First Polarized Proton Collisions at PHENIX

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The RHIC started operation as a polarized proton collider. We took data of transversely polarized proton collisions at $\sqrt{s} = 200$ GeV for the single transverse-spin asymmetry measurements of many channels with the PHENIX detector. The operation and data taking in the 2001–2002 run will be reported.

1. Introduction

The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) started operation as a polarized proton collider. All devices for the polarized proton collisions were successfully operated and first polarized proton collisions at $\sqrt{s} = 200$ GeV were achieved on December 11th, 2001.

The maximum value of the luminosity reached up to 1.5×10^{30} cm^{-2}sec^{-1}. This is 20% of luminosity which was planned many years ago for the first year luminosity. Polarization was lower than expected. The average value at one ring called as the yellow ring was 17%, and that at the blue ring was 14%. The maximum value achieved was 25%.

2. Polarized proton collisions at PHENIX

At PHENIX [1], we obtained data for the single transverse-spin asymmetry (A_N) measurements of many channels. As shown in Fig.1, the PHENIX detector consists of two central arms to cover the mid-rapidity region ($|\eta| < 0.35$), and two muon arms to cover the forward rapidity region ($1.2 < |\eta| < 2.4$). Full detectors in the two central arms and one of the muon arms (south muon arm) were operational in the 2001–2002 run.

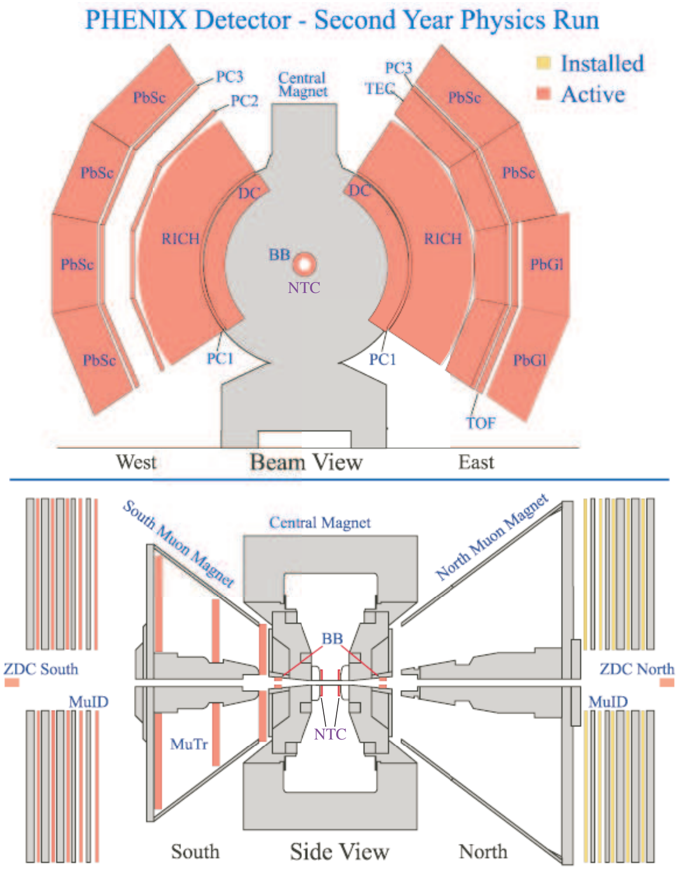

Fig. 1. PHENIX detector in the 2001–2002 polarized proton run.

In proton collisions, the event rate was much higher than heavy-ion collisions. It reached up to 40kHz. Although the data acquisition system of the PHENIX detector was upgraded to deal with 1kHz event rate and 70 MB/sec data logging, events of interest were required to be selected in the first-level trigger.

In order to select high p_T photons, π^0s, charged hadrons, and electrons in the mid-rapidity region, a trigger system with electro-magnetic calorimeters (EMCal) and ring-image Čerenkov (RICH) counters was constructed. Several types of combinations were made with different energy threshold level and coincidence level in the EMCal-RICH trigger system. In this run, the main trigger for π^0 and charged hadron measurements was 800 MeV threshold EMCal-only trigger. By using this trigger, we collected about 60-million events.

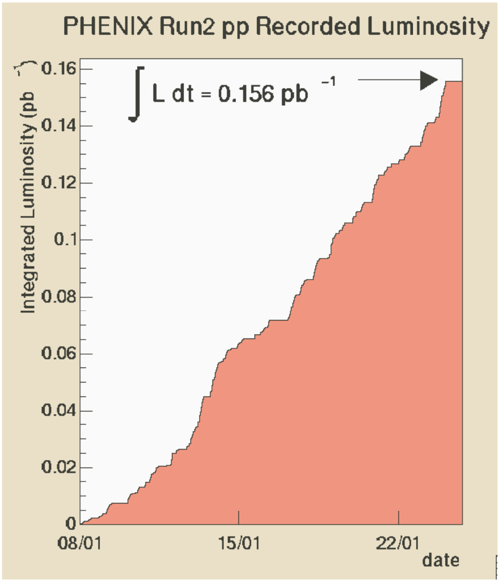

Fig. 2. Integrated luminosity recorded at PHENIX in the 2001–2002 polarized proton run.

