XP824 Li Pumping and Retention on NSTX

Charles Skinner, Rajesh Maingi, Vlad Soukhanovskii et al., NSTX Results Review 8/6/08

Introduction

- Density control via Li pumping of D is goal of multi-year Li program on NSTX.
- Measurements the fraction of the injected deuterium that is retained in the NSTX vessel both before and after PFCs are coated with fresh (active) lithium.
- The static vessel pressure rise measured after ohmic and RF discharges with all valves closed and compared to a gas-only shot.
- Present report is on progress so far.
  Definitive experiments planned for 2009 with DIII-D and C-mod.

Joint US tokamak FY 2009 milestone on pumping and retention:

- Conduct experiments on major fusion facilities to develop understanding of particle control and hydrogenic fuel retention in tokamaks. In FY09, FES will identify the fundamental processes governing particle balance by systematically investigating a combination of divertor geometries, particle exhaust capabilities, and wall materials. Alcator C-mod operates with high-Z metal walls, NSTX is pursuing the use of lithium surfaces in the divertor, and DIII-D continues operating with all graphite walls. Edge diagnostics measuring the heat and particle flux to walls and divertor surfaces, coupled with plasma profile data and material surface analysis, will provide input for validating simulation codes. The results achieved will be used to improve extrapolations to planned ITER operation. (* text updated, shown as accepted by DoE)

Overall Strategy

- Retention differences between Li / no-Li could be small so target is to measure retention with ~1% accuracy.
- Basic equation:

$$\text{Retention} = 1 - \frac{\text{Ion gauge 'IG\_110' rise with discharge}}{\text{Ion gauge 'IG\_110' rise with gas-only shot} * Q}$$

$$Q = \frac{\text{Drop in Inj \#2 sensotec pressure (PE\_102) with discharge}}{\text{Drop in Inj \#2 sensotec pressure (PE\_102) with gas-only shot}}$$

(Sensotecs monitor pressure in gas injection plenum.
Ion gauges: 'IG_110' is next to RGA at end of pump duct, 'IG' is next to vessel.)

