NSTX

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Particle fluxes and inventories with hot LLD in XP1000A

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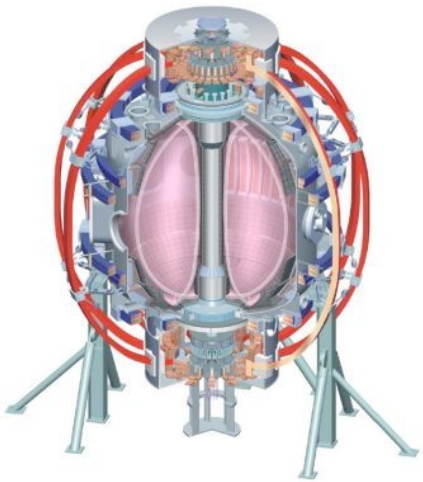
V. A. Soukhanovskii (LLNL)

Acknowledgements:
H. W. Kugel, R. Kaita, LLD and NSTX Teams

NSTX Results Review
Princeton, NJ
Tuesday, November 30, 2010



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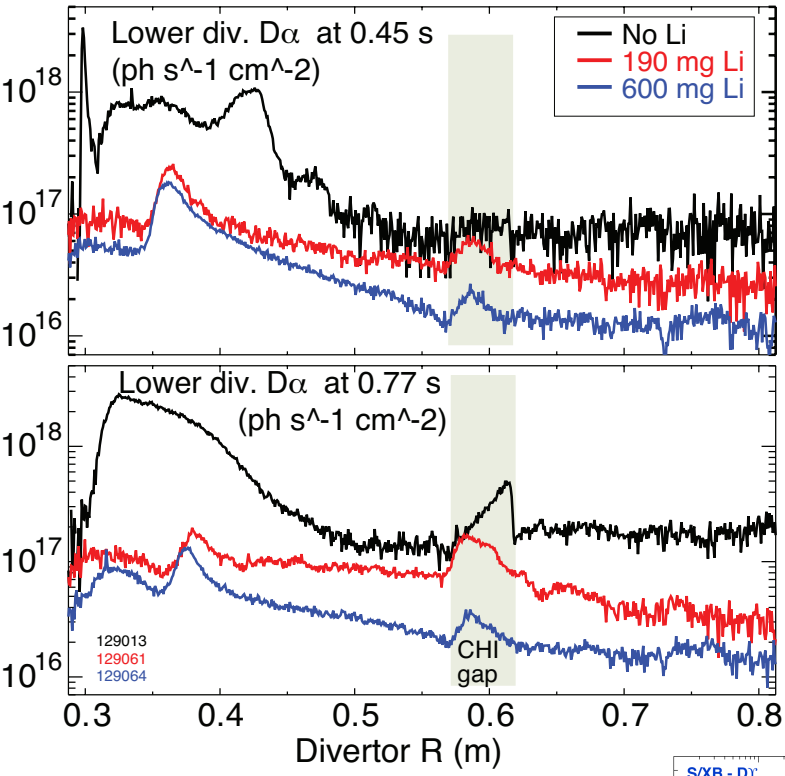
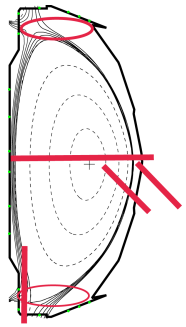
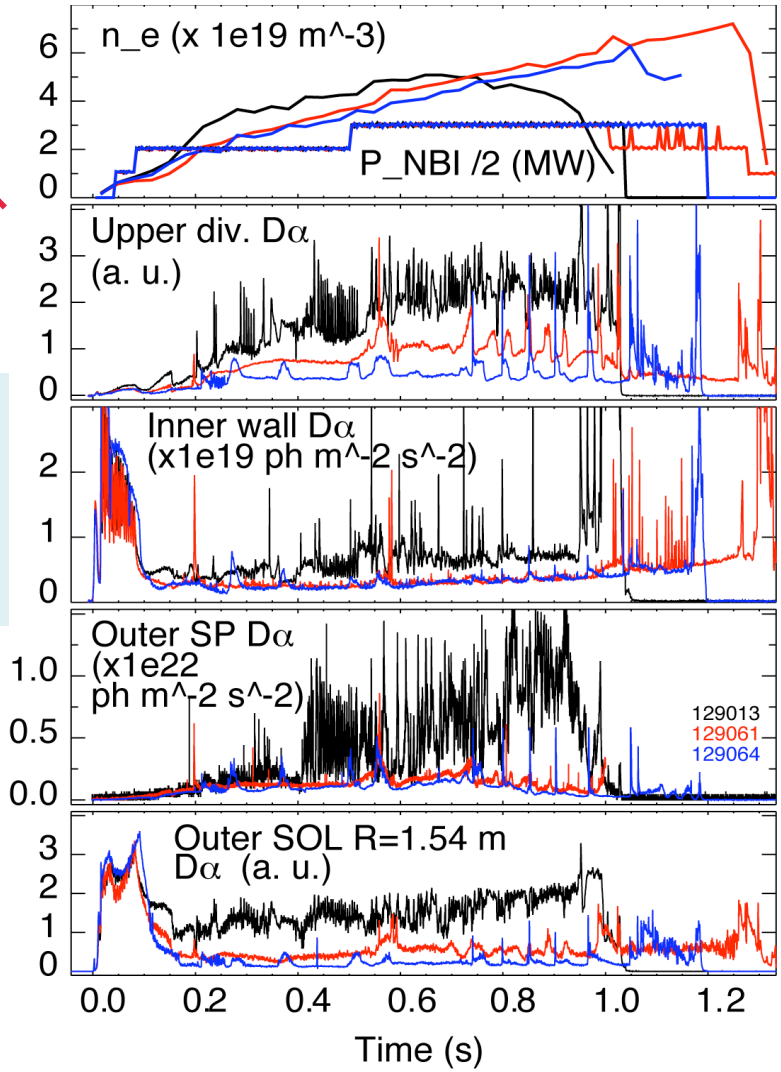
FY2008: Lithium conditioning had a profound and cumulative effect on poloidal recycling flux profile

