Advanced Light Source Upgrade (ALS-U) Project Update

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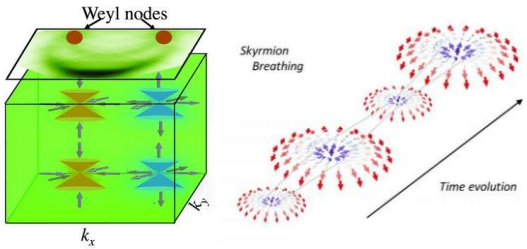
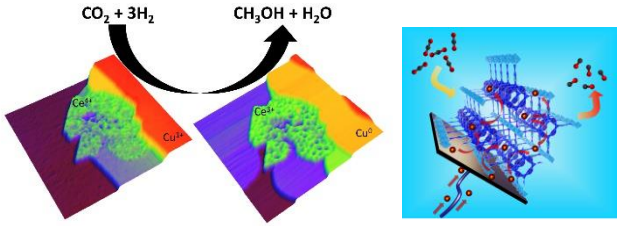
U.S. DEPARTMENT OF ENERGY | Office of Science

BERKELEY LAB

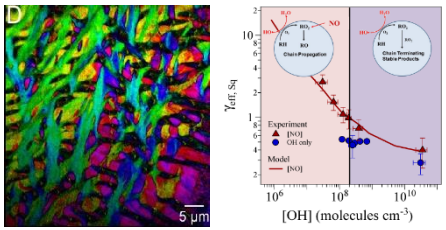
BES Basic Research Needs reports identified need to understand, predict, and control emergent material and chemical properties



