Ion acceleration from optically shaped high density gas jet targets

A. Maitrallain[1], J. R. Marquès[2], K. Bontemps[1], J. Bonvalet[3], E. F. Atukpor[1], V. Bagnoud[4], T. Carrière[3], F. Hannachi[1], J. L. Henares[5], J. Hornung[4], A. Huber[1], E. d'Hummières[3], L. Lancia[2], P. Loiseau[6,7], P. Nicolaï[3], J. Santos[3], V. Tikhonchuk[3], B. Zielbauer[4], M. Tarisien[1]

[1] *Univ. Bordeaux, CNRS, LP2I, UMR 5797, F-33170 Gradignan, France,*
[2] *LULI, CNRS, École Polytechnique, CEA, Sorbonne Université, Institut Polytechnique de Paris, F-91128 Palaiseau Cedex, France,*
[3] *Université Bordeaux-CNRS-CEA, CELIA, UMR5107, Talence, France* [4] *Plasma Physik/PHELIX, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany,*
[5] *Centro de Laseres Pulsados, C/ Adaja 8, 37185, Villamayor, Spain,*
[6] *CEA, DAM, DIF, F-91297 Arpajon, France,*
[7] *Université Paris-Saclay, CEA, LMCE, 91680 Bruyères-le-Châtel, France,*

maitrall@cenbg.in2p3.fr

Laser-driven ion acceleration is well established using solid targets mainly through the TNSA (Target Normal Sheath Acceleration) regime. To follow the increasing repetition rate available on ultra high-intensity lasers, the use of high-density gas targets has been explored in the past decade. When interacting with targets reaching denisties close to the critical one (n_c>10^{21} e/cm^3 for $\lambda \approx 1$ µm laser), the laser pulse can trigger the CSA mechanism (Collisionless Shock Acceleration) [1]. Particle-In-Cell simulations show that such mechanism can accelerate a collimated, narrow energy spread and few hundreds of MeV ion beam on the laser axis. Nevertheless the laser will not only interact with an over critical plasma slab, but also with lower density regions surrounding the core of the gas jet, extending to several hundreds of µm. The interaction of the laser with these relatively low density wings will lead to non linear effects such as filamentation that will reduce the available energy to drive the shock in the very high density region of the target.

For that reason, one of this collaboration's goal is to optically shape the high-density gas target [2] to circumvent this issue. During this contribution, I will present the results of several experiments conducted on the PICO2000 and the PHELIX laser that aimed at testing different shaping configurations. One was a trasverse shaping driven by ns laser pulses to generate blast waves and form a plasma slab [3] while the second one consisted of using a co-propopagating ps pre pulse to create a lower density plasma channel to facilitate the propagation of the main pulse [4]. I will present the results from the optical diagnostics looking at the plasma evolution as well as the ones obtained from spectrometers used to measure the energy of the accelerated particles and draw comparisons on the effect of the different shaping methods.

References

[1] F. Fiuza et. al., Phys. of Plasma **20**, 5 (2013)
[2] J. L. Henares et. al., Rev. Sci. Inst. **90**, 6 (2019)
[3] J. R. Marquès et. al., Phys. of Plasma **28**, 2 (2021)
[4] P. Puyuelo Valdes et. al., Phys. of Plasma **26**, 12 (2019)