BES and the National Laboratories

Advancing DOE Missions for 40 Years

Dr. Steven Ashby
Director, Pacific Northwest National Laboratory
Chair, National Laboratory Directors' Council

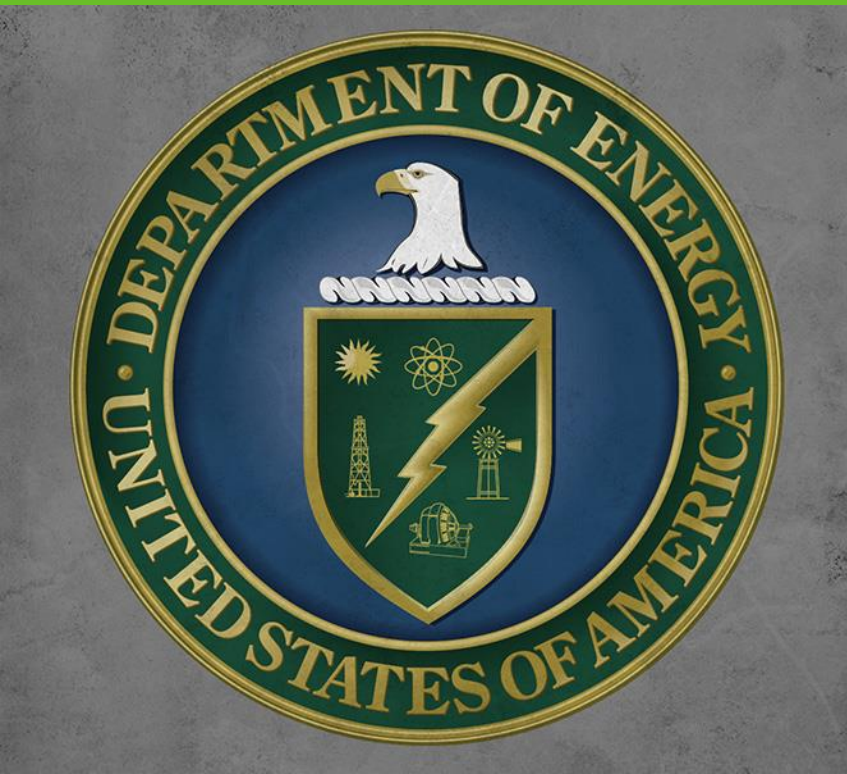
PNNL-SA-127533

1977

The Founding of BES

Created to link federally funded fundamental research to energy technologies

Our World in 1977



Foundational Goals

- Explore fundamental phenomena
- Create scientific knowledge
- Provide unique user facilities necessary for conducting basic research

2017 BES Structure

Harriet Kung

$1.87B

2017 Budget

- Materials Sciences and Engineering Division
- Scientific User Facilities Division
- Chemical Sciences, Geosciences, and Biosciences Division

BES by the Numbers

(FY 2016)

150 Academic, nonprofit, and industrial institutions	**15,000** Users	**25** Research areas
17 DOE National Laboratories	**5,400** Investigators	**1,000** Research projects
47 States + Washington, D.C.	**1,700** Students	**3,500** Peer-reviewed publications

BASIC ENERGY SCIENCES

Nobel Prizes

Nine since 1986

1986
in Chemistry

For the dynamics of chemical elementary processes including a new type of experiment that revealed the evolution of a chemical reaction, step by step.

1987
in Chemistry

For the development and use of molecules with structure-specific interactions of high selectivity, including the incorporation of guest molecules into hollow host molecules.

1994
in Physics

For pioneering neutron scattering techniques, now widely used around the world to understand materials structure, chemistry, and properties.

1995
in Chemistry

For pioneering contributions to understand the formation and decomposition of ozone in the atmosphere, including the “hole” in the ozone layer at the poles.

1996
in Chemistry

For discovery of a novel form of carbon consisting of 60 carbon atoms with a soccer ball-like structure, the first of a vast new class of carbon-structures with novel properties.

1997
in Chemistry

For revealing how enzymes synthesize adenosine triphosphate (ATP), the molecule that stores energy to power cellular processes.

2003
in Physics

For advances in the theory of superconductors, materials that can conduct electricity with no energy losses, thus opening new avenues to energy technologies.

