AKBP 2: Novel Accelerator Concepts I

Time: Tuesday 13:45–15:45 Location: ZHG004

Group Report AKBP 2.1 Tue 13:45 ZHG004

Energy Compression of a Laser-Plasma Accelerator — •Paul Winkler[1], Max Trunk[1], Lars Hübner[1], Alberto Martinez de la Ossa[1], Sören Jalas[1], Manuel Kirchen[1], Ilya Agapov[1], Sergey A. Antipov[1], Reinhard Brinkmann[1], Timo Eichner[1], Angel Ferran Pousa[1], Thomas Hülsenbusch[1], Guido Palmer[1], Matthias Schnepp[2], Kaja Schubert[1], Maxence Thévenet[1], Paul A. Walker[1], Christian Werle[1], Wim P. Leemans[1,2], and Andreas R. Maier[1] — [1]Deutsches Elektronen Synchrotron, DESY — [2]Universität Hamburg

Laser-Plasma accelerators (LPAs) promise a compact alternative to modern RF-technology, and support orders of magnitude higher electric fields. GeV-energy LPA electron beams from cm-scale sources have been demonstrated. However, the central energy jitter and energy spread, both on the percent-level, have yet prevented LPAs to drive real-world applications.

Here, we present active energy compression of laser-plasma accelerated electron beams. At the LUX experiment at DESY, a dipole chicane stretches the beams in time and thereby imprints an energy-time correlation (a chirp), which is subsequently removed inside an RF cavity. Our setup reduces the fluctuation in central energy as well as the energy spread of the beams by more than an order of magnitude down to the permille-level. We demonstrate performance so far only attributed to modern RF based accelerators which opens the door for a variety of applications, such as compact plasma-based injectors for synchrotron storage rings.

AKBP 2.2 Tue 14:15 ZHG004

Ultrafast plasma wave shadowgraphy for laser wakefield acceleration — •Paula Sedlatschek, Marc Osenberg, Thomas Heinemann, Mirela Cerchez, Onur Bilen, Edgar Hartmann, and Bernhard Hidding — Institute for Laser- and Plasmaphysics, Heinrich Heine University Düsseldorf

Plasma Shadowgraphy via an ultrashort laser pulse can be utilized to probe the small and fast processes in laser wakefield accelerators (LWFAs). This high-resolution technique reveals the plasma dynamics in the sub-micrometer, femtosecond-regime and visualizes the accelerating plasma wave. We present our approach to implement such a probe laser, using a low-power split-off from the main laser driver which is subsequently and further spectrally broadened. The modulated spectrum of the probe laser enables the use of cut-off filters which block the fundamental spectrum from the accelerating main laser. This is leading to precise visualization of density gradients within the plasma. By integrating this method, we aim for a comprehensive characterization of critical LWFA parameters, such as plasma density evolution, wakefield stability, and laser-plasma coupling. This non-intrusive diagnostic intends to improve our laser wakefield accelerator.

AKBP 2.3 Tue 14:30 ZHG004

Optical Imaging as Synthetic Diagnostic in PIConGPU — •Finn-Ole Carstens[1,2], Richard Pausch[1], Klaus Steiniger[1], Fabia Dietrich[1,2], Jessica Tiebel[1,2], Nico Wrobel[1,2], Susanne Schöbel[1], Patrick Ufer[1,2], Arie Irman[1], Michael Bussmann[1], Ulrich Schramm[1,2], and Alexander Debus[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Dresden, Deutschland — [2]Technische Universität Dresden, Dresden, Deutschland

We present a synthetic shadowgraphy plugin for the particle-in-cell code PIConGPU. By time-integrating electric and magnetic fields and propagating them onto a screen in the far field with Fourier methods, shadowgram images equivalent to experimental measurements can be produced.

Our in-situ plugin enables recording few-cycle probe pulses after they propagate through plasma structures of e.g. laser-plasma accelerators. Propagation of the probe pulse takes place during the normal PIC cycle, meaning that all laser-plasma interactions are self-consistently taken into account. By analyzing these shadowgrams alongside the 3D, time-resolved density distribution from the simulation, one can trace the origin of specific features, such as cavity elongation and deformation and a variety of scattering signals that allow improving our understanding of the cavity formation and dynamics in experiments.

