GDA electronics module for Compton suppressed HPGe detectors

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Introduction

Modern gamma detector arrays employ large number of Compton suppressed high purity germanium (HPGe) detectors for gamma ray spectroscopy. Each unit of these detectors consists of a HPGe detector inside an anti-Compton shield (ACS) made of scintiallator detectors of Bismuth Germanate Oxide (BGO) and NaI(Tl) crystals. At IUAC, the Gamma Detector Array (GDA) is an example of such a set-up and many experiments were done with conventional NIM electronics signal processing extracting energy and time information for the gamma rays emitted from excited nuclei.

The conventional NIM electronics used in GDA has large number of conventional electronics modules like spectroscopy amplifier, Timing Filter Amplifier (TFA), constant fraction discriminator (CFD), coincidence units, delay modules, and gate stretchers making cabling and troubleshooting of electronics for full array very complicated and expensive. To increase the operational reliability and ease of operation we have developed a compact double width GDA electronics NIM module. The inspiration for this module came from our experience of Clover module developed [1,3] for Indian National Gamma Array (INGA) [2]. The features and the test results of the module are described below.

GDA electronics module

GDA electronics module is a double width NIM module, containing complete two channels of front end electronics to process both energy and timing signals from two independent HPGe detector with ACS. Block diagram of GDA electronics is is shown in Fig. 1. for a single channel.

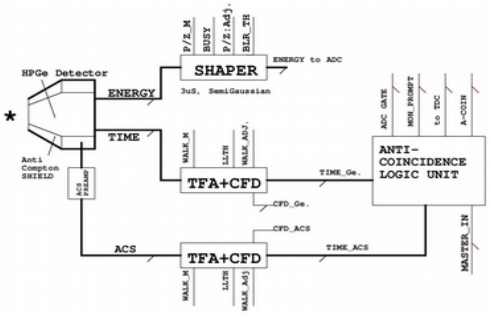

Fig:1. Block diagram of GDA electronics module

High resolution spectroscopy amplifier (shaper) have fixed 3 uS shaping constant and three gain settings (2, 4, 6 MeV) which are jumper selectable. The DC baseline is stabilized with Gated BLR, while P/Z correction and BLR threshold adjustments are provided. The quasi-Gaussian unipolar output has dynamic range of 8 V across 50 Ohms. Unipolar outputs (2 way) are given in front panel.

Timing from HPGe and ACS detectors Filter Amplifier (TFA) with fixed shaping time constants and gain settings are provided. 100 ohm drive capable TFA is designed with single operational amplifier (CFA) gain stage and baseline is stabilized with twin diode Robinson restorer. These amplifiers have rise time of better than 10 ns with dynamic range of 2.5 volts across 100 ohms. Constant fraction discriminator (CFD) with amplitude and rise time compensation (ARC) is realized with fixed delay

of 25 ns and a constant fraction of x0.3. Lower Level Threshold (LLTH), walk adjustment and monitoring are provided on front panel. CFD outputs (fast NIM logic) with dead time of 2 us is further processed in ACL card. The CFD (fast NIM) signal is also available on rear panel.

ACS timing signal received from ACS Preamplifier is processed with identical TFA + CFD without any dead time. Prompt timing logic signals received from CFD of HPGe detector and ACS detector are processed to affect Anti-coincidence. TFA and CFD outputs from ACS are provided for ease of adjustment. Logic functions performed are Pileup Rejection, individual ADC GATE-ing, Anti-Coincidence output and delayed STOP signal for TDC. All these logic outputs are buffered and available in standard logic levels on the panel through Lemo_00 series connectors.

This module can be configured either as "stand alone" or a part of an array with master logic trigger gate 'MGATE_IN' provision available on the front panel.

Test results

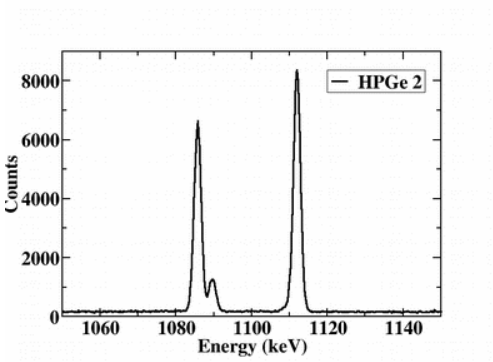

Fig. 2. Part of gamma ray spectrum from ^{152}Eu source using GDA module.

A part of gamma spectrum acquired using the GDA module with ^{152}Eu radioactive source is shown in Fig. 2. for clarity. Peaks at 1085.8 and 1089.7 KeV are well resolved in this spectrum. Resolution for the 1408 keV gamma transition was measured to be 2.5 keV. The module was kept under continuous operation for about a week and no gain drift was observed. TAC (time to amplitude converter) spectrum between the two HPGe detectors using the GDA module is given in Fig. 3.

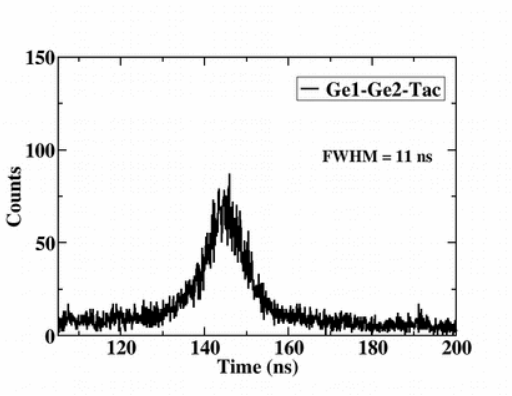

Fig:2. TAC spectrum between two HPGe detectors acquired with ^{152}Eu

TAC spectrum between the two HPGe detectors using the GDA module is given in Fig. 3. The fwhm for this TAC spectrum was found to be 11 ns using ^{152}Eu source for all gamma rays recorded. Non-linearity of the module was found to be very good for the measured energy range of 121 keV to 1460 keV and the non-linearity coefficient was found to be close to 10^{-8}.

The performance of Compton suppression electronics is being recorded with ^{60}Co source and suppressed HPGe spectrum will be presented in conference.

References

[1] Technical Report on clover electronics module, S. Venkatramanan et al., NSC/TR/SV/2002-03/30
[2] S. Muralithar et al., NIM A 622 (2010) 281.
[3] Invited talk on INGA & NAND Instrumentation at IUAC, S. Venkatramanan et al. DAE symposium on nuclear physics. Vol.52 (2007)