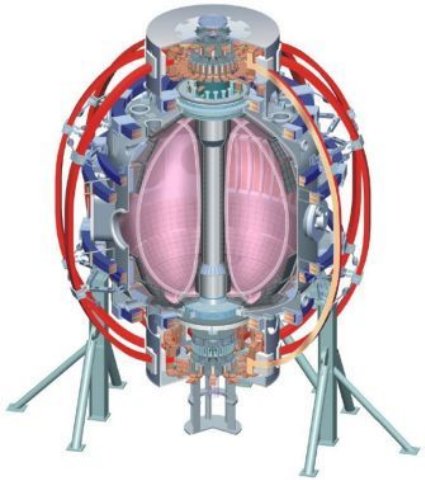
College W&M
Colorado Sch Mines
Columbia U
CompX
General Atomics
INL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
ORNL
PPPL
PSI
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Illinois
U Maryland
U Rochester
U Washington
U Wisconsin

Highlights from LLD Commissioning (XP1000, 1041A, 1059, 1000A)

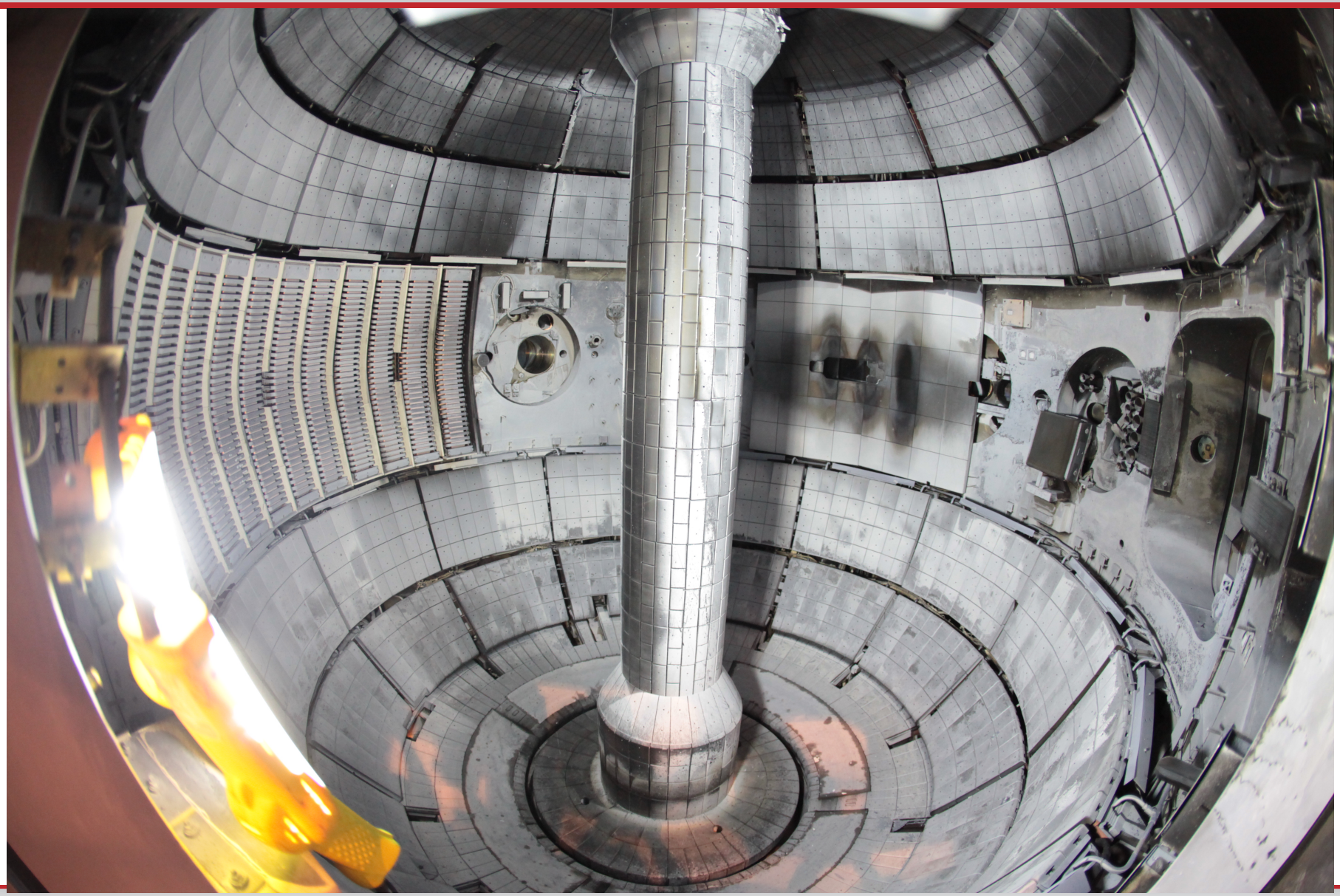
H. W. Kugel, et al.,

NSTX Results Review
November 30, 2010



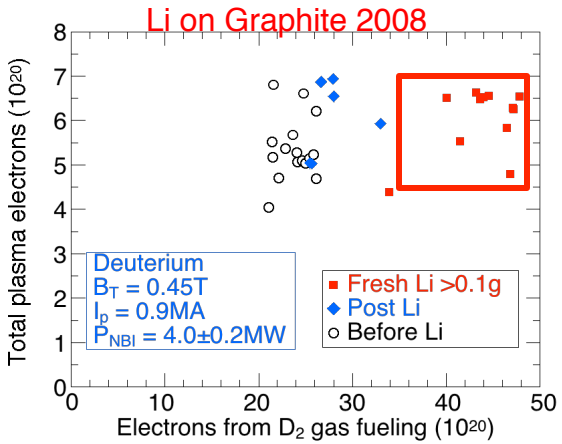
Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

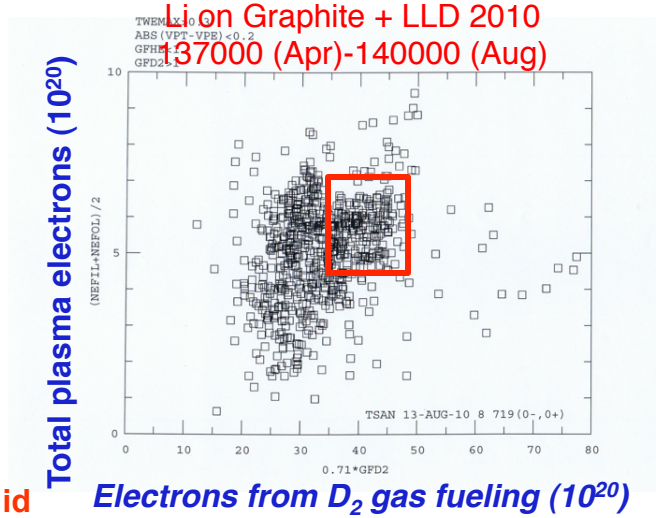
Photo of NSTX Interior Following 1.347 kg Lithium Deposition Applied During 2010 Experimental Campaign Indicates Extensive Lithium Coverage Due to Direct Evaporation and Plasma Transport



