Simulation and design of a large area position sensitive TOF MCP detector at the Rare RI Ring

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In order to transport nuclei of interest individually to the central orbit of the Rare RI Ring[1)](R3) with high efficiency and to improve the resolution of the in-ring TOF mass measurements at the R3, we plan to develop a large area (~42mm x 190mm) position sensitive TOF MCP detector for R3, which has the properties of low energy loss, good timing and high position resolution.

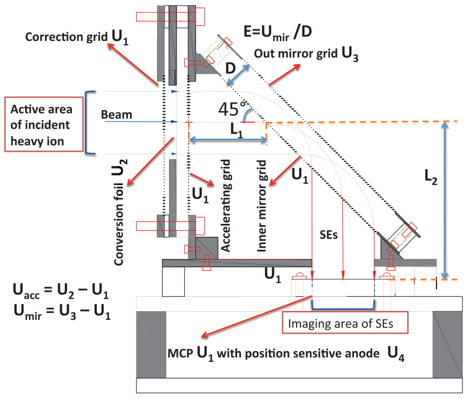

Fig. 1. Structure of the MCP detector and description of the parameters of the imaging mirror detector.

Information on the heavy ions that possess high energy can be reproduced by measuring the secondary electrons (SEs) induced from conversion foils with MCP which has a high intrinsic timing (20 ps-100 ps) and position resolution (0.1 mm). Detectors with magnetic field can't be used inside R3 because of the accumulation of the bending power of the magnet for the multi-turn circulation of fully stripped heavy ions and the influence on the homogeneity of the magnetic field of R3. Therefore, we chose a mirror-electrostatic-field-type detector for in-ring TOF position measurements. The detector consists of two chevron type micro-channel plates (MCPs) coupled with a position sensitive anode, a thin electron conversion foil, and a mirror electric field for bending the SEs ejected from a thin conversion foil (40 ug/cm^2) passing through by the highly charged heavy ion (^{78}Ni region with ~ 170 MeV/nucleon energy for the next experiment).

To achieve high resolution, an isochronous condition[2)] is chosen, at which the total time of flight consists of 3 parts: the accelerating grid to the inner mirror wires, bending path between the inner and outer mirror wires, free drift region from the inner mirror wires to the MCP. The relation of the so-called isochronous condition is $D/(L_1 + L_2) = 0.236\frac{U_{mir}}{U_{acc}}$[2)]. U_{acc} and U_{mir} are, respectively the acceleration potentials between the conversion foil and the accelerating grid, and the mirror deflection potential between the mirrors are described in Fig. 1 together with L_1 and L_2.

To optimize the performance of the detector, a simulation was performed via SIMION.[3)] By keeping the high voltage (HV) potential of the MCP, accelerating grid and inner mirror at -2500 V and by varying the accelerating HV of the foil and outer mirror grid at the isochronous condition we obtained the results shown in Fig. 1. With the increase of the accelerating HV, the resolution of timing and position is improved and reaches a plateau at a certain HV value. The Y position resolution is better than that of X, which is due to the mirror electric field effect in the Y direction. From the simulation results, the intended timing and position resolution of ~100 ps in sigma and ~1 mm in FWHM is satisfied, which is required for mass measurement (10^{-6}) and velocity reconstruction (10^{-4}). The detector has already been constructed and is now being tested.

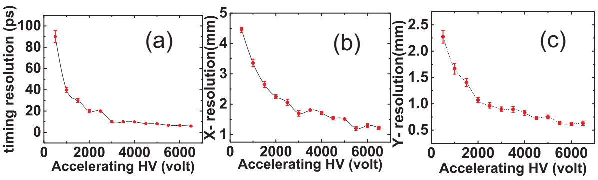

Fig. 2. Simulation results by *SIMION*[3)] (with a mean energy value of 2 eV and a Gaussian distribution in energy of the SEs). (a) Timing resolution (in sigma) as function of the accelerating HV potential (the HV difference between the accelerating grid and conversion foil). (b) and (c) X- and Y-position resolution (in FWHM) dependence of the accelerating HV supply.

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References

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2) N. Nankov et al., Wiss. Tech. Berichte FZR-423, 25 (2005) (Annual Report 2004).
3) http://www.simion.com.