DIII-D's Role in Advancing U.S. Interests in Fusion Energy Development

by
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Presented to the
FESAC Subcommittee on MFE Priorities
Bethesda, Maryland

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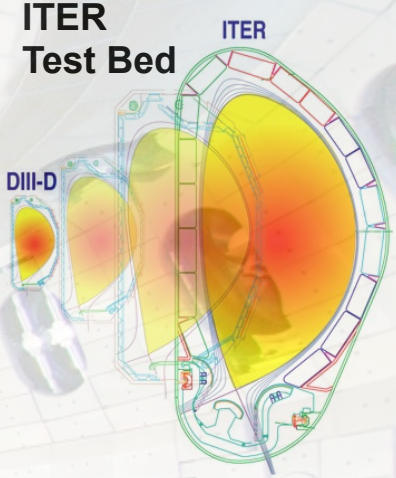
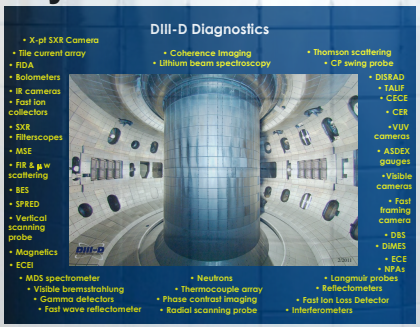
International Team

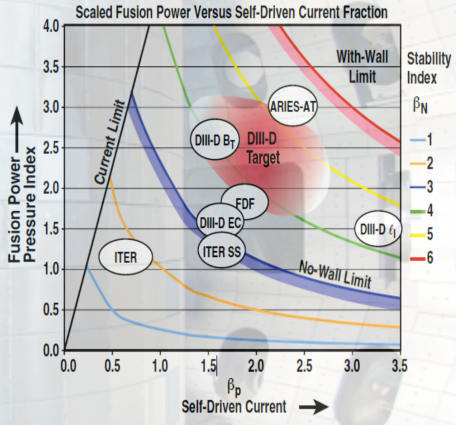
ITER Test Bed



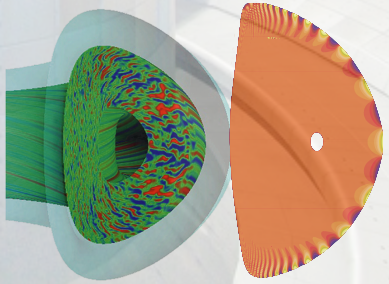
Physics Measurements



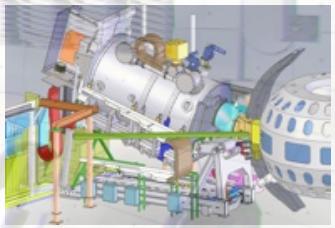
Scenario Development

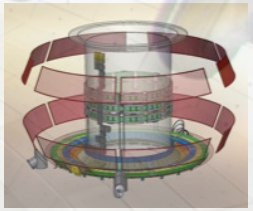


Theory & Simulation



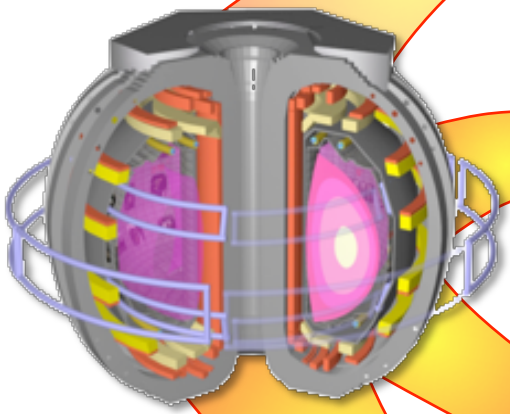
Plasma Control



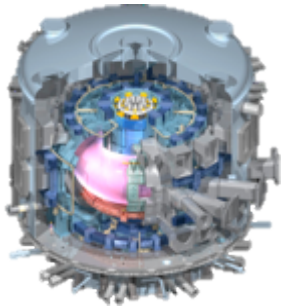


DIII-D Is a Critical Element in Advancing and Informing U.S. Program Elements on the Path to Fusion Energy

