

Pulse Shape Discrimination of Intrinsic Gamma and Alpha Rays in LaBr₃:Ce Scintillation Detector

Mingi Eom ^{a,b}, Jaegi Lee ^{a*}, Young Rang Uhm ^a, Bo-Young Han ^a, Gwang-Min Sun ^a, Sung-Joon Ye ^b
^a HANARO Utilization Division, Korea Atomic Energy Research Institute, Daejeon, 34057, Republic of Korea
^b Program in Biomedical Radiation Sciences, Department of Transdisciplinary Studies, Graduate School of Convergence Science and Technology, Seoul National University, Suwon, 16229, Republic of Korea
^{*} Corresponding author: jgl@kaeri.re.kr

1. Introduction

The LaBr₃:Ce scintillation detector has high resolution for γ -rays (3% at 662 keV) that is lower than half of the resolution of NaI(Tl) scintillation detector [1]. In addition, due to its high γ -ray detection efficiency, it's useful for the monitoring low-intensity γ -rays like environmental monitoring. However, the ²²⁷Ac impurities emit high-energy α particles with 1.8–2.6 MeV from their decay making it challenging to differentiate high-energy γ peaks in the spectrum. Using the difference of the pulse shapes of γ and α , the pulse shape discrimination (PSD) can be applied to γ and α discrimination. The conventional PSD method, charge comparison method (CCM) was used in this study.

2. Materials and Methods

2.1 Experimental Setup

The LaBr₃:Ce scintillation detector (Saint Gobain, France) was set up with lead shielding to measure the only intrinsic background radiations, as shown in **Fig. 1**. The photomultiplier (PMT) (Ortec 276, USA) was connected to the 2"×2" LaBr₃:Ce scintillation detector. We applied +700 V to the LaBr₃:Ce scintillation detector using the high voltage power supply (Ortec 556, USA).

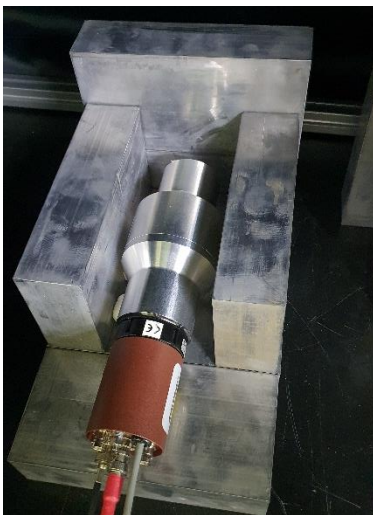


Fig. 1. LaBr₃:Ce scintillation detector shielded by lead shielding

The Flash ADC (FADC) (Notice Korea, FADC5G-8, Republic of Korea) with 5 Gsps was used for digitizing the analog signals from the PMT. We obtained 100,000

samples, including γ of 1436 keV and major α peaks as shown in **Fig. 2**.

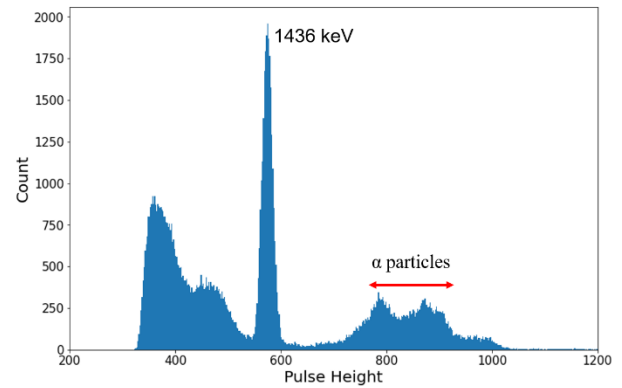


Fig. 2. The pulse height spectrum shows the γ peak (1436 keV) and α peaks above 1.8 MeV.

2.2 PSD method

The Charge Comparison Method (CCM) is a conventional PSD method based on the different pulse shapes of γ and α [2]. Unlike the pulse shapes of neutron and γ , there's little difference between the pulse shapes of α and γ as shown in **Fig. 3** [3]. The CCM for α and γ is calculated by the equation (1).

$$CCM = \frac{Q_p}{Q_t} = \frac{\int_{t_1}^{t_2} T(t)dt}{\int_{t_{min}}^{t_{max}} T(t)dt} \quad (1)$$

For the pulse ($T(t)$) over time t , Q_p is the integral of the pulse over the period $t_1 - t_2$, which is the time region where the remarkable difference between two pulses occurs (in this study 100 – 250 channel). The Q_t is the integral of the pulse over the whole period.

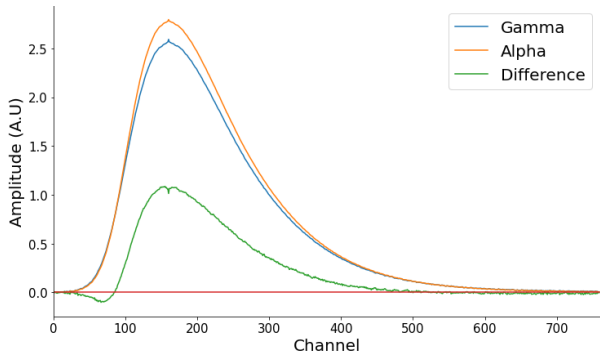


Fig. 3. The pulse shapes of γ and α peaks. The green line shows the difference ($\alpha - \gamma$) and (t_1, t_2) was set where the difference is positive.

3. Results and Discussion

The calculated CCM values of each pulse height channel are plotted in **Fig. 4**. The points of α particles are plotted on higher CCM than γ -rays at the whole region. Not only low-energy γ -rays but low-activity and high-energy γ -rays are observed with low density inside the red box with lower CCM than α particles. However, there's no clear separation of the CCM region between γ and α rays. The noise of the pulse signals made the area of each particle fluctuate. Hence, the process for noise reduction is necessary, and optimized calculation of the CCM should be studied. For example, the set of t_1 and t_2 is optimized to maximize the difference of pulse shapes between γ and α . In addition, higher counts of high-energy γ -rays are required to confirm the apparent trend of CCM value for the whole γ -rays.

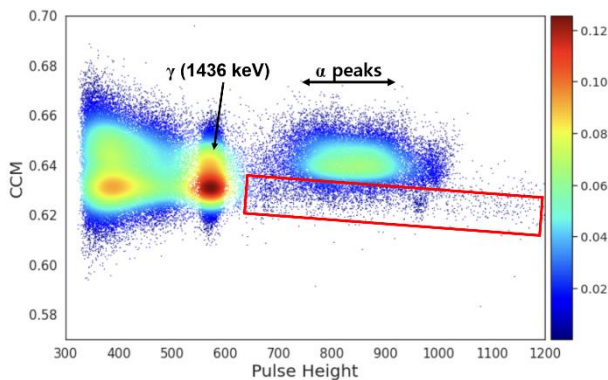


Fig. 4. Charge Comparison Method (CCM) values of each pulse height channel

4. Conclusions

We measured the intrinsic background radiations of the $\text{LaBr}_3:\text{Ce}$ scintillation detector with the lead shielding. The high-energy α peaks were observed, and they were required to be removed to measure the low-activity γ -rays. The conventional PSD method, CCM, was calculated with simple signal processing, and the result showed the possibility of the discrimination of γ

and α particles. More detailed methodologies for both measurement and calculation algorithms will be carried out for further study.

REFERENCES

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