NSTX

Supported by U.S. DEPARTMENT OF ENERGY Office of Science

Enhancement of edge stability with lithium wall coatings in NSTX

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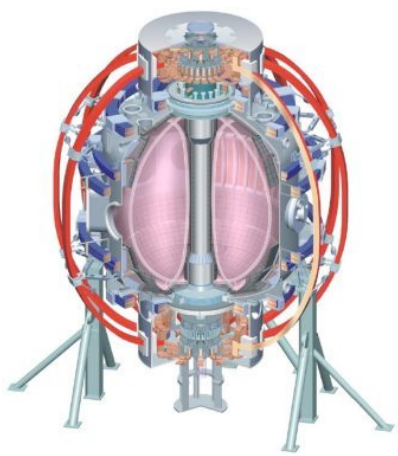
and the NSTX Research Team

50th APS/DPP meeting
Dallas, TX
17-21 November, 2008



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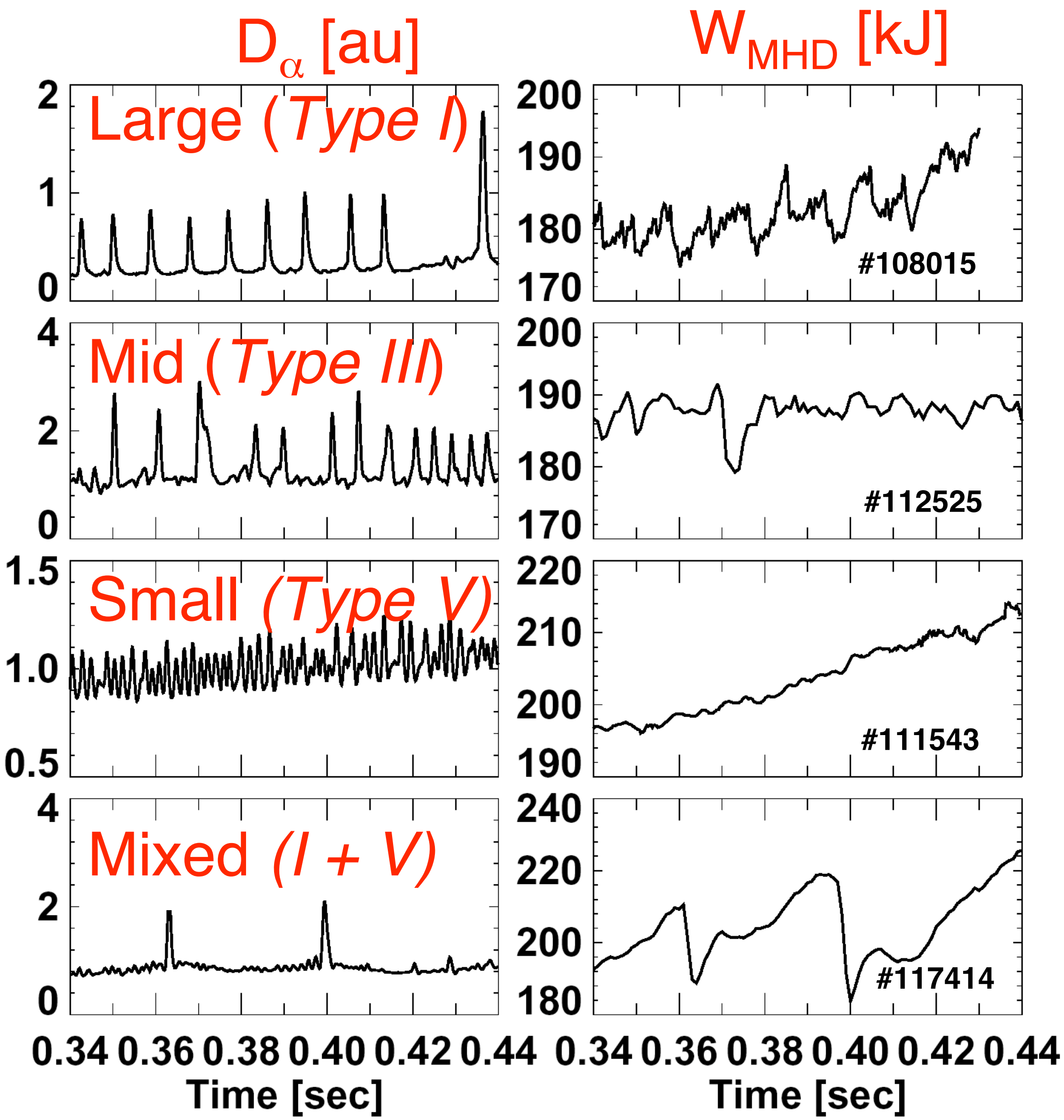
ELMs routinely observed in nearly all NSTX discharges



