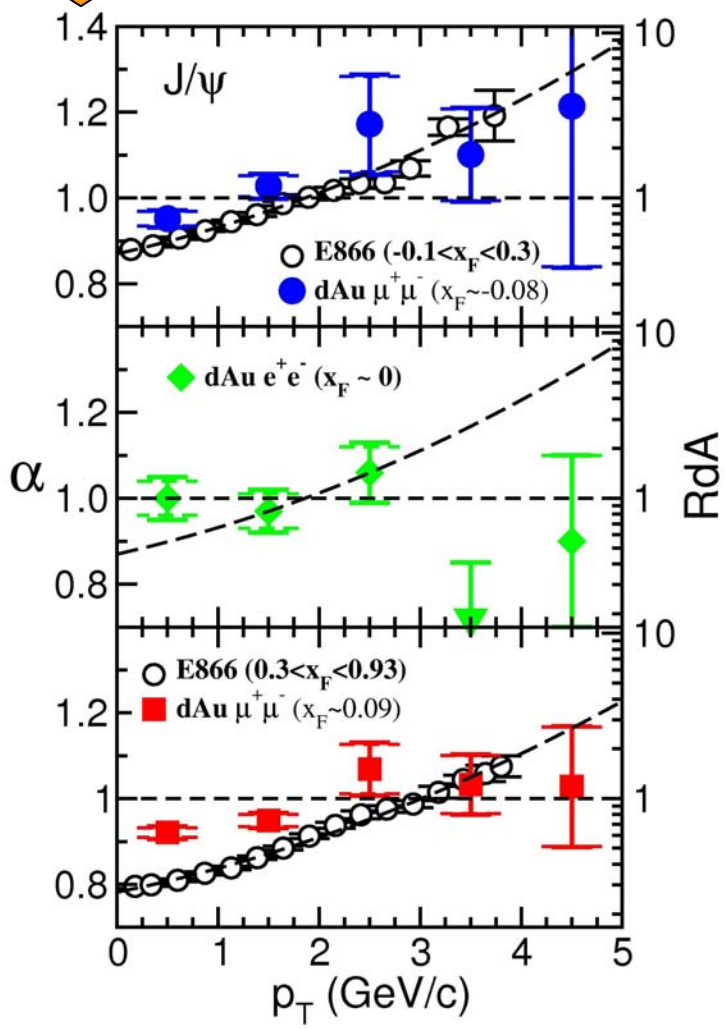
Some p_T broadening

R_{dAu} versus p_T

$$\sigma_{dA} = \sigma_{pp}(2\times197)^{\alpha}$$

R_{dA}



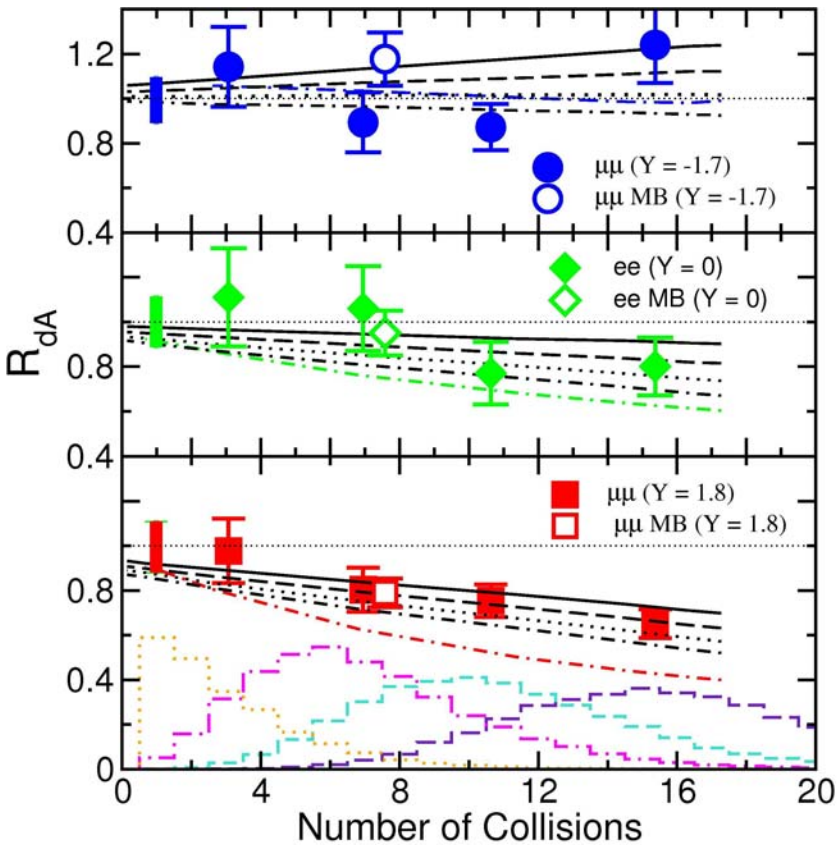


Broadening comparable to lower energy ($\sqrt{s}$ = 39 GeV in E866)

R_{dAu} versus N_{coll}

R_{dA}

High x_2 ~ 0.09



Low x_2 ~ 0.003

This is the first J/ψ centrality dependence measurement in dA (or pA) !

- Black lines:
  - EKS98 from 0 to 3 mb
- Coloured lines:
  - FGS for 3 mb
- Slopes consistent with shadowing models
  - Especially @ low x_2 !

PHENIX, PRL96 (2006) 012304

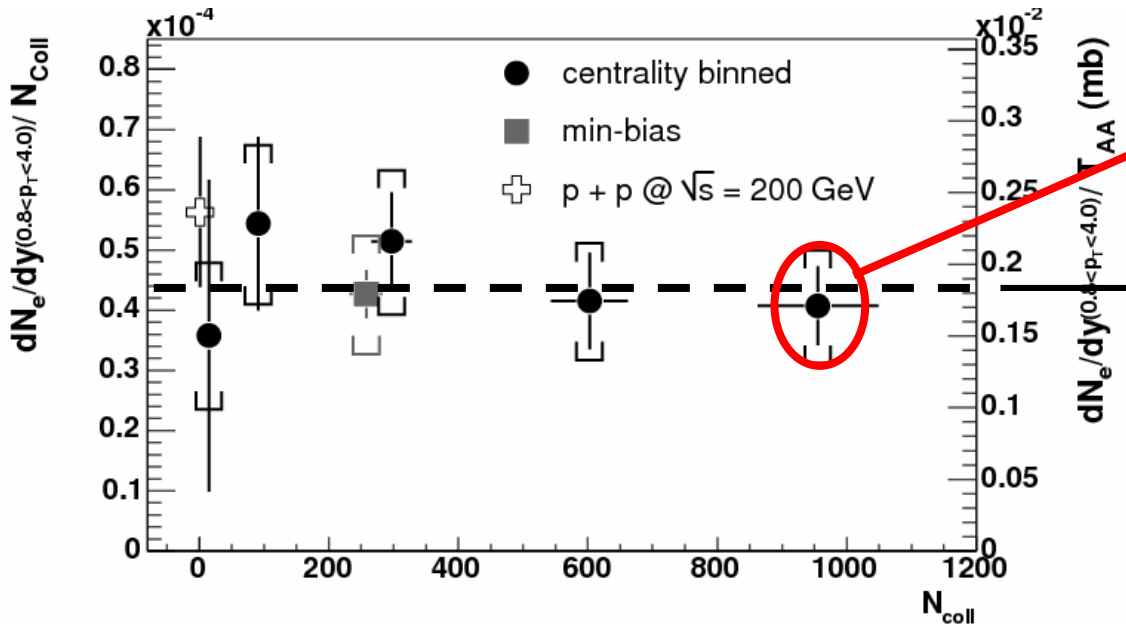
d+Au perspectives

- We have seen small nuclear effects !
  - Weak shadowing / antishadowing
  - Weak absorption (~ 1 to 3 mb)
  - p_T broadening similar to lower energies
- Difficult to disentangle given statistics
  - Need more luminosity !
- But, no large nuclear effect !
  - Good news to see J/ψ modification in Au-Au !

J/ψ in nucleus-nucleus (phenix preliminary)

Quick look to open charm

- Through semileptonic decays (D → e)



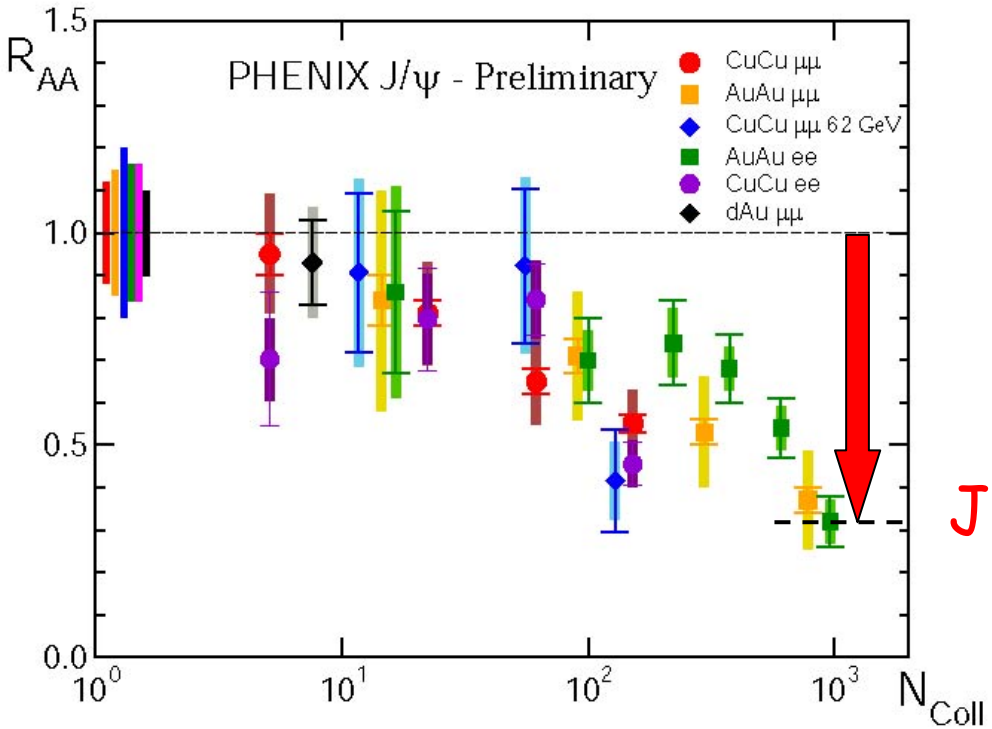
10 to 20 $c\bar{c}$ pairs !
(→ 40 acc. STAR)

N_{coll} scaling

PHENIX, PRL94 (2005) 082301

~25% systematic uncertainties (without Silicon vertex detector upgrade)

R_{AA} versus N_{coll}



J/ψ → μμ
Muon arm
1.2 < |y| < 2.2

J/ψ → ee
Central arm
–0.35 < y < 0.35

J/ψ suppressed by a factor of ~3 !

dAu μμ 200 GeV/c	AuAu μμ 200 GeV/c	CuCu μμ 200 GeV/c	AuAu ee 200 GeV/c	CuCu ee 200 GeV/c	CuCu μμ 62 GeV/c

Hugo Pereira da Costa, for PHENIX, QM05, nucl-ex/0510051

Opening parenthesis from dA to AA

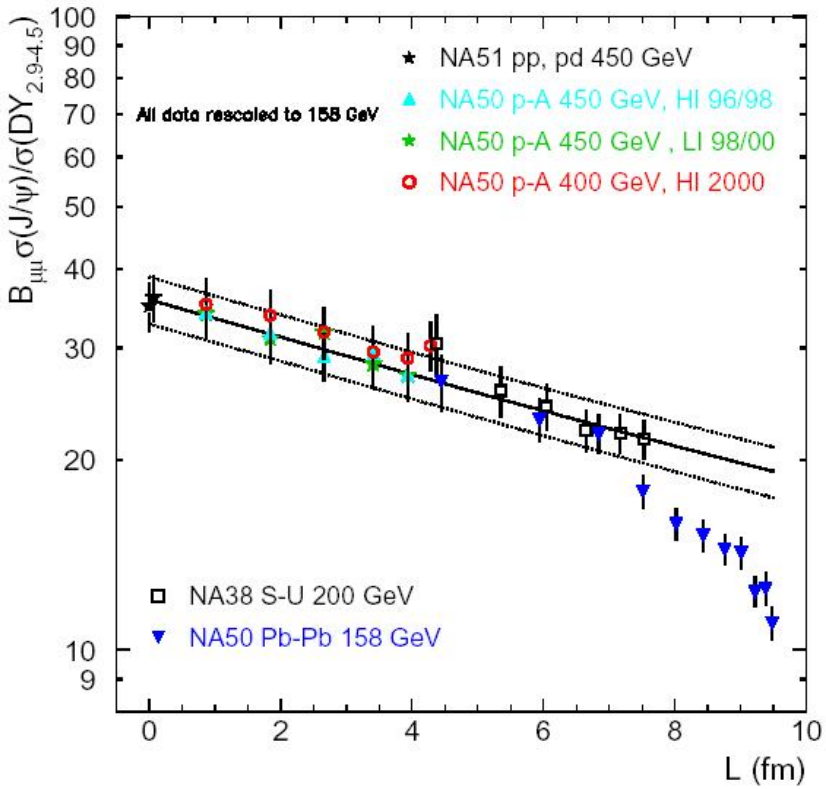
How is it done @ SPS ?

- Normal nuclear absorption does a splendid job in describing pA, SU, peripheral Pb-Pb…
- $\exp(-\sigma_{abs}\, \rho^{\circ}\, L)$ with

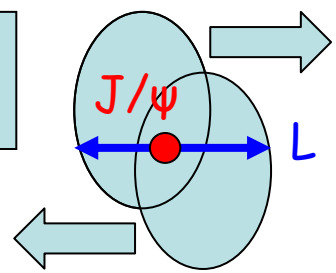
L nuclear thickness &

σ_{abs} = 4,18 ± 0,35 mb

- (or sophisticated Glauber model)
- No need/care for (anti)shadowing



NA50, EPJ C39 (2005) 335
See Carlos & Marzia talks !



From dA to AA @ RHIC

What is on the market ?

First, the dA data are poor…

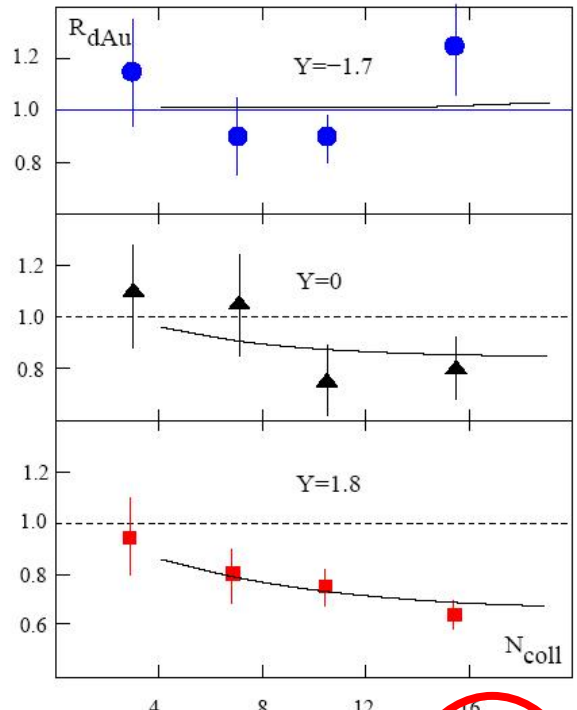
1. A model of nuclear absorption + (anti)shadowing

   (Ramona Vogt, nucl-th/0507027)

2. σ_{diss} from fits on dA data →
   - exp $-(\sigma_{diss}(y)+\sigma_{diss}(-y))n_0 L$
   - But shadowing doesn't go like L…

   (Karsch, Kharzeev & Satz)

3. My own toy model
   - (next 3 slides)



$$\sigma_{diss}(y = 1.8) = 3.1 \pm 0.2 \text{ mb}$$

$$\sigma_{diss}(y = 0) = 1.2 \pm 0.4 \text{ mb}$$

$$\sigma_{diss}(y = -1.7) = -0.1 \pm 0.2 \text{ mb}$$

KKS, PLB637(2006)75

(These errors must be underestimated)

My own toy model (1/3)

- Data driven, as much as possible…
- Phenomenological fit to $R_{dA}(b) \rightarrow$
- Plug this in AuAu Glauber model:

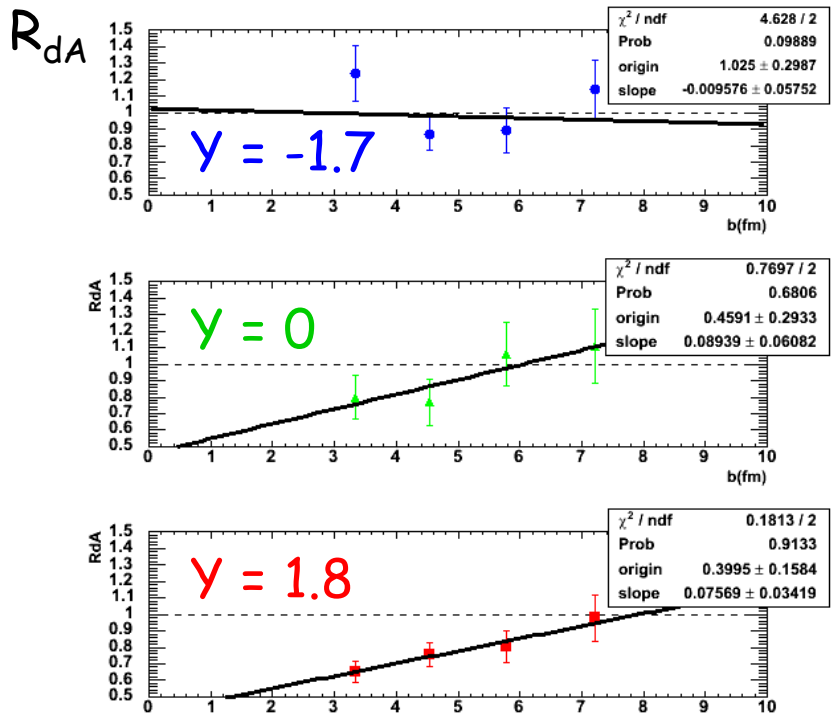
$R_{AA}(y,b_{AA}) = \Sigma_{collisions}$

