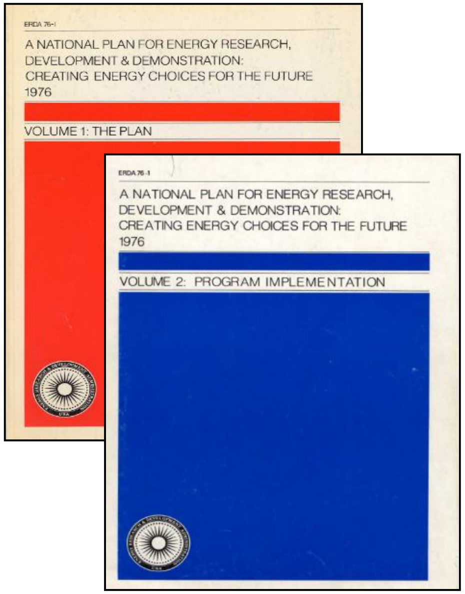
Basic Energy Sciences Overview

High Energy Physics Advisory Panel Meeting
December 1, 2017

Harriet Kung
Associate Director of Science
For Basic Energy Sciences
U.S. Department of Energy

BES Organizational History: A 40-Year Legacy



ERDA's 1976 R&D plan, *A National Plan for Energy Research, Development, and Demonstration: Creating Energy Choices for the Future (April 15, 1976).*

- The formation of BES was part of the *Department of Energy Organization Act of 1977* to provide for basic energy research in non-nuclear areas.
- Basic research activities within the *Energy Research and Development Administration* (ERDA) were first grouped as the BES program in the FY 1977 Budget Request (released February 1976). The BES organization was formed in June 1977 in preparation for the creation of DOE in October 1977.
- **While BES has gone through many changes in structure and program emphases, the mission of BES has not changed. As stated in 1976,** "The primary purpose of the BES program is to increase knowledge of the physical phenomena relevant to the goal of meeting our nation's energy needs."

The research activities and subprograms of BES have undergone substantial changes over the past three decades. For a detailed evolution of the BES program, see: http://science.energy.gov/bes/about/organizational-history/

The origins of the federal research programs that became BES are rooted in the nation's research efforts to win World War II. The goals of the early U.S. science programs that evolved into BES were to explore fundamental phenomena, create scientific knowledge, and provide unique user facilities. **In this sense, the BES program predates the establishment of the *Atomic Energy Commission* in 1946**, which became part of ERDA on October 11, 1974, as a result of the *Energy Reorganization Act of 1974*.

The Energy Crises: 1973 and 1979

- Significant reshaping of R&D priorities to include
  - To improve fossil energy utilization
  - Expand use of non-fossil energy technologies, e.g., solar, renewables, energy efficiency, etc.
  - Physical sciences research extends into nonnuclear energy technologies

Historical context:

- 1973 Oil Embargo
- **Energy Research & Development Administration (ERDA) established (January 1975).**
- **Department of Energy (DOE) established (August 1977).**

ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION USA

DEPARTMENT OF ENERGY UNITED STATES OF AMERICA

ERDA to DOE Transition

Source: Foreword of Materials Sciences Program Summary (1977)

During FY 1977 a new Department of Energy was proposed by the President and approved by Congress. This Department is now (August, 1977) scheduled for activation about October 1, 1977. The Energy Research and Development Administration will be transferred to the Department of Energy together with other agencies and parts of agencies within the Federal government. Also during FY 1977 the Division of Physical Research of ERDA was reorganized into two Divisions, one called Basic Energy Sciences and one called High Energy and Nuclear Physics. At the time of this writing the organizational structure of the new Department of Energy has been established only at the functional levels. However, it is expected that the Divisions of Basic Energy Sciences and High Energy and Nuclear Physics will report to the Director of the D.O.E. Office of Energy Research. The Director of this Office will be appointed by the President with Senate consent. The Director shall advise the Secretary on the physical research program transferred to the Department from ERDA; monitor the Department's R&D programs; advise the Secretary on management of the multipurpose laboratories under the jurisdiction of the Department excluding laboratories that constitute part of the nuclear weapon complex; and advise the Secretary on basic and applied research activities of the Department.

OFFICE OF ENERGY RESEARCH (1977)

DIRECTOR

DEPUTY

ASSOCIATE DIRECTORS

1. FIELD & LABORATORY COORDINATION
2. PROGRAM ANALYSIS
3. RESEARCH POLICY
4. HIGH ENERGY & NUCLEAR PHYSICS
5. BASIC ENERGY SCIENCES
   - MATERIALS SCIENCES
   - CHEMICAL SCIENCES
   - ENGINEERING, MATHEMATICS & GEOSCIENCES
   - NUCLEAR SCIENCES
   - EXPLORATORY ENERGY CONCEPTS

- ADMINISTRATION
- SPECIAL PROGRAMS

Office of Science Organization Structure (2017)

- **Office of the Director**
  Vacant
  - **Deputy Director for Field Operations**
    Joseph McBrearty
    Associate Deputy – Juston Fontaine
    - Ames Site Office — *Cynthia Baebler*
    - Argonne Site Office — *Joanna Livengood*
    - Berkeley Site Office — *Paul Golan*
    - Brookhaven Site Office — *Frank Crescenzo*
    - Fermi Site Office — *Michael Weis*
    - Thomas Jefferson Site Office — *Joseph Arango*
    - ORNL Site Office — *Johnny Moore*
    - Princeton Site Office — *Peter Johnson*
    - Pacific NW Site Office — *Roger Snyder*
    - SLAC Site Office — *Paul Golan*
    - Chicago Office — *Roxanne Purucker*
    - SC Integrated Support Center
    - Oak Ridge Office — *Kenneth Tarcza*
    - Office of Safety and Security Policy — *Marcus Jones*
    - Office of Laboratory Policy — *John LaBarge*
    - Office of Operations Program Management — *Marcus Jones (A)*
    - New Brunswick Laboratory Program Office — Yacouba Diawara
  - **Deputy Director for Science Programs**
    J. Steve Binkley
    - Advanced Scientific Computing Research — *Barbara Helland*
    - Basic Energy Sciences — *Harriet Kung*
    - Biological & Environmental Research — *Sharlene Weatherwax*
    - Fusion Energy Sciences — *James Van Dam (A)*
    - High Energy Physics — *James Siegrist*
    - Nuclear Physics — *Timothy Hallman*
    - Workforce Development f/Teachers & Scientists — *James Glownia*
    - Project Assessment — *Stephen Meador*
    - SBIR/STTR Programs Office — *Manuel Oliver*
  - **Deputy Director for Resource Management**
    Jeffrey Salmon
    Executive Officer - *Helen DeHart*
    - Budget — *Kathleen Klausing*
    - Grants & Contracts — *Michael Zarkin*
    - Scientific and Technical Information — *Brian Hitson*
    - Information Technology and Services — *Vasilios Kountouris*
    - SC Communications and Public Affairs — *Rick Borchelt*
    - Office of Management — *Cynthia Mays*

Basic Energy Sciences (2017)

Office of Basic Energy Sciences

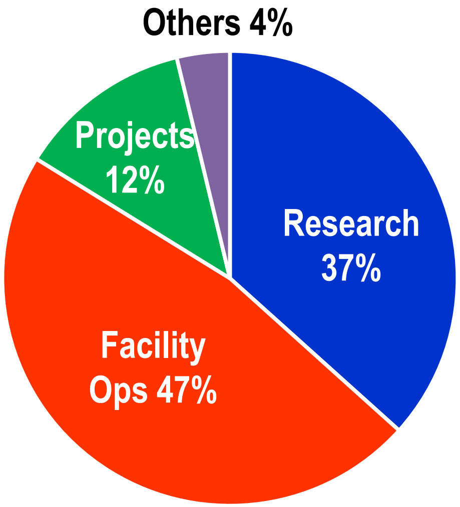
- **Materials Sciences and Engineering Division**
  - Materials Discovery, Design and Synthesis
  - Condensed Matter and Materials Physics
  - Scattering and Instrumentation Sciences
- **Scientific User Facilities Division**
  - X-ray and Neutron Scattering Facilities
  - Nanoscale Science Research Centers
  - Construction and Major Item of Equipment Projects
  - Accelerator and Detector Research
- **Chemical Sciences, Geosciences and Biosciences Division**
  - Fundamental Interactions
  - Photochemistry and Biochemistry
  - Chemical Transformations