DIII-D

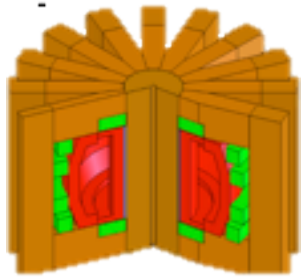


Resolve key physics issues for ITER design and performance optimization ✔



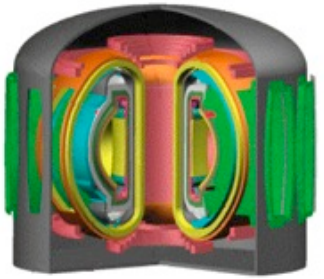
ITER

Inform decisions on next-step facility aimed at fusion energy development ✔



FNSF

Provide physics basis for steady-state power plant ✔

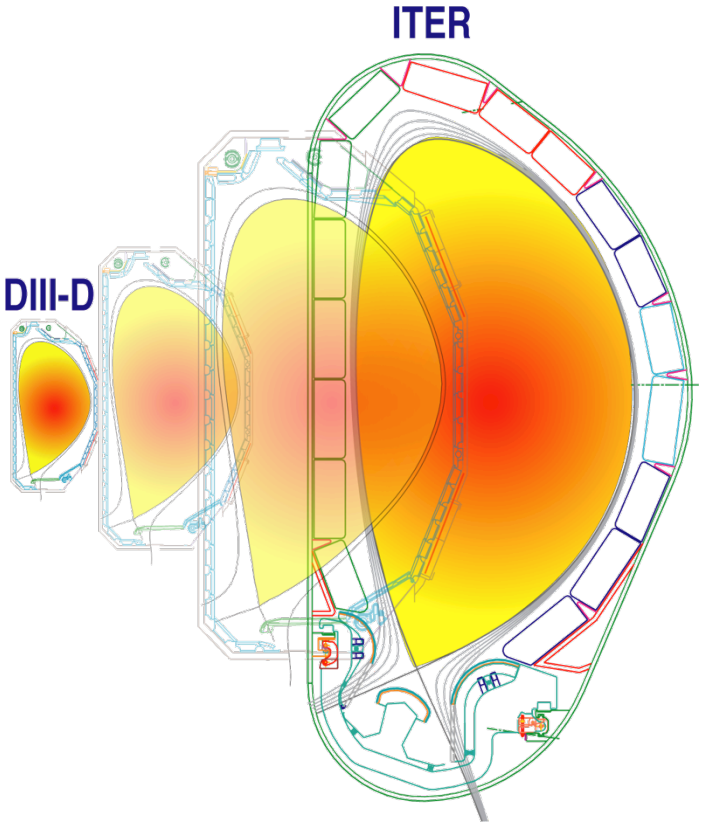


DEMO

Train the next generation of scientists for ITER and next-step devices ✔

DIII-D is Uniquely Positioned to Resolve Key Physics Challenges and Ensure ITER's Success

- Qualify techniques for ELM control in ITER
- Develop reliable means to avoid and mitigate damaging effects of ITER disruptions
- Determine limitations imposed by new superconducting coil constraints
- Develop reliable plasma control techniques consistent with ITER capabilities
- Develop and quantify performance of plasma regime expected in ITER (dominant electron heating, low NBI torque)
- Provide physics basis for improved confidence in ITER heat flux control plans

