Supported by

Office of Science

NSTX

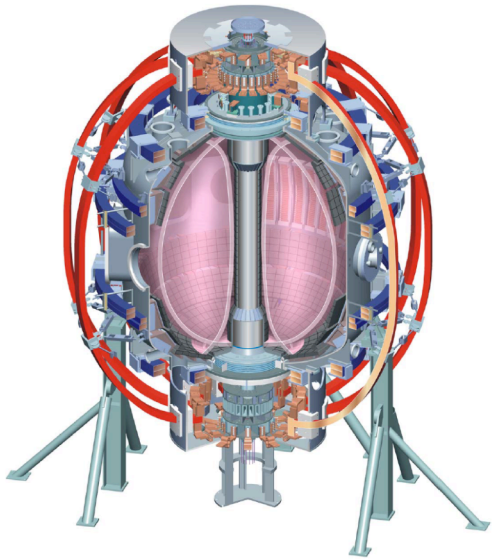
Recycling Measurements Following Repeated Lithium Pellet Injection

H. W. Kugel, M. Bell, T. Gray, D. Mueller, B. LeBlanc, R. Kaita, T. Stevenson, C. H. Skinner, A. L. Roquemore (PPPL), C.Bush, R. Maingi (ORNL), V.Soukhanovskii (LLNL), R. Raman (UWa)

47th APS – DPP Meeting
Oct 24-28, 2005
Denver, Co.

College W&M
Colorado Sch Mines
Columbia U
Comp-X
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
ORNL
PPPL
PSI
Princeton U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Maryland
U Rochester
U Washington
U Wisconsin

Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAERI
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec



NSTX Has Been Investigating Lithium Pellet Injection for Reduced Recycling as Part of a 3 Phased Approach to Lithium PFCs: (I) Li Pellet Injection, (II) Li Evaporators, (III) Liquid Li Divertor

• TFTR obtained reduced recycling and significantly enhanced performance by starting with a thoroughly degassed limiter and applying lithium deposition techniques directly into low density plasmas.

• Since TFTR, Lithium Pellet Injection was applied directly into normally fueled, diverted C-MOD, DIII-D, TdeV, and NSTX plasmas, but without thorough wall degassing, and has yielded no similar significant performance improvement other than a small decrease in impurities.

• The goal of these NSTX experiments was to make contact with the TFTR lithium experience, starting with the recycling effect.

• These experiments investigated recycling, first from the *NSTX Inner Toroidal Limiter* (Center Stack), and then from the *Lower Divertor* following repeated lithium pellet injection.

Recent Experiments in NSTX Were Guided by the TFTR Lithium Experience

1) Center Stack Limited discharges (CSL) and Lower Single Null (LSN) discharges were used.

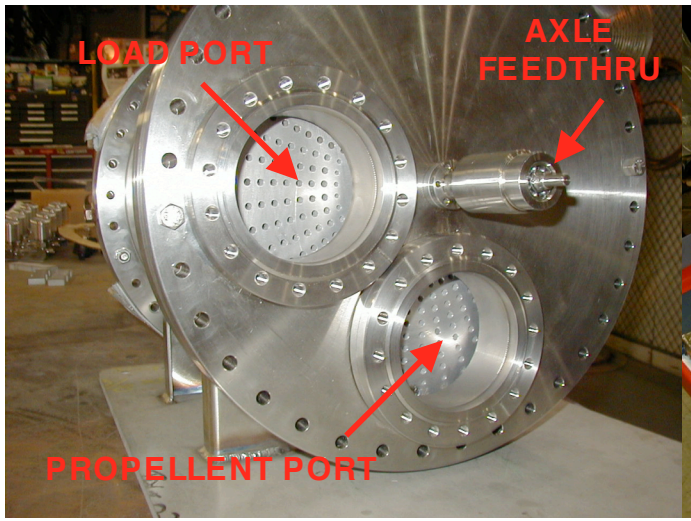
2) Ohmic Helium Conditioning discharges were used to *degas* the Center Stack (Exp-1 & Exp-2) and the Lower Divertor (Exp-3).