Under initial 2010 Conditions, Solid and Liquid Lithium Divertor Surfaces Pumped D Efflux About the Same, as Indicated by Gross Fueling Needed for Stable Plasma Conditions. – May indicate similar surface impurity effects

- *Rate of LLD Pumping* as indicated by the required fueling for stable plasma conditions with OSP on LLD warm or cold was the about the same as that for solid Li coatings on graphite.
- *Duration of Li graphite + LLD Pumping* was longer for thick coatings.
  (Loaded LLD provided Li edge conditions yielding ELM-free H-modes for at least 30 shots; ~150,for hi-δ)





Studies 1971-2002 indicate similar pumping for thick LI and liquid

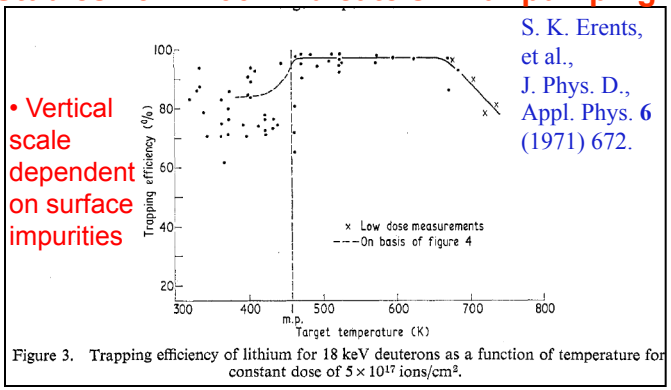


Figure 3. Trapping efficiency of lithium for 18 keV deuterons as a function of temperature for constant dose of 5×10^{17} ions/cm².

