
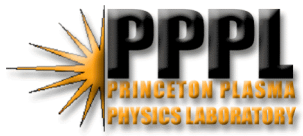

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Helium retention in lithium and implications for NSTX

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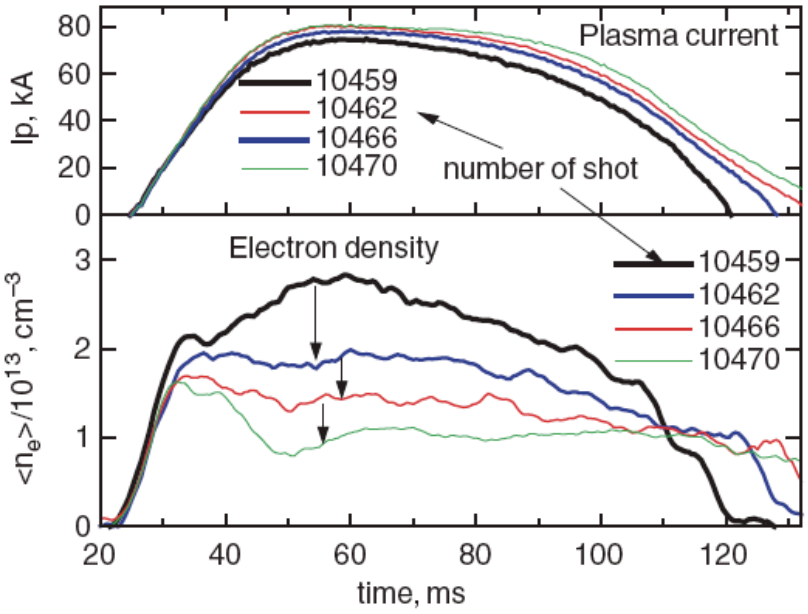
Princeton, NJ

Helium does not chemically interact with lithium (tokamak experience)

- Fresh lithium surface can *adsorb* a helium atom
- A helium atom can *desorb* from the surface

- Russian experience (S. V. Mirnov, V. A. Evtikhin, T-11M):
  - ✓ Ohmic helium plasmas in T-11M with CPS lithium limiter and lithium-coated walls
  - ✓ No chemical interaction between He and Li (unlike H_2/D_2 that dissolve and form hydrides / deuterides)
  - ✓ No anomalous erosion of lithium under helium flux
  - ✓ Retention of He in Li limiter observed
  - ✓ Density reduced in Helium shots
  - ✓ Slow helium removal (outgassing) rate (20-100 s after plasma shot)
  - ✓ Retention was avoided by operating with walls heated to 50-100 C, and at 150 C helium recycling completely restored (did not work for D_2 even at 250-300 C)
  - ✓ Plasma Phys. Control. Fusion 48 (2006) 821–837
  - ✓ Plasma Phys. Control. Fusion 44 (2002) 955–977

T11-M results: helium interaction with lithium coated walls



Density reduced by operating with lithium limiter even in helium plasma discharges, presumably due to helium recycling reduction

Figure 17. Electron density evolution from shot to shot in discharges with high initial temperature at lithium limiter (about 500°C); helium taken as working gas.

