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XP1000 LLD Characterization Preliminary Results

H. W. Kugel

and the NSTX Research Team

NSTX Monday Physics Meeting
B-318, 12-APR-2010

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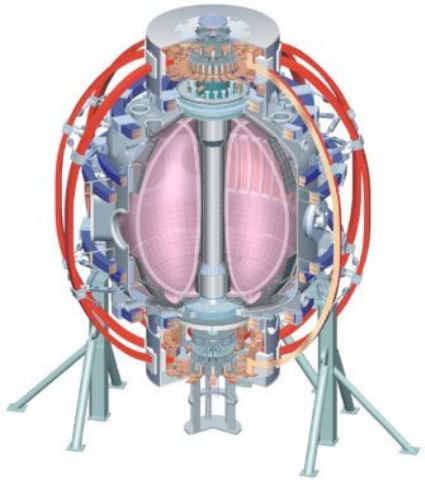
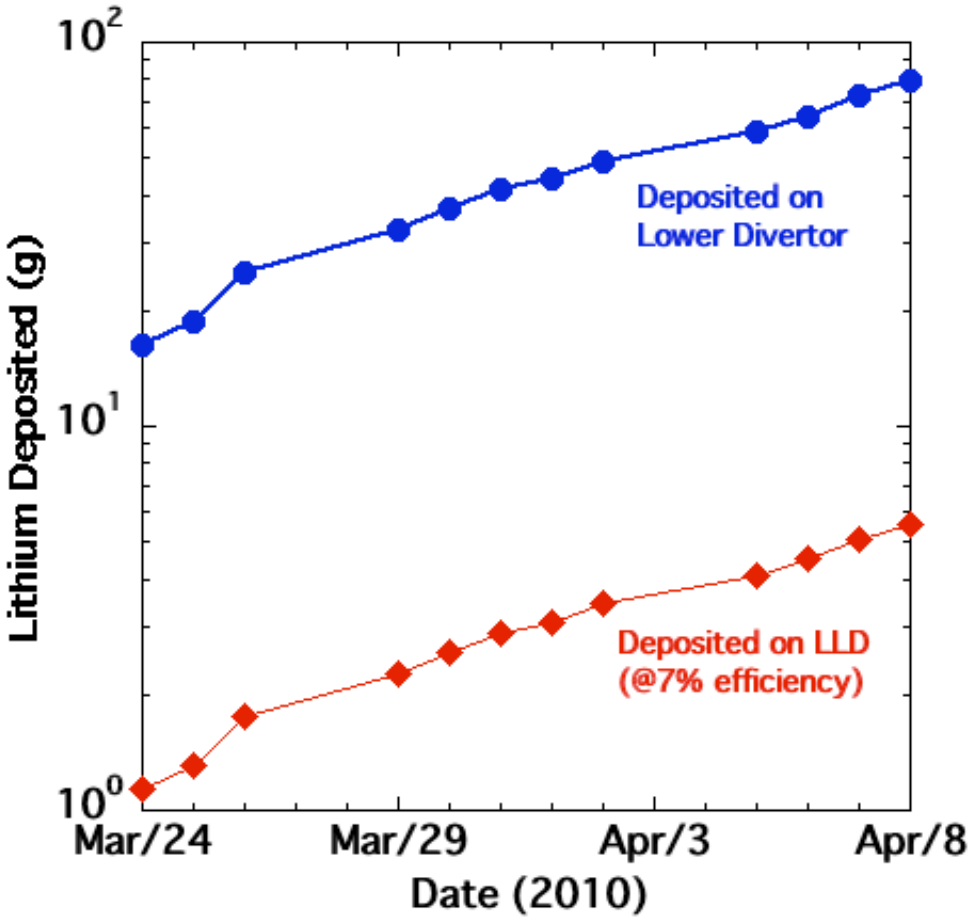


XP1000 Daily Outline

- Fri., 02APR10 started XP1000 Part 1B, R=50cm, LLD 220°C.
  - LLD 220°C, Did IR and Phantom calibrations
  - OSP control development
  - 3 ref at 2, 2MW and 3MW, raised LLD to 250°C
- Mon., 05APR10 returned to 02APR10 conditions, LLD 220°C
  - OSP control development, R=50, 63 cm
  - Reduced Dα relative to 02APR10
- Tue, 06APR10, LLD rm temp, 250°C
  - OSP control development R=50, 63 cm
  - LLD @rm temp. Recovered ELM-free H-modes at R=35cm
  - At R=50cm, improved OSP, increased front-end fuelling, reduced NBI
  - Obtained ELM-fee H-mode flattops
- Wed., 07APR10, LLD 320°C
  - OSP control development, R=50, 63 cm
  - LLD raised to 320°C
  - Little change in core n_e and edge T_e and n_e profiles
  - Less flux consumption early in discharge
- Thu., 08APR10, LLD 320°C
  - OSP control development
  - LLD raised to 320°C, R=63cm , 70cm

