U.S. DEPARTMENT OF ENERGY | Office of Science

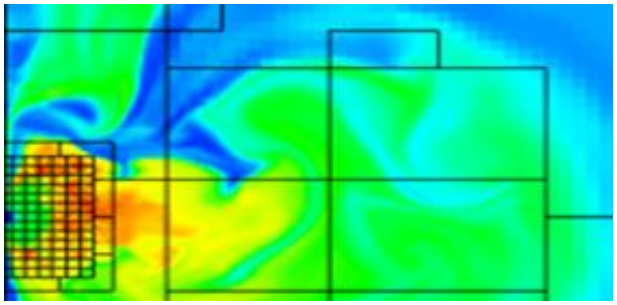
Office of Science Update

BESAC Meeting

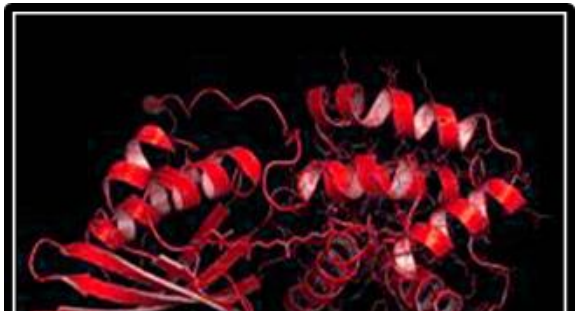
June 8, 2016

Cherry A. Murray
Director, Office of Science
cherry.murray@science.energy.gov

Office of Science Programs

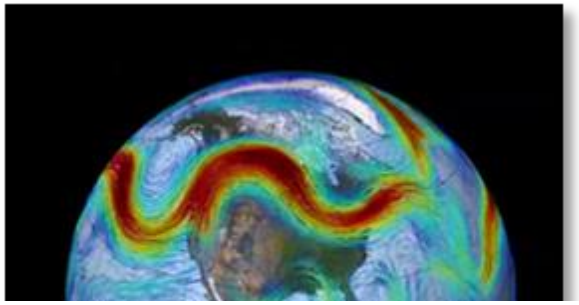


Advanced Scientific Computing Research
FY2016 $621M



Basic Energy Sciences

FY2016 $1849M



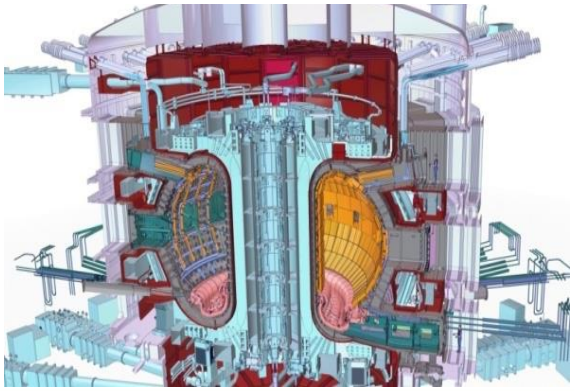
Biological and Environmental Research
FY2016 $609M

