PHENIX

Results on High p_T Particle Production from the PHENIX-Experiment at RHIC

Nucleus-Nucleus Collisions 2003, Moscow

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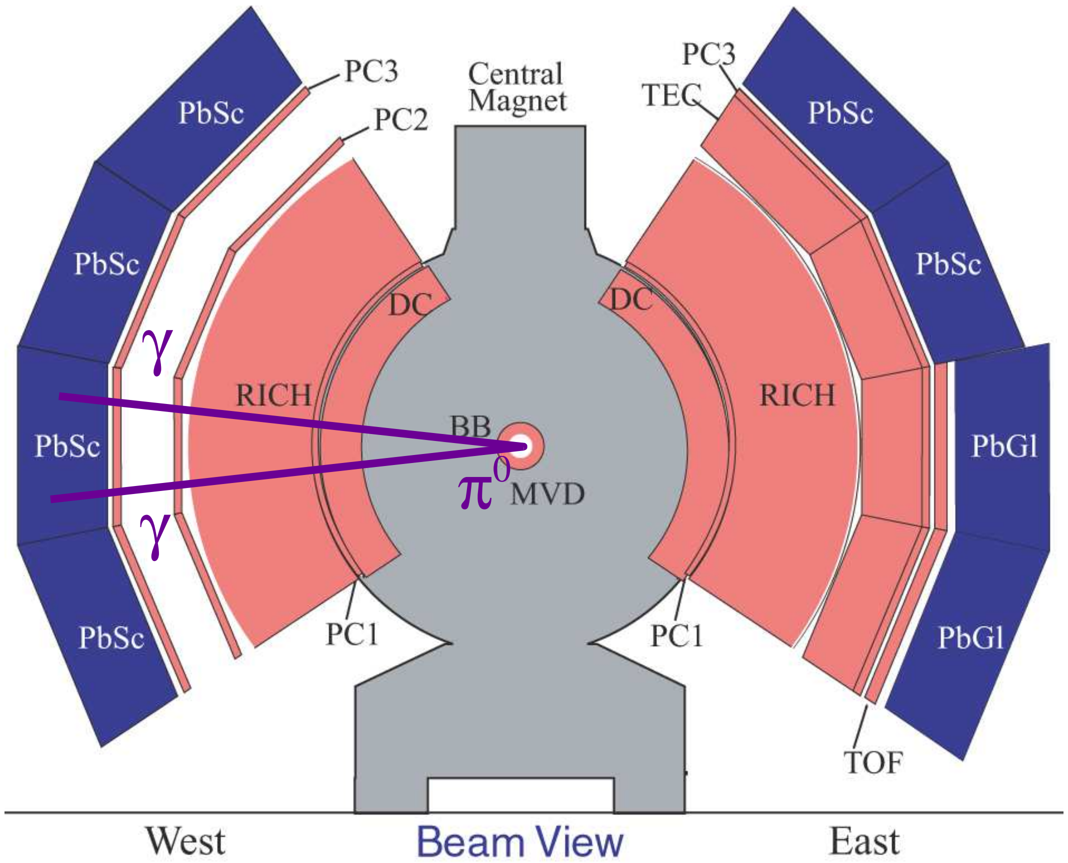
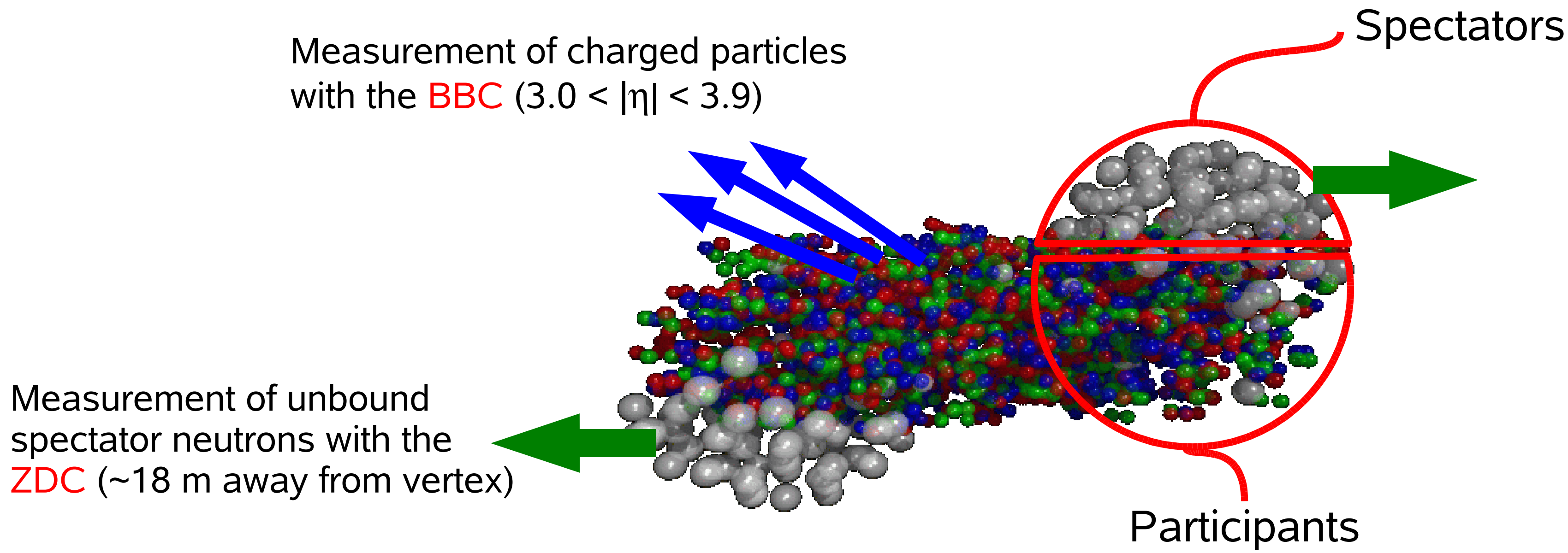
for the PHENIX Collaboration

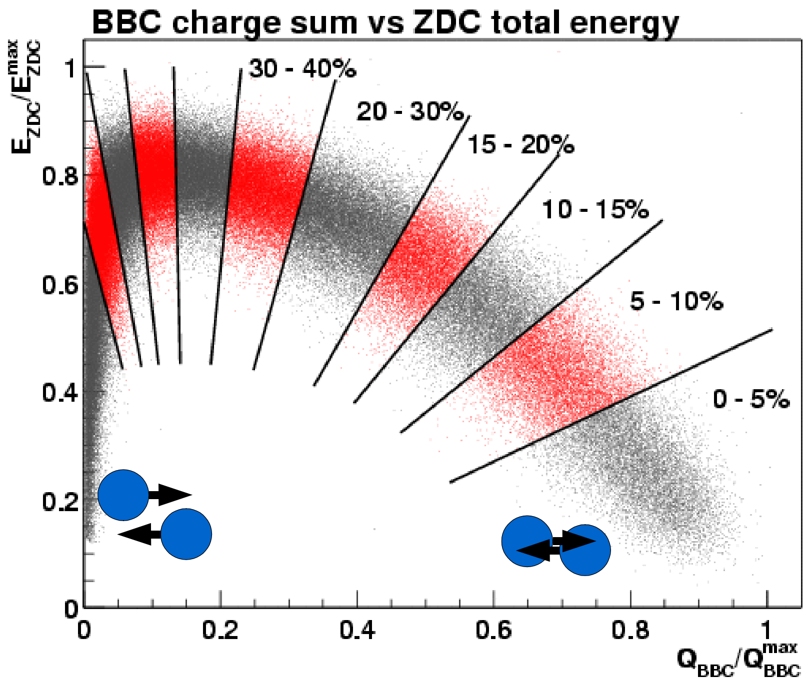
PHENIX-Setup



- Relevant for this talk: Detectors in the central spectrometer arms (pseudorapidity $|\eta| < 0.35$)
  - Charged Particle Tracking:
    - Drift-Chambers (DC)
    - Pad-Chambers (PC)
  - Identification of charged hadrons:
    - Tine-of-Flight (TOF) with start signal from the Beam-Beam-Counters (BBC)
  - π^0 via $\pi^0 \rightarrow \gamma\gamma$:
    - Lead scintillator calorimeter (PbSc)
    - Lead glass calorimeter (PbGl)

