Identified Charged Hadron

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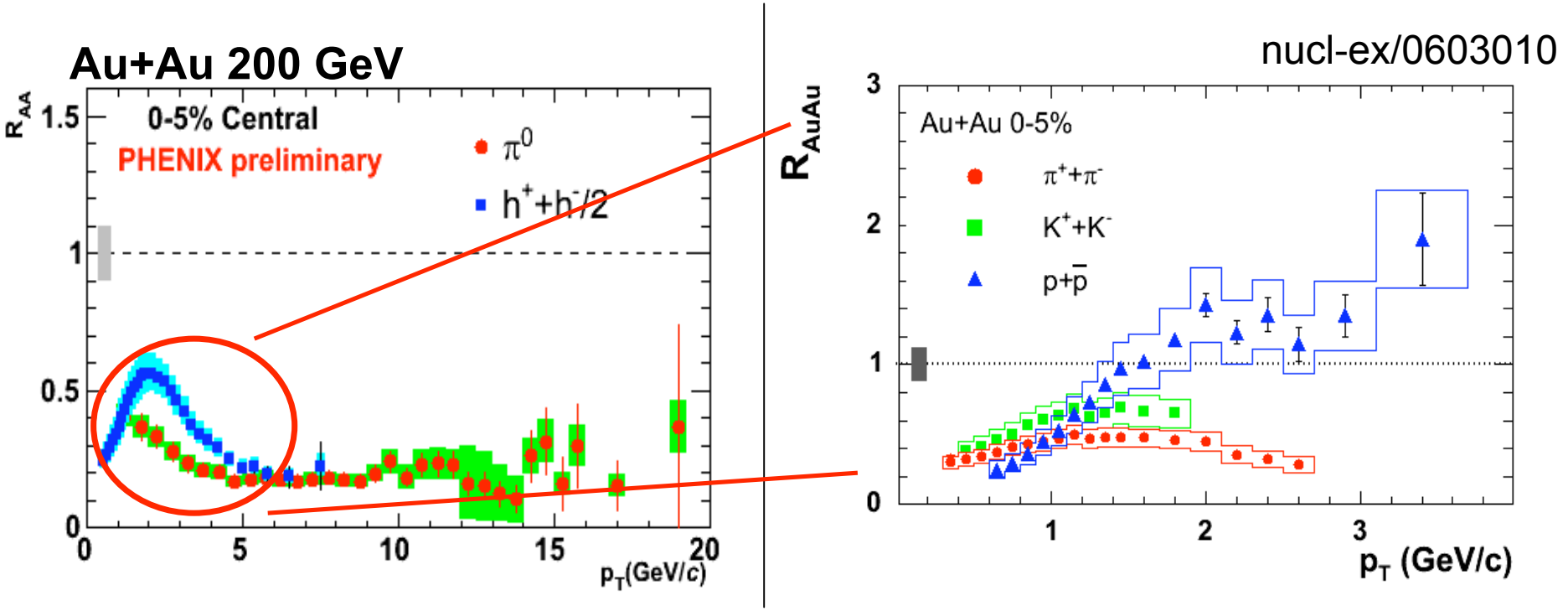
Physics motivation

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

Nuclear Modification Factor R_{AA}

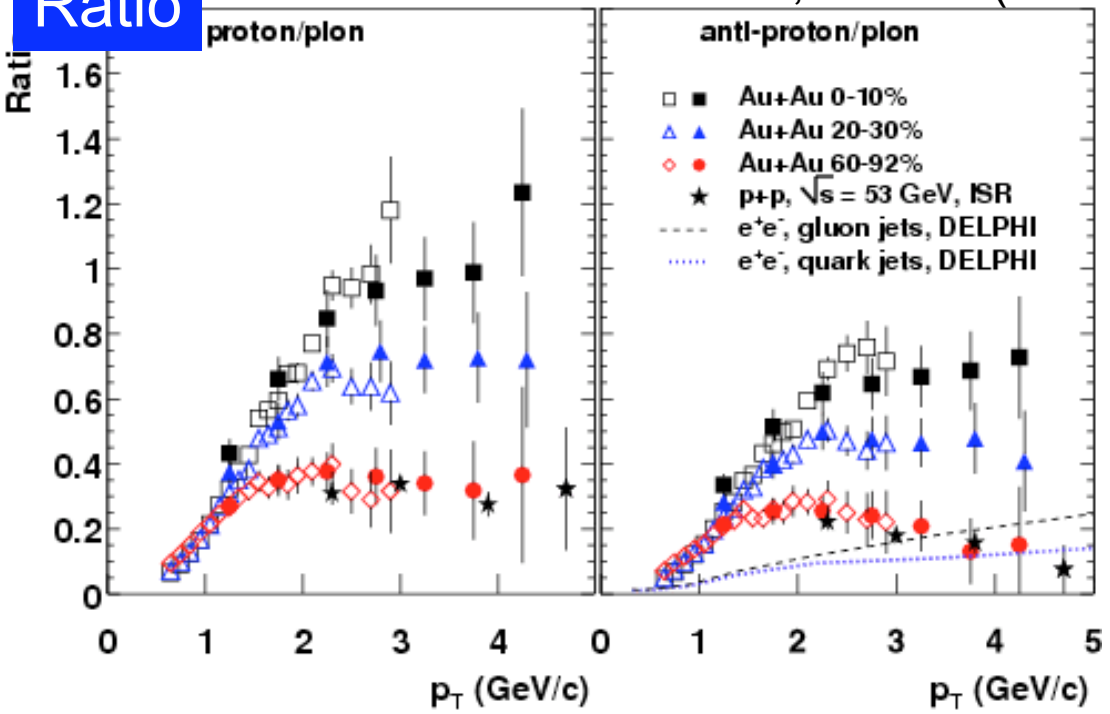


- High-p_T suppression due to parton energy loss in the medium (jet quenching).
- The suppression patterns depend on particle type. Protons are enhanced, while pions and kaons are suppressed.