BES Program Overview

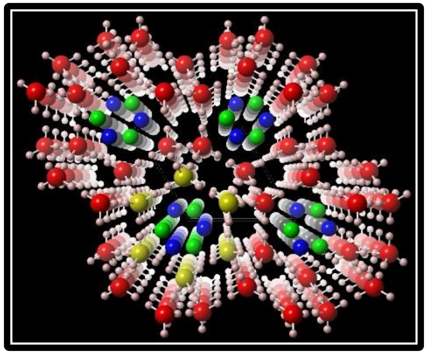
Understanding, predicting, and controlling matter and energy at the electronic, atomic, and molecular levels

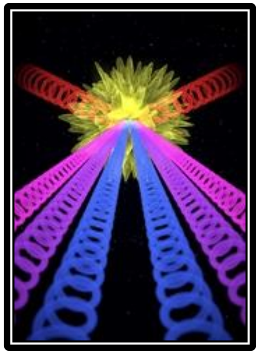
Research: condensed matter and materials physics, chemistry, geosciences, and aspects of biosciences—to discover new materials and design new chemical processes that touch virtually every important aspect of energy resources, production, conversion, transmission, storage, efficiency, and waste mitigation.

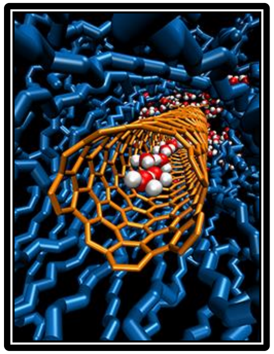
Facilities: x-ray light sources, neutron sources, nanoscale science research centers for the atomic-level visualization and characterization of materials of all kinds, including biological molecules. Construction of the next-generation facilities to maintain international competitiveness.

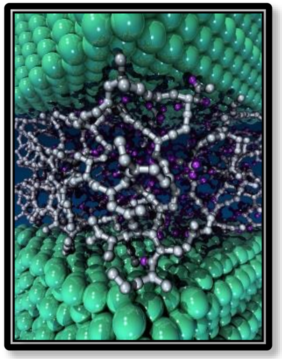


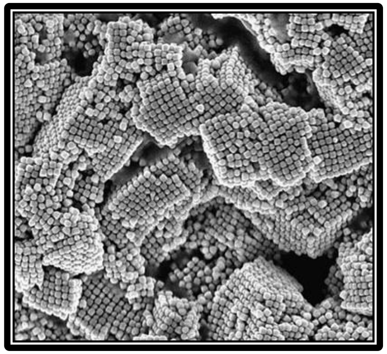
FY 2017 BES $1.87 B











Engaging BES Advisory Committee and Scientific Community in planning for:

- ## Science for Discovery

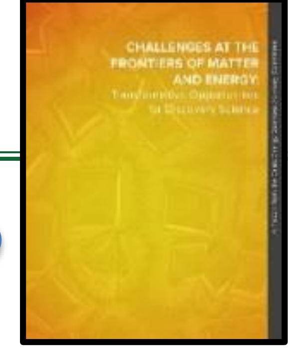
- ## Science for National Needs

- ## National Scientific User Facilities, the 21st century tools of science

BESAC Grand Science Challenges Report:
Directing and Controlling Matter and Energy

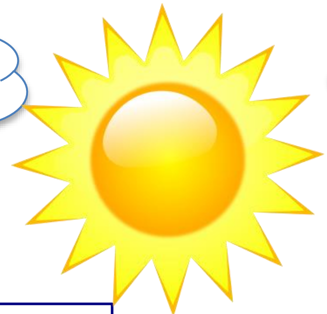
- Synthesize, atom by atom, new forms of matter with tailored properties
- Synthesize man-made nanoscale objects with capabilities rivaling those of living things
- Control the quantum behavior of electrons in materials
- Control emergent properties that arise from the complex correlations of atomic and electronic constituents
- Control matter very far away from equilibrium

Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science



2015

Instrumentation & Tools



Human Capital

Synthesis

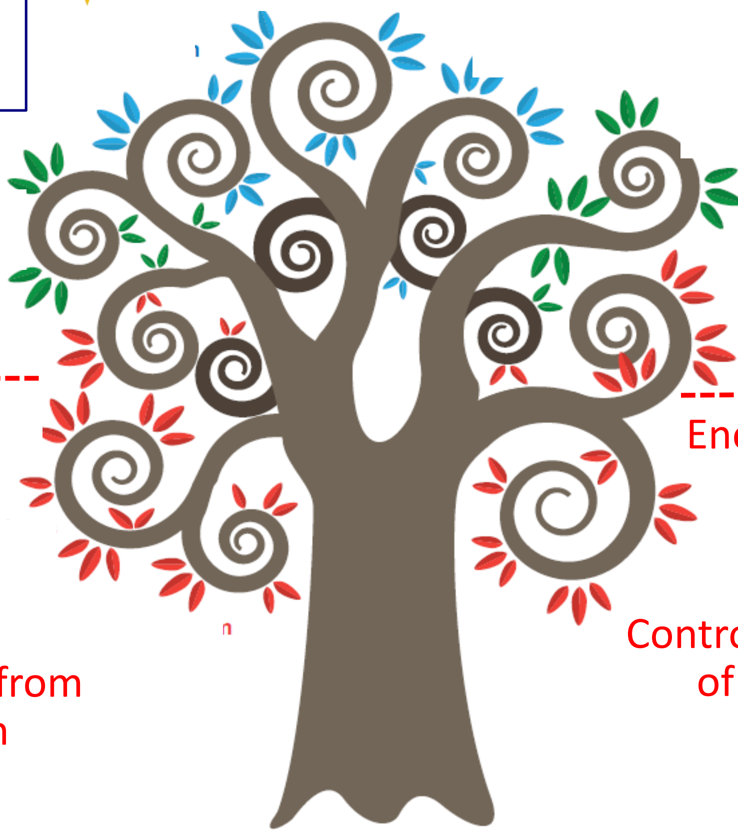
Beyond Ideal Materials and Systems

Mastering Hierarchical Architectures

Harnessing Coherence in Light and Matter

Imaging Matter across Scales

Data, Algorithms and Computing



Efficient Synthesis for Tailored Properties

Energy and Information on the Nanoscale

Correlated Systems

Systems Away from Equilibrium

Control at the Level of Electrons

2007

Basic Research Needs for Quantum Materials for Energy Relevant Technology
February 8-10, 2016

Workshop Chair: Collin Broholm (JHU)
Associate Chairs: Ian Fisher (SLAC/Stanford)
Joel Moore (UC-Berkeley/LBNL)
Margaret Murnane (UC-Boulder)
SC Technical Leads: Linda Horton and Jim Horwitz (BES)

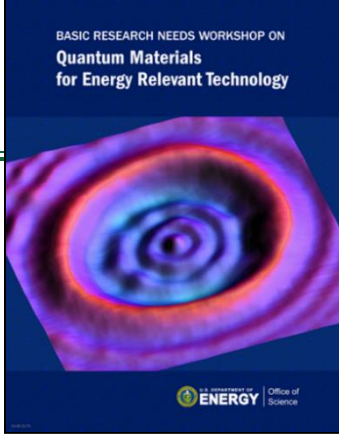
CHARGE: Identify basic research needs and priority research directions for quantum materials with a focus on new, emerging areas with potential for transformative scientific advances and for impact on energy technologies. The phenomena of quantum materials are examined in the broad categories of:
(1) superconductivity and charge-related order, (2) magnetism and spin, (3) transport and non-equilibrium dynamics, (4) electronic topology, (5) nano-structure or heterogeneity.

