π^0 with high p_T in p+p, d+Au and Au+Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV

Measured by the PHENIX Experiment

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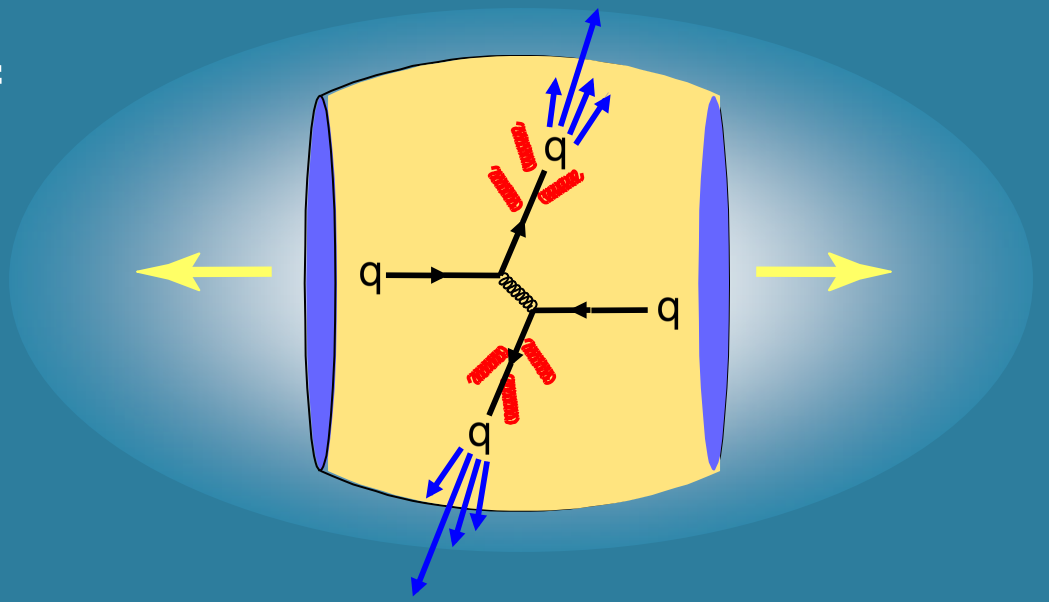
DNP - Chicago , Oct. 30 2004

High p_T Particle Production

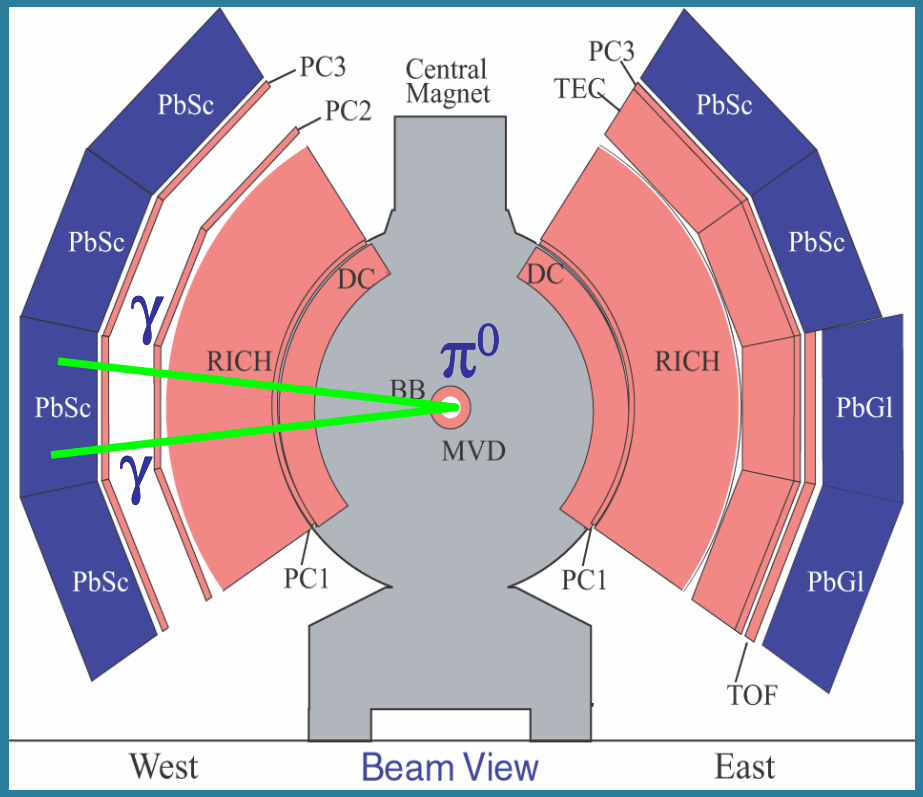
- Mapping contributions of
  - Initial-state effects
  - Final-state effects

- Possible initial-state effects:
  - Initial-state multiple soft scatterings
    (Cronin effect)
    $R_{AA} > 1$
  - Modifications of nuclear structure functions in nuclei
    (Shadowing)
    $R_{AA} < 1$
  - Gluon saturation
    (Color Glass Condensate)
    $R_{AA} < 1$?



- Final-state effects
  - dense partonic medium
    parton energy loss (and recombination)
    (Jet Quenching)
  - Dense hadronic medium
    hadronic energy loss

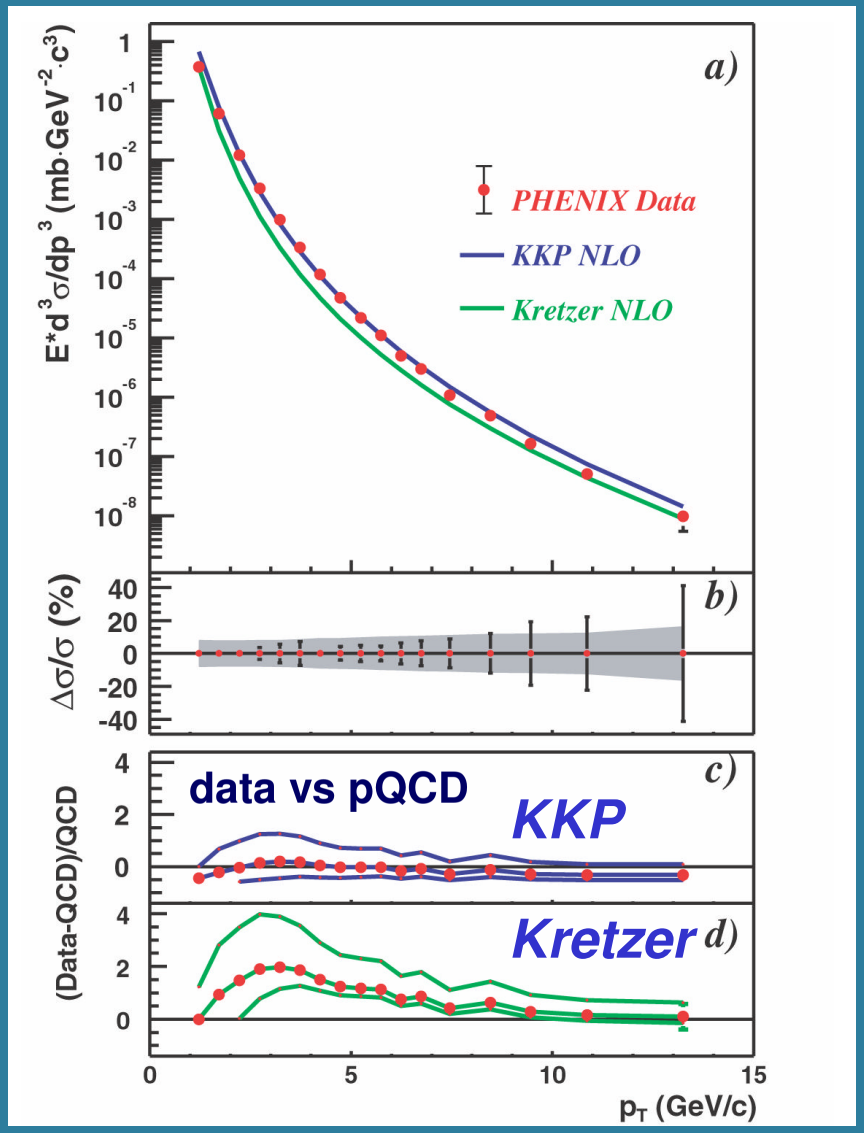
PHENIX-Setup



- **Relevant for this talk:**
- **Detectors in the central spectrometer arms**
  - **π^0 via $\pi^0 \rightarrow \gamma\gamma$:**
    - **Lead-scintillator calorimeter (PbSc)**
    - **Lead-glass calorimeter (PbGl)**
- **Centrality, vertex**
  - Beam-Beam Counter (**BBC**) $3.0 < |\eta| < 3.9$
  - Zero-Degree Calorimeter (**ZDC**)

