筑波大学
University of Tsukuba

PHENIX

Identified Charged Hadron Production at High p_T

- in $\sqrt{s_{NN}}$ = 200 GeV Au+Au Collisions at RHIC-PHENIX -

Masahiro Konno
(Univ. of Tsukuba)
for the PHENIX Collaboration

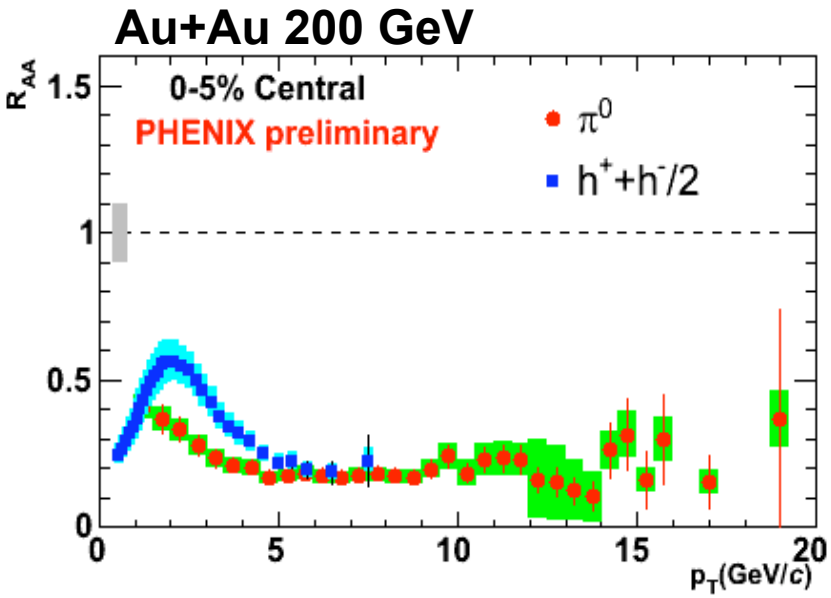
Outline

- Physics motivation
- PHENIX detector
- Data analysis
- Results
- Collision system dependence
- Comparison with models
- Summary

Physics motivation

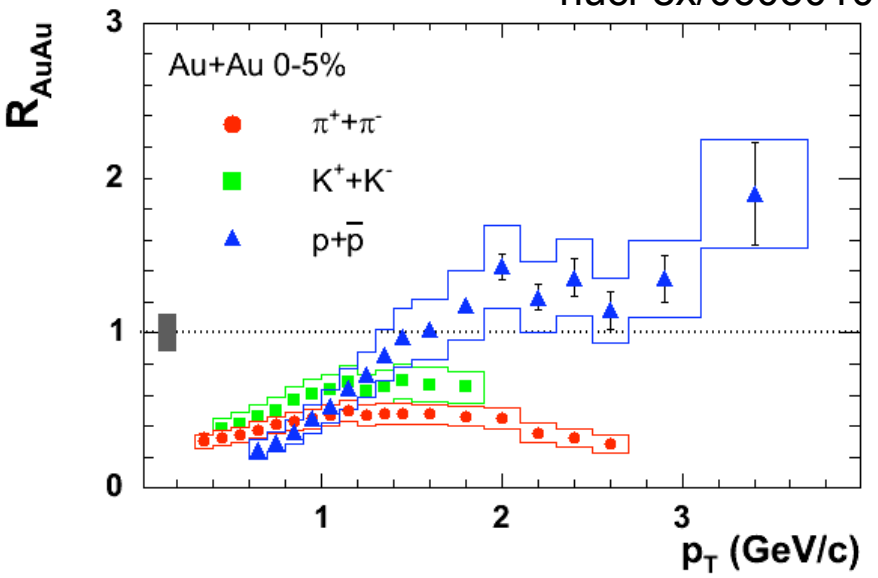
Nuclear Modification Factor R_{AA}

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



High-p_T suppression due to parton energy loss in the medium (jet quenching).

nucl-ex/0603010

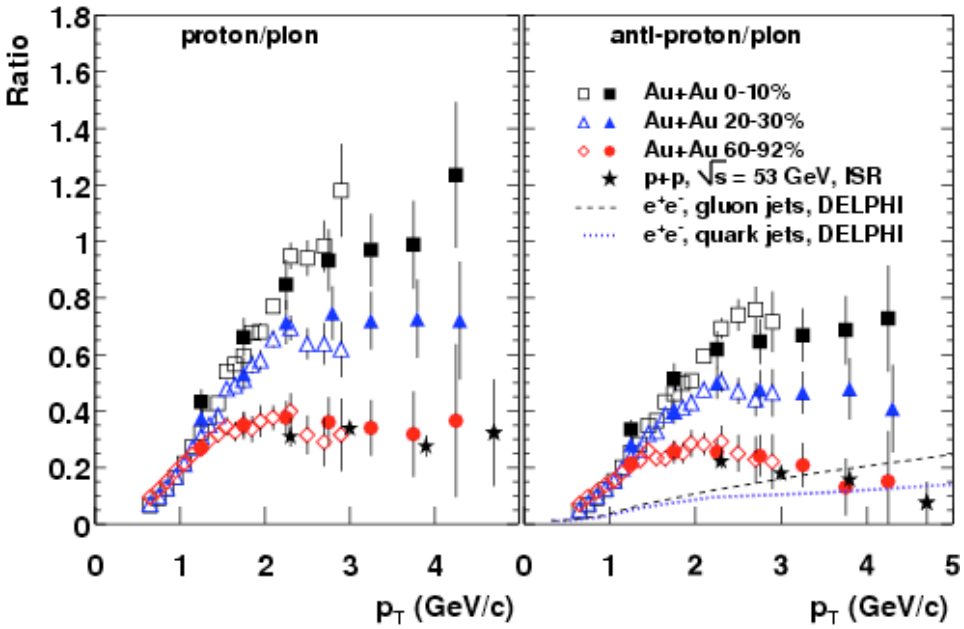


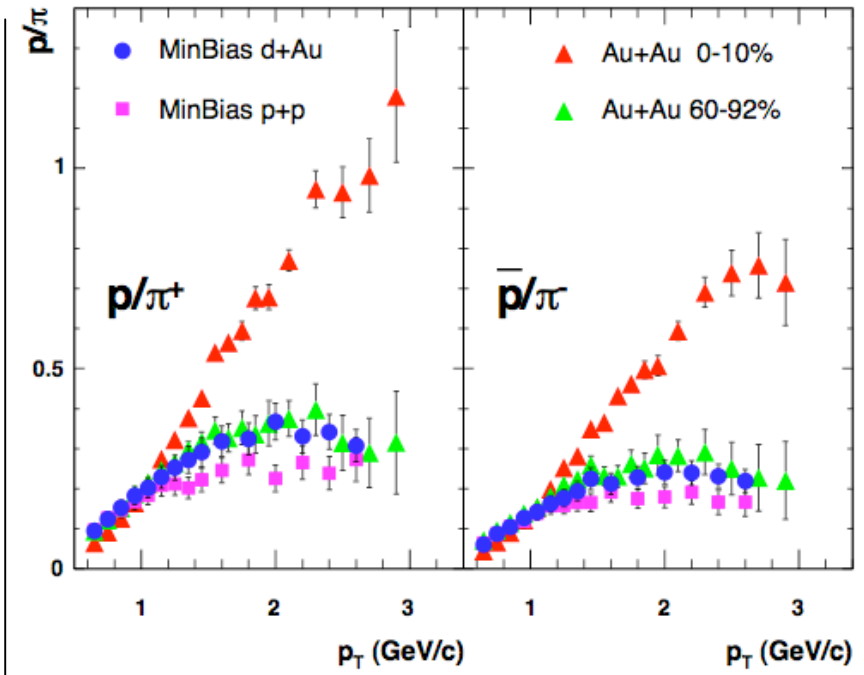
The suppression patterns depend on particle type. Protons are enhanced, while pions and kaons are suppressed.

Physics motivation

Baryon Enhancement

PRL 91, 172301 (2003)





- d+Au similar to peripheral Au+Au but much smaller than central Au+Au

- p/π ratio ~1 for central Au+Au at intermediate p_T (2-4 GeV/c).
- Larger than expected from fragmentation (measured in pp, e^+e^-).
- Baryon / Meson difference at intermediate p_T.
  (on R_{AA} (nuclear modification factor) , v_2 (elliptic flow) etc.)

