Analysis of the effect of energy chirp in implementing EEHG at SXL

Mihai Pop[1]*, Francesca Curbis[1], Saeid Pirani[1], Sverker Werin[1] ,Weilun Qin [1,2]

Abstract

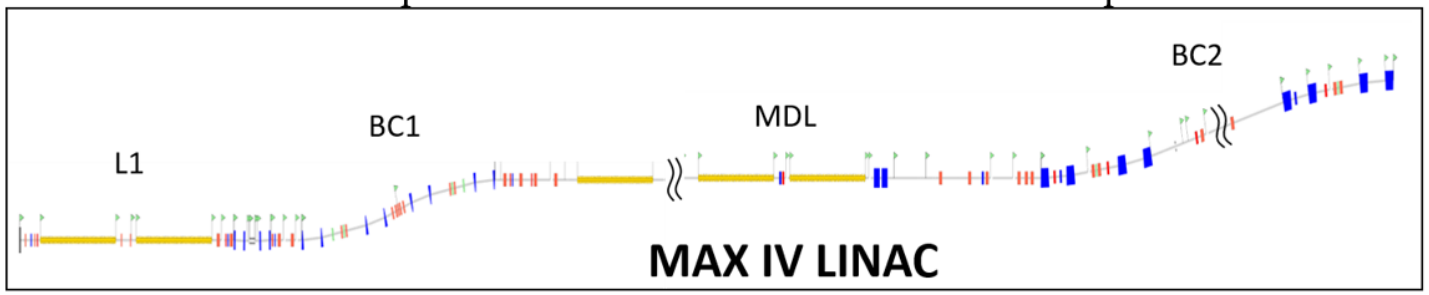
A Soft X-ray Laser (the SXL) has been designed for the MAX IV Laboratory. The FEL would span 1-5 nm radiation wavelengths. In order to improve longitudinal coherence we propose to use the EEHG seeding technique.
The EEHG system will be inserted in the final compression stage. We show how the effect of a remaining chirp in the electron pulse is mitigated.

[1]Lund University, Physics department
[2]Deutsches Elektronen-Synchrotron (DESY)
*corresponding author : mihai.pop@maxiv.lu.se

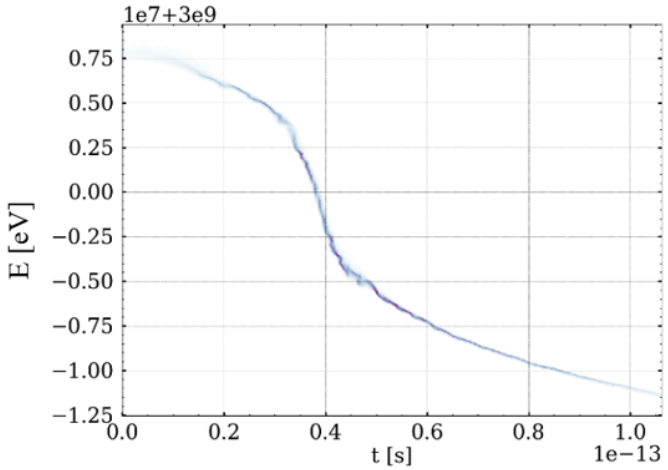
LUND UNIVERSITY

Layout and Hardware requirements

L1 - Linac structure
BC1 - first bunch compressor
MDL - main drive line Linac structure
BC2- second bunch compressor

