# The Administration's Proposed Budget for Fusion Energy Sciences in FY 2015

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Office of Science, U.S. Department of Energy

March 7, 2014

U.S. DEPARTMENT OF ENERGY | Office of Science

# *This proposal reflects a commitment to burning plasma science domestically and internationally, but also concern about the international ITER Project*

- **The US is committed to the goals of ITER, but is concerned about the status and progress of the project.** While the US ITER Project is performing well, review and on-the-ground assessments reveal that ITER has significant problems to overcome. This proposal supports the Administration commitment to meeting the FY 2015 needs of the project while accounting for weak international project execution. The Administration is focused on doing what it can to improve international project execution.

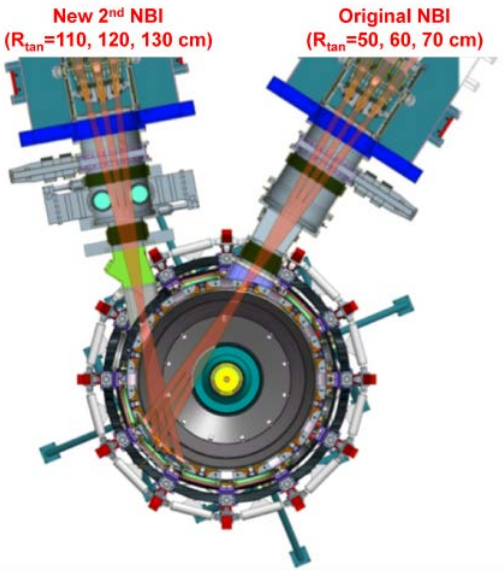
- **This budget supports the completion and a vigorous run campaign on NSTX-U.** Following project completion, 18 weeks of run time are supported for this upgrade. Together with DIII-D, NSTX-U will enable an assessment this decade of scientific and technical issues that will help determine the mission and risk profile for either geometry in supporting a fusion nuclear science mission

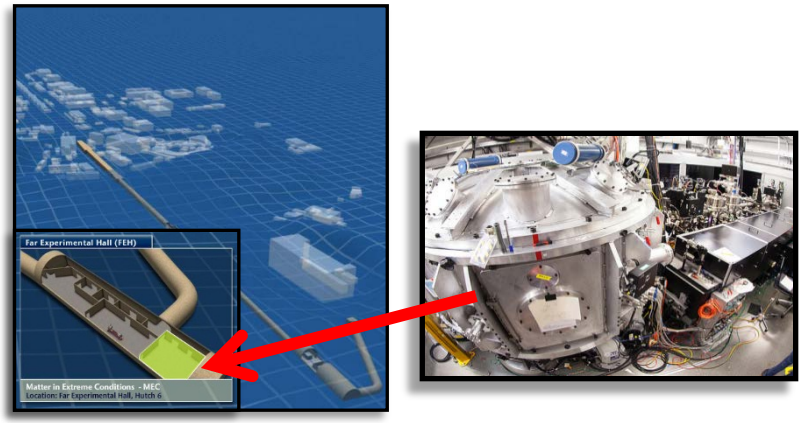
- **Alcator C-Mod research is supported for 5 weeks of operations**. Experiments will be conducted on the facility that are relevant to the ITER program and that support graduate student research

- **There is no support this year for the HEDLP joint program with NNSA.** However, some joint FES/NNSA work that has been forward-funded will continue. Also, the emergent MEC station at LCLS is poised with one-of-a-kind capability.

U.S. DEPARTMENT OF ENERGY
Office of Science

# *Upgrades and improvements make these FES national facilities best in class*




## NSTX-Upgrade (PPPL)

- Upgrade construction project will be completed and research operations will resume in early FY 2015
- The upgrade will double the magnetic field strength, the plasma current, and the externally applied heating power, and will lengthen the operation period from one to five seconds, making NSTX-Upgrade the highest-performance spherical torus experiment in the world.