Physics motivation

What is the origin of (anti-)proton enhancement at intermediate p_T?

To distinguish the different production mechanism for protons and pions at intermediate and higher p_T.

Possible sources (medium effect) :

- Strong radial flow
- Recombination
- Baryon junction

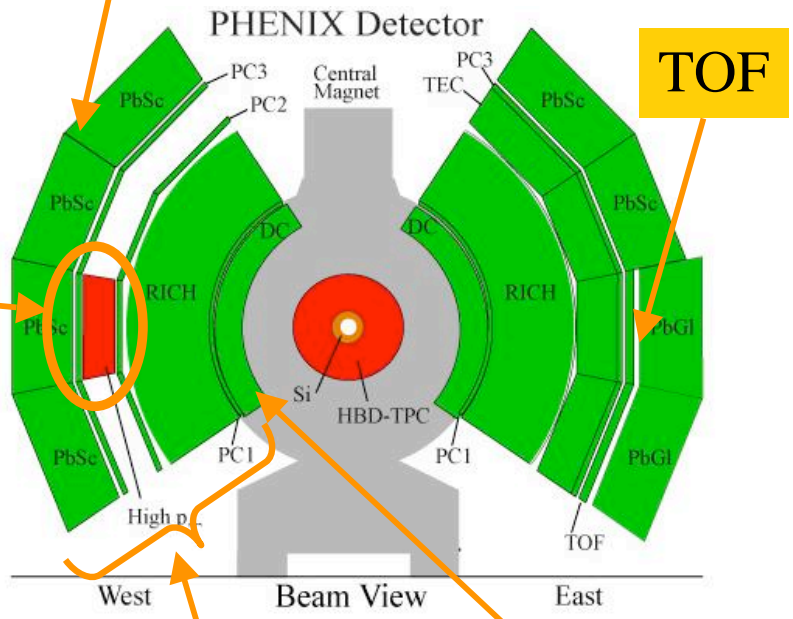
Transverse momentum spectra provide the most basic tool to investigate the mechanisms of hadron production.

PHENIX detector

- Central Arm Detectors
  (magnetic spectrometer)
- Event Characterization detectors

EMCal

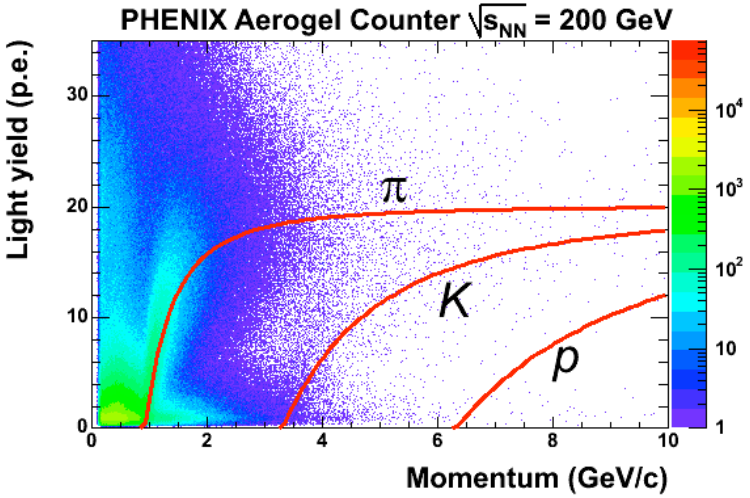
TOF

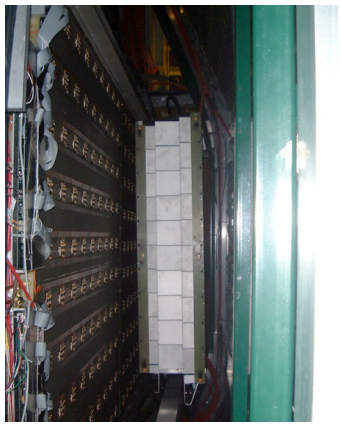


Aerogel Cherenkov Counter

Hadron Identification at High p_T

- n = 1.0113.
- Full installation in 2004.
- Proton separation from π /K up to 8 GeV/c.





Drift Chamber
(momentum meas.)

Tracking detectors
(PC1,PC2,PC3)

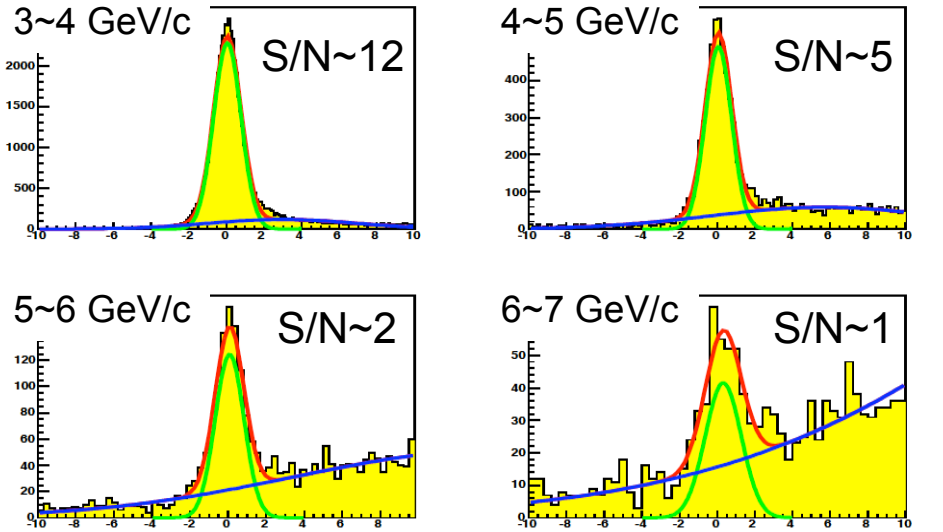
Data Analysis

- Data set: Au+Au 200 GeV (taken in Run4, 2003-2004)
- High statistics (440M events used)
- Charged Hadron PID:
  - TOF
  - Aerogel (for PID extension toward high p_T, Run4-)
- MC Simulations:
  - Acceptance, efficiency (occupancy) corrections
- No feed-down correction.

BG Subtraction

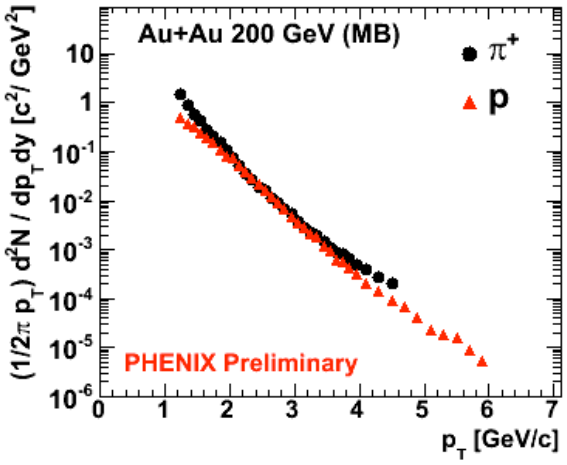
Using residual bending in ϕ direction.

