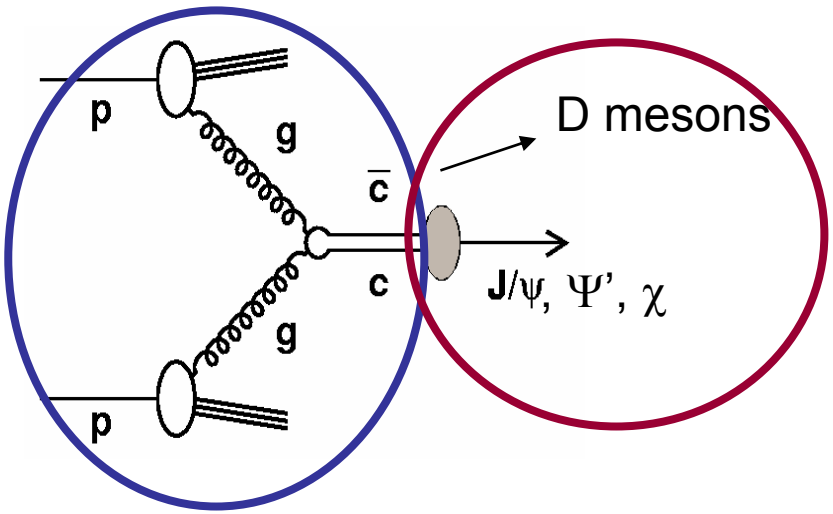
J/Ψ from PHENIX

- J/Ψ production and use as a probe
- Review of current analyses that are nearing completing
- J/Ψ from AuAu
- Outlook

Models of Charm and J/Ψ Production



Factorize calculations:

- pQ̄CD to calculate cc production
- cc propagation and Hadronization

- Production sensitive to gluon distribution function
- In polarized pp, sensitive to gluon polarization
- Common pQCD for open charm, J/Ψ used to distinguish between initial and final-state effects

Input to Models:

- Many input parameters to both pQCD portion and hadronization portion of models

- Total cross sections and Differential vs. y, p_T, $\sqrt{s}$, etc. necessary to simultaneously constrain theoretical uncertainties

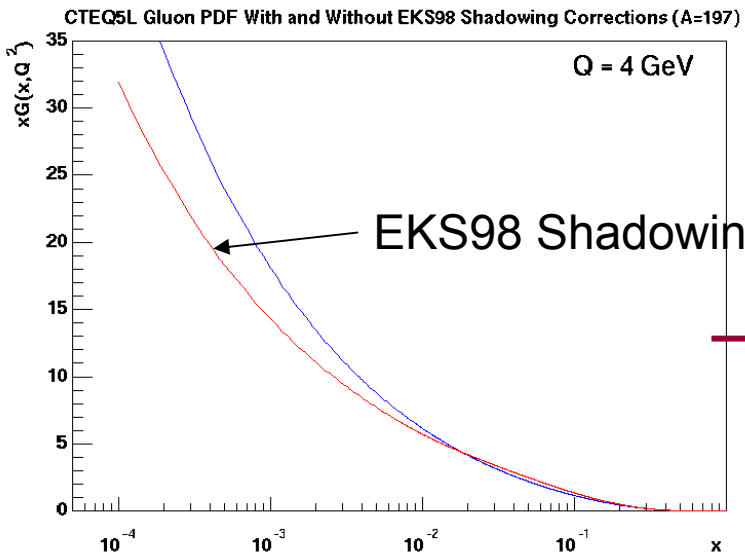
Nuclear Effects on Charm, J/Ψ Production in dA

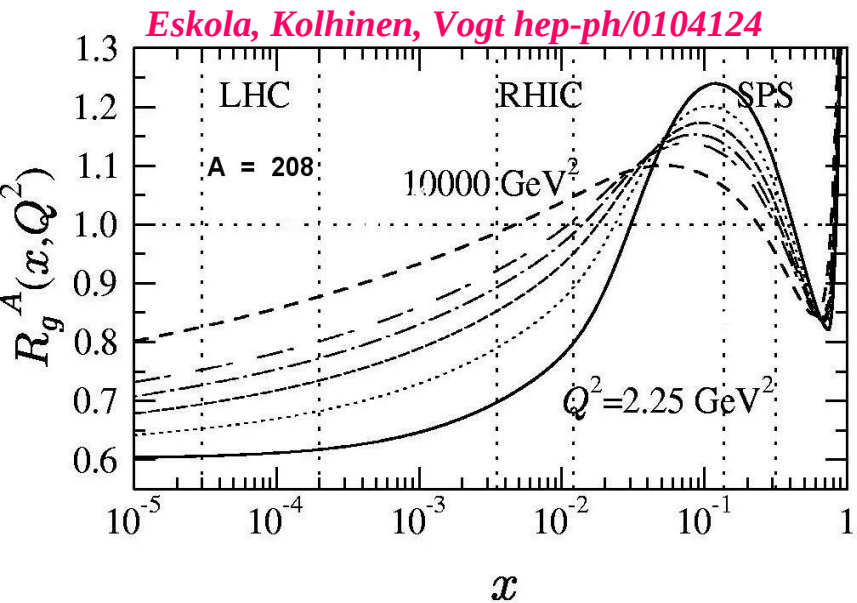
Initial state/final state interactions with medium

- Multiple scattering→broadening of p_T spectra
- Energy loss
- Absorption reduces J/Ψ as $c\bar{c}$, J/Ψ propagate through nucleus

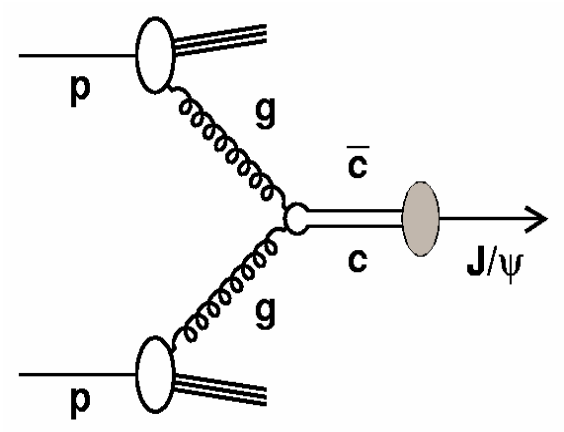
Modification of the parton distribution functions:

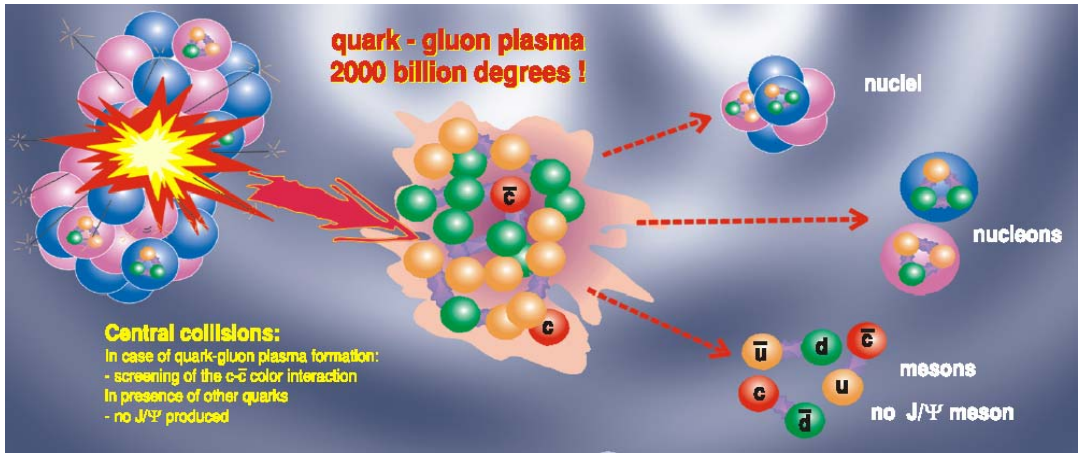
- Gluon shadowing would lead to reduction of production at low x. Antishadowing would give enhancement at moderate x





