LCLS Facility Update

International Forum on Detectors for Photon Science

25 March 2021

U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

Outline

- LCLS Facility Status
- Detector Department Highlights
- Development Projects Status Overview

LCLS Status: Summary

LCLS-II project is >90% complete

- Project current “early finish” date is August 2022
- All cryomodules installed (37)
- All Soft X-ray Undulators installed (21)
- All Hard X-ray Undulators installed (32)
- System ready for Linac cooldown in Sep 2021

Copper Linac online for user science (from August 2020)

- 120Hz SXR Line operating, >5mJ/pulse
- 120Hs HXR Line operating, >2.5mJ/pulse
- Photon energy reach increased to 25keV

SLAC NATIONAL ACCELERATOR LABORATORY

BERKELEY LAB
Lawrence Berkeley National Laboratory

Argonne NATIONAL LABORATORY

Fermilab

Jefferson Lab

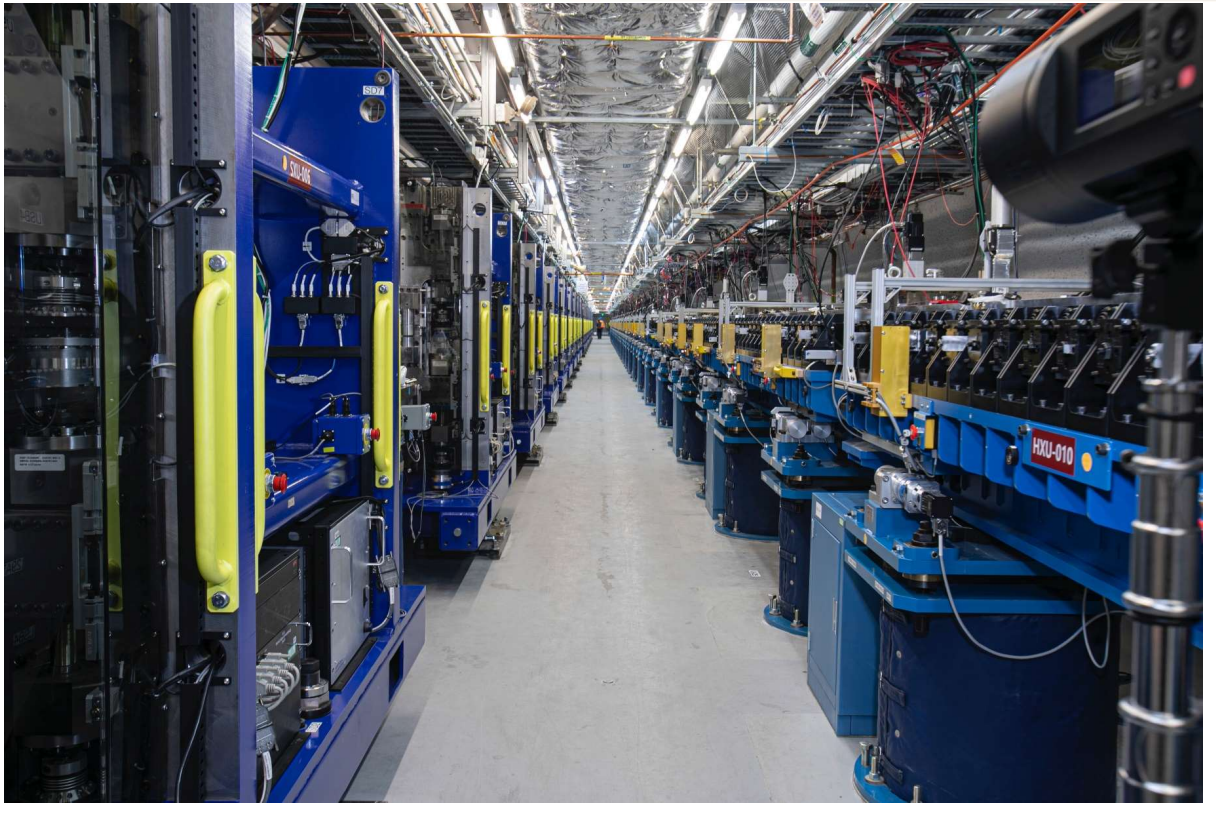
Cornell University

LCLS-II Status: Accelerator Systems

- All cryomodules installed in the tunnel
- Vacuum interconnections 90% complete
- All helium line joint welds complete

