π/K/p production and Cronin effect from p+p, d+Au and Au+Au at $\sqrt{s_{NN}}$=200 GeV from the PHENIX experiment

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STATE UNIVERSITY OF NEW YORK

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2004

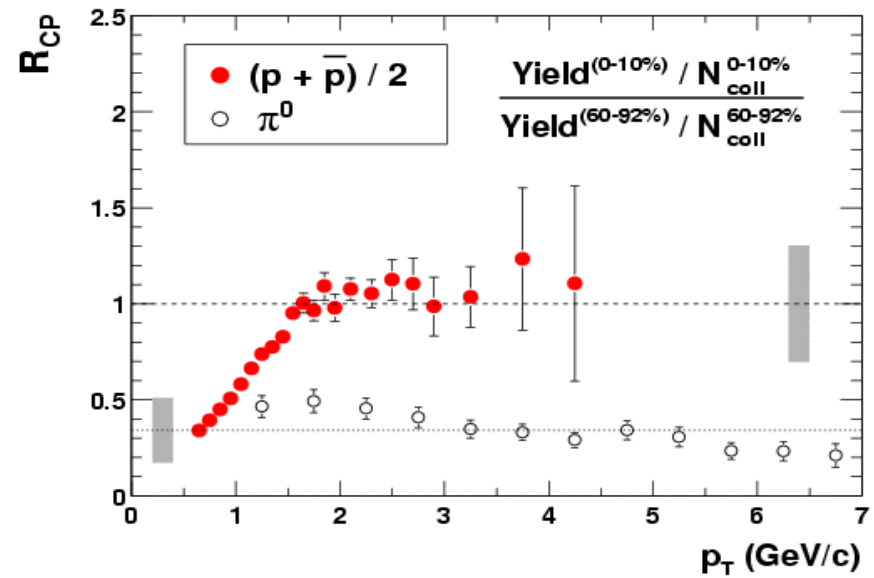
Overview.

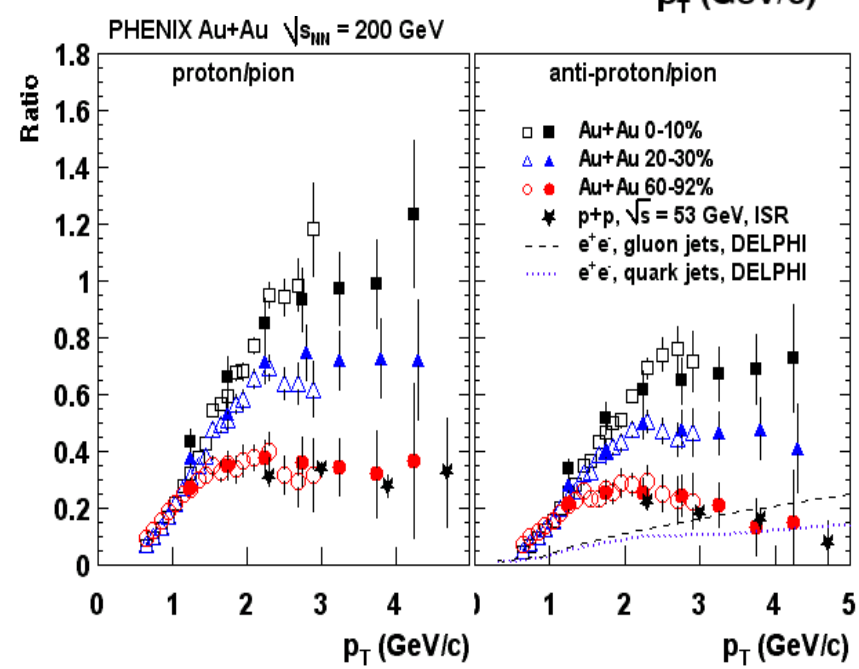
- The role of identified particles.
- Final results from Au+Au collisions.
- The d+Au and p+p run: Initial state and how to disentangle cold vs. hot nuclear matter effects.
- Comparisons: What remains the same, what is different.
- Cronin effect in d+Au.
- Conclusions.

Production of particles in a dense medium.

PHENIX: PRL 91, 172301 (2003), nucl-ex/0305036
PHENIX: Phys. Rev. C, nucl-ex/0307022

- Striking differences between protons and pions.
- Protons scale with Ncoll above pt~1.5 GeV.
- Pions stay suppressed even at pt~7 GeV.
- Particle composition inconsistent with known fragmentation functions 2-5Gev.
- Exciting Possibility: a new dominant source for protons from recombination requiring a dense partonic system.
- Other candidates: Baryon junctions, strong radial flow.





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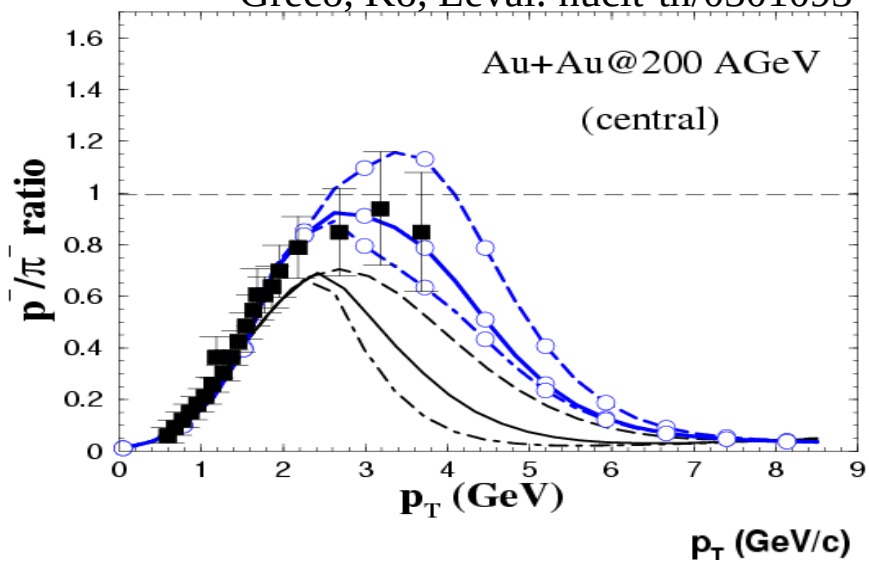
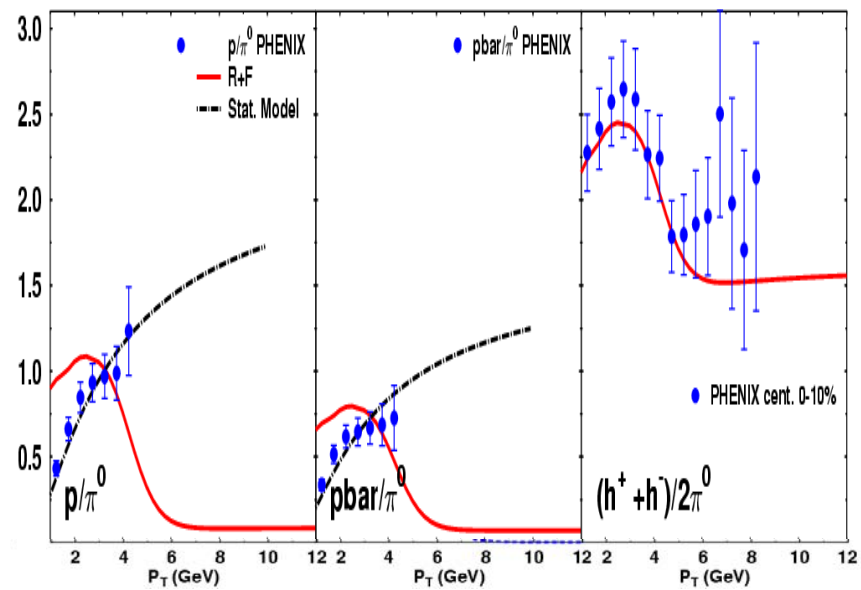
Greco, Ko, Levai: nuclt-th/0301093



Fries, Nonaka, Muller,Bass: nucl-th/0306027



The Cronin Effect & Initial State

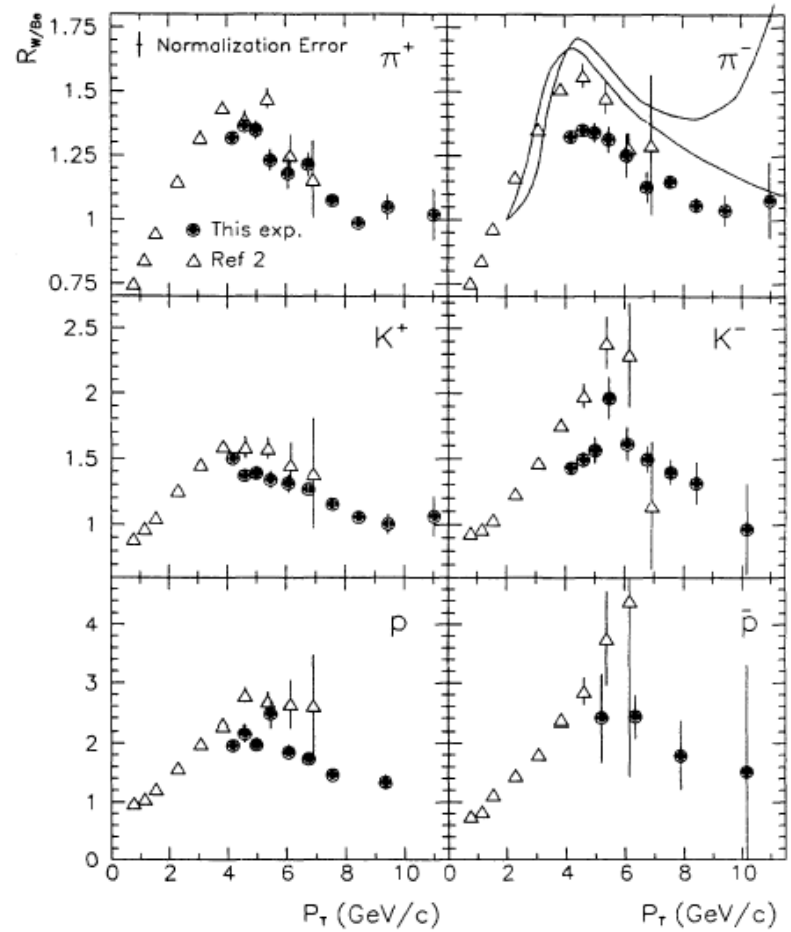
J.Cronin et al. Phys.Rev. D11, 3105(1975)

- Copious production of hadrons in proton-nucleus collisions.

$$R(p_T) = \frac{B}{A}\frac{d\sigma_{pA}/d^2p_T}{d\sigma_{pB}/d^2p_T}$$

- R=1 in absence of nuclear effects.
- Bound nucleons "cooperate" producing high-pT particles.
- Suppression at small pT.
- Explained by initial multiple scattering.

P.B.Straub et al., Phys.Rev.Lett., **68**,452(1992)



A survey of theoretical models:
A.Accardi, hep-ph/0212148

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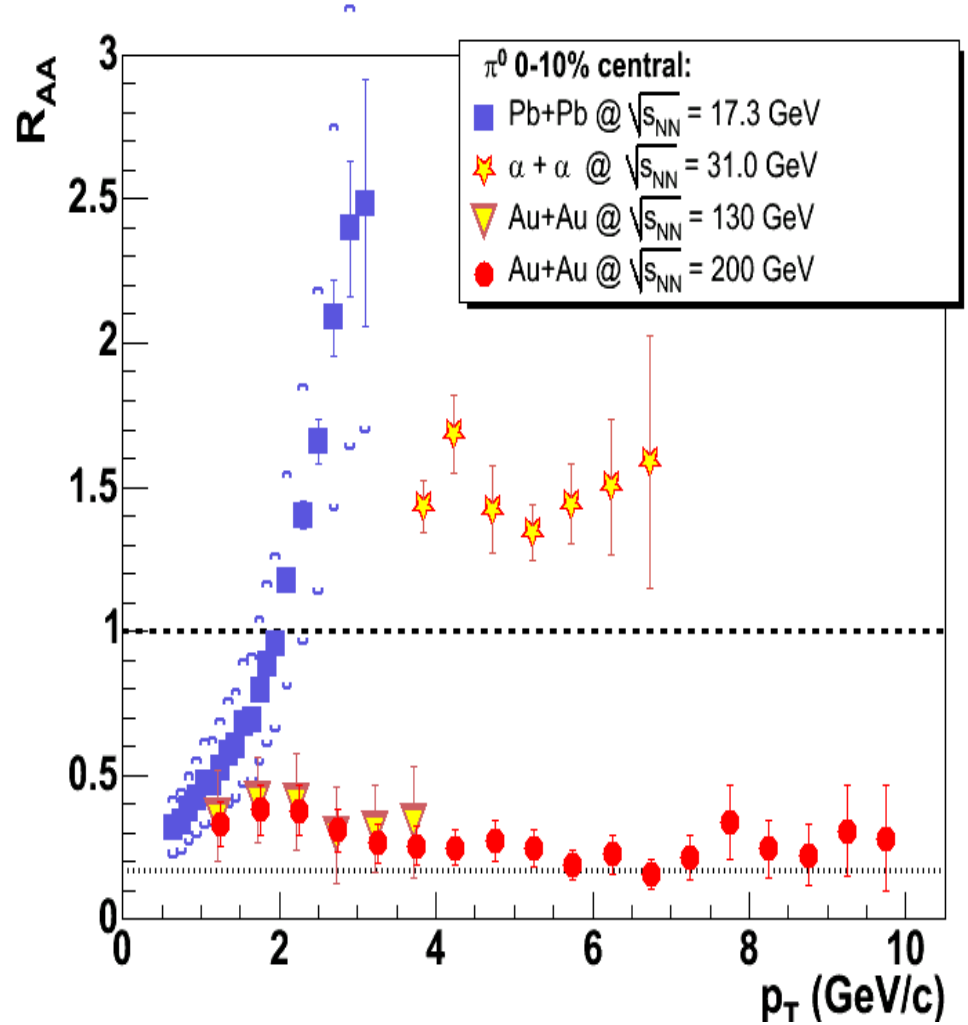

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Why is it important to know the size of the effect ?

Because:

A)Cronin.

B)Shadowing.

C)Saturation.

constitute the initial state effects that provide the reference for Au+Au calculations.