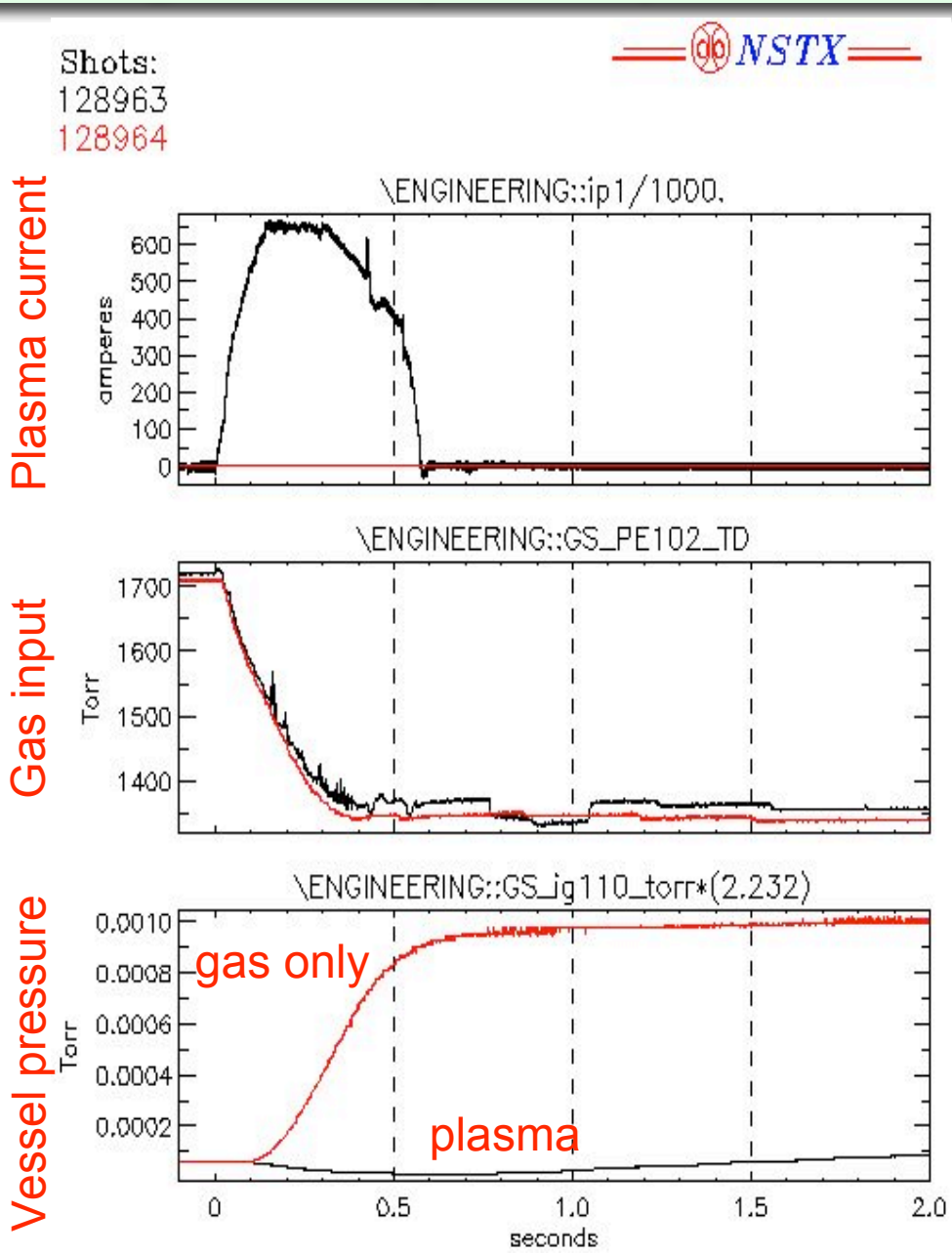
Plan:

- Start with 0.45 T, ramp down Ip to avoid reconnection events & disruptions that could release gas from wall.
- Include gas only shots for calibration
- ± He GDC, ± RF to vary stored energy.
- After XP leave all valves closed ~ 24 h to track long term outgassing.

Before Li, Plasma / gas-only comparison

Overview:

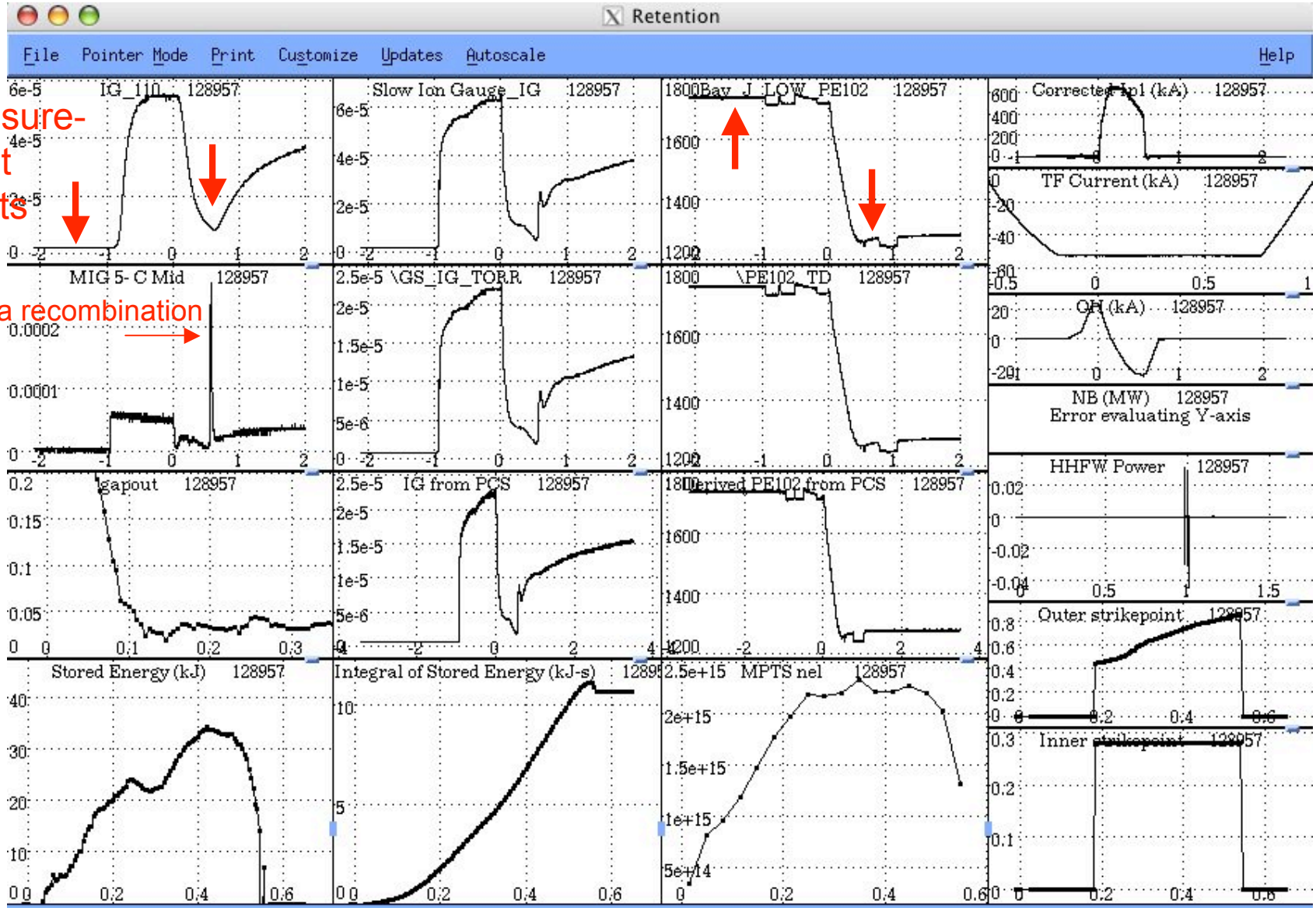
- NB TIV closed
- TMP TIVs closed @ -30s
- 650 kA, 4.5 kG, adjusted density (after 3x GDC) and optimized IP rampdown (5 shots)
- Then add ≤ 2.6 MW RF
- Integral stored energy increased from 11 ohmic to 16 kJ-s with RF.
- Increase TF from 4.5 kG to 5.5 kG to avoid locked mode
- Vessel pressure minimum occurs before ig110 and sensotec equilibration
- Gas-only shots confirm negligible retention



