ELM Suppression in DIII–D with Resonant Magnetic Perturbations

by
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in collaboration with

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DIII–D
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GENERAL ATOMICS

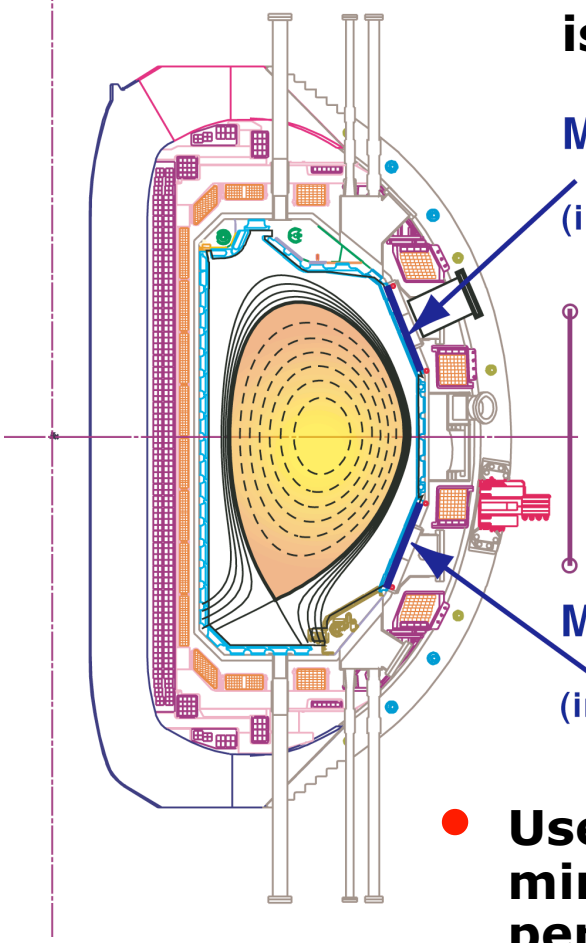
Overview

- Motivation and approach
  - Magnetic perturbation coil description
- ELM suppression results with $n_e \geq 6.5 \times 10^{19}$ m^{-3} ($\nu_* \geq 0.5$)
  - Global change in edge dynamics
  - Reduction in main chamber wall n_e impulses
  - Reduction in divertor impulses
- Variations in ELM suppression behavior with plasma shape (δ) and collisionality (ν_*)
- Summary and Conclusions

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

Evans EO3.007

- ELM control is an important issue for ITER



MHD control I-coil (inside vacuum)

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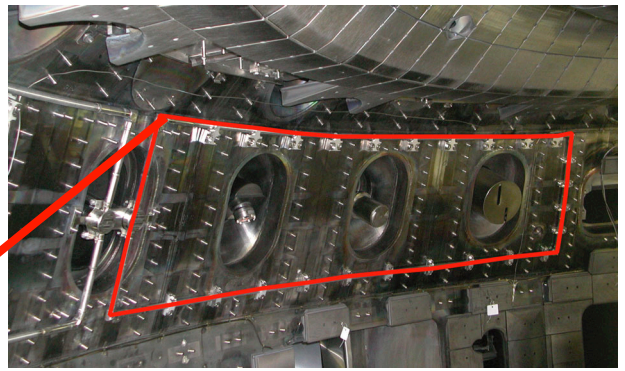