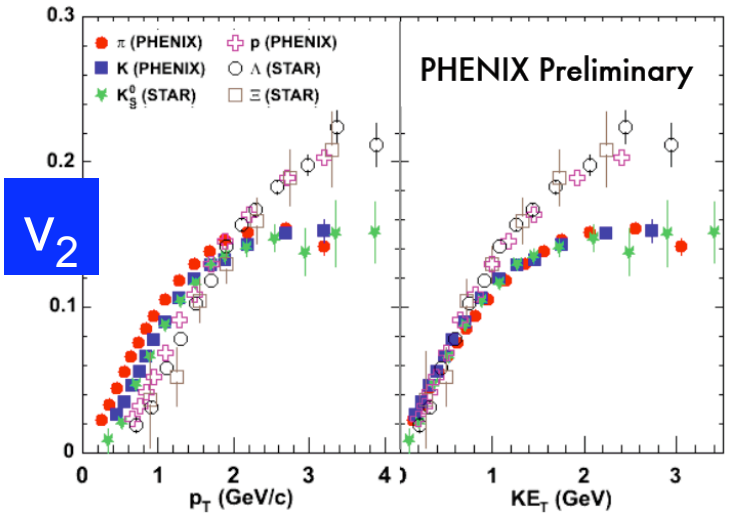
Baryon Enhancement

Ratio

PRL 91, 172301 (2003)



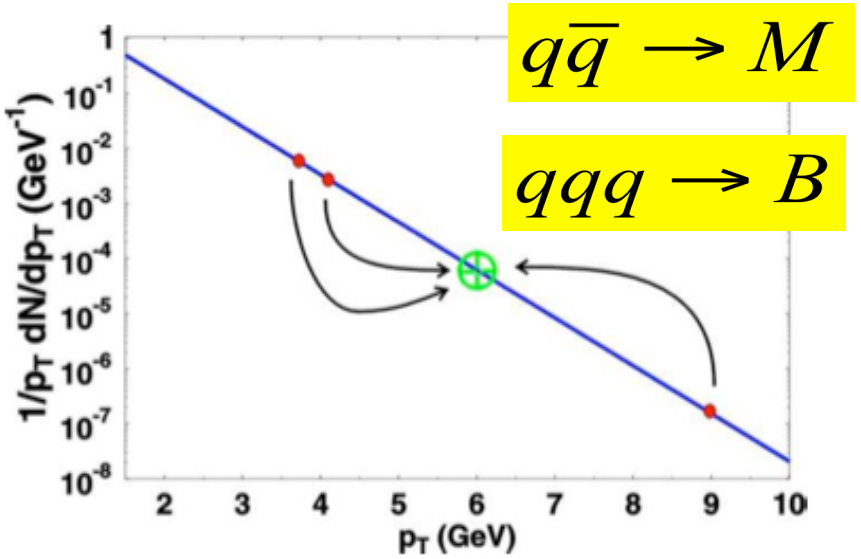
v_2

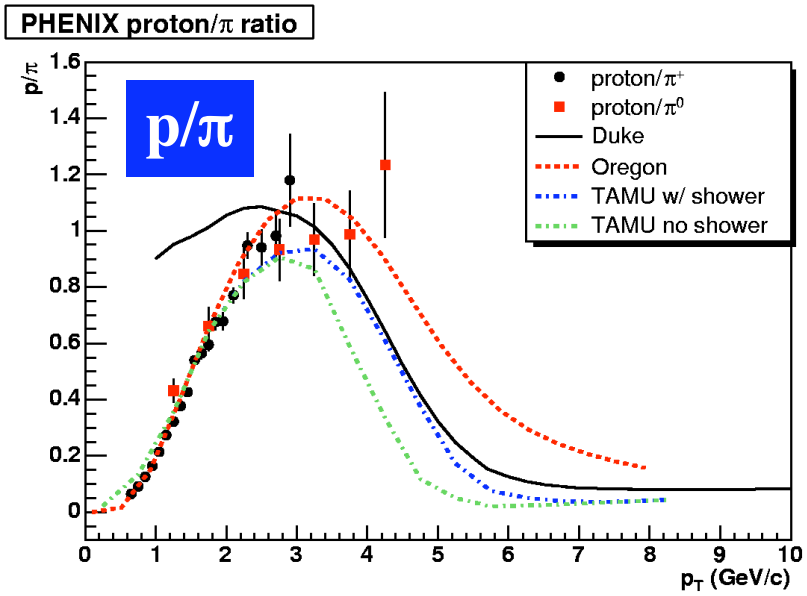


- p/π ratio ~1 for central Au+Au at intermediate p_T (2-4 GeV/c).
- Larger than expected from jet fragmentation (measured in pp, e^+e^-).
- Baryon / Meson difference at intermediate p_T.

  (on R_{AA} (nuclear modification factor) , v_2 (elliptic flow) etc.)

Quark Recombination





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

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

A number of models predicted a turnover in the B/M ratio at p_T just above where the available data finished…

What we should do:

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

Possible sources (medium effect) :

- Strong radial flow
- Recombination of quarks
- Baryon junction

pT spectra and particle ratios (Baryon/Meson) provide the most basic tool to investigate the hadronization mechanisms.

