DIFFER activities in PRD-LMD

T.W. Morgan[1,2], P. Rindt[2], F. Romano[1], W. Ou[1], J. Scholten[1], Y. Hayashi[3], K. Li[4], W. Arnold Bik[1], N.J. Lopes Cardozo[2]

[1]DIFFER, Eindhoven, the Netherlands

[2]Eindhoven University of Technology, Eindhoven, the Netherlands

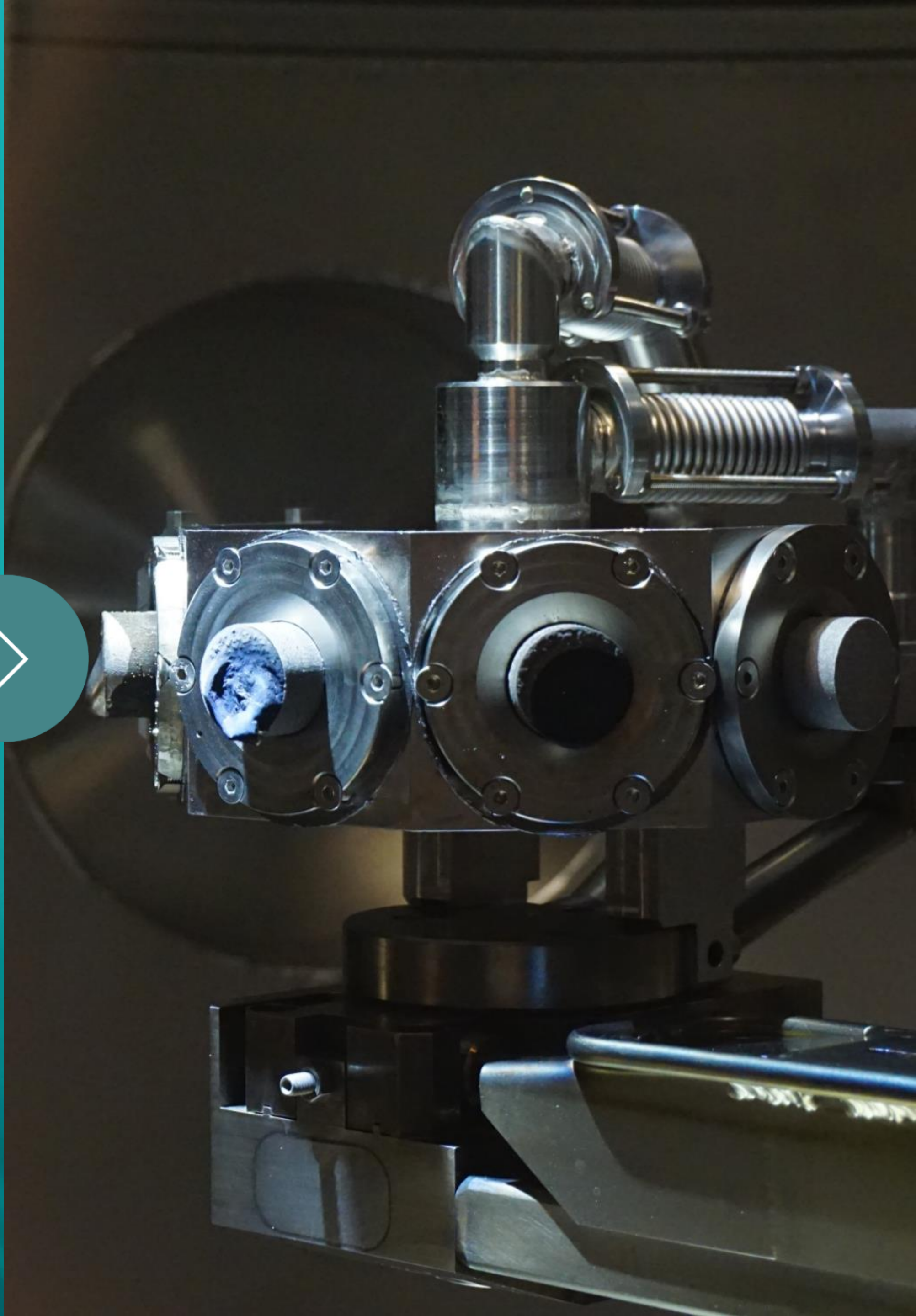
[3]NIFS, Toki, Japan

[4]Tsinghua University, Beijing, China

PRD-LMD Kick-off June 2021

DIFFER

NWO



Activities in 2020

1. Investigation of vapor shielding effects on plasma
2. Retention of D in liquid Li at high fluxes and temperatures

Assessment of influence of VS on plasma parameters

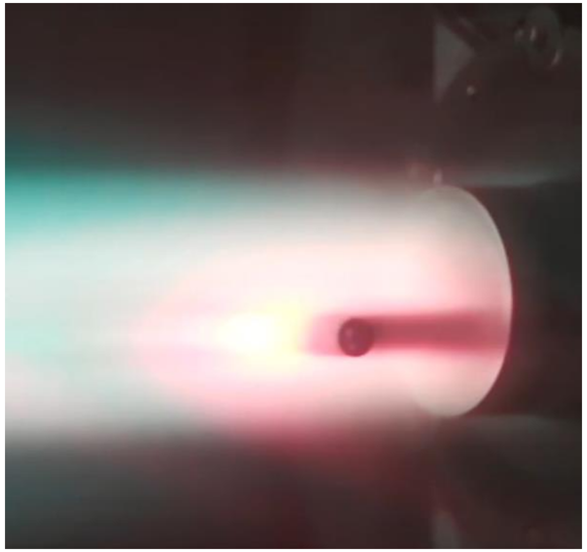
What happens to plasma during vapor shielding (VS)?

