Design of a hemisphercial detector for large area radiation monitoring: Monte Carlo study

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Radiation monitoring system is necessary in various industrial fields for public and personnel radiation safety. A number of monitoring systems have been developed to detect radioactive materials, however, there were limitations in identifying and localizing nuclear material over a large area in a short time. In this study, we propose a large-area monitoring system for tracking nuclear materials.

The proposed monitoring system consists of 18 detector modules in a curved row with angular pitch of 10 degrees, and a single row repeats 18 times to cover 2π field of view. A detector module is composed of an 8 mm thick trapezoidal diverging-collimator, and GAGG cylindrical scintillator with diameter/thickness of 2.54 cm coupled to a photomultiplier tube. Each detector module monitors non-overlapped independent spot in the field of view.

To evaluate the system performance, a monitoring area of $2500 \times 2500 \times 400 \; cm^3$ was modeled using GATE simulation toolkit. The proposed system was placed on the center of the ceiling and Cs-137 (662 keV, 100 GBq) sources were placed in different locations on the floor. By analyzing the total count distribution of each detector module, the location of the radioactive fixed or moving source was identified with a 10-degree angular resolution. The results demonstrate the potential use of proposed monitoring system in public or radiation facilities.
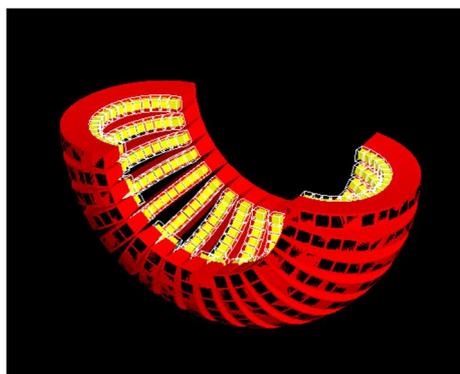

Fig. 1. Simulated geometry of 2π monitroing system consisting of 18×18 detector modules
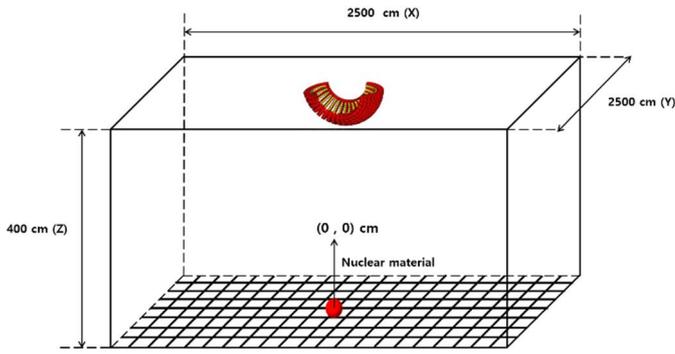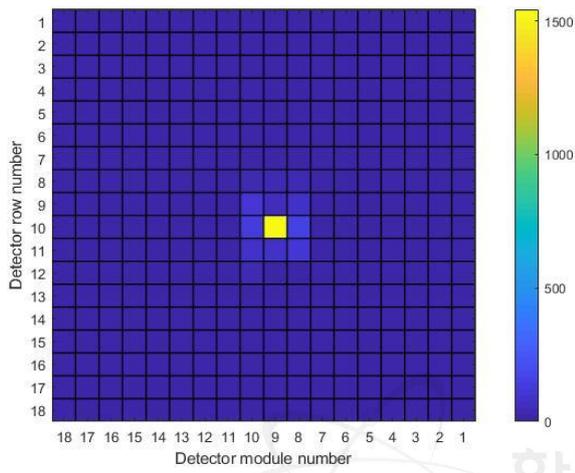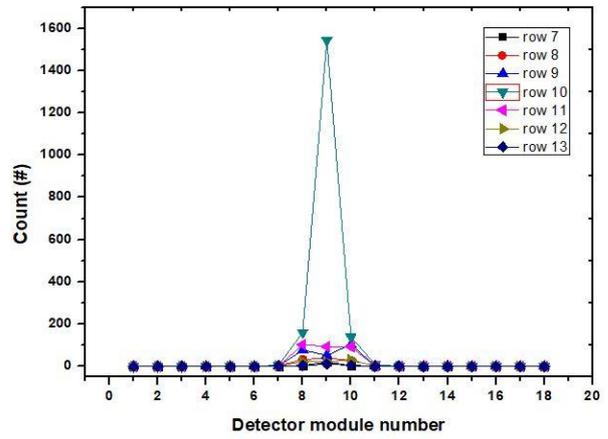
Fig. 2. An example of simulation setup.

(A)   (B)

Fig. 3. Simulation results. (A) 2D image of the source at the center (B) Image profile of the source at the center.