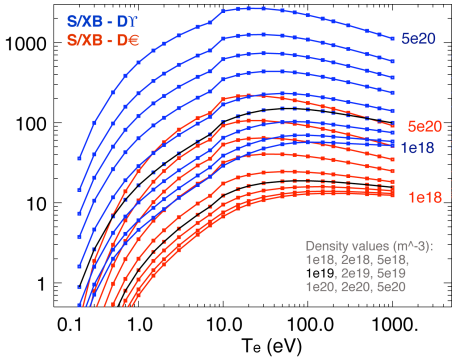




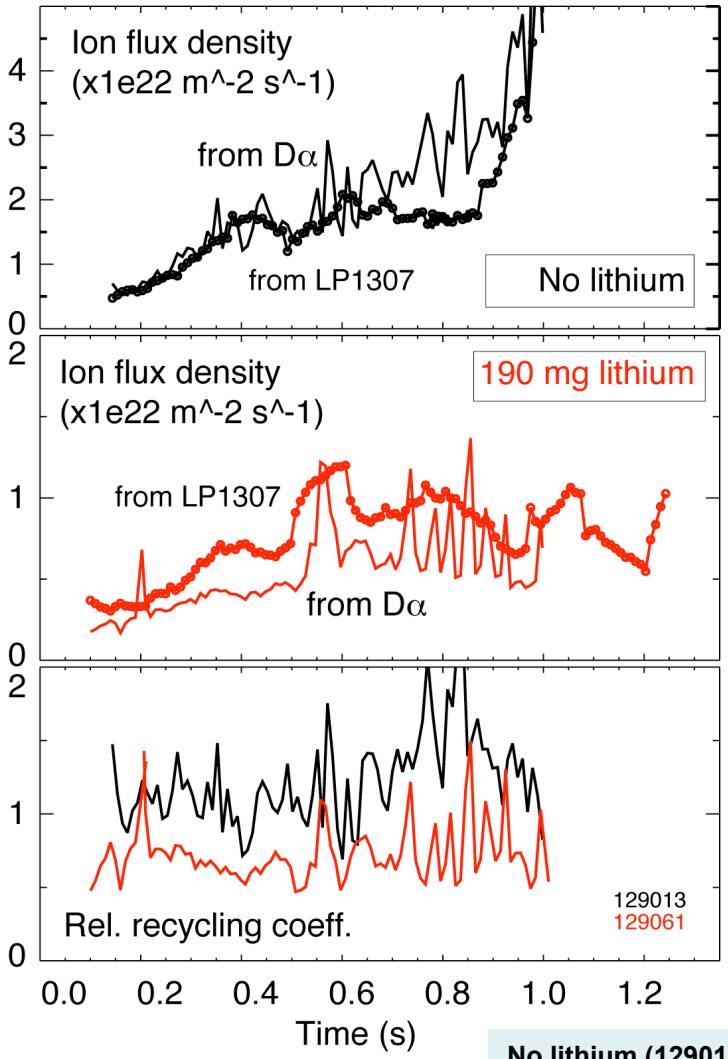
No lithium (129013)
190 mg lithium (129061)
600 mg lithium (129064)

