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

Fusion Energy Sciences Program

Technology of Fusion Energy
American Nuclear Society Meeting

Excellent Science
Attractive Energy
Office of Fusion Energy Sciences

www.ofes.fusion.doe.gov

Dr. N. Anne Davies
Associate Director
for Fusion Energy Sciences

September 14, 2004

U.S. Fusion Energy Sciences Program Mission

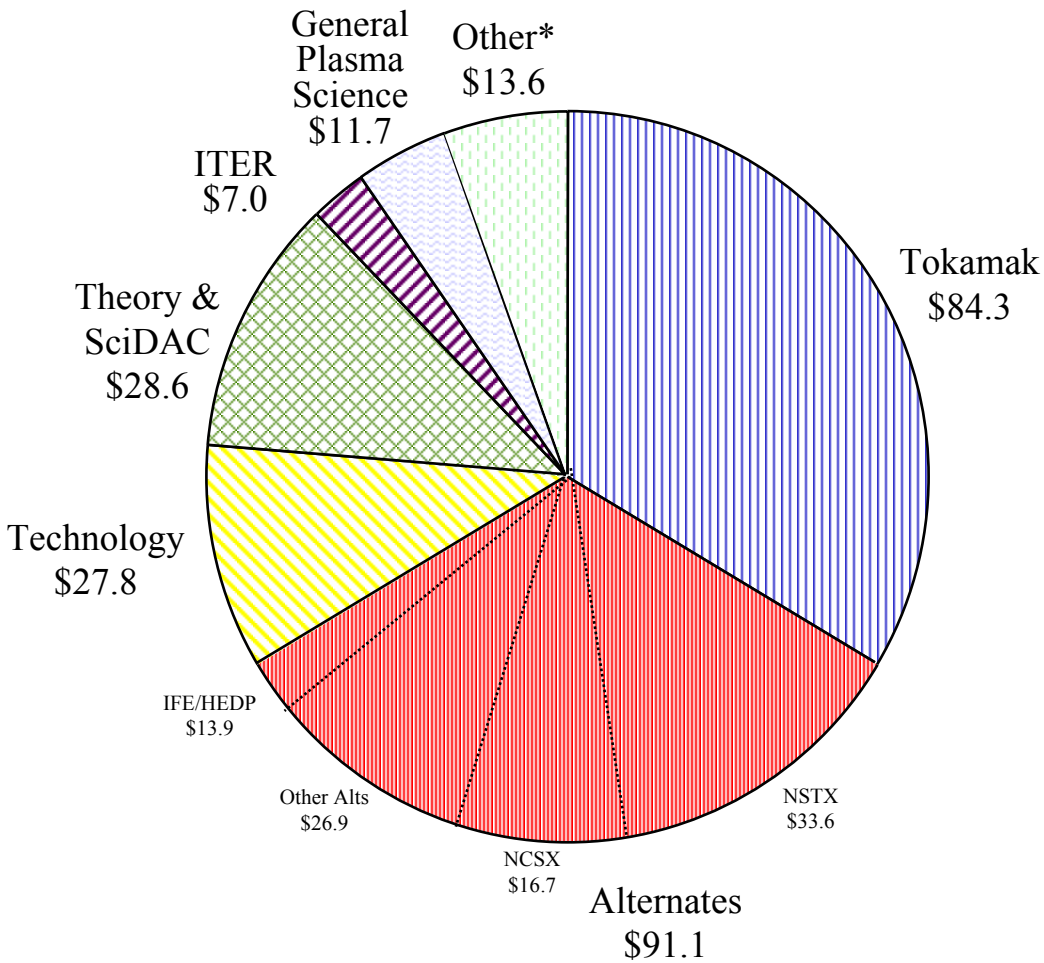
"Advance plasma science, fusion science, and fusion technology-- the knowledge base needed for an economically and environmentally attractive fusion energy source."

Fusion is a Potentially Attractive Domestic Energy Source

- Abundant fuel, available to all nations
  - Deuterium and lithium easily available for thousands of years
- Environmental Advantages
  - No carbon emissions, short-lived radioactivity
- Can't blow up, resistant to terrorist attack
  - Less than 5 minutes of fuel in the chamber
- Low risk of nuclear materials proliferation
  - No fissile or fertile materials required
- Compact relative to solar, wind and biomass
  - Modest land usage
- Not subject to daily, seasonal or regional weather variation
  - No large-scale energy storage nor long-distance transmission
- Cost of power estimated similar to coal, fission
- Can produce electricity and hydrogen
  - Complements other nearer-term energy sources

FY 2005 Congressional Request
Fusion Energy Sciences Budget

($ in Millions)

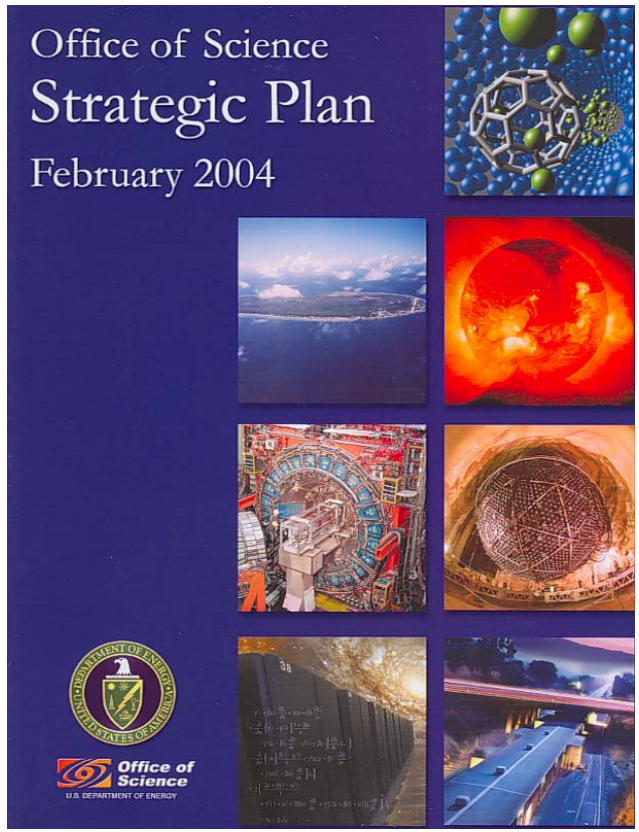


$264.1 M

*SBIR/STTR
GPP/GPE
ORNL Move
Reserve
Environmental Monitoring

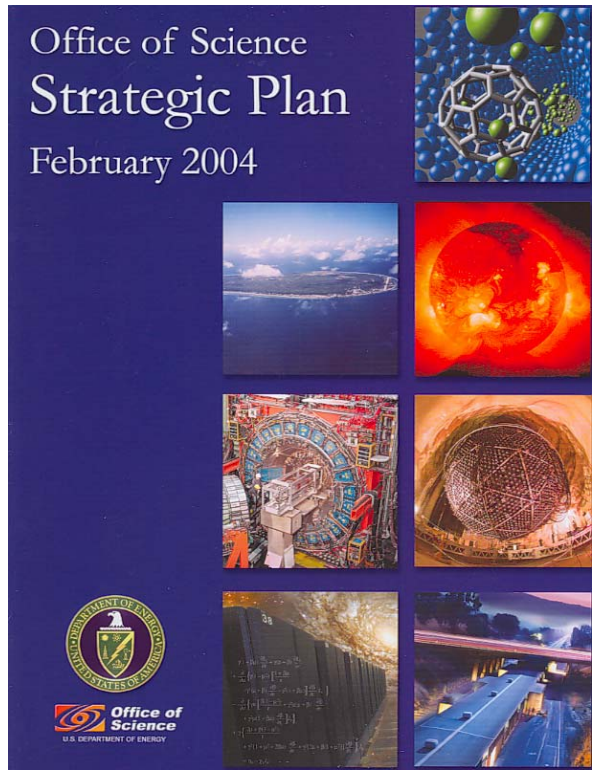
Office of Science Strategic Plan

- Published February 2004; electronic version available at www.sc.doe.gov/
- Fusion "Broad Goals"
  - Demonstrate with burning plasma fusion's scientific/technological feasibility
  - Develop fundamental understanding for predictive capabilities
  - Determine most promising approaches and configurations for energy
  - Develop new materials, components and technologies for energy