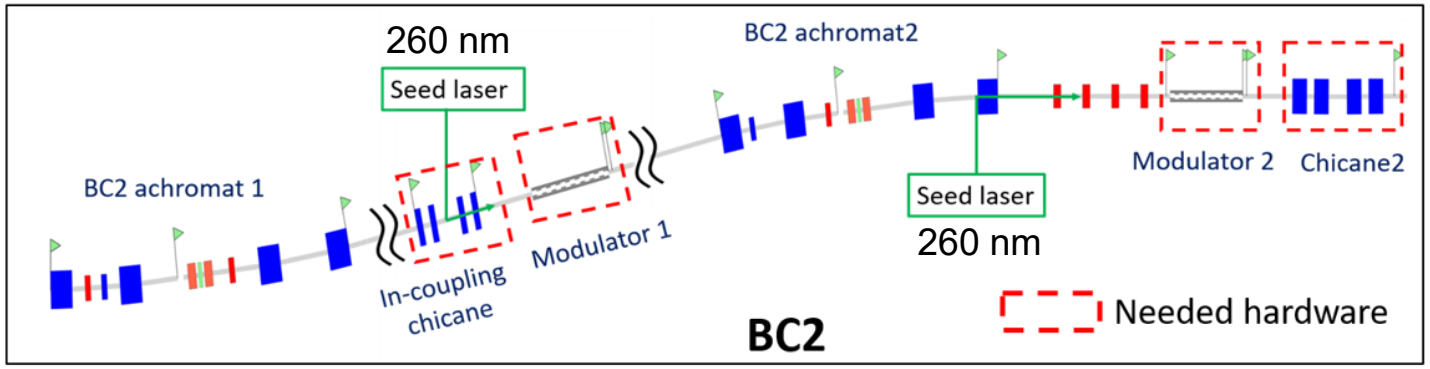


Layout of the full MAX IV LINAC

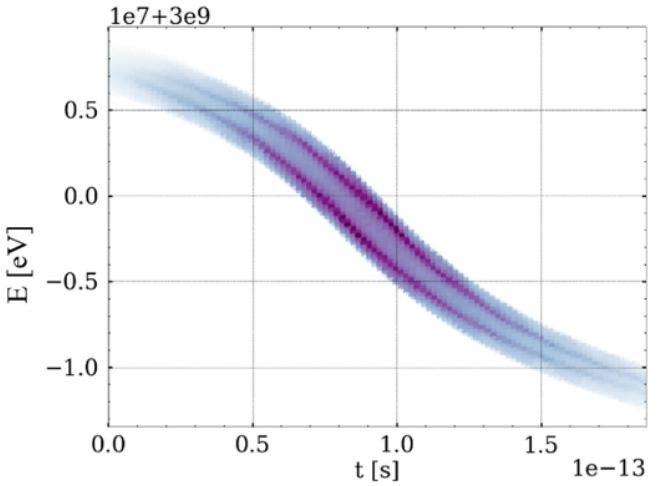


Longitudinal phase space at end of BC2 without EEHG hardware.

We use the existing hardware of the second achromat in BC2 to both compress the beam and also act as the strong dispersive section in the EEHG scheme.



Layout of BC2 of the MAX IV LINAC with EEHG hardware in dashed red squares. We use the last bunch compressor as a part of the EEHG scheme

