

Development of Scintillator Readout System with MPPC for Potable Compact Gamma-ray Spectrometer

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After the Fukushima Daiichi nuclear accident, the public necessity increases to measure and identify the radioactive isotopes from the environment. Although Ge detectors are powerful with the high energy resolution, it is too expensive (and heavy) to be used widely. Therefore, we developed an inexpensive portable compact gamma-ray spectrometer with the combination of CsI(Tl) scintillator and Multi-Pixel Photon Counter (MPPC) detector, a silicon photomultiplier developed by Hamamatsu Photonics. In this paper, we present (1) how we chose the sizes of CsI(Tl) and MPPC, (2) the development of the feedback circuit to keep the MPPC gain stable against the temperature variation, and the calibration of the spectrometer at Facility of Radiation Standards of Japan Atomic Energy Agency, and (3) some example of actual environment measurements.

Among many photon readout detectors, MPPC, photo-multiplier, photo-diode, avalanche photo-diode, we chose the 6 x 6 mm² MPPC according to the high quantum efficiency, small detector size, light weight, and low operational high voltage. CsI(Tl) scintillator was selected from the relatively high stopping power with the low price. The size of CsI(Tl) crystal was determined as large as 1-inch cubic to identify ¹³⁷Cs and ¹³⁴Cs lines (662 keV and 605 keV) separately with keeping the energy resolution better than 8% at 662 keV (FWHM). There is small deviation (~7%) from the linear correlation between the gamma-ray energy and output pulse height above ~1 MeV. It is reasonable due to the pileup effect of some photons into one pixel, since the number of CsI(Tl) scintillation photons is 56000/MeV with the decay time constant of ~1 us.

The temperature dependence of MPPC gain was measured for 10 units of 1-inch cubic CsI(Tl) and MPPC. The results show that there is almost no difference about the slope of the relation, while the offset changes for unit by unit. The spectrometer includes the feedback circuit of the high voltage with temperature monitor.

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