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Deposition of ^{13}C from injected methane in L- and H-mode plasmas in DIII-D

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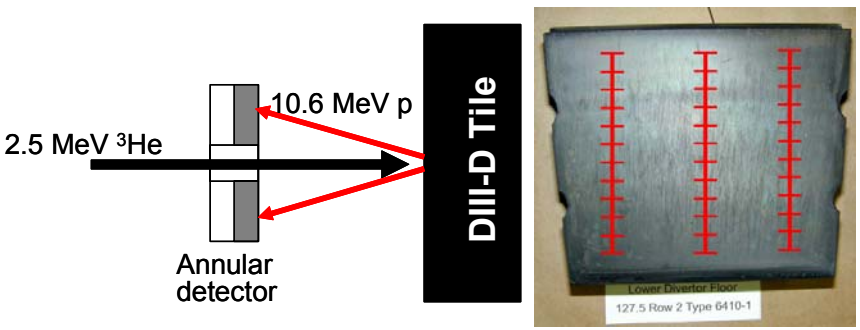
Introduction

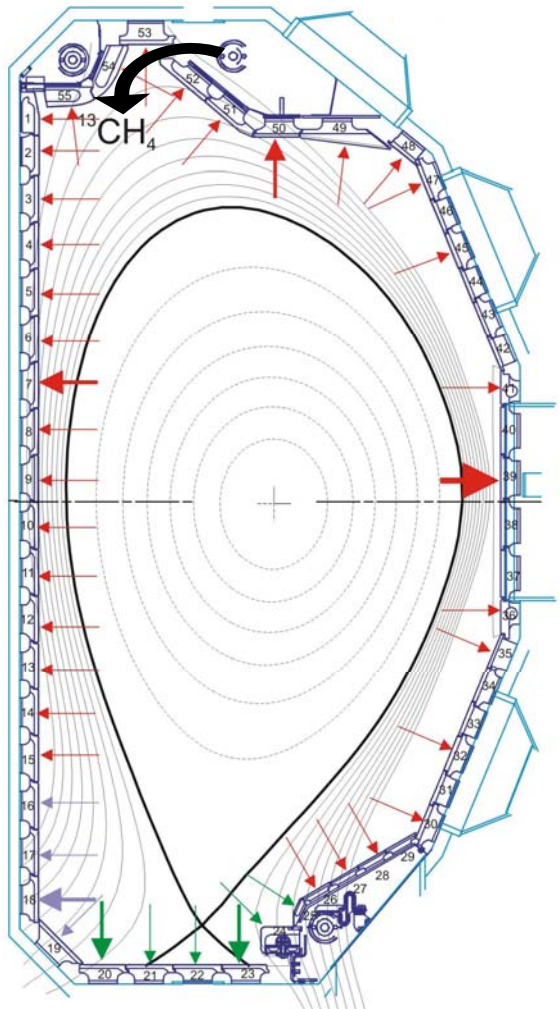
- Plasma-wall interactions with carbon PFCs produce hydrocarbons in the main plasma chamber, which dissociate in the SOL and deposit back onto plasma facing surfaces along with DT. - Where?
- Controlling carbon erosion and redeposition is critical for managing tritium inventory in tritium fueled devices with carbon PFCs such as ITER.
- Experiments are being conducted in DIII-D to determine where this carbon redeposition occurs.

Experiments

- $^{13}CH_4$ was injected from the upper divertor plenum into lower single null divertor plasmas at a rate that did not significantly perturb plasma conditions. (toroidally symmetric injection).
- This plasma geometry, and location of injection far from the divertor, were chosen to simulate methane originating from plasma interactions with carbon on the main chamber wall.
- Tiles were then removed for nuclear reaction analysis of ^{13}C deposition.
  $^{13}C(^3He,p)^{15}N$ Sandia National Laboratories
  $^{13}C(p,\gamma)^{14}N$ University of Wisconsin