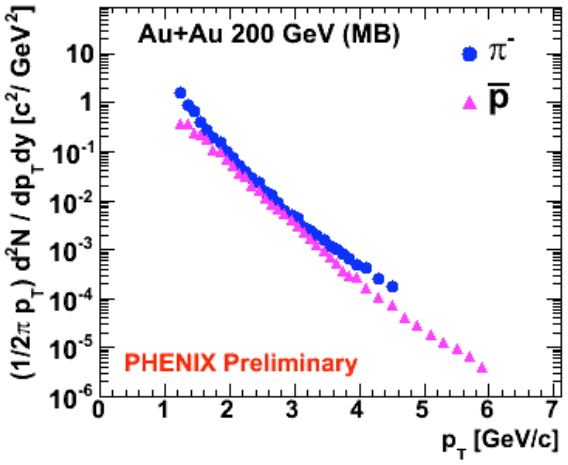
Backgrounds:
- random association
- electrons from photon conversion
- decayed products

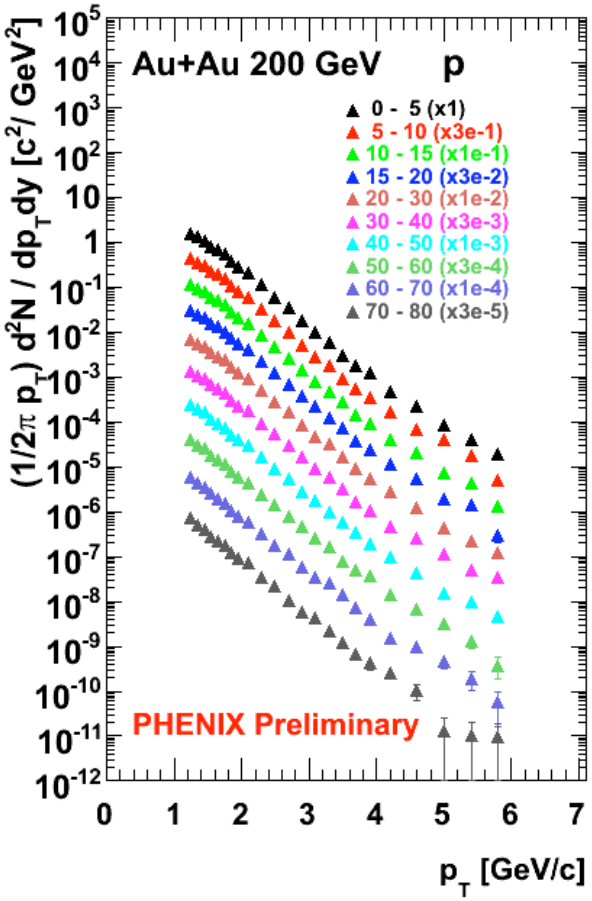


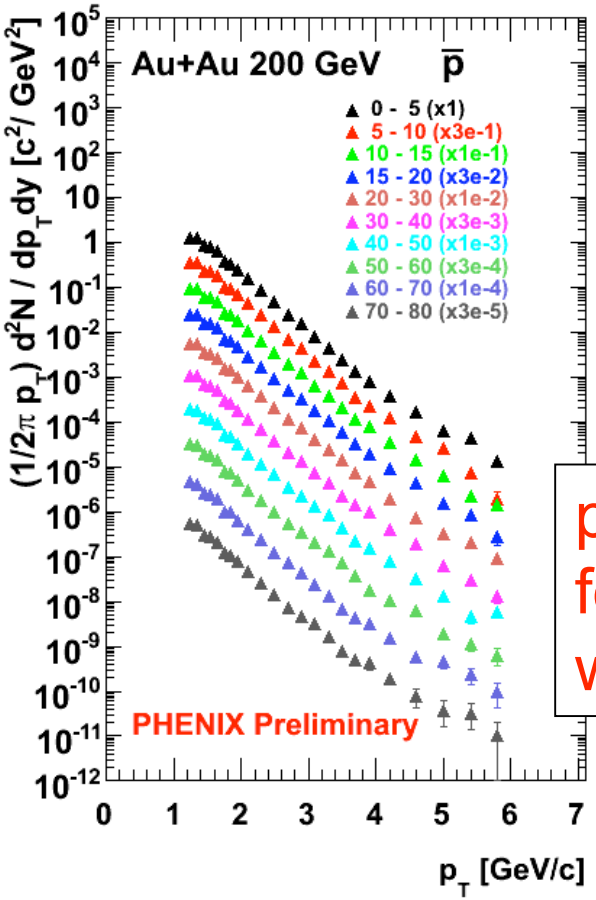
Results

p_T spectra of (anti-)proton





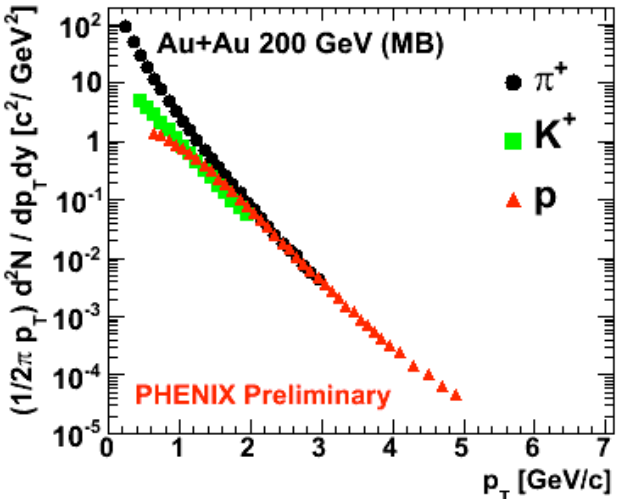


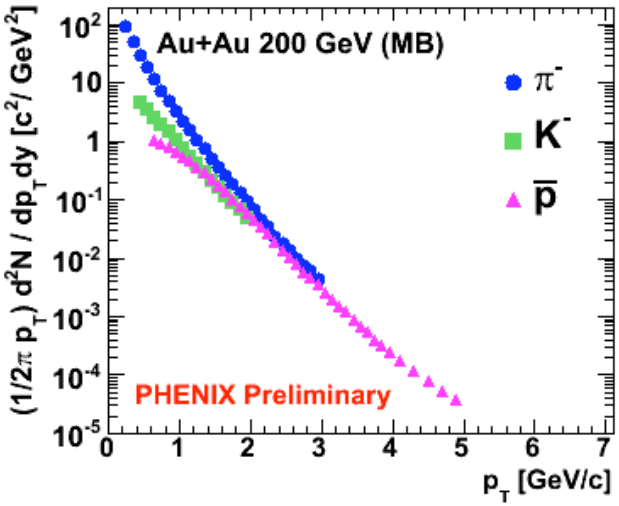


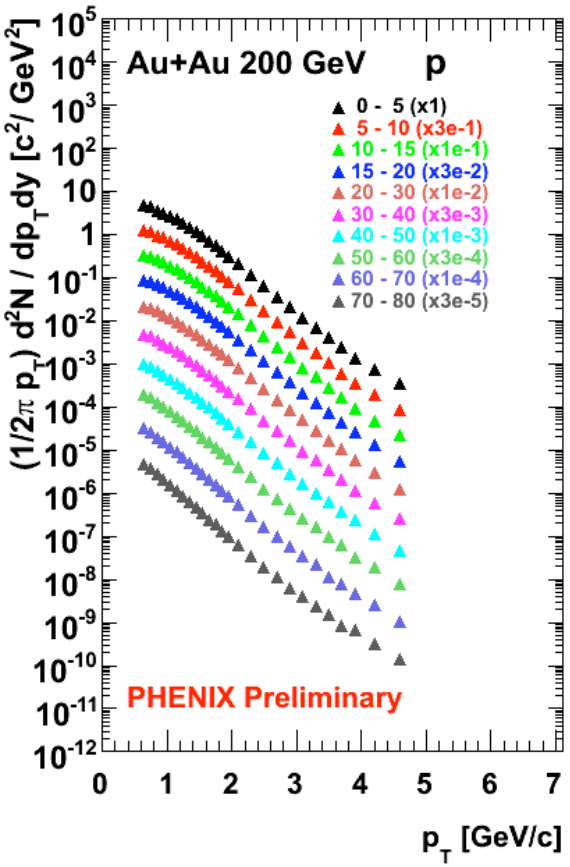
Identified with ACC

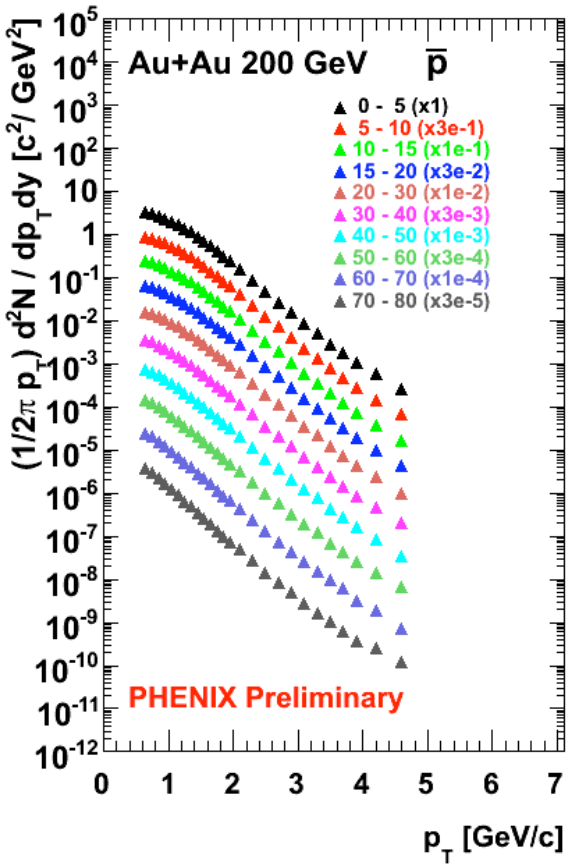
p_T reach extended for (anti-)protons with fine centrality bins.

