

Establishing the scientific basis for fusion energy
and understanding the plasma universe

Update on the Fusion Energy Sciences Program

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Fusion Power Associates Annual Meeting
December 11, 2013

<http://science.energy.gov/fes>



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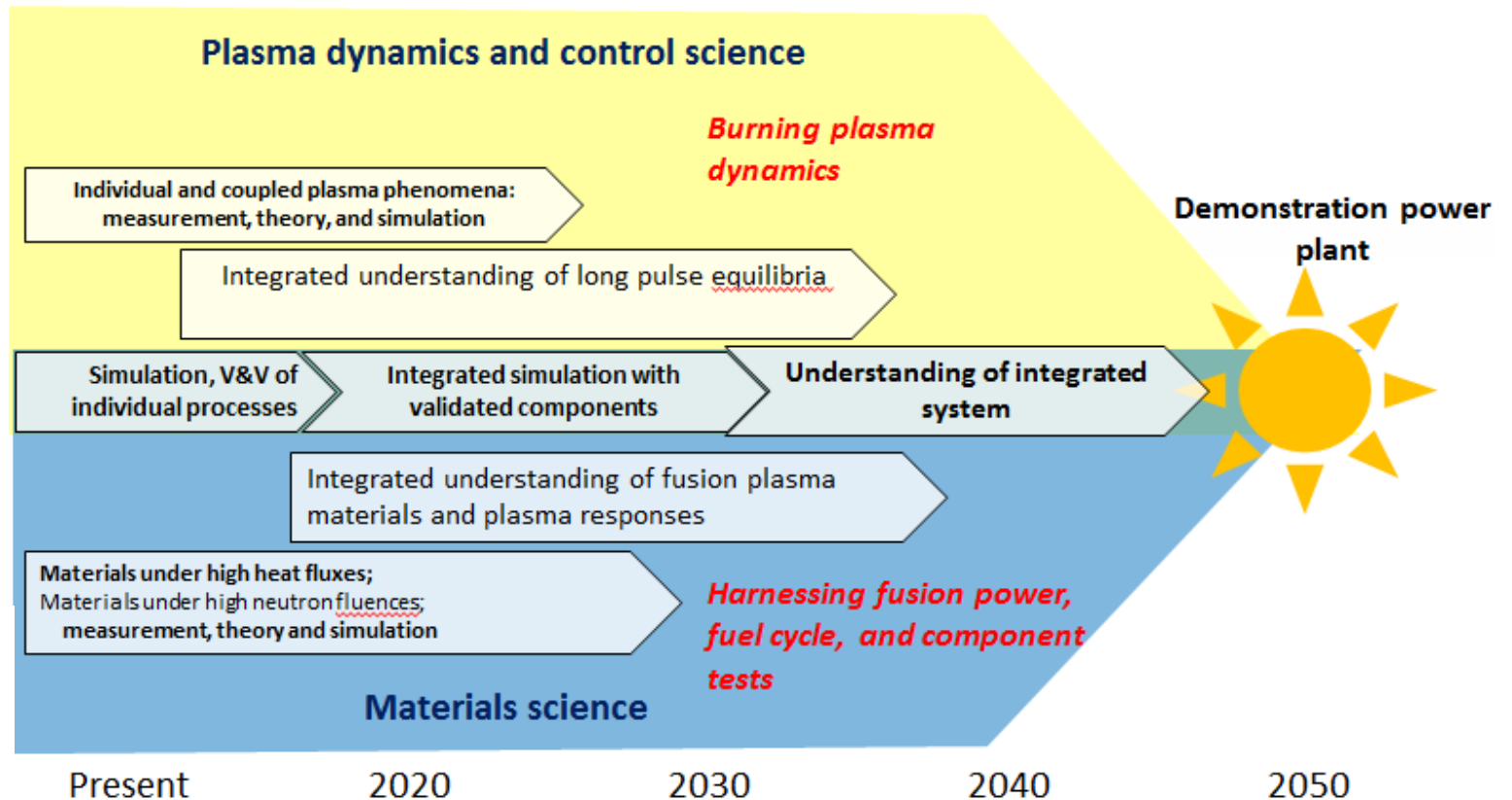
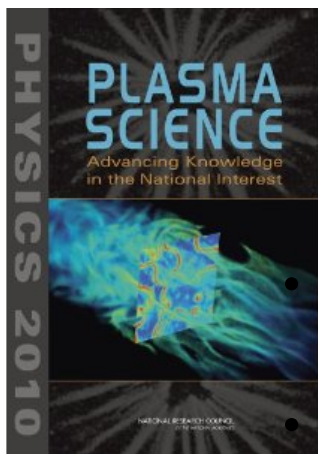
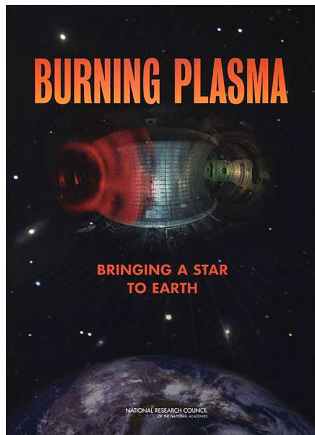
Elements of the Program Vision



