U.S. DEPARTMENT OF ENERGY | Office of Science

FY 2017 Budget Request to Congress for DOE's Office of Science

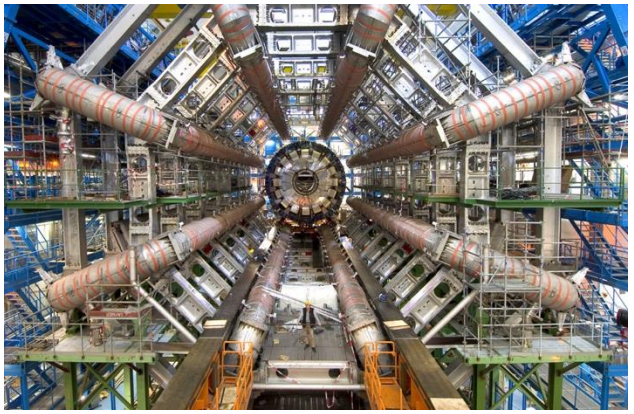
HEPAP Meeting, March 31, 2016

Cherry A. Murray
Director, Office of Science
www.science.energy.gov

Department of Energy Mission Areas

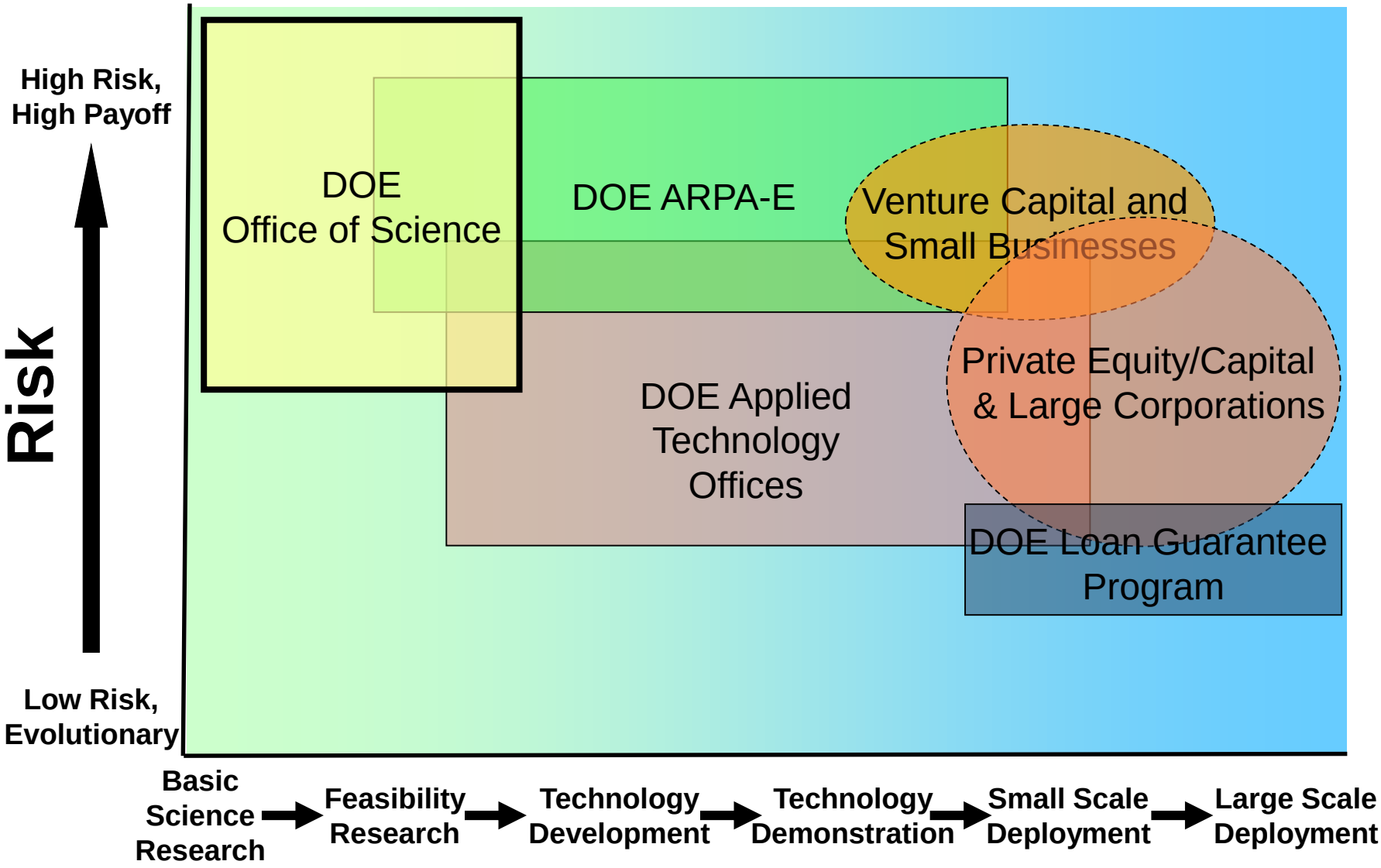
Energy

Science

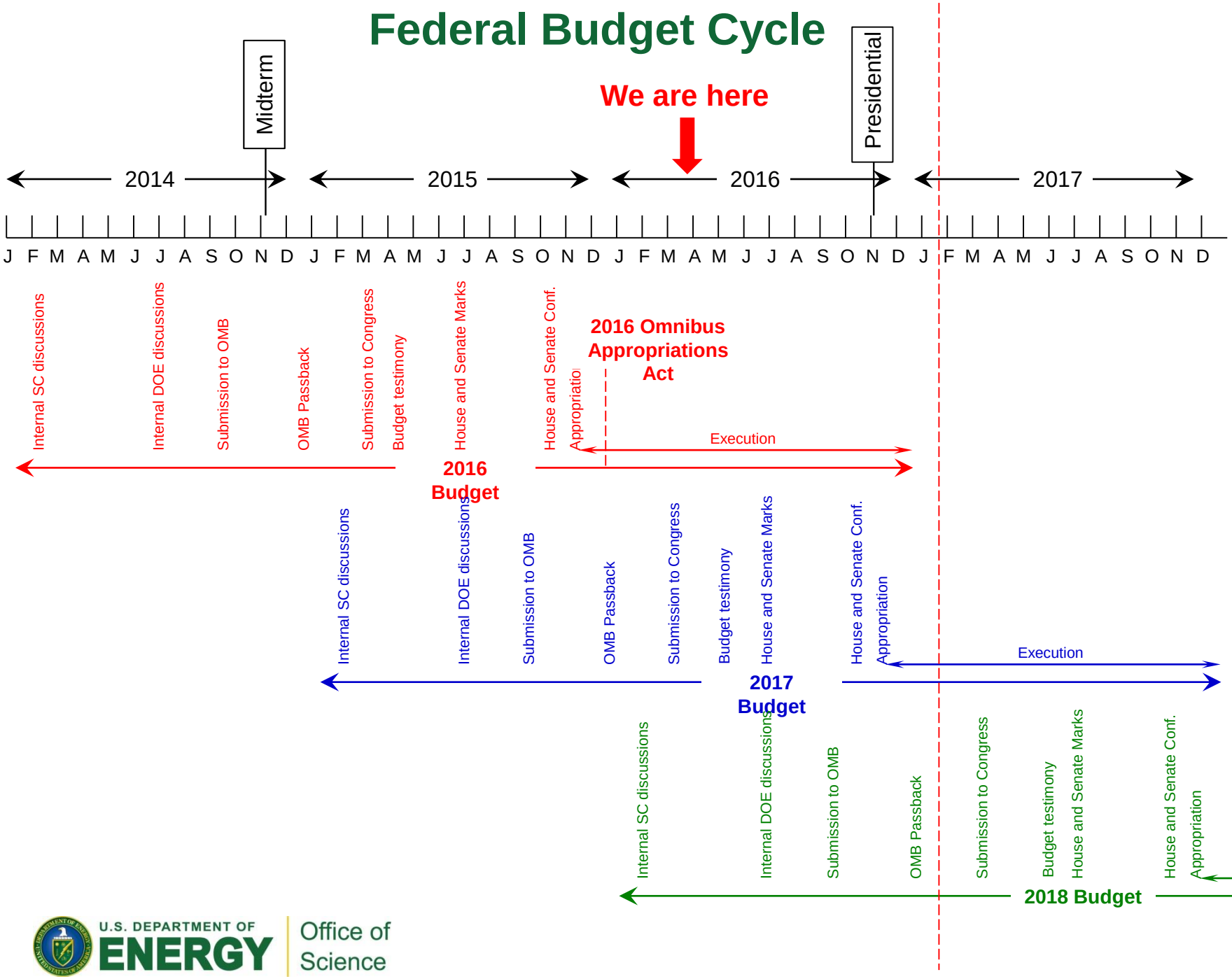


Nuclear Safety and Security

Environmental Cleanup


High Risk,
High Payoff
Risk
Low Risk,
Evolutionary
DOE
Office of Science
DOE ARPA-E
Venture Capital and
Small Businesses
Private Equity/Capital
& Large Corporations
DOE Applied
Technology
Offices
DOE Loan Guarantee
Program
Basic
Science
Research
Feasibility
Research
Technology
Development
Technology
Demonstration
Small Scale
Deployment
Large Scale
Deployment
Technology Readiness Level

Federal Budget Cycle



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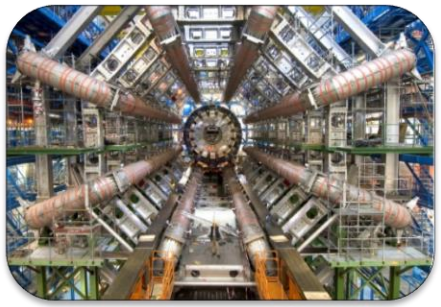
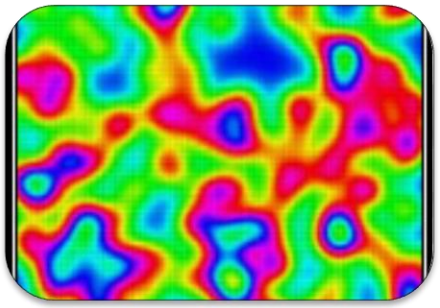
Office of Science FY16 - $5.35B

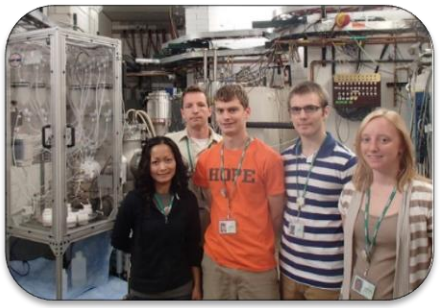


Largest Supporter of Physical Sciences in the U.S.



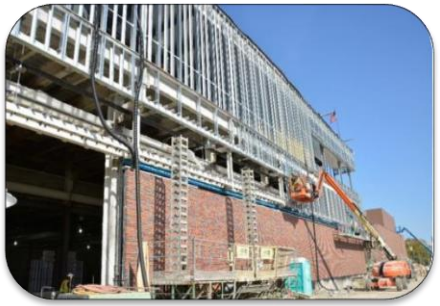
Research: 42%, $2.2B

~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

>30,000 Scientific Facility Users

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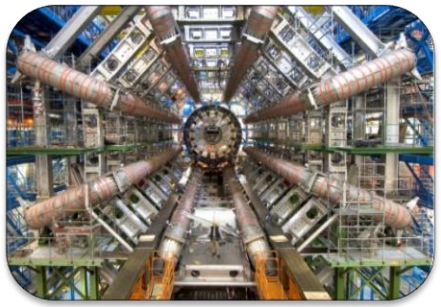
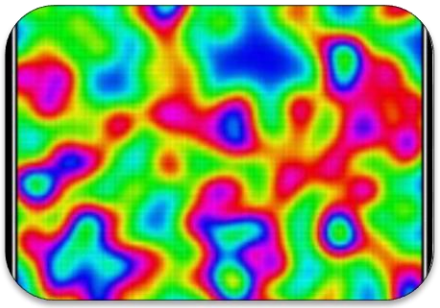
Office of Science FY17 Request: $5.67B, +6.1%

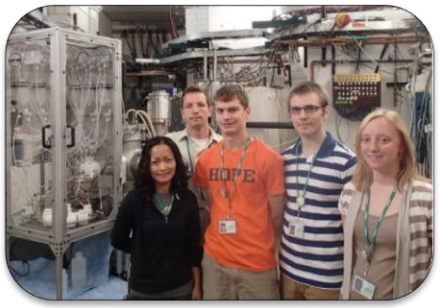


Largest Supporter of Physical Sciences in the U.S.



