XP?? Improved lithium coverage with diffusive Li injection

Charles Skinner and NSTX team.

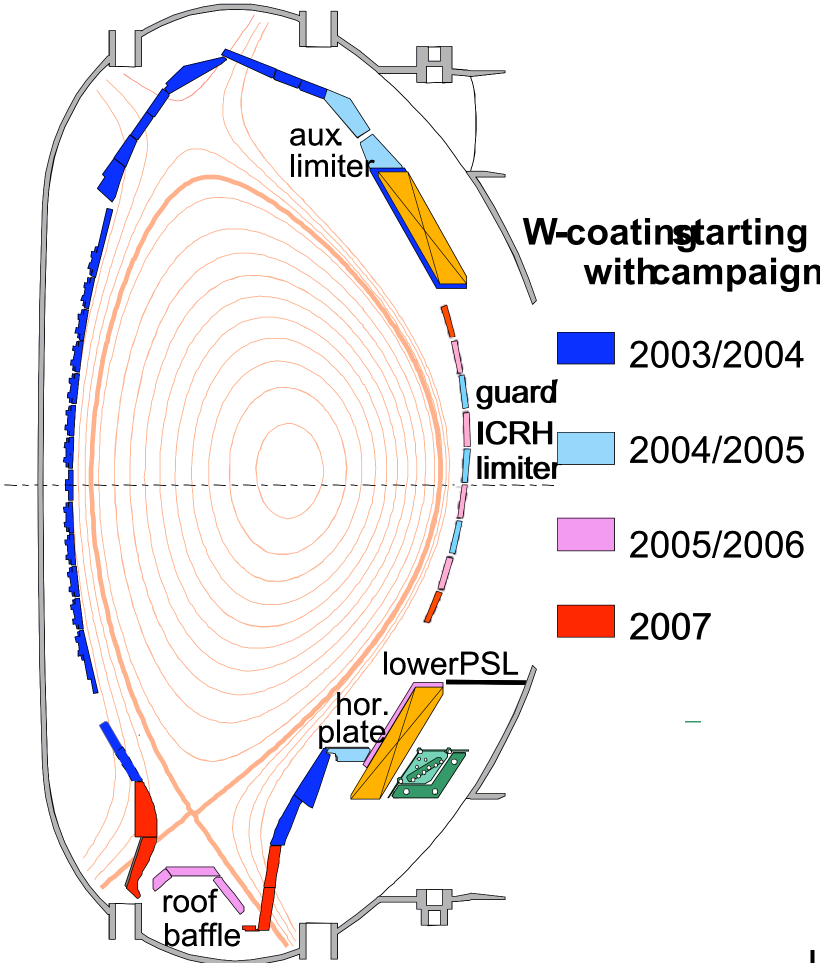
Motivation:

- Density and impurity control is goal of multi-year Li program on NSTX.
- But so far elimination of ELMs by Li has caused impurity accumulation late in discharge.
- Core carbon levels actually increase with Li. (R. Bell).
- Asdex experience showed that carbon impurities were not reduced without complete W coating of C.
- Complete Li wall coverage in NSTX may be essential to reap full benefits of Li.

Potential methods:

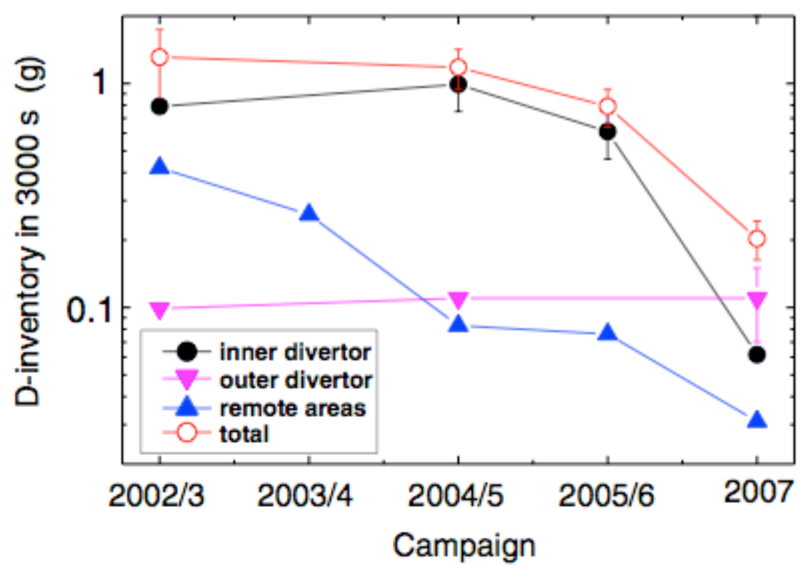
- Combination of LiTER + Li Dropper (XP913)
- Diffusive injection of Li (this XP).

