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

BESAC Meeting, February 11, 2016

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

Office of Science FY16 - $5.35B
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

U.S. DEPARTMENT OF ENERGY
Office of Science
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advanced Scientific Computing Research</td>
<td>541,000</td>
<td>523,411</td>
<td>621,000</td>
<td>663,180</td>
<td>+42,180 +6.8%</td>
</tr>
<tr>
<td>Basic Energy Sciences</td>
<td>1,733,200</td>
<td>1,682,924</td>
<td>1,849,000</td>
<td>1,936,730</td>
<td>+87,730 +4.7%</td>
</tr>
<tr>
<td>Biological and Environmental Research</td>
<td>592,000</td>
<td>572,618</td>
<td>609,000</td>
<td>661,920</td>
<td>+52,920 +8.7%</td>
</tr>
<tr>
<td>Fusion Energy Sciences</td>
<td>467,500</td>
<td>457,366</td>
<td>438,000</td>
<td>398,178</td>
<td>-39,822 -9.1%</td>
</tr>
<tr>
<td>High Energy Physics</td>
<td>766,000</td>
<td>745,232</td>
<td>795,000</td>
<td>817,997</td>
<td>+22,997 +2.9%</td>
</tr>
<tr>
<td>Nuclear Physics</td>
<td>595,500</td>
<td>580,744</td>
<td>617,100</td>
<td>635,658</td>
<td>+18,558 +3.0%</td>
</tr>
<tr>
<td>Workforce Development for Teachers and Scientists</td>
<td>19,500</td>
<td>19,500</td>
<td>19,500</td>
<td>20,925</td>
<td>+1,425 +7.3%</td>
</tr>
<tr>
<td>Science Laboratories Infrastructure</td>
<td>79,600</td>
<td>79,600</td>
<td>113,600</td>
<td>130,000</td>
<td>+16,400 +14.4%</td>
</tr>
<tr>
<td>Safeguards and Security</td>
<td>93,000</td>
<td>93,000</td>
<td>103,000</td>
<td>103,000</td>
<td>.....</td>
</tr>
<tr>
<td>Program Direction</td>
<td>183,700</td>
<td>183,700</td>
<td>185,000</td>
<td>204,481</td>
<td>+19,481 +10.5%</td>
</tr>
<tr>
<td>University Grants (Mandatory)</td>
<td>.....</td>
<td>.....</td>
<td>.....</td>
<td>100,000</td>
<td>+100,000 +10.0%</td>
</tr>
<tr>
<td>Small Business Innovation/Technology Transfer Research (SC)</td>
<td>.....</td>
<td>132,905</td>
<td>.....</td>
<td>.....</td>
<td>.....</td>
</tr>
<tr>
<td>Subtotal, Science</td>
<td>5,071,000</td>
<td>5,071,000</td>
<td>5,350,200</td>
<td>5,672,069</td>
<td>+321,869 +6.0%</td>
</tr>
<tr>
<td>Small Business Innovation/Technology Transfer Research (DOE)</td>
<td>.....</td>
<td>65,075</td>
<td>.....</td>
<td>.....</td>
<td>.....</td>
</tr>
<tr>
<td>Rescission of Prior Year Balance</td>
<td>-3,262</td>
<td>-3,262</td>
<td>-3,200</td>
<td>-3,200</td>
<td>-100.0%</td>
</tr>
<tr>
<td>Total, Science</td>
<td>5,067,738</td>
<td>5,132,813</td>
<td>5,347,000</td>
<td>5,672,069</td>
<td>+325,069 +6.1%</td>
</tr>
</tbody>
</table>
Priorities for FY 2017

- Maintain strong support for discovery science and world-class science facilities
  - Maintain a healthy balance among PI research, groups and centers, and facility operations
  - Continue to use community priorities to make difficult choices and design, build, operate, and sunset world-class facilities
  - Lead and steward the US accelerator science R&D capabilities
  - Lead and steward the US computational R&D capabilities, in collaboration with NNSA – garner support for and execute the exascale initiative
  - Support partnerships and collaborations

- Be proactive in supporting science for clean energy
  - Basic research needs workshops – partner with DOE technology offices and industry
  - Science-based transformational energy technology in Mission Innovation

