Lithium experiments in CDX-U
and a brief summary of the TFTR, T11-M experiences

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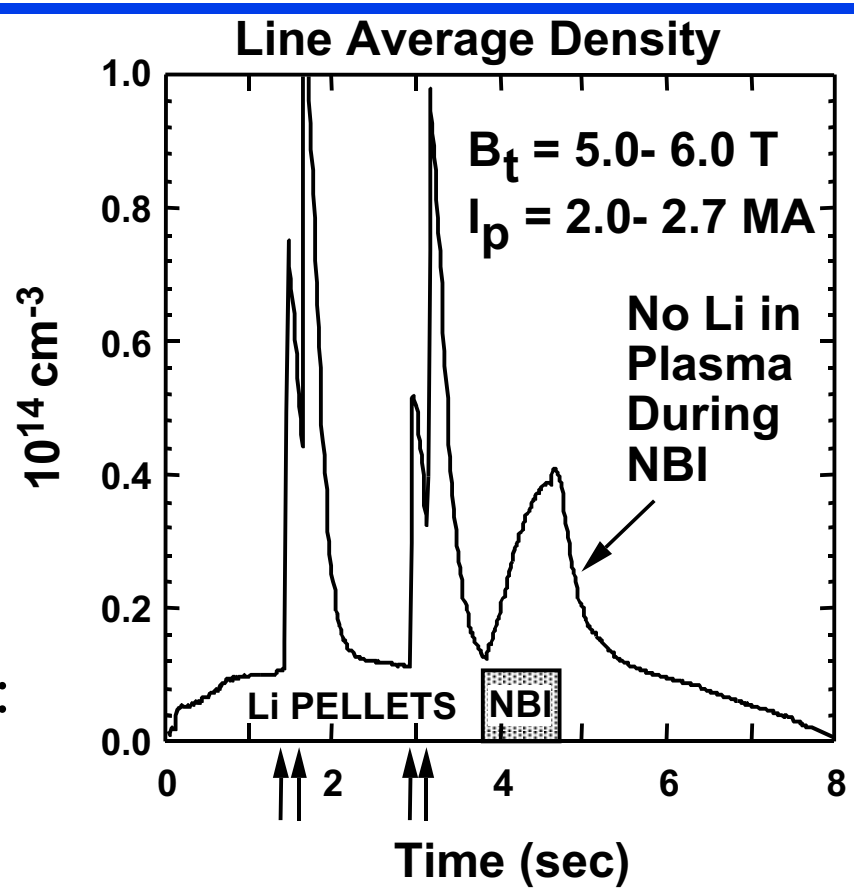
Introduction

- CDX-U operated with solid and liquid lithium limiters for several months
  - Total inventory in the rail limiter > 30 cm^3
  - Highest operating temperature (with plasma) 260 ^oC
  - Lithium edge influx can be significant
    - » Lots of lithium emission at the limiter
    - » *No effect* on plasma current (⇨plasma resistivity)
    - » Plasma ingested only a few drops of ~ 2mm scale
- Most lithium used during the TFTR experiments was during DOLLOP operation
  - Estimate 21 mg/sec for 8 sec (0.3 cm^3 total) (D. Mansfield)
  - No adverse effects. *However* Dennis cautions that there were many disruptions during the initial implementation of the Li pellet injector
- T11-M operated extensively with their capillary lithium limiter without a problem
- Not so for DIII-D!

TFTR: Lithium Introduced onto Limiter by Injection of Pellets

D. Mansfield

- Li pellets introduced Li into the limiter.
- This improved fusion performance during NB injection.

