Control of laser-driven ion acceleration

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In laser-driven ion acceleration, there are issues, including repetitive ion source, ion beam quality, energy efficiency from laser to ion beam, the total number of ions accelerated, laser efficiency, particle energy, etc. [1]

We have worked on a multi-stage laser ion acceleration as shown in Fig. 1 in order to control the ion beam quality and to fulfill the requirements toward laser-ion cancer therapy.

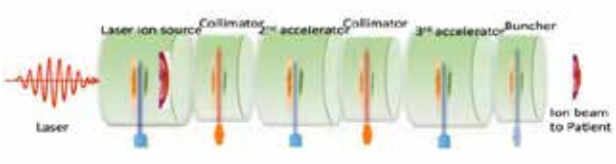

Fig.1 A concept for a future laser ion accelerator for cancer therapy

Figure 1 shows the concept of the future ion acceleration system. An ion beam is generated by an intense laser, and each stage / component has one function to control the ion beam quality by the beam bunching and the collimation. The ions are generated by the interaction of the intense laser with a thin film target. The laser-produced ions tend to have a divergence angle as shown in Fig. 2a) by the laser-produced transverse electric field. However, when the target has the hole in Fig. 2b) the focusing transverse electric field is created at the hole wall and a collimated ion beam is successfully generated.

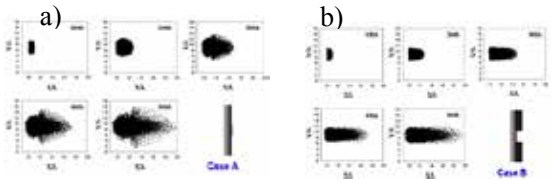

Fig.2 A hole target generates a collimated ion beam.

Figure 3 shows an example of a simulation model of the ion-beam collimation. The ion beam transverse divergence is suppressed by the walls behind the target. At the walls behind the target, the transverse electric field is also created to collimate the pre-accelerated ion beam. In Fig. 3 the Al thin foil substrate has another fine structure to absorb the laser energy efficiently.

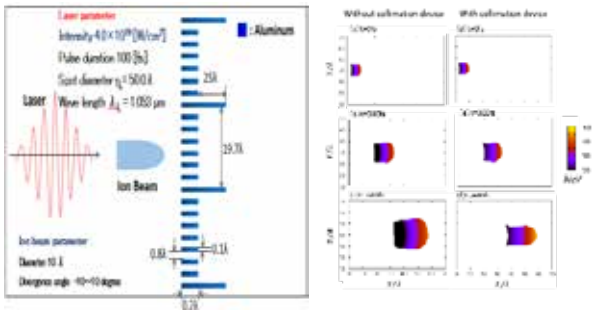

Fig. 3 The ion beam collimation is realized by the structured target shown here. The transverse electric field at the walls behind the thin foil target reduces the pre-accelerated ion beam transverse divergence.

Figure 4 shows an example simulation for the beam bunching of the pre-accelerated ion beam. The longitudinal electric fields generated at the target surfaces are designed to reduce the velocity tilt as shown in Fig. 4.

In this paper, we will present the latest research related to the control of laser-driven ion acceleration.

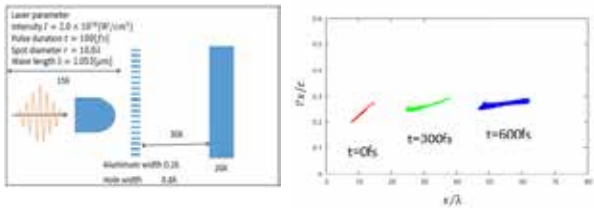

Fig. 4 The bunching of the pre-accelerated ion beam is realized by the multi-foil target.

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Reference

[1]S.Kawata, et al., Laser Therapy, 22, 103(2013).