Erents *et al* [16] and Fisher *et al [17] used ion beams to study hydrogen* isotope burial in liquid lithium and their results agree well with the findings of the present study.

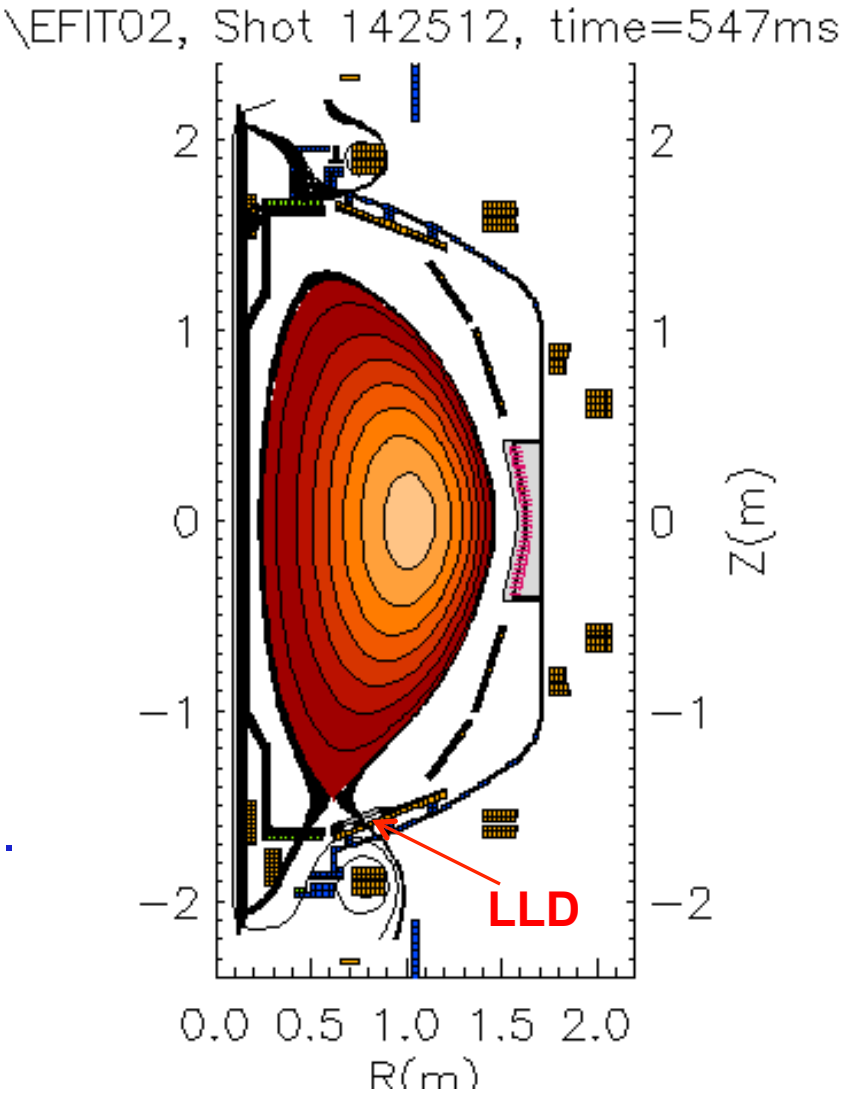
-M.J. Baldwin, et al., Nuc.Fus. 42(2002) 1318

- Under recent conditions, experiments with the LLD indicated constant core density, as lithium surface of LLD liquefied, despite deuterium fueling increase.

