Time Dependent Study for an X-ray FEL Oscillator at LCLS-II.

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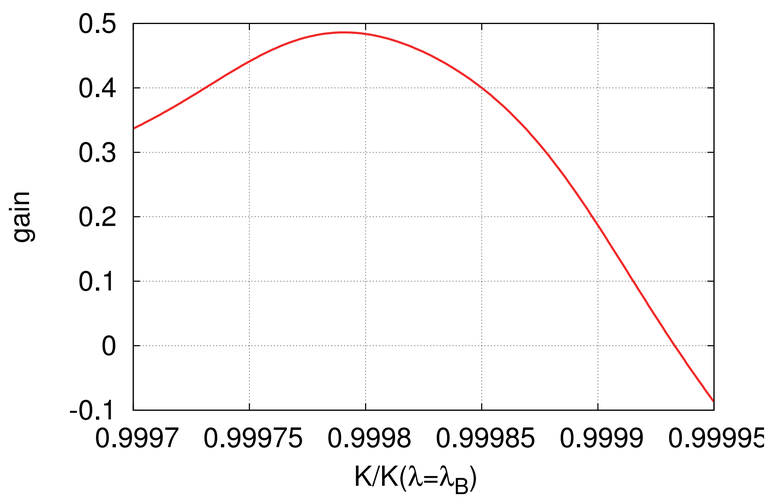
Summary

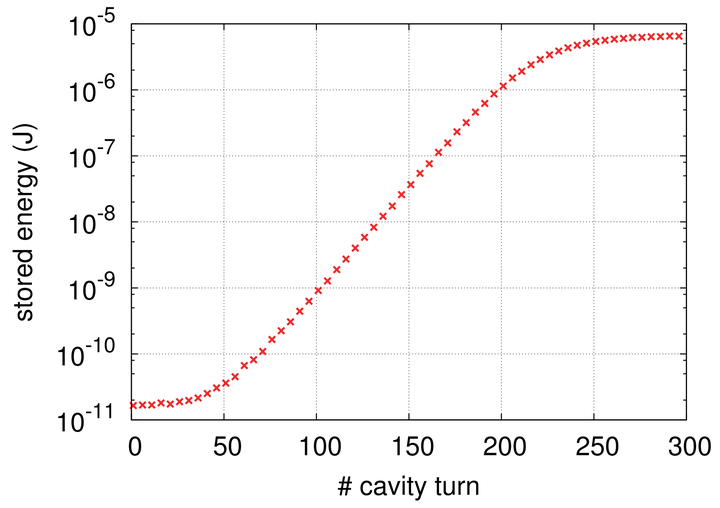
- Time dependent study of X-ray free electron laser oscillator (XFELO) driven by super-conducting LCLS-II linac with 4 GeV beam energy.
- Amplifying fifth harmonics of FEL radiation to reach hard X-ray wavelength.
- High reflectivity crystal cavity using Diamond Bragg reflection assumed.
- Orders of magnitude larger spectral flux at 14.4 keV than storage ring based sources.
- Study done with ideal Gaussian temporal bunch profile and Gaussian energy spread.
- Next step is to use a start to end simulated bunch with a more realistic phase space distribution.

Gain study

single-pass steady state gain



intra cavity pulse energy vs cavity pass number



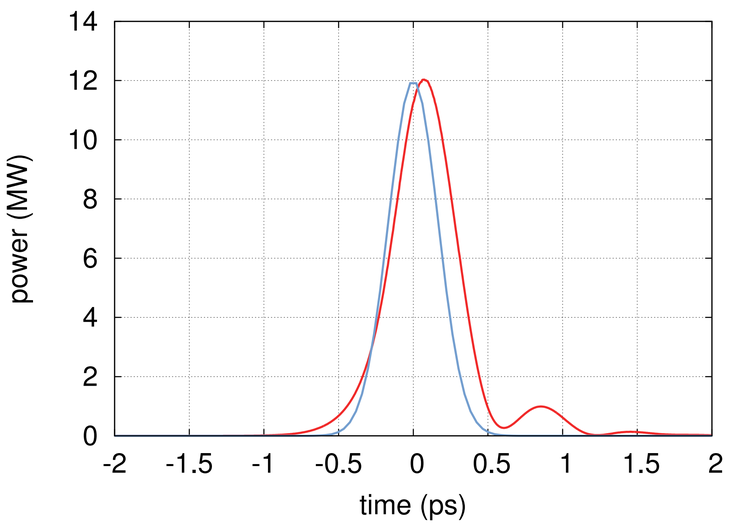
K: Undulatorparameter λ_B: Bragg wavelength

