# FES Update and the FY 2015 Budget Proposal

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## Fusion Energy Sciences

U.S. DEPARTMENT OF ENERGY

Office of Science

Presented to FESAC
April 9, 2014

http://science.energy.gov/fes

# *Welcome, and thank you all*

- This is a critical time for the program
- The program has to evolve, yet the Administration's budget outlook is challenging
- ITER has immense challenges, yet it is the vehicle for our next step

The place of FESAC for giving sound advice will be important in enabling us to develop our path

# Outline for this meeting

- This morning: I would like to talk about the FY 2015 budget proposal from the Administration; the choices made, the relation to FY 2014

  I would like to talk about this in the framework of future budget proposals and our future Strategic Plan

- This afternoon I will talk further about the Strategic Plan charge, and the process I will be asking you to follow as we seek your advice

- We will talk about ITER, policy and status (me; Sauthoff)

- Access to federally funded research (Biven)

- Tomorrow: Charge, workforce development; COV; Lab Astro (Ji)

- We will hear perspectives from ASCR (Steve Binkley)

# *But first… let me express some gratitude*

## Statement of Recognition for Albert L. Opdenaker

In recognition of 24 years of dedicated service as the Federal representative to the Fusion Energy Sciences Advisory Committee (FESAC). Your diligent efforts serving several Associate Directors of the Office of Science for Fusion Energy Sciences and interfacing with numerous FESAC members have been instrumental in enabling the Committee to give expert advice to the Department concerning the fusion energy sciences program. Your service for many years to the Committee and its members is sincerely appreciated.

# More gratitude

**Thanks to John Sauter, who retired Dec 31, 2013**

- 20 years service in U.S. Navy; rose to Senior Chief Petty Officer
- 5 years service as associate executive director, YMCA (Brunswick, MD)
- 20 years service as Program Analyst, FES, USDOE: responsibility for all procurements (grants, cooperative agreements, interagency agreements, and contracts)

# This has been a complex time

## Budget motion

| | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| Office of Science | $4621M | $5066M | $5111M |
| FES | $378M | $505M | $416M |

**Request** total $398M; ITER $150M; non-ITER $248M

Then CR, sequestration, reprogramming…
➔ **Enacted** $378M; ITER $124M; non-ITER $254M

**Request** total $416M; ITER $150M; non-ITER $266M
**Enacted** ?

**Request** total $458M; ITER $225M; non-ITER $233M

**Enacted** $505M; ITER $200M; non-ITER $305M

***What do we make of all of this?***

# What do we make of all of this?

**The Administration is committed to having a balanced program**

- Proposal to cap U.S. ITER at $225M in FY 2014 plan
- CR/Sequestration resource shift in FY 2013 led to growth in non-ITER program, reducing U.S. ITER

**The U.S. is committed to the science of ITER, but it will not issue a blank check**

- In the last year, it became painfully clear that the project has major challenges. I will discuss the state of play and U.S. actions
- The $150M is appropriate due to the lack of an IO ITER schedule
- From the Administration standpoint, shifts between ITER and the rest of the program are not zero sum

**There is considerable good will on the Hill for fusion, but patience is being taxed**

- There is a desire for a realistic assessment of needs for ITER and for U.S. fusion
- ITER and NIF challenges are both having challenges


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# The Administration view

**Change is essential in the FES program in the coming years if long-term goals are to be met and if credibility is going to be retained or grown within the Administration and outside of it. This includes both ITER and the rest of the program.**

Over the next decade, maintaining the status quo for the non-ITER program presents risks in itself, even if the level of effort is kept constant

In the near term, getting ITER right is critical


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# FES can respond to enduring forces

**Budgets from the Administration for fusion will continue to be tougher than most would like**

**Nonetheless, wonderful opportunities are available even in tight budgets if**

- a clear vision is articulated and understood
- nascent resources are identified and captured
  - leverage needs to be utilized – cross-SC, cross-agency, internationally


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# *We will be working with you towards a strategic plan*

**Charge issued; to be discussed this afternoon**

**Your task will be to recommend priorities to ensure that:**

*The U.S. will assert leadership in scientific frontiers required to establish a validated, predictive capability in burning plasma fusion science, fusion materials science, and exploratory laboratory plasma research*


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# FY 2015 Congressional Budget Request
## (described in the proposed new budget structure)

# Full funding is required for the Office of Science

- **Congressional directive**
  - *"…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."* [FY 2014 Appropriation Act]

- **Current policy**
  - Any grant or cooperative agreement whose total amount is less than $1M must be fully obligated in the year awarded, starting in FY 2014

- **Impact of the transition to full funding**
  - Office of Science memo (Jan 30, 2014): "*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 the transition period, success rates should return to historic norms*."
  - FY 2014 FES Enacted Budget largesse is being used for this transition

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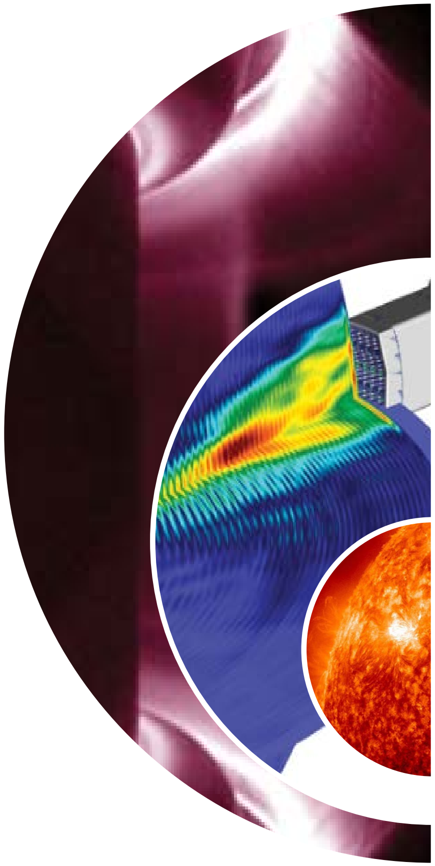
# Organizing along scientific topical lines can help align community interests with national mission needs



## *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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## Burning Plasma Science

# Foundations

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

- *Highly collaborative; strong university partnerships*
- *High scientific complementarity between these facilities*
- *High potential for growing student engagement on our nation's major fusion science experimental facilities*

**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*


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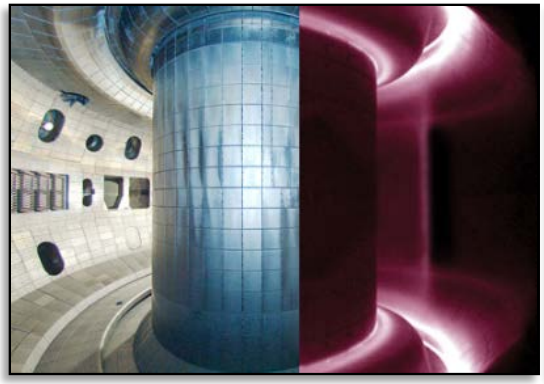
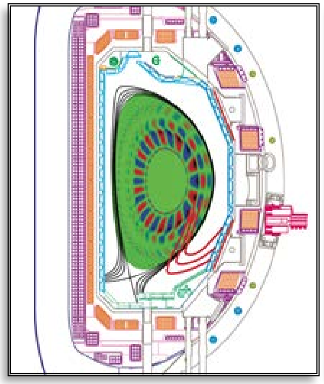
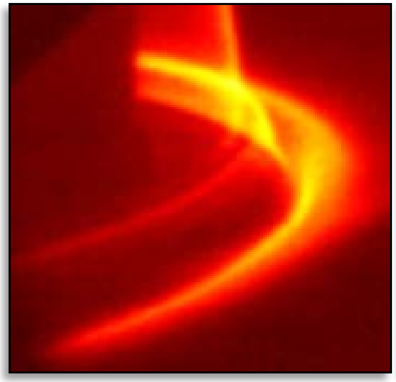
# The DIII-D tokamak: Overview







20 graduate students, 14 post docs

## The DIII-D facility (General Atomics)

The DIII-D user facility is the largest magnetic fusion research experiment in the U.S. and can magnetically confine plasmas at temperatures relevant to burning plasma conditions.  Researchers from the U.S. and abroad are able to perform experiments on DIII-D for studying stability, confinement, and other properties of fusion-grade plasmas under a wide variety of conditions.