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

>30,000 Scientific Facility Users

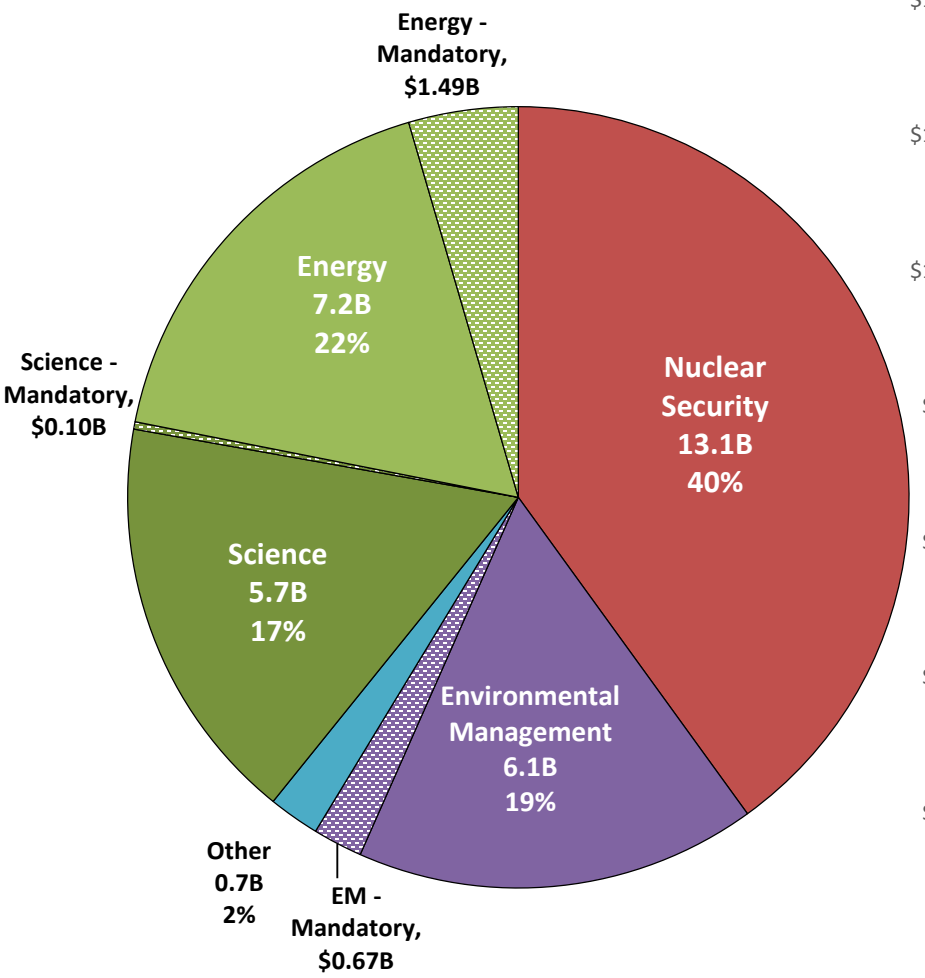
$1.8B Mission Innovation

Office of Science FY 2017 Budget Request to Congress

(Dollars in thousands)

	FY 2015 Enacted Approp.	FY 2015 Current Approp.	FY 2016 Enacted Approp.	FY 2017 President's Request	FY 2017 President's Req. vs. FY 2016 Enacted Approp.	
Science						
Advanced Scientific Computing Research	541,000	523,411	621,000	663,180	+42,180	+6.8%
Basic Energy Sciences	1,733,200	1,682,924	1,849,000	1,936,730	+87,730	+4.7%
Biological and Environmental Research	592,000	572,618	609,000	661,920	+52,920	+8.7%
Fusion Energy Sciences	467,500	457,366	438,000	398,178	-39,822	-9.1%
High Energy Physics	766,000	745,232	795,000	817,997	+22,997	+2.9%
Nuclear Physics	595,500	580,744	617,100	635,658	+18,558	+3.0%
Workforce Development for Teachers and Scientists	19,500	19,500	19,500	20,925	+1,425	+7.3%
Science Laboratories Infrastructure	79,600	79,600	113,600	130,000	+16,400	+14.4%
Safeguards and Security	93,000	93,000	103,000	103,000	.....	.....
Program Direction	183,700	183,700	185,000	204,481	+19,481	+10.5%
University Grants (Mandatory)	.....	.....	.....	100,000	+100,000	.....
Small Business Innovation/Technology Transfer Research (SC)	.....	132,905	.....	.....	.....	.....
Subtotal, Science	5,071,000	5,071,000	5,350,200	5,672,069	+321,869	+6.0%
Small Business Innovation/Technology Transfer Research (DOE)	.....	65,075	.....	.....	.....	.....
Rescission of Prior Year Balance	-3,262	-3,262	-3,200	.....	+3,200	-100.0%
Total, Science	**5,067,738**	**5,132,813**	**5,347,000**	**5,672,069**	**+325,069**	**+6.1%**

President's DOE FY 2017 Proposed Budget



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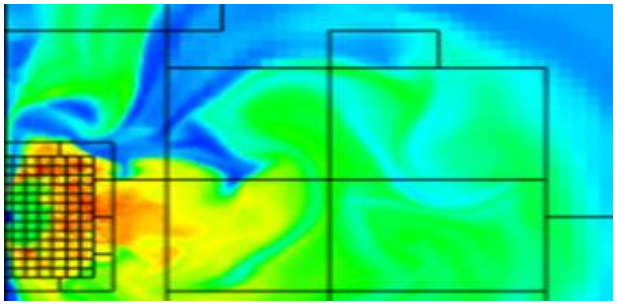
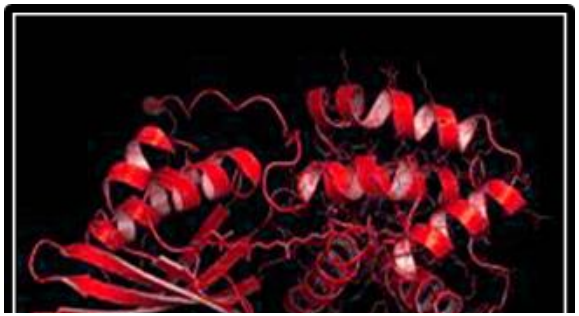
Office of Science Programs



Advanced Scientific Computing Research

FY2016 $621M

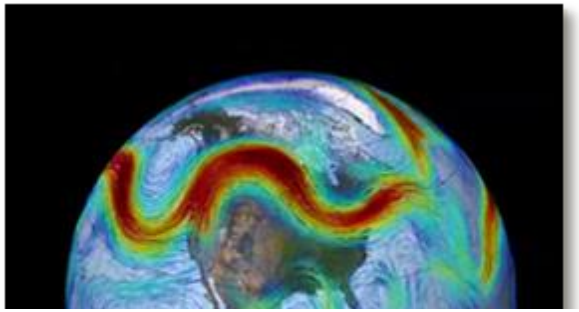
FY2017 Request +6.8%



Basic Energy Sciences

FY2016 $1849M

FY2017 Request +4.7%



Biological and Environmental Research

FY2016 $609M

FY2017 Request +8.7%

High Energy Physics

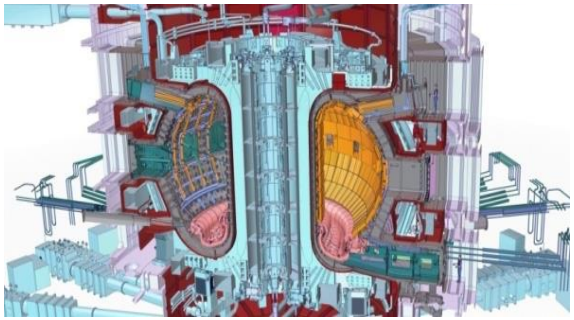
FY2016 $795M

FY2017 Request +2.9%

Fusion Energy Sciences

FY2016 $438M

FY2017 Request -9.1%



Nuclear Physics

FY2016 $617M

FY2017 Request +3.0%

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SC Increases Academic Research by $100M (Mandatory) in FY 2017

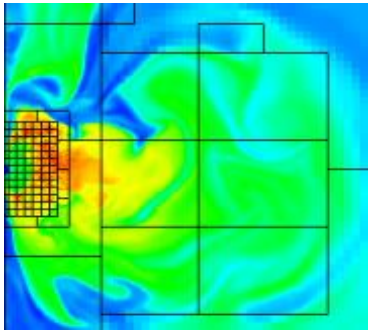
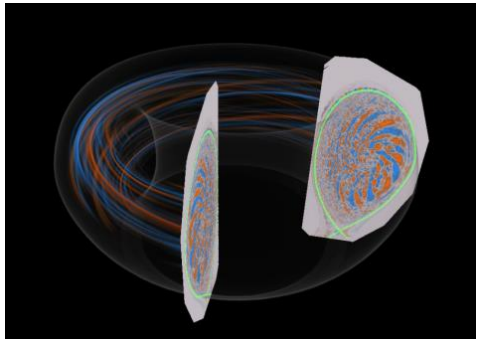
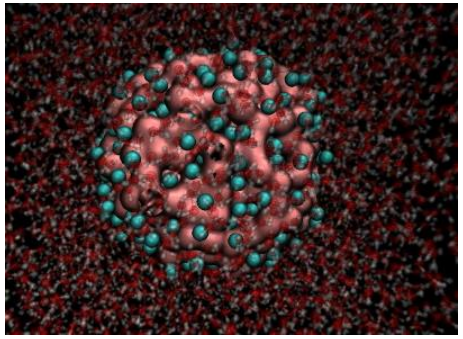
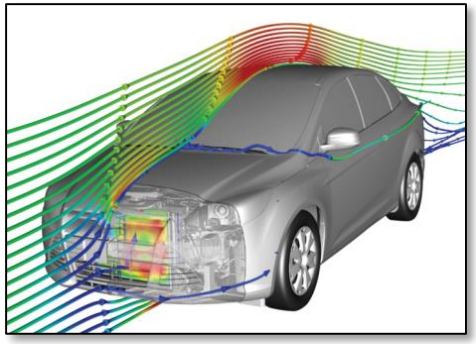
Investments are made in all of the SC programs, emphasizing emerging research areas, especially those recently identified by Federal Advisory Committees or other community activities. A few examples are:

- **ASCR**: Applications software, applied mathematics, and computer science for capable exascale computing; mathematics for large-scale scientific data; neuromorphic computing architectures and information processing for extreme and self-reconfigurable computing architectures
- **BES**: Topics described in the 2015 BESAC Report *Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science*, including hierarchical architectures, non-equilibrium matter, non-ideal systems, coherence in light and matter, modeling & computation, and imaging across multiple scales.
- **BER**: New platform microbes for biofuels and bioproducts engineering; biofuel crop modeling for incorporation into a predictive framework.
- **FES**: Plasma/fusion research centers emphasizing the results of the 2015 community workshops, including for example low-temperature plasmas, plasma measurements, and verification & validation for magnetic fusion.
- **HEP**: Topics described in the 2014 HEPAP Long Range Plan and also topics that span multiple SC programs, including quantum information sciences/the entanglement frontier and quantum field theory across disciplines.
- **NP**: Topics described in the 2015 NSAC Long Range Plan, including research to accelerate discovery at FRIB, fundamental nuclear structure and nuclear astrophysics, fundamental symmetries, and super-heavy elements.