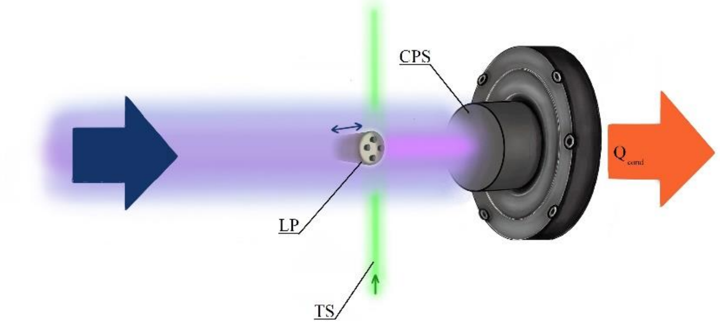
Use Li as easier to reach VS regime (H plasma)

Targets are 3D printed CPS

Thomson scattering not possible with LMs (risk of damage to laser optics) ⇒ use reciprocating Langmuir probe

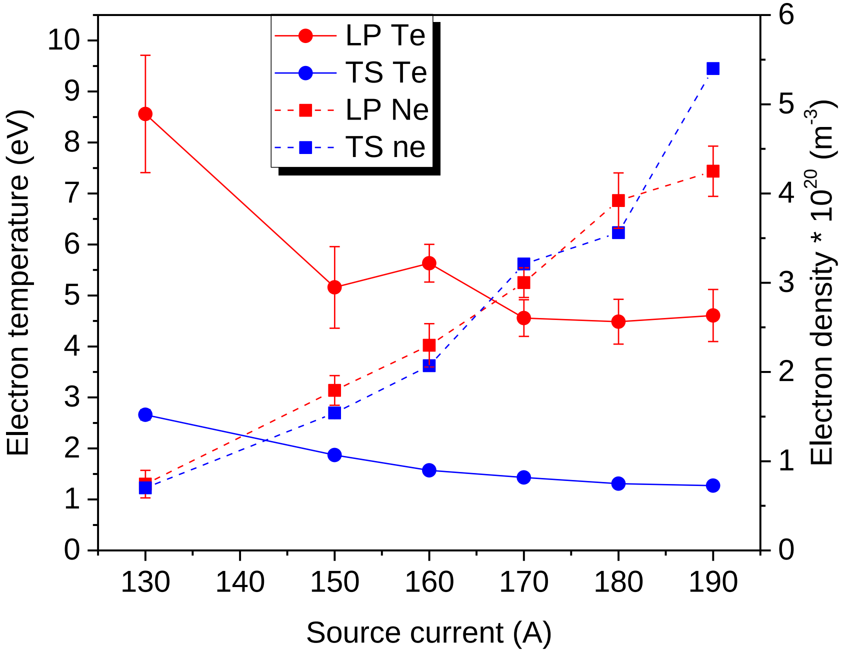
Single probe mode, 200 ms dwell time, 5MHz sampling





