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Microcalorimetry of carbon ion beam for medical treatment by transition edge sensor

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Abstract

We precisely measured the energy of each charged particle in carbon ion beam for treatment using a transition edge sensor (TES). The TES was irradiated by Carbon ion beam of 100 MeV/u in Heavy Ion Medical Accelerator in Chiba (HIMAC). We used TES which is made of a bilayer of Ir and Au, and a Sn absorber was thermal linked to the TES through Au bump post and a small dot epoxy on the post. We have succeeded in measuring the energy of charged particle in the carbon ion beam. This will contribute to the establishment of a new method of dosimetry of carbon ion beam for radiotherapy.

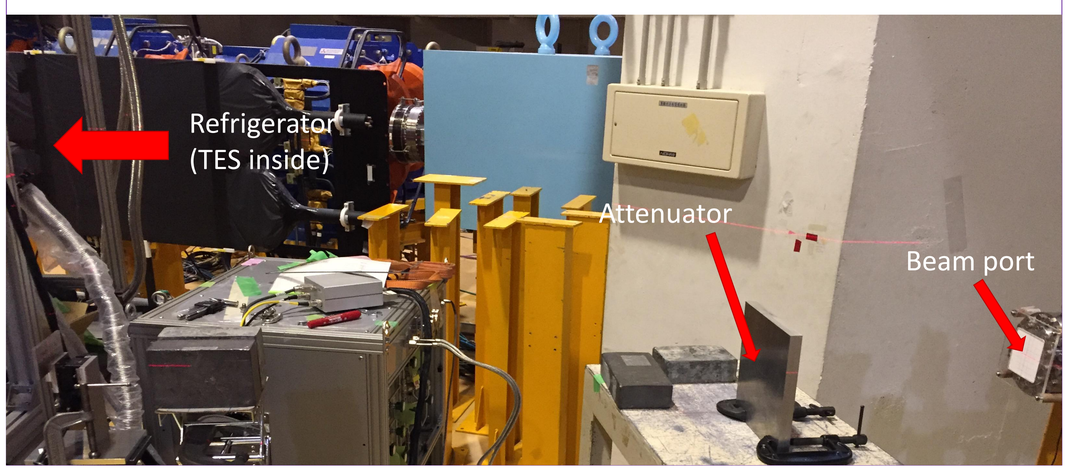
Objective

Direct ionization plays a large role in radiotherapy using carbon ion beam. However, the factors that enable carbon ion cure cancer with direct ionization has not been quantitatively evaluated yet. The evaluation of these factors may be able with the calorimetry by TES.

Measurement with ionizing chamber	Measurement with TES
$\Delta D[Gy] = \frac{Charge[C]}{Mass[kg]} \cdot \frac{Energy[J]}{Charge[C]}$	$\Delta D[Gy] = \frac{Energy[J]}{Mass[kg]}$