Breakout Sessions and Chairs:

Superconductivity and charge order: Adriana Moreo (U Tennessee) and John Tranquada (BNL)
Magnetism and spin: Meigan Aronson (Texas A&M) and Allan MacDonald (U Texas Austin)
Transport and non-equilibrium dynamics: Dimitri Basov (UCSD) and Jim Freericks (Georgetown)
Topological quantum materials: Eduardo Fradkin (U of Illinois) and Amir Yacoby (Harvard)
Heterogeneous and nano-structured quantum materials: Nitin Samarth (PSU) and Susanne Stemmer (UCSB)

Priority Research Directions:

- Control and exploit fluctuations in quantum matter for the design of bulk materials with novel functionality
- Harness topological states for groundbreaking surface properties
- Drive and manipulate quantum effects (coherence, entanglement) in nanostructures for transformative technologies
- Design revolutionary tools to accelerate discovery and technological deployment of quantum materials



Control and exploit fluctuations in quantum matter for the design of bulk materials with novel functionality

Looking beyond the standard paradigms of simple metals and semiconductors, how do strongly-interacting electrons organize themselves in quantum materials, and how can this be controlled for energy-relevant technologies?

- **Understand and control competing, coexisting, and intertwined order**
- **Predict, realize, and probe new states of quantum magnets**

Harness topological states for groundbreaking surface properties

Building on recent advances in the field of topological insulators, what new topological states of matter can be realized, what are their signatures, and how can these be used for energy-related applications?

- **Discover new topological quantum materials**
- **Design new platforms to probe and exploit topology**

Drive and manipulate quantum effects (coherence, entanglement) in nanostructures for transformative technologies

How can the extraordinary properties of coherent quantum states be controlled and utilized for energy-related applications?

- **Employ nanoscale structuring to elucidate and exploit coherence and entanglement**
- **Understand transport in quantum materials**
- **Dynamically visualize and manipulate quantum materials**

Design revolutionary tools to accelerate discovery and technological deployment of quantum materials

What new methodologies and tools are needed to advance synthesis of quantum materials and our ability to probe and predict their properties?

- **Enhanced synthesis of quantum materials**
- **Develop new windows into quantum materials**
- **Develop efficient methods for static and dynamic states beyond 1-electron paradigms**

BES Roundtables on Quantum Information Sciences

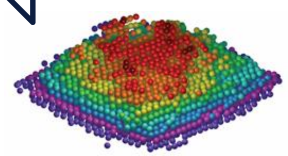
- **Opportunities for Basic Research for Next-Generation Quantum Systems**
  - October 30-31, 2017 (1.5 days)
  - Chair – David Awschalom (UChicago/ANL)
    Co-chair – Hans Christen (ORNL)
  - Identify opportunities for basic materials and chemical sciences, including nanoscale research, to enable the next-generation of quantum devices and systems.

- **Opportunities for Quantum Computing in Chemical and Materials Sciences**
  - October 31 – November 1 (1.5 days)
  - Chair – Joel Moore (UC-Berkeley/LBNL)
    Co-chair – Alan Aspuru-Guzik (Harvard U)
  - Identify opportunities for quantum computing (QC) to enable significant and impactful advances in understanding of important fundamental challenges in chemical and materials sciences

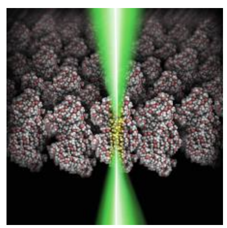
BES & Quantum Information Science

- Quantum materials and chemistry supported by BES core research and EFRCs are foundational to exploring and controlling novel quantum behaviors.
- BES Nanoscale Science Research Centers capabilities are key to nano-to-micro-scale electronic/ photonic quantum structure fabrication. Integration and testing will couple closely with theory, design and systems efforts.
- Research will enable next-generation qubit concepts, innovative quantum and classical architectures (beyond ion traps, quantum dots, nitrogen vacancies, donor centers, etc.)

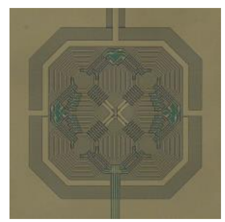
Theory, Modeling, Synthesis, Characterization, Design, Fabrication, Prototypes



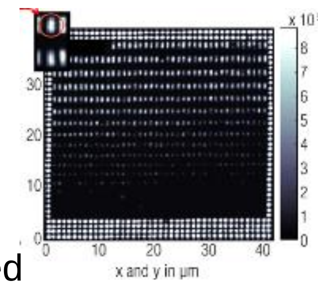
Characterization with Atomic Spatial Resolution and Ultrafast Precision



