NSTX

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Modification of edge plasma profiles in ELM -suppressed discharges with lithium coatings in NSTX

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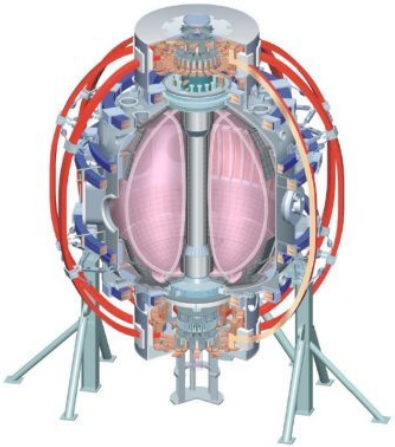

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Summary

We think we understand

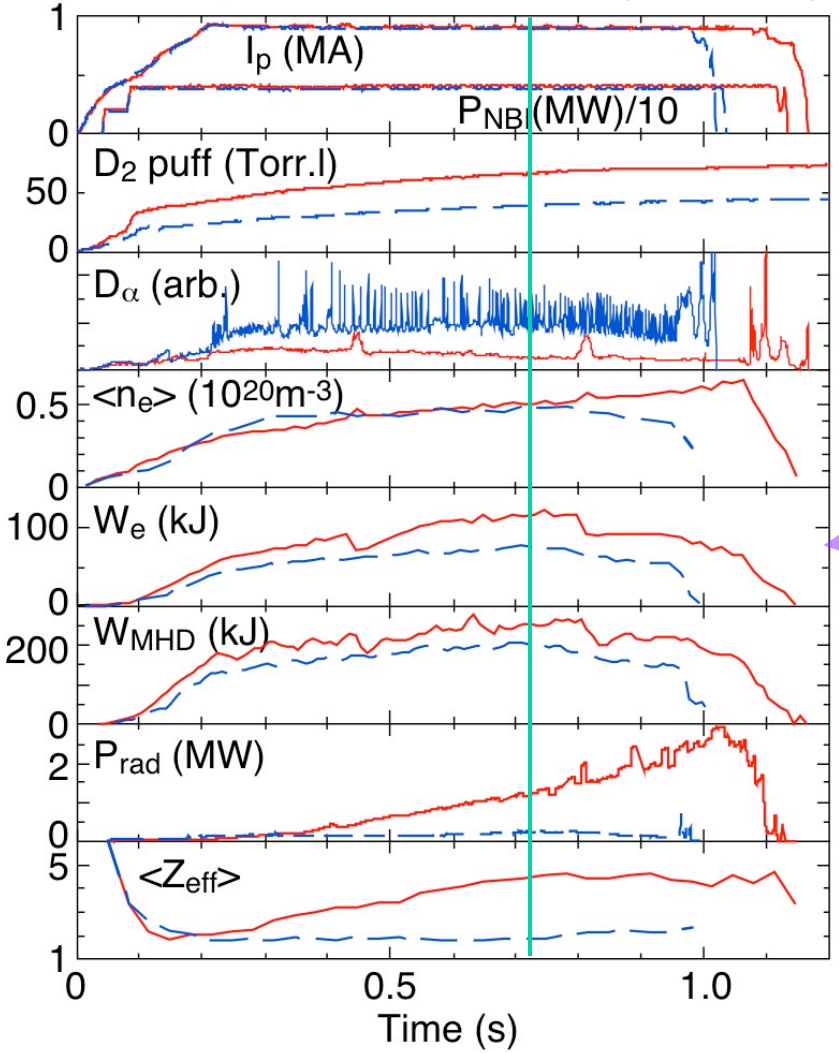
- Lithium wall coatings improve confinement and induce ELM-free H-mode
- Hypothesis: reduction of peak P_e (n_e) gradient and shift toward region of reduced magnetic shear responsible for ELM stabilization

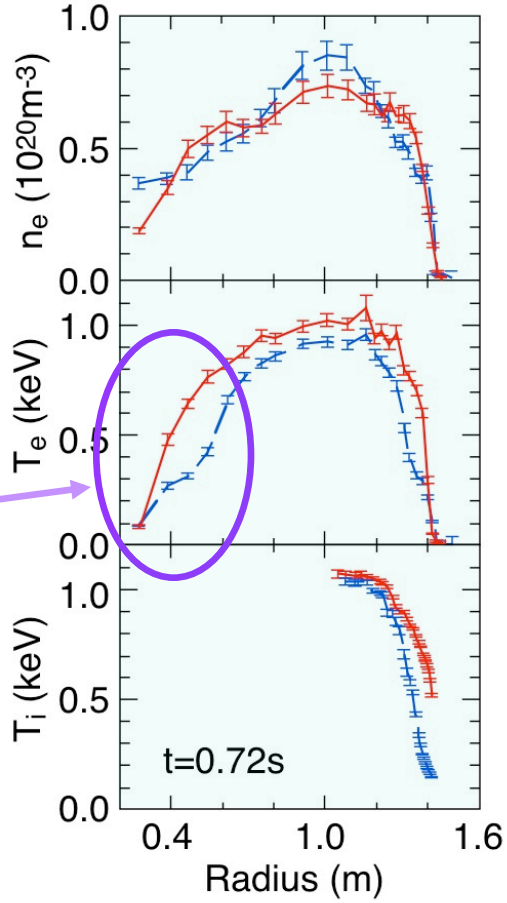
We need more analysis to understand:

- Complete evolution: why do ELMs go away the way they do i.e. with increasing periods of quiescence?
- Is the initial ELM suppression at constant NBI power related to reduced collisionality?
- Do the profiles change, leading to ELM suppression, or do the ELMs get suppressed, leading to profile changes?