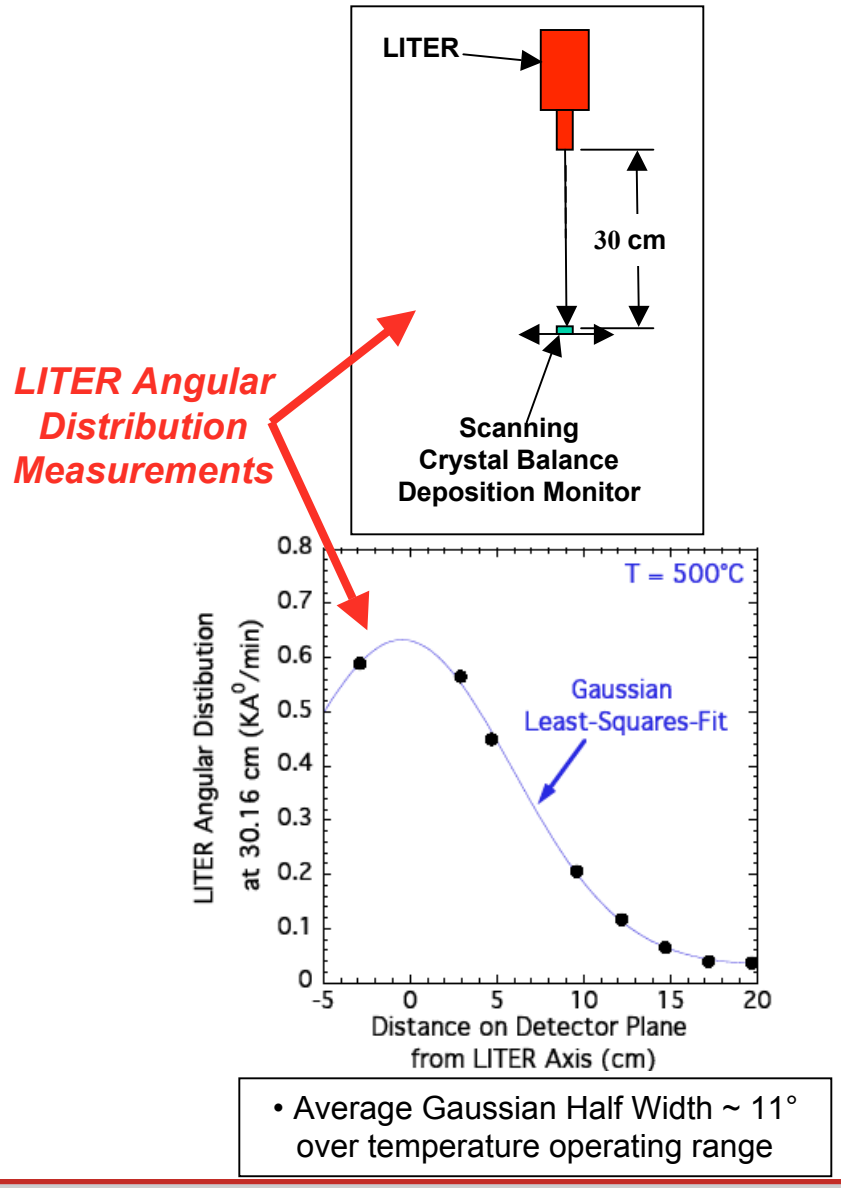
NSTX 2010 Lithium Deposition Sequence



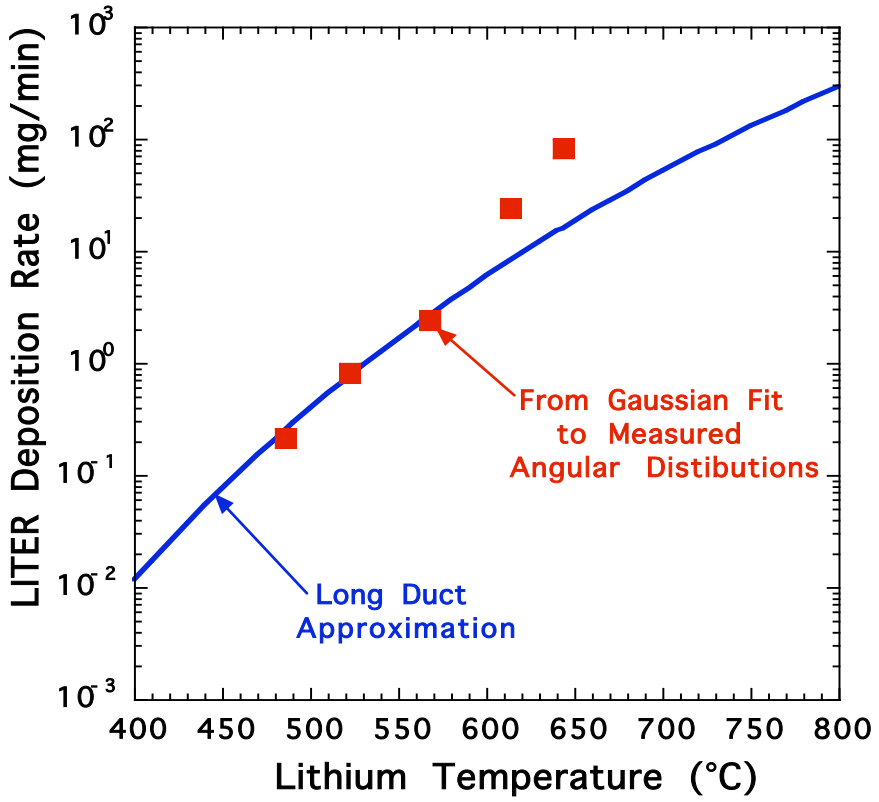
- Deposition on LLD ~5.6g (15% of 37g capacity)
- LITER mg/min calibration may be underestimating actual rate/total