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The US needs to be a strong force in advancing burning plasma science, and the power and beauty of plasma science overall



Universities, through strengthened partnerships with labs, are vital to both the fusion and plasma science goals

Office of Science role regarding fusion energy: establish the scientific basis on which fusion energy development will build



World fusion science landscape will look considerably different in a decade (1 of 3)



ITER will begin operations in the next decade

The FY 2014 budget proposal reflects an agreed-upon plan for support of ITER construction that is aimed at meeting our obligations and at promoting a sustainable FES future that will lead to a strong program in the burning plasma era.

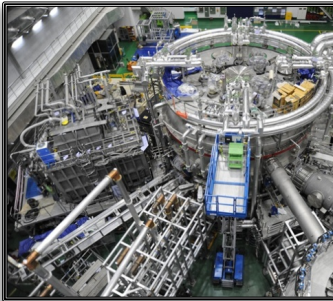


The US research effort has to effectively reap maximal benefit from ITER with a world-leading workforce

The FY 2014 budget proposal has tough elements, but it puts forward a broad, impactful program in experiment, theory/computation, and enabling R&D at labs, universities and industry. The portfolio supports research of 360 individual graduate students. Still, to get to where we need to be in a decade, we need to make better use of our larger lab facilities to the benefit of our university programs.

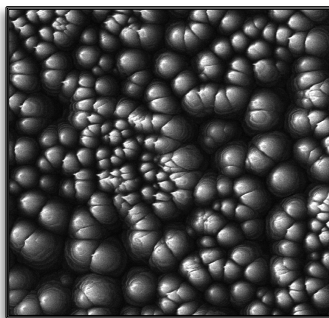


World fusion science landscape will look considerably different in a decade (2 of 3)



There will be mature, cutting-edge research facilities around the globe addressing the needs of ITER and looking beyond

The FY 2014 budget continues to invest in international partnerships, and new endeavors launched have significant university engagement and leadership.

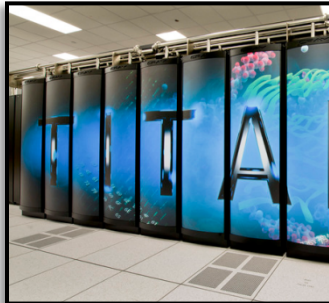


Fusion materials science will be an increasing focus globally

The FES research program now has elements that will be key to determining how research should proceed to close gaps in fusion materials science. This area supports a large number of university researchers.

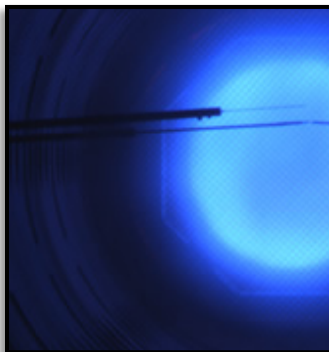


World fusion science landscape will look considerably different in a decade (3 of 3)



Fusion will increasingly take advantage of massively parallel computing

FES research makes focused investments in advanced scientific computing in partnership with ASCR, and in experimental validation of theory. The SciDAC and Theory programs focus on burning plasma science and ITER. Plasma research at universities continues to strengthen the foundations of the science of magnetic confinement, numerical simulation science, and experimental validation & verification.



Leverage will become increasingly important in the fusion and plasma sciences with tough budgets

Leverage is especially key in tough budgetary times. ITER represents the height of leveraging capabilities internationally. The HEDLP program maintains a cross-SC partnership with BES at LCLS (SLAC) for first-of-a-kind science. International partnerships will target high-leverage opportunities that build on US strengths. The general plasma science portfolio has a strong partnership with NSF that is effective in doing great science and in developing early career plasma scientists. FES materials scientists are leading users of HFIR, another BES facility. Fusion computing leverages partnership with ASCR through the SciDAC program.



