Why QGP physicists should want to study e+A

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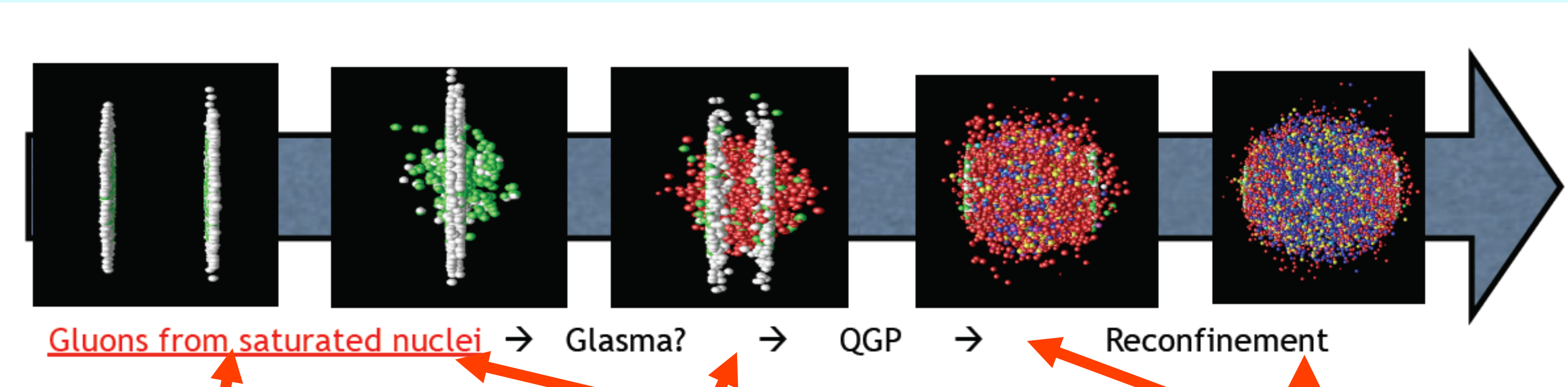
Steps in a heavy ion collision



• Nuclear wave function at small x: nuclear structure functions. Measure in pA/eA. Mixing them wise? Structure vs. parton dynamics!

• Particle production at the beginning: does it factorize? Coherence?

• How can the system reach ~ isotropy so fast?: initial conditions for plasma formation in AA and in pA.

• Probe medium with energetic particles (e.g. jet quenching): modification of QCD radiation and hadronisation in the nuclear medium.

pA for initial conditions

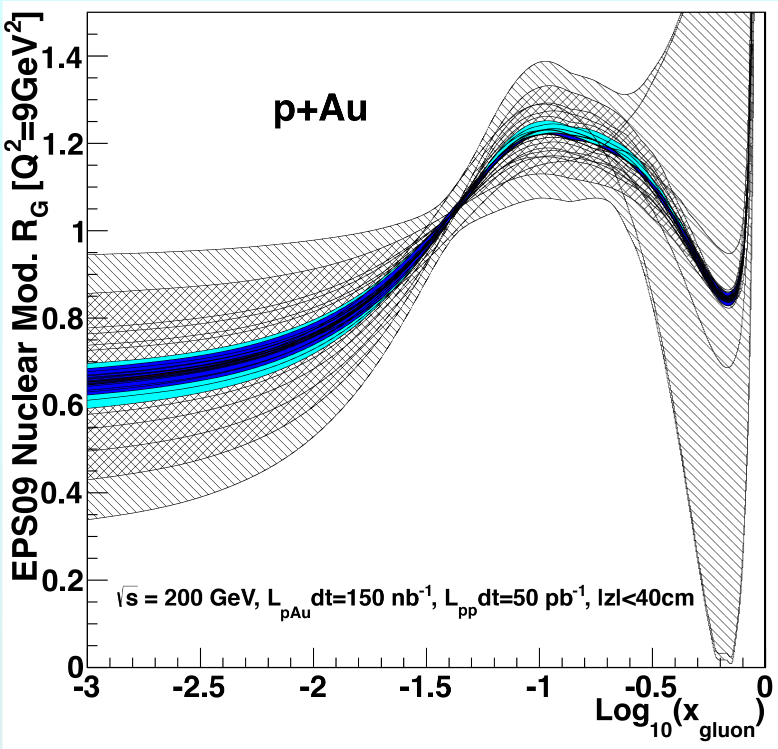
In p/d+A we probe cold nuclear matter with a parton, not a photon.

- It can lose energy before the hard scattering
- It can lose energy after the hard scattering
- It can experience multiple scattering
- These may be not be independent!

