Fusion Energy Sciences
FY 2009 Program Update

NRC Plasma Science Committee
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Outline

- Mission, Goals and Issues
- Funding
- Major Facilities and Collaborations
- ITER
- Program Planning for Near and Longer Term

Entering a New ITER/Burning Plasma Era

- **Mission:**
  - Advance science and technology research to develop the knowledge for a fusion energy source and provide stewardship for the field of plasma science, including High Energy Density Laboratory Plasmas with the National Nuclear Security Administration (NNSA).

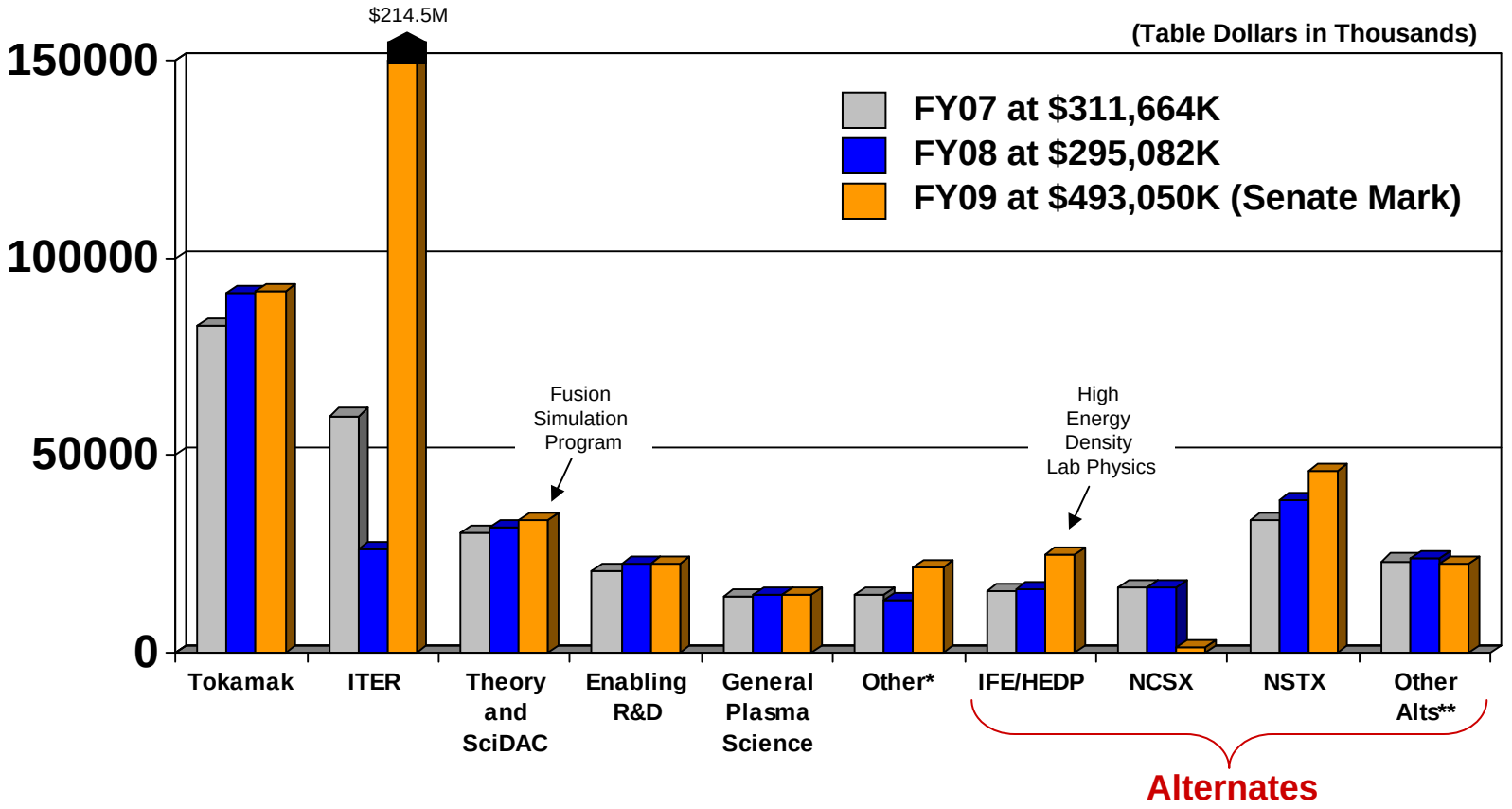
- **Goals:**
  - Assure ITER success both in construction and operation
  - Develop and implement a strategic plan to address all of the scientific challenges of fusion energy including fusion engineering, materials sciences, and plasma physics
  - Generate the knowledge that U.S. industry can use to develop a 1st generation fusion energy facility during the next 25 years (the ITER timeframe)
  - Continue to advance fusion science and technology to ensure success and facilitate future 2nd generation fusion energy concepts

