Identified particle spectra from pp, dA and AA collisions

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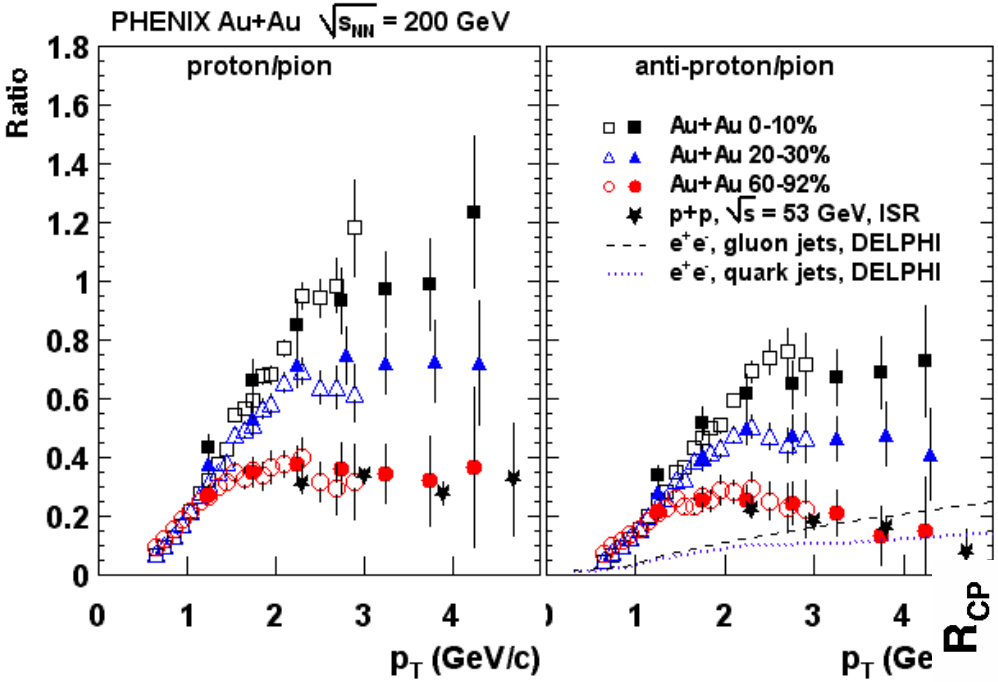
Quark Matter 2004
January 15

Outline

- **This talk focuses on:**
  - **Identified particles**
  - **Mid-rapidity**
  - **Intermediate p_T**

- **Results not covered in this talk:**
  - **PHOBOS: Important measurement at very low m_T from AuAu + broad momentum range π,K,p dAu spectra**
    - **Talk by G.Veres**
  - **BRAHMS – broad momentum range π,K,p spectra measured vs rapidity (AuAu and dAu)**
    - **Talks by D. Ourdane, Z. Yin**

Motivation: the baryon "anomaly"



Phys. Rev. Lett 91, 172301 (2003).

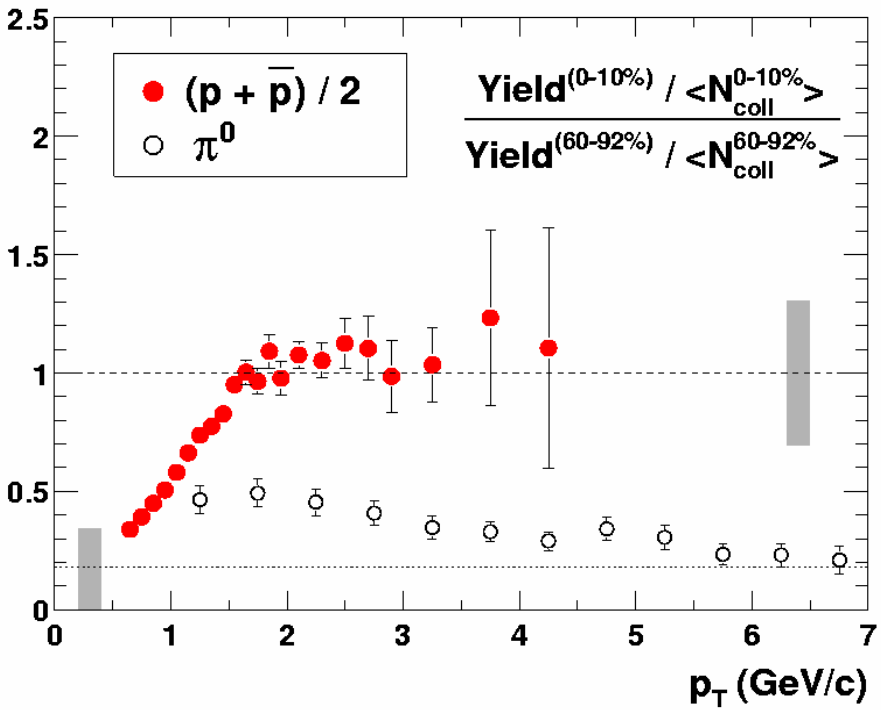
Peripheral: consistent with standard fragmentation

Central: a factor ~ 3 higher than peripheral, e^+e^- and ISR pp data

Pions are suppressed at high pT in central Au+Au collisions

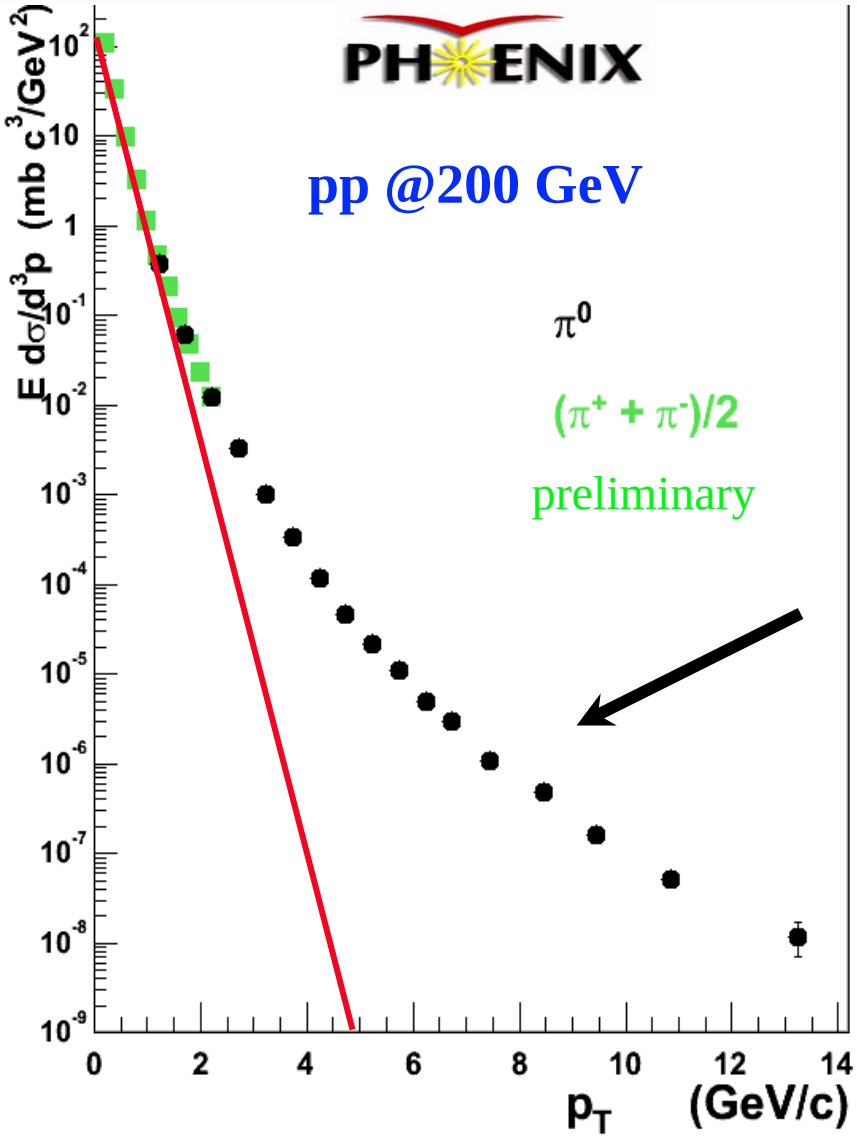
No apparent proton suppression for 2-4 GeV/c

different production mechanism ?



Start “simple”: pions in p+p collisions

soft production: exponential

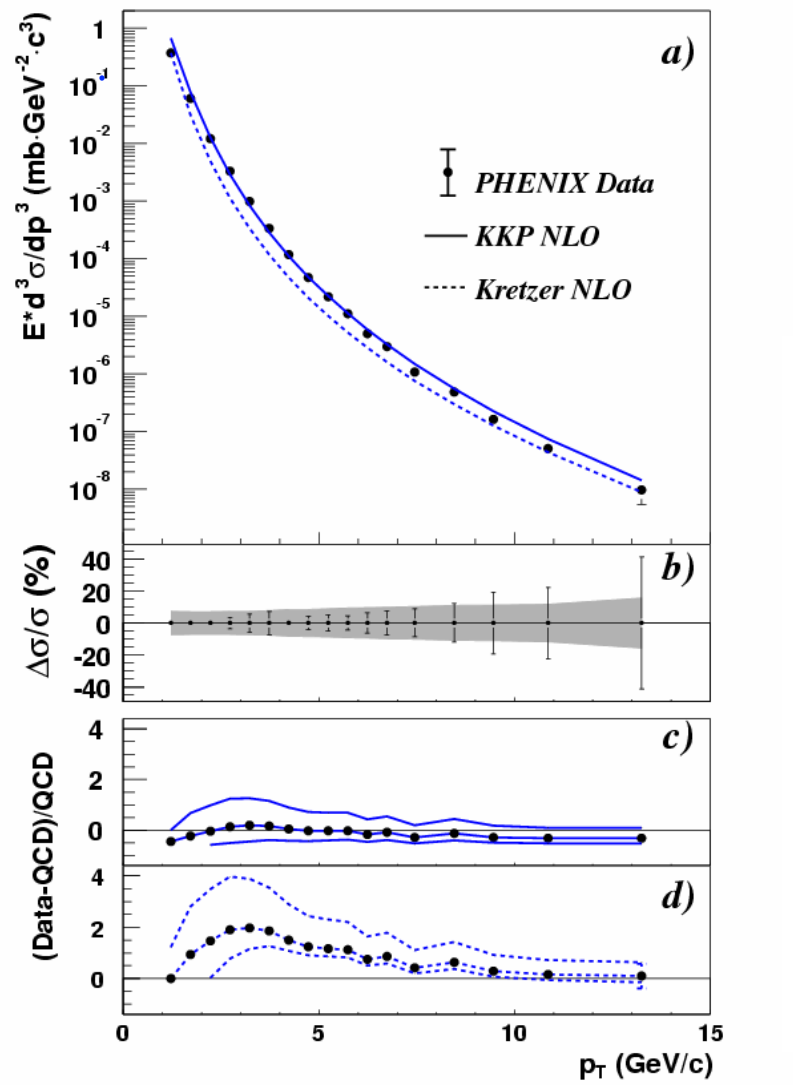


hard scattering: power-law “tail”

Charged pion data: Poster M.Harvey

pQCD description in pp

Phys. Rev. Lett. 91, 241803 (2003)

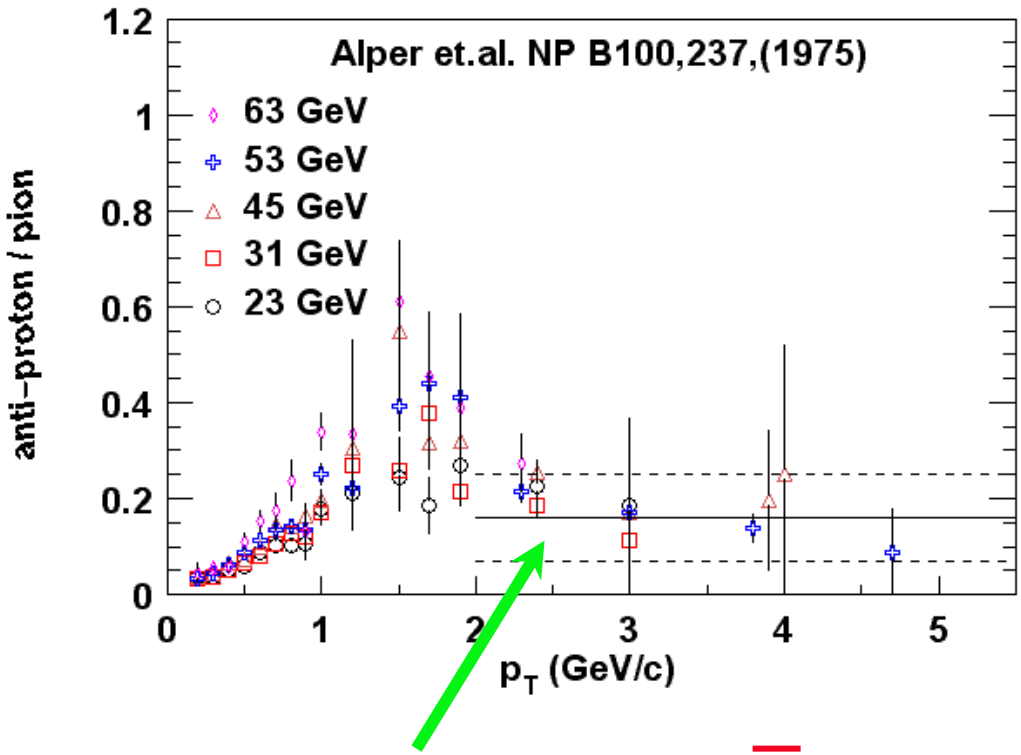


pQCD calculations work

Note:

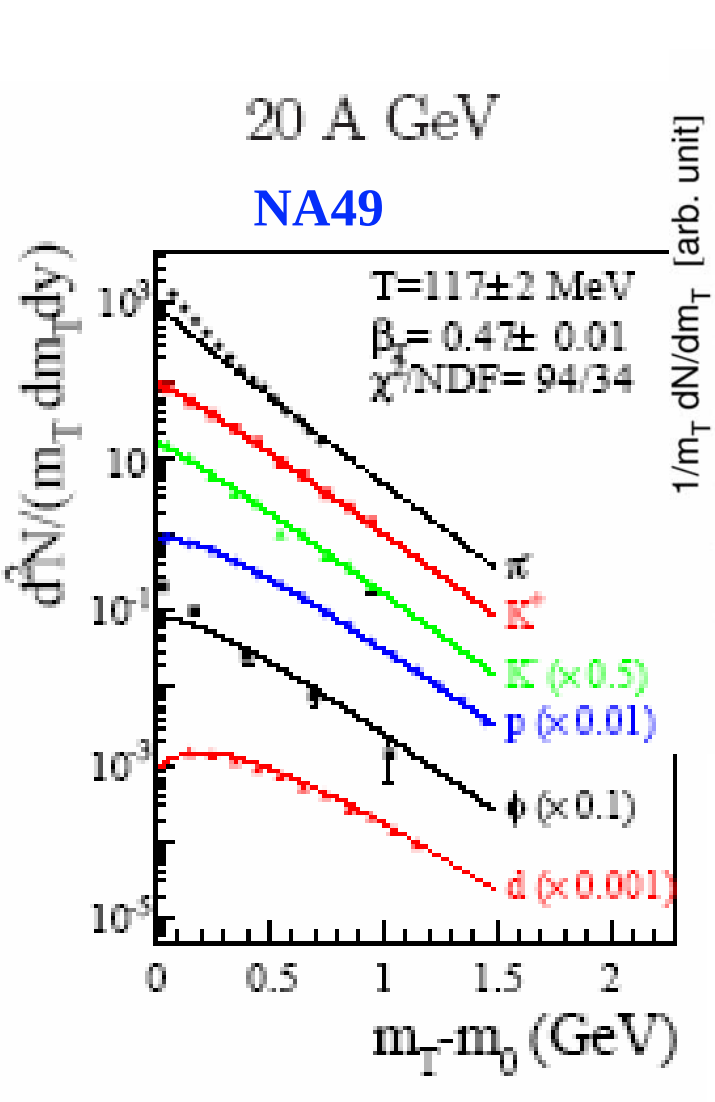
fragmentation function

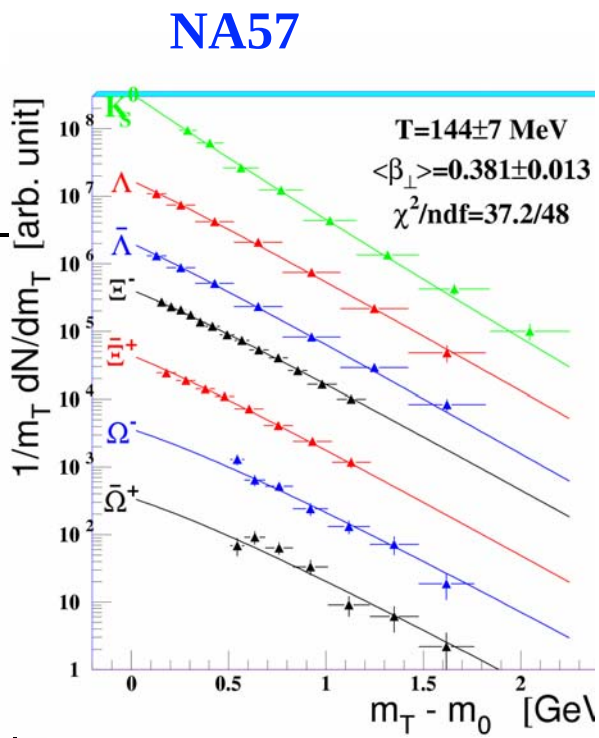
input from experiment

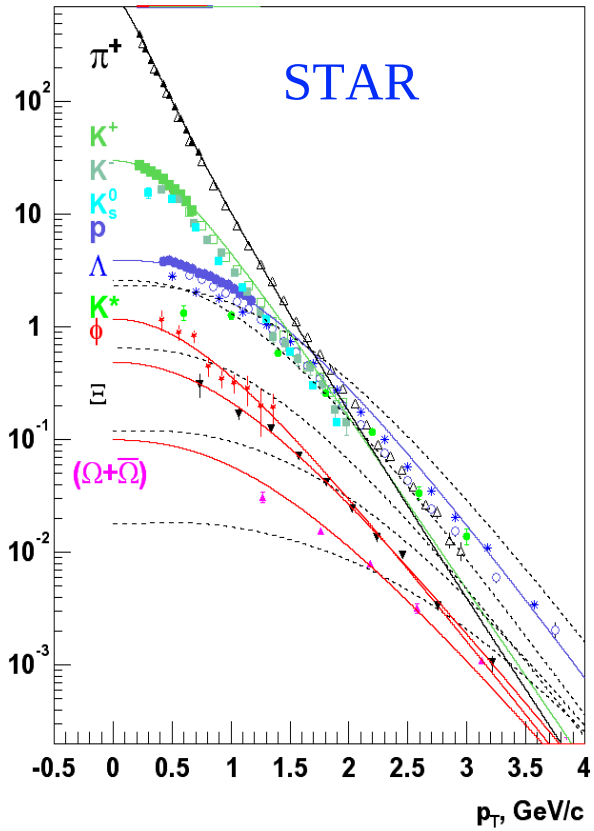


Soft to hard transition in $\bar{p}/\pi$ ratio

Nuclear modifications: Soft physics







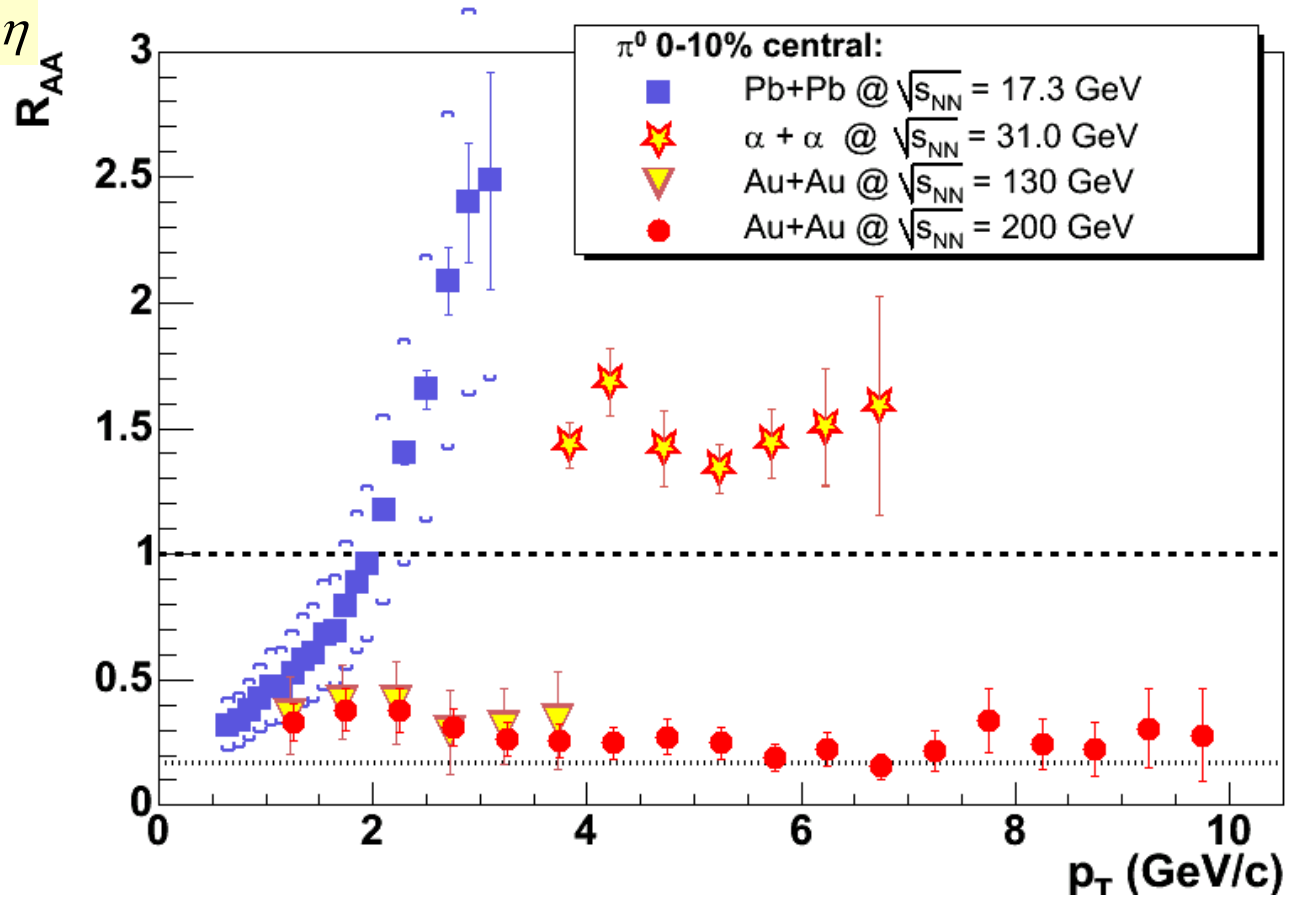
Collective radial flow described by hydrodynamics from 20AGeV PbPb to top RHIC energy

Nuclear modifications to hard scattering

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

Large Cronin effect at SPS and ISR

Suppression at RHIC

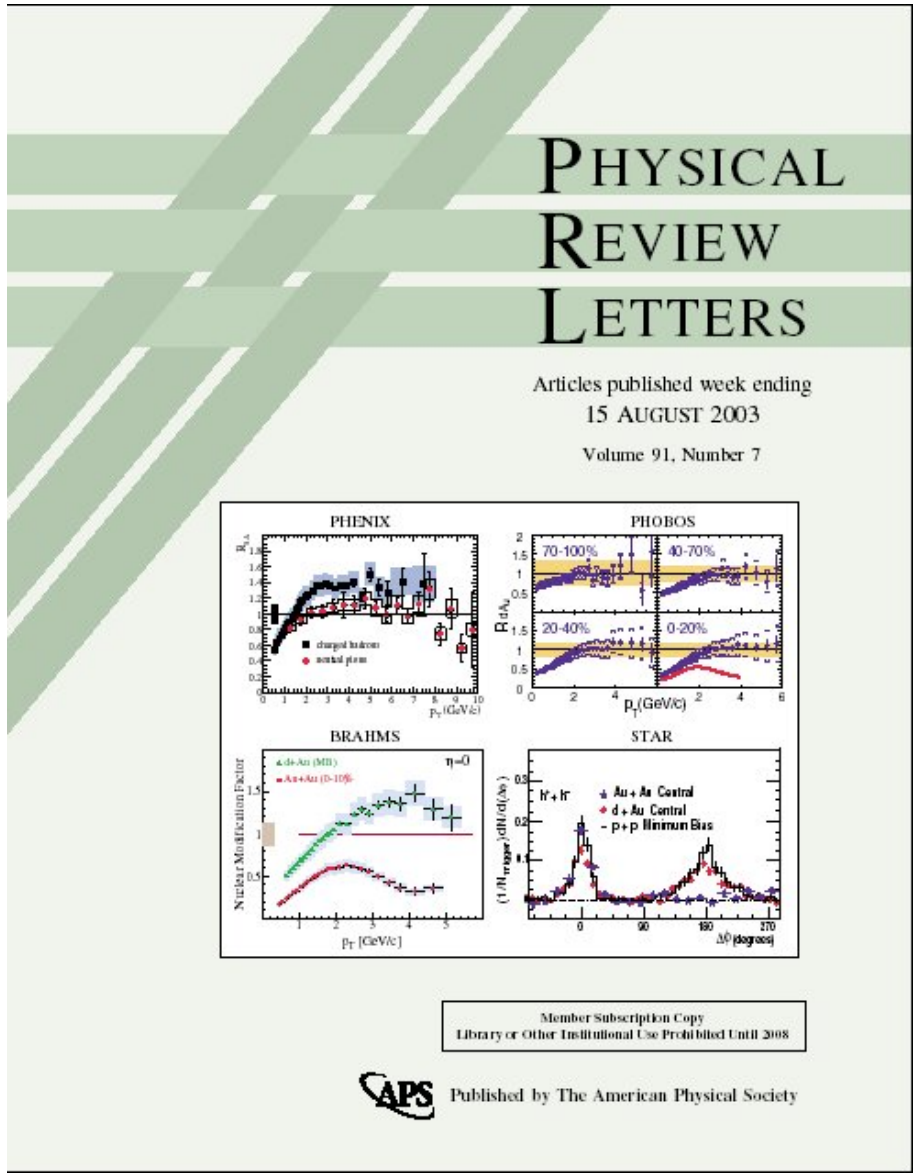


Is the suppression due to the medium? (initial or final state effect?)

The null result on the cover of PRL: dAu

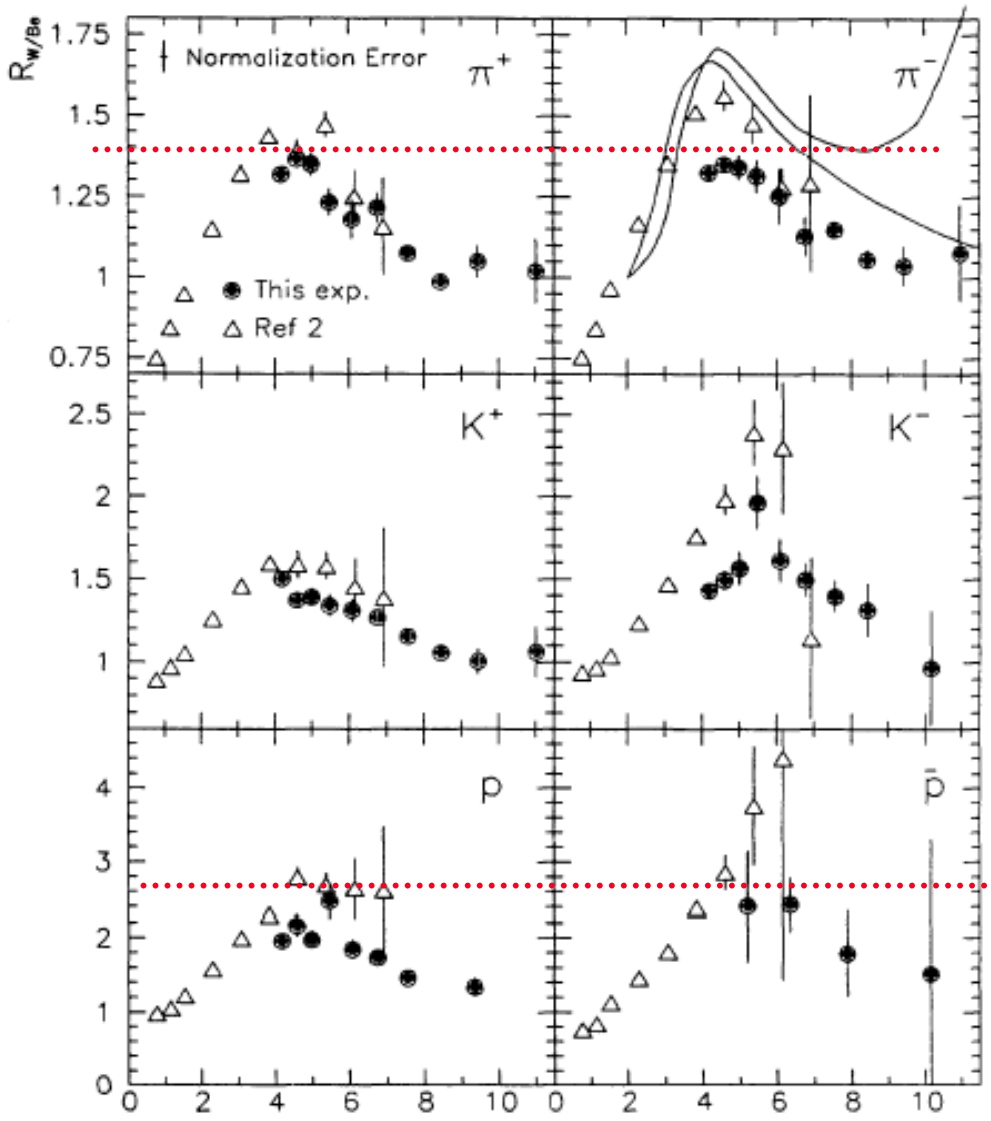
The suppression of hadrons at mid-rapidity is due to the medium produced in the collisions.

