# ITER Test Blanket Module (TBM) Error Field Experiments in DIII–D

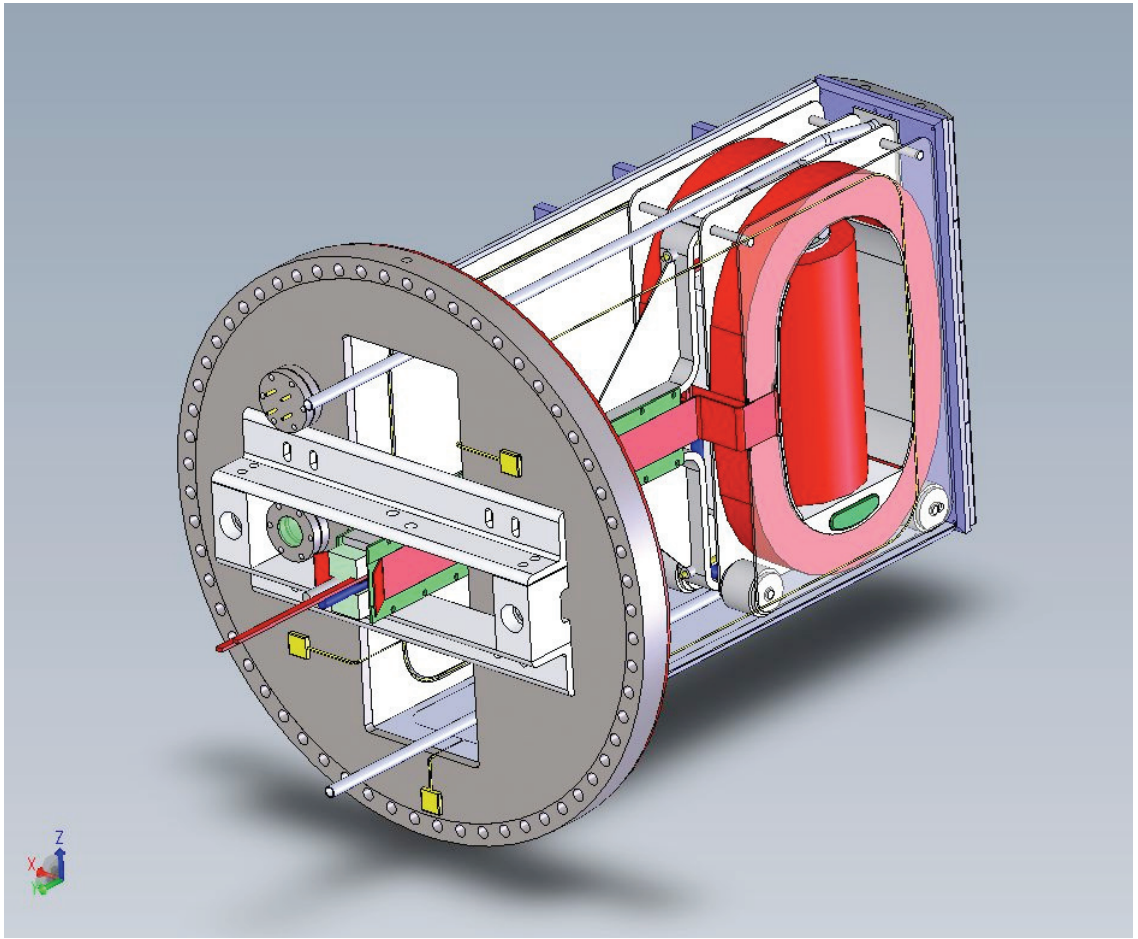
by

M.J. Schaffer[1]

and

J.A. Snipes[2]

[1]General Atomics
[2]ITER Organization



Presented at
Fifty First APS Meeting of
the Division of Plasma Physics
Atlanta, Georgia

November 2–6, 2009

# An International Team of Experts is Participating with DIII–D Team Members

**International Team**

| | |
|---|---|
| Joseph Snipes | IO |
| Valery Chuyanov | IO |
| Naouki Oyama | Japan |
| Kouji Shinohara | Japan |
| Hogan Jhang | S Korea |
| Kwang-Il You | S Korea |
| Xiang Gao | China |
| Songlin Liu | China |
| Yanjing Chen | China |
| Guoyao Zheng | China |
| Gabriella Saibene | Europe |
| Peter de Vries | Europe |
| N. Subramanian | India |
| R. Srinivasan | India |
| Don Spong | USA |
| David Gates | USA |
| Jong-Kyu Park | USA |