- **Achieving the Goals:**
  - Support ITER and complimentary domestic “burning plasma” program
  - Begin two initiatives now—Fusion Simulation Program (FSP) and Joint Program (with NNSA) in High Energy Density Laboratory Plasmas (HEDLP)
  - Conduct Major Research Needs Workshop that will help us to develop a strategic plan to address the issues

Confronting Significant Issues

- **Rebuild a full complement of staff in the Office**
  - Find a permanent Associate Director and fill other FES management positions
- **Support for ITER and the burning plasma program**
  - Integration of program vision
- **Addressing most issues in a flat-budget climate, at best**
  - Distribution of resources to fulfill the mission elements
  - Multi-year planning, despite single-year funding
- **New Initiatives needed, even on a flat budget**
  - Major Facilities utilization
  - ITER scientific program and national research team
  - Fusion Simulation Program: the culmination of the MFES program
  - Future: confronting the fusion-plasma-materials challenges
  - HEDLP science needs
  - Plasma Sciences renewal (e.g. modest Low-Temperature Plasma Science Initiative)
- **Need for strategic plans to guide decisions**
  - Resource redistribution likely

Fusion Energy Sciences Budget



- **Terminated the National Compact Stellarator Experiment (NCSX) in FY 2008. New stellarator initiative planned.**
- **Full funding for ITER**
- **Increase in facilities operations including upgrades for NSTX**
- **Increase for two initiatives -- FSP and HEDLP**

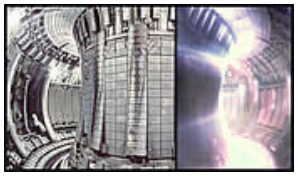
***Includes: International, HBCU, Education, Reserve, IPA/Detailees, SBIR/STTR, GPP/GPE, Env. Monitoring**
****Includes: Experimental Plasma Research and Madison Symmetrical Torus**

Major Facilities

- **DIII-D:** Research in ITER-relevant low rotation regimes. Advancing the Advanced Tokamak to complement and look beyond ITER through detailed control of plasma profiles

- **Alcator C-Mod:** Research in the steady-state high Z wall, high field tokamak for ITER and beyond. Radiofrequency wave heating and plasma wall interactions at ITER parameters

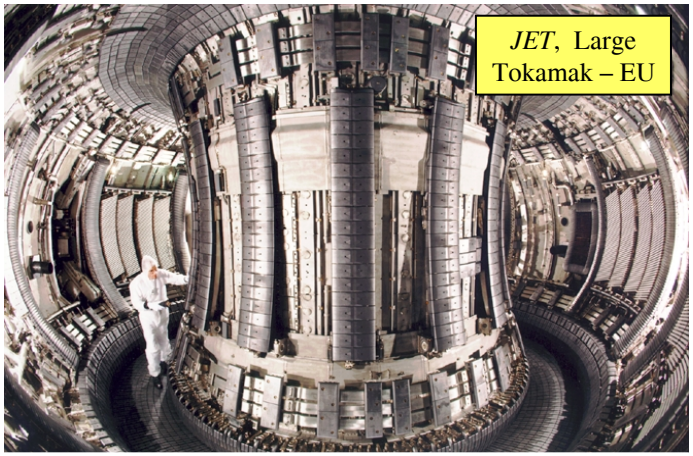
- **National Spherical Torus Experiment (NSTX):** Research at the extremes of geometry for toroidal confinement and stability understanding. Developing spherical torus scenarios for potential next-step options for domestic activities in ITER era



- **International Collaborations:** Identify and utilize opportunities that are available abroad that can complement and/or enhance the U.S. fusion program activities -- EU (JET, ASDEX-UG), Japan (JT-60), Korea (KSTAR), and China (EAST)