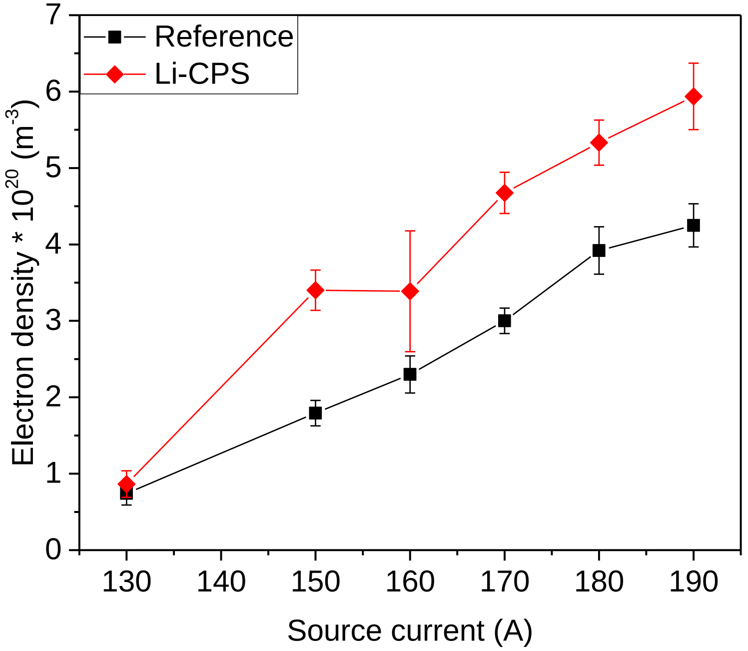
Langmuir probe results

Comparison TS and LP on Mo reference



LP can successfully reproduce n_e, but not T_e

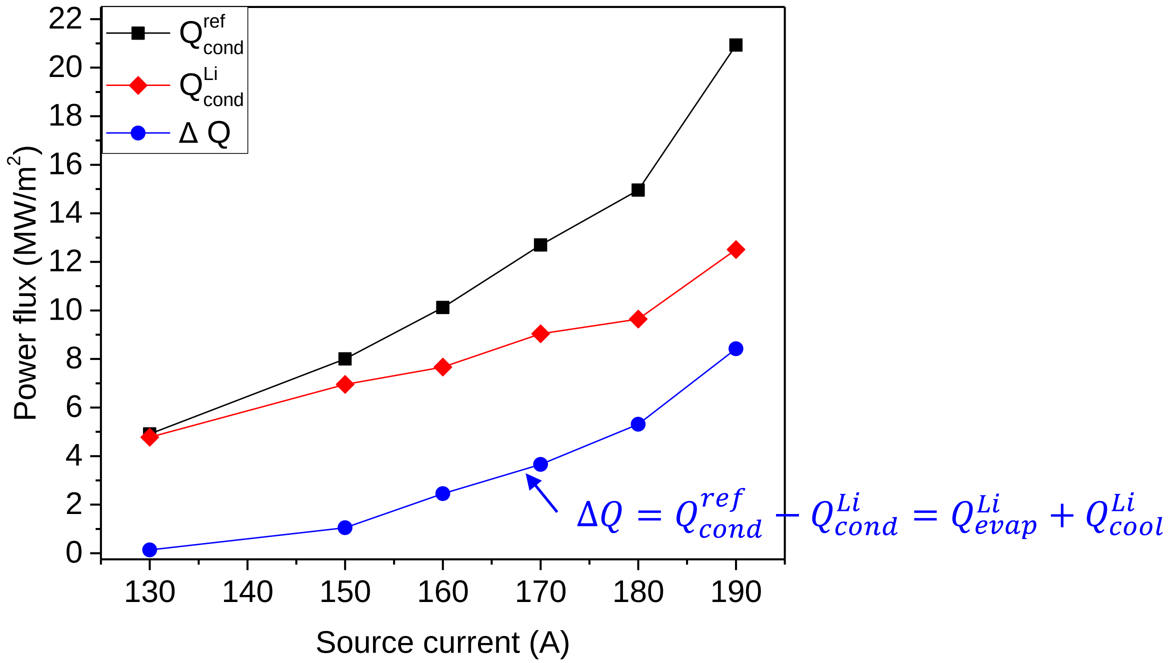
n_e measured for reference and Li



Electron density increased for Li during VS compared to Mo

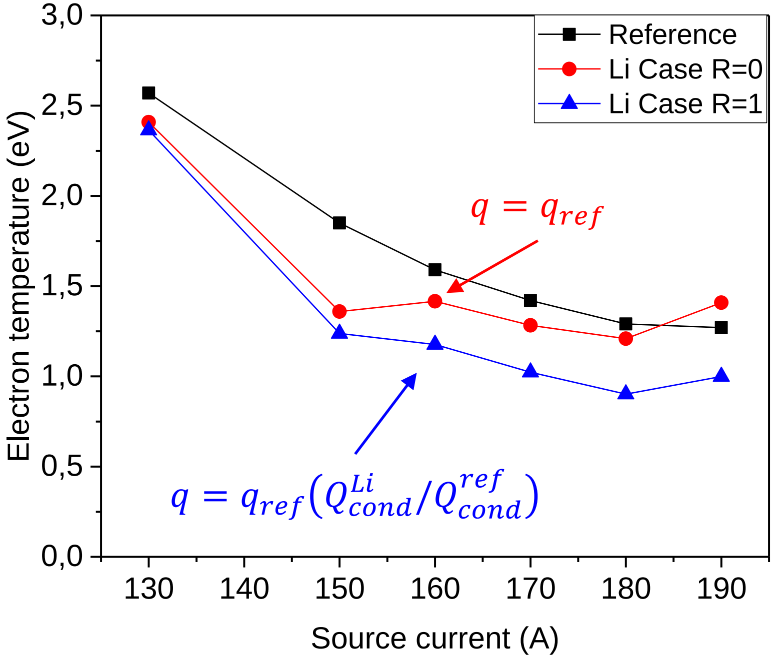
Can infer a reduction in $\underline{T_e}$ due to VS power/momentum losses

Comparison TS and LP on Mo reference



