



U.S. Department of Energy's
Office of Science

Fusion Energy Sciences Program Update

**Fusion Power Associates Meeting
Oak Ridge, TN
December 3, 2007**

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Topics

- Budget status
- ITER
- HEDLP Joint Program
- Plasma Science
- Issues and Plans



FY 2008 Fusion Energy Sciences Congressional Budget Request

	(\$ Millions)		
	FY 2006	FY 2007	FY 2008
	<u>Actual</u>	<u>Sept AFP</u>	<u>CONG</u>
Science	148.7	144.6	159.6
Facility Operations	104.2	146.3	247.5
Enabling R&D	<u>27.8</u>	<u>20.8</u>	<u>20.8</u>
OFES Total	280.7	311.7	427.9
DIII-D	55.1	56.7	59.7
C-Mod	21.5	22.3	23.5
NSTX	34.2	33.5	36.1
NCSX	17.8	16.6	16.6
ITER	24.6	60.0	160.0
Non-ITER	256.1	251.7	267.9





FY 2008 Appropriations

- **House Mark**

- The Committee recommendation for fusion energy sciences is \$427,850,000, the same as the budget request, and reflecting the \$100,000,000 growth in the budget for ITER.
- The Committee **does not support funding for a new program in High Energy Density Physics (HEDP) and provides no funds for this research area.** (Resources for HEDP should be redirected to other programs).
- The Committee notes that major growth in support for ITER ... is affecting the overall funding picture for Fusion Energy Sciences and for the Office of Science as a whole. When direct funding for ITER is excluded, Fusion Energy Sciences increases by just 3.8 percent and the increase requested for the Office of Science, while still large, is 13.4 percent rather than 15.8 percent. If delays in ITER associated with international cooperation reduce the amount that can be spent on ITER in fiscal year 2008, the Committee directs the Office of Fusion Energy Sciences to invest the funds made available in Theory, materials research within Enabling R&D, Alternative Concept Experimental Research and operating time at the three U.S. user facilities rather than retaining the money for ITER and carrying it over to future fiscal years.

- **Senate Mark**

- Committee recommends \$427,850,000.
- High Energy Density Plasma Laboratory Program- The Committee **is pleased that the Department has developed a multidisciplinary research program, which this Committee has been an advocate for the past several years.** The Committee believes this program will provide greater interaction between the Office of Science researchers and the NNSA scientists and provide greater access to user facilities such as the Z machine, NIF and Omega. ...The Committee encourages the Department to increase their investment in this modest program to ensure its future success. The Committee supports the budget request of \$12,281,000 for the Office of Science. The Committee notes a similar amount has been included in the NNSA program.





ITER Agreement Ratification Process Complete



- November 21, 2006 – the ITER Agreement was signed by the seven Members.
- October 24, 2007 – the ITER Agreement entered into force and the ITER Organization became a legal entity.
- November 27-28, 2007 - with completion of the above milestones, the first official ITER Council Meeting was held.



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The Secretariat of the International Atomic Energy Agency presents its compliments to the Permanent Mission of the United States of America and has the honour to acknowledge the deposit, on 8 June 2007, of the instrument of acceptance, by the United States of America, of the Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project.

The deposit of the instrument of acceptance by the United States of America will be duly notified in accordance with the terms of the above Agreement.

The Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project, pursuant to Article 22, "shall enter into force thirty days after the deposit of instruments of ratification, acceptance or approval of this Agreement by the People's Republic of China, EURATOM, the Republic of India, Japan, the Republic of Korea, the Russian Federation and the United States of America." Accordingly, the Agreement will become effective for the United States of America on the date of its entry into force.

The Secretariat of the International Atomic Energy Agency avails itself of this opportunity to renew to the Permanent Mission of the United States of America the assurances of its highest consideration.

