PPAC high-rate study with $Z \sim 50$ beams (MS-EXP15-09)

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Position-sensitive Parallel Plate Avalanche Counter (PPAC) is one of the important focal plane detectors for the $B\rho$ measurement at RIBF[1]). Owing to the fast response of the PPAC with the delay line readout, the PPAC operated under the counting-rate of several MHz with the 2.5 MeV/u ^{4}He beam[2]). However, sometimes a discharge of the PPAC due to high-rate heavy-ion beams results in damage to the electrodes and causes the high voltage (HV) modules to trip[1]). Therefore, it is important to investigate the tolerance of the PPAC against intense heavy-ion beams.

An endurance test of the PPAC against high-rate heavy-ion beams was carried out in November 2015. Two double-PPACs[1]) were placed in the F3 chamber of the BigRIPS separator. The upstream and downstream PPAC are named as F3-1 and F3-2, respectively. The size of F3-1 (F3-2) is 150 mm(X) × 150 mm(Y) (240 mm(X) × 150 mm(Y)). Each double-PPAC has two delay-line PPACs in its case, termed A- and B-side. Each PPAC is equipped with an anti-discharge unit, which is currently under development [3]). A mixed beam of around ^{132}Sn was used, whose energy at F3 was around 220 MeV/u. The beam size in σ at F3-1 was 2.1 mm (X) and 3.1 mm (Y), and at F3-2 the beam size was 7.5 mm (X) and 9.0 mm (Y).

Before irradiating the PPACs with intense beams, the HV dependence of individual detection efficiencies for each cathode was measured with a 1 kHz beam (Fig. 1). Subsequently, the HV was adjusted for all cathodes so as to realize the individual efficiency of around 95%. At that time, the total efficiency for X and Y plane, η_X and η_Y, was 99.86% and 99.92%, respectively. Here, η_X is defined as

$$\eta_X = \{1-(1-\eta_{F3\text{-}1AX})(1-\eta_{F3\text{-}1BX})\} \times \{1-(1-\eta_{F3\text{-}2AX})(1-\eta_{F3\text{-}2BX})\},$$

where $\eta_{F3\text{-}1AX}$ is the individual efficiency of the X cathode of the A-side PPAC at F3-1; η_Y is similarly defined.

Under this HV condition, PPACs were irradiated with high-rate beams in the range from 1 kHz to 1000 kHz, and the occurrence of the discharge and the change of the total efficiency were monitored. Firstly, there was neither discharge nor trip of the voltage modules even in the case of irradiation with the 600 kHz and 1000 kHz beams for 70 and 60 minutes, respectively. Secondly, the total efficiency decreased as beam rate increased as shown in Table 1. If the electrodes in the PPACs sustain damage, this decrease of the total efficiency will happen and will be irreversible. However, η_X and η_Y obtained with the 1 kHz beam in runs 612 and 621, which were performed just after irradiation with the 600 kHz and 1000 kHz beam respectively, reproduce the values obtained with the first 1 kHz beam in run 602. Thus, we can conclude that the electrodes in the PPACs were not damaged by the high-rate beams up to 1000 kHz. The reason for the decrease of η_X and η_Y can be explained by the property of the delay line: the total delay time of the signal (118 ns for 150 mm delay line length and 192 ns for 240 mm) results in the dead time of the PPAC. As a result, the efficiency decreases for high-rate beams.

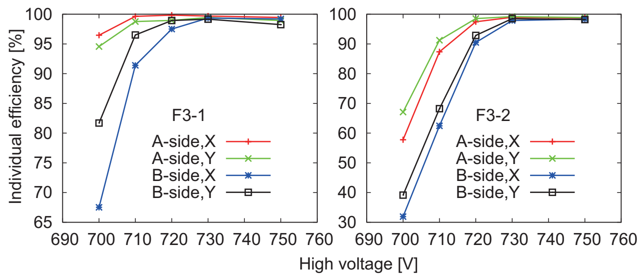

Fig. 1. Individual efficiency of each cathode. The adjusted voltage for each PPAC is as follows: F3-1A, 700 V; F3-1B, 720 V; F3-2A, 720 V; F3-2B, 730 V.

Table 1. Total efficiencies of η_X and η_Y.

run number	beam rate @F3 [kHz]	irradiation time [min]	η_X [%]	η_Y [%]
602	1	5	99.86	99.92
605	50	10	99.70	99.83
606	100	10	99.74	99.80
608	200	10	99.57	99.72
609	400	10	98.89	99.30
610	600	10	97.71	98.52
612	1	5	99.95	99.96
613	600	30	97.65	98.49
615	600	30	97.75	98.52
616	1000	30	90.83	93.30
617	1000	30	92.94	94.57
621	1	5	99.94	99.96

References
1) H. Kumagai et al.: Nucl. Instrum. Meth. B **317**, 717 (2013).
2) H. Kumagai et al.: Nucl. Instrum. Meth. A **470**, 562 (2001).
3) Y. Sato et al.: JPS Conf. Proc. **6**, 030124 (2015).

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