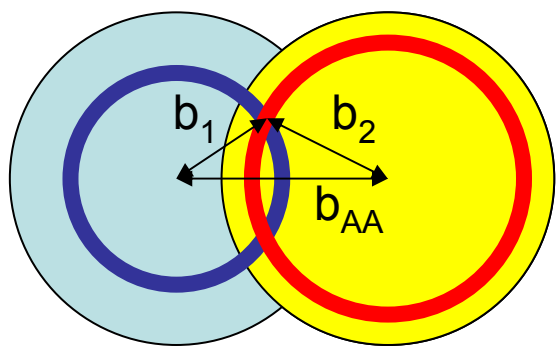
$[\ R_{dA}(-y,b_1) \times R_{dA}\ (y,b_2)\ ]$

- Works for absorption & shadowing since: production ~

pdf1 x pdf2 x exp $-n\sigma(L_1+L_2)$

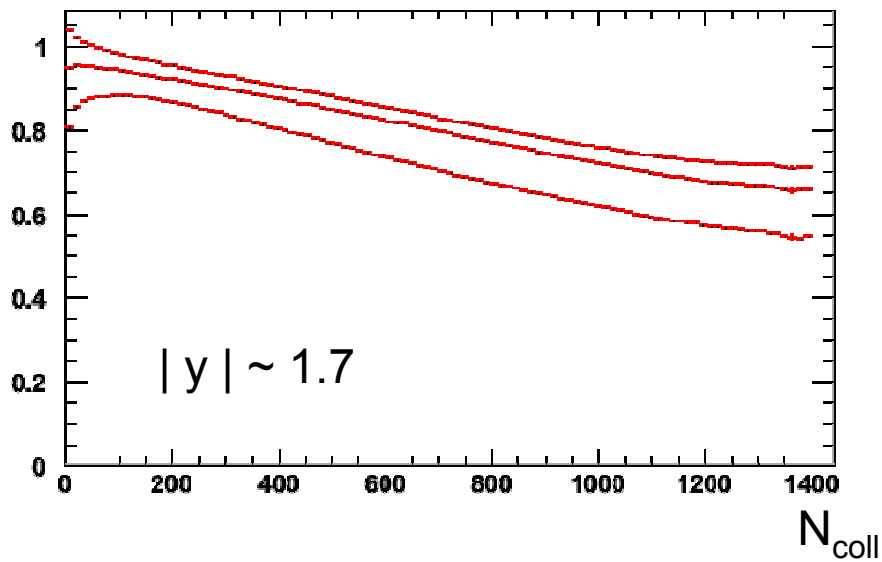
RGdC, Hard Probes 2006



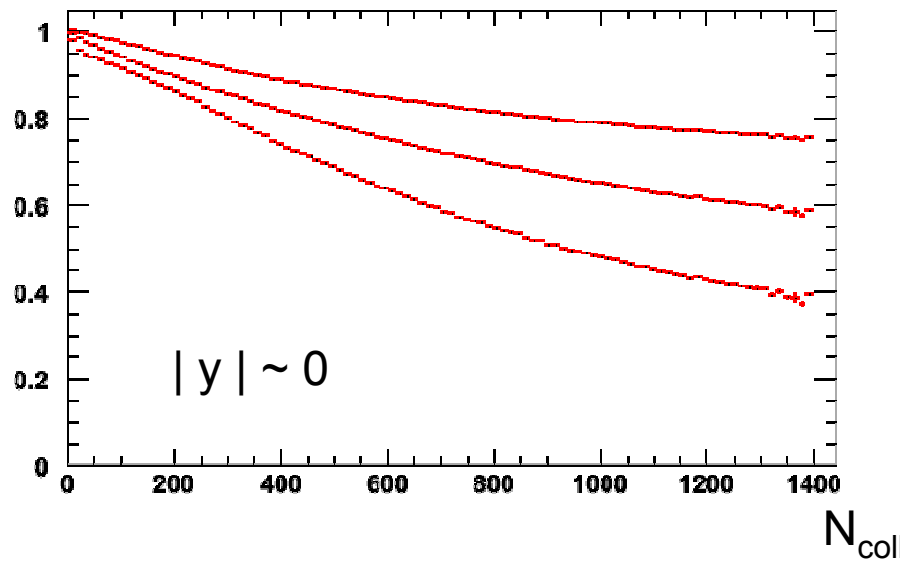


My own toy model (2/3)

Cold nuclear matter R_{AA}



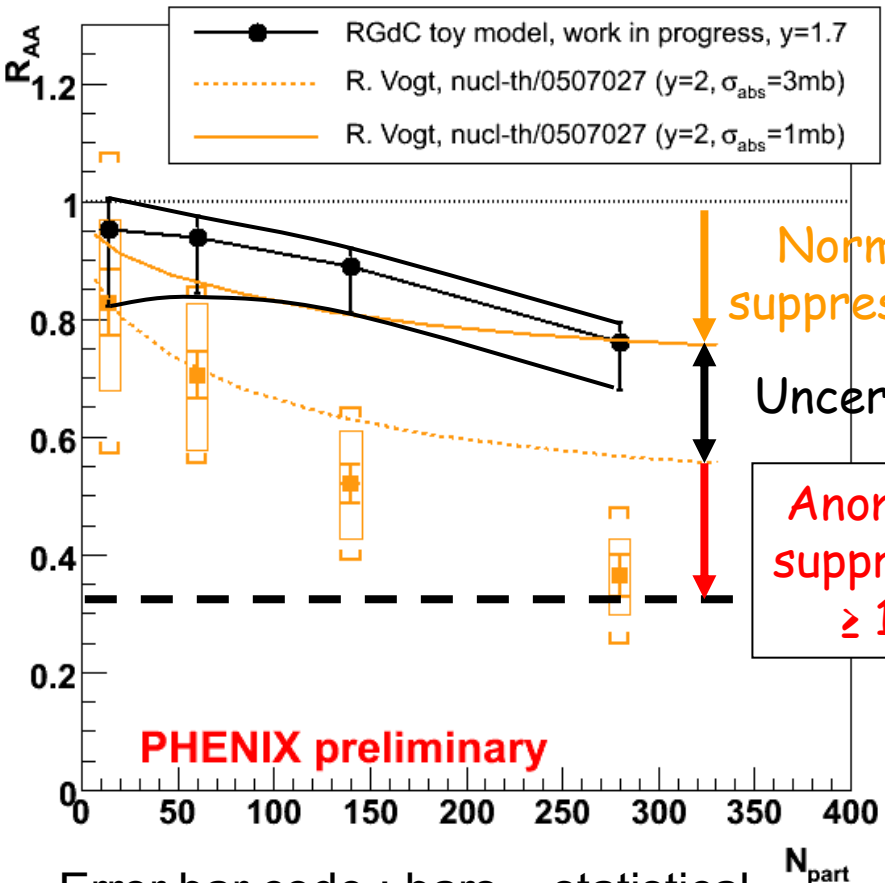
Cold nuclear matter R_{AA}

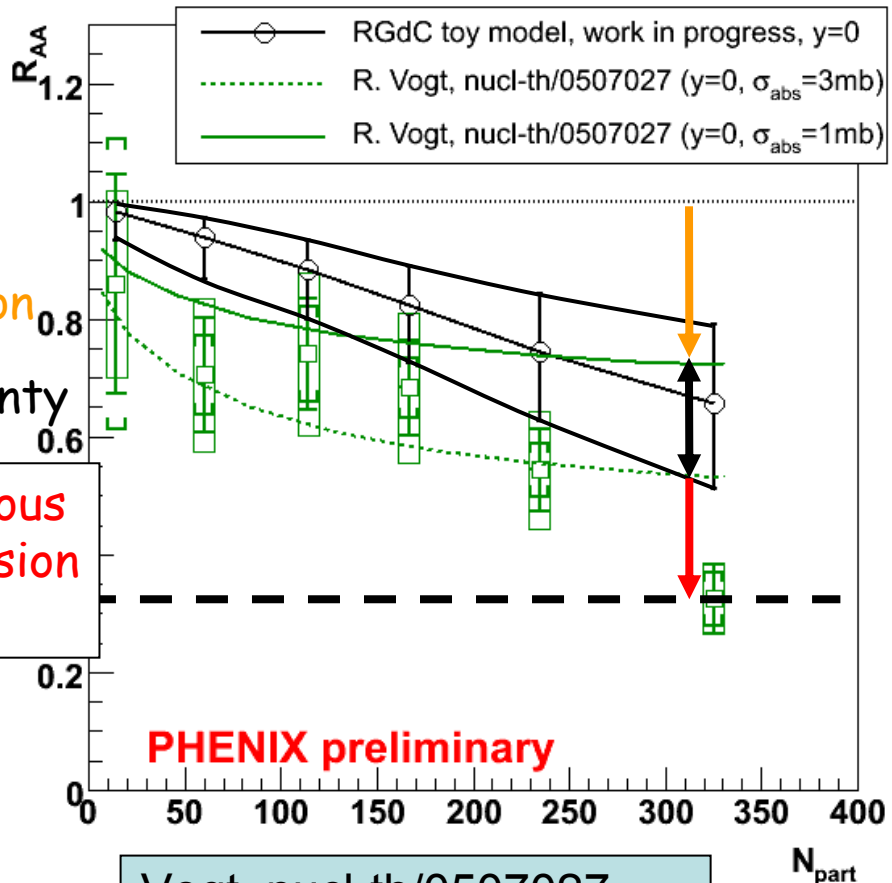


- Bands are statistical and systematic errors from dAu
- No systematics from the method itself (work in progress)
- Then, I take the average on AuAu centrality classes to compare to data…

My own toy model (3/3)

Comparison to Ramona's model and AuAu data…





Error bar code : bars = statistical, bracket = systematic, box : global.

Vogt, nucl-th/0507027
RGdC, Hard Probes 2006

Closing parenthesis
Back to (preliminary) AA

"NA50 only" effects

- Cold effects + …

——— Comovers (hadrons or partons?)

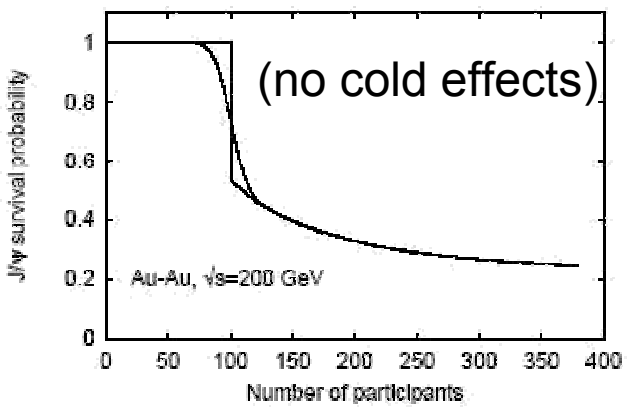
- - - - - Kinetic model ($J/\psi \rightarrow c\,\bar{c}$)

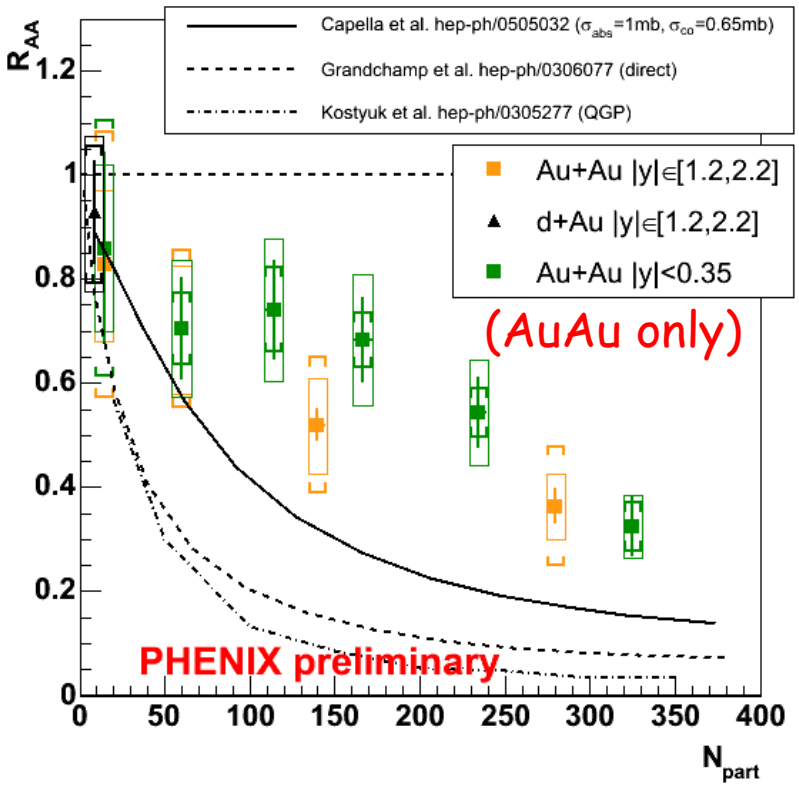
-·-·-·- Thermal plasma

All overestimate suppression !

So does parton percolation (↓)

- Onset at $N_{part} \sim 90$
- Simultaneous $J/\psi + \chi_c + \psi'$





↑ Capella, Ferreiro, EPJC42 (2005) 419
Grandchamp et al, PRL92 (2004) 212301
Kotstyuk et al, PRC68 (2003) 041902
← Digal, Fortuno, Satz, EPJC32 (2004) 547
+ Private communications +

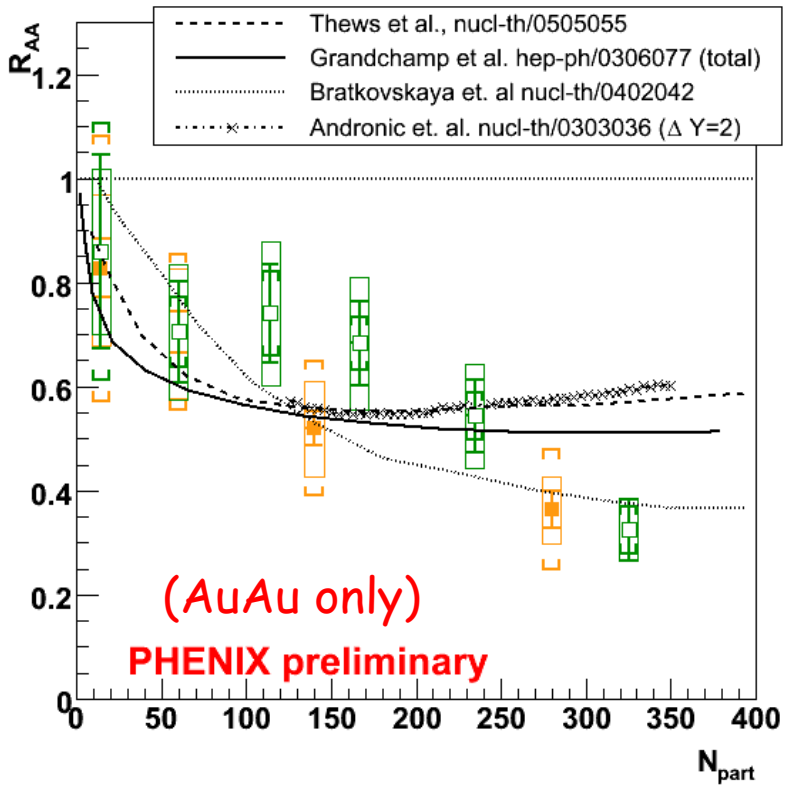
Is something new affecting J/ψ @ RHIC energies ?

(I will answer "yes" once and "no" twice)

1st. Recombination ?

A variety of recombination & coalescence models can accommodate the suppression… $c\bar{c} \rightarrow J/\psi$

" *But early results suggest some competing mechanism, such as reformation of J/ψ particles, may occur at these densities.* " Riordan & Zajc, Scientific American



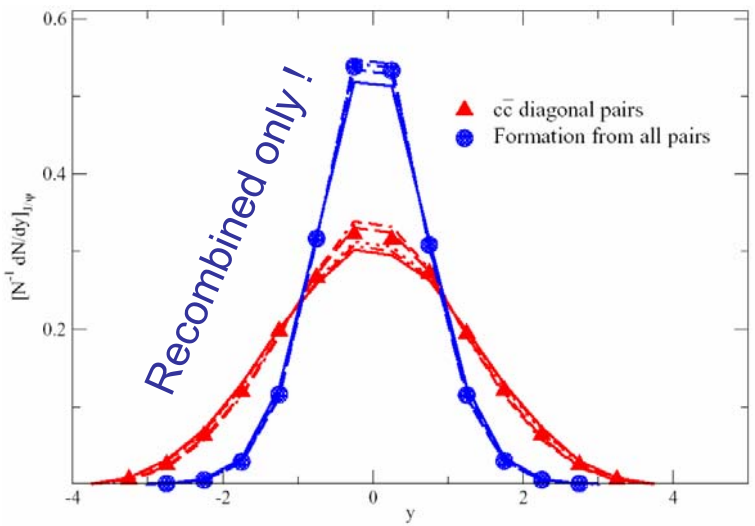
Amount of regeneration not precisely know (open charm ? phase space ?)

