AKBP 13: PWA, DLA, Thomson and Compton Scattering

Zeit: Donnerstag 14:00–16:00 Raum: S1/05 24

AKBP 13.1 Do 14:00 S1/05 24

Synthetic radiation diagnostics in PIConGPU - integrating spectral detectors into particle-in-cell codes — •Richard Pausch[1,2], Alexander Debus[1], Heiko Burau[1,2], Axel Huebl[1,2], Klaus Steiniger[1,2], René Widera[1], and Michael Bussmann[1] — [1]Helmholtz-Zentrum Dresden - Rossendorf — [2]Technische Universität Dresden

We present the in-situ far field radiation diagnostics in the particle-in-cell code PIConGPU. It was developed to close the gap between simulated plasma dynamics and radiation observed in laser plasma experiments. Its predictive capabilities, both qualitative and quantitative, have been tested against analytical models. Now, we apply this synthetic spectral diagnostics to investigate plasma dynamics in laser wakefield acceleration, laser foil irradiation and plasma instabilities.

Our method is based on the far field approximation of the Liénard-Wiechert potential and allows predicting both coherent and incoherent radiation spectrally from infrared to x-rays. Its capability to resolve the radiation polarization and to determine the temporal and spatial origin of the radiation enables us to correlate specific spectral signatures with characteristic dynamics in the plasma. Furthermore, its direct integration into the highly-scalable GPU framework of PIConGPU allows computing radiation spectra for thousands of frequencies, hundreds of detector positions and billions of particles efficiently.

In this talk we will demonstrate these capabilities on resent simulations of laser wakefield acceleration (LWFA) and high harmonics generation during target normal sheath acceleration (TNSA).

AKBP 13.2 Do 14:15 S1/05 24

Modeling Traveling-wave Thomson scattering using PIConGPU — •Alexander Debus[1], Klaus Steiniger[1,2], Richard Pausch[1,2], Axel Huebl[1,2], Ulrich Schramm[1], Thomas Cowan[1], and Michael Bussmann[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden — [2]Technische Universität Dresden, 01062 Dresden

Traveling-wave Thomson scattering (TWTS) laser pulses are pulse-front tilted and dispersion corrected beams that enable all-optical free-electron lasers (OFELs) up to the hard X-ray range. Electrons in such a side-scattering geometry experience the TWTS laser field as a continuous plane wave over centimeter to meter interaction lengths.

After briefly discussing which OFEL scenarios are currently numerically accessible, we detail implementation and tests of TWTS beams within PIConGPU (3D-PIC code) and show how numerical dispersion and boundary effects are kept under control.

AKBP 13.3 Do 14:30 S1/05 24

Towards the Realization of a Dielectric Laser Accelerator Beamline: Staging and Transverse Dynamics — •Joshua McNeur, Martin Kozak, Norbert Schönenberger, Ang Li, Alex Tafel, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Staudtstr. 1, 91058 Erlangen

Dielectric laser accelerators (DLAs) belong to a novel regime of accelerators that aim to reduce both the cost and footprint of state-of-art Microwave Linacs. Their orders-of-magnitude smaller footprints and larger acceleration gradients potentially enable University-lab scale (and smaller) high energy electron sources with a wide range of applications, ranging from tumor irradiation to x-ray generation. However, to progress from the proof of principle DLA experiments [1,2] to a DLA-based accelerator beamline, many challenges need to be addressed. Here, we discuss experimental confirmation of DLA-based staging, deflection and focusing, crucial steps towards the realization of a DLA-beamline [3].

1.Peralta, E. A. et al. Demonstration of electron acceleration in a laser-driven dielectric microstructure Nature 503, 91-94 (2013).

2.Breuer, J. & Hommelhoff, P. Laser-Based Acceleration of Non-relativistic Electrons at a Dielectric Structure. Phys. Rev. Lett. 111, 134803 (2013).

3.McNeur, J., Kozak, M. et al., submitted

AKBP 13.4 Do 14:45 S1/05 24

Application of dielectric laser acceleration technique for temporal and spatial characterization of charged particle beams — •Martin Kozák, Joshua McNeur, Norbert Schönenberger, Alex Tafel, Ang Li, and Peter Hommelhoff — Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Staudtstrasse 1, 91058 Erlangen, Germany, EU

In this contribution we show the use of dielectric laser acceleration for sub-optical cycle temporal gating and transverse streaking of free electrons at sub-relativistic energies (25-30 keV). Utilizing the inverse Smith-Purcell effect [1,2], the energy and/or transverse momentum of electrons are modulated by the interaction with near-fields of a dielectric nanostructure. The sub-cycle temporal structure of the femtosecond laser pulse is transferred to the electron beam. Combined with high-pass energy filtering of accelerated electrons, this allows us to achieve temporal resolution of 1.3 fs. This technique can have direct applications in ultrafast diffraction and microscopy or as a tool for temporal characterization of attosecond particle bunches, potentially offering 10 as temporal resolution. Moreover, the sub-wavelength spatial decay of optical near-fields at the nanostructure can be used for beam position monitoring applications with spatial resolution better than 500 nm.