Outgassing of helium is observed after a plasma discharge for 10-100 s

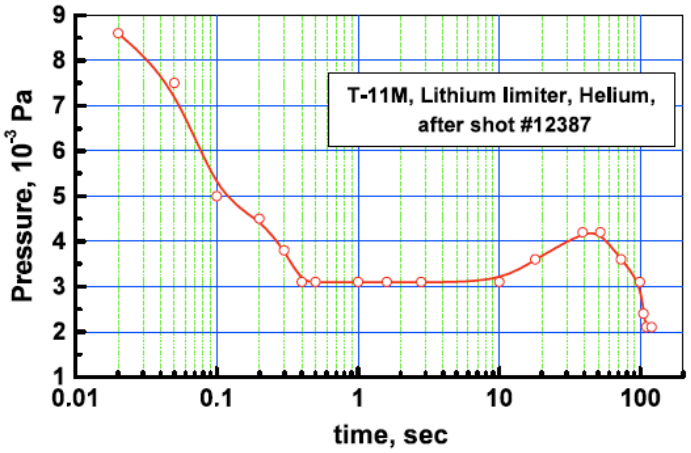


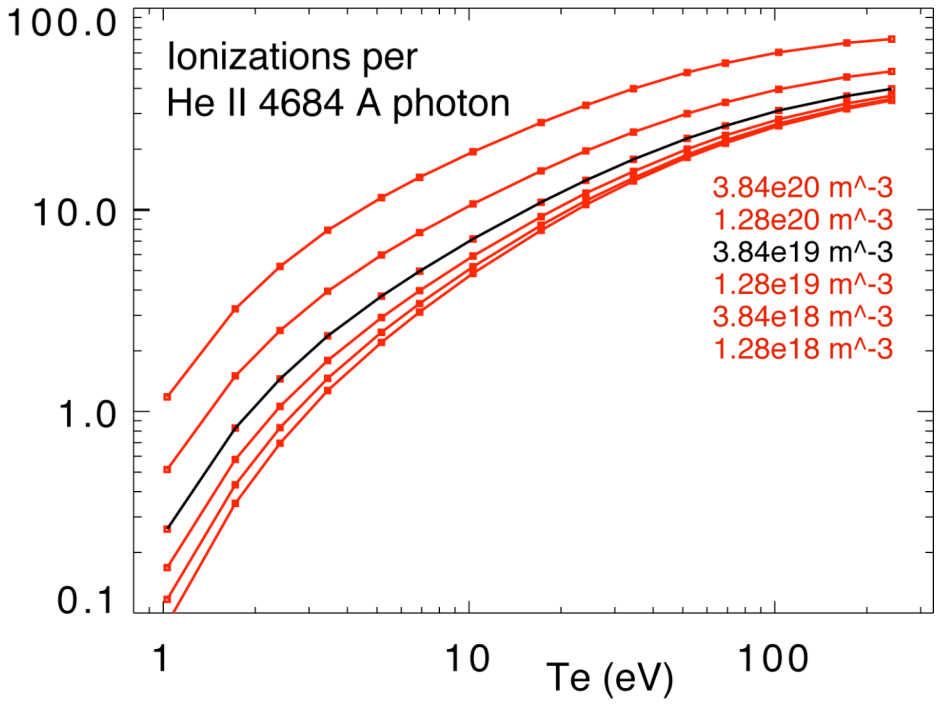
Figure 15. The behaviour of the gas pressure (He) in the tokamak vacuum vessel after the He discharge.

NSTX helium diagnostics and analysis

- Spectroscopy:
  - ✓ He I ionization potential - 24.6 eV, He II ion. pot. - 54.4 eV
  - ✓ Midplane He EIES with He II (4686 A) filter - **He II ion influx**
  - ✓ Lower divertor 1D cameras with He II (4686 A) filter - **He II ion influx**
  - ✓ Midplane ERD spectrometers, He II (4686 A) line - **He II ion density** (using atomic emission rates from ADAS), **He II ion temperature, rotation**
  - ✓ VIPS spectrometer - **He I, He II ion flux, temperature**
  - ✓ SPRED spectrometer - relative He influx