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FES Strategic Plan Development



Perspectives on U.S. fusion and planning

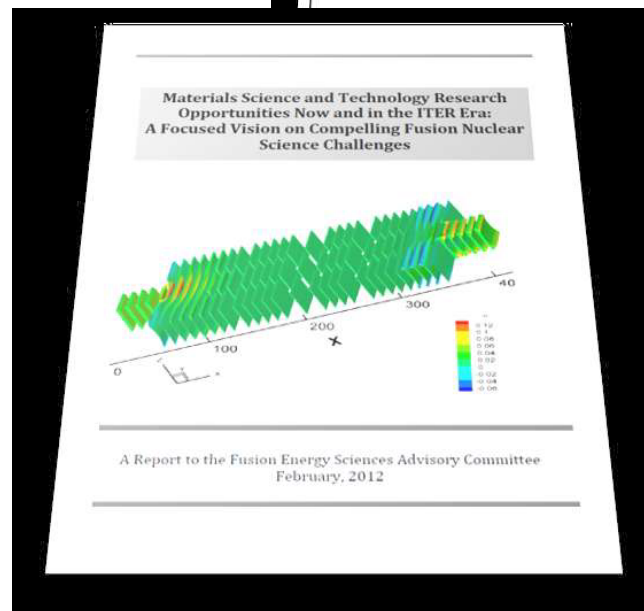
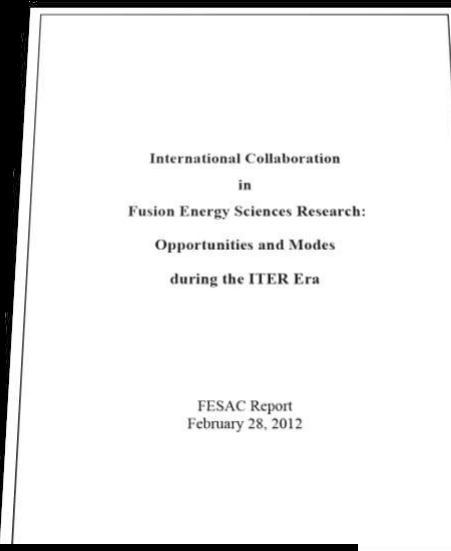
- Maintaining the status quo – i.e., managing the elements we have if our spending power remains flat – is itself a risky path with guaranteed consequences
- The competition in the Office of Science is intense. Programs that grow are programs that promote change
- Scientific and intra-DOE isolation is a risky attribute that FES has lived with, both scientifically and politically. But smart leverage through partnerships can help change this
- Scientifically: Our challenges are too deep, and the stakes are too high, to not use resources outside of our immediate sphere that could help advance the fusion cause.
- Politically: No one will help you fight for research dollars and defend you if they don't have a shared interest in and respect for your program



We have community input that will inform the strategic plan that FES is developing

- ***International Collaboration in Fusion Energy Sciences Research: Opportunities and Modes during the ITER Era (2012)***
 - Chair: Dale Meade
- ***Materials Science and Technology Research Opportunities Now and in the ITER Era: A focused Vision on Compelling Fusion Nuclear Science Challenges (2012)***
 - Chair: Steve Zinkle
- ***Priorities of the Magnetic Fusion Energy Science Program (2013)***
 - Chair: Robert Rosner
- ***Prioritization of Proposed Scientific User Facilities for the Office of Science (2013)***
 - Chair: John Sarff

All reports available on the Fusion Energy Sciences Advisory Committee web page at: <http://science.energy.gov/fes/fesac/reports/>





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)

