CsI based charged particle array for reaction studies at IUAC

*A. Jhingan[1], P. Sugathan[1],

[1]*Inter University Accelerator Centre, P. O. Box 10502, New Delhi - 110067, INDIA*

* *email:* akhil@iuac.res.in

Introduction

Developmental activities in charge particle detector array for investigating reaction dynamics has been initiated at IUAC. The array will consist of CsI(TI) detectors coupled to photo-diode and is being developed to study fusion-fission dynamics and will also serve as an ancillary detector system for National Array of Neutron Detectors (NAND). The array will be used for the detection of light charged particles such as p, d, t, 3He, 4He etc. . The array can be used stand alone for studying the nuclear level density parameters in excited nuclei, determination of cross-sections in heavy ion fusion reactions and that for astrophysical interest, measurement of statistical properties of nuclei such as excitation energy, angular momentum etc. by measuring the kinetic energy spectra of evaporated light particles mentioned above. The array can be used with other detectors such as MWPC, Silicon detectors, gas ionization chambers, Neutron detectors etc. for investigating pre-scission charged particle multiplicity, deep inelastic collisions etc.

Description of the detector system

The proposed detector array will be fabricated using CsI(TI) detectors coupled to photo-diodes. Conventionally Silicon detector telescopes have been used for the same. Requirements for such studies is to have a thin Silicon detector (40um to 300um) followed by thick Silicon detector (3 mm – 5 mm). Silicon detectors are generally very expensive and at the same time very prone to radiation damage. Thick detectors of 5 mm are Lithium drifted and are very expensive and have storage issues. They generally have a short life. CsI(TI) scintillators coupled to photo diodes offer a very flexible and inexpensive solution for the same. One of the main characteristics of CsI(TI) detectors is its intrinsic ability to discriminate between different light charged particles such as protons, alphas, electrons (gamma photons) etc. according to their stopping power. This gives rise to different decay time constants in the light output (fast component) for different particles. At the same time CsI(TI) have reasonably good energy resolution of about 200 keV for 5.48 MeV Alphas which is sufficient to carry out studies described earlier. The proposed array is likely to have 32 detectors. Each crystal will have a thickness of 3 mm with an active area 20 mm x 20 mm coupled to a 10 mm x 10 mm photo-diode. The 3 mm thickness is sufficient to stop up to 25 MeV of protons. The detectors will be mounted in groups of four (2x2) as shown in fig. 1

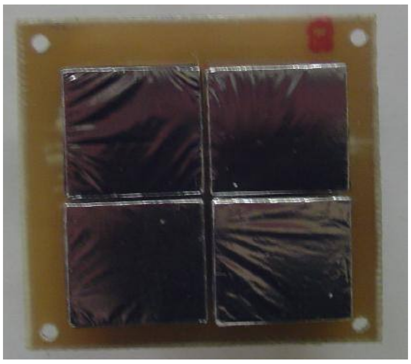

Fig.1 : Quad CsI detector

Detector Instrumentation

The instrumentation for this array needs to be competent to exploit the features mentioned above. The photo-diodes coupled to CsI(TI) detectors are read by conventional charge sensitive pre-amplifiers (CSP). Since the charge generated in photo-diodes is extremely small, it is desirable for the CSP to have a high gain, good timing features (ability to distinguish between different decay times from CsI), and low power consumption so that it can be placed next to photo-diode in vacuum to avoid degradation of signal. For large number of detectors in small volume, power dissipation needs to be small for each preamp. A preamp[1] has been developed in-house with the above requirements in mind. It has a low power consumption ~ 30 mW, a gain of 2 V/pC (Si equivalent) and exhibits good timing characteristics for particle identification. It has a dynamic range of ± 1V. The preamplifier has been realized in the form of a 8 pin SIL hybrid with a dimension of 1" x 0.8". The preamplifier has a differential output so as to drive signals through inexpensive twisted pair cables.

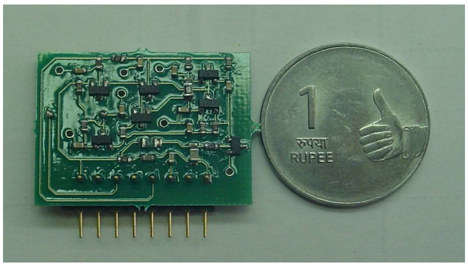

Fig.2: Preamplifier daughter card

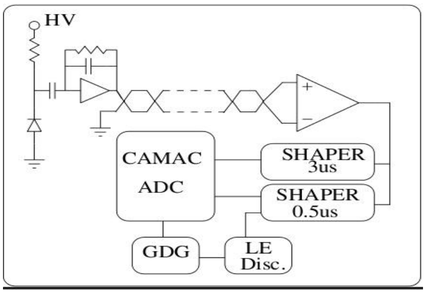

Fig.3 : Signal processing block diagram

Fig.3 shows the signal processing requirements to generate energy information, logic signal, and identity of the particle (p, α, γ etc.) striking the detector. Charge comparison technique has been used for particle discrimination. For each detector, two shaping amplifiers are required: one with shorter shaping time (0.5 µs) and other with larger shaping time (3 µs – gives total energy). Logic signal is generated using a leading edge discriminator from the 0.5 µs shaper output.

Performance test

Performance of the detector system was evaluated in terms of energy resolution particle identification, noise measurements, cross talk etc. by carrying out offline measurements. Negligible cross-talk was observed.

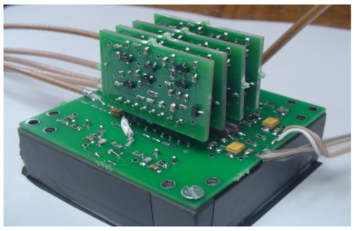

Fig.4: Assembled detector with preamps

Fig. 4 shows one assembled quad set of CsI detector mounted on a mother board with preamplifiers and biasing network. Off-line test were carried out with this quad detector using radioactive sources Cs^{137}, Co^{60}, Am^{241}. Typical charge sensitivities observed were about ~ 5 mV/MeV for Alphas and 10 mV/MeV for gammas. Energy resolution of 200 keV (for 5.48 MeV alpha) and 68 keV (1332 keV gamma) were observed. Fig. 5 shows the PSD spectrum of the four crystals obtained using charge comparison technique. The preamplifier output was fed to Mesytec STM 16+ amplifier units. The output of these units are digitized using CAMAC 7164H ADC from Phillips. The common logic signal was generated using summed output of fast shaper of each crystal as shown in fig.3

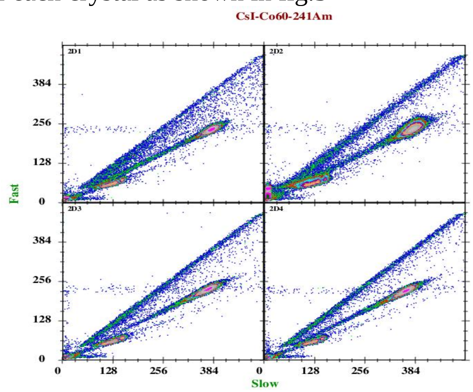

Fig.5: PSD spectrum of 4 CsI crystals

Detailed test results and activities on instrumentation development and design will be presented.

References :

[1] *Development of a charge sensitive preamplifier to operate in vacuum*
Proc. DAE-BRNS symposium on Nuclear Physics G38 pg457 Vol.50(2005)