An Annular Parallel Plate Proportional Counter

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Introduction

The characteristics and performance of an annular parallel plate proportional counter (APPPC) developed for performing heavy ion nuclear physics experiments are presented. The main motive of developing this detector system is to perform Coulomb excitation (Coulex) experiments using particle-γ coincidence technique. The detector system has been integrated with the existing GDA facility at IUAC to perform Coulex measurements with germanium detectors. The APPPC provides information about the scattering angles of the reaction products which along with TOF (velocity) information is used for correcting Doppler energy shift of γ events coming from in-flight decay of reaction products. The detector system can be used to perform experiments such as ER gated gamma spectroscopy and neutron multiplicity, fission and transfer induced spectroscopy.

Description of the detector

The detector has been designed and fabricated with two electrode geometry namely a cathode and an anode. Cathode is segmented to provide azimuthal angle (ϕ), whereas the anode is segmented to provide polar angles (θ) of the reaction products. The electrodes have an inner active diameter of 5 cm and outer active diameter of 25 cm. Total active area is about 460 cm^2. The transmission type cathode is fabricated using a 1.5 μm aluminized mylar foil stretched on a 3.2 mm thick FR4 board. As shown in fig.1, the foil is segmented into a cake-like structure with 16 sectors so as to provide ϕ information with an angular pitch of 22.5 degrees. The anode is made on printed circuit board, segmented into two halves with each half having tin plated copper tracks etched in the form of concentric rings as shown in fig.2. Each ring has a width of 1 mm. These rings are interconnected by Rhombus LC delay line chip (TZB12-5). There are a total of 80 rings at 1.27 mm pitch in each half, with an end to end delay of 160 ns. Each half of the anode segment is perfectly aligned to cover 8 cathode sectors each, dividing the detector into equal right and left halves. Inter-electrode separation is 3.2 mm. The entire electrode assembly is housed inside an aluminium chamber. The detector is isolated from vacuum with a 2 μm mylar foil. The detector has central through hole of 20 mm for beam passage. The detector is operated at 7-13 mbar iso-butane gas.

Fig.1: Cathode frame with 16 segments.

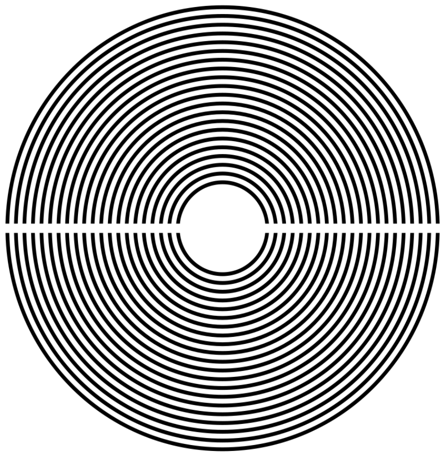

Fig.2 : Layout of anode ring.

Front-end electronics

The APPPC provides 20 timing signals : 4 for delay line anode and 16 for the cathode. The cathode is biased with a negative voltage of 500-600 V (particle and count rate dependent). Equal bias is fed in two groups of 8 segments each. The timing signals are extracted using in-house fabricated fast timing amplifiers (FTA) [1]. The FTA outputs are fed to Ortec CF8000 CFD units. The units used for cathode segments generate logic signal at 20% fraction whereas it is 40 % fraction for anode delay line. The respective logic outputs are fed to Phillips 7186 TDC. The common trigger logic output of CF8000 provides master start for anode delay lines as well as for TOF, and also acts as a trigger for coincidence with gamma detectors. The individual CFD outputs in TDC provides hit pattern to identify the cathode segment or ϕ of the incident particle.

Performance

The detector was tested with ^{241}Am alpha source at a pressure of 13 mbar and a bias voltage of -650V. The signal strengths from cathode segments were about 300-500 mV with rise times ~ 5 ns. Anode delay line signals were ~ 30 – 150 mV. Fig.3 shows a plot between cathode segment hit pattern and anode delay line.

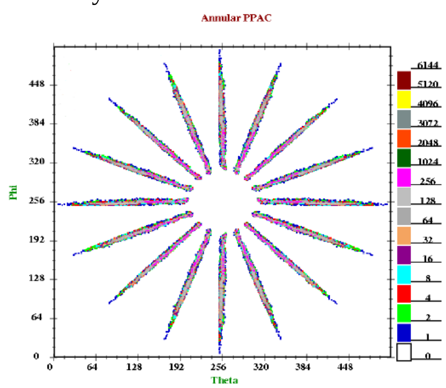

Fig.3: θ and ϕ plot of APPPC with α.

The detector was used to perform Coulex measurements, using 175 MeV ^{58}Ni beam from IUAC Pelletron, for ^{120,122,124}Te, ^{112,116,118,120,122,124}Sn, and ^{132}Ba targets. The detector along with a SS target chamber was mounted in GDA facility of IUAC (fig.4). The detector had an angular coverage of 15 to 45 degree. Four clover germanium detectors were mounted at 153 degree ($\pm$ 25 degree out of plane). During experiments, the detector was operated at 10 mbar gas pressure, with a bias voltage of – 500 V. The cathode signal amplitudes were as high as – 3 V for target recoils and about -1 to -2 V for beam like particles. The count rate for each cathode segment was restricted to 15 k pps as delay lines are counting at 120 k pps. Master trigger rate is decided by the particle – γ coincidence.

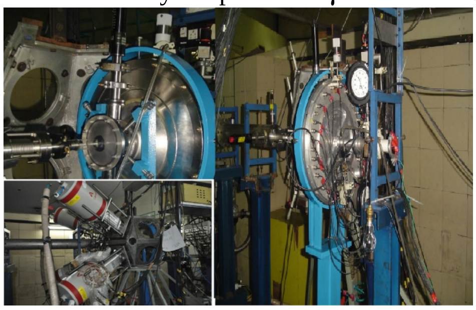

Fig. 4: Coulex set-up in GDA.

Fig. 5 shows the raw and Doppler corrected γ-spectrum for ^{58}Ni + ^{122}Te [2]. Doppler correction is performed using the relation :

$E_\gamma \sim E_{\gamma 0}$ [1 + v/c cos($\theta_{p\gamma}$)]

where E_γ is the Doppler shifted γ energy, $E_{\gamma 0}$ is the actual γ energy, v is the particle velocity and $\theta_{p\gamma}$ is the angle between particle and γ.

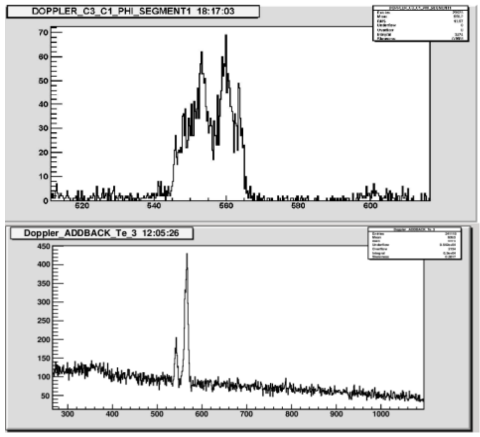

Fig.5 : Raw γ-spectrum (top) and Doppler corrected γ-spectrum (bottom) for ^{58}Ni + ^{122}Te.

More details about the design and performance will be described during the conference. We acknowledge the support of A. Kothari and P. Barua in installation of detector set-up, and Pelletron-group for providing good quality beam during experiments.

References :

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