New helical coil design with controlled dispersion for the post-acceleration and focusing of TNSA protons

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Helical targets [1] allow us to focus and post-accelerate a proton beam generated by Target Normal Sheath Acceleration (TNSA) [2]. This scheme uses the discharge current [3] generated by the charge ejection from the laser-plasma interaction. The current will be driven through a conducting helical coil (HC), generating a localised electro-magnetic pulse (EMP) inside the coil which will focus, post-accelerate and bunch part of the TNSA proton beam. This scheme was validated for constant pitch and diameter HC on several experiments [1, 4] and is of great interest for numerous applications, from isochoric heating of dense material to isotopes or neutrons production [5].

I will present the development of a new HC design surrounded by a metallic sheath in order to strongly reduce the discharge current dispersion in the HC. Large-scale Particle-In-Cell (PIC) Simulations via SOPHIE [6], a code developed at CEA-CESTA, show a drastic effect of the metallic sheath on the current propagation through the helical targets and, by extension, the EMP generation inside the coil.

The PIC simulations as well as the results of the theoretical model we developed in our team show two main effects of the sheath depending on the HC used. The first one is a strong bunching effect above and under the characteristic energy of the HC, the second is the strong post-acceleration possible when using a progressive pitch which allows to synchronise the current pulse with the accelerated protons.

The first shots with this sheath scheme have been performed at the end of 2022 on the APOLLON laser and future shots to observe both the bunching and the post-acceleration will take place on the ALLS installation at INRS in 2023.

References

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