## Matter in Extreme Conditions (MEC) instrument, on LCLS (SLAC)

- MEC provides access to high-energy-density regimes, coupled with the LCLS high-brightness x-ray source
- A recent upgrade of the short-pulse lasers to 200 TW will allow scientific users to perform up to four weeks of stand-alone experiments on MEC, in addition to experiments with LCLS x-ray beam

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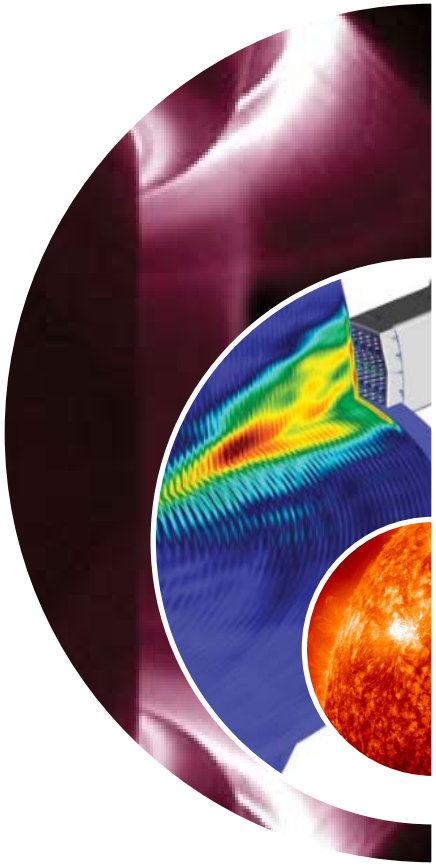
# *Organizing along scientific topical lines can help align university and large facility interests with national mission needs*



## *Burning Plasma Science*

***New budget structure being developed in FES***

### Foundations

Focusing on domestic capabilities; major and university facilities in partnership, targeting key scientific issues. Theory and computation focus on questions central to understanding the burning plasma state

***Challenge***: Understand the fundamentals of transport, macro-stability, wave-particle physics, plasma-wall interactions

### Long Pulse

Building on domestic capabilities and furthered by international partnership

***Challenge***: Establish the basis for indefinitely maintaining the burning plasma state including: maintaining magnetic field structure to enable burning plasma confinement and developing the materials to endure and function in this environment

### High Power

ITER is the keystone as it strives to integrate foundational burning plasma science with the science and technology girding long pulse, sustained operations.

***Challenge***: Establishing the scientific basis for attractive, robust control of the self-heated, burning plasma state

## *Discovery Science*

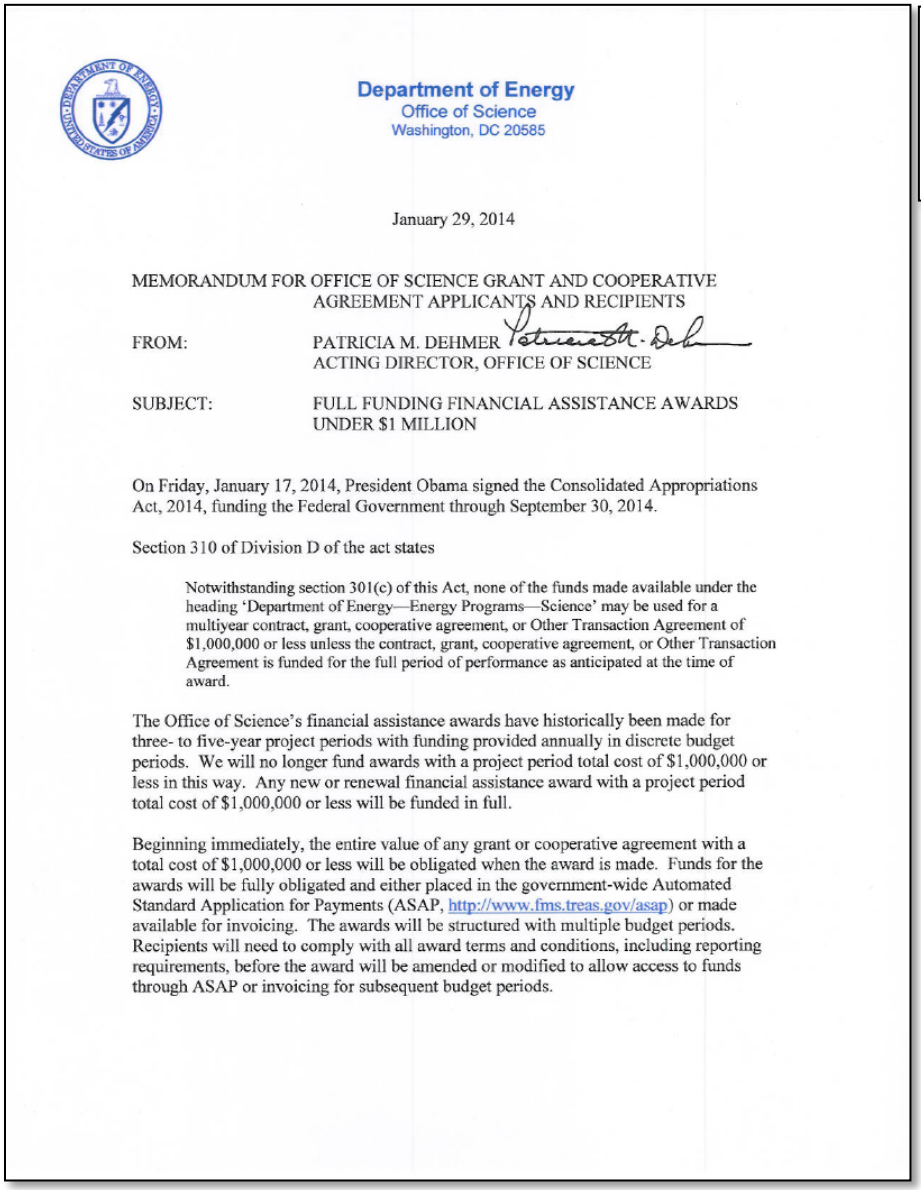
### Plasma Science Frontiers and Measurement Innovation