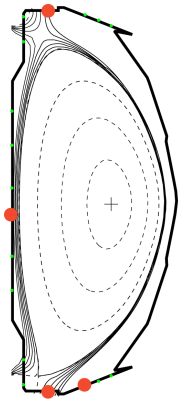


$\Gamma_{recy} \sim SX/B\ I_{D\alpha}$



FY2008: Lithium conditioning reduced local ion recycling coefficients on PFCs except in the near-SOL region





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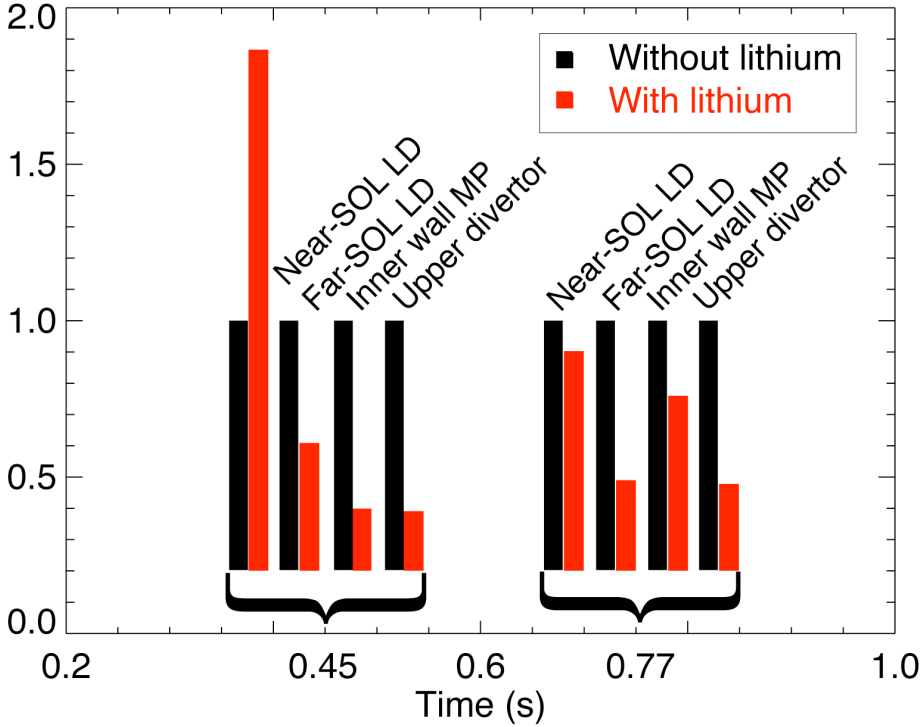
190 mg Lithium (129061)



- Local recycling $R_{local}=\Gamma_i^{out} / \Gamma_i^{in}$
  - Ion flux into LLD Γ_i^{in} is measured by Langmuir Probes (LPs)
  - Ion outflux Γ_i^{out} estimated from measured Dα fintensity and S/XB (ionizations/photon) coefficient from ADAS