2005
in Chemistry

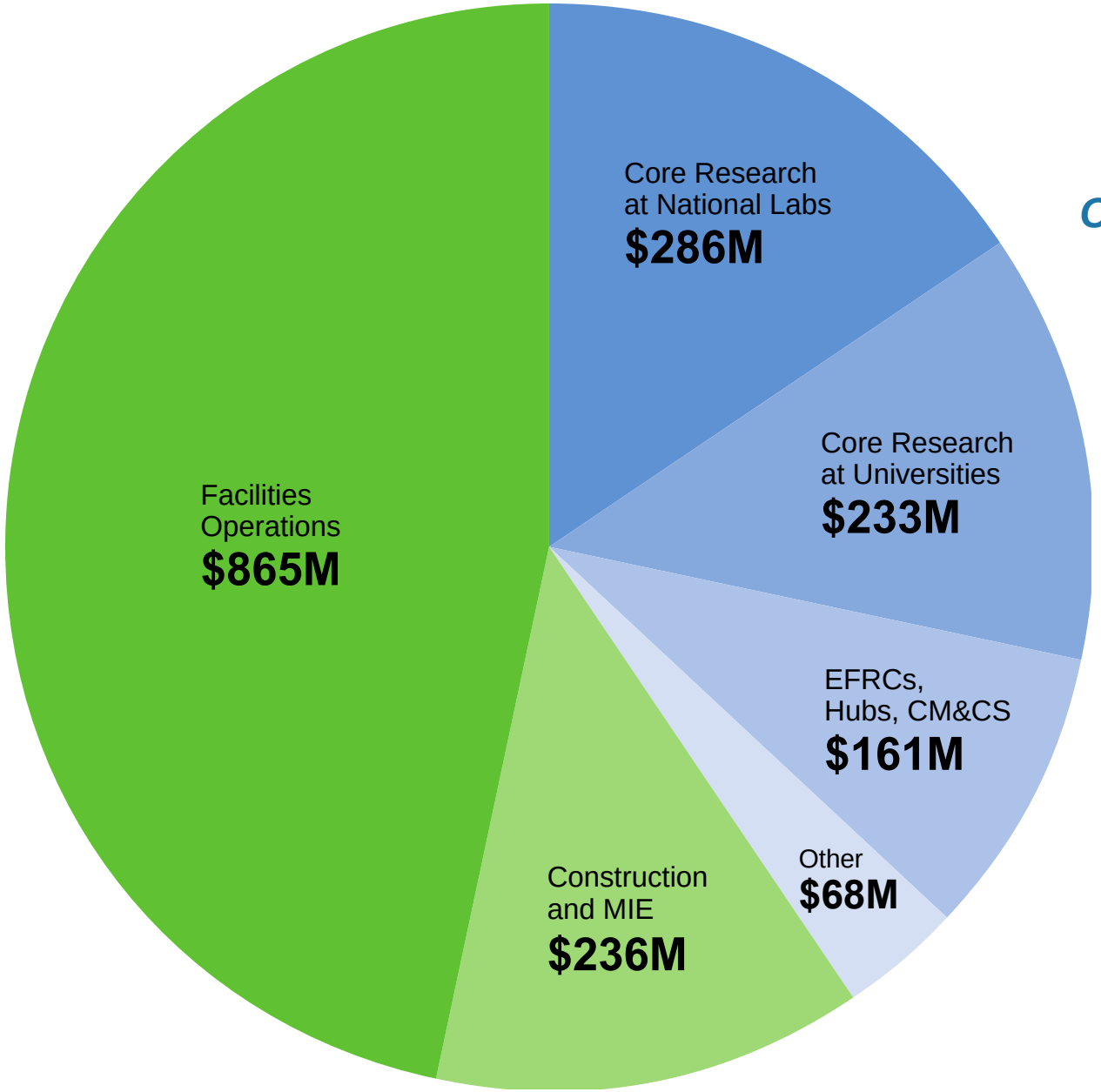
For devising new methods of organic synthesis, now used in the chemical, food processing, and biotechnology industries.

2009
in Chemistry

For mapping (with BES synchrotron light sources) the structure and inner workings of the ribosome, the cell’s machinery for churning out proteins from the genetic code.

