Delay-line Anode for MCP-based Position Sensitive Detector at Rare RI Ring

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Rare RI Ring[1] (R3) is a newly developed mass spectrometer for the measurement of exotic nuclei with a high precision of 10^{-6}. In order to achieve this goal, beam diagnostics need to be on the beam line (including BigRIPS, SHARAQ, and R3 injection)[1] for several reasons: (1) velocity measurement with a precision of 10^{-4} is needed for mass determination;[2] (2) in order to improve the transport efficiency, emittance matching should be applied, which requires emittance measurement before the ring.[3,4] To achieve a precision of 10^{-4} for the velocity measurement, new position sensitive detectors with energy loss as low as 10^{-5} are needed, which cannot be achieved by conventional PPAC. High position resolution (< 1 mm) and high efficiency ($\sim$100%) are also needed. For these detectors, it is very important to use position sensitive anodes for collecting the secondary electrons. To achieve high position resolution, we chose 2D delay-line anode for Micro-Channel-Plate (MCP) based detectors. The result of the calibration and position resolution of the anode is shown in this report.

A mask with several holes (the size of the holes were 1 mm and 0.5 mm in diameter) was placed on the MCP, whose active area had a diameter of 120 mm, as illustrated in Fig. 1. We used the vacuum gauge as the source of electrons to calibrate the position of the anode. For each dimension of the delay-line anode, the sum of the times from the two ends, $T_{\rm sum}$, should be constant, see Fig. 1. We chose 3σ of $T_{\rm sum}$ as a gate to cut the noise signal in both dimensions. The time information of each hole was obtained by projecting the points in the X axis and Y axis, and by fitting it using the Gauss function. It is not possible to use a linear function to calibrate the relationship between the time and position. Therefore, a quadratic function is chosen since it has a higher accuracy as shown in Fig. 2(b)(c). The position information of the holes after calibration is shown in Fig. 2(a). For holes with a diameter of 1 mm, the resolution in both the x and y directions is smaller than 0.6 mm in σ, which is required for high-resolution position sensitive detector.

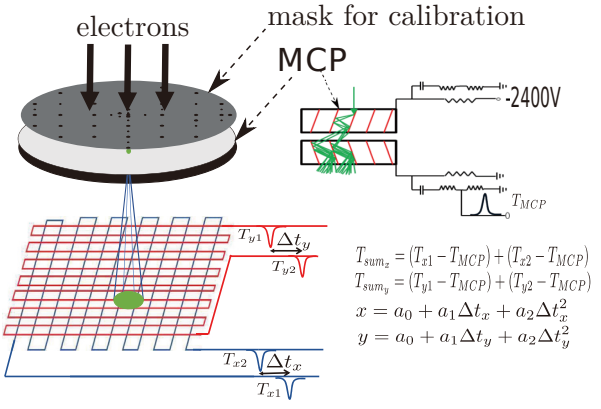

Fig. 1. Principle of the MCP with 2-D delay line anode; the MCP was placed in vacuum (3.5×10^{-3} Pa).

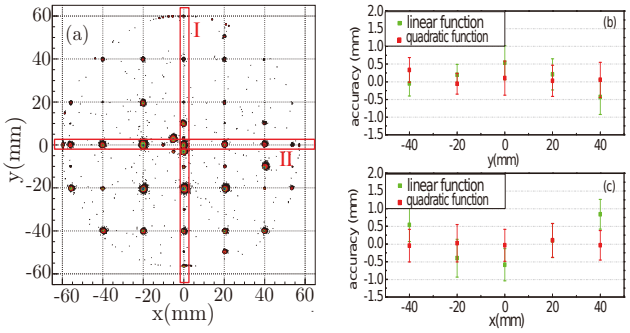

Fig. 2. (a) Image produced by the electrons that pass through the mask's holes and hit the MCP; (b), (c) Accuracy of the points in slice I and II in (a) by using linear and quadratic functions; the error bar represents the σ of the peak.

An MCP with a delay-line anode that has a resolution smaller than 0.6 mm in σ is adequate for a position sensitive detector. One detector has already been developed and is under testing.[5] In the coming years, other position sensitive detectors with the same delay-line anode will be developed.

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