Contribution ID: **9** Type: **Talk**

Offline Reinforcement Learning-Based Control of LEIR Injection Efficiency via Data-Driven Surrogate Modeling

Thursday, April 3, 2025 3:50 PM (20 minutes)

Aging of the stripper foil and unexpected machine shutdowns are the primary causes for reduction of the injected intensity from CERN's Linac3 into the Low Energy Ion Ring (LEIR). As a result, the set of optimal control parameters that maximizes beam intensity in the ring tends to drift, requiring daily adjustments to the machine control settings. This paper explores the design of a Reinforcement Learning (RL) based autopilot that compensates for the drift of parameters and maintains a optimal beam intensity in the LEIR ring. It observes Time of Flight (ToF) measurements of the ion beam in the linac and Schottky signals in the ring to act on the relevant control knobs.

This autonomous agent is pre-trained on a data-driven surrogate model built from historical exploration of the high dimensional parameter space. A comparison of the performances of several RL algorithms will be done on different surrogate models designs to evaluate future design of the operational autopilot. This work holds promise for pre-training offline RL agents through data-driven surrogate models on tasks that are too complex or computationally expensive to simulate.

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Session Classification: Talks