R_{dAu} Measurement with muons from light and heavy flavor decay in pp and dAu collisions at 200 GeV

Xiaorong Wang for PHENIX collaboration

New Mexico State University

Motivation:

- **Why open charm?**

  Provides a constraint on the parameters used in pQCD calculations.

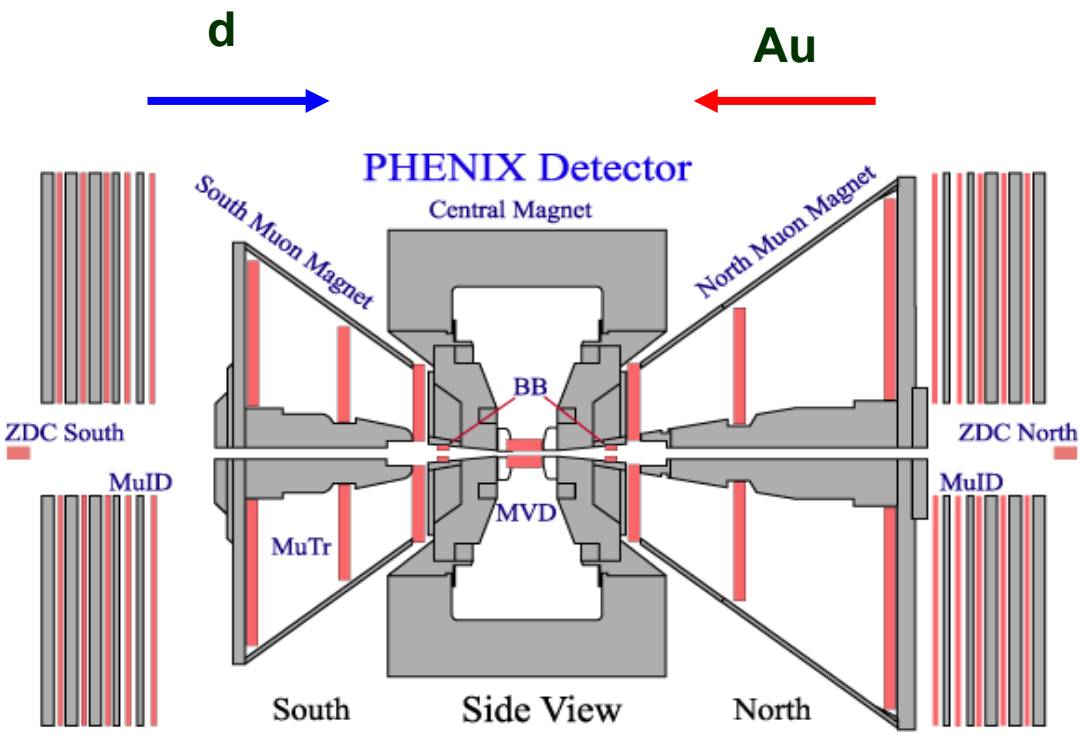
- **Probe cold nuclear medium effect in dAu collisions**
  - Gluon saturation/CGC at forward rapidity (small x) ?

$$y \sim 0: \quad d\sigma \propto N_{coll}$$
$$y \sim 2: \quad d\sigma \propto N_{part}$$

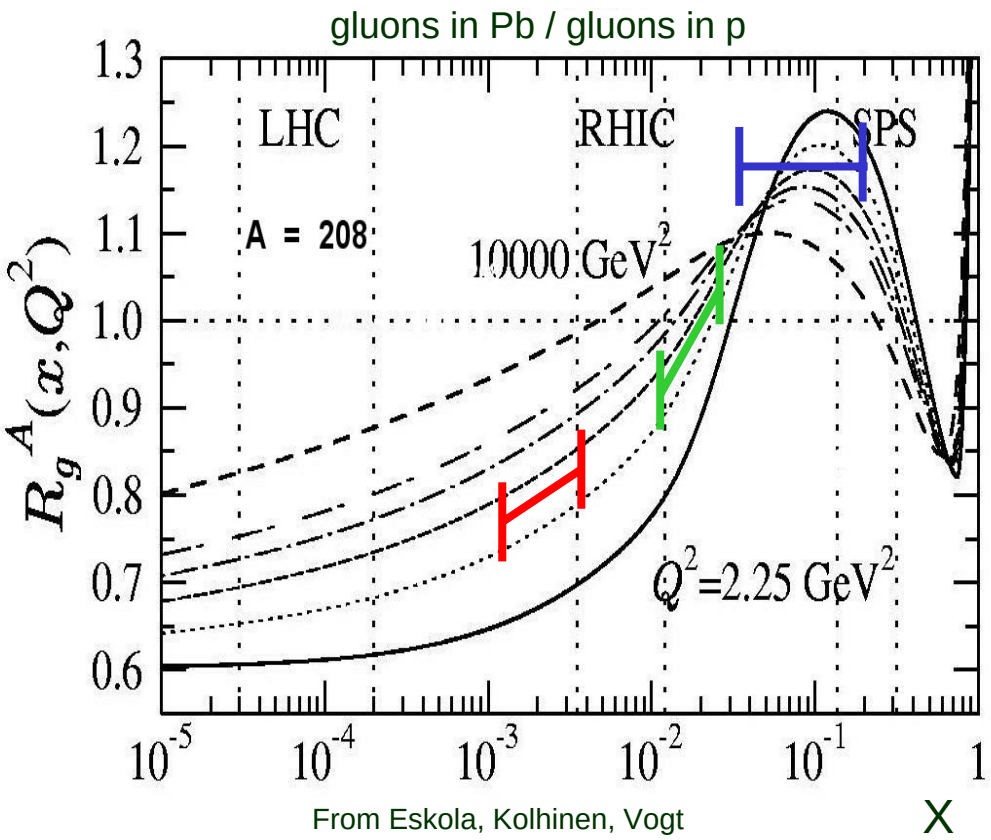
  - Coherent multiple scattering and X_B rescaling ?

