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 -

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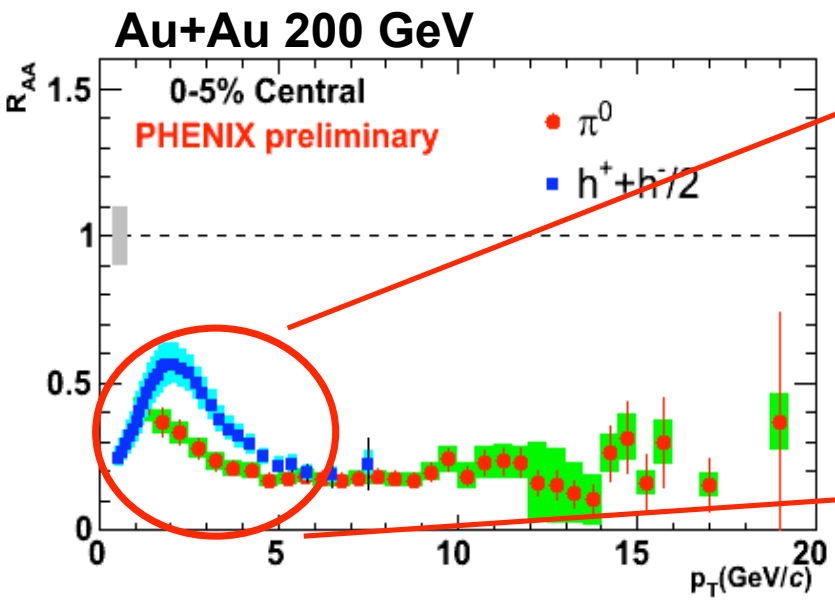
Outline

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

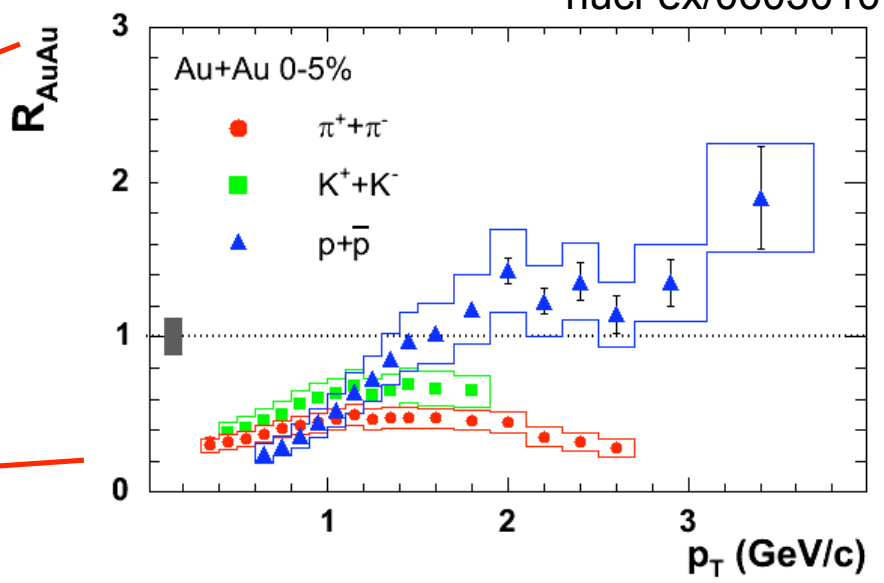
Physics motivation

Nuclear Modification Factor R_{AA}

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



nucl-ex/0603010



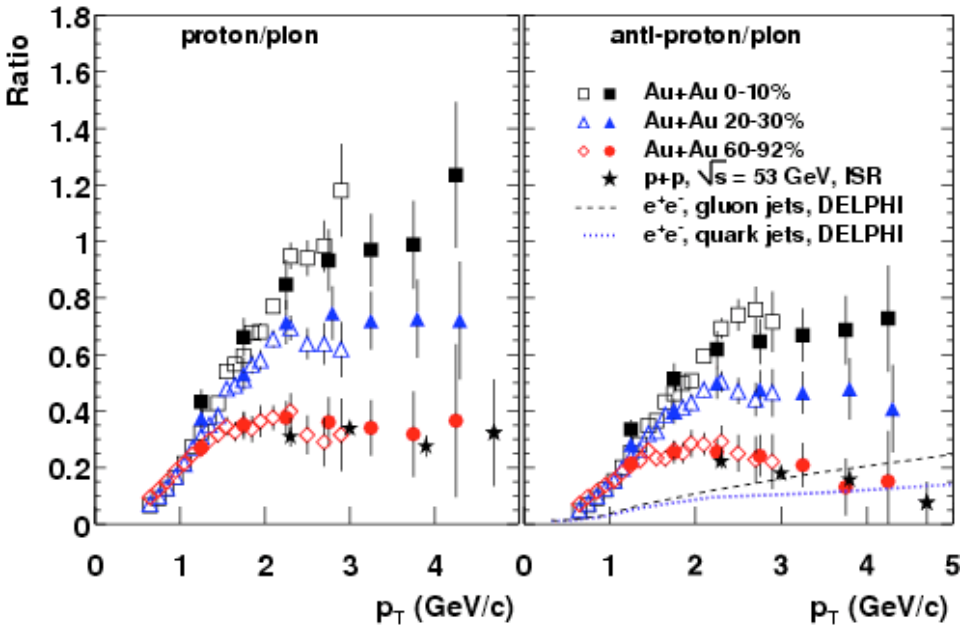
High-p_T suppression due to parton energy loss in the medium (jet quenching).

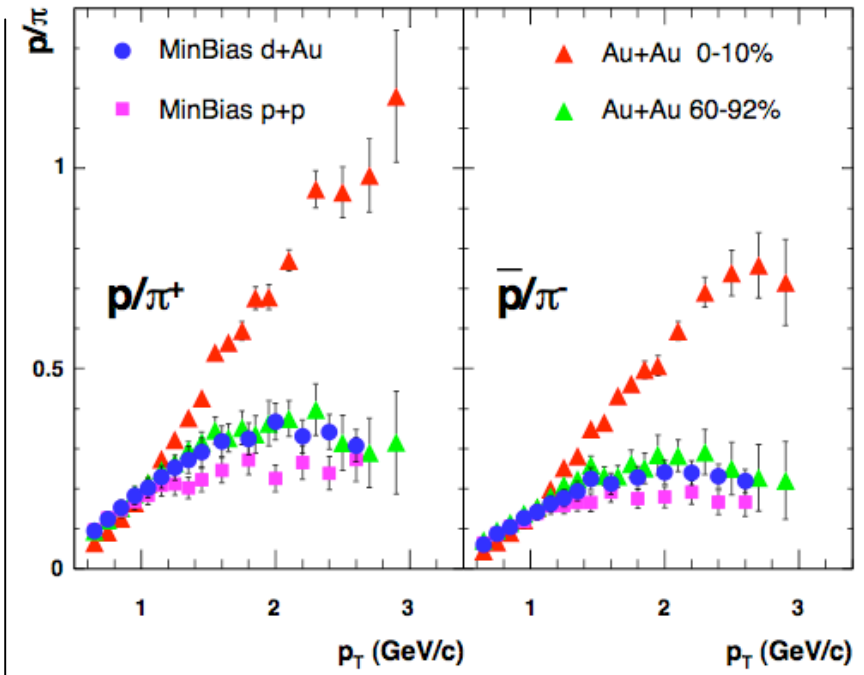
The suppression patterns depend on particle type. Protons are enhanced, while pions and kaons are suppressed.

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?

