Lithium Surface Experiments on the Current Drive Experiment-Upgrade

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Contributors

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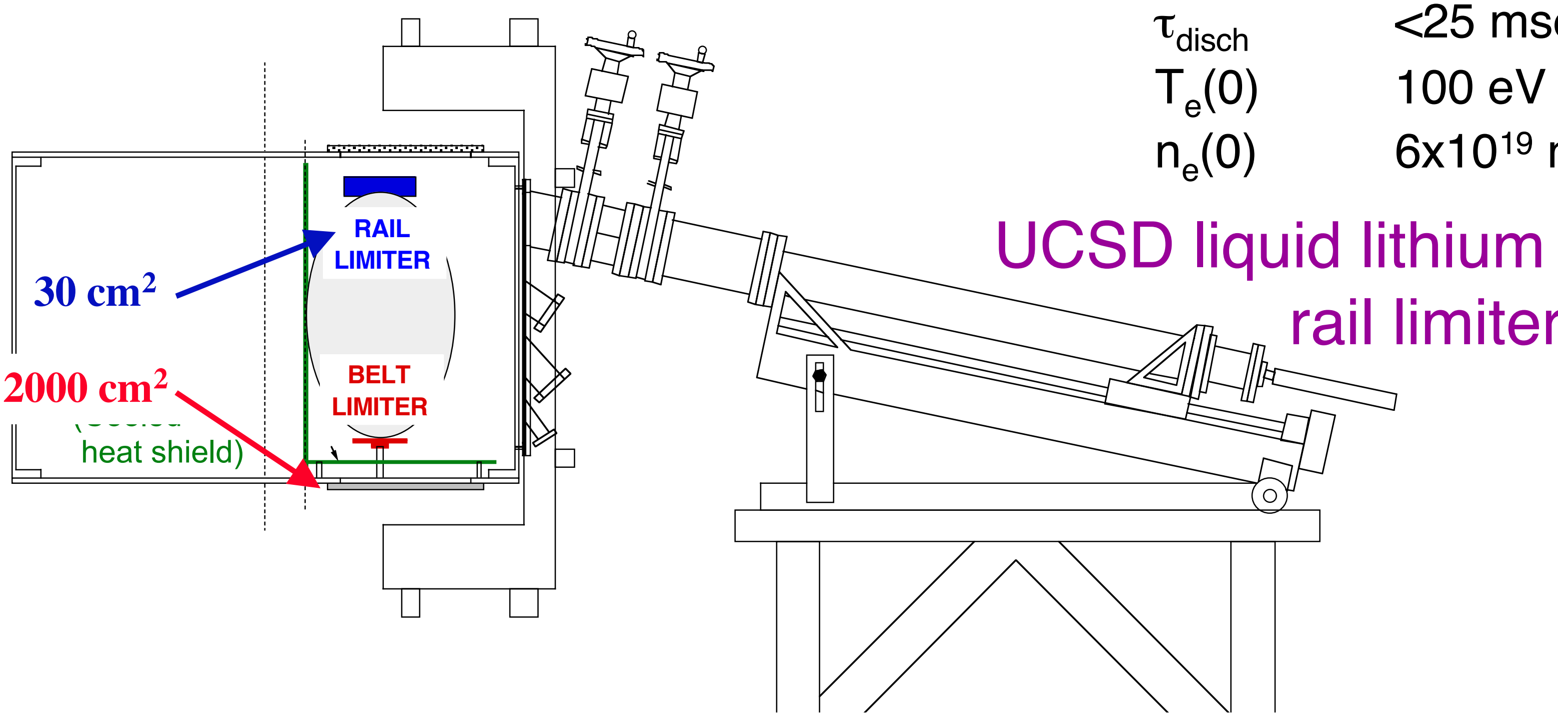
CDX-U goal - develop liquid lithium technology for fusion and study its interactions with plasmas

R_0	34 cm	κ	≤1.6
a	22 cm	$B_T(0)$	2.2 kG
$A=R_0/a$	≥1.5	I_P	≤ 80 kA
		P_{rf}	<200 kW
		τ_{disch}	<25 msec
		$T_e(0)$	100 eV
		$n_e(0)$	$6x10^{19}$ m^{-3}



- *CDX-U experiments support NSTX because of the potential of liquid lithium to address its power and particle handling needs*