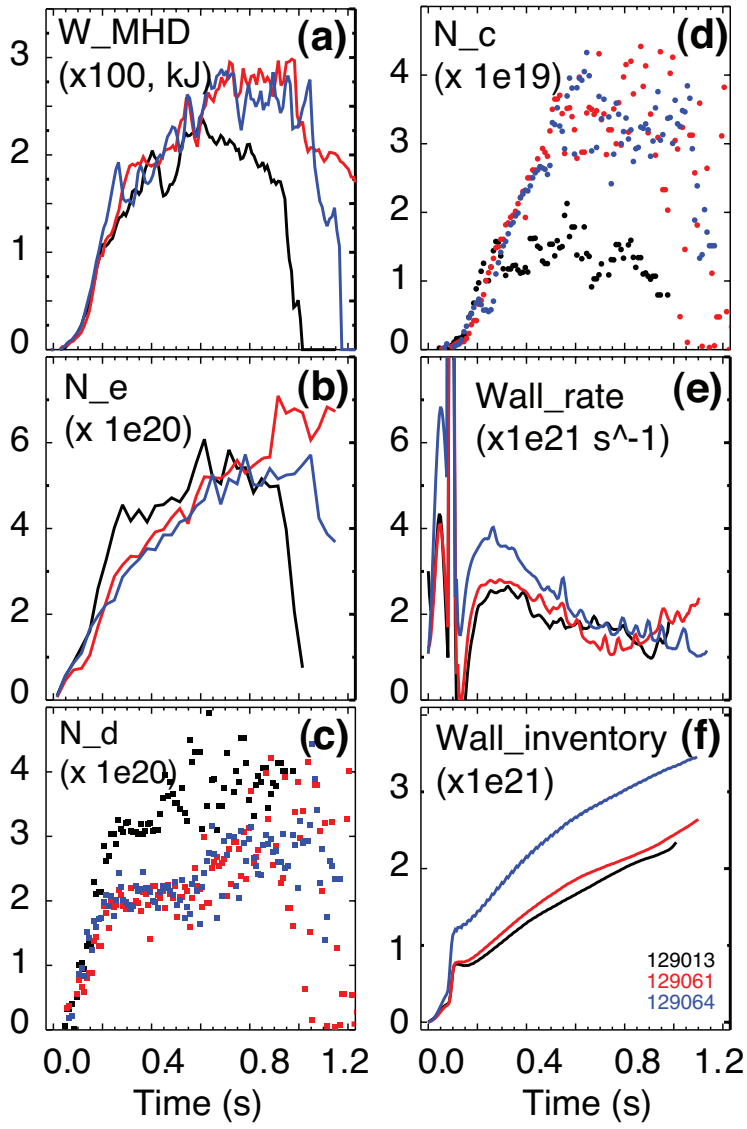
FY2008: Ion density was reduced by up to 50 % in 4-6 MW H-mode discharges by lithium conditioning

- Particle balance model
  - Continuous pumping throughout a discharge
  - cumulative coatings provide higher pumping rate
  - Wall in pumping state far from saturation

$$\frac{dN_p}{dt} = \Gamma_{gas} + \Gamma_{NBI} + \Gamma_{NBI\_cold} + \Gamma_{NBI\_cryo} + \Gamma_{wall} + \Gamma_{pump} + \frac{dN_n}{dt}$$

Change in ion inventory	Gas feed rate	NBI fueling rate	NBI cryopump rate	Wall loading rate	Turbo. pump rate	Neutrals build-up rate

- Particle inventory balance: $N_e = 6\,N_C + N_i$
- 0.9 MA, 4.5 kG, 4-6 MW NBI
- High κ~2.3, δ~0.6 shape
- Biased DN with δr_{sep} ~-6mm



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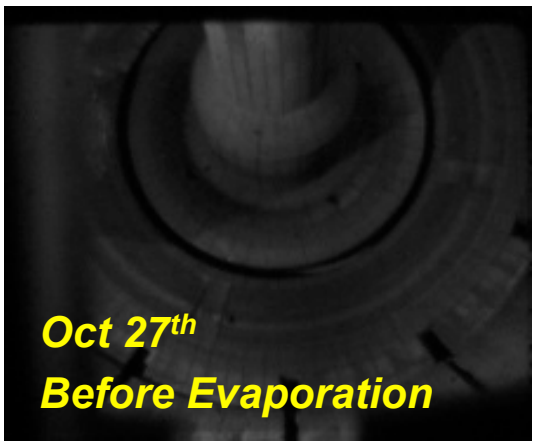
190 mg Lithium (129061)
600 mg lithium (129064)

