

Progress on on-line FEL optimization software

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Motivation and status

- Getting the “last 20%” of performance at an FEL usually works empirically
- Automation can reduce manual process tuning time
- Do automation in the same framework as simulation to facilitate converging from both directions
- Empirical optimizer developed as part of OCELOT
- Optimizer has been used for XFEL commissioning

Generic Ocelot Optimizer at XFEL

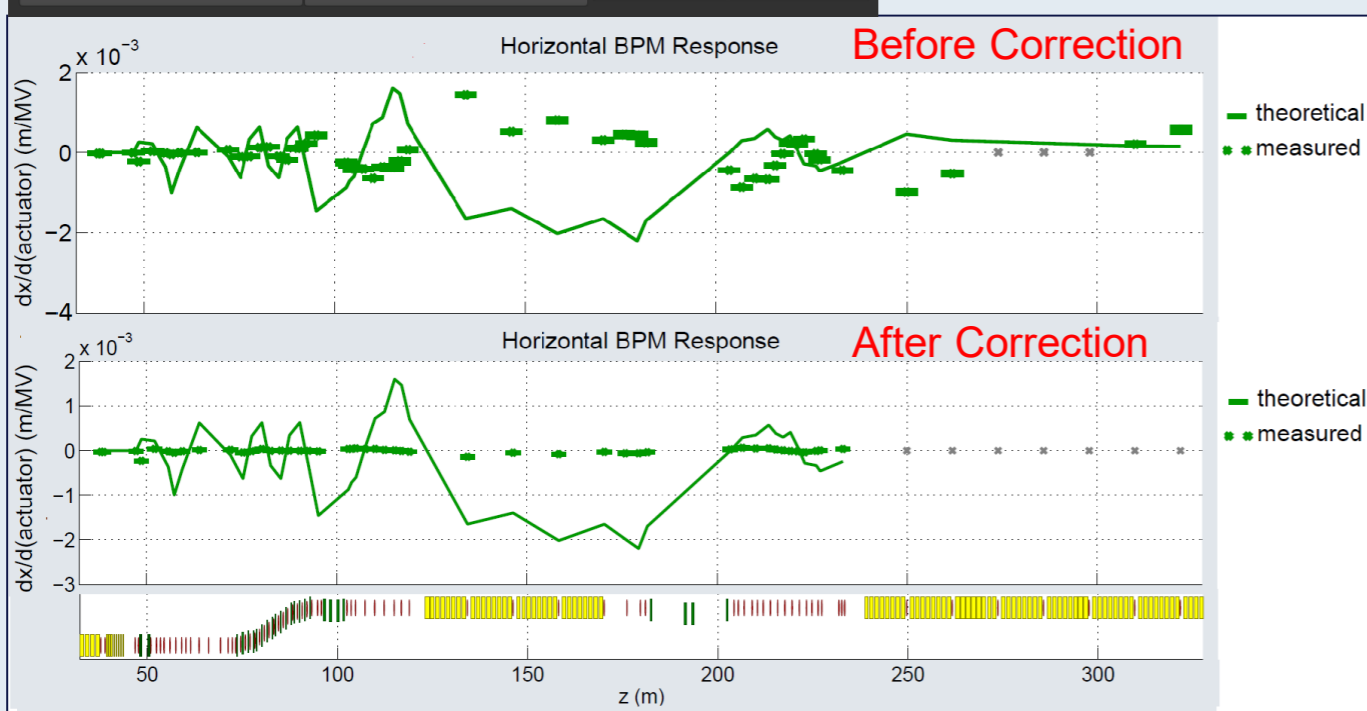
Versatile optimization engine

Dispersion Correction

1. Dispersion measured at BPM locations by changing energy
2. Sum of squared dispersions at selected locations used as objective function
3. Simplex method used for minimization



The generic optimizer GUI and dispersion optimization after I1D (XFEL elogbook entry).

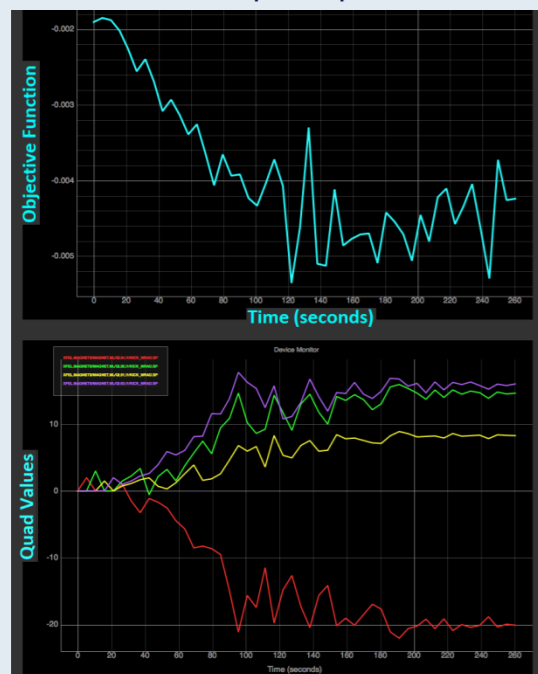


SASE Pulse Energy Maximization

Essential part of machine start-up First tested at FLASH, later implemented at LCLS. Used during XFEL commissioning

