Focal plane detector system for HYRA

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Introduction

The focal plane detector system of gas filled separator HYRA [1] at IUAC is currently under development. The detection system and its front-end electronics is being developed to study the fusion reaction products from heavy ion induced nuclear reactions in A≥200 region. Currently the detection system has a position sensitive multi wire proportional counter (MWPC) followed by Silicon detector. The MWPC provides position signals (***x,y)*** and timing signals of the incoming particles. Silicon detector provides the total energy , and at the same time acts as a recoil implanter providing position and timing of the recoil and its subsequent decay. The present & proposed detector system is inspired by the systems at other recoil separators such as Dubna, Ship, Berkeley, Rikken etc.

Description of the detectors

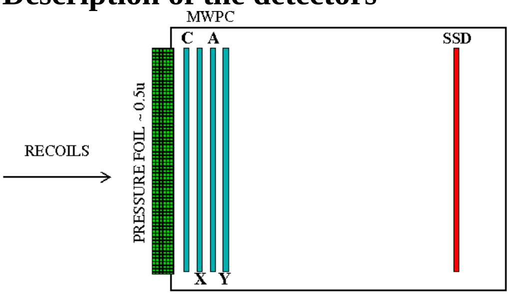

Fig.1: Schematic of focal plane detector

Fig.1 shows the schematic of the focal plane detector setup. The focal plane chamber is isolated from HYRA with 0.5 μm mylar foil. The foil is transparent to heavy recoils, A≥200, which are produced in very asymmetric reactions and have very low kinetic energies (0.02 – 0.1 MeV/A). Active area of foil is 120 mm x 50 mm and is supported by 0.3 mm thick nylon wires at 1cm separation to prevent bulging. Behind the foil is the MWPC. Core of the MWPC consists of four wire frames each with an active area of 150 mm x 50 mm^2. The wire frames are a cathode, X- position wire frame, a central anode frame, and Y - position wire frame. The distance between adjacent wire frames is 2.4 mm. The position wire frames are made from gold plated tungsten wires of 20μm diameter stretched on a 2.4 mm thick printed circuit board. The separation between adjacent wires is 0.05" (1.27 mm). Position signals are extracted using delay line technique. Cathode also uses 20 μm wire with separation 0.025" (~0.63 mm). Central anode is identical to cathode except for that it uses 10 μm diameter wire. Such a design gives higher gains since the detector has to be routinely operated at low pressures (1-2 Torr) owing to the very low energy of heavy recoils. The geometrical transmission efficiency is 92 % for this design. The electrodes are housed inside a rectangular chamber milled out from a solid aluminum block. The detector is operated with iso-butane gas . Anode is read using fast current amplifier OrtecVT120A. Position signals are read by OrtecVT120B. The cathode is read using Ortec 142IH.

MWPC is followed by position sensitive silicon detector. Variety of detectors are available commercially. Currently a double sided Silicon strip detector (design W) from Micron Semiconductors UK is installed. The detector has 16 strips each on both front and back side and has an active area of 5 x 5 cm^2. The front end electronics of strip detector is a 32 channel preamplifier MPR-32 followed by Shaping Amplifier cum discriminator (STM 16+) from Mesytec (Germany). The energy signals are fed to Phillips ADC 7164. The discriminator outputs (ECL logic) are fed to Phillips TDC 7186H. The timing signals will generate bit pattern for the identifications of the strips firing at a given instant. Each identified event will be time stamped using the in-house developed Global Event identifier

Module (GEM). This will help in identifying the implanted recoils and their subsequent decays using the coincidence & anti-coincidence with MWPC signal. Signals from preamplifier to Amplifier units are driven via hundred ohm impedance, shielded round & twisted pair cables (34 way) from spectra strip. Length of the cables is 15 m and no distortion or loss of signal has been observed.

The present silicon detector has a disadvantage of having smaller active area and thick dead layer at the entrance (0.5 μm). This will not detect low energy heavy recoils efficiently. Remedy lies in using detectors with thinner entrance window (0.1 μm). Examples of such detectors are Design X from Micron Semiconductors, PF-RT series PAD detectors from Canberra. The detectors have strips which are resistive thus generating position information in the coordinate orthogonal to the orientation of the strip. Design X was tested off-line with source. Fig. 2 shows the position spectrum with a mask. A position resolution of 1 mm fwhm was observed. Energy is obtained by adding the signal from both ends of the resistive chain. Fig. 3 gives the position gated energy spectrum with an energy resolution of 60 keV fwhm. This is inferior as compared to design W which gives about 40 keV resolution. This is due to impedance differences in the connections at either end of the strips. A software correction can be applied to improve the resolutions.

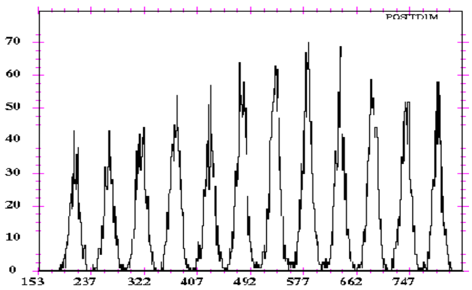

Fig.2: Position spectrum from strip

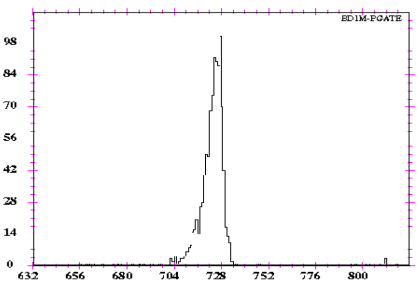

Fig.2: Position gated energy

Other option is to use the resistive anode detectors [2] from Eurysis/Canberra having readouts from the four corners. All these detectors can be stacked together to have larger active area. Fig. 4 shows three such detectors stacked together to give an active area of 15 cm x 5 cm thus covering the entire focal plane. The detectors belong to the CATE setup of RISING campaign at GSI. The detector system has 15 readouts. As shown in figure, provision has been made to have on-board preamplifier for good resolutions. In off-line tests, an energy resolution of ~ 80 keV for 5.48 MeV alphas. This system will be used for experiments not demanding very high energy resolutions but requiring larger active area, low count rates and thin entrance window for low energy heavy ions.

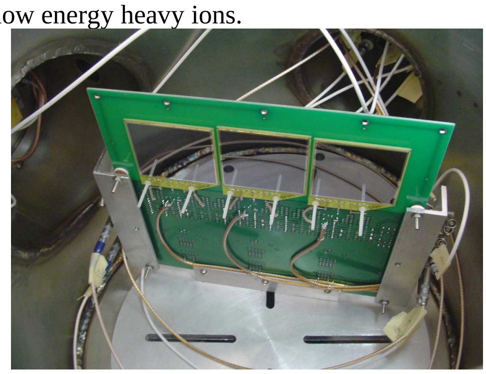

Fig.4: Three resistive anode detectors

The detectors has been tested off-line with ^{241}Am source and used in experiments with IUAC Tandem-Superconducting LINAC combination. In future we plan to install Canberra PAD detector [3] with an active area of 12 x 4 cm^2 having 12 resistive strips. The detector is intended for decay spectroscopy experiments.

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References :

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