11 June 2007





First Official ITER Council Meeting Highlights

- Project site mostly cleared; site excavation to begin in mid-2008.
- IO is staffed to a level of about 200 personnel (including service support contractors), roughly 1/3 of that expected in steady state.
- ITER Management Staff and Chairs/Vice Chairs of Council and Subsidiary Bodies have been appointed.
- Design Review has produced a reference design. Council requested the IO, with the active support of the Members including Domestic Agencies, further optimise the design in relation to the key issues which are still open.
- Council also requested the IO to prepare an integrated Project Plan and Resource Estimates based on this reference design for presentation to IC-2 in June 2008. This will entail an Integrated Project Schedule and updated cost estimate.
- US ITER Project Office expects to place long-lead procurements in 2008-2009 once Procurement Arrangements are established with the IO.
- Council endorsed the proposal for development of guidelines for accession of new ITER Members. Kazakhstan has indicated serious interest.
- Next Council Meeting scheduled for June 17-18, 2008 in Japan.



ITER - What's Happening Next?

- Numerous project management and technical meetings to be attended by OFES, USIPO and fusion community participants
- Spring, 2008 – Leading towards Baseline Design
 - STAC Spring 2008 – Cadarache (P. Kaw, Chair)
US reps: Goldston, Milora, Taylor, Van Dam, Oktay
 - MAC Spring 2008 – Cadarache (Bob Iotti, Chair)
US reps: Baker, Hawryluk, Hoy, Moses
 - Council Preparatory Working Group - April/May 2008
- June 17-18, 2008 – Second ITER Council meeting - Japan
 - Continue to advance on tough issues
 - Approve Baseline Design, including Scope, Schedule, Cost



ITER Design Review Summary

- ITER design review activity completed, but further design activities continue:
- STAC considers the design sound, but recommended further evaluation on several issues (endorsed by the Council):
 - **Technical performance:** Vertical stability, shape control and PF coils, flux swing, 17 MA capability, ELM control, load specification on vacuum vessel and in vessel components;
 - **Strategies for:** Heating & CD, PFCs, TBM, Cold Coil Test, Hot Cell Design, Remote Handling,
- IO is establishing a work-plan with DAs to address these issues by the end of February 2008
 - Continue the involvement of the scientific community (more than 150 involved in the Design Review)
 - USBPO, USIPO, and VLT carries out the US contributions
- STAC will review the new work at its third meeting on 3/31-4/2
- The new Baseline with scope, cost, and schedule will be submitted to ITER Council meeting in June 2008



ITPA, USBPO Coupling to ITER Physics

- IO invited ITPA to operate in the future under the ITER auspices
 - ITPA Coordinating Committee welcomes this invitation
- Next step is to adapt the ITPA charter for operation under ITPA auspices
 - ITPA is expected to enhance its response to ITER physics needs
 - Modify its Topical Group structure to meet ITER needs, and
 - Continue its activities in the broader burning plasma research
- Will help link the U.S. scientific community to preparations for and participating in ITER physics operations.
 - The US ITPA CC members and USBPO leadership linked organizations for enhanced partnership
 - ~ 50 official U.S. ITPA members representing the USBPO (~ 250 members)
 - USBPO supports ITPA with domestic program; ITPA enhances BPO international communication
 - USBPO head = USIPO Chief Scientist => Domestic Agency access to IO



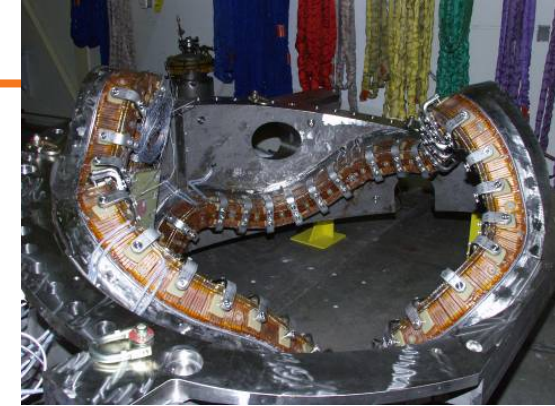
New: NRC Committee to Review U.S. ITER Science Participation Planning Process