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

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

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

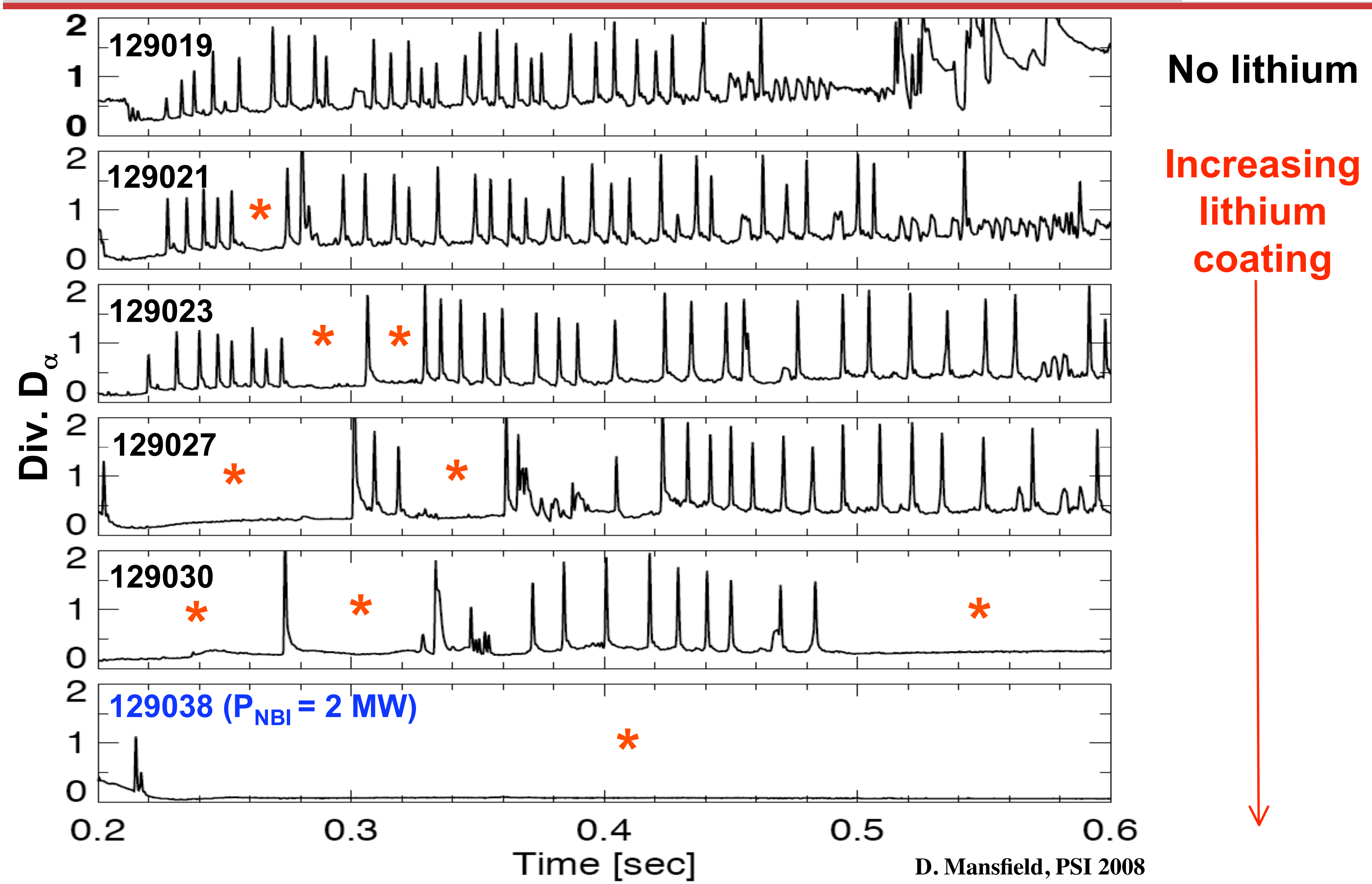
$\Delta W_{MHD}/W_{MHD} \leq$ 30%
High P_{heat}, β_N

R. Maingi, JNM 2005

Suppression of all ELMs with lithium wall coatings

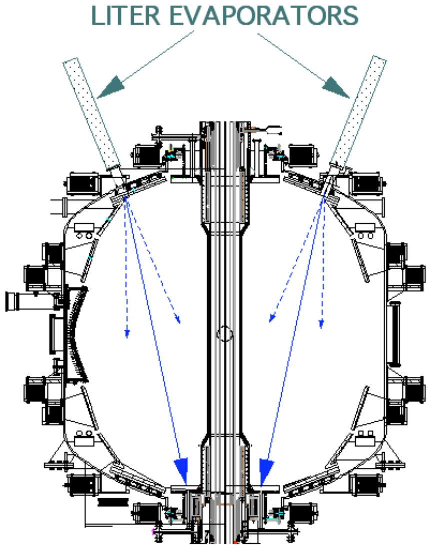
- Lithium wall coatings improve confinement and induce ELM-free H-mode
  - Core stability limits (β_N ~ 5.5) encountered before edge (ELM) stability limits
  - Impurities accumulate and radiated power increases with time
- Preliminary stability analysis indicates reduction of edge n_e, P_e gradients responsible for stabilization of ELMs
  - Pedestal width increases in post-Li discharges
  - Pre-lithium discharges unstable to n=3 (peeling-ballooning mode)
  - Post-lithium discharges marginally stable
    - Instability growth rates reduced by 70-100% in post-lithium discharges