Possible sources (medium effect) :
- Strong radial flow
- Recombination
- Baryon junction

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

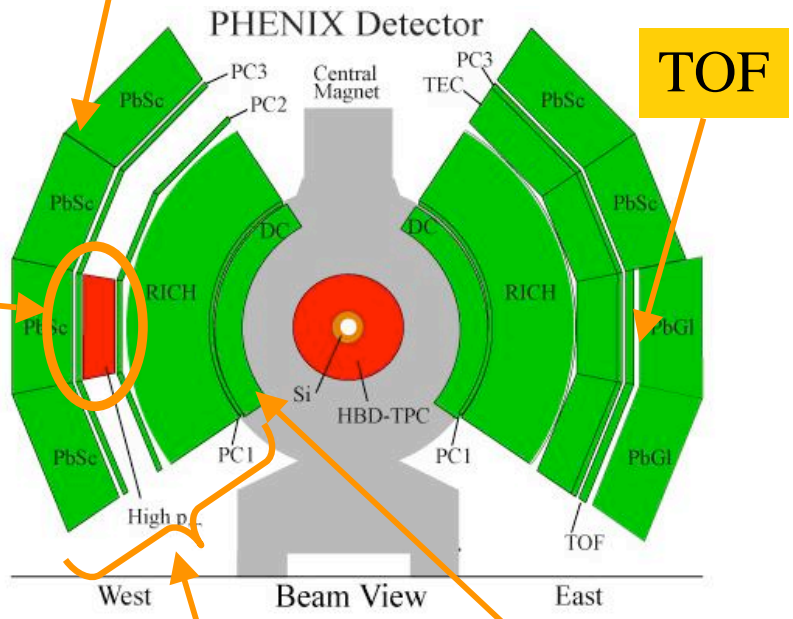
To distinguish the different production mechanism for protons and pions at intermediate and higher p_T.

PHENIX detector

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

EMCal

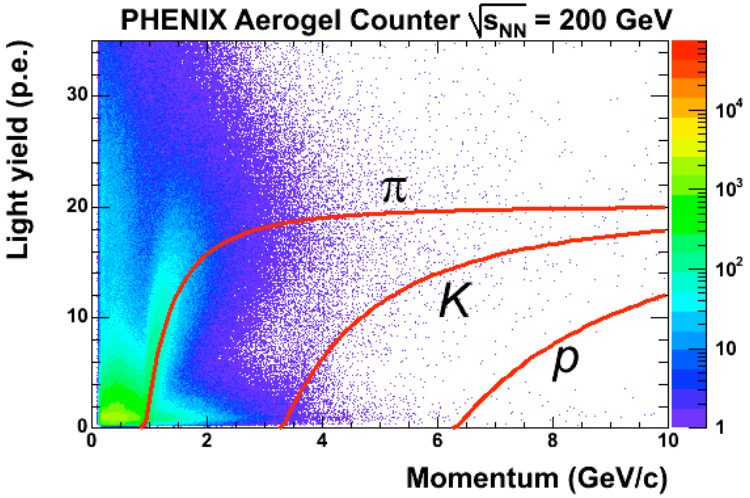
TOF

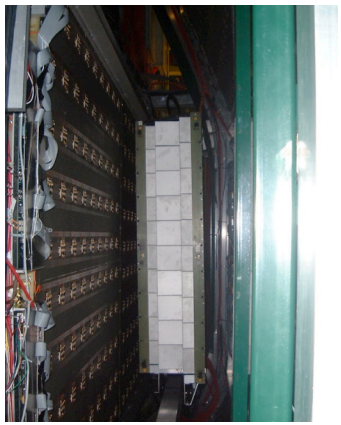


Aerogel Cherenkov Counter

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)

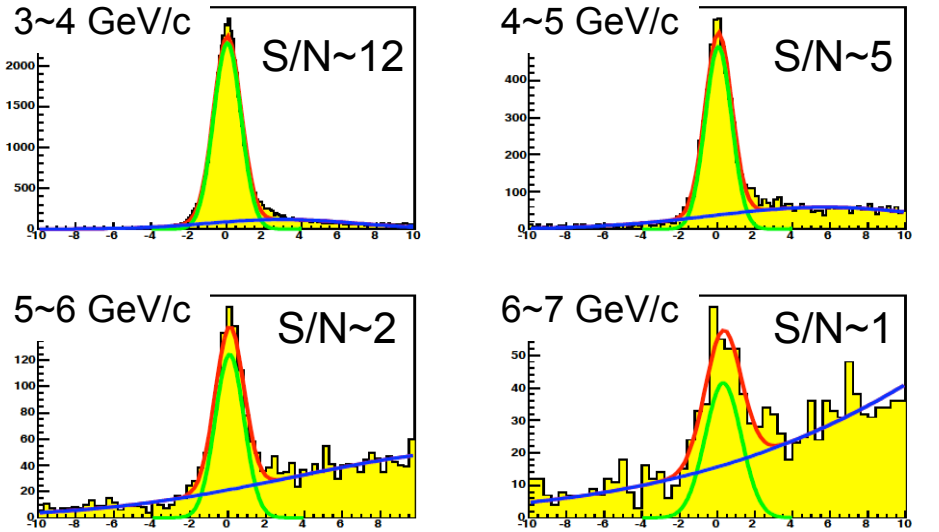
Data analysis

- 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

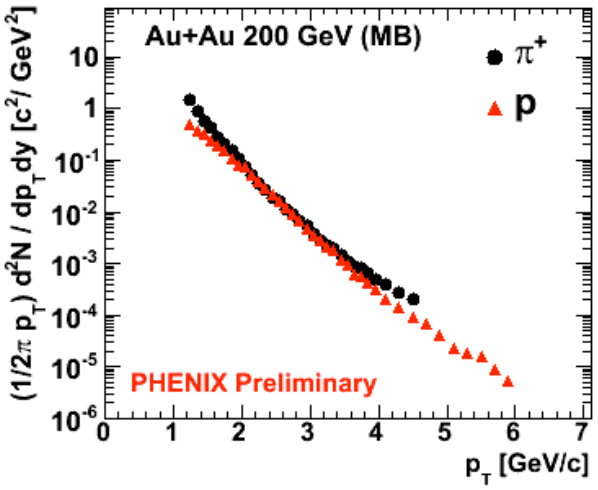
Using residual bending in ϕ direction.

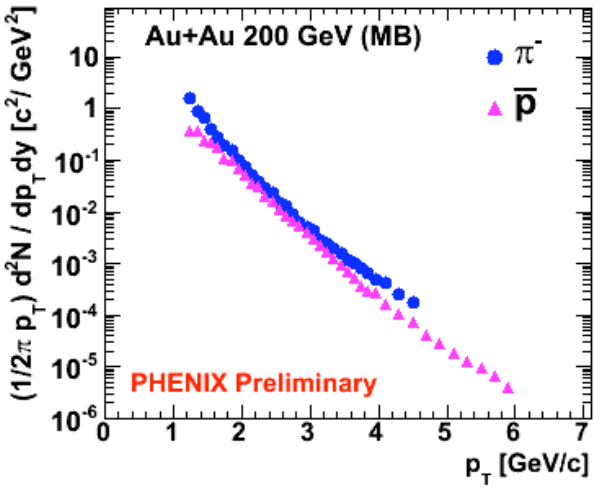
Backgrounds:
- random association
- electrons from photon conversion
- decayed products