Advanced Scientific Computing Research

Computational and networking capabilities to extend the frontiers of science and technology

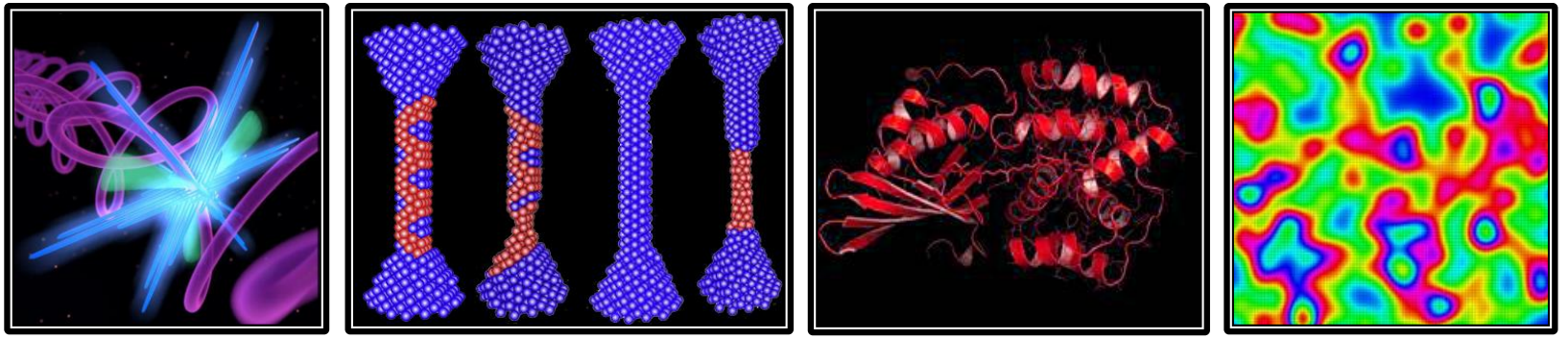
- **Exascale Computing Initiative (ECI) and Exascale Computing Project (ECP).** The ECP is initiated as a joint ASCR/NNSA partnership using DOE's formal project management processes. A new budget line is created for the ECP.
- **Facilities** operate optimally and with >90% availability; deployment of 10-40 petaflop upgrade at NERSC and site preparations for NERSC-9; upgrade of high traffic links on Esnet; and continued preparations for 180-200 petaflop upgrades at ALCF and OLCF.
- **SciDAC partnerships** will be recompeted in FY 2017 with new activities to include accelerating the development of clean energy technologies.
- **Applied Mathematics research** addresses challenges of increasing complexity and **Computer Science research** addresses exploration of "beyond Moore's law" architectures and supports data management, analysis, and visualization techniques.
- The **Computational Sciences Graduate Fellowship** is funded at $10,000K.

Basic Energy Sciences

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

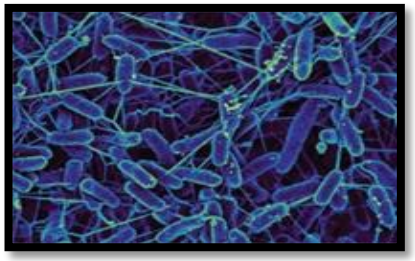
- Increased funding for **Energy Frontier Research Centers** (EFRCs) will fully fund up to five new awards in the area of subsurface science, with an emphasis on advanced imaging of geophysical and geochemical signals.
- A new activity in **Computational Chemical Sciences** will leverage U.S. leadership in computational chemistry community codes for petascale and in anticipation of exascale computing.
- Core research increases to advance the **Mission Innovation** agenda, targeting materials and chemistry for energy efficiency and for use in extreme environments.
- Both **Energy Innovation Hubs** continue. Joint Center for Energy Storage Research (JCESR) will be in its 5th year. Joint Center for Artificial Photosynthesis (JCAP) will be in its 3rd year of renewal.
- To maintain international competitiveness in discovery science, support continues for the **Linac Coherent Light Source-II (LCLS-II)** construction project and the **Advanced Photon Source Upgrade (APS-U)** major item of equipment project.
- BES **user facilities** operate at optimal levels.

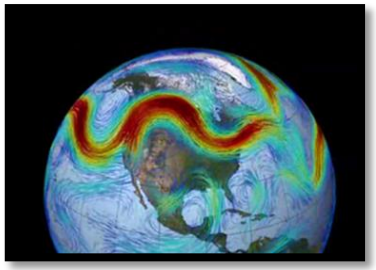


Biological and Environmental Research

Understanding complex biological, climatic, and environmental systems

- **Genomic sciences** supports the Bioenergy Research Centers, new microbiome research, and increases efforts in biosystems design for bioenergy and renewable bioproducts.
- **Mesoscale-to-molecules** research supports the development of enabling technology to visualize key metabolic processes in plant and microbial cells at the subcellular and mesoscale.
- **Climate and Earth System Modeling** supports development of physical, chemical, and biological model components to simulate climate variability and change at regional and global scales.
- **Atmospheric System Research (ASR)** addresses major uncertainties in climate change models: the role of clouds and the effects of aerosols on precipitation, and the atmospheric radiation balance.
- **Environmental System Science** supports research to provide a robust, predictive understanding of terrestrial surface and subsurface ecosystems. Includes Next Generation Ecosystem Experiments targeting climatically sensitive terrestrial ecosystems not well represented in models.
- **Climate and Environmental Data Analysis and Visualization** employs server side analysis to simplify analysis of large scale observations with model-generated data.
- **User facilities operate at optimal levels: ARM** continues measurements at fixed sites, and mobile facilities deploy to the Arctic, Antarctic, and the Atlantic Ocean. **JGI** provides genome sequence data, synthesis, and analysis. **EMSL** continues novel research using the High Resolution and Mass Accuracy Capability.

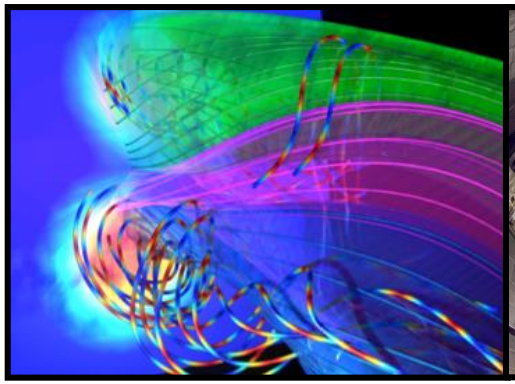





Fusion Energy Sciences

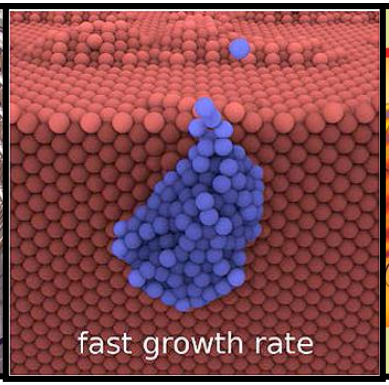
Matter at very high temperatures and densities and the scientific foundations for fusion

- Research is supported for the DIII-D and NSTX-U national programs.
- NSTX-U operates for 16 weeks; DIII-D operates for 14 weeks; Alcator C-Mod ceases operation as scheduled and MIT scientists collaborate full-time on domestic and international facilities.
- Support continues for U.S. research involvement on international machines EAST (China), KSTAR (Korea), and W7-X (Germany).
- HEDLP research is focused on the MEC instrument at LCLS.
- General plasma science activities continue, including the partnership with NSF for discovery-driven plasma science and engineering research.
- U.S. contributions to ITER support US ITER Project Office; the US direct contribution; and progress on hardware contributions, including fabrication of the central solenoid magnet modules and structures and the toroidal field magnet conductor.

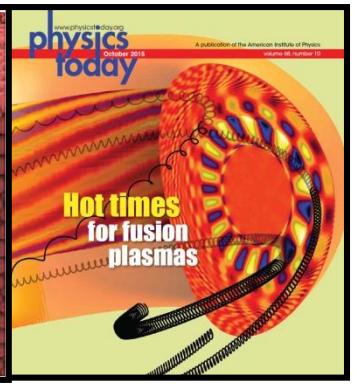


Magnetic reconnection driven by 3-D flux-rope interaction in the Large Plasma Device

New central solenoid magnet inside NSTX-Upgrade



Growth of helium bubbles that degrade tungsten performance

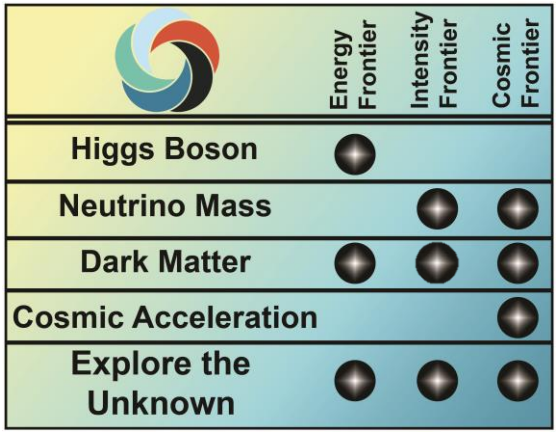


Gyrokinetic simulation of energetic ions in tokamak plasma

High Energy Physics

Understanding how the universe works at its most fundamental level

- Particle Physics Project Prioritization Panel (**P5**) report in May 2014 presents an actionable long-term strategy for U.S. particle physics that enables discovery and maintains the U.S. position as a global leader in particle physics.
  - **Five intertwined science drivers**, compelling lines of inquiry that show great promise for discovery:
    - Use the ***Higgs boson*** as a new tool for discovery
    - Pursue the physics associated with ***neutrino mass***
    - Identify the new physics of ***dark matter***
    - Understand ***cosmic acceleration***: dark energy and inflation
    - ***Explore the unknown***: new particles, interactions, and physical principles



  - Science drivers identify the scientific motivation while the ***Energy, Intensity, and Cosmic Research Frontiers*** provide a useful categorization of experimental techniques

http://science.energy.gov/~/media/hep/hepap/pdf/May-2014/FINAL_P5_Report_053014.pdf

High Energy Physics

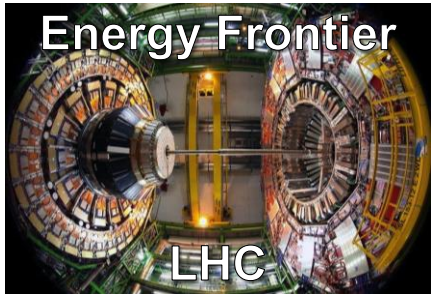
Understanding how the universe works at its most fundamental level

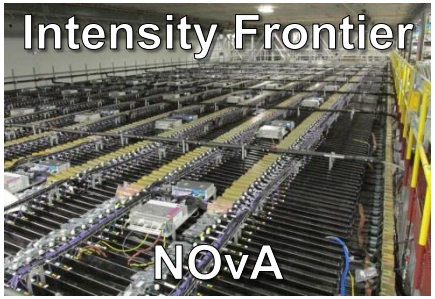
- The FY 2017 HEP budget reflects the way the P5 plan has evolved as the U.S. and international community have adopted and responded to it

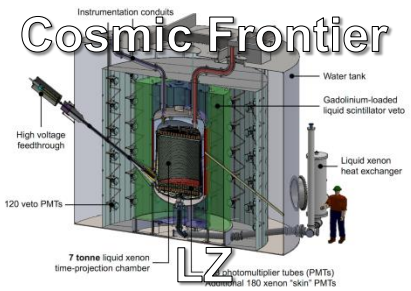
- **Energy Frontier:** Continue active engagement in highly successful LHC program
  - Initial LHC detector upgrade project funding ends in FY 2017
  - Scope being determined for high luminosity(HL)- LHC, P5's highest priority near-term project; CD-0 in 2016
  - The U.S. will continue to play a leadership role in LHC discoveries by remaining actively engaged in LHC data analysis of world's highest energy particle collider data, at 13 TeV

- **Intensity Frontier:** Solidify international partnerships for U.S.-hosted LBNF/DUNE
  - Rapid progress on LBNF/DUNE has attracted attention from interested international partners, and FY 2017 investments in site preparation and cavern excavation aim to solidify formal agreements
  - Fermilab will continue improvements to accelerator complex while serving high-intensity neutrino beams to short-and long-baseline experiments enabling full utilization of the FNAL facilities

