

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

Update on the Fusion Energy Sciences Program

Ed Synakowski
*Fusion Energy Sciences
Office of Science
USDOE*



U.S. DEPARTMENT OF
ENERGY

Office of Science

University Fusion Association Meeting
November 11, 2013

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

Your concerns expressed during the past year include:

- ***What about the prospect of unbridled ITER growth?***
 - A: The Administration has proposed an approach in which US ITER funding is capped, starting in FY 2014

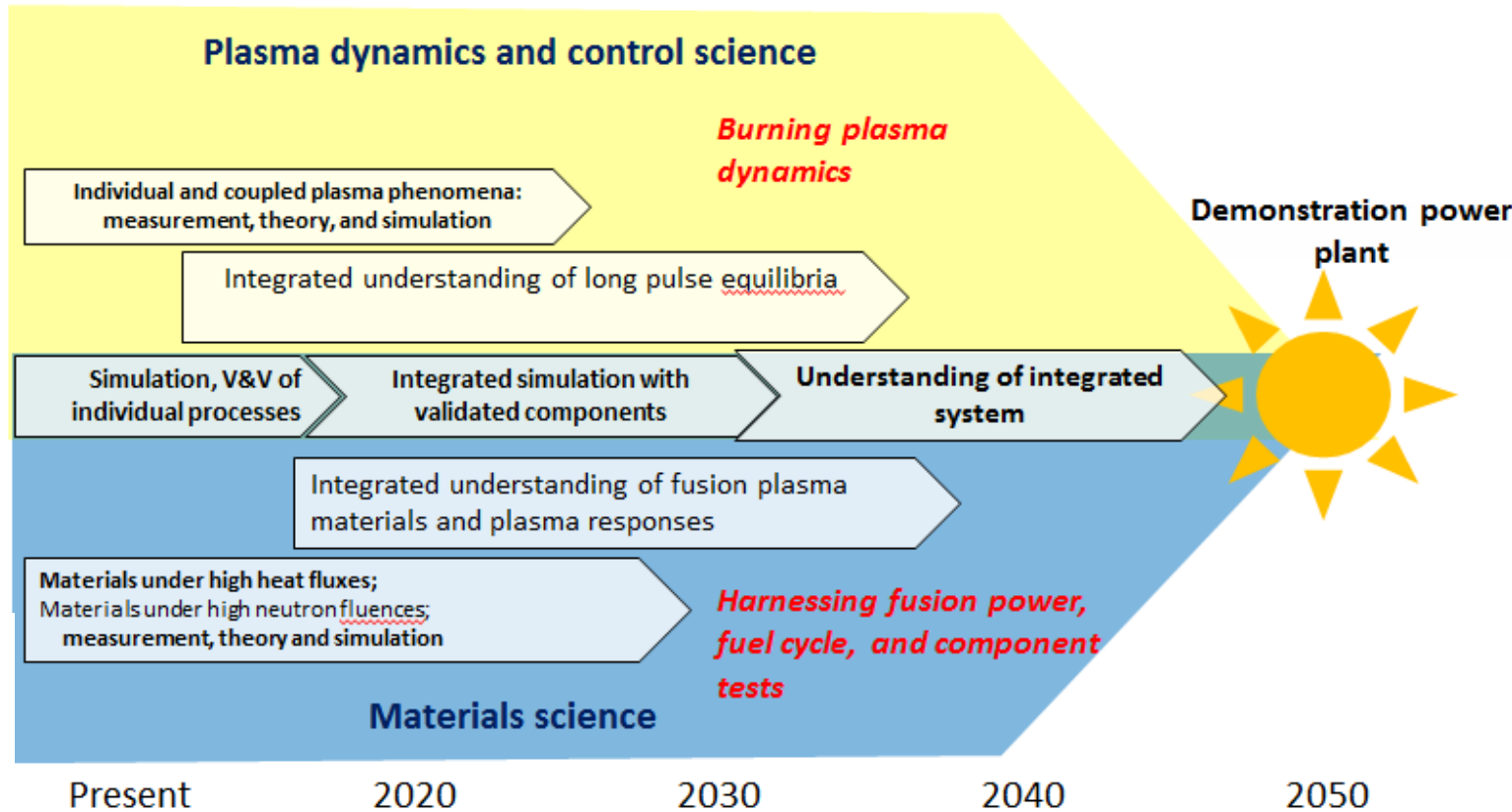
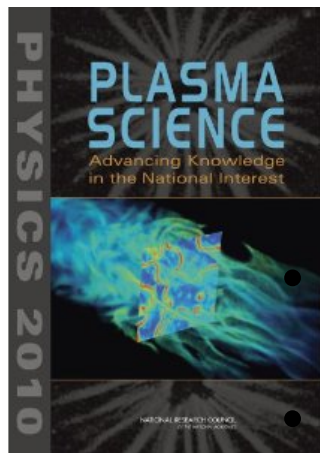
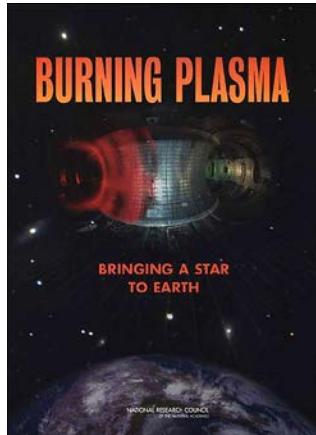
- ***What are the workforce implications of the choices FES is making?***
 - A: This year, FES has surveyed you, in detail, to get a better understanding of the present state of play regarding student education and post docs in the fusion and plasma sciences