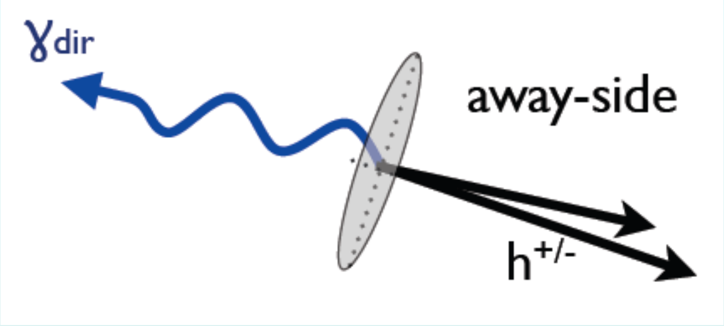
These are not just "background"

The physics is interesting, not well understood, and also relevant for parton-plasma interaction !

NB: Collective effects make life more "interesting"



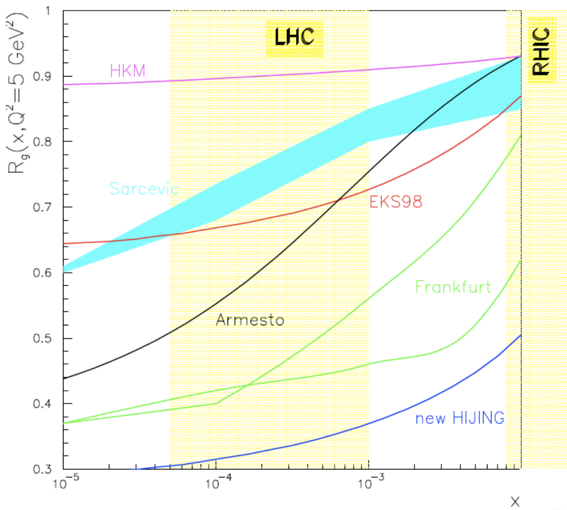
Tool of choice: QCD Compton Scattering



Direct γ reflect structure + initial state energy loss

- ***Also measure γ-h correlations in cold nuclear matter!***
- ***p+A: γ vs. h maps interactions AFTER hard scattering***
  Can do p+A at RHIC & LHC
  PHENIX will probe as function of y (x in the Au) in 2015
- ***e+A vs. p+A: turn off initial state scatterings***
  Needs the EIC!!!!