- The Energy Policy Act of 2005 requires the NRC to review the USBPO Report of June 2006 on U.S. Participation in ITER
 - The NRC established a Panel, chaired by Pat Colestock (LANL)
 - Details: <http://www7.nationalacademies.org/bpa/CRISPPP.html>
- Statement of Task: The committee will prepare a short report addressing the following tasks:
 - Review the document "Planning for U.S. Fusion Community Participation in the ITER Program." Determine whether the plan provides a good initial outline for effective participation of U.S. plasma scientists in research at ITER.
 - Evaluate the following required elements of the plan: (1) an agenda for U.S. research at ITER, (2) methodologies to evaluate ITER's contribution to progress toward a power source, (3) description of the anticipated relationship between the U.S. ITER research program and the overall U.S. fusion program.
 - The committee will recommend next steps in the development of the plan, including: (a) appropriate elements and/or goals for the plan; (b) procedures to facilitate further development of the plan; and (c) metrics for measuring progress in establishing robust U.S. participation in the ITER research program.
- Panel will meet at NRC on December 14 to receive reports
 - See OFES web site (Program News) for presenters & topics





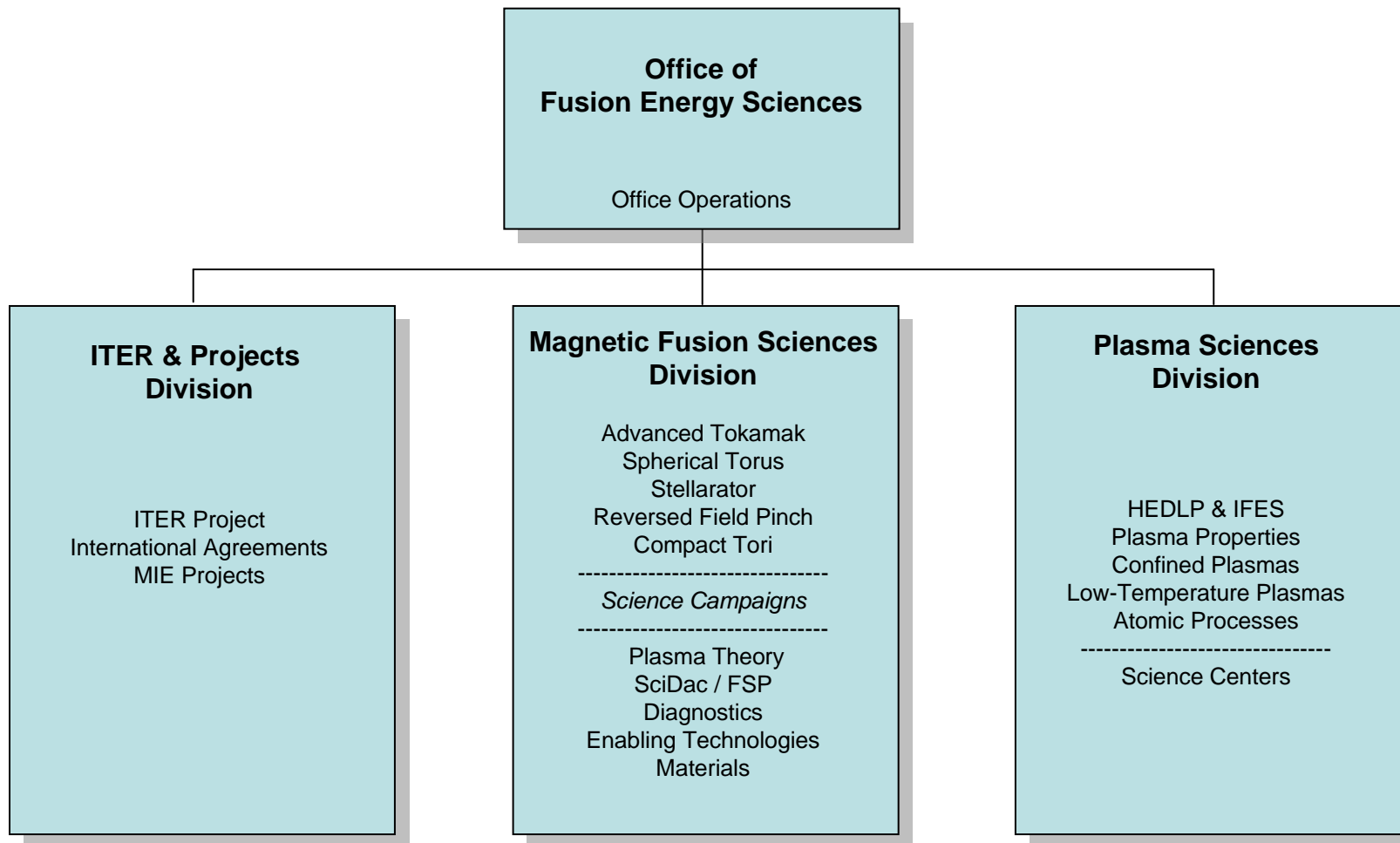
NCSX Reviews



- Plasma confinement with deep magnetic symmetry
 - Physics simplicity vs mechanical complexity
 - Stellarators address critical problems for magnetic fusion
 - *Steady state without current drive*
 - *Stable without feedback control; No disruptions*
 - *Compact Stellarator: tokamak comparison; better economy?*
- MIE funding problem: Projecting \$40 - 50M, 2+year overruns
 - Required re-evaluation: Impact on FES program, and SC
- Reviews
 - SC (Lehman Review): new proposed baseline is credible.
 - FESAC scientific/programmatic review: science is valuable
 - External technical review of design-to-date: OK so far
 - *Critical info from Field Period Assembly in April '08*
 - Office of Engineering and Construction Management will conduct an External Independent Review if SC re-baselines.
- Re-baselining or cancellation impacts FY 2009 and later



Draft, Conceptual OFES Organization



- Organize via concepts/topical areas rather than specific facilities
- Cross-cut with coordinated campaigns on identified priority issues





Working to Develop a 5-20 year Vision and Plan for OFES Programs

- Main goal: develop the knowledge base for a fusion energy system
