Study on Digital Pulse Shape Discrimination System in BF_3 Detector

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1. Introduction

For the nuclear non-proliferation and safeguards, an accurate and reliable measurement of nuclear material is essential. The nuclear material emits neutron and γ-ray, simultaneously. For the accurate detection of the nuclear material, neutron should be discriminated from γ-ray or background radiation. In previous study, N.S. Jung developed pulse shape analysis method based on NIM and CAMAC system [1]. However, applications of other discrimination methods based on different detection modules or changing parameters are time-and-money consuming procedures in analogue systems. Today, the performance of digitizers is improved and it replaces some radiation measurement systems which require simple and portable equipment. Digital Pulse Shape Discrimination (PSD) method by using a digital oscilloscope is developed and applied to a neutron detection system by using BF_3 detector in this study.

2. Methods

2.1 Digital PSD method

Signals of different particle can be discriminated through the difference of pulse shape. Bipolar signals of spectroscopy amplifier is used for inhibit to occur of amplitude walk [2]. The 2-D distribution is composed of height and width of pulse. Pulse height is determined by the maximum value of voltage. Pulse width is determined by the time interval between the start point of the pulse (t_{start}) and zero-crossover point (t_{stop}) as shown in Figure 1. For determination of width, the zero crossover point of amp bipolar signal is set to t_{stop}. And there are two methods of set to t_{start}.

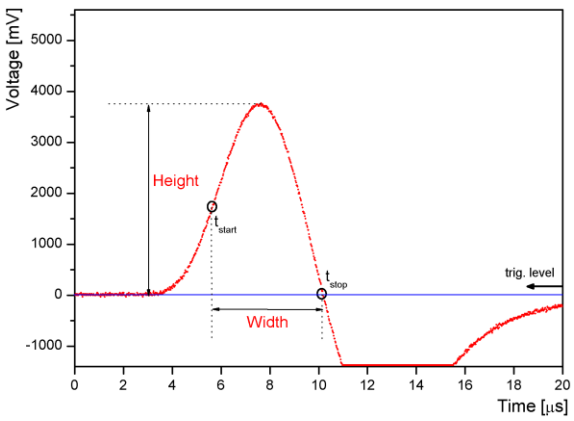

Fig. 1. Screen of digital oscilloscope and timing pick-up points for the determination of pulse height and width.

2.2 Data acquisition system

1-GHz Digital oscilloscope of Tektronix DPO7104C model is used for a pulse acquisition. Maximum sampling rate of DPO7104C is 20GS/s and the vertical resolution is 8-bit. The Fastframe acquisition mode is used to acquire signals effectively. A code for a signal acquisition and pulse processing is developed by using Matlab.

Measurement was performed by a BF_3 neutron detector without neutron sources. The specification of the BF_3 detector is followed in Table 1.

Table 1. Specification of the BF_3 detector.

Model	LND 20264
Diameter	25.4 mm
Active length	508.0 mm
Gas pressure	700 Torr
Cathode material	1100 Aluminum
Sensitivity	17.5 cps/nv

3. Performance

Firstly, t_{start} is set to the point of passing certain threshold voltage (200 mV). Its spectrum forms a smooth curve as shown in Figure 2. This leading edge triggering method was applied to the CAMAC system, and similar spectra were observed [1]. This curved shape occurs due to the amplitude walk. This shape of graph is hard to set objective regions for neutron and other radiations. The upper group of signals are neutrons, and the lower are background radiations.

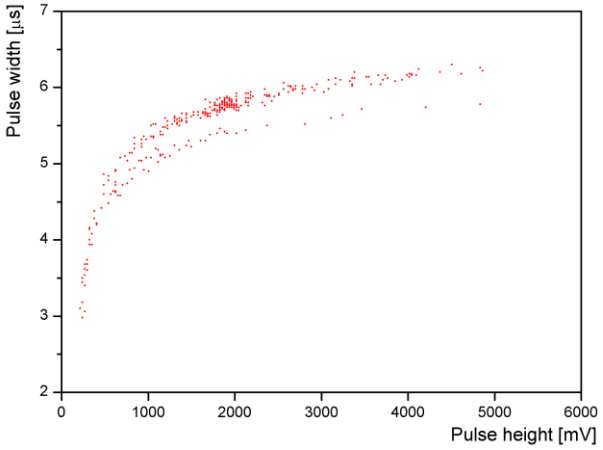

Fig. 2. Two-dimensional distribution for background by leading edge trigger method.

Secondly, t_{start} is set to the point of passing certain ratio of maximum height in another method. If the t_{start} is set to half of maximum height, the Figure 3 is obtained as follows. Spectrum forms two parallel regions, hence it is relatively easy to discriminate two regions of neutron and other radiations.

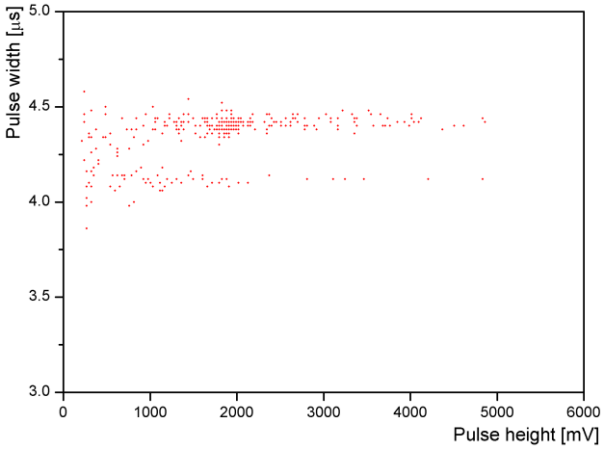

Fig. 3. Two-dimensional distribution of pulse height and shape for background (t_{start} : half of max. height).

4. Conclusion and further work

In this study, we develop the digital PSD system and discriminate the background signal of BF_3. Spectrum shapes are different according to the t_{start} setting method, and it is favorable to set it as the certain ratio of maximum height.

In future, it will be performed to vary t_{start} point to optimize the pulse discrimination. To quantify the performance, Figure Of Merit (FOM) will be determined.

Acknowledgements

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[2] G. F. Knoll, Radiation Detection and Measurement, 4th ed., John Wiley & Sons, New York, pp.681-682, 2010.