- **Backup**

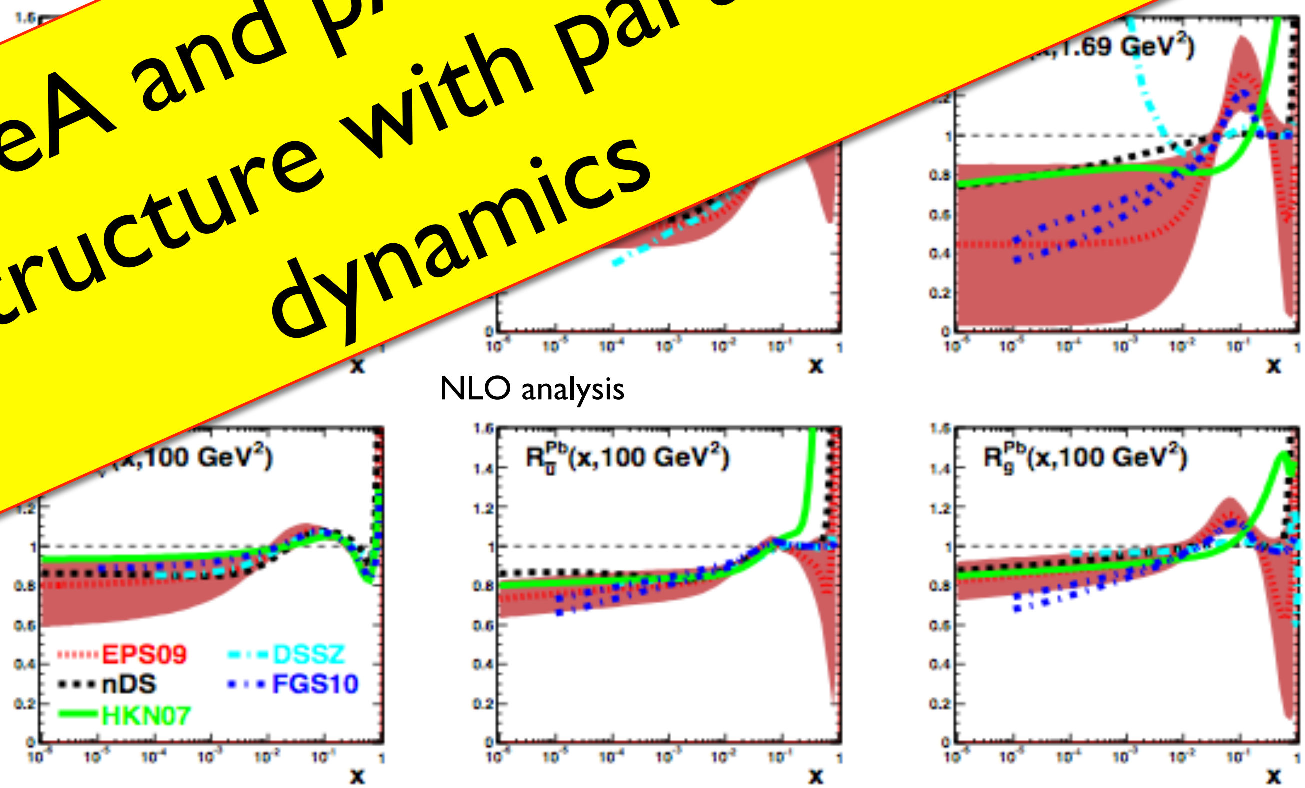


nPDFs: $R = \frac{f_{i/A}}{A f_{i/p}} \approx$ measured / expected if no n... effects

• Lack of data ⇒ mo... results for the ... x: probl...

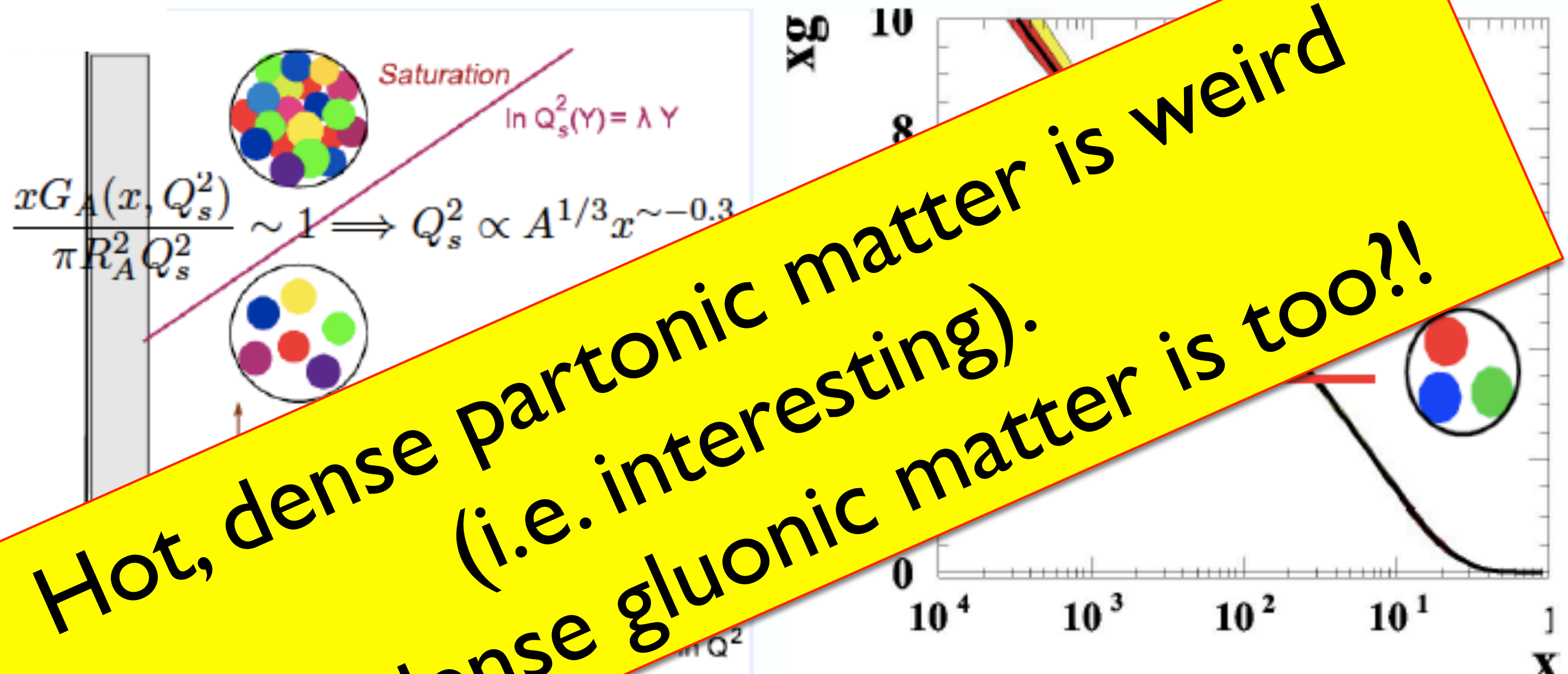
Yellow Report on Har... Probes, 2004

• ... a... sh... unc... small ... nd x.



