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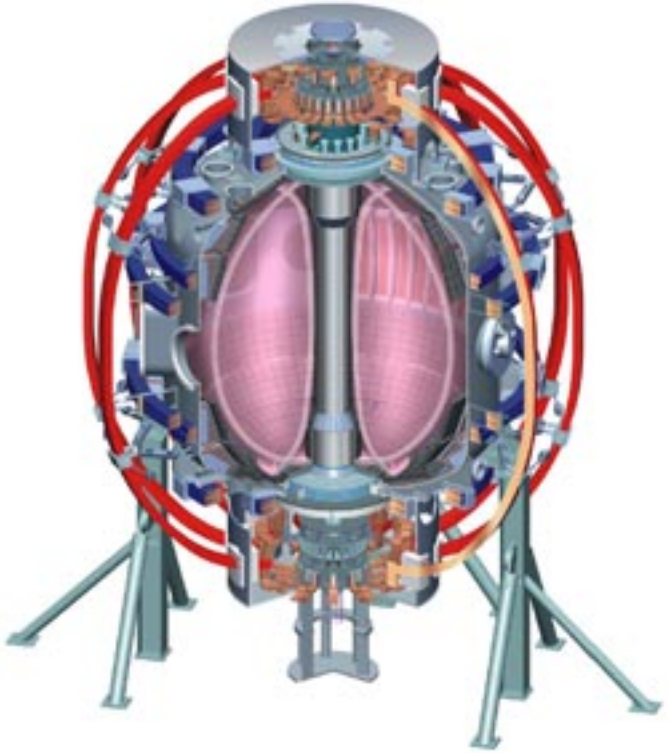
Testing Lithium-based Particle Control



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On behalf of the NSTX National Team

NSTX PAC-17th Meeting

January 20 – 21, 2005
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Outline

1) Lithium Experiments in CDX-U

2) NSTX Lithium Pellet Injection Progress

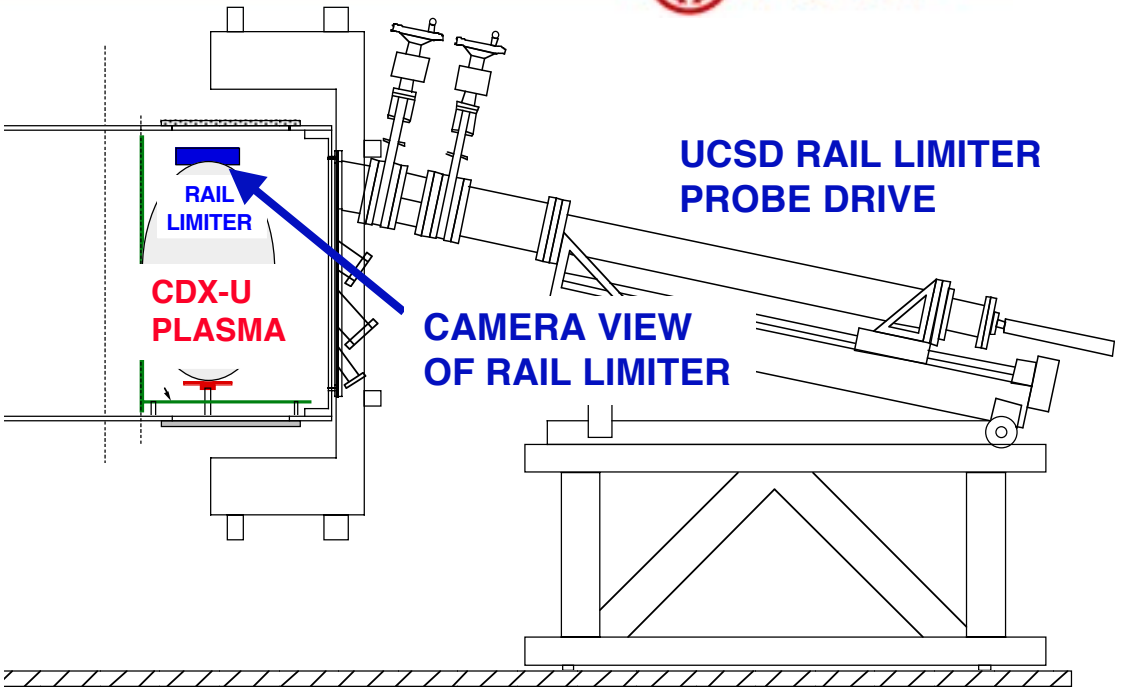
3) Plans for Coatings with Lithium Pellets and Evaporator