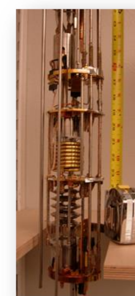
Single-nm lithography



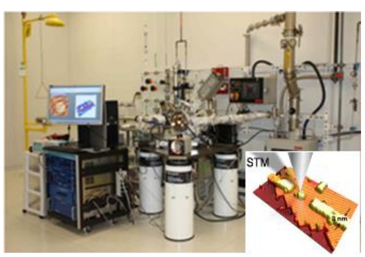
Quantum-Limited Sensors



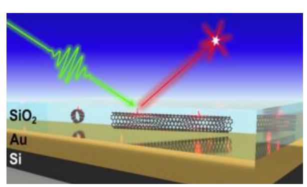
Entangled Qubit Arrays



Quantum Chip Testing

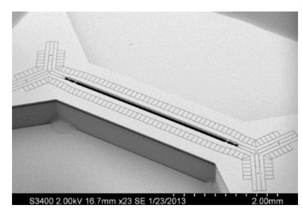


Atomic Precision Fabrication



Single Photon Emitters and Detectors

Nanoscale 3D Printing



Waveguides, Cavities, Traps

Quantum Computing

Encrypted Communi- cations

Sensors & Detectors

ASCR, HEP NP, BER

BES

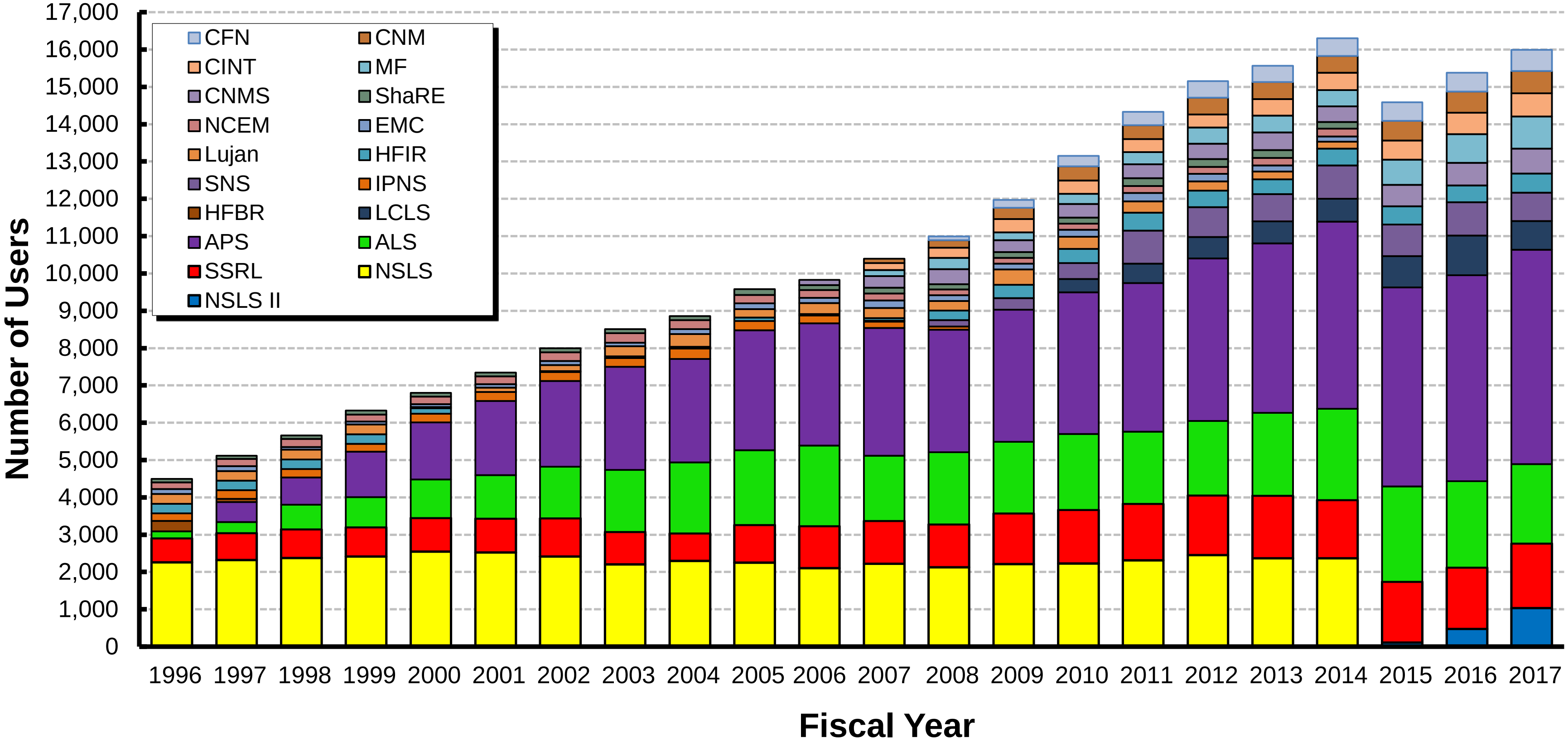
Office of Science Released Dear Colleague Letter on QIS

Nov. 29, 2017

BES Scientific User Facilities

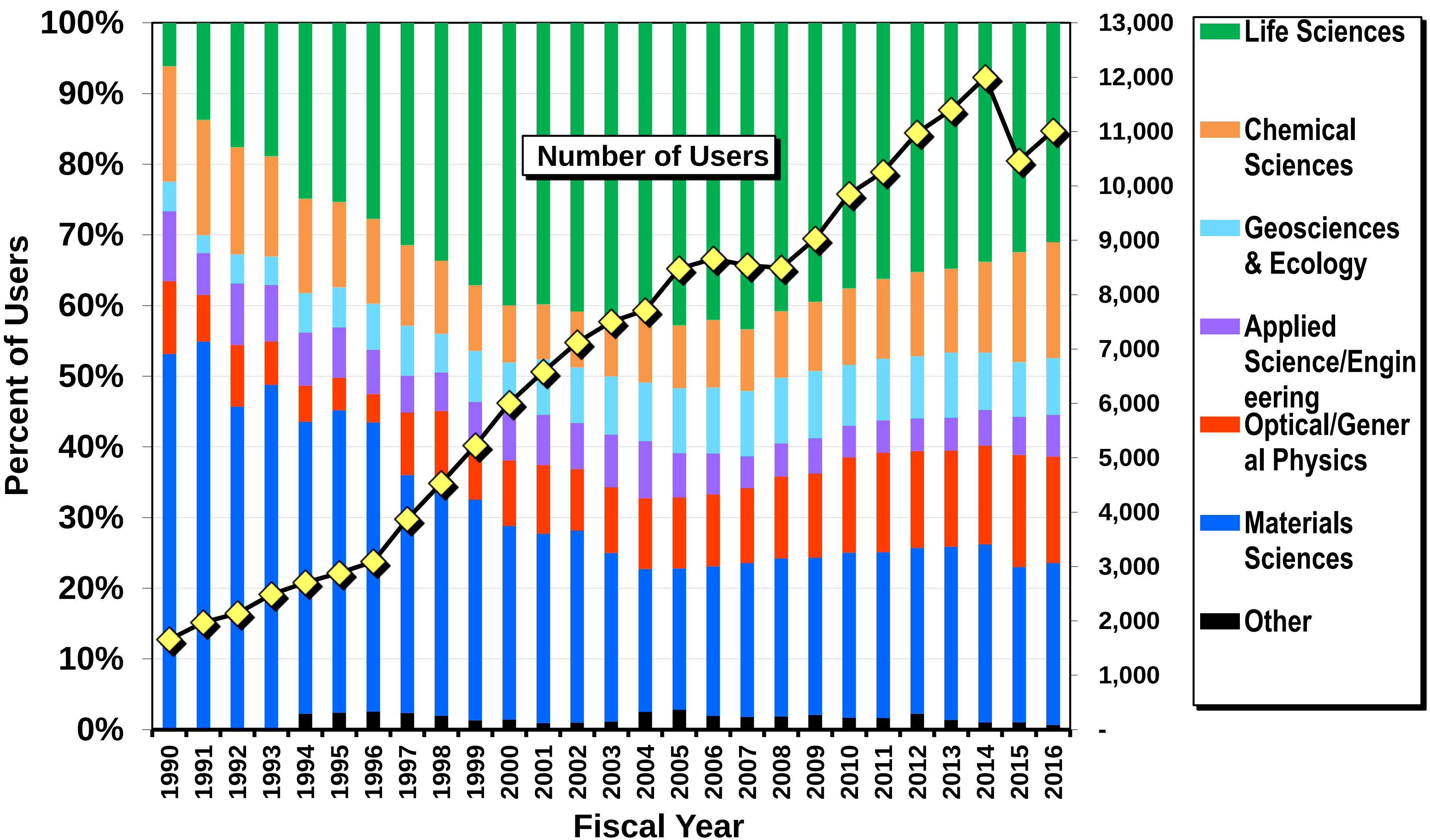
Unique research facilities *and* scientific expertise for ultra high-resolution characterization, synthesis, fabrication, theory and modeling of advanced materials

BES User Facilities Hosted Nearly 16,000 Users in FY 2017



- The newly constructed NSLS-II started early operations in FY 2015 (hosted 110 users); NSLS closed on 9/30/14.
- The three electron beam microcharacterization centers were merged administratively with their respective neighboring NSRCs in FY 2015.
- BES operations at the Lujan Neutron Scattering Center ceased operations in FY 2014.

Users by Discipline at the Light Sources



Linac Coherent Light Source at SLAC

1992: Proposal (Pellegrini), Study Group(Winick)

1994: National Academies Report http://books.nap.edu/books/NI000099/html/index.html

1996: Design Study Group (M. Cornacchia)

1997: BESAC (Birgeneau) Report http://www.sc.doe.gov/production/bes/BESAC/reports.html

1998: LCLS Design Study Report SLAC-521

1999: BESAC (Leone) Report http://www.sc.doe.gov/production/bes/BESAC/reports.html
$1.5M/year, 4 years

2000: LCLS- the First Experiments (Shenoy & Stohr) SLAC-R-611

2001: DOE Critical Decision 0

2002: LCLS Conceptual Design
DOE Critical Decision 1
$36M for Project Engineering Design

2003: DOE Critical Decision 2A
$30M in 2005 for Long Lead Procurements

2004: DOE 20-Year Facilities Roadmap

2005: Critical Decision 2B: Define Project Baseline
Critical Decision 3A: Long-Lead Acquisitions