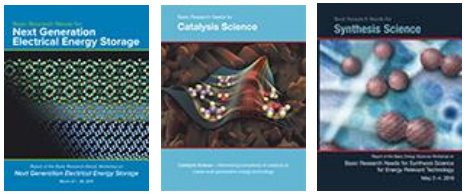
Quantum materials & information

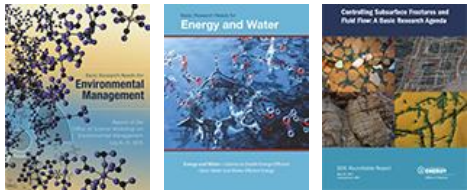


Catalysis; synthesis science



Earth & environmental systems



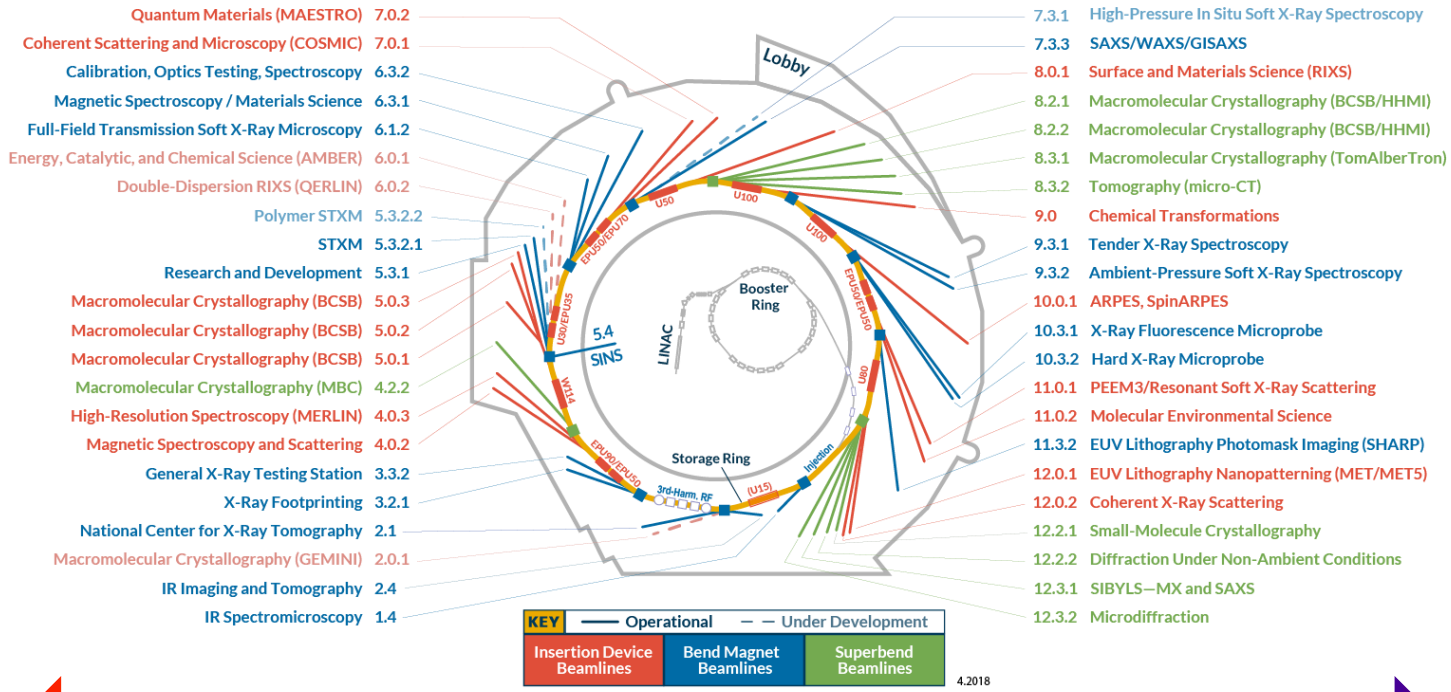


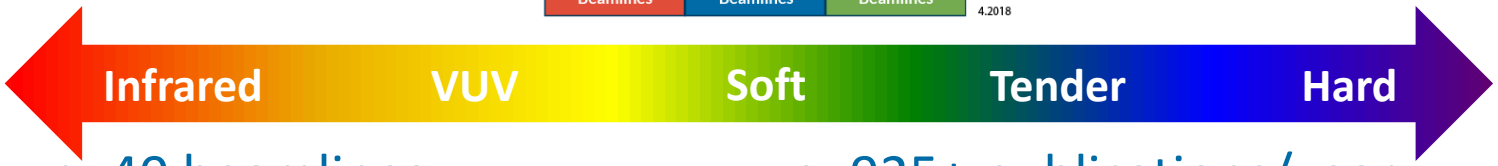
1. High chemical and material contrast
2. Nanoscale spatial sensitivity
3. Broad temporal sensitivity to nanoscale motion

Today's light sources lack this combination of capabilities

We need high soft x-ray brightness and coherent flux

Today's ALS serves a broad and diverse user community from IR to harder x-rays but is optimized for soft x-rays





- 40 beamlines
- 2,000+ users/year
- 925+ publications/year
- 20% in high-impact journals

ALS provides most of the soft x-ray capacity in the US

ALS-U Project will upgrade the ALS to provide users with highest brightness, coherent light in the soft x-ray region

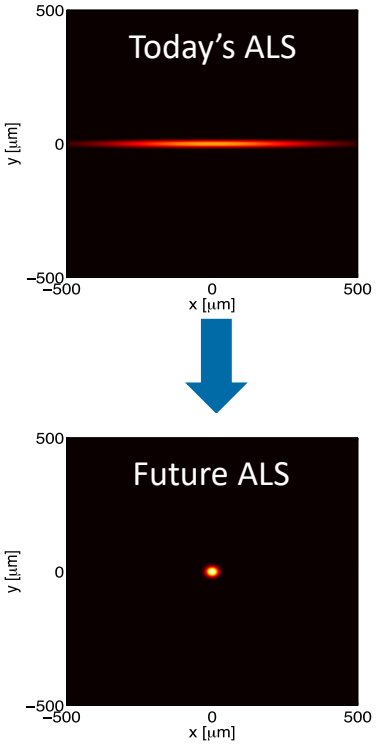
Features

- World-leading soft x-ray brightness and capabilities
- More than 100x increase in soft x-ray brightness and coherent flux compared with today's ALS
- Excellent IR and hard x-ray capabilities

Impact

- Enable scientific advances in a diverse range of fields, improving our economy, healthcare, and national security
- Continue the ALS tradition of serving a large and scientifically diverse user community

