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Long-lasting laser-driven proton source

In recent decades, there has been a growing interest in laser-driven ion acceleration as an alternative to conventional accelerators currently in use, thanks to a comparatively compact size and reduced costs **[1]**. The ultrashort, large flux ion beams produced are advantageous in several fields, such as medicine, for FLASH therapy, or proton radiography of micro and nano structures **[2]**. The small source size and ultra-high beam quality also allows to generate a compact neutron source using a closely coupled secondary target **[1,3]**. Moreover, laser-driven ion beams are also useful to replicate outer space conditions due to the broad ion spectrum, as well as the simultaneous presence of other kinds of radiation, including electrons and gamma rays **[3]**.

At the Laser Laboratory for Acceleration and Applications (L2A2) of the University of Santiago de Compostela, a high repetition rate femtosecond laser of 45 TW is used for ion acceleration. It can deliver pulses of 1.2 J and 25 fs at 10 Hz, which are focused down to a few microns spot achieving intensities greater than 10^{19} W/cm^2. Following the interaction, the target is destroyed, making it necessary to continuously replace it for a fresh one. Furthermore, such a fresh target must be placed at the focal plane with precisions in the few microns range. In the context of radionuclide production, this process must be performed for extended periods of times, on the order of tens of minutes for an accelerator operating at Hertz repetition rates, in order to reach the required activation levels of the secondary target. For this purpose, a novel targetry system needs to be developed to accomplish these requirements. Here, we present the design of a tape-drive target which consists of two spools that move a thin tape, while ensuring the tension and positioning of the target remain constant. This target system allows several thousands of shots since it can mount up to 50 metres of the few microns tapes required for efficient laser-ion acceleration. Preliminary measurements indicate a stability of up to 8 µm standard deviation (˜40 microns peak to peak), with ongoing developments to further improve these values.

In addition to replacing the target at such repetition rates, a future laser-based accelerator also requires the laser system to remain stable throughout long irradiation sessions. For this reason, the laser stability has been characterised for an extended period of up to 6 hours, focusing on its energy, pointing, and wavefront. Results showed a slow variation of the laser properties, with slight energy loss, pointing drift and an introduction of astigmatism in the wavefront, with potential solutions to these issues being currently explored.

[1] A. Macchi, M. Borghesi, and M. Passoni, *Reviews of Modern Physics* 85.2 (2013): 751.

[2] P. Chaudhary, et al. *Radiation Oncology* 17.1 (2022): 1-14.

[3] H. Daido, N. Mamiko, and A. S. Pirozhkov. *Reports on progress in physics* 75.5 (2012): 056401.

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