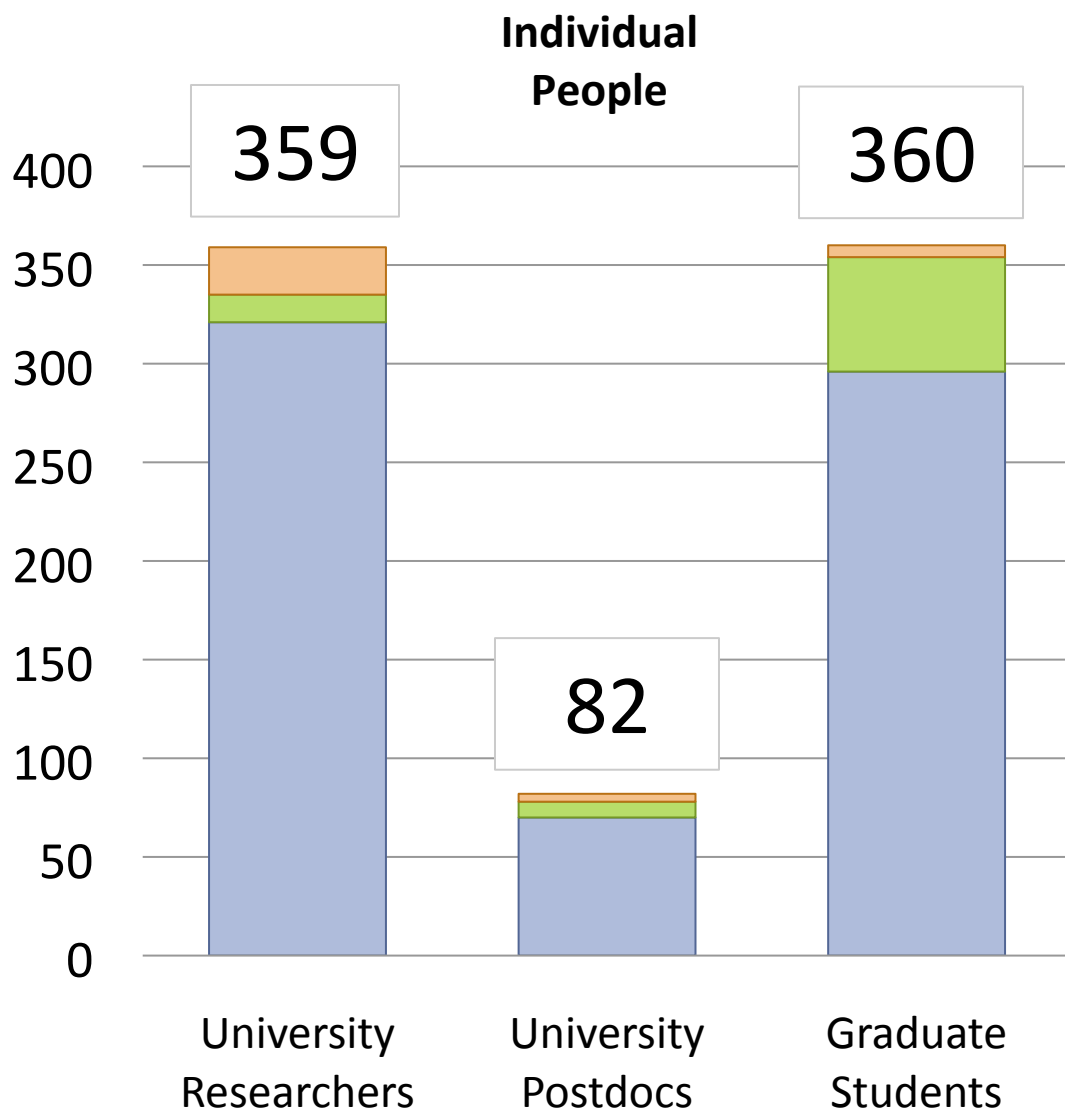
Motivation: Accurate employment reporting for FMIS and budget narrative

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 to be 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

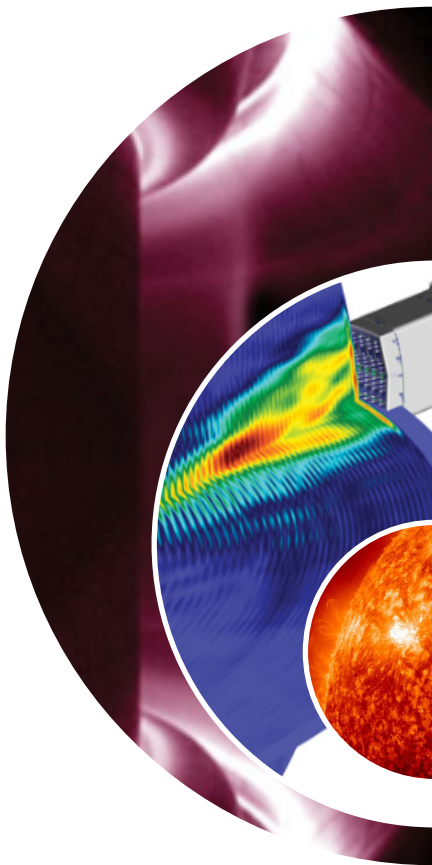


University scientists are engaged in research at:

- Universities
- DOE National Labs
- Industry Partners



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



Burning Plasma Science

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

New budget structure being developed in FES

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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Administration FY 2014 budget proposal



FY 2014 budget headlines

- **Budget request growth**
 - \$458M request in FY 2014, compared to FY 2013 request for \$398M (+ \$60M). This is the largest fractional increase in Office of Science, and the second largest total increase in dollars
- **Administration agreement on U.S. ITER spending reached**
 - Capped at \$225M per year, with this amount proposed for FY 2014
- **NNSA/DOE joint program in HEDLP proposed to be reduced**
- **So far in FY 2014, operating on a three-month Continuing Resolution**
 - Sequestration is again a possibility