MFE Research is Integrated Worldwide

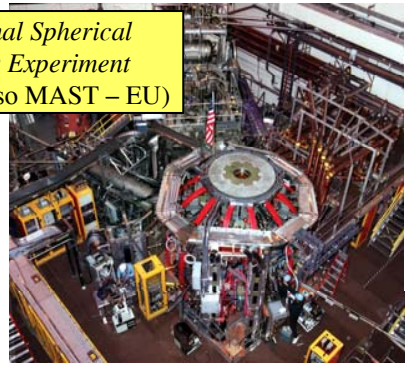
C-Mod, Tokamak MIT

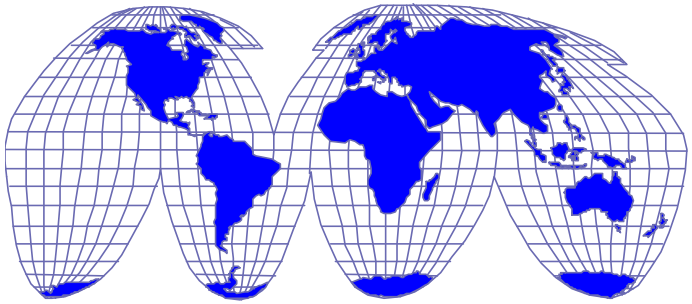


JET, Large Tokamak – EU

W7-X, Large Superconducting Stellarator – EU

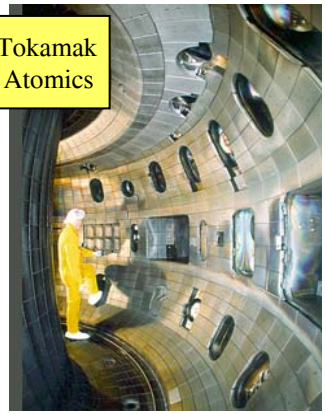
National Spherical Torus Experiment PPPL (also MAST – EU)

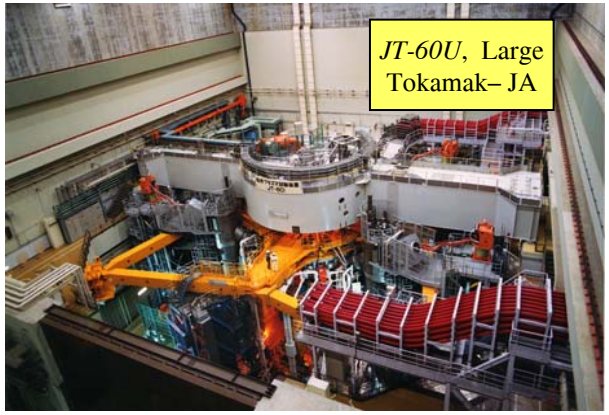




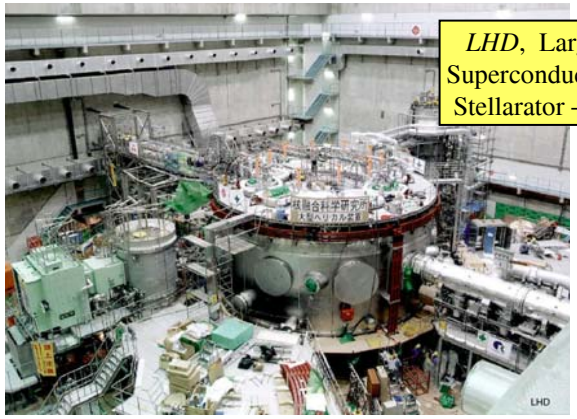
EAST, SST-1, *KSTAR* Superconducting Tokamaks, – China, India, Korea

DIII-D, Tokamak General Atomics





JT-60U, Large Tokamak– JA



LHD, Large Superconducting Stellarator – JA

ITER – a unique international scientific endeavor

- **Mission: demonstrate the scientific and technical feasibility of fusion power**
  - Designed to produce 500 MW of fusion power (Q ≥ 10) for at least 300-500 seconds (Achieved to date Q<1 for ~ a few seconds)
  - Will optimize physics and integrate many of key technologies needed for future fusion power plants
  - Includes joint design, construction, operation, and decommissioning
- **Members: EU (Host), China, India, Japan, Korea, Russia, and the U.S.**