Office of Science Strategic Plan

- Success Indicators (www.science.doe.gov/measures)
  - Progress in developing benchmarked predictive capability for burning plasma
  - Progress in demonstrating enhanced understanding of magnetic confinement and in improving basis for designing future burning plasma experiments through research on confinement configuration optimization
  - Progress in developing predictability of high-energy density physics including energy applications



Office of Science

20 Year Facilities Plan

"These Department of Energy facilities are used by more than 18,000 researchers from universities, other government agencies, private industry and foreign nations."

- Secretary of Energy
Spencer Abraham

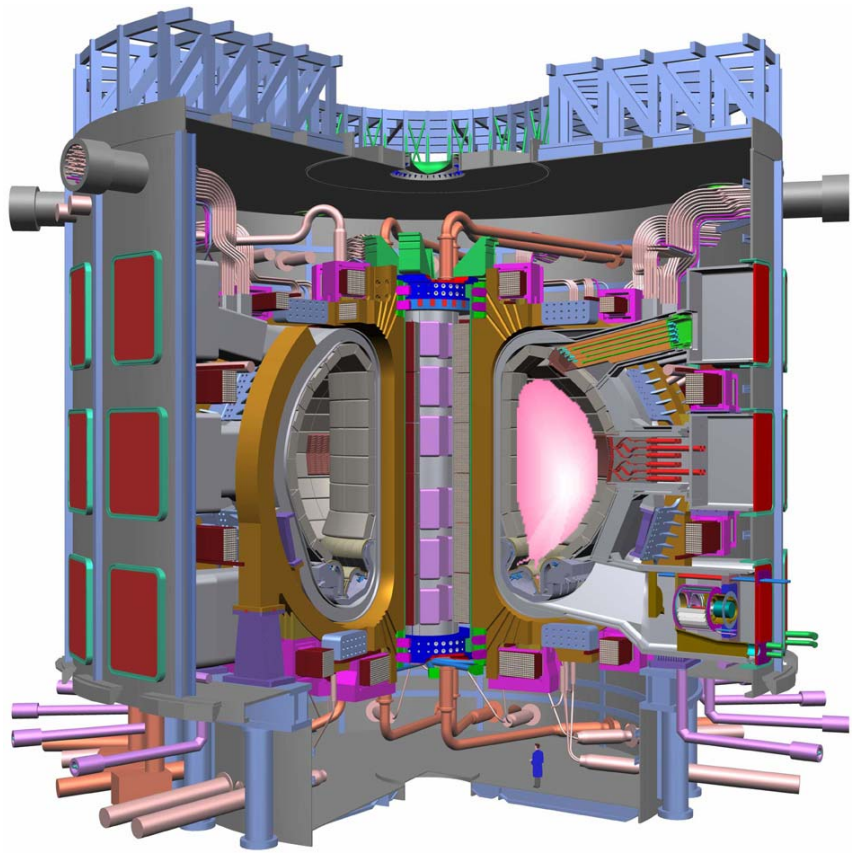
Excerpts from Secretary of Energy Spencer Abraham's Speech to the National Press Club

November 10, 2003

"The prospect of a limitless source of clean energy for the world leads with our commitment to join the international fusion energy experiment known as ITER.

This is a Presidential priority with enormous potential. Successful negotiations among the international partners will lead to the first-ever fusion science experiment capable of producing a self-sustaining fusion reaction.

If we reach agreement, ITER will be our top facility."



U.S. Department of Energy Office of Science 20-Year Facility Outlook Peak of Cost Profile

Programs:

ASCR = Advanced Scientific Computing Research
BES = Basic Energy Sciences
BER = Biological and Environmental Research
FES = Fusion Energy Sciences
HEP = High Energy Physics
NP = Nuclear Physics

Site Selection Negotiations Continue

Rokkasho, Japan (northern Japan)

Cadarache, France, EU (southern France)

- **On June 18th, 2004, the Third Preparatory (Negotiations) Meeting for ITER Decision Making was held at Ray Orbach's level. All six ITER Parties were present.**

Common Message from 3rd Preparatory Meeting for ITER Decision Making

(IAEA Vienna, 18th June 2004)

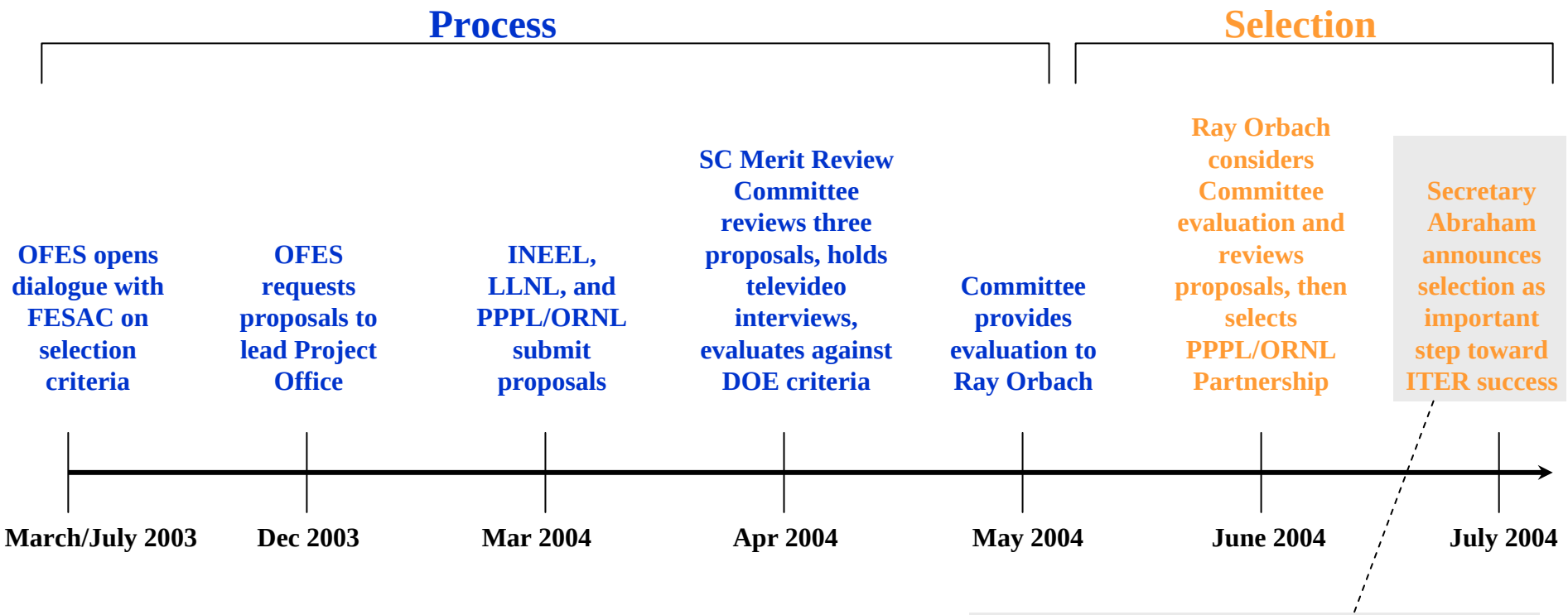
Delegations from China, European Union, Japan, the Republic of Korea, the Russian Federation, and the United States met at the IAEA headquarters in Vienna on 18th June 2004 to advance the ITER negotiations.

