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AI-driven autonomous tuning of radioactive ion beams

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The Californium Rare Isotope Breeder Upgrade (CARIBU) at Argonne National Laboratory is a pivotal facility for studying rare and unstable atomic nuclei, providing radioactive ion beams (RIBs) from the spontaneous fission of Californium-252. Since 2008, CARIBU has significantly impacted nuclear structure studies, nuclear astrophysics research, and national security applications. However, the traditional extraction and transport of these beams have relied on expert-driven tuning methods, which are time-consuming and involve manually optimizing hundreds of parameters, thus hindering operational efficiency and scientific output. To address these challenges, a novel system utilizing Artificial Intelligence (AI) has been introduced at CARIBU to automate the beam delivery process. This system employs machine-learning techniques, specifically Bayesian Optimization, to autonomously tune each section of the beam line. Live tests have shown that the AI-driven system can achieve transport efficiency and delivery times on par with experienced experts. Extending this methodology to other RIB facilities globally promises to significantly enhance the field by improving operational efficiency and accelerating research in nuclear physics and related areas. This integration of AI-driven systems represents a significant step towards autonomous scientific discovery.

Footnotes

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