LITER Calibration Presently Assumes Molecular Flow

-Actual Rate Increases Strongly Above 5mg/min Due to Viscous Flow



• Average Gaussian Half Width ~ 11° over temperature operating range



• Above 600°C, LITER evaporation rate increase may be due to non molecular flow (PM5.00002. L. Zakharov)

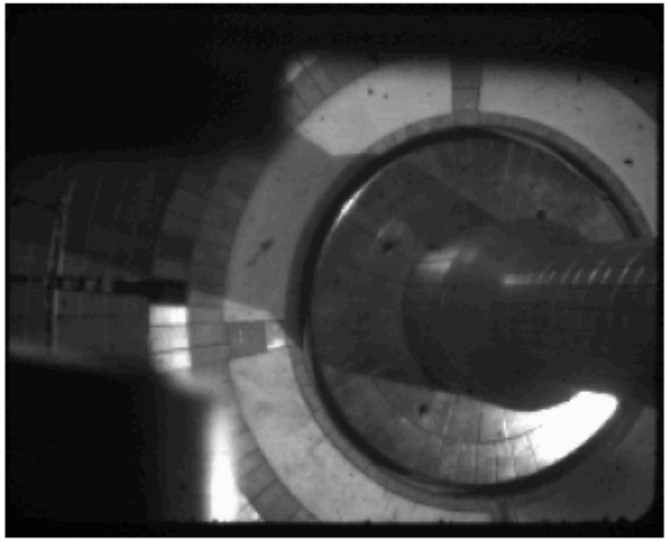
Downward Viewing Fast Phantom Camera Images

- **After first Li deposition, unheated plate exhibited higher reflectivity than heated plates**

Bay E Top View

Pre Lithium

Cold plates

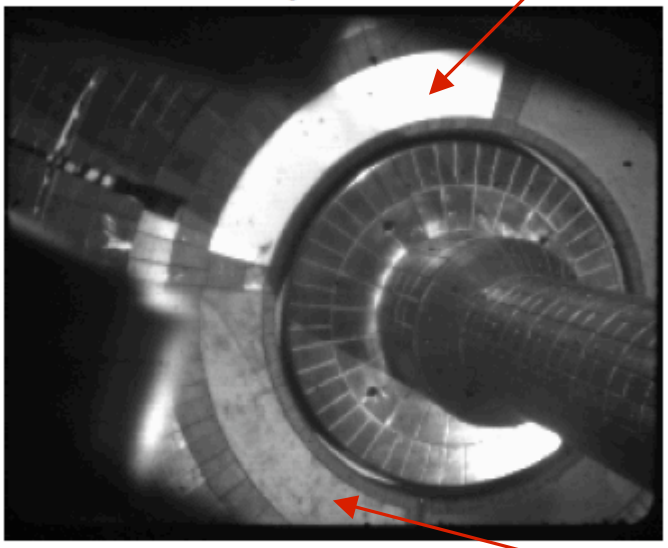


March 23rd

After bake (no Lithium)

Post Lithium

Cold plates



March 25th

After first evaporation (warm plates at the time of evaporation)

- **Unheated**
- **220°C during LITER**
- ***F. Scotti***

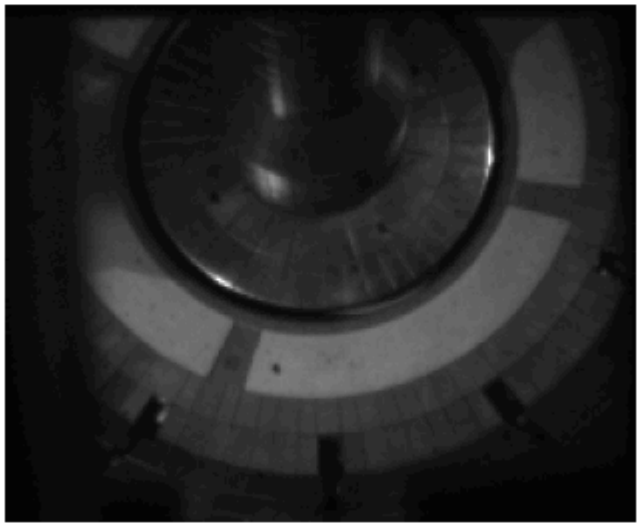
Downward Viewing Fast Phantom Camera Images