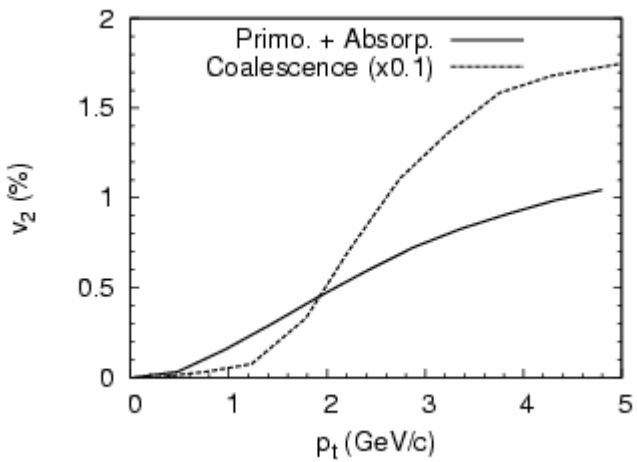
Charm and J/Ψ in Heavy Ion Collision



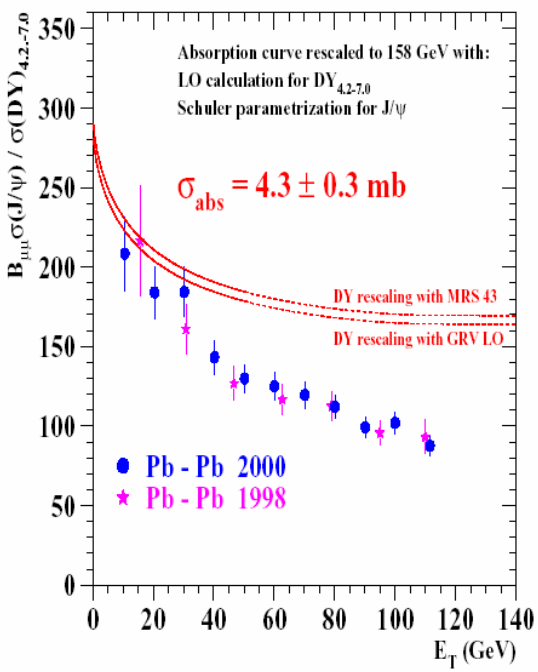


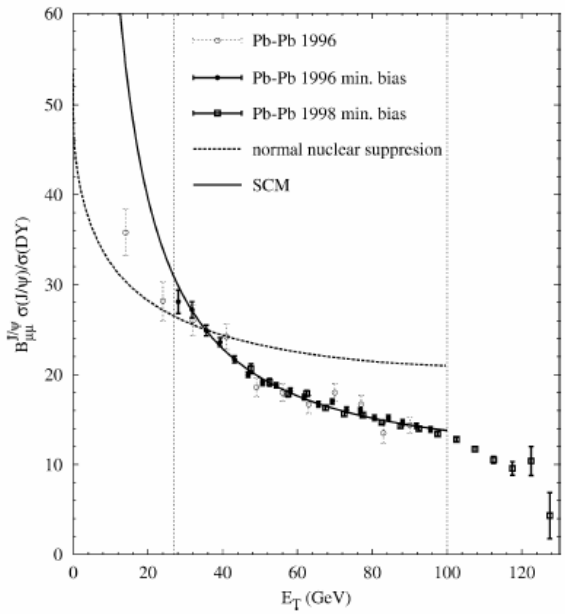
pA effects scaled up PLUS

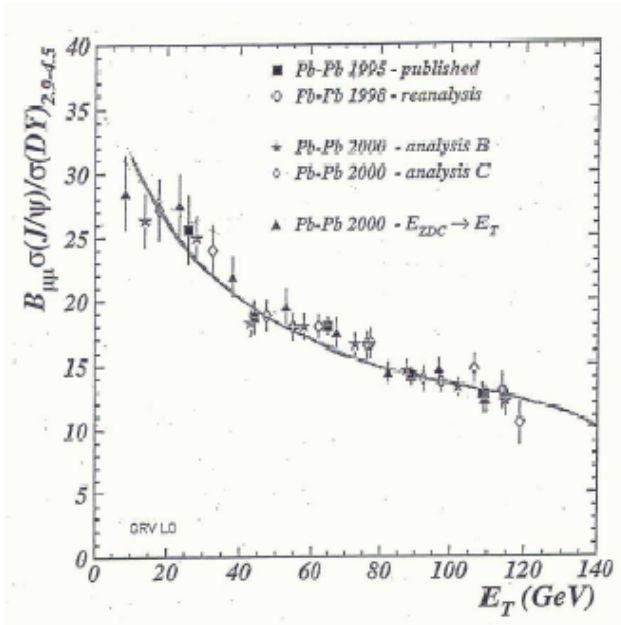
- Hot hadron gas, comovers
- QGP/dense matter modifications to production:
  - Debye screening,
  - Enhancement in coalescence models, balan
  - Thermal production of charm
  - Energy loss and dead cone effect



J/Ψ Suppression in Pb-Pb at NA50



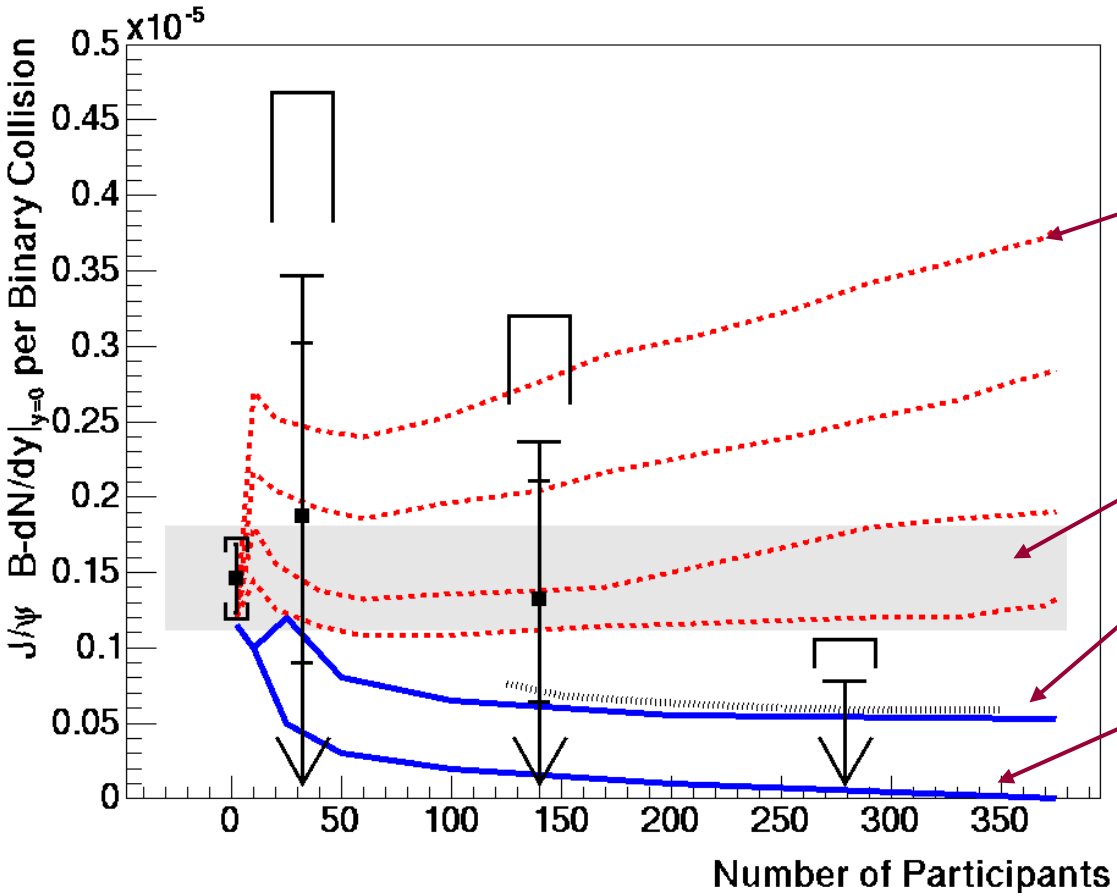




- Suppression with respect to normal nuclear suppression expectations
- Theorists have produced various alternative models which also reproduce data:
  - Statistical coalescence model (also needs enhanced open charm)
  - Comovers

RHIC data on J/Ψ highly desired to compare

J/Ψ from AuAu Collisions at 200 GeV, Run 2



R. L. Thews, M. Schroedter, J. Rafelski, Phys Rev C 63, 054905
Plasma Coalescence Model

Binary Scaling

Absorption (Nuclear + QGP) + final-state coalescence

Absorption (Nuclear + QGP)
L. Grandchamp, R. Rapp, Nucl Phys A709, 415; Phys Lett B 523, 60

•Not enough statistical significance to distinguish various models but strong enhancement seems to be disfavored.