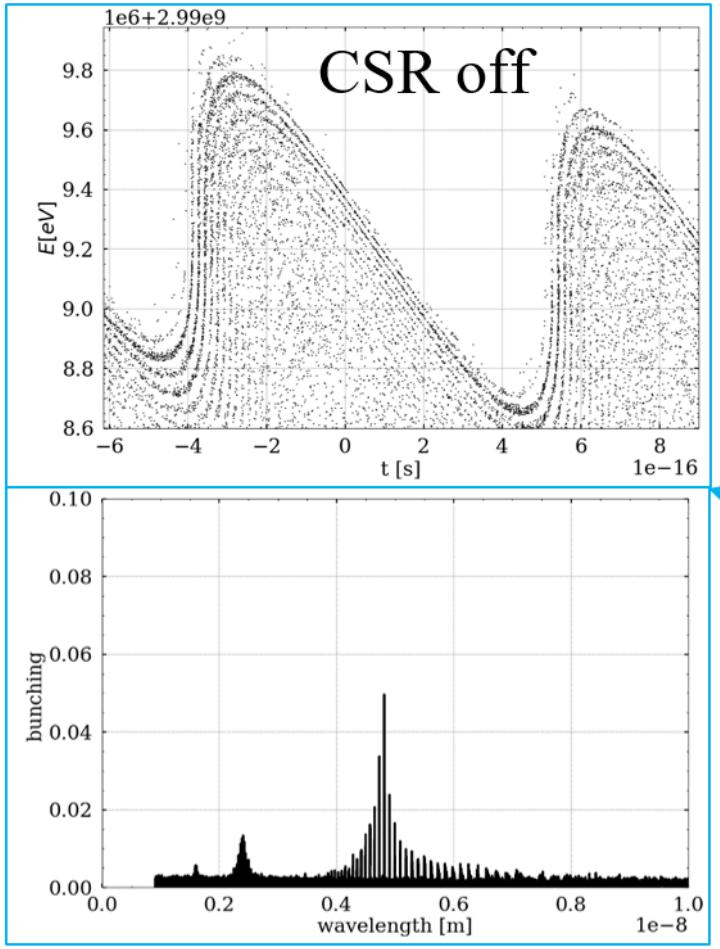


Longitudinal phase space at the end of Chicane2 with EEHG hardware.

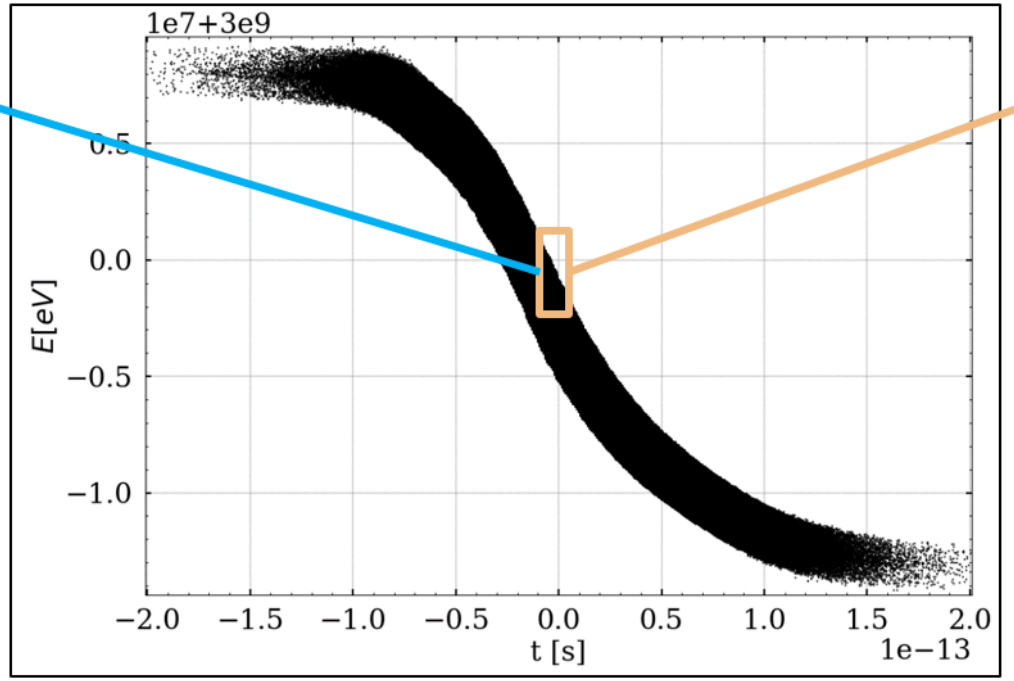
Phase space, bunching and the effect of CSR