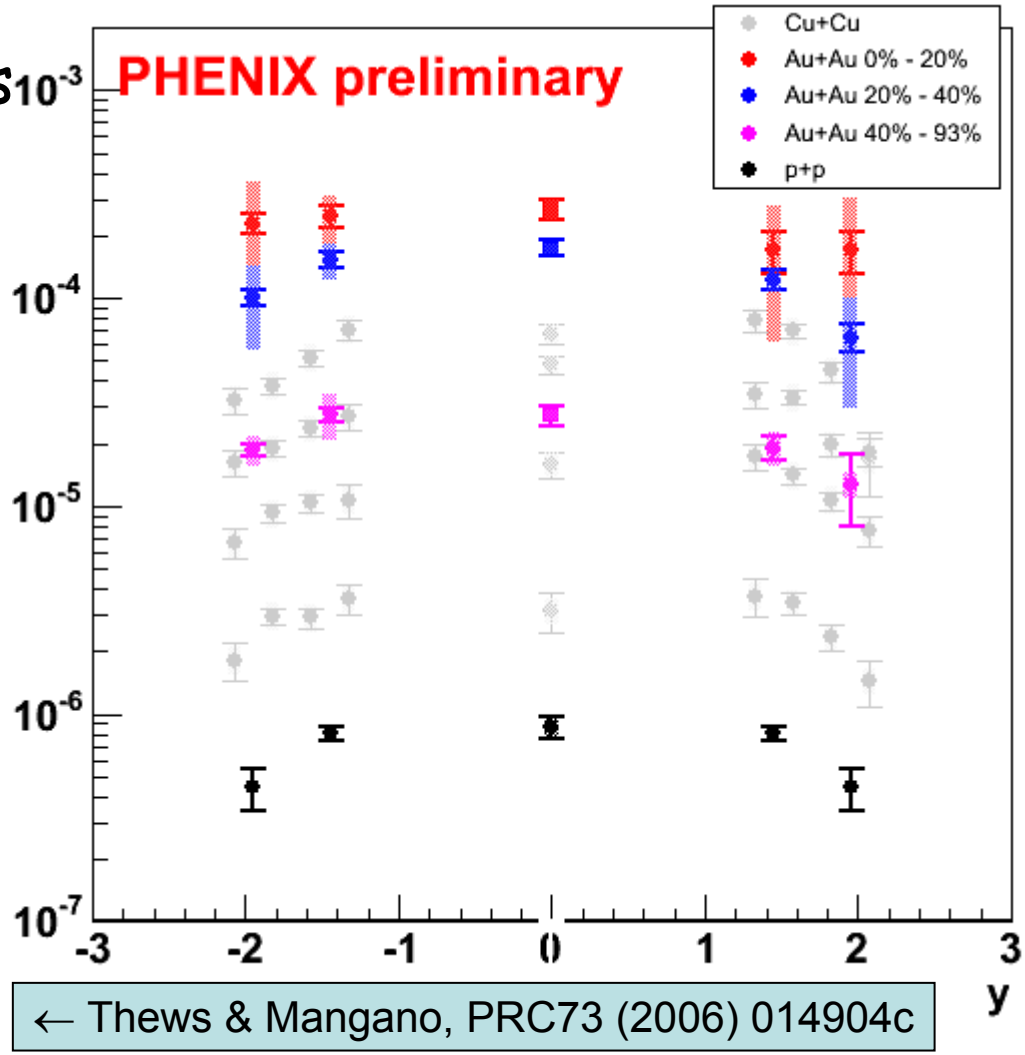
To know more, look at y, p_T…

Grandchamp et al, PRL92 (2004) 212301
Bratkoskaya et al, PRC69 (2004) 054903
Andronic et al, PLB571 (2003) 36
Thews & Mangano, PRC73 (2006) 014904c
+ Private communications +
See Also David and Anton's talk yesterday

y shape (vs recombination)

- Recombination emphasizes quark y-distribution
- Quark (open charm) y-distribution unknown
- No significant change in rapidity in data…



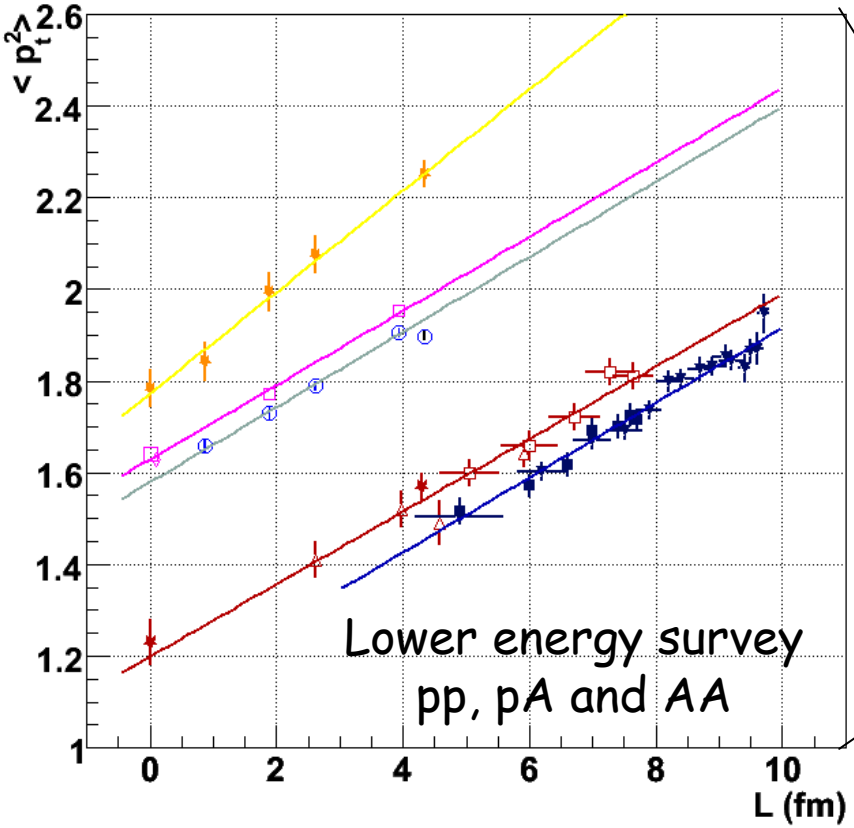


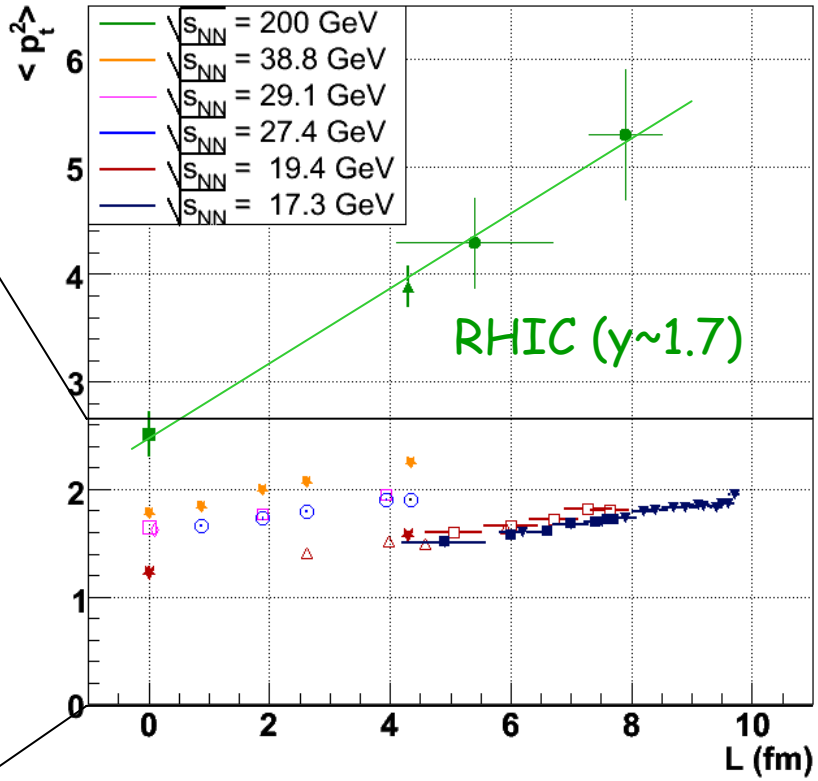
← Thews & Mangano, PRC73 (2006) 014904c

$\langle p_T^2 \rangle$ (vs Cronin effect)

$\langle p_T^2 \rangle_{AB} = \langle p_T^2 \rangle_{pp} + \rho\, \sigma\, \Delta p_T^2 \times L$ [nuclear matter thickness]

(random walk of initial gluons)





VN Tram, Moriond 2006 & PhD thesis

Cronin versus recombination

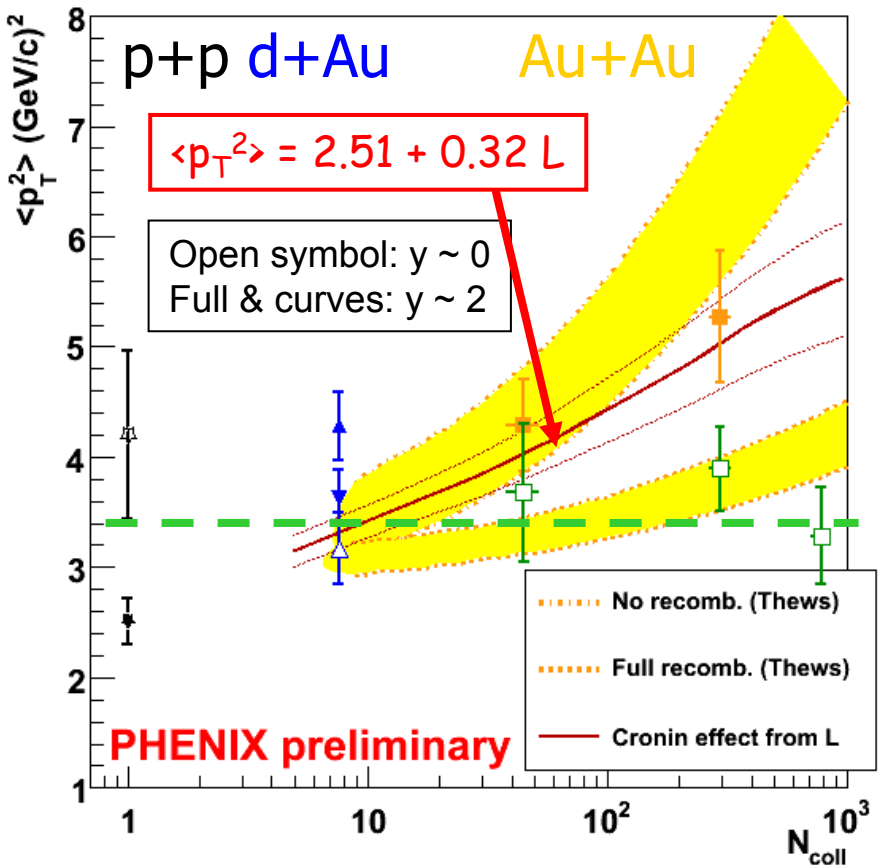
1. At forward rapidity (closed symbols)
   - from pp & dA:

$\langle p_T^2 \rangle = 2.51 + 0.32\ L$

(L <-> N_{coll} conversion)

No sign of recombination !

2. At mid rapidity (open symbols)
   - Negligible Cronin !?...
   - Need better pp !



VN Tram, Moriond 2006 & PhD thesis
Bob Thews, Hard Probes 2006

2nd. Hydro + J/ψ transport

One detailed QGP hydro + J/ψ transport (Zhu et al)

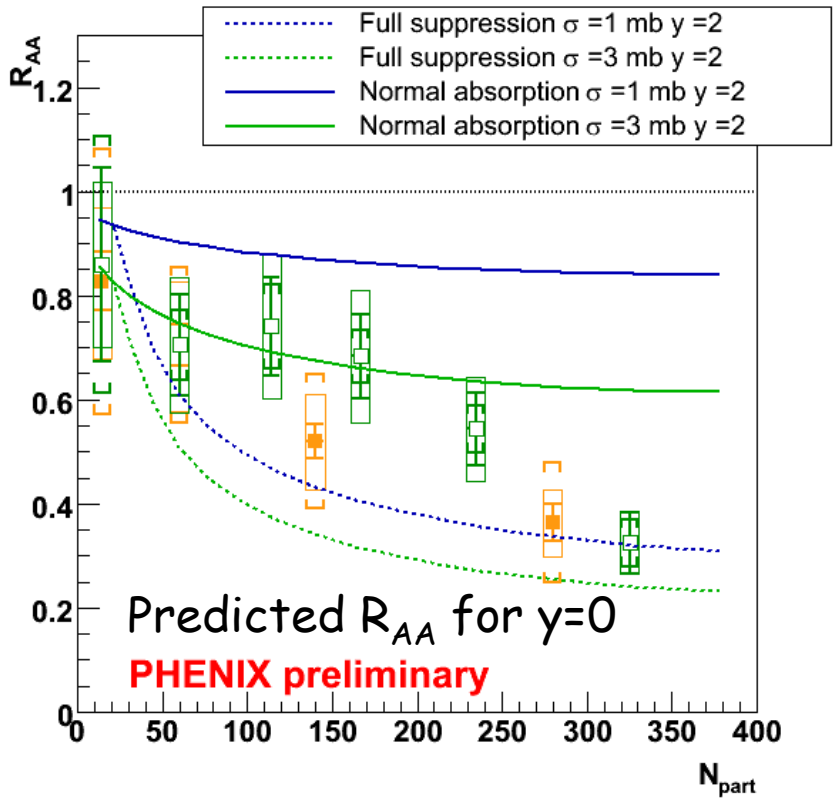
- $g + J/\psi \rightarrow c + \bar{c}$
- Leakage of higher p_T J/ψ

First published without cold nuclear effects, but here :

+ Nuclear absorption (1 or 3 mb)
+ Cronin effect from dAu
  $\langle p^T{}_2 \rangle$ ok (as on previous slide)

Model should be valid for y=0

- But match y=1.7
- (and central y=0)

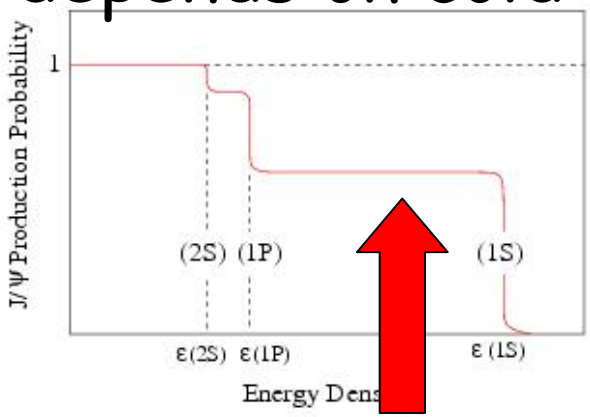


Zhu, Zhuang, Xu, PLB607 (2005) 107
+ private communication

In nucl-th/0608010, same authors consider regeneration & multiply by ~2 most central

3rd (simple) explanation

- Amount of anomalous suppression depends on cold nuclear effects amplitude
- But could be as low as 30 to 40%
- Compatible to feed-down ratio
  - 100 J/ψ ~ 60 J/ψ + 30 χ_c + 10 ψ′
  - HERAB says 21±5 χ_c & 7.0±0.4 ψ′
- Recent lattice $T_d^{\psi} \sim 1.5 - 2.5\ T_c$
  - $\varepsilon \times (T_d^{J/\psi} \sim 2T_c)^4 = 2\ \varepsilon_c$ → $\varepsilon_d^{J/\psi} \sim 32\ \varepsilon_c$!
- Wait for LHC to melt J/ψ ?



We may still be here

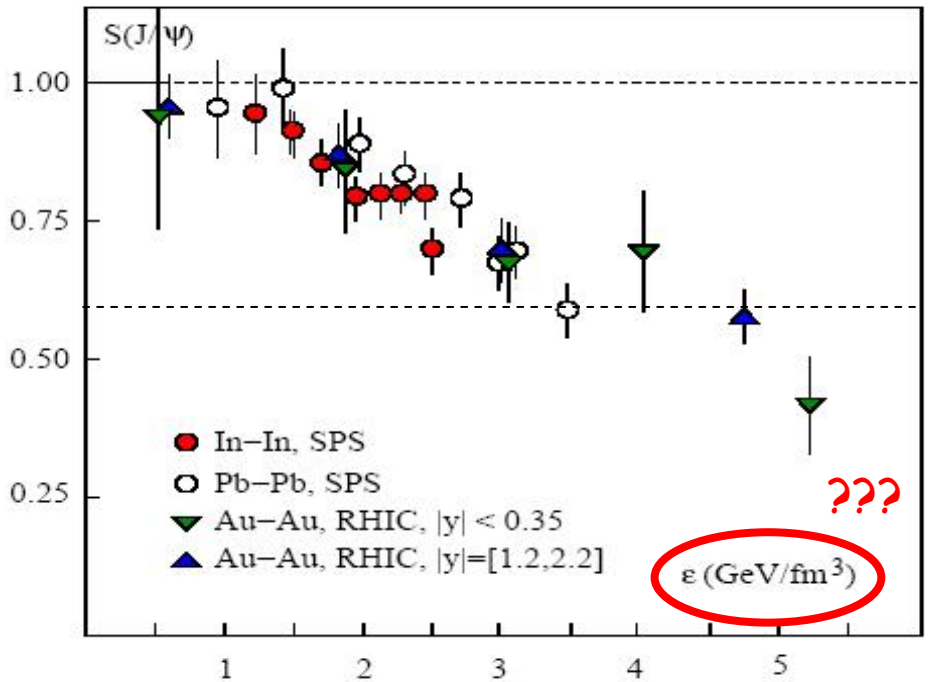
state	$J/\psi(1S)$	$\chi_c(1P)$	$\psi'(2S)$	$\Upsilon(1S)$	$\chi_b(1P)$	$\Upsilon(2S)$	$\chi_b(2P)$	$\Upsilon(3S)$
T_d/T_c	2.10	1.16	1.12	> 4.0	1.76	1.60	1.19	1.17

Datta & al, hep-lat/0409147
Alberico & al, hep-ph/0507084
Wong, hep-ph/0408020
←Satz, hep-ph/0512217

3rd applied to SPS & RHIC

- Sequential melting scenario
  - J/ψ survival only
  - Excited states melting from ψ' suppression pattern @ SPS
- Be careful when showing this!
  - NA60 and PHENIX are PRELMINARY…
  - No systematic uncertainties on PHENIX points
  - No uncertainties from cold nuclear matter effects
- However, it does a good job and sequential melting clearly is a possibility !…

J/ψ survival probability



– Assuming same formation time @ SPS and RHIC…

Karsch, Kharzeev & Satz PLB637(2006)75

A+A perspectives

What's new at RHIC ?

