# AKBP 8: Advanced IT Tools

Time: Wednesday 15:45–17:15 Location: CHE/0183

AKBP 8.1 Wed 15:45 CHE/0183

**Image space reconstruction algorithm for LPS tomography at PITZ** — •Namra Aftab[1], Prach Boonpornprasert[1], Georgi Georgiev[1], Matthias Gross[1], Andreas Hoffmann[1], Mikhail Krasilnikov[1], Xiangkun Li[1], Anne Oppelt[1], Christopher Richard[1], Frank Stephan[1], Grygorii Vashchenko[1], Wolfgang Hillert[2], and Andrew Reader[3] — [1]Deutsches Elektronen-Synchrotron, Zeuthen, Germany — [2]University of Hamburg, Institute for Experimental Physics, Hamburg, Germany — [3]School of Biomedical Engineering and Imaging Sciences, Kings College London, UK

At the Photo Injector Test facility at DESY in Zeuthen, longitudinal phase space (LPS) before the booster is determined by an iterative reconstruction method called Algebraic Reconstruction Technique (ART). Although ART is simple to implement with good convergence speed, the results show many artefacts and overestimate energy spread and bunch length. Recently LPS tomography was done via Image Space Reconstruction Algorithm (ISRA) which showed promising results owing to its assurance of non-negative solution. The weight matrix crucial for successive updates was improved by bilinear interpolation. The initial guess for iterations was established from low energy section momentum measurements. The aforementioned reforms resulted in reduced noise-like artefacts, better convergence speed and accurate longitudinal emittance. ISRA was tested on simulations as well as on experimental data. It can diagnose not only linear chirp in LPS but also higher order effects. Experiments with modulated laser beams were also designed to demonstrate the diagnostic capability.

AKBP 8.2 Wed 16:00 CHE/0183

**Injection Optimization via Reinforcement Learning at the Cooler Synchrotron COSY** — •Awal Awal[1,2], Jan Hetzel[2], and Jörg Pretz[1] — [1]RWTH Aachen University — [2]GSI Helmholtzzentrum für Schwerionenforschung

In accelerator facilities, it is important to have a particle beam with high intensity and small emittance in a timely manner for the successful operation of the experiments. The main challenges limiting the availability of the beam to the users and limiting the beam intensity in storage rings are the lengthy optimization process and the injection losses. The setup of the Injection Beam Line (IBL) depends on a large number of configurations in a complex, non-linear, and time-dependent way. Reinforcement Learning (RL) methods have shown great potential in optimizing various complex systems. However, unlike other optimization methods, RL agents are sample inefficient and have to be trained in simulation before running them on the real IBL. In this research, RL agents are trained to learn the optimal injection strategy of the IBL for the Cooler Synchrotron (COSY) at Forschungszentrum Jülich. The challenge of sim-to-real transfer, where the RL agent trained in simulation does not perform well in the real world, is addressed by incorporating domain randomization. The goal is to increase the beam intensity inside COSY while decreasing the setup time required. This method has the potential to be applied in future accelerators like the FAIR facility.

AKBP 8.3 Wed 16:15 CHE/0183

**Beam Trajectory Control with Lattice-Agnostic Reinforcement Learning** — •Chenran Xu[1], Erik Bründermann[1], Jan Kaiser[3], Anke-Susanne Müller[1,2], and Andrea Santamaria Garcia[2] — [1]IBPT, KIT, Karlsruhe — [2]LAS, KIT, Karlsruhe — [3]DESY, Hamburg

In recent work, it has been shown that reinforcement learning (RL) is capable of outperforming existing methods on accelerator tuning tasks. However, RL algorithms are difficult and time-consuming to train and currently need to be retrained for every single task. This makes fast deployment in operation difficult and hinders collaborative efforts in this research area. At the same time, modern accelerators often reuse certain structures within or across facilities such as transport lines consisting of several magnets, leading to similar tuning tasks. In this contribution, we use different methods, such as domain randomization, to allow an agent trained in simulation to easily be deployed for a group of similar tasks. Preliminary results show that this training method is transferable and allows the RL agent to control the beam trajectory at similar lattice sections of two different real linear accelerators. We expect that future work in this direction will enable faster deployment of learning-based tuning routines, and lead towards the ultimate goal of autonomous operation of accelerator systems and transfer of RL methods to most accelerators.

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AKBP 8.4 Wed 16:30 CHE/0183

**Sensitivity Analysis and Online Surrogate Construction at the S-DALINAC Using Polynomial Chaos and Neural Networks** — •Dominic Schneider, Michaela Arnold, Jonny Birkhan, Ruben Grewe, Norbert Pietralla, and Felix Schliessmann — Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany

Particle accelerators are complex systems that coincide with their ideal design within the tolerances of its large number of technical components. Quantitative understanding of the beam dynamics and the analysis of their sensitivity to various components are challenging tasks. Machine learning methods provide the potential for the optimized operation of particle accelerators. In this contribution, the application of so-called surrogate models to the electron accelerator S-DALINAC will be discussed. This machine learning technique gives access to predict future behavior and an extensive set of characteristics that can be extracted by analyzing the trained model. The talk will include the presentation of a series of measurements performed in the injector section of the S-DALINAC to study the behavior of beam-influencing elements. Surrogate models, constructed and based on the acquired data, are being evaluated to reveal the behavior of these elements. Based on the information obtained, optimizations of the alignment of magnets as well as the beam dynamics simulations at the S-DALINAC will be discussed.

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AKBP 8.5 Wed 16:45 CHE/0183

**Generating synthetic shadowgrams with an in-situ plugin in PIConGPU** — •Finn-Ole Carstens[1,2], Klaus Steiniger[1], Richard Pausch[1], Susanne Schöbel[1,2], Yen-Yu Chang[1], Arie Irman[1], Ulrich Schramm[1,2], and Alexander Debus[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf — [2]Technische Universität Dresden

Few-cycle shadowgraphy is a valuable diagnostic for laser-plasma accelerators for obtaining insight into the $\mu$m- and fs-scale relativistic plasma dynamics. To enhance the understanding of experimental shadowgrams, we developed a synthetic shadowgram diagnostic within the fully relativistic particle-in-cell code PIConGPU.

In the shadowgraphy diagnostic, the probe laser is propagated through the plasma using PIConGPU, and then extracted and propagated onto a virtual CCD using an in-situ plugin for PIConGPU based on Fourier optics. The in-situ approach circumvents performance limitations of a post-processing workflow, like storing and loading large output files that result from large-scale laser-plasma simulations.

In this talk we present the in-situ plugin and preliminary synthetic shadowgrams from laser wakefield accelerator simulations.

AKBP 8.6 Wed 17:00 CHE/0183

**X-ray radiation transport in GPU accelerated Particle In Cell simulations** — •Paweł Ordyna, Thomas Kluge, Thomas Cowan, and Ulrich Schramm — HZDR, Dresden, Germany

Ultra-high-intensity laser pulse interactions with solid density targets are of central importance for modern accelerator physics, Inertial Confinement Fusion(ICF) and astrophysics. In order to meet the requirements of real-world applications, a deeper understanding of the underlying plasma dynamics, including plasma instabilities and acceleration mechanisms, is needed. X-ray radiation plays a substantial role in plasma physics, either as an integral part of a physical system itself or as a useful diagnostic, hence it should be included in computational models. Therefore, we bring a Monte Carlo based X-ray radiation transport module into our Particle In Cell simulation framework PIConGPU. It allows, among others, for Thompson scattering, e.g. for small-angle X-ray scattering (SAXS), and Faraday effect calculation for X-ray polarimetry - as online, in-situ diagnostics.