Centrality Selection in Au+Au



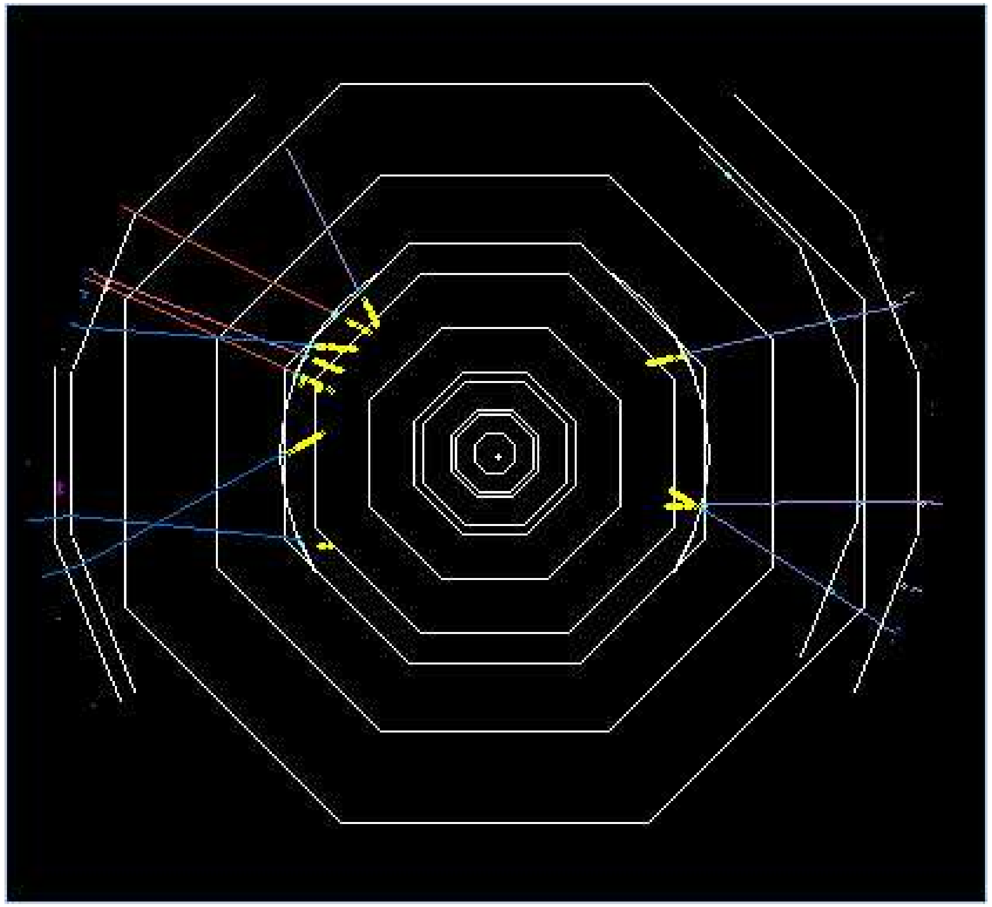


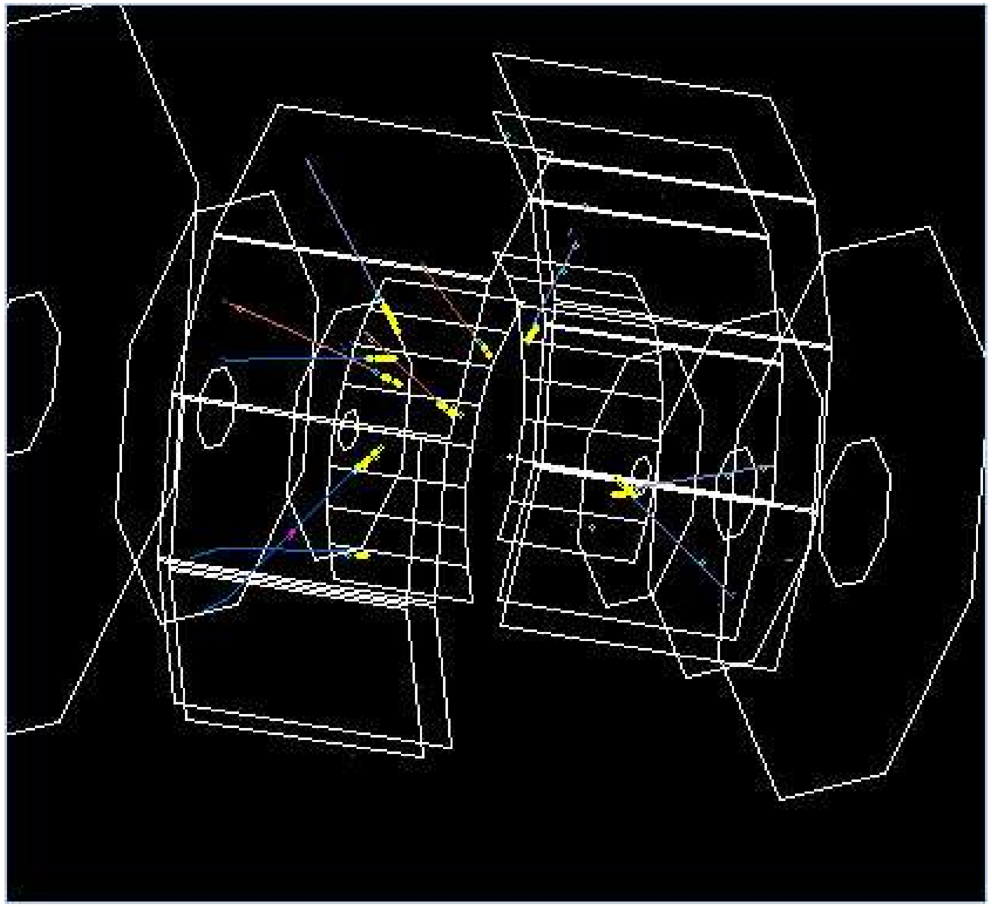
Centrality characterized by

- N_{part}: Number of nucleons which suffered at least one inelastic nucleon-nucleon collision
- N_{coll}: Number of inelastic nucleon-nucleon collisions