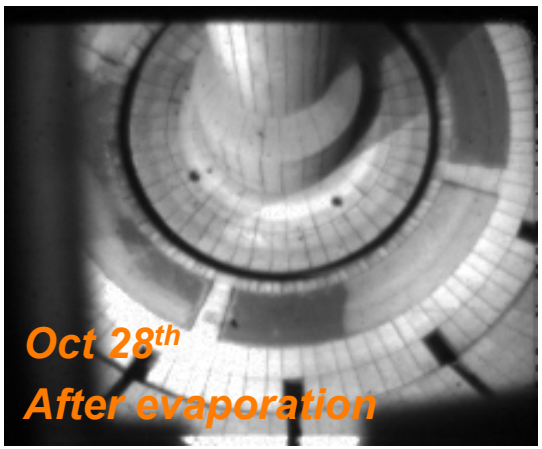
XP1000A "LLD pumping" on Oct. 28-29 encountered many challenges

- XP1000 etc in March-April 2010
  - Clean evaporation from both LITERs
  - Eventually, failure of ohmic LLD heaters
  - No obvious recycling reduction or pumping
- XP1000 etc in August 2010
  - Mega-evaporation from both LITERs + LLD heating by OSP
  - Lithium coatings turned white before run - signs of compromised coating?
  - No obvious recycling reduction or pumping
- XP 1000A in October 2010
  - New air-heating system + LLD heating by OSP
  - One LITER
  - Again, lithium coatings turned white before run
  - 0.8 MA, 4 MW NBI low-δ discharges with OSP at R=0.73 and 0.78 m
  - SGI pulses for recycling measurements

White appearance of lithium coatings in XP1000A suggested that lithium has reacted and turned into compounds $LiCO_3$, LiD, LiOH

- When PFCs and vacuum are "clean" – e.g. right after the 350 C bake (little water) – no white appearance is observed





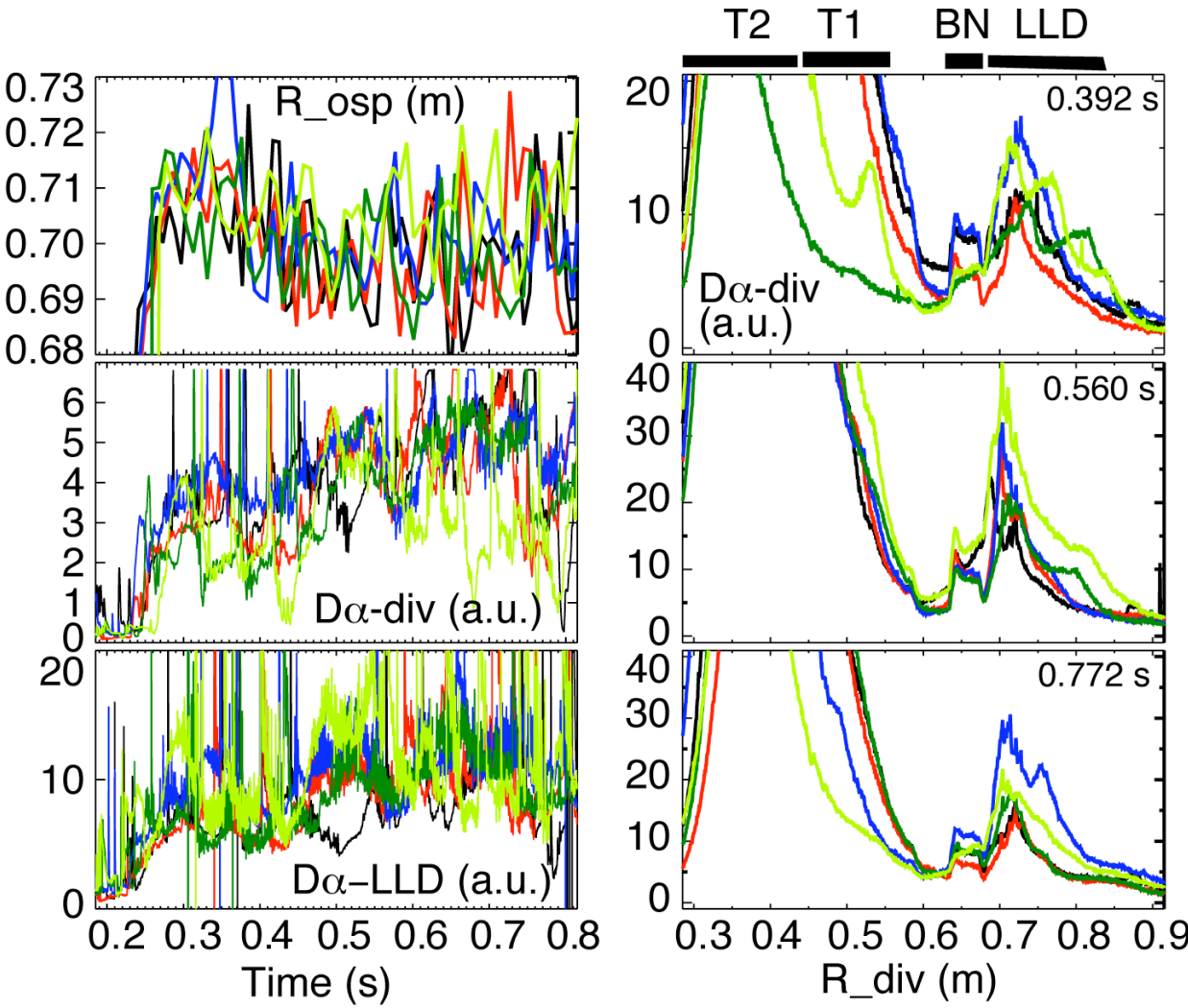
- Observed on mornings of Oct 28th and Oct 29th when XP 1000A was run

