Transient Electromagnetic Fields for High Energy-Density Beam Tailoring Driven by ps-Laser Pulses

M. Ehret* [1,2], J. Alpiñaniz [3], V. Bagnoud [4], M. Bailly-Grandvaux [1], C. Brabetz [4], J.-L. Feugeas [1], E. d'Humières [1], Ph. Korneev [5], S. Malko [3], A. Morace [6], L. Volpe [3], M. Roth [2], G. Schaumann [2], and J.J. Santos [1]

[1] *Laboratoire CELIA, UMR 5107, Université de Bordeaux, France*

[2] *Institut für Kernphysik, Technische Universität Darmstadt, Germany*

[3] *Centro de Láseres Pulsados, Salamanca, Spain*

[4] *GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany*

[5] *National Research Nuclear University MEPhI, Moscow, Russian Federation*

[6] *Institute of Laser Engineering, Osaka University, Japan*

* E-Mail : michael@michelmaxx.de

We present first results and optimization prospects of an open-geometry platform for energy selective tailoring of laser-accelerated particle beams. The all-optical principle is based on high intensity ps-laser pulse driven electromagnetic (EM) target-discharges and subsequent propagation of strong transient EM-fields guided by the target geometry. A sub-mm coil-shaped part of the target rod creates lensing effects, in particular we imaged energy-selective proton beam focusing over cm-scale distances by proton-deflectometry.

The experiment was carried out at the PHELIX/GSI laser facility, using 500 fs, 50 J laser pulses focused at $5 \cdot 10^{18}$ W/cm^2 into a flat-disc target conductively connected to a 50 µm-thick wire shaped as a coil of 500 µm diameter. The discharge time and spatial scales were captured by proton-deflectometry (Figure 1), revealing the propagation of transient EM-fields emanating from the laser-plasma interaction. The measured phase speed through the target rod is (0.95 ± 0.05) c. The discharges stream around the coil over ≈ 25 ps, producing efficient focusing of the protons passing inside the coil: 12 MeV-protons are collimated over distances of several cm. In Fig. 1, the emittance of 6 MeV protons shrinks to 30% of the initial value. Energy-selection for the focused particles is possible by tuning the delay between the laser driving the coil and the one accelerating the proton beam. Preliminary PIC simulations [1] as well as transport- and field-simulations using PAFIN [2] capture the discharge dynamics, distinguishing EMP, fast electrons and a target-surface neutralization wave propagation. The comparison of the experimental data with synthetic deflectometry images quantifies the strength of the EM-fields, with electric fields of the order of the GV/m and magnetic fields at the coil center of a few tens of T.

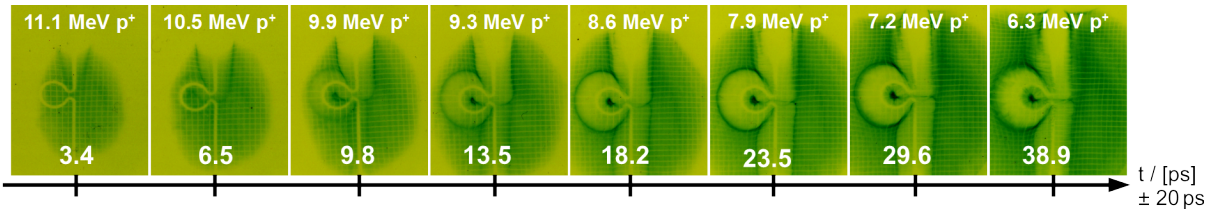

Figure 1: Proton-deflectometry images from one shot of a laser-driven EM-discharge propagating along coil-shaped wire target.

References

[1] A. Morace *et al.*, Proc. SPIE, 10328 (2017)

[2] M. Ehret. TNSA-Proton Beam Guidance with Strong Magnetic Fields Generated by Coil Targets. [DOI: 10.13140/RG.2.1.3855.7847] Master Thesis, TU Darmstadt (2016)