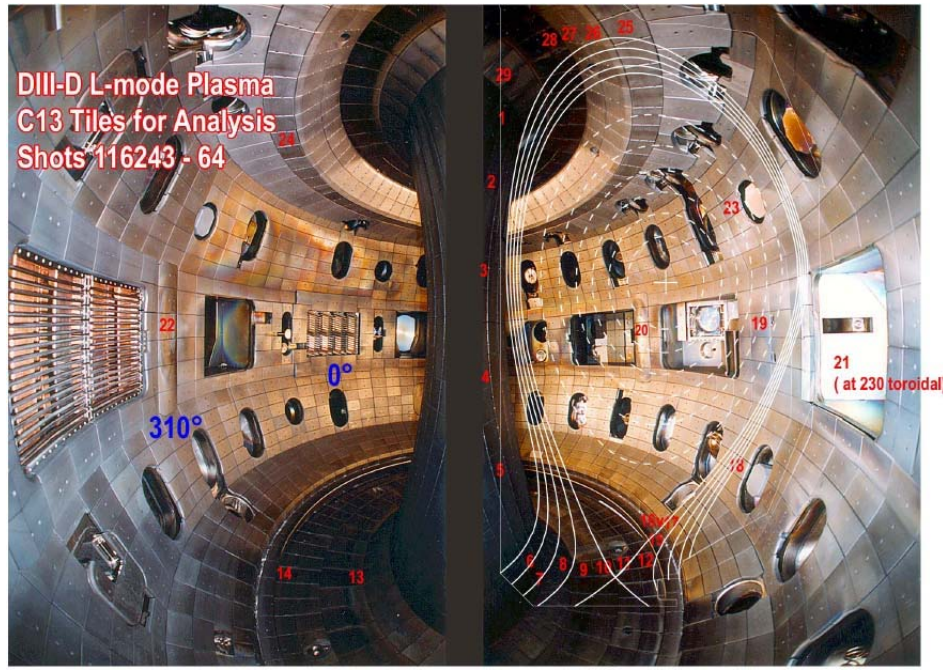
$^{13}CH_4$ injected into the top of LSN plasmas



Arrows indicate tiles removed for analysis

$^{13}C_4$ Injected into L-mode & H-mode plasmas

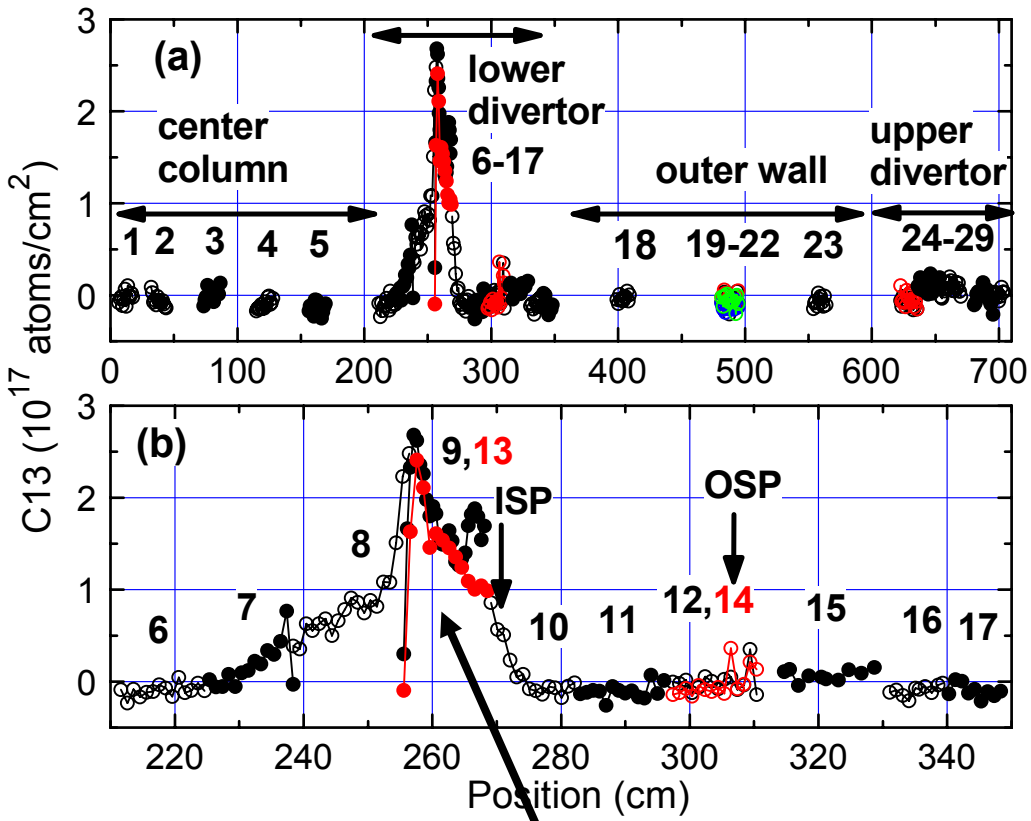
Year	2003	2005
Plasma	SAPP L-Mode	PDD ELMy H-mode
Repeat shots	22	17
Power (MW)	0.17	6.6
^{13}C injection * (10^{22} atoms)	1.0	2.2
Tiles removed	29	77

