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SULF laser-driven proton acceleration

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Laser-driven ion acceleration is attracting widespread interests because of the prospects of realizing compact and desktop ultrafast ion sources, which has potential applications in many fields, such as cancer therapy, fast ignition fusion, proton imaging etc. This report will introduce the recent progress on laser-driven proton acceleration carried out in the Shanghai Superintense Ultrafast Laser Facility (SULF)

SULF is the first 10 PW-class laser facility in China, located in Shanghai PuDong New District, which was proposed and constructed by the Shanghai Institute of Optics and Fine Mechanics in 2016. In 2017, the SULF-10 PW beamline has realized output peak power up to 10.3 PW with 339 J output pulse energy compressed to 21 fs pulse duration. This peak power was further increased to 12.9 PW in 2019.

In the commissioning phase of SULF-10 PW laser beamline, the laser energy of 72±9 J is directed to a focal spot of ~6 μm diameter (FWHM) in 30 fs pulse duration, yielding a focused peak intensity around 2.0×10^{21} W/cm^2. As shown in Fig.1, high-energy proton beams with maximum cut-off energy up to 62.5 MeV are achieved using flat copper foils at the optimum target thickness of 4 μm via target normal sheath acceleration (TNSA) mechanism. [1]

Meanwhile, we also apply the 3D-printed microwire array structure to enhance the proton acceleration. [2] After optimizing the laser contrast of SULF-10 PW laser beamline with the single plasma mirror, by using the 1.7 PW laser interacting with microwire array targets, the 62.8 MeV proton beams are obtained at the optimal structure period, which is enhanced by 36% compared with flat foils.

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References

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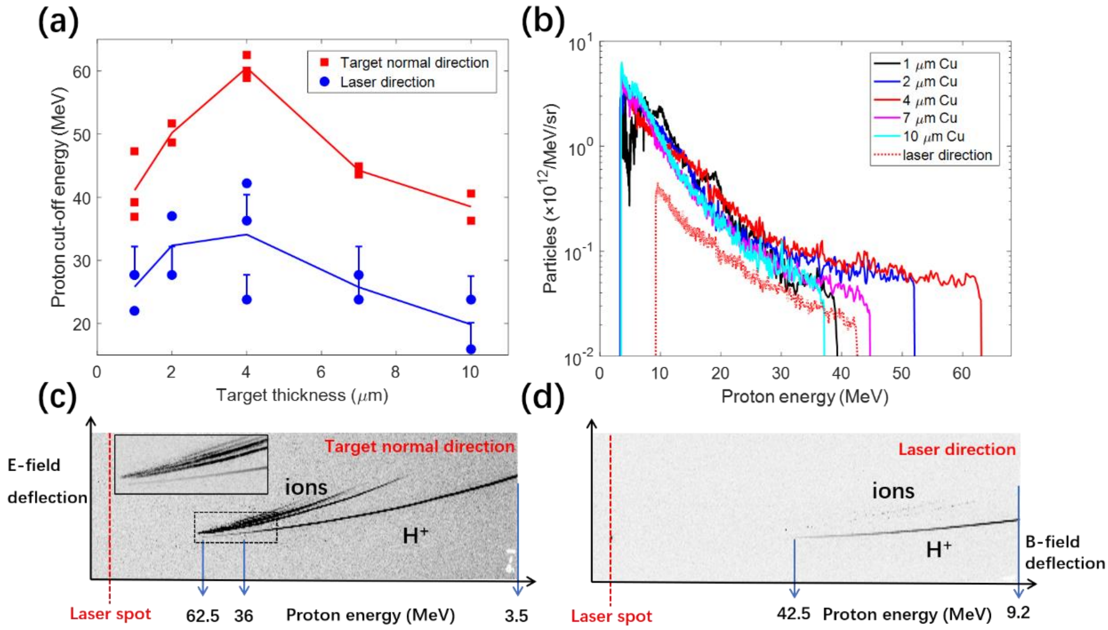

Figure 1. The proton cut-off energy as a function of the target thickness of the plain Cu foils measured in the target normal direction (red squares) and in the laser propagation direction (blue circles). (b) Typical proton spectra for five target thicknesses. (c)-(d) The raw IP data in the target normal direction and laser direction for the best result of proton acceleration from a shot on a 4-μm Cu foil, where the inset in (c) is a magnified image of the ion trace in the high-energy region.