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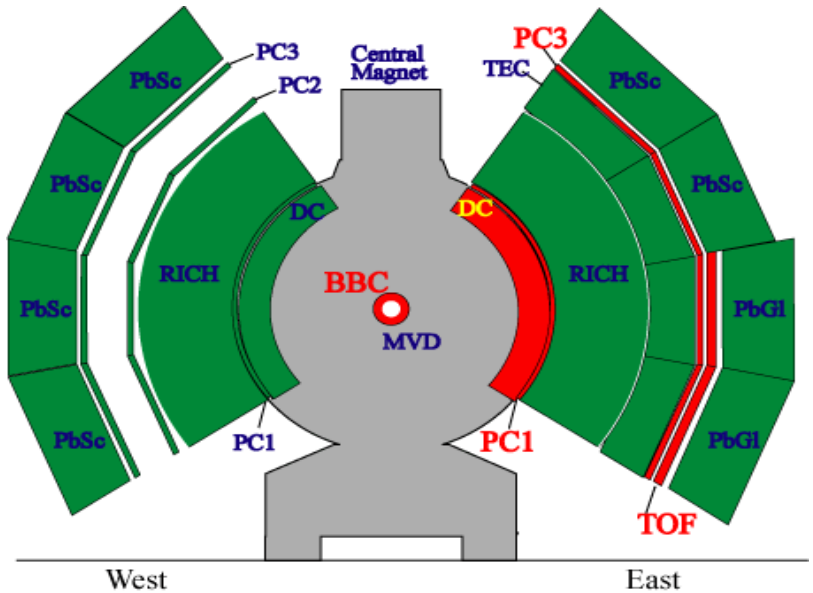
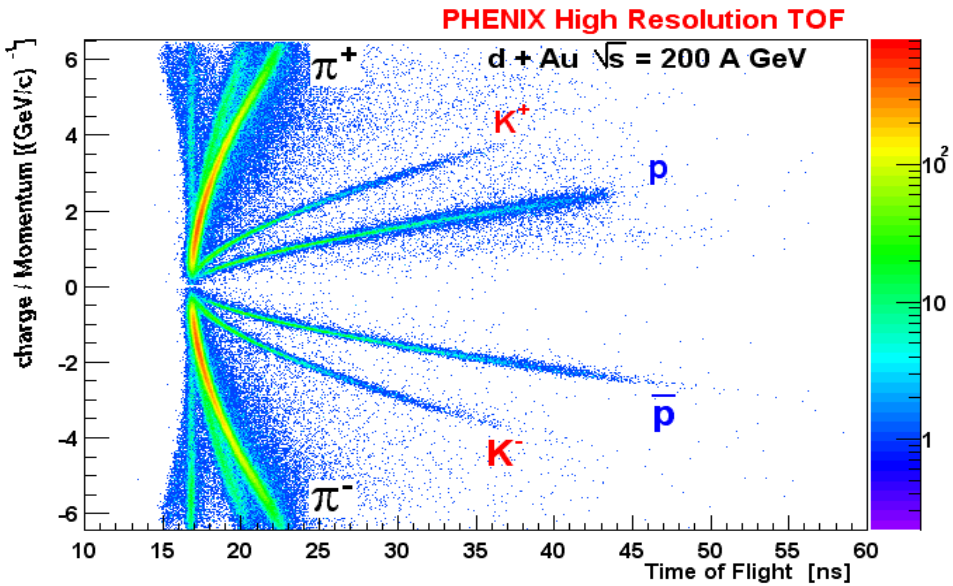
PHENIX RUN03: the d+Au run

- Time of Flight Particle Identification.
- Same techniques and analyses in p+p,d+Au, Au+Au.
- TOF resolution ~135ps
- $\pi/K < 2$ GeV/c
- $K/p < 3.5$ GeV/c
- Acceptance: $\Delta\phi=\pi/8$, $\Delta\eta = 0.7$
- 14.3M Events, 30 cm vertex cut.





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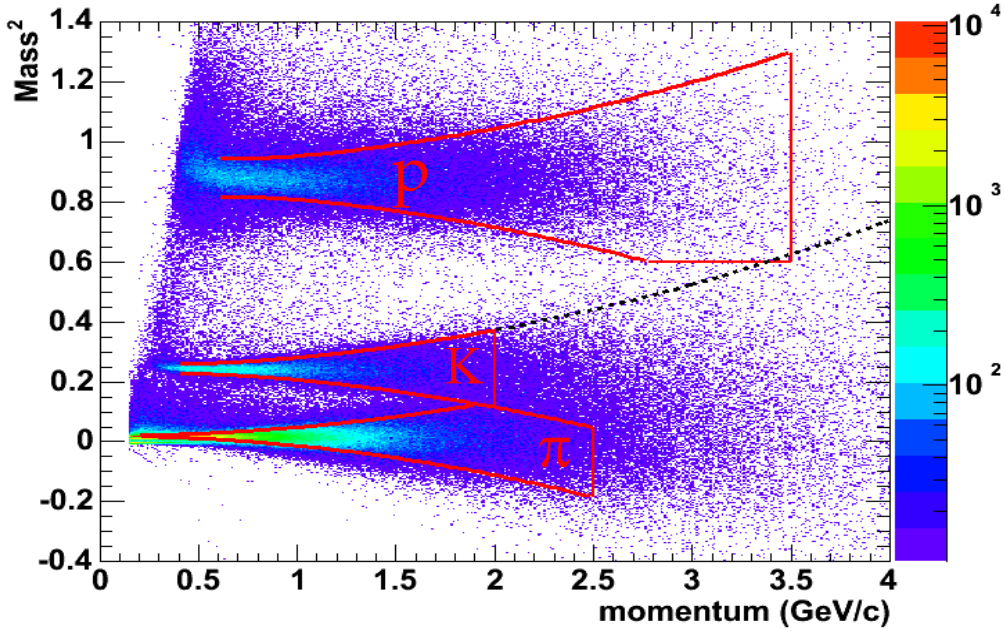
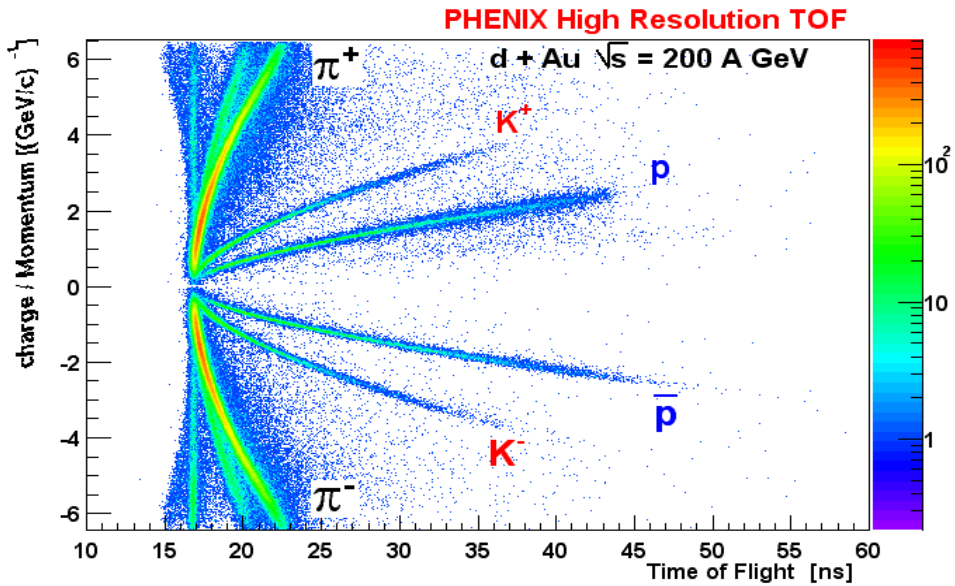
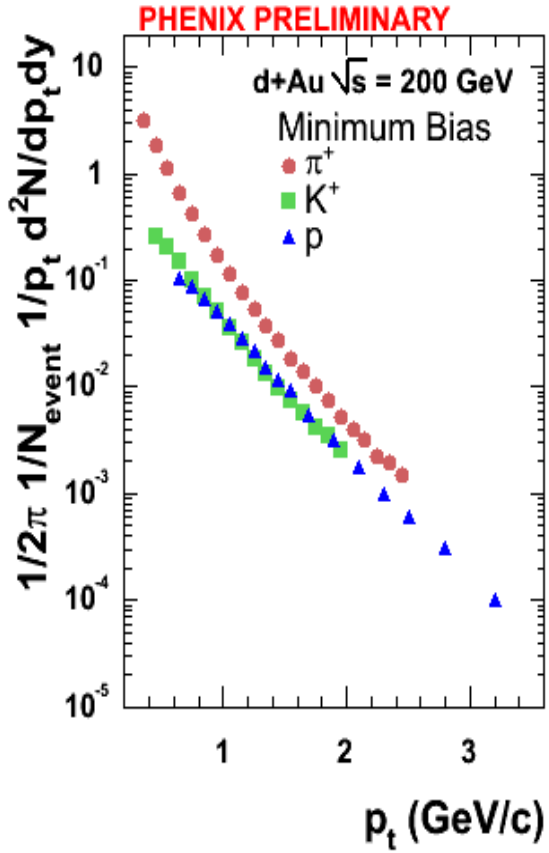
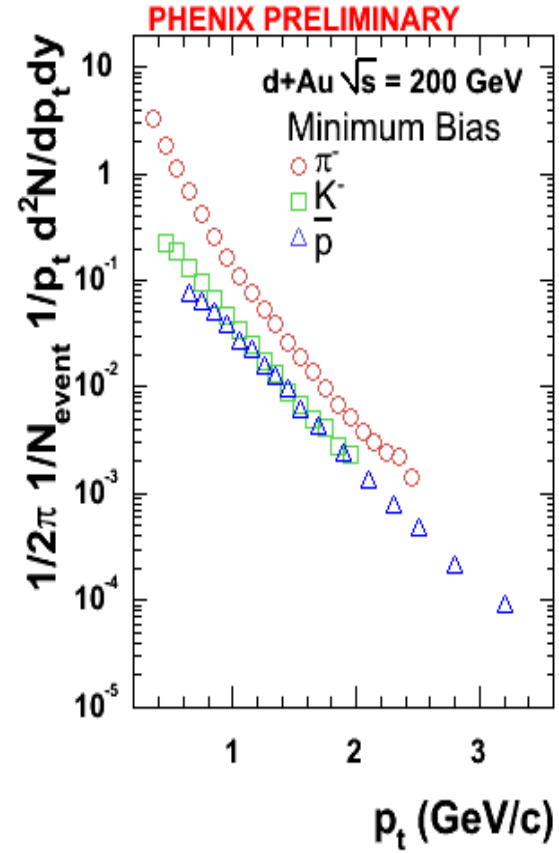




Minimum Bias d+Au

- Completely different behavior from central Au+Au.
- Protons do not cross the pions.
- Remarkable agreement with neutral pions.
- Phenix measures pions up to 10 orders of magnitude.





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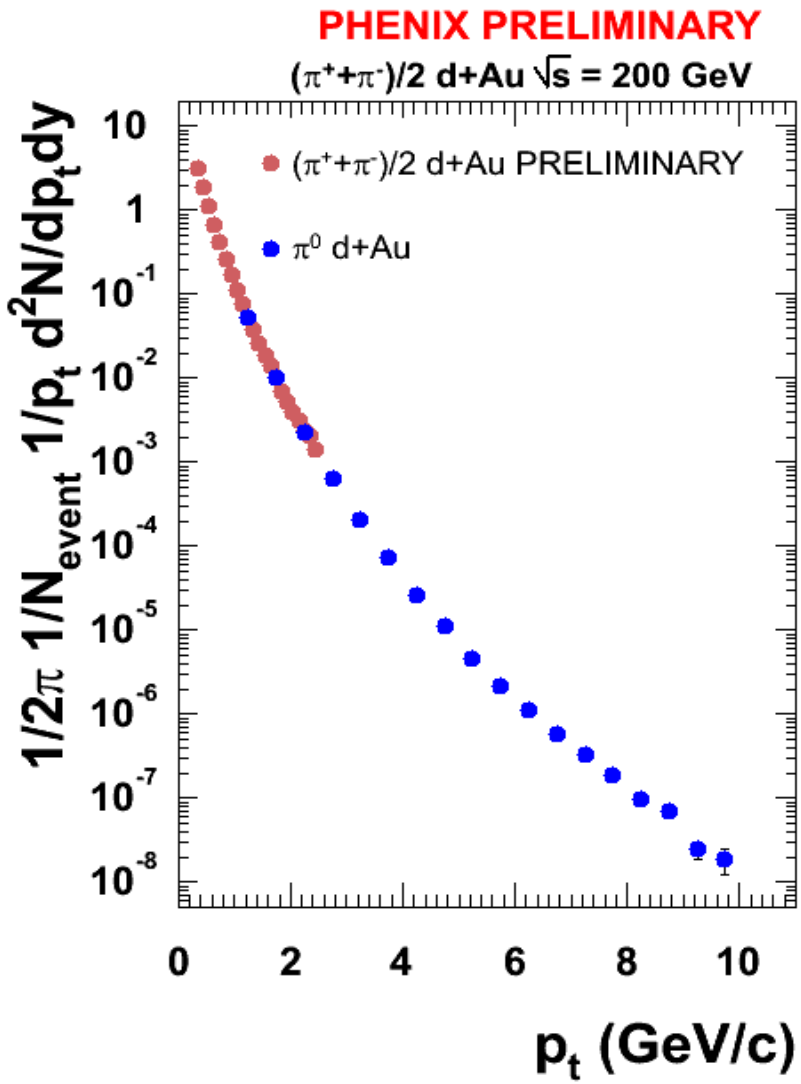

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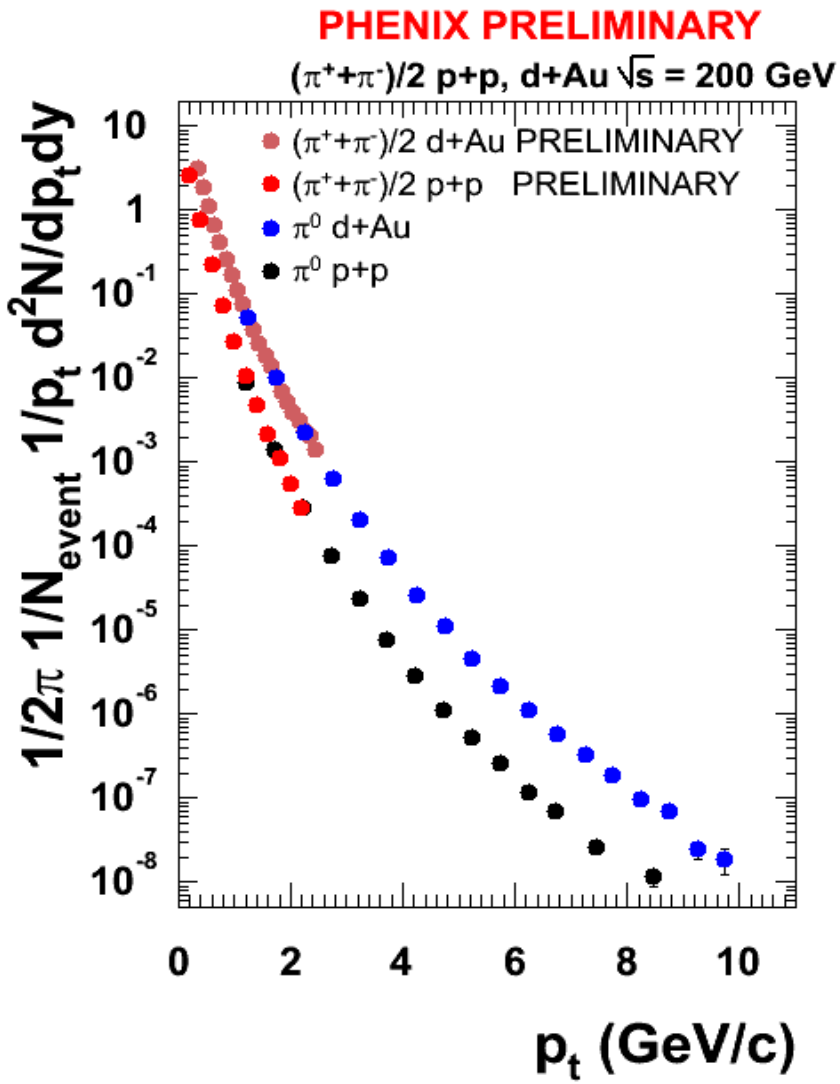

