

Update on the Fusion Energy Sciences Program

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Acting Associate Director
Office of Science
Fusion Energy Sciences



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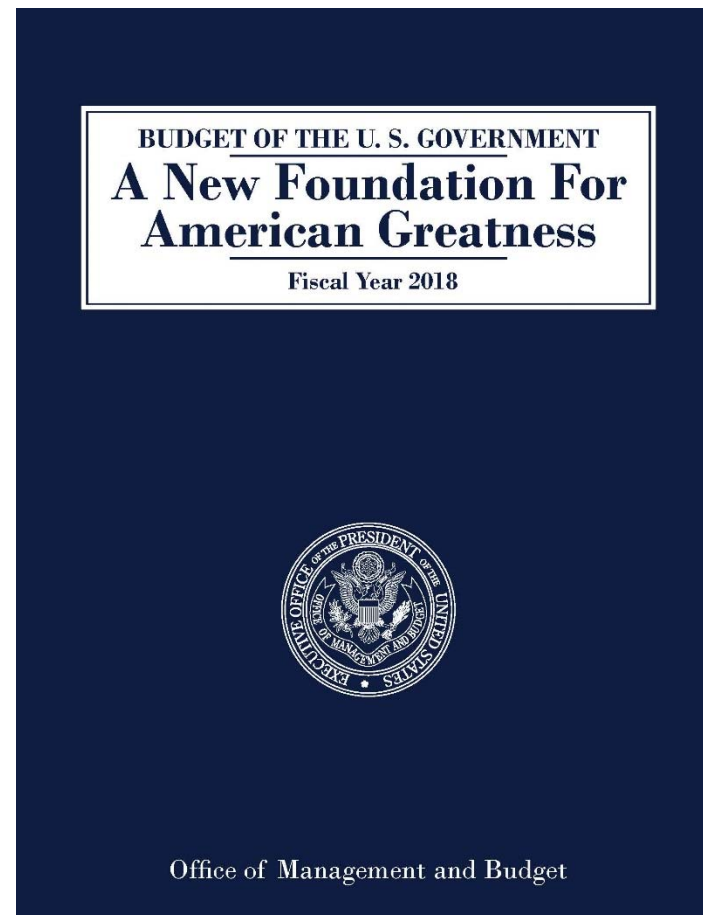
University Fusion Association Meeting
59th APS DPP Annual Meeting
October 23, 2017



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1. Budget Updates





- **FY 2018**

- Under a Continuing Resolution until **December 8, 2017**
 - *Bill H.R. 601 funds all programs at the FY 2017 enacted level less a 0.6791% across-the-board cut*
- Funding actions for grants and cooperative agreements are being processed, following a priority order based on the starting date of their FY 2018 budget periods
- Labs (and some large cooperative agreements) are funded incrementally

- **FY 2019**

- Awaiting OMB pass-back on proposed budget
- Administration issued R&D priorities for FY 2019



Highlights from the House and Senate marks for FY 2018 budget

- **From the Senate Energy and Water Development mark [July 2017]**
 - The Committee recommends **\$232,000,000** for Fusion Energy Sciences.
 - The Committee recommends **no funding for the U.S. contribution to ITER.**
 - The Committee remains concerned about the **timeline of facility repair and recovery actions for NSTX-U** and directs the Department to assess science drivers for the NSTX-U to support future planning and reconfiguration for the Fusion Energy Sciences program; DOE must provide a briefing to the Committees on Appropriations of both Houses of Congress upon completion.
 - The Committee recommends **prioritization of research and operations for DIII-D and supports continued research on HEDP.**
- **From the House Energy and Water Development mark [July 2017]**
 - The Committee recommends **\$395,000,000** for Fusion Energy Sciences, \$15,000,000 above fiscal year 2017 enacted and \$85,060,000 above the budget request.
 - Recognizes that **“University-led research helps further U.S. research in fusion energy and trains the next generation of scientists”** and directs DOE to summarize the fusion energy sciences program’s current collaborations with universities and report back to the Committee
 - Specific marks for two programs (HEDLP & SciDAC)
 - The Committee recommends **\$63,000,000** for the U.S. contribution to the ITER project



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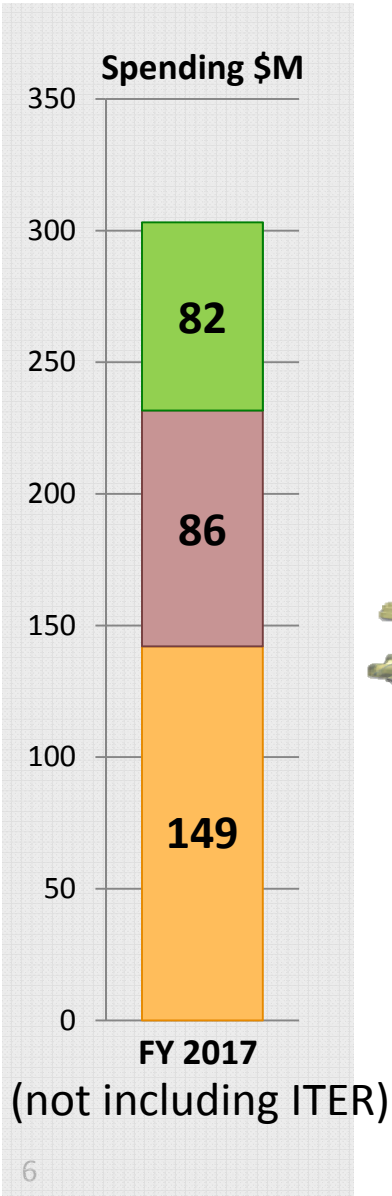
2. Programmatic Updates



