Neutron pulse discrimination of BF_3 detector through pulse shape analysis

N.S. Jung [a], J.H. Kim [a], S.H. Byun [a,b] and H.D. Choi [a]
[a] *Seoul National University, Shinlim-Dong, Gwanak-Gu, Seoul 151-744, Korea, vandegra@plaza.snu.ac.kr*
[b] *McMaster University, Hamilton, Ontario, L8S 4K1, Canada*

1. Introduction

In the nuclear non-proliferation and safeguards, reliable detection and verification of nuclear materials is very important. An assay by passive or active neutron detection is the preferred technique when the sample is too dense to measure the accurate energies of γ-rays from its inside. For accurate neutron measurement, neutrons should be discriminated from γ-rays and other background radiations.

In this study, neutron pulses of a BF_3 detector were discriminated against other pulses including γ-rays and background radiations by using a CAMAC based pulse processing system to record the distribution of detection events over two-dimension [1].

2. Methods and Results

The BF_3 detector detects neutrons using $^{10}B(n,\alpha)$ reaction and its specification is shown in Table 1. The neutron source is a D-D neutron generator developed at Seoul National University [2]. To enhance the neutron detection efficiency, the detector is installed in a thick cylindrical polyethylene to moderate fast neutrons from the generator. The periphery of the polyethylene is covered with borated poly-urethane to prevent neutrons scattered by surrounding materials from entering the detector.

Neutron and other pulses of the BF_3 detector are discriminated through the rise time of each pulse. The pulse processing system is shown in Fig. 1. The pulse from the BF_3 detector, after passing a preamplifier, is provided to a shaping amplifier. Unipolar output pulses of shaping amplifier are provided directly to an input #1 of the Analog-to-Digital Converter (ADC) for pulse height (energy) analysis while bipolar output pulses are provided to a Pulse Shape Analyzer (PSA) for rise time analysis. As shown in Fig. 2, a fast rising input pulse

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

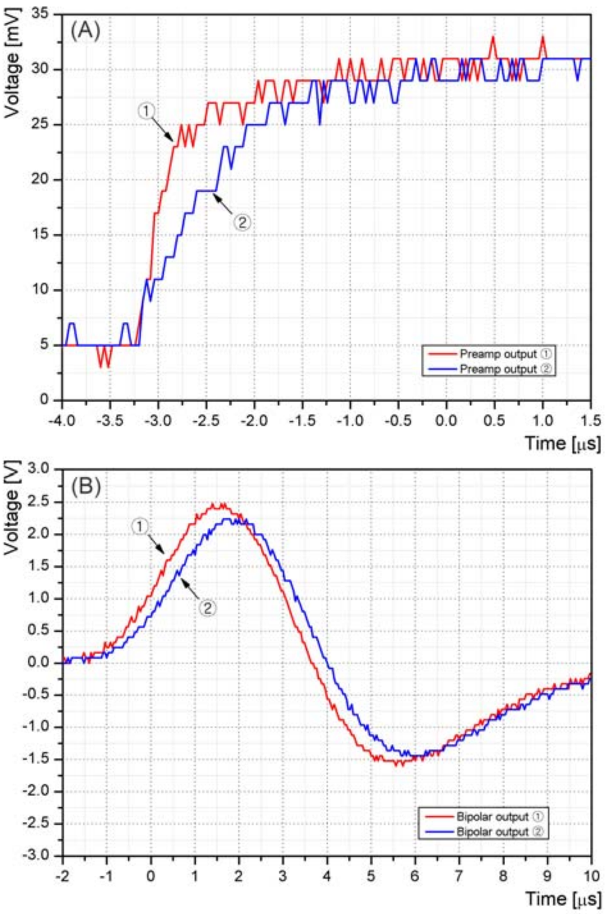

Fig. 2. Two preamp pulses with different rise time (A) and corresponding responses of the bipolar shaper (B).

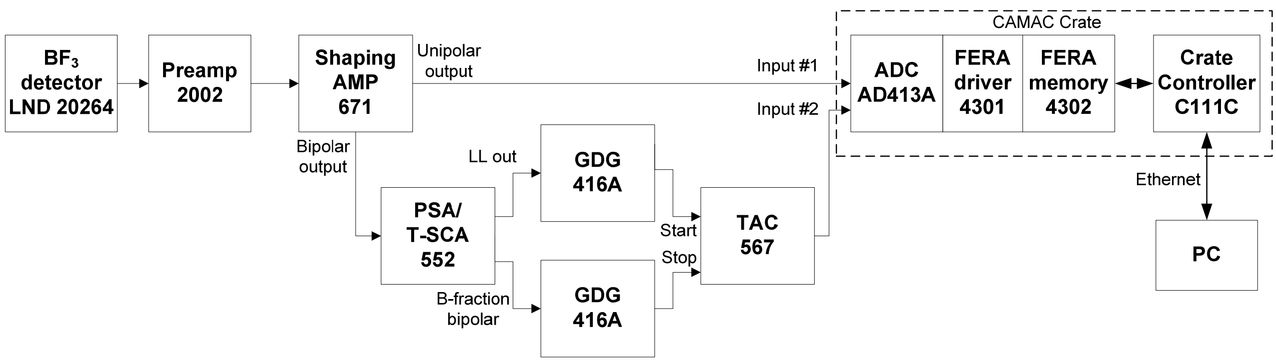

Fig. 1. Block diagram of the system for the discrimination of neutron and background pulses of the BF_3 detector.

