Robust energy enhancement of ultrashort pulse laser accelerated protons from reduced mass targets

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We present a systematic study of the ultrashort pulse laser driven acceleration of protons from thin targets of finite lateral size, so-called reduced mass targets (RMTs). Reproducible series of targets varying in size, thickness, and mounting geometry were manufactured with lithographic techniques. Irradiating these targets at the 150 TW Draco Laser facility of the Helmhotz-Zentrum Dresden-Rossendorf with ultrashort (30 fs) laser pulses of intensities of about 8×10^{20} W/cm^2, a robust maximum energy enhancement of almost a factor of two was found when compared to reference irradiations of plain foils of the same thickness and material. Furthermore, these targets exhibit a reduced performance dependence on target thickness compared to standard foils, which, based on detailed PIC simulations can be explained by the influence of the RMT geometry on the electron sheath. The performance gain was, however, restricted to lateral target sizes of about 50 μm which was attributed to edge and mounting structure influences. The contribution of the large electric fields at the target edges to the proton acceleration performance was investigated with measurements of the proton beam profile as well as optical pump and probe experiments.