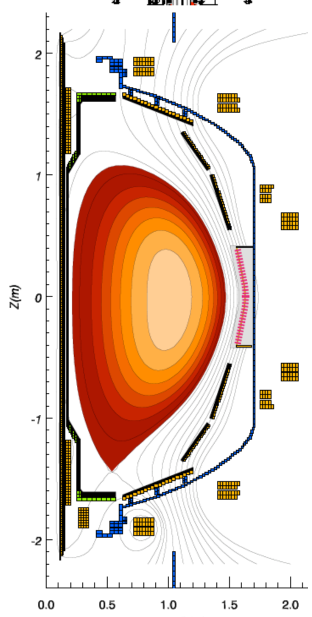
Quiescent phases (*) increase with increasing lithium coating (P_{NBI} = 4 MW)

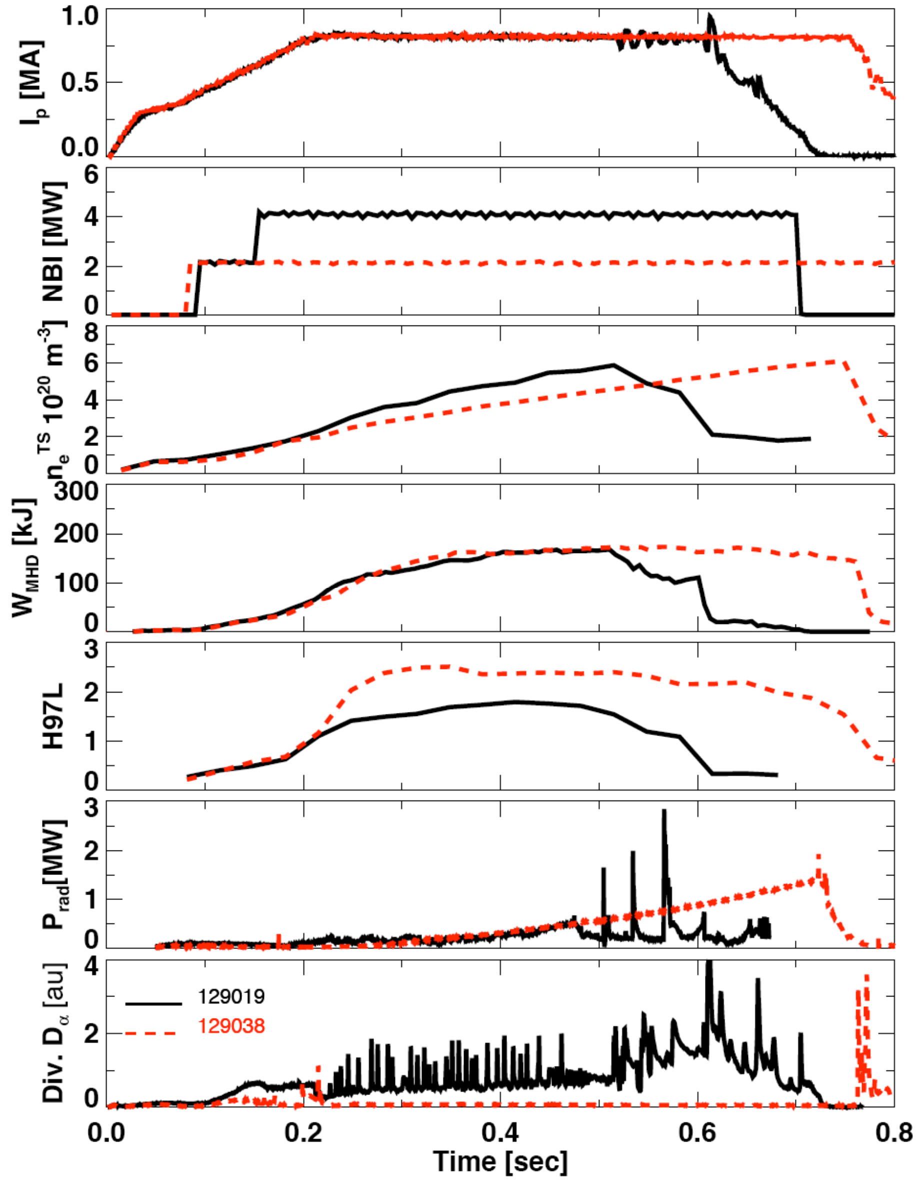


D. Mansfield, PSI 2008

ELM-free H-mode induced by lithium wall coatings

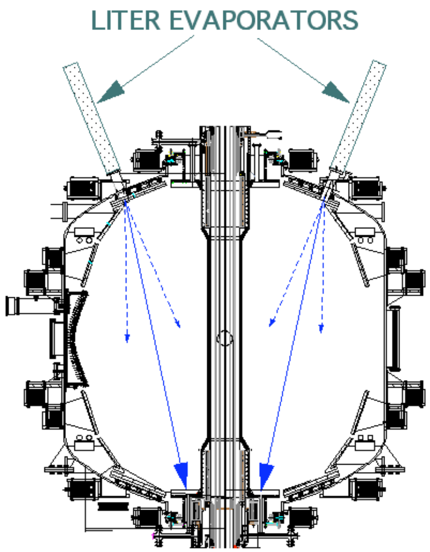


