Staging Helical Coil Modules to Enhance Post-Acceleration of Ions

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All-optical approaches to ion acceleration are attracting a significant research effort internationally. While ion beams are readily generated using high intensity lasers via the target normal sheath acceleration (TNSA) process [1], there are limitations in the ion energies that can be achieved through this process depending on the laser intensity and the characteristics of the target. Methods for boosting ion energies by capturing and reaccelerating the particles have been proposed in the past, but experimental demonstrations have been limited. A recent concept demonstrated post-acceleration of TNSA ions employing a miniature helical coil, which harnesses the extremely high electric fields of the electromagnetic pulse launched into the coil from the laser irradiated target [2]. Additional benefits of such approach is its ability to guide and post-accelerate a narrow energy band of protons within the broad spectrum produced by the TNSA process. Recent experiments have demonstrated pencil beams up to 50 MeV through deployment of the scheme at a Petawatt-class laser [3]. In a proof-of-principle experiment, we investigated the possibility of staging helical coil modules using the TITAN Laser at the Lawrence Livermore National Laboratory in California. The experiment employed the dual beam laser configuration and a two-stage geometry, where each beam interacted with a separate helix target. This arrangement allowed the second helix's effect on the proton beam produced by the first helix to be studied through varying the time delay between the two laser beams. Results from this experiment will be presented along with particle tracing simulations.

[1] M. Borghesi, 2014, Laser-driven ion acceleration: State of the art and emerging mechanisms, Nuclear Instruments and Methods in Physics Research A

[2] S. Kar et al, 2016, Guided post-acceleration of laser-driven ions by a miniature modular structure, Nature Communications

[3] H. Hamad, S. Kar et al, to be submitted 2018, Quasi-monoenergetic pencil beam up to 50 MeV employing laser-driven helical coil