Measurements of light-output ratios using inorganic and organic scintillators to identify gamma-ray emitting radionuclides

Seunghyeon Kim, Siwon Song, Taeseob Lim, Jae Hyung Park, Jinhong Kim, Jin Ho Kim, and Bongsoo Lee

Department of energy systems engineering
Chung-Ang University

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1. Introduction

- Scintillator is widely used for radionuclide identification.

- Plastic optical fiber coupled sensor has more advantages such as long-distance measurement, flexibility.

- Radionuclide identification requires sufficient size of scintillator to obtain better energy resolution and peak-to-total ratio.

- Plastic optical fiber coupled sensor has the poor energy resolution due to modal dispersion.

- Plastic optical fiber coupled small size scintillator sensor is unsuitable for conventional radionuclide identification method.

- In this study, two gamma radionuclides are identified with light-output ratio of two different scintillators.

2-1. Method

- Measured light-output of scintillator is affected by energy and intensity of incident gamma-ray, characteristics of scintillator.

- Even if the intensity and energy of incident gamma-ray are same, the amount of energy deposited will differ due to the differences in characteristics of scintillator

- The light-output ratio is different depending on the composition of the scintillator and the energy of the incident gamma-ray.

- With the light-output ratio of two scintillators, the energy of incident gamma-ray can be specified.
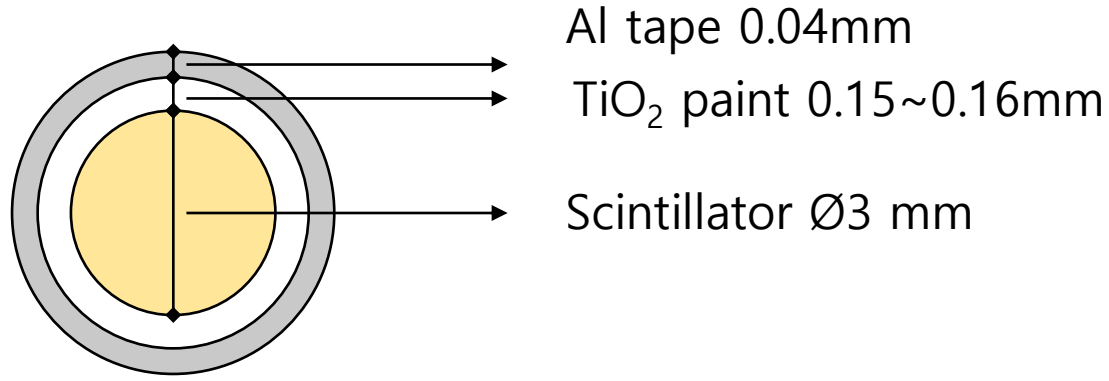
- Physical Characteristics of GAGG:Ce, YSO, BCF-12 and BCF-20

Scintillator	GAGG:Ce	YSO	BCF-12	BCF-20
Density [g/cm^3]	6.6	4.5	1.05	1.05
Peak emission wavelength [nm]	530	420	435	492
Light yield [photons/MeV]	42000	11000	~ 8000	~ 8000
Hygroscopicity	No	No	No	No

- Specific properties of H11890-210

Spectral response range [nm]	230 to 700
Peak sensitivity wavelength [nm]	400
Effective area [mm]	Ø 8
Dark count [s^{-1}]	50

Al tape 0.04mm

TiO$_2$ paint 0.15~0.16mm

Scintillator Ø3 mm

- The selected scintillators were unified to cylindrical shape with diameter of 3 mm and height of 15 mm.

- In order to maximize the light collection efficiency and to minimize the external noise, TiO$_2$ paint was applied to the scintillator surface.

- The brass holder with density of 8.73 g/cm^3 was used as shielding material to eliminate the interference with each scintillator

2-2. Materials and Experimental setup
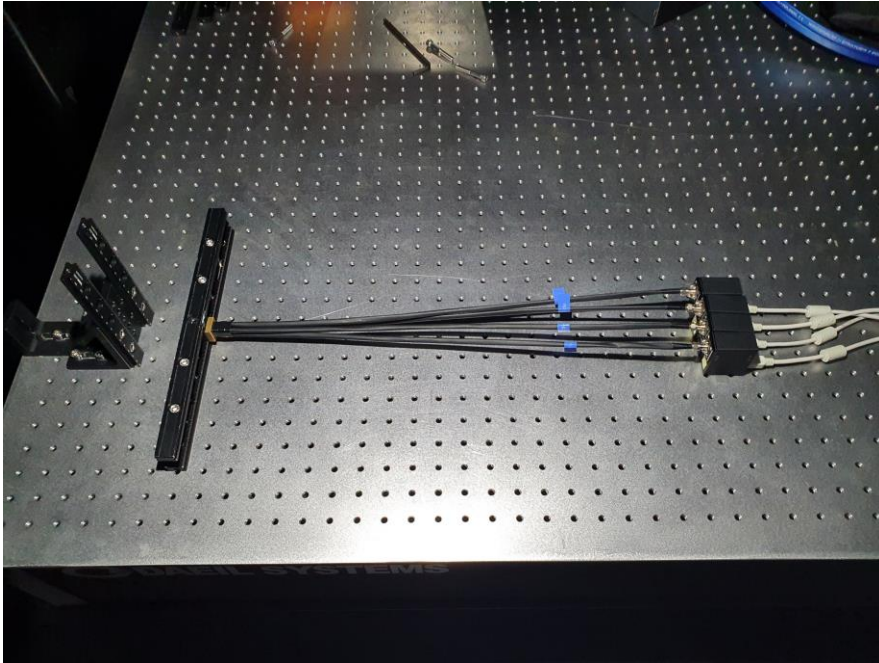
- A 0.5 m-long plastic optical fiber with a diameter of 2 mm was attached to the bottom part of each scintillator.

- Four photon counting modules were used as a light measuring detector.

- The light-outputs emitted from each scintillator were measured simultaneously with four photon counting modules by 5 seconds interval.

- The ^{137}Cs and ^{60}Co check sources were used.

- The gamma-ray intensity was adjusted by the distance between check source and the sensor.

- The background of scintillator and dark count of photon counting module were measured before each experiment and subtracted as noise.

2-3. Results

- The light-output ratio of ^{137}Cs and ^{60}Co

Distance [mm]	GAGG:Ce/ BCF-12	GAGG:Ce/ BCF-20	YSO/ BCF-12	YSO/ BCF-20
12	26.722	32.291	13.934	16.837
37	24.492	30.327	12.955	16.04
62	24.746	30.682	13.084	16.217

Light output ratio of ^{137}Cs

Distance [mm]	GAGG:Ce/ BCF-12	GAGG:Ce/ BCF-20	YSO/ BCF-12	YSO/ BCF-20
12	14.74	17.913	6.844	8.32
37	13.997	17.966	6.935	8.902
62	14.112	17.857	7.077	8.955

Light output ratio of ^{60}Co

3. Conclusions

- The light-output ratio is not affected by incident gamma-ray intensity, but only by incident gamma-ray energy.

- Among six combinations of scintillator, the combinations of the inorganic scintillator and the organic scintillator are effective for radionuclide identification.

- The combined sensor has relatively low relative standard deviation than four independent scintillator sensors, in same experimental condition.

- With light output ratio of the inorganic scintillator and the organic scintillator, two gamma radionuclides can be identified.

Thank you