Beam and cavity parameter

Parameter	Value	Units
e^--beam energy	4.0	GeV
Peak current	120.0	A
Bunch charge	50.0	pC
Bunch length (rms)	166.7	fs
Energy spread	200.0	keV
Norm. emittance	0.3	μm
Photon energy at 5^{th} harmonic	14.4	keV
Undulator period	26.0	mm
Number of undulator periods	1250	
Undulator parameter K	1.433	
loss per round-trip	15.0	%
Rayleigh length	12.0	m
Distance rad. waist-undulator center	-1.0	m

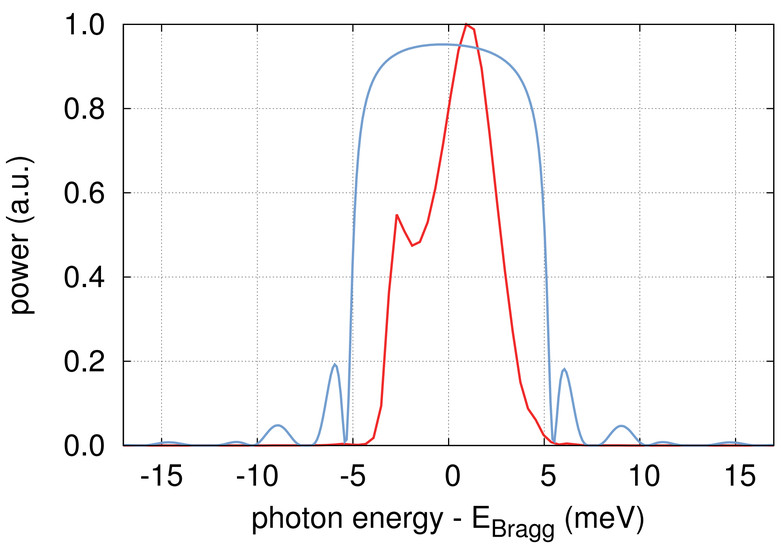
Pulse shape

intra cavity temporal pulse profile



red: temporal profile of photon pulse
blue: normalized current profile

intra cavity spectral pulse profile



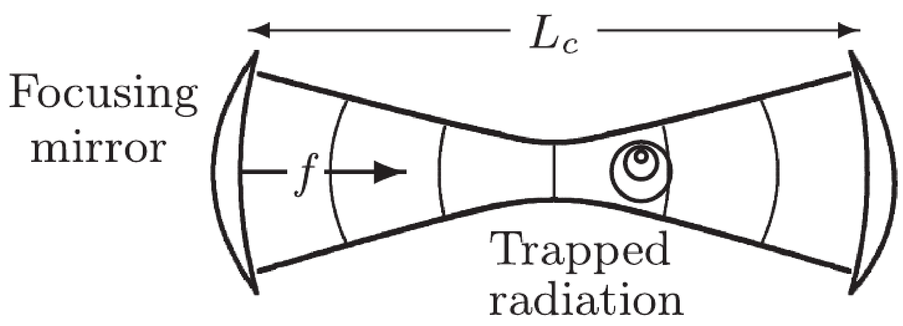
red: spectral profile of photon pulse; E_{Bragg}: Bragg photon energy
blue: combined (thick and thin) crystal reflectivity

Photon pulse parameter
out-coupled

Parameter	Value	Units
Out-couple ratio	4.0	%
Pulse energy at saturation	0.26	μJ
Photons per pulse	$1.1 \cdot 10^8$	
Spectral flux (2 MHz rep-rate)	$4.0 \cdot 10^{13}$	ph/s/meV
Pulse length at saturation (rms)	205.0	fs
Pulse bandwidth at situation	5.0	meV
Pass number to saturation	250	
Gain per cavity pass	7.6	%

Cavity design

- For simulation a simplified cavity design is used.
- Cavity build up out of two focusing mirrors and a filter.
- Filter applied by an external table containing the wavelength dependent complex reflectivity of the Bragg crystals.
- To be comparable to the more advanced tunable cavity design only Rayleigh length has to be the same.



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