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## **Commissioning and First Operation of East Japan Heavy Ion Center at Yamagata University**

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A world smallest carbon ion radiotherapy facility, East Japan Heavy Ion Center, Faculty of Medicine, Yamagata University, started treatment operations in February 2021. The treatment system consists of an ECR ion source, an RFQ and IH-type drift tube linac, a 430 MeV/u synchrotron and a spot-scanning irradiation system. It has two treatment rooms, one is a fixed horizontal beam port and the other is a rotating gantry beam port with superconducting magnets.

The ECR ion source is the 6th Kei2-type permanent magnet 10 GHz ECR ion source with a maximum field of 0.8 T. All the improvements of the previous facilities are applied to the ion source, such as helium gas-assisted operation and changes in the shape of an anode electrode and a cathode electrode to reduce the discharge. Owing to these improvements, the ion source has been operated stably during the commissioning and clinical operation.

The irradiation system of Yamagata University eliminated the plastic block range shifter to realize a compact gantry, and has 600 energy levels to control the beam range in step of 0.5 mm. In order to optimize the beam transport parameters quickly, automation tools for orbit correction were developed.

Machine commissioning and clinical commissioning were carried out in parallel to allow treatment to begin earlier. First, the horizontal fixed beam port was commissioned by verifying the dose distribution of the treatment planning system. Then, the gantry beam port was commissioned by full beam distribution measurement for representing beam angle of 90 degree, and other angles were sequentially released after the compatibility measurement of beam position, beam size, and two-dimensional uniformity. In September 2022, we were able to accept all treatment sites in the gantry port with angle step of 30 degrees. By March 2023, 890 cancer patients had been treated and 24 angles with a 15 degree step were available. Further improvements to increase beam efficiency are ongoing.

### **Funding Agency**

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Yes

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