MEASUREMENT OF HEAVY FLAVOUR PRODUCTION IN P-P AND D-AU COLLISIONS AT RHIC BY THE DETECTION OF THE INCLUSIVE MUONS

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The RHIC offers new opportunities to study perturbative quantum chromodynamics. We can learn production of the high p_T hadrons and the heavy flavour in the forward and backward rapidity from the single muon analysis in PHENIX. Developement of new techniques to separate hadrons, decay muons, and prompt muons, makes the measurement possible. As a snap shot of the current progress, we report nuclear modification factor R_{cp} with high p_T hadrons.

1. Motivation

The parton model, improved by perturbative Quantum Chromodynamics (**QCD**), has been successful so far in predicting production of large transverse energy, high p_T hadrons, jets, direct γ's, heavy flavors, and Drell-Yan lepton pairs for various hadron collisions. [1] These partonic processes was measured or will be measured for the various collisions delivered by the Relativistic Heavy Ion Collider(RHIC). So far RHIC has delivered collisions of p - p ($\sqrt{s} = 200\ GeV$), d - Au ($\sqrt{s_{NN}} = 200\ GeV$), and Au - Au ($\sqrt{s_{NN}} = 65, 130, 200\ GeV$). Experiments performed at RHIC have reported exciting results, [2] one of which is the production of high p_T hadrons. [3]

Parton model is justified by the **QCD** factorization theorem. The production of the heavy flavour can be taken as a specific example to describe general structure of the factorization theorem. [4] The production cross sec-

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tion for charmed hadron is given by

$$d\sigma[A \to B] = \Sigma_{ij} f_{i/A} \otimes f_{j/B} \otimes d\hat{\sigma}[ij \to c\bar{c} + X] \otimes D_{H/c} \quad (1)$$

where $f_{i/A,j/B}$ is the parton distribution function of the incoming hadrons A and B, $d\hat{\sigma}$ is the partonic cross section, and $D_{H/c}$ is the fragmentation function for c quark. Corrections to Eq. 1 depend on the considered process but are power-suppressed by the ratio between **QCD** scale parameter λ_{QCD} and the scale of interaction Q. The $f_{i/A}$ is inherent to the hadron and considered as distributions of point-like particles inside A. The $f_{i/A}$'s are determined from other parton model processes as a function of x, momentum fraction carried by the parton. [1]

Parton distribution function inside nuclei is roughly proportional to the number of nucleons. Details of the distribution show deviations of about 10-20% when x is 0.01 (shadowing) or x is 0.1 (anti-shadowing). [5] The parton model, when applied to the collisions of nuclei, exhibits *scaling* with the number of *binary* nucleon collisions. Measurements by the PHENIX show that the production of high p_T hadrons at midrapidity follows *binary scaling* for collisions of p+p and d+Au. [6] On the other hand, production of high p_T hadrons in the collisions of Au+Au is suppressed from the scaling by a large factor. It is an open question whether the anomalies observed in the central Au-Au collisions can be understood by extending factorization theorem [7] or is generically non-factorizable effect caused by a sudden change in the non-perturbative dynamics such as phase transition to the quark gluon plasma. If the approach based on factorization is possible, the effect will be due to the higher twist terms power-suppressed by λ_{QCD}/Q, and systematic study of the scaling violation will provide a valuable clue.

The PHENIX muon spectrometer has unique capability to measure muons and hadrons produced in the forward and the backward rapidity and is an ideal tool to study scaling violations. The measured hadrons can be used to study the high p_T hadron production, and the measured muons can be used to deduce the heavy flavour production.

2. Setup and Techniques

The PHENIX muon detection system is made up of two nearly identical spectrometers located in the South ($-2.2 < \eta < -1.2$) and in the North ($1.2 < \eta < 2.4$). [8] Detector schematics relavant to the current discussion are now reviewed. Front absorbers start 40 cm away from the nominal collision point and are about 5 interaction lengths thick. About 1% of the incident hadrons penetrate the front absorber. Active tracking volume made of three tracking stations follows the front absorber and determines momenta of the charged tracks. Muon identification system, made of 5 layers of *steel absorber-chamber(Iarocci tubes)* sandwich, starts at approximately 6 m downstream of the collision point. Absorbers suppress hadron flux in the muon spectrometer and make trigger and measurement of muons possible. Reconstructed tracks reaching the 3rd, the 4th, or the 5th identifier layer are used in the analysis.