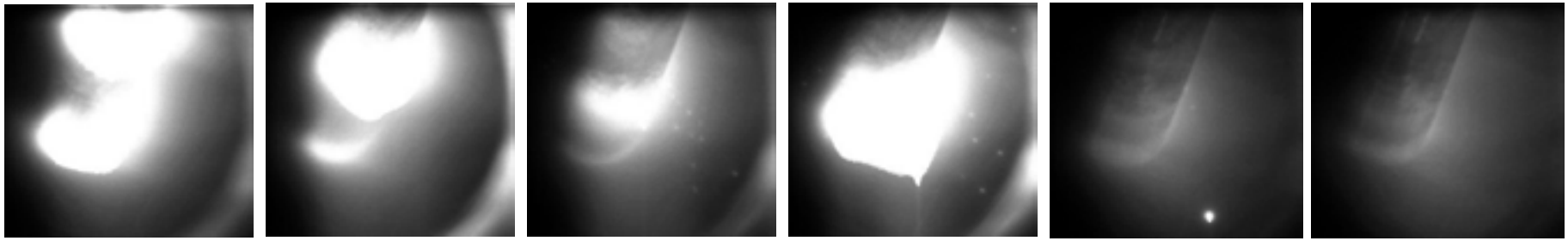
4) Flowing Liquid Lithium Module Concept

5) Summary

Small area lithium rail limiter had little effect on CDX-U plasmas

- Safe lithium handling demonstrated
- Clear plasma interaction with lithium
  - Lithium "spraying" and droplet formation observed
- *No* noticeable change however in discharge evolution or oxygen levels