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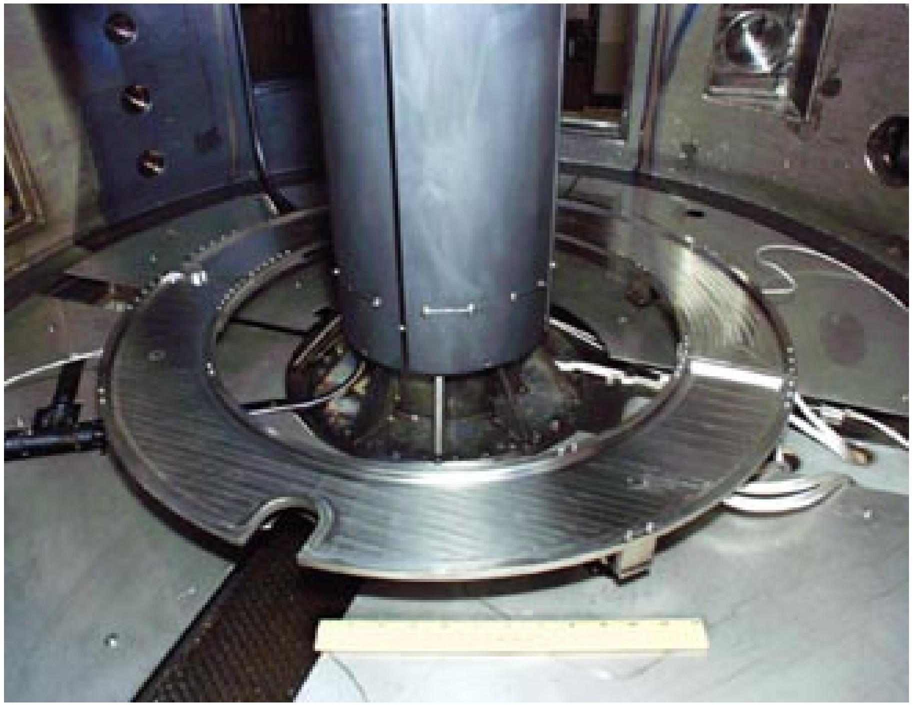
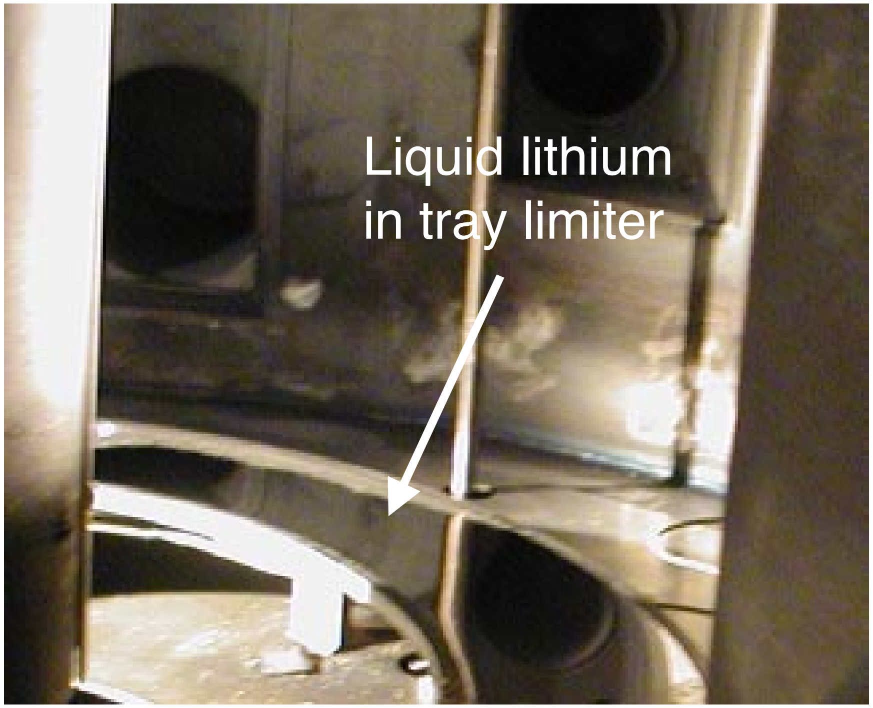
Safe handling and *mechanical stability* of liquid lithium shown in tray loading and plasma operations

- 34 cm major radius, 10 cm wide, 0.64 cm deep
- Two halves with toroidal break
- Heaters for $T_{max} \approx 500^{o}C$
- Argon glow discharge cleaning and tray heating removed surface coatings
- Lithium remains in tray with currents to ground ≈100A at $B_p \approx 0.1T$ for ≈10ms



Empty limiter with heater leads and heat shields



Liquid lithium in tray after ~40 discharges.

