Simulation of ^{85}Kr Detector using Monte Carlo code MCNP in Air

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1. Introduction

The radioactive noble gas ^{85}Kr (beta emitter, Emax: 687 keV, half-life: 10.76 years) distribution in the atmosphere can be used as an indicator of nuclear weapons [1]. When measuring ^{85}Kr, nuclear activity can be detected. Recently, we need surveillance technology to detect North Korea`s nuclear test. Currently, the ^{85}Kr capture method is gas chromatography. The gas chromatography system is shown in Fig. 1. and A well-used method is to capture ^{85}Kr in the air and measure it with a gas proportional counter. The gas proportional counter is used while charging the noble gas shows an efficiency of 80 %. In some cases, manpower and cost may be wasted due to the continuous charging of the noble gas. Therefore, in this study, to use it efficiently, we studied to use a scintillator detector instead of a gas proportional counter. When the electron beam is incident on the detector, it is generated as light and acts on the PMT. Beta energy has a short range, so it should be composed of plastic scintillators of appropriate size and low density. The plastic scintillator with a diameter of 5.08 cm and a thickness of 0.5 cm was simulated with Monte Carlo code MCNP to show the tendency for the collected amount depending on the distance. This paper is the basis for developing instruments.

Fig. 1. Gas Chromatography System.

Fig. 2. Existing Gas Proportional Counter.

2. Methods

Monte Carlo code MCNP 6.2.1 was used. Geometry was constructed with a plastic scintillator with a diameter of 5.08 cm, a thickness of 0.5 cm, and a density of 1.04 g/cm^3. The length between two facing plastic scintillators increased by 0.5, 1, 1.5, 2, 2.5 and 3 cm, and the volume was increased. The MCNP code uses the coincidence input. It is expected that much noise will be generated in the low energy area. So the energy cut-off less than 50 keV. The efficiency of the detector was determined using the emission probability between 50 keV and 700 keV. The detector is constructed as show in Fig. 3.

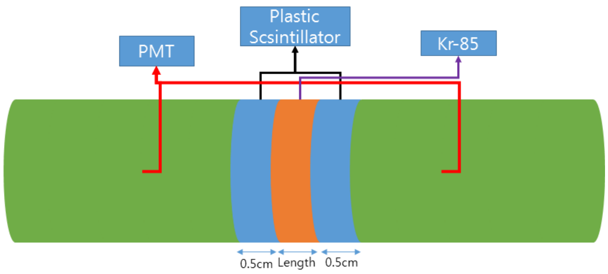

Fig. 3. Detector Configuration.

3. Results

Assuming that the ^{85}Kr collection amount is 100%, The spectrum of each thickness are shown in Fig. 4. The efficiency was determined as the emission probability between 50 keV and 700 keV. The efficiency of the instrument is shown in Table. 1. When the length is

0.5 cm, the efficiency is the best at 26.1 % and the volume at this time is 11.53024 cm^3. It can be seen that the efficiency becomes maximum then the amount is the smallest, and the efficiency decreases as the volume increases. Because of the nature of the beta-emitting nuclides, it is important to know how close to the detector, as the volume increases and the efficiency is not so good. The reason for this is that ^{85}Kr is a beta-emitting nuclide. It is short range.

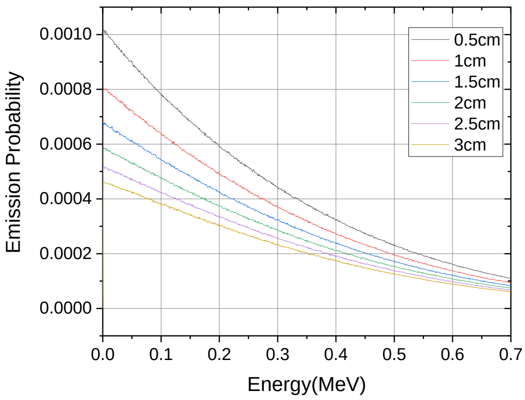

Fig. 4. Coincidence mode Spectrum of each volume using MCNP.

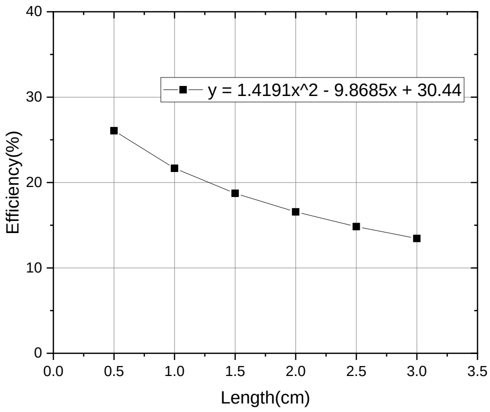

Fig. 5. Coincidence mode Graph of efficiency for each volume using MCNP.

Table. 1. Coincidence mode Efficiency results for each distance.

Length(cm)	Volume(cm^3)	50keV~700keV	Efficiency(%)
0.5	11.53024	2.61E-01	2.61E+01
1	23.06047	2.17E-01	2.17E+01
1.5	34.59071	1.87E-01	1.87E+01
2	46.12095	1.66E-01	1.66E+01
2.5	57.65119	1.48E-01	1.48E+01
3	69.18142	1.34E-01	1.34E+01

4. Conclusions

This paper is based on MCNP simulation, so there is no definite evidence. We use MCNP to calculate the efficiency of the instrument when we assume that ^{85}Kr is 100 % collected. The best efficiency is obtained at 0.5 cm thickness, but volume is 22 cm^3 when using PE vial to collect existing ^{85}Kr. Although the volume dose not increase significantly, the ideal volume is assumed to be 1 cm, and it is believed that more than 22m^3 can be as efficient as a proportional counter. And it is expected that efficiency will be lower than Monte Carlo code MCNP if we do accurate experiment. However, since the tendency is somewhat visible, future research will measure the collected ^{85}Kr directly by making instrument.

REFERENCES

[1] M. Aoyama, K. Fujii, K. Hirose, Y. Igarashi, K. Isogai, W. Nitta, H. Sartorius, C. Schlosser, W.Weiss, Establishment of a Cold Charcoal Trap-Gas Chromatography-Gas Counting System for ^{85}Kr Measurements in Japan and Results from 1995 to 2006, Technical Reports of the Meteorological Research Institute No. 54, Meteorological Research Institue, Japan, 2008.