N_{part} and N_{coll} from Glauber calculations

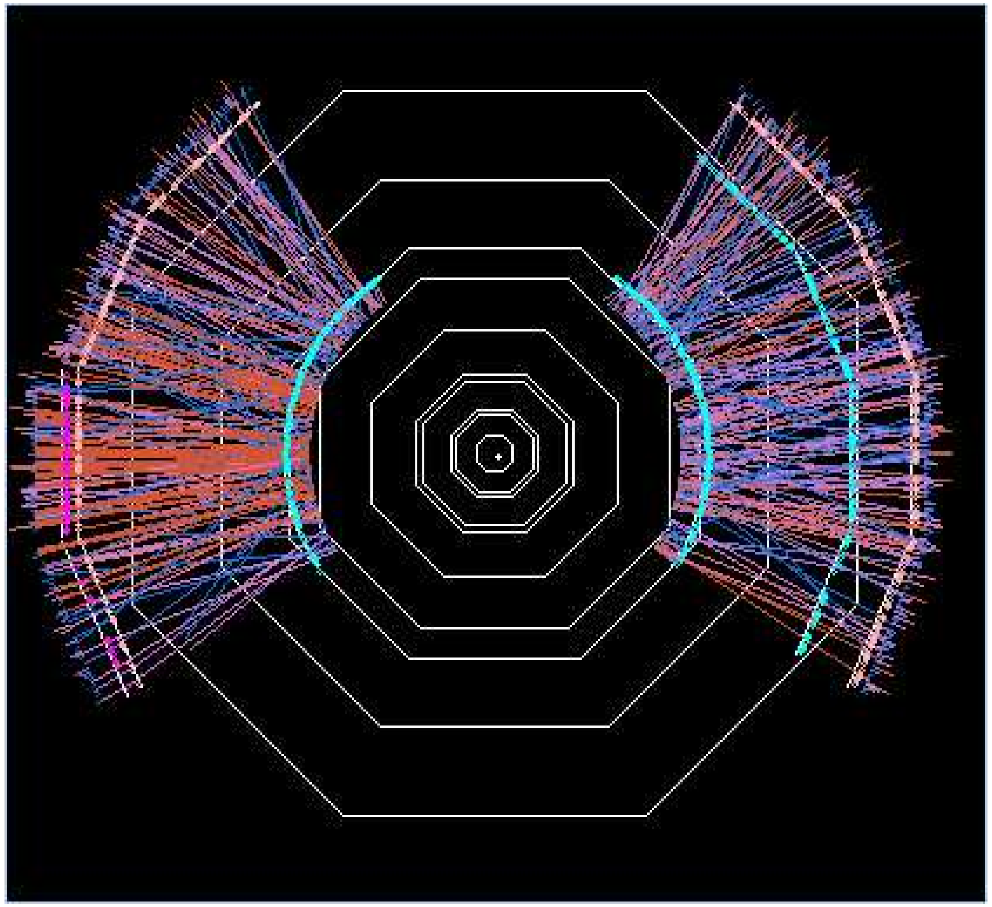
p+p-Collision at $\sqrt{s}$ = 200 GeV

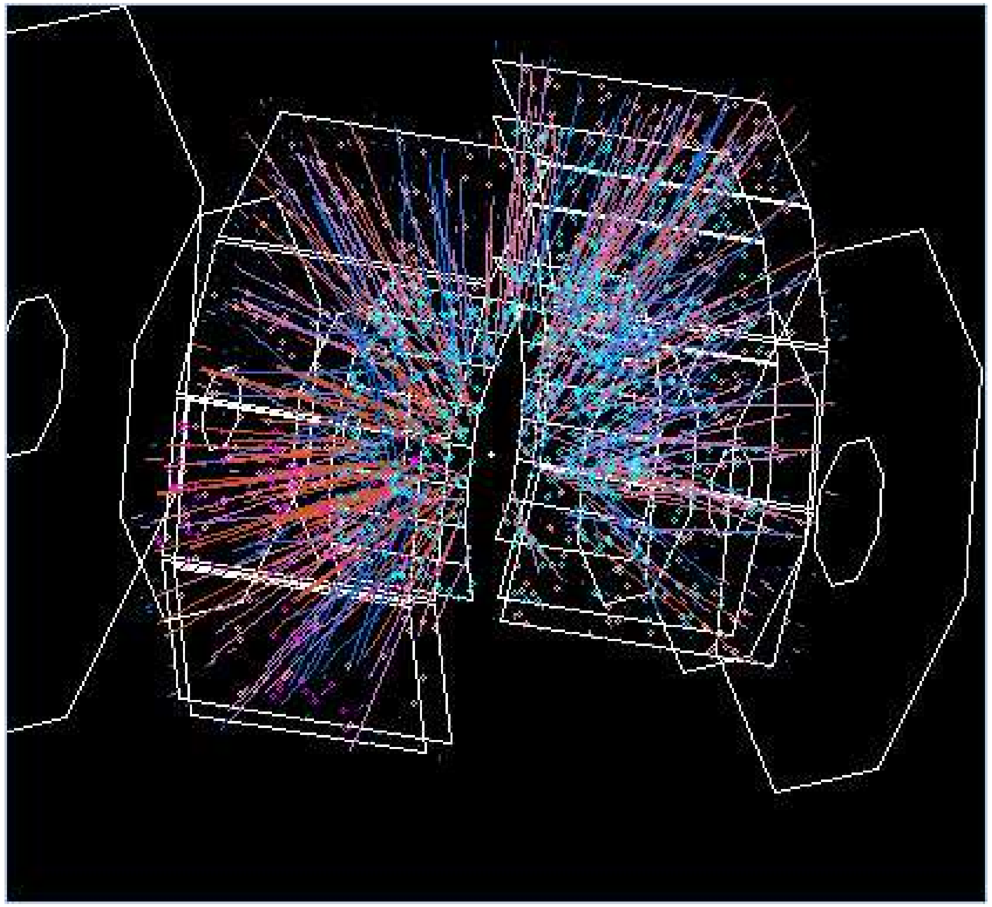




PHENIX Event-Display by J. Mitchell, BNL

Au+Au-Collision at $\sqrt{s_{NN}}$ = 200 GeV



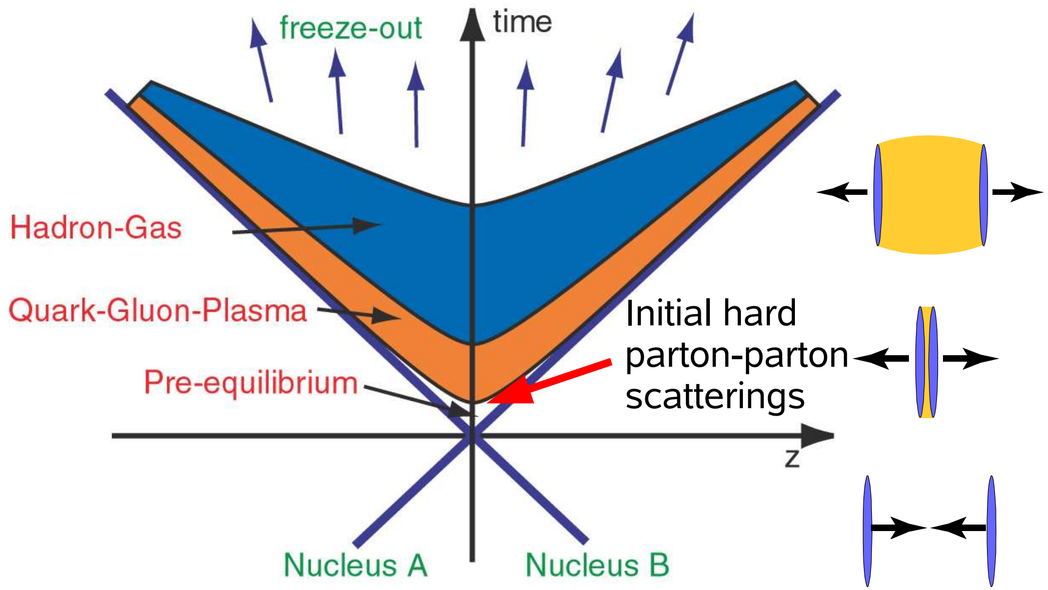


PHENIX Event-Display by J. Mitchell, BNL

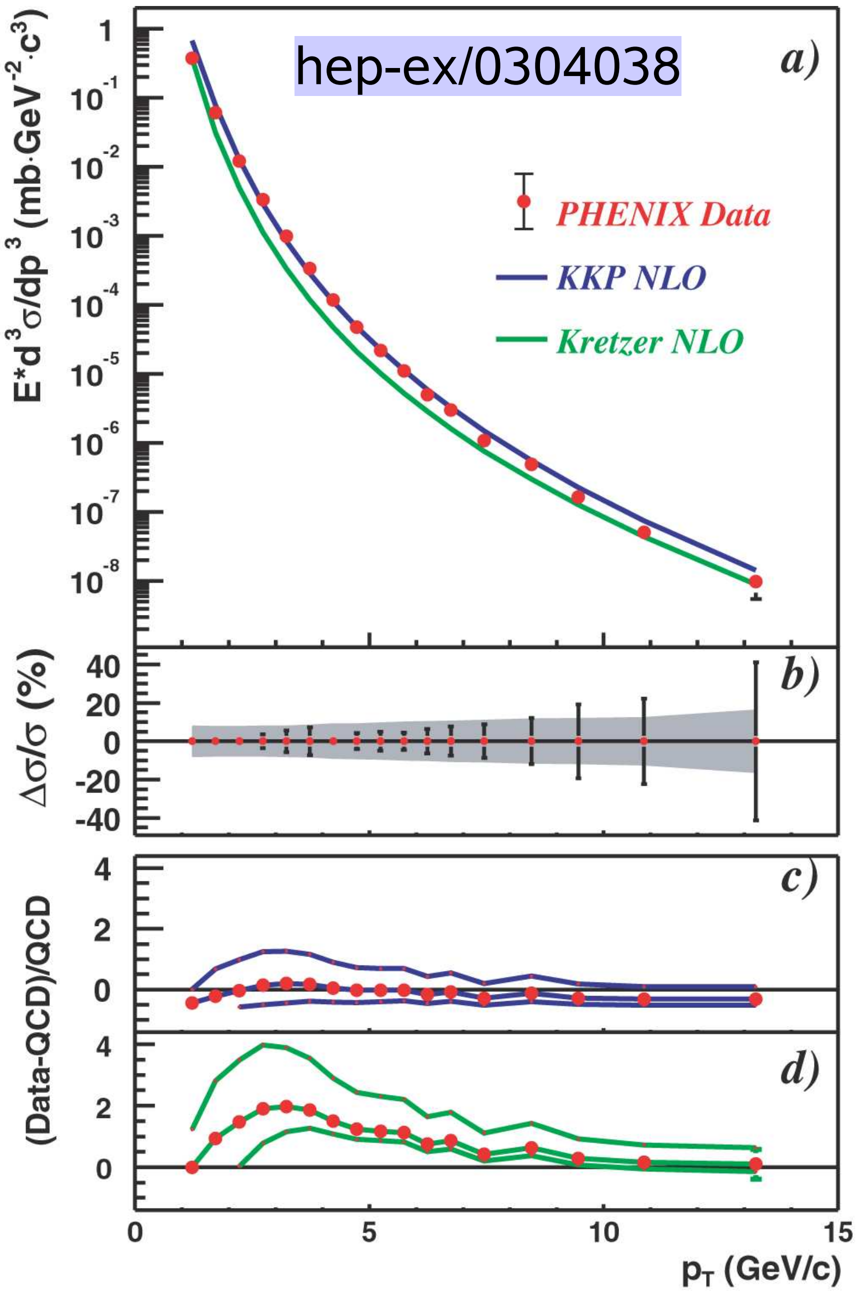
High p_T Particle Production

- High p_T particles in p+p and A+A
  - Result from parton-parton scatterings with high momentum transfer Q^2 (*hard* processes)
- p+p:
  - Fragmentation of partons to hadrons in the QCD vacuum
- A+A:
  - Hard parton-parton scatterings in the early stage of the collision
  - Thus, high p_T partons are probes of the hot and dense nuclear matter formed in later stages