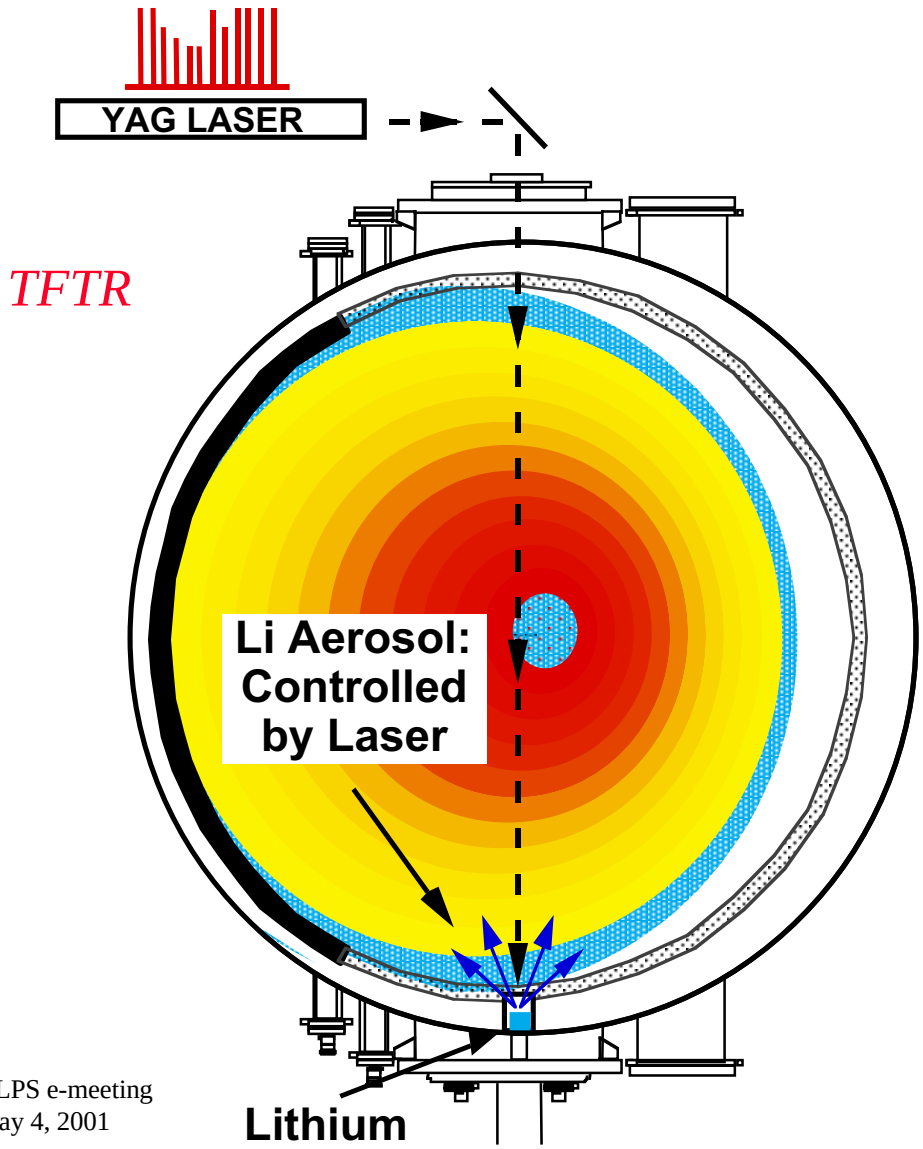


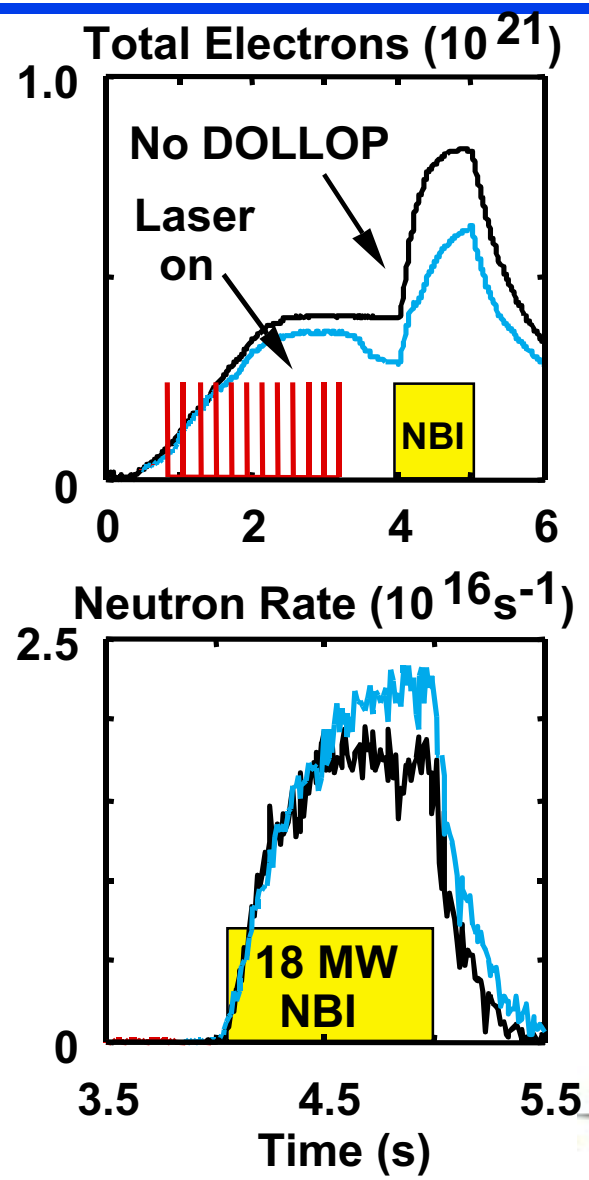
- "Background" level of lithium in TFTR (no pellets): ~0.7% (n_i/n_e)

- **Extended Clean-up Campaign Necessary**
- **Li Accumulated by Pre-conditioning**
- **Minimizing Limiter Contact is Helpful**

DOLLOP: Li Aerosol Controls Influxes and Increases Performance - Nonperturbing and Controllable

D. Mansfield



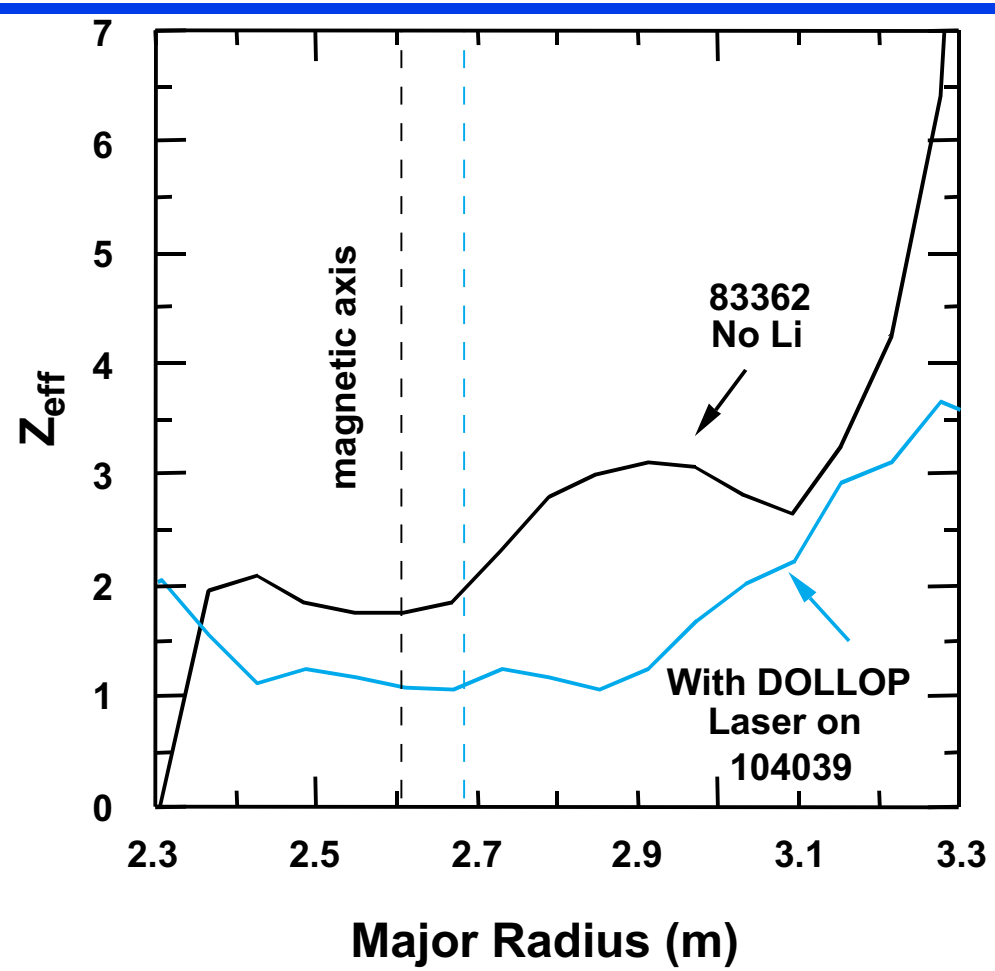


Z_{eff} Profiles With and Without Li

D. Mansfield

TFTR

- Li flux to the plasma edge resulted in LOWER Zeff both at the edge and in the plasma core.



