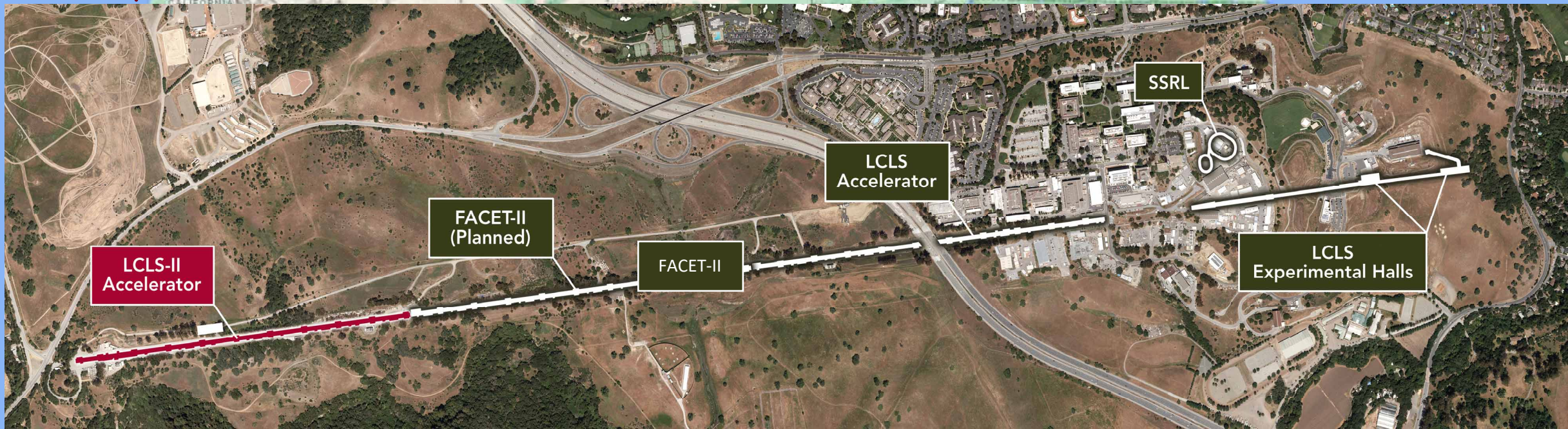


Status of the LCLS-II Superconducting Linac

Dan Gonnella, SC-Linac-Physics Department Head
On behalf of the LCLS-II Collaboration

