Gas Balance in L-mode plasmas

Goals:

Accurate measure of (D retained)/(D input)----compare DIII-D and C-Mod
Measure of (D Retained)/(D^+ flux to wall)
Pumped and unpumped discharges

Implications:

Step 1: Simple as possible --- No pumping (Cryo's "warm", vessel turbo TIV's closed)
No beam heating (difficult to get accurate D input/exhaust from beams)—beam TIV's closed
Repeatable gas puffing programs.
Run multiple shots to search for wall equilibrium—no between shot He glow cleaning
D^+ flux from Langmuir probe Isat and $D\alpha$ monitors, attached divertors

Step 2: Add divertor cryopumping
Regenerate pump between each discharge

Step 1: Gas Balance in L-mode plasmas: No pumping case

Issues regarding plasma shape:

Good Langmuir probe data at OSP and ISP—this points to USN
Window frame requires 4 cm flux surface touching only at upper baffle knee
Want outer gap consistent with midplane probe plunge to separatrix
Want good core Thomson data in SOL

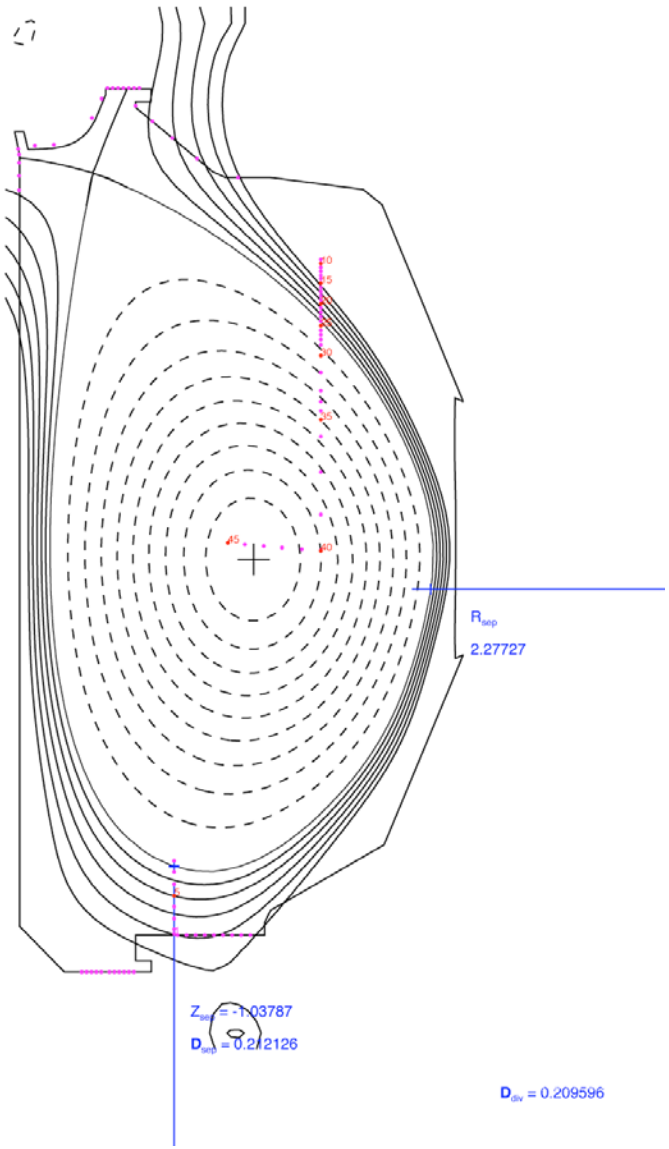
Shot 131235 is good USN, forward Bt case. OSP and ISP positioned on Langmuir probes,
Both ASDEX_upbaf and ASDEX_rdp working well,
Use probes on lower shelf for windowpane measurements.
GradB drift away from x-point-- high L-H transition
ExB drift pushs particles from inner to out divertor leg, probably changes co-dep on the ISP.
Lower Bt = 1.77 T, Keep Ip at 1.1 MA (q_{95} drops to 4.2).