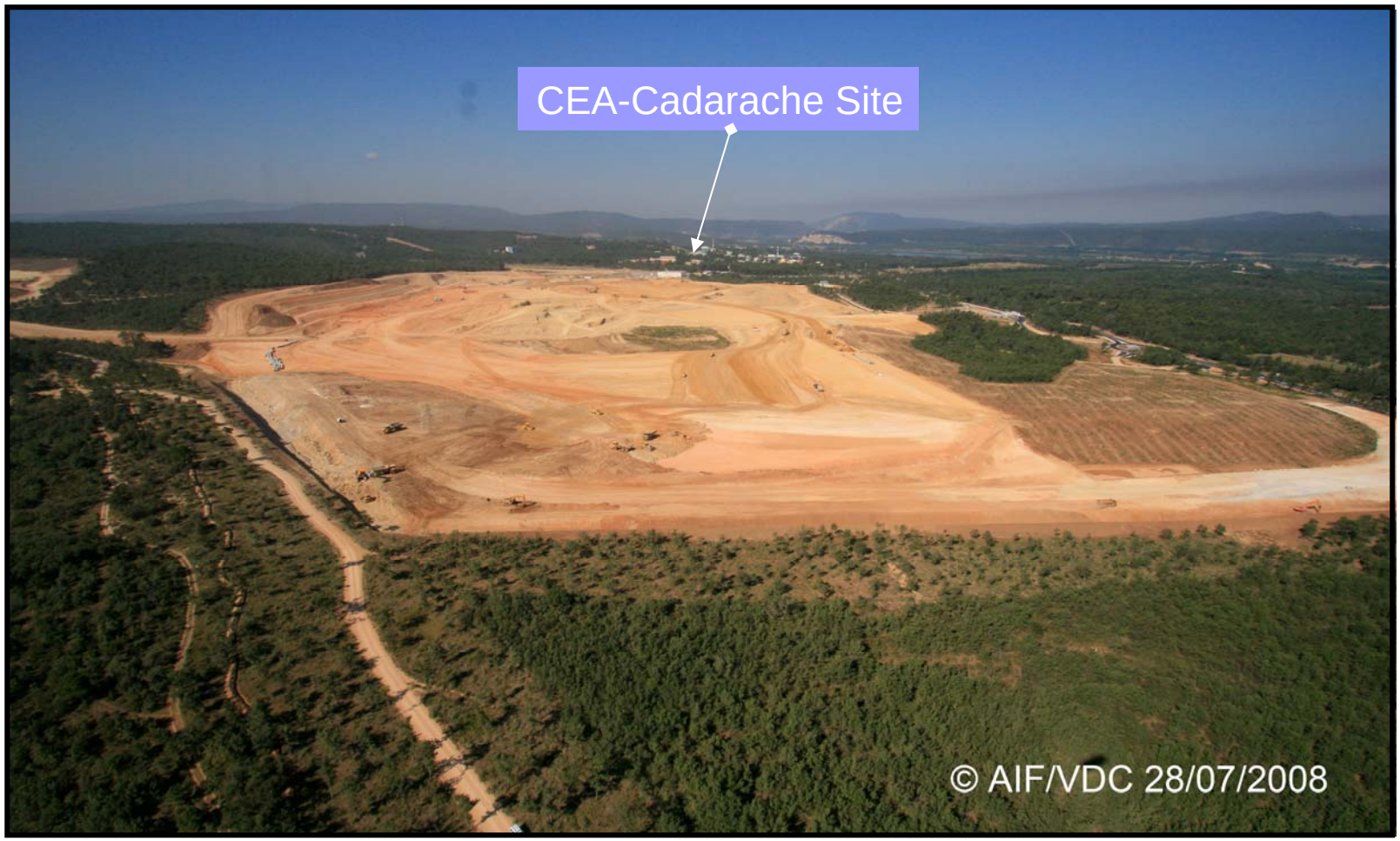
Present ITER Office Building

ITER Site – Cadarache, France

- **"Green Field" area located at Cadarache, France – adjoining the CEA Laboratory, a leading French nuclear research center. Nearest cities are Aix-en-Provence and Marseille.**
- **CEA provides numerous support services per a Site Support Agreement with the ITER Organization.**
- **Site clearing and platform leveling are mostly complete. Construction permitting and licensing are on track to support Tokamak Building excavation starting in early 2009.**
- **First (temporary) office building for 300 staff to be ready in October 2008.**