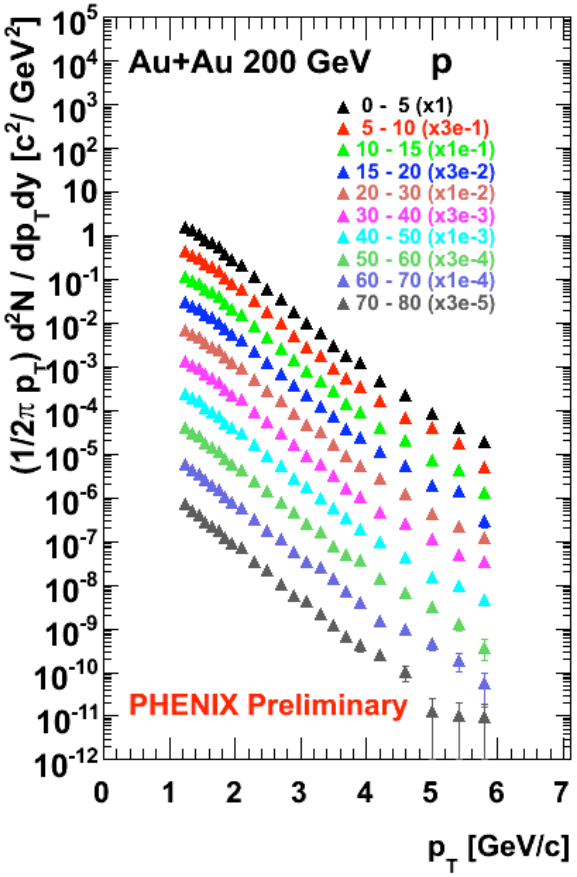


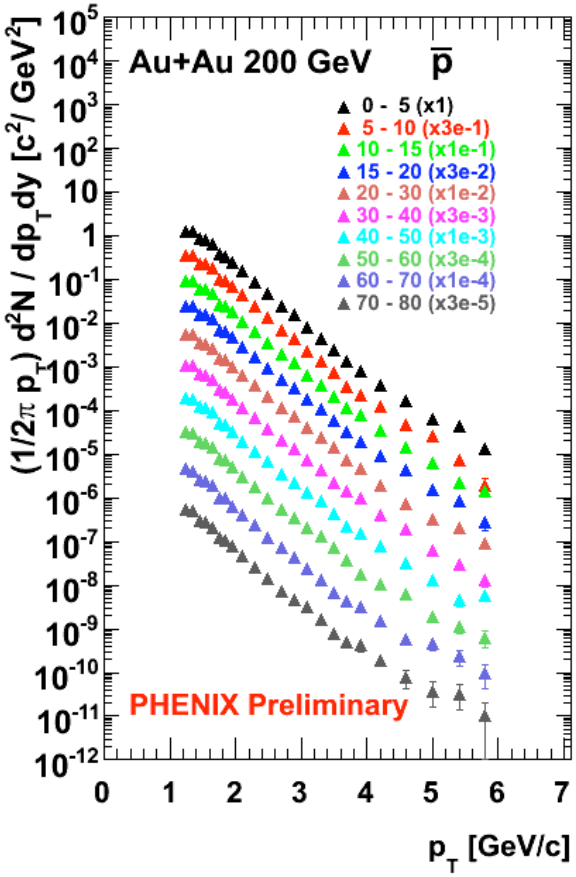
Results

p_T spectra of (anti-)proton





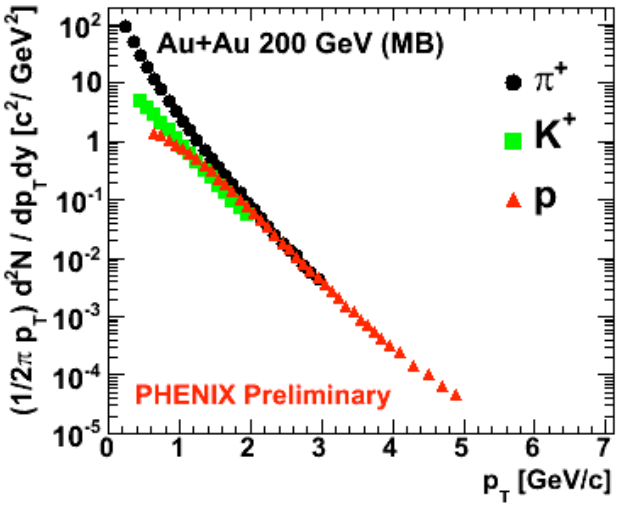


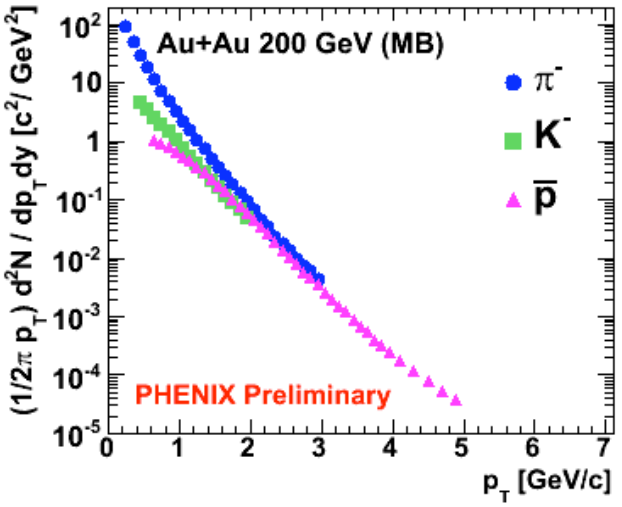


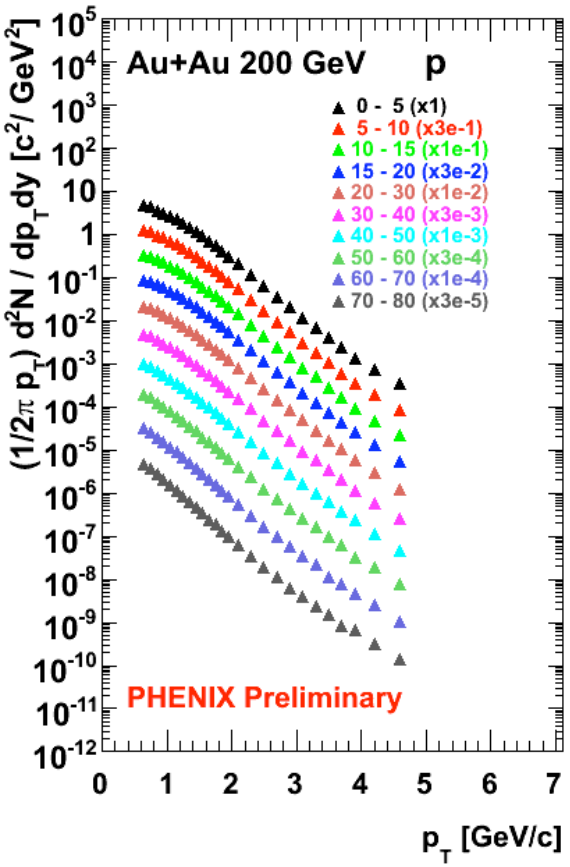
Identified with ACC

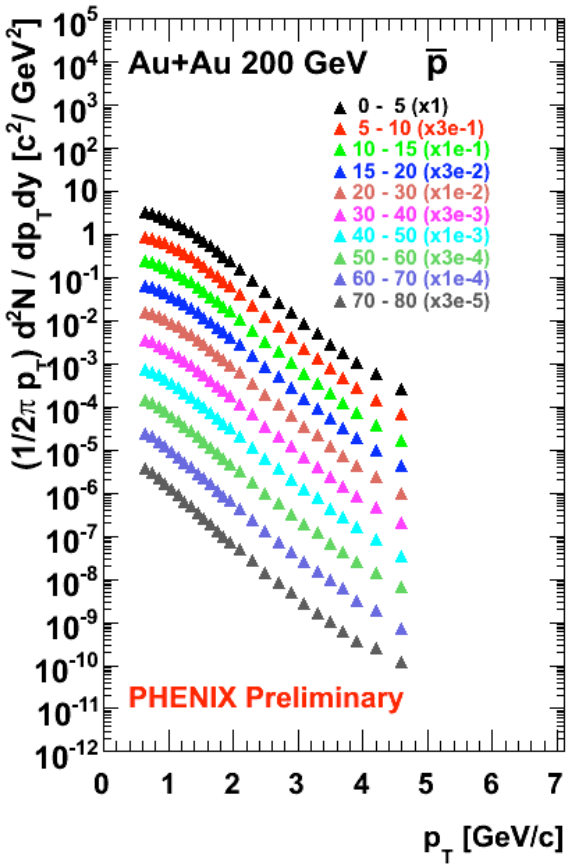
p_T reach extended for (anti-)protons with fine centrality bins.