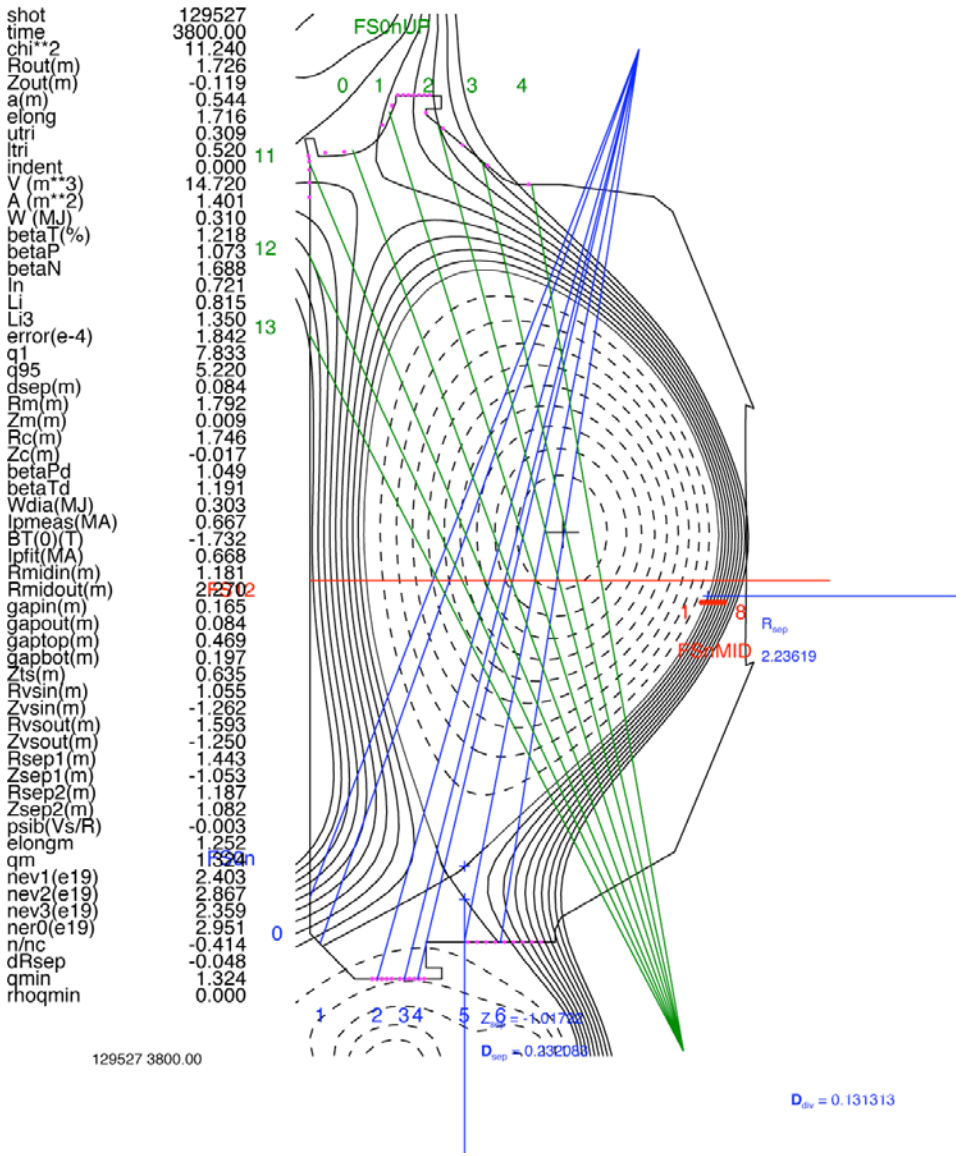
Shot 129527 C-Mode shape, not good for windowpane, LSN may be impossible to get
Langmuir probe data on both OSP and ISP.

THOMSON

shot	131235
time	3000.00
chi**2	24.124
Rout(m)	1.697
Zout(m)	0.017
a(m)	0.588
elong	1.823
utri	0.775
ltri	0.193
indent	0.000
V (m**3)	18.856
A (m**2)	1.834
W (MJ)	0.163
betaT(%)	0.360
betaP	0.224
betaN	0.395
In	0.912
Li	1.328
Li3	1.043
error(e-4)	9.847
q1	13.071
q95	4.817
dsep(m)	0.068
Rm(m)	1.734
Zm(m)	-0.096
Rc(m)	1.691
Zc(m)	-0.084
betaPd	0.264
betaTd	0.425
Wdia(MJ)	0.192
Ipmeas(MA)	1.080
BT(0)(T)	-2.007
Ipfit(MA)	1.076
Rmidin(m)	1.110
Rmidout(m)	2.280
gapin(m)	0.093
gapout(m)	0.068
gaptop(m)	0.116
gapbot(m)	0.187
Zts(m)	0.634
Rvsin(m)	1.016
Zvsin(m)	1.136
Rvsout(m)	1.346
Zvsout(m)	1.348
Rsep1(m)	-9.990
Zsep1(m)	-9.990
Rsep2(m)	1.241
Zsep2(m)	1.090
psib(Vs/R)	-0.072
elongm	1.282
qm	0.874
nev1(e19)	-3854.459
nev2(e19)	3.111
nev3(e19)	2.412
ner0(e19)	3.384
n/nc	-0.791
dRsep	0.400
qmin	0.874
rhoqmin	0.000

