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Development of a New Compact ECR Ion Source with all Permanent Magnets for Carbon 5^+ Production

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A compact accelerator for high energy carbon-ion radiotherapy (C-ion RT) has been studied in Heavy Ion Medical Accelerator in Chiba (HIMAC) at National Institute of Radiological Sciences (NIRS) since 2004. Compact accelerator for Gunma University (Gunma University heavy ion medical center: GHMC), Saga C-ion RT facility (Saga Heavy Ion Medical Accelerator in Tosu: SAGA HIMAT) and Kanagawa C-ion RT facility (Ion-beam Radiation Oncology Center in Kanagawa: i-ROCK) has been operated for medical use. The Electron Cyclotron Resonance Ion Source (ECRIS) with all permanent magnets (Kei series) are used at these C-ion RT facilities. The Kei series has a magnetic field structure optimized for production of $C4^+$ ions.

It is possible to reduce operation costs by using ion sources that can supply sufficient $C5^+$ ions. Therefore, we design a new compact ECRIS with all permanent magnets to produce $C5^+$ ions. At first, we aimed to determine an optimum mirror magnetic field for production of sufficient $C5^+$ ions by using NIRS-HEC ion source, because magnetic field is the most important specification in order to develop a desirable ECRIS.

Experiments were performed to measure beam currents of $C5^+$ ions with various mirror magnetic field, microwave power and frequency. As a results, we confirmed that the beam currents of $C5^+$ ions were achieved to more than 0.3 mA with coil currents of electromagnets optimized. The magnetic field distribution was calculated from value of the coil currents with poisson/superfish. We will describe the details of the experiments and the design of the permanent magnets in this paper.

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