The DIII-D research goal is to establish the scientific basis for the optimization of the tokamak approach to magnetic confinement fusion. Much of this research concentrates on the development of the advanced tokamak concept, in which active control techniques are used to manipulate and optimize the plasma to obtain conditions scalable to robust operating points and high fusion gain for ITER and future fusion reactors. Near-term targeted efforts address scientific issues important to the ITER design. Longer-term research is focused on advanced scenarios to maximize ITER performance. Another high-priority DIII-D research area is foundational fusion science, pursuing a basic scientific understanding across all fusion plasma topical areas.



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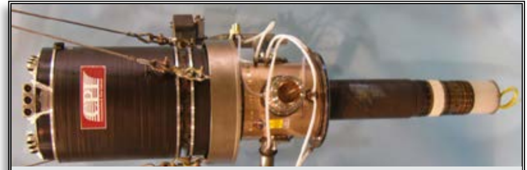
# DIII-D National Fusion Facility

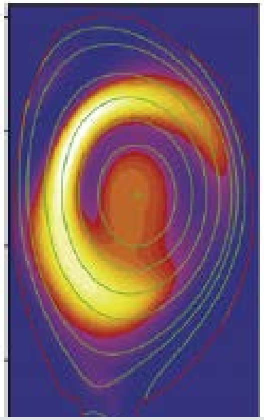
The DIII-D research goal is to establish the scientific basis for the optimization of the tokamak approach to magnetic confinement fusion. This includes addressing near-term scientific issues for ITER and advanced operating scenarios, and is important for the mission of a future Fusion Nuclear Science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

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

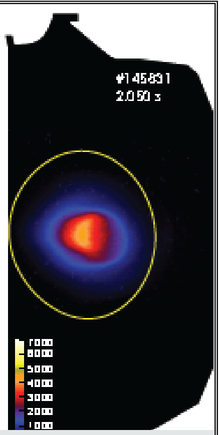
| Operations | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| DIII-D | 31,461 | 43,960 | 37,385 |



Electron cyclotron heating gyrotron



Thermal quench

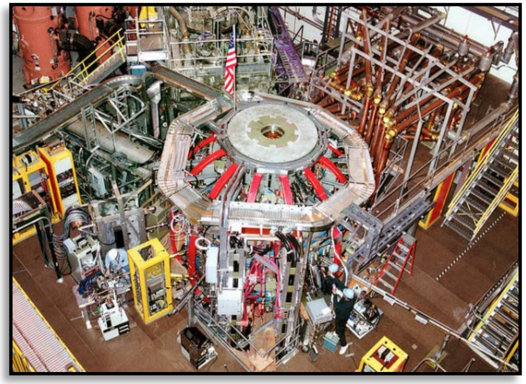


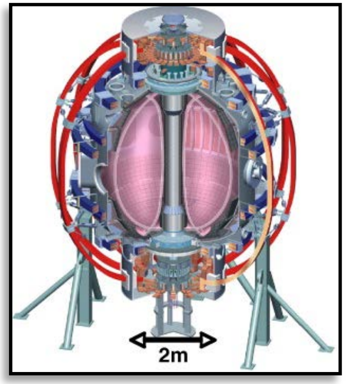

Runaway electrons

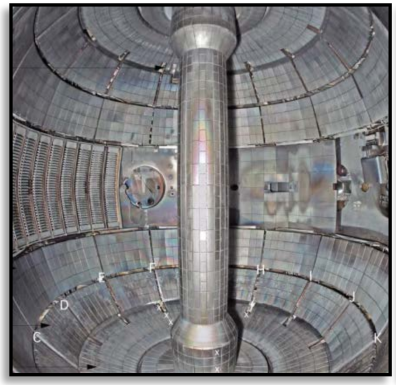
## FY 2015 budget highlights

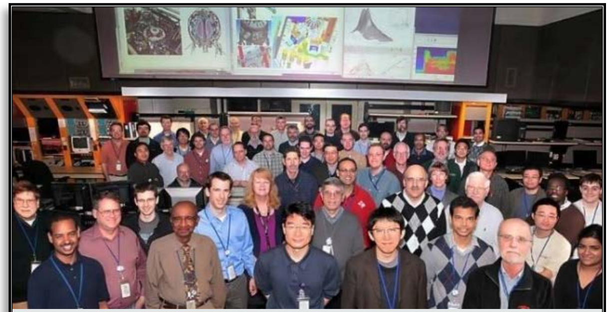
- **Research:** Conduct experiments to address milestones on the ITER disruption mitigation system, transport models and performance in ITER-like conditions, and integrated core-edge scenarios.
- **Facility Operations:** 15 weeks of operation, and support for some high-priority facility upgrades and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

# National Spherical Torus Experiment Upgrade (NSTX-U): Overview







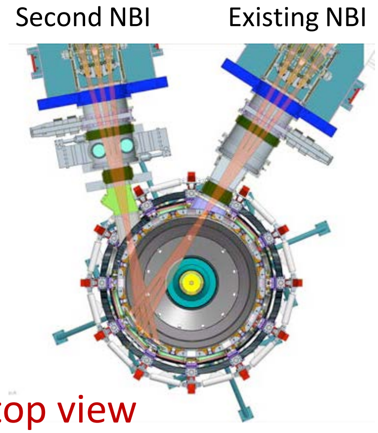
31 graduate students, 16 post docs

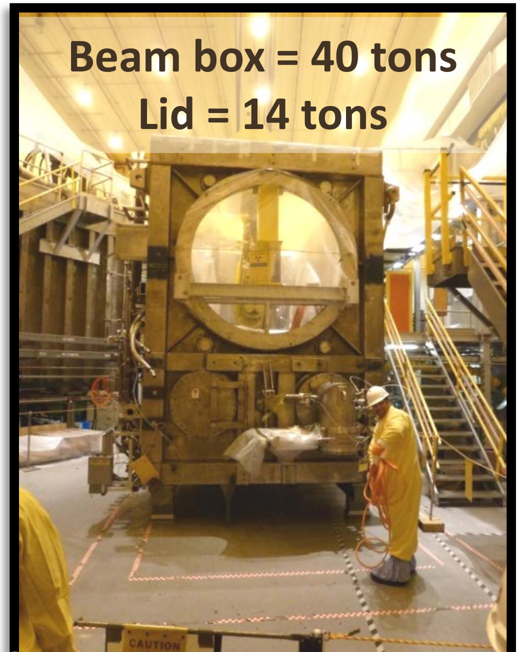
## The NSTX-U facility (PPPL)

