Development of fast-response PPAC with strip-readout for heavy-ion beams†

S. Hanai,[*1] S. Ota,[*2,*1] R. Kojima,[*1] S. Masuoka,[*1] M. Dozono,[*3] N. Imai,[*1] S. Michimasa,[*1] S. Shimoura,[*1,*4,*2] J. Zenihiro,[*3] K. Inaba,[*3] Y. Hijikata,[*3,*4] R. Longhi,[*5] and R. Nakajima[*1]

A parallel plate avalanche counter (PPAC) is standard position sensitive detector that is widely used in beamlines at several RI beam facilities such as RIKEN,[1)] and FRIB.[2)] The PPAC contains a few micrometer-thick electrode films and the counter gas typically maintained at a few Torrs. The property of thin and uniform material thickness facilitates a transparent beamline detector in suppressing the multiple scattering of beam particles, which deteriorates the emittance.

In the conventional type of PPAC called delay-line PPAC (DL-PPAC),[3)] the strip electrodes are connected to a delay-line, which has a delay of 0.8 ns/mm. The signal is collected from the two ends of the delay-line. The signal delay changes depending on the beam position and the maximum delay time is approximately 100 ns for a 100 mm delay line. The non-negligible signal pileup occurs and results in lower single-hit detection efficiency for the widely spread and high-intensity beams such as 10^6 cps (counts per second).

PPAC itself has an inherently quick response time because it amplifies the electrons drifting between two electrodes a few millimeters apart and the typical drift time of electrons is within 30 ns. We have developed a PPAC with a direct strip-readout for the achievement of detection efficiency greater than 99% even for the high-intensity heavy-ion beam near 10^6 cps, while maintaining the typical position resolution of DL-PPAC, that is, a few hundred micrometers.

Figures 1(a) and (b) show the schematic view of the inner structure and the photograph of a strip-readout PPAC (SR-PPAC), respectively. The electrodes and the layout of the SR-PPAC are the same as a typical DL-PPAC used in BigRIPS, RIBF. A readout board made of printed circuit board (PCB) was newly designed to read out the charge induced in each strip of the cathode plate. Connectors for flexible printed circuits (FPC) were mounted on the readout board dealing with 94 and 58 channels for the horizontal (X) and vertical (Y) directions, respectively. The signal collected from each strip was obtained by using the Time-over-Threshold method, which converted the pulse height information to time duration of over a set threshold voltage. Using the difference of pulse width between two adjacent strips, the beam position was determined more precisely than the strip size of approximately 2.6 mm.

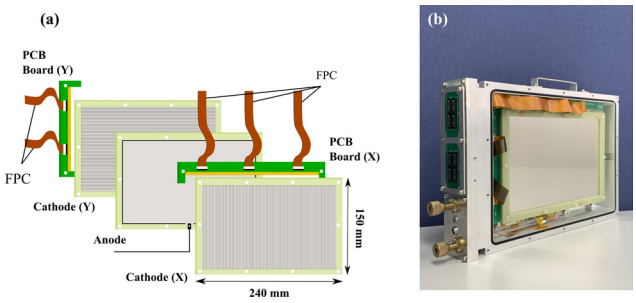

Fig. 1. (a) Exploded view of the inner structure of a standard-type SR-PPAC. (b) Photograph of a Standard-type SR-PPAC without the entrance window.

The performance of the SR-PPAC was evaluated in HIMAC, Japan, using the ^{132}Xe beam at 115 MeV/nucleon. Pure isobutane was used for a counter gas at 5 Torr. The detection efficiency exceeded 99% for 700 kppp (ppp; particles per pulse) beam. Figure 2 shows the position resolution as a function of beam intensity. Herein, 126 μm (σ) was achieved at 700 kppp. The SR-PPAC was also tested in RIBF and the position resolution of 170 μm (σ) for ^{48}Ca (atomic number $Z = 20$) beams at 300 MeV/nucleon with approximately 770 kHz beam intensity was achieved.

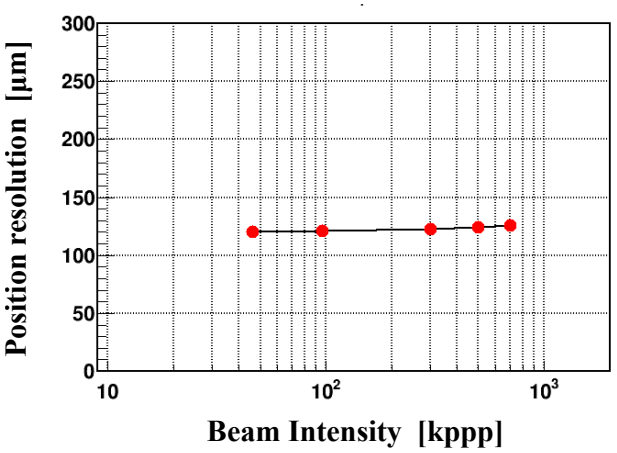

Fig. 2. Beam intensity dependence of the position resolution. The gas pressure was 5 Torr and the applied bias was 525 V.

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*1 Center for Nuclear Study, University of Tokyo
*2 Research Center for Nuclear Physics (RCNP), Osaka University
*3 Department of Physics, Kyoto University
*4 RIKEN Nishina Center
*5 Instutute of Modern Physics, Chinese Academy of Sciences

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