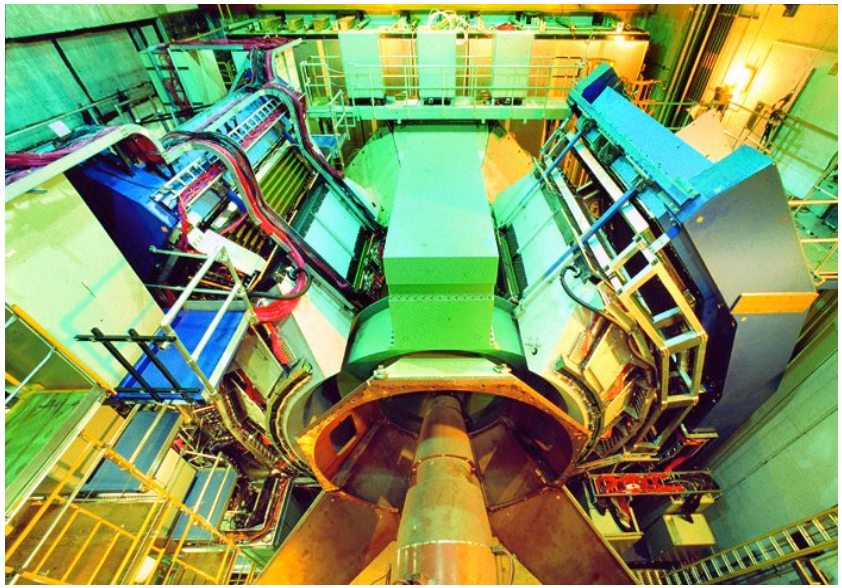
To distinguish the different production mechanism for protons and pions at intermediate and higher p_T.

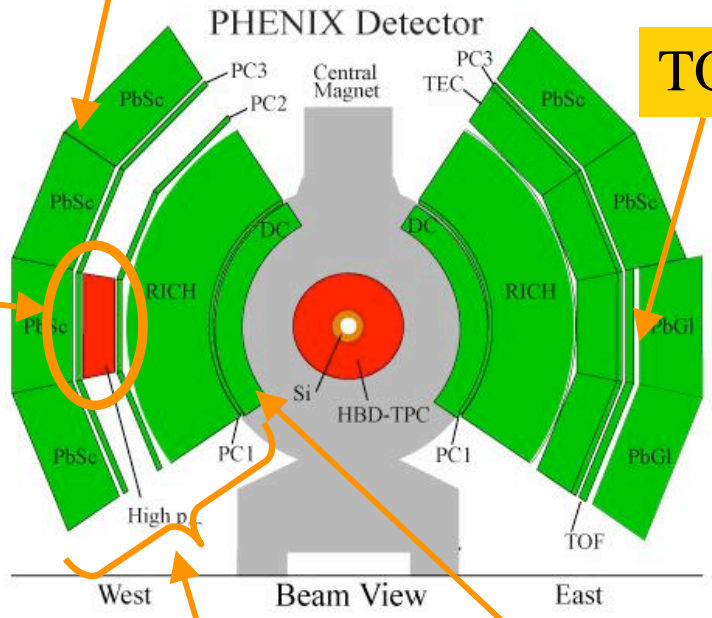
PHENIX detector

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

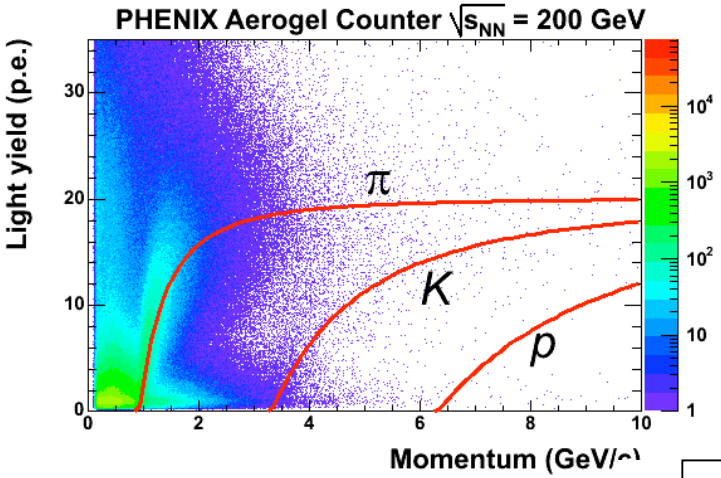
Aerogel Cherenkov Counter

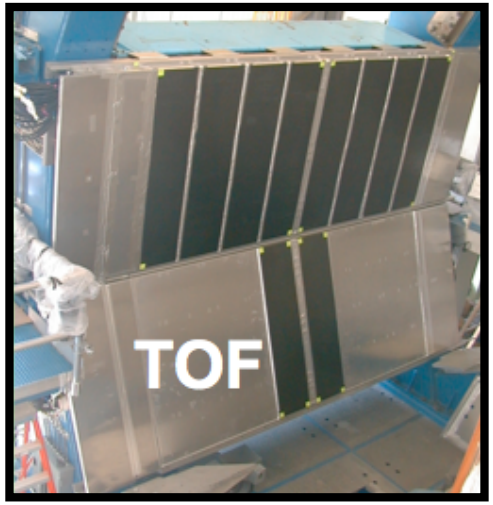
Hadron Identification at High p_T
- n = 1.0113.
- Full installation in 2004.
- Proton separation from π /K
  up to 8 GeV/c.