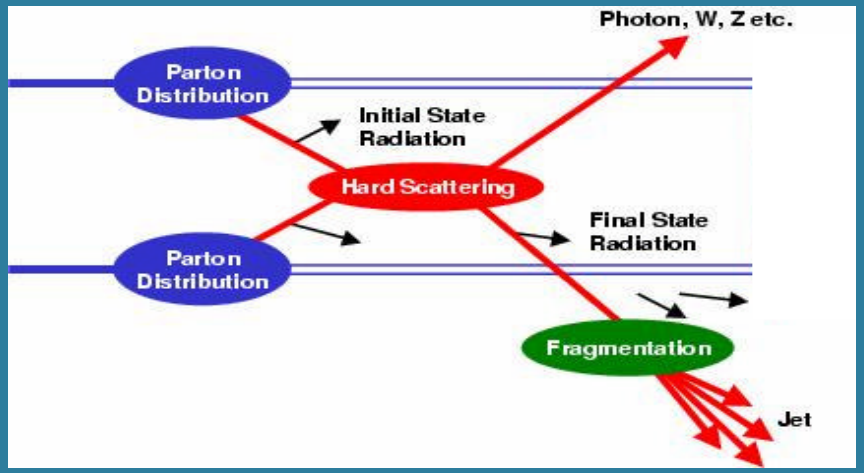
(pseudorapidity $|\eta| < 0.35$)

π^0 production in p+p



- **Good agreement with NLO pQCD**
  - Factorization theorem:

$$\sigma_{AB \to hX} \propto f_{a/A}(x_a,Q^2_a) \otimes f_{b/B}(x_b,Q^2_b) \otimes \sigma_{a\,b \to cd} \otimes D_{h/c}(z_c,Q^2_c)$$

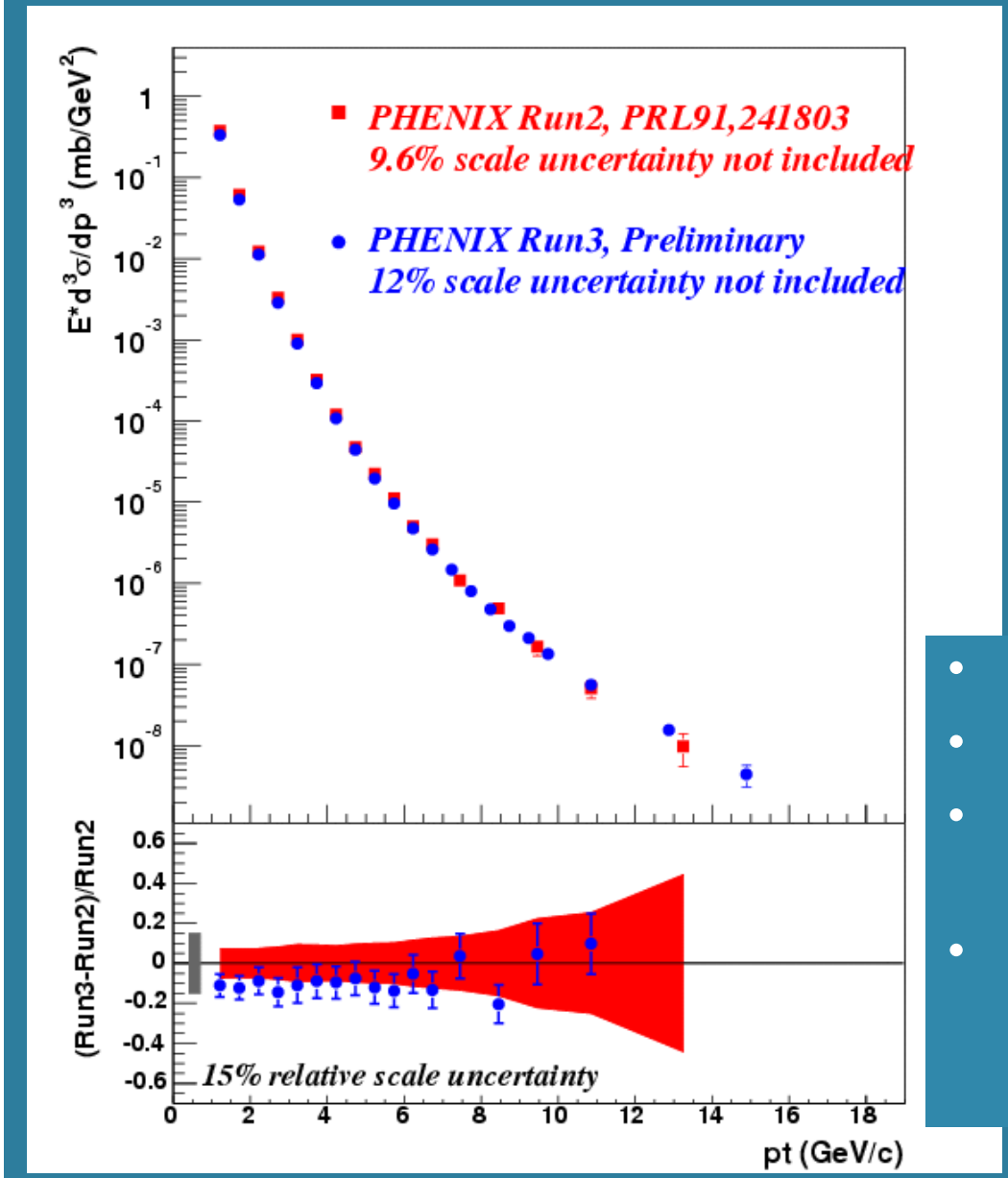


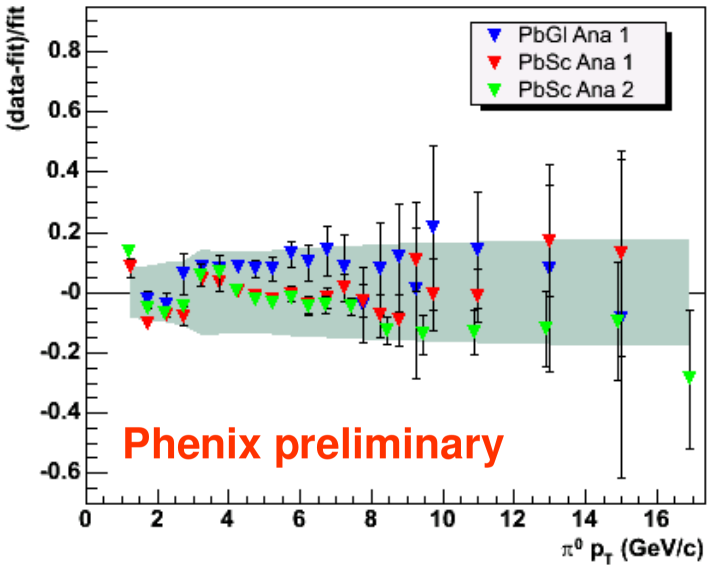
- **Constrains Fragmentation Function D(Gluon-pi)**
- **Reference for Au+Au spectra**

Phys. Rev. Let 91, 241803 (2003)

