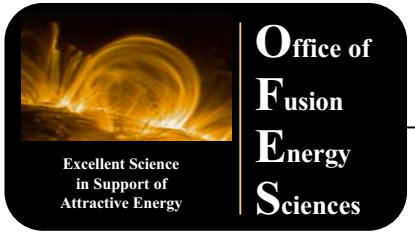


U.S. Fusion Energy Sciences Program

Presented at the

Fusion Power Associates Annual Meeting

By

Dr. Anne Davies

Associate Director
for Fusion Energy Sciences
Office of Science
Department of Energy

December 3, 2002

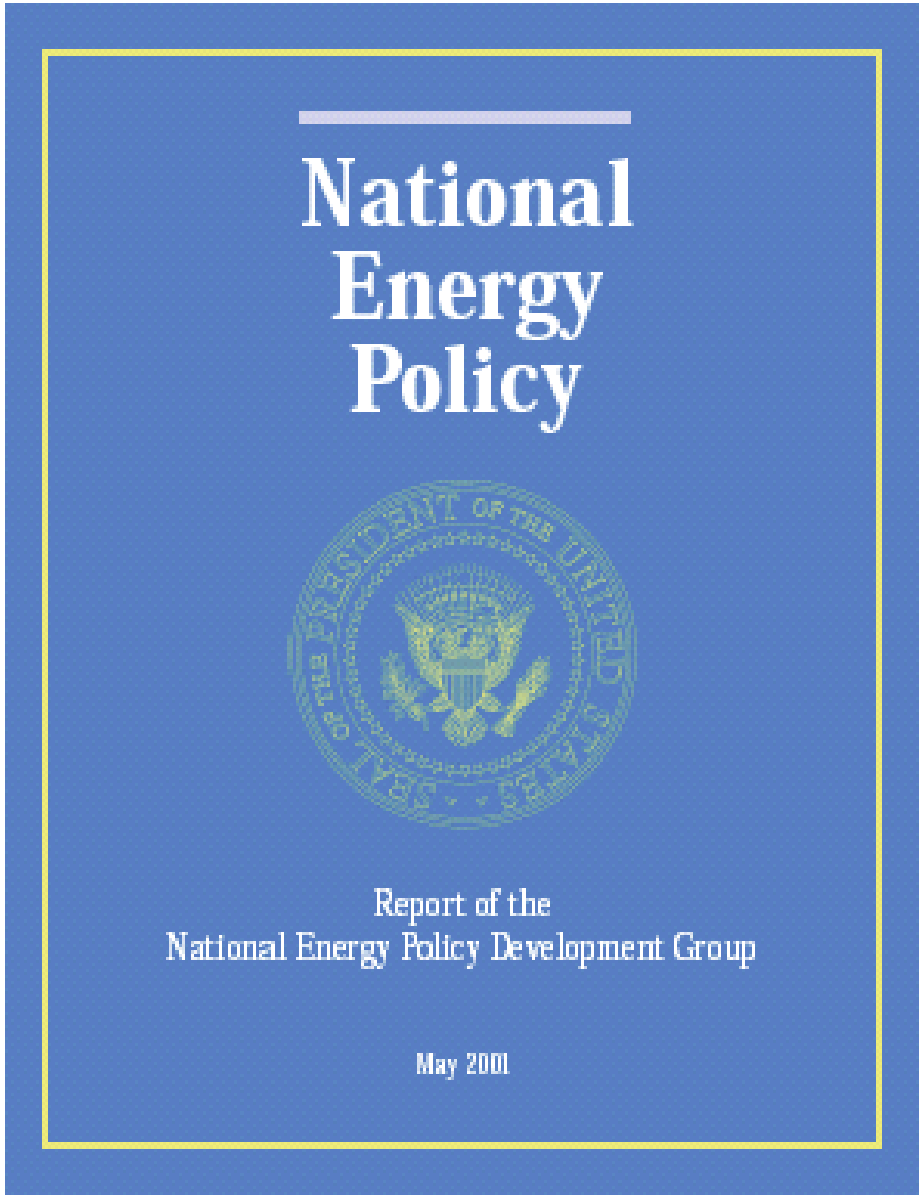
www.ofes.fusion.doe.gov

Excellent Science in Support of Attractive Energy

U.S. Fusion Energy Sciences Program Mission

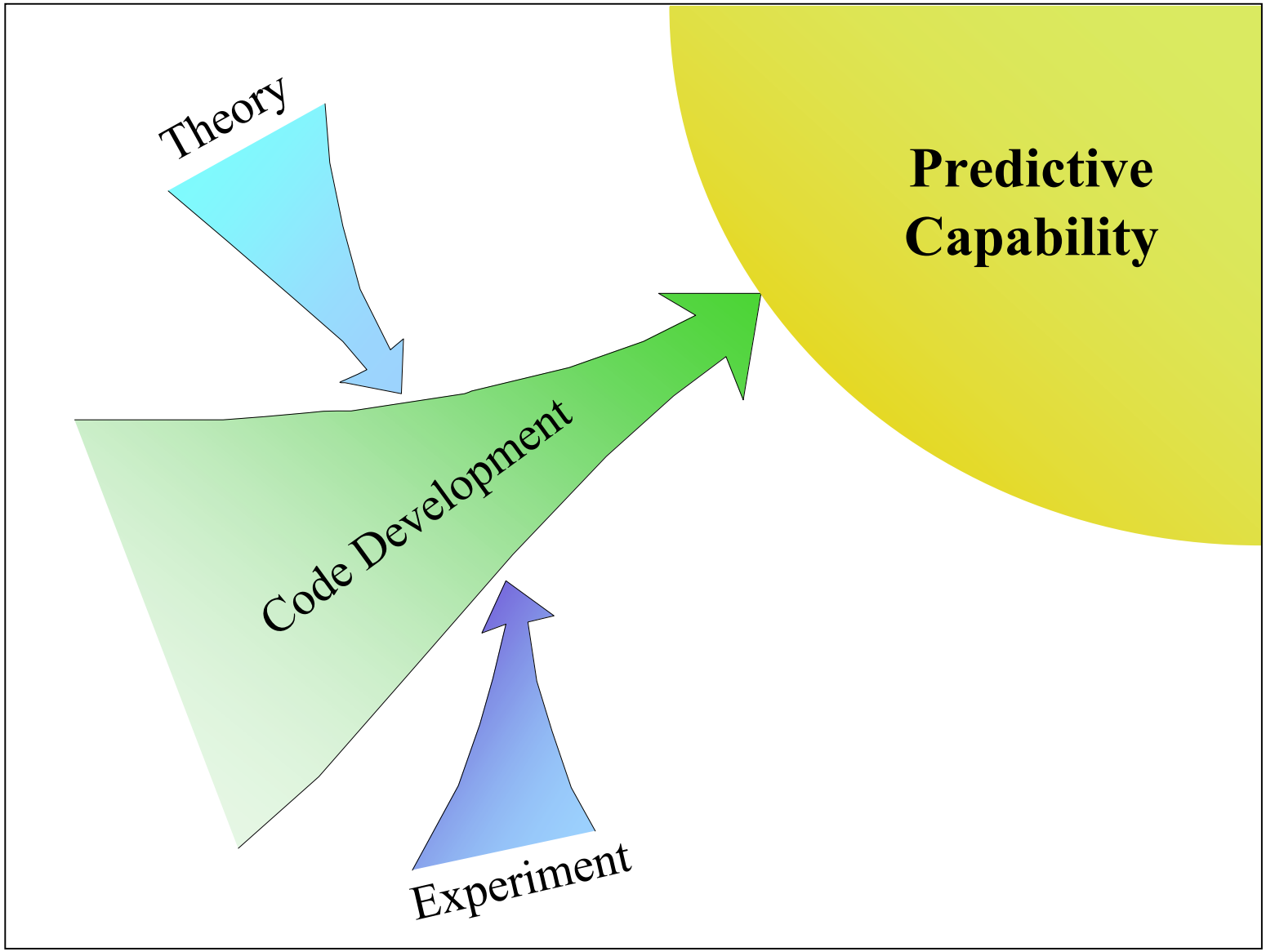
"Advance plasma science, fusion science, and fusion technology-- the knowledge base needed for an economically and environmentally attractive fusion energy source."

