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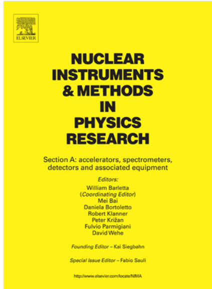

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Controlling laser driven proton acceleration using a deformable mirror at a high repetition rate

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Abstract

We present results from a proof-of-principle experiment to optimize energy spectrum of laser driven protons by directly feeding back its spectral information to a deformable mirror (DM) controlled by evolutionary algorithms (EAs). By irradiating a stable high-repetition rate tape driven target with ultra-intense pulses of $\sim 10^{20}$ W/cm^2, we optimize the maximum energy of the accelerated protons with a stability of less than ~5% fluctuations near optimum value. Moreover, due to spatio-temporal development of the sheath field, modulations in the spectrum are also observed. Particularly, a prominent narrow peak is observed with a spread of ~15% (FWHM) at low energy part of the spectrum. These results are helpful to develop high repetition rate optimization techniques required for future laser-driven ion accelerators.

Keywords: Laser driven protons, TNSA, Deformable mirror, Evolutionary algorithm, High rep. rate

1. Introduction

The acceleration of ions beams using high power lasers emerges as a promising alternative to conventional accelerators and have attracted considerable interest over the last decade due to potential applications in science, industry and health care. Some of these applications are ion driven fast ignition, investigation of warm dense matter and high energy physics, generation of secondary radations, plasma radiography and hadron therapy [1]. In this context, the most investigated mechanism is the target normal-sheath acceleration (TNSA) [1]. In this mechanism, ions acceleration is due to the development of a large sheath electric field (TV/m) at the rear side of the target as the hot electrons, generated in the interaction, propagtes through the target. Protons, being lighter than other hydrocarbon contaminents present on the rear surface of the target, are accelerated most effectively in the normal direction to the target [1]. These proton beams exhibit unique properties, viz. short pulse duration, high brightness and low transverses emittance [1]. However, the characteristic broad energy spectrum and large angular spread poses significant challenges for their use in potential applications including proton therapy for cancer treatment and fast ignition [1, 2]. In order to use laser-driven protons for aforementioned applications, improvement in different parameters e.g, stability, maximum energy and broad energy spread are essential [3]. In addition to use the complex target designs or ultrathin targets [4, and references therein] for optimization of laser-driven proton beams, many publications [3–10] show the control of the spectrum by manipulating the laser beam profile. Control of the proton beams using optical methods are peferable [11]. Since this will be advantegeous for the development of next generation sources at a given high repeition rate [12, 13]. Use of deformable mirrors (DMs) is considered as a simple way of shaping a laser beam profile [5]. Recently, DMs have been

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