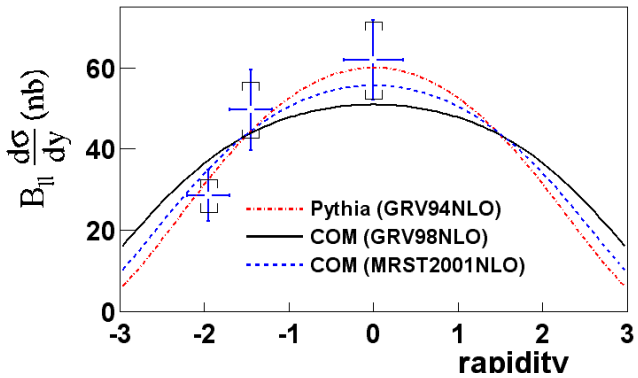
J/Ψ Measurements from PHENIX

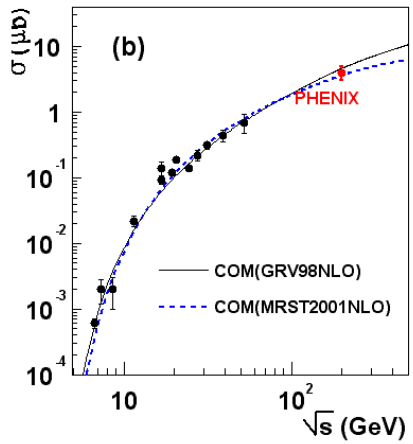
- pp at 200 GeV (Runs 2, 3 and 4 at RHIC)
  - Baseline for understanding modifications in dAu, AuAu
  - J/Ψ polarization (may help in understanding production)
  - Gluon contribution to spin
- dAu at 200 GeV (Run 3)
  - Nuclear modifications to procution in cold-nuclear matter.
- AuAu at 200 GeV (Run 2 and 4)
  - How does hot dense matter formed modify production, what does this imply about matter formed?

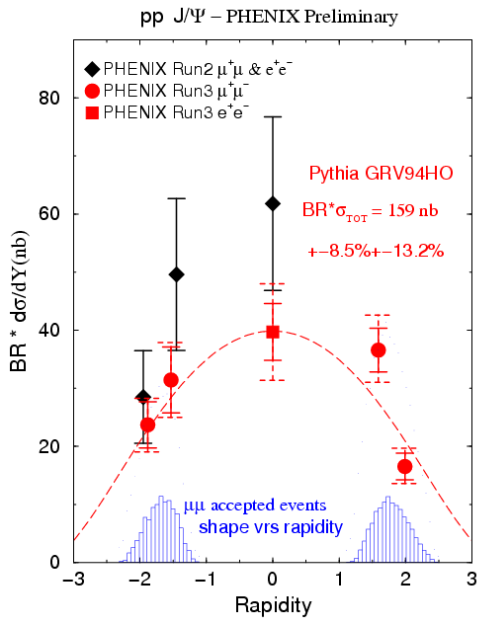
LANL Contributions to J/Ψ efforts

- In addition to hardware, detector commisioning, etc.:
- Run 2 pp
  - All MuTr analysis software from LANL
  - First J/Ψ measurement from RHIC
  - Small group producing cross section output; LANL 1 of 6 on paper-writing committee
- Run 3 dAu
  - LANL continued to be major contributor to analysis software
  - LANL headed up analysis and paper-writing of results
- Run 4 AuAu
  - Much larger analysis team now, but LANL still playing one of lead roles in tool development and analysis
  - Work in progress
- Run 5 CuCu and pp
  - Plan to work on spin and polarization pp measurement. Most likely some work contributing to CuCu

J/Ψ from pp Collisions at 200 GeV (Runs 2+3)







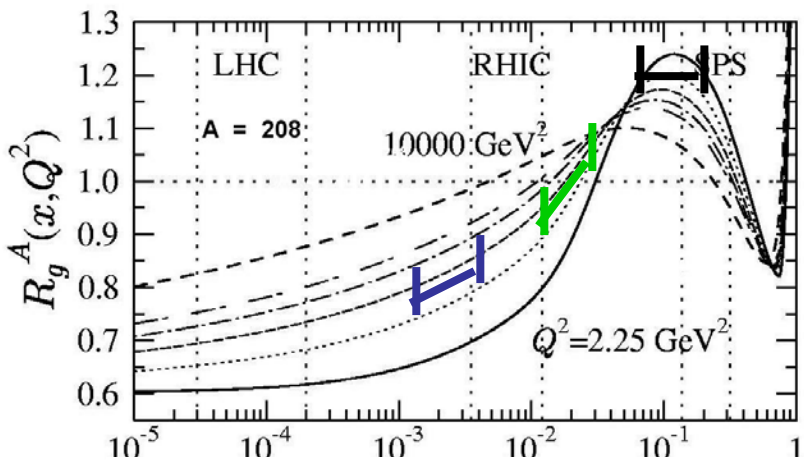
Central and forward rapidity measurements:

- Rapidity shape consistent with various PDFs
- √s dependence consistent with various PDFs with factorization and renormalization scales chosen to match data

