Development of a compact MWPC detector

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Introduction

Conventionally silicon detectors are used for detection of charged particles. However, for heavy particles like fission fragments, these are not suitable due to their fast degradation of performance with radiation damage and small geometrical efficiency. Large area position sensitive silicon detectors are commercially available but with high cost and poor energy resolution due to large capacitance. The multiwire proportional counter (MWPC) detectors have been an efficient solution to the above problem which provide very good timing and position resolutions, higher count rate handling capability and also insensitivity to radiation damage [1,2]. They can also be fabricated easily with various sizes according to the need for experimental investigations.

In the present work, we describe development of a large area position sensitive compact multiwire proportional counter for the detection of fission fragments in heavy ion experiments. The detector has been tested successfully with alpha source as well as fission source.

Detector design

The core of the detector consists of five frames each with an active area 12.5 × 7.5 cm^2. As shown in Fig. 1, the arranged wire frames starting from the entrance of the detector are: a cathode, an X-frame, an anode, a Y-frame and a second cathode (shorted with the first cathode). The design is similar to the one developed by Breskin [1]. Such a design provides high gain for both heavy and light ions at low pressure [∼1-5 torr]. All wire frames are made from gold plated tungsten wire with 20μm diameter, stretched on a 1.6 mm thick printed circuit board. All the frames are stacked one after another. The X frame is made from 100 wires whereas the remaining frames have 60 wires each. The separation of two consecutive wires is 1.27 mm. Using commercially available rhombus delay line integrated chips (model TZB12-5) position information from X and Y frames are extracted. In position electrodes, wires are shorted in pair and connected to one tap of delay line chip. End to end delay in X and Y-position frames are 100 and 60 ns, respectively. The position frames are kept at ground potential by terminating both ends of delay lines through 150 kΩ resistors. The electrode assembly is mounted inside a rectangular metal housing milled out from a solid aluminum block of dimension 21.2 cm × 15.6 cm. At the entrance of the detector 1.5 μm thick mylar foil has been used to

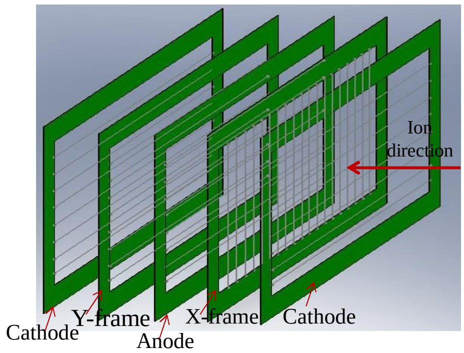

FIG. 1: Schematic diagram showing arrangement of PCB frames.

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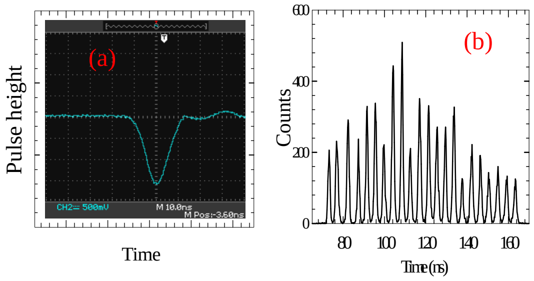

FIG. 2: (a) Preamplifier output of anode signal in oscilloscope and (b) X-spectra in presence of a mask in between the source and the detector.

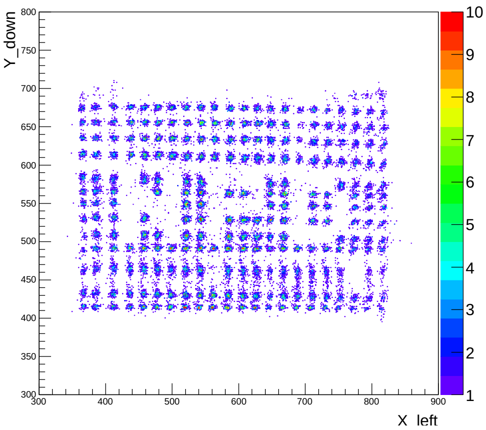

FIG. 3: 2-D pattern obtained from the detector testing.

isolate it from the vacuum chamber. The foil is supported by nylon wire. The detector is operated with flowing iso-butane gas at ∼1-4 torr pressure depending on the type of incident particle.

Detector testing

The detector has been tested with ^{229}Th alpha source and ^{252}Cf fission source. For fission fragment detection +360V and -180V were supplied to anode and cathode respectively. Readout electronics is as important as other parameters like gas pressure, operating voltages etc. to get its best timing and position resolution. The cathode signal is read out by homemade low gain charge sensitive preamplifier. Typical pulse height of 1-10 V were observed from cathode signal which also shows clear distinction between light and heavy charged particles. Anode signal (negative) is read out by a non-inverting fast preamplifier developed in house and pulse height of 500 mV-1.5V were observed with a rise time less than 10 ns as shown in Fig. 2(a). The positive signals from the position wire frames are processed through inverting fast preamplifiers to convert the polarity. Typical pulse height of 100-300 mV were observed from position frames. It is further amplified by fast amplifier (PHILIPS 777). All the timing signals are fed into CFD to generate NIM logic pulse. Anode and position signals serve as start and stop signal respectively for timing measurement whereas anode signal is used for master trigger in data acquisition system.

To determine position resolution one mask made of aluminum plate with (22 × 14) holes with 1 mm diameter and separation of 5 mm between two adjacent holes were placed in front of the detector at a distance of ∼25 cm from the source and the mask is at ∼2 cm from the first electrode. The x projection of the mask on the detector has been shown in Fig. 2(b) where peak to peak separation is 5 mm. The FWHM of the peaks for X and Y frames have been found to be 1.5 mm and 1.7 mm respectively. Few holes were blocked deliberately to show the 2D pattern as shown in Fig. 3. The sum of the position signals (XL+XR) and (YU+YD) is equal to the total delay of the delay line which remains constant. Time dispersion of 1.7 ns in the detector as well as electronics setup has been determined from the width of the peaks of sum spectra.

With satisfactory test performance including position resolution and time dispersion, the detector is ready for online fission measurements.

References

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