National Energy Policy

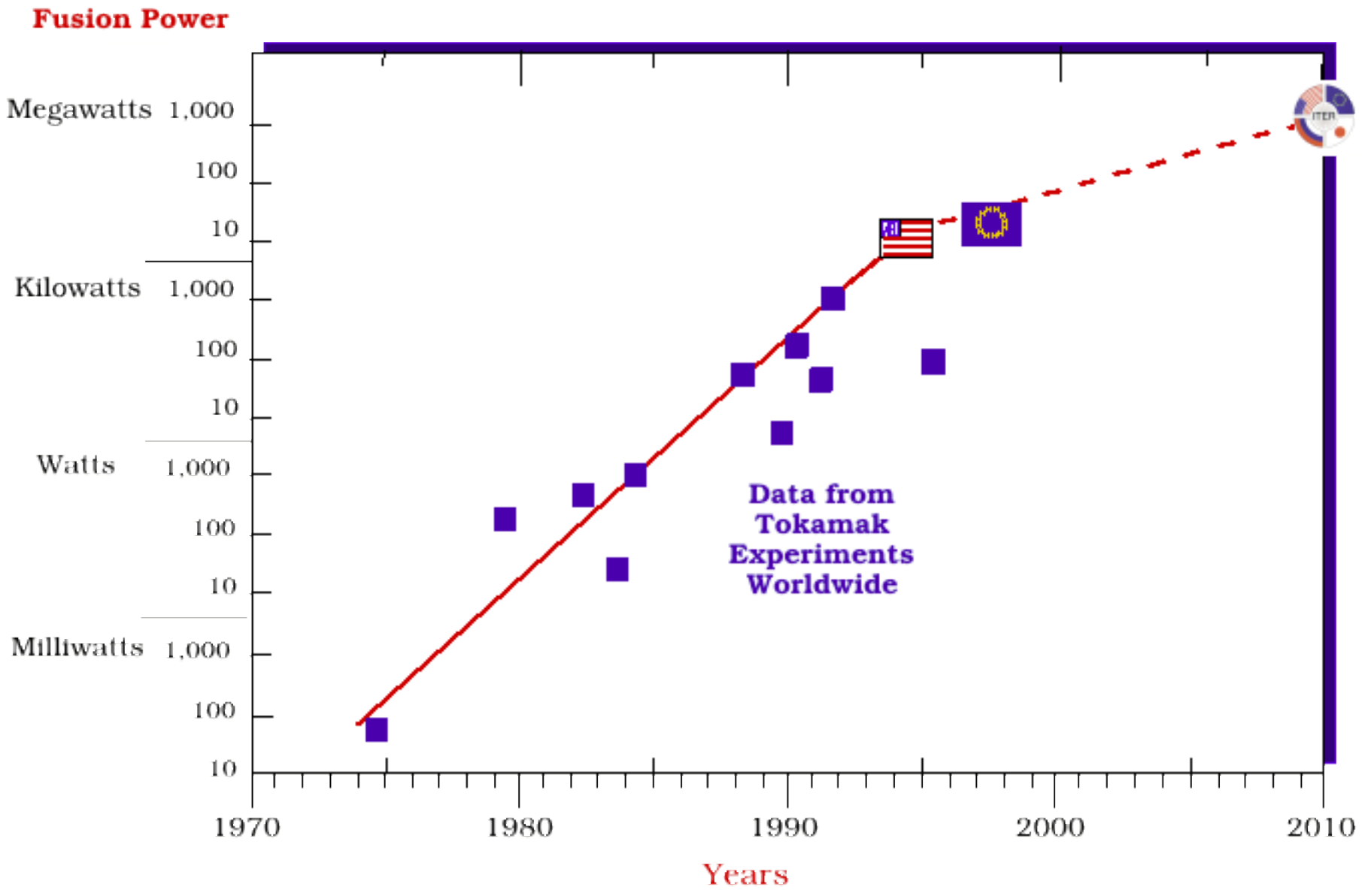


"The NEPD Group recommends that the President direct the Secretary of Energy to develop next-generation technology--including hydrogen and **fusion**."

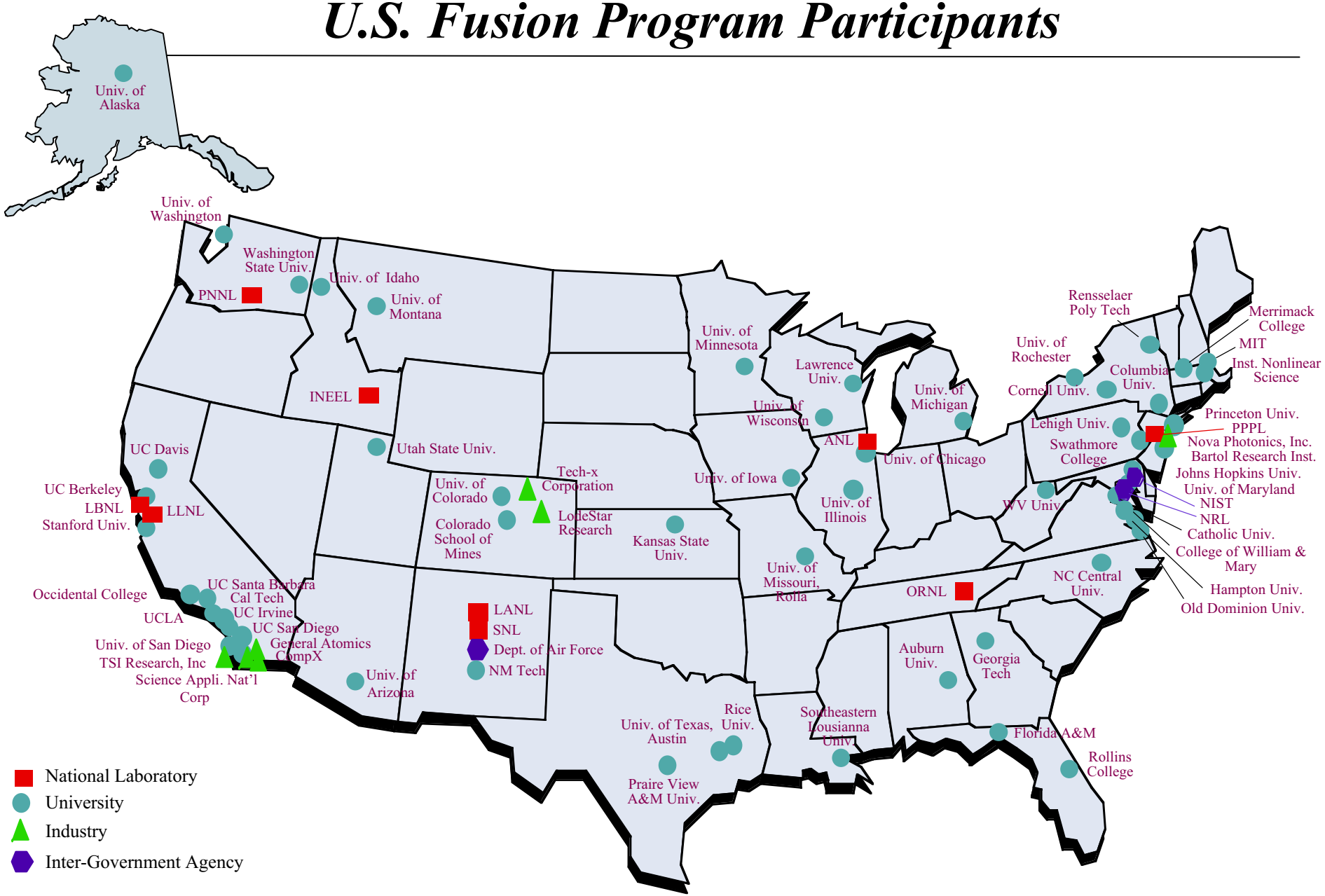
Objective of the U.S. Fusion Energy Sciences Program