Why PHENIX muon arms?

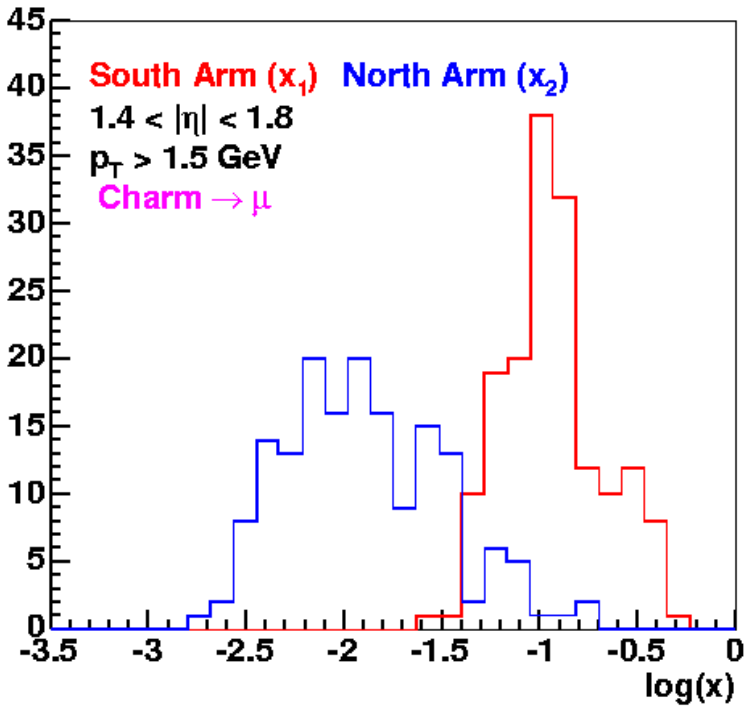
Particle production in the deuteron direction is sensitive to the small-x parton distribution in the Au nuclei; whereas particle production in the gold direction is sensitive to the large-x parton distribution



PHENIX muon arms coverage



From Eskola, Kolhinen, Vogt
Nucl. Phys. A696 (2001) 729-746.

