AKBP 6: Diagnostics, Control and Instrumentation I

Time: Wednesday 14:00–16:15 Location: AKBPa

AKBP 6.1 Wed 14:00 AKBPa

Development of a fast betatron tune and chromaticity measurement system — •Philipp Niedermayer, Bernd Breitkreutz, Andreas Lehrach, and Vsevolod Kamerdzhiev — Forschungszentrum Jülich, IKP-4, Jülich, Deutschland

A fast tune measurement is developed for the Cooler Synchrotron COSY at the Institut für Kernphysik of Forschungszentrum Jülich. Betatron oscillations of the beam are excited with an appropriate RF signal via a stripline kicker. Resonant transverse oscillations are then observed using capacitive beam position monitors. Based on the bunch-by-bunch beam position data the betatron tune is determined. The usage of bunch-by-bunch data is characteristic of the new system. It allows for a discrete tune measurement within a few milliseconds, as well as continuous tune monitoring during beam acceleration.

The high precision tune measurement also enables determination of the beam chromaticity. Therefore, the beam momentum is varied by means of the RF frequency and the subsequent tune change is determined. For routine use during beam operation and experiments, the developed method is integrated into the control system.

AKBP 6.2 Wed 14:15 AKBPa

Status of slice emittance measurements at PITZ — •Raffael Niemczyk[1], Prach Boonpornprasert[1], Maria-Elena Castro-Carballo[1], Georgi Georgiev[1], James Good[1], Matthias Gross[1], Christian Koschitzki[1], Mikhail Krasilnikov[1], Anusorn Lueangaramwong[1], Xiangkun Li[1], Osip Lishilin[1], David Melkumyan[1], Sandeep Mohanty[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

The Photo Injector Test facility at DESY in Zeuthen (PITZ) conditions and optimises high-brightness electron sources for X-ray free-electron lasers (FELs). Due to a relatively low energy beam at PITZ (∼20 MeV), the main tool to optimize electron source brightness was projected phase space measurement with a slit mask scan technique. Recently, a new procedure to measure the time-resolved phase space, i.e. slice emittance, was systematically commissioned at PITZ, which adds a transverse deflecting cavity to the slit mask scan. The slice emittance setup optimizations, e.g. time resolution and signal-to-noise ratio, and its applications for electron source optimizations will be presented.

AKBP 6.3 Wed 14:30 AKBPa

Concept of a Beam Diagnostics System for the Multi-Turn ERL Operation at the S-DALINAC* — •Manuel Dutine, Michaela Arnold, Ruben Grewe, Lars Jürgensen, Norbert Pietralla, Felix Schliessmann, and Manuel Steinhorst — Institut für Kernphysik, TU Darmstadt

The S-DALINAC [1] is a thrice-recirculating linear electron accelerator operating in cw-mode at a frequency of 3 GHz. Due to the implementation of a path-length adjustment system capable of a 360° phase shift, it is possible to operate the accelerator as an energy-recovery linac (ERL) [2]. While operating the accelerator in multi-turn ERL mode, there will be two beams in the same beamline. For this mode, a non-destructive beam diagnostics system is necessary in order to measure the beam position of both, the accelerated and the decelerated beam simultaneously in the same beamline. The conceptional study of a 6 GHz resonant cavity beam position monitor will be presented together with a wire scanner measurement and a test measurement of the currently existing 3 GHz monitors as alternative solutions.

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

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

*Work supported by DFG through GRK 2128, BMBF through grant No. 05H18RDRB2 and by the state of Hesse through the LOEWE Research Cluster Nuclear Photonics.

AKBP 6.4 Wed 14:45 AKBPa

Coherent Smith-Purcell radiation for minimally invasive bunch length measurement at the subpicosecond time scale — •Philipp Heil[1,2,3], Kurt Aulenbacher[1,2], Max Bruker[4], Frank Fichtner[1], Simon Friederich[2], and Christoph Matejcek[1] — [1]Institut für Kernphysik, Johannes Gutenberg-Universität Mainz — [2]Helmholtz Institut Mainz — [3]GSI Helmholtzzentrum für Schwerionenforschung Darmstadt — [4]Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA

We have designed a tool to measure the bunch length of an electron beam in a minimally invasive way by means of coherent Smith-Purcell radiation (SPR). The technique has been employed successfully at a test apparatus for the Mainz Energy-recovery Superconducting Accelerator *MESA*, demonstrating it is possible to determine the bunch length while losing less than 0.6 % of the electron beam. The impact of the space charge on the bunch length can be reduced while tuning the longitudinal bunch preparation system during a live measurement at beam currents up to 1 mA. Doing so, it is possible to achieve RMS bunch lengths of 70 μm in a typical operating mode of the low-energy beam transport system of MESA. In addition to the bunch length measurements, typical properties of the generated SPR are demonstrated.