***Comments on program vision, and
on connections to university-based
research***



What I have argued for: the US as 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

The 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 reflected an agreed-upon plan for support of ITER construction that is aimed at meeting our obligations while promoting a sustainable FES future



The US research effort has to effectively reap maximal benefit from ITER with a world-leading workforce with budgets that may be constrained

The FY 2014 budget proposal has tough elements, but it puts forward a broad program in experiment, theory and computation, and enabling R&D at labs, universities and industry. The portfolio supports research of over 350 individual students in fusion and the plasma sciences. 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 and the nation

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

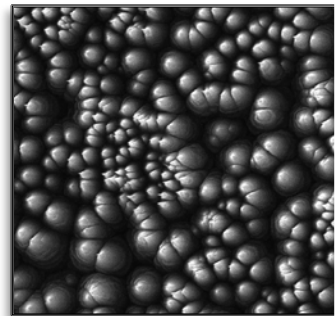
There will be mature, cutting-edge research facilities around the globe addressing the needs of ITER and looking beyond

The FY 2014 budget continues to invest in international partnerships. The Administration point of view is that these partnerships must lever a strong domestic program. New endeavors launched have significant university participation, including leadership



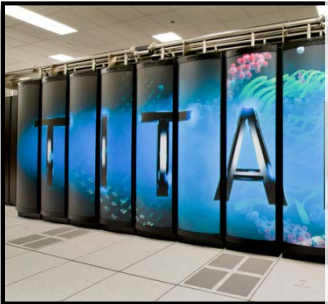
Fusion materials science will be an increasing focus globally

The FES research program now has elements that will be key to determining how research should proceed to close gaps in fusion materials science. We likely will have to choose where we focus if budgets are constrained. However, even now this area supports a large number of university researchers and presents significant opportunities for cost-effective leverage across Offices.



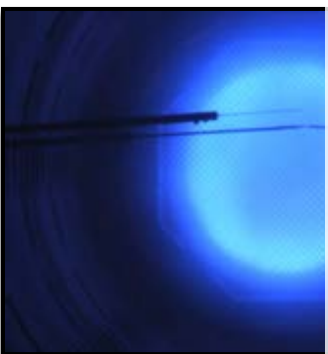
The world fusion science landscape will look considerably different in a decade (3 of 3)

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 Department is putting a great deal of attention on Exascale Computing. Our computing effort via the SciDAC and Theory programs needs to be prepared to be responsive to this. In this, university efforts can and should be strong.

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

- 
- ITER represents the height of leveraging capabilities internationally.
 - Despite HEDLP reductions, FES maintains a partnership with BES at LCLS (SLAC) for first-of-a-kind science that has great promise.
 - International partnerships will give researchers and students access to classes of fusion science not available stateside, keeping us on the leading edge.
 - The general plasma science portfolio, which has a strong partnership with NSF, executes great science and develops early career plasma scientists.
 - FES materials scientists are leading users of HFIR (at ORNL), another BES facility.
 - Fusion computing leverages partnership with ASCR through the SciDAC program.



***Enacting the FY 2013 budget,
and the Administration proposal
for FY 2014***

- **FES response to the rules of a Continuing Resolution, and the new effects of Sequestration:**
 - Under the Spend Plan with the CR, the total FY 2013 FES budget was eventually enacted at \$385M.
 - The overall effect of Sequestration for FES (including funding for research, facility operations, and MIE construction) was smaller by percentage and dollars than for any other science program in the Office of Science—and overall, the Office of Science was treated well
 - FY 2013 levels enacted for research and operations besides the US ITER Project were held at least at the FY 2013 request; some were increased
 - The enacted US ITER Project level was \$124M