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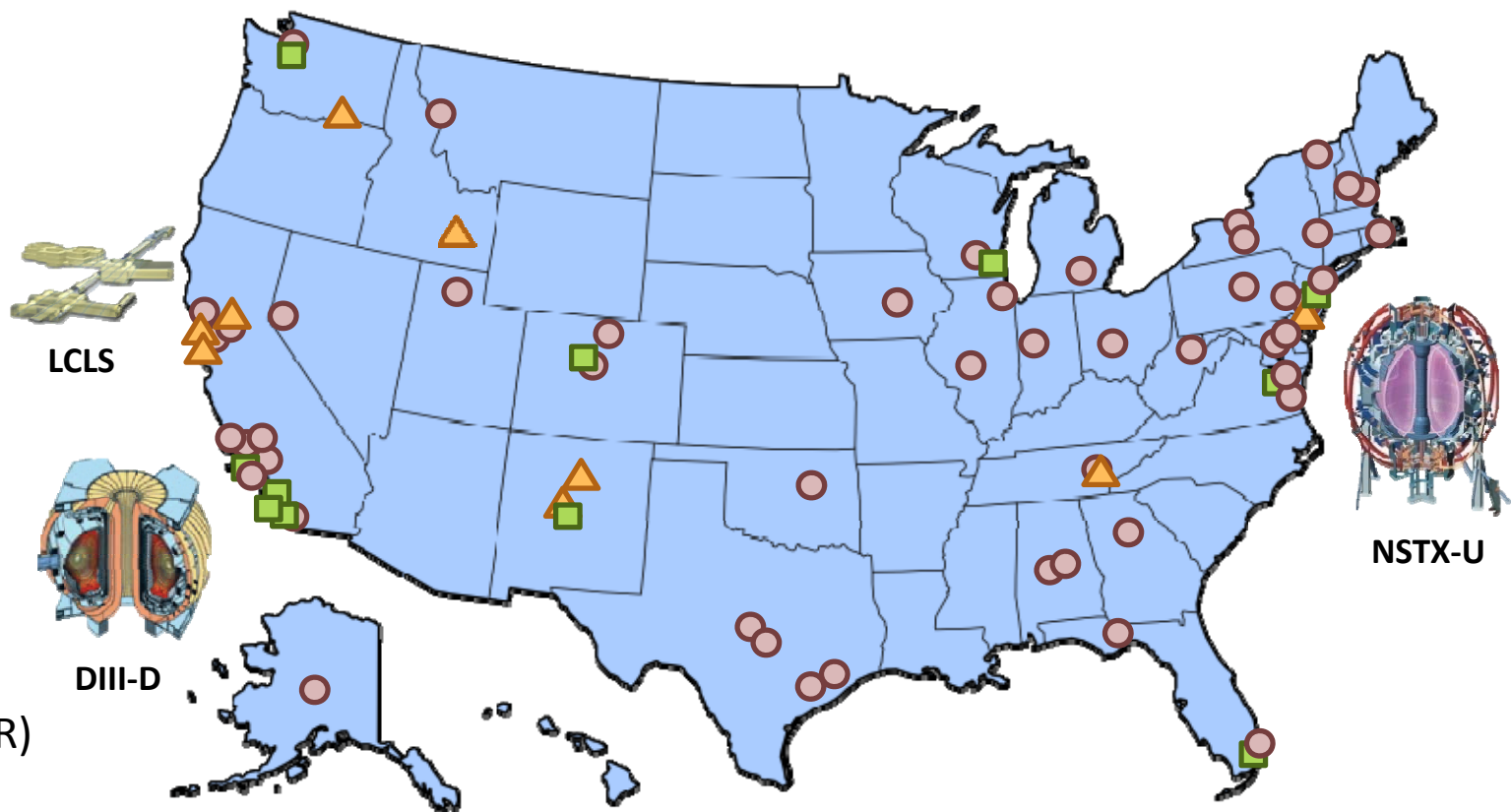
FES research is carried out at a diversity of US institutions



41
universities

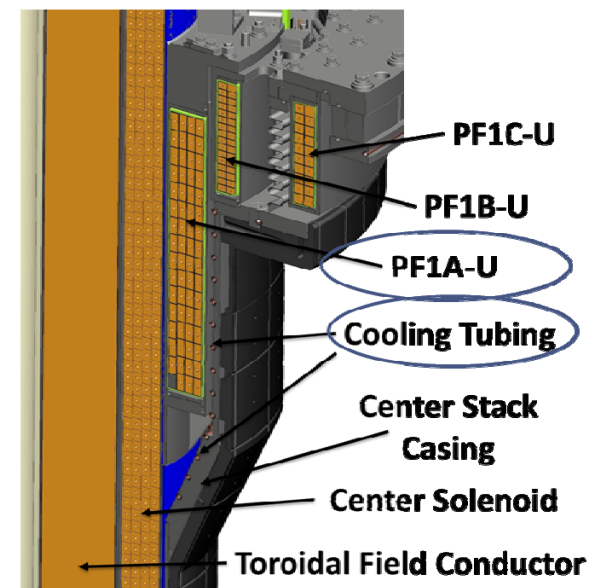
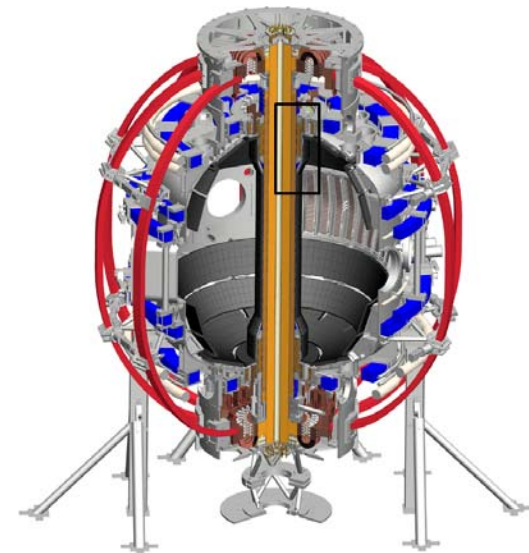
11
industry

10
laboratories





- **Research operation of NSTX-U:**
 - Plasma operations commenced after the completion of the NSTX Upgrade project.
 - However, after ten weeks of experimental operation, a series of hardware failures rendered the machine inoperable, stopping operations prematurely in 2016.
- **In response, FES directed PPPL to:**
 - Conduct an independent investigation of all policy and procedural causes of the NSTX-U project difficulties
 - Identify all design, construction, and operational deficiencies with the NSTX-U facility.
- **These activities led to the development by PPPL of a corrective action plan and proposed recovery activities to effect the necessary repairs to NSTX-U**
 - An external review of a preliminary schedule prepared by PPPL for the recovery of NSTX-U operations was recently completed.