- Increase relationship building with Congress
- Increase relationship building with research universities
- Given the importance of the DOE national labs in US R&D, institutionalize best practices in national lab management
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%
**SC Investments for Mission Innovation**

$100M in new funding in FY 2017

---

**ASCR (+$10M)**
- Computational Partnerships with EFRCs on solar, CO$_2$ reduction, catalysis, storage, subsurface, and biofuels; possibly new partnerships in wind and nuclear ($10M)

**BES (+$51M)**
- Energy Efficiency: Catalysts, modeled after nature’s enzymes, that can operate at low-temperature and under ambient conditions; lightweight metallic materials; thermocaloric materials ($34.4M)
- Materials for Clean Energy: Self-healing materials for corrosive and high radiation environments (next-gen corrosive-resistant materials based on experiments and multi-scale modeling; chemistry under harsh or extreme environments) ($16.6M)

**BER (+$35M)**
- Biosystems design (computationally design and then bio-engineer biosystems) to introduce beneficial traits into plants and microbes for clean energy applications ($20M)
- Bioenergy Research Centers: New investments to translate 10 years of BRC research to industry ($15M, $5M per BRC)

**FES (+4M)**
- Whole-device fusion modeling and simulation using SciDAC partnerships ($4M)
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.
# BES FY 2017 Budget Request to Congress

(Dollars in thousands)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Materials Sciences and Engineering</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td>258,951</td>
<td>259,209</td>
<td>250,319</td>
<td>280,989</td>
<td>+30,670 +12.3%</td>
</tr>
<tr>
<td>Experimental Program to Stimulate Competitive Research (EPSCoR)</td>
<td>9,951</td>
<td>9,951</td>
<td>14,776</td>
<td>8,520</td>
<td>-6,256 -42.3%</td>
</tr>
<tr>
<td>Energy Frontier Research Centers (EFRCs)</td>
<td>50,800</td>
<td>50,800</td>
<td>55,800</td>
<td>55,800</td>
<td>...</td>
</tr>
<tr>
<td>Energy Innovation Hubs—Batteries and Energy Storage</td>
<td>24,175</td>
<td>24,175</td>
<td>24,137</td>
<td>24,088</td>
<td>-49 -0.2%</td>
</tr>
<tr>
<td>Computational Materials Sciences</td>
<td>8,000</td>
<td>8,000</td>
<td>12,000</td>
<td>12,000</td>
<td>...</td>
</tr>
<tr>
<td>SBIR/STTR</td>
<td>12,008</td>
<td>...</td>
<td>12,758</td>
<td>14,448</td>
<td>+1,690 +13.2%</td>
</tr>
<tr>
<td><strong>Total, Materials Sciences and Engineering</strong></td>
<td>363,885</td>
<td>352,135</td>
<td>369,790</td>
<td>395,845</td>
<td>+26,055 +7.0%</td>
</tr>
<tr>
<td><strong>Chemical Sciences, Geosciences, and Biosciences</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td>239,086</td>
<td>238,164</td>
<td>231,129</td>
<td>256,853</td>
<td>+25,724 +11.1%</td>
</tr>
<tr>
<td>Energy Frontier Research Centers (EFRCs)</td>
<td>49,200</td>
<td>49,200</td>
<td>54,200</td>
<td>86,766</td>
<td>+32,566 +60.1%</td>
</tr>
<tr>
<td>Energy Innovation Hubs—Fuels from Sunlight</td>
<td>15,000</td>
<td>15,000</td>
<td>15,000</td>
<td>15,000</td>
<td>...</td>
</tr>
<tr>
<td>Computational Chemical Sciences</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>13,635</td>
<td>+13,635 ...</td>
</tr>
<tr>
<td>General Plant Projects (GPP)</td>
<td>600</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>...</td>
</tr>
<tr>
<td>SBIR/STTR</td>
<td>10,350</td>
<td>...</td>
<td>10,732</td>
<td>14,102</td>
<td>+3,370 +31.4%</td>
</tr>
<tr>
<td><strong>Total, Chemical Sciences, Geosciences, and Biosciences</strong></td>
<td>314,236</td>
<td>303,364</td>
<td>312,061</td>
<td>387,356</td>
<td>+75,295 +24.1%</td>
</tr>
<tr>
<td><strong>Scientific User Facilities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synchrotron Radiation Light Sources</td>
<td>447,186</td>
<td>450,103</td>
<td>481,906</td>
<td>489,059</td>
<td>+7,153 +1.5%</td>
</tr>
<tr>
<td>High-Flux Neutron Sources</td>
<td>244,113</td>
<td>245,050</td>
<td>264,645</td>
<td>261,177</td>
<td>-3,468 -1.3%</td>
</tr>
<tr>
<td>Nanoscale Science Research Centers</td>
<td>113,649</td>
<td>114,925</td>
<td>118,763</td>
<td>122,272</td>
<td>+3,509 +3.0%</td>
</tr>
<tr>
<td>Other Project Costs</td>
<td>9,300</td>
<td>9,300</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Major Items of Equipment</td>
<td>42,500</td>
<td>42,500</td>
<td>35,500</td>
<td>20,000</td>
<td>-15,500 -43.7%</td>
</tr>
<tr>
<td>Research</td>
<td>31,713</td>
<td>26,847</td>
<td>34,853</td>
<td>37,537</td>
<td>+2,684 +7.7%</td>
</tr>
<tr>
<td>SBIR/STTR</td>
<td>27,918</td>
<td>...</td>
<td>31,182</td>
<td>33,484</td>
<td>+2,302 +7.4%</td>
</tr>
<tr>
<td><strong>Total, Scientific User Facilities</strong></td>
<td>916,379</td>
<td>888,725</td>
<td>966,849</td>
<td>963,529</td>
<td>-3,320 -0.3%</td>
</tr>
<tr>
<td><strong>Subtotal, Basic Energy Sciences</strong></td>
<td>1,594,500</td>
<td>1,544,224</td>
<td>1,648,700</td>
<td>1,746,730</td>
<td>+98,030 +5.9%</td>
</tr>
<tr>
<td><strong>Construction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-SC-10 Linac Coherent Light Source-II (LCLS-II), SLAC</td>
<td>138,700</td>
<td>138,700</td>
<td>200,300</td>
<td>190,000</td>
<td>-10,300 -5.1%</td>
</tr>
<tr>
<td><strong>Total, Basic Energy Sciences</strong></td>
<td>1,733,200</td>
<td>1,682,924</td>
<td>1,849,000</td>
<td>1,936,730</td>
<td>+87,730 +4.7%</td>
</tr>
</tbody>
</table>
Energy Frontier Research Centers
FY 2016 = $110M; FY 2017 = $143M

