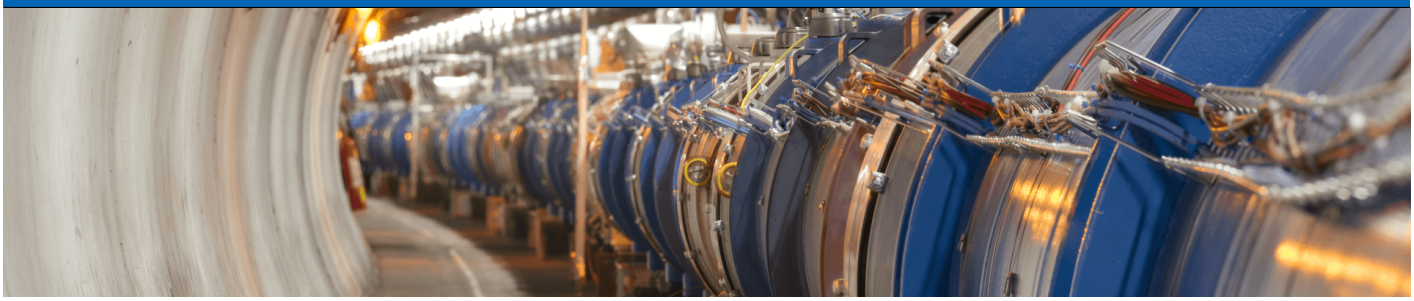
# High-intensity Ion Beams for FAIR: Modelling with Machine Learning Techniques & GPU Simulations

Proposal for a Bachelor's thesis | Master's thesis
Study field: Accelerator Physics



## Description

The Facility of Antiproton and Ion Research (FAIR) is currently under construction at the GSI Helmholtz Centre in Darmstadt. Key to the success of the future experiments is that the synchrotrons SIS18 and the new SIS100 will supply heavy-ion beams of highest intensities. In this regime, it must be avoided that the beam of particles will be perturbed by linear and nonlinear magnetic field errors, which can lead to beam loss. Studying these limitations in detail and improving the performance is therefore of critical importance, which is one of the main tasks of the accelerator physics activities at GSI and TEMF: high-performance computing tools are used to simulate the affiliated beam dynamics on the Green IT Cube and its new GPU cluster at GSI. Current research focuses on new models involving machine learning methods (i.e. supervised learning) to identify magnetic field errors driving these resonances. The goal of the Bachelor or Master thesis projects would be to contribute to the establishment of these new models, which will help to push the performance of the synchrotrons.

## Work plan

- Use machine learning techniques to develop a surrogate model for the heavy-ion synchrotron
- Investigate alternative learning algorithms to the presently used stochastic gradient descent to improve prediction efficiency.
- Establish predictions on harmful resonances.
- Validate predictions by comparing to simulation results with the existing models and tools.

## Prerequisites

Joy in programming, interest in machine learning and particle beam dynamics simulations, solid knowledge of the basics of electrodynamics and physics.


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Figure 1: SIS100 magnets. (Image: Babcock Noell GmbH)

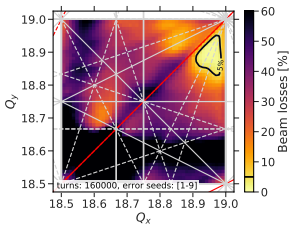


Figure 2: SIS100 simulations of resonances and beam loss.