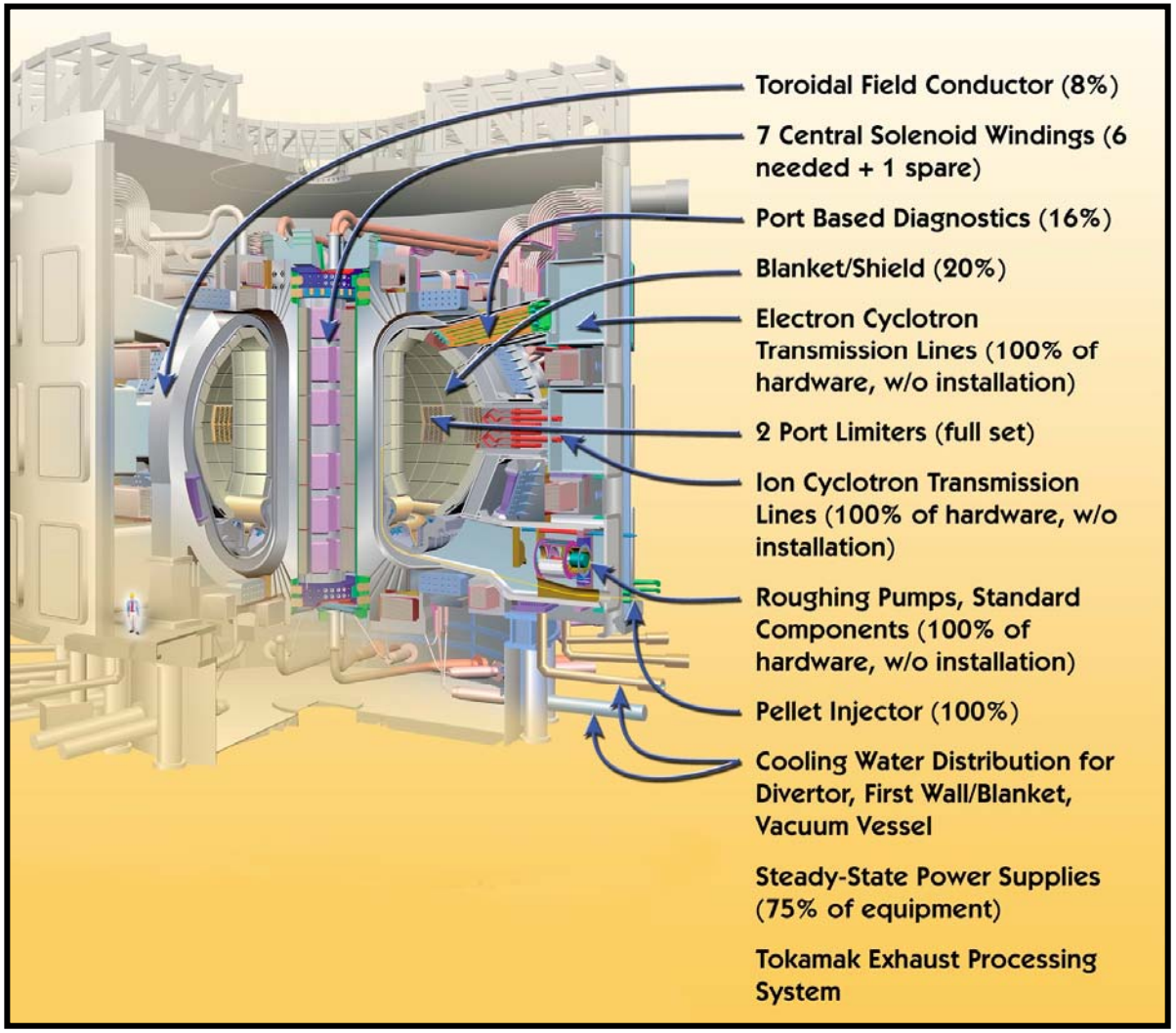
ITER Site – Cadarache, France

Site viewed from SE on 7/28/08
Platform leveling (~75% complete)



U.S. ITER Project Scope

- **Final design and fabrication (mostly by industry) of assigned "in-kind" hardware and its delivery to France. This is ~3/4 of the Total Project Cost.**
- **Assignment of secondees ("in-kind" personnel) to the ITER Organization**
- **Cash to the IO for R&D and Common Fund expenses (e.g., IO direct staff and services, some hardware, machine assembly, installation, commissioning)**
- **Operation of U.S. ITER Project Office at ORNL along with partner labs PPPL and SRNL**
- **Cash to the IO's Central Reserve (upon Council approval)**



Status of U.S. ITER Project

- **Despite the FY2008 Budget shortfall, the U.S. ITER Project remains the highest priority in the DOE Office of Science's *Facilities for the Future of Science: A Twenty-Year Outlook*.**
- **U.S. ITER Project is continuing in a "Survival Mode" waiting for the FY 2009 Appropriation ($214.5M requested), which will allow the U.S. part of the project to get back "on track"**
  - Uncosted FY 2007 funds of $30.7M, plus the $10.6M FY2008 Appropriation and $15.5M Supplemental, are sustaining a core team that has remained engaged with the ITER Organization (IO) in finalizing the ITER design and establishing a realistic construction schedule. Five U.S. secondees were retained on assignment with the IO in France.
  - Deferred U.S. scope:
    - Most design and R&D, including industrial involvement
    - Long-lead procurements (magnet conductor material)
    - Cash contributions to the IO (~$11M in 2008 + ~$15M in 2009)
  - Funding situation has cast serious doubt on U.S. commitment to ITER and could jeopardize U.S. participation in other large international science efforts

Stewardship in Plasma Science

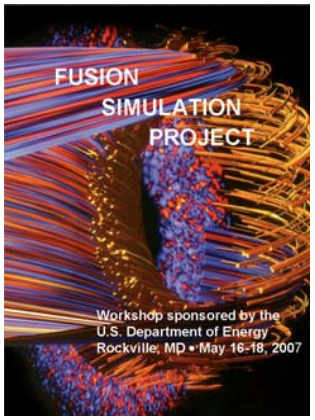
- **National Science Foundation (NSF)/DOE Partnership in Basic Plasma Science and Engineering Research (Universities)**
  - Since 1997, jointly funded university grants in the fundamental physics of plasmas.
- **DOE Laboratory Plasma Science (Laboratories)**
  - Started in FY2000 and recompeted in FY2006.
- **Plasma Science Centers are supported through 5 year cooperative agreements.**
  - Solicitation Underway
- **Plasma Physics Junior Faculty Award Program**
- **The Center for Magnetic Self-Organization (CMSO) is one of the NSF's Frontier Physics Centers.**
  - Performs multi-disciplinary research into the origin of magnetism in the Universe, magnetic reconnection and related astrophysical phenomena
  - DOE funds supporting laboratory work
- **The Basic Plasma Science Facility (BAPSF) at the University of California, Los Angeles is jointly funded, under a Memorandum of Understanding (MOU) between the NSF and DOE.**
  - Provides flexible experimental facility for the plasma research community
- **Atomic, Molecular, and Particle-Surface interaction for fusion**

