Suppression of large edge localized modes with a stochastic magnetic boundary in high confinement DIII-D plasmas

Evans EX2-5Ra

Presented by

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EX/2-5Ra

20th IAEA Fusion Energy Conference

1-6 November 2004, Vilamoura, Portugal

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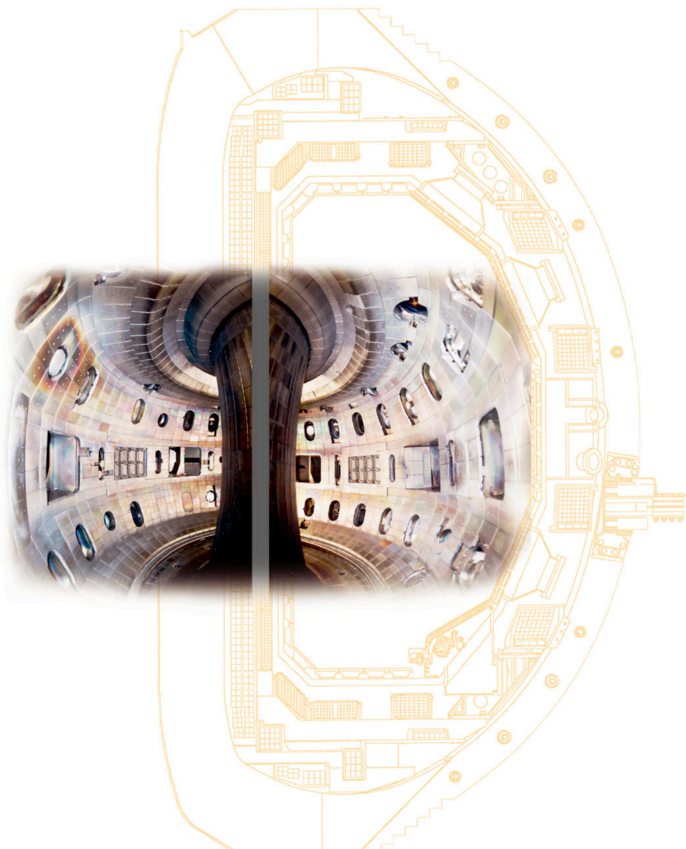
GENERAL ATOMICS

Structure, stability and ELM dynamics of the H-mode pedestal in DIII-D

Fenstermacher EX2-5Rb



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EX/2-5Rb

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DIII-D has made substantial progress on developing pedestal solutions for ITER

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ELM Suppression (EX/2-5Ra)*

- Type-I ELMs are suppressed with resonant magnetic perturbations
  - no confinement degradation
  - good suppression for $\Delta t \sim 9\tau_E$ (some isolated ELMs remain)
- A new type of dynamical state replaces Type-I ELMs
  - transport dominated by small, high frequency fluctuations
  - divertor surface temperature spikes reduced by at least a factor of 5

Fenstermacher EX2-5Rb

Pedestal Structure, Stability and Dynamics (EX/2-5Rb)*

- Structures resembling Peeling-Ballooning modes observed in CIII
- Neutral penetration physics dominates in setting n_e pedestal width
- Measured edge currents agree with NCLASS code

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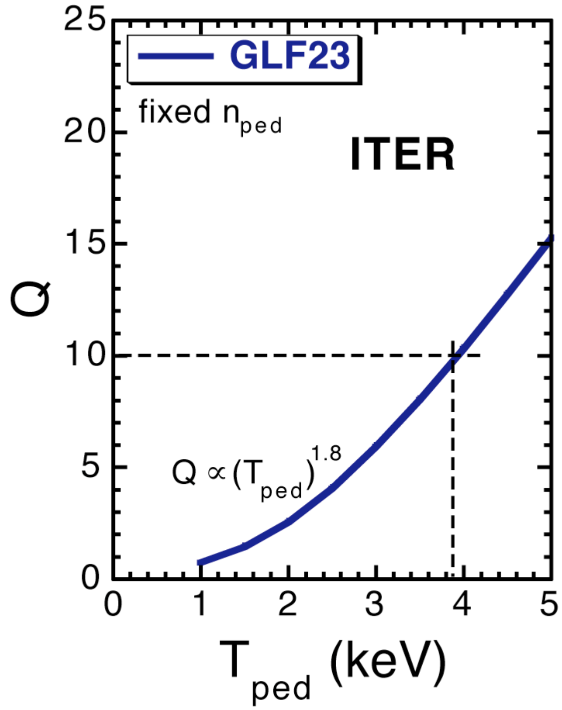
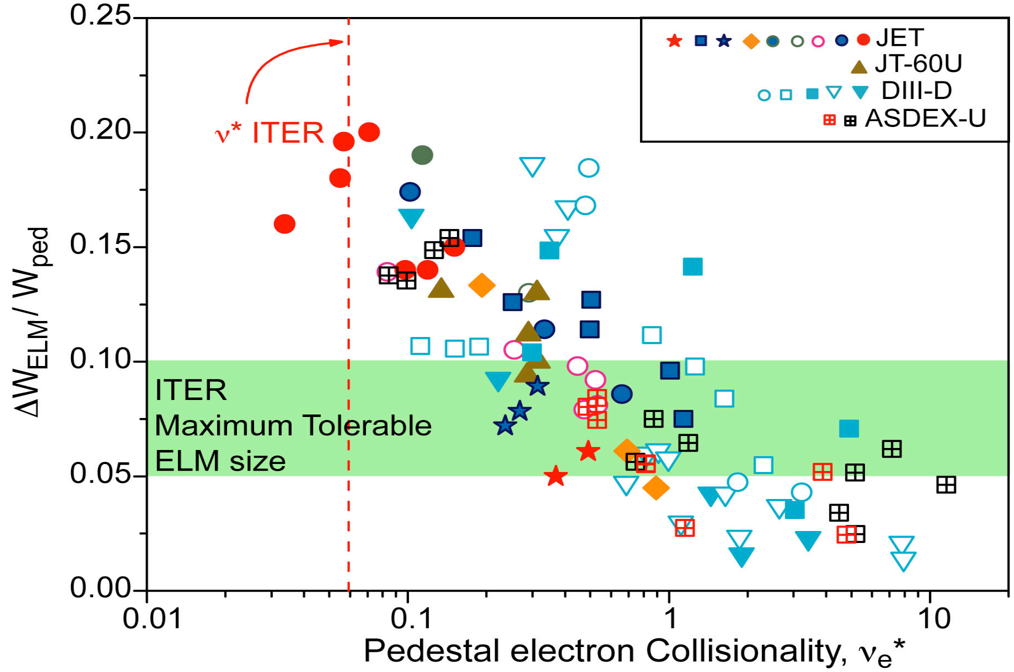
*See posters Wednesday morning

