NSTX

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Effects of Lithium-Coated Plasma-Facing Components on NSTX Discharges

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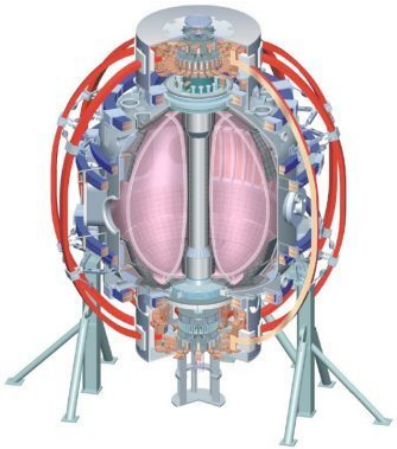
November 17, 2008



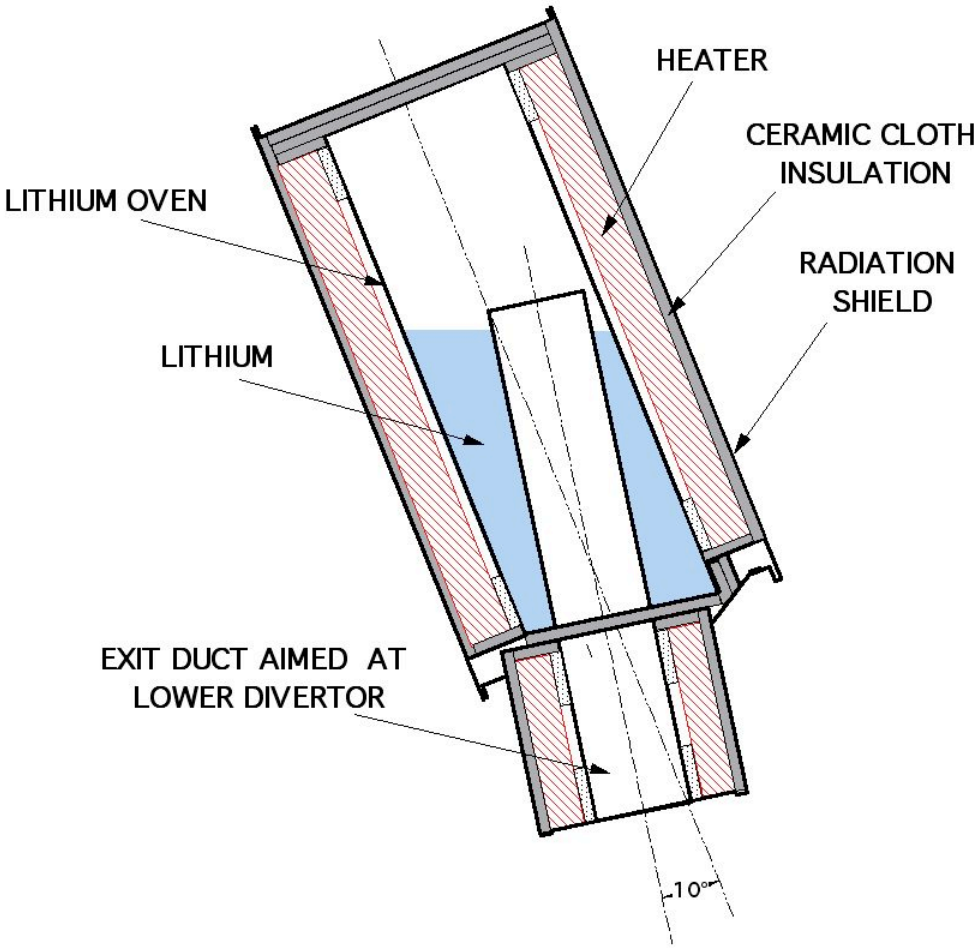
Introduction

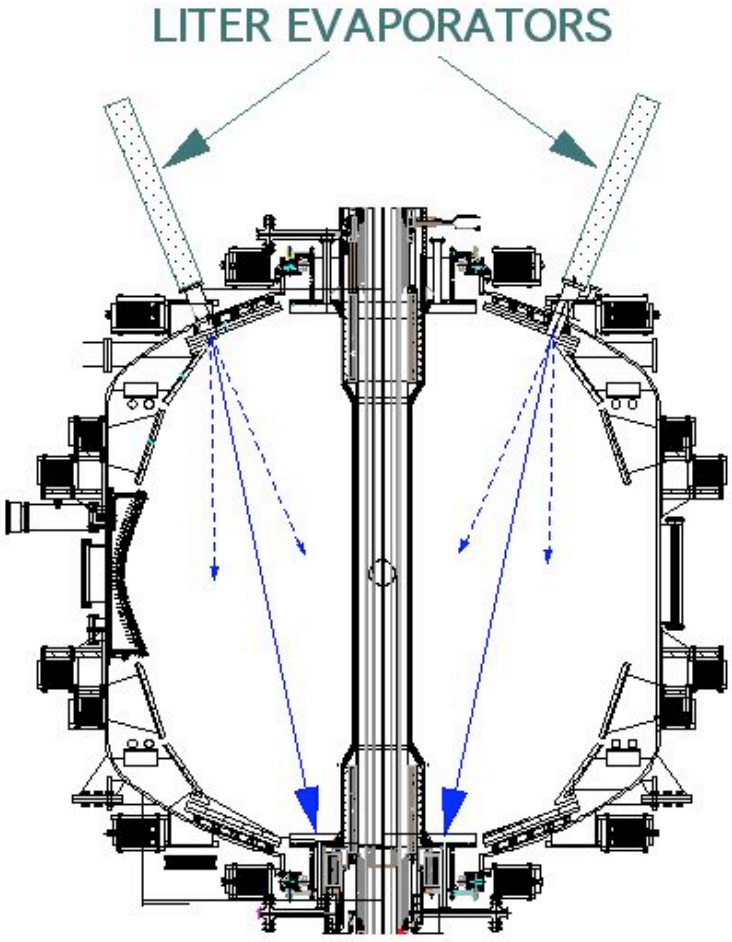
- Lithium plasma-facing components (PFCs) have potentially attractive features for reactors, e. g., reducing recycling and mitigating effects of high heat and radiation fluxes