- **After first Li deposition, unheated plate exhibited higher reflectivity than heated plates**

Bay J Top View

Pre Lithium

Cold plates

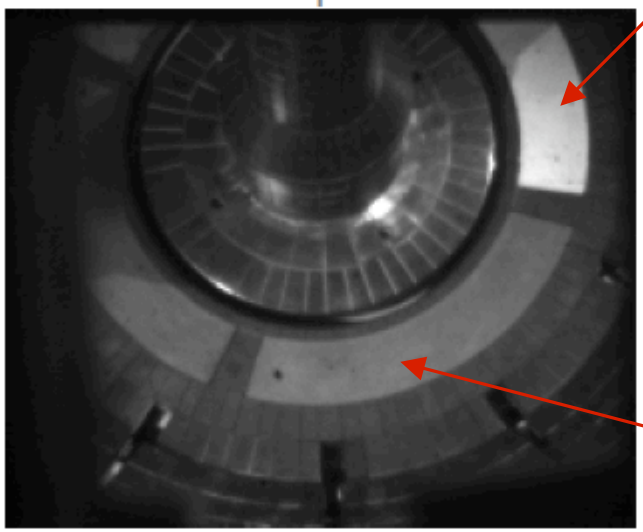


March 23rd

After bake (no Lithium)

Post Lithium

Cold plates



March 25th

After first evaporation (warm plates at the time of evaporation)

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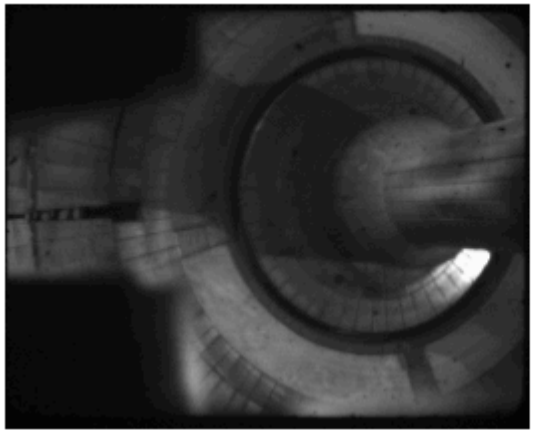
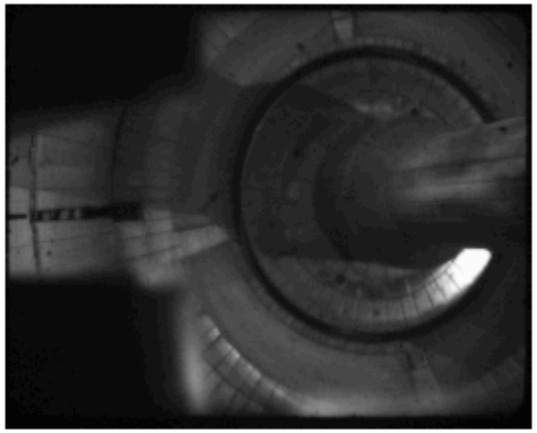
- ***F. Scotti***

Downward Viewing Fast Phantom Camera Images



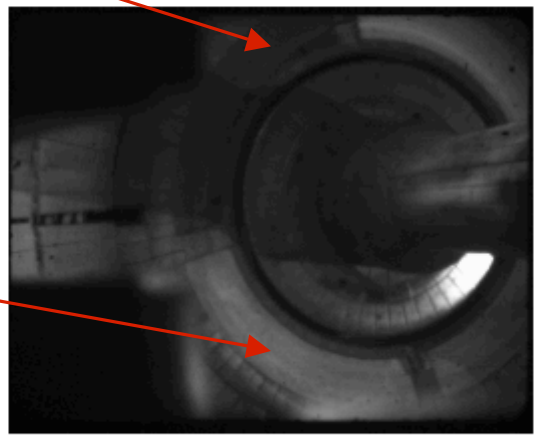
Cold plates, before plasma operation, morning April 6th



Cold plates, after plasma operation with cold plates, noon April 6th

Bay E

- **Unheated**
- **Heated**



Cold plates after plasma operations with warm plates at 250C, evening April 6th

- **As Li deposition on plates increased, unheated plate exhibited less reflectivity than heated plates**

