Office of Fusion Energy Sciences

Excellent Science in Support of Attractive Energy

U.S. Fusion Energy Sciences Program

Presented to

National Research Council
Burning Plasma Assessment Committee

By

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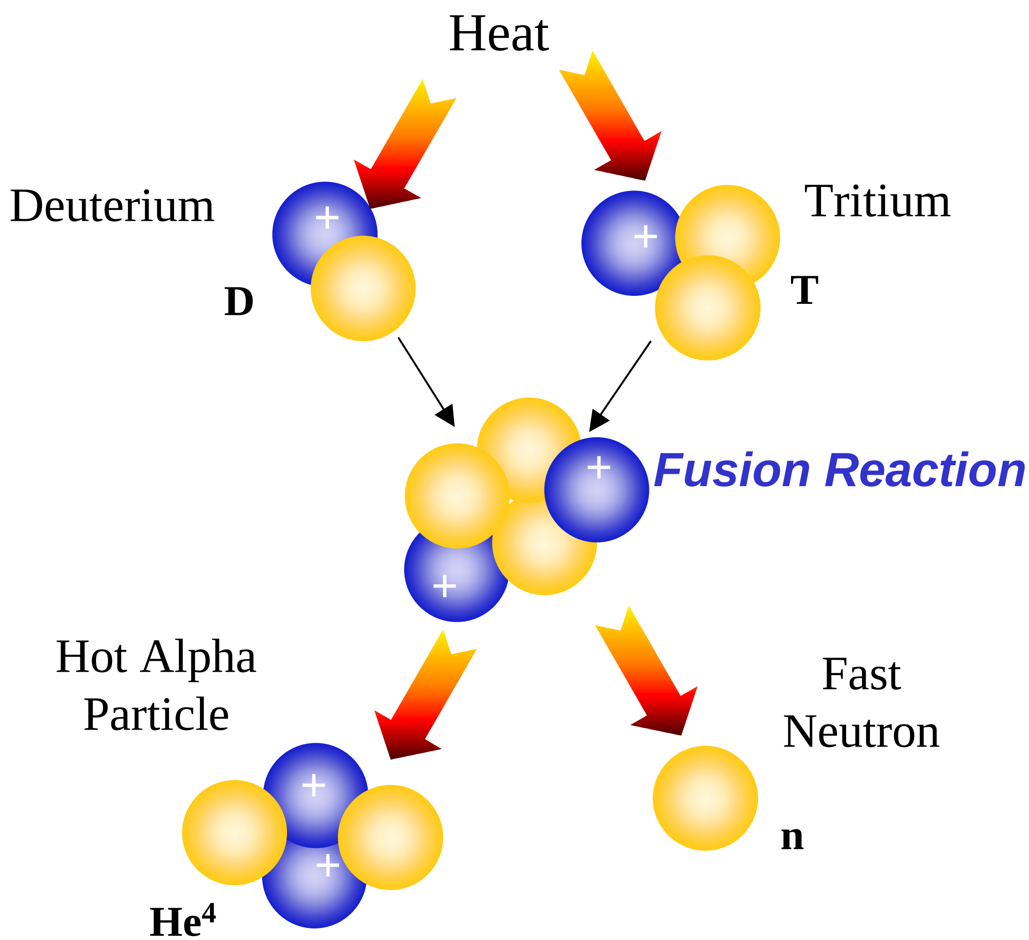
www.ofes.fusion.doe.gov

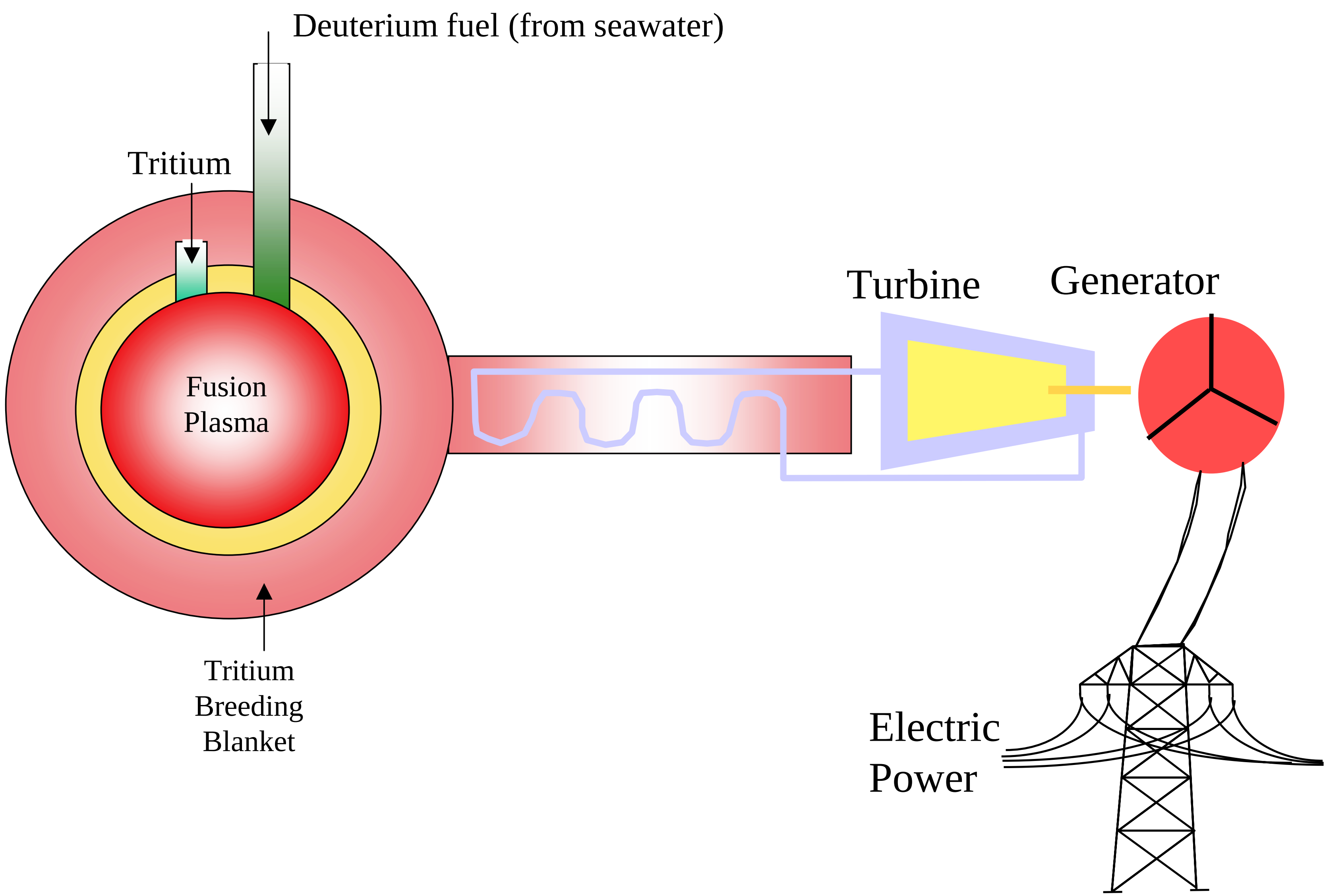
Excellent Science in Support of Attractive Energy