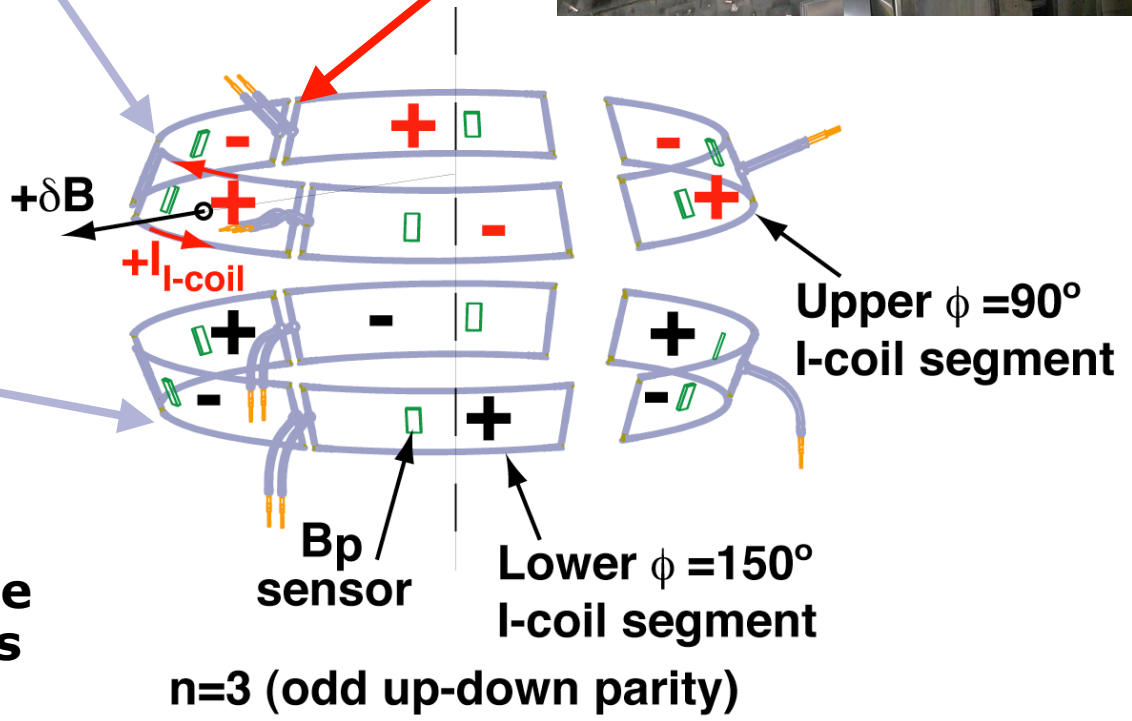

n=3 (odd up-down parity)

- Use n=3 to minimize core perturbations

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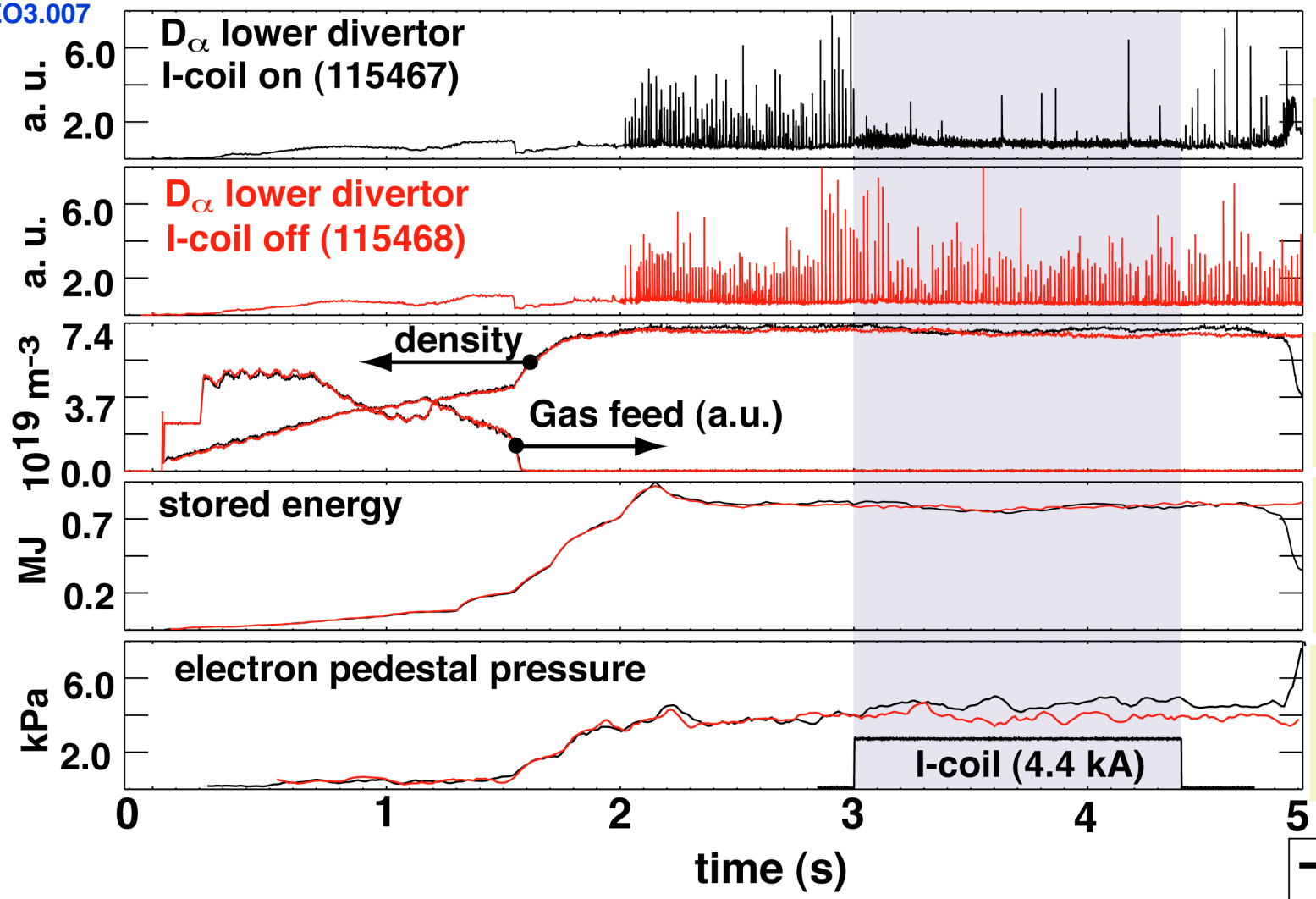
ELMs are suppressed without degrading confinement