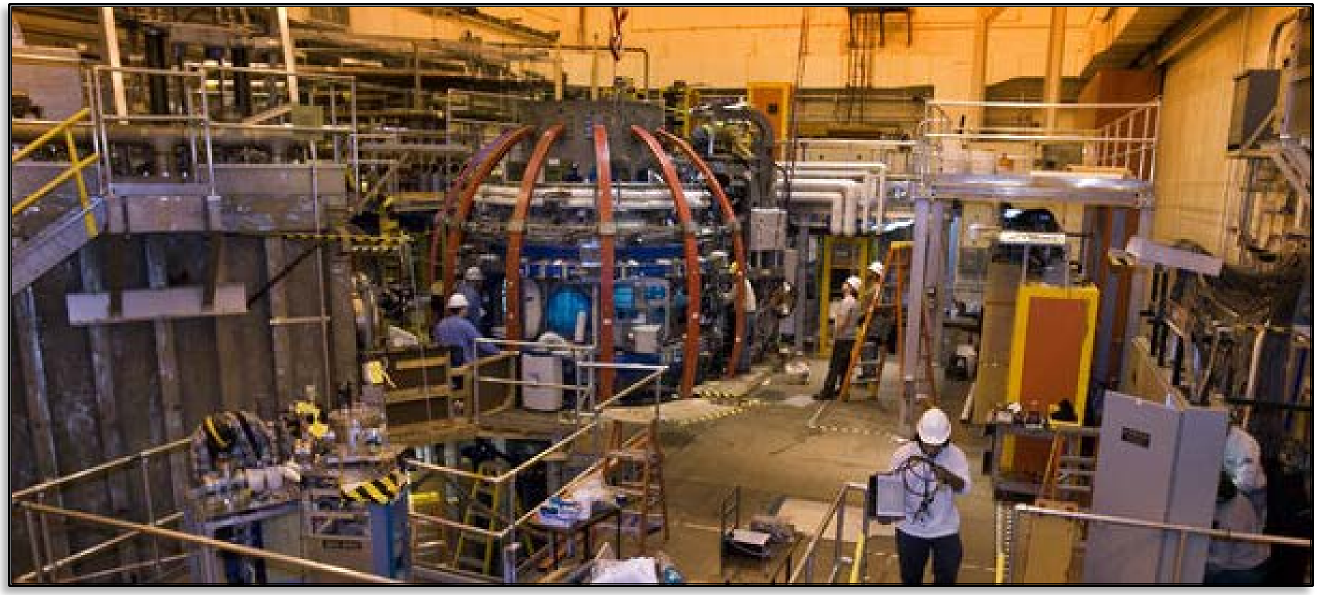
The NSTX user facility is an innovative fusion science facility at the Princeton Plasma Physics Laboratory (PPPL) based on a spherical torus (ST) confinement configuration. A major advantage of this configuration is the ability to confine plasma with pressure that is high compared to the magnetic field energy density, which could lead to the development of an efficient fusion nuclear science experiment based on the ST configuration.

The NSTX Upgrade is currently underway and will be completed early in FY 2015. The upgrades will enable a doubling of the magnetic field and plasma current and an increase in the plasma pulse length from 1 to 5 seconds, making NSTX the world's highest-performing ST. Together, these upgrades will support a strong research program to develop the improved understanding of the ST configuration required to broaden scientific understanding of plasma confinement, and maintain U.S. world leadership in ST research.

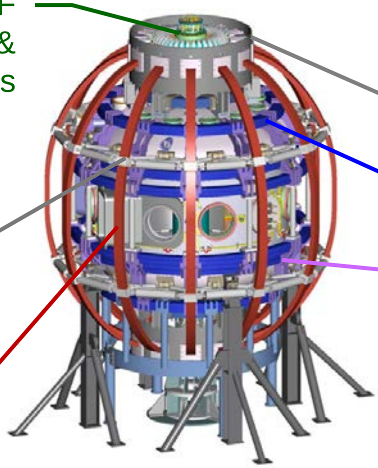
# NSTX: Upgrade project is going well



## Upgrades:




Also… modify coil power system, protection system & ancillary support systems

# NSTX

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 |

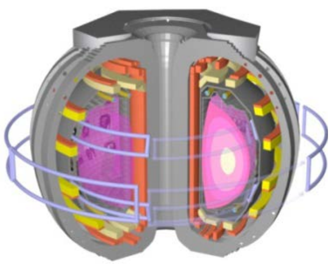
| Construction Projects | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| NSTX Upgrade | 22,800 | 23,700 | 3,470 |

## 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.

# DIII-D and NSTX are a scientifically powerful pair

DIII-D NATIONAL FUSION FACILITY



NSTX-U

## Core Contributions

**DIII-D:**

- Transport in ITER burning plasma regime
- Advanced scenarios
- Dynamics and control of self-sustained plasmas

**NSTX-U:**

- Fast ion parameter space overlaps and extends beyond ITER in $V_{fast}/V_{alfven}$ and $\beta_{fast}/\beta_{tot}$
- Power and particle exhaust

## Key Physics Parameters

- ✔ Aspect ratio
- ✔ Normalized size
- ✔ Collisionality
- ✔ High $\beta$
- ✔ Rotational shear
- ✔ Electron gyroradius
- ✔ Sub- versus super-Alfvénic energetic ions
- ✔ $T_e$ / $T_i$

*Together*, these facilities provide access to an extended range of key physics parameters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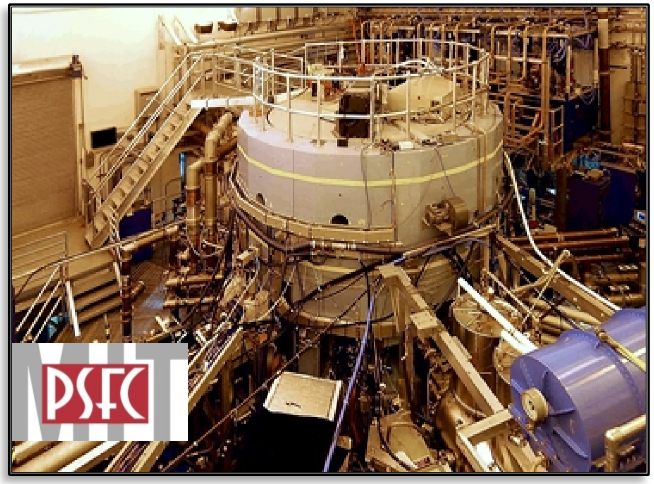
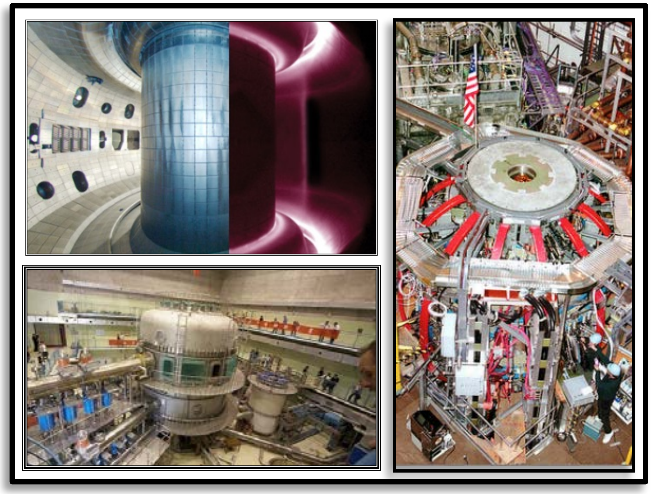
# Alcator C-Mod FY 2015 research and facility operations plans



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

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.