Deuterium-Tritium Fusion Reaction

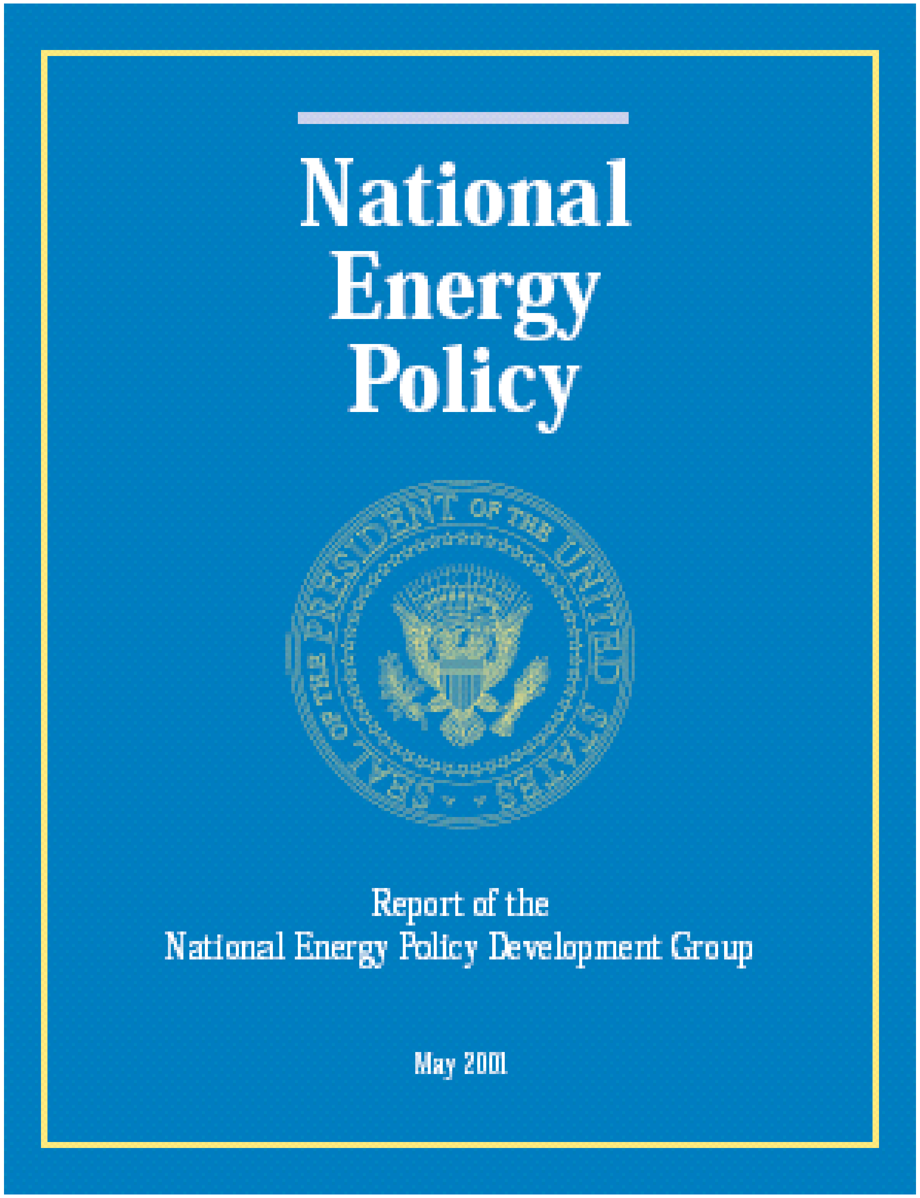


Energy Multiplication
About 450:1

Magnetic Fusion Power Plant



National Energy Policy



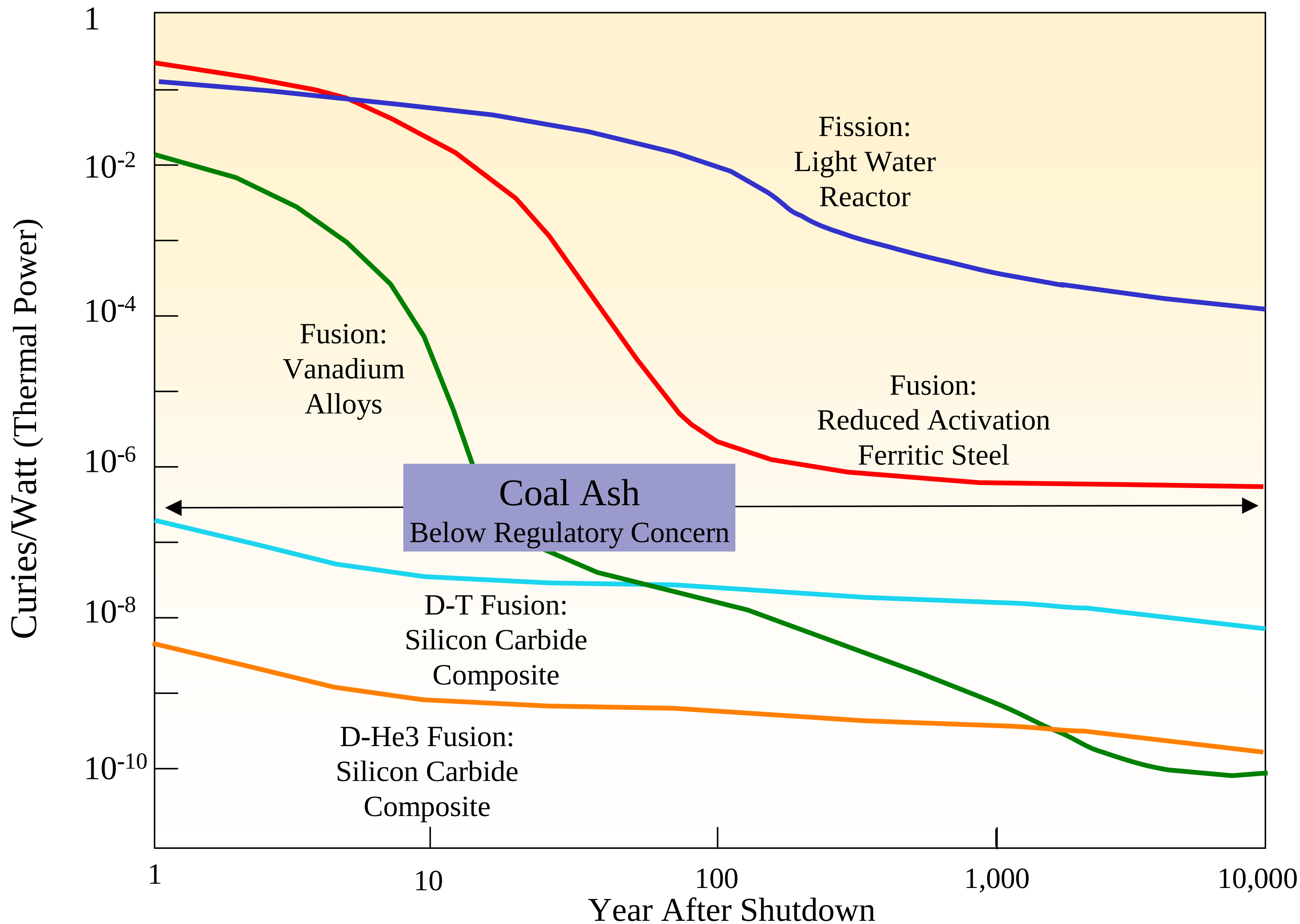
"The NEPD Group recommends that the President direct the Secretary of Energy to develop next-generation technology--including hydrogen and **fusion**."

Why Develop Fusion Energy

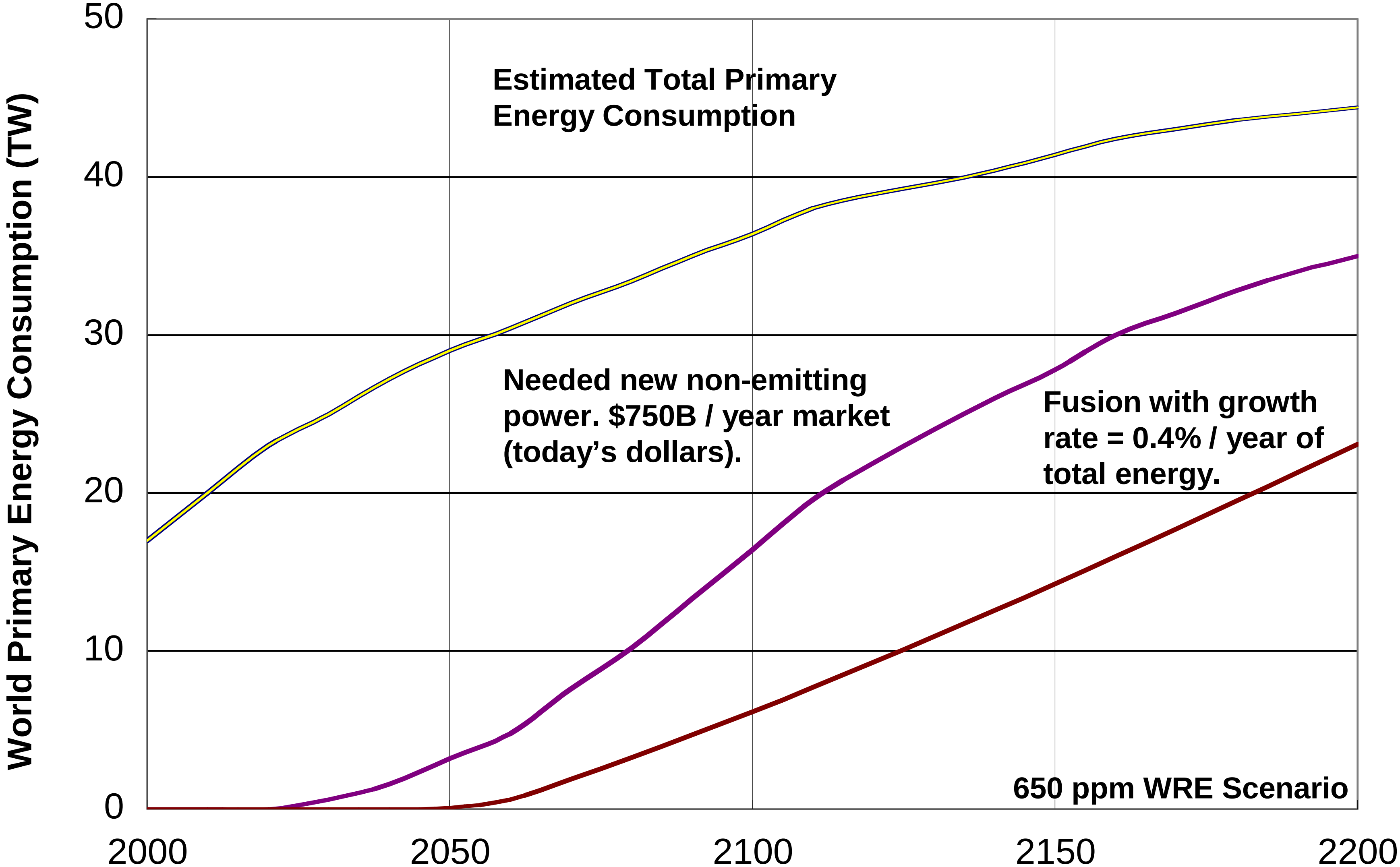
Fusion is a unique energy option with:

- Secure inexhaustible fuel reserves
  - Fuel obtained from seawater
  - One pound of fusion fuel = 25,000 barrels of oil
- Multiple end uses
  - Electricity
  - Fissile fuel
  - Hydrogen production
- Attractive environmental and safety features
  - No long-lived reaction products
  - Radioactive structure is relatively easy to manage
  - No combustion pollutants are produced
  - No possibility of runaway reaction
- Ancillary Benefits, such as, advanced science and technology/spinoffs/education

Comparison of Fission and Fusion Radioactivity After Shutdown

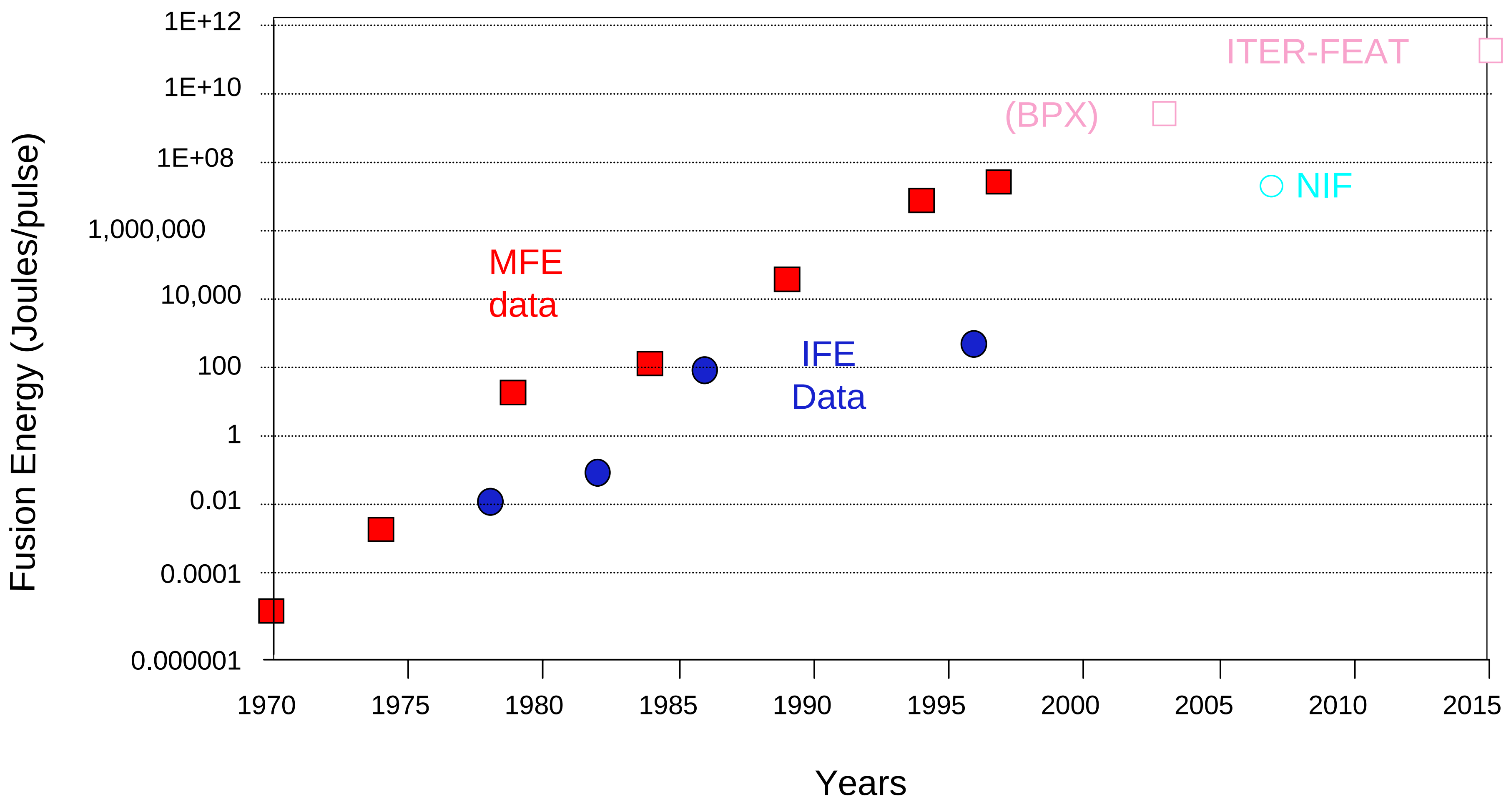


Fusion Can Contribute to Carbon Management on a Timley Basis

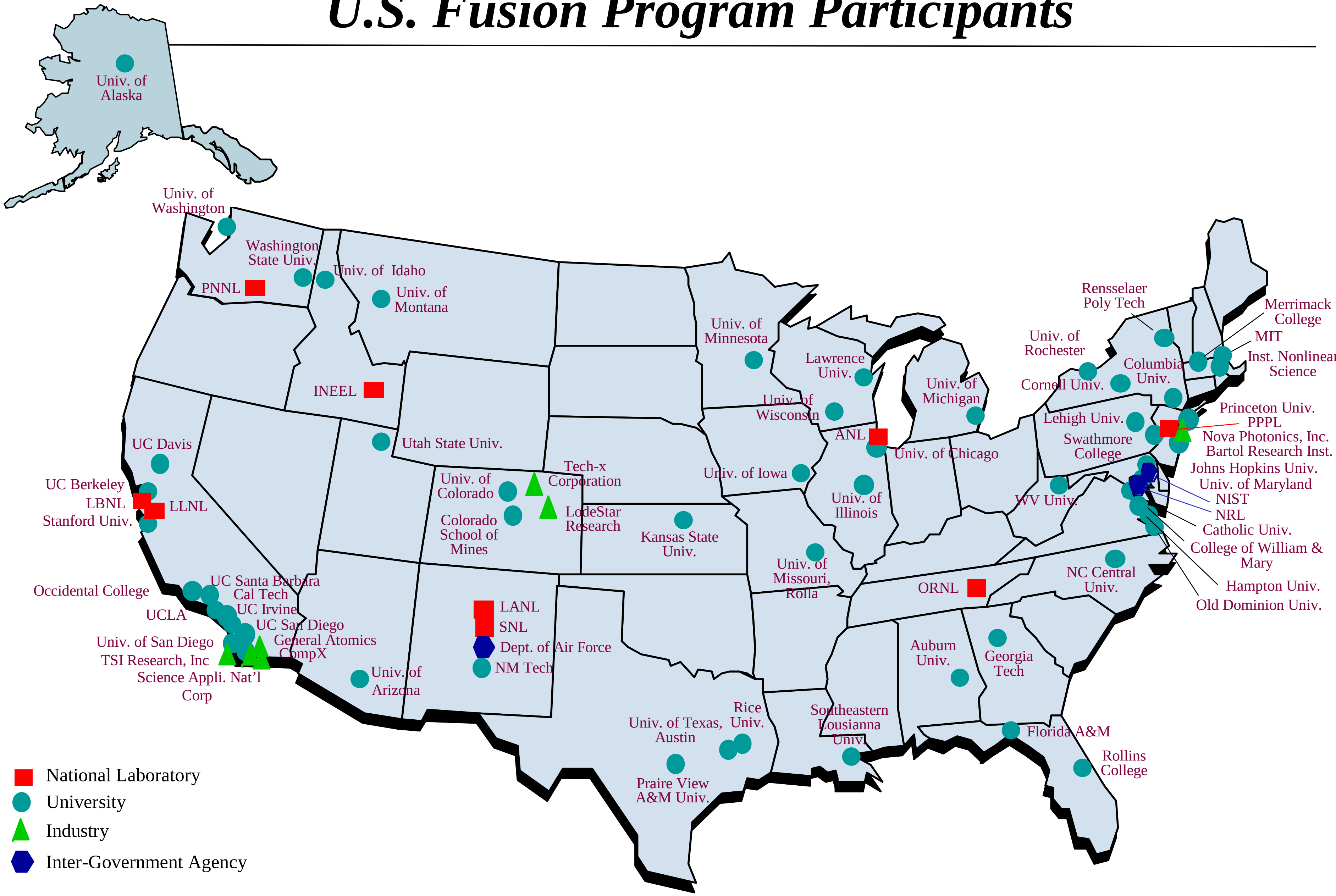


World population growth will be in cities and "megacities," requiring large new power stations.