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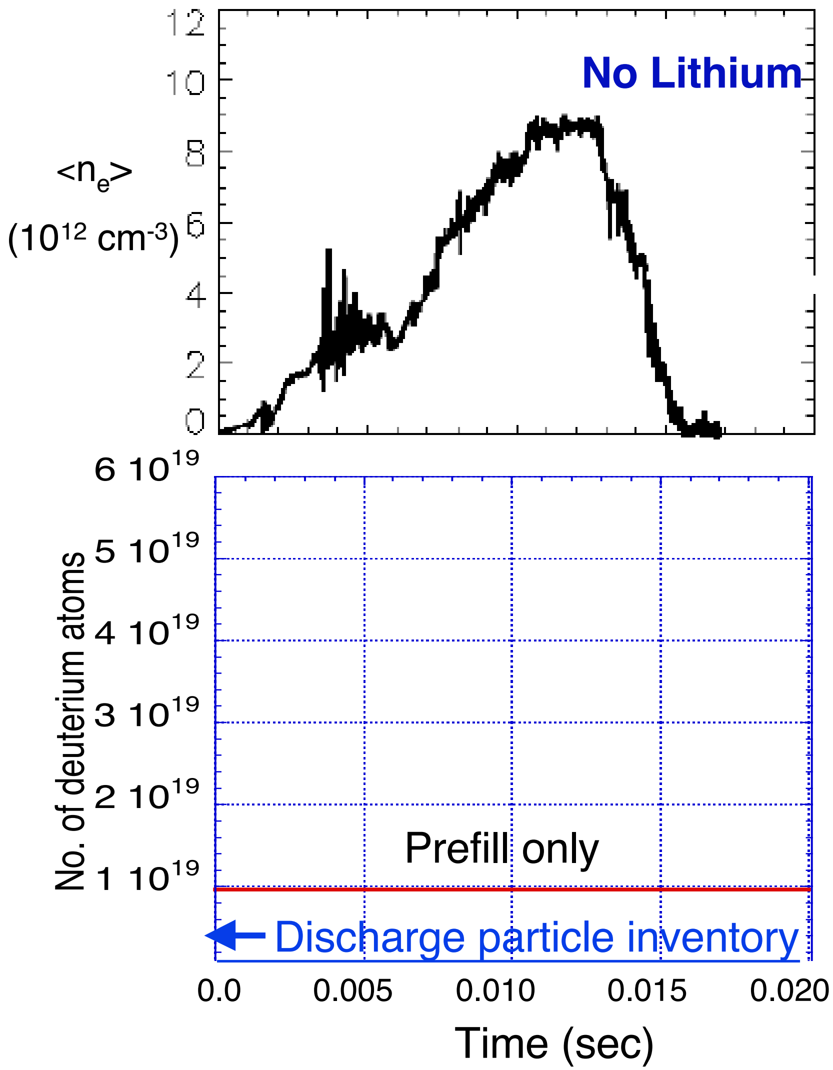
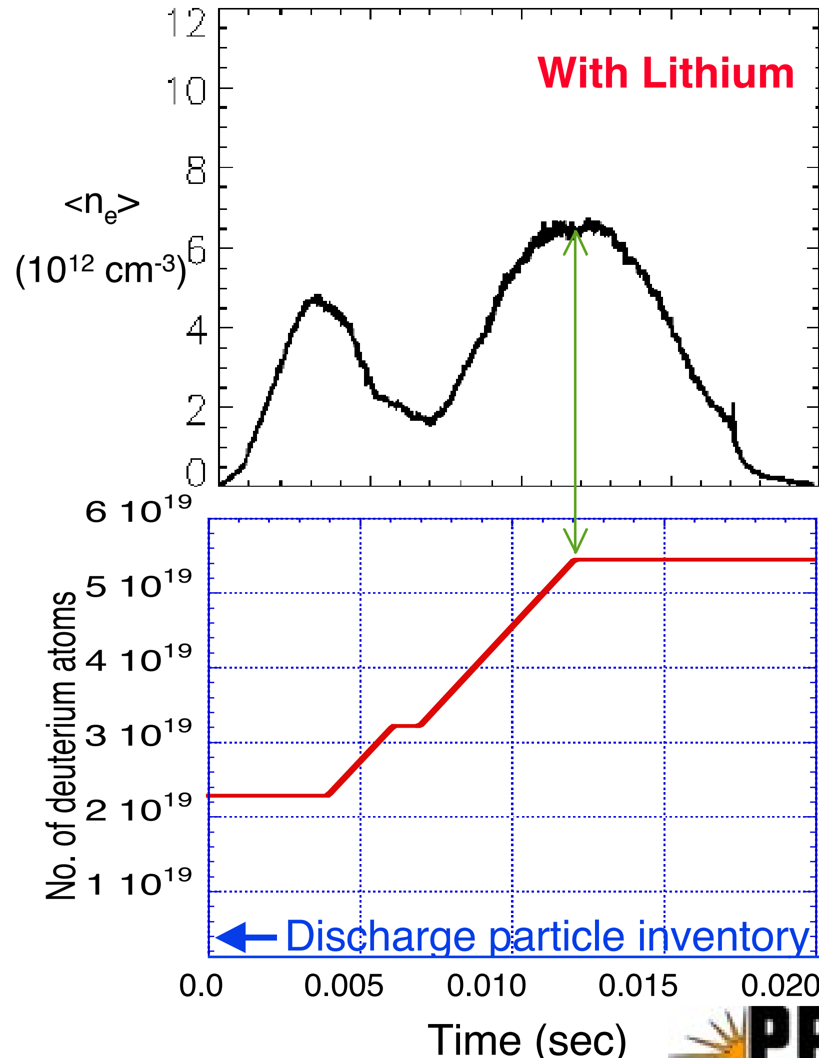
Particle pumping capability of liquid lithium shown by higher gas puffing needed to sustain density