p_T spectra of (anti-)proton





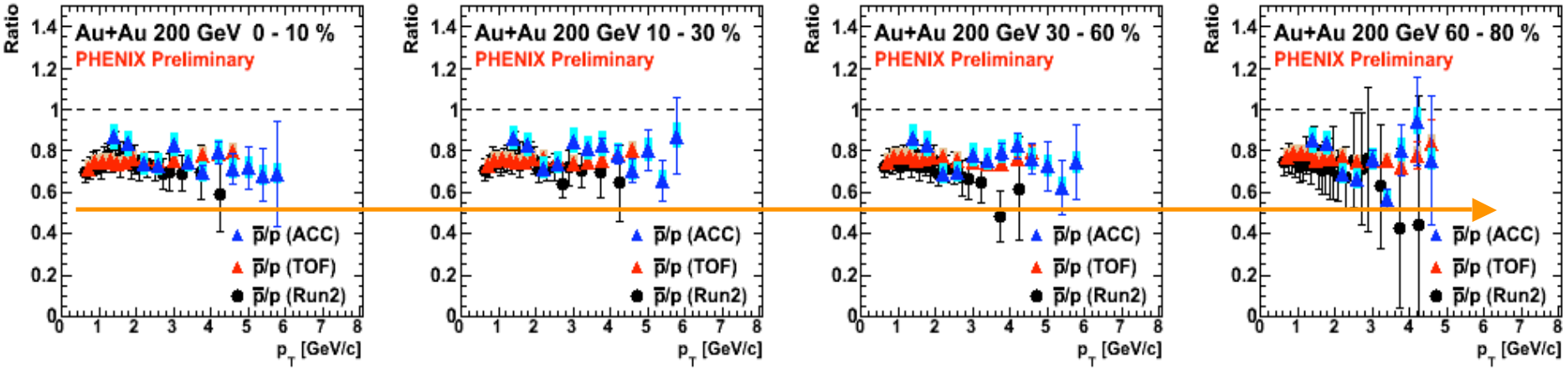




Identified with TOF

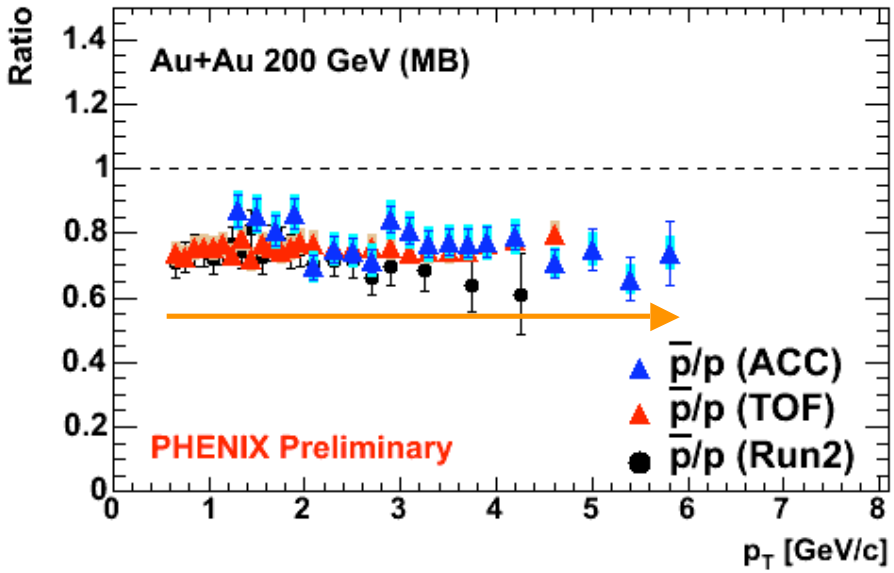
Precise measurement at high p_T thanks to high statistics.

pbar/p vs. p_T



Central

Peripheral

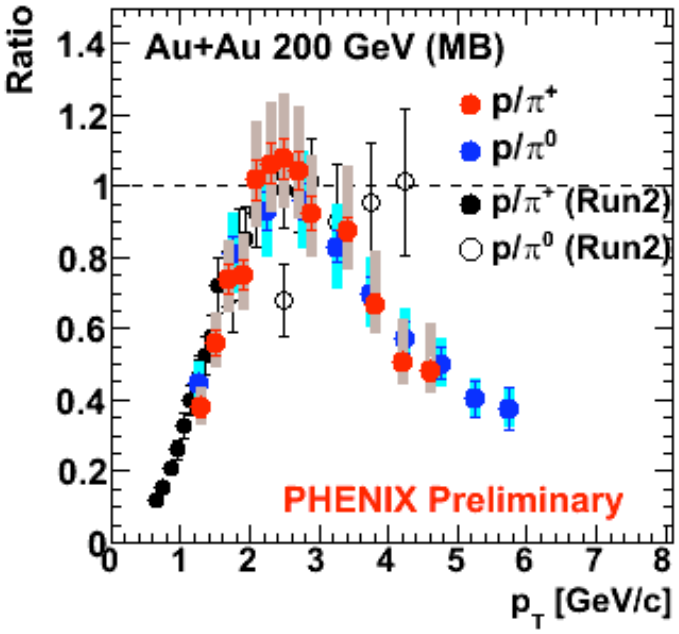


No significant centrality or p_T dependence (up to 6 GeV/c).