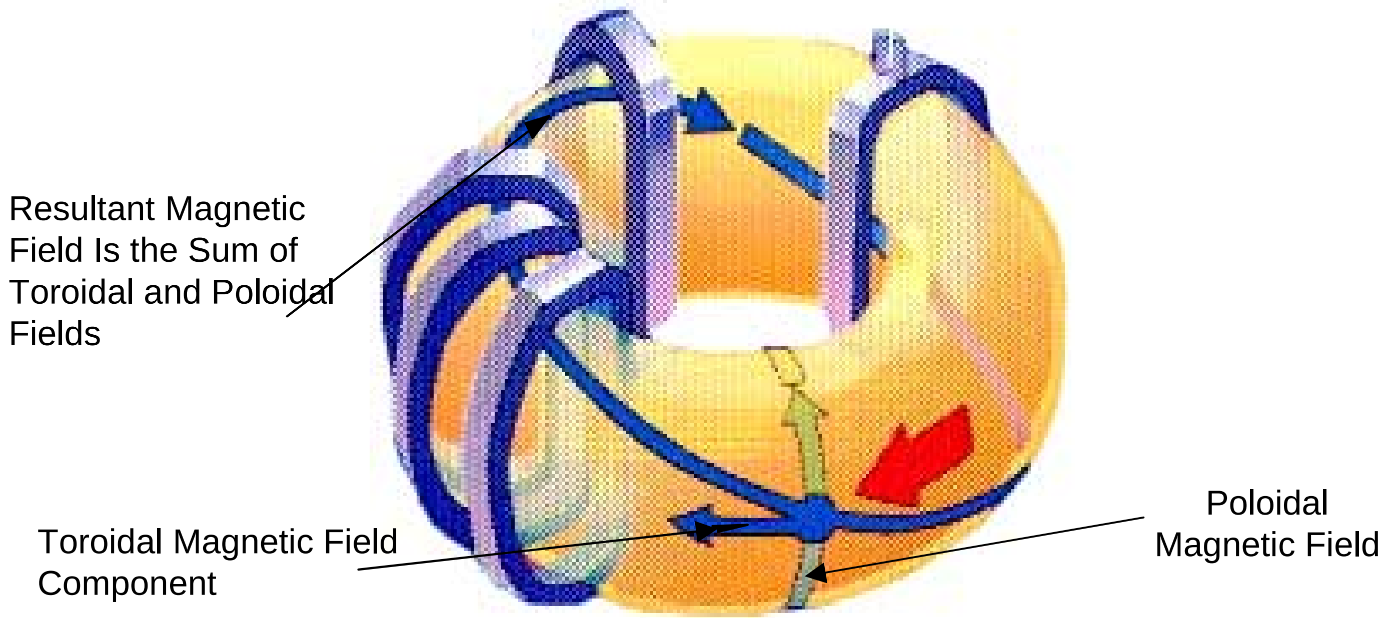
Progress in Fusion Energy has been Dramatic



U.S. Fusion Program Participants



The Tokamak -- The Workhorse of Fusion Science



Science Issues

Configuration Stability

Confinement and Transport

Heating, Fueling, Current Drive

Boundary Physics

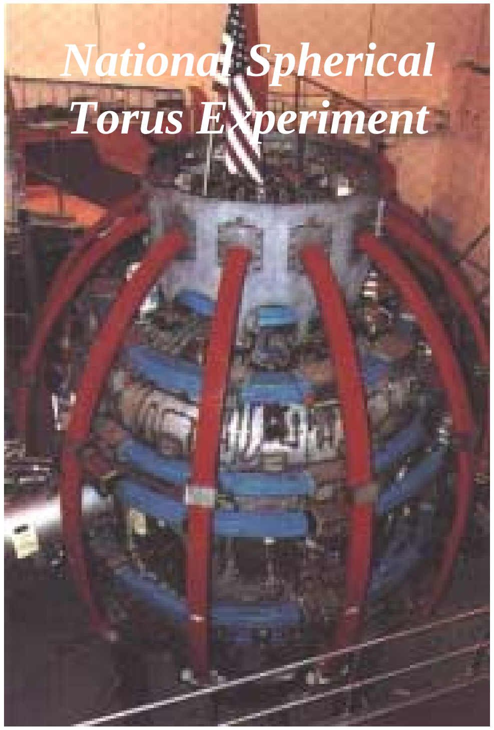
Integration

Burning Plasma Physics

Major U.S. Magnetic Fusion Facilities

General Atomics

Doublet III Started Operations In 1978



Princeton Plasma Physics Laboratory

NSTX started Operations in 1999

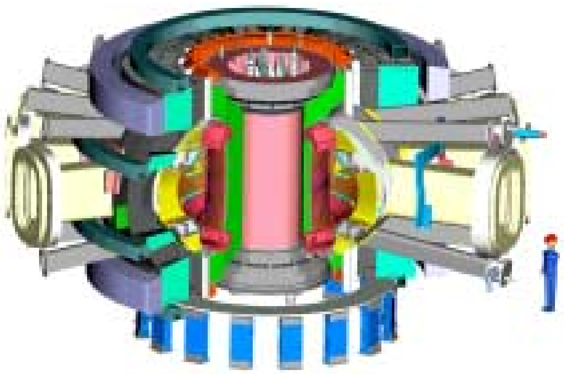
Massachusetts Institute of Technology
C-MOD Started Operations in October 1991

Princeton Plasma Physics Laboratory

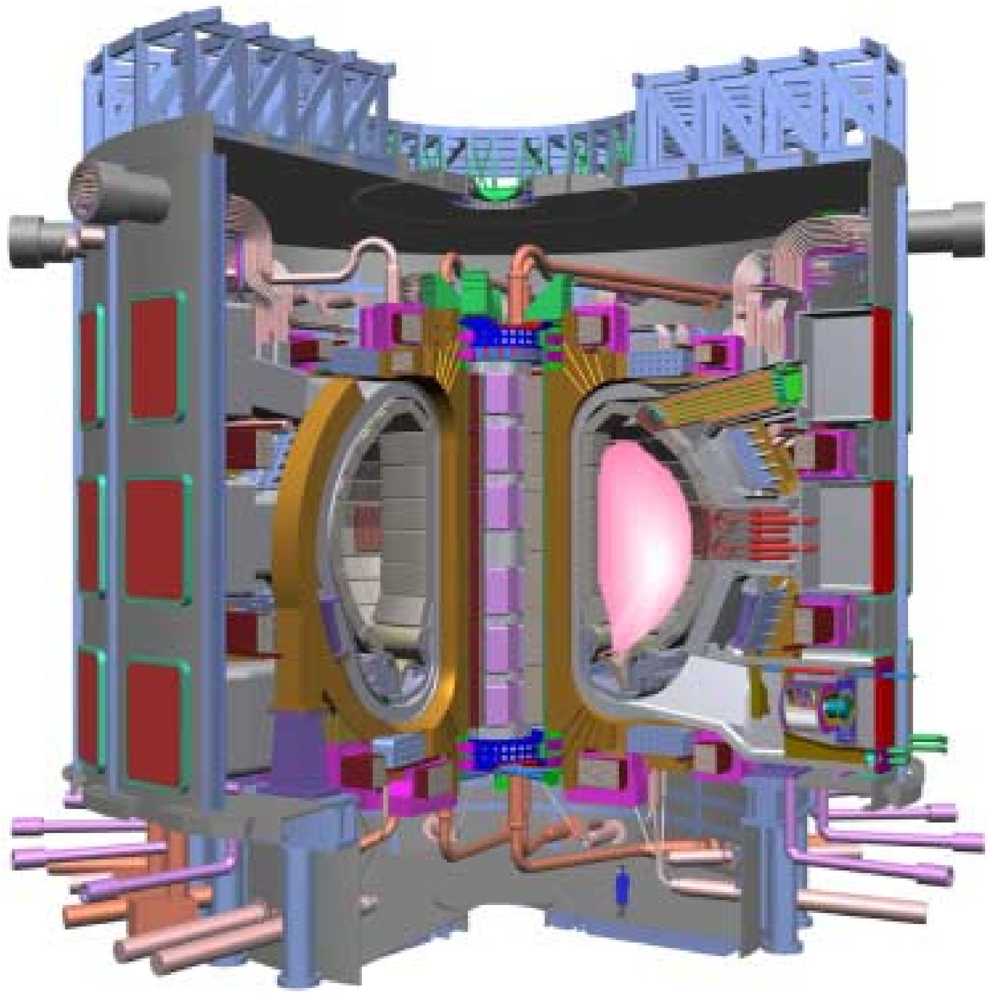
NCSX Fabrication: FY 2003-2007

Burning Plasma Physics
The Next Frontier

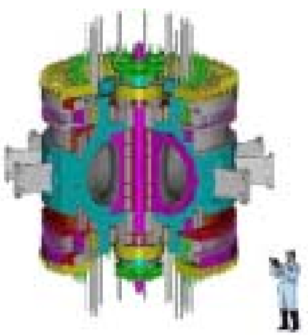
Three Options
(Different Scales)



FIRE



ITER

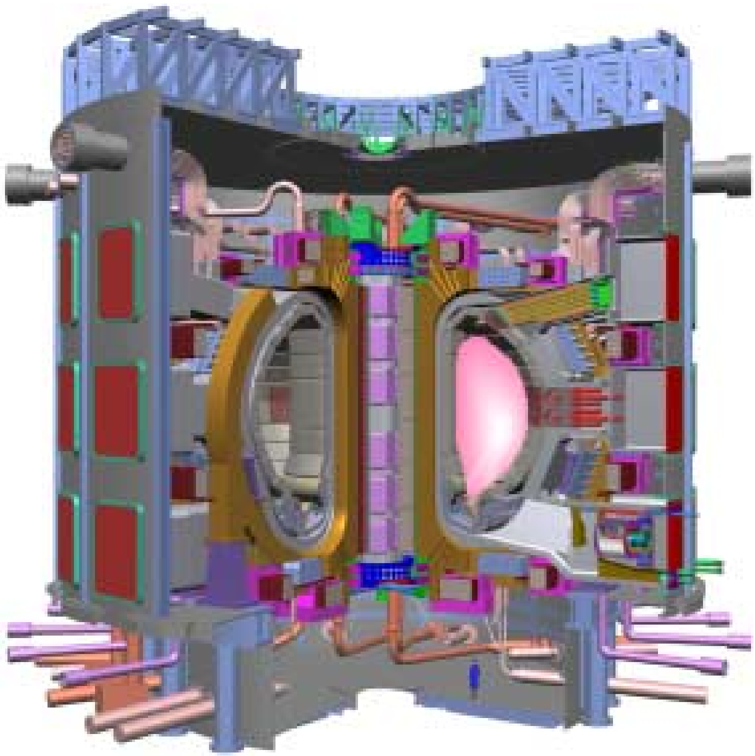


IGNITOR

Upcoming ITER Decision is Crucial for Fusion World-wide

Merging of Fusion Science and Fusion Energy
Burning Plasma Physics & Power Plant Relevant Technologies