High Energy Physics

FY2016 $795M

Fusion Energy Sciences

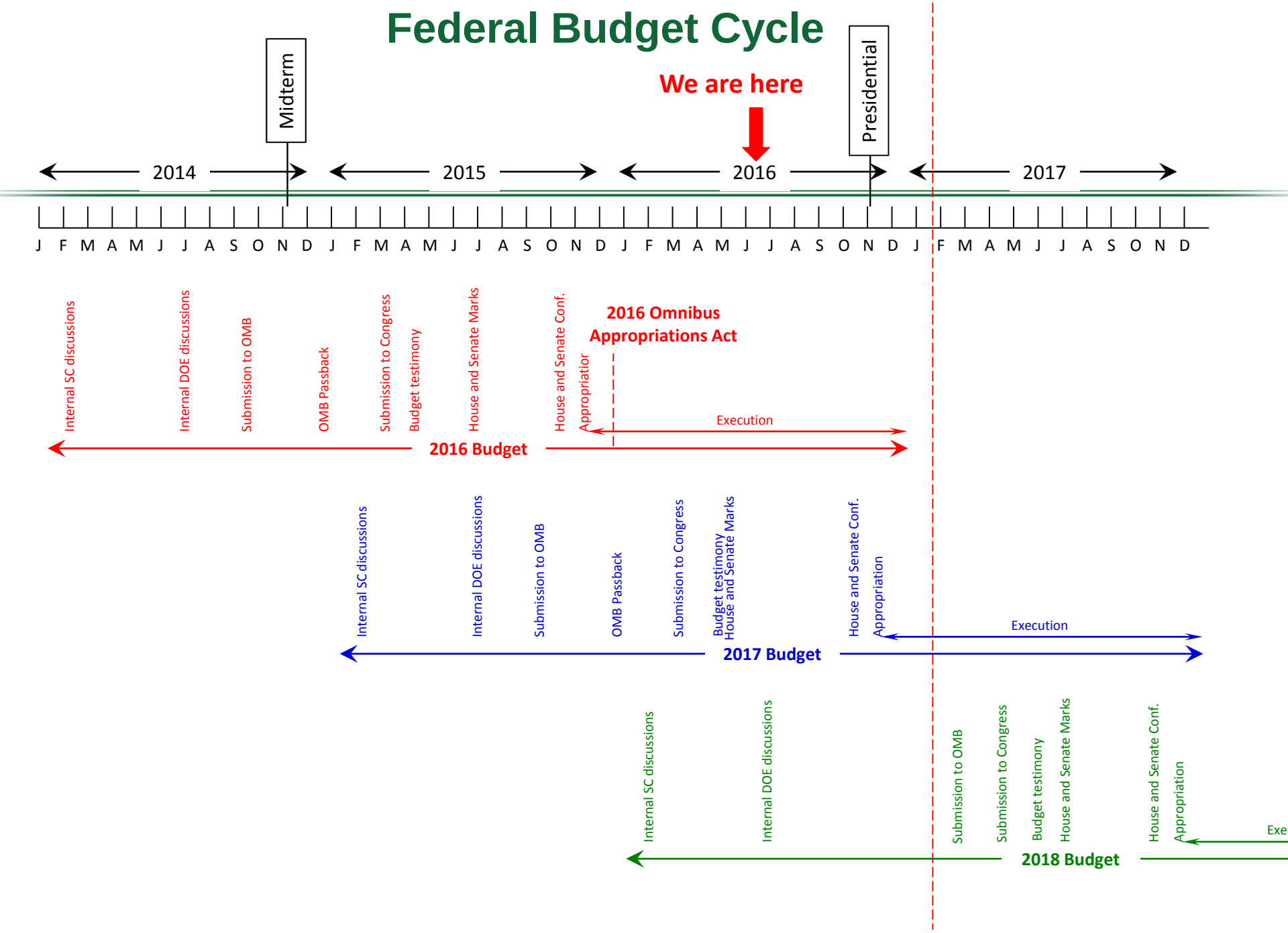
FY2016 $438M



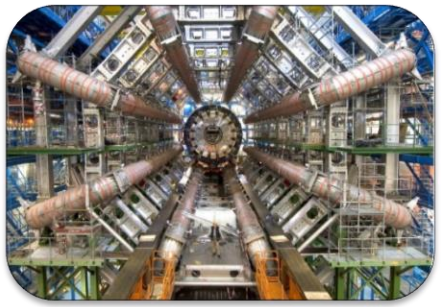
Nuclear Physics

FY2016 $617M

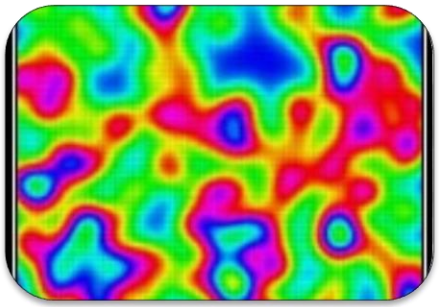
Federal Budget Cycle



Office of Science FY16 - $5.35B

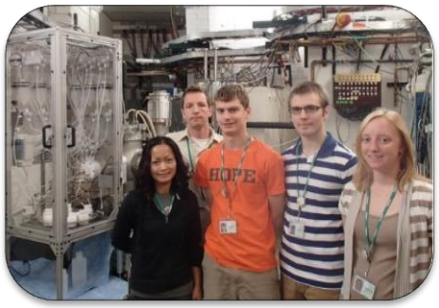


Largest Supporter of Physical Sciences in the U.S.*



Research: 42%, $2.2B

~40% of Research to Universities



> 20,000 Scientists Supported

Funding at >300 Institutions including all 17 DOE Labs

Construction: 13.5%, $723M

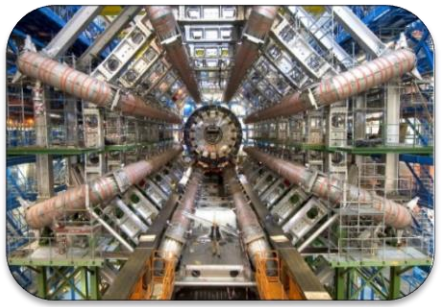
Facility Operations: 38%, $2.02B

>35,000 Scientific Facility Users**

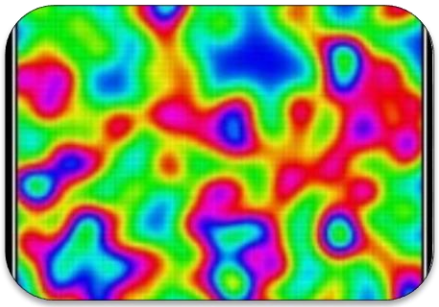
* 43% of all physical sciences, 30% of computer science and math

** from all 50 states and DC

Office of Science FY17 Request: $5.67B, +6.1%

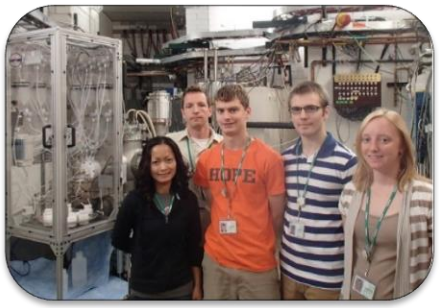


Largest Supporter of Physical Sciences in the U.S.



Research: 42%, $2.4B

~40% of Research to Universities



> 20,000 Scientists Supported

Funding at >300 Institutions including all 17 DOE Labs

Facility Operations: 36%, $2.06B

>35,000 Scientific Facility Users

$1.8B Mission Innovation

Without $100M mandatory, $5.57B, +4%

FY17 HEWD and SEWD Appropriations Marks, 4-14-16

- **Science - +3% for both marks compared to FY16 enacted but some differences of opinion**

FY 2017 Appropriations Action for Science Detail

FY17 HEWD and SEWD marks
2.9% increase over FY2016 enacted, 1% decrease from FY17 disc. request

Department of Energy / Office of Science
($000's)

	FY 2016 Enacted	FY 2017 President's Request	FY 2017 House Mark	House Mark - Request	FY 2017 Senate Mark	Senate Mark - Request
Advanced Scientific Computing Research	621,000	663,180	621,000	(42,180)	656,180	(7,000)
Basic Enrgy Sciences	1,849,000	1,936,730	1,859,972	(76,758)	1,912,630	(24,100)
Biological and Environmental Research	609,000	661,920	595,000	(66,920)	637,000	(24,920)
Fusion Energy Sciences	438,000	398,178	450,000	51,822	280,110	(118,068)
High Energy Physics	795,000	817,997	823,009	5,012	832,997	15,000
Nuclear Physics	617,100	635,658	620,000	(15,658)	635,658	-
Workforce Development for Teachers and Scientists	19,500	20,925	20,925	-	20,925	-
Science Laboratories Infrastructure	113,600	130,000	122,397	(7,603)	130,000	-
Safeguards and Security	103,000	103,000	103,000	-	103,000	-
Program Direction	185,000	204,481	184,697	(19,784)	191,500	(12,981)
University Grants (Mandatory)	-	100,000	100,000	-	100,000	-
Total Budget Authority and Obligations	**5,350,200**	**5,672,069**	**5,500,000**	**(172,069)**	**5,500,000**	**(172,069)**
Rescission of Prior Year Balances	(3,200)	-	-	-	-	-
Appropriation, Office of Science	5,347,000	5,672,069	5,500,000	(172,069)	5,500,000	(172,069)

Detailed differences of opinion, esp. for FES, BER

FY 2017 Appropriations Action

Basic Energy Sciences

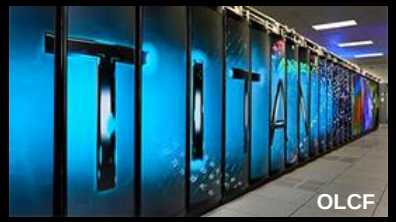
- **House Mark:** Reduces funding for new Energy Frontier Research Centers (EFRC's); does not support new Computational Chemical Sciences component of the Exascale crosscut; and, limits proposed Mission Innovation investments in light weight materials, corrosion, quantum materials, chemistry under extreme environments and catalysis; planned research in thermocaloric materials will not proceed; planned geosciences research in support of the Subsurface crosscut will proceed. Strong support is provided for the Advanced Photon Source Upgrade project.

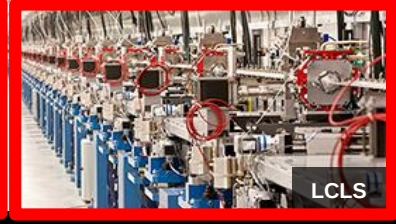
- **Senate Mark:** Provides a modest increase for EFRC's; reduces Mission Innovation by almost eight percent allowing limited enhancements to research in lightweight materials, corrosion, quantum materials and catalysis, planned research in thermocaloric materials and chemistry under harsh/extreme environments will not proceed; planned geosciences research in support of the Subsurface crosscut will proceed. Strong support is provided for the Advanced Photon Source Upgrade project.

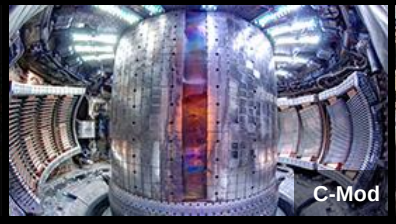
FY2017 Issues and Priorities

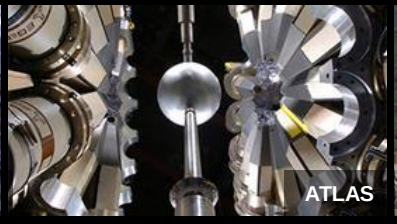
- **BALANCE - Research funding vs scientific user facilities construction vs operation**
  - **BESAC study of 5 proposed user facility upgrades**
- **BALANCE - Discovery research vs science for clean energy and departmental crosscuts**
- **Exascale Computing Project! National Strategic Computing Initiative**
- **International partnerships in Big Science**
  - **ITER**
  - **LHC CMS, ATLAS upgrades at the same time as LBNF/DUNE**

