High Energy Physics
FY 2018 Budget Request

June 2017

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Office of Science, U.S. Department of Energy
The High Energy Physics Program Mission

...is to understand how the universe works at its most fundamental level:

– Discover the elementary constituents of matter and energy
– Probe the interactions between them
– Explore the basic nature of space and time

The Office of High Energy Physics fulfills its mission by:

– Building projects that enable discovery science
– Operating facilities that provide the capability to perform discovery science
– Supporting a research program that produces discovery science
HEP received $825M in the FY 2017 Congressional Appropriation, about $7M above the FY 2017 President’s Budget Request

• Congressional direction increased funding for projects
  – Congress provided LBNF/DUNE with an increase of $4.9M over the request
  – Congress directed HEP to spend $12.5M for LZ, increase of $2M over the request
  – Congress directed HEP to spend $12M for TEC for DESI, $3M over the request

• HEP Research Program funding was reduced as a result of Project funding increasing more than the HEP top line increase
  – More details on FY 2017 execution in HEP Program Status talk by Glen Crawford

![Table showing high energy physics budget details for FY 2016, FY 2017 Request, and Final Bill]
The U.S. Federal Budget Cycle

- **Formulation:** Executive branch prepares the President's Budget Request
  - White House Office of Management and Budget (OMB) controls process, gives guidance
- **Congressional:** Enacts laws that control spending and receipts
  - Congress considers the Budget Request, enacts laws that control spending and receipts
- **Execution:** Executive branch agencies carry out program
  - OMB apportions funds to Executive Branch agencies, which obligate and disperse funding
- **This year’s cycle is not “typical”**
  - Congress used Continuing Resolutions (CRs) until passing an appropriation on May 5
  - White House released the “skinny budget” on March 13, guiding the budget formulation
  - FY 2018 President’s Budget Request released on May 23

<table>
<thead>
<tr>
<th>FY 2017 Budget</th>
<th>OMB Review</th>
<th>Congressional Budget and Appropriations</th>
<th>CR</th>
<th>Spend the Fiscal Year Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 2018 Budget</td>
<td>DOE Internal Planning with OMB and OSTP Guidance</td>
<td>OMB Review</td>
<td>Congressional Budget and Appropriations</td>
<td>Spend the Fiscal Year Budget</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
</tr>
</thead>
<tbody>
<tr>
<td>CY 2015</td>
<td>Calendar Year 2016</td>
<td>Calendar Year 2017</td>
<td>Calendar Year 2018</td>
<td></td>
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You are here
The FY18 budget request attempts to refocus and refine our mission on several critical fronts that directly affect the safety and security of the American public.

The $28 billion FY 2018 budget advances the DOE mission in key areas through significant investments to:

- Modernize the country’s nuclear weapons arsenal
- Achieve exascale computing
- Advance the Nation’s nuclear waste management program
- Protect our national electric grid from cyberattacks
- Shift the Department’s focus to early-stage research and development at our national laboratories to more efficiently and cost effectively advance American dominance in scientific and energy research
In support of the President’s FY 2018 Budget Request, the Office of Science makes the following points:

- The President establishes the priorities for the Budget Request.
- Historically, budgets have gone up and down. Our job is to deliver the best science we can with the resources we are given by the President and Congress.
- There will be some challenges for FY18, and it’s not easy to say at this early stage exactly how the budget will impact our programs—we’ll be working out the details over the next weeks and months.
- We’re going to need to be very clear about our priorities.
- We’re going to be working very hard to deliver the best science we can with the resources we have when Congress votes and the President finally signs an FY18 budget.
- We’ll do our best to keep you informed as we learn more.
Shown is a portion of SLAC’s two-mile-long linear accelerator (or linac), which provides the electron beam for the new Linac Coherent Light Source – the world’s first hard x-ray, free-electron laser. For nearly 50 years, SLAC’s linac had produced high-energy electrons for physics experiments. Now researchers use the very intense X-ray pulses (more than a billion times brighter than the most powerful existing sources) much like a high-speed camera to take stop-motion pictures of atoms and molecules in motion, examining fundamental processes on femtosecond timescales.

