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Comparison of Diverted Plasmas Incident on Lithiated Molybdenum and Graphite Surfaces

For Research Milestone R(12-1) and NSTX-U Planning

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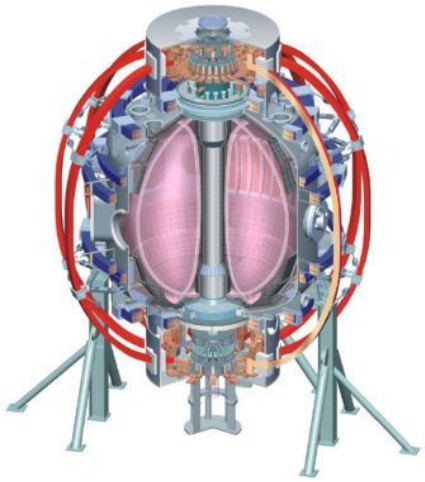
H. W. Kugel, V. Soukhanovskii, M. Jaworski….

NSTX Research Forum
March 15-18, 2011



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Overview of 2010 and 2011-2012 Lithium Conditions

- **2010 Experimental Campaign**
  - Liquid Lithium Divertor (LLD) on outer divertor, partially heated only during special experiments, cold at other times.
  - Continual lithium deposition 10-40mg/min for 10 mins between discharges, or up to 260g (3 days) for special experiments.
  - LLD endured 5 argon vents, continual redeposition of outward sputtered C and Li from inboard operation (J. Brooks simulation).
  - Evidence of significant buildup (strata) of Li and C complexes on surface of LLD (Some indications that Li did not enter deeply into LLD porosity).
  - LLD plates appear to have become ungrounded early in the run due to disruption currents possibly resulting in intermittent biasing.

- **2011-2012 Experimental Campaign**
  - LLD supports and grounding upgraded, no active heating, only plasma auto-heating (~10°C/shot).
  - Molybdenum tiles on outer-row of inner divertor.
  - 2008-type LITER depositions, typ. ~10-20 mg/min between discharges.

2010 Lithium Results Summary

• Early work by McCracken, Erents, and others found fast deuterium retention in clean solid lithium and liquid lithium to be close to unity *for a clean lithium surface*.

• Results from laboratory studies after TFTR and NSTX 2006-2009 for solid Li on graphite, suggested that the retention of D in solid NSTX Li might be limited to less than unity due to: (1) Li intercalation in graphite, (2) Li interactions with impurities in graphite, (3) Li reactions with vacuum gases, and (4) D saturation of the Li, surface layers,
and that probably liquid Li would provide more retention for longer durations.

Vertical scale dependent on surface impurities

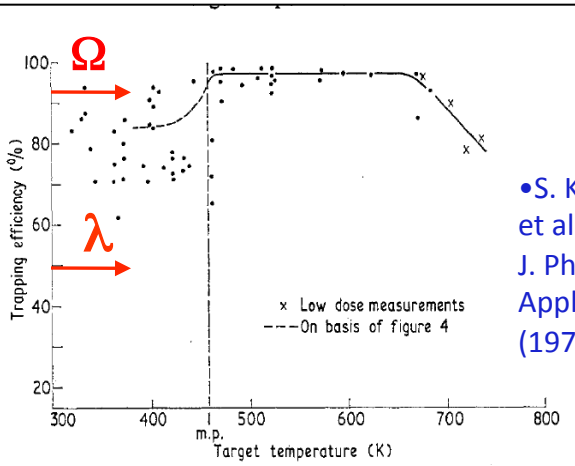


Figure 3. Trapping efficiency of lithium for 18 keV deuterons as a function of temperature for constant dose of 5×10^{17} ions/cm^2.