The two potential Host Parties, European Union and Japan, presented their positions, taking account of recent bilateral discussions on a broader approach to realising fusion energy. The parties noted that the contents of these offers were essentially symmetrical and showed a readiness of each of the potential Host Parties to contribute significantly to the realisation of elements of the Broader Approach other than ITER in addition to their contributions to ITER itself.

All Parties stressed the urgency of reaching a rapid resolution of the siting issue so as to move forward to implementation of ITER in a framework of international collaboration.

- **Resolution continues to be largely in the hands of the EU and JA.**

Path to Selection of US ITER Project Office



Next Steps:

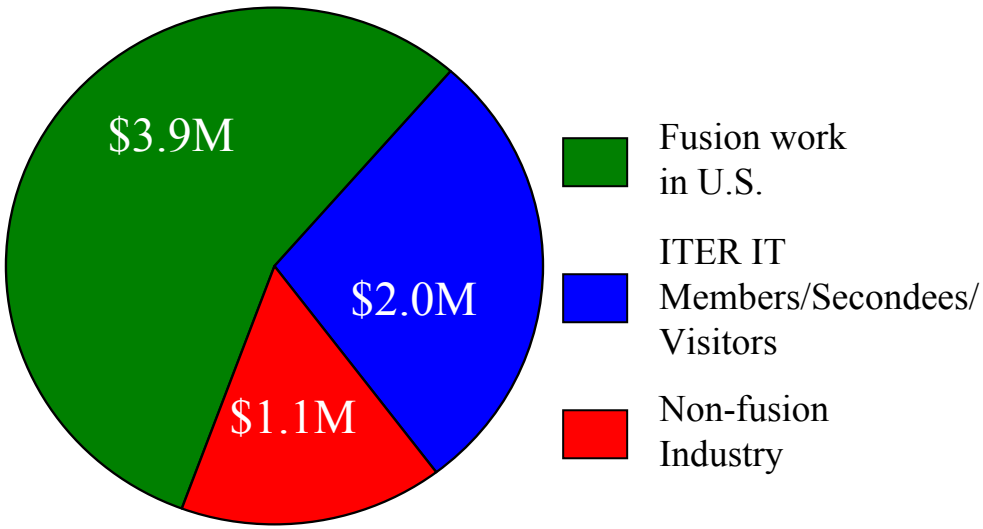
- Define project organization
- US ITER Project Office, under leadership of Ned Sauthoff, works with community to select key personnel
- Consider, define and organize the US ITER/Burning Plasma Program

"I am confident that our partners in the ITER negotiations will recognize our choice of PPPL/ORNL to manage the U.S. participation in ITER for what it is: the clearest possible indication that our Nation takes ITER – and our role in ITER – very seriously."

Secretary Abraham
July 13, 2004

ITER Direct Funding for FY05

Distribution of Funding



Total of $7.0M in FY05

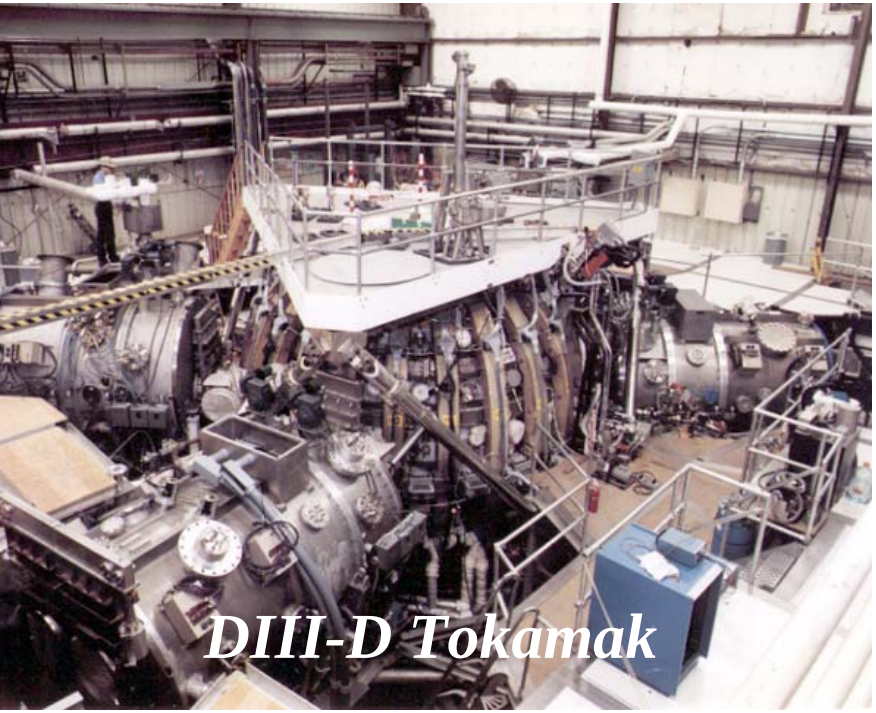
Specific Task Areas

- Magnet design and R&D
- PFC design and R&D
- Tritium processing design
- Safety, power supplies, etc.
- Project and procurement management
- Magnets/PFC Secondees
- ICH Visitors
- Diagnostics Visitor
- Strand qualification
- Power Supply/Cooling water cost estimates

Work done in conjunction with VLT activities

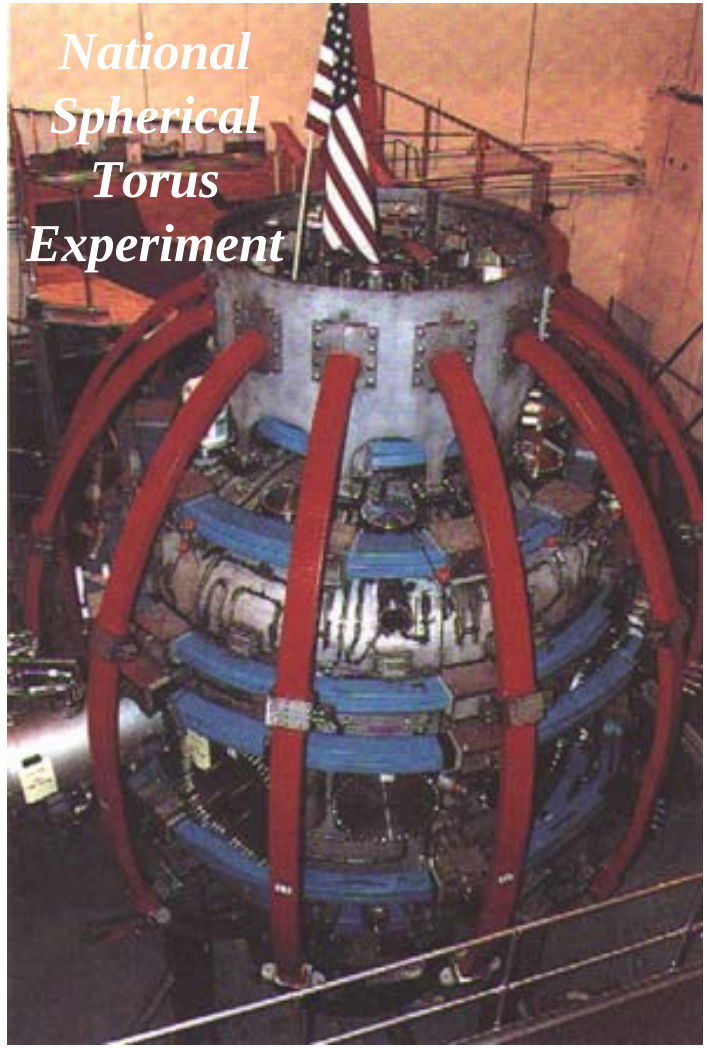
International Tokamak Physics Activity (ITPA) and ITER Physics

