MEASUREMENT OF HIGH-P_T AND LEPTONIC OBSERVABLES WITH THE PHENIX EXPERIMENT AT RHIC

T. SAKAGUCHI*
FOR THE PHENIX COLLABORATION
Center for Nuclear Study, Graduate School of Science, University of Tokyo
RIKEN, 2-1 Hirosawa, Wako-shi, Saitama 351-0198, Japan

The PHENIX experiment at Relativistic Heavy Ion Collider have successfully been operated in Year-1 and Year-2 Runs. The recent results on the measurement of high transverse momentum hadrons, J/ψ, and single electrons and photons are presented.

1. Introduction

It is predicted from lattice QCD calculations that at high energy density, a phase transition from hadronic matter to a plasma of deconfined quarks and gluons may occur to form a Quark Gluon Plasma (QGP) similar to that found in the early universe a few microseconds after the Big Bang. Relativistic heavy ion collisions at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) are expected to produce a similar phase transition.

2. Experimental Setup

Figure 1 shows the PHENIX[1] detector at RHIC. Beam-beam counters and zero-degree calorimeters provide the minimum bias trigger, measure the vertex position, and are used for centrality selection. π^0's are reconstructed via decay channel of $\pi^0 \to \gamma\gamma$ with Electromagnetic Calorimeter (EMC). Charged particle tracks are reconstructed with drift chambers (DC) and three layers of pad chambers. Electrons are primarily identified with Ring Imaging Cherenkov detector, and selected by energy/momentum matching

*e-mail: takao@phenix.cns.s.u-tokyo.ac.jp

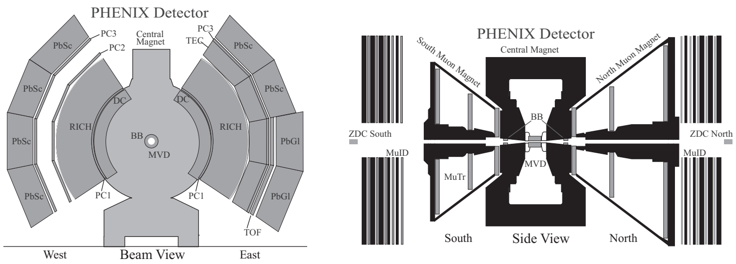

Figure 1. PHENIX detector. Views from beam axis (left), from top side (right).

using informations from DC and EMC. The acceptance of the PHENIX detector is $|\eta|$ <0.35 in pseudo-rapidity (η), and π in azimuth (ϕ). The PHENIX measured electrons, photons, hadrons and muons in 130 GeV Au-Au collisions in Year-1 and in 200 GeV Au-Au and p-p collisions in Year-2.

3. High p_T hadron measurement

Partons produced in initial Au-Au collisions will interact with hot dense medium formed after the collisions, loose their energy, and finally turn into jets. Since most of the high p_T hadrons are fragments of jets, the effect can be seen in terms of a suppression of yield on high p_T hadron spectra[2]. The left panel of Fig. 2 shows the p_T spectra of π^0 for 60-80 % and 0-10 % central collisions at $\sqrt{s_{NN}}$ =130 GeV in Year-1 Au-Au Run[3], and the middle and

