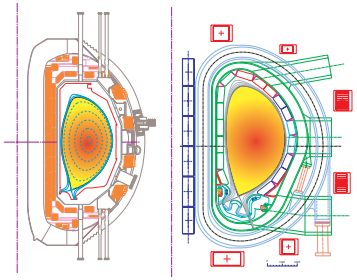
Overview of Recent DIII-D Experimental Results

by

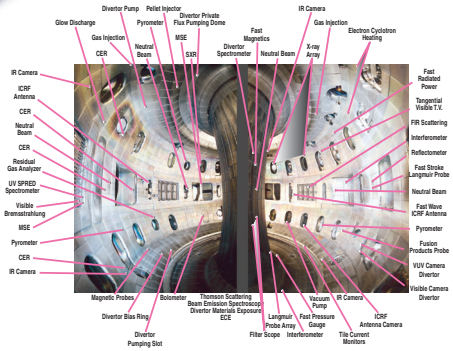
M.R. Wade

International Research Team

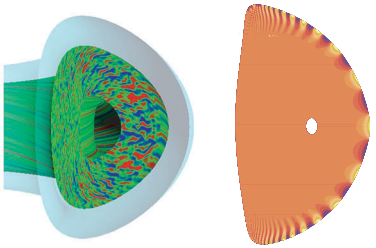
Scientific Flexibility
DIII–D is 1/4 Scale ITER



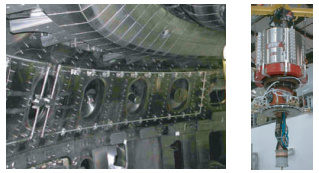
Physics Measurements

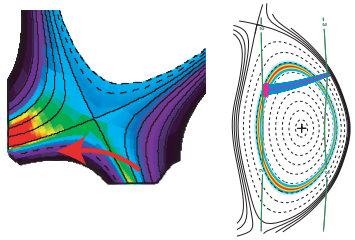


Theory and Simulation

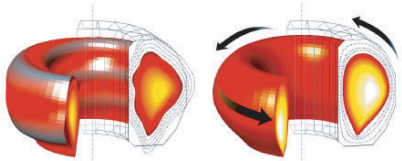


Plasma Control





Scientific Breakthroughs



Unstable Stable

Presented at
Forty-Seventh Annual Meeting
American Physical Society
Division of Plasma Physics
Denver, Colorado

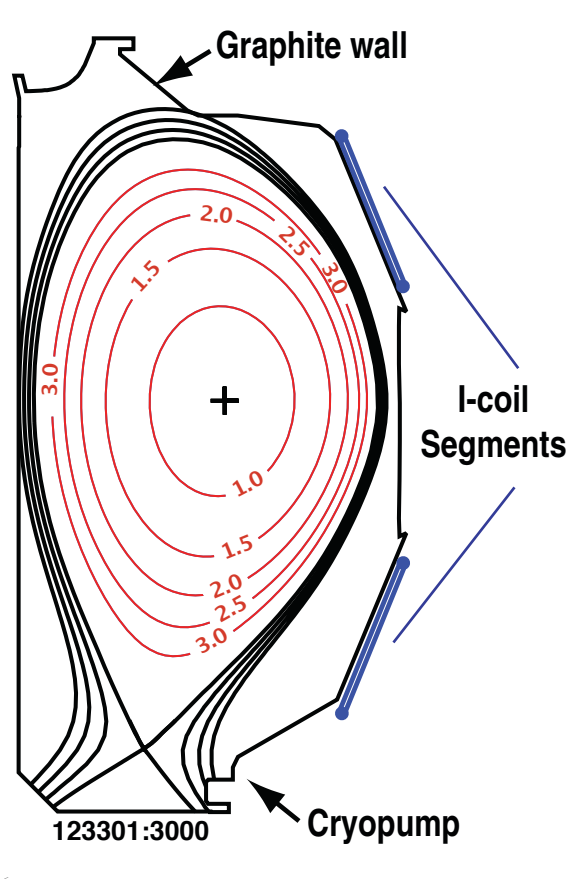
October 24–28, 2005

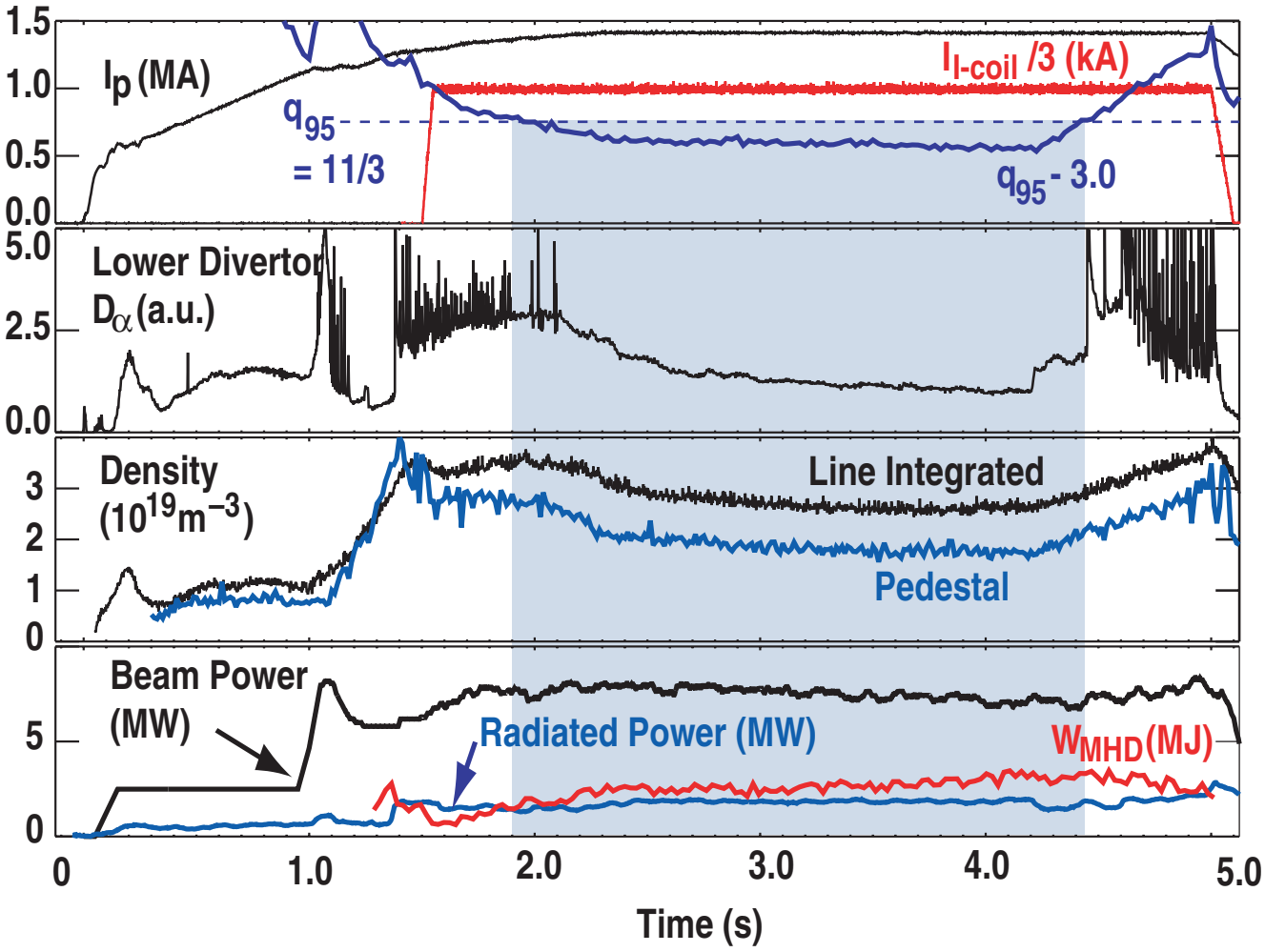
The 2004–2005 DIII-D Experimental Campaign Advanced the Understanding and Solutions of Key ITER and Fusion Science Issues