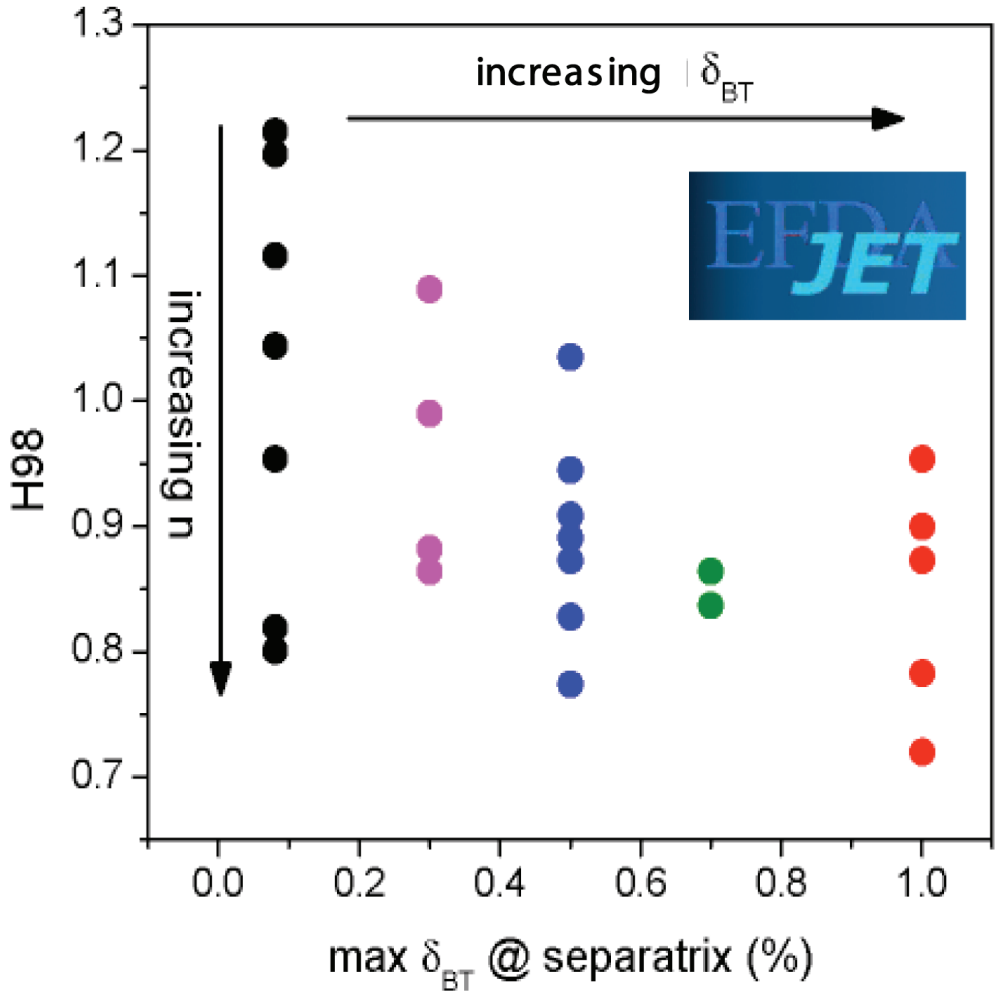
**Task Force Leaders:**
**Michael Schaffer**
**Joseph Snipes**

