Beitrag ID: **20** Typ: **Talk**

High-charge electron acceleration in the self-modulated laser-wakefield acceleration regime at PHELIX

Montag, 26. Januar 2026 18:40 (20 Minuten)

Laser–plasma accelerators promise a compact alternative to conventional radio-frequency accelerators, but achieving simultaneously high charge, high stability, and scalability at high repetition rates remains a major challenge. Here, we demonstrate that self-modulated laser wakefield acceleration (SM-LWFA) driven by picosecond laser pulses provides a robust pathway to generate electron bunch-charges of 100s of nanocoulomb. These experiments at the PHELIX facility, supported by three-dimensional particle-in-cell simulations, reveal that the acceleration dynamics are governed primarily by the laser power relative to the plasma density, rather than by the initial focal intensity. Once the relativistic self-focusing threshold is exceeded, the laser self-organizes to a smaller spot size dependent on the density, making the process largely insensitive to the focusing geometry. This finding overturns the conventional view that tight focusing is essential for efficient acceleration and provides a simple scaling law linking beam charge and cutoff energy mainly to the laser power and plasma density. We report on the results of the commissioning experiment, with beam charges up to (500+-160) nC and cutoff energies beyond 300 MeV. Extrapolating our scaling-results to upcoming lower-energetic 20 J, 100 Hz picosecond-class laser systems allow for average beam currents above 25 μA, which approach the capabilities of conventional accelerators. These results could establish SM-LWFA as a powerful and experimentally accessible regime for generating high-charge electron beams, enabling high-brightness x-ray, gamma-ray sources for fundamental research and applications.

Autor: HORNUNG, Johannes (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Co-Autoren: WINTER, Victor (TU-Darmstadt); BOLLER, Pascal; TARISIEN, Mehdi; MAITRALLAIN, Antoine; MINJOU-GARCÍA, Élodie; SCHULTHEIS, Carl-Simon; KUSCHEL, Stephan; GUTIERREZ, David; MARTÍNEZ, Cecilia; SALGADO, Carlos; HENARES, José-Luis; BRABETZ, Christian; BERTINI, Denis; ZIELBAUER, Bernhard; BAGNOUD, Vincent

Vortragende(r): HORNUNG, Johannes (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Sitzung Einordnung: Session 3 - Short Pulse 1