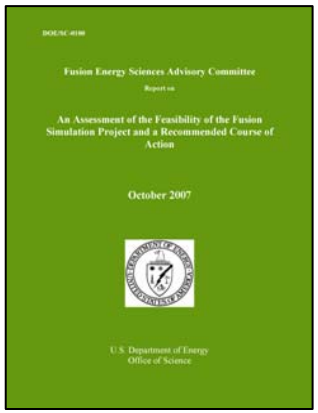
High Energy Density Laboratory Plasma Program (HEDLP)

- **Existing FES Program:**
  - Stewardship of HEDLP as a compelling area of fundamental science and fusion-energy inspired basic science
  - High-risk, high-payoff research in basic high energy density plasma science to facilitate ignition and to obtain higher fusion gain-efficiency product, with attractive targets, in pulsed high density fusion
- **Joint HEDLP Program with NNSA (New Initiative):**
  - Working in partnership with the National Nuclear Security Administration (NNSA), extend our present program to other areas of fundamental HEDLP science, including laboratory astrophysics
  - Enable SC to capture opportunities afforded by successes on the National Ignition Facility or other NNSA facilities towards a potential program in inertial fusion energy sciences (IFES)
  - Solicitation for HEDLP Joint Program currently underway.

New Initiative
Fusion Simulation Program (FSP)

- A computational initiative led by FES with collaborative support from the DOE's Office of Science Advanced Scientific Computing Research (ASCR) Program.





- A new program to develop a world-leading predictive simulation capability for fusion burning plasmas by taking advantage of the emergence of petascale computing capabilities and the scientific knowledge enabled by the FES and ASCR research programs
- Contains clear deliverables targeted at the end of five, ten, and fifteen years.
- Funding is expected to start at approximately $2M for the in FY 2009 and ramp up to about $25M per year (combined FES and ASCR funding).
- The long term vision of the FSP is a tool that embodies our predictive understanding of magnetically confined fusion plasmas, properly coordinated and integrated with analytic theory and experiment.

Input for Program Planning

FESAC Report on Priorities, Gaps and Opportunities: Towards a Long-Range Strategic Plan for MFE, Oct 2007

	Areas Where the U.S. has Leadership	Areas Where the U.S. is Strongly Competitive	Areas Where the U.S. is in Danger of Losing Standing	Opportunity to Sustain Leadership through Strategic Planning	Opportunity to Gain Leadership through significant investment
Measurement	X		X	X	
Theory and Predictive Modeling	X			X	
Control	X		X	X	
Plasma-Wall Interactions		X	X	X	
Integrated, Sustained, High Performance Plasmas		X	X		
Safety/Environment		X	X		
Materials			X		X
Antennae and Launchers			X		
Magnets			X		
Plasma Facing Components			X		X

Magnetic Fusion Energy Sciences (MFES) Program Evolving to New Phase

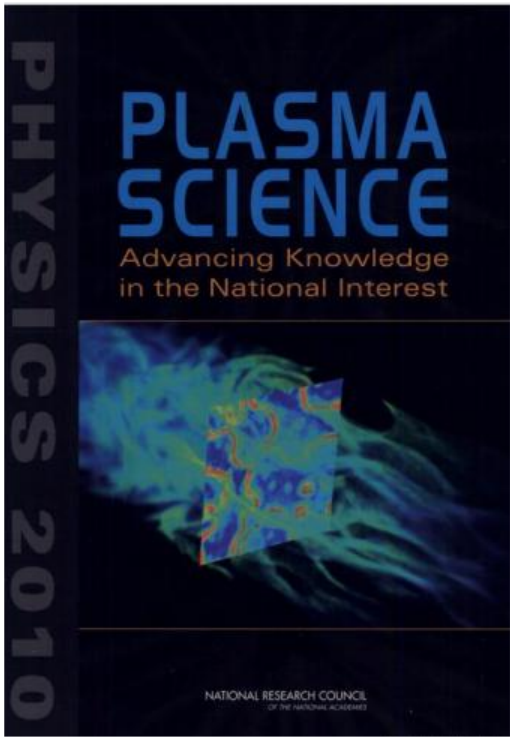
- **Entering a time of transition to the ITER/Burning Plasma Era**
  - Leading to a major step in state-of-the-art in fusion science
  - Past decade: consolidation & redirection, with excellent scientific progress

- **Must start addressing growing issues in the program**
  - What should the domestic program look like?
  - How can we capture a qualitatively new level of sciences in the domestic program?
  - What are the compelling science and technology issues?
  - What are the opportunities in which the US can take a world leadership role?
  - What must we do to effectively steward plasma physics and HEDLP?

