Scintillator Array Sensor for Position Measurements of Radioactive Sources

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Introduction

nuclear utilization in various industries → radioactive waste generation increases → **radioactive waste management getting more important**

nuclide identification, radioactivity measurement, etc.

finding hot spots is important because most of the radioactive sources are concentrated in theses points

general gamma detector in nondestructive assay, **HPGe**
- hard to use in various environments because of disadvantages such as high cost, large volume and cooling requirement

∴ an inexpensive and easy-to-handle detector system for nondestructive assay is needed

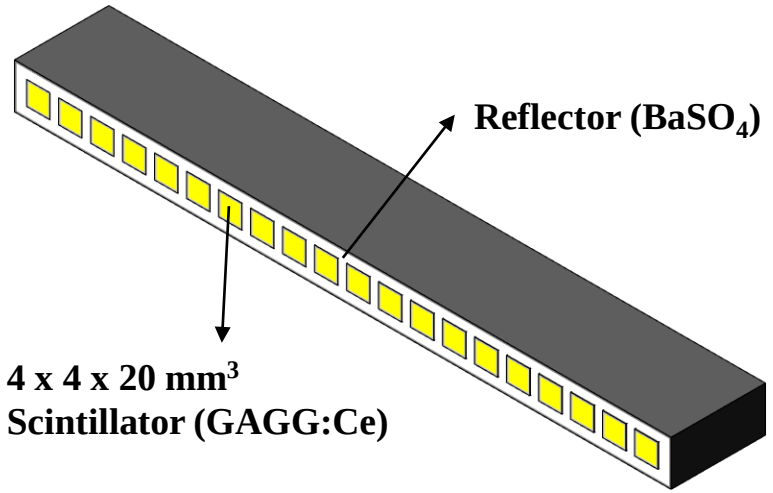
“scintillation detector system”

Materials and Methods

GAGG:Ce	
Density (g/cm^3)	6.63
Light Yield (photon/MeV)	46,000
Decay Time (ns)	88
Peak Wavelength (nm)	520
Energy Resolution	4.9% @ 662 keV
Hygroscopicity	No
Self-Radiation	No

- high density
- high light yield
- short decay time
- absence of hygroscopicity and intrinsic radioactivity

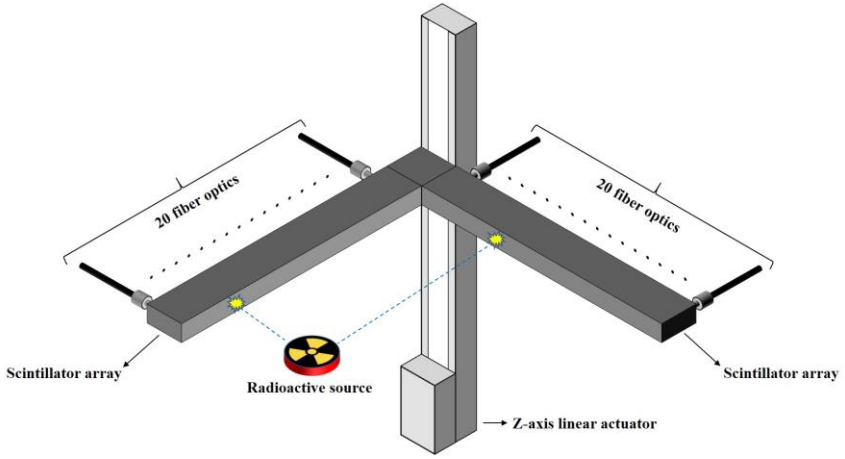
→ expected to generate sufficient light with small dimension and be stable with low noise in various environment



GAGG:Ce scintillator array sensor

- 4 x 4 x 20 mm^3 GAGG:Ce crystals, 20 pieces
- covered with $BaSO_4$ reflector to optimize light collection
- each crystal is directly connected with plastic optical fiber to transmit scintillation light to the detector (Φ 1 mm)

Materials and Methods



Experimental setup

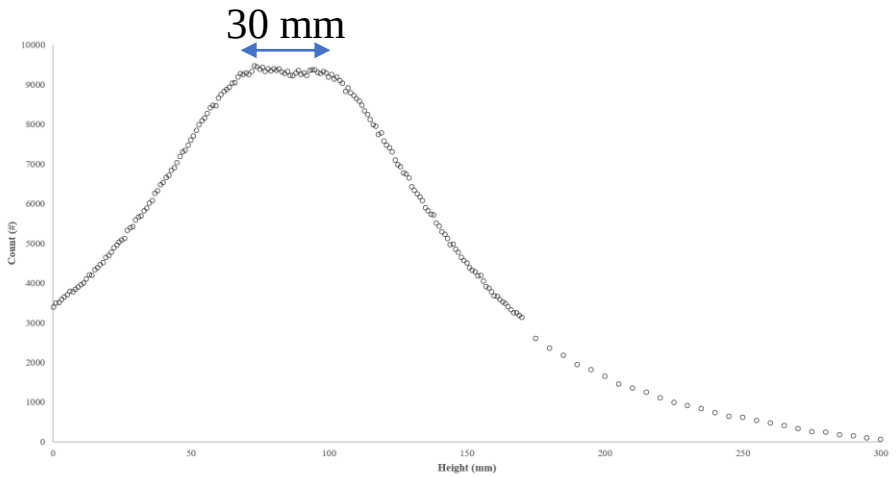
- two scintillator array sensors are combined as an L-shape and affixed to the driving part of an electric linear actuator
- the length of the array sensor is 100 mm and the length of the actuator driving part is 300 mm, so the dimension of measurement region is 100 x 100 x 300 mm^3