**Task Force Deputy:**
**Charles Greenfield**

**DIII–D Team**

# Test Blanket Modules (TBM) are Planned in ITER

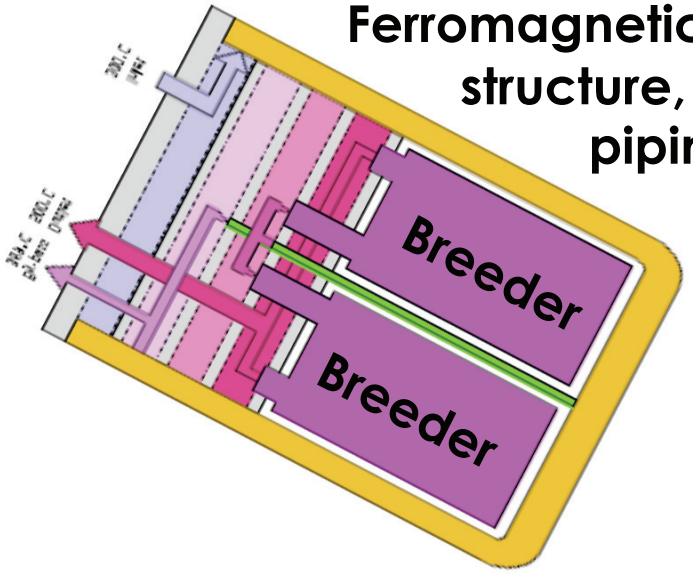
- **Each TBM will have ~ 1 tonne of martensitic steel**
  - For reactor relevance
  - It's ferromagnetic
- **TF ripple reduces H-mode confinement in JET and JT-60U**
- **What will TBM error field do?**

