XP1065 **Methane injection to assess carbon impurity screening**

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Overview:

- We aim to assess the screening factor for carbon impurities originating from the midplane and divertor PFCs
- We plan to inject a set amount of deuterated methane from a lower dome gas injector and separately, inject methane from a midplane gas injector.
- We will compare the increase in core carbon density as measured by CHERS for a known injection of methane and compare the corresponding screening factors for the private flux region and outboard SOL.

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Theoretical/empirical justification:

- NSTX is considering changing the inner divertor tiles to Mo.
- Asdex has found the plasma core are dominated by midplane sources.
- Screening by the Asdex divertor is successful in keeping most of the impurities in the divertor region.
- NSTX has a more open divertor than Asdex, so in planning impurity control measures it is important to check how effectively the NSTX divertor screens impurities.

- *"…The outer divertor is by far the strongest source region, especially in discharges with high divertor temperature in- between ELMs.*
- *In the main chamber, the central column is usually the first limiting structure and produces then larger W erosion fluxes than the outboard limiters.*
- *Nevertheless, the tungsten influx from the outboard limiters has a much stronger effect on the tungsten content in the confined plasma…."*

Asdex: Dux PSI18 abstract JNM 390 - 391, 858, (2009)

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Experimental run plan <u>Pre-run calibration:</u>

1. Install CD_4 bottle to CHI branch 5 injector
2. Gas only test shots to inject a range from of CD4 from 0.01 torr-l to 1 torr-l.
3. Move deuterated methane for injector #3 midplane J lower. Set plenum pressure to 100 torr only.
4. Inj. #3 gas only test shots to inject a range of CD4 from 0.01 torr-l to 1 torr-l.
5. Adjust waveform to match time history of CHI gas injection.

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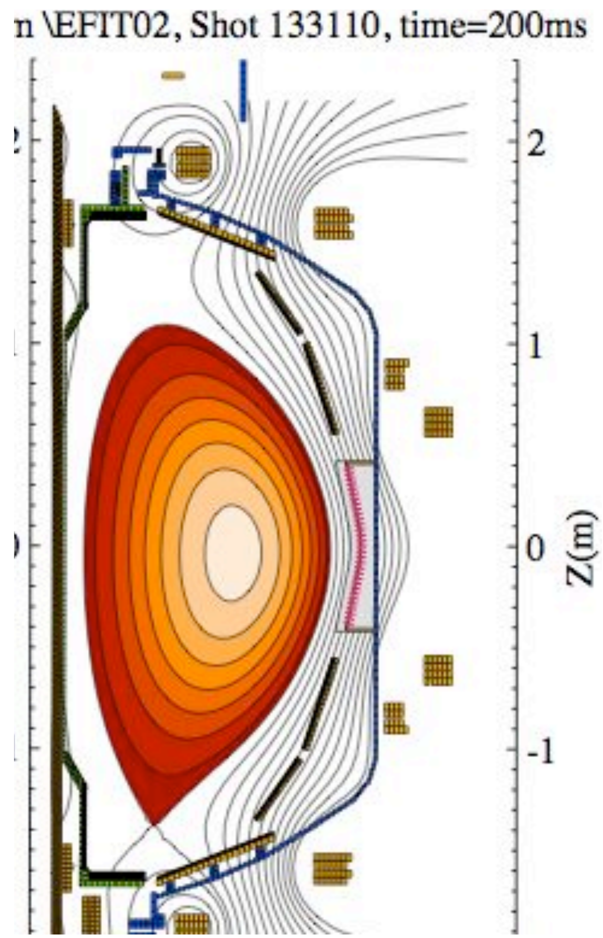
Experimental run plan Plasma ops:

1. Reproduce high performance, low triangularity fiducial with normal Li evaporation rate (20 mg/m for 10 mins)
   e.g. 133110 shape but longer pulse length
2. Inject X torr-l of CD_4 from lower dome branch 5 gas injector. Assess increase of core carbon density from CHERS diagnostic.
3. Increase methane injected until increase of core carbon density is measurable. Repeat final setting (5-7 shots total)
4. Controlled access to switch CD_4 bottle to midplane gas injector (2nd CD4 bottle would allow 4-5 more shots)
5. Inject X torr-l of deuterated methane from midplane gas injector. Assess increase of core carbon density from CHERS diagnostic. Repeat final setting (5-7 shots total)
6. Increase methane injected until increase of core carbon density is measurable.



