Lithium Research Topical Science Group Mini-run Assessment FY2010

Charles Skinner for LRTSG

30 Sept. 2010

Outline:

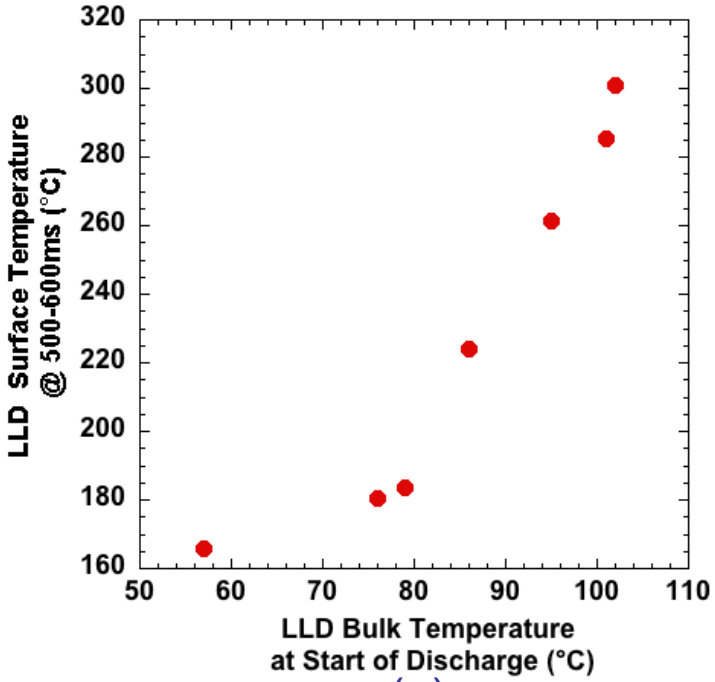
- Kugel: results from XP1000, 1041A, 1059.
- Soukhanovskii: results from XP1001
- Mansfield: results from XP1056
- Remaining XPs.

Does not include XPs reported in Mid-run assessment of 8/27/10

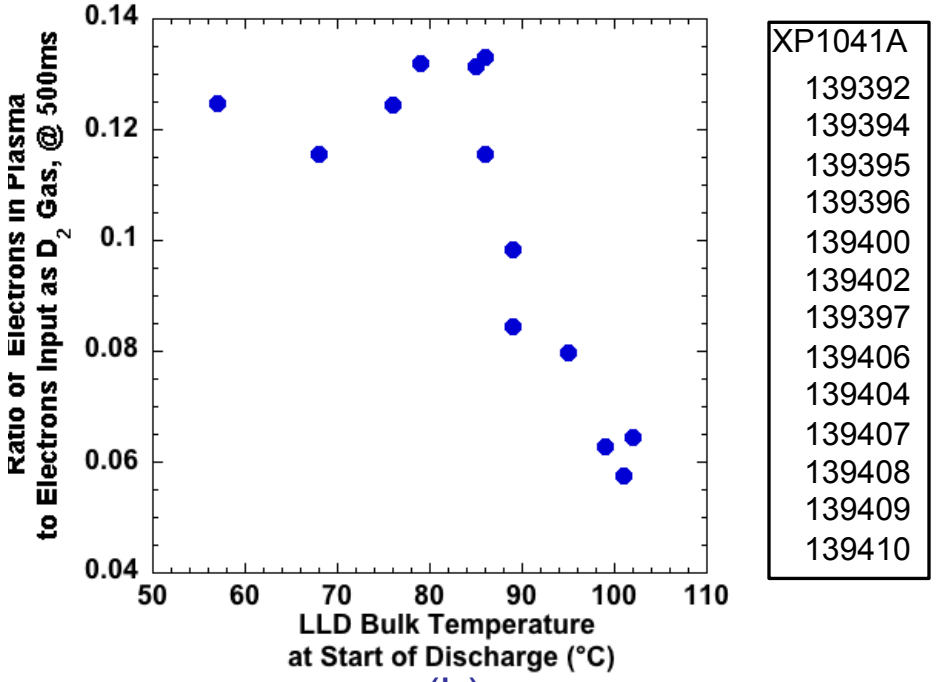
Summary of LLD Characterization: XP1000, 1041A, 1059

Henry Kugel

1. Plasma density decreases and deuterium retention increases as lithium surface of LLD liquefies
   (a) LLD surface temperature measured with a 2-color IR camera averaged between 500-600 ms versus LLD bulk temperatures measured using thermocouples at start of discharge.
   (b) Ratio of electrons in plasma to electrons input as D_2 gas at 500 ms.