The headlines in the FY 2014 budget request

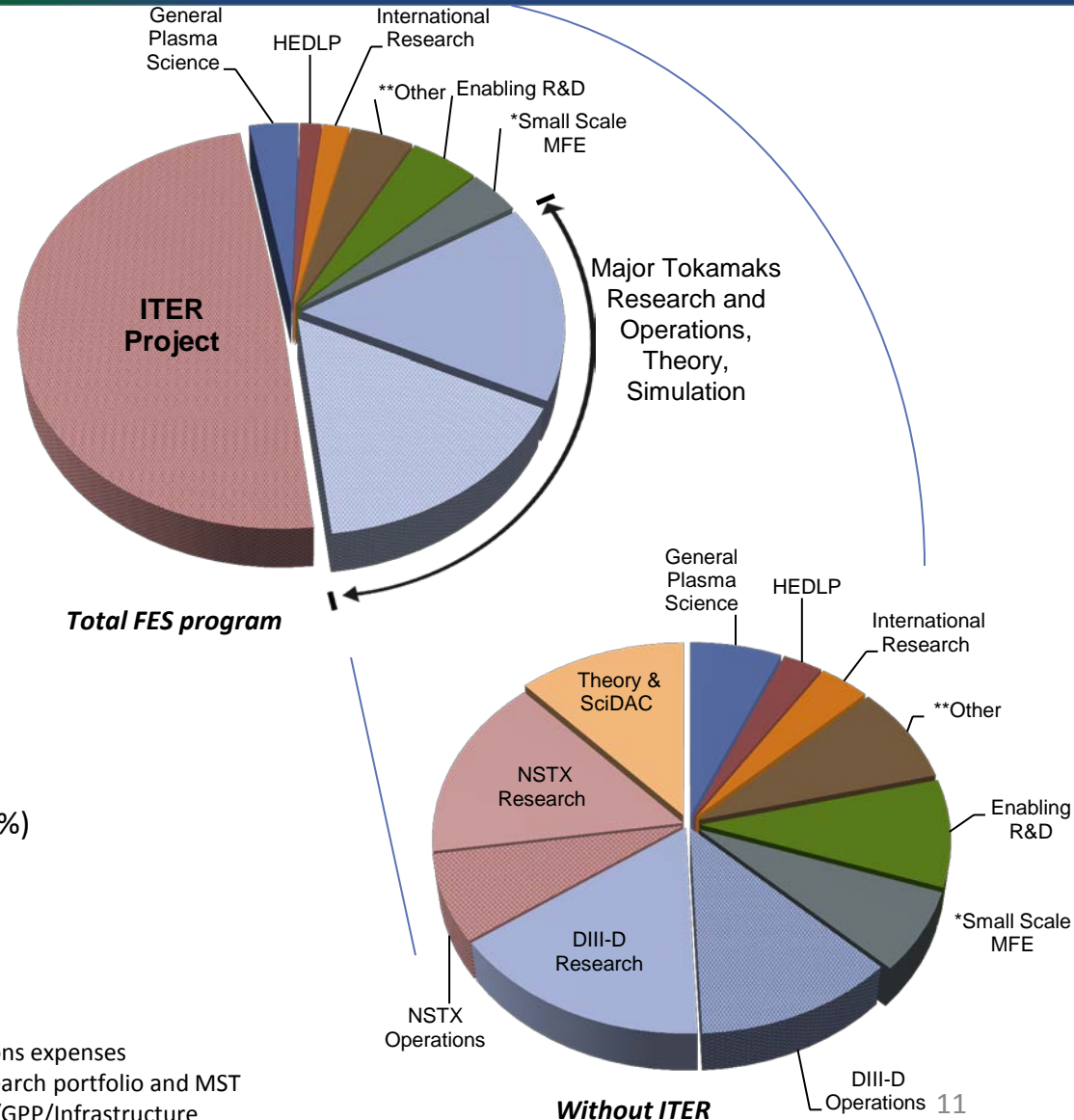
- **Overall budget grows**
 - \$458M request in FY 2014 compared to FY 2013 request for \$398M (+\$60M). This is the largest fractional increase in Office of Science; second largest total increase in \$
- **Administration agreement on US ITER spending reached**
 - Capped at \$225M per year, with this amount proposed for FY 2014
- **NNSA/DOE joint program in HEDLP reduced**
 - \$16.9M in FY 2013 to \$6.6M proposed in FY 2014

Science: \$160,064K

- Major Tokamak's Research (45.7 %)
 - DIII-D
 - NSTX
 - Theory & SciDAC
- Small Scale Magnetic Fusion Energy (10.1 %)
 - Experimental Plasma Research
 - Madison Symmetric Torus
- Enabling R&D (13.3 %)
 - Plasma Technology
 - Advanced Design
 - Materials
- International Collaborations (5.2 %)
- High Energy Density Laboratory Plasmas (4.1 %)
- General Plasma Science (9.4 %)

Facility Operations: \$299,160K

- ITER at \$225M, per Administration agreement (75 %)
- DIII-D (12 %)
- NSTX Upgrade (12 %)
- GPE/GPP/Infrastructure



Hatched areas indicate project and operations expenses

*Smaller Scale MFE includes Experimental Plasma Research portfolio and MST

**Other includes SBIR/STTR, Diagnostics, and GPE/GPP/Infrastructure

Proposed approach for US ITER: no more than \$225M per year, with a rolling planning horizon of two years

From the FES 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.”