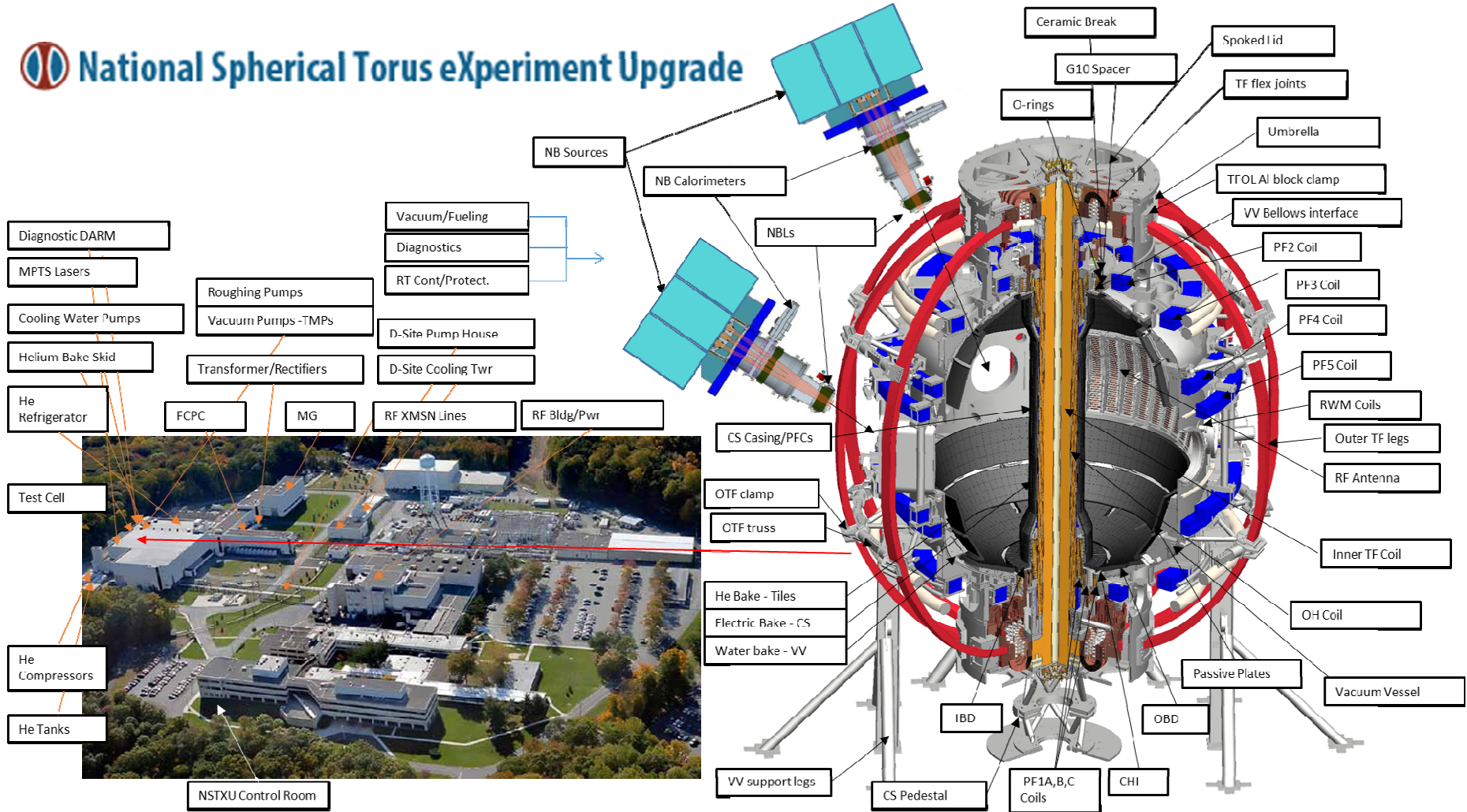
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Extensive "Extent of Condition" assessment



National Spherical Torus eXperiment Upgrade

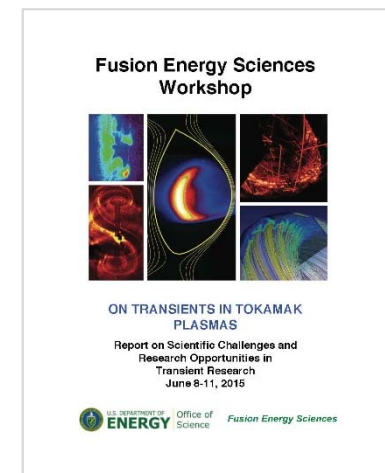
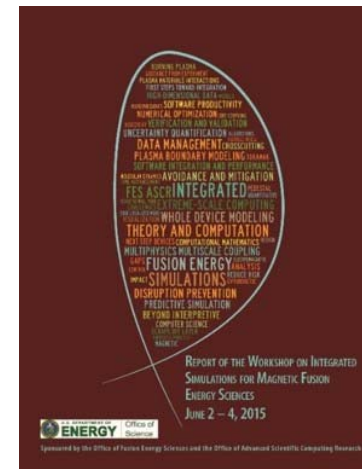


A new SciDAC portfolio addresses priorities identified in community workshops

- The FES SciDAC program accelerates progress in fusion plasma science by capitalizing on SC investments in leadership-class computing systems and associated advances in computational science
- The FES SciDAC portfolio was recompeted in FY 2017
 - FES and ASCR invested **\$24M** in FY 2017 to support **seven** multi-institutional and interdisciplinary SciDAC partnerships – an **eighth** project will be supported by FES in FY 2018
 - 11 universities, 8 DOE national laboratories,, and 5 private industry institutions (including small businesses) in 13 states
 - **Four projects** are led by **university scientists**; strong university participation in others
- The new portfolio strengthens the U.S. domestic fusion program, advances U.S. world-leadership and competitiveness in fusion simulations, and addresses research opportunities identified in recent community workshops



27 PF Titan @ OLCF

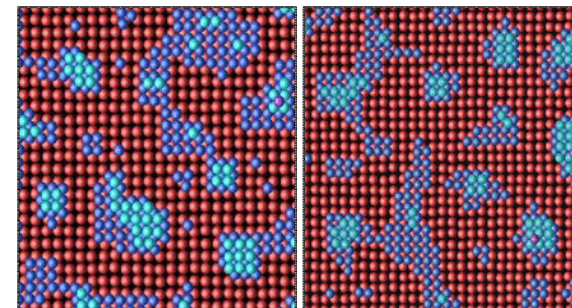
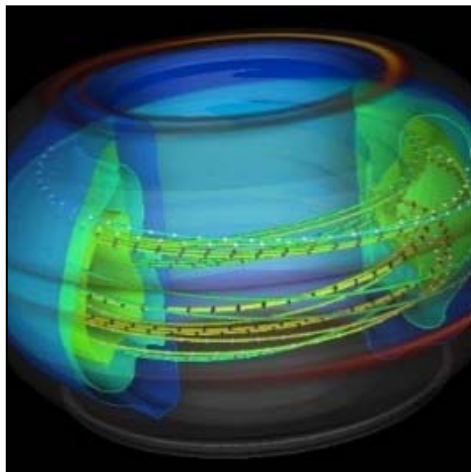
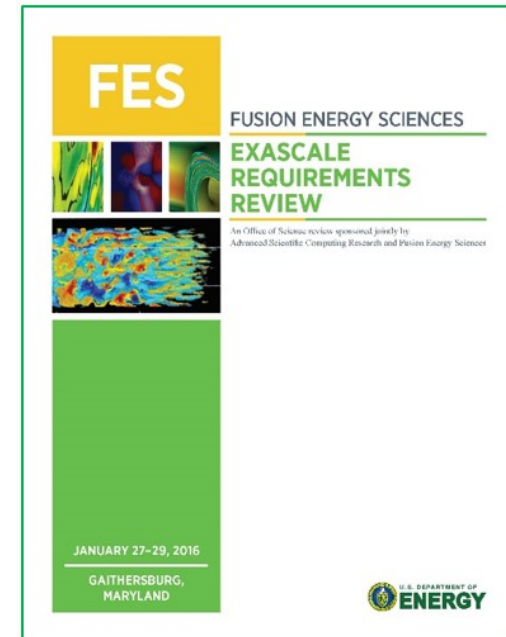