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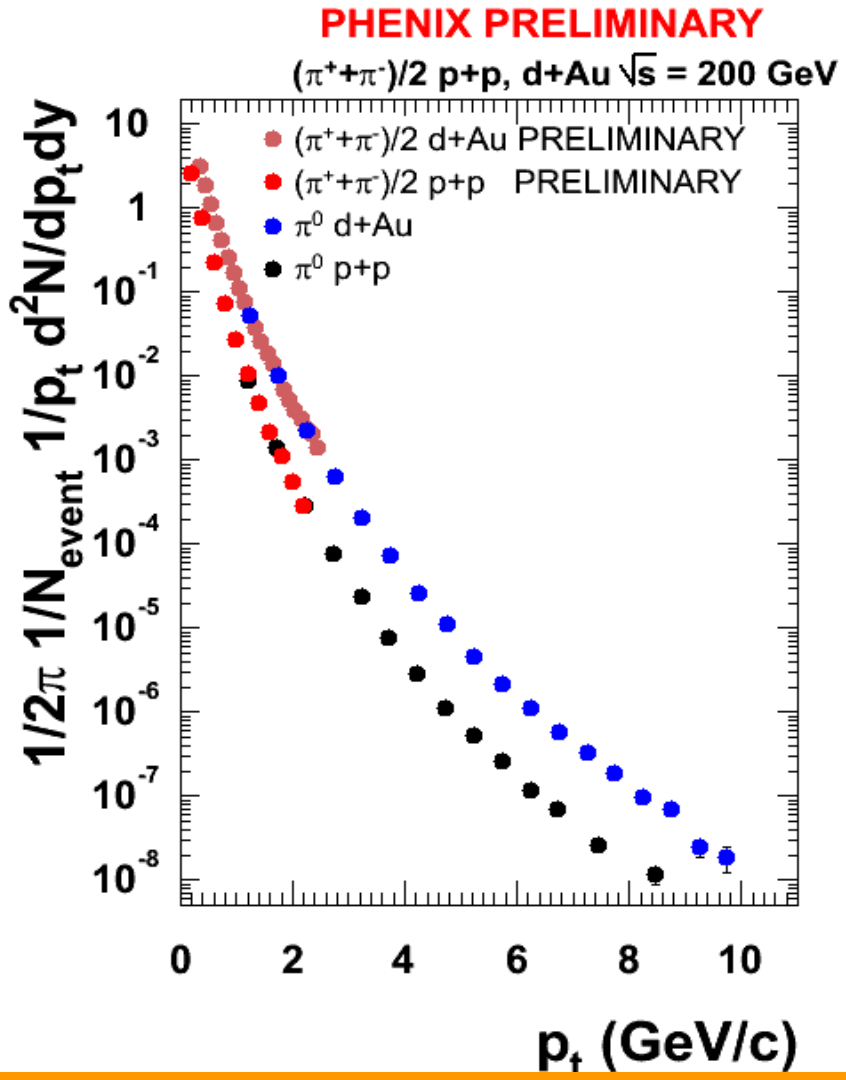
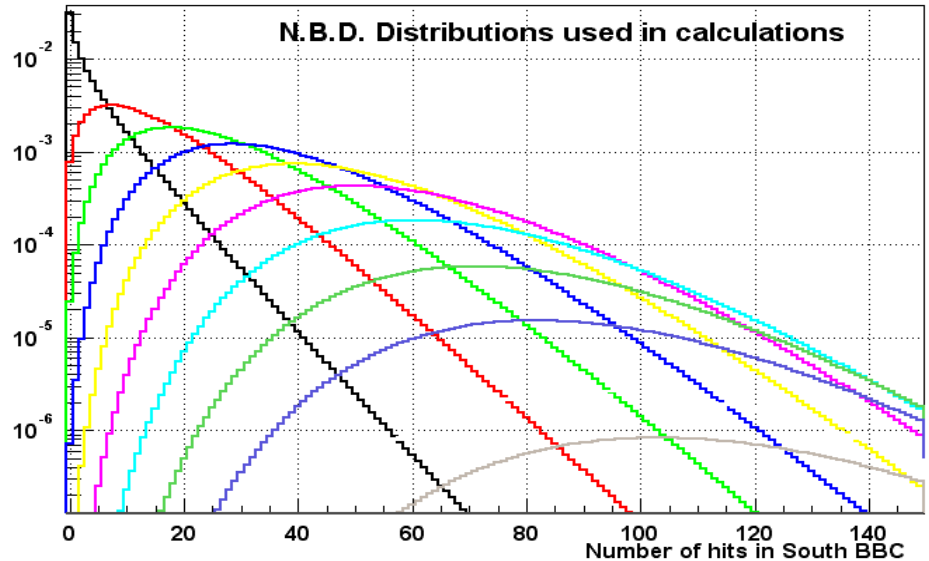


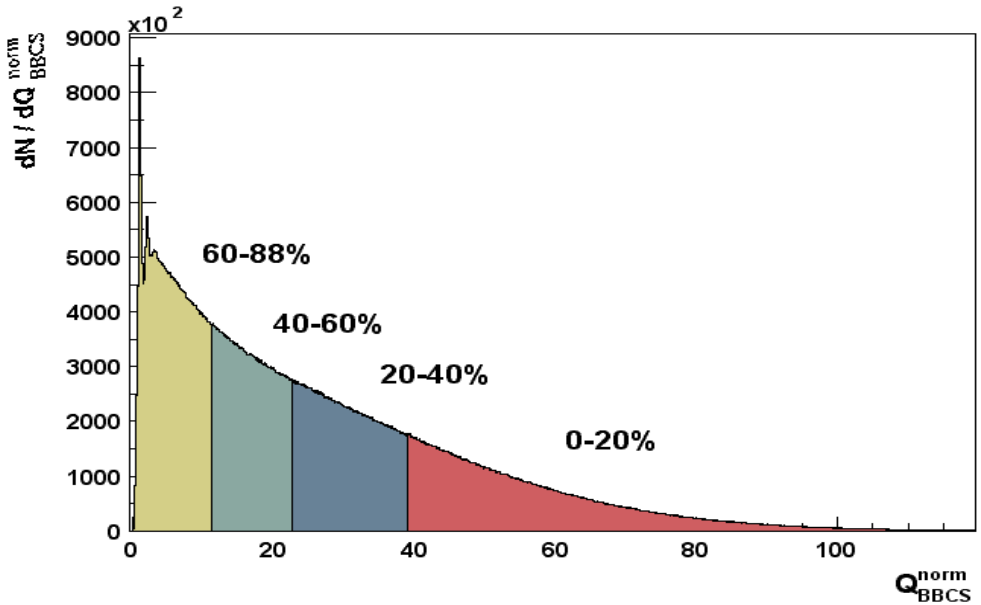
Mark Harvey: Identified Charged Hadrons at Midrapidity in p+p collisions at RHIC.

Centrality determination in d+Au

- BBCS (Au-side) response scales with the number of participants in the Au nucleus.
- Use Negative binomial distributions weighted by a Glauber model to reproduce the BBC charge distribution.
- Assumption is validated by the excellent description of the BBC charge distribution.

	Ncoll
0-20 % :	15.0 ± 1.0
20-40 % :	10.4 ± 0.7
40-60 % :	6.9 ± 0.6
60-88 % :	3.2 ± 0.3





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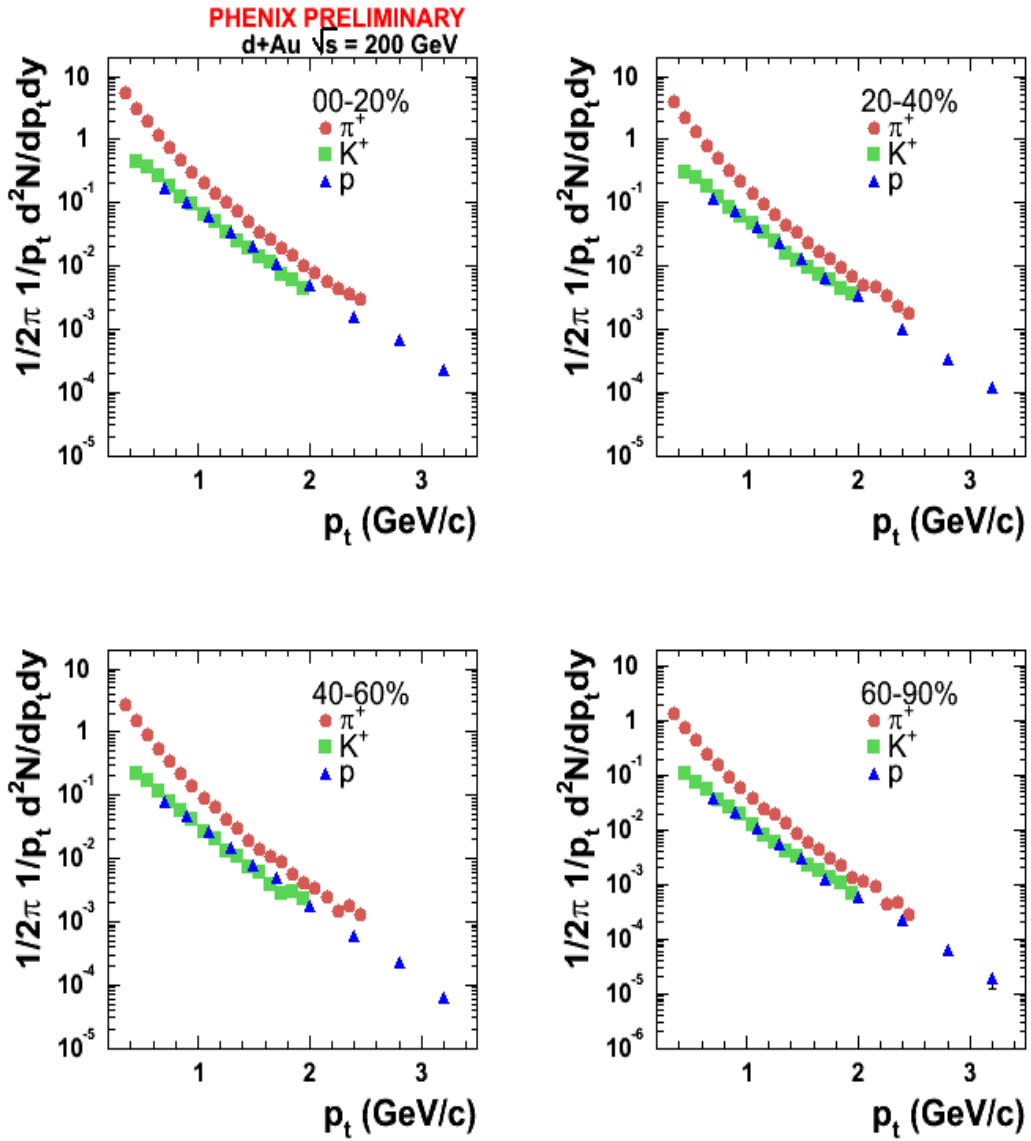

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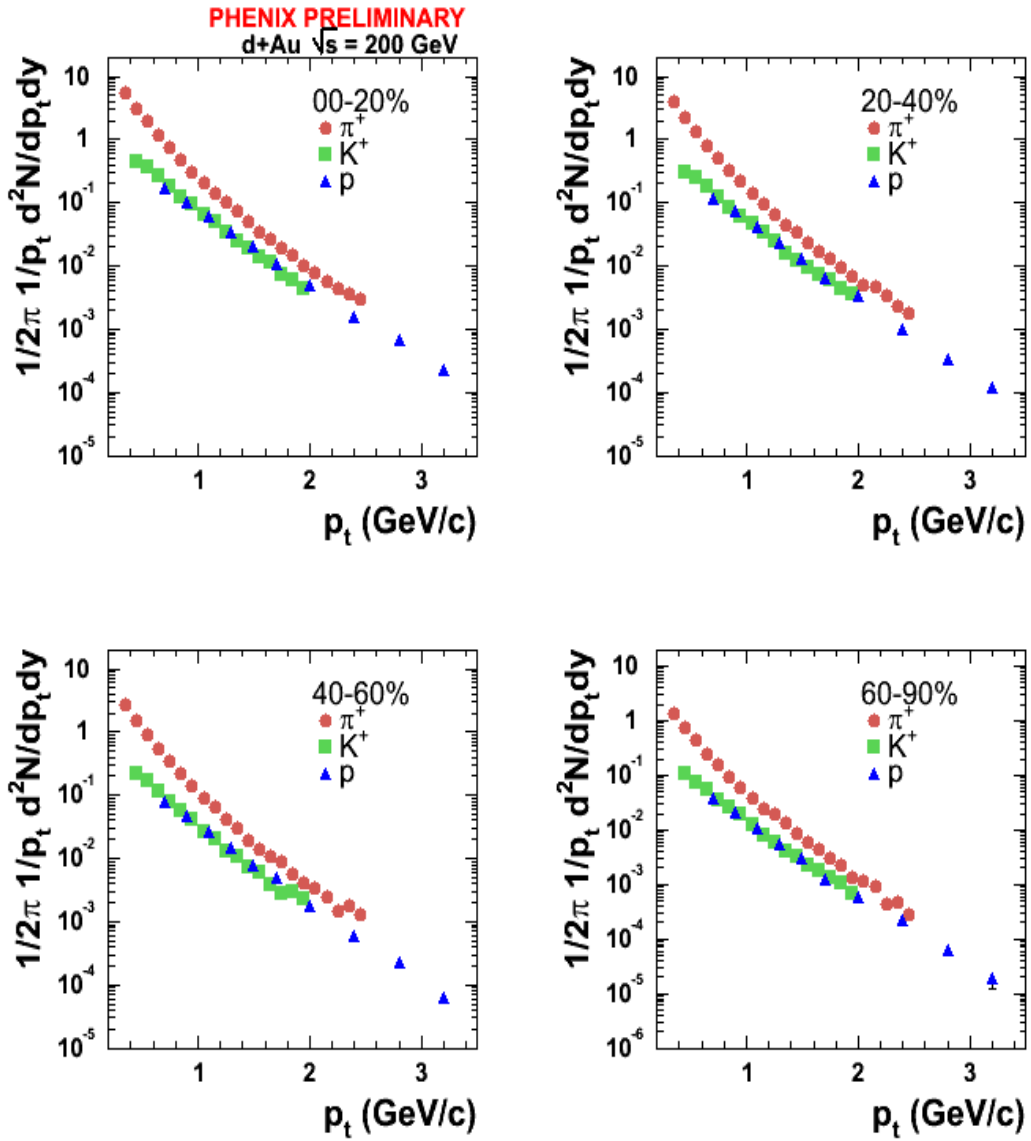
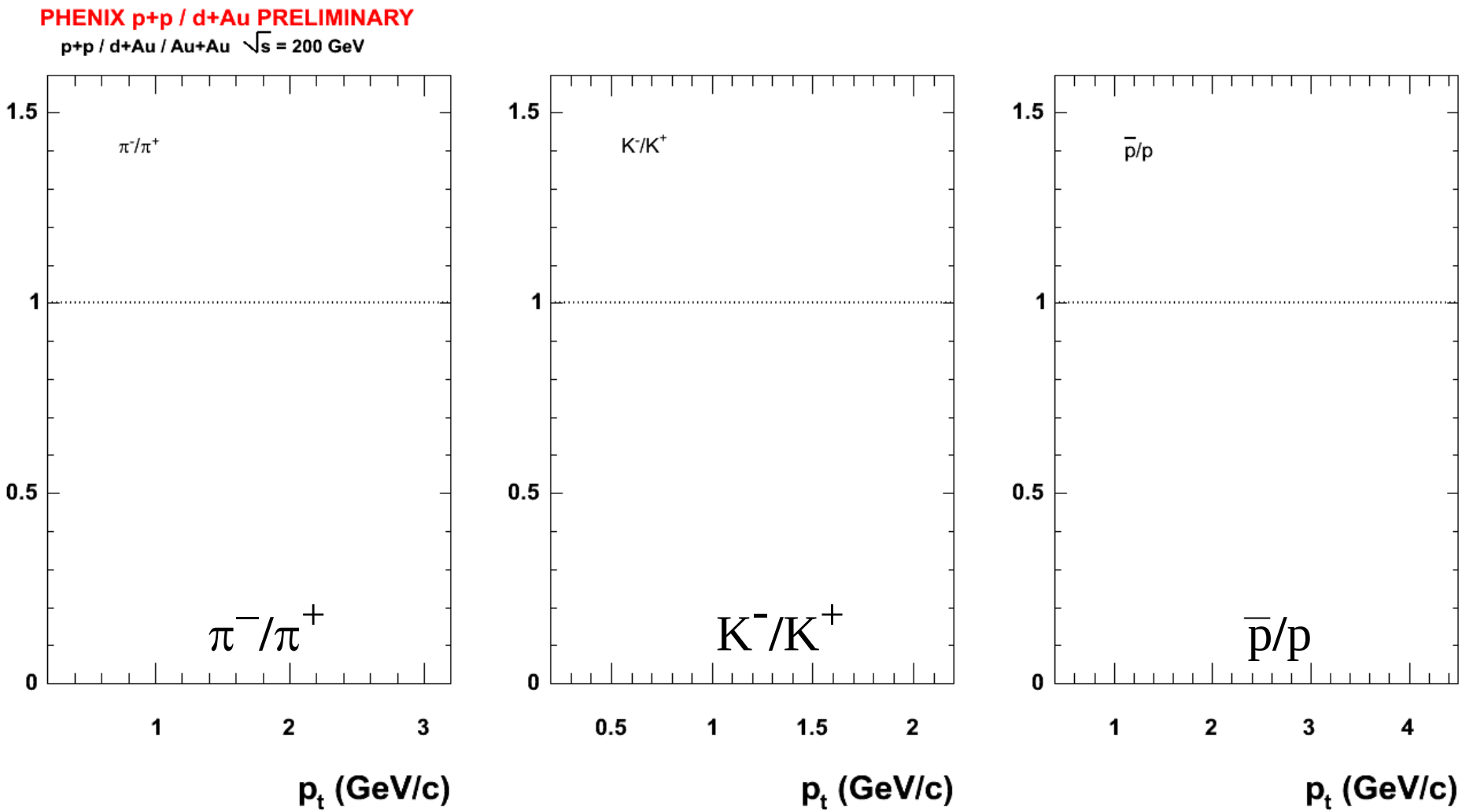


Poster by Sasha Milov.