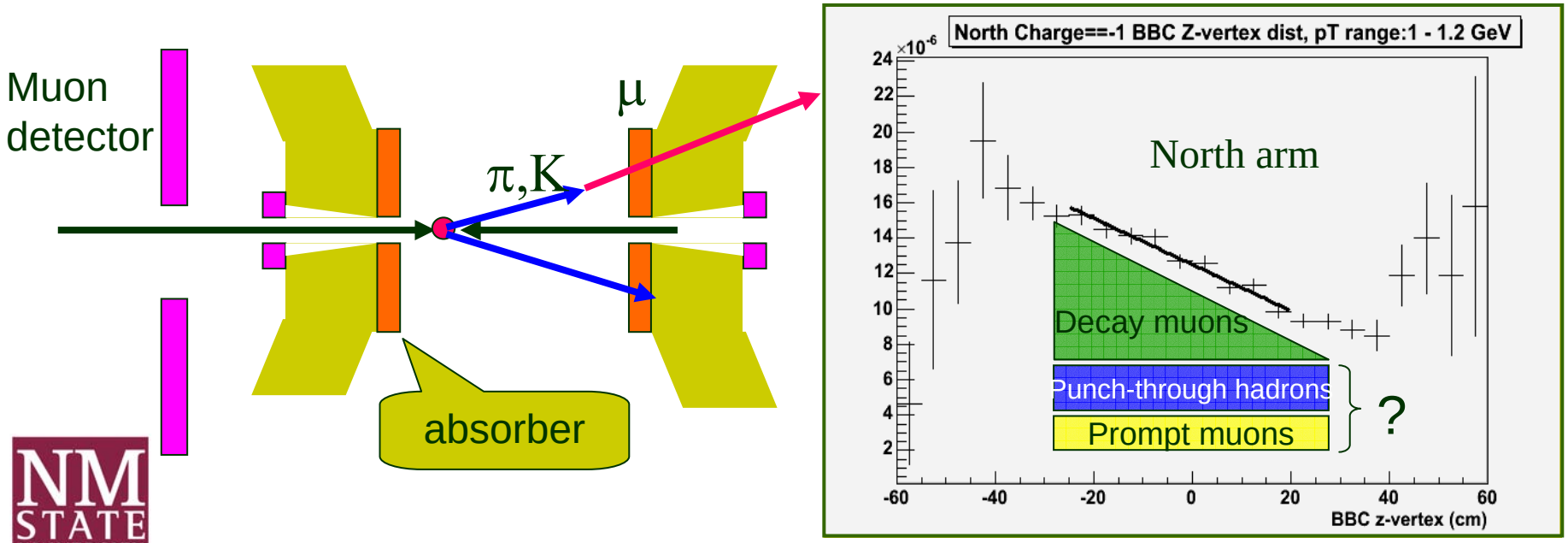


How muon detector measures muons from light hadron and heavy flavor decay

The normalized muon event vertex distribution

$$\frac{1}{N^{MB}_{measured}(Z)}\frac{d^3N(Z,\eta,P_T^{\mu^\pm})}{dZdP_T^{\mu^\pm}d\eta}\approx\{\alpha(P_T,\overline{\eta})\cdot(Z-Z^0_{eff})+\beta(P_T,\overline{\eta})\}$$

Light Hadron Decay muons can be separated by vertex distribution analysis



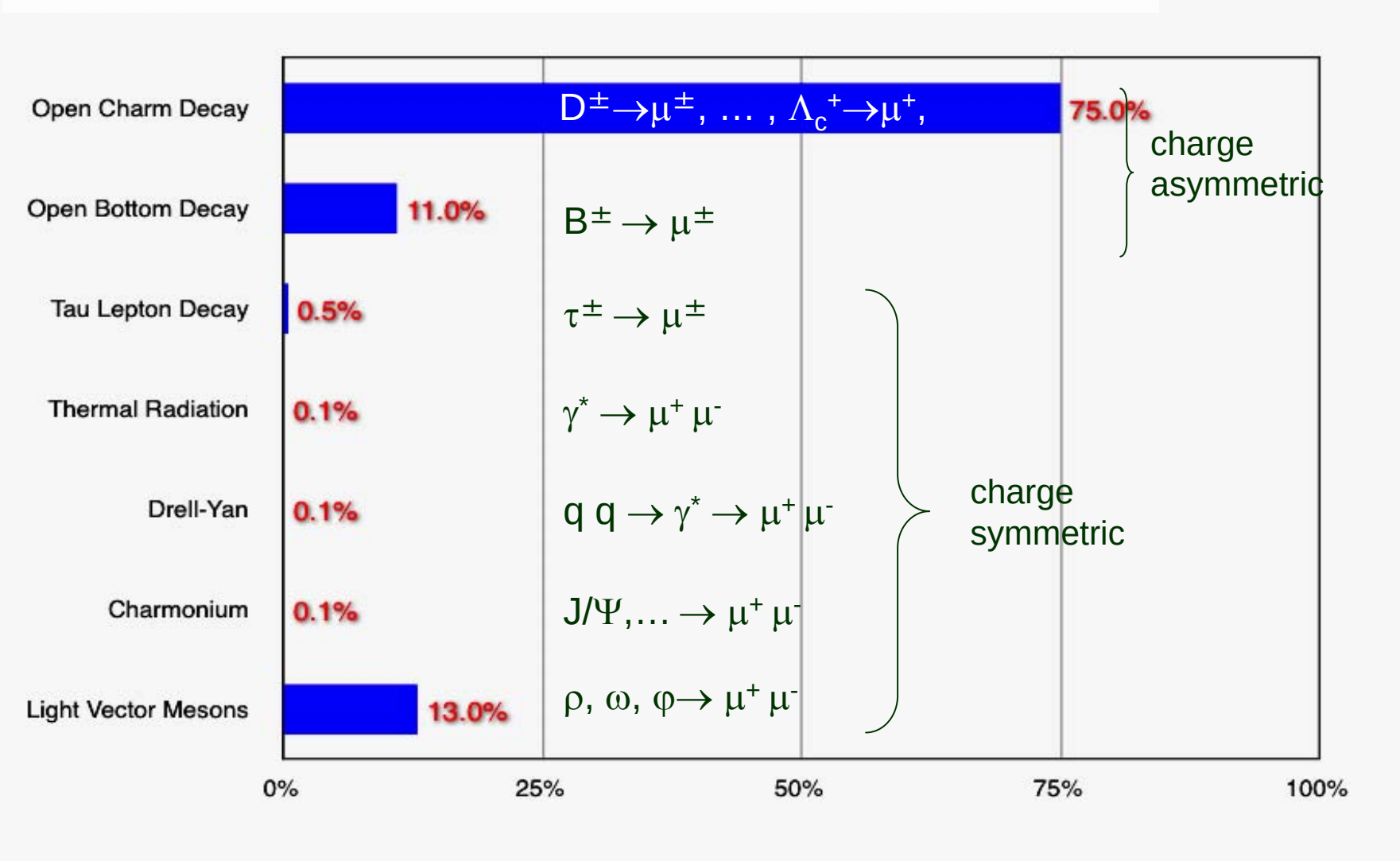
How to extract prompt muon signal

- "Prompt" muons from semi-leptonic decays

  $N_{prompt} = N_{inclusive\ tracks} - N_{punch\text{-}through} - N_{free\text{-}decay\text{-}muons} - N_{decay\text{-}track\text{-}volume}$

