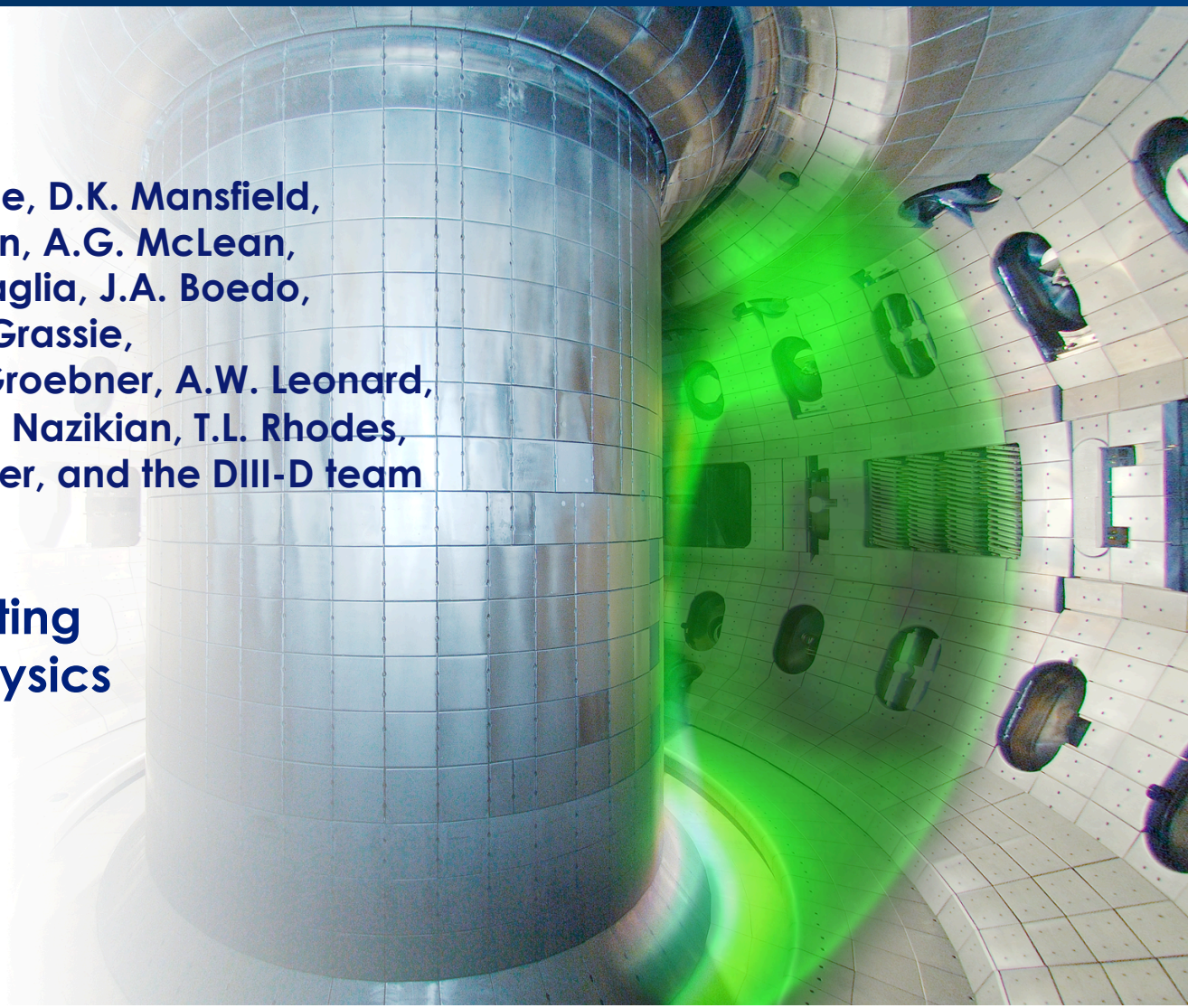
H-mode Pedestal Enhancement and Improved Confinement in DIII-D with Lithium Injection



by

G.L. Jackson,

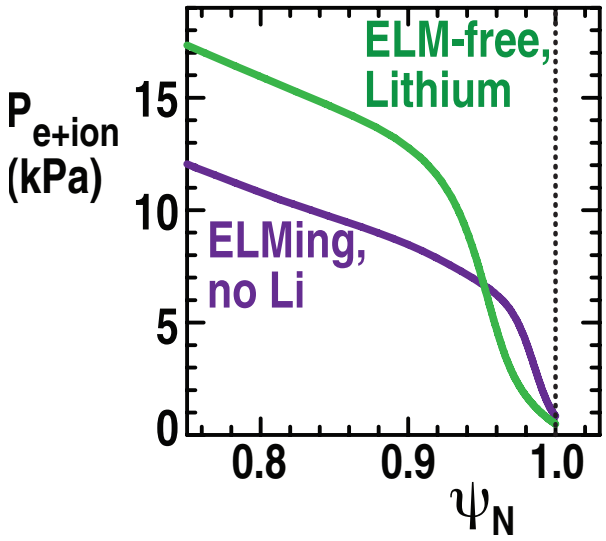
with R. Maingi, T.H. Osborne, D.K. Mansfield, C.P. Chrobak, B.A. Grierson, A.G. McLean, Z. Yan, S.L. Allen, D.J. Battaglia, J.A. Boedo, A.R. Briesemeister, J.S. deGrassie, M.E. Fenstermacher, R.J. Groebner, A.W. Leonard, G.R. McKee, R.A.Moyer, R. Nazikian, T.L. Rhodes, A.L. Roquemore, P.B. Snyder, and the DIII-D team