- **In order to accomodate a one-year upgrade period in 2005–2006, the 2004 and 2005 experimental operating periods were run contiguously (March 04–April 05)**
  - Total of 34 weeks of plasma operations completed
- **Scientific advances were made on a broad front**
  - Provided critical information on design issues for ITER
    - ELM suppression
    - Disruption mitigation
    - NTM stabilization
    - Carbon migration
  - Demonstrated existence proof and improved the physics basis for advanced operating regimes in ITER
    - Fully non-inductive, moderate β (β_N = 3.5) operation
    - Sustained, high β operation (β_N = 4 for 2 s)
    - Stationary, long-pulse hybrid operation
  - Produced seminal contributions in various areas of fusion science

Complete ELM Suppression Using n=3 Magnetics Pertubations Has Been Demonstrated at ITER Relevant Collisionality

Evans, Tues. AM
Moyer, This Session



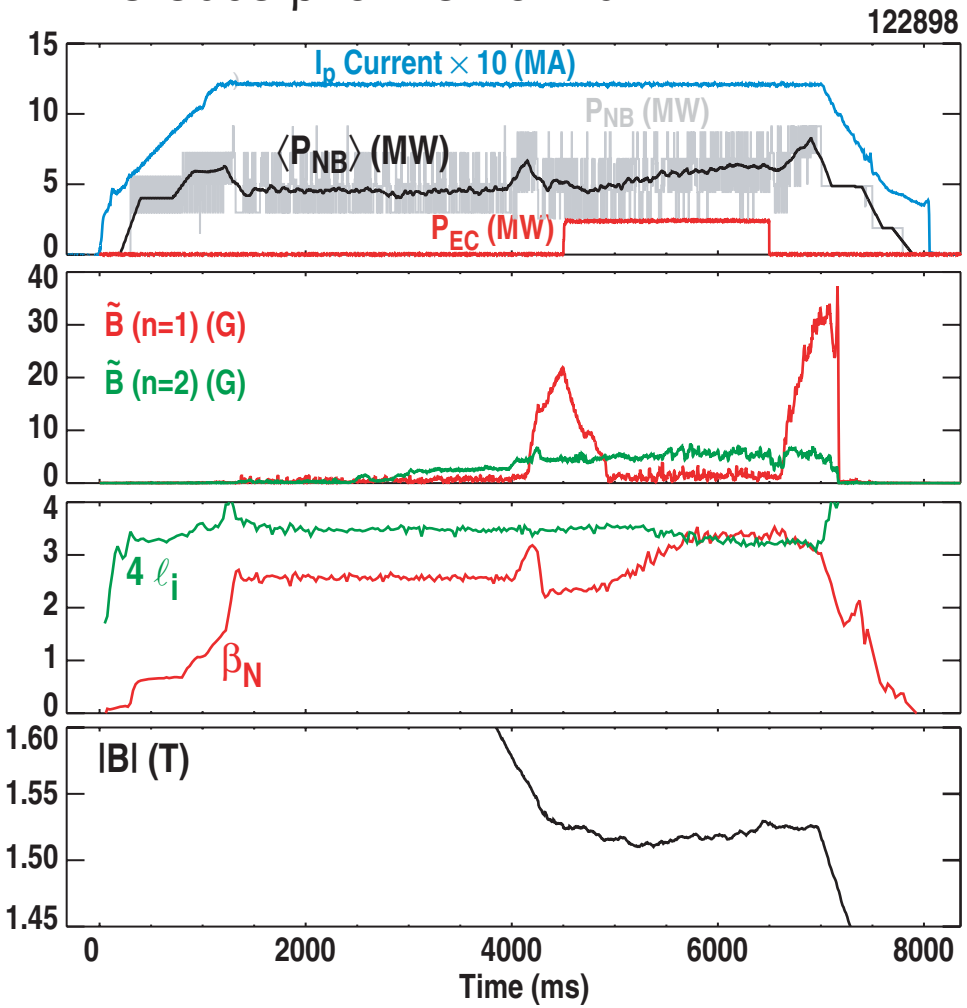


⇒ **Potential for solving ELM heat pulse issue in ITER**

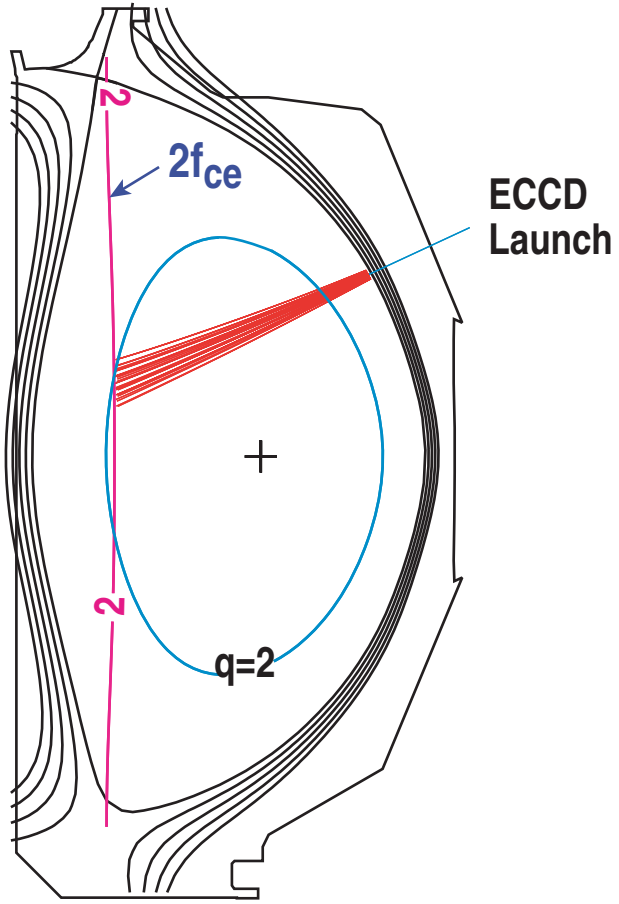
DIII–D Experiments Have Demonstrated the Ability to Suppress 2/1 Tearing Modes Using ECCD