- Liquid lithium limiter increases fueling requirement by 5-8x





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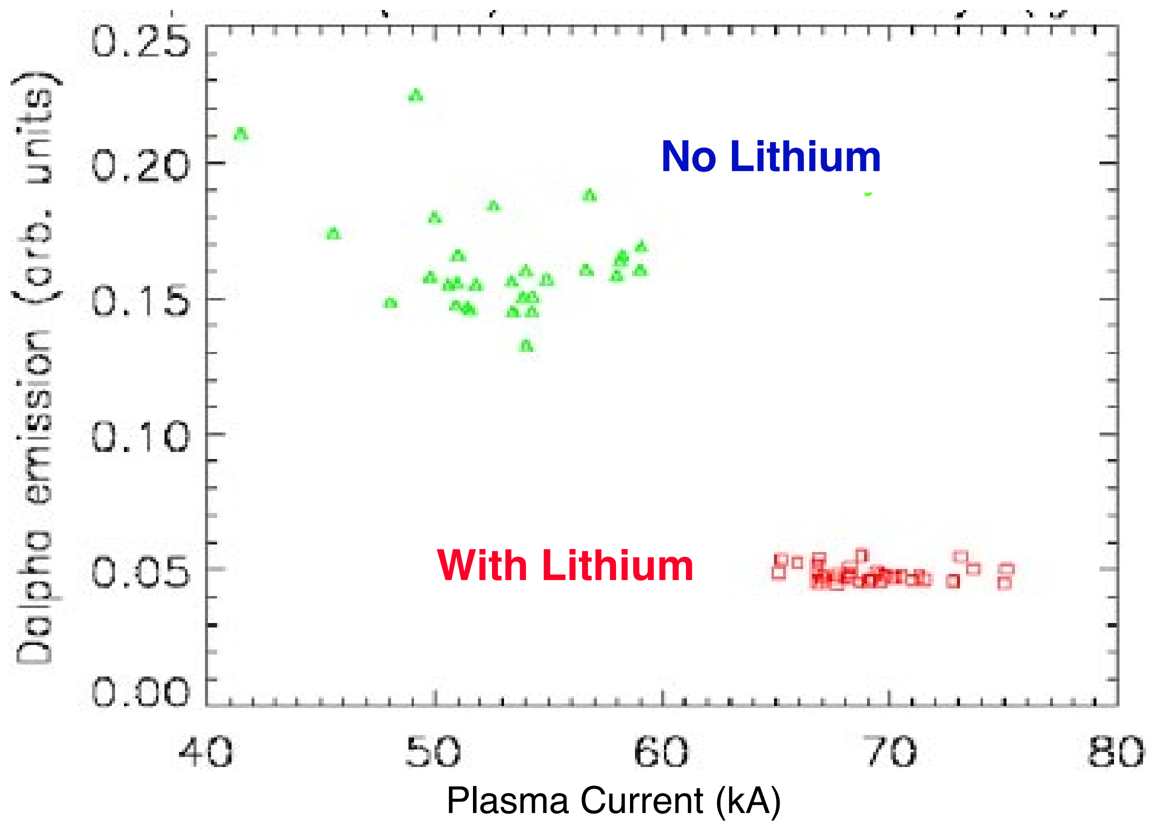
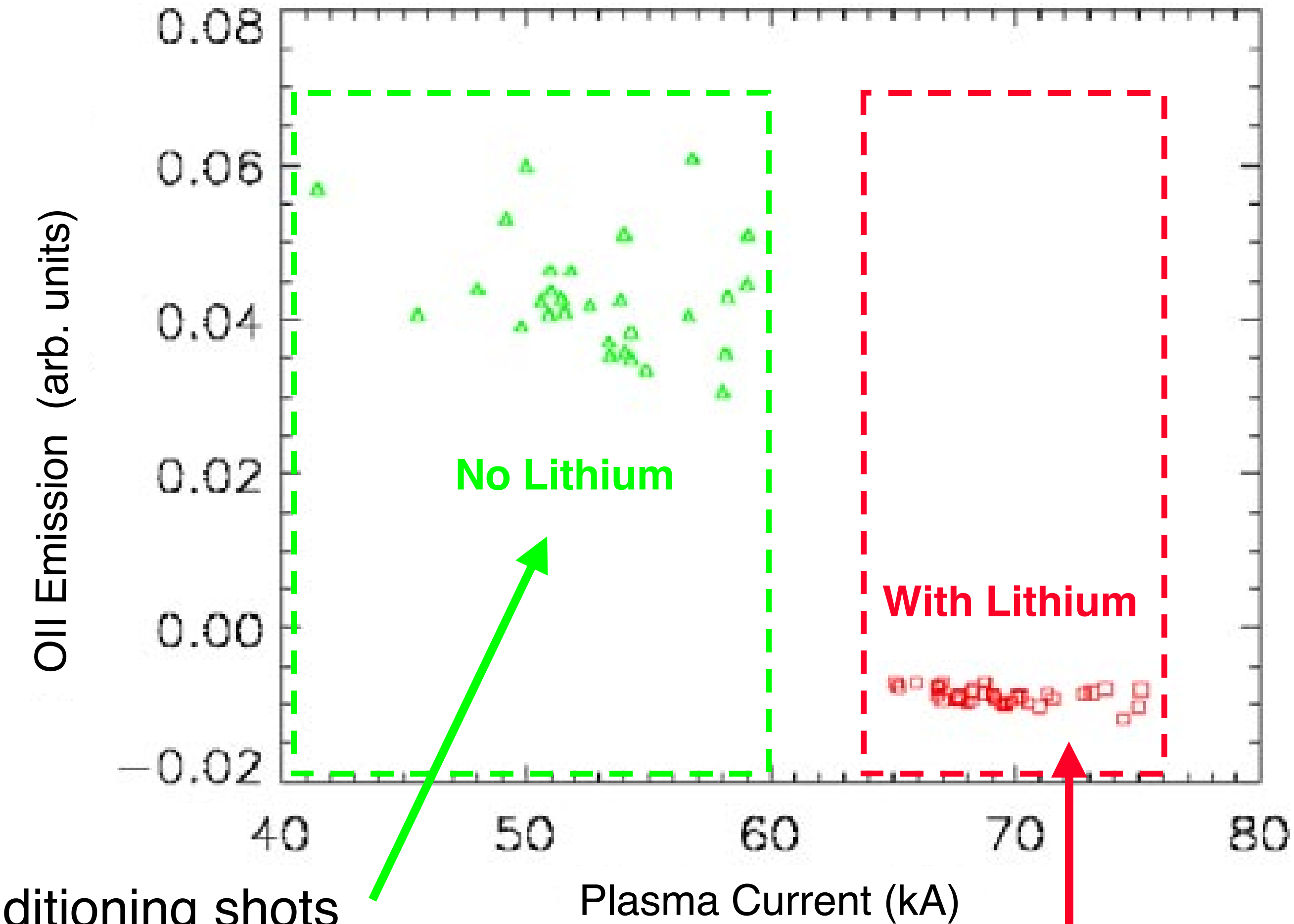
Ability of liquid lithium to pump deuterium supported by reduced D_α emission

- Visible emission from view of center stack indicates strong reduction in global D_α with liquid lithium limiter