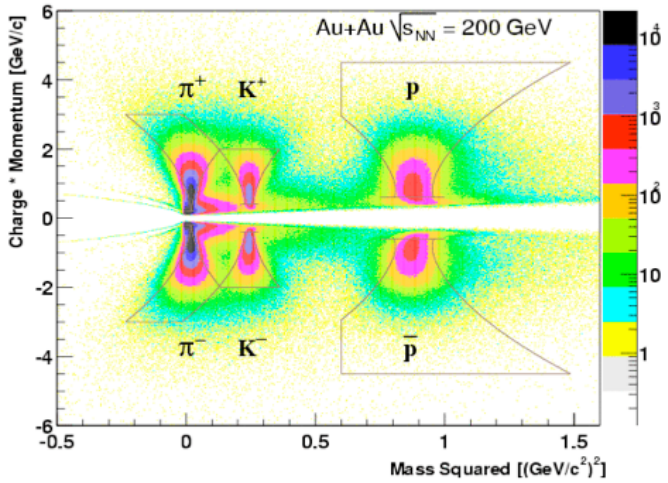


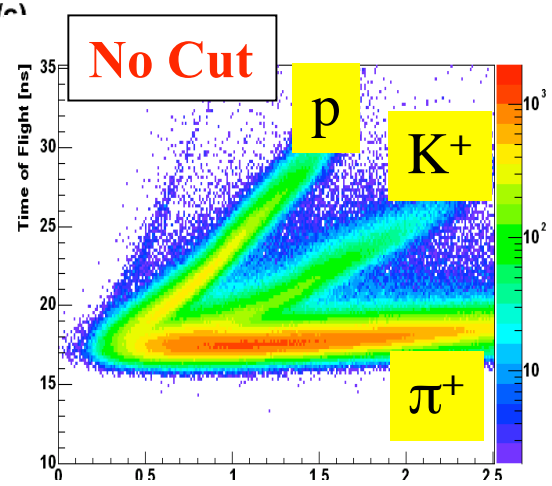


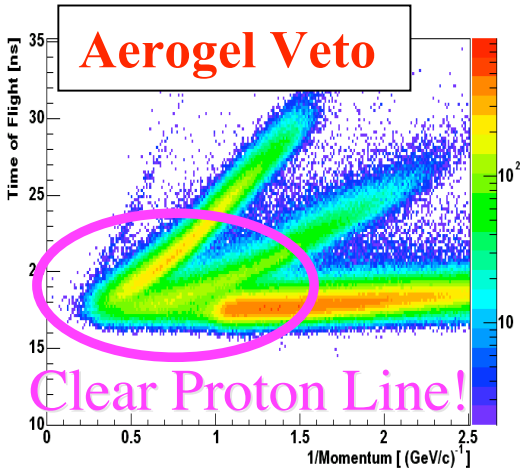
PID detectors











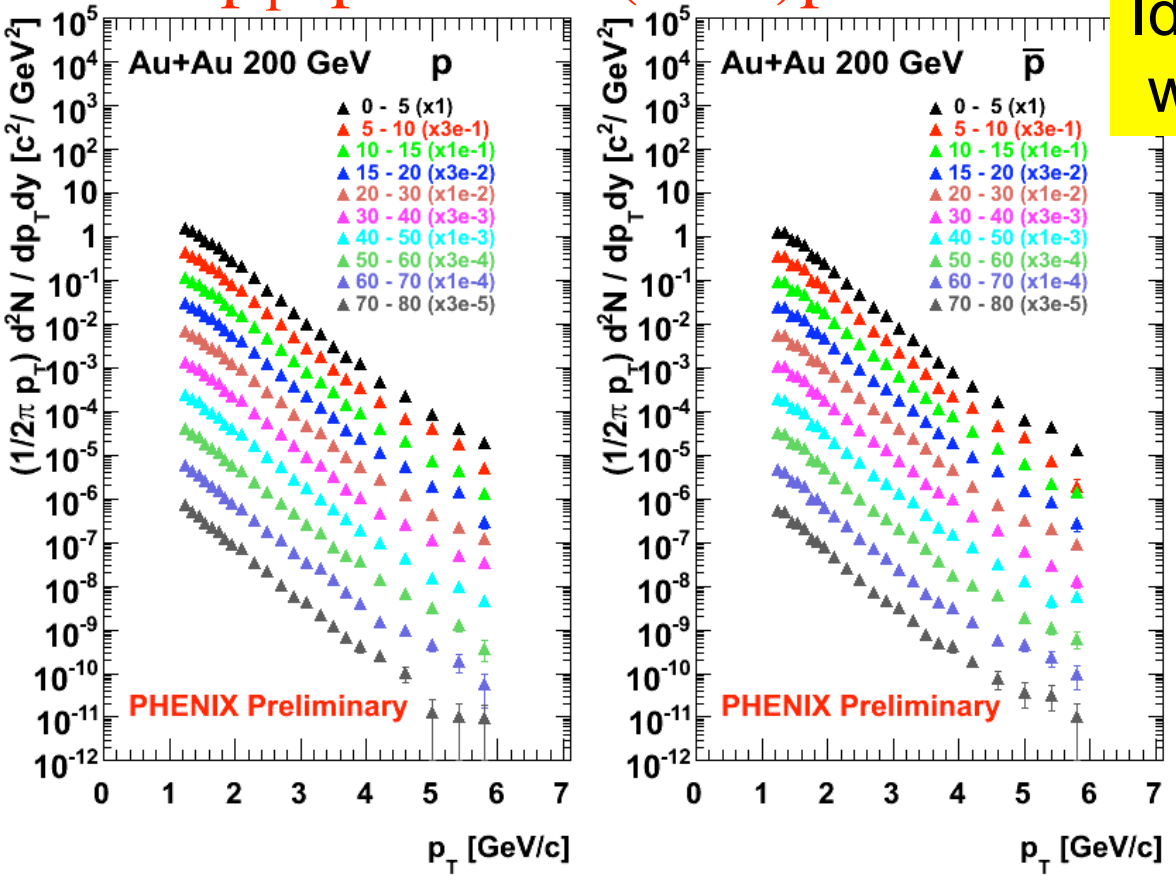
Results