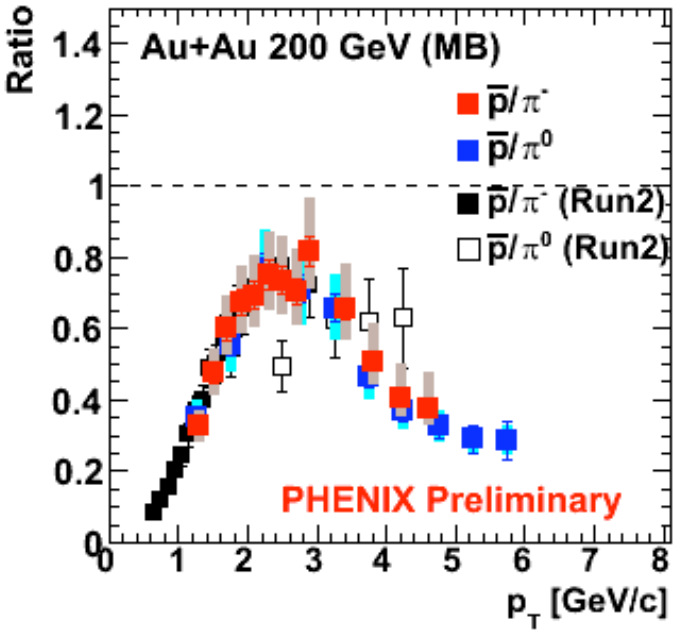
p/π vs. p_T

ACC

p/π



$\bar{p}/\pi$



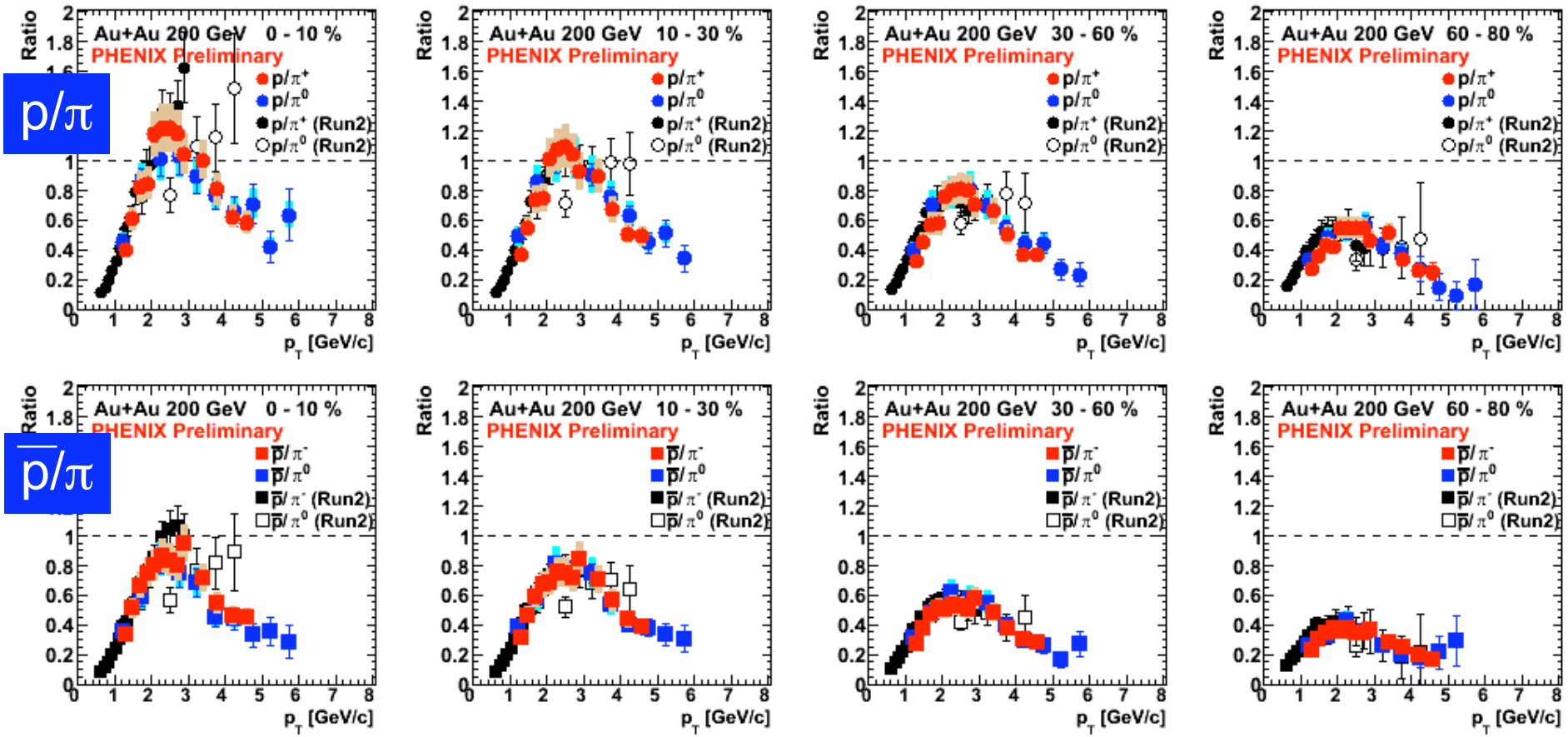
* No feed-down correction.

- 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.)

ACC

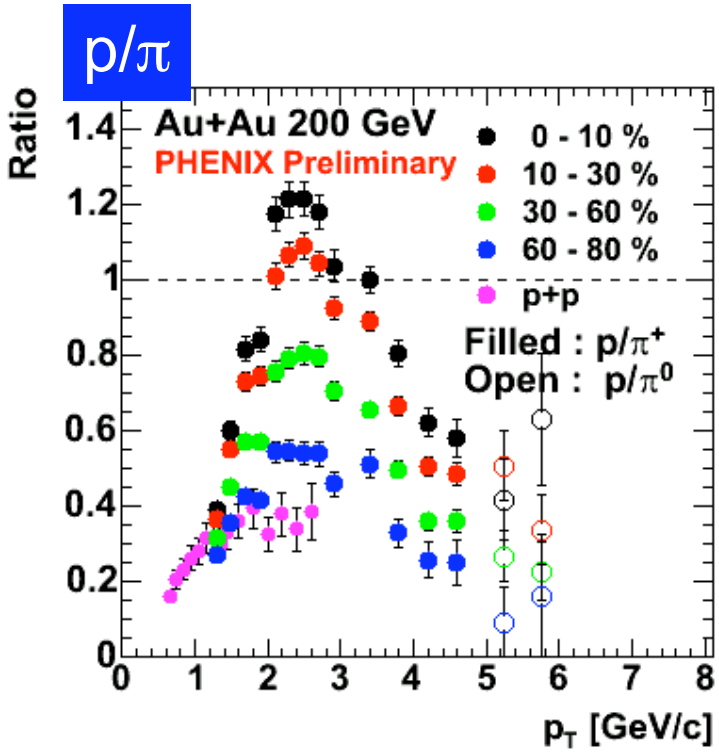
* No feed-down correction.

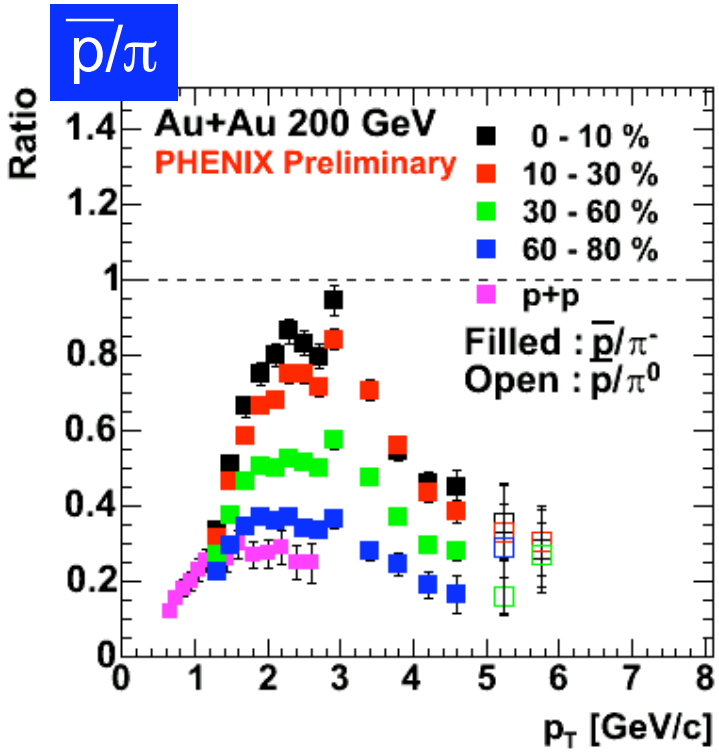


- p/π ratios look to have a peak at intermediate p_T (2-4 GeV/c).
- Clear peak in central events than that in peripheral.

p/π vs. p_T (centrality dep.)

ACC





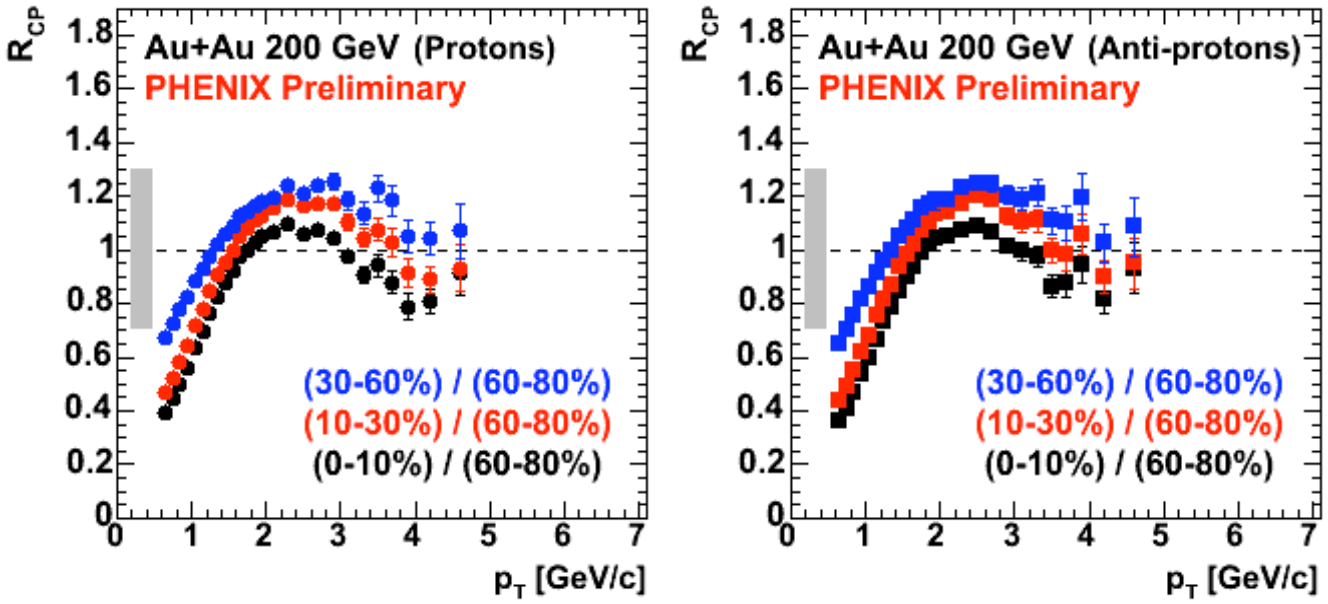
* No feed-down correction.
* p+p data (nucl-ex/0603010)