- ITER Parties (EU, JA and RF) have completed design for reduced cost (~$5B) and technical objectives (same mission)
  - ITER would be first burning plasma physics device
- ITER Parties (now EU, JA, RF and Canada) want the U.S. to join negotiations

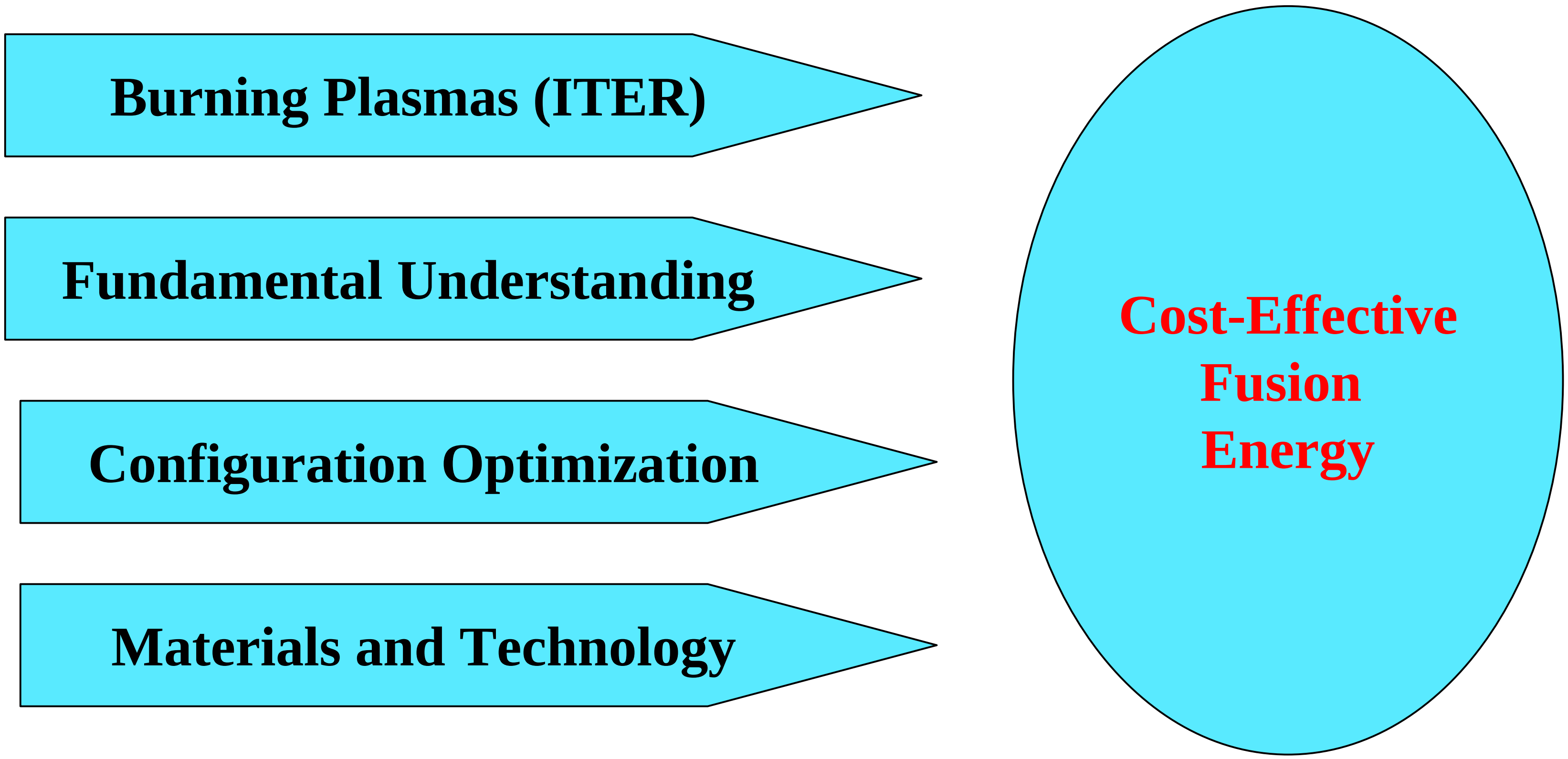


Fusion Power: 500MW
Burn Pulse: 400-3600 sec

Why the U.S. Left ITER

- "ITER won't work" --"Science" article, 12/96
  - Physics of Plasmas paper, 3/00 -- extensive analysis showed critical 12/96 article was wrong
- "ITER costs too much" -- $10B
  - Now $5B after revision to reduce costs through reduction in detailed technical objectives, thereby--reduced size, mass, power and cost.
- "Partners will never agree to move forward" -- EDA extension
  - Negotiations underway
  - Multiple sites offered

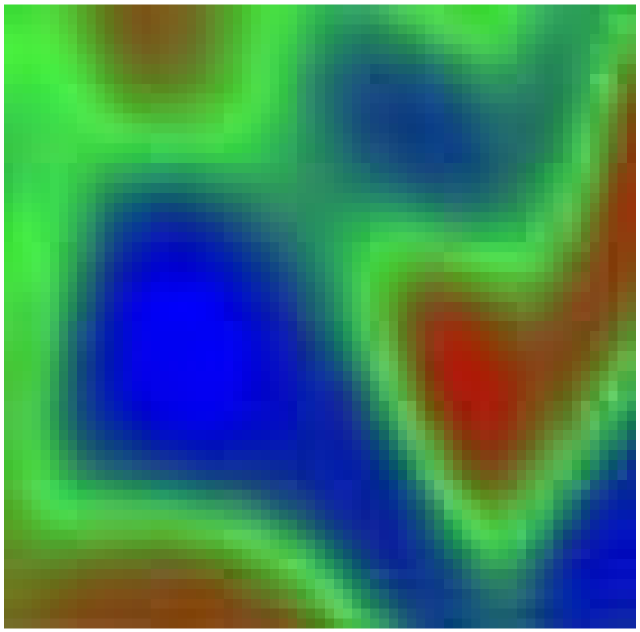
Four Thrust Areas are Required for Practical Magnetic Fusion Energy



Areas defined by the
Fusion Energy Sciences Advisory Committee.

Scientific Understanding of Fusion Plasmas has Increased Dramatically

Advanced Computing



Simulation of turbulence in magnetic fusion plasma.

Plasma Measurements

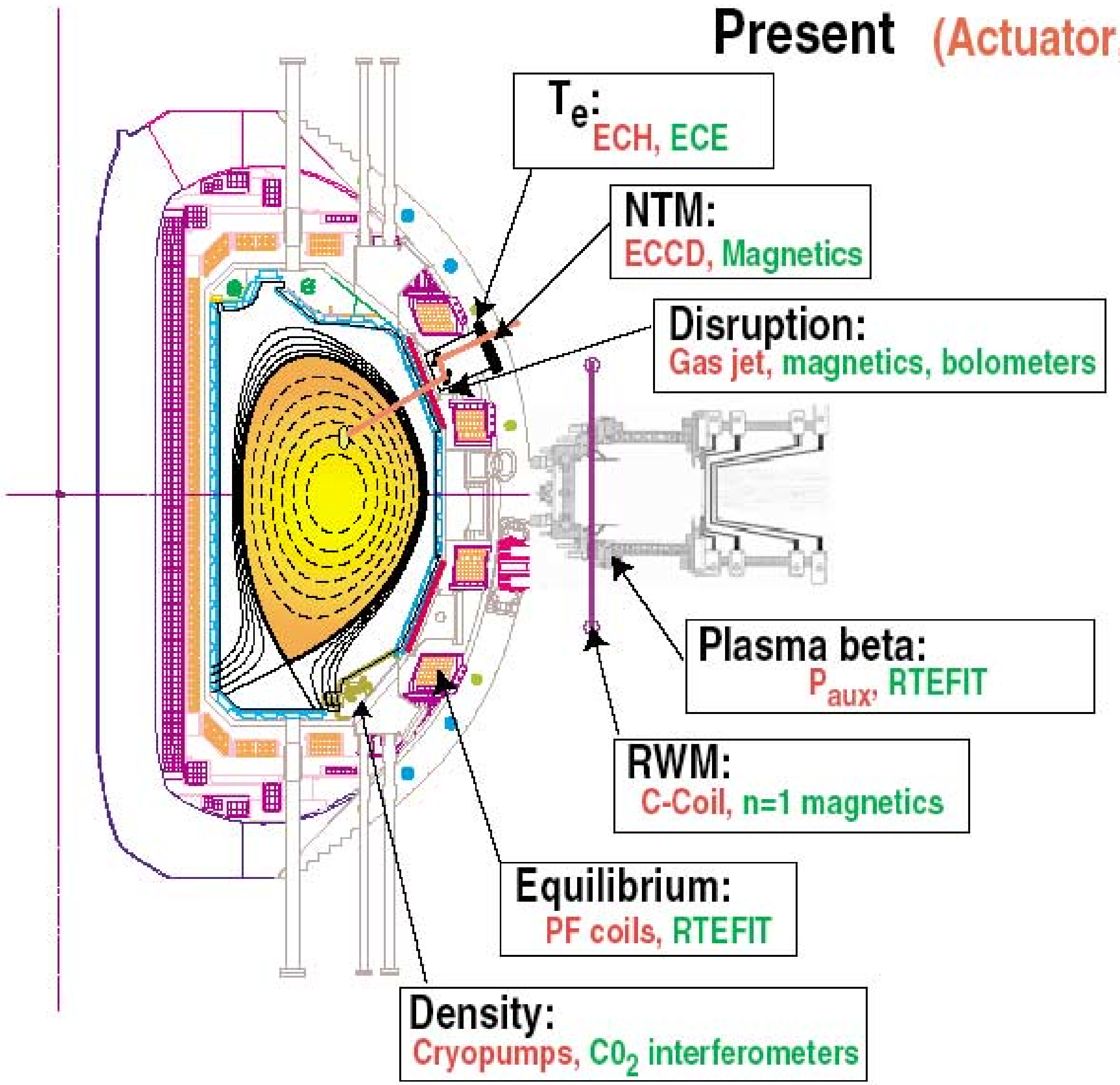
QuickTime™ and a
decompressor
are needed to see this picture.

