Energy and timing characteristics of Silicon-Pad detector for fission fragments

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Introduction

Silicon detectors are widely used in heavy-ion reactions for charged particle spectroscopy due to its good energy resolution and fast timing properties. In many experiments these detectors are used in ΔE-E combination for the identification of the charged particles. Pulse shape discrimination technique is also found to be suitable for the particle identification by mounting the detector in the reverse geometry. In such cases, the charged particles are injected from the ohmic side of the detector (generally termed as rear side), the pulse shape differences for different ions are enhanced [1]. Single-sided segmented silicon-pad detectors of 300 μm thickness have been fabricated for their use in the Charged Paricle Detector Array (CPDA) at pelletron-LINAC, facility, TIFR for the identification of various charged particles produced in heavy-ion reactions [2]. These Si-pad detectors have an active area of 400 mm^2 with the junction side segmented into 4 equal square pad in 2 x 2 matrix.

In the present paper, we report the timing properties of the Si-pad detectors for fission fragments to explore the possible use of this detector for the measurement of the mass of the fission fragments.

Experimental Setup:

We have developed a time of flight setup, where the Si-pad detector has been used for the detection of fission fragments and a Barium Fluoride (BaF_2) scintillation detector is used for the detection of prompt coincidence gamma rays emitted from the fragment nuclei. The coincidence timing between the fission fragments and gamma rays was obtained with the start signals from Silicon detector and stop signals from a BaF_2 detector (with suitable delay in the stop signal). The Silicon detector was placed at a distance 24.3 cm from the ^{252}Cf source on a platform inside a scattering chamber as shown in Fig.1. The BaF_2 detector was placed in the same line outside the flange of scattering chamber. The chamber was evacuated to a vacuum of 1.0 x 10^{-2} mbar.

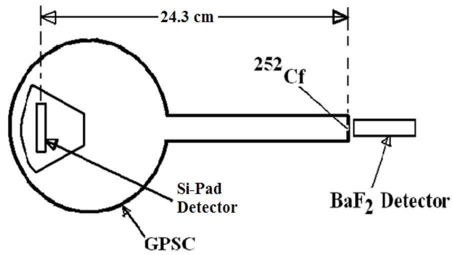

Fig.1 Schematic diagram of Time of Flight setup.

The common cathode of the silicon-pad detector was given a positive voltage of 90 Volts and the pads were grounded. The signal from silicon detector is amplified with the help of a charge sensitive preamplifier. The pulses from charge sensitive preamplifier were having rise time of ~ 29 ns and amplitude varying from 80-100 mV for alpha particles to hundreds of mV for fission fragments. The pre-amplifier signal is amplified with a pulse shape amplifier to measure the energy spectrum as shown in Fig.2. For the timing measurement, the pre-amplifier signal is passed through Timing

Filter Amplifier (TFA) for amplification and shaping of the pulses, to get improved signal-noise characteristics. The shaped and amplified signal is fed to the constant fraction discriminator (CFD) and the output is given to the start of time to amplitude converter (TAC) as well as the master gate of CM88NADC analog to digital converter (ADC). The output pulse from BaF_2 detector was found to be sharp in timing with rise time of ~2.6 ns and in amplitude around 500 mV, no shaping and amplification was used. The pulse was directly fed to CFD. The signal pulses corresponding of the gamma rays are then given to a delay box with suitable delay and the delayed signal is given to the stop of the TAC. The output pulse of the CFD was given to stop of the TAC as well as the master gate of CM88NADC ADC. The pulse of CFD was delayed through a delay box and eventually fed to the stop of the TAC. The TAC module converted pulses to TTL form and was given to CM88NADC ADC and acquired using LAMPS software.

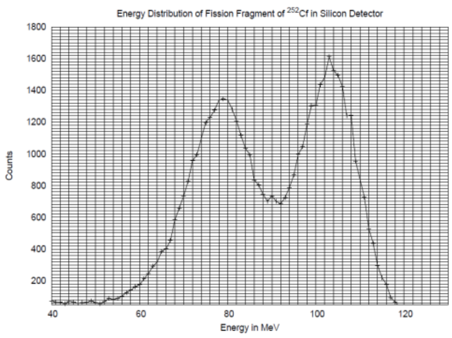

Fig.2 Energy distribution for fission fragments measured by Si-pad detector.

Results and Discussion

The timing characteristics were investigated for the BaF_2 detector in an independent experiment using two such detectors and measuring the coincidence gamma rays from ^{60}Co source. The timing resolution was found to be 330 psec. The timing spectrum obtained for the fission fragments for 200ns delay given between the start and stop signal. The time distribution spectrum is shown in Fig.3 and shows two peaks due to the different flight time of the heavy and light fission fragment groups. In the same plot the data has also been plotted the time calibration for the heavy and light fragments using two other delay values (150ns and 250 ns) and the corresponding peak channels are shifted accordingly. From the known delay and peak channel shift, the timing calibration was obtained showing linear behavior.

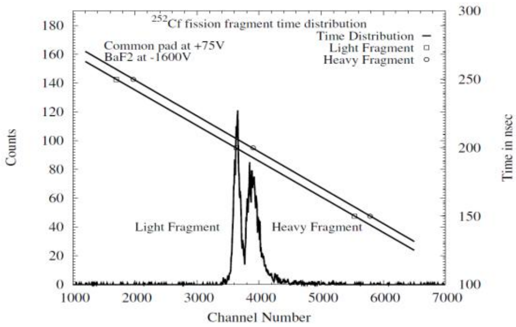

Fig.3 Time distribution for the fission fragments measured by BaF_2-Silicon setup.

The peaks due to the light and heavy fission fragments were fitted with a double Gaussian function. From the fitted values of the timing distribution, we have obtained the width corresponding to the fission fragments of heavy and light fragment groups. Thus we have measured the time resolution (FWHM) of the Si-Pad detector and it was found to be equal to 2.7 ns for light fragments and 5.2 ns for heavy fission fragments.

References:

[1] G. Pausch et al., Nucl. Instr. and Meth. A 365 (1995).

[2] B.V. John Nucl. Instr. and Meth. 609 (2009) 24.