Presented at

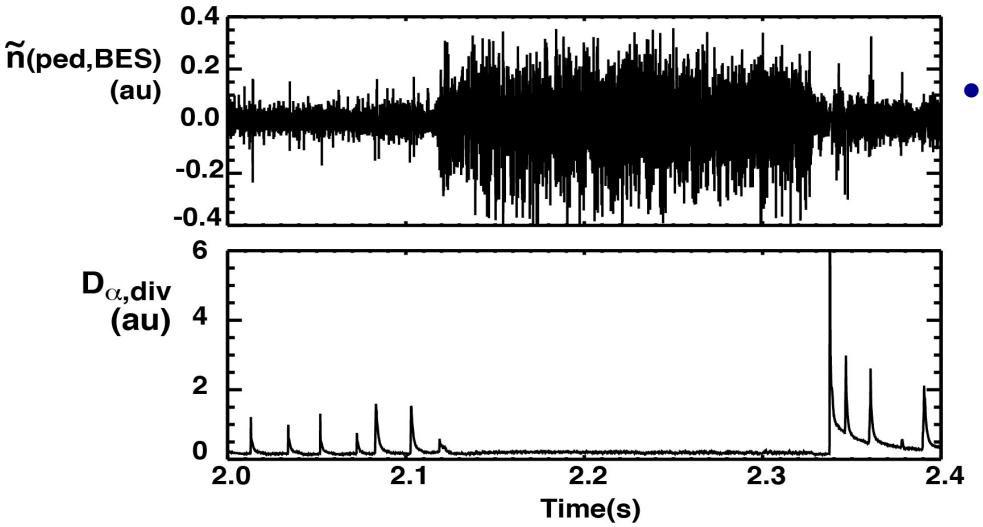
56th Annual APS Meeting
Division of Plasma Physics
New Orleans, LA

October 27-31, 2014

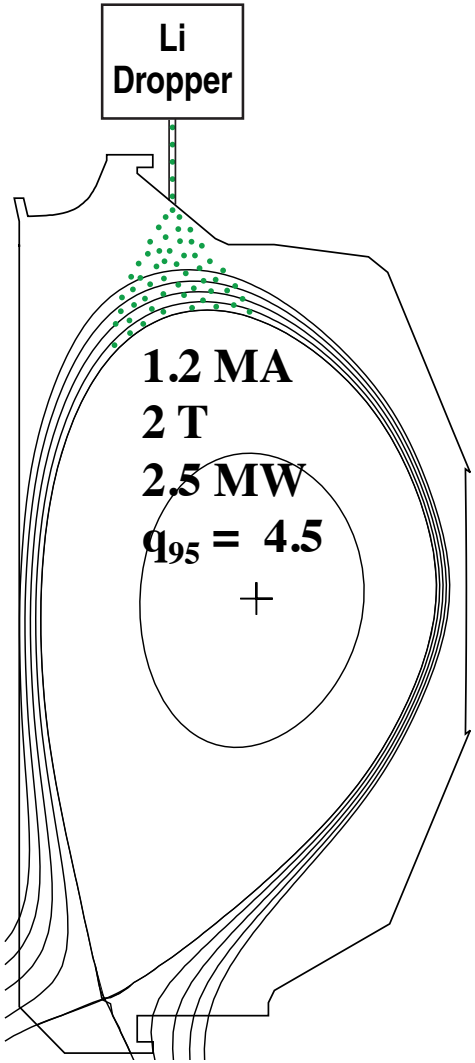
Lithium Injection has Produced ELM-free Phases with an Enhanced Pedestal and High Edge Fluctuations



- Pedestal Widths Increase more than 150%



- Pedestal fluctuations increase edge impurity transport (ELM-free)