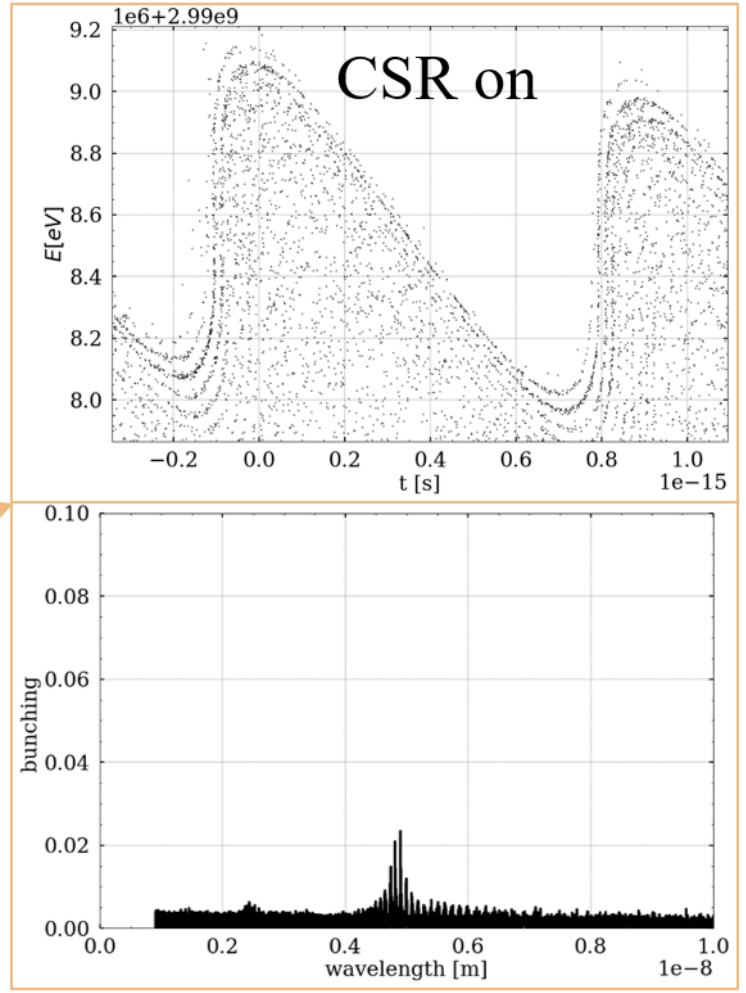
The fact that BC2 also compresses the beam means that a strong CSR effect will be imprinted on the beam. To gauge this effect we analyzed the bunching in the electron beam prior to injection in the undulator line while CSR was enabled (right) and disabled (left) in the bending magnets.

There is clear deterioration of the fine structures generating the bunching in the phase space when switching CSR on.



Longitudinal phase space (top) and bunching (bottom) at the end of Chicane2





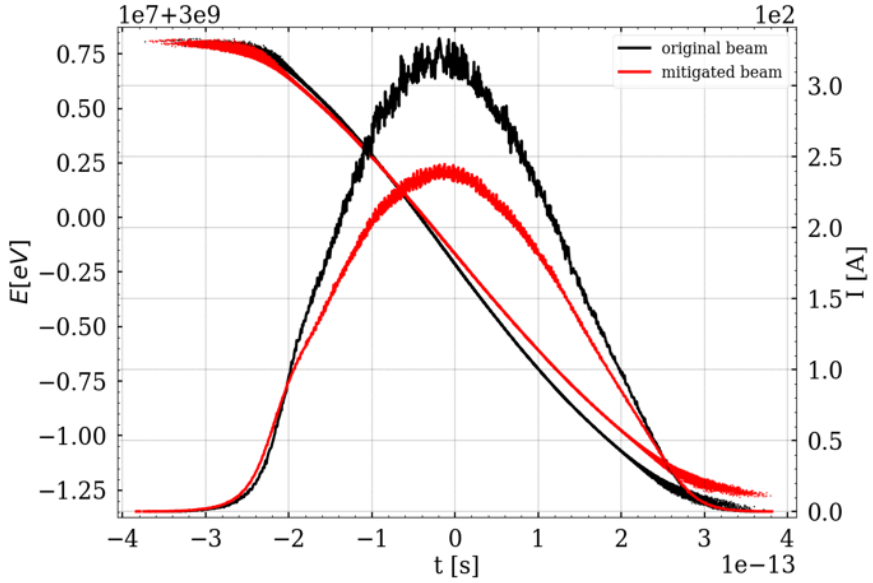
Longitudinal phase space (top) and bunching (bottom) at the end of Chicane2