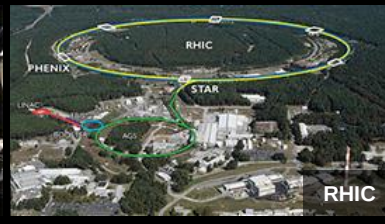
FY 2016
28 user facilities





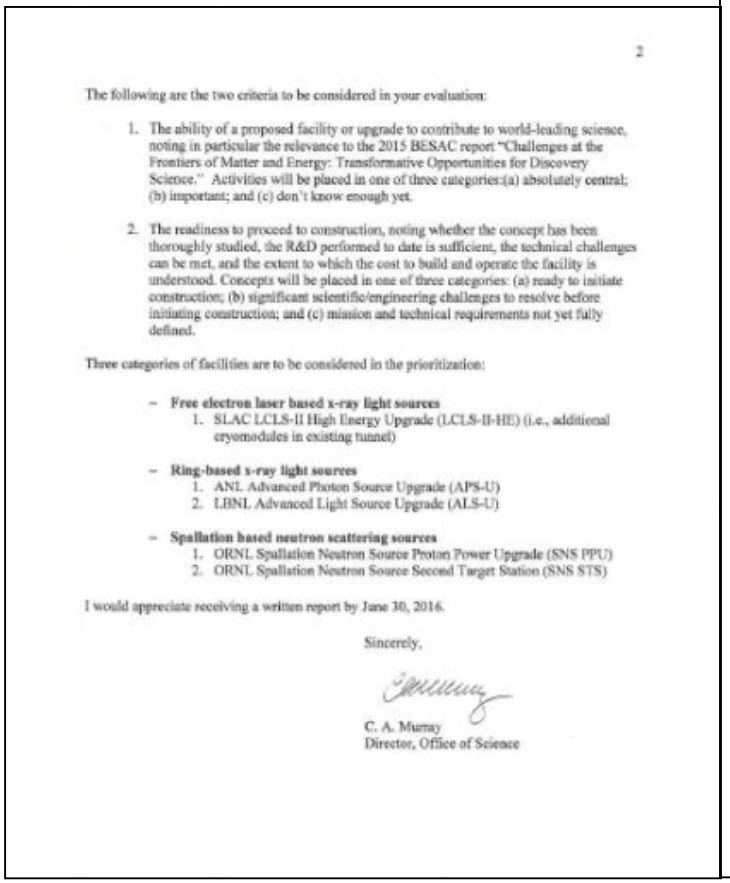






U.S. DEPARTMENT OF
ENERGY
Office of Science

BESAC New Charge on Prioritization of Facility Upgrades



2

The following are the two criteria to be considered in your evaluation:

1. The ability of a proposed facility or upgrade to contribute to world-leading science, noting in particular the relevance to the 2015 BESAC report "Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science." Activities will be placed in one of three categories:(a) absolutely central; (b) important; and (c) don't know enough yet.

2. The readiness to proceed to construction, noting whether the concept has been thoroughly studied, the R&D performed to date is sufficient, the technical challenges can be met, and the extent to which the cost to build and operate the facility is understood. Concepts will be placed in one of three categories: (a) ready to initiate construction; (b) significant scientific/engineering challenges to resolve before initiating construction; and (c) mission and technical requirements not yet fully defined.

Three categories of facilities are to be considered in the prioritization:

- **Free electron laser based x-ray light sources**
  1. SLAC LCLS-II High Energy Upgrade (LCLS-II-HE) (i.e., additional cryomodules in existing tunnel)
- **Ring-based x-ray light sources**
  1. ANL Advanced Photon Source Upgrade (APS-U)
  2. LBNL Advanced Light Source Upgrade (ALS-U)
- **Spallation based neutron scattering sources**
  1. ORNL Spallation Neutron Source Proton Power Upgrade (SNS PPU)
  2. ORNL Spallation Neutron Source Second Target Station (SNS STS)

I would appreciate receiving a written report by June 30, 2016.

Sincerely,

C. A. Murray
Director, Office of Science

From: Dr. Cherry A. Murray (Director, Office of Science)

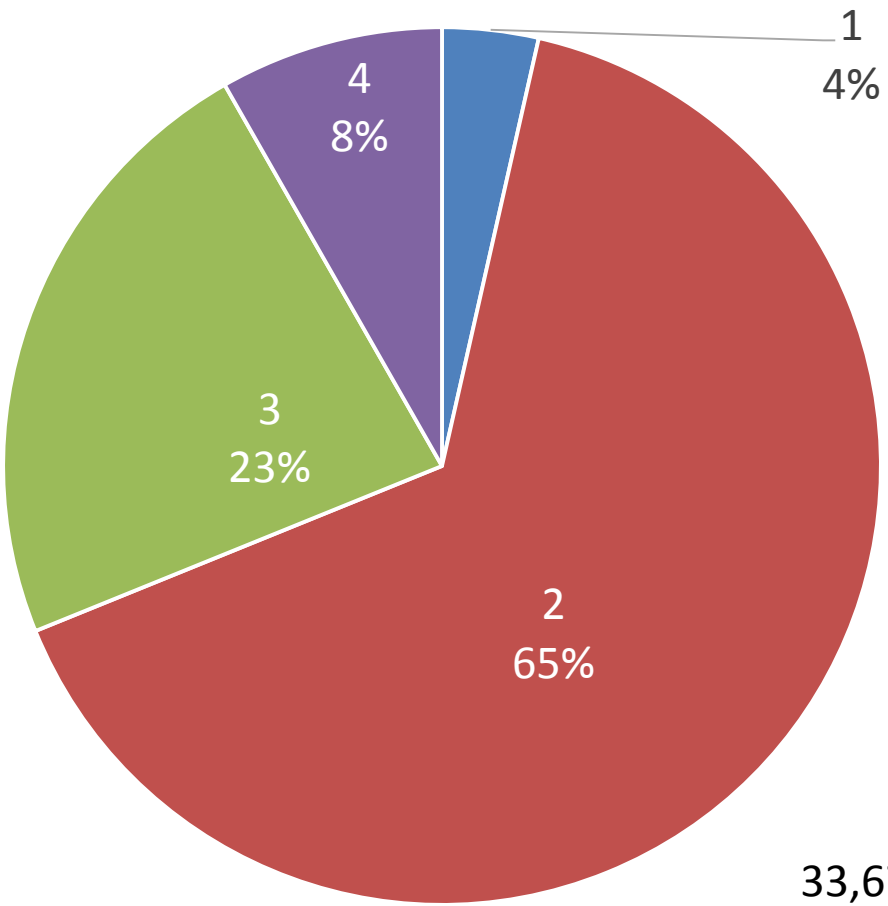
I am writing to present a new charge to BESAC, related to the prioritization of upgrades of existing user facilities and major construction projects for new user facilities.

The following are the two criteria to be considered in your evaluation:

1. **The ability of a proposed facility or upgrade to contribute to world-leading science,** noting in particular the relevance to the 2015 BESAC report "Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science." Activities will be placed in one of three categories:(a) absolutely central; (b) important; and (c) don't know enough yet.

2. **The readiness to proceed to construction**, noting whether the concept has been thoroughly studied, the R&D performed to date is sufficient, the technical challenges can be met, and the extent to which the cost to build and operate the facility is understood. Concepts will be placed in one of three categories: (a) ready to initiate construction; (b) significant scientific/engineering challenges to resolve before initiating construction; and (c) mission and technical requirements not yet fully defined.

