42) Topic: Effects of prepulses on laser-driven ion acceleration

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Abstract: Plasma produced by high intensity lasers may generate quasistatic electric fields which are able to accelerate ions to MeV energies over micron-scale distances. In a typical experiment, solid or liquid target is irradiated by ultrashort laser pulse of intensity which hugely exceeds ionization threshold of any material and is able to heat electrons to relativistic velocities. The pulse duration ranges from tens of femtoseconds to a few picoseconds, depending on the laser system used. Laser systems generating shortest pulses (< 100 fs) have been developed to operate at high repetition rate (>= 1 Hz) which can be useful for potential applications. One of the main problems of the using of ultrashort pulses is the existence of laser pedestal and / or short prepulses preceding the main pulse. This nanosecond pedestal and femtosecond prepulses are able to destroy thin targets even before its interaction with the main pulse. There are various methods how to reduce the intensity of this laser pedestal/prepulses and to increase substantially laser pulse contrast (ratio of peak laser pulse intensity to prepulse intensity). However, it is very challenging to reduce the prepulse intensity below ionisation threshold which can be about ten orders of magnitude below the intensity of the main pulse. Thus, even with ultrahigh laser contrast, target can be partially ionized and evaporated before the main pulse which can create the so-called preplasma. Also, the so-called rear-side plasma (or skirt) can be created behind the rear surface of the target which strongly reduces the efficiency of laser-driven ion acceleration.

It is quite challenging to interpret experimental results on ion acceleration using finite laser pulse contrast. Target state before the main pulse arrival can be measured experimentally with only very limited spatial and temporal resolution, not sufficient for any serious interpretation of the achieved results. Supporting numerical simulations may help. However, various numerical methods have to be used to describe the whole interaction. Therefore, the main goal of this dissertation is to integrate experimental and theoretical effort in the description of laser-driven ion acceleration with finite contrast laser pulses. PhD student should obtain broad skills both in experimental group led by L. Giuffrida at ELI-Beamlines as well as in plasma particle-in-cell simulations useful for the description of ionized target interaction with main laser pulse (supervised by J. Psikal) and in hydrodynamic simulations useful for modelling of target interaction with laser pulse pedestal and possibly prepulses (supervised by M. Kucharik).