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

NSAC Meeting, March 23, 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
Risk

High Risk, High Payoff

DOE Office of Science

DOE ARPA-E

Venture Capital and Small Businesses

Private Equity/Capital & Large Corporations

DOE Loan Guarantee Program

Low Risk, Evolutionary

Basic Science Research

Feasibility Research

Technology Development

Technology Demonstration

Small Scale Deployment

Large Scale Deployment

Technology Readiness Level
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
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)

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Science</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Advanced Scientific Computing Research</td>
<td>541,000</td>
<td>523,411</td>
<td>621,000</td>
<td>663,180</td>
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<tr>
<td>Fusion Energy Sciences</td>
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<td>Workforce Development for Teachers and Scientists</td>
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<td>Safeguards and Security</td>
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<td>103,000</td>
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<td>Program Direction</td>
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<td>185,000</td>
<td>204,481</td>
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<td>University Grants (Mandatory)</td>
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<td>...</td>
<td>...</td>
<td>100,000</td>
<td>+100,000 ...</td>
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<td>Small Business Innovation/Technology Transfer Research (SC)</td>
<td>...</td>
<td>132,905</td>
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<td><strong>Subtotal, Science</strong></td>
<td>5,071,000</td>
<td>5,071,000</td>
<td>5,350,200</td>
<td>5,672,069</td>
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<tr>
<td>Small Business Innovation/Technology Transfer Research (DOE)</td>
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<td>65,075</td>
<td>...</td>
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<td>Rescission of Prior Year Balance</td>
<td>-3,262</td>
<td>-3,262</td>
<td>-3,200</td>
<td>...</td>
<td>+3,200 -100.0%</td>
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<td><strong>Total, Science</strong></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>
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</tbody>
</table>
President’s DOE FY 2017 Proposed Budget

- **Energy** - Mandatory, $1.49B
- **Science** - Mandatory, $0.10B
- **Science** - 7.2B, 22%
- **Energy** - 5.7B, 17%
- **Environmental Management** - 6.1B, 19%
- **Nuclear Security** - 13.1B, 40%
- **Other** - 0.7B, 2%

**FY15**
- Nuclear Security: $11.6B
- Science: $5.1B
- Environmental Management: $5.9B
- Other: $0.7B

**FY16**
- Nuclear Security: $12.8B
- Science: $5.3B
- Environmental Management: $6.2B
- Other: $0.7B

**FY17**
- Nuclear Security: $13.1B
- Science: $5.7B
- Environmental Management: $6.8B
- Other: $0.7B

21st Century Clean Transportation Plan Investments:
- Energy: $1.3B
- Science: $4.7B
- Environmental Management: $0.7B

Note: The pie chart and bar graph illustrate the distribution of the proposed budget across different categories for FY15, FY16, and FY17.
### Office of Science Programs

<table>
<thead>
<tr>
<th>Program</th>
<th>FY2016</th>
<th>FY2017 Request</th>
<th>Percentage Change</th>
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</thead>
<tbody>
<tr>
<td>Advanced Scientific Computing Research</td>
<td>$621M</td>
<td>+6.8%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Basic Energy Sciences</td>
<td>$1849M</td>
<td>+4.7%</td>
<td>4.7%</td>
</tr>
<tr>
<td>Biological and Environmental Research</td>
<td>$609M</td>
<td>+8.7%</td>
<td>8.7%</td>
</tr>
<tr>
<td>High Energy Physics</td>
<td>$795M</td>
<td>+2.9%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Fusion Energy Sciences</td>
<td>$438M</td>
<td>-9.1%</td>
<td>-9.1%</td>
</tr>
<tr>
<td>Nuclear Physics</td>
<td>$617M</td>
<td>+3.0%</td>
<td>3.0%</td>
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</tbody>
</table>
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)
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.
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>
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<td>154,000</td>
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<tr>
<td>Basic Energy Sciences</td>
<td>17,600</td>
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<td>41,300</td>
<td>0</td>
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<td>84,900</td>
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<td>Biological and Environmental Research</td>
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<td>10,000</td>
<td>0</td>
<td>24,300</td>
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<td>34,300</td>
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<tr>
<td>Safeguards and Security</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>27,197</td>
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<tr>
<td>Total, SC Contribution Crosscuts</td>
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<td>190,000</td>
<td>41,300</td>
<td>24,300</td>
<td>27,197</td>
<td>300,397</td>
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</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 CO₂ 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).
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.
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
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
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.
NP FY 2017 Budget Request to Congress  
(Dollars in thousands)