ELM control is a high priority ITER issue

Evans EX2-5Ra

- $T_e^{ped} \geq \sim 4$ keV for $Q \geq 10$ in ITER





- Normalized ELM energy ($\Delta W_{ELM}/W_{ped}$) increases with T_e^{ped}
- In ITER $\Delta W_{ELM}/ W_{ped} > 20\%$
  - exceeds carbon ablation limit by a factor of 2-4

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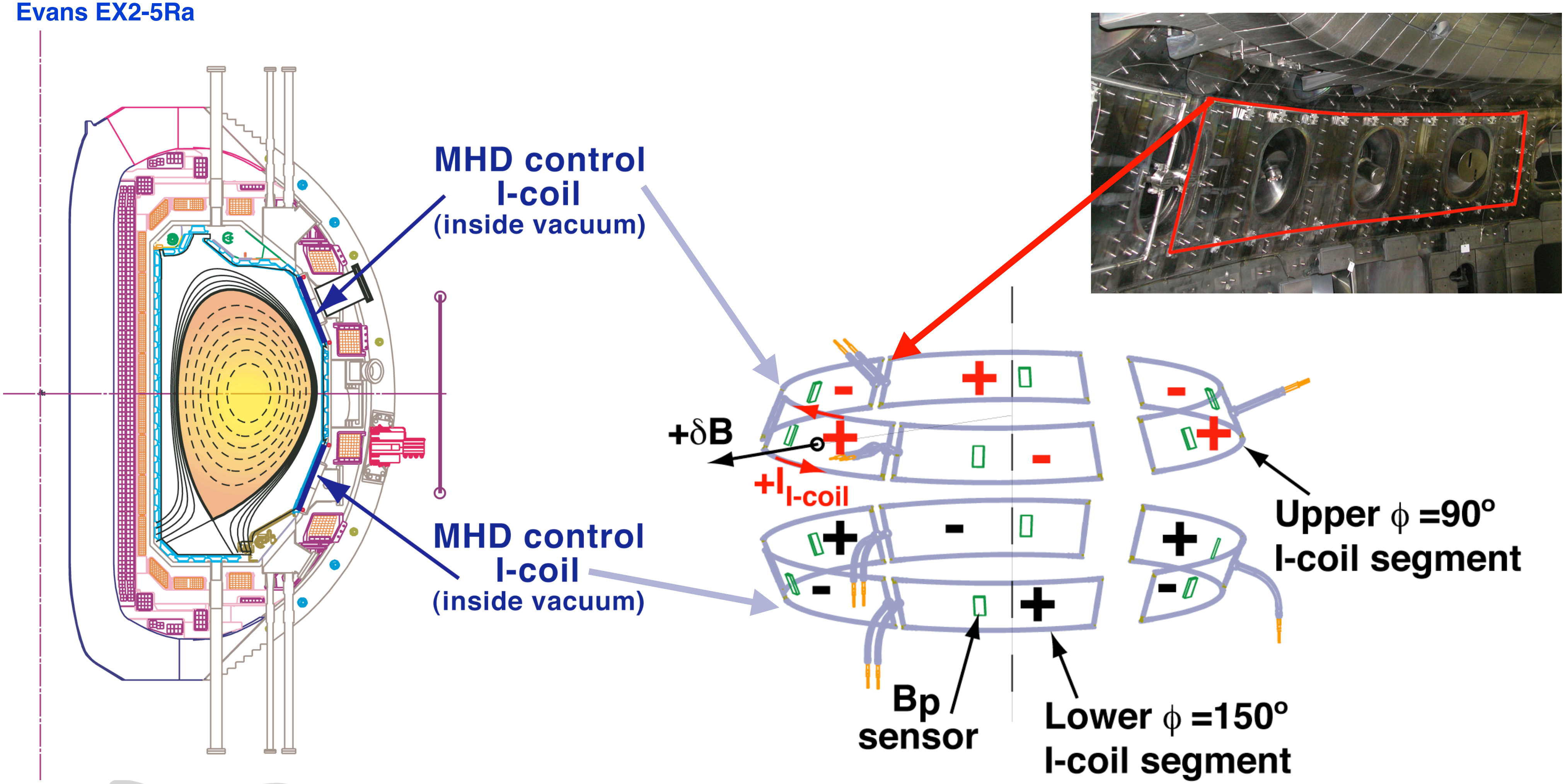
The DIII-D I-coil provides a flexible system for n=3 ELM control experiments

Evans EX2-5Ra



n=3 (odd up-down parity)

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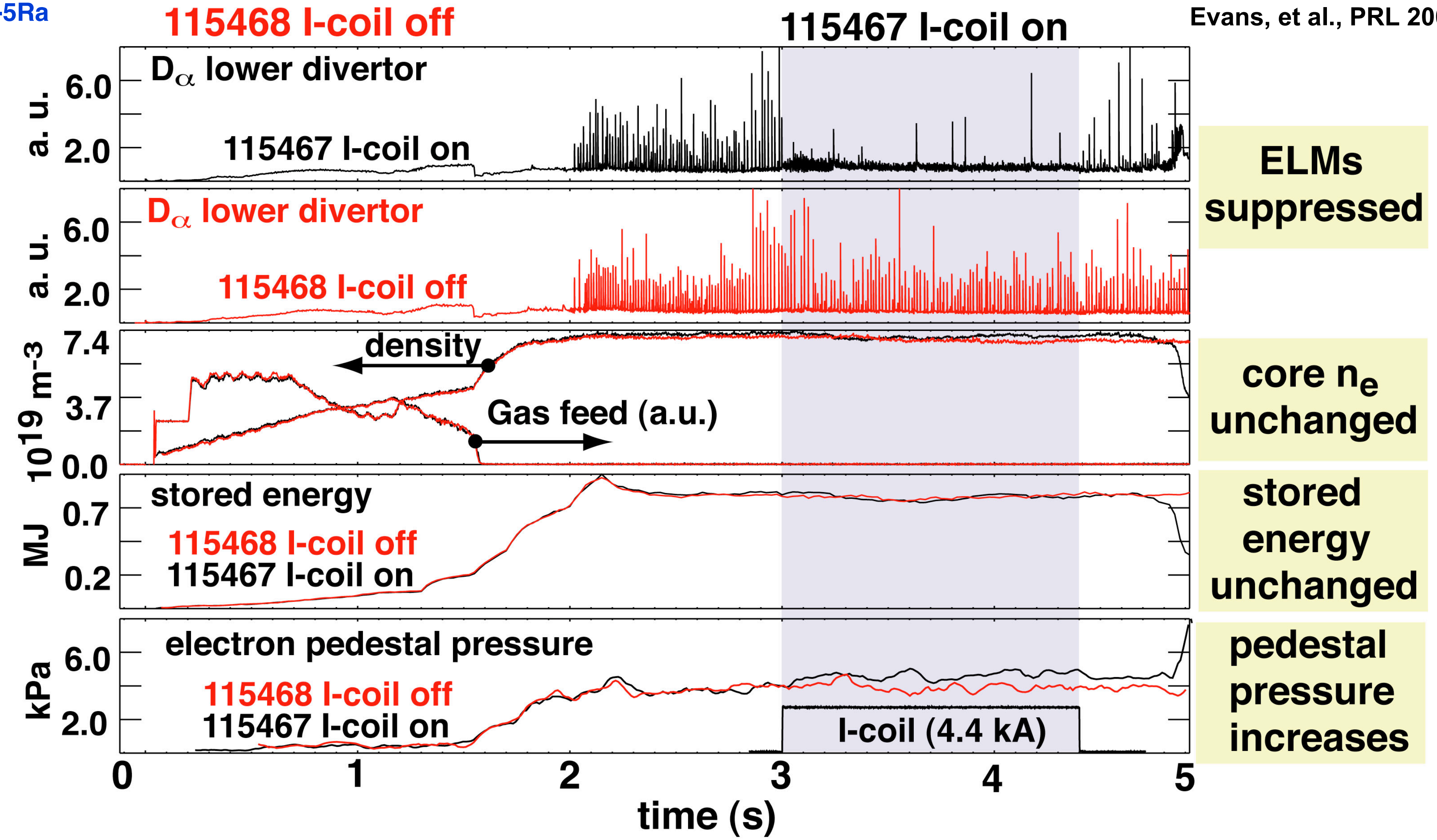
ELMs are suppressed without degrading confinement

