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Manufacture and Performance Evaluation of Real-Time Data Acquisition System for ^{3}He proportional chamber

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1. Introduction

As a survey meter for wide energy neutrons, ^{3}He, which has a large thermal neutron cross section, is commonly used in a chamber form combined with a bonner sphere [1]. In previous studies, precise n/γ discrimination algorithm for such detector was developed and it had a better discrimination performance compared to existing pulse height analysis method (PHA method) at various gamma-ray background [2]. However, it has a limitation in terms of separation after signal storage and real-time system is required to be applied to the survey meter. In this study, real-time signal processing system applying the algorithm was manufactured and the performance was evaluated.

2. Methods and Results

2.1 Manufacture of real-time data acquisition system

The real-time data acquisition system (DAQ module) applying the algorithm developed in previous study was manufactured using SoC integrated with ADC, FPGA and CPU in order to digitize and separate the signals and store the resulting data immediately. It is equipped with the ability to adjust the threshold to remove noise and parameter for n/γ discrimination (RTH, rise-time-to-pulse-height ratio). Output data include flag (neutron or gamma ray), pulse height, rise-time, RTH, time stamp of each signal. Table 1 summarizes the specification of DAQ module and figure 1 shows appearance of it.

Table I: Specification of DAQ module

Contents	Design value
Digitizer	• Resolution : 12 bit • Input range : 2 V peak-to-peak • Sampling rate : 50 MHz
Digital processor	• ADC, FPGA, CPU integral type • SoC : XC7Z020-1CLG48C
Data memory	• SRAM : 100 k sample
PC interface	• TCP/IP
Form	• 19' rack mount box • 220 V Power

Fig. 1. Appearance of manufactured DAQ module.

The pulse height and rise time for the RTH calculation in DAQ module are defined as the height from the baseline to the peak of the signal and the time length from the point at 10% of the pulse height at the rising edge of the signal to the peak point, respectively.

2.2 Experimental setup

Using the DAQ module, the same response experiment as the previous study was conducted. The high gamma-ray environments ranging 0.1 to 5 R/h were realized using ^{137}Cs sources and the rail system which can adjust the distance between source and detector. The 5.6 μCi ^{252}Cf was used as a neutron source and attached to the polyethylene shield. The side of shield containing the ^{3}He detector was positioned facing the gamma ray source.

In the measurement systems, the CANBERRA 133NH30/5 ^{3}He Proportional chamber was used as a detector, CANBERRA Model 2006 for preamplifier, Ortec`s 572A for amplifier and Ortec`s 556 for high voltage power supply. Output pulses from amplifier are discriminated through the DAQ module in real-time. Figure 2 shows schematic view of experimental setup.

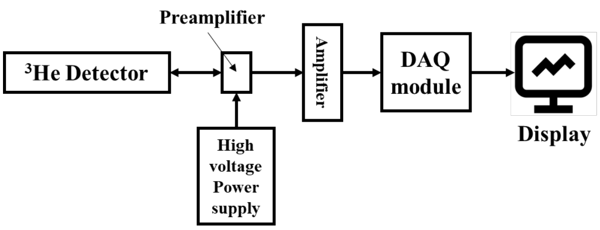

Fig. 2. Schematic view of the experimental setup.

2.3 Gamma ray elimination

In order to evaluate the gamma ray elimination performance, the gamma elimination ratio, which is the ratio of the gamma ray signals removed from the entire signal, was calculated. Figure 3 shows gamma elimination ratio at each environment. It is confirmed that it has better performance than the PHA method and difference is lager at higher exposure rate.