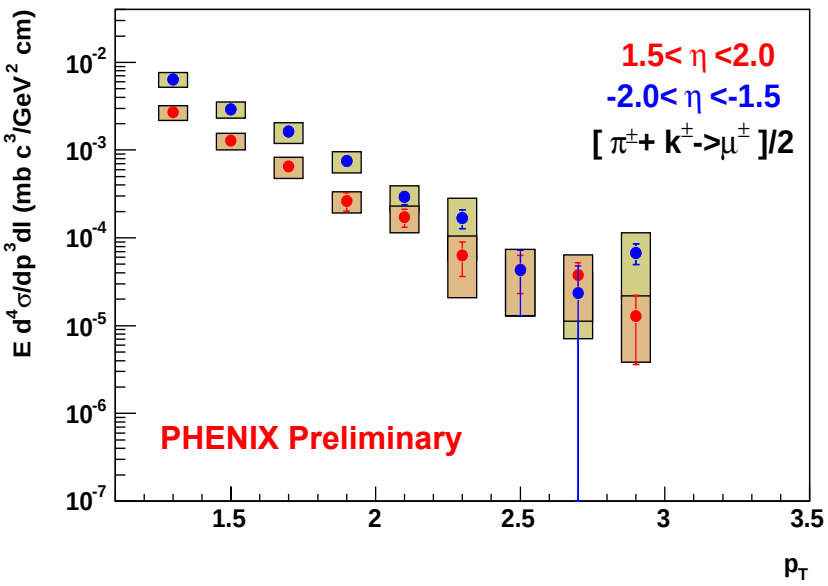
- Backgrounds cannot be removed on a event by event basis, but can be successfully dealt with on a statistical basis.
  - Punch-through hadrons:
    - Data driven method: to estimate attenuation.
  - Decay in track volume:
    - estimate the decay in track volume contribution relative to decay muons by hadron simulation.

Sources of Prompt Muons (p_T> 0.9GeV) (determined from Pythia)

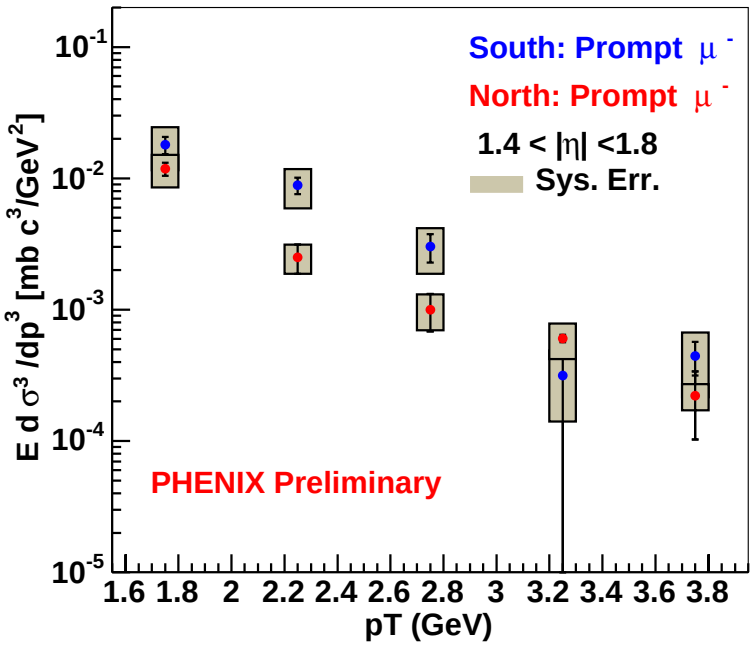


p_T spectra in dAu collisions

Decay μ's (from light hadrons)

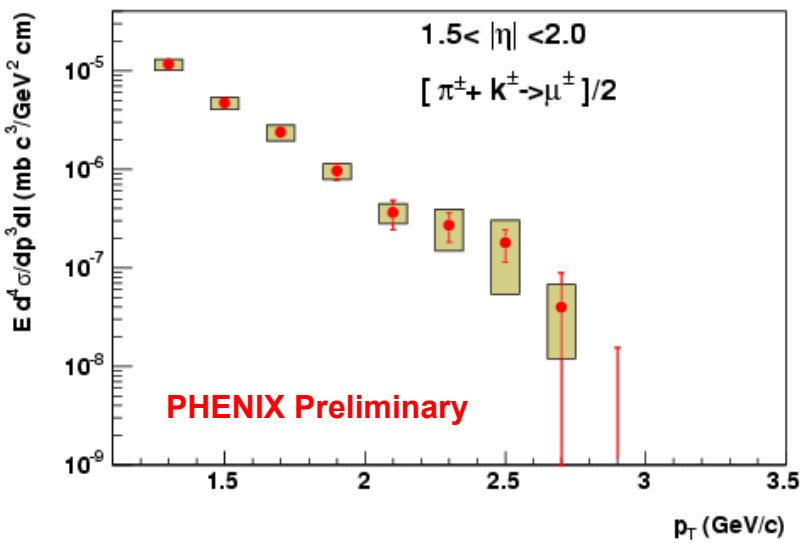


Prompt μ's (from heavy quarks)

