§3. The Proposal for Gamma-ray CCD Camera

Yamanishi, H., Yamaguchi, S., Obayashi, H.,
Sakuma, Y., Uda, T., Hirabayashi, H.,
Miyake, H.
Ueki, K. (Ship Research Institute)
Teramachi, Y. (Univ. Indust. Tech.)
Masutoh, N. (Toyohashi Univ. Tech.)
Satoh, T. (School of Science, Nagoya Univ.)
Mori, C. (School of Engineering, Nagoya Univ.)
Makino, S. (Toshiba)

We have been developing a radiation detector system which can obtain gamma-ray imaging data of far-off radiation source in nuclear facilities, for example deposited radionuclide on wall surface or induced radioactivity of instrument. The system can identify distribution and intensity of radiation source, and it can visualize remote existing source together with visible scene.

Since gamma-rays reach a detector from every direction without collimator, it is necessary to limit a visual field by collimator for radiation detection in order to specify the object of gamma-ray imaging. For shielding gamma-rays whose energy is about 1 MeV, 10 cm thick of lead block is required.

First, we designed the system combined X-ray CCD detector and pin-hole lead collimator. However, its detection efficiency is fairly small for distant radiative source, because of its narrow solid angle. When there is a 1 Ci radiation source at 10 m distant from detector, 29 gamma-rays reach the detector per second through 1 mm^2 pin hole. This gives only poor count on detecting gamma-rays. In addition, the range of recoiled electron is too long to obtain fine image resolution on CCD.

For improving detection efficiency, lead pipe collimator is adopted instead of pin hole collimator. If the size of pin hole has 2 mm diameter, and that of pipe hole has 20 mm diameter, the solid angle of view increases 100 times. On the other hand, in order to increase the sensitivity of the detector, we use semiconductor detector, for example CdTe. It has 160-350 times sensitivity on photoelectric effect, about 50 times on compton scattering than that of Si. This means that detection efficiency for 1 MeV gamma-ray by CdTe detector corresponds to that for 30-15 keV X-rays by Si detector. Additionally, since the thickness of depression layer of CdTe is not less a few times than that of CCD for X-rays detector, it is expected that the sensitivity raises higher.

Then, we have changed the design to combination semiconductor detector, for example CdTe, and lead pipe collimator as shown in Fig.1. Visible image is obtained by visible CCD camera. Radiation image is obtained by CdTe with lead pipe collimator, which can be scanning in the scope of visible CCD image by scanning device. The obtained radiation imaging data at one point angle is narrower than that of the visible image. Therefore, the radiative image is shown as a circle on CRT monitor. This circle indicates the solid angle of detected gamma-rays. Visible image and radiation image are projected in CRT monitor at the same time. The obtained gamma-rays information of energy spectrum and count are indicated on the corner of the CRT screen.

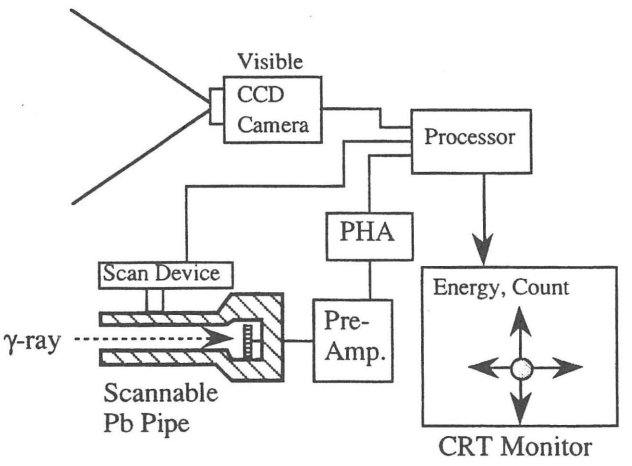

Fig. 1. System of gamma-ray CCD camera.