Higher statistics needed to constrain PDFs

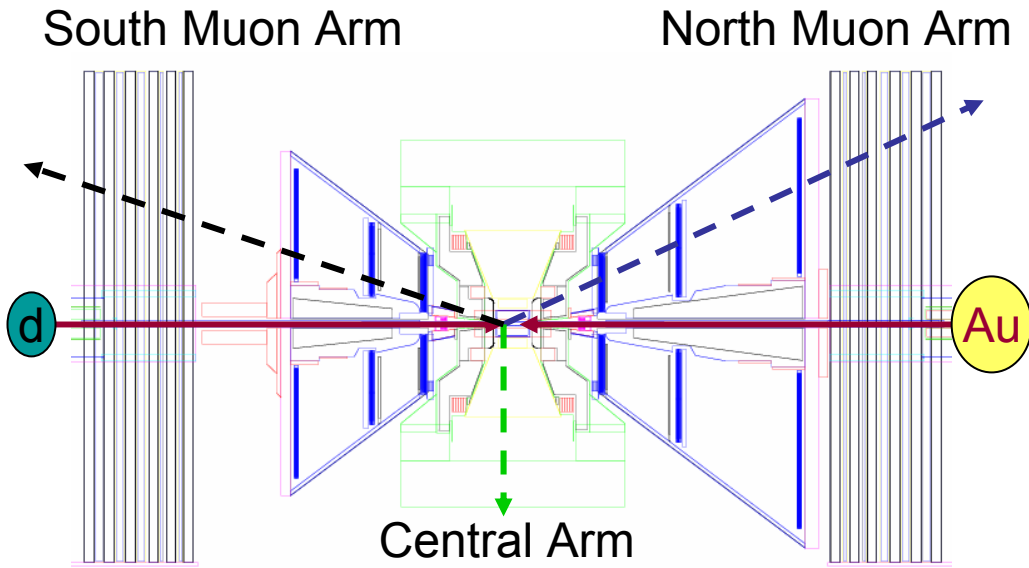
PHENIX: J/Ψ in dA

Eskola, Kolhinen, Vogt hep-ph/0104124



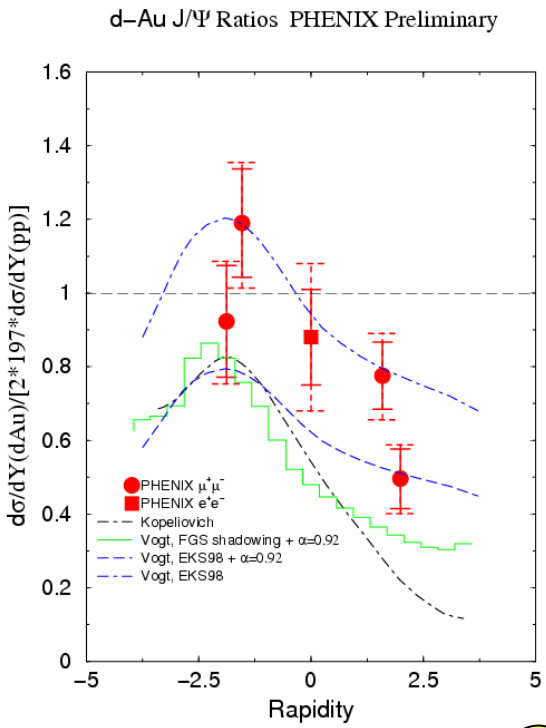
PHENIX μ, North **PHENIX μ, SOUTH**

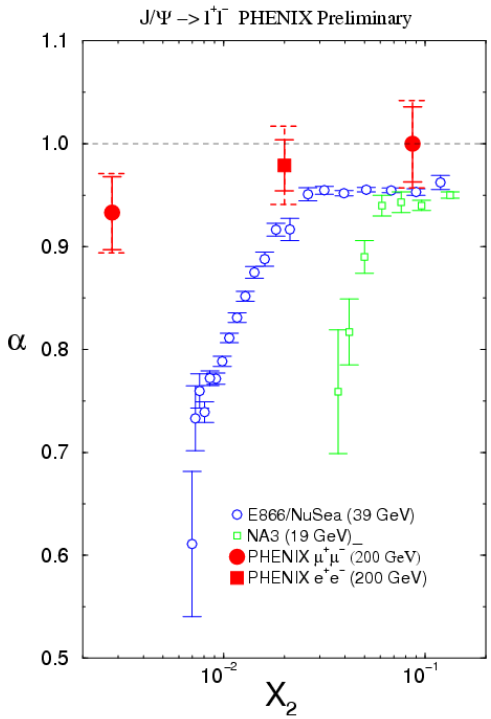
PHENIX e

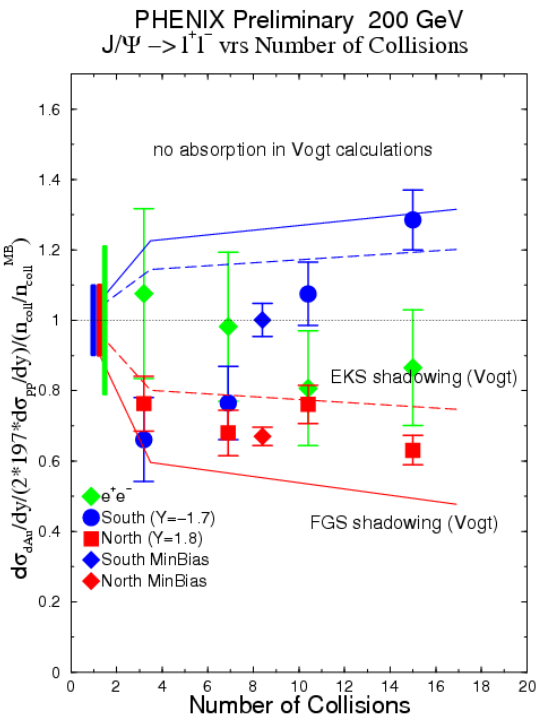


- PHENIX measurements cover expected shadowing, anti-shadowing range
- All expected to see p_T broadening
- dE/dx not expected to be significant effect at RHIC energies
- Overall absorption expected