Antimatter over Matter

the 200 GeV case

Phenix beam pipe



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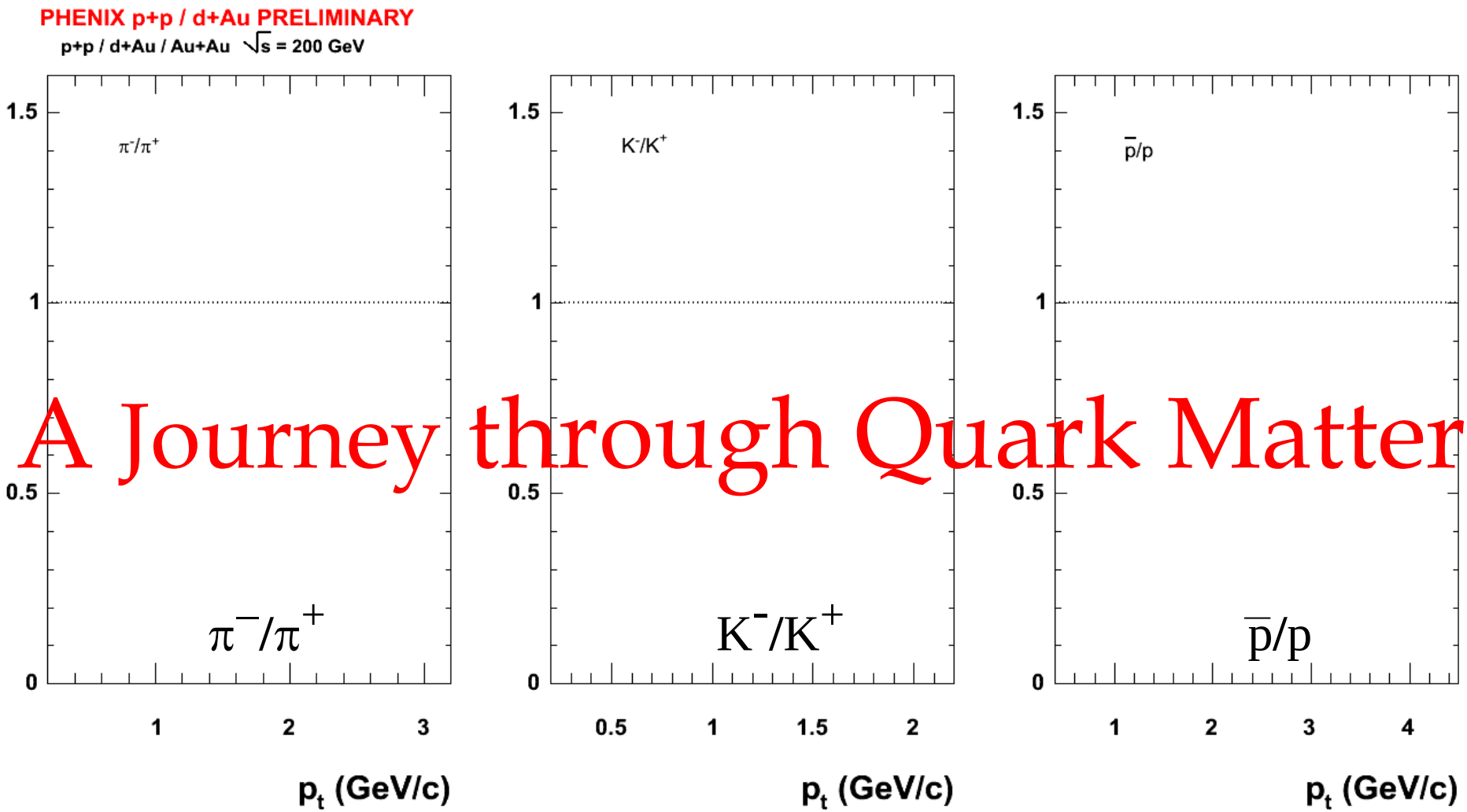

A Journey through Quark Matter.

Antimatter over Matter

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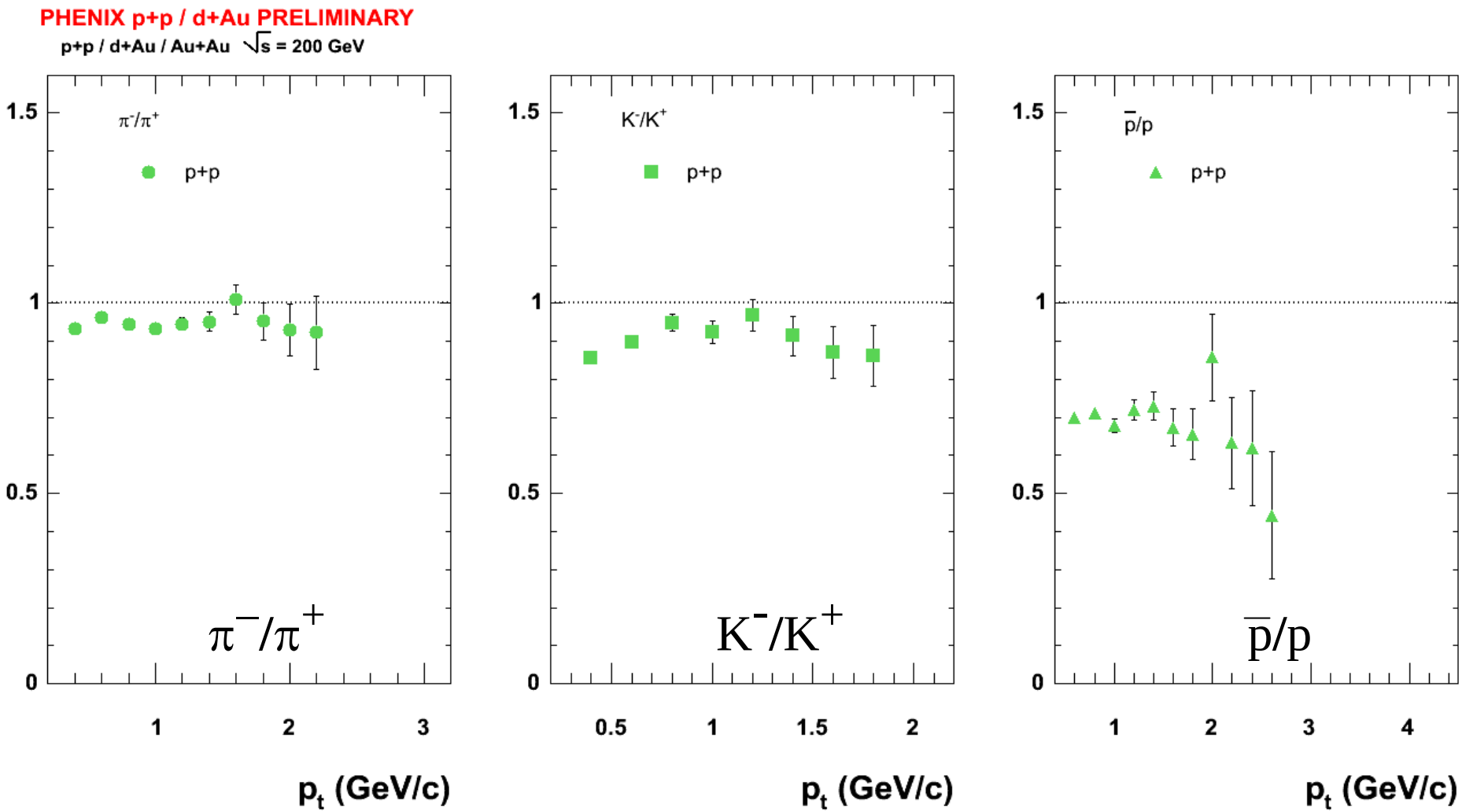

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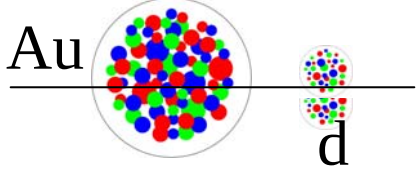

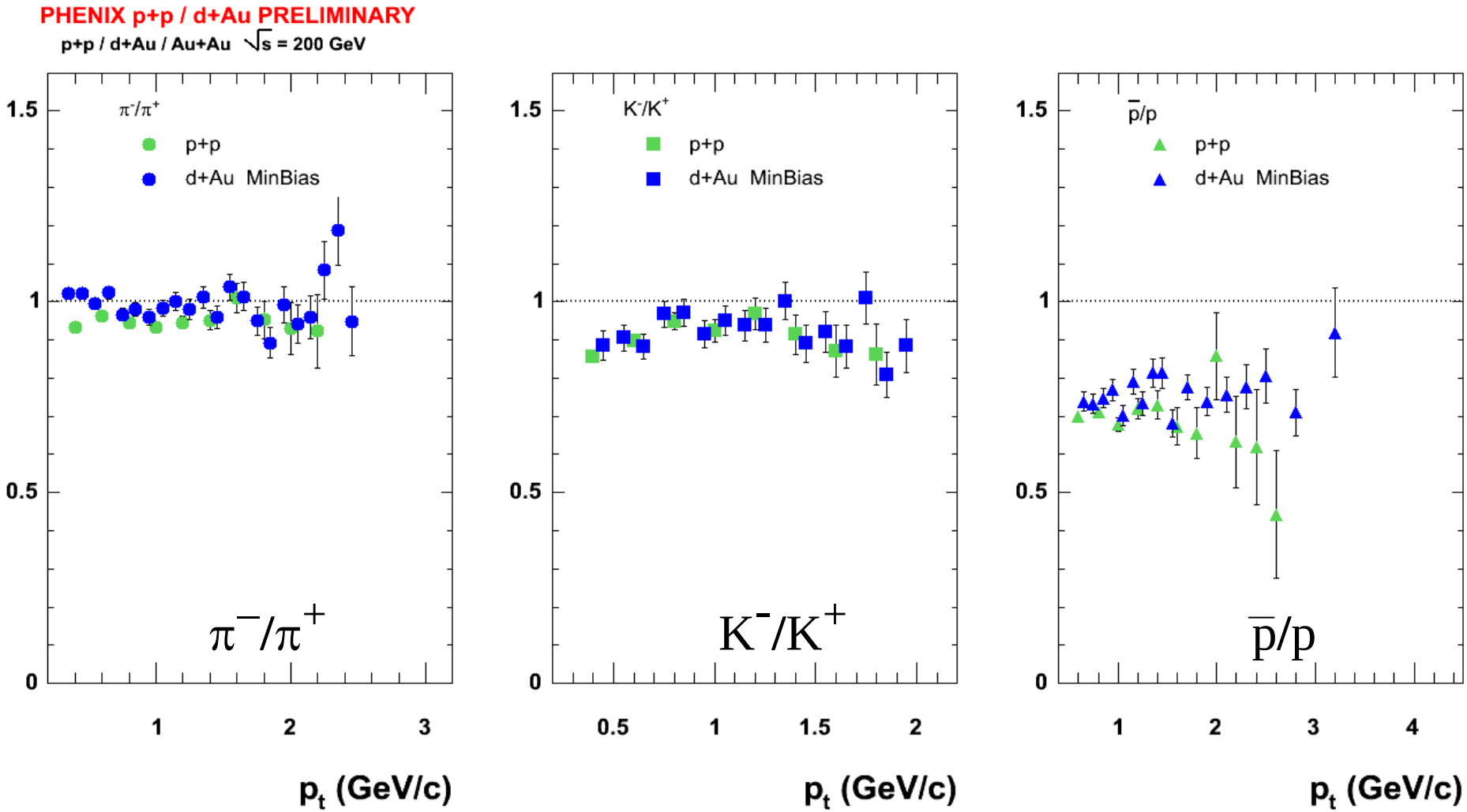

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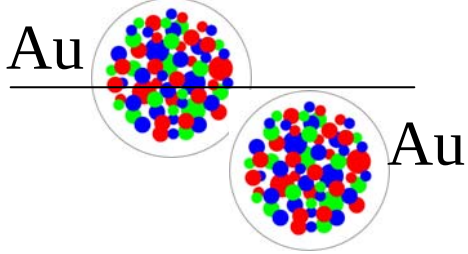

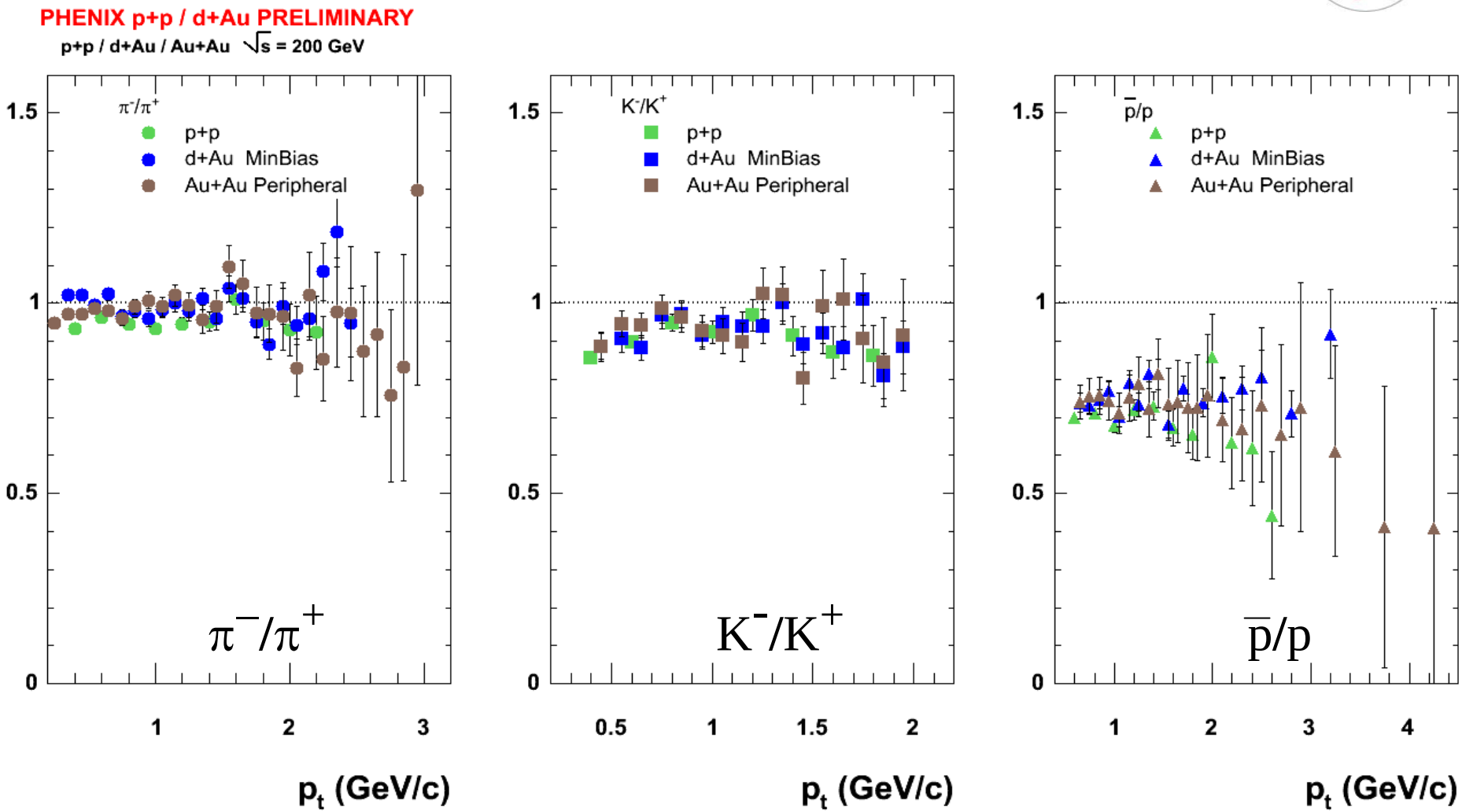

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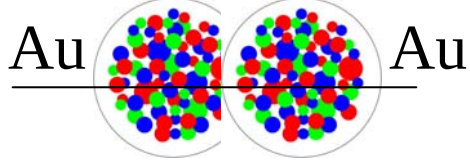