2006: Critical Decision 3B: Groundbreaking

2009: First Light

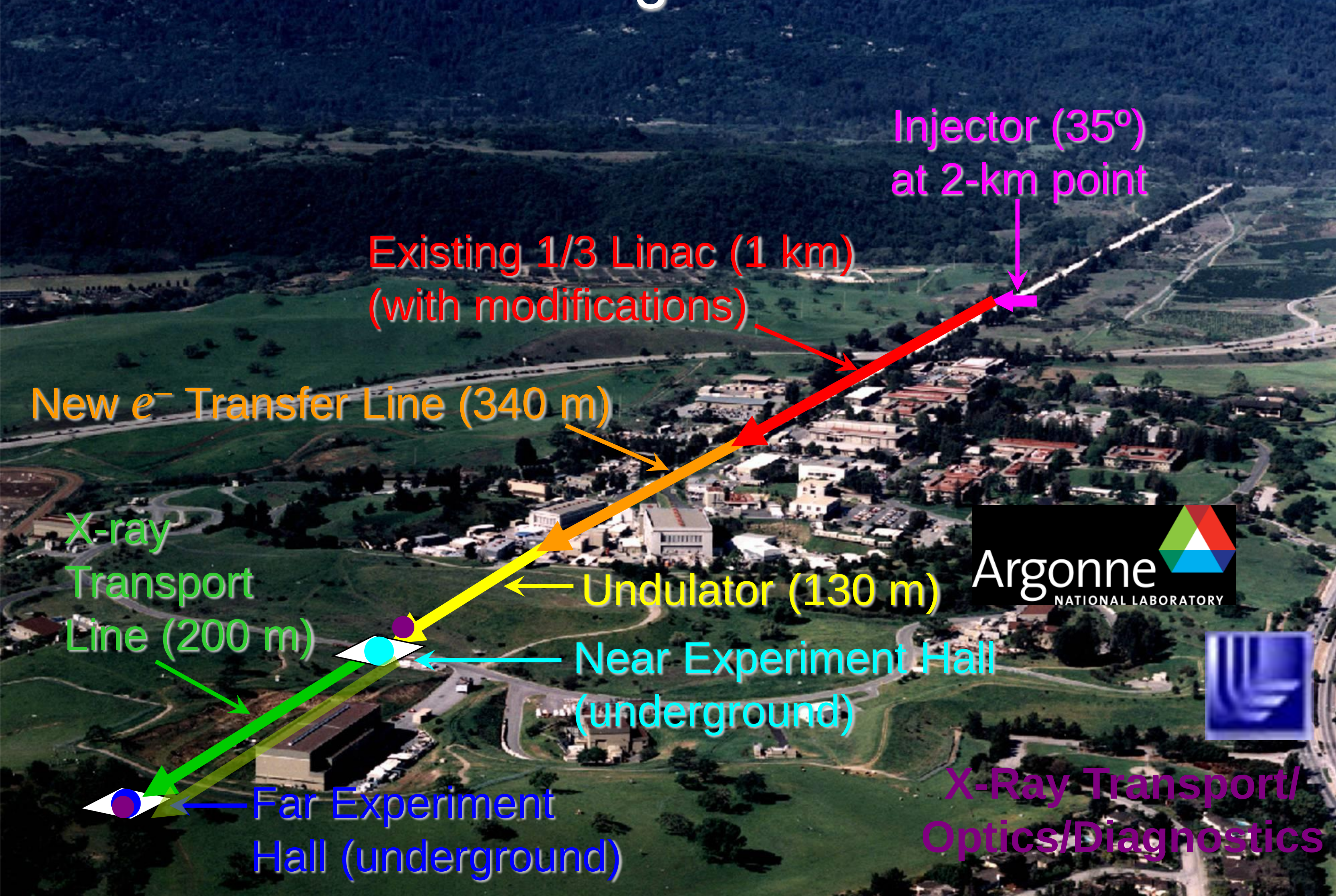
2010: Project Completion

LCLS Design Parameters

Fundamental FEL Radiation Wavelength	**1.5**	**15**	Å
Electron Beam Energy	14.3	4.5	GeV
Normalized RMS Slice Emittance	1.2	1.2	mm-mrad
Peak Current	3.4	3.4	kA
ρ Parameter	4×10^{-4}	8×10^{-4}	
Bunch/Pulse Length (FWHM)	≤230	≤ 230	fs
Relative Slice Energy Spread @ Entrance	<0.01	0.025	%
Saturation Length	87	25	m
FEL Fundamental Saturation Power @ Exit	8	17	GW
FEL Photons per Pulse	1	29	10^{12}
Peak Brightness @ Undulator Exit	0.8	0.06	10^{33} *
Transverse Coherence	Full	Full	
RMS Slice X-Ray Bandwidth	0.06	0.24	%
RMS Projected X-Ray Bandwidth	0.13	0.47	%

* photons/sec/mm^2/mrad^2/ 0.1%-BW

Linac Coherent Light Source at *SLAC*



Light Sources: A Global Race to the Top

Many other new & upgraded facilities are in the design stage: It’s a very competitive landscape!

2016 BESAC Charge on Prioritization of Facility Upgrades

Three categories of facilities were considered in the prioritization:

Ring-based x-ray light sources
ANL Advanced Photon Source Upgrade (APS-U)
LBNL Advanced Light Source Upgrade (ALS-U)

Free electron laser based x-ray light sources
SLAC LCLS-II High Energy Upgrade (LCLS-II-HE) (i.e., additional cryomodules in existing tunnel)

Spallation-based neutron scattering sources
ORNL Spallation Neutron Source Proton Power Upgrade (SNS PPU)
ORNL Spallation Neutron Source Second Target Station (SNS STS)

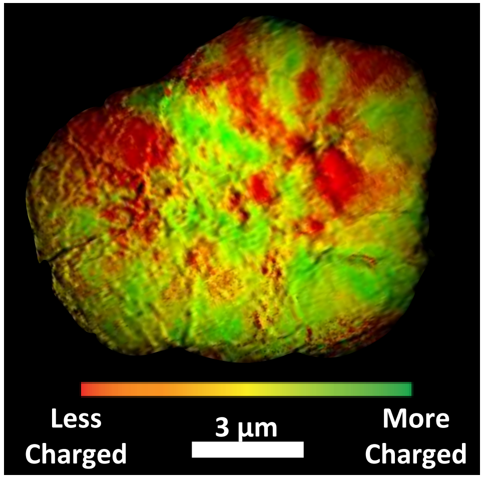
2016 BESAC Facility Prioritization Report

Summary Table of Assessment

Facility Upgrade	Contribution to World-leading Science	Readiness to Proceed with Construction
APS-U	Absolutely Central	Ready to initiate construction
ALS-U	Absolutely Central	Ready to initiate construction
LCLS II-HE	Absolutely Central	Ready to initiate construction
SNS Proton Power Upgrade	Absolutely Central	Significant scientific/engineering challenges to resolve before initiating construction
SNS Second Target Station	Absolutely Central	Significant scientific/engineering challenges to resolve before initiating construction

The Power of Light Sources

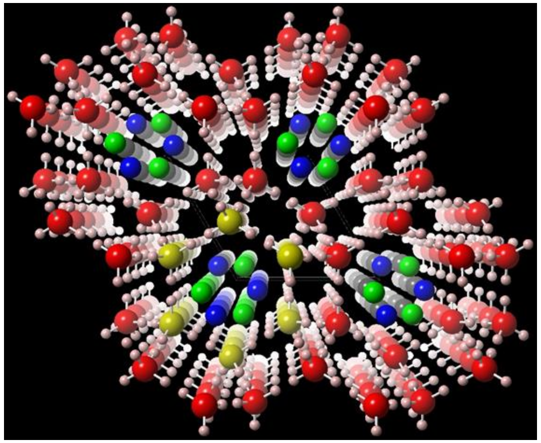
Seeing the Invisible in Real Materials



Compositional heterogeneity in a $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ battery after hundreds of hours charging

Adv. Materials (2016)

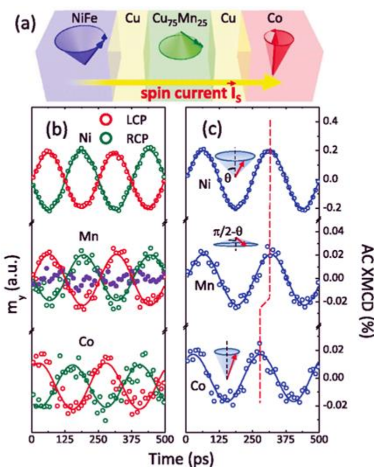
Where are the Atoms?