p_T spectra of (anti-)proton





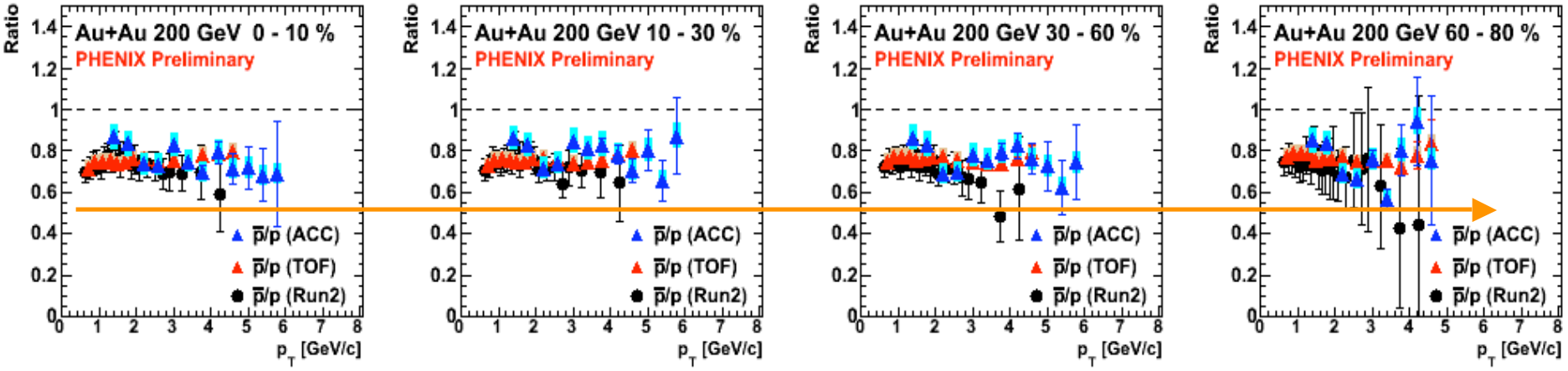




Identified with TOF

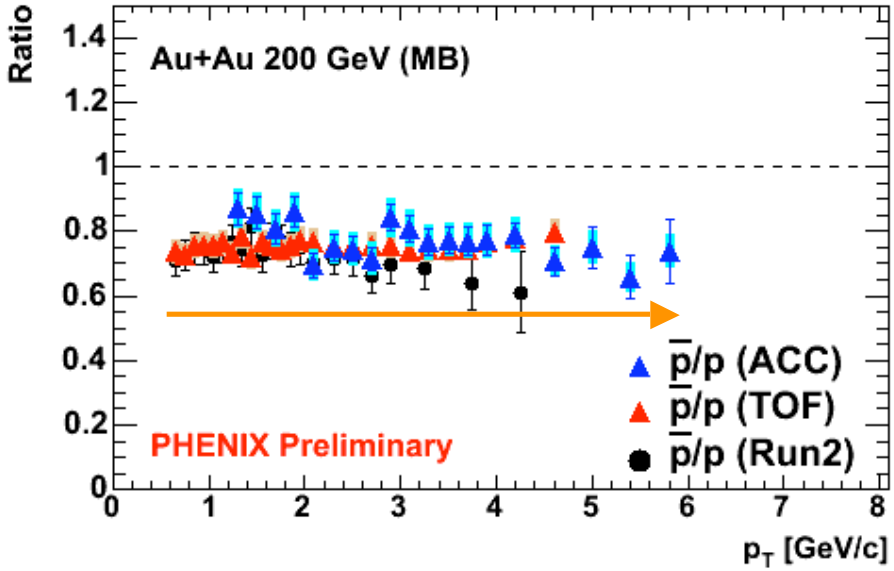
Precise measurement at high p_T thanks to high statistics.

pbar/p vs. p_T



Central

Peripheral

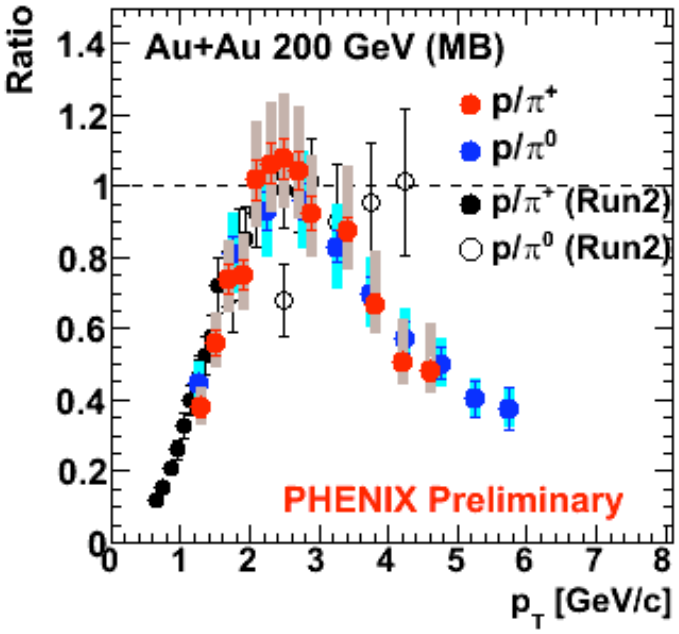


No significant centrality or p_T dependence (up to 6 GeV/c).

