Neutron detector array for fusion-fission studies at IUAC.

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Introduction

The study of fission dynamics using heavy ion induced reactions has been a topic of considerable research interest in recent years. It has now been experimentally well established that, competition from reaction process other than fusion-fission can be dominant in heavy systems, thereby hindering the formation of super heavy systems in complete fusion reactions. Near the Coulomb barrier energies, fusion-fission and quasi-fission exhibit their own characteristics reaction times, that can be probed by measuring the pre-scission component of neutron and charged particle multiplicities[1-3]. Contrary to the standard statistical model predictions, an excess of pre-scission multiplicities has been measured in many fusion-fission reactions. The pre-scission neutron multiplicity has a strong correlation with the evolution of the composite system in the nuclear deformation space[4]. Over the years, the measurement of pre-scission and post-scission neutron multiplicity in coincidence with fission fragment has been used as a powerful tool to study the dynamics of the fissioning system and a large number of such experiments have been performed[5-7]. These experimental results provided evidence to the hindrance of fission process.

At Inter University Accelerator Centre(IUAC) New Delhi, heavy ion beams from the tandem plus LINAC accelerator are used for fusion-fission reaction studies around the Coulomb barrier energies. Using DC and pulsed beams, we have performed a number of experiments probing the fusion-fission dynamics in our scattering chamber and neutron array facility[8-10]. The scattering chamber facility consist of 1.5 m diameter vacuum chamber and a time of flight spectrometer for fission fragment mass measurements. The neutron detector array consisted 24 liquid scintillators(at a flight distance of 2m) and a pair of multi-wire proportional counters(MWPC) for fission-fragment detection. Over the years, these facilities have been used for many experiments measuring fission fragment mass distribution, angular distribution and extraction of pre and post scission neutron multiplicities. The observed excess of pre-scission multiplicities has been explained by including the effect of dissipation on the collective flow of matter through fission barrier. Recently, by measuring total neutron multiplicity for three isotopes across a major closed shell, the influence of shell closure on fission observables has been explored [10]. In order to distinguish the time scale of different dynamical process in fission, it is also necessary to experimentally extract the correlation between the pre- and post scission multiplicities as a function of excitation energy. Clearly more experiments are needed, especially in neutron-neutron correlations and multiplicity distribution studies. To enhance further studies in this field, a bigger neutron detector array has been proposed and a large array consisting 100 neutron detectors is currently being installed at IUAC. The new detector array will use the time of flight (TOF) technique for the determination of neutron energy and the pulse shape discrimination(PSD) technique to discriminate the neutrons from gamma rays. This detector array would be a national facility being built as a collaboration of IUAC and other participating universities with the support from the Department of Science and technology, Govt. of India. The design features and the technical developments will be discussed in this paper

Large Neutron detector array

The large neutron detector array will have 100 individual neutron detectors made of 5”x5” organic liquid scintillator cell BC501A coupled to 5” photo multiplier tube(PMT). They are mounted on a metallic geodesic dome structure at a radial distance of 1.75 m from the target.. The center of the array is at 1.4 m above the ground level and all the neutron detectors are mounted on eight rings on a geodesic-dome structure, the lowest ring being 15 degree below the target plane. The first phase of the project consist 50 neutron detectors which are currently installed in the beam hall. To process signals from each detectors, we use standard analog NIM electronics and data readout using CAMAC/VME data acquisition system. For this purpose, custom made electronics have been built and tested offline.

From each detector cell, the light output, pulse shape discrimination(PSD) and time of flight are recorded using custom built modules. A home made PSD module[11] has been used for the signal readout. It is a single width two channel module containing the integrated electronics for n-γ discrimination, time of flight and energy. Other logic signals and monitoring signals are also provided on its front panel. Total 50 channels of PSD modules have been fabricated and tested for its performance. The typical figure of merit (FOM) for the detector and electronics combinations is found to be 1.6 at 110keV recoil electron energy. Home made customized high voltage power supplies are used to operate the photomultiplier tubes in each detector. A one meter diameter spherical scattering chamber is used to accommodate the fission and other ancillary detectors. For data acquisition, VME version of LAMPS has been tested using commercial CAEN ADC/TDC with more than 300 parameters. Fission fragments will be detected using conventional multi wire proportional counters(MWPC). Custom made electronics has been made for the readout of the MWPC detectors.

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