- Dramatic effects of lithium PFCs on plasma performance demonstrated on TFTR, T-11M, FT-U, CDX-U, TJ-II, etc.

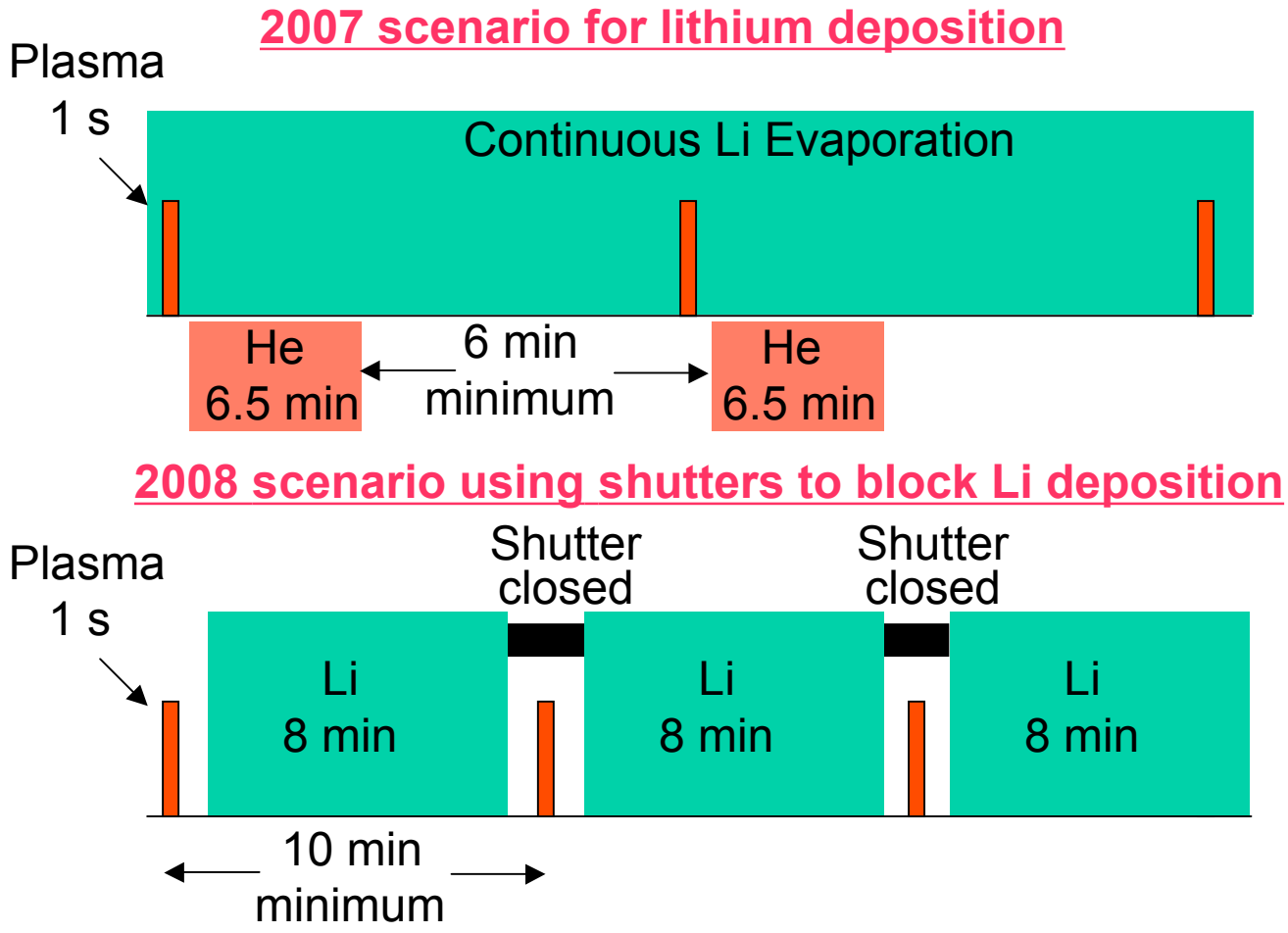
- Recent NSTX experiments have shown significant and recurring benefits of lithium PFCs including:
  - Reduced plasma density early in discharge
  - ELM suppression and longer pulse length
  - Improved energy confinement
  - Reduced flux consumption
  - Broader electron temperature profile
  - Reduced scrapeoff layer plasma density