Is mixing eA and pA in nPDFs wise? Mixes structure with parton probe dynamics

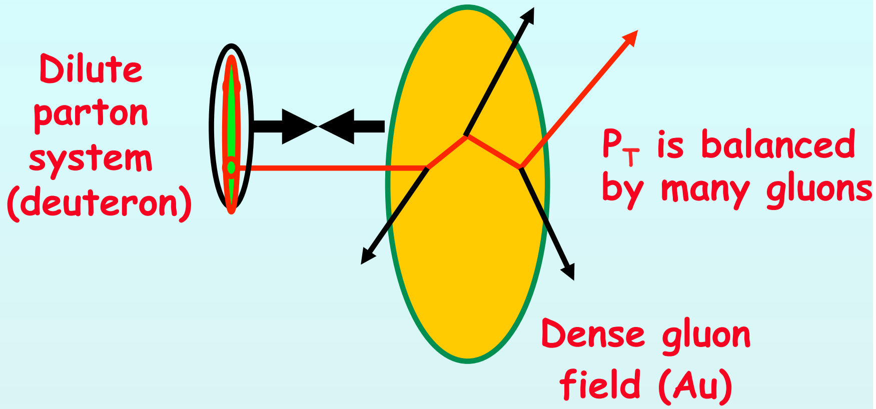
Small x and saturation:

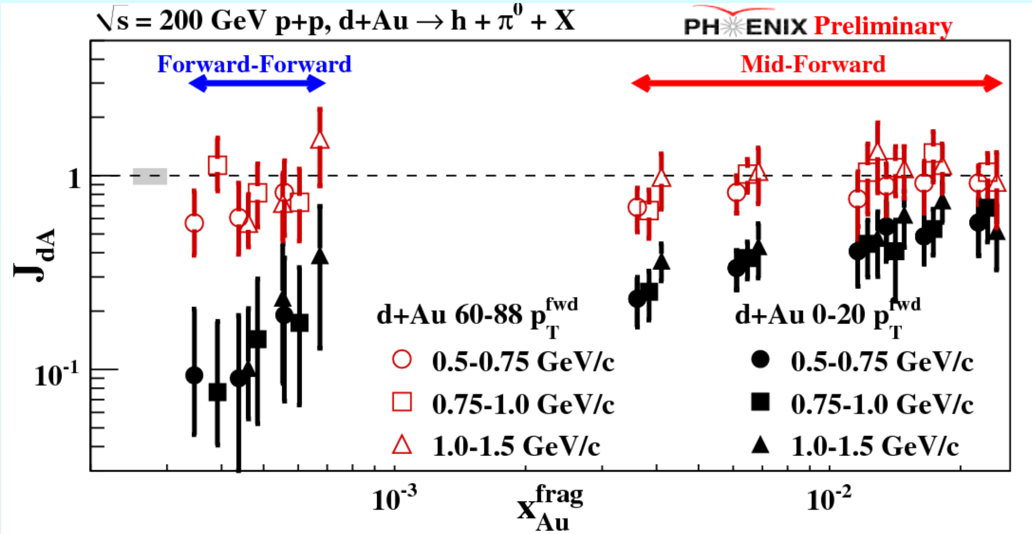


Hot, dense partonic matter is weird (i.e. interesting).
Cold, dense gluonic matter is too?!

- C… …ons when x decreases leads to a large num… (gluons), provided each parton evolves indep…tly (linearly, Δ[xg] ∝ xg).
- This independent evolution breaks at high densities (<u>small x or high mass number A</u>): non-linear effects (gg→g, Δ[xg] ∝ xg - k(xg)^2).

