Dual Energies in the LCLS Copper Linac

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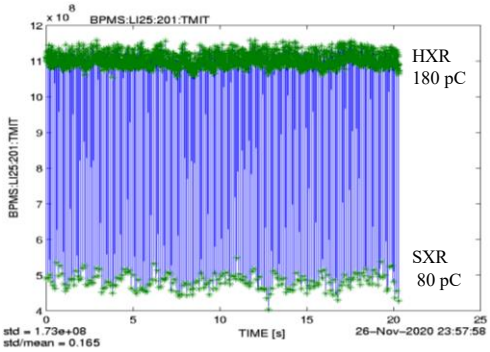
Abstract

For LCLS-II two undulators were installed at SLAC, one for soft and one for hard x-rays. Before the superconducting linac gets turned on the copper linac is providing beams at 120 Hz to these two beam destinations. The 120 Hz can be split in many different ratios between soft and hard via a pulsed magnet. To get an optimized beam for the quite different photon energies the pulsed linac components like modulators and RF can provide many different beam parameters, mainly energies and bunch lengths for the two undulator lines. How this was implemented with timing setups of triggers and finally after the split the necessary matching of the transverse phase space will be discussed.

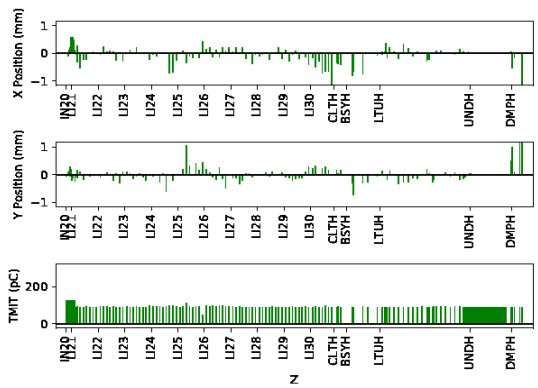
Phased Approach

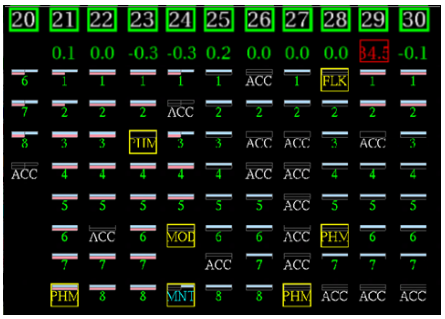
Phase 0: SAME energy for HXR and SXR: 5, 6, 8, 10 GeV
Phase 1: L3 "Dual Energy", e.g.: 6 and 12 GeV + beta matching
Phase 2: Different bunch lengths for HXR (short) and SXR (long) by different chirp settings (L2 phase).
Phase 3: Special setups, e.g.: Different energy in L1 to cut only one horn and leave the other horn for femto-second spike for SXR. Different intensities with different lasers [needs trigger].



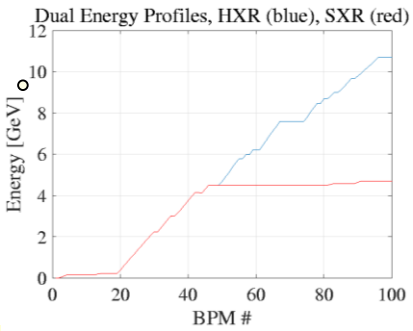
Cutting charge in Bunch Compressor 1 (BC1) for HXR the typical 250 to 180 pC, while for SXR it is down to 80 pC (or even 30 pC), see below.