3) Lithium Pellets were injected into CSL and LSN Ohmic Helium discharges to coat the plasma wetted surfaces and *prevent lithium saturation by the fuel gas*.

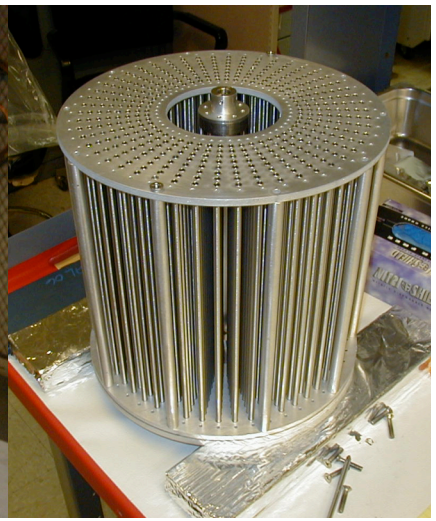
4) Then CSL, and LSN low density, deuterium NBI reference plasmas were applied to measure recycling changes due to lithium pumping of the edge plasma.
   - Low density reference plasmas were used to avoid saturating the available lithium pumping capacity.

Lithium Pellets Injected into NSTX Discharges

• 111 mg injected, using 1.7 to 5mg pellets, 100-150 m/s, 1-2 pellets/shot



OUTBOARD VIEW

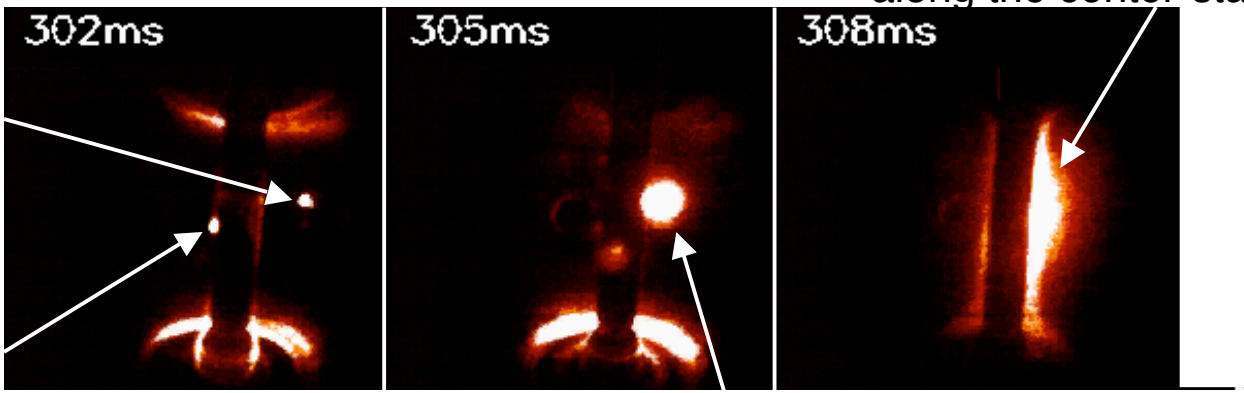


400 BARREL TURRET

- Sabot (cartridge) style injector for injecting solid pellets (<1 – 5 mg) & powder (micro-pellets)
- 10 – 200 m/s radial injection
- 1 – 8 pellets per discharge
- 400 pellet capacity