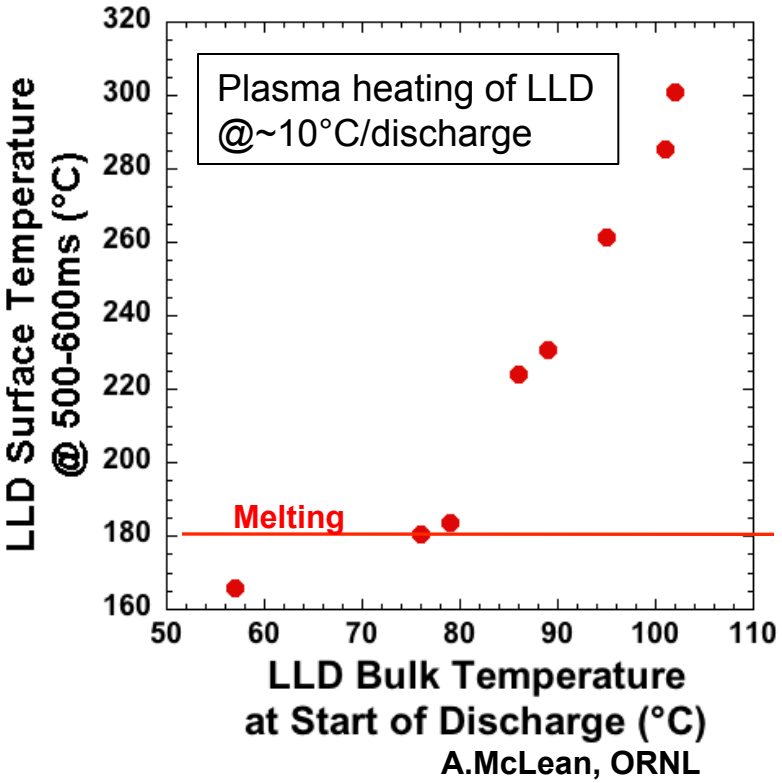
Discharges Run With Outer Strike Point on Liquid Lithium Divertor

- **Discharge**
  I_p = 0.8MA,
  P_{NB} = 4.0MW
  B_T = 0.48T
  R_{OSP} = 0.78m

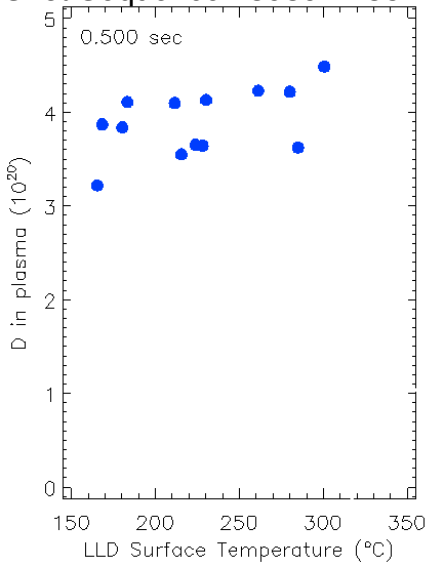
- **LLD Lithium Content**
  - LLD loaded using 1 LITER (2.5% eff. at LLD radius)
  - 7.5g evaporated from one LITER preceding the exp.
  - Estimated fresh Li coating on LLD 0.025 x 7.5g =0.188g.
  - Fresh Li thickness ~0.35μm.



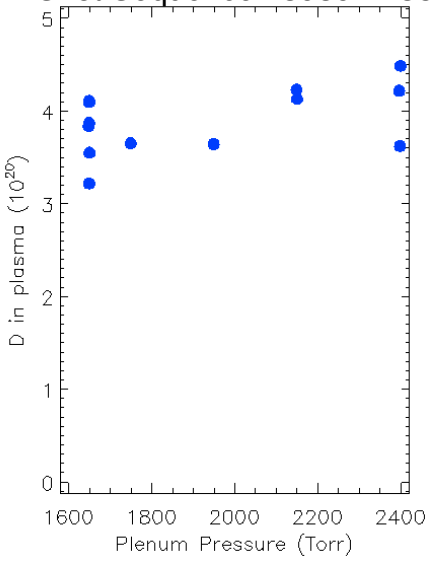
Discharges With Outer Strike Point on LLD and Increasing Fueling Exhibit Constant Core Particle Content as LLD Liquefies