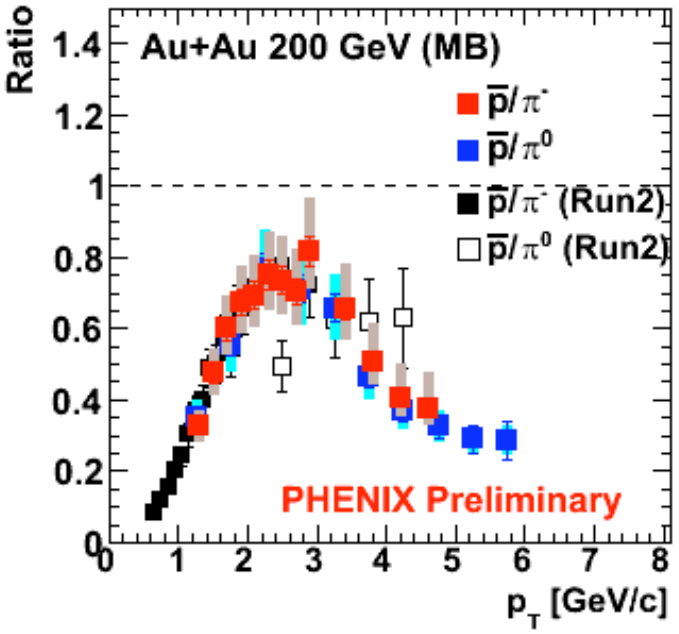
p/π vs. p_T

Identified with ACC

p/π



$\bar{p}/\pi$

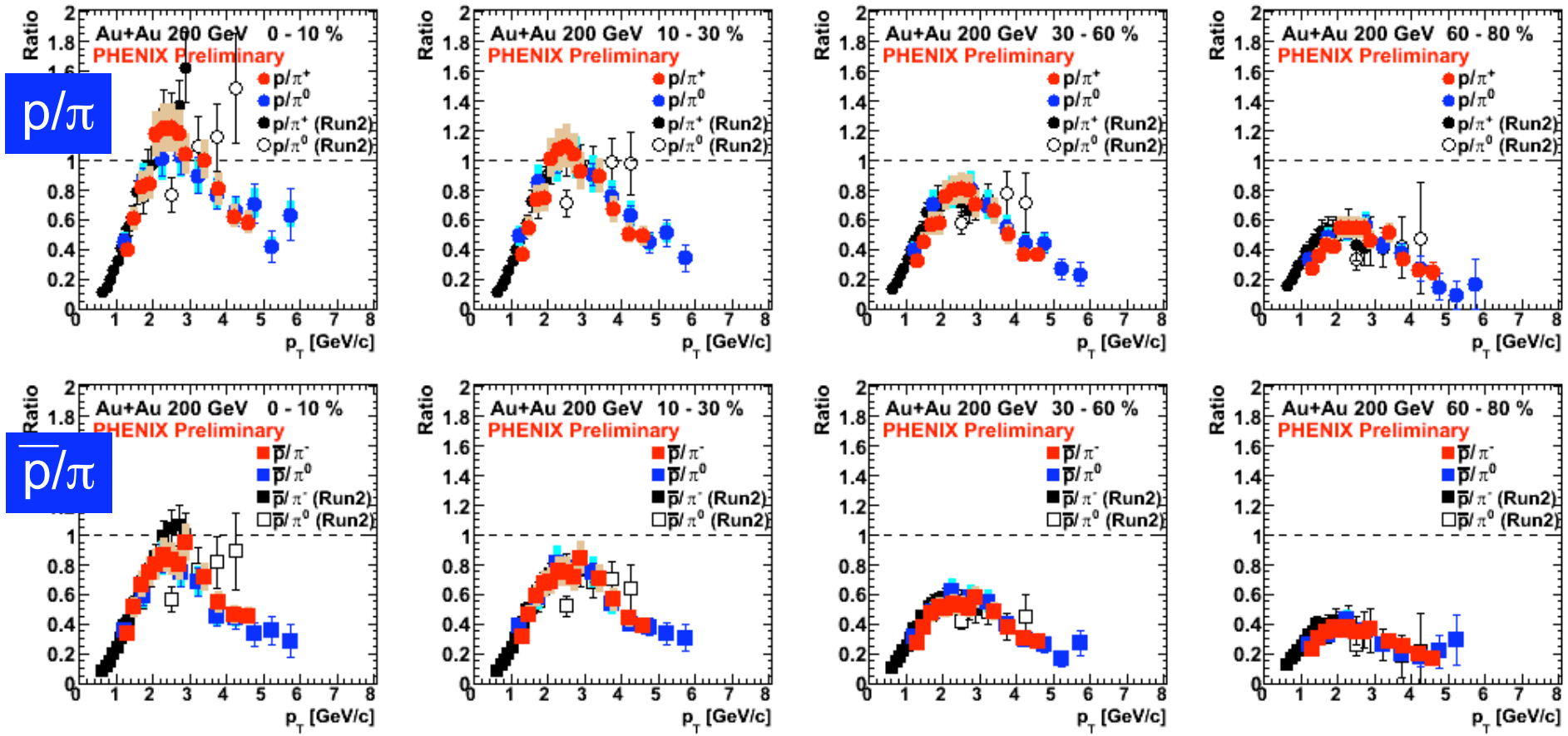


* No feed-down correction.

- p/π (pbar/π) ratios seem to turn over at intermediate p_T, and close to the value of fragmentation at higher p_T.
- Indicating transition from soft to hard at intermediate p_T.

p/π vs. p_T (centrality dep.)

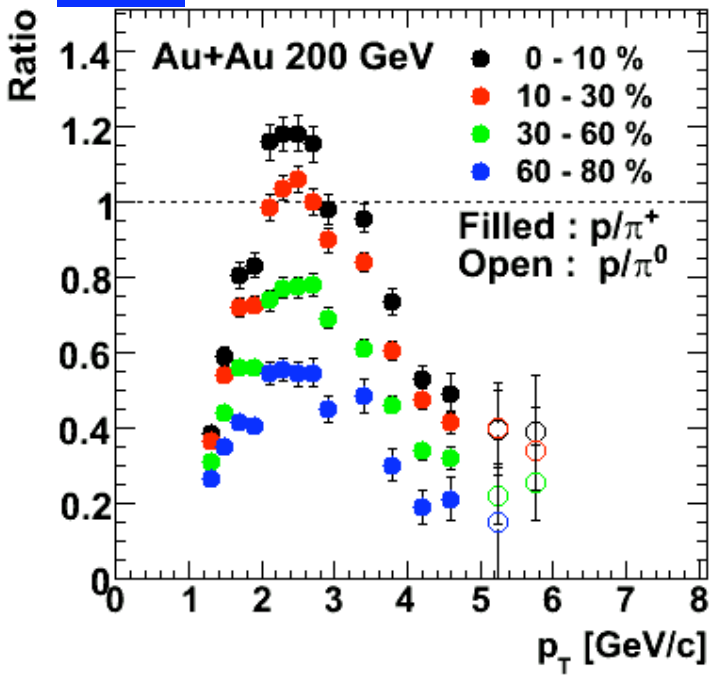
* No feed-down correction.



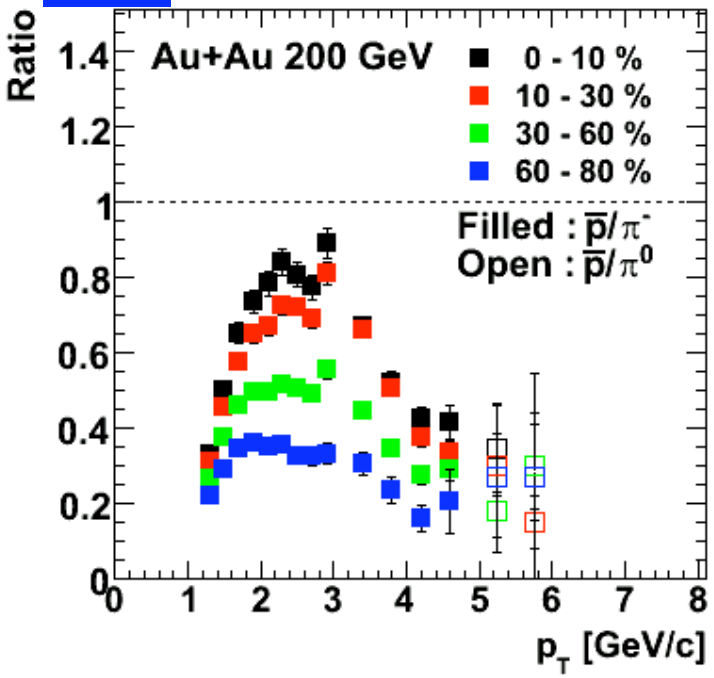
- p/π ratios look to have a peak at intermediate p_T (2-4 GeV/c).
- Clear peak in central events than that in peripheral.

p/π vs. p_T (centrality dep.)

p/π



$\bar{p}/\pi$



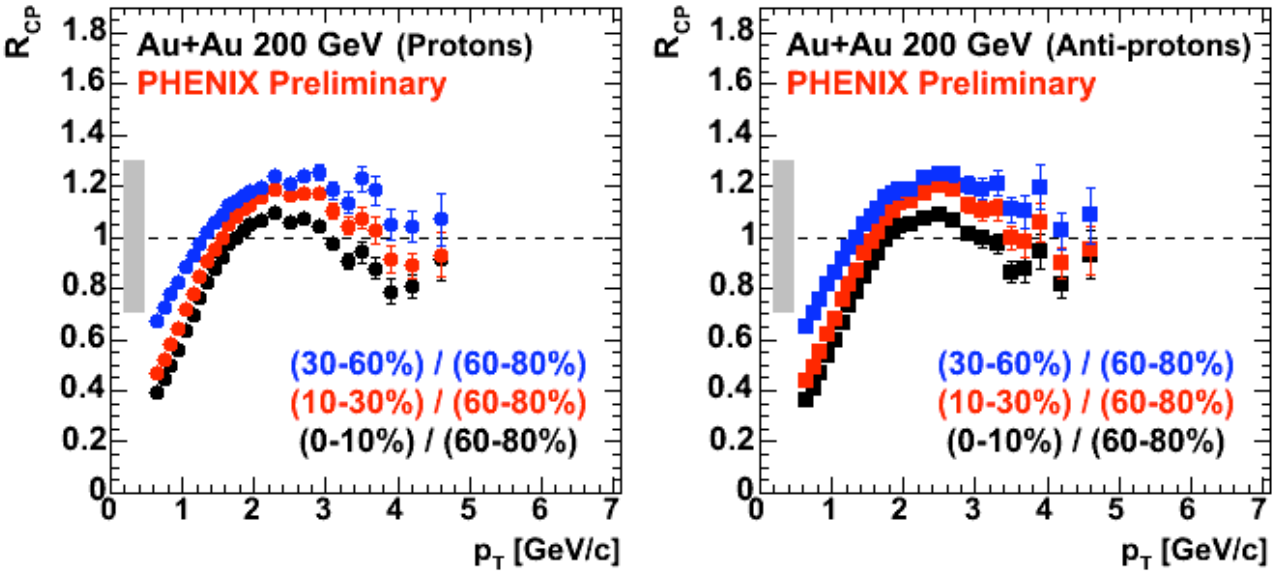
* No feed-down correction.
* p+p data (nucl-ex/0603010)

- Centrality dependence seen in the magnitude.
- p/π ratio in peripheral lies slightly above the p+p ratio.