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

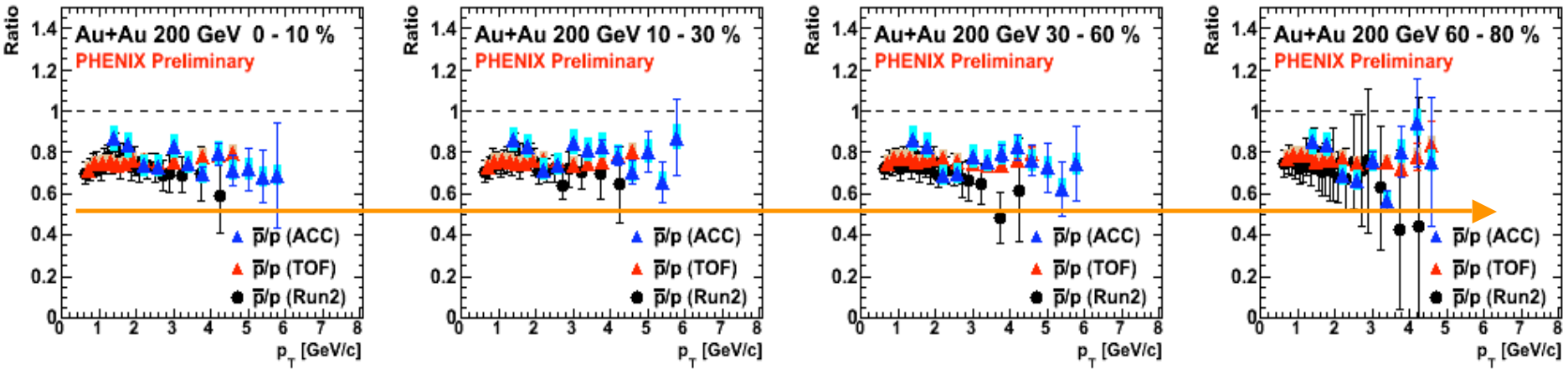
p_T spectra of (anti-)protons

Identified with ACC



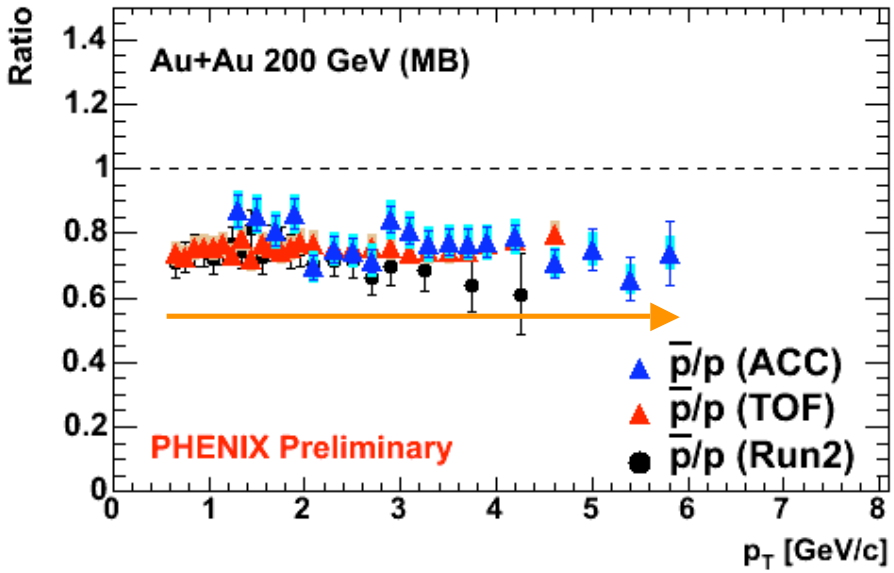
p_T reach extended for (anti-)protons with fine centrality bins.

