FPGA-based real-time n/γ Discrimination for a CLYC Scintillation Detector

Yuliang Huang[1,2], Changqing Feng*[1,2], Keqing Zhao[1,2] Yichao Wang[1,2], Shubin Liu[1,2]
[1]State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei 230026, China,
[2]Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China

Introduction

Cs2LiYCl6:Ce3+ (CLYC) scintillation detector is a promising detector for neutron/gamma mixed filed detection. As a replacement of traditional 3He gas detectors, CLYC is cheaper, easier to use, which makes it more conducive to engineering applications.In this work, we implement a n/γ discrimination algorithm in a low power flash FPGA for CLYC scintillation detector. In order to make the whole algorithm more suitable for the real-time radiation detection applications, pile-up rejection and noise discrimination are also concerned in FPGA program.

Pluse shape discrimination (PSD) methods

The FPGA algorithm is designed based on the PSD. In this work, we compare two PSD methods. Charge comparison (CC) method is commonly used in neutron/gamma PSD. The PSD parameter of CC is the ratio of long integral to short integral. As shown in FIG.1 (a), The integral of T1 and T2 is long integral and the integral of T1 is short integral.Charge-to-peak ratio (CPR) method only has one integral time window. The integral of Tw is partial integral is defined in FIG.1 (b). The PSD parameter of CPR is the ratio of partial integral to peak.

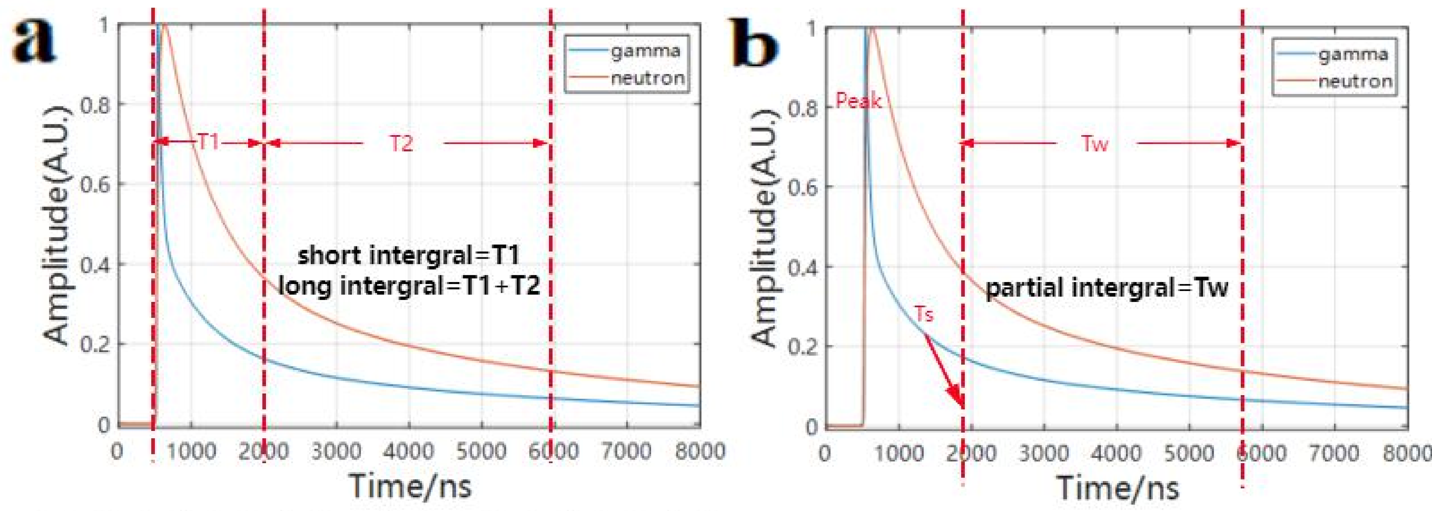

Fig. 1. (a)Integral time window T1 and T2
(b)Integral start point Ts and Integral time window Tw

FPGA implementation

The FPGA diagram is shown in FIG.2. The pulse data from ADC are divided into two channels. One channel uses a differential high-pass filter for trigger and pile-up rejection. Another channel uses a low-pass filter to increase the signal- to-noise ratio. After trigger, Some relevant parameters are calculated or recorded. Finally, the real-time accumulated energy spectrum or sampled waveform is sent to the PC.

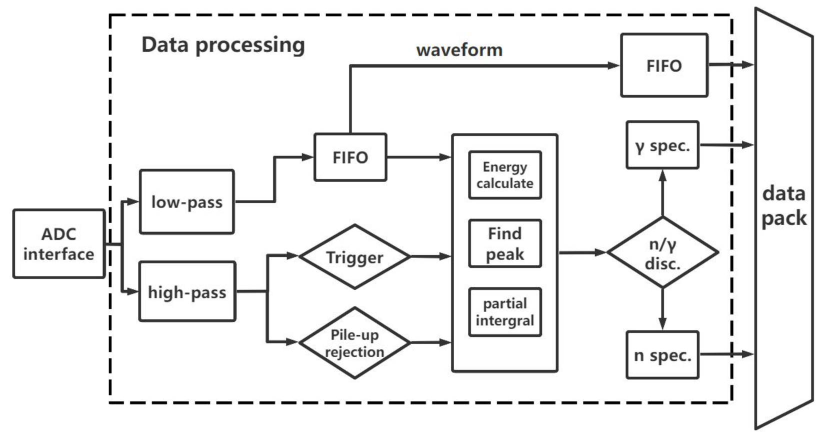

Fig. 2. FPGA logic design diagram

Fig. 3. Date process unity (pcb)

Test results

The whole experiment setup is shown in FIG.4.The detector includes a cylindrical CLYC crystal with 1 inch in diameter and 1 inch in height，which coupled with an R6231-100 PMT and a readout base.