La Haye, This Session
Humphreys, Wed. PM

- Post-onset suppression and then increase β to the no-wall limit



- ECCD aimed at q = 2 surface



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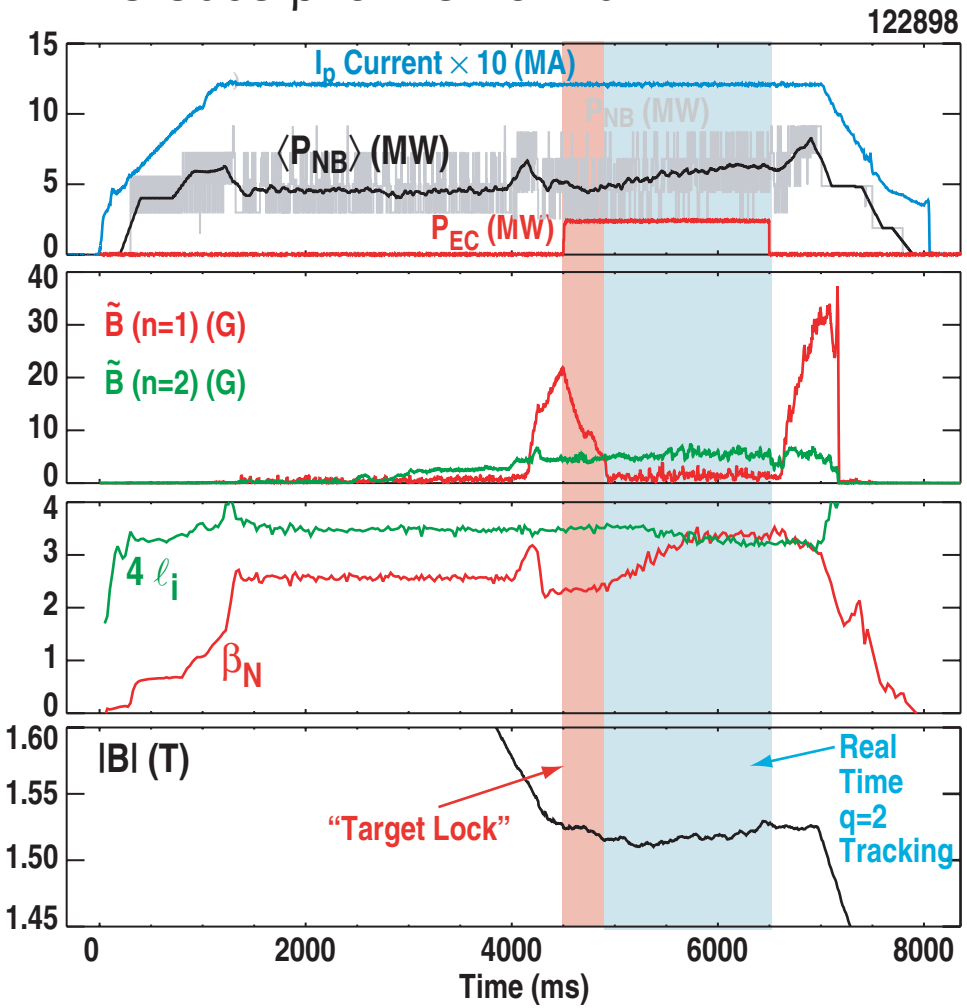
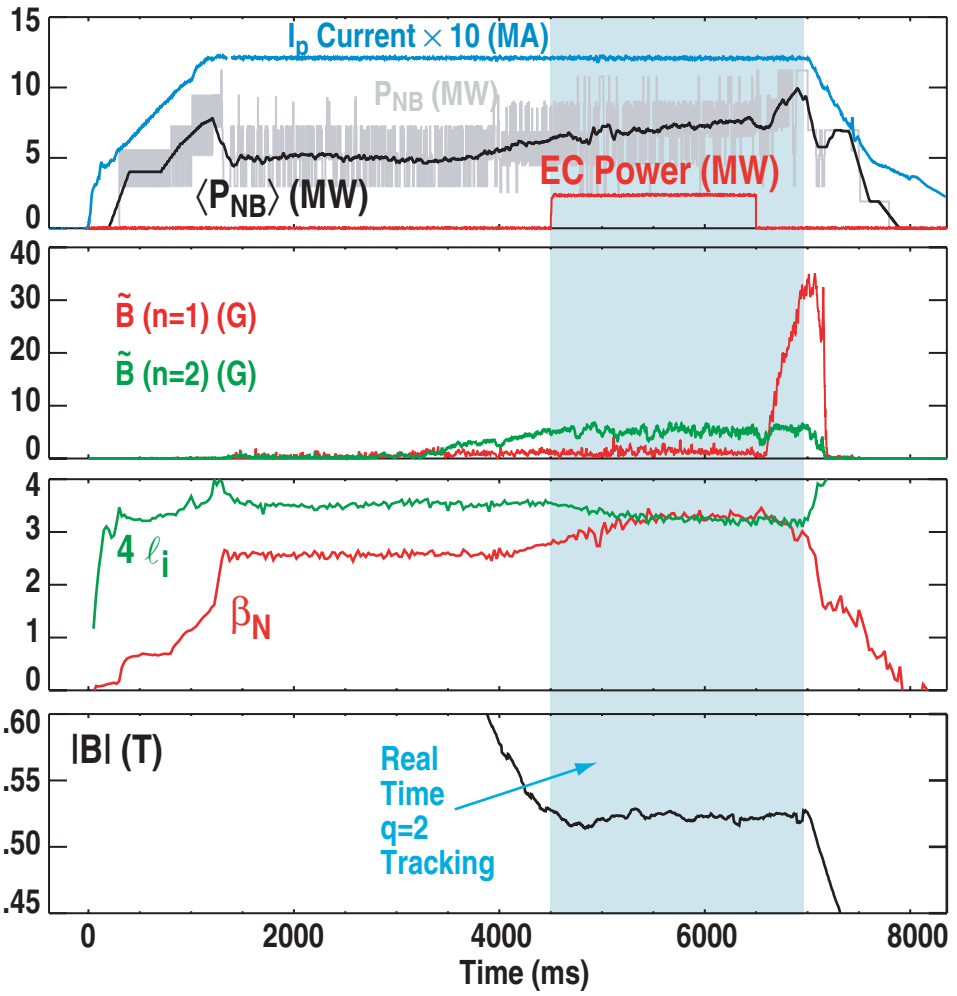
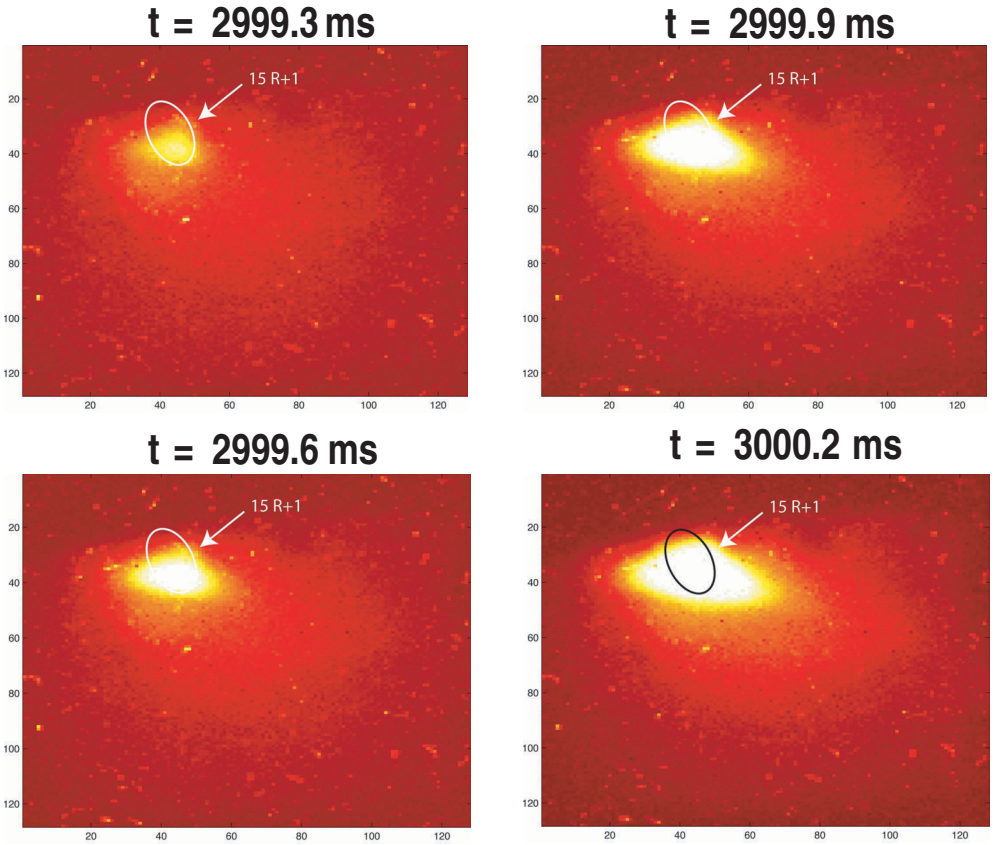


