Measurements of Ion Stopping around the Bragg Peak and its Dependence on Temperature and Density in High-Energy-Density Plasmas

Johan FRENJE[1], Chikang LI[1], Maria GATU JOHNSON[1], Fredrick SEGUIN[1], Hong SIO[1], Richard PETRASSO[1], Riccardo FLORIDO[2], Roberto MANCINI[3], Taisuke NAGAYAMA[4], Paul GRABOWSKI[5], Hans RINDERKNECHT[5], Vladimir GLEBOV[6] and Sean REGAN[6]

1) Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA
E-mail: jfrenje@psfc.mit.edu

2) Departamento de Física, Universidad de Las Palmas de Gran Canaria, Spain

3) Department of Physics, University of Nevada, Reno, Nevada 89557, USA

4) Sandia National Laboratory, Albuquerque, New Mexico 87185, USA

5) Lawrence Livermore National Laboratory, Livermore, CA 94550, USA

6) University of Rochester, Rochester, New York 14623, USA

Over the last few decades, ion stopping in weakly- to strongly-coupled plasmas has been subject to extensive analytical and numerical studies, but only a limited set of experimental data exists to check the validity of these theories. In addition, most of these experiments did not probe the detailed characteristics of the Bragg peak (peak ion stopping) and its dependence on temperature and density. To the best of our knowledge, only a couple of experiments have been able to measure ion stopping ranging from linear low-velocity stopping, through the Bragg peak, to high-velocity stopping [1,2]. The work described in this presentation makes significant advances over previous experimental efforts by quantitatively characterizing the ion stopping, around the Bragg peak and its dependence on temperature and density. This was achieved by measuring the energy loss of DD-tritons, D^3He-alphas, DD-protons and D^3He-protons, with distinctly different velocities, in well-characterized plasma conditions, i.e., measured $n_e(r,t)$ and $T_e(r,t)$, and the results indicate that the Bragg peak varies strongly with T_e and n_e. These experiments also represent the first sensitive test of state-of-art plasma-stopping-power theories around the Bragg peak, which is an important first step in obtaining a fundamental understanding of DT-alpha stopping in HED/ICF plasmas, a prerequisite for understanding ignition margins in implosion designs with varying hot spot areal density at the National Ignition Facility.

The work described herein was performed in part at the LLE National Laser User's Facility (NLUF), and was supported in part by US DOE (Grant No. DE-FG03- 03SF22691), LLNL (subcontract Grant No. B504974) and LLE (subcontract Grant No. 412160-001G).

References

[1] D. G. Hicks et al., Phys. Plasmas 7, 5106 (2000).

[2] J. A. Frenje et al., Phys. Rev. Letters 115, 205001 (2015).