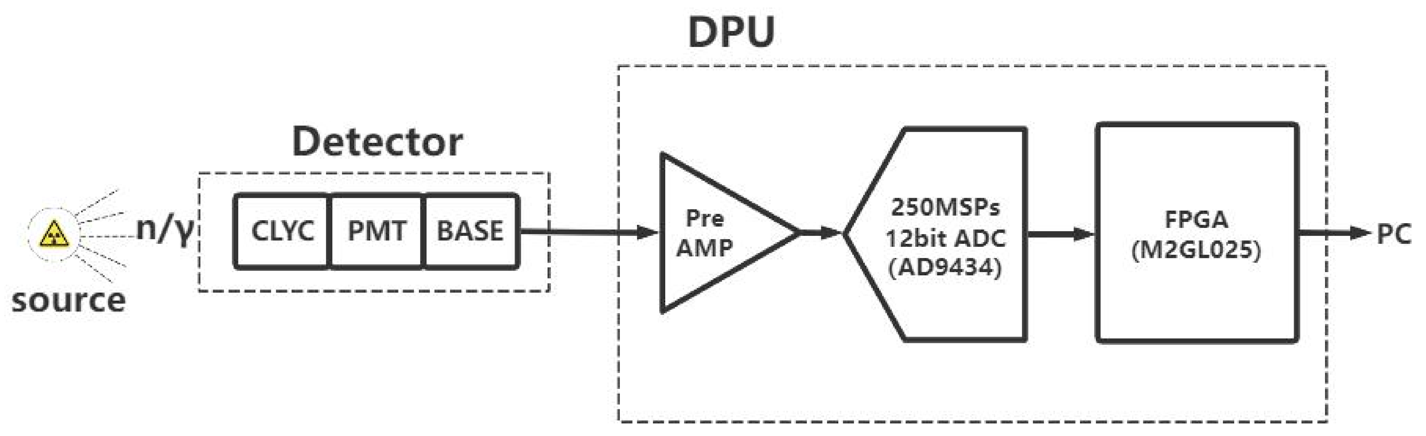

Fig. 4. Block diagram of the experiment platform

For real-time data processing test, the spectrum of ^{137}Cs at different dose rates are shown in FIG.5(a). The energy resolution can reach 4.86%@662keV while thedose rate is 5.09uSv/h. And the PSD result of Am-Be source is shown in FIG.5(b)(c)(d). The best FOM can reach 3.31 for AmBe source

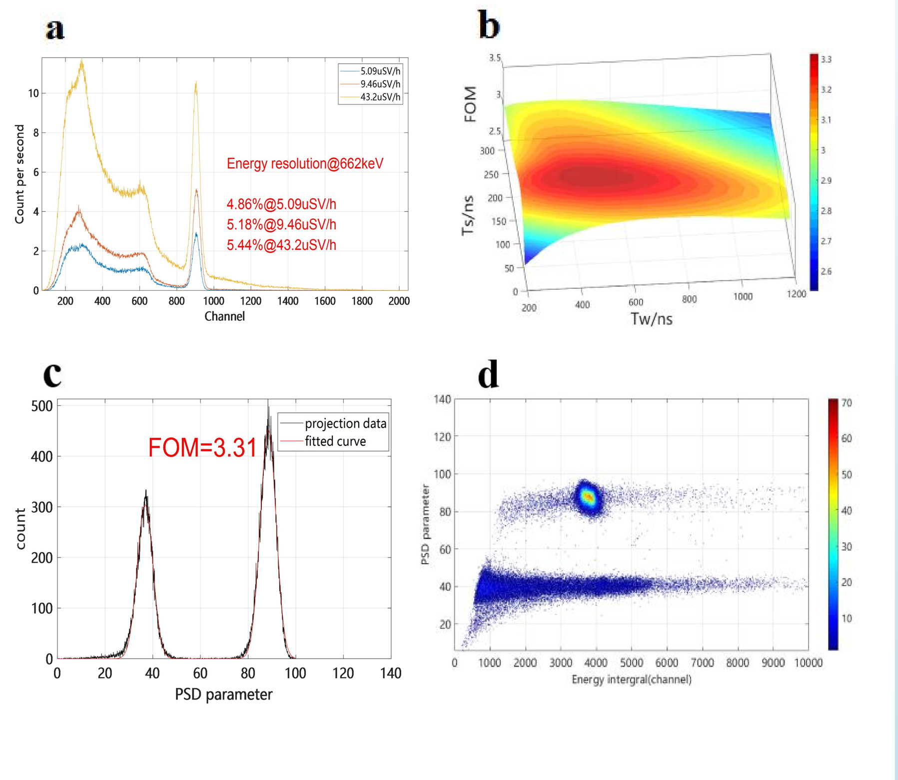

Fig. 5.(a) Energy spectrum of 137Cs
(b) FOM of CPR under different Ts and Tw
(c) PSD spectrum with FOM
(d) plot of CPR's PSD versus energy integral

Conclusion

In this work, we discuss a neutron/gamma ray discrimination algorithm, then implement it on FPGA in real time. By considering the characteristics of neutron/gamma pulse signal and combining the advantages of PCR method to obtain a better FOM than CC method. At the same time, we also deal with the pile-up in the case of high events rate.

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Corresponding author: fengcq@ustc.edu.cn

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