(a)



(b)

A. McLean

M. Bell, H. Kugel

Summary of LLD Characterization: XP1000, 1041A, 1059

Henry Kugel

2. For many discharges on the LLD, the amount of required fueling was similar to that for 2008-2009 solid lithium coatings on graphite over a range temperature, NBI, triangularity, and other parameters. This needs further investigation. Possible causes:
   - lithium impurity compounds on the LLD inhibiting pumping.
   - Li temperature reaching LiD disassociation regime (~350-400°C): D outgassing.
   - deliberate changes in operating conditions to fix discharge problems.
3. The duration of lithium pumping, (i.e., ELM-free H-modes, lower edge density, higher edge temperature) was:
   - ~2-3 discharges for a fresh thin lithium coating (~500-1000 nm) for the outer strike point on either the graphite inner divertor or the LLD.
   - ~100 discharges for a 35% fill of the LLD porosity (i.e., 13g in LLD, more than 260g of lithium on inner divertor graphite, and with the outer strike points varied between the graphite inner divertor and the LLD, i.e., no fresh LITER evaporations between discharges were necessary to maintain ELM-free H-modes.
4. LLD and associated diagnostic systems commissioned successfully:
   - No apparent damage to LLD or LLD inter-quadrant diagnostic tiles observed
   - No significant molybdenum influxes or halo current effects observed.

Proposed Additional 2010 Measurements

Henry Kugel

- Repeat XP1041A/1059 using new LLD Air Heating System.
  - Determine impurity radial contours from ISP outward to across the LLD.
  - Characterize the increase in Dα luminosity across the LLD strike point versus LLD surface temperature (is LiD disassociating at higher temperatures?).
  - Using DIMS, measure D, C, O Li luminosity at outer strike point versus discharge time to determine how surface impurities change.
  - Determine if strike point, in-out, power deposition ratio changes with LLD pumping, i.e, is there any evidence that LLD pumping causes edge flows to change.
  - Determine via SGI diagnostic measurements if particle confinement time versus OSP changes from R=55cm to R=78cm.

Analysis suggested that mega-evaporation in August was compromised by interaction with vacuum impurities

