XP824 Li Pumping and Retention on NSTX

Charles Skinner et al., BP ET Mtg 4/8/08 1:30 PM

- Density control via Li pumping of D is goal of multi-year Li program on NSTX but not yet measured directly.
- XP aims to measure 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 will be measured after ohmic and RF discharges with all the valves closed and compared to a gas-only shot.

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. This is beyond the previous scope of the pressure gauges and RGA.
- Basic equation:

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

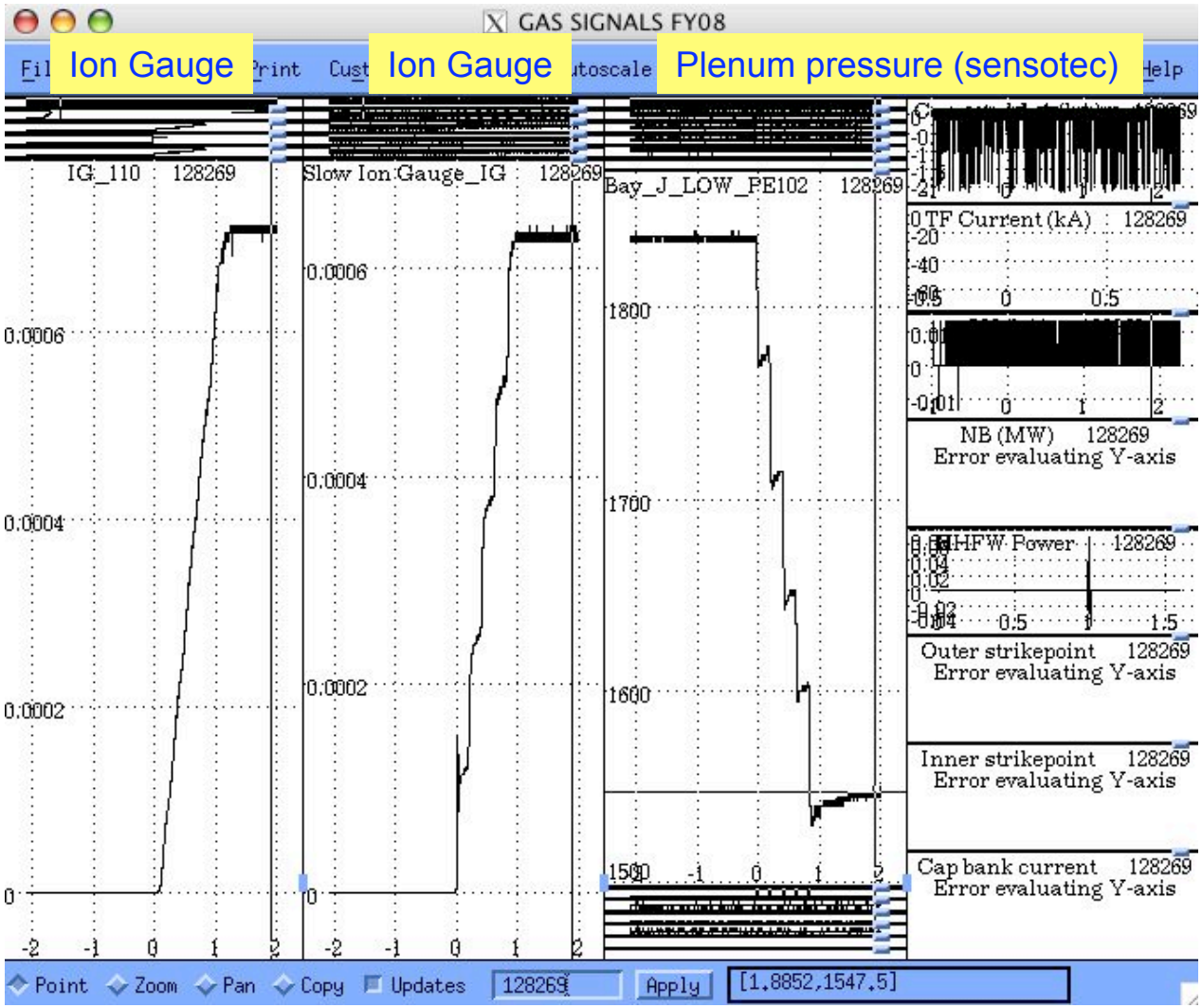
$$Q = \frac{\text{Drop in Inj \#2 sensotec pressure (PE\_102) with discharge}}{\text{Drop in Inj \#2 sensotec pressure (PE\_102) with gas-only shot}}$$

This initial XP deals with no-Li baseline retention.
XP also aims to identify path for a more accurate measurement and calibrations and simulations in 2009.

(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.)

