LCLSII Injector Commissioning Beam Based Measurements

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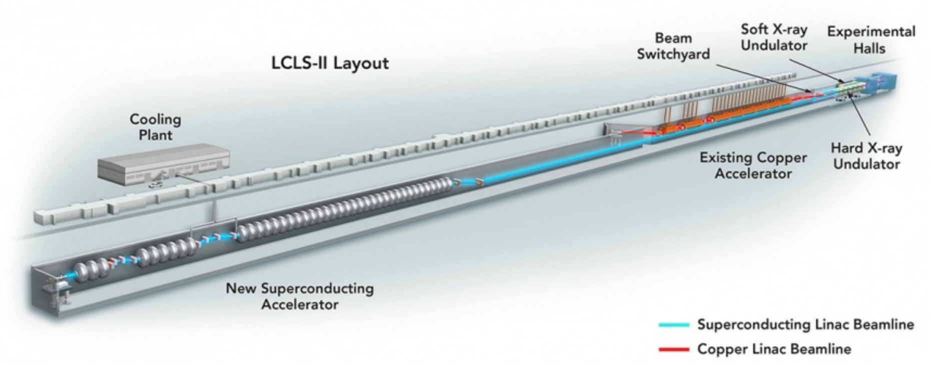
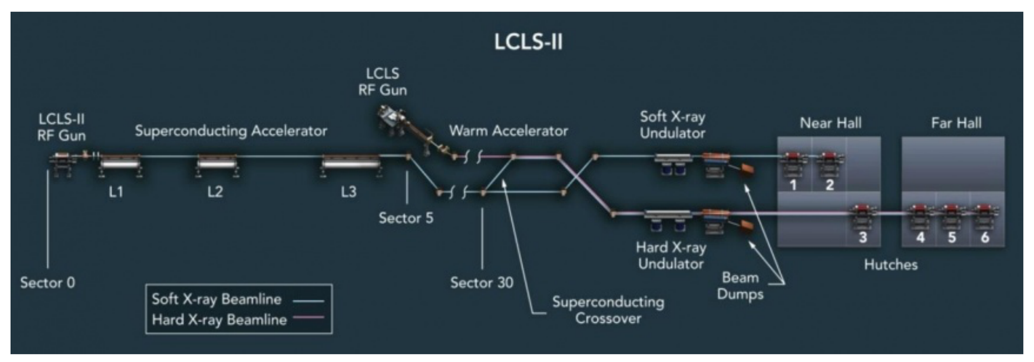
Introduction

LCLS-II early injector commissioning is underway at SLAC. New beam-based measurements of injector components have been devised, and initial tests of automation are underway. Methodology and first results will be presented.

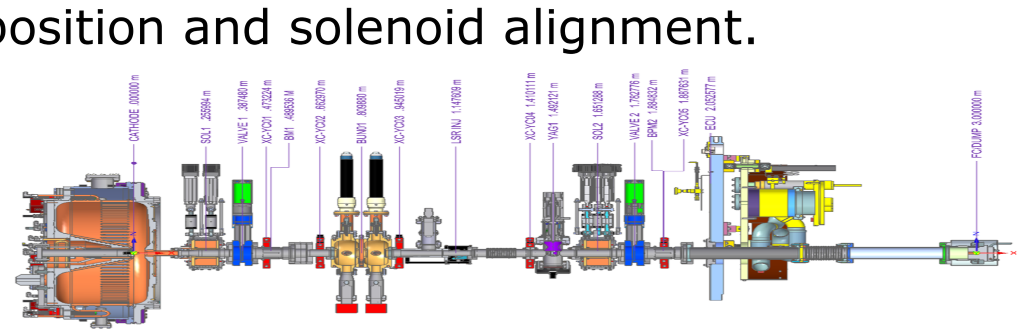


Background



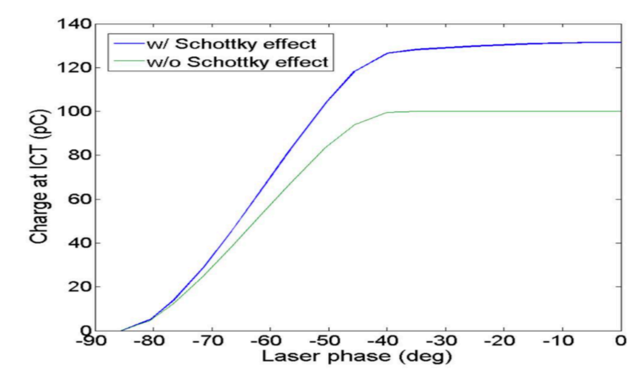
LCLS-II is an upgrade to the existing LCLS Free Electron Laser, and will be a 4GeV MHz repetition-rate superconducting accelerator feeding two undulator lines to generate hard and soft X-rays at energies ranging from 0.2 to 25keV.