VS ranged from 0-50%

T_e inferred from calorimetry and Bohm condition



T_e decreases by up to 33% due to collisions with Li vapour

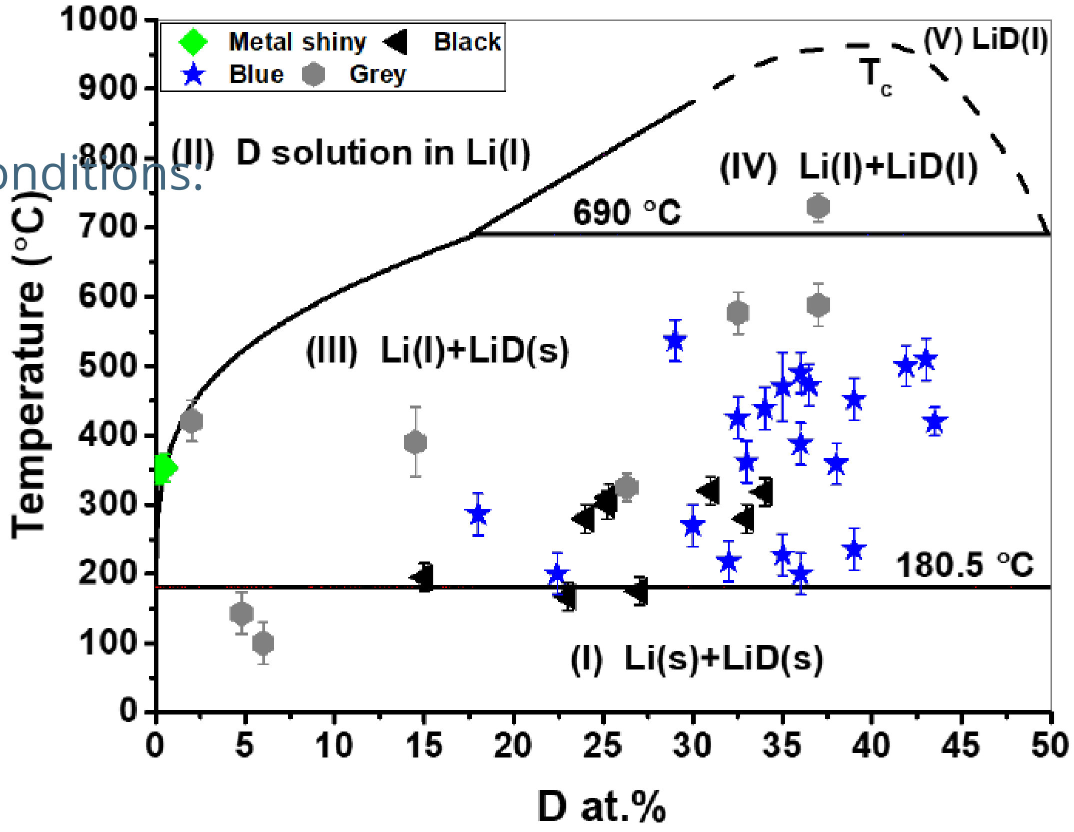
Determination of D retention in Li in-situ and at high temp/fluxes

The Li-H system is well studied but complex

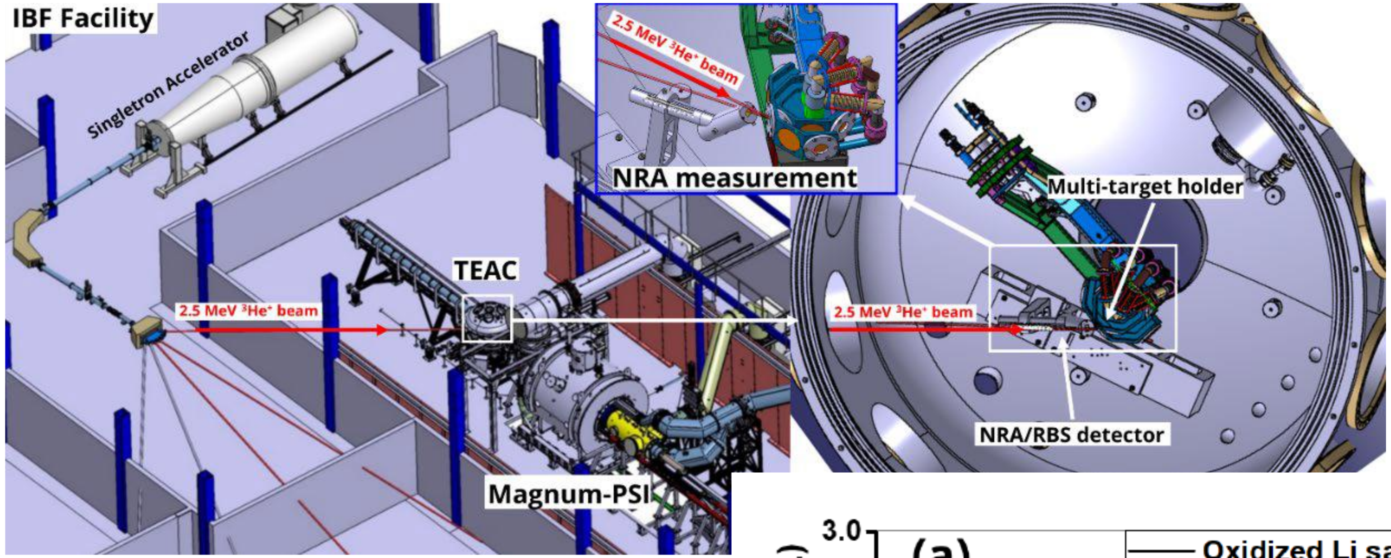
Missing studies under more relevant fusion conditions:

- High flux
- High temperatures

What is retention under these conditions?