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

Focus experiments on addressing high-priority issues of ITER-relevant boundary and divertor physics, including disruption studies.

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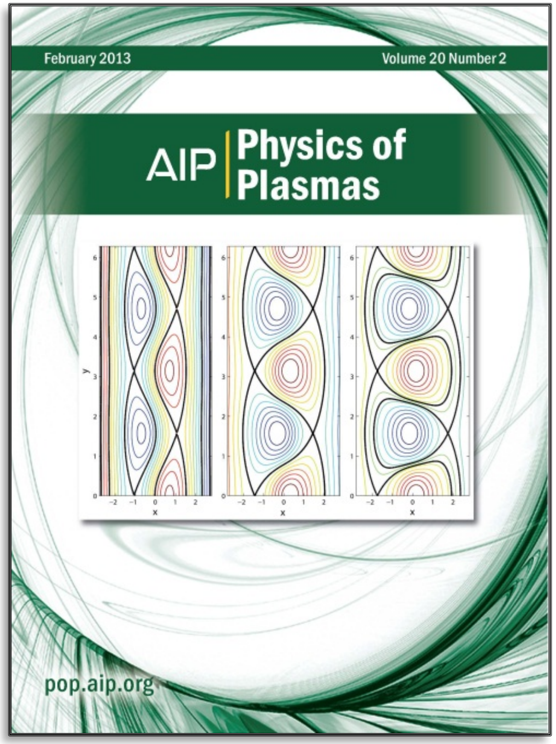
# Theory program advances fundamental science of magnetic confinement

| | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| Theory | 23,051 | 24,029 | 21,170 |

## The MFE **Theory** program:

- Focuses on fundamental plasma science of magnetic confinement with emphasis on burning plasma science
- Supported areas include macroscopic stability, confinement and transport, interaction of RF waves with plasmas, energetic particle physics, and plasma boundary physics
- Efforts range from small single-investigator grants, mainly at universities, to large coordinated teams at national laboratories, universities, and private industry
- Provides theoretical underpinning for advanced simulation codes (SciDAC) and Supports validation efforts at major experiments




## In ***FY 2015***:

- Continued support for ongoing research including efforts addressing high-priority issues for ITER and burning plasma
- Coordination between theory and experiment leading to model validation will be emphasized, particularly in areas where the resolution of essential physics issues is urgently needed before first plasma in ITER



*Involves approximately 46 graduate students, 14 postdocs*

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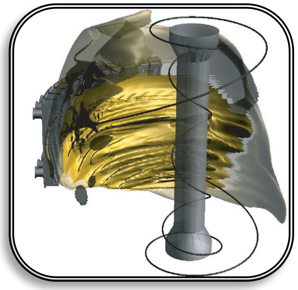
# SciDAC program advances fusion science through high performance computing

| | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| SciDAC | 6,556 | 9,375 | 7,000 |

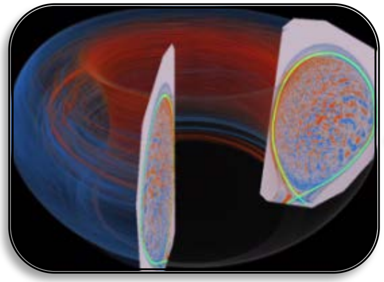

The FES **SciDAC** program:

- The FES Scientific Discovery through Advanced Computing (SciDAC) program advances scientific discovery in fusion plasma science by exploiting SC leadership class computing resources and associated advances in computational science
- Addresses grand challenges in burning plasma science and materials science
- Highly collaborative program, leverages strengths of FES and ASCR



In ***FY 2015***:

- The FES SciDAC centers will continue to contribute to the FES goal of developing a predictive capability for fusion plasmas



**Milestones:**

- Extend PIC gyrokinetic plasma turbulence codes to simulate 3-D resonant magnetic field perturbations for suppressing edge-localized instabilities on ITER
- Release new version of continuum reaction-diffusion plasma facing components simulation code



*Supports: At least 7 graduate students, 9 postdocs*

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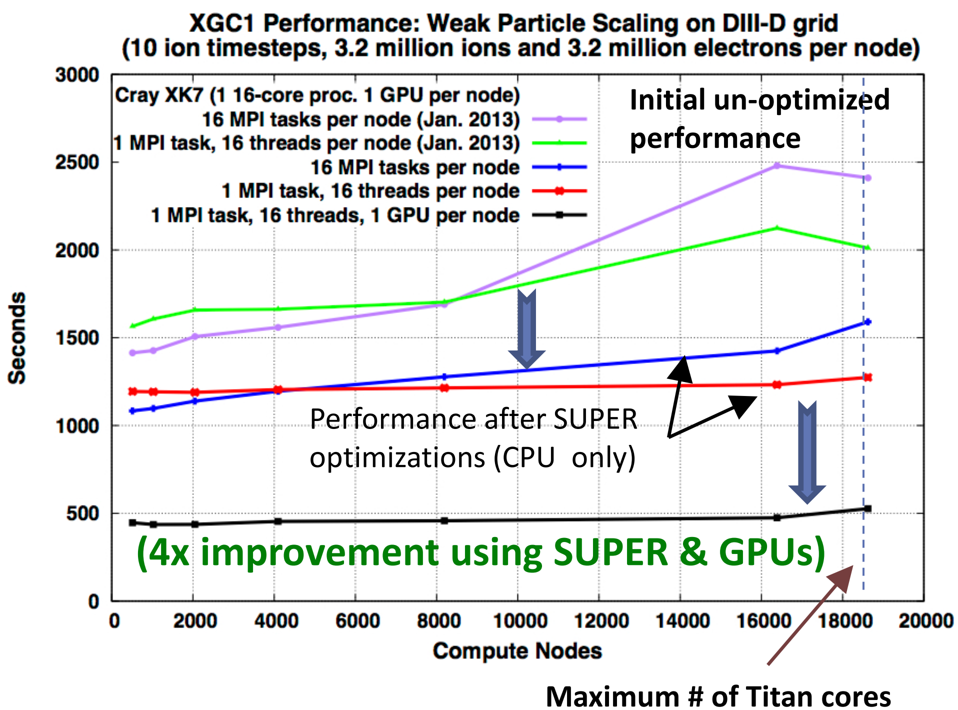
# Highlight: FES-ASCR partnership advancing state of the art fusion modeling




## *the Science*:

- New version of XGC1 using both multi-core CPUs and GPU on Cray XK7 (Titan) achieves 4X speedup for target problem size over earlier code using just multi-core CPUs.
- Performance improvements enabled excellent scalability to over 16,000 nodes (over 256,000 processor cores) on Titan and on IBM Blue Gene/Q (Mira) for a range of problem sizes

## *the Impact*:

- The physics of the edge plasma is one of the highest priority research areas for the success of ITER, as the edge affects the fusion efficiency in the core plasma and the degradation of the reactor wall in critical ways.
- XGC1 makes efficient use of leadership class computing for full ITER scale simulation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## *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*
- *Generate 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*


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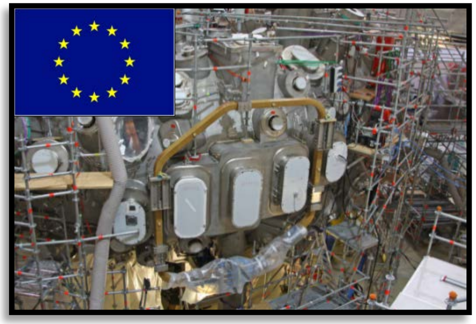
# With access to international facilities, US scientists are impacting and can lead in the area of fusion plasma sustainment



## W7-X (Germany) & Large Helical Device (Japan): Stellarators

US contributions of trim coils, power supplies, high heat flux divertor components, and IR imaging diagnostics will support future collaboration on Wendelstein 7-X (Germany).

