Development of a low pressure PPAC for detection of heavy charged particles

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Introduction

In recent times, fission fragments mass distribution has been proved to be an important tool to study the dynamics of the fusion-fission reaction process. The best method to measure the masses of the fission fragments is to measure the time of flight (TOF) of the fission fragments produced in a nuclear reaction. This requires detectors with excellent time resolution. Usually, large area multi wire proportional counters are used [1] to generate the STOP signal in a time of flight measurement (TOF) setup and beam pulsing time (for pulsed beam) is used for the START signal. However, the experiment using cyclotron, where the resolution of the beam pulsing is generally poor (few nano-second) or the experiments with dc beam, requires a suitable detector to generate START signal for the TOF measurement. Since low pressure parallel plate avalanche counters (PPACs) provide good timing resolution [2], they have been used for the detection of heavy ions in nuclear reaction experiments for many years. PPACs are known instrument for precise timing measurement in nuclear physics research. At VECC, we have designed and developed a parallel plate avalanche counter for detection of heavy charged particles.

Design and construction of detector

A schematic diagram of different electrodes and photograph of detector is shown in Fig. 1. The active area of the detector is 50 mm x 35mm It consists of three electrode wire planes: two cathodes and one anode. All the electrode planes are kept in parallel to ensure a uniform electric field. The gaps between each electrode are 3.2 mm.

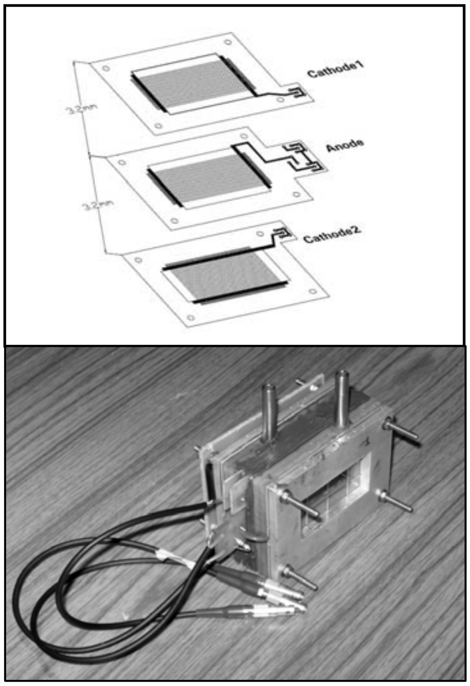

Fig.1 (a) Schematic diagram of different electrodes and (b) photograph of PPAC.

The anode wire planes consists of 10 μm diameter gold plated tungsten wires and the cathode wire planes are made of 20 μm diameter gold coated tungsten wire, placed 1 mm apart. The anode and cathode wires are soldered on conducting strips. All the wire planes are made of G–10 quality single sided plated copper board

(PCB). Successive layers of PCBs with spacers, also of G-10 boards, are vacuum sealed with RTV 88 sealant (make: General Electric, USA) and 4 screws. The two cathode wire planes are shorted outside and connected to a power supply through a charge sensitive pre-amplifier. This provides energy signal from the cathode. Stretched polypropylene films (of thickness ~ 0.4 micron) are used as the entrance windows of the detector. 1 cm × 1 cm wire mesh of stainless steel wires of diameter 0.4 mm is used as a support to the polypropylene film the thickness of wire- mess plane was 6 mm. One inlet and outlet gas feed-through made of stainless steel are connected to the front and back support frames to flow gas continuously through the detector at a constant pressure flow mode with a baratron feed-back closed loop flow control system (make: MKS, USA).

Performance test

After fabrication, the detector was tested in the laboratory for energy read outs and timing pulses. A ^{252}Cf source was mounted in front of the detector which was placed inside an evacuated chamber. Iso-butane was selected as the circulating gas in the PPAC due to its large gas amplification. With precise regulation of gas pressure the detector was operated in constant flow mode at a pressure of 2 Torr. The operating voltages for anode and cathode were 300 Volts and 260 Volts respectively. Fig. 2a shows the typical timing signal from the detector boosted by a fast current sensitive ORTEC preamplifier of gain 200 and bandwidth 1.2 GHz. The signal pulse height was more than 300 mV with rise time ~ 3 ns. The signal to noise ratio was better than 40. Since the detectors are operated at low pressure, heavy fragment loses only a fraction of its energy in the detector. The energy loss signals are sometime useful to separate fission fragments from the elastics/beam like particles. Fig. 2b shows the typical energy loss signal from an amplifier (ORTEC572, with gain 50) with pulse height more than 2 Volt.

Conclusions

We have described the design and construction of a low pressure Parallel Plate Avalanche Counter for detecting fission fragment. The detector response with a ^{252}Cf source at the laboratory has been reported. Further rigorous testing for estimation of timing resolution efficiency and long term stability of PPAC detectors are underway and will be reported during the symposium.

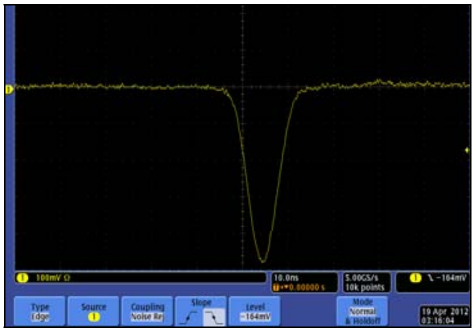

Fig. 2 a. Typical timing pulse from PPAC.

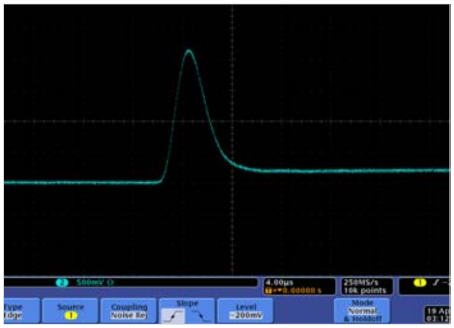

Fig. 2 b. Typical energy loss signal from PPAC.

References

[1] T.K. Ghosh. et al. Nuclear instruments and methods. A 540, 285 (2005).

[2] Fabio Sauli, Nuclear instruments and methods. A 422, 257 (1999)