- 5th ITPA Coordinating Committee meeting held in Shanghai on June 10-11, 2004:
  - Korea joined ITPA.
  - Ron Stambaugh is selected as the new Chair of the committee.
  - Topical Physics Groups are working on the Tokamak Physics Basis update for submission to Nuclear Fusion In December 2004.
- Technical work in ITPA is progressing well:
  - Joint experiments among the world tokamaks, coordinated through ITPA and IEA Agreements, are productive.
  - Next series of Topical Group meetings will be held in Lisbon after the IAEA Fusion Energy Conference.
- We need to improve interaction with the International Team on ITER Physics Tasks:
  - ITER relevant experiments and modeling studies should be developed into ITER Physics tasks.



General Atomics

Doublet III Started Operations In 1978

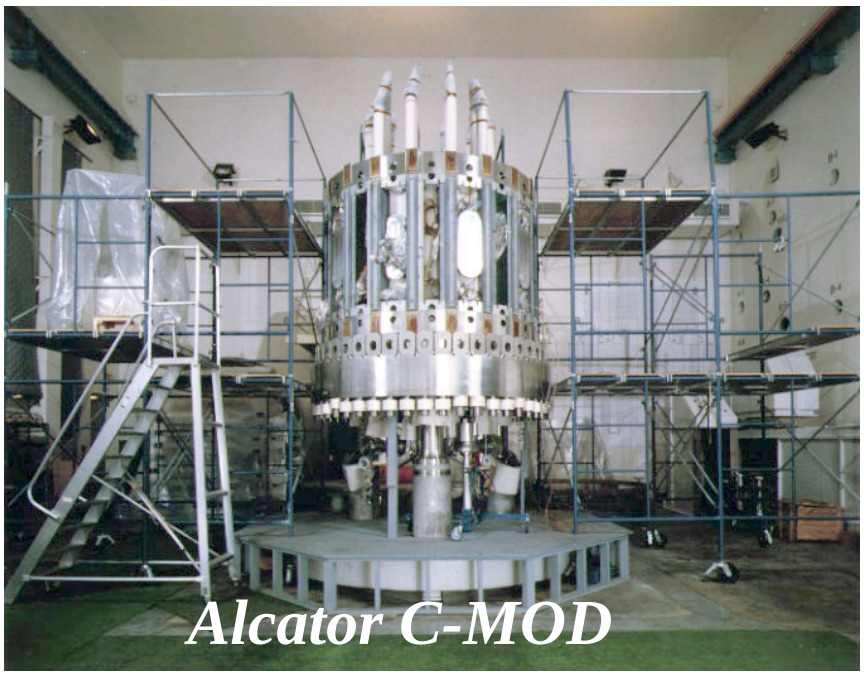


Princeton Plasma Physics Laboratory

NSTX started Operations in 1999

Massachusetts Institute of Technology

C-MOD Started Operations in October 1991



Scientific Discovery Thru Advanced Computing

- Peer review of new and renewal proposals completed in June 2004
- Two proposals selected for funding
- Center for Extended Magnetohydrodynamic Modeling, Stephen Jardin PI
  - Further investigation of extended MHD equations, algorithms
  - Focus on problems of interest to burning plasma
  - Begin work on integrated calculation with RF (pace depends on RF theory funding)
- Center for Gyrokinetic Particle Simulation of Turbulent Transport in Burning Plasmas, W. Lee, PI
  - Study electron transport
  - Work on transport barrier physics
  - Begin to investigate effects of energetic particles on turbulent transport
- Remaining SciDAC ($1 million) funds set aside to begin work on the SciDAC Fusion Simulation Project (FSP) in collaboration with OASCR, which would provide matching funds

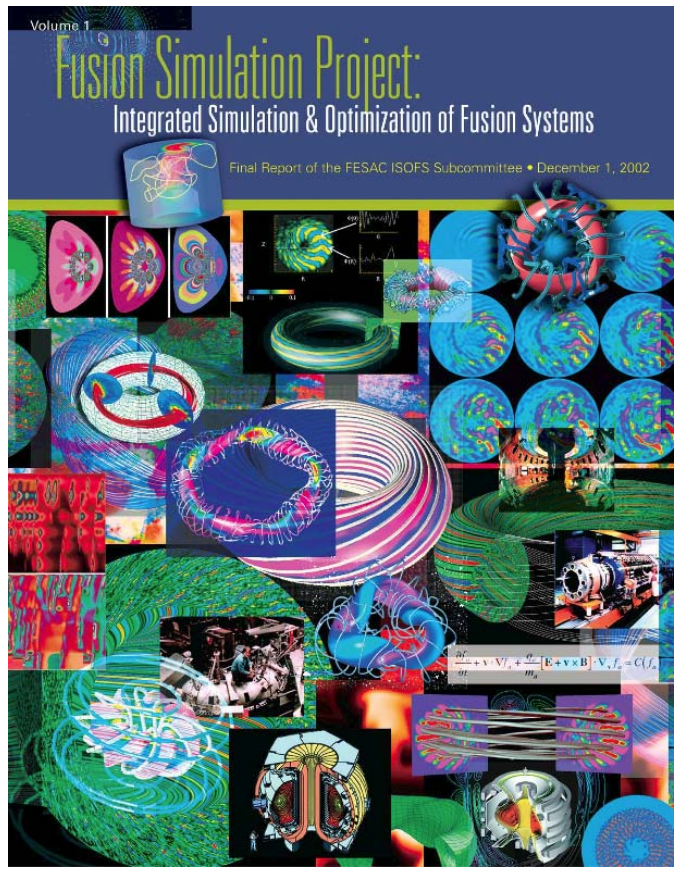
Fusion Simulation Project Status

- The Fusion Simulation Project (FSP) will unify and accelerate progress on a complete, integrated simulation and modeling capability for ITER-class burning plasma

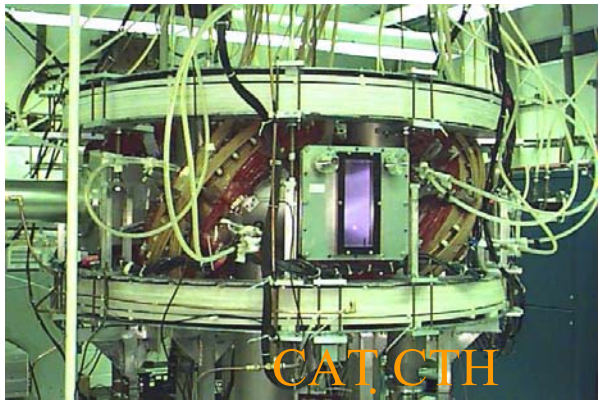
- Creating this capability entails integrating physics that heretofore has largely been considered in isolation

- In FY 2005, OFES and OASCR are planning to begin the first phase of the FSP by soliciting proposals for the initial integration efforts called "Focused Integration Initiatives" in the FESAC Report