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<tbody>
<tr>
<td>Medium Energy Nuclear Physics</td>
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<tr>
<td>Research</td>
<td>35,646</td>
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<td>37,802</td>
<td>40,017</td>
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<td>Operations (TJNAF)</td>
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<td>97,050</td>
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<td><strong>Total, Medium Energy Nuclear Physics</strong></td>
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<td><strong>155,793</strong></td>
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<tr>
<td>Heavy Ion Nuclear Physics</td>
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<tr>
<td>Research</td>
<td>33,894</td>
<td>33,013</td>
<td>35,822</td>
<td>36,431</td>
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<td>Operations (RHIC)</td>
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<td>166,072</td>
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<td><strong>Total, Heavy Ion Nuclear Physics</strong></td>
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<td><strong>199,085</strong></td>
<td><strong>207,910</strong></td>
<td><strong>216,131</strong></td>
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<td>Low Energy Nuclear Physics</td>
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<tr>
<td>Research</td>
<td>48,377</td>
<td>50,764</td>
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<td>Gamma-Ray Energy Tracking Array (GRETA) (MIE)</td>
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<td>+500</td>
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<td>Operations</td>
<td>26,819</td>
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<td>27,402</td>
<td>25,499</td>
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<td><strong>Total, Low Energy Nuclear Physics</strong></td>
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<td><strong>77,793</strong></td>
<td><strong>78,785</strong></td>
<td><strong>79,893</strong></td>
<td><strong>+1,108 (%1.4%)</strong></td>
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<tr>
<td>Nuclear Theory</td>
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<tr>
<td>Theory Research</td>
<td>35,715</td>
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<td>Nuclear Data Activities</td>
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<td><strong>Total, Nuclear Theory</strong></td>
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<td><strong>43,174</strong></td>
<td><strong>45,775</strong></td>
<td><strong>46,465</strong></td>
<td><strong>+690 (%1.5%)</strong></td>
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<td>Isotope Development and Production for Research and Applications</td>
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<tr>
<td>Research</td>
<td>4,815</td>
<td>4,815</td>
<td>6,033</td>
<td>10,344</td>
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<td>15,035</td>
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<td>Stable Isotope Production Facility (SIPF) (MIE)</td>
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<td>2,500</td>
<td>+2,500</td>
</tr>
<tr>
<td><strong>Total, Isotope Production and Applications</strong></td>
<td><strong>19,850</strong></td>
<td><strong>19,850</strong></td>
<td><strong>21,337</strong></td>
<td><strong>29,370</strong></td>
<td><strong>+8,033 (%37.6%)</strong></td>
</tr>
<tr>
<td>Subtotal, Nuclear Physics</td>
<td><strong>489,000</strong></td>
<td><strong>474,244</strong></td>
<td><strong>509,600</strong></td>
<td><strong>635,658</strong></td>
<td><strong>+26,058 (%5.1%)</strong></td>
</tr>
<tr>
<td>Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14-SC-50 Facility for Rare Isotope Beams, MSU</td>
<td>90,000</td>
<td>90,000</td>
<td>100,000</td>
<td>100,000</td>
<td>...</td>
</tr>
<tr>
<td>06-SC-01 12 GeV CEBAF Upgrade, TJNAF</td>
<td>16,500</td>
<td>16,500</td>
<td>7,500</td>
<td>...</td>
<td>-7,500 (%-100.0%)</td>
</tr>
<tr>
<td><strong>Total, Construction</strong></td>
<td><strong>106,500</strong></td>
<td><strong>106,500</strong></td>
<td><strong>107,500</strong></td>
<td><strong>100,000</strong></td>
<td><strong>-7,500 (%-7.0%)</strong></td>
</tr>
<tr>
<td><strong>Total, Nuclear Physics</strong></td>
<td><strong>595,500</strong></td>
<td><strong>580,744</strong></td>
<td><strong>617,100</strong></td>
<td><strong>635,658</strong></td>
<td><strong>+18,558 (%3.0%)</strong></td>
</tr>
</tbody>
</table>
Recommendations:

1. Capitalize on investments made to maintain U.S. leadership in nuclear science.
2. Develop and deploy a U.S.-led ton-scale neutrino-less double beta decay experiment.
3. Construct a high-energy high-luminosity polarized electron-ion collider (EIC) as the highest priority for new construction following the completion of FRIB.
4. Increase investment in small-scale and mid-scale projects and initiatives that enable forefront research at universities and laboratories.
Relativistic Heavy Ion Collider

- RHIC operates for 24 weeks, 4 more than FY 2016.
- The FY 2017 request enables incisive tests of our understanding of QCD and exploration of new phenomena in quark gluon plasma formation.

(Nature, 11/4/15)
Physicists measure the force that makes anti-matter stick together.