Images courtesy of F. Scotti

XP1001A: No systematic trend in divertor recycling with LLD temperature

- No systematic trend in OSP Dα
- Inner divertor detached -> little pumping
- Approx. LLD bulk temperatures

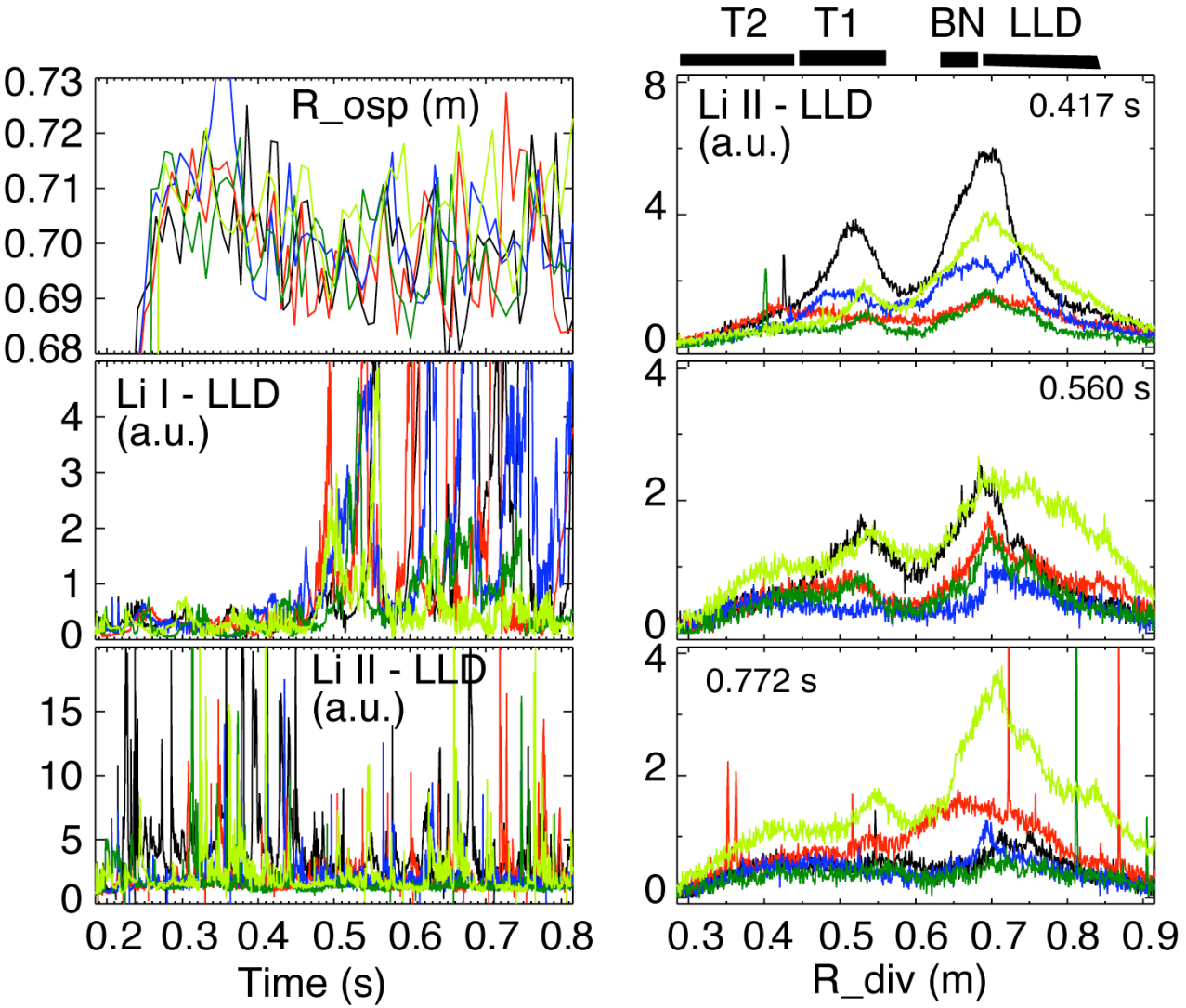
142489 - T=55 C
142498 - T=108 C
142505 - T=120 C
142516 - T=100 C
142521 - T=200 C