1st Recombination ?

- But no sign of y or p_T^2 modifications…
- $J/\psi \propto (N_{cc})^2$ (but how much is N_{cc} ?)

2nd J/ψ transport ? High p_T J/ψ escape ?

3rd Sequential melting ?

- Only excited states melt ? J/ψ still survive ?

These three models assume a QGP !

Lots of ingredients needed to answer…

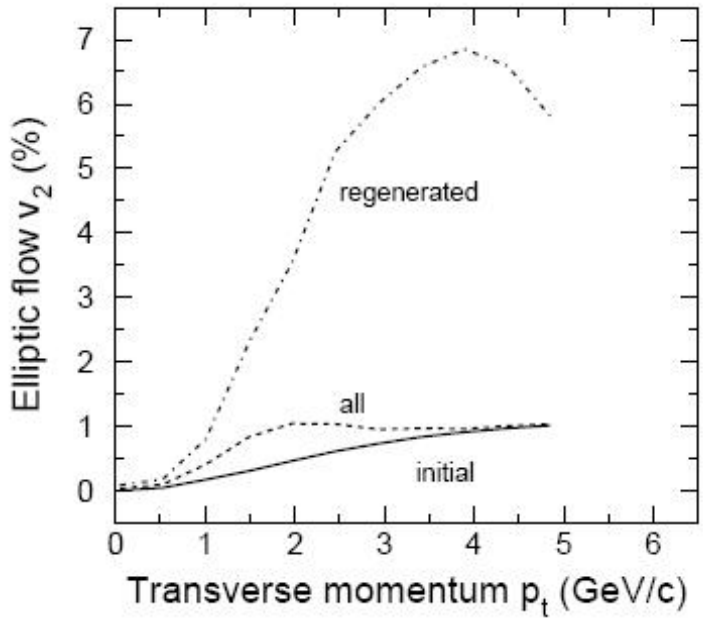
- Cold nuclear effects, open charm,…

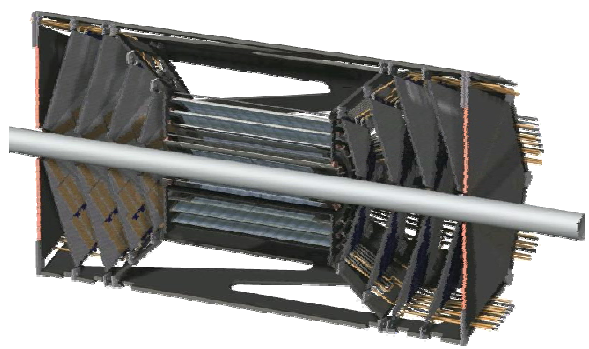
Some steps beyond

What do we need to answer ?

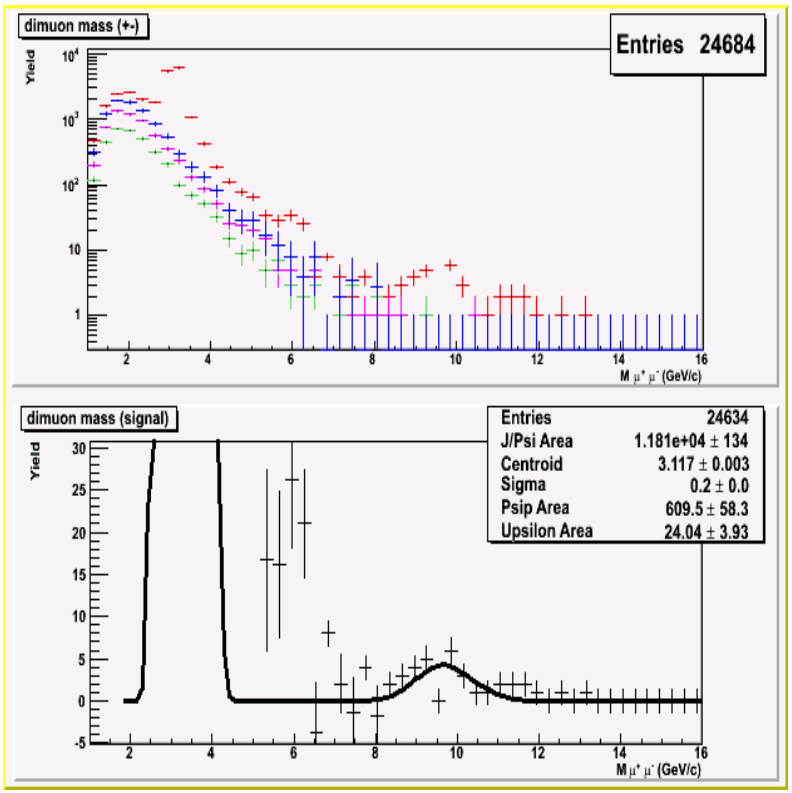
- Final AA analysis
  - Smaller systematic ?
  - A bit more data and bins
  - Better pp reference (Run 5)
  - Elliptic flow measurement ? (→)
- More AA statistics !
  - Could be run 7 ?
- Better knowledge of dA baseline !
  - Could be run 8 ?
- Better open charm measurements
  - Si VTX upgrade (working on it) →
- First look at other quarkonia
  - Going on with run 5 & 6 pp…
- LHC !

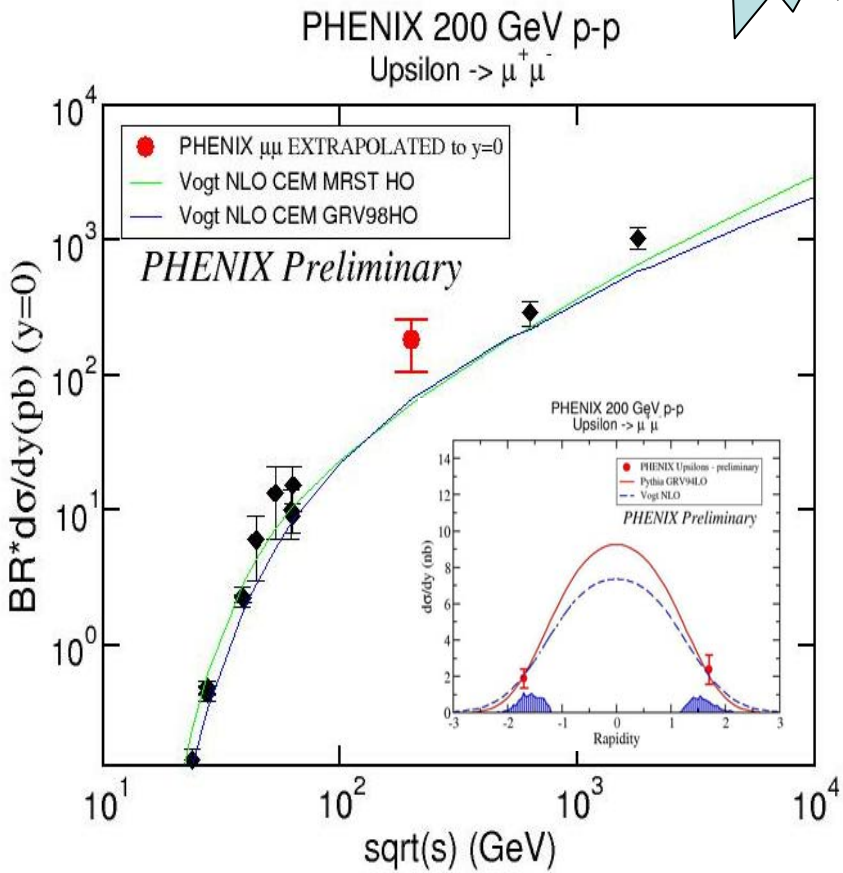
Yan, Zhuang, Xu, nucl-th/0608010





New quarkonia ahead !

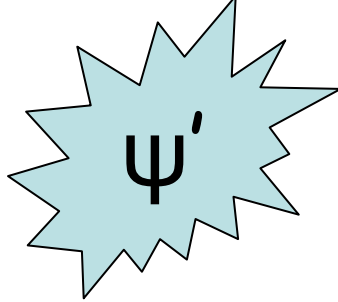


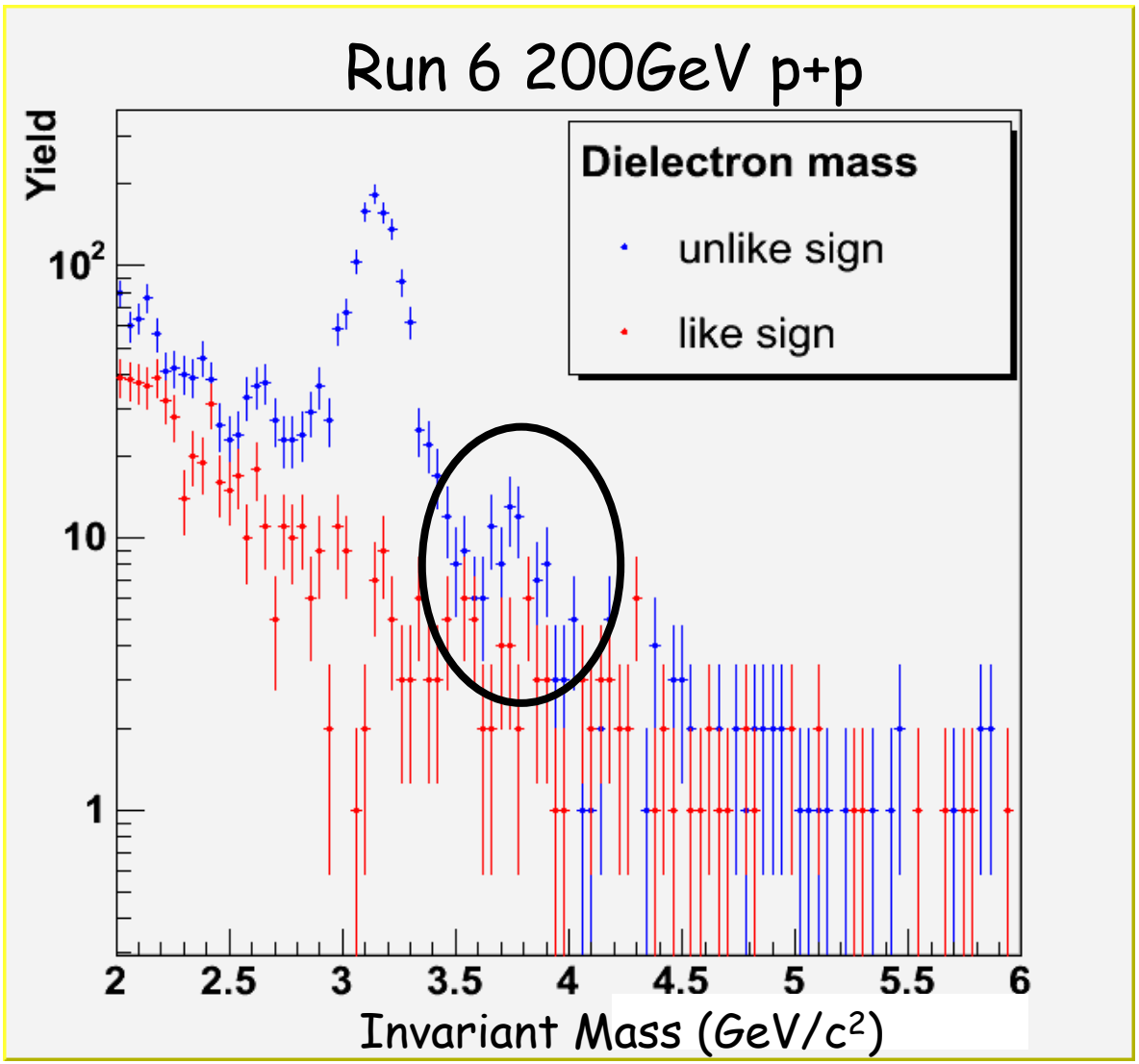


- Run 5 pp (3 pb^{-1})

Hie Wei, Quark Matter 2005

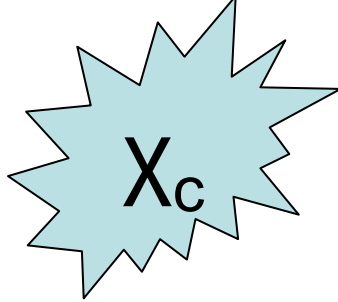
New quarkonia ahead !

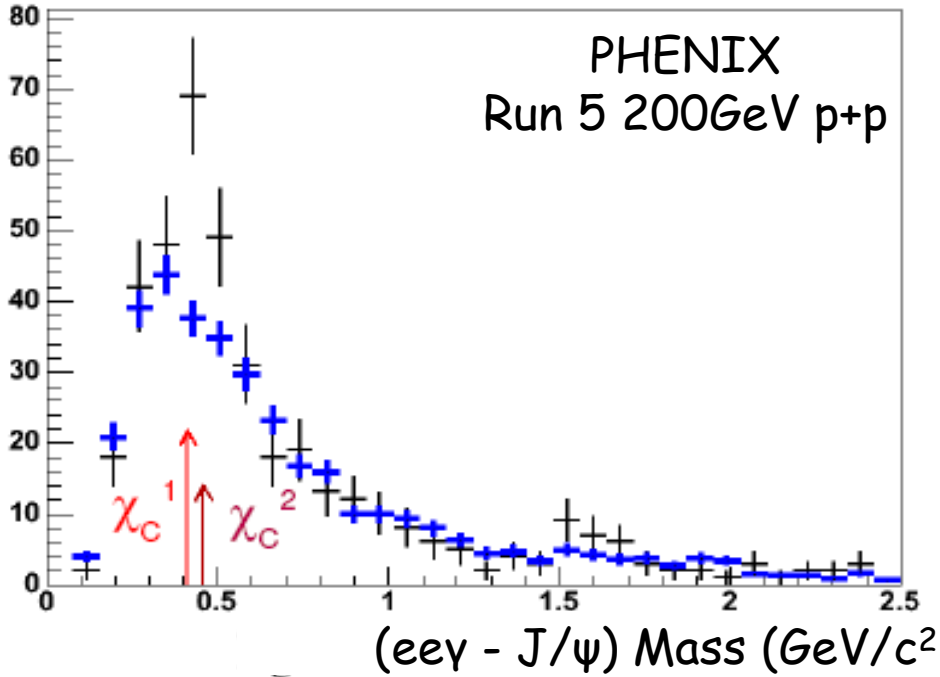


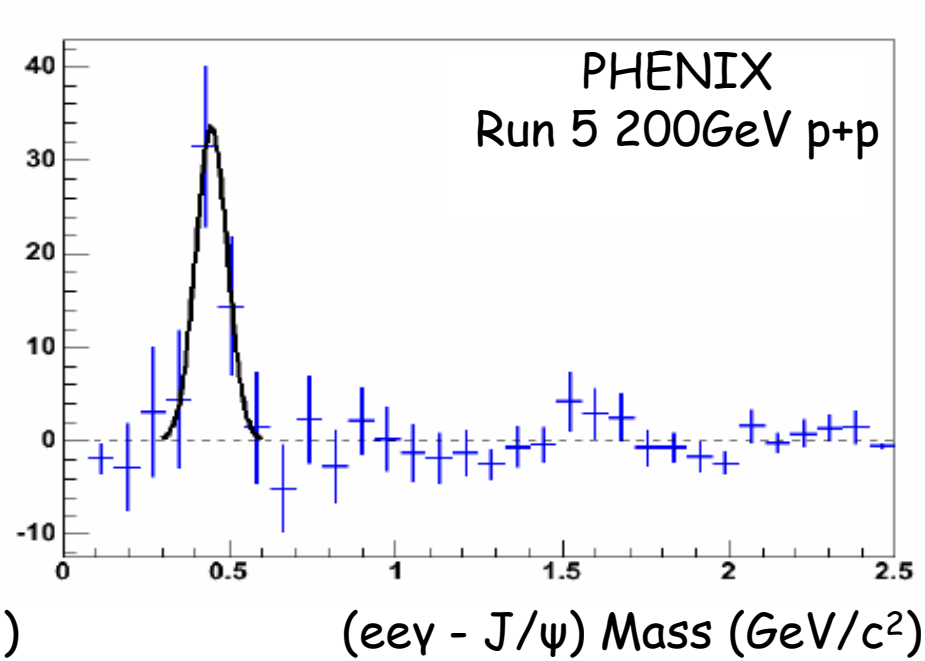


Work in progress…

New quarkonia ahead !







Work in progress…

New quarkonia ahead !