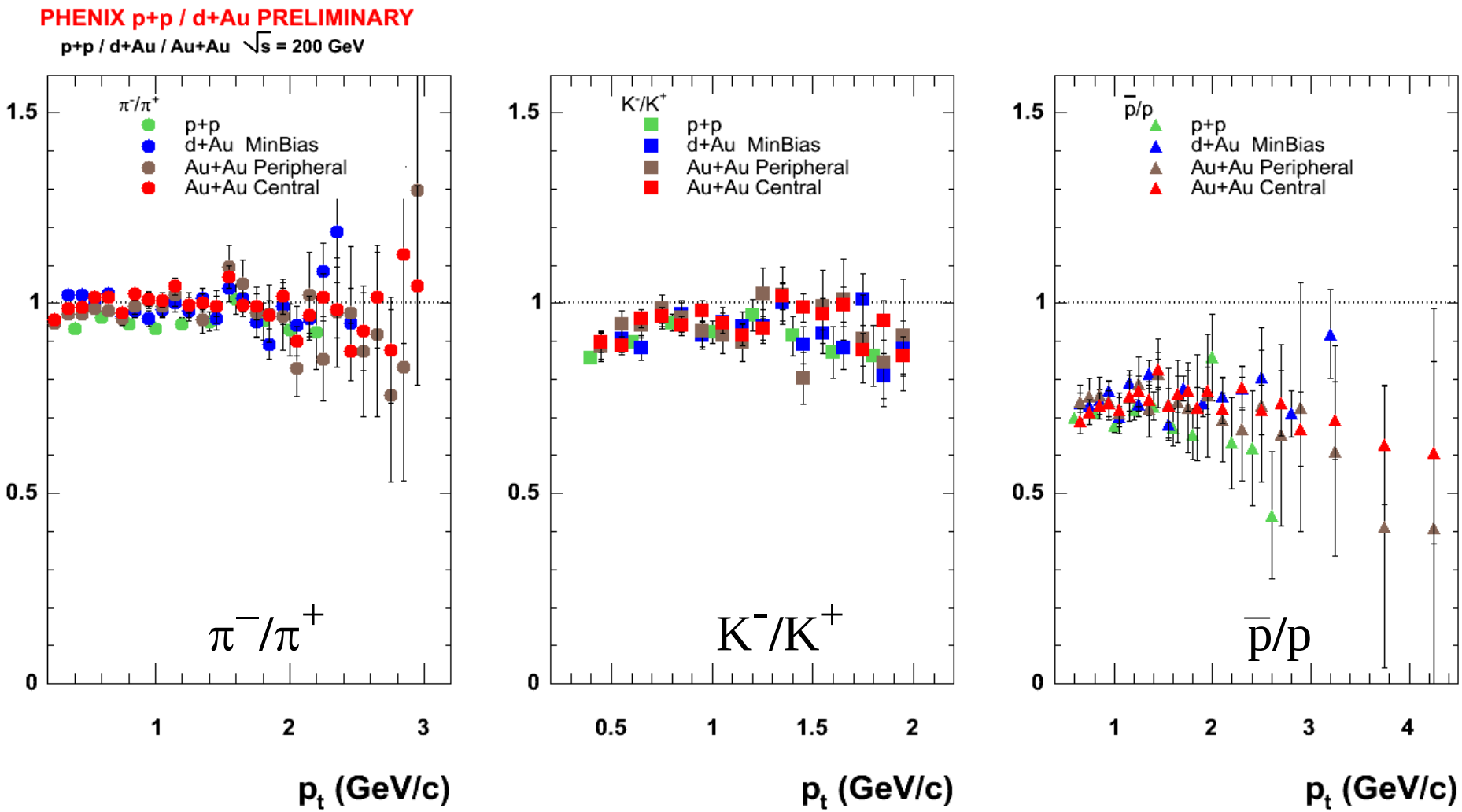

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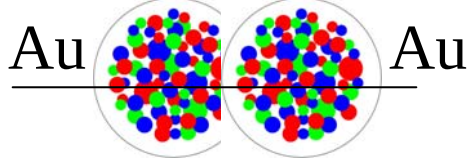
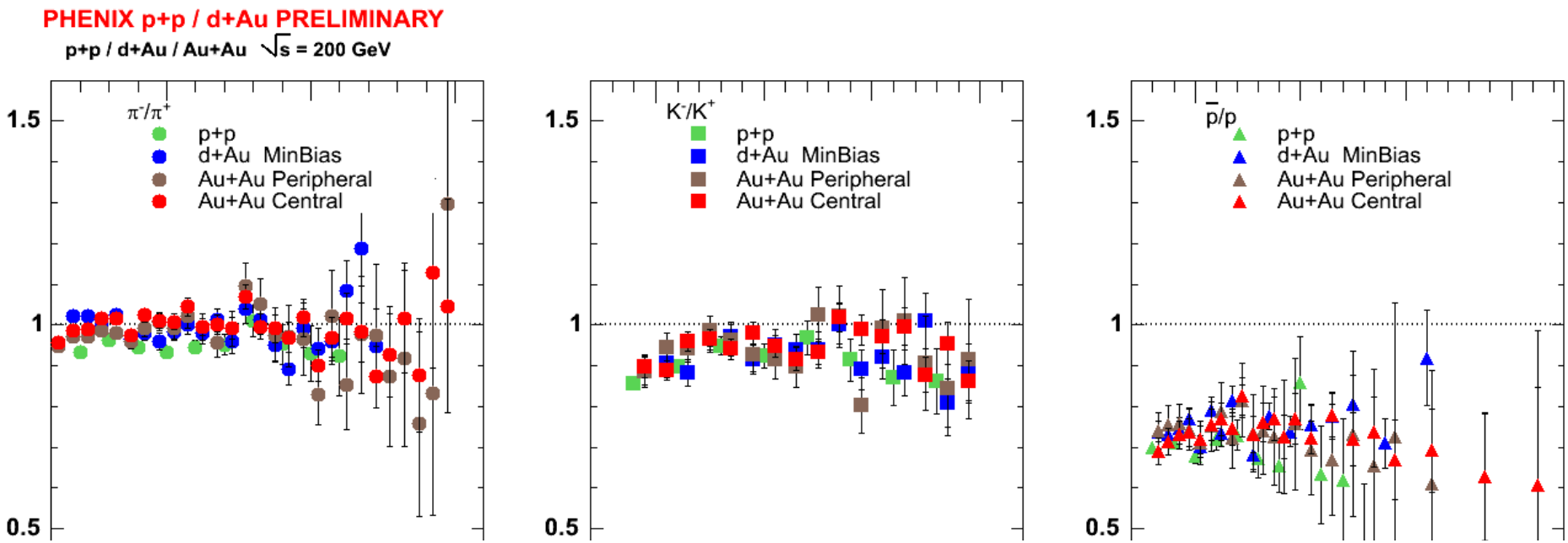
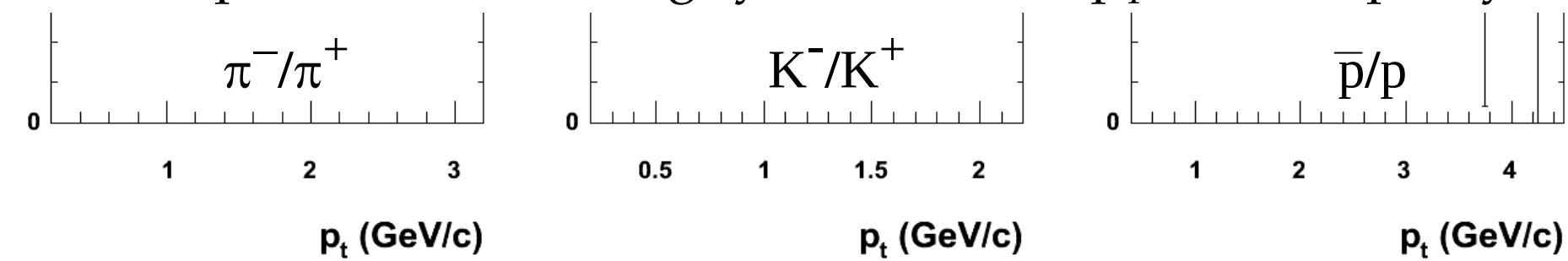


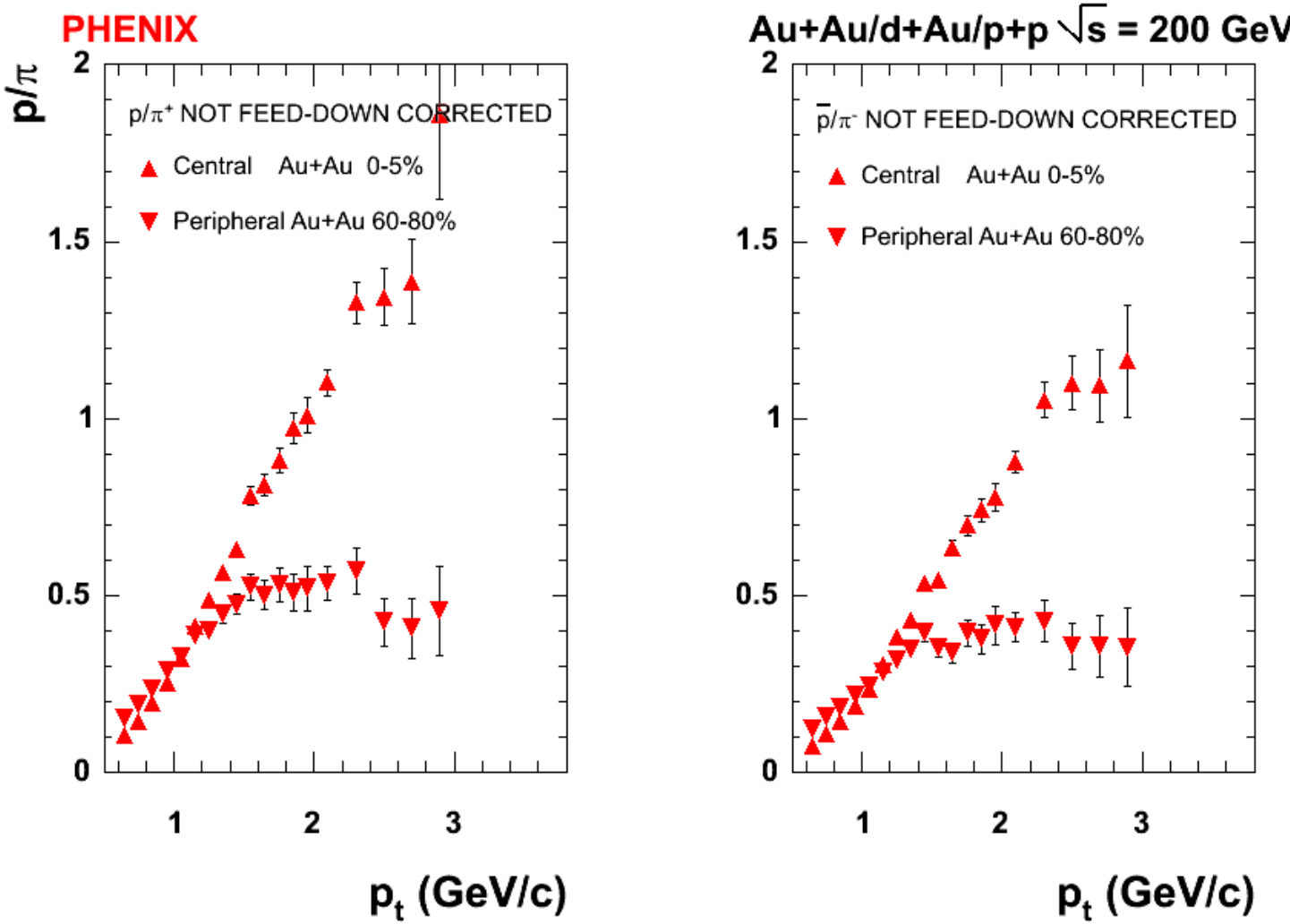


Independent of colliding system, ~flat in p_T at midrapidity



Proton to Pion Ratio.

- d+Au is following peripheral Au+Au.
- p+p is lower.
- Notice: Not Feed-down corrected.
- Assumes that Λ/p ratio is similar in d+Au and Au+Au.
- Neutral pions used to extend the pt range.