Evans EX2-5Ra

Evans, et al., PRL 2004

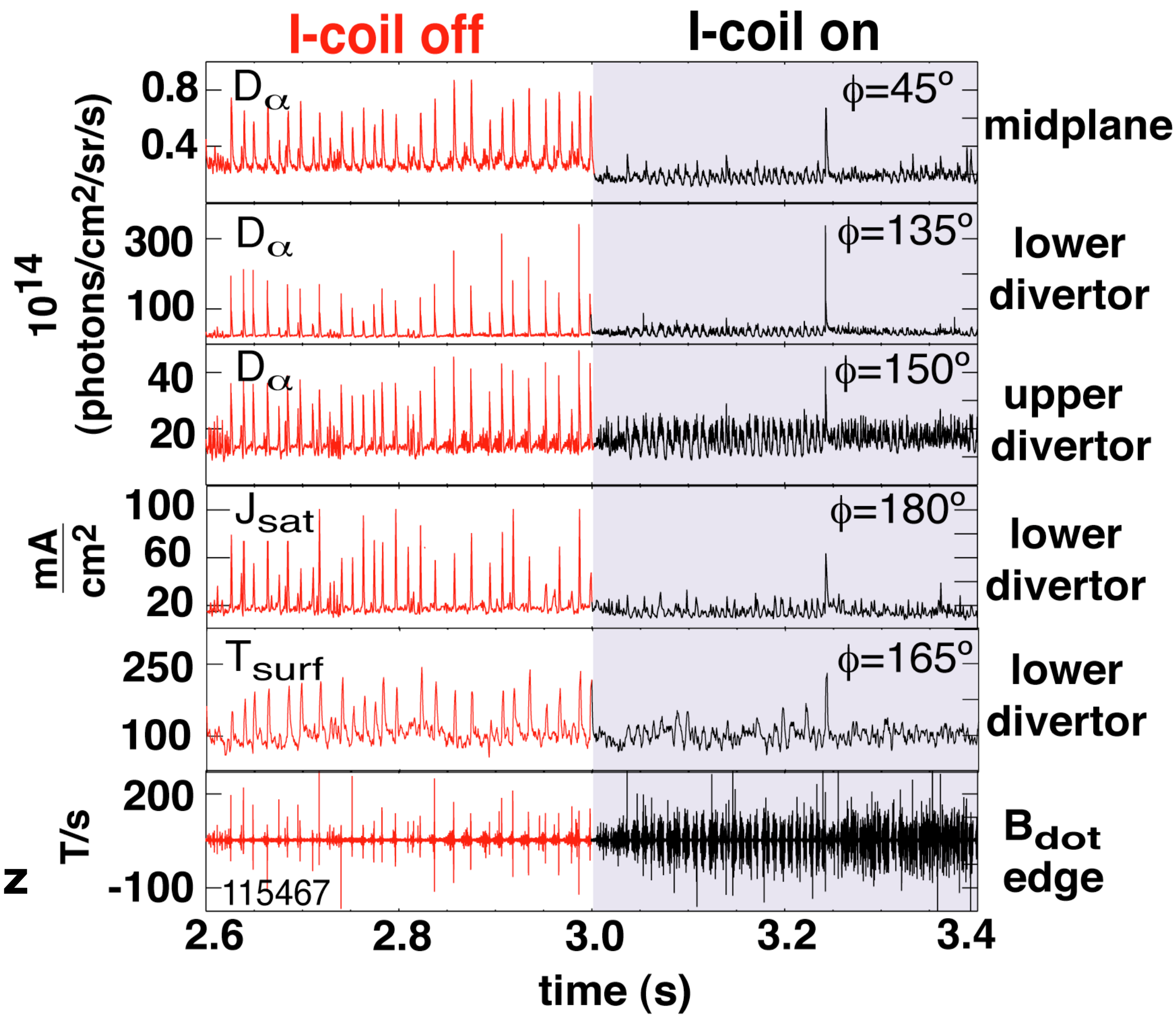


- Several isolated ELM-like events remain
- ELMs return after I-coil pulse turns off

Dynamical state of pedestal changes globally

Evans EX2-5Ra

- **Suppression seen on:**
  - all D_α arrays (outer midplane, upper and lower divertor, inner wall)
  - particle flux and heat flux to the primary (lower) divertor
- **ELM transport is replaced by an increase in the edge magnetic field and density fluctuations**
  - modulated by a 130 Hz coherent oscillation



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Stored energy drops are smaller and slower with the I-coil reducing the impulses by > 3X