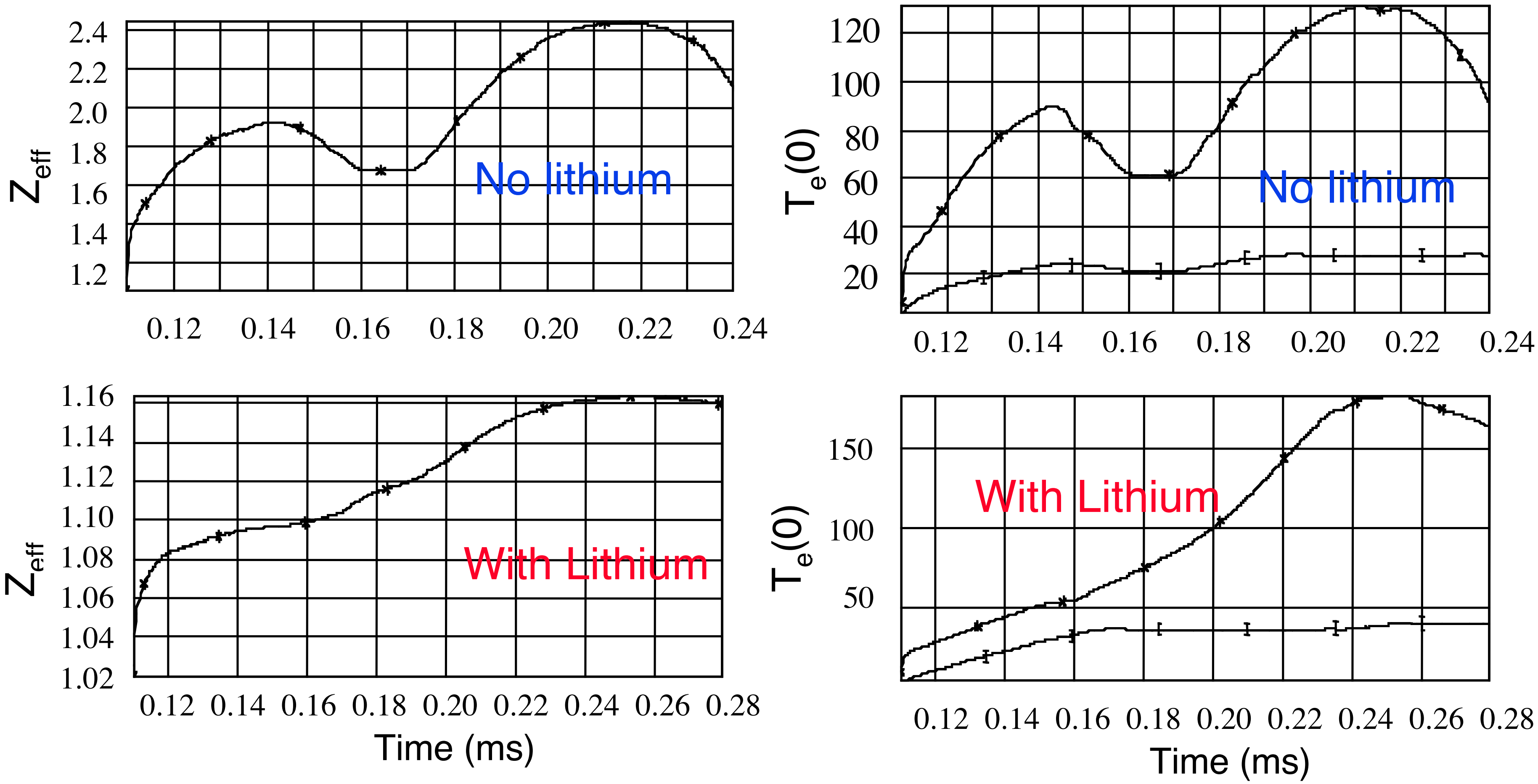
Impurity control with liquid lithium indicated by reduction of oxygen emission



Many conditioning shots required with empty limiter tray before currents ≈60kA were achieved

No conditioning shots required with liquid lithium limiter tray to achieve currents > 60kA

Low Z_{eff} with liquid lithium limiter consistent with modeling based on CDX-U plasma parameters



- Tokamak Simulation Code calculations constrained by experimental estimates of electron temperature, density, and loop voltage
- Plasma resistivity with lithium limiter requires very low Z_{eff}

