Calibration of real-time neutron monitor for BNCT utilizing a national neutron standard field

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In BNCT, the dose delivered to a patient is directly proportional to the number of nuclear reactions, which is a function of neutron fluence. Accordingly, accurate measurements of neutron fluence is a determining factor in the quality of the neutron beam. The current gold standard for in-phantom fluence measurements in BNCT is the Au radio-activation method. This method, however, is an offline, time-consuming method. To advance BNCT, we are developing a real-time neutron fluence/ flux measurement system. The detector in this system consists of a small grain Eu-doped $LiCaAlF_6$ scintillator, and optical quartz fiber, and photo-multiplier tube. This detector is capable of discriminating neutrons from gamma rays without significantly perturbing the neutron field. We have previously shown that the system dynamic range is sufficient to be used in a water phantom under irradiation by the clinical-level BNCT beam. In this study, we calibrated the system response utilizing a national neutron standard field in order to determine the neutron fluence distribution in an absolute scale.

The system was calibrated under the neutron standard field at the National Metrology Institute of Japan, the National Institute of Advanced Industrial Science and Technology. After obtaining the calibration constant, we measured the neutron fluence distribution along the beam axis in a water phantom irradiated by a cyclotron-based epithermal neutron source (C-BENS). The measured distribution was compared with that calculated by Monte Carlo simulation codes, MCNPX and PHITS.

The obtained calibration constant was consistent with the detection efficiency estimated by the detector scintillator size. For comparison of the fluence distributions, we introduced a scaling factor to scale the distribution calculated by the Monte Carlo simulation, which was in a relative scale. With an appropriate scaling factor, we found that the two distributions agreed well.

In this work, we have determined the calibration constant for our measurement system. In addition, we have shown that the neutron fluence distribution measured by this system agrees well with that calculated by the Monte Carlo simulation code if scaled appropriately. This implies that with the conversion factor determined using our system, one could calibrate the input simulation source.