All numbers are first rough estimates (including trigger and reconstruction efficiencies) for 12 weeks Au+Au run ($\int L_{eff}\, dt \sim 18\ nb^{-1}$)

Signal	RHIC Exp.	Obtained	RHIC I (>2008)	RHIC II	LHC/ALICE [+]
$J/\psi \rightarrow e^+e^-$	PHENIX	~800	3,300	45,000	9,500
$J/\psi \rightarrow \mu^+\mu^-$		~7000	29,000	395,000	740,000
$\Upsilon \rightarrow e^+e^-$	STAR	-	830	11,200	2,600
$\Upsilon \rightarrow \mu^+\mu^-$	PHENIX	-	80	1,040	8,400
$B \rightarrow J/\psi \rightarrow e^+e^-$	PHENIX	-	40	570	N/A
$B \rightarrow J/\psi \rightarrow \mu^+\mu^-$		-	420	5,700	N/A
$\chi_c \rightarrow e^+e^-\gamma$	PHENIX	-	220	2,900*	N/A
$\chi_c \rightarrow \mu^+\mu^-\gamma$		-	8,600	117,000*	N/A
$D \rightarrow K\pi$	STAR	~0.4×10^6 (S/B~1/600)	30,000**	30,000**	8000

* Large backgrounds, quality uncertain as yet

** Running at 100 Hz min bias

[+] 1 month (= year), P. Crochet, EPJdirect A1, a (2005) and private comm.

© T. Frawley, PANIC'05, RHIC-II Satellite Meeting

See Thomas' talk (next)

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- Saint-Petersburg State Polytechnical Univiversity, Politechnicheskayastr. 29, St. Petersburg, 195251, Russia

PHENIX

13 Countries; 62 Institutions; 550* Participants

- Lund University, Lund, Sweden
- Abilene Christian University, Abilene, Texas, USA
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- University of Colorado, Boulder, CO, USA
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- University of Illinois Urbana-Champaign, Urbana-Champaign, IL, USA
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- Vanderbilt University, Nashville, TN 37235, USA

***as of March 2005**

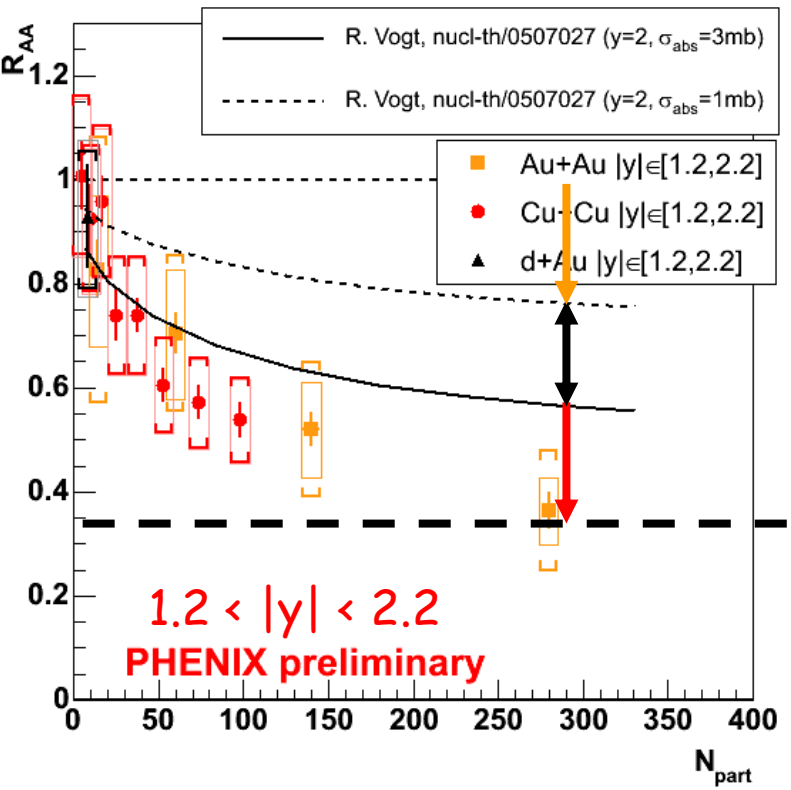
What phenixians cannot say…

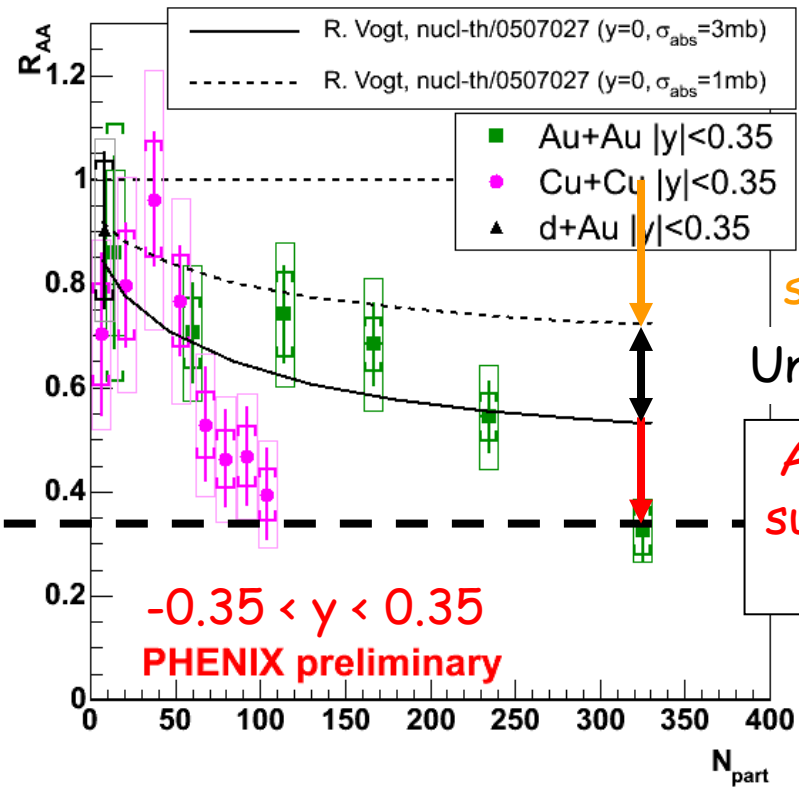
« Trentatré trentini entrarono
a Trento, tutti e trentatré,
trotterellando. »

Back up slides

What's going on @ RHIC ?

- Shadowing + nuclear absorption (crucial !)





Normal suppression

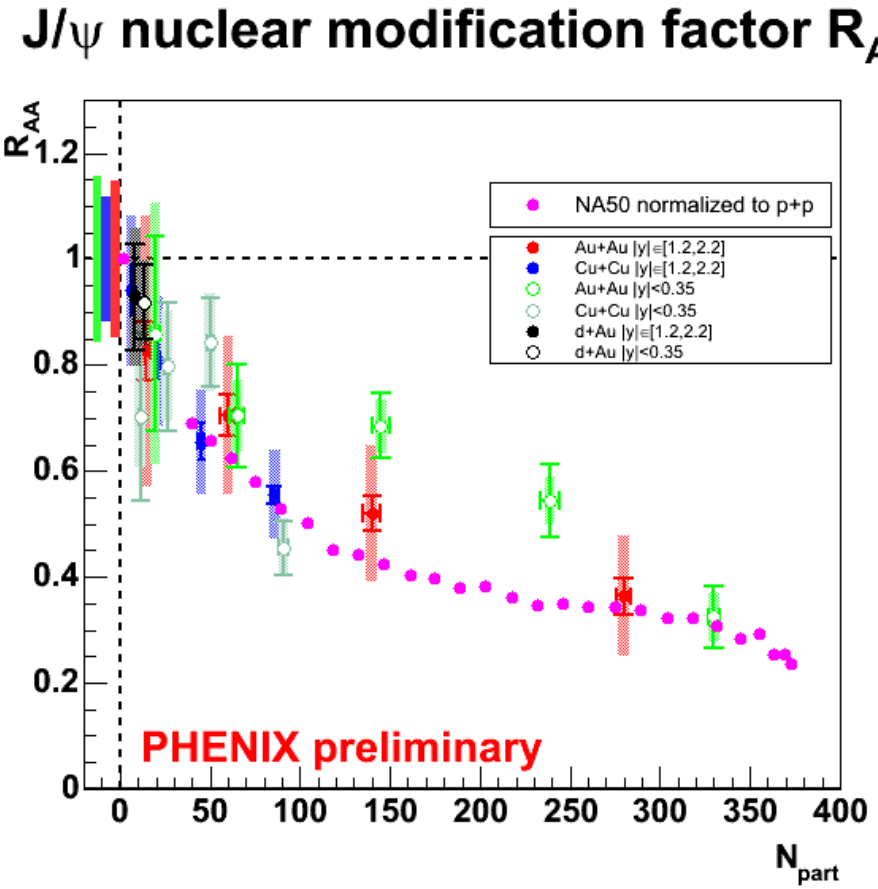
Uncertainty

Anomalous suppression ≥ 1/3

Error bar code : bars = statistical, bracket = systematic, box : global.

PHENIX, QM05, nucl-ex/0510051
Vogt, nucl-th/0507027

Quick comparison to NA50



Same magnitude

- 30% survival prob.

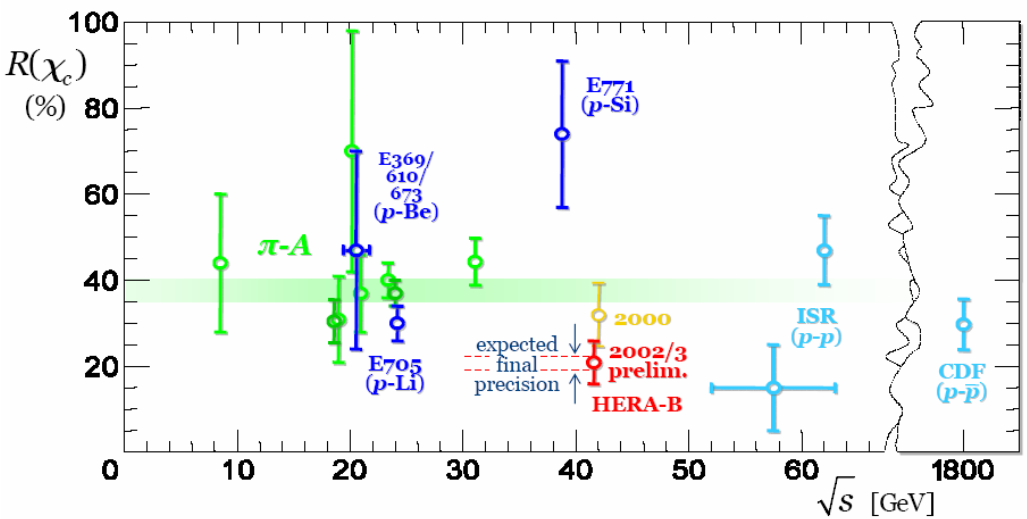
No fundamental reason

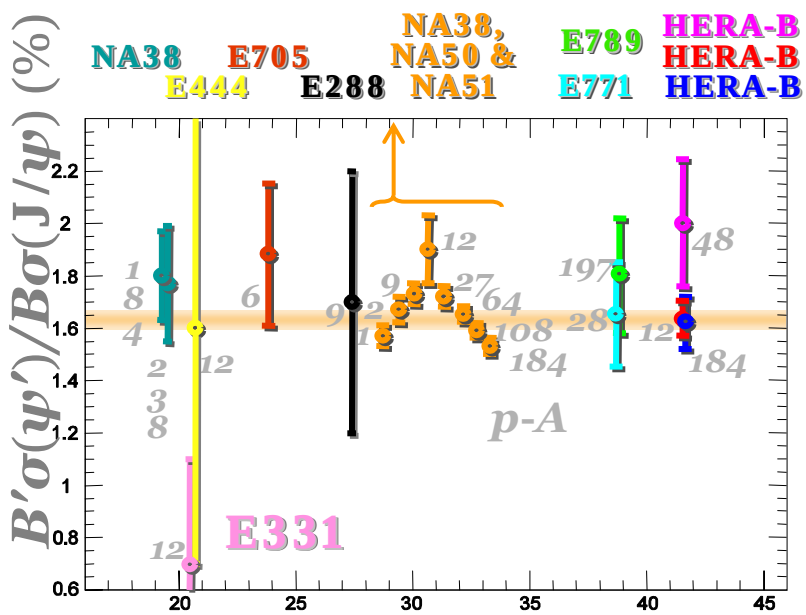
Differences:

- Energy density
- Cold / hot nuclear effects balance

Feed down ratio's ?

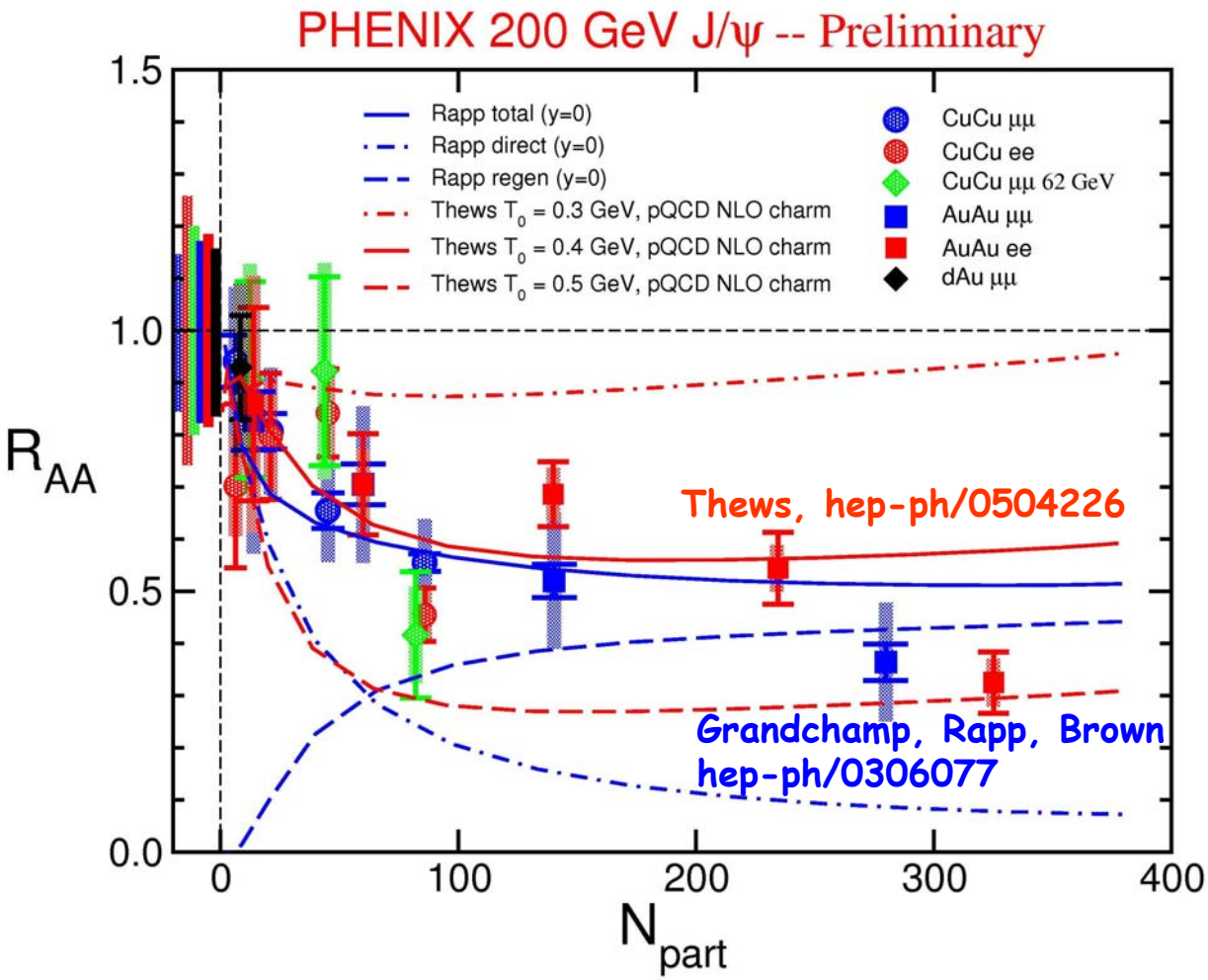
- From HERA-B (pA $\sqrt{s}$=41.6 GeV)
  - 7.0 ± 0.4 % from ψ'
  - 21 ± 5 % from χ_c
  - 0.065 ± 0.011 % from B



