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Quasi-monoenergetic proton beams from a layered target irradiated by an ultraintense laser pulse

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When an ultraintense laser pulse is focused on a thin foil, an energetic proton beam can be generated due to strong laser-plasma interactions, which attracted many scientists not only by its fundamental physics but also by its wide applications toward nuclear physics and medical therapy. Proton beams from laser-plasma interactions have attracted attentions due to its application to a cancer therapy system since the first demonstration of 60 MeV proton beam with a large laser facility [1]. There have been lots of efforts and new acceleration schemes to reach the medical requirements, such as radiation pressure acceleration (RPA) [2] and collisonless shock acceleration (CSA) [3], however its realization is still far reach.

Recently, KAERI has proposed a new target structure named as Ion-Layer Embedded Foil (ILEF) target [4], which consists of two metal foil and a proton layer positioned between the metal foils. It is the bulk electrostatic field that accelerates the embedded protons rather than surface sheath field. A two-dimensional particle-in-cell (PIC) simulation showed that it could generate a high-energy proton beam with a narrow energy spread as shown in Fig. 1, which was obtained for different target parameters with laser intensity of 10^{21} W/cm^2 [4].

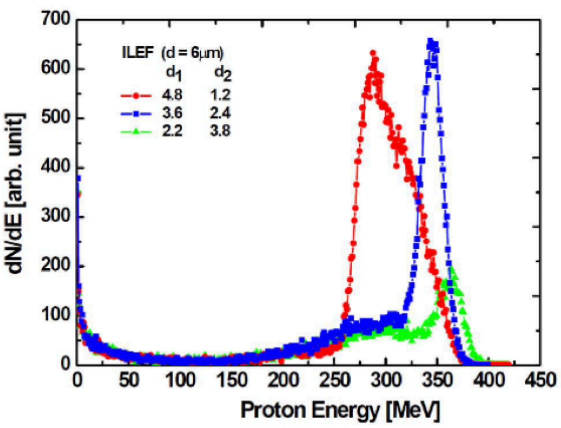

Figure 1. Proton energy spectra from ILEF targets for different target parameters. (PIC results, I = 10^{21} W/cm^2)

An experiment has been conducted to demonstrate the acceleration mechanism. For the ILEF target, two copper films are attached, which were mounted between two sapphire plates with holes for laser shot. KAERI 30 TW Ti:Sapphire laser with 30 fs pulse width, was focused on a target surface with a laser intensity of 10^{19} W/cm^2. For a proton energy spectrometer, Thomson parabola spectrometer was position 1.1 m away from the rear surface of the target in the normal direction. The protons were detected by a Si-based pixel detector, which made a real-time measurement possible. Additional laser beam was focused on a target surface to remove proton layer in the rear surface to ensure that the protons are originated from the surfaces between the metal foils.

Figure 2 shows observed proton energy spectra. Comparing proton energy spectrum from single 6-μm thick copper foil, the attached two-copper foil shows an energy peak at 1.7 MeV with maximum energy of 3 MeV, which is far from the well-known thermal-like spectrum. The spectrum with an energy peak can be attributed by the ILEF acceleration mechanism.

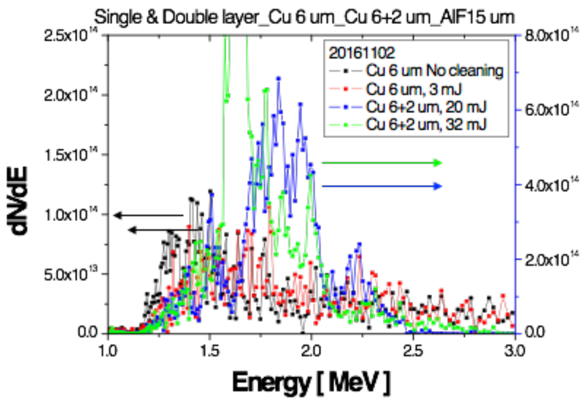

Figure 2. Proton energy spectra from attached two-metal foils of 6 and 2 μm with laser intensity of 10^{19} W/cm^2.

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