NSTX

XP: Recycling Control Using Lithium Pellet Injection

H. W. Kugel, et al.

The Goal of this XP is to Test Recycling Control using Lithium Pellet Injection

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- This XP has 2 parts
  - Day-1: Measure lithium pellet injection characteristics for application to Day-2.
  - Day-2: Use the results from Day-1 to test for the best lithium conditions and deposition sequence for achieving recycling control.

Lithium Deposition Effectiveness on Large Machines

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- TFTR found lithium deposition very effective for enhancing plasma performance. This involved:
  - Large area toroidal limiter
  - 40 helium conditioning discharges
  - Painting (optimized discharge sequence for Li deposition)
- Since TFTR-97, large diverted machines (TdeV, C-Mod, D-IIID, NSTX) have observed only small improvements in performance using lithium deposition.
  - Lithium injected into the SOL of diverted plasmas was probably transported predominantly to the divertors.

This XP Will Test a Hypothesis that Encompasses the Previous Observations

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- Test Hypothesis LPI-1

  1) Li injection into diverted discharges results in Li flows predominantly to the divertor regions.

  2) However, main chamber recycling could have been significant in previous diverted experiments.

  3) Hence, preferential Li flows to the divertor region might have resulted in insufficient Li coverage on main chamber recycling sources.

  4) Therefore,both divertor and main chamber Li deposition may be required in diverted machines to enhance performance.

Note:

NSTX main chamber fueling may be intermediate between toroidal limited and large aspect ratio diverted machines.

Applying a Sequence of Lithium Deposition Discharges

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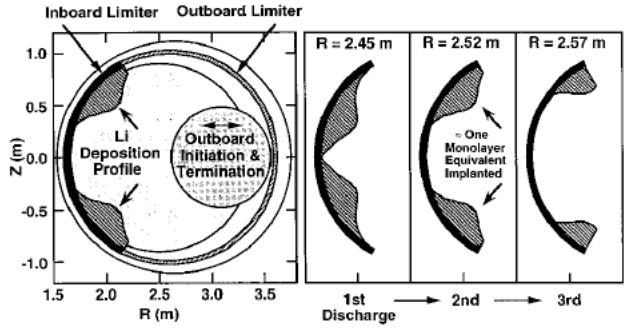
- TFTR developed "painting", an optimized sequence for Li deposition discharges

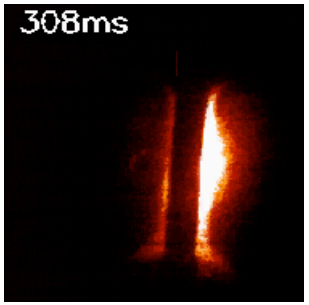


Deposition after Helium ohmic discharges of increasing major and minor radius initiated and terminated on the outboard limiter

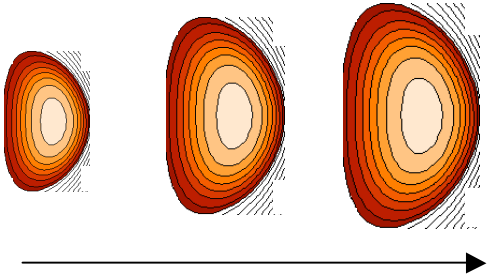
FIG. 5. The calculated distribution of Li deposited on the inboard limiter for three different plasma major radii. Also shown schematically is the plasma configuration as the discharge is initiated and terminated on the outboard limiter.

D. Mansfield, et al., Phys.Plasmas, 3 (1996) 1892.

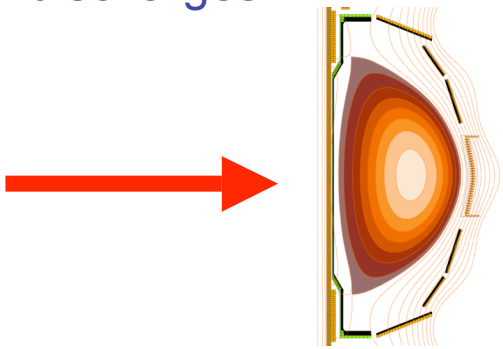
- The proposed NSTX sequence of lithium deposition discharges



Example of LPI transit thru He Ohmic Discharge to CS



Sequence of He Ohmic LPI discharges of increasing major & minor radius initiated inboard



DND, high elongation, NBI D fiducial discharge applied near & against Li coated surfaces

The XP Plan, Day 1: Characterization for Day-2

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- **DND Helium Ohmic Discharges**

[1] Condition PFC using Helium ohmic disharges. [4 shots]

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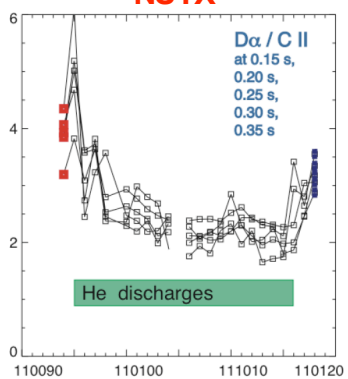

C.H.Skinner, NSTX XP304, 2/03.

- **Evaluation of D-alpha/CII**

17 conditioning discharges gave modest change in D-alpha intensity, D-a decreased by 40% cf x10 TFTR plot.

