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Progress of the PHENIX Experiment in the Year 2004

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1. Introduction

Experimental studies at the Relativistic Heavy Ion Collider (RHIC) of Brookhaven National Laboratory, USA, has been producing many interesting results since the first successful collisions between Au ions in June 2000. The goal of the studies at RHIC is to find evidence of the QCD phase transition from normal nuclear matter to deconfined quark matter, called quark-gluon plasma (QGP), and to study the properties of the hot QCD matter.

The CNS group has been participating in the PHENIX experiment, which is one of the major experiments at RHIC. A schematic view of the the PHENIX experimental setup is shown in Fig. 1. It consists of two central arms (East and West), two muon arms (North and South) and inner detectors for event trigger and event characterization. The PHENIX experiment aims to address as many signatures as possible for QGP formation, by having a very unique capability to measure photons, electrons and muons as well as hadrons.

In this article, progress of the PHENIX experiment and the activities of the CNS group in the Japanese fiscal year (JFY) 2004 are briefly summarized.

Figure 1. Layout of the PHENIX experiment.

2. Year-5 RUN at RHIC

In the JFY 2004, the latter half of the fourth physics run, RHIC RUN-4, and the first half of the fifth physics run, RHIC RUN-5, were successfully executed. In RUN-4, PHENIX collected a significant amount of Au + Au col-

lision data both at $\sqrt{s_{NN}} = 200$ GeV and $\sqrt{s_{NN}} = 62.4$ GeV. In RUN-5, Cu + Cu collisions instead of Au + Au collisions were employed, in order to have controlled data for collisions between light-mass nuclei. 8.6 G events were accumulated at $\sqrt{s_{NN}} = 200$ GeV, and 1.1 G events at lower energy, $\sqrt{s_{NN}} = 63$ GeV. After the heavy ion runs, a polarized proton run at $\sqrt{s_{NN}} = 200$ GeV is continued to the next fiscal year.

3. Activities of the CNS group

The CNS group had several distinct activities in the JFY 2004. Only brief introductions are provided in this article, and detailed descriptions will be found in the separate articles.

3.1. RICH and AEROGEL operation

The RICH (Ring Imaging Cherenkov) subsystem, which is a Cherenkov counter using CO₂ as a radiation gas, is a main device for electron identification of the PHENIX experiment. The CNS group has been responsible for its maintenance, operation during the run, and calibration for data analysis. The RICH subsystem worked without serious problems throughout the RUN-4 and RUN-5.

PHENIX has unique capability of identifying charged hadrons in a wide momentum region, with the high-resolution TOF and RICH. With increase of interest to the hadron production in the medium to high momentum region, extension of particle identification (PID) was made by adding an AEROGEL Cherenkov counter with refractive index $n \sim 1.01$. The AEROGEL project, carried out by the collaboration of Tsukuba, BNL, Russia and CNS, was completed in this year, and was successfully used in the RUN-5. Performance of the AEROGEL counter and preliminary results are described in Ref. [1].

3.2. Data analysis and results

Four physics papers were published from the PHENIX collaboration in JFY 2004, as listed in the publication list of this annual report. Several others have been submitted and are in different stages before final publication.

Major efforts of the CNS group has been on the physics with photons and leptons, and various achievements were made as described below.

Single photon is considered to be a sensitive probe of various stages of collision processes, with its property of penetration through dense matter. Detecting single photons is challenging because of very low production rate and competing backgrounds. The PHENIX succeeded in measuring direct photons from pQCD hard process in Au + Au col-

lisions. The result clearly demonstrates that N_{coll} scaling holds well for pQCD hard photon production, as described in Ref. [2]. The result also provides strong support to the interpretation that the jet quenching is a final state effect.

Systematic studies of jet quenching effect is needed to understand better the energy loss mechanism and properties of dense matter. For that purpose, π^0 production in Au + Au collisions was investigated at a lower energy of $\sqrt{s_{NN}} = 62.4$ GeV taken in the RUN-4, and preliminary results are presented in Ref. [3].

