Surpassing TNSA performance in laser proton acceleration in the relativistic transparency regime

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Exploiting the strong electromagnetic fields that can be supported by a plasma, high-power laser driven compact plasma accelerators can generate short, high-intensity pulses of high energy ions with special beam properties. By that they may expand the portfolio of conventional machines in many application areas. The maturation of laser driven ion accelerators from physics experiments to turn-key sources for these applications will rely on breakthroughs in both, generated beam parameters (kinetic energy, flux), as well as increased reproducibility, robustness and scalability to high repetition rate. Recent developments at the high-power laser facility DRACO-PW enabled the production of polychromatic proton beams with unprecedented stability [1]. This allowed the first in vivo radiobiological study to be conducted using a laser-driven proton source [2]. Yet, the ability to achieve energies beyond the 100 MeV frontier is matter of ongoing research, mainly addressed by exploring advanced acceleration schemes like the relativistically induced transparency (RIT) regime.
In this talk we report on experimental proton acceleration studies at the onset of relativistic transparency using pre-expanded plastic foils. Combined hydrodynamic and 3D particle-in-cell (PIC) simulations helped to identify the most promising target parameter range [3] matched to the prevailing laser contrast conditions carefully mapped out in great detail beforehand. A complex suite of particle and optical diagnostics allowed characterization of spatial and spectral proton beam parameters and the stability of the regime of best acceleration performance, yielding cut-off energies larger than 100 MeV in the best shots.

References

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