 - Steward underlying science areas
- What we need to do to work for more support:
 - Clearly identify important questions and why; relate to goals
 - Demonstrate progress on answering important questions
 - Define scientific missions and opportunities
 - Define ordered plan to address issues; get ducks in a row for new requests
- General plan for budget planning and priority choices
 - Planning is an evolving process; never complete
 - OFES: internal 10-year planning exercise
 - *Work off wealth of community studies (e.g., latest FESAC studies)*
 - *Stimulate discussion with FESAC*
 - Merge and develop as more extensive community discussion evolves
 - FESAC
 - Workshops, meetings



Directions for Next 5 Years

- Support ITER construction, and Burning Plasma-related research
- Evolve domestic fusion energy sciences towards world leadership in most promising thrust areas during the ITER era
 - Establish coordinated computation, theory and experimental campaigns to develop integrated simulation capabilities
 - Establish robust science roadmap to identify facility needs
 - Confront new challenges arising in the burning plasma environment
 - Develop and integrate emerging ideas for improving fusion concepts
- Strengthen stewardship of plasma science and high energy density laboratory plasmas
 - Provide focus area of Federal support for basic and mission-oriented plasma sciences
 - Support evolution of HEDLP through period of ignition science; plot course for increasing emphasis on IFES after NIF ignition demonstration
- Guidance for funding: examine resource distribution for each element
 - MFES: ITER construction + inflation for domestic activities
 - Plasma Sciences: try to make case for increases via ACI





Issues for Next 5 Years = Budget Pressure

- Chronic/Existing Issues
 - Using and upgrading major facilities
 - Role of engineering sciences and materials
 - Steward plasma physics
 - Steward HEDLP / role of Inertial Fusion Energy Sciences
 - Support for diagnostic development
 - Inflation and the cost of doing business
 - Workforce demographics
 - International Collaborations
- Capturing Opportunities => New Initiatives/Issues
 - Low-temperature plasma physics (NRC Plasma 2010)
 - Next-step facility(ies) or initiatives in the US
 - Fusion Simulation Project
 - Momentum towards IFES/HEDLP from NIF campaign
 - ITER, Burning Plasma Research Program, and Upgrades
 - *E.g., Diagnostics, Test Blanket Module (TBM) program for ITER*



