CONTROLLABLE LASER ION BEAM GENERATION

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Ion beam has a unique feature to deposit its main energy inside a human body to kill cancer cells or inside material. However, conventional ion accelerators tend to be huge in its size and its cost. In this paper a future intense-laser ion accelerator is discussed to make the laser-based ion accelerator compact and controllable. The issues in the laser ion accelerator include the energy efficiency from the laser to the ions, the ion beam collimation, the ion energy spectrum control, the ion beam bunching and the ion particle energy control. In the study each component is designed to control the ion beam quality by particle simulations. Figure 1 is concept of an example future laser ion accelerator. The energy efficiency from the laser to ions is improved by using a solid target with a fine sub-wavelength structure or a near-critical density gas plasma. The ion beam collimation is performed by holes behind the solid target. The control of the ion energy spectrum and the ion particle energy, and the ion beam bunching are successfully realized by a multi-stage laser-target interaction [1].

We study the electric and magnetic fields in the plasma especially. The intense laser interacts with the hydrogen gas plasma with the density of $0.7n_c$ and protons are accelerated at the target rear surface by TNSA and the inductive field acceleration. Figures 2 show the longitudinal electric fields, which contribute to the ion acceleration at (a)t=130fs and (b)180fs, and the magnetic fields at (c)t=130fs and (d)190fs. The maximum acceleration electric field reaches to 16.7MV/μm at the end of the target area, and the maximum magnetic field reaches to 37.0kT. The maximum proton energy is 38.9MeV at 700fs, and the energy conversion efficiency is 35.5% from the laser to the accelerated (>20MeV) protons.

The controllable laser ion acceleration would become viable based on the studies, for example, shown in Fig.1.

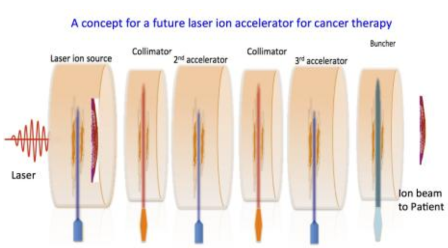

Figure 1. Concept of an example future laser ion accelerator.

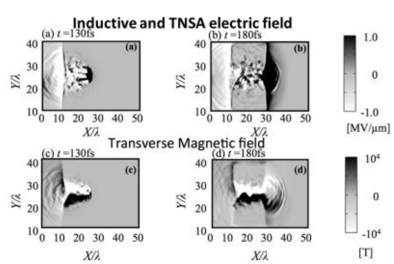

Figure 2. The longitudinal electric fields, which contribute to the ion acceleration at (a)t=130fs and (b)180fs, and the magnetic fields at (c)t=130fs and (d)180fs.

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