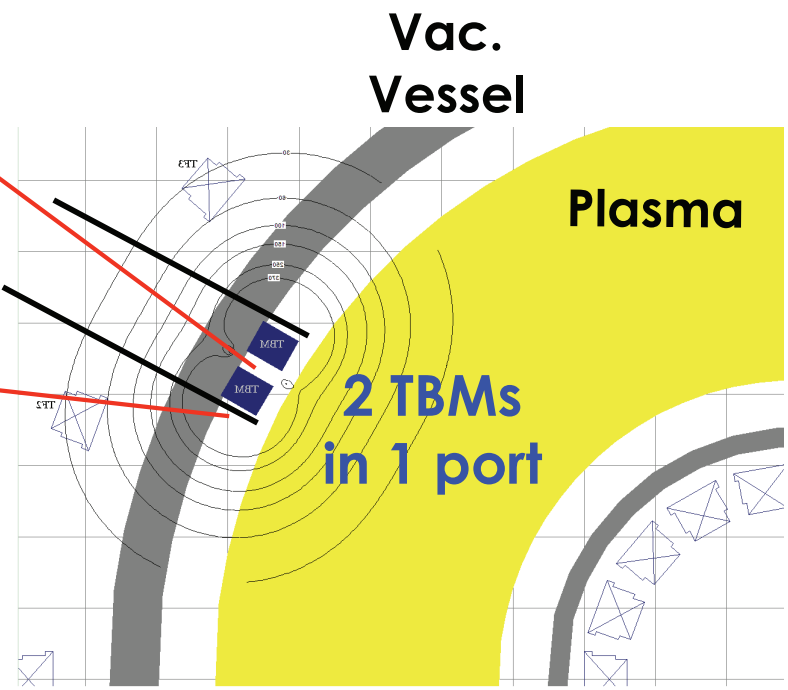



**Effects of TBM error field will be tested in DIII–D**

# ITER Will Have 2 TBMs in Each of 3 Equatorial Ports

One TBM

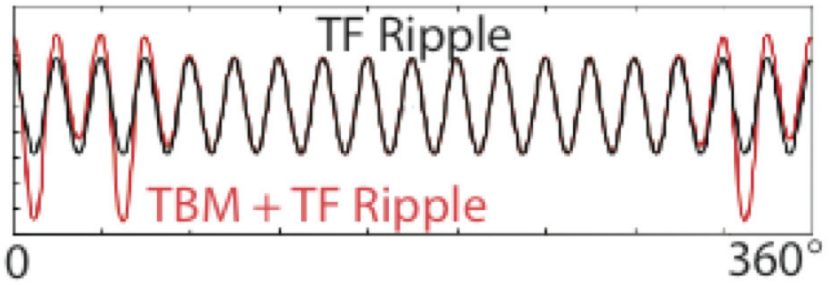



3 TBM ports will be spaced 40° toroidally

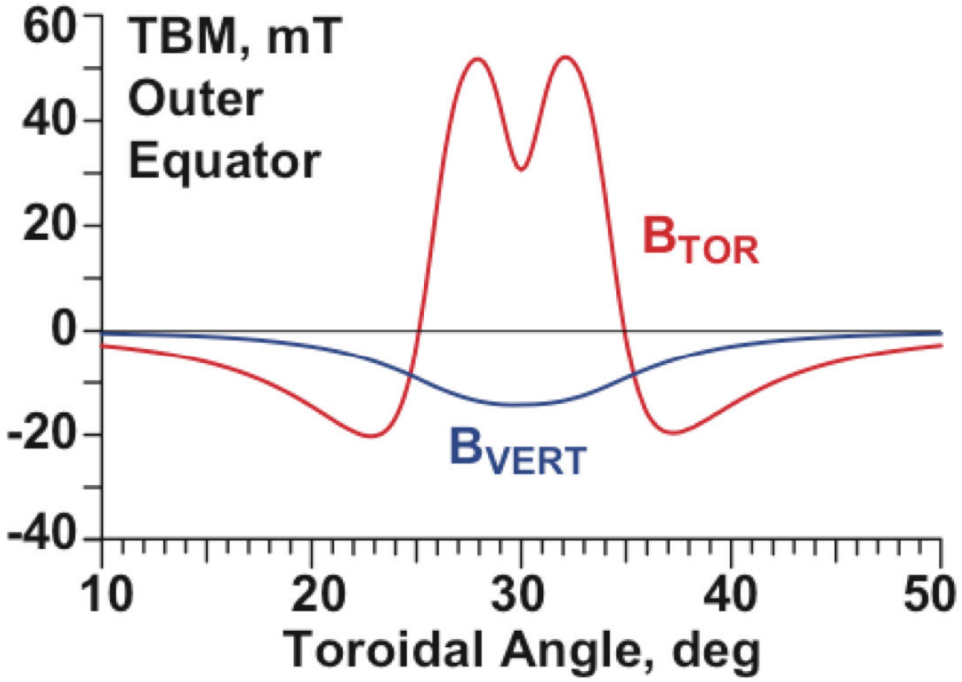
# TBM Field Would Be Larger Than TF Ripple

*Calculated by K Shinohara
20 cm into plasma




- **TBM field reduces toroidal B in the plasma**
  - **At a TF ripple minimum**
- **Separatrix will bulge out by ~12 mm**
  - Small compared to ~ 150 mm outer gap
  - More than ~ 5 mm estimated SOL

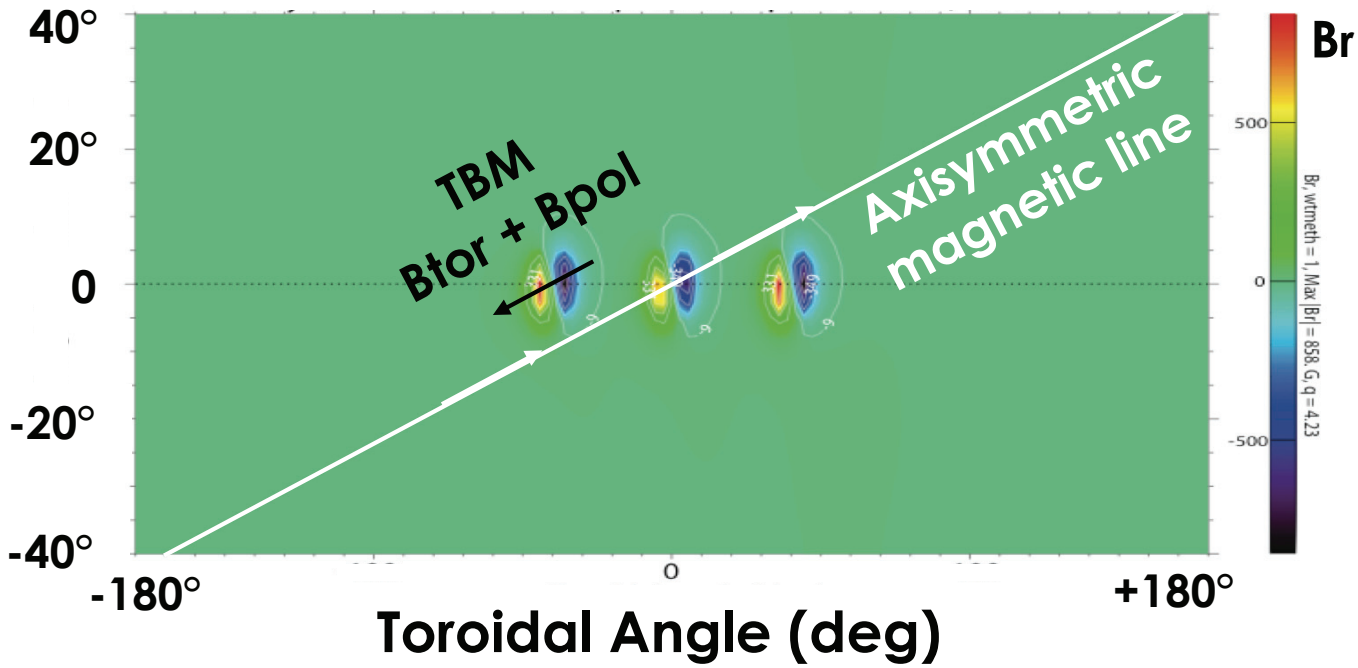
*Calculated by S Putvinski
at plasma surface