Lithium vapor spreading along the center-stack

Lithium Pellet moving through plasma after entering boundary

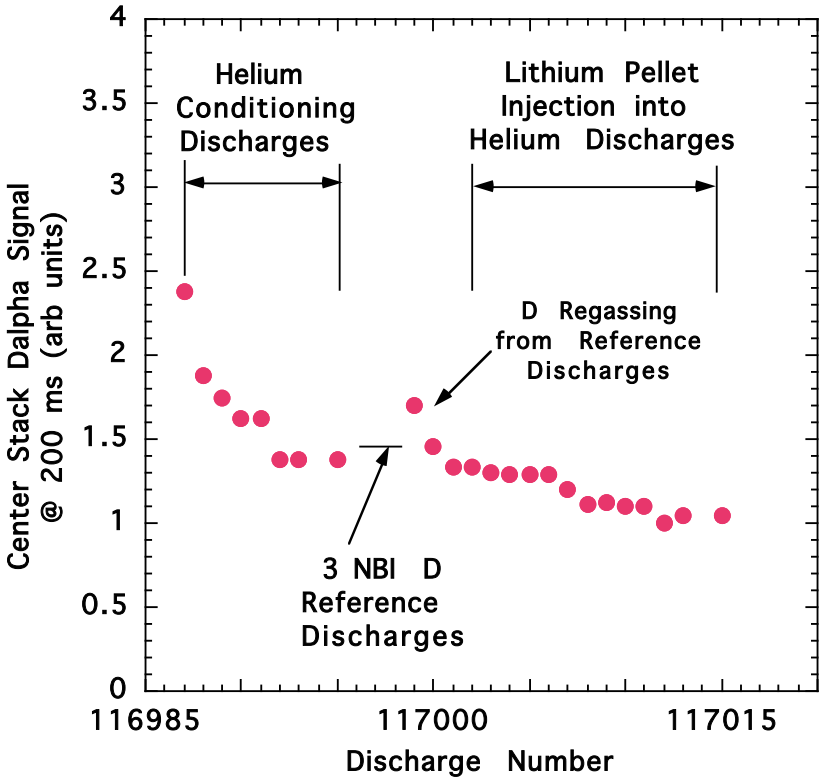


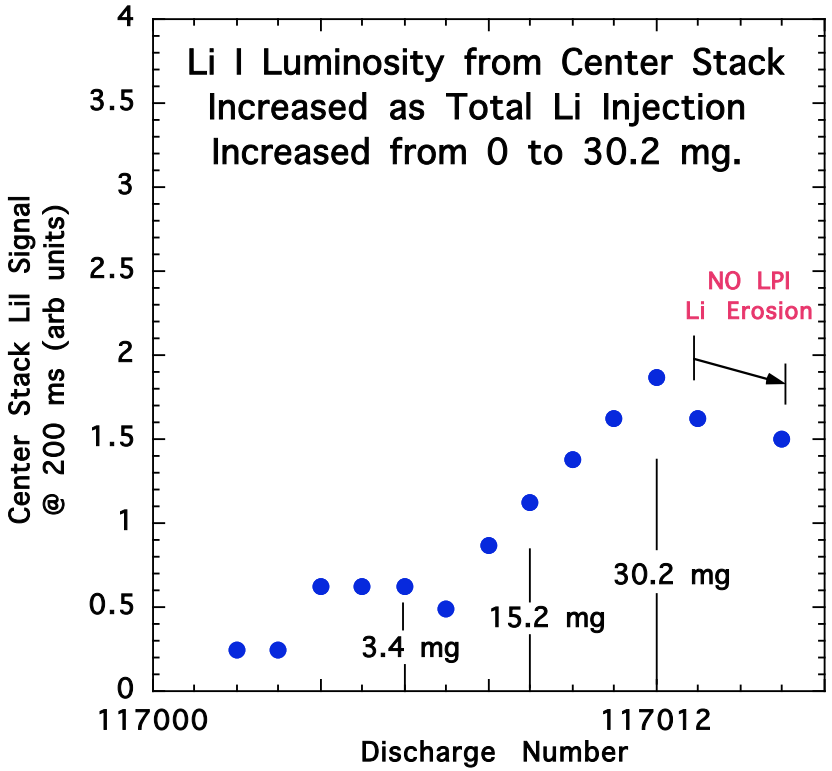
In-board gas injector

