AKBP 1: Beam Dynamics

Time: Monday 16:00–18:30 Location: AKBPa

AKBP 1.1 Mon 16:00 AKBPa

Beam Dynamics Simulations for the Multi-Turn Energy Recovery Mode at the S-DALINAC* — •Felix Schliessmann, Michaela Arnold, and Norbert Pietralla — Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany

In August 2017, the electron accelerator S-DALINAC [1] at TU Darmstadt was initially operated in the so-called energy recovery mode using one recirculation beamline [2]. Here, once accelerated electrons are guided back to the cavities with an induced phase shift of approximately 180°. In this way, the electrons are decelerated and will restore energy to the cavities, which can then be used to accelerate subsequent electrons.

In the upcoming beam time, the S-DALINAC shall be operated in energy recovery mode using two recirculation beamlines, what involves further challenges: on the one hand, two beams are now superimposed in a recirculation beamline and four beams are superimposed in the linac, and on the other hand, the phase slippages during the linac passes reach such a critical level that they have to be determined in advance and compensated by suitable amplitude and phase settings.

This contribution addresses the necessary beam dynamics simulations in order to realize this multi-turn energy recovery mode.

[1] N. Pietralla, Nuclear Physics News, Vol. 28, No. 2, 4 (2018).

[2] M. Arnold et al., Phys. Rev. Accel. Beams 23, 020101 (2020).

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AKBP 1.2 Mon 16:15 AKBPa

TRIB optics examined by Lie algebraic tools — •Jernej Frank[1,2], Michael Arlandoo[1], Paul Goslawski[1], Ji Li[1], Tom Mertens[1], and Markus Ries[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie — [2]Freie Universität Berlin

At BESSY II in Berlin, a third-generation synchrotron light source facility, two orbits can be populated with different electron bunch fill patterns and provide to some extent two different radiation sources offering unique possibilities to its users. The second stable orbit in the machine was successfully produced by generating Transverse Resonance Island Buckets (TRIBs). In an ongoing effort to get a theoretical handle on the non-linear contributions that lead to TRIBs, we employ Lie algebraic theory to classify effects by order of non-linearity. In contrast to pure numerical particle tracking these tools allow us to enter the "black box" and examine qualitative behaviors such as the impact of symmetry breaking in the operator algebra context usually encountered in quantum field theory. As the whole machine is too complex, we present simple toy models (sections of the optical lattice) that demonstrate the non-linear behavior of the individual machine elements and their impact on lattice design. This contribution revisits Lie algebraic theory as a vital tool for the theoretical understanding of non-linear dynamics and gives a progress report about the importance of basic machine elements that are usually approximated to the linear regime, but produce rich non-linear effects that should not be neglected.

AKBP 1.3 Mon 16:30 AKBPa

The Metrology Light Source 2 — •Michael Arlandoo[1,2] and Paul Goslawski[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie — [2]Humboldt-Universität zu Berlin

The Physikalisch-Technische Bundesanstalt (PTB), in cooperation with the Helmholtz-Zentrum Berlin (HZB), operates the Metrology Light Source (MLS), which is a low-energy electron storage ring. The MLS can be operated in a low-alpha mode to produce coherent synchrotron ration in the far-IR and THz spectral range. In the scope of the Conceptual Design process for a BESSY II successor, the PTB asked also for a MLS successor to cover their increasing demands on synchrotron radiation. A combination of two different machines, one optimized for low emittance (BESSY 3) and the other for flexible timing capabilities (MLS 2), will provide best radiation capabilities for our user community. In this paper, we discuss the demands on the MLS 2 and propose first lattice candidates which satisfy the needs of the PTB and HZB. Currently, we focus on linear lattices with first steps towards non-linear optimization. The lattice design has to include the option for a robust low-alpha operation mode and should be checked for the possibility of TRIBs (Transverse Resonance Island Buckets).

