Overview of PHENIX Results on Baryons and Identified Hadrons

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for the U.S. Department of Energy

Physics Interests on Identified Charged Hadron

Identified single particle hadron spectra have the entire history of dynamical evolution of the collision system.

- $< p_T >$ vs. particle mass, centrality.
- Centrality dependence of spectra shape.
- Freeze-out temperature and expansion velocity based on the hydro dynamical model (radial flow).
- Suppression of hadron yield at high p_T by parton energy loss in hot and dense matter.
- Particle ratio vs. p_T and centrality

  $\Rightarrow \mu_{ch}$, T_{ch} from thermal model
- Net baryon number @ mid-rapidity

  $\Rightarrow$ baryon transport mechanism at RHIC.

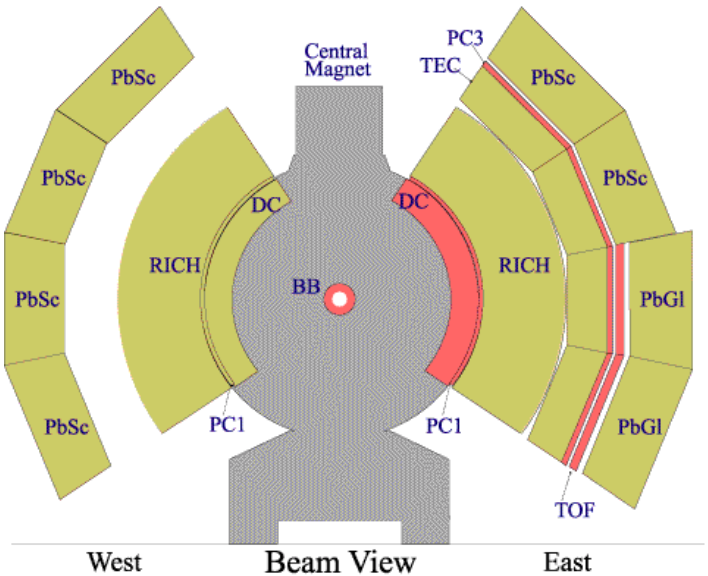
In this presentation

PHENIX Results from Au+Au @ $\sqrt{s_{NN}}$ = 130 GeV

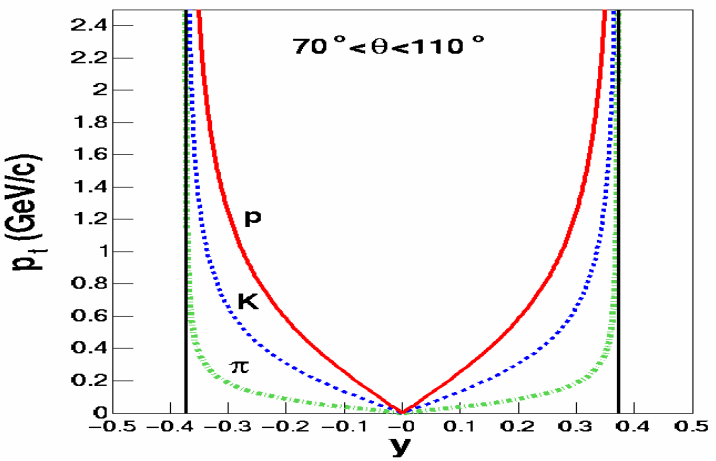
- Identified charged particle (PID by TOF)
  - Based on K. Adcox et al., (PHENIX) nucl-ex/0112008 + preliminary results
  - Centrality dependence of p_T spectra
  - $<p_T>$ vs. N_{part}
  - dN/dy vs. N_{part}
  - Anti-particle / particle ratio vs. Npart and p_T
  - K/π and p/π ratio vs. Npart and p_T
- Lambda analysis (by EMC-TOF)
  - anti-Λ/Λ ratio vs. p_T and centrality
  - Net baryon number (proton and Λ)

  $\Rightarrow$ **" Baryon/Anti-Baryon Ratios"**
  By Ilia Ravinovich at this workshop (3/30/02)

Detectors for Identified Hadron Analysis



Geometrical Acceptance @ TOF

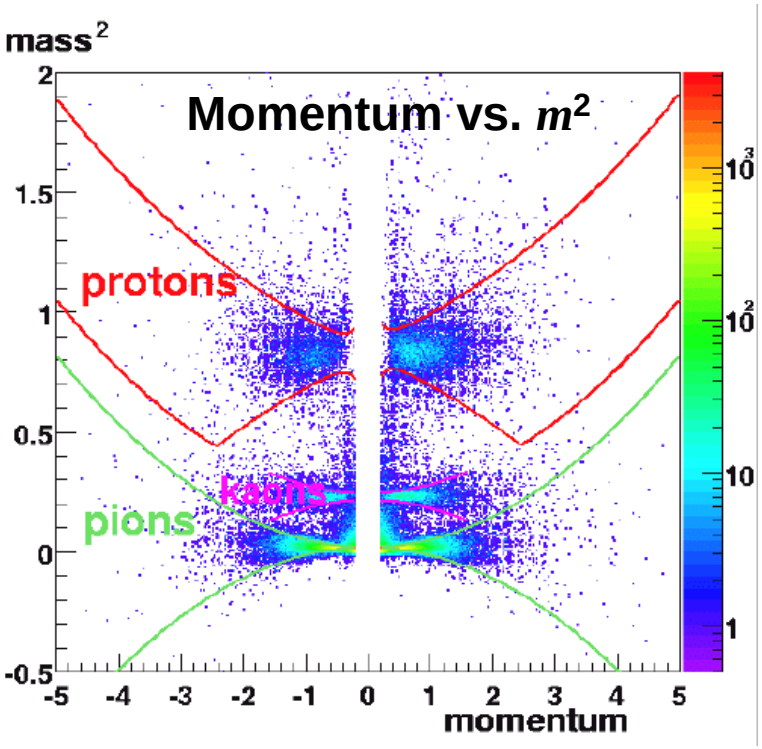


- **Beam-Beam Counter (BBC)**
  - *z vertex, start timing for TOF*
- **Time-of-Flight (TOF)**
  - *stop timing measurement*
- **Drift Chamber (DC)**
  - *momentum, flight path length*
- **Pad Chamber 1 (PC1)**
  - *additional track-z information to Dch*

- Rapidity coverage : $|\eta| < 0.35$
- ϕ coverage : $\pi/4$
- p_T range : > 0.2 GeV/c
- Overall TOF resolution : ~100 ps (Run1).
- Momentum resolution :

