Optimization of High Repetition-rate Laser-driven Particle and Radiation Sources Using Machine-learning Techniques

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Many applications of laser-driven particle sources benefit from operation at high repetition rate. Here, 20 milliJoule laser pulses are generated at 0.5 kilohertz repetition rate for a number of laser-plasma interaction experiments, including laser wakefield acceleration and kα x-ray generation. A genetic algorithm is implemented in the execution of these experiments using control of adaptive optics and a Dazzler acoustic-optic programmable dispersive filter. Utilizing the genetic algorithm in our laser-plasma interaction experiments allows for a heuristic search of optimal laser pulse parameters or target parameters for each experiment.

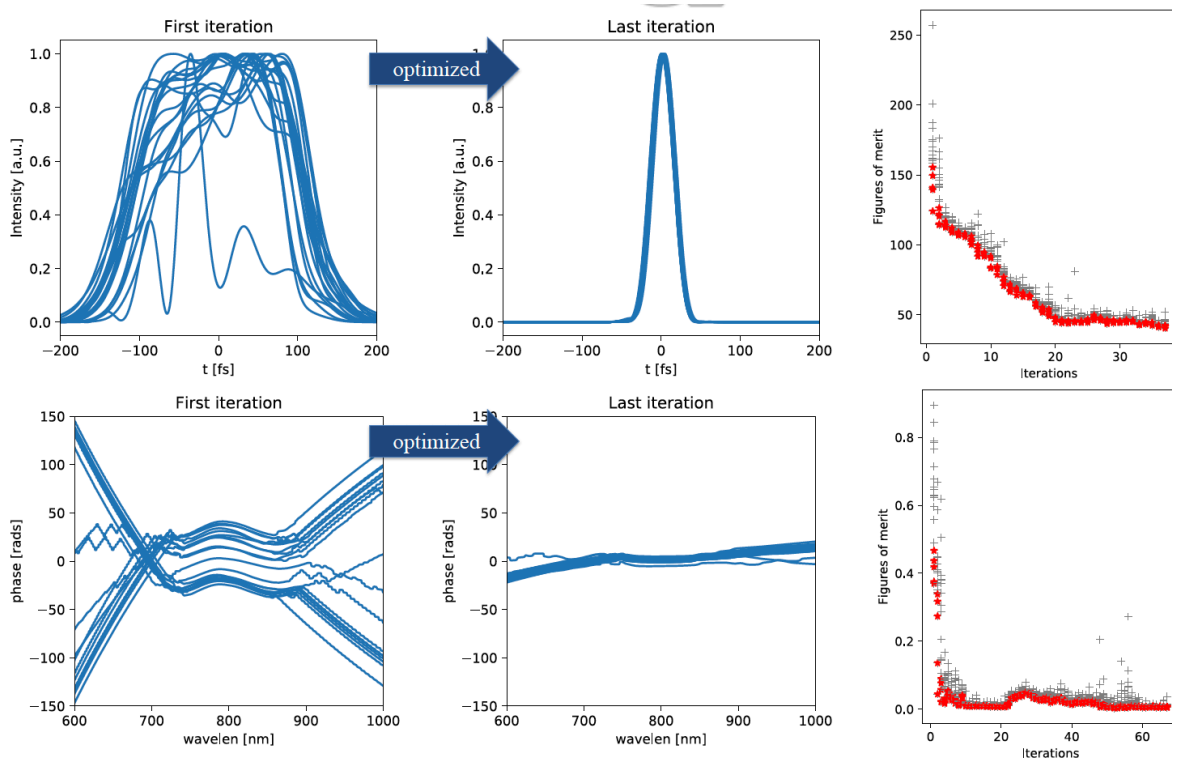

Figure 1 – Measurements of various laser pulse parameters pre- and post-optimization via the genetic algorithm coupled with the Dazzler AOPDF, shown with respective optimization curves showing convergence.
Top - Figure of merit: *minimization* of (kurtosis*FWHM pulse duration) to achieve a normally distributed, short pulse.
Bottom – Figure of merit: *minimization* of slope of spectral phase to achieve a flat phase profile.