VECC array for NUclear Spectroscopy (VENUS)

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Introduction

Understanding of the nuclear structure at low and medium spin regime requires information on yrast as well as near yrast excited states, which can provide important information regarding low lying single particle excitations. These states can be populated suitably using light ion beams and investigated using γ–spectroscopy techniques. With the availability of Clover HPGe detectors it is possible to probe the shapes and structure of nuclei with precise measurements of nuclear states with spin-parity assignments. In view of this, a moderate array of Clover HPGe detectors along with BGO Compton suppression shields has been setup at VECC, Kolkata. In this paper we report the setup of VECC array for NUclear Spectroscopy (**VENUS**), which at present consists of six Clover HPGe detectors along with the BGO shields for Compton suppression. The initial performance test for all the Clovers was reported earlier [1]. Recently, this array was setup at the beam line of K-130 cyclotron at VECC, Kolkata, for its first in-beam experimental campaign. The array can also be coupled to different ancillary detection systems made of other types of detectors. An ancillary detector system based on several fast timing CeBr3 detectors were also added to VENUS setup for both in-beam and off-beam experiments, with an aim to measure lifetimes in the pico-second range [2].

Setup of VENUS at K-130 beam-line

All the six Clover detectors with BGO shields have been placed in median plane around the beam line with two detectors at forward 45^o and 55^o, two at 90^o and two at backward 30^o angles with respect to the beam direction according to the experimental requirements. The detectors set up are shown in Fig.1.The aluminium end cap of Clover detectors are placed at a distance of 26 cm from the target position. To know the Directional Correlation from Oriented states (DCO ratio) two 30^o backward detectors and two 90˚detectors can be used. The choice of angles of detectors allows to measure angular distribution of γ-rays to determine the multipolarities of various transitions. Two detectors placed at 90^o perpendicular to beam direction will enable to carry out Integrated Polarization from Directional Correlation from Oriented states (IPDCO) measurements to know the nature of transitions (Electric or Magnetic).

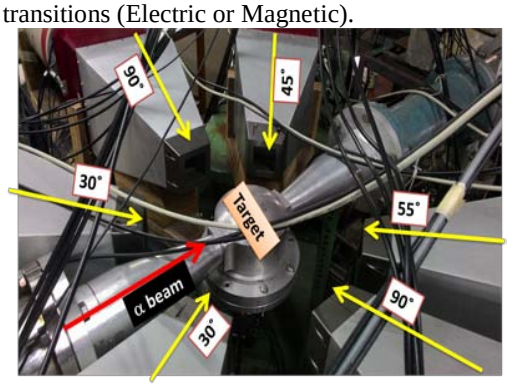

Fig 1: Setup of Compton Suppressed Clover HPGe detectors of the VENUS array at VECC K-130 Cyclotron beam line.

Electronics used for the setup

The preamplifier signals from the 24 crystals of six Clover detectors were processed by 16-channel high resolution Mesytec Amplifiers, which give analog energy signals as well as ECL standard logic signals. The energy signals were taken out with 4 μs shaping time and processed through high resolution 14-bit Mesytec VME ADCs. The logic ECL outputs of 15-channel amplifiers were converted to NIM standard and

used to make OR of signals of four crystals of each Clover detector. To process the BGO signals, NIM standard TFA and CFDs are used and the anticoincidence 'VETO' condition for the corresponding Clover detectors were applied using the quad logic unit ORTEC-CO4020. The time difference of the 'Master trigger' with each of the Clover detectors as well as with respect to the radio frequency (RF) of the beam bursts were recorded using individual Time to Amplitude Converter (TAC) modules. Other relevant logic electronics was set up, to collect the data with singles ($M_\gamma \geq 1$) as well as with doubles trigger ($M_\gamma \geq 2$). VME based data acquisition system was used in LAMPS [3] platform to collect the data in LIST mode. Master rate of 7-8K events/sec with $M_\gamma \geq 1$ could be collected with VME system without any dead time. A digital data acquisition system from UGC-DAE-CSR, (Kolkata centre) has also been tested with VENUS setup [4].

Performance tests:

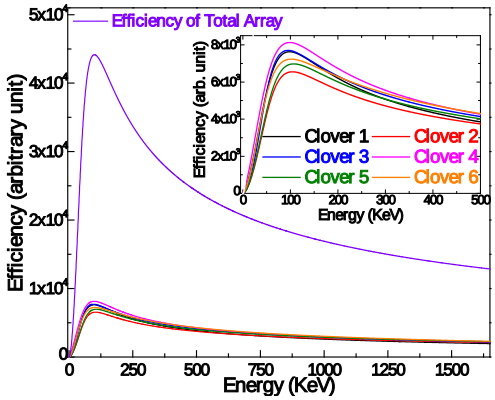

Fig 2: Relative Efficiency of VENUS setup and of the individual Clover detectors.

The array with the above electronics setup was first tested with standard radioactive sources of ^{133}Ba and ^{152}Eu. Energy resolution of ~2.2 keV at 1332 keV has been obtained for the crystals of the Clover HPGe detectors**.** The Peak/Total of each Compton suppressed Clover detector was found to be about 0.33. The efficiency of the array was measured and the corresponding relative efficiency of the array along with that of individual detectors is shown in Fig.2.

In the first experimental campaign of VENUS with alpha beam from K-130 cyclotron at VECC, Kolkata, nuclear structure studies of some of the nuclei around A~120 and A~200 mass regions were carried out, which could be uniquely populated with large cross sections using fusion reactions by alpha beams. A typical spectrum corresponding to the total projection of γ–γ matrix, obtained for the coincident γ-rays from excited states of ^{199}Hg, populated in fusion evaporation reaction ^{198}Pt(α,3n)^{199}Hg at 36 MeV beam energy, is shown in Fig.3.

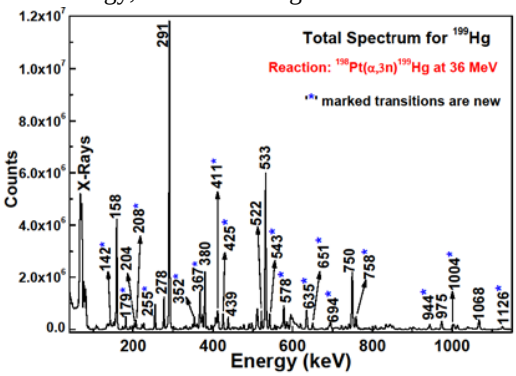

Fig 3: Total projection from γ–γ matrix, showing transitions in ^{199}Hg.

Summary

The first successful in-beam campaign of VECC array for NUclear Spectroscopy (**VENUS**) was carried out using alpha beam and VME based data acquisition system along with standard NIM electronics. The performance of the array, tested with radioactive source and beam, was found to be satisfactory. This array can now be used for further experimental campaign at VECC and can also be coupled with other detection systems existing at VECC.

The efforts of all the persons from VECC Cyclotron group are gratefully acknowledged for delivering the stable α–beam.

References

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