Particle Composition at High p_T in Au+Au Collisions at RHIC

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for the PHENIX Collaboration

Hadron Production at High p_T in *AA*

- Hard processes in *AA* are sensitive to the early partonic phase of reaction.
- Any departures from the expected binary collision scaling (N_{coll}) behavior provide the information on the strong interacting medium in *AA* collisions.

Nuclear Modification Factor

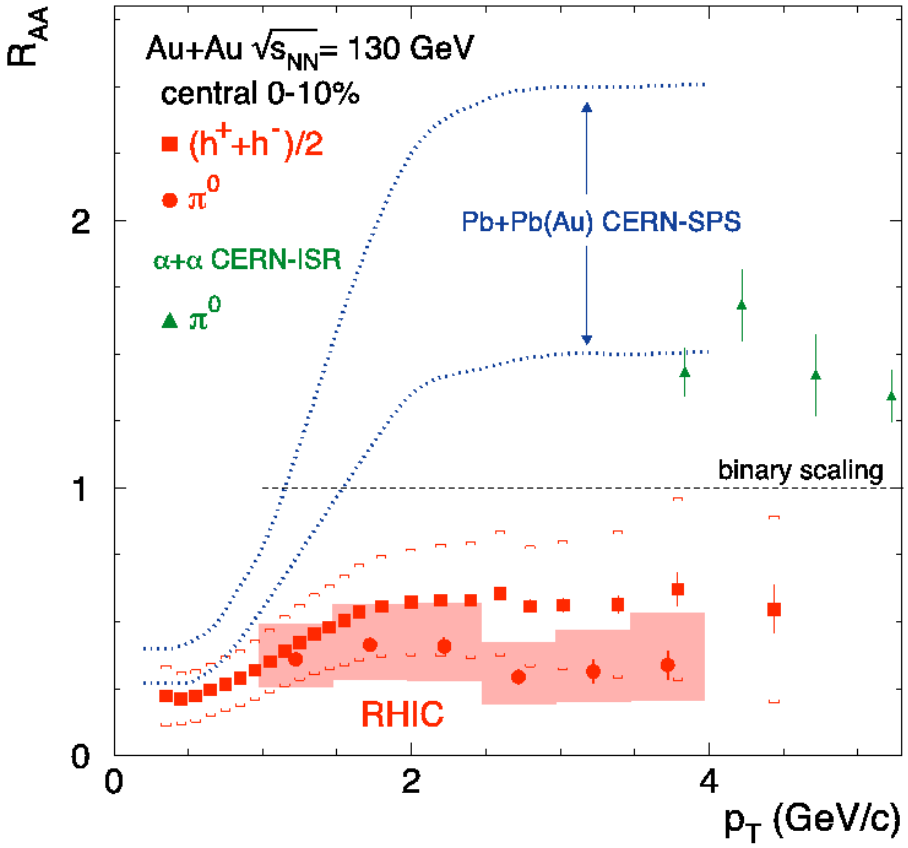
$$R_{AA}(p_T) = \frac{d^2N^{AA}/dp_T d\eta}{T_{AA}\, d^2\sigma^{NN}/dp_T d\eta}$$

$\langle N_{binary}\rangle/\sigma_{inel}^{p+p}$

NN cross section

- **Scenario 1 : R_{AA} =1 : Scale with # of binary collisions (N_{coll}).**
- **Scenario 2 : R_{AA} >1 : Cronin effect (observed in ISR and SPS).**
- **Scenario 3 : R_{AA} <1 : Suppression.**

130 GeV Results (1): π^0, *h* suppression at high p_T



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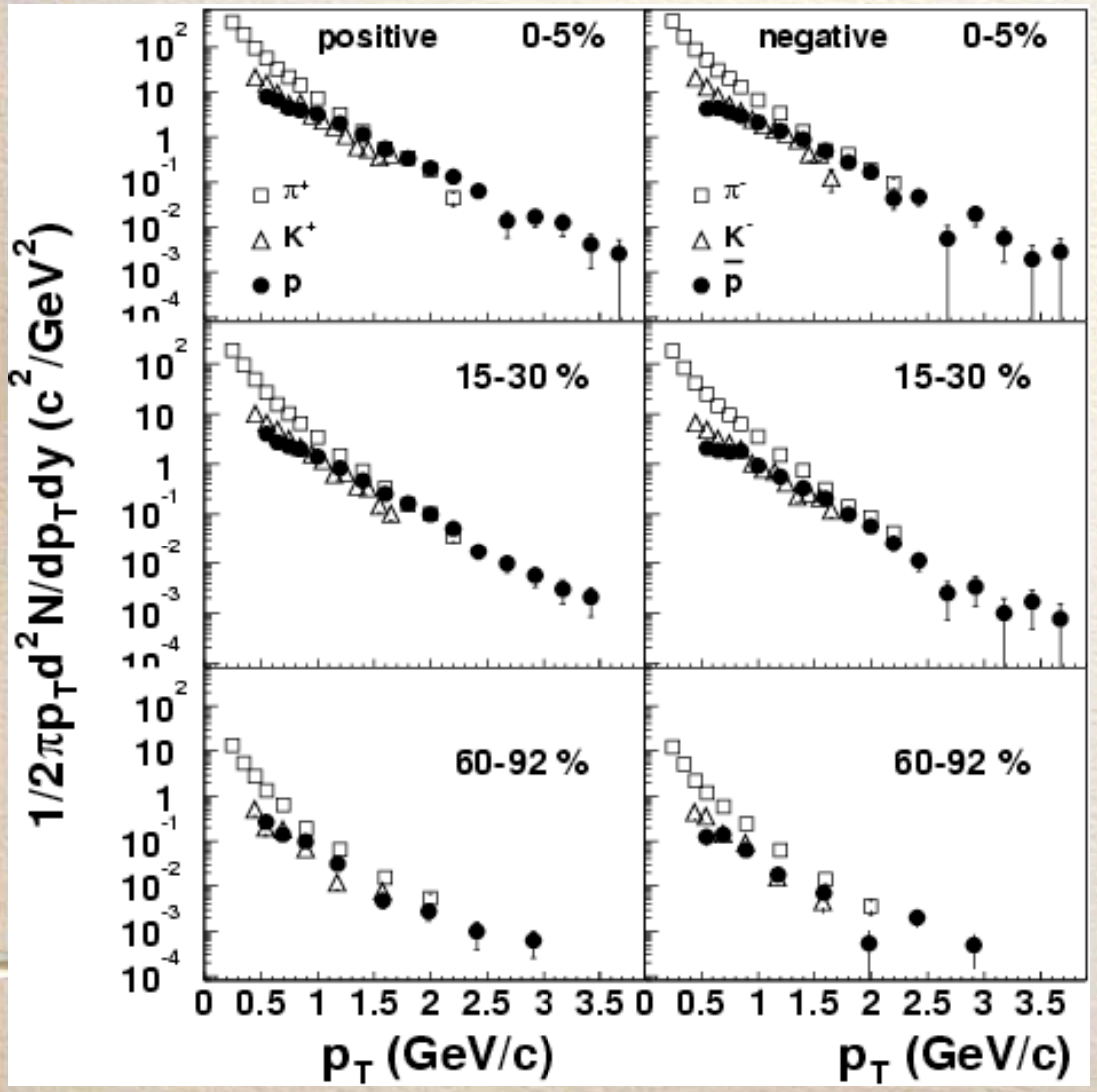
PRL 88, 022301 (2002)

- Both charged hadron and π^0 are suppressed in AuAu central at high p_T at RHIC ($R_{AA} < 1$).
  - A possible consequence of parton energy loss via gluon radiation in dense medium ("jet quenching").
- But **$R_{AA}(\pi^0) < R_{AA}(h)$** : Suggests the importance to study the particle composition at high p_T.