pbar/p vs. p_T



Central

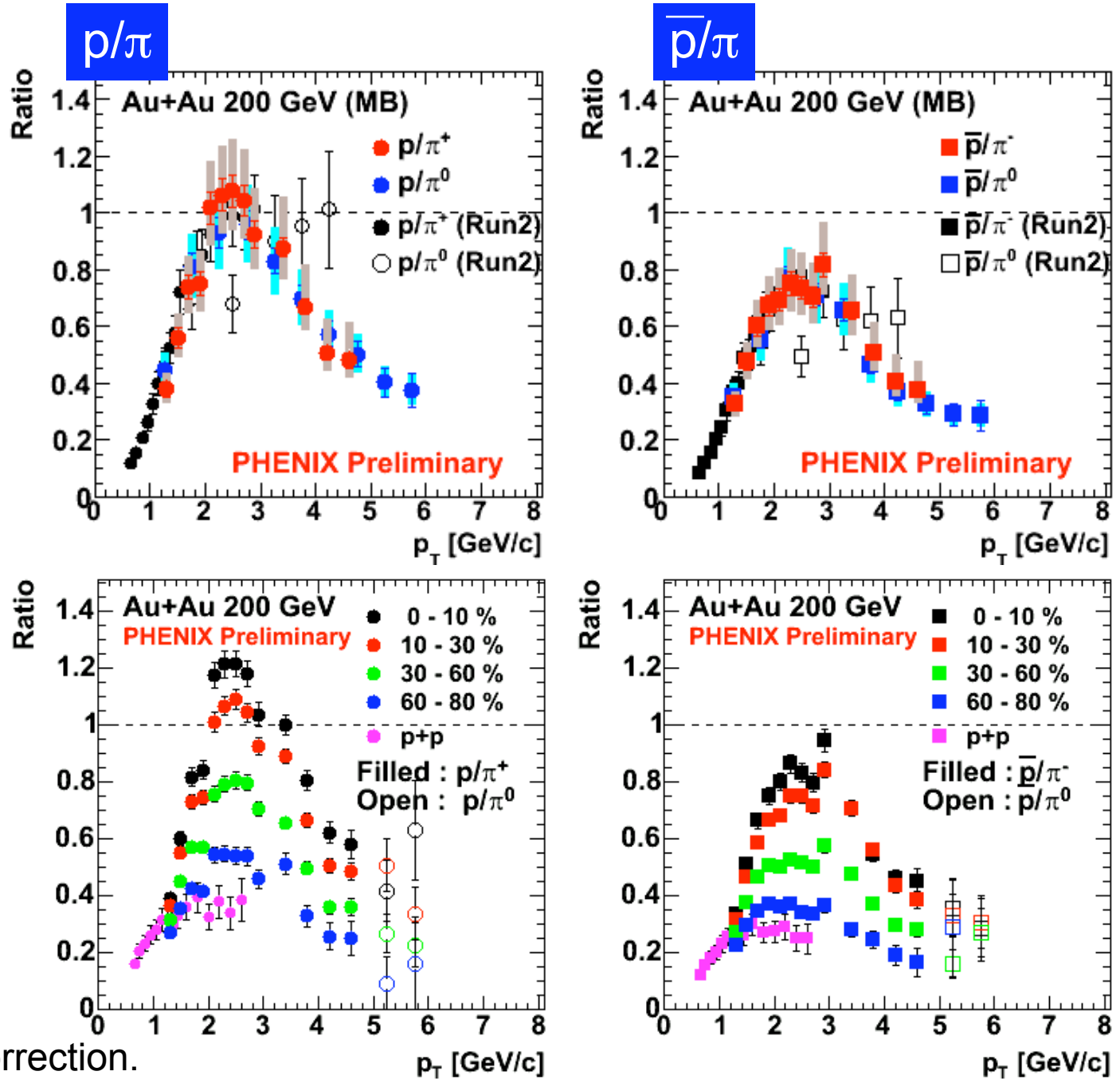
Peripheral



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

p/π vs. p_T

ACC

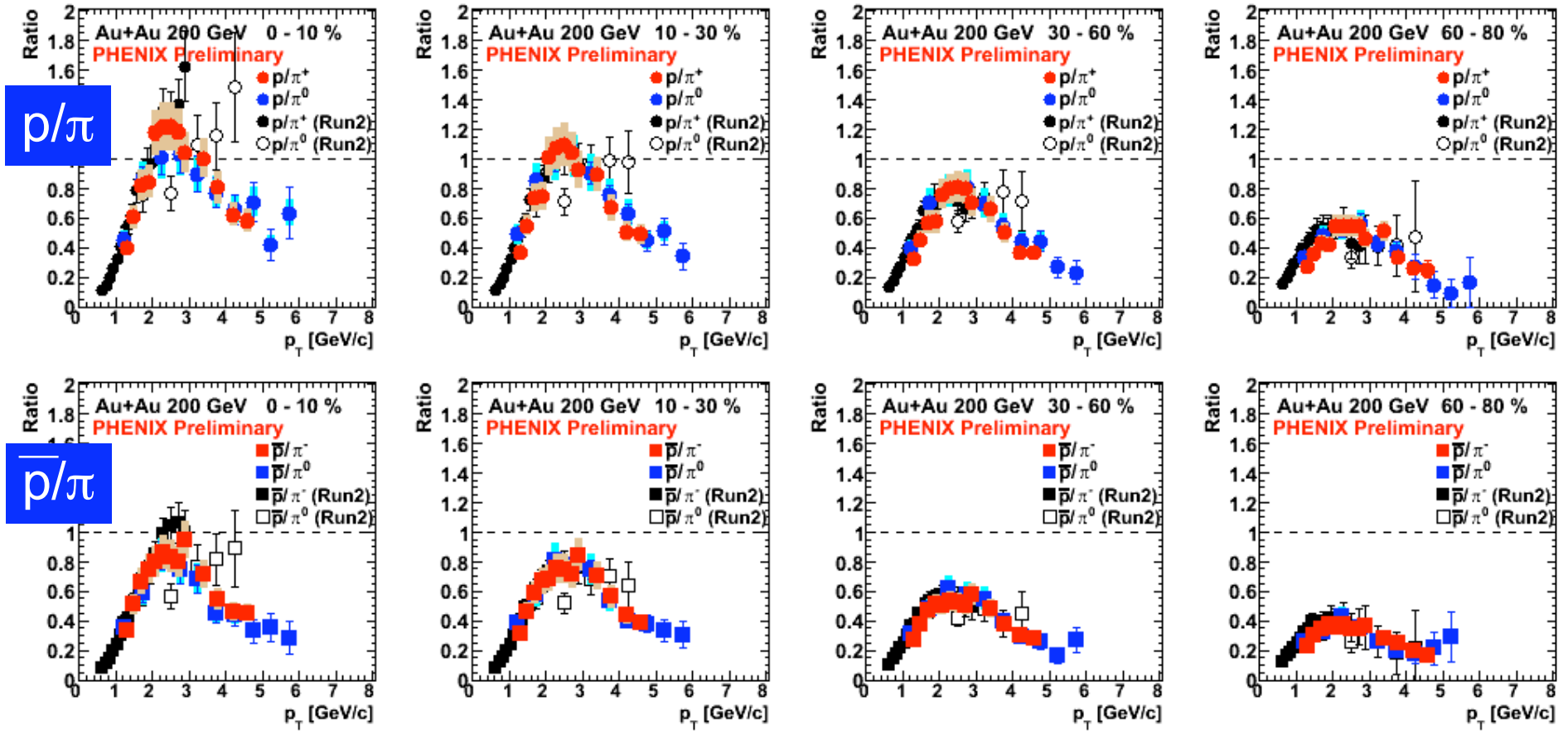


* No feed-down correction.

* p+p data (nucl-ex/0603010)

p/π vs. p_T (centrality dep.)