Electron Beam Profiles



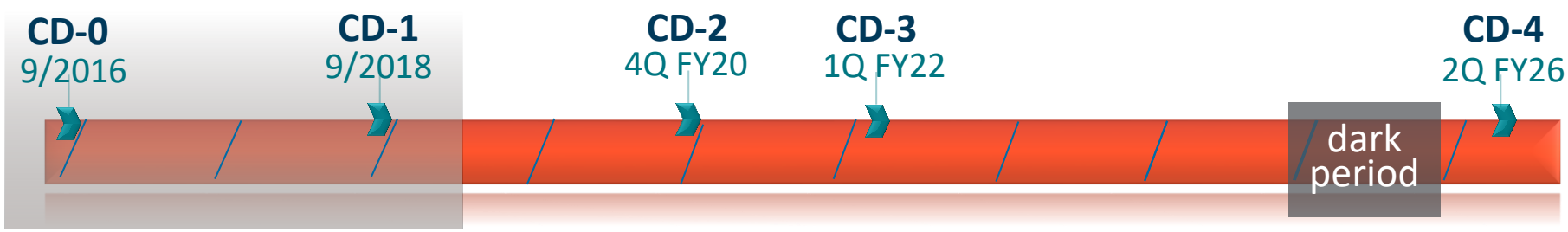
ALS-U Project parameters

Scope:

- New 2 GeV, high-brightness storage ring fed by new full-energy accumulator ring in the existing ALS storage-ring tunnel
- Suite of 2 new and 2 upgraded world-leading undulator beamlines
- 2 new full-length undulators
- Realignment of existing beamlines

Cost: Estimated total project cost (TPC) at CD-1 – $368M

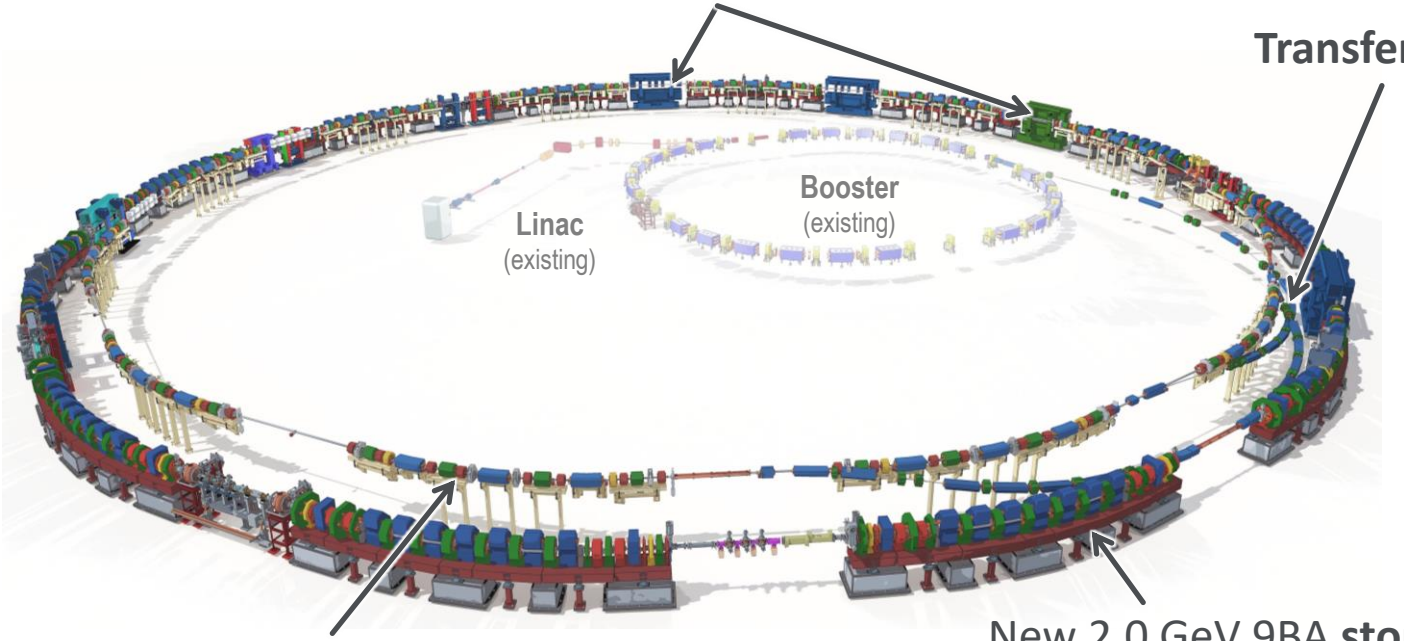
Timeline: Early finish – 2Q FY26



ALS-U accelerator scope

New full-length **undulators** optimized for high coherent flux

Transfer lines



New 2.0 GeV **accumulator ring** for full-energy swap-out injection and recovery of bunch trains