130 GeV Results (2) : Proton vs. pion



- **Proton yield is comparable to yield in central AuAu at p_T = 1.5 ~ 3.5 GeV/c.**
- **Needed more statistics.**

 200 GeV DATA

PHENIX
PRL 88, 242301 (2002)

In this presentation…

We present the high statistics proton and anti-proton p_T spectra and their centrality dependencies in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV at mid-rapidity from the PHENIX experiment.

- Feed-down corrected p and pbar p_T spectra.
- N_{coll} scaling behavior.
- Central-to-Peripheral ratio (R_{CP}) for p and π^0.
- p/π (pbar/π) ratio vs. p_T and centrality.
- h/π ratio vs. p_T and centrality.

**** To be submitted to PRL soon.***

PHENIX Experiment and PID

π^0 PID by EMCal

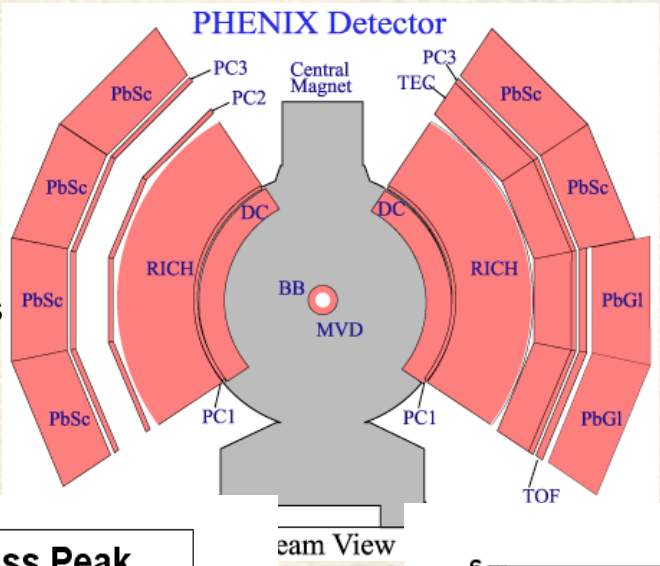
via π^0 $\gamma\gamma$ ($1<p_T<10$GeV/c)

6 lead- Scintillator (PbSc) sectors

2 lead- glass (PbGl) sectors

$\Delta\phi = \pi$

$\Delta\eta = 0.7$

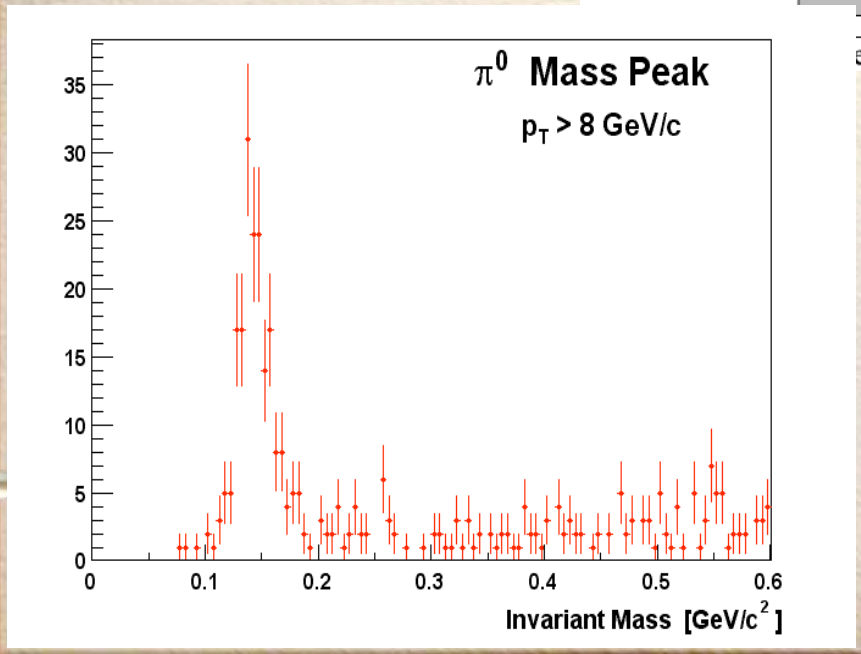


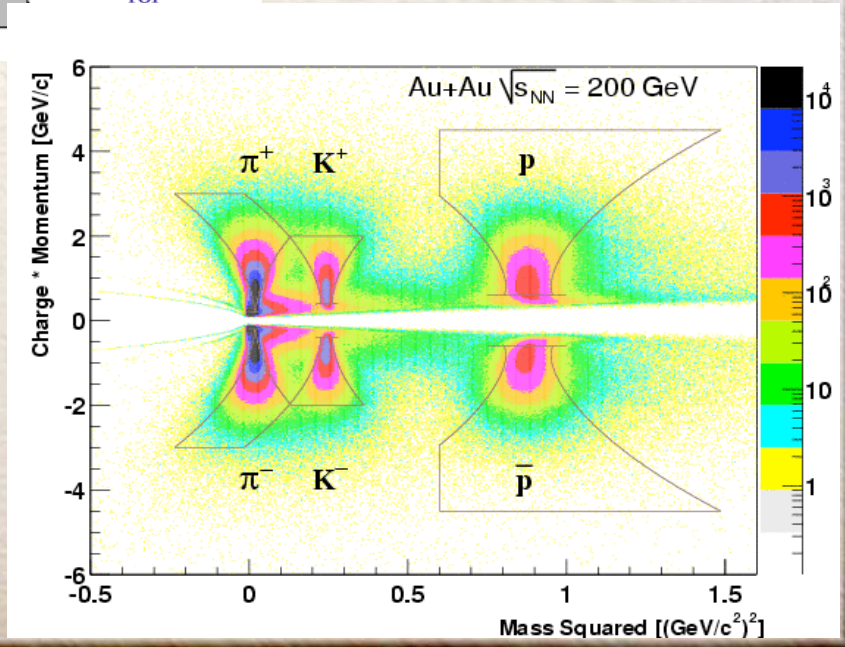
Charged PID by TOF

(DCH+PC1+TOF+BBC)