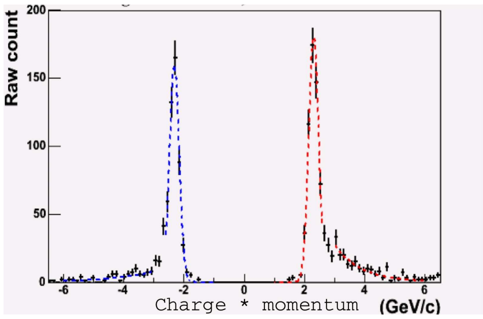

Figure 1. Momentum distribution of the positively and the negatively charged tracks reaching the 4th identifier layer exclusively

Analized tracks include *decay muons* from decays of $\pi^{\pm}$'s $K^{\pm}$'s, *punch-through hadrons* penetrating various absorbers, and *prompt muons*. Each sources of tracks have distinct characteristics, and can be separated. Fig. 1 shows the momentum distribution of the tracks reaching the 4th identifier layer exclusively. The clear peak at the lower momentum end corresponds to charged particles loosing all of their energies by the ionization process before reaching the last identifier layer. Particles experiencing hadron interaction in the following absorber layer of the sandwich detector produce the long tail at high momentum side and are tagged as hadrons. Punch-through hadrons reaching the last identifier layer are estimated from the yield of these hadrons.

Collisions occur widely along the collision axis. Small fraction of the produced $\pi^{\pm}$'s and $K^{\pm}$'s decay before they reach the front absorber, and yields of these *decay muons* decrease linearly as the collision points approach the front absorber as shown in Fig. 2. We can determine yields of *decay mouns* from the slopes. Yields of *decay muons* will disappear if the ficticious location of collision is at approximately 60 cm downstream of the collision point where particles experience one hadron interaction on average. The

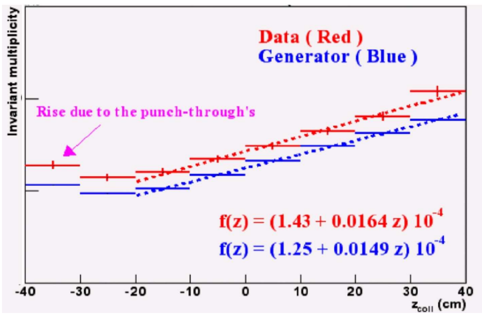

Figure 2. Invariant multiplicity of the tracks in south spectrometer vs collision pint

remaining yields apparent in Fig. 2 are due to the *prompt muons* and the *punch-through's* reaching the last identifier layer. We subtract the estimated amount of *punch-through's* to determine yields of the *prompt muons*.

According to **PYTHIA**, about 90% of the *prompt muons* come from the semi-leptonic decay of the heavy flavoured hadrons. The measurement of *prompt muons* is an effective way to study the heavy flavour production.

3. Current results and Outlook

Analysis based on the techniques discussed above is in progress. Here we describe a result based on the hadrons and the *decay muons* collected for the d+Au collisions.

The nuclear modification factor is defined as

$$R_{CP} = \frac{\frac{1}{<N_{coll}>} \frac{d^2N}{dp_T d\eta}^{(central)}}{\frac{1}{<N_{coll}>} \frac{d^2N}{dp_T d\eta}^{(peripheral)}} \tag{2}$$

where $< N_{coll} >$ is the number of binary collisions for each class of events with given centrality obtained from Glauber model. [9] Rcp would be 1 if scaling with the number of binary collisions applies. We study the centrality and rapidity dependence of Rcp for the *decay muons* and the hadrons. The centrality of the peripheral events is the 60-88%, and the R_{cp} are shown in Fig. 3 and 4 for different centralities. The dominant errors are from statistics and the uncertainties in the determination of the number of binary collisions $< N_{coll} >$ shown as a black error bar at Rcp = 1. We observe a suppression in very central collisions relative to peripheral collisions in the deuteron direction, and an enhancement in the gold direction.

In the near future, we look forward to determination of the prompt

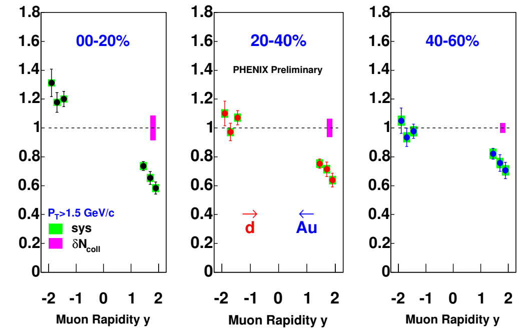

Figure 3. R_{CP}, *decay muons*

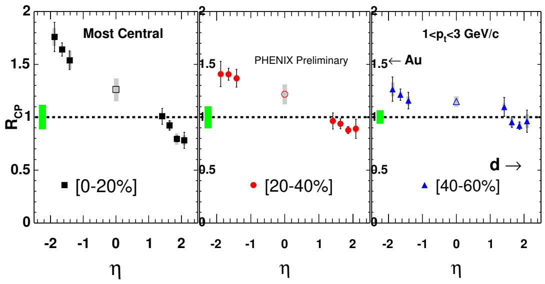

Figure 4. R_{CP}, *hadrons*

muon production and the heavy flavour production for the p+p and d+Au collisions at the RHIC, which will develope into a systematic study of the scaling violation over the various collisions.

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