Two LIThium EvaporatoRs (LITERs) oriented for coating NSTX divertor region with lithium



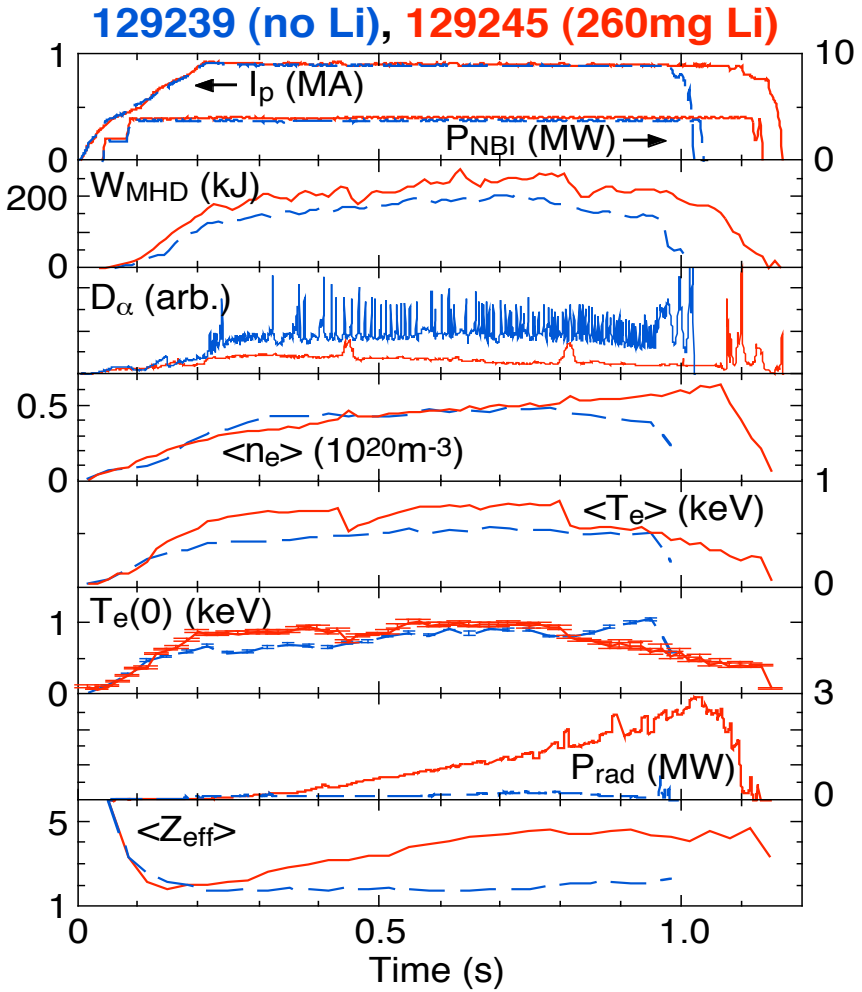


Shutter in front of LITER exit allows rapid interruption of evaporation without cooling oven