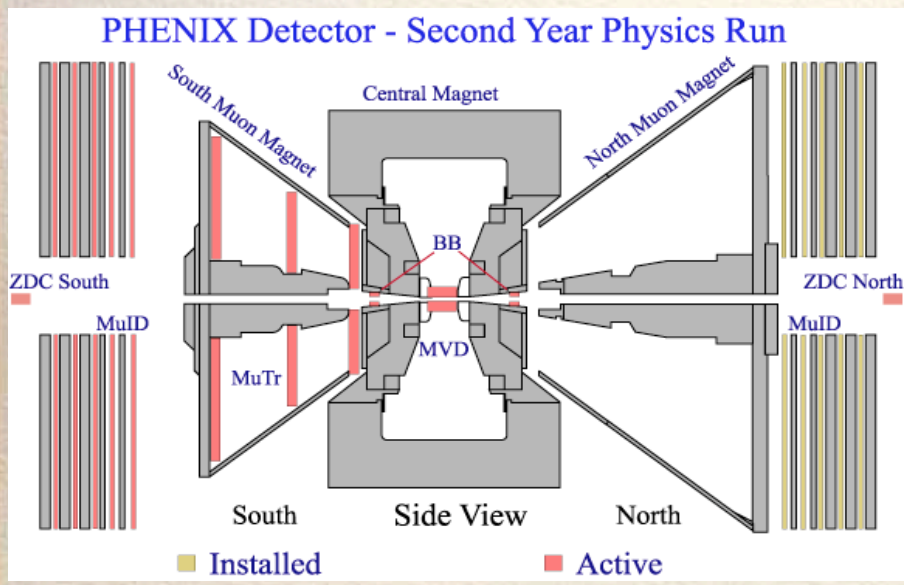
$\pi/K < 2$ GeV/c, $K/p < 4$ GeV/c

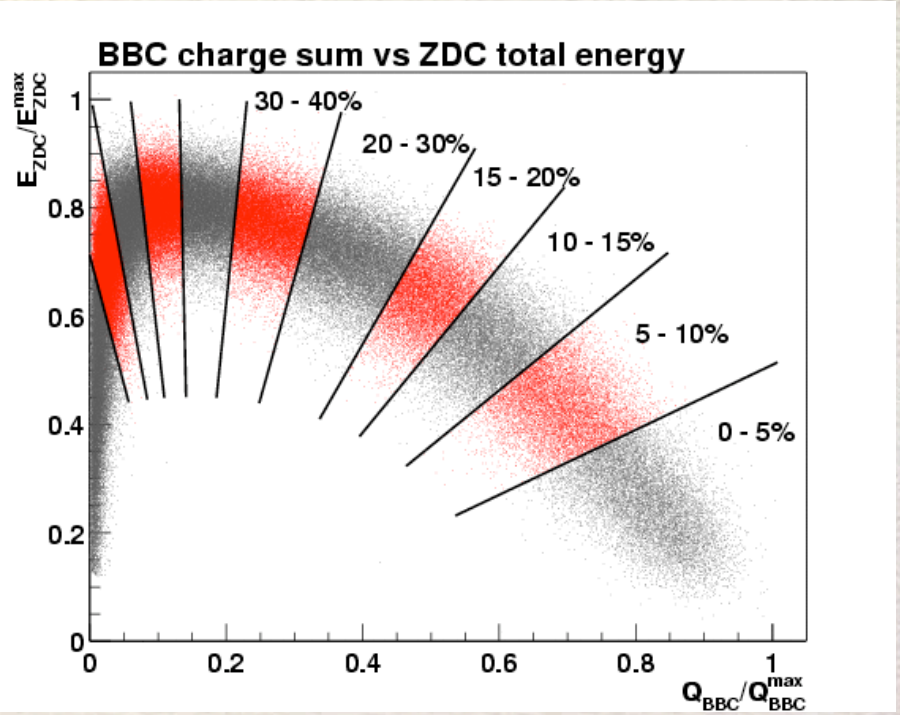
$\Delta\phi = \pi/8$





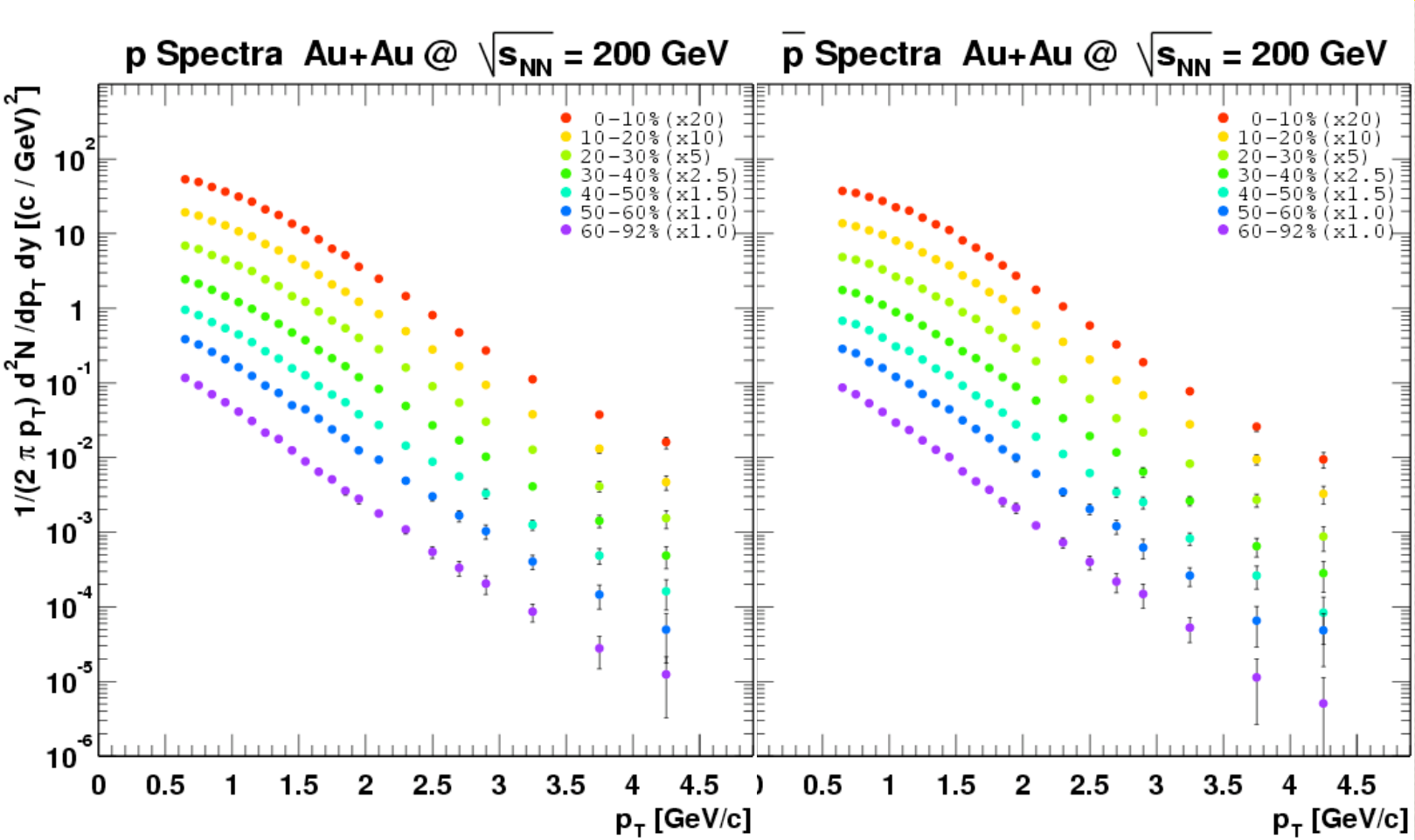
Collision Centrality Determination





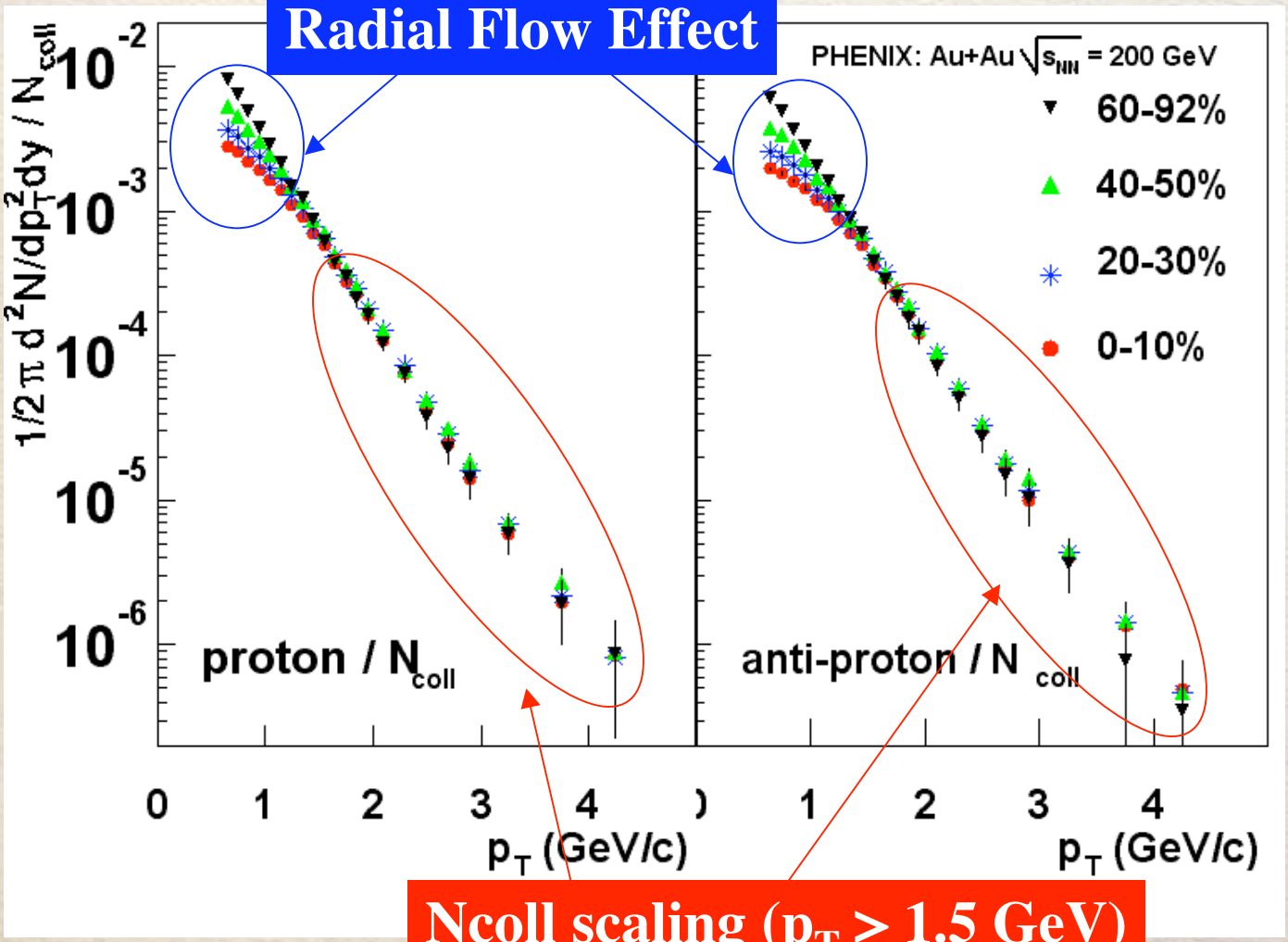
- Centrality selection : Used charge sum of Beam-Beam Counter (**BBC**, |□|=3~4) and energy of Zero-degree calorimeter (**ZDC**) in minimum bias events (92% of total inelastic cross sections).
- Extracted $\mathbf{N_{coll}}$ and $\mathbf{N_{part}}$ based on Glauber model.