(preamp output ①) ends up with a narrow output pulse (bipolar output ①) after bipolar shaping. Hence the zero-crossover time of a bipolar pulse is strongly correlated with the rise time of the preamplifier pulse. The PSA generates two logic pulses when a bipolar pulse crosses the low level threshold (40 mV) and it crosses the base line. Then a Time-to-Amplitude Converter (TAC) generates a pulse whose amplitude is proportional to the time interval of the two logic pulses. Coincidental pulse heights of the unipolar pulse and the TAC output pulse are measured and displayed as a two-dimensional plot. Separate energy and time spectra are also displayed.

The distribution for the background radiation is measured for 4147 s and results are shown in Fig. 3. Events populated in low channels are γ-ray interaction and electronic noise. A few counts of high energy background are visible as well. Fig. 4 shows the data collected for 3888 s during neutron generation. In the energy distribution (B), full-energy peaks are located at 2800 and 3400 channels, and the continuum pattern induced by the wall effect [3] is identified lower channels. From the comparison of two-dimensional distributions with and without neutron generation, neutron pulses and other pulses can be discriminated. It has turned out that the rise time of neutron pulses is slower than that of other pulses.

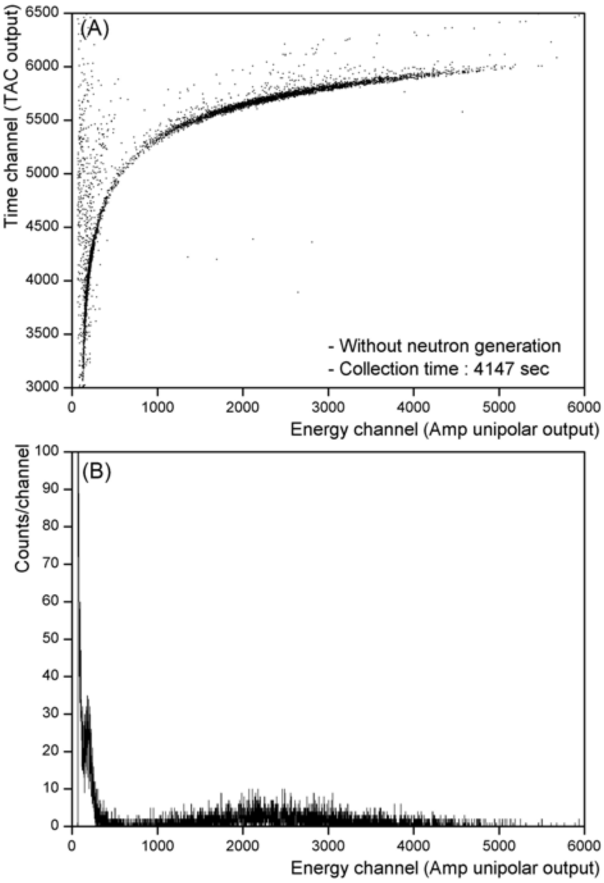

Fig. 3. Two-dimensional distribution of energy and time for background radiation (A) and the corresponding energy spectrum (B).

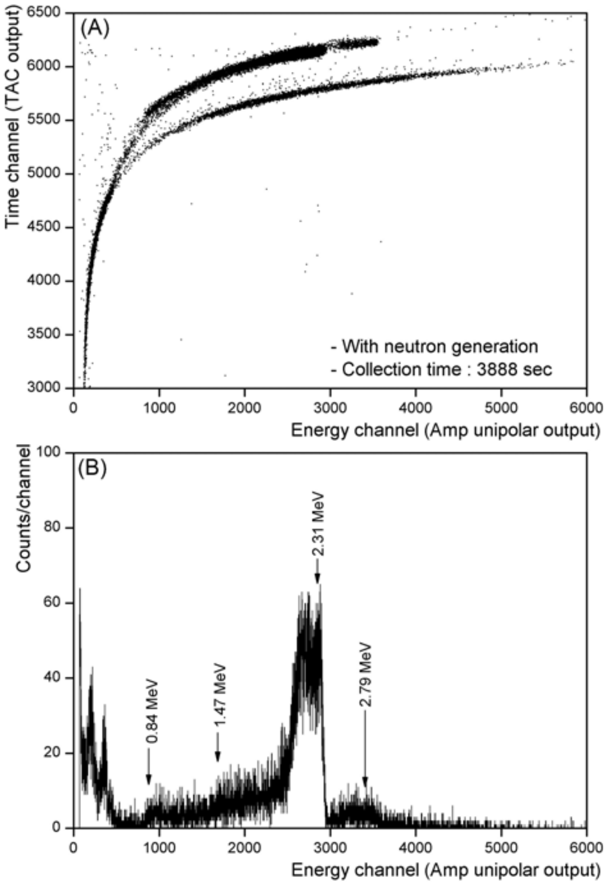

Fig. 4. Two-dimensional distribution of energy and time during the neutron generation (A) and the corresponding energy spectrum (B).

3. Conclusions and Further Works

Neutron pulses of BF_3 detector were discriminated using a CAMAC based time-energy analysis system. The present method will be applied and tested to other neutron detectors like ^{3}He detector. Other methods of pulse shape discrimination will be applied and compared with the present method.

Acknowledgement

This research was supported by the Ministry of Education, Science & Technology (MEST) of Korea and also supported by the Korea Institute of Nuclear Nonproliferation and Control (KINAC) and the Brain Korea 21 project.

REFERENCES

[1] N.S. Jung, J.H. Kim and H.D. Choi, Acquisition of Two-dimensional Pulse Height Distribution by Using CAMAC Modules, Transactions of the Korean Nuclear Society Spring Meeting, May 26-27, 2011, Taebaek, Korea.

[2] I.J. Kim, N.S. Jung, H.D. Jung, Y.S. Hwang and H.D. Choi, Nuclear Instrument and Method in Physics Research B, Vol. 266, p.829, 2008.

[3] G. F. Knoll, Radiation Detection and Measurement, 3rd Ed. John Wiley & Sons, New York, pp.512, 1999.