- **From the 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 [sic] 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.”***
- **From the 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.”*



Regarding ITER

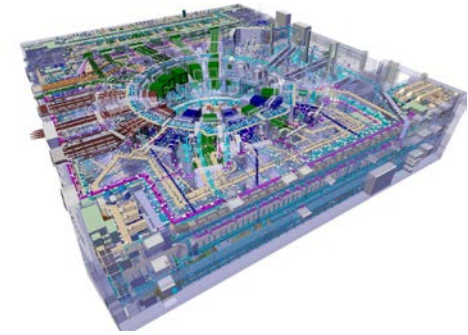


ITER site construction activity is accelerating



- 103 acre platform
- 39 buildings

the ITER Complex

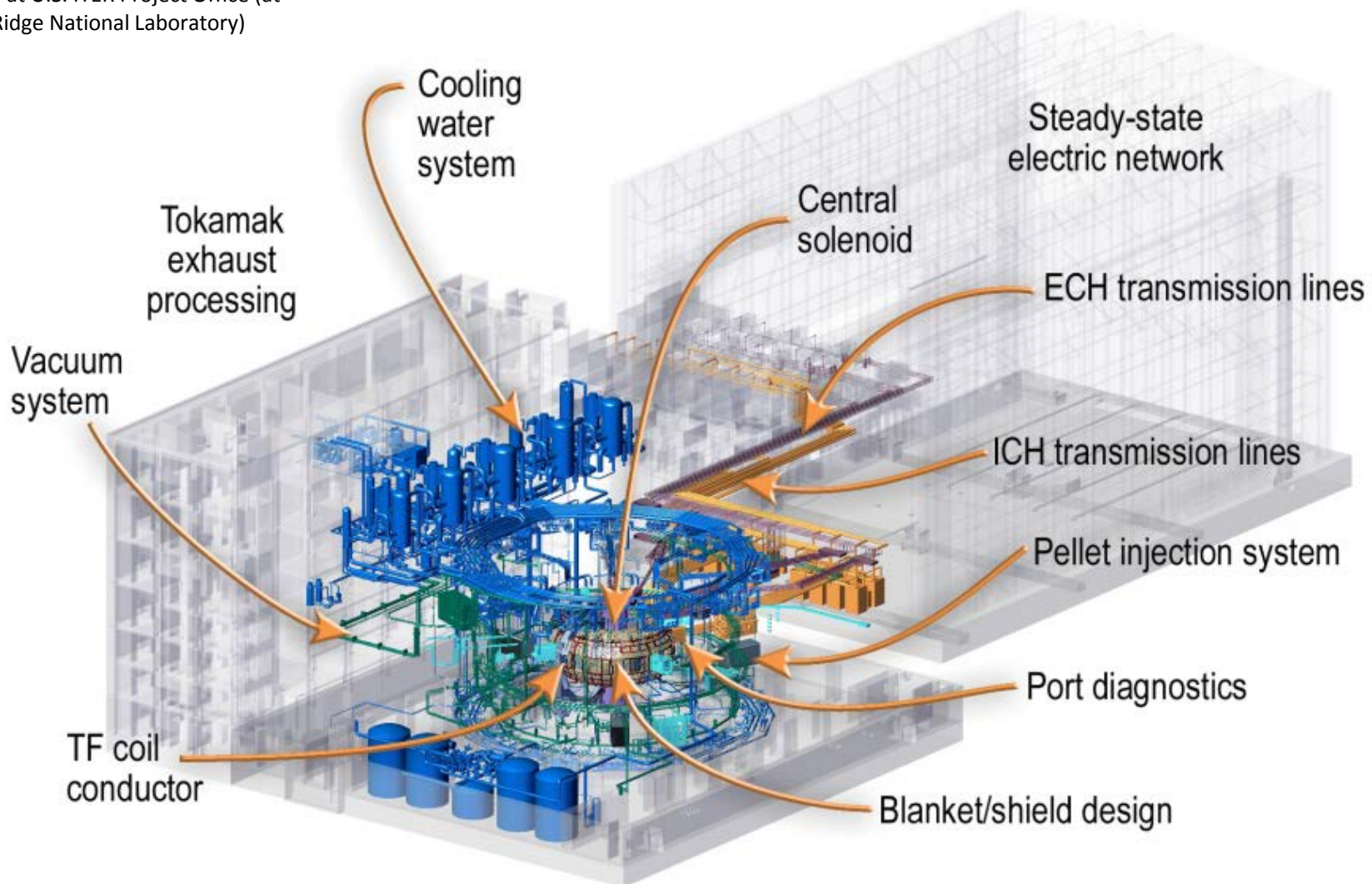


The heart of the ITER facility will be the Tokamak Complex, comprising the Tokamak Building, the Diagnostic Building, and the Tritium Plant. The seven-story Complex, measuring 118 m by 80 m and towering 57 m above the platform, will contain more than 30 different plant systems, including cooling systems and electrical power supplies, all having physical as well as functional interfaces.