- 252 of 292 Solid State Amplifiers installed
- 85% High Power RF Wave Guides installed

LCLS-II Status: Undulator Hall



SXR undulators on left, HXR on right

All Soft- and Hard-X-ray undulators have been installed and commissioned

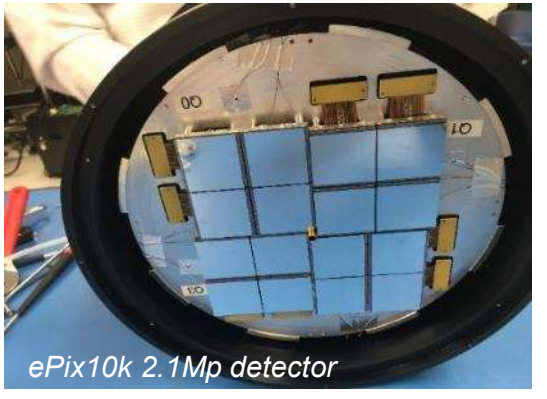
Remaining work:

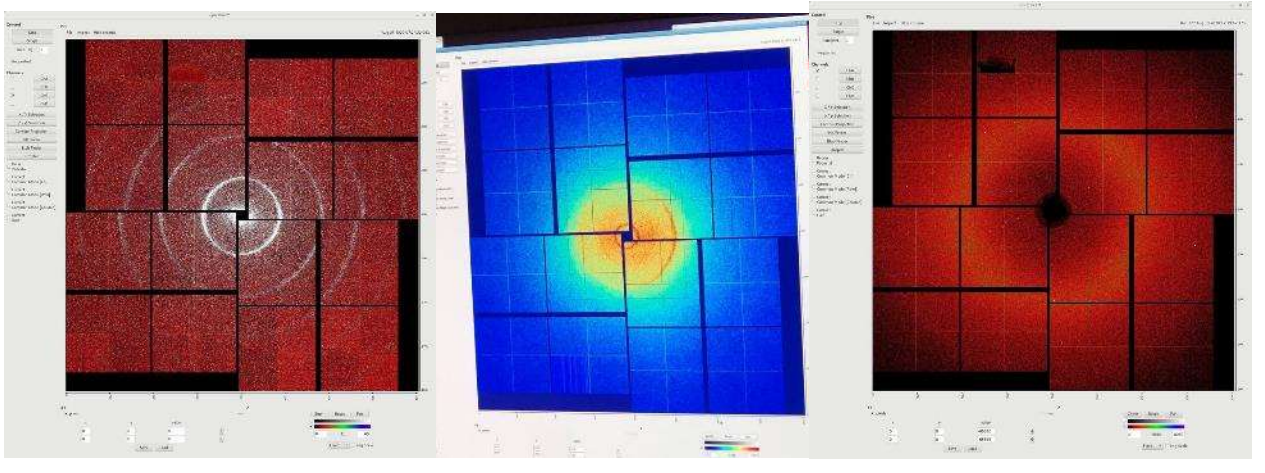
- Install and commission self-seeding monochromators.

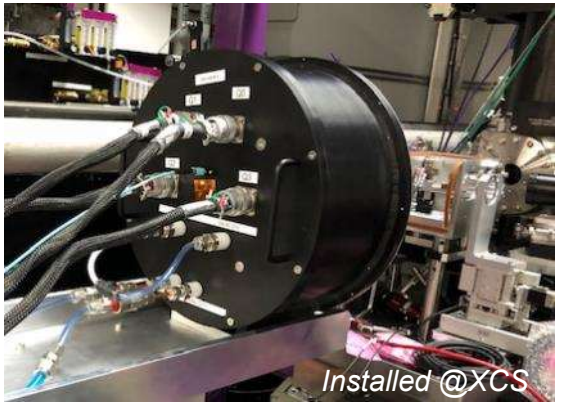
2020 Detector Program Highlights: Detector Upgrades

ePix10k-2M

- Two copies of the 2+ megapixel ePix10k deployed for use throughout the HXR hutches.
- Characterized and calibrated, supporting multiple user experiments since restart. Refining autogain calibration near switching fluence.
- First LCLS COVID publication (DeMurci et.al).
- Fully integrated in LCLS DAQ and Controls. Established as workhorse replacement for legacy CSPAD.