- **Fe is magnetized by $B_{TOR}$ and $B_{POL}$**
  - Makes error field with both these components

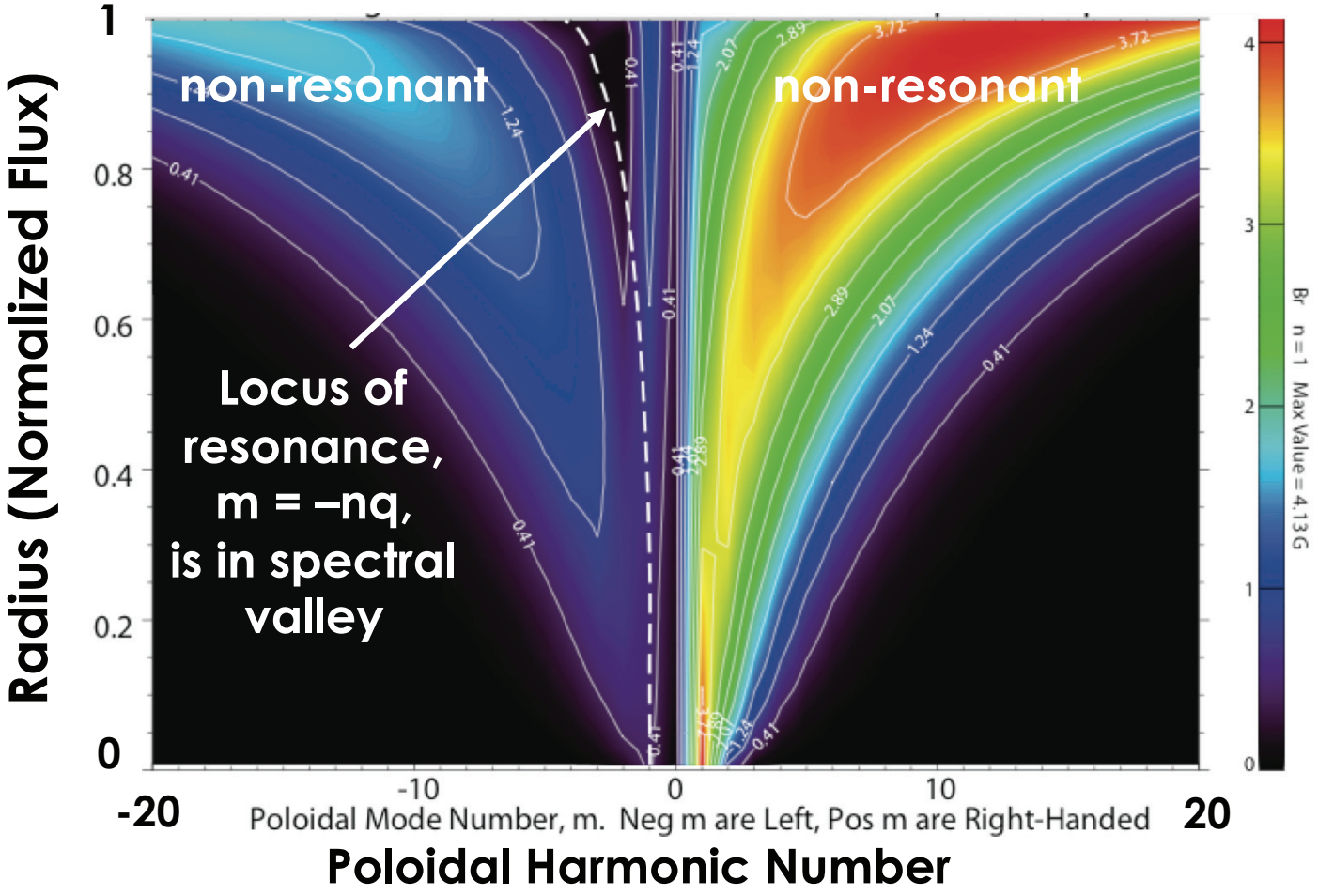
# TBM $B_r$ Field Points Rapidly In and Out on Magnetic Lines Passing in Front of It