2015 community workshops on Integrated Simulations for Magnetic Fusion Energy Sciences and Transients in Tokamak Plasmas



Fusion presence in Exascale activities - *An Administration priority*

- The upcoming Exascale era will enable transformative advances in predictive power for fusion systems, based on fundamental science and high-performance computing
- Community studies identified priorities and challenges
- Two fusion-relevant multi-institutional efforts are part of the DOE Exascale Computing Project (ECP)
- **University participation** through subcontracts with the DOE Labs

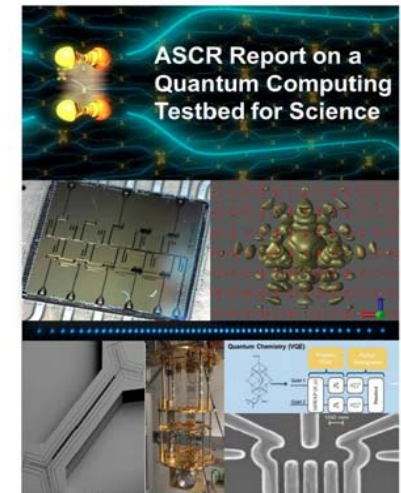


High-Fidelity Whole-Device Modeling of Magnetically Confined Fusion Plasma
(led by PPPL)

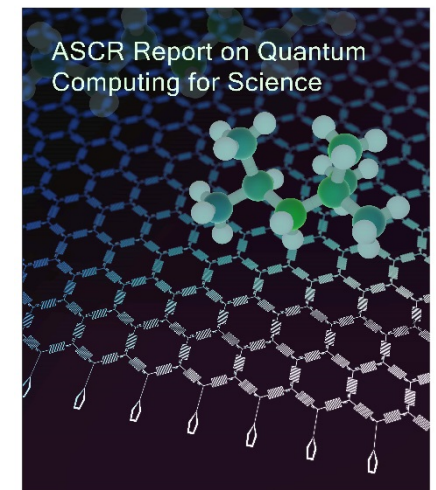
Molecular Dynamics at the Exascale: Spanning the Accuracy, Length and Time Scales for Critical Problems in Materials Science
(led by LANL; addresses needs of BES, FES, and NE)



- **Quantum Information Systems (QIS)** has emerged as an Administration priority
 - *Quantum Computing* was explicitly mentioned in the recent OMB memo on the Administration's R&D priorities for FY 2019
- SC has formed a **task force** to identify SC-wide grand challenges that will potentially be transformed by quantum computing applications
- In **early 2018**, FES will be working with the community to determine:
 - The potential of fusion and plasma science to contribute to the development of QIS
 - The potential of QIS to provide transformative advances in the science areas supported by FES



2017 ASCR report



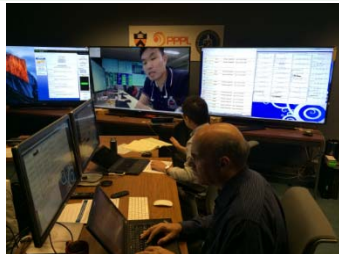
2015 ASCR report



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U.S. remote control rooms enable full utilization of international & domestic research facilities



MIT

PPPL

GA

- U.S. teams at **GA** completed a week of experiments in FY17 during EAST third shift and lead experiments at KSTAR
- **PPPL** and collaborators lead experiments on KSTAR & connect to W7-X, DIII-D
- Remote control room at **MIT** is being designed with assembly to commence in Spring FY18





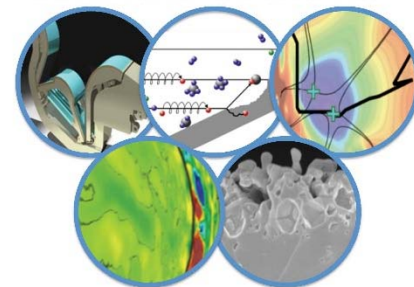
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Fusion Nuclear Science: FESS liquid metal PFC's integrated tokamak study

- **Liquid metals** PFCs are attracting increasing attention due to their potential advantages over solid PFC options, as highlighted in the 2015 Community PMI workshop report.
- FES has commissioned the **Fusion Energy Systems Study (FESS)** group to examine this class of PFCs from a systems level perspective in order to identify the most promising concepts and provide feedback on high priority, high leverage R&D on the path towards demonstrated viability.
- This two year study, initiated in February of 2017, includes participation of **six national laboratories** and **five universities**.

FUSION ENERGY SCIENCES WORKSHOP



ON PLASMA MATERIALS INTERACTIONS

Report on Science Challenges and Research
Opportunities in
Plasma Materials Interactions

MAY 4-7, 2015

U.S. DEPARTMENT OF **ENERGY** Office of Science *Fusion Energy Sciences*

2015 community workshop on
PMI



UCLA



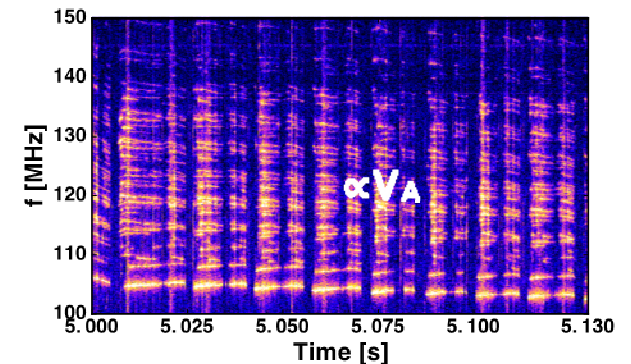
PSFC

UC San Diego

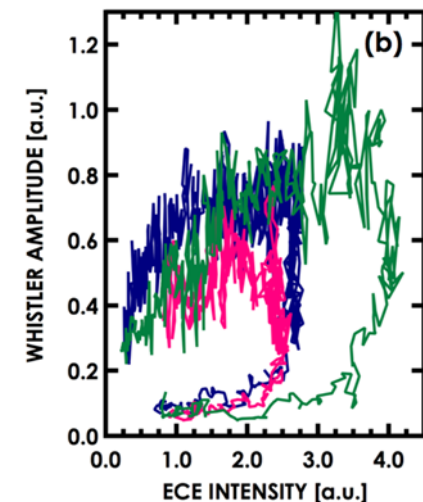




- In FY 2017, FES supported an initiative to carry out experiments on DIII-D focusing on frontier plasma science, soliciting input from the university community to identify experiments not directly related to fusion energy issues
- Four experiments were performed:
 - Interaction of Alfvén/whistler fluctuations and runaway electrons
 - Self-consistent chaos in magnetic field dynamics
 - Self-organization of kink-unstable flux ropes; and
 - Impact of magnetic perturbations on turbulence
- The initiative was very successful and resulted in a post-deadline invited paper in this meeting (*D. Spong, Y13 Session, Friday, October 27*)
- Plans are underway to continue this initiative in FY 2018



