Final Meeting
WP13–DAS02–T12
Helium-cooled divertor

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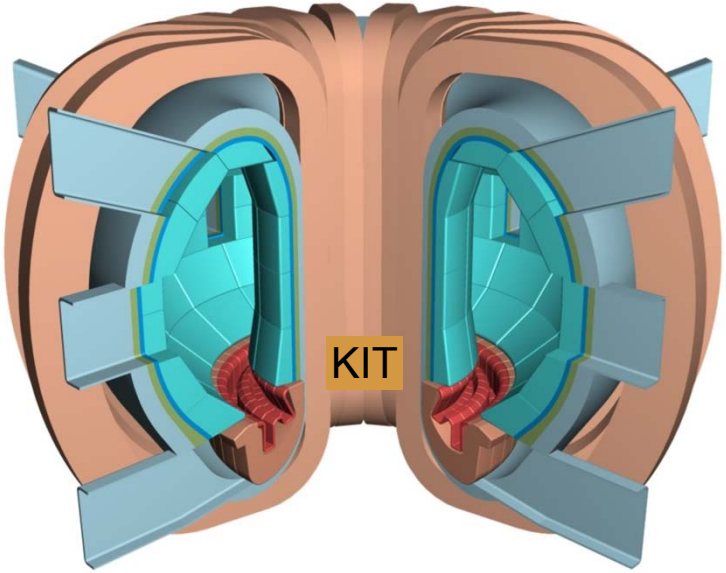
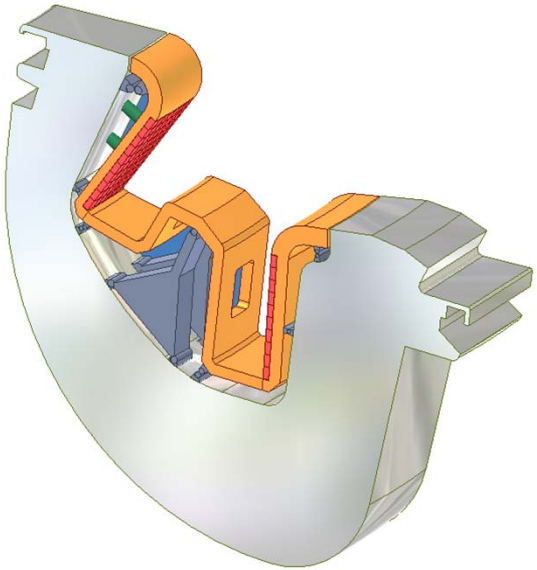
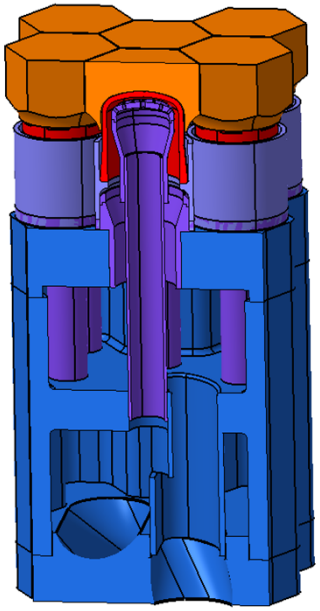
Institute for Applied Materials (IAM) @ KIT

With participations of: L. Spatafora (KIT), B. Končar (IJS), W. Basuki (KIT), R. Dahm (KIT)

KARLSRUHE INSTITUTE OF TECHNOLOGY (KIT)







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Manufacturing square finger (W square tile & Ta-10W thimble)

Machining of individual parts.

Next step: Joining and assembling for 3 cooling fingers based on [4].

CFD Analysis performed in [2,5] has confirmed the performance of 10 MW/m^2.

