Tritium Retention in TFTR

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38th Annual Meeting of the Division of Plasma Physics

Denver Co, 11-15 November 1996.

Motivation:

Tritium inventory,

Radiological hazards,

Fueling requirements

- remain highly uncertain for ITER.

More data in reacting plasma environment is needed to make high confidence decision on plasma facing materials.

TFTR has 3 years of experience with a carbon wall that experiences erosion, codeposition from DT plasmas:

841 D-T discharges

861 kCi (90 g) of tritium safely processed.

Outline:

Tritium retention in TFTR.

Tritium removal from TFTR.

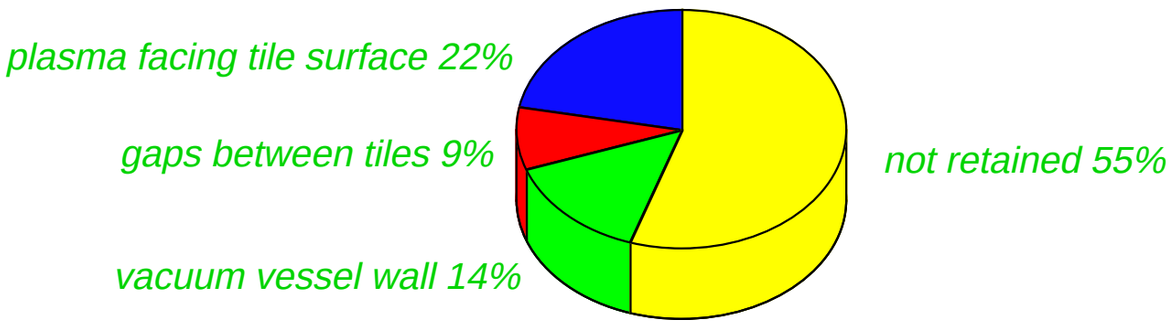
Materials studies - in progress.

Where is the tritium in TFTR ?

TFTR

Major repository is codeposited tritium and carbon.

Direct pre-DT measurements of *deuterium* in tiles available:



- Long term D retention varied 22%-63% depending on average beam power.

Tritium Global Accounting during DT period:

TFTR

Nov. 1993 - Oct. 1996:

861 kCi processed

668 kCi supplied to Neutral Beams

25 kCi entered torus (96% of T recycled on cryopanels)

15 kCi recovered from torus.

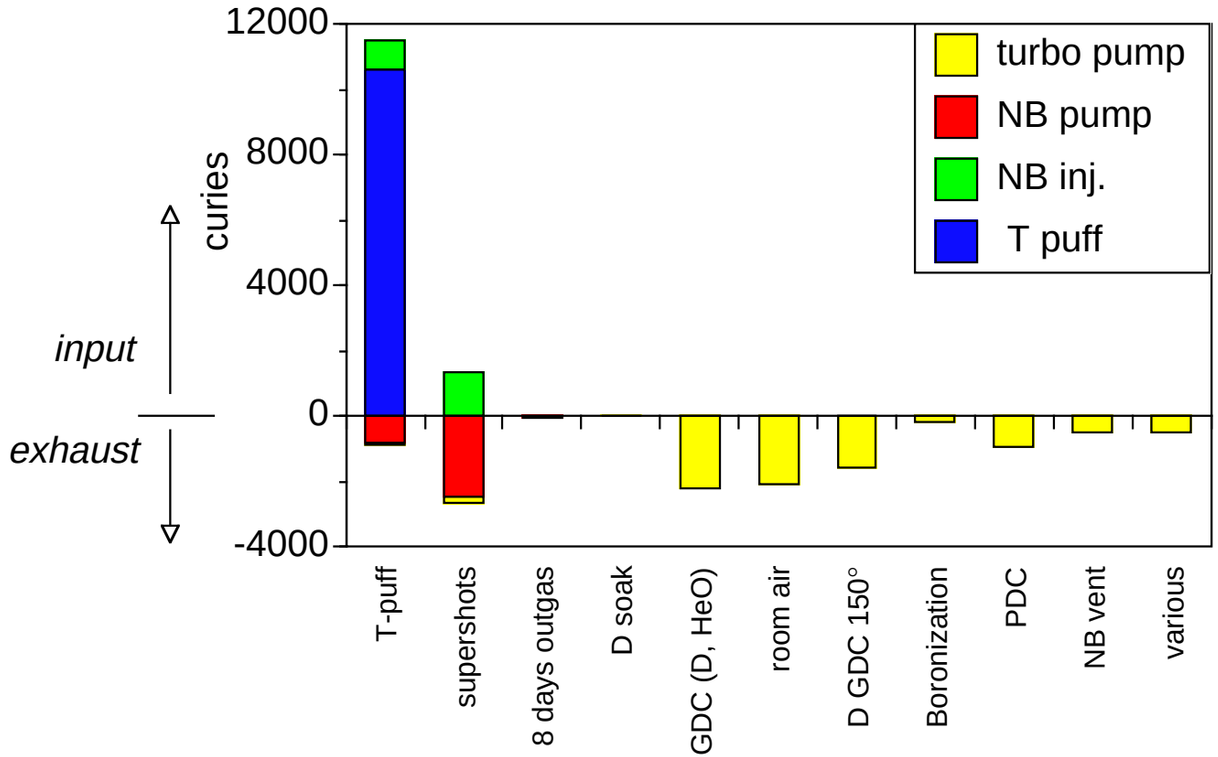
10 kCi retained.

