Fusion Energy Sciences Introduction

Presented at the SciDAC PI Meeting

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FES Mission & Strategic Goals

The mission of the Fusion Energy Sciences (FES) program is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundations needed to develop a fusion energy source

FES Strategic Goals

Current focus of FES SciDAC program

- Advance the fundamental science of magnetically confined plasmas to develop the predictive capability needed for a sustainable fusion energy source
- Support the development of the scientific understanding required to design and deploy the materials needed to support a burning plasma environment
- Pursue scientific opportunities and grand challenges in high energy density plasma science to explore the feasibility of the inertial confinement approach as a fusion energy source, to better understand our universe, and to enhance national security and economic competitiveness
- Increase the fundamental understanding of basic plasma science, including both burning plasma and low temperature plasma science and engineering, to enhance economic competiveness and to create opportunities for a broader range of science-based applications

Advanced simulations important for meeting strategic goals

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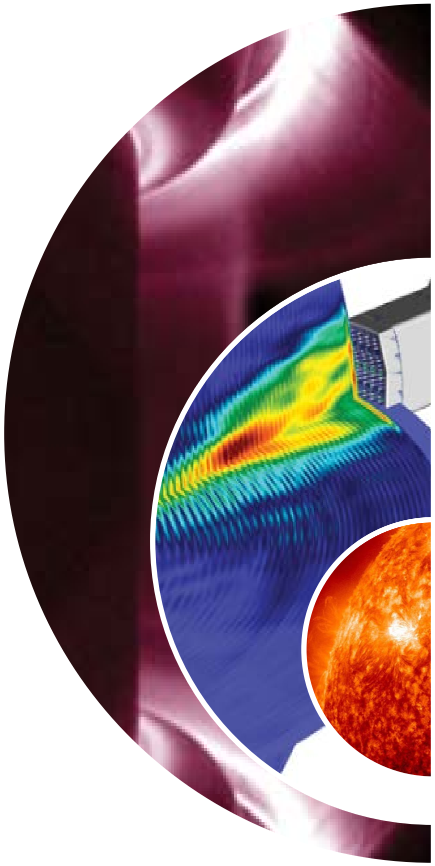
New FES Budget Structure

Organized along scientific topical lines



Burning Plasma Science

Foundations

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

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

SciDAC

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

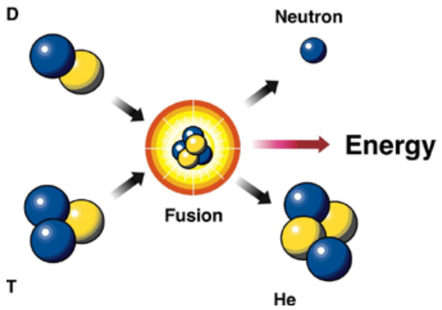
Discovery Science

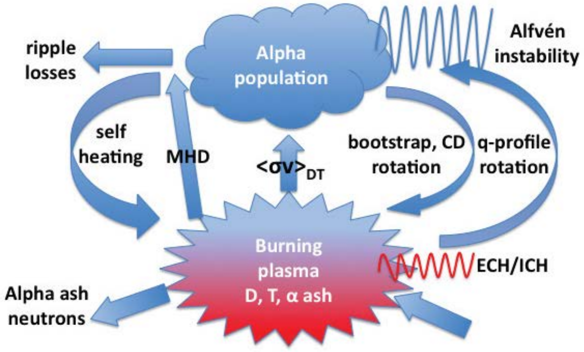
Plasma Science Frontiers and Measurement Innovation

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

What is a Burning Plasma?

In a burning or self-heated plasma, the fusion process itself provides the dominant heating source for sustaining the plasma temperature



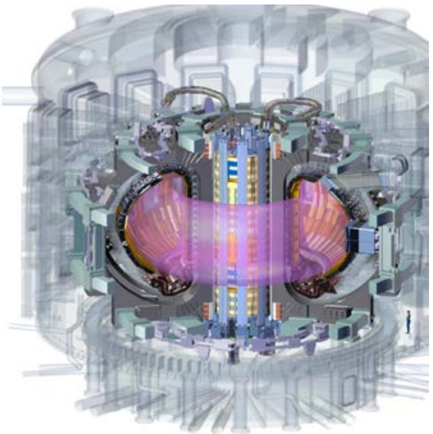


D.A. Spong, ORNL, 2009 ReNeW report

- Burning plasmas are characterized by strong nonlinear feedback loops; HPC essential for resolving the physics and accelerating scientific discovery → *integrated simulation approach is needed*
- Material issues represent another grand challenge

ITER, under construction in St. Paul-lez-Durance, France, will be the world's first MFE experiment to achieve self-heated or burning plasmas