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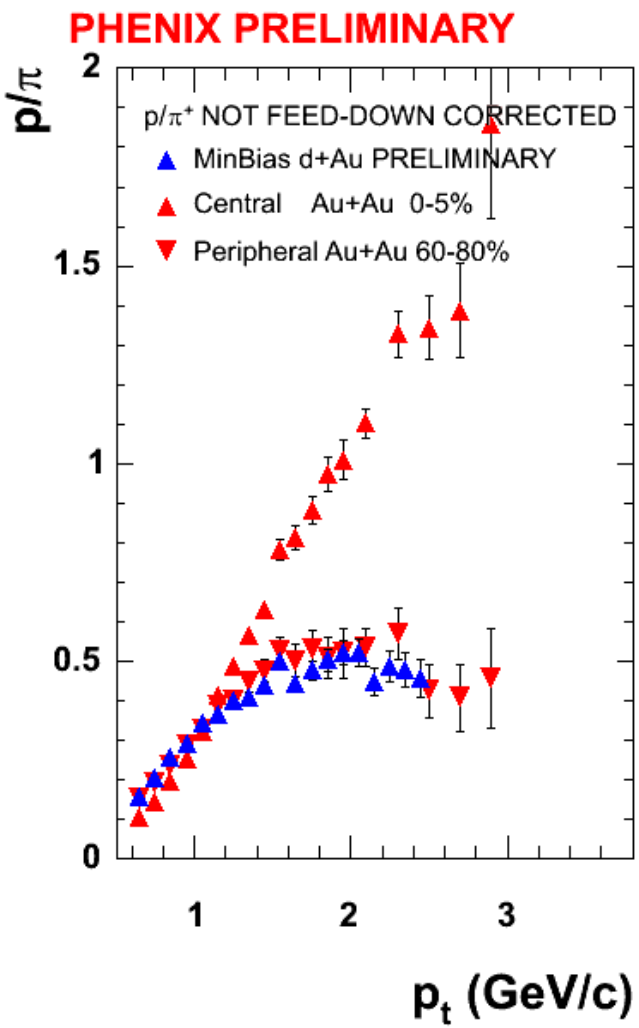

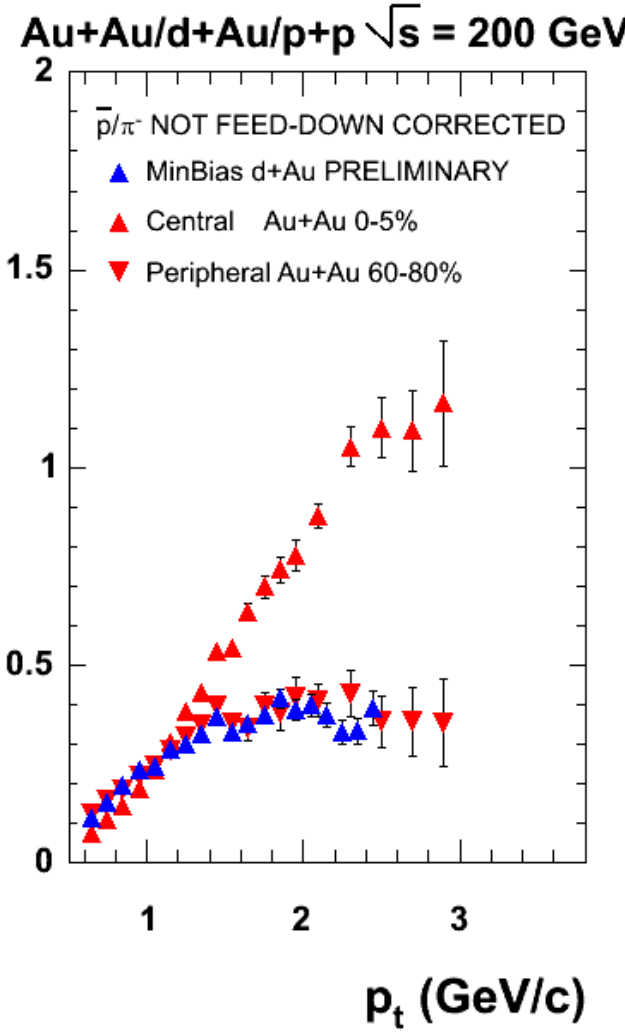

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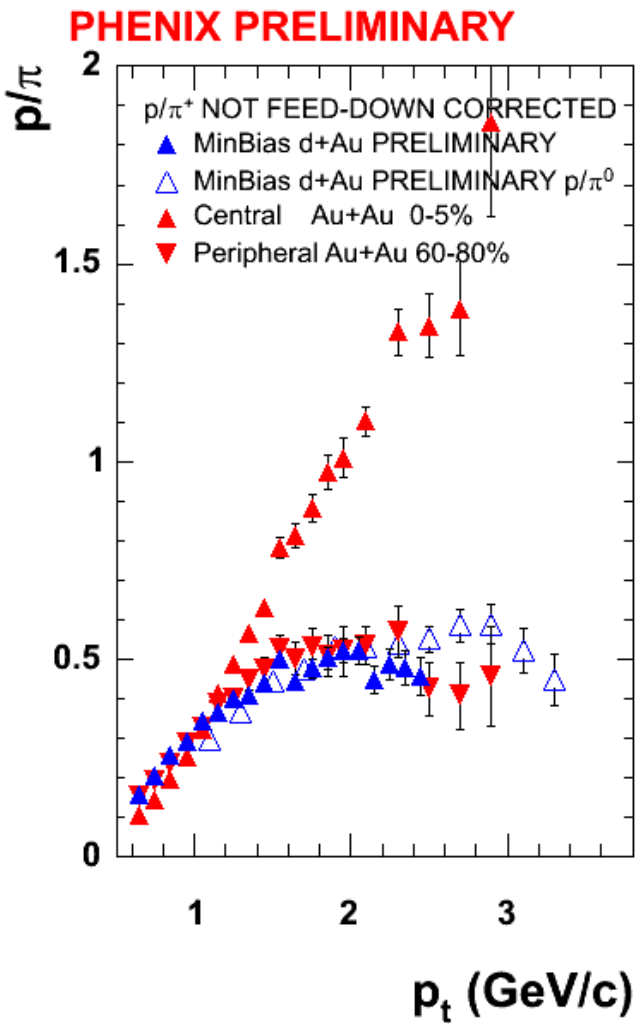

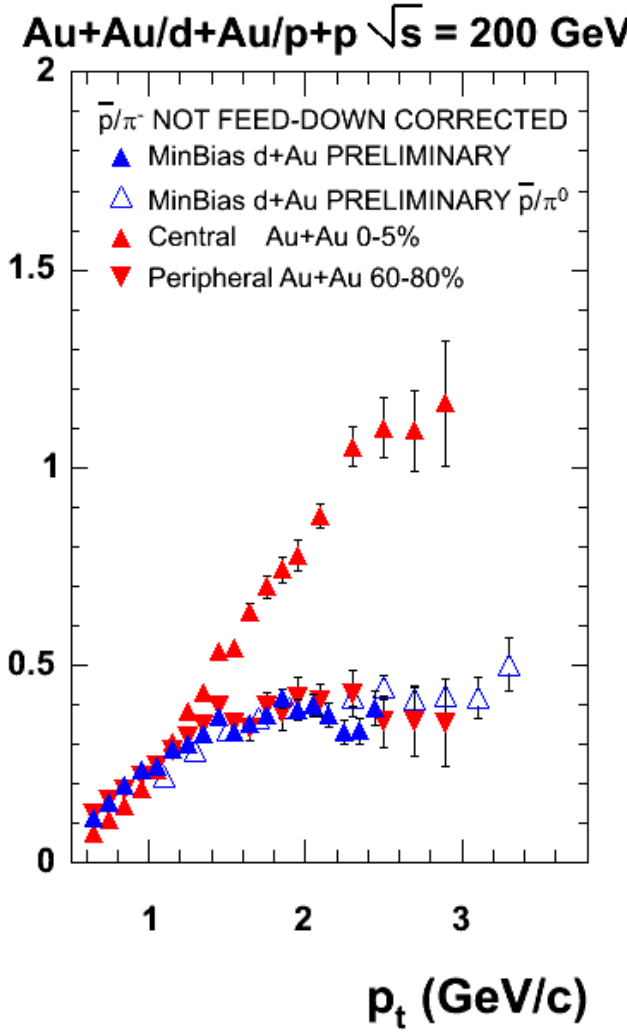

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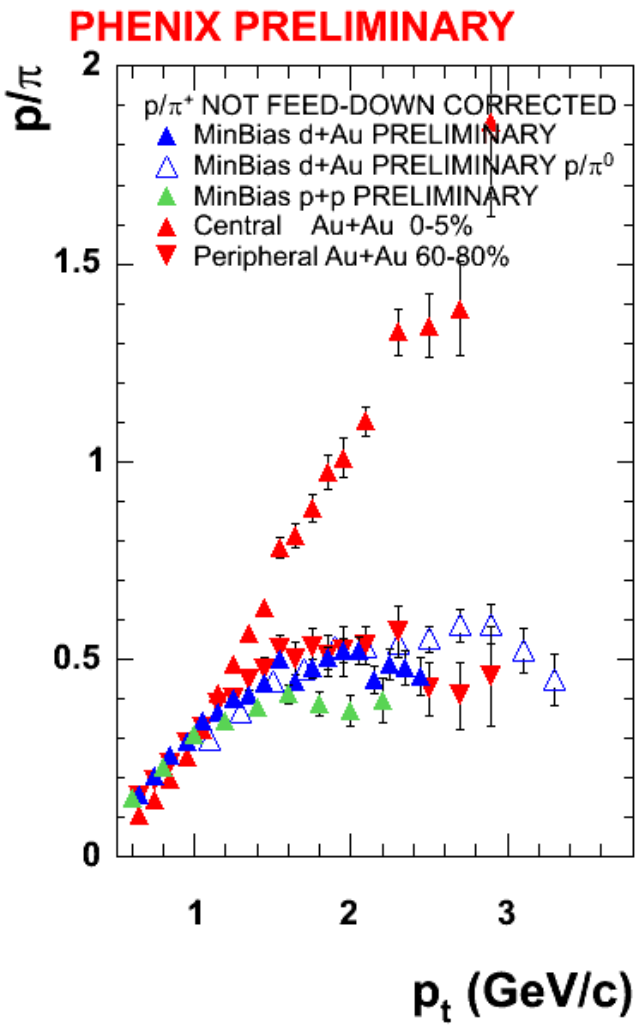
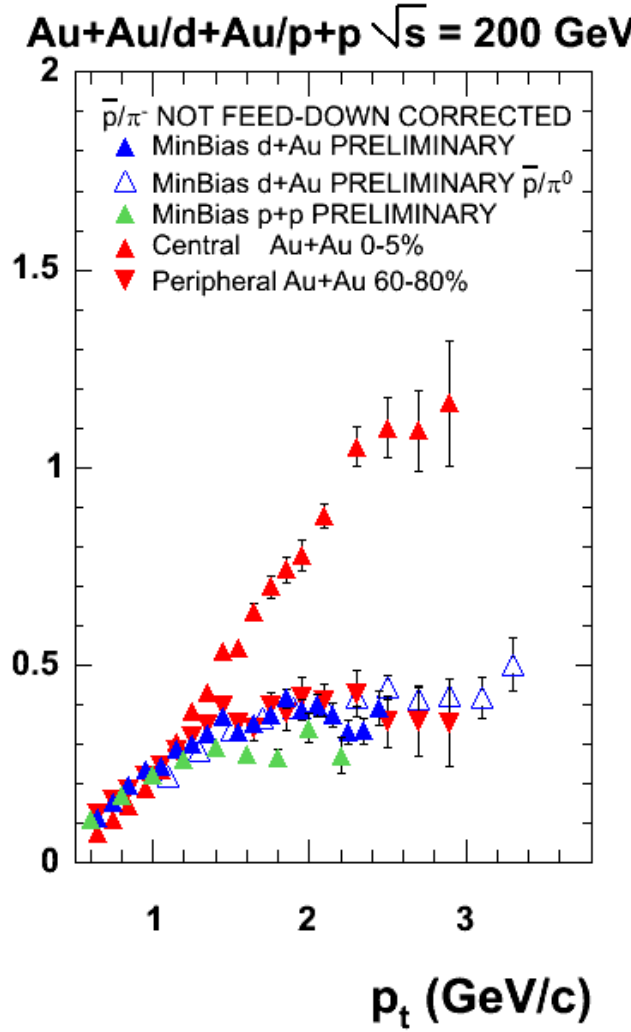
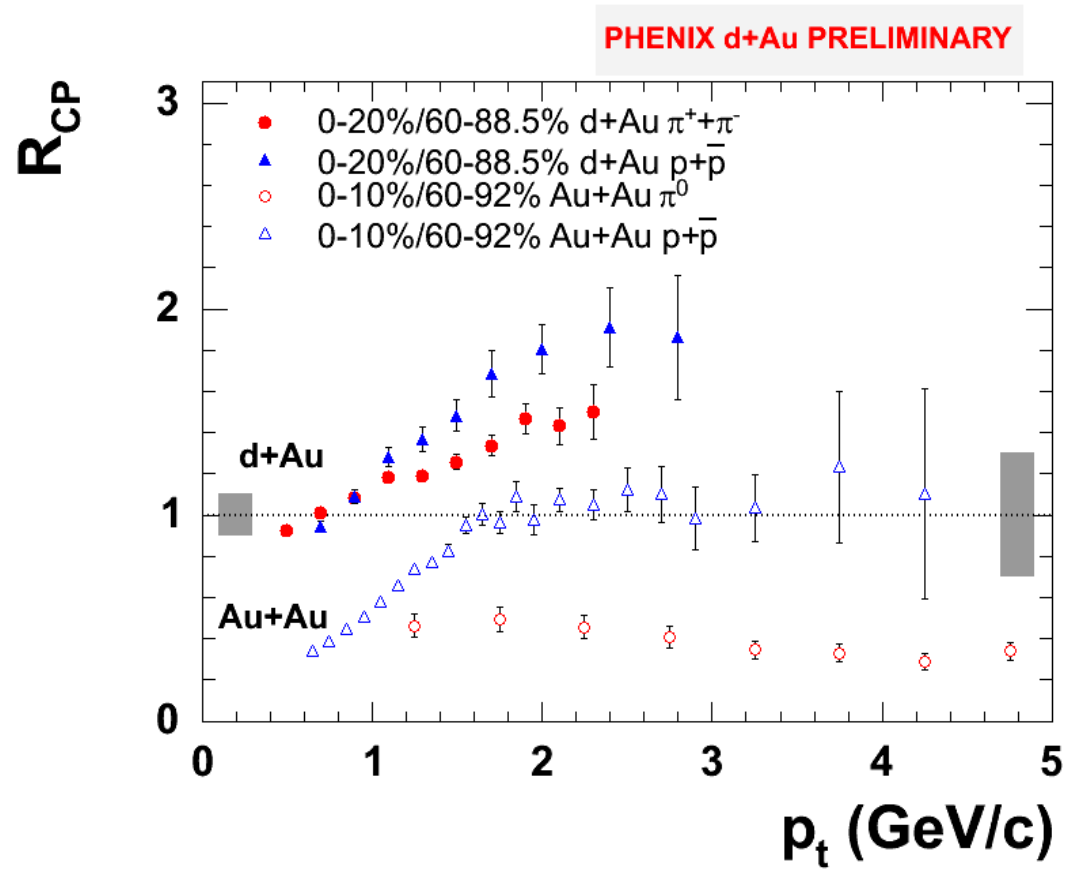




Nuclear Modification from d+Au: Cronin

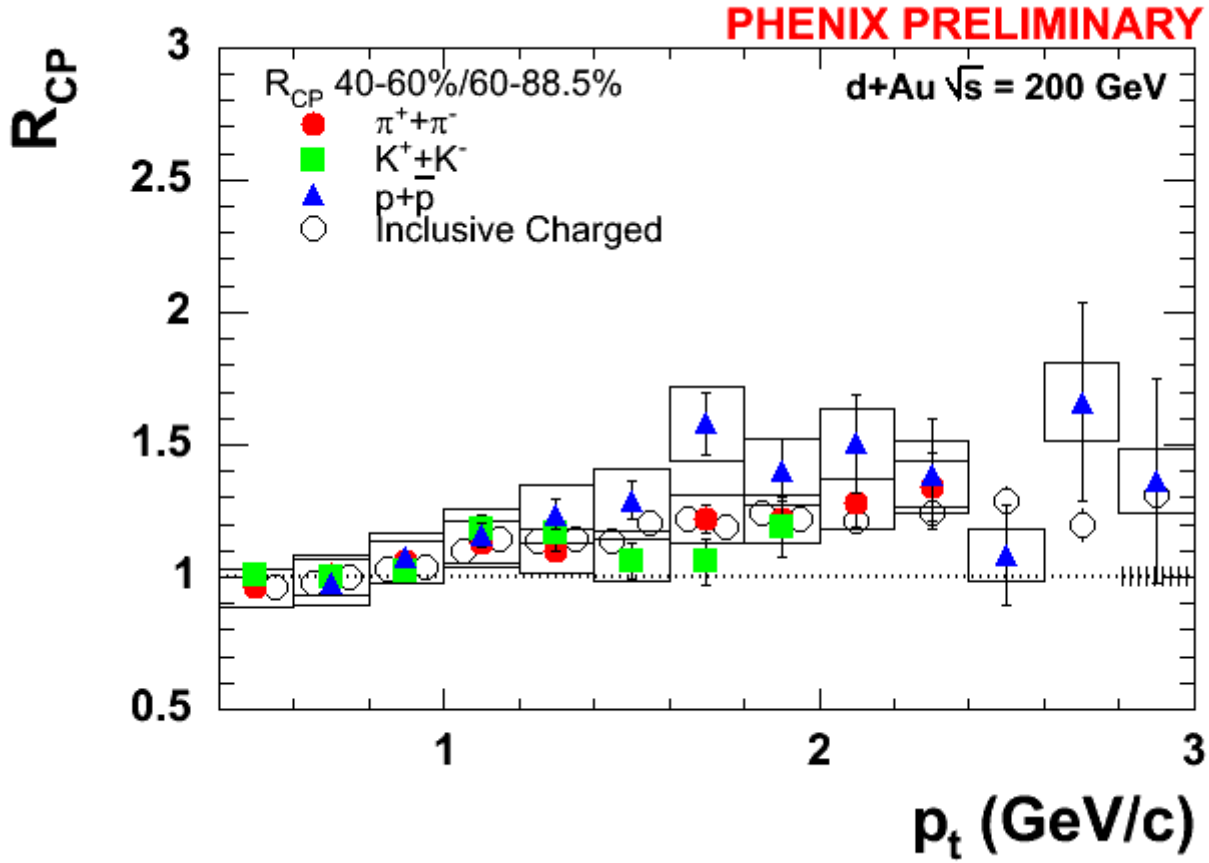
$$R_{CP} = \frac{Yield(central)/<N_{coll}(central)>}{Yield(peripheral)/<N_{coll}(peripheral)>}$$

- Strikingly different behavior in Au+Au and d+Au.
- Clearly pion suppression is a final state effect from a new state of matter.
- d+Au measurement establishes once and for all the initial state at RHIC: shadowing, Cronin, saturation scenarios at y=0.