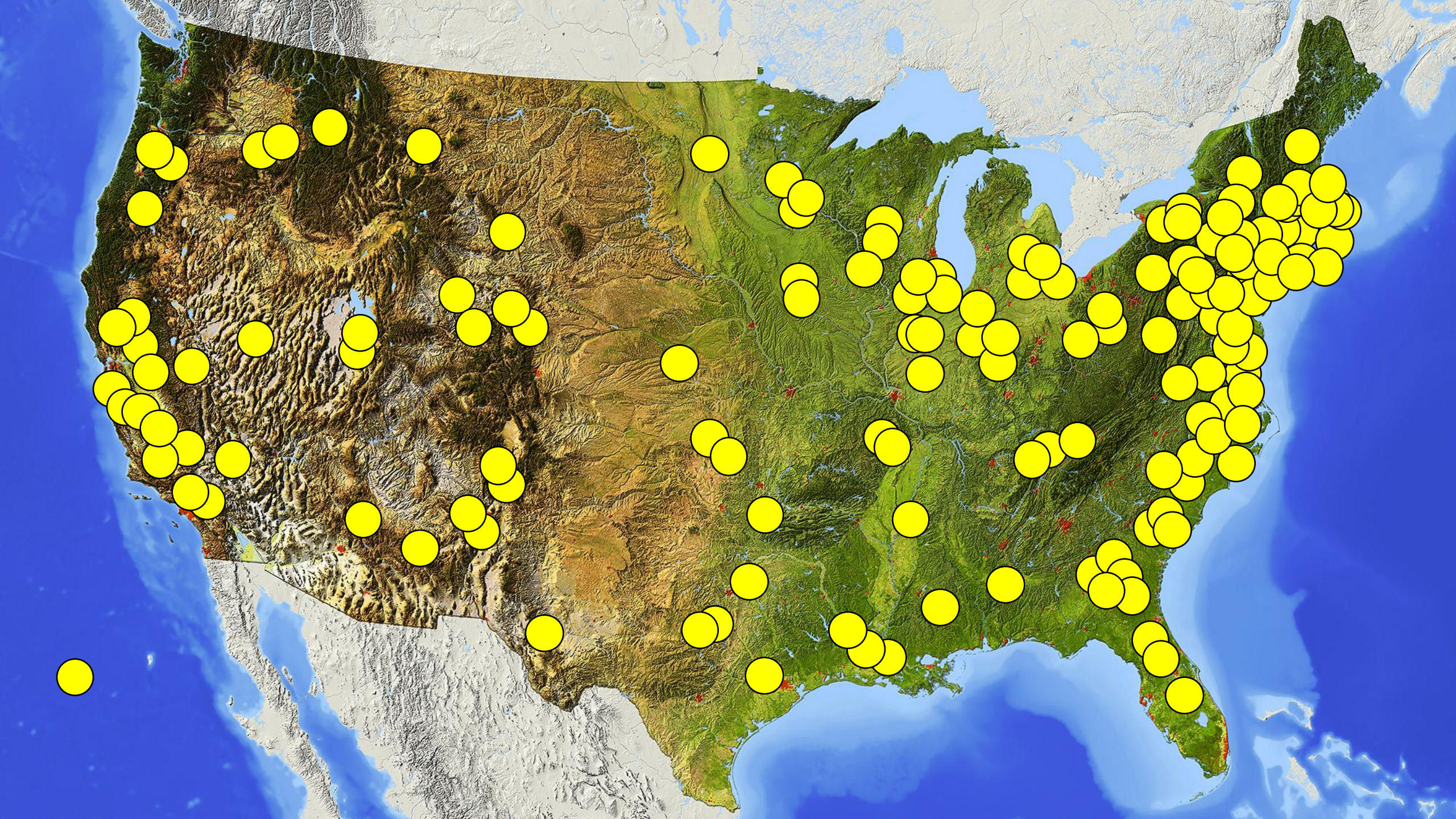
2016 Budget

12 national scientific user facilities



Core research

36 EFRCs




PNNL
INL
NREL
BERKELEY LAB
SLAC
Los Alamos
NATIONAL LABORATORY
Argonne
NATIONAL LABORATORY
BROOKHAVEN
NATIONAL LABORATORY
NETL
PPPL
JL
OAK RIDGE
National Laboratory
SRNL

The National Laboratory System

Working together to address national needs
and advance DOE missions

$14B

Annual Funding

57,000

Research & Support Staff

11,000

Peer-reviewed Publications

(Annually)

5,860

Active Licenses

(Cumulative)