Pellet plasmoid approaches center-stack

Li I Plasma-TV
-C.Bush ,ORNL

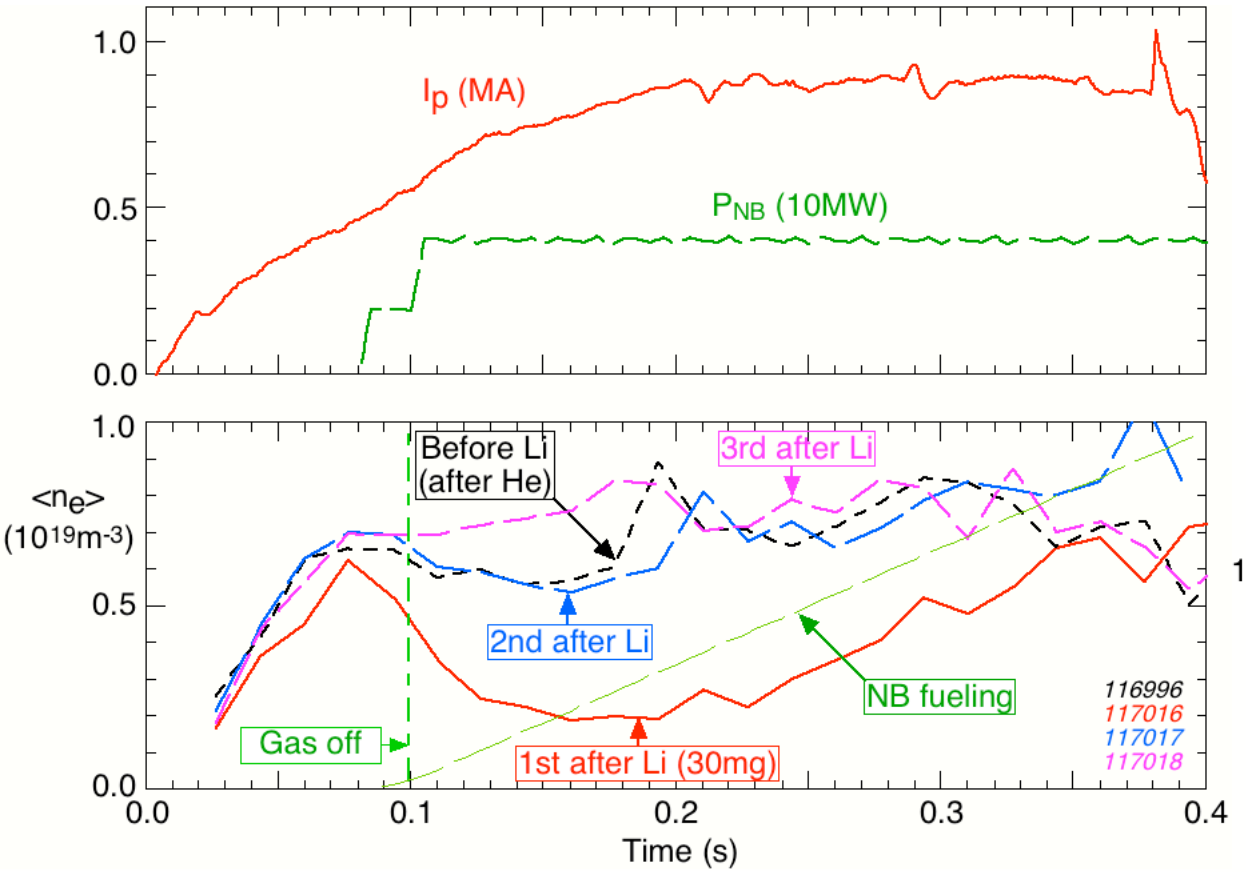
Exp-1: During LPI into CSL Ohmic Helium Discharges, Dα Luminosity from CS Decreased and Li I Luminosity Increased