Fast imaging of plasma turbulence.

Goal: **Practical fusion energy through high-quality science.**

A New Era in Plasma Control: Key to the DIII-D at Program

Present (Actuator, Sensor) **Planned**



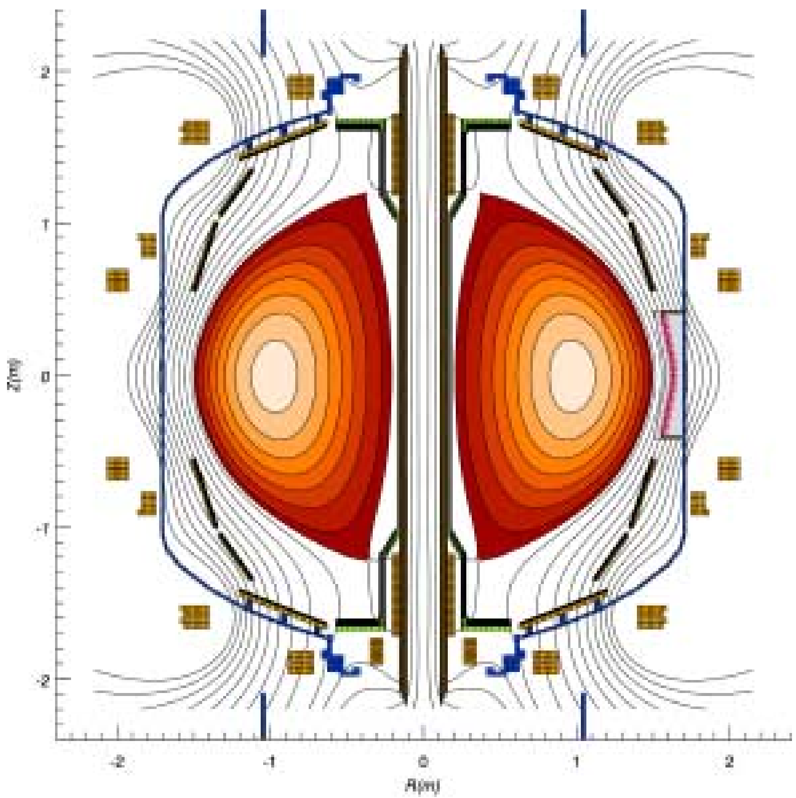
Integrated control:
Validated models
Expanded PCS

Current profile control:
ECCD/FWCD, MSE

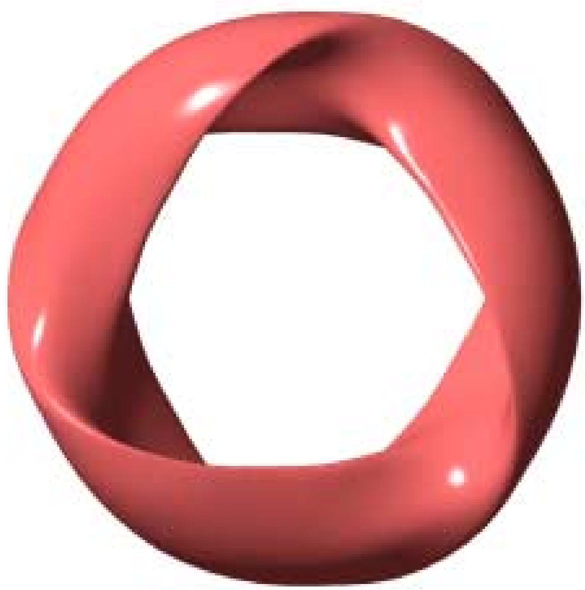
Optimized RWM control:
I-Coil
Expanded magnetics

Disruption detection, correction, mitigation:
MHD regulation — PCS
Expanded magnetics

Variations of the Toroidal Plasma Configuration Address Key Fusion Issues



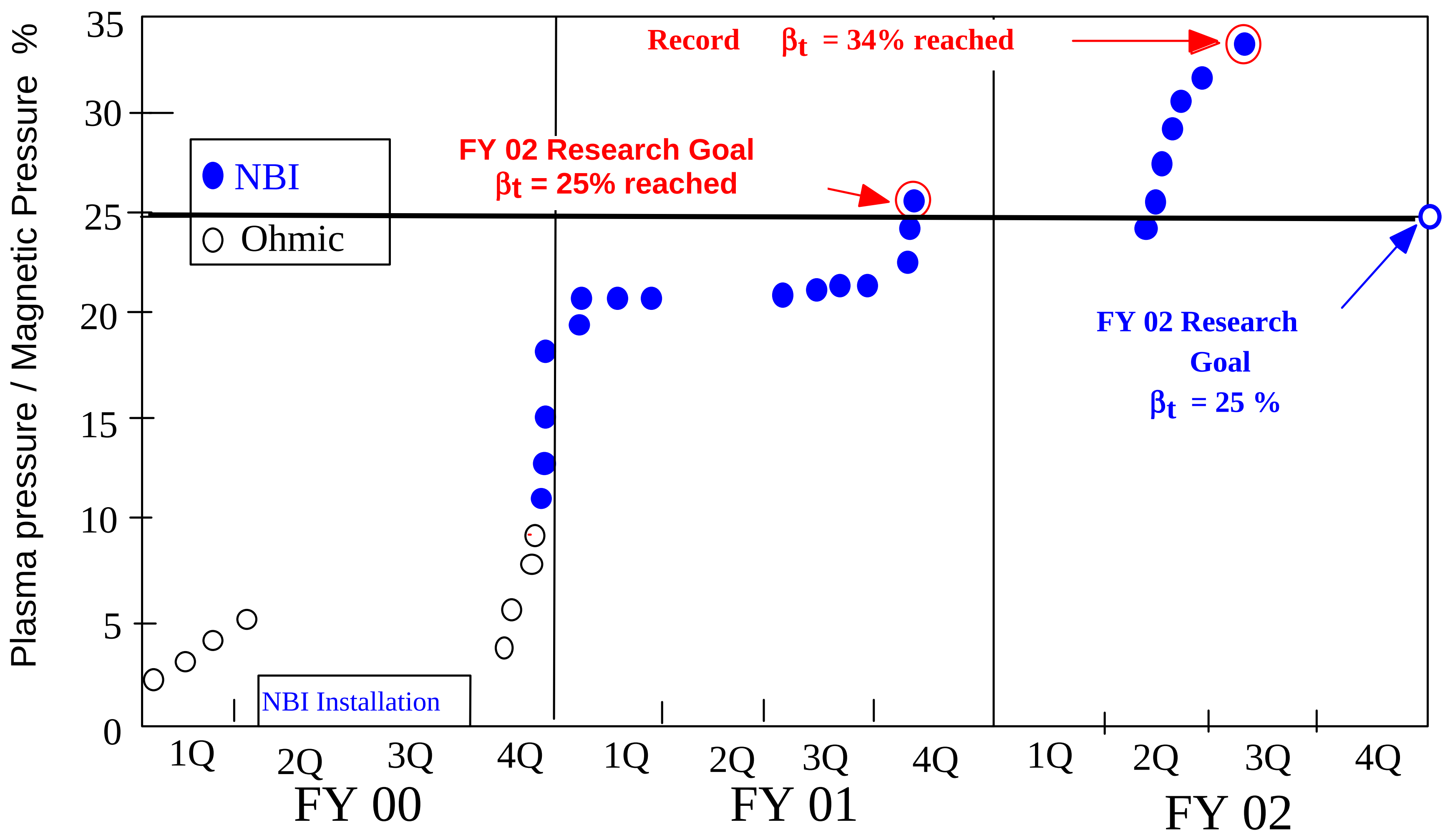
Spherical Torus offers high fusion power density at low magnetic field.



Compact Stellarator design optimizes plasma stability and steady-state properties.

Goal: Combine with ITER results for better fusion energy.