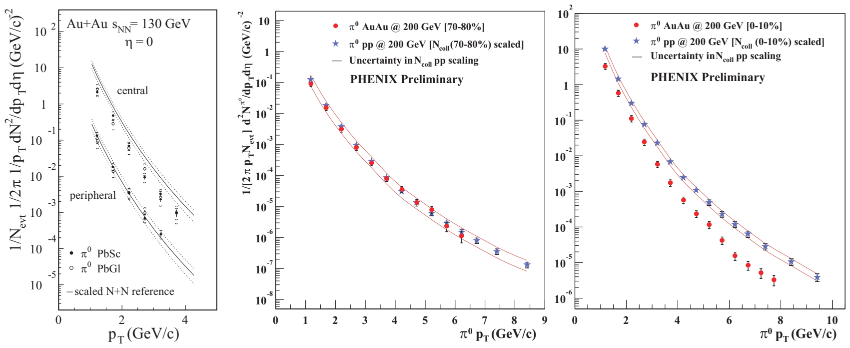

Figure 2. π^0 p_T spectra for 60-80 % and 0-10 % central collisions at $\sqrt{s_{NN}}$=130 GeV (left), and 70-80 % (middle) and 0-10 % (right) central collisions at $\sqrt{s_{NN}}$=200 GeV. Reference p-p data scaled by N_{coll} are also shown.

right panels show 70-80 % and 0-10 % central collisions at $\sqrt{s_{NN}}$ =200 GeV in Year-2 Au-Au Run[4], respectively. The reference p-p data scaled by corresponding number of binary nucleon-nucleon collisions (N_{coll}) are overlayed onto the data as well. Since p-p Run were not carried out in Year-1, the reference p-p data for 130 GeV were obtained by interpolating *ISR*, *CDF* and $Sp\overline{p}S$ data to RHIC energy[3]. At both beam energies, the peripheral (60-80 or 70-80 %) data are consistent with the reference p-p data scaled by N_{coll}, while the central (0-10 %) data are clearly suppressed. To quantify the suppression, the *nuclear modification factor* is introduced as follows:

$$R_{AA}(p_T) = \frac{\text{(Yield per A-A collision)}}{\langle N_{coll}\rangle\text{(Yield per p-p collision)}} = \frac{1/N_{evt}\ d^2N^{AA}/dp_T d\eta}{\langle N_{coll}\rangle(d^2\sigma^{pp}/dp_T d\eta)/\sigma^{pp}_{inel.}}$$

The left panel of the Fig. 3 shows the nuclear modification factors for 130 GeV central Au-Au and 17.3GeV Pb-Pb collisions[5]. The 130 GeV data is suppressed, and clearly different from the 17.3 GeV data that indicates parton multiple scattering effect. From the left panel of the figure showing

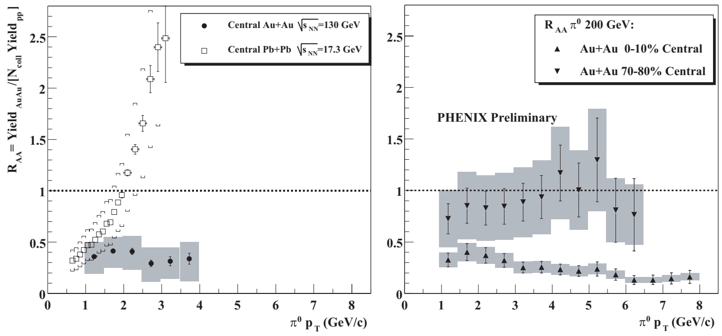

Figure 3. Nuclear Modification factors for 130 GeV 0-10 % central and 17.3 GeV Pb-Pb collisions (left), and 70-80 % and 0-10 % central collisions at 200 GeV (right).

the nuclear modification factors for 200 GeV Au-Au, it is clearly seen that the peripheral data is consistent with unity within errors, while the central data is suppressed as is seen in 130 GeV. While the inclusive charged hadron spectra show the same tendency in 200 GeV[6], the ratio of π^0 to nonidentified charged hadrons ($(h^+ + h^-)/2$) reaches constant of ∼0.4 instead of unity as is shown in Fig. 4. The result is rather different from hard processes measured in e^+e^- collisions[7]. There may be other mechanisms for enhancing the high p_T yield for protons and/or kaons in Au-Au collisions.