200 GeV - Run2

π^0 production in p+p

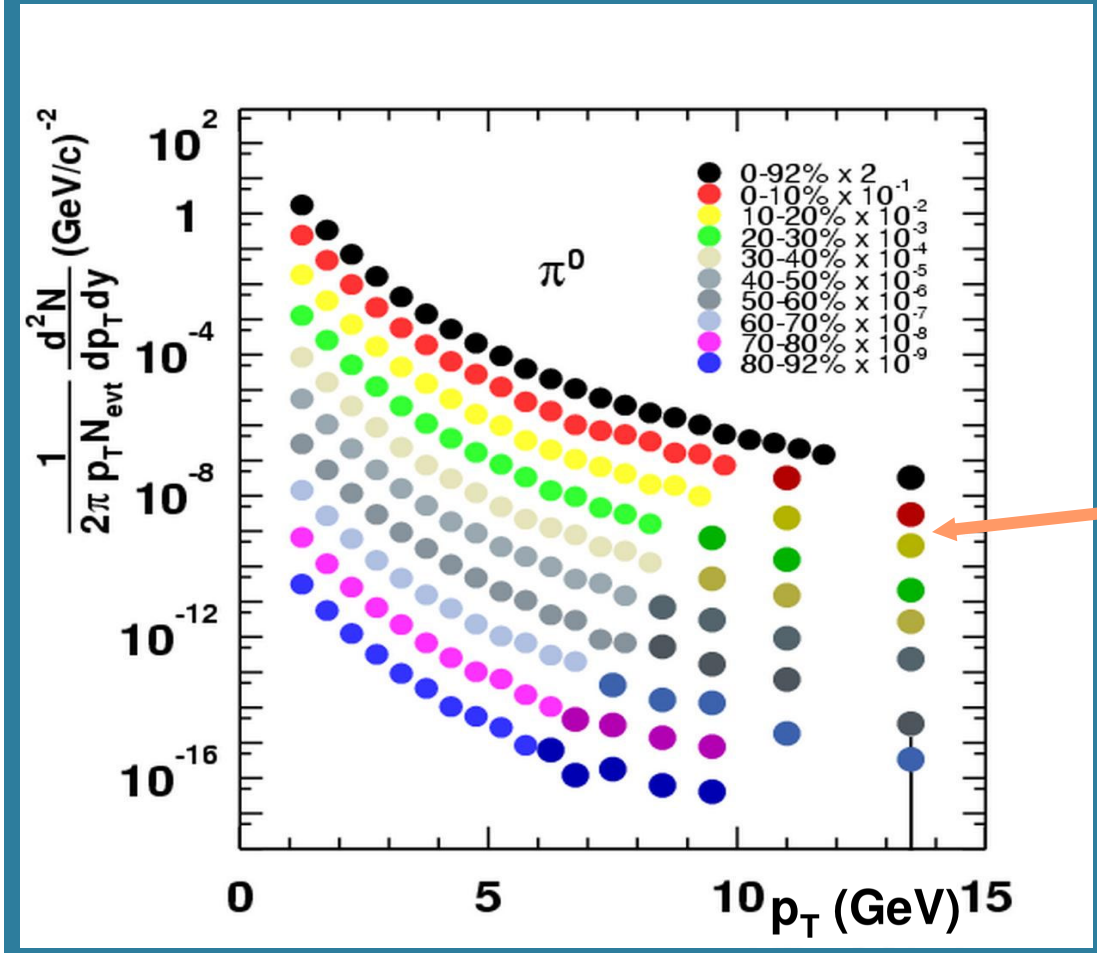




- New run3 pp data
- Reach out to pT > 16 GeV
- Good reference for run3 dAu data – reduced syst. errors
- Cross section determination under investigation

200 GeV – Run3

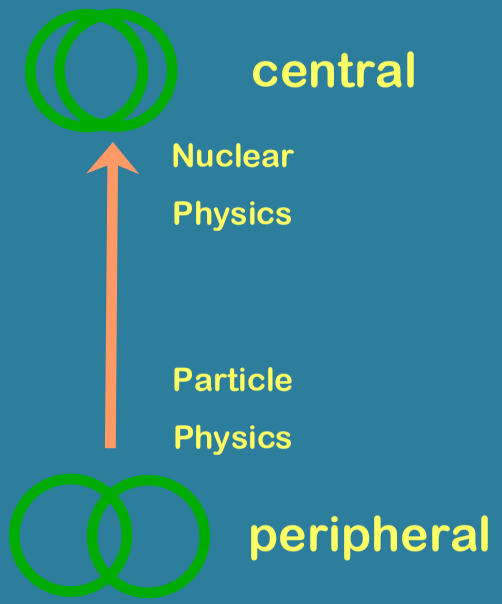
π^0 Spectra in Au+Au at 200 GeV



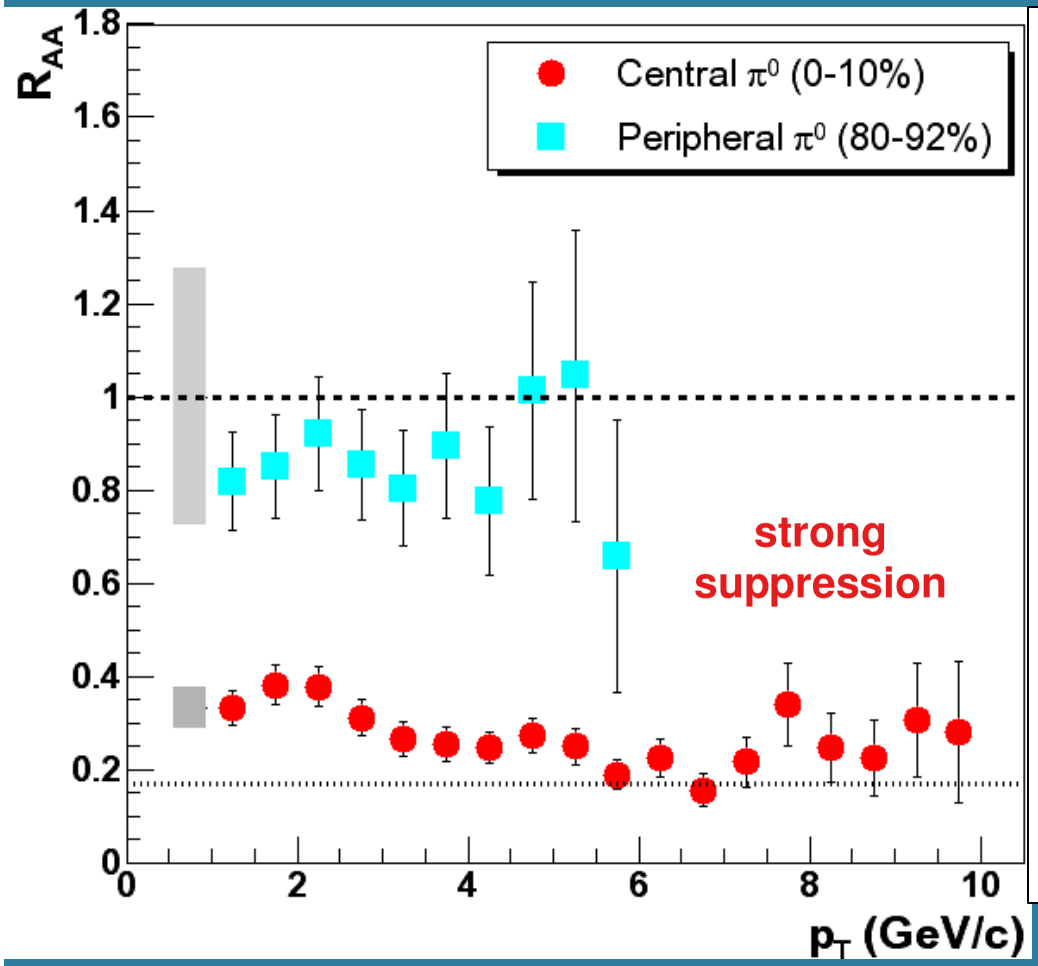
Phys. Rev. Lett. 91, 072301 (2003)