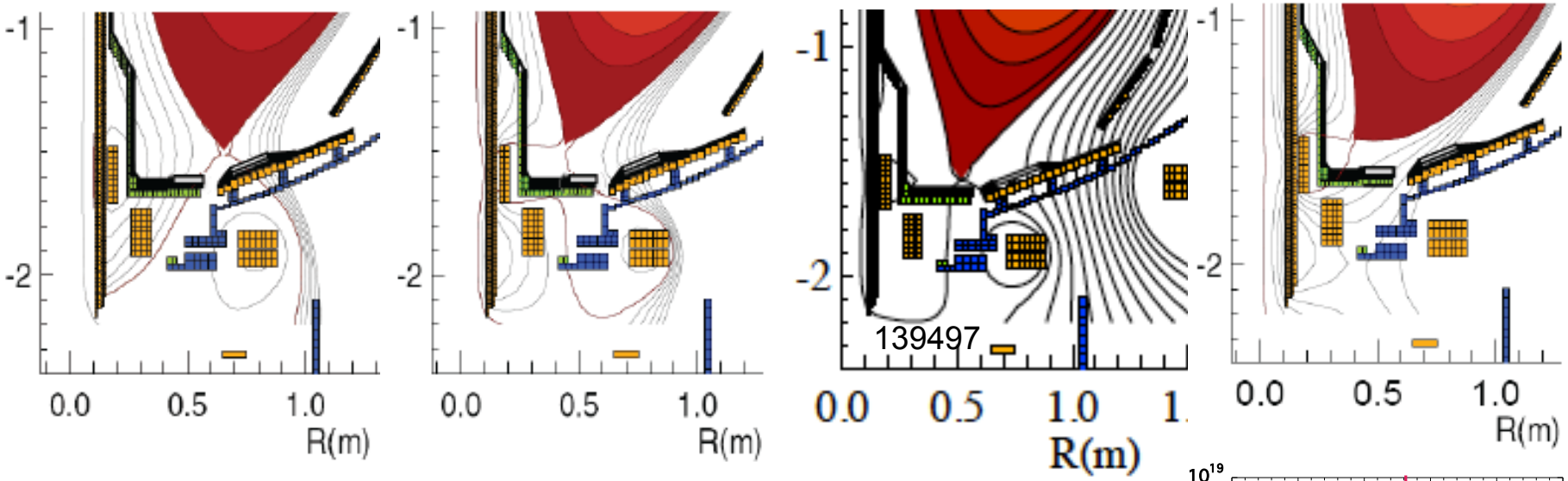
•S. K. Erents, et al., J. Phys. D., Appl. Phys. 6 (1971) 672.

• However, the 2010 LLD results based on the required fueling for stable discharges imply comparable solid and liquid Li pumping under NSTX conditions.

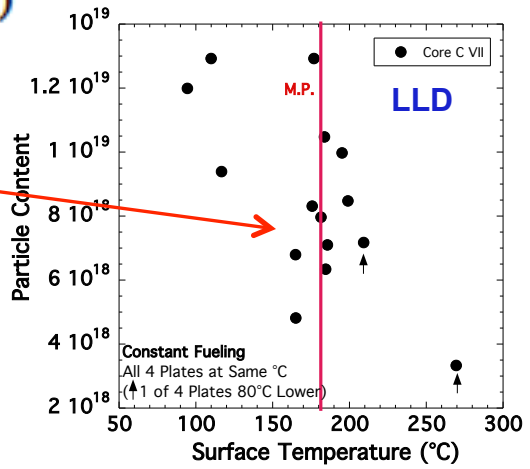
• Question: In NSTX, are the 2010 D retention percentages in solid Li and liquid Li both near unity (Ω), or both much less than unity (λ)?

Early in the Run, With Minimal Li Deposition, and Constant Fueling: *XP to Compare 4 LSN Plasmas Incident on Lithiated-Molybdenum and Lithiated-Graphite Divertor*

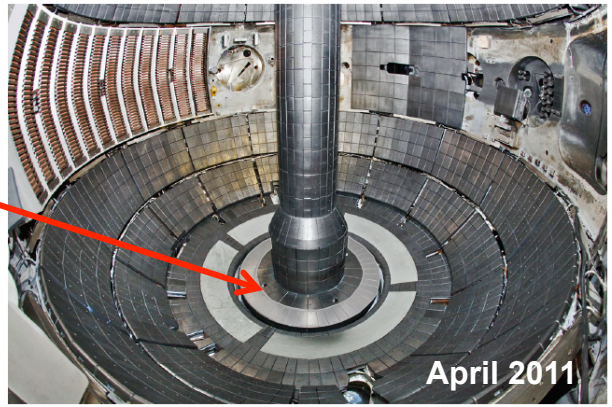
1. LSN SP on Mo-LLD and Mo (IBD-tile) | **2.OBSP Mo-tile, IBSP on ATJ** | **3.Snowflake-minus OBSP on Mo tile** | ***4.Standard IBD SPs on ATJ***



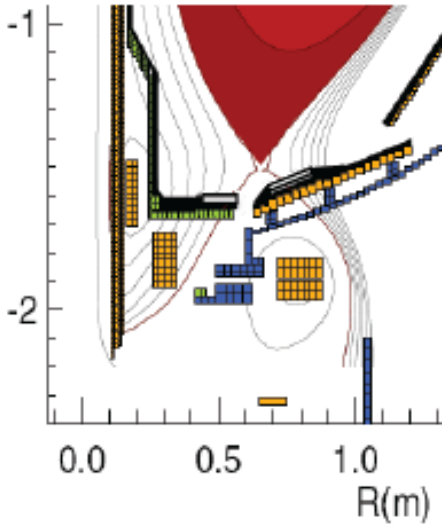
- Immediate Deliverables:
  - How does core C^{6+} change?
  - How does core D^{+} change?
  - How does electron density rate of rise change?
  - How does edge C source term change, Prad?
  - How do edge conditions (ELMs, quiesence) change?



