HYTAR : A Hybrid Telescope Array for Reaction dynamics

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Introduction

HYTAR is an array of Hybrid detector telescopes developed at IUAC for the study of reaction mechanisms around coulomb barrier. The hybrid detector module is a combination of gas (ΔE) and silicon detector (stopping). They have been developed for heavy ion detection & particle identification in nuclear physics experiments in GPSC/NAND facility at IUAC. Currently the array has 13 such telescopes. The detector telescopes have been earlier used for studying the angular distribution of fission fragments [1]. The detector system can also be used to identify projectile like fragments and thus can be used for studying quasi-elastic scattering, transfer and breakup reactions. Use of gas detector as ΔE detector makes it transparent for very low energy heavy ions such as target recoils, fission fragments etc. By varying the gas pressure, the effective thickness of the ΔE detector can be varied. This is an advantage as compared to the conventional Silicon ΔE-E telescopes.

Description of the detector system

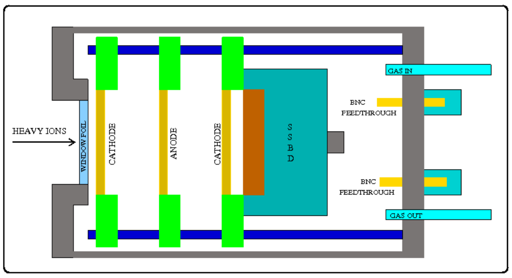

Fig.1: Schematic of hybrid telescope

Fig.1 shows the schematic of the hybrid telescope. It consists of a gas ionization chamber, operating in axial field geometry mode, followed by a Silicon detector. Two types of Silicon detectors were used. In one case PIN diodes from Detection Technologies of area 10mm x 10mm with thickness 300 μm are used. In other case we used PIPS detector form Canberra of area 150 mm^2 and thickness 300 μm. The ionization chamber (IC) is composed of three wire frames of active diameter 25 mm. The wire frames are a cathode, a central anode frame, and another cathode wire frame. The distance between adjacent wire frames is 9 mm. All wire frames are made from gold plated tungsten wires of 20 μm diameter stretched on a 1.6 mm thick printed circuit board. The separation between adjacent wires is 1 mm. The two cathodes are grounded, and signal is extracted from anode by applying positive voltage with a reduced field of about 2 V cm^{-1} Torr^{-1}. The electrodes are housed inside a cylindrical stainless steel tube. The detector is operated with Isobutane gas at a pressure of 70 Torr. Entrance foil used is 0.9 μm Mylar. The telescopes are arranged in three groups. One group has 4 telescopes mounted in a ring at 170 degree w.r.t. beam direction from the accelerator. They detect the back-scattered projectiles. Another group of six is placed in arc at 20 degree pitch detecting particles from 140 degree to 40 degree. Third set of 3 telescopes is placed at forward angles from 30 degree to 54 degree at 12 degree pitch. The set up also has two silicon PIPS detector as monitor detectors at ± 10 degree w.r.t. beam direction.

Front end electronics

Fig.2 shows the schematic of front end electronics for the hybrid detector telescopes. For thirteen telescopes, a total of 26 readout channels are required which includes charge sensitive preamplifiers (CSPA), shaping amplifiers, ADC, detector bias supplies, discriminators etc.

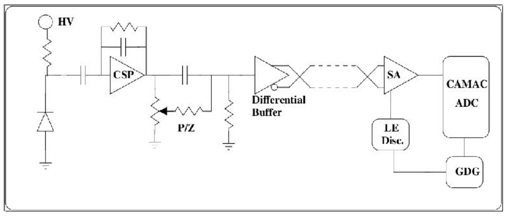

Fig.2: Signal processing block diagram

Custom designed CSPA were developed for the telescopes. Each CSPA is realized as a SIL hybrid. Two versions were developed : one for gas detector with gain 90 mV/MeV (Si equi.) and other for Silicon with gain 3.5 mV/MeV. Both of them have power consumption of 30 mW. Dynamic range for Silicon detector CSPA is 300 MeV and that for gas is 100 MeV. The hybrids are mounted on a mother board in groups of 8 and 4. Entire assembly is housed inside a box milled from solid Aluminum block. The CSPA is placed next to the detectors inside vacuum. The CSPA output is fed to a differential driver unit which drives the signals using shielded twisted pair cables to Mesytec STM 16+ shaping amplifier units. Thereafter they are fed to Phillips 7164H ADC units for digitization. The master trigger is provided by the STM 16+ unit of Silicon detectors. Shaping time in both cases is 3 μs. Detectors are biased using the MHV-4 units from Mesytec. Gas detectors are fed with common bias.

Performance

The detectors were tested off-line with ^{229}Th alpha source. The detectors were operated at 75 Torr gas pressure with a bias voltage of +150 V . Fig. 3 shows scatter plot between DE and E for alphas.

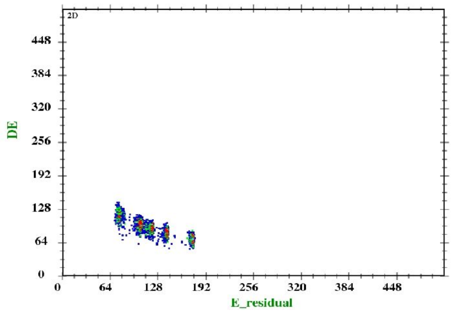

Fig.3: Alpha spectrum of IC

Fig. 4 shows the detector setup performing quasi-elastic scattering experiment for the systems ^{28}Si + ^{154}Sm.

Fig.4: Detector setup inside GPSC

Fig. 5 shows the plot from the detectors placed at 170 degree, at an energy of 128 MeV, showing separation between projectile like particles.

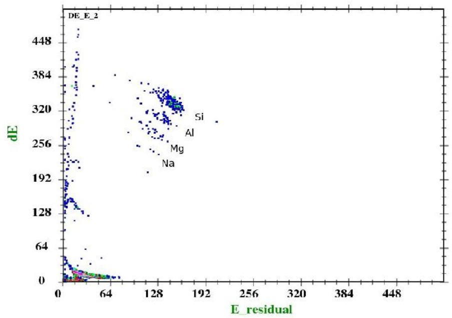

Fig.5: DE – E plot from ^{28}Si + ^{154}Sm

Future Perspective

In future we plan to have the array in NAND scattering chamber in beam hall II with possibility of having more detectors at a pitch of 10 degree so as to perform quasi-elastic scattering and fission angular distribution experiments with superconducting LINAC beams. More details about the set up and instrumentation will be presented during the workshop.

Acknowledgments

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References :

[1] “Hybrid telescopes for heavy ion detection” A. Jhingan et. al. Proc. DAE-BRNS Symp. on Nuclear Physics G 5, pg 1040 Vol. 56(2011)