- the experiment was conducted by moving the sensors
- the radioactive source was fixed at random position in the measurement region

1. measure the height distribution according to Z-direction of the source
   : used the channel which was on the same line with the source, moved in a 1 mm step, from 0 to 300 mm
2. measure the 2-dimensional (XY plane) source distribution
   : used 40 channels, placed at the same plane with the source

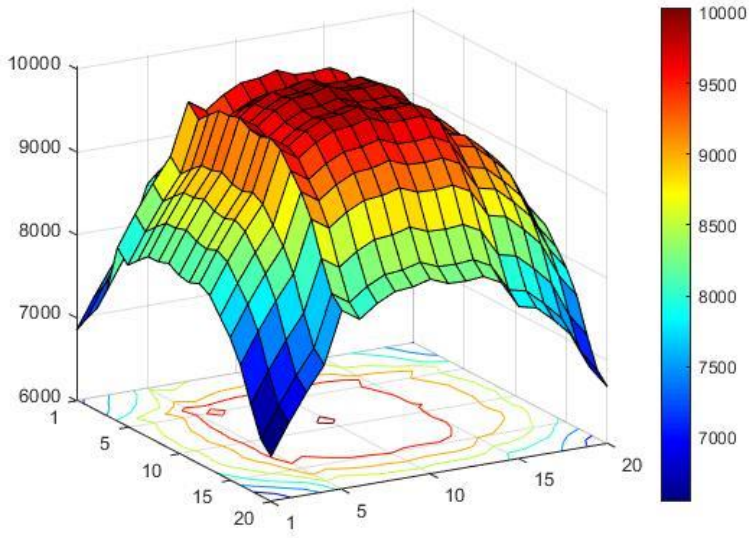
- light measuring device : compact photon counting head (H11890-210, Hamamatsu)
- radioactive source : ^{60}Co with 43.21 μCi

Results and Discussion



the single channel light output variation according to the Z-direction of the source

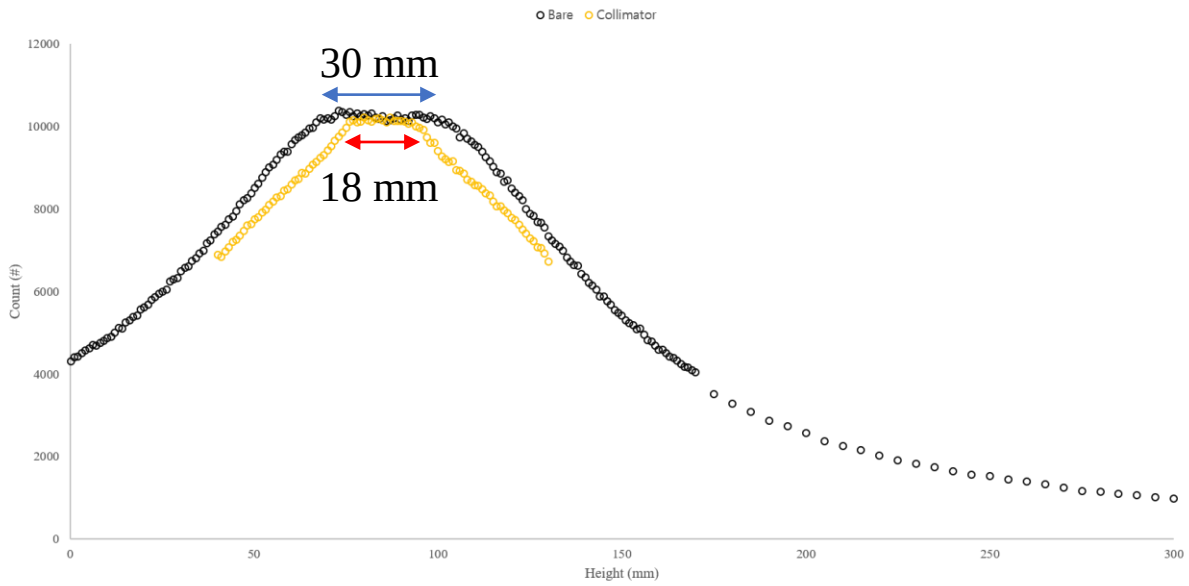
- the length of the plateau is about 30 mm, which means the source is located between 70 and 100 mm
- diameter of the source disc 25.4 mm, the hot spot position could be estimated between 82.7 and 87.3 mm
- very symmetrical and exponential trend, reasonable to say that the hot spot is in the middle of the plateau (85 mm)



the light output distribution over the measurement area

- the dark red area in the middle of the contour plot is the highest count area, where the source is estimated to be located
- considering each channel as a 2-D coordinate, the source position could be expressed with a channel number as (10, 10)

Results and Discussion



- to narrow the plateau length, 2 mm thick lead plates with Φ 2 mm pinhole was used
- the plateau length decreased from 30 mm to 18 mm
- although the theoretical calculation was only 13% decrease at ^{60}Co energy range, it shows that even the simple lead collimator can improve the spatial resolution

Conclusion

In this paper, we fabricated the scintillator array sensor and conducted the position measuring experiment of the radioactive source. GAGG:Ce was selected as inorganic scintillator because of its fine properties.

With 43.21 μCi ^{60}Co source, the symmetrical and exponential plot was acquired in the Z-direction single channel measurements. In the 2-D measurements, the source position was acquired as channel number coordinate. Also, the spatial resolution improvement was shown when the lead collimator was used.

Acknowledgements

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Thank you.