An Integrated large area MWPC-SSD for velocity-energy measurements of reaction products at VAMOS

Akhil Jhingan[1*], C. Schmitt[2], A. Lemasson[3], N. Saneesh[1], S. Biswas[3], M. Rejmund[3], M. Kumar[1], C. Spitaels[3], J. Goupil[3], R. Ahuja[1], B. Jacquot[3], P. Sugathan[1], A. Navin[3]

[1]*Inter University Accelerator Centre, P. O. Box 10502, New Delhi - 110067, India*
[2]*IPHC, Université de Strasbourg - CNRS, 67037 Strasbourg, France*
[3]*GANIL, CEA/DSM – CNRS/IN2P3, Bd Henri Becquerel, BP 55027, F-14076 Caen Cedex 5, France*
** email: akhil@iuac.res.in*

Introduction

The characteristics and performance of a two dimensional position sensitive Multi Wire Proportional Counter (MWPC) integrated with a Silicon Strip Detector (SSD) are presented. The detector system has been developed for simultaneous measurement of velocity, energy and position (scattering angle) of the reaction products in the target chamber of VAMOS [1], in coincidence with reaction products at VAMOS focal plane in heavy ion induced binary reactions. The salient feature of this detector is the stacking of a transmission type, low pressure position sensitive MWPC with a SSD in the same detector housing. The active area is 10 x 10 cm^2 for both detectors. An important design feature of the MWPC is the reduced wire pitch of 0.317 mm for the timing electrode, and 0.635 mm for the position electrodes which significantly improves the avalanche gains and timing resolutions. The other salient feature is the integration of both timing and energy preamplifier units with the detector body, eliminating cables between them. Position resolution for MWPC is 1.2 mm and the timing resolution has been estimated to be 200 ps. An energy resolution of 75 keV is observed for the 8.37 MeV alphas in case of SSD. The detector has been used to perform fission measurements with VAMOS.

Detector Description

Fig.1 shows the schematic diagram of the detector system. The first detection layer is composed of a transmission type MWPC. This layer gives the required velocity (using TOF) and scattering angle information. It has a three electrode geometry having a central cathode (provides master timing) sandwiched between two position anodes providing information on horizontal and vertical trajectory of the incident heavy ions. The position electrodes are prepared using stretched gold plated tungsten wires on PCB frames. Wire pitch is 0.025″. Two sets of frames were prepared: one using 20μm and other using 10 μm diameter wire. Also two types of cathode frames were prepared. First one had a mylar foil, aluminized on both sides. Second frame was prepared using 20 μm diam. wires at 0.0125″ pitch. The advantage of using wires in cathode frame is that it eliminates energy loss and straggling in the mylar foil which varies from 15-30 MeV for fission fragments. The reduced wire pitch provides faster charge collection and more uniform field resulting in better timing and gains. The aluminized mylar foil provides higher gains due to more uniform field as compared to wire frame. Position information is extracted using delay line technique. The delay lines were prepared using chip inductors and capacitors.

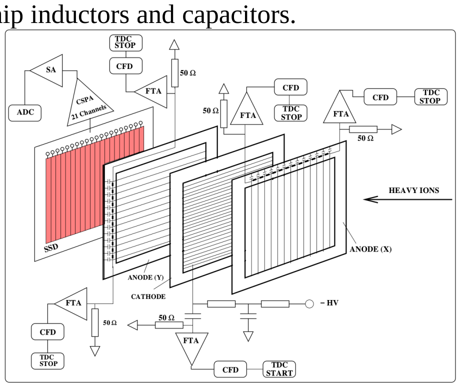

Fig.1: Schematic of Integrated MWPC-SSD

The second or final detection layer is the 300 μm thick SSD: model TTT12 from Micron Semiconductors, UK. It has 20 strips on the front side, each with a width of ~ 5 mm and length 100 mm. Back side is plane with only one readout. A 24 pin FRC connector is used for signal extraction. This detector is placed about 5 mm down the last MWPC electrode. The entire assembly is housed inside an aluminum chamber. Housing of SSD and

MWPC in the same chamber eliminates the exit mylar window between them which otherwise will add to energy loss/straggling. There are 26 signals (21 for SSD and 5 for MWPC). All the signals are extracted through the FR4 back flange. SSD signals are extracted through a 48 (24x2) pin FRC header feed-through on the back flange. The MWPC signals are also extracted from this flange via plated through hole. Fig.2 shows an assembled detector with wire cathode. A 0.9 μm mylar foil is used as the entrance window.