J/Ψ from dAu Collisions at 200 GeV





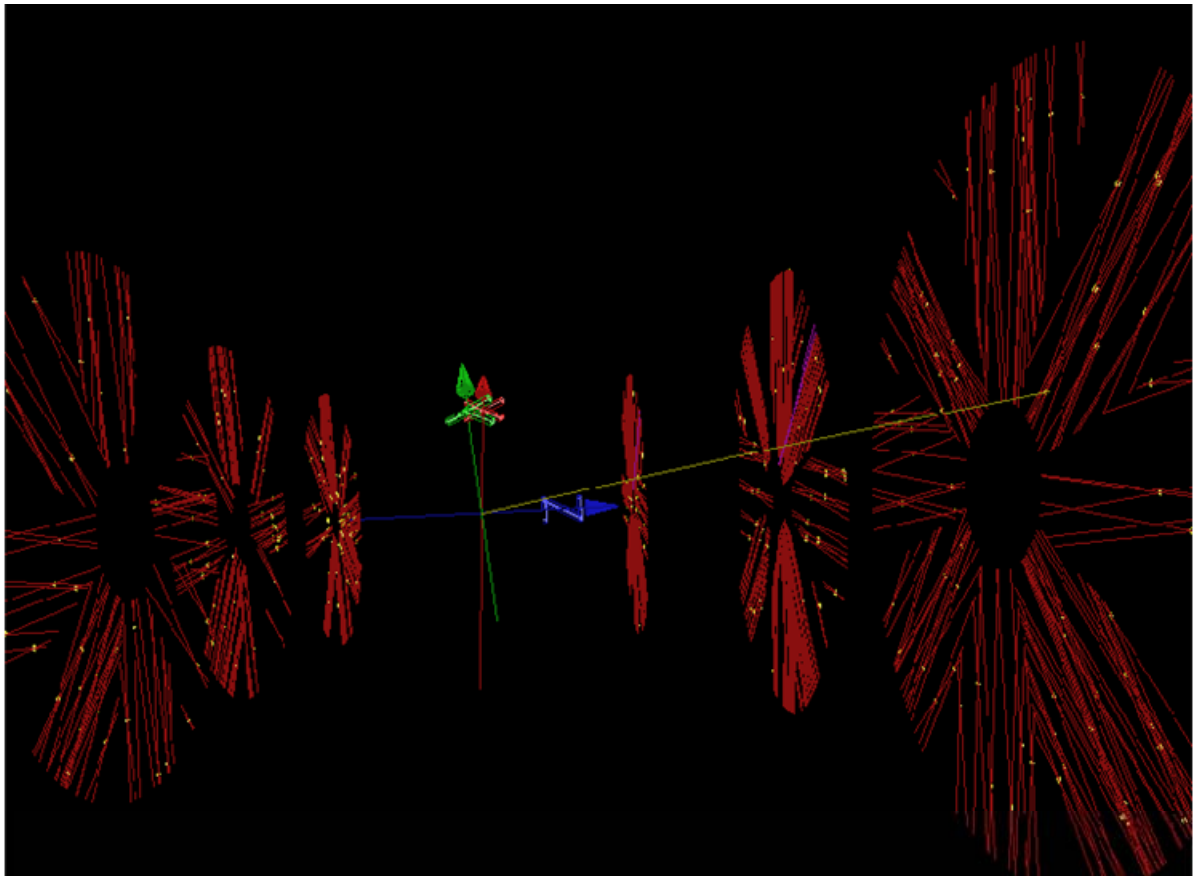


•Suppression in deuteron direction consistent with some shadowing but can't distinguish among various models, Overall absorption

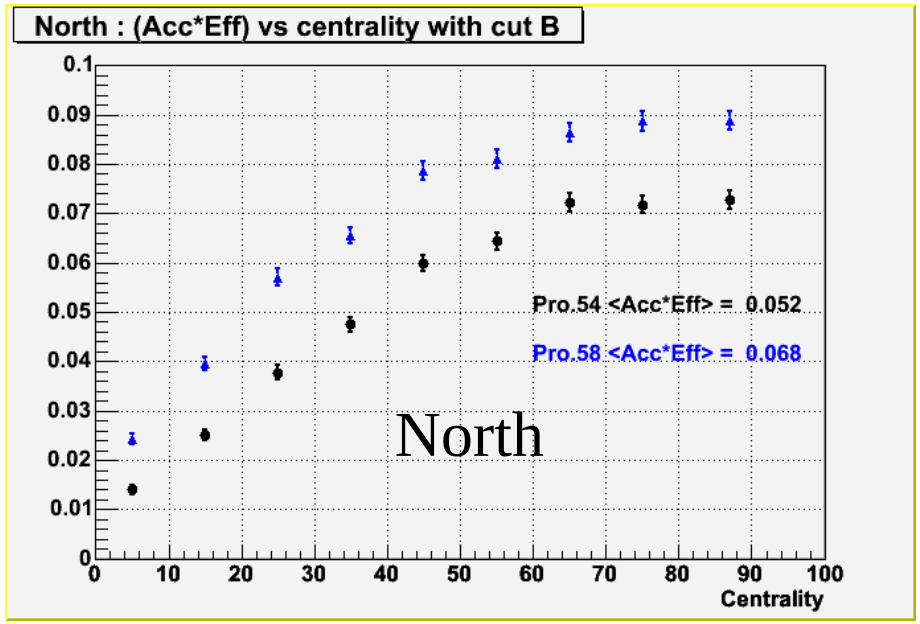
J/Ψ from AuAu Collisions at 200 GeV

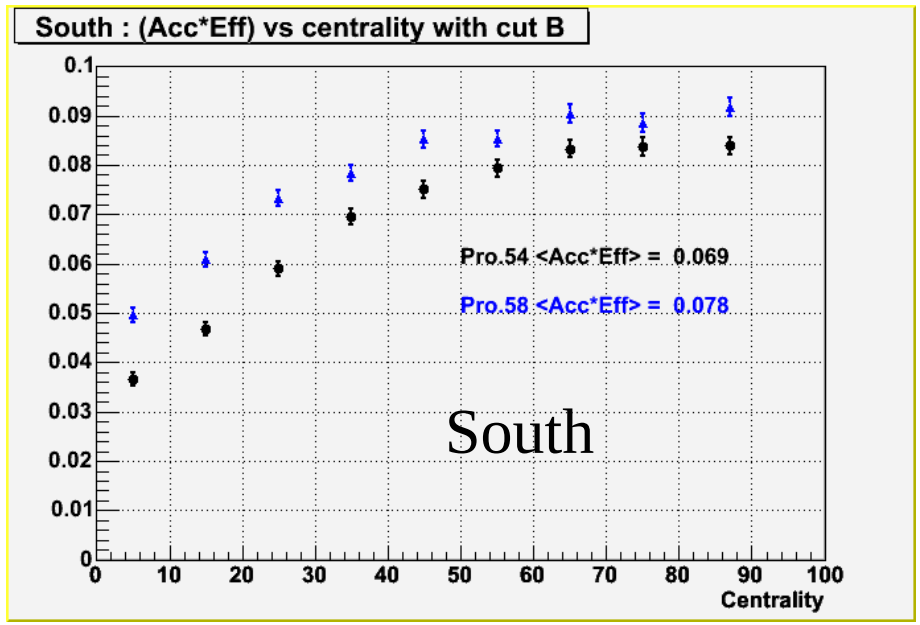
- Technical Challenges
  - Very high occupancy environment
  - Large data set to analyze in timely manner
- Physics Challenges
  - Theoretical Expectations cover Large Range
  - Interpretation may be challenging
- Expectations
  - Few thousand J/Ψs from each arm
  - Yield versus centrality, rapidity p_T
  - Flow measurement