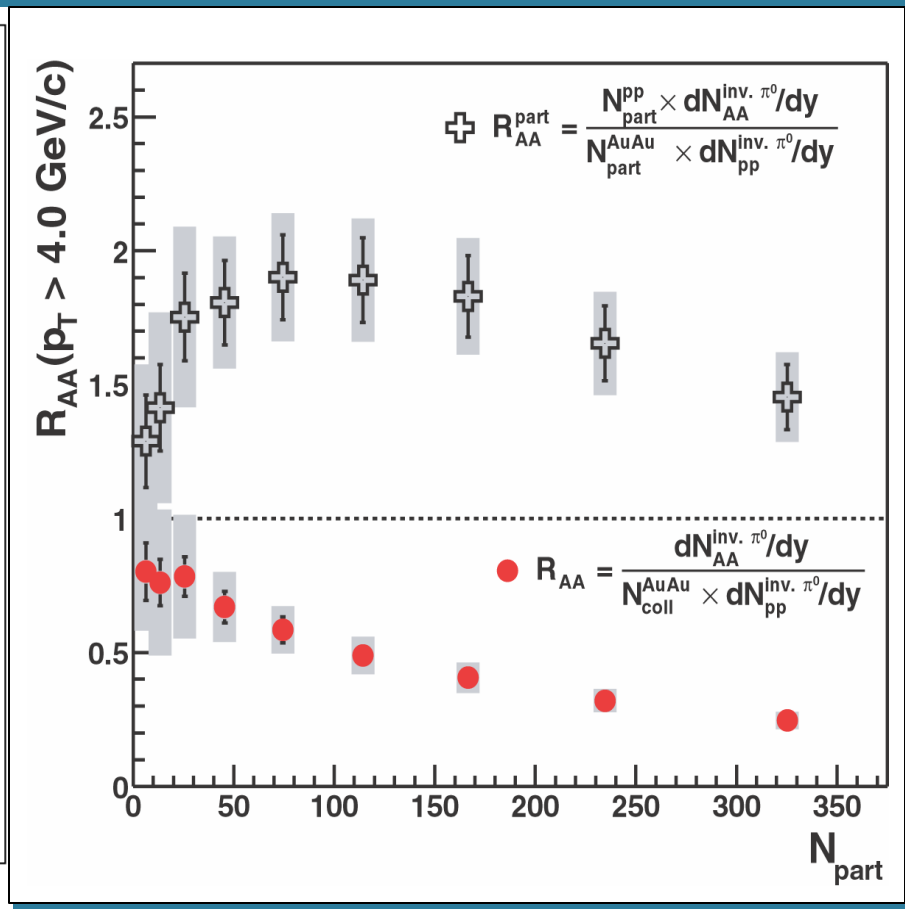
- **Use p+p as base line measurement**

spectra up to 15 GeV/c



Nuclear Modification Factor R_{AA}





$$R_{AB} = \frac{\left(1/N_{AB}^{evt}\right) d^2N_{AB}/dydp_T}{\langle T_{AB} \rangle \, d^2\sigma_{pp}/dydp_T}$$

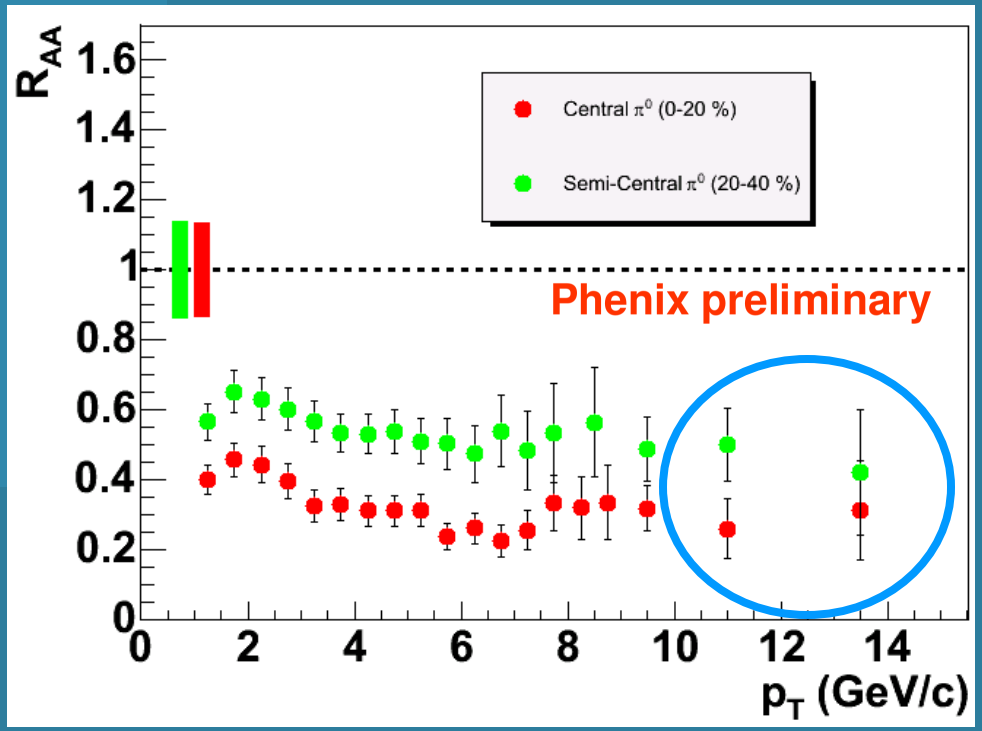
integrated π^0 yield above p_T = 4 GeV/*c*

Phys. Rev. Lett. 91, 072301 (2003)

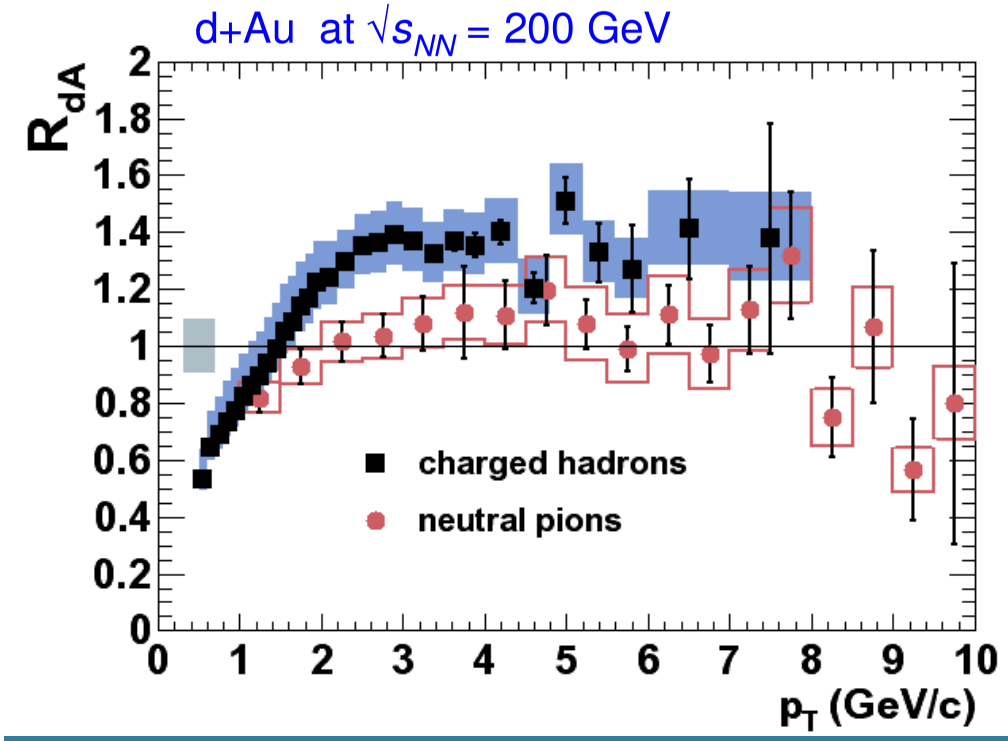
Nuclear Modification Factor R_{AA}

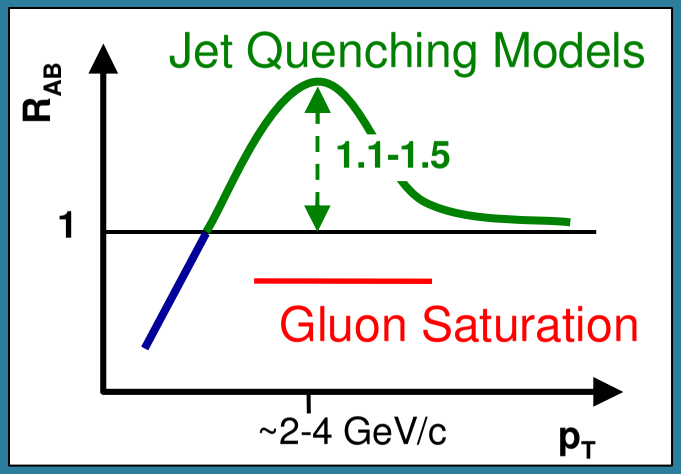
- New run3 pp reference
- Reduced stat. errors
- Reach to higher p_T

$$R_{AB} = \frac{\left(1/N_{AB}^{evt}\right) d^2N_{AB}/dydp_T}{\langle T_{AB} \rangle \, d^2\sigma_{pp}/dydp_T}$$