Whistler frequency bands showing intermittency from sawtooth and whistler scattering



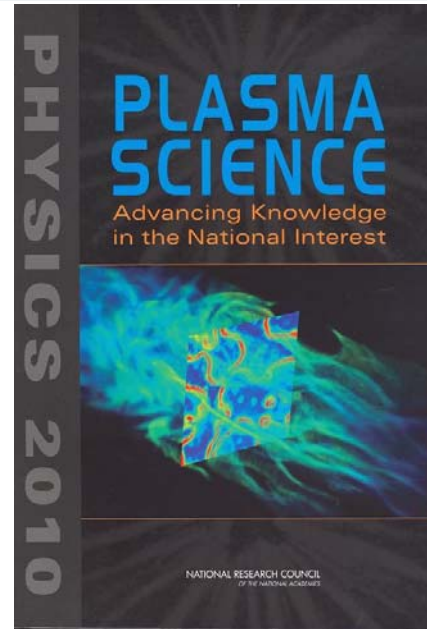
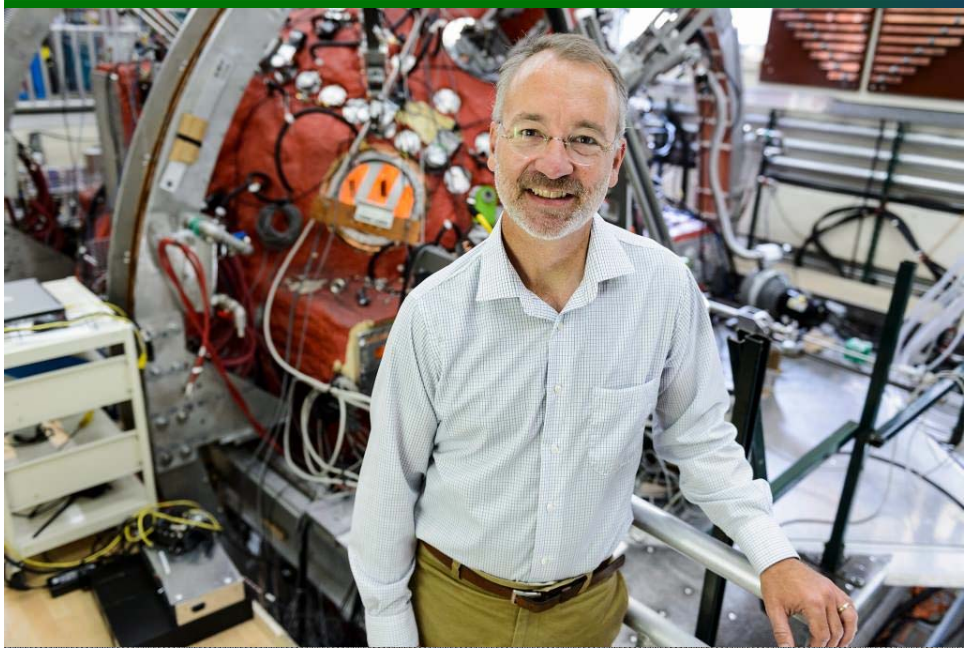
Predator-prey limit cycles between whistler wave amplitude and electron cyclotron emission – related to scattering of runaways



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A new intermediate-scale facility was awarded by FES for the first time in nearly two decades



The DOE Office of Fusion Energy Sciences has awarded \$12.5 million FY17 funds over five years to the University of Wisconsin–Madison to develop an intermediate-scale, integrated, collaborative plasma science user facility that will expand the frontiers of plasma astrophysics. Two existing experiments, the Big Red Plasma Ball and the Madison Symmetric Torus, are combined into the new Wisconsin Plasma Physics Laboratory (WiPP). The new project will join the expertise of more than two dozen UW–Madison scientists and technicians with outside plasma scientists, who will gain access to the facility and establish new collaboration.

“Several areas of basic plasma science would benefit from new intermediate-scale facilities.”(2010 Decadal Study)

“There is a need for creation and exploration of new regimes in the laboratory.” (2016 PSF Report)



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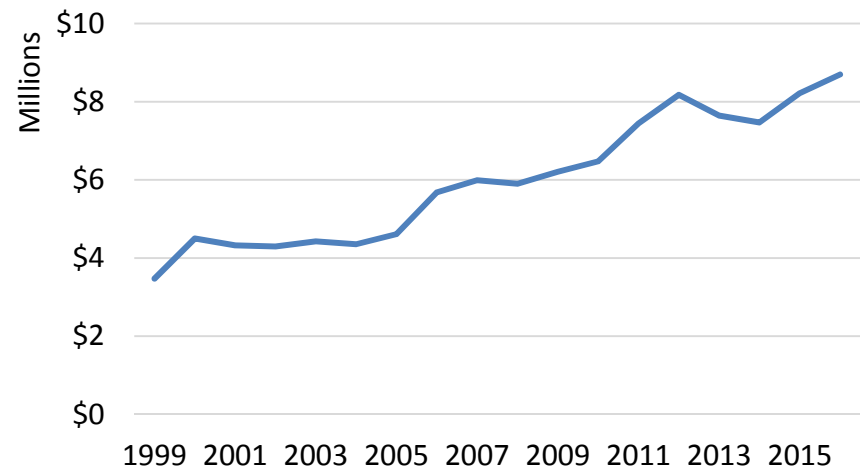
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Recent workshop celebrated 20 years of NSF-DOE Partnership in basic plasma science



Attendees at workshop (Jan 9-11, 2017)

Annual FES Funding Profile for the Partnership



- The NSF/DOE Partnership is one of the longest-running interagency joint programs in the federal government.
- Main objective of original Memo of Understanding (1996) was to “provide enhanced opportunities for university-based research in fundamental processes in plasma science and engineering.”
- DOE funding increased from \$3.5M in 1999, to \$8.7M in 2016. DOE provided additional funding in 2016 of \$6.7M, which increased the award success rate to 28%.



