§60. Plasma Mirror for Proton Acceleration on LFEX Laser

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1. Introduction

The GXII-LFEX laser facility at the Institute of Laser Engineering, Osaka University, is the largest laser facility in Japan, and one of the largest in the world. In particular LFEX laser is nowadays the highest power kJ-class laser in the World, capable of delivering in the present status, up to 2kJ of laser energy in 1 ps.

2.1 Plasma mirror setup

A spherical PM device [1] was also installed on LFEX laser in order to further increase the laser contrast. The PM reflectivity was previously characterized to be 50 ± 5 % for laser fluences between 60 and 100 J/cm^2 (see and the radius of curvature was chosen in such a way to refocus the LFEX pulse, which was offset by 3 mm, right at the Target Chamber Centre (TCC). The PM and target were aligned externally on an alignment station, including a model or "skeleton" of LFEX laser for fine PM tuning. It was then installed on the magnetic base mounted on the LFEX target manipulator inside the chamber (Fig. 1).

3. Experimental results

The performances of LFEX in the last experimental campaign have been tested by studying both ion acceleration and fast electron generation. The two topics are of direct interest for pure science as well as for Fast Ignition research purposes. In this brief summary, we will focus our attention on the ion data, while a more throughout presentation will be provided at the conference.

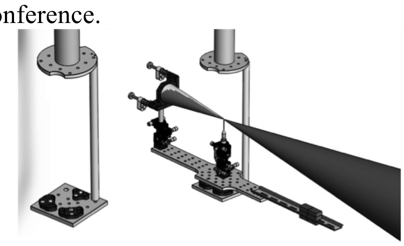

Fig. 1. Setup of the PM device in the LFEX chamber. The LFEX beams are refocused in TCC by the PM.

3.1 Ion acceleration results.

The ion acceleration testing stage provided very interesting results for LFEX laser both with and without PM. LFEX shows the capability to shoot thin Al foils, both μm and sub-μm scale, at full energy (1.5-1.7 kJ). A very remarkable result is in particular represented by the peak proton energy for 10 μm Al shot case (directly comparable with other data in literature), corresponding to ~42 MeV. The result was confirmed by RCF stack measurement.

This result differs form previous TNSA scaling models by a large factor [2-3], assuming the LFEX intensity on target to be around 10^{19}W/cm^2.

Using PM technology on LFEX, allows to further increase the laser contrast and to shoot for the first time ultra-thin CH foil targets with kJ, PW-class laser. The 0.2 and 0.1 mm CH targets were aligned with an angle of 30^o with respect to the laser normal, and a RCF stack was aligned on the target rear surface in such a way to register protons directed both along the laser axis and the target normal. The experimental results (Fig. 2) show that the highest energy protons appear to be collimated along the laser axis for 0.2 μm CH target, while for the 0.1 μm case, a more complex structure appears, with protons both collimate towards the laser axis as well as close to target normal. More detailed investigation is required and eventually even thinner foils should be tested before providing scientific conclusions.

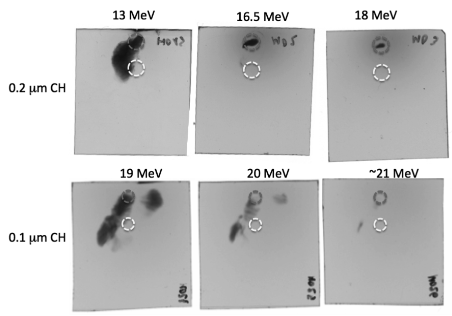

Fig. 2. RCF data for protons accelerated form 0.2 and 0.1 mm CH foils. The red circle represents the laser axis while the yellow circle the target normal.

4. Conclusions

In this work we presented preliminary results obtained at LFEX laser facility in the 2015 experimental campaign. The extremely improved LFEX laser performances allowed to shoot μm and sub-μm foils obtaining relevant proton data results in high and ultra-high (with PM) contrast conditions.

[1] B. Dromey et al. "The plasma mirror-A subpicosecond optical switch for ultrahigh power lasers", Review of Scientific Instruments, 75, 645 (2004).

[2] L. Robson, et al. "Scaling of proton acceleration driven by petawatt-laser-plasma interactions", Nature Physics 3, 476 (2006).

[3] A. Macchi, M. Borghesi, M. Passoni "Ion acceleration by superintense laser-plasma interaction", Reviews of Modern Physics, 85, 751 (2013)