- **Cosmic Frontier:** Advance our understanding of dark matter and dark energy
  - Fabrication funding ramp up in FY 17 supports key P5 recommended Cosmic Frontier projects to study dark matter and dark energy: LSSTcam, DESI, SuperCDMS-SNOLab, and LZ





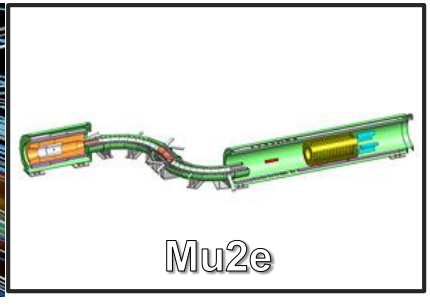


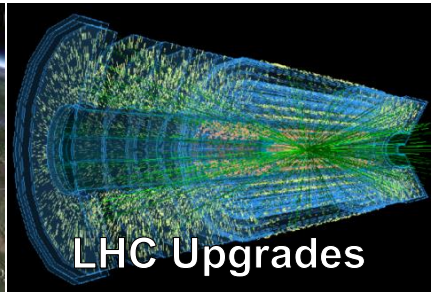
	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●

High Energy Physics

The technology and construction needed to pursue to physics

- Construction & project support increases to implement the P5 strategy:
  - LBNF/DUNE aims to solidify partnerships with FY 2017 investments in site preparation and excavation of caverns for the neutrino detectors and cryogenic infrastructure
  - LHC ATLAS and CMS Detector Upgrade projects continue fabrication; HL-LHC upgrades begin
  - Muon g-2 completes project funding profile and will begin receiving beam at Fermilab
  - Dark energy: LSSTcam and DESI fabrication support increase according to planned profiles
  - Dark matter: LZ will continue fabrication as SuperCDMS-SNOLab proceeds to final design
  - Construction continues for the Muon to Electron Conversion Experiment (Mu2e)
  - FACET-II support begins, in order to create a new facility that will enable accelerator R&D aimed at dramatically improved capability and cost-effectiveness in future high-energy colliders
- Accelerator Stewardship
  - AS works to make particle accelerator technology widely available to science and industry by supporting use-inspired basic research in accelerator science and technology
  - FY17 Request supports research activities at laboratories, universities, and in industry for technology R&D areas such as laser, ion-beam therapy, and accelerator technology for energy and environmental applications
  - FY17 Request supports Brookhaven Accelerator Test Facility (ATF) operations and the continuation of the Accelerator Stewardship Test Facility Pilot Program





HEP FY 2017 Budget Request to Congress

(Dollars in thousands)

	FY 2015 Enacted Approp.	FY 2015 Current Approp.	FY 2016 Enacted Approp.	FY 2017 President's Request	FY 2017 President's Req. vs. FY 2016 Enacted Approp.	
Energy Frontier Experimental Physics						
Research	78,782	84,387	77,270	76,811	-459	-0.6%
Facility Operations and Experimental Support	53,802	53,670	54,453	55,220	+767	+1.4%
LHC CMS Detector Upgrades (MIE)	7,500	5,162	9,500	7,967	-1,533	-16.1%
LHC ATLAS Detector Upgrades (MIE)	7,500	2,821	9,500	8,500	-1,000	-10.5%
ATLAS HI-Lum Upgrades (MIE)	…	…	…	1,250	+1,250	…
CMS HI-Lum Upgrades (MIE)	…	…	…	1,250	+1,250	…
Total, Energy Frontier Experimental Physics	**147,584**	**146,040**	**150,723**	**150,998**	**+275**	**+0.2%**
Intensity Frontier Experimental Physics						
Research	55,181	54,122	56,104	56,509	+405	+0.7%
Facility Operations and Experimental Support	165,073	158,658	151,317	153,066	+1,749	+1.2%
Belle-II (MIE)	970	970	…	…	…	…
Muon g-2 Experiment (MIE)	13,000	13,000	10,200	6,349	-3,851	-37.8%
Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment (Line Item OPC)	10,000	10,000	…	…	…	…
Proton Improvement Plan II (Line Item OPC)	…	…	18,015	15,220	-2,795	-15.5%
Future Project R&D	20,000	23,000	7,485	3,000	-4,485	-59.9%
Total, Intensity Frontier Experimental Physics	**264,224**	**259,750**	**243,121**	**234,144**	**-8,977**	**-3.7%**
Cosmic Frontier Experimental Physics						
Research	49,310	48,777	49,910	49,934	+24	+0.0%
Facility Operations and Experimental Support	11,832	11,327	13,837	9,935	-3,902	-28.2%
Large Synoptic Survey Telescope Camera (LSSTcam) (MIE)	35,000	35,000	40,800	45,000	+4,200	+10.3%
LUX-ZEPLIN (LZ) (MIE)	2,800	3,050	10,500	10,500	…	…
SuperCDMS-SNOLab (MIE)	2,000	2,250	3,000	4,000	+1,000	+33.3%
Dark Energy Spectroscopic Instrument (DESI) (MIE)	3,603	3,878	10,300	10,000	-300	-2.9%
Other Projects	2,225	1,025	2,035	…	-2,035	-100.0%
Future Project R&D	100	1,200	200	700	+500	+250.0%
Total, Cosmic Frontier Experimental Physics	**106,870**	**106,507**	**130,582**	**130,069**	**-513**	-0.4%

HEP FY 2017 Budget Request to Congress

(Dollars in thousands)

	FY 2015 Enacted Approp.	FY 2015 Current Approp.	FY 2016 Enacted Approp.	FY 2017 President's Request	FY 2017 President's Req. vs. FY 2016 Enacted Approp.	
Theoretical and Computational Physics						
Research	58,274	60,848	57,083	57,656	+573	+1.0%
Projects (Other)	1,000	1,000	2,000	2,000	…	…
Total, Theoretical and Computational Physics	**59,274**	**61,848**	**59,083**	**59,656**	**+573**	**+1.0%**
Advanced Technology R&D						
Research	89,936	88,217	83,644	83,360	-284	-0.3%
Facility Operations and Experimental Support	30,318	35,870	29,750	26,925	-2,825	-9.5%
FACET II (MIE)	…	…	2,100	8,000	+5,900	+281.0%
Total, Advanced Technology R&D	**120,254**	**124,087**	**115,494**	**118,285**	**+2,791**	**+2.4%**
Accelerator Stewardship						
Research	5,900	4,891	3,378	6,853	+3,475	+102.9%
Facility Operations and Experimental Support	4,100	5,109	5,622	6,891	+1,269	+22.6%
Total, Accelerator Stewardship	**10,000**	**10,000**	**9,000**	**13,744**	**+4,744**	**+52.7%**
SBIR/STTR	**20,794**	**…**	**20,897**	**22,580**	**+1,683**	**+8.1%**
Subtotal, HEP	**729,000**	**708,232**	**728,900**	**729,476**	**+576**	**+0.1%**
Construction						
11-SC-40 Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment, FNAL	12,000	12,000	26,000	45,021	+19,021	+73.2%
11-SC-41 Muon to Electron Conversion Experiment, FNAL	25,000	25,000	40,100	43,500	+3,400	+8.5%
Total, Construction	**37,000**	**37,000**	**66,100**	**88,521**	**+22,421**	**+33.9%**
Total, High Energy Physics	**766,000**	**745,232**	**795,000**	**817,997**	**+22,997**	**+2.9%**

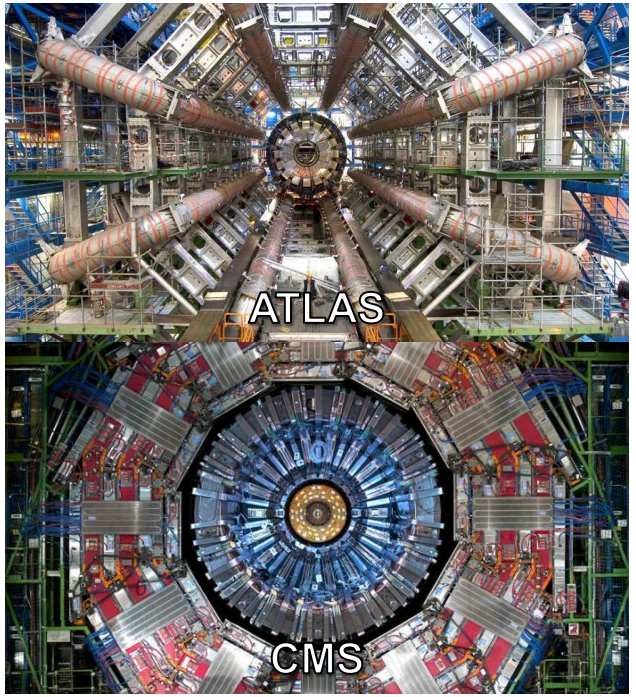
High Energy Physics

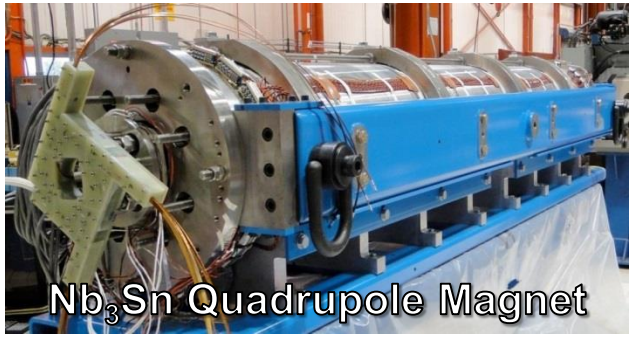
Understanding how the universe works at its most fundamental level

- **The P5 report recognized that <u>particle physics is a global field</u>**
  - "The scientific program required to address all of the most compelling questions of the field is beyond the finances and the technical expertise of any one nation or region.
  - … major players each host one of the large projects most needed by the worldwide scientific community and scientists use facilities in the U.S. and other regions to carry out the full scientific program "
  - International agreements are being developed to support this vision, most importantly the CERN agreements on LHC and neutrinos have been completed.

LHC: The Central Component of the Energy Frontier Program

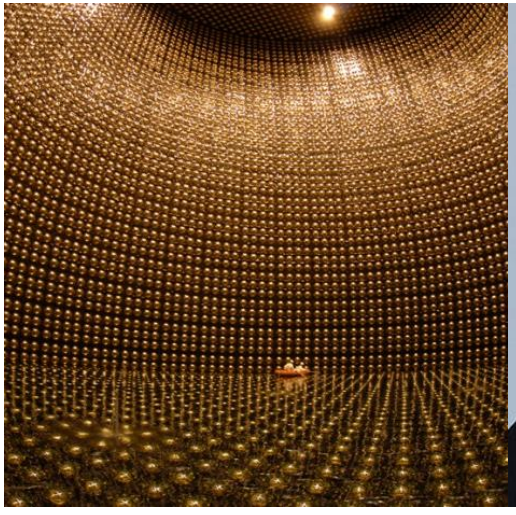
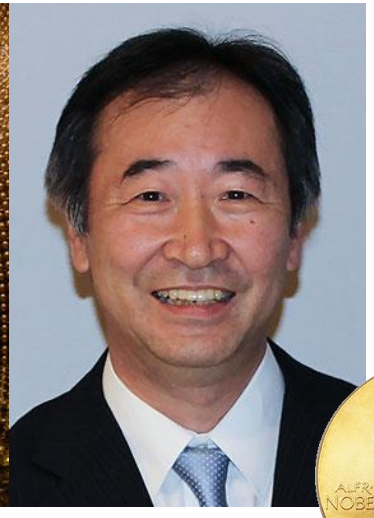
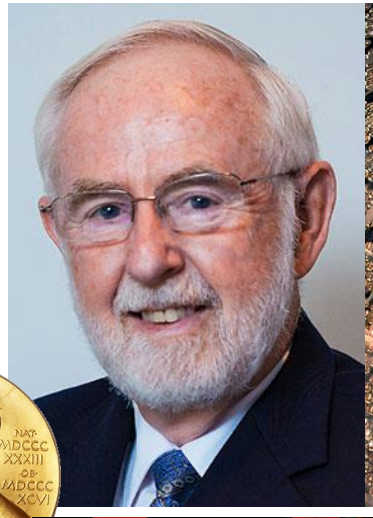
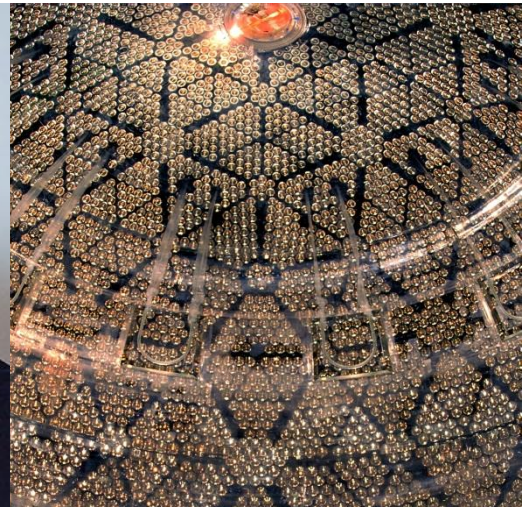
- U.S. investments enable leading roles in LHC collaborations
- P5 report **identified LHC upgrades as the highest priority near-term large project**
  - HL-LHC upgrades will extend discovery potential by increasing luminosity a factor of 10
- U.S. leadership in superconducting magnet technology in general, and with Nb_3Sn in particular, is essential to the success of the HL-LHC project
  - LHC Accelerator Research Program (LARP) uses this expertise to serve HEP community needs
- U.S. laboratories and institutions will develop and build major subsystems for the upgraded ATLAS and CMS detectors
  - Detector expertise and support provides foundation for continued U.S. leadership in HL-LHC scientific research program