Current EFRCs ($100M in FY 2015)
- 32 awards; $2-4M/year for 4 years (22 renewal, 10 new centers)
- Lead institutions by type: 23 universities; 8 DOE National Laboratories; 1 nonprofit organization
- Over 100 participating institutions, located in 33 states plus the District of Columbia

EFRCs 2009-14 ($100M/year+$277M ARRA)
- 46 EFRCs of $2-5M per year for 5 years

FY 2016 Appropriation
- In 2016, there will be a Funding Opportunity Announcement (FOA) for up to five new EFRCs that focus on research directions under-represented in the current EFRC portfolio; included will be topics identified at the 2015 Basic Research Needs for Environmental Management Workshop.
- EFRC solicitations begin a two year FOA cycle.

FY 2017 Budget Request
- FY 2017 budget request includes an increase of $33M to fully fund up to 5 new EFRCs in subsurface science relevant to the Departmental Subsurface crosscut.
- The new EFRCs will support multidisciplinary teams to address the grand challenge identified in 2015 strategic planning activities: “Advanced imaging of geophysical and geochemical signals in the subsurface.”
A new activity -- $14M is requested to support 4-5 teams of researchers to capitalize on existing investments in quantum chemistry codes and upgrade them to be compatible with the current and future generations of high performance computers.

Assemble teams of mathematical and computational chemists to develop open-source software with new algorithms to allow simulation of chemical processes of complex systems.

Rewrite software and algorithms to fully realize the current and future gains in efficiency offered by massively parallel computing platforms.