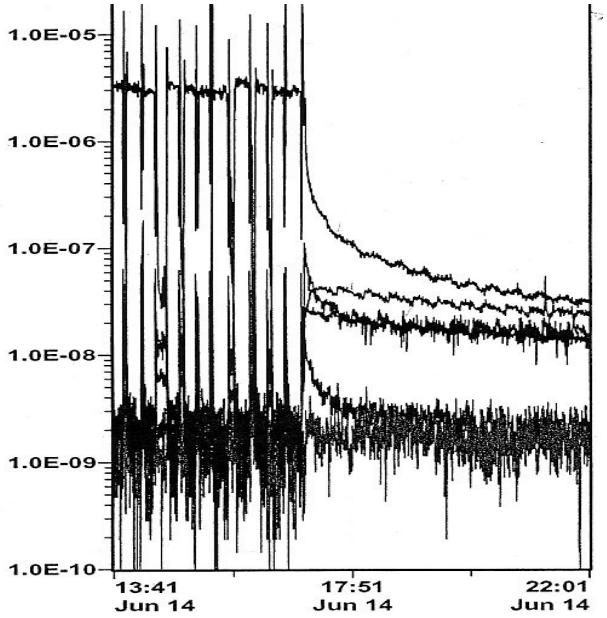
Example of scope signals gas-only shot:

- Preliminary gas-only data:
- Start/end values are averaged in IDL to reduce bit noise.
- Sichta to provide spreadsheet with trending data (24/7 every 10 s) from engineering tree.



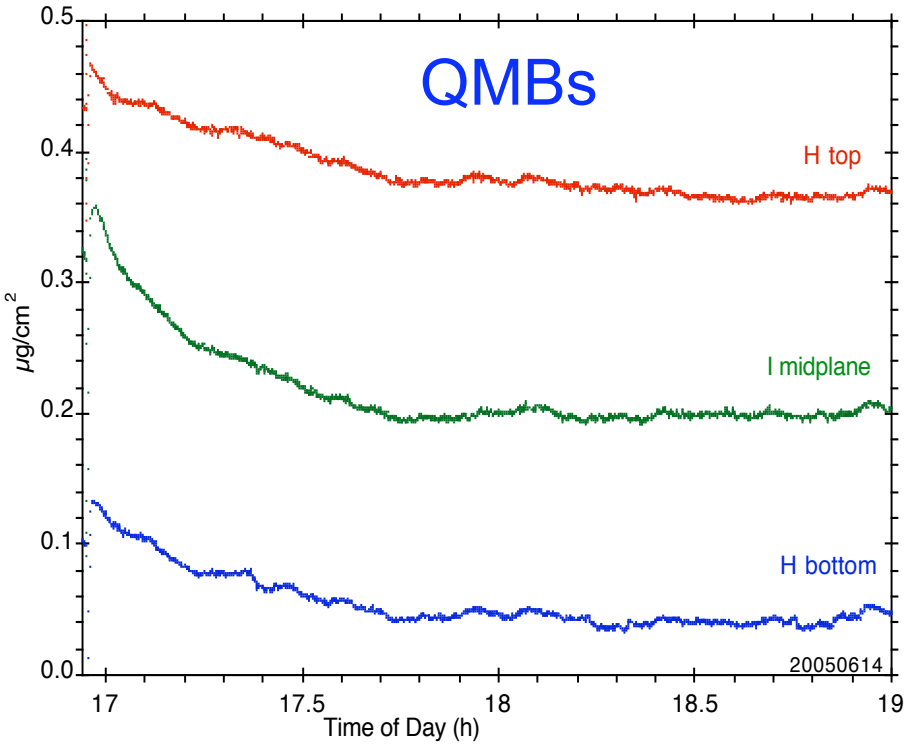
RGA, QMB, and ion gauge show > hour outgassing:

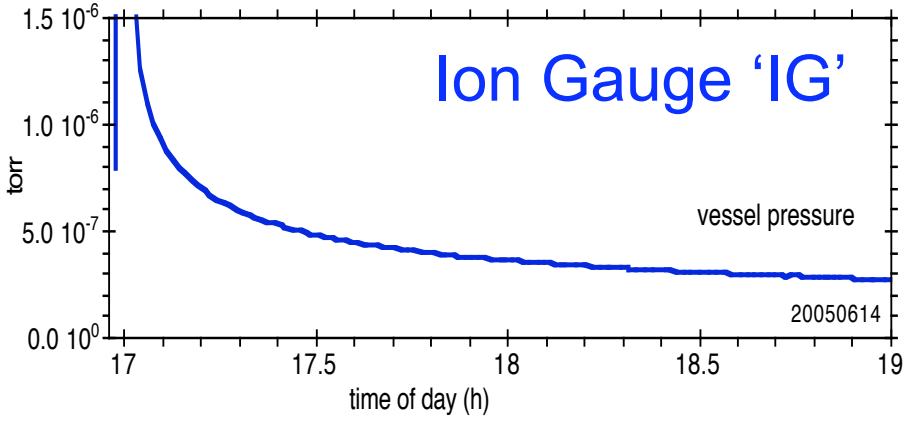
RGA



Mass
4 (D_2)
28 (CO)
18 (H_2O)
44 (CO_2)