Innovative diagnostics on Large Helical Device (Japan).

***The US has been given a role in program leadership at W7-X as a result of FES-sponsored contributions.***

## EAST Tokamak (Hefei, China)

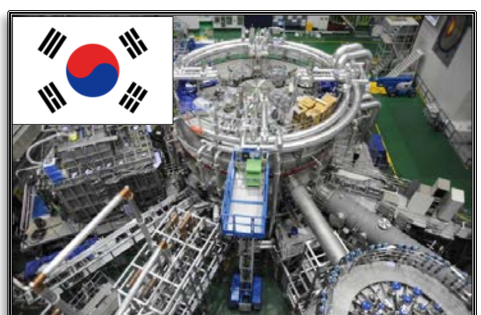
*"Our machine is your machine,"*
*J. Li, EAST Program Leader*

Goal: 1000s pulse, 1 MA

*Features*: Superconducting magnets, upgrades soon to high heating power. Rapidly growing diagnostic set

*Heating*: 2014 upgrades will yield heating capabilities rivaling DIII-D

***EAST has offered to US 3rd shift operation, via remote control. The world's longest high confinement plasma (H Mode) was created on EAST and controlled from General Atomics***



## KSTAR superconducting tokamak (Daejon, S. Korea)

Goal: 300s pulse, 2 MA

*Features*: 2015 plan is 50 second high power pulse, towards 300s goal. MHD mode control capability in place, an area US has pioneered on NSTX, DIII-D and at universities.

***Columbia University researchers have brought their mode stabilization leadership to KSTAR and extended its operating space***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# International collaboration teams will continue work in FY 2015

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


## The **International Collaboration** program:

In addition to their work on domestic facilities, U.S. researchers participate in experiments at facilities in Europe, Japan, Russia, China, South Korea, and India. Collaborations focus on facilities in China (**EAST**), Korea (**KSTAR**), United Kingdom (**JET**), Germany (**Wendelstein 7-X**), and Japan (**Large Helical Device**)

*Carried out under international bi-lateral agreements*

## In ***FY 2015***:

- Continue support for two U.S. research teams led by MIT and General Atomics on EAST and KSTAR
- Continued support for ongoing collaborations with Wendelstein 7-X, led by PPPL and including ORNL, LANL, and U of Wisconsin

## Milestones:

- Complete the design of the scraper element for the W7-X steady-state divertor, to enable exploration of the edge magnetic configuration
- Scientific collaborations on EAST and KSTAR will continue


*US domestic facilities are vital to leverage these collaborations*

*Involves: approx. 2 graduate students and 3 postdocs*


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# 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, including long pulses.

| | 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.

*Involves: approx. 41 graduate students and 23 postdocs*

## 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


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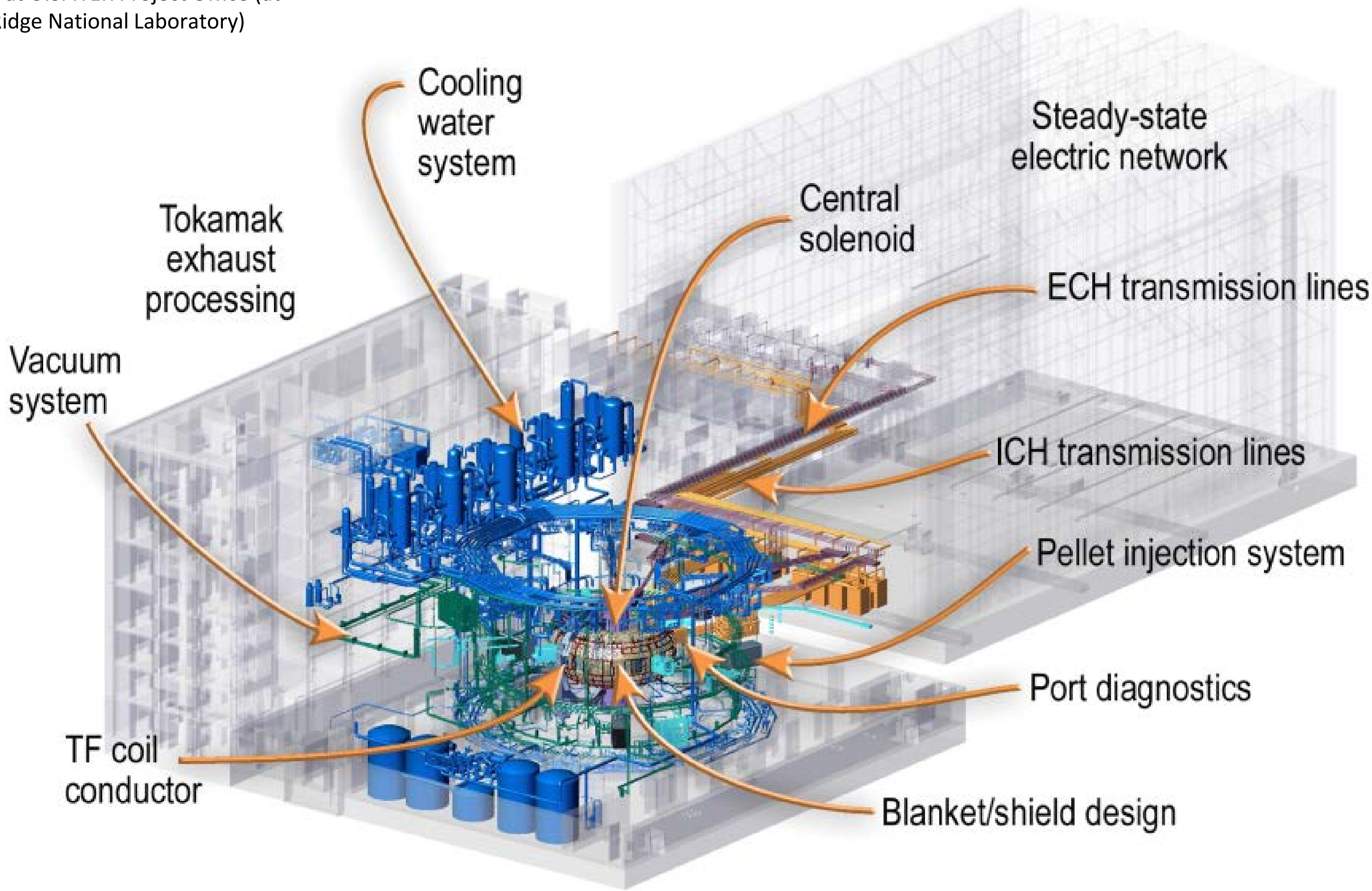
# About 80% of US ITER funding is for in-kind hardware contributions built in U.S.