The Control Experiment: d+Au



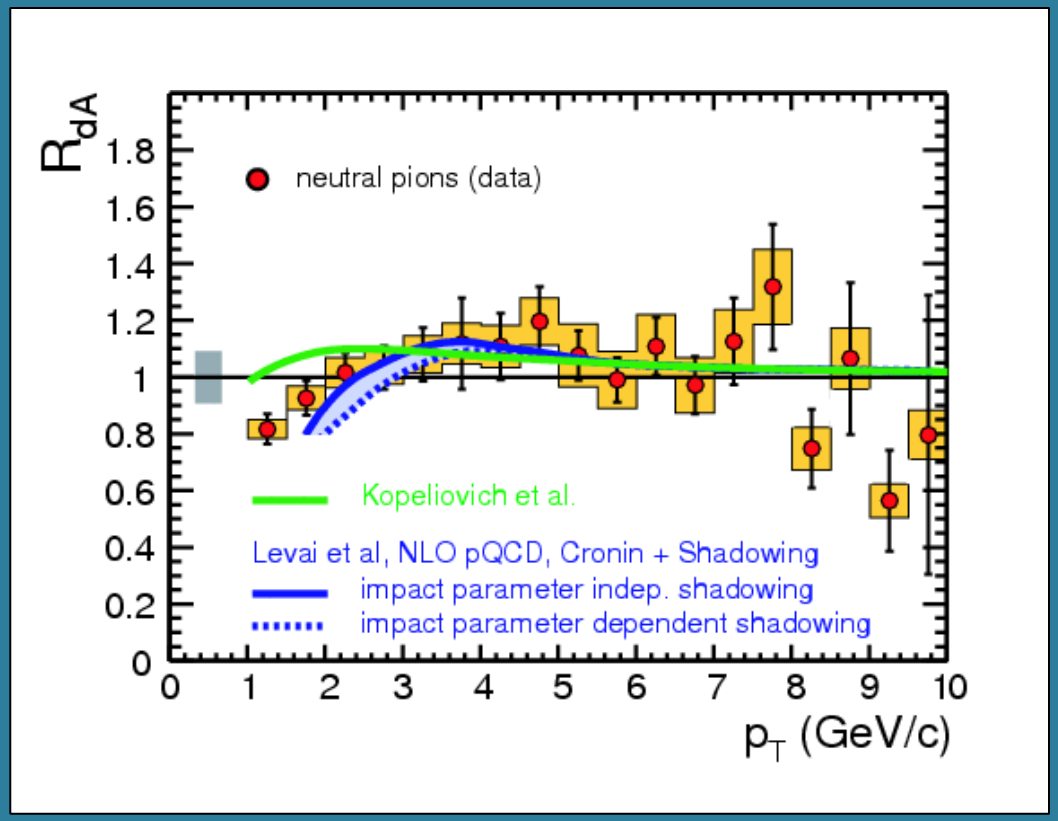


Kharzeev, Levin, McLerran, hep-ph/0210332

- **No suppression in d+Au**
- **Initial-state effects ruled out as explanation for suppression in Au+Au at mid rapidity**

Phys. Rev. Lett. 91, 072303 (2003)

π^0's in d+Au: Data vs. pQCD

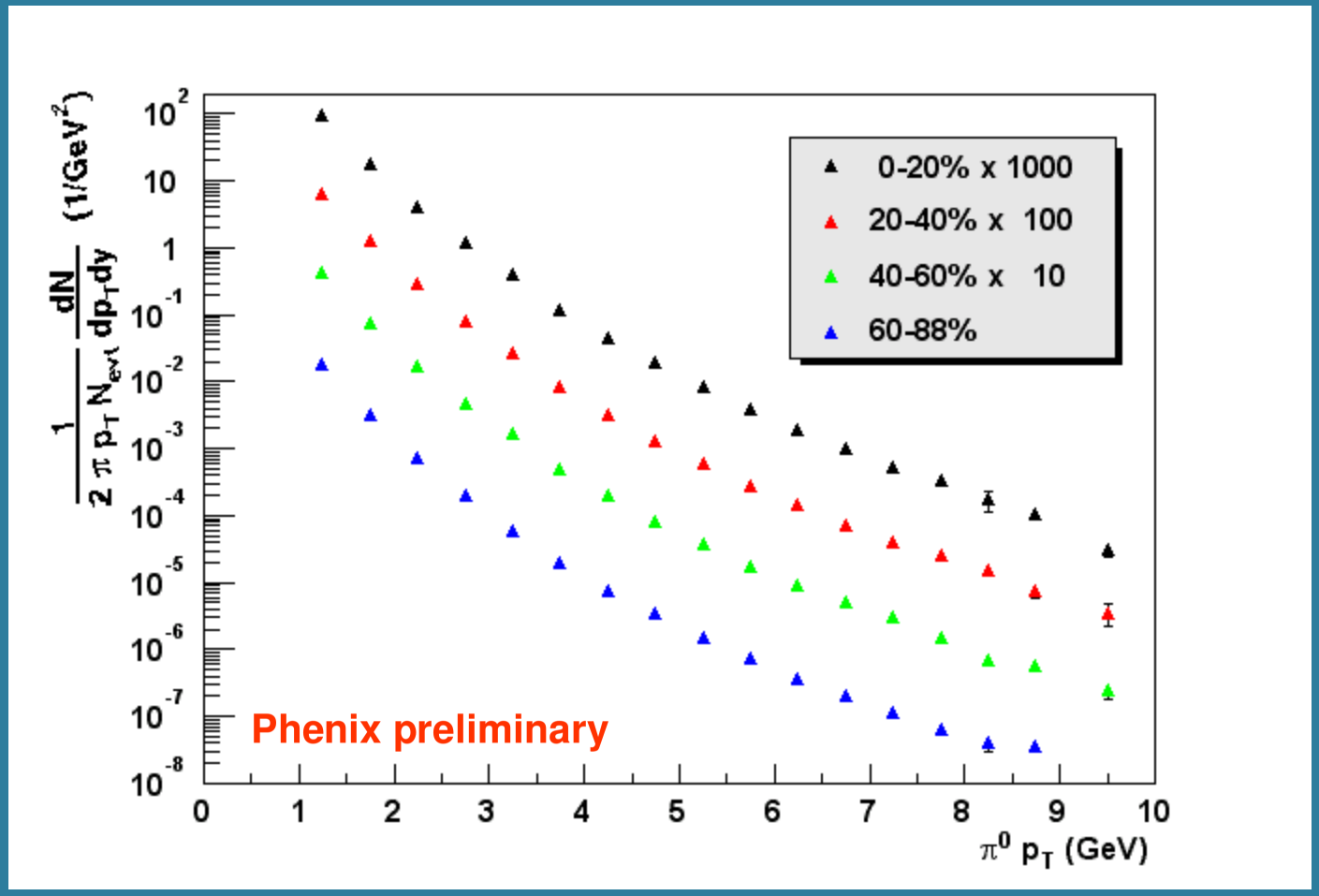


- **Data well reproduced by**
  - **NLO pQCD calculation, plus**
  - **Phenomenological model of Cronin-Effect, plus**
  - **Shadowing**

Levai et al., nucl-th/0306019

Kopeliovich et al., Phys. Rev. Lett. 88, 232303 (2002)