- **SC delivers scientific discoveries and tools to transform our understanding of nature and advance the energy, economic, and national security of the U.S.**

- **Research**
  - Provides about half of the U.S. Federal support for basic research in the physical sciences;
  - Supports about 19,000 Ph.D. scientists, graduate students, engineers, and support staff at over 300 institutions and 10 DOE national laboratories;
  - Maintains U.S. and world leadership in high-performance computing and computational sciences;
  - Continues to be the major U.S. supporter of physics, chemistry, materials sciences, and biology for discovery and for energy sciences.

- **Scientific User Facilities**
  - SC maintains the world’s largest collection of scientific user facilities (aka research infrastructure) operated by a single organization in the world, used by more than 27,000 researchers each year.
• Focus on cutting edge, early stage research and development; achieve 40% funding for research
  – The Office of Science (SC) is the largest Federal supporter of basic research in the physical sciences in the United States. SC supports research at the frontiers of science—discovering nature’s mysteries, from the study of subatomic particles, atoms, and molecules that are the building blocks of the materials of our everyday world, to the DNA, proteins, and cells that are the building blocks of entire biological systems.
  – SC also supports science for energy—advancing a clean energy agenda through fundamental research on energy production, conversion, storage, transmission, and use, and through advancing our understanding of the earth.

• Continue operations of the national laboratories
  – SC oversees the operation of ten DOE national laboratories. SC conducts a formal laboratory strategic planning process annually with its labs to understand future directions, immediate and long-range challenges, and resource needs. SC also conducts an annual evaluation of the scientific, technological, managerial, and operational performance of the management and operating contractors of its laboratories. In addition, SC funds mission-ready infrastructure and investments that foster safe and environmentally responsible operations at the labs.
    – Increase funding for Exascale Computing

• Maintain all on-going projects and start two new construction projects
### Office of Science FY 2018 President’s Request
(Dollars in thousands)

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<tbody>
<tr>
<td>Advanced Scientific Computing Research</td>
<td>621,000</td>
<td>621,000</td>
<td>619,819</td>
<td>647,000</td>
<td>+101,010 +16.3%</td>
<td>+75,010 +11.6%</td>
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<tr>
<td>Basic Energy Sciences</td>
<td>1,849,000</td>
<td>1,849,000</td>
<td>1,845,485</td>
<td>1,871,500</td>
<td>-294,500 -15.9%</td>
<td>-317,000 -16.9%</td>
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<tr>
<td>Biological and Environmental Research</td>
<td>609,000</td>
<td>609,000</td>
<td>607,842</td>
<td>612,000</td>
<td>-317,000 -16.9%</td>
<td>-263,050 -43.0%</td>
</tr>
<tr>
<td>Fusion Energy Sciences</td>
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<td>438,000</td>
<td>437,167</td>
<td>380,000</td>
<td>-58,060 -13.6%</td>
<td>-58,060 -18.4%</td>
</tr>
<tr>
<td>High Energy Physics</td>
<td>795,000</td>
<td>795,000</td>
<td>793,489</td>
<td>825,000</td>
<td>-75,000 -9.7%</td>
<td>-75,000 -9.7%</td>
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<tr>
<td>Nuclear Physics</td>
<td>617,100</td>
<td>617,100</td>
<td>615,927</td>
<td>622,000</td>
<td>-64,000 -10.4%</td>
<td>-64,000 -10.4%</td>
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<tr>
<td>Workforce Development for Teachers and Scientists</td>
<td>19,500</td>
<td>19,500</td>
<td>19,463</td>
<td>19,500</td>
<td>-500 -2.6%</td>
<td>-500 -2.6%</td>
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<tr>
<td>Science Laboratories Infrastructure</td>
<td>113,600</td>
<td>113,600</td>
<td>113,384</td>
<td>130,000</td>
<td>-66,400 -5.7%</td>
<td>-66,400 -5.7%</td>
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<tr>
<td>Safeguards and Security</td>
<td>103,000</td>
<td>103,000</td>
<td>102,805</td>
<td>103,000</td>
<td>-150 -1.4%</td>
<td>-150 -1.4%</td>
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<tr>
<td>Program Direction</td>
<td>185,000</td>
<td>185,000</td>
<td>184,648</td>
<td>182,000</td>
<td>-360 -1.9%</td>
<td>-360 -1.9%</td>
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<tr>
<td>Subtotal, Science</td>
<td>5,350,200</td>
<td>5,350,200</td>
<td>5,340,029</td>
<td>5,392,000</td>
<td>4,472,516 -16.4%</td>
<td>-919,484 -17.1%</td>
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<tr>
<td>Recission of Prior Year Balances</td>
<td>-3,200</td>
<td>-3,200</td>
<td>-3,194</td>
<td>-239</td>
<td>... +3,200 100.0%</td>
<td>+239 100.0%</td>
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<tr>
<td>Total, Science Appropriation</td>
<td>5,347,000</td>
<td>5,347,000</td>
<td>5,336,835</td>
<td>5,391,761</td>
<td>4,472,516 -16.4%</td>
<td>-919,245 -17.0%</td>
</tr>
</tbody>
</table>