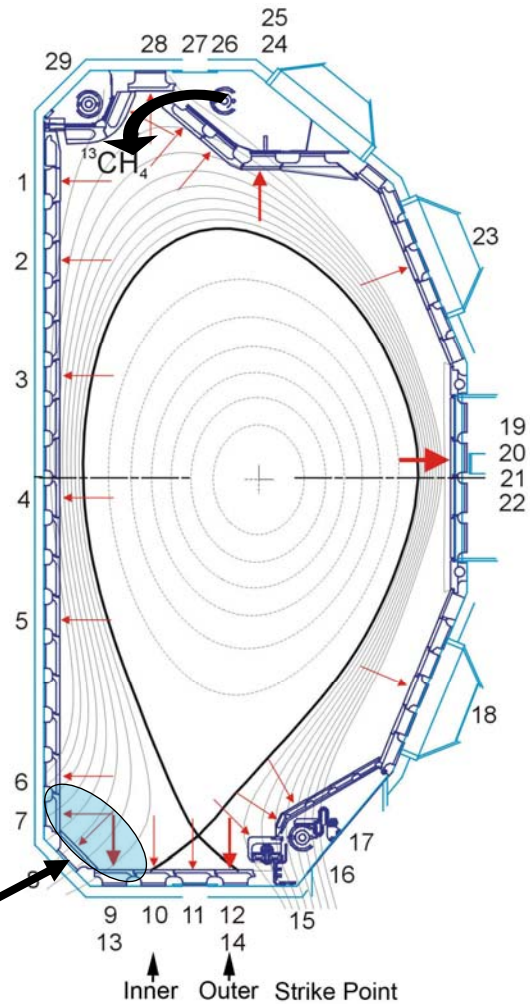


Divertor & SOL plasma characterized by Langmuir probes, Thompson scattering, spectroscopy, heat flux by IRTV.

* 10^{22} carbon atoms deposited uniformly in DIII-D is about 10^{16} atoms/cm^2 or 1nm of carbon.