Asdex experience



Poloidal cross section with colour coded PFCs representing the time of implementation of W coated tiles.

A. Kallenbach *et al* Nucl. Fusion **49** (2009) 045007



total deposited in 3000 s (g):

	2002/3	2004/5	2005/6	2007
C	14.6	13.8	2.2	1.0
B	2.8	4.7	2.3	≈0

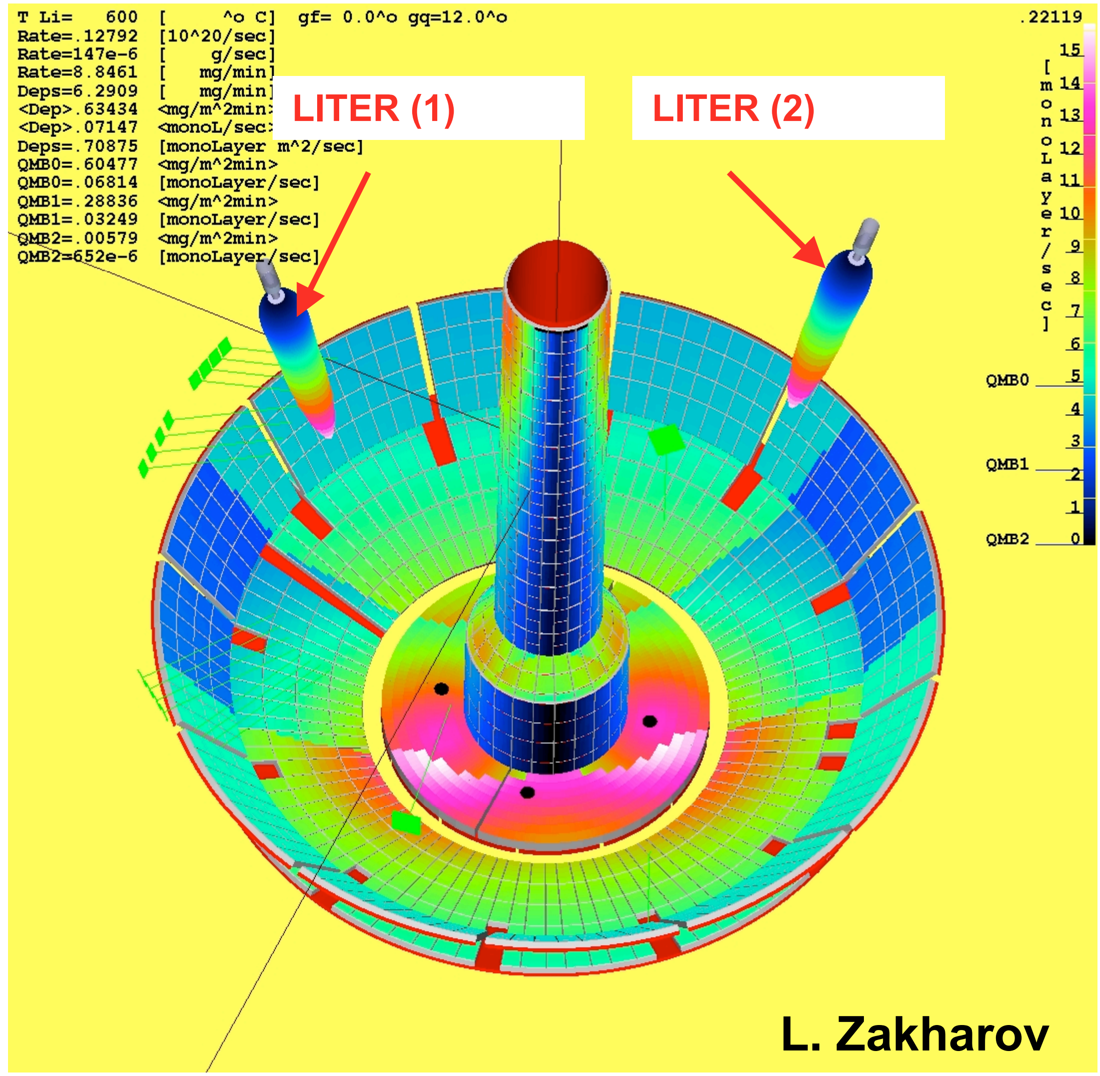
In 2002/3, the inner heat shield and upper inner divertor were W coated, the coating of the lower divertor before the 2007 campaign completed the transformation to full W. Also shown is the temporal evolution of the D content for various plasma facing components. The table gives the total amount of deposited C and B in the inner divertor.

