

Project title: Ion sources for Fast Ignition of fusion fuel

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Helpful existing knowledge:	A good physics background would be sufficient, but some previous knowledge of plasma physics would be helpful.
Funding status:	To be confirmed

Project Description:

Beyond the recent demonstration of indirect-drive target-gain at US's National Ignition Facility, further progress towards Inertial Fusion Energy (IFE) requires significantly higher target gains than achieved so far, which motivates research in alternative approaches able to satisfy this requirement. Amongst these, the concept of Fast Ignition (FI) is based on the idea of heating the fuel through the energy deposited by an intense, short burst of particles at the end of a laser-driven compression. The use of protons, or higher-Z ions, accelerated by a separate intense laser pulse, has been proposed for this purpose. A key requirement is the generation of very large fluxes of ions, which is reflected in the need for acceleration mechanisms capable of converting efficiently the laser energy into kinetic energies of the particles.

The project will investigate ponderomotive ion acceleration on PW and multi-PW system with the aim of producing dense beams of protons and mid-Z ions (Carbon, Boron). In particular, the hole-boring mechanism, accelerating ions from the front of an extended, irradiated target has great potential for generating high-flux ion beams in energy ranges of 10s of MeV/nucleon (suitable as a trigger in a fast ignition configuration). By employing suitable targets, e.g. foam-coated foils, where the laser interacts with a controlled density layer, we plan to investigate and characterize ion acceleration under a range of different irradiation and target conditions, in national and international laser facilities such as EPAC, ELI Beamlines/NP, APOLLON, with the aim of providing source guidance for future integrated experiments on systems such as the VULCAN2020 laser. The project will be run in collaboration with the Central Laser Facility of the Rutherford Appleton Laboratory, and, in addition to the experimental component, will include a programme of numerical simulations employing Particle in Cell codes.

Useful references

- M. Roth et al, Phys. Rev. Lett., **86**, 436 (2001)
- A.P.L. Robinson et al, Plasma Phys. Control. Fusion, **51**, 024004 (2009)
- A. Macchi, M. Borghesi, M. Passoni, Rev. Mod. Phys., **85**, 751 (2013)
- D. Molloy et al, Phys. Rev. Res., **7**, 013230 (2025)