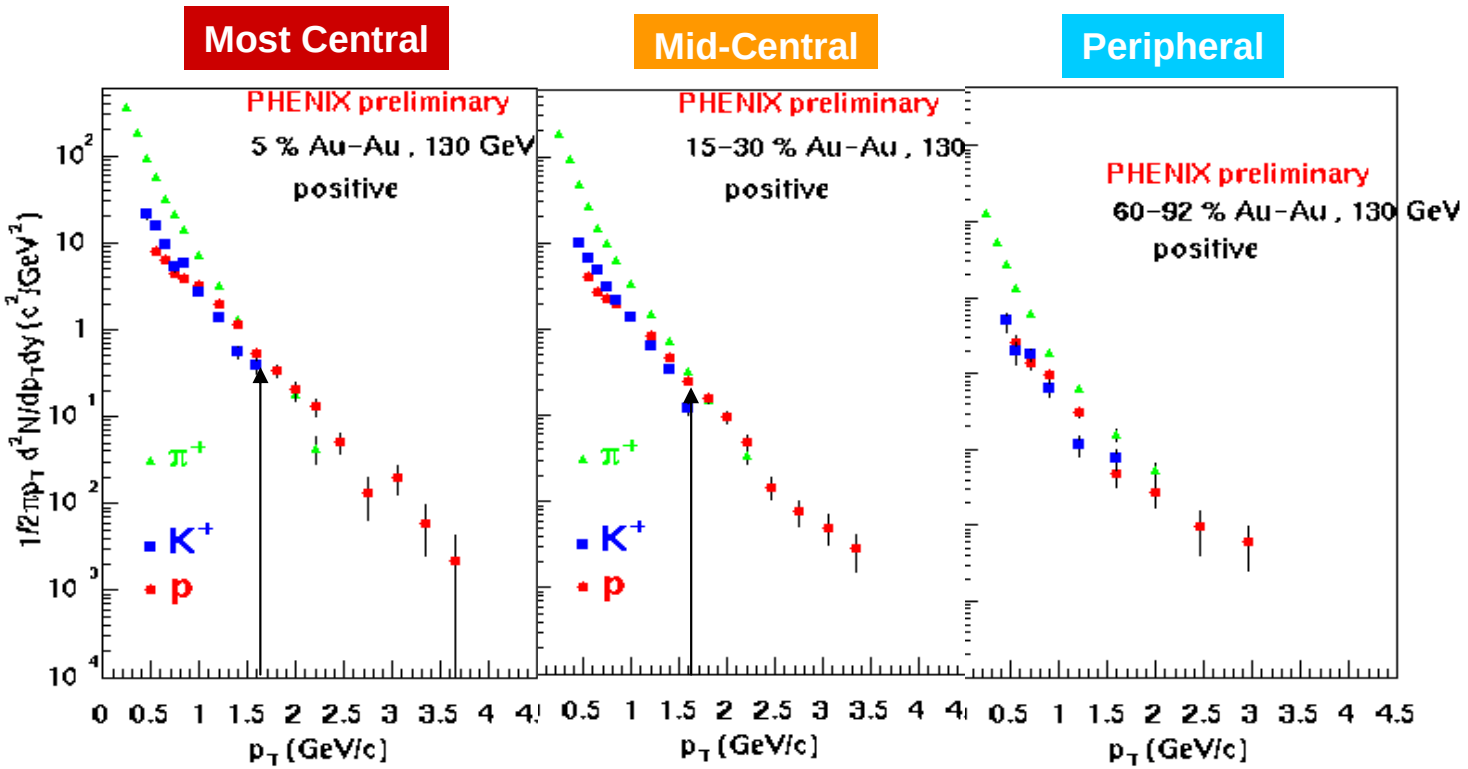
  $\delta p/p = 0.6\ \% \oplus 3.6\%\ p$ [GeV/c] (Run1)

Hadron Identification by TOF



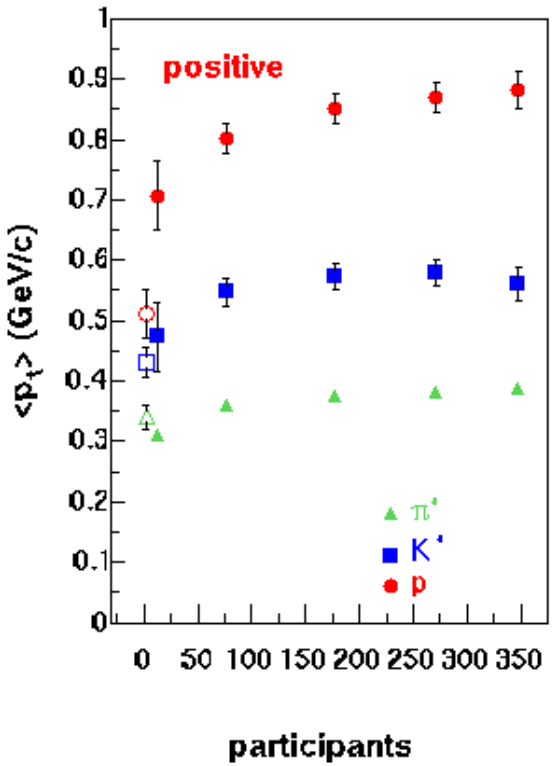
- **Charged hadron Identification by TOF**
  - Identified in m^2 vs. momentum space.
  - Applied 2.0 σ momentum dependent PID cut.
- **Corrections to raw spectra**
  - Based on single particle Monte Carlo simulation.
  - Geometrical acceptance @ TOF
  - Decay correction for π, K
  - Multiple scattering effect.
  - Software reconstruction efficiency.
  - Multiplicity dependence of track reconstruction (embedding MC in real data).

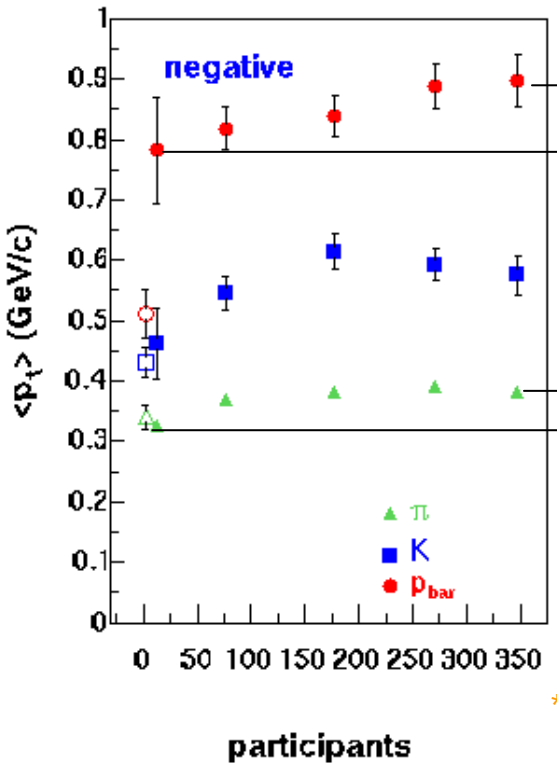
Particle Composition @ High p_T



- **Nucleons dominate mesons at ~ 1.5-2 GeV/c (π/p crossing).**
- **Centrality dependence of π/p crossing point ?**
- **Suppression of high p_T pions (PRL 88, 022301 (2002)) and radial flow in the protons may explain the observed crossing region in the spectra.**

