Experimental and simulation studies on muti-stage proton acceleration

Hyung Taek Kim* and Chang Hee Nam

W. P. Wang, B. F. Shen*, H. Zhang, X. M. Lu, J. F. Li, S. H. Zhai, S. S. Li, X. L. Wang, R. J. Xu, C. Wang, Y. X. Leng, X. Y. Liang, R. X. Li, and Z. Z. Xu**

State Key Laboratory of High Field Laser Physics, Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Shanghai 201800, China

* E-mail address: bfshen@mail.shcnc.ac.cn

** E-mail address: zzxu@mail.shcnc.ac.cn

With the development of ultra-intense laser technology, laser intensity can increase up to the order of ~10^{22} W/cm^2 in the laboratory. Ion beams in the MeV range and even the GeV range, driven by terawatt or petawatt lasers, exhibit ultra-short pulse duration, excellent emission, and ultra-high peak current. Thus, they can potentially be applied in fast ignition of inertial confinement fusion, medical therapy, proton imaging, and pre-accelerators for conventional acceleration devices. However, the generation of quasi-monoenergetic proton beams for realistic applications is still an experimental challenge. Here, the optimum and controllable two-stage proton acceleration is realized for the first time by a novel double beam image (DBI) technique in experiment. Two laser pulses are successfully tuned on two separated foils with both spatial collineation and time synchronizing, resulting in spectrum tailoring and an energy increase at the same time. Such a novel DBI technique can help us to realize the optimum two-stage acceleration in a feasible way, which opens the door for the exact manipulation of multi-stage acceleration to further improve the energy and spectra of particle beams.

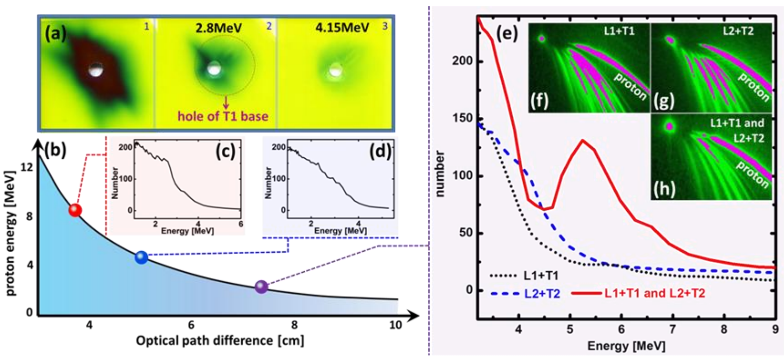

Figure 1. (a) Proton images on RCFs for the two-stage proton acceleration. Laser one (L1) irradiates on target one(T1), and Laser one (L2) irradiates on target one(T2). (b) The relation between optimum optical path difference（L_{OPD}） and the proton energy E_p. Energetic spectra for (c) L_{OPD} = 3.64 cm, (d) L_{OPD} = 4.86 cm, and (e) L_{OPD} = 6.3 cm. The images on IP plates for the cases of (f) L1 + T1, (g) L2 + T2, and (h) L1 + T1 and L2 + T2.