AKBP 13: Novel Accelerators II

Time: Thursday 11:30–12:30 Location: SCH/A117

AKBP 13.1 Thu 11:30 SCH/A117

High-Repetition-Rate Electron Beams from a Multi-kHz LPA Driven by an Industrial Laser System — Bonaventura Farace[1], Kristijan Poder[1], •Taegyu Pak[1], Esmerando Escoto[1], Nikita Khodakovskiy[1], Christoph Heyl[1], and Wim Leemans[1,2] — [1]Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany — [2]University of Hamburg, Department of Physics, Jungiusstr. 9, 20355 Hamburg, Germany

Laser-plasma accelerators (LPAs) provide a compact platform for generating ultrashort, high-brightness electron beams and are gaining attention as next-generation electron sources. For practical use, the driving laser must operate stably at high repetition rates with high average power and scalability. Here, we report the first demonstration of electron acceleration using an industrial Yb-based laser compressed via a multi-pass cell (MPC) post-compression stage. The Yb:YAG laser was spectrally broadened in a 2-m long MPC and compressed from 1.3 ps to 49 fs, delivering 9 mJ on target at repetition rates up to 12.5 kHz. With these post-compressed pulses, we generated high-repetition-rate electron beams and characterised their charge, energy spectrum and transverse beam profile. The source produced 10 pC per shot with a thermal-like spectrum extending up to 5 MeV and operated robustly in the multi-kHz regime. These results demonstrate a new technological route for generating high-repetition-rate electron beams with industrial Yb lasers. They also open pathways toward applications that require high repetition rates and ultrashort pulses, including ultrafast electron diffraction and FLASH-type irradiation schemes.

AKBP 13.2 Thu 11:45 SCH/A117

Temperature diagnostics for MHz-repetition-rate plasma accelerator sources — •Juan Pablo Díaz[1,2], Judita Beinortaite[1], Maryam Huck[1], Harry Jones[1], Anna Křivková[1], Gregor Loisch[1], Gudrid Moortgat-Pick[1,2], Lukas Müller[1], Trupen Parikh[1], Stephan Wesch[1], Matthew Wing[3,1], and Jonathan Wood[1] — [1]DESY, Hamburg, Germany — [2]Universität Hamburg, Germany — [3]University College London, UK

Electron-bunch-driven plasma-wakefield accelerators promise to revolutionize particle acceleration by providing compact and cost-effective energy boosters for electron linacs which could, for example, significantly enhance the photon energies produced by free-electron lasers. The FLASHForward facility at DESY has made substantial progress, demonstrating that accelerated electron bunches can maintain their charge, energy spread, and emittance during plasma acceleration. A major challenge remains in achieving high-repetition-rate operation. Reaching MHz-level repetition rates, necessary to match superconducting RF linac bunch patterns, means generating reproducible plasma acceleration events at MHz frequencies. Doing so poses significant challenges: keeping the plasma density uniform over these rapid cycles and dealing with the high heat load placed on the plasma cell by the plasma formation process and the drive beam. In this contribution, we report on recent efforts to characterize the long-term heating effects arising in a discharge plasma source at repetition rates up to 1 kHz. We will present measurements of the time evolution of the discharge plasma source and discuss the implications of these results.

AKBP 13.3 Thu 12:00 SCH/A117

Statistical analysis of sources of instability in electron beam quality in laser plasma accelerators preparing for Bayesian optimization — •Franziska Marie Herrmann[1,2], Maxwell Laberge[1], Yen-Yu Chang[1], Amin Ghaith[1], Jeffrey Kelling[1], Susanne Schöbel[1], Patrick Ufer[1,2], Ulrich Schramm[1,2], and Arie Irman[1] — [1]HZDR, Dresden, Germany — [2]Technische Universität Dresden, Dresden, Germany

Laser-electron accelerators are emerging as novel, compact sources of high-quality relativistic electron beams for a wide range of applications. Each experimental application requires unique electron parameters. Additionally, all the input parameters are interconnected, resulting in a highly complex parameter space. To address this issue, we have developed a semi-automated Bayesian optimization loop that adjusts six input parameters simultaneously to achieve optimal electron beam parameters. However, the high nonlinearity of laser wakefield acceleration poses a challenge for automated optimization, as even minor fluctuations in input parameters can lead to significant changes in electron beam properties. To quantify and mitigate the effects of these statistical fluctuations, we have compiled an extensive dataset through systematic studies of their characteristics and influence on the electron beam quality. Alongside demonstrating an initial prototype for semi-automated Bayesian optimization, this work will enhance the understanding of the underlying sources of instability in laser-plasma acceleration experiments, which are essential for more complex machine learning experiments.

AKBP 13.4 Thu 12:15 SCH/A117

Characterization of kinetic instabilities in high-intensity, short-pulse, laser-driven solid-density plasmas — •Jannis Schulz — TU Dresden — HZDR

We present a study of instabilities in plasmas generated by the interaction of electron beams accelerated by intense femtosecond laser pulses with dense solid targets. At intensities exceeding 10^{18} W/cm^2, the beam-plasma system develops collective processes that strongly influence energy and particle transport. As an overarching framework, the analysis of linear stability properties is used to systematically describe the emergence and evolution of characteristic structures. The main emphasis lies on transverse filamentation instabilities, in particular the collisional-resistive regime, whose growth is strongly affected by electrical conductivity and current distribution. In addition, longitudinal processes such as the two-stream instability are examined, arising from counter-propagating electron populations. The classification relies on analytically derived dispersion relations, which allow the comparison of growth rates and wavelengths with numerical simulations and latest experiments performed at LCLS and EuropeanXFEL. The objective is to clarify the mechanisms that drive the development of these instabilities, connect them to the structures observed in the simulations, and ultimately connect them to the underlying plasma conditions (e.g. beam and background densities and effective temperatures).