Nobel and Breakthrough Prizes for Neutrino Physics

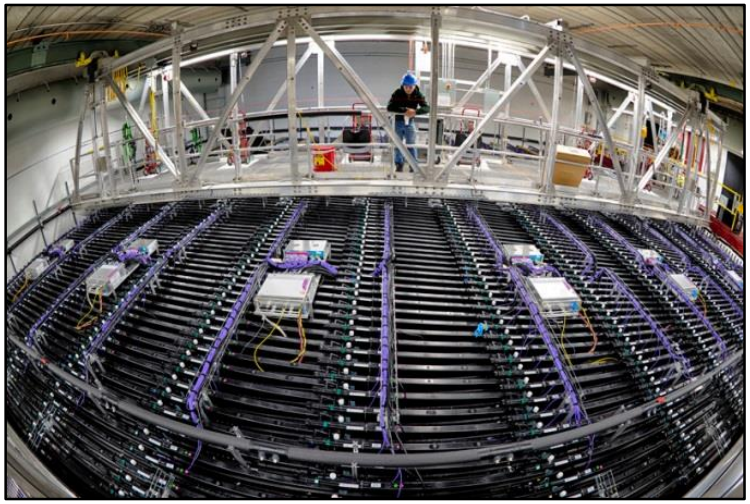
- The Nobel Prize in Physics for 2015 was awarded to T. Kajita and A.B. McDonald for the discovery of neutrino oscillations, which shows that neutrinos have mass
  - DOE Office of Science helped enable the discovery by providing substantial support to the construction, operation, and research efforts of Super-K and SNO


- The 2016 Breakthrough Prize in Fundamental Physics was awarded to five experiments investigating neutrino oscillations that all received support from DOE HEP
  - Daya Bay; KamLAND; K2K/T2K; SNO; Super-K

Short- and Long-baseline Neutrino Experiments at Fermilab

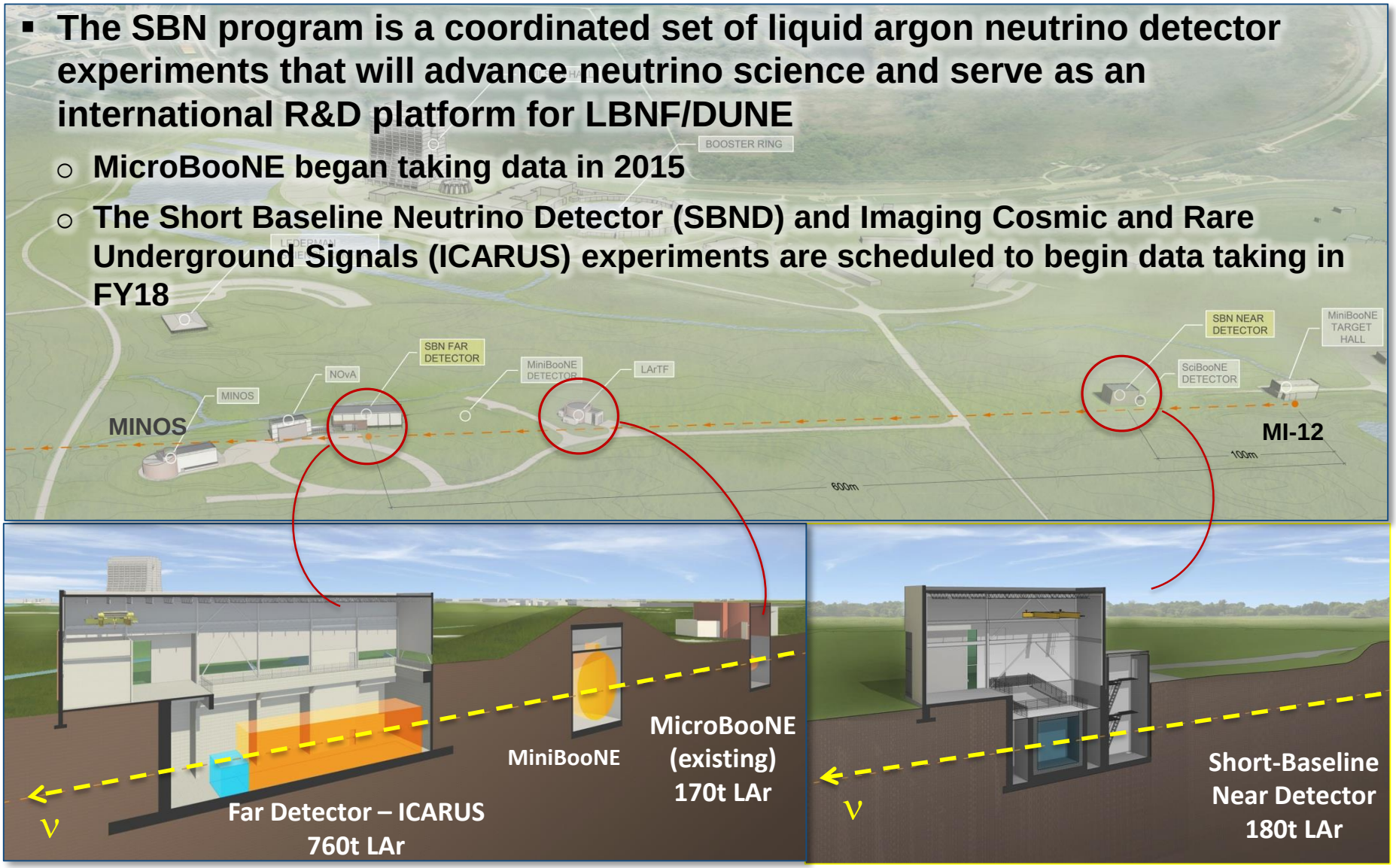
- NOvA is taking data using the world's most powerful neutrino beam and the world's longest baseline
  - World's highest intensity neutrino beam sent 500 miles from Fermilab to Ash River, MN
  - Currently operating as part of the planned six-year run
  - May switch to antineutrino mode in 2017 based on results from first 2 years of data



- The first experiment in the Fermilab Short Baseline Neutrino (SBN) program, MicroBooNE, began three year run in 2015
  - SBN program established in response to the P5
  - Will advance neutrino physics while serving as an international platform for R&D activities necessary to establish LBNF/DUNE

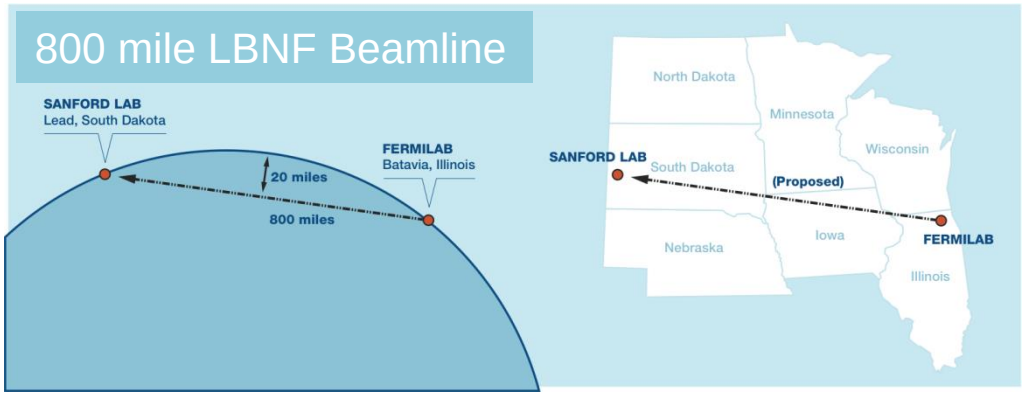
FNAL Short Baseline Neutrino Program

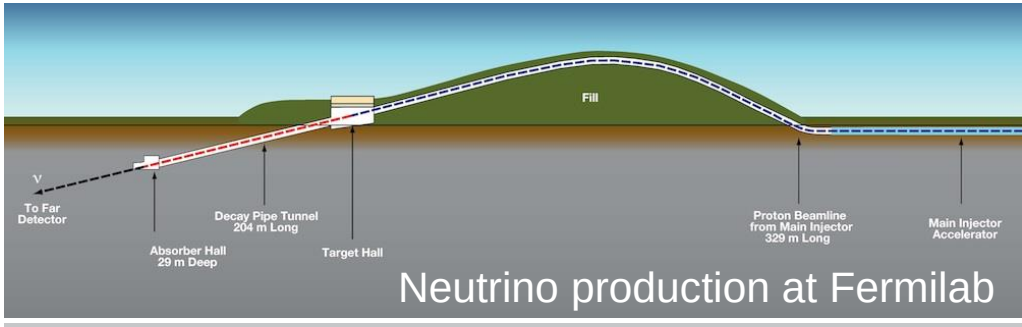
- **The SBN program is a coordinated set of liquid argon neutrino detector experiments that will advance neutrino science and serve as an international R&D platform for LBNF/DUNE**
  - **MicroBooNE began taking data in 2015**
  - **The Short Baseline Neutrino Detector (SBND) and Imaging Cosmic and Rare Underground Signals (ICARUS) experiments are scheduled to begin data taking in FY18**

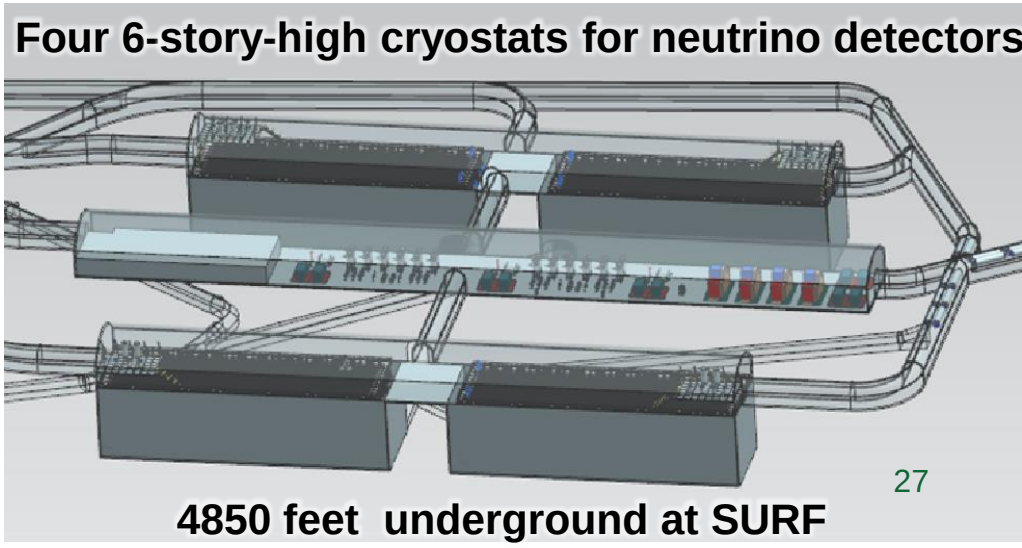


Long Baseline Neutrino Facility

- U.S.-hosted, world-class **Long Baseline Neutrino Facility identified by P5 as "the highest-priority large project in its timeframe."**
- Community, led by Fermilab, has made significant progress in past year:
  - Established international governance based on successful LHC model
  - Reformulated conceptual design based on P5 recommendations and input from established and potential international partners
- Current design features:
  - New neutrino beam at Fermilab with over 1 megawatt initial beam power
  - 800 mile distant large Liquid Argon Time Projection Chamber (LArTPC) detector deep underground at Homestake mine in Lead, SD