Use mds scope pointer tool to measure retention at pressure minimum

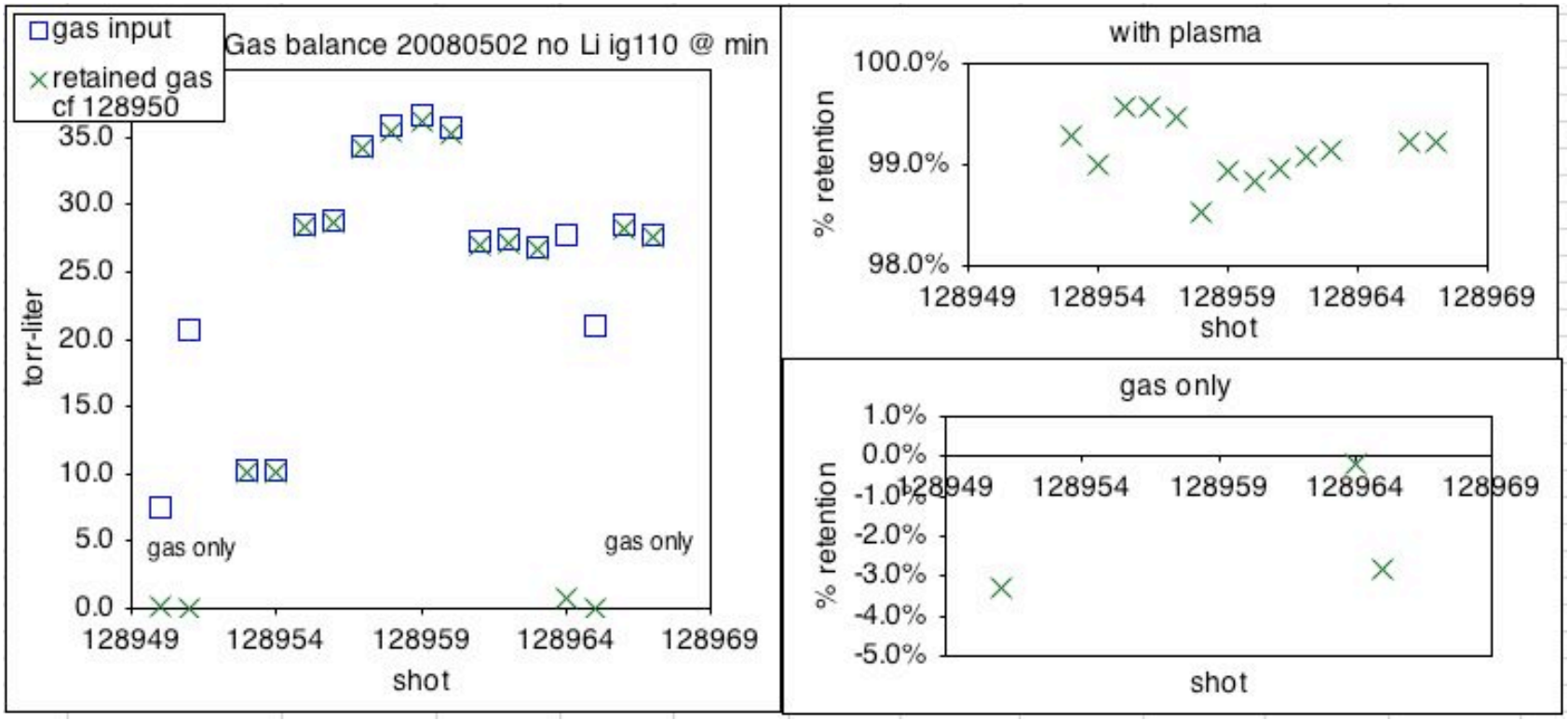
Measure-ment points

Plasma recombination



Before Li, Immediate Retention ~ 97% - 100%

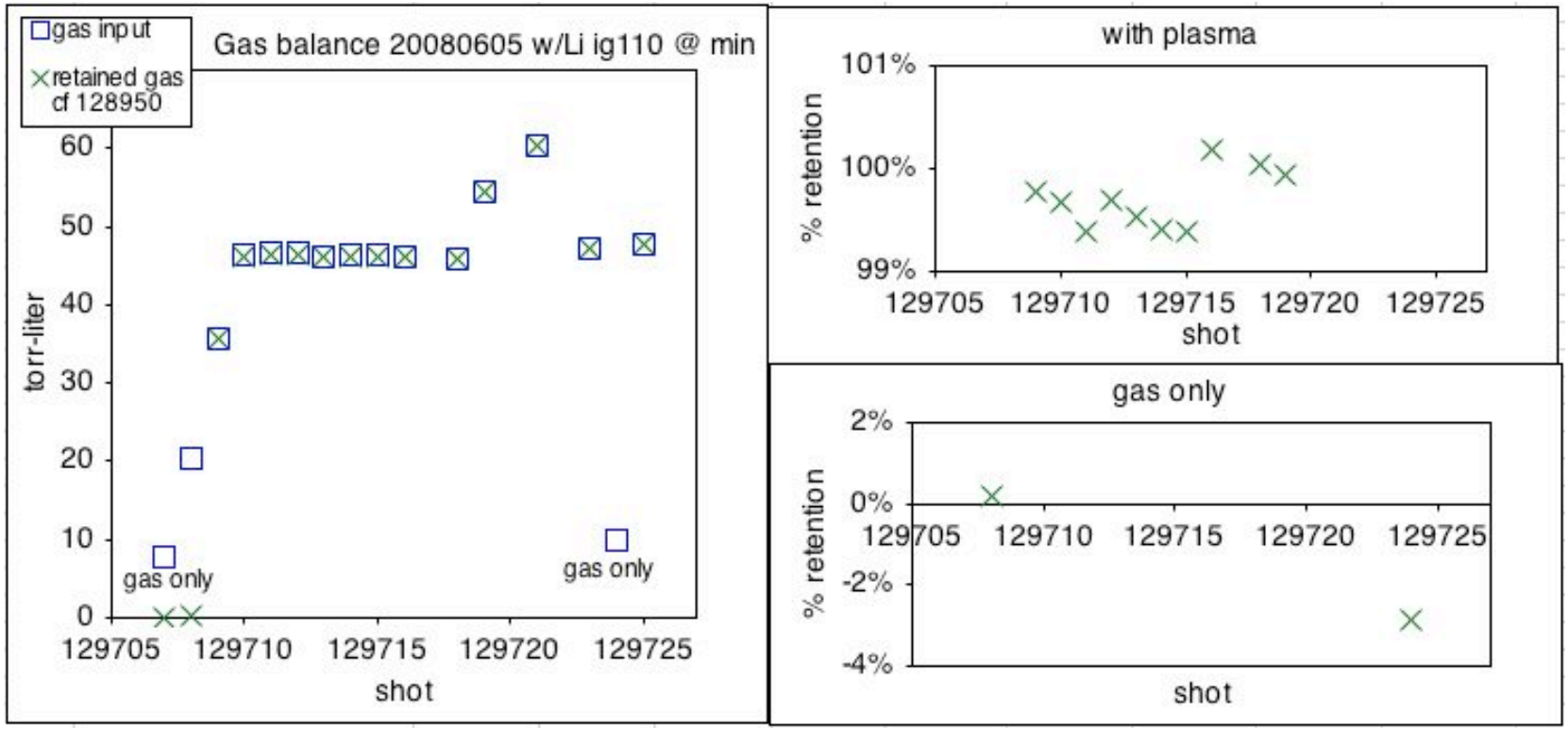
- Compare gas input to vessel pressure rise (IG110 @ minimum after plasma recombination)
- Compare to gas-only shot 128950.



- From gas only shots deduce net retention of ~ 97% - 100% with few % uncertainty from bit noise and transient effects.
- Consistent with dynamic retention measured by QMB.