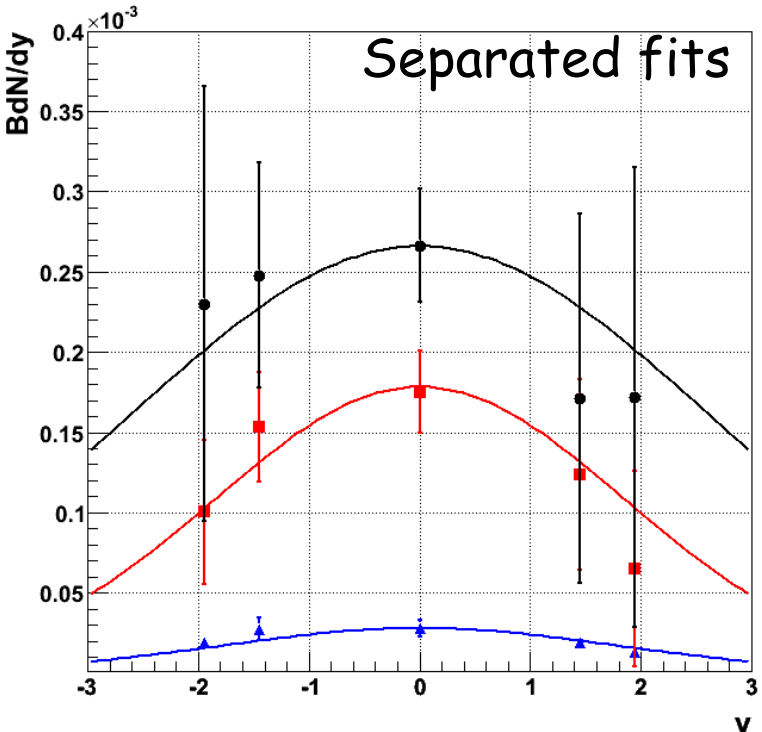


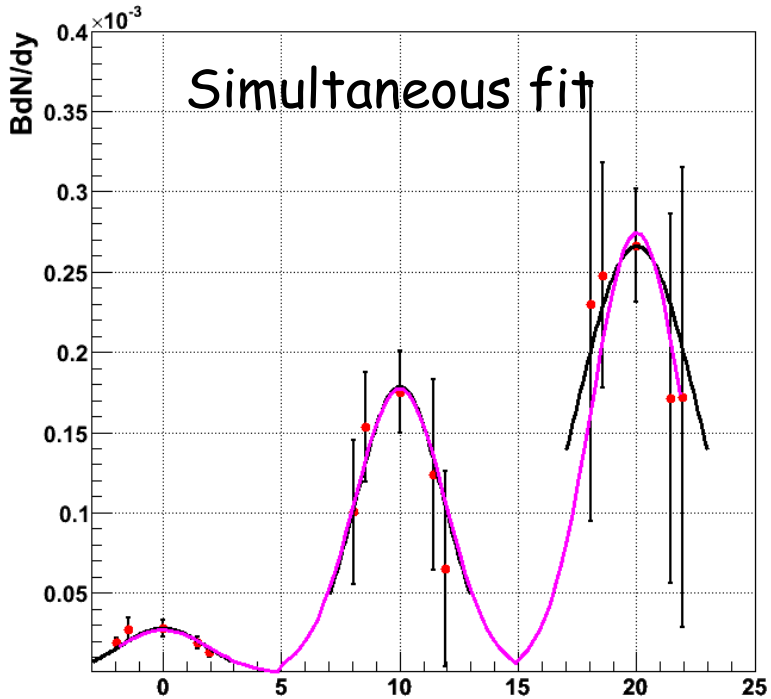
Faccioli, Hard Probes 2006

Competing recombination/suppression



Rapidity width





σ = 2.61 $\pm$ 2,54 χ^2/dof = 0.21

σ = 1.85 $\pm$ 0,53 χ^2/dof = 0.41

σ = 1.82 $\pm$ 1,00 χ^2/dof = 1.39

Width = 1,90 $\pm$ 0,32

χ^2/ndl = 0,55

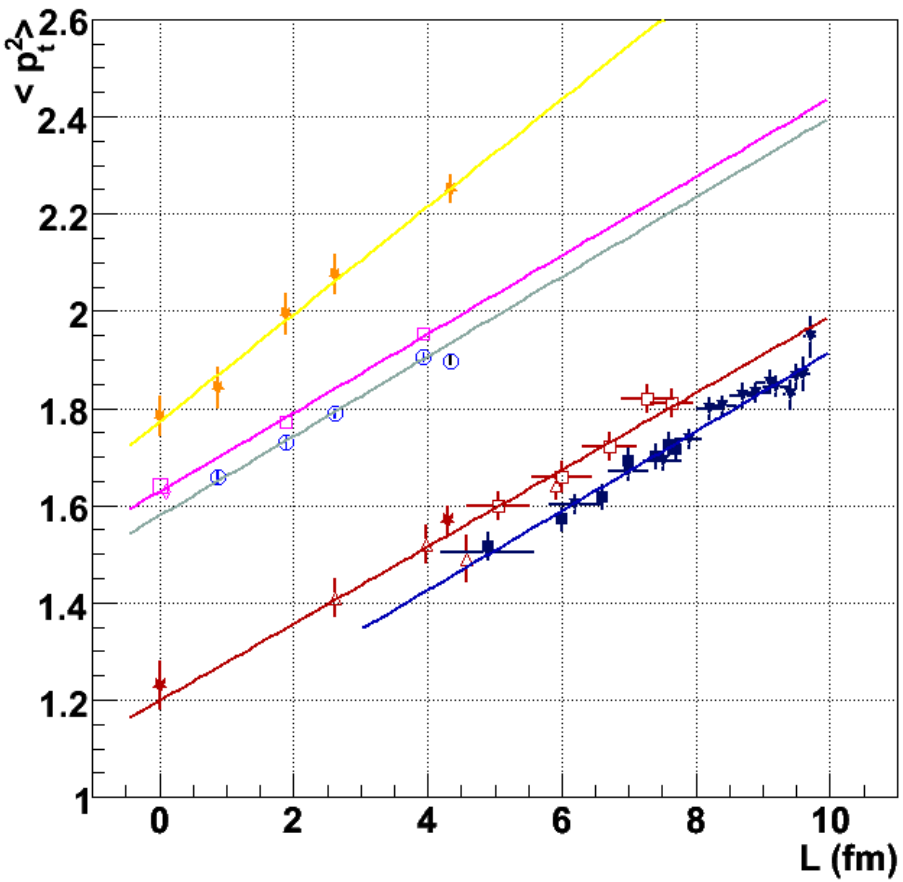
Width pp = 1,75 $\pm$ 0,21

No noticeable change in rapidity width

ViNham Tram thesis

Cronin effect

Scattering of initial gluons of nucleon before ccbar formation
random walk : $<p_t^2>_{AA} = <p_t^2>_{pp} + \rho\sigma\Delta(<p_t^2>) L_{AA}$



$\sqrt{s}$ =17.3 GeV : NA50/60 Pb+Pb, In+In

$\sqrt{s}$ = 19.4 GeV : NA3 p+p, NA38 p+Cu, p+U,O+U, S+U

$\sqrt{s}$ = 27.4 GeV : NA50 p+Be, p+Al, p+Cu, p+W

$\sqrt{s}$ = 29.1 GeV :NA51 p+p, p+d, NA50 p+Al, p+W

$\sqrt{s}$ = 38.8 GeV : E866/789/771

ρ nuclear density, σ elastic gluon-nucleon scattering cross section, $\Delta(<p_t^2>)$ kick given by each scattering and L average thickness of nuclear matter

More on J/ψ transport model…

- 2+1D hydro
- Boltzman-type transport
- Local equilibrium
  - (0.8 & 0.6 fm/c)
  - Normal to anomalous
- T_c = 165 MeV
- T_{fo} = 60 MeV
- $g+\Psi \rightarrow c\bar{c}$
- High p_T leakage
- 40% feeddown
- No in-medium mod.
- No absorption @RHIC

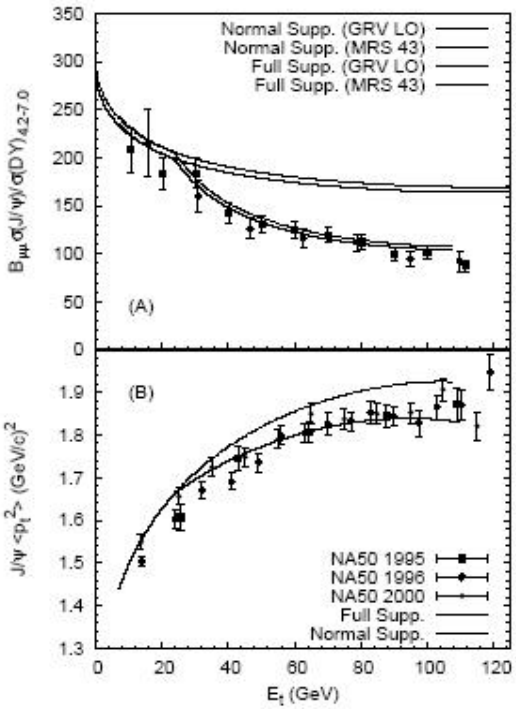


FIG. 1: The J/ψ suppression and $\langle p_t^2 \rangle$ as functions of centrality at SPS energy.

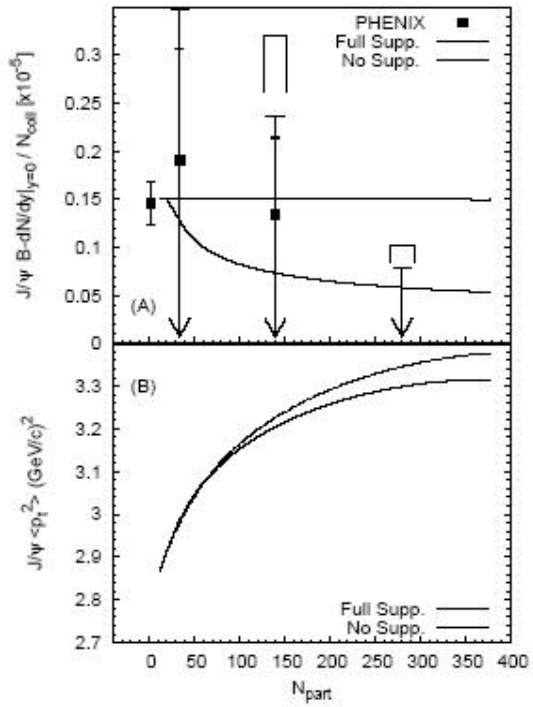
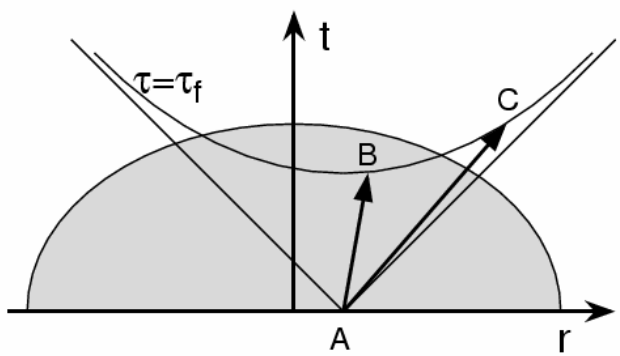
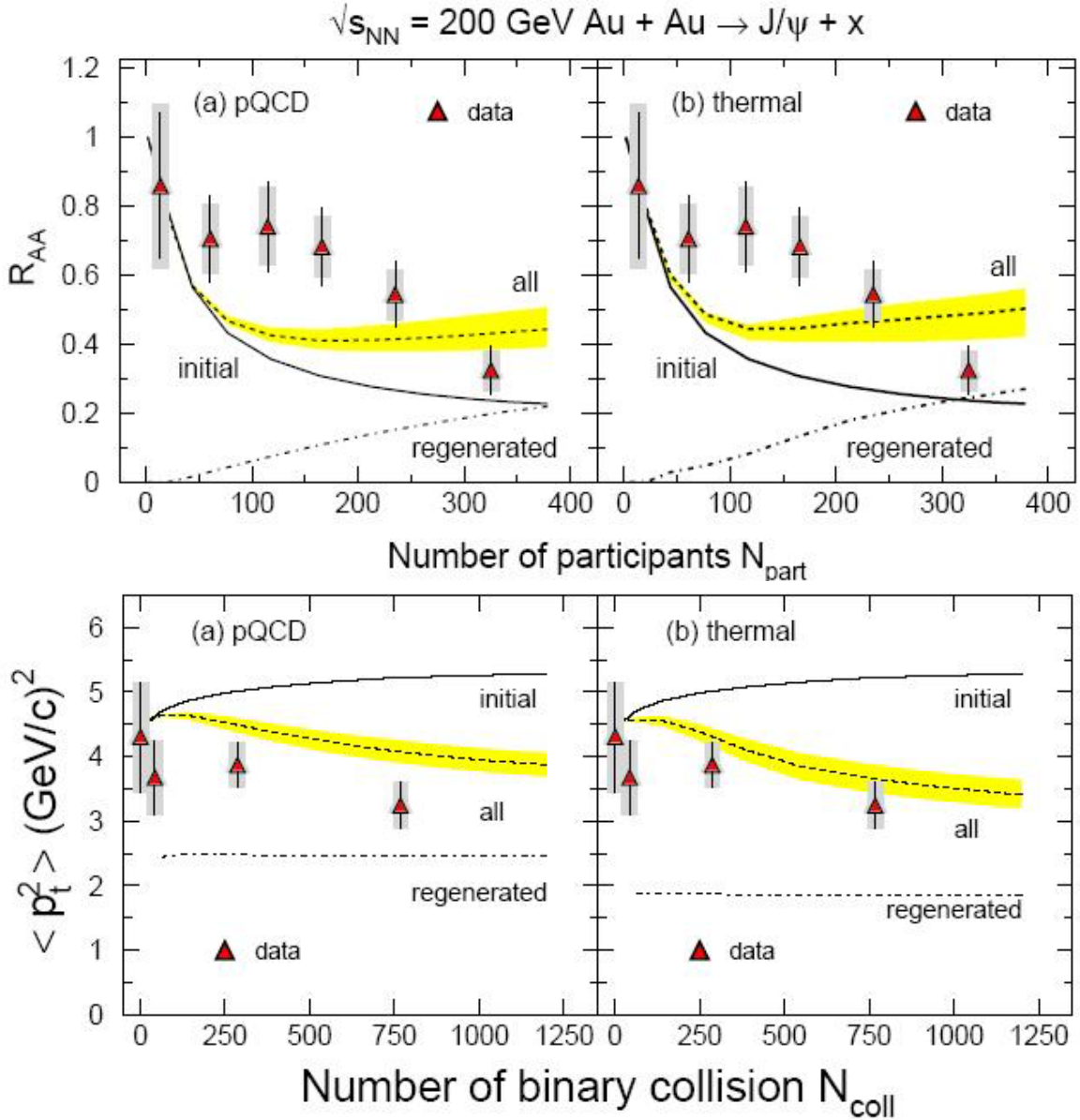


FIG. 2: The J/ψ suppression and $\langle p_t^2 \rangle$ as functions of centrality at RHIC energy.



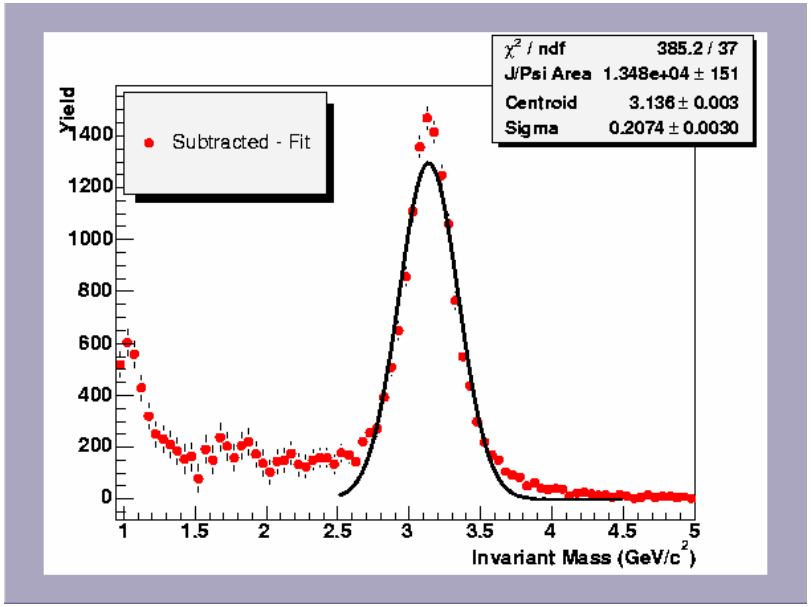
Zhu, Zhuang, Xu, PLB607 (2005) 107

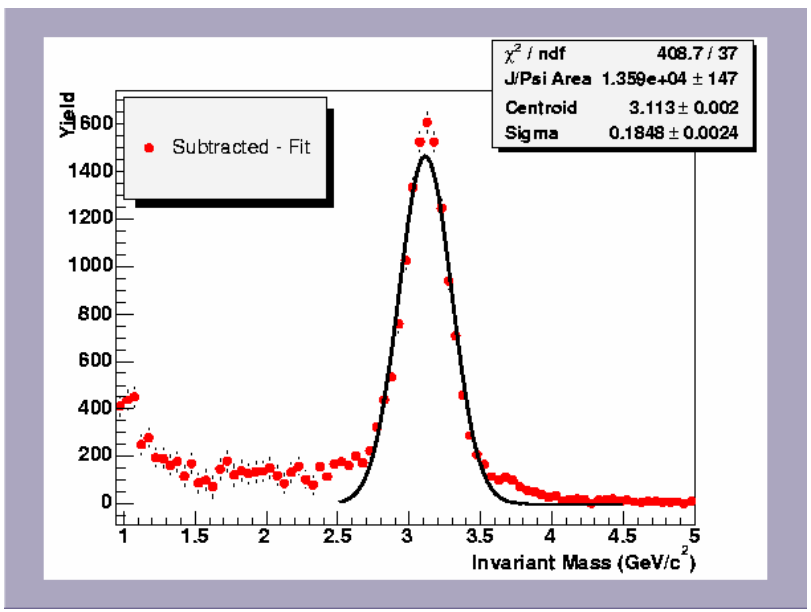
More on J/ψ transport model…

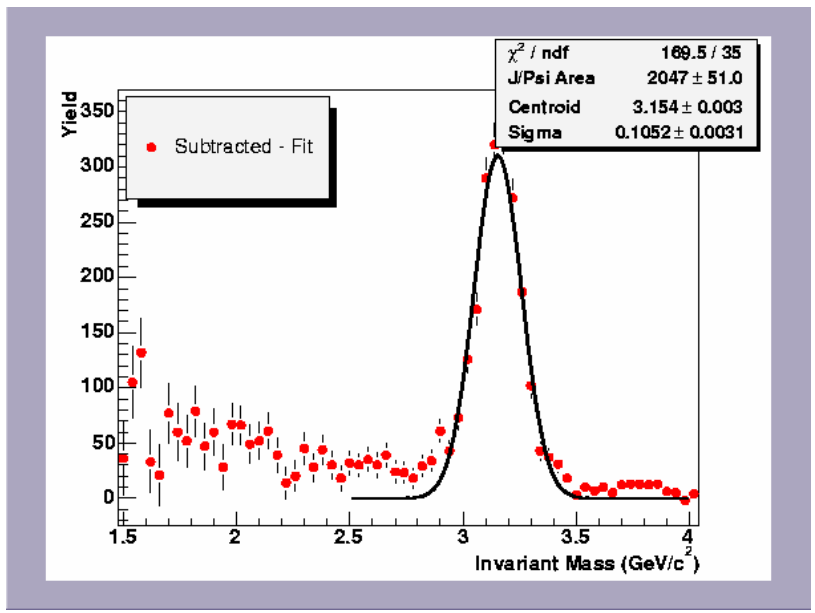


In nucl-th/0608010, same authors consider regeneration & multiply by ~2 most central

