Energy Loss and Flavor Dynamics from Single Particle Measurements in PHENIX

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# Outline

- Introduction and Physics Motivation
- Experimental Setup
- Results and Discussion
- Conclusion and Outlook

## **Baryon/Meson Production**

PRL.91.172301

Nucl.Phys.A.757:184-283



- Observed baryon enhancement at intermediate p<sub>T</sub>
- Recombination may explain difference from jet fragmentation
- Need to extend  $p_T$  reach of measurement

# **Color Charge Dependence**



S. Wicks et al - Nucl.Phys.A784:426-442,2007

S. Albino, B.A. Kniehl, and G. Kramer - NPB 725 (2005) 181

- Gluons expected to lose more energy by gluon radiation
- Gluon fraction is different for pion and proton
- Measurements of pion and proton  $R_{CP}$  and  $v_2$  can help us study flavor dependence of energy loss

# Jet Flavor Conversion

- Elastic scattering in medium can change flavor of leading parton of jet
  - Annihilation  $q+q \leftrightarrow g+g$
  - Compton Scattering
    q+g ↔ g+q
- Differences in jet energy loss may be mitigated



W. Liu and R. Fries – PRC 77 (2008) 054902

# PHENIX

- PHENIX Run 7
- Au+Au 200 GeV
- TOFW+ACC subsystems used for this analysis
  - TOFW new for Run 7
- RICH may be used in future studies



# **TOFW and Aerogel Detectors**



- TOFW has 75 ps intrinsic timing resolution
- Aerogel has n=1.0113
- Together, they can be used to identify protons and pions to high  $p_T$ 
  - At least 6 GeV/c, possibly higher if the RICH is included in the PID for pions

# **Pion Spectra**



- Previously published PHENIX measurements have had charged pion spectra up to 3 GeV/c
  - PRC.69.034909
- Our results extend to 5 GeV/c with greatly enhanced statistical precision

### **Proton Spectra**



- Previously published PHENIX measurements have had proton/antiproton spectra up to 4.5 GeV/c
  - PRC.69.034909
- Our results extend to 5 GeV/c with greatly enhanced statistical precision

### Centrality Dependence of $p/\pi$ Ratio

- p/π increases
  significantly with
  increasing centrality
- $p/\pi$  peaks at mid  $p_T$  and falls off



# Model Comparisons of $p/\pi$ Ratio



- All models shown agree for  $p_T < 2 \text{ GeV/c}$
- Disparities show up at higher  $p_T$

#### Centrality Dependence of p/p Ratio

- p/p is roughly flat for all centralities
- p is expected to have larger gluon contribution, but ratio does not fall with p<sub>T</sub> up to 5 GeV/c



# Nuclear Modification: R<sub>CP</sub>



- R<sub>CP</sub> = Yield(central)/Yield(peripheral)\*N<sub>coll</sub>(peripheral)/N<sub>coll</sub>(central)
- Protons not suppressed at intermediate p<sub>T</sub>
- At higher  $p_T$  proton  $R_{CP}$  approaches but does not merge with pion  $R_{CP}$
- R<sub>CP</sub> consistent with recombination models

### Quark Scaling and v<sub>2</sub>



- $KE_T = (p_T^2 + m^2)^{1/2} m_0$
- Scaling breaks at KE<sub>T</sub>/nq > 1 GeV
- (Thermal) Recombination does not dominate for  $p_T > 4$  GeV/c
  - Could be TT  $\rightarrow$  TS for mesons and TTT  $\rightarrow$  TTS  $\rightarrow$  TSS for baryons (see e.g. Hwa arXiv:0801.2183)

# $R_{CP} \text{ and } v_2$



	R <sub>CP</sub>	v <sub>2</sub>
reco	1	1
eloss	$\downarrow$	1

Relative change for protons to pions

- Recombination dominates for  $p_T 2-4$  GeV/c
- Jet fragmentation takes over at higher  $p_{\text{T}}$
- At high  $p_T$  pion and proton have similar  $v_2$ , possibly suggesting flavor conversion

# Double R<sub>CP</sub>



- Flavor conversion  $r(p/\pi) \sim 1$
- No flavor conversion  $r(p/\pi) < 1$
- No sensitivity in this  $p_T$  range

# **Conclusion and Outlook**

- Recombination models qualitatively describe proton  $R_{CP}$  and  $p/\pi$  ratio for  $p_T = 1-4$  GeV/c
- The p/p ratio and R<sub>CP</sub> of p & p indicates similar energy loss for particles and antiparticles
- $R_{CP}$  and identified  $v_2$  results indicate interplay between recombination and other mechanisms
- The double  $R_{CP}[p/\pi]$  seems not to be sensitive to jet flavor effects below 5 GeV/c
- Higher  $p_T$  is needed for a better test, stay tuned

## **Backup Slides**

# p/pi in p+p and d+Au

- d+Au is like peripheral Au+Au
- p+p is lower
- PRC.74.024904





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#### Hydro comparisons



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### **RCP** from recombination



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#### p/pi from eloss

