KOM WPPRD LMD 2022: ENEA

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OUTLOOK

- State of the art of the target design
- Wetting, corrosion, protection
- Future work and conclusion

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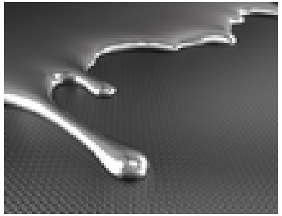
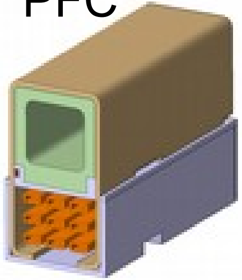
Regarding the target design

Many subsystems need to be combined to an integrated component

Liquid metal confinement

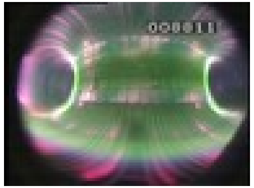


Integrated PFC

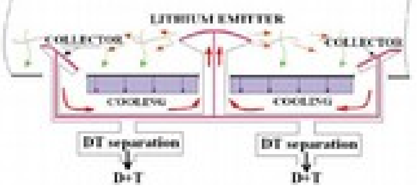


Cooling system

Safety

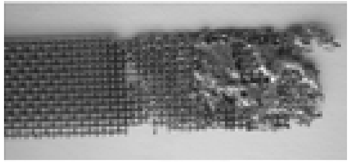


Plasma scenario



Closed loop

Structural materials



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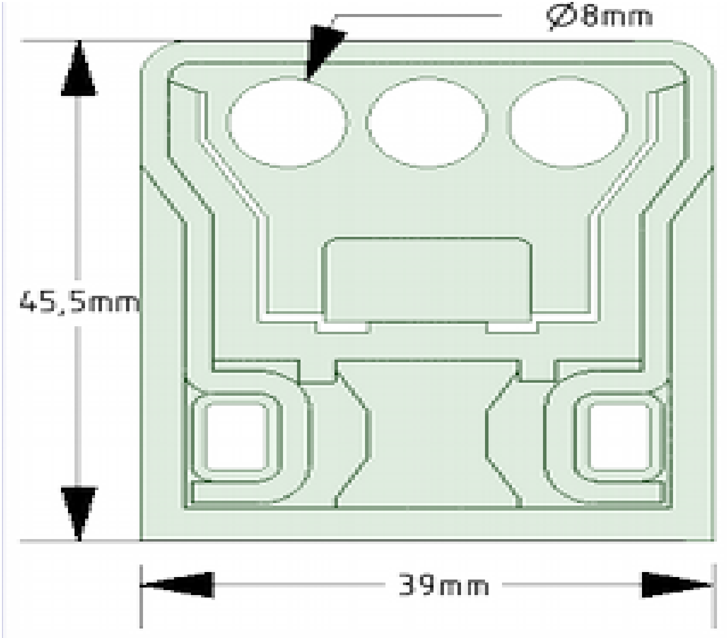
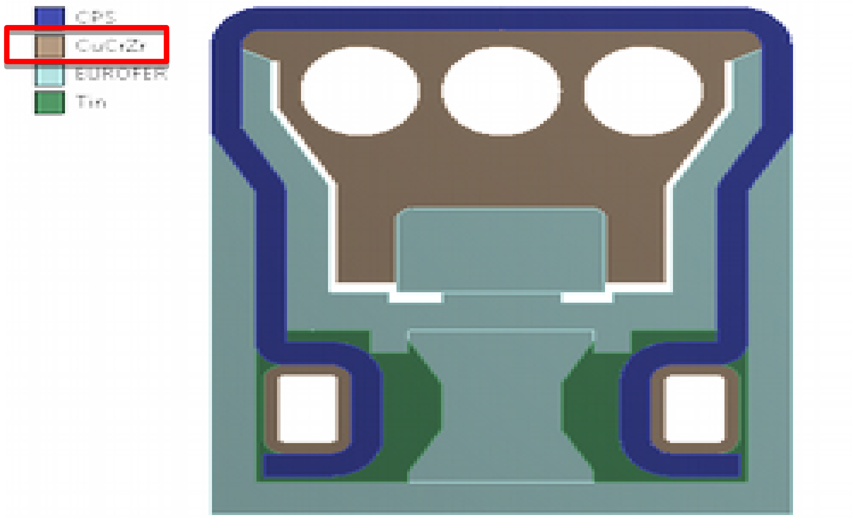
CuCrZr PFU thermal analysis



