Charged particle detectors in NAND : current status

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Introduction

The present status of the charged particle detector systems developed for investigating heavy ion induced fusion-fission reactions is discussed here. The main motive of developing these detector systems is to perform fission angular distribution, mass-angle, mass-kinetic energy distribution experiments, mass-gated neutron multiplicity measurements, elastic scattering, quasi-elastic excitation function experiments etc. These experiments provide a rich source of information to understand fusion and fusion-fission dynamics. To perform these measurements, position sensitive proportional counters (MWPC) [1], and hybrid telescopes have been developed at IUAC over last several years. Recently we upgraded our detector systems by making few modifications in design for MWPC and increasing the number of telescopes in HYTAR [2] for performing experiments with LINAC beams in beam hall II of IUAC. The detector setup in beam hall II is described briefly.

HYTAR

HYTAR [2] 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 (E). They have been developed for heavy ion detection and particle identification in nuclear physics experiments performed using GPSC/NAND facility at IUAC. Currently the array has 16 such telescopes. HYTAR was earlier used in GPSC facility in beam hall I with 13 telescopes for performing fission angular distribution and quasi-elastic scattering measurements [2]. The setup with 16 telescopes was installed in 1 m spherical scattering chamber of NAND facility. Fig. 1 shows the picture of the setup. A new dome was fabricated to mount four telescopes in a ring at 173 degree w.r.t. beam direction for extracting quasi-elastic barrier distribution. Eight telescopes are mounted from 160 degree to 90 degree at 10 degree pitch. Remaining four telescopes are mounted from 105 to 75 degree on the other arm of the chamber. Each telescope subtends a solid angle of 0.75 msr. The four telescopes at 173 degree together subtend an angle of 3 msr for quasi-elastic barrier distribution. The entrance window is 0.9 μm mylar. The telescopes were operated at 60 mbar iso-butane gas for measuring the quasi-elastic barrier distribution of the system ^{48}Ti + ^{232}Th.

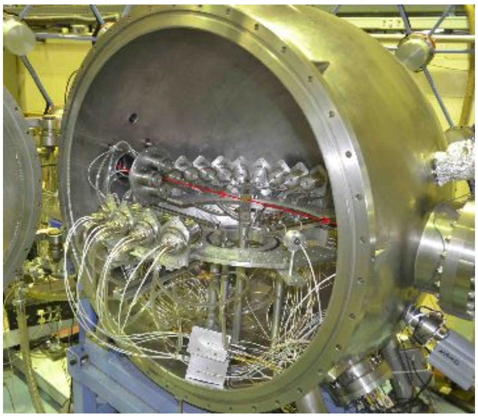

Fig.1: Schematic of HYTAR in NAND

Signal extraction for each telescope is realized using in-house developed charge sensitive preamplifiers (CSPA) placed inside vacuum to avoid degradation of detector signals in long coaxial cables. A total of 32 CSPA were mounted inside the scattering chamber. The signal transmission to shaping amplifiers is via 100 feet long Amphenol shielded twisted pair cables driven by NIM differential drivers [3]. More details about the detector design and front-end electronics is described in reference [2]. The ECL timing output of each telescope is fed to a Phillips

TDC for generating a bit pattern.

MWPC

Two new MWPC were developed to replace the older aging counters [1] of NAND. The older detectors of active area 5″ x 3″ were replaced with new ones of active area 6.4″ x 4.4″. The detectors have a three electrode geometry, having a cathode sandwiched between two position sensitive anodes. Cathode is realized using a stretched mylar foil (Aluminized on both sides). X-position anode at the entrance is fabricated using 10 μm diameter gold plated tungsten wires stretched on a 1.6 mm thick PCB. Wire pitch is 0.025″. Y-position anode has 88 gold plated Copper strips, each with a width of 1 mm at 0.05″ pitch. The position information is extracted using delay line technique. Unlike in previous design [1], where we had used 14 pin DIP package from Rhombus for delay line, in this case we fabricated delay line using discrete SMD inductors and capacitors. Each tap is made using a π-filter (Fig.2). Tap to tap delay is 1 ns and impedance 50 Ω.

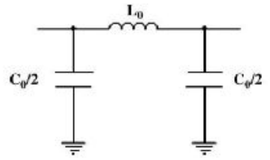

Fig.2: Electrical schematic of delay cell.

Fig. 3 shows the assembled delay line for the X-position frame. The use of SMD components for delay line made the frame more compact and enabled us to short two wires for one delay cell/tap, thus giving a position resolution of ~ 1.2 mm. In comparison, previous design [1] had a position resolution of about 2.2 mm where four wires were shorted and given to one tap of the delay chip from Rhombus.

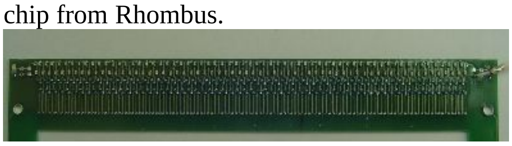

Fig.3: Assembled delay line.

The detector was operated with iso-butane gas at pressures of 7 mbar for alpha particles and 3 mbar for heavy fission fragments with operating cathode voltages of -600V and -430 V respectively. Entrance foil is 0.9 μm mylar. Fig. 4 shows the X-position spectrum with alpha particles. As shown, each delay element is resolved. FWHM of each peak is observed to be ~ 400 ps (± 50 ps). This is achievable only if charge collection times approach ~ 100 ps.

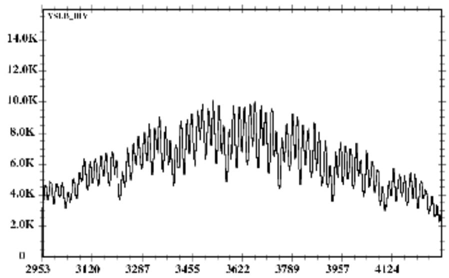

Fig. 4: X-position spectrum.

The fast timing preamplifiers, developed in-house [4] for signal extraction, were placed inside vacuum for preserving timing. The timing logic signals for TOF as well as positions were generated using Phillips 715 CFD.

Future Perspective

In future we plan to add more detectors to HYTAR so as to have elastic scattering data at an angular pitch of five degree starting from 173 degree to 50 degree. We also plan to have start-stop detector system at both arms so as to have absolute time of flight for fission fragments. More details about the setup and instrumentation will be presented during the workshop.

Acknowledgments

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