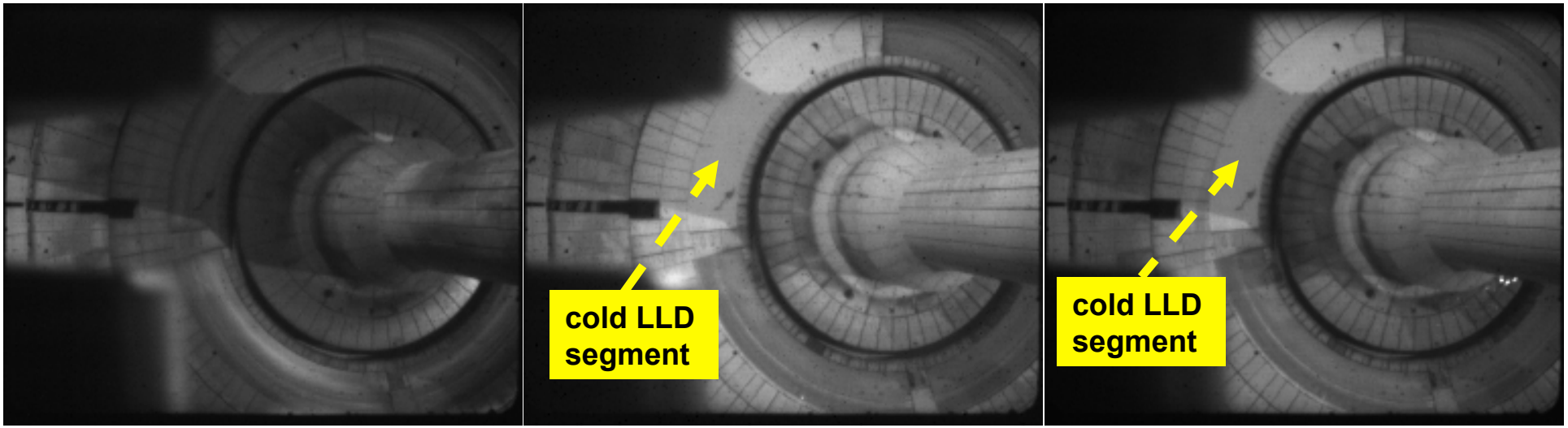
Vlad Soukhanovskii

- During and after mega-evaporation, white coatings on nearly all PFCs were observed
  - Suggested that fresh lithium turned into $LiCO_3$, LiD, LiOH
  - No vacuum vessel leaks or vacuum excursions have been reported

Aug. 4th
Before evaporation
Exposure 41ms

Aug. 6th
Half mega-evaporation
Exposure 10 ms

Aug. 9th
After mega-evaporation
Exposure 10 ms



Images courtesy of F. Scotti

LLD performance and pumping studies after mega-evaporation were challenging

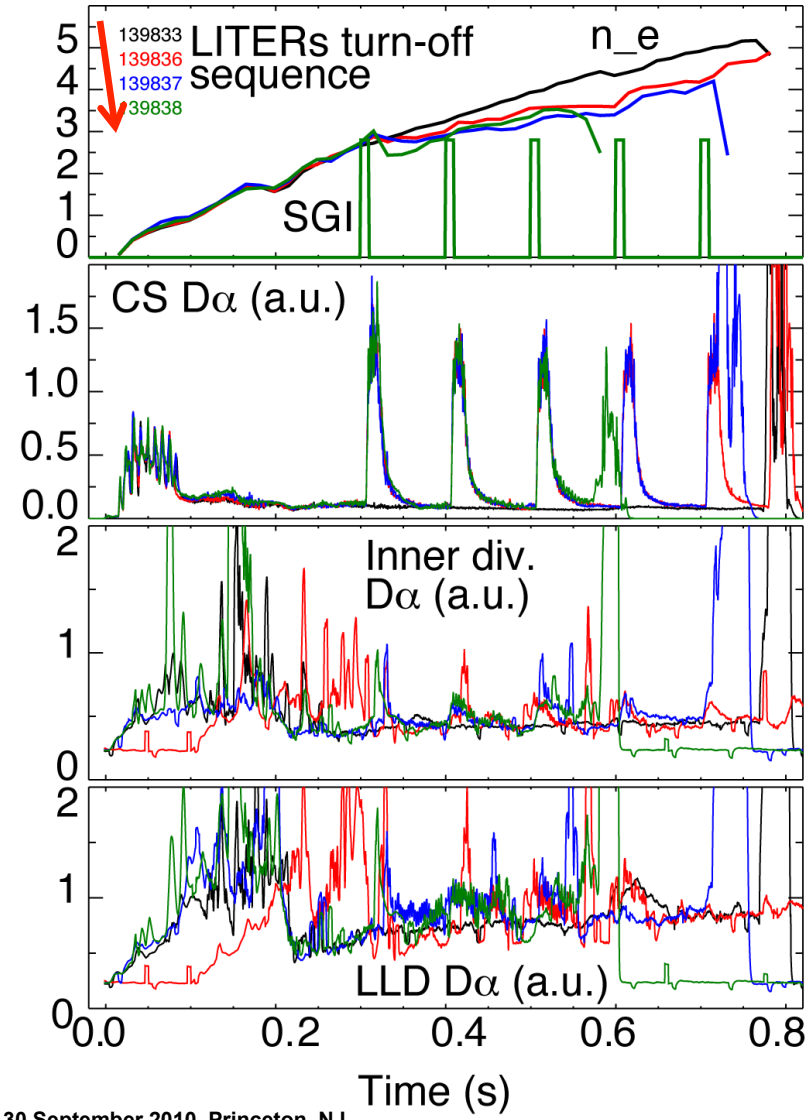
Vlad Soukhanovskii

XP 1059, from start to completion, followed by XP 1001

- plasma struggled, but after a few shots, a conditioning effect was observed and more gas fueling was required
- Observed ELMs from the first shot in XP1059 albeit mega-evaporation
- Frequent L-modes, and H-L transitions