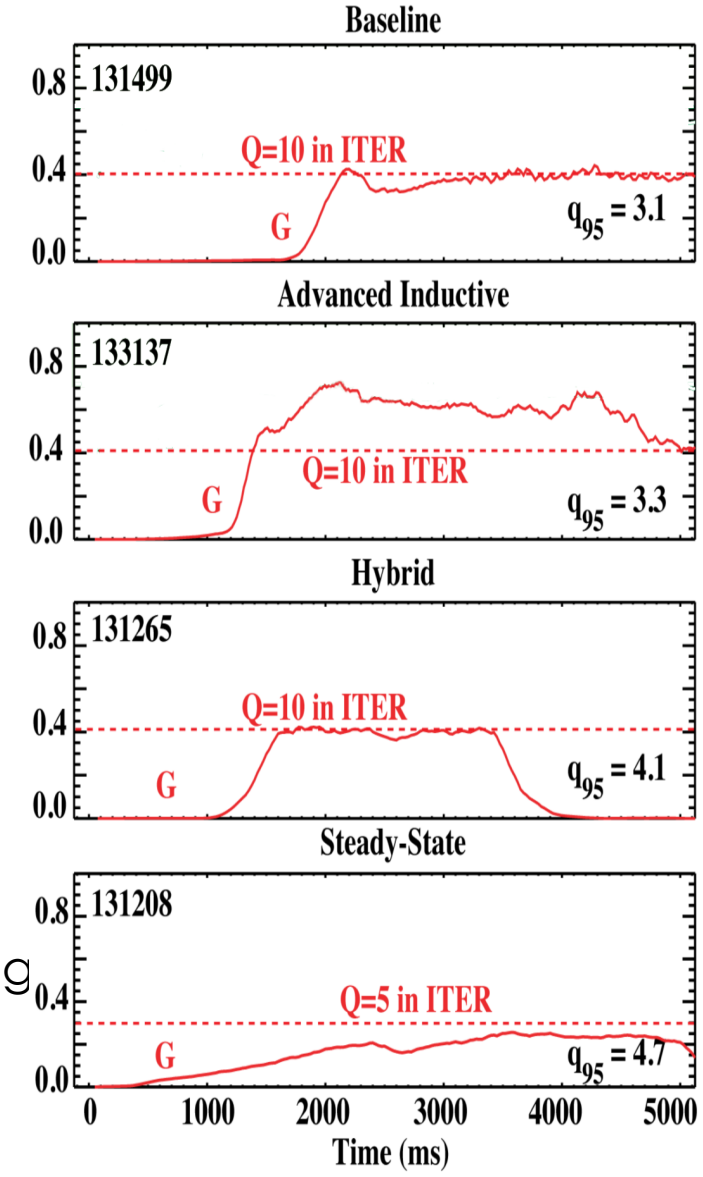


DIII-D: U.S.'s ITER Simulator ~1/4 size ITER Prototype

Facility capabilities and responsive team enable rapid answers to ITER urgent requests

DIII-D Capabilities Indicate Opportunity for Extending the Technical Reach of ITER

- **ITER baseline scenario provides minimal level of performance for U.S. science needs**
  - DIII-D has demonstrated performance well beyond this level
- **Potential exists on ITER for:**
  - Q = 10 at lower plasma current (less risk to ITER)
  - Q > 10 inductive (ignition possible)
  - Q > 5 steady-state (FNSF/DEMO proof-of-principle)
- **Such capabilities on ITER would expedite development of fusion energy**
  - Improved understanding of key processes in burning plasmas (e.g., transport, energetic particles, 3D fields)
  - Define path to performance optimization in DEMO
  - Control tool development and strategy testing

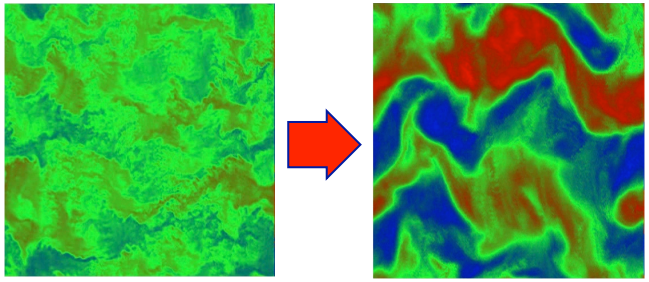


Fusion Gain Figure of Merit
$G = \beta_N H_{89} / q_{95}^2$

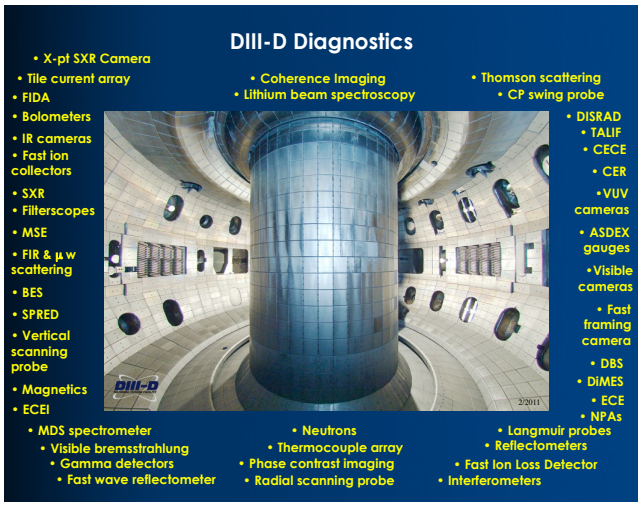
DIII-D Will Enable U.S. to Take Leadership Positions in ITER Science