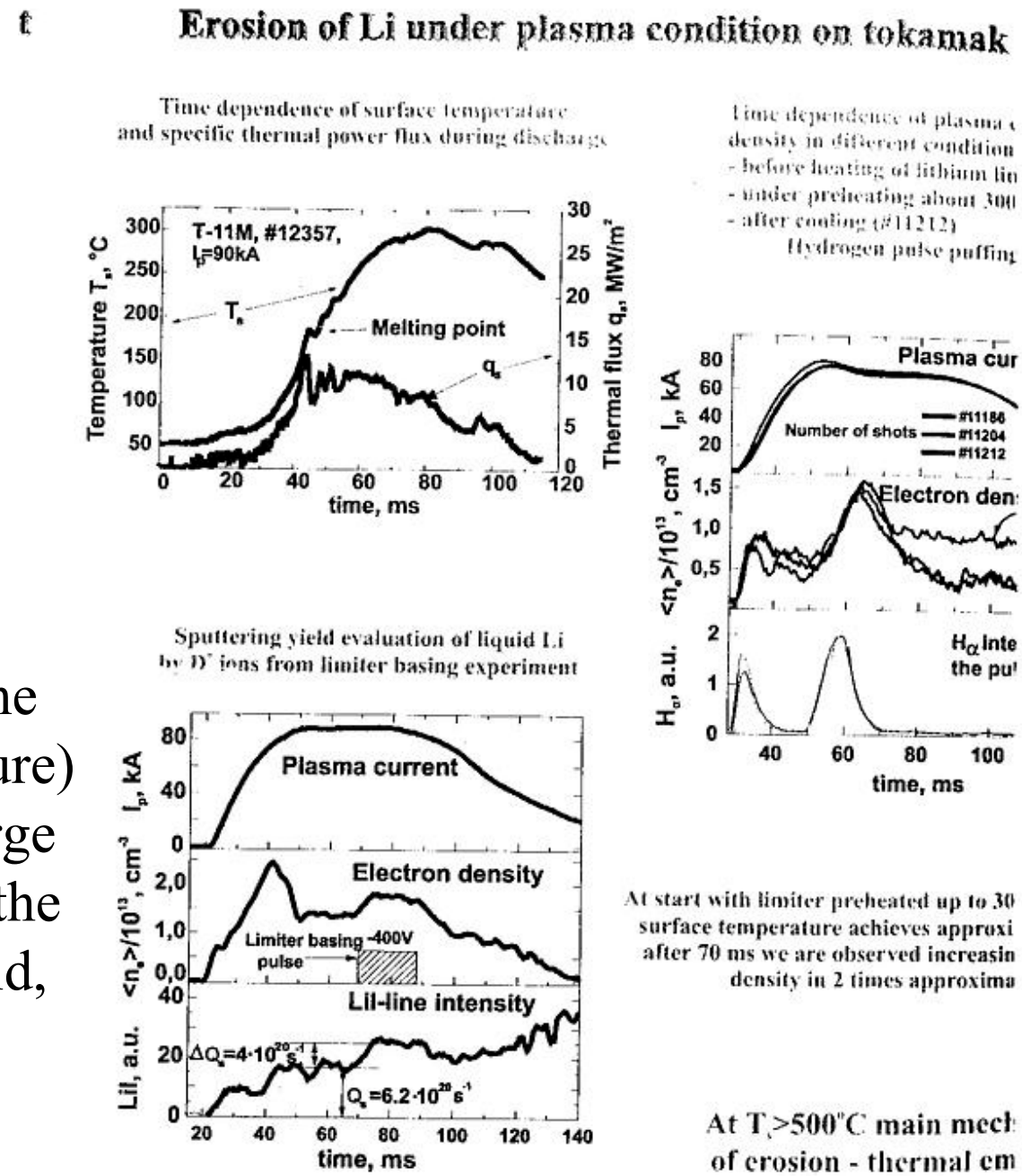
- **Zeff data determined spectroscopically and displayed at t = 4.4 sec for discharges with identical externally- controlled parameters.**

(R = 2.52 m, I_p = 2.3 MA, B_t = 5.6 T, P_b = 18 MW).

T-11M

S. Mirnov

Energy deposition on the Li limiter (top-left picture) during a typical discharge on T-11M (reported at the ISFNT meeting, Madrid, Spain, August, 2000)



T-11M

S. Mirnov

Temporary behavior of the Li radiation during the T-11M discharge for different initial temperatures of the CPS limiter.

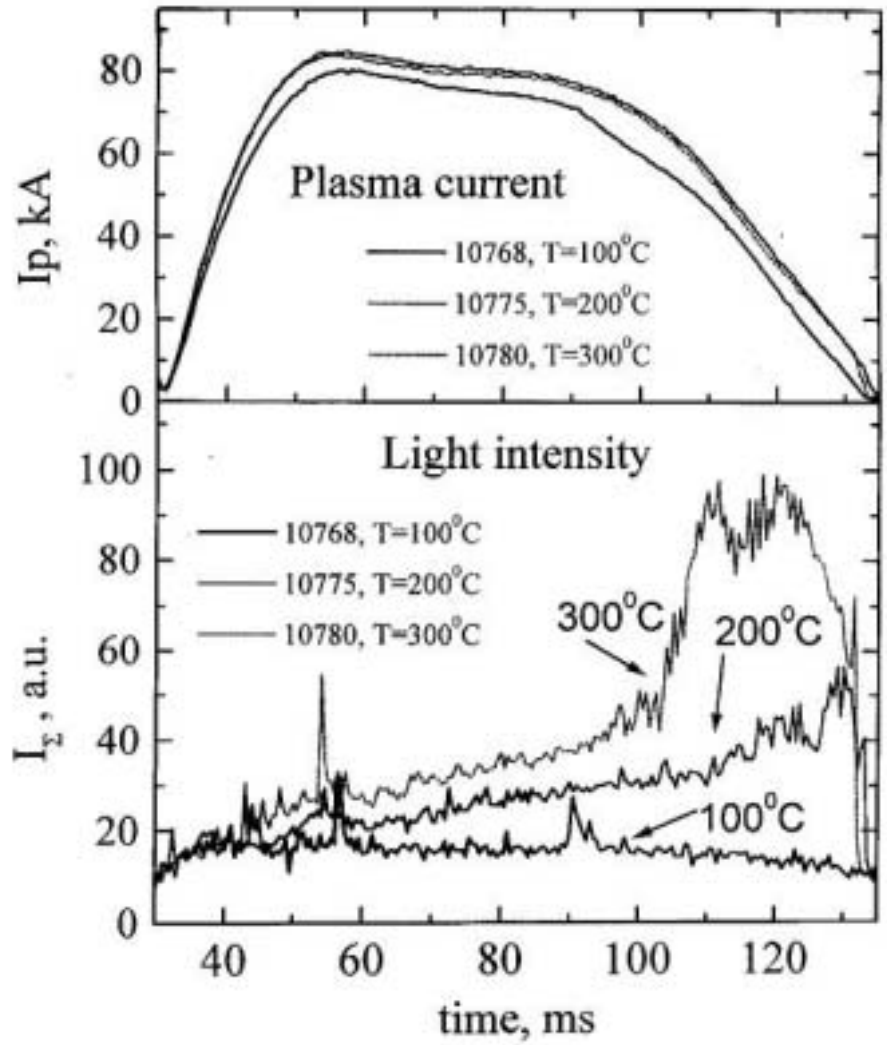


Fig.2.Light intensity near the limiter during same shots for different initial lithium temperatur 100°- 300° C.

T-11M

S. Mirnov

He discharges on T-11M with the hot Li limiter demonstrate reduction in the plasma density with the number of discharges.

Explained by the gettering effect of the Li coating of the side walls.