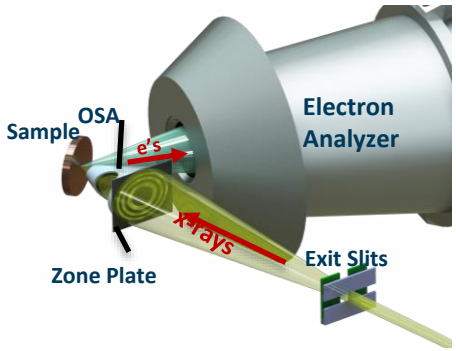
New 2.0 GeV 9BA **storage ring** in existing tunnel optimized for low emittance and high soft x-ray brightness and coherent flux

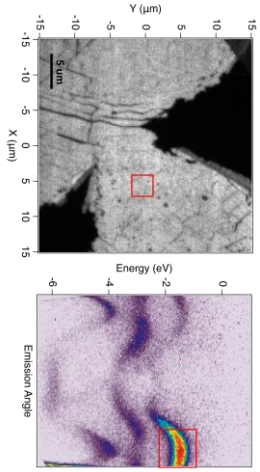
Plan to install and commission the accumulator ring early to minimize risk and duration of the main dark period

The ALS-U Project scope includes 4 new and upgraded undulator beamlines that were selected in January 2019

MAESTRO upgrade

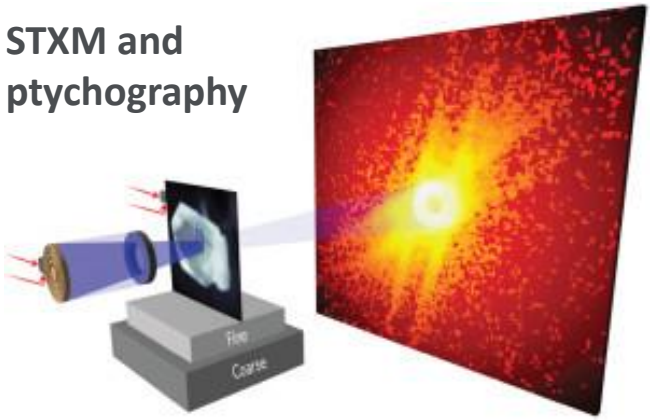
Angle-resolved photoemission spectroscopy (ARPES)





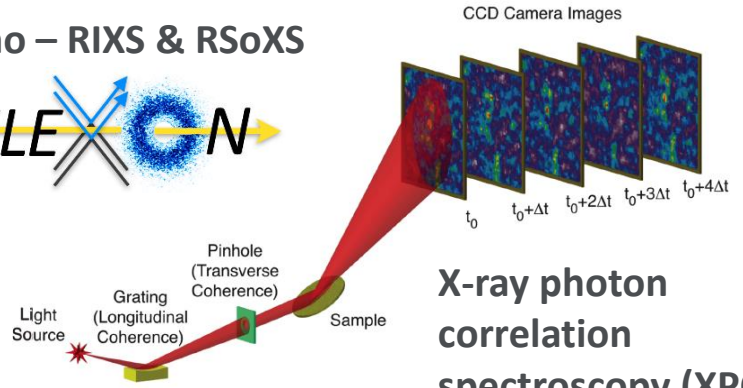
COSMIC upgrade

STXM and ptychography



New soft x-ray beamline

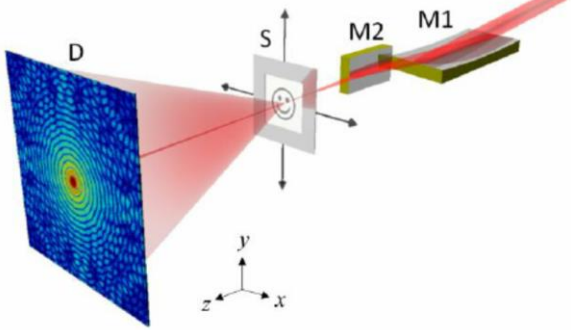
Nano – RIXS & RSoXS



X-ray photon correlation spectroscopy (XPCS)