Proton and anti-proton spectra in AuAu at 200 GeV



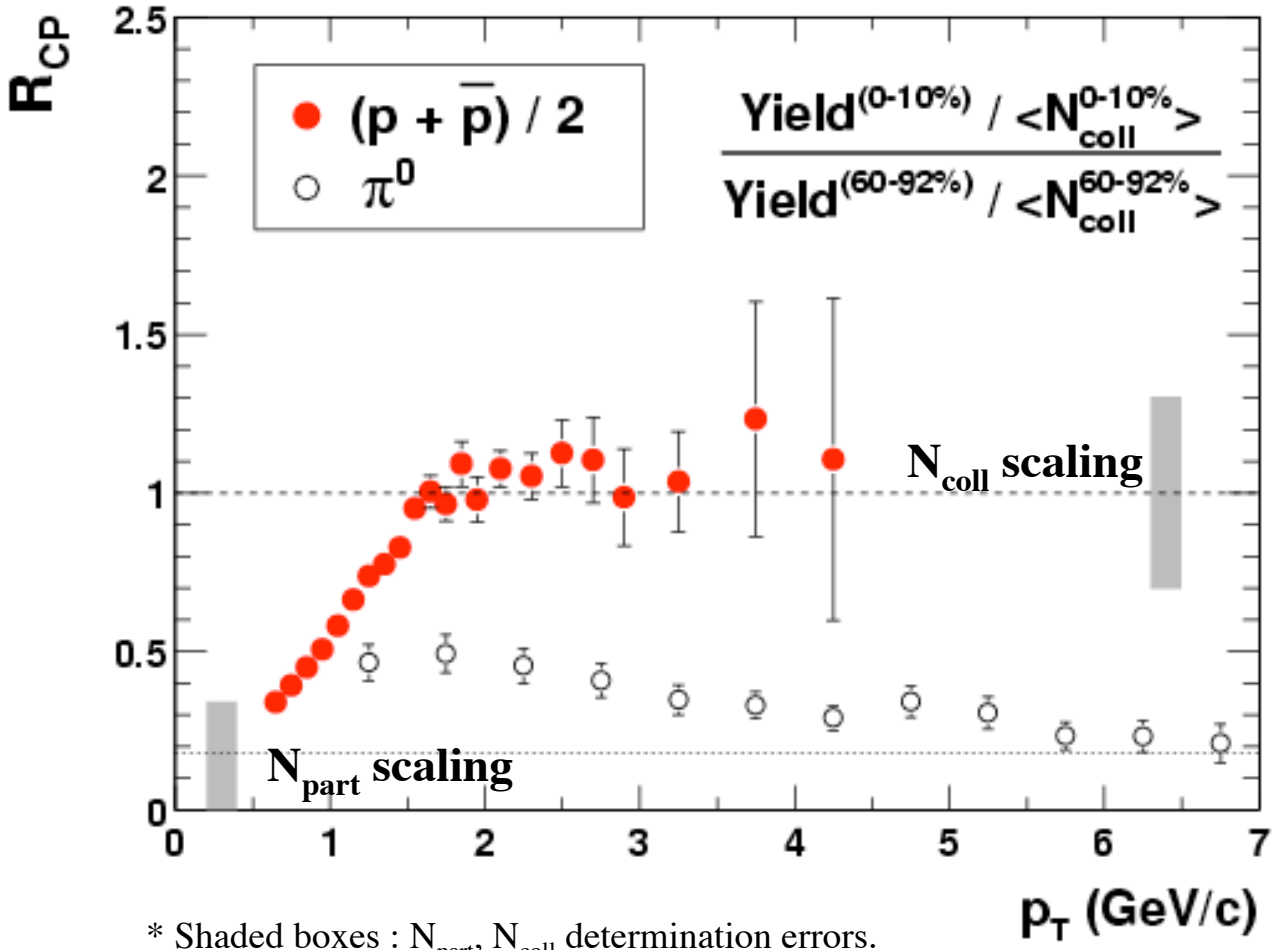
- Corrected for weak decay feed-down effect (~40% at 0.6 GeV/c, ~25% at 4 GeV/c).
- **Strong centrality dependence in spectra shape at low p_T (< 1.5 GeV/c).**

N_{coll} scaled p_T spectra for p and pbar



Ncoll scaling (p_T > 1.5 GeV) for all centrality bins

Central-to-Peripheral Ratio (R_{CP}) vs. p_T



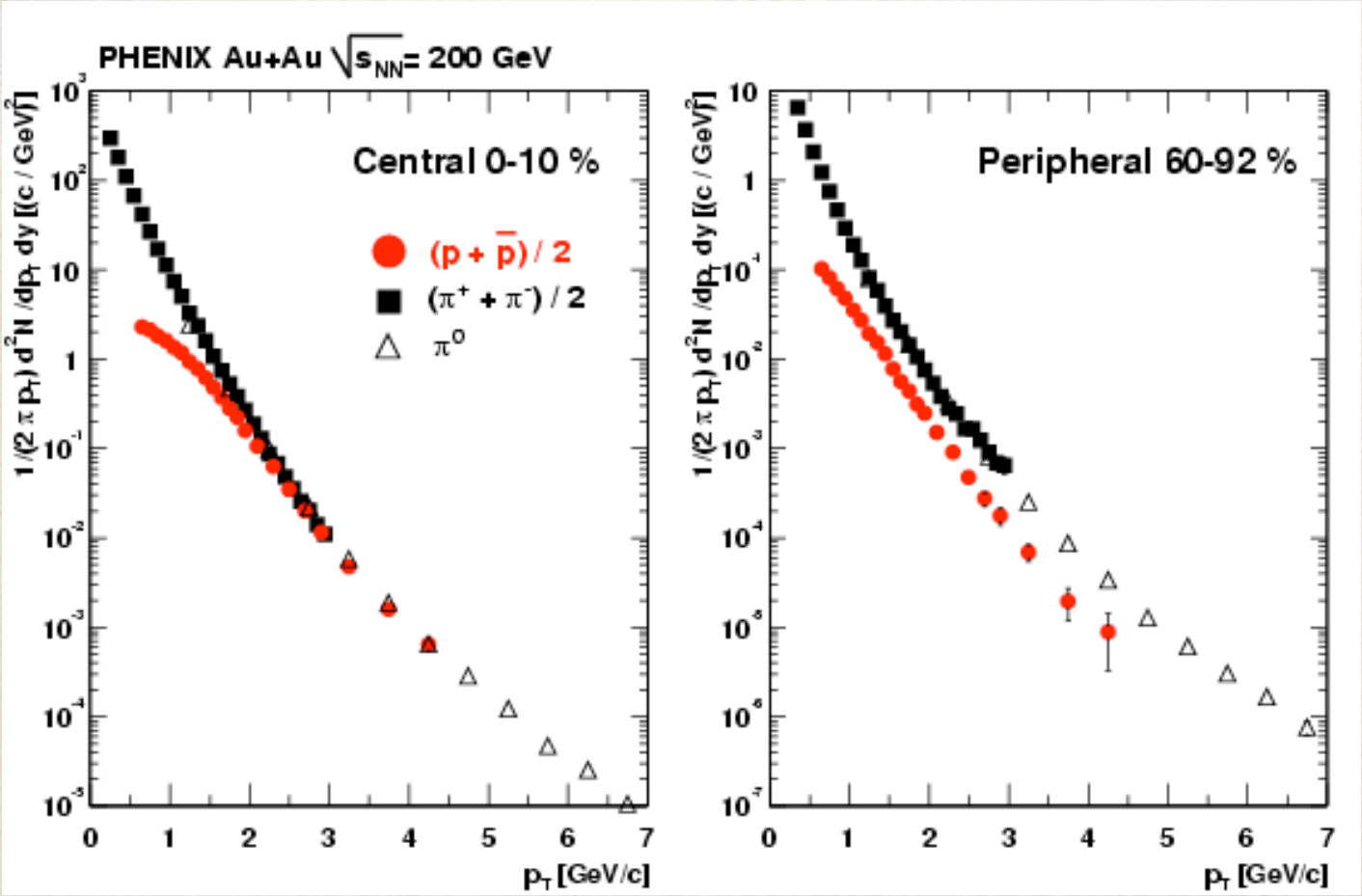
* Shaded boxes : N_{part}, N_{coll} determination errors.