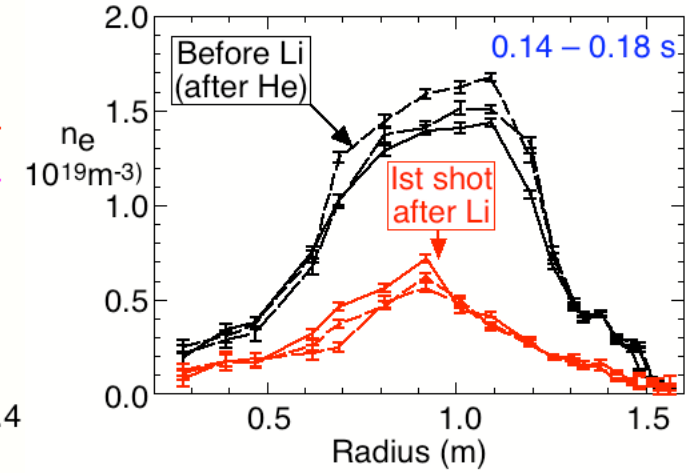


- 12 He discharges (05.MA, 0.45 T), 9 with LPI of either 1.7, 3.4, or 5.0 mg.
- Small conditioning decrease in Dα luminosity during LPI He discharges.

Exp-1: Initial CSL NBI Deuterium Reference Shot Following 30 mg of Lithium Deposition on CS Exhibited ~x3 Decrease in Density and Peaked Profiles