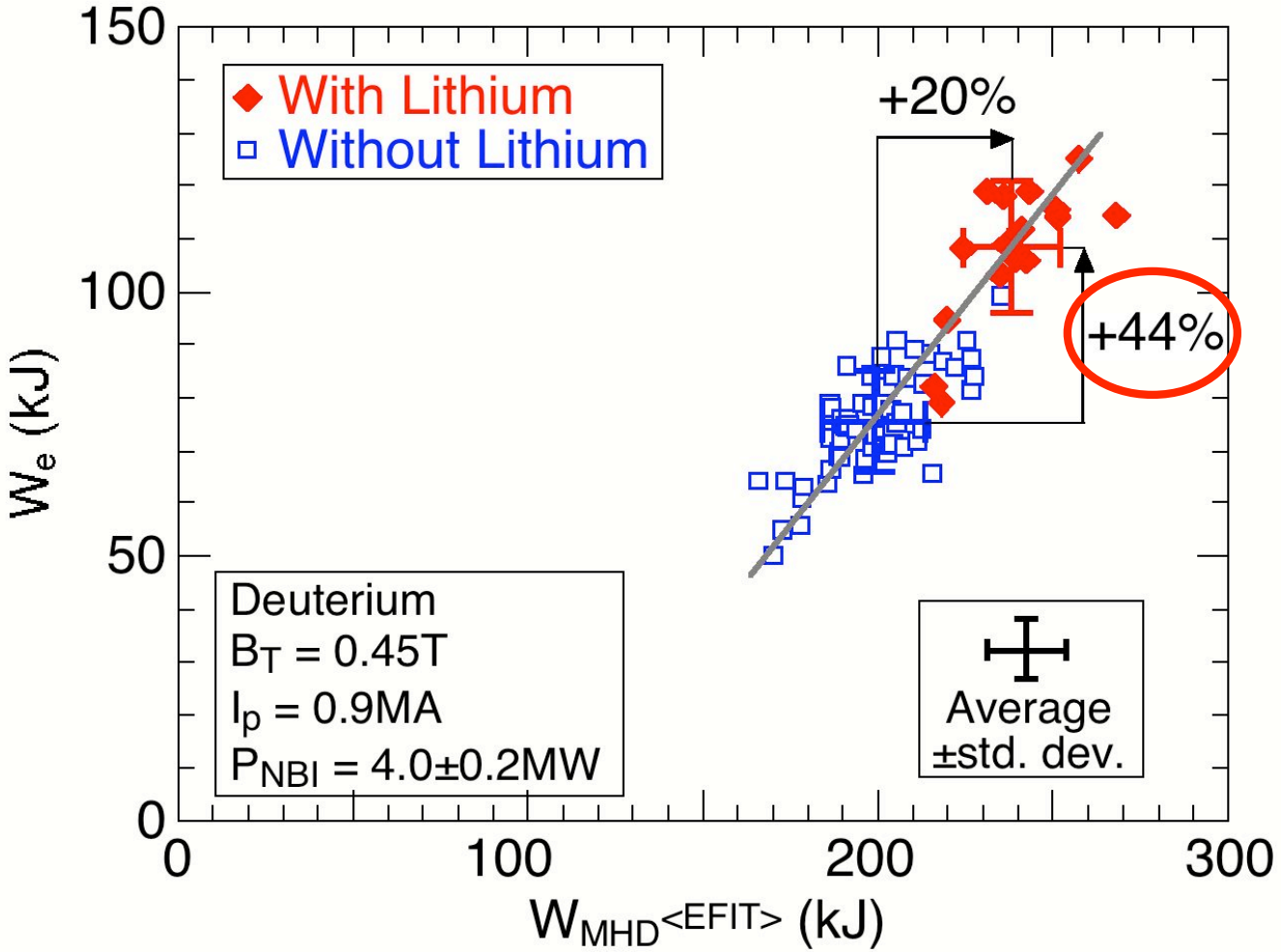
- Helium glow discharge cleaning eliminated between shots
  - Helium no longer trapped by lithium

ELMs suppressed and discharge duration extended in plasmas with lithium PFC coatings