12
14
40





2005 data

Uncertainties: ion gauges, sensotec :

- Retention is time dependent (outgassing after shot).
- Track vessel pressure over ~ 5 mins (compromise between sampling different conditions with different discharges and the hours/days needed for complete outgassing).
- Paul Sichta to provide data logging of ion gauges every 10 s.
- Uncertainties in absolute gauge calibrations and vessel and plenum volumes are not a factor.
- Average over bit noise to make most accurate ion gauge & sensotec readings (Rajesh IDL routine).
- Results of preliminary work to establish measurement uncertainty in gas-only shots (ideal result would be zero):

"Retention" Summary:	All gas-only shots	IG	IG_110	IG	IG_110
4/3/08		scope point	scope point	IDL	IDL
2-puff	128266 use as calib shot	0%	0%	0%	0%
2-puff	128267	2.78%	1.65%	0.59%	0.147%
4-puff	128268	1.97%	-0.33%	1.41%	-0.838%
4-puff	128269	2.30%	-0.45%	1.70%	-0.785%

Uncertainties- Gas composition

- Planned 2-shot comparison does not rely on absolute measurements of pressure or plenums - just sensotec/ion gauge linearity and tracking impurities.
- Gas calibration shots show 'IG_110' ion gauge linear to < ~ 1%
- Minimise secular changes by performing gas-only shots on run day.

'IG' measures total pressure - what about impurity gasses water, CO etc…?

- If impurities < 1% it would simplify analysis.
- If impurities > 1% need both RGA 'gauge factor' and ion gauge 'gauge factor'
- Gas-only 129269 mass 18 etc / mass 4 ratio ~ 0.3% (impurities negligible)
- Plasma exhaust: 128828 4/4/08 2MW NBI impurities < 1% on shot RGA !
- Will look for high power NBI shot too.
- Dana / Bill are working on RGA software and data archiving to MDS.

Tracking Helium (from HeGDC) ?

- RGA more difficult, mass 4 = both He/D_2 , need cracking pattern of He and D_2.
- Penning Gauges better - Vlad / Mark Cropper working on them.
- Can do 100% D or 100% He calib now - need to order gas mixtures for few% He in D.

- For absolute pressure calibrations a new 1 mtorr Baratron with fresh NIST calibration is required.

Shot list - 0.5 day (repeat with Li later):

Assume previous XP 807 ends with usual 10 min He-GDC.

Gas-only calibration (2-3 shots):

- 2 gas-only shots, check relative retention < 1%.
- If > 1% then vessel is still outgassing, one more gas only shot - then continue.

Discharge development (3-5 shots)

- use the RF conditioning shot #128133 for reference
- Drop Bt to 0.45 T
- Ramp down the current before OH runs out, e.g. at 0.5 sec. to make sure it is smooth
- NB valve is always closed. TMP valves close 30 s before shot. (RGA valve is open)
- TMP valves remain closed for 5 mins followed by HeGDC.
- Establish He-GDC needed for consistent discharges (5 mins ?)
- Repeat optimal Ohmic Discharge
- Gas-only calib. (total 7-10 shots so far)

RF discharges (5 shots)

- Three @ 0.65 MA, 1.5 MW RF power, (enough to get into H-mode?). Could use ohmic discharges as baseline, with steady RF power added during flattop and maybe part of rampup.
- Repeat gas-only calibration.
- Final RF discharge as above, no HeGDC following, leave all valves closed over weekend to track long term outgassing.
- If time runs out skip RF part, but finish with additional ohmic leaving valves closed.
- Repeat when LiTER operates and 10,20,30 mins after LiTER shutter closed. XP tbd.

Diagnostics:

"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." *(from milestone)*.

- Ion Gauges.
- Sensotec for Inj. #2.
- Trend RGA trend and shot RGA.
- Penning gauges.
- Infrared cameras
- Bolometers
- 1D Hα camera
- Quartz Microbalances.
- TS, CHERS, Midplane Langmuir Probe, GPI, Edge neutral density.

Pending:

- RF support Joel is available Fri PM
- *Extension of PE_102 record to 4 seconds ? (Paul Sichta)*
- *IG and IG_110 trending data (Paul Sichta).*
- *Penning gauge piggy back data on VIPS2 ? (Vlad / Mark Cropper).*
- *Penning gauge data from He & D gas-only shots. To be arranged for after 5:00 ?*
- *RGA data transfer to MDS tree. Data is on PC - transfer can be done later (Dana).*
- *Piggy back data on RGA impurity fraction with higher power NBI if available (Blanchard).*

Extras:

Model shot