T-11M was operated with the lithium limiter at 500º C

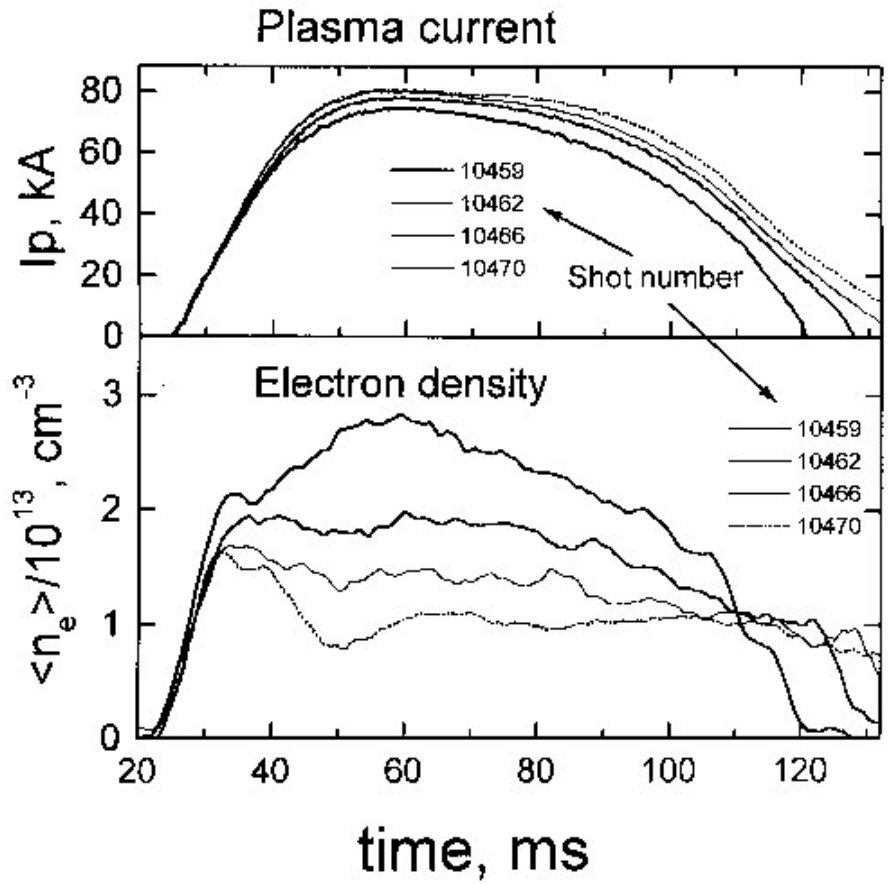
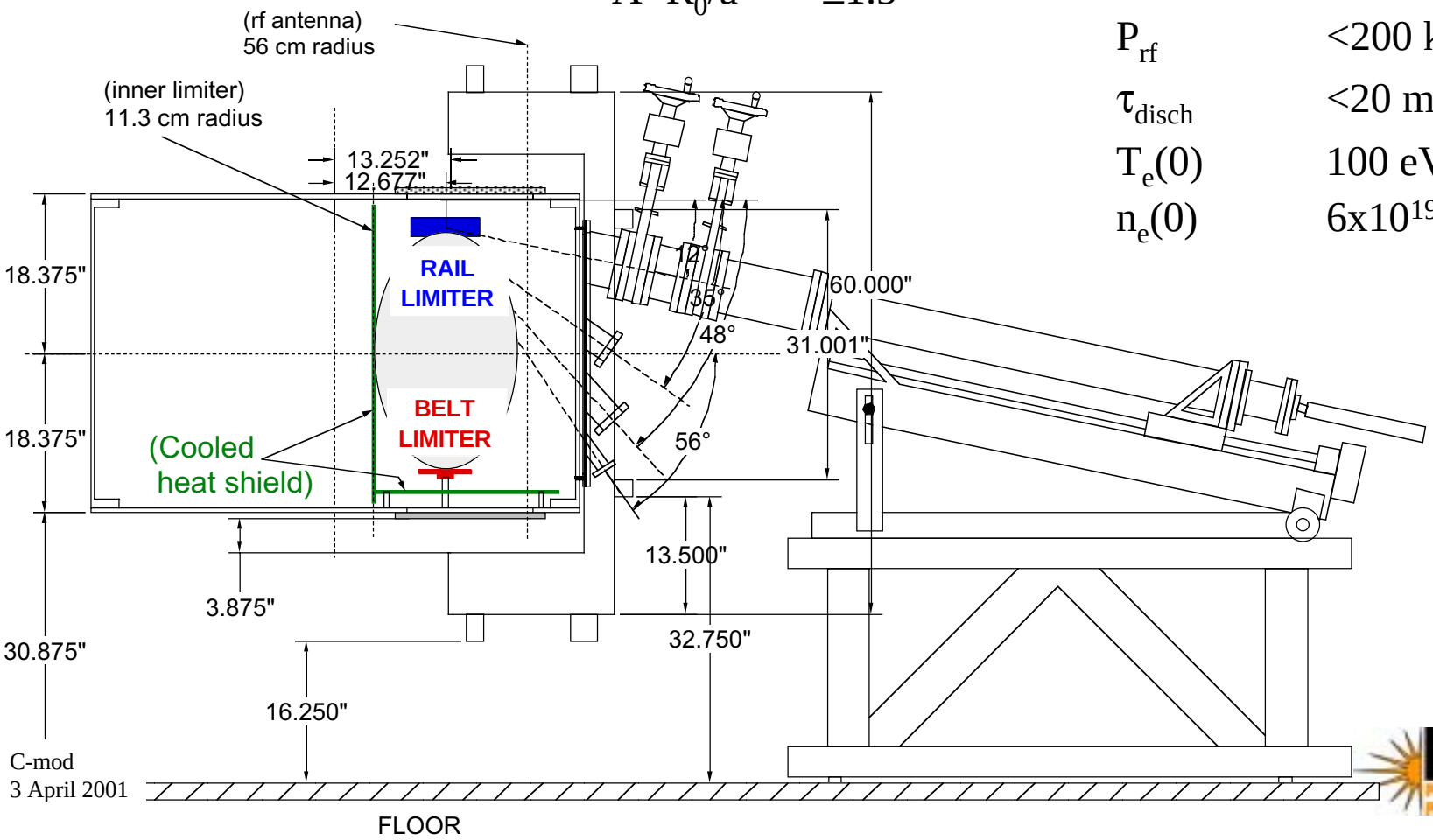


Fig.9. Elecron density evolution from shot to shot in dischages with high temperature (approx. 500°C) Lithium limiter. Operational gas - He.