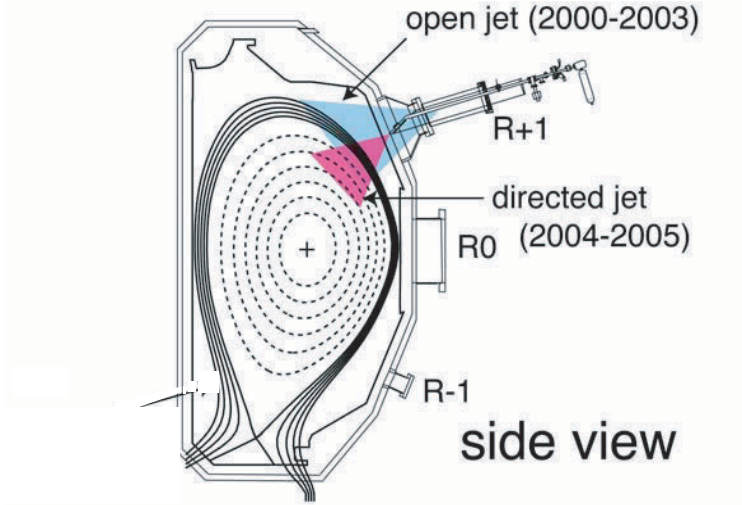
- **Pre-emptive avoidance while raising β to the no-wall limit**

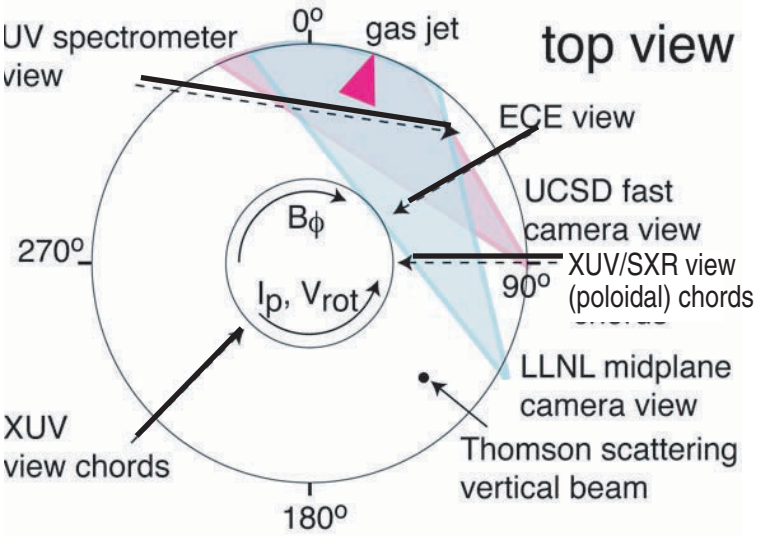


DIII-D Experiments are Developing the Physics Basis for Disruption Mitigation in ITER

- **Fast camera measurements indicate little impurity neutral penetration**







- **Confirm very little neutral penetration**

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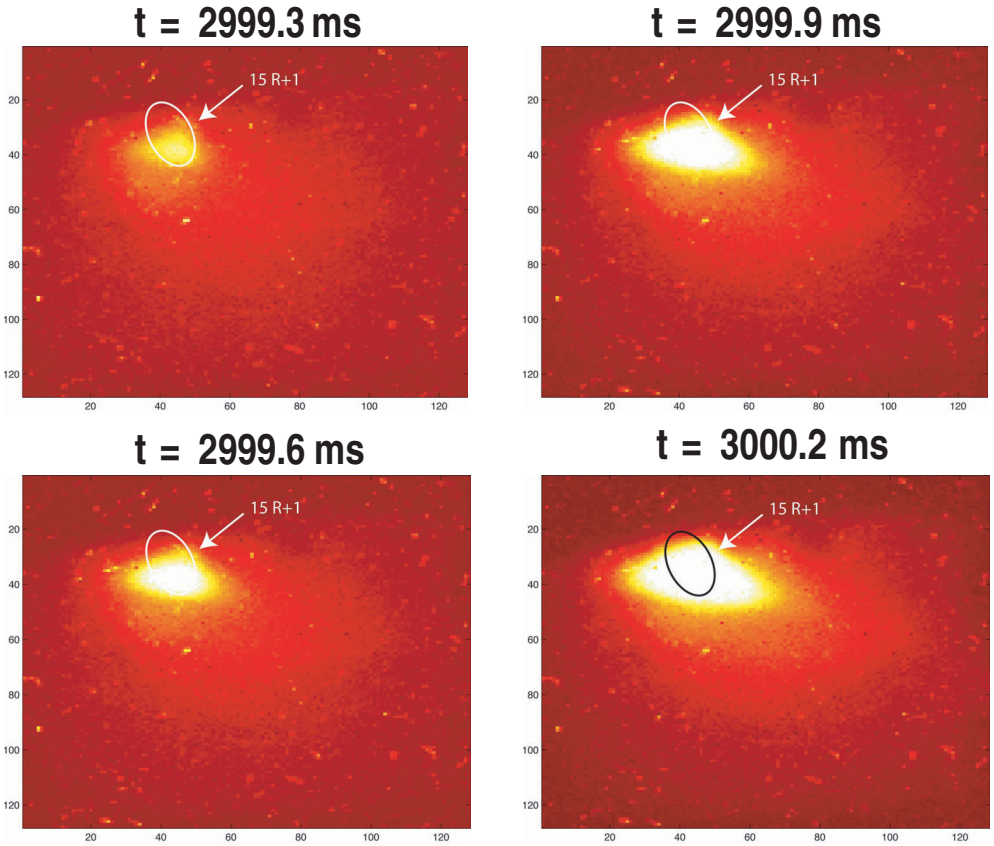
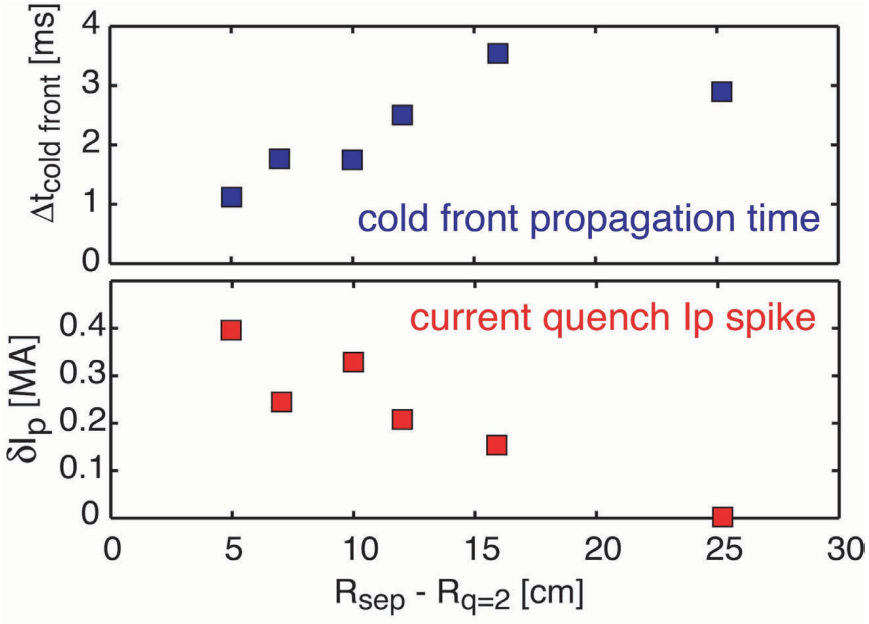