[1] J. Breuer, and P. Hommelhoff, Phys. Rev. Lett. 111, 134803 (2013). [2] E. A. Peralta, et al. Nature 503, 91-94 (2013).

AKBP 13.5 Do 15:00 S1/05 24

Commissioning of the LUX Beamline for Laser-Plasma Driven Undulator Radiation — •A. R. Maier — Center for Free-Electron Laser Science & Department of Physics University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Plasma-based accelerators promise ultra-compact sources of highly relativistic electron beams, especially suited for driving novel x-ray light sources. Within the LAOLA Collaboration, the University of Hamburg and DESY work closely together, combining university research with the expertise of a large and well-established accelerator facility, to enhancing the performance of plasma accelerators for applications. Here, we discuss and show first results from the commisssioning of the so-called LUX beamline for plasma-driven undulator radiation. We cover laser operations using an accelerator controlls system, laser transport and diagnostics, as well as target area design. As an outlook, we will discuss the experimental strategies in Hamburg towards a first proof-of-principle FEL experiment using plasma-driven electron beams available today.

AKBP 13.6 Do 15:15 S1/05 24

Tailoring Laser Wakefield Accelerated electron beams; an experimental study on the influence of experimental conditions on electron beam parameters — •Jurjen P. Couperus[1,2], Alexander Koehler[1,2], Omid Zarini[1,2], Axel Jochmann[1], Axel Huebl[1,2], Alexander Debus[1], Arie Irman[1], and Ulrich Schramm[1,2] — [1]Institute of Radiation Physics, Helmholtz-Zentrum Dresden - Rossendorf, Germany — [2]Technische Universität Dresden, Germany

Laser wakefield acceleration (LWFA) has emerged as a promising concept for the next generation of high energy electron accelerators. In LFWA a high intensity ultrashort laser pulse drives plasma density waves, inducing a high accelerating field gradient in the order of GV/m.

To create stable reproducible electron beams, tailoring of experimental parameters like gas density, laser energy and laser pulse duration is required. In this talk we present an overview of our experimental studies with the DRACO (3J on target, 30 fs) laser on ultrasonic gas-jet targets (He & He-N_2 mixtures). We discuss the influence of experimental parameters on beam parameters like beam charge, shot-to-shot stability and energy distribution, both in the self-injecting bubble regime as well as in the ionisation injection regime.

AKBP 13.7 Do 15:30 S1/05 24

Measuring of ultrashort electron bunch durations from Laser-wakefield accelerators via a broadband, single-shot spectrometer. — •Omid Zarini[1,2], Jurjen Couperus[1,2], Alexander Köhler[1,2], Axel Jochmann[1], Alexander Debus[1], Arie Irman[1], and Ulrich Schramm[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf — [2]Technische Universität Dresden

Laser-wakefield accelerators (LWFA) feature electron bunch durations ranging from several fs to tens of fs. Due to the nonlinear nature of the injection and acceleration process in such accelerators, small changes in experimental conditions lead to the electron bunch properties which are often subject to large shot-to-shot variations. Single-shot measurement of a broadband coherent and incoherent transition radiation produced by the LWFA electron bunches is a promising way to deduce the longitudinal structure of such bunches. In this talk we present results from our recent measurement campaign by analyzing transition radiation spectra produced as LWFA electron bunches pass a metal foil. We investigate electron bunch longitudinal structure generating from different acceleration regimes, i.e., ionization-injection and self-injection. Knowledge and control of the electron bunch duration is essential for the design of future table-top and x-ray light-sources.

AKBP 13.8 Do 15:45 S1/05 24

Plasma-based ultrashort electron bunch diagnostic — •Irene Dornmair[1], Carl B. Schroeder[2], Klaus Floettmann[3], Barbara Marchetti[3], and Andreas R. Maier[1] — [1]Center for Free-Electron Laser Science & Department of Physics, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg — [2]Lawrence Berkeley National Laboratory, California 94720, USA — [3]Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg

Ultrashort electron bunches of few femtoseconds length are highly desirable for a large number of applications, such as ultrafast electron diffraction, free-electron lasers or for external injection into plasma wakefields. A precise knowledge of the longitudinal phase space is crucial for these applications and in order to optimize bunch compression. However, measuring the bunch length or even the current profile becomes increasingly challenging for ever shorter bunches. We will present a new method to diagnose ultrashort bunches using laser-driven plasma wakefields and explore its limitations in terms of resolution in time and energy spread.