$= R_{CP} \approx R_{AA}$

p : N_{coll} scaling at 1.5 GeV - 4.5 GeV
(Not suppressed for all centralities)

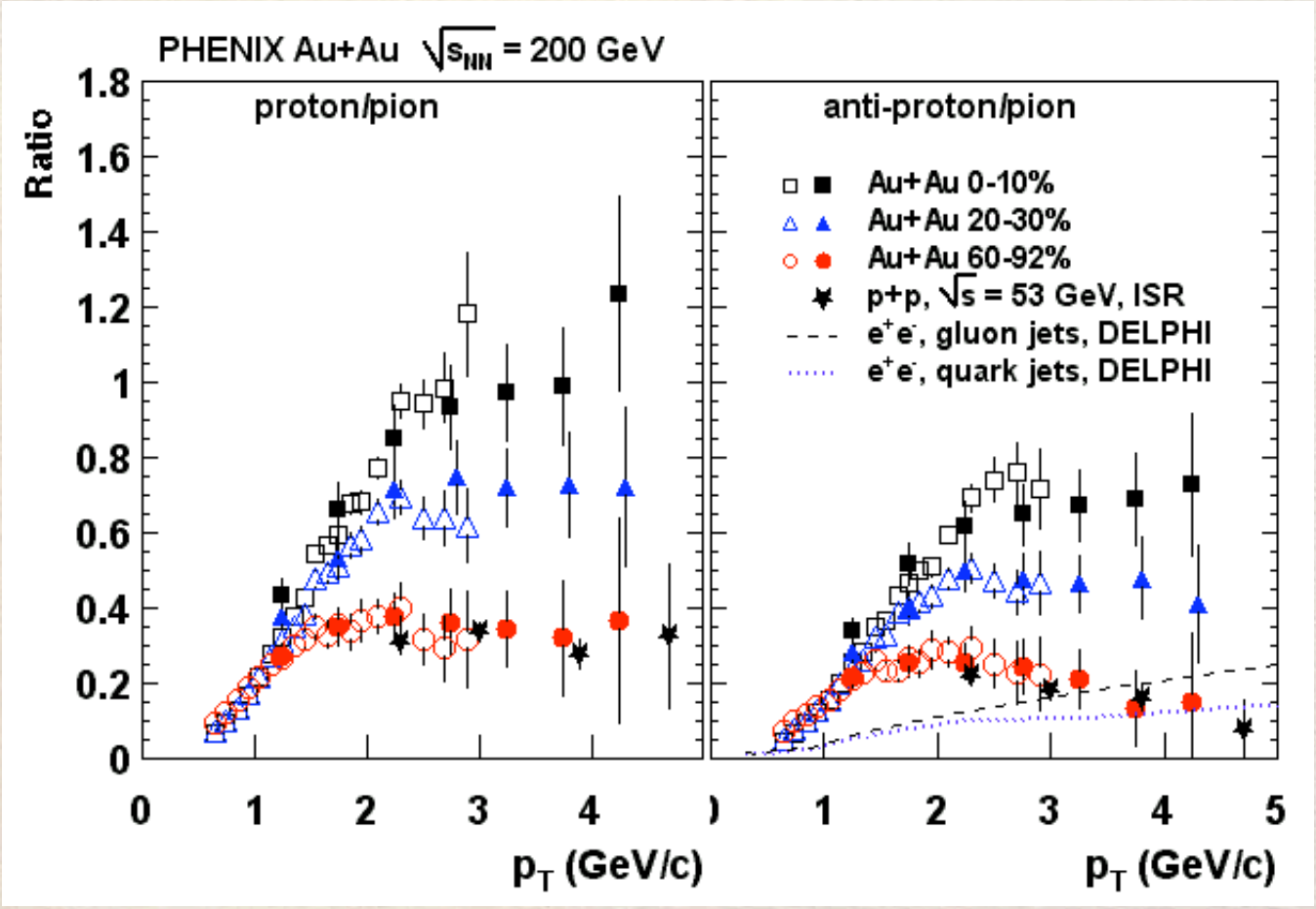
π^0: Suppression
(central > peripheral)

p_T spectra (p vs. □) in Au+Au @ 200 GeV



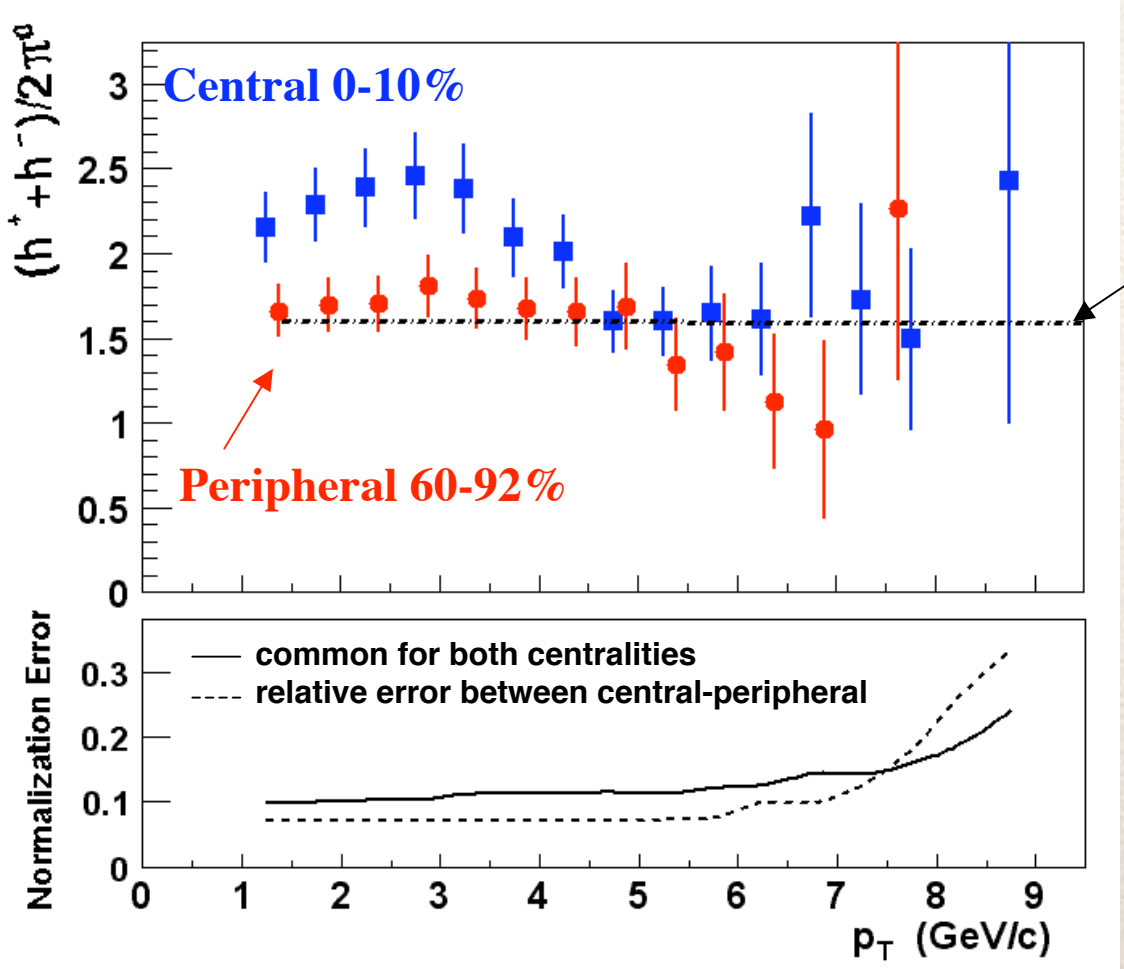
- Clearly seen p-□ merging at $p_T \sim 2$ GeV/c in central.
- No p-□ merging in peripheral.
- Suggested significant fraction of p, pbar at pt = 1.5 - 4.5 GeV/c in central.

