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Energetic ion beams from relativistically transparent ultra-thin foils

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In high intensity laser solid interactions, it has been supposed that going to ultra thin foils will allow access to novel regimes of acceleration such as radiation pressure, hole boring and relativistic transparency. We present data from an experiment on the Vulcan Petawatt laser at the Central Laser Facility, UK. We irradiated ultra-thin CH foils with a 220J, 1ps laser pulse focussed to a 9.5μm spot at 0° incidence to accelerate ions of >50MeV.

The use of ultra thin foils necessitates the use of a high contrast laser pulse. The improved OPCPA front end of Vulcan PetaWatt produced a contrast ratio at 1ns before the pulse of 10-10, allowing us to obtain energetic protons from CH foils down to 25nm thickness, without the use of a plasma mirror. A study of optimum target thickness was carried out and a thickness of 250nm was found to give the highest energy proton beams.

During relativistic transparency the bulk electron population is heated to super-ponderomotive energies, resulting in strong longitudinal accelerating fields. These findings are supported by an analytical model and 2D particle-in-cell simulations.

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