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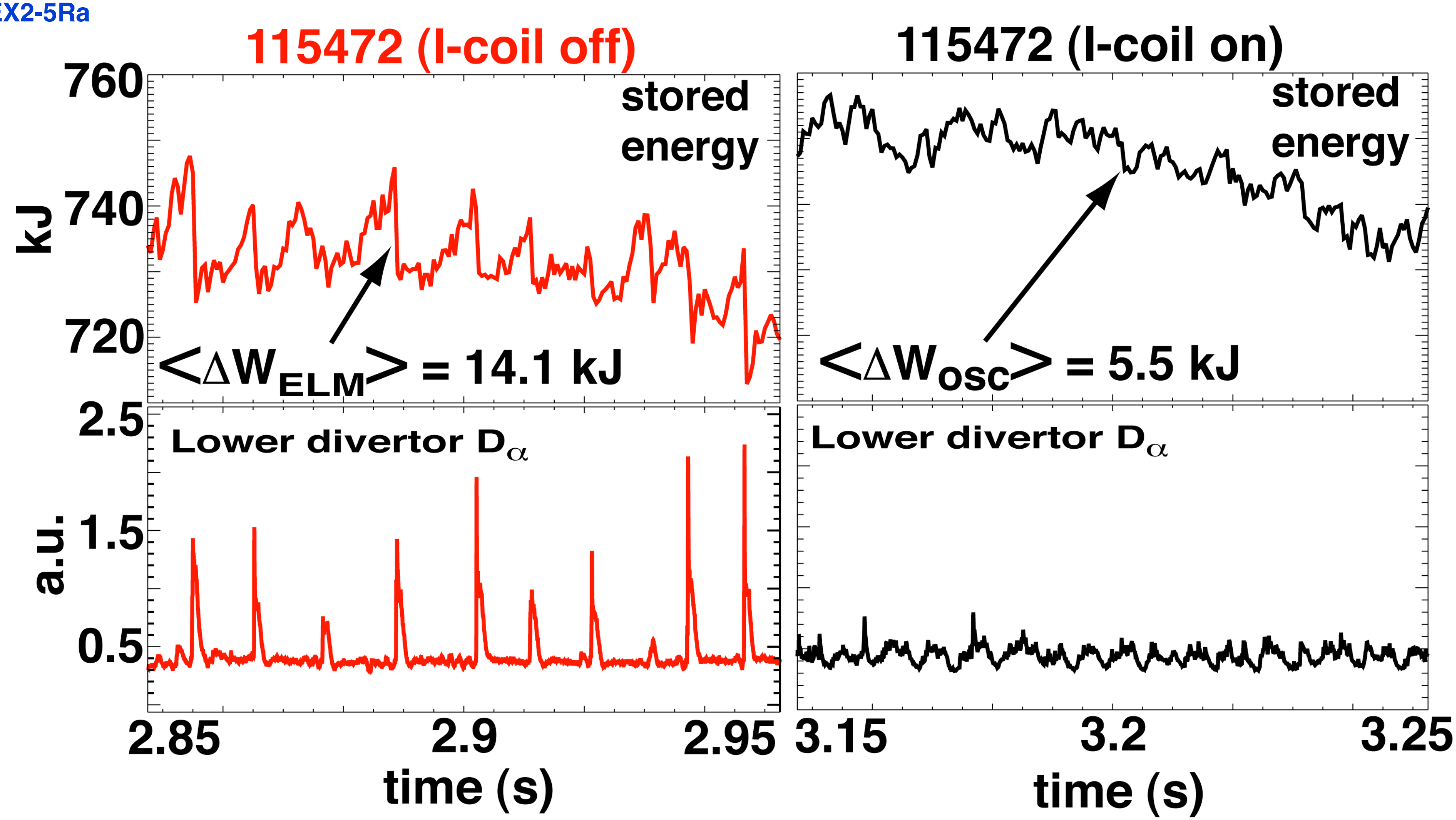

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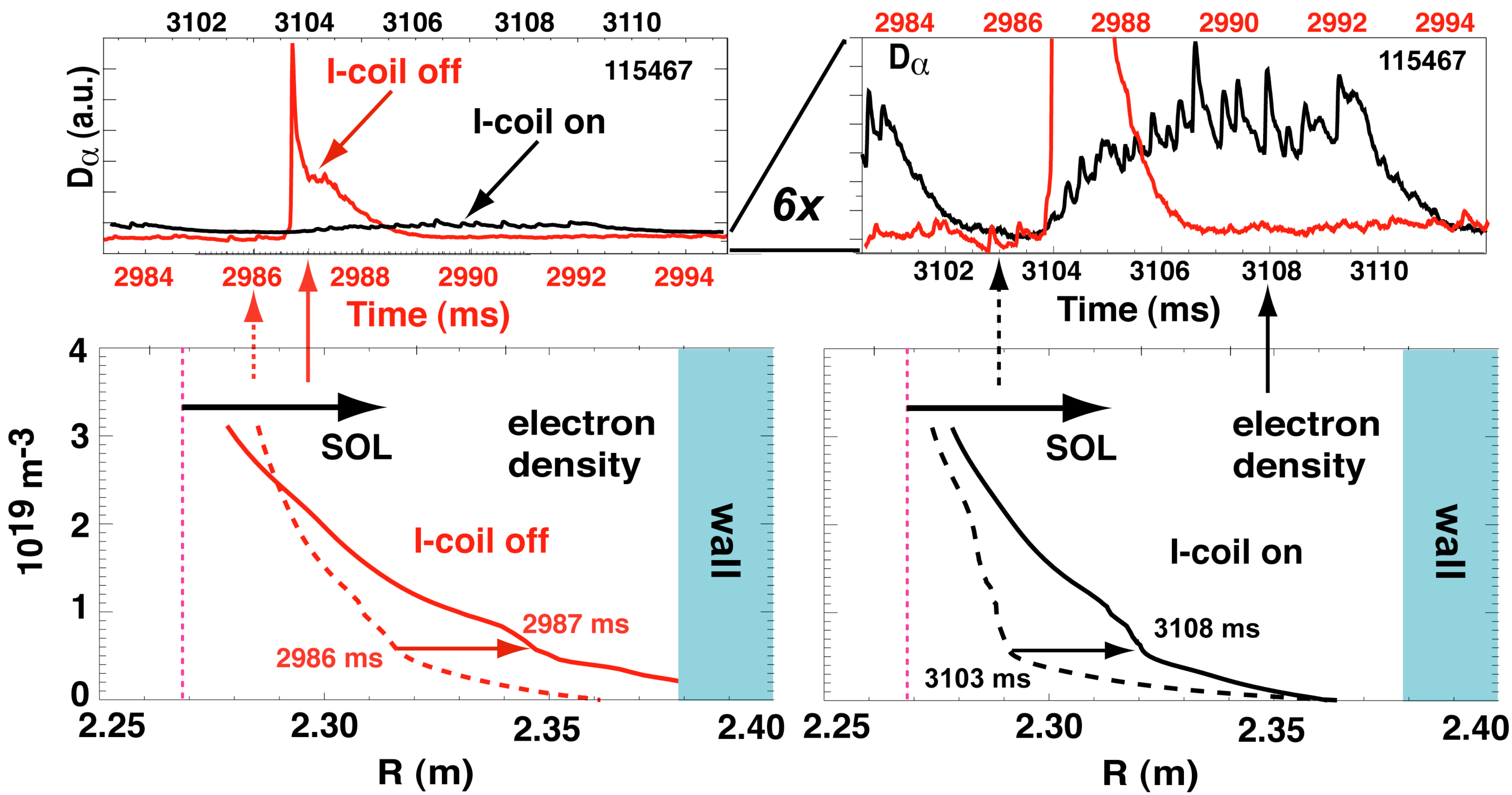
I-coil reduces ELM density impulses to the wall