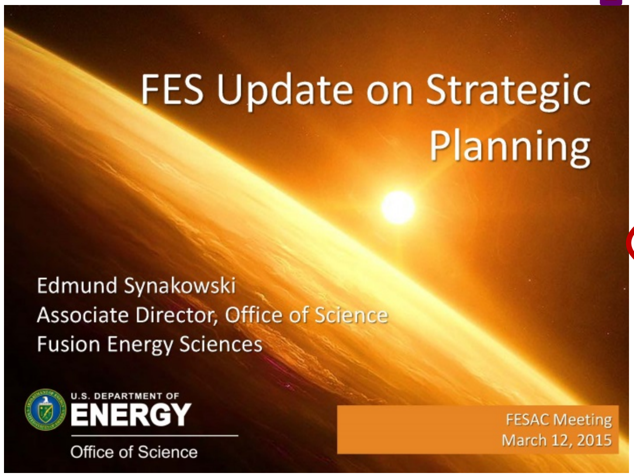
- *Aims to generate* ***30 times*** *the level of fusion power achieved to date and to exceed the external power applied to the plasma by at least a factor of* ***10***



http://www.iter.org/

Strategic Planning Activities

In 2014 and 2015, FES has undertaken strategic planning with active community engagement:



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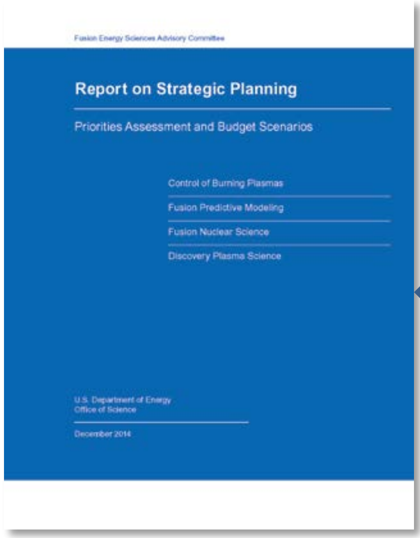
Major considerations for the DOE plan

- First, massively parallel computing with the goal of validated whole-fusion-device modeling will enable a transformation in predictive power, which is required to minimize risk in future fusion energy development steps.
- Second, materials science as it relates to plasma and fusion sciences will provide the scientific foundations for greatly improved plasma confinement and heat exhaust for long pulse lengths.
- Third, research in the prediction and control of transient events that can be deleterious to toroidal fusion plasma confinement will provide greater confidence in machine designs with stable plasmas.
- Fourth, continued stewardship of discovery at the plasma science frontier that is not expressly driven by the energy goal will address frontier plasma science issues underpinning great mysteries of the visible universe.
- Fifth, FES facilities will be kept world-leading through robust operations and regular upgrades.



[2014 FESAC report on Strategic Planning]

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Community Engagement Workshops

- **FES is seeking further community engagement and input through a series of research needs workshops in 2015:**

Workshop	Date	Location	Chair / Co-Chair	DOE Contact
Integrated Simulations for Magnetic Fusion Energy Sciences	June 2-4	Rockville, MD	Paul Bonoli (MIT) / Lois Curfman McInnes (ANL)	John Mandrekas (FES) / Randall Laviolette (ASCR)
Transients	June 8-12	GA, San Diego, CA	Charles Greenfield (GA) / Raffi Nazikian (PPPL)	Mark Foster
Plasma - Materials Interactions	May 4-7	PPPL	Rajesh Maingi (PPPL) / Steve Zinkle (U Tennessee)	Mark Foster
Plasma Science Frontiers	Aug 20-21 Oct 22-23 (Town Hall Meeting: June 30 – July 1)	Washington, DC area	Fred Skiff (Iowa) / Jonathan Wurtele (UC Berkeley)	Sean Finnegan

Workshop information: https://burningplasma.org/activities/?article=FES%20Community%20Planning%20Workshops%202015

Workshop Structure

Integrated Simulation for Magnetic Fusion Energy Sciences

Integrated Science Applications

- **Disruptions** (prevention, avoidance, mitigation)
- **Plasma Boundary** (including pedestal, scrape off layer, plasma-materials interactions)
- **Whole Device Modeling**
- **New Opportunities**

Mathematical and Computational Enabling Technologies

- **Multiphysics and Multiscale Coupling**
- **Beyond Interpretive Simulation**
- **Data Management, Analysis, and Assimilation**
- **Software Integration and Performance**

Focus: Integration

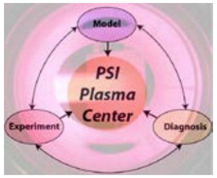
FES SciDAC-3 Partnerships aligned with priority research directions

FES Partnership Presentations at the PI Meeting

The three FES SciDAC-3 partnerships continue to address critical problems in burning plasma science and materials science:

Edge Physics Simulation (EPSI), CS Chang, PPPL
Wednesday, 2:30 – 3:00 PM

Advanced Tokamak Modeling: AToM, Jeff Candy, GA
Thursday, 3:15 – 3:45 PM



Plasma Surface Interactions (PSI), Brian Wirth, U Tennessee / ORNL
Friday, 9:00 – 9:30 AM

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Thank you!