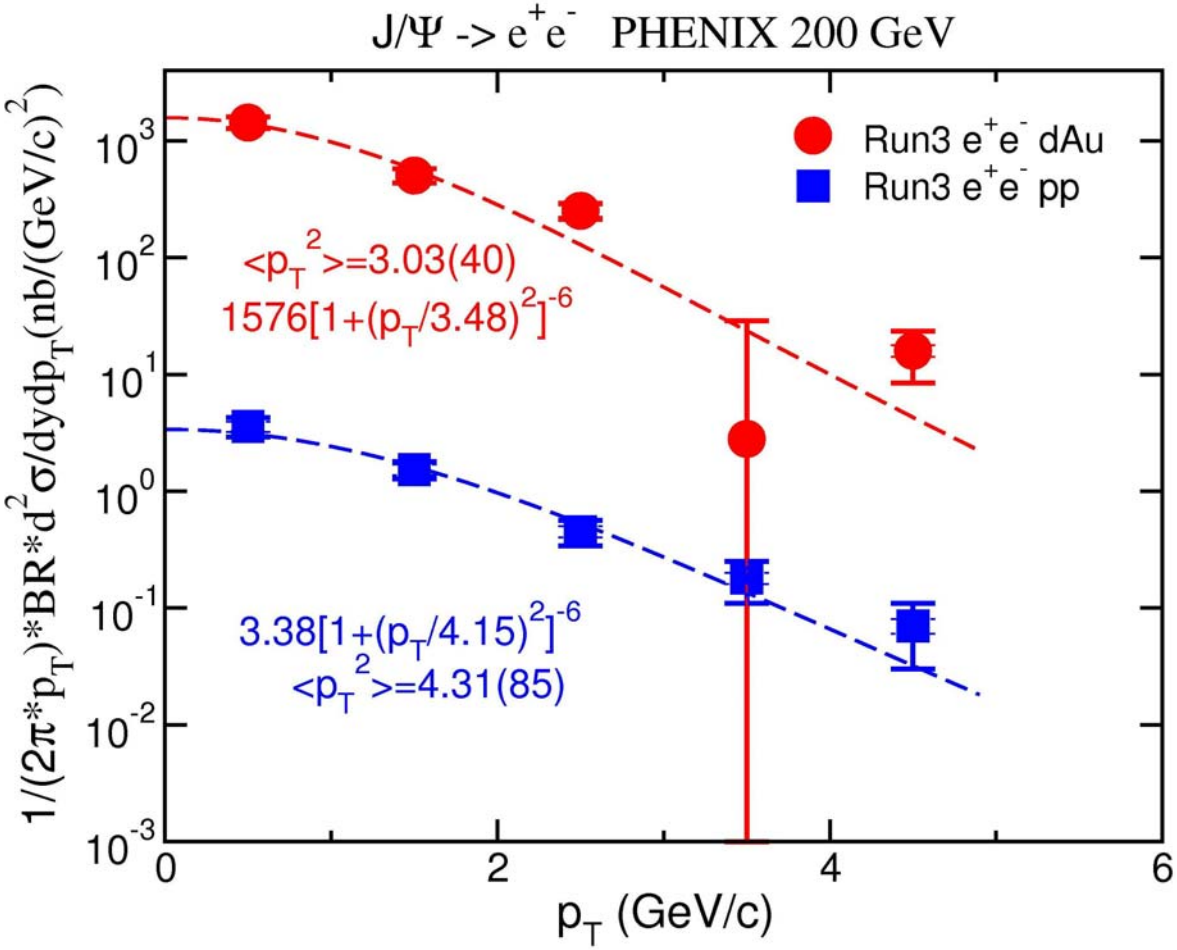
Run6 p+p


χ^2 / ndf 385.2 / 37
J/Psi Area 1.348e+04 ± 151
Centroid 3.136 ± 0.003
Sigma 0.2074 ± 0.0030
Subtracted - Fit
Yield
Invariant Mass (GeV/c^2)


χ^2 / ndf 408.7 / 37
J/Psi Area 1.359e+04 ± 147
Centroid 3.113 ± 0.002
Sigma 0.1848 ± 0.0024
Subtracted - Fit
Yield
Invariant Mass (GeV/c^2)

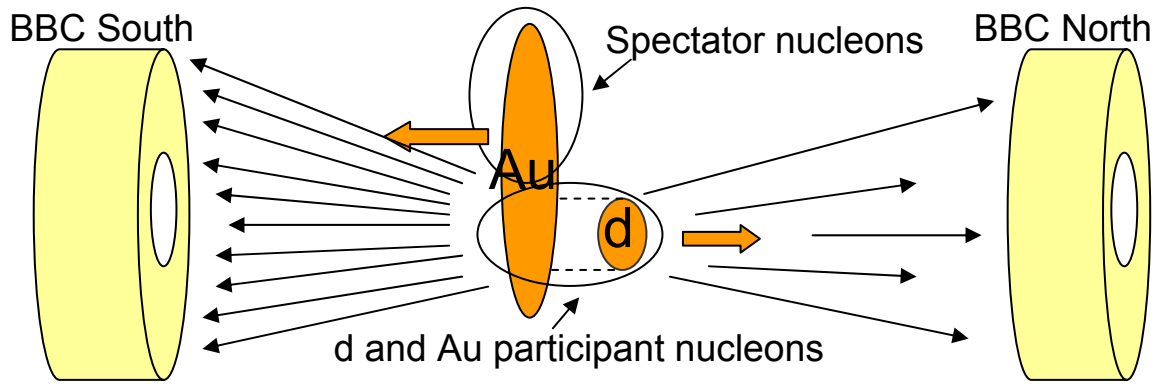

χ^2 / ndf 169.5 / 35
J/Psi Area 2047 ± 51.0
Centroid 3.154 ± 0.003
Sigma 0.1052 ± 0.0031
Subtracted - Fit
Yield
Invariant Mass (GeV/c^2)

Dielectron pp and dA



Centrality analysis

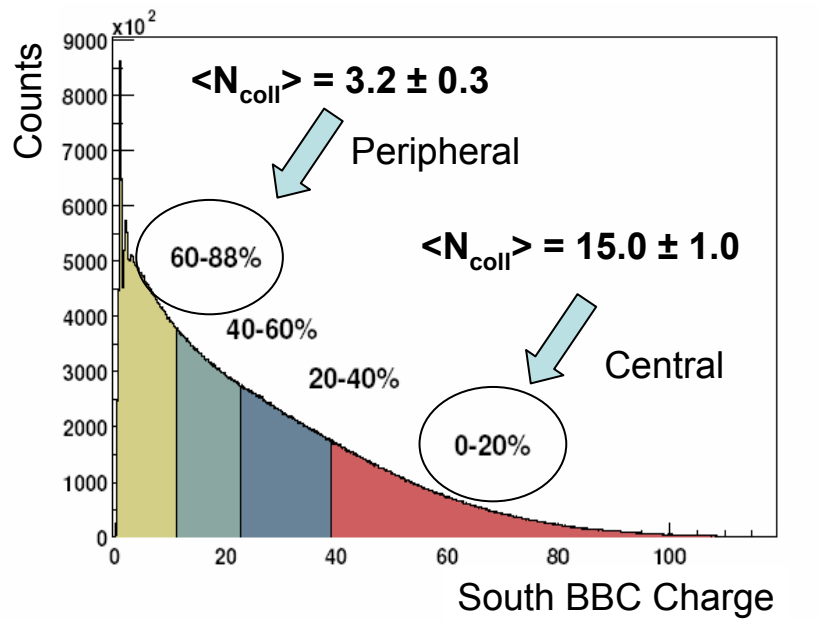
Au breaks up in our south beam counter



- Define 4 centrality classes
- Relate centrality to $\langle N_{coll} \rangle$

through Glauber computation

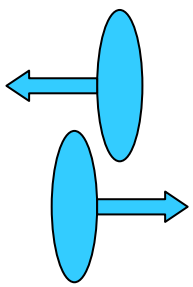
- $\langle N_{coll}^{MB} \rangle = 8.4 \pm 0.7$

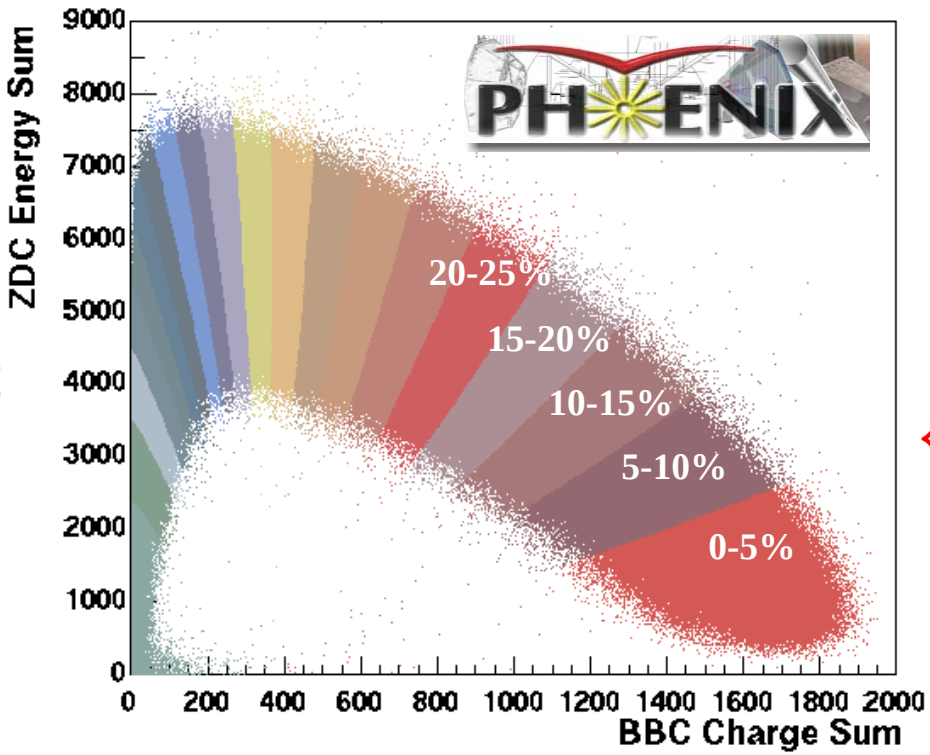


Centrality analysis

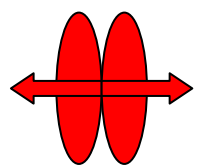
BBC charge versus ZDC energy

Most peripheral
80 – 92.2%
$\langle N_{part} \rangle = 6.3 \pm 1.2$
$\langle N_{coll} \rangle = 4.9 \pm 1.2$



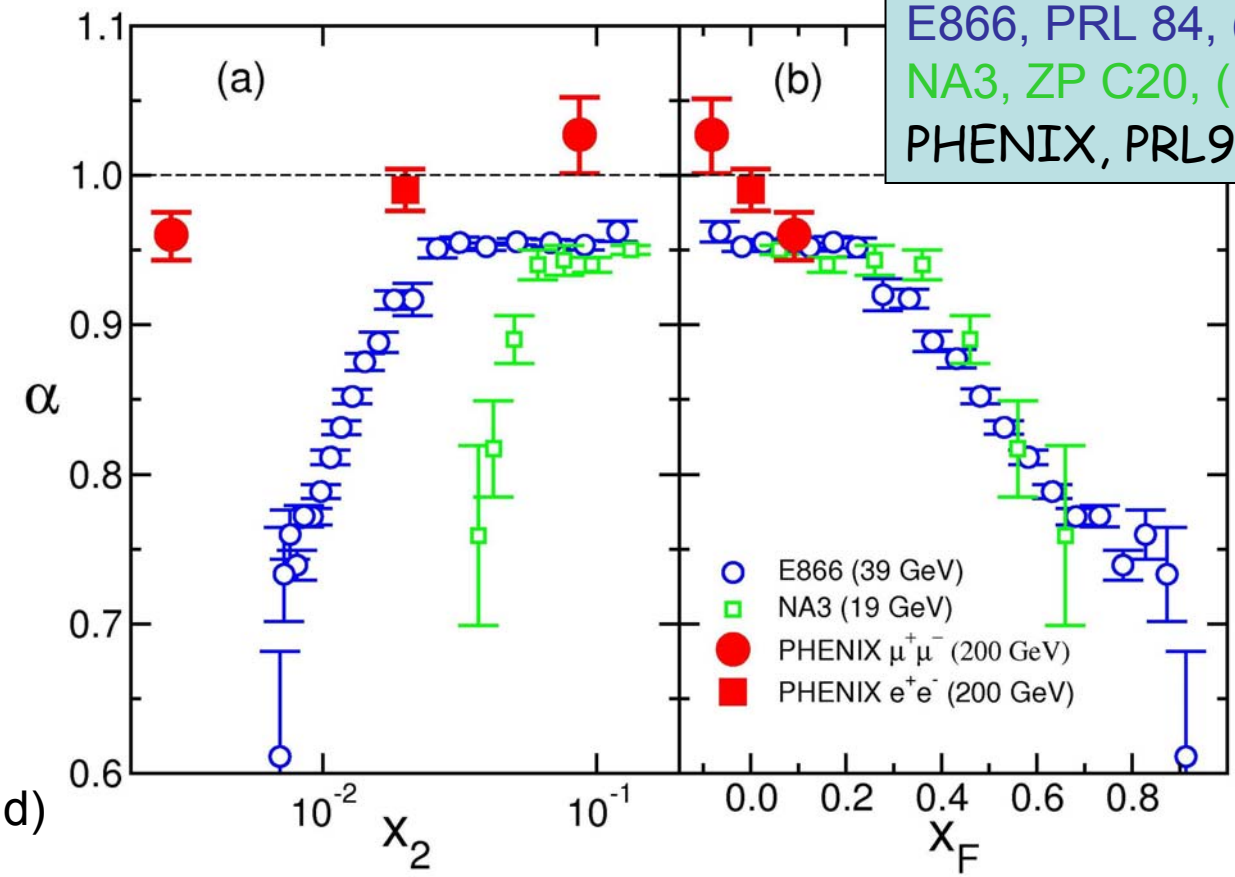


Most central
0 - 5 %
$\langle N_{part} \rangle = 351 \pm 2.9$
$\langle N_{coll} \rangle = 1065 \pm 105$



α versus X compared to lower √s

E866, PRL 84, (2000) 3256
NA3, ZP C20, (1983) 101
PHENIX, PRL96 (2006) 012304

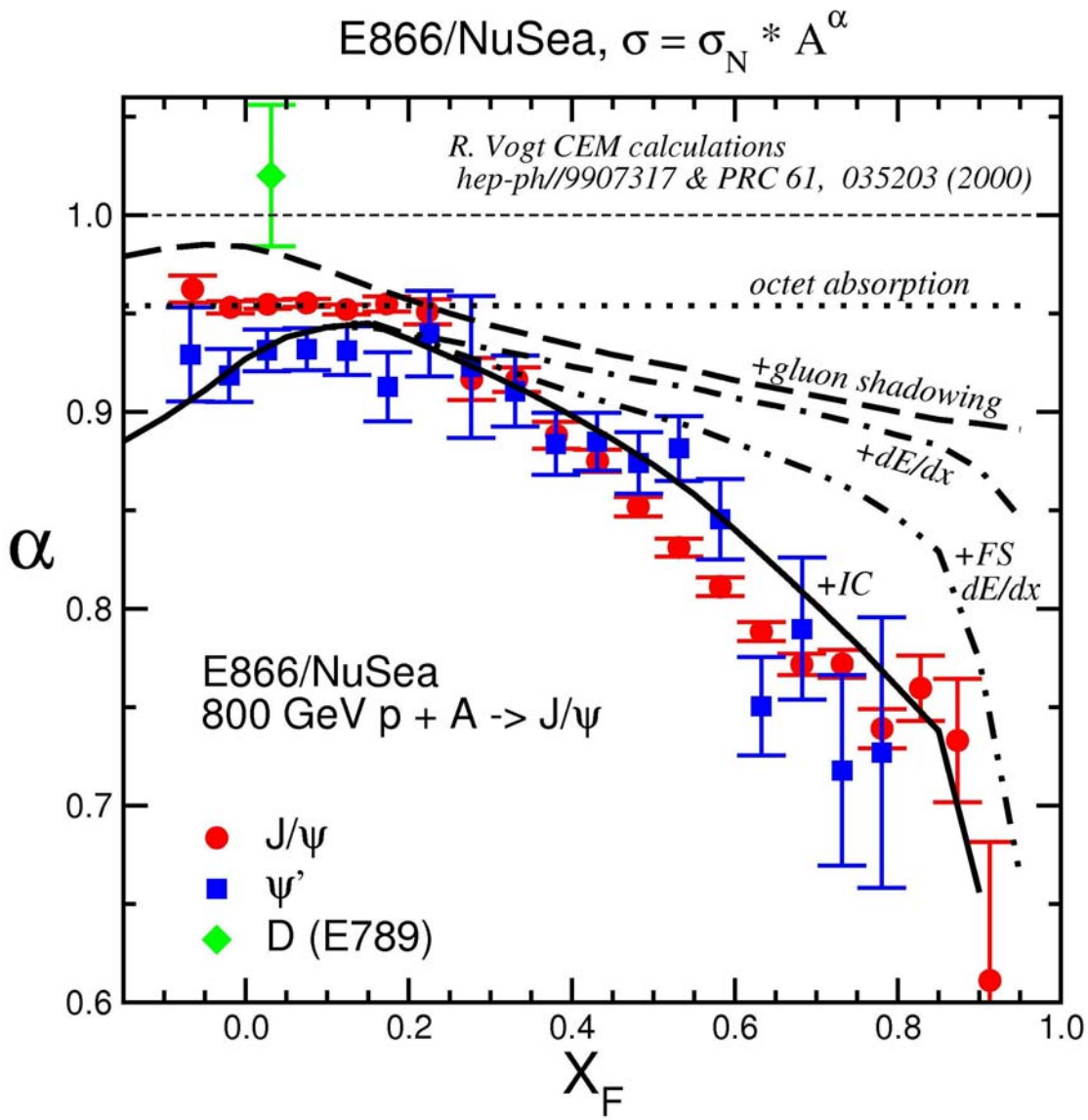


X_2 (in gold)

