Pulse Shape Discrimination and Time of Flight measurements for n/γ with CAEN digitizer

Sathi Sharma[1], Shruti De[2], Dipayan Chattopadhyay[1], Sangeeta Das[1], and M. Saha Sarkar[1]*
[1]*Saha Institute of Nuclear Physics, HBNI, Kolkata - 700 064, INDIA and*
[1]*Lady Brabourne College, Kolkata - 700 017, INDIA*

Introduction

Neutron and gamma ray discrimination is crucial for measurements with detectors sensitive to both neutron and gamma radiation. All neutron sources usually emit gamma rays to which the detectors are sensitive. So, we need to seperate the gamma events from the neutron events. Two major techniques which are generally used to identify n/γ events, are Pulse Shape Discrimination (PSD) and Time of Flight (TOF). PSD and TOF was simultaneously performed using digital oscilloscope by our group using $LaCl_3$(Ce) and BC501 liquid scintillator with ^{252}Cf fission source [1]. We have also characterized a uni-directionally grown 1,3,5-Triphenylbenzene (3PB) single crystal using TOF technique with conventional analog electronics. The neutron energy spectrum of ^{252}Cf was reproduced nicely (see Ref. [2]). In the present work, we have used CAEN made digitizer to do PSD and TOF measurements simultaneously with Digital Pulse Processing (DPP) technique. In this measurement, the 3PB crystal which is previously characterized, has been reused to discriminate the n/γ. The main motivation of the recent work is to validate the capability of the digitizer with our experimental set up for n/γ discrimination.

Experimental details

Two scintillation detectors are used in our experimental set up - $LaCl_3$(Ce) and 3PB. The $LaCl_3$(Ce) detector is fixed at 90^o and the 3PB detector is at 0^o w.r.t. the position of the ^{252}Cf fission source. For the data acquisition, a CAEN DT5730 digitizer has been used. Its sampling rate is 500 MS/s with 14 bits ADC. The digitizer is operated both in PHA (Pulse Height Analyzer) and PSD (Pulse Shape Discrimination) modes [3]. Here, the data is acquired in DPP-PSD mode. PSD is done between n/γ by looking at the shape of the corresponding pulses. PSD is defined as the ratio of the difference of long gate charge integration value (Q_L) and short gate charge integration value (Q_S) divided by Q_L. The

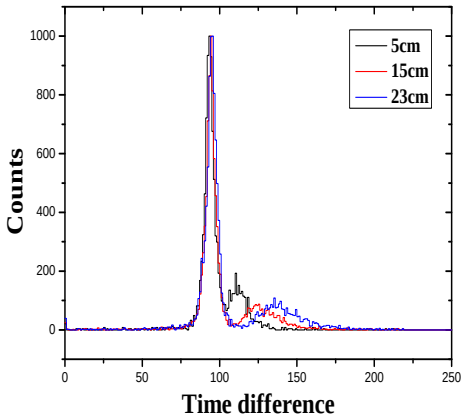

FIG. 1: The TOF spectrum with ^{252}Cf source with 3PB detector at distances 5 cm (black color), 15 cm (red color) and 23 cm (blue color) respectively from the source position. Here, we do not use any energy gate. The prompt gamma and delayed neutron bunches are seperated nicely with the digitizer set up. As the distance of the stop detector increases, the neutron bunch is seperated more clearly in TOF spectrum.

*Electronic address: maitrayee.sahasarkar@saha.ac.in

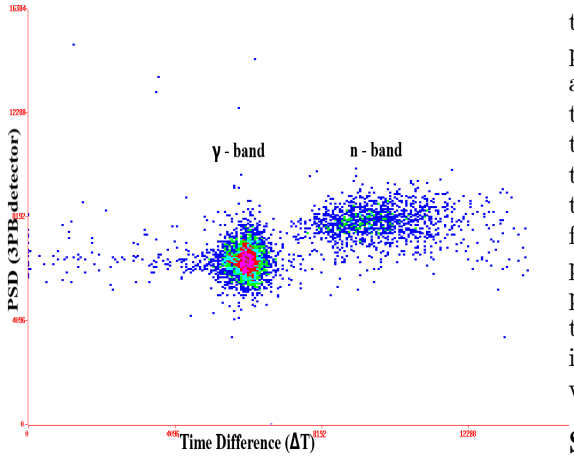

FIG. 2: The 2D spectrum with ^{252}Cf source with time difference (ΔT) as X - axis and PSD of 3PB detector as Y- axis. As our source is not very strong, the intensity of the neutron band at 30 cm is not very high. But, the seperation of n/γ through PSD is quite well.

short gate has been kept at 80 ns and long gate at 600 ns. To determine the time resolution of the TOF set up with digitizer, ^{60}Co source has been used. The observed time resolution is 1.79 $\pm$ 0.03 ns without any gate at energy spectrum. The $LaCl_3$(Ce) detector is used as a start detector. The arriving time of the stop pulse at 3PB detector is compared with the reference beginning time of the start detector. In this way, the neutron and gamma branches are seperated in the timing spectrum depending on their in-flight time.

Analysis and Results

The data is taken in list mode with 40 ns correlation window. The list mode data files are saved in .csv format. For the data analysis, the offline analysis software LAMPS has been used [4]. The time difference histogram is plotted in FIG. 1. For TOF measurement, the data has been taken at several distances. Here, we have shown the TOf spectra at three distances at 5 cm, 15 cm and 23 cm respectively. From FIG. 1, it is clear that the prompt gamma and delayed neutron bunches are nicely seperated in TOF technique and the seperation is more prominent at large distance compared to smaller distance. To identify the n/γ pulses, PSD values of 3PB detector is plotted along Y - axis and time difference along X - axis. As the tail part of the pulse is longer in case of neutrons compared to photons, the PSD value for neutron is greater than the photons. The 2D spectrum is shown in FIG. 2. The neutron and gamma are also well seperated through PSD method.

Summary and Future Plan

In this work, the n/γ are distinguished and seperated using PSD and TOF measurements simultaneously using DT5730 digitizer. The experimental set up with $LaCl_3$(Ce) and 3PB detector is also justified with such nice experimental results. In future experiments, we can easily use this set up to seperate the n/γ events.

Acknowlegdement

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