Total shots 14 + controlled access anticipate ~ 1/2 day.

Options with more time:

- Compare with / without lithium (R.R. concern on reproducibility without Li)
- Inject CD_4 from CS shoulder injector (R.R. concern on time constants)
- RR suggests repeating midplane, then lower dome inj. 1,2,3 into private flux.

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4. Required machine, NBI, RF, CHI and diagnostic capabilities

- LiTER operating.
- CHERS
- ERD for CIII emission
- VIPS, D-alpha camera, Divertor spectrometer (DIMS), TGS, SPRED, LOWEUS, XEUS filterscopes, chord Z-eff.
- No RF, No CHI no LLD needed.

5. Planned analysis

- Compare screening factor (gas in / change in total carbon in plasma) for private flux and outboard SOL.
- MIST analysis.

6. Planned publication of results

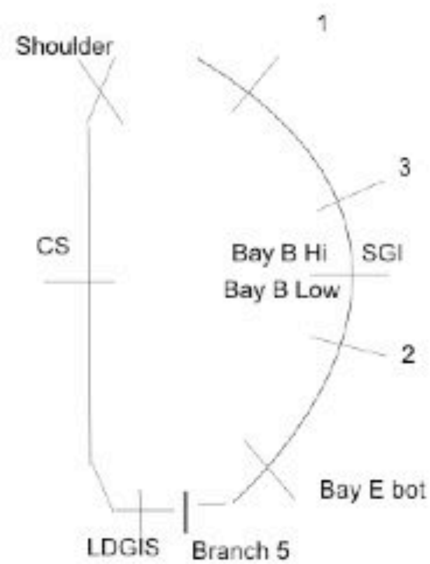
- DPP APS 2010, PoP

Extras:

NSTX Gas injection:

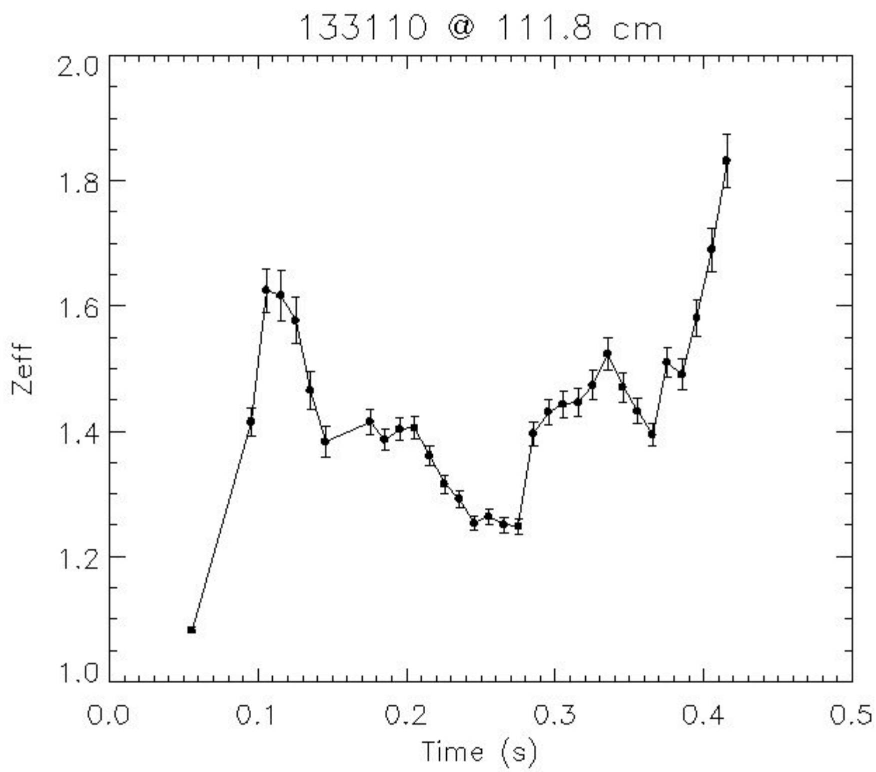
Update No. 6 (June 7, 2010)