- **ITER is potentially impacted by new physics**
  - Small gyroradius (ρ*) effects
  - Transport in burning plasma regime
  - Fast ion instabilities in "sea" of modes
- **DIII-D provides excellent scientific platform for developing physics models of these effects**
  - Flexible control tools and geometry
  - Comprehensive diagnostic set
  - Access to ITER regimes
- **DIII-D is an outstanding facility for training the next generation of fusion scientists and can help build the U.S. team for exploitation of ITER**

Scale of turbulent eddies predicted to change in burning plasma regime

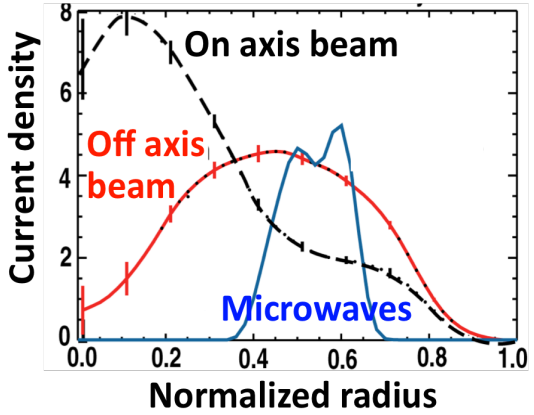


Comprehensive diagnostics

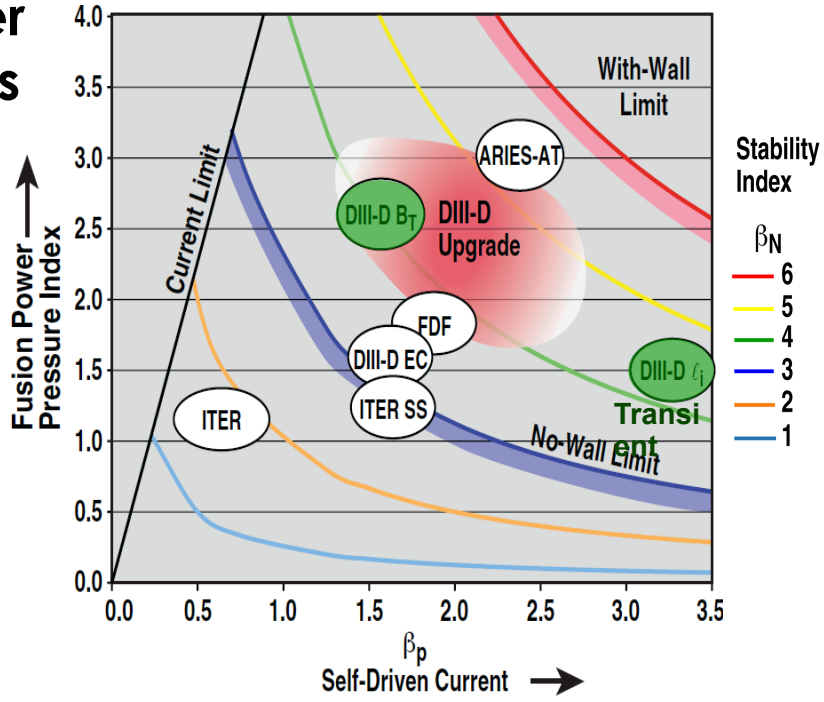


DIII-D Capabilities Enable US to Maintain Leadership on Path to Fusion Energy Beyond ITER

- **Steady-state operation raises new challenges:**
  - Broad profiles to enable high beta access and full non-inductive operation
  - Detached boundary to eliminate erosion