Evans EX2-5Ra

L. Zeng UCLA



- High frequency transport replaces ELM transport
  - bursty, intermittent and less impulsive

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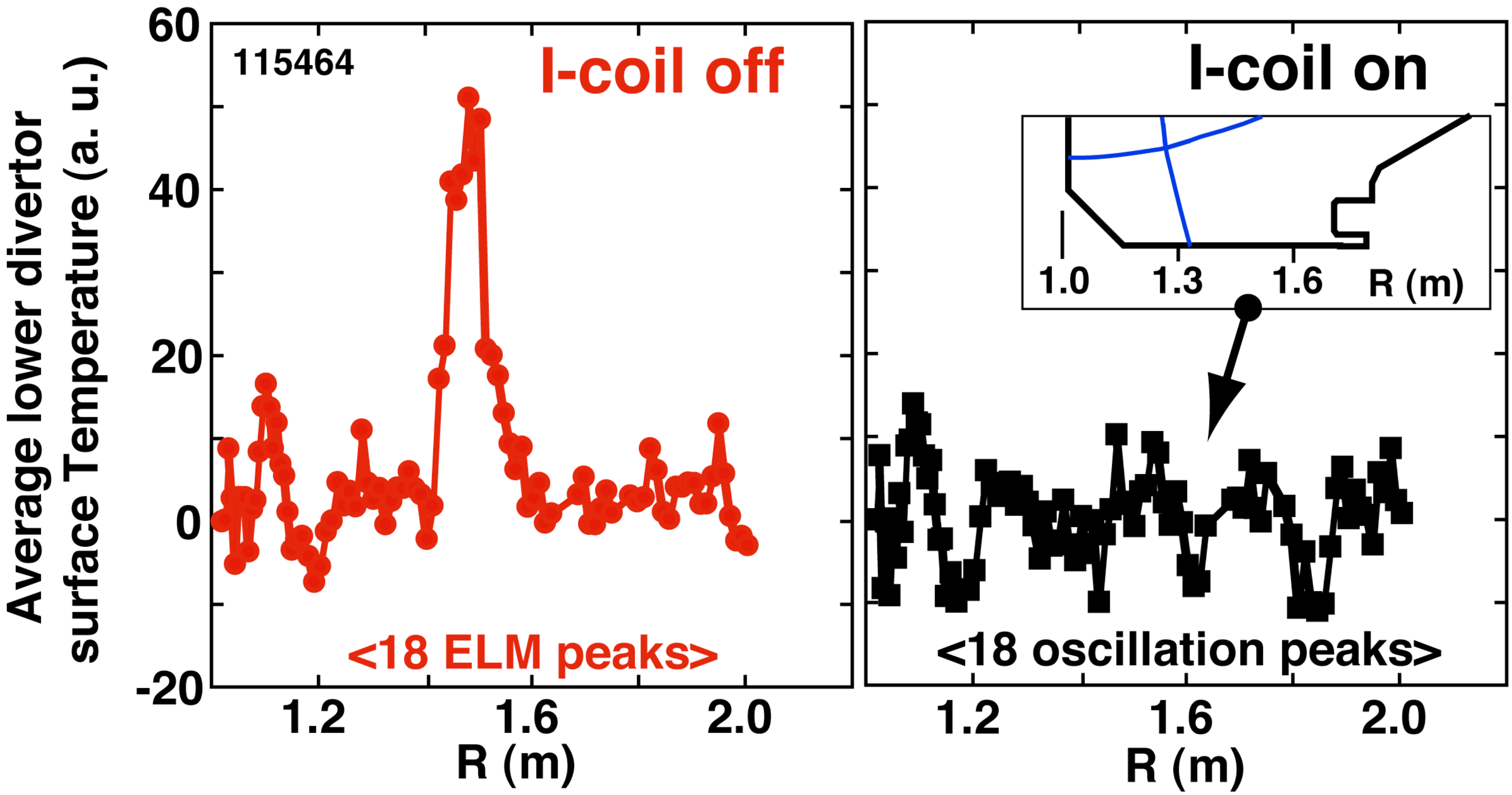
Peaks in the divertor surface temperature due to ELMs are reduced by at least a factor of 5 with the I-coil

Evans EX2-5Ra

C. Lasnier LLNL



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Good ELM suppression is obtained in LSN, high triangularity and ITER scenario 2 shapes

