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（博士課程）
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論 文 要 旨

THESIS SUMMARY

専攻： Department of	Nuclear Engineering　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　(Engineering)
学生氏名： Student's Name	HALES Brian Patrick	指導教員（主）： Academic Advisor(main)	Masayuki IGASHIRA
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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

A hypothetical system for online dosimetry imaging in boron neutron capture therapy (BNCT), prompt gamma single photon emission computed tomography (PG-SPECT) has been designed, based upon single photon emission computed tomography (SPECT), which measures the prompt 478 keV gamma-ray produced by ^{10}B(n,$\alpha\gamma$)^{7}Li, using a CdZnTe primary detector and a BGO Compton-suppression anti-coincidence secondary detector. An experimental 1-dimensional test version of the hypothetical design has been constructed and has been experimentally tested at the Pelletron facility at the Tokyo Institute of Technology, using the ^{7}Li(p,n) reaction as a neutron source, using near-threshold protons, which is expected to be a common neutron source for accelerator-based BNCT. The Monte Carlo particle simulation program PHITS was used to calculate the probability of a 478 keV photon emitted at a given position in the phantom depositing all of its energy in each detector element (absolute efficiency).

In a phantom irradiation experiment, the number of 478 keV net counts for each detector position and angle was experimentally measured (projection data). Using only the experimental projection data and the calculated absolute efficiency, image reconstruction was successful using the experimental test system. In this way we have experimentally proven proof-of-concept of the system. It was also experimentally proven that the imaging resolution of the system is less than 2 cm, by cleanly separating 2 tumor regions spaced 2 cm apart. (Theoretical calculated value for imaging resolution is 1.04 cm.) Additionally, the expected number of background counts in the 478 keV ROI was experimentally measured for each detector position and angle, and was found to be constant. Notable experimental parameters were a neutron fluence of 1.3x10^{9} n/cm^{2}, a healthy tissue region using pure water, and a tumor region using 5% ^{nat}B-borated polyethylene.

Using the Monte Carlo calculation program LIYIELD, the ^{7}Li(p,n) reaction, the neutron energy and angle spectra resulting from the ^{10}B(n,$\alpha\gamma$)^{7}Li were calculated, and that information was input into PHITS, which then simulated the distribution of photons in the phantom under theoretical clinical settings, and the distribution of 478 keV photon production from the ^{10}B(n,$\alpha\gamma$)^{7}Li reaction. Notable parameters for the theoretical clinical case were a fluence of 1.0x10^{13} n/cm^{2}, a healthy tissue region of 10 ppm ^{10}B-borated water, and a tumor tissue region of 30 ppm ^{10}B-borated water, typical values for a BNCT clinical irradiation. By multiplying the calculated 478 keV photon production distribution by the calculated absolute efficiency in relation to measuring 478 keV photons, we calculated the expected number of 478 keV full-energy deposition events resulting from the ^{10}B(n,$\alpha\gamma$)^{7}Li reaction in the CdZnTe detectors for each designed detector position and angle, for the theoretical clinical case. The simulation was also conducted using the parameters in the experimental irradiation, and the calculated number of expected 478 keV net counts in the Monte Carlo simulation was compared to the experimentally measured number of net 478 keV net counts, and the two distributions were found to be similar, although with some discrepancies existed. Combining the calculated number of 478 keV photon full energy deposition events in the clinical case with the experimentally measured number of background events in the 478 keV ROI from the experiment, the number of 478 keV net counts, as well as the expected statistical distribution thereof was calculated, for the theoretical clinical case.

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The effects of the statistical fluctuations relating to the number of 478 keV net counts was then extrapolated through the image reconstruction process, by using a random number generator applied to the expected statistical distribution. These random numbers were then applied to the image reconstruction process, to evaluate the quality of an image reconstructed in the theoretical clinical case. This process was repeated 100 times to measure the amount of difference between simulated number of 478 keV photons produced in a given region with the reconstructed number of 478 keV photons produced in that region. Looking at the value of the maximum photon production pixel, we have predicted that the error of the system relating to measuring the number of 478 keV photons produced in the maximum production region is 9.2%. By comparison, current BNCT dosimetry techniques have an error of about 5% in measuring the amount of dose in phantom experiments, and it is thought that they have an error in excess of 20% in actual clinical irradiations.

Using the above method, we were able to experimentally prove proof-of-concept of PG-SPECT, experimentally prove that the imaging resolution of the system is less than 2 cm, and to evaluate the performance of the system under clinical settings, demonstrating that the amount of error relative to the value of the maximum pixel dose is equal to 9.2%.