*The FY 2016 Enacted column printed in the FY 2018 Congressional Budget Justification (President’s Request) includes SBIR/STTR funding in the program lines and reflects programmatic updates through the end of the fiscal year.

b This column provides the Annualized CR amount (CR through April 28, 2017; P.L. 114-254). It is calculated by reducing the FY 2016 Enacted by 0.1901%
HEP FY 2018 President’s Budget Request

- The 2018 President’s Budget Request for HEP is an overlay of:
  - Administration priorities
  - SC priorities (interagency partnerships, national laboratories, accelerator R&D, FACET-II, Quantum Information Science as a new SC initiative)
  - P5 priorities (preserve vision, modify execution)

- FY18 Budget Request reduces near-term science for P5-guided investments in mid- and long-term program
  - All projects continue, some with delays
  - Research maintained at 40% of the program budget
  - Operations support for ongoing experiments reduced to make this possible

- The new administration supports the overall P5 strategy

<table>
<thead>
<tr>
<th>HEP Funding ($ in thousands)</th>
<th>FY 2016 Enacted</th>
<th>FY 2017 Annualized CR</th>
<th>FY 2017 Enacted</th>
<th>FY 2018 Request</th>
<th>FY 2018 vs. FY 2016</th>
<th>FY 2018 vs. FY 2017 Enacted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>341,663</td>
<td>352,344</td>
<td>347,852</td>
<td>272,887</td>
<td>-68,776</td>
<td>-74,965</td>
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<tr>
<td>Facility/Operations</td>
<td>258,236</td>
<td>252,084</td>
<td>255,162</td>
<td>213,813</td>
<td>-44,423</td>
<td>-41,349</td>
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<tr>
<td>Projects &amp; Constr.</td>
<td>195,101</td>
<td>189,061</td>
<td>221,986</td>
<td>186,000</td>
<td>-9,101</td>
<td>-35,986</td>
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<tr>
<td>Total</td>
<td>795,000</td>
<td>793,489</td>
<td>825,000</td>
<td>672,700</td>
<td>-122,300</td>
<td>-152,300</td>
</tr>
</tbody>
</table>

HEP FY 2018 Budget Request
FY 2018 Request for HEP guided by priorities of Administration, Office of Science, and P5 report strategy