ACC



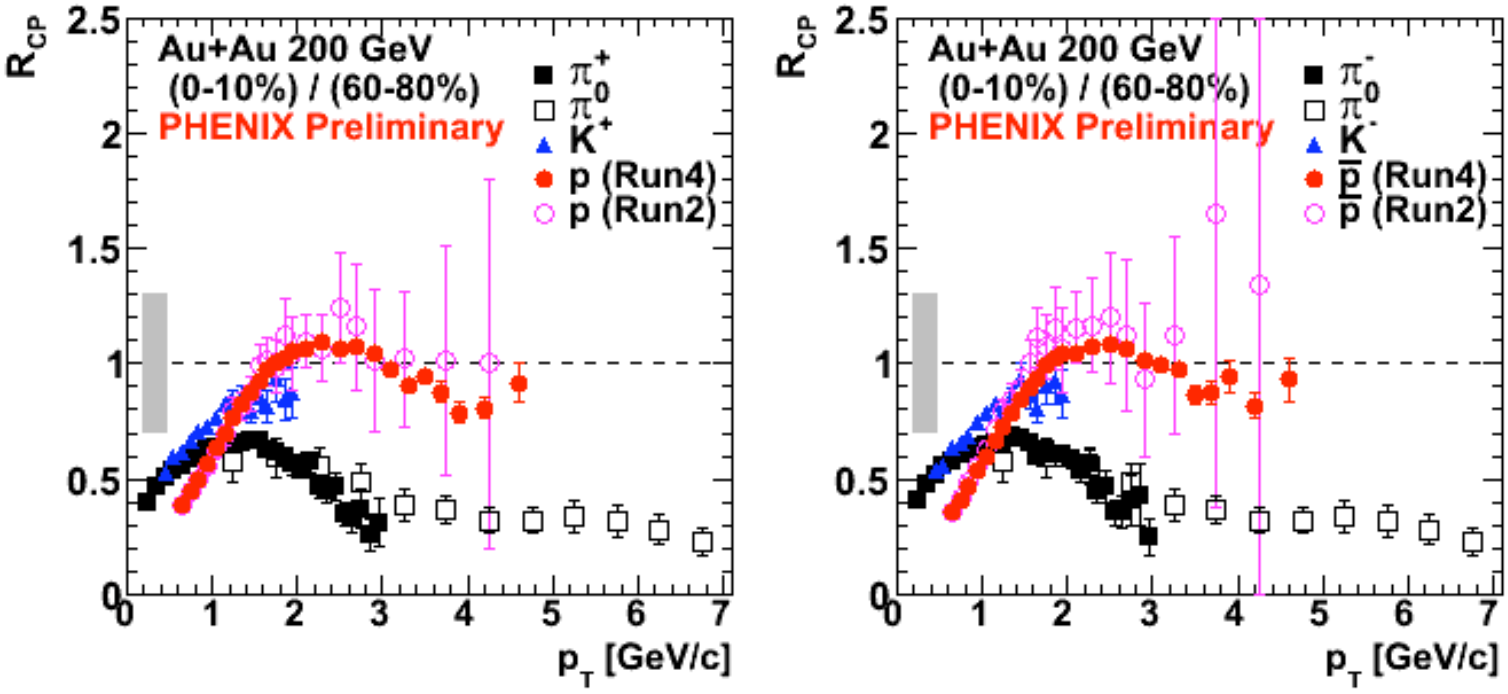
Central ⟷ Peripheral

- p/π ($\bar{p}/\pi$) 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.

Proton R_{CP}

$$R_{CP} = \frac{\text{Yield}_{\text{Central}} / \langle N_{\text{binary}} \rangle_{\text{Central}}}{\text{Yield}_{\text{Peripheral}} / \langle N_{\text{binary}} \rangle_{\text{Peripheral}}}$$