R. Neu APS07

Li injection

- Li atoms injected under high vacuum conditions follow line of sight trajectories to lower divertor.
- Li atoms injected into low pressure gas will diffuse according to mean free path.

- Think Windex !
  - switch from stream to spray !

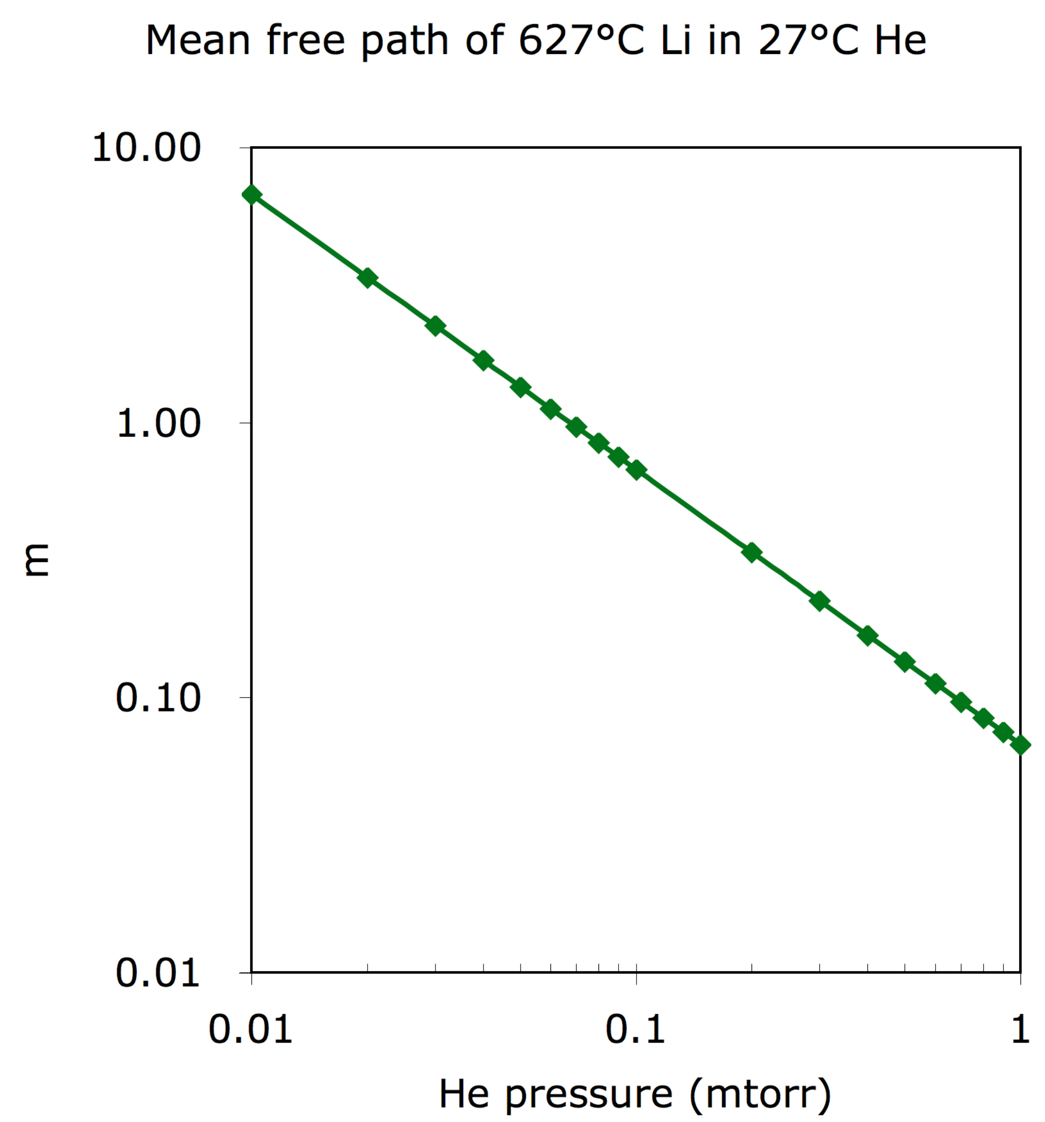


Li mean free path in helium

Calculation by Kristic Predrag for PSI18

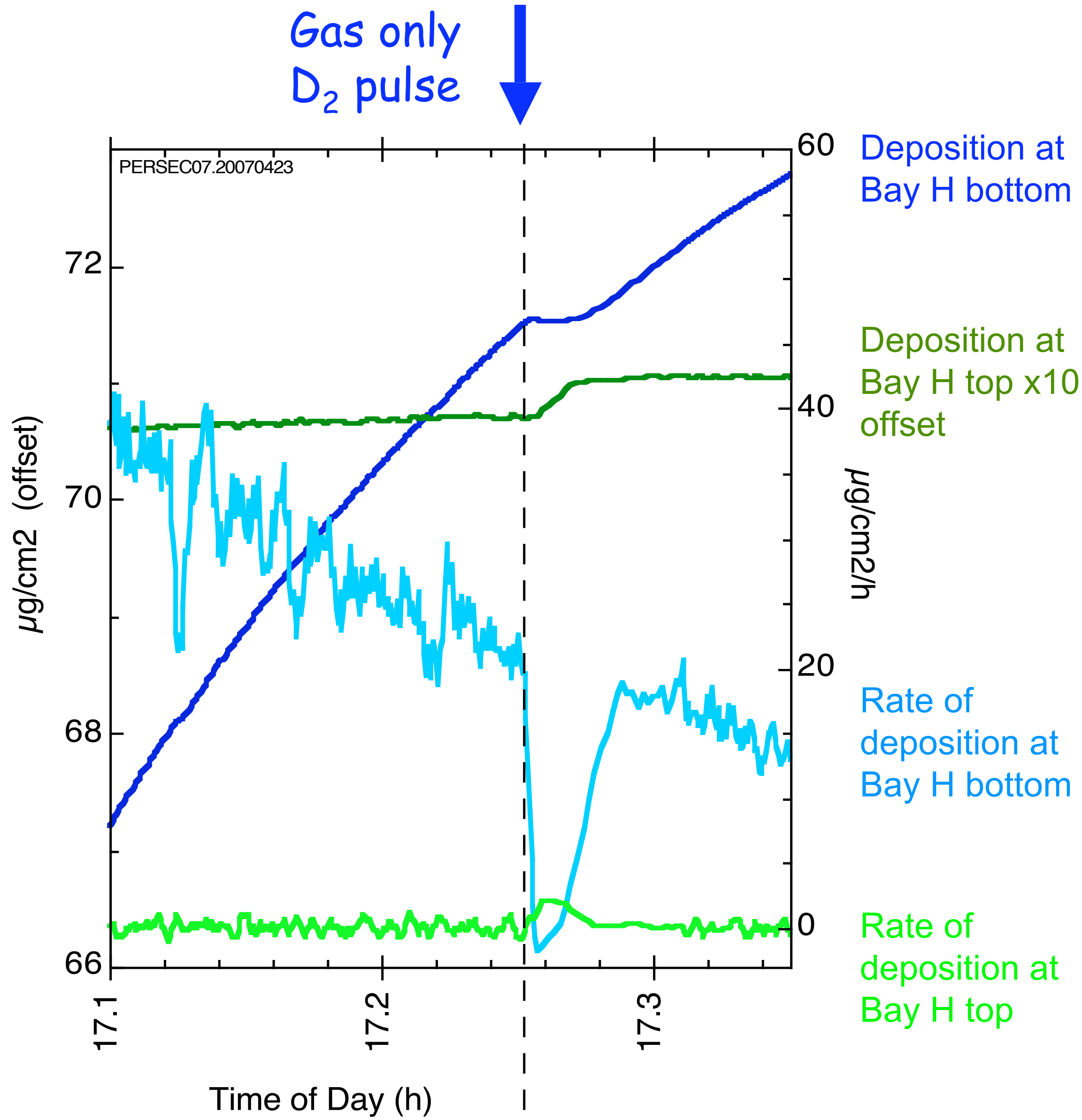
•The mean free path (λ_1) of neutral lithium in molecular deuterium was calculated from the momentum transfer scattering cross section (σ_{12}) using the formalism in [] for a multicomponent gas with, i=1,2, the average velocities of species i, and averaging over the angles of the relative velocity. The cross sections were calculated on basis of highly accurate calculations of LiH ground singlet () and triplet () potential curves, using coupled cluster singles-doubles-triples-quadruples (CCSDTQ) method with unrestricted Hartree-Fock [], equivalent to the full configuration interaction for 4 electron systems, and are in good agreement with the full valence CI calculations of Boutalib et al. []. Fully quantum-mechanical calculations of the cross sections, convergent in partial waves, were performed in the range 10^{-4} – 0.12 eV, using Johnson method of logarithmic derivatives [,] and applying plane-wave boundary conditions for nuclear motion at R_{max}=100 Bohrs. The singlet and triplet potentials were smoothly matched to the asymptotic Van der Walls form []. The calculated mean free path of Li at 627 °C in a hypothetical atmosphere of 1 mtorr (0.13 Pa) of atomic deuterium at 27 °C is 3.94 cm. The momentum transfer cross section of lithium on molecular deuterium was estimated from Li+D cross section using analogy with comparison of fully quantal results of H+D and $H+D_2$ in refs. [,].