BES: The Continuum of Research, Development, and Deployment

Grand
Challenge
Research

Discovery
Research

Use-Inspired
Basic
Research

Applied
Research

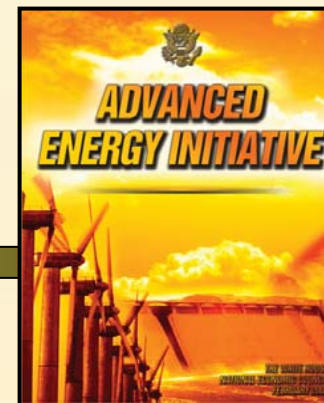
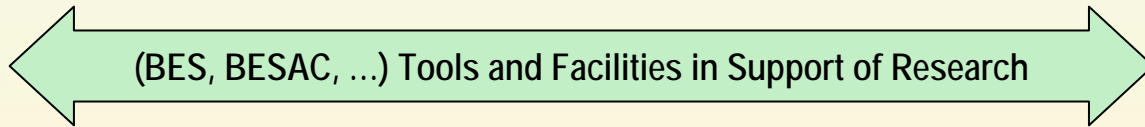
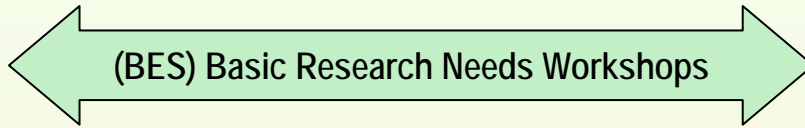
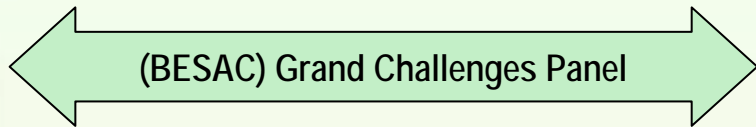
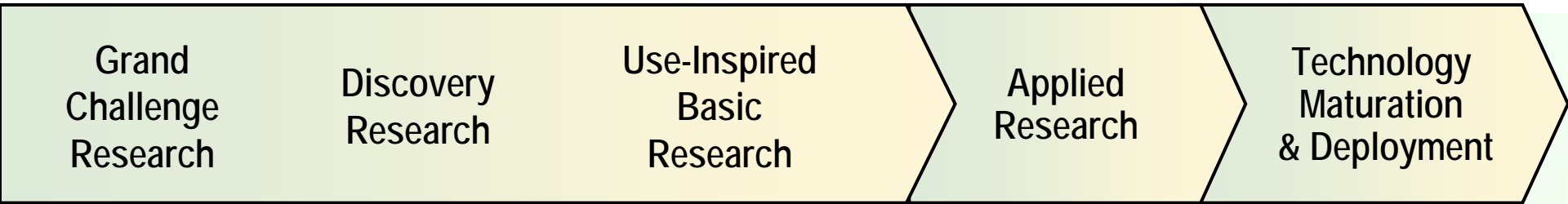
Technology
Maturation
& Deployment

- Basic research to address fundamental limitations of current theories and descriptions of matter in the energy range important to everyday life – typically energies up to those required to break chemical bonds.
- Basic research for fundamental new understanding on materials or systems that may revolutionize or transform today's energy technologies
- Basic research for fundamental new understanding, usually with the goal of addressing showstoppers on real-world applications in the energy technologies
- Research with the goal of meeting *technical milestones*, with emphasis on the development, performance, cost reduction, and durability of materials and components or on efficient processes
- Proof of technology concepts
- Scale-up research
- At-scale demonstration
- Cost reduction
- Prototyping
- Manufacturing R&D
- Deployment support

Goal: new knowledge / understanding
Focus: phenomena
Metric: knowledge generation

Goal: practical targets
Focus: performance
Metric: milestone achievement

BES: The Continuum of Research, Development, and Deployment



"Basic Research Needs" Workshops

We have identified the basic science needed for the next-generation energy technologies

Basic Research Needs to Assure a Secure Energy Future

BESAC Workshop, October 21-25, 2002
The foundation workshop that set the model for the focused workshops that follow.