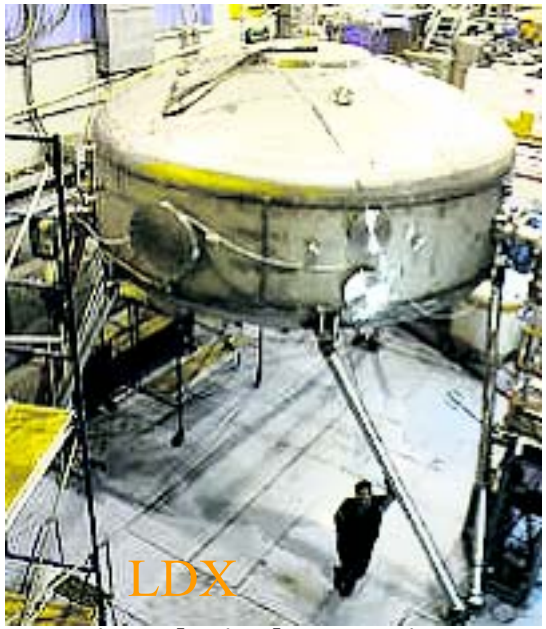
- From 1-3 projects would be started in FY 2005 depending on the FY 2006 budget outlook



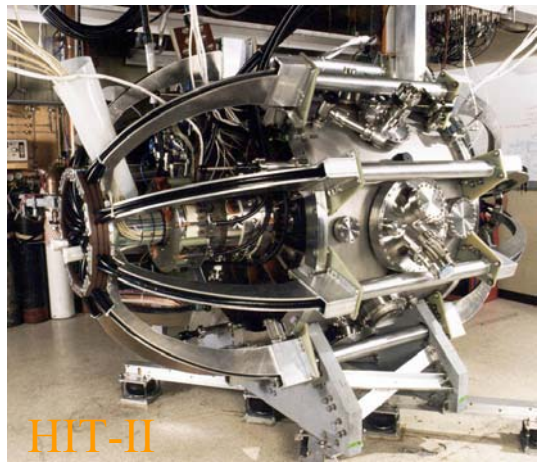
Innovative Confinement Concepts



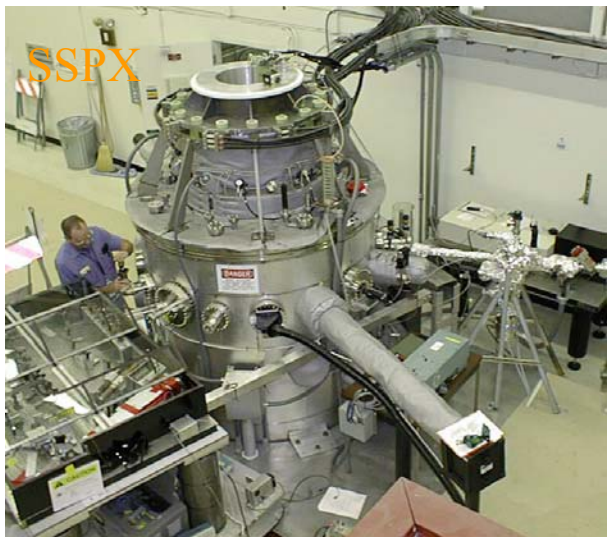
Compact Auburn Torsatron becoming
Compact Toroidal Hybrid
Auburn University, Auburn Alabama



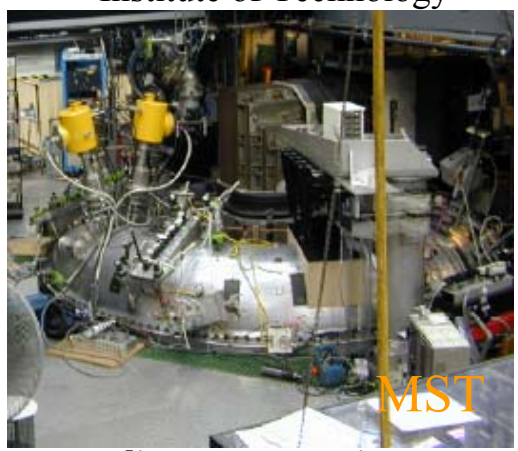
Levitated Dipole Experiment
Columbia University/Massachusetts Institute of Technology



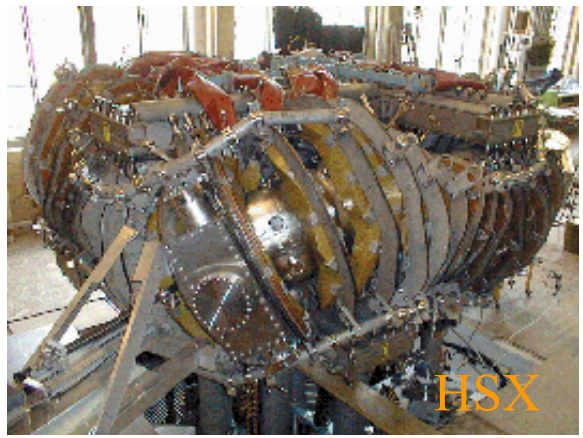
Helicity Injected Torus-II Experiment
University of Washington, Seattle