## In-kind hardware contributions

managed at U.S. ITER Project Office (at Oak Ridge National Laboratory)





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# 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

- **Funding is provided for critical path items.** Funding also provided for U.S. ITER Project Office operations and the U.S. cash contribution ($40M)

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

- **The funding request for the U.S. ITER Project** is driven by our best understanding of the ITER construction schedule, and the view that the U.S. cannot simply write a blank check given the project's performance. The requested level of funding will allow the U.S. to meet its obligations on critical path items and will mitigate risk to the U.S. if the schedule continues to slip.

- **The U.S. ITER Project Office focus** is on delivering 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 Administration has expressed its great 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, the Lehman Review, 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**: In concert with the new ITER Council Chair, the U.S. has introduced reforms to the way the Council performs. With insistence from the US on acting on all of the recommendations of the Management Assessment, the ITER Council has adopted them all

# Actions taken by the Council, and developing a Corrective Action Plan

- **Actions by the Council:** The Council Chair sought, and obtained, the formation of three working groups to: (1) develop a process for leadership succession, (2) identify ways to improve IO-Domestic Agency interactions, and (3) evaluate senior leadership performance

- **Developing a Corrective Action Plan:** There are 8 recommendations in the MA that the IO must respond to (the others are Council actions on leadership evaluation and succession planning, already taken). The Council has adopted all of the MA recommendations and demanded IO action

  – **Initial response by the IO:** In the IO's first response presented at the February Council meeting, the Council accepted 3 of the responses proposed by the IO, and sent the remainder back for further development

  – **Council Chair response:** The Council Chair prescribed an outline of actions on the remaining five, and the IO has indicated its intent to act accordingly. We expect to hear from the IO its proposed plans for these remaining five actions

  – **Outcome sought:** When the 8 proposed actions by the IO in response to the MA are adopted by the Council, this will constitute the IO's Corrective Action Plan. Goal is to receive an acceptable plan that will be formally approved by written procedure by the Council as soon as possible

# US fabrication of ITER in-kind hardware components is advancing

U.S. DEPARTMENT OF ENERGY
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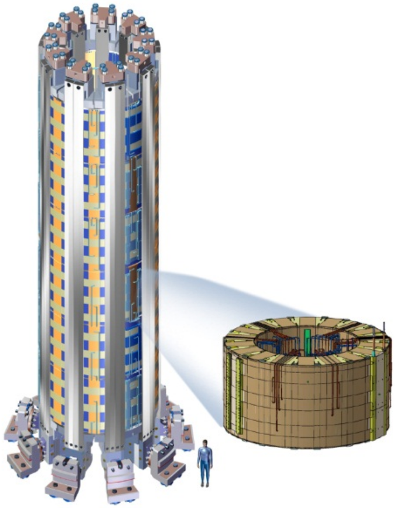
## Central Solenoid



**1,000 metric ton magnet induces magnetic flux change needed to:**

- Initiate plasma
- Generate and maintain plasma current

**This will be the most powerful pulsed superconducting electro-magnet in history**
(5.5 Gigajoule stored energy capacity, 13 Tesla)

*General Atomics*

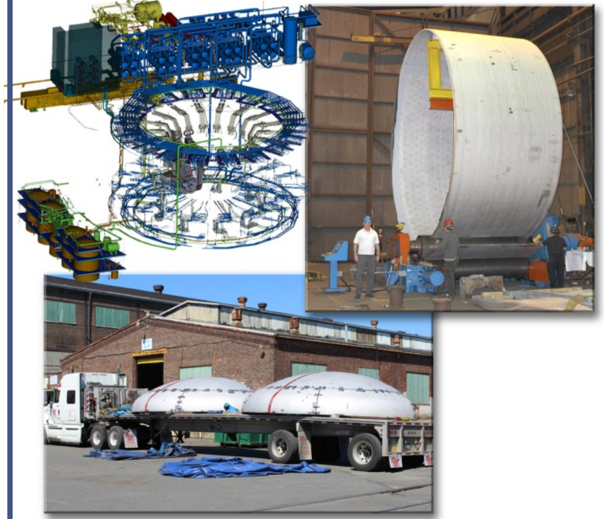
## Toroidal Field Conductor

**4 miles of niobium-tin superconducting strand**

**Completed batch of production cable**

*Luvata, OST, NE Wire, High Perf Magnetics*

## Tokamak Cooling Water System

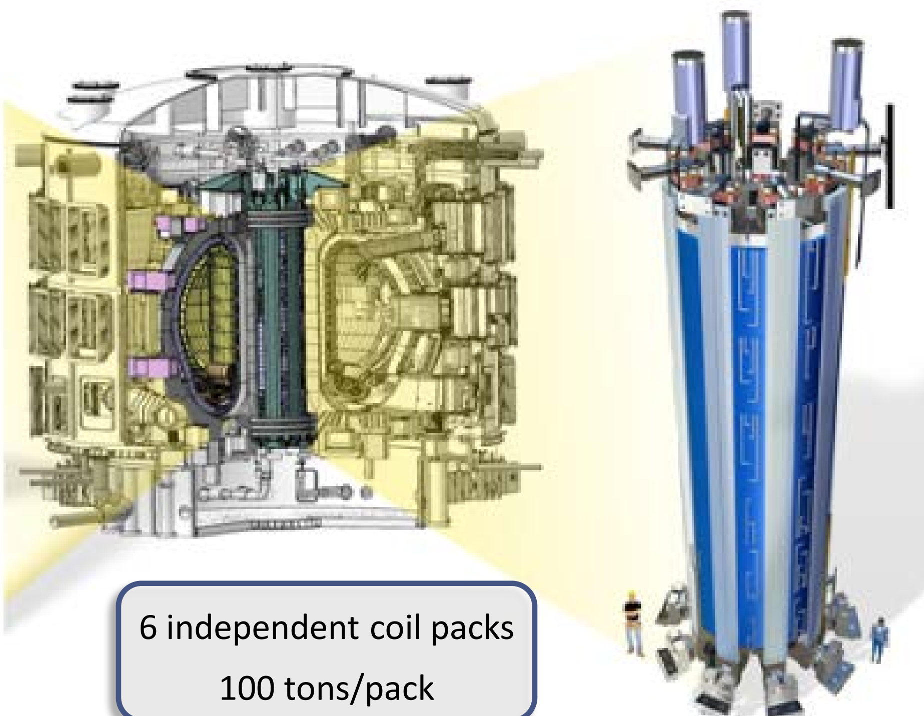


**22 miles of piping, 230 pieces of equipment, drain tanks**
Classified as “safety important” for confinement of radioactivity

*AREVA, Joseph Oat*

# Central solenoid fabrication is making progress

*Technical problems with conductor were resolved with U.S. project management leadership*



6 independent coil packs

100 tons/pack

General Atomic's new central solenoid module fabrication facility in Poway, CA, is preparing for tooling stations. The large crates contain dummy conductor for the mock-up module.

910 meter dummy conductor.