General plasma science, non-tokamak and non-stellarator magnetic confinement, HEDLP, and diagnostics

U.S. DEPARTMENT OF ENERGY

Office of Science

# There is a recently enacted requirement for full funding of contracts, grants, or cooperative agreements totalling less that $1M



Department of Energy
Office of Science
Washington, DC 20585

January 29, 2014

MEMORANDUM FOR OFFICE OF SCIENCE GRANT AND COOPERATIVE AGREEMENT APPLICANTS AND RECIPIENTS

FROM: PATRICIA M. DEHMER
ACTING DIRECTOR, OFFICE OF SCIENCE

SUBJECT: FULL FUNDING FINANCIAL ASSISTANCE AWARDS UNDER $1 MILLION

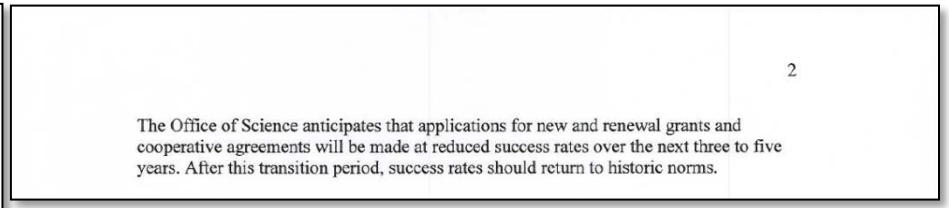
On Friday, January 17, 2014, President Obama signed the Consolidated Appropriations Act, 2014, funding the Federal Government through September 30, 2014.

Section 310 of Division D of the act states

> Notwithstanding section 301(c) of this Act, none of the funds made available under the heading 'Department of Energy—Energy Programs—Science' may be used for a multiyear contract, grant, cooperative agreement, or Other Transaction Agreement of $1,000,000 or less unless the contract, grant, cooperative agreement, or Other Transaction Agreement is funded for the full period of performance as anticipated at the time of award.

The Office of Science's financial assistance awards have historically been made for three- to five-year project periods with funding provided annually in discrete budget periods. We will no longer fund awards with a project period total cost of $1,000,000 or less in this way. Any new or renewal financial assistance award with a project period total cost of $1,000,000 or less will be funded in full.

Beginning immediately, the entire value of any grant or cooperative agreement with a total cost of $1,000,000 or less will be obligated when the award is made. Funds for the awards will be fully obligated and either placed in the government-wide Automated Standard Application for Payments (ASAP, http://www.fms.treas.gov/asap) or made available for invoicing. The awards will be structured with multiple budget periods. Recipients will need to comply with all award terms and conditions, including reporting requirements, before the award will be amended or modified to allow access to funds through ASAP or invoicing for subsequent budget periods.



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The Office of Science anticipates that applications for new and renewal grants and cooperative agreements will be made at reduced success rates over the next three to five years. After this transition period, success rates should return to historic norms.

The funding directed towards FES by Congress in FY 2014 is in part being used to mitigate the effects of a transition to this new way of funding.