- ***F.Scotti***

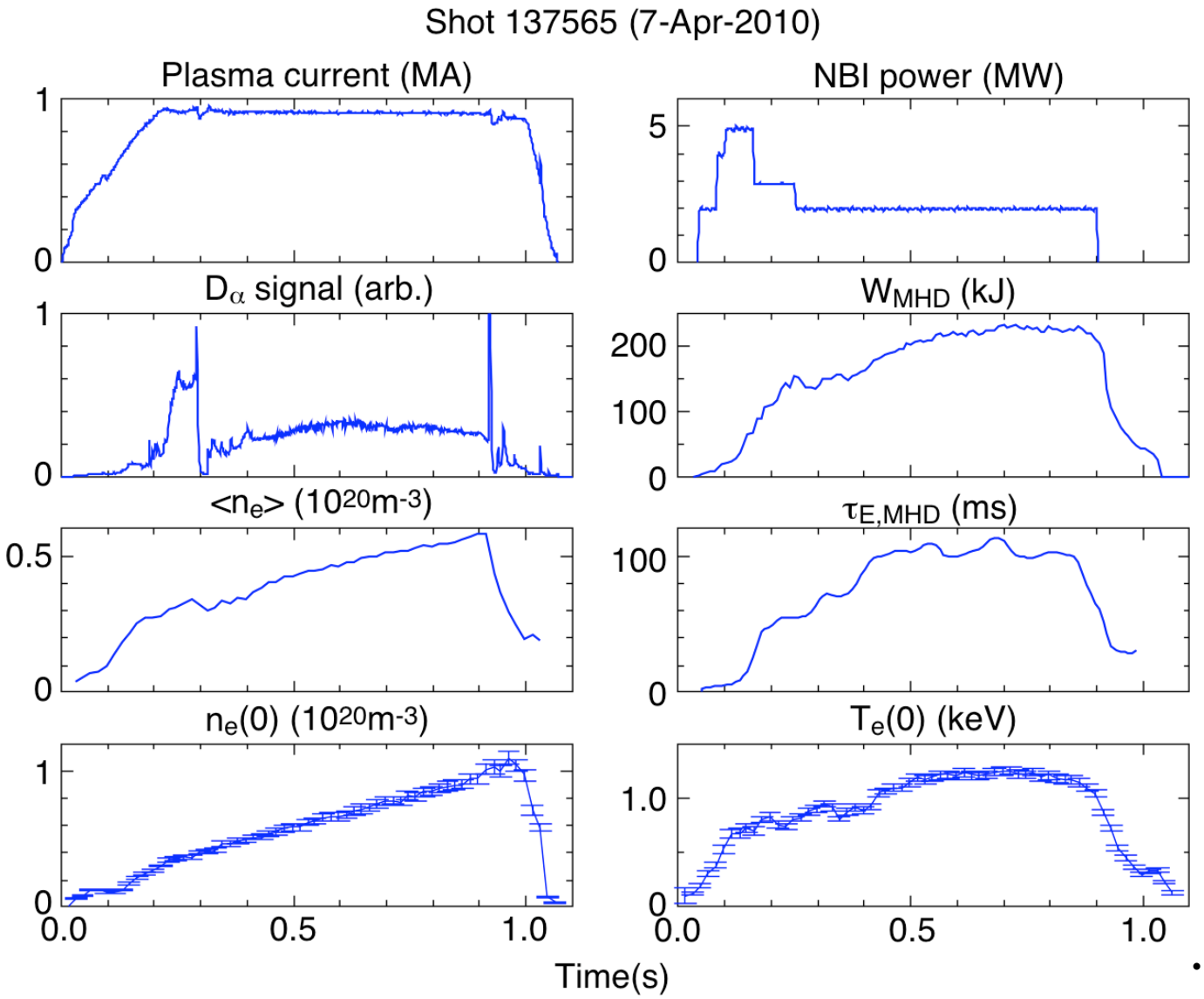
XP1000 Preliminary Summary

1. XP1000 began Friday afternoon 4/2/10 and continued through Thursday 4/08/10.
2. With LLD, lithium-free, IR emmissivity was measured by calibrating the Fast 2-Color IR camera, and Slow IR camera systems against the LLD thermocouples as the LLD temperature was raised from room temp to 220°C.
3. Simultaneously, the LLD visible reflectivity was measured using the Phantom fast cameras.
4. Then, lithium depositions on the LLD with temperatures ranging from room temperature to 220°C were started using the LITER system at a rate of 20-40mg/min.
5. When the LLD was heated above melting, the outgassing of D increased significantly indicating perhaps the effect of fuel and/or impurity accumulation from previous operations and/or the need for additional conditioning procedures.
6. As lithium deposition increased, reproducible, ELM-free, H-mode, flattops were obtained with outer strike points at major radii of R=0.35m (near center stack), R=0.50m (mid inner divertor) and R=0.63m (the outer divertor tile ring just inboard of the LLD and outboard of the CHI gap).

XP1000 Preliminary Summary (cont.)