- Hot and dense matter created in A+A might affect
  - High p_T particle yields
  - Ratio of particle species
  - Jet-like angular correlations



π^0-Production in p+p at $\sqrt{s}$ = 200 GeV



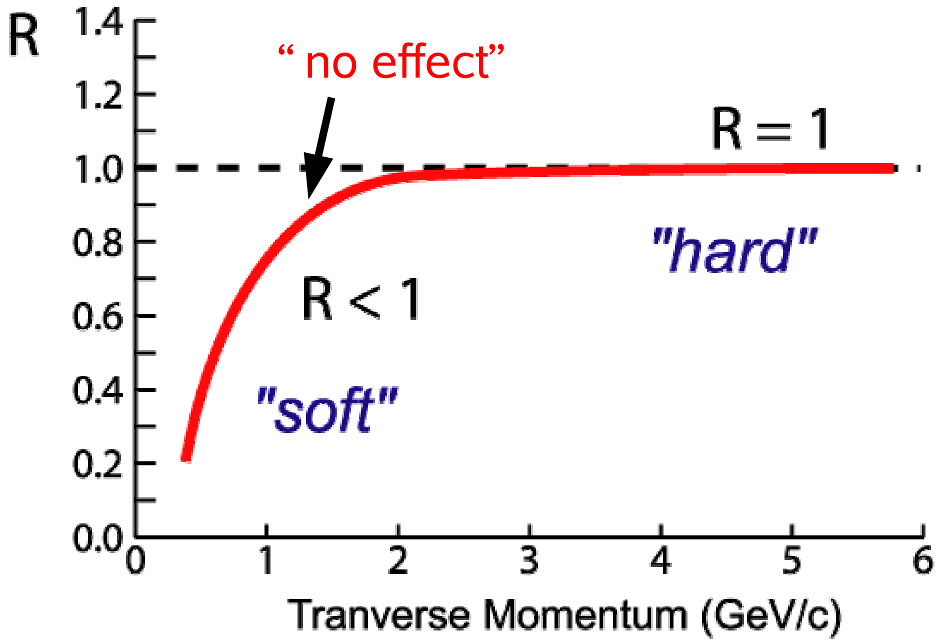
- Good agreement with NLO pQCD
- Constrains *D*(Gluon→π) fragmentation function
- Result needed as reference for interpretation of Au+Au-Spectra

Nuclear Modification Factor

$$R_{AA} = \frac{\frac{dN}{dp_T}(A+A)}{N_{coll} \cdot \frac{dN}{dp_T}(p+p)}$$

average number of inelastic nucleon-nucleon collisions

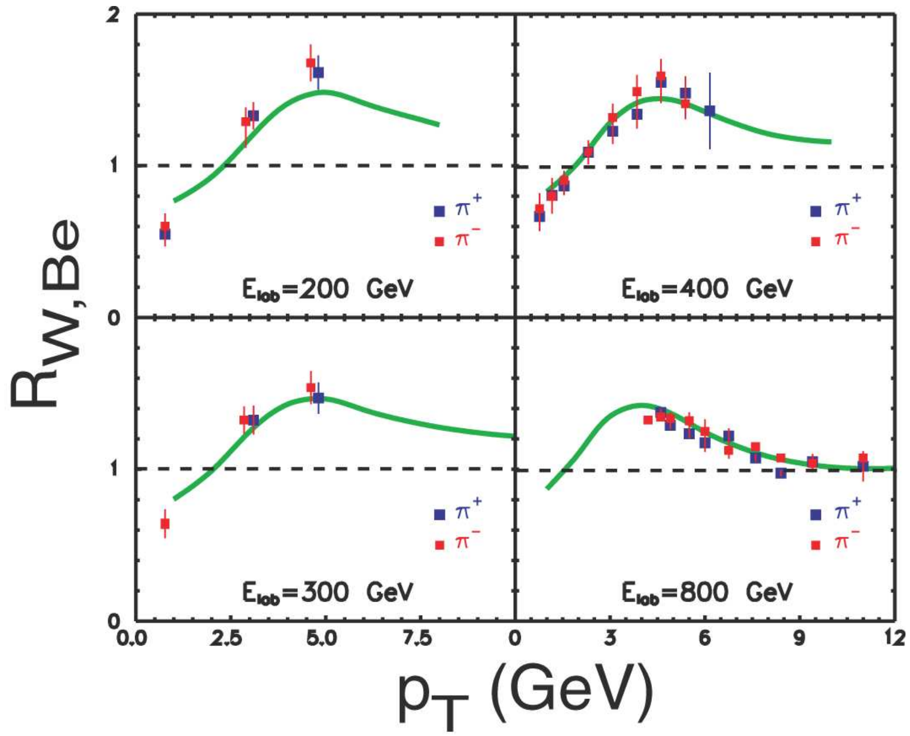
- Hard processes: Yield scales with N_{coll} (reason: small cross sections, incoherent superpositions)
- In the absence of nuclear effects: R_{AA} = 1 at high p_T