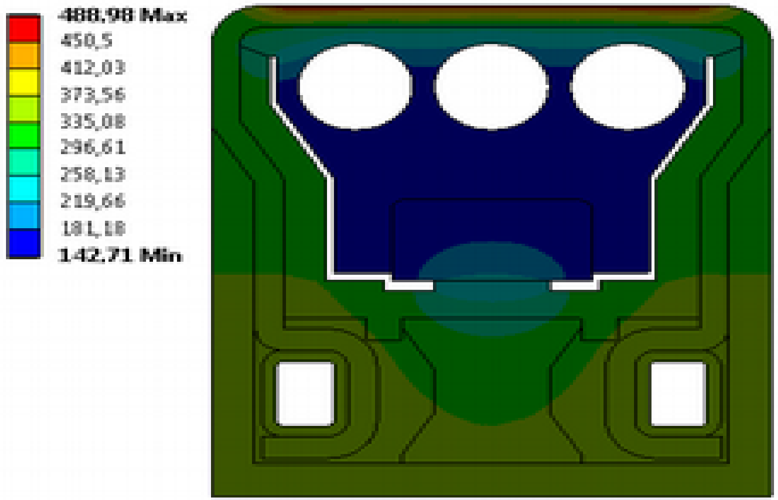


Gas temperature
T = 350°C

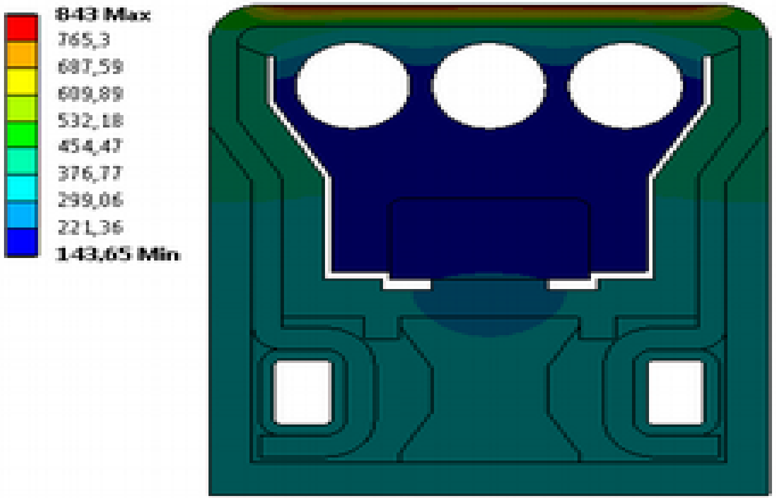
Water hydraulic parameters
T_{bulk} = 140°C
p= 5 MPa
v= 12m/s