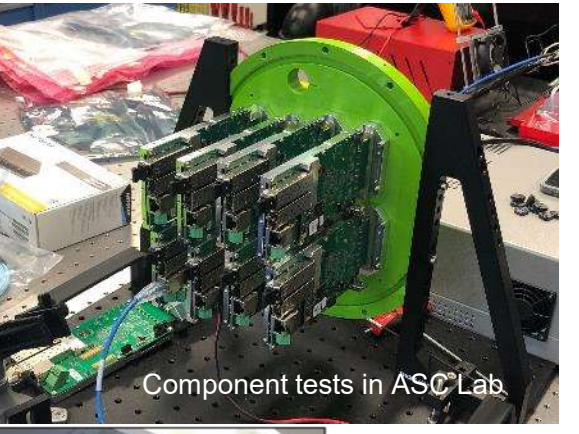

ePix10k 2.1Mp detector

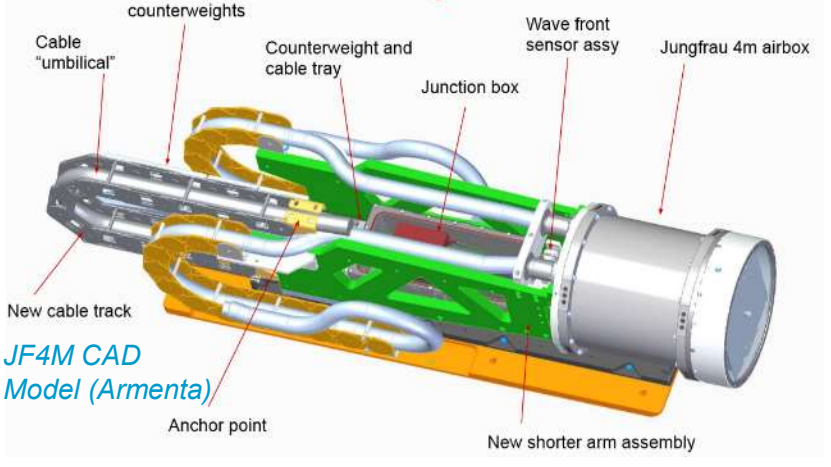



Installed @XCS

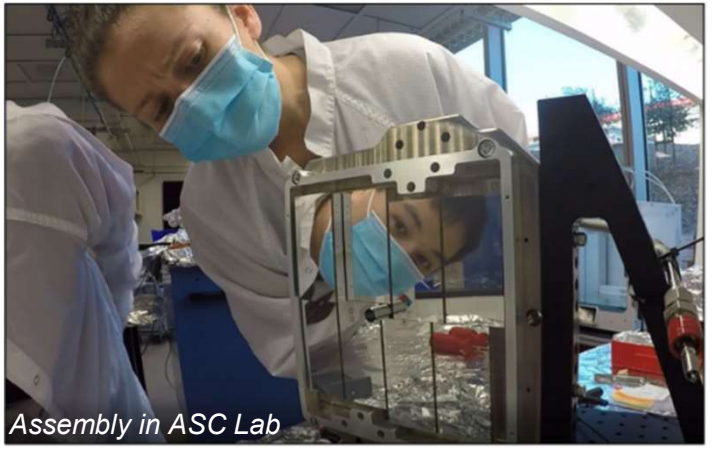
2020 Detector Program Highlights: Detector Upgrades

- **Jungfrau 4Mp for CXI**
  - Novel re-entrant airbox Jungfrau packaging for in-vacuum operation at HXR/CXI, supporting user experiments.
  - Packaging of components and chamber integration by SLAC staff (R. Armenta lead).
  - Assembled and tested in LCLS ASC Calibration Lab, system integration by CXI and CDS teams.