AKBP 6.5 Wed 15:00 AKBPa

OTR diagnostic measurements for the High-Energy Scraper System of the S-DALINAC* — •M. Fischer, M. Arnold, M. Dutine, L. Jürgensen, and N. Pietralla — IKP, TU Darmstadt

The S-DALINAC is the thrice recirculating superconducting electron accelerator at the TU Darmstadt [1]. It delivers electron beams with energies up to 130 MeV which are used, among other things, for experiments in fundamental nuclear physics research. For the high-energy experiments at the S-DALINAC, a small momentum spread of the electron beam is of crucial importance. To reduce the momentum spread and improve the stability of the beam, a high-energy scraper system in the extraction beamline is used. In order to verify the impact of the scraper system, a new beam diagnostic setup was installed in a subsequent dispersive section. It is used to characterize the beam profile and quantify temporal fluctuations of the beam by optical transition radiation (OTR). In this talk, the beam diagnostic setup, its commissioning, and the results of the first measurements will be presented.

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

* Work supported by DFG through GRK 2128.

AKBP 6.6 Wed 15:15 AKBPa

A Diagnostics Setup for Low-Energy Beam Characterization at the Injector of the S-DALINAC* — •A. Brauch, M. Arnold, J. Enders, N. Pietralla, and S. Weih — Technische Universität Darmstadt, Darmstadt, Deutschland

A new superconducting cavity, which is optimized for capturing particles with non maximum velocity $\beta = 0.86$, will be installed at the injector of the superconducting Darmstadt electron linear accelerator (S-DALINAC [1]). For a successful operation of the upgraded injector, detailed knowledge of beam-parameters upstream the capture section is crucial. Therefore, a vertical diagnostics beamline is currently being installed. Capable of transverse and longitudinal beam parameter measurements, the setup will be used to characterize the beams from the thermionic and polarized electron guns. With the anticipated diagnostics data we aim at an acceleration in the superconducting injector linac optimized with respect to energy spread and both longitudinal and transverse beam quality. This contribution introduces the general layout of the diagnostics beamline, the current status, and the design of a transverse deflecting cavity which is planned to be installed for bunch length measurements.

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

*Work supported by the DFG-funded GRK 2128 "AccelencE" and by the Hessian HMWK through the LOEWE research cluster "Nuclear Photonics"

AKBP 6.7 Wed 15:30 AKBPa

Extremum-Seeking-driven RF Control Optimization at the S-DALINAC* — •Manuel Steinhorst, Michaela Arnold, and Norbert Pietralla — IKP, TU Darmstadt

The radiofrequency (rf) control system of the S-DALINAC [1] allows for precise acceleration of the electron beam by keeping the amplitude and phase of the electric accelerating field constant. Residual fluctuations of amplitude and phase due to an unoptimized setting of the rf control parameters can increase the energy spread of the elec-

tron beam. In order to minimize corrsponding contributions to the energy spread, an algorithm based on extremum-seeking control was developed for optimized parameter settings. By minimizing a so-called costfunction, it adjusts the setting of the control, that its contribution to the energy spread is minimized. In this talk, the basic concept of the algorithm and data measured at the S-DALINAC are presented.

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

*Supported by the DFG through GRK 2128 and by the state of Hesse through the LOEWE Research Cluster Nuclear Photonics.

AKBP 6.8 Wed 15:45 AKBPa

Sensitivity Analysis of Beam-influencing Parameters at the S-DALINAC Using Surrogate Models* — •Dominic Schneider, Michaela Arnold, Jonny Birkhan, Norbert Pietralla, and Felix Schliessmann — Institut für Kernphysik, TU Darmstadt, Darmstadt

Machine learning methods provide a significant potential for the optimized operation of complex machinery, such as particle accelerators. In this contribution, the first application of so-called surrogate models to the electron accelerator S-DALINAC [1] will be discussed. This machine learning technique, based on polynomial fitting, gives not only access to predict future behavior based on training data, but also an extensive set of characteristics that can be extracted by analyzing the trained model. The talk will focus on a series of measurements that have been performed at the S-DALINAC in order to investigate the behavior and correlations of beam-influencing elements on the one hand and the performance of surrogate models on the other hand. Particularly, the global sensitivity analysis as well as Sobol indices will be discussed.

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

*Work supported by DFG through GRK 2128

AKBP 6.9 Wed 16:00 AKBPa

Investigation of the pickup signal for bunch arrival-time monitors with ultra-short electron bunches in free electron laser applications — •Bernhard Erich Jürgen Scheible[1,3], Marie Kristin Czwalinna[2], Wolfgang Ackermann[3], Holger Schlarb[2], Herbert De Gersem[3] und Andreas Penirschke[1] — [1]Technische Hochschule Mittelhessen, Friedberg, Germany — [2]DESY, Hamburg, Germany — [3]Technische Universität Darmstadt, Germany

X-ray free-electron lasers (XFEL) open up new frontiers across many areas of research and science. Numerous experiments require ultra-short pulse durations for measurements in fs-time-scales. Therefore, a reliable synchronization system with sub-10 fs precision is necessary, even for ultra-low bunch charges. The established all-optical synchronization systems depend on transient fields of passing electron bunches coupled into the pickups of the bunch arrival-time monitors (BAM). The extracted signal is imprinted on reference laser pulses by amplitude modulation in a Mach-Zehnder type electro-optical modulator. The sensitivity of the BAM depends in particular on the slope of the bipolar signal at the zero-crossing. In order to understand the limitations of the current pickups and to enable advances in design, it is crucial to examine the pickup signal by numerical and analytical methods. In this contribution, the theoretical foundations are reviewed with special attention to the less common case of ultra-short bunch lengths.