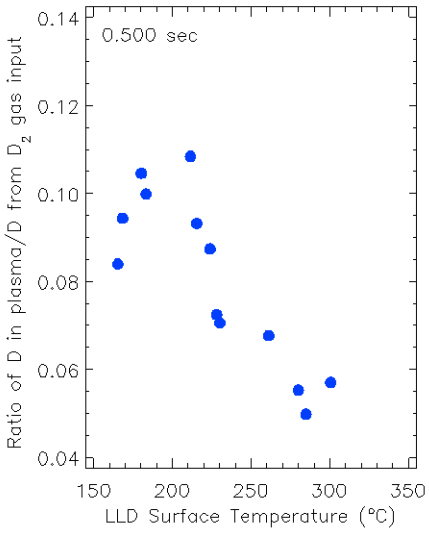


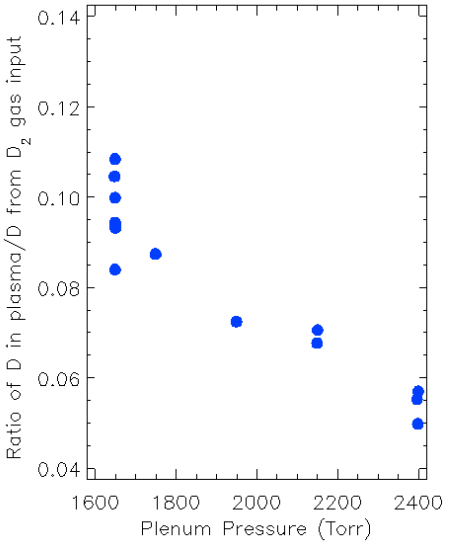
Shot Sequence 139392-138410



Shot Sequence 139392-138410

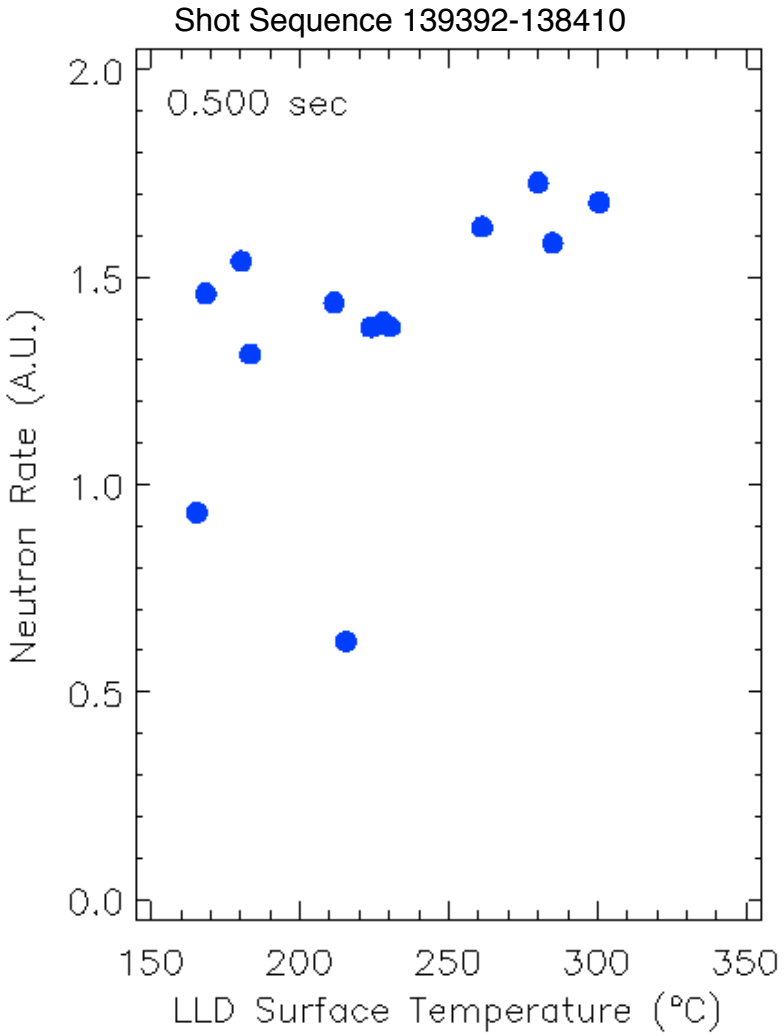


