Study of chromatic focusing, post-acceleration and bunching of protons accelerated by Target Normal Sheath Acceleration in helical targets

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Helical coils (HC) [1] allow focusing and post-acceleration of protons accelerated by Target Normal Sheath Acceleration (TNSA). This scheme uses the discharge current, generated by the charge expulsion from the laser-plasma interaction, as it flows through a conducting helix. The current's propagation produces an electromagnetic pulse (EMP) inside the helix that focuses, post-accelerates and bunches part of the proton beam. This device has been validated, for constant pitch and diameter helixes, by several experiments [1, 2]. This technique is promising for several applications requiring high maximum proton energies and very collimated beams..

Experimental results have been compared to large-scale Particle-In-Cell (PIC) simulation with the SOPHIE code. The good agreement between experimental results and simulated data gives us a better understanding of the phenomenology behind the processes inside the device and allows us to use PIC simulations for the design of future experiments.

New experimental campaigns, lead on the LULI2000 installation with high energy laser pulses (50J, 1ps) irradiating helical coils, allowed us to deepen the study of focusing, bunching and post-acceleration of proton beams. We have observed the efficiency of micro-coils in modulating the TNSA proton beam, the influence of the coil geometry on the output proton beam as well as the current limitations of the device, such as the low yield in charge.

We have also developed a numerical model based on the traveling wave tubes theory and validated by comparaison to PIC simulations. It will be used for optimisation work in the design of the next experimental campaigns, as it is more adapted than PIC codes for this purpose.

References

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