•The Li-He mean free path was calculated using the same approach as for deuterium with the diffusion cross sections from ref. []. The mean free path of neutral lithium at 627 °C in 2.5 mtorr of helium at 27 °C was calculated to be 2.7 cm.



Lithium deposition changed by D_2 puff

- Quartz Microbalance data.
- Gas only D_2 pulse 1.3 mtorr.
- Deposition in line-of-sight QMB at Bay H bottom interrupted
- Deposition of shadowed QMB at Bay H top begins.
- Situation reverts on D_2 pumpout.



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0.5 day XP

1) Establish baseline LSN, Li conditioned, ELM-free H-mode with impurity accumulation.

2) Perform staged Li deposition, both LiTERs 10 mg/min:

Fill to 2.5 mtorr He with GDC system (no plasma), close TMPs, then partial pump out to:

0.225 mtorr He (0.30 m mfp), 3 minutes then partial pump out,

0.096 mtorr He (0.70 m mfp), 3 minutes then partial pump out,

0.045 mtorr He (1.50 m mfp), 3 minutes then full pump out,

base vacuum, 3 minutes.

Wait 5 mins for any helium pump out (note no HeGDC and lower pressure He than 2007)

3) Repeat ELM free H-mode and check on impurity accumulation.

4) Repeat step 2 and 3

6) Repeat step 2 and 3

8) Try 3 discharges at shorter mfp (0.1, 0.2, 0.3 m)

9) Try 3 discharges at longer mfp (1, 1.5, 2 m) to coat sides of centerstack.

Increase 5 min wait to 10 mins if helium 304Å line becomes prominent on SPRED.

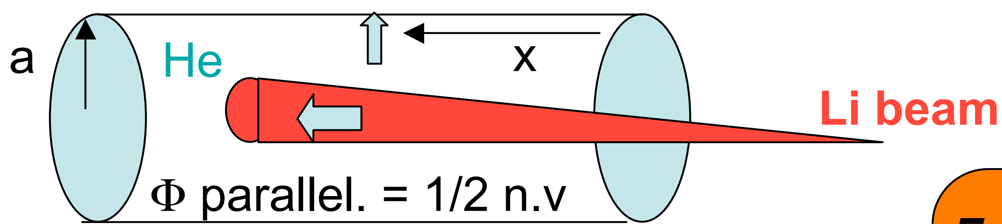
Key Diagnostics: Radiated power, Zeff, CHERS core C density, SPRED

TJ-11 Coating System Upgrade
(Tabares talk April 09)

Searching for homogeneity:

8 ovens, loaded for repetitive, in situ evaporation (6-8 cycles)

- Diffusion can help: Φ dif.= 1/3 λ.v.n/a, λ @10^{-5} mbar He ~80cm



n (x)~$1/x^2$.exp(-x/λ)

Φ_{diff} (x)= $n_0$exp(-x/λ)/λ.2πa, λ~1/P_{He}

***Free* Parameters:**
- -Type of gas
- -Bkgnd pressure
- -Distance between ovens

Long term: LLL in TJ-II(?)