Workshop on Future Light Sources
28 August 2023



Remove SLAC
Linac from
Sectors 0-10

New Injector and
New Superconducting Linac

New Cryoplat

Existing Bypass
Line

New Transport Line

LCLS-II

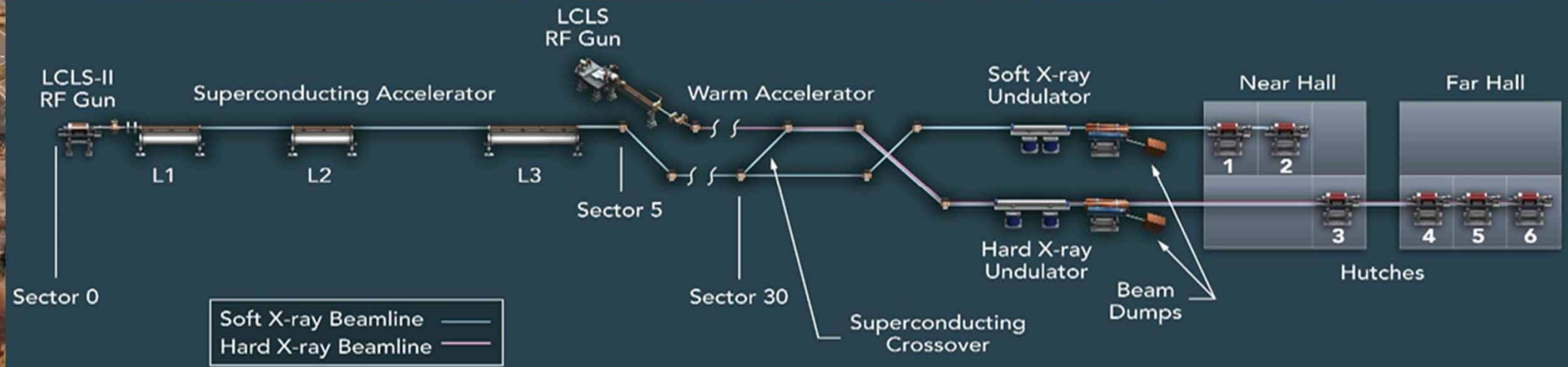
SLAC

NATIONAL
ACCELERATOR
LABORATORY



Fermilab

Jefferson Lab



LCLS-II Technical Parameters

Performance Measure	Threshold	Objective
Variable gap undulators	2 (soft and hard x-ray)	2 (soft and hard x-ray)
Superconducting linac-based FEL system		
Superconducting linac electron beam energy	3.5 GeV	≥ 4 GeV
Electron bunch repetition rate	93 kHz	929 kHz
Superconducting linac charge per bunch	0.02 nC	0.1 nC
Photon beam energy range	250–3,800 eV	100–5,000 eV
High repetition rate capable end stations	≥ 1	≥ 2
FEL photon quantity (10^{-3} BW) per bunch	5×10^8 (10x spontaneous) @2,500 eV	$> 10^{11}$ @ 3,800 eV
Normal conducting linac-based system		
Normal conducting linac electron beam energy	13.6 GeV	15 GeV
Electron bunch repetition rate	120 Hz	120 Hz
Normal conducting linac charge per bunch	0.1 nC	0.25 nC
Photon beam energy range	1–15 keV	1–25k eV
Low repetition rate capable end stations	≥ 2	≥ 3
FEL photon quantity (10^{-3} BW ^a) per bunch	10^{10} (lasing @ 15 keV)	$> 10^{12}$ @ 15 keV