Lithium Coating Reduces Deuterium Recycling, Suppresses ELMs, Improves Confinement

No lithium (129239); **260mg lithium** (129245)

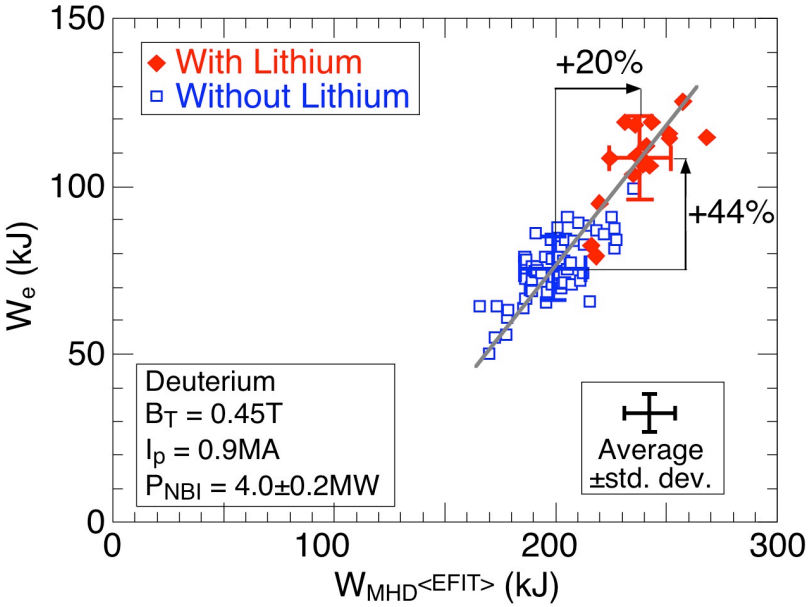


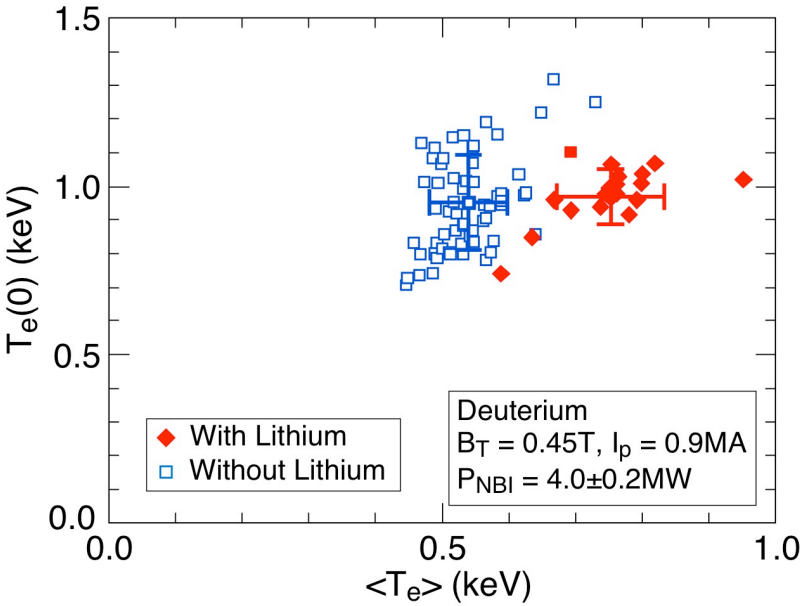


H. Kugel (M. Bell, this conference)

- H-mode threshold power reduced by Li
- Without ELMs, impurity accumulation increases radiated power and Z_{eff}

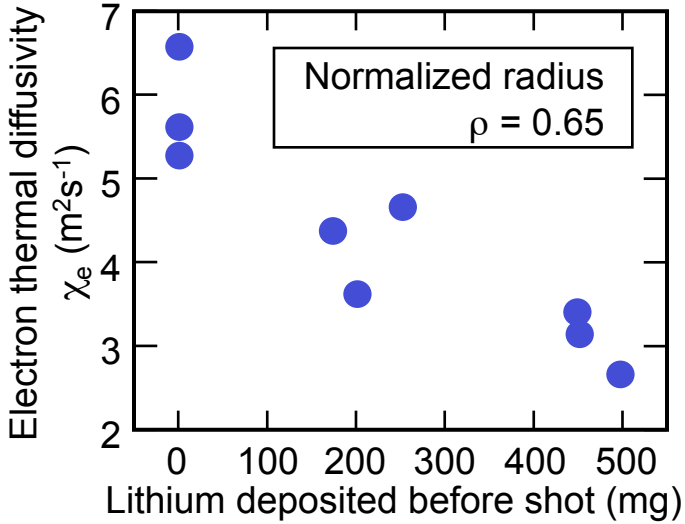
Improvement in Confinement Arises from Broadening of Temperature Profiles