Proton R_{CP}

TOF

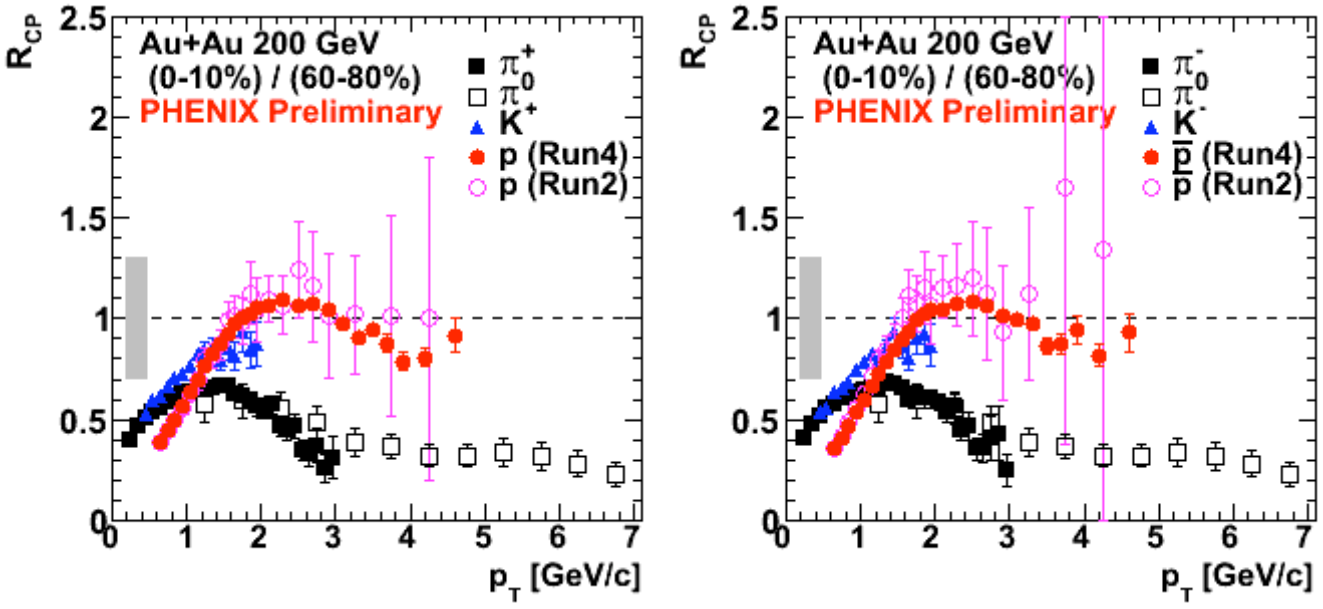
$$R_{CP} = \frac{Yield_{Central} / \langle N_{binary} \rangle_{Central}}{Yield_{Peripheral} / \langle N_{binary} \rangle_{Peripheral}}$$



- Proton R_{CP} shows unity above 2 GeV/c
- Peak structure at 2~3 GeV/c

Proton R_{CP}

TOF

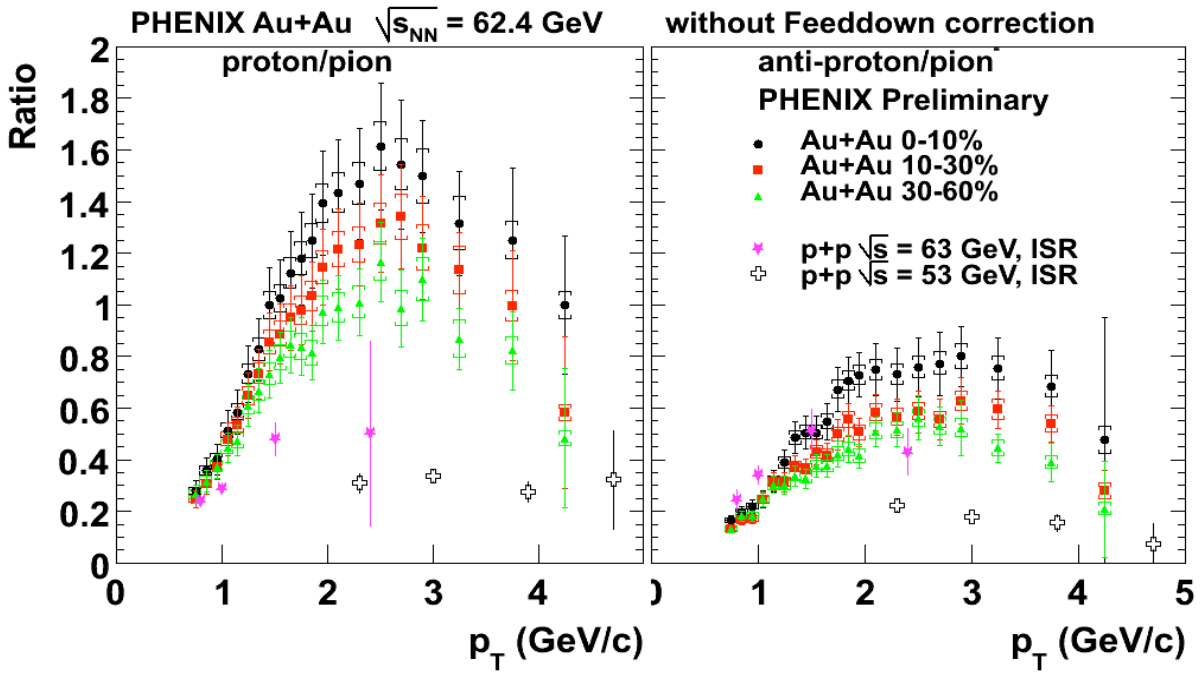


- Proton R_{CP} shows decreasing above 3 GeV/c
- Need more statistics to look at high-p_T points.

Collision system dep.

