Cross section and asymmetry measurement of very forward neutral particle production at RHIC

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Although air shower observations at the surface of the earth have been carried out to understand the origin of the ultrahigh energy cosmic rays, these observations have uncertainties in the interpretation of the observed data from the present phenomenological nuclear collision models. The LHCf experiment has been performed at LHC for understanding cosmic ray generation from the collider experiment data[1–3]. Precision measurements of the very forward particle production in the collider experiments improve the understanding of particle production processes in the nuclear collisions, and largely affect the interpretation of the observed data and the origin of the cosmic rays.

A large 10% single transverse-spin asymmetry (SSA) in neutron production from transversely polarized proton collisions was found at RHIC in 2002[4]. This provides an important clue to study elementary processes in air shower generation because the large SSA indicates that there are dominant contributions from processes that strongly interfere with each other. Because the SSA measurement of neutron production provides interference measurement with one pion exchange with a spin flip, it is sensitive to a meson exchange without spin flip[5]. Although the SSA of very forward neutrons at collision energies of 62 GeV, 200 GeV, and 500 GeV was measured at RHIC, the transverse-momentum resolution of the data was limited.

We will perform a new collider experiment at RHIC, the so called RHICf experiment, which uses a LHCf detector (which is called the RHICf detector) with a high resolution and wide coverage of transverse-momentum measurements in order to improve the studies performed at RHIC and LHC. RHIC is a dedicated machine for QCD physics and it allows flexible operation to achieve our physics goals. In the RHICf experiment, we will have an improved transverse-momentum resolution using the RHICf detector. The LHCf experiment has measured very forward neutral particle cross section at collision energies of 0.9 TeV and 7 TeV. We will obtain precision measurements of very forward neutral particles (neutron, photon, neutral pion) at a collision energy of 510 GeV at RHIC. These data of various collision energies will provide an understanding of air shower generation and the limitations in the origin of the ultrahigh energy cosmic rays.

The RHICf detector will be located in front of the Zero-Degree Calorimeter (ZDC) in the north side, 18 m from the PHENIX collision point. In this area, all charged particles are swept out by the last dipole magnet for colliding beams at RHIC, and only neutral particles are detected. The RHICf detector consists of two sampling EM (electromagnetic) calorimeters with 44 interaction-length tungsten, 16 layers of scintillators, and 8 layers of silicon strip detectors; one with 25 mm × 25 mm and another with 32 mm × 32 mm cross sectional area. The ZDC detector is a sampling hadron calorimeter composed of Cu-W alloy absorbers with PMMA (Polymethyl methacrylate)-based optical fibers. The detection, identification, and energy measurement of photons and neutrons are performed using EM and hadron calorimeters. A schematic view of the RHICf detector installation and the structure of the calorimeter are shown in Fig. 1.

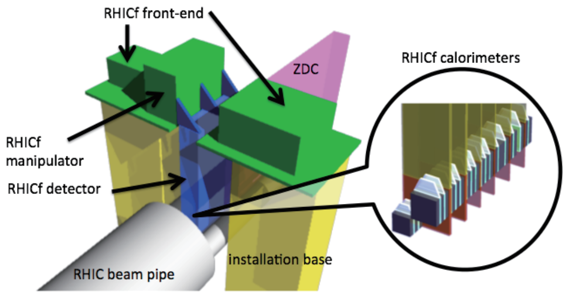

Fig. 1. Schematic view of the RHICf detector installation and the structure of the calorimeter.

We have proposed to perform a dedicated run for 1 week in 2016 with 510 GeV polarized proton collisions[6], and we are preparing for it. In the dedicated RHICf run, we will use the normal accelerator condition of the RHIC, except the beta function value at the PHENIX collision point, $\beta^* = 10$ m, in order to obtain parallel beam collisions. We need 12 h to achieve sufficient luminosity for cross section measurements of photons, neutrons, and neutral pions including the transverse-momentum scan. The SSA can be measured with the same data set with higher statistics than the measurements in the past.

References

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