

Experimental and numerical investigations of ion acceleration by ultraintense laser pulses in near-critical transparent gas jets

Valeria Ospina-Bohórquez^{1,2,3}, C. Salgado³, M. Ehret^{1,3,4}, S. Malko⁸, F. Consoli⁹, C. Verona¹⁰, G. Prestopino¹⁰, M. Salvadori⁹, T. Pisarczyk¹¹, Z. Rusiniak¹¹, T. Chodukowski¹¹, R. Dudzak¹⁴, C. Vlachos¹, G. Perez-Callejo¹, P. Guillon¹², M. Lendrin¹, J. Dostal¹⁴, M. Krupka¹⁴, M. Huault³, J.A. Perez-Hernández³, J.I. Apiñaniz³, F. Hannachi⁵, M. Tarisien⁵, D. de Luis³, J. Hernández-Toro³, C. Méndez³, O. Varela³, A. Debayle², T.-H. Nguyen-Bui¹, J.L. Henares^{3,5}, G. Revet¹, J. Caron¹, T. Ceccotti⁷, R. Nuter¹, D. Raffestin¹, N. Bukharskii¹³, G. Schaumann⁴, X. Vaisseau³, L. Volpe³, L. Gremillet² and J.J. Santos¹

¹ Univ. Bordeaux, CNRS, CEA, CELIA, UMR 5107, Talence, France

² CEA-DAM/DIF, CEA/DAM Île-de-France, Arpajon, France

³ CLPU - Universidad de Salamanca, Salamanca, Spain

⁴ Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany

⁵ CENBG, CNRS-IN2P3, Université de Bordeaux, Gradignan, France

⁶ Plasma Physik/PHELIX, GSI, Darmstadt, Germany

⁷ CEA/IRAMIS, SPAM, Gif-sur-Yvette, France

⁸ Princeton Plasma Physics Laboratory, Princeton, USA

⁹ ENEA Fusion and Technologies for Nuclear Safety Department, Rome, Italy

¹⁰ Industrial Engineering Department, University of Rome "Tor Vergata" Rome, Italy

¹¹ Institute of Plasma Physics and Laser Microfusion, 23 Hery St., 00-908 Warsaw, Poland

¹² Ecole Polytechnique, Institut Polytechnique de Paris, 91128 Palaiseau cedex, France

¹³ National Research Nuclear University MEPhI, 115409 Moscow, Russian Federation

¹⁴ Institute of Plasma Physics of the Czech Academy of Sciences, Prague, Czech Republic

Fast ion sources driven by ultraintense lasers are promising in many fields of fundamental and applied science. While laser-based ion acceleration from solids has been extensively studied, near-critical-density plasmas have been little addressed so far due to difficulties in achieving well-controlled high gas densities. Such plasmas are predicted to give rise to a mix of acceleration mechanisms combining target normal sheath and collisionless shock acceleration, as well as hot-electron production beyond the standard ponderomotive scaling. Here we report on a particle-in-cell simulation study of this process and on two experiments conducted at the 200 TW VEGA II and 1 PW VEGA III laser systems (CLPU, Spain). The first aimed at studying the potential for ion acceleration of a state-of-the-art gas jet coupled with shock nozzles. The second revealed, through time-of-flight measurements, the generation at a moderately high repetition rate of ~ 0.6 MeV/amu. alpha particles with relatively low energy dispersion and divergence. It also confirmed the copious hot electron generation predicted by numerical simulations.