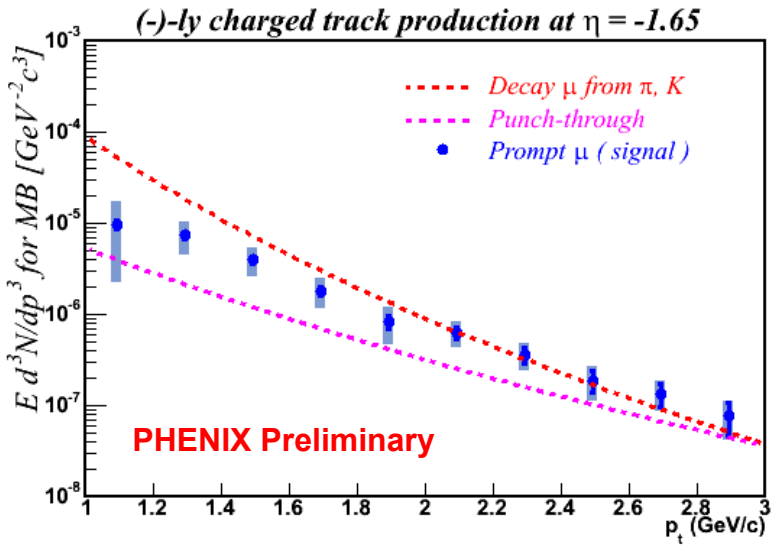


pT spectra in pp collisions

Decay μ's (from light hadrons)

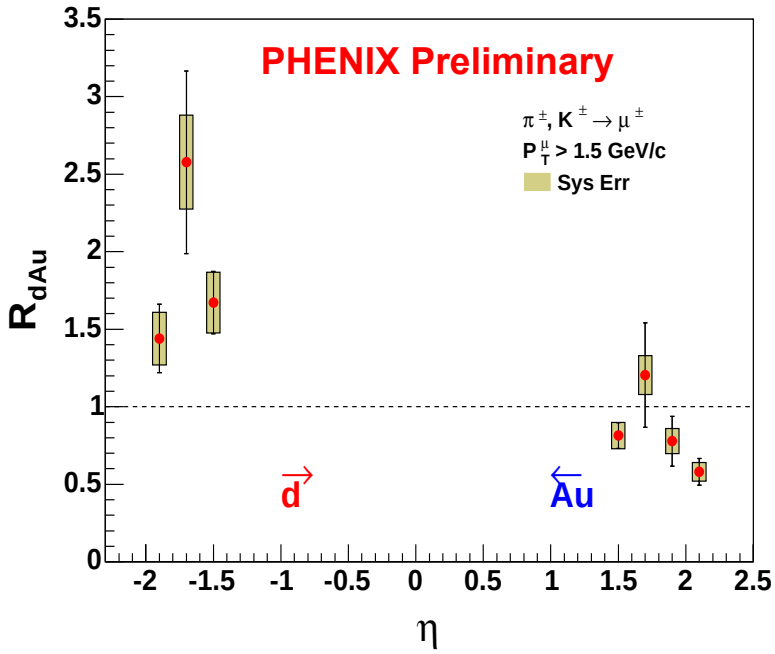


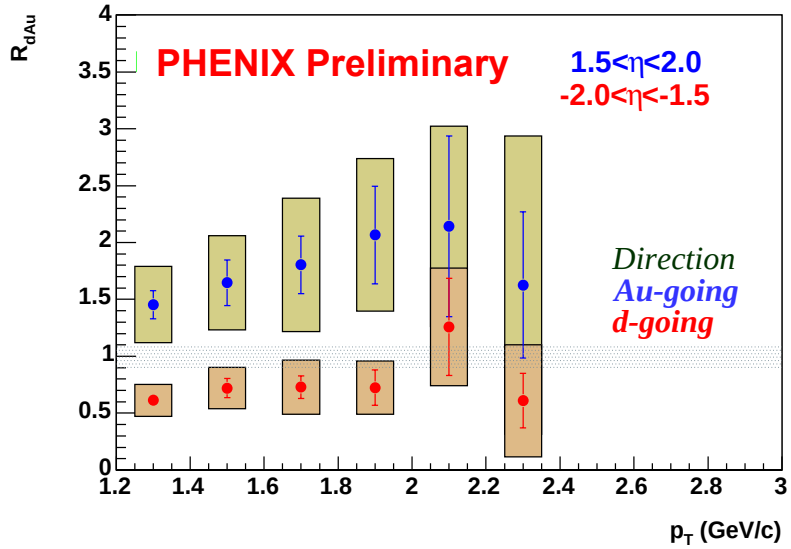
Prompt μ's (from heavy quarks)