Sustained Spheromak Plasma Experiment
Lawrence Livermore National Laboratory



Madison Symmetric Torus
University of Wisconsin, Madison

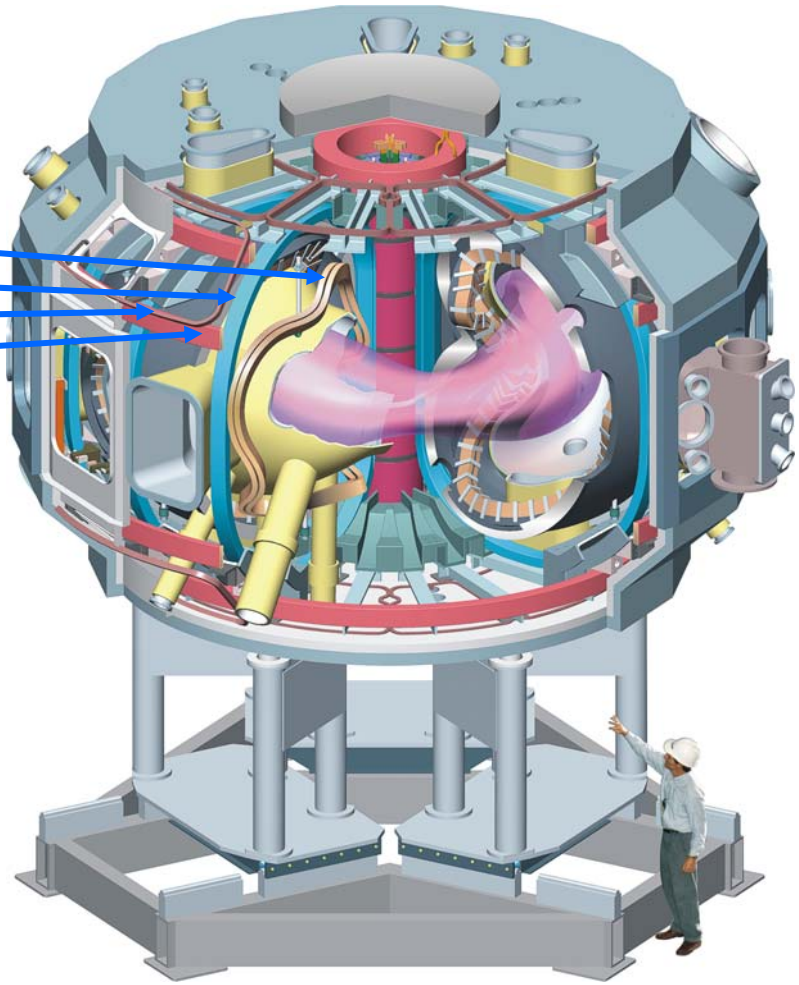


Helically Symmetric Experiment
University of Wisconsin, Madison

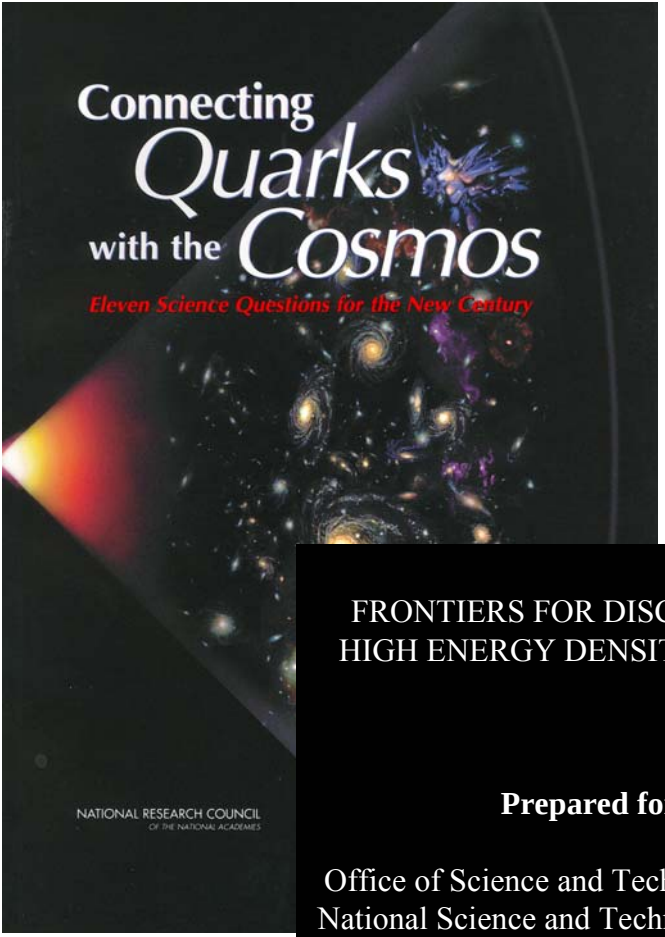
National Compact Stellarator Experiment
PPPL/ORNL

- **NCSX designed to flexibly access a wide range of magnetic configurations**
  - Unique feature of NCSX design
  - 3 modular coil types
    + TF coils
    + trim coils
    + 6 poloidal field coils
  - Will allow systematic study of 3D confinement and stability physics

- **NCSX configuration designed for improved confinement and stability**
  - Quasi-axisymmetry
  - 3D shaping of magnetic field distribution to increase pressure limit
  - Need to measure characteristics of range of configurations as first stage of research investigations.



NCSX



FRONTIERS FOR DISCOVERY IN
HIGH ENERGY DENSITY PHYSICS

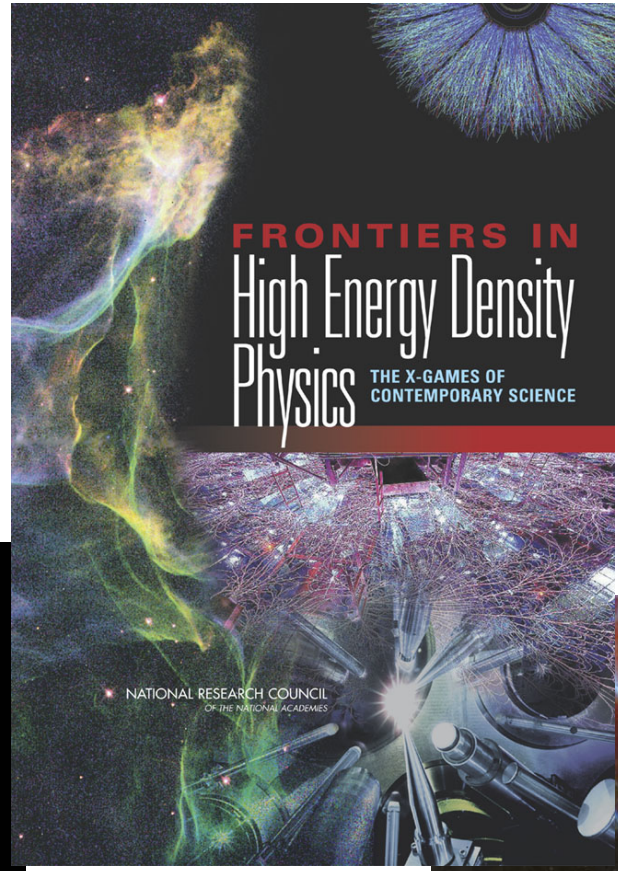
Prepared for

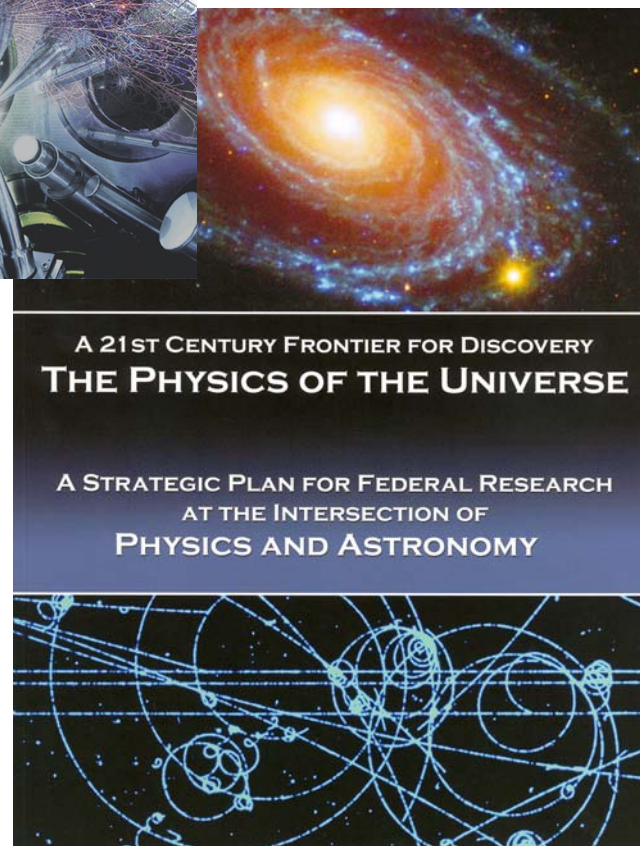
Office of Science and Technology Policy
National Science and Technology Council
Interagency Working Group on the
Physics of the Universe