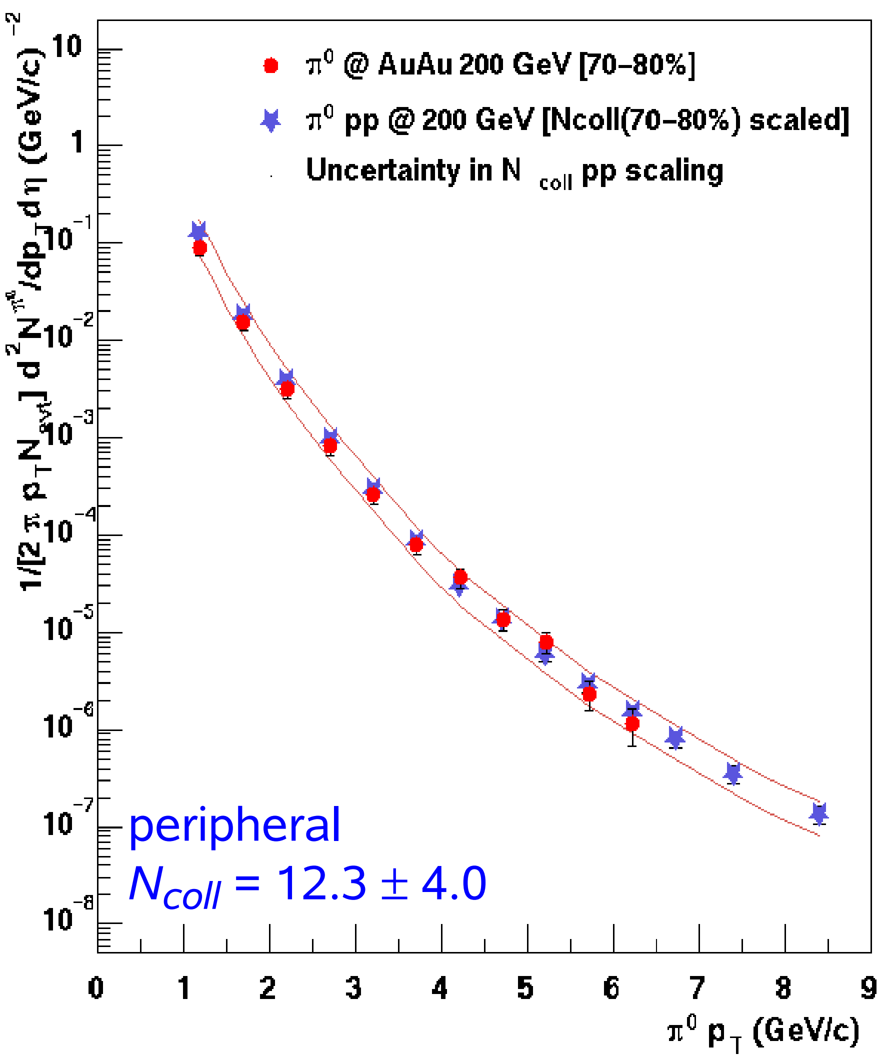
Initial State Effects

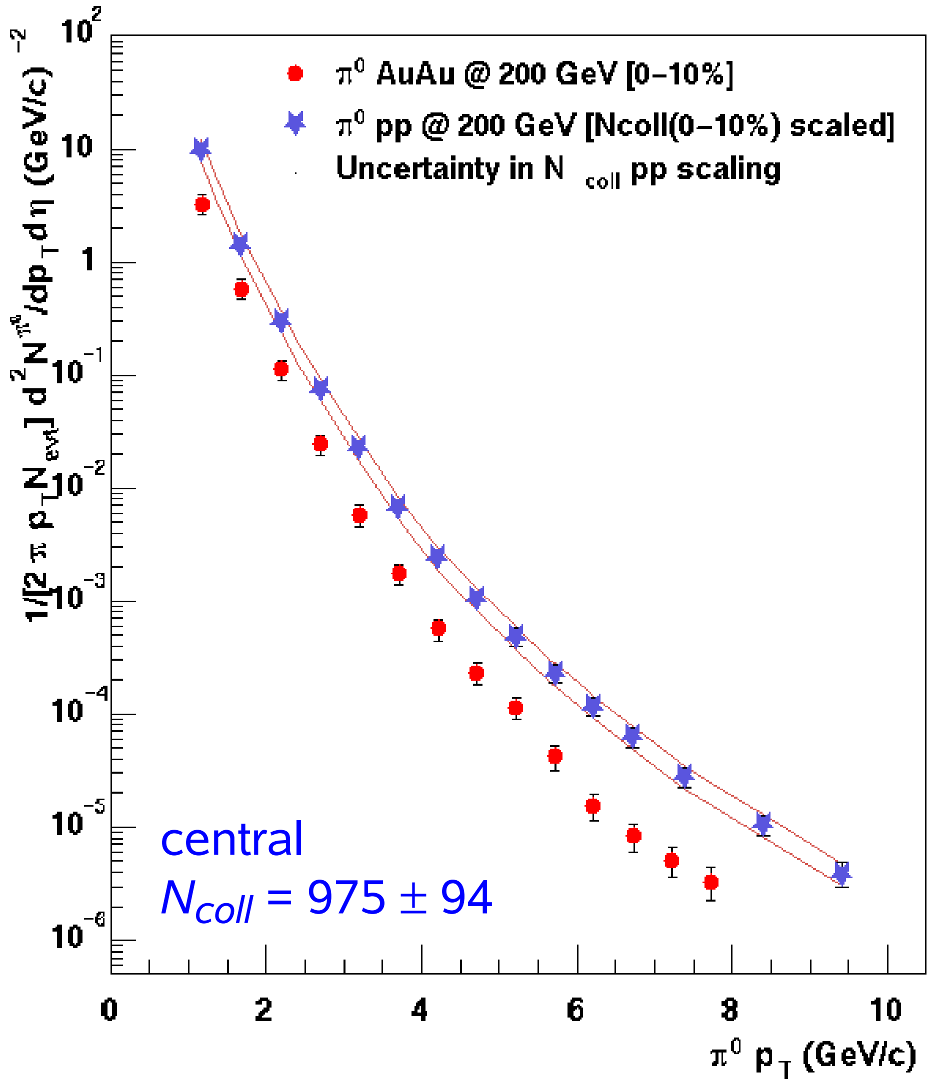
- Initial State Effects:
  Effects which lead to $R_{AA} \neq 1$ at high p_T but which are not related to properties of the hot and dense nuclear matter
- Suspects:
  - Initial state multiple soft scatterings (Cronin Effect): increases R_{AA}
  - Modification of the nucleon structure functions in nuclei (Shadowing): decreases R_{AA}
  - Gluon saturation (Color Glass Condensate): decreases R_{AA} (?)

Cronin-Effect observed in fixed target experiments:



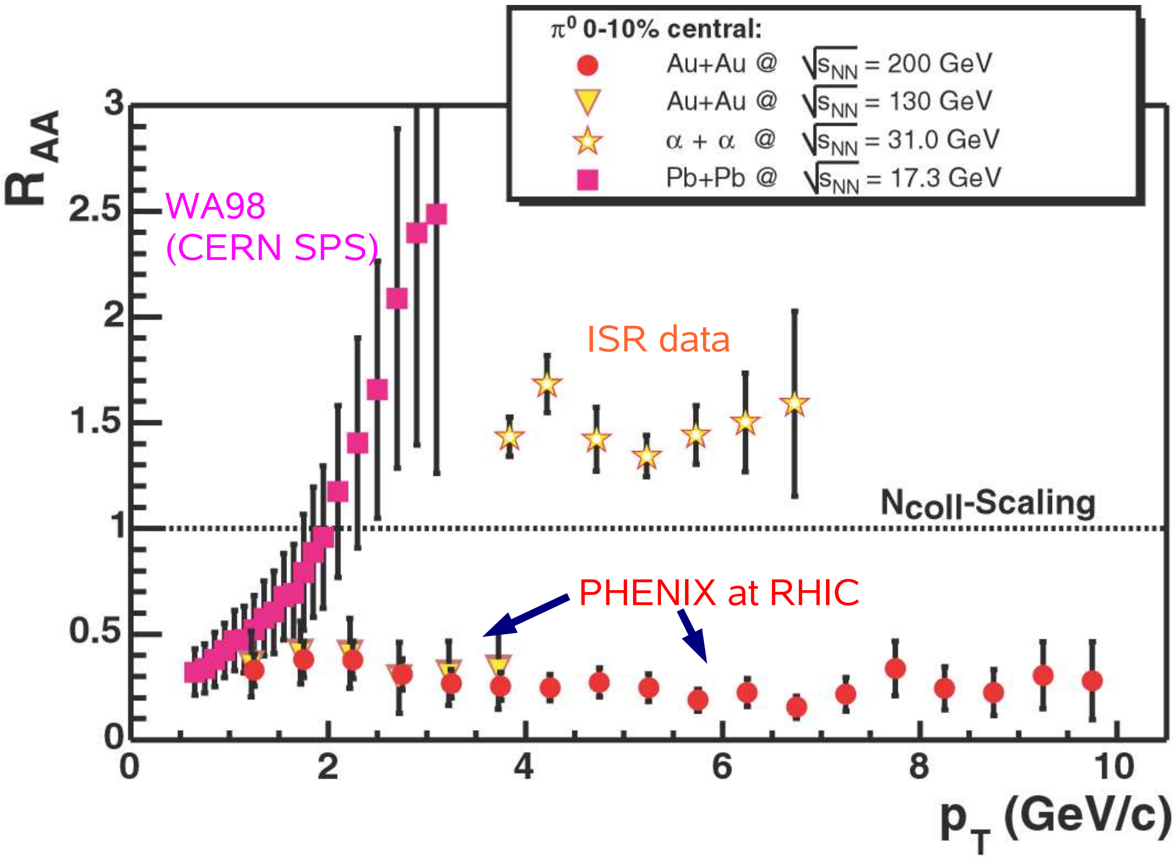
π^0-Production in Au+Au at $\sqrt{s_{NN}}$ = 200 GeV





→ N_{coll}-scaling works in peripheral Au+Au, but strong suppression in central Au+Au