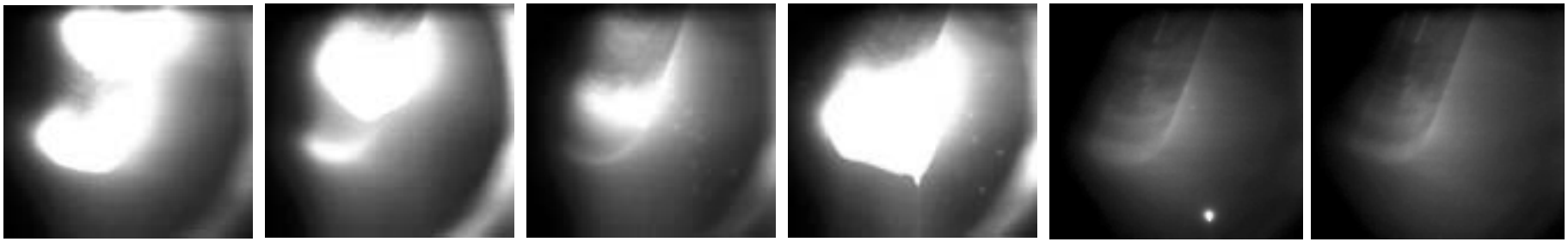
Reminder of typical CDX-U parameters

R_0	34 cm
a	22 cm
$A=R_0/a$	≥1.5

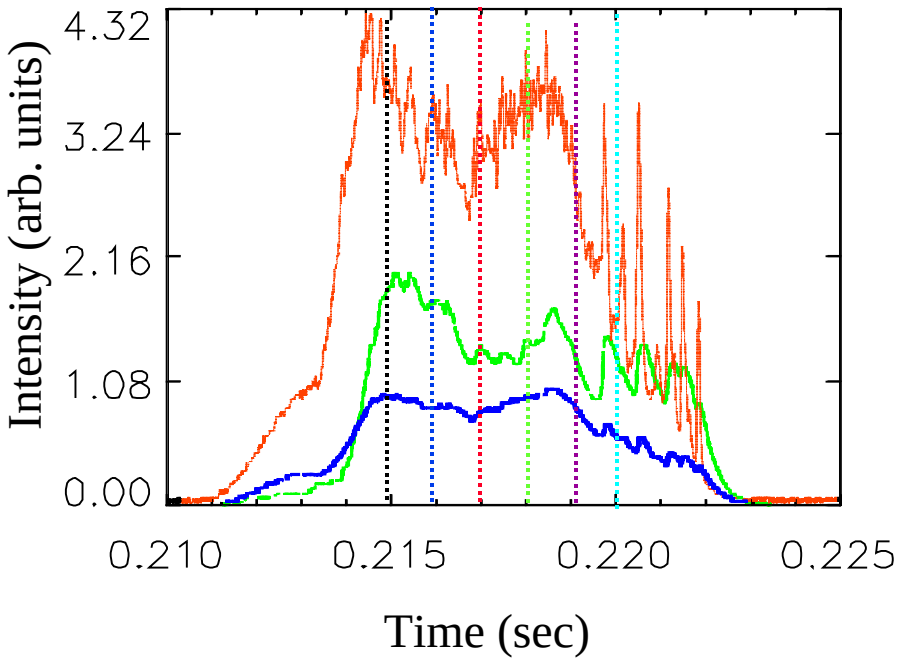
κ	≤1.6
$B_T(0)$	2.2 kG
I_P	≤ 80 kA
P_{rf}	<200 kW
τ_{disch}	<20 msec
$T_e(0)$	100 eV
$n_e(0)$	6×10^{19} m^{-3}

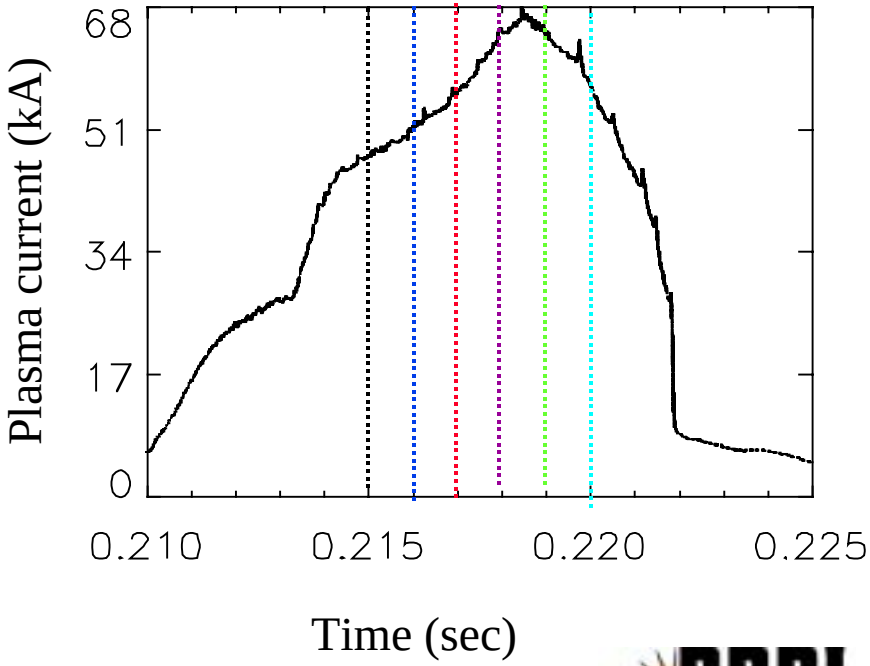


Large lithium influx does not disrupt discharge

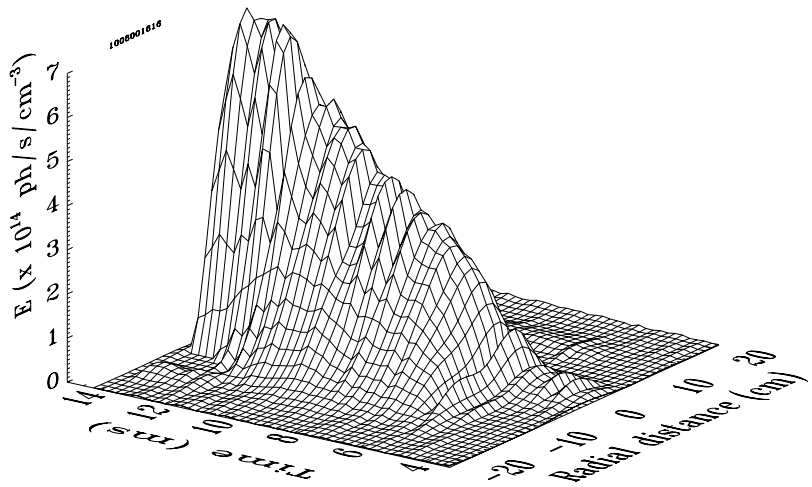


0.215s 0.216s 0.217s 0.218s 0.219s 0.220s

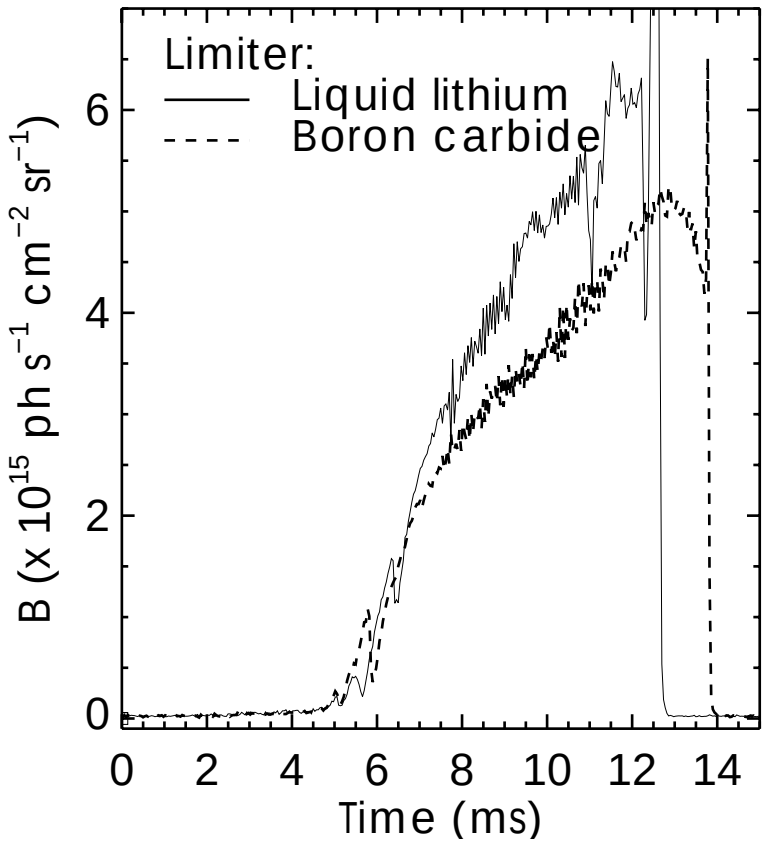




Examples of MLM array data (Shots 1006001616 (boron carbide limiter) and 1006001812 (lithium)