Achieved

Cryomodule Installation

Last CM (spare) Delivered in May 2021

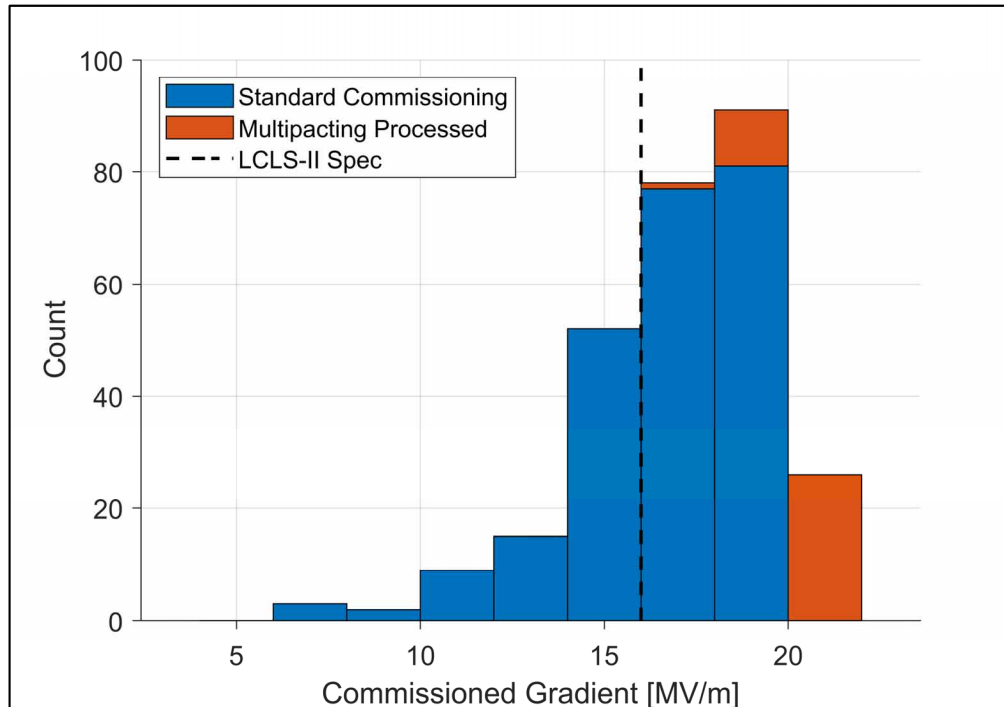


CM Installation Complete
February 2021



Overall SRF Commissioning Status

Gradient Performance

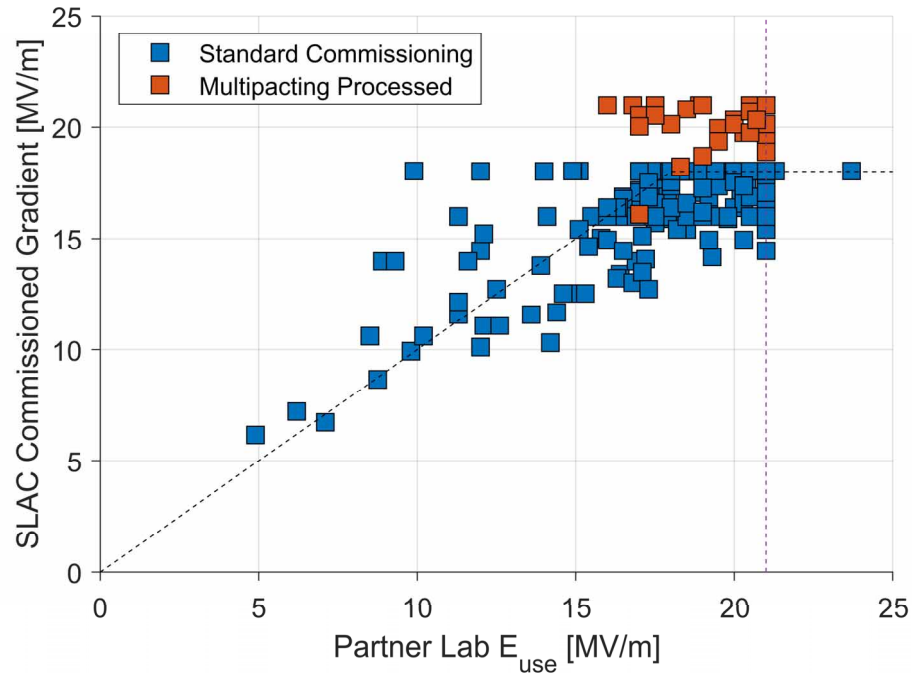


- Cryomodule commissioning was completed in summer 2022 and was very successful
- 97% of installed cavities fully operational (planned 94%)
- Majority of testing included an admin limit of 18 MV/m
- Total commissioned voltage **exceeds design by >20%**

Total Commissioned Cavity Voltage: 4.9 GV

Gradient Performance

Comparison with Acceptance Test

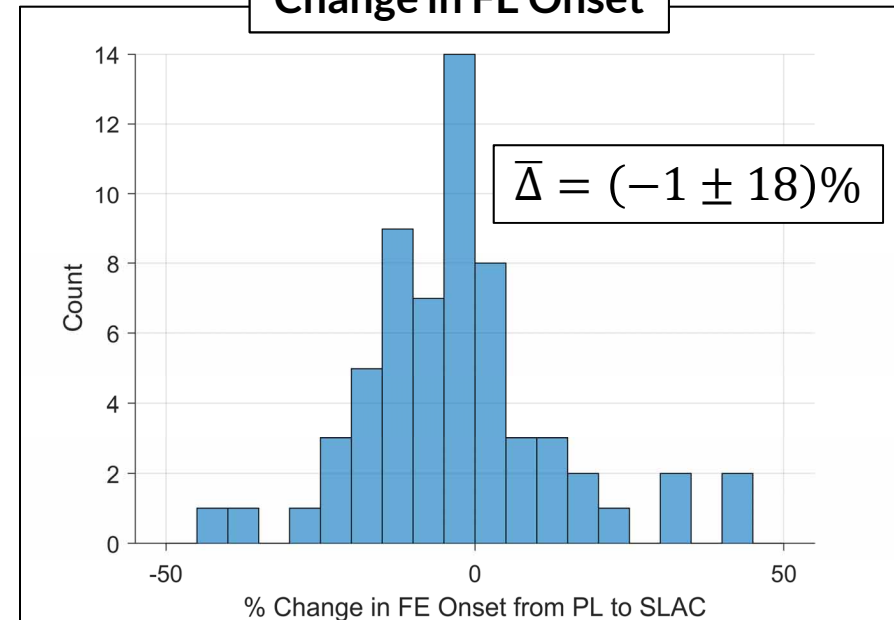


Admin limits:

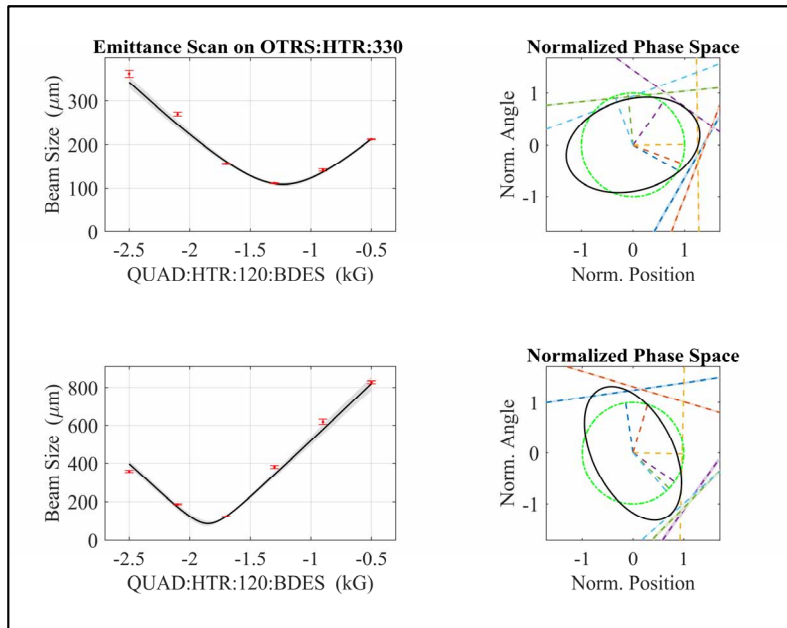
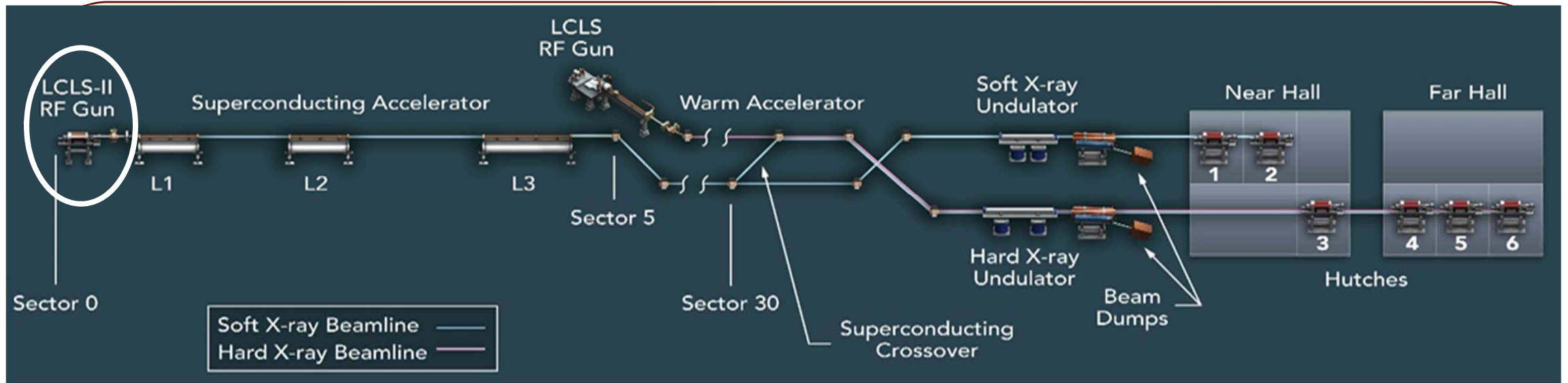
- 18 MV/m in commissioning
- 21 MV/m in acceptance test

- Gradient performance is in line with CM acceptance test measurements at FNAL and JLab
- **No observable change in field emission onsets or magnitude from installation**
 - Remarkable achievement by the SLAC installation team