Basic Research Needs for the Hydrogen Economy

BES Workshop, May 13-15, 2003

Nanoscience Research for Energy Needs

BES and the National Nanotechnology Initiative, March 16-18, 2004

Basic Research Needs for Solar Energy Utilization

BES Workshop, April 18-21, 2005

Advanced Computational Materials Science: Application to Fusion and Generation IV Fission Reactors

BES, ASCR, FES, and NE Workshop, March 31-April 2, 2004

The Path to Sustainable Nuclear Energy: Basic and Applied Research Opportunities for Advanced Fuel Cycles

BES, NP, and ASCR Workshop, September 2005

Basic Research Needs for Superconductivity

BES Workshop, May 8-10, 2006

Basic Research Needs for Solid-state Lighting

BES Workshop, May 22-24, 2006

Basic Research Needs for Advanced Nuclear Energy Systems

BES Workshop, July 31-August 3, 2006

Basic Research Needs for the Clean and Efficient Combustion of 21st Century Transportation Fuels

BES Workshop, October 30-November 1, 2006

Basic Research Needs for Geosciences: Facilitating 21st Century Energy Systems

BES Workshop, February 21-23, 2007

Basic Research Needs for Electrical Energy Storage

BES Workshop, April 2-5, 2007

Basic Research Needs for Materials under Extreme Environments

BES Workshop, June 10-14, 2007

Basic Research Needs for Catalysis for Energy