Newly discovered structure of a hydrogen-stuffed, quartz-like form of ice

JACS (2016)

Where are the Electrons & Spins?



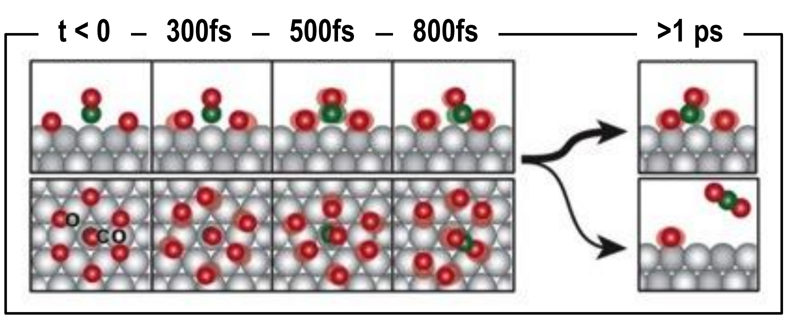
Direct measurements of "pure" ac spin currents (flow of spin angular momentum without flow of charge)

PRL (2016)

What are the Dynamics?

Capturing the transient behavior of catalytic bond formation

Science (2015)



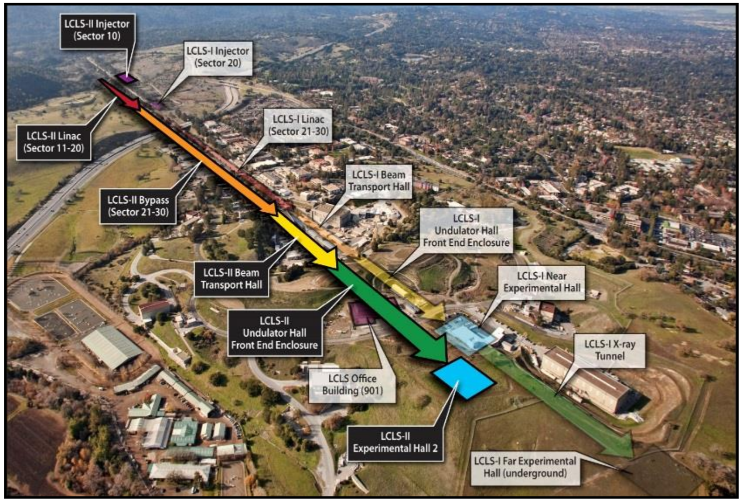
U.S. DEPARTMENT OF ENERGY | Office of Science

Goal: Control Matter & Energy on These Scales!

LCLS-II and APS-U Construction Projects

Linac Coherent Light Source-II (LCLS-II)

- When completed, LCLS-II will provide high-repetition-rate, ultra-bright, transform-limited femtosecond x-ray pulses with polarization control and pulse length control to ~1 femtosecond. The hard x-ray range will be expanded to 25 keV.
- The upgrade adds a 4 GeV superconducting linac; an electron injector; and two undulators, which will provide x-rays in the 0.2–5 keV energy range.

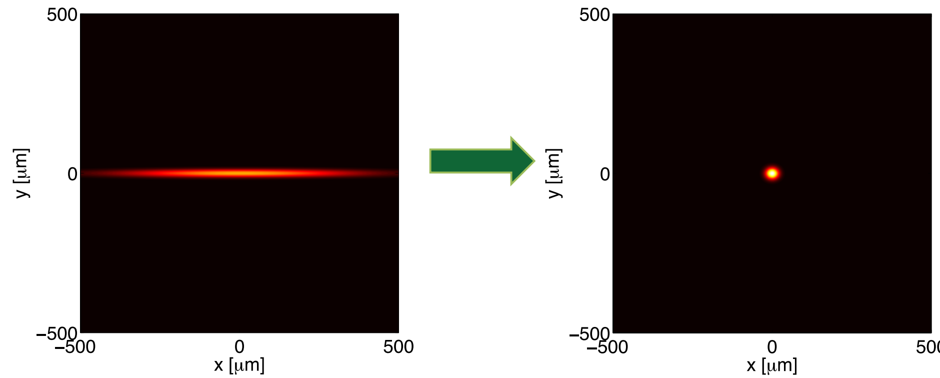


Advanced Photon Source Upgrade (APS-U)

- FY 2018: R&D, design, prototyping, testing, fabrication, site preparation, installation, and long lead procurements.
- APS-U will provide an x-ray source with world-leading transverse coherence and extreme brightness.
- The upgrade provides a new storage ring incorporating a multi-bend achromat lattice, new insertion devices, superconducting undulators, and new or upgraded beamlines.

Advanced Light Source Upgrade (ALS-U) at LBNL

Goal:
High coherent flux in soft x-ray region (~50-2,000 eV) necessary to resolve nanometer-scale features and enable real-time observation of chemical processes and materials as they function

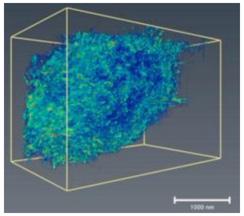


Comparison of the beam profiles of ALS (left) and ALS-U (right).

Map nano-objects' 3D electronic, chemical, & magnetic structure

Understand Roles of Heterogeneity

- **Connect spatial, chemical, and temporal heterogeneity with real-time movies**

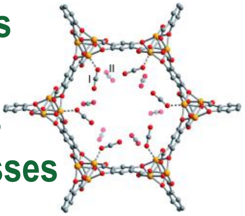


- **Potential benefit – optimize material processes & properties, e.g., low carbon footprint concrete**

Control chemical kinetics in confined spaces

Master Hierarchical Architectures

- **Reveal relationships between nanoscale chemical structures & the kinetic processes they support**

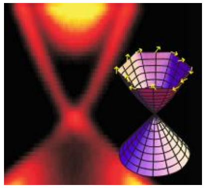


- **Potential benefit – chemical catalytic reactors, solar fuel production, water purification**

Deploy spin, quantum, and topological materials

Harness Coherence in Light & Matter

- **Probe electronic structure of single domains and gated structures of complex materials**



- **Potential benefit – ultralow-power computing, new classes of sensors, spin-based devices**

LCLS-II High Energy (LCLS-II-HE) at SLAC

Goal:

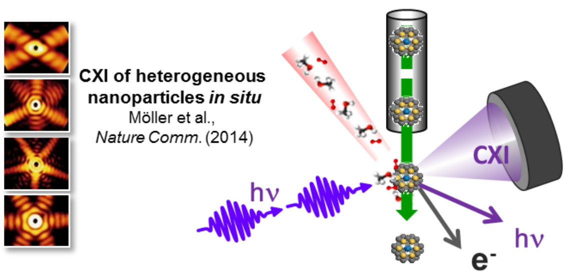
- To deliver ultrafast, coherent x-rays with Angstrom resolution (≥12 keV) at high average power to enable spectroscopic analysis of additional key elements in the periodic table, deeper penetration into materials, enhanced resolution of experiments, and studies of structural dynamics at the atomic scale.