Plenum name	Volume in (cc)
NSTX vessel	**28,712 Liters 156 Liters (0.5%)**
Bay K Top – Inj 1 (PZV control valve)	89.08 0.03 cc
Bay J Mid/Lower – Inj 2 (PZV cont valve)	72 CC (STARTING May 2, 2002)
Bay-J Mid/Upper – Inj 3 (PZV cont valve)	70 CC (starting May 2, 2002)
Bay-E bottom (PZV puff valve)	Can put several pulses
SGI – (PZV puff valve)	
LDGIS (new small plenum) to Fy 03 Starting Fy 04 – Inj 4 Bay C – AV120 – 9.26cc Bay I – AV121 Bay F – AV122 Branch 5 – 1.3cc (Bay K bottom) from 5/2/2006	73.48 0.4 cc ~4x9.26 = 37.04 cc
Bay B Hi Flow –Ricky – NuPro – single pulse	26.85 0.5 cc
Bay B Low Flow (Ar): Nupro – single pulse	67.08 0.8 cc
CS – Inj. 4	
Shoulder – Inj. 4	

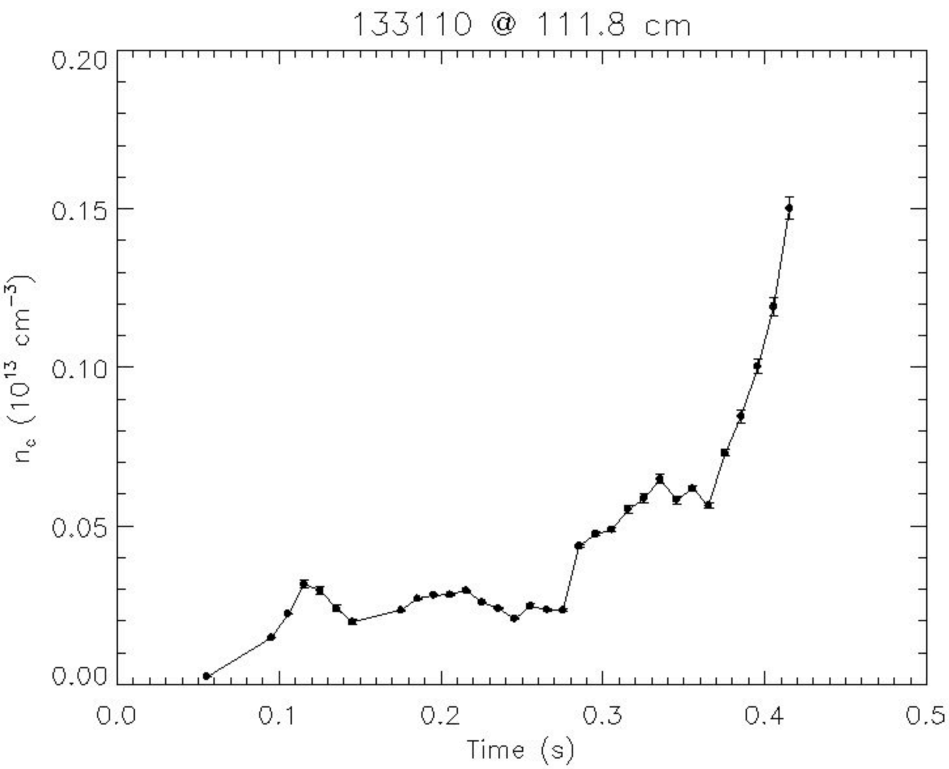


Extras: 133110 waveforms

Z-effective



Carbon density



Integrate to identify effect of puff ?