Centrality dependence of $<p_T>$



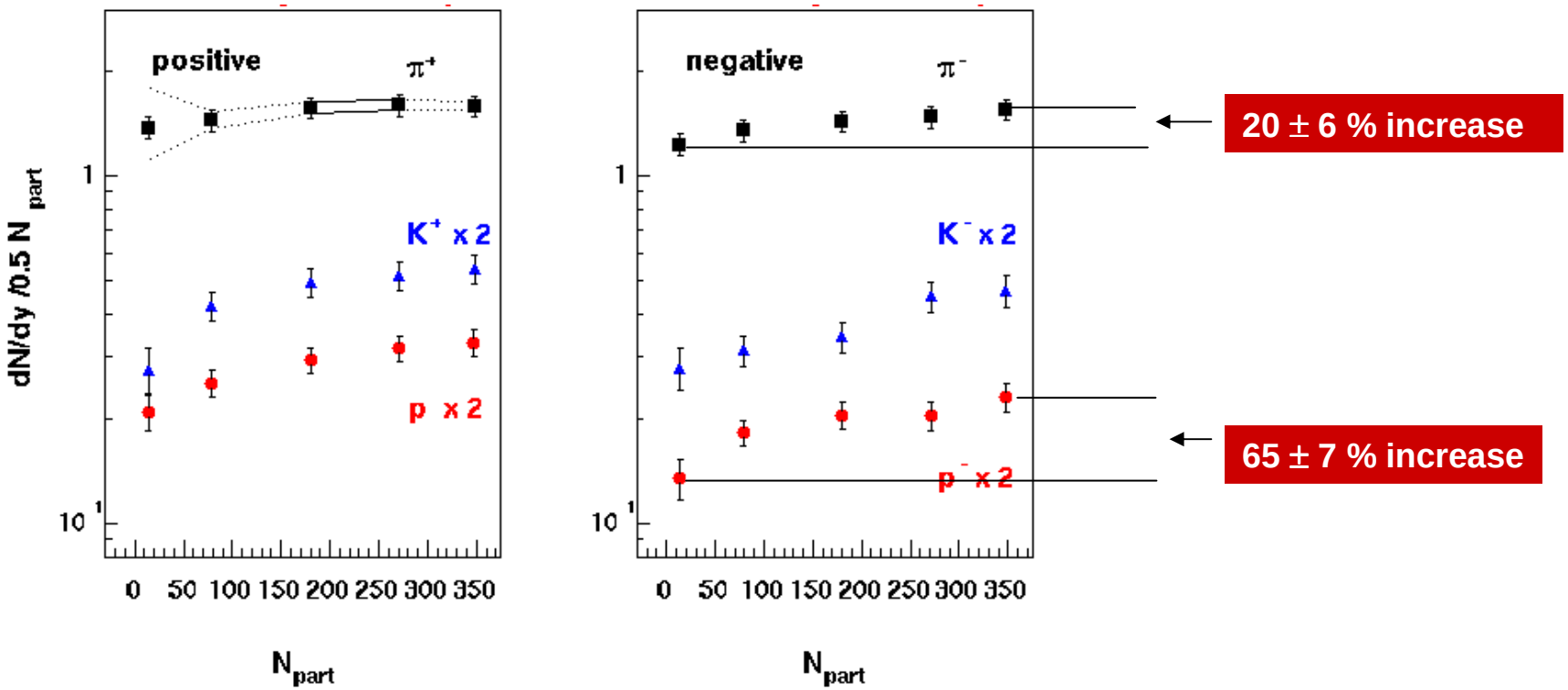


20 ± 5 % increase

* Open symbol : extrapolation form pp

- **$<p_T>$ increase with N_{part} and particle mass - consistent with radial flow.**
- **(Anti) proton $<p_T>$ significant increase from pp collisions.**
- **The same relative increase from peripheral to central for all particles species.**

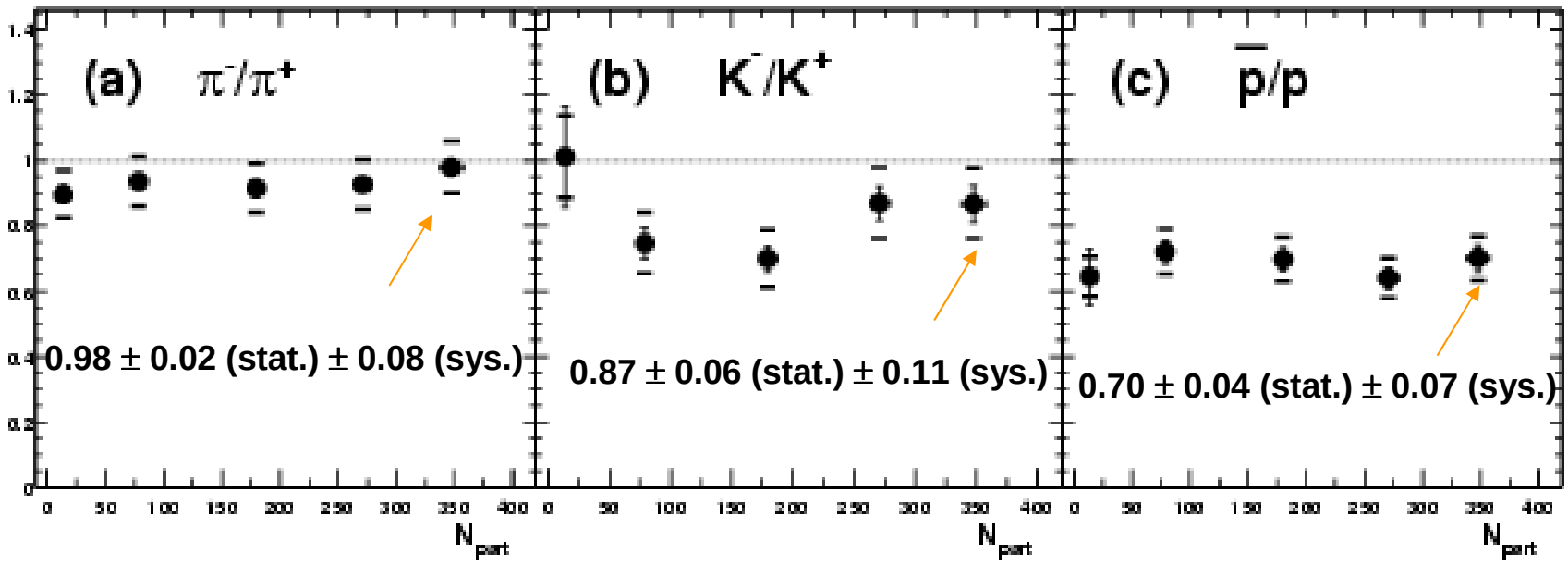
Centrality Dependence of Particle Yield



- **(Anti) proton yields per participant pair increase faster than pion yields with N_{part}.**
- **Similar behavior in K^+, K^-, π^+ and π^-.**