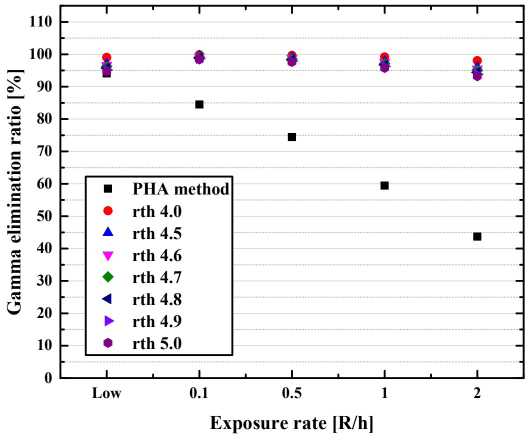

Fig. 3. Gamma elimination ratio at 0.1 to 5 R/h gamma-ray exposure rate.

2.4 Neutron counts

The neutron counts measured for 300 seconds without gamma ray source was taken as true value. It is compared with the neutron counts derived after n/γ discrimination at the high gamma-ray environments. Figure 4 shows neutron counts from DAQ module at various gamma-ray exposure rate and true neutron counts value. Although the PHA method has an overestimation of up to 10 times based on true value, stable counts of the same level as the true value are derived from the developed system.

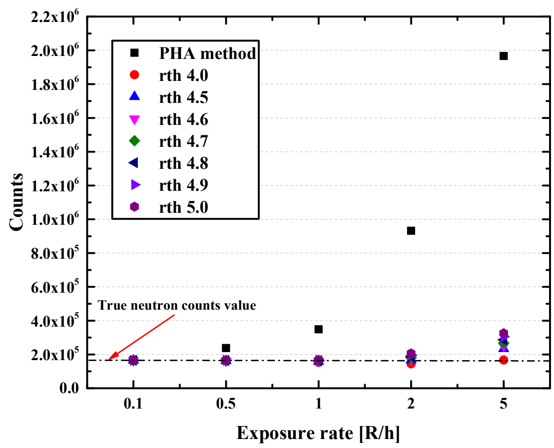

Fig. 4. Comparison between true value and neutron counts from DAQ module at 0.1 to 5 R/h gamma-ray exposure rate.

In order to confirm that neutron counts increase linearly with neutron dose, additional experiment was conducted using an ^{241}Am-Be standard neutron source with a release rate of 2.334×10^5 (Reference date, 2012.11.01). Distance between source and the detector was changed from 0 to 45 cm. Figure 5 shows neutron counts at various distance. The neutron counts are inversely proportional to the distance and it is expected that the counts will be proportional to the neutron dose in conversion.

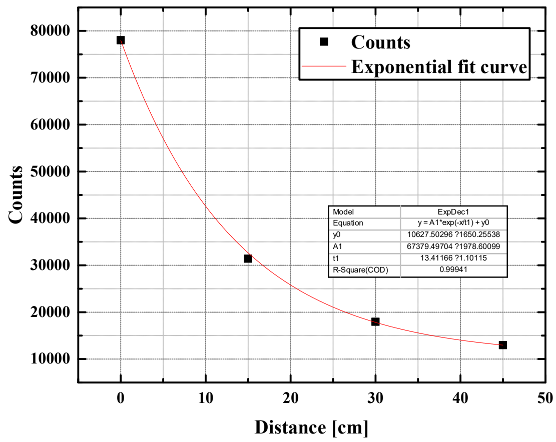

Fig. 5. Neutron counts derived from DAQ module at 0 to 45 cm

3. Conclusions

The real-time data acquisition system for n/γ discrimination of ^{3}He proportional chamber was developed using SoC applying the algorithm developed in previous study. As a result of performance evaluation in terms of gamma ray elimination and neutron counts, it was found that it has better performance compared to existing PHA method and expansion to the real-time system is possible. It is expected that it will be possible to carry out precise n/γ discrimination by applying the system developed in this study on neutron survey meter in the future.

REFERENCES

[1] Peurrung, A. J, Recent developments in neutron detection. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 443.2-3: 400-415, 2000.

[2] J.Choi, S.Park, J.Park, J.Son, Y.K.Kim, Improved Signal Processing Algorithm for the 3He Proportional Chamber in High Gamma-Ray Fields, Transactions of the Korean Nuclear Society Spring Meeting, May.17-18, Jeju, Korea, 2018.