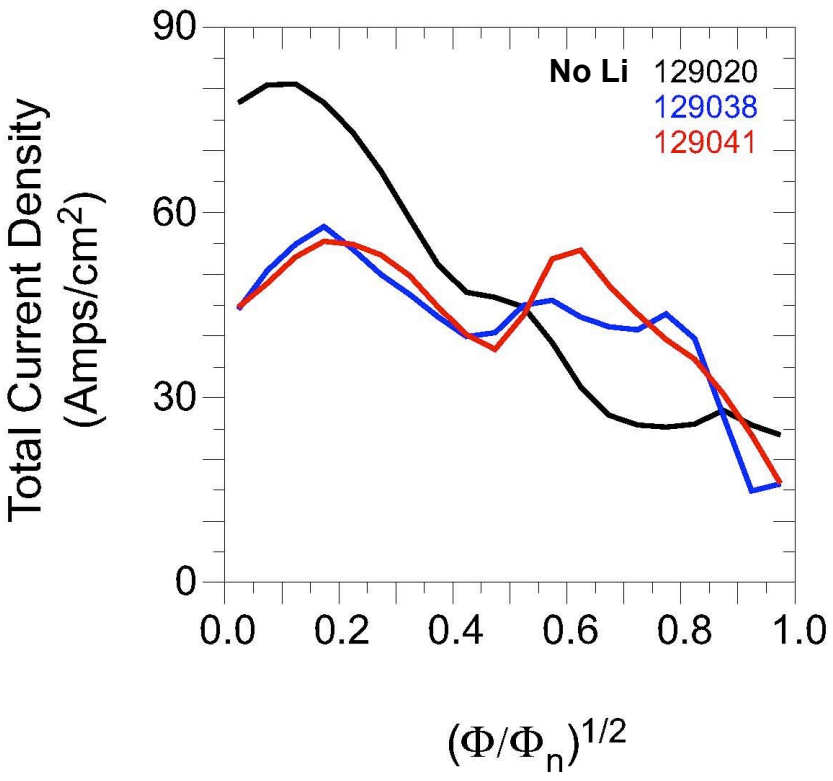


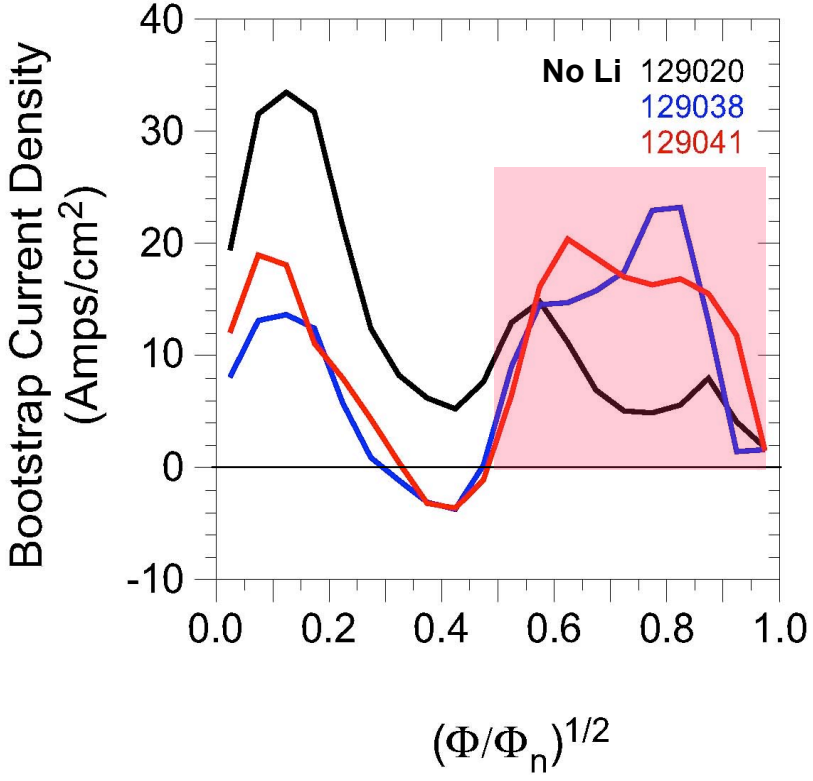
- Plasma density reduced early in discharge

Increase in stored energy (W_{MHD}) with lithium mostly through rise in electron stored energy (W_e)



