A novel self-sustained digital acquisition system employing multi-frequency digitizers for the BARC Clover + $LaBr_3$ array

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Introduction

With the advent of next generation large Ge detector arrays, sophisticated electronics and data acquisition system, and the realistic possibility of taking a stride in the hitherto unknown territory of nuclear landscape, the low- and medium-energy nuclear physics are at a crossroads of exciting exploration. It is obvious that the quality and the quantity of the data are central to all the physics exploration and therefore, these two factors have remained the main driving force over the years toward the development of better instrumentation. Development of digital signal processing based data acquisition system and its integration with large gamma detector arrays are being pursued vigorously all over the world [1, 2]. The main advantages of such system over the conventional analog one are well known.

The (n_{th},f) and (n_{th},γ) reactions are unique for the exploration of low- and medium-spin structures and associated nuclear phenomena in a large number of otherwise inaccessible nuclei. In order to cater to the need of carrying out both these types of experiments using thermal neutrons at the DHRUVA reactor facility, BARC, a high-efficient gamma array coupled with a state-of-the-art digital data acquisition system is of great importance.

Here in this paper, the details of the digital data acquisition system, developed in collaboration with CAEN, Italy, have been presented.

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Architecture details

Presently, the acquisition system is designed for an array of 8 Compton-suppressed clover Ge detectors and 16 $LaBr_3$(Ce) fast scintillators. The analog signals from the clover Ge detector preamplifiers are sampled by four 8-channels 100 MSPS 14-bit V1724 CAEN digitizers, whereas one 16-channels 500 MSPS 14-bit V1730 CAEN digitizer takes care of the signals from the $LaBr_3$(Ce) fast scintillators. In a novel approach to make the system a self-sustained one, the signals from the BGO anti-Compton shields were also digitized by a 8-channels 250 MSPS 12-bit V1720 CAEN digitizer. The digitized ACS signals are then fed to a logic unit which implements a programmable delay, and generates the veto signals for the clovers, making also a fan-out of 1 to 4. The veto signals, thus generated, are fed to the LVDS I/O port of the V1724 digitizers. The above-mentioned logic unit can be accessed via VME; this allows the user to write an appropriate delay at its internal register and also to use the board as a test pulser. The trigger signals of the digitizers are generated internally as soon as a programmable voltage threshold is reached. The synchronization among the digitizers is initiated using the TRG IN-TRG OUT daisy chain cable connectors. The time correlation of events is further maintained by distributing the clock among the digitizers. This is done by phase-locking to the V1724 master clock digitizer. Data transmission and necessary communications with the boards (digitizers) are performed through optical fibre cables which connect each board directly to the PCI Express CONET2 controller with multiple optical links in a highconfiguration computer. Employing CAEN CONET proprietary protocol, data transfer rate up to 80 MB/s per each optical link is possible.

The Graphical User Interface (GUI) has been conceptualized and subsequently designed in an user friendly manner in LINUX platform. Among many useful features in the GUI, the provision to perform online calibration and to observe online add-back spectra have been incorporated.

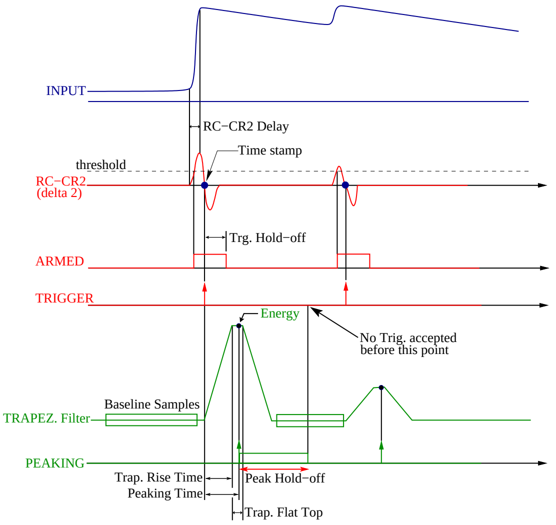

FIG. 1: Simplified schematic diagram of pulse processing steps as implemented in the firmware.

Performance report

Using the Digital DAQ system, the energy resolution of $LaBr_3$(Ce) detectors has been obtained as ∼3% at 662 keV. On-line time-of-flight (TOF) spectrum for two $LaBr_3$(Ce) was obtained using ^{60}Co radioactive source. From the online TOF spectrum, timing resolution for $LaBr_3$(Ce) detectors was obtained as ∼350 ps. It is to be noted that due to the implementation of the digital CFD in the DPP-PSD firmware, a fine time-stamp of the order of ∼2 ps can be achieved in the 500 MHz digitizer. This particular advantage of the system is going to be crucial in terms of measuring lifetimes of sub-nanosecond nuclear isomeric levels. For the clover Ge detectors, crucial parameters like peak-to-total (P/T) ratio, add-back factor were extracted in order to characterize and optimize the system. In an unsuppressed clover, the P/T ratio for each detector segment was found to be ∼0.13. In the add-back mode, the P/T ratio was found to be ∼0.25 (without ACS veto) and ∼0.43 (with Compton suppression). The latter number can actually be further improved if the γ-ray background in our CIRUS laboratory could be fully avoided. The add-back factor was extracted as ∼1.50 at 1.3 MeV. Further improvement and subsequent in-beam characterization of the system will shortly be undertaken, the details of which will be presented during the symposium.

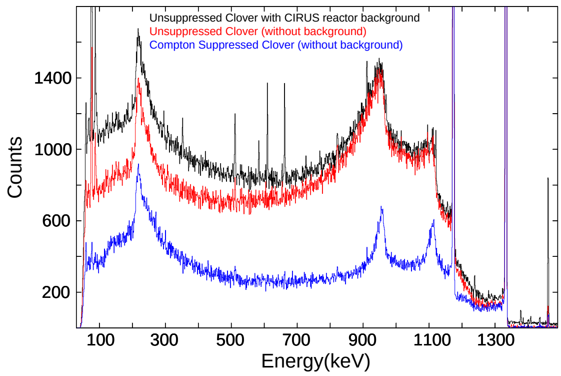

FIG. 2: Effect of Compton suppression on the spectrum from the decay of a ^{60}Co source.

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