R_{AA} for Neutral Pions in Central Collisions



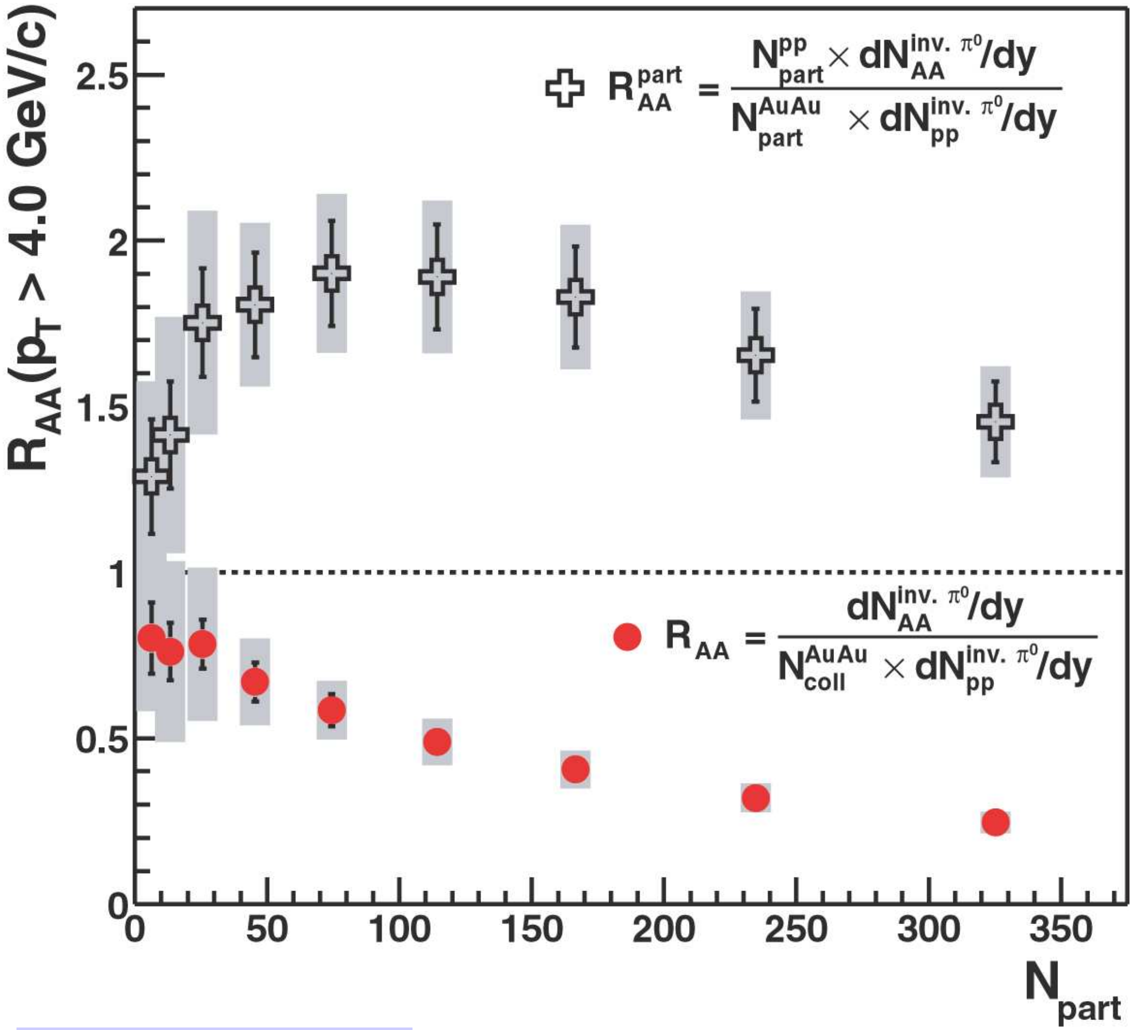
nucl-ex/0304022

- Expectation from Cronin-Effect: $R_{AA} > 1$
- Observed:
  Factor 4-5 suppression in central Au+Au-collisions at $\sqrt{s_{NN}}$ = 130 and 200 GeV

$$R_{AA} = \frac{\frac{dN}{dp_T}(A+A)}{N_{coll} \cdot \frac{dN}{dp_T}(p+p)}$$

Centrality Dependence of the Suppression

Au+Au at $\sqrt{s_{NN}}$ = 200 GeV



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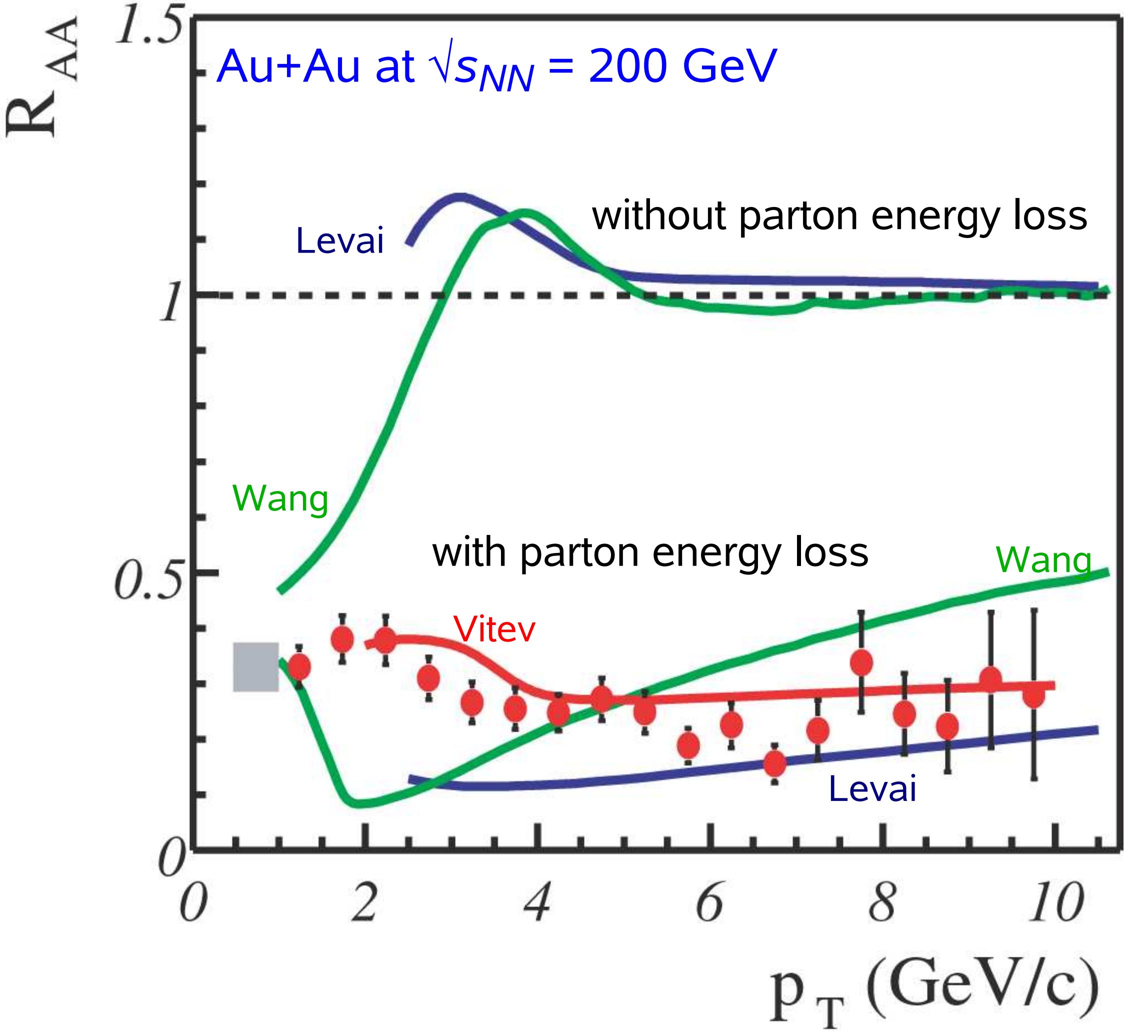
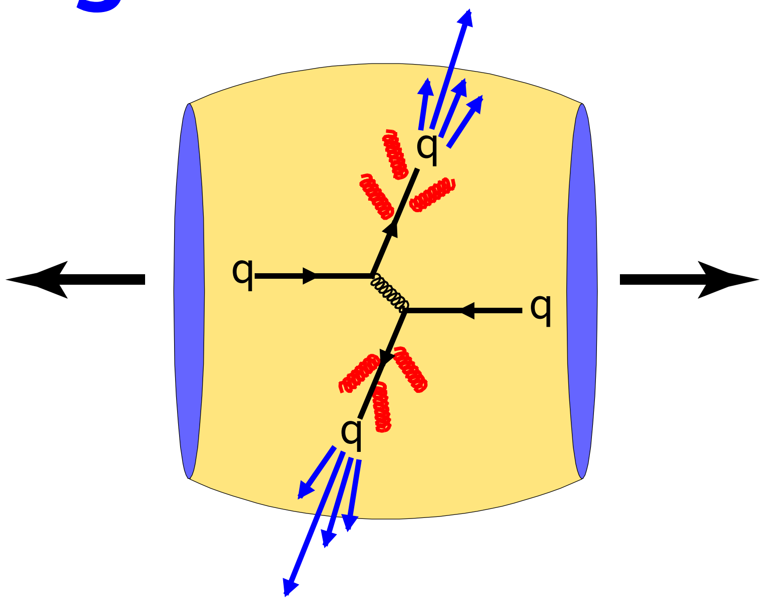
- Consider integrated π^0 yield above p_T = 4 GeV/c
- Smooth increase of suppression with centrality
- Neither N_{coll}- nor N_{part}-scaling

Jet-Quenching?