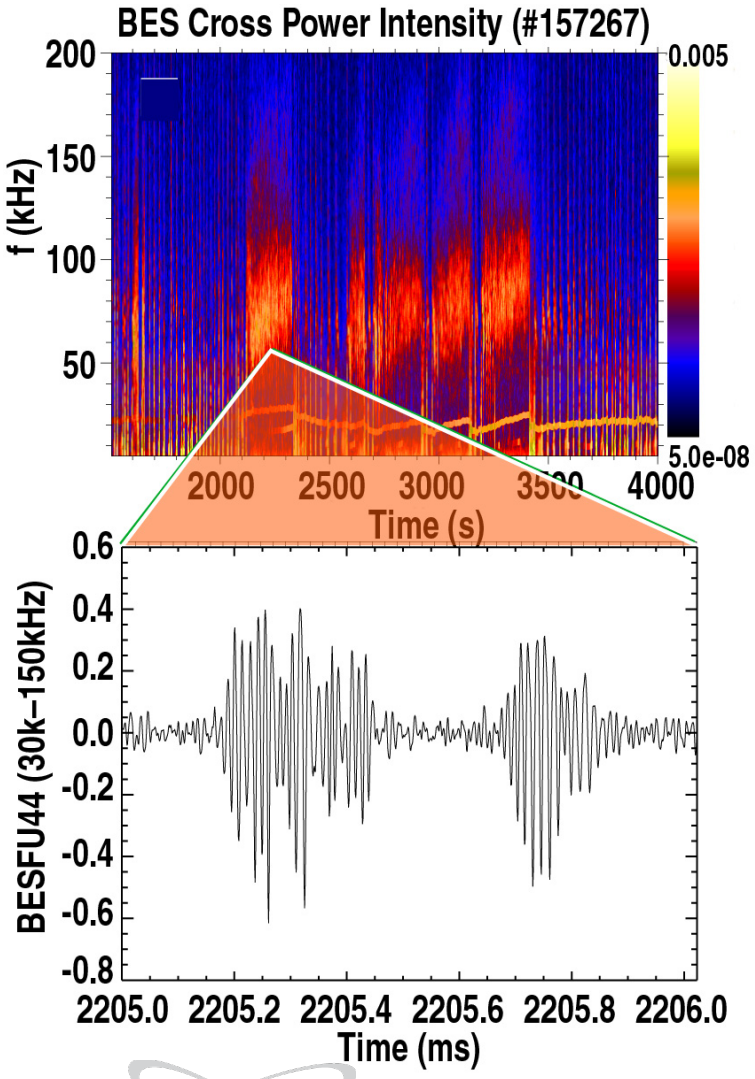


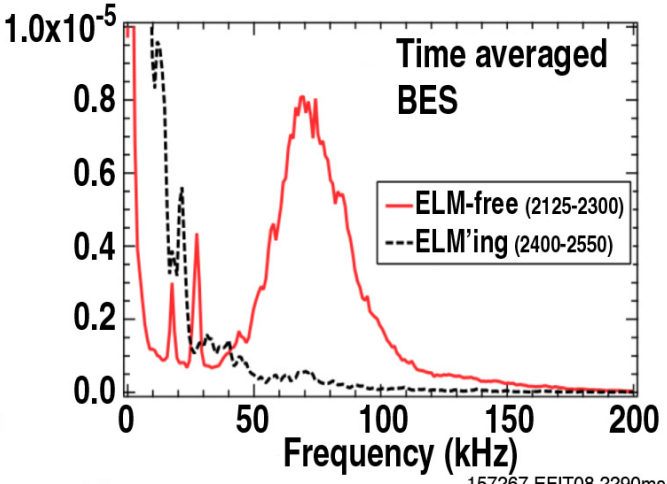
D. Mansfield, FED (2011)
R. Maingi GP8.36

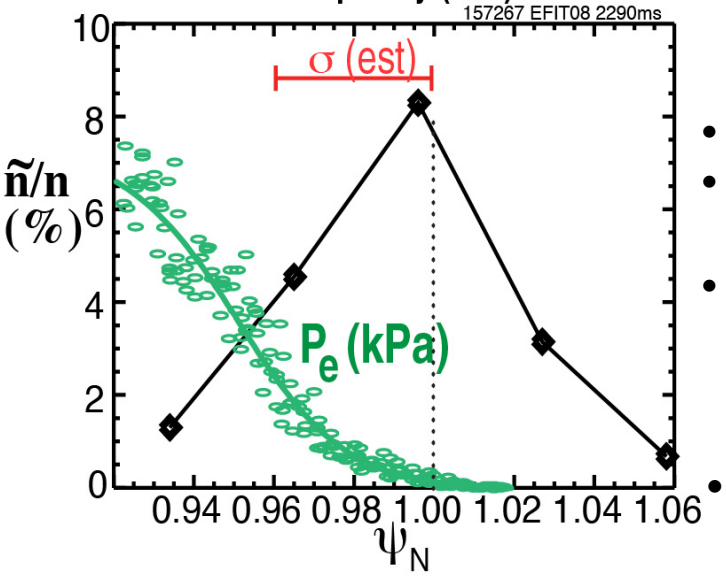
Outline

- **Characteristics of Pedestal Fluctuations**
  - Bursty Chirping Mode (BCM)
- **Enhanced Pedestal**
- **Particle Transport**
- **Summary**