p/π ratio vs. p_T and centrality



- Both p/π and pbar/π ratios are enhanced compared to peripheral Au+Au, p+p and e^+e^- at p_T = 1.5 ~ 4.5 GeV/c.
- Consistent with gluon/quark jet fragmentation in peripheral AuAu (> 3 GeV/c)

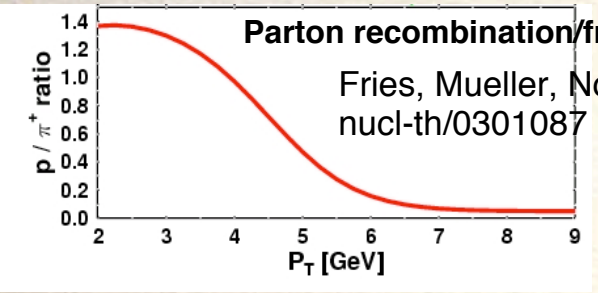
Particle composition beyond 5 GeV …



~1.6 (p+p data at s_{NN} = 53 GeV)

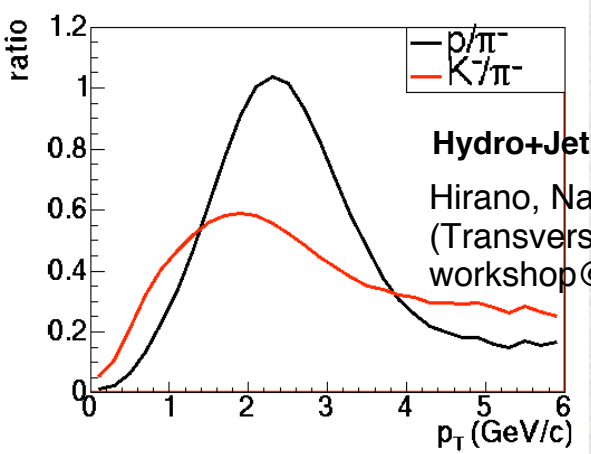
- Deduced particle compositions at high p_T from h/π^0 ratio.
- Peripheral data is consistent with p+p data.
- **Suggested p and pbar contributions in central are limited up to p_T ~ 5 GeV/c.**

What is the PHYSICS behind?



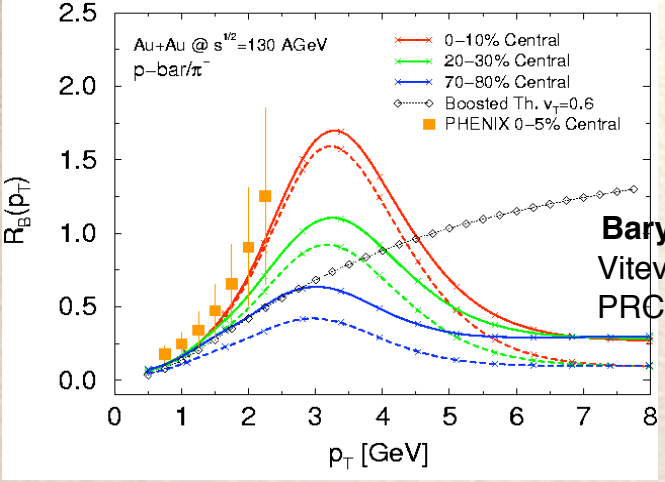
Parton recombination/fragmentation

Fries, Mueller, Nonaka,Bass
nucl-th/0301087



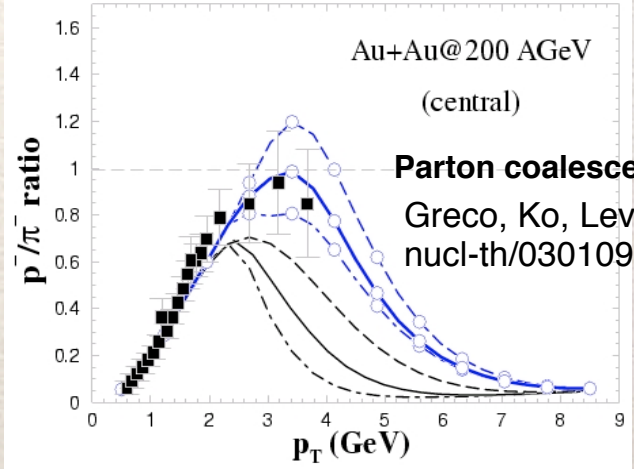
Hydro+Jet

Hirano, Nara
(Transverse Dynamics workshop@ BNL)



Baryon Junction

Vitev, Gyulassy
PRC 65, 041902, 2002



Parton coalescence

Greco, Ko, Levai
nucl-th/0301093

- Both **Parton Recombination/Coalescence** and **Baryon Junction** models reproduce p/π ratio (p_T and centrality dep.) qualitatively.
- Both models predict p/π enhancement is limited < 5 GeV/c.
- Another scenarios: Different formation time between baryons and mesons ?
  or Strong radial flow + hard scattering ?

Summary

We presented the yield of protons and anti-protons as a function of centrality and p_T in Au+Au at s_{NN} = 200 GeV.

- In central collisions at intermediate p_T ($1.5 < p_T < 4.5$ GeV/c), protons and anti-protons are a significant fraction of the total yield.
- Scaling behavior:
  - p: N_{coll} scaling behavior at intermediate p_T for all centralities.
  - □: suppression @ $p_T > 2$ GeV (central > peripheral).
- pbar/□ and p/□ ratios are enhanced compared to peripheral Au+Au, p+p and e^+e^-.
- This enhancement is limited to $p_T < 5$ GeV/c as deduced from h/$□^0$ measurement at p_T = 1.5 - 9.0 GeV/c.