Office of Science User Facility Statistics FY14

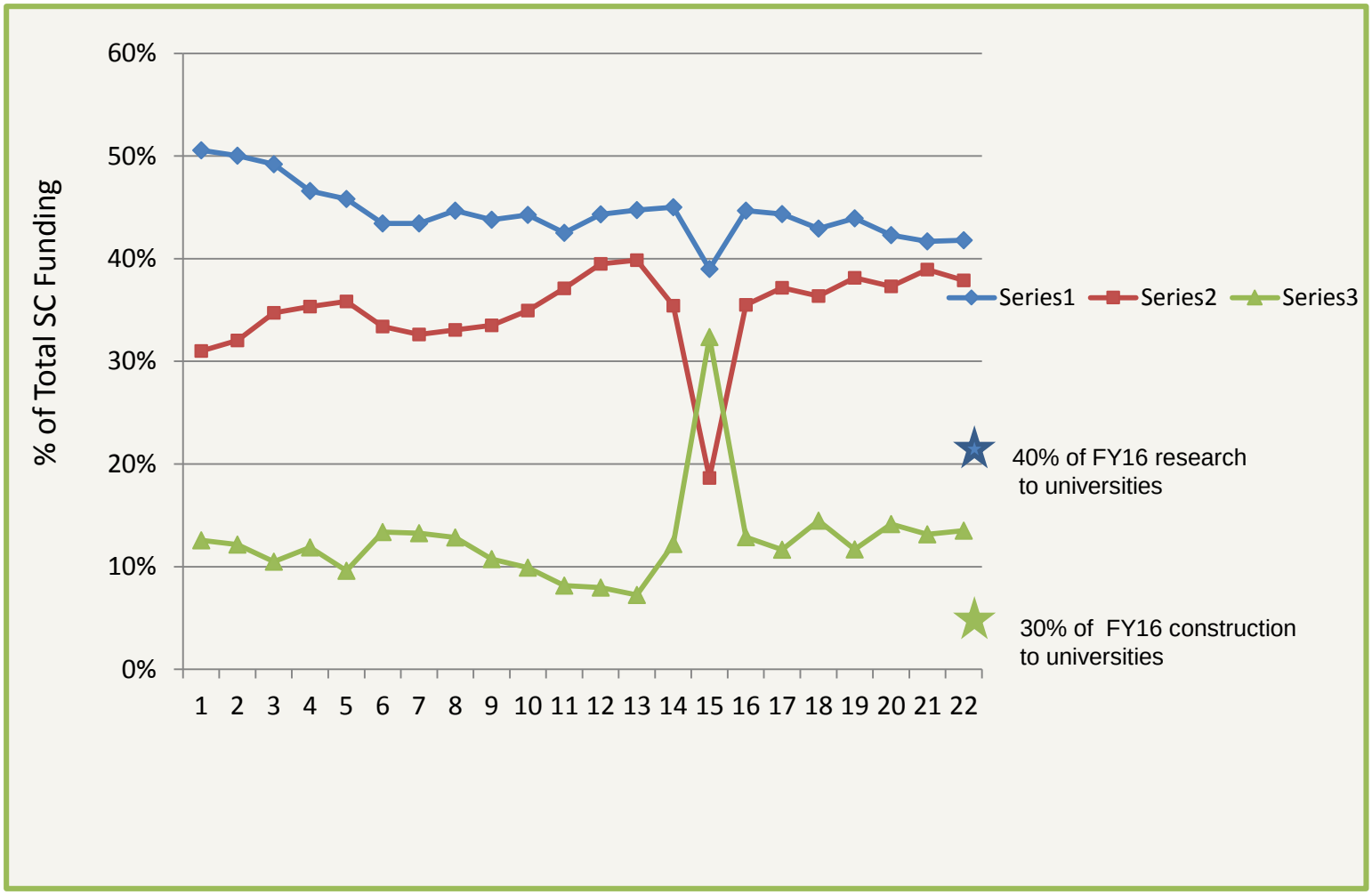


33,671 Total Users

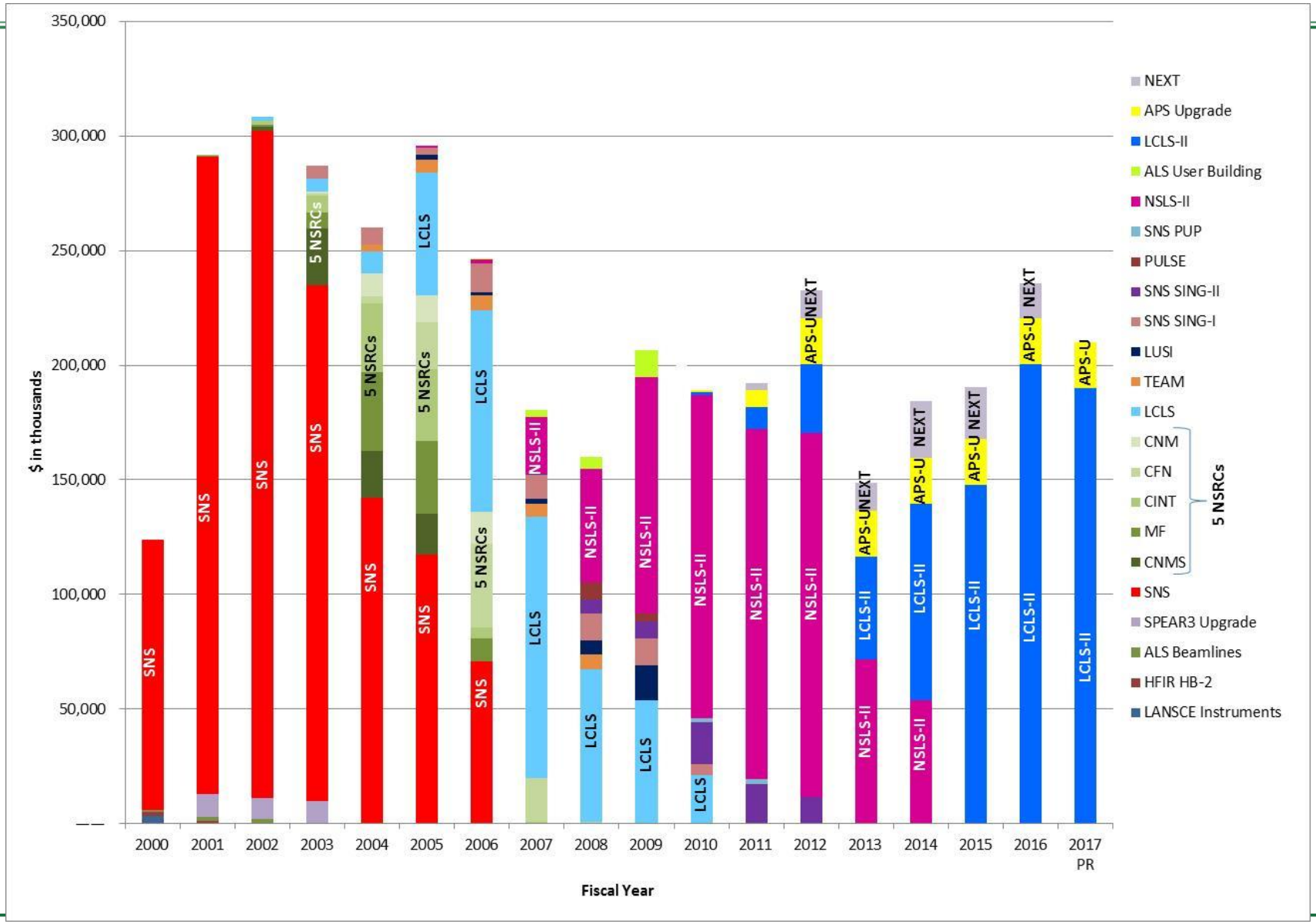
U.S. DEPARTMENT OF ENERGY | Office of Science