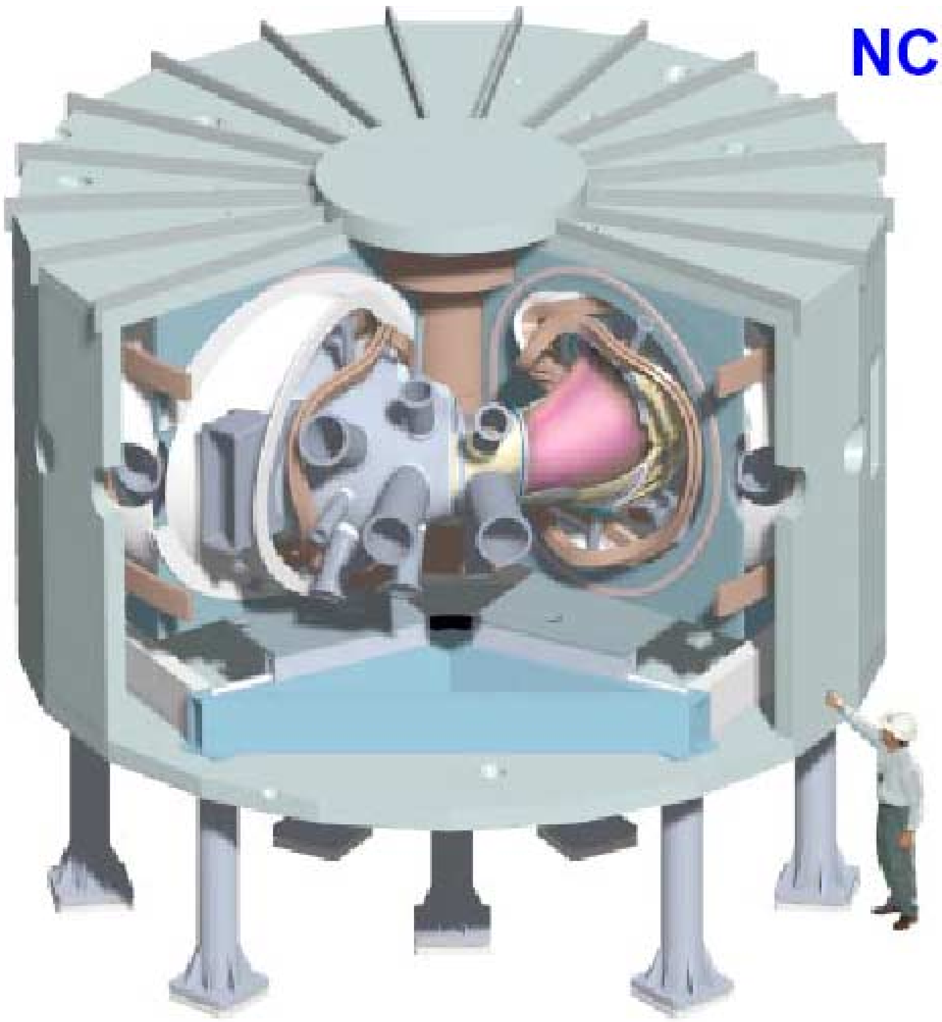
NSTX is Delivering Above Expectations and Ahead of Schedule



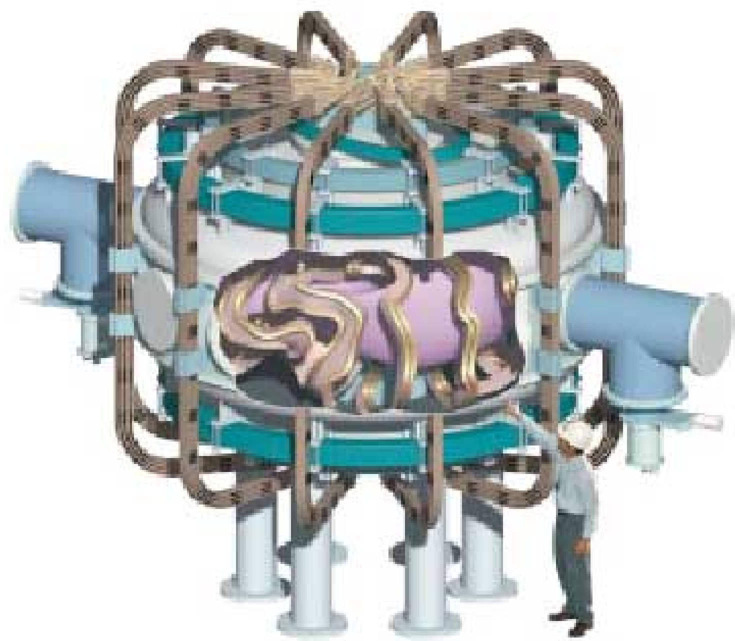
The U.S. is Planning Two Compact Stellarator

Different configuration and design approaches are used

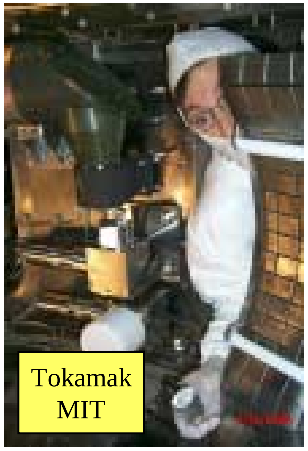
NCSX

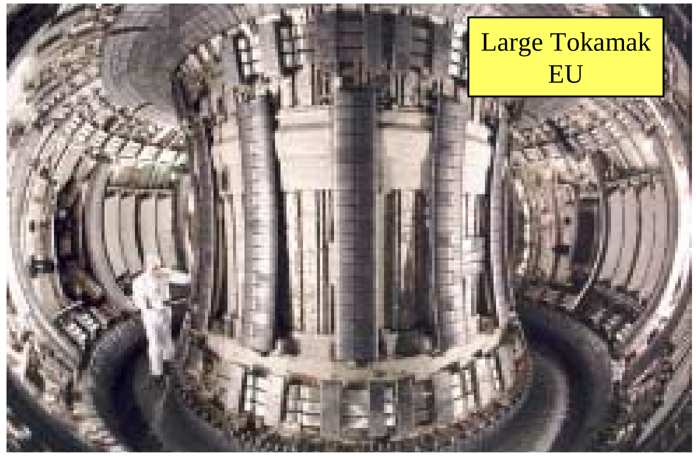


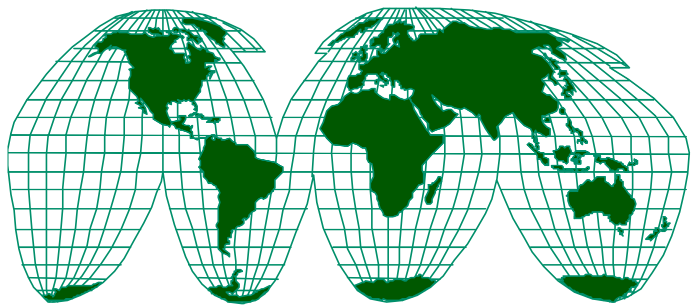
Q PS

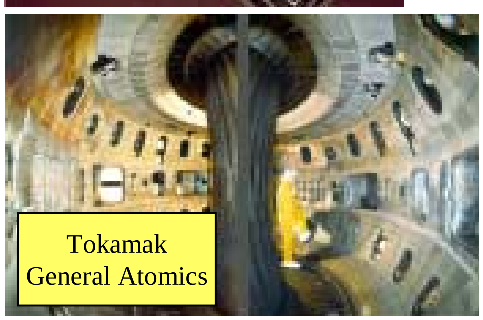


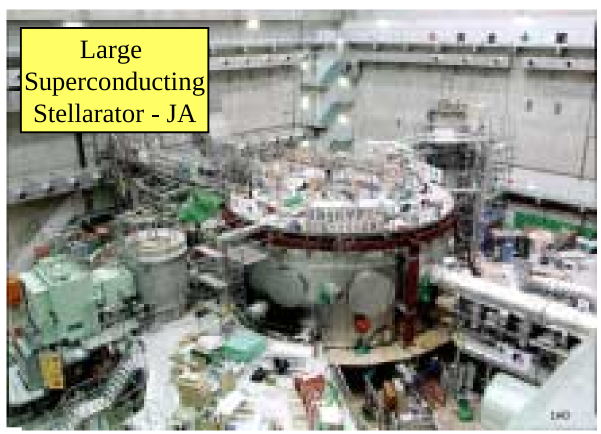
High Performance Facilities Support ITER and Look Beyond to Fusion Energy