131235 3000.00




shot 129527
time 3800.00
chi**2 11.240
Rout(m) 1.726
Zout(m) -0.119
a(m) 0.544
elong 1.716
utri 0.309
ltri 0.520
indent 0.000
V (m**3) 14.720
A (m**2) 1.401
W (MJ) 0.310
betaT(%) 1.218
betaP 1.073
betaN 1.688
li 0.721
Li 0.815
Li3 1.350
error(e-4) 1.842
q1 7.833
q95 5.220
dsep(m) 0.084
Rm(m) 1.792
Zm(m) 0.009
Rc(m) 1.746
Zc(m) -0.017
betaPd 1.049
betaTd 1.191
Wdia(MJ) 0.303
Ipmeas(MA) 0.667
BT(0)(T) -1.732
Ipfit(MA) 0.668
Rmidin(m) 1.181
Rmidout(m) 2.270
gapin(m) 0.165
gapout(m) 0.084
gaptop(m) 0.469
gapbot(m) 0.197
Zts(m) 0.635
Rvsin(m) 1.055
Zvsin(m) -1.262
Rvsout(m) 1.593
Zvsout(m) -1.250
Rsep1(m) 1.443
Zsep1(m) -1.053
Rsep2(m) 1.187
Zsep2(m) 1.082
psib(Vs/R) -0.003
elongm 1.252
qm 1.324
nev1(e19) 2.403
nev2(e19) 2.867
nev3(e19) 2.359
ner0(e19) 2.951
n/nc -0.414
dRsep -0.048
qmin 1.324
rhoqmin 0.000
129527 3800.00
FS0nUP
0
1
2
3
4
11
12
13
0
1
2
3
4
5
6
7
8
FS2MID
2.23619
R_{sep}
D_{div} = 0.131313

Procedures:

No Helium glow cleaning between discharges. Do standard glow before daily reference shot, then no more Helium glow for the remainder of the day.

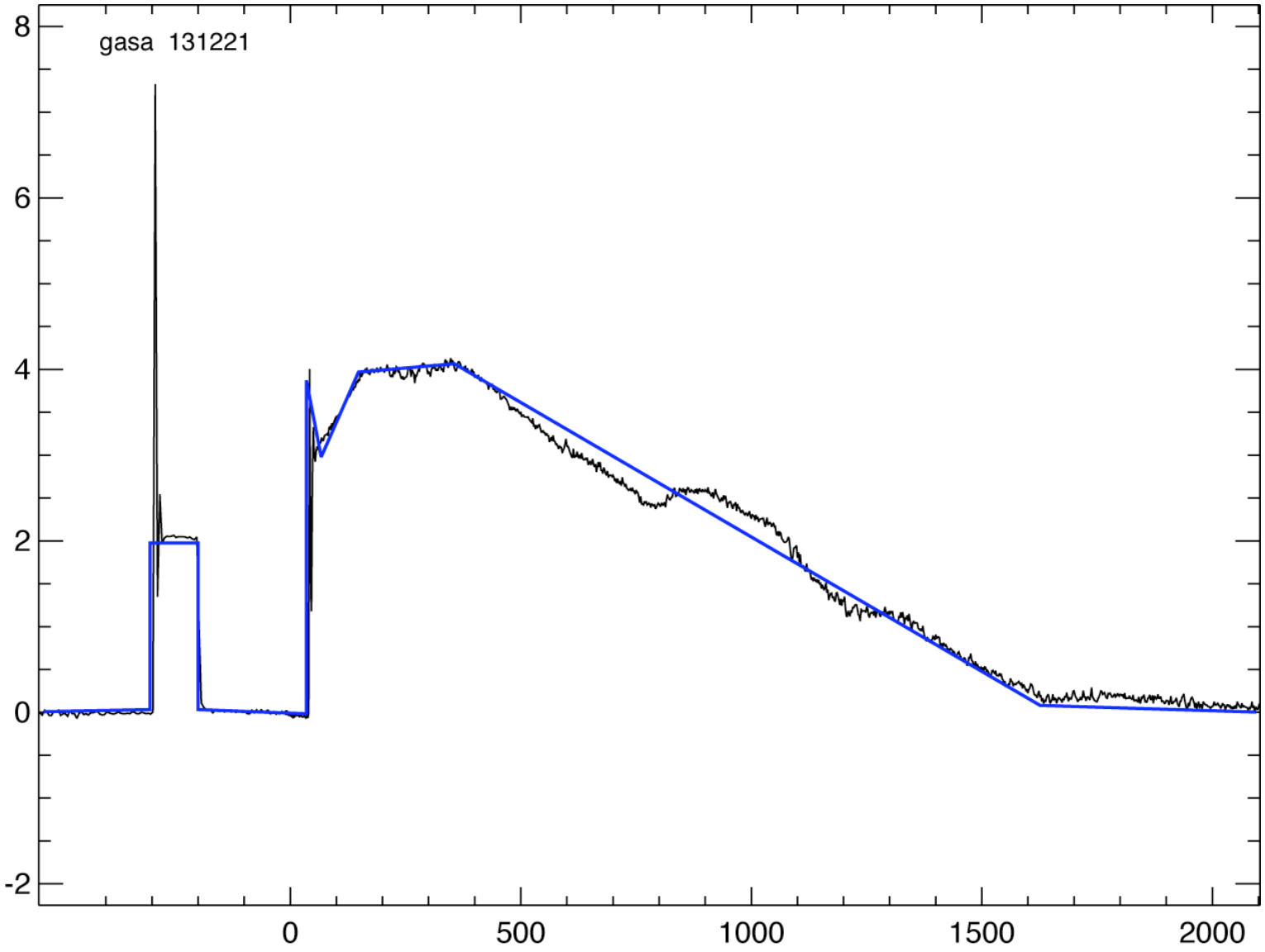
Upper cryopumps at room temperature or at LN2 ?