With Li, Immediate Retention ~ 97% - 100 %

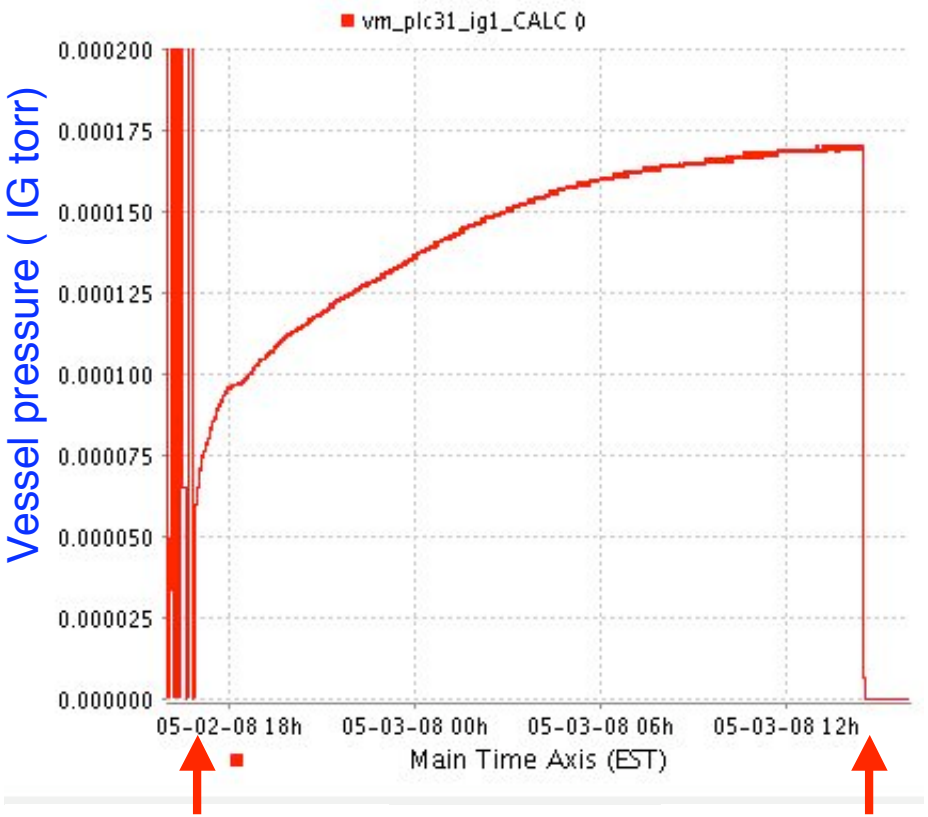
- Compare gas input to vessel pressure rise (IG110 @ minimum after plasma recombination)
- Gas retained calculated from comparison to gas-only shot 129707.



- Vessel pressure minimum occurs before ig110 and sensotec equilibration
- From gas only shots deduce net retention of 97% - 100% with few % uncertainty from bit noise and transient effects.