(final state)



But what happens to the protons ?

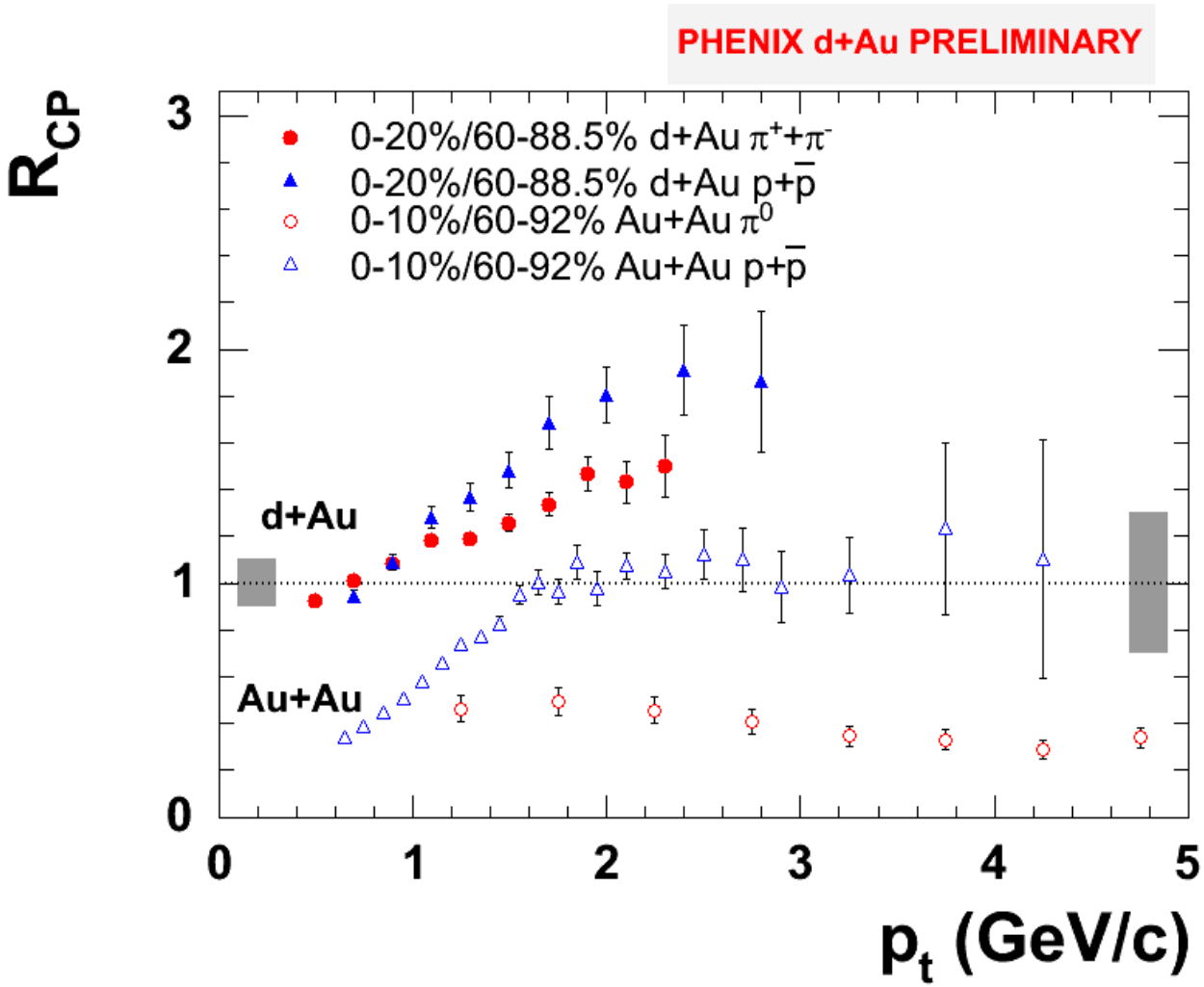
- **Can Cronin effect produce the enhanced p/π ratio in AuAu ?**
- **What is Cronin effect? Theorists seem to agree:**
  - **"Initial state multiple scattering leading to pt broadening."**
- **Why is it different for protons and pions ?**
  - **"Nobody really knows."**



P.B. Straub et al., PRL 68 (1992)
FNAL experiments measuring R (W / Be)
for identified particles at sqrt(s) of 27.4 and 51.3 GeV.

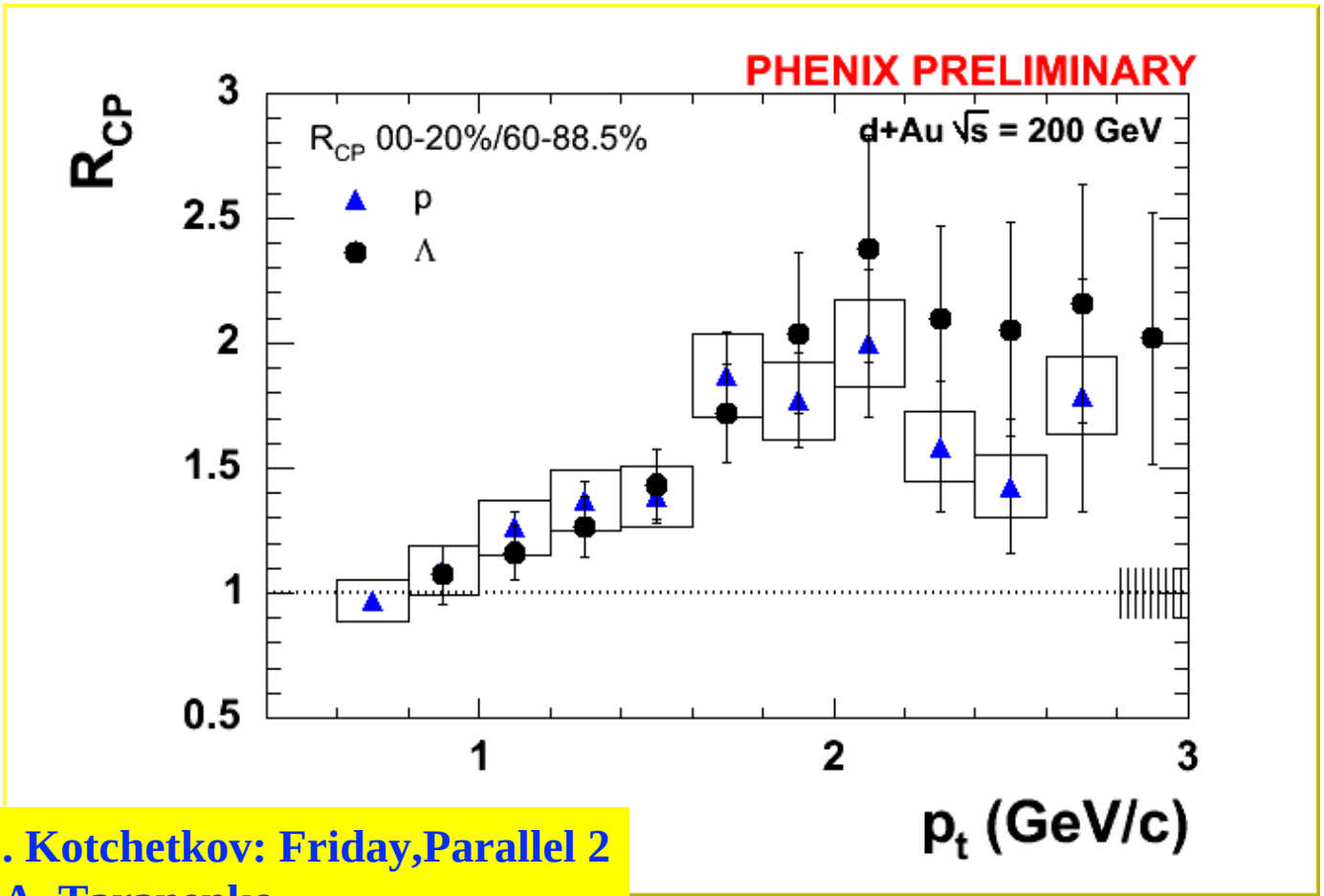
Cronin effect for protons and pions

- **Protons exhibit stronger Cronin enhancement**
- **Not enough to account for factor of 3 increase of p/π in central AuAu**



Does strangeness “matter” ?

- **Does Cronin enhancement depend on strangeness content ? Compare p and Λ.**



Talk: D. Kotchetkov: Friday,Parallel 2
Poster: A. Taranenko

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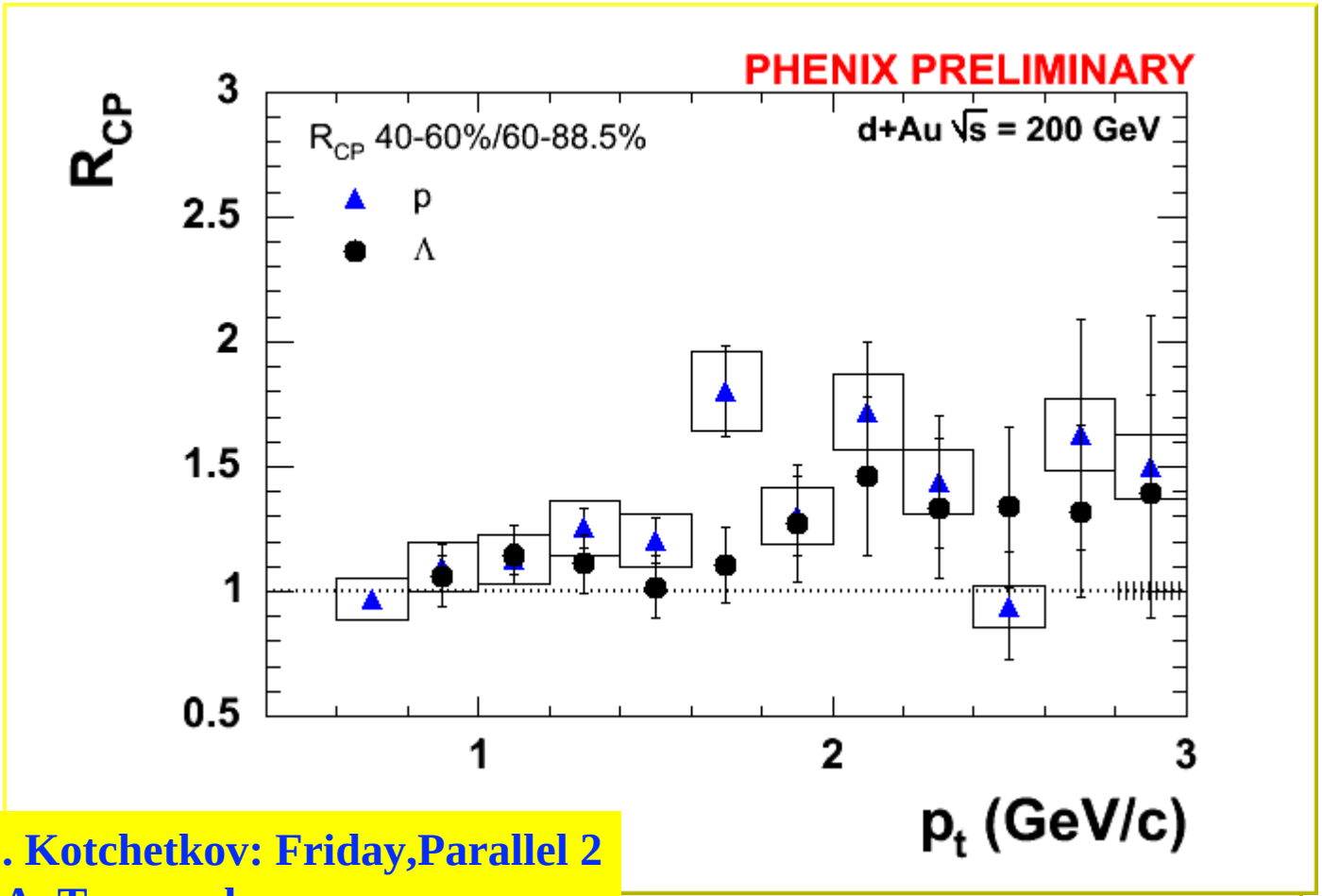