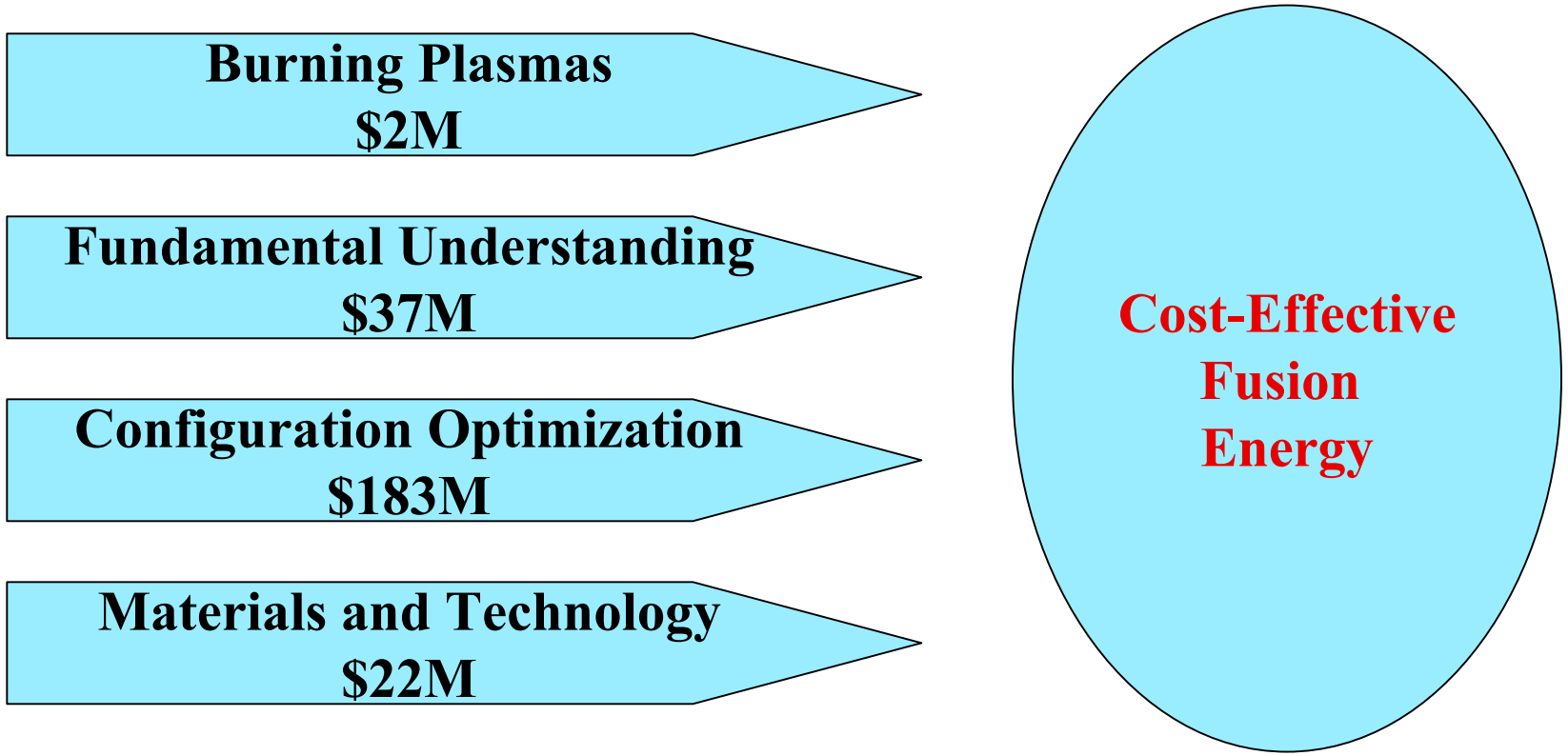
Progress in Magnetic Fusion Research



U.S. Fusion Program Participants



Four Thrust Areas are Required for Practical Magnetic Fusion Energy

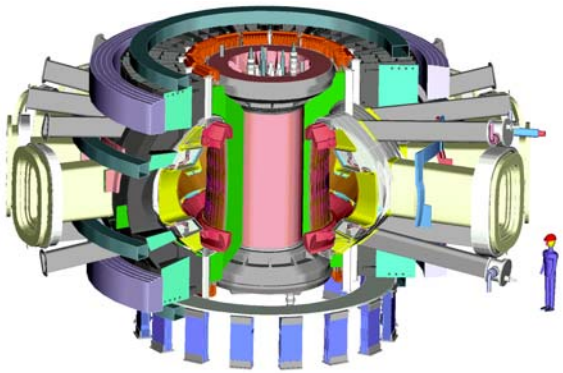


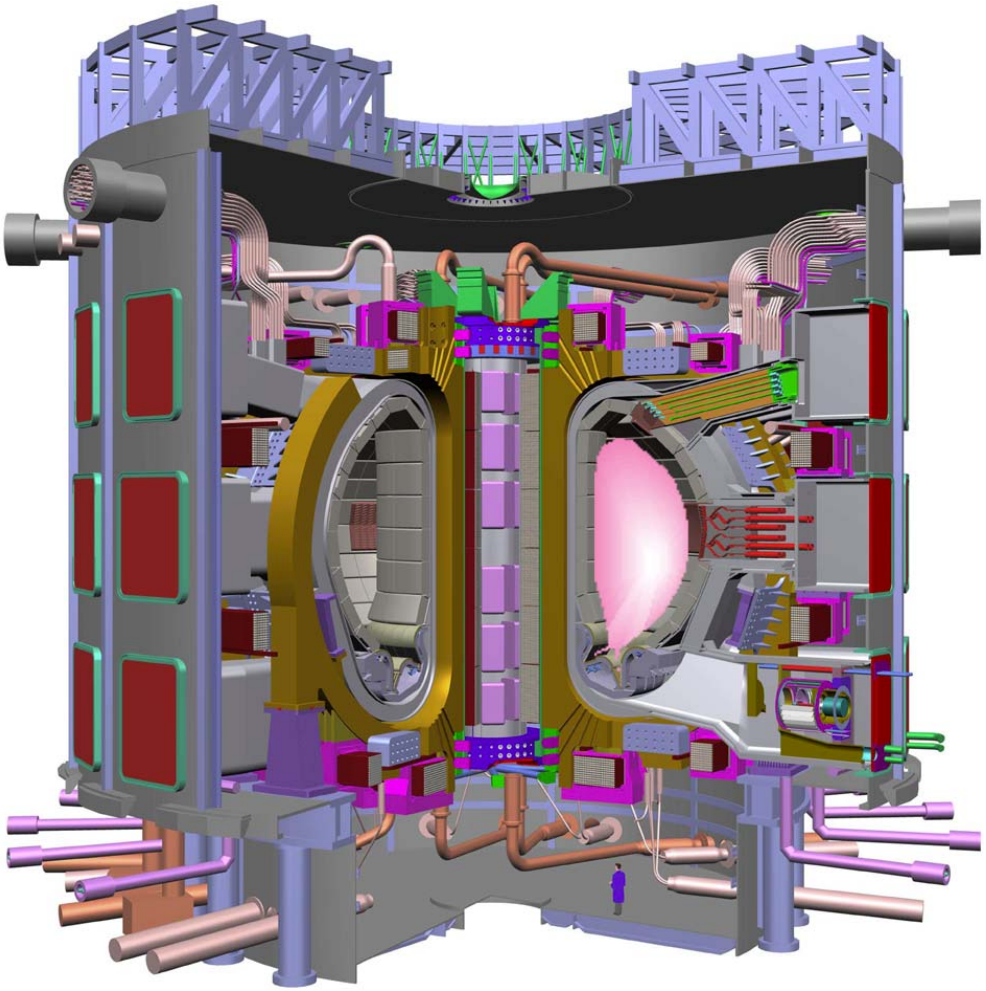
Areas defined by the Fusion Energy Sciences Advisory Committee.

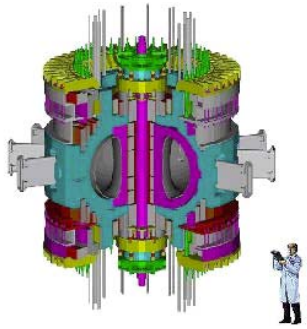
$ are FY 2003 President's Request

Burning Plasma Physics
The Next Frontier

Three Options
(Different Scales)







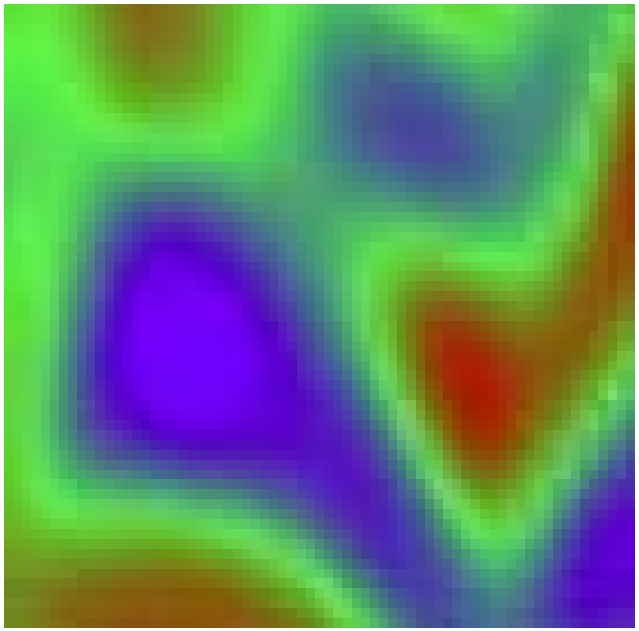
FIRE

ITER

IGNITOR

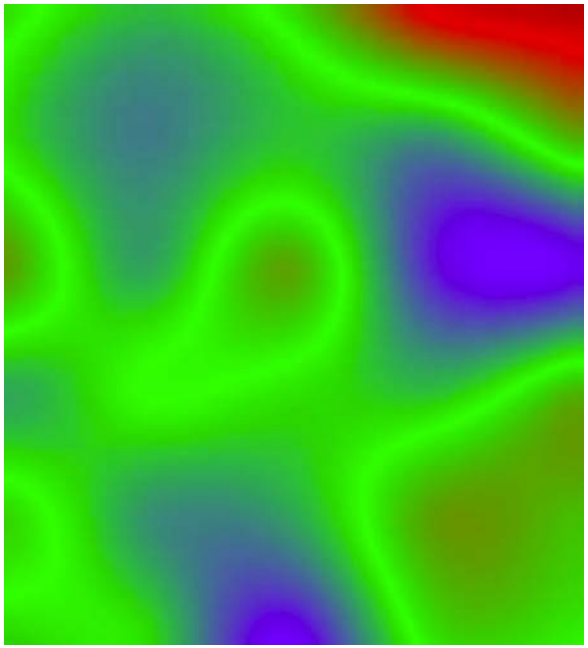
Scientific Understanding of Fusion Plasmas has Increased Dramatically

Advanced Computing



Simulation of turbulence in magnetic fusion plasma.

Plasma Measurements



Fast imaging of plasma turbulence.

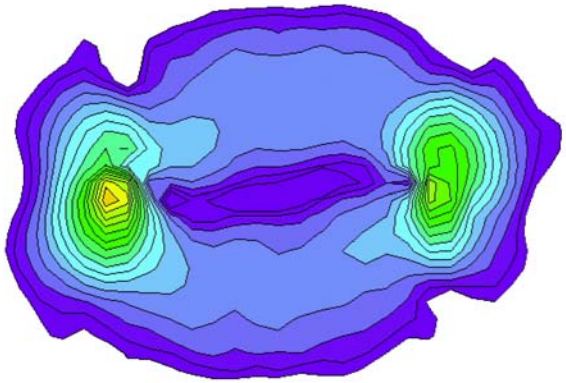
Goal: Practical fusion energy through high-quality science.