- **What are elements of a 5, 10, and 20-year strategic plan?**
  - MFE driven by mission-related science needs
  - Plasma sciences must be more generally defined

- **Need to define the dynamic evolution in research and facilities**

Building off of recent guidance…



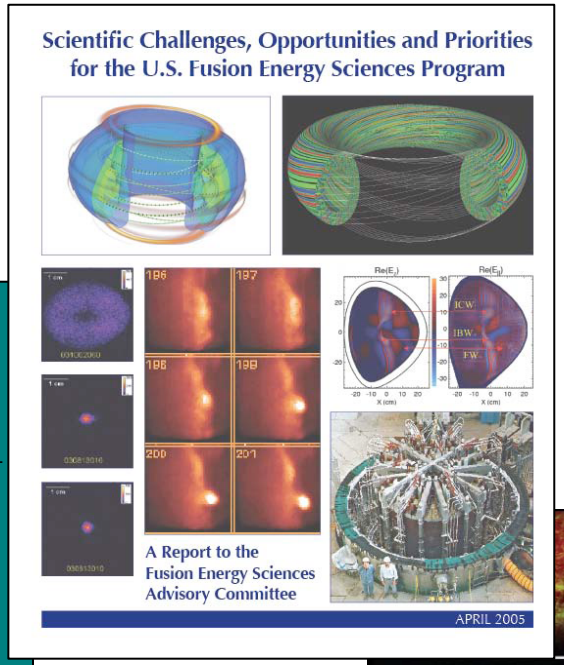
Fusion Energy Sciences Advisory Committee

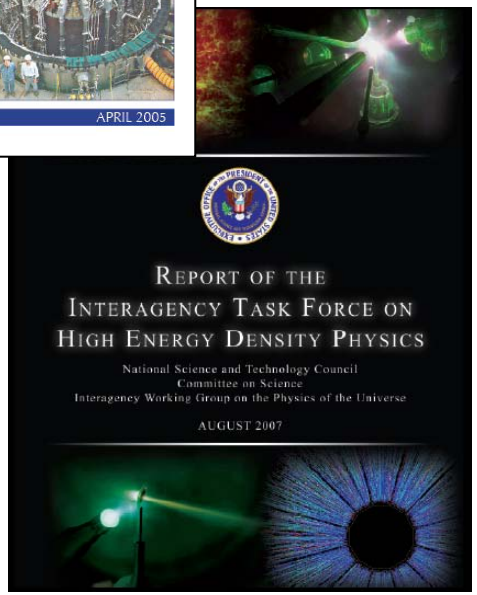
Report on

Priorities, Gaps and Opportunities: Towards a Long-Range Strategic Plan for Magnetic Fusion Energy

October 2007

U.S. Department of Energy
Office of Science
Office of Fusion Energy Sciences
Germantown, Maryland 20874-1290