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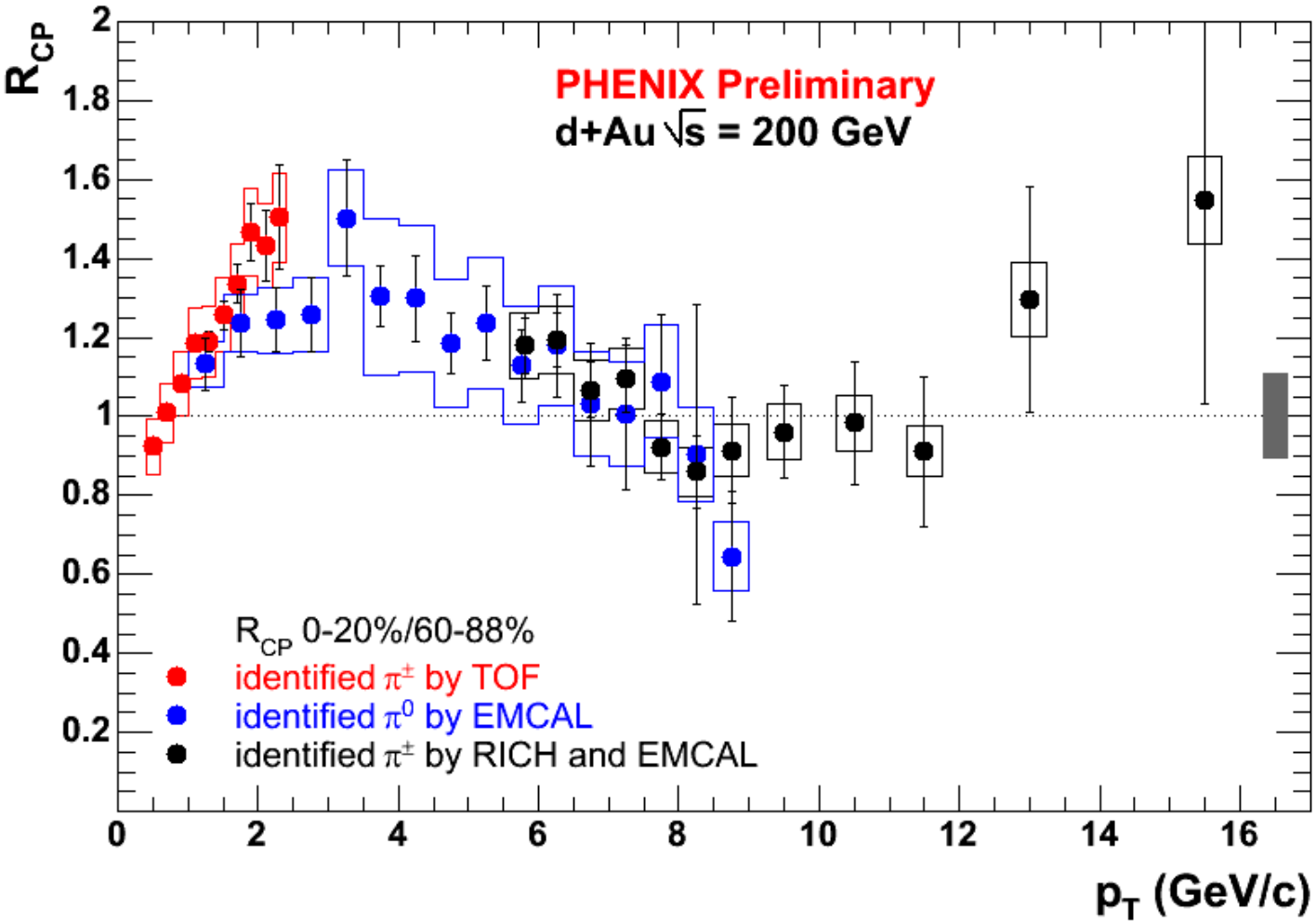
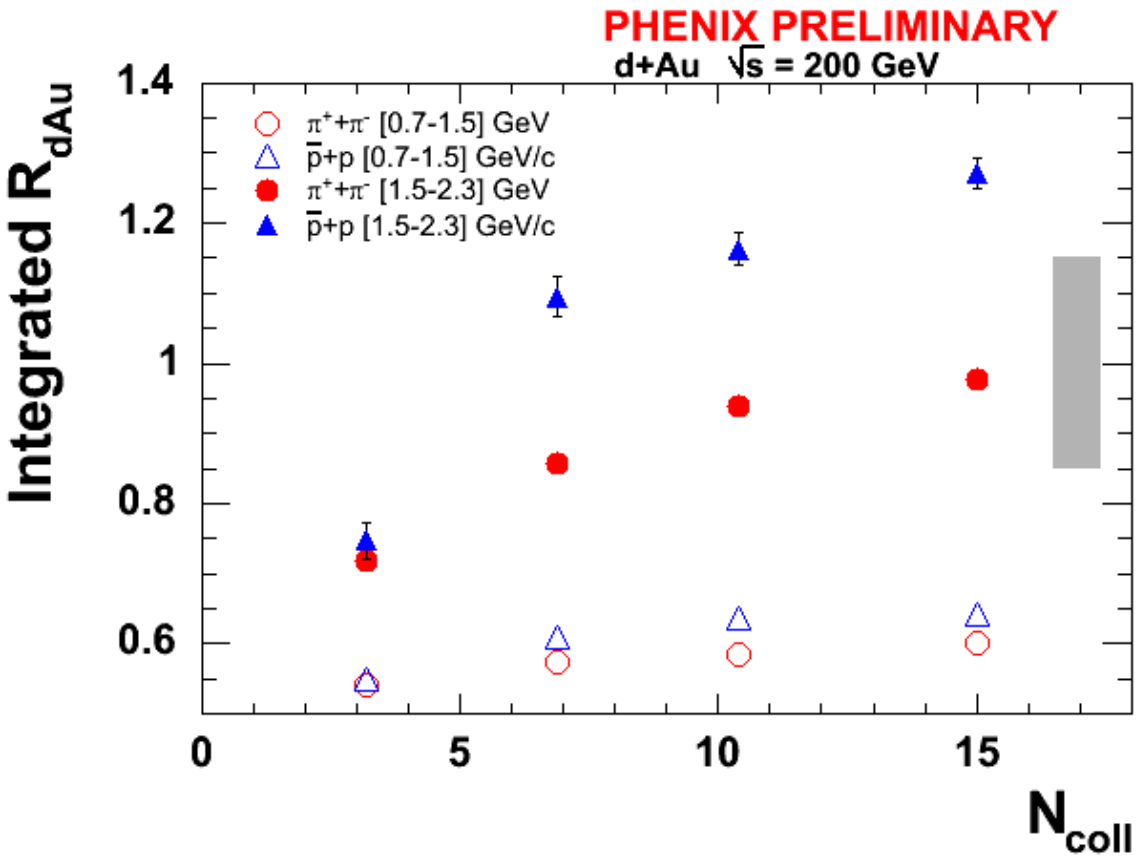
Cronin effect for pions at high pt

- **The effect disappears at high pt**



Poster by J.Jia

Centrality dependence of Cronin effect



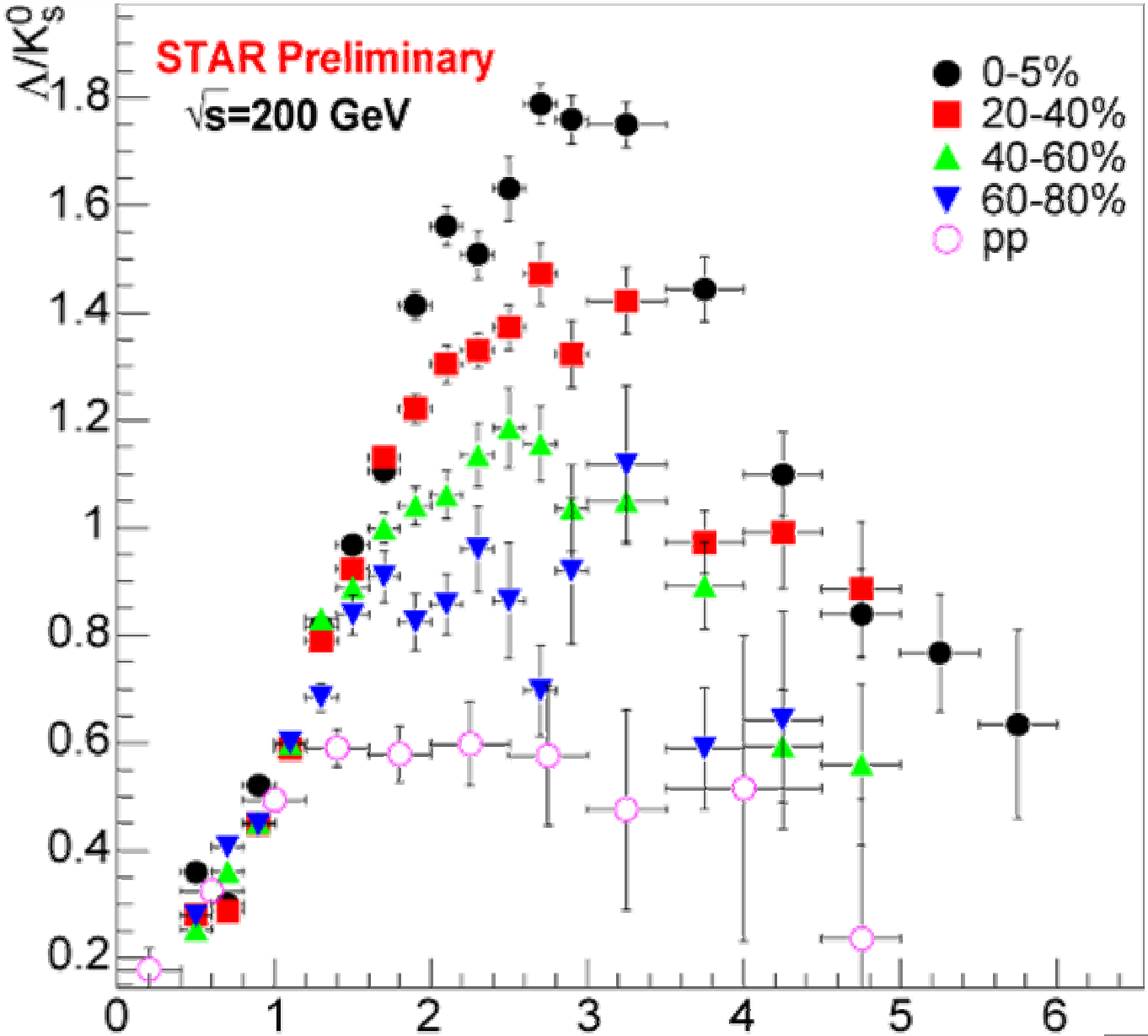
- **Similar centrality dependence for all particle species**
- **Enhancement grows with Ncoll and tends to saturate**
  - **See Talk by Felix Mathatias : Parallel 1,Thursday**

Cronin effect summary

- **Mass dependence:**
  - **$\pi < p \sim \Lambda$**
  - **or is it baryon/meson ?**
- **Flavor depdendence:**
  - **Does not depend on strangeness content: $p \sim \Lambda$**
- **Centrality dependence:**
  - **Increases with Ncoll**
  - **Tends to saturate**
- **Pt depdendence:**
  - **Limited to pt <8 GeV/c**
- **Seems insufficient to explain the mid-pt baryon enhancement in AuAu**

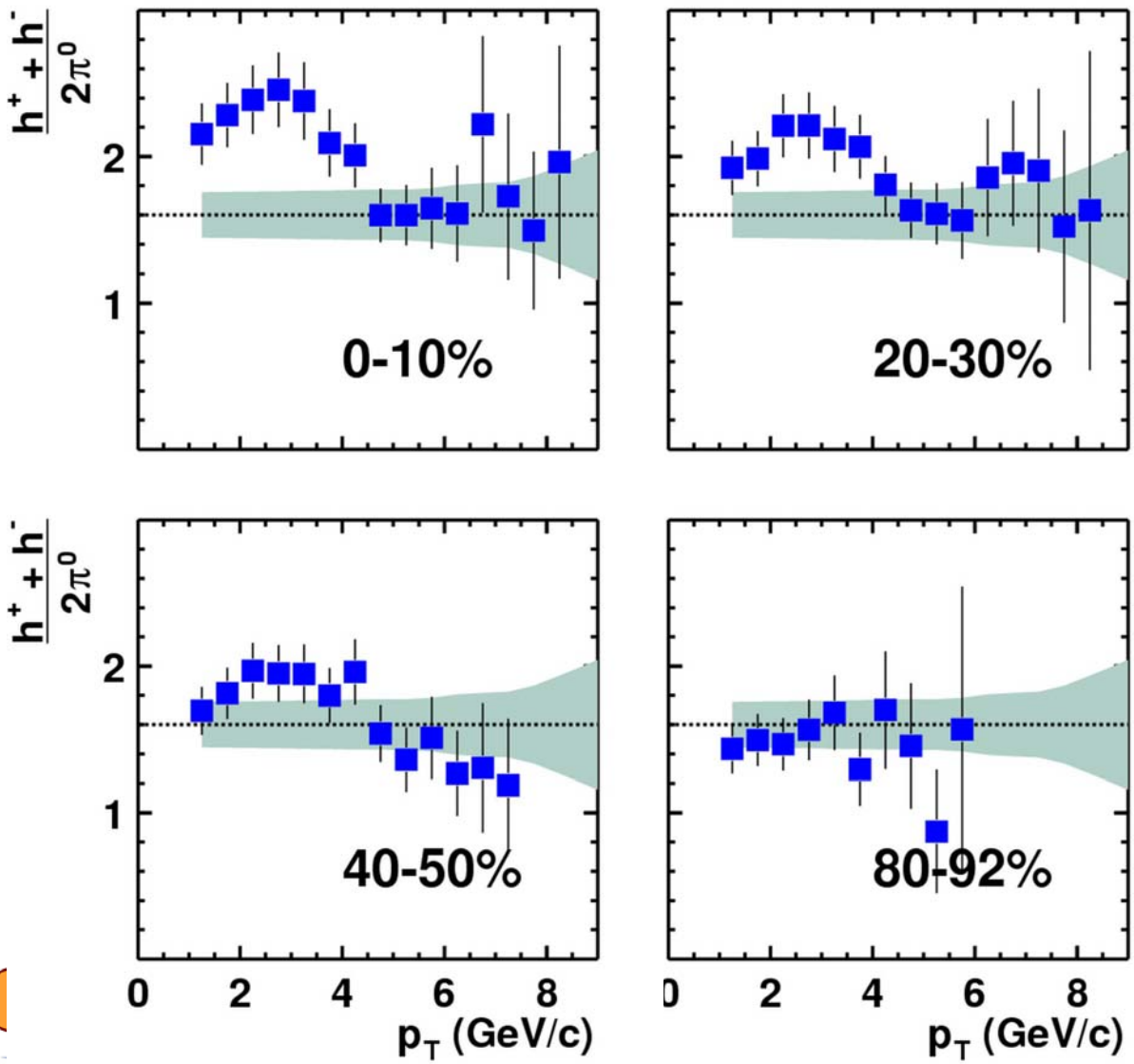
Strange baryon/meson ratios

- The mid-pT anomaly not unique to p/π
- Λ/K^0_s has a peak at ~ 3GeV/c
- Height depends on centrality
- Peripheral – above pp data



The proton "bump" in the h/π ratios

Au+Au @ 200AGeV



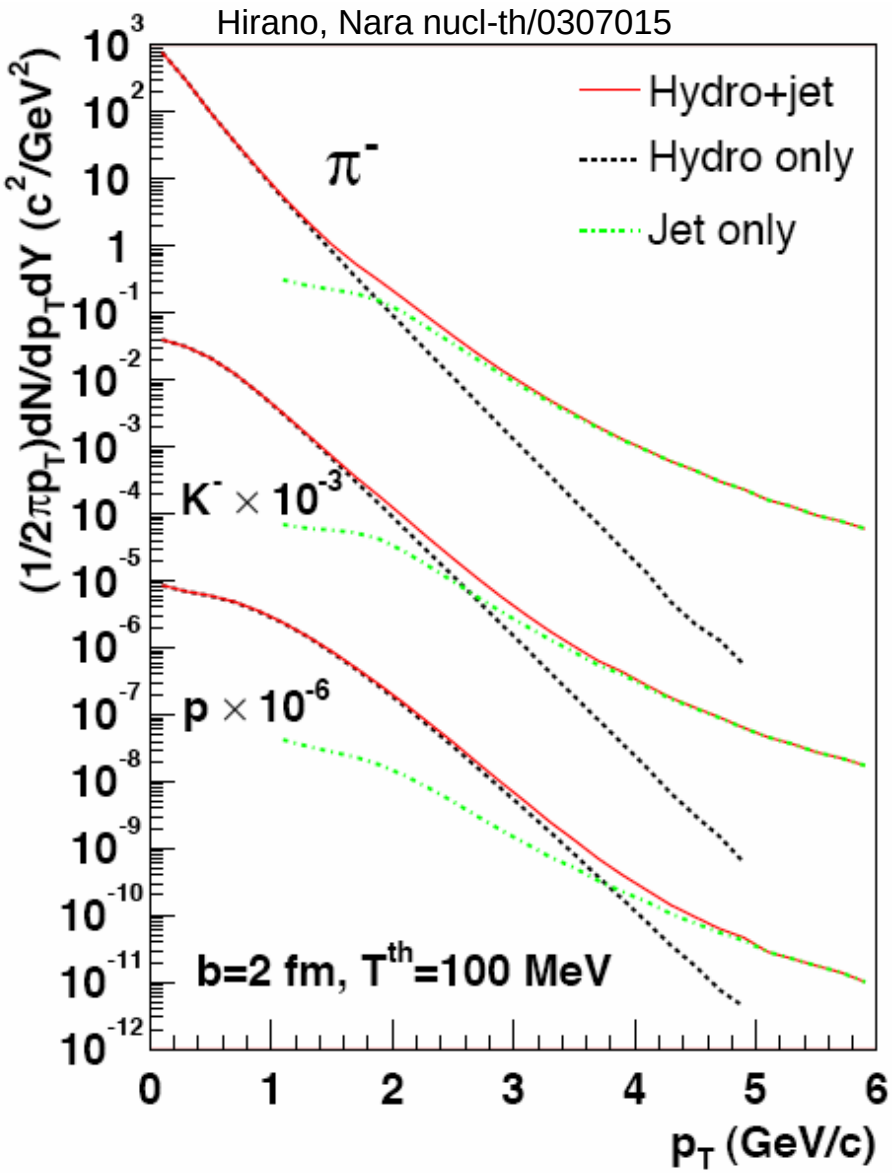
Expectation (pp, e^+e^-):