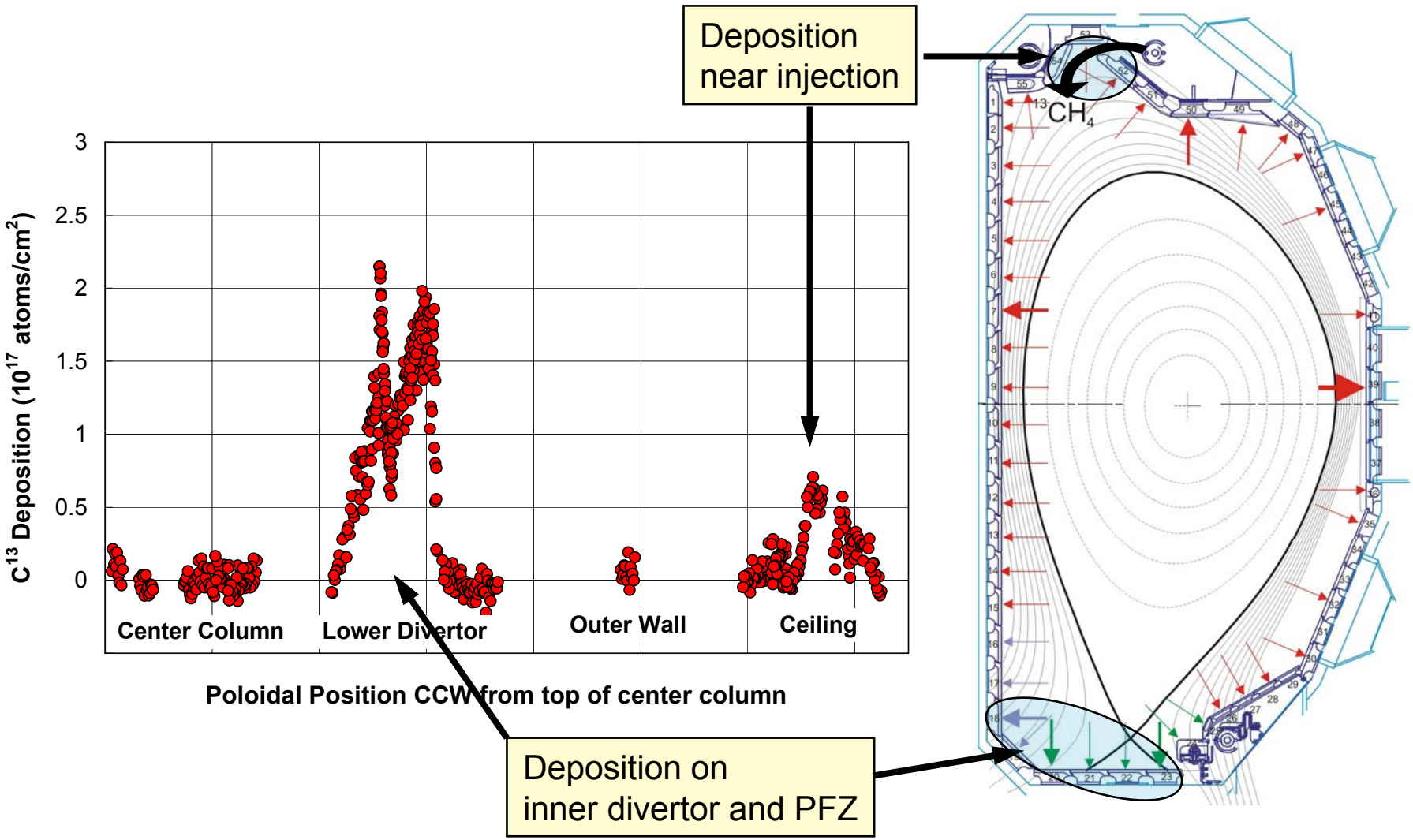
Results: L-Mode 2003





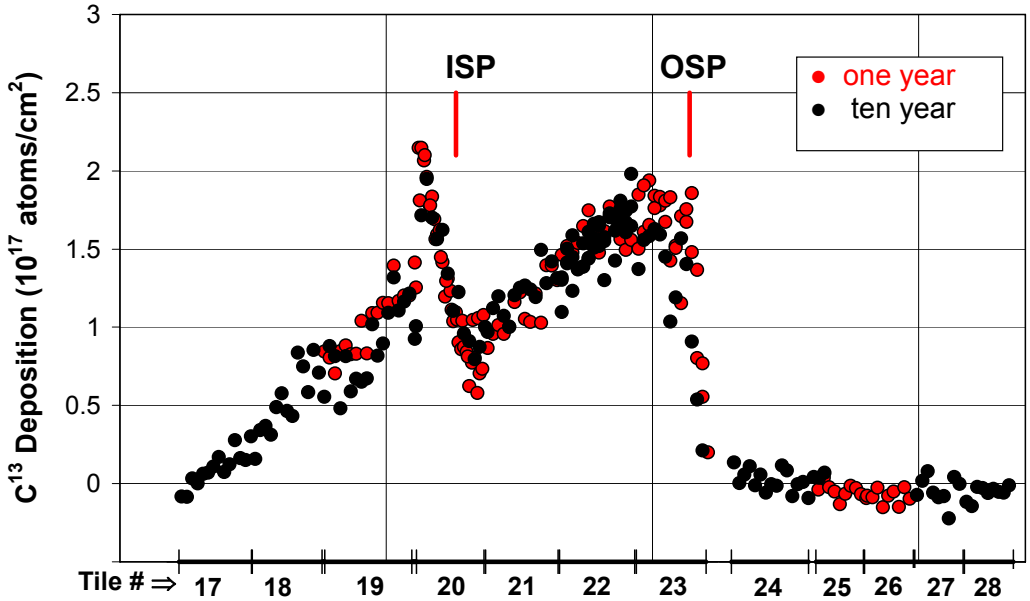
^{13}C deposition heaviest near inner divertor