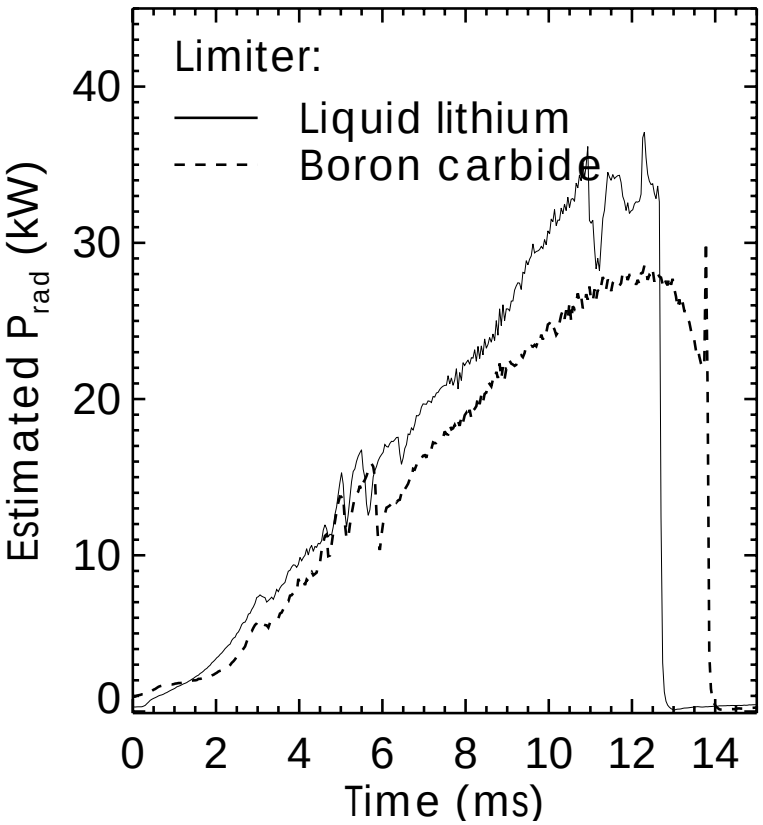
135 Å emissivity profile evolution



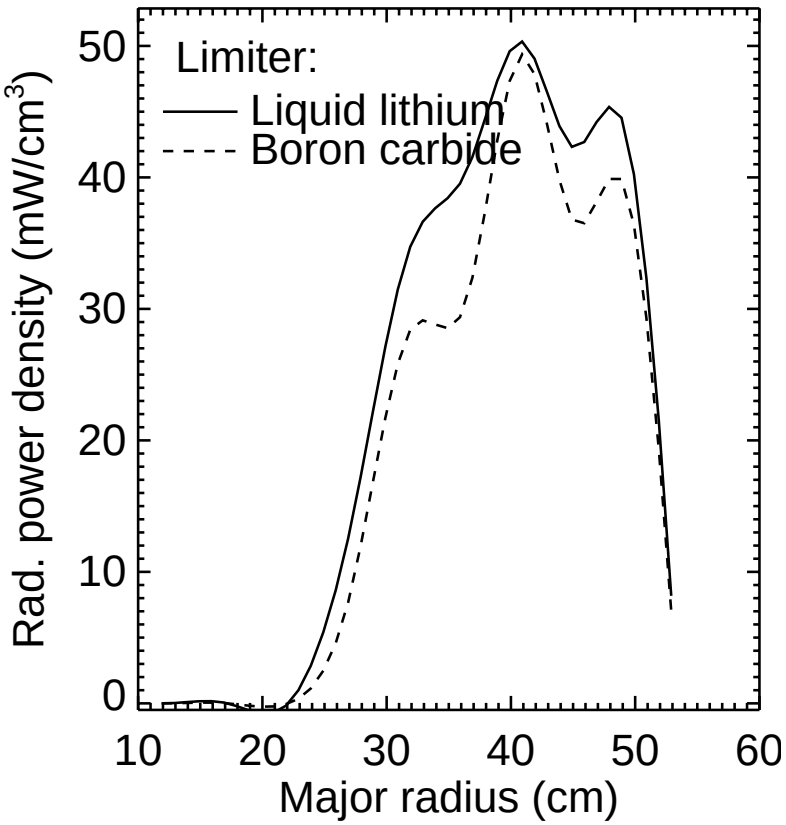
Central 135 Å time evolution

⇨Marginal evidence of lithium in plasma

Radiated power (comparison of 1006001616 (BCL) and 1006001812 (fresh lithium)