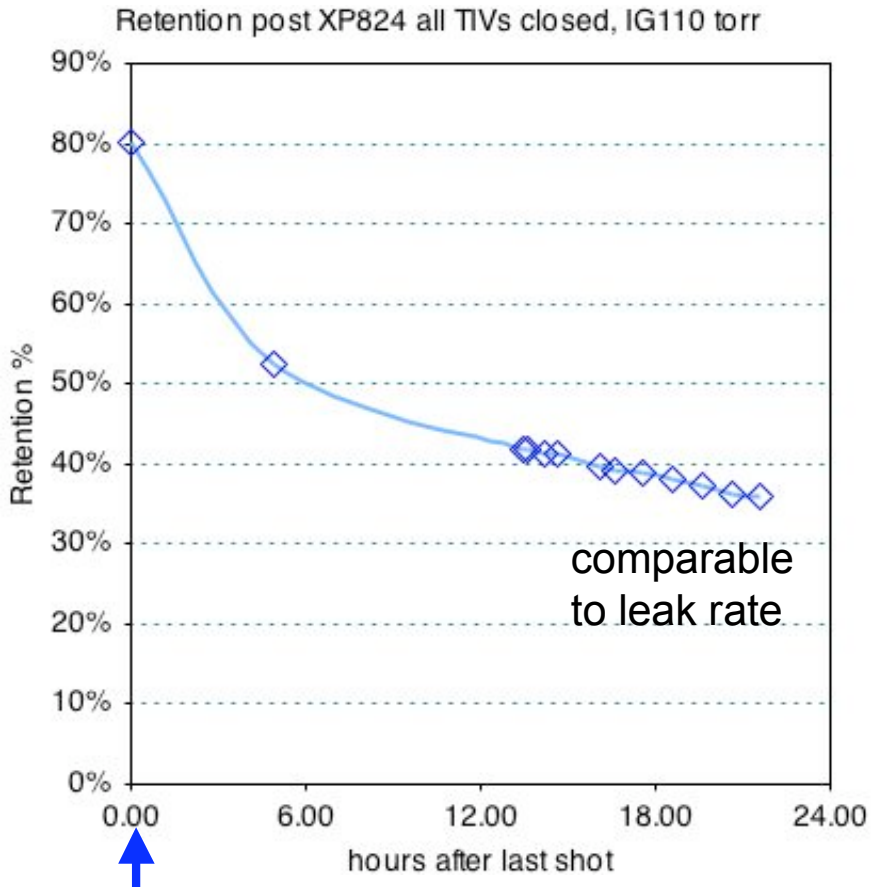
Longer term retention before Li

- Leave all TIV's closed for 21.5 h Friday PM - Saturday end of 1st shift.
- Monitor outgassing pressure rise on IG and IG110.