Scientific Discovery Thru Advanced Computing

Three Principal Projects

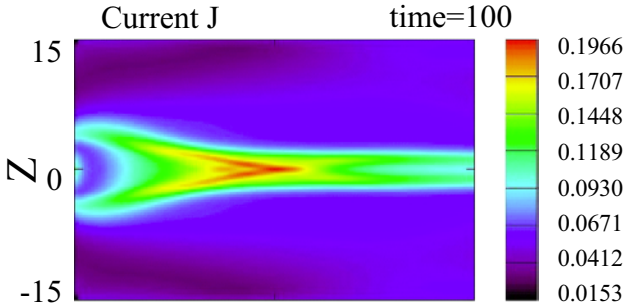
Terascale Atomic Physics

Auburn, Rollins, ORNL



Magnetic Reconnection Code

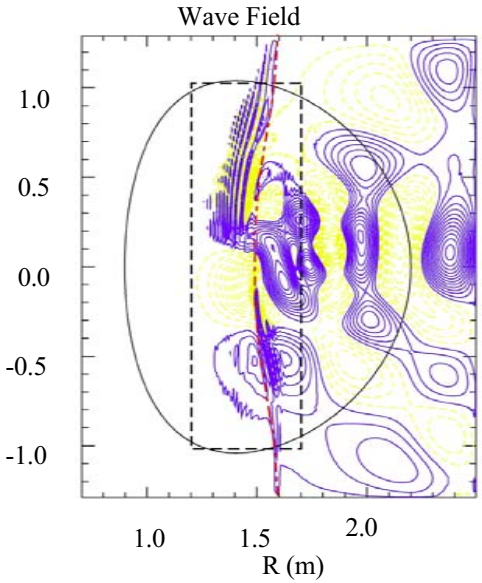
U. Iowa, U. Chicago, U. Texas



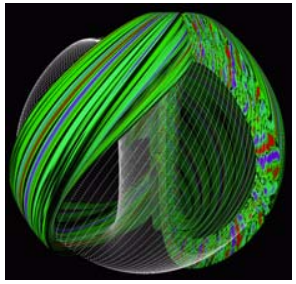
Substorm in the Magnetotail

Computation of Wave Plasma Interactions

ORNL, PPPL, MIT, Lodestar, CompX

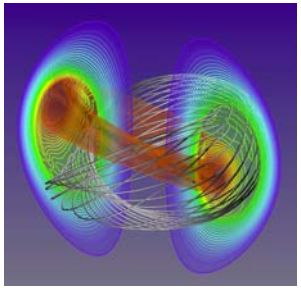


Two Pilot Projects



Plasma Microturbulence

LLNL, GA, PPPL, U. Maryland, U. Texas, U. Colorado, UCLA



Extended MHD Modeling

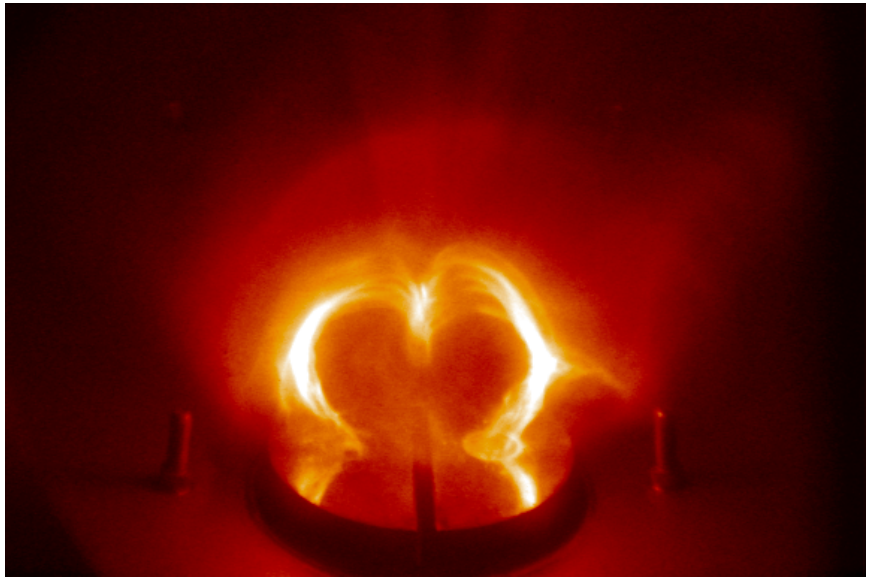
PPPL, SAIC, U. Wisconsin, NYU, U. Colorado, MIT, Utah State U., GA, LANL, U. Texas

General Plasma Science

Since its inception, there have been 15 Plasma Physics Junior Faculty Development Program Awards (+1 in cooperation with NSF)

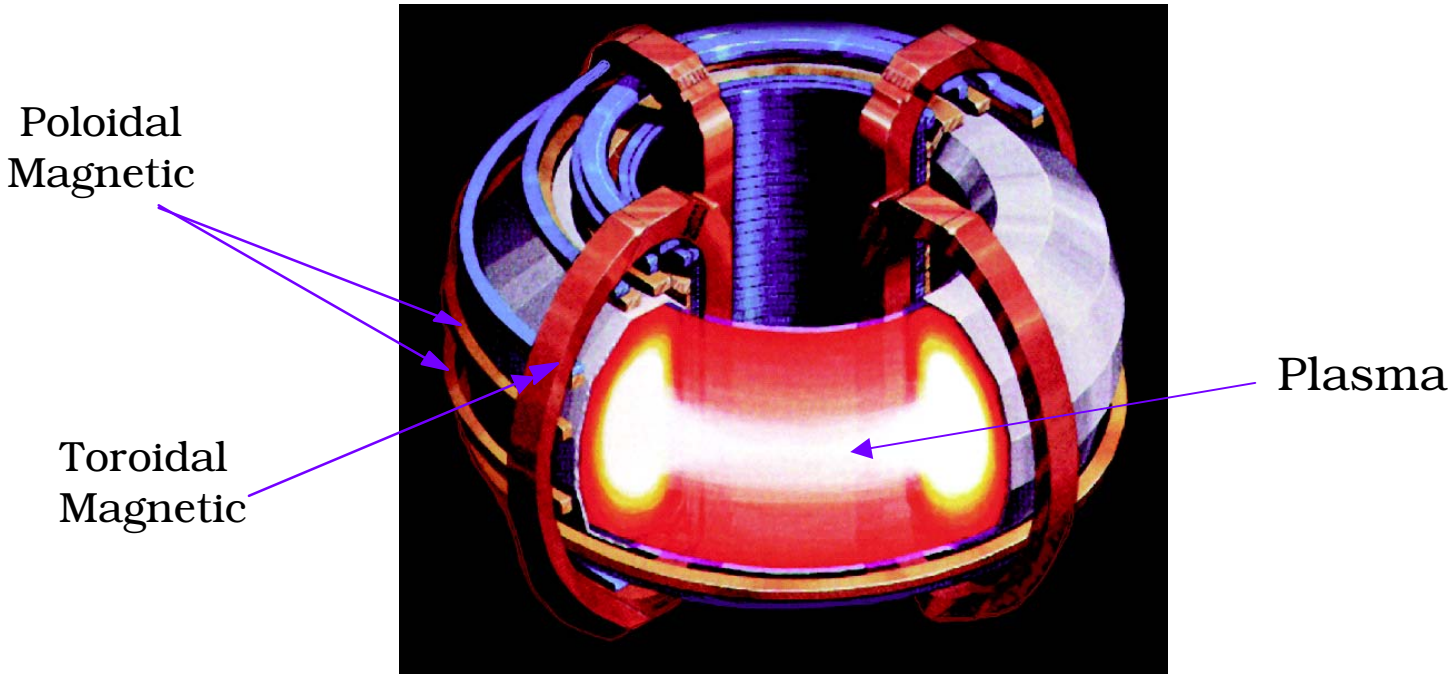
Dense Z Pinch
University of Nevada-Reno

There are presently 34 NSF/DOE grants under the partnerships in Basic Plasma Science and Engineering Awards