Findings could offer insight into the possible existence of larger chunks of antimatter and may also help scientists explore why the universe today consists mainly of ordinary matter with virtually no antimatter to be found.
Continuous Electron Beam Accelerator Facility

12 GeV CEBAF Upgrade Project:

- Major milestones planned in FY 2017 include completing the beam commissioning in Halls B & C and the entire 12 GeV CEBAF Upgrade Project (CD-4B).
- Project funding is provided for commissioning the upgraded experimental Halls B and C as the project is completed and transitioned to the 12 GeV CEBAF experimental program.

CEBAF operates for 27 weeks in FY 2017

With the completion of the 12 GeV CEBAF Upgrade, researchers will address:

- The search for exotic new quark-anti-quark particles to advance our understanding of the strong force.
- Evidence of new physics from sensitive searches for violations of nature’s fundamental symmetries.
- A microscopic understanding of the internal structure of the proton, including the origin of its spin, and how this structure is modified when the proton is inside a nucleus.
Facility for Rare Isotope Beams

FRIB will increase the number of isotopes with known properties from ~2,000 observed over the last century to ~5,000 and will provide world-leading capabilities for research on:

**Nuclear Structure**
- The limits of existence for nuclei
- Nuclei that have neutron skins
- Synthesis of super heavy elements

**Nuclear Astrophysics**
- The origin of the heavy elements and explosive nucleo-synthesis
- Composition of neutron star crusts

**Fundamental Symmetries**
- Tests of fundamental symmetries, Atomic EDMs, Weak Charge

This research will provide the basis for a model of nuclei and how they interact.

**The FY2017 Request supports:**
- Completing key conventional construction such as the target high bay, linac support area, and the cryoplant area.
- Enabling start of work on the cryogenics plant and distribution system which are on the project’s critical path.
- Continuing major procurements, fabrication, and assembly efforts of technical systems such as the linac front end, cryomodules, and experimental systems.
Gamma-Ray Energy Tracking Array (GRETA)

- The Request initiates the GRETA Major Item of Equipment (MIE), a premiere gamma-ray tracking device that will exploit the new capabilities of FRIB.

- GRETA was identified by NSAC as an instrument that will “revolutionize gamma-ray spectroscopy and provide sensitivity improvements of several orders of magnitude.”

- GRETA will advance the rare-isotope science at FRIB and investigate reactions of importance for nuclear structure and nuclear astrophysics.

- FY 2017 Request: $0.5M
  Est. Total Project Cost: $52M-$67M
Stable Isotope Production Facility (SIPF)

- The Request initiates the SIPF MIE, which restores domestic capability lacking since 1998.
  - Renewed enrichment capability will benefit nuclear and physical sciences, industrial manufacturing, homeland security, and medicine.
  - Nurtures U.S. expertise in centrifuge technology and isotope enrichment, useful for a variety of peaceful-use activities.
  - Addresses U.S. demands for high priority isotopes needed for neutrinoless double beta decay, dark matter experiments, target material for Mo-99 production, and more.
  - Removes U.S. foreign dependence of stable isotope enrichment
  - Responds to Nuclear Science Advisory Committee – Isotopes (NSACI)
    o 2009 Recommendation: “Construct and operate an electromagnetic isotope separator facility for stable and long-lived radioactive isotopes.”
    o 2015 Long Range Plan: “We recommend completion and the establishment of effective, full intensity operations of the stable isotope separation capability at ORNL.”
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**

**Discovery Research**
- **Goal:** new knowledge / understanding
- **Focus:** phenomena
- **Metric:** knowledge generation

**Use-Inspired Basic Research**
- **Goal:** practical targets
- **Focus:** performance
- **Metric:** milestone achievement

**Applied Research**

**Technology Maturation & Deployment**

**Office of Science**

**ARPA-E**

**Applied Programs**

**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

Fy17 $4.8B scored as Mission Innovation by OMB, 70% of applied energy, 32% of science
Office of Science User Facility Statistics FY14

- Private Sector: 4%
- Other: 8%
- DOE Laboratories: 23%
- Universities: 65%

33,671 Total Users

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

% of Total SC Funding

- % Research
- % Facility Operations
- % Construction & MIEs

FY 1996 to FY 2016

- 40% of FY16 research to universities
- 30% of FY16 construction to universities

40% of FY16 research to universities
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.
Exascale Computation Grand Challenge


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
“…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
Office of Science Laboratories  Total FY15 $5.5B, SC funding $3.4B
National Labs Address Multidisciplinary S&T Challenges

Most of the national labs have broader scope than Office of Science.
Flow of Funds between DOE Programs to Labs, 2015
END