Single electron production in p + p, d + Au, and Au + Au collisions has been investigated. Sources of single electrons are categorized into two; ‘photonic’ and ‘non-photonic’. Main ‘non-photonic’ sources at the RHIC energies are leptonic decay of charm and bottom mesons, which are considered to be good probes of hard processes. ‘Photonic’ sources, majority of which comes from Dalitz decay of neutral mesons and external conversion of photons, are severe background sources for measuring ‘non-photonic’ sources. Converter method was employed to estimate and subtract the photonic background sources, which is considered to have smaller ambiguity compared to a Cocktail method which depends heavily upon the simulation. Current status of analysis efforts are described in Ref. [4].

Suppression of J/ψ yield has been considered to be a direct evidence of deconfinement. Recently, possible enhancement of the yield has been proposed by theorists which is due to coalescence production of J/ψ from charm and anti-charm quarks in QGP phase or in the hadronization stage. The CNS group has been taking leading roles in the analysis of J/ψ productions through electron-positron decay channel. The J/ψ production in d + Au collisions from RUN-3 is in its final stage [5], whose result should serve as a reference to that in heavy ion collisions. The J/ψ yield as well as p_T distribution for a few centrality bins in Au + Au collisions has been preliminary obtained from the RUN-4 [6].

Important research subjects still left over at RHIC are low-mass vector mesons and low-mass lepton-pair continuum. Measuring vector mesons via lepton-pair decay channel is crucial in order to extract information relevant to chiral symmetry restoration. Importance of low-mass lepton-pair continuum originated from thermal sources cannot be over-emphasized. Huge combinatorial background makes it impossible to deduce clear signals of light-mass vector mesons. Current status of analysis of low-mass electron-pairs are presented in ref. [7]. HBD (hadron blind detector), which is the gaseous Cherenkov counter with a UV-photon detector, is the most promising yet ambitious detector for reducing background sources, and the current status of its development for the PHENIX experiment is also mentioned in the report.

3.3. R & D efforts

GEM (gas electron multiplier) has been a central subject of detector development and application of our group in the last few years. GEM (gas electron multiplier), which has a very simple structure having regularly arrayed holes pierced through a Kapton sheet coated at both sides with copper

foils, was originally developed at CERN. The CERN-GEM has an intrinsic problem of gain variation due to charge-up, and a new method of piercing the holes was recently established to reduce significantly the variation. Current status is presented in Ref. [8].

A micro-TPC (Time Projection Chamber) prototype with GEM’s for electron multiplication were developed and tested using the unseparated beams from KEK-PS. Performance of this prototype is presented in Ref. [9].

3.4. R & D of ALICE TRD

The CNS group has been involved in the R & D effort for the development of TRD (transition radiation detector) in the ALICE experiment at CERN-LHC, which is planned to start operation in 2007. The TRD, when installed, will provide unique capability of electron identification to the ALICE experiment.

The CNS group participated in the test of TRD large-scale prototypes using secondary beams from CERN-PS in the fall of 2004. The prototypes have the same size with the production ones, with prototype electronics installed. Performance of TRD performance are currently under investigations [10].

4. Summary and Outlook

In the year 2004, the PHENIX experiment had two successful runs, RUN-4 and RUN-5, and had archived large amount of data for Au + Au and Cu + Cu collisions at $\sqrt{s_{NN}} = 200$ GeV and $\sqrt{s_{NN}} = 63$ GeV, as well as polarized p + p collisions.

The major activities of the CNS groups are presented, which includes data analysis efforts, R & D efforts related to GEM, and ALICE TRD.

References

- [1] N. Kurihara *et al.*, CNS Annual Report 2004 (2005) 57.
- [2] T. Isobe *et al.*, CNS Annual Report 2004 (2005) 55.
- [3] T. Sakaguchi *et al.*, CNS Annual Report 2004 (2005) 47.
- [4] F. Kajihara *et al.*, CNS Annual Report 2004 (2005) 49.
- [5] S. Kametani *et al.*, CNS Annual Report 2004 (2005) 51.
- [6] T. Gunji *et al.*, CNS Annual Report 2004 (2005) 53.
- [7] K. Ozawa *et al.*, CNS Annual Report 2004 (2005) 59.
- [8] Y. L. Yamaguchi *et al.*, CNS Annual Report 2004 (2005) 93.
- [9] S. X. Oda *et al.*, CNS Annual Report 2004 (2005) 89.
- [10] Y. Morino *et al.*, CNS Annual Report 2004 (2005) 91.