This complicates the interpretation of funding levels enacted in FY 2014 as compared to those proposed for FY 2015

## Burning Plasma Science

# Foundations

**Advanced Tokamak (DIII-D, C-Mod) & Spherical Tokamak (NSTX-U)**

- *Highly collaborative; strong university partnerships*
- *Aim to lever scientific complementarity*

**Theory and Simulation**

- *US strength in engaging with experiment to develop predictive understanding*
- *Essential if high-risk gaps in fusion are to be closed*
- *Leverages DOE investments in leadership-class computing resources*

# DIII-D National Fusion Facility

The DIII-D research goal is to establish the scientific basis for the optimization of the tokamak approach to magnetic confinement fusion. This includes addressing near-term scientific issues for ITER and advanced operating scenarios, and important for the mission of a future Fusion Nuclear Science Facility.

| Research | FY'13 Sept AFP | FY '14 Current | FY'15 CONG Request |
|---|---|---|---|
| DIII-D | 32,617 | 30,998 | 32,038 |

| Operations | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| DIII-D | 31,461 | 43,960 | 37,385 |

## FY 2015 budget highlights

- **Research:** Conduct experiments to address milestones on the ITER disruption mitigation system, transport models and performance in ITER-like conditions, and integrated core-edge scenarios.
- **Facility Operations:** 15 weeks of operation, and support for some high-priority facility upgrades and system refurbishments.

# NSTX Upgrade

The NSTX program will contribute to science important for ITER and deepening understanding of plasma confinement, control, and optimization. This includes being used to evaluate the potential of the ST for achieving the high plasma performance required for a Fusion Nuclear Science Facility.

| Research | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| NSTX | 18,316 | 22,056 | 26,000 |

| Operations | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| NSTX | 12,293 | 16,600 | 33,884 |

| Construction Projects | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| NSTX Upgrade | 22,800 | 23,700 | 3,470 |

## FY 2015 budget highlights

- **NSTX Upgrade Project:** On track for project completion by or ahead of the agreed-upon baseline.
- **NSTX Facility Operations and Research:** Funding is ramped up to prepare the power supplies, diagnostics, auxiliary heating systems, etc., for rapid resumption of research operations upon project completion and to support 18 weeks of operation for the NSTX-U research program.

# Alcator C-Mod

The C-Mod research mission is to help establish the plasma physics and engineering requirements for a burning plasma tokamak experiment

| Research | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| Alcator C-Mod | 8,021 | 7,890 | 6,145 |

| Operations | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| Alcator C-Mod | 8,656 | 14,050 | 11,855 |

## FY 2015 budget highlights

- **Research:** Focus experiments on addressing high-priority issues of ITER-relevant boundary and divertor physics, including disruption studies.
- **Facility Operations:** 5 weeks of operation, and support for near-term facility upgrades and system refurbishments that will impact the research program in FY 2015 and FY 2016.

FES will engage with MIT to develop a path forward to a research program beyond the Alcator C-Mod closeout at the end of FY 2016

# Theory and SciDAC

Advance scientific understanding of fundamental physical processes governing the behavior of magnetically confined plasmas and develop predictive capability by exploiting leadership-class computing resources.

## FY 2015 budget highlights

| | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| Theory | 23,051 | 24,029 | 21,170 |
| SciDAC | 6,556 | 9,375 | 7,000 |

- **Theory**: Emphasis on research relevant to burning plasmas and ITER and on closing gaps in critical areas. Research activities in some areas will be reduced.
- **SciDAC**: Maintain support for continuing joint FES-ASCR partnerships.

## Burning Plasma Science

# Long Pulse

### Long-Pulse Tokamaks & Long-Pulse Stellarators

- *Using partnerships on international facilities where US expertise is valuable and desired*
- *Creating opportunities for continued US leadership this decade in areas critical to fusion science*
- *Generating access for our scientists and students to what are becoming leading research endeavors around the globe*

### Materials and Fusion Nuclear Science

- *Investments will enable US leadership in fusion nuclear materials science and plasma-material interactions*

# International Research

A new generation of international facilities provides exciting opportunities for U.S. scientists to collaborate on research on long-pulse control of high-performance plasmas, both tokamaks and stellarators.

| Research | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| International Research | 10,132 | 9,954 | 8,545 |

## FY 2015 budget highlights

- Funding will continue to support two U.S. research teams working on major international fusion research facilities in Asia and Europe.
- Funding will also support a research team to participate in international stellarator programs.