International Competition:

- SACLA (Japan) has been in operation since 2011 (5-20 keV, 60 Hz)
- EuXFEL is now operational but not yet at full capability (designed for 0.2-25 keV, 28 kHz in 10 Hz bursts)
- PAL XFEL (Korea, designed for 0.3-20 keV, 60 Hz) and SwissFEL (Switzerland, designed for 0.2-12 keV, 100 Hz) are now online but not yet at full capability

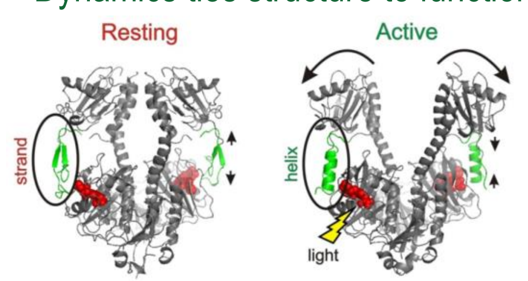
Heterogeneity & complexity in ground & excited states

- Correlate catalytic reactivity and structure
- Real-time evolution with chemical specificity and atomic resolution



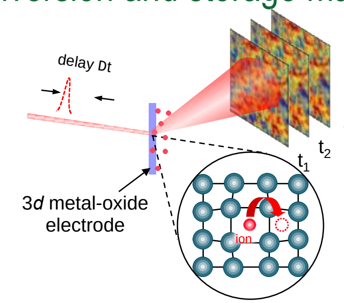
Dynamics of biomolecules and molecular machines

- Study large scale conformational changes via solution scattering
- Physiological conditions
- Dynamics ties structure to function



Fluctuations in the ground state and spontaneous evolution

- Characterize statistically dynamic systems without long-range order
- Inform directed design of energy conversion and storage materials



US Response based on 2016 BESAC Prioritization Report

	Storage Rings		FEL	
Project	**ANL APS-U**	**LBNL ALS-U**	**SLAC LCLS-II** →	**SLAC LCLS-II-HE**
Project Scope	Hard X-ray ~Diffraction Limited 6 GeV MBA Ring	Soft X-ray ~Diffraction Limited 2 GeV MBA Ring	High Rep-Rate, Soft X-ray FEL, 4 GeV SC Linac	High Rep-Rate, Medium Energy X-ray FEL, 8 GeV SC Linac
Current Status of Facility	APS is operational since 1996; ring will be replaced	ALS is operational since 1993; ring will be replaced	LCLS is operational since 2010; LCLS-II is under construction	LCLS is operational since 2010; LCLS-II is under construction
Worldwide Competition	EU **ESRF** Germany **PETRA 3,4** Japan **SPring-6** China **HEPS**	Sweden **MAX-IV** Brazil **SIRIUS** CH **SLS-II** China **NSRL-U**	EU **XFEL** Japan **SACLA** Korea **PAL XFEL** CH **Swiss FEL**	EU **XFEL** China **SCLF**
Dark Time	~1 yr	~0.75 yr	~1 yr	Cu Linac: No Dark Time SRF Linac: ~ 1 yr
Status FY2017	**CD-3b**	**CD-0**	**CD-3**	**CD-0**

The ALS-U, APS-U & LCLS-II-HE proposals were each deemed “absolutely central to contribute to world leading science & ready to initiate construction”

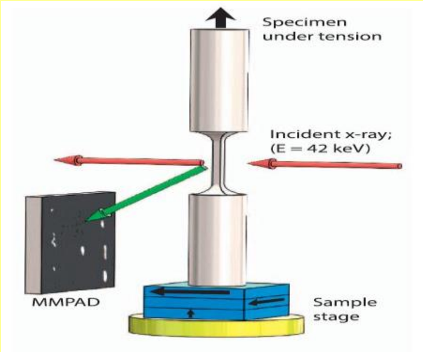
BES Detector Research

Development of higher-precision, more efficient detectors capable of acquiring data several orders of magnitude faster than state-of-the-art detectors

- ❖ More efficient sensors
- ❖ Improvements in time-resolved imaging
- ❖ Improvements in data acquisition, visualization tools, and analysis workflows

- ❑ **Three integral parts of a beam-based experiment:**
  - **Sources and optics to condition the sources**
  - **Samples and sample environments**
  - **Detectors**

- ❑ **Detectors are the science enabler**
  - **Scattering**
    - **Diffraction: area sensitive, high spatial resolution, time-resolved**
    - **Small-angle scattering: area sensitive, dynamic range, time-resolved**
  - **Imaging**
    - **Tomography and radiography: high flux, high-temporal and spatial resolution**
    - **Phase contrast imaging: fast, efficient, high spatial resolution (sub-µm pixels)**
  - **Spectroscopy**
    - **EXAFS, XANES: energy dispersive, time-resolved, dynamic range**

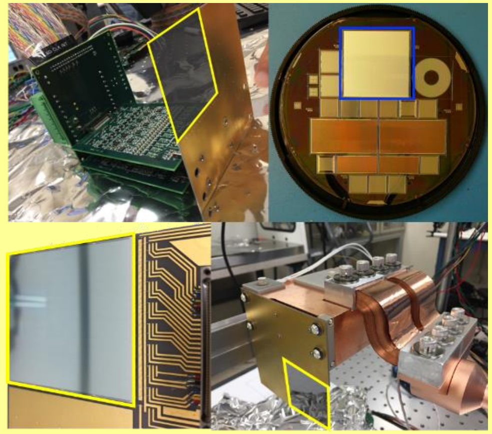


Mixed-Mode Pixel Array for **high energy X-rays**

-- 1 kHz frame rate

-- high dynamic range

S. Gruner (Cornell U)

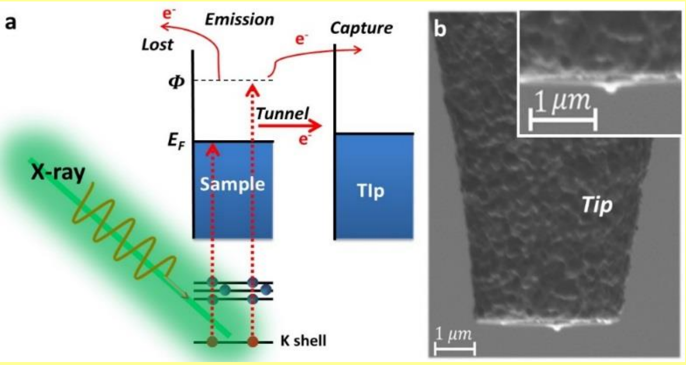


"Day 1" LCLS-II Soft X-ray Detector

5-10 kHz, high QE

Coherent Imaging, Scattering and Diffraction; Inelastic Scattering

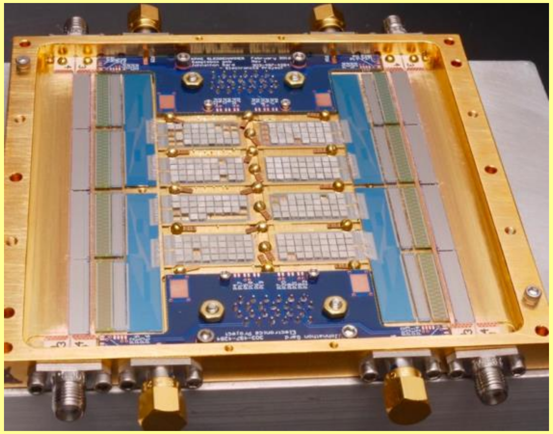
P. Denes (LBNL); G. Carini (SLAC)



Nanofabricated Smart Tip Detectors

Coaxial metal-insulator-metal tip detectors as probe in synchrotron x-ray STM

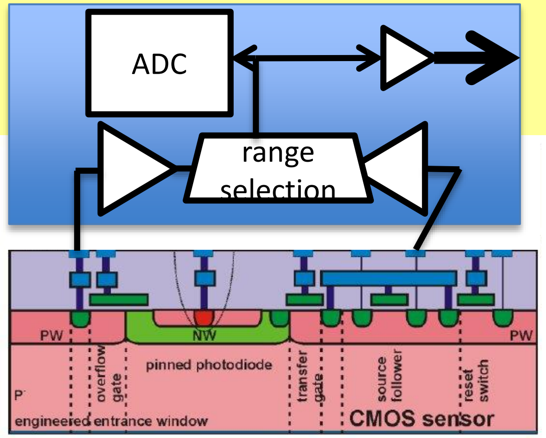
***V. Rose (ANL)* – Early Career FY12**



Fast, high-efficiency *superconducting X-ray detector* using transition-edge sensors