Laboratory Simulation of Solar Prominences
California Institute of Technology

The Tokamak -- The Workhorse of Fusion Science



Science Issues

Configuration Stability

Confinement and Transport

Heating, Fueling, Current Drive

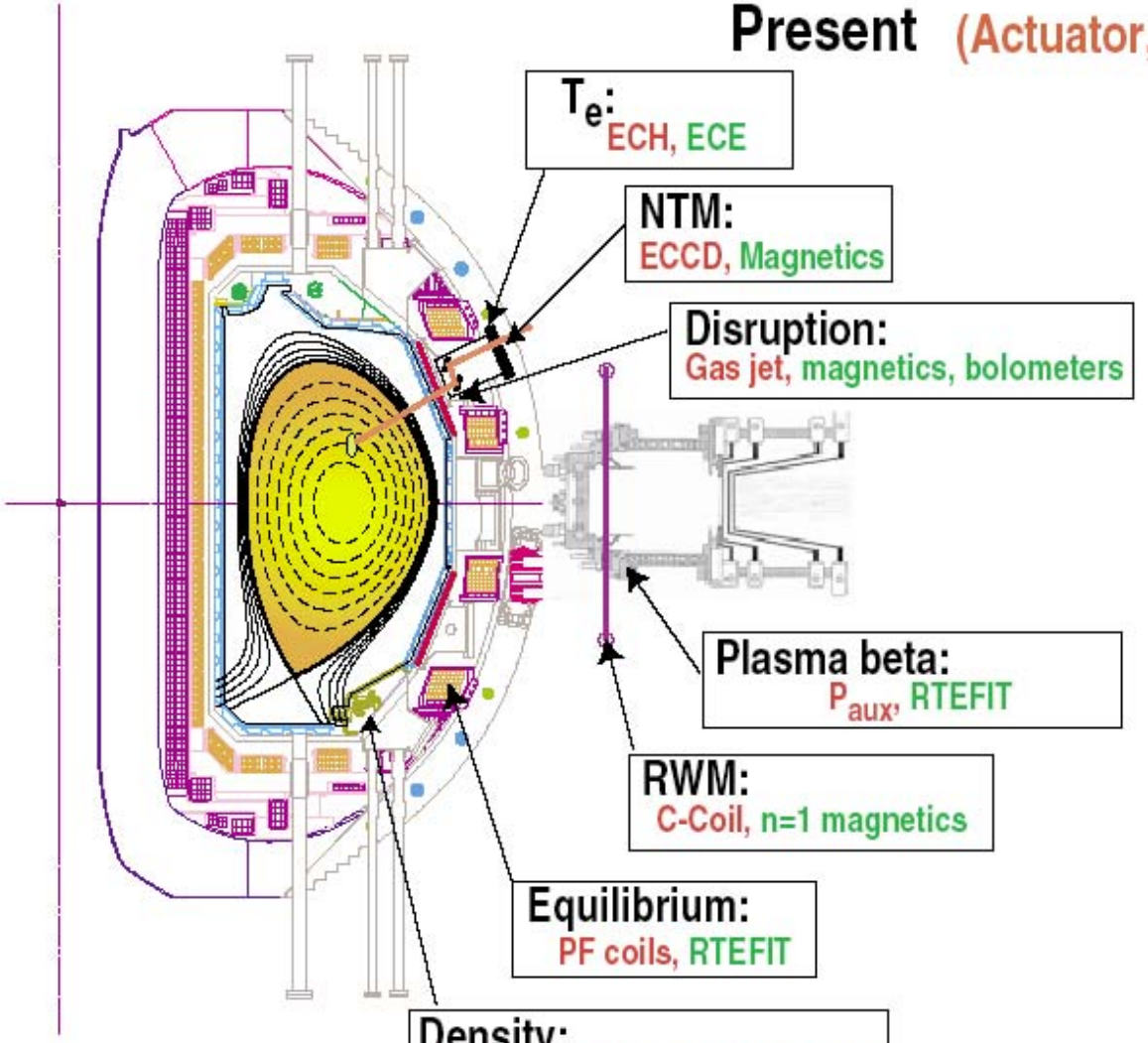
Boundary Physics

Integration

Burning Plasma Physics

A NEW ERA IN PLASMA CONTROL: KEY TO THE DIII–D AT PROGRAM

Present (Actuator, Sensor) **Planned**



T_e: ECH, ECE

NTM: ECCD, Magnetics

Disruption: Gas jet, magnetics, bolometers

Plasma beta: P_{aux}, RTEFIT

RWM: C-Coil, n=1 magnetics

Equilibrium: PF coils, RTEFIT

Density: Cryopumps, $C0_2$ interferometers

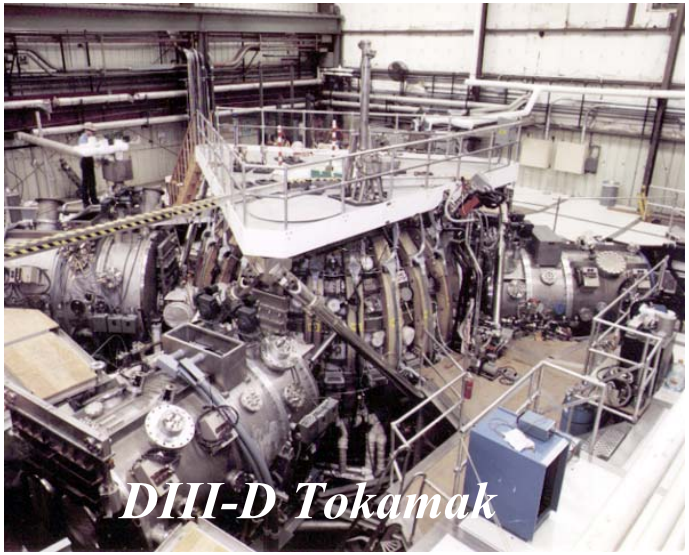
Integrated control:
Validated models
Expanded PCS

Current profile control:
ECCD/FWCD, MSE

Optimized RWM control:
I-Coil
Expanded magnetics

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

Major U.S. Magnetic Fusion Facilities

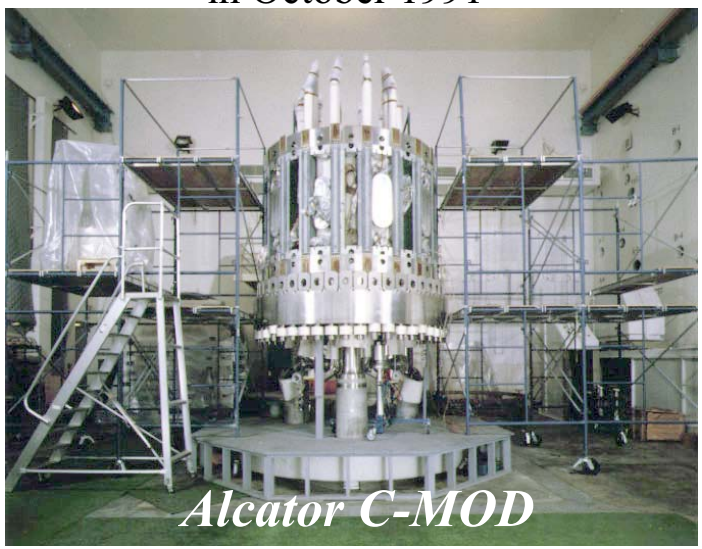


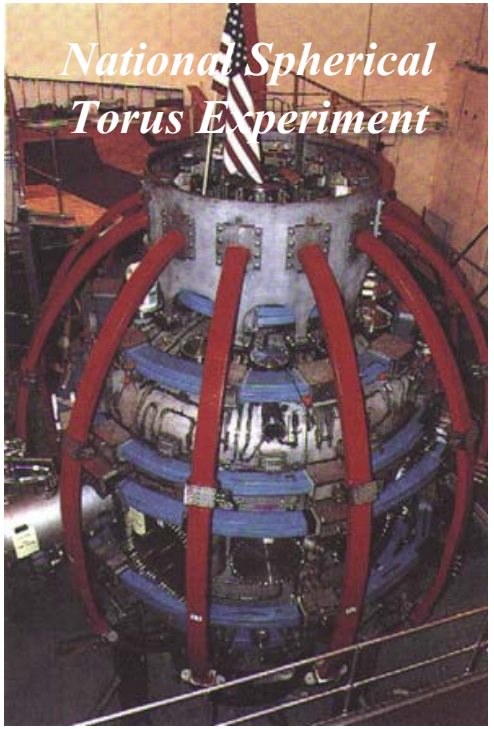
General Atomics

Doublet III Started Operations In 1978

Massachusetts Institute of Technology

C-MOD Started Operations in October 1991





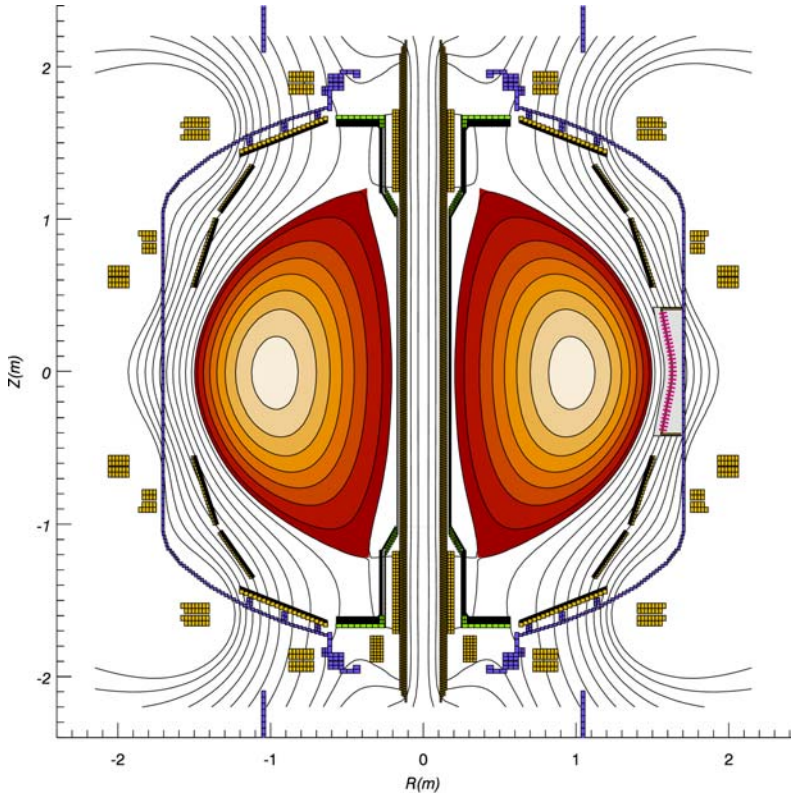
Princeton Plasma Physics Laboratory

NSTX started Operations in 1999

Princeton Plasma Physics Laboratory

NCSX Fabrication: FY 2003-2007

Variations of the Toroidal Plasma Configuration Address Key Fusion Issues



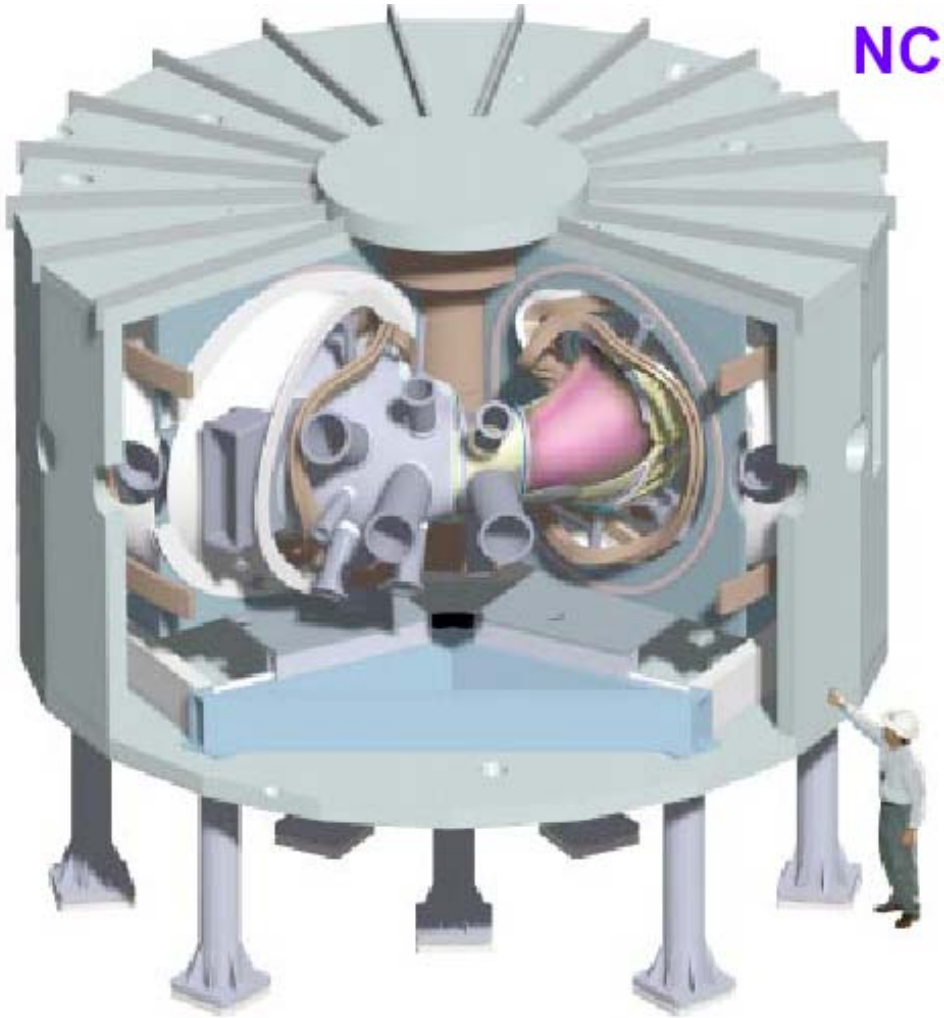
Spherical Torus offers high fusion power density at low magnetic field.