# 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*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# General Plasma Science Program

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

The General Plasma Science (GPS) program addresses outstanding questions related to fundamental plasma properties and processes through discovery-based investigations in basic and low-temperature plasma science

*Major components of the program include*: the NSF/DOE Partnership in Basic Plasma Science and Engineering; research at DOE national laboratories; multi-institutional collaborative centers, and small- to medium-scale plasma user facilities

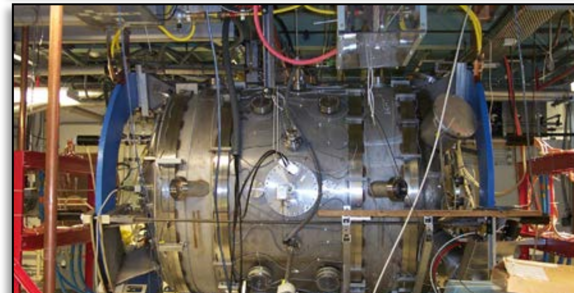
## In *FY 2015*:

- NSF/DOE Partnership – annual competitive review of single-investigator-scale research at universities and industries
- *Prioritize portfolio*: Review of centers and intermediate-scale facilities which expand experimentally accessible parameters and provide broad access to users

## Milestones:

- Initiate the process of identifying new small- to medium-scale general plasma science facility

Large Plasma Device @ UCLA Basic Plasma Science Facility



Magnetic Recconection Experiment (MRX) @ PPPL

**"There are important basic plasma problems at intermediate scale that cannot be addressed effectively either by the present national facilities or by single investigator research."**

**- Conclusion, p. 214**
***National Research Council***

*Supports: approx. 77 graduate students, 35 postdocs*

# High Energy Density Laboratory Plasmas

| | FY'13 Sept AFP | FY'14 Current | FY'15 CONG Request |
|---|---|---|---|
| HEDLP | 17,295 | 17,315 | 6,700 |

## The **HEDLP** program:

High Energy Density (HED) physics is the study of ionized matter at extremely high density and temperature, approximately 100 billion Joules per cubic meter

- Supports the Matter at Extreme Conditions (MEC) end station of LCLS user facility at SLAC, enabling experiments at the frontier of high energy density physics, laboratory astrophysics, laser-particle acceleration, and nonlinear optical science

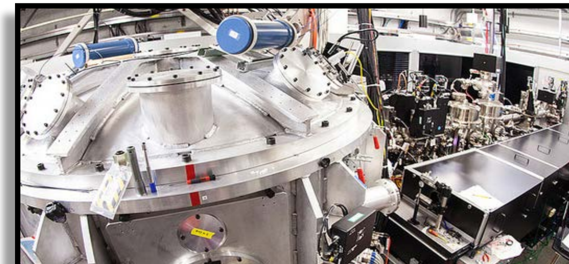
## In ***FY 2015***:

- Continued support for MEC beam-line science team at SLAC
- Support external HED science users at MEC
- There is no support for the SC/NNSA joint HEDLP program, but some work will continue through forward funding

## Milestones:

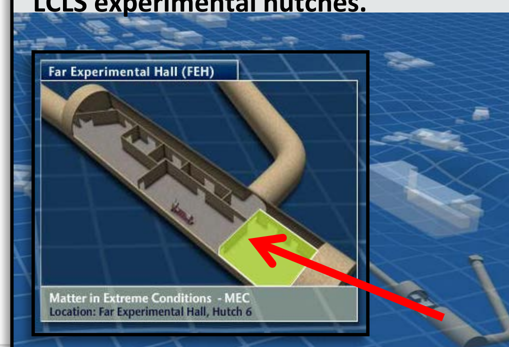
- Complete phase two of short-pulse laser upgrade to deliver 200TW peak power on target

*Short-pulse laser upgrade will serve as the front-end for potential future upgrades to peta-watt class world leading high intensity science at SLAC*



**The MEC provides scientific users with access to HED regimes uniquely coupled with a high-brightness x-ray source**

**The operation of MEC as a stand-alone experiment makes it unique among LCLS experimental hutches.**

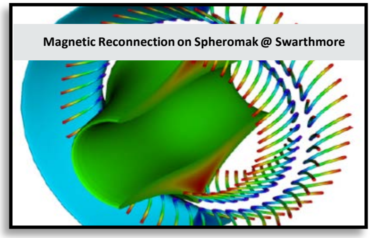


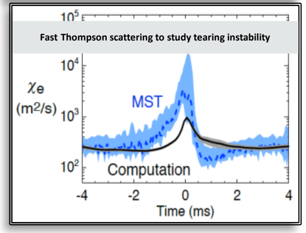

*Involves: approx. 46 graduate students, 17 postdocs*

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

EPR provides data in regimes of relevance to mainline magnetic confinement and materials science efforts, supports validation and verification 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

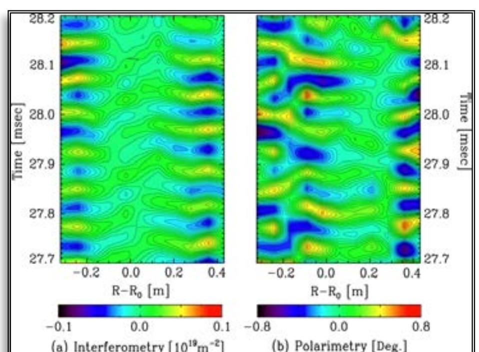
- EPR: Examine range of magnetic confinement concepts to establish scientific connections and help establish experimentally validated predictive capability.
- MST: Measure the scaling of tearing mode fluctuations with current and temperature and support the validation of nonlinear MHD codes.

*Supports: about 60 graduate students*

# Diagnostics

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 |




**Faraday-Effect Polarimetry**

**Heavy Ion Beam Probe (HIBP)**

## 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.

*Diagnostics Involves: approx. 12 graduate students, 2 postdocs*

# 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 | N/A | N/A |
| **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)** | **N/A** | **199,500** | **150,000** |
| **Total, Fusion Energy Sciences** | **377,776** | **504,677** | **416,000** |

# *Proposed budget restructuring for Fusion Energy Sciences*

## OBJECTIVES

- *Construct new budget categories that help tell the story for the FES program*
- *Refocus the perspective as we enter the "burning plasma era" with ITER*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# Comparison of budget categories

## Existing categories

| SCIENCE |
|---|
| DIII--D Research |
| C-Mod Research |
| International Research |
| Diagnostics |
| Other (HBCU, Education, Outreach, Reserves, etc.) |
| SBIR/STTR |
| NSTX Research |
| Experimental Plasma Research |
| High Energy Density Lab Plasmas |
| MST Research |
| Theory |
| SciDAC |
| Fusion Simulation Program |
| General Plasma Science Research |

| FACILITY OPERATIONS |
|---|
| DIII--D Operations |
| C-Mod Operations |
| NSTX Operations |
| NSTX Upgrade MIE |
| Infrastructure/GPP/GPE |
| ITER Line Item |

| ENABLING R&D |
|---|
| Plasma Technology |
| Advanced Design Studies |
| Materials Research |

