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Advancement of high intensity laser driven particle accelerators to application readiness

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Improved control of high intensity laser beam parameters on target recently enabled proton energies beyond 100 MeV, dose-controlled sample irradiation experiments, and the demonstration of seeded FEL light.
This presentation focuses on the chain of developments at the Petawatt laser DRACO at Helmholtz-Center Dresden-Rossendorf that enabled the first dose controlled systematic irradiation of tumors in mice [1] with laser accelerated protons. Details on acceleration mechanisms and strategies to increase stability and energy will be discussed [2] as well as beam transport by means of a dedicated pulsed solenoid beamline to a secondary target together with online metrology and dosimetry. In parallel, improved control of interaction parameters together with different types of targets operated close to relativistic induced transparency enabled the exploitation of acceleration mechanisms surpassing target normal sheath acceleration [3,4]. Here proton energies well beyond 100 MeV could be reached at repetition rate compatible laser parameters.
With improved LWFA parameters, in particular spectral charge density and beam divergence, a dedicated beamline operated by Synchrotron Soleil at HZDR enabled the first observation of seeded FEL light from a laser plasma electron accelerator [5]. Strategies to develop this source to the EUV range, of interest for probing of plasma densities relevant for ion acceleration, will be discussed.

References:
[1] F. Kroll, et al., Nature Physics 18, 316 (2022)
[2] T. Ziegler, et al., Scientific Reports 11, 7338 (2021)
[3] N. Dover, et al., Light: Science and Applications 12, 71 (2023), T. Ziegler et al., Nature Physics 20, 1211 (2024)
[4] M. Rehwald, et al., Nature Communications 14, 4009 (2023)
[5] M. Labat, et al., Nature Photonics 17, 150 (2023)

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