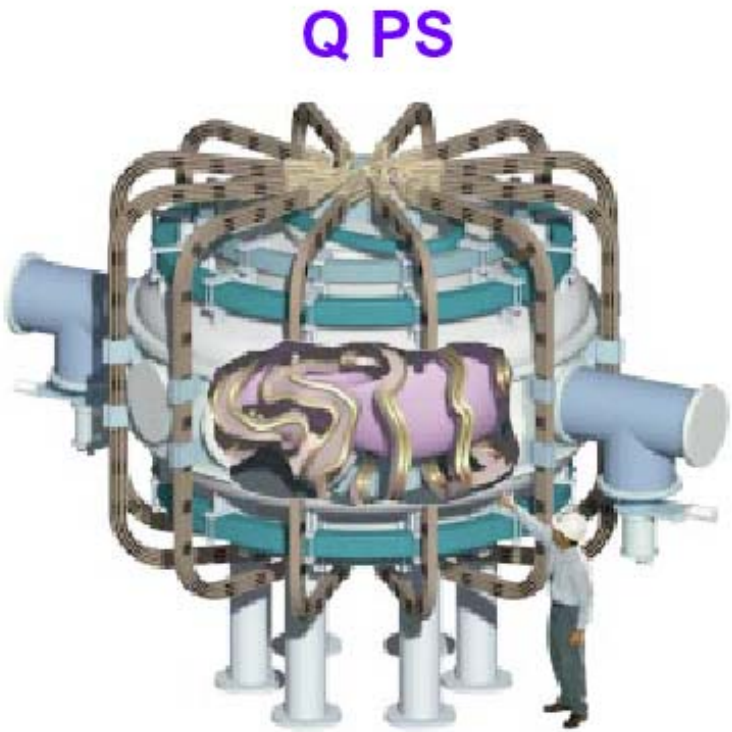
Compact Stellarator design optimizes plasma stability and steady-state properties.

Goal: Combine with ITER results for better fusion energy.

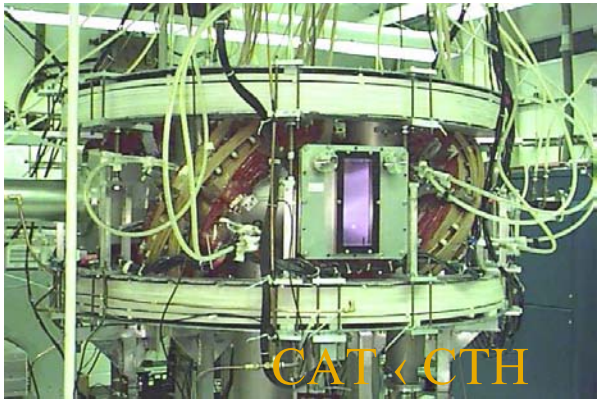
The U.S. is Planning Two Compact Stellarators

Different configuration and design approaches are used



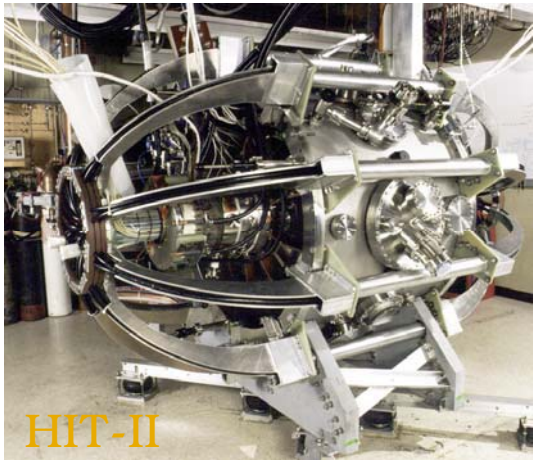


Innovative Confinement Concepts



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

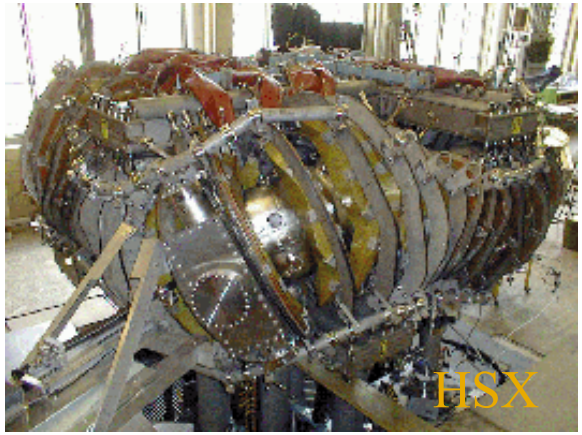
Levitated Dipole Experiment
Columbia University/Massachusetts
Institute of Technology



Helicity Injected Torus-II Experiment
University of Washington, Seattle

Sustained Spheromak
Plasma Experiment
Lawrence Livermore National Laboratory

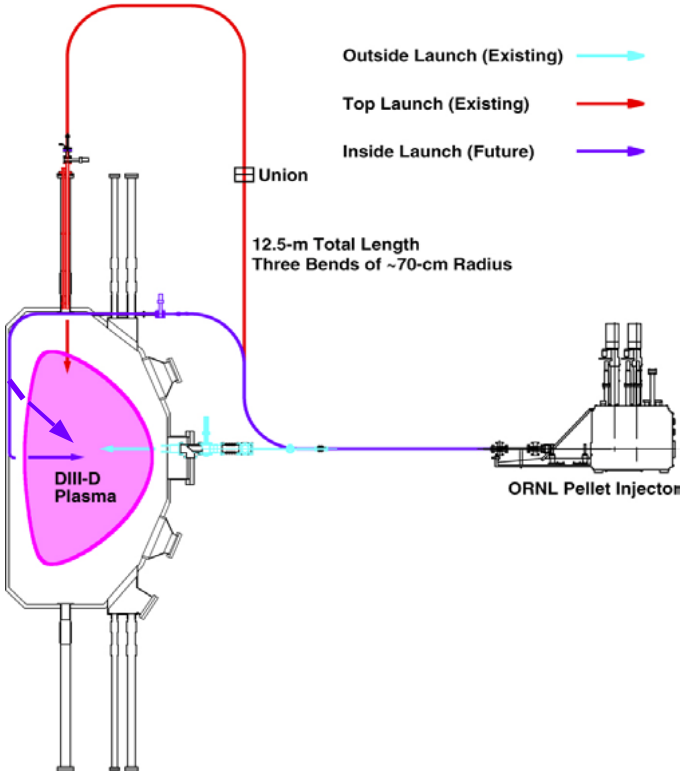
Electric Tokamak
University of California, Los Angeles



Helically Symmetric Experiment
University of Wisconsin, Madison

Enabling Technologies Program

Pellet Injector in DIII-D for Plasma Fueling



100 GHz Gyrotron Tube (1MW power in 1 second pulse) for Plasma Heating and Control

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

Inertial Fusion Energy

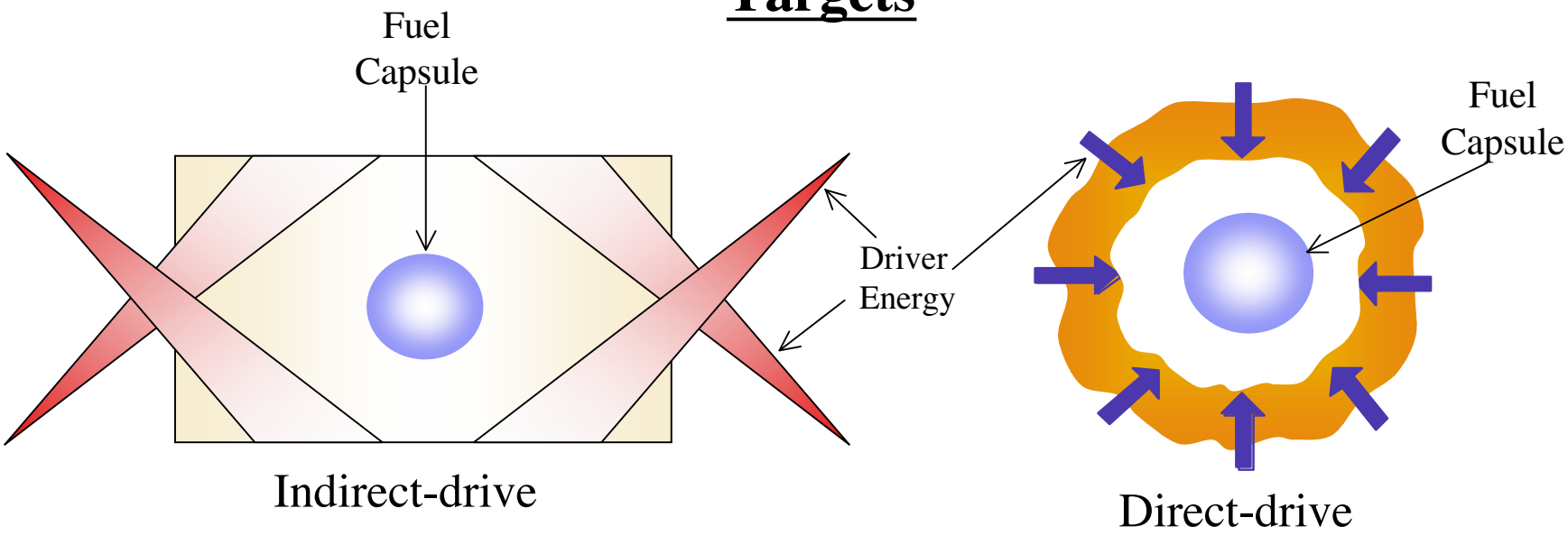
- Defense Programs conducting high energy density physics using OMEGA, and NIKE lasers; National Ignition Facility under construction; results are used by Science in designing energy producing targets

- SC developing components for energy applications, especially accelerator-based driver and target chamber technologies