ADP cryopump at room temperature

No beams to avoid beam fueling and post shot exhaust, all beam TIV's closed.

ECH heating? Do we want ~0.5 MW ECH central heating to help keep OSP attached?

Need accurately calibrated gas puff, Use a pre-programmed gas puff that can be repeated with closed vessel and no plasma for benchmarking the gas input? Run three L-mode shots first with density feedback at $n_e/n_{GW} \sim 0.3$. Model preprogrammed gas puff from the third shot with feedback control. If density rises on a shot to shot basis, consider cutting back gas puff empirically (goal is to keep OSP attached).


gasa 131221
8
6
4
2
0
-2
0
500
1000
1500
2000

Tools:

ECH, one gyrotron, desired.
Bt flattop to 9.0 s (for ASDEX Gauge data after shot)
VPLOWS and PCM240TOR data for 10 minutes after shot.
RGA data with vessel pressure ~ 2e-3 torr.

Essential Diagnostics:

CO_2 interferometer
ASDEX_UPBAF, ASDEX_RDP
At least one of these two: ASDEX_PRI, or ASDEX_LOBAF
PCM240TOR or PCM105BAF
GASA_CAL (best possible calibration of GASA
Vessel Ionization Gauge (VPLOWS)
Upper Langmuir Probes + a few probes on the lower shelf
Upper Tangential TV (or upper IRTV if available)

Desired Diagnostics

Thomson (core, tangential, and divertor)
IRTV (upper or lower TBD)
Bolometry
RGA
CER
Fast Stroke Probes (Midplane and “X-point”)

Langmuir Probes in priority order:

61, 85, 83, 81, 79, 111, 107, 59, 65, 77, 75, 35, 33, 37, 31, 23, 19, 21, 27, 11, 71, 67

Prior Evening Checkout:

RDP and Upbaf Cryopumps and LN2 shields at room temp (or LN2)
ADP Cryopump at room temp.
VPLOWS, PCM240tor, rdpo_tout, on extended time domain for data acquisition
(out to 10 minutes)
Bt in desired direction
RGA set to store data between shots (mass scan from 2 to 50).

Morning Checkout:

Beam Line TIV's closed
ECH ready
Cryopumps in proper condition
Glow for 10 minutes, if in forward Bt then exhaust glow gas from manifold and lockout glow power supply

Shot Plan: USN, No Pumping

Gas Puffing Check:

Run gasa program and Bt as for shot 1 with no e-coil (no plasma current). All TIVs closed. Need all pressure measurements.

DRS: Daily Reference Shot

If forward Bt, the skip daily reference shot, if reversed Bt do a reference shot

If reversed Bt then 7 minute glow, exhaust He from gas manifold and lock out glow power supply

Shot 1: Reference shape is 131234.02050

Reduce Bt to 1.77 T and extend pulse length to 12 minute cool down time(allows more time for ASDEX gauges measurements after plasma is over)

Remove LOB1 and LOB2 puffs

Use preprogrammed gas puff derived from shot 131221 (see figure).

Move Ip rampdown to start at 4500 ms end at ~5500 ms (allows more time for ASDEX gauges measurements after plasma is over)

Modify zvsiu sweeps 1.132 to 1.117 to 1.153 to 1.132 m, rvsou sweeps 1.342 to 1.297 to 1.342 m.

Do these sweeps from 3.8 to 4.2 s

Between shot activities:

Keep all TIV's closed.

Monitor all pressure measurements for at least 10 minutes. If pressures do not come to equilibrium within 10 minutes on first shot, adjust data acquisition to allow for longer monitoring on next shot.

Record RGA data, mass 2 through 50, for 10 minutes (RGA may need conductance limiting aperture to work)

After 10 minutes, open TIV to vessel turbos and exhaust vessel.

Shots 2-10: Repeat shot 1.

If line average density begins to rise, adjust pre-programming for gasa to reduce fueling.

Continue between shot activities as above.