LCLS-II-HE Project

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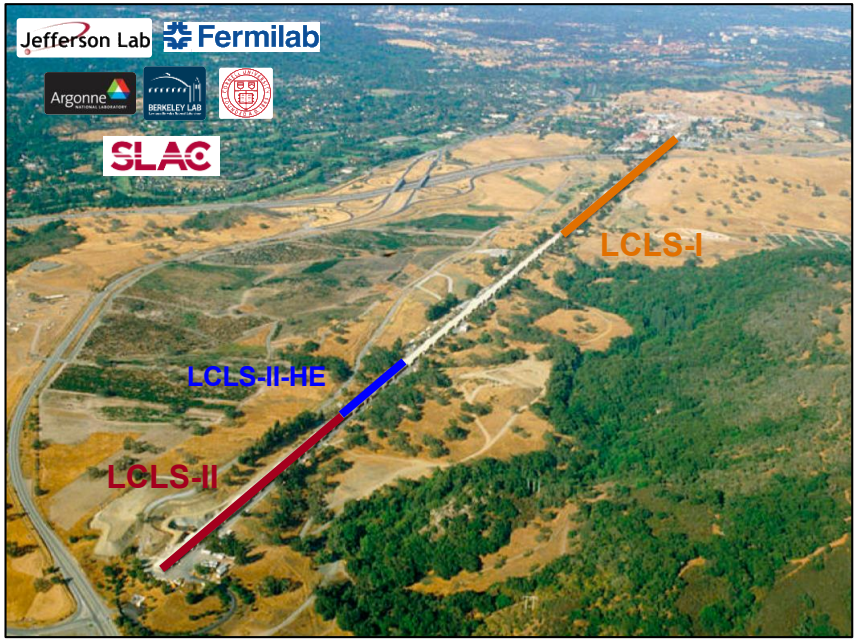
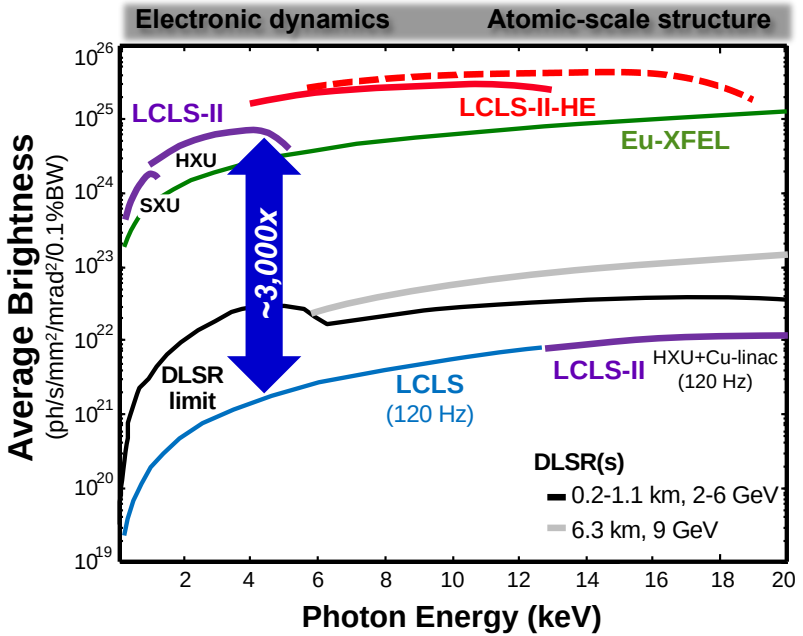
SLAC NATIONAL ACCELERATOR LABORATORY

Fermilab Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Stanford University

LCLS-II-HE will upgrade LCLS-II and deliver photon energies beyond 12 keV (< 1Å) in a continuous pulse train up to 1 MHz.





