Kyoto Multiplicity Array for the SπRIT experiment

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The SπRIT experiment, which aimed to investigate the nuclear equation of state at supra-saturation densities, was performed in the spring of 2016 at RIKEN-RIBF. The integral or momentum spectrum of π^-/π^+ produced in central heavy-ion (HI) collisions can be a useful probe[1)] and was measured in this experiment. In order to identify multi fragments including charged pions generated from HI collision and to reconstruct their momenta, a large time projection chamber (SπRIT-TPC[2)]) and ancillary trigger detectors were constructed. These detectors were used in the SAMURAI spectrometer with a magnetic field of 0.5 T.

The "Kyoto Multiplicity Array" has a sensitivity to sideward charged particle multiplicity which correlates with collision centrality. This detector consists of 2×30 plastic scintillator bars that are in close contact with both sides of the SπRIT-TPC. The enclosure of the SπRIT-TPC has 1-mm-thick aluminum window parts allowing light fragments from the reaction to pass through and be detected by the external triggering system. The dimensions of each plastic bar are 450×50×10 mm^3, and the plastic bars are coated with oxidized titanium for light reflection. Each bar has a hole of about 1.5 mmϕ centered along its length for a wavelength-shifting fiber as a light guide. The light propagated in the fiber of 1 mmϕ will be detected by a 1.3-mm^2 multi-pixel photon counter (MPPC) capable of use in a magnetic field. Figure 1 shows the geometrical setup of detectors in the SAMURAI magnet.

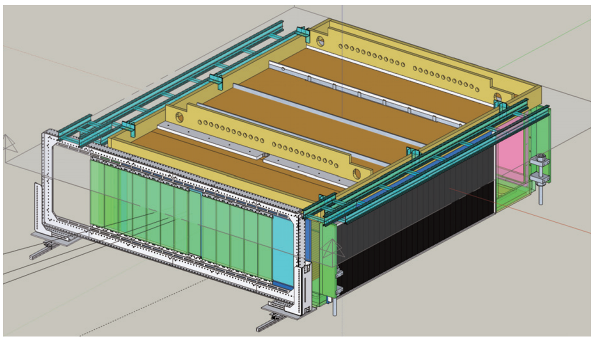

Fig. 1. Schematic drawing of SπRIT-TPC and ancillary detectors from beam-left downstream side. One-sided Kyoto Multiplicity Array is indicated by black, and the other side is behind the SπRIT-TPC.

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The ASD chip designed to readout photodiode type detectors - EASIROC - is used for shaping MPPC signals. For handling the EASIROC and its digital outputs from discriminators, FPGA is integrated in one board together with EASIROC (VME-EASIROC[3)]). The number of digital signals, as charged-particle multiplicity, is calculated by a combination of ROMs and adder circuits, which is implemented in the FPGA. If the calculation result surpasses the user-set threshold, a trigger signal will be generated within about 52 ns for the whole electronics. In addition to the online triggering function, multi-hit TDC with 1 ns time resolution is also implemented in the FPGA for offline analysis. In the SπRIT experiment, triggered event multiplicity was required to be greater than 4.

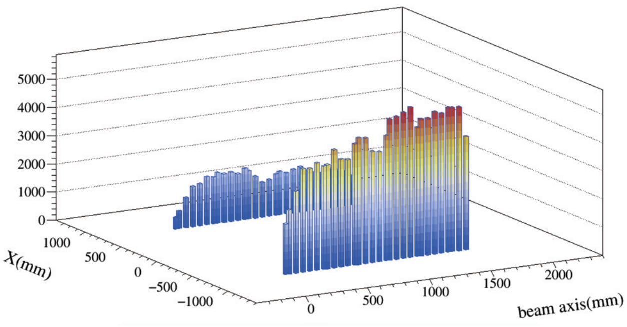

Fig. 2. Number of hits in each plastic bar in offline analysis from beam-right upstream side. The coordinates correspond to the position of each bar, and the target was located at X=0 mm and beam axis=–8.9 mm.

Although this was the first operation in the magnetic field, the data for TPC with ancillary detectors were acquired without major problems. The hit pattern obtained by the detector is presented in Fig. 2, where the effect of the magnetic field on charged particles can be observed. While there are some fluctuations, detailed analysis is necessary to understand the bias for triggered events and the impact parameter information.

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