AKBP 10: Plasma Accelerators, Diagnostics I

Time: Wednesday 15:00–16:15 Location: SCH/A117

Topical Talk AKBP 10.1 Wed 15:00 SCH/A117

Multiscale longitudinal electron bunch characteristics of LWFA bunches determined by single-shot CTR spectroscopy — •Alexander Debus[1], Maxwell LaBerge[1], Omid Zarini[1,2], Susanne Schöbel[1], Jessica Tiebel[1,2], Finn-Ole Carstens[1,2], Nico Wrobel[1,2], Richard Pausch[1], Klaus Steiniger[1], Yen-Yu Chang[1], Jurjen Couperus Cabadağ[1], Alexander Köhler[1,2], Thomas Kurz[1,2], Rafal Zgadzaj[3], Michael Downer[3], Michael Bussmann[1], Ulrich Schramm[1], and Arie Irman[1] — [1]HZDR, Dresden, Germany — [2]TU Dresden, Germany — [3]UT Austin, USA

The longitudinal structure of ultra-short electron bunches produced in laser-wakefield accelerators (LWFAs) is strongly influenced by the rapid injection dynamics as well as by ongoing interactions between the driving laser and the accelerated beam. Gaining a detailed picture of these bunch structures is key for progressing toward compact FELs and other advanced secondary light sources.

We report experimental findings derived from single-shot broadband coherent transition radiation (CTR) spectroscopy (spanning UV to mid-IR, 250 nm - 11.35 μm) generated as LWFA electron bunches traverse a metal foil. Through analysis of the CTR spectra, we reconstruct the corresponding electron bunch profiles. Our results reveal that electron bunches originating from different injection processes exhibit intricate longitudinal structures spanning multiple temporal scales, from the overall envelope down to sub-micrometer features. These patterns vary systematically with the injection regime and align with signatures observed in the electron spectrometer.

AKBP 10.2 Wed 15:30 SCH/A117

Novel approaches of using transition radiation to diagnose driver dynamics in plasma wakefield accelerators — •Nico Wrobel[1,3], Finn-Ole Carstens[1,3], Alexander Debus[1], Arie Irman[1], Maxwell La Berge[1], Susanne Schöbel[1], Ulrich Schramm[1,3], Klaus Steiniger[1,2], Jessica Tiebel[1,3], Patrick Ufer[1], and Richard Pausch[1] — [1]Helmholtz-Zentrum Dresden - Rossendorf e.V., DE — [2]Center for Advanced Systems Understanding, Görlitz, DE — [3]TU Dresden, DE

LPWFA is a new hybrid accelerator concept which combines laser wakefield accelerators (LWFA) and plasma wakefield accelerators (PWFA), resulting in an ultra-compact form factor while promising improved beam quality, compared to LWFA. The dynamics of the PWFA driver are investigated due to their impact on the capabilities to accelerate particles in the plasma wake. Since the driver beam dynamics cannot be directly observed in experiment, new diagnostic methods had to be explored, which we will present here.

Coherent transition radiation (CTR) was investigated to diagnose longitudinal and transversal driver dynamics with the help of the open-source particle-in-cell code PIConGPU. We were able to detect the breakup of the driving bunch through the emitted CTR spectrum and developed a novel diagnostic approach, which may be able to reconstruct time-dependent driver dynamics, like driver oscillation, from CTR measurements.

AKBP 10.3 Wed 15:45 SCH/A117

From studying to controlling injection dynamics in laser wakefield accelerators — •Jessica Tiebel[1,2], Richard Pausch[1], Michael Bussmann[1], Finn-Ole Carstens[1,2], Alexander Debus[1], Klaus Steiniger[1], René Widera[1], and Ulrich Schramm[1,2] — [1]Helmholtz-Zentrum Dresden - Rossendorf — [2]Technische Universität Dresden

Laser Wakefield Accelerators (LWFAs) enable the generation of highly relativistic, high charge, low emittance electron beams within only a few millimeters of acceleration. Their compactness and favorable electron beam properties make them attractive for many applications, like compact plasma wakefield drivers, synchrotron sources or free electron lasers. Enabling application-ready operation requires precise control over the sensitive and non-linear acceleration process, and therefore a deep understanding of the injection process and bunch evolution.

We used the open-source, multi-GPU particle-in-cell code PIConGPU to perform a comprehensive investigation of the acceleration and injection process. This enabled us to explain discontinuities in the injection process of self-truncated ionization injection (STII) and their consequent impact of the spatial and spectral charge distribution of the electron bunch. Based on these findings, we provide a practical guide for controlling STII to achieve the targeted electron beam parameters.

AKBP 10.4 Wed 16:00 SCH/A117

Time-Resolved Interferometry Measurement of Ultrasound Pulses generated by Laser-Accelerated Ions in Water — •Hannah Forsthuber, Julia Liese, Florian Schweiger, Alexander Prasselsperger, Sonja Gerlach, Xiang Chen, Kumudini Pagare, and Jörg Schreiber — LMU München, Fakultät für Physik - Medizinische Physik, Am Coulombwall 1, 85748 Garching

Recent progress in laser-driven ion acceleration and its applications in radiation-therapy research demands sensitive techniques to probe processes like ionoacoustic pressure waves. Building on earlier work using optical detection of refractive-index changes caused by ion beams in water, this project investigates a Mach-Zehnder interferometric approach operated near destructive interference. By combining high optical intensities with a balanced-detection scheme, the setup aims to enhance sensitivity to the weak acoustic signatures generated by laser-accelerated ion bunches at LMU's Center for Advanced Laser Applications. The method targets temporally and spatially resolved measurements of the pressure-wave evolution within the interaction volume, providing complementary information to transducer-based diagnostics [1]. The performance of the interferometric system will be evaluated in forthcoming experiments, with initial results expected by the time of the conference. Ultimately, this optical technique aims to deepen the understanding of ion-induced acoustic phenomena and to advance diagnostic capabilities for laser-accelerated ion sources in radiation-research environments.[1] S. Gerlach et al., High Power Laser Science and Engineering 11, 38 (2023)