Pulse Shape Analysis of a two fold clover detector with EMD based algorithm

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Introduction

The Next-generation of gamma ray spectrometer viz. AGATA[1] and GRETA [2] arrays are based on Pulse Shape Analysis (PSA) and Gamma-ray Tracking Algorithms. The detector involved will have high energy resolution with remarkable detection efficiency and have strong ability to discriminate the weak gamma lines even under strong background radiation. It involves complete digitization of the input signal with high performance pulse processing units with a dedicated data acquisition trigger software. The pulse processing units will operate series of operation to the input signal an provide the best throughput for the energy and timing spectra. Such detectors will involve the assembly of composite HPGe detector with high granularity. By using the concept of PSA one can find the interaction point in the active volume of Germanium detector. Therefore, provides the γ-ray interaction position in addition to energy and timing information. The detector involves two type of signals one is known as the core signal which is produced in a voxel where actual interaction took place, other is known as mirror signal which is generated in a neighboring voxel due to capacitive coupling among the electrodes. Core signal gives the information about the depth of interaction and mirror signal gives the azimuthal co-ordinate information. Core pulses are the strong pulses and least affected by noise, whereas mirror signals are weak pulses and strongly affected by noise. The level of noise strength involved in the mirror signal distort the image resolution [3]. Therefore, in this context it is important to study the mirror signal time series in order to produce better azimuthal co-ordinate information.

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EMD based noise reduction method

The Empirical Mode Decomposition is a standard technique which is most widely used in analyzing the linear, nonlinear and chaotic time series data in nonlinear dynamics, astrophysics, signal processing etc., areas of research[4]. EMD decomposes the data into a series of expansion of different Intrinsic Mode Functions (IMFs) with a unique timescale property and hence, captures the dynamics of the system at different time regions of the data set.Therefore, the data set $x(t)$ can be written as.

$$x(t) = \sum_{i=1}^{N} IMF_i + r(t) \qquad (1)$$

Where IMF_i is the ith decomposed component and $r(t)$ is the corresponding residue obtained by the sifting process [4]. Unlike in wavelet filtering, EMD generates the basis functions derived from the signal itself and are

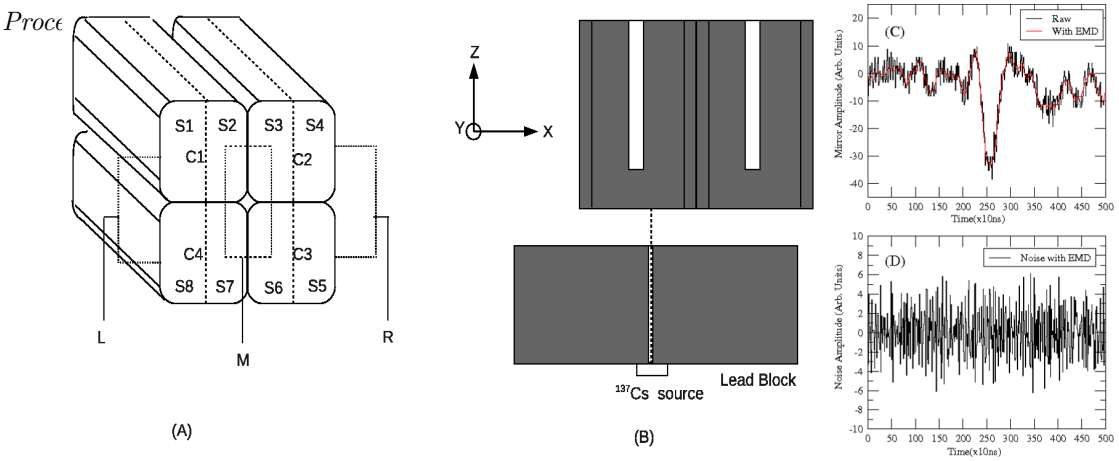

FIG. 1: Two fold clover detector with scanning arrangement (A,B) and the comparison between raw mirror signal with enhanced signal (red) with corresponding noise at position P1 is shown (C,D).

almost orthogonal to each other [4]. The noise filtering approach implemented in the present investigation is based on the frequency distribution and correlation coefficient calculations performed both in frequency and time domain respectively. Such that the reconstructed signal can be obtained by the truncated correlation curve in time domain [5].

Experimental Set up and Data Analysis

A two fold clover detector (from TIFR, Mumbai) has been used to investigate the implications of the algorithm [5] for the PSA. It has four HPGe crystals with two fold of electrical segmentation such that each of the crystal is further divided into two segments as shown in Fig. 1(A). Therefore, in addition to four energy signals from crystals C1,C2,C3,C4 it also provides three position signals Left (L), Middle (M) and right (R) as shown in Fig. 1(A). Therefore, in order to store the pulses at various position a lead collimator arrangement has been prepared which can scan the detector along X and Y directions respectively using ^{137}Cs source having 258kBq source strength as shown in Fig. 1(B). A lead block carries the dimensions of 152mm along X, 152mm along Y and 50mm along Z directions respectively with surface is at a fix distance of 15mm from the detector surface and is placed one the movable platform which can move along X and Y directions with a precision of 1mm and 0.5mm respectively. A square hole of cross sectional area 1mm^2 bored along Z direction and lies at the center of XY plane of the lead block. By considering center of clover detector as (0mm,0mm) co-ordinates and using the mentioned arrangement we record the pulse shapes at four different positions having co-ordinates with respect to the center of clover detector as (13mm,-25.5mm)(P1), (-16mm,-35.5mm)(P2), (-36mm,16mm)(P3) and (29mm,-35.5mm)(P4) respectively. The Data processing is done with VME based Data Acquisition System [6].

The mentioned algorithm [5] has been implemented on mirror signal on event-by-event basis and the noise oscillations are suppressed therefore, results in enhanced mirror signal as shown in Fig. 1(C,D). It has been observed that the noise strength distribution varies with scanning position and the algorihm produce shift in mean centroid value of the mirror signal [6].

Acknowledgments

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