4. J/ψ(M=3.1 GeV/c^2) measurement

In case of deconfinement, the color screening may result in a dissociation of $c\overline{c}$ and thus a decrease in the production of charmonium[8]. There are also models that predict an enhancement of charmonium due to $c\overline{c}$ coalescence

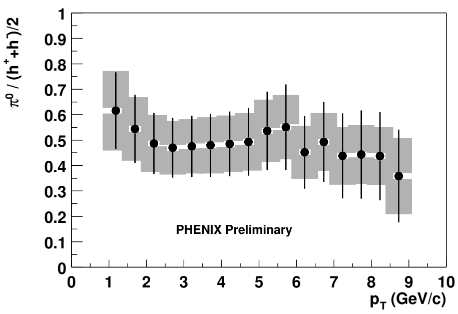

Figure 4. Ratio of π^0 to $(h^+ + h^-)/2$ in 200 GeV Au-Au minimum bias collisions.

as the collision volume cools[9]. Therefore, the measurement of J/ψ which is a bound state of $c\bar{c}$ has been an interesting topic. Figure 5 shows the e^+e^- invariant mass spectra around J/ψ mass region in p-p and Au-Au collisions at $\sqrt{s_{NN}}$=200 GeV. This is the first measurement of $J/\psi \rightarrow e^+e^-$ in heavy

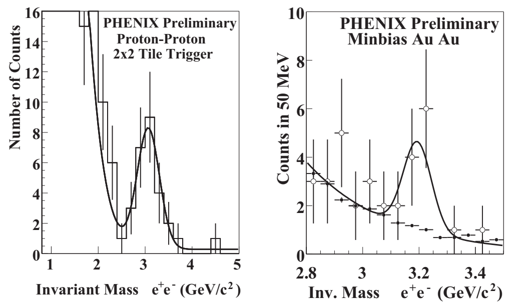

Figure 5. e^+e^- invariant mass spectra around J/ψ mass region in p-p (left) and Au-Au (right) collisions at $\sqrt{s_{NN}}$=200 GeV.

ion collisions. Although the statistics are poor, the yield of J/ψ per N_{coll} are evaluated in three centralities as shown in Fig. 6. The result shows that models assuming nuclear absorptions fit the data, but the simple binary scaling model does not.

5. Leptonic and Photonic Observables

The leptonic and photonic observables have long been considered to be an excellent probe because they do not strongly interact once produced. The thermal radiation turns into both electrons and photons, the heavy quarks produced in the collision's earliest stages decay into electrons, and the initial hard scattering produces photons.

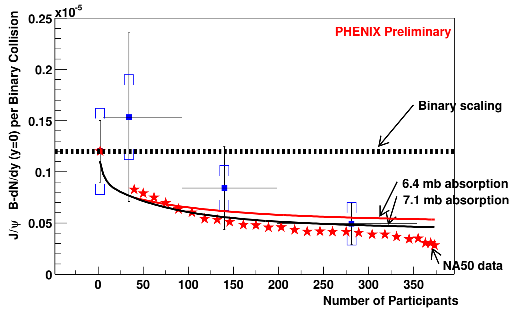

Figure 6. J/ψ yield per N_{coll} as a function of centrality.

5.1. *Electron measurement*

Single electrons are measured both at $\sqrt{s_{NN}}$=130 and 200 GeV. The left panel of Fig. 7 shows the single electron spectra at 130 GeV for central and peripheral collisions. The spectra were obtained after subtracting back-

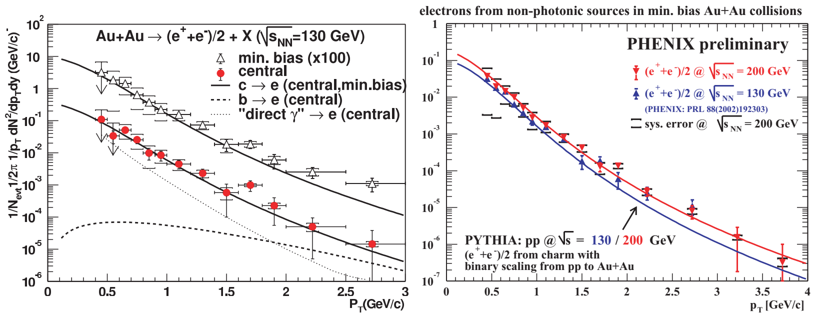

Figure 7. Single Electron spectra for both peripheral and central collisions at 130 GeV (left) and both beam energies (right).

