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Efficient Dynamic and Momentum Aperture Optimization for Lattice Design Using Multipoint Bayesian Algorithmic Execution- 15'+5'

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This paper presents a novel application of Multipoint Bayesian Algorithmic Execution (multipointBAX) to optimize dynamic aperture (DA) and momentum aperture (MA) in lattice design. DAMA optimization is a critical design task for storage rings, ultimately determining the flux of x-ray sources and luminosity of colliders. Traditionally, solving this multi-objective optimization problem has relied on genetic algorithms (GA) and/or Bayesian optimization (BO), requiring extensive particle tracking simulations for each trial configuration, which in turn limits the quality of the final design. Here we instead use multipointBAX to select, simulate, and model a single particle for each trial configuration, resulting in two orders of magnitude higher end-to-end efficiency, while also integrating random magnet error seeds to increase robustness. The multipointBAX implementation involved several advances, including a neural-network surrogate model, a batch acquisition strategy, and the concept of a "Pareto front region" to improve stability. A proof-of-principle demonstration on the SPEAR3 storage ring design validates our approach, with multipointBAX achieving equivalent Pareto front results with only 1% of the tracking computations required by GA. We are now applying the method to the design of future light sources and colliders.

Authors: RATNER, Daniel (SLAC); HUANG, Xiaobiao; ZHANG, Zhe

Presenters: RATNER, Daniel (SLAC); ZHANG, Zhe

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