# Enabling R&D

The Enabling R&D subprogram addresses scientific challenges by developing and continually improving the hardware, materials, and technology incorporated into existing and next-generation fusion research facilities, allowing the exploration of new scientific regimes.

| | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| Plasma Technology | 10,686 | 12,922 | 11,910 |
| Advanced Design Studies | 1,231 | 1,400 | 1,500 |
| Materials Research | 11,503 | 9,969 | 8,550 |
| Total, Enabling R&D | 23,420 | 24,291 | 21,960 |

## FY 2015 budget highlights

- **Plasma Technology**: Research on fueling, heating, chamber technologies for fuel cycle development, and safe operation of future facilities.
- **Advanced Design Studies**: Identify ways to address the gaps in materials and nuclear science research and help crystallize the FNSF concept.
- **Materials Research**: Elucidate the complicated response of materials under extreme fusion conditions and provide critical data for future fusion devices.

Burning Plasma Science

# High Power

**US Contributions to the international ITER Project**

- U.S. ITER Project requirements and plans
- Concerns and approach regarding the international project

# *The state of play of the international ITER project prompts the Administration to slow the pace of contributions, but still meet the project's needs for FY 2015*

| Project construction | FY'13 Sept AFP | FY '14 Current | FY'15 CONG Request |
|---|---|---|---|
| U.S. ITER | 124,000 | 199,500 | 150,000 |

- Funding is provided for critical path items to ensure that U.S. in-kind contributions maintain U.S. commitments to FY 2015 project needs. Funding is provided for ITER Project Office operations, the U.S. cash contribution, and continued progress on in-kind contributions.

- **The U.S. ITER Project Office is on track** to deliver four shipments of toroidal field conductor to the toroidal field magnet fabricator, drain tanks for tokamak cooling water, and hardware for the steady-state electrical network. In addition, the U.S. ITER Project Office starts fabrication of the first central solenoid module, completes various design reviews for the vacuum auxiliary system, and awards subcontracts for diagnostic design work.

- **The funding request for the U.S. ITER Project** is driven by the U.S. best estimate of the ITER construction schedule. The requested level of funding will allow the U.S. to meet its obligations, based on the recent reviews, and will mitigate risk to the U.S. if the project schedule continues to slip.

# *The Administration has expressed its high level of unease with the status and progress of the international ITER Project and is working to right the ship*

- **Stance**: The U.S. has indicated to all the Members its high level of unease concerning the Project's progress. Factors informing this judgment include the ITER Management Assessment Report and on-the-ground observations enabled by US participation in leadership committees and the US IPO's engagement with the IO and the other Domestic Agencies.

- **Responses**: The U.S. is responding in a number of ways, including analysis of project execution between U.S. ITER and the IO and other Domestic Agencies, and discussions at high political levels.

- **Reforms**: Within the ITER Council, we have responded to the IO's proposals for a corrective action plan. Also, in concert with the new ITER Council Chair, the U.S. is introducing reforms to the way the Council performs. We are also insisting on acting on all of the recommendations of the Management Assessment; the other ITER Members have agreed to do so.

# Discovery Plasma Science

**Plasma Science Frontiers**

- *General plasma science portfolio: FES stewardship of non-MFE plasma science areas*
- *High energy density laboratory plasma research: matter at extreme conditions*
- *Small/intermediate-scale MFE experimental research: platforms for verification & validation, study plasma self-organization*

**Measurement Innovation**

- *High-impact R&D on new plasma diagnostic techniques*

# Experimental Plasma Research (EPR) & Madison Symmetric Torus (MST)

EPR provides data in regimes of relevance to mainline magnetic confinement and materials science efforts, supports V&V efforts, and contributes to discovery science. MST increases fundamental understanding of the RFP configuration and has an important place in V&V and discovery science.

| | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| MST | 5,750 | 5,700 | 5,900 |
| Experimental Plasma Research | 10,480 | 10,500 | 10,750 |

## FY 2015 budget highlights

- EPR: Examine range of magnetic confinement concepts to establish scientific connections and help establish experimentally validated predictive capability.

- MST: Measure the scaling of tearing mode fluctuations with current and temperature and support the validation of nonlinear MHD codes.

# General Plasma Science (GPS)

The GPS activity addresses questions related to fundamental plasma properties and processes through discovery-based investigations in basic and low-temperature plasma science.

| | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| General Plasma Science | 13,456 | 15,000 | 15,500 |

## FY 2015 budget highlights

- The Administration support for the NSF/FES Partnership is strong.
- All core research elements of the GPS program will continue.
- With input from the NRC Plasma Science Committee, the program will also explore supporting:
  - Multi-institutional teams targeting interdisciplinary connections.
  - Intermediate-scale facilities expanding experimentally accessible parameters and providing broad access to users.