In XP 1059, XP 1001

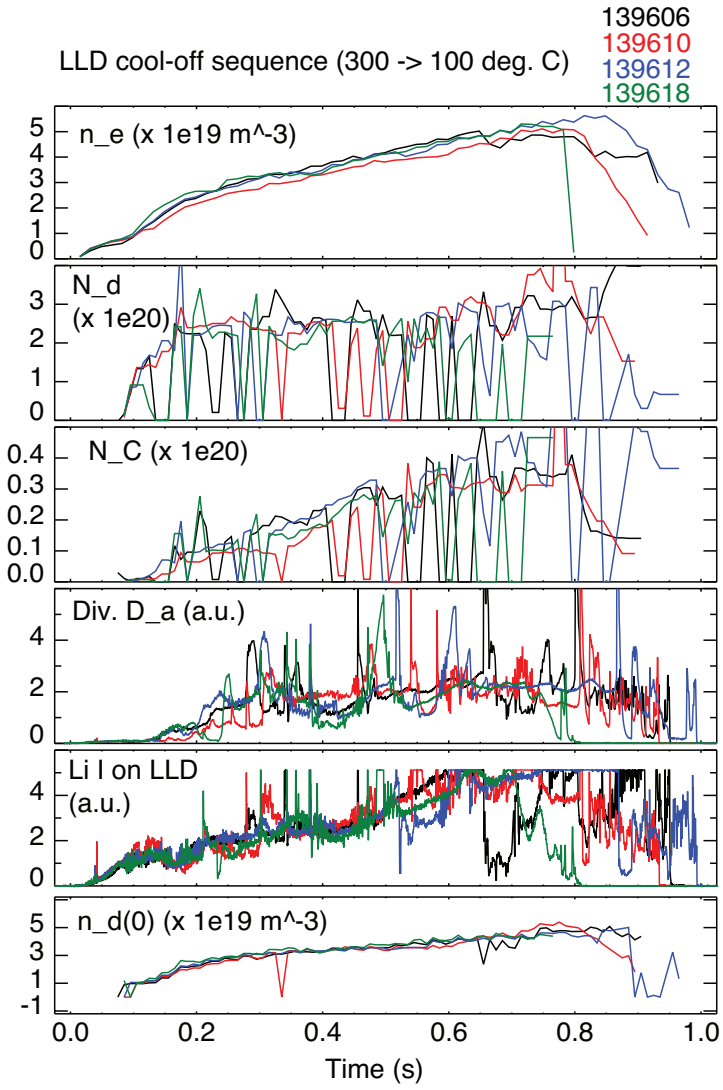
- Significant Li I flux from LLD suggested much lithium was deposited from mega-evaporation
- Reduced molecular LiD and O II emission (flux) from LLD (c.f. lithium-coated graphite tiles nearby) suggested lithium purity and freshness on LLD
- No routine influx of moly or iron from LLD (occasional transient influx due to ELMs or large MHD events interacting with LLD)
- Diagnostic SGI pulses did not produce discernable recycling difference between LLD and lower divertor tiles