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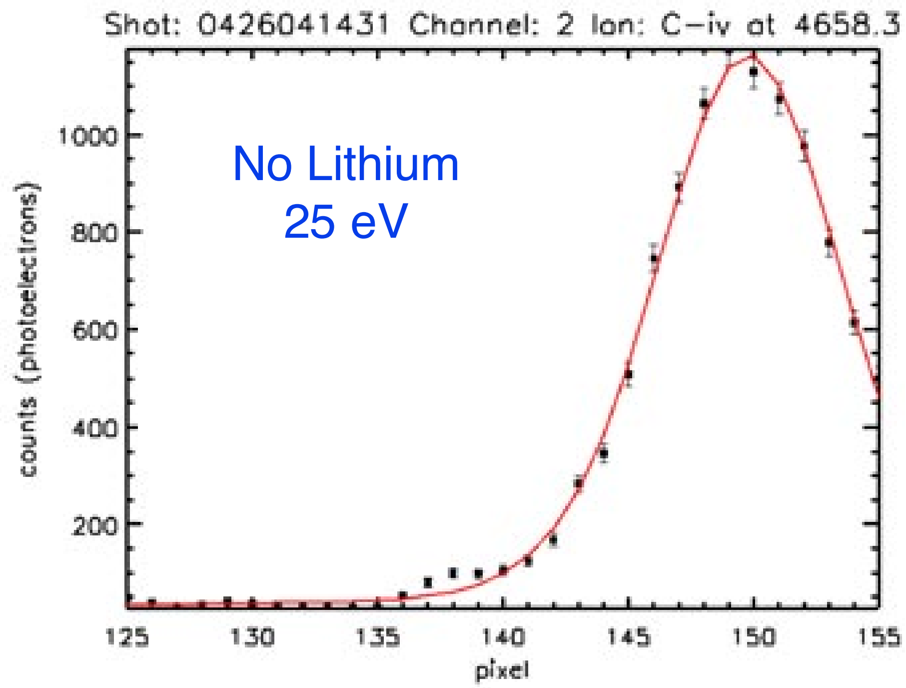
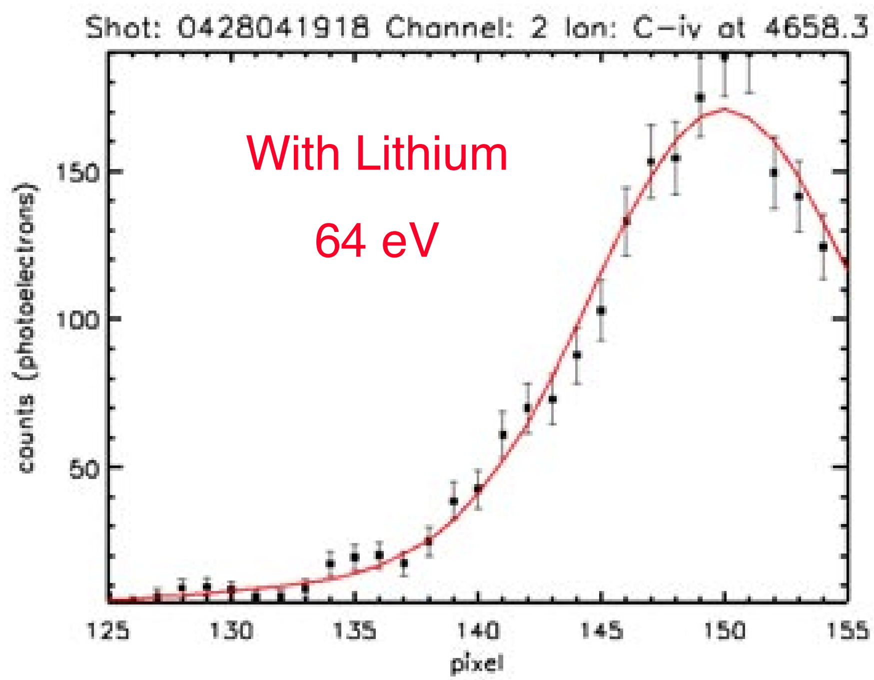
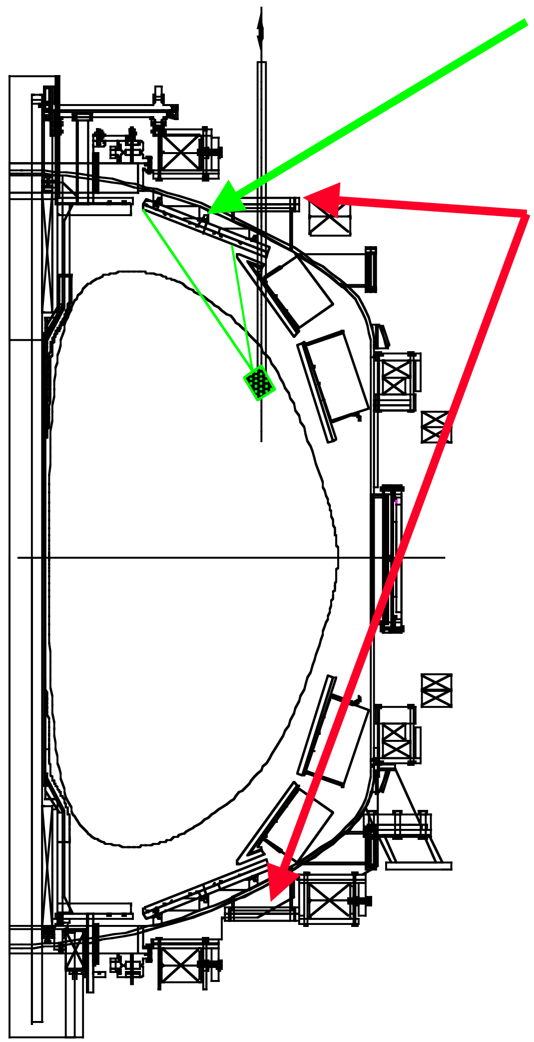
Improved plasma parameters with liquid lithium suggested by increase in ion temperature

