# In-beam Tests of PIXIE-16 Digitizer based Data Acquisition System at VECC

S. Das[1], S. Samanta[1], R. Bhattacharjee[1], A. Ghosh[1], D. Arora[1], S. Chatterjee[1], K. Basu[1], R. Raut[1],* S. S. Ghugre[1], A. K. Sinha[2], R. Banik[3], S. Bhattacharya[3], A. Dhal[3], S. Imran[3], S. Bhattacharyya[3], G. Mukherjee[3], A. Goswami[4], R. Palit[5], and H. Tan[6]

[1] *UGC-DAE CSR, Kolkata Centre, Kolkata 700098, INDIA*
[2] *UGC-DAE CSR, Indore 452017, INDIA*
[3] *Variable Energy Cyclotron Centre, Kolkata 700064, INDIA*
[4] *Saha Institute of Nuclear Physics, Kolkata 700064, INDIA*
[5] *Tata Institute of Fundamental Research, Mumbai 400005, INDIA and*
[6] *XIA LLC, California 94544, USA*

## Introduction

The advent of digitizer based pulse processing and data acquisition systems has ushered an era of compact, fast and improved experimental facilities in several domains of research, including nuclear spectroscopy. Indeed, the large $\gamma$-ray detector arrays in the recent times are being based on digitizers that are capable of handling the increased data rates through application of signal processing (recursive) algorithms and record time stamped list mode data, thus providing better flexibility in the subsequent analysis. The Indian National Gamma Array (INGA), which has been the principal experimental tool for nuclear structure research in the country for more than one and a half decade, has used digitizer based processing and acquisition in its last campaign at the Pelletron LINAC Facility in Tata Institute of Fundamental Research (TIFR), Mumbai [1]. A series of experiments were performed under this campaign and produced significant physics output. For instance, the use of time stamped data for extracting lifetimes of isomers [2] was an interesting development in this campaign. Based on the experience of using the digitizer based system with INGA at TIFR, a similar system was envisaged for the subsequent campaign of the array scheduled at the Variable Energy Cyclotron Centre (VECC), Kolkata. The trigger logic for the new system was proposed by the Nuclear Physics Group of the UGC-DAE Consortium for Scientific Research (UGC-DAE CSR), Kolkata Centre. The system was developed and manufactured by the XIA LLC, USA. The trigger logic was conceived in compliance with the same practised with the analog electronics and was essentially based on the multiplicity of Compton suppressed Clovers. The daq system consists of PIXIE-16 digitizer modules, each with 16-channels, housed in a PXI Crate. Each module can support 3 Compton suppressed Clover detectors, in case the Compton suppression signal for the Clovers is generated inside the module with the preamplifier signal of the respective Anti-Compton Shield (ACS) being fed as one of the inputs (in the specified port). Alternatively, each module can be used for 4 Clover detectors with the respective ACS signals processed externally (using NIM electronics) and fed into the module as veto. The present work pertains to the testing of the system preceding its intended use in the INGA campaign at VECC.

## Experimental Details and Data Analysis

The system was subjected to extensive offline tests with radioactive sources, before using it for in-beam experiments at VECC. The typical parameters that were checked for validating the performance of the digitizer

*Electronic address: rraut@alpha.iuc.res.in

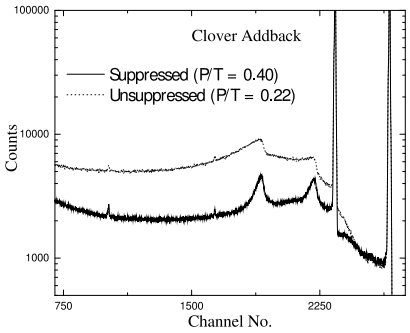


FIG. 1: Comparison of Compton suppressed and unsuppressed spectra acquired with the new digitizer system.

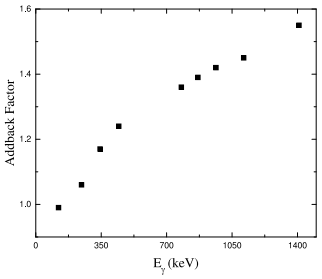


FIG. 2: Variation of addback factor with energy, as acquired with the new digitizer system.

system include energy and timing resolution, peak-to-total (P/T) ratio (for the quality of suppression), addback factor and event profile (proportion of events of different multiplicities). These parameters were found to be compliant with the desired range and in agreement with the known values obtained with the analog electronics. The Compton suppression and addback factors obtained with the digitizer system are respectively illustrated in Figs. 1 and 2. Two separate reactions were carried out for the in-beam testing of the digitizer system, using the $\alpha$-beam available from the K130 room temperature cyclotron at VECC. They were, $^{181}$Ta$(\alpha, 2n)^{181}$Re and $^{115}$In$(\alpha, 2n)^{117}$Sb at $E_\alpha$ = 28 MeV. These reactions were very clean ones with the total cross section principally dominated by one of the residue channels, identified above, thus rendering sufficient statistics for reliable comparison with the existing experimental data on the nuclei. The detection system used was an array (VENUS acronymed for VEcc array for NUclear Spectroscopy) of six Compton suppressed Clover detectors, positioned in a planar geometry. Two digitizer modules were used in the experiments wherein the preamplifier signals from the Clovers and the respective ACS were fed into the specified ports. The coincidence data was, for most part of the experiments, acquired with a multiplicity trigger of two suppressed Clover detectors and the coincidence event rate was $\sim$ 1 kHz.

The acquired data was sorted using a set of programs developed for the purpose. The various steps in the data reduction include rewriting the data in a simplified format (for economising the storage), time sequencing the data from a single module, time sequenced collation of data from multiple modules and finally creating spectra and matrices that can be analyzed using the standard RADWARE [3] package. The data analysis is currently in progress to probe the different aspects of the digitizer system. For instance, lifetime of the 418 ns isomer in $^{117}$Sb has been extracted from the present time stamped data, for validating the same, and has been found to be in agreement with the quoted value. The results of the analysis shall be detailed at the Symposium.

The help and support received from the Accelerator Group and the Health Physics Unit of VECC, during the experiments, is deeply appreciated and gratefully acknowledged.

## References

[1] R. Palit *et al.* Nucl. Instr. Meth. Phys. Res. A**680**, 90(2012).
[2] S. Rajbanshi *et al.* Phys. Rev. C**89** 014315(2014).
[3] D C. Radford Nucl. Instr. Meth. Phys. Res. A**361** 306(1995).