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

Proton R_{CP}

TOF

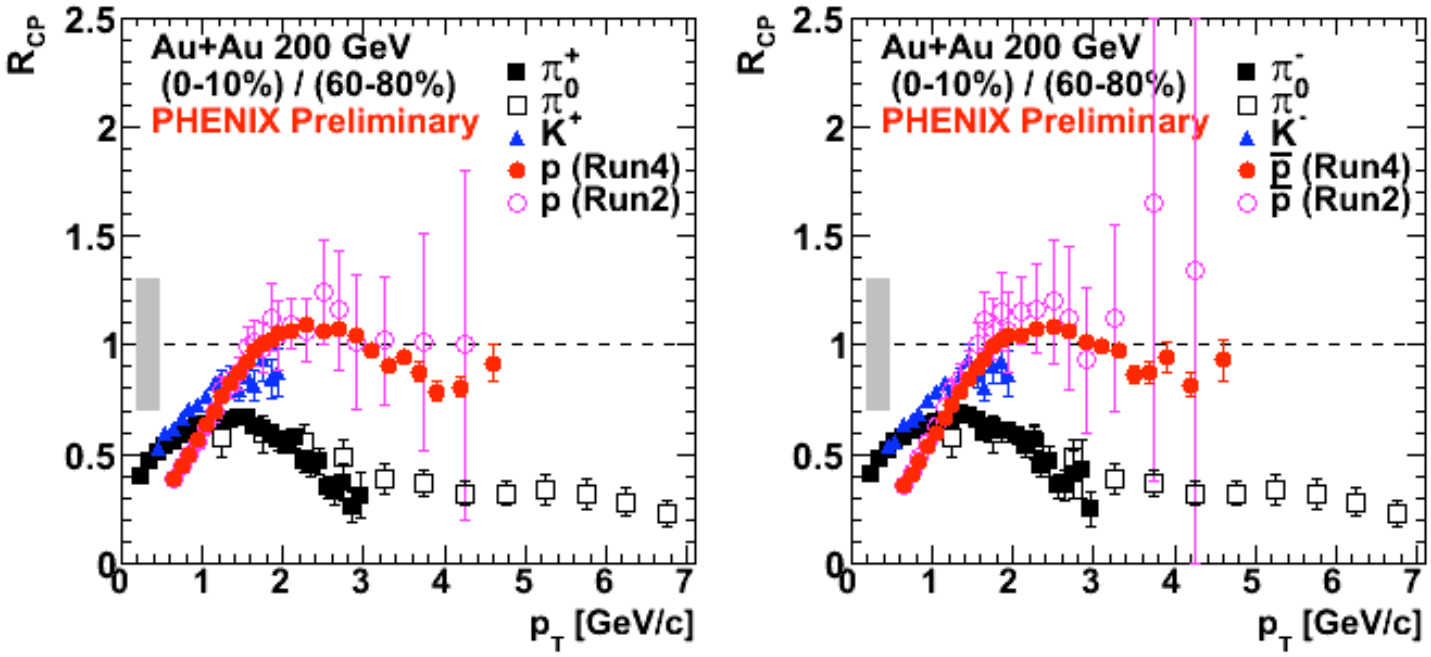
$$R_{CP} = \frac{Yield_{Central} / \langle N_{binary} \rangle_{Central}}{Yield_{Peripheral} / \langle N_{binary} \rangle_{Peripheral}}$$



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

Proton R_{CP}

TOF

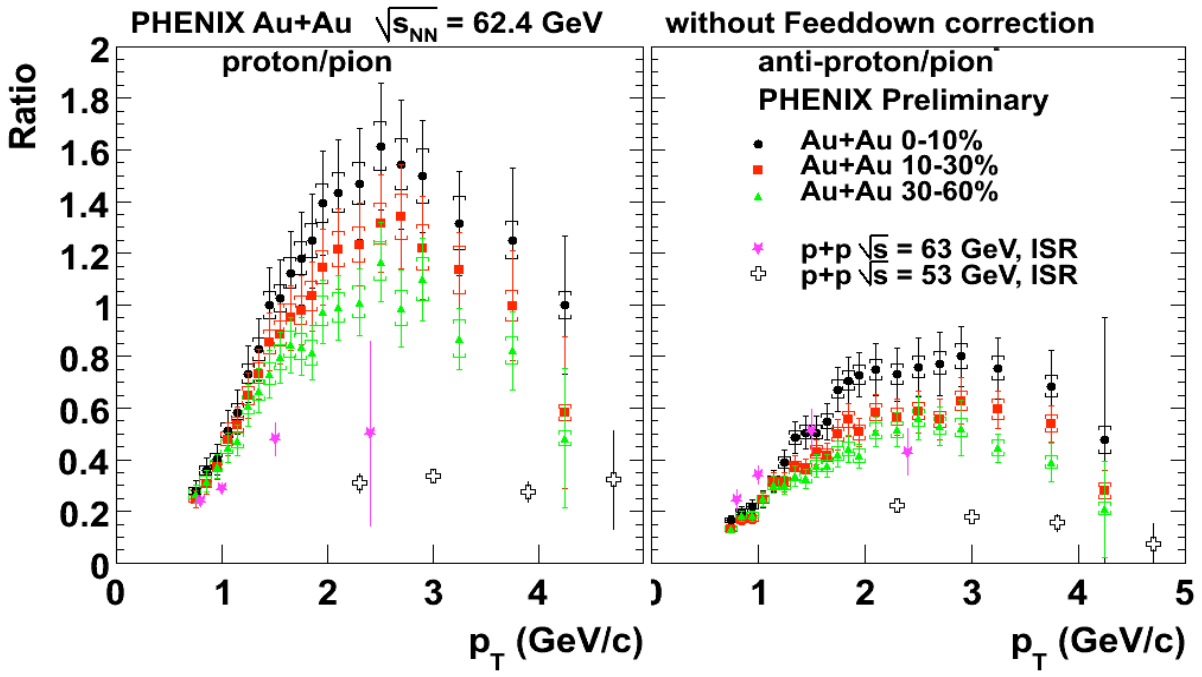


- Proton R_{CP} seems to show decreasing above 3 GeV/c.
- Expected to merge to pion R_{CP} at higher p_T.
- Need more statistics to look at high-p_T points.

Collision system dep.