p/π vs. p_T

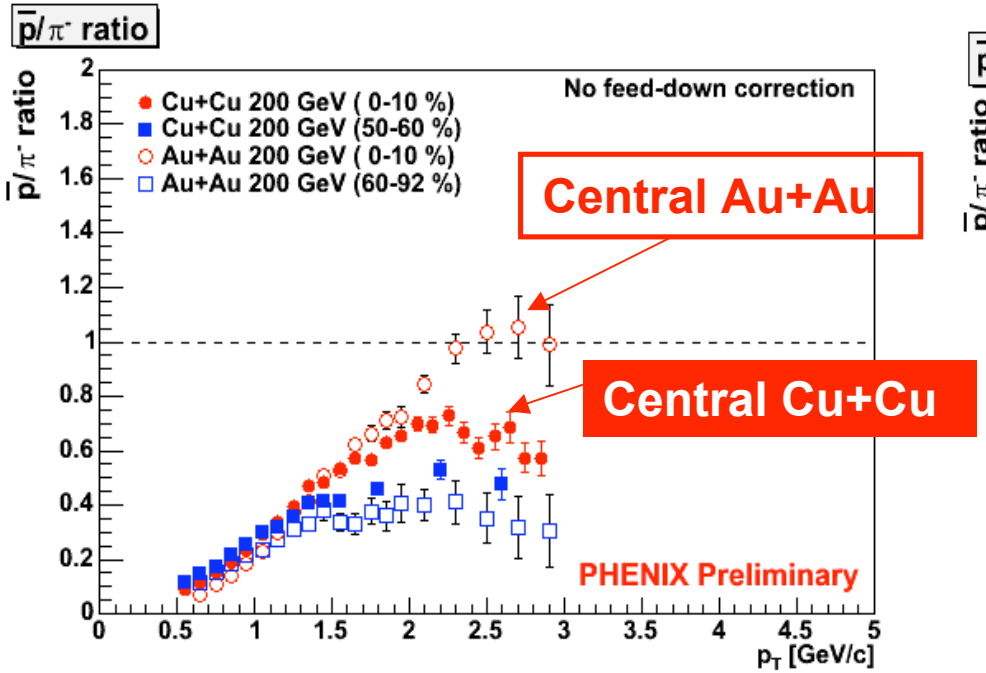
62 GeV Au+Au

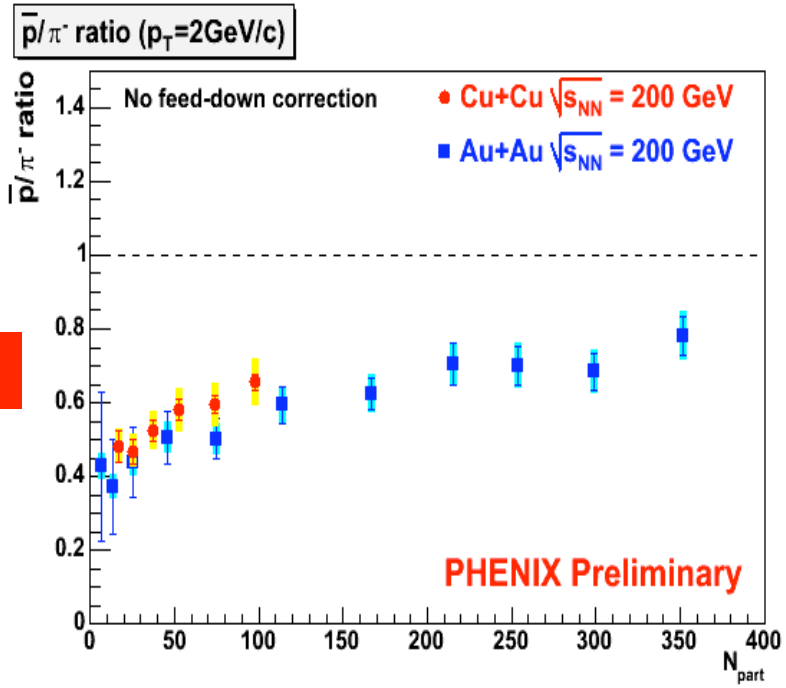


- Rapidly increasing with p_T for 62 GeV.
-Weaker centrality dependences (62GeV) than those of 200 GeV.
- Significant difference for p and pbar at 62 GeV
  (Indicating more baryon transport and less p-pbar pair production at 62 GeV than 200 GeV.)

p/π ratio in Cu+Cu / Au+Au

200 GeV Cu+Cu



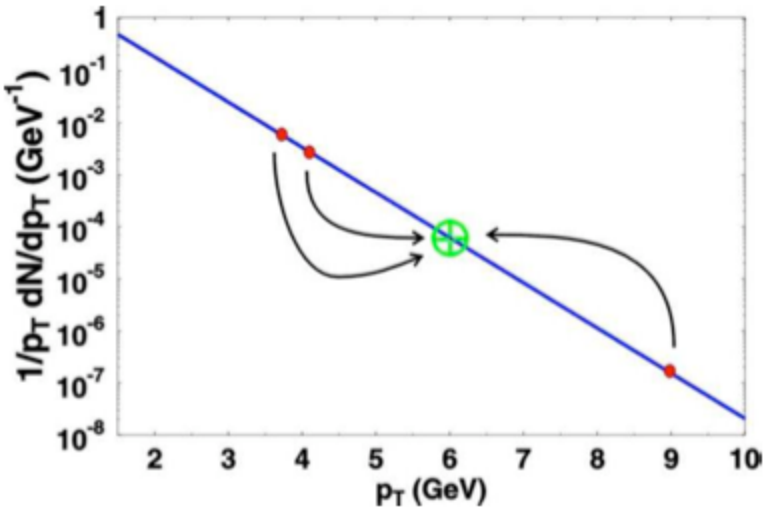


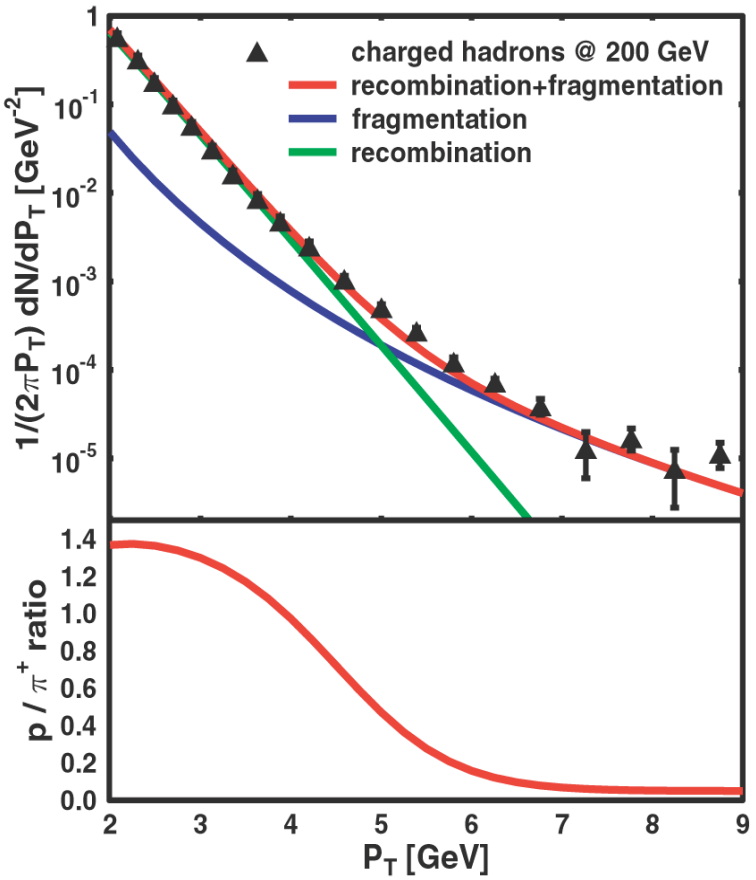
* No feed-down correction.

- Observed a large p,pbar contribution at intermediate p_T, as seen in 200 GeV data.
- N_{part} dependences on particle ratios have similar trend as in Au+Au (N_{part} scaling).

Comparison with models

Recombination





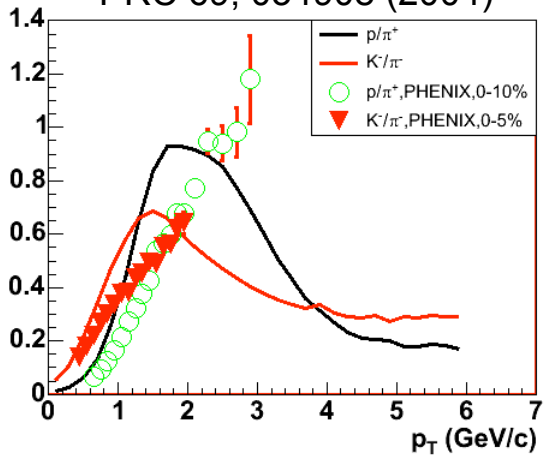
At intermediate p_T recombination of partons may be a more efficient mechanism of hadron production than fragmentation

Fries, R et al PRC 68 (2003) 044902
Greco, V et al PRL 90 (2003) 202302
Hwa, R et al PRC 70(2004) 024905