**Contours of Br from 6 TBMs on 0.9975 Poloidal Flux Magnetic Surface**




- TBM field is very *localized*; Peak $B_r$ ~ 800 G
- TBM vector $B_{tor} + B_{pol}$ in nearby plasma is nearly *antiparallel* to the axisymmetric $B_{tor} + B_{pol}$

# The n=1 $B_r$ Harmonic Spectrum of 6 ITER TBMs Has a "Resonance Valley"




Largest helical $B_r$ harmonic here is ~ 4 G, *vs* ~ 800 G of peak physical $B_r$

TBM field contains hundreds of harmonics

**Harmonics are dominantly NON-Resonant**
**Islands should be small, but non-resonant torque large**

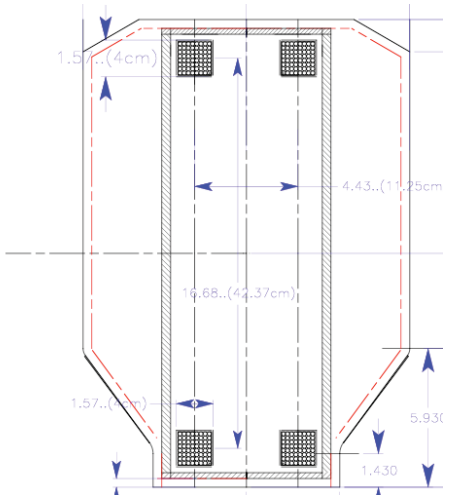
# DIII–D Experiments Will Address TBM Effects of Concern

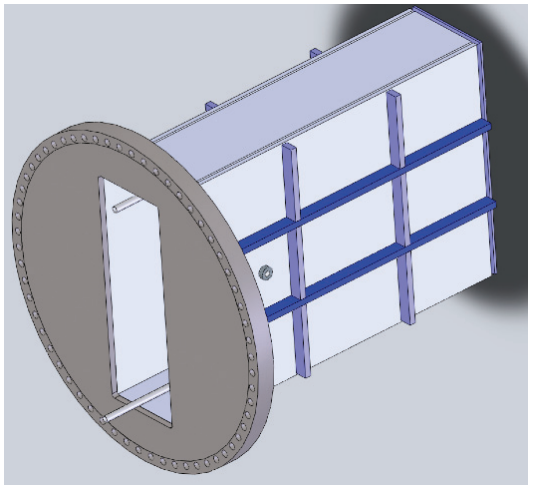
- **H-mode confinement**
  - Energy, particle, momentum confinement
  - H-mode pedestal changes
  - Plasma rotation, momentum, braking, NTV
- **ELM suppression by RMP**
- **Locked modes and correction of TBM error**
- **L–H transition**
- **Fast ion transport**

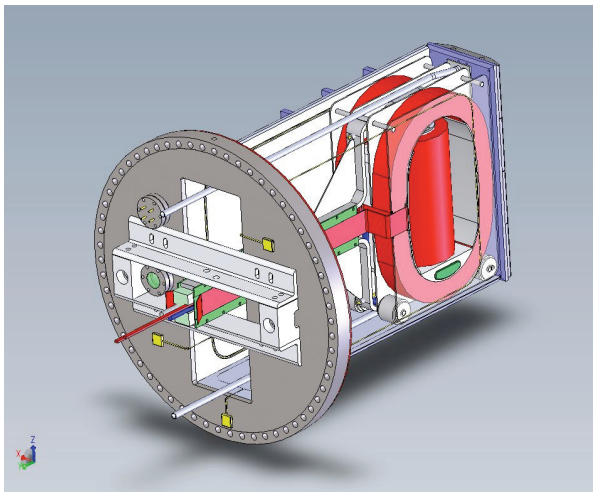
**Results will inform the IO for Test Blanket Module implementation in ITER**

