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Off-harmonic optical probing of high intensity laser interaction with cryogenic hydrogen jet target

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High-intensity short-pulse lasers in the Petawatt regime offer the possibility to study new compact accelerator schemes by utilizing high-density targets for the generation of energetic ion beams. The optimization of the acceleration process demands comprehensive exploration of the plasma dynamics involved, for example via optical probing. In particular, experiments using low density cryogenic hydrogen jet targets with μm -scale transverse size are well suited to deliver new results which can then be compared to predictive particle-in-cell simulations. However, strong plasma self-emission and conversion of the plasma's drive laser wavelength into its harmonics often masks the interaction region and complicates data analysis. Here, we present a stand-alone probe laser system operating at 1030 nm, far off the plasma's drive laser wavelength of 800 nm and its implementation into an experiment dedicated to laser-proton acceleration from the hydrogen jet target irradiated by the DRACO PW laser at Helmholtz-Zentrum Dresden –Rossendorf. We show that the plasma self-emission in the probe images is significantly suppressed and we are able to measure the pre-expansion of the target by the DRACO PW laser for intrinsic and for plasma mirror enhanced laser contrast. The influence of the plasma pre-expansion on the measured proton acceleration performance is presented.

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