Technical Challenges - High Occupancy



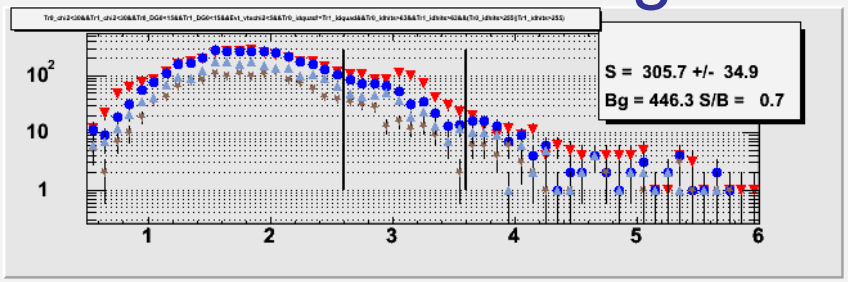
Difficult to Find Everything with High Efficiency

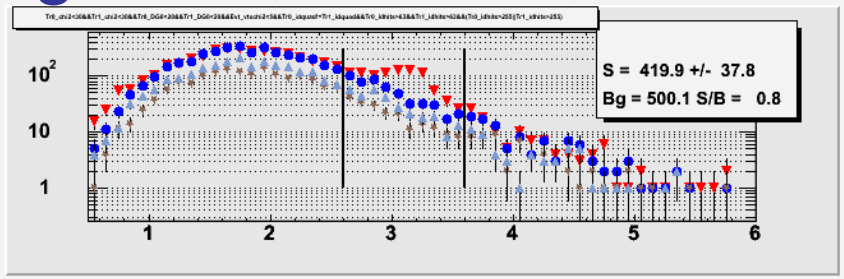


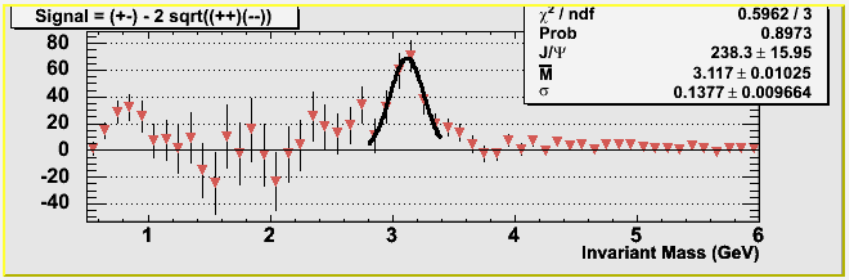


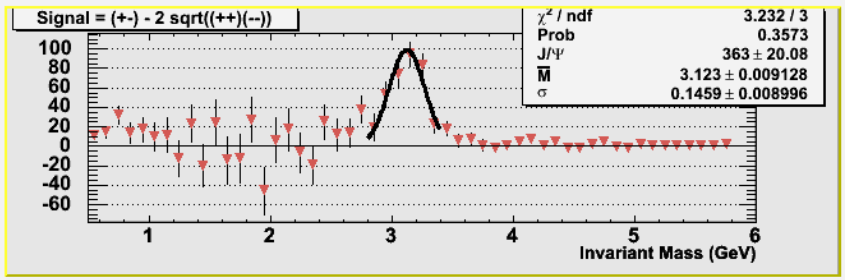
- Much work over past months to improve performance (mostly LANL) with noticeable headway, but may require additional work
- Plan to proceed with a pass on data and preliminary result

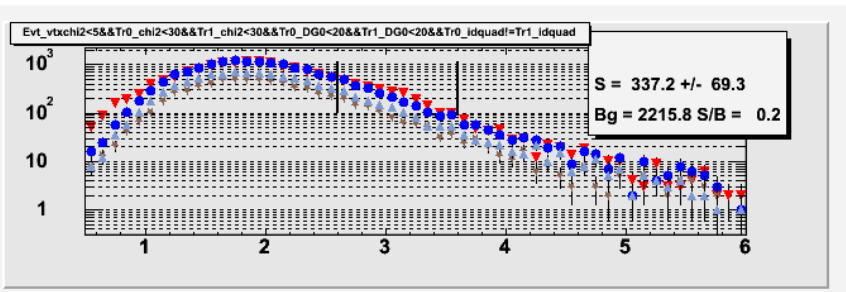
Current State of Signal:Background, 40-92%, 20-40%