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DOE celebrates 40th Anniversary

DOE 40th Anniversary

THE OFFICE OF SCIENCE PRESENTS:
Research milestones over the past 40 years

1977 - 2017

Celebrating 40 years of research at the
Department of Energy



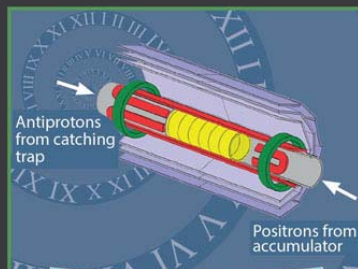
THE OFFICE OF SCIENCE PRESENTS:
RESEARCH MILESTONES OVER THE PAST
FORTY YEARS



DOE 40th Anniversary

Office of Science .
RESEARCH MILESTONE • **1978**

N.J. Fisch, PRL 41(13), 873
(1978)
Confining a tokamak
plasma with rf-driven
currents



DOE 40th Anniversary

Office of Science .
RESEARCH MILESTONE • **2010**

G.B. Andresen et al.,
Nature 468, 673 (2010)
Trapped antihydrogen



DOE 40th Anniversary

Office of Science .
RESEARCH MILESTONE • **1990**

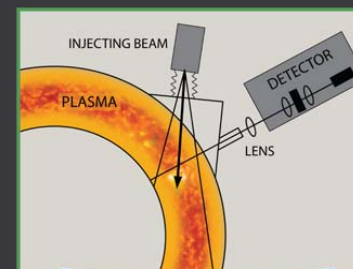
R.J. Groebner et al., PRL 64,
3015 (1990)
Role of edge electric field
and poloidal rotation in the
L-H transition



DOE 40th Anniversary

Office of Science .
RESEARCH MILESTONE • **1994**

J.D. Strachan et al.,
PRL 72, 3526 (1994)
Fusion power
production from TFTR
plasmas fueled with
deuterium and tritium



DOE 40th Anniversary

Office of Science .
RESEARCH MILESTONE • **1989**

F.M. Levinton et al.,
PRL 63, 2060 (1989)
Magnetic field pitch-angle
measurements in the PBX-
M tokamak using the
motional Stark effect



In FY 2017, the community had several opportunities to provide input to various planning activities:

- **FESAC subcommittee** to identify the most promising **transformative enabling capabilities** for the U.S. to pursue that could promote efficient advance towards fusion energy, building on burning plasma science and technology
 - Report will be available soon and will be discussed at a future FESAC meeting
- **National Academy of Sciences (NAS) Burning Plasma Study:**
 - Two community workshops on magnetic fusion research strategic directions in order to provide input to NAS:
 - July 24-28, at the University of Wisconsin-Madison
 - December 11-15, at The University of Texas at Austin
 - Meetings organized by NAS:
 - June 5-6, at Washington, DC
 - August 29-31, at Irvine, CA
 - December 15-16 at Austin, TX (following the community workshop)
 - February 26-28, in San Diego, CA

2020 Plasma Science Decadal Survey

- Charge and Statement of Task have been finalized
- NAS submitted a proposal to FES, which is under review
- The Decadal Survey will be carried out over 24 months



2017 FES Early Career Awards



Dr. Jason Trelewicz
Stony Brook Univ.
Plasma-facing materials
applications



Dr. Julia Mikhailova
Princeton University
Attosecond light-field control
of high-density plasmas



Dr. Juan Trelles
U. Massachusetts-Lowell
Plasmas in contact with liquids



Dr. David Green (ORNL)
Simulation of magnetically
confined fusion plasmas



Dr. Frederico Fiuza (SLAC)
Particle acceleration in
HED plasmas



Dr. Adam Sefkow (U. Rochester)
Hybrid fluid-kinetic modeling
efforts for HEDP and ICF Science



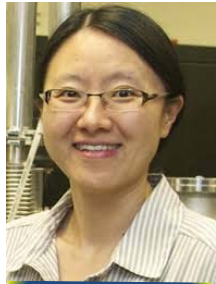
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2 PECASE, 3 Weimer, 2 FPA , and 1 Fabre award winners from FES in five years

Yuan Ping (LLNL)

2011 Katherine E. Weimer Award



Stephanie Hansen (SNL)

2014 PECASE Award



Adam Sefkow (UR)

2017 Fusion Power Associates Award



2013

2015

2012

2016

Daniel Sinars (SNL)

2011 PECASE Award



Anne White (MIT)

2014 Katherine E. Weimer Award
2014 Fusion Power Associates Award



Félicie Albert (LLNL)

2017 Katherine E. Weimer Award
2017 Edouard Fabre Prize





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Three new FES ORISE postdoctoral researchers join existing awardees at UW-Madison, PPPL, and MIT