- Long term retention of tritium is 40 %, consistent with earlier D measurements.
- Short term retention can be much higher
  (First day of strong T gas puff: retention ≥90%)
- Tritium removal rate with HeO glow: 0.004nm/s
  20x less than lab. measurements (Hsu).
- Overall fueling T/D ratio 3%.

J. Vac. Sci. Technol. A14 (6) Nov/Dec (1996)

Short term tritium retention high with strong tritium puffs

TFTR



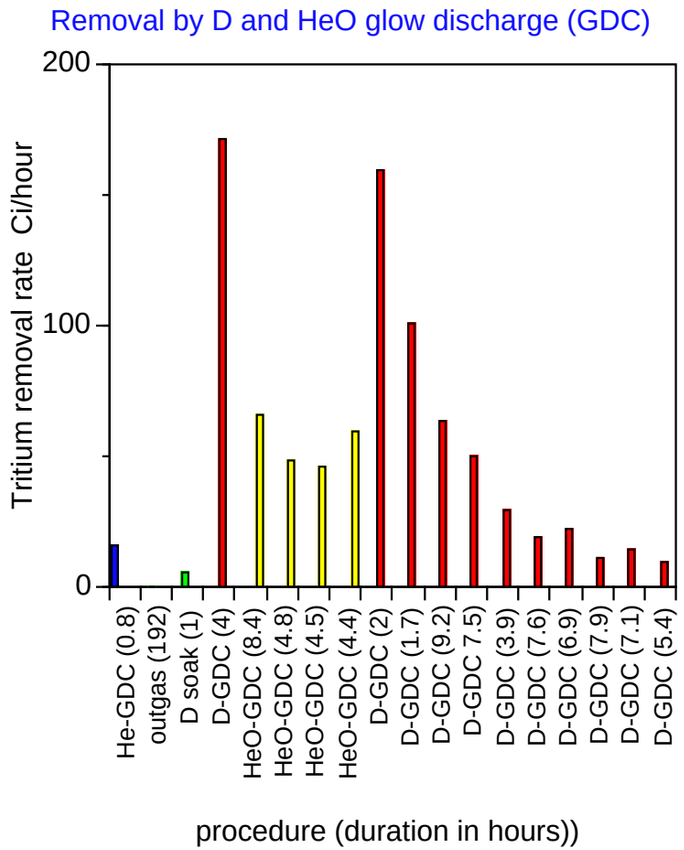
Tritium fraction maximized for L-mode study, (September 1995)
Short term retention >90%

Tritium successfully removed by combination of glow discharge (D and HeO), room air, and pulsed discharges.

