Development of a Time-of-Flight Spectrometer for Fission Fragment Studies

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Introduction:

There are several methods and techniques have been applied for identification and study of fission fragments in heavy ion induced fission reaction studies. One of the methods for measuring a fission fragment mass is using the conservation of momentum and energy. In this case, the velocity and kinetic energy of both the fragments are measured simultaneously to resolve fragment mass (often referred to as the "2V,2E" method[1,2]). In this method the TOF is measured between a start and stop detector and energy from a SSB detector which is placed behind the stop detector. It is straight forward to show that the fragment mass (M_f) can be found by $M_f = 2E_f / v_f^2 = 2E_f / (x/t)^2$, Where E_f is the fragment kinetic energy, x is the distance between "start" and "stop" detectors and t is the TOF.

The start and stop detectors consist of a conversion foil (usually thin C-foil) for producing secondary electrons due to the passage of fission fragments, a focusing element (electrostatic mirror) to guide the electrons in a particular direction where they are detected by a micro channel plate (MCP). In this work we report the design, fabrication and initial test results of the electrostatic mirror that can be used at Pelletron-LINAC facility, Mumbai for Heavy Ion fission reaction studies.

Design & fabrication of the focusing element:

The focusing element with wire mesh has been designed and fabricated at BARC. Fig.1 shows a schematic diagram of the electrostatic mirror ("start" detector and would be identical for "stop" detector). The structure is made of Fibre-epoxy(FR4) and the base plate (for housing the MCP) is of Teflon. In Figs.2 and 3 we show the actual fabricated detector. The wire grid composed of Cu-Be wire (Cu98/Be2) with a spacing between wires is 1mm. For test measurement we have used wire diameter of 200μm which will be replaced by 50μm in actual experiment. The MCP is of Photonique make (area 85mm X 65mm) and a tantalum plate was fabricated to be used as anode for taking the MCP signal o/p.

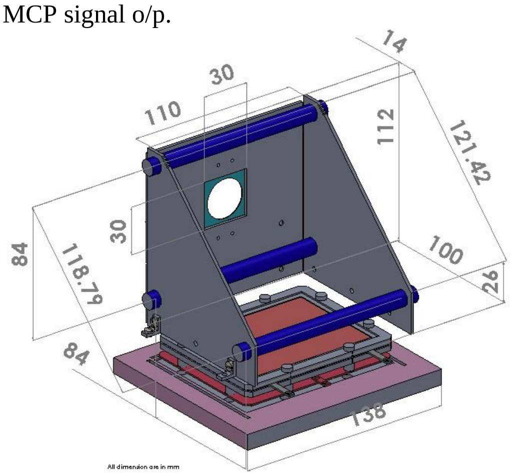

Fig.1 A schematic diagram of the electrostatic mirror along with the base plate for MCP and anode plate. All dimensions are in millimeters.

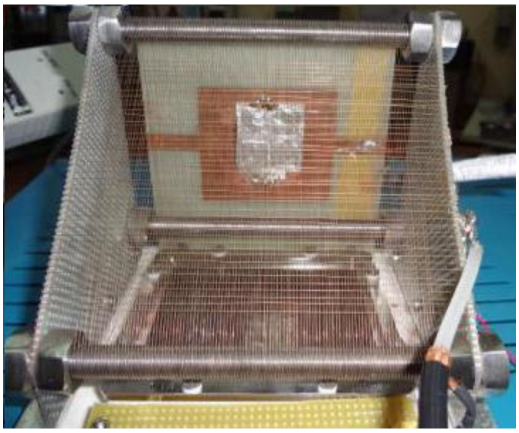

Fig.2 The focusing element showing the construction of the electrostatic mirror with wire grids.

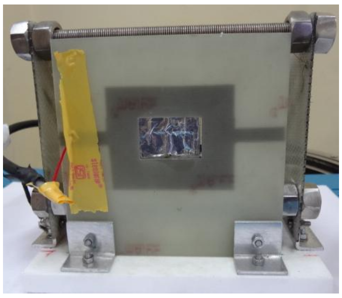

Fig.3 Front view of Fig.2 showing the conversion foil for secondary electron production

Simulation and Test Results:

Detailed simulations for electron trajectories inside the focusing element have been performed and optimum voltage across the electrostatic mirror grids was decided accordingly. Some simulation results are shown in Figs.4 and 5 showing the focusing action of electrons as the grid voltage increases. In Fig.6 we plot the time taken by the electrons to reach the MCP as a function of accelerating voltage.

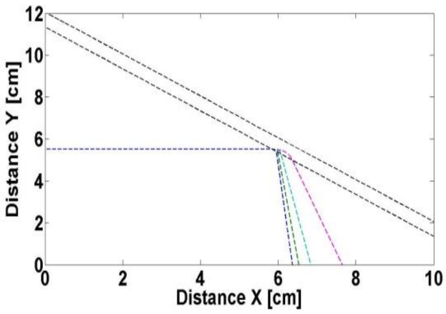

Fig.4 Focusing action inside the electrostatic mirror.

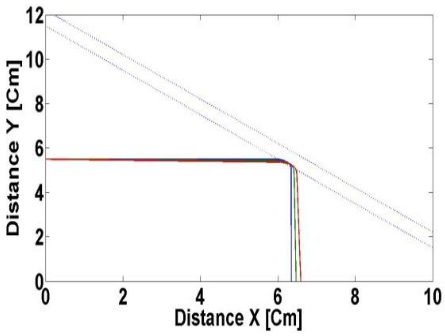

Fig.5 Same as Fig.3 but for different initial electron energies and increased grid voltage.

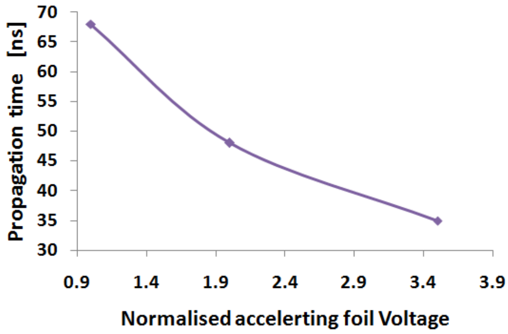

Fig.6 Study of electron propagation time vs. accelerating voltage.

The MCP has been tested (Fig.7) in vacuum with electrons from ^{90}Sr/^{90}Y β^- source. MCP response is very fast and typical signal rise time < 5ns is observed. Performance of the mirror is being tested with secondary electrons knocked out from the conversion foil by an α-source. Results will be presented.

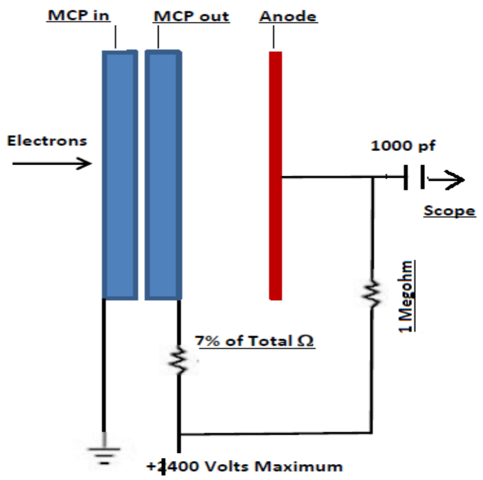

Fig.7 Connection diagram for the MCP.

Acknowledgement:

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References

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[2] A. Oed et al., Nucl. Inst. and Meth. in Phys. Res. 219 (1984) 569-574