The injector for LCLS-II is composed of a 750keV 186MHz CW normal-conducting photoelectron gun and a 1.3GHz CW buncher. The gun utilizes a Cesium Telluride cathode with high quantum efficiency when struck with a 257.5nm UV laser. Beam based measurements will repeatedly and reliably need to be made for laser phase, gun and buncher phase/amplitude, cathode position and solenoid alignment.



Methods

- **Laser phase** vs. gun RF (schottky phase) is measured by scanning timing to find where charge is extinguished
  - This gives zero crossing, then phase is set near crest

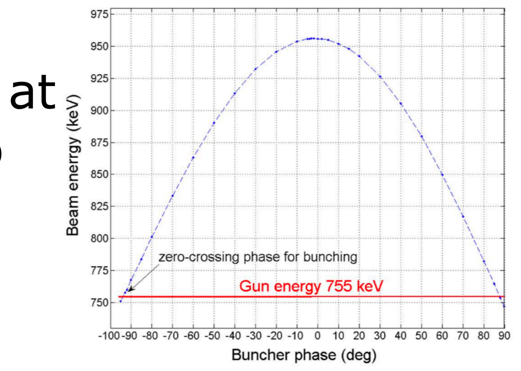


- The LCLS-II injector has no diagnostic/dispersive region, so beam energy measurements are made using a corrector dipole according to the following equation:

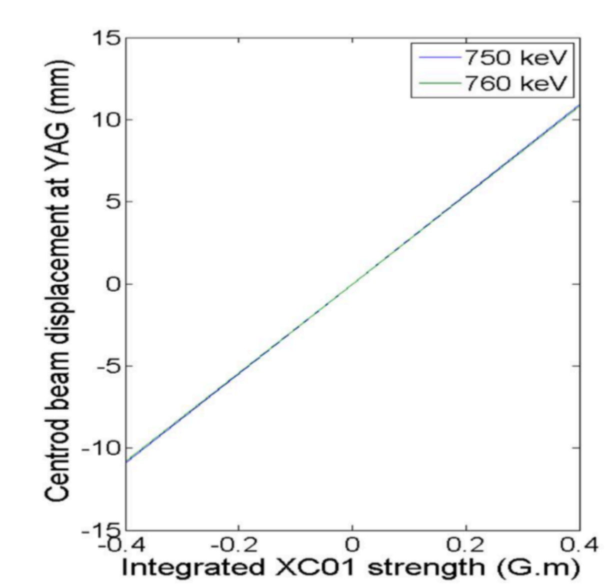
$$E_k = 0.511\cdot 10^{-3}\cdot\left(\sqrt{\left(\frac{d}{33.356\cdot 0.511\cdot 10^{-3}}\cdot\frac{1}{\frac{x}{BL(kG.m)}}\right)^2+1}-1\right)$$

Where d is the distance between the corrector and the screen, BL is the integrated strength of the corrector, x is the beam displacement at the screen, and E_k is the kinetic energy

- **Both gun and buncher energies** can be empirically determined by scanning beam position vs. corrector strength
  - Then fitting the data and inserting the slope into the above equation
- **Buncher phase is** measured by finding phase at which energy contribution from buncher is zero

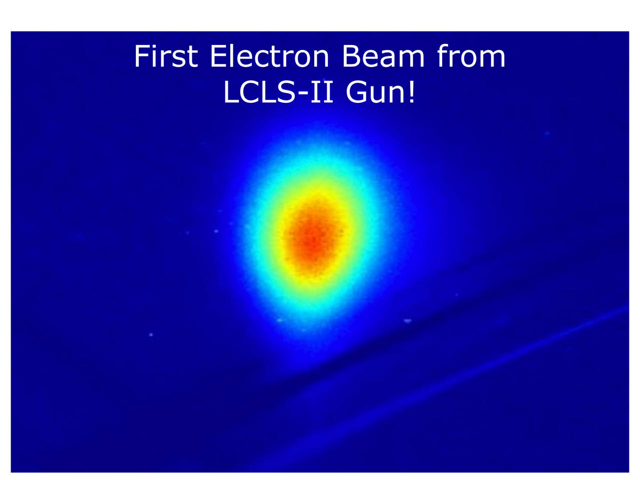


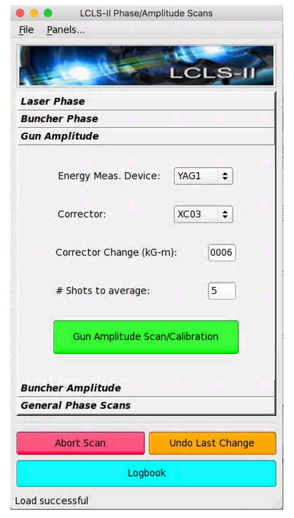
- **Laser position on cathode** measured by scanning UV laser mirror up/down/left/right to see where charge extinguishes
- **Solenoid alignment** measured by looking at transverse solenoid kicks at different solenoid settings

