Characterization of a ΔE_{gas}-$E_{Si\text{-}Pad}$ hybrid detector telescope for fission fragments

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Introduction:

Gas ionization chambers are generally used for charged particle spectroscopy studies, where identification of the particle is done by the measurement of energy loss (ΔE) of the ions in a thin transmission type detector backed by another detector in which the residual energy (E_R) is measured. Such arrangement is commonly known as detector telescope and if the ΔE and E_R are detectors are of different media (like gas and silicon in the present case) it is called hybrid detector telescope [1].

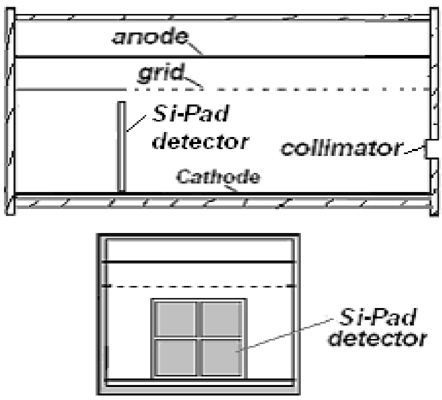

Fig.1: Schematic diagram of the hybrid detector telescope.

In the present work, we report the development of a hybrid detector telescope that consists of a gas and a large active area (400 mm^2) Si-Pad detector mounted inside the gas ionization chamber for the identification of charged particles. This hybrid ΔE_{gas}-$E_{Si\text{-}Pad}$ detector telescope has been developed for particle identification purpose and charge determination of fission fragments by measuring energy loss in gas (ΔE) and residual energy in Si-Pad detector.

Description of the detector:

The schematic diagram of the hybrid telescope detector is shown in fig. 1. The main body of the detector is made of S.S material. The gas detector has parallel plate geometry having a cathode plane, a grid mesh and an anode plate made of PCB material. The dimension of anode and grid is about 48 mm (W) x 68 mm (L) and 30 mm (W) x 68 mm (L) respectively. The separation between the grid-cathode and grid-anode planes is 40 mm and 10 mm respectively. A Si-Pad detector is mounted at the back of the gas detector at a distance of 68 mm from the collimator window (mylar foil of 2.5 μm thickness). The Si-Pad detector has four equal square pads (10 mm x 10 mm each) in a 2 x 2 matrix with a separation of 500 micron between the pads. Si-Pad detector is having dimension 20 mm x 20 mm x 300 micron (thickness). The details of the Si-Pad detector and it's performance has been reported earlier [2].

Performance test of the detector:

The hybrid detector telescope having an inlet and outlet for gas flow was placed inside a scattering chamber of inner diameter of about 52 cm. A ^{252}Cf source (strength = 4 x 10^5 fission/min) was mounted in front of the hybrid detector telescope window. The chamber was filled with P-10 gas at a pressure of 400 mbar, so that the fission fragments are stopped completely in the gas. The cathode, grid and anode were applied -100V, +400V and +1400V respectively. The bias to anode plate was applied through a charge sensitive pre-amplifier. The energy outputs of anode ΔE_{gas} is shaped through shaping amplifier and fed to the data acquisition system. The timing output of cathode pre-amplifier is amplified and filtered through TFA and fed to CFD. The Si-Pad detector has energy and time output signals for the detection of fission fragments. The master gate was generated from the 'OR' of the cathode and Si-Pad time output. For full energy loss measurement of FFs in Si-Pad detector, the hybrid detector telescope was fully evacuated and energy spectrum was recorded.

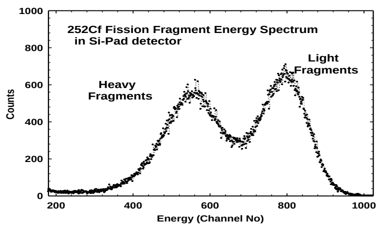

Fig.2: 1-D plot of energy spectrum of fission fragments from ^{252}Cf in Si-Pad detector.

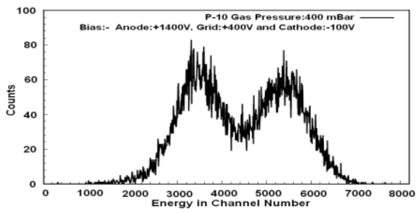

Fig.3: 1-D plot of ΔE_{gas} for fission fragments from ^{252}Cf source.

Fig.2 depicts the energy spectrum of the fission fragments detected in Si-Pad detector when hybrid detector telescope is fully evacuated. Fig.3 shows a ΔE_{gas} for fission fragments (fully stopped in gas) from ^{252}Cf source, where heavy and light fragment peaks are clearly separated.

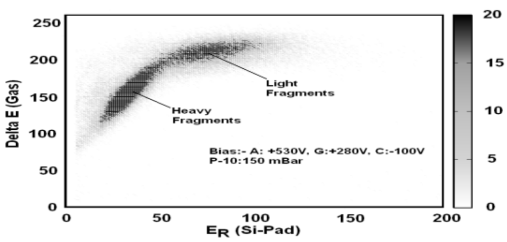

Fig.4: 2-D plot of ΔE_{gas}-$E_{Si\text{-}Pad}$ for fission fragments from ^{252}Cf source.

For simultaneous measurement of ΔE_{gas} and $E_{Si\text{-}Pad}$, the detector telescope was filled with P-10 gas at a pressure of 150 mbar. The Si-Pad detector was given a bias of +75 V. The cathode, grid and anode were applied -100V, +280V and +530V respectively. In Fig.4 we have plotted the ΔE_{gas} vs $E_{Si\text{-}Pad}$, where the two groups of fission fragments are well separated. This detector will be very suitable in heavy ion experiments for the measurement of energy of fission fragments as well as identification of reaction products.

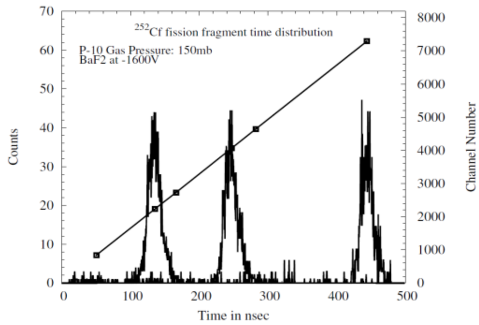

Fig.5: TAC spectrum between the fission fragments in gas and gamma rays in BaF_2 detector.

We have also studied the timing characteristics of the gas detector for fission fragments using the "start" signal from a BaF_2 detector mounted at a distance of 18.0 cm from the gas detector window. The "stop" signal is taken from the cathode of the gas detector due to the fission fragments from ^{252}Cf source and the TAC (time to amplitude converter) spectrum is shown in Fig. 5. The time calibration was obtained by collecting the spectrum for three different time delays and the time resolution was found to be about 21.6 ns.

References:

[1] D.C. Biswas *et al.* , Nucl. Instr. Meth. B 53 (1991) 251.
[2] B.V. John Nucl. Instr. and Meth. 609 (2009) 24.