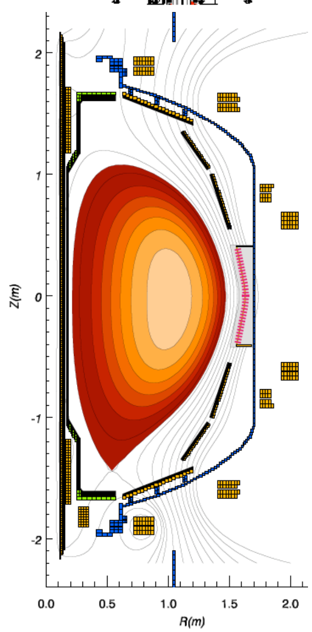


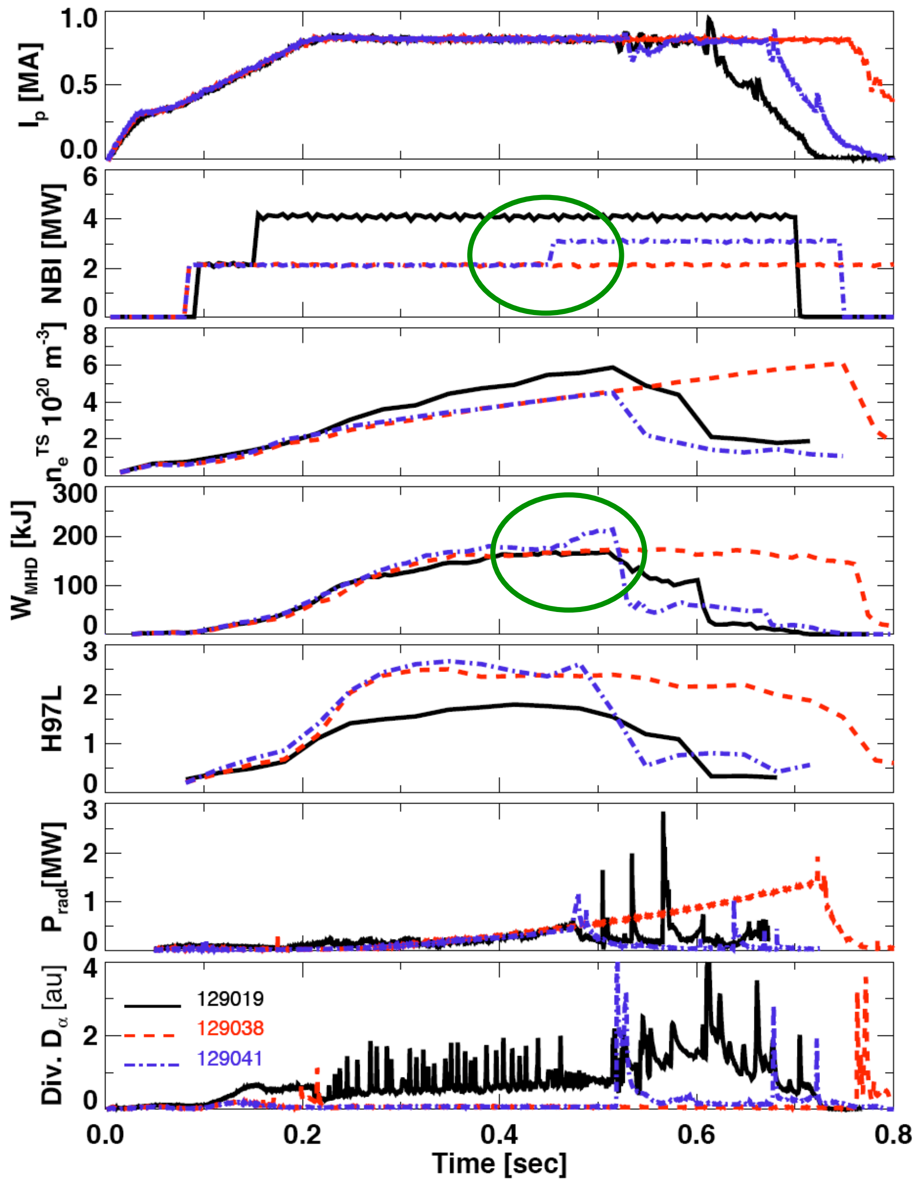


- Pre-Li, Post-Li
- Lower NBI to avoid β limit
- Lower n_e
- Similar stored energy
- H-factor 40%↑ (more than hi δ,κ)
- Higher P_{rad} /P_{heat}
- ELM-free, reduced divertor recycling