Particle Ratio vs. N_{part}

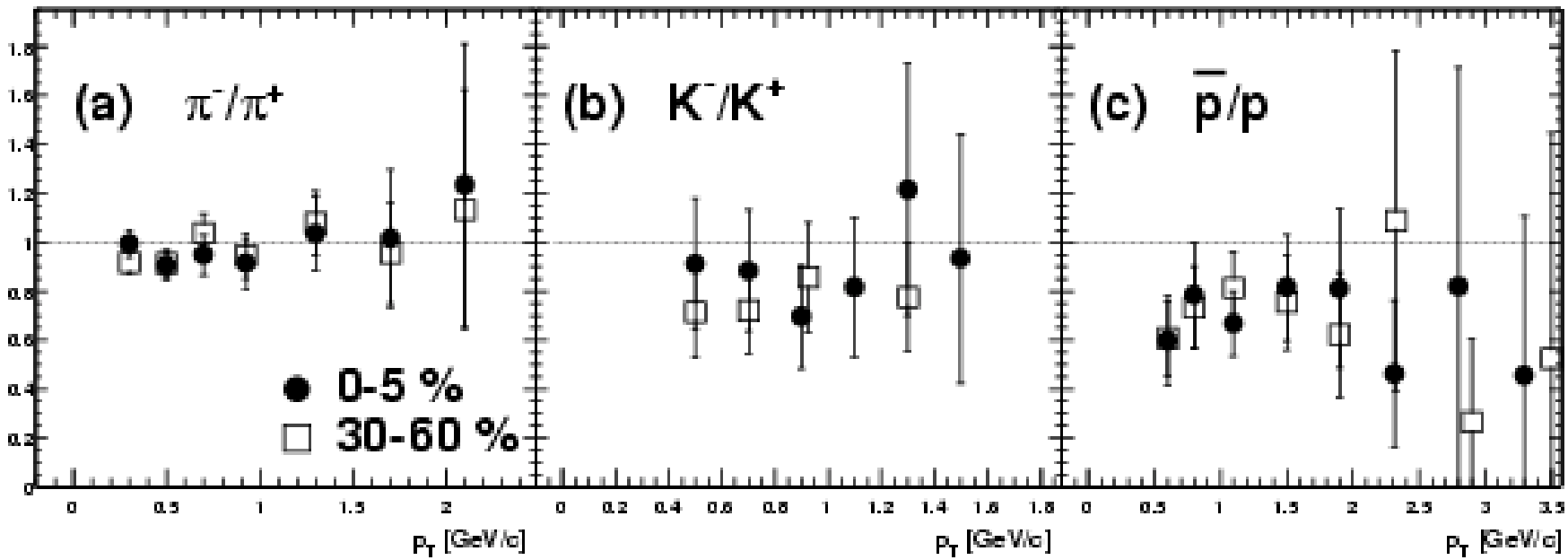
PHENIX Preliminary



- **No Centrality dependence for all (anti-particle)/ (particle) ratios.**
  ⇒ Suggest that μ_{ch} may not vary much vs. centrality.

Particle Ratio vs. p_T

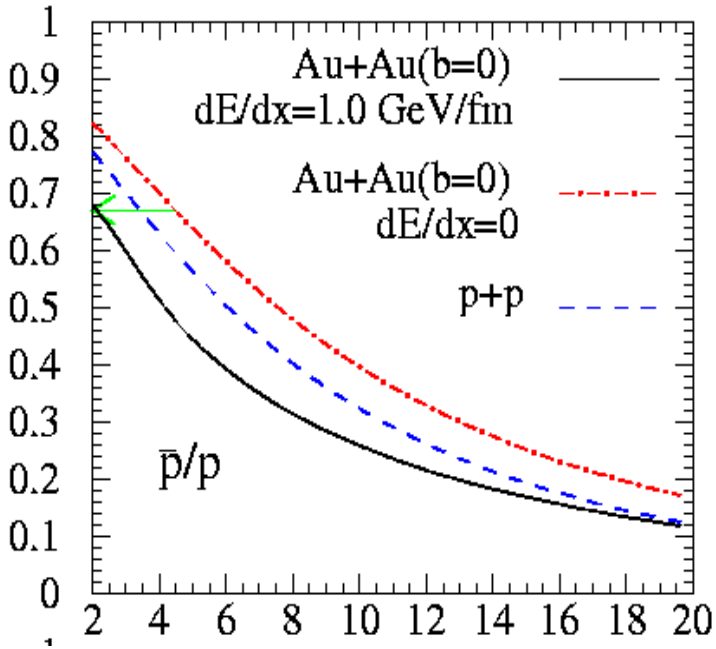
PHENIX Preliminary

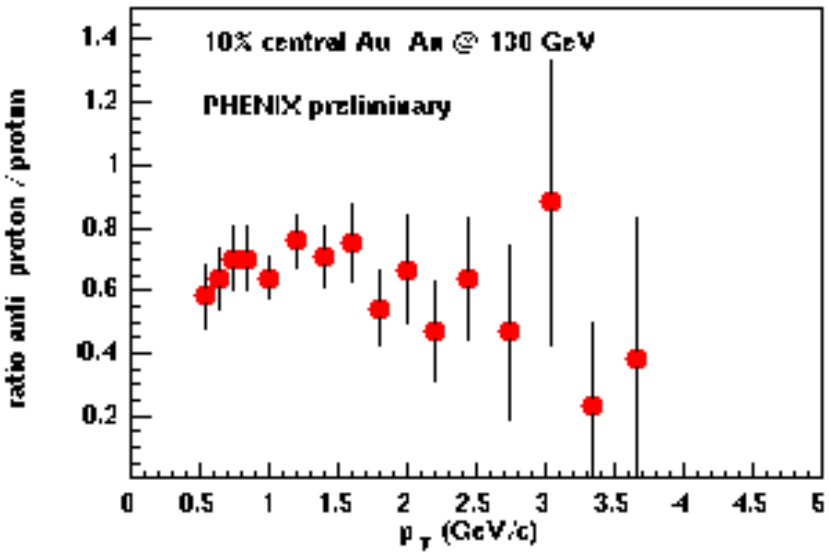


- **No p_T dependence identical particle ratios in measured p_T ranges.**
  $\Rightarrow$ Consistent with the predictions of thermal model with expanding statistical system.

