MOGA OPTIMIZATION DESIGN OF LCLS-II LINAC CONFIGURATIONS*

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ABSTRACT

This paper briefly summarizes the preliminary optimization study on the configurations of LCLSII with superconducting cavity. The setup of each configuration is first optimized using Multi-Objective Genetic Algorithm (MOGA) with LiTrack which includes the longitudinal phase space only. For each operation mode, MOGA is applied to optimize the machine parameters in order to get flat top current profile and zero energy chirp at the beginning of the undulator. The geometric wake of the RF cavities and resistive wall wake of the beam pipe are included, but the coherent synchrotron radiation (CSR) wake is not included. Finally, ELEGANT code is used to do full 3-dimension particle simulation, which includes the CSR and ISR effect. Therefore, the emittance growth due to CSR can be checked. A new code has been recently developed to integrate all the wake field and CSR in the MOGA optimization.

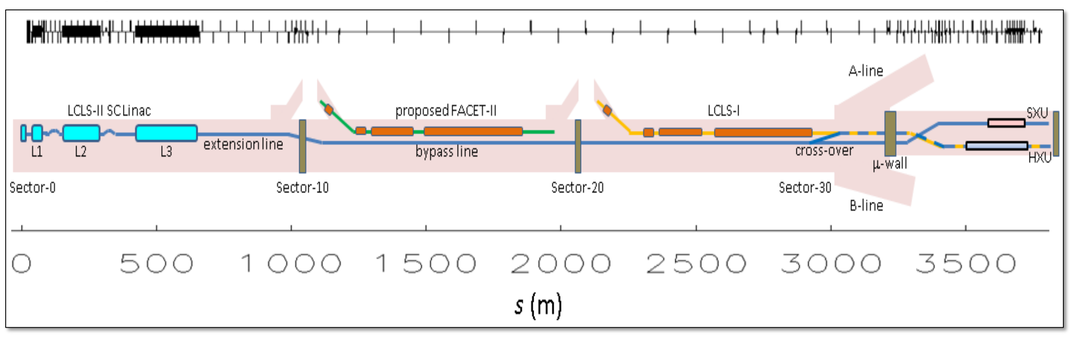


Fig. 1: LCLS-II layout in existing SLAC tunnels

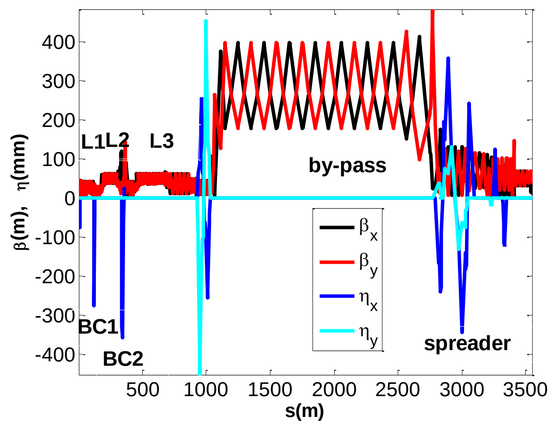


Fig. 2: Optics of LCLS-II linac.