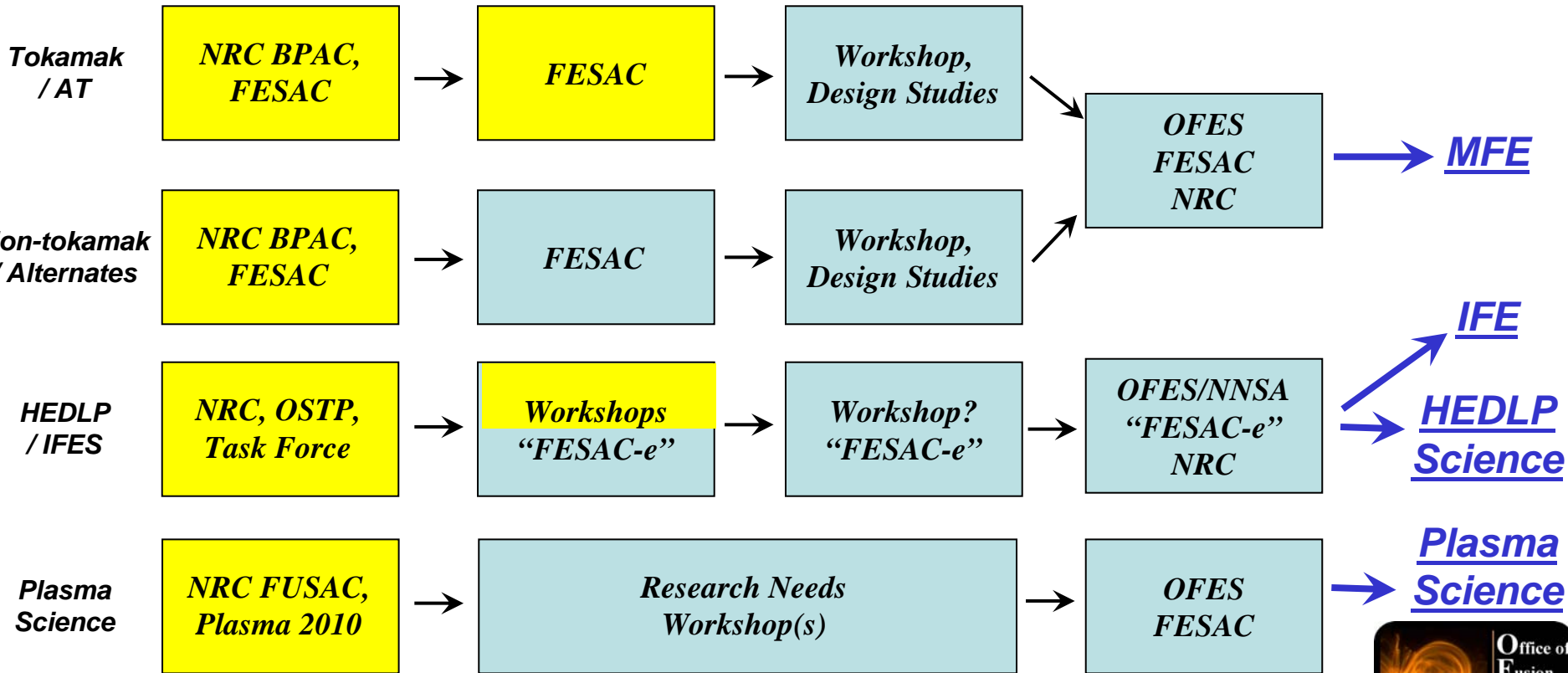
BES Workshop, August 5-10, 2007





Planning for OFES Science Research Programs

Grand Challenges	Research Needs	Campaigns / Initiatives	Ordering / Prioritization
----- Limitations of Knowledge for goals; Discovery Topics	----- Specific topics; Opportunities for Leadership; Gaps	----- Approaches Readiness Scope; Missions	----- Balance Map to Resources





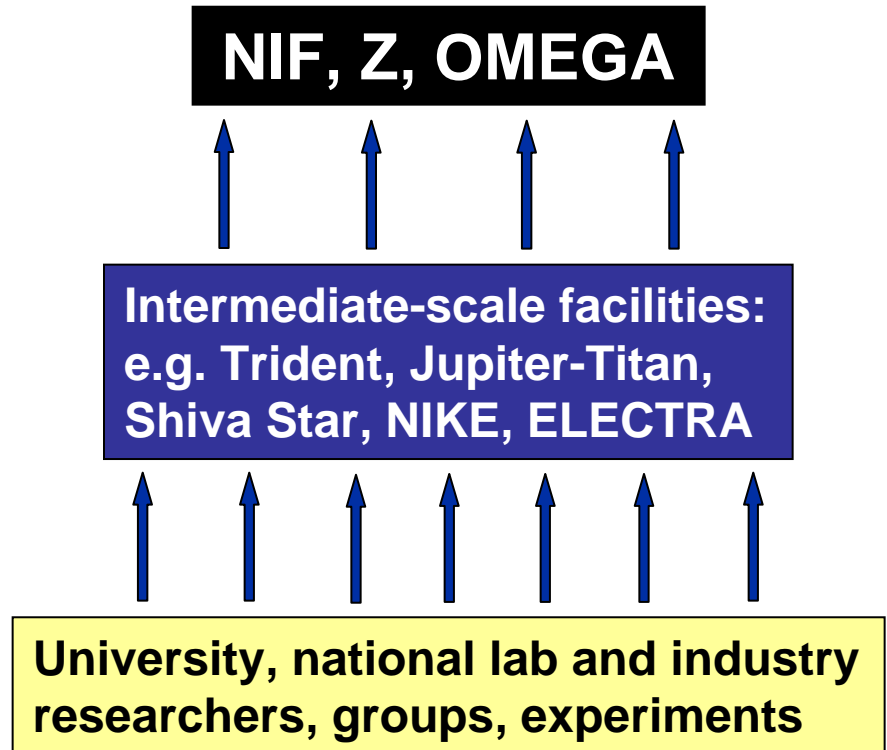
Near-Term Planning Activities...

- Identify scientific challenges
 - Define scientific missions and opportunities
- Charges for FESAC
 - HEDLP & IFES (w/NNSA)
 - *Next 5, 10, 15 years: before and after NIF ignition campaign*
 - *Define steps to be resolved for IFE initiative beyond NIF era*
 - *Stewardship of HEDLP as science discipline*
 - Alternate investigations in MFES
 - *Gaps, opportunities*
 - *Role in ITER era*
 - Fusion materials and engineering sciences
 - *Framing underlying scientific issues and technical challenges*
 - *Opportunities?*
- Workshops
 - Plasma Sciences research roadmap
 - *NRC Plasma 2010 follow-up*
 - *Campaigns and initiatives: Low-temp; Confined; Fundamental Properties*
 - Tokamak campaigns, initiatives in ITER era to make the case for fusion energy
 - *Follow-up to latest FESAC (Greenwald) report*