TRANSP analysis indicates increase in edge current

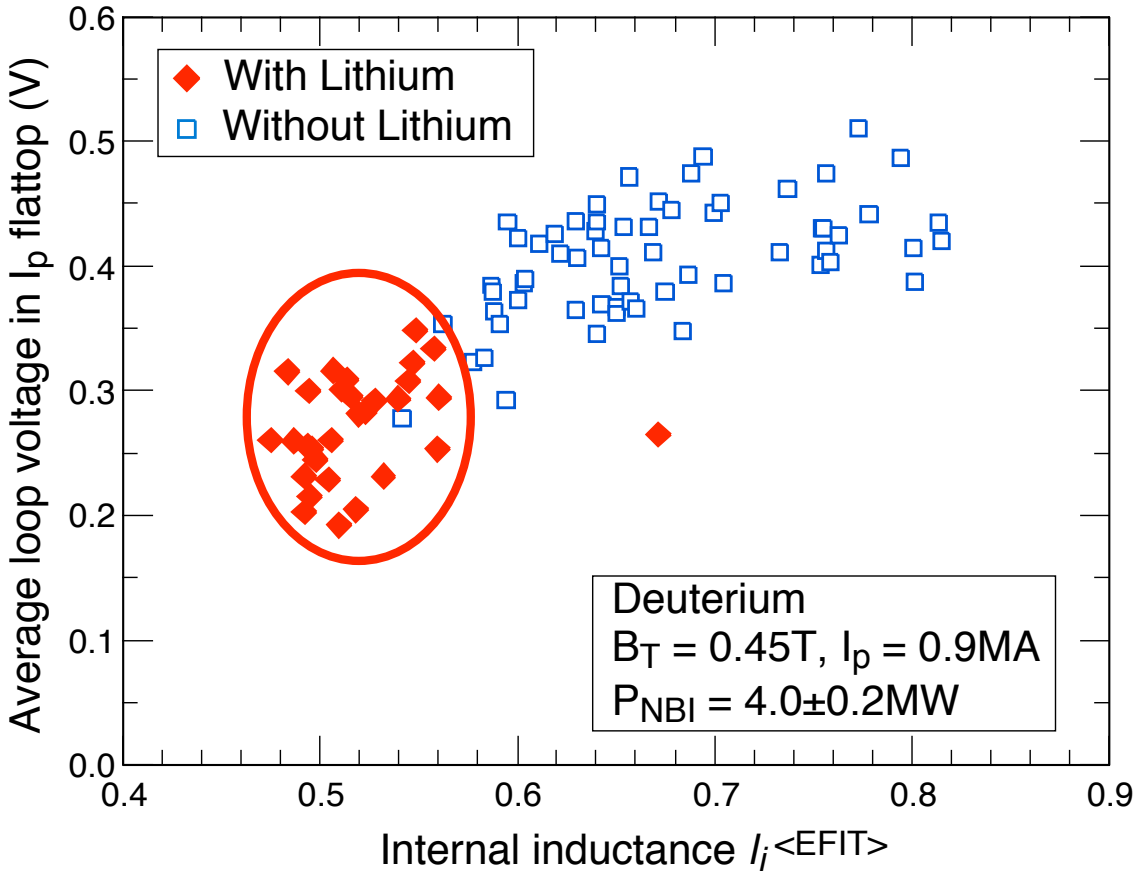




- Higher pedestal gradients raise edge boostrap current
  - Consistent with “second stability” and ELM suppression

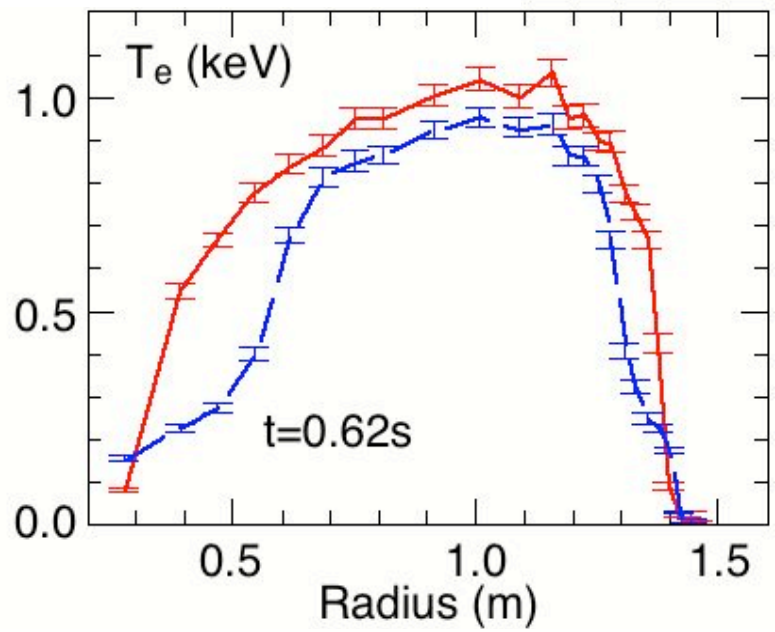
Lithium PFC coatings reduce OH flux consumption

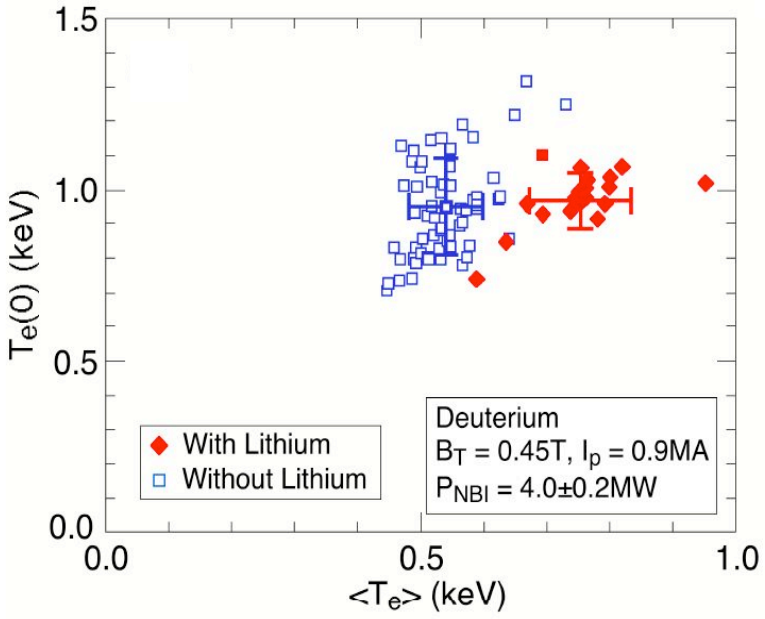
- Lower average loop voltages mean more efficient flux consumption
  - Internal inductance decreases as electron temperature profile broadens