Beam Emission Spectroscopy Shows Large Fluctuations in the Edge Region--Bursty Chirping Mode (BCM)





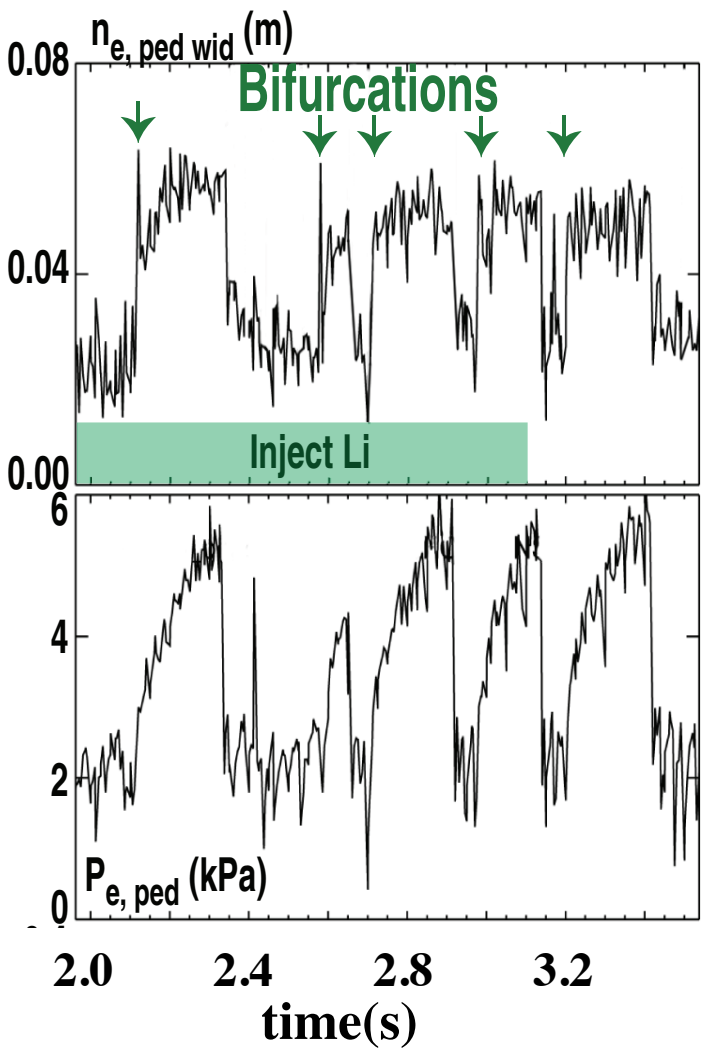


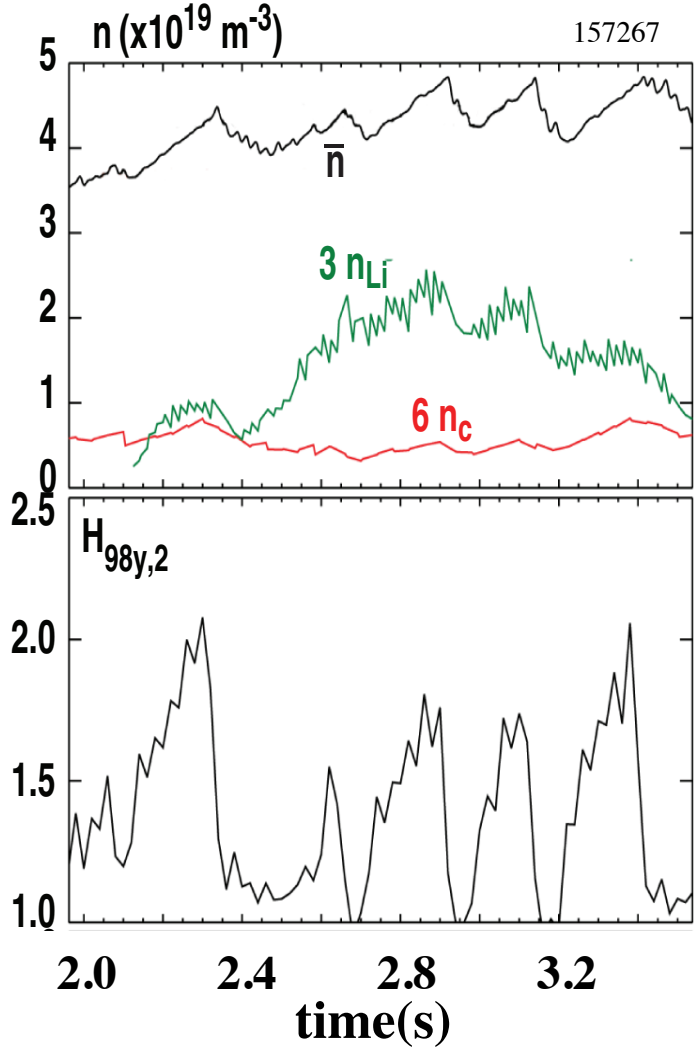
- Coherent fluctuations ≈ 70 kHz
- Bursty behavior also exhibits frequency chirping
- Propagation in electron drift direction
- $k_\theta \approx 0.4$ cm^{-1}
- $k_\theta \rho_s \approx 0.08$
- Fluctuations begin just after an ELM
- Fluctuations cease just before or at next ELM