- Developing international collaboration through bilateral agreements

Inertial Fusion Energy Options

Targets



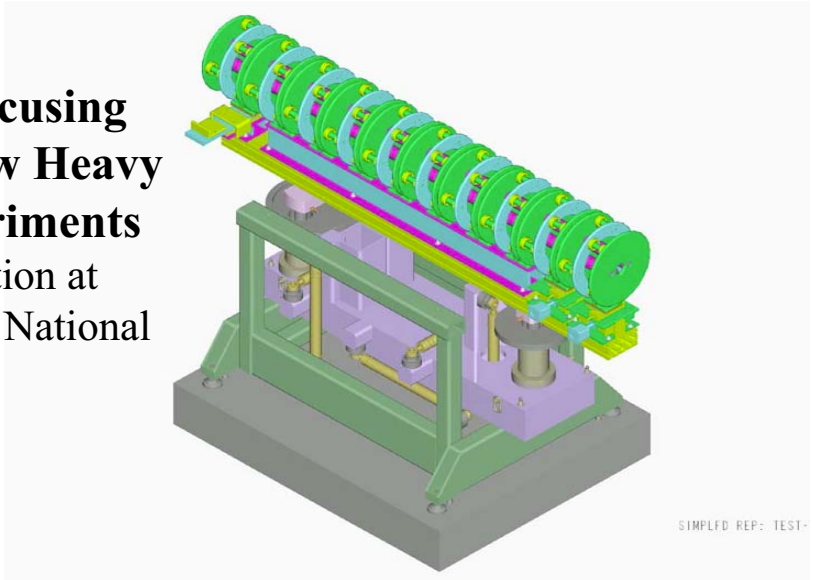
Drivers

Heavy Ions
KrF Laser
Diode Pumped Solid State Laser
Z Pinch

Inertial Fusion Energy Experimental Facilities

Liquid wall chamber protection flow experiment
Georgia Tech

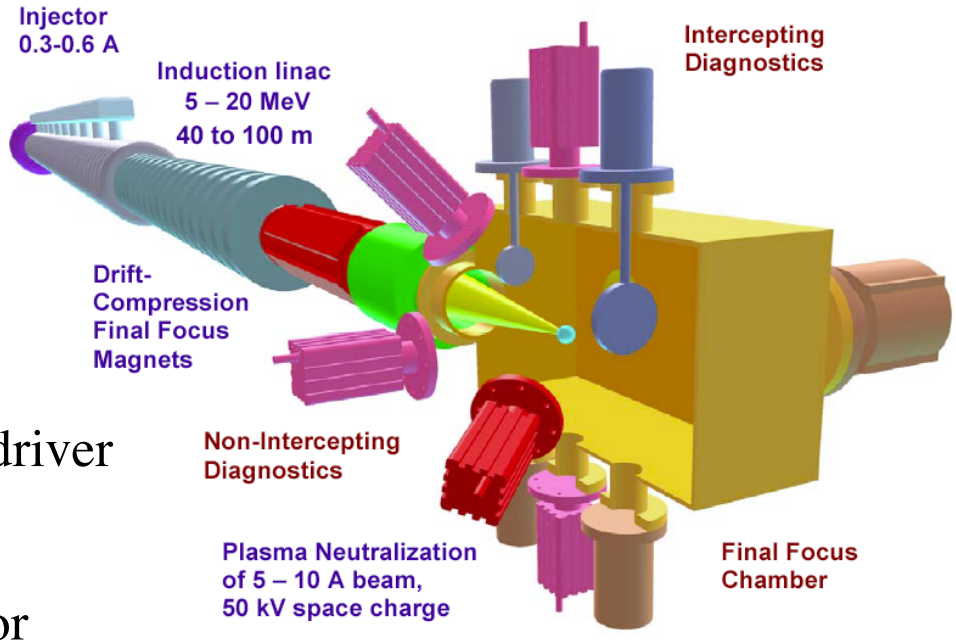
Quadrupole Focusing Assembly for New Heavy Ion Beam Experiments
(Under construction at Lawrence Berkeley National Lab)



Multi-beam Transport Experiment
Lawrence Berkeley National Lab

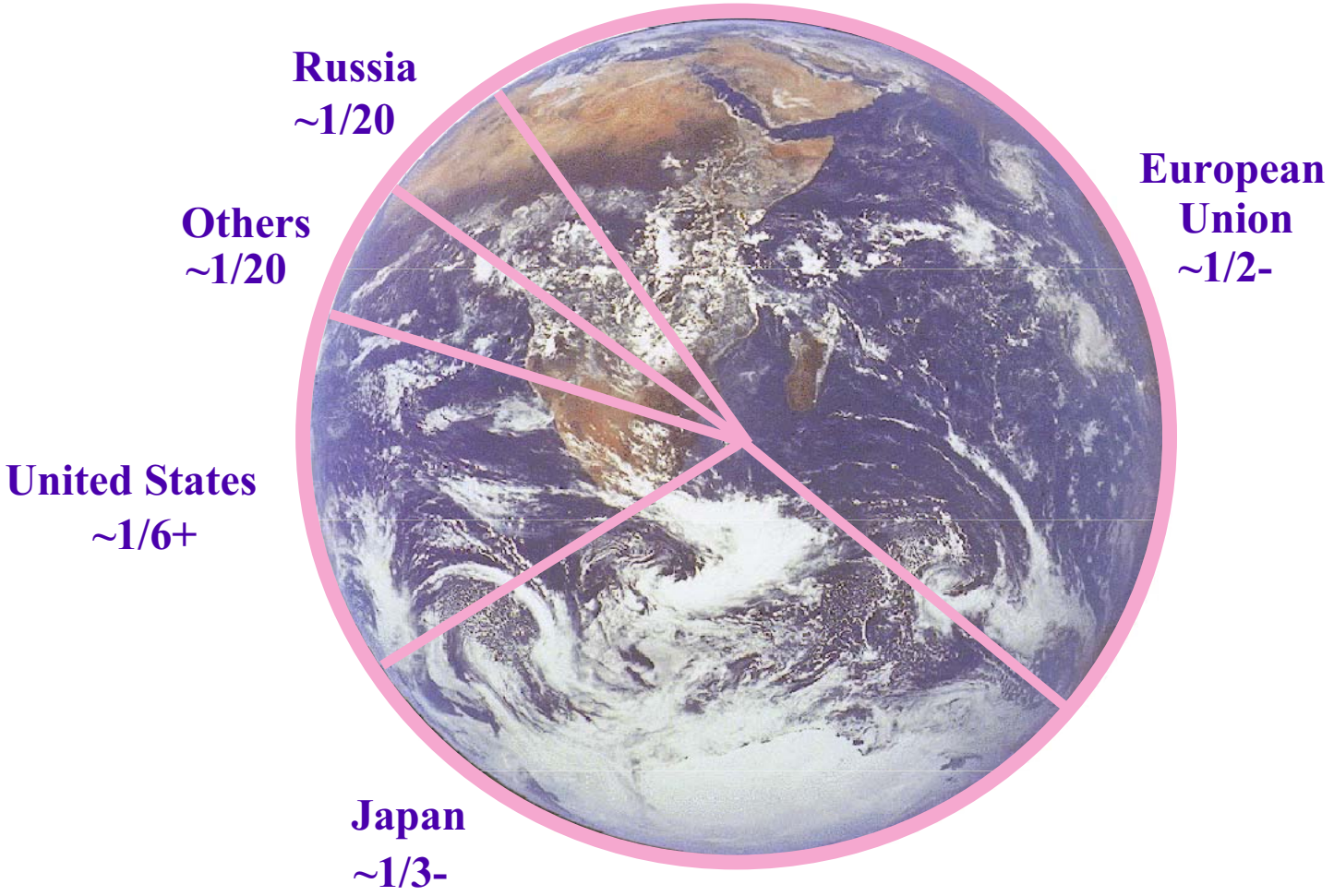
Integrated Beam Experiment

- TPC $67M
- Location LBNL
- Build 2005 – 2009



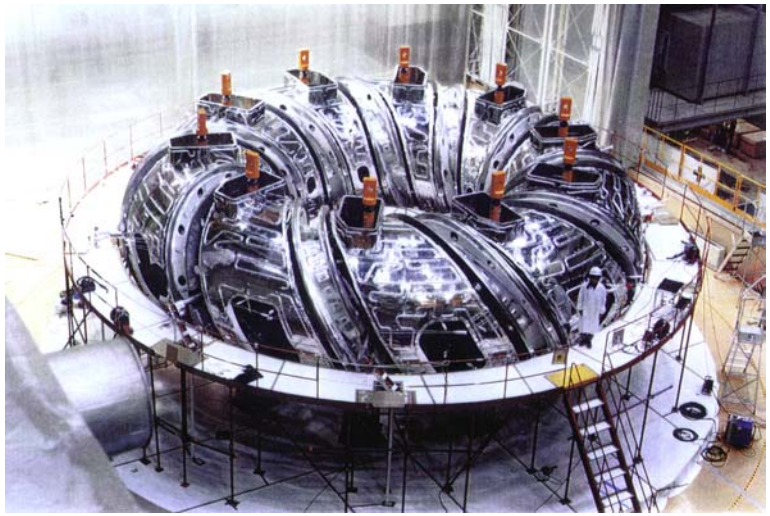
- Mission of IBX is to validate the physics of heavy ion beams with driver level currents, acceleration, beam shaping, pulse compression and focusing to spot sizes necessary for energy producing targets.
- IBX is the first of 3 integrated facilities that conclude with the Inertial Engineering Test Facility that would demonstrate the viability of inertial fusion energy.
- Will provide new insight into the behavior of high current beams that are essentially non-neutral plasmas that display a variety of instabilities.

