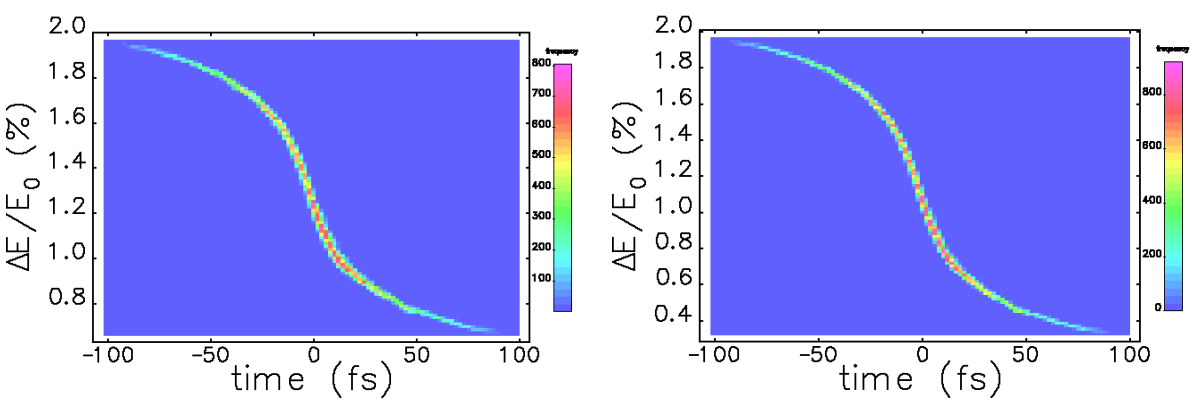
Larger Bandwidth above 5 keV for crystallography (2%-4% BW)

Z. Huang, J. Zemella

Wide bandwidth FEL pulses can be produced by electron bunches with relatively large energy spread if the energy deviation is correlated with its longitudinal coordinate. The output SASE pulse will be frequency chirped and will possess a relatively wide bandwidth. Such a wide bandwidth pulse can be useful for applications such as serial femtosecond crystallography in order to index a large number of Bragg peaks within a single pulse for crystal orientation determination.

In the LCLS (or LCLS-II driven by Cu linac for above 5 keV hard x-ray photons), large bandwidth FEL can be generated by over-compressing electron bunches in BC2. Part or perhaps most part of the electron bunch will contribute to lasing and will generate a wide bandwidth FEL with the relatively large bandwith in the range of 0.5-1\% at hard x-ray photon energies. To further increase the radiation bandwidth for crystallography, a pair of corrugated structures will be installed and tested in the LCLS. The device will be used typically to reduce the electron energy chirp under normal operation (hence the name “dechirper”). However, when the electron bunch is over-compressed, the device will increase the electron energy chirp and the final radiation bandwidth. The device to be tested on the LCLS this year is 4 m long with the minimum full gap of 1 mm (in collaboration with RadiaBeam. In Figure 1, we show the Elegant simulation of longitudinal phase space for 11.8 GeV, 250 pC bunch at the exit of the 4-m corrugated structures and 8-m corrugated structures. The FWHM energy spread after the 4-m device is 1.2% and after the 8-m device is 1.6%. The pair of the corrugated structures are oriented first in the horizontal direction and followed by the vertical orientation so that the transverse wakefield effects are largely canceled. Elegant simulations show 6% and 36% vertical emittances growth for the 4-m and 8-m devices respectively, while no emittance growth is observed in the horizontal direction.



(a) (b)

Figure 1. Longitudinal phase space of the 11.8 GeV, 250 pC bunch at the exit of (a) 4-m corrugated structures, and (b) 8-m corrugated structures in the LCLS accelerator.

The GENESIS simulations for such large energy spread beam have not been carried out yet. The peak current of the core bunch is about 3.5 kA. Assuming the middle 50-fs bunch will contribute to FEL lasing due to its relatively high peak current, we estimate the FWHM SASE bandwidths at 6 keV are 1.5% and 2% for the 4-m and the 8-m device respectively. Reaching bandwidth larger than 2% will require a longer corrugated structure with different period and gap parameters to minimize the transverse wakefield effects. The estimated cost for an 8-10 m corrugated structure is about $1M.