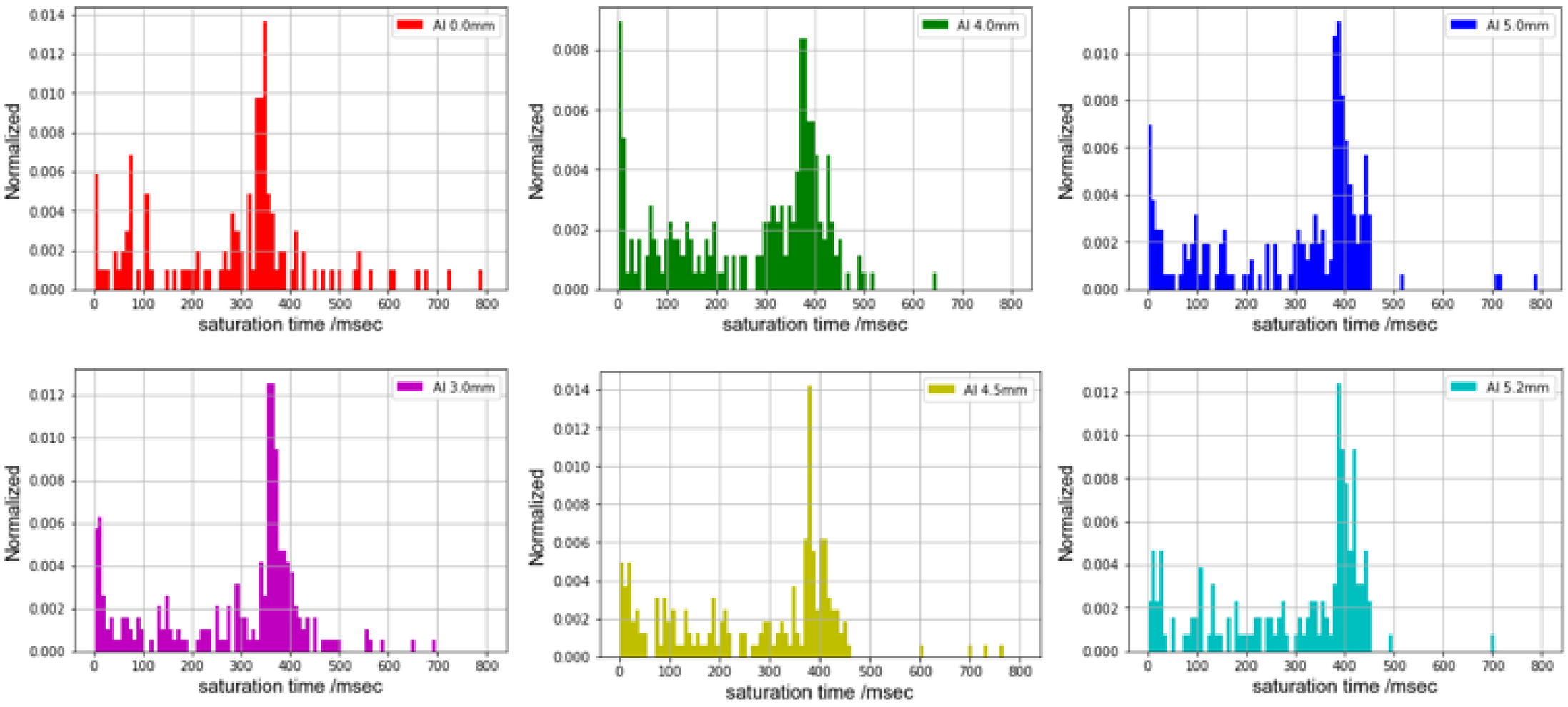
Setting

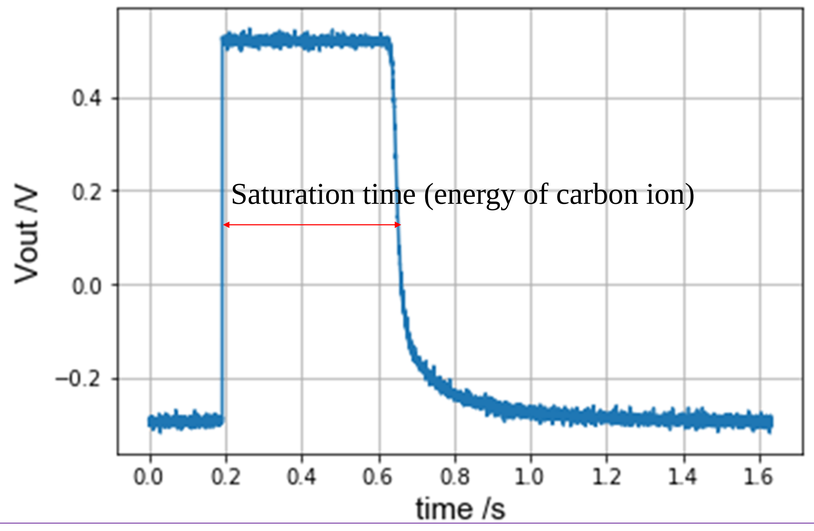
Attenuators made of aluminum was set between the beam port and the TES

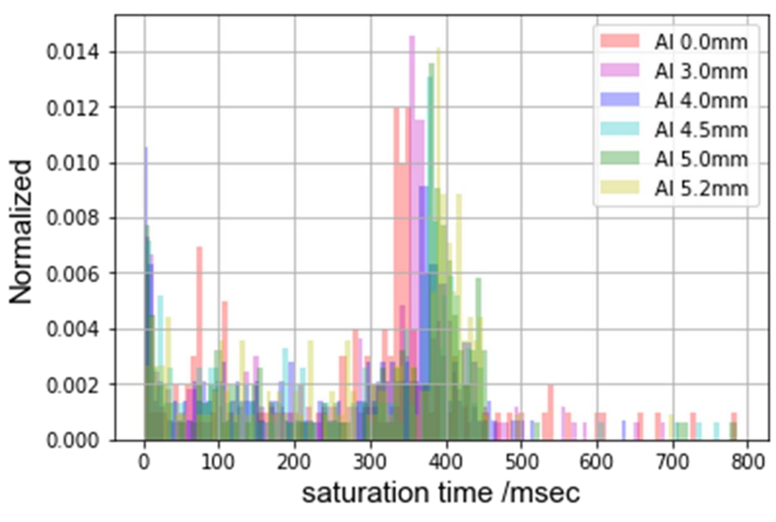


Results

The energy of the beam was so large that the absorber was saturating during events. There is a correlation between this saturation time and the energy of the heavy ion[1)] . The data of the saturation time were collected, and a histogram was made for each thickness of the attenuator. The histograms are shown below.
The saturation time which showed the peak of each histogram increased, as the thickness of the attenuator increased. This means that the energy of the carbon ion was following the Bragg Curve of carbon ion beam. In addition, it appears that the variation of the histogram increased, as the thickness of the attenuator increased. It is assumed that the high energy resolution of the TES was able to detect the outcomes from the interaction between the carbon ion and the Al attenuator.







Conclusion

We succeeded in the energy of each charged particle in carbon ion beam of 100 MeV/u for radiotherapy using a transition edge sensor. It was shown that the signals from the incident of carbon ions to the TES corresponded to the energy of each carbon ion. This suggests that the microcalorimetry using a transition edge sensor will contribute to the clarification of the factors which enables the carbon ions cure cancer.

[1)] M. Ohno et.al. , Journal of Low Temperature Physics 193(5), 1222-1227, 2018