Global β_N limit encountered before edge stability limit with lithium coatings

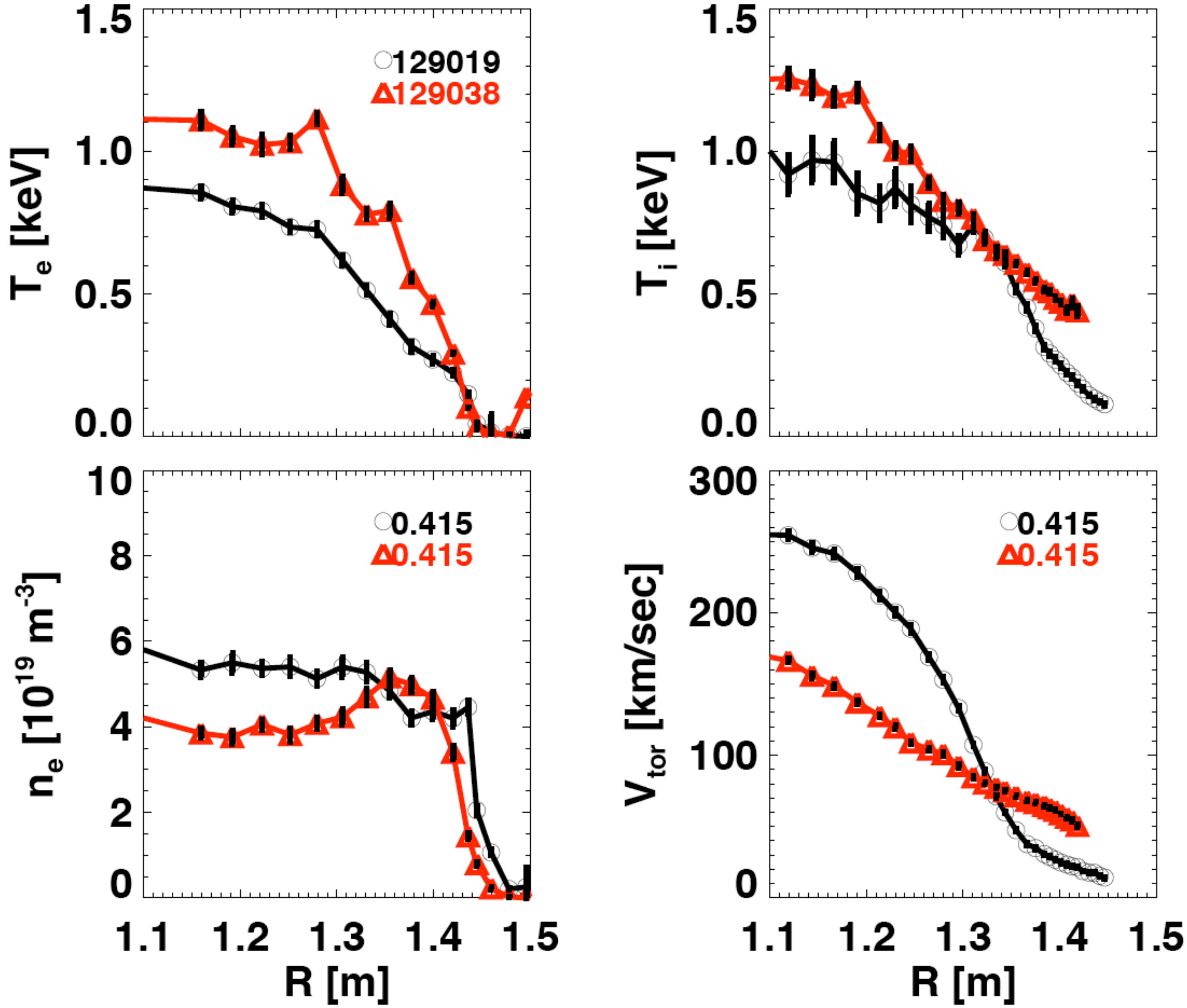






- Pre-Li, Post-li, Post-li at β limit
- Intermediate NBI to probe β limit
- β limit at P_{NBI}=3 MW (β_N =5.5)