p/π ratio in 62 GeV Au+Au

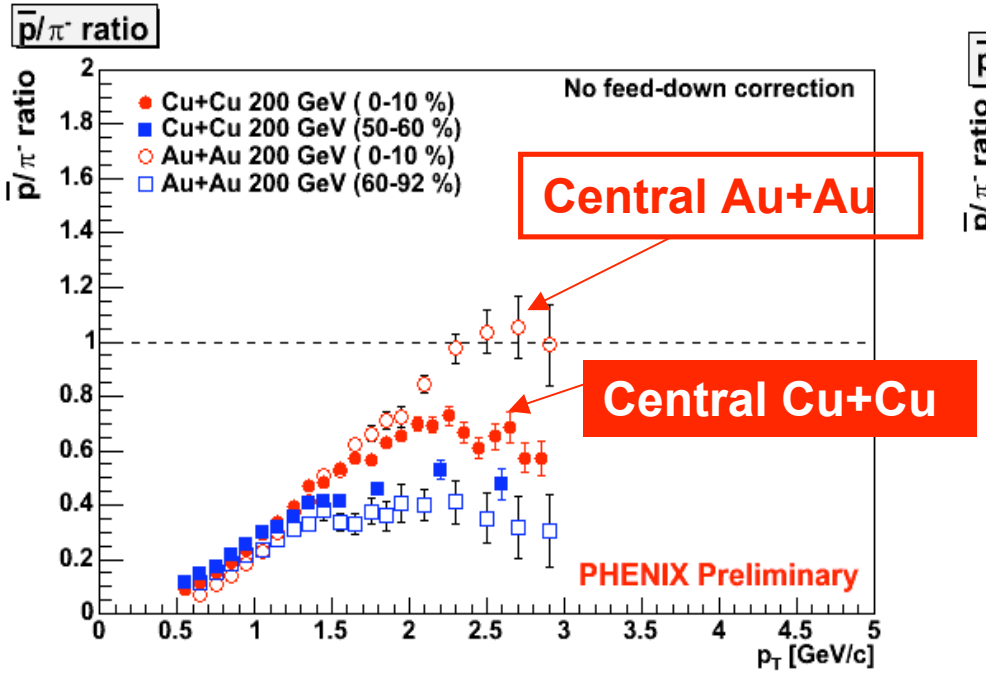
62 GeV Au+Au

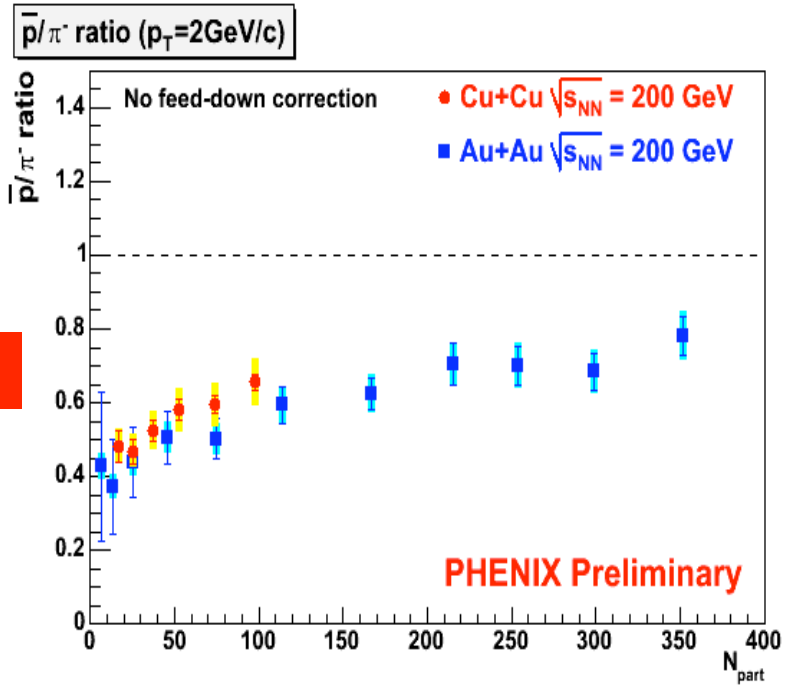


- Rapidly increasing with p_T for 62 GeV.
- Weaker centrality dependences (62GeV) than those of 200 GeV.
- Significant difference for p and pbar at 62 GeV.
  (Indicating more baryon transport and less p-pbar pair production at 62 GeV than 200 GeV.)

p/π ratio in Cu+Cu / Au+Au

200 GeV Cu+Cu





* No feed-down correction.

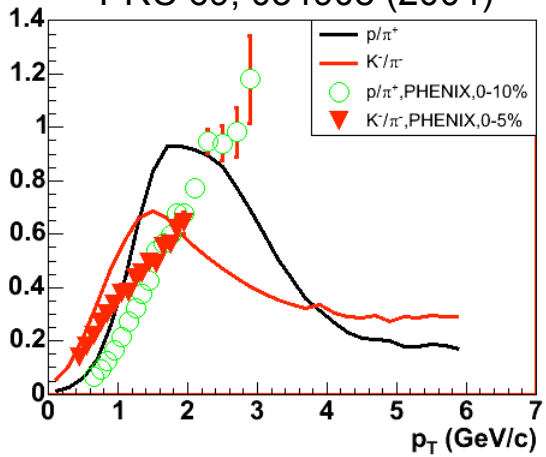
- Observed a large p,pbar contribution at intermediate p_T, as seen in 200 GeV data.
- N_{part} dependences on particle ratios have similar trend as in Au+Au (N_{part} scaling).

Comparison with models

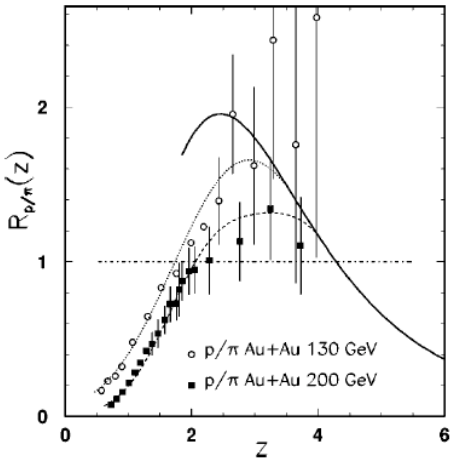
Comparison with models

p/π

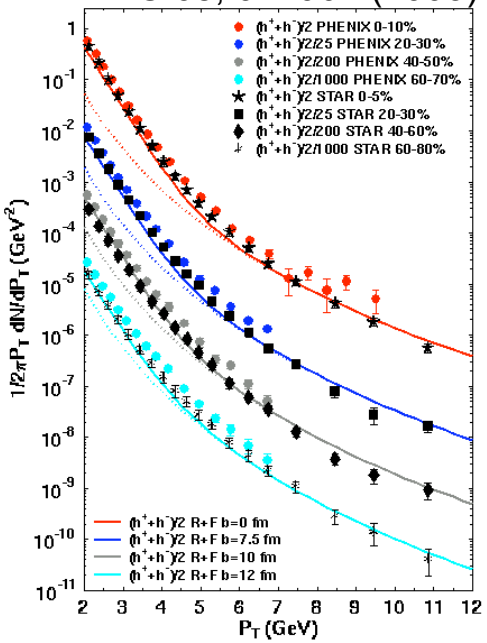
PRC 69, 034908 (2004)



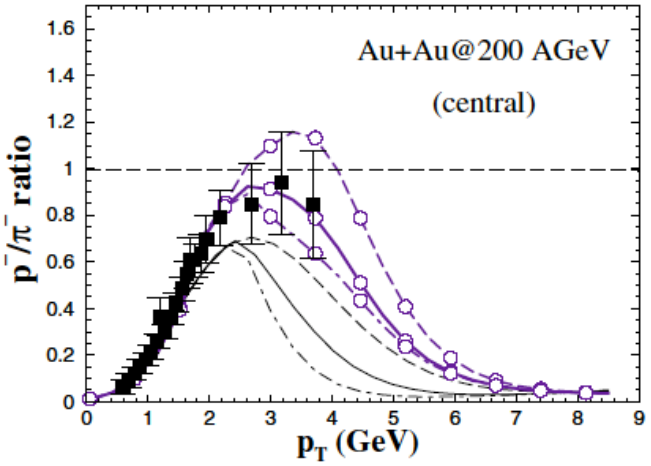
PRC 67, 034902 (2003)



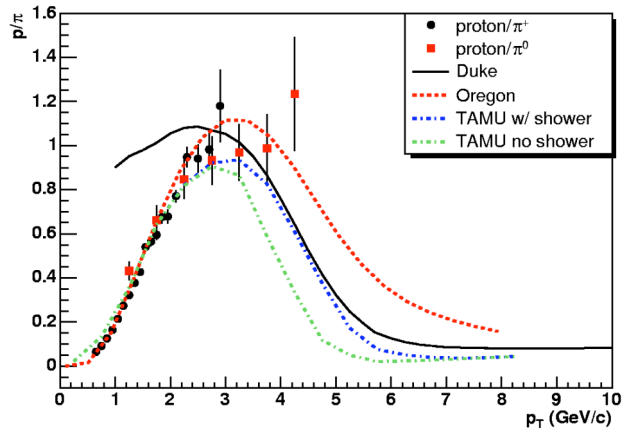
PRC 68, 044902 (2003)



PRL 90, 202302 (2003)