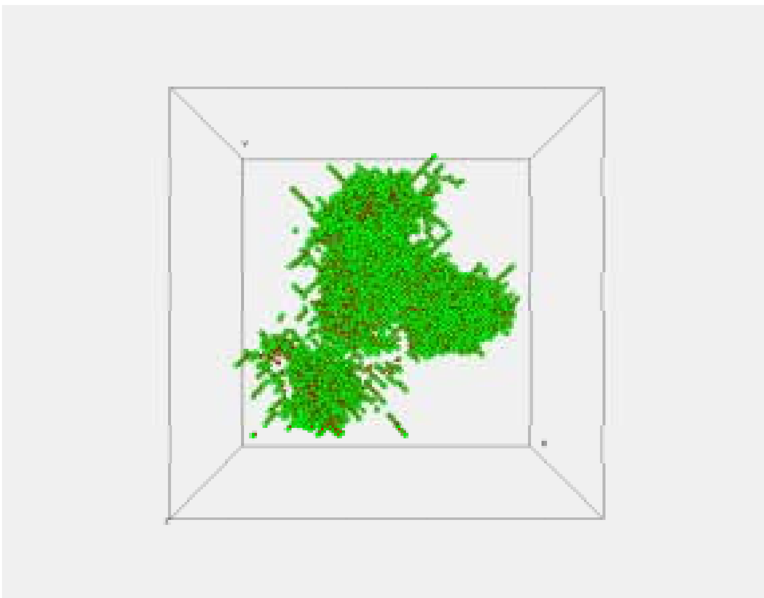




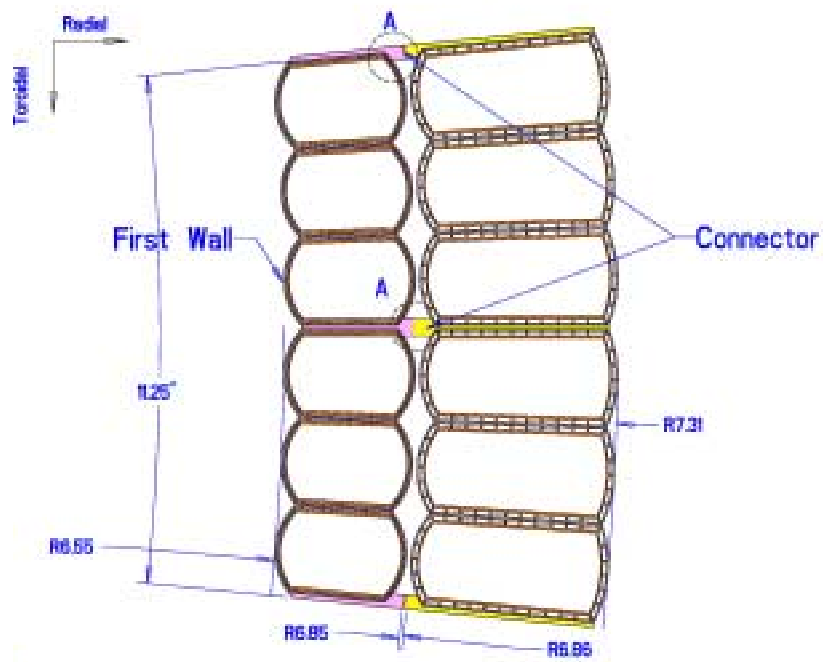




Nanoscience and New Designs are Advancing Fusion Materials and Technologies



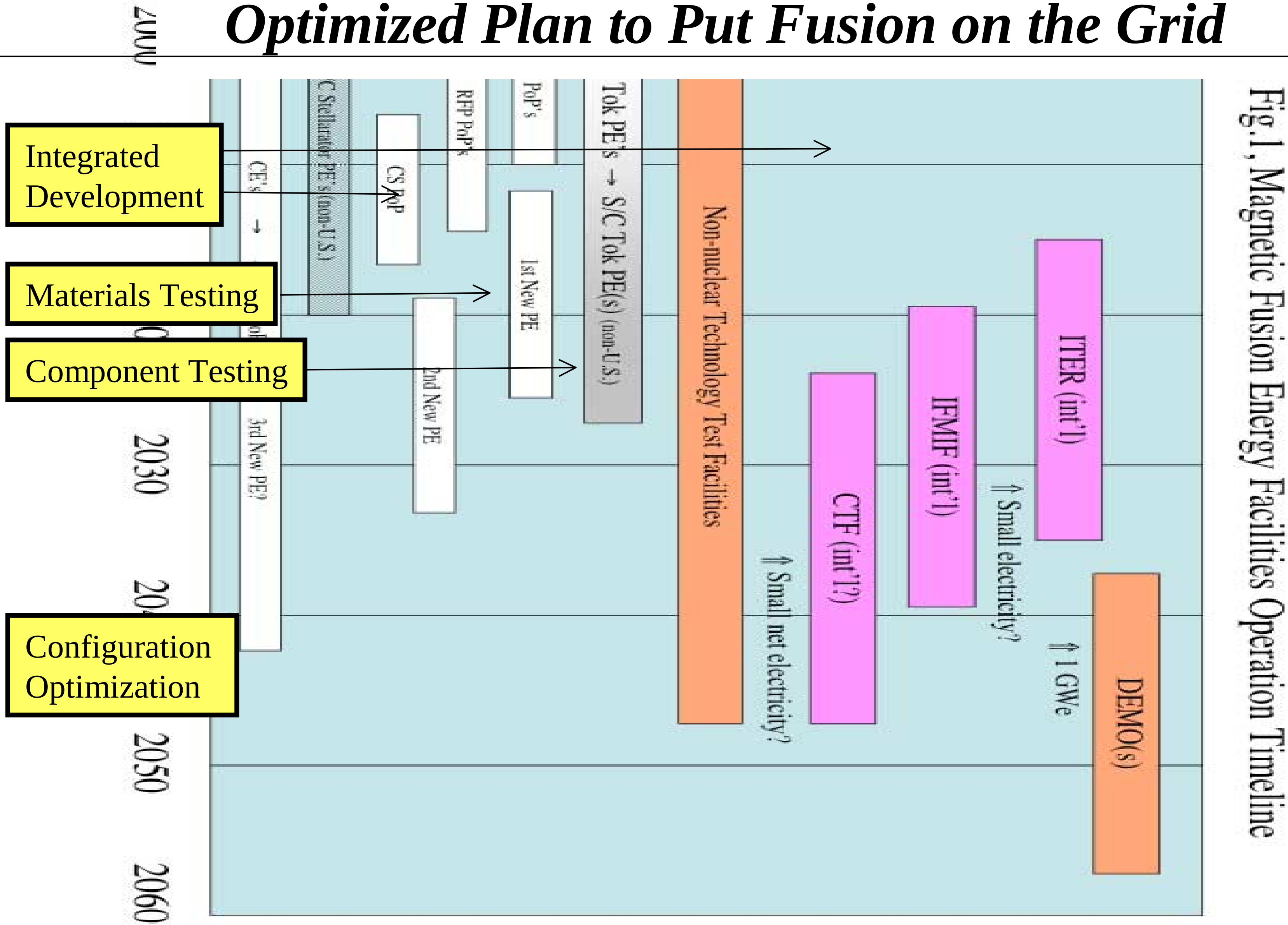
Molecular Dynamics calculation of atomic displacements due to neutron impact.



Simplified blanket designs allow high electrical efficiency and low radioactivity.

Goal: Convert fusion power to electricity with high efficiency and minimum radioactivity.

U.S. MFE Program Leaders have Developed an Optimized Plan to Put Fusion on the Grid

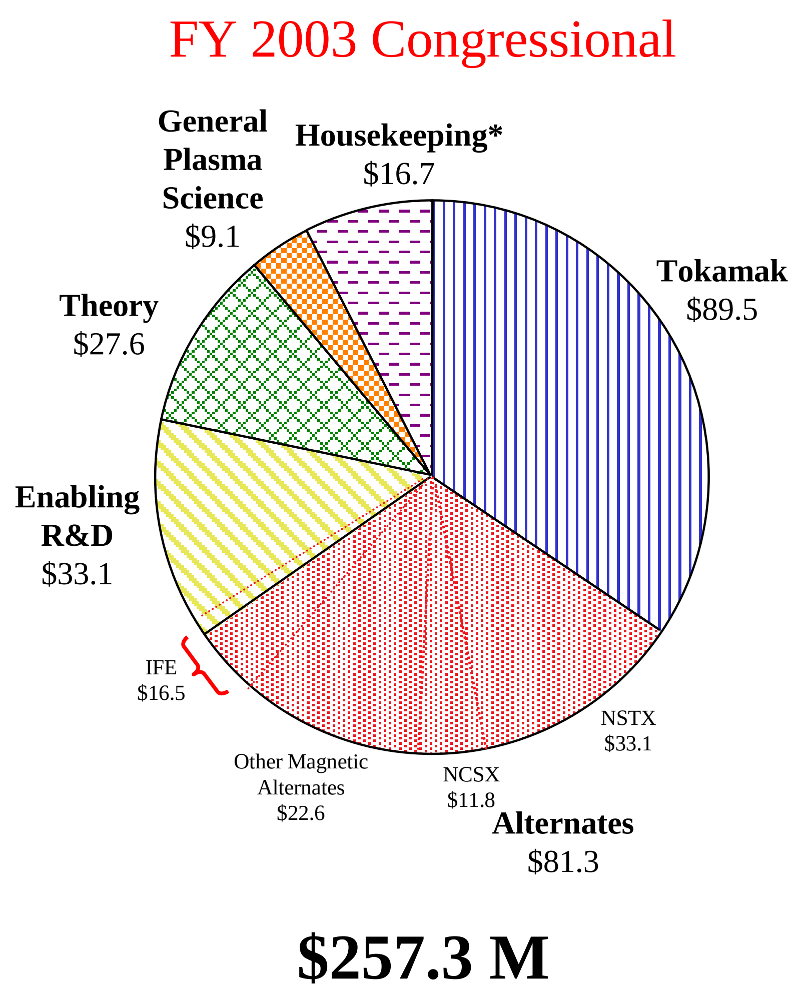


Being reviewed by FESAC

Burning Plasma Decision Process

September 2001	FESAC Report on Burning Plasma Physics
July 2002	Fusion Community Workshop to assess options for a Burning Plasma Experiment
September 2002	FESAC Recommendations for a Burning Plasma Program Strategy
December 2002	NRC Letter Report on Strategy

Fusion Energy Sciences Budget



* Housekeeping includes SBIR/STTR, GPE/GPP, TSTA cleanup, D-Site caretaking at PPPL, HBCU, Education, Outreach, ORNL Move, and Reserves