Evans EO3.007

Evans, et al., PRL 2004



ELMs suppressed

$\nu_* = 0.56$

core n_e unchanged

stored energy unchanged

pedestal pressure increases

I-coil on

I-coil off

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

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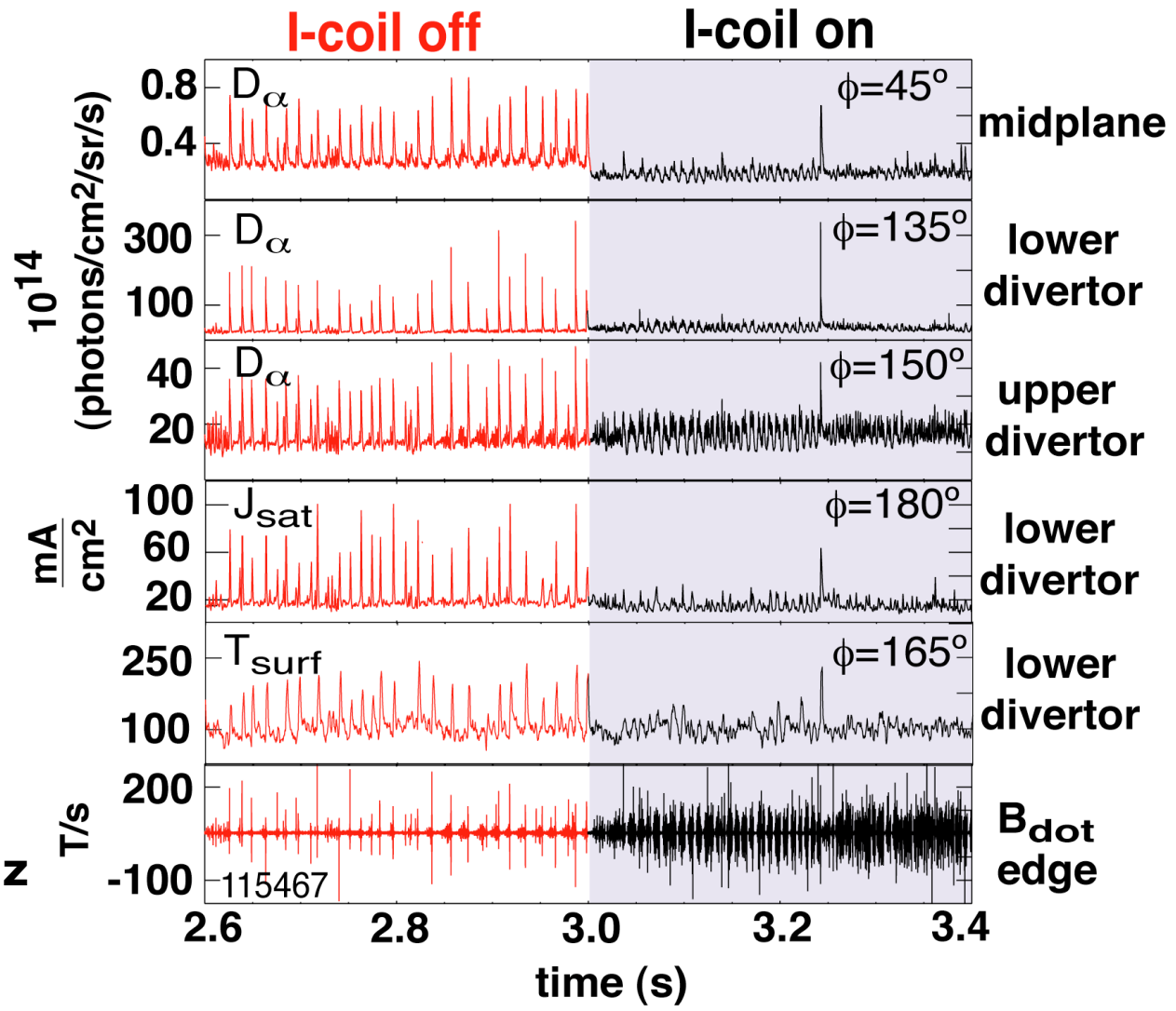
Dynamical state of pedestal changes globally