7. The ELM-free, H-mode, flattop conditions were obtained using :
   - improvements in the outer strike point control,
   - optimizing fueling in the early discharge,
   - and reducing NB power as lithium deposition increased.
8. LLD characteristics at temperatures up to 320°C were measured at these radii.
9. Although slight reductions were observed in the central and edge densities, no strong pumping due to the LLD was found at temperatures of up to 320°C, with strike points out R=0.70m and the initial LLD surface conditions.
10. These ELM-free discharges, however, exhibited noteworthy reproducible energy confinement times of 100 ms and reduced flux consumption early in these discharges.

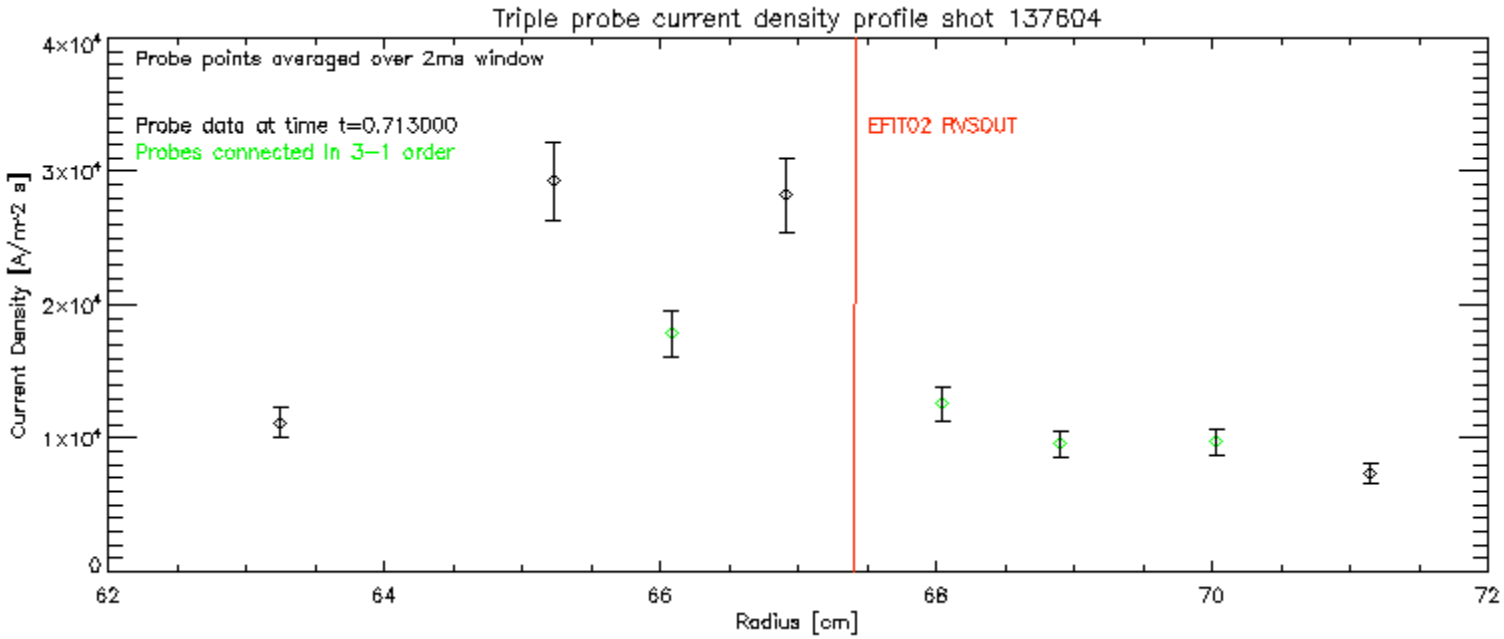
D, LSN, OSP R=50cm, LLD=319°C



- ***M.G. Bell***

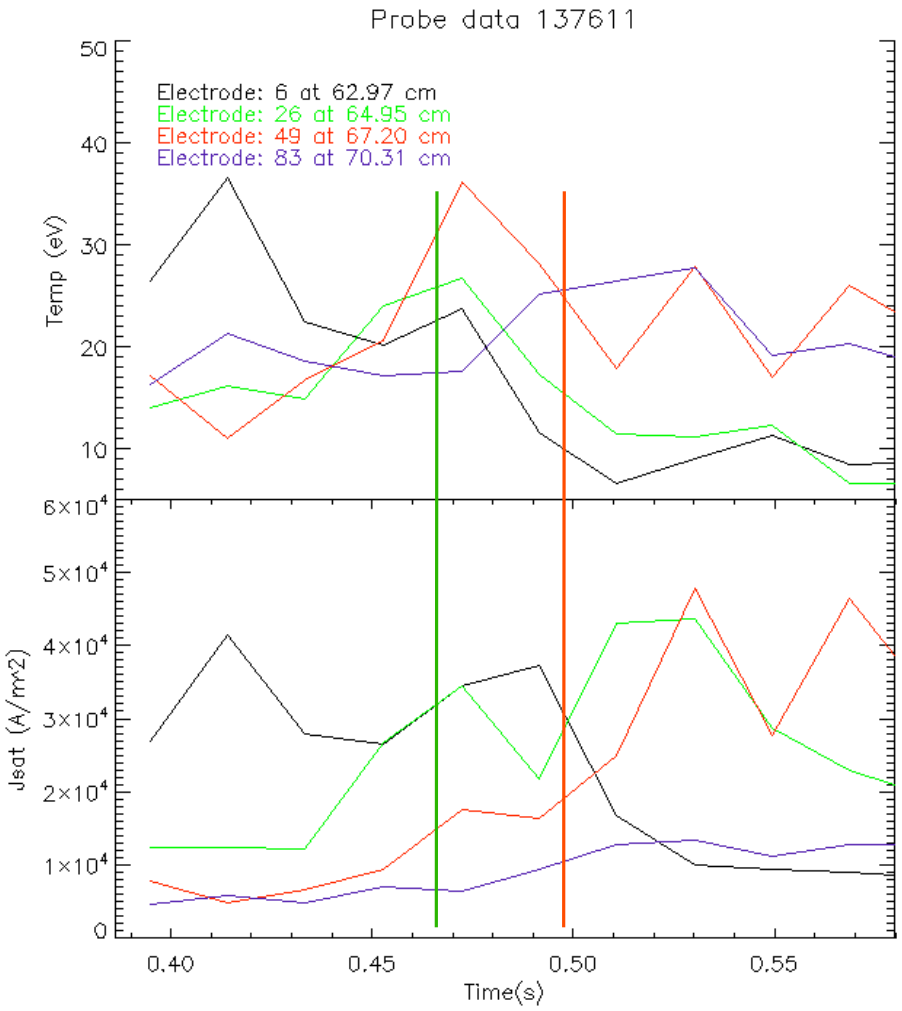
Strike Point Location via Langmuir Probes

- Current density increase observed on Langmuir probes during strike point sweep
- Position roughly agrees with EFIT and IR camera data
- Determined that PCS system is about 3cm outboard of actual strike point location