Prepared by

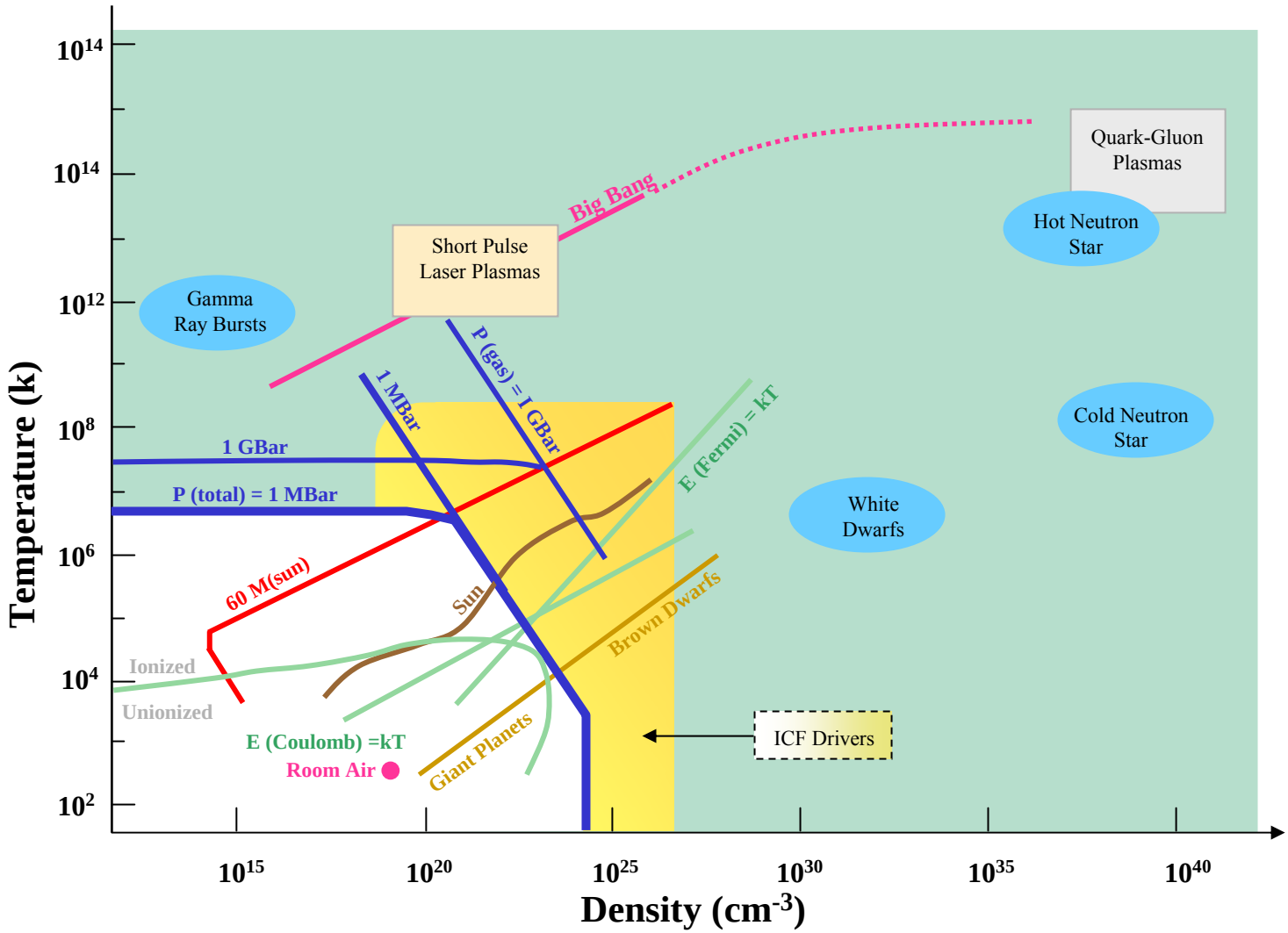
National Task Force
on High Energy Density Physics

July 20, 2004





Map of the HED Universe



Four Major HEDP Research Areas

1. High energy density physics in astrophysical systems;

2. Beam-induced high energy density physics (Relativistic Heavy Ion Collider, heavy ion fusion, high-intensity accelerators, etc.);

3. High energy density physics in Stockpile Stewardship facilities (Omega, Z/ZR, National Ignition Facility, etc); and

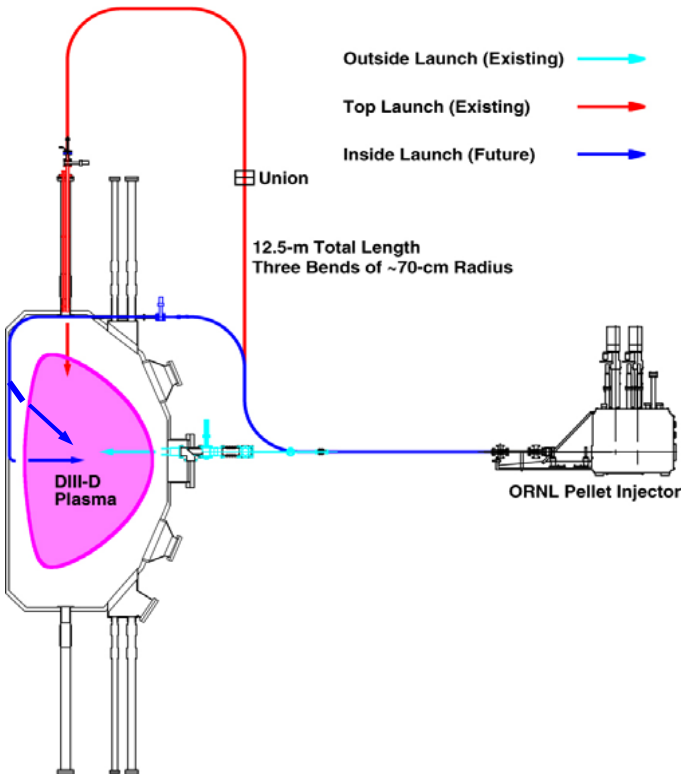
4. Ultrafast, Ultraintense Laser Science

Fusion Science Centers

- Competitive peer review in 2004
- 2 centers funded for 5 years, with the possibility of renewal for an additional 5 years
- University of Maryland and UCLA Center will focus on Multiscale Plasma Dynamics using facilities at both of the schools
  - Total funding of $6.4 million over five years
  - Other institutions involved are Princeton University, the Massachusetts Institute of Technology (MIT), and the University of Michigan
  - More information available at: http://cmpd.umd.edu/
- The University of Rochester Center will study Extreme States of Matter and Fast Ignition Physics
  - Total funding of $5.5 million over five years
  - Partners include MIT, General Atomics, University of California at San Diego, Ohio State University, UCLA and the University of Texas at Austin
  - Collaboration with the National Nuclear Security Administration programs at Rochester and Lawrence Livermore National Laboratory
  - For more information see: http://fsc.lle.rochester.edu/