LCLS-II Currently 80% complete. Users online in 2021

LCLS-II-HE CD-1 approved Sept 2018. Targeting mid-decade users

LCLS-II-HE Scope

Double the electron energy of the accelerator (4 ➔ 8 GeV)

- Extends X-ray energy limit from 5 keV to 12.8 keV

Install a second bypass line to provide a dual source

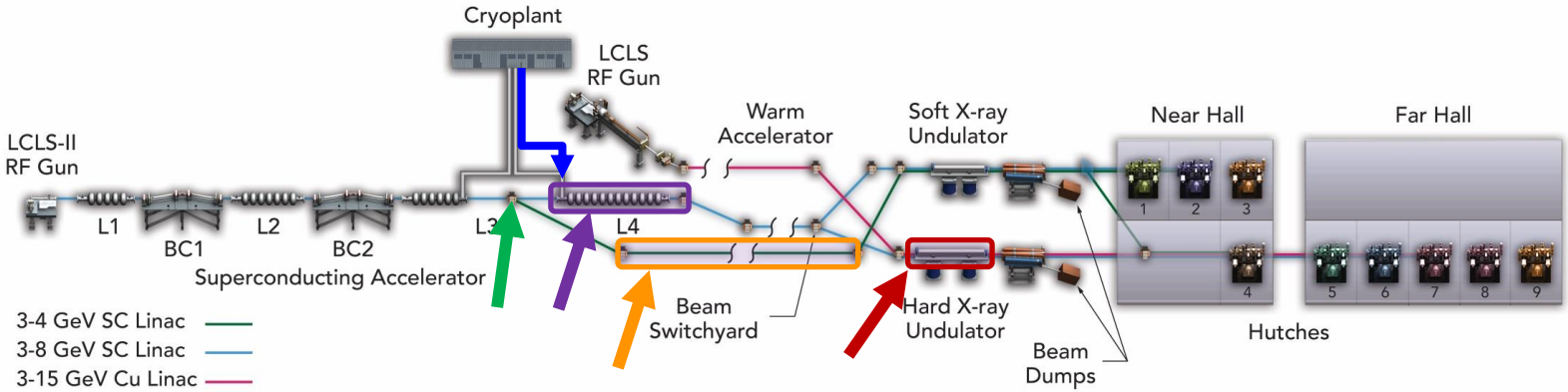
- Delivers simultaneous soft X-ray and hard X-ray beams at high rep-rate

Provide specialized instruments for unique new source

- Delivers optimized measurement capabilities and enables science immediately from the onset of commissioning

This provides a qualitatively new capability, unique in the world, delivering ultrafast, Ångström performance at high average power.

LCLS-II-HE accelerator upgrades will enable hard X-rays at high rep-rate and increase the experimental capacity.



1. Add 20 additional cryomodules (L4 linac) to increase the LCLS-II accelerator energy to 8 GeV.
2. Install new cryogenic distribution box and transfer line between the cryoplant and the new L4 linac.
3. Add low-energy extraction point at 3.8 GeV to enable quasi-independent operation of the soft-X-ray and hard-X-ray programs.
4. Use existing transport line to bypass downstream linacs and install new dump in the beam switch yard
5. Install high rep-rate Hard X-ray Self Seeding capability in the hard X-ray undulator

New and upgraded instruments will address the science needs and take advantage of the transformative nature of LCLS-II-HE.

Instr.	Upgrade Plan	Science Opportunities
XPP	New detector Upgraded diagnostics	• Understand coupled dynamics of molecular structure and charge & their role in energy flow • Characterize materials heterogeneity, fluctuations & link to function
DXS	Repetition rate enhancement IXS capability	• Map collective excitations & understand their relation to emergent phenomena in complex materials • Characterize materials heterogeneity, fluctuations & link to function
CXI	New optics & detector Enhanced DAQ	• Reveal the role of structural dynamics in biological function • Catalysis: Reveal the correlation between chemical reactivity & structural dynamics

- Key Performance Parameter
  - 3 upgraded endstations
- Objective KPP
  - 5 upgraded endstations

LCLS-II-HE Project KPPs

Preliminary Threshold and Objective KPPs

Performance Measure	Threshold	Objective
Superconducting linac electron energy	7 GeV	8 GeV
Electron bunch repetition rate in linac	93 kHz	929 kHz
Charge per bunch in SC- linac	0.02 nC	0.1 nC
Photon energy range	200 – 8,000 eV	200 to **≥** 12,800 eV
High rep-rate-capable HXR end stations	≥ 3	≥ 5
FEL photon quantity (10^{-3} BW)	5×10^{8} (50× spont. @ 8 keV)	$> 10^{11}$ @ 8 keV (200 μJ) or **$> 10^{10}$ @ 12.8 keV (20 μJ)**