Comparison with model calculations with and without parton energy loss:

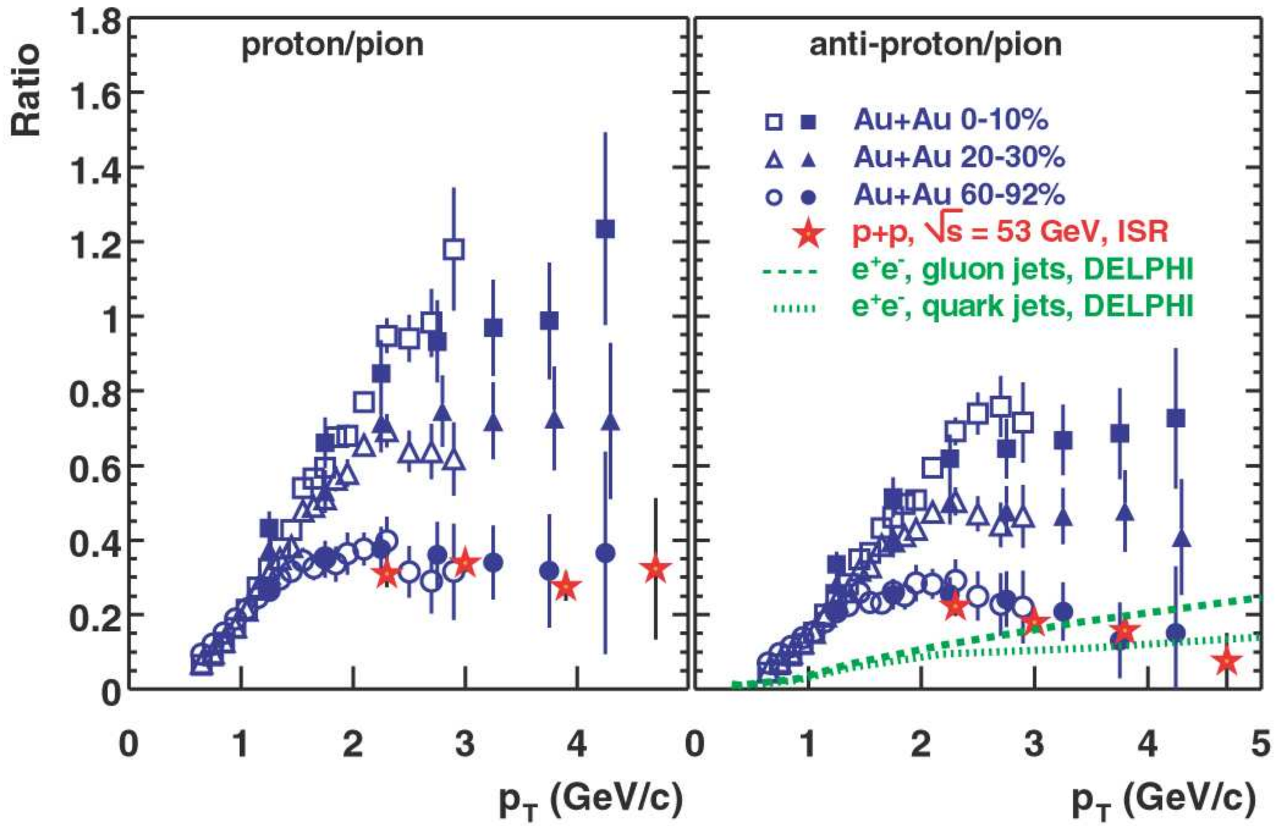




- Pion-suppression reproduced by models with parton energy loss
- p_T-dependence not well described
- Other explanations not ruled out at this stage

p/π – Ratio

Au+Au at $\sqrt{s_{NN}}$ = 200 GeV

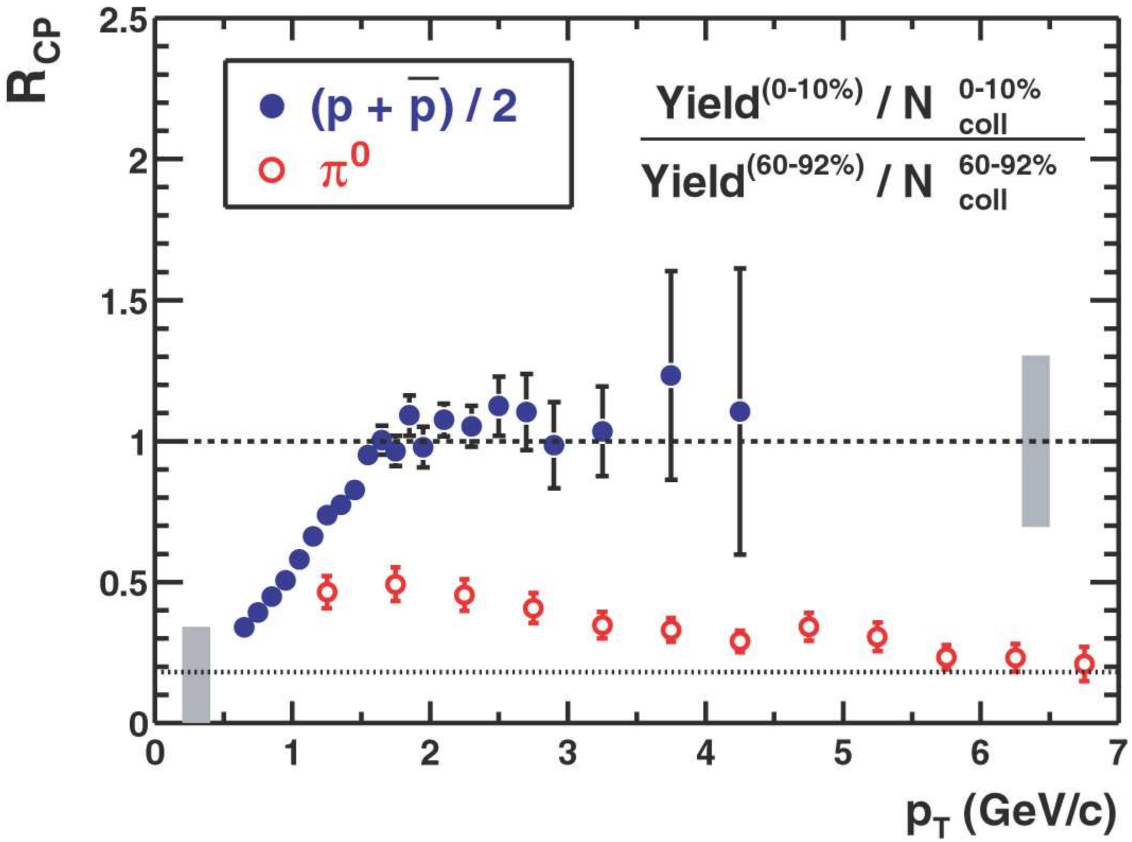


nucl-ex/0305036

- Expectation for particle production from jet-fragmentation: p/π less than ≈0.25 at high p_T
- Observed:
  - Strong centrality dependence
  - Central Au+Au: p/π ≈ 1