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Comparison of source strengths and fueling from main chamber PFCs

IPP

radial sweeps of outer plasma radius at two puff levels

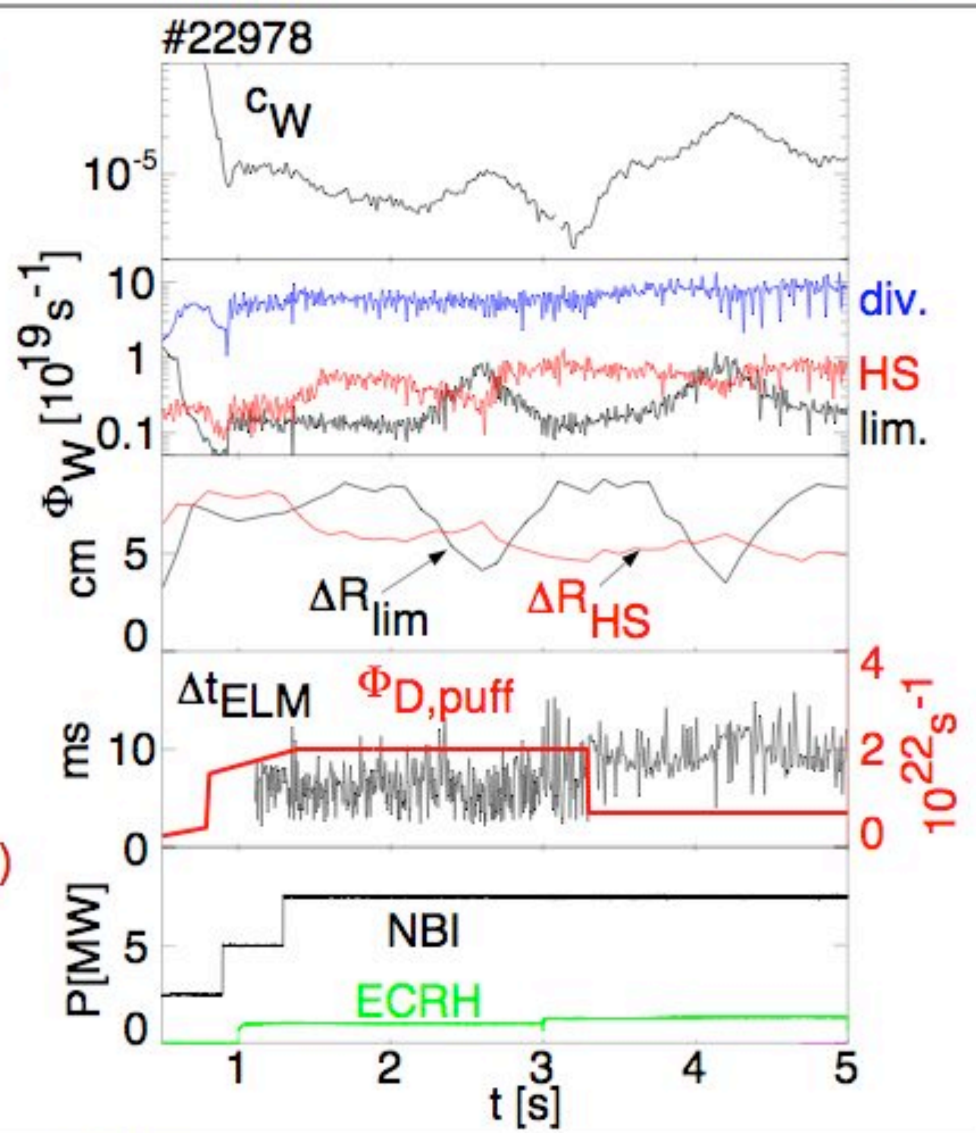
divertor source dominant

limiter source becomes largest main chamber source when ΔR_lim < ΔR_HS

tungsten concentration modulates with the limiter source

mean tungsten concentration increases with the ELM period (ELM period is controled by puff level)

(no ICRF heating in this discharge)



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Conclusion

ASDEX Upgrade has succesfully started the second experimental campaign with a full tungsten wall without using boronisations.

