Large Area Multi Wire Proportional Counters for Fission fragment Detection

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Introduction

The study of heavy ion induced fusion-fission reactions have demanded variety of charged particle detectors suitable for timing and imaging fission fragments in coincidence measurements. These detectors provide the energy, timing and position information of interacting charged particle that are crucial for kinematic reconstruction of nuclear reaction process. Since the cross sections of nuclear process are very low (~ mb or low), large area detectors are highly preferred. In practice, it is difficult to find a single detector fulfilling all these requirements. Large area Multi Wire Proportional Counters(MWPC) are most commonly used class of detectors that can provide two dimensional positions (X,Y) and timing of fission fragments. At Inter University Accelerator Centre (IUAC), MWPC based time of flight spectrometer[1] has been used for fragment gated neutron multiplicity measurements using the neutron detector array (NAND)[2]. A new set of detectors with additional features have been fabricated and tested recently. The geometry of these detectors has been modified to have better angular coverage and additional energy loss information. Also, care has been taken to avoid any extra material in the reaction chamber as it can act as neutron scattering centers. These detectors will be mounted at folding angle to act as fission fragment correlation set up.

This article reports the design parameters and characterization of new large area MWPC with standard radioactive sources.

Description of the detector system

The design of detector followed Breskin's four electrode geometry [3] where timing electrode was sandwiched between position electrodes and a cathode was mounted after one of the position electrodes to act as pre-amplification stage (X-A-Y-C). The detector has an active area of 20 cm x 10 cm with an inter electrode spacing of 3.2 mm. Timing and position electrodes were fabricated using gold plated tungsten wires of 20 um diameter, stretched on PCB of 3.2 mm thickness and 1.2 mm pitch. The positions were extracted using delay line method. Wires were inter connected using Rhombus delay chip TZB 12-5 having a fixed delay of 2ns per tap and a characteristic impedance of 50 ohms. The end-to-end delay of X and Y positions were 160 ns and 80 ns respectively. The tap to tap delay of the position frames were tested and verified using pulser signal. The cathode frame was developed from a single sided aluminised Mylar foil of thickness 4 um, stretched on a 3.2 mm thick PCB. The electrodes were properly wired and assembled in the aluminium chamber made in transmission type geometry. A gas handling system was connected to maintain the detector gas pressure ~3-4 mbar keeping the reaction chamber at ~4 x 10-6 mbar. A positive voltage to anode and negative voltage to cathode were applied by keeping position electrodes at ground potential. The voltage applied between cathode and Y position electrode would act as ionization region. Avalanche multiplication occurs at distances very close to anode wire (4-5 r). The timing signal was derived from the charge induced at anode caused by the movement of fast electrons. The energy loss signal was obtained by integrating the charge collected at cathode which is crucial for species identification.

Radioactive source test

The MWPC was tested offline with ^{252}Cf, a spontaneous fission source mounted ~ 20 cm away to ensure a uniform irradiation in the detector medium. The bias voltage applied was +340V and -230V at anode and cathode respectively. The improved uniformity of electric field attained with cathode foil helped to obtain excellent amplitude and appreciable signal rise time at moderate bias voltage. As the bias was increased further, triggering from intense alpha band was observed. The stability against breakdown has been confirmed by monitoring the leakage current for a few days. The raw timing signal from MWPC is shown in fig. 1. The rise time was found to be ~ 8 ns with an amplitude of ~1.5V.

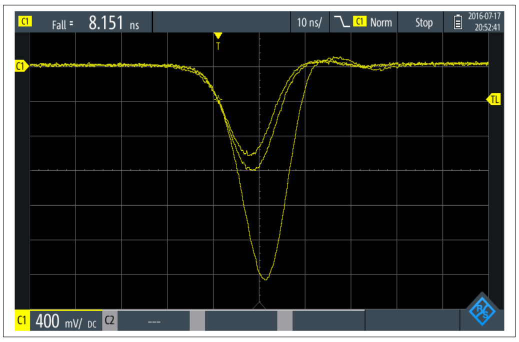

Fig. 1 The anode timing signal from MWPC

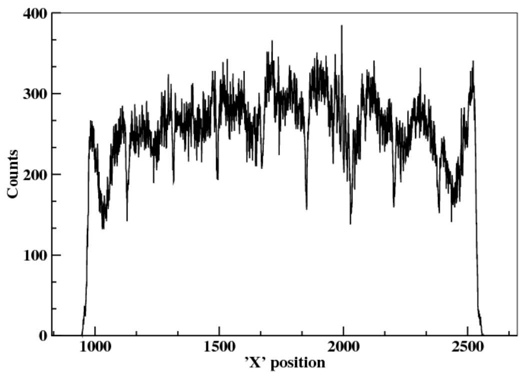

Fig. 2 One of the position signals obtained by delay line method

The signals were processed using conventional analog electronic units to extract energy loss, X and Y positions. One of the four position signals is shown in fig. 2. The position resolution was measured by mask test and it was found to be ~1.2 mm. The position signals were gated with sum spectra in order to avoid random events and plotted X v/s Y to inspect the detection efficiency which is depicted in fig. 3. It shows that the detector has been fired uniformly without any dependency on position.

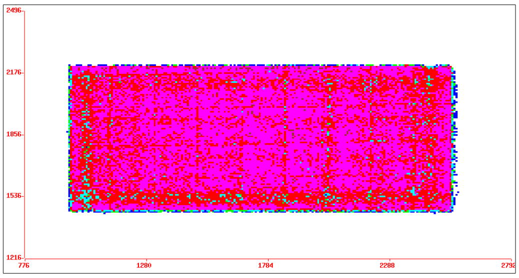

Fig. 3 Two dimensional XY position spectrum.

In summary, we have developed a pair of large area MWPC for fission fragment detection. The modifications implemented to the existing geometry are expected to improve the performance in experiments. The offline test shows that the detector performance is excellent for heavy ion induced fusion fission reaction studies.

Acknowledgment

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References

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