

Present and Future Accelerator Performance for Carbon Ion Radiotherapy

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Abstract

Carbon ion radiotherapy is an effective radiotherapy which can treat radioresistant cancer. Owing to high Linear Energy Transfer (LET) and sharp dose distribution of carbon ion beam, preferable clinical outcomes are reported especially for bone and soft tissue cancer, head and neck cancer, etc. [1] Carbon ion radiotherapy is now in the international wide-spreading phase based on such clinical results.

Present treatment machine for carbon ion radiotherapy consists of an ECR ion source [2], a 4 MeV/u RFQ+IH-DTL injector [3], a 430 MeV/u slow-extraction synchrotron [4] and a spot-scanning irradiation system combined with rotating gantry using superconducting magnets [5]. East Japan Heavy Ion Center, Faculty of Medicine, Yamagata University is the new standard model of carbon ion treatment machine, and has treated more than 1200 patients since Feb. 2021. Compared with conventional broad beam irradiation system, spot-scanning irradiation system require high precision of beam position of ± 1 mm and beam current of 20% at the patient position. Though these irradiation precisions are realized by position and intensity feedback system, stability of the beam current in the accelerator is also important. Beam current deviation of larger than 20% will increase re-injection frequency and will extend treatment time. The ECR ion source of Yamagata University generated 150 μA of C^{4+} beam with $\pm 3\%$ of standard deviation.

Based on the experience of rotating gantry with superconducting magnets, small size superconducting synchrotron [6] called as “4th generation Quantum Scalpel” is under construction. To realize further compact accelerator, replace of ion source and injector by a laser-plasma accelerator will be necessary. The requirement from the clinical side for performance, reproducibility, machine availability, and maintenance time of the laser-plasma injector for carbon ion radiotherapy will be discussed in this presentation.

References

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