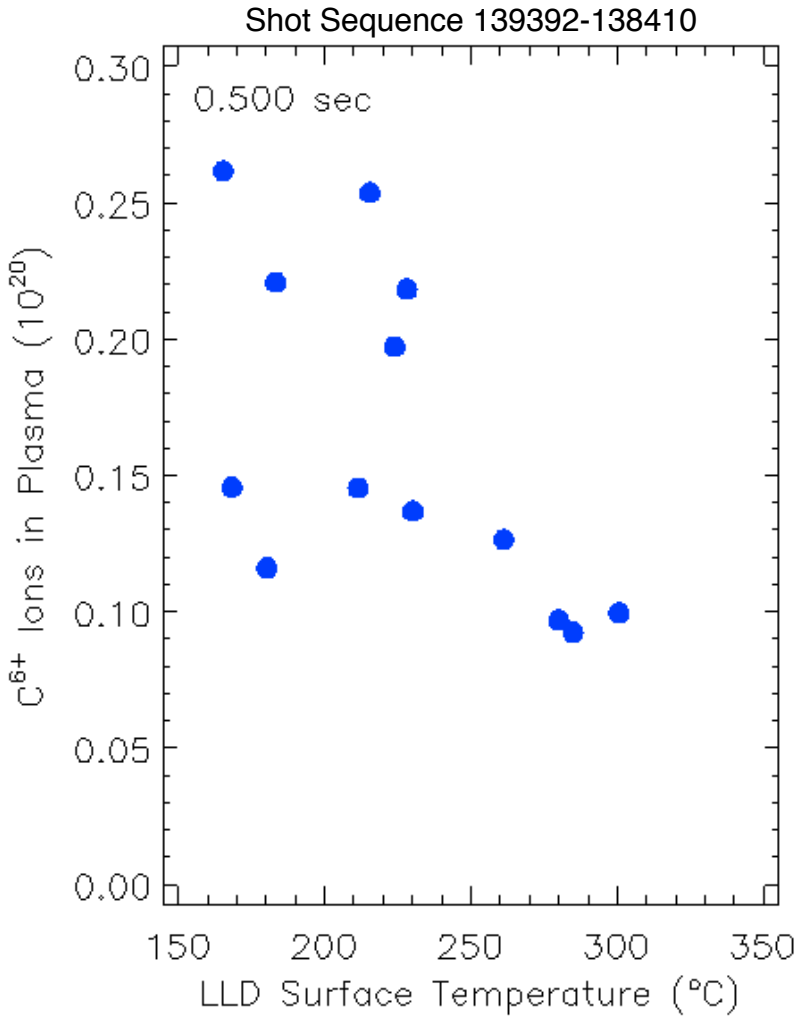




R.Bell

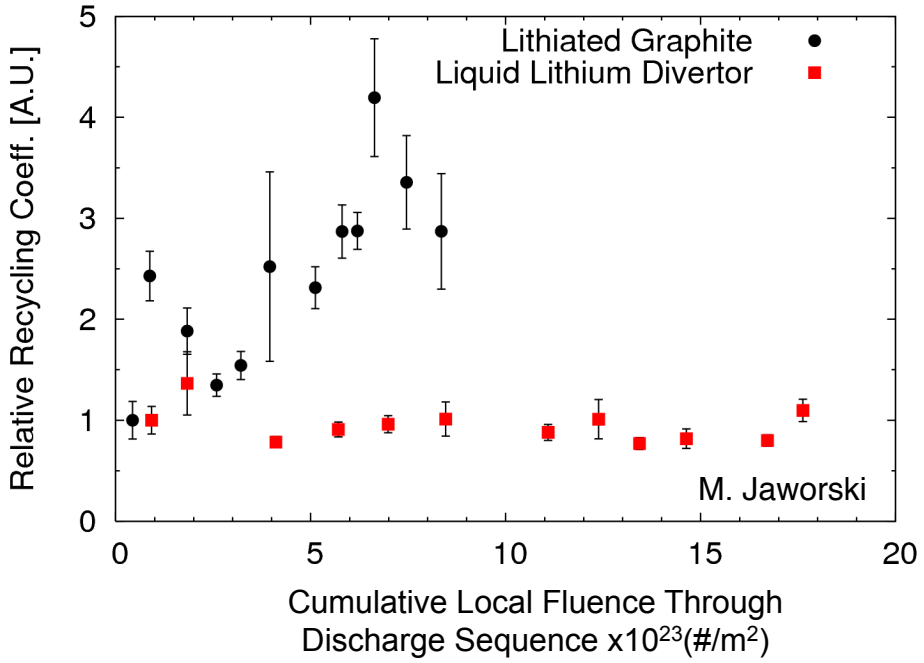
Discharges With Outer Strike Point on LLD and Increasing Fueling Exhibit Decreasing Carbon and Increasing Neutrons as LLD Liquefies