TOF

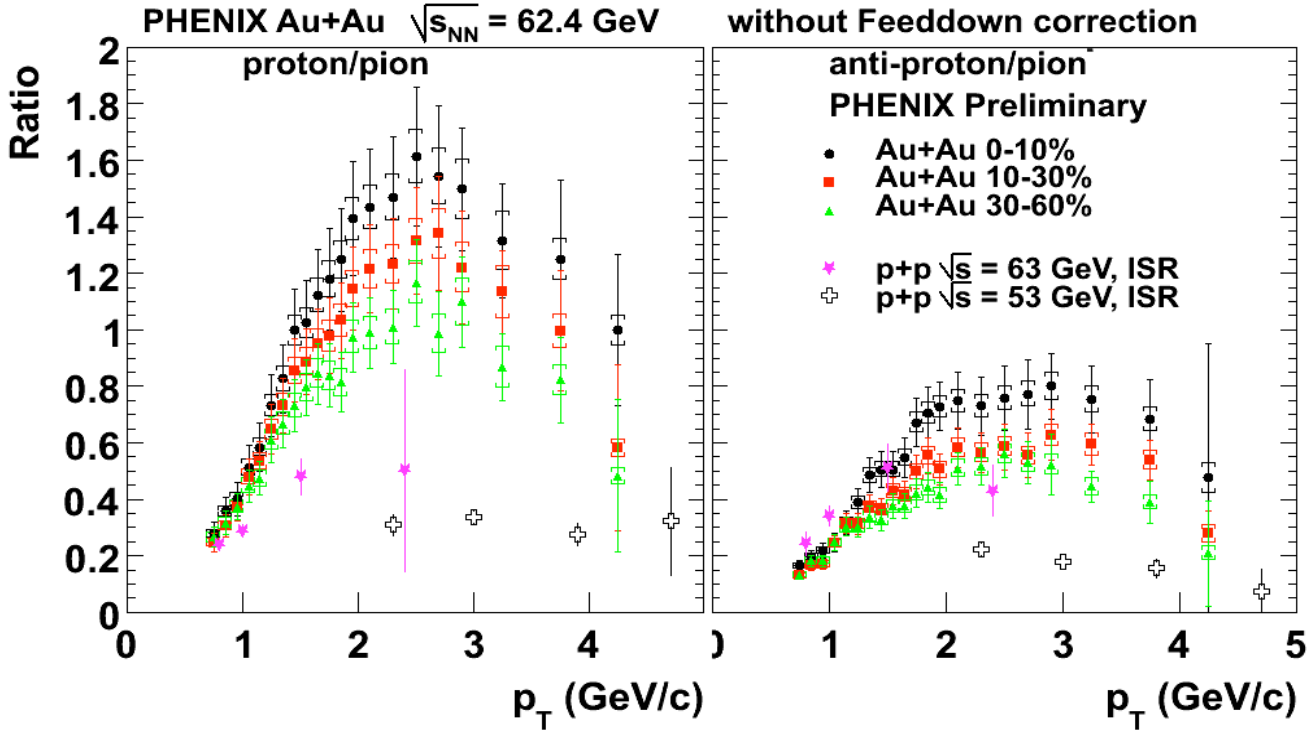


- Proton R_{CP} shows unity above 2 GeV/c.
- Peak structure at 2~3 GeV/c.

- 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.

p/π ratio in 62 GeV Au+Au

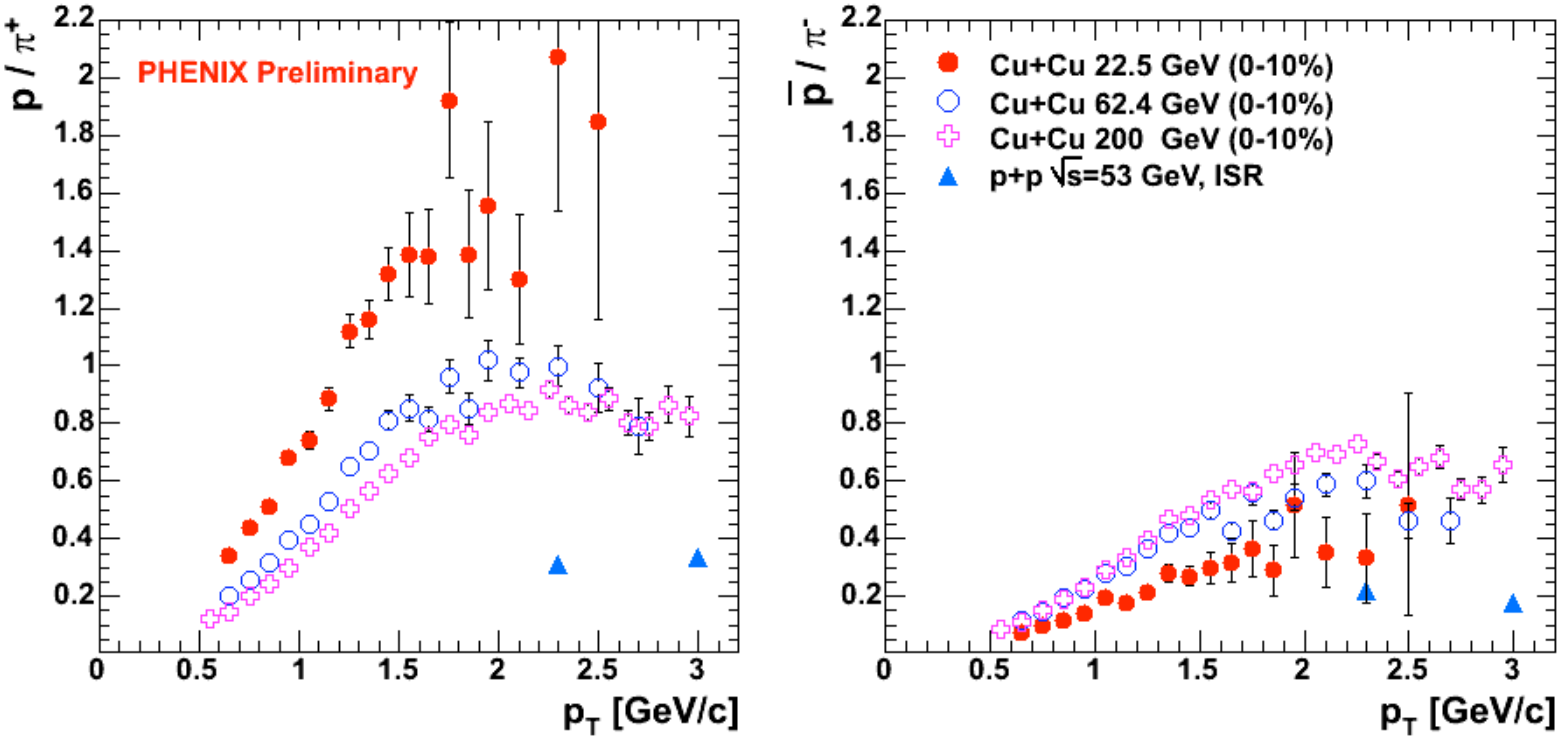
62 GeV Au+Au



- Rapidly increasing with p_T for 62 GeV.
- Weaker centrality dependences 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



- **p/π^+ ratio** : decreasing as a function of $\sqrt{s_{NN}}$.
- **$\bar{p}/\pi^-$ ratio** : increasing as a function $\sqrt{s_{NN}}$.
  - Cu+Cu 22.5 GeV central data reaches the p+p values.
  - Cu+Cu 62.4 GeV central data is higher than that in 22.5 GeV.

Suggests a significant contribution of incoming protons (not by the produced protons) in lower energies Cu+Cu.

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