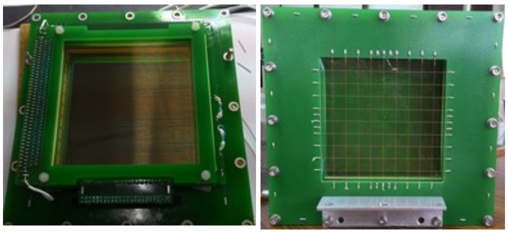

Fig.2: Assembled detector

Signal processing & Performance

The SSD signals are processed by charge sensitive preamplifier (CSPA) units [2], while the MWPC signals are processed using fast timing amplifier (FTA) units [2]. A custom designed 5 channel FTA card was prepared with gain 150 and input impedance 50 Ω, and was directly integrated on the back flange of the detector. Power consumption of FTA is ~ 2W. Another 21 channel CSPA card was prepared and directly plugged on the header connector of SSD feed-through. This arrangement eliminated or minimized the length of the cables between detector and preamp units. Gain of the CSPA was kept at 3.5 mV/MeV (~ 3.5W) having a dynamic range of about 1 GeV. Timing signals from FTA are fed to CFD followed by TDC. The CSPA outputs are fed to 16 channel spectroscopy amplifier units, from Mesytec or CAEN, followed by ADC.

Off-line measurements, using radioactive sources, for the evaluation of detector characteristics was performed using alpha emitters such as ^{229}Th etc., and fission fragments from ^{252}Cf. The MWPC was operated at 8 and 4 mbar (iso-butane gas) for alphas and fission fragments respectively. A rise time of about 4 ns and 5 ns were observed with mylar and wire cathode frames respectively. The amplitudes with mylar cathode (~ 600 mV) were twice in comparison with wire cathode. The time resolutions are estimated to be ~ 100 and 200 ps respectively for mylar and wire cathode.

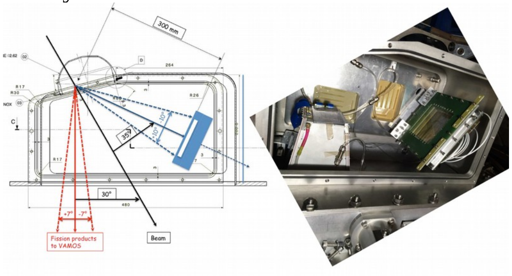

Fig.3: Detector setup at VAMOS target chamber

The detector, with wire cathode, was used to perform fission mass distribution measurements for ^{178}Hg, formed by shooting 530 MeV ^{124}Xe beam on ^{54}Fe, using the VAMOS facility in GANIL-France. As shown in fig. 3, the detector was mounted in target chamber (30 cm from target) to detect one fission fragment at an angle of 35° *w.r.t.* beam direction. VAMOS was oriented at 29° *w.r.t.* the beam direction, on the other side, to catch the second fission fragment which is detected at its focal plane detection system. A coincidence is setup between the two detector systems to extract the mass distribution. The VAMOS apparatus provides (*M*,*Z*) information of one of the fission fragments. This in combination with the velocity, energy and scattering angle information of the 2nd (heavier) fragment will be used for extracting pre- and post-scission mass distributions. Fig.4 shows the plot of time correlations between the events detected at VAMOS focal plane, and the detector in target chamber. The central gated portion corresponds to fission fragments with elastics on both sides. More details on the detector will be presented.

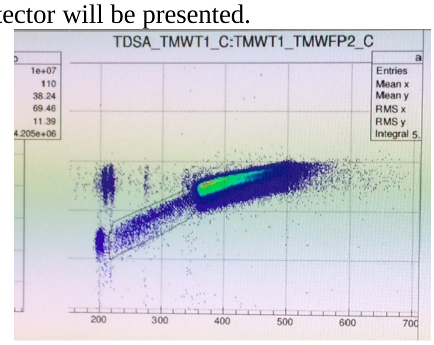

Fig.4: TOF correlation plot

References :

[1] M. Rejmund et al., NIM A,646(2011)184

[2] A. Jhingan, Pramana J. Phys., 85(2015)483