CuCrZr PFU thermal analysis

Heat flux = 10 MW/m²



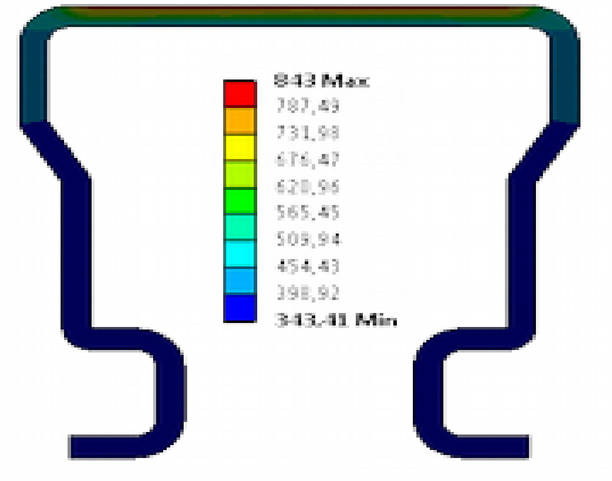
Heat flux = 20 MW/m²



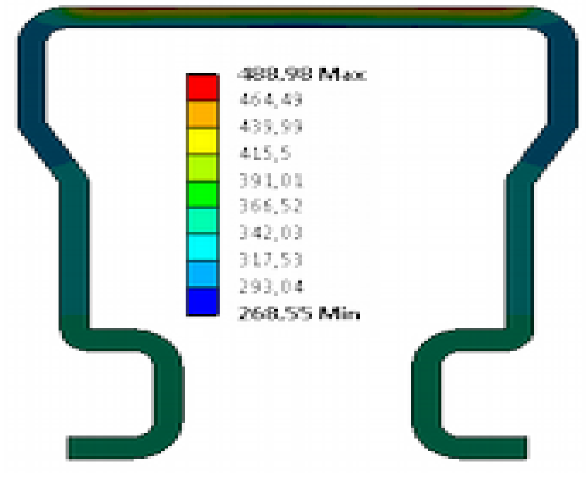
In both cases evaporation is negligible because CPS surface temperature is below 1300 °C