- **Relative depth of q = 2 is important in thermal quench**

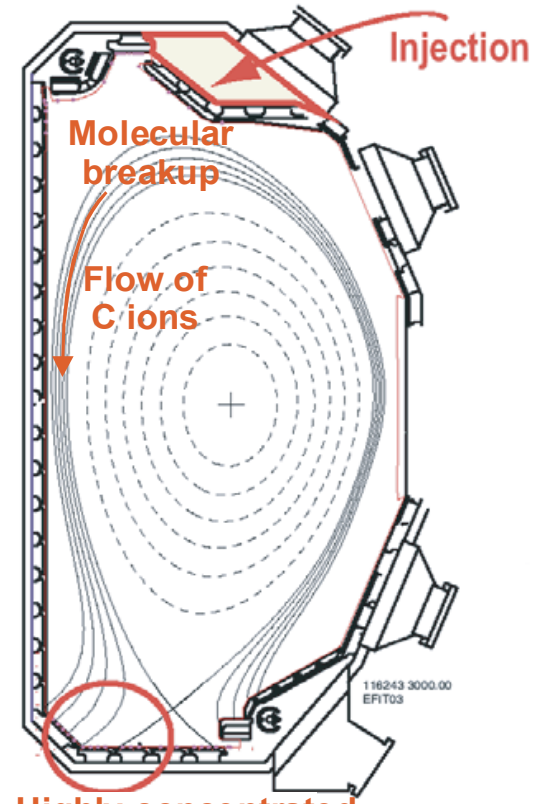


⇒ **MHD mixing appears to be important in impurity penetration**

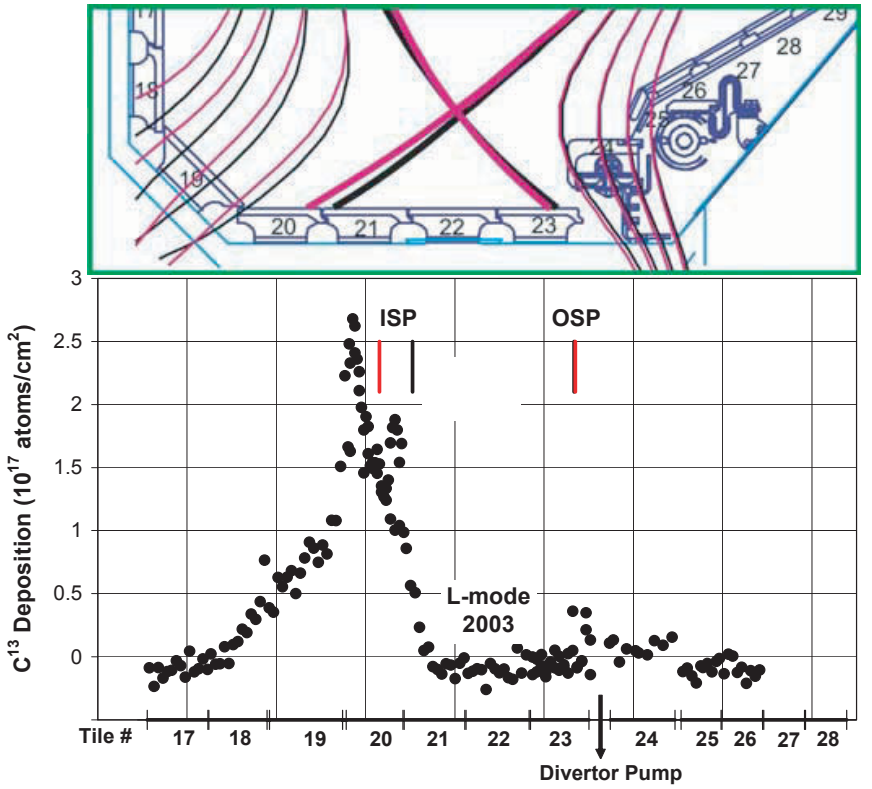
- **Confirm very little neutral penetration**

$^{13}CH_4$ Injection Experiments Demonstrate that Strong SOL Are Addressing Tritium Uptake Via Carbon Redeposition in ITER

McLean This Session



$^{13}C(^3He,p)^{15}N$ nuclear reaction analysis
W.R. Wampler, Sandia National Laboratories



- H-mode data indicates substantial deposition in private flux region

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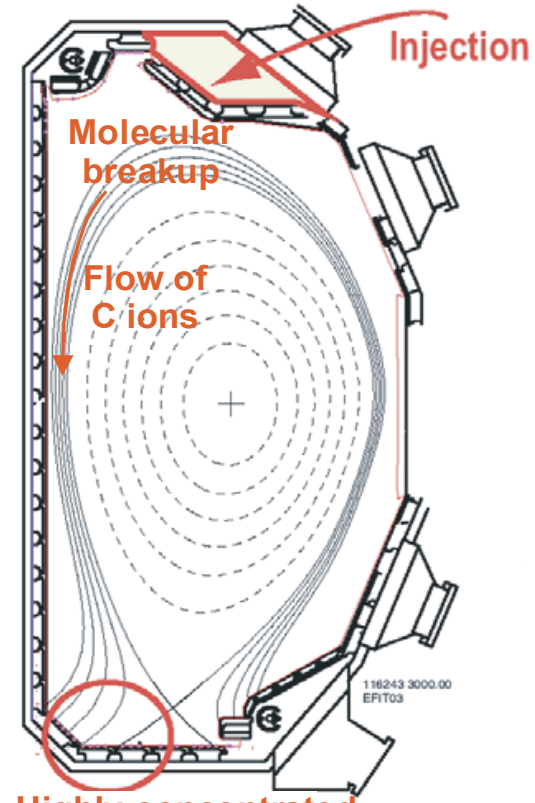
McLean This Session



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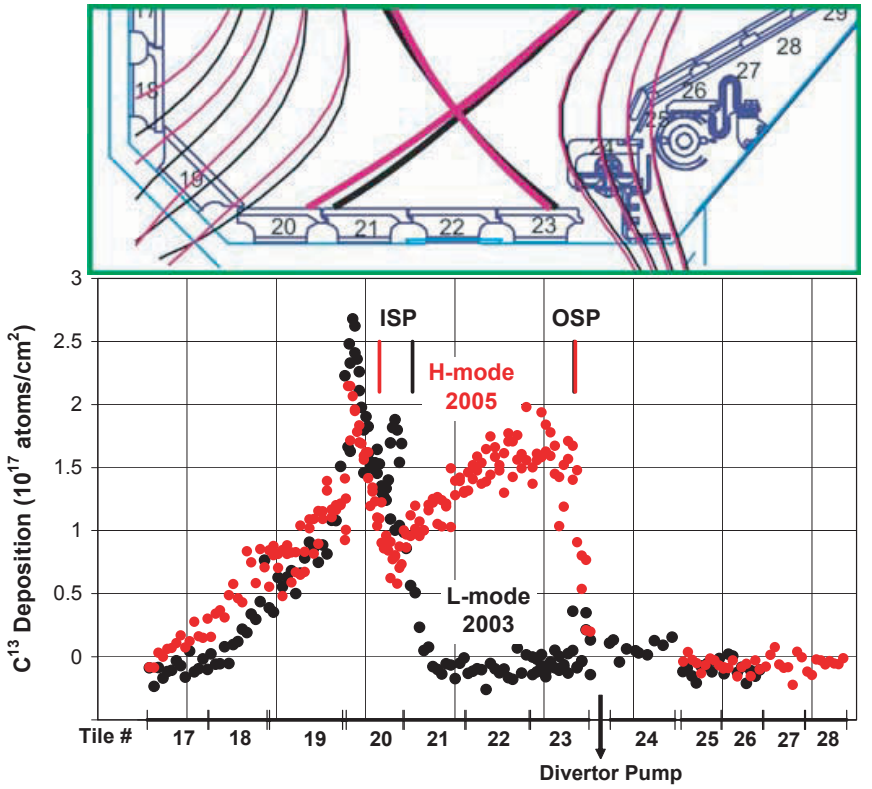
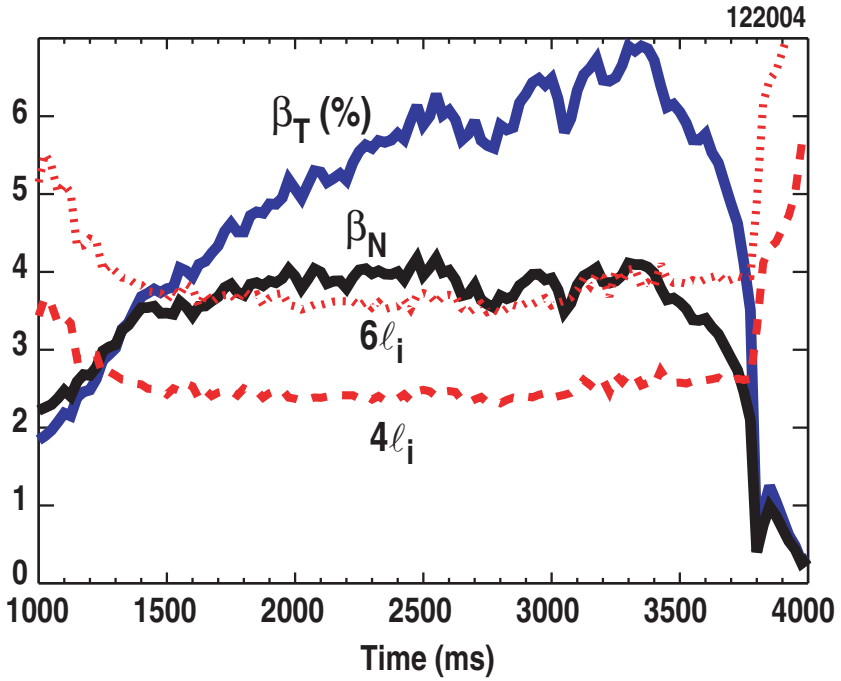


