Contribution ID: **29** Type: **not specified**

Use of AI/ML for higher brightness and higher polarization of hadron beams

Monday 27 October 2025 11:30 (25 minutes)

We report on the use of AI/ML techniques to advance the pursuit of higher brightness and polarization of hadron beams in the RHIC/EIC injector chain. Bayesian inference applied to individual magnet strengths reduced quadrupole field uncertainty by a factor of two while shifting mean values away from prior expectations, thereby improving the reliability of accelerator models. Bayesian optimization has enabled automated, high-performance tuning of injection alignment and matching, reaching results comparable to expert operators but at faster timescales. Reinforcement learning agents have achieved one-shot optimization of RF voltages for bunch merging and are now being trained for the stabilization of Booster-to-AGS beam transfer under drifting machine conditions. Collectively, these developments demonstrate the capacity of AI/ML methods to deliver adaptive and precise control strategies in support of next-generation polarized hadron beams.

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Session Classification: AI/ML for Accelerators