Towards Stopping Power Experiments with LIGHT

Haress Nazary[1], Martin Metternich[1], Dennis Schumacher[2], Abel Blazevic[2,5], Florian-Emanuel Brack[3,4], Florian Kroll[3,4], Christian Brabetz[2], Ulrich Schramm[3,4], Vincent Bagnoud[1,2,5], Markus Roth[1]
[1]*Technische Universität Darmstadt, Darmstadt, Germany*
[2]*GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany*
[3]*Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany*
[4]*Technische Universität Dresden, Dresden, Germany*
[5]*Helmholtz-Institut Jena, Jena, Germany*
h.nazary@gsi.de

The Laser Ion Generation, Handling and Transport (LIGHT) beamline at GSI is part of the ATHENA distributed facility, where phase-space manipulations of laser-generated ion beams is the main emphasis. In the last few years, the LIGHT collaboration was able to routinely generate and focus intense 8 MeV proton bunches with a temporal duration shorter than 1 ns (FWHM).

An interesting area of application that exploits the short ion bunch properties of LIGHT is the study of the ion-stopping power of plasmas, a key process in inertial confinement fusion for understanding energy deposition in dense plasmas. The most challenging regime is found when $v_{projectile} \approx v_{thermal,e}$, a regime for which ion stopping is difficult to describe and the existing theories show high discrepancies. Since conclusive experimental data is missing in this regime, we plan to conduct experiments on laser-generated plasma probed with ion bunches generated and shaped with the LIGHT Beamline at higher temporal resolution than previously achievable. The high temporal resolution is important because the parameters of laser-generated plasmas are changing on the nanosecond timescale. Therefore, the temporal length of the plasma-probing ion bunches should be as short as possible to reduce the uncertainties caused by the averaging over the fast-changing plasma parameters.

To meet this goal, our recent studies have dealt with ions of lower kinetic energies. In 2021, laser accelerated carbon ions were transported with two solenoids and focused temporally with LIGHT's radio frequency cavity. A pulse length of 1.2 ns (FWHM) at an energy of 0.6 MeV/u was achieved. In 2022, protons with an energy of 0.6 MeV/u were transported and temporally compressed to a pulse length of 0.8 ns. The temporally compressed and spatially focused ion beam will be used for energy loss measurements. The plasma will be generated by a nanosecond laser (nhelix).

In my talk, I will present the planned experiment, its requirements and show its feasibility based on preliminary experiments done with LIGHT and predictive simulations.