CuCrZr PFU thermal analysis

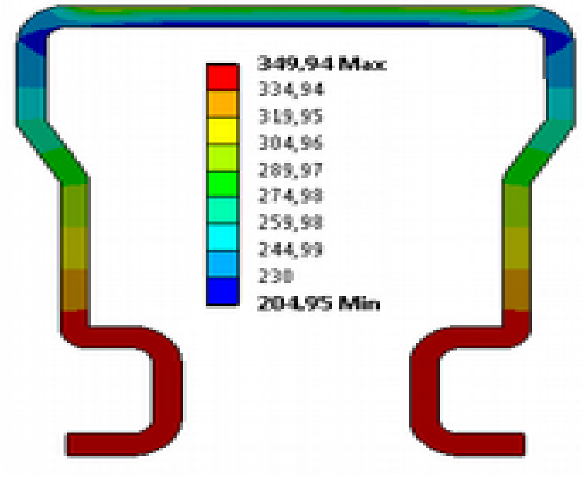
Heat flux = 20 MW/m^2



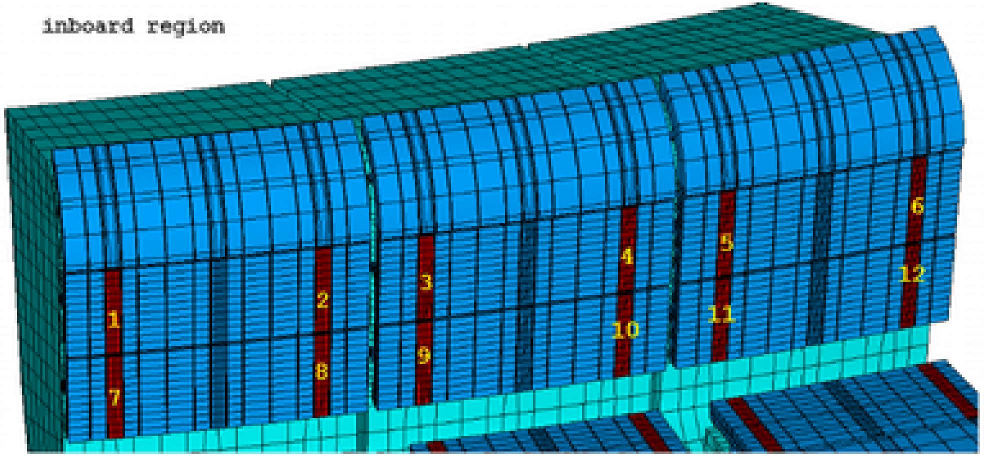
Heat flux = 10 MW/m^2

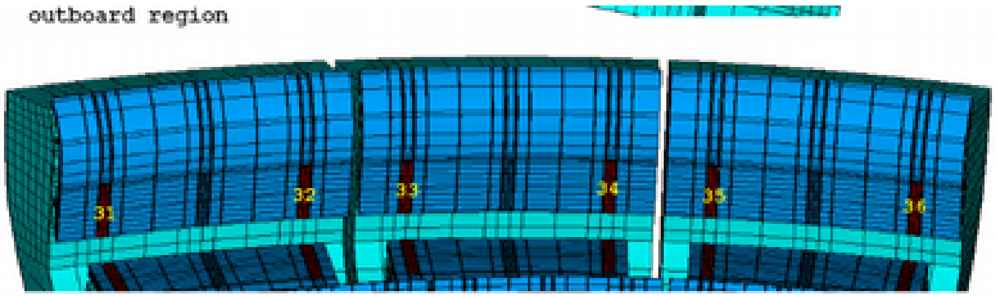


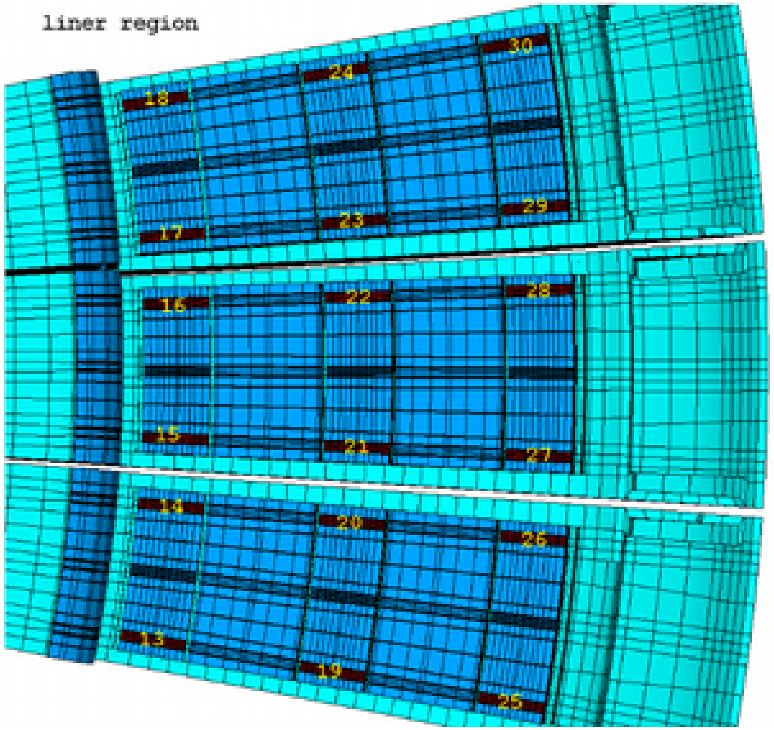
Heat flux = 5 MW/m^2



Electromagnetic load calculations



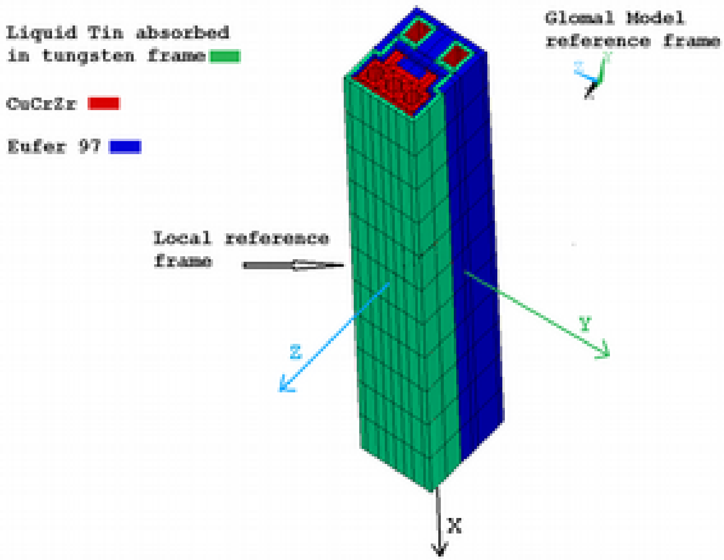




Details of the Units used in the calculations

Electromagnetic load calculations

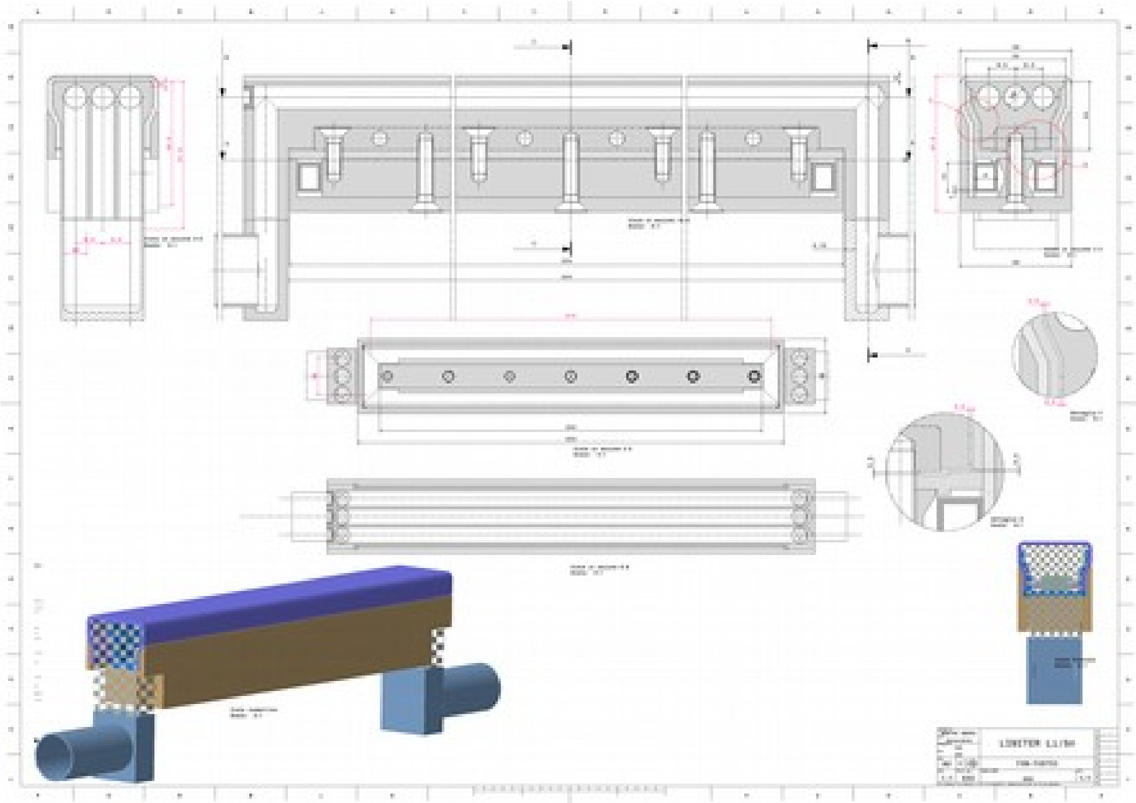
- The analyses showed that the driving loads of the PFC are the **force components in Z**
- Taking into account several contributions (eddy currents, halo currents and magnetization force) the highest positive value of F_z is **1400 N** on two units (27-28) These units lie on the **liner very near to the outboard target**. This load is still somewhat high (between **1100 and 1200 N**) for the two units (31-36) that are attached to the outboard target.