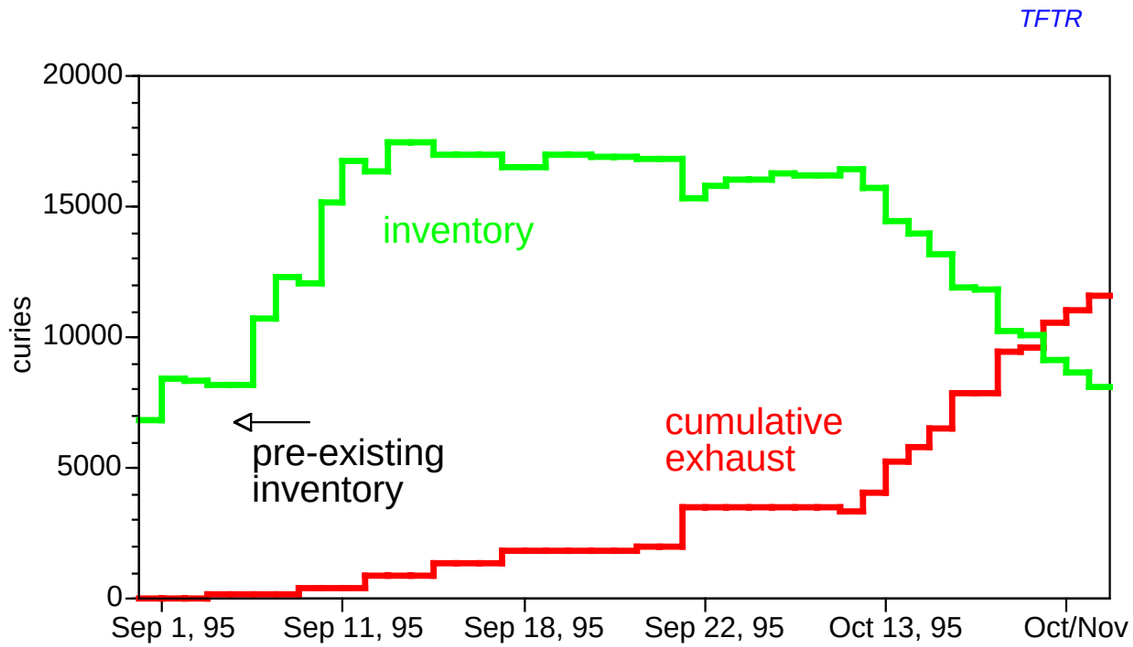
Comparison of tritium removal techniques, (1995)

TFTR

He-GDC, outgas, D soak	Ineffective
D-GDC	Initial removal rate high (>170 Ci/hour), declining to 10 Ci/hour. Accesses only tritium on surfaces exposed to discharge.
HeO-GDC	Rate ≈ 50Ci/hour - constant with time
room air	2,086 Ci removed, access to all surfaces
Disruptions	Flash heating of limiter surface near midplane. - Release of recently retained tritium.
Pulse discharge cleaning	Heats limiter to 250° C. 956 Ci removed over 23 hours.
Boronization	Little tritium released, most near surface tritium already removed.



Increased tritium inventory successfully removed



Inventory increased from 6,800 Ci to 17,500 Ci with tritium puffs

Short term retention high
- active removal effective in reducing inventory.

Tritium continues to be released at low level in any plasma operation

First in-vessel maintenance after extensive DT operations

TFTR

- Changeout of RF antennas and diagnostic windows
  - Vessel open for first time in 3 years
  - No personnel entry to vessel.
- Tritium removal sequence:

  Deuterium glow discharge cleaning at 150°C.

  Pulse discharge cleaning at 150°C .