Proton-Scaling

Au+Au at $\sqrt{s_{NN}}$ = 200 GeV

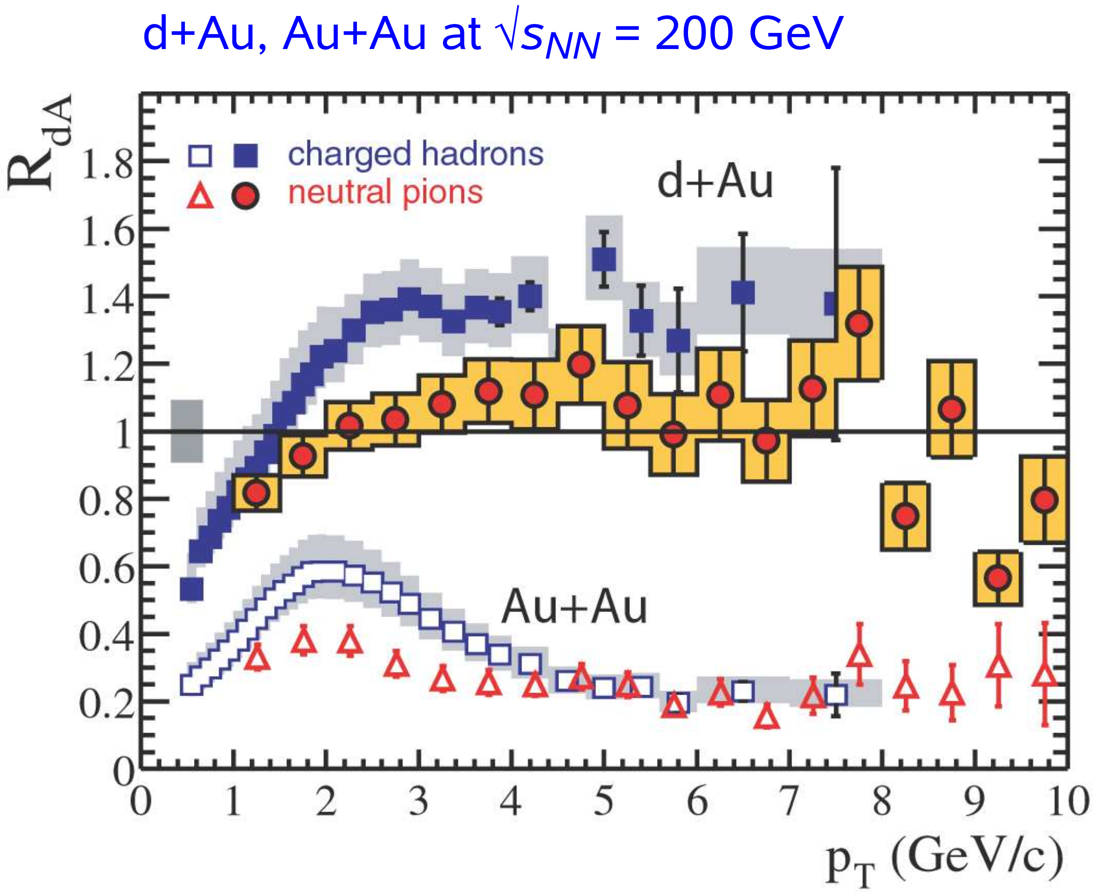


- Proton/anti-proton-yield scales with N_{coll} in the range 2 GeV < p_T < 3 GeV

- Possible explanations
  - Collective expansion (*hydrodynamic flow*)
  - Jet-Fragmentation within quark-gluon plasma

$$R_{CP} = \frac{\frac{dN}{dp_T}(A+A\text{, central}) \;/\; N_{coll}^{\text{central}}}{\frac{dN}{dp_T}(A+A\text{, peripheral}) \;/\; N_{coll}^{\text{peripheral}}}$$

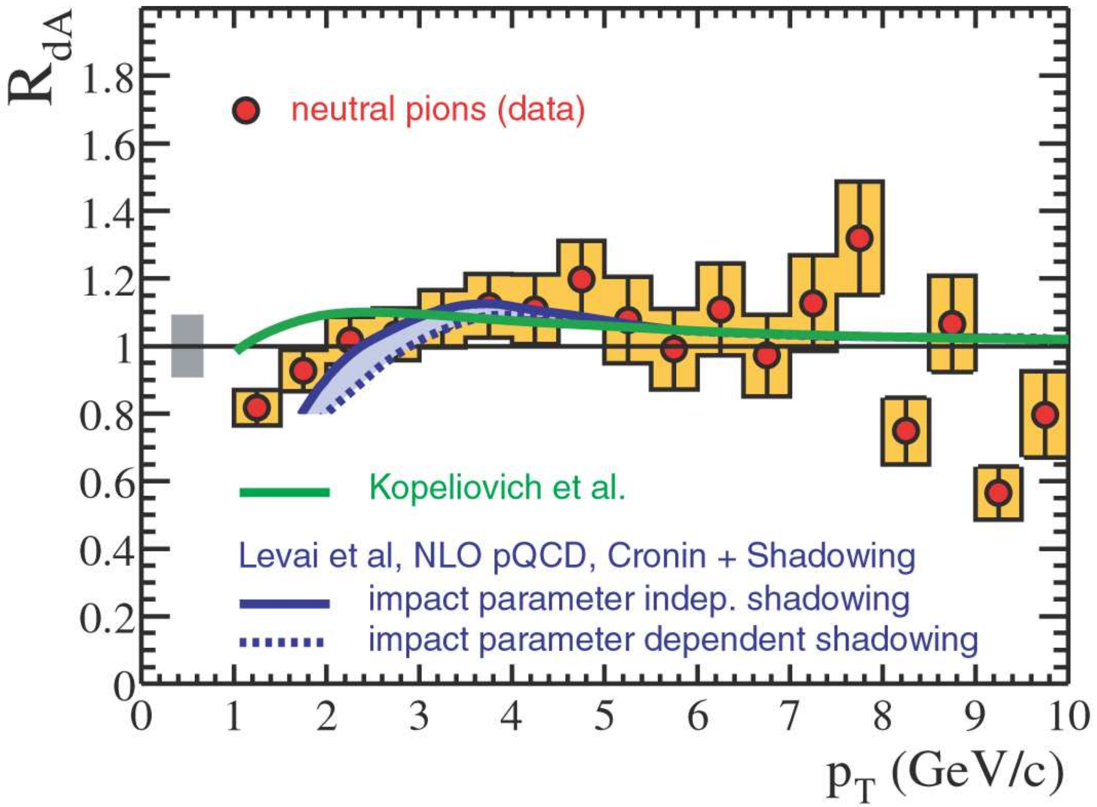
The Control Experiment: d+Au



Paper will be submitted to preprint server today (June 17th, 2003)!

- Two possible explanations for suppression in central Au+Au:
  - Initial state effects
  - Final state effects
- Final state effects minimal in d+Au
- No suppression in d+Au
- Initial state effects ruled out as explanation for suppression in Au+Au

π^0's in d+Au: Data vs. Theory



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

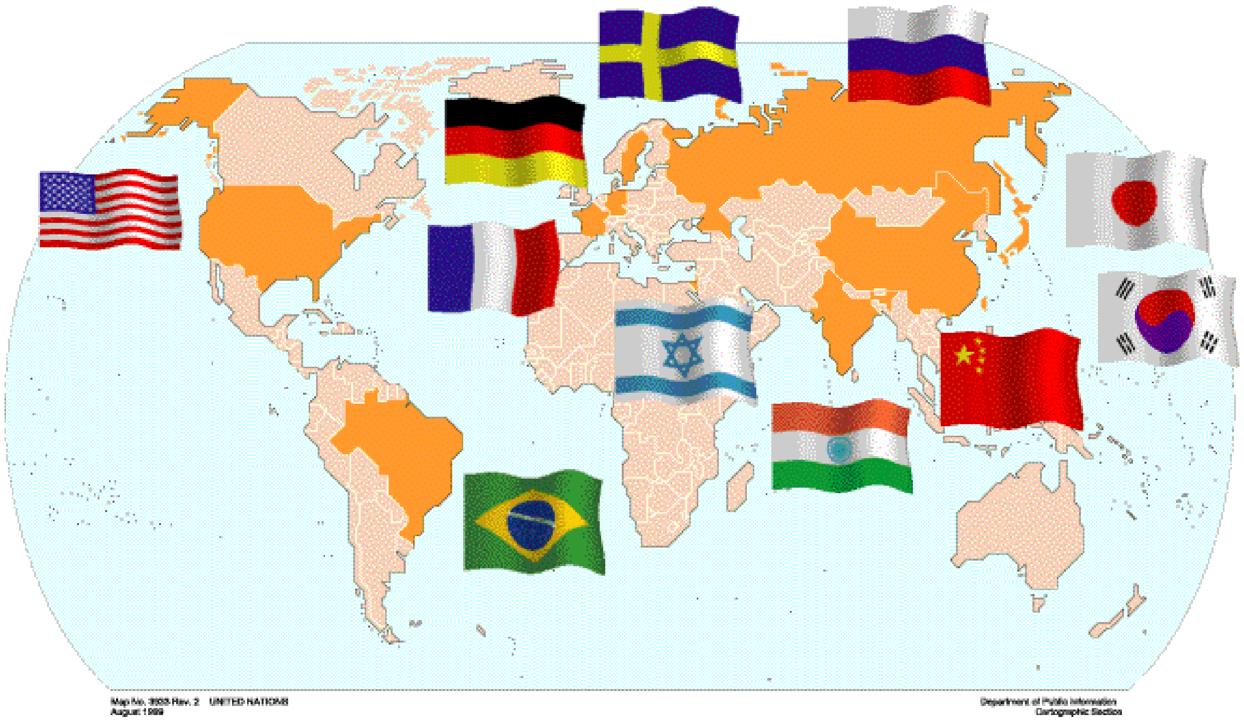
Levai et al., nucl-th/0306019

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

Summary

- Strong suppression of high p_T particle production in central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV with respect to N_{coll}-scaled p+p-reference
- No suppression seen in $\sqrt{s_{NN}}$ = 200 GeV d+Au
- Suppression of particle production in Au+Au is caused by properties of the created hot and dense medium

PHENIX



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