# DIII–D Port Availability Constrains TBM Mockup Geometry

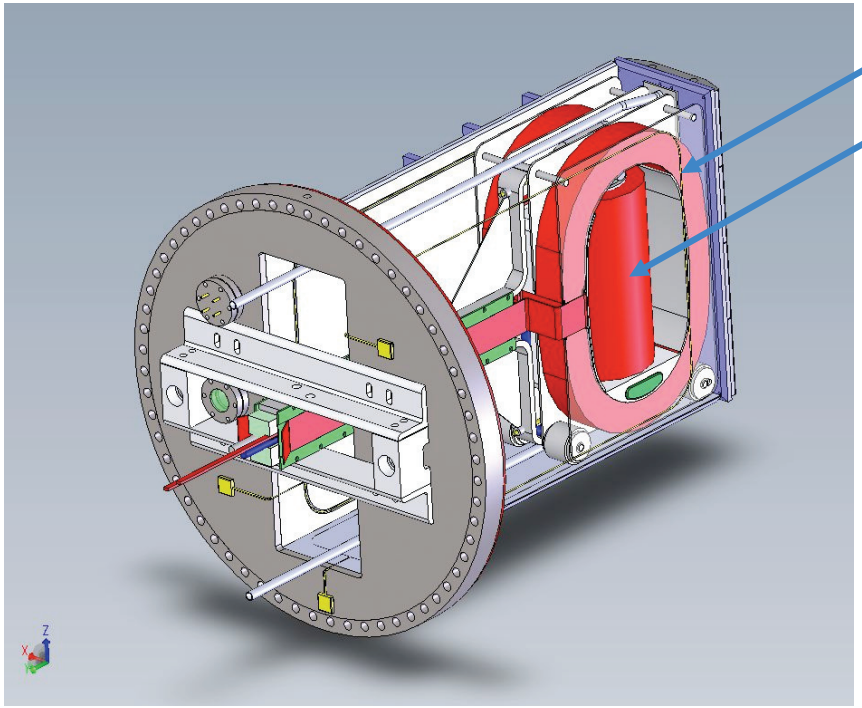
- **The midplane port**
  - The FULL rectangular opening is close to a scaled ITER equatorial port
  - Actual DIII–D port has intrusions from TF-coil hardware





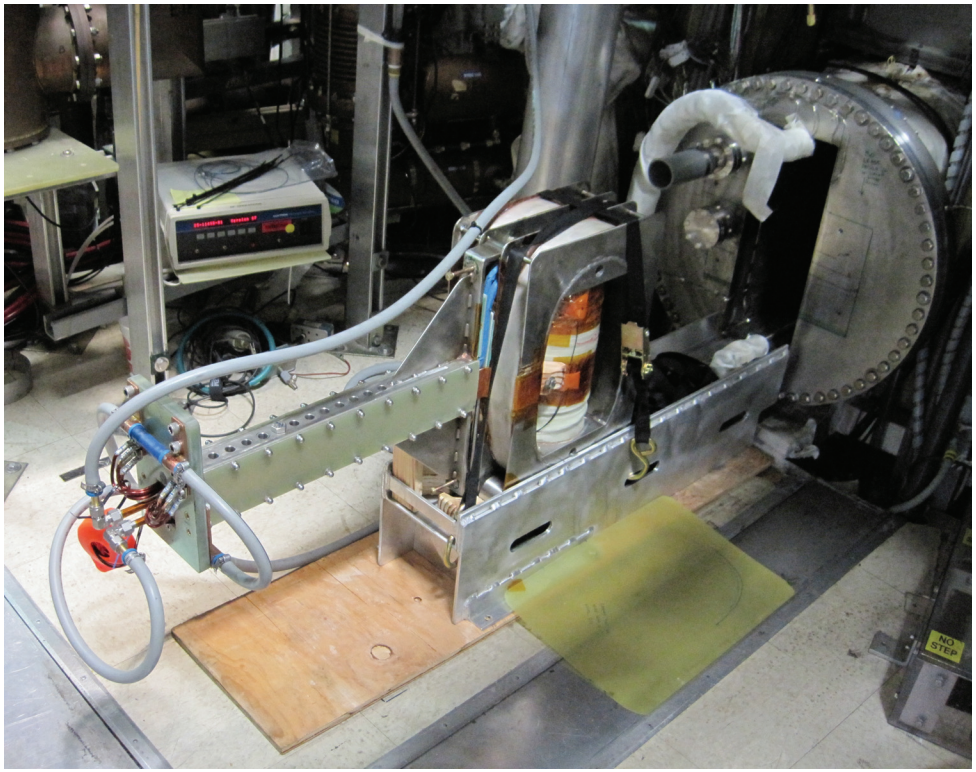
# TBM Mockup Is Designed to Approximate Two ITER TBMs in One ITER Port