[1] P. Norajitra et al., Final Report WP12–DAS02–T05-D1, EFDA_D_2LDRJW, 2012.
[2] B. Končar, M. Draksler, P. Norajitra, Design and cooling of the edge segments of the DEMO divertor target plates, Fus. Eng. Des. 88 (2013) 1831–1835.
[3] P. Norajitra et al., proc. SOFE-25, San Francisco, USA, 2013.
[4] P. Norajitra, M. Richou, L. Spatafora, Technological study on manufacturing of multi-finger module of He-cooled DEMO divertor and investigation of NDE method, FS&T Vol. 62, 2012.
[5] B. Končar, S. Košmrlj, P. Norajitra, Design description report of square helium-cooled multijet fingers using WL10 or T111 as thimble material, Final Report WP13–DAS02–T12D2, EFDA_D_ 2M69VL, 2013.

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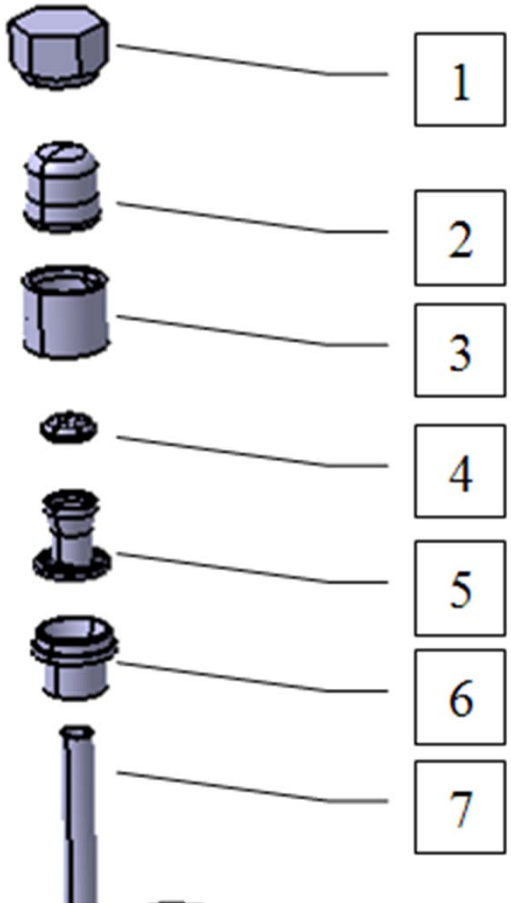
Assembling square finger (W square tile & Ta-10W thimble)