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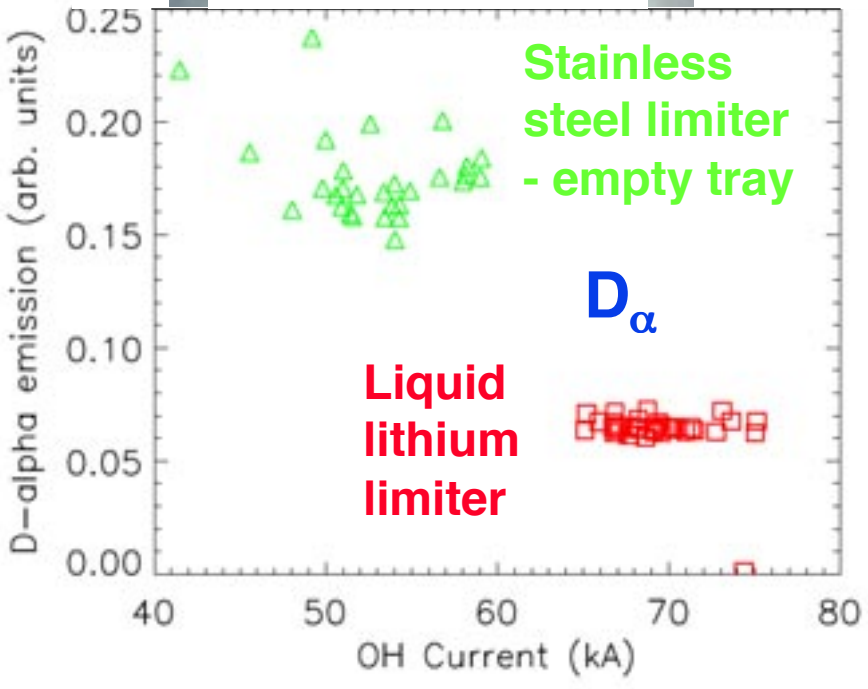
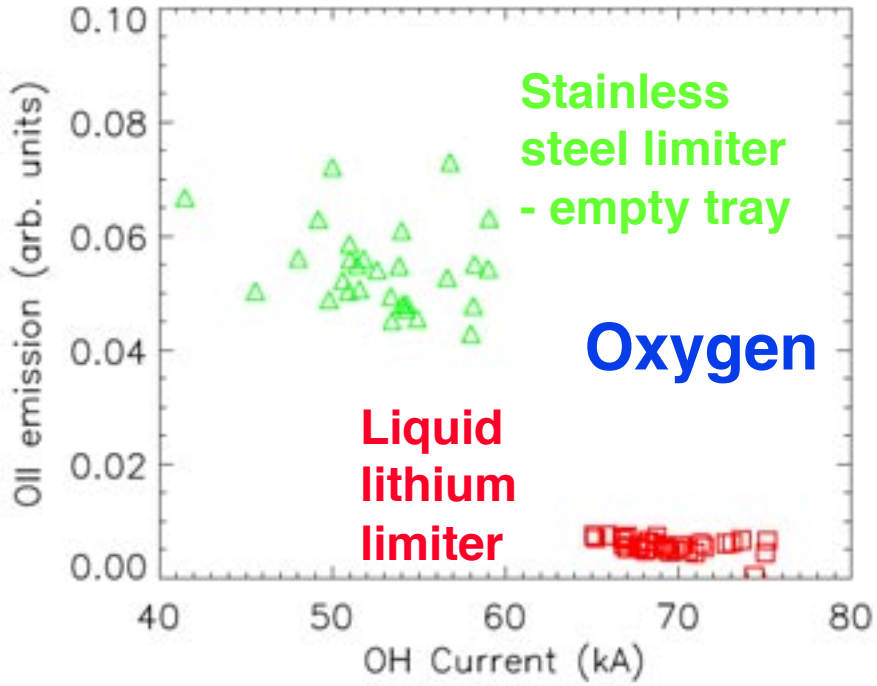
• Fast camera images in lithium light of rail limiter contacting plasma

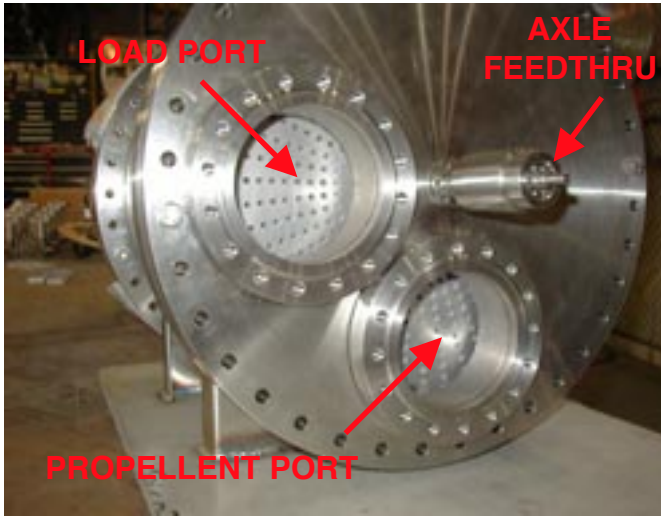
Subsequent experiments with large area toroidal liquid lithium limiter showed improved plasma performance

- Low recycling
- Reduction in oxygen impurity
- Improved confinement
- Increased MHD stability
- More efficient loop voltage utilization