World Magnetic Fusion Effort (2001)



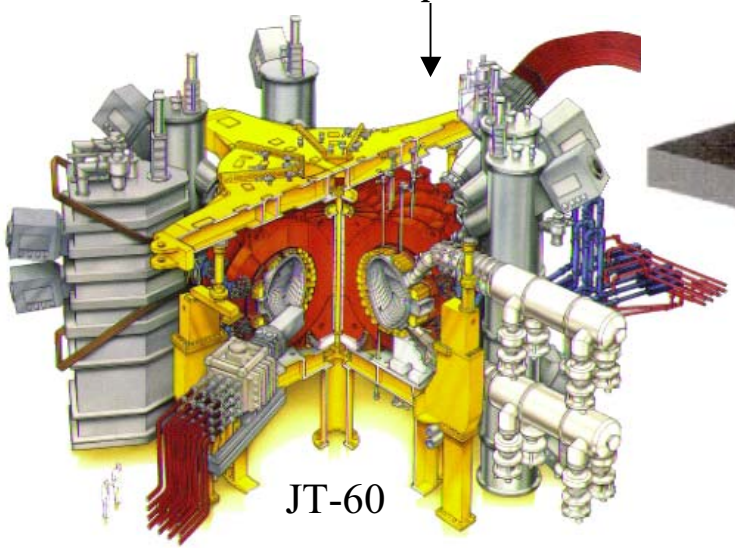
[Relative levels based on published budgets, rough estimates of personnel not included in budgets and rough conversions to dollars]

Major International Facilities

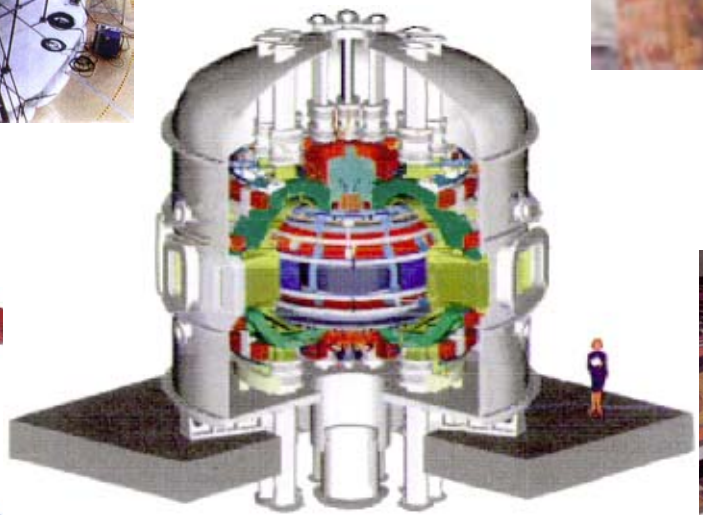


Large Helical Device (LHD)

Japan

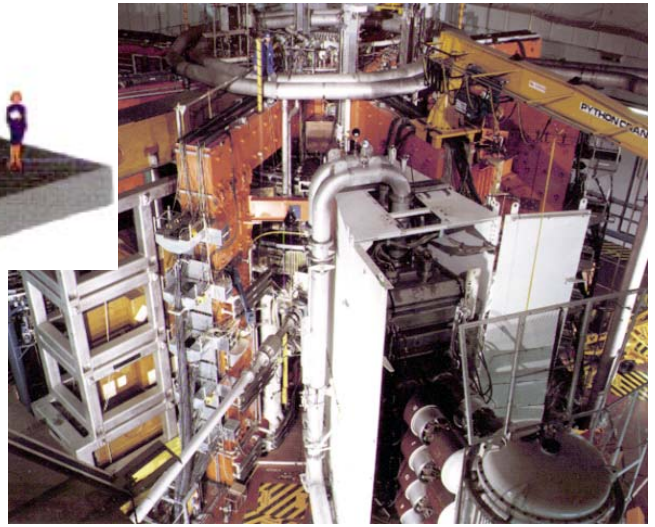


JT-60



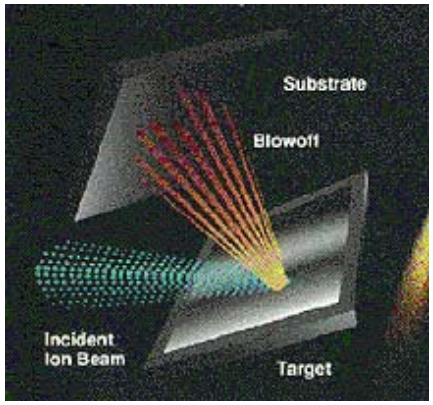
KSTAR (Korea)

Wendelstein 7-X
(Germany)



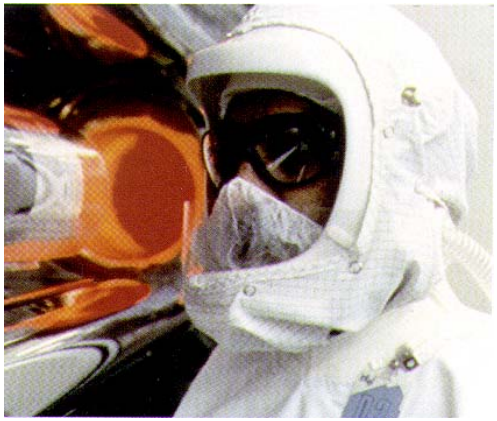
Joint European Torus (JET)

Near-term Applications of Fusion Research



Coatings
and Films

Saturn Engines

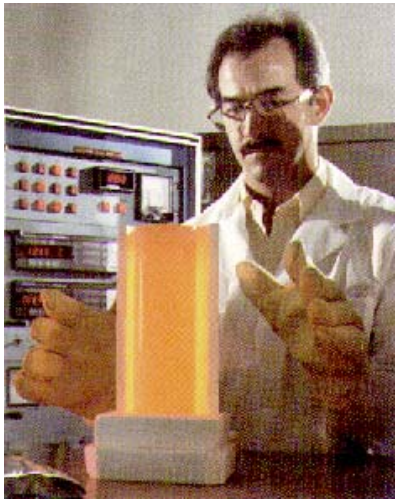


Plasma Processing
of Chips and
Circuits

Computers

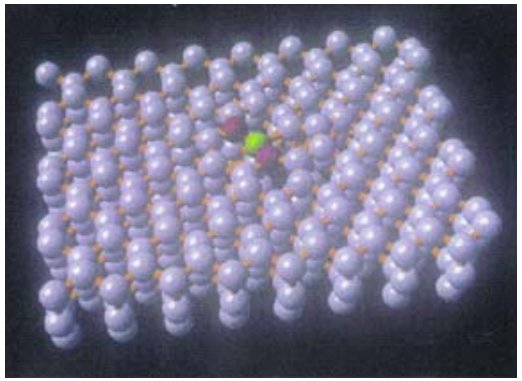
Waste
Processing

Cleaning
Contaminated
Surfaces



New
Materials

Carbon Fiber
Composites

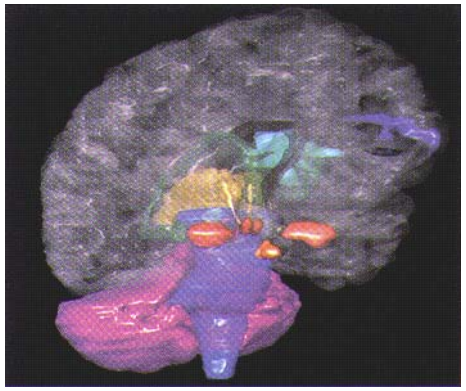


Plasma
Electronics

Flat Panel
Displays

Biomedical
Applications

Artificial
Hip Joints



FES Strategic Theme and Tactics

CREATING A STAR ON EARTH—PROVIDING A FUNDAMENTALLY NEW ENERGY SOURCE FOR ALL PEOPLE

BURNING PLASMAS: Through international collaboration, explore self-heated fusion plasmas and demonstrate the scientific and technological feasibility of fusion energy

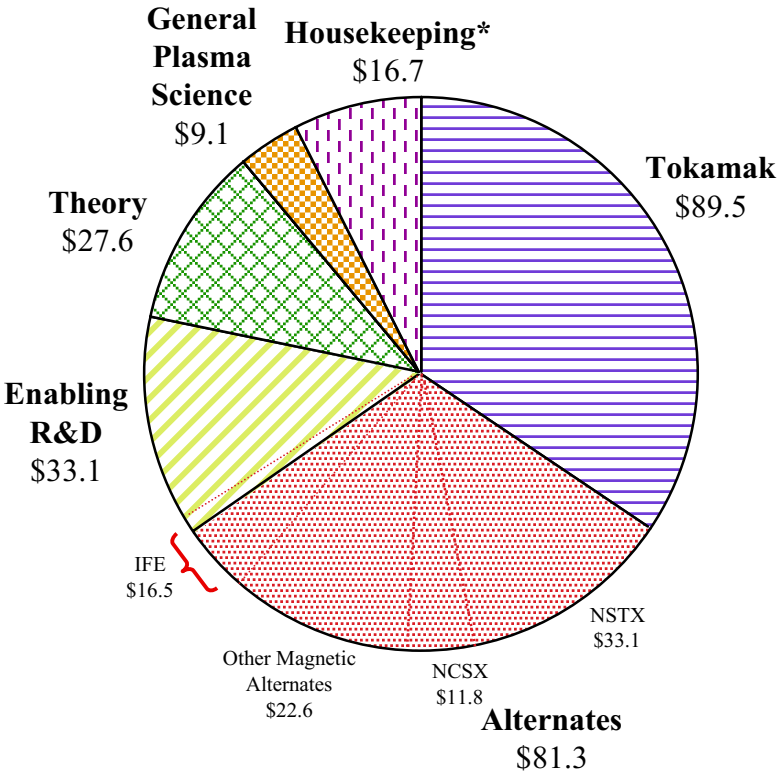
FUNDAMENTAL UNDERSTANDING: Reveal complex plasma behavior across many orders of magnitude in space and time. Integrating theory, simulation and experimental results, develop a predictive capability for fusion energy systems

CONFIGURATION OPTIMIZATION: Explore a wide range of innovative approaches to confining hot plasmas for ultimate fusion energy systems, including both MFE and IFE concepts

MATERIALS AND TECHNOLOGY: Use modeling, nanotechnology, and neutron irradiation to develop materials and energy conversion systems for fusion applications, in order to maximize environmental & economic aspects of fusion energy systems

Fusion Energy Sciences Budget

FY 2003
Congressional
$257.3 M



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

OFES FY 2003 Budget Status

Request	House	Senate
$257,310,000	$248,495,000	$259,310,000