$h/\pi \approx 1.6$

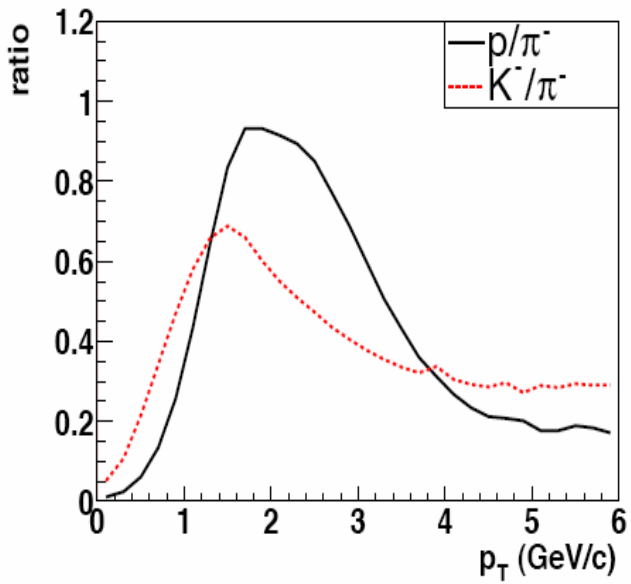
Above 5 GeV/c and in peripheral collisions: recover standard fragmentation

Talk: C.Klein-Boesing

Hydro + Jet Model

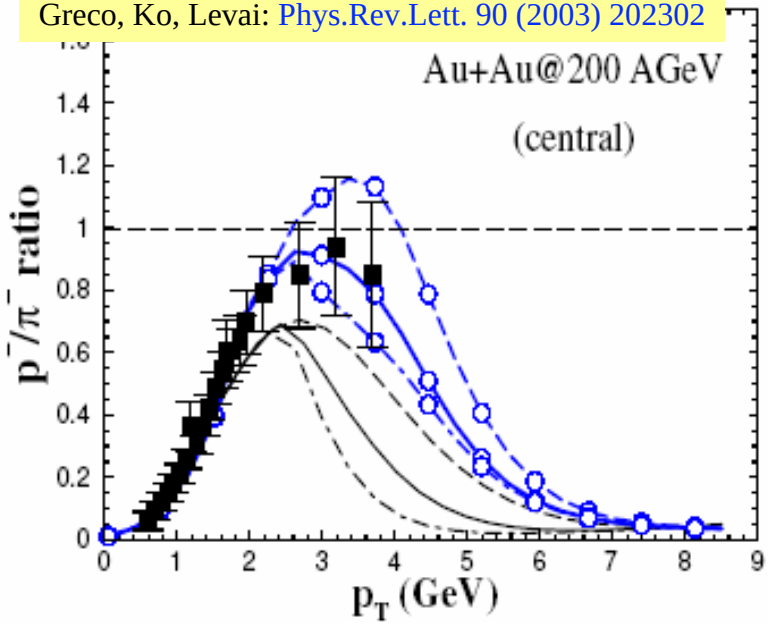


- Hydrodynamics can describe the spectra up to ~ 2 GeV/c.
- **Jet contributions > 2 GeV/c.**
- Needed detailed comparison with data (e.g. centrality dependence) .
- **Proton enhancement (with respect to the pions) is a mass effect.**



Coalescence/recombination models

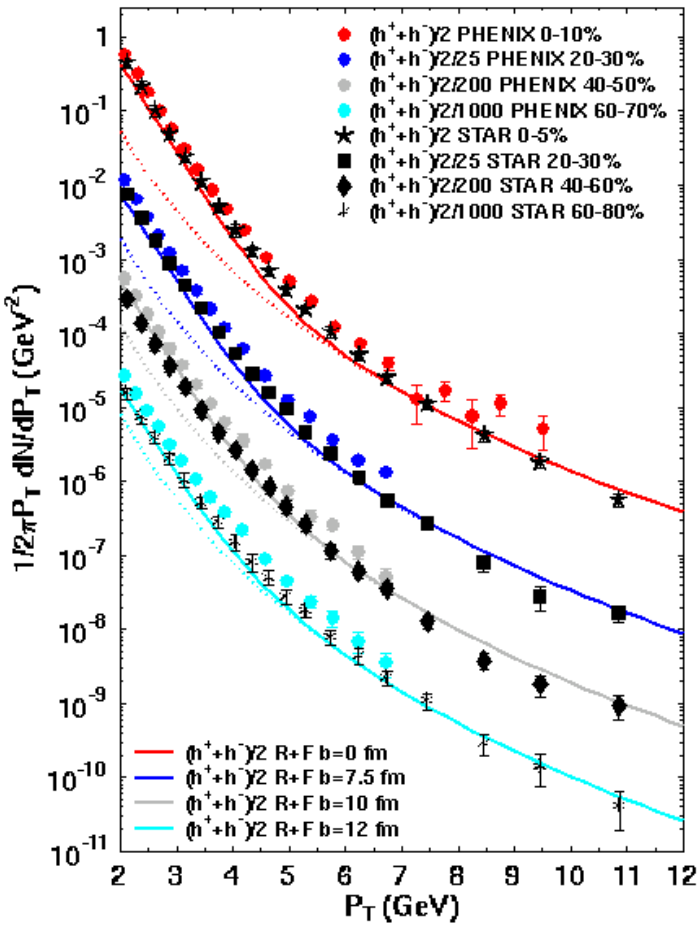
Greco, Ko, Levai: Phys.Rev.Lett. 90 (2003) 202302



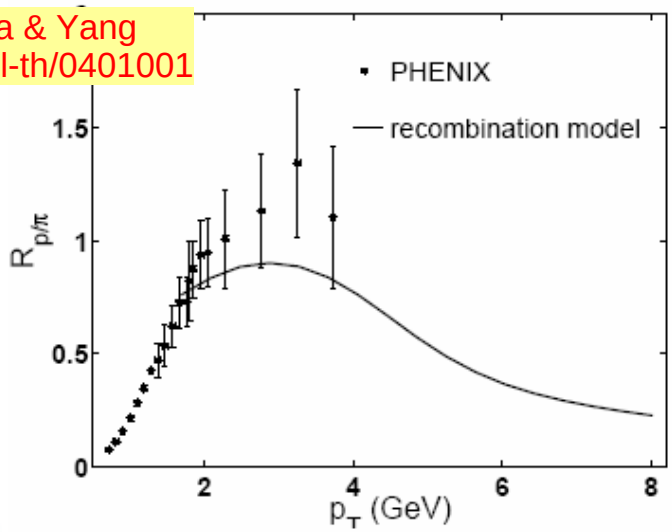
- describe particle ratios and spectra:

- **p_T(baryons) >p_T(mesons)>p_T(quarks)**

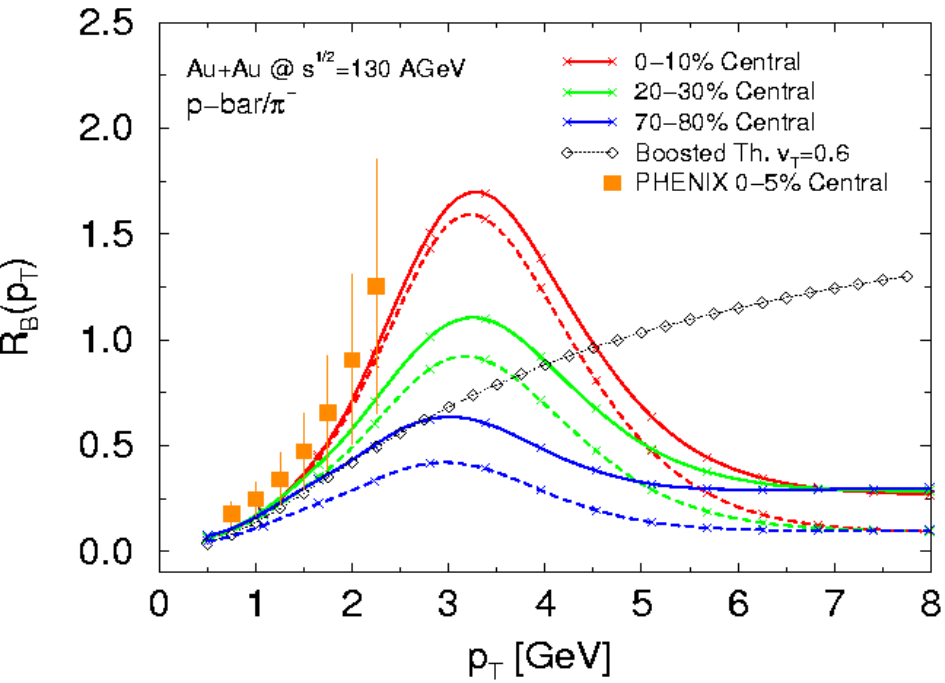
Fries et al: Phys.Rev. C68 (2003) 044902



Hwa & Yang
nucl-th/0401001

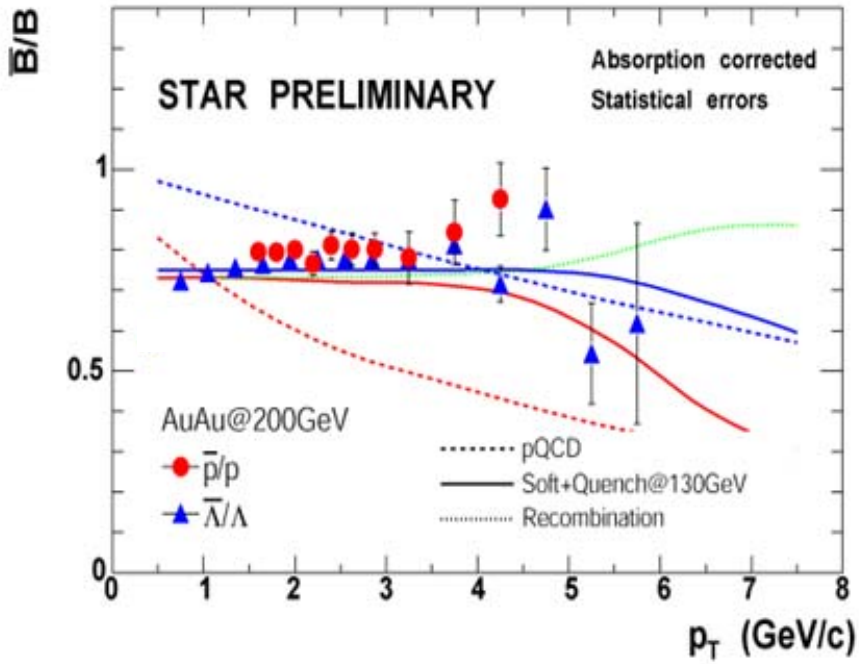


Another non-perturbative mechanism: Baryon junctions



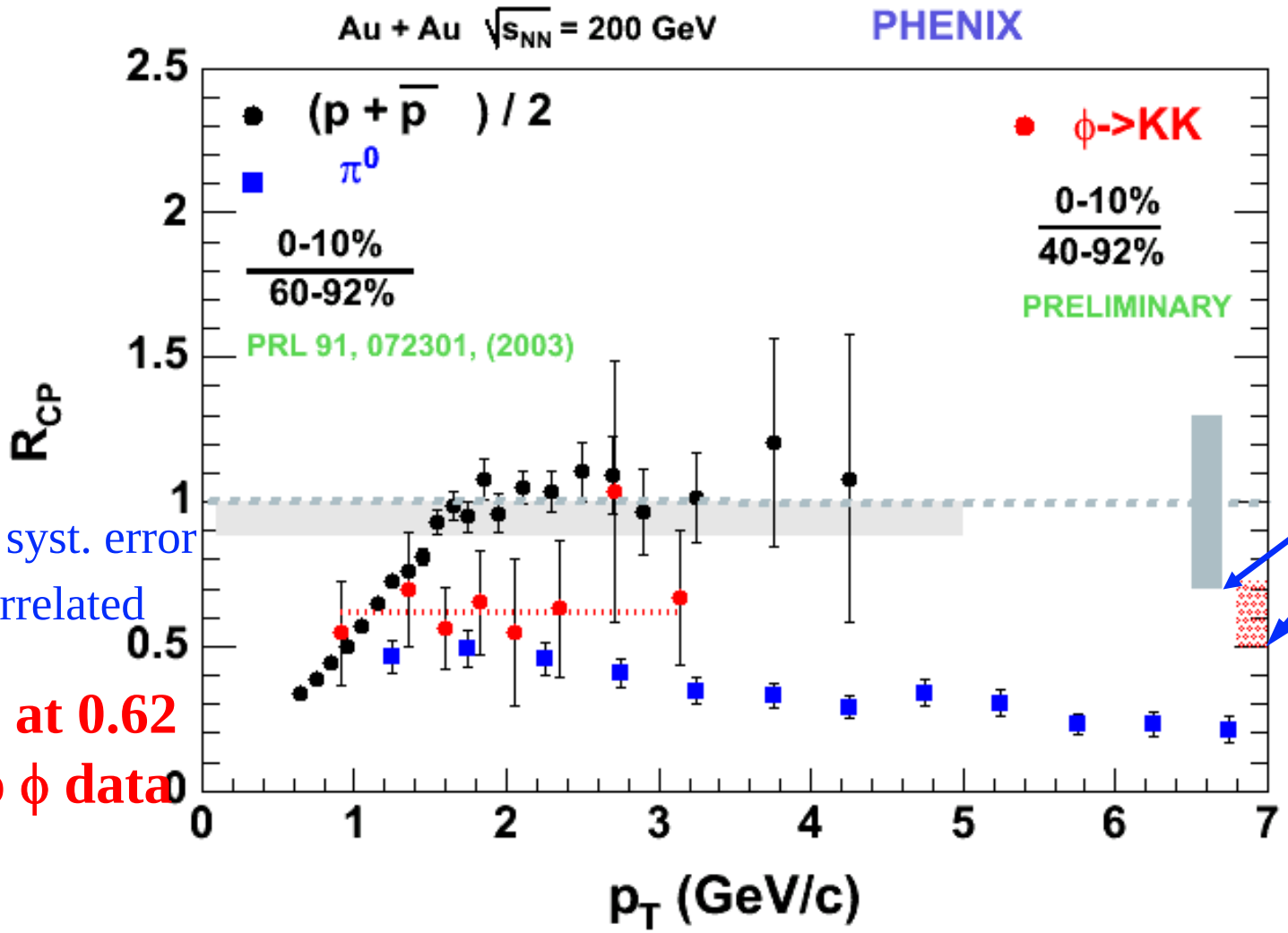
Baryon Junction

Vitev, Gyulassy
PRC 65, 041902, 2002



Predicted centrality dependence of p/π ratio and anti-baryon/baryon ratio

Centrality scaling of mesons and baryons:



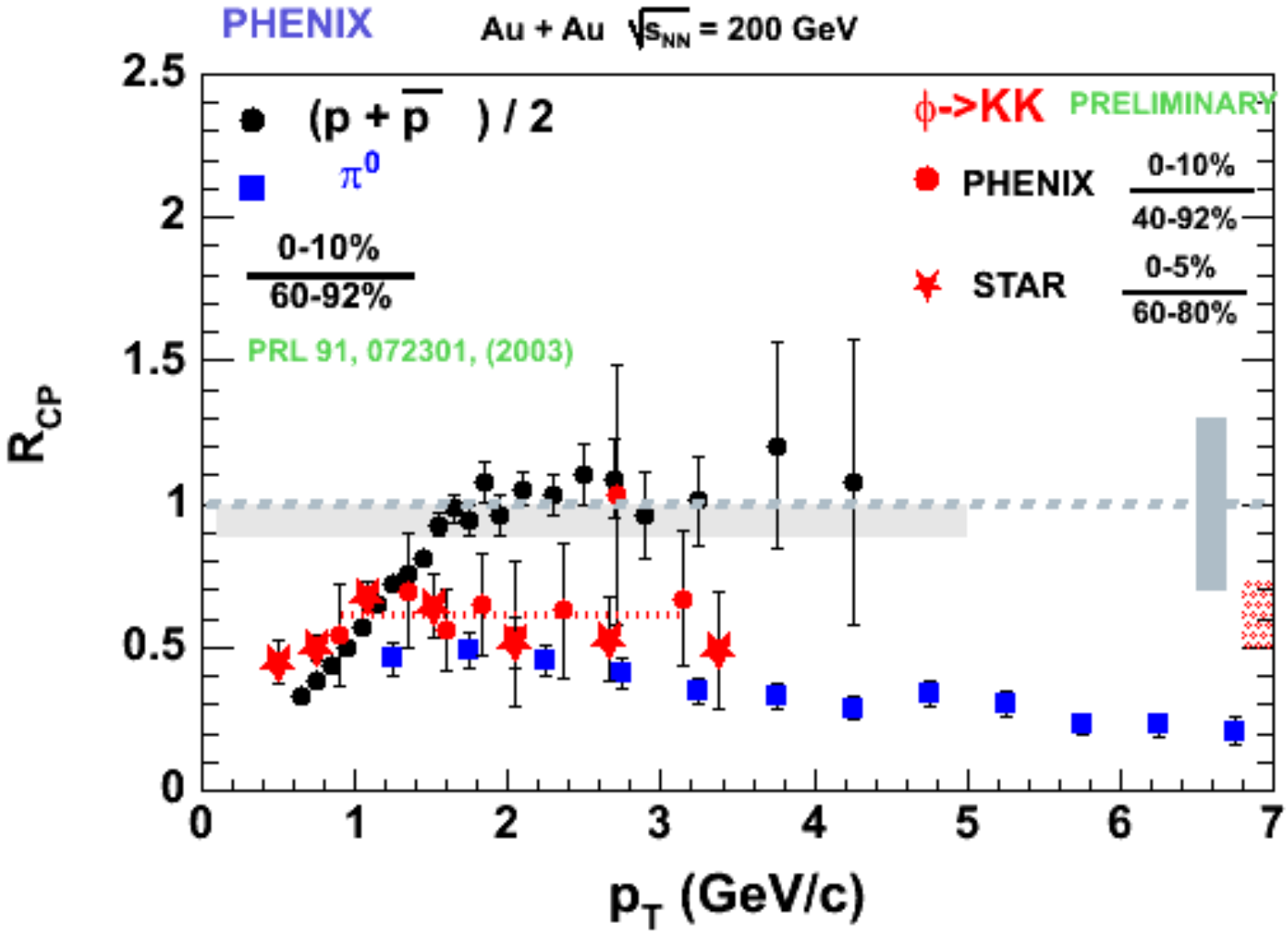
12% syst. error uncorrelated

N_{coll} errors correlated

Line at 0.62 fit to ϕ data

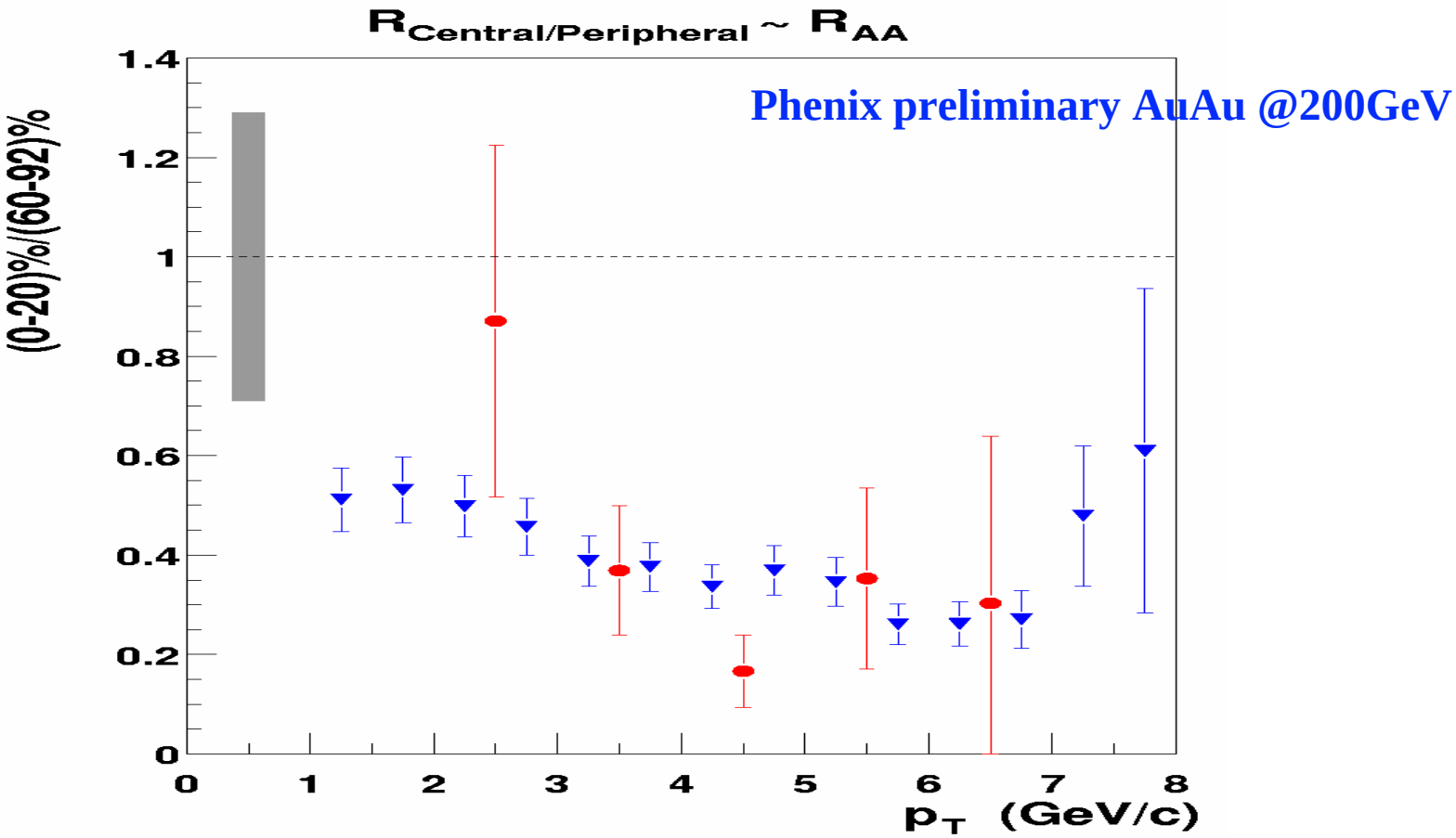
Difference between R_{CP} of $p+\bar{p}$ and ϕ beyond the systematic error

Compare ϕ scaling across experiments



- **Remarkable agreement between PHENIX and STAR**

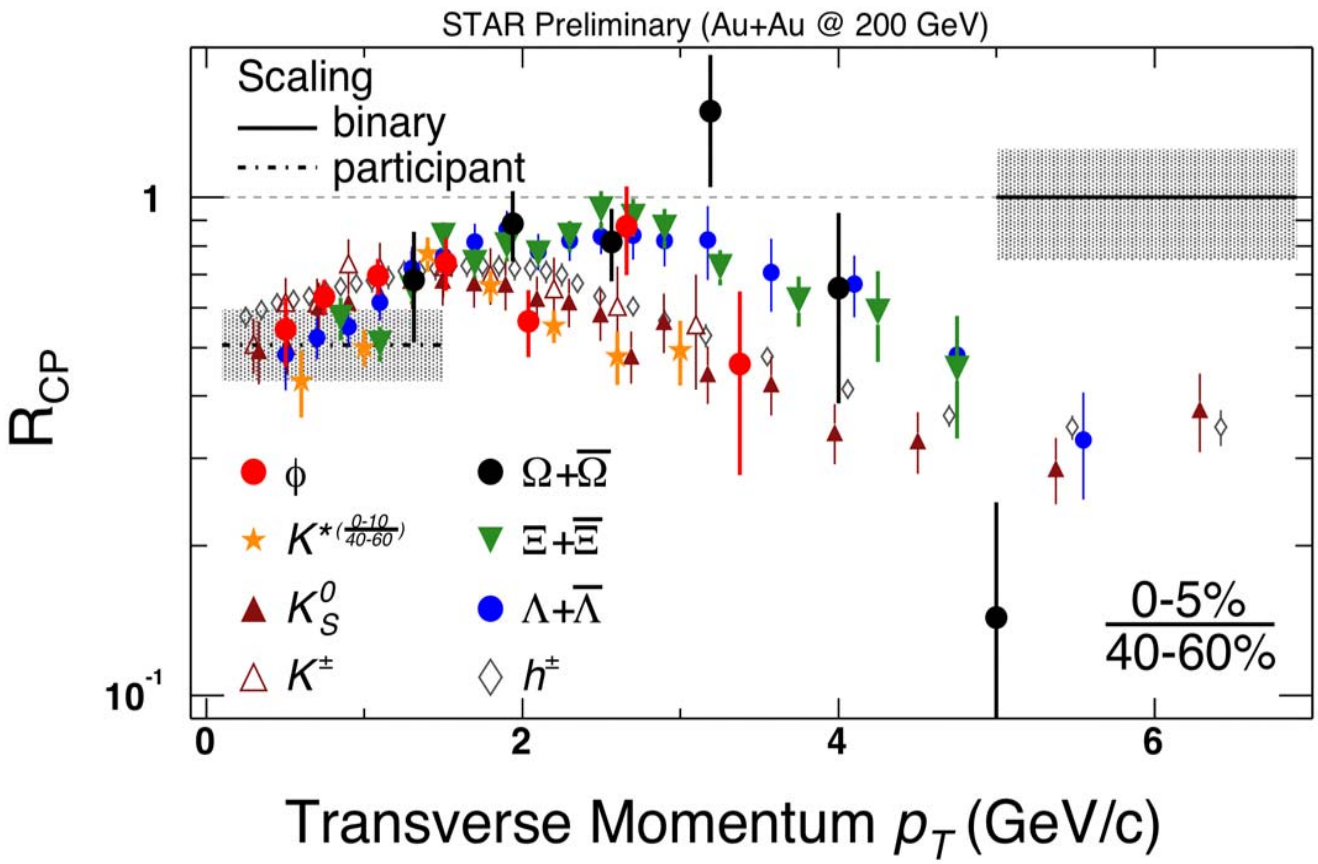
The η meson: high-pt comparison with π^0



- **Adding η into the mix: agrees with π^0 within errors**

poster S.Mioduszewski : High pT 8

Centrality scaling of mesons and baryons :



Talk byM.Lamont
Tuesday, Parallel 1

Compilation of R_{cp} results from STAR

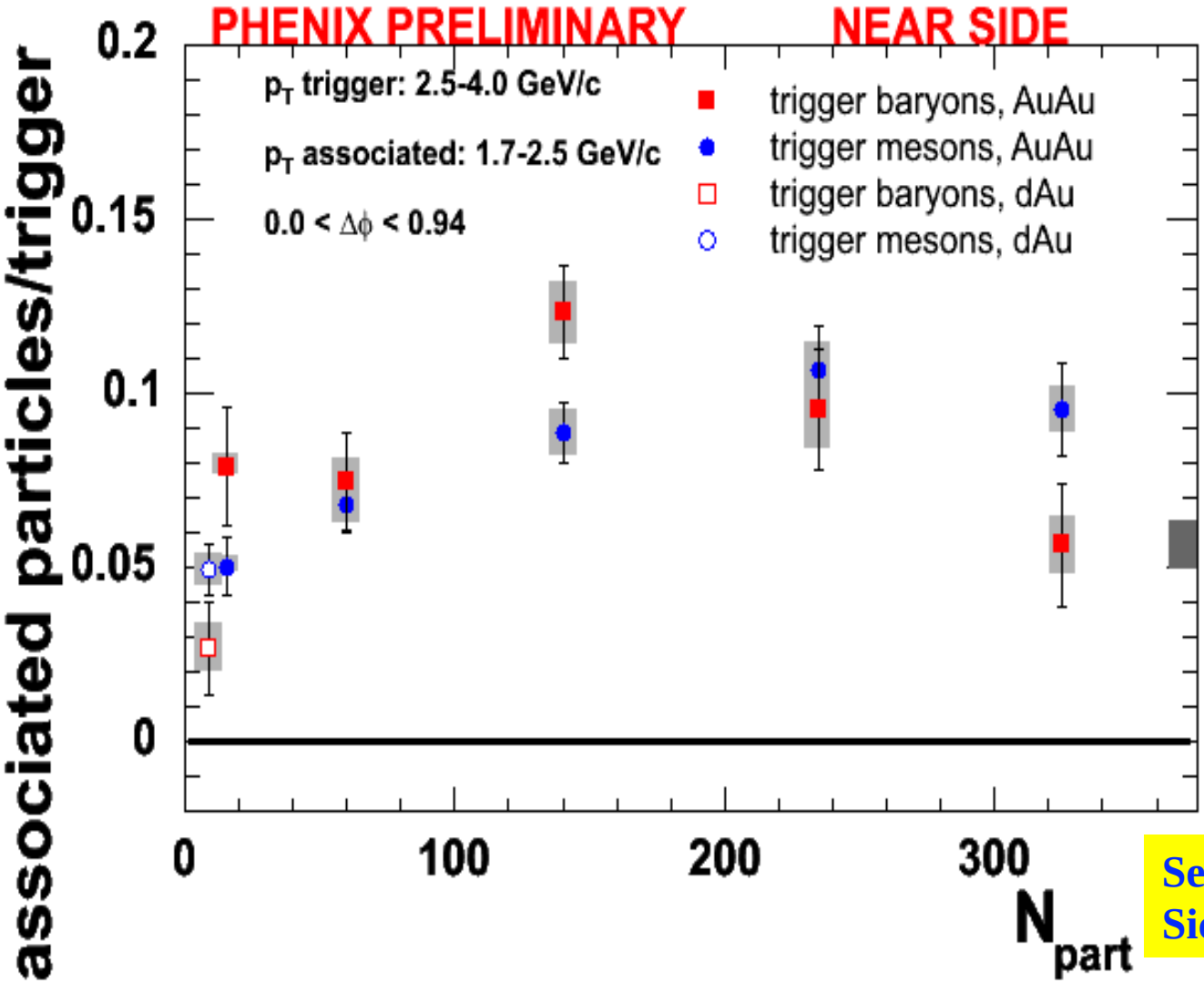
follows baryon/meson distinction (independent of mass)

Baryons and mesons are different

Do soft and hard partons recombine, or is it just soft+soft ?