ground electrons from known hadronic sources. The result shows that the electron spectra are consistent with ones from charm quarks calculated with PYTHIA scaled by N_{coll}. In contrast to the high p_T hadron measurement, the suppression of the yield in the central collisions is not seen, suggesting possible smaller energy loss of charm quarks. The yield of electrons is sensitive to the beam enegies as shown in right panel of Fig. 7, indicating that electrons may play a role as a thermometer of the system.

5.2. *Photon measurement*

Photons have been measured at both beam energies and both peripheral and central collisions. Figure 8 shows the ratio of the measured inclusive photons to the calculated photons from hadronic sources at $\sqrt{s_{NN}}$=130 GeV and 200 GeV[10]. So far, no significant excess are seen in either centralities or beam energies within current errors.

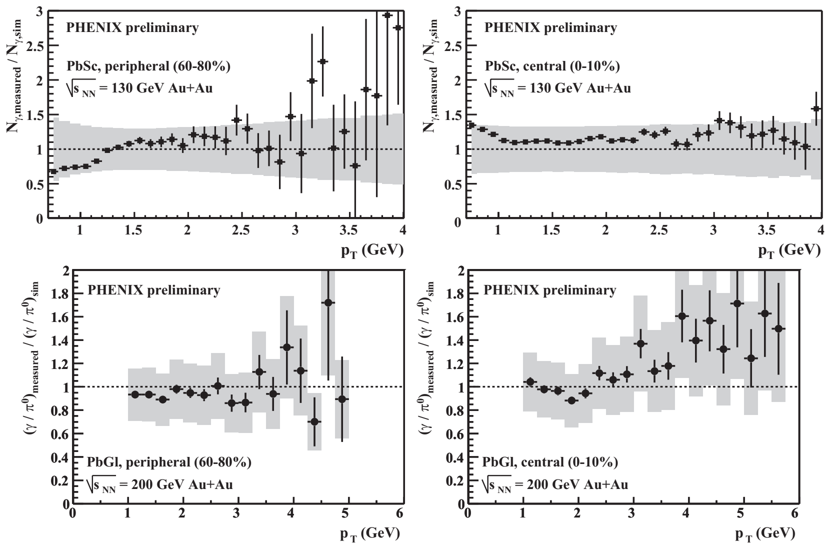

Figure 8. Ratio of the measured inclusive photons to the calculated photons from hadronic sources in Au-Au collisions at $\sqrt{s_{NN}}$=130 GeV and 200 GeV.

6. Conclusion

The PHENIX experiment at RHIC have successfully been operated in Year-1 and Year-2 Runs. The recent results on the measurement of high transverse momentum hadrons, J/ψ, single electrons and photons were shown.

References

1. PHENIX Collaboration, *Nucl. Inst.* to be published.
2. X.N. Wang, *Phys. Rev.* **C58**, 2321 (1998).
3. K.Adcox et al.(PHENIX Collaboration), *Phys. Rev. Lett.* **88**, 022301 (2002).
4. D. d'Enterria, for the PHENIX Collaboration, **hep-ex/0209051** (2002).
5. M.M. Aggarwal et al.(WA98 Collaboration), *Eur. Phys. J.* **C23**, 225 (2002).
6. S. Mioduszewski, for the PHENIX Collaboration, **nucl-ex/0210021** (2002).
7. P. Abreu et al.(DELPHI Collaboration), *Eur. Phys. J.* **C17**, 207 (2000).
8. T. Matsui and H. Satz, *Phys. Lett.* **B178**, 416 (1986).
9. R.L. Thews et al., *Phys. Rev.* **C63**, 054905 (2001).
10. K. Reygers, for the PHENIX Collaboration, **nucl-ex/0209021** (2002).