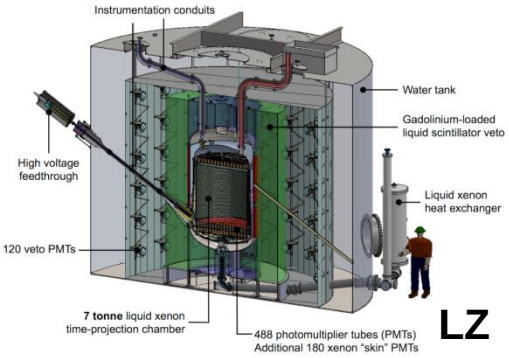




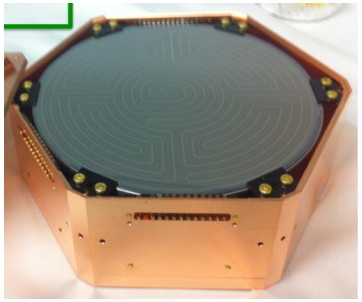


Investments in Dark Matter and Dark Energy

- P5 recommended **immediate investments in the second generation dark matter direct detection program**
  - LUX-Zeplin (LZ) and SuperCDMS–SNOLab will collectively provide sensitivity to both low- and high-mass WIMPs
    - Both had MIE in 2015, LZ will baseline in 2016, SuperCDMS will baseline in 2017
  - Small-scale ADMX-Gen2 supported to perform complementary search for axions
  - Program includes broad, coordinated R&D for future experiments



LZ


SuperCDMS-SNOLab

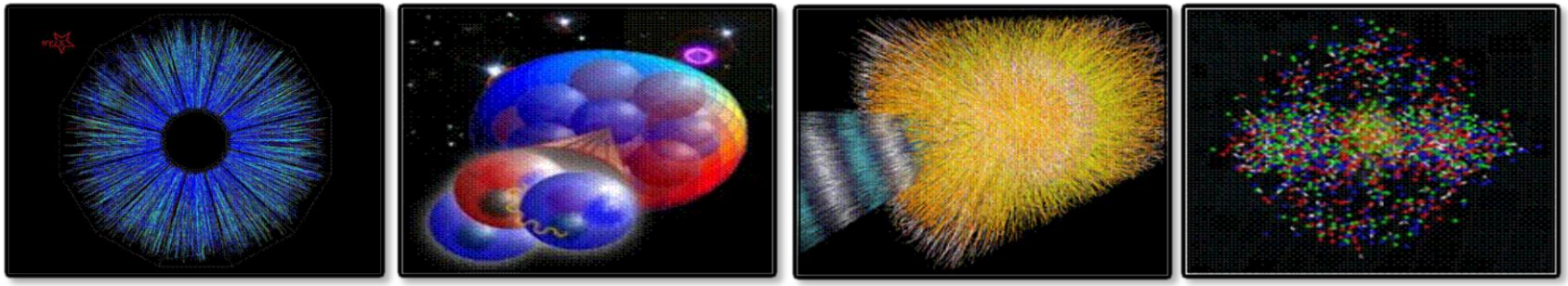
- P5 encouraged support for the Dark Energy Spectroscopic Instrument (DESI) as part of the dark energy program
  - DESI had MIE start and was baselined in 2015
  - Will provide spectroscopic complement to imaging-based LSST


DESI

Nuclear Physics

Discovering, exploring, and understanding all forms of nuclear matter

- Funding for **research** increases to advance activities across the program, including R&D to develop new approaches for isotopes not currently available in sufficient quantities.
- A **graduate traineeship** is initiated in radiochemistry and nuclear chemistry with an emphasis in isotope production ($1M).
- Operations at **RHIC** increase to explore the properties of the quark gluon plasma first discovered there and to enable studies of spin physics.
- The **12 GeV CEBAF Upgrade** is completed in FY 2017 and the scientific program is initiated promising new discoveries and an improved understanding of quark confinement.
- Construction continues on the **Facility for Rare Isotope Beams.** The **Gamma-Ray Energy Tracking Array (GRETA)** MIE is initiated to exploit the scientific potential of FRIB.
- Fabrication begins for a **Stable Isotope Production Facility (SIPF)** to produce enriched stable isotopes, a capability not available in the U.S. for almost 20 years.



FY2017 Issues and Priorities

- **BALANCE - Discovery research vs science for clean energy and departmental crosscuts**
- **BALANCE - Research funding vs scientific user facilities construction vs operation**
- **Exascale computing Project! National Strategic Computing Initiative**
- **International partnerships in Big Science**
  - **Defining moment in fusion sciences**
  - **LHC CMS, ATLAS upgrades at the same time as LBNF/DUNE**
- **Enhance communications with Congress and research universities**
- **Best practices in national lab management**

DOE Funding Modalities

Office of Science

ARPA-E*

Applied Programs

Goal: new knowledge / understanding
Focus: phenomena
Metric: knowledge generation

Goal: practical targets
Focus: performance
Metric: milestone achievement

Consortia, Crosscuts

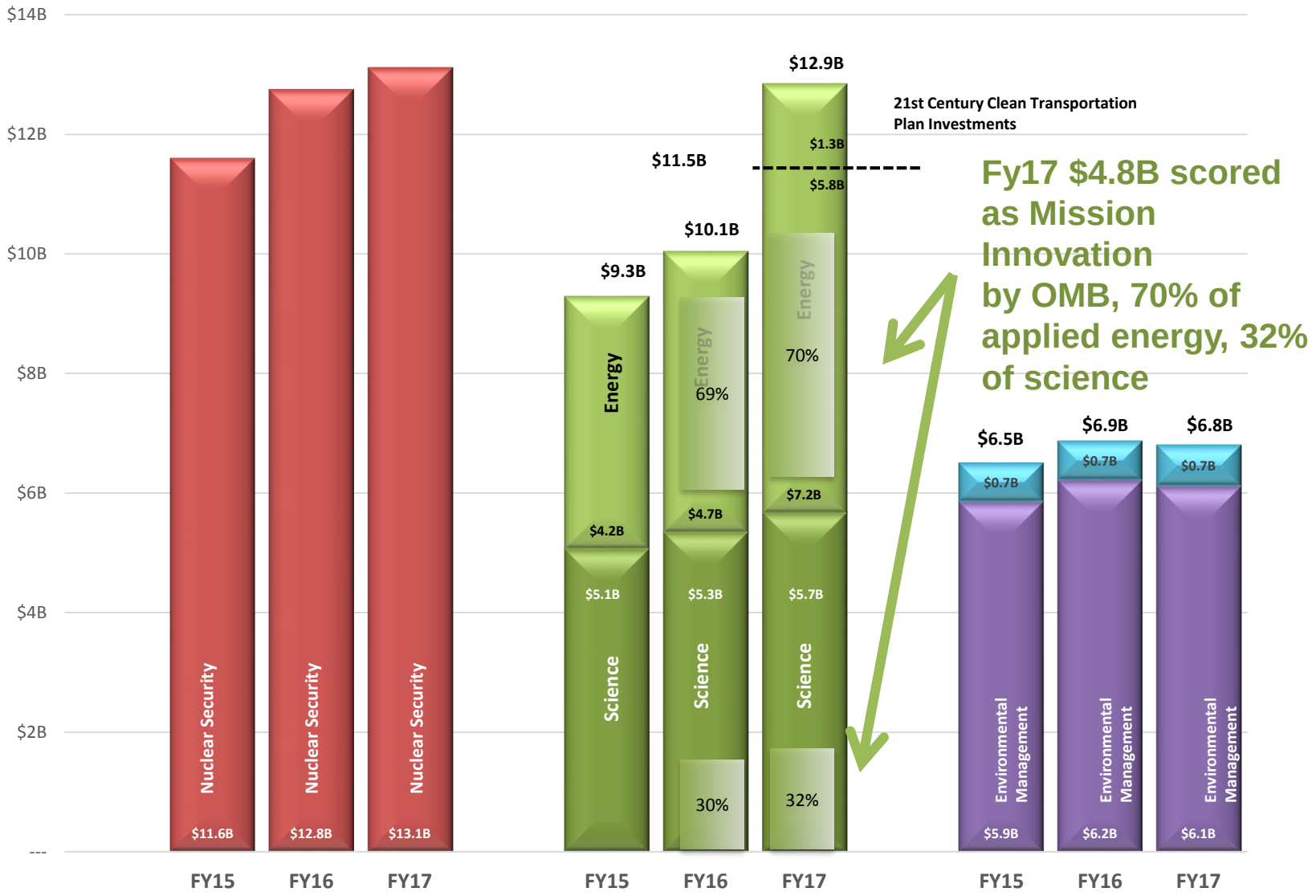
Bioenergy Research Centers, Hubs

Energy Frontier Research Centers

Core Research / Individual PIs

* ARPA-E targets technology gaps, high-risk concepts, aggressive delivery times

DOE Mission Innovation R&D, FY 16 and 17



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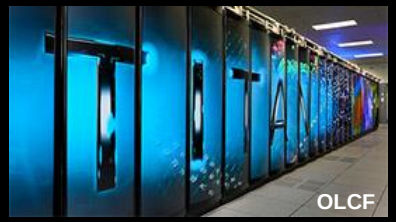
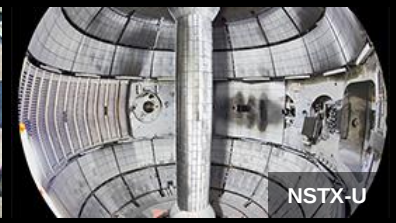
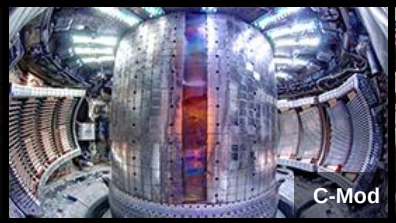
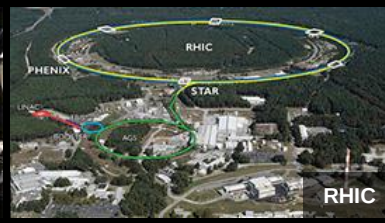
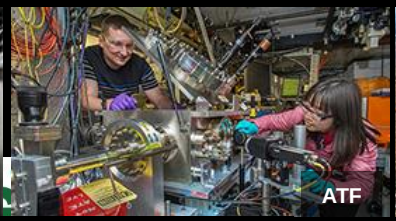
FY 2016
28 user facilities