- Currently in the midst of “Building for Discovery” to support the future program
- Highest priority P5 projects supported with least adjustment possible to scope and schedule
- Other efforts across Research, Facility Operations, and Projects have scope reduced or schedules delayed, based on factors including the P5 report strategy and project maturity
HEP FY18 President’s Budget Highlights

- **Energy Frontier:** Actively engage in successful LHC program and High-Luminosity LHC (HL-LHC) upgrades
  - P5’s highest priority near-term large projects are the High-Luminosity Large Hadron Collider (HL-LHC) Accelerator Upgrade (new MIE start) and HL-LHC ATLAS & CMS detector upgrades

- **Intensity Frontier:** Support establishing a U.S.-hosted world-leading neutrino program
  - LBNF/DUNE is the highest P5 priority in its time frame and FY 2018 investments in initial far-site construction are crucial to enable scheduled delivery of contributions from international partners

- **Cosmic Frontier:** Advance understanding of dark matter and dark energy
  - P5 recommended a complementary suite of projects to study dark matter and dark energy and to support CMB experiments as part of core program
P5 was charged to consider three 10-year budget scenarios for HEP within the context of a 20-year vision for the global field

- Scenario A was the lowest constrained budget scenario
- Scenario B was a slightly higher constrained budget scenario
- Scenario C was “unconstrained,” but not considered unlimited

FY 2018 President’s Budget Request was generated under tight time constraints as a formulation plan that reflects the P5 vision

- More time is necessary to reformulate the long-term execution plan for P5 at this funding level

HEP Budget vs. P5 Funding Scenarios

HEP FY 2018 Budget Request
FY18 Request: Projects and New Initiatives

- P5 strategy balances small & large projects, provides continuous science output. Adjustments based on factors including P5 strategy, project maturity:
  - Projects fully supported in FY 2018 according to planned funding profile: Muon to Electron Conversion (Mu2e), LSST camera, and LZ direct-detection dark matter
  - Projects adjusted in FY 2018 with respect to profiles in latest DOE Critical Decision reviews (will coordinate with other SC offices, agencies, international partners):
    - *LBNF/DUNE* investment growth slowed; investments made are necessary to enable international contributions
    - *Proton Improvement Plan II (PIP-II)* for Fermilab Accelerator Complex is slowed
    - *High-Luminosity LHC (HL-LHC) Accelerator Upgrade Project* and *HL-LHC ATLAS* and *CMS* detector upgrade projects are minimally adjusted
    - *SuperCDMS-SNOLAB* will be delayed as it transitions from design to fabrication
    - *DESI* project will be rebaselined
    - *FACET-II* accelerator project will be delayed, requiring coordination with the BES *LCLS-II* project to plan a new schedule for installation

- New initiatives
  - *HL-LHC Accelerator Upgrade Project* is a new start Major Item of Equipment (MIE) in FY 2018
  - *Quantum Information Science (QIS)* is a new area of HEP emphasis in the SC and national program, and includes quantum computing and foundational QIS, quantum sensor technology, and small experiments exploiting entanglement.
• In the midst of “Building for Discovery” for the future, must keep P5 projects moving forward
  – Research and Facilities Operations are adjusted in order to maintain project support
• FY 2018 Request will reduce Research activities at the National Laboratories and Universities, with higher priority given to:
  – Laboratory research programs that are critical to executing the P5 recommendations
  – R&D that requires long-term investments (i.e., “seeding the future”) including Accelerator Stewardship, Detector R&D, and Quantum Information Science (QIS)
• FY 2018 Request provides reduced funding for the Fermilab Accelerator Complex to operate and support the neutrino and muon experiments
  – FY 2018 experiment operations will include NOvA, MicroBooNE, ICARUS, and Muon g-2
  – Proposal to run 1,800 hours of Fermilab Accelerator Complex operations (37.5% of optimal 4,800) will require further discussion with Fermilab regarding program impacts
Quantum Information Science (QIS)