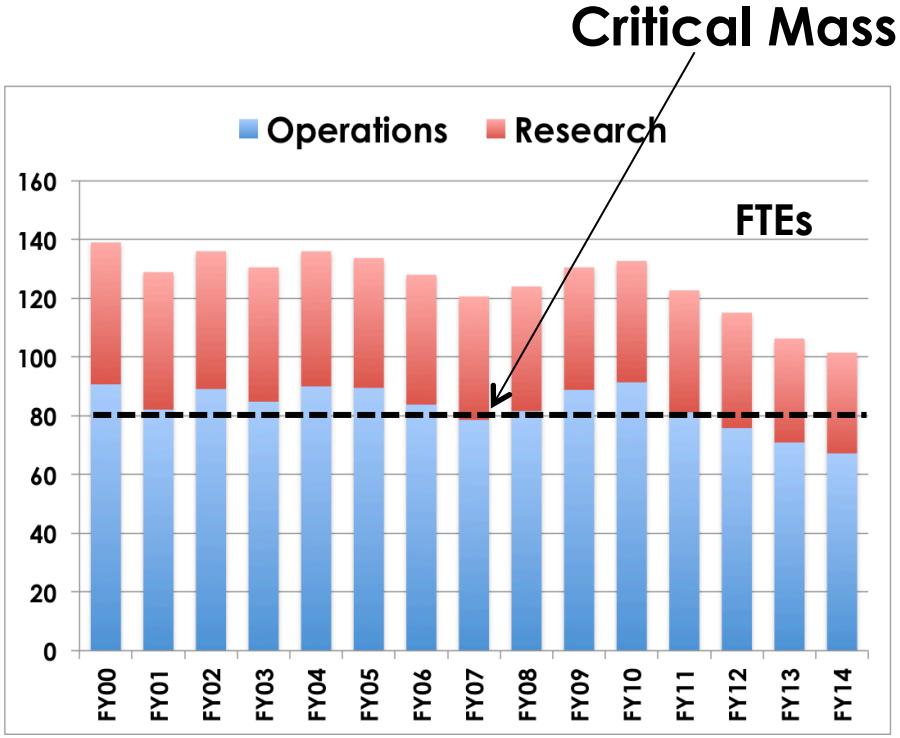
- **DIII-D's flexible heating and current drive offer basis to inform decisions on next step devices**
  - Off-axis current drive provides access to regimes of interest for FNSF and DEMO
  - Sufficient power to probe stability limits
  - Dominant electron heating to assess impact of transport



- **Shape flexibility allows exploration of using boundary geometry to optimize divertor detachment**

Additional Funding is Required to Properly Exploit DIII-D Capabilities in Pushing Fusion Energy Forward

- **Available budget is near critical level to support safe, reliable operations**
- **FES guidance of 10 weeks operations in FY13 will limit program's ability to advance fusion energy development**
  - Requires hard choices on research priorities
- **Long-term impact will be loss of U.S. leadership in key areas**
  - E.g., scenarios, transport, energetic particles, 3D fields



"Existing technical staff appears marginally adequate to support the combination of operations, maintenance of aging equipment." - DoE DIII-D Facility Review Panel, May 2008

With the guidance budget, DIII-D is the only operating U.S facility in FY13-14

Further Upgrades to DIII-D Will Advance U.S. Leadership in Key Areas for Fusion Energy Development

Burning Plasma Regimes

- Dominantly electron heated
- Low torque
- Low fueling & collisionality
- Fast ion physics

Manage stability & transients

- ECCD stability control
- Anticipate, avoid & mitigate disruptions
- 3D optimization: ELMs error fields, RWM

Proposed DIII-D Upgrades:

- EC: 12 MW
- NBI: 30 MW total, 10 MW off-axis
- Advanced 3-D Capability
- New diagnostics for physics validation

Steady-state Plasma Operation

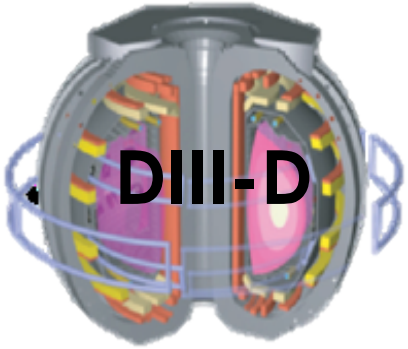
- Fully noninductive
- Self-driven well aligned currents
- High confinement
- Spread heat & cool exhaust

Compelling Physics Basis for Fusion Energy Development

ITER

FNSF

DIII-D Is a Critical Element in U.S. Preparations for ITER and in Defining Next Facility on Path to Fusion Energy



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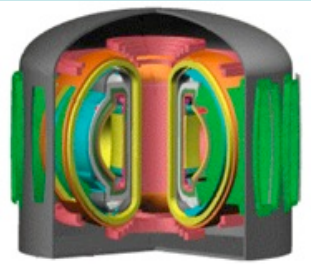
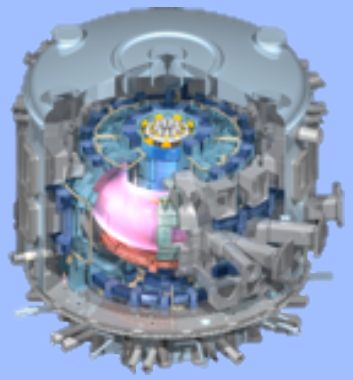


DEMO

Resolve key physics issues for ITER design and performance optimization

FNSF



ITER

Discover, understand, and exploit physics that has high leverage in optimizing performance

Science & Technology Base