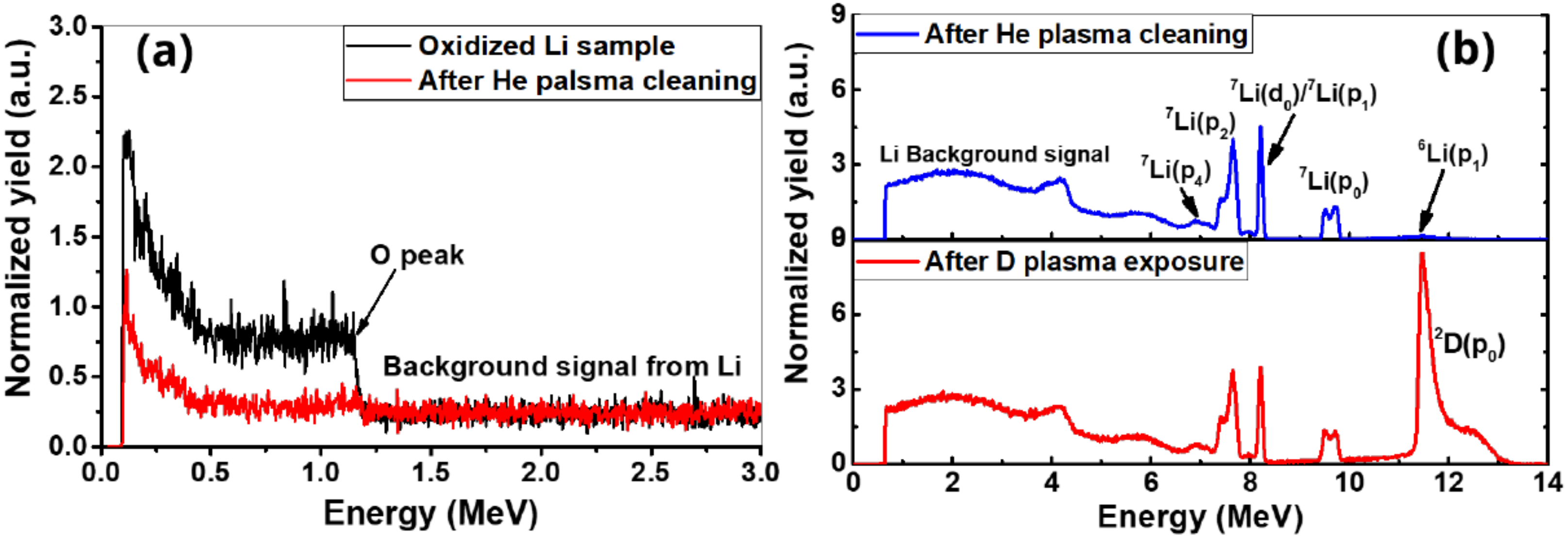


In-situ NRA avoids atmospheric contamination Li



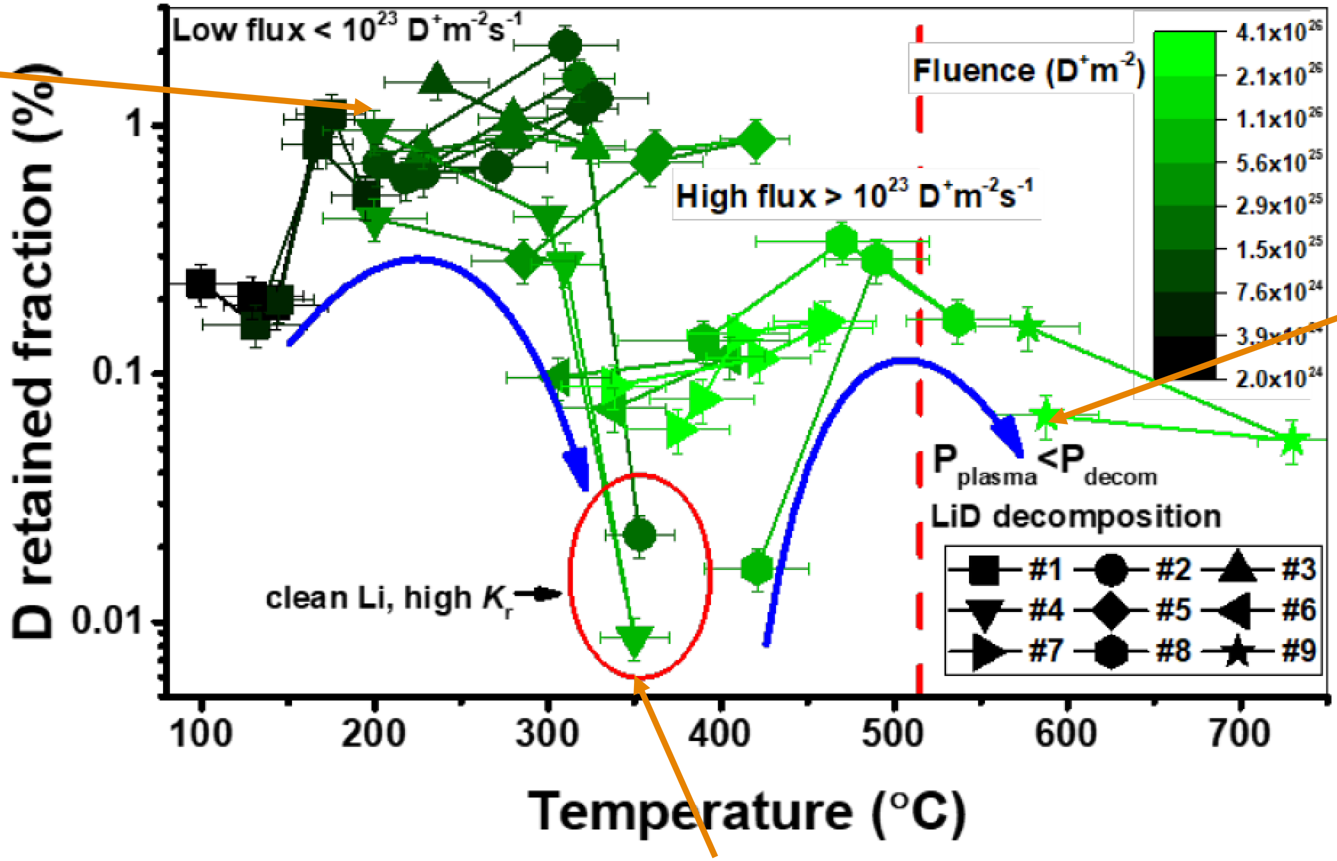
NRA carried out before and after

In-situ (translated to TEAC) such that no N, O, H_2O CO_2 reactions possible



Retention in Li is much lower than 100%

Formation of solid LiD crust

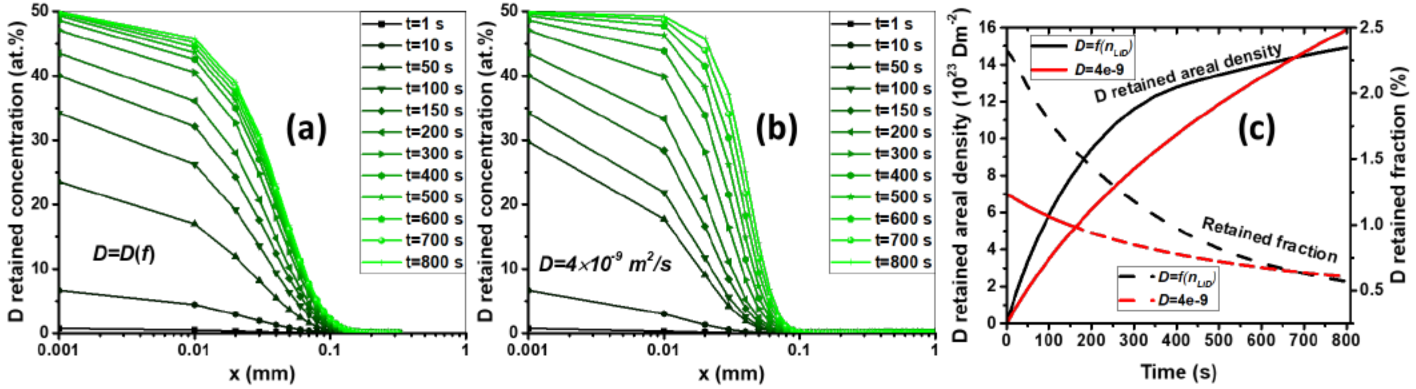


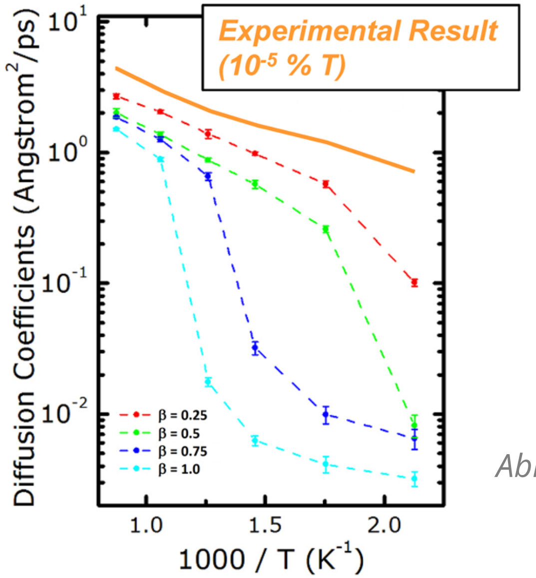
For higher temperatures decomposition starts to outcompete new formation LiD

If flux low and Tsurf high then can stay below solubility limit

Why is retention much lower than expected?

