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AI-ML developments for Heavy Ion Linac operations

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At a heavy-ion linac facility, such as ATLAS at Argonne National Laboratory, a new ion beam is tuned once or twice a week. The use of artificial intelligence can be leveraged to streamline the tuning process, reducing the time needed to tune a given beam and allowing more beam time for the experiment. After establishing the required automatic data collection procedures, we have developed and deployed machine learning models to tune and control the machine. We have successfully trained online different Bayesian Optimization (BO)-based models for different sections of the linac, including the commissioning of a new beamline. We have also demonstrated transfer learning from one ion beam to another allowing fast tune switching between different ion beams. And more importantly, we have demonstrated transfer learning from the simulation to the online machine model using Neural Networks as the kernel for the BO optimization instead of Gaussian Processes (GP). This latest development allowed fast convergence even when including a multitude of variable parameters. We have also explored Reinforcement Learning (RL)-based models which showed some promising results but will require more development. These models will be later generalized for the whole ATLAS linac and can, in principle, be adapted to control other heavy-ion linacs and accelerators with modern control systems.

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Footnotes

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