Development of a twin grid back-to-back ionization chamber for fast neutron induced fission studies

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Introduction

A Twin Grid Back-To-Back (BTB) ionization chamber with an X-ray detector port has been developed for the purpose of studying the Mass, Total Kinetic Energy and Charge distributions of Fission fragments in the fast neutron induced fission of actinides. Fast neutron-induced fission of actinides is important for energy applications since fragment yields influence reactor function through the total energy release, and the production of long-lived waste [1]. Though thermal neutron induced fission data is abundantly available, the data on isotopic and charge yields at energies relevant for Gen-IV reactors (2-5 MeV) are extremely sparse. It should also be noted that, besides the applications, the energy partitioning in the fission process is also a matter of intense investigation both experimentally and theoretically [2].

The chamber and experimental setup

The chamber consists of two cylindrical ionization sections in a back-to-back geometry sharing a common cathode (Figs. 1 & 2). Each of the two sections consists of a cathode, grid and an anode, all in the form of discs of 1 mm thickness and 10 cm diameter, except the grid. The grid is annular in shape with an inner diameter of ~ 8 cm having a 1mm pitch wire plane. The source/target is mounted on the common cathode and the chamber is operated in approximately 1.1 -1.2 atmosphere pressure of P-10 (A mixture of Argon-90 % and Methane-10%) gas in flow mode (2-4 ltr/hr).

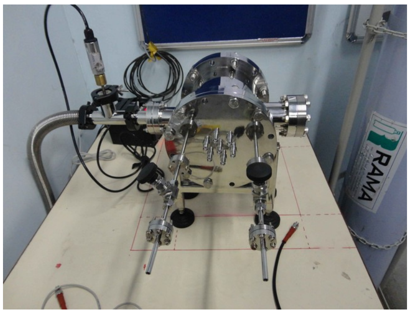

Fig. 1. The assembled Ionization Chamber setup.

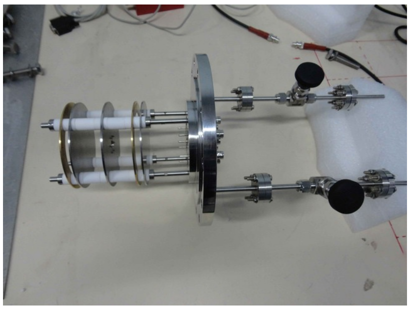

Fig. 2. The electrodes assembly and the gas flow ports.

For the characterization of the detector, a ^{252}Cf source was mounted on the cathode. With appropriate insulating spacers placed along the guiding rods, the grid wire plane and anode discs were mounted at the corresponding spacing. The chamber was then vacuum sealed and evacuated by pumping out using a rotary pump. After reaching the required vacuum (~ 10^{-3} Torr), the chamber was isolated from the pump and gas flow to the chamber was initiated. Once the required pressure and flow rate pf P-10 gas was achieved, voltages were applied gradually to the electrodes while observing the signals through the oscilloscope. While the cathode was applied -1500 V approximately, the anode was kept around +1000 V and the grid plane was kept grounded. Once the optimum voltages were reached, the pulses were electronically processed and acquired through the data acquisition system. As the source is one sided, only one half of the detector was active. Three charge sensitive pre-amplifiers were used to extract the signals from the electrodes. The timing signal from the cathode after processing through a timing filter amplifier and a constant fraction discriminator, was used to create the master gate for the data acquisition system. The pulse heights of all the three electrodes processed through shaping amplifiers (shaping time constant 1-2 μs) were acquired through a CAMAC based analog to digital converter.

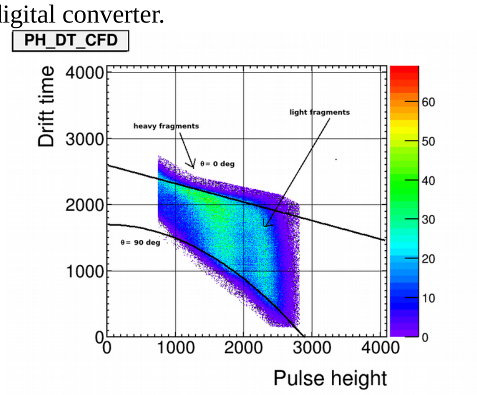

Fig. 3. 2D plot of drift time (ch #) vs anode pulse height.

For obtaining the angular distribution of the fragments, the timing signal from the cathode and the anode are processed through constant fraction timing units and the time difference is recorded using a time-to-amplitude converter. The time difference between the cathode and the anode signals is proportional to the drift time of the electron cloud formed due to a given fission fragment. Fig. 3 shows the preliminary 2D plot of drift time vs the anode pulse height. The cosine of the angle of the fission track with the axis (electric field direction) of the detector is then given by

$$\cos(\theta)=(T_{90}-T_d)/(T_{90}-T_0) \quad (1)$$

where T_{90} and T_0 are approximated to linear and quadratic function of anode pulse height respectively [3-7].

To account for the energy loss in the source as well as the thin film layer on the source, a correction factor is applied to the pulse height (P_{anode}) using the following equation:

$$\Delta P = q/\cos(\theta) \quad (2)$$

$$P=P_{anode} + \Delta P \quad (3)$$

where q is a constant proportonal to the thickness of the source/target. The corrected pulse height (P) vs cos(θ) is shown in Fig.4.

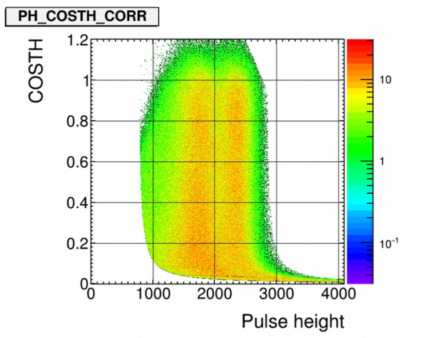

Fig. 4. 2D plot of cos(θ) vs anode pulse height.

Optimization of various parameters viz, the electric field, operating pressure to obtain the best performance of the detector is in progress.

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