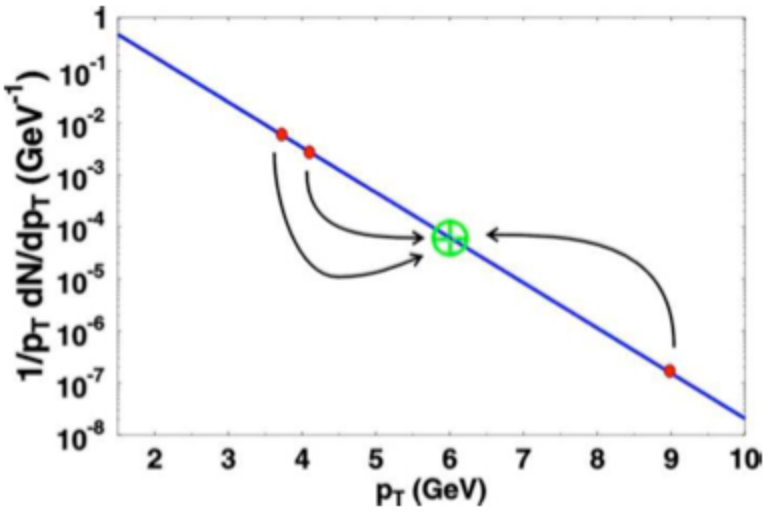


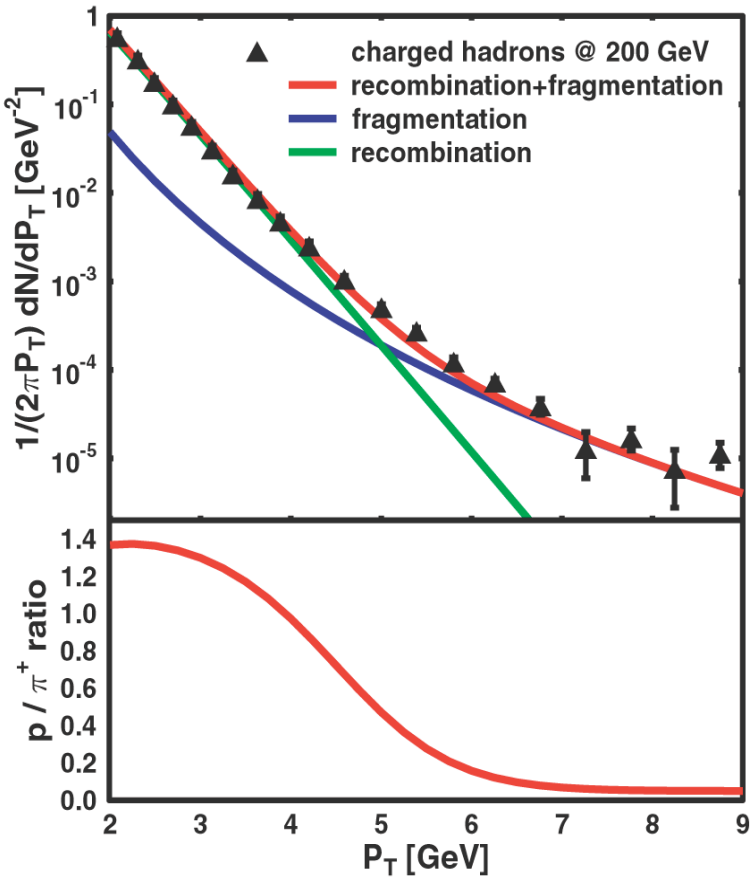
PHENIX proton/π ratio



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

Recombination



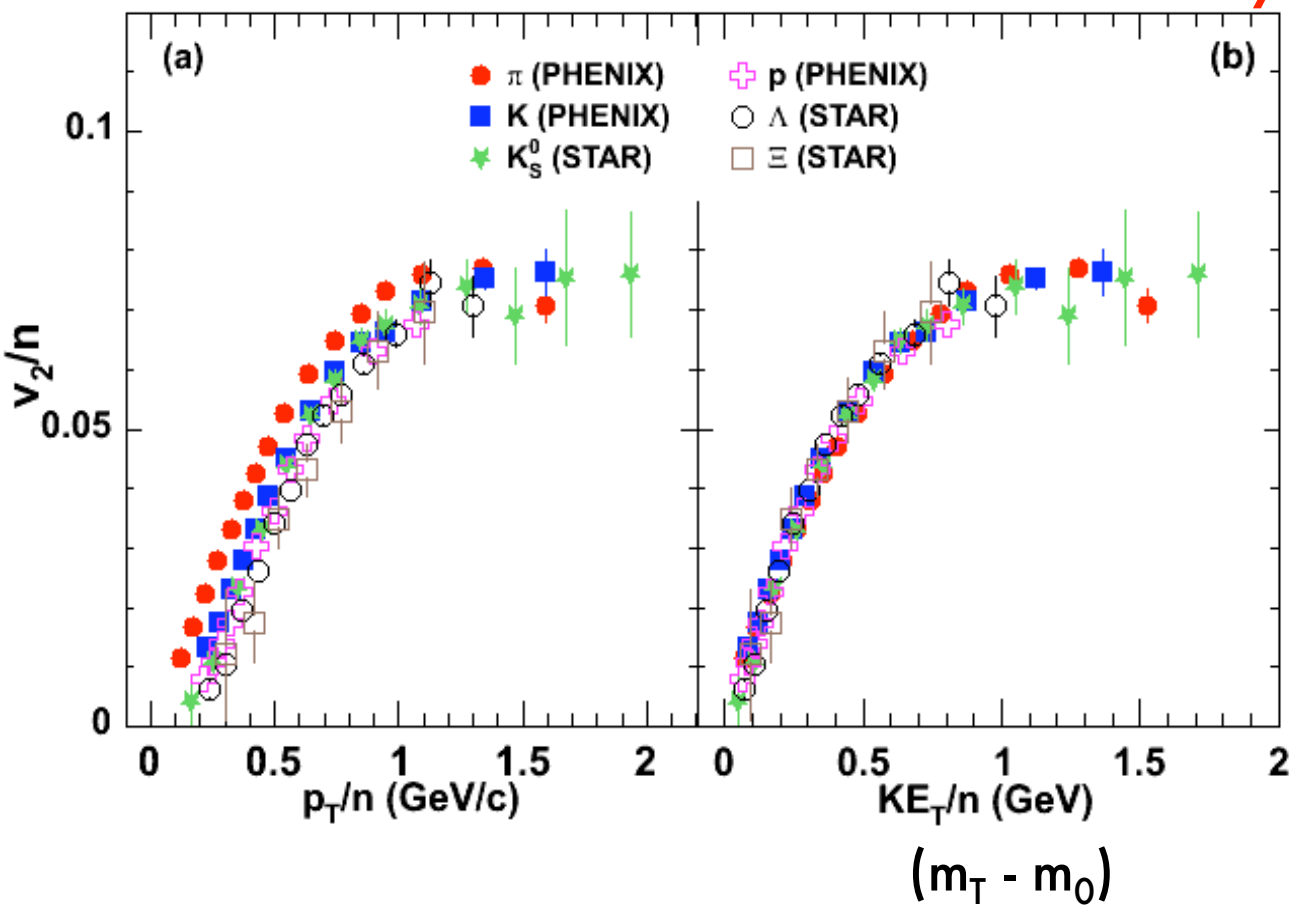


At intermediate p_T, recombination of partons may be a more efficient mechanism of hadron production than fragmentation.

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

Scaling of elliptic flow

PHENIX Preliminary



Example of partonic degrees of freedom

Summary

- **p_T reach of PID (especially for p, pbar) extended with:**
  - High statistics 200 GeV Au+Au data
  - New PID detector (Aerogel)
- **Results:**
  - pbar/p ratio No centrality or p_T dependence
  - p/π ratio Indicating transition from soft to hard at intermediate p_T
  - R_{CP} (Anti-)proton R_{CP} shows decreasing above 3 GeV/c
- **Collision system dependence:**
  - Similar turnover curve on p/π in 62 GeV Au+Au
  - N_{part} scaling on particle ratios (Cu+Cu / Au+Au)
- **Comparison with models:**
  - Recombination models seem to be matched to the experimental data.

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