Mitigating the CSR effect

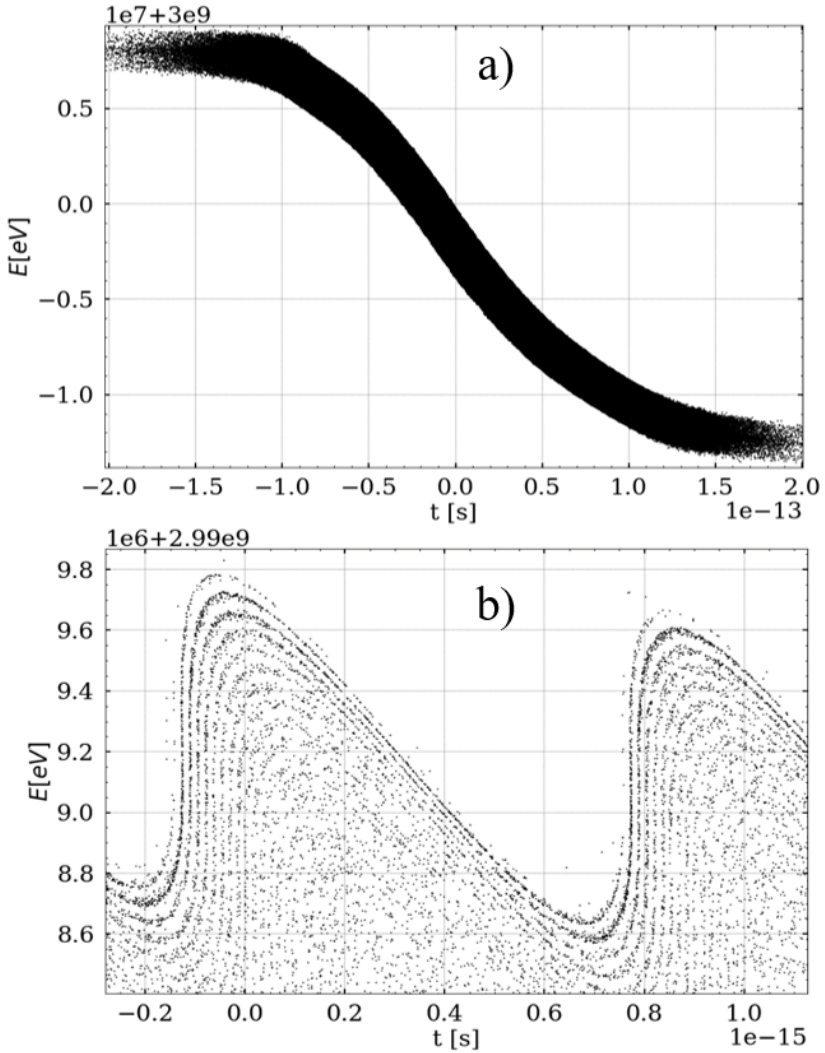
We employed 2 mitigation steps:

1. Reduce charge from 100 pC to 80 pC.

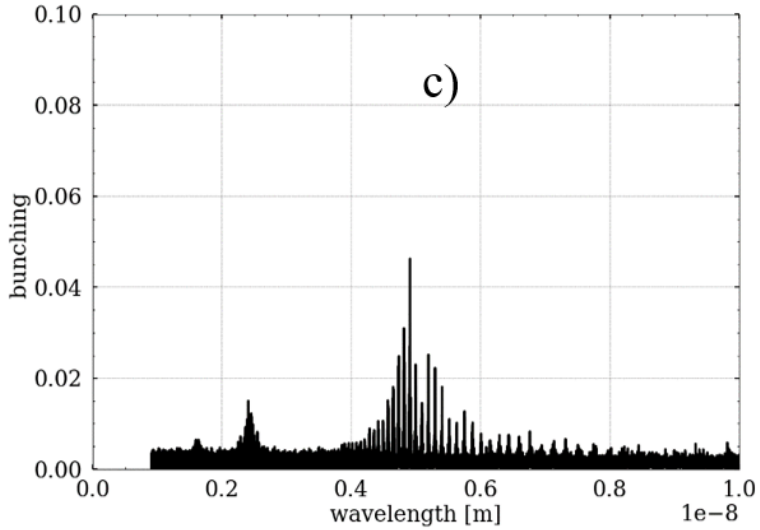
2. Change RF accelerating phase in L1 from 26.3 to 26 degrees to reduce chirp.