Change in FE Onset



Injector Beam Emittance



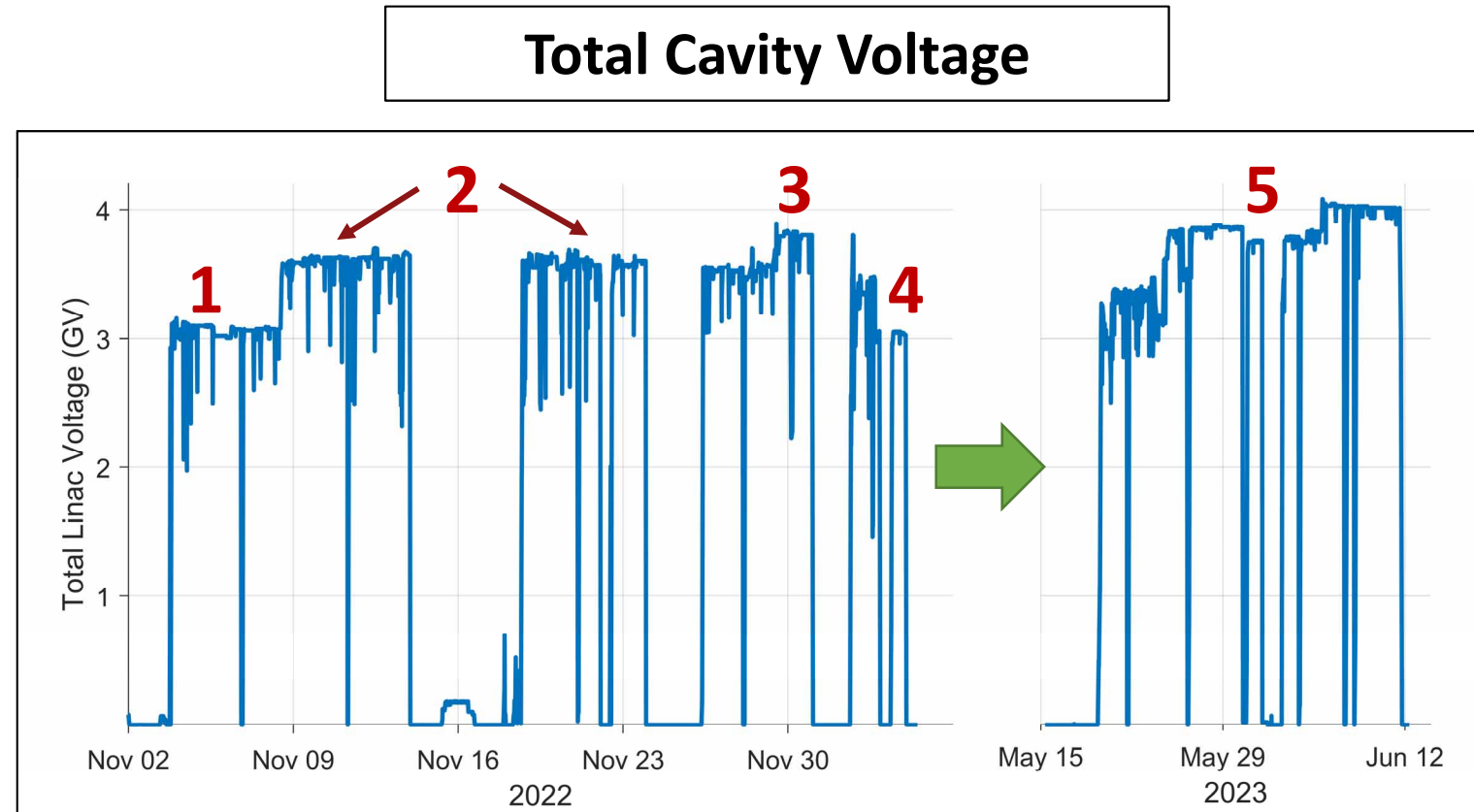
50 pC beam

Dimension	Emittance (μm)
$\gamma\epsilon_x$	0.58 ± 0.02
$\gamma\epsilon_y$	0.56 ± 0.02