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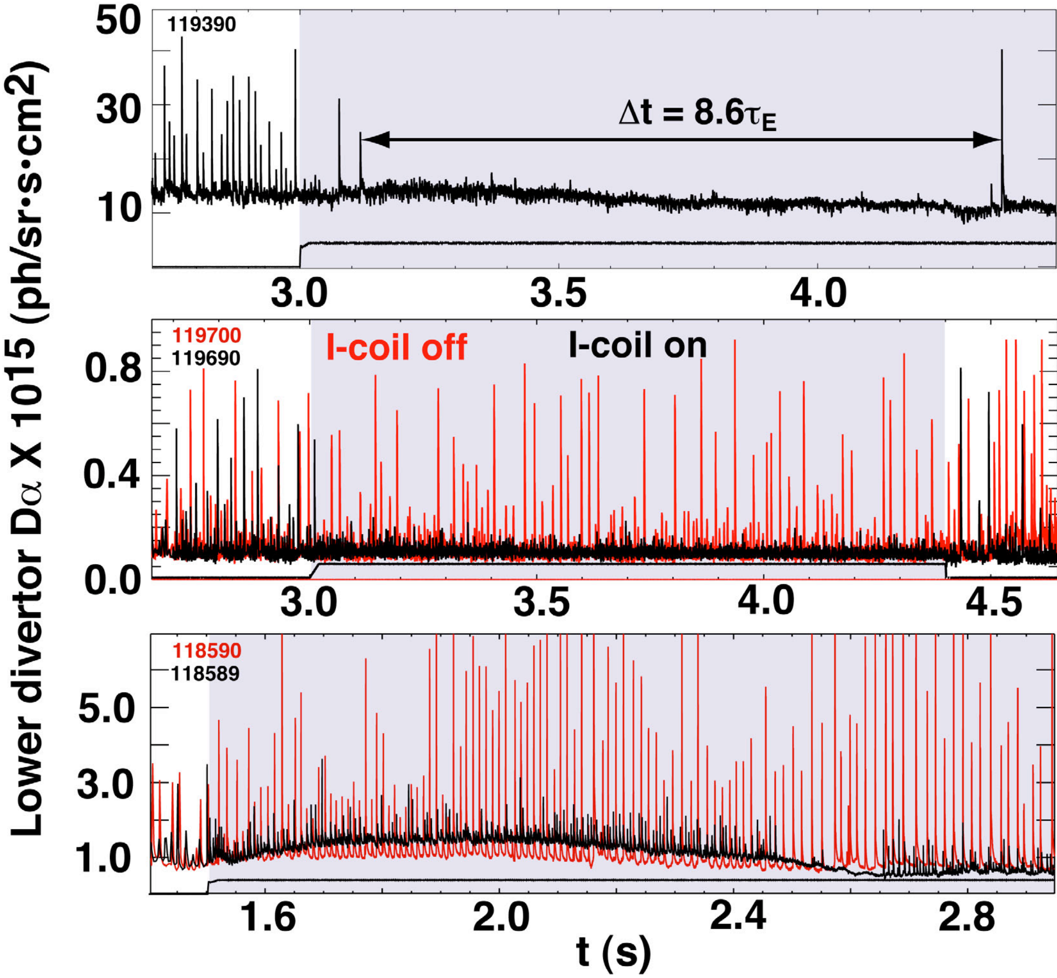
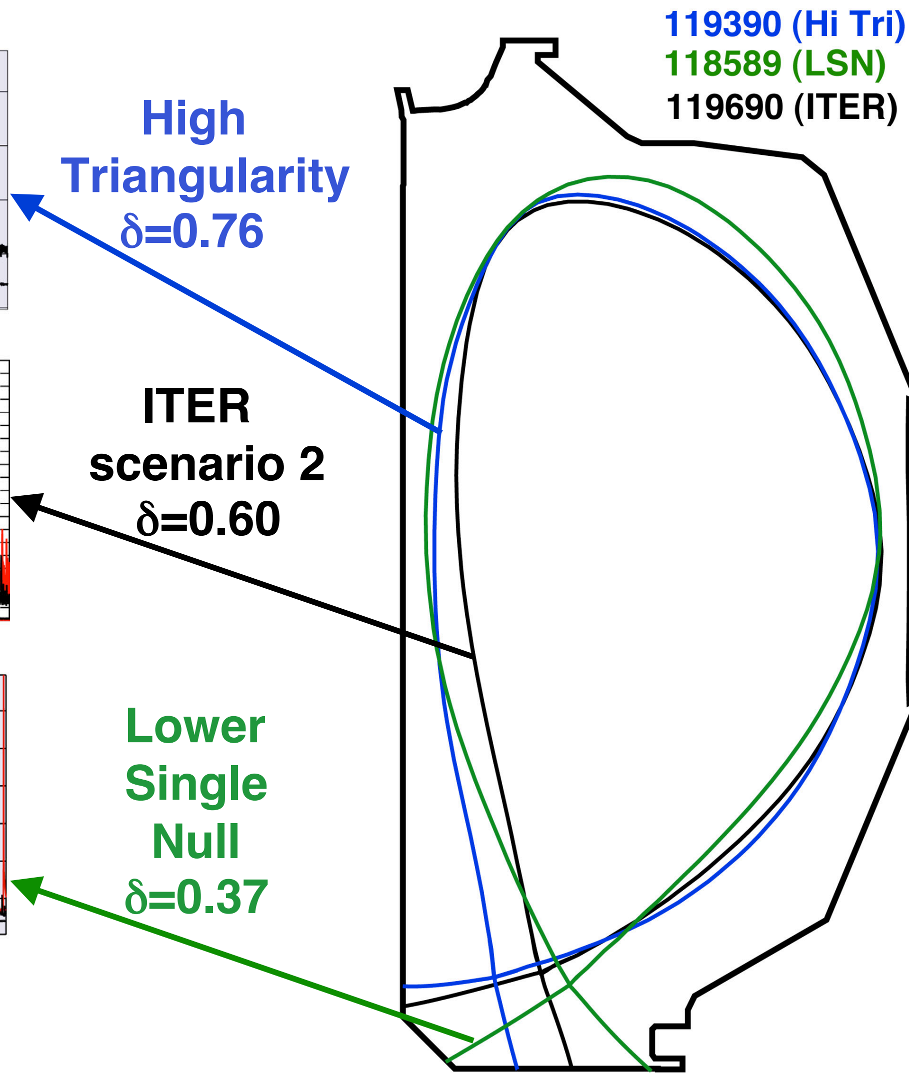
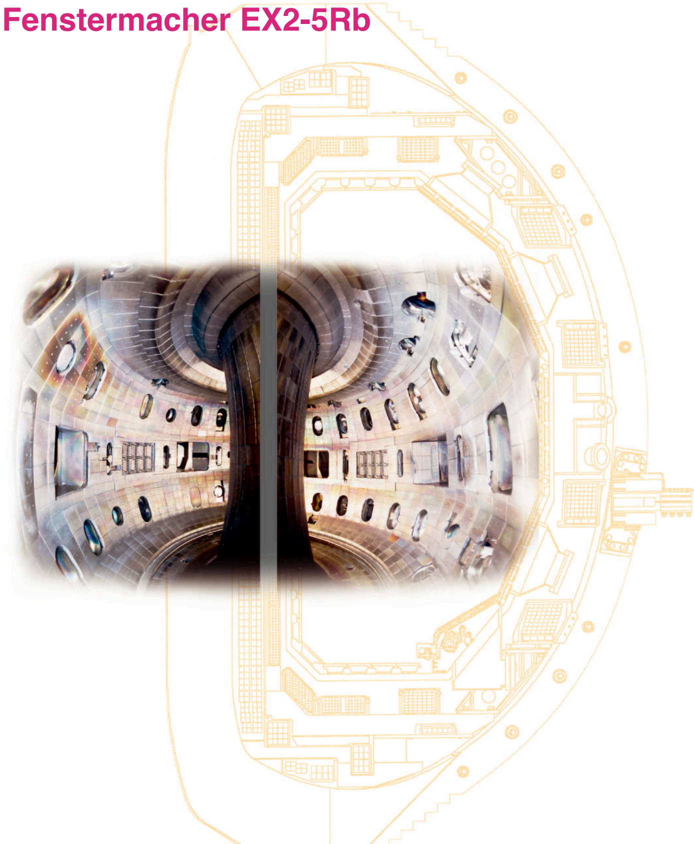