T_e, T_i increased and edge n_e decreased with lithium coatings



No lithium

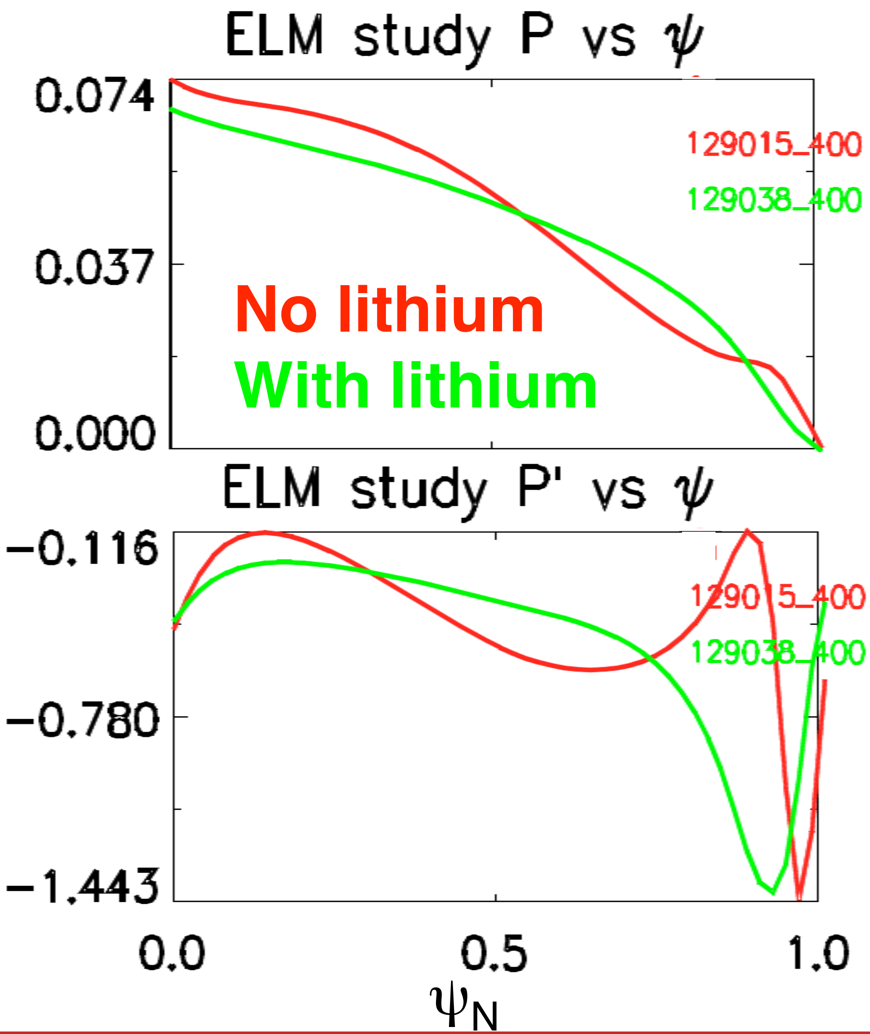
With lithium

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

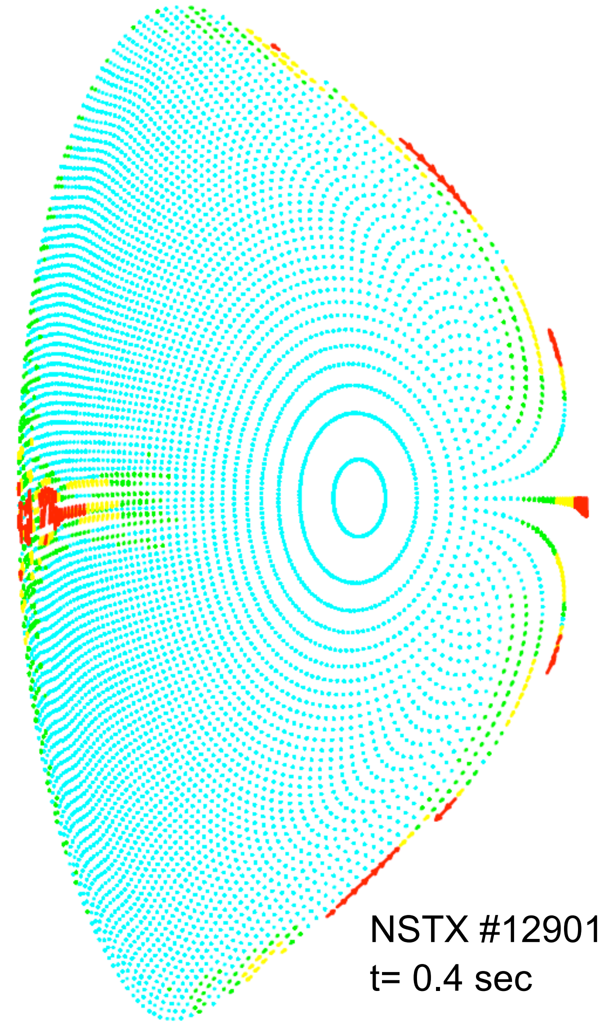
n=3 mode most unstable from PEST analysis on kinetic EFIT