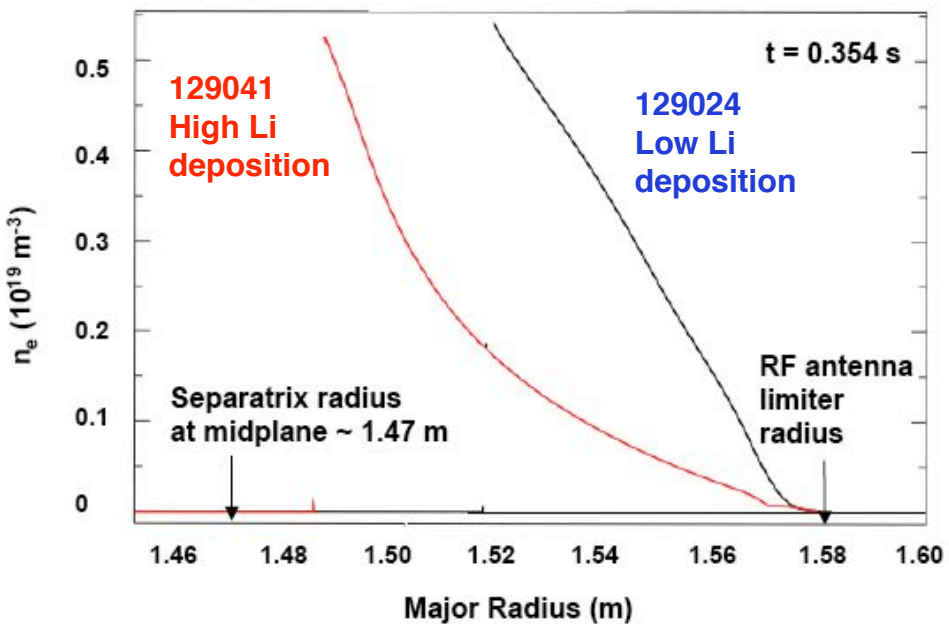
Electron temperature profile broadening observed in discharges with lithium PFC coatings

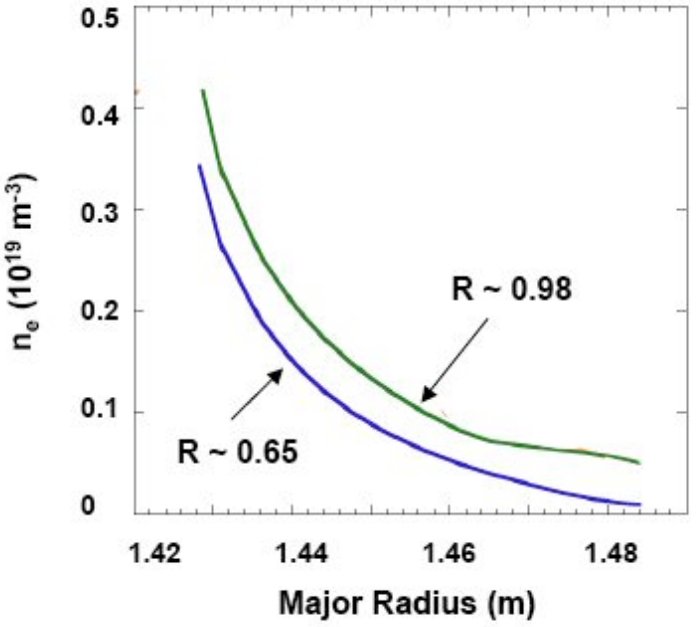
12939 (no Li), 12945 (260mg Li)





Scrapeoff layer profiles indicate density reduction with lithium-coated PFCs and suggests lowered recycling