- Initial ion temperatures determined spectroscopically from CIV line broadening show increase in liquid lithium limiter plasmas
- Ability of liquid lithium to reduce impurities requires measurements to be repeated with carbon pellet injection to compensate for low signal levels





Phased lithium implementation on NSTX begins with a static lithium divertor coating



- Evaporator to be inserted between shots
  - Heat load during plasma liquefies lithium on divertor surfaces
- Port covers and gate valves installed on upper and lower dome ports for retractable coating system
  - Retractable probe successfully tested with insertion of supersonic gas injector during FY04 NSTX operating period
- CDX-U will test coating system in early FY2005
  - Lithium evaporator undergoing tests in "off-line" chamber
- Operation planned for FY06 NSTX run

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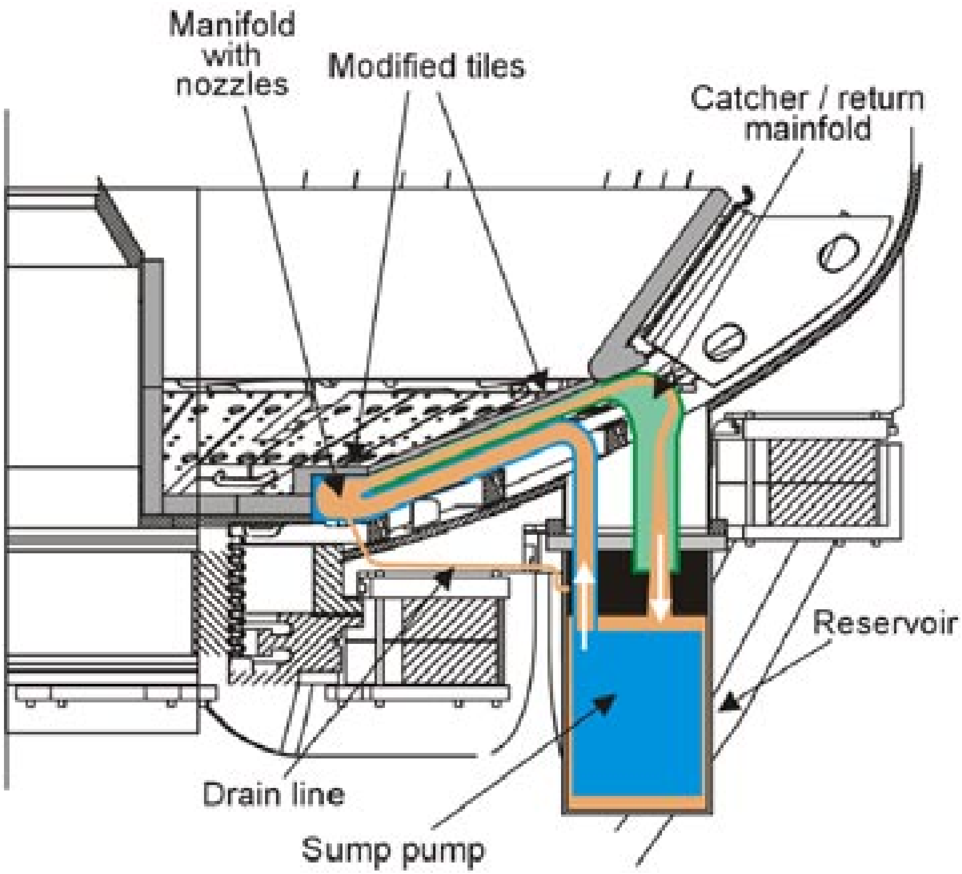
Next step is intended to address power handling and flowing liquid lithium technology issues



Concept courtesy of C.Eberle, ORNL

- Module area ~ 1 m^2
- Flow liquid lithium at ~7-12 m/s to avoid evaporation at full power
- Decision on installation in FY08 requires following
  - Additional data from free liquid lithium surface CDX-U experiments
  - NSTX results with static lithium divertor coating
  - Liquid lithium jet results from Sandia National Laboratories
  - Free-surface liquid metal experiments and simulations at UCLA