$\bar{p}/p$ ratio vs. p_T

PRC 58 (1998) 2321 X.N. Wang



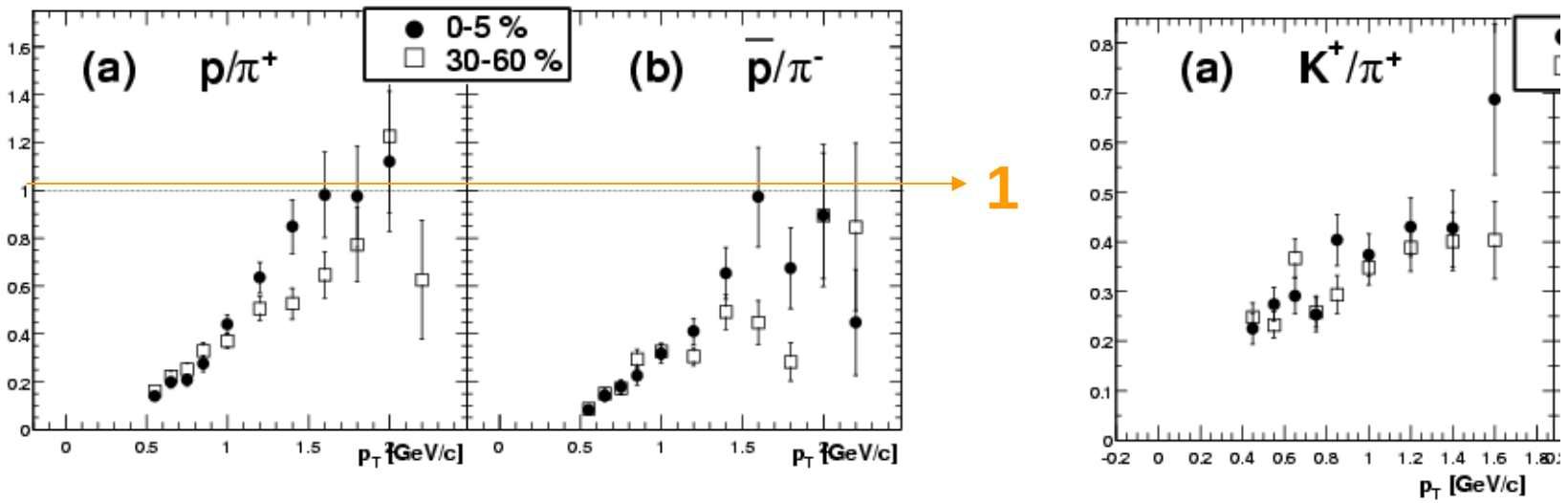


p_T [GeV/c]

- **pQCD predicts that (pbar/p) ratio falls as a function of p_T** (Hydro : flat distribution)
- Not clear @ high p_T due to the statistical limitation (> 3 GeV/c).
- Can be clarified in 200 GeV data.

