



# Issues for Fueling and Particle Control

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# Goal is to formulate plan for FY06 decision point

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- What are NSTX particle control requirements?
  - Experimental evidence to date
  - Near-term and long-term needs
  - Adequacy of present and planned capabilities
    - Surface conditioning (bakeout, boronization, helium GDC, pellet injection, etc.)
- What are NSTX power handling needs?
  - Near-term and long-term needs
    - “Realistic” schedule for long-pulse ( $\approx 5$  s) operations
  - Adequacy of existing PFC’s and planned upgrades

# Common understanding of results to date needed

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- What are implications of past lithium experiments?
  - “Uniqueness” of TFTR results
  - Research on other magnetic confinement devices
  - Experience from PFC community
- Is cryopump experience sufficient for predicting future performance?
  - Past efforts appear to be based on installation of cryopump, collection of comprehensive data set, and adjustment model for “best fit”
    - Extensive modifications required for implementation on NSTX may preclude such “cut and try” approaches

# Possible conclusion may be that neither cryopumping nor flowing liquid lithium divertor module may be necessary

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- Evaporative coating may be sufficient for particle control
  - Primary means of particle control in LTX
  - Implementation already planned for NSTX Experience from PFC community
  - UEDGE-2-D code combined with 3-D REDEP/WBC code by Brooks at ANL predict lithium to be confined to divertor region
- Cryopump requires extensive and expensive modifications to passive plate geometry
  - Little flexibility for testing various “throat” configurations in absence of reliable predictive modeling
- Flowing liquid lithium divertor module loses primary
  - Five-second pulses may not be realistic for NSTX or necessary for its mission
  - Argument for prototyping reactor chamber technology becoming less compelling with growing focus on ITER needs

# ***Urgent immediate issue concerns installation of new divertor PFC's this opening***

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- Evaporative lithium coatings require surfaces other than carbon to prevent intercalation
  - High velocity oxygen fueled (HVOF) spraying of molybdenum on carbon tiles may be possible
- Need to determine how much of divertor surface can be covered by evaporator(s) planned for upcoming run
  - Will coverage have measurable effect on recycling even with "perfect" substrate?
- "Technology testing" rather than consequences for plasma performance may be more realistic goal for upcoming run
  - Reliability of evaporator probe drive operation and performance of lithium oven or e-beam on lithium sample can be checked
  - NSTX run time *not* required to confirm well-established intercalation results

## Arguments could be made for *not* replacing any tiles this opening

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- “Technology testing” rather than consequences for plasma performance may be more realistic goal for upcoming run
  - Reliability of evaporator probe drive operation and performance of lithium oven or e-beam on lithium sample can be checked
  - NSTX run time *not* required to confirm well-established intercalation results
- Useful results could still be obtained with carbon tiles
  - Might reported upper limit of  $\approx$ 30% lithium at “saturation” of carbon still have measurable effect on recycling?

## Question for upcoming run concerns usefulness of devoting some of limited run time to “duplicating” TFR lithium results

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- Will extensive conditioning and pellet injection to coat center stack for limiter plasmas be sufficient?
- Will developing such scenarios be informative and useful if NSTX program emphasizes divertor plasmas?

# Need to include preparation for FY06 decision point on particle control options in FY05 run planning



NSTX

<u>NSTX Issue</u>	<u>Cryopump Assessment Status</u>	<u>Cryo Assessment Basis or Schedule for Achievement</u>	<u>Liquid Lithium Module Assessment Status</u>	<u>Liquid Lithium Module Assessment Basis or Schedule for Achievement</u>
Capability for Particle Control	Ability established with operational caveats (see comments under "Operation" in next table)	DIII-D (GA) results on edge plasma modification available - although <i>predictive</i> capability for "first principles" NSTX design needs more work	Ability established	UCSD (PISCES) and UIUC results on hydrogen retention and PPPL (CDX-U) results on recycling reduction
Capability for Power Handling	Not applicable (must be protected from high heat flux)	Not applicable	Required flow rate is 7-12 m/s from analysis	PISCES results on temperature dependence of lithium evaporation confirm temperature limits; power handling tests at LIMITS facility (Sandia) planned but not started
Safety	Cryogens handled routinely	Experience on DIII-D, NSTX, and elsewhere	1) Static "pools" of liquid lithium handled safely 2) Circulating Li system assessment required	1) CDX-U has safe handling experience with static fully-toroidal liquid lithium limiter 2) Tests of flowing lithium hardware in progress at LIMITS facility; assessment to be completed in mid-FY05

# NSTX experiments in FY05 can investigate operational issues that need to be addressed for FY06 decision point



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Installation	In-vessel modifications substantial but potentially straightforward: <ul style="list-style-type: none"> <li>• Close passive plate gaps and redesign secondary passive plate supports</li> </ul>	Preliminary assessment completed – Menon (ORNL - ret.)	In-vessel modifications could be limited but have special requirements: <ul style="list-style-type: none"> <li>• Permit lithium flow into, through, and out of NSTX</li> <li>• Accommodate CHI “gap” and diagnostic penetrations</li> </ul>	Preliminary assessment completed – Nelson (ORNL); prototype flowing liquid metal systems being tested at MTOR (UCLA) and LIMTS; conceptual design for NSTX flow configuration requires experimental data and MHD modeling results for NSTX divertor geometry (UCLA/Hypercomp)
<i>Operation</i>	Pumping dependence of separatrix distance to plenum limits achievable plasma geometries	Preliminary assessment completed – Menon (ORNL - ret.)	MHD effects on liquid lithium may limit permissible magnetic field ramp rate; <b>assess ELM, thermoelectric current, and plasma wind effects; control external current loops</b>	Experimental and computational assessment of MHD effects on liquid lithium flow in NSTX fields in progress at SNL and UCLA; <b>ELM effects and other issues related to NSTX plasmas require further investigation on large MFE facilities</b>