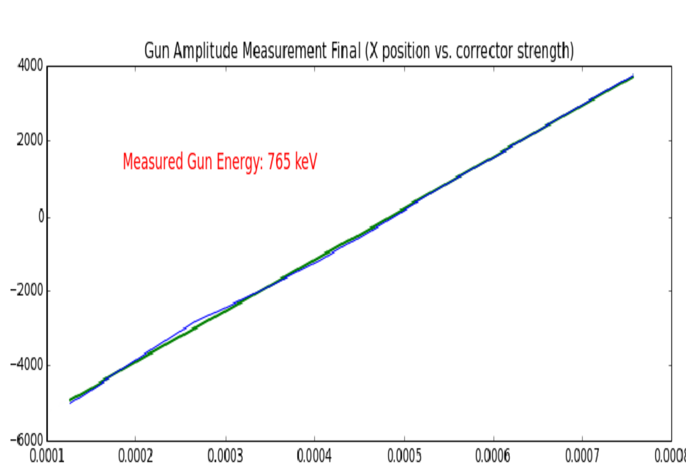


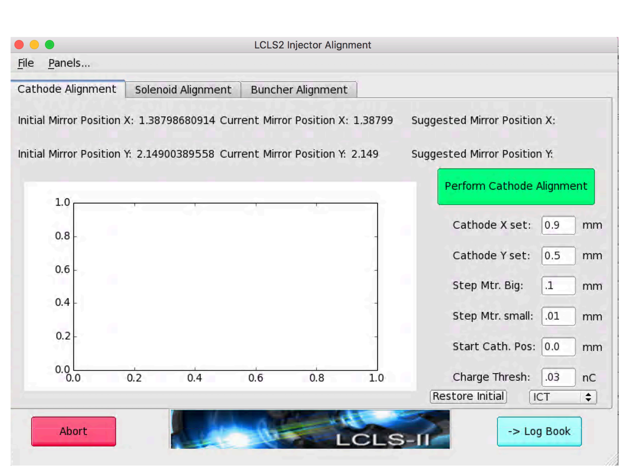
Results

The gun energy has been measured to be almost exactly as designed: 766keV. Energy measurements were initially made manually and then by using a new Python-based automated measurement GUI which agreed with the manual measurement. Phase, amplitude and cathode position measurements will be taken soon. All measurements have been automated, with the exception of solenoid alignment.



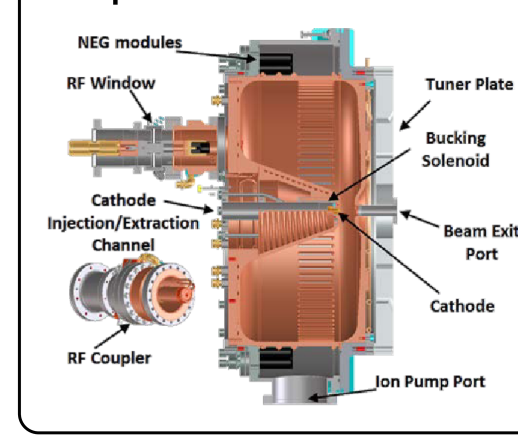






Discussion

A high quantum efficiency Cs_2Te cathode will be installed in the coming weeks. Once higher charge (>20pC) beam has been produced, we will time in remaining diagnostics and proceed with testing the remaining automated measurement algorithms. These new algorithms will be adjusted and refined as necessary in order to provide highly reliable and reproducible measurements.



Parameter	Nominal	Range	Units
Electron energy at gun exit	750	500-800	keV
Electron energy	98	95-120	MeV
Bunch charge	100	10-300	pC
Bunch repetition rate	620	0-929	kHz
Dark current		0-400	nA
Peak current	10	5-30	A
Average current	0.062	0-0.3	mA
Average beam power	6.1	0-36	kW
Normalized slice emittance (rms)	0.4	0.2-0.6	µm
Bunch length (rms)	1	0.3-10	mm
Slice energy spread (rms)	1	1-5	keV
Vacuum pressure in gun	1	0.1-1	nTorr
Cathode quantum efficiency	2	0.5-10	%
Laser (UV) energy at cathode	0.02	0-0.3	µJ
Laser (IR) energy at laser heater	1	0-15	µJ
Average CW RF gradient	16	15-18	MV/m

Conclusions

The LCLSII Gun and Buncher have been successfully run up to full power with CW RF. Low charge beam has been produced with a Mb cathode, and the beam energy has been measured at ~760keV which matches the design energy. Beam charge will be increased and the rest of the automated measurement algorithms tested in the coming months.

Acknowledgments

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