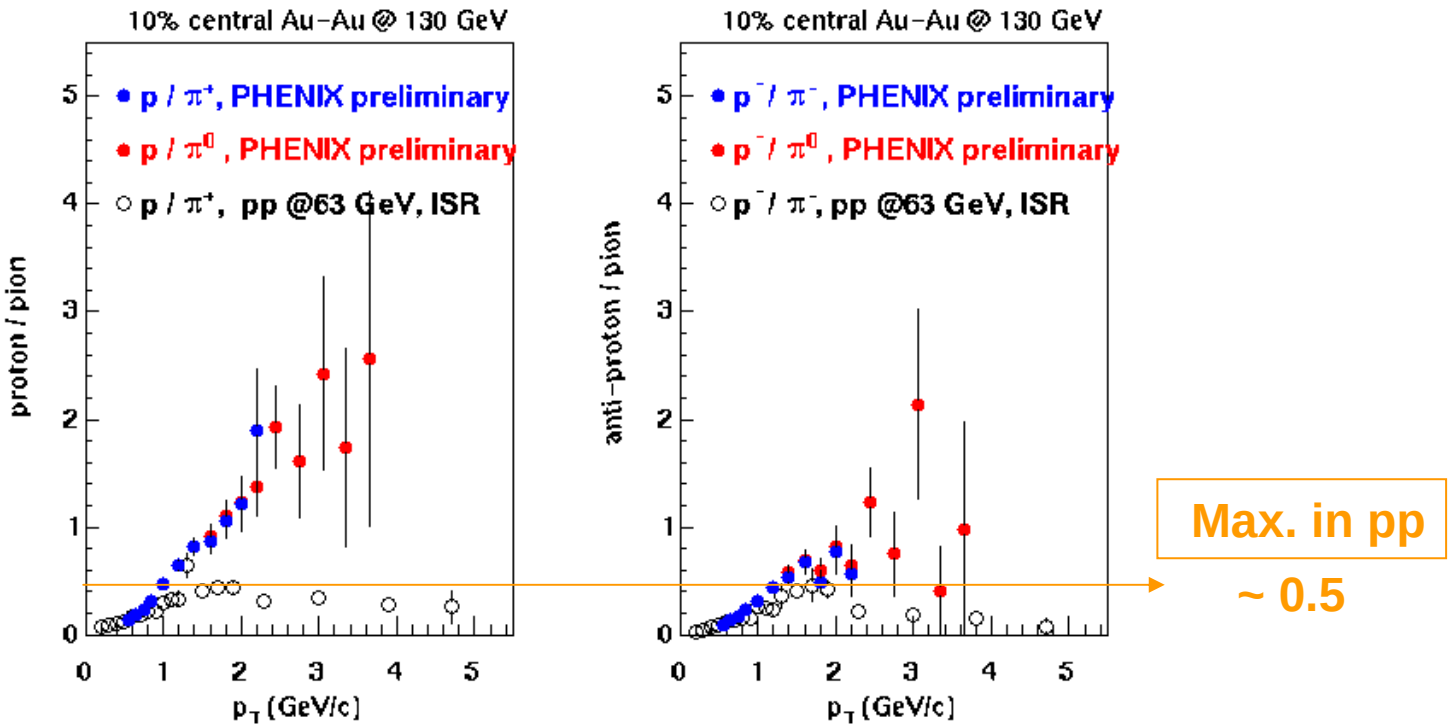
p/π and K/π ratios vs. p_T

PHENIX Preliminary



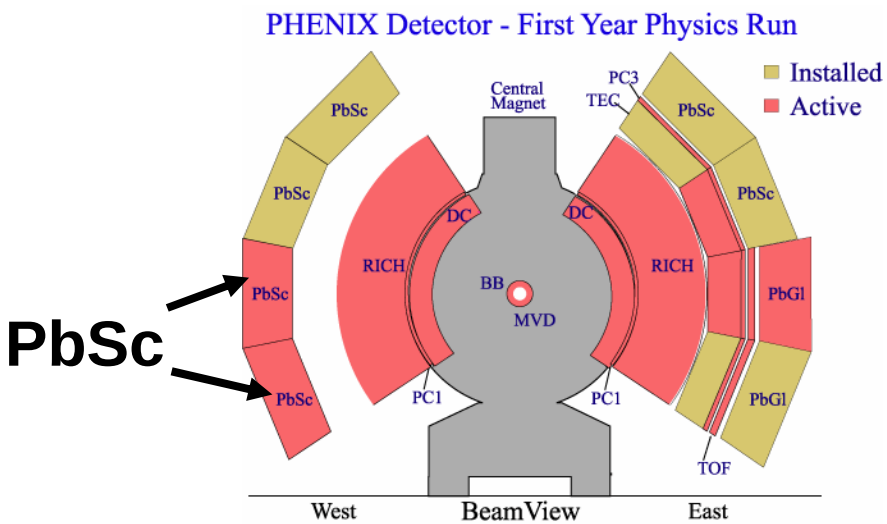
- **K/π and p/π ratios increase as a function of p_T. (K/π < p/π)**
- **Both p/π^+ and pbar/π^- ratios reach a value of unity.**

p/π ratio @ high p_T

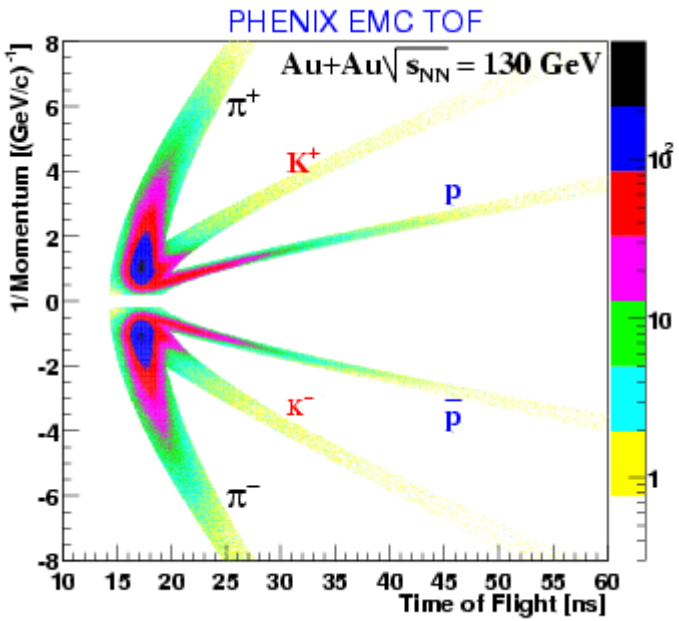


- Used the published π^0 results.
- Steady increase in p/π^0 ratio with p_T, peak *or* saturate (?) in pbar/π^0 ratio ~ 3 GeV/c.
- $(p/\pi)_{AuAu} > (p/\pi)_{pp}$: consistent with a strong expansion in AuAu

Λ Analysis

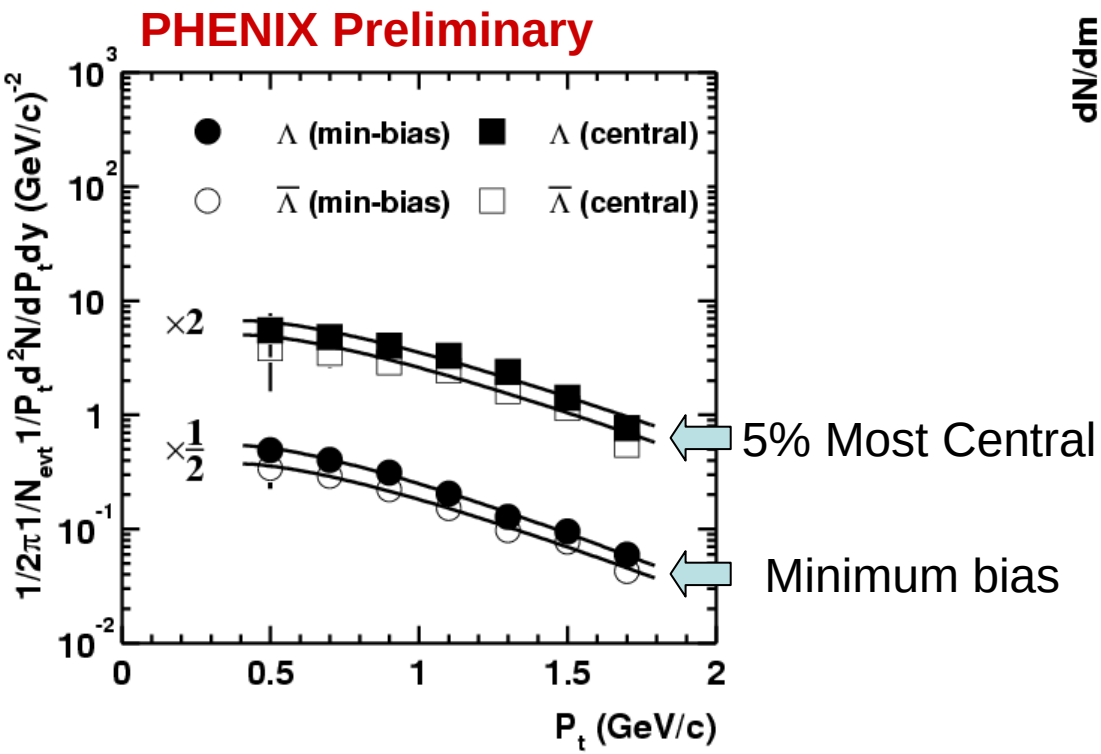


PbSc



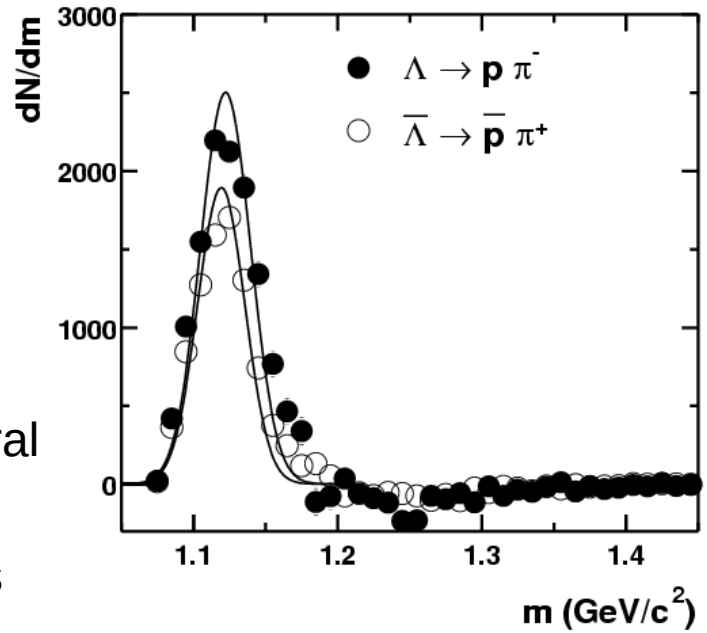
- Used 1.3 M minimum bias events with 20 cm z-vertex cut.
- BBC + DC + PC1 **+ EMC (PbSc)**
- West arm PbSc EMC-TOF (σ_{TOF} ~700 ps in Run1) for PID (2σ cut)
- Pion ID : p_T < 0.6 GeV/c, proton ID : p_T < 1.4 GeV/c
- Used combinatorial method to extract lambda.