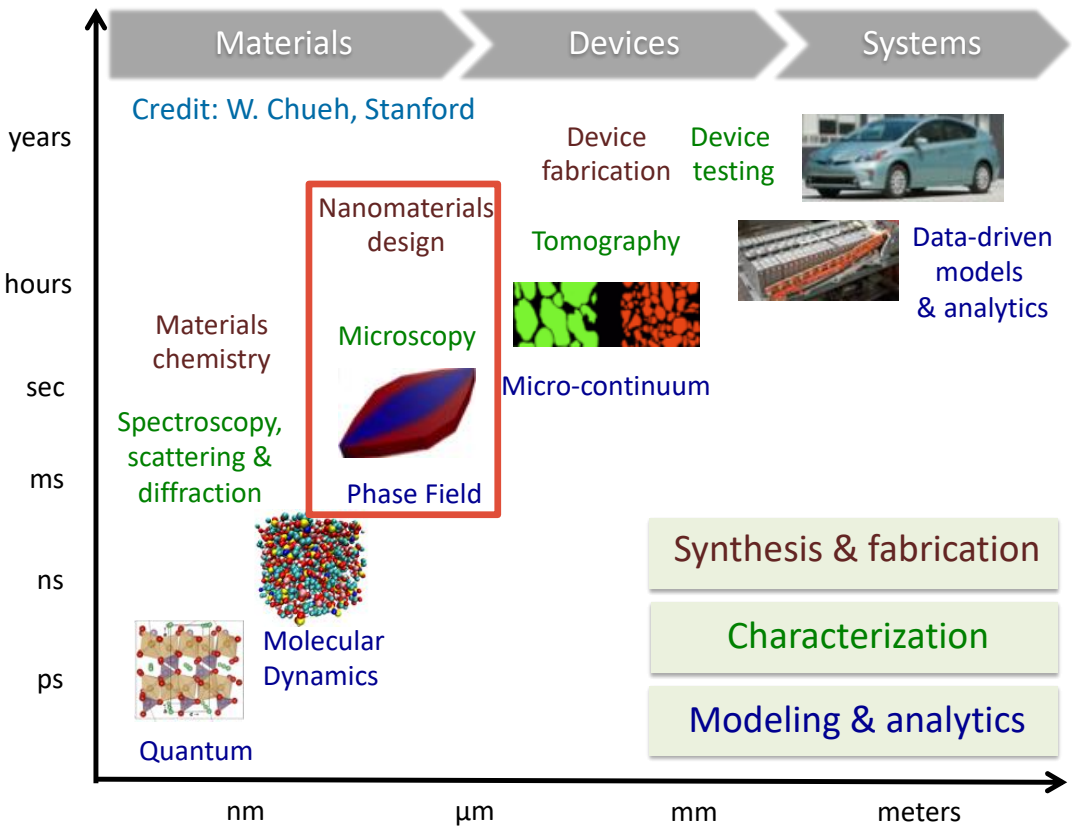
New tender x-ray beamline

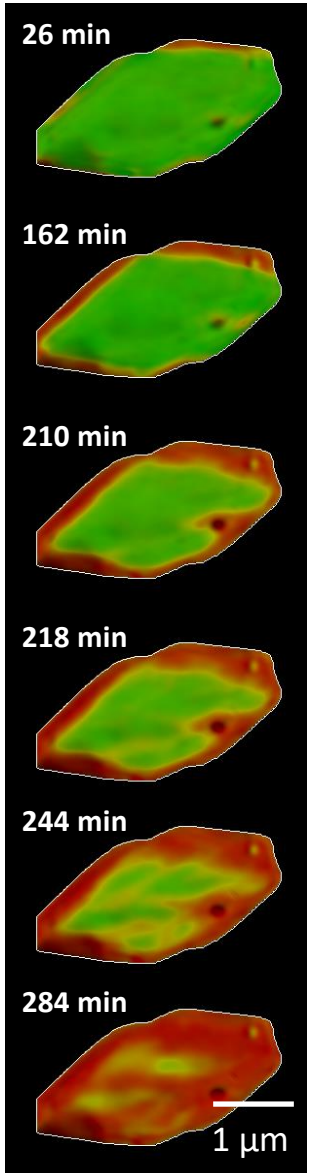
Tender-nanoprobe and coherent scattering



