11-1 Ion Acceleration from Near-Critical Density Plasma Produced by Lasers

–Proposal of a Novel Ion Acceleration Method for Cancer Therapy–

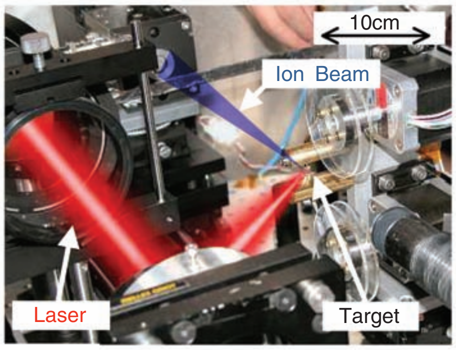

Fig.11-3 Laser ion accelerator
A laser pulse is focused onto a thin-foil target with intensity exceeding 10^{18} W/cm^2, which generates high-density plasma at the focal spot. This plasma produces a MeV-scale proton beam.

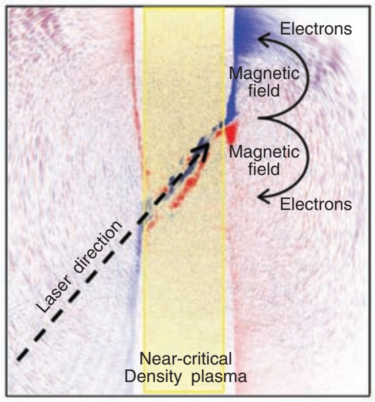

Fig.11-4 A novel mechanism of ion acceleration
A laser pulse can invade into a near-critical density plasma target, and the laser energy is efficiently converted into electron kinetic energy.

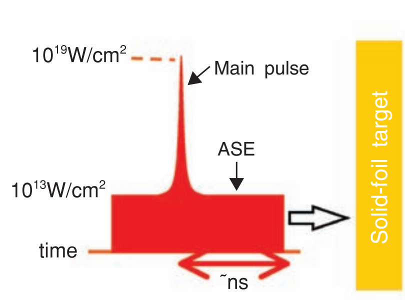

Fig.11-5 Near-critical density plasma production method
A solid foil target is converted into near-critical density plasma by the amplified spontaneous emission (ASE) light preceding the main laser pulse.

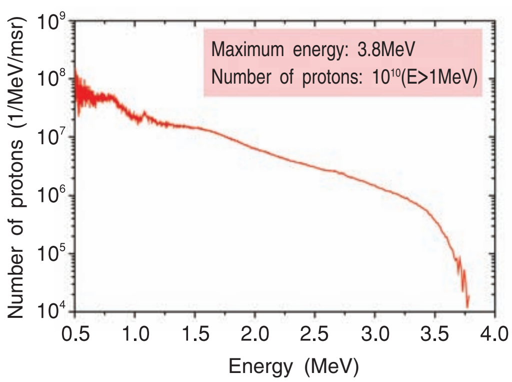

Fig.11-6 A proton energy spectrum
We have successfully obtained protons of 3.8 MeV maximum energy.

When a laser pulse is focused onto a thin-foil target with intensity exceeding 10^{18} W/cm^2, high-intensity plasma is induced at the laser focal spot, generating several kinds of radiation including high-energy ions. By using this phenomenon of laser-ion acceleration, conventional ion accelerators, that have lengths of tens of meters, can be replaced by a compact apparatus as shown in Fig.11-3. The Photo-Medical Research Centre (PMRC) aims to develop a compact and novel laser-driven ion accelerator for cancer therapy.

Recently, we proposed and demonstrated experimentally a new method of laser-ion acceleration by which laser pulse energy can be converted more efficiently into ion kinetic energy. The method is based on creation of a near-critical density plasma target. In the case of a usual solid target, the target surface can reflect a large part of the laser pulse energy. By contrast, a laser pulse can penetrate into a near-critical density plasma target (Fig.11-4), where laser energy is efficiently converted into electron kinetic energy. The vortex of moving electrons thus created generates a magnetic field on the target rear surface and sustains an electrostatic ion-accelerating field. A solid foil target is converted into near-critical density plasma by the part of the light pulse that precedes the main high intensity laser, amplified spontaneous emission (ASE) (Fig.11-5).

In experiments we have generated protons with maximum energy of 3.8 MeV. Fig.11-6 shows the proton energy spectrum, which also shows that approximately 10^{10} protons are generated by a single laser shot. Higher-energy protons will be achieved by optimizing the target density through control of the ASE intensity and duration.

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Reference

Yogo, A. et al., Laser Ion Acceleration via Control of the Near-Critical Density Target, Physical Review E, vol.77, no.1-2, 2008, p.016401-1-016401-6.