Λ's p_T spectrum



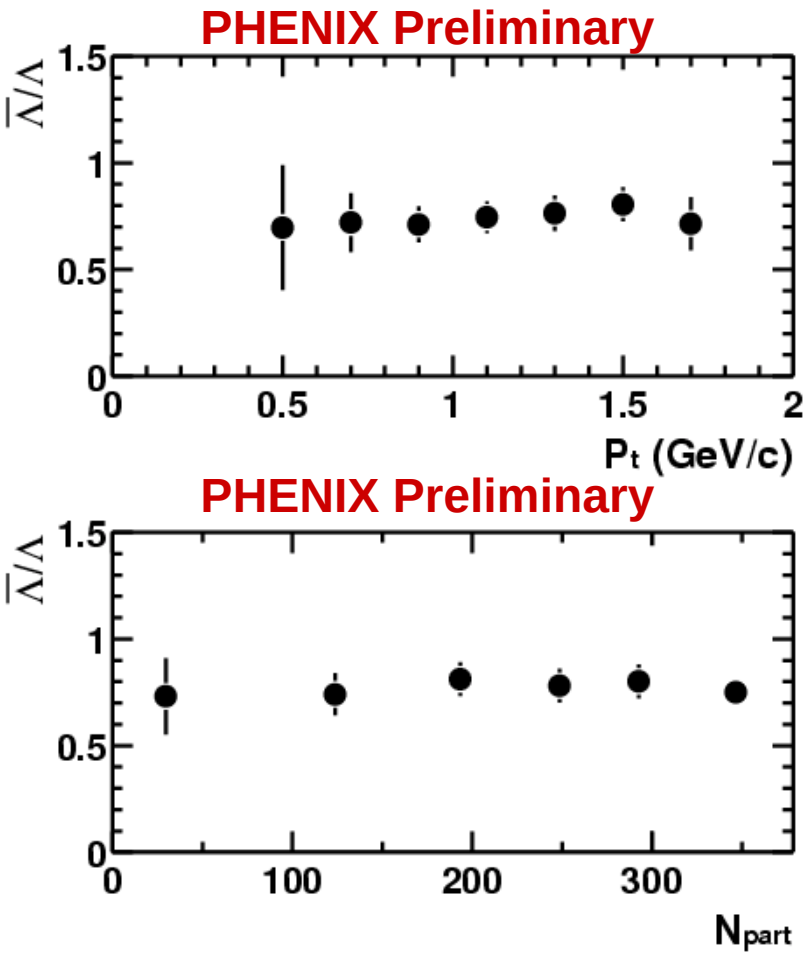
5% Most Central

Minimum bias



Well described by Boltzmann function ($0.4 < p_T < 1.8$ GeV/c) in both centrality classes.

$\overline{\Lambda}/\Lambda$ ratio vs. p_T and N_{part}



- No p_T and N_{part} dependences in anti-Λ/Λ ratio
- Averaged anti-Λ/Λ ratio : **0.75 ± 0.09**
- No p_T dependence $\Rightarrow$ Consistent with the statistical thermal model

Λ/p ratio and net baryon numbers

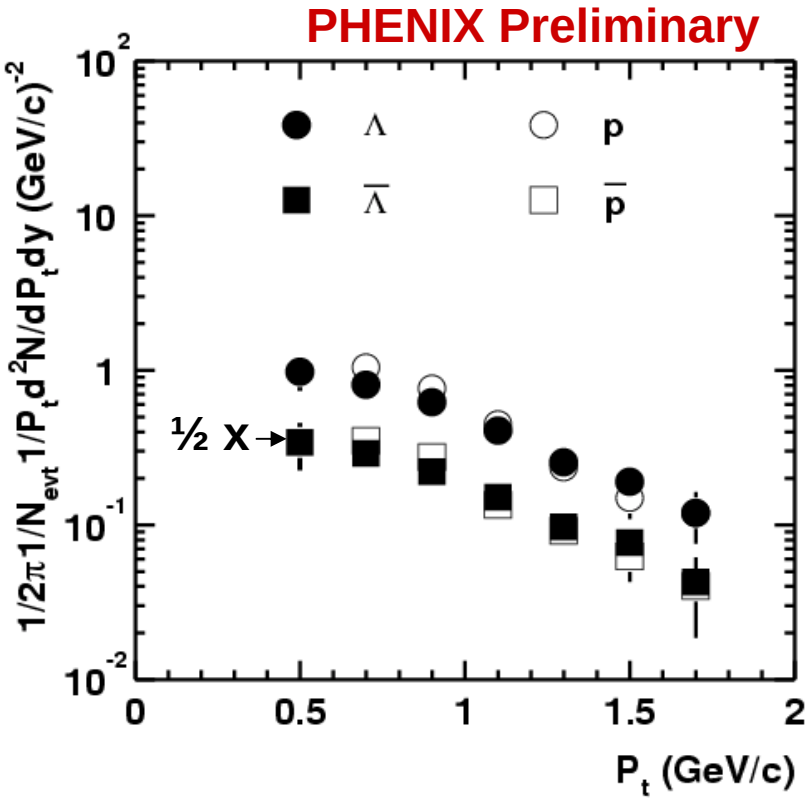
- **Corrected feed down effects from lambda in (anti-) proton spectra**

Λ/p = 0.89 ± 0.07
(anti-Λ)/(anti-proton) = 0.95 ± 0.09

Comparison with HIJING and HIJING/B

Net baryon number	Data (PHENIX, central 5%)	HIJING	HIJING/B
(Λ – anti-Λ)	4.6 ± 2.5	~1	~5
(p – anti-p)	5.6 ± 0.9	~5	~11