Evans EO3.007

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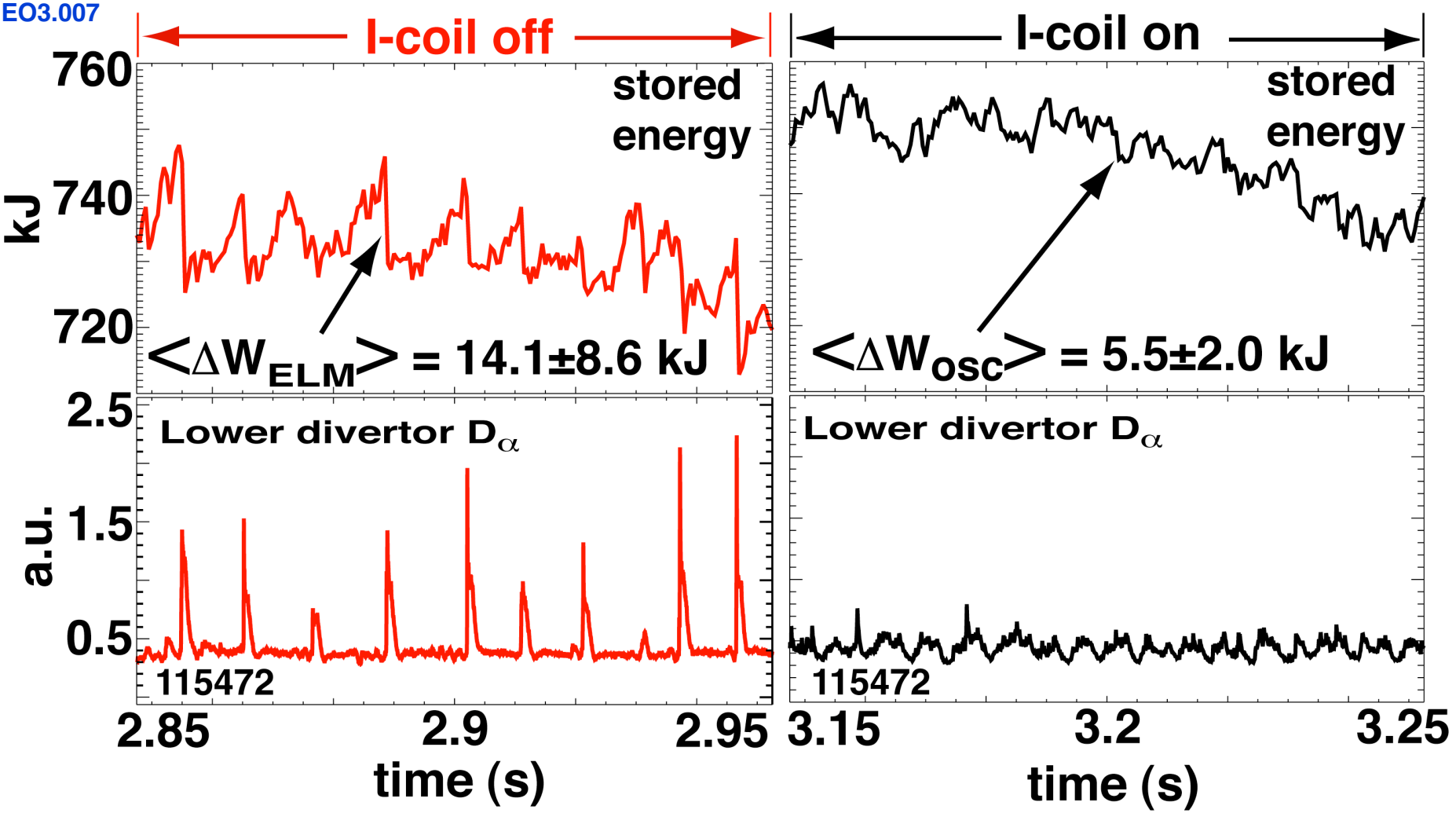
Stored energy drops are smaller and slower with the I-coil reducing the impulses by > 3X