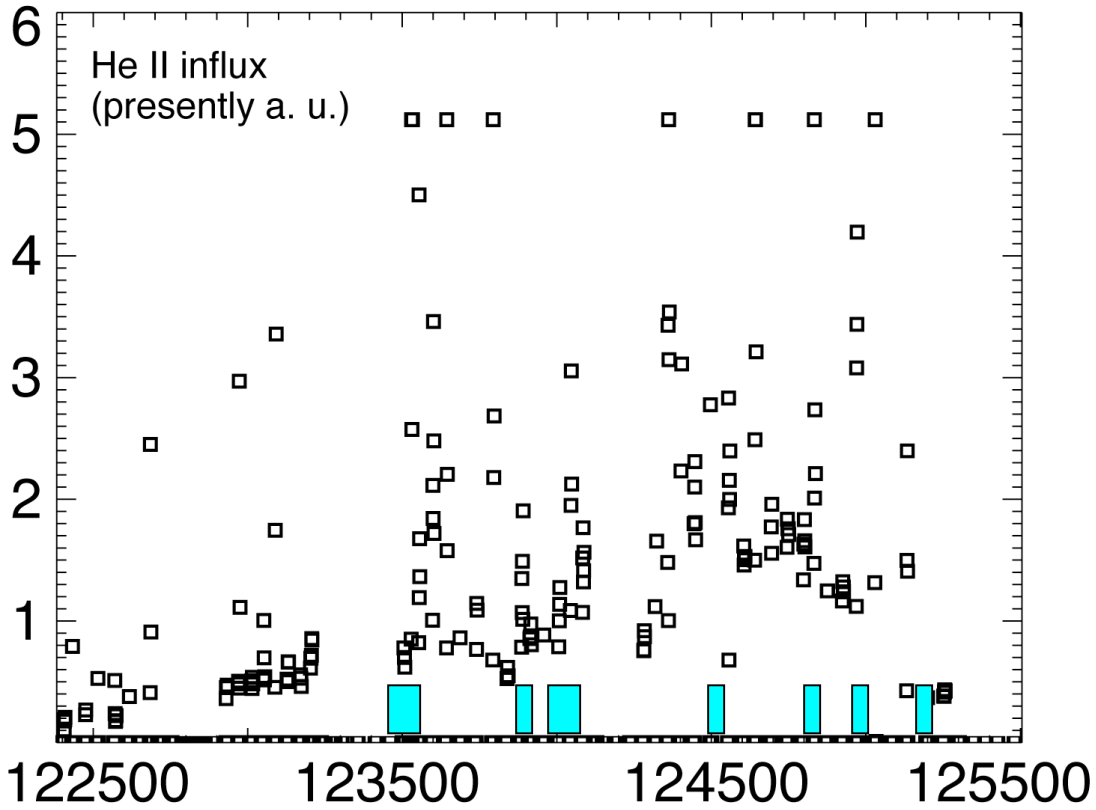
- Presently using ADAS data for interpretation -->

- **However, need confirmed MPTS data to interpret measurements**



Preliminary results indicative of helium accumulation throughout LITER campaign

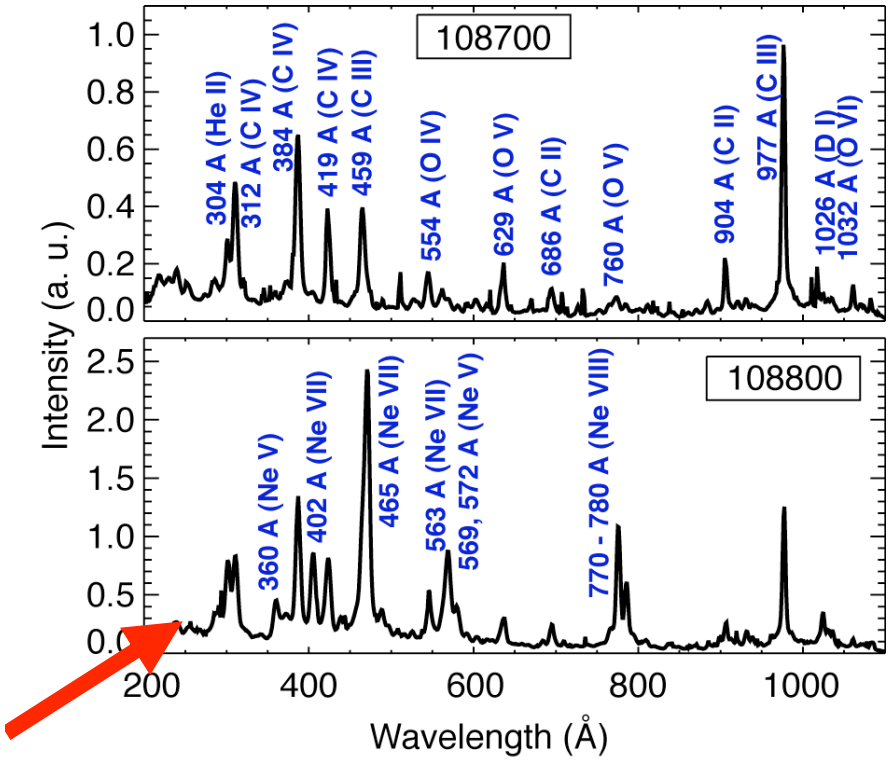
- Did not observe He accumulation in LITER experiments in 2006
- In 2007 LITER was evaporated throughout plasma discharges and in He GDC between discharges
- Apparently trapped helium in walls

