On the irrelevance of W and other metals in the physics and operation of present tokamaks

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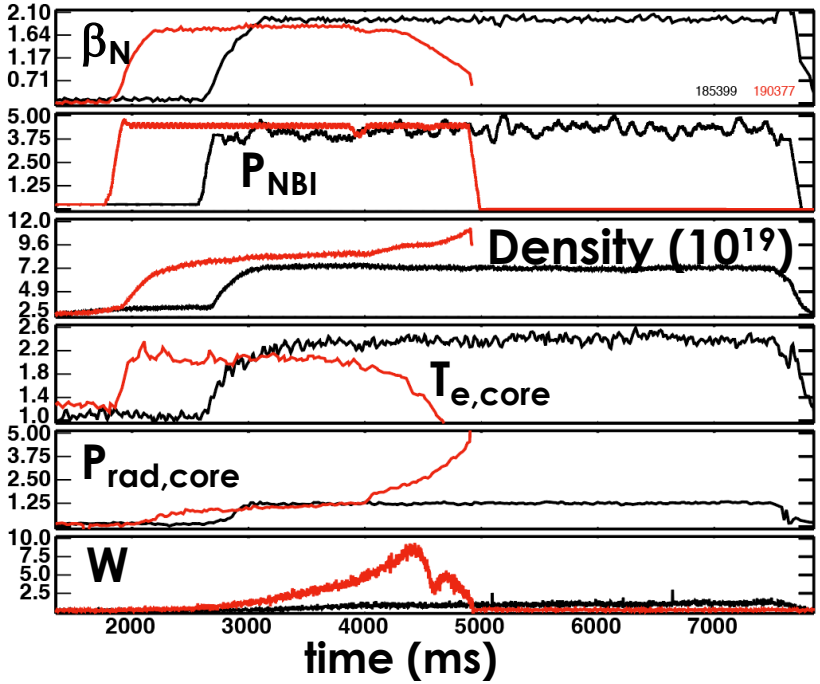
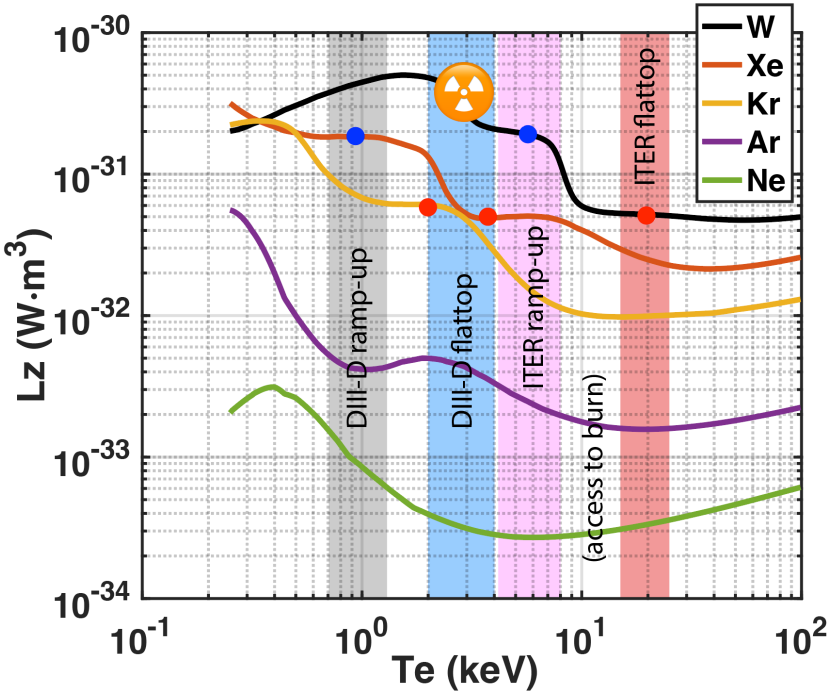
DIII-D
NATIONAL FUSION FACILITY

W is not relevant as a radiator: tiny amounts prevent many scenarios from running/performing