XP1001A: No systematic trend in lithium flux from LLD with temperature

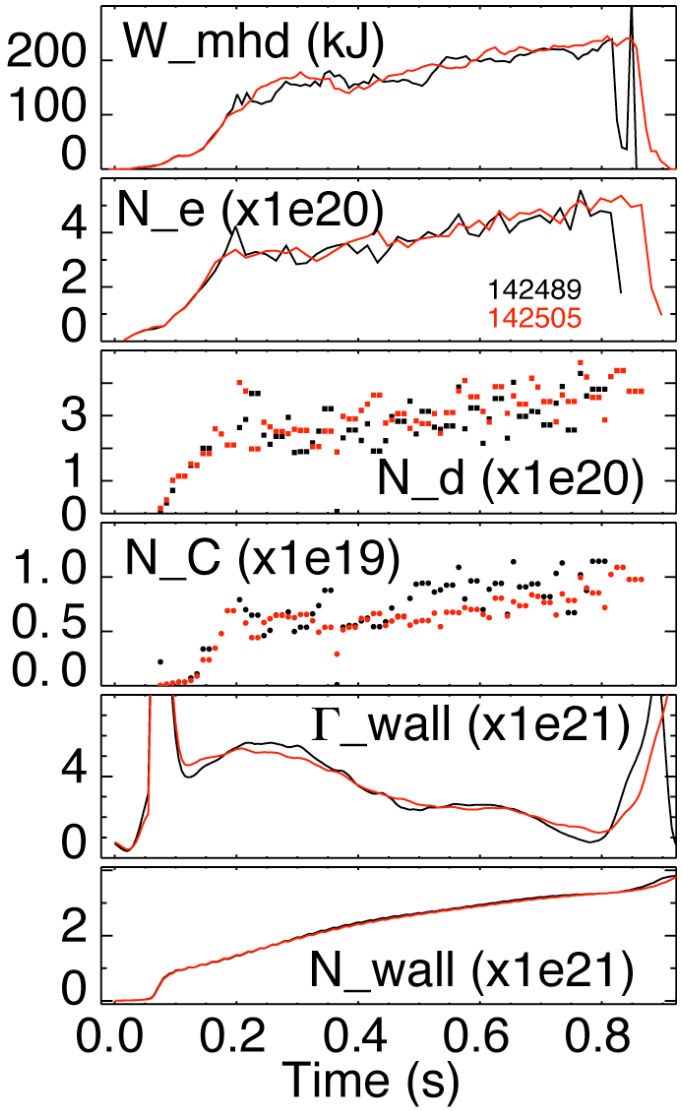
- No systematic trend in LLD Li I or Li II fluxes
- Approx. LLD bulk temperatures

142489 - T=55 C
142498 - T=108 C
142505 - T=120 C
142516 - T=100 C
142521 - T=200 C



XP1001A: Global particle balance does not show systematic trends in wall inventory or loading rate