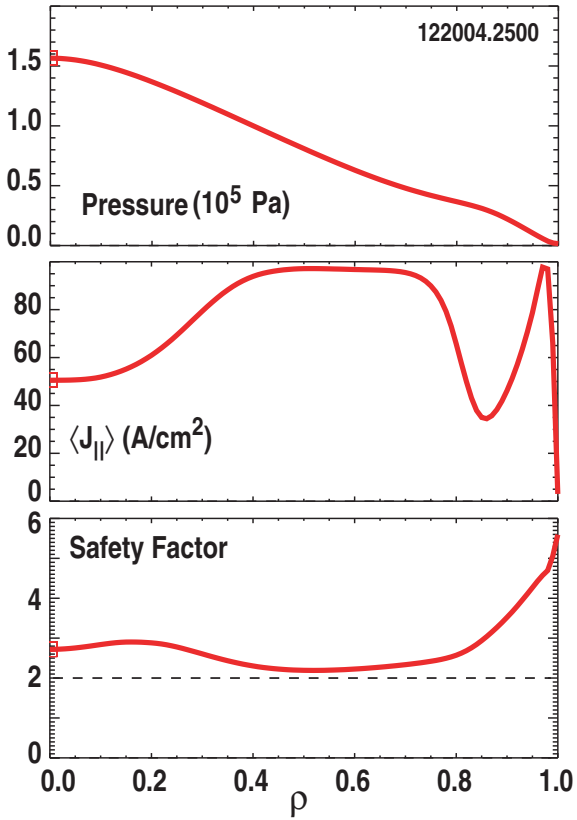
- H-mode data indicates substantial deposition in private flux region

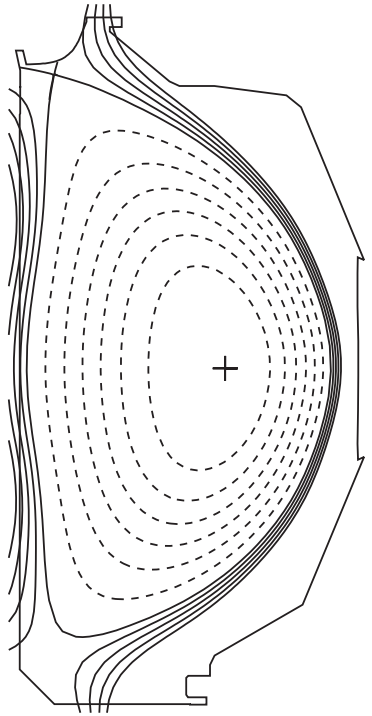
RWM Stabilization Has Opened Up Possibility of Sustained Opeartion Approaching the Ideal Wall Limit in ITER

Reimerdes, Tues. PM
Garofalo, Fri. AM

- **Optimization of current and pressure profile using**
  - ★ Simultaneous feedback control of error field and RWM
    - – Off-axis ECCD
    - – High triangularity shape
- **$\beta_N \approx 4$ (50% above n=1 limit) sustained for ~ 2 s**



