# Timing characteristics of a multi-wire cathode strip detector for the measurement of fission fragments

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## Introduction:

Because of the fast timing response, multi-wire proportional counters (MWPC) are largely used in heavy ion induced fission reaction studies for the measurement of fragment mass distribution [1]. Recently, we have developed a gas filled two-dimensional multi-wire cathode strip detector (MCSD) for the detection of fission fragments (FFs) [2]. The position resolution was found to be about 1.0 and 1.5 mm in X and Y-directions respectively**.** The detector has three electrode planes consisting of cathode strip (X-plane), anode wires and split-cathode wires (Y-plane). Each thin wire of the anode plane placed between the two cathode planes is essentially independent and behaves like a proportional counter. The position information has been obtained by employing high impedance discrete delay line read out method for extracting position information in X and Y-directions. The construction of the detector in detail has been reported earlier [2].

In the present work we report the timing characteristics of MCSD detector to explore the possible use of this detector for the measurement of the mass of the fission fragments produced in heavy ion induced fission reactions.

## Description of Time of Flight Setup:

For the investigation of the timing characteristics of the MCSD for fission fragments, we have developed a time of flight setup as shown in Fig.1. The fission fragments were detected by using the MCSD and the prompt gamma rays emitted from the fission fragments were measured in coincidence by using a Barium Fluoride ($BaF_2$) scintillation detector. The MCSD is mounted inside a scattering chamber on a rotatable arm of the chamber with its one port extended outside of the chamber and the fission source ($^{252}Cf$) is mounted on its flange from inside. A $BaF_2$ scintillation detector placed outside of the flange detects the prompt gamma rays emitted from the fission fragments. The path length from fission source to MCSD is 91 cm. Fig.1 depicts the schematic diagram of TOF setup.

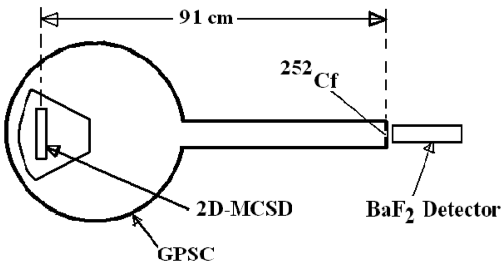


**Fig.1**: Schematic diagram of Time of Flight setup

## The experimental details:

The scattering chamber and the MCSD detector were evacuated to a vacuum ~ $10^{-3}$ torr using a rotary pump. The MCSD was then filled with iso-butane gas at a pressure of 6 mbar and operated in gas flow mode. The Anode and Cathode were biased at +510 V and -10V respectively. The $BaF_2$ detector was biased at -1800 V. The 'Start' and 'Stop' timing signals were taken from the $BaF_2$ detector and the anode of the MCSD respectively. They are fed to a Time to Amplitude Converter (TAC) module for measuring the TOF of the fission fragments. Different energies of the fission fragments were achieved by putting 1-layer, 2-layers and 3-layers of Mylar foil (thickness = 2.5 micron) in front of fission source. Fission fragment energy was derived from anode of MCSD using shaping amplifier. The energy of the gamma rays was measured by amplifying the pre-amp signal using a shaping amplifier. All the required parameters were acquired through a PC based data acquisition system using LAMPS software.

## Results and discussion:

Fig.2 shows the 2D-plot of Fragment Energy v/s TOF spectrum for fission fragments. From the spectrum it is clear that light fission fragments having more velocities reach earlier in the MCSD as compared to heavy fission fragments.

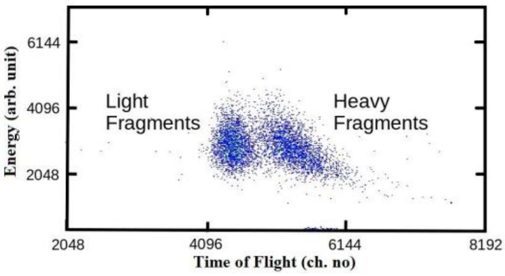


**Fig.2:** Fragment Energy and Time of Flight correlation spectrum without any Mylar foil.

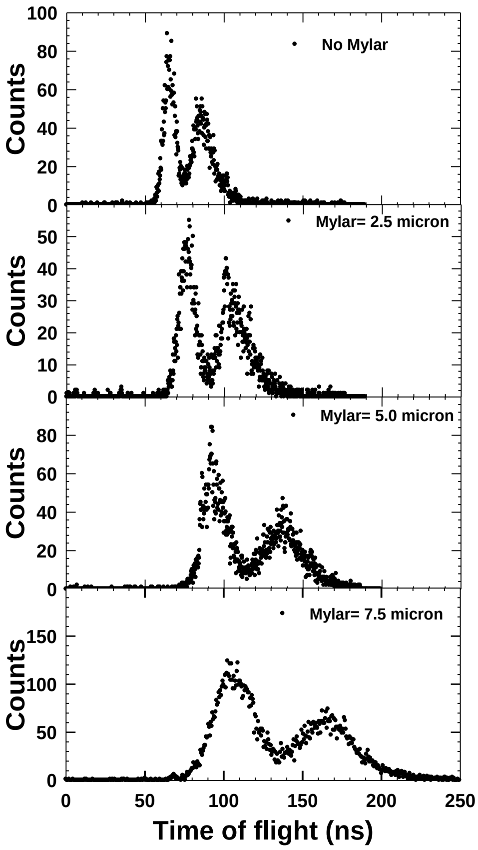


**Fig.3:** Time of Flight spectrum for fission fragments after energy degradation with different thickness of Mylar layer.

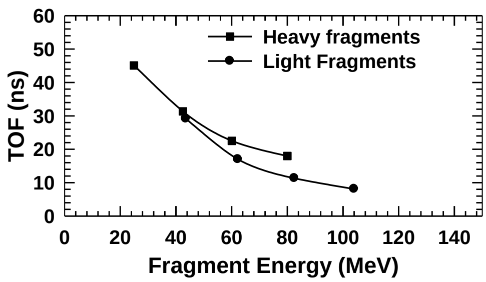


**Fig.4:** Time of Flight FWHM v/s Fragment Energy spectrum for fission fragments.

**Table-1**

| Mylar Thickness (micron) | Energy of most probable Light frag. after Mylar (MeV) | Energy of most probable Heavy frag. after Mylar (MeV) |
|---|---|---|
| 0.0 | 104 | 80 |
| 2.5 | 82.56 | 60.07 |
| 5.0 | 62.26 | 42.49 |
| 7.5 | 43.58 | 24.92 |

We have calculated FFs residual energy after passing through 1, 2 and 3 layers of Mylar using SRIM software and their values are given in Table-1. The TOF spectrum for fission fragments after energy degradation with different thickness of Mylar layer is shown in Fig.3. It is seen that with the decrease in the energy of the fission fragment the width of the peak broadens. By using Gaussian fits to the timing spectrum, we have obtained the width of the TOF distribution. The width (FWHM) corresponding to various fragment energies is plotted in Fig.4. It is observed that the TOF increases significantly as the fragment energies are reduced after passing through the Mylar foils and the distribution becomes asymmetric due to degradation in the foil.

## References:

1. T. K. Ghosh et al., Phys Rev C 69, 031603(R) (2004); C. Yadav et al., Phys Rev C 86, 034606 (2012).

2. R.P. Vind et al. IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 60, NO. 6, pp. 4650-4655 DECEMBER 2013.