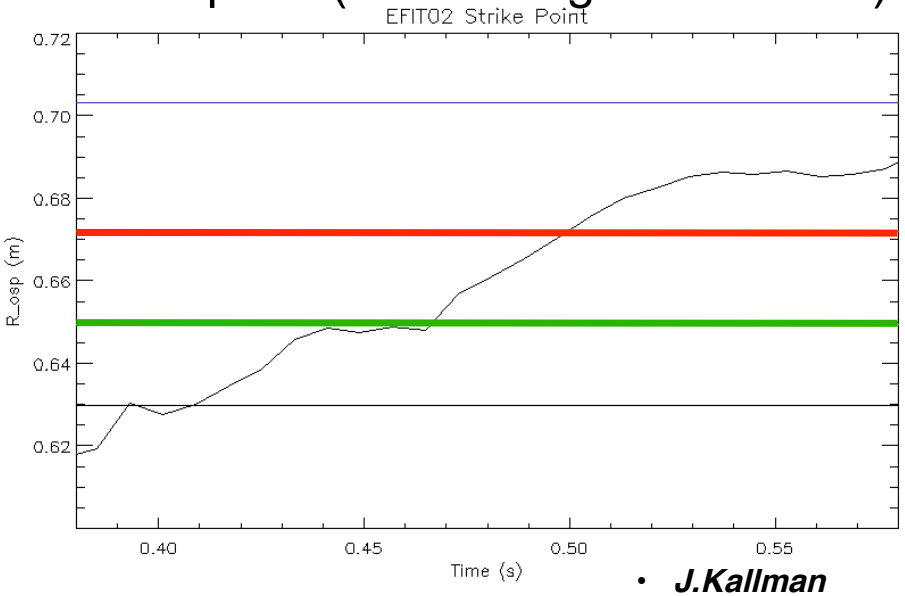


- ***M. Jaworski***

Swept probes track n, T profiles as OSP moves



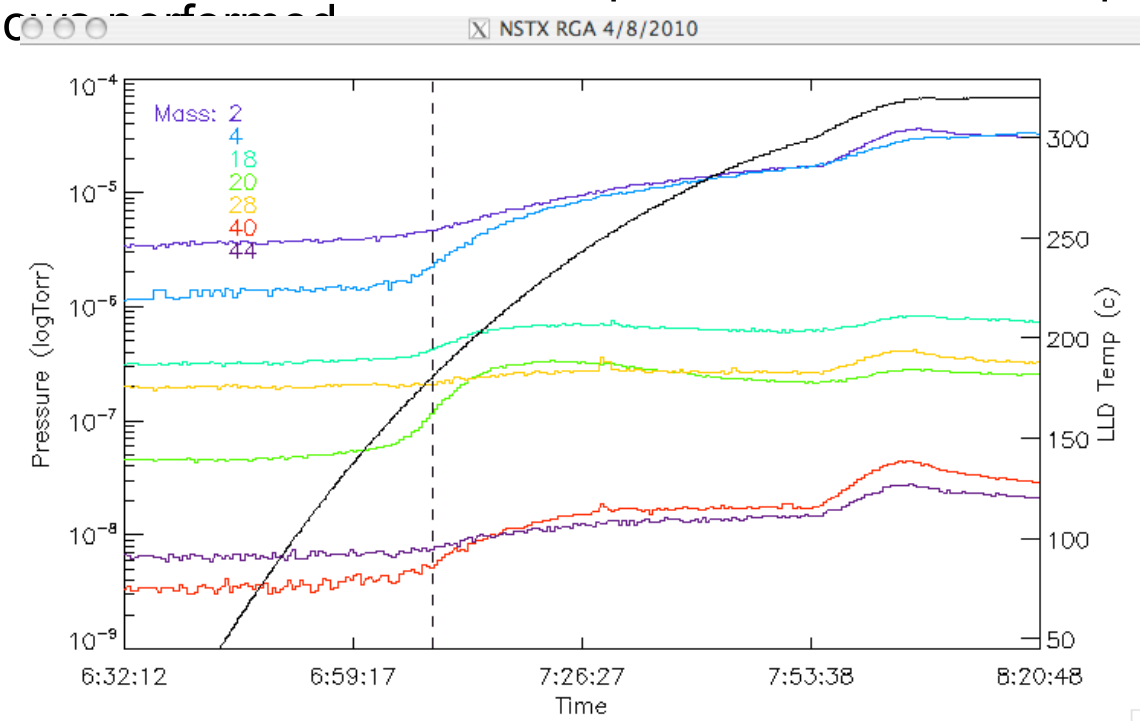
- Swept probes track motion of strike point during discharge
- Temperature and density drop as probes enter private flux region
- Increase in saturation current appears to lag increase in temperature by a few ms – rising n, dropping T due to increased recycling by strike point over LLD?
- EFIT strike point outboard of actual strike point (control segment effects)



- ***J.Kallman***

Preliminary Outgassing Data

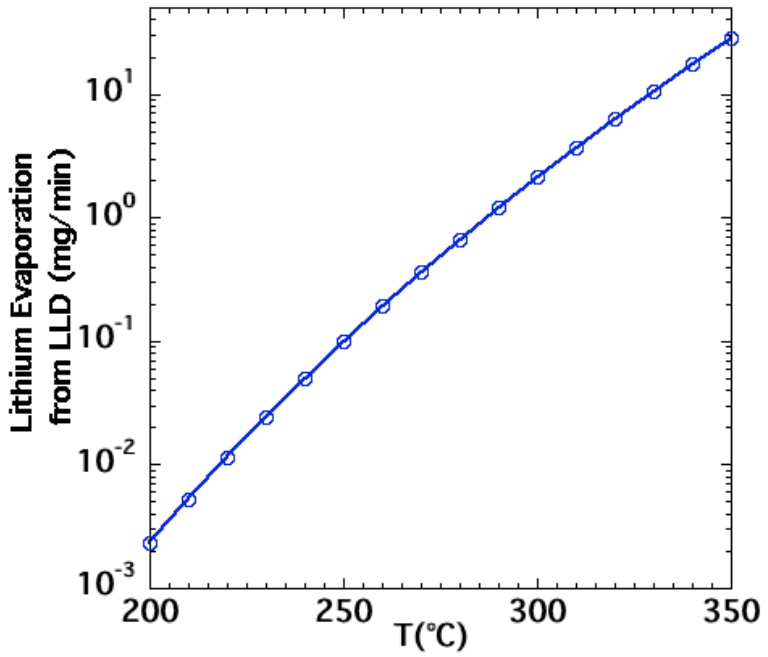
- RGA shows that deuterium, hydrogen entrained in LLD
- Lab experiments showed rise in H_2, drop in H_20 when lithium 'active' – not observed conclusively on NSTX
- Although mass 2 seems to saturate and decrease during heating, mass 4 continues to increase
- Longer experiment necessary to more fully outgas LLD and measure various species inventories
- Also desirable to measure surface temperature w/IR and to quantify any effects of gl[illegible]



- ***J.Kallman***

XP1000 Next Steps

- The effects of gettered surface impurities, and increasing the rate and total Li deposition on the LLD continue under investigation.
- It may be necessary to briefly raise LLD above 300°C to dissolve impurities
- Above 305°C, Li evaporation from LLD begins to exceed typical LITER deposition rates (e.g. 20mg/min).



- Candidate next steps:

1. Perform LITER deposition during Maintenance Week sufficient to fill LLD to 50-60% of capacity.
2. With LITER on, take R=70m comparison shot.
3. Continue these discharges, turn off LITER, let the cold Li coating saturate, and measure effect of LLD liquid lithium pumping.