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Z. Yan, GP8.38

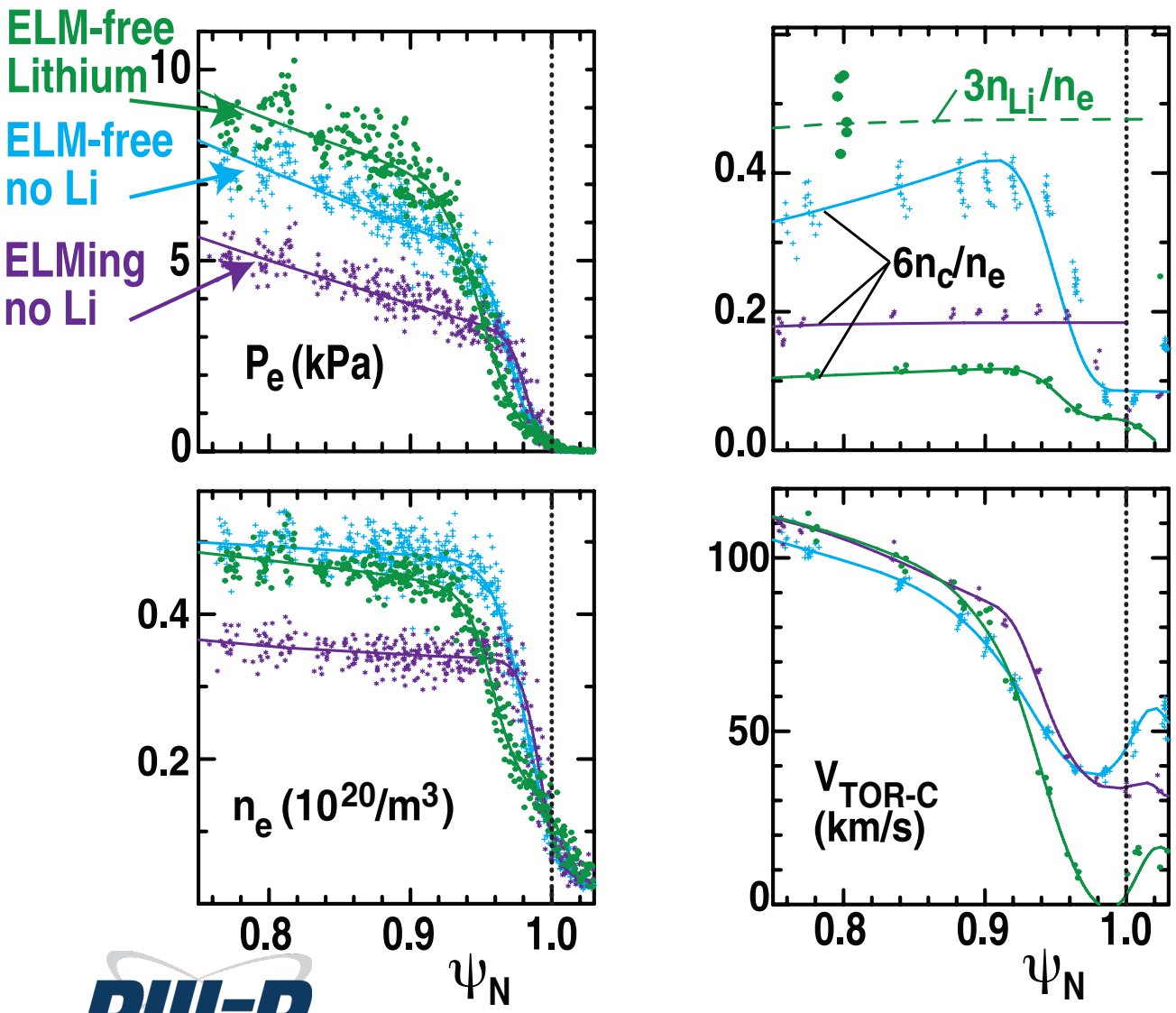
With Lithium Injection, Long ELM-free Periods Obtained with Wider Edge Pedestal and No Increase in Carbon





- Fast pedestal bifurcations (< 10 ms typical)
- Edge fluctuations increase in ELM-free phase
- Pedestal pressure monotonically increases
- H factor similar to Very High confinement (VH) mode