Centrality dependence of Cronin.

- Importance of multiple centrality classes.
- Probing the response of **cold** nuclear matter with increased number of collisions.
- Propagation of quarks through the color field of a nucleus.



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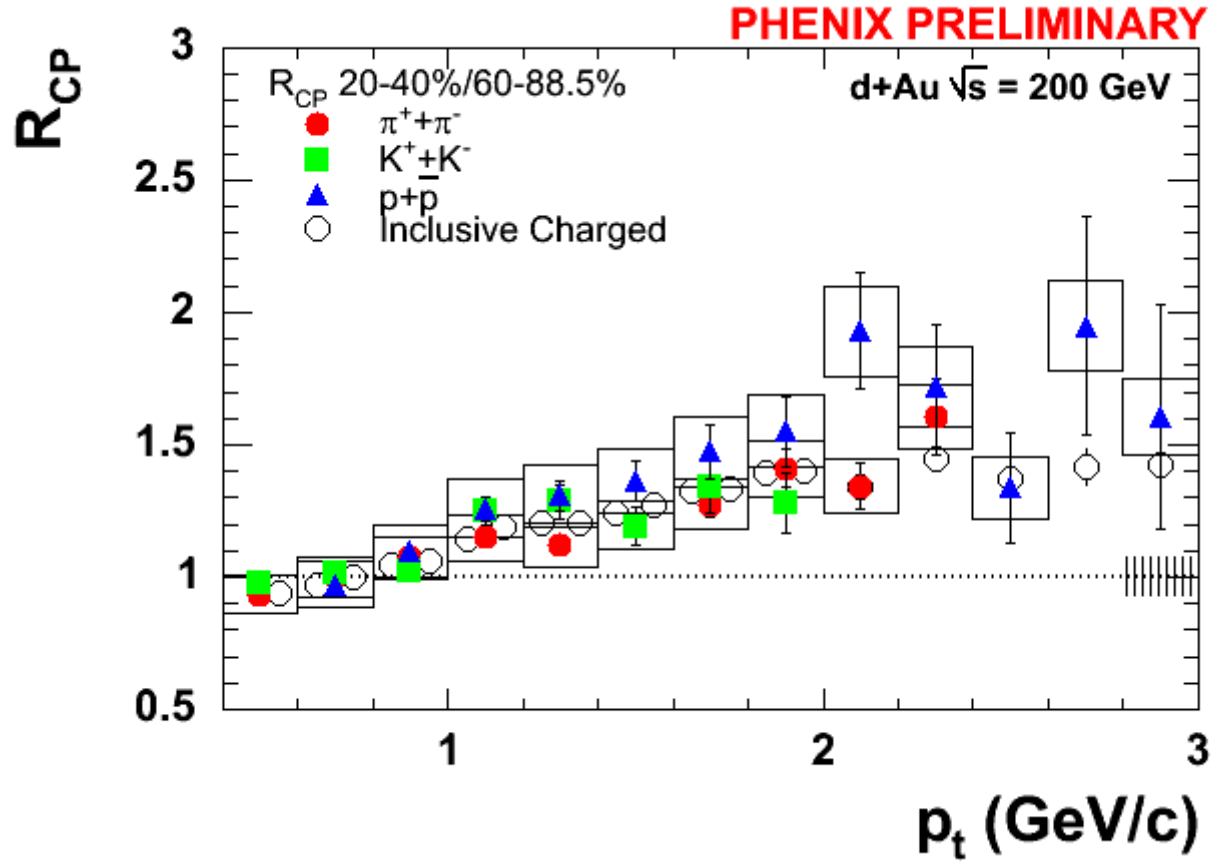

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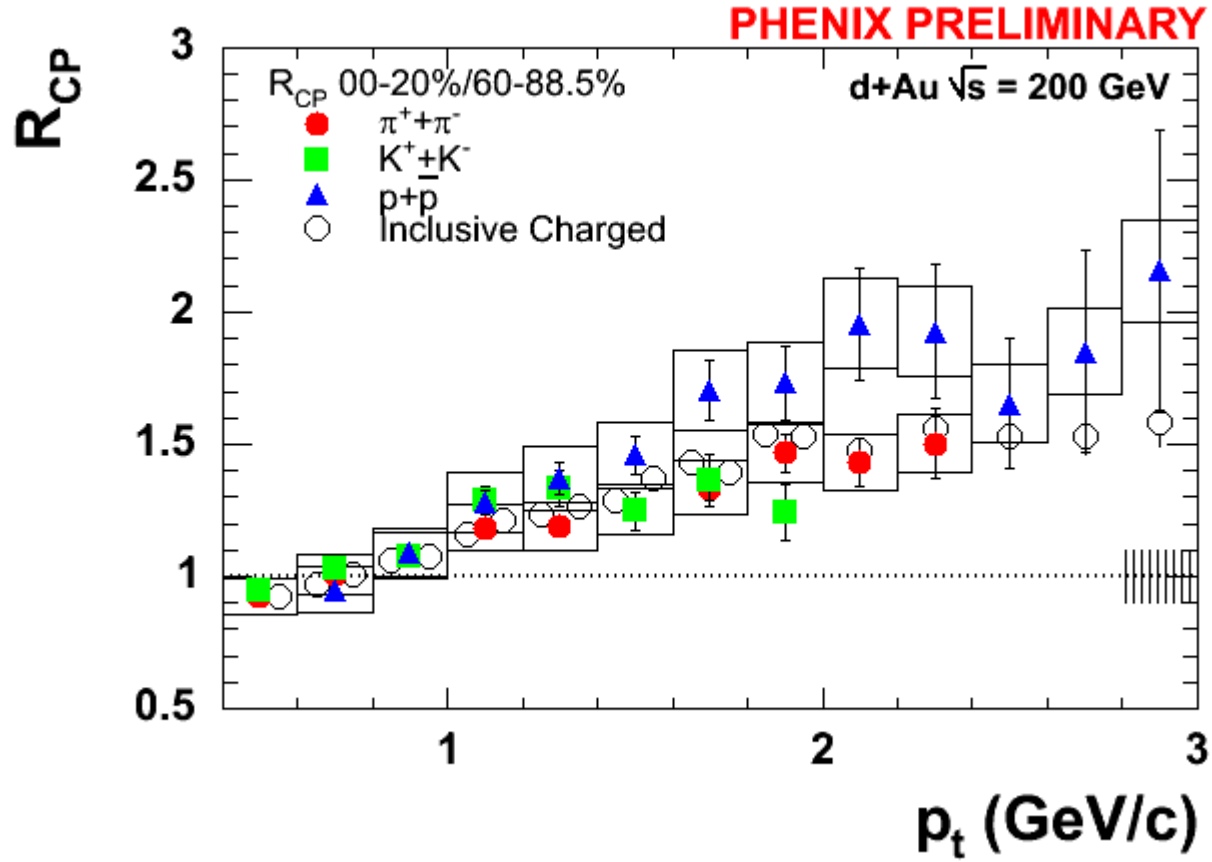

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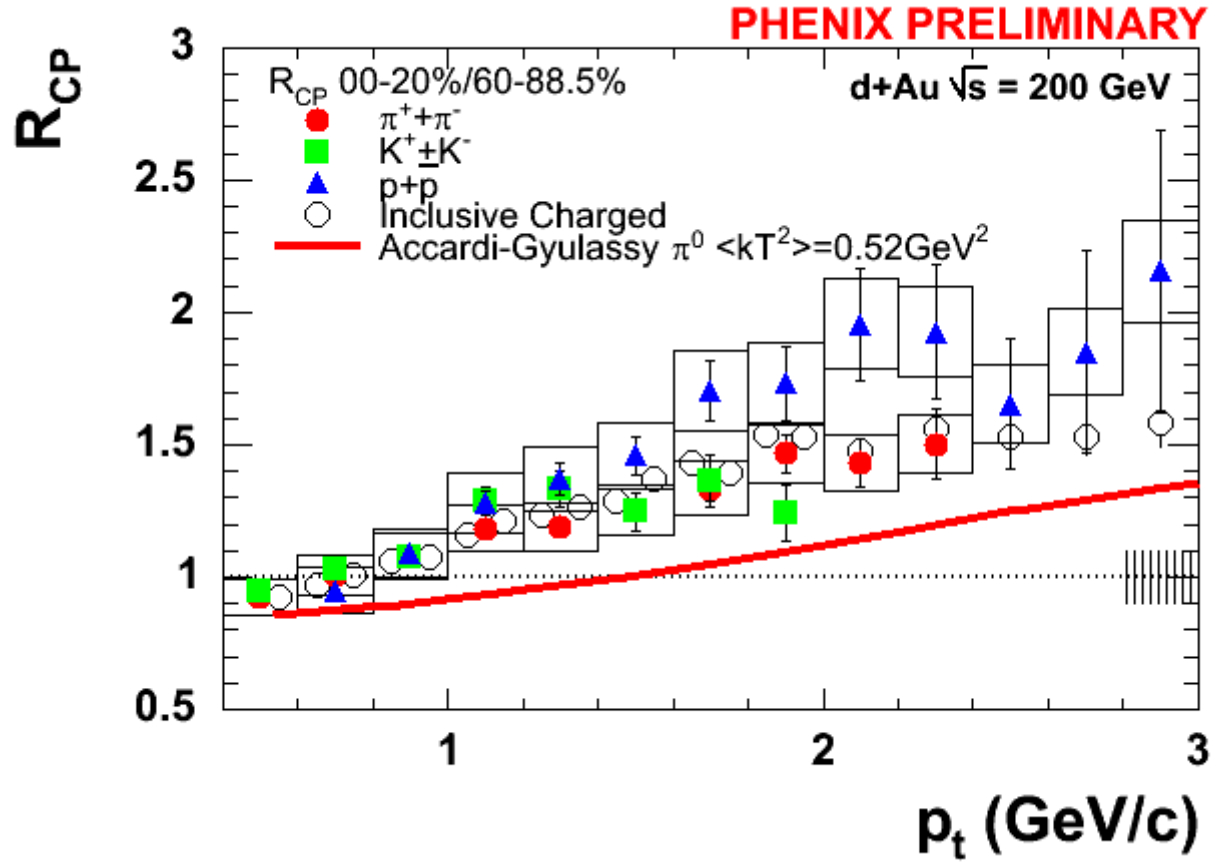
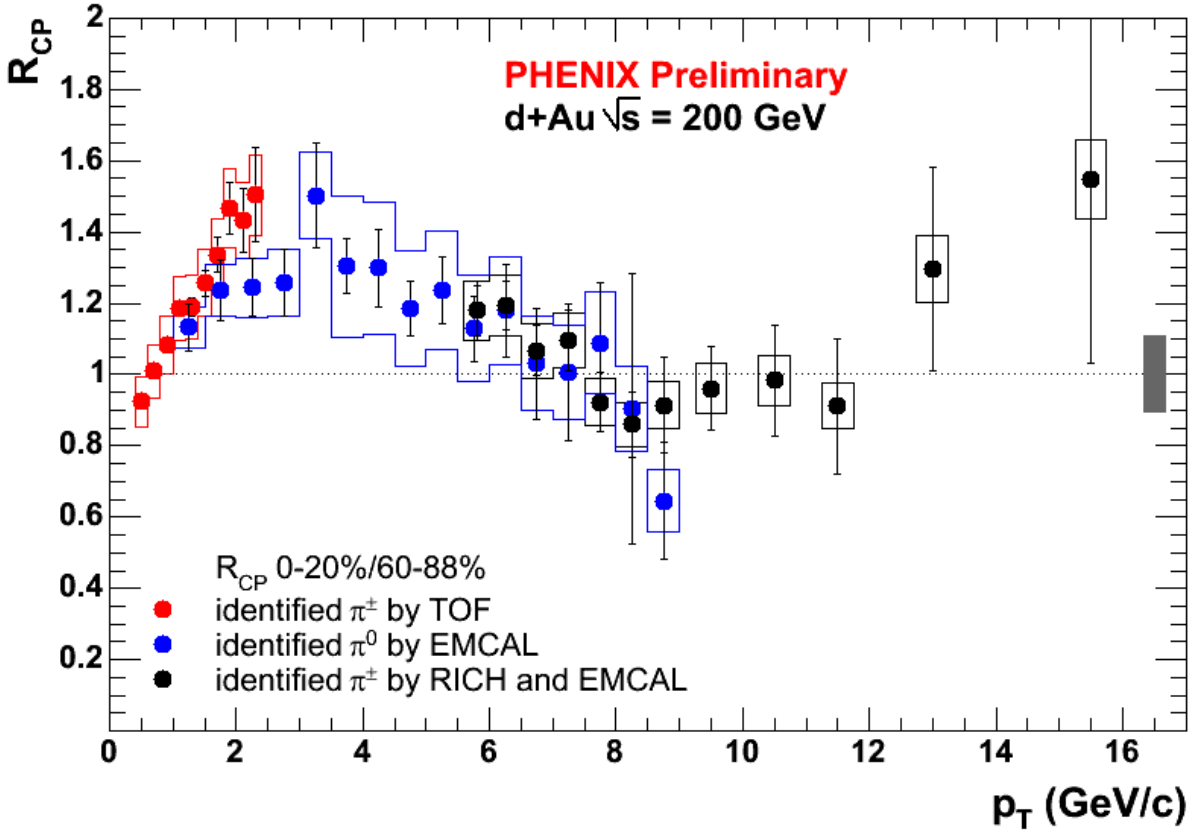


Qualitative agreement with model by Accardi and Gyulassy.
Partonic Glauber-Eikonal approach:
sequential multiple partonic collisions. nucl-th/0308029

Pion R_{CP} from 3 different detectors.

- Charged pions from TOF.
- Neutral pions from EMCAL.
- Charged pions from RICH+EMCAL.