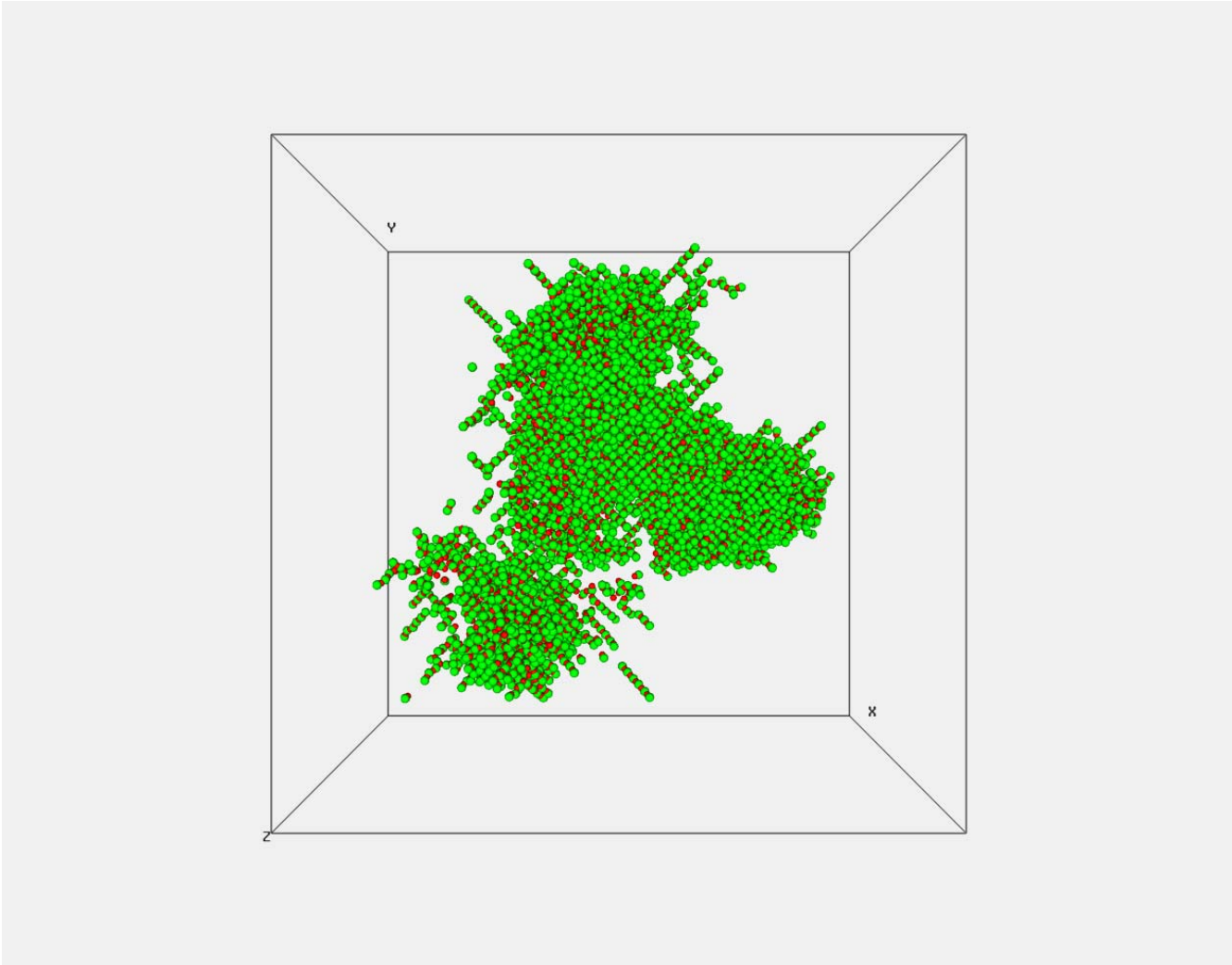
Enabling Technologies Program

Pellet Injector in DIII-D for Plasma Fueling



DiMES probe in DIII-D provides data on plasma material interactions.

Nanoscience is Advancing Fusion Materials



Molecular Dynamics calculation of atomic displacements due to neutron impact.

cience: Application to Fusion and Generation IV Fission Reactors

March 31 – April 2, 2004
(organized by ORNL at the request of BES)

Select international scientific committee convened to determine whether increased effort on modeling and simulation could bridge gap between data needed for design of advanced nuclear technologies and data from existing experiments

Discussion focused on fusion (where the "gap" is larger)

Clear consensus that IFMIF-like irradiation facility is needed, but no agreement that IFMIF was the best approach

Aggressive theory and modeling effort could reduce the time and experimental investment required for materials development

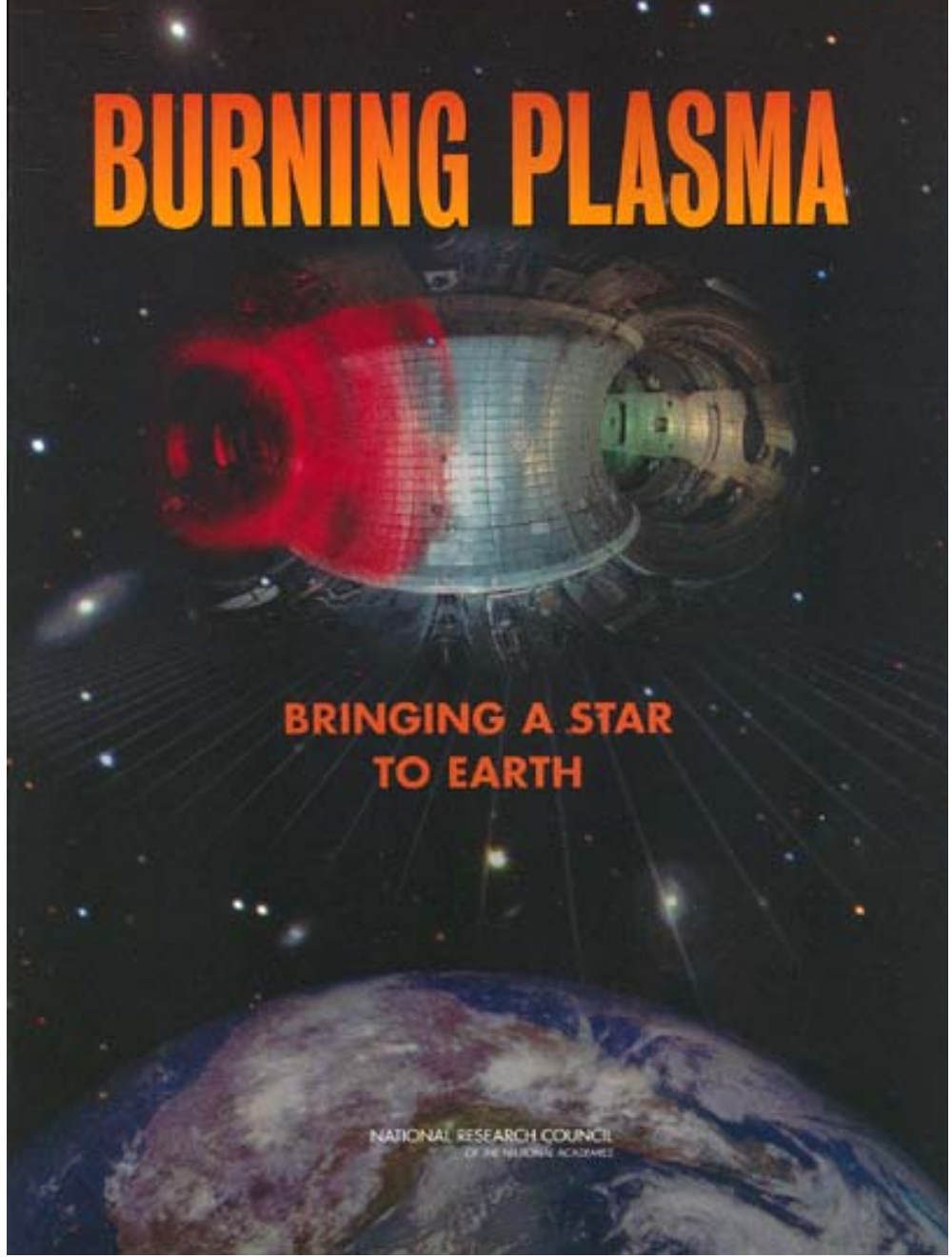
Complete report available at: http://www.csm.ornl.gov/meetings/SCNEworkshop/DC-index.html

Report of the Burning Plasma Assessment Committee

Released September 2003

U.S. participation in ITER

Fusion program priority setting



Program Goals and Overarching Themes

- **FESAC Priorities Panel started with a nearly diagonal transformation of the three program goals of the 1996 restructuring…**

– Advance plasma science in pursuit of national science and technology goals.
– Develop fusion science, technology, and plasma confinement innovations as the central theme of the domestic program.
– Pursue fusion energy science and technology as a partner in the international effort.

- **Into three "overarching themes":**

– O1. Understand the dynamics of matter and fields in the high temperature plasma state.
– O2. Create and understand a controlled, self-heated, burning starfire on earth.
– O3. Make fusion power practical.

Charles C. Baker
Panel Chair
FESAC Panel on Priorities

The U.S. and ITER

Science Opportunities

U.S. Direct Experience

ITER Design

Technology Opportunities

U.S. Industry and ITER

The Path to Fusion Energy

Office of Science
U.S. DEPARTMENT OF ENERGY