Results: H-Mode 2005

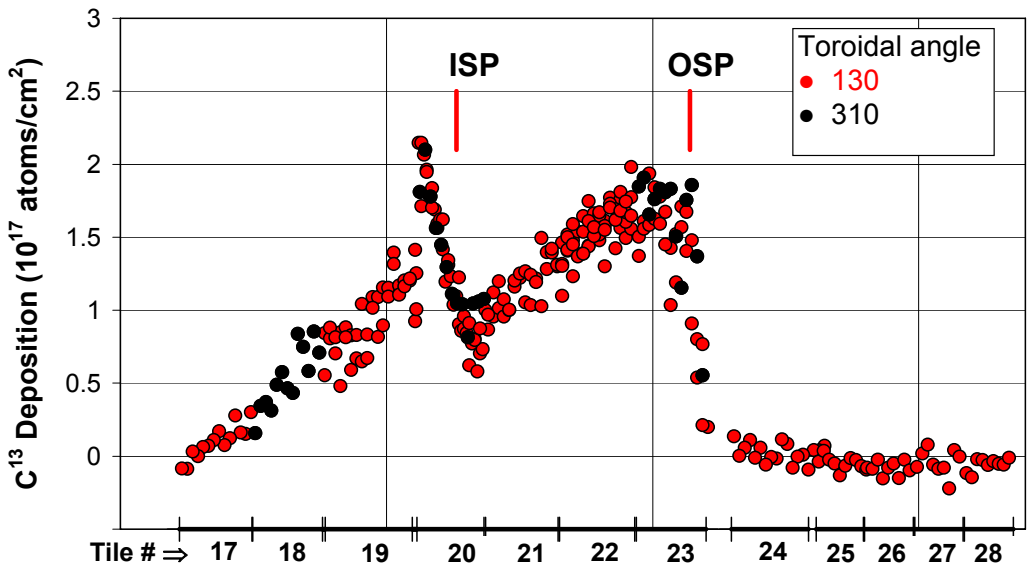


Results: H-Mode 2005

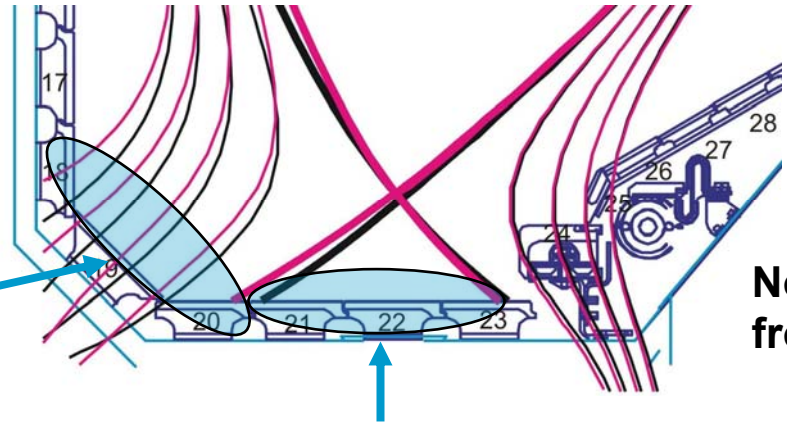
^{13}C deposition was the same on tiles that had been in DIII-D for 10 years or only 1 year