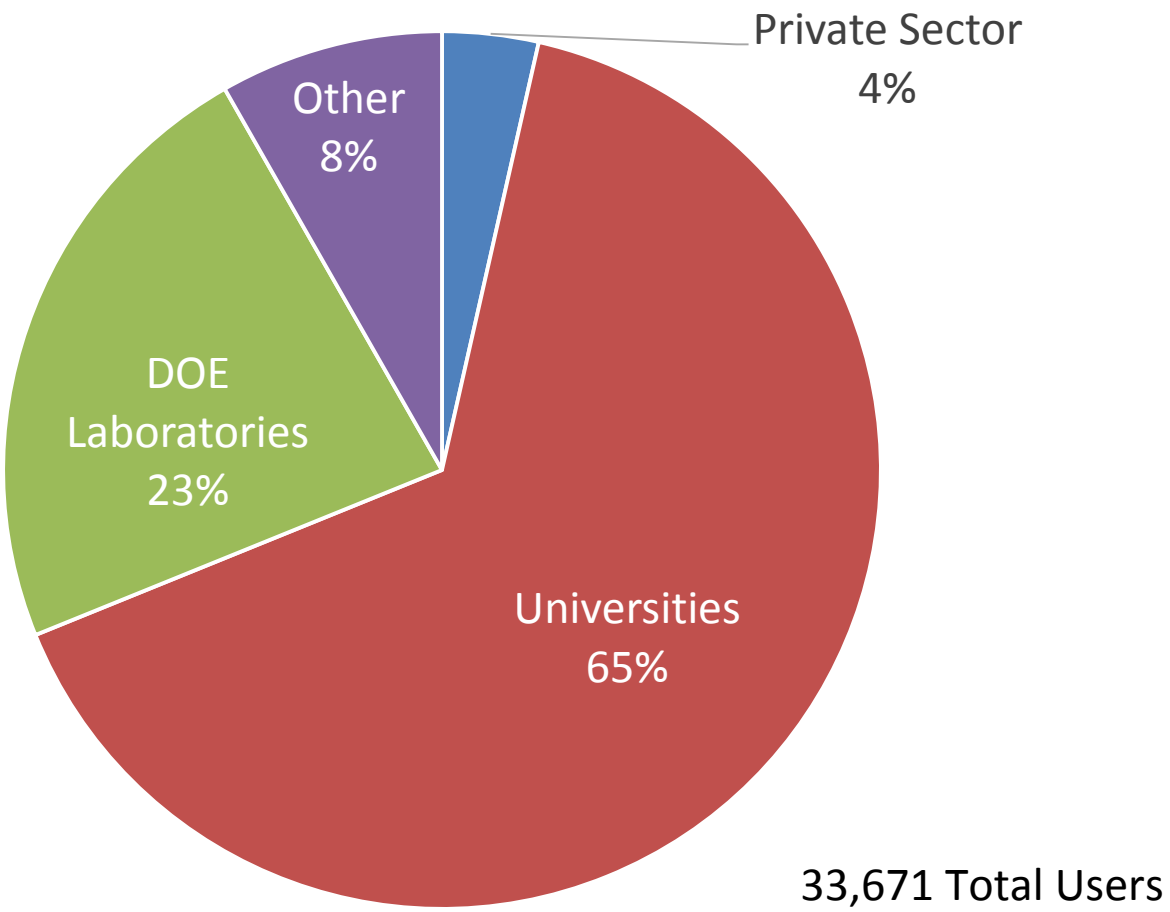






U.S. DEPARTMENT OF
ENERGY
Office of Science

Office of Science User Facility Statistics FY14



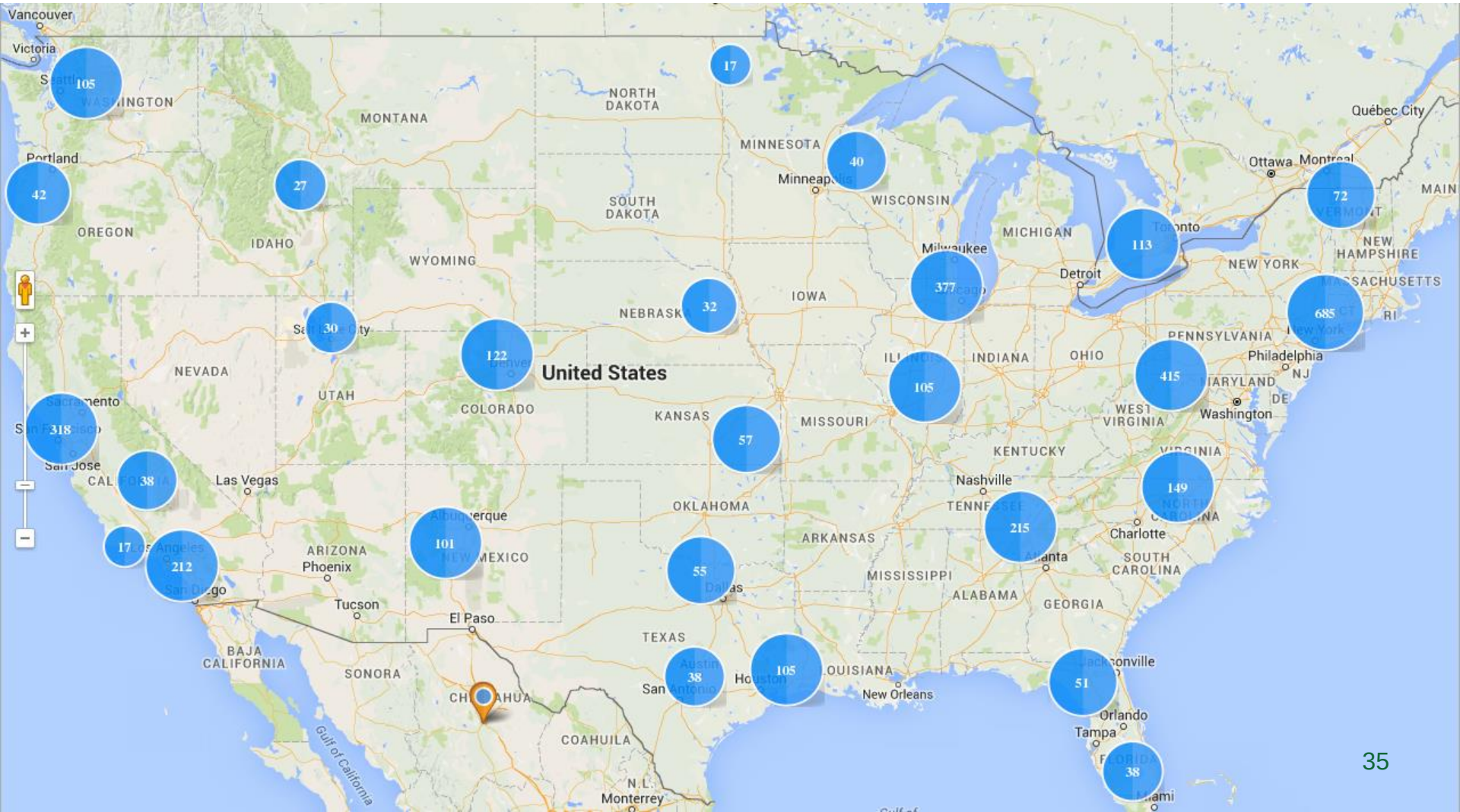
U.S. DEPARTMENT OF ENERGY | Office of Science

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

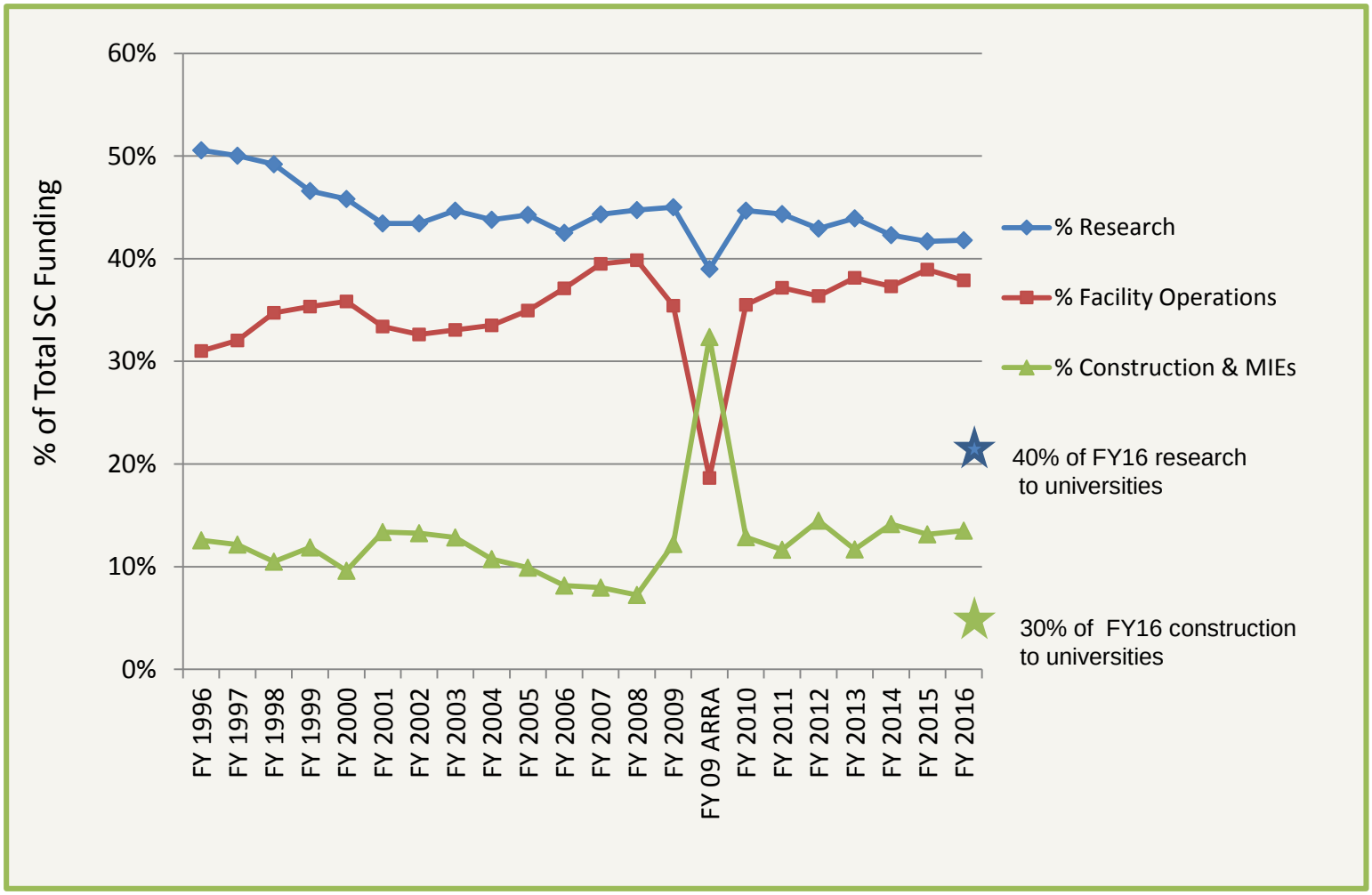
Data on University Grants and Users Across Country

http://science.energy.gov/universities/interactive-grants-map/

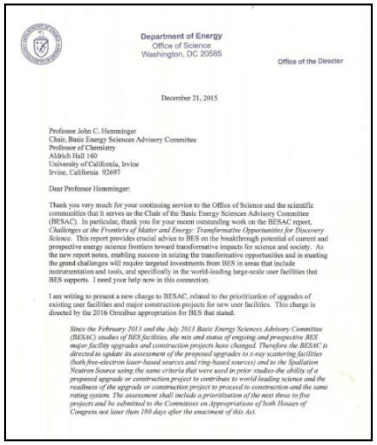
http://science.energy.gov/user-facilities/user-statistics/



SC Investments in Research, Facilities, and Construction



BESAC New Charge on Prioritization of Facility Upgrades



Department of Energy
Office of Science
Washington, DC 20585

Office of the Director

December 21, 2015

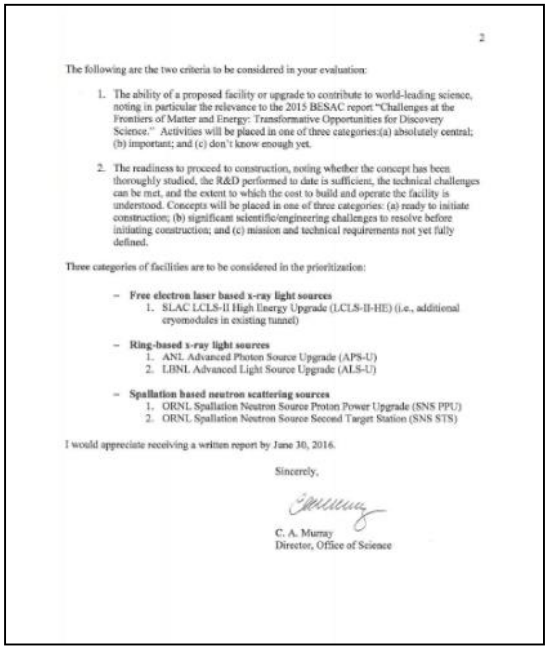
Professor John C. Hemminger
Chair, Basic Energy Sciences Advisory Committee
Professor of Chemistry
Aldrich Hall 160
University of California, Irvine
Irvine, California 92697

Dear Professor Hemminger:

Thank you very much for your continuing service to the Office of Science and the scientific communities that it serves as the Chair of the Basic Energy Sciences Advisory Committee (BESAC). In particular, thank you for your recent outstanding work on the BESAC report, *Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science*. This report provides crucial advice to BES on the breakthrough potential of current and prospective energy science frontiers toward transformative impacts for science and society. As the new report notes, enabling success in seizing the transformative opportunities and in meeting the grand challenges will require targeted investments from BES in areas that include instrumentation and tools, and specifically in the world-leading large-scale user facilities that BES supports. I need your help now in this connection.