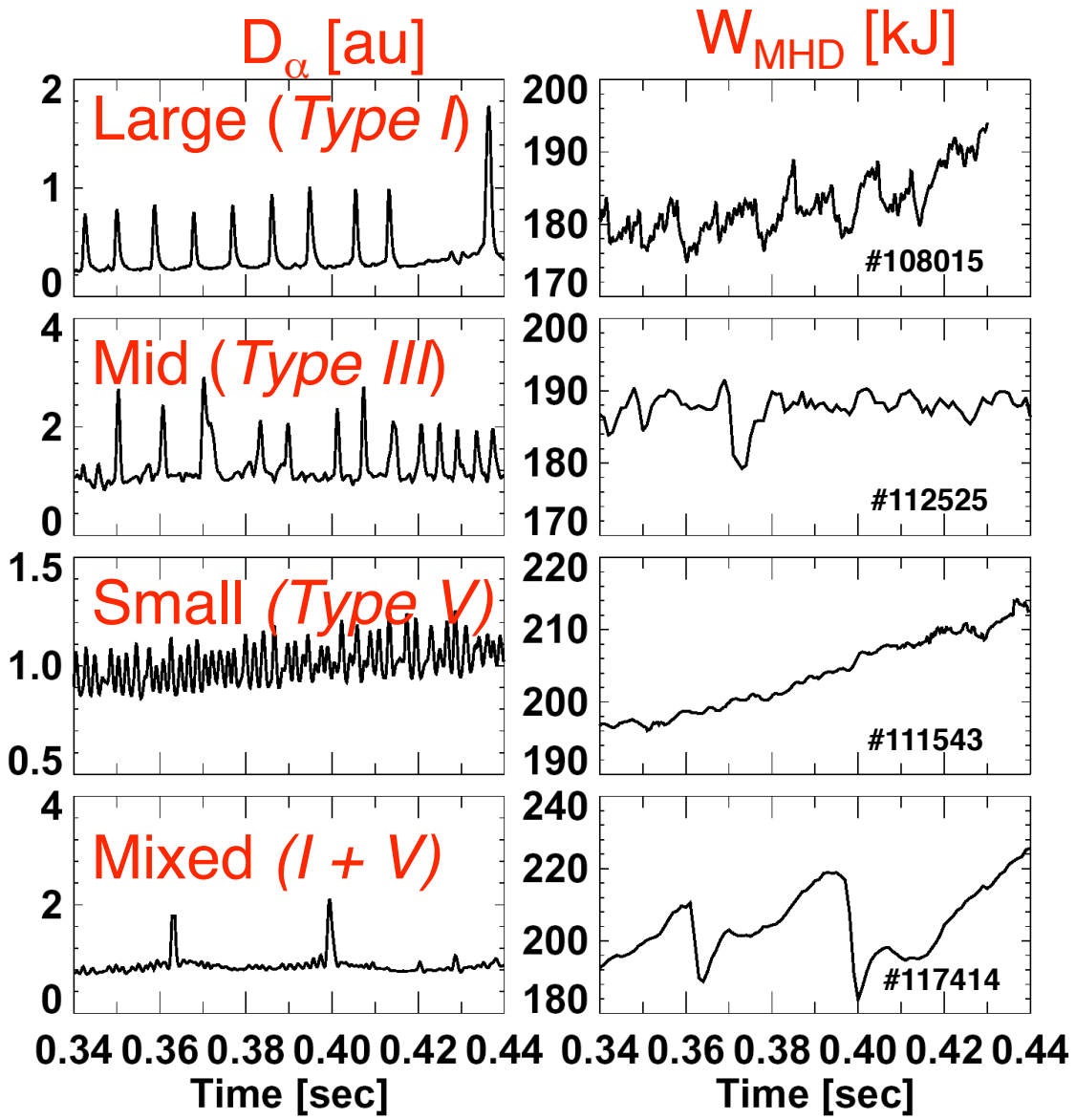


- All data in H-mode
- TRANSP analysis confirms electron thermal transport in outer region progressively reduced by lithium
- Ion transport at neoclassical in non-li and lithium discharges

M. Bell, S. Ding (M. Bell, this conference)



ELMs routinely observed in nearly all NSTX discharges



$\Delta W_{MHD}/W_{MHD} \sim$ 3-15%
$P_{heat} >> P_{L-H}$

$\Delta W_{MHD}/W_{MHD} \sim$ 1-5%
$P_{heat} \geq P_{L-H}$

$\Delta W_{MHD}/W_{MHD} \leq$ 1%
Wide P_{heat} range

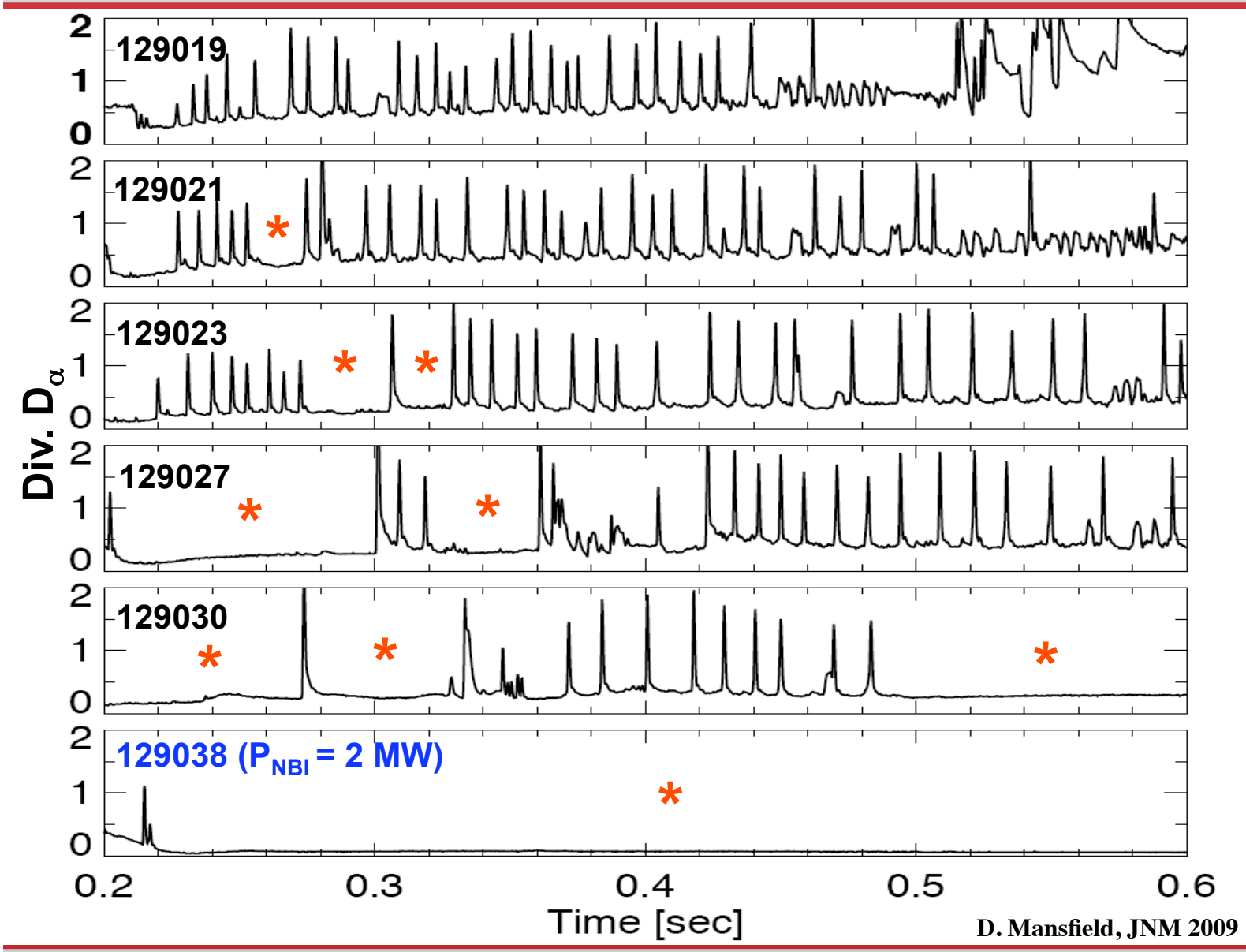
$\Delta W_{MHD}/W_{MHD} \leq$ 30%
High P_{heat}, β_N