Component tests in ASC Lab



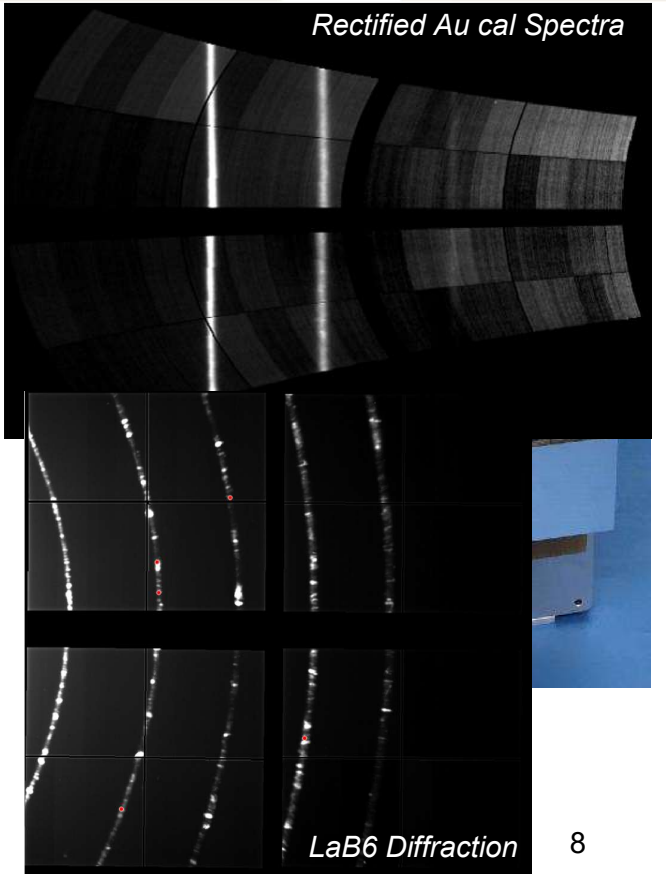
JF4M CAD Model (Armenta)


Assembly in ASC Lab

2020 Detector Program Highlights: Detector Upgrades

ePix10k with 1mm Si sensor layers:

- ePix10k-Quad, 500k pixel
  - Articulated set of four detector heads to sweep q-space at MEC.
  - First unit delivered to MEC, in test.
  - Each Quad includes four tiled ePix10k modules.
  - **1mm sensor provides immediate, usable (~40%) QE** for >20keV
  - Near-term solution while Hi-Z options mature.
  - Enclosure designed to mitigate EMP effects.
- ePix10k 135k pixel
  - Side-viewing small-format camera including 1mm Si.
  - Available throughout HXR hutches, nearing completion.
  - Delivery delayed by Covid.



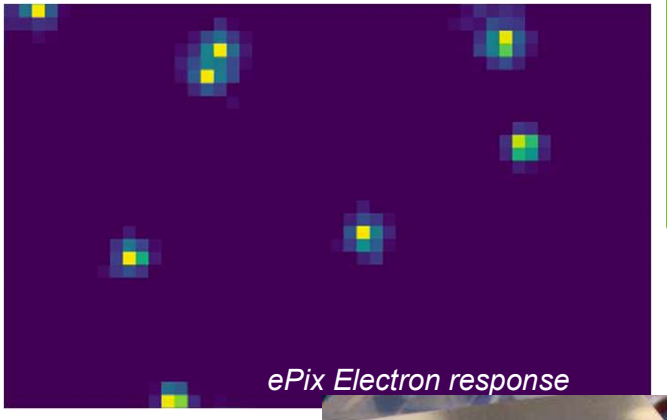
Calibration images courtesy Dimitri Khaghani/MEC