Excellent Injector Emittance Achieved

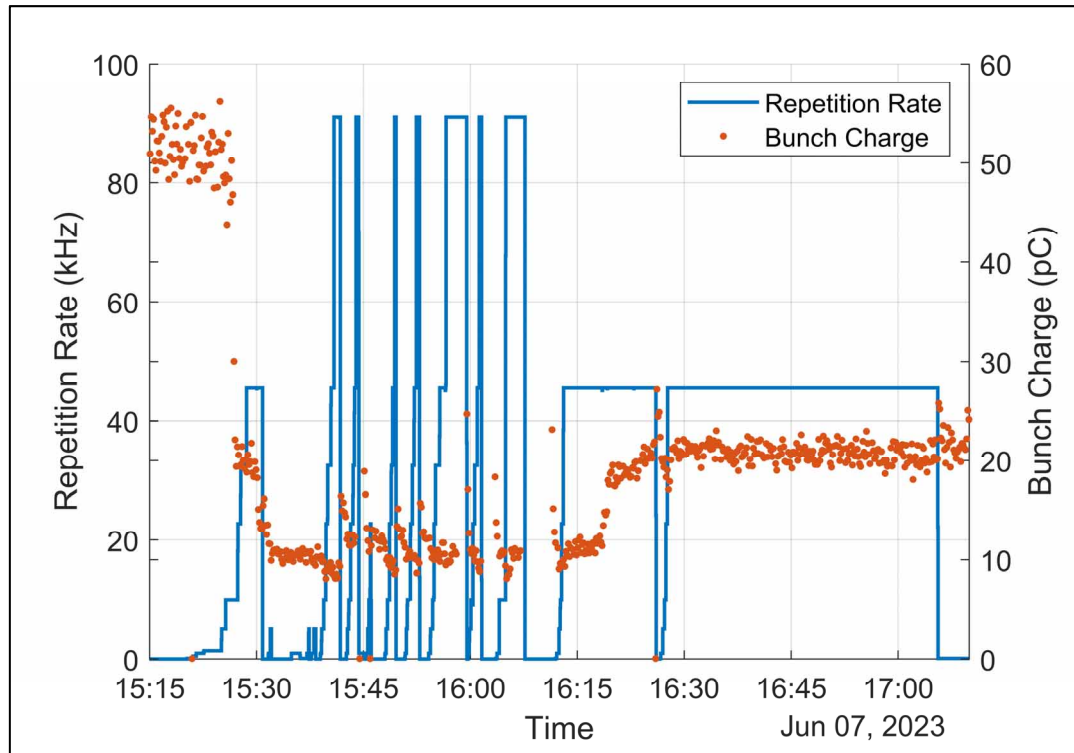
Demonstration of 3.5 GeV Beam

1. Stable 3 GeV beam to BSY achieved on 10/28
2. Stable 3.5 GeV beam (on crest) to BSY achieved on 11/8
 - Ran stably through end of November
3. 3.5 GeV beam with L1 and L2 at nominal phase (off crest) at end of November
4. Lowered to 3 GeV for remaining beam tasks until December break
5. Following restart in May 2023, 3.5 GeV beam has been used exclusively

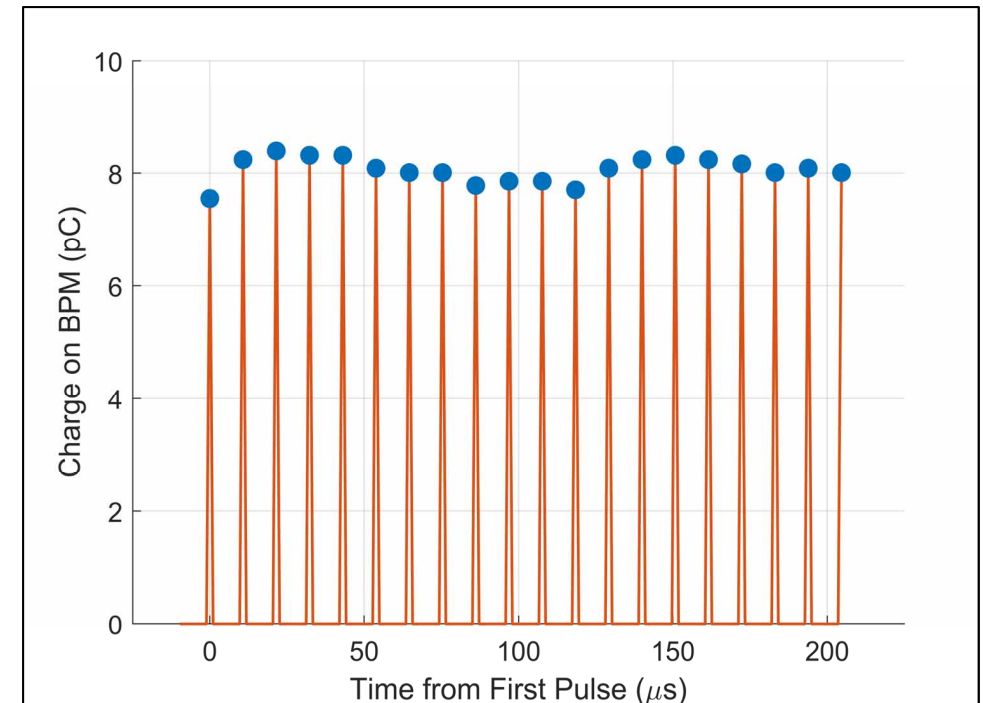


93 kHz Operation

- Repetition rate was ramped up to 93 kHz on 6/7 for the first time
- Subsequent measurements were carried out at half the rate but at same beam power for additional testing
- This was the final performance metric for the linac side of the LCLS-II project