For high p_T muons, another first-level trigger with muon-identification detectors was made. In the south muon arm, we took data to measure A_N of muons whose momentum was more than 2 GeV/c. We collected about 30-million muon events.

To make the minimum-bias trigger with higher efficiency for inelastic reactions and to monitor luminosity, we made a new counter which is called a normalization trigger counter (NTC). The minimum-bias trigger was made with the NTC and beam-beam counters. We collected about 200-million minimum-bias trigger events.

Luminosity was integrated from January 7th when the final trigger configuration was fixed until January 24th, 2002. The final integrated luminosity at PHENIX was 0.16 pb^{-1}. Figure 2 shows the integrated luminosity in this period.

In the 2001–2002 run, we measured the single transverse-spin asymmetry, A_N, with transversely polarized proton collisions. Statistics of the A_N measurement is estimated by integrating the figure of merit, $P^2 \cdot L$, where P is polarization and L is luminosity. It was 4.5 nb^{-1} at the yellow ring and 3.2 nb^{-1} at the blue ring.

3. A_N measurements

In 1990, Fermilab-E704 measured A_N of π^0, $\pi^\pm$, and η in large-x_F kinematic region [2]. They observed unexpectedly large A_N. In order to explain these phenomena, many theoretical models have been developed. Qiu and Sterman calculated a twist-3 effect [3]. Anselmino *et al.* made a model with time-reversal odd fragmentation functions [4]. They both explain the E704 data well. Although these models are applicable just at high p_T, E704 data is lower than the high-p_T criteria. Physics in the E704 kinematic region and that in the RHIC region can be very different. The data of E704 can be dominated by the soft physics, and that of RHIC can be dominated by the hard physics.

In the central arms, we took data to measure A_N of π^0s and charged hadrons in the mid-rapidity region with transverse momentum up to 8 GeV/c. The asymmetry of π^0 in the mid-rapidity region was also measured at E704 [5]. They observed the asymmetry consistent with zero. On the other hand, a large asymmetry was observed in the lower p_T region [6]. The statistics at PHENIX is much larger than E704 data especially at high p_T. Figure 3 shows expected statistical errors of the A_N measurement of π^0 at PHENIX compared with those at E704. Qiu and Sterman's model calculation on the figure was made with their code, although their model is not applicable in this kinematic region.

Another A_N measurement we performed at another collision point (called "12 o'clock area") at RHIC is a very forward region measurement with a lead tungstate ($PbWO_4$) calorimeter. The calorimeter was located at upstream of the last dipole magnet at the collision point. Since all charged particles from interactions at the collision point were swept out by the dipole magnet, just neutral particles were observed. The detector was configured by the calorimeter, a pre-shower detector, and two scintillators to veto neutrons for photon and π^0 asymmetry measurement, and to identify neutrons for neutron asymmetry measurement.

The goal of the measurement is a development of new polarimeter to install at PHENIX in the future. If there is finite A_N in these measurements, we can use the data to confirm spin dynamics at PHENIX. This is important for the operation with spin rotators at PHENIX in the 2002-2003 run. We will implement position sensitive counters in the zero degree calorimeter (ZDC) at PHENIX, and use the A_N of neutron at the very forward region as a polarimeter.

4. Summary and outlook

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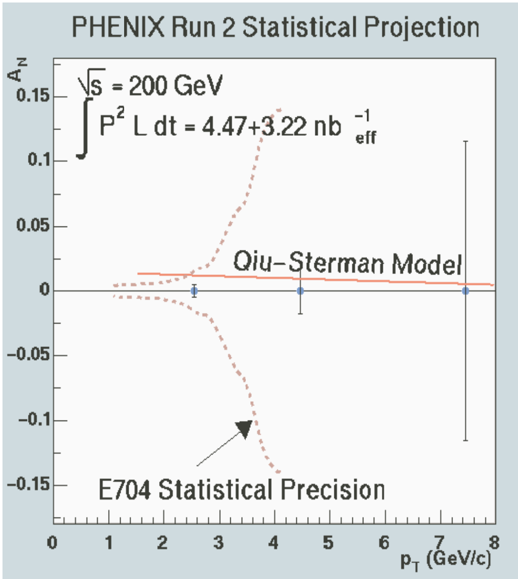

Fig. 3. Expected statistical errors of the A_N measurement of π^0 at PHENIX compared with those at E704.

A_N measurements of many channels with the PHENIX detector. The A_N of π^0s, charged hadrons, and muons will be shown in the near future. We also took data of neutral particles in the very forward region at the 12 o'clock area. This will be applied for the polarimeter at PHENIX in the 2002–2003 run. We will take data of longitudinally polarized proton collisions in this run for the gluon polarization measurement [7].

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