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Proposed approach for U.S. ITER support: no more than \$225M per year

From the FY 2014 Budget Narrative:

- *“The U.S. ITER Project CD-1 cost range established in 2008 is \$1,450,000,000 - \$2,200,000,000. Since that time, factors that delayed CD-2 approval (e.g., schedule delays, design and scope changes, and risk mitigations) have also placed upward pressure on the cost range. In the spring of 2012, in efforts to address budgetary constraints, DOE and its oversight organizations agreed to support an annual funding level of **no more than \$225,000,000 per year beginning in FY 2014**. DOE believes these annual funding levels will enable the U.S. to fulfill its obligations...”*
- *“Until such time as CD-2 can be approved, the U.S. contributions will be managed with a performance plan that focuses on a two-year time horizon and that is also supportive of the longer-term project requirements. This two-year plan is developed, executed, and monitored with the use of the project management principles in DOE Order 413.3b with project management systems (Earned Value, Risk Management, Project Reporting) tailored specifically to this project’s circumstances.”*

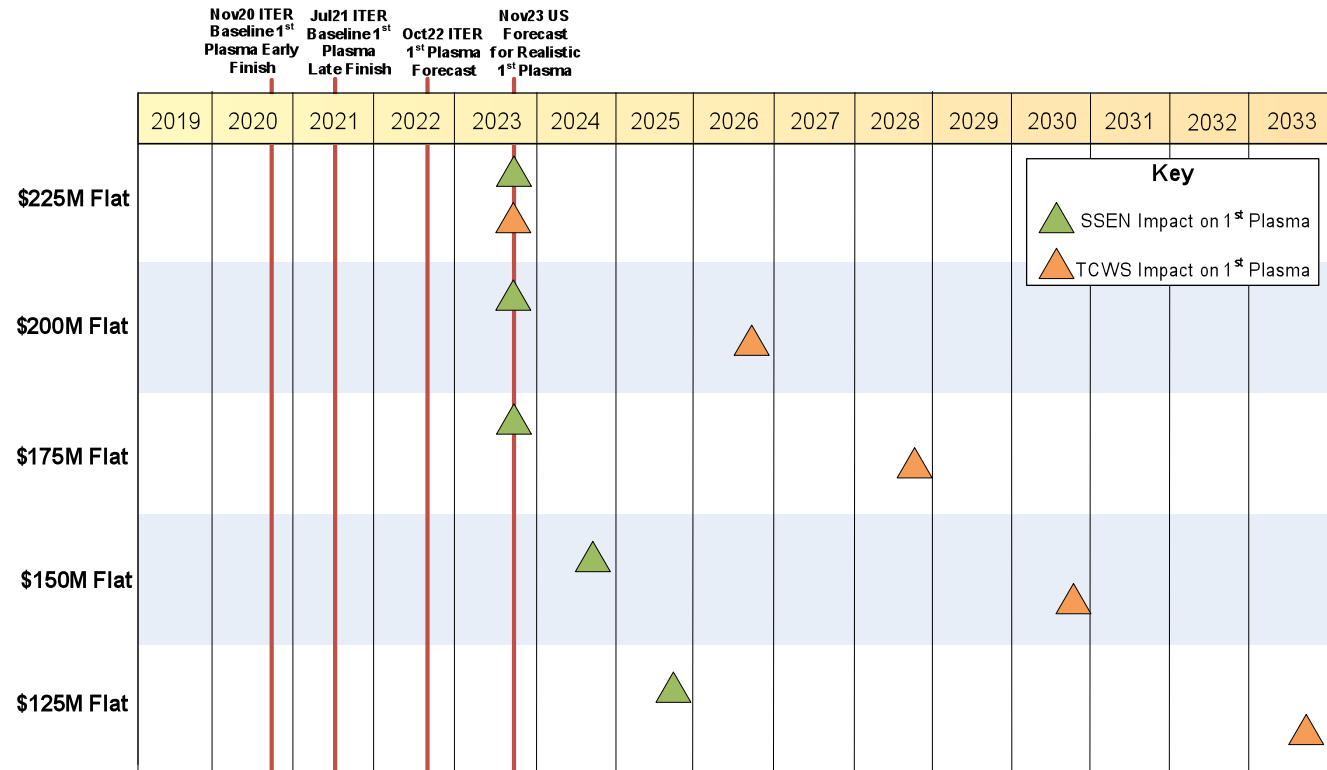


FY 2014 marks for ITER, and the Administration response

- **Senate SEWD mark [S. 1245, Report No. 113-47, June 27, 2013]**
 - **That no funding may be made available for the U.S. contribution to the International Thermonuclear Experimental Reactor project until the Secretary of Energy submits to the Committee on Appropriations of the U.S. Senate a baseline cost, schedule, and scope estimate** consistent with DOE Order 413.3b for the U.S. contribution to ITER needed to complete all construction activities.
- **House HEWD mark [Report 113-135, July 2, 2013]**
 - **The recommendation includes \$217,500,000 for the United States contribution to ITER**, the international collaboration to construct the world's first self-sustaining experimental fusion reactor, \$93,500,000 above fiscal year 2013 and \$7,500,000 below the budget request.
 - The Committee recommendation restores most of the proposed cuts to the domestic fusion program while also increasing ITER funding as the project enters its full construction phase.
 - As the Department continues to assert, ITER is one of the top priorities of the nation's science program as a whole, and as such should require investments across all programs within science.