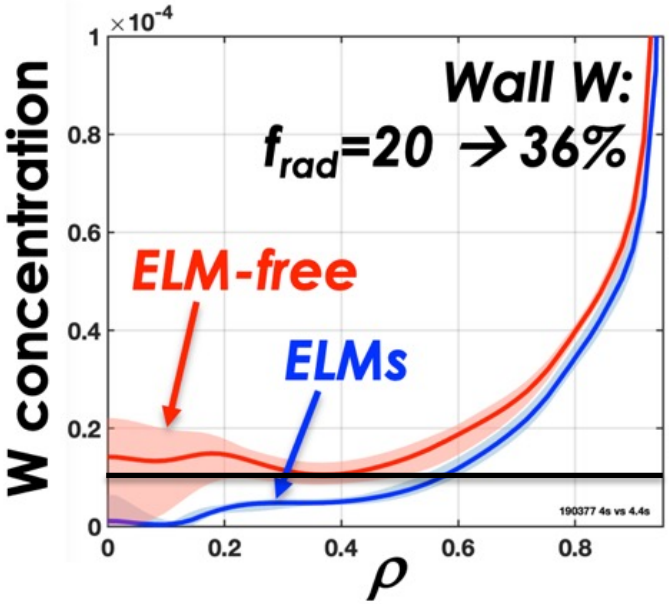
- Radiation curves of W at DIII-D T_e<=10 keV are x5-10 wrong
- Different scenarios react differently – but ALL underperform, or die
- But not for a relevant and physics-worthy reason!



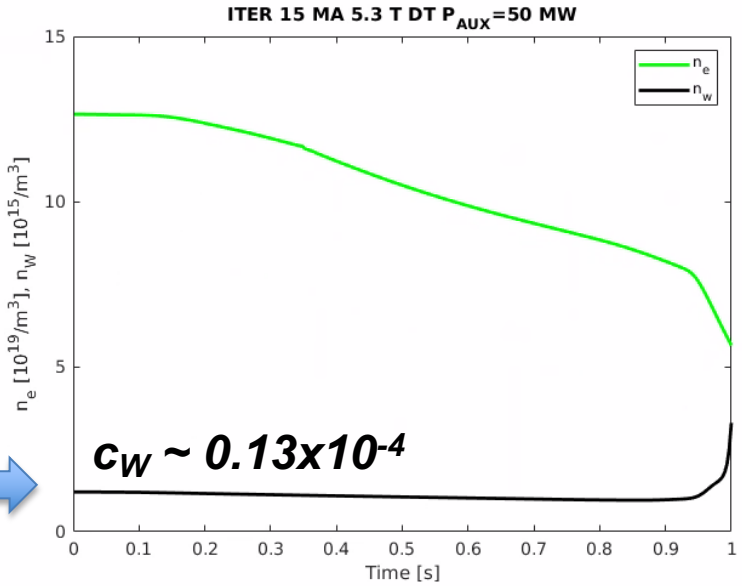


Transport of metals in present machines is very different from ITER/FPPs, and not projectable