Scientific Discovery

Energy Independence

Advancing DOE

MISSIONS

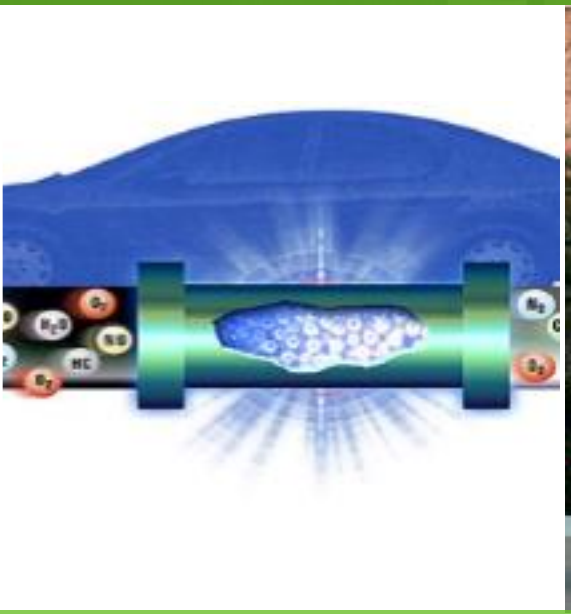
National Security

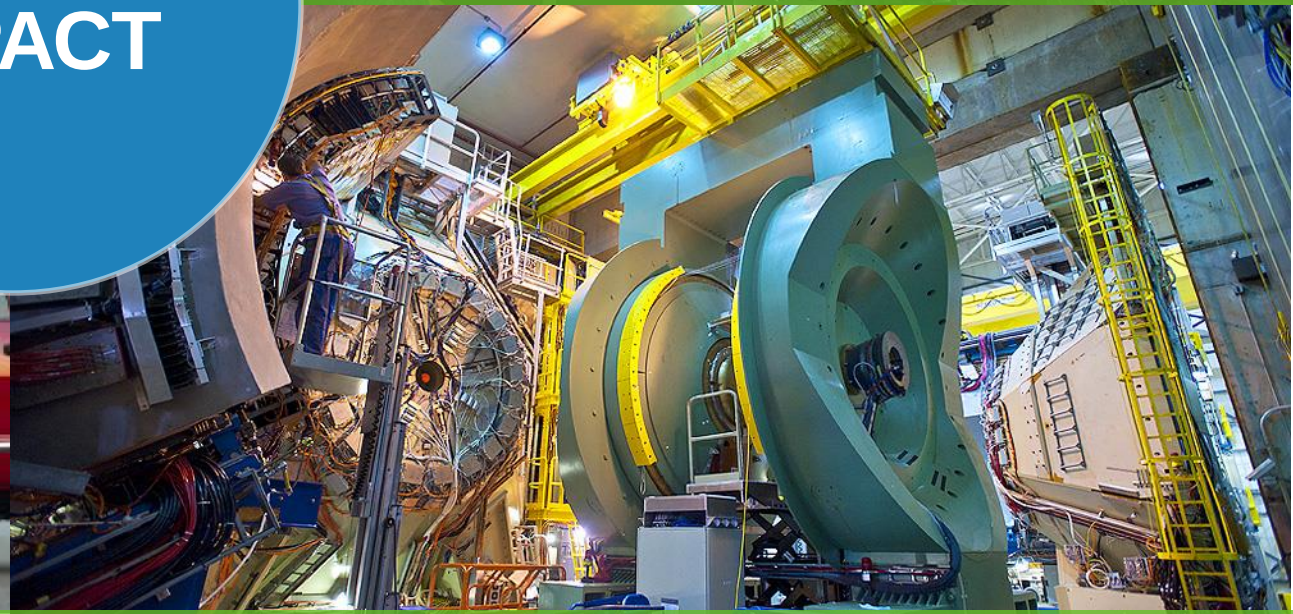
Environmental Management

Address National Needs

Delivering
IMPACT

Steward S&T Capabilities





Enhance Economic Competitiveness

Operate Unique Facilities and Instrumentation

9/11 Terrorist Attacks

Deep Water Horizon Oil Spill

Responding to

CRISES

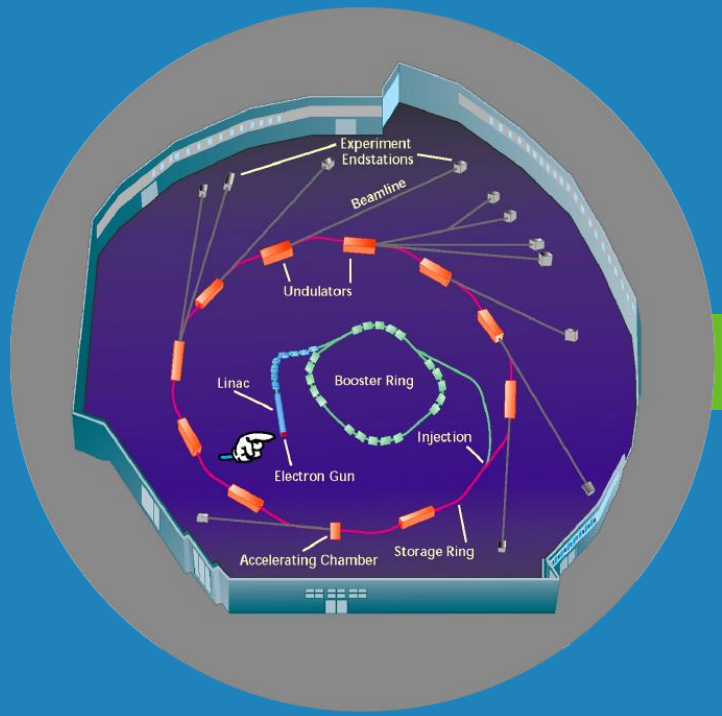
Fukushima Daiichi Nuclear Disaster

Aliso Canyon Gas Leak

The National Labs and BES

Partnering to advance scientific discovery

The National Labs play a critical role in designing, constructing, and operating BES user facilities