Pulse Spacing Measurement on Last BPM



Spacing of $\sim 10.7 \mu\text{s}$ between pulses demonstrates 93 kHz

First Lasing

1. Electron beam commissioning:

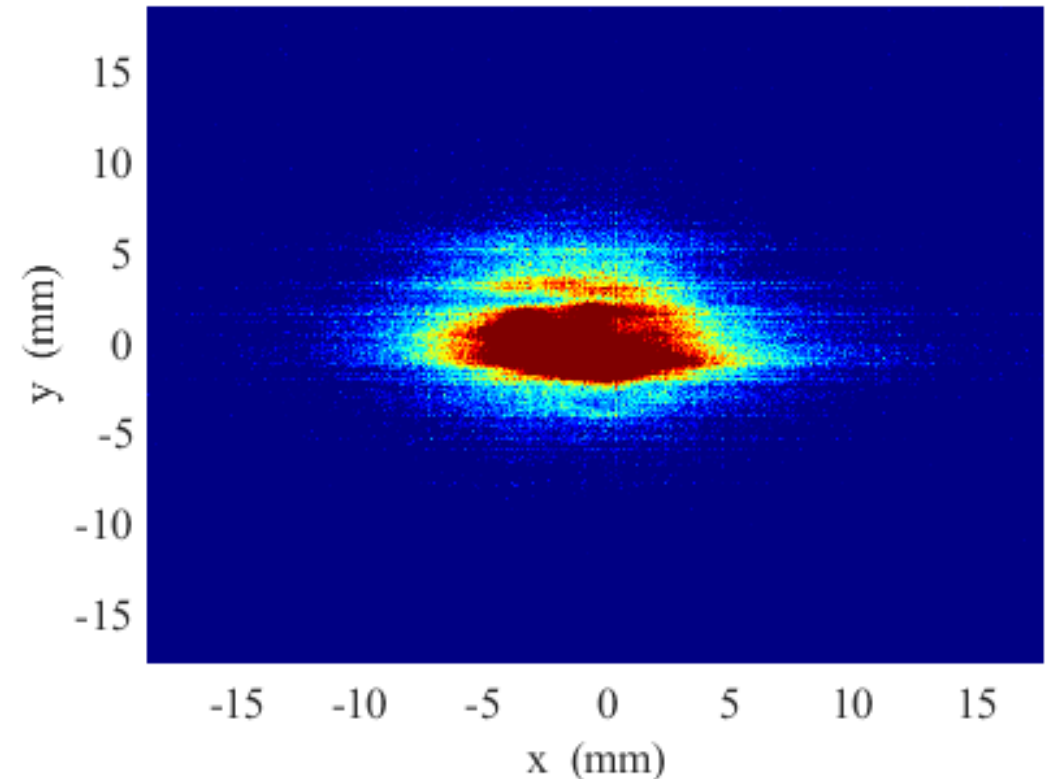
- 1st beam sent through the undulators last week
- Lasing demonstrated for the first time at 450 eV in the SXR on 8/23

2. X-ray beam commissioning

- Over the next month, the FEL will be tuned and photon energy and power will be measured
- Expect to complete the LCLS-II project by the end of September

**First Lasing
on 8/23/23**

Profile Monitor IM2K0:XTES:CAM 23-Aug-2023 15:13:43



SC Linac Commissioning Accomplishments & Remaining Tasks

Linac Commissioning

- ✓ Established the **first-time beam through the three main SC linac** sections (L1B, L2B, and L3B) in October 2022
- ✓ **3.5 GeV beam** transported to BSY dump in November 2022
- ✓ **Record injector performance** has been demonstrated
- ✓ Demonstration of **repetition rate of 93 kHz** in June 2023

Photon Commissioning

- ✓ Beam transport to undulator halls in August 2023
- ✓ First photons in August 2023
- 3. Verification of photon energy

Estimate to complete September 2023