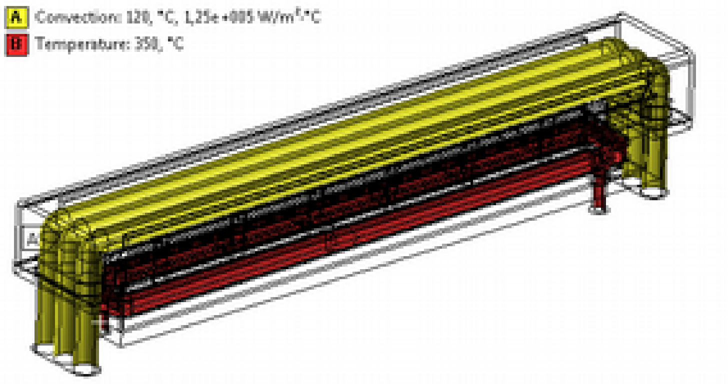


- Two disruptions cases have been analyzed: fast VDE (74ms) and slow VDE (400ms).
- It can be noted that, due to the contribution of the halo current, that in the slow VDEDW400ms are about two times higher than in the fast VDEDW74ms, **the worst EM transient must be considered the VDEDW400ms**.

At this stage these forces are compatible with the actual design.

LMD mock-ups need to be tested





Many FEM analyes have been carried out, and the mock-ups are now available.

LMD mock-ups need to be tested

Two mock-ups have been already manufactured: CuCrZr and W-Cu/80-20

We have to provide the W protection layer, then we could assemble the CPS with tin.

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Activities at Frascati Liquid Metal Laboratory

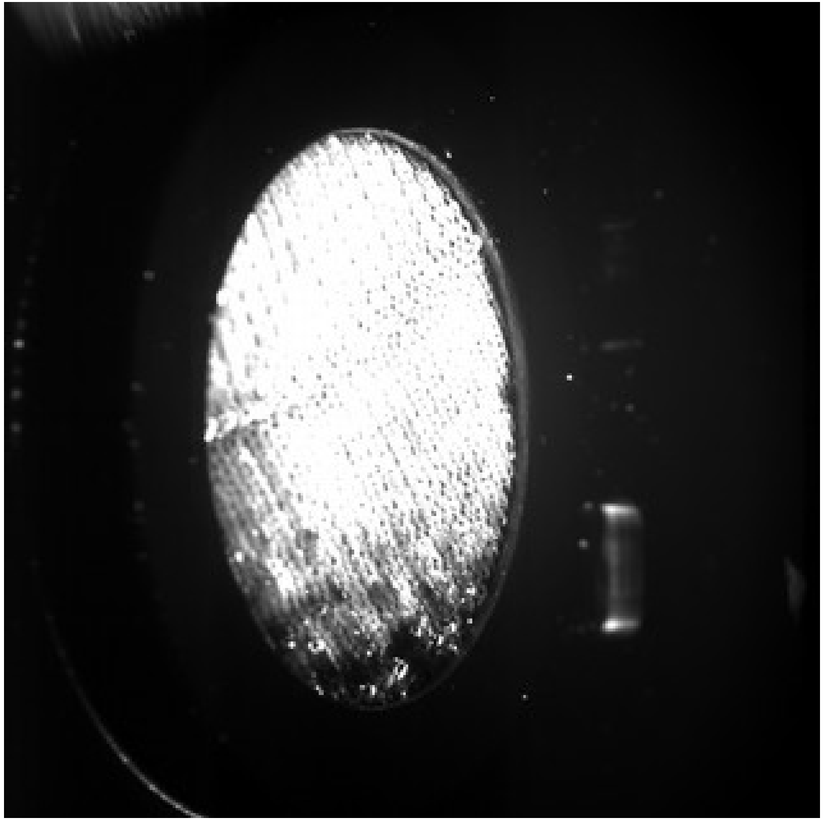
We are mainly focus on wetting and corrosion prevention

Wetting

Example of wetting of large and complex CPS compatible with our divertor project module.