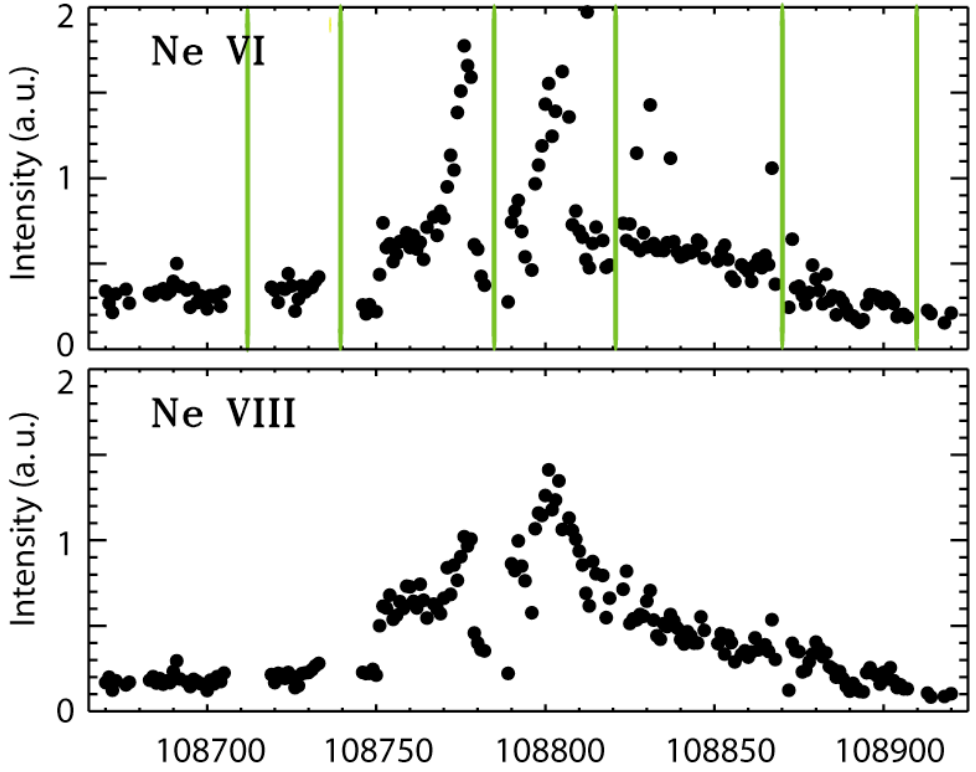


LITER

NSTX experience in FY2007 is similar to FY2002 experience with Ne GDC + Boro

- Boronization was performed after Ne GDC
- Neon interacts with solid surface through attachment (adsorbtion) and implantation
- Neon spectral lines seen in SPRED spectra (left figure, before and after)
- Neon traces observed in plasmas over one week of operations (right figure - neon vs shot number for ~ 8 days following NeGDC+Boro)





Backup: S/XB technique is used to infer ion influx from spectroscopic measurements

$$\Gamma_{ph} = \int_{x_1}^{x_2} n_i \, n_e \, X \, B \, dx$$

- Technique originally developed by L. C. Johnson & E. Hinnov, and further by A. Kallenbach
- Used for deuterium and impurities

$$\frac{\partial n_i}{\partial t} + \frac{\partial}{\partial x}(v_i \, n_i) = S^{i-1} \, n_e \, n_{i-1} - S^i \, n_e \, n_i$$

$$\Gamma_{ph} = -\frac{X \, B}{S^i} \left(v_i \, n_i \Big|_{x_1}^{x_2} - \int_{x_1}^{x_2} S^{i-1} n_{i-1} \, n_e \, dx + \int_{x_1}^{x_2} \frac{\partial n_i}{\partial t} \, dx \right)$$

$$\Gamma_i = -v_i \, n_i \Big|_{x_1}^{x_2} + \int_{x_1}^{x_2} S^{i-1} n_{i-1} \, n_e \, dx$$

$$\Gamma_i = \frac{S}{X \, B} \, \Gamma_{ph}$$

- 1D viewing geometry
- x_1- recycling / erosion boundary, x_2 - detector location
- Recombination neglected
- Excitation and ionization occur in the same volume
- Steady-state condition