Development status of the iBNCT device as a linac-based neutron source of the University of Tsukuba

Hiroaki Kumada[1], Kenta Takada[2], Yoshitaka Matsumoto[1], Susumu Tanaka[1], Fujio Naito[3], Toshikazu Kurihara[3], Akira Matsumura[1], Hideyuki Sakurai[1] and Takeji Sakae[1]

[1] *Faculty of medicine, University of Tsukuba, Tsukuba, Japan*

[2] *Gunma Prefectural College of Health Science, Maebashi, Japan*

[3] *Accelerator Division, High Energy Accelerator Research Organization, Tsukuba, Japan*

E-mail: kumada@pmrc.tsukuba.ac.jp

[Introduction] An industry-academia-government collaboration team in Tsukuba, Japan is being developed a treatment device of boron neutron capture therapy (BNCT) [1]. The iBNCT as the demonstrator of the linac based BNCT treatment device was constructed at the end of 2016 and is being improved to increase neutron intensity. At present, the iBNCT enables to generate sufficient neutrons for BNCT treatment and has become to be able to drive stably a long time. To verify the performance for the iBNCT device and for neutron beam generated by the device, several characteristic measurements are being performed.

[Materials and Methods] To confirm the applicability of the neutron beam to the clinical study of BNCT, neutron irradiation experiments with a water phantom were performed. In experiments, a rectangular water phantom made of PMMA was set to the irradiation position in the treatment room of the iBNCT device and was irradiated neutron beam. To determine distributions for both thermal neutron flux and gamma-ray dose in the phantom, gold wires and TLDs were set inside the phantom. Next, in order to confirm the stability of the linac, repeated operation of continuous operation for 90 minutes was carried out 50 times or more. And we evaluated the stability and life time of the beryllium target.

[Results and discussions] For distribution for thermal neutron flux in the phantom, when the accelerator was operated with average 1.4 mA proton beam current, the maximum thermal neutron flux at the peak point (2 cm in depth) in the phantom was approximately 7.8 x 10^8 (n/cm^{2}s). For gamma-ray dose rate, the maximum value was approximately 2.8 Gy/h at the same point of the peak point of the thermal neutron flux. The results demonstrated that the device can generate sufficient neutrons for clinical use. And these results proved that our development concept for the accelerator-based neutron source as “the combination with proton energy: 8 MeV, proton current: a few milliamperes and beryllium target” allows generating sufficient neutrons for BNCT. In the test for the stability of the operation of the iBNCT linac, we conducted the runs 56 times where each run was for a continuous duration of 90 min. The success rate was approximately 87%. Considering that the continuous operation test is for a state-of-the-art accelerator with a high current of the order of milliamperes, the result is considered to be excellent. Result for the life time of the beryllium target indicated that the target can use to treatment for at least 650 patient or more.

[Conclusion] We had performed several characteristic measurements for the neutron beam for iBNCT device. The results demonstrated the device can produce proper neutron beam applicable to BNCT treatment. Recently the average current of the linac has been further increased to 2.8 mA in order to increase neutron intensity. We are performing the verification to perform continuously the non-clinical study.

References

1. H. Kumada, A. Matsumura, et al., Project for the development of the linac based NCT facility in University of Tsukuba. Appli. Radiat. Isot., Vol.88, 211-215 (2014).