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Optimizing Intense Laser-Plasma Interactions with Evolutionary Algorithms and Machine Learning

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Intense lasers have the ability to accelerate ions to high energies over very short distances, but the beam quality generated through these methods is not yet ready for many applications. We developed a framework using evolutionary algorithms to automatically run thousands of one-dimensional (1D) particle-in-cell simulations to optimize the conversion from laser energy to ion energy. The "optimal" 1D target found with this approach also outperformed conventional targets in more-realistic fully-three-dimensional (3D) simulations. We plan to extend this approach to develop synthetic datasets and use machine learning techniques to help control ion beam properties and to better understand the complex relationship between computationally-inexpensive reduced-dimensionality (1D/2D) simulations with more realistic, but computationally-expensive 3D simulations and experiments.

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