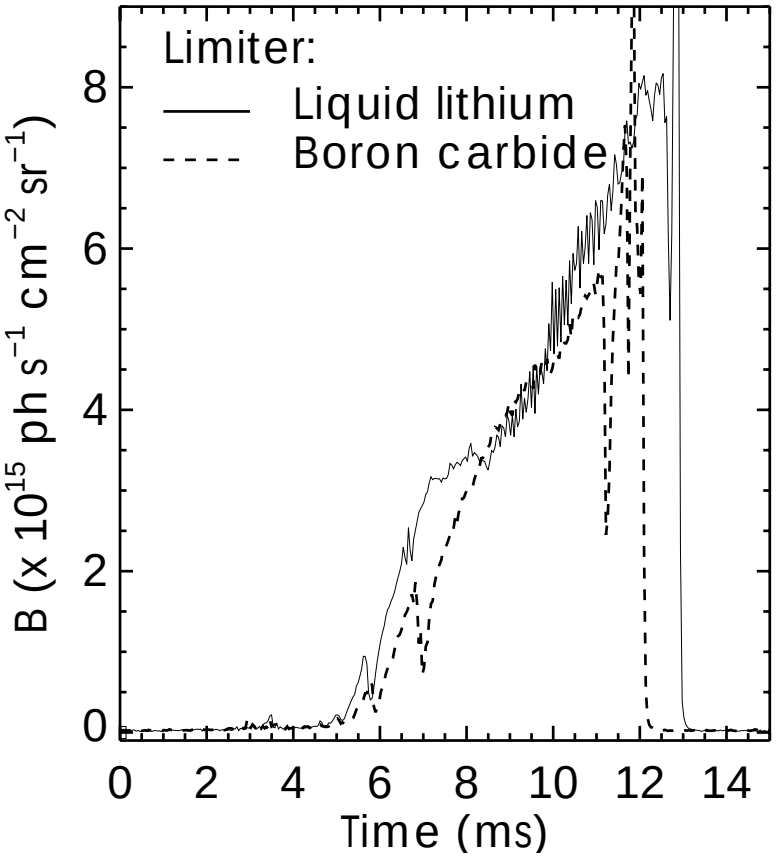


Estimated total radiated power

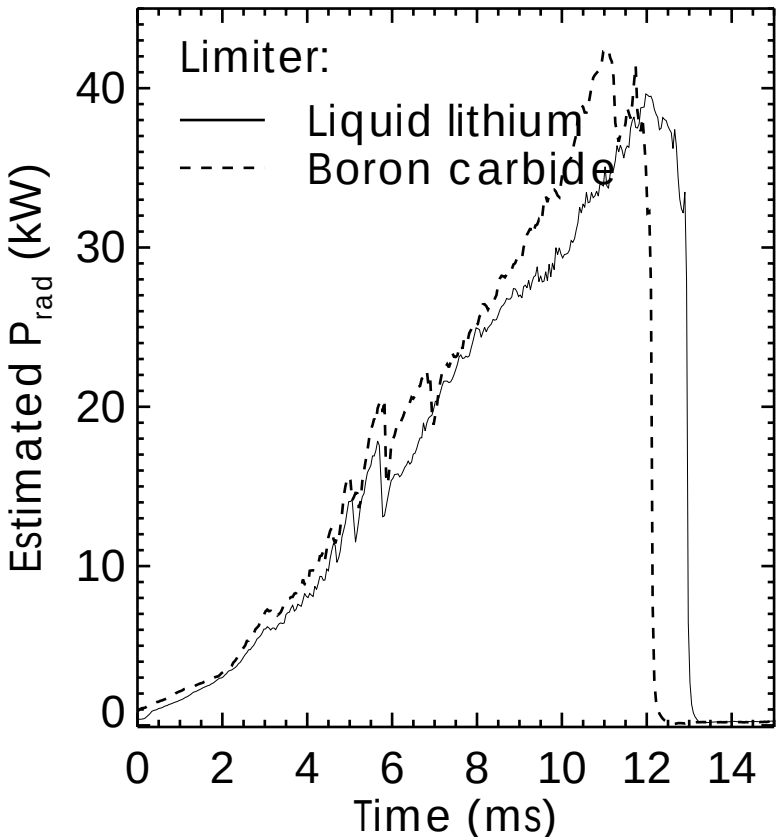


Radiated power profile at 8 ms (before signals saturated)

Comparison between 1006001327 (boron carbide limiter) and 1006001900 (dirty lithium)



MLM array central brightness (135 A)

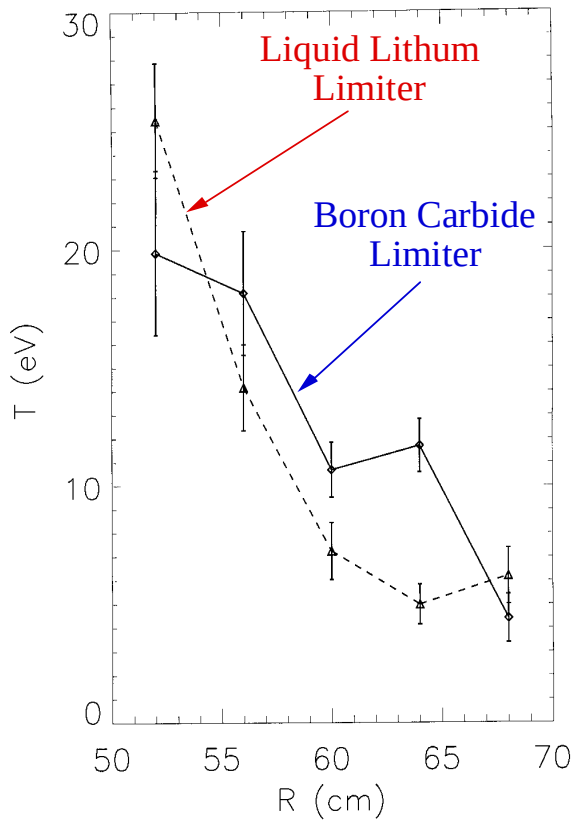


Estimated total radiated power

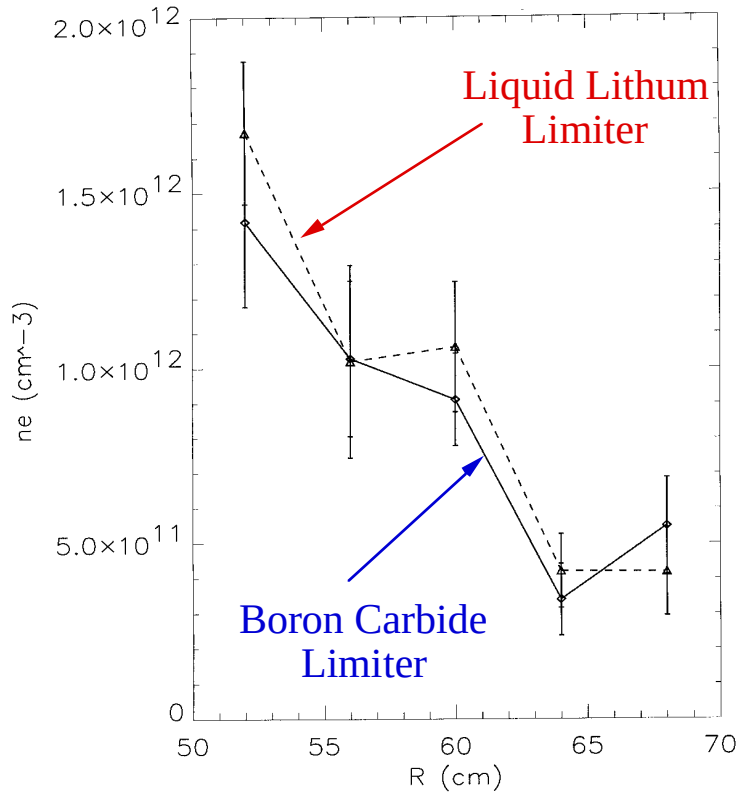
No evidence of lithium in plasma

Edge electron temperature and density profiles comparable for plasmas with boron carbide and liquid lithium limiters

