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Dose distribution visualization by multi-pixel photon detectors containing lead(II) iodide for the development of radiation safety management system of radioactive source

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Safety regulation of technologies like this has increasingly strengthened as national safety management systems have globally taken roots for the safe use of radiation. Significant amounts of time and resources have therefore been invested in developing a radiation safety management system to prevent radiation disasters in NDT; In particular, to perform gamma radiography safely, it is essential to determine the radioactive source location.[1,2] In the current industry field, to monitor the location of radioactive source, the research on gamma camera composed of scintillator that converts radiation to visible ray and photo-diode that converts visible ray to electrical signal has been performed variously. However, as compton recoil electron occurred by high energy radiation gets damage, photo-diode based on silicon might show single event latch-up and it would ultimately increase the possibility of electrical error.[3] Therefore, the development of a new detector which is suitable for NDT field that uses high energy radiation is necessary. In this paper, visualizes the dose distribution of radioactive source in real time, the research was performed with a purpose of developing MPPD(multi-pixel photon detectors) based on PbI2 (Lead iodide) in order to construct the safety management system of radiation that can prevent potential accidents in advance. To decide on the distance and CF (calibration factor) between pixels of MPPD, basic evaluation on the pixel detector was performed. Response characteristic and directional dependence based on the distance between radioactive source and pixel detector was each evaluated by PID (Percentage Interval Distance) and CV (coefficient of variation). Additionally, active area of pixel detector was produced with 1 x 1 cm2 and gamma ray source used Ir-192(effective energy is approximately 300keV). As a result of experiment on the response characteristic based on distance of pixel detector, PID value was shown as a curve form of exponential decay and maximum readable range was analysed to be 11.3 cm; considering this result, the distance between pixels of MPPD was decided to be 7cm. Also, as a result of experiment on directional dependence about effective angle of $8^\circ \leq \theta \leq 172^\circ$, difference of less than 1% was analysed; In order to visualize more accurate dose distribution, CF was drawn based on this. After that, in order to visualize the dose distribution, MPPD based on 7 pixel was produced and reproducibility and linearity on radioactive source were each evaluated by CV and R-sq(coefficient of determination). As a result of reproducibility experiment, the credibility of MPPD was verified as CV was analysed in less than 0.5%. Also, as a result of linearity experiment, all pixels was analysed to R-sq more than 0.99. Finally, conformity of dose distribution was verified based on the relationship between planned irradiation time and signal measure at MPPD. As a result of experiment on conformity of dose distribution, it corresponds well with the time rate which was planned by using a remote controller. Based on the research results, we verified MPPD, through visualization, based on PbI2 to confirm the dose distribution on radioactive source in real time. Also, It suggested the possibility as a safety management system of radiation that is suitable to international trend to use the NDT apparatus.

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