Design

Build

Operate

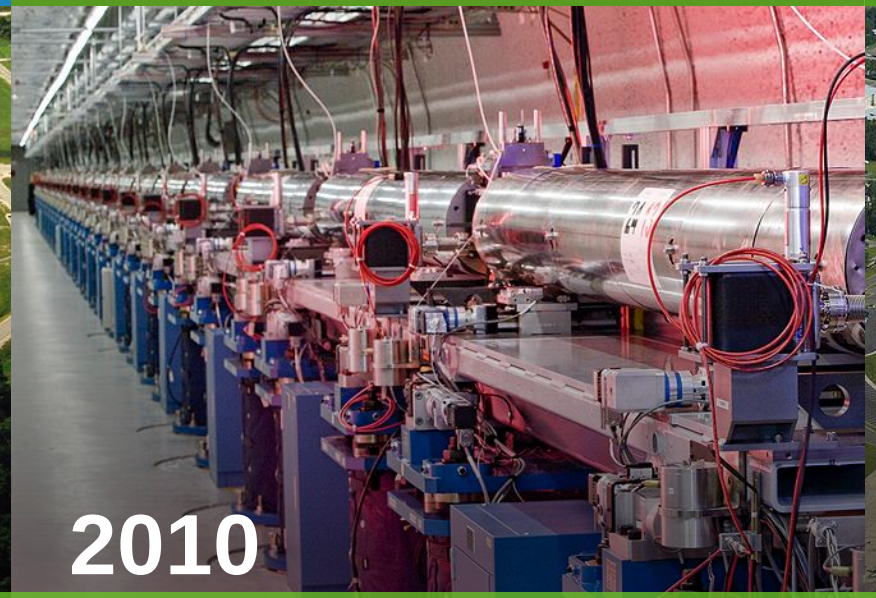
ADVANCED LIGHT SOURCE

X-Ray Light Sources

Stanford Synchrotron Radiation Light Source
SLAC

Advanced Light Source
LBNL

Advanced Photon Source
ANL



LINAC Coherent Light Source
SLAC

National Synchrotron Light Source II
BNL

Nanoscale Science Research Centers

2006

Center for Integrated Nanotechnologies
SNL/LANL

2006

Center for Nanophase Materials
ORNL

2006

The Molecular Foundry
LBNL

2007

Center for Nanoscale Materials
ANL

2008

Center for Functional Nanomaterials
BNL

Neutron Scattering

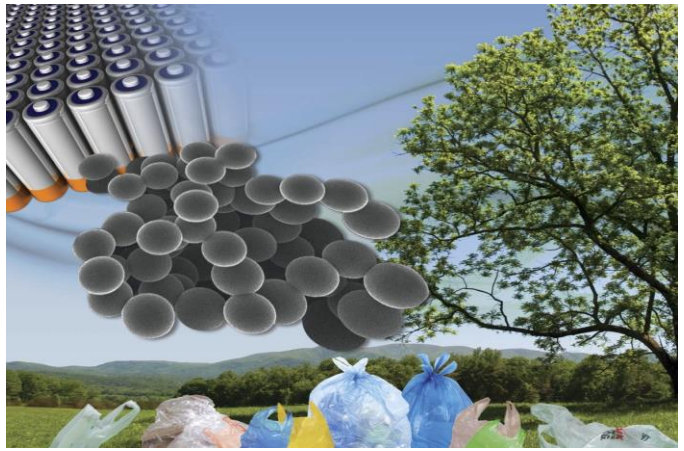
1966

High Flux Isotope Reactor
ORNL

2006

Spallation Neutron Source
ORNL

EFRC Highlights

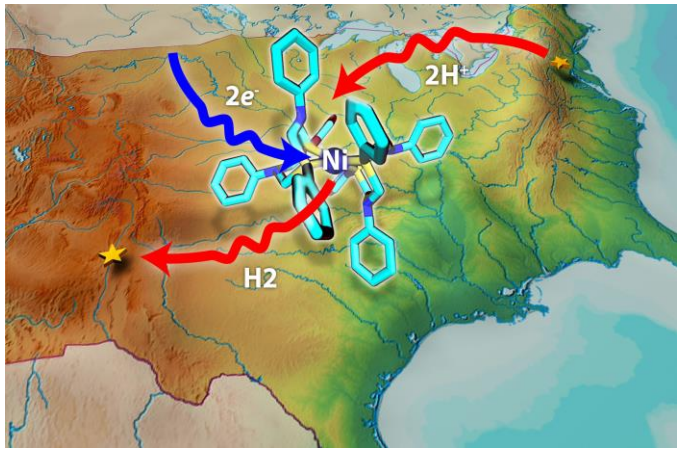


Energy Storage Material

M. Thackeray, ANL

Energy & Environmental Science, 2011

Center for Electrochemical Energy Science: Scientists developed new electrode materials for energy storage--carbon particles and nanotubes.

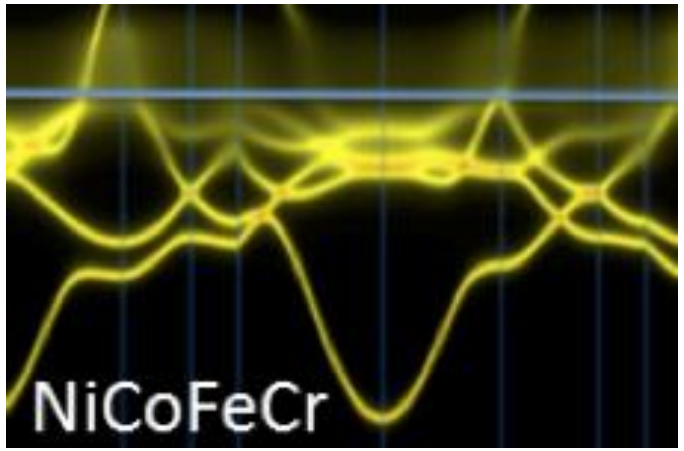


Synthetic Ni Electrocatalyst

R. Bullock, PNNL

Science, 2011

Center for Molecular Electrocatalysis: Scientists created a catalyst that is 10x faster than nature in hydrogen production.



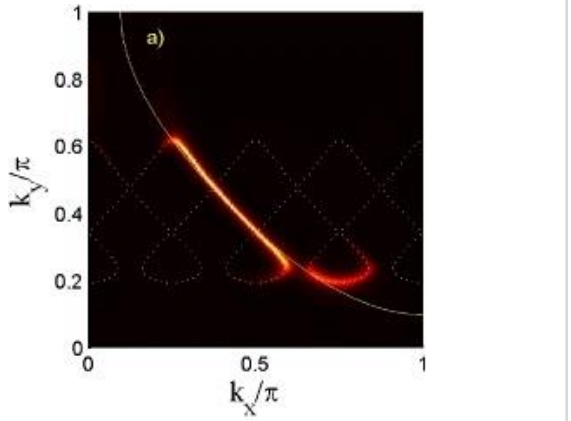
Suppressing Rad. Damage

Y. Zhang, ORNL

Nature Communications, 2015

Energy Dissipation to Defect Evolution: Chemically complex or high entropy alloys could lead to materials with suppressed damage accumulation under irradiation.

Materials Science and Engineering

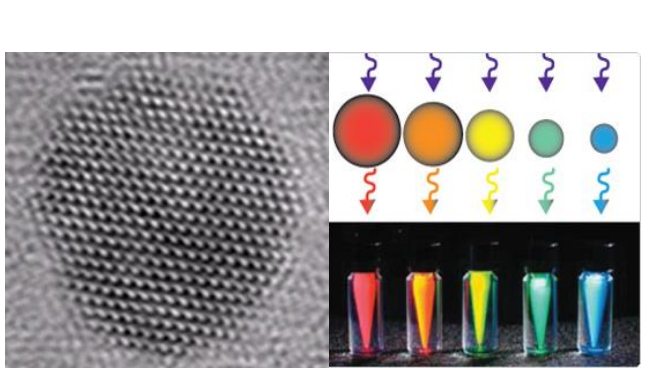


Stripes in Superconductors

J. Tranquada, BNL

1995 highly cited paper in *Nature*

Scientists discovered striped phases in semiconductors; this discovery necessitated developing new principles that describe charge transport in materials able to conduct electricity without resistance.