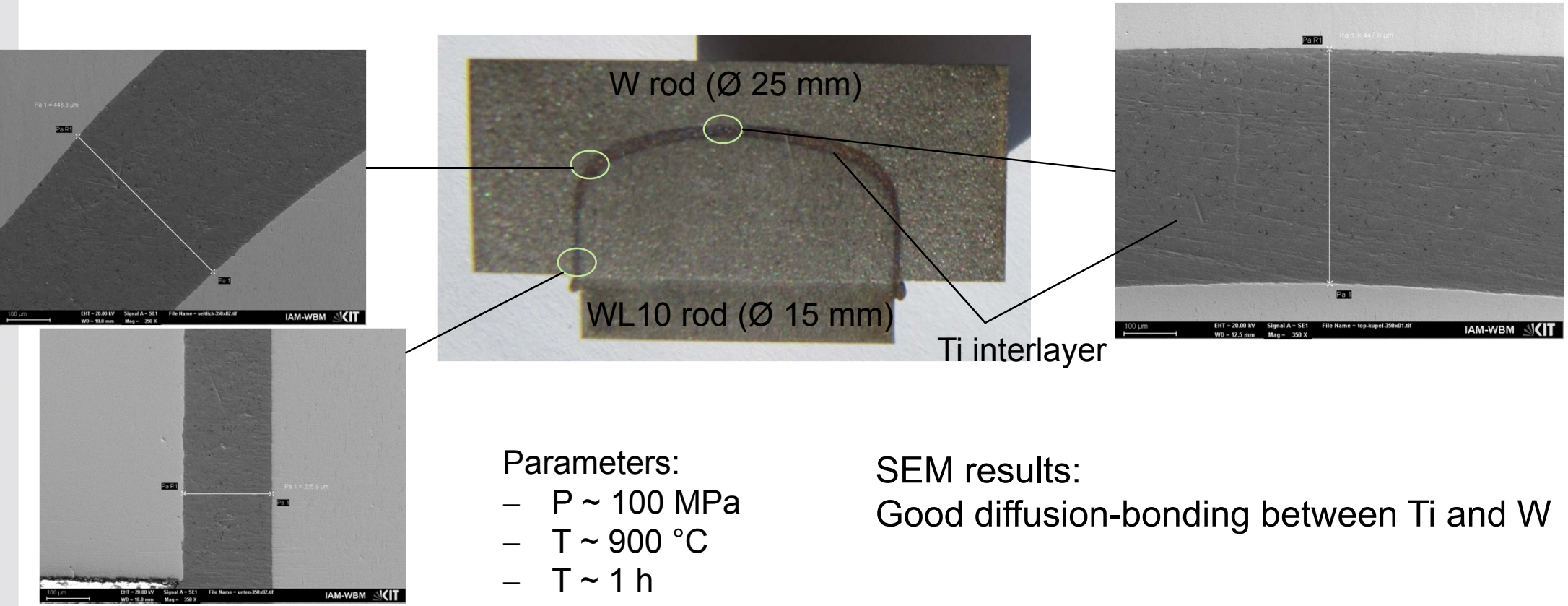
Step	Action
1	Diffusion bonding part 1 with part 2 (Ti, @900°C) (advanced joining tech.)
2	HT brazing of parts 2 and 3 (Pd18Cu82, 1120°C)
3	Laser welding of parts 4, 5, and 6 without filler material
4	Electron beam (EB) welding of joint between parts 3 and 6
5	EB welding of joint between parts 6 and 8
6	EB welding of joint between parts 8 and 9
7	Laser welding parts 7 and 9 without filler material
8	EB welding of joint between parts 9 and 10

additional steps for 9-finger module

1: W tile, 2: Ta-10W thimble, 3: steel conic sleeve, 4: steel jet cartridge cap, 5: steel cartridge body, 6: steel cartridge bottom, 7: steel flow guide tube

Advanced W joining using LA Ti interlayer

New technology: W–Ti–W joining by diffusion bonding [5]



Parameters:
- P ~ 100 MPa
- T ~ 900 °C
- T ~ 1 h

SEM results:
Good diffusion-bonding between Ti and W

[5] P. Norajitra, W.W. Basuki, L. Spatafora, U. Stegmaier, He-Cooled Divertor for Demo: Technological Study on Joining Tungsten Components with Titanium Interlayer, ICFRM-16, Beijing, China, 2013.