• QIS identified as a national (interagency) and Office of Science priority
• HEP QIS emphasis (both near-term and long-term) is on:
  – P5 science drivers – exploiting entanglement and QIS technology
  – New computational and foundational techniques via QIS
  – Advancing the national QIS enterprise
• Approach: Interdisciplinary partnerships via connections with other SC programs and/or other federal agencies
• Areas of focus for HEP research via coordinated partnerships:
  – Quantum Computing and Foundational QIS
    • Simulations, entanglement, algorithms, machine learning, data analysis on qubit systems
  – Quantum Sensor Technology
    • Sensors developed in alignment with qubit technology that expand the measurement ranges for experiments
  – Experiments Exploiting Quantum Entanglement
    • New windows on research utilizing QIS foundations, tools, and techniques
• Reports available at:
  – http://science.energy.gov/hep/community-resources/reports/
• Program Manager: Lali Chatterjee
Closing Remarks

• In the immediate future:
  – Keep “Building for Discovery!”
    • The FY 2018 Budget Request supports all P5 projects, with some on a delayed schedule
  – Keep producing great science!
  – Communicate your concerns with us

• In the coming months:
  – Keep producing great science!
  – It is unknown what the final appropriation will be, but we must be ready to execute come October 1, 2017
    • HEP will work with laboratory management to prepare to execute the FY 2018 President’s Budget Request
    • HEP will work with Project Managers to examine multiple scenarios so we are prepared to execute the eventual appropriation
# HEP FY18 President’s Budget Request by Activity

<table>
<thead>
<tr>
<th>HEP Funding Category ($ in K)</th>
<th>FY 2016 Enacted</th>
<th>FY 2017 Enacted</th>
<th>FY 2018 Request</th>
<th>Explanation of Changes (FY18 vs. FY16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>341,663</td>
<td>347,852</td>
<td>272,887</td>
<td>Higher priority for lab efforts critical to P5 and R&amp;D requiring long-term investments (Acc. Stewardship, Det. R&amp;D, QIS)</td>
</tr>
<tr>
<td>SBIR/STTR</td>
<td>20,847</td>
<td>22,279</td>
<td>18,680</td>
<td>In FY 2018, SBIR/STTR funding will be assumed to be 3.65% of non-capital funding</td>
</tr>
<tr>
<td>Facilities</td>
<td>258,236</td>
<td>255,162</td>
<td>213,813</td>
<td>Reduced to support critical P5 projects</td>
</tr>
<tr>
<td>Projects</td>
<td>129,001</td>
<td>128,486</td>
<td>86,700</td>
<td></td>
</tr>
<tr>
<td>Energy Frontier Projects</td>
<td>21,085</td>
<td>24,017</td>
<td>39,000</td>
<td>HL-LHC AUP (FY18 MIE start) and HL-LHC ATLAS and CMS detector upgrades</td>
</tr>
<tr>
<td>Intensity Frontier Projects</td>
<td>29,001</td>
<td>21,569</td>
<td>14,100</td>
<td>PIP-II OPC and LBNF OPC</td>
</tr>
<tr>
<td>Cosmic Frontier Projects</td>
<td>64,600</td>
<td>73,700</td>
<td>31,600</td>
<td>Planned profile for LSSTCam and LZ. Delay SuperCDMS-SNOLAB, rebaseline DESI.</td>
</tr>
<tr>
<td>Other Projects</td>
<td>2,100</td>
<td>3,500</td>
<td>2,000</td>
<td>Delayed schedule for FACET-II</td>
</tr>
<tr>
<td>Construction (Line Item)</td>
<td>66,100</td>
<td>93,500</td>
<td>99,300</td>
<td>Planned profile for Mu2e. Slight LBNF/DUNE increase, but delay vs. CD-3A schedule.</td>
</tr>
</tbody>
</table>

**Total** 795,000* 825,000 672,700

* SBIR/STTR added to FY 2016 for comparison to FY 2017/2018