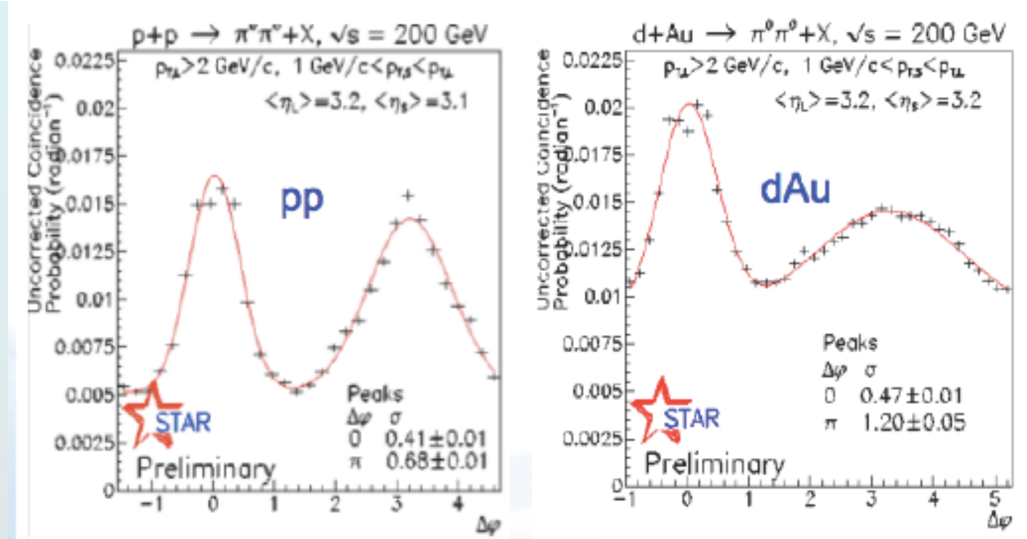
First hints at RHIC for saturation of gluons





Saturation = dense gluon field

Easier to equilibrate???



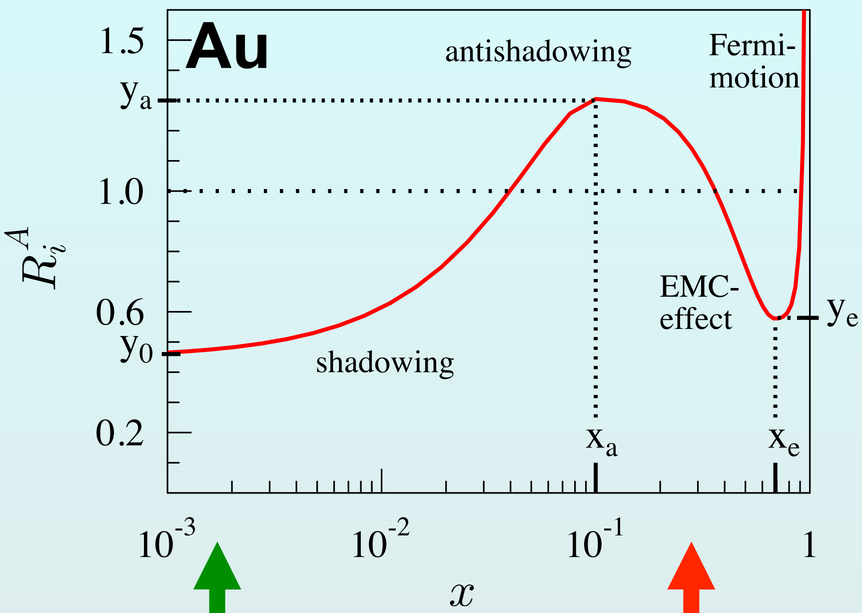
QCD Compton scattering to find out (q+g -> q+γ):