1. When LiD is formed the diffusivity of D is reduced which naturally limits D concentration to a relatively thin layer
2. At higher temperatures LiD decomposition starts to remove D





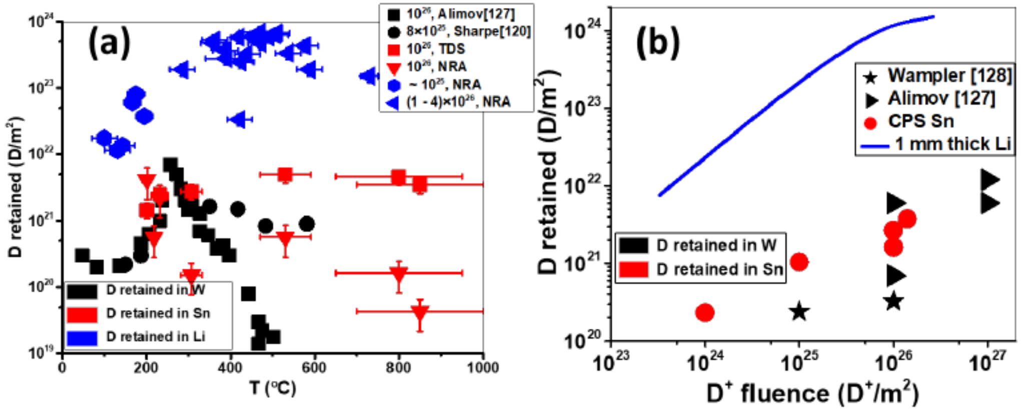
Abrams NF (2016)

Implications for reactor

Retention in Li seems not as bad as 1:1

Caveat: flowing Li would lead to mixing (reason for disagreement Baldwin*?)

Overall retention still too high to be tolerable



D removal by isotope exchange or impurity

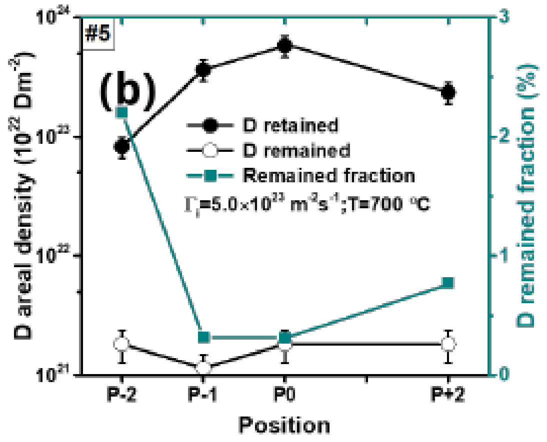
Operation with Li requires method to reduce T uptake

Investigated potential of H and He to do this on previous exposed samples (no atmospheric exposure)

