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Study of Performance Parameters for a SiPM-Based Digital Positron Annihilation Lifetime Spectrometer

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Positron annihilation spectroscopy (PAS) is an outstanding technique to study defects in material science such as polymer, semiconductor and irradiated material. Positron annihilation lifetime spectroscopy (PALS) which measures the lifetime of positrons specialized in analyzing defects of materials among various PAS technique. [1]. DRS4 evaluation board are widely used for PALS system and Silicon Photomultiplier (SiPM) has many advantages compared with PMT. Our goal is development cheap SiPM-DRS4 based PALS and investigate the performance of system according to various parameters.

3.07 x 3.07 mm² size of two SiPMs which mounted on evaluation board are used for PAL spectrometer (MicroFJ-SMA -30035, SensL, Ireland). They have fast signal output which improve coincidence timing resolution (CTR) of detector. The DRS4 evaluation board (PSI, Switzerland) has high bandwidth (700MHz) and high sampling rate (5.12Gs/S). LYSO scintillators (Epic crystal, China) is coupled with optical grease (EJ-550, Eljen Technology) to SiPM in sizes of 3 x 3 x 20 mm³, 3 x 3 x 15 mm³ and 3 x 3 x 10 mm³.

CRT measurement was performed using two radiation sources (²²Na, ⁶⁰Co) that emit a pair of 511 keV and 1173, 1332 gamma rays simultaneously. Each of sources were used to optimize the CTR of start and stop signal detector. Off-line digital constant fraction discrimination (dCFD), one of the time pick off method which eliminate time walk occurred from pulse height difference, was used to determine the arrival time of gamma ray [2]. To recover the discrete signal from DRS4 board, we conduct various interpolation methods (Linear, Spline, Polynomial, Gaussian) to find the best algorithm for our system. We found the best fraction value for each detector and the optimal applied voltage to SiPM from 30V to 33V with 0.5V steps. In addition, we investigate the trade-off relationship between energy window and CTR.

After optimizing the parameters, we measure PAL spectrum and analyse it by PALSFit program and investigate the material analyse ability.

Primary authors: Mr CHOI, Hyunwoong (Korea Advanced Institute of Science and Technology); Mr KO, Kilyoung (Korea Advanced Institute of Science and Technology); Prof. YI, Yongsun (Kalifa University); Mr KIM, Wonku (Korea Advanced Institute of Science and Technology)

Co-author: Prof. CHO, Gyuseong (Korea Advanced Institute of Science and Technology)

Presenter: Mr CHOI, Hyunwoong (Korea Advanced Institute of Science and Technology)

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