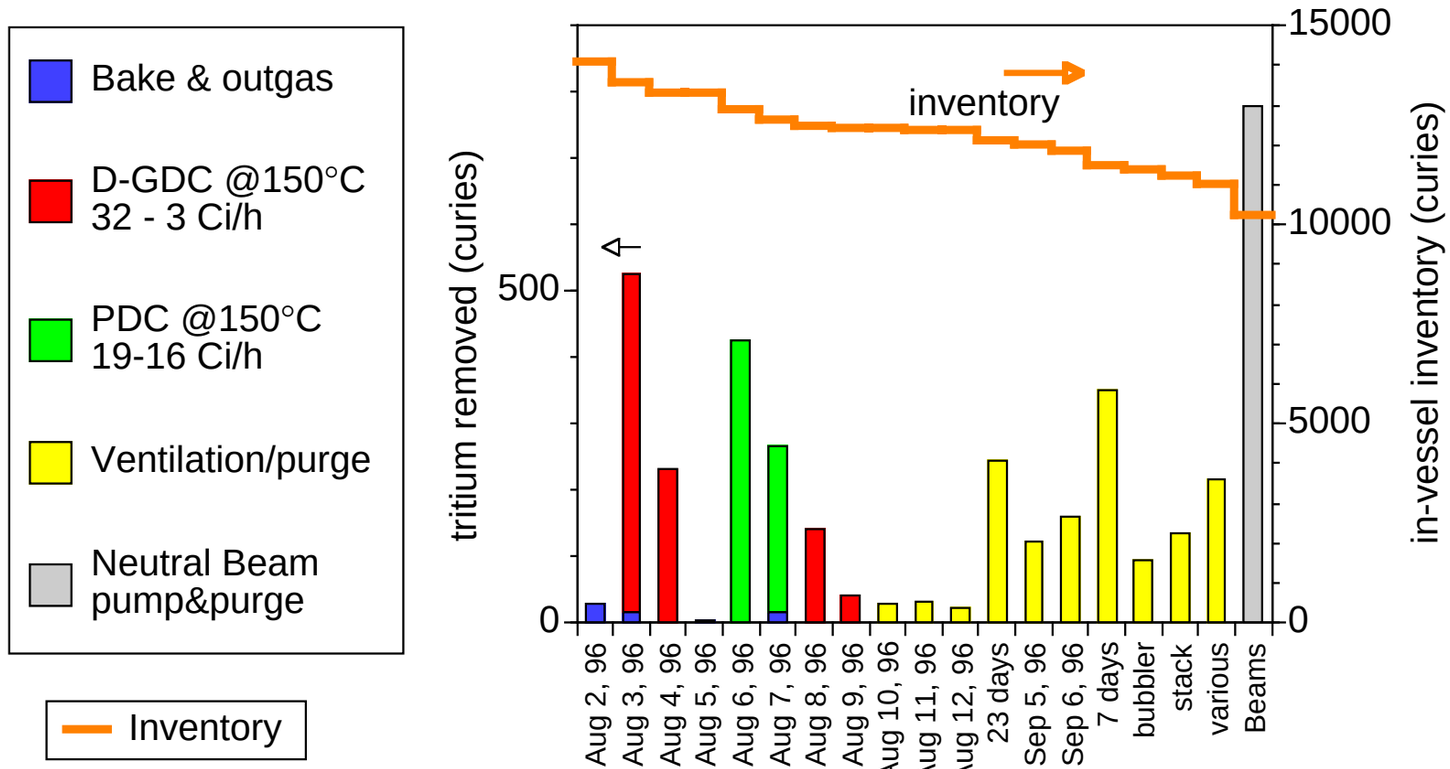
  Room air purges: 5x @ 20 torr, 2 x @ 740 torr.

  Continuous flow of room air through vessel.
- Tritium released to in-vessel air reduced to ≈ 4 Ci / day.
- Personnel radiation exposure well within PPPL administrative limits:
  2.2 person-rem in 1996 to date, mostly from activation.
  (similar to CY 1994 and 1995).

D Mueller poster, Monday,

Tritium removal for 1996 in-vessel maintenance.

