AKBP 4: Beam Dynamics

Time: Monday 16:45–18:00 Location: SCH/A117

AKBP 4.1 Mon 16:45 SCH/A117

Improving Energy spread of MESA beam in ERL operation
— Esraa Khidr and •Florian Hug — Johannes Gutenberg university Mainz

Precise control of longitudinal beam dynamics is crucial at the Mainz Energy-Recovering Superconducting Accelerator (MESA), particularly in support of the MAGIX experiment, which operates in ERL mode. Comprehensive simulations were conducted using the elegant tracking code; starting with 4 ps bunch length, the full acceleration and deceleration process in ERL was modeled by optimizing the RF phase and the accelerating gradient field in off-crest operation, resulting in the desired energy gain in each linac section. At low energies, improved energy spread is required with a short bunch length; therefore, the injection arc was optimized for a 2 ps bunch by adjusting the arc momentum compaction R56 and introducing an energy*position correlation (chirp) downstream of MAMBO. The resulting optimization provides enhanced bunch compression and reduces the longitudinal phase-space width, while preserving longitudinal emittance and thereby enhancing overall beam quality not only at the lowest but also at all energies.

AKBP 4.2 Mon 17:00 SCH/A117

Determining the influence of transversal beam excitation on beam size and dynamics at KARA
— •Simon Braner[1], Marvin-Dennis Noll[1], Johannes Steinmann[1], Erhard Huttel[1], Anke-Susanne Müller[1], Erik Bründermann[1], and Michele Caselle[2] — [1]IBPT, KIT, Karlsruhe — [2]IPE, KIT, Karlsruhe

Significant beam dynamics parameters, such as energy spread or transversal beam size, can be calculated from the transversal bunch profile. At the Karlsruhe Research Accelerator (KARA), located at the Karlsruhe Institute of Technology (KIT), the beam size in the storage ring is being investigated using the KArlsruhe Linear arraY detector for MHz rePetition rate SpectrOscopy (KALYPSO), a line array that examines the synchrotron radiation emitted at a five-degree port of a dipole magnet. Trench-Isolated Low-Gain Avalanche Diode (TI-LGAD) technology provides superior sensitivity compared to conventional silicon detectors, thereby facilitating the study of low-charge bunches. As the KALYPSO system can be triggered at several megahertz, turn-by-turn analysis can be performed at KARA, which has a revolution frequency of 2.7 MHz. In addition to the study of the energy spread, the analysis of beam size and position modulations can be performed. These can either occur naturally or be induced by a white noise signal on a strip line. In this contribution, the influence of transversal beam excitation on beam size and time-resolved dynamics at KARA is investigated.

AKBP 4.3 Mon 17:15 SCH/A117

Coulomb Crystallization in Free Electron Beams
— •Valerio Di Giulio[1,2], Rudolf Haindl[1,2], and Claus Ropers[1,2] — [1]Max Planck Institute for Multidisciplinary Sciences, Göttingen, Germany — [2]University of Göttingen, Göttingen, Germany

In the context of electron beams, the Coulomb repulsion experienced by the constituents of high-current probes is usually regarded as a detrimental effect, leading to emittance growth. However, under suitable conditions, electron-electron interactions can be exploited to produce phase space distributions with well-defined energy-time correlations, as recently observed in few-electron pulses photoemitted from a metallic nanotip and imaged in a transmission electron microscope (R. Haindl et al., 2023). Such correlations can be leveraged to harness specific beam properties by selecting a portion of the probe. Extending this concept to higher currents and larger particle numbers, the beam can enter a crystalline state, forming an electron lattice defined by Coulomb repulsion, a Wigner crystal. In this work, we employ Monte Carlo simulations to examine the conditions under which Coulomb crystallization can emerge in both few-particle and continuous electron beams, exploring the interplay between beam temperature, current, and electromagnetic confinement. We compute properties associated with different structural phases, revealing a strong enhancement of beam brightness in the crystalline regime. We also present new measurements of electron-electron energy correlations in pulses containing from 4 to 8 particles, demonstrating the transient formation of an ordered electron chain during propagation in the microscope.

AKBP 4.4 Mon 17:30 SCH/A117

Status of the Compton Backscattering Source COBRA at the S-DALINAC*
— •Lisa B. Dingeldein, Michaela Arnold, Ruben Grewe, Julian Hauf, Maximilian Herbert, Katharina E. Ide, Lars Jürgensen, Maximilian Meier, Clemens M. Nickel, Norbert Pietralla, and Dominic Schneider — Institut für Kernpysik, Technische Universität Darmstadt, Darmstadt, Germany

The COBRA source (Compton Backscattering at a Recirculating Accelerator) utilizes a 100 W Yb:YAG laser, which is synchronized with the electron beam of the superconducting Darmstadt linear accelerator S-DALINAC [1] for head-on collisions. The backscattered photons can be collimated into a quasi-monochromatic beam for electron beam diagnostics and as a technology demonstrator. This contribution highlights recent upgrades and developments of the detector setup, the laser beamline and the beam-stabilization systems of COBRA. The first collision of the electron and laser beam is planned in an upcoming beamtime with multi-turn recirculation. Later, COBRA is foreseen to be operated during energy-recovery mode [2] serving as a demonstrator for future Compton scattering light sources.

[1] N. Pietralla, Nucl. Phys. News **28**(2), 4 (2018)
[2] F. Schliessmann *et al.*, Nat. Phys. **19**, 597-602 (2023)

*This work is supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - Project-ID 499256822 - GRK 2891 'Nuclear Photonics'.

AKBP 4.5 Mon 17:45 SCH/A117

Towards plasma-wakefield photon acceleration and its potential applications
— •Michael Quin[1], Tom Blackburn[1], and Mattias Marklund[2,1] — [1]Department of Physics, University of Gothenburg, SE-41296 Gothenburg, Sweden — [2]Department of Physics, Chalmers University of Technology, SE-41296 Gothenburg, Sweden

A laser pulse copropagating with a relativistic plasma wave (wakefield) can experience a continuous upshift in frequency known as "photon acceleration". Recent particle-in-cell (PIC) simulations have demonstrated how an optical laser pulse can be accelerated to extreme ultraviolet (XUV) frequencies in an electron-beam-driven plasma-wakefield using a tailored plasma density profile. Intense ($I_0 > 10^{17}\,\mathrm{W/cm^2}$) XUV laser light is highly sought after for collision experiments with multi-GeV electrons; the high photon and electron energy indicates the onset of effects in strong-field quantum electrodynamics, such as non-linear Compton scattering and Breit-Wheeler pair production. By combining PIC simulations of photon acceleration with Monte-Carlo simulations of the electron-photon collision, we show how the brilliance, yield, and polarization of the emitted γ-rays can be optimized for applications in nuclear and particle physics.