Capillary pressure exceeds 30 cm equivalent liquid tin hydrostatic pressure

Test in OLMAT see slides from Eider

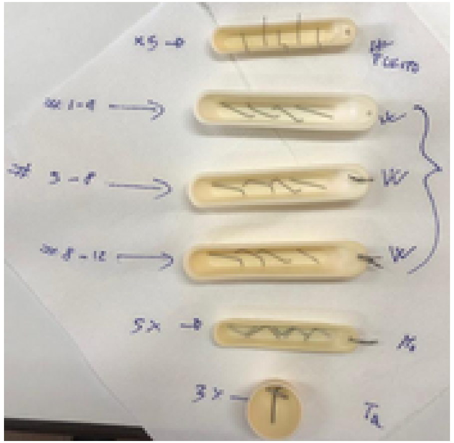


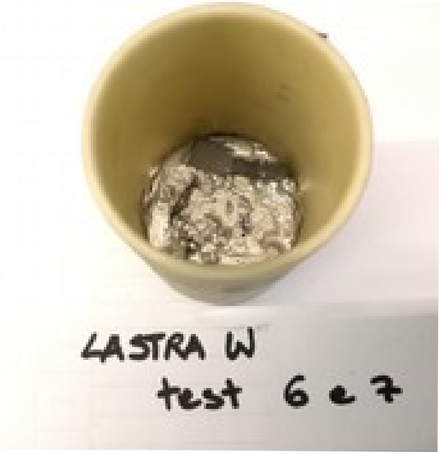
File Info.
FASTCAM SA1.1 model 675K-M1
10000 fps
1/frame sec
768 x 768
Start
1409 frames
0.1409 sec

- Droplet ejection clearly decreases with initial temperature.
- Possible effect of CPS conditioning repeat in inverse order, from higher initial temperatures to lower initial temperatures.
- Possible effect of window metallization.
- No damage of CPS observed (maximum H_F=15 MW/m^2)