AKBP 1.4 Mon 16:45 AKBPa

Optics Studies at the DELTA Storage Ring — •Benedikt Büsing, Shaukat Khan, Stephan Kötter, Carsten Mai, Boris Sawadski, Detlev Schirmer, and Gerald Schmidt — Center for Synchrotron Radiation (DELTA), TU Dortmund University, Dortmund, Germany

DELTA is a 1.5-GeV synchrotron light source operated by the TU Dortmund University providing synchrotron radiation in a spectrum from hard X-rays to the VUV regime. A new 22-pole 7-T superconducting wiggler has been installed in 2020, optics studies and beta function measurements were performed to compensate the vertical focussing effect. Also studies on bunch shortening by reducing the momentum compaction factor will be presented.

AKBP 1.5 Mon 17:00 AKBPa

Split-ring-resonator experiment at FLUTE - Simulation results — •Jens Schäfer for the FLUTE-Collaboration — KIT, Karlsruhe, Deutschland

FLUTE (Ferninfrarot Linac- Und Test-Experiment) is a compact linac-based test facility for accelerator and diagnostics R&D. An example for a new accelerator diagnostics tool currently studied at FLUTE is the split-ring-resonator (SRR) experiment, which aims to measure the longitudinal bunch profile of fs-scale electron bunches. Laser-generated THz radiation is used to excite a high frequency oscillating electromagnetic field in the SRR. Particles passing through the SRR gap are time-dependently deflected in the vertical plane, which allows a vertical streaking of an electron bunch. This principle allows a diagnosis of the longitudinal bunch profile in the femtosecond time domain and will be tested at FLUTE. This contribution presents an overview of the SRR experiment and the results of various tracking simulations for different scenarios as a function of laser pulse length and bunch charge. Based on these results possible working points for the experiments at FLUTE will be proposed.

AKBP 1.6 Mon 17:15 AKBPa

Detailed studies of the effects of solenoid misalignment and development of beam-based alignment methods for FLUTE — •Micha Reissig for the FLUTE-Collaboration — KIT, Karlsruhe, DE

FLUTE (Ferninfrarot Linac- Und Test-Experiment) is a versatile linac-based test facility at the Karlsruhe Institute of Technology (KIT). It is designed to generate strong ultra-short THz pulses and to provide a platform for detailed accelerator studies and diagnostic development. The aim of wideband THz generation requires electron bunches with a length of a few femtoseconds, therefore a photoinjector is used as electron source. Shortly after the photoinjector, a solenoid is installed to focus the initially diverging beam. Accurate alignment of the magnet is required to avoid transverse deflection of the beam when adjusting operational parameters such as the beam energy or the focal length of the magnet. This presentation provides a detailed study on the effects of solenoid misalignment based on numerical tracking simulations for the FLUTE injector section. Based on this study, an iterative beam-based alignment procedure has been developed. In addition, this contribution provides a proof-of-concept for a software routine that fits the results of simulations to measurement data and, thereby, determines the misalignment of the solenoid.

AKBP 1.7 Mon 17:30 AKBPa

Single-shot spectral fingerprints for continuous observation of the microbunching instability at KARA — •Miriam Brosi[1], Erik Bründermann[1], Carsten Mai[3], Matthias Martin[2], Martin Laabs[4], Niels Neumann[4], Patrick Schreiber[2], Marcel Schuh[1], Johannes L. Steinmann[1], and Anke-Susanne Müller[1,2] — [1]IBPT, KIT, Karlsruhe — [2]LAS, KIT, Karlsruhe — [3]Technische Universität Dortmund — [4]Technische Universität Dresden

The micro-bunching instability occurring in an electron storage ring for short electron bunches leads to the emission of coherent synchrotron radiation (CSR) in the terahertz range. This collective instability can be studied by observing the resulting fluctuations in the emitted CSR power with fast THz detectors. The measurements presented in this contribution were conducted at the KIT electron storage ring KARA (KArlsruhe Research Accelerator) in a dedicated short-bunch operation mode. For the measurements of these instability-induced CSR power fluctuations, an on-chip THz spectrometer providing a spectral fingerprint was used. The mm-sized chip contains eight antennas that are sensitive in different frequency ranges from 50 GHz up to 700 GHz, each connected to a Schottky-diode detector element. The on-chip spectrometer was read-out with the new version of the KArlsruhe Pulse Taking and Ultrafast Readout Electronics system, KAPTURE-2, providing continuous bunch-by-bunch data.