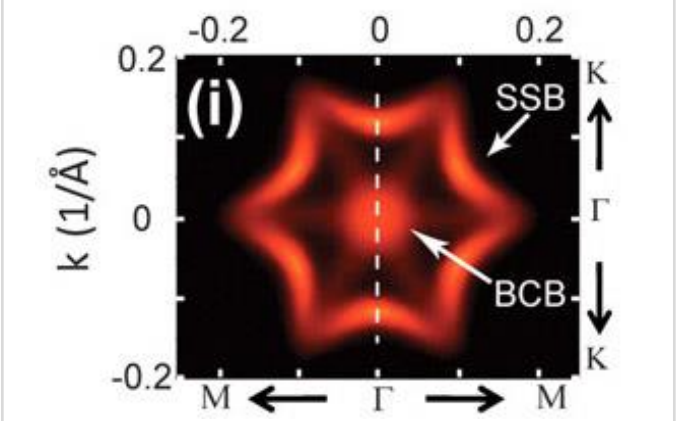


Quantum Dots

A.P. Alivisatos, LBNL

1996 highly cited paper in *Science*

Quantum dots exhibit strong size-dependent optical electric properties. The ability to join the dots into complex assemblies creates many opportunities for scientific discovery in electron behavior plus opportunities in solar cells, tracking devices and more.



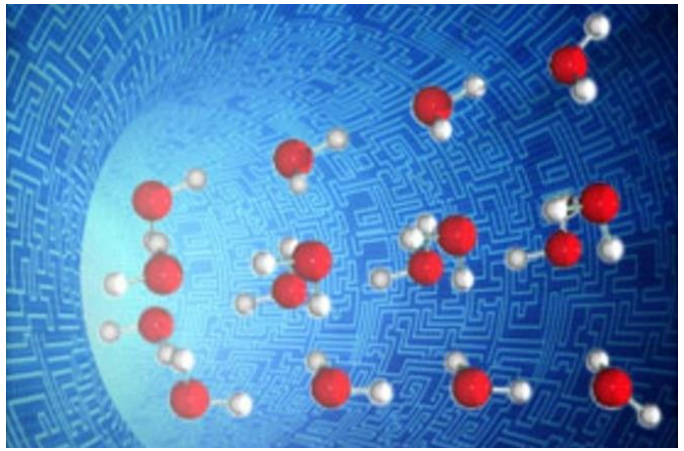
3-D Topological Insulators

Z.X. Shen, SLAC

2009 highly cited paper in *Science*

By investigating the surface state of Bi_2Te_3, scientists demonstrate that the surface state consists of a single nondegenerate Dirac cone. The discovery may provide new routes to generating novel materials, possibly finding uses in next-generation computing.

Chemical and Biosciences

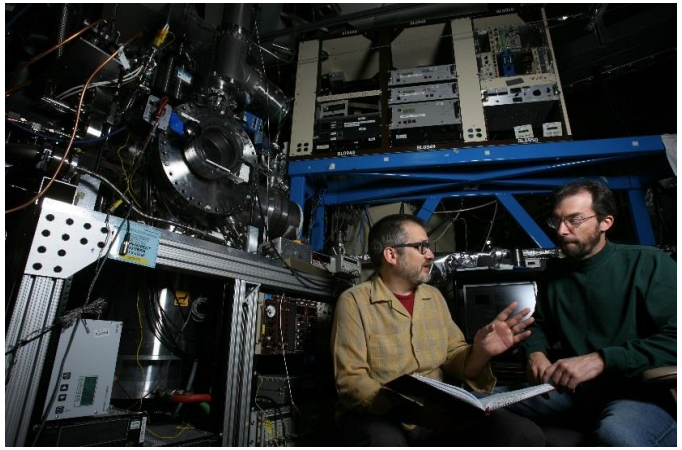


Morphology of Water

B. Kay, PNNL

1999 highly cited paper in *Science*

The morphology of water can be controlled by the angular distribution of condensing molecules, giving us insight into rare forms of water.

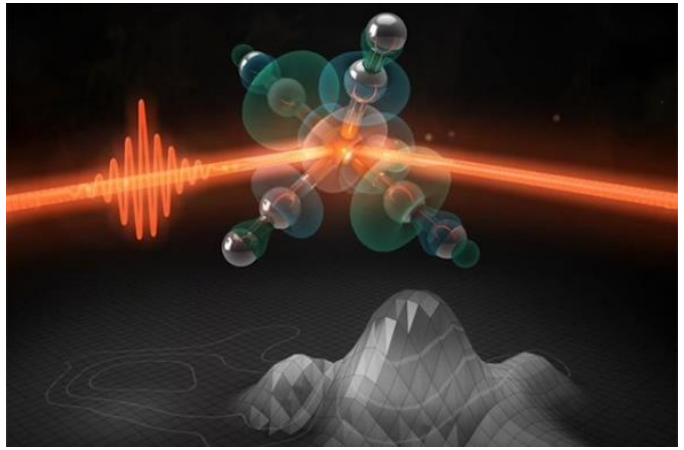


Combustion Kinetics

O. Welz, SNL

2012 “breakthrough paper” in *Science*

CRF measurements of gas-phase reaction intermediates using photoionization mass spectrometry provide direct knowledge of poorly understood kinetics.