Nonlinear beam from injector

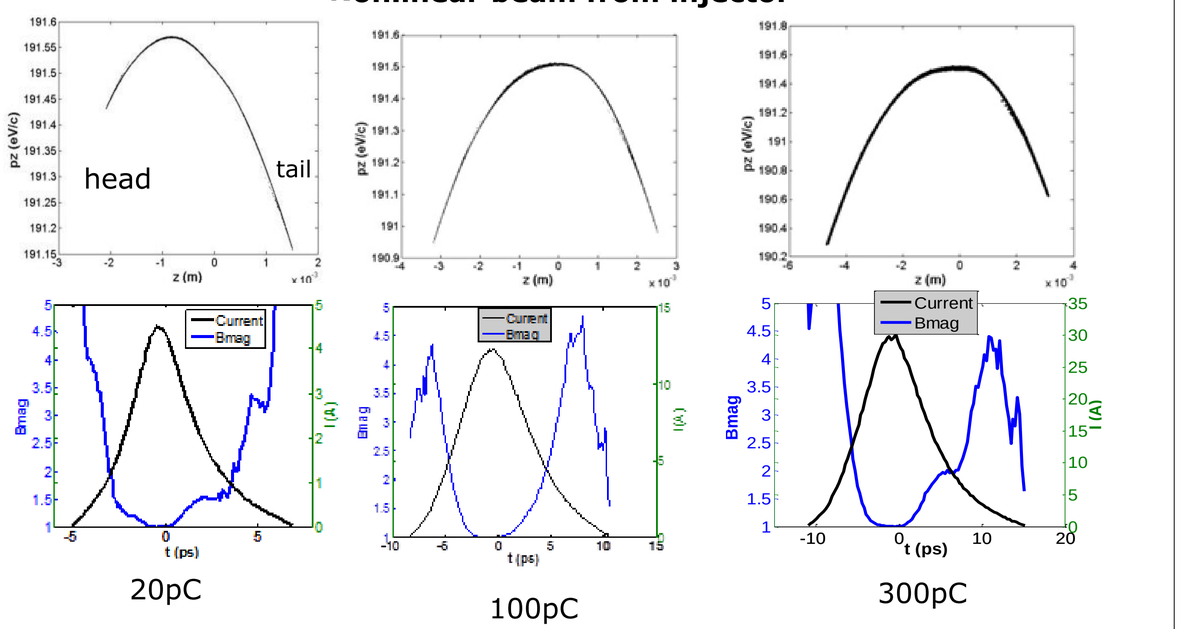


Fig. 3: Phase space and current profile at the exit of injector linac (98MeV) after the injector for 20pC (left), 100pC (middle) and 300pC (right) bunch charge. Bunch head is to the left

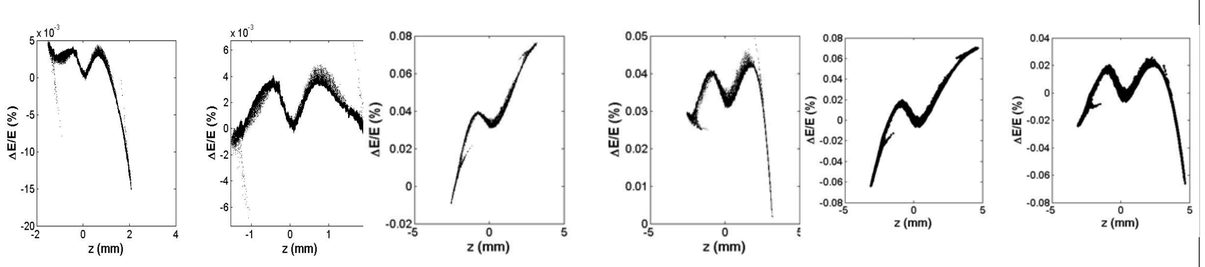
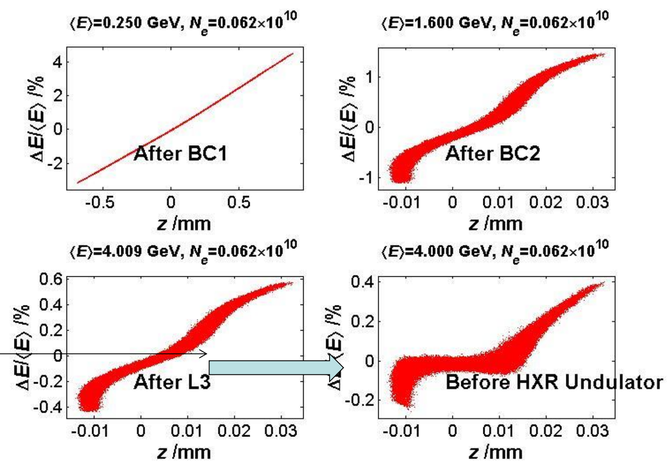


Fig.4: 3rd-order term (left column) and high order terms (right column) at the exit of injector linac (98MeV) for 20pC (left), 100pC (middle) and 300pC (right) bunch charge.

Strong Resistive Wall Wake as a natural de-chirper



Strong de-chirper by resistive wall wake at 2km by-pass

Fig. 5: evolution of Longitudinal phase spaces for 100pC 1kA beam

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Table 2: Configurations for BC1 energy 250MeV and BC2 energy 1.6GeV, without de-chirper