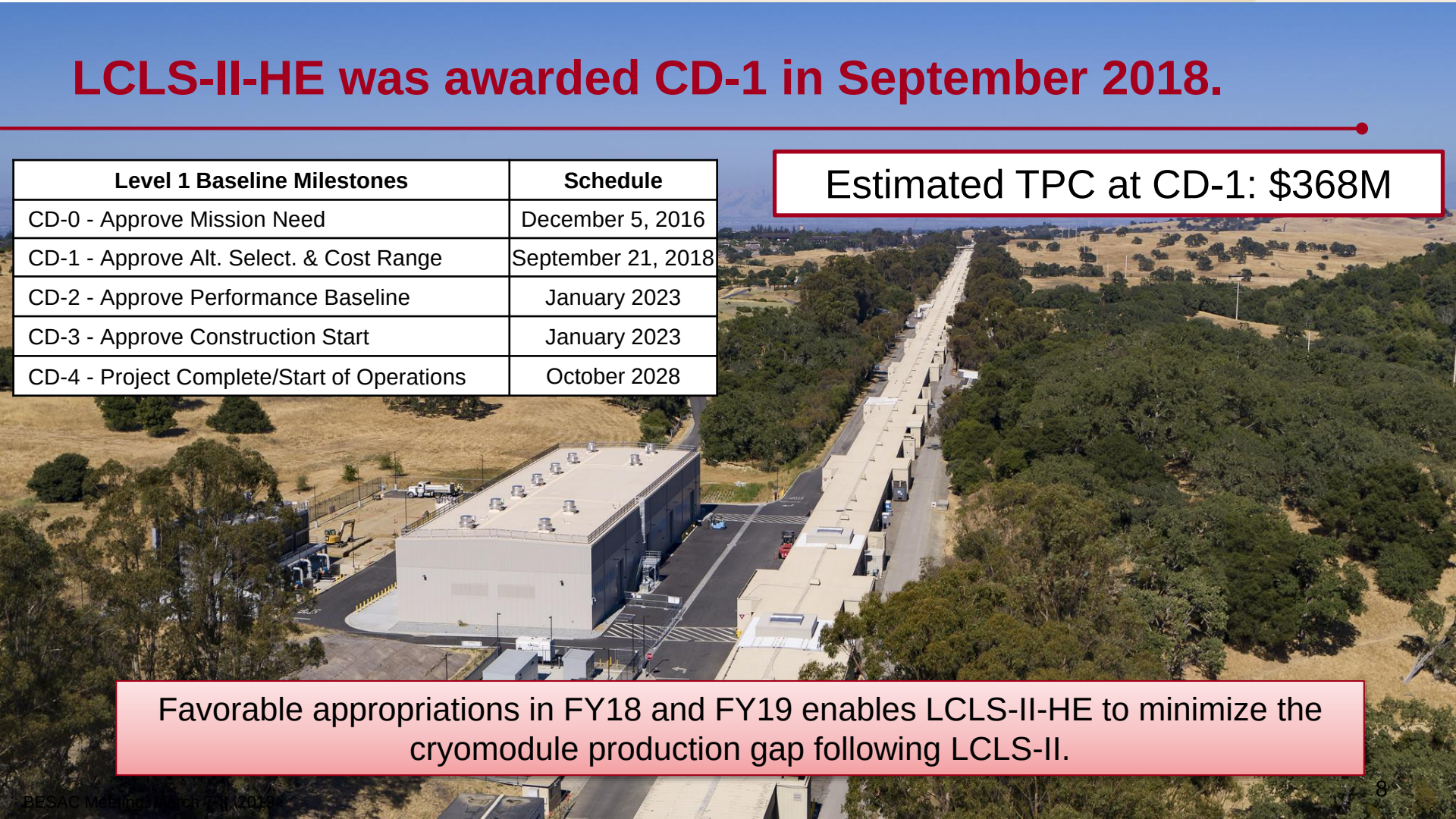
LCLS-II-HE Project Collaboration (proposed)

SLAC NATIONAL ACCELERATOR LABORATORY	• Accelerator and FEL Design • Cryomodule and accelerator installation • Cryoplant modifications & Helium distribution installation • High Power RF, low-level RF, and Controls • X-ray instruments design & installation
Fermilab	• High Q0 & High Gradient R&D • Cryomodule design • 50% of cryomodule production • Processing for high Q • Helium distribution system design and procurement
Jefferson Lab EXPLORING THE NATURE OF MATTER	• High Q0 & High Gradient R&D • 50% of cryomodule production • Processing for high Q
CORNELL UNIVERSITY FOUNDED A.D. 1865	• High Q0 & High Gradient R&D
BERKELEY LAB	• Accelerator Physics

LCLS-II-HE was awarded CD-1 in September 2018.