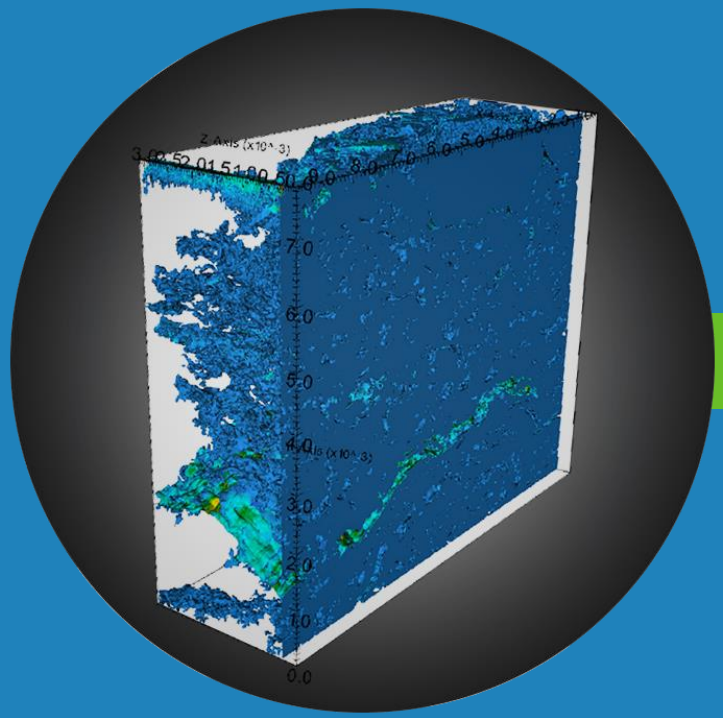
Formation of a Catalyst

P. Wernet, SLAC

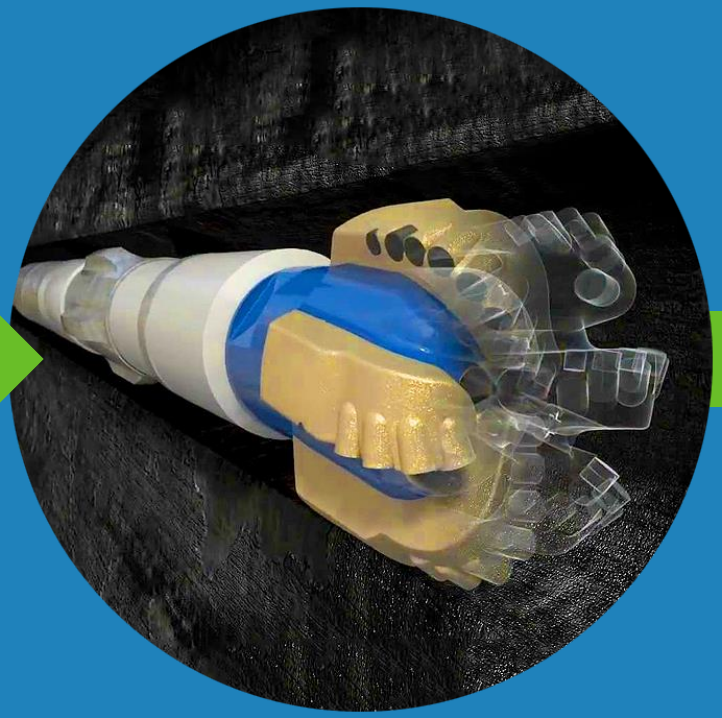
2015 highly cited paper in *Nature*

Light rearranges the outermost electrons of $Fe(CO)_5$ and turns it into an active catalyst. Light could be used to enhance active sites.

Geosciences: Discovery to societal impact



Subsurface
Characterization



Horizontal
Drilling

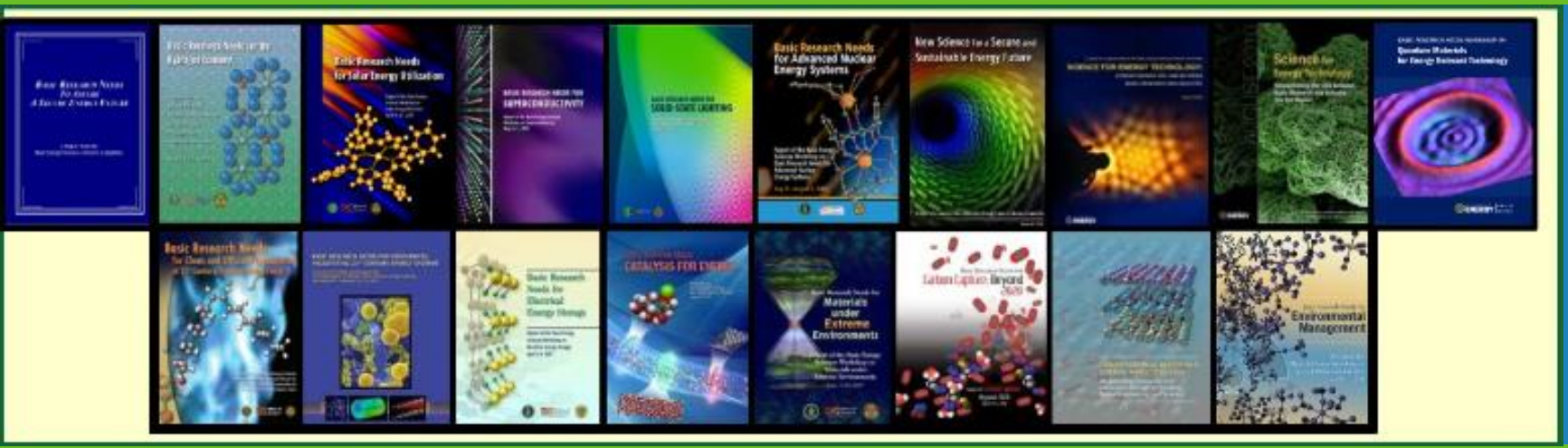
Natural
Gas

Envisioning the Future

Engaging the community in a time-tested strategic planning process

The BES Planning Process

Science for Discovery



Science for National Needs

The BES User Facilities

Basic Research Needs Workshops

- Quantum materials for energy-relevant technology
- Synthesis science for energy-relevant technology
- Innovation/discovery of transformative experimental tools
- Next-generation electrical energy storage*
- Catalysis science to transform energy technologies*
- Energy-water issues: new approaches to ensure robust and secure energy and water systems
- Basic research needs for future nuclear energy*