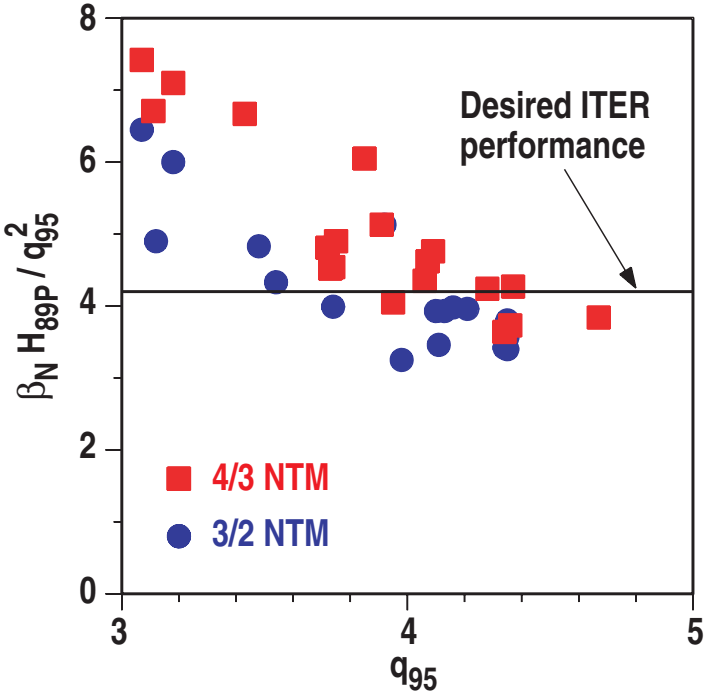


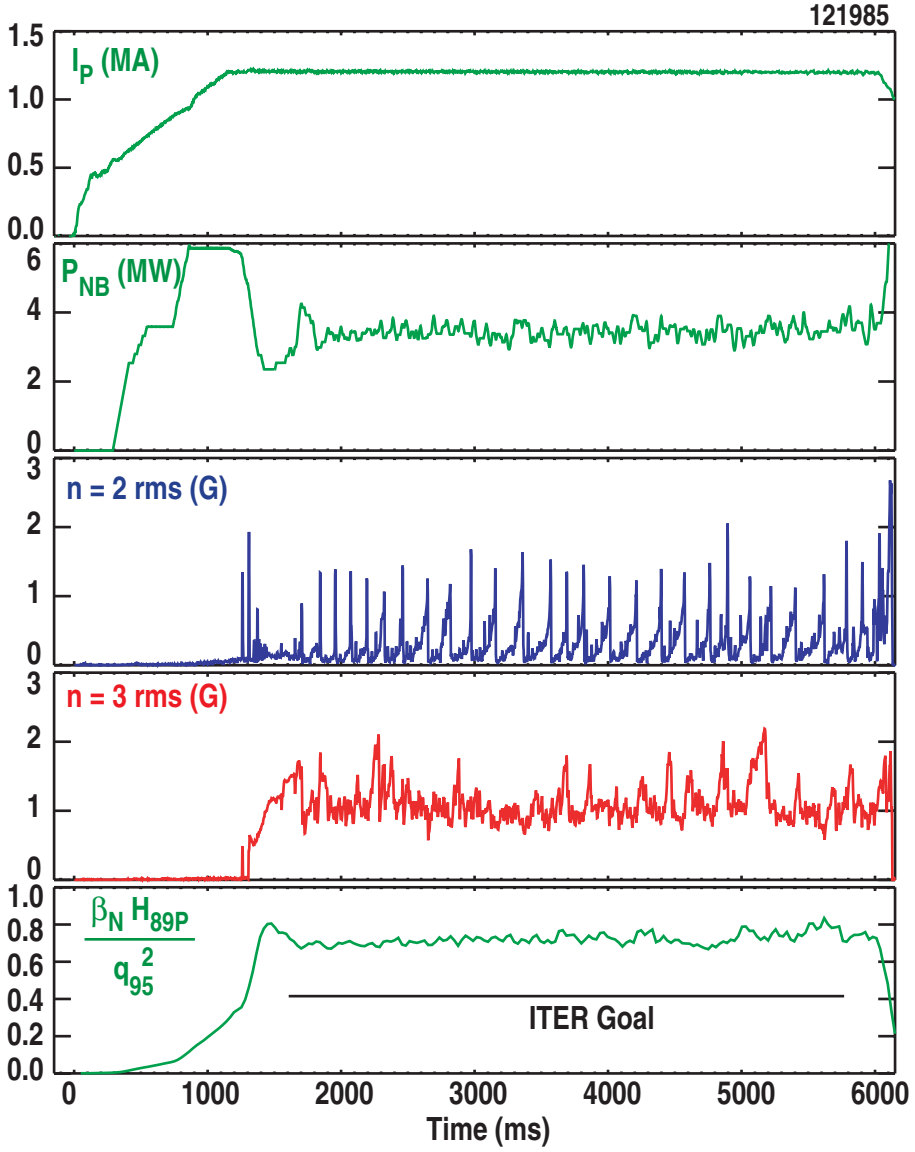


Hybrid Discharges with Dominant 4/3 NTM Offer Potential of Extremely High Performance in ITER

Petty,
This Session

- 30% improvement in confinement relative to 3/2 dominant cases
- In best case (q_{95} = 3.2) performance is 70% above desired ITER value

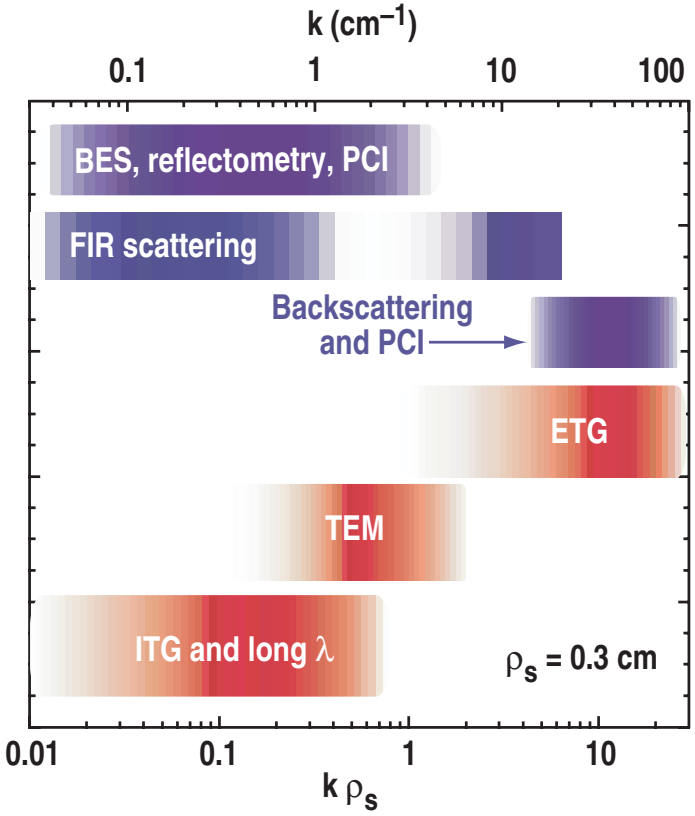




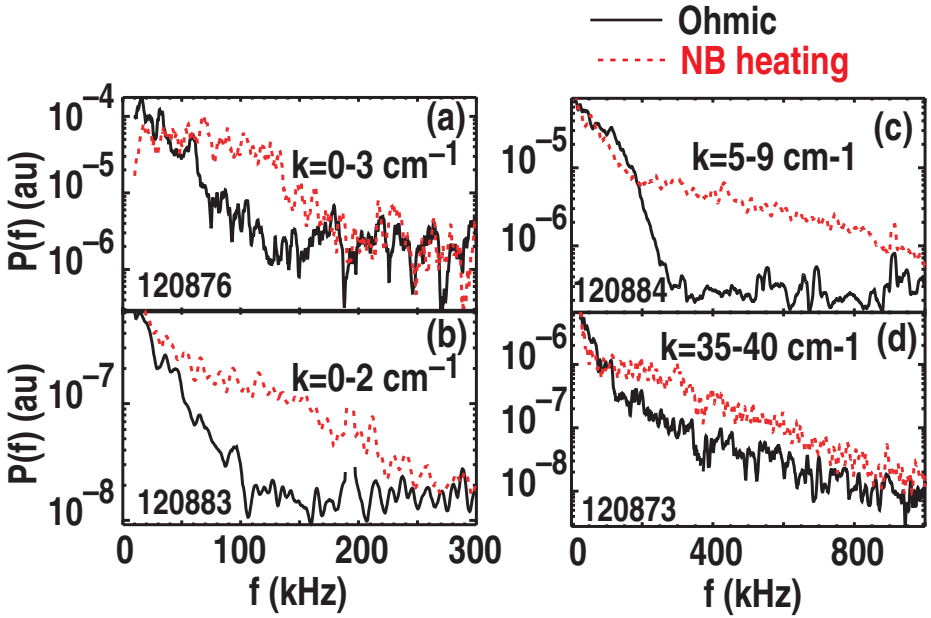
Ability to Measure Fluctuations at At All Relevant Wavelengths Is Allowing Comparisons with Theory