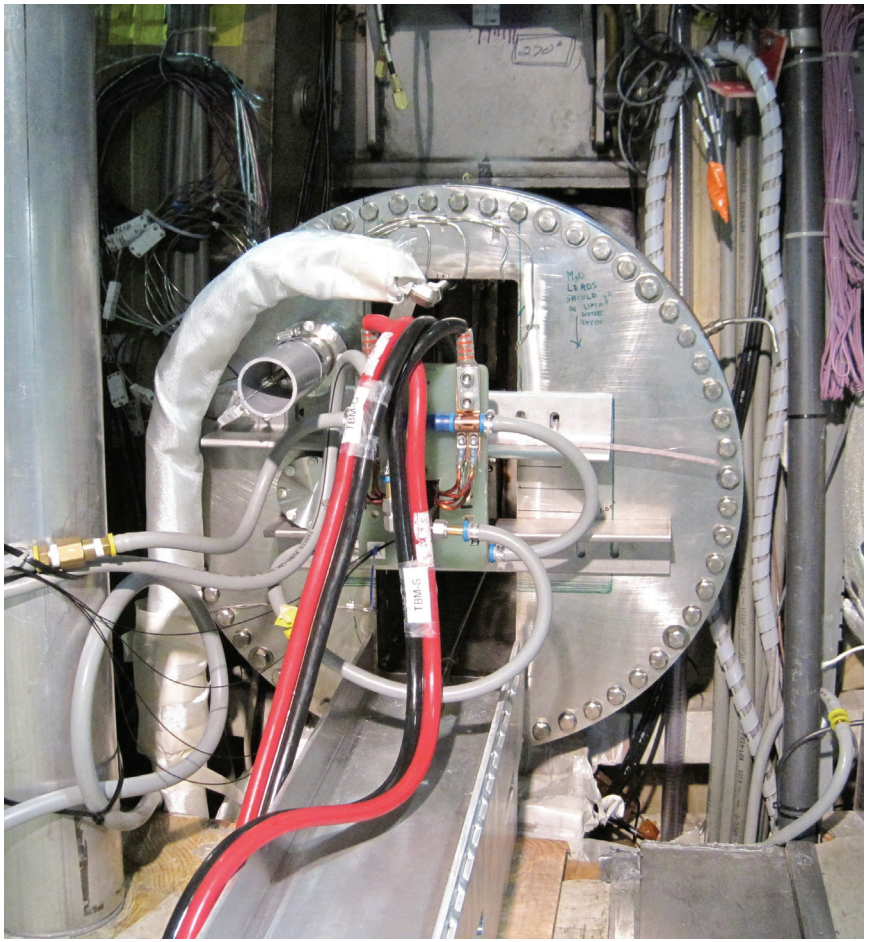


- **Racetrack coil pair for $\Delta B_{TOR}$**
  **Vertical solenoid for $\Delta B_{POL}$**
  - Two separate power supplies for experimental flexibility
- **Matches ITER TBM far field**
  - Cannot match near field in detail
- **Moveable, $\Delta R \approx 1.0$ 'ITER meter'**
  - To model TBM retraction
- **Mockup capable of ~3x ITER $\Delta B/B$**
  - Can match surface-average amplitude of 6 ITER TBMs
  - Cannot match their spectrum
- **5 magnetic loops to measure plasma response**

# TBM Mockup Assembly at DIII–D

**Mockup on stand, cooling water attached**





**Mockup inserted into port**

# Finally …

- **Mockup coils have been power tested and are ready for experiments**
- **TBM experiments are planned for the two weeks, 2009 Nov. 9–20**
  - Allocated 4 run days of 12 hours each
  - Additional time as requested and approved by the director