Comparison of No-Lithium and Lithium Pulses

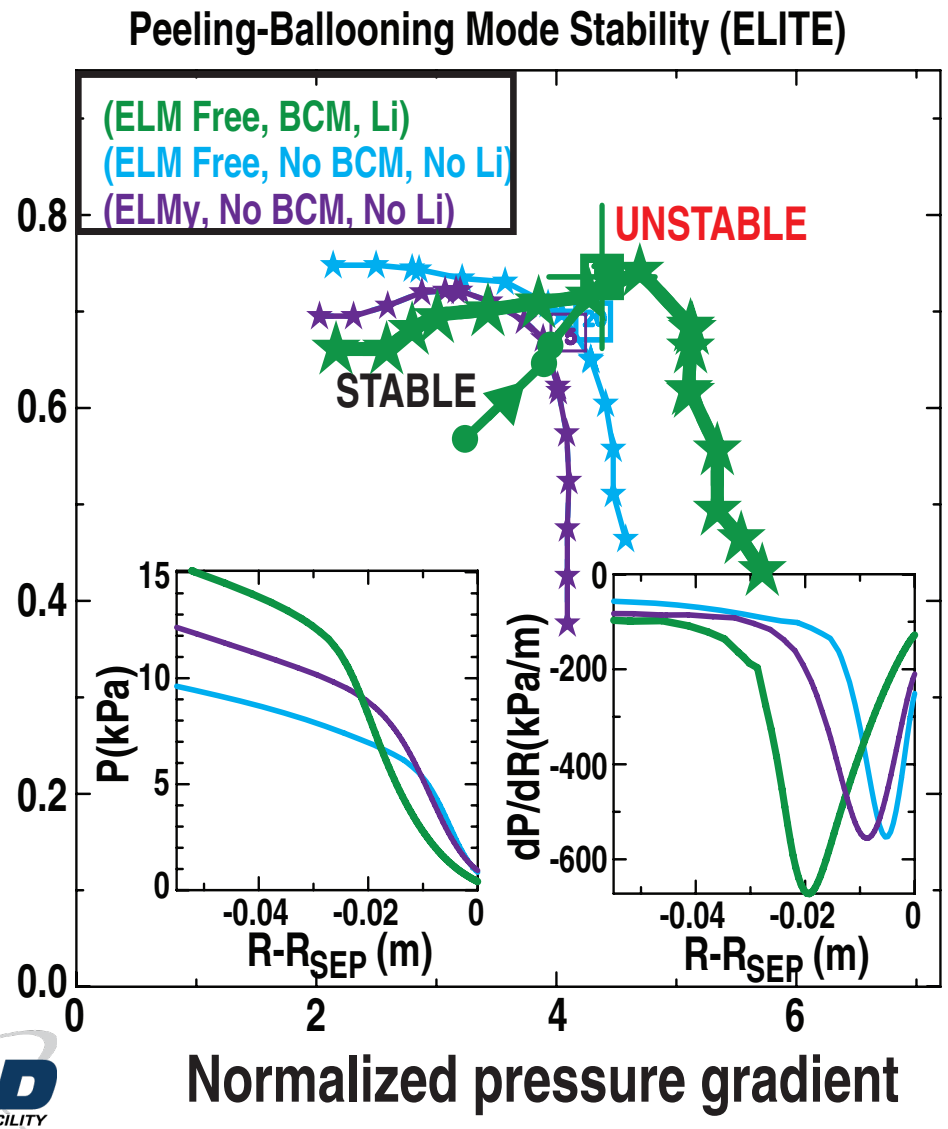


- ELMing pulses have modest pedestal width and height
- ELM-free without Li show higher pedestal but also large carbon influx
- Lithium ELM-free have highest pedestal widths, inward shift of gradients, and lowest carbon content