<u>no final state effects on γ!</u>

Forward rapidity to reach

small x & high g density

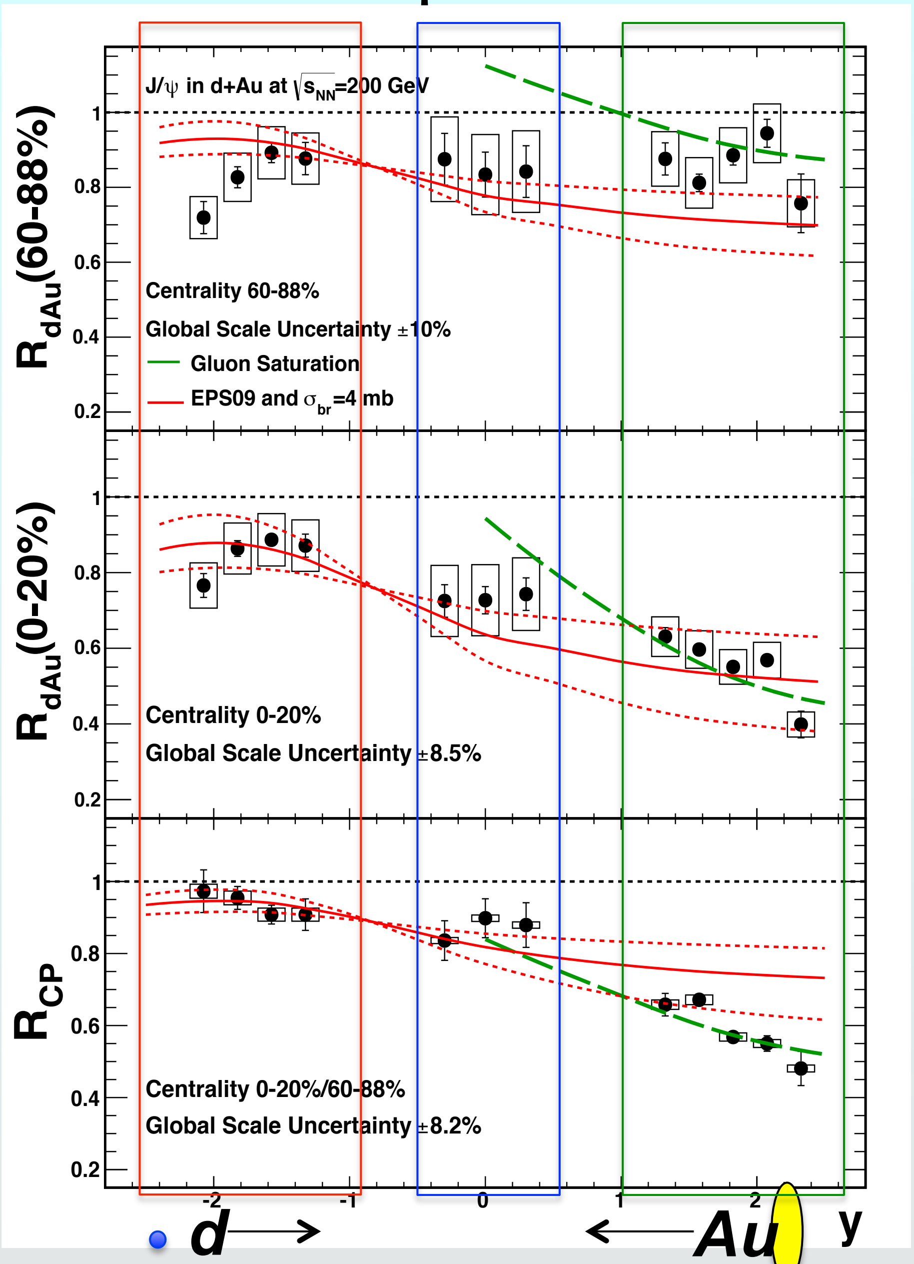
Initial State: what's where?



