Progress of Neutron Discrimination System for Sonoluminescence

Chan Kyu Kim [1], Hyunduk Kim [2], Gyuseong Cho [1*], Ho-Young Kwak [3], Ilgon Ko [3]
[1]*Korea Advanced Institute of Science and Technology, Taejon, Korea*
[2]*Korea Institute of Radiological & Medical Sciences, Seoul, Korea*
[3]*Chung-Ang University, Seoul, Korea*
[*]*Corresponding author: gscho@kaist.ac.kr*

1. Introduction

The sonoluminescence and its possibility for fusion reaction in the bubble are famous issues at one time. There are a lot of controversies over the experiment of R.P Taleyarkhan[1]. As Electric Power Research Institute (EPRI, USA) Project, we at KAIST and our subcontractor colleagues at Chung-Ang University are investigating this phenomenon and its applications which include the possibility of bubble fusion. We are carefully interested in the neutron detection in our measurement when the fusion reaction should occur in the chilled deuterated acetone. To sense existence of fusion reaction, neutron-gamma discrimination system has been installed and tested by neutron and gamma-ray sources. By performing two method at the same time, discrimination between neutron pulse and pile-up events are improved. And it can be applied to bubble fusion system.

2. Methods and Results

In this section composition of system and two methods applied to system are described. The discrimination system consists of BC501A scintillation detector, NIM modules and GPIB device. And both of the charge integration and zero crossover timing method are performed at the same time.

2.1 Composition of System

Figure1 and Figure2 are picture and whole diagram of discrimination system. A signal from BC501A was separated into three output signals. The one is used to a Gate signal of ADC and TDC, another is inserted into an ADC for charge integration method, and final signal is converted into a logic pulse which depends on a timing character of input signal.

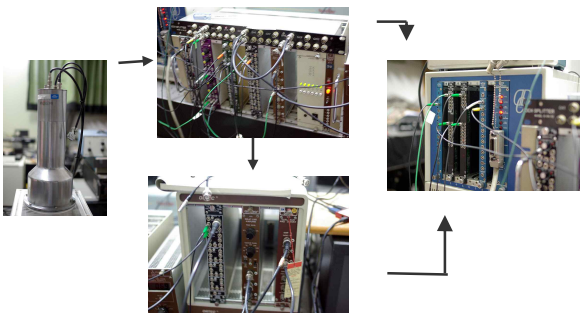

Fig. 1. Picture of neutron discrimination system. System consists of Scintillator, NIM modules, and GPIB devices.

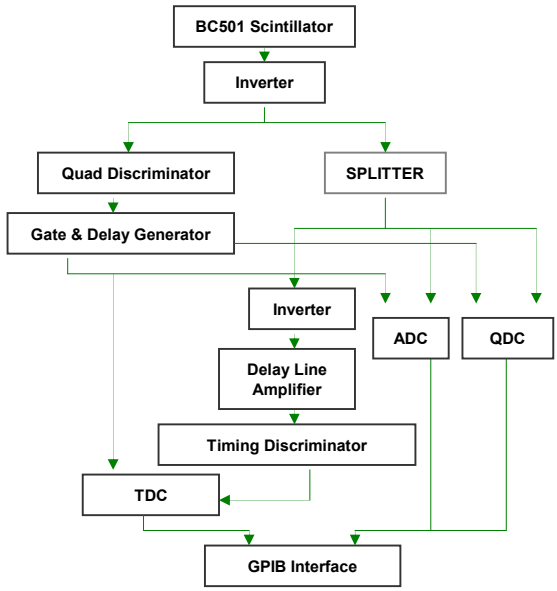

Fig. 2. Diagram of neutron discrimination system. Left part and right part of diagram is related to zero crossover timing method and charge integration method each.

This pulse plays the part of the input signal of TDC for timing method. A data from ADC and TDC in CAMAC is saved at the personal computer by means of GPIB communication device. This process is performed using LABVIEW under windows XP.

2.2 Zero Crossover Timing Method

Zero crossover timing method is most popular way to discriminate between neutron and gamma-ray. In this technique, the difference of pulse shape between neutron and gamma-ray is revealed by their timing information. [2, 3] Two different discriminators (zero crossover discriminator, constant fraction discriminator) make a logic pulse each, and these logic signals reach Timing to Digital Converter (TDC). TDC convert the time interval between two logic signals to digital value.

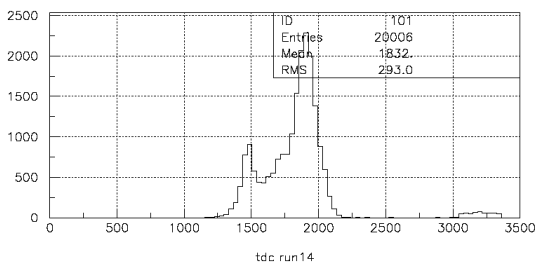

Fig. 3. Test result of zero crossover timing method in neutron discrimination system using Am-Be source.

Due to the pulse shape of neutron and gamma is quite different from BC501A liquid scintillator [4], two different peaks appear in result plot (Figure3).

2.3 Charge Integration Method

The best conventional way in neutron detection field was zero crossover timing method. But, charge integration method has gained in popularity over recent years. [2, 5, 6] In the charge integration method, the amount of charge over gate is used to discriminate neutron and gamma-ray instead of time information. Because each ADC has been controlled by different gate signal, One ADC integrates almost pulse from BC501A and other one integrates a fraction of pulse. And this result is shown as two-dimensional plot like Figure4. X-axis means amount of total charge and Y-axis means amount of tail charge. There are two thick lines in the plot; upper one is neutron and lower one is gamma-ray line. There are also many noise points around two lines. It is part that must be improved.

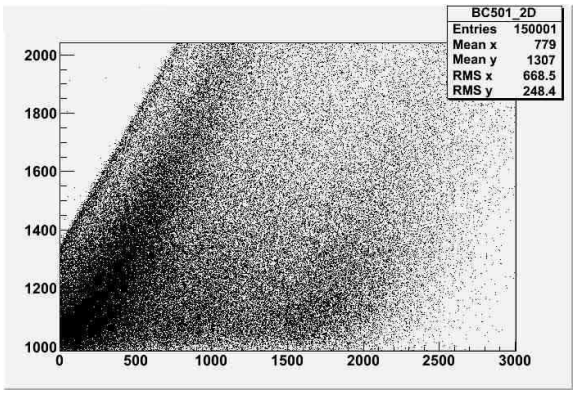

Fig. 4. Test result of charge integration method in neutron discrimination system using ^{252}Cf neutron source and ^{57}Co gamma–ray source.

2.4 Merit of Using Two Method at the Same Time

In radiation detection field, the problem of pile-up event can always occur. And sometimes, the result from pile-up event is very similar to that of other radiation. So, there is possibility of misinterpretation. Especially, in this experiment, accuracy of result is quite emphasized. But, if both of charge integration and zero-crossover timing method are used at the same time, then the possibility of misinterpretation decreases sharply. This is why we designed discrimination system as above way.

3. Conclusions

The experiment of bubble fusion is the issue which has engendered a lot of controversy. In this experiment, accurate discrimination system is required. Thus discrimination system which performs charge integration method and zero crossover timing method both at the same time is designed. Using Am-be source and ^{252}Cf/^{57}Co source, the system has tested and the result shows discrimination ability between neutron and gamma-ray. This system is useful for discrimination case which must avoid misinterpret with pile-up events. And it can be applied to bubble fusion system.

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