Evans EO3.007



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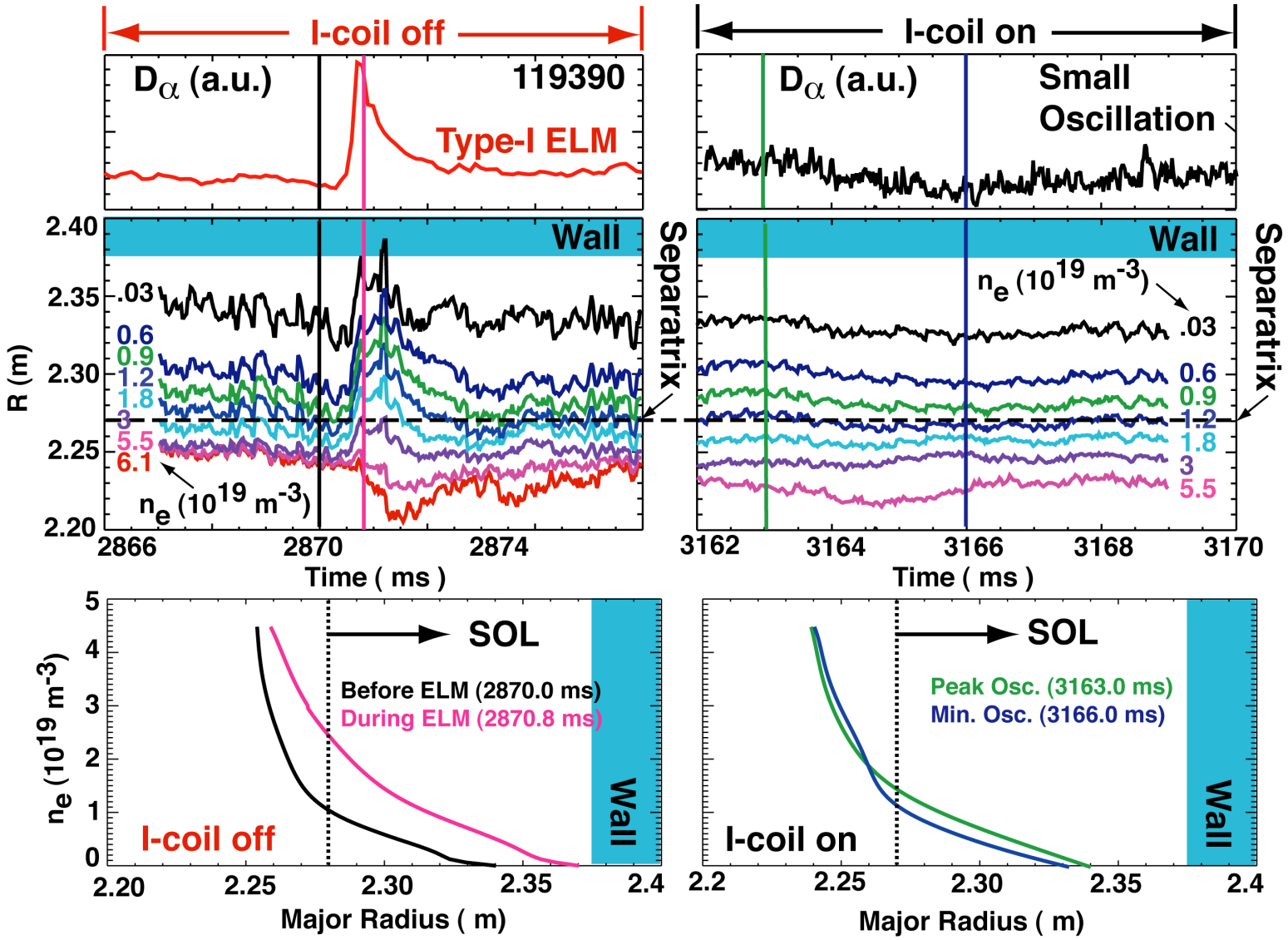
I-coil reduces ELM density impulses to the wall