π^0 d+Au – centrality dependence

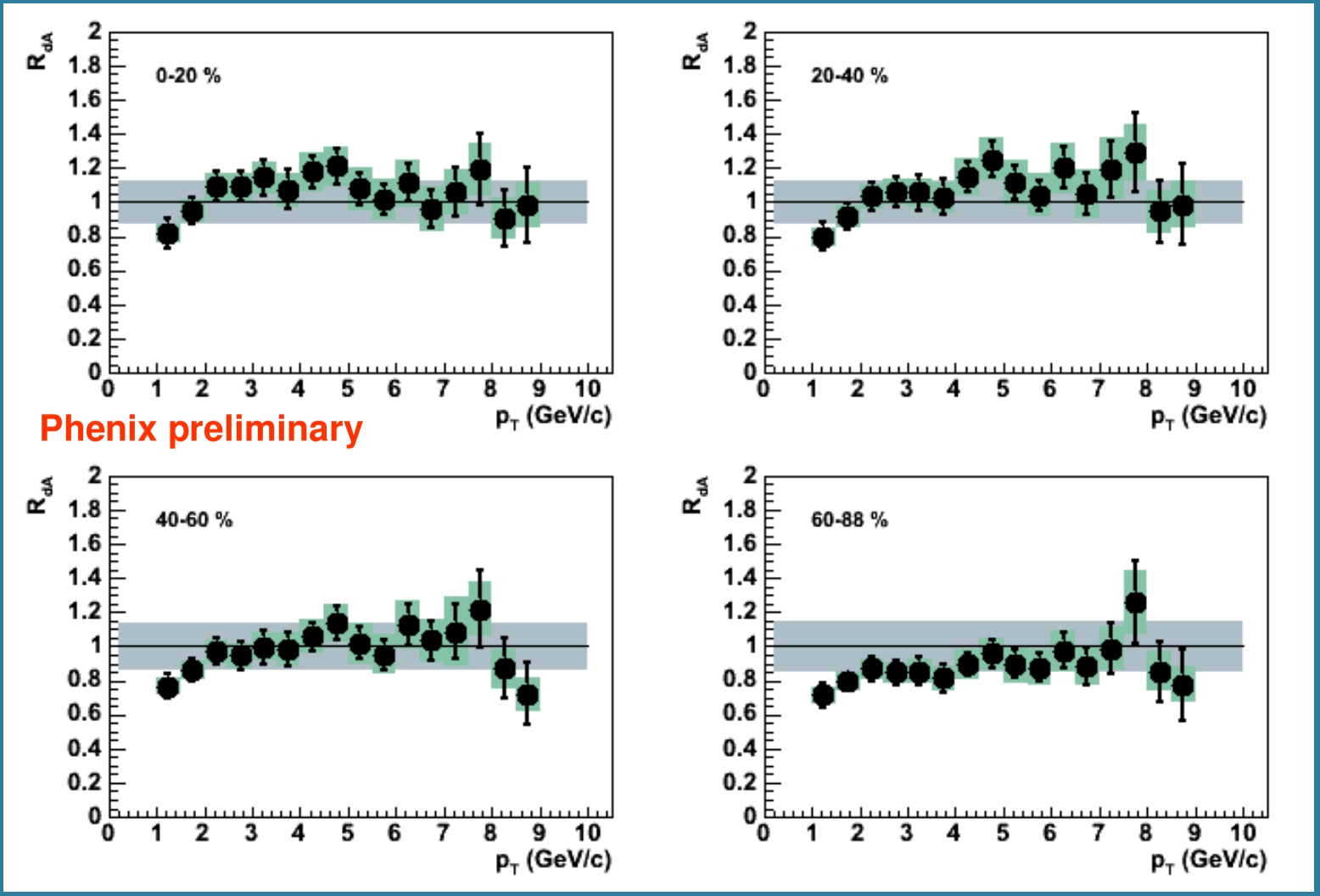


Kharzeev, Levin, McLerran, hep-ph/0210332

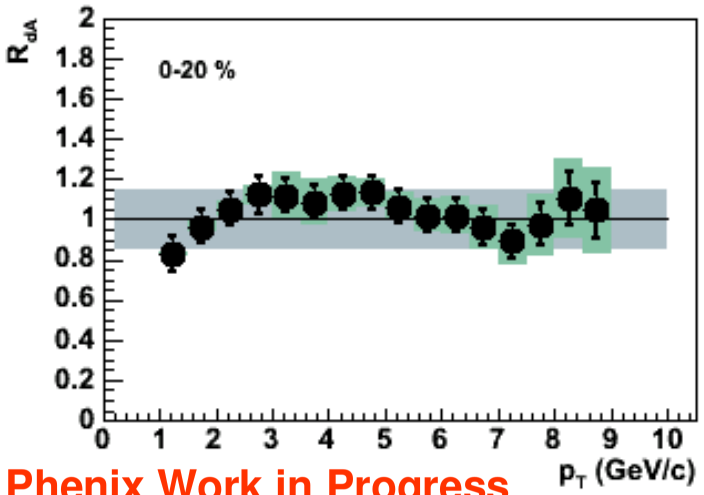
$(N_{part,\ Au})^{1/2}$ scaling

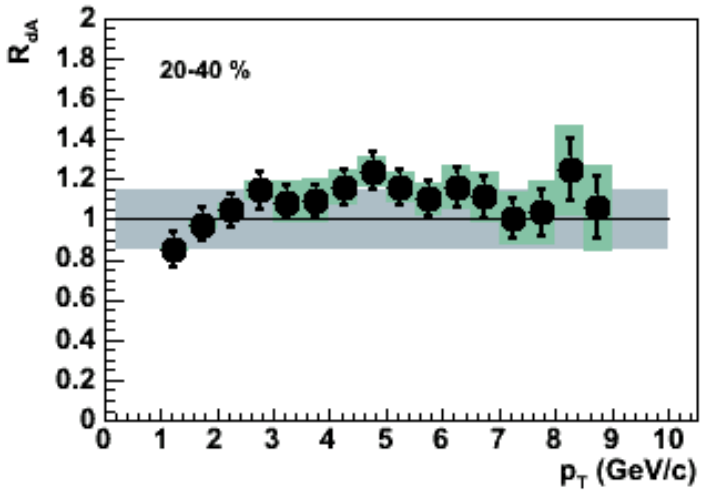
$R_{AA} \approx 0.7$ in central d+Au

π^0 d+Au – centrality dependence

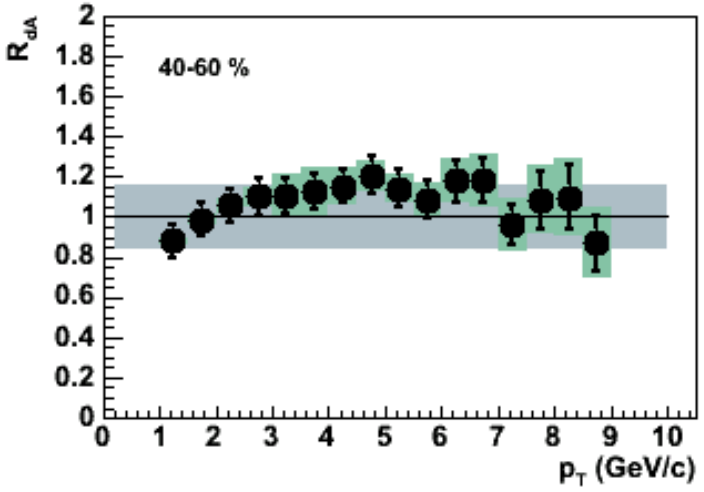


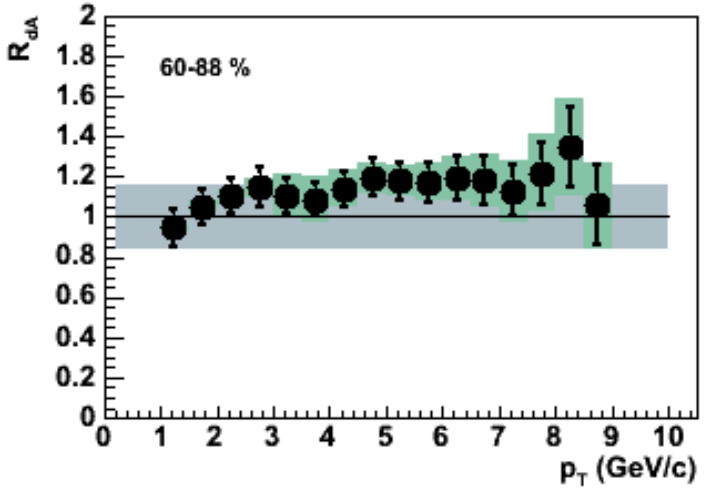
π^0 d+Au – centrality dependence





Phenix Work in Progress

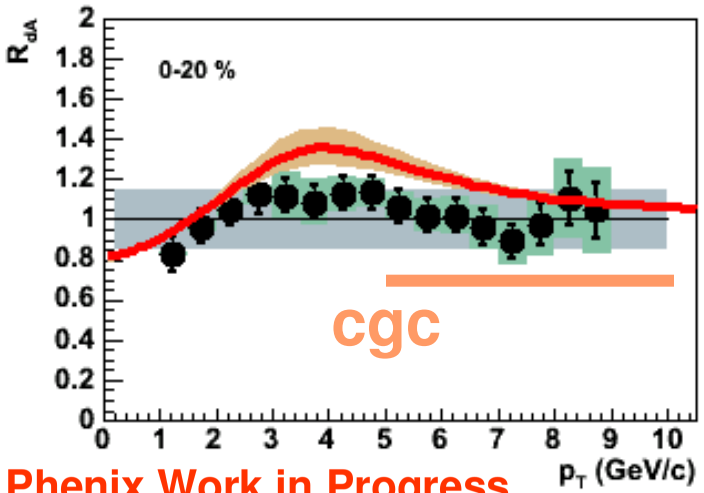




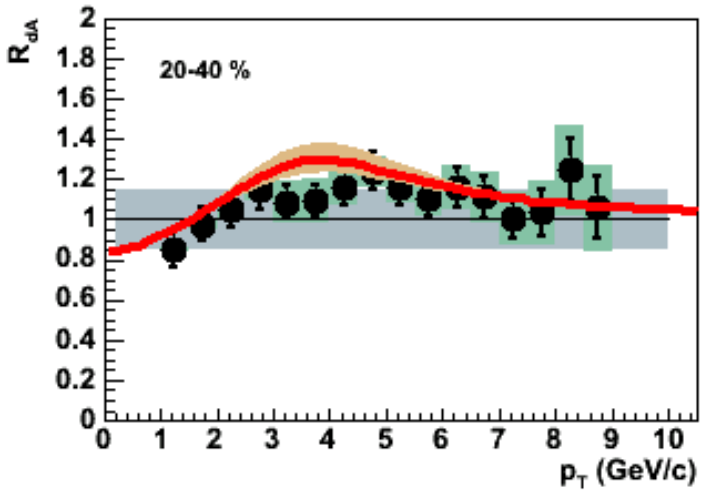
Work in progress:

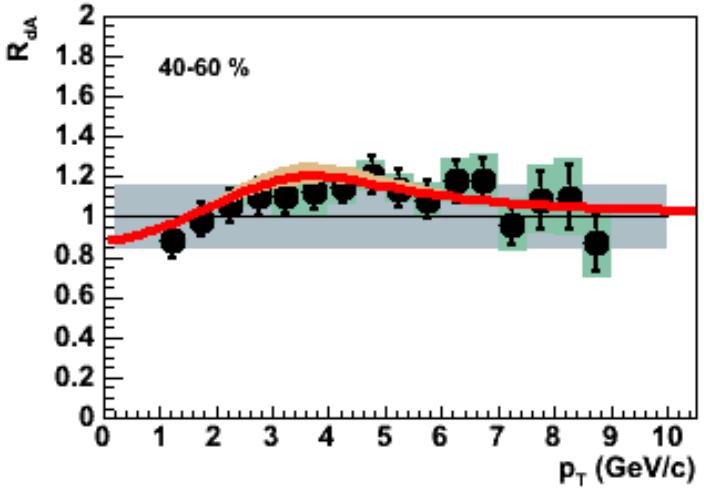
New run3 pp reference, New trigger Bias evaluation