Na	1071eV
Mg	1303eV
Al	1560eV
Si	1839eV
P	2145eV
S	2472eV
Cl	2822eV
Ar	3206eV
K	3608eV
Ca	4038eV
Sc	4492eV
Ti	4966eV

Ptychographic imaging at the upgraded COSMIC beamline



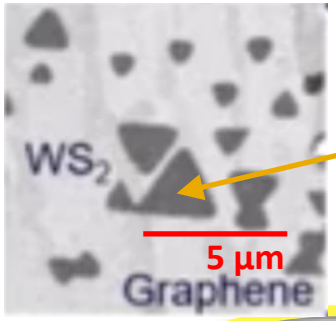


Lim, Yu, Chueh, Shapiro et al.
In preparation.

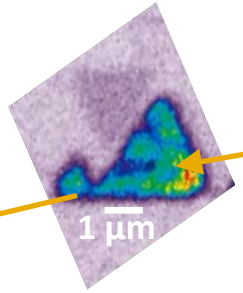
- Significantly enhanced spatial and temporal resolution for operando imaging of chemical states
- Access to the meso-time gap, allowing studies on time scales of industrial interest

NanoARPES at the upgraded MAESTRO beamline

WS_2 on graphene

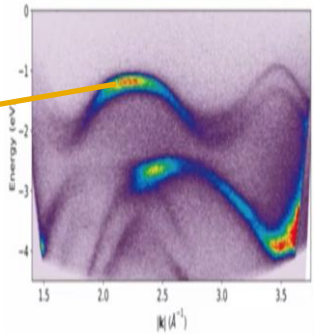


SEM



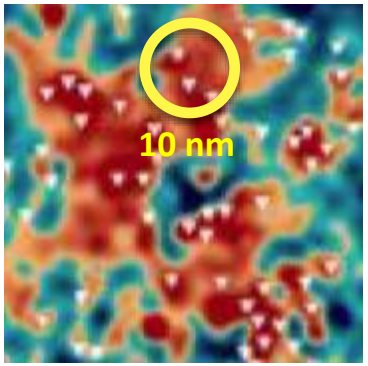
nARPES spatial map of photoemission at a single energy

Kastl 2D Mater. 2018



nARPES energy dispersion

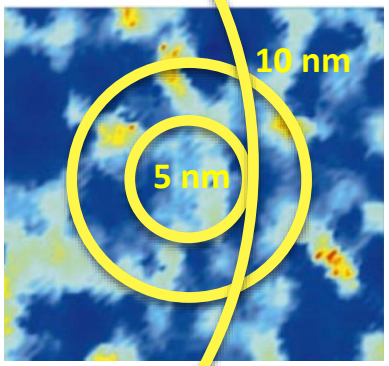
$(Bi,Mn)Te_3$
Topological insulator



Yazdani Nat. Phys. 2011

STM (no momentum information)

BSCCO
High Tc superconductor



Kapitulnik Phys. Rev. B 2003

100 nm spot size

Today

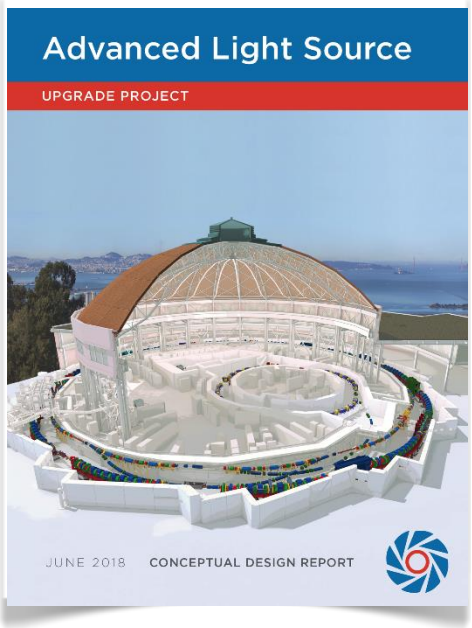
- Electronic structure maps with ~100 nm spatial resolution
- Lack the ability to resolve inhomogeneity in quantum states across a sample