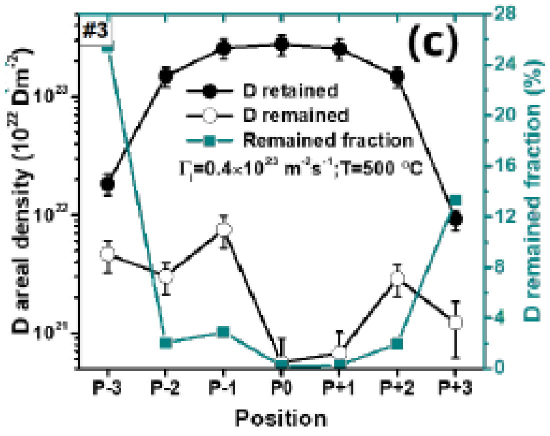
Both found to remove at least 99% in most cases

Potential to utilize this as a removal method/influence of combined loading requires further study

He plasma



H plasma

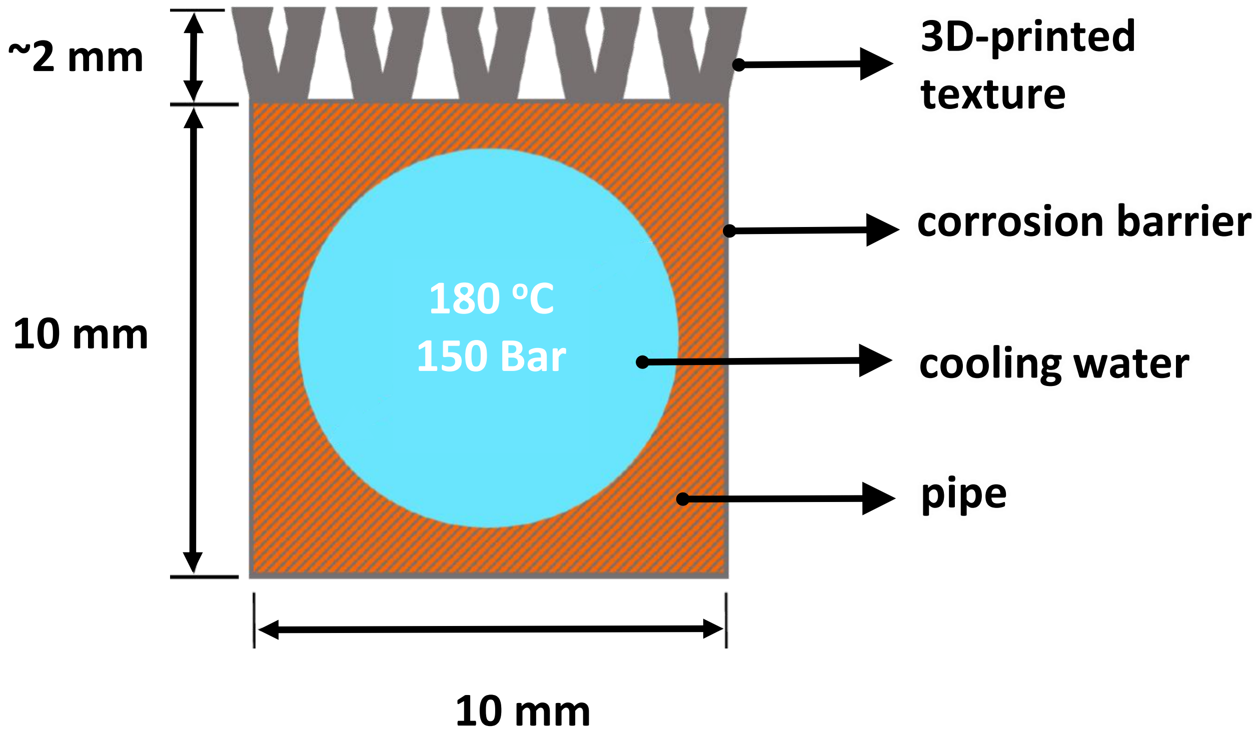


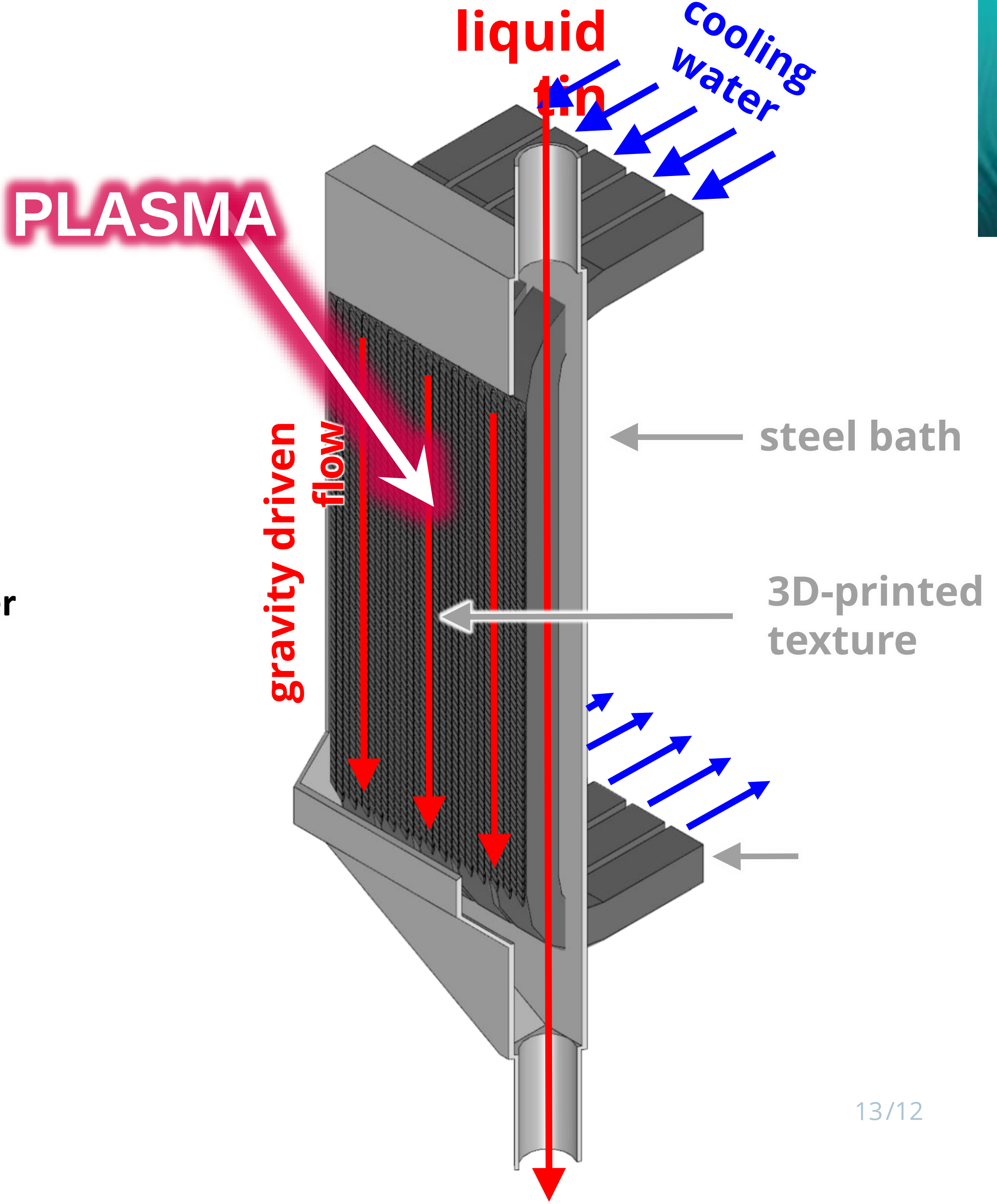
Plans 2021

1. Prototype development

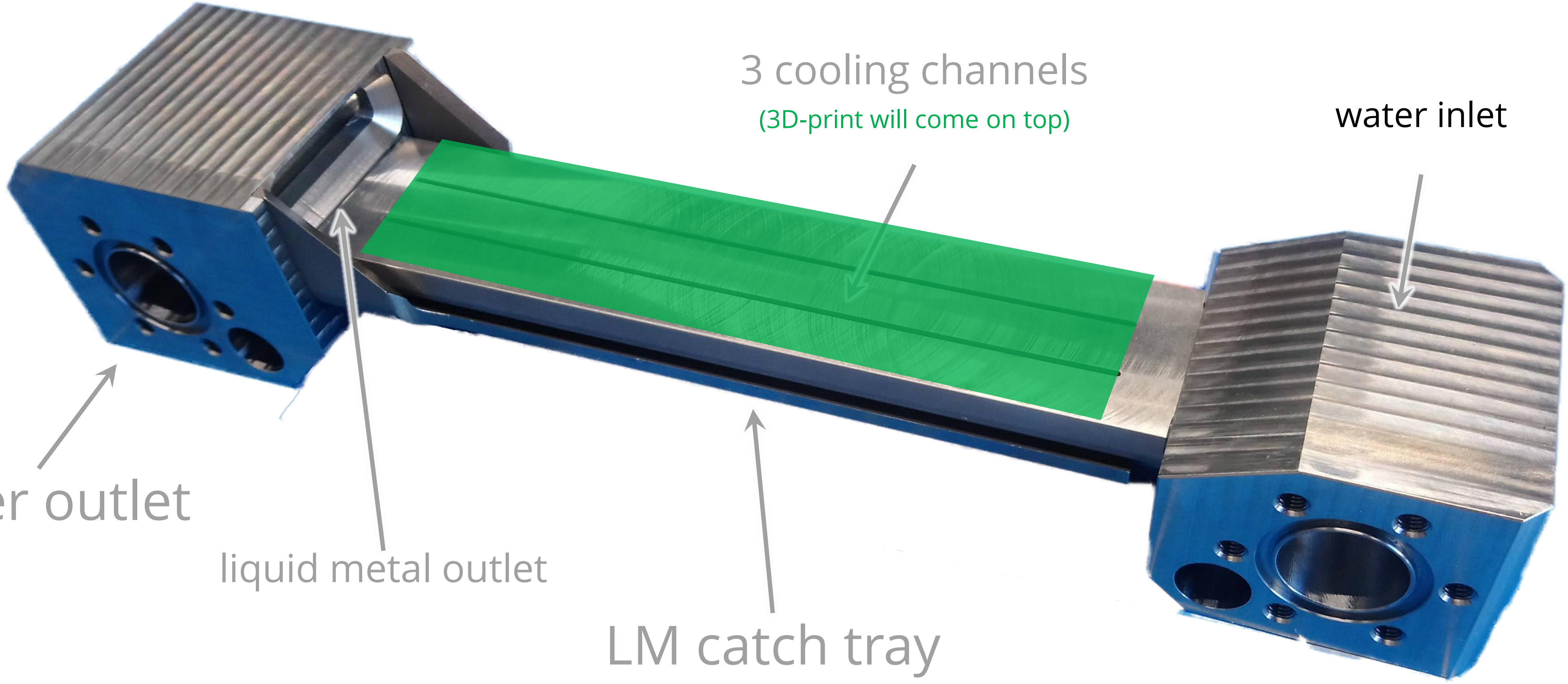
2. Prototype testing AUG (and testing in Magnum-PSI in preparation)