End of XP824 TIVs closed before final shot Friday

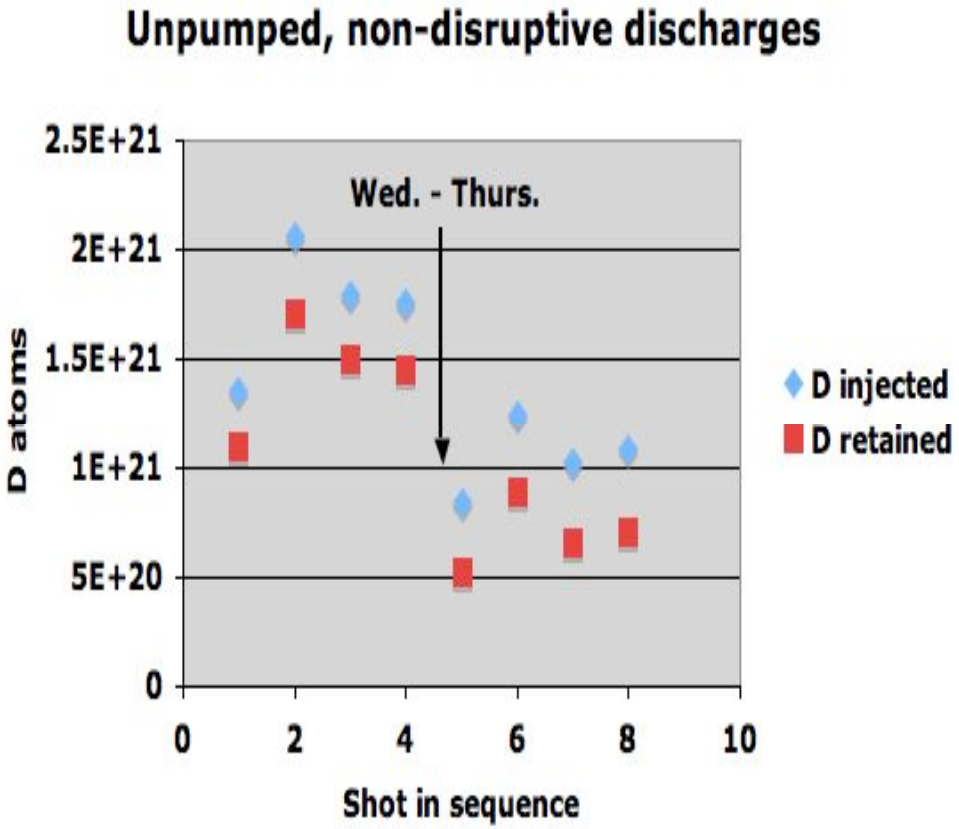
TIVs opened Saturday 2:30 PM



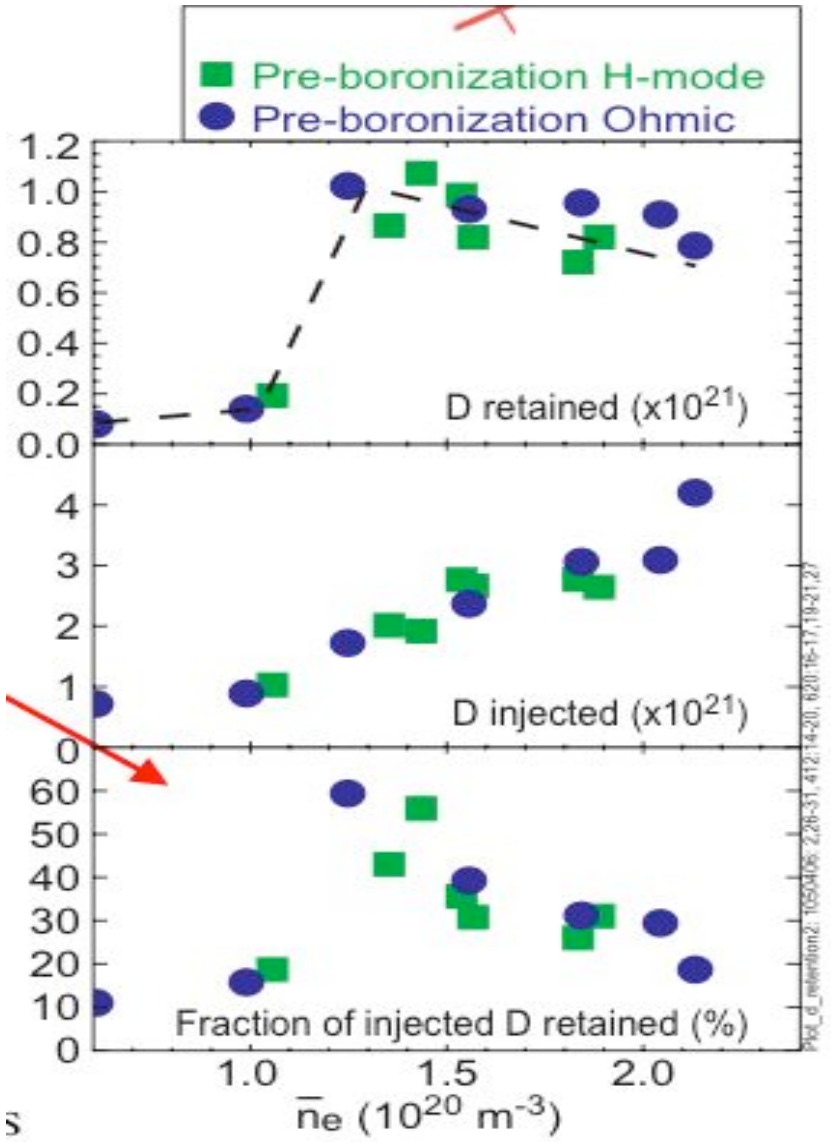
2 mins after last shot

With Li behavior similar

Comparison to DIII-D & C-mod



DIIIL-D (carbon)
Whyte et al….



C-mod (Mo / W)
Lipschultz et al PSI18

Summary

Conclusion:

- Hydrogenic retention close to 100% immediately after discharge.

Hypothesis:

- Nearly all incoming gas ionized in SOL, transported on open field lines and implanted in divertor or wall.
- Short term solute fractions >> usual long term value of H/C ~ 0.4
  (Andrew & Pick, J.Nucl.Mater.,220-222(1995) 601)
- Time scales less than 1 second significant

NSTX Data analysis continues…

- Comparison to modeling of trapped and solute hydrogen.
- Refine error analysis
- Linearity check of RGA and IG gauge
- Export long term trend data from EPICS
- Improve Barytron readout
- Replace IG1 and IG2 with micro-ion gauge
- Improve software for data export from EPICS
- Prepare for XP in 2009 ….

Thanks to:

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