## Proposed new categories

| BURNING PLASMA SCIENCE: FOUNDATIONS |
|---|
| Advanced Tokamak |
| Spherical Tokamak |
| Theory & Simulation |
| GPE/GPP/Infrastructure |
| **BURNING PLASMA SCIENCE: LONG PULSE** |
| Long Pulse: Tokamaks |
| Long Pulse: Stellarators |
| Materials and Fusion Nuclear Science |
| **BURNING PLASMA SCIENCE: HIGH POWER** |
| Line Iterm: US Contributions to ITER Project |
| **DISCOVERY PLASMA SCIENCE** |
| Plasma Science Frontiers |
| Measurement Innovation |
| SBIR/STTR and Other |



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# Programmatic and Policy Updates

# FES carried out a complete survey of 2013 sponsored research employment data

**Initiated**: August 22, 2013

**Completed**: October 31, 2013 (100% response from the community)

**Motivation**: Accurate employment reporting for FMIS and budget narrative

**Who was included**: *ALL* FES-sponsored research projects

**How the data call was conducted**:

- Principal Investigators of FES-sponsored research projects received an email from their respective program managers containing:
  1. Instructions
  2. Excel spreadsheet completed and returned
- Information was sought that would enable FES to remove duplication and double counting across program elements
- Some institutions which support a large number of researchers consolidated their responses (e.g., PPPL, LLNL, GA)

# FES programs supported 801 university researchers and students in FY 2013

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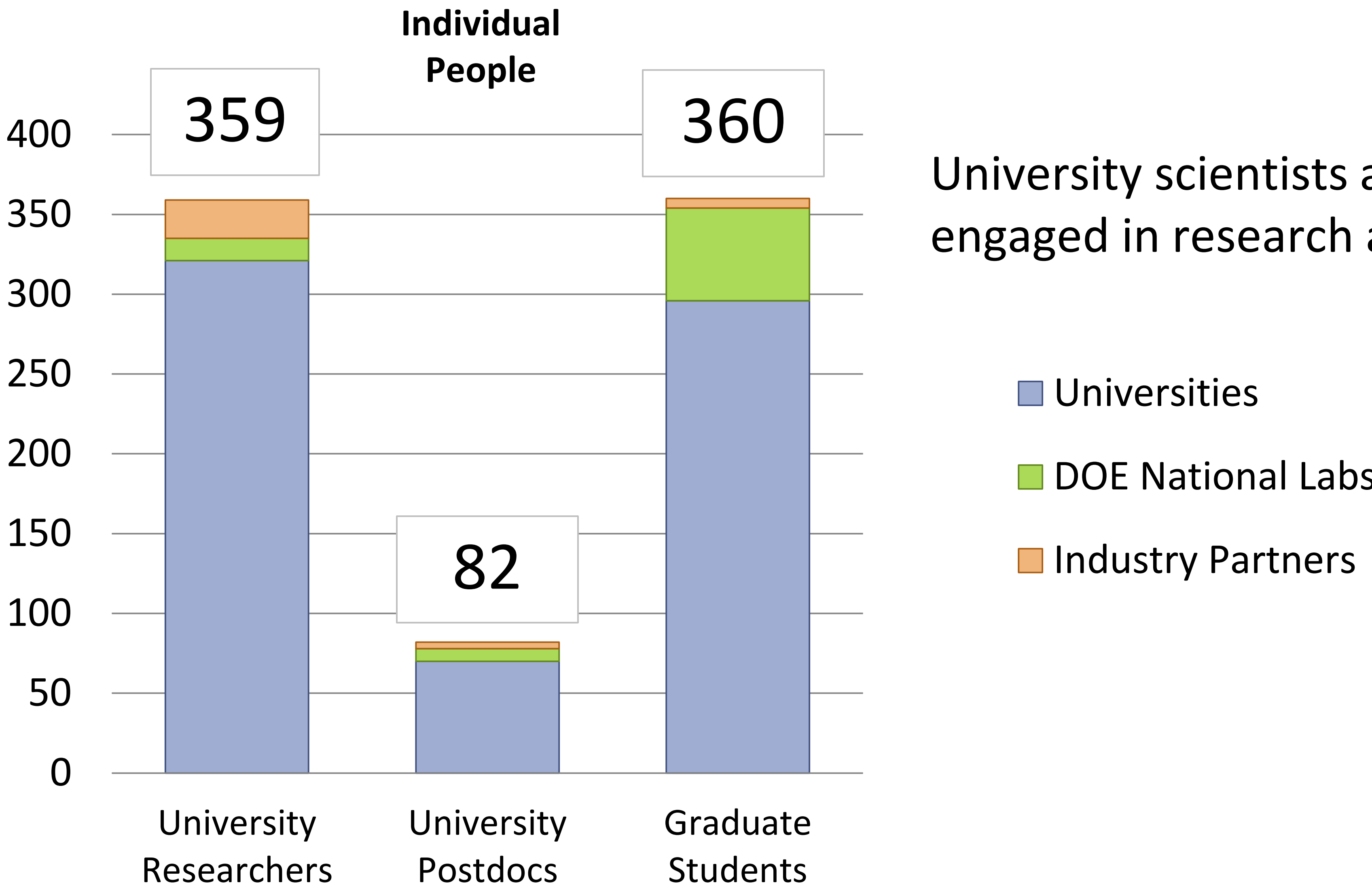


University scientists are engaged in research at:

U.S. DEPARTMENT OF ENERGY

Office of Science

# Status of recent solicitations

| Solicitation | Status | Announced $ | FES POC |
| --- | --- | --- | --- |
| Theoretical Research in Magnetic Fusion Energy Science | 11 awards | $3,800,000 | J. Mandrekas |
| NSTX Collaboration (non-lab) | 11 awards | $2,000,000 | S. Eckstrand |
| MEC Optical-Only Experiments | 2 awards | Experimental shot time | S. Finnegan |
| SBIR/STTR Phase II | 6 awards | $6,000,000 | B. Sullivan |
| Early Career Research Program | 3 awards | $1,750,000 | N. Podder |
| SBIR/STTR Phase I | 11 awards | $1,650,000 | B. Sullivan |
| NSF-DOE Partnership in Basic Plasma Science and Engineering | 167 proposals, under review | $2,600,000 | A. Satsangi & GPS Team |
| FES-ASCR SciDAC Partnership in Multi-scale Integrated Modeling | Proposals due May 2 | $1,250,000 | J. Mandrekas |
| Theoretical Research in Magnetic Fusion Energy Science | Proposals due June 19 | $3,200,000 | J. Mandrekas |

# GAO assessment of ITER Project

- **House-Senate request to Government Accountability Office (May 2013)**
  1. *What is the current cost and schedule for completion of ITER? Do experts believe this cost and schedule are realistic given the technical challenges of the fusion energy project?*
  2. *Could U.S. deliverables be delayed or adjusted without compromising this schedule? How do U.S. deliverables related to the timely completion of the construction?*
  3. *Are there strategies or alternatives to reduce the cost of the U.S. deliverables*?

- **Status**
  – Expect preliminary draft of the report toward end of April
  – Final report in June

# Plan for integrated fusion simulations

- **FY 2014 Appropriations Act directive**
  - *"Not later than 180 days after enactment of this Act, the Department shall submit to the Committees on Appropriations of the House of Representatives and the Senate a plan with research goals and resource needs to implement a Fusion Simulation program."*
- **Approach**
  - FES will prepare and submit a plan for an integrated fusion simulation program
  - A meeting with ASCR leadership was recently held to discuss possible ASCR participation
  - The plan will be consistent with the ten-year FES strategic plan

# *Thank you*