Evans EO3.007

L. Zeng &
G. Wang UCLA

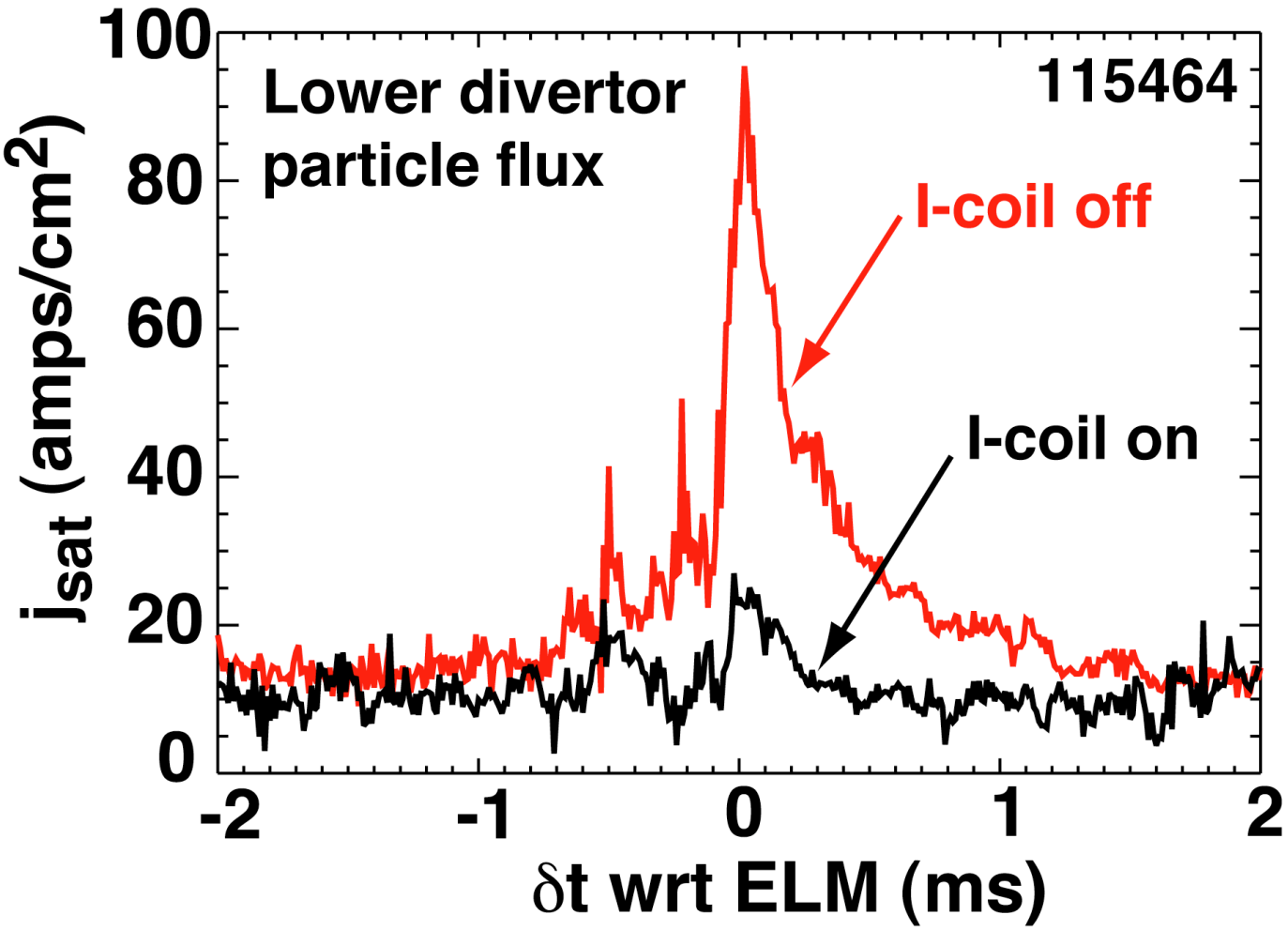


See G. Wang, et al., EO3.010

Langmuir probes show a factor of 8 reduction in the impulsive particle flux to the divertor

Evans EO3.007

J. Watkins SNL



- Reduction in particle flux impulses due primarily to amplitude reduction not δt