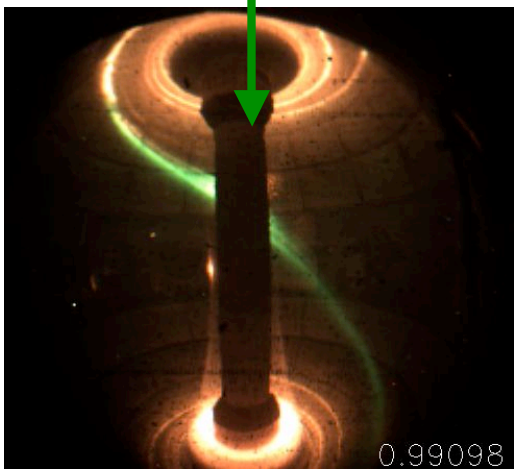


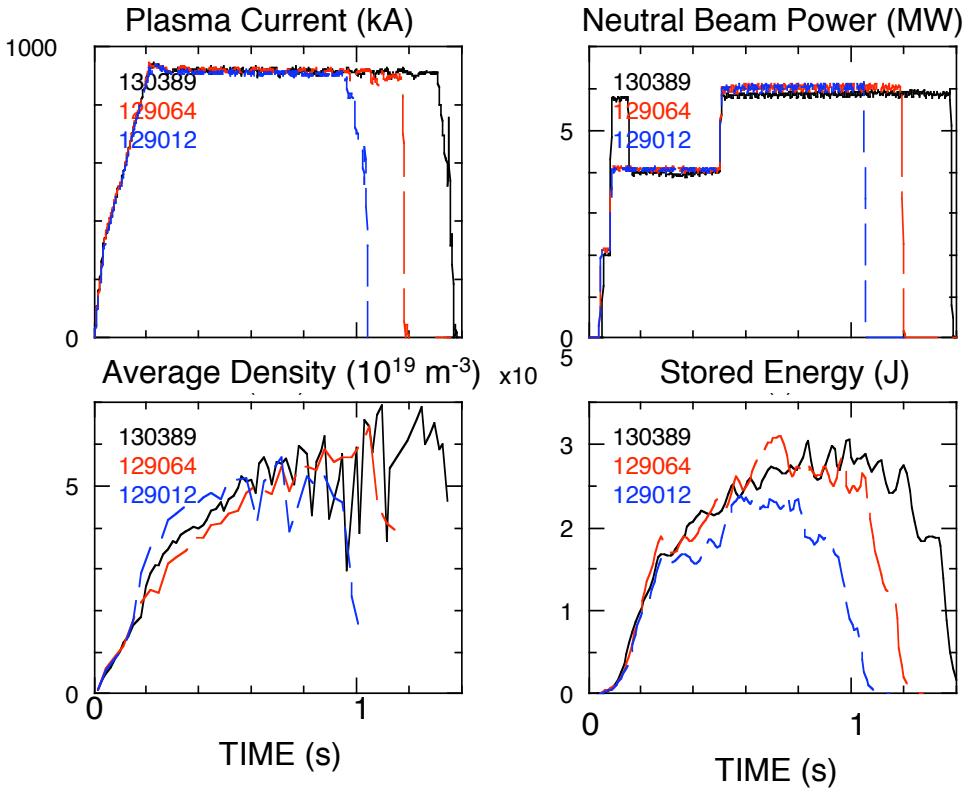


- Modeling in progress with UEDGE multi-fluid transport code
  - Shows variation in magnitude of edge density with recycling coefficient
  - Presently matches density profile shape only in high Li deposition case
    - Suggests need to include change in transport in simulations

Lithium coating from stream of lithium powder into scrapeoff layer similar to LITER in effect on plasma performance

~40μm lithium particles dropped from canister above during discharge





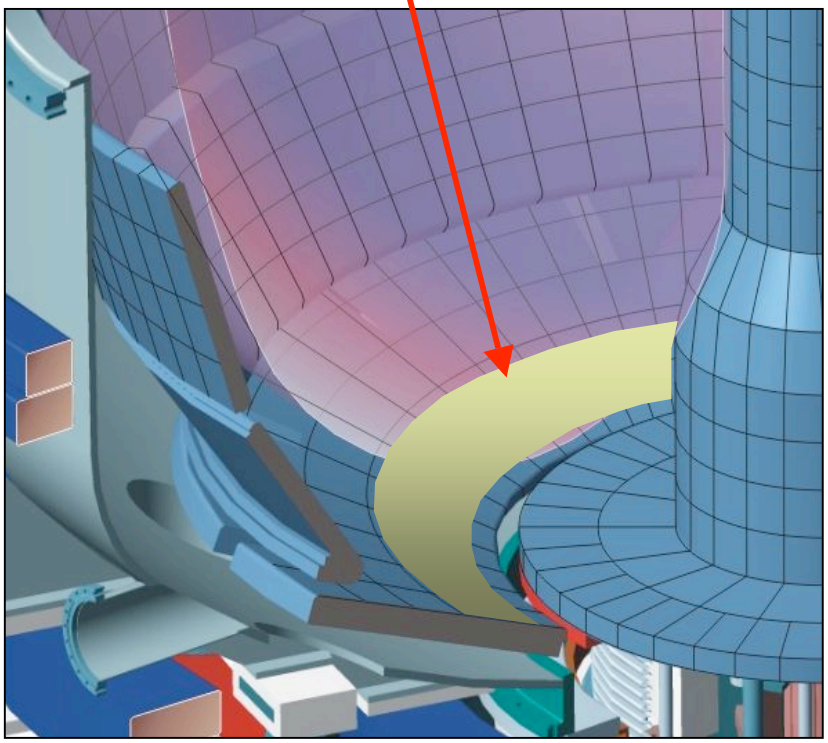
No lithium; 700mg LITER; 7 mg Powder

Summary

- Recent NSTX experiments have shown improved plasma performance with lithium-coated PFCs
  - Obtained with lithium evaporation and lithium powder
  - Helium glow discharge cleaning between shots eliminated for achieving H-mode
  - Plasma density reduced in early phase of discharge
  - ELMs suppressed
  - Energy confinement improved
  - Discharge length increased
  - Flux consumption reduced
  - Electron temperature profile broadened
  - Scrapeoff layer plasma density reduced
    - Consistent with lowered recycling

Next step in NSTX is to begin investigation of liquid lithium on plasma facing components

Liquid Lithium Divertor (LLD) to be installed on lower divertor in 2009



- Lithium in porous molybdenum surface to be kept liquid by heated copper substrate
- Objective is to determine if liquid lithium can sustain deuterium pumping beyond capability of solid lithium coatings

Contributors and acknowledgments

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See posters NP6.00084, NP6.00085, NP6.00087, and NP6.00112 on Wednesday morning for more details