Other includes many institutions, such as: non-DOE labs, federal agencies, research hospitals, K-12 students, and international institutions

SC Investments in Research, Facilities, and Construction



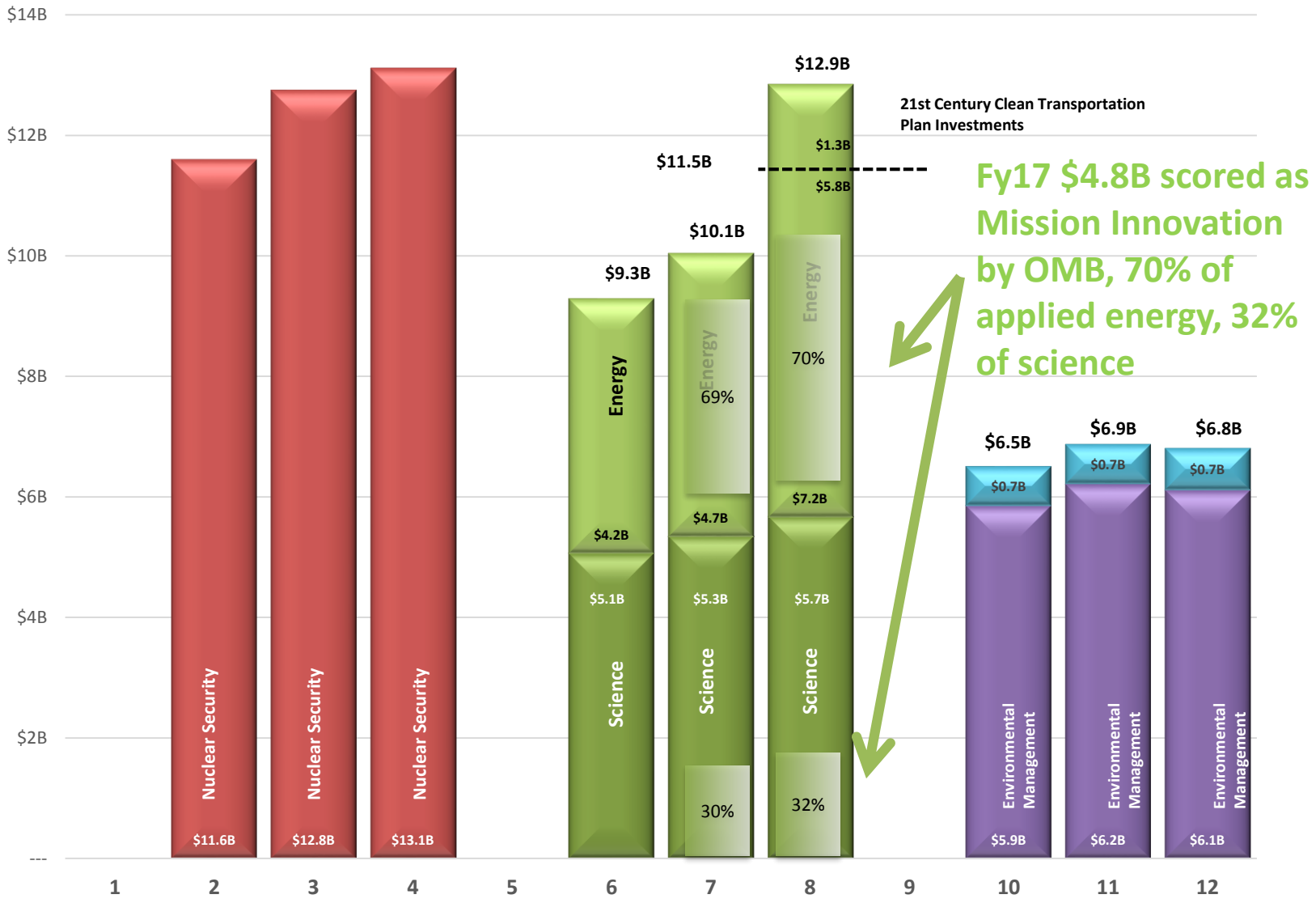
BES Construction/MIE Funding Profile 2000 – 2017



FY2017 Issues and Priorities

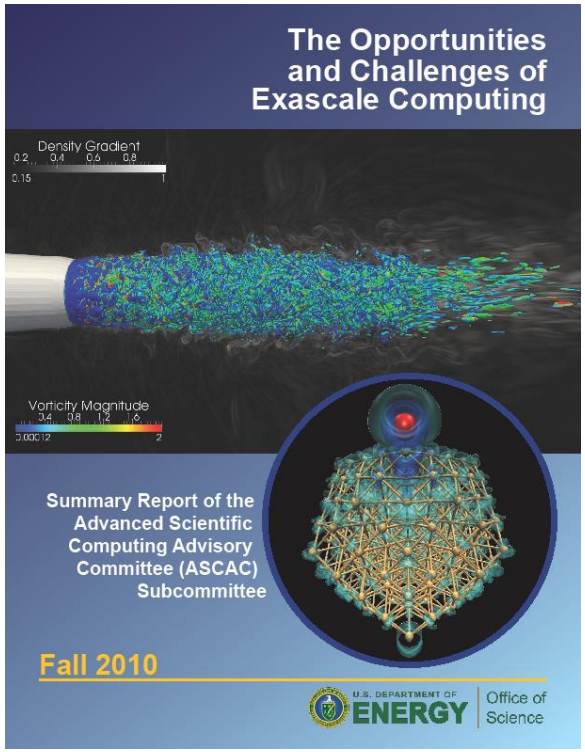
- BALANCE - Research funding vs scientific user facilities construction vs operation
  - BESAC study of 5 proposed user facility upgrades
- **BALANCE - Discovery research vs science for clean energy and departmental crosscuts**
- Exascale Computing Project! National Strategic Computing Initiative
- International partnerships in Big Science
  - ITER
  - LHC CMS, ATLAS upgrades at the same time as LBNF/DUNE

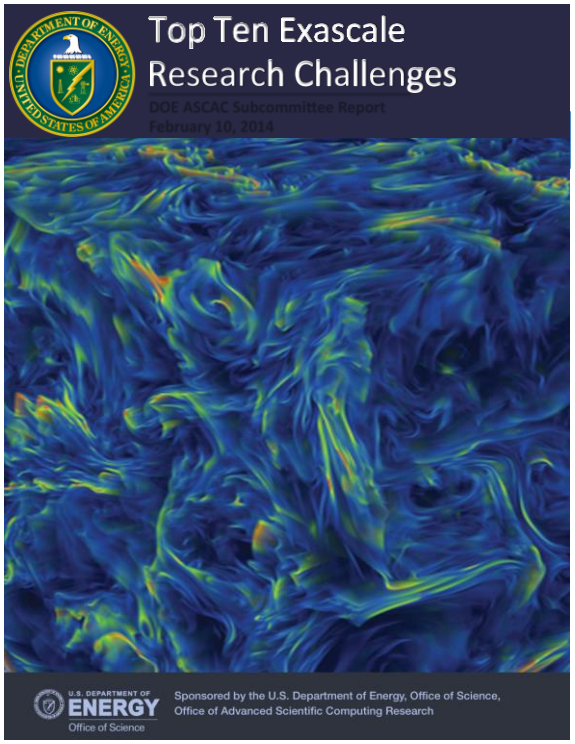
DOE Mission Innovation R&D, FY 16 and 17 proposed