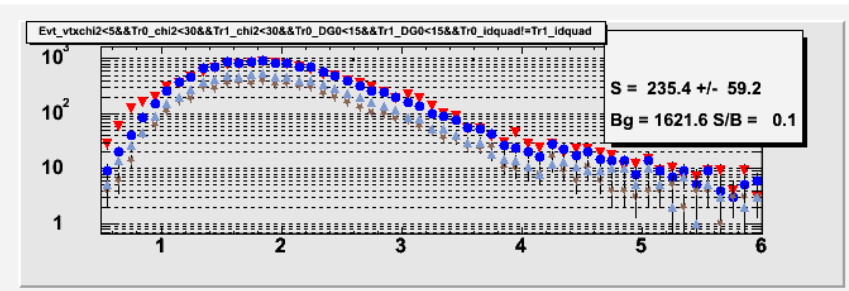


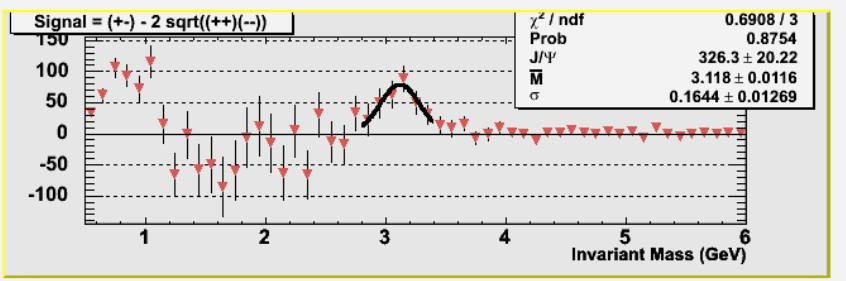


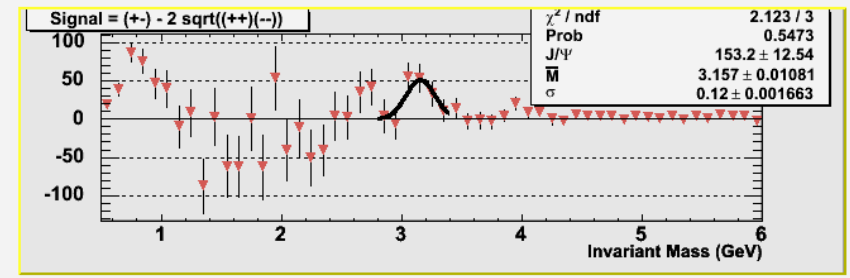












South

North

Future J/Ψ

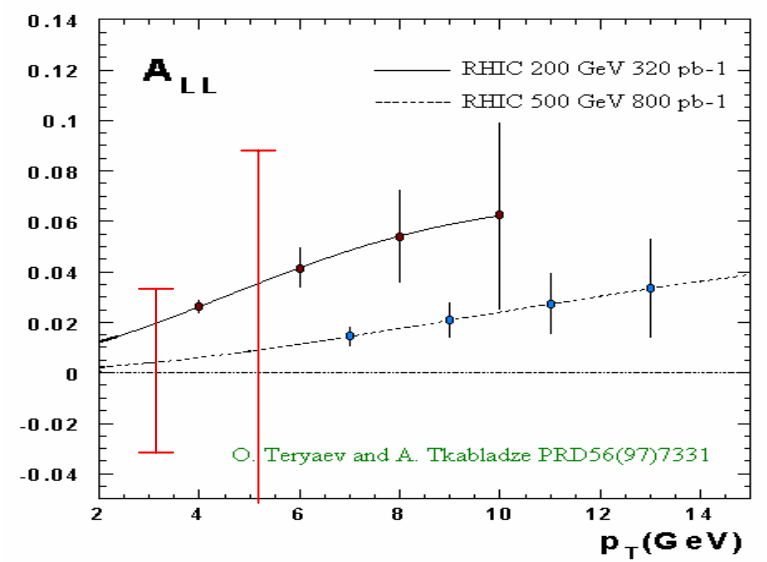
- Run 5 and Run 6 pp
  - Significant J/Ψ polarization measurement
  - Possibility for gluon polarization, certainly techniques and tools will be established
- Improved signal:background in AuAu events with forward silicon
- Combine with other vector meson measurements (Ψ', Υ, chi?)

Backups

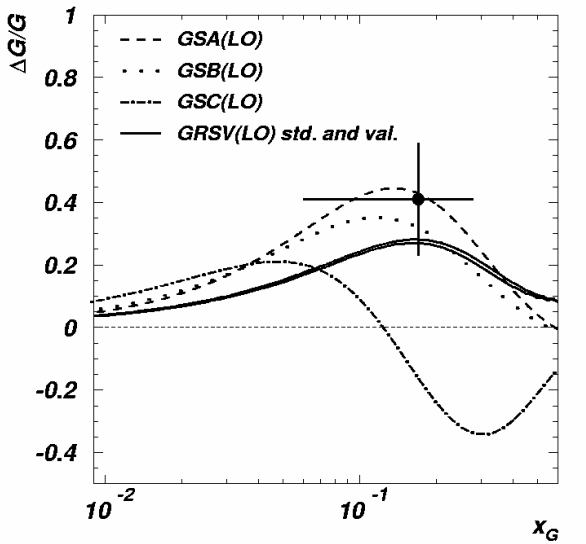
Gluon Polarization (feasible in Run 5/6)

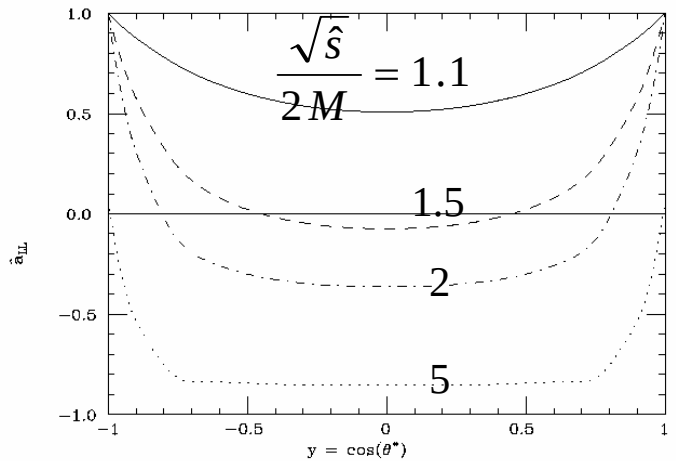
- A_LL from J/Psi

$$A_{LL}^{pp\to Q\bar{Q}X}(x_1,x_2)=\frac{\sigma_{+-}-\sigma_{++}}{\sigma_{+-}+\sigma_{++}}$$
$$=\frac{\Delta G(x_1)}{G(x_1)}\frac{\Delta G(x_2)}{G(x_2)}a_{LL}^{gg\to Q\bar{Q}}$$



7.5pb^{-1},P_B=50%, One Arm





$$\delta A_{LL}(J/\Psi)=\frac{1}{p^2}\frac{1}{\sqrt{N}}\sim\frac{1}{0.5^2}\frac{1}{\sqrt{10{,}000}}=4\%$$