2020 Detector Program Highlights: Detector Upgrades

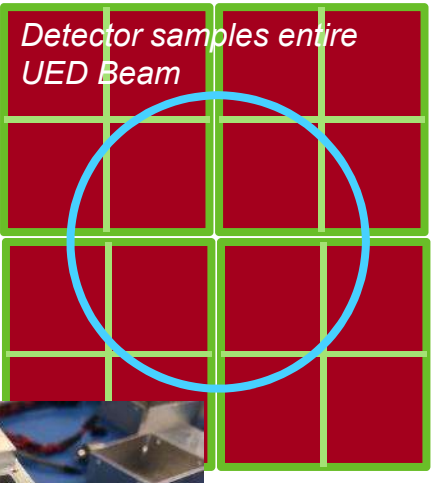
SLAC

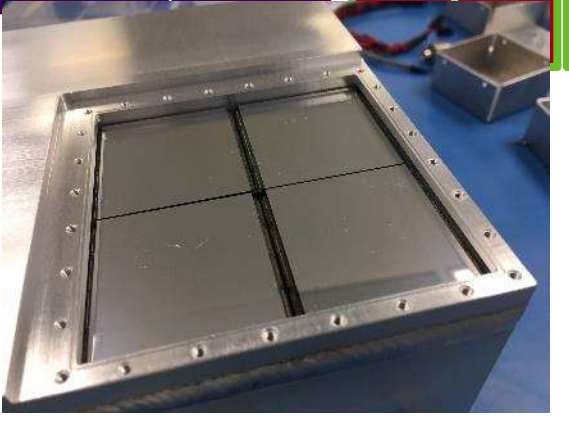
ePix10k Quad for UED

- Single electron discrimination
- 500MeV full-scale signal
- Vacuum operation
- SNR >500 (1MeV electrons)
- 360 Hz frame rate
- Leverages ePix platform, DAQ investments.



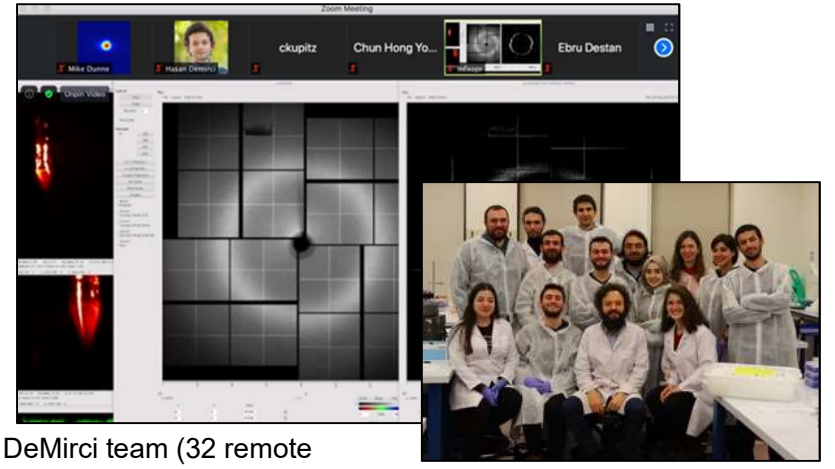
ePix Electron response





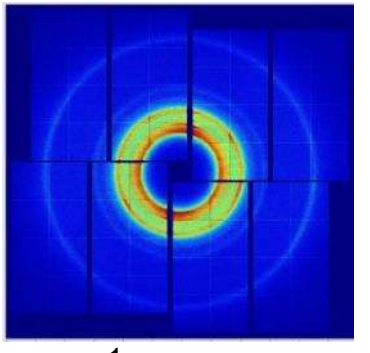
2020 Detector Program highlights: Science Data in Run 18

- **SARS-CoV-2 MPro (DeMirci, ePix10k2M)**
  - Main protease + inhibitors (drug targets)
  - Complete datasets obtained, published
    https://www.biorxiv.org/content/10.1101/2020.09.09.287987v1.full.pdf
- **N95 structure (Takacs, JF4m)**
  - First LCLS “rapid access”
  - Single fiber studies not possible on a synchrotron (radiation damage) or electron microscope (fiber thickness)
- **SARS-CoV-2 MPro dynamics (Schmidt, ePix10k2M)**
  - 2 structures submitted to archive already*
  - Room temperature, radiation damage-free reference structures, in two different crystal forms where nothing is bound.
  - See differences to cryo, SR structures
  - Elusive binding to key drug target



DeMirci team (32 remote users, ePix10k2M at MFX)

N95 fiber scatter (Jungfrau-4M at CXI)