Physics that controls pedestal structure, stability and ELM dynamics is critical to understanding ELM suppression



Structure, stability and ELM dynamics of the H-mode pedestal in DIII-D

M. E. Fenstermacher

LLNL, CA, USA

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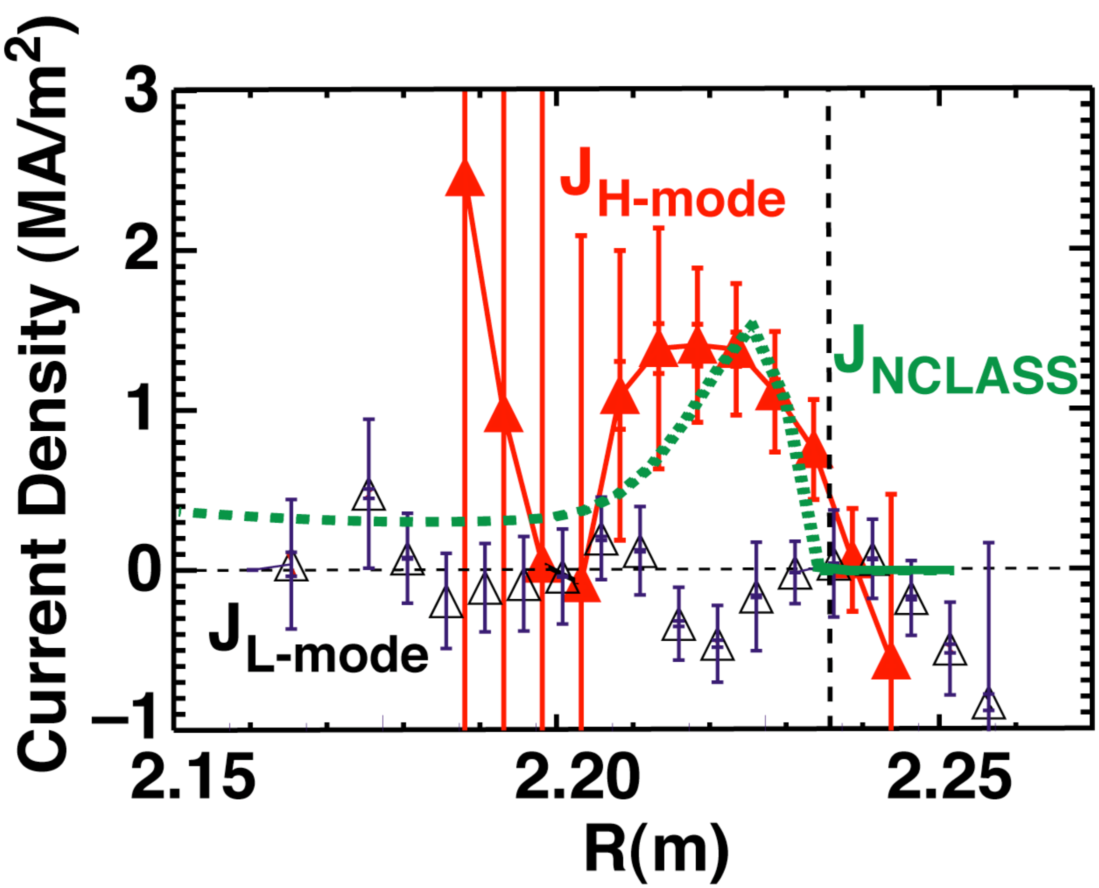
Measured edge current in H-mode large compared with L-mode; agrees with NCLASS calculation

Fenstermacher EX2-5Rb

Thomas, Leonard, et al. PRL 2004



- **Large $J_{H\text{-}mode}$ = 1.5 MA/m² measured in H-mode compared with negligible $J_{L\text{-}mode}$ in L-mode**
- **Magnitude of $J_{H\text{-}mode}$ agrees with calculation of $J_{NCLASS} = J_{BS} + J_{PS}$ from NCLASS code**
- **Effect of edge current on stability important to understand ELM onset and ELM suppression**

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DIII-D/JET pedestal similarity experiments show importance of neutral penetration