TFTR



Personnel radiation exposure mostly from activation, not from tritium.

Chemical analysis of lithium from limiter surface

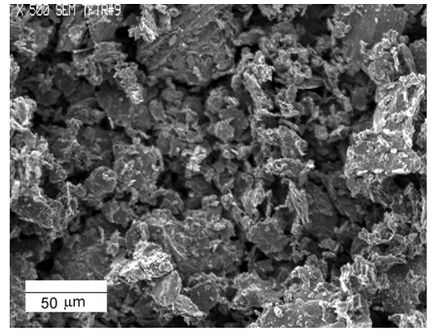
TFTR

Motivation:

- Lithium conditioning has dramatically improved TFTR performance.
  - understanding of mechanism has yet to be demonstrated
  - chemistry, atomic & molecular physics, surface physics and plasma physics involved.
- Chemical state of lithium in limiter important
- Samples from lithiumized limiter have been obtained by micro-machined sampling disk on 10 foot pole.
  - to be analyzed with X-ray Photoelectron and Thermal Desorption Spectroscopy at U.C.S.D.

RELATED POSTER: [6Q.11] 'Development of Lithium Deposition Techniques for TFTR'

ORAL [7F.11] 'In-Vessel Component Materials .....'



Electron Microscope image of sample from tile

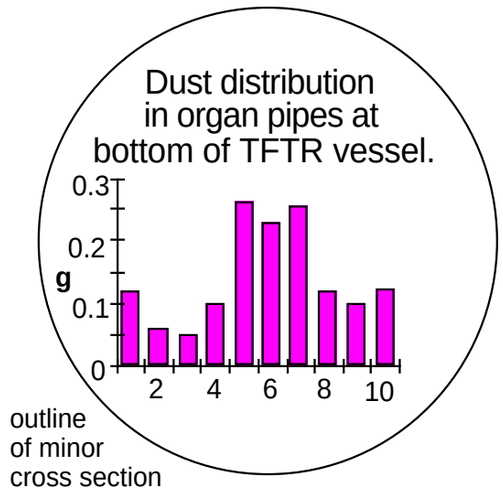
No digitized data available Hard copy only

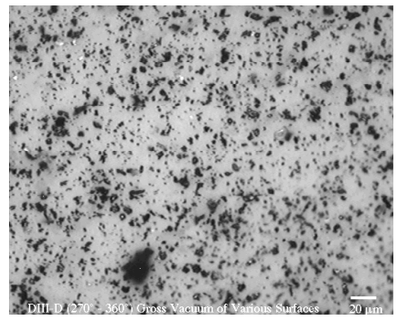
Energy-Dispersive X-ray analysis of initial sample from unused tile (lithiumized sample in progress)

Sampling of TFTR dust for ITER safety analysis

- Dust is a high radioactive source term in ITER.
  Mobile with accidental water or air ingress.
  Safety issue because potential steam reaction produces hydrogen.
- 1992 measurements of dust vacuumed from TFTR were in ‘several kilogram’ range, extrapolating to hundreds of kG for ITER.
- Recently, 1.3g of dust collected from 10 windows at bottom of TFTR vessel.
  Total dust inventory uncertain but likely reduced order of magnitude by improved limiter alignment and CFC tiles.
  - good news for ITER !
- Dust samples taken from interior surfaces.
  Particulate size measurement in progress.

TFTR





Particulate from DIII-D
Carmack *et al.*
4th Int. Symp. on Fusion Tech.

Summary:

- Safe operation with DT plasmas and first in-vessel maintenance of tritiated machine demonstrated.
- Tritium retention and removal measured in environment of reacting DT plasmas.

  Global retention around 50%
  - dependent on discharge history.
  Tritium removed by deuterium glow, pulse discharge and air ventilation.

- Studies of lithium chemistry in graphite and dust in progress.

- Low level of dust is good news for ITER

More information: J. Vac. Sci. Technol. A14 (6) Nov/Dec (1996).
PSI '96 - Proceedings, J. Nucl. Mater. (1997)