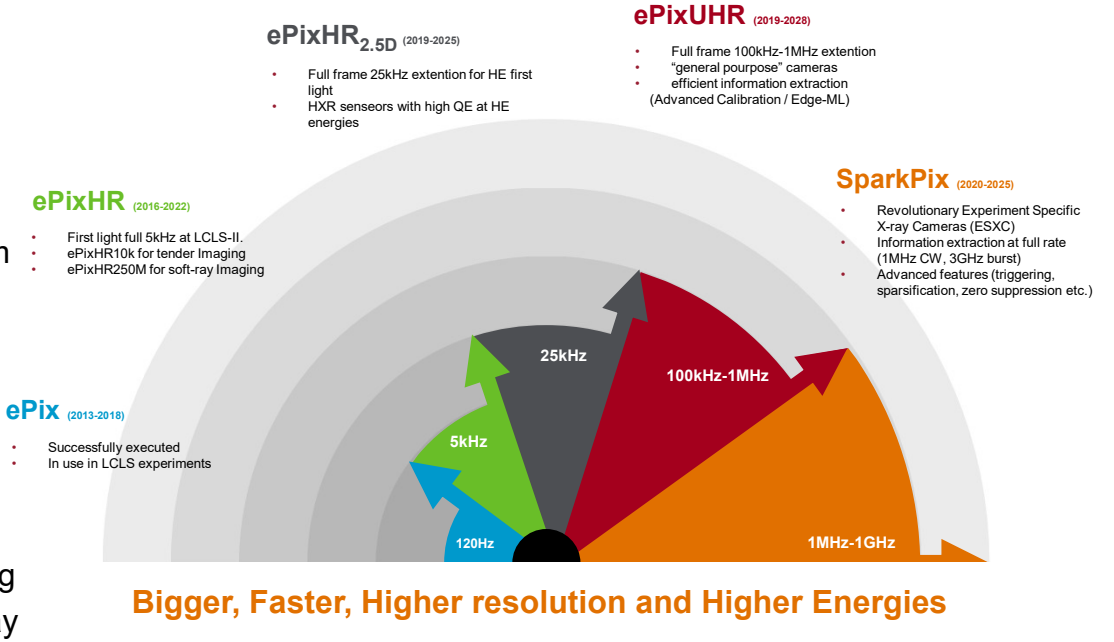
*** Solved structures (Schmidt et al):**
- Monoclinic C2 room temperature structure of the SARS CoV-2 3CLpro to 2.3 A
- Orthorhombic P212121 room temperature structure of the SARS CoV-2 3CLpro to 2.4 A

Active Project Summary Status

Project	Completion date	Comment
TES Spectrometer (NIST/ SLAC/SU)	FY23+	Single-pixel performance near 0.5eV energy resolution demonstrated by NIST/CU team.
ePix10k Camera (Kenney, TID)	FY19	2.2Mp detectors delivered for Run 18. Thick-Si Quads for MEC delivered (in production).
ePixHR Ph. IV (Dragone, TID)	FY20	5kHz operation demonstrated. 2mp Detector for TXI in early production stage.
ePixM Ph. III (Dragone, TID)	FY21	Back-end and pixel matrix received, in test.
RIXS-CCD (STA/SLAC)	FY21	Working device in-hand, acceptance tests complete. Upgrade to larger sensor in progress.
vFCCD Ph. II (Denes/LBL/BES)	FY21	Demonstrator unit in test, working toward 2020 downselect.
Hi-Z Collaboration (Segal, TID)	FY23	Evaluation of commercial detector materials on mature ASICs for XFEL and DSLR applications.

High-Rep Imaging/Scattering Detectors

- Near-term: Deliver evolving **ePix** platform for LCLS Science.
- Extended development: push full-frame platform to 100kHz across LCLS spectrum. Develop experiment-specific optimizations from SparkPix toolkit for shot-by-shot science at highest rates.
- Continue adoption of effective solutions from external developers.
- Long-term developments steered by developing science requirements and SLAC Strategic X-ray Detector Framework.



Bigger, Faster, Higher resolution and Higher Energies

ePix10k, ePix100, @1kHz (now)	ePixHR @5kHz (21)	ePixHR2.5 @25kHz+ (25)	UHR, SparkPix exp-specific (25+)