SASE optimization using quadrupoles

- List of quadrupoles included in the optimizer configuration
- 4 most effective quadrupoles identified and activated for the optimization shown



Objective: inverse pulse energy
 100 -> 200 μ J

SASE optimization using orbit correctors

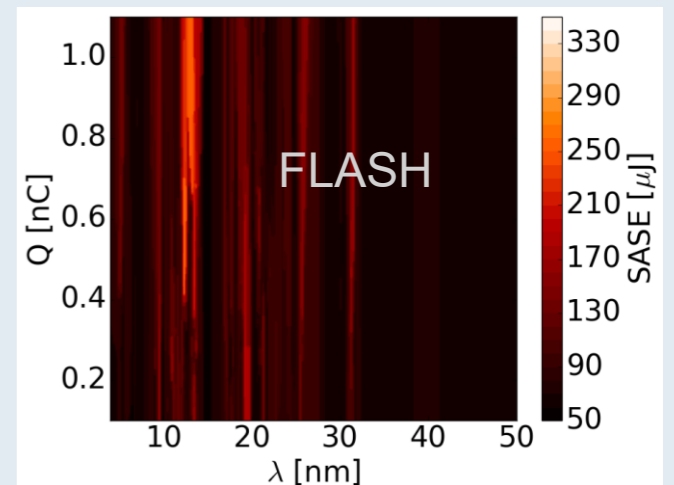
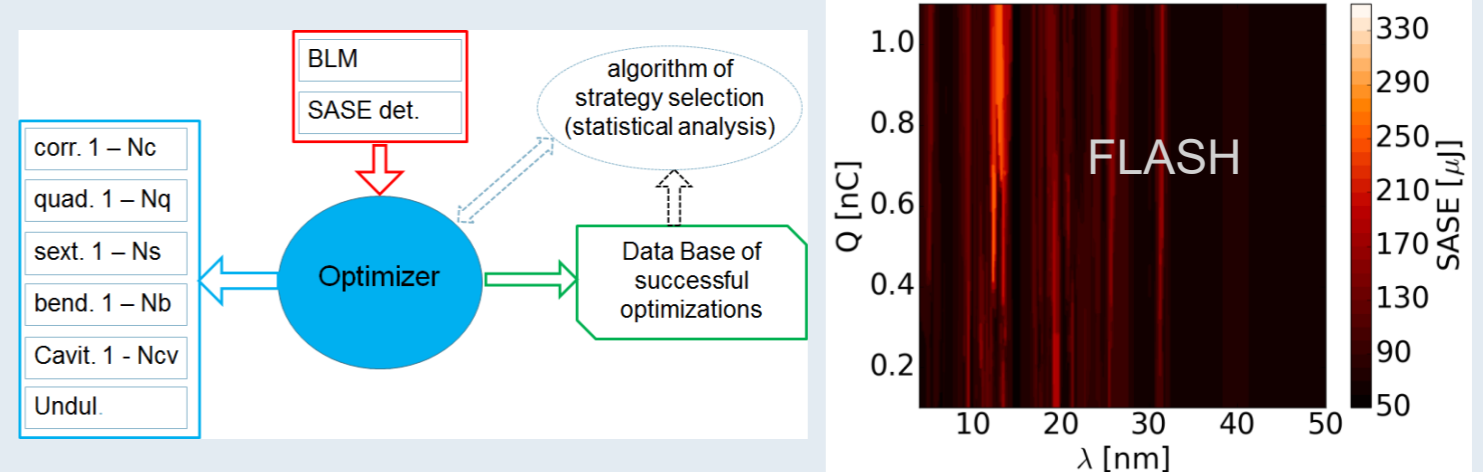
- 4 correctors upstream from the undulator section (launch steerers) are effective for SASE tuning and routinely used. Other correctors included but typically less efficient

Objective: inverse SASE pulse energy



Data Analytics

- DAQ archive could be used, however the data complexity is suboptimal for ML applications
- Optimizer includes a separate analytics engine (MySQL database + scikit-learn)
- Tuning knob efficiency evaluation and parameter prediction is possible
- This functionality needs significant investment to be made use of



Model-based optimization

- OCELOT features advanced beam dynamics module for linacs
- On-line model based on magnet/RF parameter readout is in place
- Optics can be read out on-line and changed (played with) in flight simulator mode
- Using the model for optimization and feedback into the model from the optimizer is an open research topic



XFEL linac optics monitor based on on-line readout

Conclusions and outlook

- Generic empirical optimizer in place for XFEL
- Started implemented data analytics tools, significant effort still needed
- On-line optics model in place, significant effort still needed to exploit it in optimization