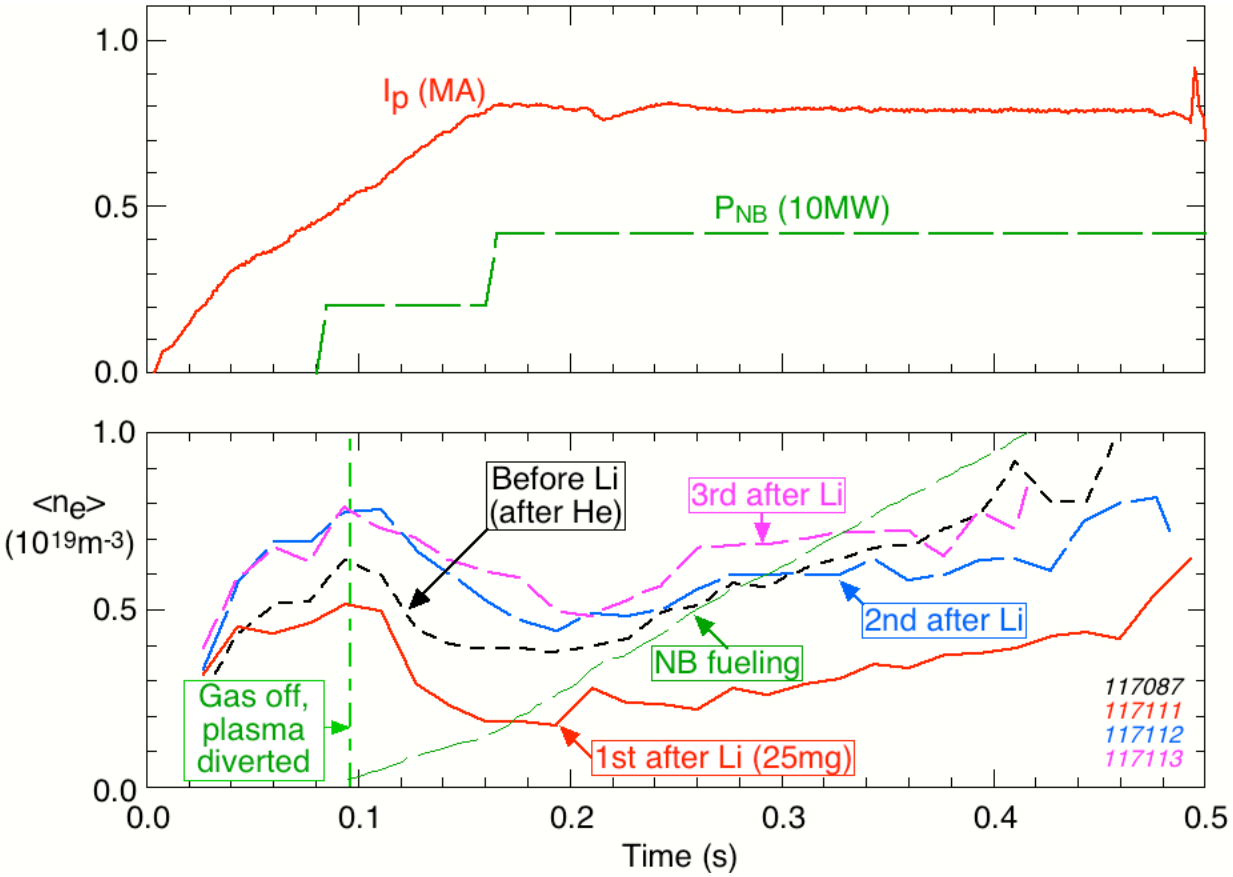


Center-stack limiter discharges,
0.9 MA, 0.45T,
D_2 gas fueling 3.5mg

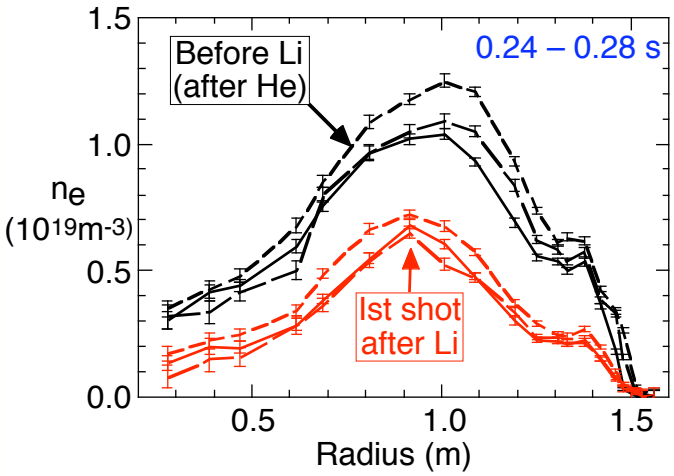


- 30 mg of lithium pumping of edge density saturated after the 3 Reference Discharges and returned to pre Li wall conditions.
- Exp-2 using an additional 24 mg Li duplicated these a CSL results.

Exp-3:LSN NBI D Reference Shot Following 25 mg of Li Deposition on Lower Divertor Exhibited ~x2 Decrease in Density and Peaked Profiles



Lower single-null divertor discharges, 0.45T, D_2 gas fueled 3.5mg



- 25 mg of lithium pumping of edge density saturated after the 3 Reference Discharges and returned to pre Li wall conditions.
- Expected if most injected gas reacts with the deposited lithium

Conclusions

- The results are consistent with the consumption of the deposited lithium.

  E.g. ~30 mg Li = 2.6×10^{21} Li atoms available to react with 2.6×10^{21} D

  ~9×10^{20} D/Shot, and Li pumping stops ~2-3 shots (1.8-2.7×10^{21} D removed)

- The CSL recycling results made contact with the TFTR lithium recycling experience.
- The LSN results extended the TFTR lithium recycling experience to a diverted configuration.
- LPI directly into LSN plasmas yielded no pumping effect (similar to previous NSTX and other diverted results).
- NSTX Phase I (Li Pellet Injection) experiments demonstrated that surfaces *pre-coated with lithium*, edge pumped a diverted plasma and exhibited an increased peaking of the density profile.
- NSTX Phase II (Lithium Evaporator) is in preparation for performing routine thick lithium coating depositions over a significant fraction of the plasma facing surfaces for the first Experimental Proposals in early 2006.