 - The Committee strongly encourages the Department to treat the U.S. contribution to ITER as a line-item construction project and directs the Department to submit a project baseline and cost schedule to the Committees on Appropriations of the House of Representatives and the Senate not later than 180 days after enactment of this Act.
- **This led to an intensive “Lehman review” of the US ITER Project in late August.**
 - The Administration has reported to the Senate in response to its request.

Funding levels below those planned for U.S. ITER will have significant impacts

- The 2-year US plan, including \$225M for FY 2014, was designed in response to meet a realistic 1st plasma date of 2023
- The ability for the US to deliver on time even to a several year delay is highly sensitive to the enacted funding levels



SSEN is the first US hardware needed for 1st Plasma; TCWS deliveries have the greatest impact on 1st Plasma in constrained funding profiles. The impact of the deliveries of components of the eight other US systems needed for 1st Plasma fall within these ranges.



- **Combined House-Senate request to Government Accountability Office (3 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 relate to the timely completion of the construction?
 3. Are there strategies or alternatives to reduce the cost of the U.S. deliverables?

- **Activities so far:**
 - SC/FES entrance interview with GAO (July 1)
 - Lehman review of U.S. ITER Project Office baseline-equivalent documentation (August 27-28); report finished October 11; briefed to GAO (Oct 25)
 - GAO meetings with SC, FES, GC, etc., in Washington, DC (Sept 17)
 - GAO meeting with U.S. ITER Project Office in Oak Ridge (Nov 4-6)



U.S. is energetically engaging ITER Council about schedule slippage and project performance

- The recent ITER Council Meeting (Nov 19-20) included discussion of the 2013 Management Assessment report, which contained a number of recommendations to both the Council and the ITER Organization
- Because of the complex and far-reaching nature of the recommendations, the Council has scheduled an out-of-cycle special Council meeting in February 2014 that will focus exclusively on responses to the Management Assessment report
- The Administration is fully engaged and is watching these developments closely



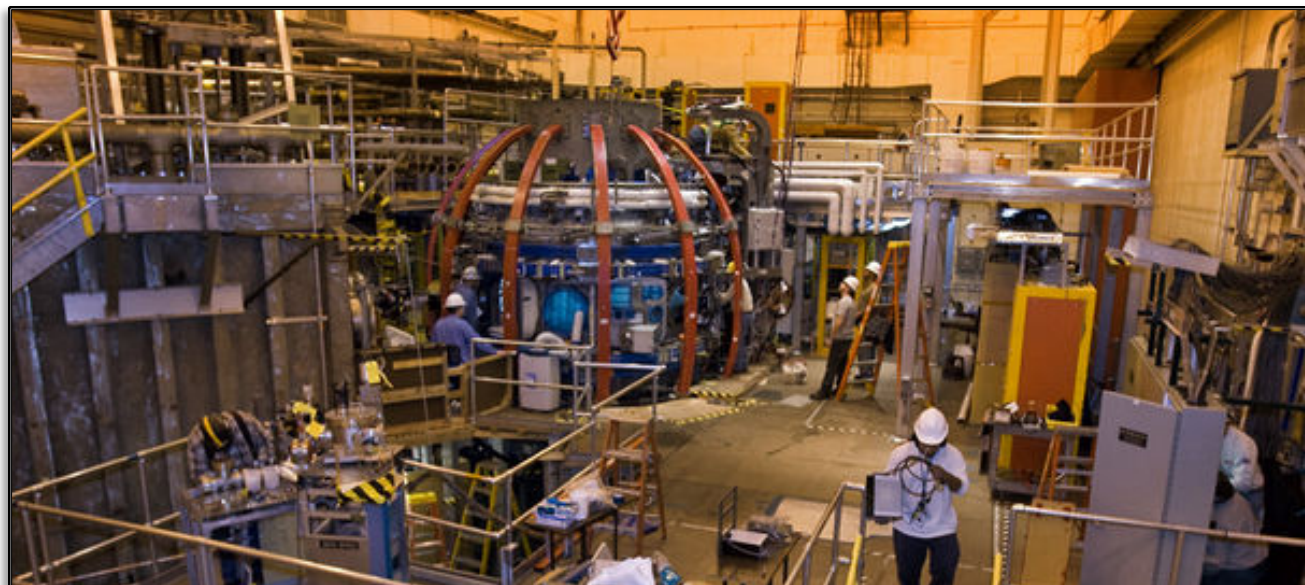
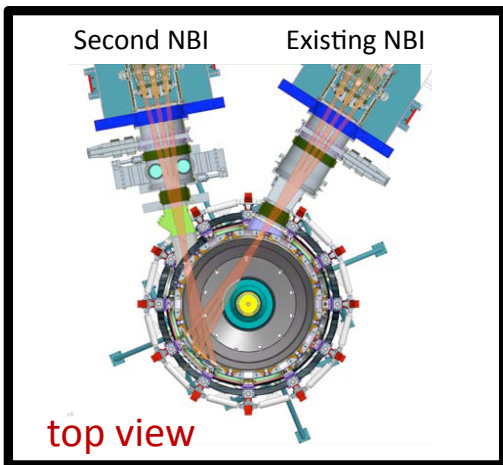
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Recent FES Program Developments