Prototype DEMO divertor design

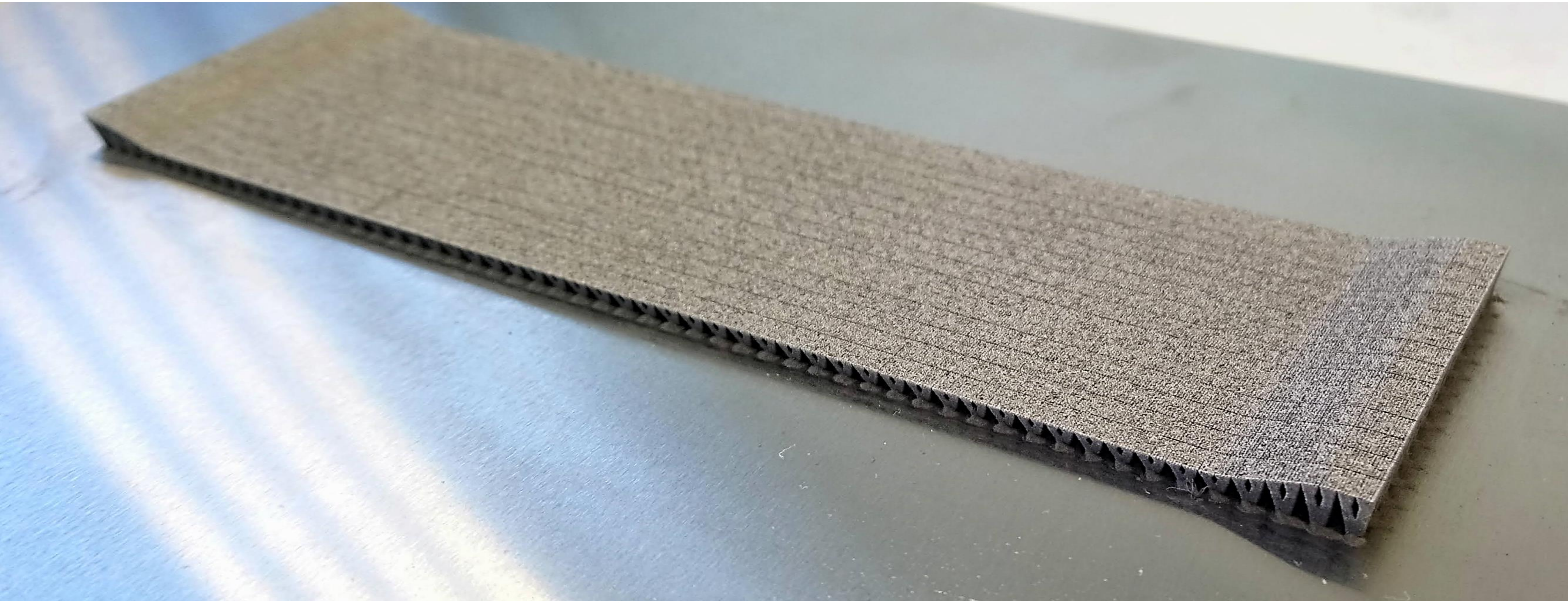




Mock-up for Magnum-PSI almost complete



3D printed tungsten armor for LMD mock-up (test print steel plate)

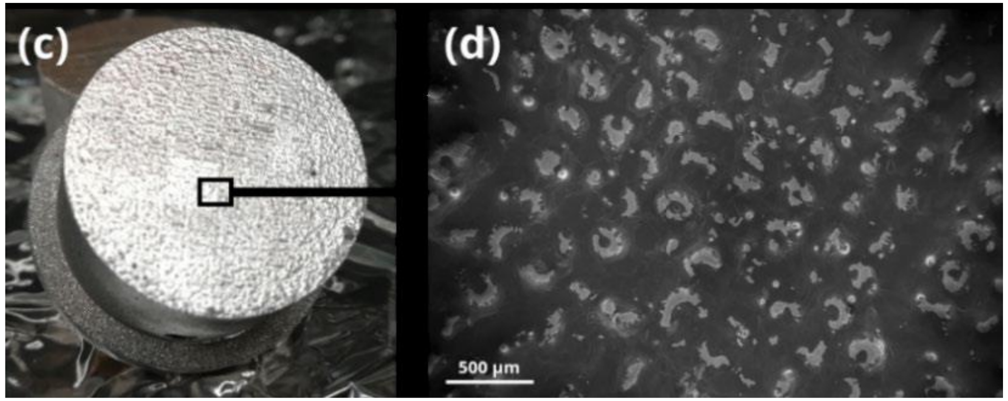


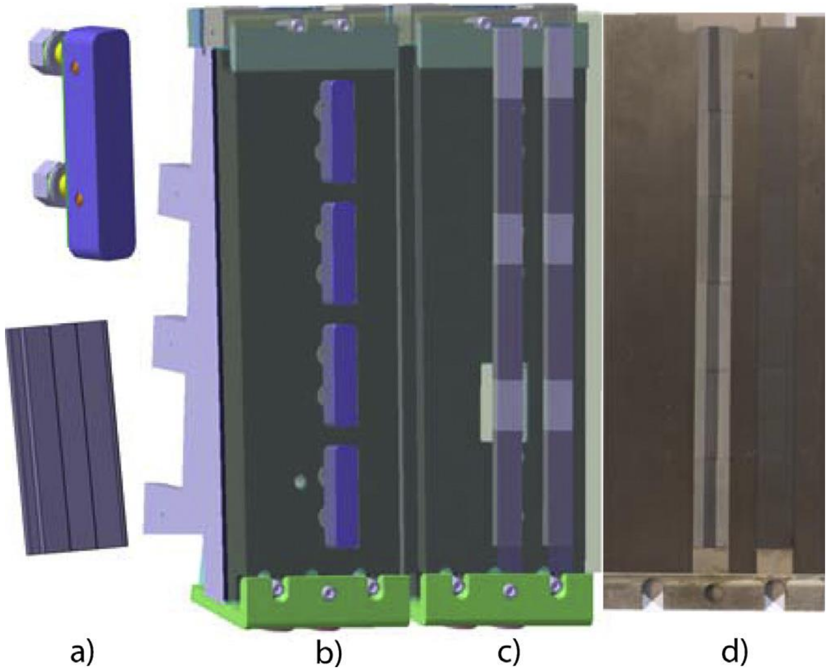
Testing of mock-up in Asdex Upgrade

Preparing for experiment to test LMD mock-up in AUG using DIM2 manipulator

Experiments planned for summer 2022

Use small mock-up based on 3D printed W design, focusing on influence on core, fuel retention, surface stability



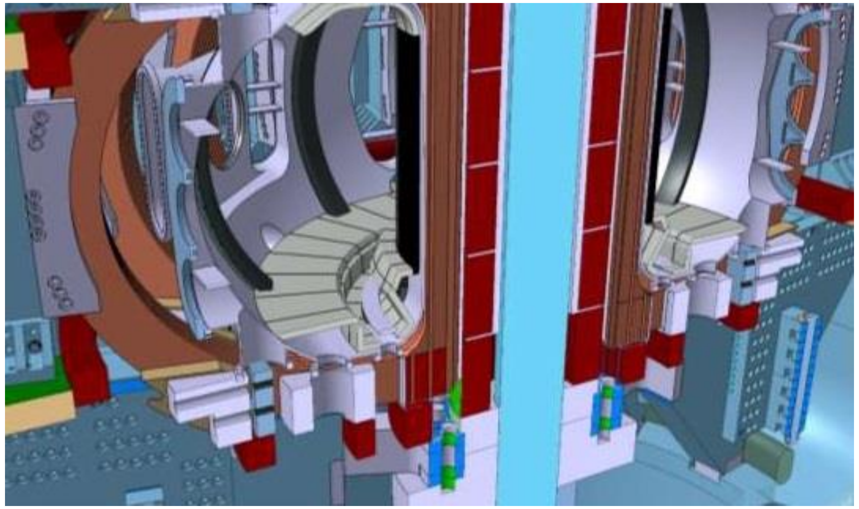


Outlook: design for larger scale mock-up in COMPASS-U

Testing in COMPASS-U (goal ~2025/2026)

Larger scale mock-up placed in special changeable OVT sections

Contribute design activities together with IPP.CR



High field device
Closed high density divertor
High PB/R
Hot wall operation (300 ºC)
Flexible exchange of divertor possible

Thanks for listening
Questions?

DIFFER