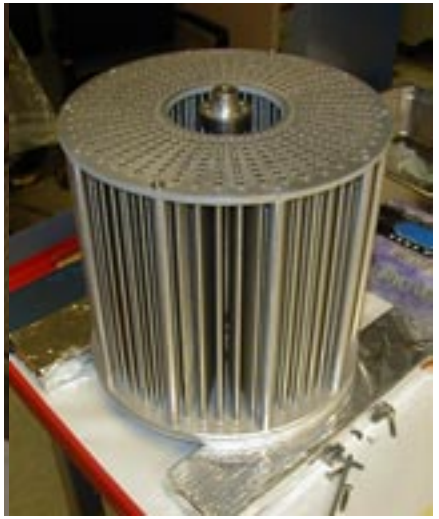




NSTX lithium experiments began phased implementation with pellet injection tests in FY04



OUTBOARD VIEW

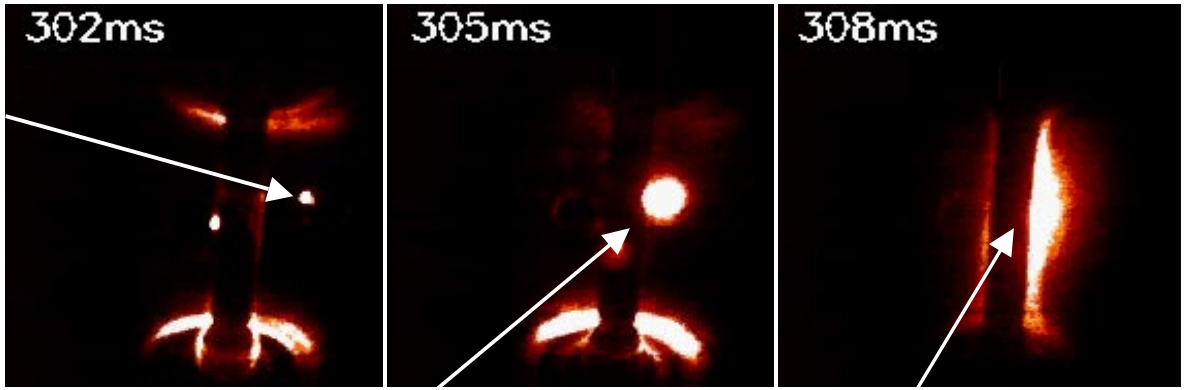


400 BARREL TURRET CAPABLE OF INJECTING UP TO 8 PELLETS PER SHOT

- Injection of up to two 2 mg Li pellets at 100 m/s per plasma successfully demonstrated
  - Pellets reach center stack in Ohmic discharges
  - Pellets ablate at edge in NBI discharges
- Total of 34 mg Li in 17 pellets

