Timing performance of a mirror-type MCP detector use for mass measurements at the Rare RI Ring

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High resolution time-of-flight (TOF) measurements are crucial for mass measurements via TOF methods such as in-ring isochronous TOF or beam-line Bϱ-TOF. To characterize and optimize the timing resolution of a mirror-type micro-channel plate (MCP) detector[1)] with a timing anode, an experiment aimed at studying the performance of the detector was conducted at HIMAC (Heavy Ion Medical Accelerator in Chiba). We demonstrate preliminary online results of the timing detector which can be used for the revolution time measurement inside the Rare RI Ring[2)] (R3), start TOF of the total TOF for in-ring circulation, beam-line TOF measurement for beam-line mass determination and velocity reconstruction for in-ring mass correction.

To investigate the properties of the detector, a primary beam of $^{84}Kr^{36+}$ at the energy of 200 MeV/nucleon is used. The experimental setup is shown in Fig. 1(a). The setup consisted of two parallel plate avalanche chambers (PPACs) for beam tracking, one electrostatic MCP detector, two plastic scintillators for intrinsic timing resolution deduction of the mirror detector. The MCP with a diameter of 40 mm is mounted on a triangular detector structure as shown in Fig. 1(b). The conversion foil is made of mylar (2 μm) coated with aluminium. The accelerating grid consisting of gold-plated tungsten (W+Au) wires (40 μm in diameter) possesses a distance of 8 mm from the conversion foil with a 1 mm pitch, and wires (W+Au) for the inner and outer mirror grids are arranged with a 3 mm pitch. During the experiment, the high voltage (HV) potential of the MCP, accelerating grid and inner mirror were set at 2.5 kV and the accelerating HV of the foil and outer mirror grid were varied. The timing resolution for isochronous and non-isochronous condition[3)] has both been studied by the experiment and simulation performed via SIMION[4)] as shown in Figs. 1(c) and (d). The distance between the outer mirror and inner mirror is 20 mm for isochronous condition, while it is 8 mm for the non-isochronous condition. As demonstrated from Figs. 1(c) and (d), when the accelerating HV is increased, the timing resolution improves for both configurations with the corresponding settings.

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As can be seen from Figs. 1(c) and (d), the trends of timing resolution (only statistical errors included) as a function of the accelerating HV for the simulation and experimental results are consistent with each other. Simulation results show that a timing resolution of less than 20 ps could be achieved. However, the experimental results could not be achieved and seem to be saturated around 40 ps for both conditions. One possibility could be systematic error from the data acquisition electronics. The detection efficiency reaches $\sim$ 96% by suitable arrangement of the MCP position on the support plate of the triangular structure from the theoretical calculation of the electromagnetic motion of the secondary electrons inside the detector.

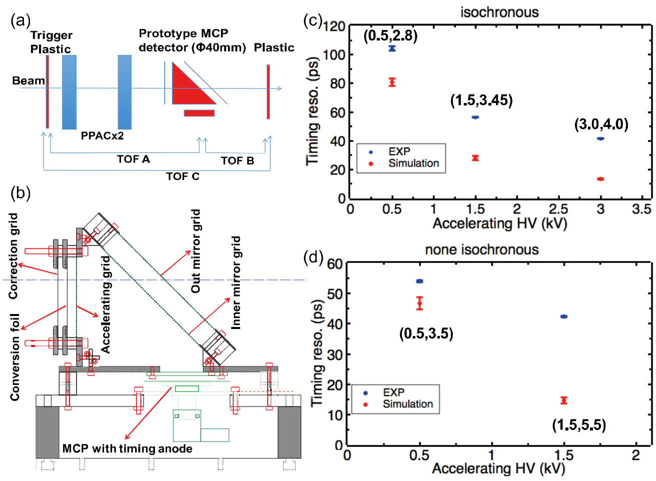

Fig. 1. (a) Schematic diagram of the setup for HIMAC experiment. (b) The side view of the MCP detector structure. (c) and (d) depict the timing resolution (in σ) as function of the accelerating HV potential (the HV difference between the accelerating grid and conversion foil) for isochronous and non-isochronous condition, respectively. The red points are simulation results and the blue points display the experimental results. The HV values described in this report are all negative and in the unit of kV, and values in brackets correspond to (accelerating HV, outer mirror HV).

References

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4) `http://www.simion.com.`