BC1 Energy set point	0 MeV	-5 MeV	-7 MeV
Charge	180 pC	80 pC	30 pC
L1S Ampl.	110 MeV	105.2 MeV	103.5 MeV
BC1 Orbit	0 mm	+5.2 mm	+7.4 mm
BC1 Peak Current	195 A	130 A	40 A
BC2 Peak Current	3200 A	1700 A	800 A

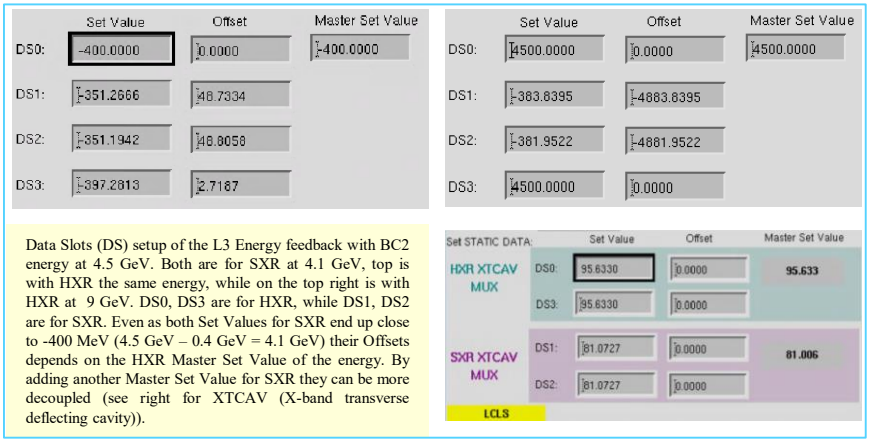




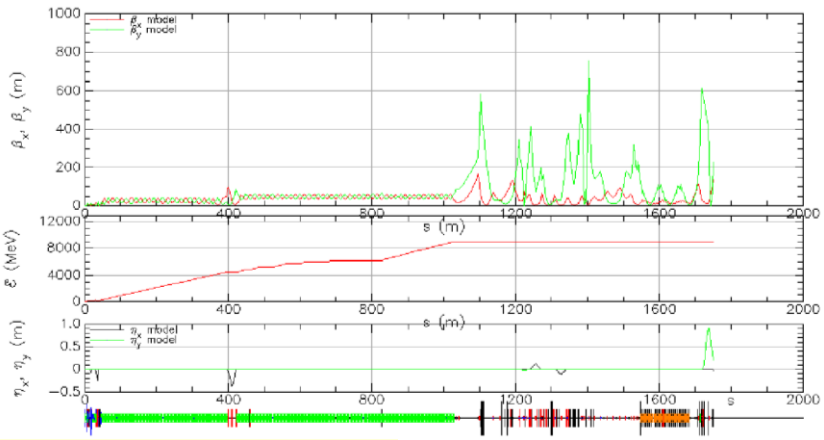
Klystron CUD (Overview) Panel showing the status of all the LCLS klystron. Whether they are on for the beam going to the hard x-ray line (blue) and/or soft x-ray line (red) is indicated by horizontal, coloured bars, in this case 10.7 and 4.7 GeV in Dual Energy Mode. The yellow boxes indicate problems, like PHM (Phase Mean), Modulator, Maintenance, or stations with ACC are ready to be used for acceleration.



Energy Profile along the Linac. For hard x-rays (HXR) it is 10.7 GeV, while for soft x-rays (SXR) it is 4.7 GeV at the end.



Data Slots (DS) setup of the L3 Energy feedback with BC2 energy at 4.5 GeV. Both are for SXR at 4.1 GeV, top is with HXR the same energy, while on the top right is with HXR at 9 GeV. DS0, DS3 are for HXR, while DS1, DS2 are for SXR. Even as both Set Values for SXR end up close to -400 MeV (4.5 GeV – 0.4 GeV = 4.1 GeV) their Offsets depends on the HXR Master Set Value of the energy. By adding another Master Set Value for SXR they can be more decoupled (see right for XTCAV (X-band transverse deflecting cavity)).



Top: Betatron lattice before implementing the predictive match for the HXR line,. This gets the betatron functions to design values beyond s = 1200 m.

← Left: HXR orbit with excursions up to 1 mm close to the branching point (CLTH). The HXR beam was setup after the SXR beam at design quadrupole strengths and steered down to 0.3 mm. The steering can be done with closed (for one beam) 3-corrector bumps, which are open for the other energy beam.

Right: Tuning both beams with Li26 Quads. → GDET (blue) in HXR is typically more sensitive, while the GMD (green divided by 10) from SXR is up to 6 mJ and less sensitive.