Explore correlations with leading baryons and mesons

Do mid-p_T baryons have jet-like correlations ?



- **jet partner equally likely for trigger baryons & mesons**
- **no significant decrease with centrality!**

See talk by Anne Sickles: Friday Parallel 1

Conclusions

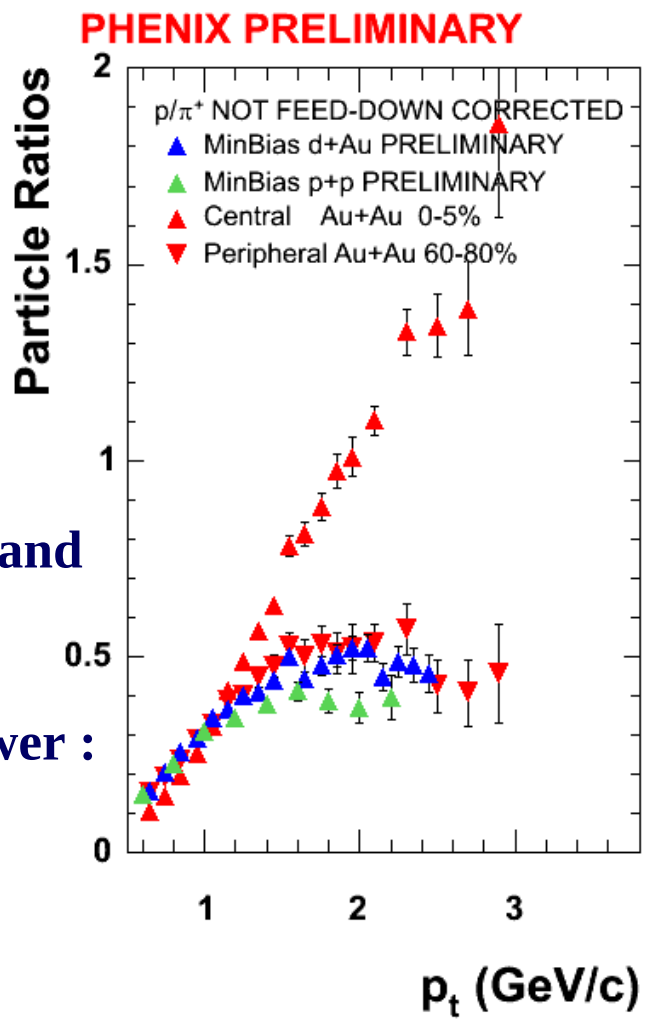
- **Intermediate p_T with distinct baryon dynamics from AuAu data**
- **Cronin effect shows (weak) mass dependence:**
  - **Is it enough to explain the large p/π ratio in AuAu ?**
  - **Need better theoretical understanding**
- **The suppression/non-suppression at mid-p_T follows baryon/meson lines (not mass effect)**
- **Mid-p_T leading baryons show jet-like correlations**
  - **Soft-soft recombination models excluded**
  - **Need to recombine hard-soft**

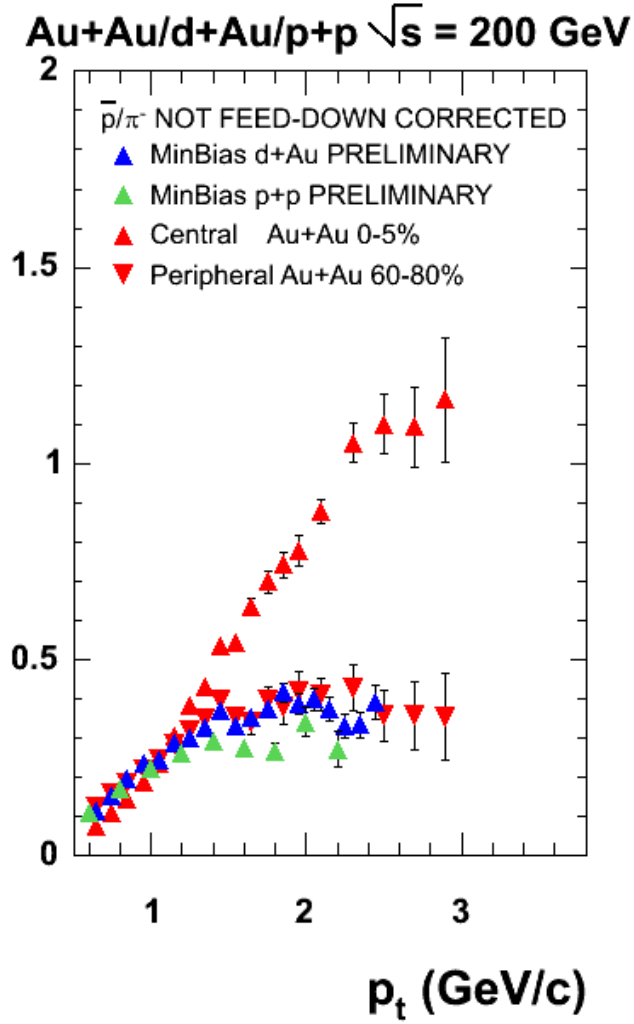
Experimental Outlook

- **The RHIC experiments are taking AuAu data (as I speak)**
- **High statistics run:**
  - **Expect much smaller error bars on the singles measurements**
  - **Expand (with enough statistics) v2 and correlation mesurements**
- **Provide data that will help in understanding the hadronization process**

EXTRA

System size dependence of p/π ratio





Peripheral AuAu and dAu agree

pp data ~ 25% lower : different Cronin enhancement for protons and pions

Caveat: (anti)proton data not feed-down corrected

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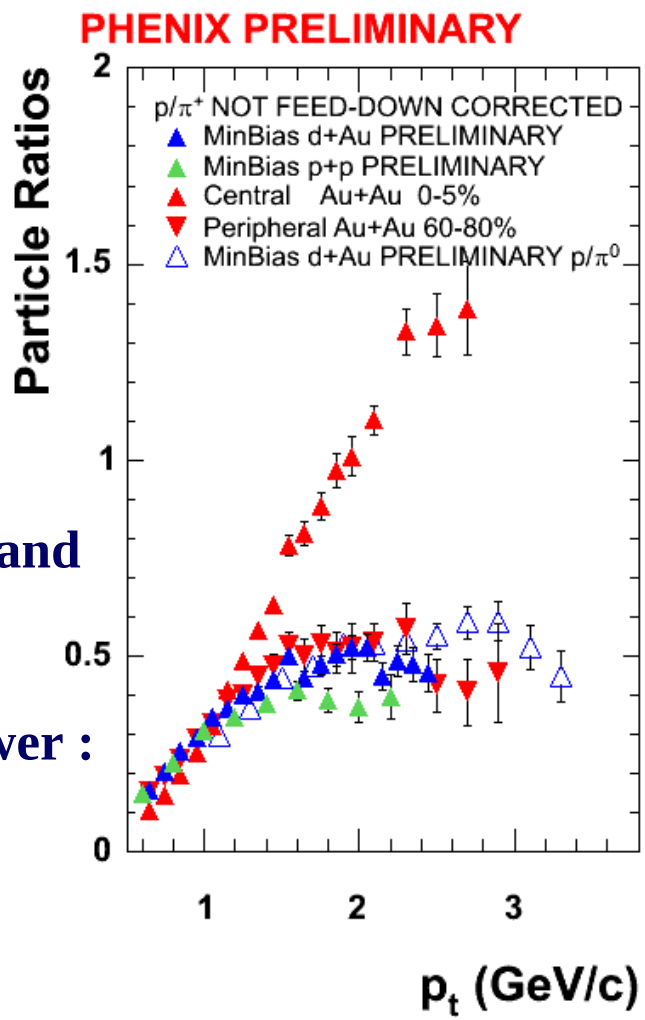

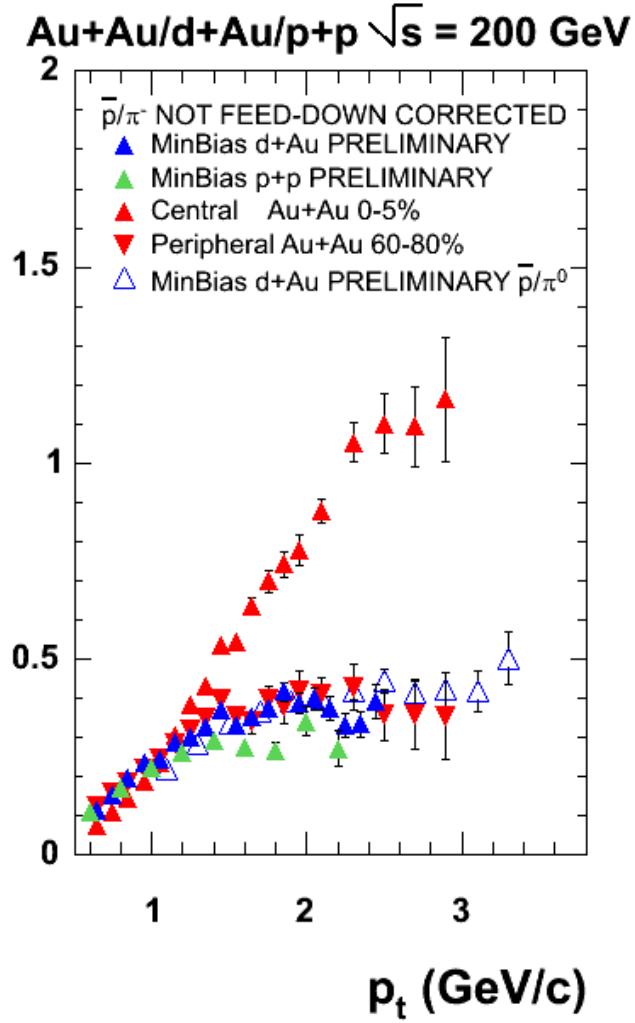

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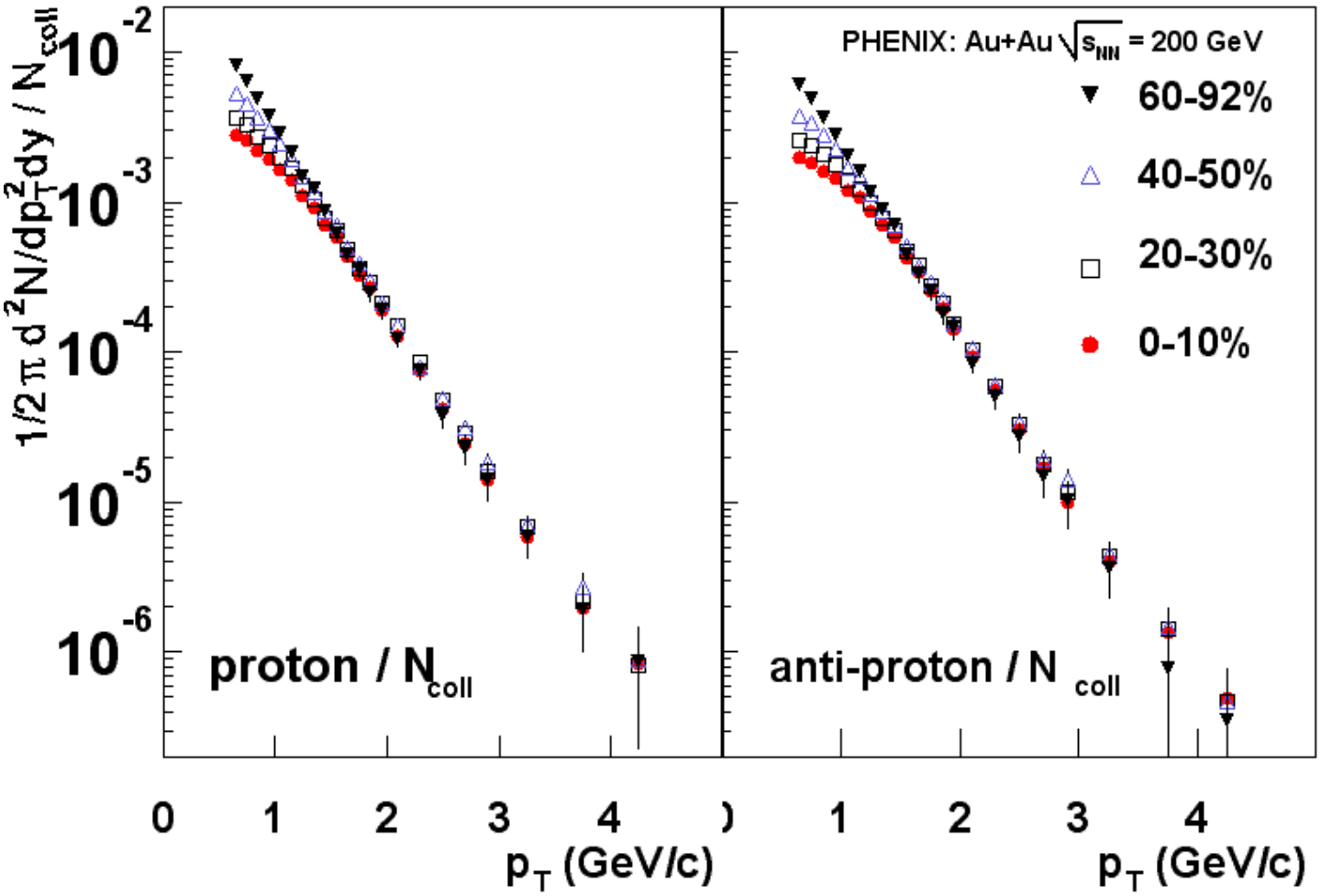
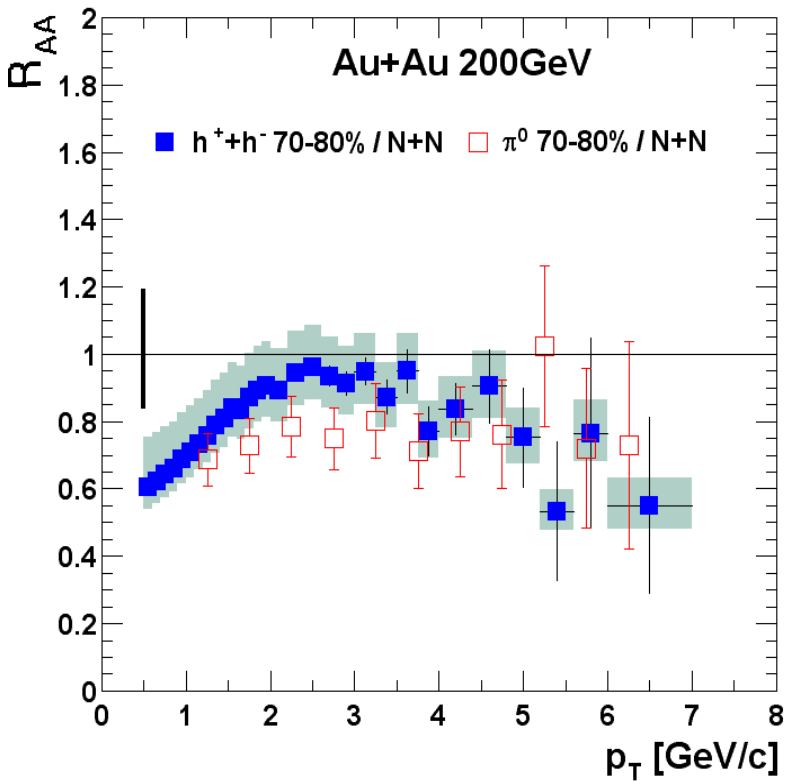

PHENIX: Au+Au $\sqrt{s_{NN}}$ = 200 GeV
60-92%
40-50%
20-30%
0-10%
$1/2\pi\, d^2N/dp_T^2dy\ /\ N_{coll}$
proton / N_{coll}
anti-proton / N_{coll}
p_T (GeV/c)
p_T (GeV/c)

R_{AA} for π^0 and charged hadron

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



PHENIX AuAu 200 GeV

π^0 data: PRL 91 072301 (2003), nucl-ex/0304022.

charged hadron (preliminary) : NPA715, 769c (2003).