Longitudinal phase space and current at the entrance to the EHHG module (Mod1).

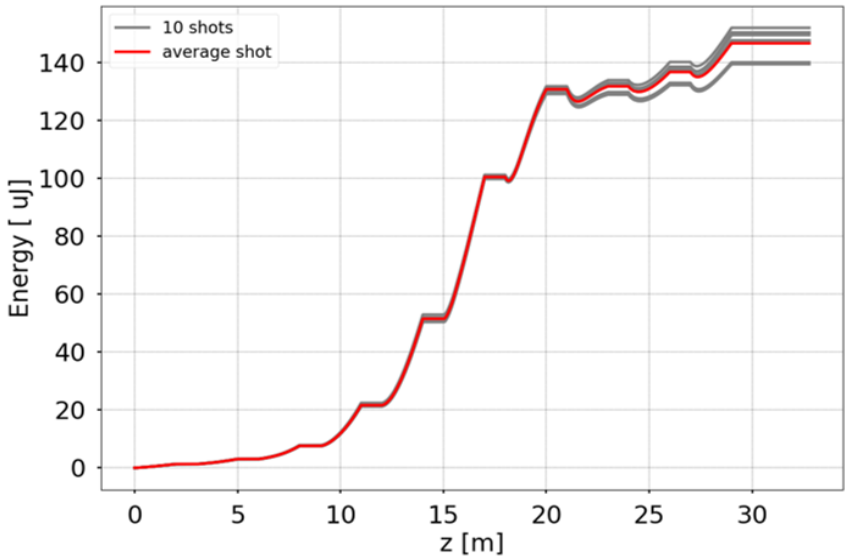


The combination of reduced chirp and lower bunch charge meant that the CSR is diminished to the extent that the fine structures are re-gained (b) and the bunching reaches almost the same maximum value.



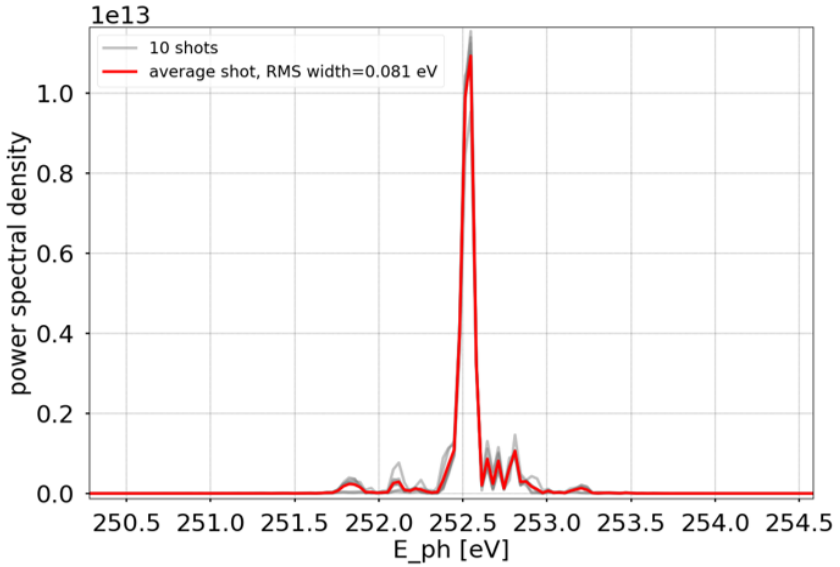
Longitudinal phase-space (a) and zoomed in phase space (b) after Chicane2. Bunching (c) vs wavelength at the undulator line entrance for the mitigated beam.

FEL results and conclusions



Average Gain curve (left) and FEL spectra (right) for 10 shots.

There is a clear saturation point at 20 m and the spectrum is typical of seeded FEL, with some background



Conclusions

Our proposal for EEHG at MAX IV SXL manages to create sufficient bunching at 5nm after implementing a mitigation scheme. By running the resulting beam through the undulator line proposed for SXL we are able to reach saturation at 20 m with good spectral properties