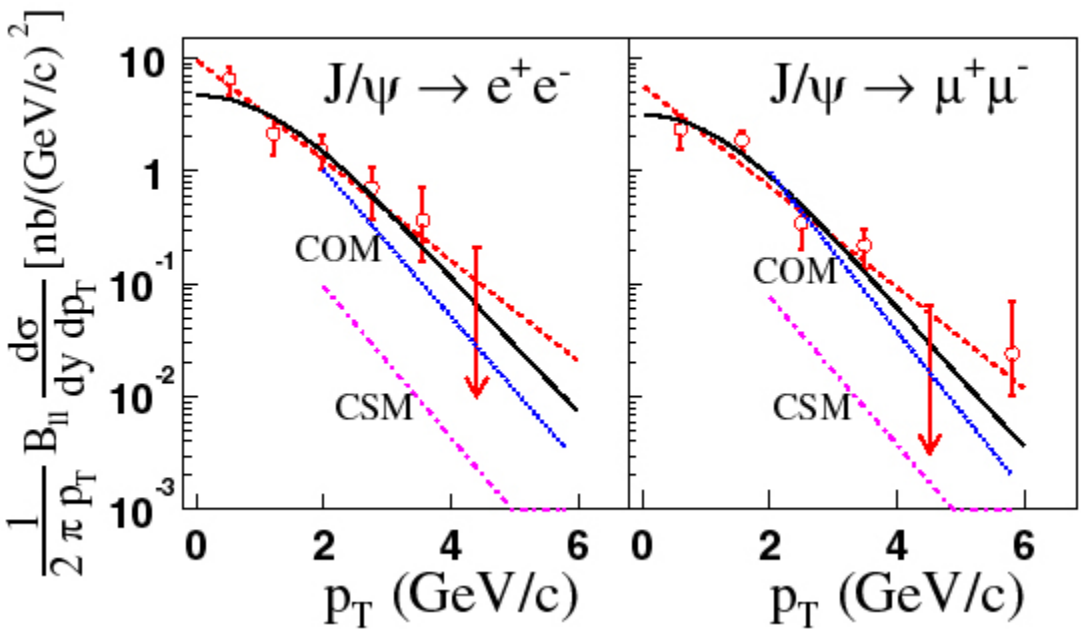
$X_F = X_d - X_{Au}$

- Not universal versus X_2 : shadowing is not the whole story.
- Same versus X_F for diff √s. Incident parton energy loss ? (high X_d = high X_F)
- Energy loss expected to be weak at RHIC energy.

How to get x_F scaling ?



J/ψ transverse momentum (run2)



Color Singlet Model

Color Octet Model

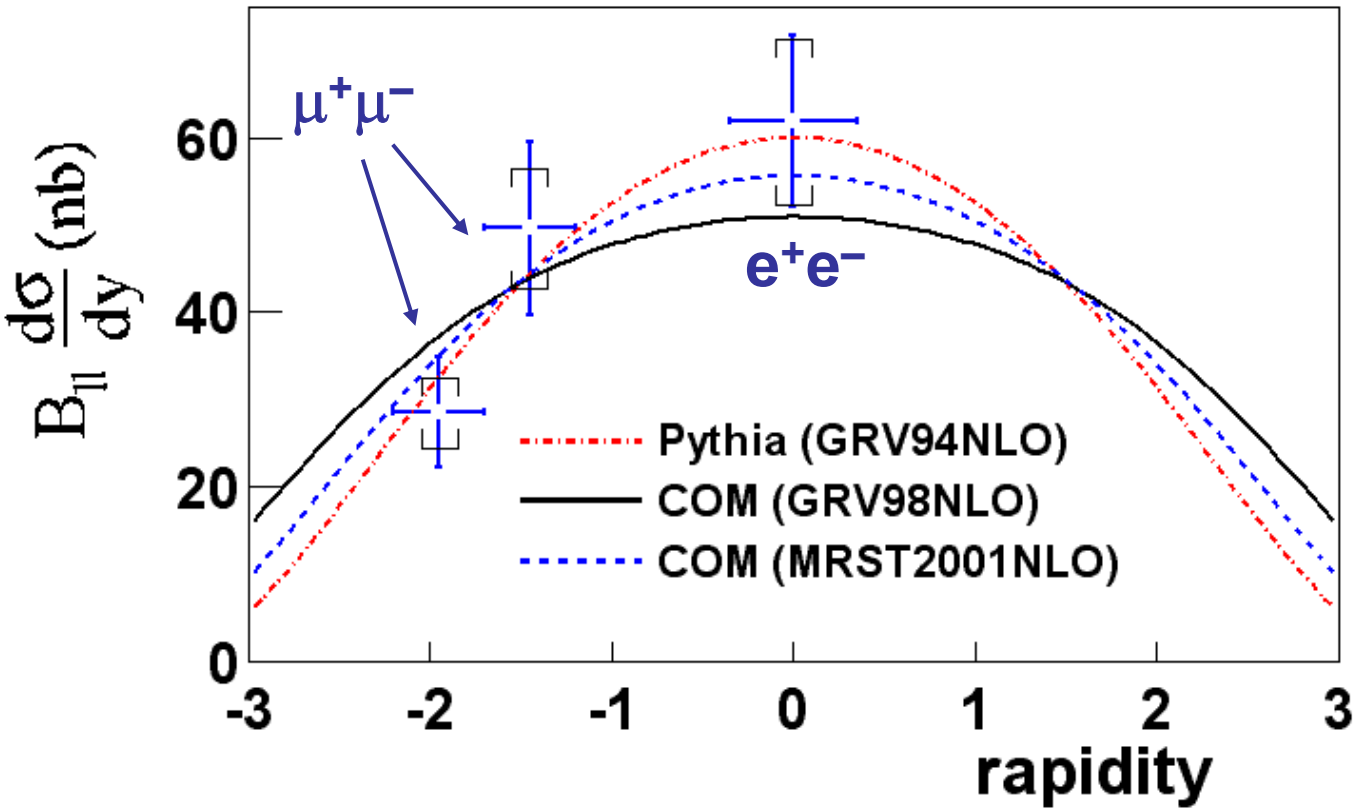
(from Nayak et al. hep/ph 0302095)

COM contribution is dominant, as for high p_T J/Ψ @ Tevatron

Phenomenological + exponential fits of dimuon and dielectron data give mean p_T :

<pT> = 1.80 ± 0.23 (stat) ± 0.16 (sys) GeV/c

J/Ψ cross section from run 2



Results consistent with shapes from various models and PDF.

Take the PYTHIA shape to extract our cross-section

Error from absolute normalization

Integrated cross-section :

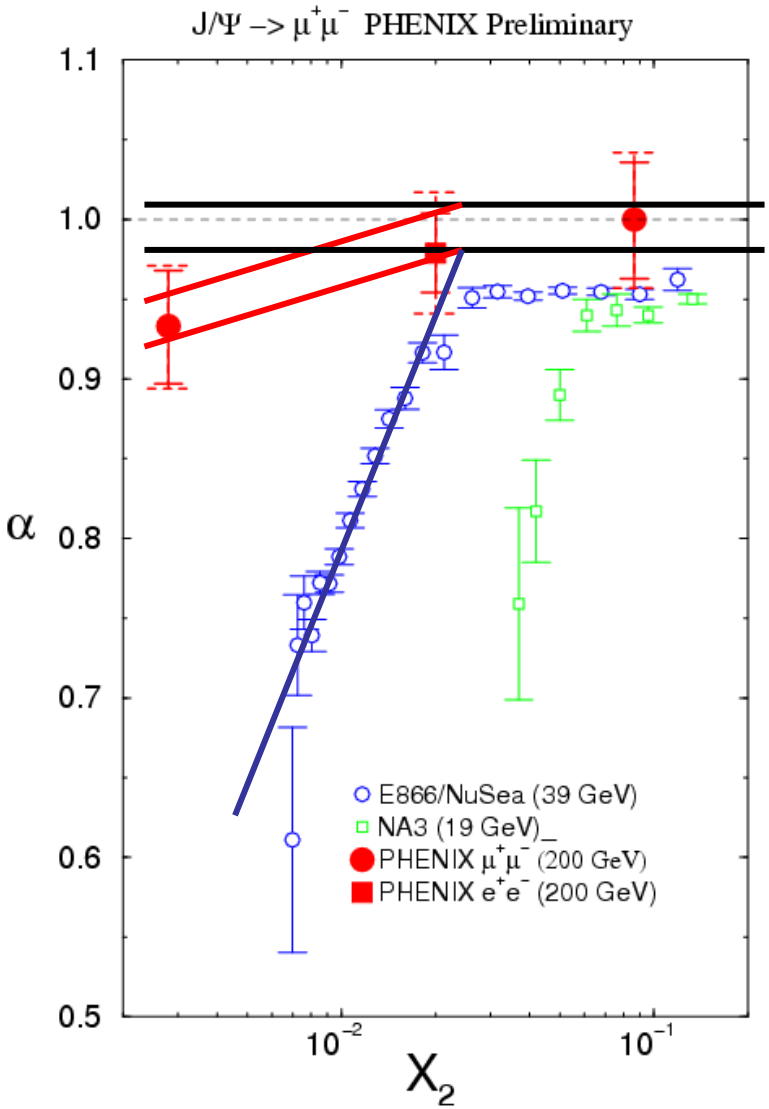
RUN2 234 ± 36 (stat) ± 34 (sys) ± 24(abs) μb

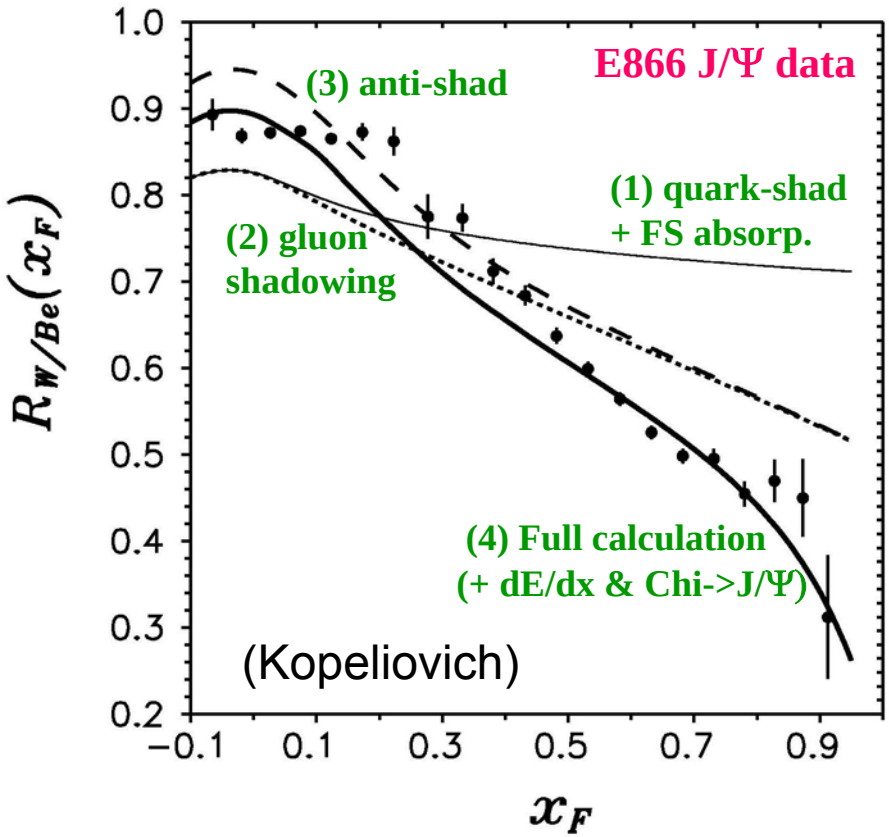
RUN3 159 nb ± 8.5 % (fit) ± 12.3% (abs)

Consistent (1.3 sigma difference)

Naive picture

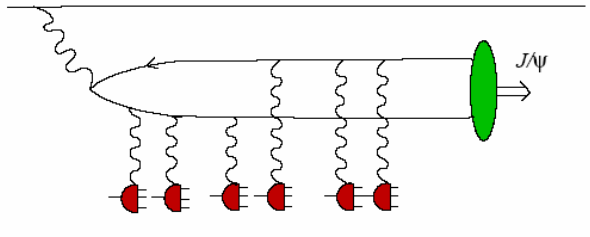
- Less absorption
- Shadowing
- Energy loss

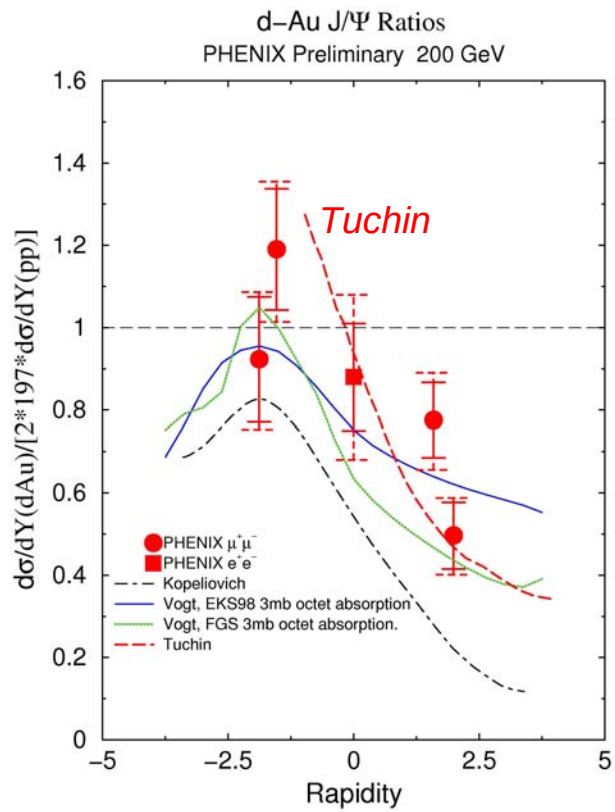




Tuchin & Kharzeev

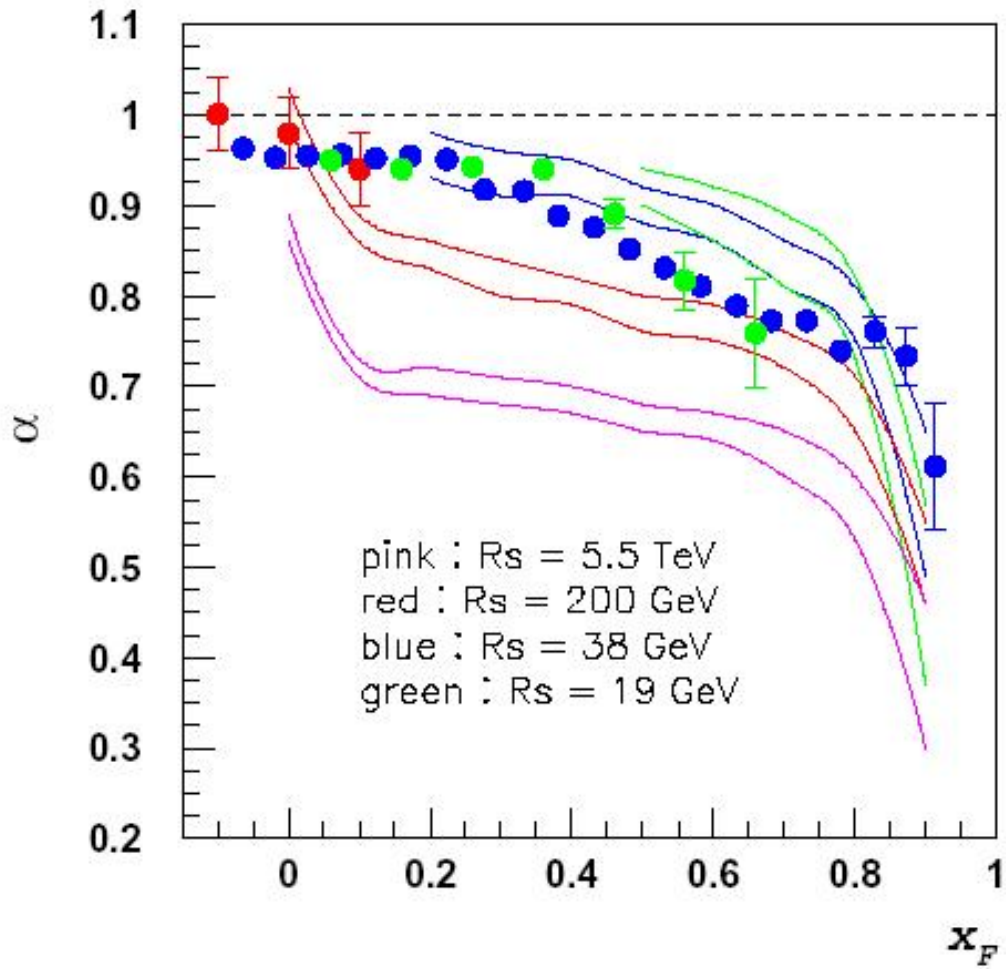
- Hard probes 2004
  - hep-ph/0504133
- Coherent production of charm (open or closed)
  - (y<0 production time to low to make computation)
  - Shadowing from CGC computation…





Tuchin & Kharzeev…

+ absorption for SPS & fermilab



… gold+gold extrapolation …