* Note : HIJING and HIJIN/B results @ 200 GeV

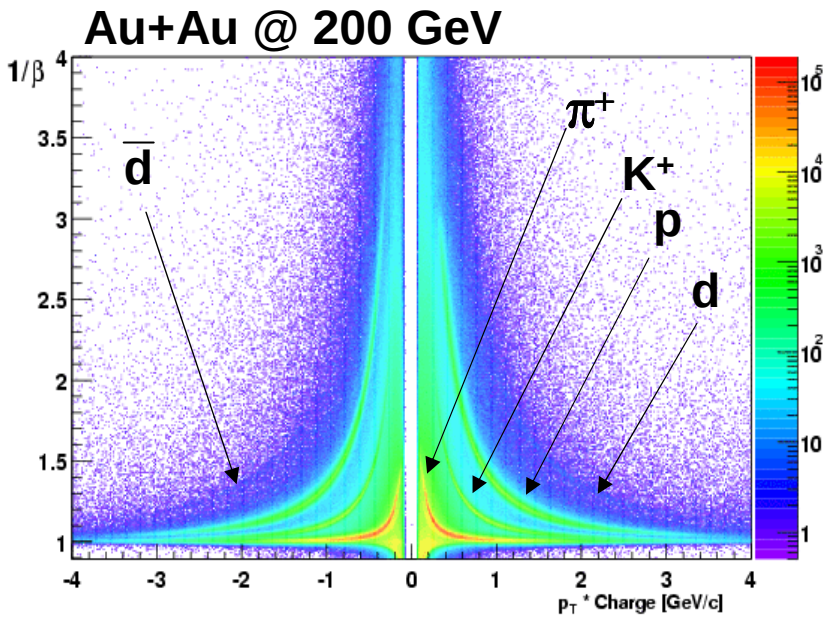


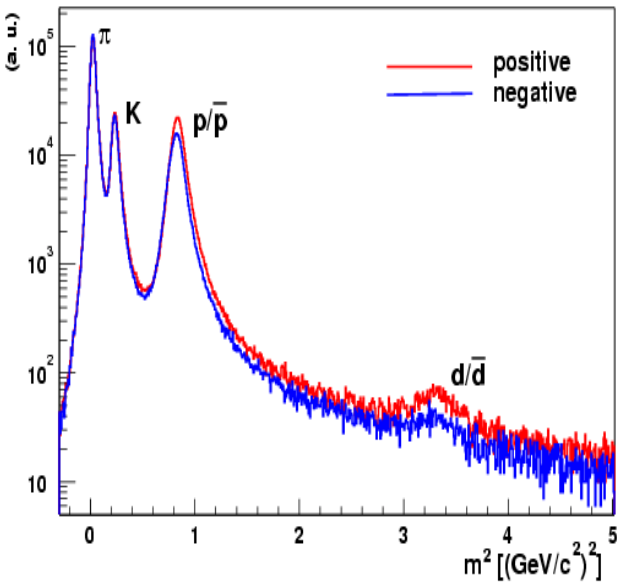
- **Well reproduced the net Λ yield by HIJING/B model (non perturbative gluon junction mechanism)**

Summary

- **We presented identified charged hadron spectra and ratios in Au+Au @ 130 GeV.**
  - Nucleons dominate mesons at ~ 1.5-2 GeV/c (π/p crossing).
  - $< p_T >$ increase with N_{part} and mass.
    $\Rightarrow$ consistent with radial flow picture
  - (Anti) proton yields per participant rise faster than pion yields with N_{part}.
  - No centrality and p_T dependence in identical particle's ratio, including anti-Λ/Λ ratio $\Rightarrow$ consistent with thermal model.
  - K/π and p/π ratio increase with p_T.
  - Measured Λ/p ratios and net baryon number (p – pbar) and (Λ – Λbar).

Status of Run2 (Au+Au 200 GeV) Analysis





- **Collected 92 million minimum bias triggered events in Au+Au at 200 GeV.**
- Analyzed 15 Million event within 30 cm z-vertex.
- π/K separation < 2 GeV/c , 2 σ K/proton separation < 4 GeV/c by TOF.
- Observed deuteron and anti-deuteron.

Outlook for 200 GeV data analysis

1. Precise measurements of p_T spectra and ratios in 200 GeV data.
2. Centrality dependence of $<p_T>$, spectra shape and yield @ high p_T.
3. Conclusion on π/p crossing (vs. centrality).
4. Conclusion on pbar/p and p/π ratio vs. p_T.
5. Comparison with pp data.
6. Deuteron and anti-deuteron spectra.

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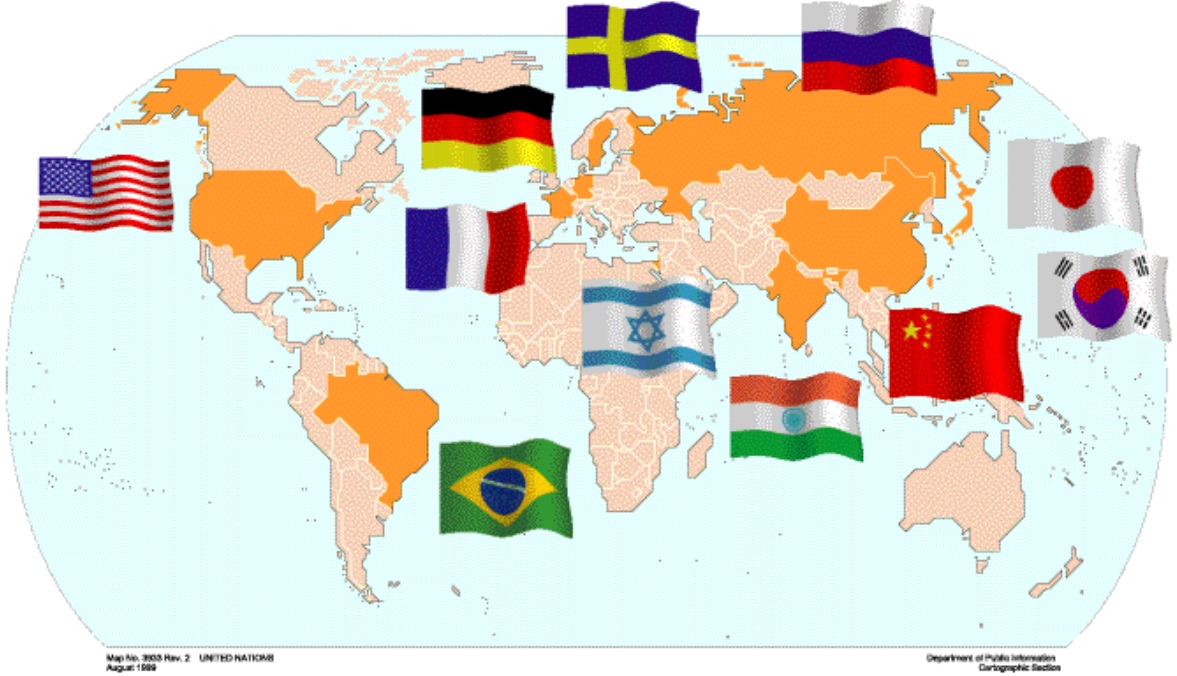

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