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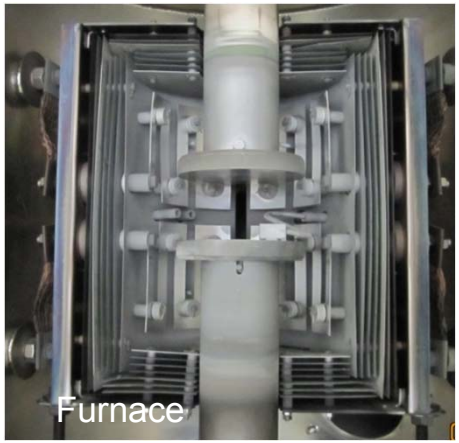
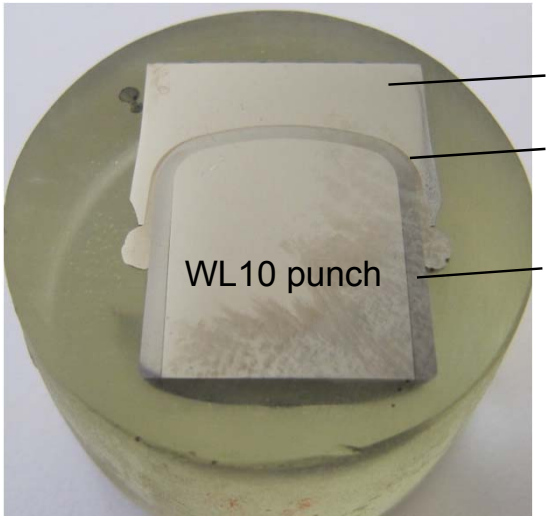
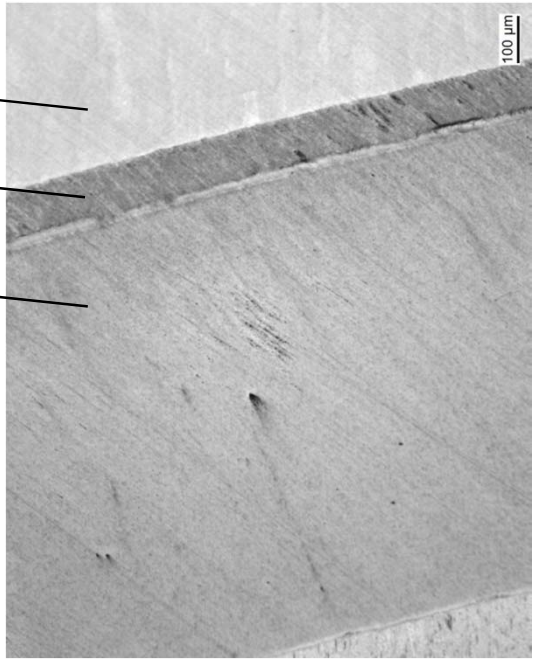
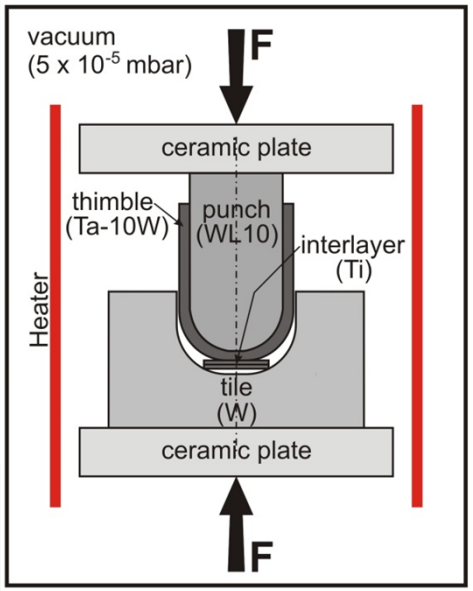
Postexamination of diff. bonded W / Ti / Ta-10W joint









F_{max} 40 kN, T_{bond} 900°C,
displacement control @ 1 µm/s

First sample: pressure punch was firmly wedged.

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W / Ti / Ta-10W joint successfully diffusion bonded

Boron nitride spray applied on the pressure punch.