Maximum pressure gradient shifted inward with lithium



No lithium: γ_{lin}/ω_A ~ 0.1-0.2

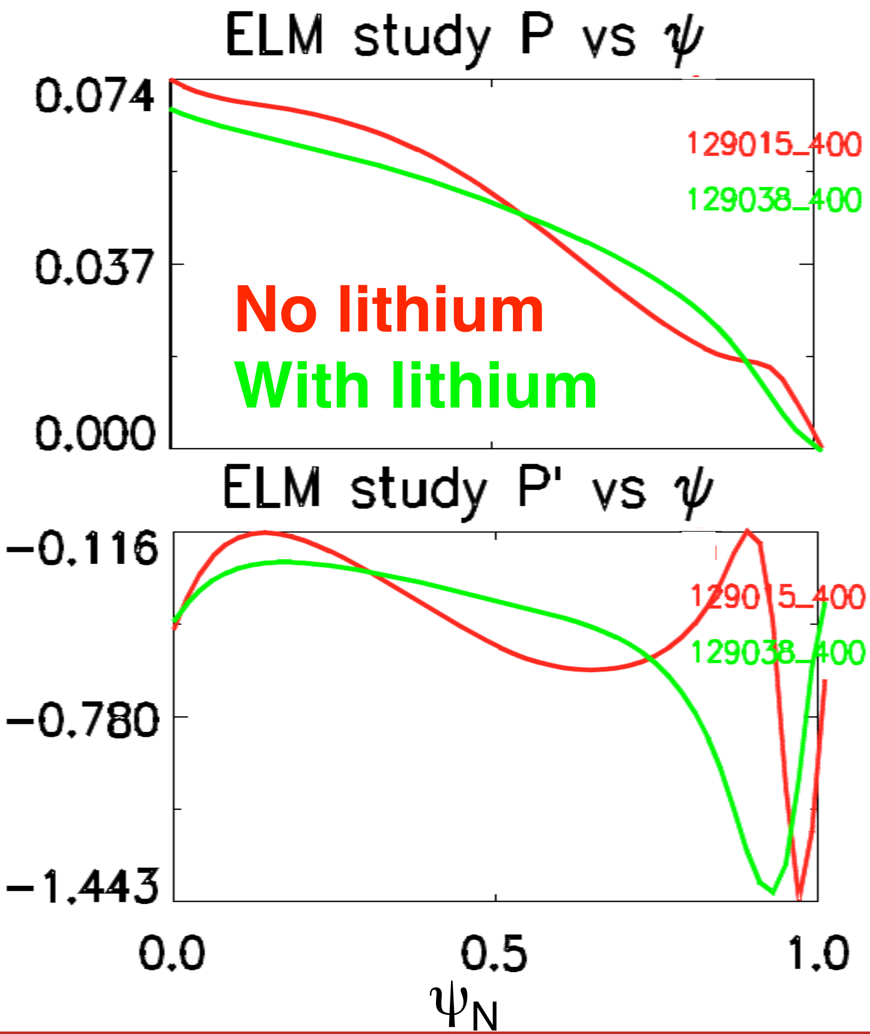
Projection of displacement ξ (n=3)