R. Maingi, JNM 2005

Suppression of all ELMs with lithium wall coatings

- Lithium wall coatings improve confinement and induce ELM -free H-mode
  - Core stability limits (β_N ~ 5.5-6) encountered before edge (ELM) stability limits
  - Impurities accumulate and radiated power increases with time
- Reduction of peak P_e (n_e) gradient and shift toward region of reduced magnetic shear responsible for stabilization of ELMs
  - Pedestal n_e profile shifts inward -> P_e profile broadens
  - Pre-lithium discharges unstable to n=3 (peeling-ballooning mode)
  - Post-lithium discharges stable
    - Instability growth rates reduced by 70-100% in post-lithium discharges

Quiescent phases (*) increase with increasing lithium coating (P_{NBI} = 4 MW)

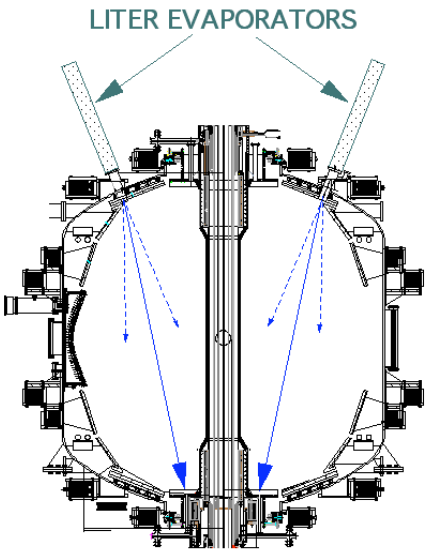


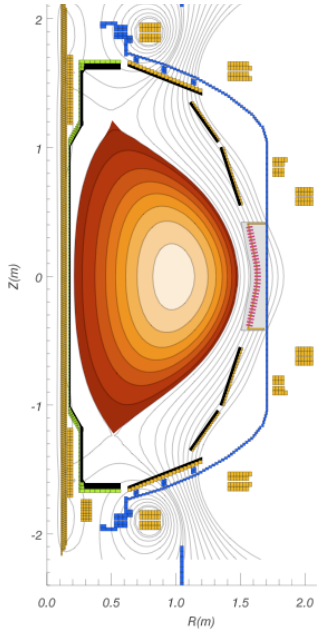
No lithium

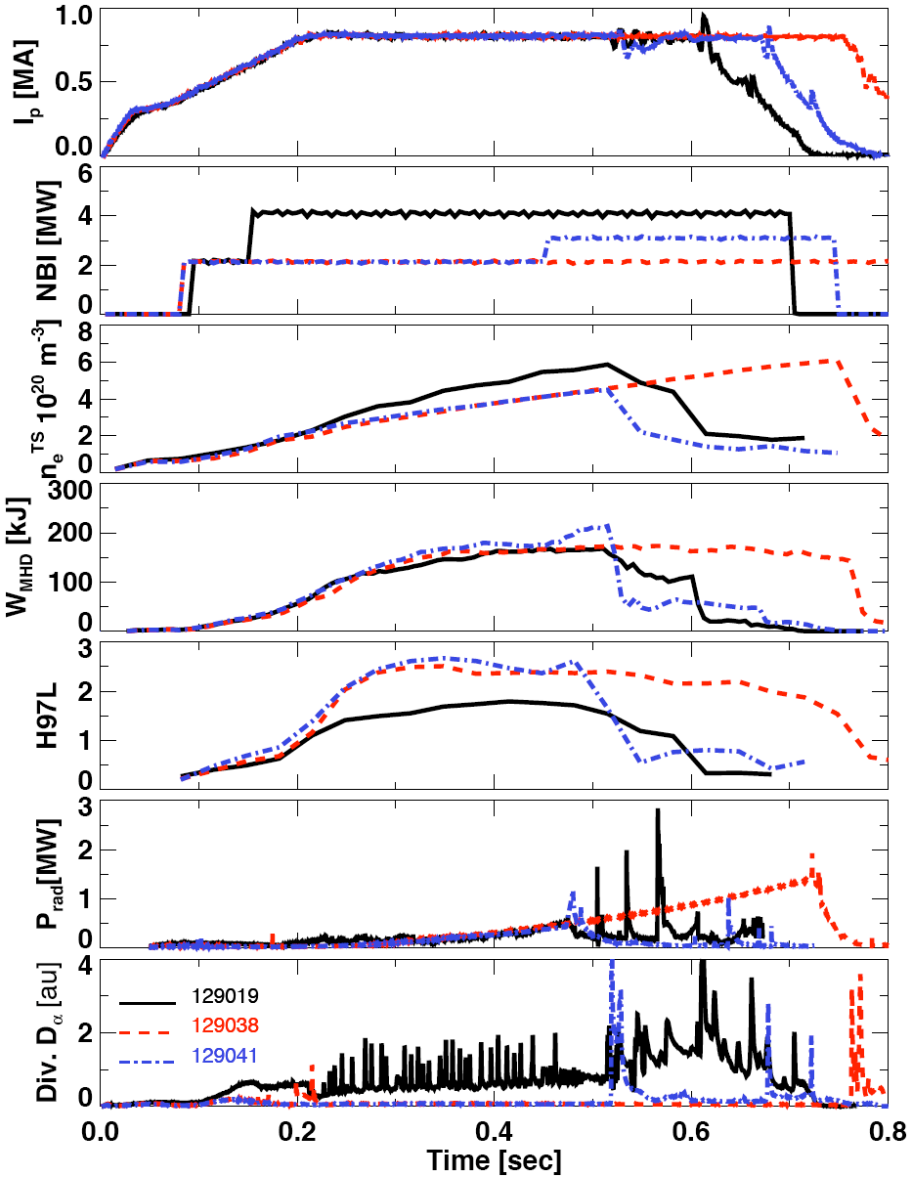
Increasing lithium coating

D. Mansfield, JNM 2009

ELM-free H-mode induced by lithium wall coatings

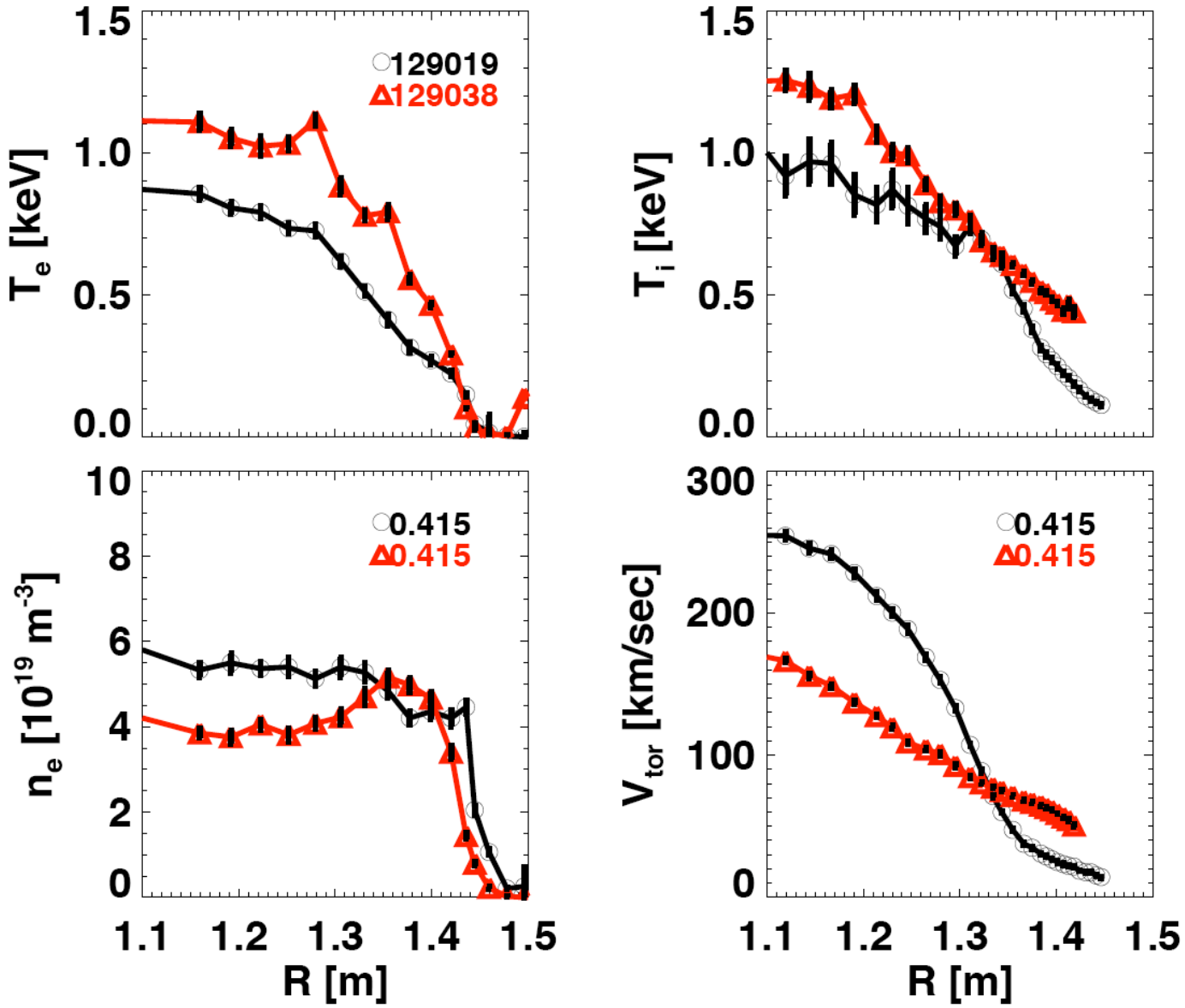






- Pre-Li, Post-Li, Post-li at β limit
- Lower (med) NBI to avoid (probe) β limit
- Lower n_e
- Similar W_{MHD} (β_N =5.5 -> RWM)
- H-factor increased by 40%
- Higher P_{rad} /P_{heat}
- ELM-free, reduced divertor recycling