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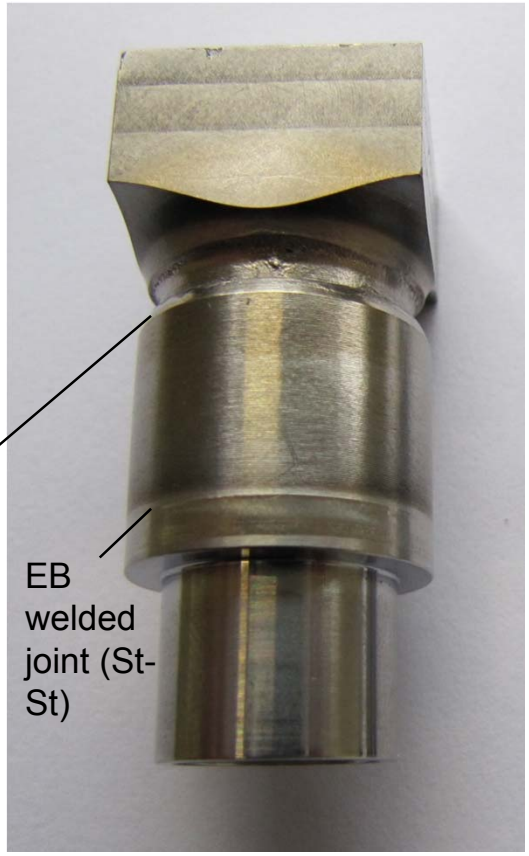
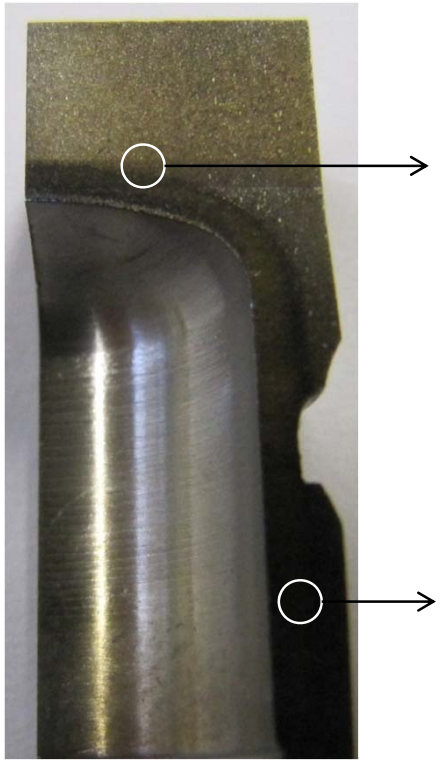
After PdCu braze joining Ta-10W thimble with steel sleeve, cooling fingers were completely manufactured

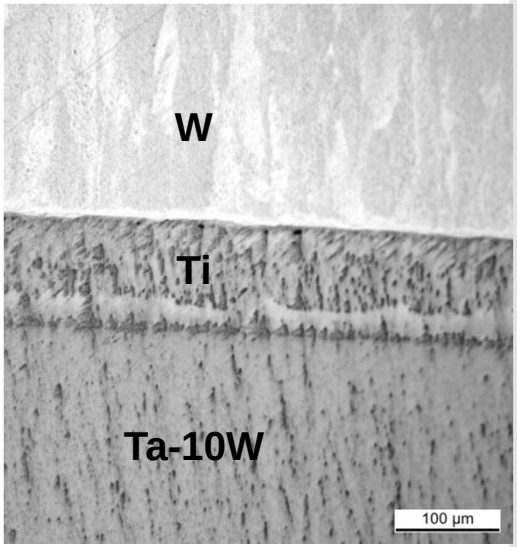
High-vacuum quartz tube furnace for Ta-10W-Steel brazing with PdCu @ 1100 °C

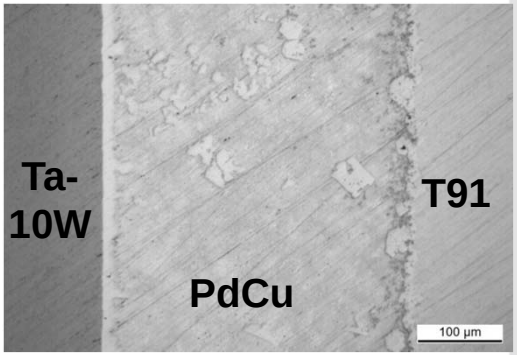


Ta-10W finger ready for HHF tests



Ta-10W finger, EDM cut after PdCu brazing for post examination.





Optical micrographs.