^{13}C deposition was Toroidally symmetric



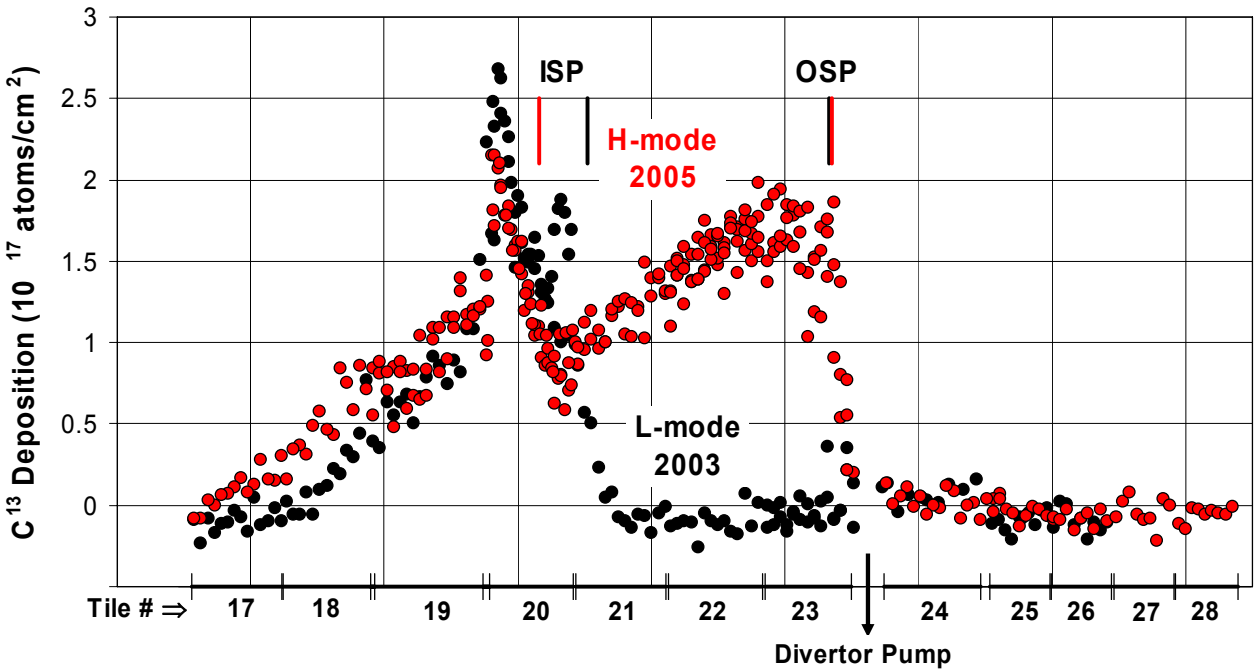
H-mode vs L-mode : Lower Divertor



Deposition at inner leg from L-mode (30%) and H-mode (13%)

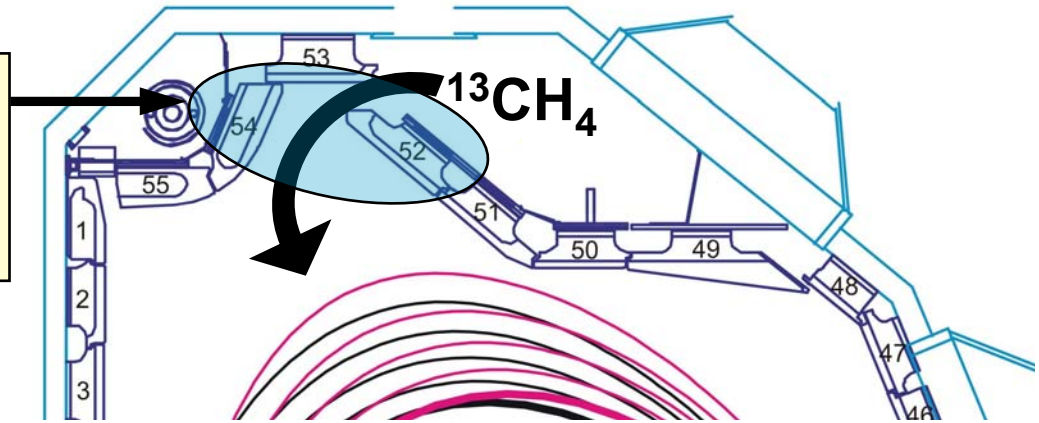
No deposition at outer leg from L or H-mode

