

RL control for AGS Injection in silico

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We present an RL-based approach for optimizing beam injection into the Alternating Gradient Synchrotron (AGS) using a fully differentiable in silico environment. Beam diagnostics from multiwire screens in the BtA transfer line and turn-by-turn beam position monitors throughout the AGS lattice are leveraged to characterize injection quality, quantify beam survival time, and localize beam losses along the ring. These observables are incorporated into the RL reward structure, enabling the agent to directly optimize beam survival and transmission efficiency. The simulation framework models nonlinear beam dynamics, lattice optics, and operational constraints, allowing gradients to be propagated through the environment for efficient policy learning. To ensure robustness and generalization, domain randomization is applied over initial beam distributions and lattice misalignments during training. Results demonstrate that the trained agent learns control policies that improve beam survival and reliably mitigate loss mechanisms across a range of perturbed machine conditions. This work establishes a foundation for robust, data-driven injection optimization and supports future translation of RL-based control strategies to accelerator operations.

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