TFTR

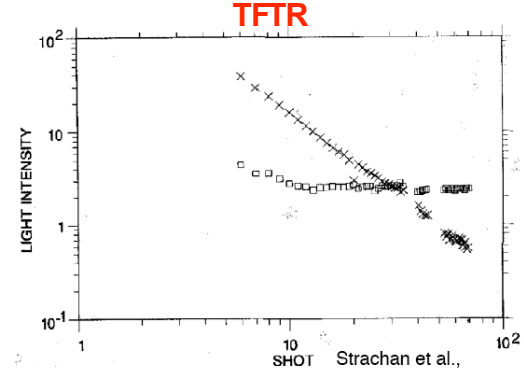

Fig. 11. Hydrogen (×) and carbon (□) influx in helium discharge cleaning pulses following a 1 MA ohmic disruption near the end of a disruptive discharge cleaning campaign.

J.D.Strachan, et al, J.Nucl. Mater., 196-198 (1992) 28.

[2] For constant mass (2 mg), vary velocity (25, 50, 100, 200 m/s). [8 shots]

[3] For constant velocity (100 m/s), vary mass(0.5, 1, 2, 5 mg). [8 shots]

The XP Plan, Day 1: Characterization for Day-2 (cont.)

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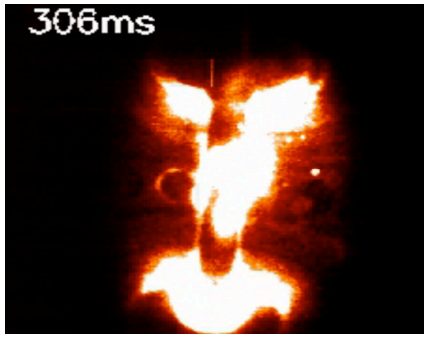
- **DND, Deuterium, NBI Discharges**

[4] For a selected mass (2mg) and velocity (100m/s), inject into ohmic ramp-up and vary NBI turn-ON to intercept the pellet & control penetration depth.[8 shots]

- *LPI penetration depth into ohmic discharges pre-heated with NBI, was found sensitive to 10 ms change in NBI off-time relative to pellet arrival*

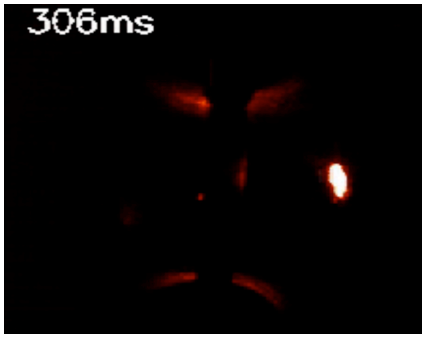
- ***Arrival of NBI <u>during</u> pellet transit will heat the plasma and may give increased control of the ablation profile and the deposition region.***

Li I Filtered Plasma-TV JUL04



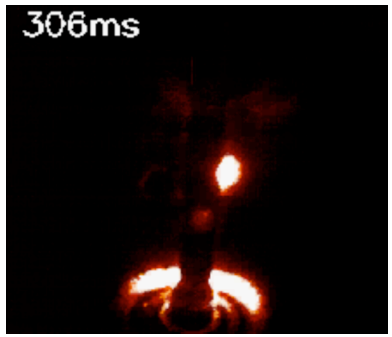
113720
LPI Arrival 294 ms

- **NBI Preheat Off @250ms**
- **LPI Reaches HFS**



113722
LPI Arrival 294 ms

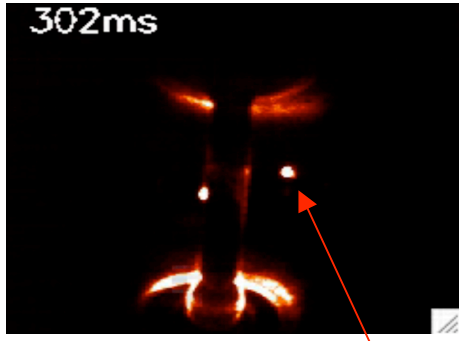
- **NBI Preheat Off @275ms**
- **Penetration greatly decreased; LPI Ablates Near Outer Boundary**



113723
LPI Arrival 294 ms

- **NBI preheat Off @260 ms**
- **LPI Plasmoid reaches HFS**

EXAMPLE TARGET



113723
LPI Arrival 294 ms

Pellet in transit

The XP Plan, Day 2 - Test Hypothesis LPI-1

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- **DND Helium Ohmic Lithium Deposition Sequence -1(same R_0)**

[1] Perform DND helium ohmic fiducial at $R_0 = R_1$; measure D_{alpha}, Li I, B, C. [1 shot]

[2] Inject LPI through DND helium ohmic discharge at $R_0 = R_1$ to CS; 6 shots. [6 shots]

[3] Apply DND high elongation NBI D discharge; 2 shots. [2 shots]

[4] If effective continue #3 for 3 more shots to observe the performance decay.[3 shots]

- **DND Helium Ohmic Lithium Deposition Sequence -2 (vary R_0)**

[5] LPI through DND, $R_0 = R_1$, helium ohmic discharge at to CS. [2 shots]

[6] LPI through DND, $R_0 = R_2$, helium ohmic discharge to CS. [2 shots]

[7] LPI through DND, $R_0 = R_3$, helium ohmic discharge to CS. [2 shots]

[8] Apply DND high elongation NBI D discharge 2 times. [2 shots]

[9] If effective continue #8 for 3 more times to observe the performance decay.[3 shots]

[10] If effective but decaying then do LPI into #8 during ohmic phase and vary NBI Turn-On to vary LPI penetration depth and change deposition region. [5 shots]