PLASMA TV IMAGES WITH LITHIUM FILTER - ORNL/PPPL

Lithium pellet moving through Ohmic plasma after entering boundary

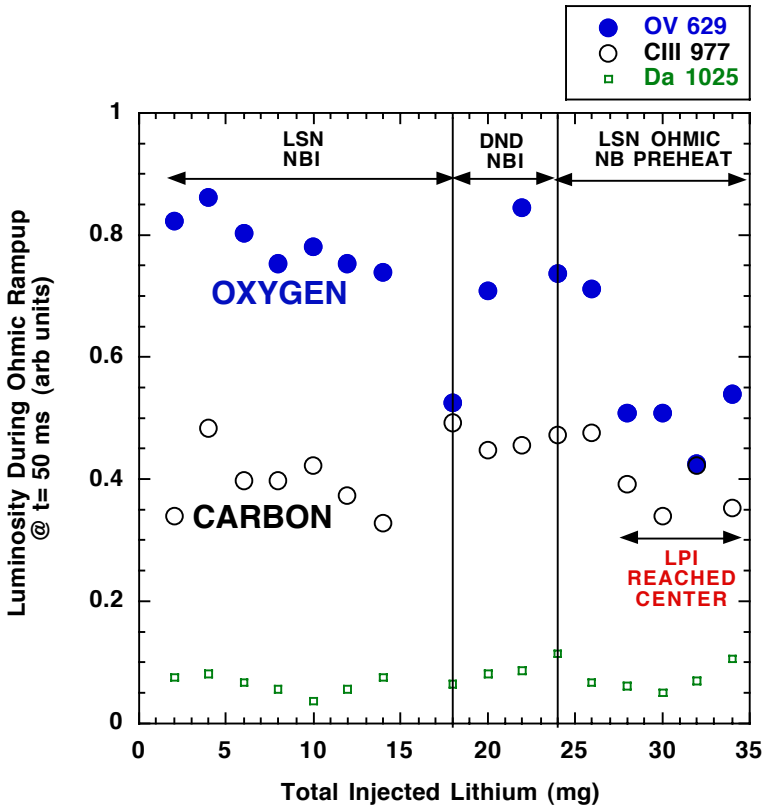


Lithium emission as pellet approaches center-stack

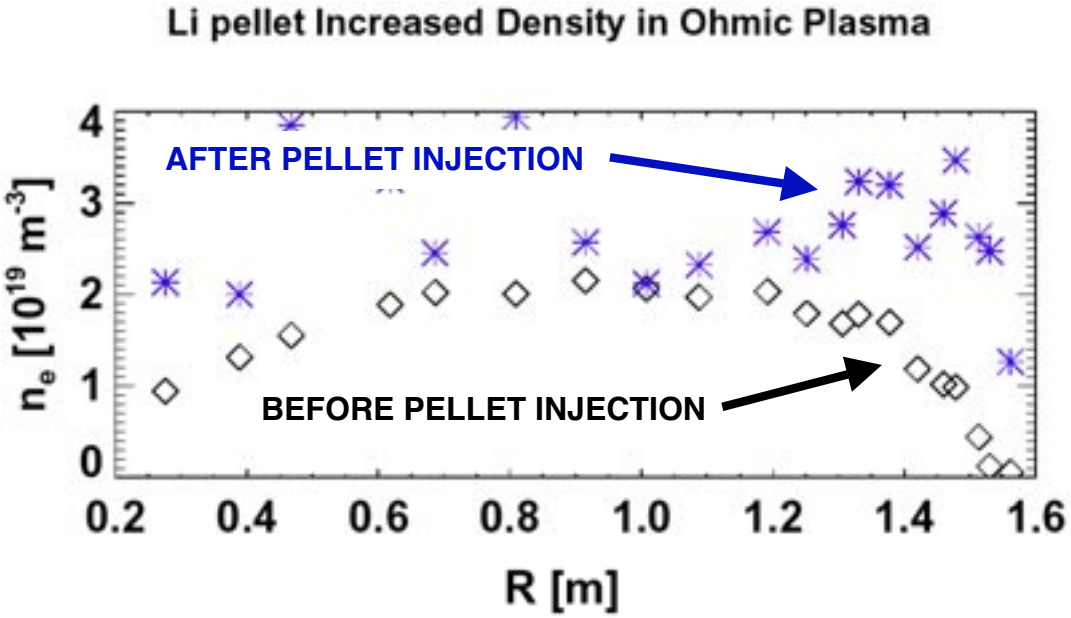
Lithium spreading along the center-stack

Oxygen levels appear to be affected by total lithium inventory but change in density is limited with lithium pellet injection

- Trend in luminosity measured during Ohmic ramp-up phase of plasmas may indicate decrease in oxygen as lithium accumulates



- Effect of pellet on density observed on outboard side of some Ohmic shots
  - May reflect ablation and penetration details that require further study

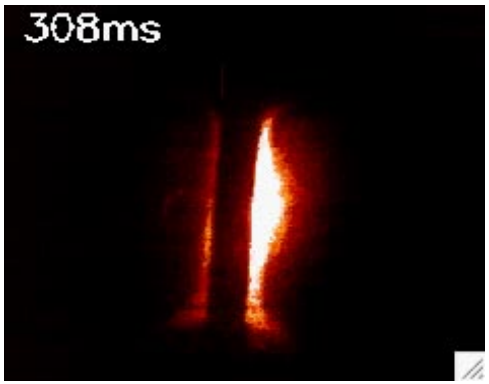


Next step is to inject more lithium into NSTX to increase lithium coverage of plasma facing surfaces

