Average $n - \gamma$ pulse shapes from BC501 liquid scintillator detector

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Introduction

The performance of digital neutron-gamma pulse shape discrimination (PSD) methods is very much dependent on various components of the detection system. The advent of digital devices such as fast ADCs has allowed the development of more precise and unambiguous methods by allowing the offline processing of raw data. The raw pulses obtained from a detector possess statistical variations and noise due to random nature of nuclear decay processes. These fluctuations affect the performance of a PSD method significantly [1].

The average pulses can be calculated from the raw data to check the actual response of a detector to the nuclear radiation [2]. Further, the PSD analysis of average pulse shapes gives better insight of the working procedure of a PSD method and can lead to the development of more accurate and optimized PSD methods. In this work the response of BC501 liquid scintillator detector to the neutron and γ-ray events is investigated by calculating the average pulse shapes at different energy thresholds.

Experimental setup

A data set of mixed $n - \gamma$ pulses from AmBe source is recorded with the help of 5”×5” BC501 liquid scintillator coupled to R4144 PMT from Hamamatsu. The anode output of PMT was fed to 12 bit digital oscilloscope from Lecroy. The pulses obtained are sampled at the sampling rate of 2.5 GSamples/s. The source was placed coaxially with PMT at an optimized distance of 15 cm from the detector as shown in fig. 1. The distance was optimized to get an appreciable count rate with least number of pile-up events. An edge trigger was applied to the falling edge of the pulse to collect a big number of pulses. The time width of each pulse is 200 ns. The calibration of detection system was done by using standard γ-ray sources viz. Co-60, Cs-137 and Na-22.

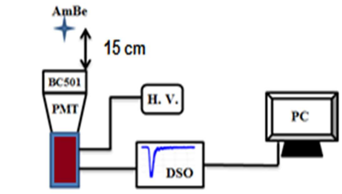

Fig.1. The diagram of experimental setup.

The channel number at 75% of Compton edge maximum was used to calculate calibration line.

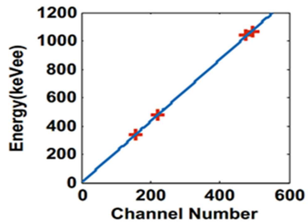

Fig.1: Calibration line plotted at 75% Compton edge of pulse integration spectra

Pulse Shape discrimination

Four data sets were obtained from the original data set with energy ranges 150keVee to 500keVee, 500keVee to 1500keVee, 1500keVee to 2500keVee and 2500keVee to 5000keVee with the help of calibration line. Each of these datasets is processed with digital charge comparison (DCC) method at optimized processing gate. The processing gate duration was 12ns for short integration and 80 ns for long integration with respect to peak amplitude of the pulses [3]. The figure 2 shows the probability distribution graph for the energy range 500keVee to 1500keVee. The figure of obtained by fitting the data with Gauss2 fit. The FOM obtained was 0.8522 which gives an appreciable discrimination of events. The neutron and gamma rays events are separated from standard deviation values of each Gauss fit. The Gamma and neutron boundaries are shown in figure 2. The events corresponding to mixed region are discarded in the calculation of average pulse shapes. Separate neutron and gamma ray events in each energy range were stored for the calculation of average pulse shapes.

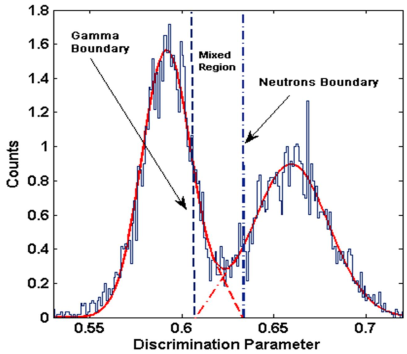

Fig.2: Probability distribution graph obtained with DCC for AmBe data at 500-1500keVee

Average *n*-γ Pulse Shapes

The average pulse shapes are obtained from each data set with the help of an algorithm developed in MATLAB. Figure 3 shows average gamma ray pulse and figure 4 shows average neutron pulses for different energy range. The amplitude of the pulses is proportional to the energy range in each case.

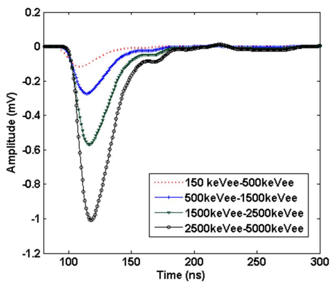

Fig.3: Average gamma ray pulses obtained from BC501 liquid scintillation detector

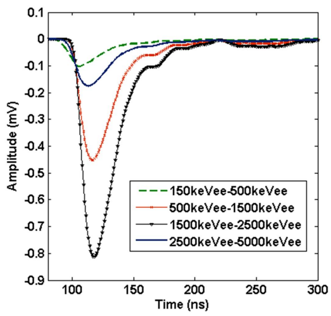

Fig.4: Average Neutron pulses obtained from BC501 liquid scintillation detector

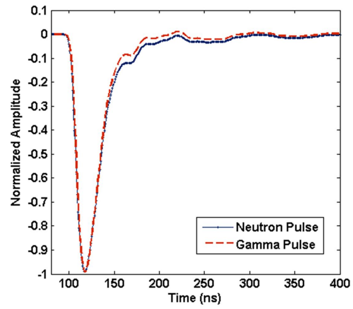

Fig.5: Comparison of amplitude normalized average n-γ.

The average n-γ pulse shapes are normalized to unity amplitude for comparison of neutron and gamma ray pulse shapes. Figure 5 shows the normalized pulses in energy range 1500-2500keVee. The neutron pulse being a heavy particle has longer decay time as compared to gamma ray [4]. This feature is clearly shown in figure 5.

Conclusion

The average pulse shapes for neutron and gamma ray events have been calculated from BC 501 liquid scintillator detector with the help of a DSO. These pulse shapes can be used to develop and optimize the pulse shape discrimination algorithms for better resolution of detection system.

References

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