Marlene Patino

*Plasma Material Interaction
Studies at PISCES (UCSD)*



Anton Neff

*DIII-D Impurity Collector
Probe Analysis (ORNL)*



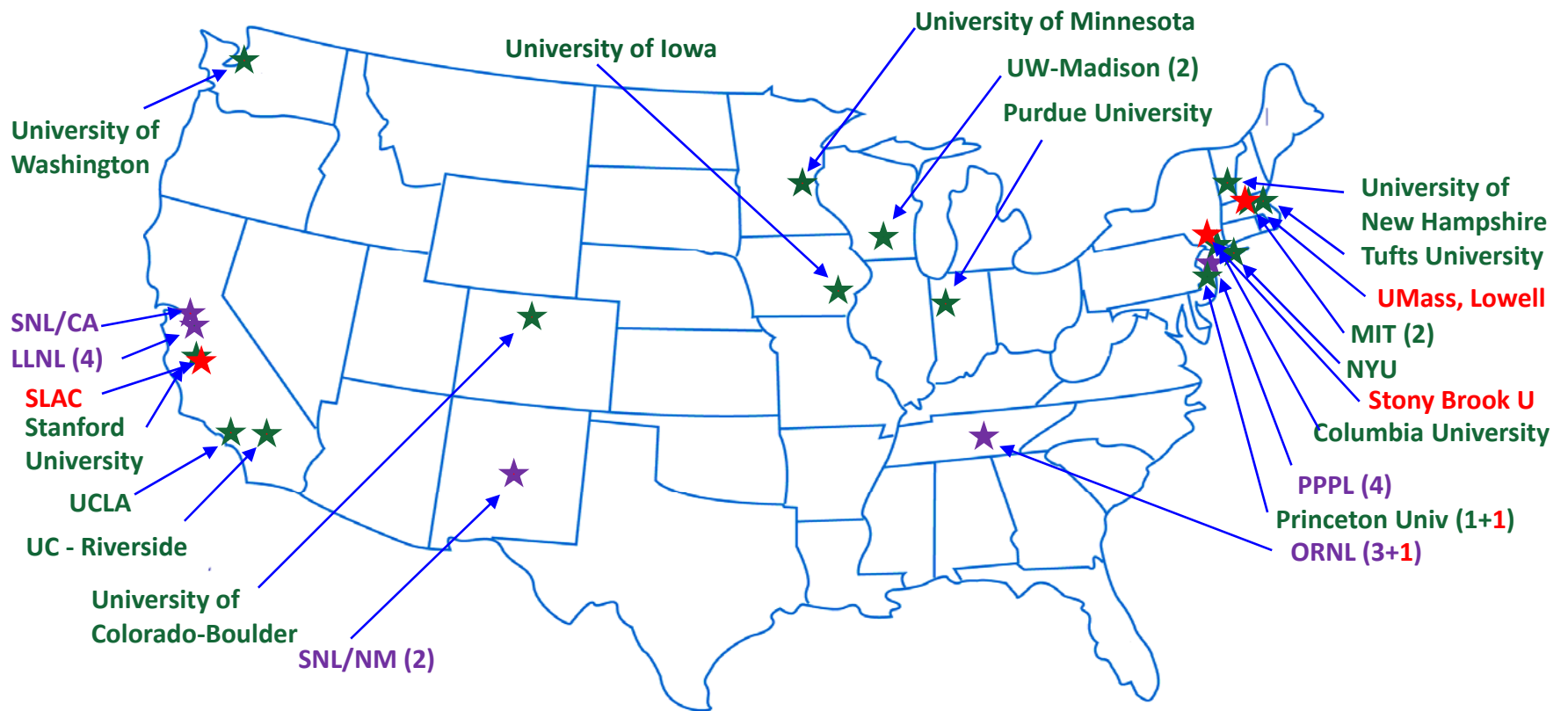
Jacob Nichols

*Whole-Device Modeling
(U. Tenn. – Knoxville)*



Recent new universities to the program

- Stony Brook University
- University of Massachusetts - Lowell



★ = university
 ★ = national laboratory



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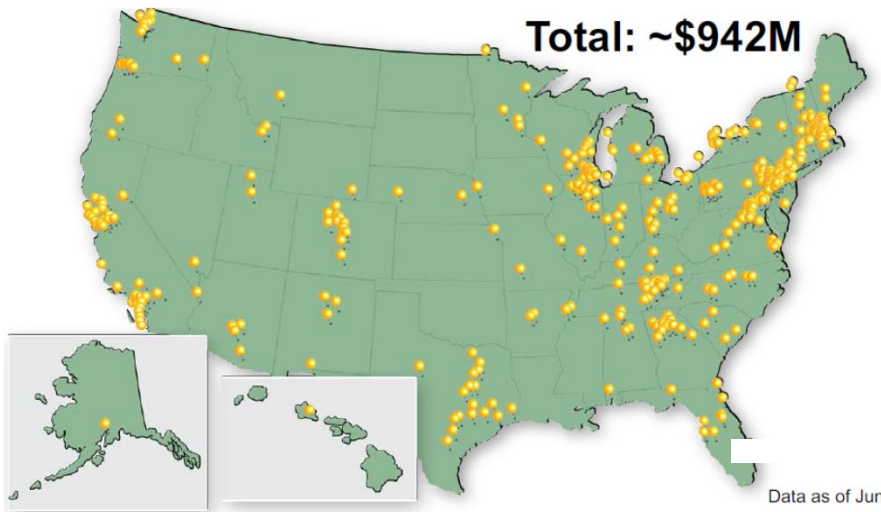
3. ITER Updates



Progress of U.S. ITER project

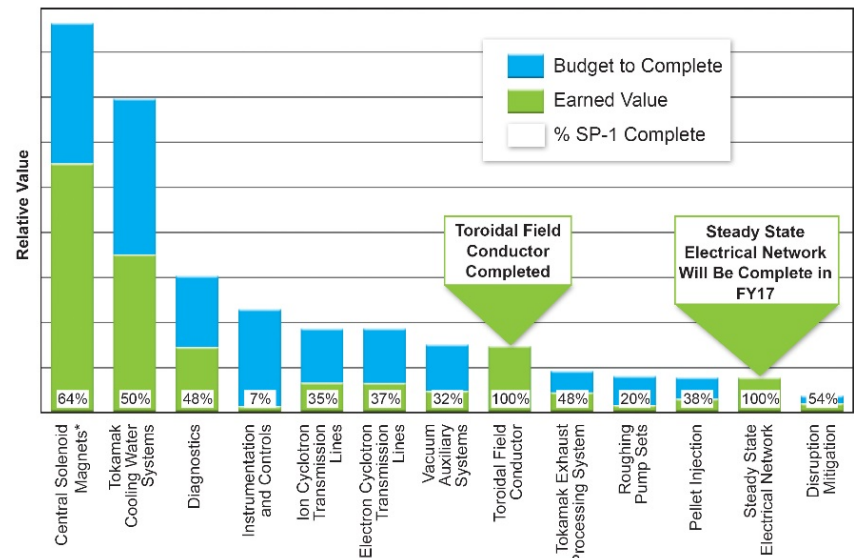
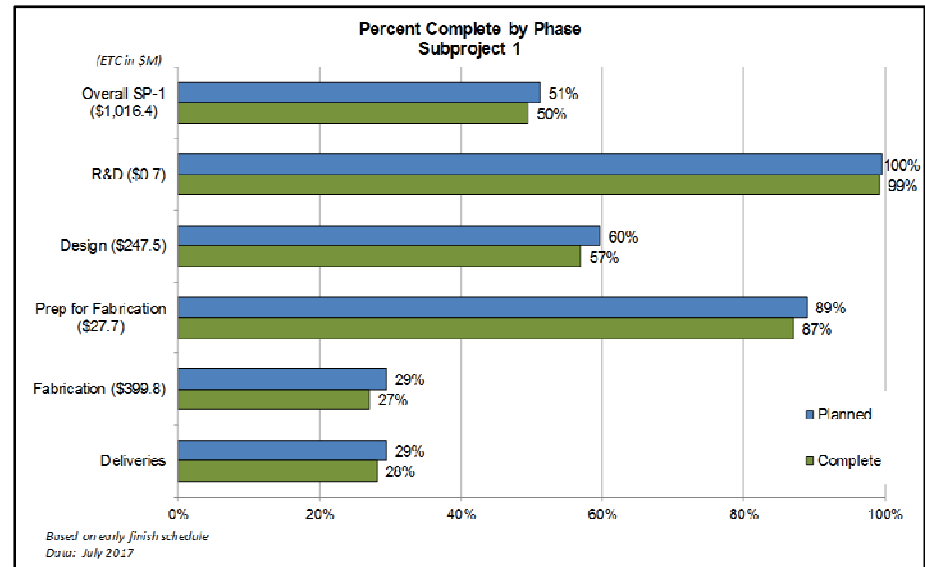
80% of fabrication awards for U.S. ITER project remain in the U.S.