AKBP 2.4 Tue 14:45 ZHG004

Multidimensional sensitivity analysis of laser wakefield accelerated electrons in dependence on laser and plasma parameters — •Jessica Tiebel[1,2], Richard Pausch[1], Finn-Ole Carstens[1,2], Fabia Dietrich[1,2], Franziska Herrmann[1,2], Arie Irman[1], Susanne Schöbel[1,2], Klaus Steiniger[1,3], René Widera[1], and Ulrich Schramm[1] — [1]Helmholtz-Zentrum Dresden - Rossendorf — [2]Technische Universität Dresden — [3]CASUS, Görlitz

Laser-plasma accelerators (LPAs) are a promising tool for generating high-charge, low-emittance electron beams, with broad applications in science and research. LPAs are highly sensitive to variations in laser and plasma parameters, some of which are detectable and others of which are difficult or impossible to measure. In addition, many of these parameters are subject to significant fluctuations. The limited knowledge of the parameters and the non-linear nature of laser wakefield acceleration (LWFA) make experimental investigations of the dependencies between laser and plasma parameters and electron beam properties challenging. In this work, we present a simulation-based study to develop a multi-dimensional mapping of laser and plasma parameters to electron beam parameters for self-truncated ionization injection in LWFA. Using the multi-GPU particle-in-cell code PIConGPU and an automated Snakemake workflow, we performed a comprehensive exploration of the parameter space. This study reveals complex multidimensional dependencies and provides actionable insights for experimentalists to optimize input parameters and achieve high quality electron beams with greater efficiency.

AKBP 2.5 Tue 15:00 ZHG004

Metrology of gas targets designed for laser plasma wakefield accelerators — •Natascha Thomas, Thomas Heinemann, Constantin Aniculaesei, and Bernhard Hidding — Institute of Laser- and Plasmaphysics, Heinrich Heine University Düsseldorf

Laser Wakefield Acceleration (LWFA) relies on the precise formation of plasma waves (wakes) driven by intense laser pulses to accelerate charged particles. The dynamics of this process thereby depend on the generated plasma density profile, which is, in turn, determined by the underlying gas density of the utilized targets. For this reason, an accurate and reliable measurement of their characteristics is an essential prerequisite for optimizing LWFA experiments. We present the development and application of an optical diagnostic setup built for the characterization of such gas jets over a wide range of densities and profiles. The system's design offers high flexibility and rapid adaptation to a range of various targets. Additionally, first results and further ideas for improved data collection and analysis are discussed.

AKBP 2.6 Tue 15:15 ZHG004

Recent developments of the cSTART project — •Markus Schwarz, Erik Bründermann, Robert Ruprecht, Axel Bernhard, Bastian Härer, Dima El Khechen, Anton Malygin, Michael Johannes Nasse, Gudrun Niehues, Alexander Papash, Jens Schäfer, Marcel Schuh, Nigel Smale, Pawel Wesolowski, Christina Widmann, Thiemo Schmelzer, Nathan Ray, David Squires, Alexander Saw, Joseph Natal, Anke-Susanne Müller, and Matthias Fuchs — KIT, Karlsruhe, Germany

The combination of a compact storage ring and a laser-plasma accelerator (LPA) can serve as the basis for future compact light sources. One challenge is the large momentum spread (about 2%) of the electron beams delivered by the LPA. To overcome this challenge, a very large acceptance compact storage ring (VLA-cSR) was designed as part of the compact STorage ring for Accelerator Research and Technology (cSTART) project, which will be realized at the Karlsruhe Institute of Technology (KIT, Germany). Initially, the Ferninfrarot Linac- Und Test-Experiment (FLUTE), a versatile source of ultra-short bunches, will serve as an injector for the VLA-cSR to benchmark and emulate LPA-like beams. In a second stage, a laser-plasma accelerator will be used as an injector. The small facility footprint, the large-momentum spread bunches with charges from 1 pC to 1 nC and lengths from few fs to few ps pose challenges for the lattice design, RF system and beam diagnostics. Recently, the Technical Design Report was developed in cooperation with Research Instruments and subcontractors. This contribution summarizes the latest state of the project.

AKBP 2.7 Tue 15:30 ZHG004

Laser-plasma accelerator as injector for the cSTART storage ring — •David Squires, Alexander Saw, Nathan Ray, Joseph Natal, and Matthias Fuchs — IBPT, KIT, Karlsruhe, Germany

Laser-plasma accelerators (LPAs) are promising options for next-generation accelerator facilities. Accelerating structures on the millimeter scale and accelerating gradients several orders of magnitude higher than RF cavities suggest that LPAs can be used as compact accelerators that produce ultrashort pulses of high intensity electrons. We plan to develop an LPA-based injector for cSTART, a compact, high-acceptance storage ring to be built at the Karlsruhe Institute of Technology (KIT).

The LPA injector for our compact storage ring must produce electron beams with a comparatively low beam energy (50-90 MeV) for an LPA, have a narrow relative energy spread (4%), and a high shot-to-shot stability. Reaching these parameters is challenging and requires extensive simulation work before physical devices are built. In our study, we have used fbpic to simulate an ionization injection scheme in combination with tailored plasma density profiles to generate stable LPA beams. The density profile enables us to reach the desired beam energy and energy spread.