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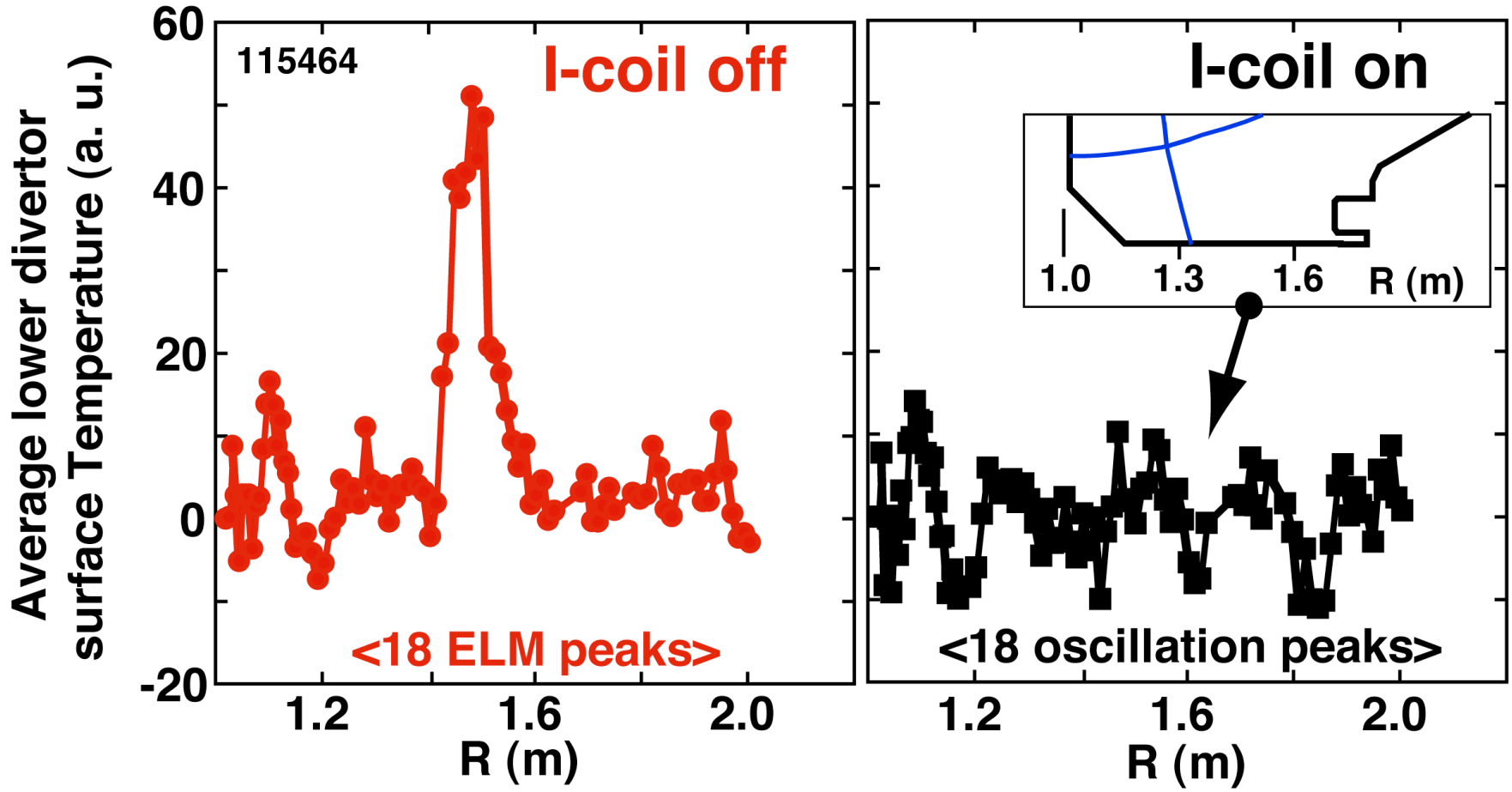
Peaks in the divertor surface temperature due to ELMs are reduced by at least a factor of 5 with the I-coil