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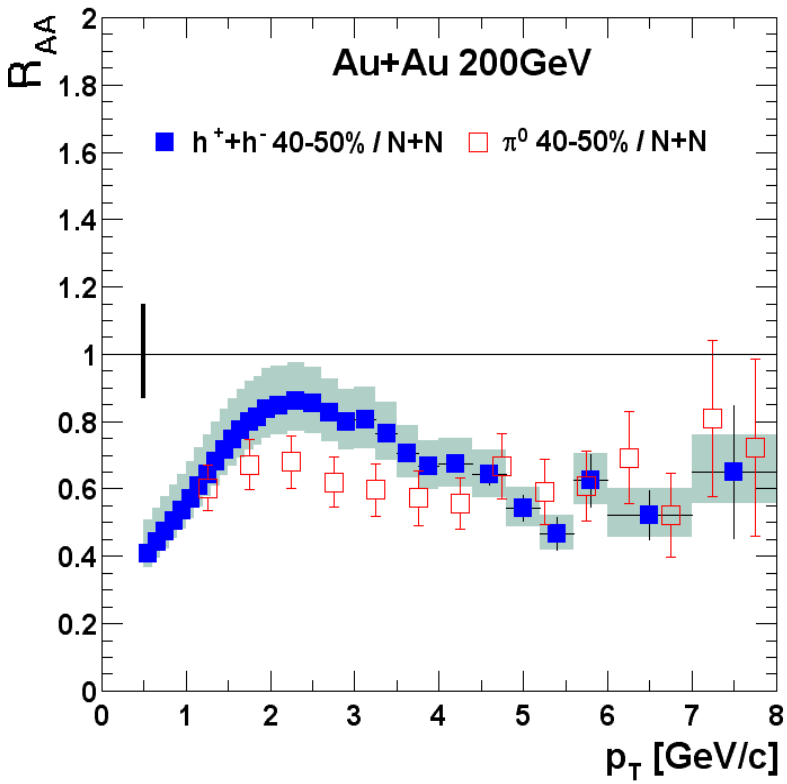

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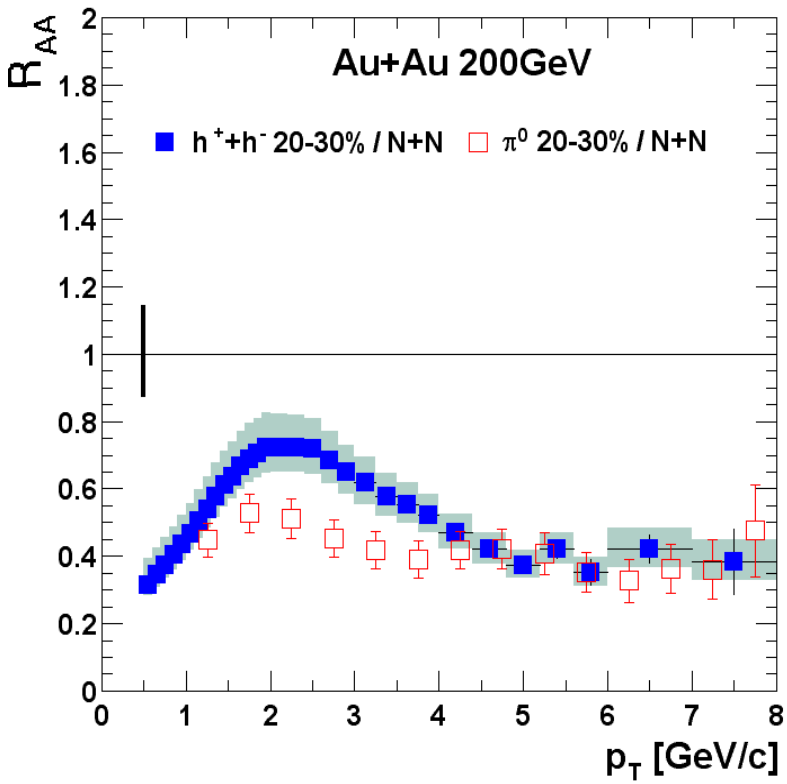

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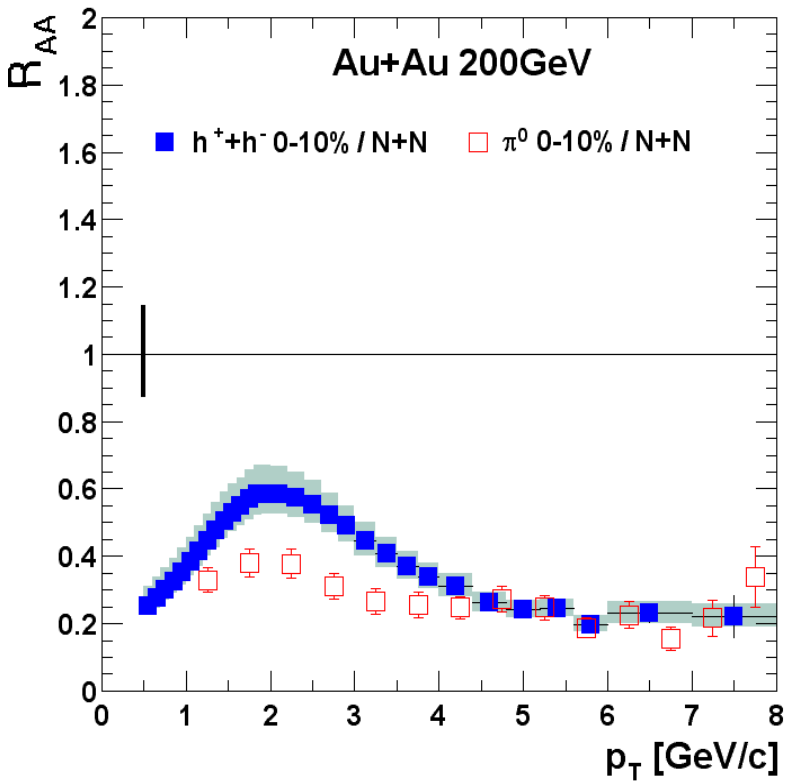

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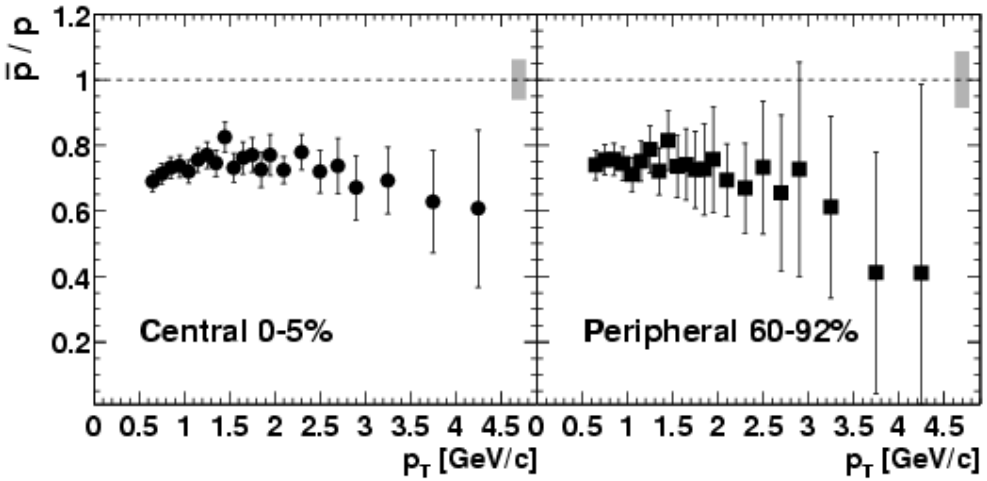
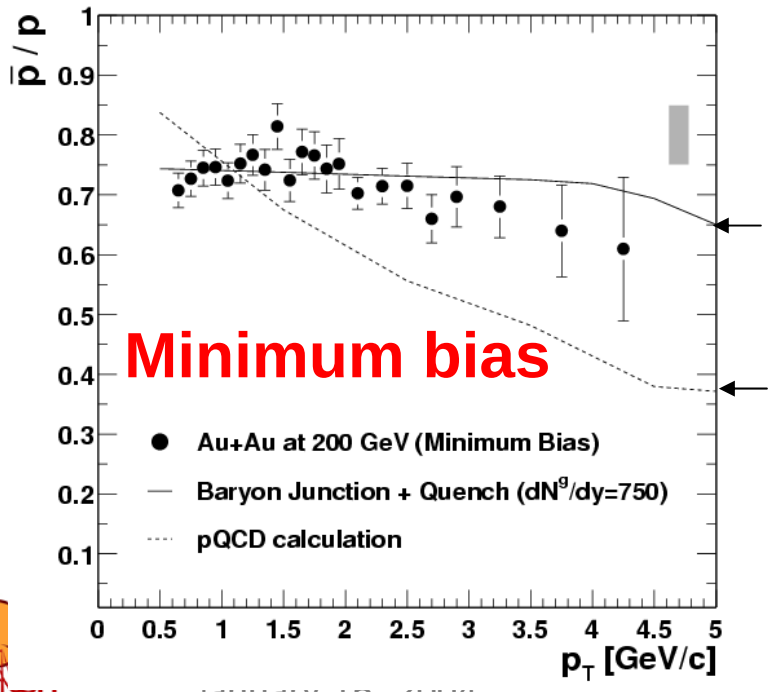
$\bar{p}/p$ ratio vs. p_T



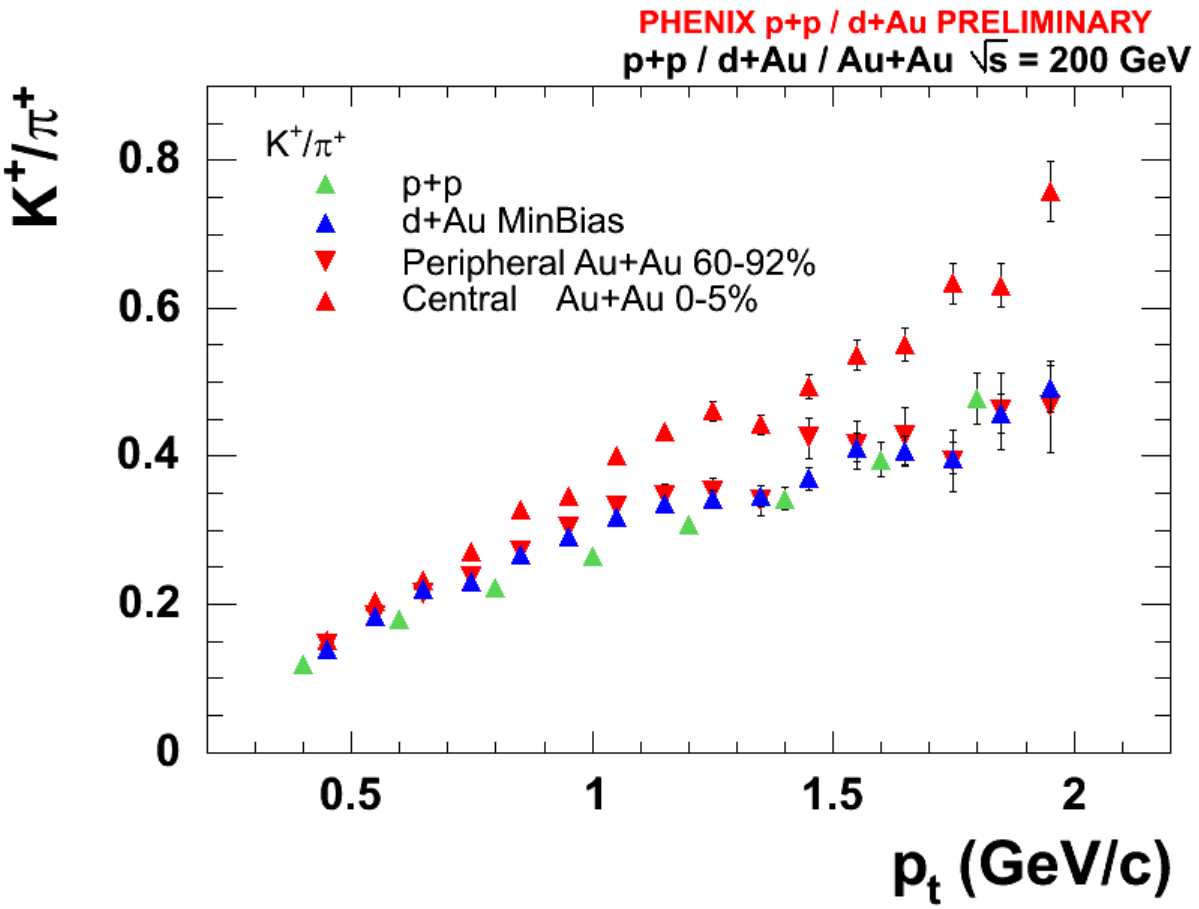
Constant within the experimental errors



Baryon Junction

Vitev, Gyulassy
NPA 715, 779c (2003)

pQCD


PHENIX p+p / d+Au PRELIMINARY
p+p / d+Au / Au+Au √s = 200 GeV
K+/π+
K+/π+
p+p
d+Au MinBias
Peripheral Au+Au 60-92%
Central Au+Au 0-5%
0
0.2
0.4
0.6
0.8
0.5
1
1.5
2
pt (GeV/c)