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Intense, double pulse irradiation of targets for MeV proton acceleration

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The efficient generation of MeV proton beams using lasers is an area of interest due to its potential applications, ranging from radiotherapy to the fast ignition concept for inertial confinement fusion. Various efficiency-enhancing schemes have been put forward, including using ultra-clean pulses with nm thick foils, and structured targets such as hemispheres to enhance fields. One method, temporally separating sub-picosecond, ultra-intense pulses, has been shown to increase the conversion efficiency of laser energy to MeV protons[1]. Using this scheme, we performed an experimental characterization of proton acceleration at the Titan laser at Lawrence Livermore National Laboratory. Thin (um-scale) foil targets were irradiated by two 700 fs, 1ω pulses separated by 1 to 5 ps; the total beam energy was 100 J, with 5-20% of the total energy contained within the first pulse. Radiochromic film stacks and magnetic spectrometers were used to measure the proton beam spectrum and conversion efficiency. The effect on electron generation, which is an intermediate stage of proton acceleration, was measured using Kα x-ray emission from buried Cu tracer layers, while specular light diagnostics indicated the laser coupling efficiency into the target. A substantial increase was not observed, likely due to a moderating effect of laser prepulse energy, which was on the order of 10 mJ. These results will be presented and compared to particle-in-cell (PIC) simulations.

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[1] Brenner et al., Appl. Phys. Lett. 104, 081123 (2014).

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