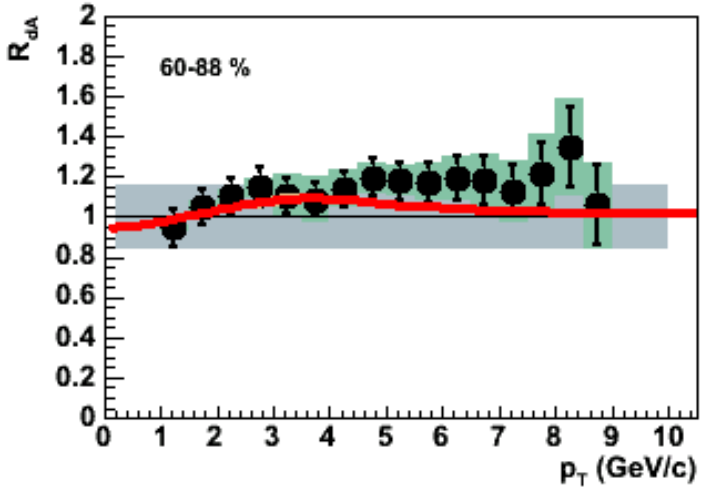
R_{dAu} for different centralities



Phenix Work in Progress

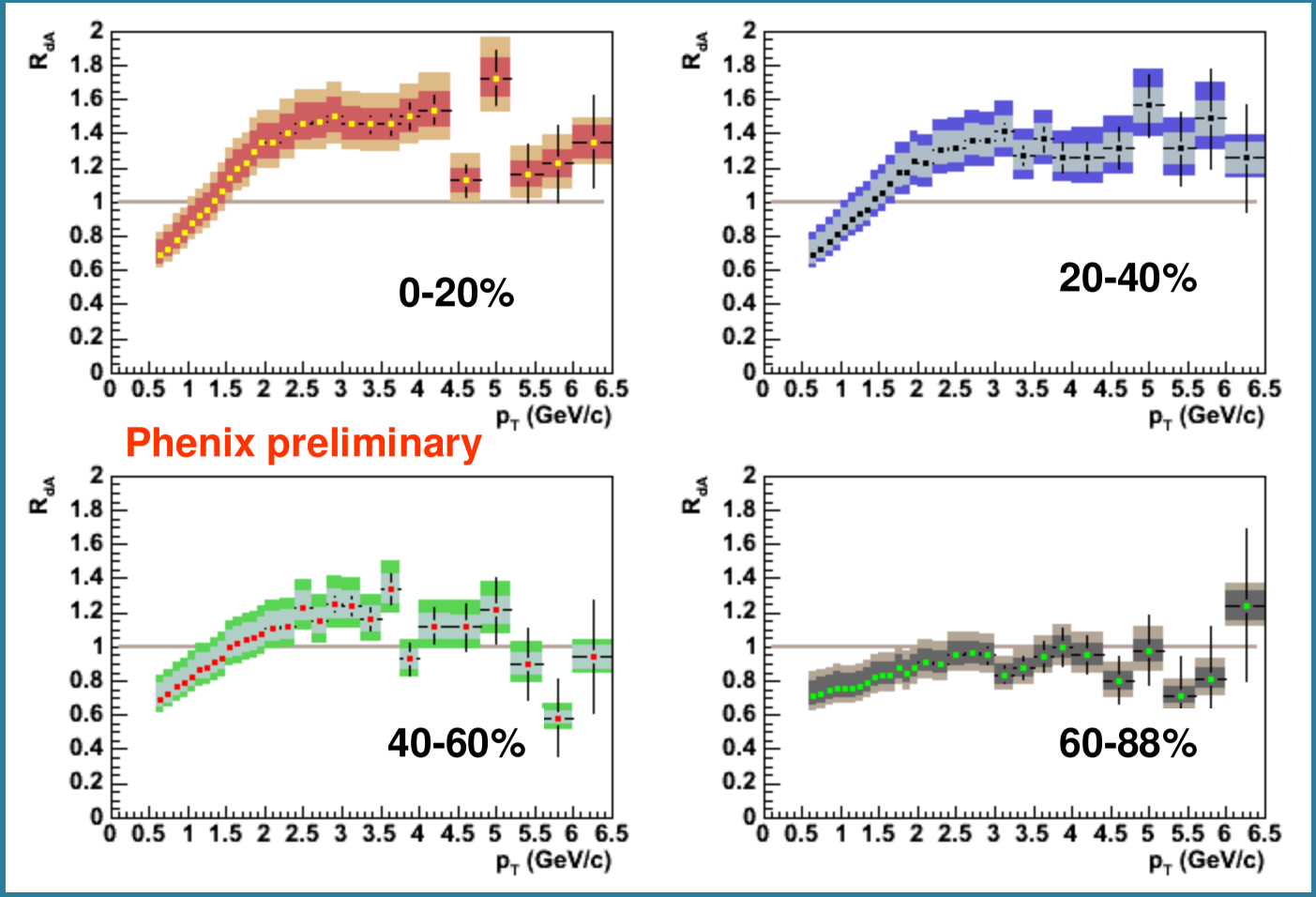




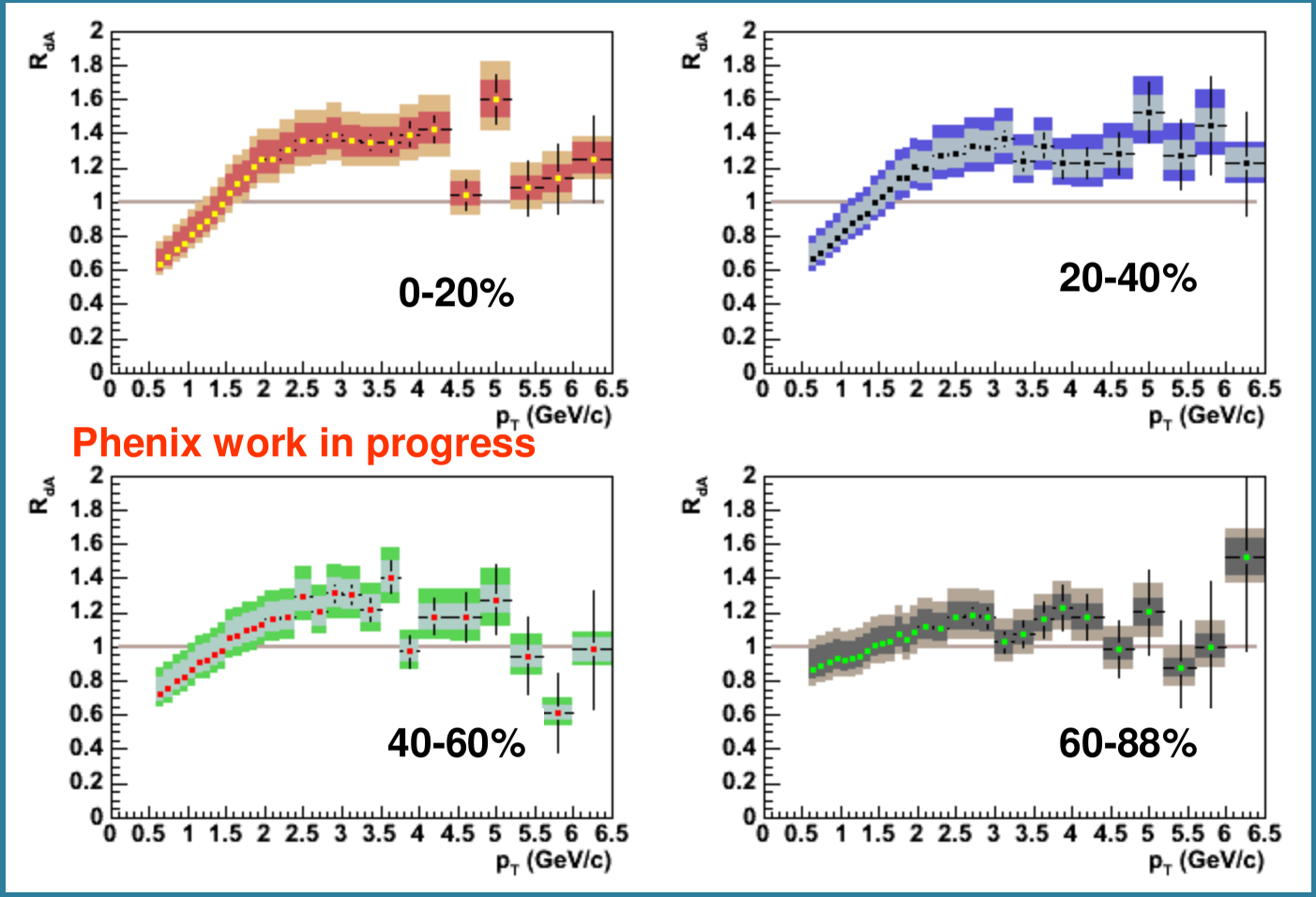


Qualitative agreement with model by Accardi and Gyulassy.
Partonic Glauber-Eikonal approach: sequential multiple partonic collisions.
nucl-th/0308029 v2

Compare to charged d+Au



Compare to charged d+Au

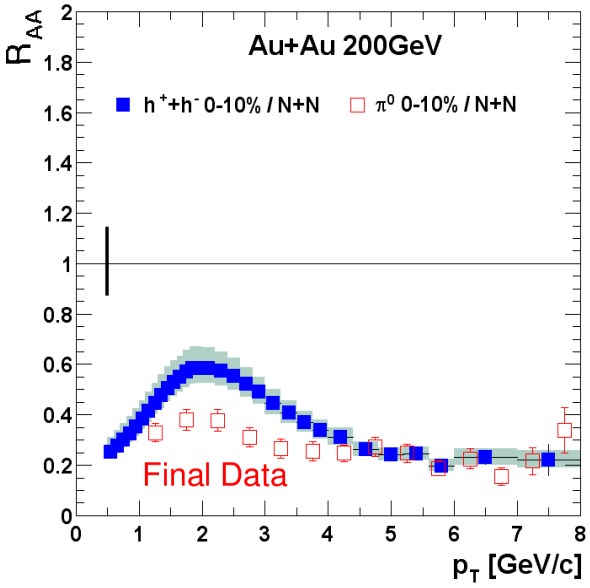


Work in progress:

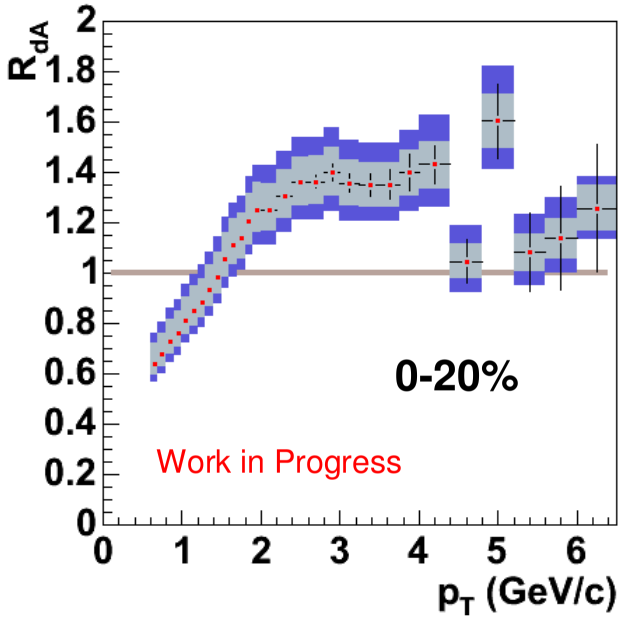
New trigger Bias evaluation

Centrality Dependence in d+Au

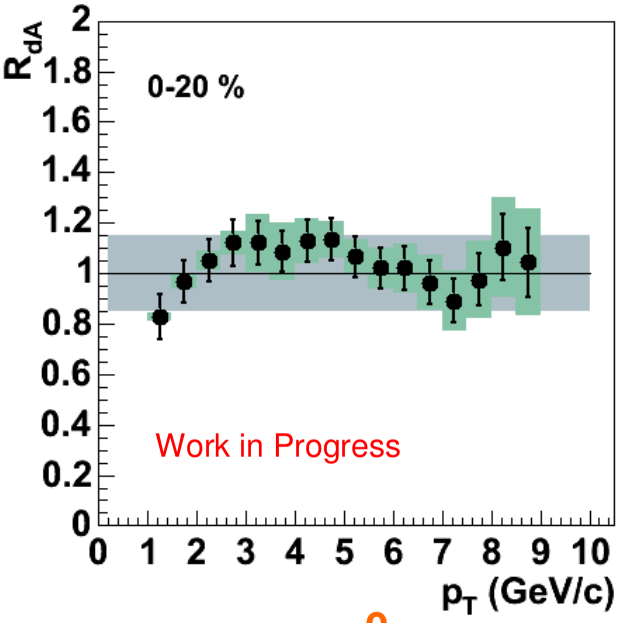
Au + Au Experiment



d + Au Control Experiment



charged



π^0

- opposite behavior with increasing centrality in Au+Au and d+Au
  - R_{AuAu} decreases
  - R_{dAu} charged increases
  - RdAu π^0 within errors no centrality dependence

Summary

- New preliminary data for π^0 at 200 GeV p+p (run3)
- New preliminary data for R_{AA} for π^0 at 200 GeV Au+Au
- π^0 at 200 GeV d+Au
  - centrality dependence

- Inclusive spectra suppressed in Au+Au
  - by a factor of 4-5 at 200 GeV
- No suppression in 200 GeV d+Au
- Centrality dependence:
  - opposite behavior with increasing centrality in Au+Au and charged hadrons in d+Au
  - within errors no centrality dependence in π^0

PHENIX
OVER ONE BILLION SERVED