	20pC, 500A	100pC, 1kA	100pC, 1kA,New baseline [3]	100pC,1.5kA	300pC, 1kA	300pC, 600A
$\phi_{L1}(^\circ)$	-21	-21	-12.2	-21.9	-19.85	-20
$\phi_{Linearizer}(^\circ)$	-165	-165	-150	-164.5	-162.2	-162
$\phi_{L2}(^\circ)$	-21.1	-21	-21.1	-28.4	-28.86	-29
$\phi_{L3}(^\circ)$	0	0	0	0	0	0
V_{L1} (MV)	219.6	219.6	216	225	222	222
$V_{Linearizer}$ (MV)	54.78	54.78	64.90	58.7	59.58	59.58
BC1 R_{56} (mm)	-53	-55	-55	-53.46	-47.4	-44.7
BC2 R_{56} (mm)	-61.8	-60	-37.5	-45.5	-49.2	-49.2
σ_{z0} (mm)	0.627	1.02	1	1.02	1.30	1.30
I_{pk0} (A)	4.5	12	12	12	31	31
σ_z^{BC1}(mm)	0.187	0.283	0.15	0.246	0.43	0.48
I_{pk}^{BC1} (A)	15	43	82	50	91	82
σ_E^{BC1}(%)	0.835	1.36	1.6	1.469	1.857	1.857
σ_z^{BC2}(μm)	5.16	8.85	9.2	5.516	29	48
I_{pk}^{BC2} (kA)	0.515	1.355	1.36	2.723	1.18	0.75
σ_E^{BC2}(%)	0.295	0.458	0.378	0.53	0.822	0.884
σ_E^{UndBEG}(%)	0.055	0.065	0.066	0.079	0.239	0.346
$P_E^{BC2CSR}(W)$		42		88	117	84

MOGA Solutions without CSR

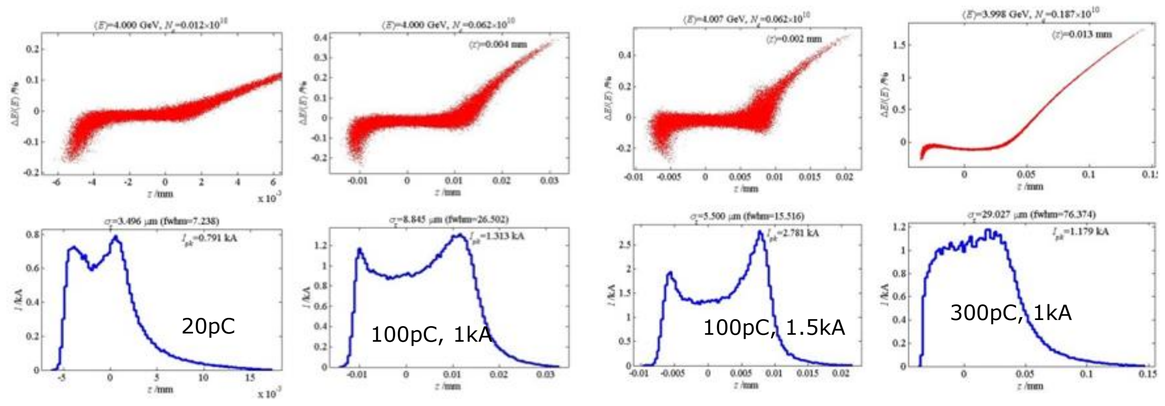

Fig. 6. MOGA solutions of phase space and current profile before the undulator for different configurations, Litrack code used in tracking, including RF structure wake, resistive wall wake, but without CSR

EELGANT simulation with CSR

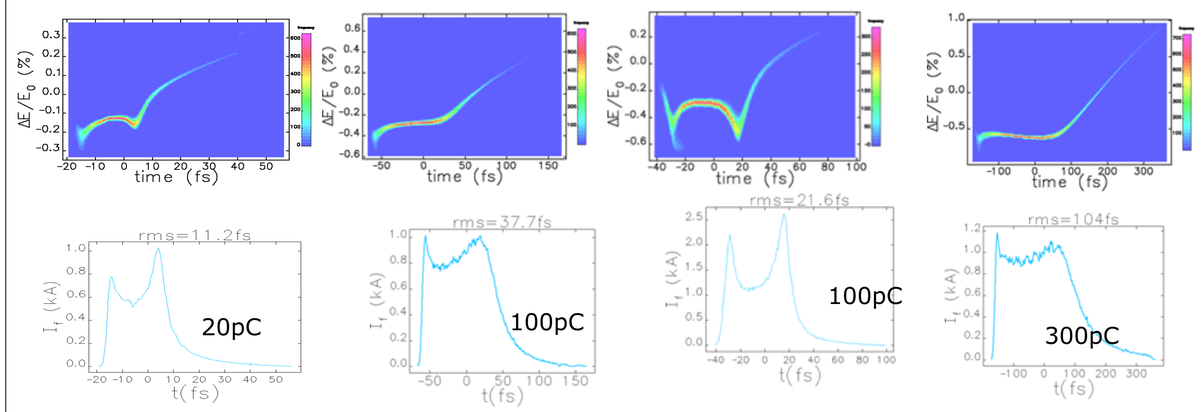

FIG.7: Phase space and current profile before undulator from Elegant simulation, including RF structure wake, resistive wall wake and CSR