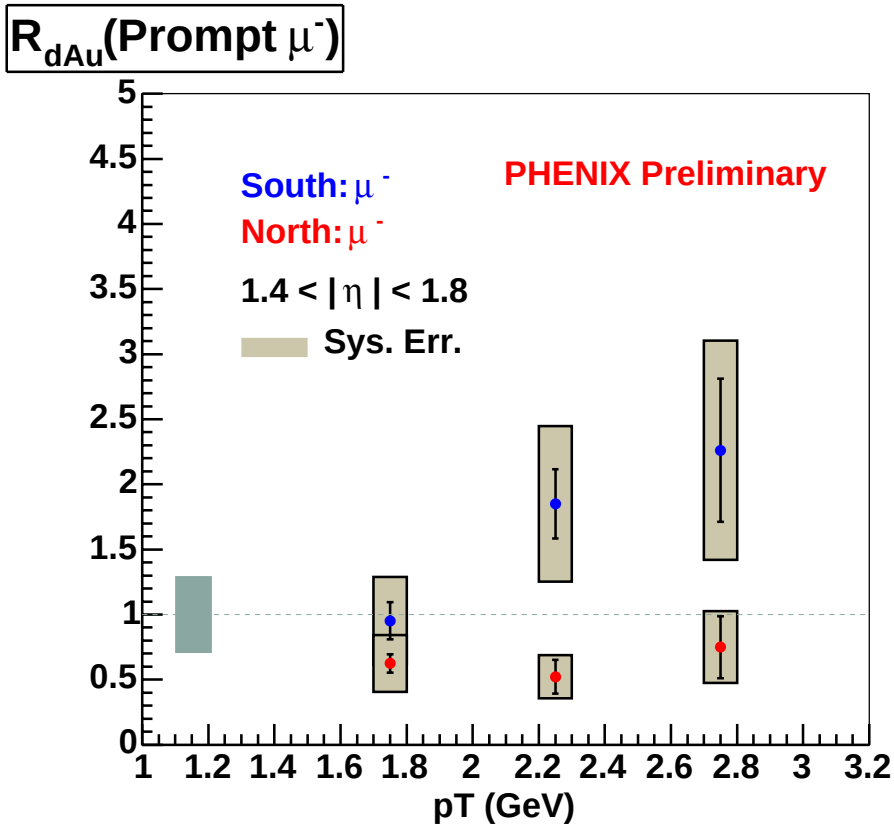
Nuclear Modification Factor: R_{dAu} (decay μ from light hadrons)

$$R_{dAu}(p_T,\eta) \equiv \frac{\frac{1}{2\times 197}\frac{d^2\sigma^{d+Au\to\mu+X}}{dp_T d\eta}}{\frac{d^2\sigma^{p+p\to\mu+X}}{dp_T d\eta}}$$





Nuclear Modifiation Factor: R_{dAu} (prompt μ from heavy quarks)



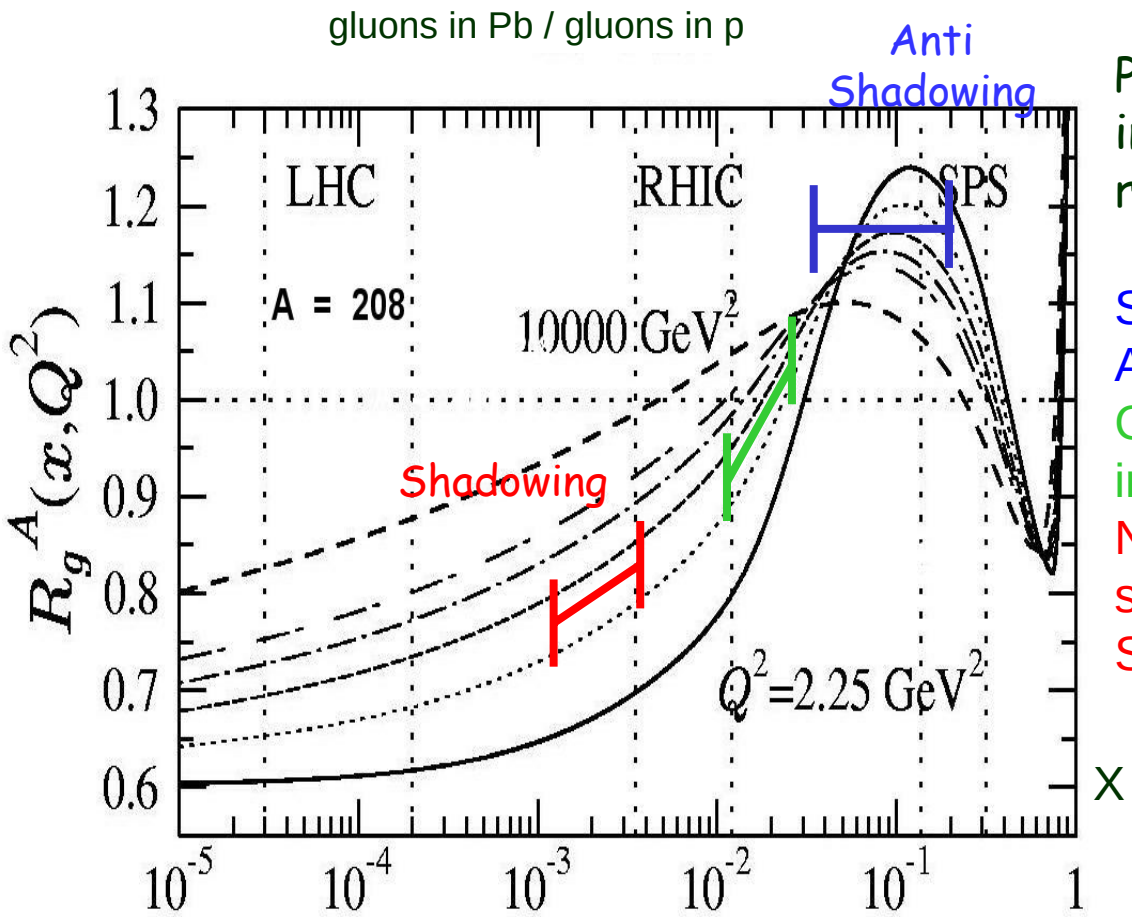
Summary:

- PHENIX measured production of decay μ and prompt μ at forward/backward rapidities in p+p at $\sqrt{s}$ = 200 GeV and d+Au at $\sqrt{s_{NN}}$ = 200 GeV.

- For both muons from hadron and open heavy flavor decay, a suppression in forward rapidity is observed. It is consistent with shadowing.

- The mechanism of the observed enhancement at backward rapidity needs more theoretical investigation. Anti-shadowing and Cronin-like effects could cause this enhancement.

Cold nuclear medium effect and gluon shadowing in dAu collisions

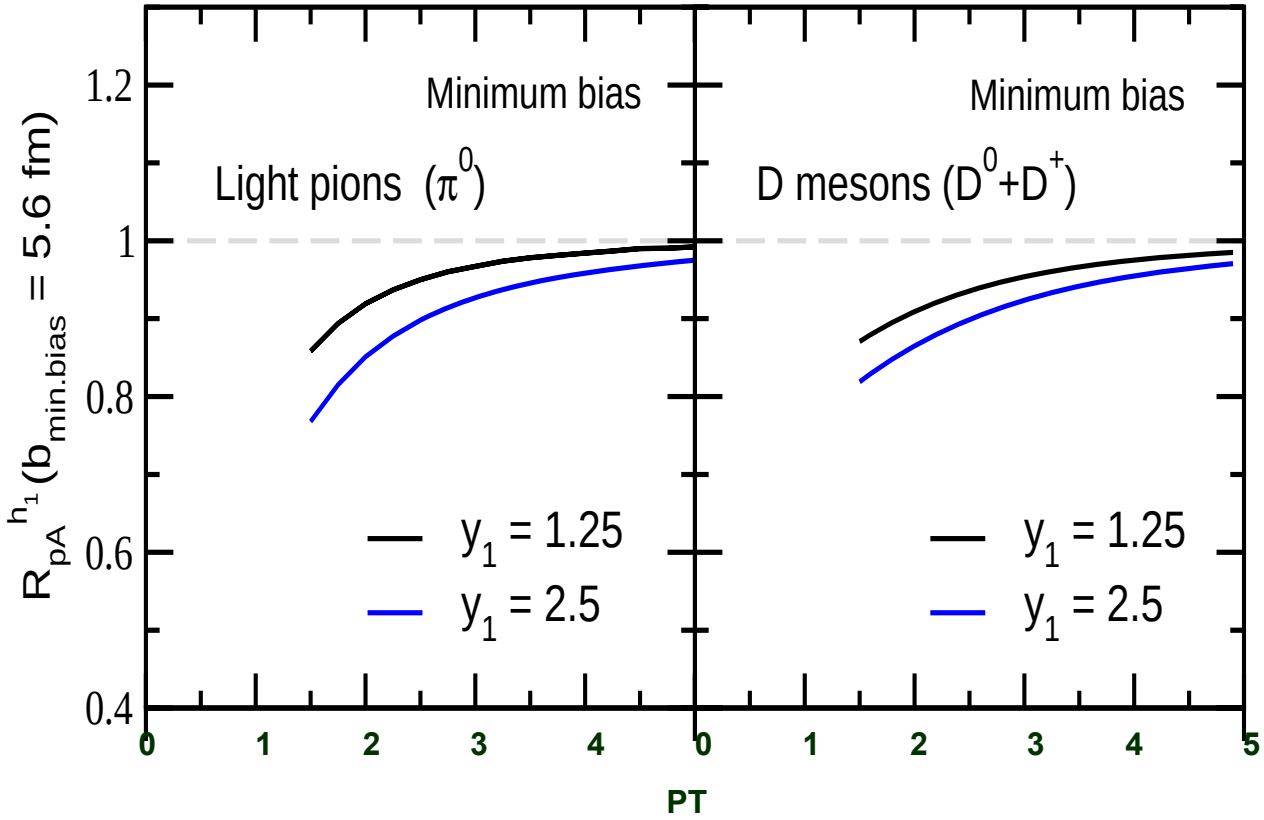


Probe parton momentum fraction in nucleus in three different rapidity ranges

South (y < -1.2) : large X_{Au} ~ 0.090
Anti-shadowing/Cronin regime
Central (y ~ 0) :
intermediate X_{Au} ~ 0.020
North (y > 1.2) :
small X2 ~ 0.003
Shadowing/suppression regime