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. This charge is directed by the 2016 Omnibus appropriation for BES that stated:

Since the February 2013 and the July 2013 Basic Energy Sciences Advisory Committee (BESAC) studies of BES facilities, the mix and status of ongoing and prospective BES major facility upgrades and construction projects have changed. Therefore the BESAC is directed to update its assessment of the proposed upgrades to x-ray scattering facilities (both free-electron laser-based sources and ring-based sources) and to the Spallation Neutron Source using the same criteria that were used in prior studies-the ability of a proposed upgrade or construction project to contribute to world-leading science and the readiness of the upgrade or construction project to proceed to construction-and the same rating system. The assessment shall include a prioritization of the next three to five projects and be submitted to the Committees on Appropriations of both Houses of Congress not later than 180 days after the enactment of this Act.



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.

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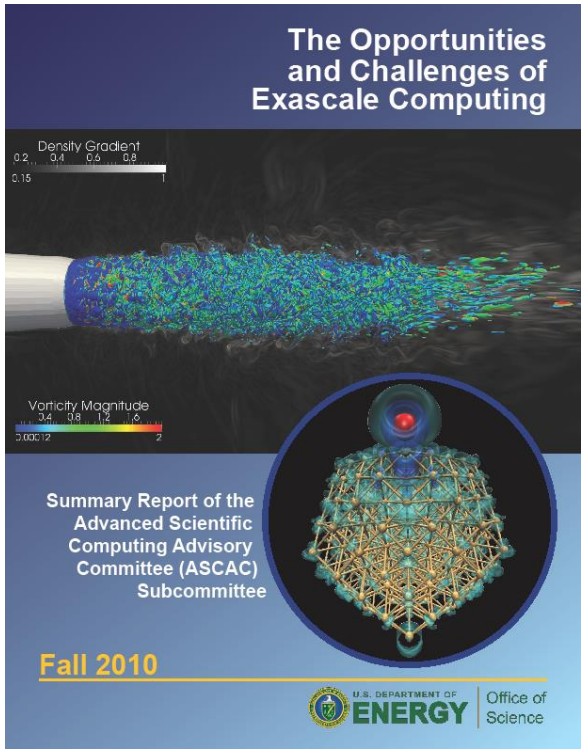
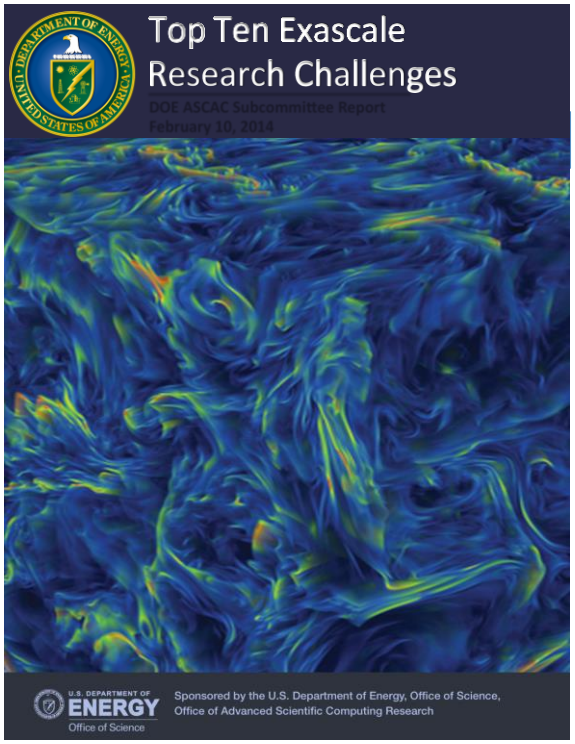
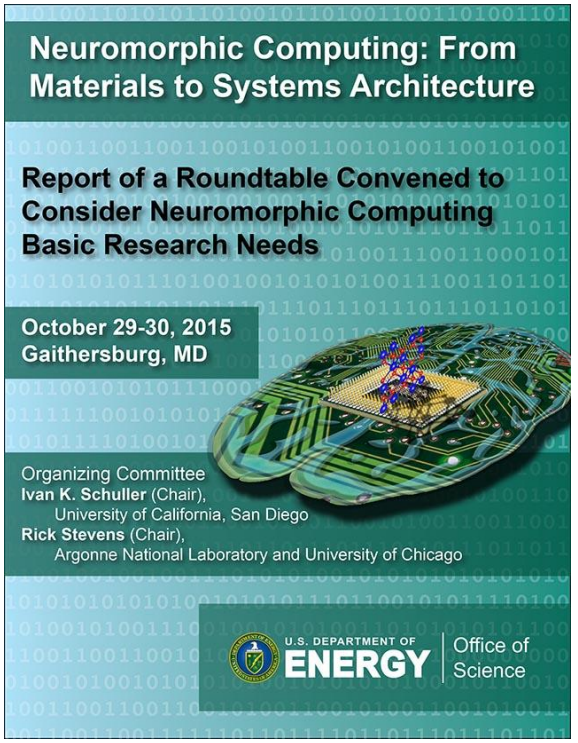
Exascale Computation Grand Challenge







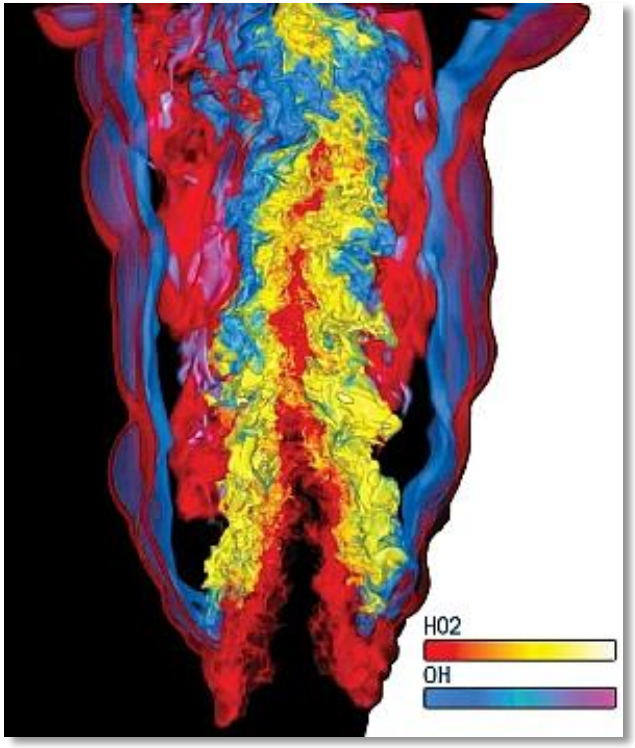
http://science.energy.gov/~/media/ascr/ascac/pdf/reports/Exascale_subcommittee_report.pdf

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

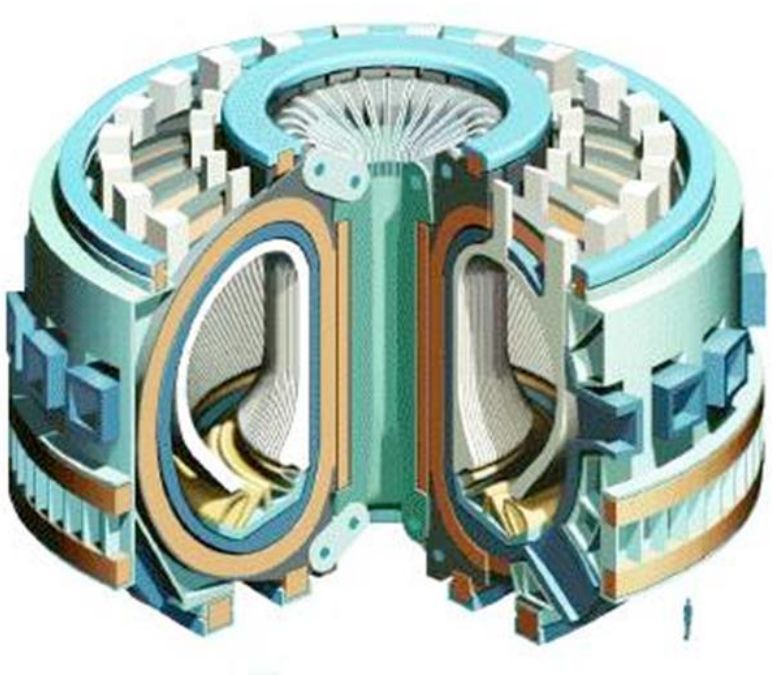
http://science.energy.gov/bes/community-resources/reports/abstracts/#NCFMtSA

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



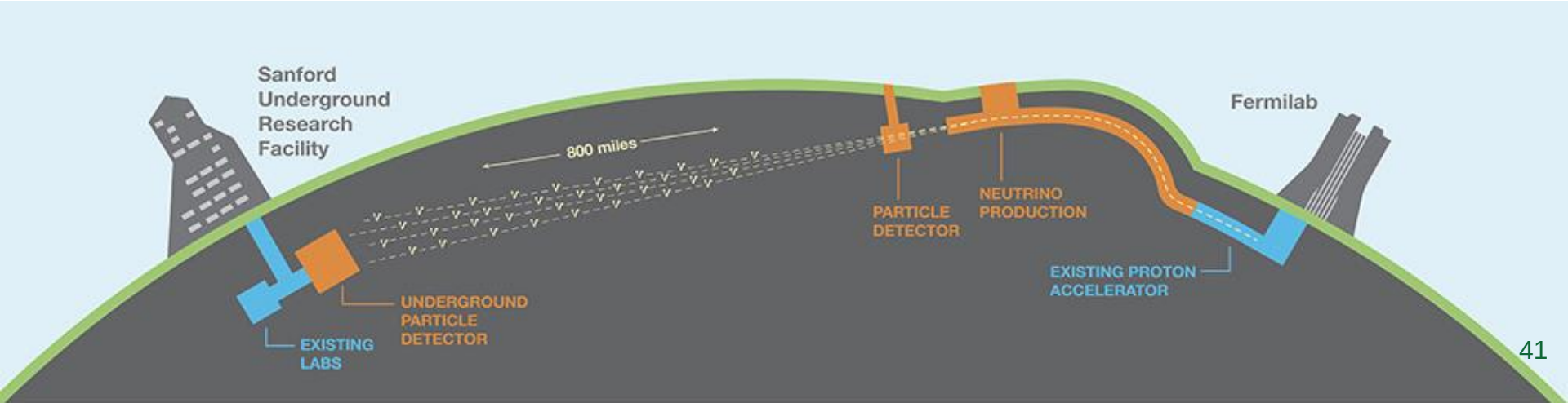
ITER Congressional Language



"…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."

Long Baseline Neutrino Facility

- P5 recommended LBNF as the centerpiece of a U.S.-hosted world-leading neutrino program
  - 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



END