# High Energy Density Laboratory Plasmas

High Energy Density Laboratory Plasma (HEDLP) involves cross-cutting research in areas ranging from laboratory astrophysics to materials under extreme conditions.

| | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| High Energy Density Laboratory Plasma | 17,295 | 17,315 | 6,700 |

## FY 2015 budget highlights

- HEDLP program will concentrate on research connected to MEC at LCLS, a world-leading capability for broad HEDLP science unique to the Office of Science.
- Contraction of the HEDLP program will result in:
  - No new academic grants as part of the SC/NNSA joint program in HEDLP science
  - No new or renewal research projects in basic HEDLP science at DOE national laboratories
  - The cessation of operations of the NDCX-II facility at LBNL.
- Elements of HEDLP are retained in General Plasma Science portfolio.

# FES portfolio activities

Diagnostics, the scientific instruments used to make detailed measurements of the behavior of plasmas, are key to advancing our ability to predict and control the behavior of fusion plasmas.

| | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| Diagnostics | 3,539 | 3,500 | 3,575 |
| Other | 4,408 | 11,562 | 2,508 |
| GPP/GPE | 1,525 | 5,900 | 3,125 |
| SBIR/STTR | 0 | 8,797 | 8,490 |

## FY 2015 budget highlights

- **Diagnostics**: Efforts will continue on developing innovative techniques to address current and emerging measurement needs in the FES program. A community-informed planning activity will be undertaken to assess the need for long pulse, plasma control, disruption, and burning plasma diagnostics.
- **Other**: Funding will continue to support USBPO activities, HBCUs, peer reviews for solicitations, and FESAC.
- **GPP/GPE**: Support for non-research infrastructure at PPPL will continue in order to upgrade and replace existing systems. Environmental monitoring needs at PPPL will be supported.
- **SBIR/STTR**: This is statutorily set at 3.3% of non-capital funding in FY 2015.

# Budget summary, FES

Fusion Energy Sciences
FY 2015 Congressional Budget
(Budget Authority in thousands)

| | FY 2013 Sept AFP | FY 2014 Current | FY 2015 Request |
|---|---|---|---|
| **Science** | | | |
| DIII-D Research | 32,617 | 30,998 | 32,038 |
| C-Mod Research | 8,021 | 7,890 | 6,145 |
| International Research | 10,132 | 9,954 | 8,545 |
| Diagnostics | 3,539 | 3,500 | 3,575 |
| Other | 4,408 | 11,562 | 2,508 |
| NSTX Research | 18,316 | 22,056 | 26,000 |
| Experimental Plasma Research | 10,480 | 10,500 | 10,750 |
| HEDLP | 17,295 | 17,315 | 6,700 |
| MST Research | 5,750 | 5,700 | 5,900 |
| Theory | 23,051 | 24,029 | 21,170 |
| SciDAC | 6,556 | 9,375 | 7,000 |
| General Plasma Science | 13,456 | 15,000 | 15,500 |
| SBIR/STTR | 0 | 8,797 | 8,490 |
| **Total, Science Research** | **153,621** | **176,176** | **154,321** |

| | FY 2013 Sept AFP | FY 2014 Current | FY 2015 Request |
|---|---|---|---|
| **Facility Operations** | | | |
| DIII-D | 31,461 | 43,960 | 37,385 |
| C-Mod | 8,656 | 14,050 | 11,855 |
| NSTX | 12,293 | 16,600 | 33,884 |
| MIE: NSTX Upgrade | 22,800 | 23,700 | 3,470 |
| Other, GPE, and GPP | 1,525 | 5,900 | 3,125 |
| MIE: U.S. Contributions to ITER Project | 124,000 | 0 | 0 |
| **Total, Facility Operations** | **200,735** | **104,210** | **89,719** |
| **Enabling R&D** | | | |
| Plasma Technology | 10,686 | 12,922 | 11,910 |
| Advanced Design | 1,231 | 1,400 | 1,500 |
| Materials Research | 11,503 | 9,969 | 8,550 |
| **Total, Enabling R&D** | **23,420** | **24,291** | **21,960** |
| **Construction (ITER)** | **0** | **199,500** | **150,000** |
| **Total, Fusion Energy Sciences** | **377,776** | **504,677** | **416,000** |

# Regarding the upcoming FESAC meeting…

- Next meeting is April 9 and 10, Rockville MD Hilton Hotel
- Fuller discussion of this budget proposal
- ITER and the state of play: policy and project execution
- Charges
  - Discussion of strategic planning process and charge
  - Charge for a COV
  - The recent charge on workforce development

# *Thank you*