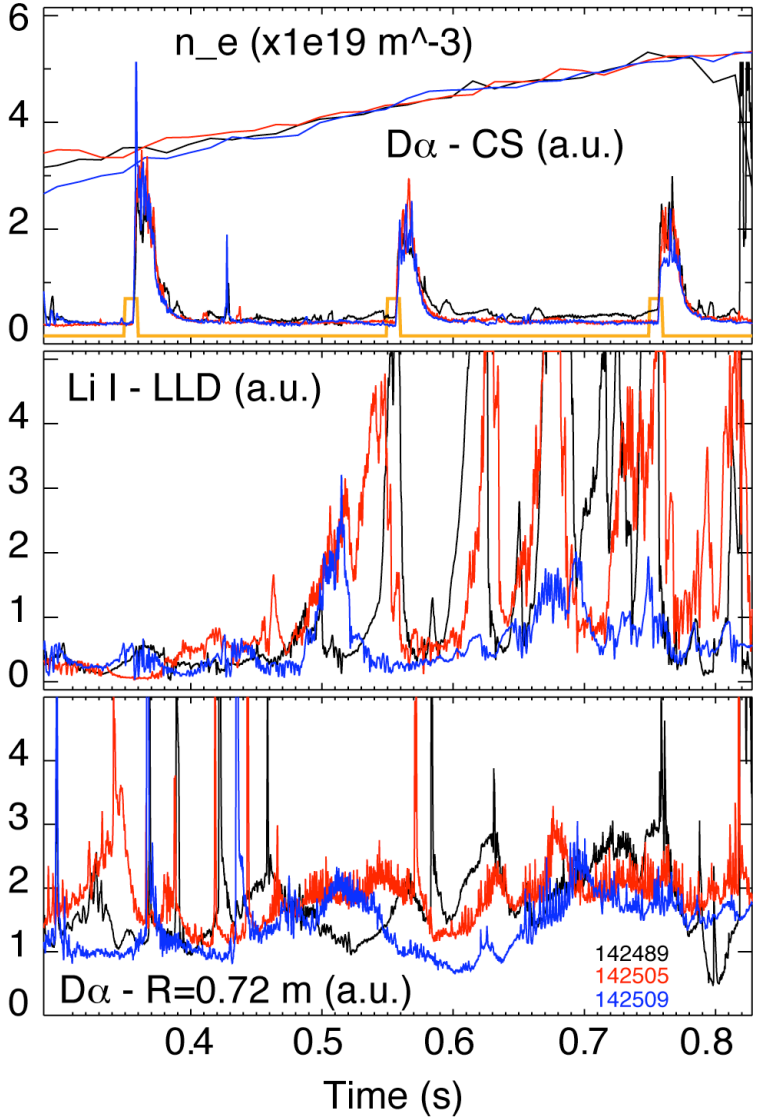
- Two shots compred
  - 142489 – T=55 C
  - 142505 – T=120 C
- No systematic trend in N_e, N_d, N_C
- Global particle balance does not show any ion pumping
- Used HFS 1600 Torr instead of actual 1900 Torr, need to correct, does not change relative results



$$\frac{dN_p}{dt} = \Gamma_{gas} + \Gamma_{NBI} + \Gamma_{NBI\_cold} + \Gamma_{NBI\_cryo} + \Gamma_{wall} + \Gamma_{pump} + \frac{dN_n}{dt}$$

XP1001A: SGI pulses did not produce desirable change in divertor recycling

- Three SGI pulses were used
  - Deuterium at ~ 150 Torr l /s
  - 10 ms duration at 0.35, 0.55, 0.75 s
- Particle balance weakly affected
- SGI pulses often induced ELMs (also seen previously)
  - To follow-up with XP in 2011
- Weak particle flux change in OSP region (unlike previous experience with high-δ discharges)



Forthcoming analysis of LLD experiments and Future plans

- LLD experiments
  - Oxygen, lithium, carbon, moly fluxes and yields (if LP measurements available)
  - Molecular spectroscopy and lithium chemistry (w/ Purdue U.)
- Analysis of divertor recycling and impurity fluxes in FY2010 as function of local particle and heat fluxes
  - How does strike point plasma interact with lithium coatings – erosion, evaporation, ablation?
  - What affects divertor lithium coating lifetime most?
  - What can be said about divertor (ISP, OSP) vs main chamber?
- Carbon and lithium production and transport