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

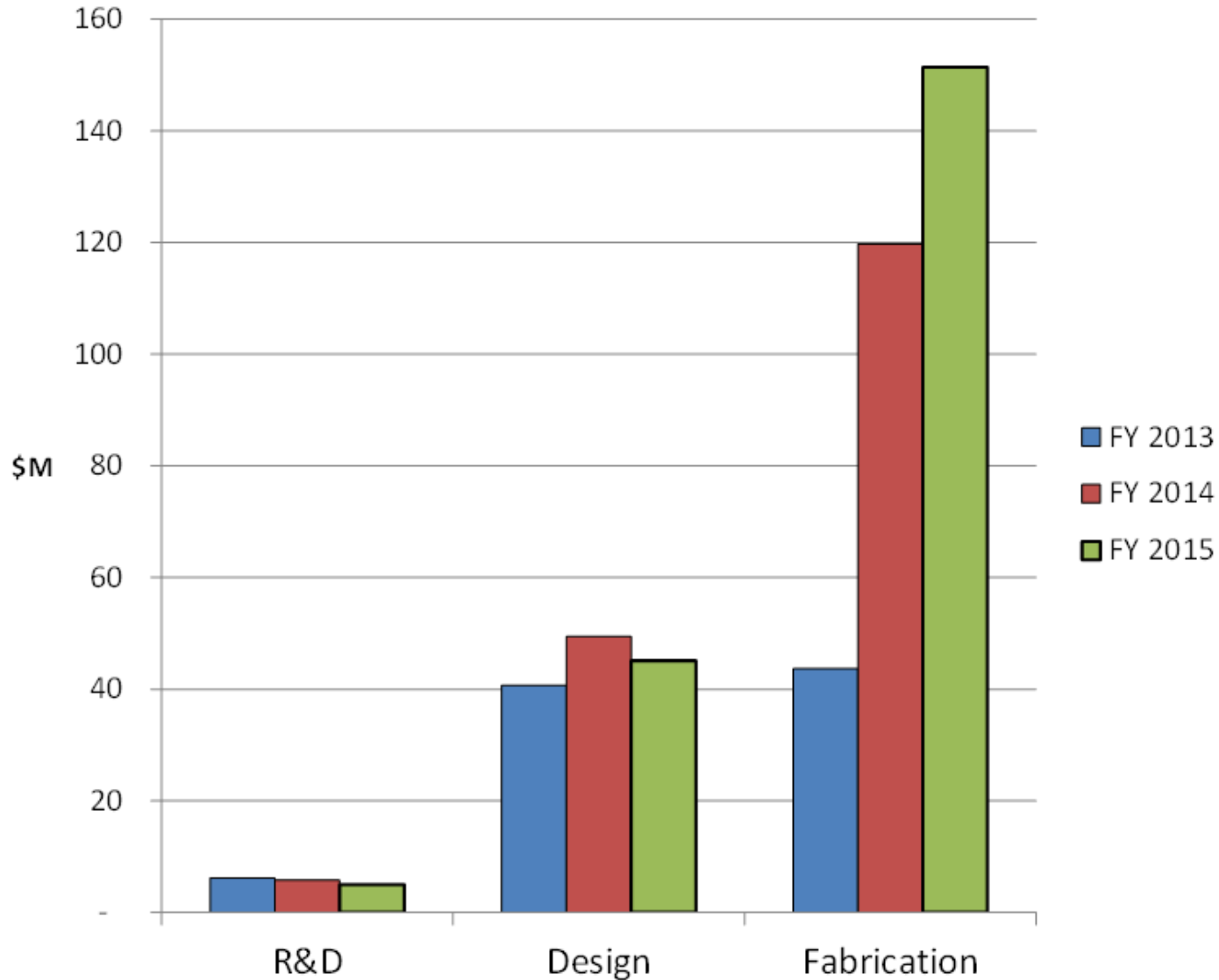
In-kind hardware contributions

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



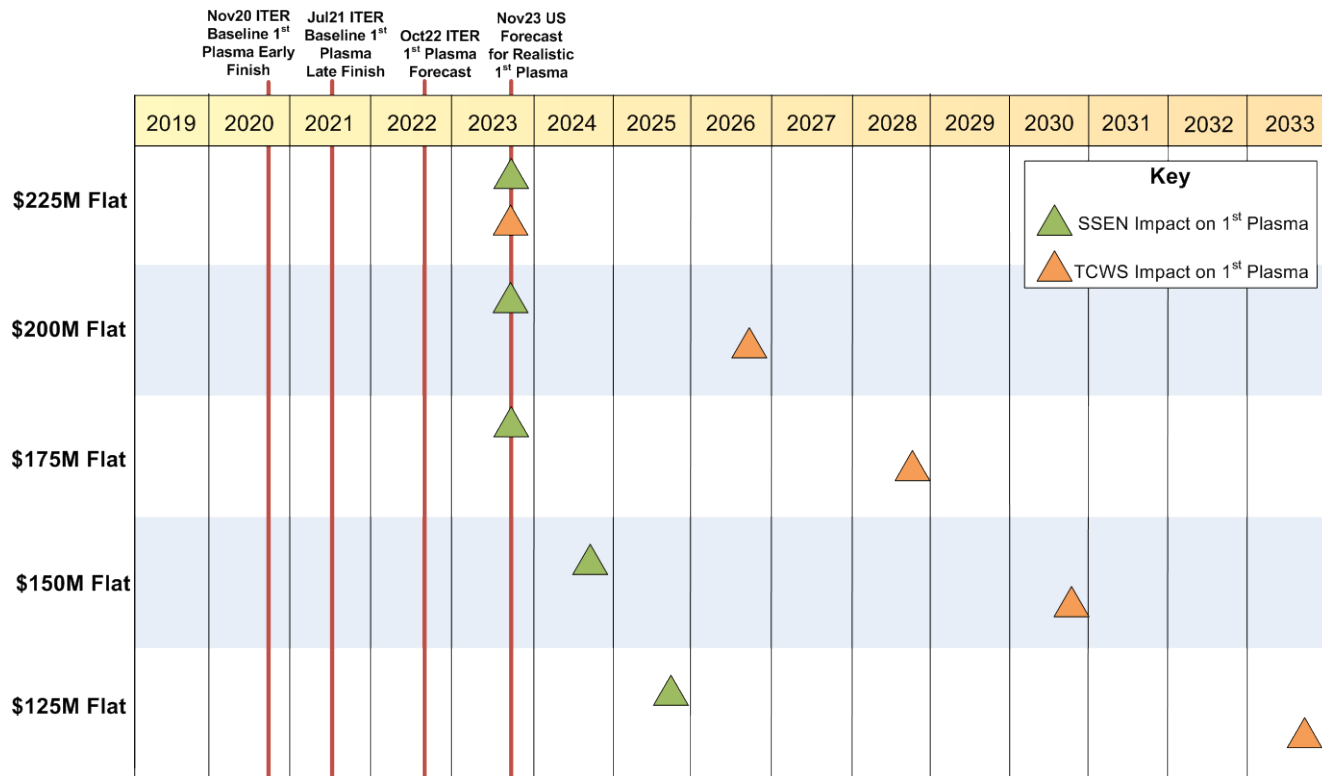


Transitioning from R&D/design to fabrication



Funding levels below those planned for US ITER will have significant impacts

- The 2-year US plan, including \$225M for FY 2014, was designed in response to ITER schedule slippages beyond the planned first plasma date of November 2020
- 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.



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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

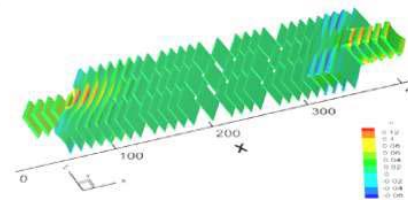
- ***International Collaboration in Fusion Energy Sciences Research: Opportunities and Modes during the ITER Era (2012)***
 - Chair: Dale Meade
- ***Materials Science and Technology Research Opportunities Now and in the ITER Era: A focused Vision on Compelling Fusion Nuclear Science Challenges (2012)***
 - 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/>

International Collaboration
