Getting the most out of laser-ion acceleration - Recent proton acceleration results, published in PRL, point to a novel scheme to enhance the proton flux from laser-foil interaction.

The acceleration of protons and light ions from intense laser-foil interaction has come to prominence as a potential alternative to conventional ion acceleration concepts. The exceptional properties of the emitted beams have prompted speculation about their use in conventional fast ion applications e.g. ion implantation and inducing nuclear reactions, and a range of novel applications made feasible by the unprecedented short burst duration and peak brightness of the laser based sources.

A recent experiment carried out by a team of researchers from the CLF, Queen's University Belfast, the University of Strathclyde and the University of Darmstadt at the Vulcan Petawatt laser facility has successfully demonstrated a novel approach to laser ion source optimisation. The researchers found that the flux of MeV protons accelerated from a thin hydrocarbon layer on the surface of gold foils could be significantly enhanced by adding a relatively low energy prepulse to the incident laser profile. Employing a prepulse containing 10% of the total laser energy, the energy of the multi-MeV proton population was seen to increase by up to a factor of 3.3. The relative delay between the prepulse and the main laser pulse was shown to be critical in boosting the proton numbers and required sub-picosecond control. Simulations carried out at the CLF helped establish the mechanism of this flux enhancement. It was shown that the prepulse increases the absorption of the main pulse in the target foil and also affects the acceleration in the hydrocarbon layer, where the repulsion between heavy carbon ions and light protons provides a strong additional source of energy transfer to protons.

These results suggest it is possible to significantly increase the fraction of the laser energy transferred to multi-MeV protons with a tailored laser pulse shape. As this approach is purely optical and doesn't require complex targets it is scalable to high shot repetition rates. High flux laser-accelerated proton beams may find applications in warm dense matter studies and light ion fast ignition ICF schemes.