Characterization of multiplicity filter module

N. Saneesh[1],* S. Venkataramanan[1], Mohit Kumar[1], and P. Sugathan[1]
[1]*Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi - 110067, India*

Introduction

The National Array of Neutron Detectors (NAND) facility at IUAC is a multi-detector array for the study of nuclear reaction around the Coulomb barrier [1]. The array is being used for pre-scission neutron multiplicity measurements to study fission time scale, quasi-fission characteristics, etc. where signals from any of the fission detectors in coincidence with rf of the beam pulse was used as the acquisition trigger. All the neutrons interacted with neutron cell within a given time window (400 ns or 500 ns) were included in the acquisition.

In exclusive measurements such as neutron gated fission, neutron-neutron correlation, etc. it is necessary to have a master logic for data collection which includes signals from neutron detectors also. The acquisition trigger would be released when a given number (fold one, fold two, etc.) of neutron detectors are fired in coincidence with the fission detectors. The new mode of data acquisition will improve the data collection efficiency as we reduce the unwanted triggers from monitor detectors and fission detectors.

To meet these requirements, we have developed a Multiplicity Filter Module (MFM) which accepts signals from neutron detectors. It provides two outputs; a linear output proportional to the number of neutron detectors triggered in an event (called SUM/multiplicity) and logic OR of all the inputs (called OR). In this report, we present the characterization of multiplicity filter module to use it for neutron gated fission experiments.

*Electronic address: saneesh@iuac.res.in

Multiplicity filter module

The multiplicity logic for NAND array is realized using a set of 8 NIM modules (16 channels each) and a master module. These modules would be used in combination with home-made Pulse Shape Discrimination (PSD) modules [2]. It accepts logic signals from PSD module which was later shaped to 250 ns, known as inspection time. Any neutron detector fired within inspection time would be considered as a real event and an output would be generated proportional to the number of detectors triggered. The OR output is made available as standard fast NIM signal and multiplicity is realized by analog summing of -2mA per channel, within inspection time, at a common node.

The signals from individual MFM were processed further in Master Multiplicity module. The SUM and logic OR signals from all modules were gathered in this unit. The OR output then represents logic OR 100 neutron detectors. The current SUM signals are summed across 50Ω resistor to develop a voltage signal which was later suitably attenuated to maintain the linearity to number of detectors without saturation.

As known, the neutron detectors give enormous pulses upon gamma rays interaction. To get rid of this, we have used 'gamma rejected' output of PSD module. The PSD modules were tuned to have gamma rejection better than 95 %

Experiment set up

The multiplicity filter module was tested offline using a pair of neutron detectors, BC501A of NAND array. A spontaneous fission source, ^{252}Cf, was used as the source of neutrons. The source was mounted close to one of the neutron detectors which was considered as the master detector for data acquisition. Signals from both of these neutron de-

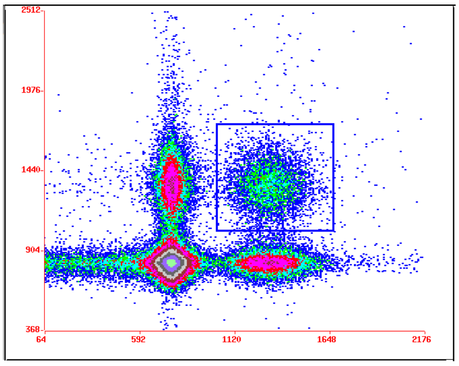

FIG. 1: Two dimensional plot of PSD_1 v/s PSD_2. The marked region shows neutron-neutron correlation events

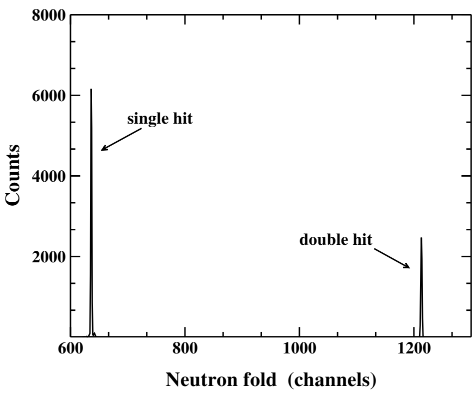

FIG. 2: The SUM output of multiplicity filter module when two detectors are connected

tectors were processed separately to find light output and n-gamma discrimination. In addition, a 'gamma rejected' time pick off signal from each PSD modules were given as input to the multiplicity filter module. Finally, light output and n-gamma discrimination signals from both detectors and SUM output from MFM were collected event by event.

Results and discussion

Fig. 1 shows a two dimensional plot of PSD from $BC501A_1$ versus $BC501A_2$. Various correlation possible between $BC501A_1$ and $BC501A_2$ such as gamma-gamma, gamma-neutron, neutron-gamma and neutron-neutron are shown. The neutron-neutron correlations are marked using a rectangular cut. The MFM provides 100 mV per channel. So, the SUM spectrum is expected to have two distinct peaks corresponding to 100mV and 200 mV for single hit (when only one detector is triggered) and double hit (when both detectors are triggered) respectively. The SUM spectrum obtained is given in fig. 2

As MFM accepts only gamma rejected inputs, the second peak (channel number $\sim$ 1200) represents neutron-neutron correlation. Analysis shows that the area under second peak in SUM spectrum and volume of neutron-neutron correlation gate in fig. 1 are in reasonable agreement considering the contamination caused by unrejected gamma pulse.

The measurement was repeated by incorporating a timing detector, BaF_2, as the master detector for acquisition. BaF_2 was used for gamma detection and neutrons emitted in the same event were detected using two BC501A. A triple coincidence among BaF_2-$BC501A_1$-$BC501A_2$ corresponds to gamma-neutron-neutron correlation. In this case also, the area under second peak of SUM spectrum and volume of neutron-neutron correlation band was found to be same within error bars.

Results of both these measurements clearly indicates that the amplitude of SUM output of MFM is directly proportional to number of input pulses from neutron detectors. Hence the OR output may be used in coincidence with the fission detectors to veto any unwanted data when neutron detectors are not triggered.

Acknowledgments

We acknowledge the support by Department of Science and Technology (DST) under grant no IR/S2/PF-02/2007.

References

[1] P. Sugathan et al., Pramana **83**, 807 (2014)

[2] S.Venkataramanan et al., NIM A, **596**, 248 (2008).