Current SC/NNSA Joint Program in HEDLP

- **Initial main scientific themes¹:**
 - Create, probe, and control new states of matter in HEDLP
 - Address challenges in inertial fusion energy sciences
- **Program evolution will be guided by Advisory Committee and planning exercises**
- **First joint solicitation planned for 2008-2009**
 - Details are being developed



1. Recommended by community HEDLP Workshop at the Argonne National Lab (May 23–24, 2007) **Chaired by Dr. Robert Rosner and Dr. John Browne**



Planning for HEDLP/IFES

- A MOU is being developed between SC and NNSA to use FESAC to provide advisory functions for HEDLP/IFES.
 - FESAC subcommittees will address charges jointly formulated by SC and NNSA
 - Chairs and memberships of the subcommittees jointly agreed upon by SC and NNSA
 - Additional HEDLP/IFES expertise to be added to FESAC membership
- A FESAC charge is being developed, pending MOU agreement
 - Opportunities, priorities and balance between research supporting NNSA and SC missions, and fundamental HEDLP
 - Scientific roadmap for non-energy related HEDLP
 - Scientific roadmap for IFES: cover three conceptual phases:
 - *Pre-NIF ignition: Preparing for ignition science experiments*
 - *Post-NIF ignition near-term: exploring implosion and target physics related to HEDLP and IFES; develop the case for IFES concentration*
 - *Far-term: Develop case for dedicated IFES next-step(s)*
 - *Note: include laser + other emerging concepts*



Basic Plasma Science

- New National Academies Plasma 2010 Decadal Study released:
 - Central recommendation:
“To fully realize the opportunities in plasma research, a unified approach is required. Therefore, the Department of Energy’s Office of Science should reorient its research programs to incorporate magnetic and inertial fusion energy sciences, basic plasma science, non-mission-driven high-energy density plasma science, and low-temperature plasma science and engineering.”
- OFES will try to help address these needs, but requires research community help!
 - Define and prioritize exciting campaigns and initiatives for plasma sciences and HEDLP
 - Compete in the ACI world
 - Considering workshop(s), FESAC charges, etc.
 - Suggestions welcome

Plasma
Science:
Advancing
Knowledge in
the National
Interest

May 2007





OFES Staffing Plans

- General needs independent of changes to organizational structure
- FY 2007:
 - Recruited a Physical Scientist and an Admin Support person to OFES
- FY 2008: (pending CR end)
 - Fill division head positions (2/3)
 - Recruit three technical staff members and one program assistant to OFES
 - Recruit one technical staff member and one program assistant to DOE ITER Project Office at Oak Ridge



Summary

- Waiting for info on budget and CR
- ITER is a real, legal entity
 - Design review process making progress, but challenges...
- Program and OFES structure under consideration
- Multi-tiered planning process needed
 - Address increasing demands on budget
 - To coordinate with FESAC
 - Short-term and long-term

Grand Challenges
How nature works

Discovery and Use-Inspired Basic Research
Materials properties and functionalities by design

Applied Research

Technology Maturation & Deployment

- Controlling materials processes at the level of quantum behavior of electrons
- Atom- and energy-efficient syntheses of new forms of matter with tailored properties
- Emergent properties from complex correlations of atomic and electronic constituents
- Man-made nanoscale objects with capabilities rivaling those of living things
- Controlling matter very far away from equilibrium

- Basic research for fundamental new understanding on materials or systems that may revolutionize or transform today's energy technologies
- Development of new tools, techniques, and facilities, including those for the scattering sciences and for advanced modeling and computation

- Basic research, often with the goal of addressing showstoppers on real-world applications in the energy technologies

- Research with the goal of meeting *technical milestones*, with emphasis on the development, performance, cost reduction, and durability of materials and components or on efficient processes
- Proof of technology concepts

- Scale-up research
- At-scale demonstration
- Cost reduction
- Prototyping
- Manufacturing R&D
- Deployment support