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T. Osborne GP8.37

ELM Occurs When Discharge Reaches the Peeling-Ballooning Limit in All Cases

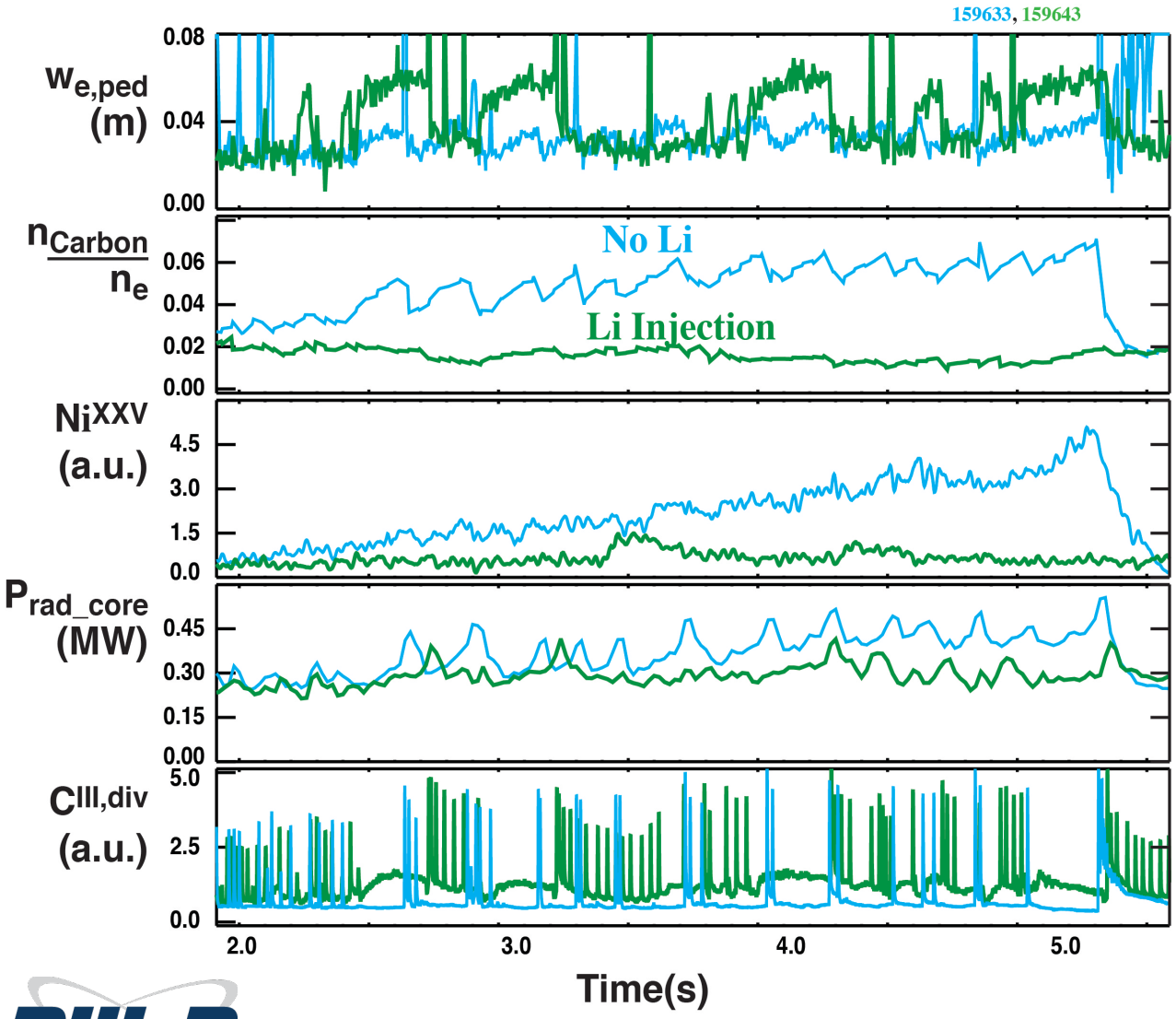


- Higher pressure at similar α at end of ELM-free phase for lithium pulse
- dP/dR moves inward with Li-induced BCM
- Hypothesis: $n_{Li,ped}$ and $Z_{eff,ped}$ higher with BCM and pedestal shifts inward. Pedestal remains stable at higher P, allowing longer ELM-free phase