Rhodes, This Session

- Turbulence diagnostics now cover all relevant spatial scales

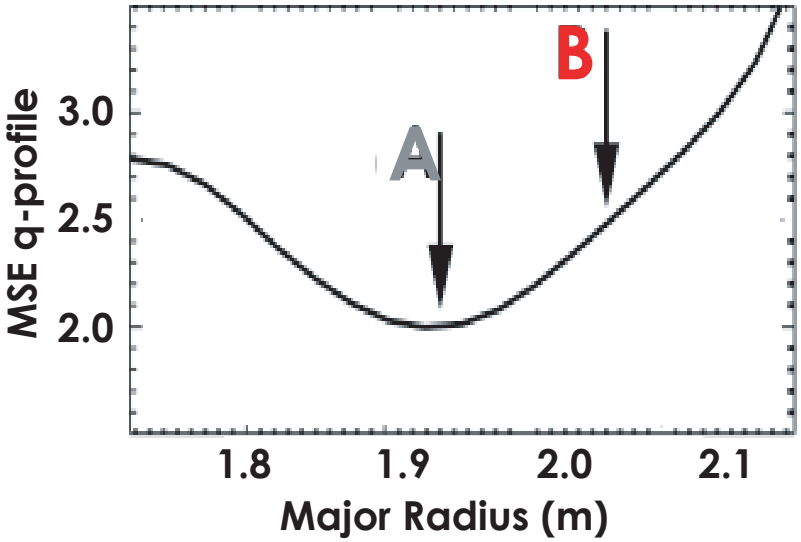


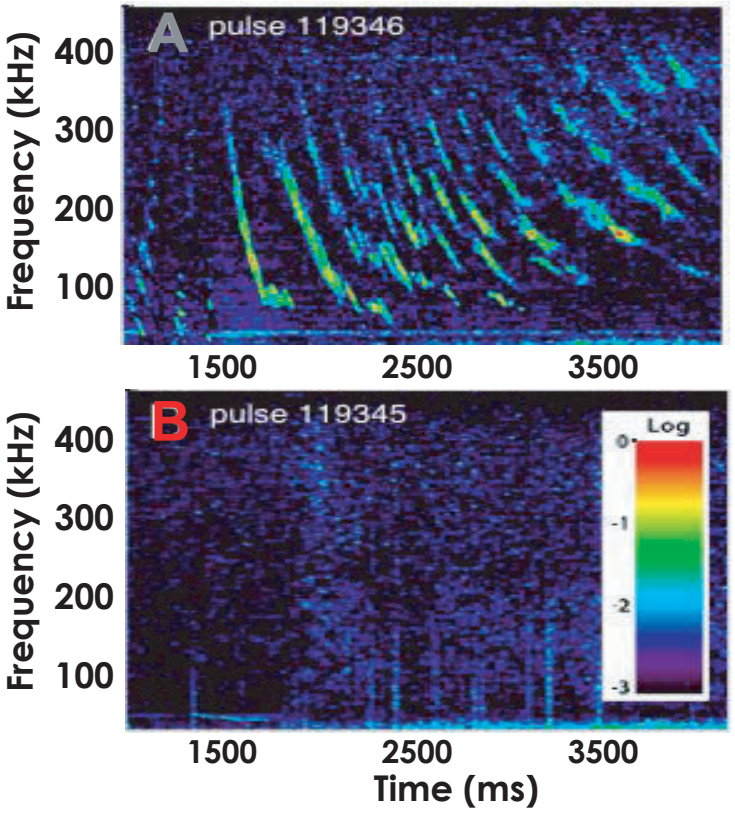
- Increase in fluctuations observed at all wavelengths when heating is applied



- Initial comparisons to linear stability calculations (GKS) show consistencies between data and theory

Localized Fluctuation Measurements Also Allow Characterization of Alfvén Eigenmodes



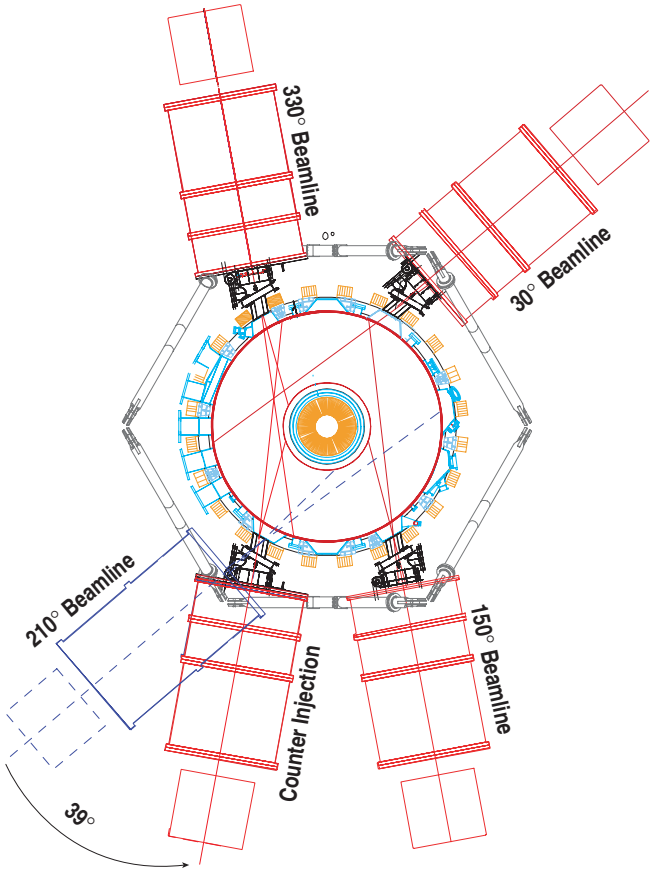


- BES measurements confirm high-n reversed shear Alfvén eigenmode structure is localized near q_{min}

DIII–D Versatility and Capability Will be Greatly Enhanced by Several Hardware Modifications/Upgrades

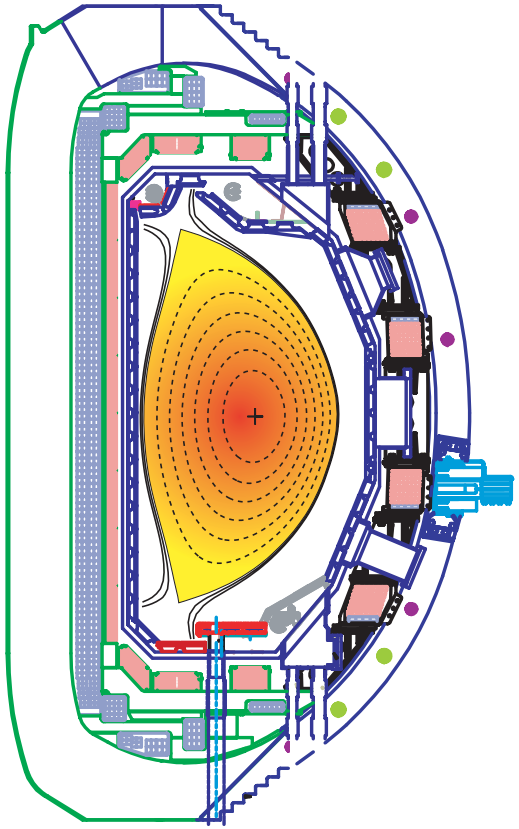
Tooker, This Session

- **Reorientation of beamline**



⇒ **Rotation control**

- **Lower divertor modification**

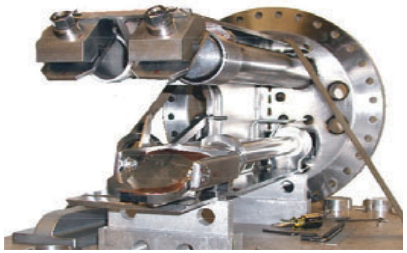


⇒ **Density control in double null plasmas**

- **EC upgrades**

6 gyrotrons –4.5 MW for 10 s

All steerable toroidally and poloidally



⇒ **J(p) control, NTM stabilization, electron transport**

Experiments Will Resume in Spring 2006

- **Based on input from the scientific staff, the DIII–D Research Council has identified the following thrusts for 2006**
  - **Advanced scenario develoment**
  - **ITER Hybrid scenarios**
  - **ELM control for ITER**
  - **RWM control for ITER**
  - **NTM control for ITER**
  - **Pedestal width physics**
- **As in the past, a significant portion of the DIII–D research program will be devoted to basic science studies in the following Topical Science Areas:**
  - **Transport**
  - **Stability**
  - **Boundary**
  - **Heating and current drive**
- **DIII–D research opportunities forum: November 15–17, 2005**
  - Proposal submission is web based
    http://fusion.gat.com/exp/2005/forum.html
  - Run-time allocation announced in December 2005
- **Proposals are encouraged from all individuals and institutions on any topic**

DIII–D Presentations at this Meeting

Review:

NTM Physics and Control	R. LaHaye	Tues. AM

Invited:

Core Barrier Formation at Integer q Surfaces	A. Austin	Mon. PM
ELM Control by Magnetic Perturbations	T. Evans	Tues. AM
Resistive Wall Mode Stabilization	H. Reimerdes	Tues. PM
Tests of Neoclassical Poloidal Rotation	W. Solomon	Wed. AM
NTM Stabilization via Active Control	D. Humphreys	Wed. PM
Modeling of Localized Alfvén Eigenmodes	G. Kramer	Thurs. AM
Sustained High Performance with an Internal Transport Barrier	A. Garofalo	Fri. AM
Fully Non-Inductive, High Performance Plasmas	M. Murakami	Fri. AM

Posters:

Session CP1 – Mon. PM Session QP1 – Thurs. AM