Courtesy of Eider Oyarzabal

Corrosion Tests

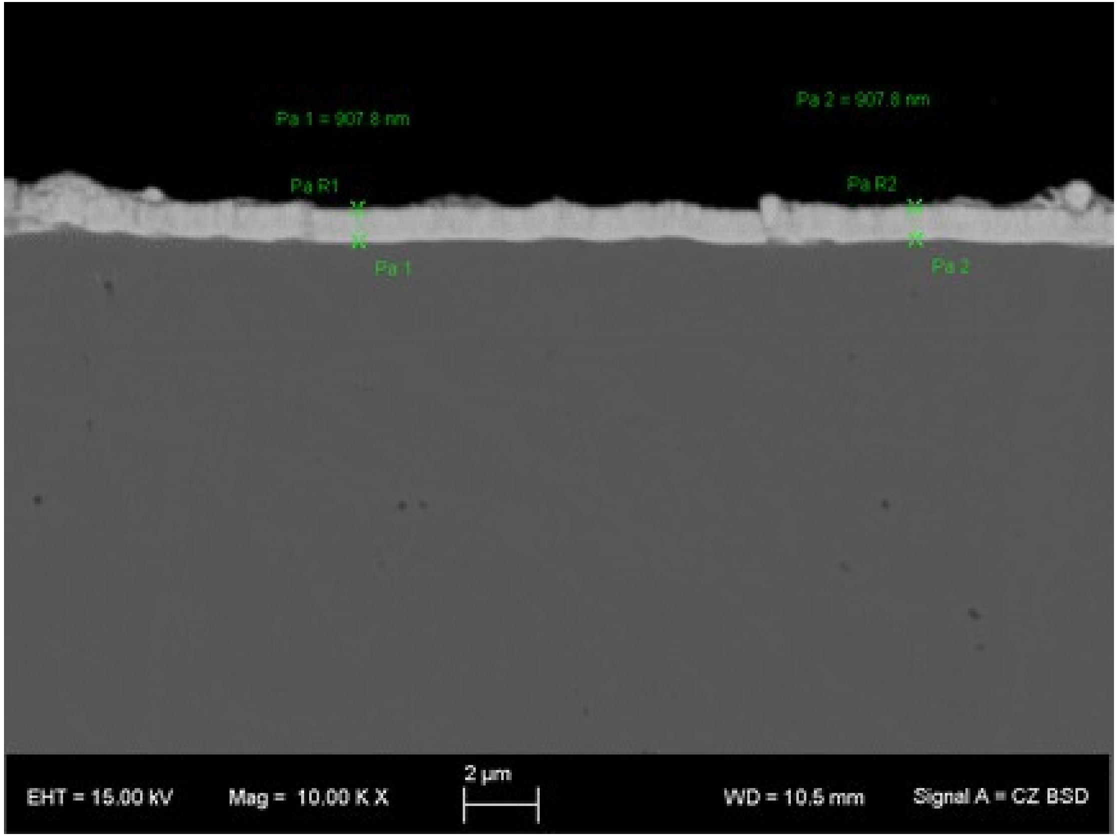




Corrosion test have been performed:

- CuCrZr and SS at low temperature (<500)
- W, Mo, Ta at high temperature (>800)

Preventing corrosion



W PVD coating tested

The results on AISI316 are promising. Further improvements for CuCrZr are required.

Preliminary results from 2021 work

AISI316

CuCrZr

Several tests confirm the satisfying behaviour of the W layer on AISI316, but show the ineffectiveness on CuCrZr.

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Future work

- Mock-ups assembly → needs the anti-corrosion layer assessment
- CPS validation in linear devices (Magnum? E-gun?)
- Start planning future experiments on tokamaks? Asdex-U manipulator? COMPASS-U? DTT? How could we conduct them together/in synergy?

Proposed work together with PoliMI

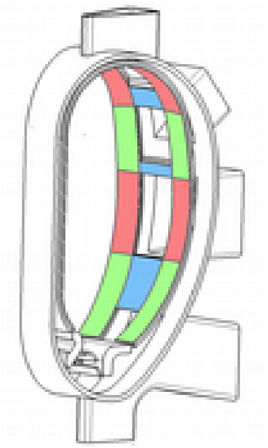
- investigate the main reason of failure of the previously deposited W layer with magnetron sputtering on CuCrZr

- try to achieve a more robust morphology of the W layer, provide an exhaustive characterization

- realize new CuCrZr samples and test them in liquid tin

- if the tests will be satisfying, plan a reliable strategy for the process industrialization

Divertor Tokamak Test Facility



DTT Objectives

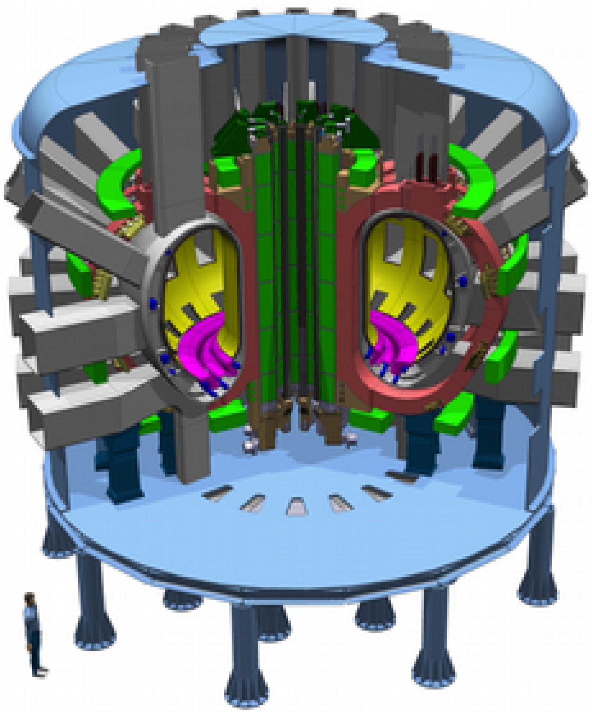
The DTT facility will test the physics and technology of various alternative divertor concepts under conditions that can confidently be extrapolated to DEMO.

First wall

- Cooled replaceable W coating panels

Standard W divertor

- compatible with advanced magnetic configurations



A liquid metal module divertor is under design.

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