After mega-evaporation, LLD did not appear to pump at a significant rate

Vlad Soukhanovskii

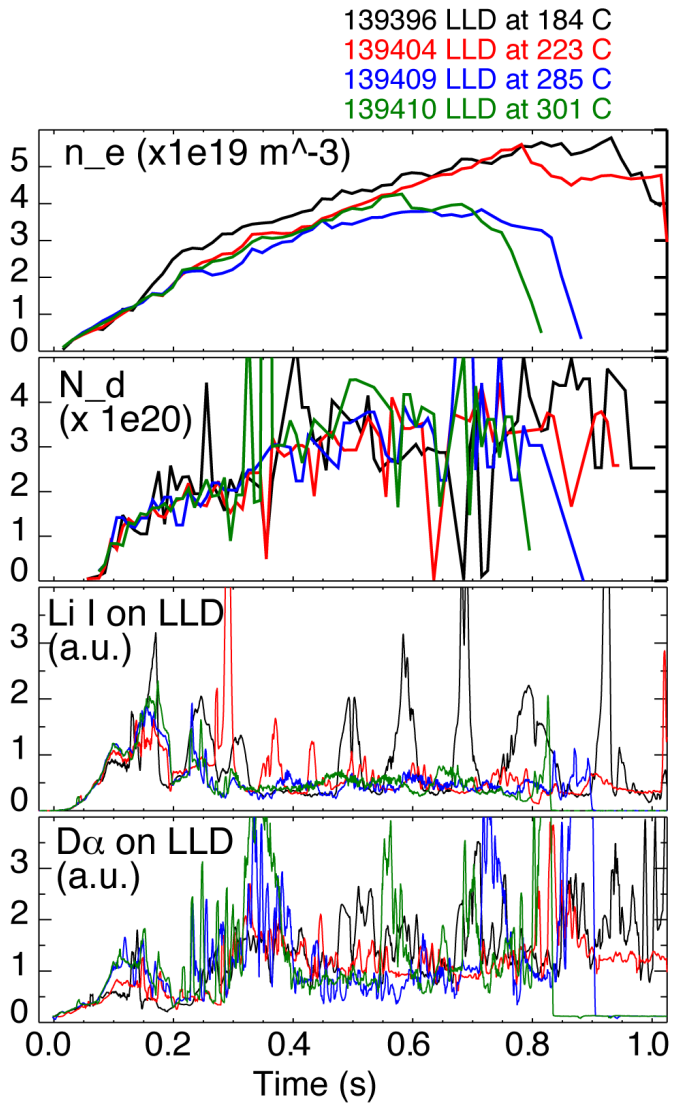
- LLD did not appear to pump at a significant rate
  - Deuteron core densities and inventories similar regardless of LLD temperature
  - Core carbon inventories similar to regular LITER discharges
  - High-recycling divertor (from Da measurements)
  - Inner divertor detached with n_e<4 x 10^{20} m^{-3} (high) and high recombination rate



Before mega-evaporation, LLD recycling and Li I flux did not appear to change with temperature

Vlad Soukhanovskii

- LLD temperature inferred from two-color IR technique recently
- Core ion inventory did not appear to change with temperature
- Li I influx from LLD did not appear to change with temperature
- Da on LLD did not appear to change with temperature



XP1056 Dennis Mansfield

- Technical success – the dropper equipment and beams and NSTX worked well.

- Scientifically likely a failure – no clear drop in radiated power although some indication of reduced metallic line radiation.
- At present no resolution of these two contradictory observations.

- Status : Could benefit from five more shots at 1 MA.

Priority 1 XPs from Research Forum and *later XPs

Color code: Already reported in mid-run assessment
XP1056, XP1002 run since mid-run-assessment 8/27/10
Still to do

LR/CC	XP1000	Kugel	LLD Commissioning	Allocation 3d	Actual/ *scheduled* 5d
LR	XP1001	Soukhanovskii	LLD Pumping Group XP	2d	0.5d
LR	XP1002	Soukhanovskii	Impurity and Prad reduction…	1d	1d
LR	XP1024	Skinner	Impurity Reduction by Diffusive Li Injection	0.75d	*0.5d*
LR*	XP1041a	Kugel	LLD Pumping doc.		1d
LR/CC	XP1054	Kugel	LLD decommissioning	0.5d	
LR	XP1056	Mansfield	Impurities reduction with Dropper…	0.75d	1d
LR	*XP1057*	*Skinner*	*D retention with LLD*	*1d*	
LR*	XP1059	Kugel	LLD 50% fill Characterization II		2.5d
LR*	XP1065	Skinner	Impurity sources via CD_4 screening		
LR*	XP???	??	Group Li XP		