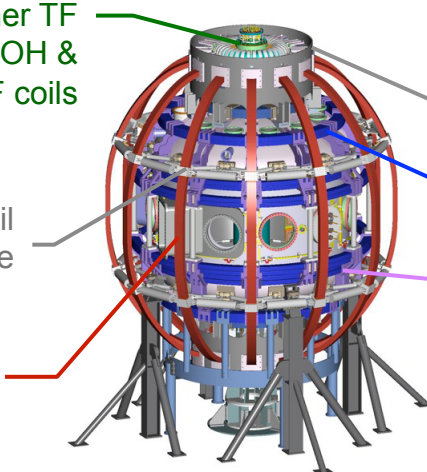
NSTX-U: Project remains on track



New solenoid, Inner TF bundle, TF joint, OH & Inner PF coils

Upgraded TF coil support structure

Existing outer TF coils



Upgrades:

Reinforced umbrella structure

Existing outer poloidal magnetic field coils – 6 total

New PF coil support structure

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



Two international collaboration teams began functioning in FY 2014

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

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





- **New approach for membership**
 - Members' terms are staggered
 - For continuity, aim for about 1/3 of members to be changed every other year
 - Generally, members will serve no more than 6 years
- **Incoming new members**
 - 8 members will return
 - 10 new members, for 3-year terms
 - Plus 3 *ex officio* members
 - Elected Chair of APS-DPP, 1-year term
 - Elected Chair of ANS-FED, 2-year term
 - IEEE-USA Member as selected by IEEE Leadership



- **Digital data management**
 - OSTP guidance on “Increasing Access to the Results of Federally Funded Research” (Feb 2013)
 - Takes into account FESAC report (summer 2011) and other FACA input
 - SC guidance will be forthcoming; each SC program office may publish additional guidance
 - Thanks to Bruce Cohen’s leadership of FESAC subpanel
- **Full funding of grants**
 - FY 2012 Appropriation conference language
 - FY 2014 HEWD mark
 - Office of Science proceeding with tailored approach designed to minimize impacts



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Kudos



Hannes Alfven Prize of the European Physical Society awarded to Prof. Miklos Porkolab (July 1, 2013, Helsinki)

Porkolab was cited *“for his seminal contributions to the physics of plasma waves and his key role in the development of fusion energy.”* Noting additional areas of his research, including the areas of magnetic reconnection, laser-plasma interaction and inertial confinement fusion, the citation concludes: *“With such a broad scientific expertise in plasma physics, unique contributions to first-rate theories, exciting and novel experiments and development of innovative diagnostic techniques, as well as with a great devotion to science education and service, Miklos Porkolab has a strong impact on fusion energy research worldwide.”*



Appreciation Award from the Office of Science



Citation on the award to Prof. Farrokh Najmabadi (UCSD):