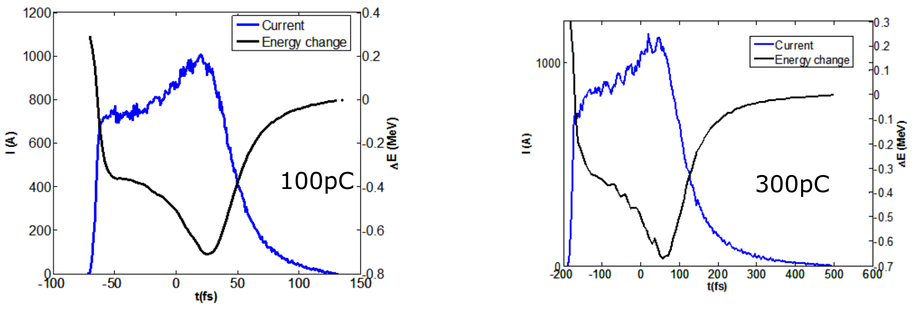

FIG. 8 Energy loss due to CSR at whole BC2 for 100pC/300pC beam. The bunch shape is also shown, with the head to the left (the blue curve).

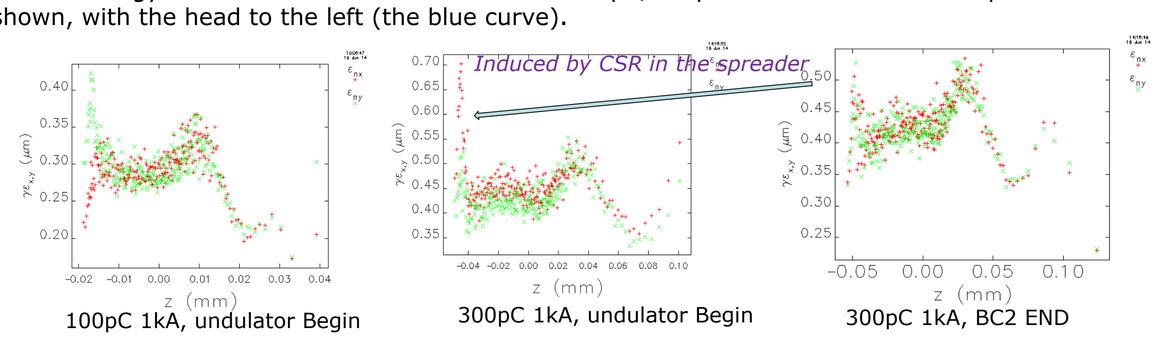

FIG. 9: Slice emittance at the beginning of undulator for 100pC 1.0kA (left) and 300pC 1kA (rmiddle), 300pC 1kA after BC2.

New High Peak current options

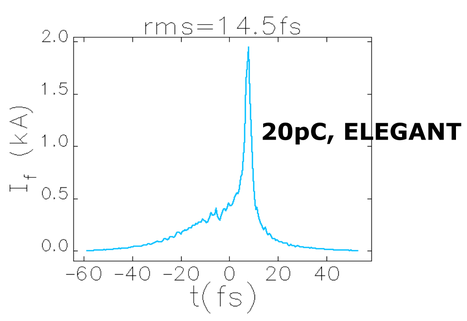

Fig. 10: Current profile of 20pC bunch before the Undulator. Elegant simulation.

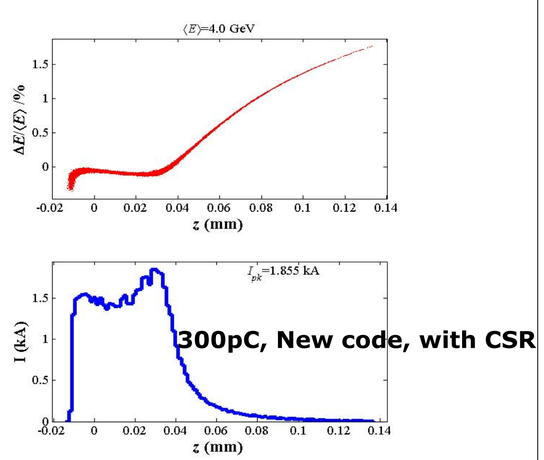

Fig. 11: new high peak current solution for 300pC charge by a new developed code. Wake fields and CSR are included