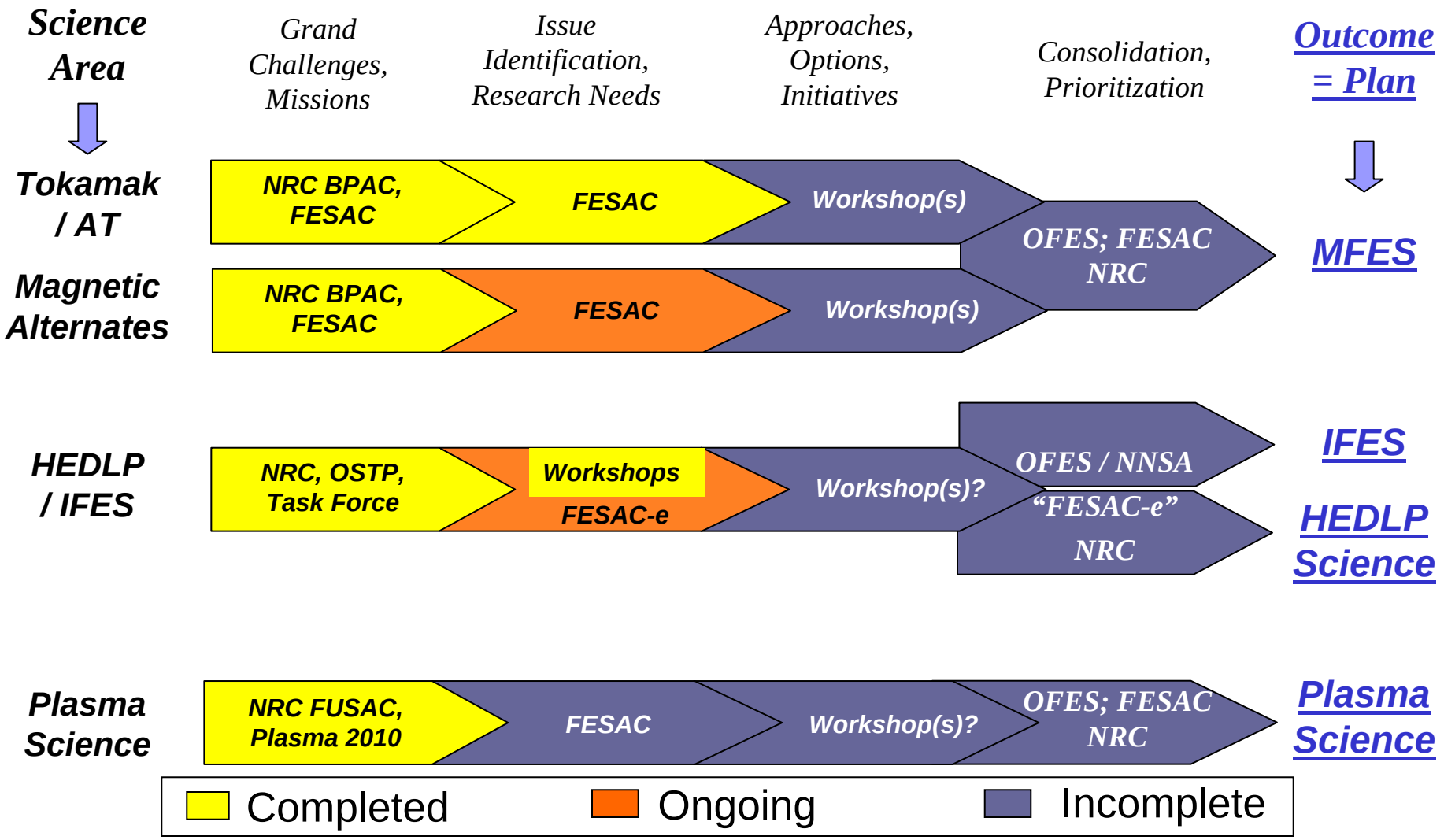




Laying the Foundation for Program Evolution

- **Moving to new strategic plans for MFES and plasma sciences**
  - Develop new mission statement and program goals
  - Work with FESAC to identify program opportunities and research gaps
    - In each sub-category of overall program
  - Plan workshops to define approaches for addressing opportunities
  - Integrate into prioritized program plans
    - Assure that program elements are exciting
    - Work with other science communities on areas of common interest

A Multi-year, Multi-Step Planning Process for *Each* Area of Responsibility



Near-Term Activities

- **OFES will prepare a 10-15 page Strategic Overview Plan to meet March 1, 2009 Congressional deadline**
  - Findings and recommendations from recent studies/reports will help to form basis
    - "Priorities, Gaps and Opportunities", October 2007 (Greenwald Panel)
    - "Scientific Challenges, Opportunities and Priorities …", April 2005 (Baker Panel)
    - "A Plan for the Development of Fusion Energy". March 2003 (Goldston Panel)
    - The National Research Council (NRC) report, entitled "Plasma Science - Advancing Knowledge in the National Interest" May 2007.
  - Highest level vision; details will be addressed in follow-on planning
- **FESAC will have the opportunity to provide comments on the plan**
  - Draft to be provided at the Nov. 6-7, 2008 FESAC meeting
  - FESAC will provide their comments to OFES at the Jan. 09 meeting

Mid-Term Activities

- **Engage the community through Research Needs Workshops patterned after the SC Office of Basic Energy Sciences workshop series and similar to Snowmass meetings**
- **Conduct the MFES workshop first and then follow it with HEDLP and Plasma Sciences workshops as appropriate**
- **Use workshop reports as basis for detailed plan**

MFES Research Needs Workshop
June 7-13, 2009, Washington, DC Area

- **Themes:**
  - Producing High-Performance Plasmas (Greenwald)
  - Taming the Plasma-Materials Interface (Greenwald)
  - Harnessing Fusion Power (Greenwald)
  - Understanding the Burning Plasma State
  - Optimizing the Magnetic Configuration
- **Will require extensive preparation and community participation**
- **Attendance at workshop will be by invitation only**