This work was supported by the BMBF projekt 05K16VKA NeoDyn (Federal Ministry of Education and Research).

AKBP 1.8 Mon 17:45 AKBPa

Electron beam studies from intensity modulated photocathode laser pulses for seeding a THz FEL — •Georgi Georgiev[1], Namra Aftab[1], Prach Boonpornprasert[1], Natthawut Chaisueb[1], James Good[1], Matthias Gross[1], Christian Koschitzki[1], Mikhail Krasilnikov[1], Xiangkun Li[1], Osip Lishilin[1], Anusorn Lueangaramwong[1], David Melkumyan[1], Sandeep Mohanty[1], Raffael Niemczyk[1], Anne Oppelt[1], Houjun Qian[1], Hamed Shaker[1], Guan Shu[1], Frank Stephan[1], Grygorii Vashchenko[1], Tobias Weilbach[1], and Wolfgang Hillert[2] — [1]Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738 Zeuthen, Germany — [2]University of Hamburg, 22761 Hamburg, Germany

A THz source is foreseen at the European XFEL for pump and probe experiments. As part of the efforts, a proof-of-principle experiment for an intense FEL-based THz source is under development at the Photo Injector Test Facility at DESY in Zeuthen (PITZ). Different FEL seeding schemes are considered, including temporal photocathode laser pulse modulation. A sub-THz modulated pulse is generated by introducing a Lyot filter into the laser system. The laser pulse is then converted into an electron bunch at the photocathode, which is transported downstream the accelerator until the location of a station for coherent transition radiation. Beam dynamics simulations and experimental results are presented.

AKBP 1.9 Mon 18:00 AKBPa

Effect of negative momentum compaction operation on the current-dependent bunch length at KARA — •Patrick Schreiber[1], Tobias Boltz[1], Miriam Brosi[2], Bastian Haerer[2], Akira Mochihashi[2], Alexander Papash[2], Robert Ruprecht[2], Marcel Schuh[2], and Anke-Susanne Müller[1,2] — [1]LAS, KIT, Karlsruhe — [2]IBPT, KIT, Karlsruhe

New operation modes are considered during the development of new synchrotron light sources. An understanding of the effects involved is inevitable for a successful operation of these schemes. At the KIT storage ring KARA (Karlsruhe Research Accelerator), new modes can be implemented and tested employing a variety of performant beam diagnostics devices. Negative momentum compaction optics at various energies have been established. Also the influence of a negative momentum compaction factor on different effects has been investigated. This contribution will show a short report on the status of the implementation of negative momentum compaction optics at KARA. Additionally, first measurements of the changes to the current-dependent bunch length will be presented.

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AKBP 1.10 Mon 18:15 AKBPa

Excitation of micro-bunching in short electron bunches using RF amplitude modulation — •Tobias Boltz, Edmund Blomley, Miriam Brosi, Erik Bründermann, Bastian Härer, Akira Mochihashi, Patrick Schreiber, Marcel Schuh, Minjie Yan, and Anke-Susanne Müller — KIT, Karlsruhe, Deutschland

In its short-bunch operation mode, the KIT storage ring KARA provides picosecond-long electron bunches, which emit coherent synchrotron radiation (CSR) up to the terahertz frequency range. Due to the high spatial compression under these conditions, the self-interaction of the bunch with its own emitted CSR induces a wakefield, which significantly influences the longitudinal charge distribution. Above a given threshold current, this leads to the formation of dynamically evolving micro-structures within the bunch and is thus called micro-bunching instability. As CSR is emitted at wavelengths corresponding to the spatial dimension of the emitter, these small structures lead to an increased emission of CSR at higher frequencies. The instability is therefore deliberately induced at KARA to provide intense THz radiation to dedicated experiments. To further increase the emitted power in the desired frequency range, we consider the potential of RF amplitude modulations to intentionally excite this form of micro-bunching in short electron bunches.

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