W concentration profile in DIII-D: microscopic source post-SAS



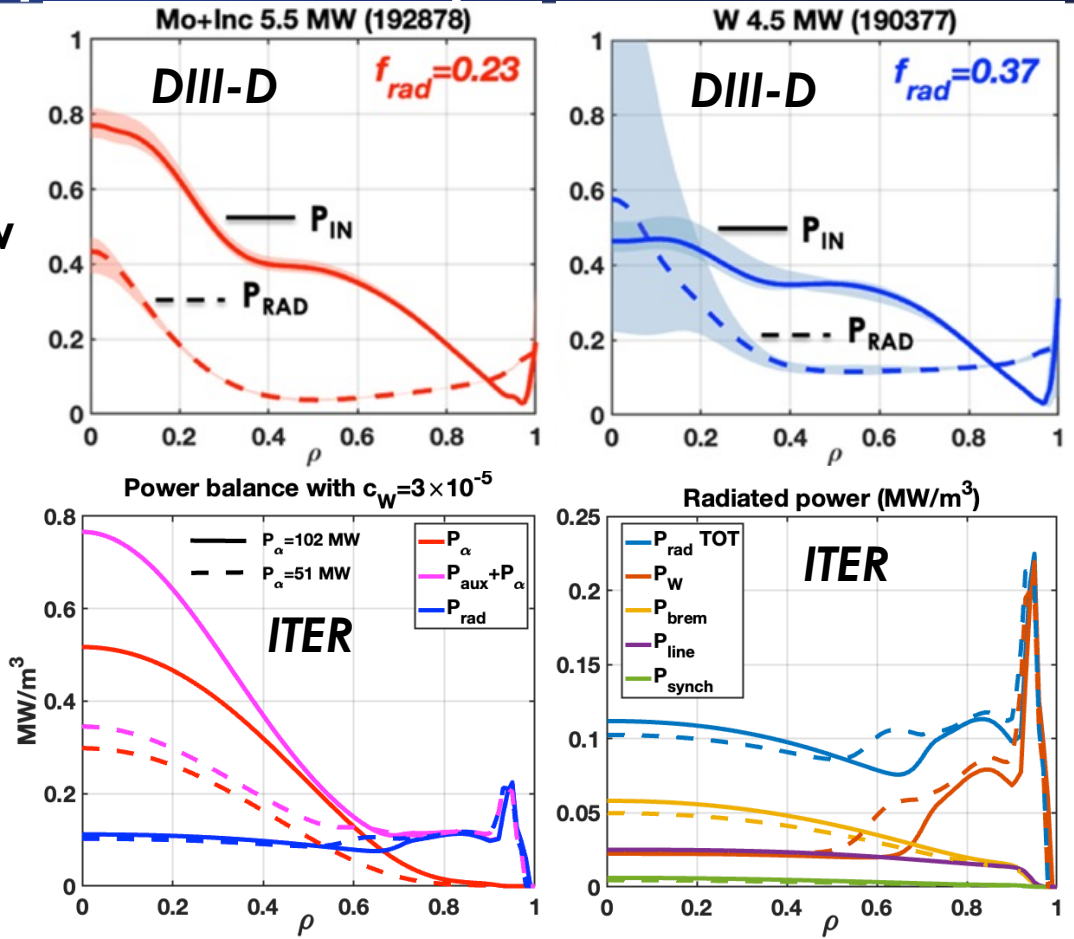
W concentration expected in ITER: source from divertor AND full wall



- **Same concentration with <1000x source → any metal is destructive**
- **Transport studies not possible → completely wrong regime**
- **It does NOT remain in the divertor (all tiles had to be sanded down)**

Power balance with same c_W in ITER shows no issues in survivability – while DIII-D plasmas collapse

- Much higher Lz for W at low temperatures
- Lz curve increases sharply below 9 keV → non-linear to low T_e
- P_{rad} too high in DIII-D, and it increases the lower the T_e
- In ITER $P_{rad,W}$ does NOT dominate
- The total radiation remains manageably low → no survivability issue