Energy accuracy ~1 eV

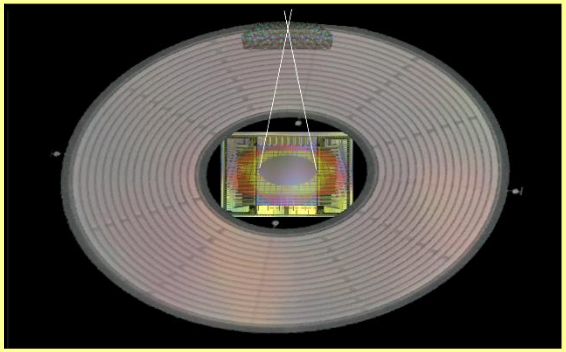
K. Irwin (SLAC); A. Miceli (APS)



***FLORA**: Fermilab-LCLS CMOS*

High dynamic range; fast frame > 10 kHz

G. Deptuch (Fermi); G. Carini (SLAC)



High-speed Scanning Transmission Electron Microscope Detector – 100 kHz

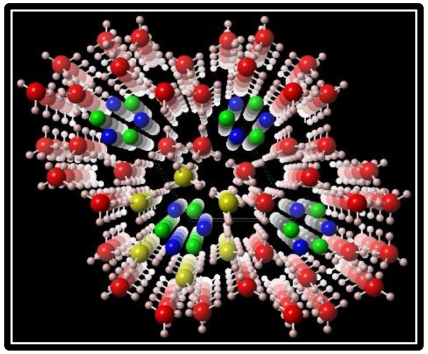
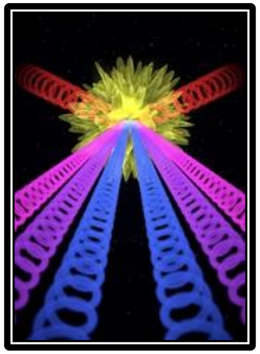
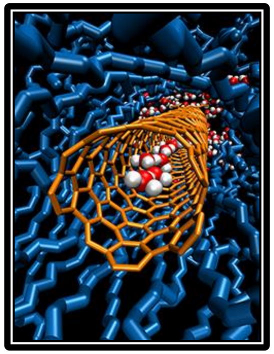
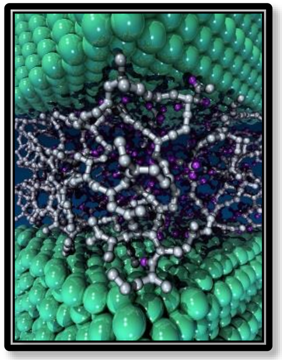
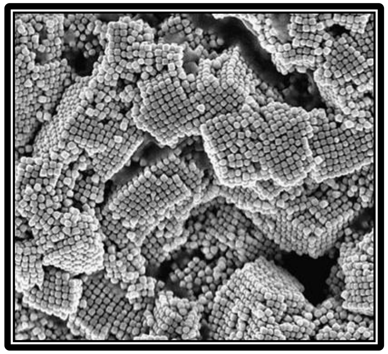
- **Massive data rates workflow**
- **Records a *diffraction pattern* at every scan point**

P. Denes (LBNL)

Backup Slides

Overview of BES FY 2018 President's Request

- The BES FY 2018 Request of **$1,554.5 million** is a decrease of $317 million or 17% from the FY 2017 Enacted level.
- The overall research funding in FY 2018 is reduced by 18% from FY 2017, requiring a significant shift in priorities with targeted reductions of activities that extend to later-stage fundamental research. Both the core research and the EFRC program will emphasize emerging high priorities in quantum materials and chemistry, catalysis science, synthesis, and instrumentation science.
- No funding is requested for the two BES-supported **Energy Innovation Hubs**, Batteries and Energy Storage and Fuels from Sunlight, or for the DOE Experimental Program to Stimulate Competitive Research.
- All BES **user facilities** will operate at below optimal levels. Selected light source beamlines and neutron flight paths will be shut down. The Stanford Synchrotron Radiation Lightsource will operate up to the first quarter and then transition to a warm standby status. No funding is requested for two **Nanoscale Science Research Centers:** the Center for Functional Nanomaterials or the Center for Integrated Nanotechnologies.
- No funding is requested for **Long Term Surveillance and Maintenance** or for the disposition of unused equipment for the **Lujan Neutron Scattering Center**.
- To maintain international competitiveness of our facilities, BES will continue to support the **Linac Coherent Light Source-II (LCLS-II)** and **Advanced Photon Source Upgrade (APS-U)** projects. APS-U will transition~~s~~ from a major item of equipment to a line item construction project.

FY 2018 HEWD Appropriations: Basic Energy Sciences

July 11, 2017

	FY 2017 Enacted Approp.	FY 2018 President's Request	FY 2018 House Mark	FY 2018 House Mark vs. FY 2017 Enacted		FY 2018 House Mark vs. FY 2018 President's Request	
Research	1,681,500	1,352,400	1,612,400	-69,100	-4.11%	260,000	19.23%
Construction							
13-SC-10 Linac Coherent Light Source-II, SLAC	190,000	182,100	192,100	2,100	1.11%	10,000	5.49%
18-SC-10 APS Upgrade, ANL	......	20,000	67,000	67,000	0.00%	47,000	235.00%
Total, Construction	190,000	202,100	259,100	69,100	34.19%	57,000	28.20%
Total	**1,871,500**	**1,554,500**	**1,871,500**	**......**	**0.00%**	**317,000**	**20.39%**

- Core research increases ~1% over FY17.
- EFRCs, CMS, CCS, EPSCoR flat with FY17.
- No funding for the Hubs, but $10M designated for competitive awards to continue similar research.
- All facilities funded at or near FY17 levels.
- APS-U increases to $67M (+$24.5M) and converts to line item construction.
- LCLS-II increases to $200M, $10M above FY17.

FY 2018 SEWD Appropriations: Basic Energy Sciences

	FY 2017 Enacted Approp.	FY 2018 President's Request	FY 2018 Senate Mark	FY 2018 Senate Mark vs. FY 2017 Enacted		FY 2018 Senate Mark vs. FY 2018 President's Request	
Research	1,681,500	1,352,400	1,641,300	-40,200	-2.4%	+288,900	+21.4%
Construction							
LCLS-II, SLAC	190,000	182,100	200,000	+10,000	+5.3%	+17,900	+9.8%
APS Upgrade, ANL	......	20,000	93,000	+93,000	0.0%	+73,000	+365.0%
ALS Upgrade, LBNL	......	......	20,000	+20,000	0.0%	+20,000	0.0%
SNS Proton Power Upgrade, ORNL	......	......	26,000	+26,000	0.0%	+26,000	0.0%
Total, Construction	190,000	202,100	339,000	+149,000	+78.4%	+136,900	+67.7%
Total	**1,871,500**	**1,554,500**	**1,980,300**	**+108,800**	**+5.8%**	**+425,800**	**+27.4%**

- The Senate mark reduces the control point from Research and Construction (shown above) to individual activities (eg. EFRCs, Hubs, CMS, CCS, individual facilities).
- Core research increases ~1% over FY17.
- EFRCs, Hubs, CMS, CCS are flat with FY17.
- EPSCoR increases from $15M in FY17 to $20M in the Senate mark.
- All facilities funded at or near FY17 levels. No funding for Lujan D&D.
- LCLS-II increases to $200M, $10M above FY17.
- APS-U increases to $93M (+$50.5M over FY17) and converts to line item construction.
- New funds provided to start the ALS-U, PPU, and LCLS-II-HE projects.
- $7M for Long Term Surveillance and Maintenance at BNL.