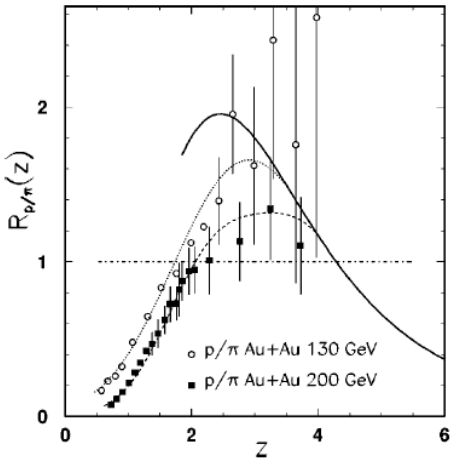
Comparison with Models

p/π

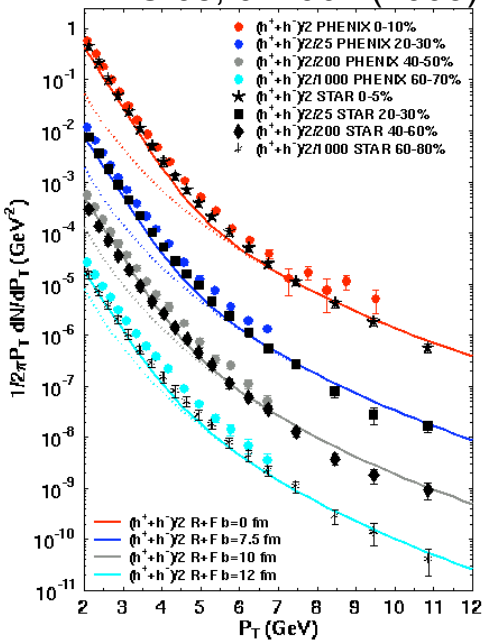
PRC 69, 034908 (2004)



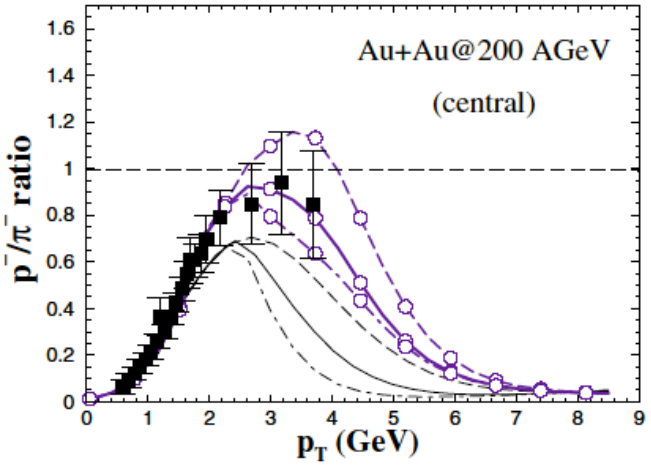
PRC 67, 034902 (2003)



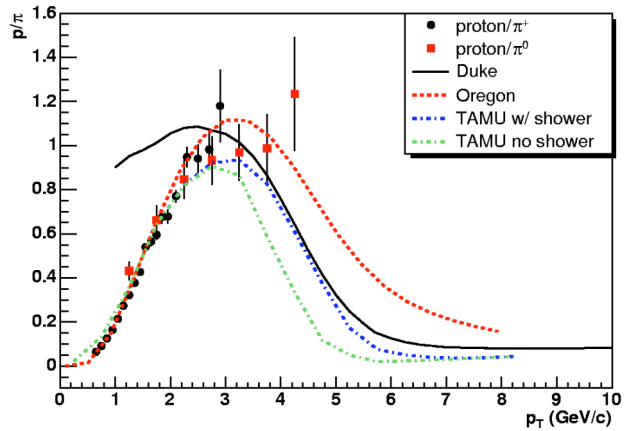
PRC 68, 044902 (2003)



PRL 90, 202302 (2003)

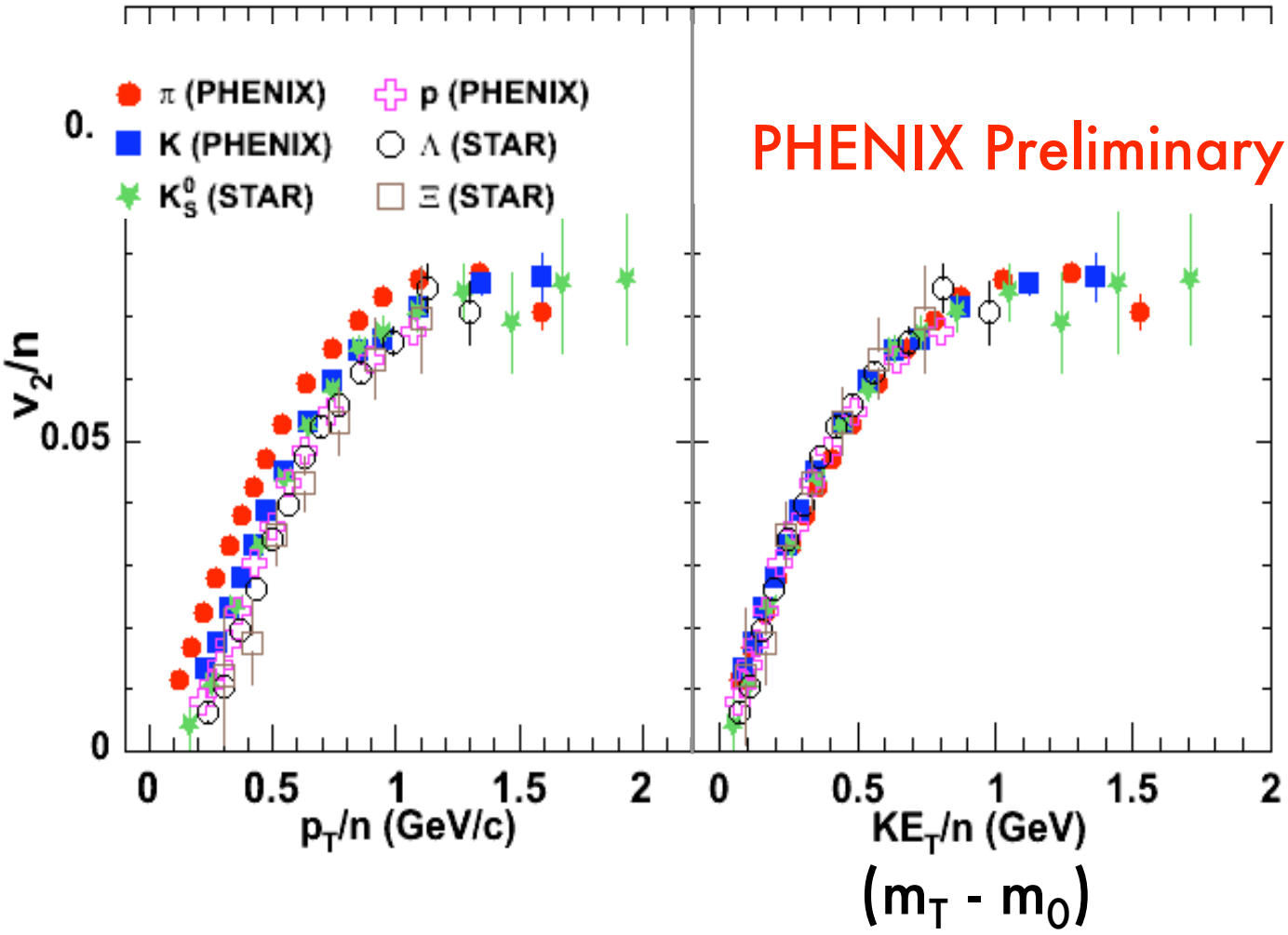


PHENIX proton/π ratio



- Only look through several models (recombination, hydro+jet, …).
- Novel mechanism of hadron production at intermediate p_T.

Scaling of Elliptic flow



Example of partonic degrees of freedom.

Summary

- p_T reach of PID (especially for p, pbar) extended with:
  - (1) High statistics 200 GeV Au+Au data
  - (2) New PID detector (Aerogel)

- Results:
  - pbar/p ratio
    - No centrality or p_T dependence.
  - p/π ratio
    - Centrality dependence seen in the magnitude.
    - Indicating transition from soft to hard at intermediate p_T.
  - R_{CP}
    - Proton R_{CP} shows decreasing above 3 GeV/c.
    - Expected to merge to pion R_{CP} at higher pT

Next

- Improve data analysis, reduce sys. errors for PID at high p_T.
- Analyze Run5 p+p (abundant) data to make R_{AA} at higher p_T.
- MRPC-TOF (σ_{TOF}~100ps) to be installed for PID upgrade.