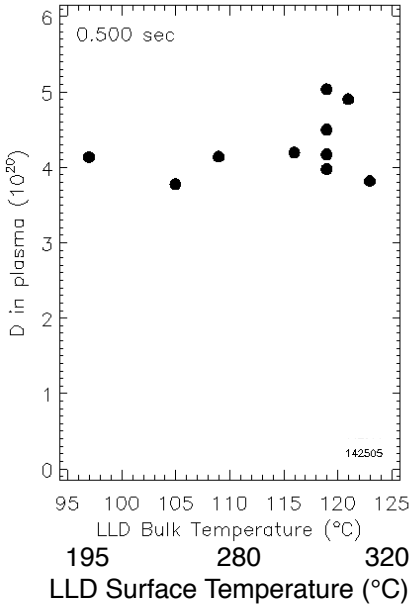


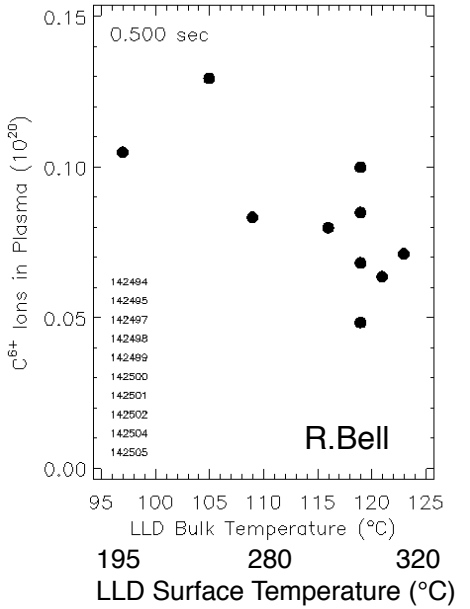


R.Bell

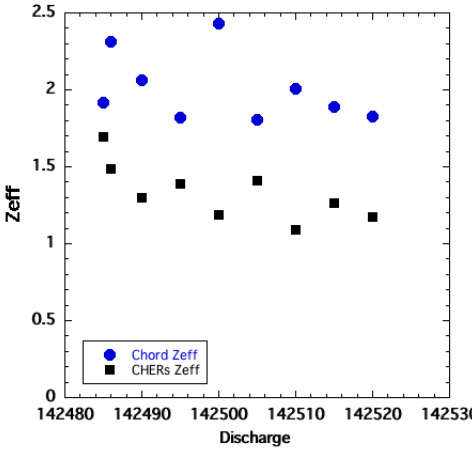
Constant Fueled Discharges With Outer Strike Point on LLD Exhibit Persistence of Recycling Behavior, Constant Core Particle Content, & Decrease in Core Carbon as LLD Liquefies



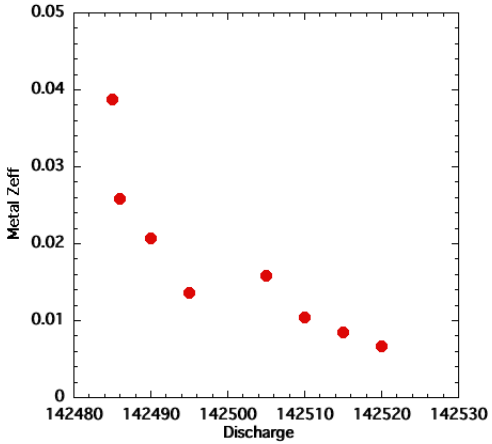




- Systematic rise in relative recycling coefficient on lithiated-graphite, but not on LLD. Indicates difference between lithiated-graphite and LLD.
- Multi-shot ion fluence indicates LLD has "reservoir" effect compared to Li-graphite.
- Liquid Li decreases core carbon.



CHERs, Chord Zeff, 0.3s



Metal Zeff, 0.3s

LLD Porous Mo Samples Analyzed 5 Lab Irradiation Scenarios to Test Various Possible NSTX Conditions

D diffuses into the bulk Li residing in the Mo-pores, and that the Li-O-D interactions indicative of D pumping on lithiated graphite are not occurring in the lab LLD samples within 10 nm of the surface. This would suggest that the Mo LLD samples are absorbing the incident D, and that all D is being absorbed except for reflected D