In recognition of your service to the U.S. Fusion Energy Sciences program in leading its Systems Studies Team. You have been a member of the Systems Studies national team for 25 years and leader of the team for 20 of those years. Under your expert and insightful leadership, the Systems Studies Team produced 12 major pre-conceptual design studies of fusion power plants, which have provided guidance to the U.S. fusion research program, as well as to overseas fusion programs. You have led U.S. delegations in scientific exchanges with Japan. You have served as an expert in the area of fusion energy developmental pathways on various review panels, and you have also served as a member of the Fusion Energy Sciences Advisory Committee. Thank you for a job well done. [September 2013]

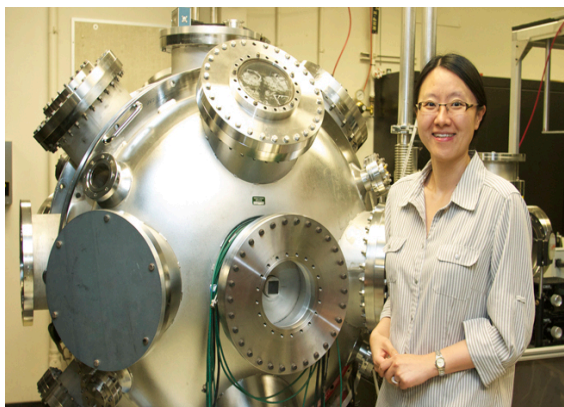


2013 FES Early Career Awards



Dr. Ahmed Diallo (PPPL)
Edge Pedestal Structure Control for
Maximum Core Fusion Performance

Dr. Sigrid Close (Stanford)
Experiments and Simulations of
Hypervelocity Impact Plasmas



Dr. Yuan Ping (LLNL)
Energy Transport in High-
Energy-Density Matter

Dr. Setthivoine You (U. Washington)
A Laboratory Astrophysical Jet to
Study Canonical Flux Tube





Dr. Scott Klasky
Scientific
Computing Group,
National Center for
Computational
Sciences, ORNL

Adaptable I/O System for Big Data, or ADIOS

- ADIOS was developed by ORNL, Georgia Institute of Technology, Rutgers University, and North Carolina State University.
- The ORNL team consisted of Scott Klasky, Qing Liu, Norbert Podhorszki, Hasan Abbasi, Jeremy Logan, Roselyne Tchoua, Jong Youl Choi and Yuan Tian.

ADIOS is a portable, scalable, easy-to-use software framework conceived to solve "big data" problems.

- As compared to other products, ADIOS significantly reduces the input or output complexities encountered by scientists running on high performance computers, along with reducing their time to solution, which allows researchers to spend more time achieving scientific insight and less time managing data. The software streamlines workflows and lays the foundation for exascale supercomputers to be able to run multiple tasks simultaneously.
- The research was funded by DOE's Oak Ridge Leadership Computing Facility, the Office of Advanced Scientific Computing Research, the Office of Fusion Energy Science, and the National Science Foundation.



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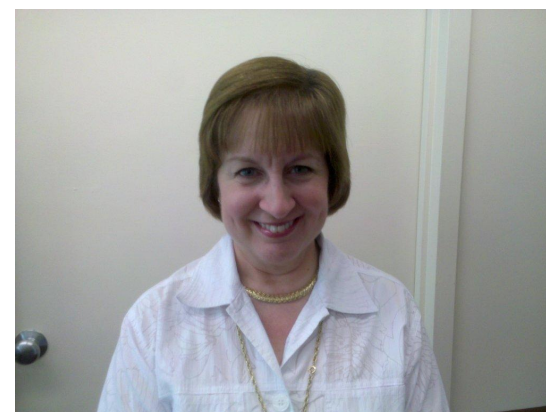
Recent FES Office Developments

Debra Frame retired in March

- **Program Analyst for fusion research international exchange activities**
 - She worked at DOE for 40 years (since 1981 at FES); retired on March 22



Participants at the US-Japan Executive Secretaries Meeting (2010)



Mrs. Debra Frame

Thank you, Debra!



John Sauter will retire December 31

- **20 years of service in the U.S. Navy**
 - Retired at rank of Master Chief
- **22 years of service at U.S. Department of Energy (mostly at FES)**
 - Expert handling of procurement, budget, and financial matters
 - Worked with university, lab, and private sector research groups to ensure provision of funding consistent with budgets
- **Vital role in developing the new Portfolio Analysis and Management System**

Thank you, John!



- **On July 30, Joe May was announced as the new director for Facilities, Operations, and Projects Division**
 - This was the former ITER and International Division
 - Joe is responsible for US Contributions to ITER Project and for operation and construction of major facilities and projects in FES portfolio
 - He has 27 years of experience in project and program management at DOE (in EM, NP, and BES)





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Thank you