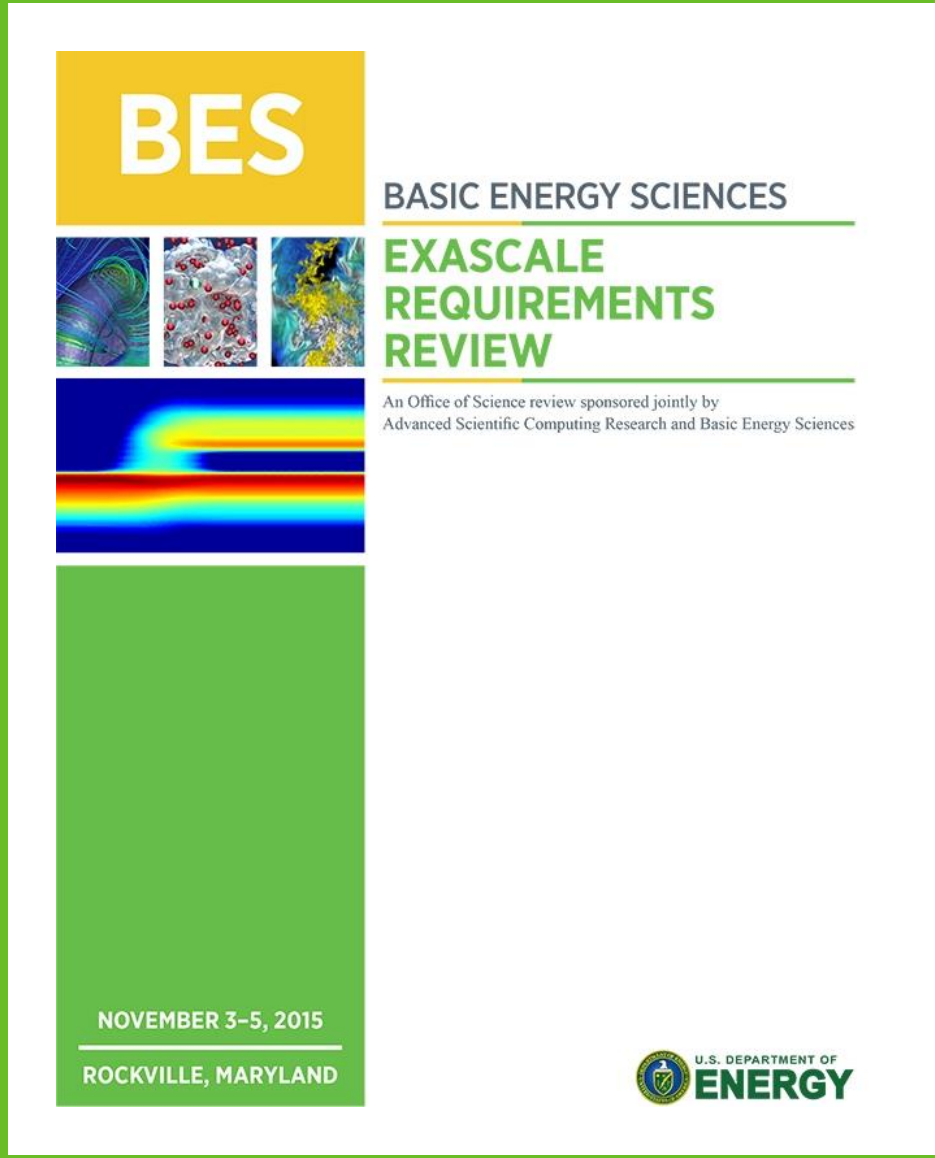
*REFRESH

BES and Computing

BES will use exascale simulation to make scientific discoveries in

- Quantum materials and chemistry
- Catalysis and combustion
- Photosynthesis and light harvesting

BES will leverage its strengths to enable beyond-CMOS computing technologies





Creating our Energy Future




AMES LABORATORY
Creating Materials & Energy Solutions
U.S. DEPARTMENT OF ENERGY
Argonne
NATIONAL LABORATORY
BERKELEY LAB
Lawrence Berkeley National Laboratory
BROOKHAVEN
NATIONAL LABORATORY
Fermilab
INL
Idaho National Laboratory
Jefferson Lab
Thomas Jefferson National Accelerator Facility
Lawrence Livermore
National Laboratory
Los Alamos
NATIONAL LABORATORY
NETL
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ENERGY
TECHNOLOGY
LABORATORY
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
OAK
RIDGE
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Pacific Northwest
NATIONAL LABORATORY
PPPL
PRINCETON
PLASMA PHYSICS
LABORATORY
Sandia
National
Laboratories
SLAC
NATIONAL ACCELERATOR LABORATORY
SRNL
SAVANNAH RIVER NATIONAL LABORATORY