Level 1 Baseline Milestones	Schedule
CD-0 - Approve Mission Need	December 5, 2016
CD-1 - Approve Alt. Select. & Cost Range	September 21, 2018
CD-2 - Approve Performance Baseline	January 2023
CD-3 - Approve Construction Start	January 2023
CD-4 - Project Complete/Start of Operations	October 2028

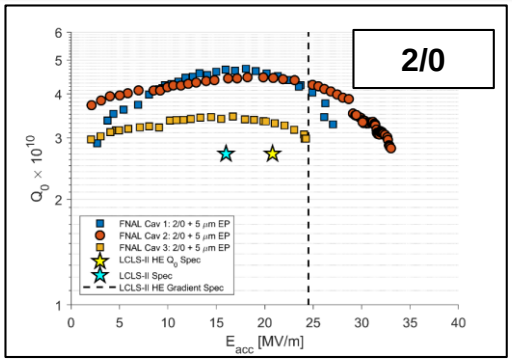
Estimated TPC at CD-1: $368M

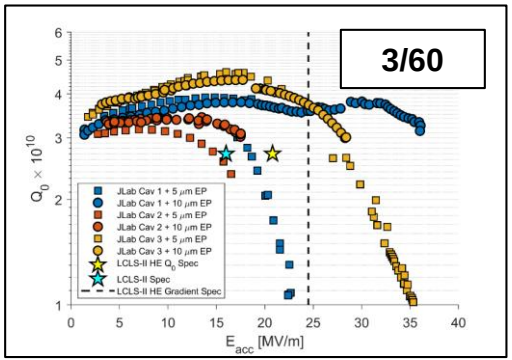


Favorable appropriations in FY18 and FY19 enables LCLS-II-HE to minimize the cryomodule production gap following LCLS-II.

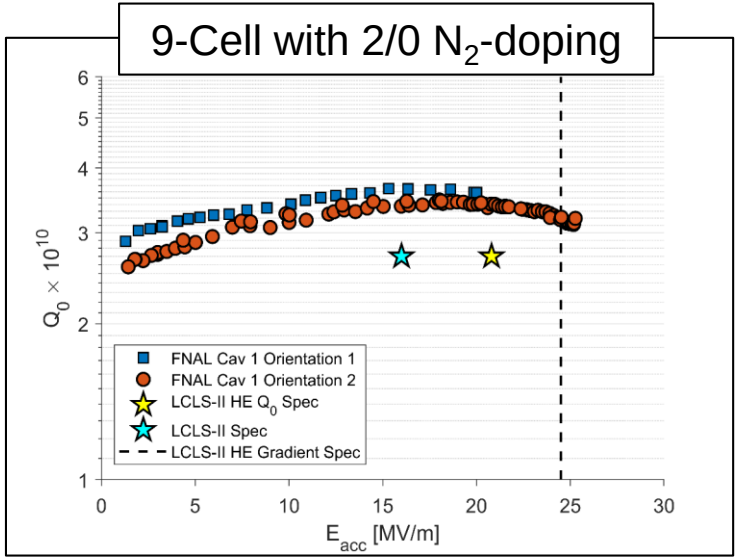
Significant progress has been made on SRF High-Gradient/High-Q0 cavity R&D

2 cavity processing methods have demonstrated HE performance requirements on single cells.





R&D now transitioning to 9-cells



2/0 cavity processing method can produce 9-cells that meet LCLS-II HE spec!

12-month Forecast

Favorable appropriations have enabled a fast project launch!

- **The Project collaboration is now being formed and will be codified under a new Memorandum of Agreement.**
- **Cavity R&D will culminate this year with 9-cells ready for prototype cryomodule demonstration.**
- **Construction of the HE Prototype cryomodule will begin after LCLS-II production ceases in late 2019.**
- **CD-3A review for cryomodule production is planned Q4FY19.**
- **Cryomodule supply chain procurements will commence following CD-3A ESAAB approval.**