Temperature



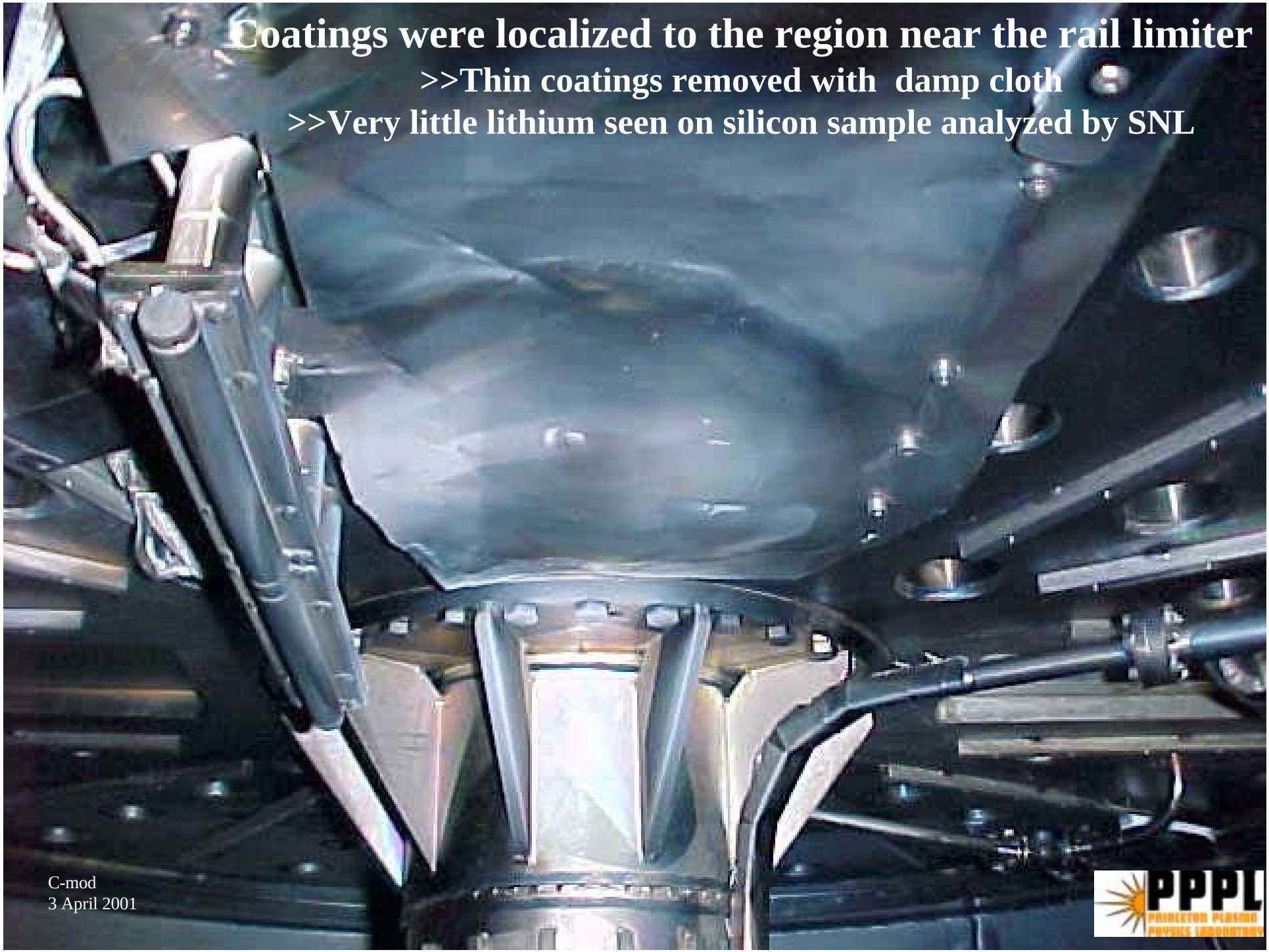
Density



Coatings were localized to the region near the rail limiter

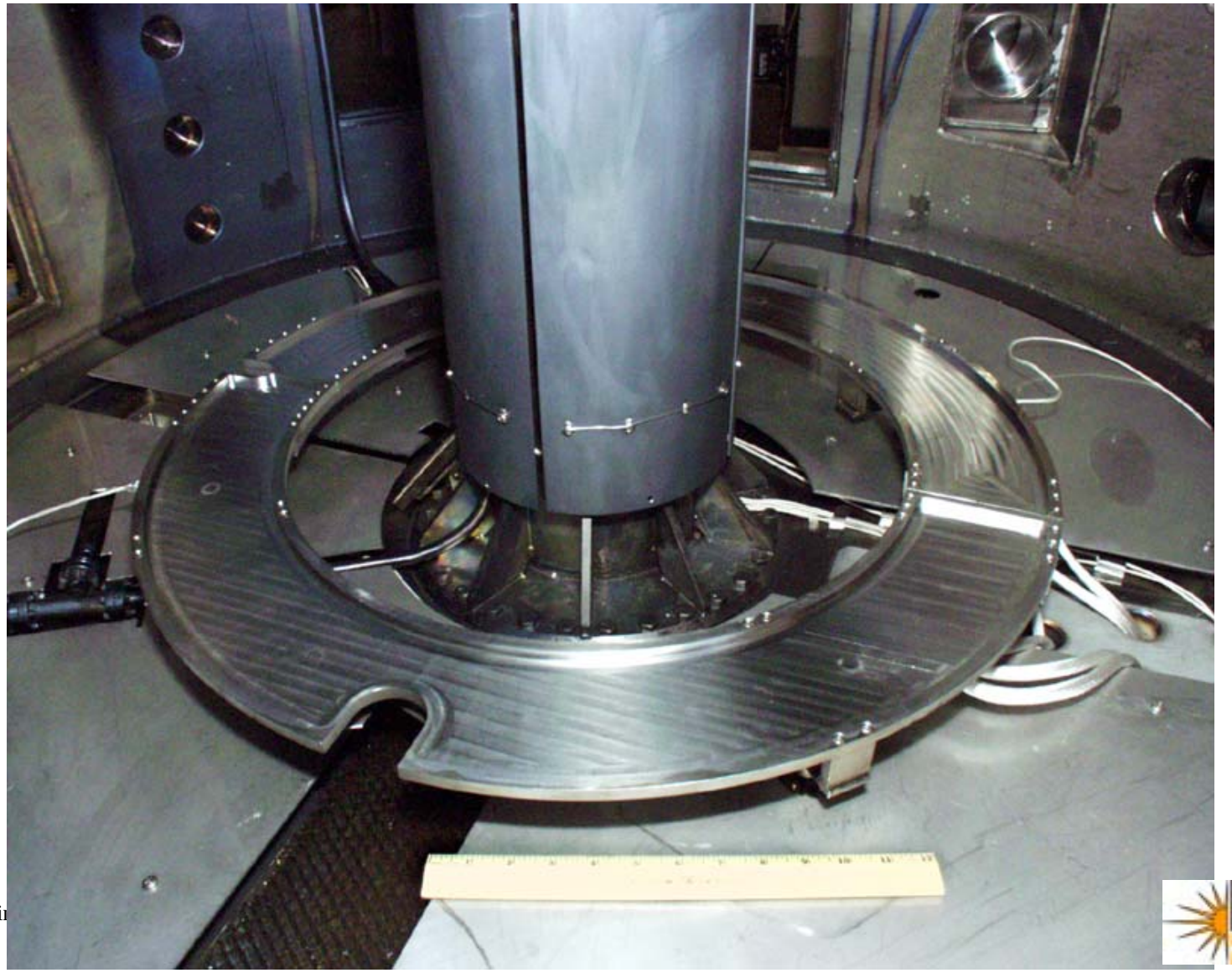
>>Thin coatings removed with damp cloth

>>Very little lithium seen on silicon sample analyzed by SNL



C-mod
3 April 2001

Toroidal tray limiter is now loaded with lithium



Summary

- Significant injection of lithium into TFTR (up to 170 mg; 0.34 cm^3 per discharge) was extremely beneficial.
  - This was a DOLLOP limit, not an operational (plasma) limit.
- T-11M ran with lithium limiters up to 500 ^oC.
  - Saw significant gettering of helium at these temperatures, due to high Li evaporation rate.
  - No difficulty with the discharges.
- CDX-U did not observe a single plasma termination which could be attributed to a lithium influx.
  - Discharge was robust to ingestion of multiple 2mm scale droplets.
- Suggested course of action:
  - Rerun the UCSD rail limiter experiments on CDX at high rail temperatures, with better plasma control.