Deliver codes that treat electronic and spin effects in order to avoid case-by-case retooling of the model of electronic potential that is embedded in many current computational methods.
LCLS-II and APS-U Underway

Linac Coherent Light Source-II (LCLS-II)

- FY 2016 = $200,300K; FY 2017 = $190,000K for R&D, design, prototyping, long lead procurement, and construction of technical systems.
- LCLS-II will provide high-rep-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.
- Added are a 4 GeV superconducting linac; an electron injector; and two undulators to provide x-rays in the 0.2–5 keV energy range.

Advanced Photon Source Upgrade (APS-U)

- FY 2016 = $20,000K; FY 2017 = $20,000K for R&D, design, and limited prototyping.
- APS-U will provide a multi-bend achromat lattice to provide extreme transverse coherence and brightness.
- Initial conceptual design for the new lattice completed; conducting R&D and key component prototyping in support of the new design. Key performance parameters are being defined for the project and the new storage ring.
- **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.
# FY 2017 SC Contributions to DOE Crosscuts

<table>
<thead>
<tr>
<th></th>
<th>Adv Mat</th>
<th>ECI</th>
<th>Subsurface</th>
<th>EWN</th>
<th>Cybersecurity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Scientific Computing Res.</td>
<td>0</td>
<td>154,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>154,000</td>
</tr>
<tr>
<td>Basic Energy Sciences</td>
<td>17,600</td>
<td>26,000</td>
<td>41,300</td>
<td>0</td>
<td>0</td>
<td>84,900</td>
</tr>
<tr>
<td>Biological and Environmental Research</td>
<td>0</td>
<td>10,000</td>
<td>0</td>
<td>24,300</td>
<td>0</td>
<td>34,300</td>
</tr>
<tr>
<td>Safeguards and Security</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27,197</td>
<td>27,197</td>
</tr>
<tr>
<td>Total, SC Contribution Crosscuts</td>
<td>17,600</td>
<td>190,000</td>
<td>41,300</td>
<td>24,300</td>
<td>27,197</td>
<td>300,397</td>
</tr>
</tbody>
</table>

**Adv Mat:** Advanced Materials Crosscut  
**ECI:** Exascale Computing Initiative Crosscut  
**Subsurface:** Subsurface Technology and Engineering RD&D Crosscut  
**EWN:** Energy-Water Nexus Crosscut  
**Cybersecurity:** Cybersecurity Crosscut
SC Contributes to Five FY 2017 DOE Crosscuts

**Advanced Materials (Adv Mat):** Identified as a priority in both the 2015 QTR and the QER, activities in the Adv Mat crosscut address faster development of new materials and reductions in the cost of materials qualification in clean energy applications, from discovery through deployment. New activities emphasize DOE-wide efforts in (1) materials design and synthesis, (2) applied design, (3) process scale-up, (4) qualification, and (5) digital data and informatics.

**Exascale Computing Initiative (ECI):** Activities in the ECI crosscut, a partnership between SC and NNSA, address accelerating R&D to overcome key challenges in parallelism, energy efficiency, and reliability, leading to deployment of exascale systems in the mid-2020s. In addition to underpinning DOE’s missions in science and national security, the computational capabilities developed in the ECI also will support R&D in DOE’s applied energy technology areas, as described in the 2015 QTR.

**Subsurface Technology and Engineering RD&D (Subsurface):** Activities in the Subsurface crosscut address coordinated research in Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, New Subsurface Signals, and Risk Assessment Tools. Over 80 percent of our total energy supply comes from the subsurface; the goals of this crosscut are enhanced energy security, reduced impact on climate change via CO$_2$ sequestration, and significantly mitigated environmental impacts from energy-related activities and operations.

**Energy-Water Nexus (EWN):** The EWN crosscut addresses the transition to more resilient energy and coupled energy-water systems. The EWN crosscut supports: (1) an advanced, integrated data, modeling, and analysis platform to improve understanding and inform decision-making; (2) investments in targeted technology research offering the greatest potential for impact; and (3) policy analysis and stakeholder engagement designed to build from and strengthen the two preceding areas while motivating community involvement and response.

**Cybersecurity:** The Department of Energy (DOE) is engaged in two categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities and improving cybersecurity in the electric power subsector and the oil and natural gas subsector. The cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center (JC3) for incident response and the implementation of Department-wide Identity Control and Access Management (ICAM).
- 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.
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
High Energy Physics
The technology and construction needed to pursue 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
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.