

## Laser-driven shock acceleration of mono-energetic ion beams

F. Fiuza

*GoLP/Instituto de Plasmas e Fusão Nuclear – Laboratório Associado*

*Instituto Superior Técnico, Lisbon, Portugal*

Ion acceleration from the interaction of ultrahigh intensity lasers with plasmas is a promising approach for compact and bright ion sources, of interest to several applications such as tumor therapy, radiography, or ion fast ignition. Most of these applications require high quality (1-10% energy spread) and high energy ( $> 100$  MeV) ion beams. However, the conditions for optimization of the beam quality and energy are not yet fully understood.

We show that the interaction of two plasma slabs/regions with different densities and/or temperatures can lead to the formation of electrostatic shocks capable of reflecting ions to high energies and with high quality.

The required conditions for shock formation and mono-energetic ion acceleration can be obtained by strongly heating a near-critical density tailored plasma profile with an intense laser. The target has a sharp ramp at the front and an exponential ramp at the back, which can be obtained by pre-heating the target in realistic experimental conditions. The control of the TNSA fields associated with the slowly decreasing density profile allows for the shock accelerated ion beam to leave the plasma maintaining a high quality. Recent experimental results have confirmed this scenario [1].

Our theoretical analysis and multi-dimensional particle-in-cell simulations demonstrate the possibility of using this scheme to generate high quality proton beams with energies in the required range for medical applications (100-300 MeV) with moderate laser intensities ( $a_0 \sim 10$ ).

*In collaboration with A. Stockem, E. Boella, R. A. Fonseca, L. O. Silva, D. Haberberger, S. Tochitsky, C. Gong, W. B. Mori, and C. Joshi*

### References

- [1] D. Haberberger, S. Tochitsky, F. Fiuza et al., Nature Physics 8, 95 (2012)