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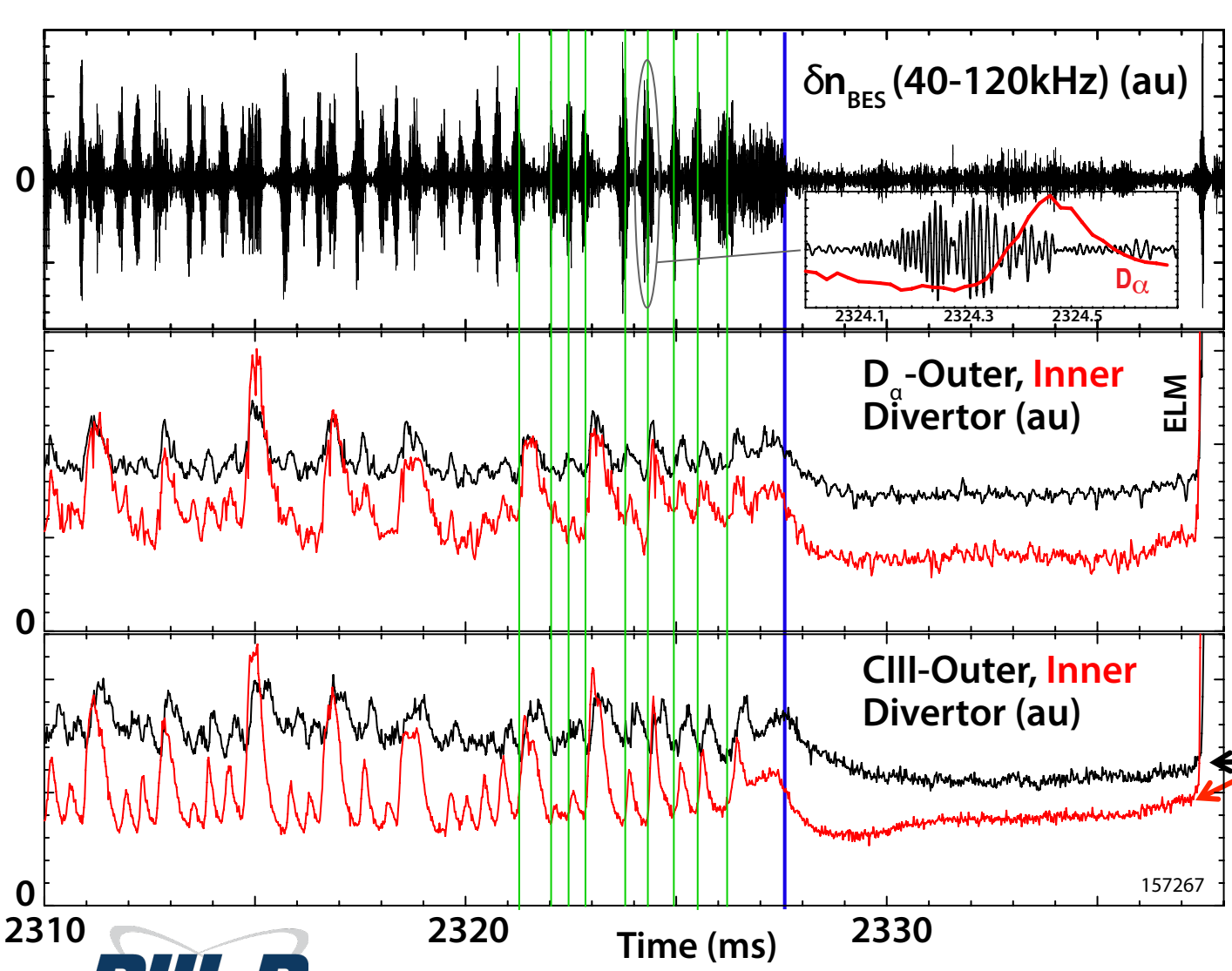
Intrinsic Impurities Are Reduced in the Plasma Core; Higher Carbon Concentrations Observed in the Divertor

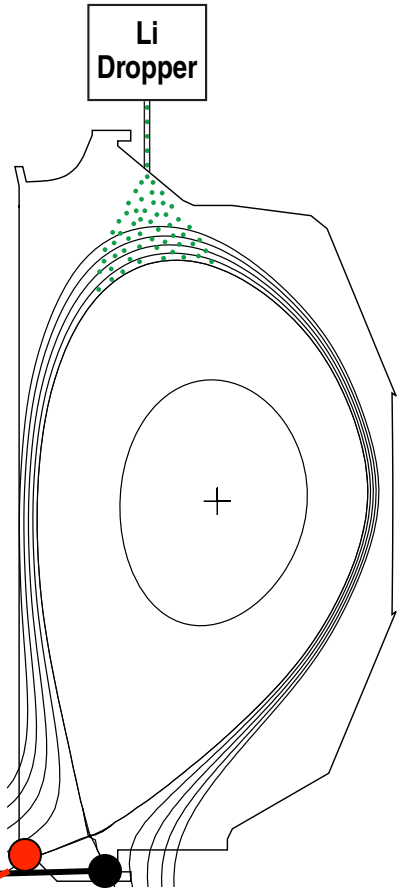


- Carbon and Ni are significantly lower in the plasma core
- Radiated power inside the separatrix is lower with Li
- Carbon intensity from the outer lower divertor is higher with Li

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CIII and D_α Light Are Higher with the Bursty Chirping Mode, Consistent with Higher Edge Particle Transport





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Summary

- **A new enhanced pedestal regime observed in DIII-D**
  - Lithium injection allowed ELM-free periods up to 0.35 s
    - Without Lithium only brief periods with BCM occasionally observed
  - Electron and ion pedestal widths extended by a factor ≥ 2
  - Global confinement, H_{98y2} up to 2.1
- **Intrinsic impurities in core reduced with lithium injection**
  - Bursting fluctuations (≈ 70 kHz) in the edge occurred during the enhanced pedestal phase
  - With fluctuations, higher edge transport observed (carbon and deuterium)
- **ELM-free and enhanced pedestal phase ends as discharge approaches P-B boundary**
  - Future work will focus on reducing density rise and maintaining edge stability allowing longer ELM-free periods

Other Lithium Talks and Posters

- R. Maingi, GP8.36
- T. Osborne, GP8.37
- Z. Yan, GP8.38
- S. Allen, C05.06