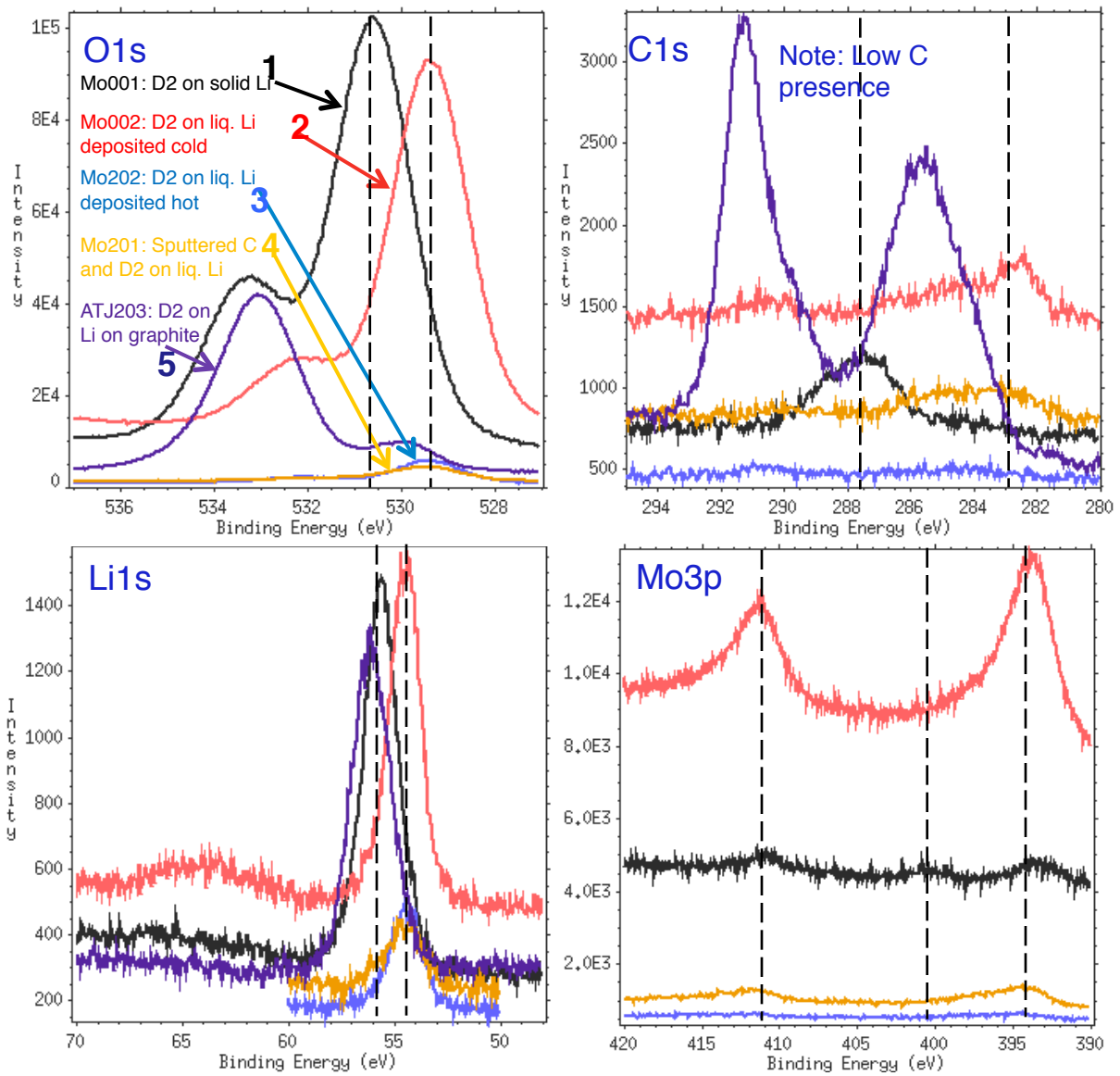
1) Mo001: 30 min D_2 irradiation on 2μm Li deposited on cold Mo.

2) Mo002: 30 min D_2 irradiation on 2μm Li at 255° C. Li deposited on cold Mo.

3) Mo202: 30 min D_2 irradiation on 3μm Li at 200° C. Li deposited on Mo at 250° C.

4) Mo203C: Carbon sputtered (via Ar) onto Li-coated Mo. 30 min D_2 irradiation at 200° C.

5) ATJ203: 30 min D_2 irradiation on ATJ graphite with 2μm Li dose.



Summary and Conclusions

- Under initial 2010 conditions, solid and liquid lithium divertor surfaces pumped D efflux about the same, as indicated by gross fueling needed for stable plasma conditions.
    - Liquid lithium surface impurities and the complex surface morphology can reduce the formation of LLD and decrease pumping.

- Under recent 2010 conditions, constant fueled discharges with outer strike point on LLD exhibit constant core particle content, decrease in recycling, and decrease in core carbon as LLD liquefies.

- Discharges with outer strike point on LLD and increasing fueling exhibit constant particle content, increasing neutrons, decreasing carbon as LLD liquefies.

- These initial LLD experiments contribute toward developing replenishable liquid lithium walls for providing a pumping, impurity flushing, low-Z, self-healing plasma facing surface for long duration discharges.