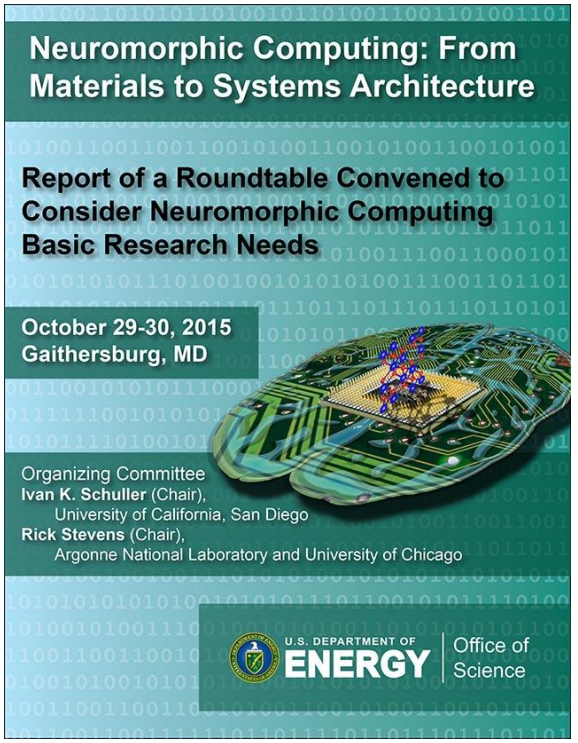


FY2017 Issues and Priorities

- BALANCE - Research funding vs scientific user facilities construction vs operation
  - BESAC study of 5 proposed user facility upgrades
- BALANCE - Discovery research vs science for clean energy and departmental crosscuts
- **Exascale Computing Project! National Strategic Computing Initiative**
- International partnerships in Big Science
  - ITER
  - LHC CMS, ATLAS upgrades at the same time as LBNF/DUNE







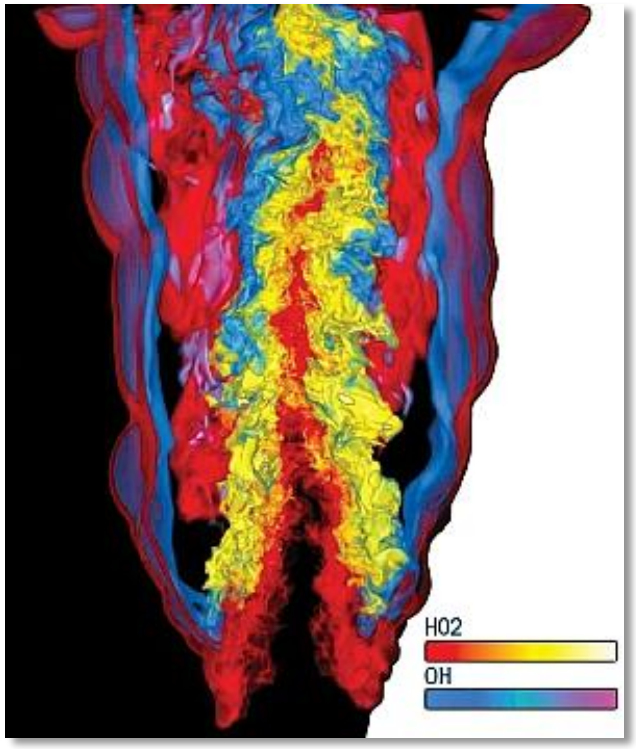
http://science.energy.gov/~/media/ascr/ascac/pdf/reports/Exascale_subcommittee_report.pdf

http://science.energy.gov/~/media/ascr/ascac/pdf/meetings/20140210/Top10reportFEB14.pdf

http://science.energy.gov/bes/community-resources/reports/abstracts/#NCFMtSA

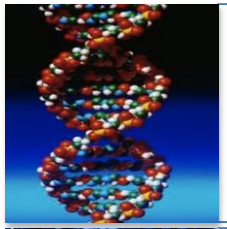
DOE's Exascale Computing Initiative:
Next Generation of Scientific Innovation

- **Departmental Crosscut – In partnership with NNSA**
- **"All-in" approach: hardware, software, applications, large data, underpinning applied math and computer science**
- **Supports DOE's missions in national security and science:**
  - Stockpile stewardship – support annual assessment cycle
  - Discovery science – next-generation materials; chemical sciences
  - Mission-focused basic science in energy – next-generation climate software
  - Use current Leadership Computing approach for users
- **The next generation of advancements will require Extreme Scale Computing**
  - 100-1,000X capabilities of today's computers with a similar physical size and power footprint
  - Significant challenges are power consumption, high parallelism, reliability
- **Extreme Scale Computing, cannot be achieved by a "business-as-usual," evolutionary approach**
  - Initiate partnerships with U.S. computer vendors to perform the required engineering, research and development for system architectures for capable exascale computing
  - Exascale systems will be based on marketable technology – Not a "one off" system
  - Productive system – Usable by scientists and engineers



Exascale Project

Extreme-Scale Science Data Explosion

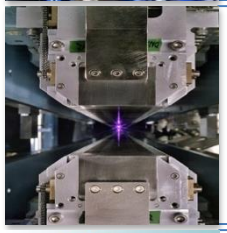


Genomics

Data Volume increases to 10 PB in FY21

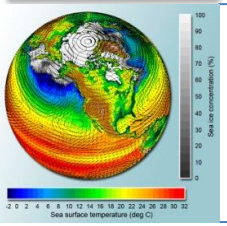
High Energy Physics (Large Hadron Collider)

15 PB of data/year



Light Sources

Approximately 300 TB/day



Climate

Data expected to be hundreds of 100 EB

Driven by exponential technology advances

Data sources

- Scientific Instruments
- Scientific Computing Facilities
- Simulation Results
- Observational data

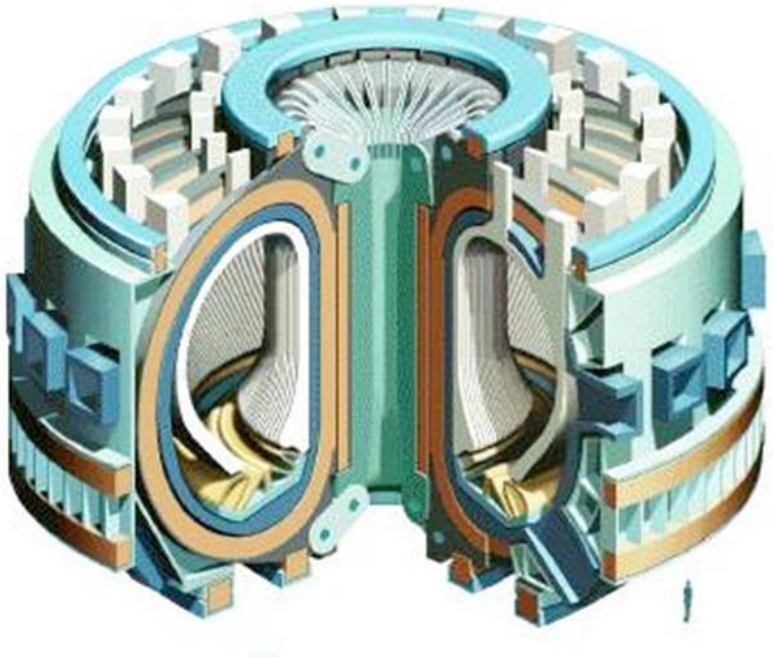
Big Data and Big Compute

- Analyzing Big Data requires processing (e.g., search, transform, analyze, …)
- Extreme scale computing will enable timely and more complex processing of increasingly large Big Data sets

