Pulse discrimination of background and gamma-ray source by digital pulse shape discrimination in a BF_3 detector

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1. Introduction

As a representative method of non-destructive assay, accurate neutron measurement is difficult due to large background radiation such as γ-ray, secondary radiation, spurious pulse, etc. In a BF_3 detector, the process of signal generation is different between neutron and other radiations. Hence, signals of different particle can be discriminated by using difference of pulse shape.

As the development of detection technique, all of signal data can be digitized by digital measurement method. In the previous study, Applied Nuclear Physics Group in Seoul National University has developed digital Pulse Shape Discrimination (PSD) method using digital oscilloscope [1]. In this study, optimization of parameters for pulse discrimination is discussed and γ-ray region is determined by measuring ^{60}Co source.

2. Methods

2.1 Digital PSD method

Bipolar signals of spectroscopy amplifier are used for PSD. The 2-D distribution is composed of the height and width of pulse. Pulse width is determined by the time interval between the start point (t_{start}) and stop point (t_{stop}) as shown in figure 1. The t_{start} is set to the point of passing certain ratio of height and t_{stop} is set to zero-crossover point of amp bipolar signal.

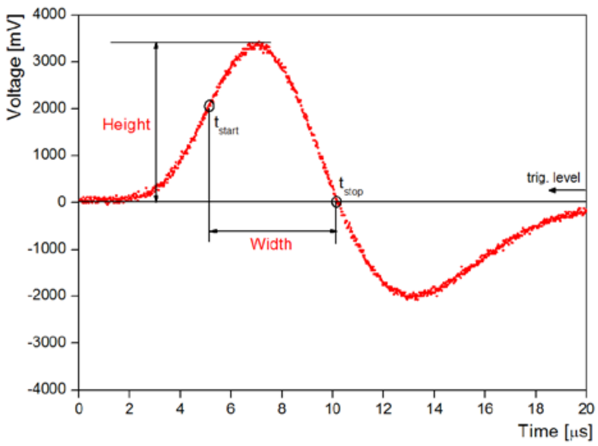

Fig. 1. Timing pick-up points for the determination of pulse height and width in amp bipolar signal.

2.2 Figure Of Merit

To optimize parameters for discrimination of each signal, it is necessary to set t_{start} point. The concept of Figure Of Merit (FOM) is imported to evaluate the discrimination performance. Generally, the definition of FOM is followed in pulse shape discrimination application [2]

$$\mathrm{FOM} = \frac{Peak\ seperation}{FWHM_A + FWHM_B}$$

where Peak separation is the distance between the center of peak A and B, and $FWHM_{A,B}$ is the FWHM of peak A, B.

3. Performance

3.1 Optimum pulse discrimination

2-D distribution spectrum of background radiation is acquired as shown in figure 2. 10,000 pulses are acquired for about 32 hours. There are two groups of pulses as shown in figure 2. Group A and B are parallel with the pulse height axis. Another pulses whose height is too low to discriminate are distributed in left side (<2000 mV). Hence, these low pulses are excluded in FOM calculation. Pulse width distribution is shown in figure 3. t_{start} point can be selected from 10% to 95% of the pulse height. The highest FOM value is 2.68 when t_{start} point is set to 55% of the pulse height.

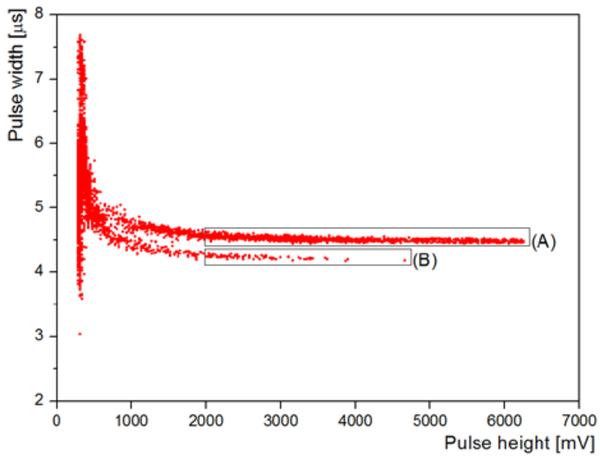

Fig. 2. 2-D distribution of pulse height and width of background (t_{start} : 55% of the pulse height).

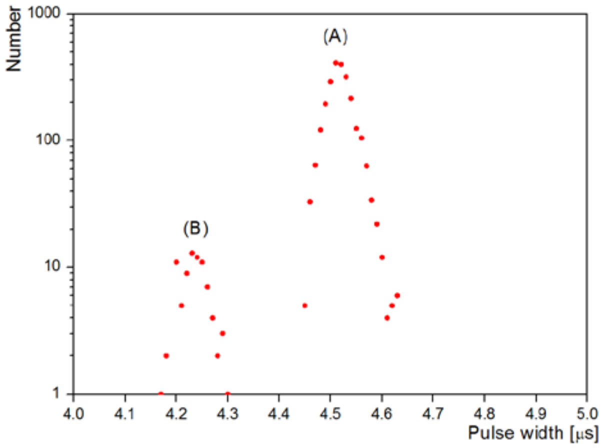

Fig. 3. Background spectrum projected to pulse height axis (t_{start} : 55% of the pulse height).

3.2 γ-ray source measurement

To identify γ-ray region, 66.01 kBq ^{60}Co source is measured as shown in figure 4. In 2-D distribution of ^{60}Co, the number of signal which is under 1100 mV is increased about 40 times comparing with background. The number of signal over 1100 mV region is same in error range. So most of low signals can be classified as γ-ray.

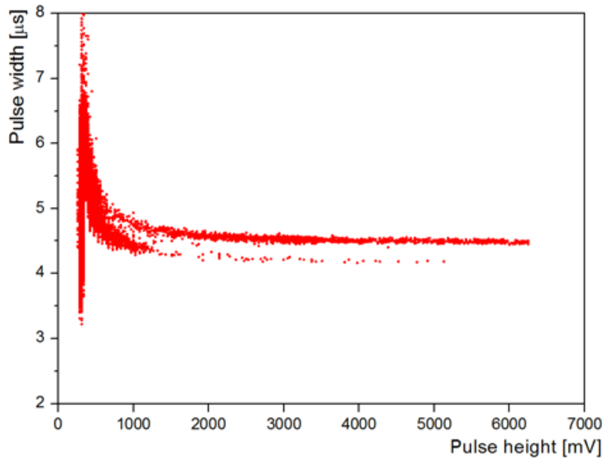

Fig. 4. 2-D distribution of pulse height and width of ^{60}Co (t_{start} : 55% of the pulse height).

4. Conclusion and further work

The background signal of BF_3 detector is discriminated by digital PSD system. Parameters for PSD are optimized through FOM calculation. And the γ-ray region is determined by measuring ^{60}Co source. In the future, the performance of developed system will be tested in low and high intensity neutron field.

Acknowledgements

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REFERENCES

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