Forward
+ y
d-going

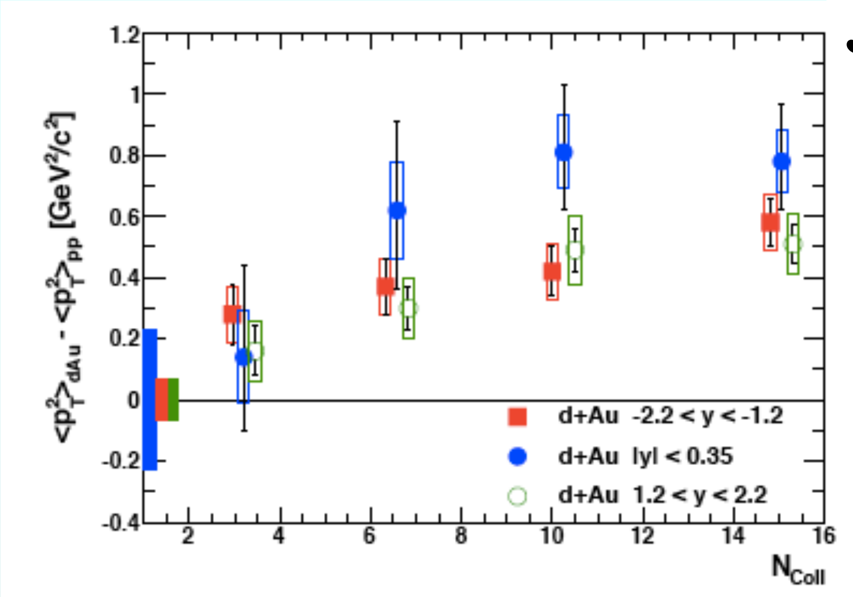
Backward
- y
Au-going

d+Au -> J/ψ from PHENIX

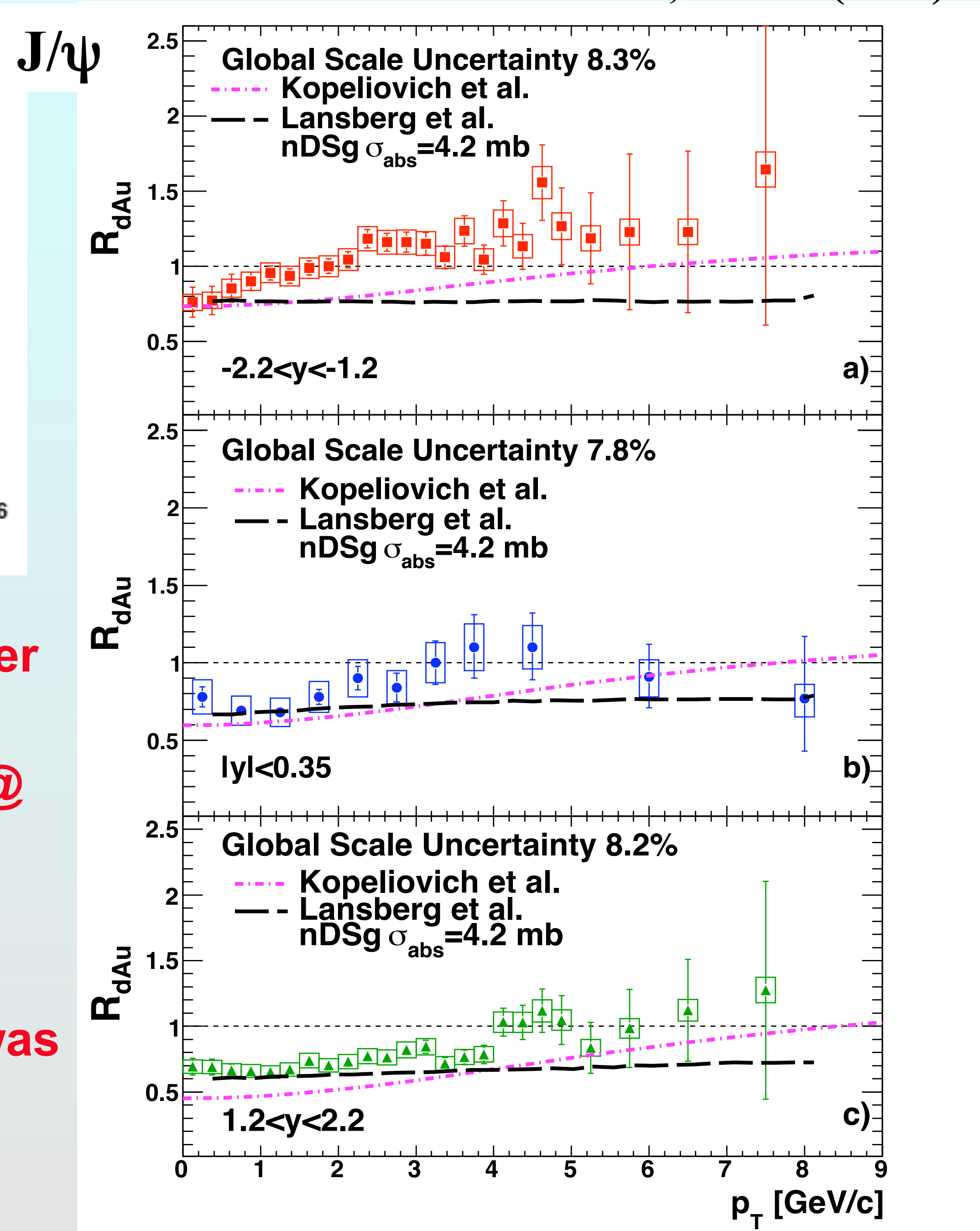


Shadowing, breakup & Cronin effect

PRC87, 034911 (2013)