FY2017 Issues and Priorities

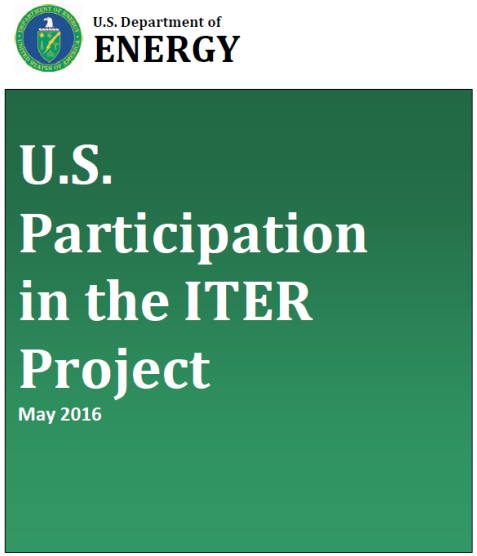
- BALANCE - Research funding vs scientific user facilities construction vs operation
  - BESAC study of 5 proposed user facility upgrades
- BALANCE - Discovery research vs science for clean energy and departmental crosscuts
- Exascale Computing Project! National Strategic Computing Initiative
- **International partnerships in Big Science**
  - **ITER**
  - **LHC CMS, ATLAS upgrades at the same time as LBNF/DUNE**

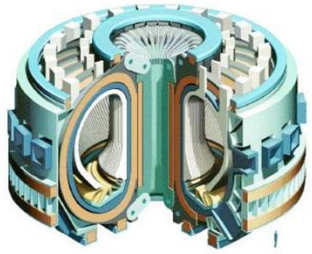
ITER Congressional Report



"…not later than May 2, 2016, the Secretary of Energy shall submit to the Committees on Appropriations of both Houses of Congress a report recommending either that the United States remain a partner in the ITER project after October 2017 or terminate participation, which shall include, as applicable, an estimate of either the full cost, by fiscal year, of all future Federal funding requirements for construction, operation, and maintenance of ITER or the cost of termination."

ITER Congressional Report

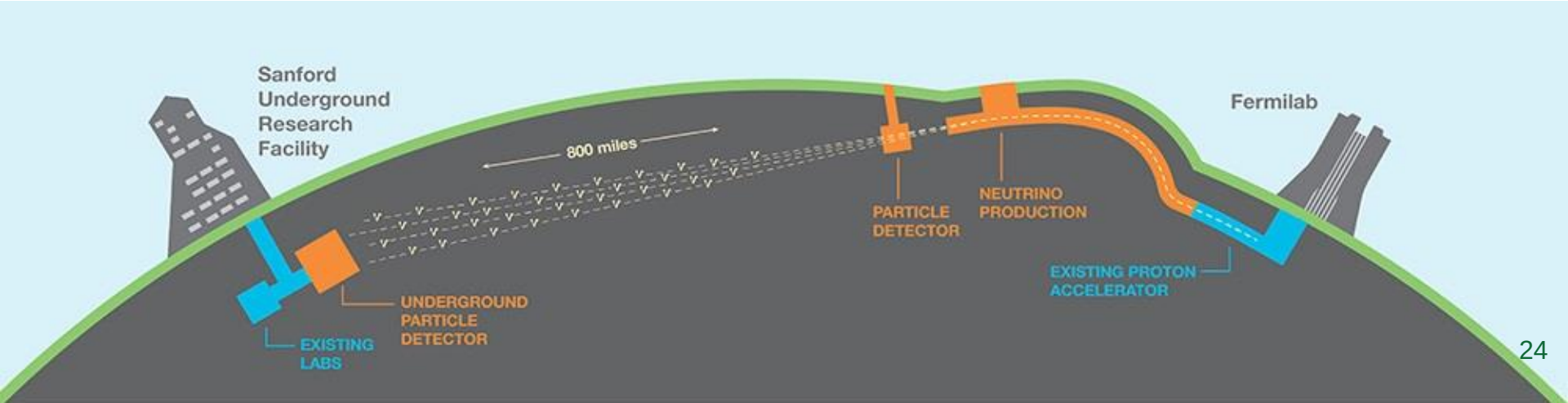




- The U.S. should remain an ITER partner through the end of calendar year 2017 (through FY18) and focus on efforts related to first plasma.
- In late calendar year 2017, the U.S. will reevaluate participation based on assessment of the performance of the ITER project management against the project schedule and milestones listed in the report.
- Under DG Bigot, there have substantial improvements to the ITER project performance and the project culture in the ITER organization.
- Significant technical, management, and funding risks that remain.
- DOE will baseline the U.S. ITER Project (the in-kind contribution to the IO) to FP in FY 2017.
- DOE will request a National Academies study on how to best advance the fusion energy sciences in the U.S., with scenarios if the U.S. is in or out of ITER.

Long Baseline Neutrino Facility

- **P5 recommended LBNF as the centerpiece of a U.S.-hosted world-leading neutrino program**
  - P5 recognized LBNF as the highest-priority large project in its timeframe
- **The world's most intense neutrino beam will be produced at Fermilab and directed 800 miles through the earth to Lead, South Dakota**
  - Fermilab will lead this effort with a few international partners, most notably CERN
- **A very large (40 kiloton) liquid argon neutrino detector will be placed in the Homestake Mine in Lead, SD**
  - An international collaboration has been established for the Deep Underground Neutrino Experiment (DUNE)
  - The U.S. will contribute to the detector as part of the LBNF project

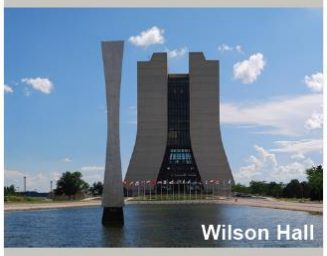


Office of Science Laboratories Total FY15 $5.5B, SC funding $3.4B

Berkeley, California
202 acres and 90 buildings
3,232 FTEs
950 students & postdocs
9,484 facility users
www.lbl.gov

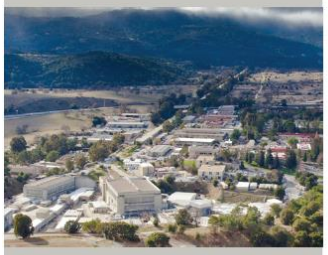
Richland, Washington
346 acres and 20 buildings
4,308 FTEs
628 students & postdocs
2,022 facility users
www.pnnl.gov

Ames, Iowa
8 acres and 12 buildings
310 FTEs
162 students & postdocs
www.ameslab.gov



Batavia, Illinois
6,800 acres and 366 buildings
1,760 FTEs
46 students & postdocs
2,340 facility users
www.fnal.gov

Argonne, Illinois
1,517 acres and 100 buildings
3,412 FTEs
620 students & postdocs
7,396 facility users
www.anl.gov



Menlo Park, California
426 acres and 147 buildings
1,422 FTEs
230 students & postdocs
2,913 facility users
www.slac.stanford.edu

Oak Ridge, Tennessee
4,421 acres and 195 buildings
4,525 FTEs
1,429 students & postdocs
2,987 facility users
www.ornl.gov