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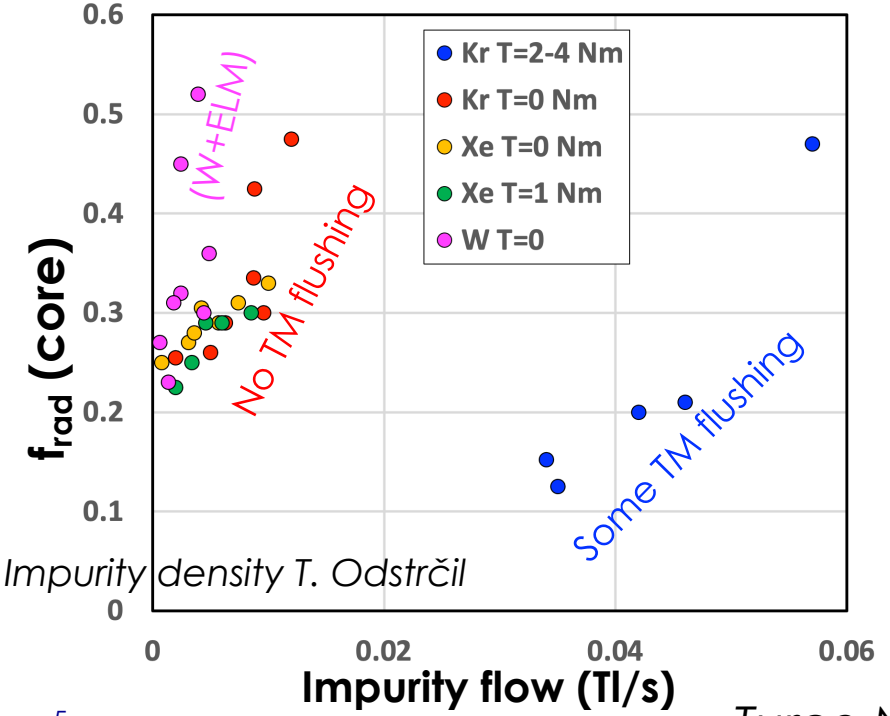
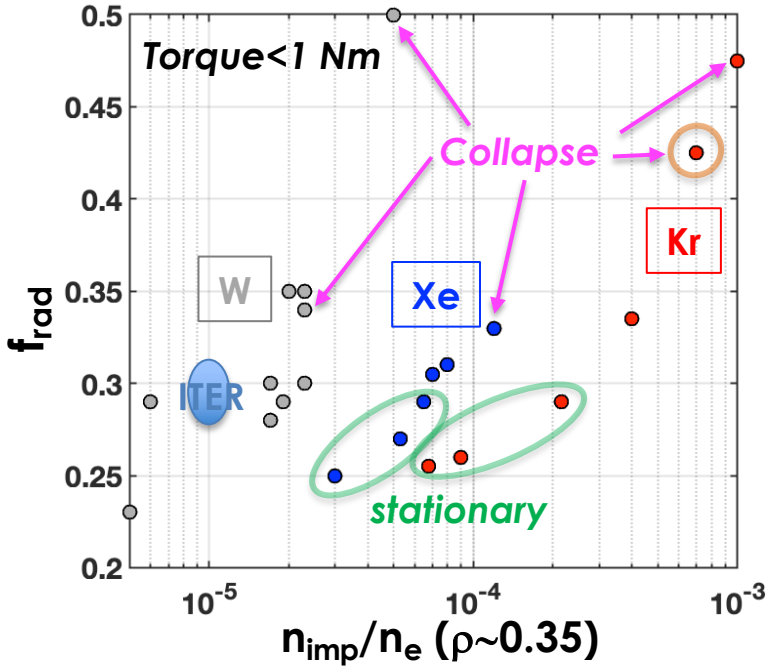
LBO-W in DIII-D is already used to achieve relevant core radiation with controllable source

- c_{Kr}~2·10^{-4}, c_{Xe}~6·10^{-5}, c_W~ 1·10^{-5} → ITER expected f_{rad}~30% with $c_{W,ITER}$~ 1·10^{-5}
- With low controllable source, W core behaviour can be studied





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Other reasons why W and other metals are not relevant, while being destructive for DIII-D operation

Wrong physics basis:

- W mitigation techniques (e.g. AUG, JET) with large D2 dosing or extremely low density destroy the scenario's confinement, and do not extrapolate to ITER/FPPs
- Divertor seeding studies are not hindered by C radiation (it is negligible)
- Long pulse machines can do materials physics that DIII-D simply cannot

Ruins uniqueness and strengths of DIII-D operation:

- CER and in vessel cameras do not work with W anymore
- He-glow cannot be done
- Tiles surface T limits DECREASE! No high power, long pulse operation anymore

No meaningful physics can be studied with metal walls in DIII-D – only repeats of 20 year old AUG and JET studies

- Not relevant for core radiation, not applicable for transport studies, not possible for long pulse material studies → **NO GAIN**
- Destructive for many scenarios, for basic operation, for diagnostics
- DIII-D would not be a leader in the fusion world, we lose our uniqueness and strengths → **HUGE PAIN**

W wall change in DIII-D seems like "Cargo cult Science"[1]: no meaningful content, pretending it makes us relevant, with no rational basis

Alternatives:

- As being done today, use W-equivalent radiators (Kr, Xe) and LBO-W in our existing, powerful and flexible C-wall machine
- Use DIMES and other sample stations to do short pulse tests of *all* materials
- Use real material test facilities (not use the only existing US tokamak for material studies)

[1] *Feynman, on integrity and critical thinking over sensationalism*