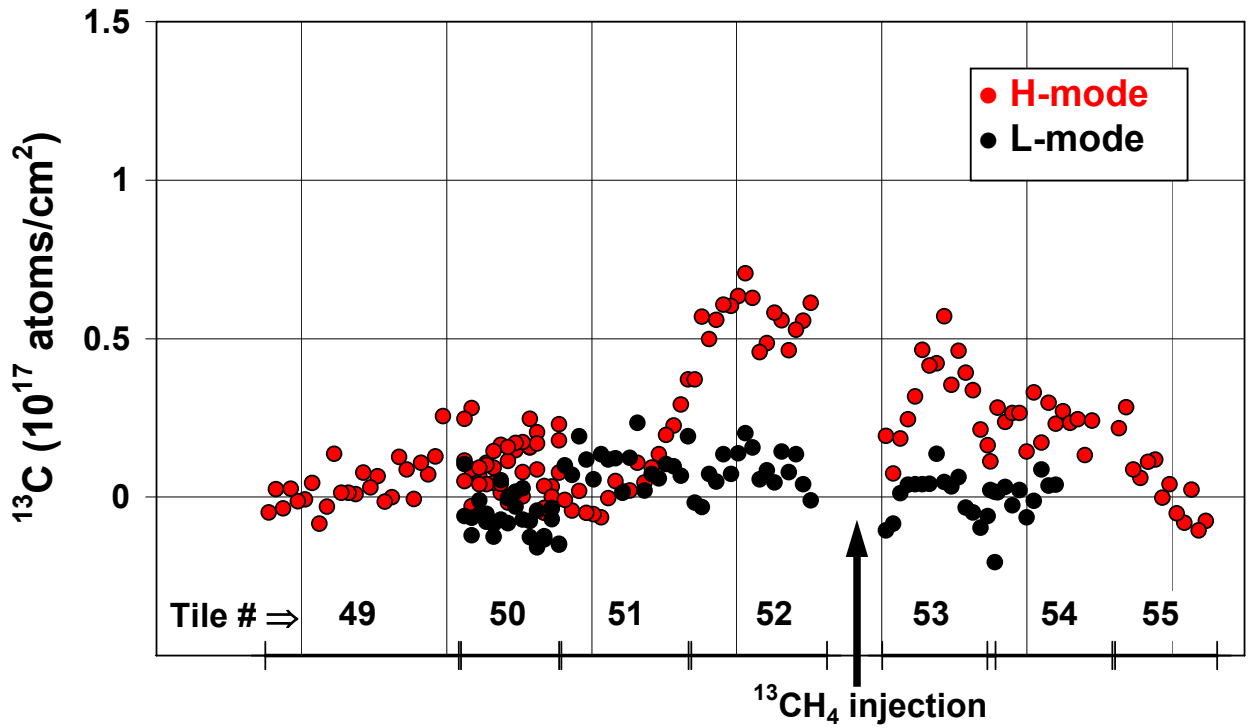
Deposition in the PFZ from H-mode only (24%)



H-mode vs L-mode : Ceiling

^{13}C deposition observed near region of injection from H-mode (8%), but below limit of detection by $^{13}C(^{3}He,p)^{15}N$ NRA for L-mode.





Conclusions : Impurity Transport

- Some local ^{13}C deposition occurs during initial breakup of injected $^{13}CH_4$.
- Observed asymmetry between ^{13}C deposition at inner and outer divertors is consistent with previous observations (e.g. JET, ASDEX-U) that detached inner divertor is often a region of net carbon deposition.
- Inner divertor plasma is cooler than outer divertor plasma (both L- and H-mode), may influence C deposition.
- In L-mode, CII and CIII emission are shifted toward inner SOL consistent with carbon transport due to poloidal plasma flow from outer to inner SOL, however a similar shift is not observed for H-mode.
- OEDGE and DIVIMP models reproduce observed ^{13}C deposition pattern and shifts in C emission with fast flow (M~0.4) in SOL towards inner divertor for L-mode.
- Models so far do not explain ^{13}C deposition in PFZ for H-mode but not L-mode.