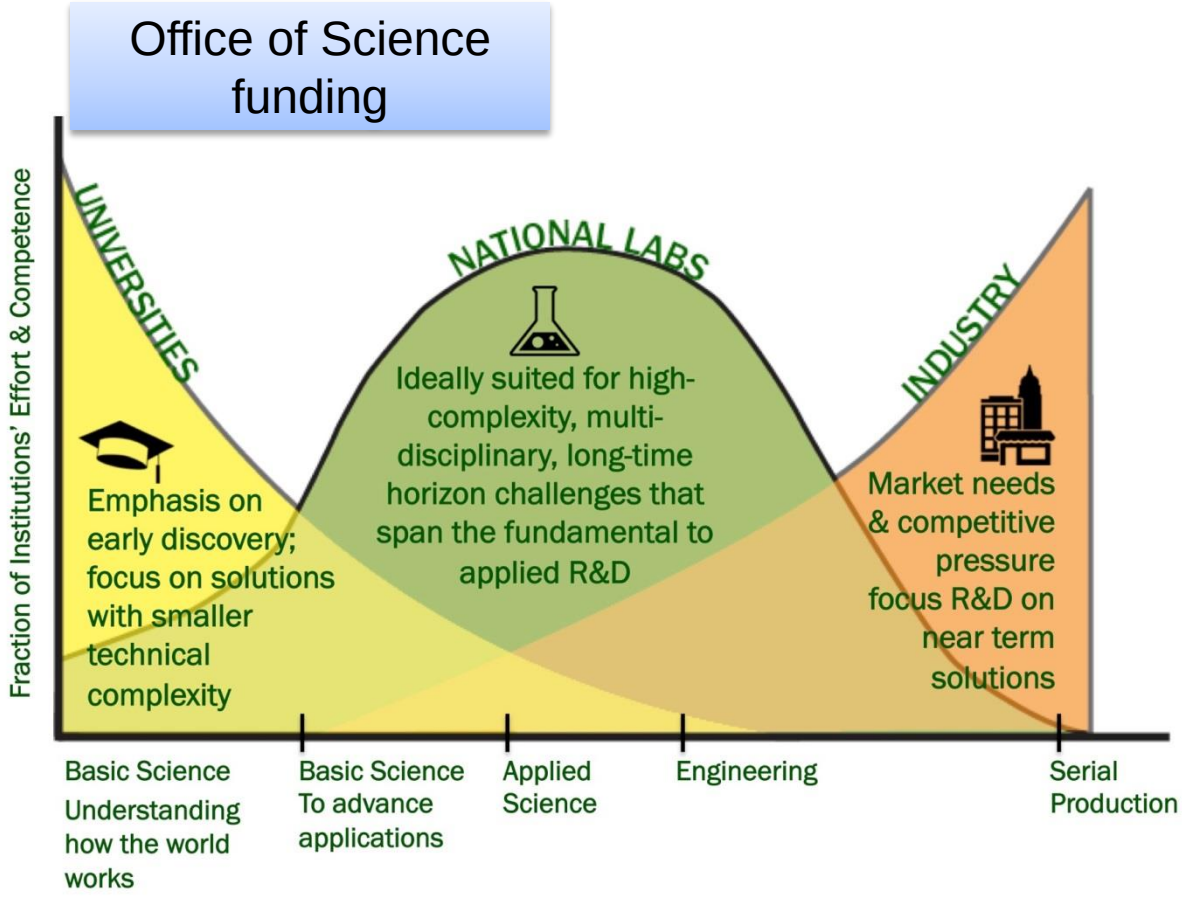
Newport News, Virginia
169 acres and 72 buildings
673 FTEs
62 students & postdocs
1,380 facility users
www.jlab.org

Princeton, New Jersey
91 acres and 32 buildings
431 FTEs
59 students & postdocs
290 facility users
www.pppl.gov

Upton, New York
5,322 acres and 319 buildings
2,788 FTEs
557 students & postdocs
4,090 facility users
www.bnl.gov

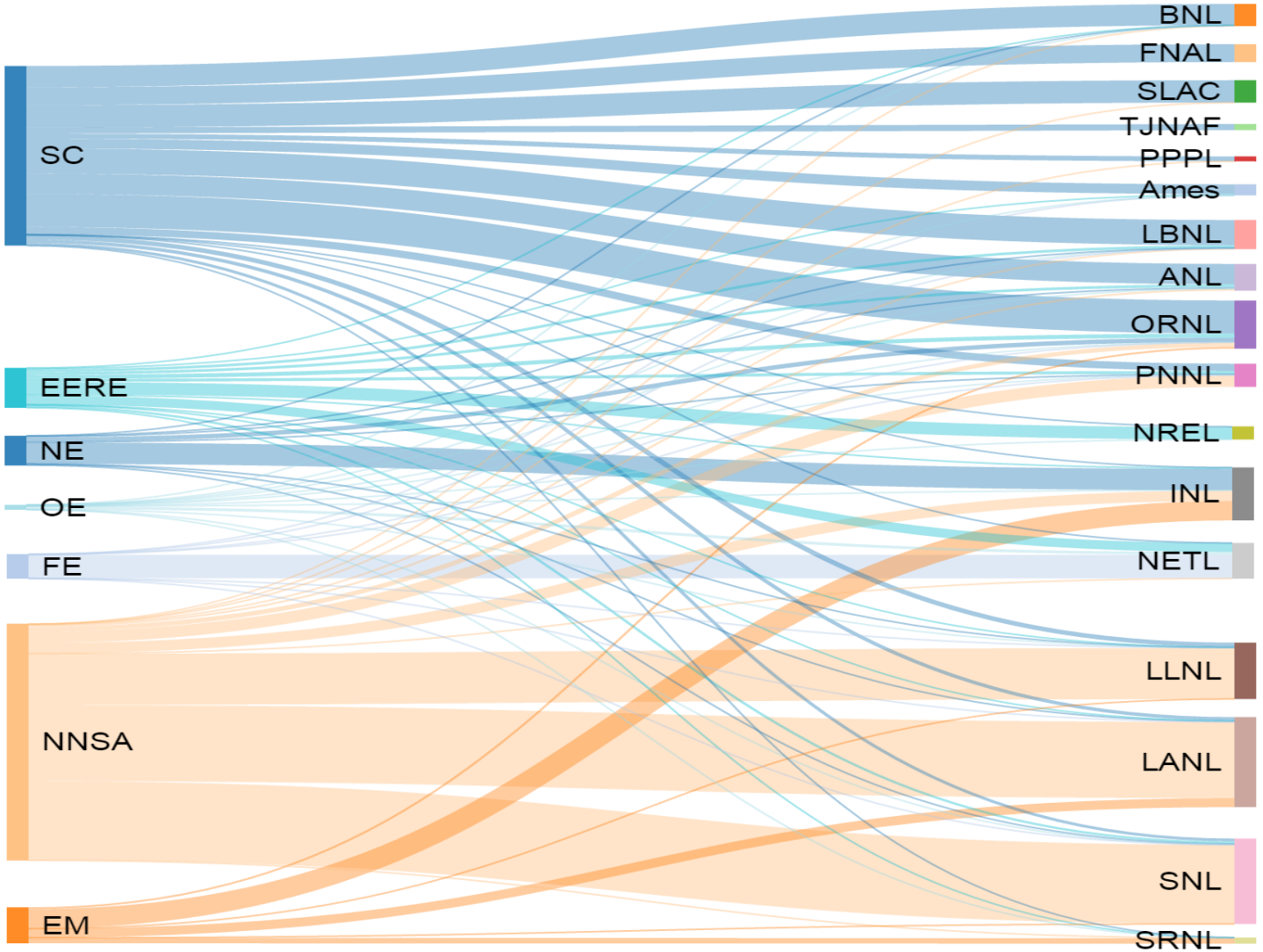
National Labs Address Multidisciplinary S&T Challenges

Most of the national labs have broader scope than Office of Science



National Laboratory Directors Council

Flow of Funds between DOE Programs to Labs, 2015



National Lab Management

- **Streamlined Contracts and partnership in FFRDCs (response to CRENEL, etc.)**
  - **“Evolutionary Working Group” – will be incorporated at FNAL**
  - **“Revolutionary Working Group” – in concurrence process at HQ**
- **Science and Energy Programs integrated Lab strategy reviews**