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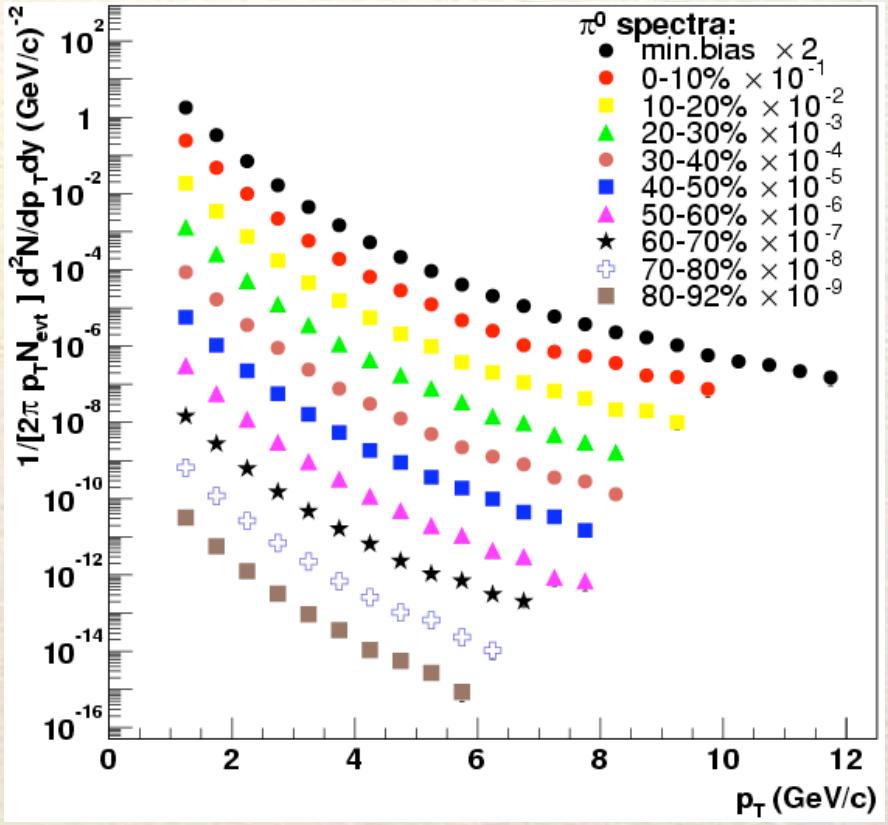
*as of July 2002

π^0 spectra AuAu 200 GeV

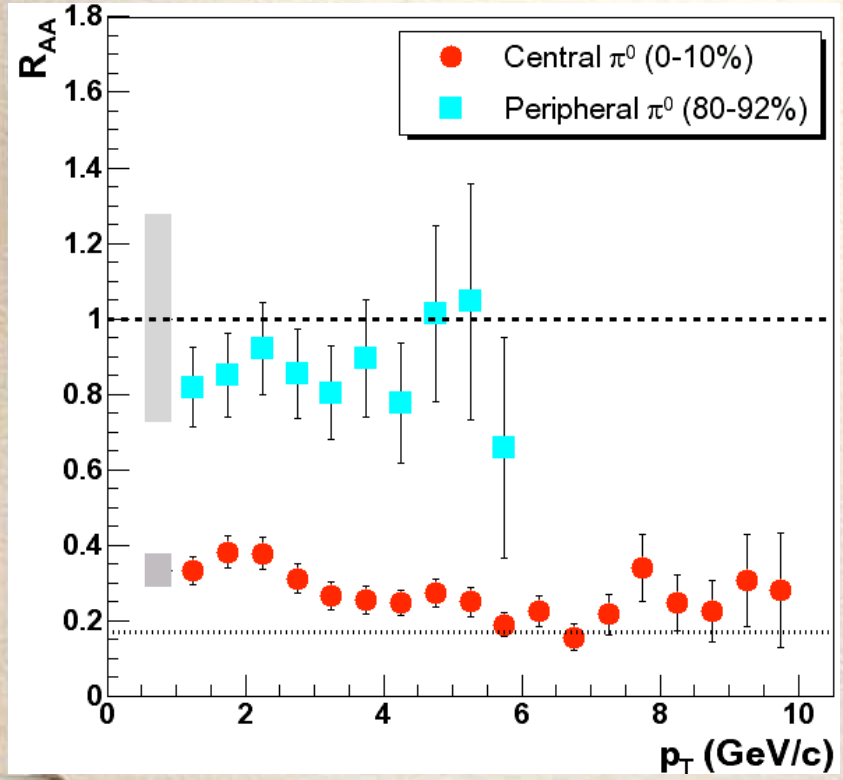


PHENIX (Au+Au)
nucl-ex/0304022

R_{AA} for π^0

$$R_{AA} = \frac{\text{Yield}_{AuAu} / \langle N_{binary} \rangle_{AuAu}}{\text{Yield}_{pp}}$$

$$R_{AA}^{part} = \frac{\text{Yield}_{AuAu} / \langle N_{part} \rangle_{AuAu}}{\text{Yield}_{pp} / 2}$$



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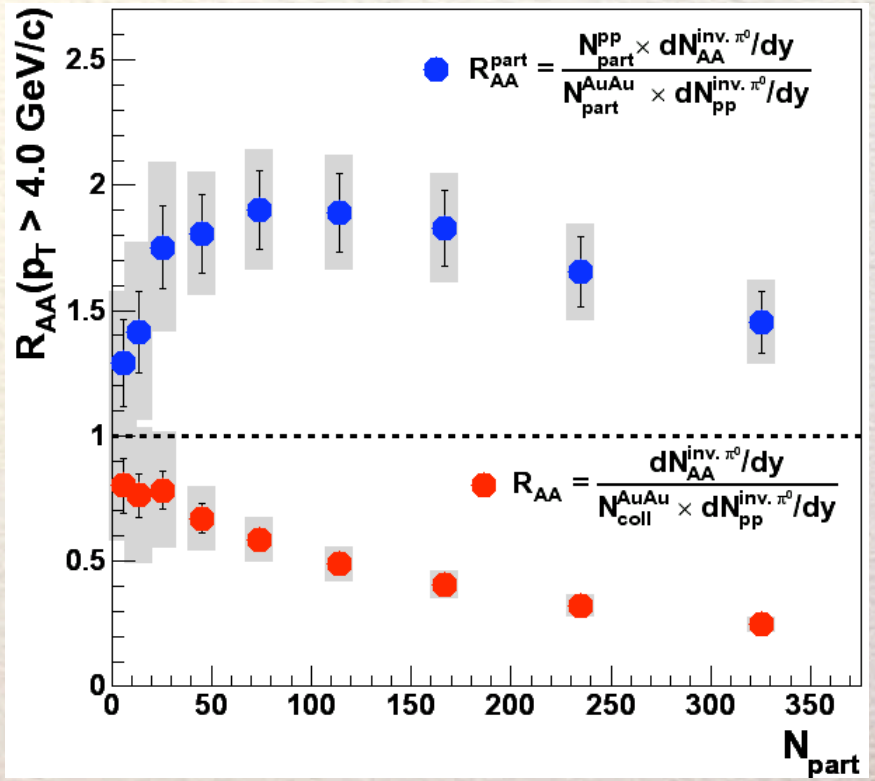

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