in
Fusion Energy Sciences Research:
Opportunities and Modes
during the ITER Era

FESAC Report
February 28, 2012

Materials Science and Technology Research
Opportunities Now and in the ITER Era:
A Focused Vision on Compelling Fusion Nuclear
Science Challenges



A Report to the Fusion Energy Sciences Advisory Committee
February, 2012

New budget structure: 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; **labs and university 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

Lever domestic capabilities and science base into exploration internationally. **Major and university facilities in partnership.** Both plasma equilibrium sustainment and **the** present portfolio of Enabling Technologies

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

High Power

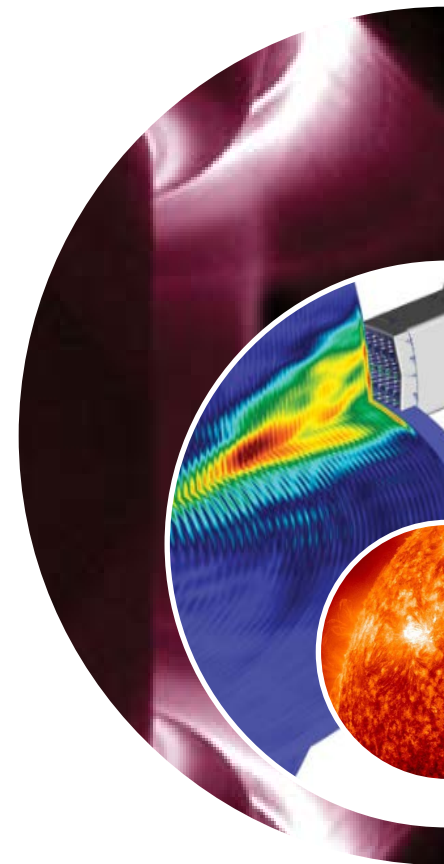
The ITER project is the keystone as it strives to integrate foundational burning plasma science with the science and technology girding long pulse, sustained operations.

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. Extend the reach of burning plasma science.





