Development of SAMURAI-TPC for the Study of the Nuclear Equation of State

T. Isobe, M. Famiano,[*3] A.B. McIntosh,[*4] T. Murakami,[*1] H. Sakurai, R. Shane,[*2] A. Taketani, M.B. Tsang,[*2] W.G. Lynch,[*2] and S.J. Yennello,[*4] for the SAMURAI-TPC Collaboration

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The nuclear equation of state (EoS) is a fundamental bulk property of nuclear matter and describes the relationships between the parameters of a nuclear system, such as energy and density. Understanding the nuclear EoS has been one of the major goals of nuclear physics.

Investigation of heavy-ion collision is one of the methods that can be used to study the nuclear EoS. An international collaboration, the Symmetry Energy Project, was formed in FY2009 to study the nuclear EoS over a wide range of nuclear matter densities. The collaboration planned to install a time projection chamber (TPC) in the SAMURAI dipole magnet at the Radioactive Ion Beam Facility (RIBF). By using TPC, experimental observables, such as the flow and yield ratios of charged particles, particularly π^+ and π^- particles, produced in heavy-ion collisions will be measured. At RIBF, a nuclear density of $\rho \sim 2\rho_0$ is expected to be achieved. Experiments using the TPC will allow us to impose constraints on the EoS isospin asymmetry term at high nuclear matter density[1].

Figure 1 shows an exploded view of the SAMURAI-TPC. The design is based on the EOS-TPC used at the BEVALAC accelerator[2]. Multi-wire drift chamber (MWDC)-type gas with a cathode-pad readout for the induced signals will be employed for obtaining good position resolution. The target will be located near the TPC entrance. Table 1 lists some specifications of the SAMURAI-TPC.

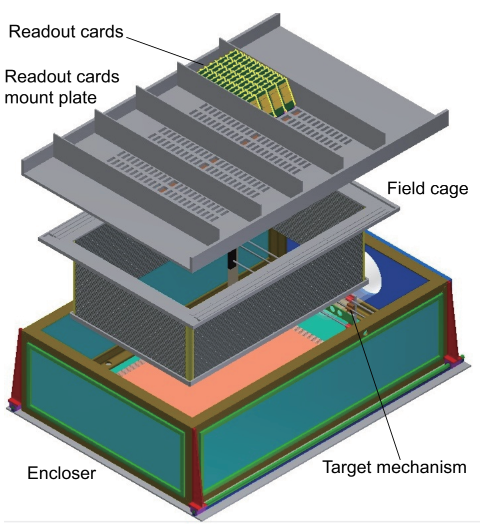

Fig. 1. Exploded view of the SAMURAI-TPC.

Table 1. Specifications of SAMURAI-TPC

pad size	8 mm × 12 mm
number of pads	11664 (108 × 108)
drift length	∼50 cm
chamber gas	P10 (Ar-90% + CH_4-10%)
magnetic field	0.5 T
pressure	∼1 atm
electric field for drift	120 V/cm

This detector is designed to measure ions ranging from pions to oxygen ions, corresponding to a wide range of stopping powers, and consequently, to a wide range of induced signals on the pads. An RHIC-STAR front end electronics (FEE) card[3] with more than 10k channels will be employed for the first phase experiment with TPC. The dynamic range of the readout is 10 bits, that of the feedback capacitor is 1.6 pF, and a switched capacitor array (SCA)-type analog buffer and Wilkinson ADCs are employed for the digitization of the data.

To determine spatial distortions, and in order to calibrate and monitor the TPC, a laser calibration system will be implemented. We plan to use 16 laser beams for simulating straight particle tracks in the TPC volume. UV-laser beams can produce ionization in gaseous detectors via a two-photon ionization process. We plan to use a Nd-YAG frequency-quadrupled laser ($\lambda = 266$ nm) and to send the laser beams into the TPC field cage through a UV optical fiber system.

The design and construction of the TPC is being performed in the United States. Testing of the TPC by using cosmic rays and UV-laser beams will be commenced after the completion of the construction. After this, the TPC is expected to be shipped to RIBF for first experiment.

*1 Department of Physics, Kyoto University
*2 National Superconducting Cyclotron Laboratory, Michigan State University, United States
*3 Physics Department, Western Michigan University, United States
*4 Cyclotron Institute, Texas A&M University, United States

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