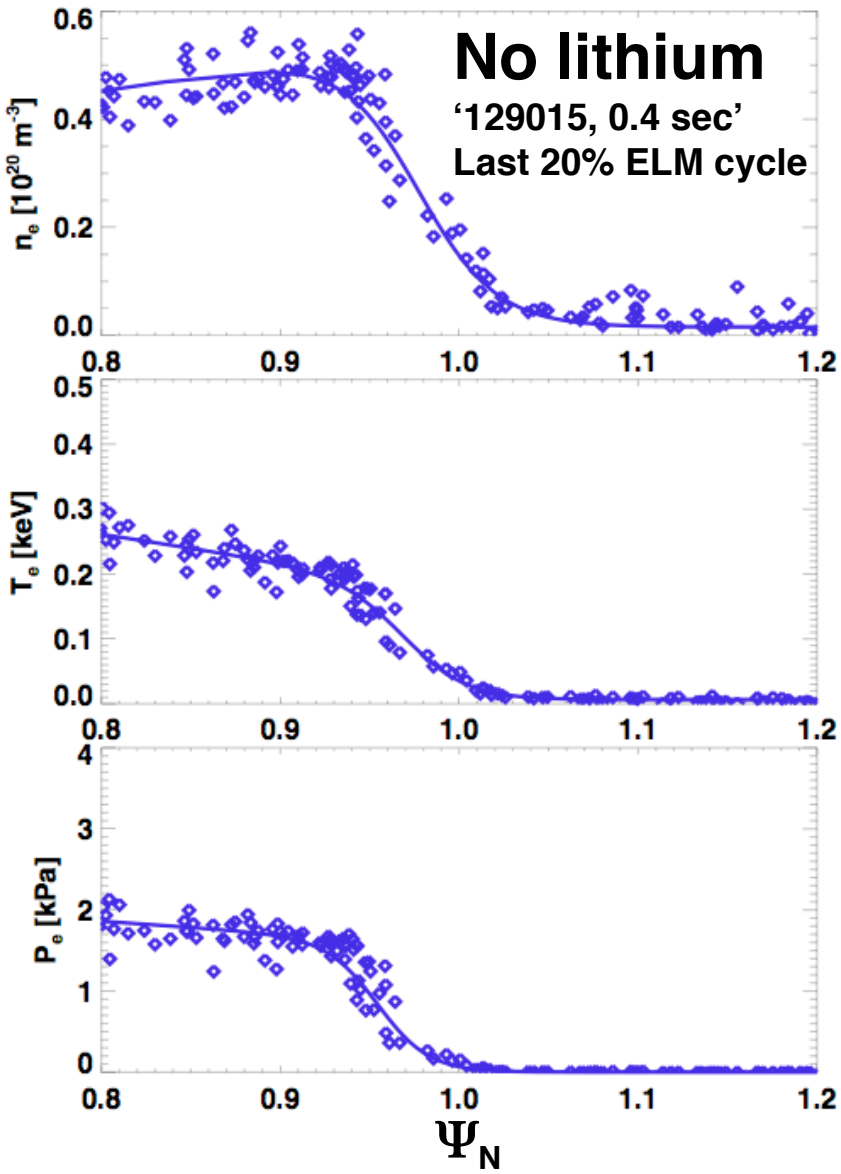
T_e, T_i increased and edge n_e decreased with lithium coatings

