Identified Charged Hadron Spectra and Ratios in Au+Au and d+Au Collisions at $\sqrt{s_{NN}}$ =200 GeV

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About this talk

- Results from new PHENIX paper arXiv:1304.3410
- I'll just show a few interesting highlights:
 - p/π in d+Au and R_{dA}
 - ${\scriptstyle \bullet}\,$ Comparisons of peripheral Au+Au and central d+Au

Physics Motivation: Baryon/Meson Production



- Strong suppression of π^0 , no apparent suppression of protons
- Heavy meson ϕ has similar mass to proton but similar suppression to pion—not a mass effect (e.g. radial flow)
- Possible explanation of baryon enhancement: parton recombination (also explains quark number scaling found in elliptic flow data)

Physics Motivation: Cold Nuclear Matter Effects



Phys. Rev. Lett. 91, 072303 (2003)

- Cronin enhancement: enhancement of particle yield at intermediate p_T in p+A collisions relative to p+p
- Similar bayron vs. meson dynamics in d+Au and Au+Au!
- Traditional explanations of Cronin do not explain baryon vs meson effect





PHENIX

- 16 detector subsystems, several million channels (mostly central and forward silicon detectors)
- This analysis makes use of the tracking system (drift chambers and pad chambers) and the time-of-flight west for PID
- 4.27 billion Au+Au events from 2007
- 1.85 billion d+Au events from 2008



Physics Motivation PHENIX and the TOFW Results Summary

PID with the time-of-flight west

To determine which tracks in m^2-p_T space belong to which particle species, we make cuts on two standard deviations of one particle and exclude two standard deviations of the other (2σ window with 2σ veto):



- The TOFW is comprised of multi-gap resistive plate chambers
- Each chamber has six 230µm gaps
- 75 ps intrinsic timing resolution—84 ps in Au+Au, 95 ps in d+Au with start time from beam-beam counter

Ratio p/π in d+Au



- Ratio rises quickly, reaches maximum at about 2.5 GeV/c, then falls off slowly
- Strong centrality dependence (small range of N_{part}!)

Physics Motivation

PHENIX and the TOFW

Results

Summary

R_{dA} of $\pi/K/p$ for different centralities



- Small centrality dependence for pions and kaons consistent within uncertainties
- Strong centrality dependence for protons

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K/π and p/π in peripheral Au+Au and central d+Au



- Very similar N_{coll} (14.8 and 15.1) and N_{part} (14.7 and 15.3) values for peripheral Au+Au and central d+Au (respectively)
- Essentially identical height and shape of both ratios in the two systems
- Suggestive of common hadron production mechanism for the two systems

Ratio of yields in peripheral Au+Au to central d+Au



- No scaling applied, *N_{coll}* and *N_{part}* have very similar values
- Flat in p_T above 2.5–3.0 GeV/c with no species dependence
- Upward trend at low p_T with possible mass ordering
- Which physics effects cancel out and which ones are at play? Cronin? Flow? Baryon enhancement? Rapidity shift? nPDFs?

Physics Motivation	PHENIX and the TOFW	Results	Summary
Summary			

- First observation of strong centrality dependence of proton enhancement in d+Au, seen in p/π ratio and R_{dA}
- $\bullet\,$ Indication of common hadron production mechanism between central d+Au and peripheral Au+Au
 - Identical K/π and p/π ratios
 - Direct ratio of spectra is flat and independent of species above 2.5 GeV/c
- Remarkable similarities between peripheral Au+Au and central d+Au suggest other asymmetric collision species (like the Cu+Au in Run12) could reveal some very interesting physics
 - Should see rapidity shift
 - nPDFs will be different
- Further theoretic investigation is warranted! Viscous hydro, recombination, baryon junctions and strong color field effects, etc...

Backups

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Centrality

Centrality	$\langle N_{coll} \rangle$	$\langle N_{part} \rangle$
Au+Au		
0-10%	960.2 ± 96.1	325.8 ± 3.8
10-20%	609.5 ± 59.8	236.1 ± 5.5
20-40%	300.8 ± 29.6	141.5 ± 5.8
40-60%	94.2 ± 12.0	61.6 ± 5.1
60-92%	$\textbf{14.8} \pm \textbf{3.0}$	$\textbf{14.7}\pm\textbf{2.9}$
d+Au		
0-20%	$\textbf{15.1} \pm \textbf{1.0}$	$\textbf{15.3} \pm \textbf{0.8}$
20-40%	10.2 ± 0.7	11.1 ± 0.6
0-100%	7.6 ± 0.4	8.5 ± 0.4
40-60%	6.6 ± 0.4	7.8 ± 0.4
60-88%	3.1 ± 0.2	4.3 ± 0.2
p+p	$\equiv 1$	$\equiv 2$

Summary

Pion Spectra



- Au+Au up to 6 GeV/c and d+Au up to 5 GeV/c
- Previous results are up to 3 GeV/c for Au+Au [Phys. Rev. C69, 034909 (2004)] and 2.6 for d+Au [Phys. Rev. C74, 024904 (2006)]

Summary

Kaon Spectra



- Au+Au up to 4 GeV/c and d+Au up to 3.5 GeV/c
- Previous results are up to 2 GeV/c for Au+Au [Phys. Rev. C69, 034909 (2004)] and 1.8 for d+Au [Phys. Rev. C74, 024904 (2006)]

Summary

Proton Spectra



- Au+Au up to 6 GeV/c and d+Au up to 5 GeV/c
- Previous results are up to 4.5 GeV/c for Au+Au [Phys. Rev. C69, 034909 (2004)] and 3.6 for d+Au [Phys. Rev. C74, 024904 (2006)]

PHENIX and the TOFW

Results

Summary

Ratio π^-/π^+



- π^-/π^+ ratio is independent of p_T , centrality, and collision system
- Ratio is essentially equal to unity
- Ratio decreases with increasing p_T in p+p

Summary

Ratio K^-/K^+



- K^-/K^+ ratio is independent of p_T , centrality, and collision system
- Ratio is slightly less than unity (0.93)
- Ratio decreases with increasing p_T in p+p

Ratio \bar{p}/p



- \bar{p}/p ratio is independent of p_T , centrality, and collision system
- Ratio is roughly 0.73 (consistent with thermal model $\mu_B = 29$ MeV)
- Ratio decreases with increasing p_T in p+p

Antiparticle/particle ratios in p+p



Ratio K/π in Au+Au



- Identical centrality dependence and p_T shapes
- Weak centrality dependence
- Ratio rises steadily over the whole available p_T range

Ratio K/π in d+Au



arXiv:1304.3410

- Identical p_T shapes
- No centrality dependence
- Ratio rises steadily over the whole available p_T range

PHENIX and the TOFW

Results

Summary

Ratio p/π in Au+Au



- Identical centrality dependence and p_T shapes
- Strong centrality dependence
- Ratio rises quickly, reaches maximum at about 2.5 GeV/c, then falls off slowly

Physics Motivation

PHENIX and the TOFW

Results

Summary

R_{AA} of $\pi/K/p$ for different centralities



- Pions and kaons have clear and monotonic centrality dependence, protons consistent within uncertainties
- Peripheral R_{AA} for protons still shows appreciable modification

Physics Motivation

PHENIX and the TOFW

Results

Summary

Ratio of yields in peripheral Au+Au to central d+Au



- No scaling applied, *N_{coll}* and *N_{part}* have very similar values
- Possible mass dependence at low p_T
- Identical trend above 2.5–3.0 GeV/c