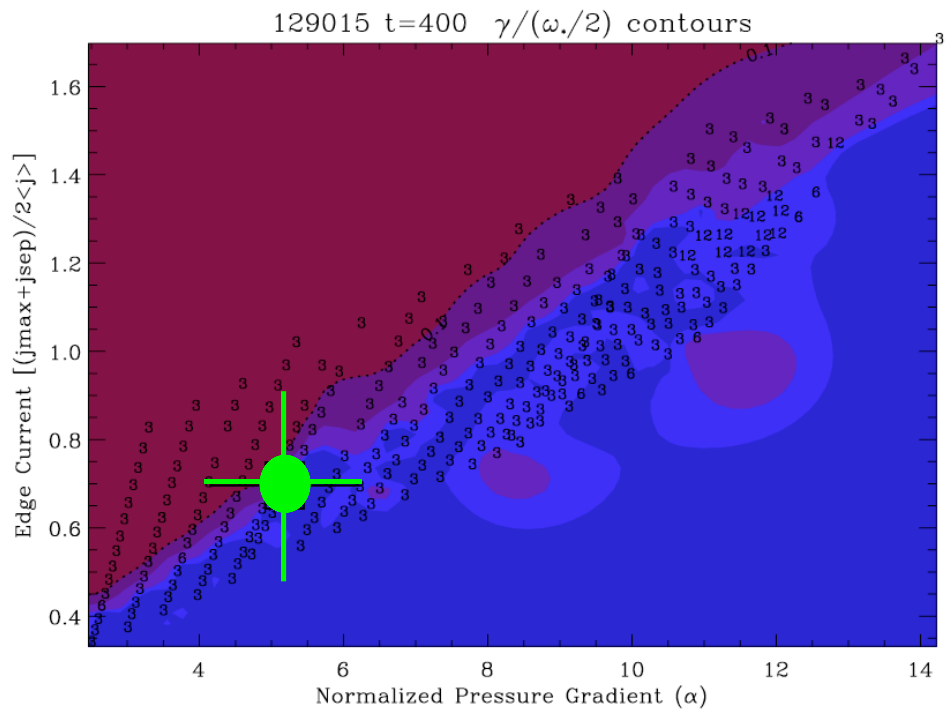
NSTX #129015, t= 0.4 sec

Edge profiles close to unstable n=3 peeling mode from ELITE analysis

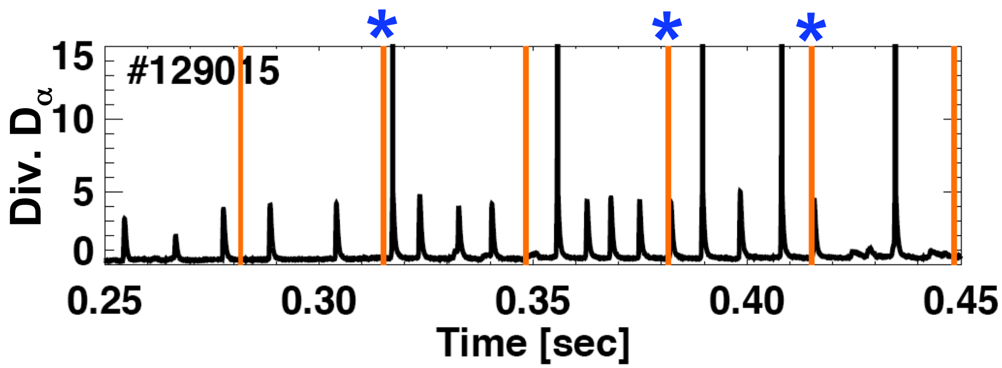
Maximum pressure gradient shifted inward with lithium

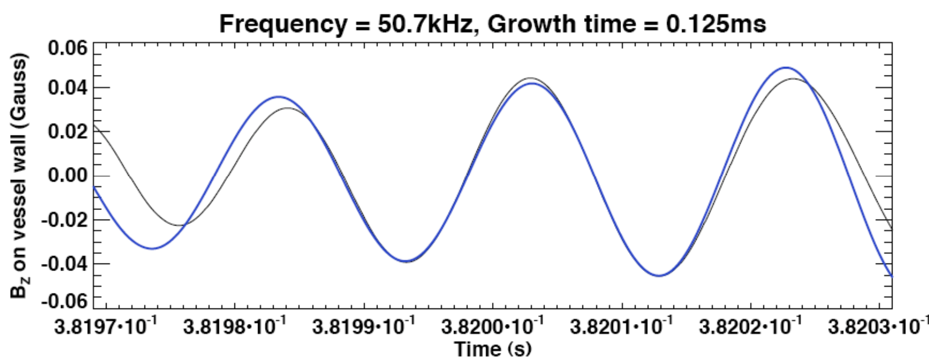


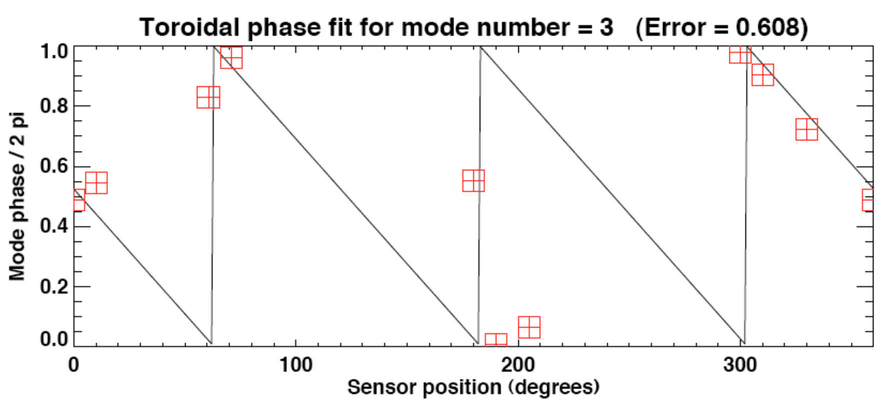
No lithium: $\gamma_{lin}/(\omega^*/2)$ becomes large at blue/purple/red boundary ('varyped' EFITs)



ELM precursor with n=3 observed in magnetics







- Discharge with optimal ELM timing relative to Thomson pulses chosen for stability analysis
  - ✓3 ELMs in last 20% of ELM cycle
- Magnetic fluctuation spectrum from 40-60kHz analyzed near ELM at t=0.382s sec
- n=3 pre-cursor oscillation identified

Enhancement 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) 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
- Preliminary stability analysis indicates reduction of edge n_e, P_e gradients responsible for stabilization of ELMs
  - Pre-lithium discharges unstable to n=3 (peeling-ballooning mode)
    - n=3 pre-cursor found in magnetics data
  - Post-lithium discharges marginally stable
    - Instability growth rates reduced by 70-100% in post-lithium discharges