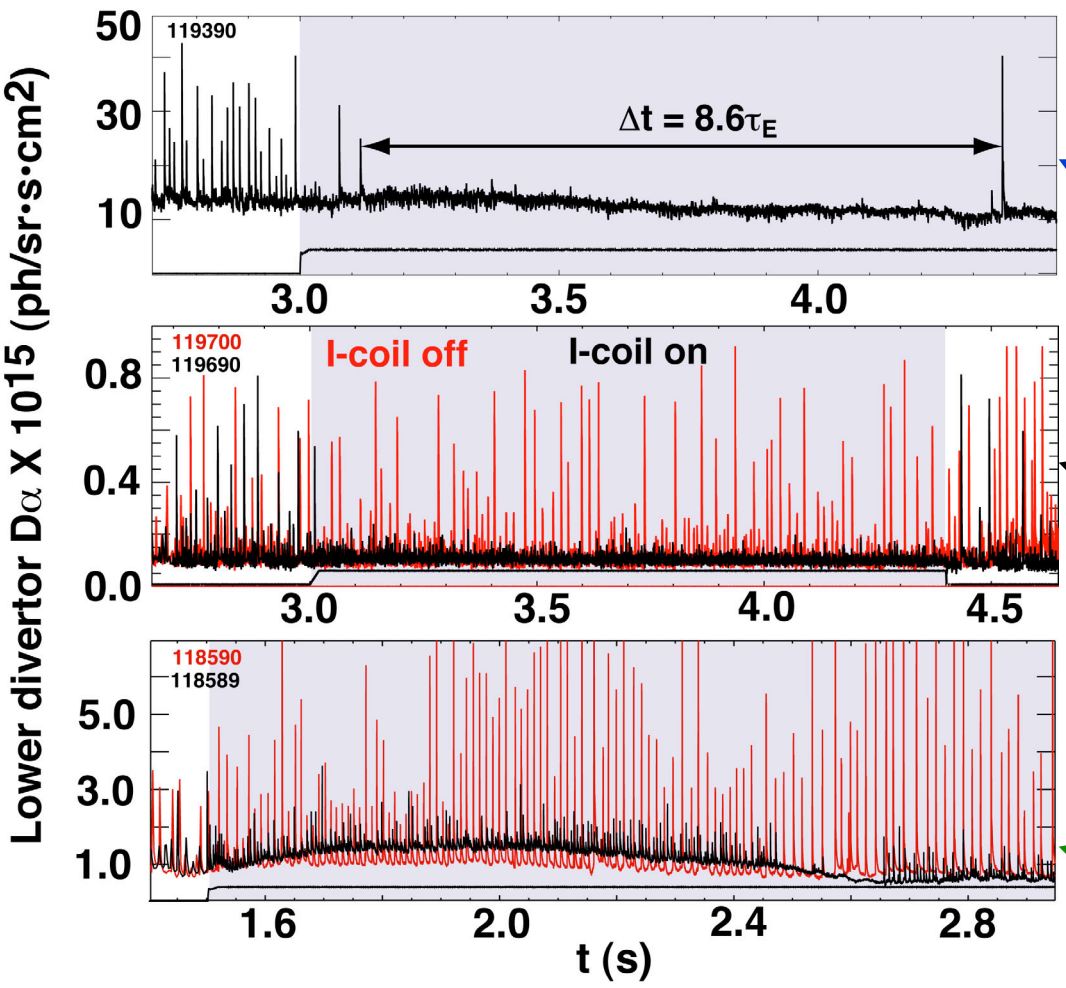
Evans EO3.007

C. Lasnier LLNL



Good ELM suppression is obtained in high and low triangularity as well as in ITER scenario 2 shapes

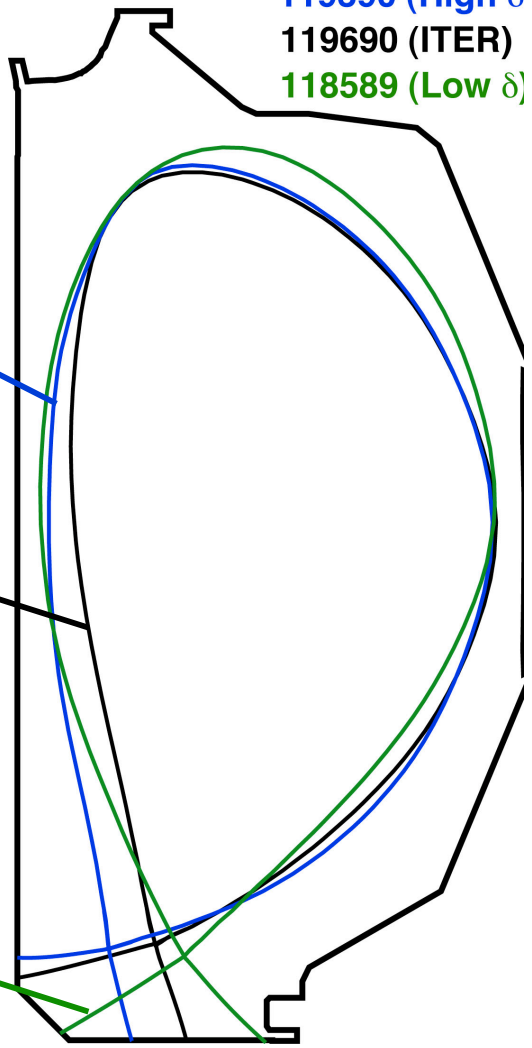
Evans EO3.007



High triangularity
δ = 0.76, ν* ~ 0.8

ITER scenario 2
δ = 0.60, ν* ~ 0.7

Low triangularity
δ = 0.37, ν* ~ 0.2



- ELM behavior and I-coil response change with shape (δ) and collisionality (ν*)

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Summary and conclusions

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- Type-I ELMs are suppressed with resonant magnetic perturbations
  - no confinement degradation
  - good suppression for $\Delta t \sim 9\tau_E$ (~1300 ms) to date
  - some isolated ELMs remain with intermittent (~60-1000 ms) quiet periods between them
  - suppression is seen globally on all ELM diagnostics
- 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
  - density impulses to the main chamber walls due to ELM are eliminated
- A variety of ELM suppression behaviors are observed in plasmas with various shapes (δ) and collisionalities (ν_*):
  - bursty transport modulated by a 130 Hz coherent oscillation
  - small irregular fluctuations (Type-II ELMs?) with substantially reduced impulses

See Moyer JI2.004 at 15:30 Wednesday afternoon for an extended discussion of this work

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