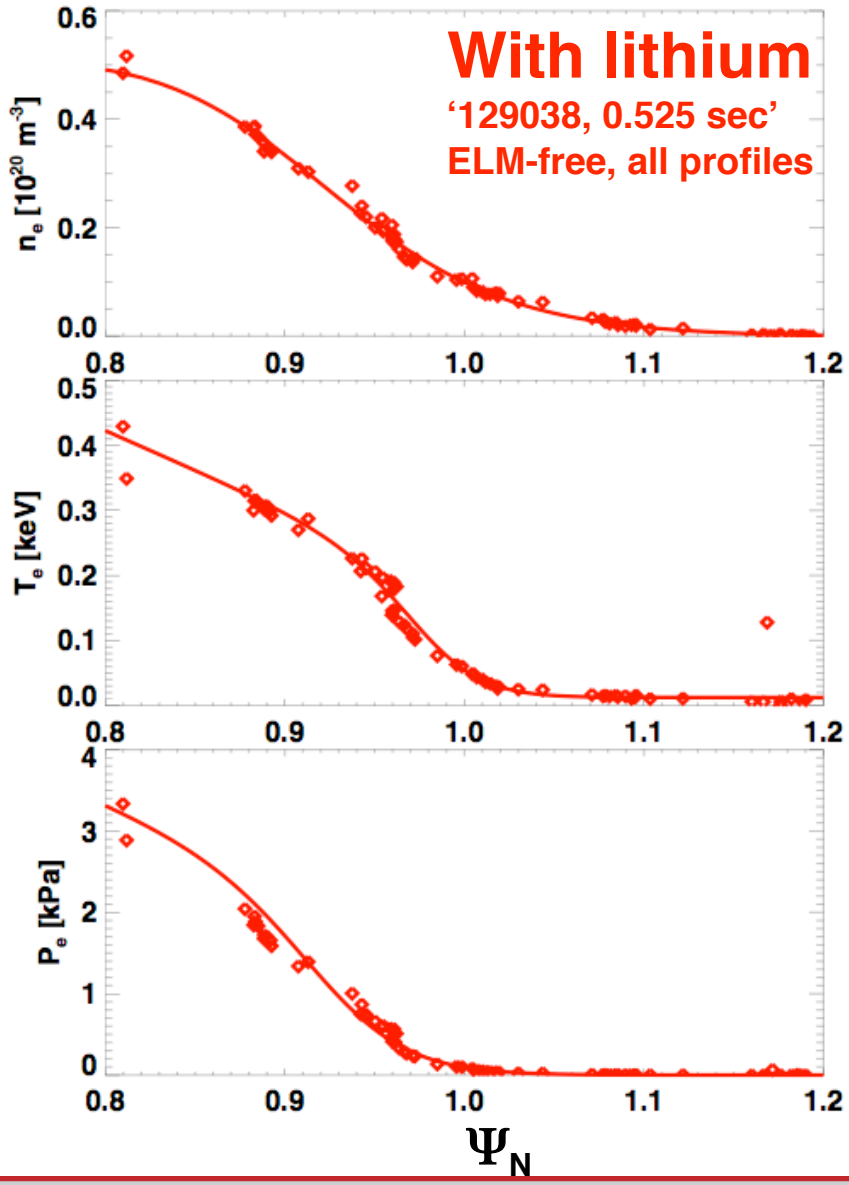


No lithium

With lithium

Multiple time slices used to characterize profiles



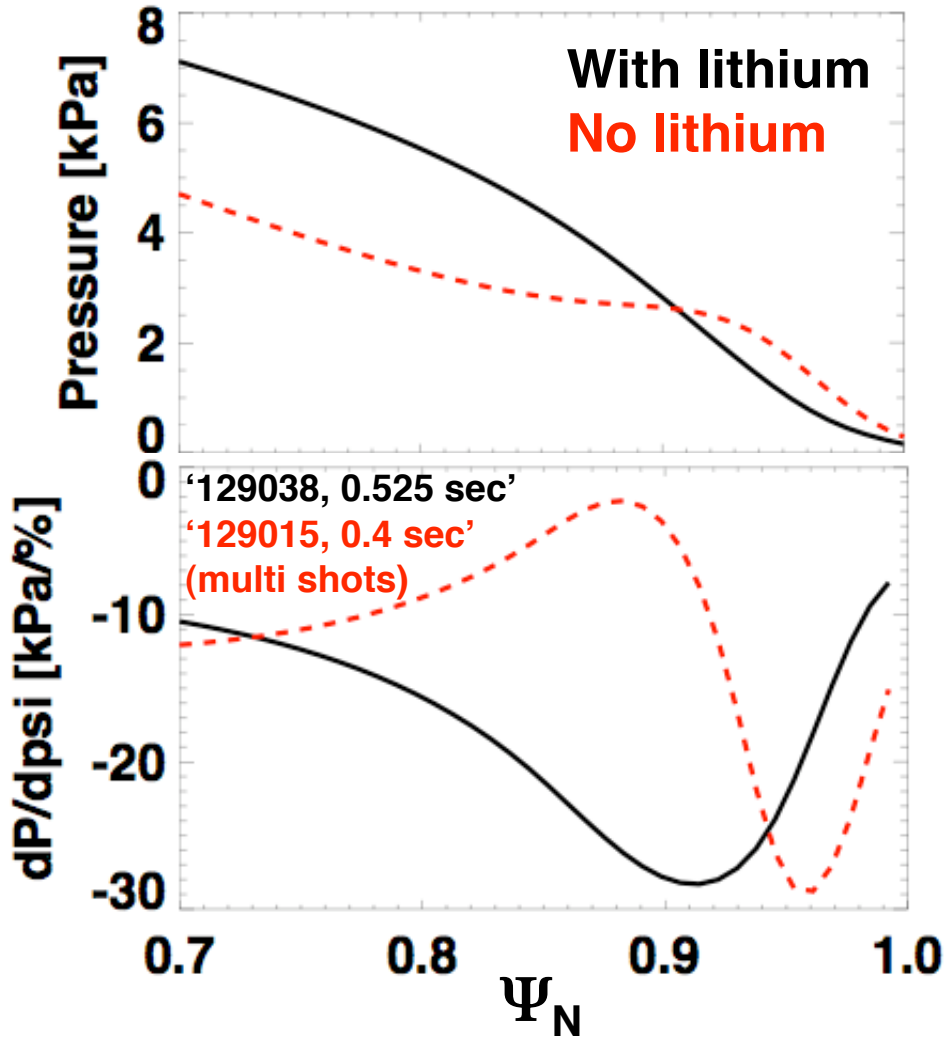


Edge stability analysis procedure

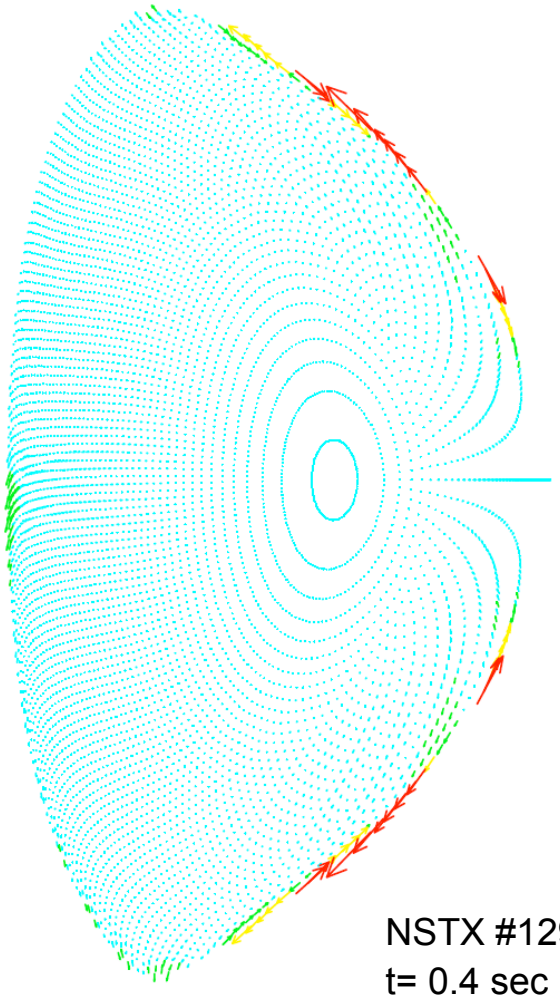
- EFIT run at Thomson profile times for ψ_N mapping
- Profile fitting of multiple time slices with standard procedures used as target for kinetic EFITs
  - Pre-lithium discharge profiles from last 20% of ELM cycle selected
  - Post-lithium discharge profiles used in 100-200 msec windows
- Free boundary kinetic EFITs run to match kinetic pressure profiles
  - Edge bootstrap current computed from Sauter model
  - Stability evaluated with PEST
- Fixed boundary kinetic EFITs run with variations of edge pressure gradient and edge current
  - Stability boundary evaluated with ELITE

n=3 mode most unstable (PEST analysis on kinetic EFIT)

Maximum pressure gradient shifted inward with lithium



No lithium: γ_{lin}/ω_A ~ 0.01-0.015
Projection of displacement ξ (n=3)

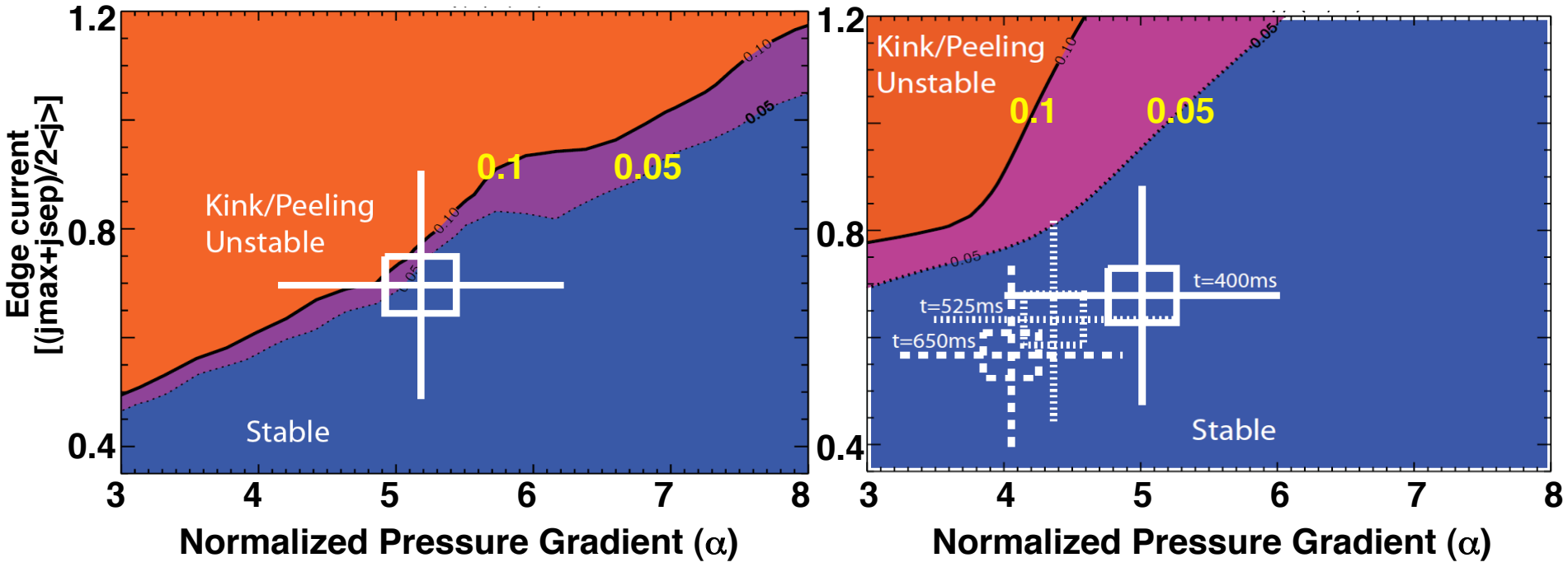


NSTX #129015,
t= 0.4 sec

Pre-lithium edge profiles close to peeling/ ballooning instability threshold (ELITE)

No lithium: $\gamma_{lin}/(\omega^*/2)$ becomes large at blue/purple/orange boundary ('varyped' EFITs)

With lithium: $\gamma_{lin}/(\omega^*/2)$ becomes large at blue/purple/red boundary ('varyped' EFITs)



- Low n=1-5 pre-cursor oscillations observed before ELM crash

R. Maingi, PRL submitted, 2009

Modification of edge stability observed with lithium wall coatings

- Lithium wall conditioning induces ELM-free H-mode
  - H-factor increased by 50%
  - Global stability limits (β_N ~ 5.5-6) encountered before edge (ELM) stability limits
  - T_e, T_i increase and profiles change substantially
  - ELM-free phases increase gradually with lithium deposition, with discharges eventually becoming ELM-free
  - Impurities accumulate and radiated power increases with time
    - Present plan: use 3d fields to trigger ELMs to purge impurities
- Reduction of peak P_e (n_e) gradient and shift toward region of reduced magnetic shear responsible for stabilization of ELMs (pre and post-lithium discharges)
- Hypothesis: lithium reduces recycling -> reduces core fueling -> reduces collisionality -> increases edge bootstrap current -> access to second stability?

Poster copies