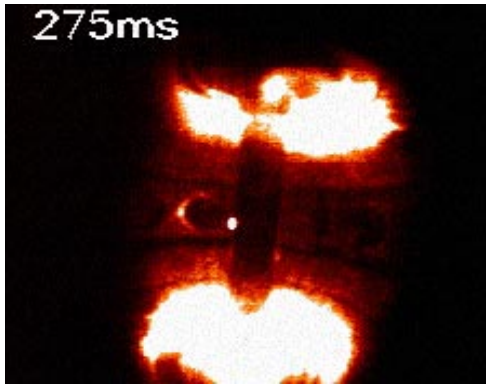
Goal: To understand effect of lithium-coated plasma facing surfaces on deuterium recycling -

1. Inject lithium pellets into helium conditioning discharges
   - Determine maximum number of pellets plasmas can absorb
   - Develop operating scenarios for coating center stack and divertor regions with lithium pellet injection

Ohmic Discharge: Li reaches center stack

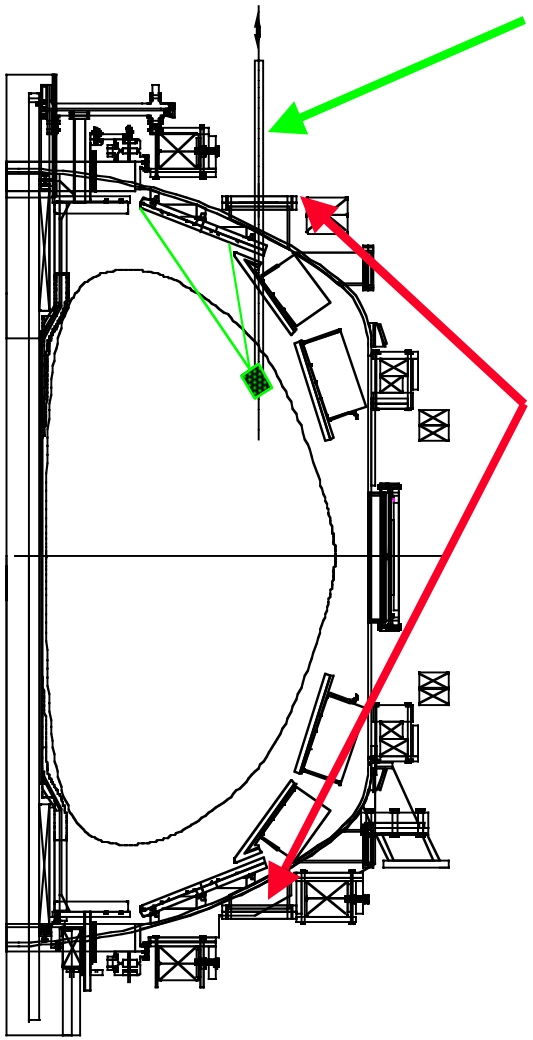


NBI Discharge: Li reaches divertor regions



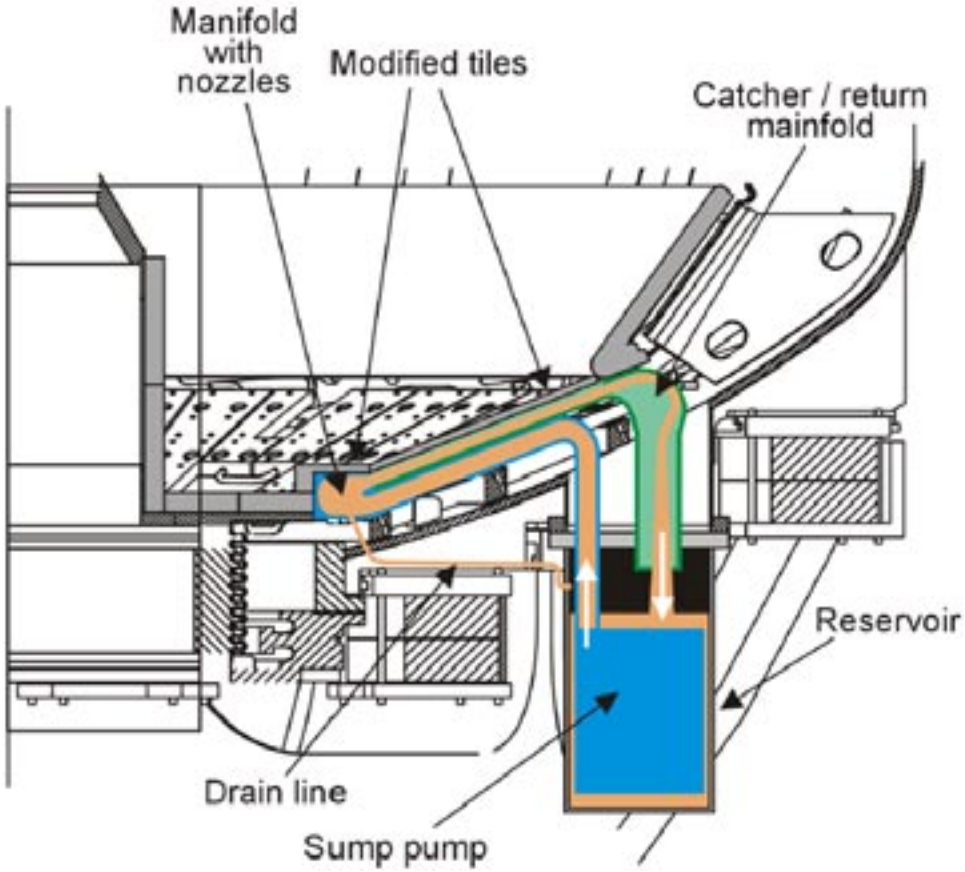
2. Test effect of lithium coatings on deuterium NBI plasma performance
   - *Limiter* plasmas in contact with center stack
   - *Divertor* plasmas with lithium coated strike points

Pellet injection will be followed by lithium evaporator for more efficient coating of plasma facing surfaces



- Evaporator to be inserted between shots
  - Deposits lithium coating on plasma facing surfaces
  - Heat load during plasma liquefies lithium on coated surfaces
- Port covers and gate valves installed on upper and lower dome ports for retractable coating system
- Lithium coating systems being evaluated
  - Resistive evaporator undergoing tests in “off-line” chamber
  - Electron beam evaporator being mounted on CDX-U vacuum vessel

Lithium pellet and evaporator research will help specify requirements for a flowing liquid lithium divertor module



Concept courtesy of C.Eberle, ORNL

- Concept permits power handling for long-pulse operation
  - Flow liquid lithium at ~7-12 m/s required to avoid lithium evaporation at full power
- Decision to implement flowing lithium module will be based on resolution of key issues
  - Necessity for handling projected power levels
  - Achievement of MHD-stable flow in NSTX magnetic fields
  - Affordable design that retains other capabilities needed for program goals

Lithium is being explored as a plasma facing surface for particle control in NSTX

- Research plan builds on spherical torus experience to date in CDX-U
  - Liquid lithium handled safely for rail and large area toroidal limiters
  - Plasma performance improvement shown by reduction of edge recycling with lithium as a plasma facing surface

- Present plans for surface conditioning with lithium in NSTX involve pellet injection and evaporative coatings
  - Lithium pellet injector successfully tested in FY04
  - Conditioning scenarios with pellet injection to be explored next
  - Plasma operation with lithium evaporator will follow pellet injection experiments

- Lithium coating experiments will help determine requirements of flowing liquid lithium module
  - Technical, programmatic, and financial issues need to be resolved prior to decision point on particle control for NSTX