Recent FES office, program, and policy developments

- **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)





- **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
- **Portfolio Analysis and Management System (PAMS) went active for proposals in October**
 - PIs and sponsored project offices should register in PAMS

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)

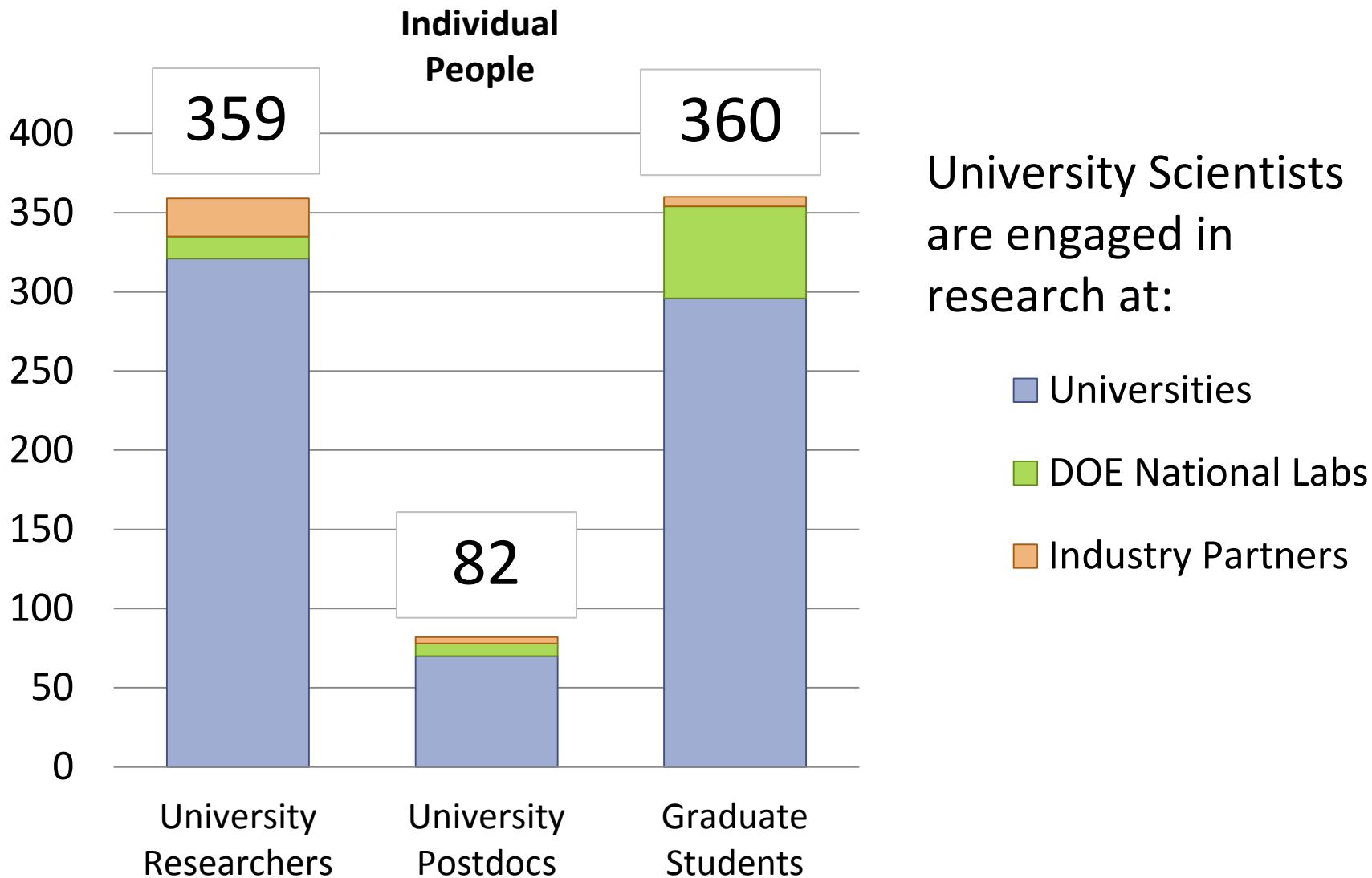
Motivation: Accurate employment reporting for FMIS and budget narrative

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)

Our programs supported 801 university researchers and students in FY 2013





Solicitation	Date Issued	Proposals Due	Total \$ Awarded in FY13	FES Point of Contact(s)
Theoretical Research in Magnetic Fusion Energy Science	March 27, 2012	May 31, 2012	\$4.2M	John Mandrekas
Collaborative Research in Magnetic Fusion Energy Sciences on International Research Facilities	April 16, 2012	June 21, 2012	\$3.2M	Steve Eckstrand
Laboratory Opportunities in Basic Plasma Science	May 11, 2012	July 16, 2012	\$1.8M	Nirmol Podder
Diagnostic Systems for Magnetic Fusion Energy Sciences	June 22, 2012	August 14, 2012	Non Lab: \$3.1M Lab: \$0.4M	Francis Thio
Collaborative Research in Magnetic Fusion Energy Sciences on the National Spherical Torus Experiment Upgrade (Laboratory Notice)	July 18, 2012	September 26, 2012	\$1.9M	Steve Eckstrand
High Energy Density Laboratory Plasma Science for Inertial Fusion Energy	June 21, 2012	October 1, 2012	\$0	Ann Satsangi, Sean Finnegan
NSF/DOE Partnership in Basic Plasma Science and Engineering	On going	October 5, 2012	\$1.5M	Nirmol Podder, Ann Satsangi, Sean Finnegan
SBIR/STTR Phase I	August 13, 2012	October 16, 2012	\$4.6M	Varies, depends on proposal area
SBIR/STTR Phase II	October 22, 2012	December 11, 2012	\$10.2M	Varies, depend on proposal area
High-Energy-Density Laboratory Plasma Science	August 13, 2012	November 16, 2012	\$4.6M	Sean Finnegan, Ann Satsangi
Office of Science Early Career Research Program (Required Pre-proposals due by September 6, 2012)	July 20, 2012	November, 26, 2012	\$1.45M	Varies, depends on proposal area