H. Buesching: Centrality Dependence of Neutral Pion Production in d+Au collisions at 200 GeV

J.Jia: High p_T $\pi^{\pm}$ production and correlation in d+Au/p+p collisions at $\sqrt{s}$ = 200 GeV

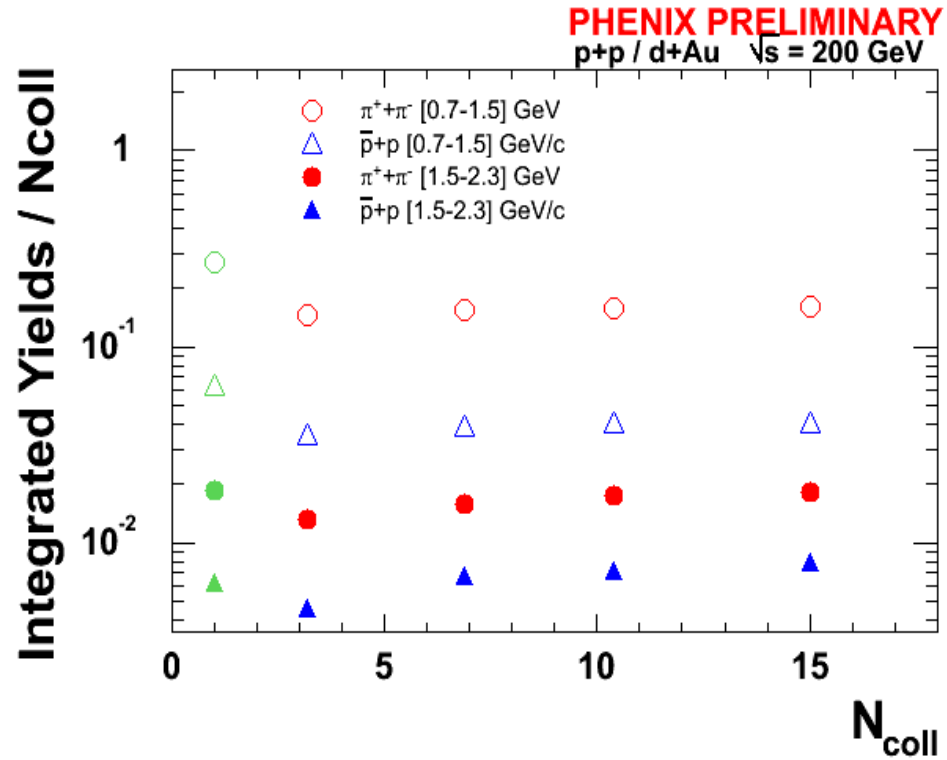
Another Microscopic Mechanism: Saturated Cronin or not ?

- A different approach to the Cronnin effect:
- Intrinsic momentum broadening in the excited projectile proton:

$$\langle k_T^2 \rangle_{pA} = \langle k_T^2 \rangle_{pp} + C \cdot h_{pA}(b) \ .$$

- h_{pA}: average number of collisions:

$$h_{pA}(b) = \begin{cases} \nu_A(b) - 1 & \nu_A(b) < \nu_m \\ \nu_m - 1 & \text{otherwise} \end{cases} \ .$$



X.N.Wang, Phys.Rev.C 61 (2000): no upper limit.

Zhang, Fai, Papp, Barnafoldi & Levai, Phys.Rev.C 65 (2002): n=4 due to proton dissociation.

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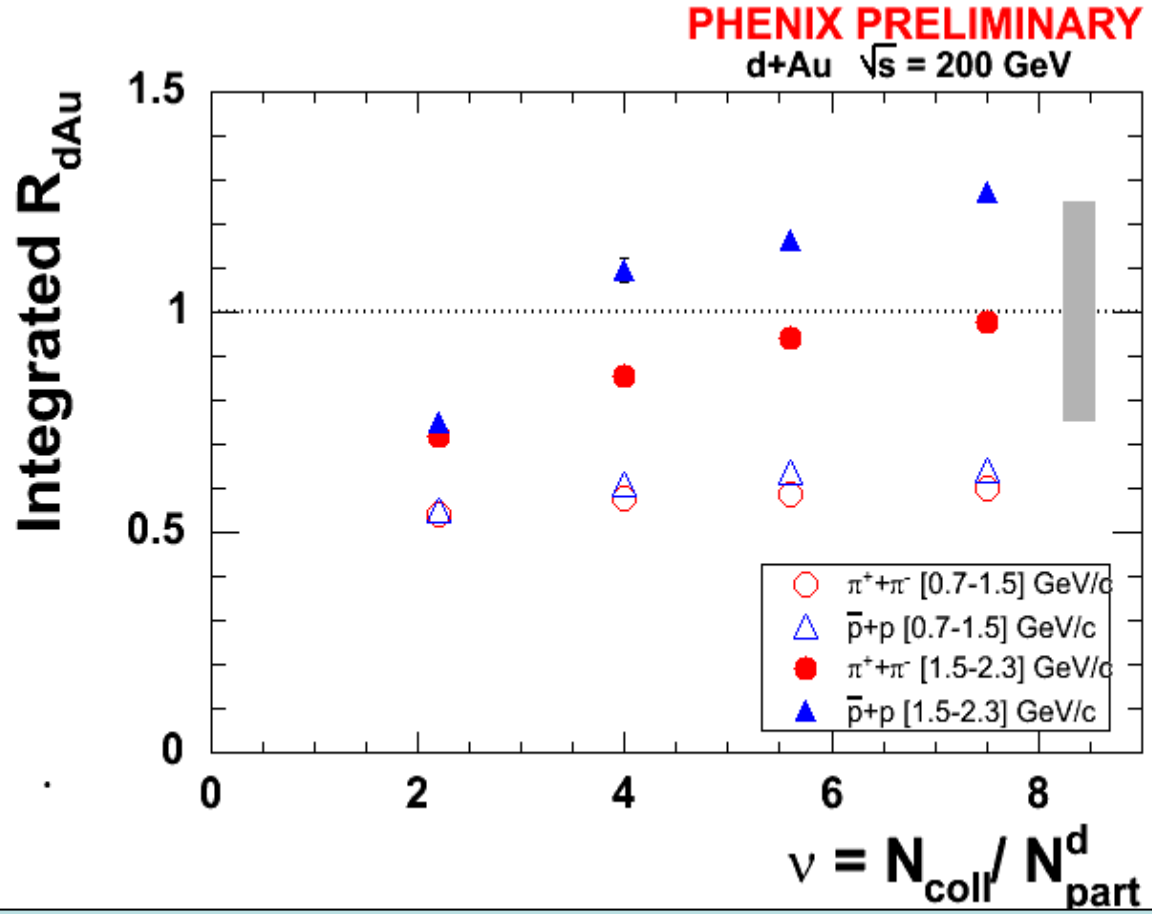

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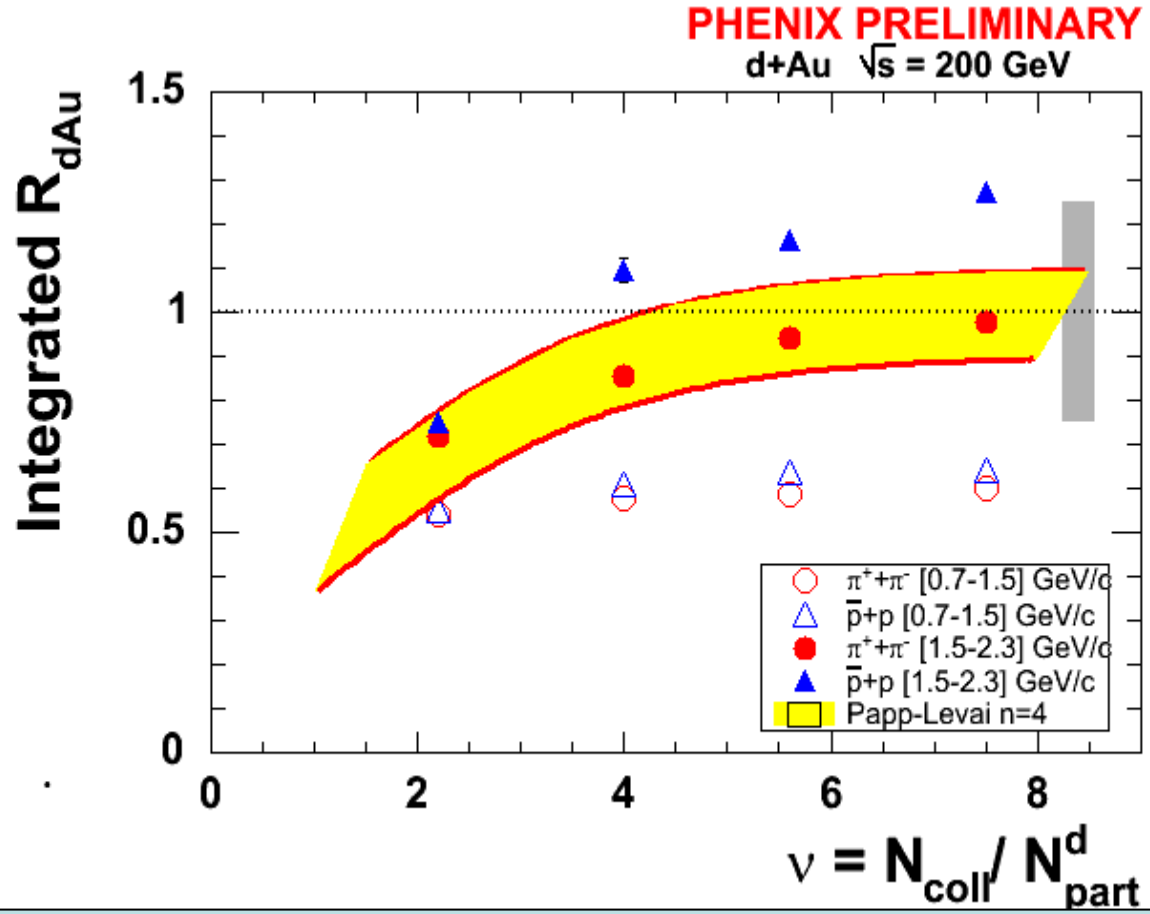

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Summary

- Properties of identified particle production have been presented for all available colliding systems at RHIC so far.
- Antimatter to matter ratios are independent of colliding systems and consistent with flat in pt at midrapidity.
- Centrality, pt and species dependence of Cronin effect in d+Au fully studied.
- Cronin enhancement increases with centality, quantitative constraints for theoretical models of multiple scattering.
- Proton Cronin higher than pions but can not explain factor of 5 baryonic enhancement in central Au+Au.
- d+Au looks very similar to peripheral Au+Au.
- Initial state effects in Au nuclei are established at y=0.
- d+Au collisions strongly point towards interpreting Au+Au phenomena as final-state within a dense partonic medium.

Brazil	University of São Paulo, São Paulo
China	Academia Sinica, Taipei, Taiwan
	China Institute of Atomic Energy, Beijing
	Peking University, Beijing
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	Dapnia, CEA Saclay, Gif-sur-Yvette
	IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, Orsay
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	SUBATECH, Ecòle des Mines at Nantes, Nantes
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Hungary	Central Research Institute for Physics (KFKI), Budapest
	Debrecen University, Debrecen
	Eötvös Loránd University (ELTE), Budapest
India	Banaras Hindu University, Banaras
	Bhabha Atomic Research Centre, Bombay
Israel	Weizmann Institute, Rehovot
Japan	Center for Nuclear Study, University of Tokyo, Tokyo
	Hiroshima University, Higashi-Hiroshima
	KEK, Institute for High Energy Physics, Tsukuba
	Kyoto University, Kyoto
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Sweden	Lund University, Lund

12 Countries; 58 Institutions; 480 Participants*

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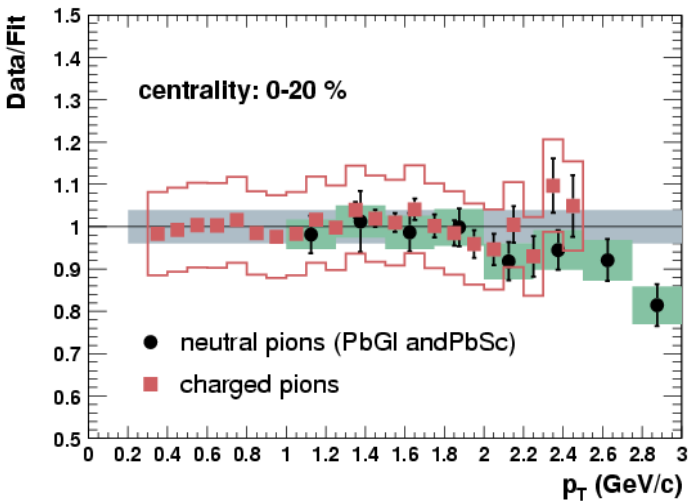
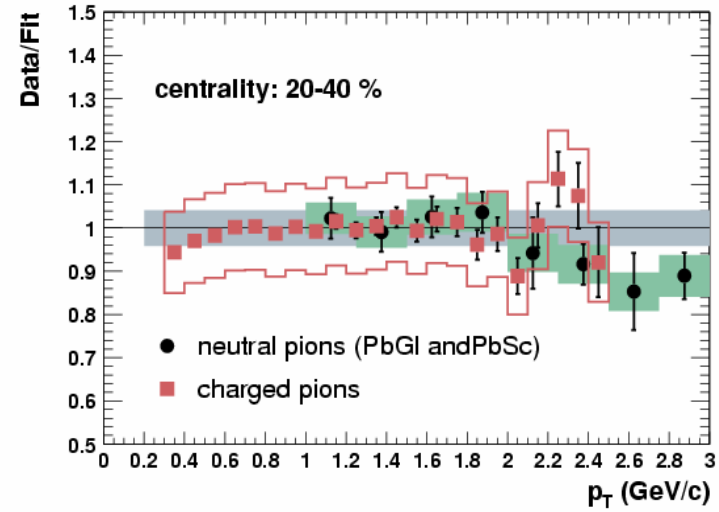
	Oak Ridge National Laboratory, Oak Ridge, TN
	University of Tennessee, Knoxville, TN
	Vanderbilt University, Nashville, TN

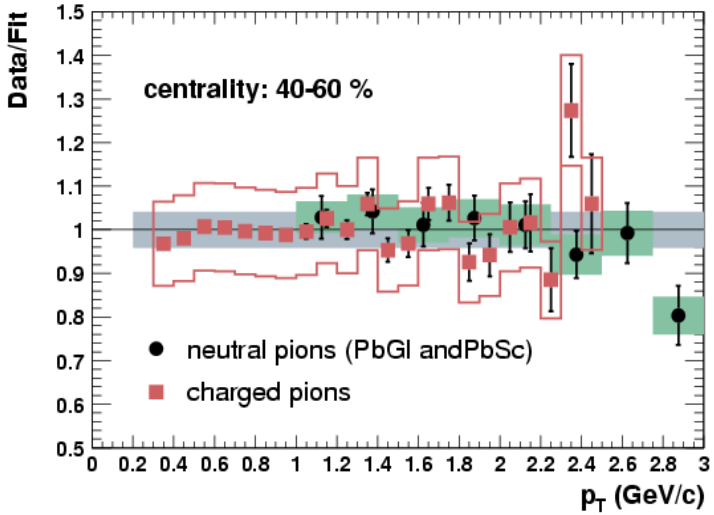
***as of January 2004**

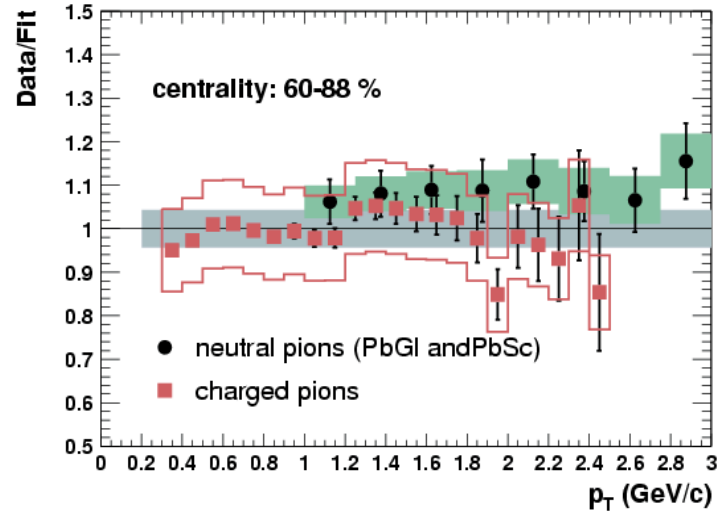
backups

Comparison with neutral pions









Number of collisions in d+Au.