Future

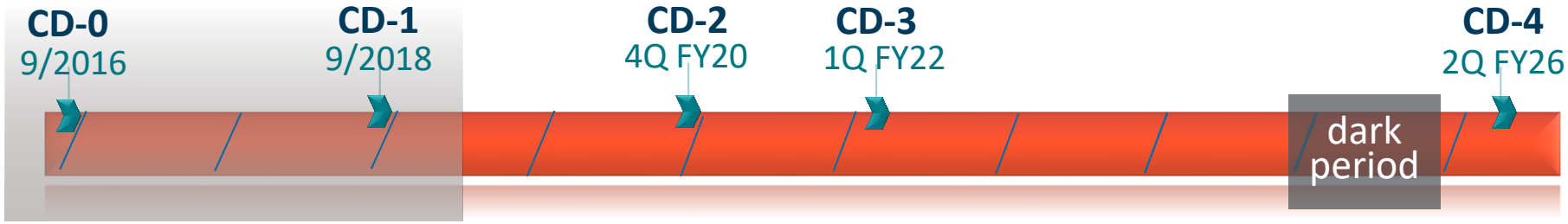
- Increased brightness will enable electronic structure maps with ~10 nm spatial resolution
- Inhomogeneities can be better measured

Strong budgets in FY18 and FY19 have allowed the project to accelerate its progress

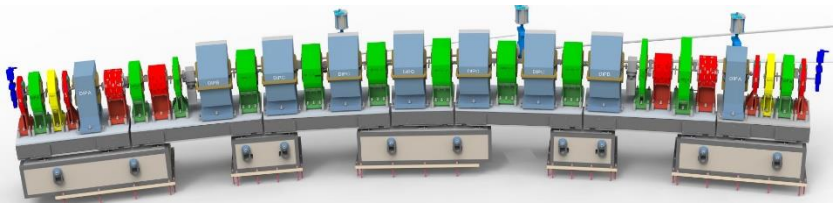
- Rapidly completed the conceptual design and achieved CD-1 approval in Sept. 2018
- Doubled FTEs in last 12 months
- Efficiently advancing the preliminary design
- Completed the beamline selection process
- Increased focus on the accumulator ring to allow early installation and commissioning
- Anticipate readiness for some long-lead procurements starting in early FY20



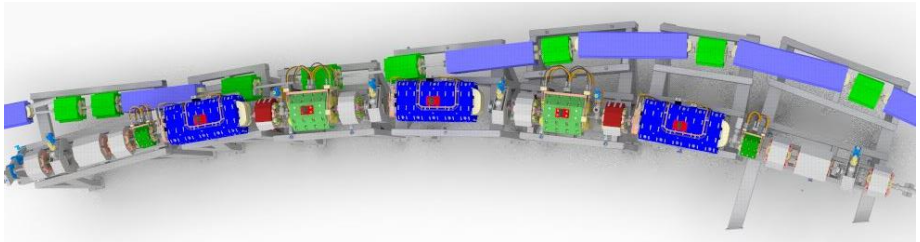
ALS-U CDR



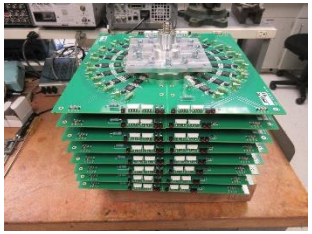
Quickly advancing the preliminary design: Some examples



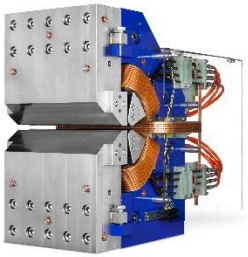
Storage ring sector and supports



Accumulator ring sector and transfer line



Testing fast injection pulsers and kickers



Prototyping key storage ring magnets

Testing coherent preserving optics

The ALS-U Project is on track

The appropriated funding in FY18 and FY19 has allowed us to:

- Successfully obtain CD-1 approval
- Advance the preliminary design towards CD-2 approval in 4Q FY20
- Be ready to begin some long-lead procurements in early FY20, more than a half a year ahead of schedule

Thank you for your attention