- 600+ contracts to U.S. industry, universities, and national laboratories in 44 states
- 500+ direct jobs, 1100+ indirect jobs per year



Data as of June 30, 2017

U.S. ITER Subproject-1 (First Plasma) is 50% done

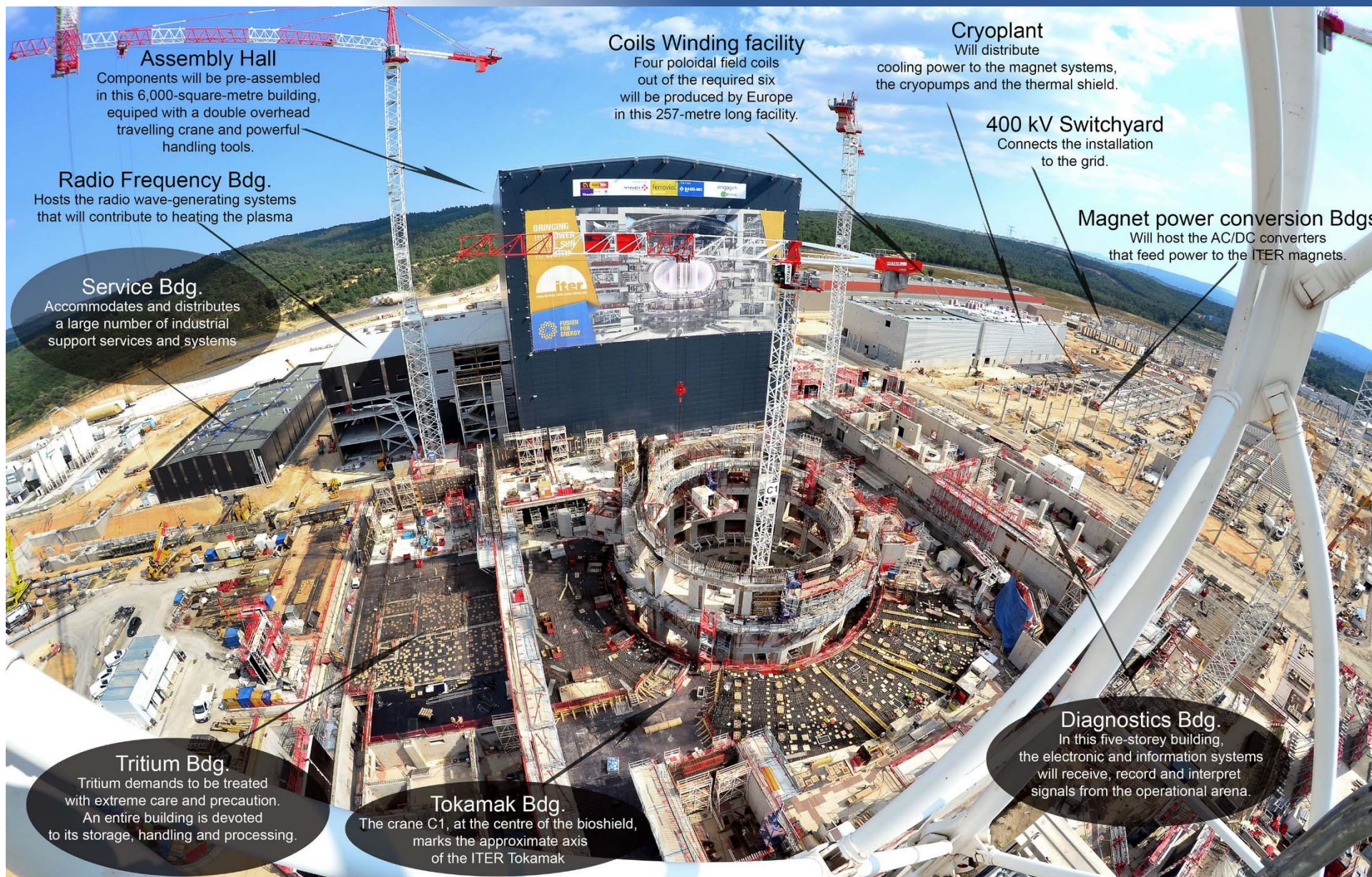


*Includes CS Modules, Structures & Assembly Tooling

Data: June 2017



Current status of ITER complex



Assembly Hall

Components will be pre-assembled in this 6,000-square-metre building, equipped with a double overhead travelling crane and powerful handling tools.

Radio Frequency Bdg.

Hosts the radio wave-generating systems that will contribute to heating the plasma

Service Bdg.

Accommodates and distributes a large number of industrial support services and systems

Tritium Bdg.

Tritium demands to be treated with extreme care and precaution. An entire building is devoted to its storage, handling and processing.

Coils Winding facility

Four poloidal field coils out of the required six will be produced by Europe in this 257-metre long facility.

Tokamak Bdg.

The crane C1, at the centre of the bioshield, marks the approximate axis of the ITER Tokamak

Cryoplant

Will distribute cooling power to the magnet systems, the cryopumps and the thermal shield.

400 kV Switchyard

Connects the installation to the grid.

Magnet power conversion Bldgs

Will host the AC/DC converters that feed power to the ITER magnets.

Diagnostics Bdg.

In this five-storey building, the electronic and information systems will receive, record and interpret signals from the operational arena.



Examples of U.S. hardware for ITER



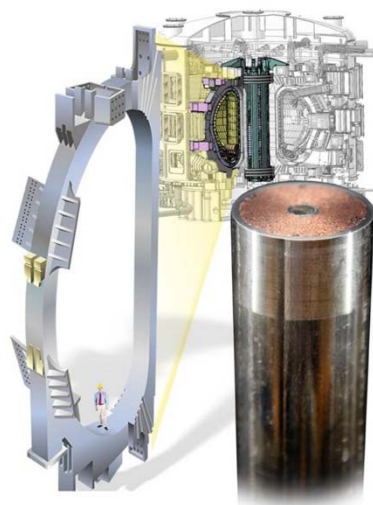
Piping fabrication in the U.S. for the Tokamak Cooling Water System at Schulz Xtruded Products in Robinsonville, MS



Central Solenoid Module 1 after completing heat treatment at General Atomics Poway, CA facility



U.S. completes Central Solenoid Assembly Structure



U.S. Toroidal Field Conductor fabrication completed and shipped to EU winding facility



U.S. completes delivery of SSEN to the ITER site



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4. People



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FESAC membership updates

Departing Members



Arati Dasgupta, NRL



John Foster, U Michigan



Chris Hegna, U Wisconsin



Val Izzo, UCSD



Linda Sugiyama, MIT

New Members



Sigrid Close, Stanford U



Diane Demers
Xantho Technologies



Paul Terry, U Wisconsin



Mitchell Walker,
Georgia Tech



Anne White, MIT



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DOE leadership updates

Mr. **Dan Brouillette** was sworn in as the Deputy Secretary of the U.S. Department of Energy on August 7, 2017



Under Secretary for Science Nominee **Paul Dabbar**

- Nomination approved by the Senate Energy and Natural Resources Committee on August 3, 2017
- Senate Confirmation TBD



Dr. **J. Stephen Binkley** continues as Acting Director of the Office of Science





- The FES Associate Director since 2009, **Ed Synakowski**, left federal service in August 2017 to join the University of Wyoming as the VP for Research and Economic Development
 - **Jim Van Dam** is the Acting Associate Director for FES
 - **John Mandrekas** is the Acting FES Research Division Director



Other transitions



Sean Finnegan left FES to join NNSA



Long-time FES program managers Steve Eckstrand, Al Opdenaker, and Francis Thio retired