FY 2014 funding opportunities published to date

Solicitation	Date Issued	Proposals Due	Total Funding available (Final amount pending FY14 Appropriations)	FES Point of Contact(s)
<i>Theoretical Research in Magnetic Fusion Energy Science</i>	March 5, 2013	May 22, 2013	\$3.8M/yr	John Mandrekas
<i>National Spherical Torus Experiment – Upgrade: Collaborative Research on Configuration Optimization</i>	August 12, 2013	October 10, 2013	\$1.8M/yr	Steve Eckstrand
NSF/DOE Partnership in Basic Plasma Science and Engineering	On going	November 26, 2013	\$2M/yr	Nirmol Podder, Ann Satsangi, Sean Finnegan
<i>SBIR/STTR Phase I</i>	November 25, 2013	February 4, 2014	TBD	Varies, depends on proposal area
<i>SBIR/STTR Phase II</i>	February 10, 2014	April 17, 2014	TBD	Varies, depends on proposal area
<i>Office of Science Early Career Research Program (Required Pre-proposals due by September 5, 2013)</i>	July 23, 2013	November 19, 2013	TBD	Varies, depends on proposal area
FY 2014 Continuation of Solicitation for the Office of Science Financial Assistance Program	October 1, 2013	Ongoing	TBD	Varies, depends on proposal area

Update on a new Office of Science prioritized facility list

- **Goal: Prioritize DOE scientific facilities for 2014-2024**
- **From the Charge Letter of last winter:**
“Goal Statement: Prioritization of scientific facilities to ensure optimal benefit from Federal investments. By September 30, 2013, formulate a 10-year prioritization of scientific facilities across the Office of Science based on (1) the ability of the facility to contribute to world-leading science, (2) the readiness of the facility for construction, and (3) an estimated construction and operations cost of the facility.”

Facilities recommended by FESAC

Facility	World-leading Science	Readiness
DIII-D National Fusion Facility	absolutely critical	(existing)
Upgraded National Spherical Torus Experiment (NSTX-U)	absolutely critical	(existing)
Fusion Materials Irradiation Facility	absolutely critical	ready to initiate construction
Fusion Nuclear Science Facility (FNSF)	absolutely critical	significant R&D before construction
Multi-Petawatt Science Facility	important	significant R&D before construction
Quasi-Symmetric Stellarator Facility	absolutely critical	significant R&D before construction
Upgrade to the DIII-D National Fusion Facility	important	ready to initiate construction

- Results of FESAC assessment have served as input to Office of Science leadership
- Outcome not known at this time



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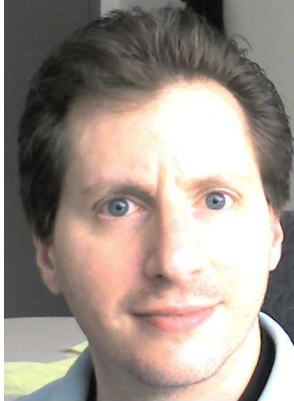
Office of Science

Good news examples



**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.”*



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.

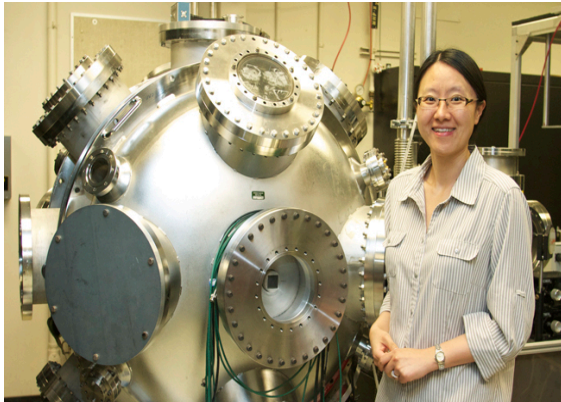
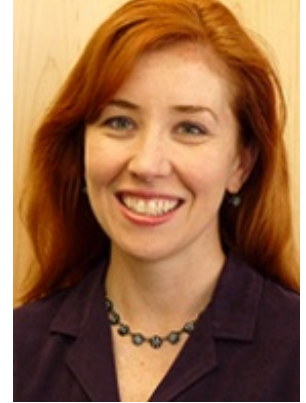


2013 FES Early Career Awards



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





Director's Appreciation Award



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]



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Thank you