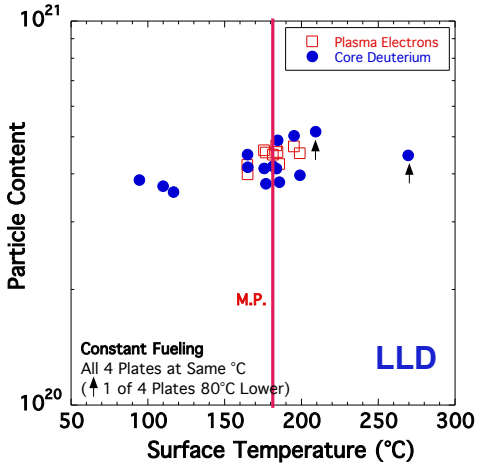
Day-1: Begin with Both LSN Strike Points on Mo-LLD and Mo (IBD-tile)



1. Both LSN SPs on Mo-LLD and Mo (IBD-tile)

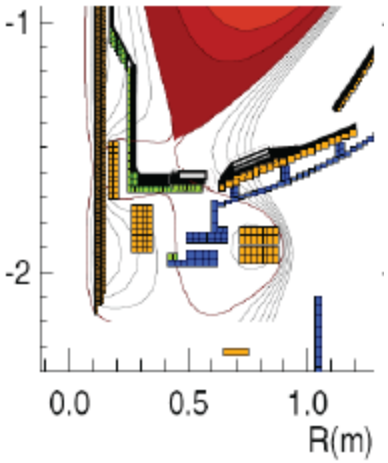


- Day-1 Measurement Plan (30 shots)
  - Early in Run, LITER 20 mg/min, constant fueling
  - Let LLD plasma auto-heat 10°C per shot
  - As LLD transitions through Li melting (180°C) measure:
    - Waveform of Core D and C^{6+} particle content
    - Electron density rate of rise
    - Li, CII, OII, Mo, Prad waveforms
    - Fast IR front face temperature waveforms
    - LP array and edge turbulence measurements
    - ELM characteristics
    - Global wall pumping characteristics
  - Scan fueling to determine effect of IBD detachment

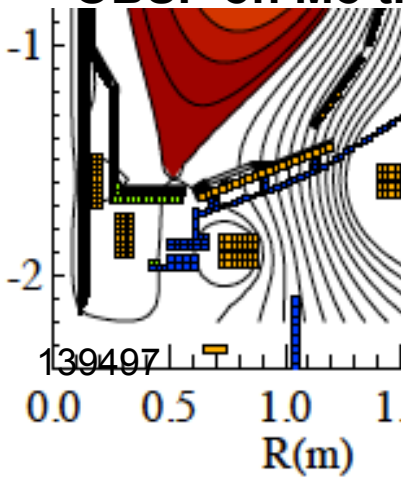


Day-2: Move Strike Points Inward and Repeat

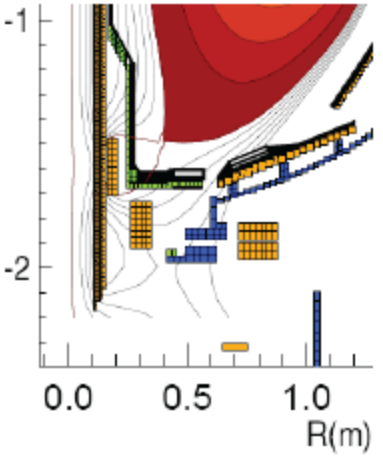
2. OBSP Mo-tile, IBSP on ATJ



3. Snowflake-minus OBSP on Mo tile



4. Standard IBD SPs on ATJ



- Day-2 Measurement Plan (10 shots per case)
  - Early in Run, LITER 20 mg/min, constant fueling
    - Waveform of Core D and C^{6+} particle content
    - Electron density rate of rise
    - Li, CII, CIII, OII, Prad waveforms
    - Fast IR front face temperature waveforms
    - LP array and edge turbulence measurements
    - ELM characteristics
    - Global wall pumping characteristics

Summary of Questions to Be Investigated by this XP as D is Diverted from Lithiated Mo to Lithiated Graphite

- How does the core D content change as the divertor substrate is changed?
- How does the core C^{6+} content change as the carbon sputtering term is changed?
- How much of the electron density rate of rise is due to the divertor sputtering source?
- How do Li, CII, CIII, OII, Mo, Prad waveforms vary during the discharge as the surface heats?
- How do the Fast IR front face temperature waveforms change for the different lithiated substrates?
- Under quiescent $D\alpha$ conditions, can local recycling coefficients be measured using LP array Isat/$D\alpha$ ratios?
- How do ELM stability characteristics change as sputtering and edge fueling change?
- How do the global wall pumping characteristics change as the lithiated substrate changes?