- The outer divertor is the strongest tungsten source, followed by the central column and the outboard limiters.
- Erosion during ELMs is usually the major erosion mechanism.
- The low-field side limiters are most efficiently fueling the plasma.
- Control of the impurity transport in the plasma centre (ECRH) and in the H-mode edge barrier (ELM frequency) allows to achieve H-mode discharges with H-factor=1.2 and W concentration below 2E-5.

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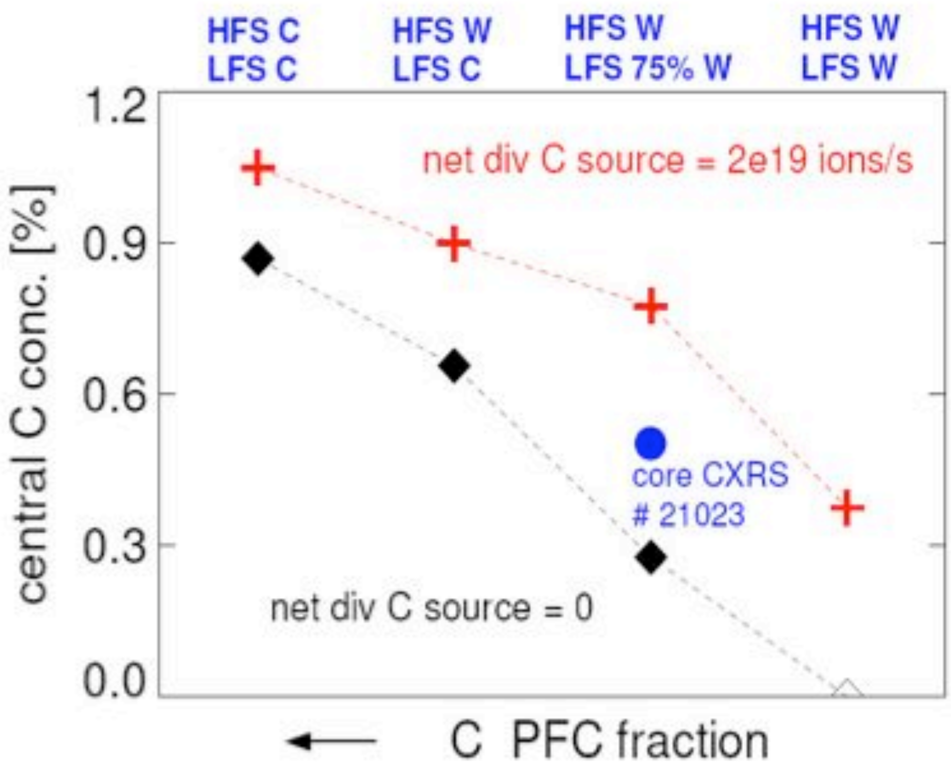
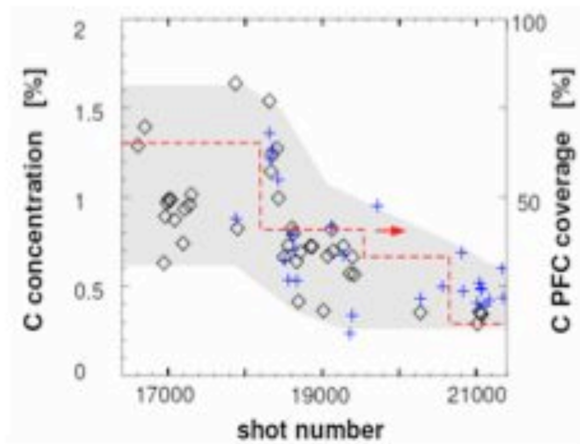
Modelling the effect of increasing W coverage on carbon conc.

IPP





C area (fig. 1):	1	0.65	0.15	0
flux weighted:	1	0.33	0.1	0

- slow decay of the carbon concentration with increasing W surface fraction
- net divertor source becomes important with diminishing C PFC area