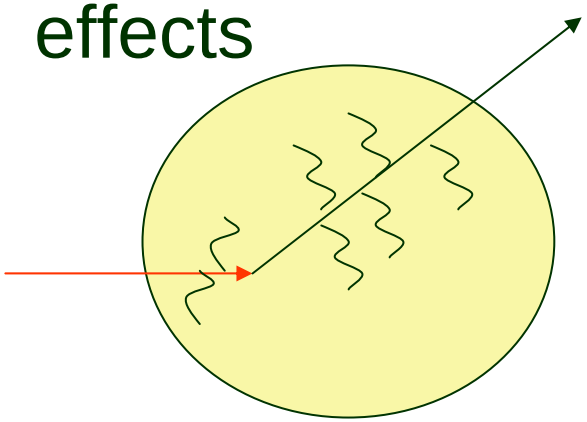
From Eskola, Kolhinen, Vogt
Nucl. Phys. A696 (2001) 729-746.

Coherent multiple scattering (power correction for open charm)

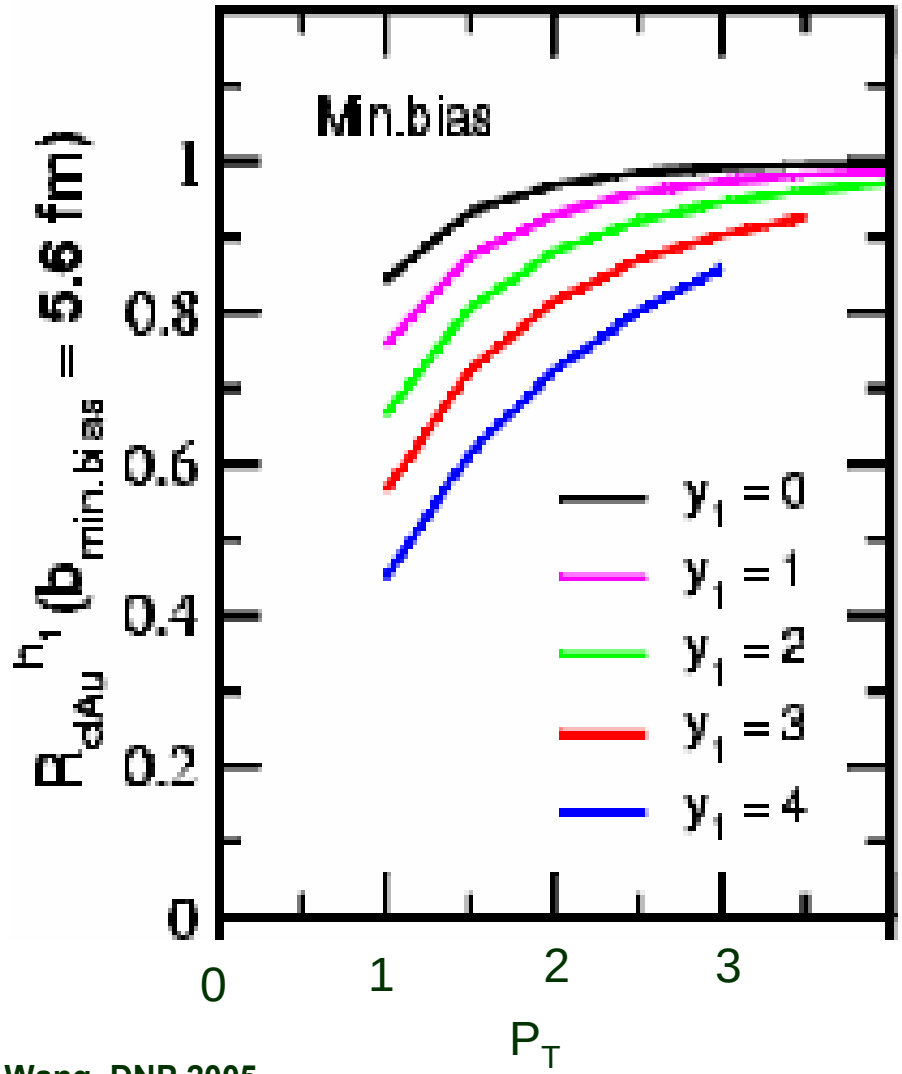


More on cold nuclear medium effects: final state scatterings

- Coherent multiple scattering and X_B rescaling
- Heavy quark mass effects



$$x_B \to x_B\left(1+\frac{M_c^2}{Q^2}+\frac{\xi^2(A^{1/3}-1)}{Q^2}\right)$$

$$\xi^2 \sim 0.1$$

J. Qiu & I. Vitev, 10/2004