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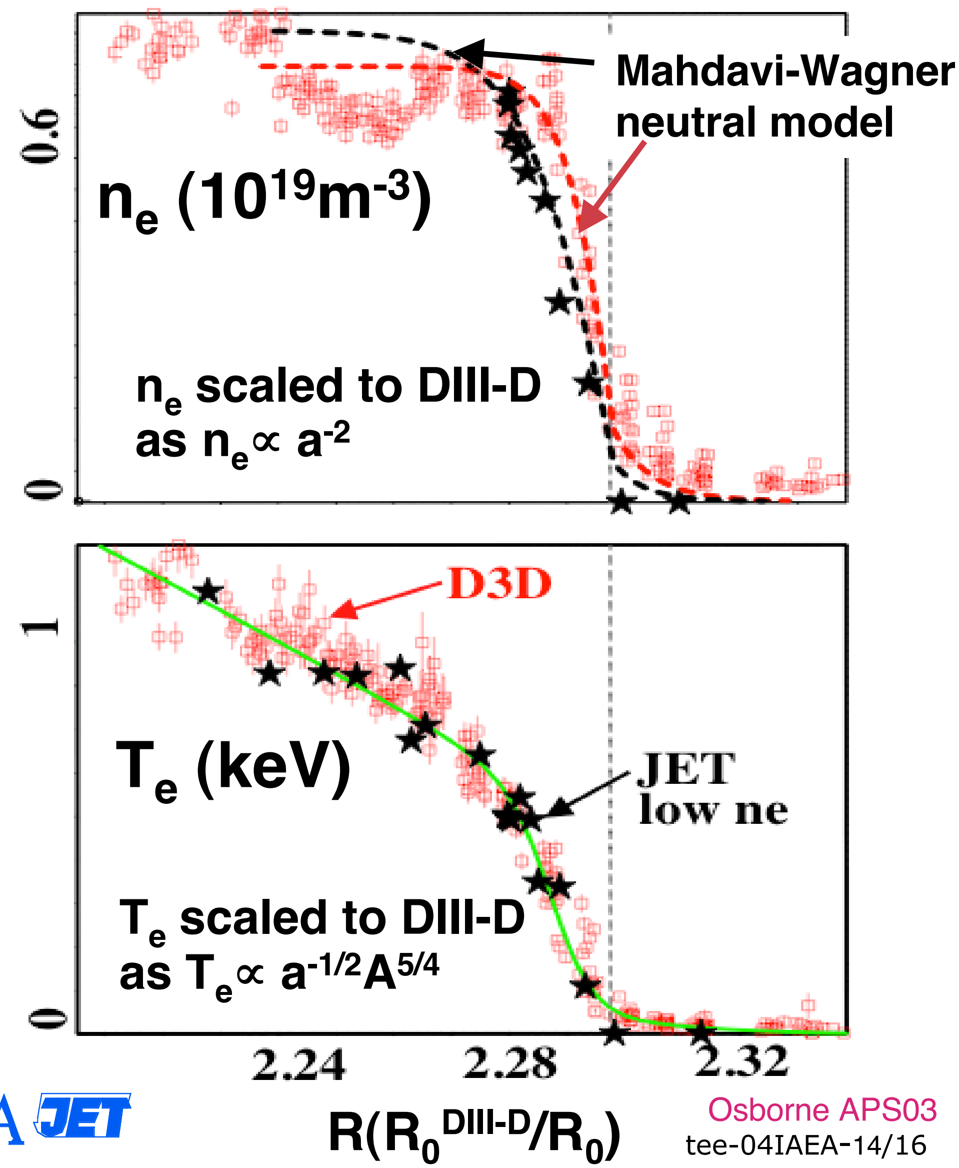
- **Matched shapes and (β, ν_*, ρ_*, q) at top of pedestal**
- **Neutral penetration physics dominates in setting the density width**
  - **Mahdavi-Wagner model reproduces differences in DIII-D vs JET profiles**
- **Plasma physics dominates in setting the transport barrier**
  - **T_e width $\propto$ a**



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EFDA JET

Osborne APS03

Structure of linear P-B ELM instability seen in CIII image data during ELM

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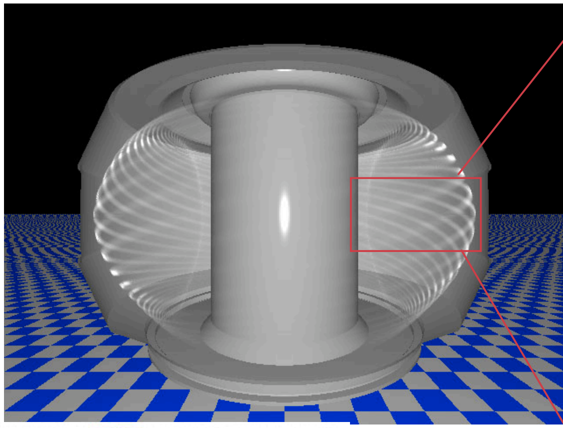
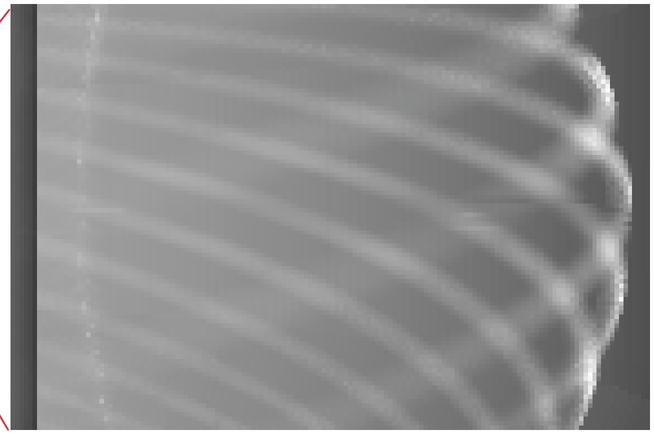
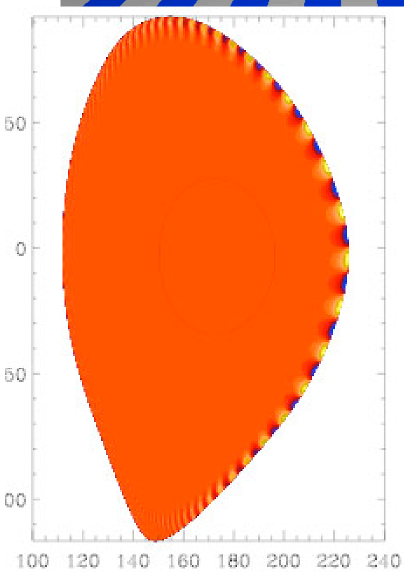
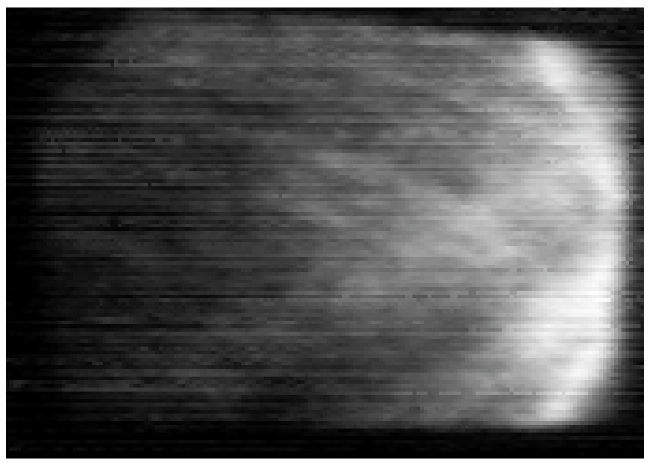
3D rendering of P-B mode structure

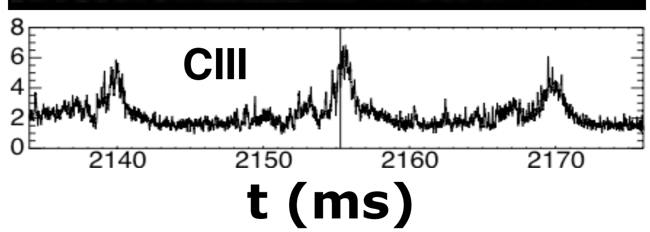




n=18 3D







- **Most unstable modes from ELITE linear P-B instability calculation are 16 ≤ n ≤ 24**
- **CIII emission structure during ELM suggests n ~ 17**

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Summary and conclusions

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