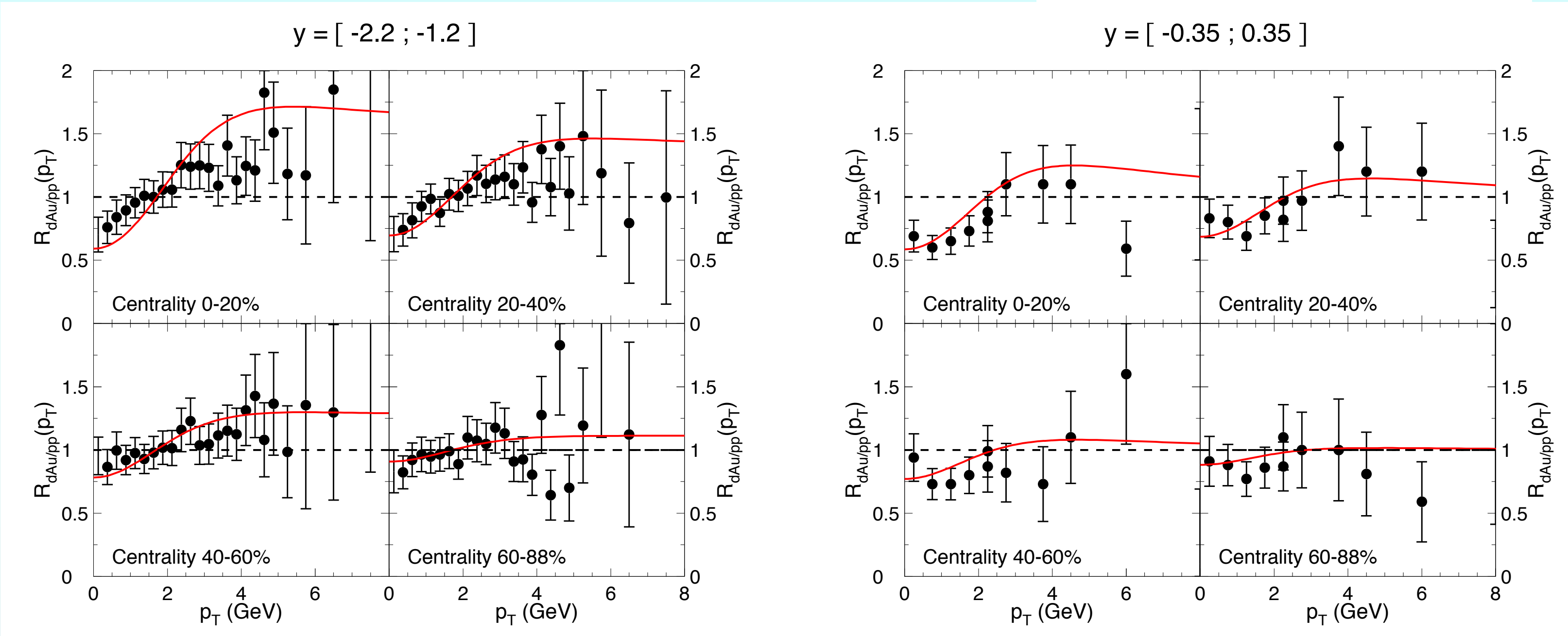


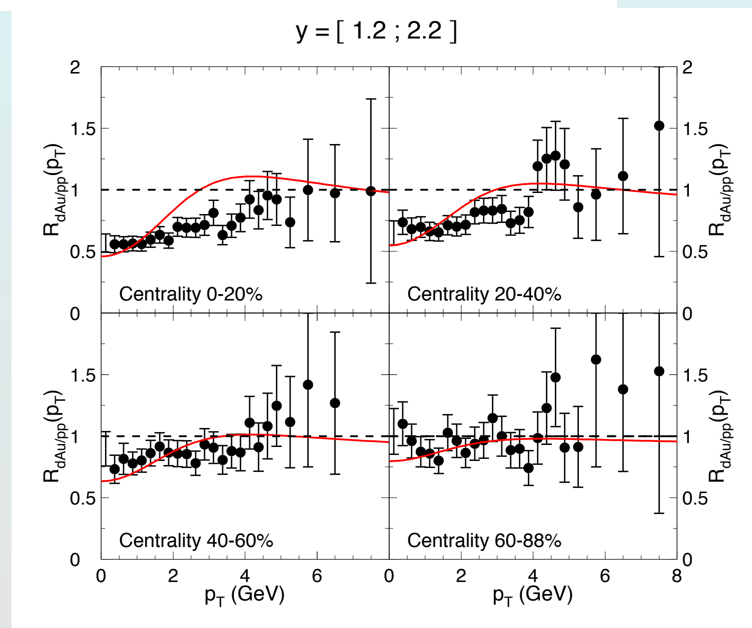
- p_T broadens (multiple scattering) w/N_{coll}; effect stronger at y=0
- J/ψ suppressed to higher p_T @ mid & forward y (lower x in Au);
- R_{dA}>1 at high p_T backward (Cronin effect in Au nucleus)
- p_T, y, centrality dependence was not reproduced by the models



but

Arleo, et al 1304.090





coherent parton energy loss and p_T broadening from multiple scattering in the nucleus is consistent with data!

$\hat{q}_0 = 0.075$ GeV^2/fm