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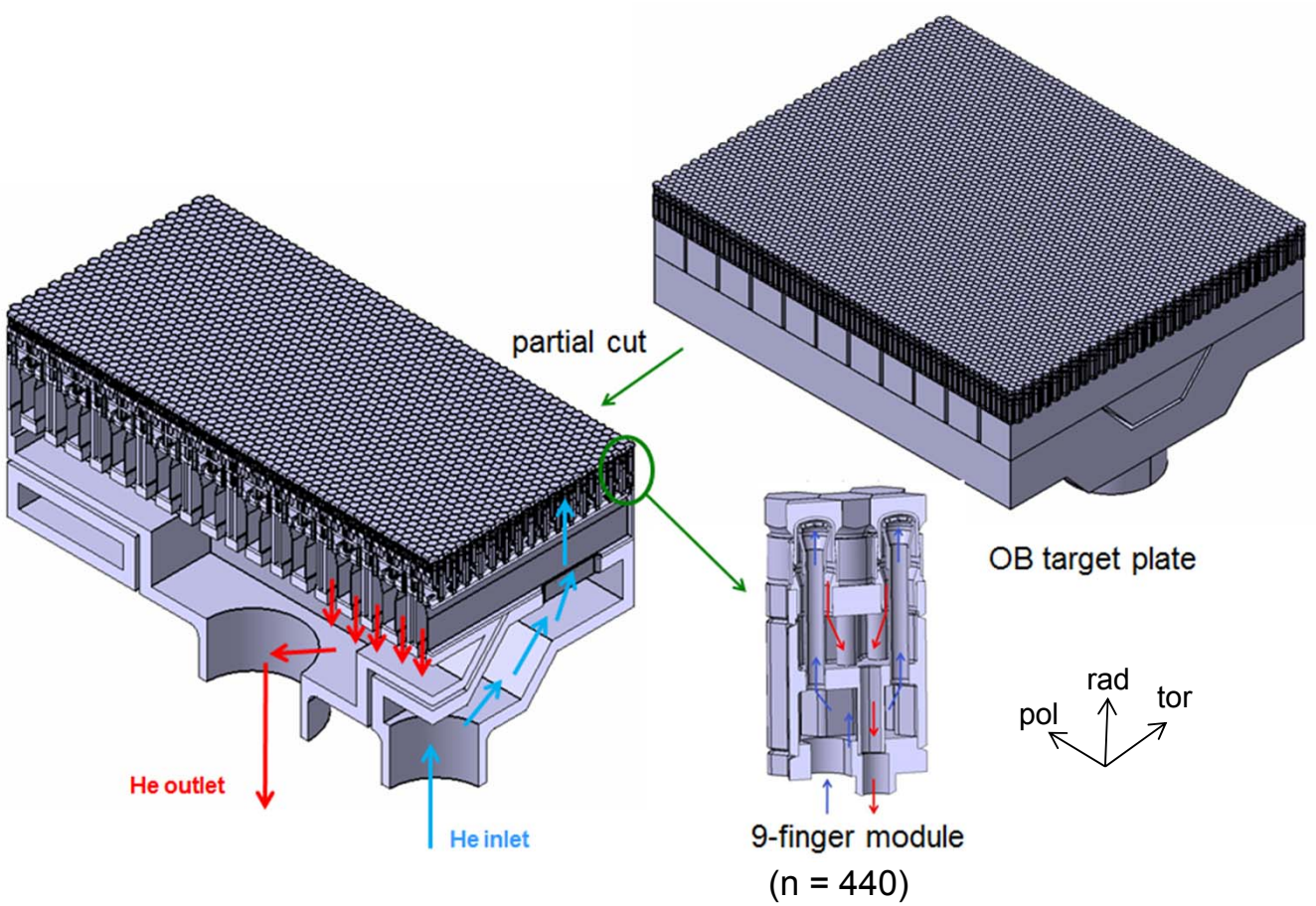
Conclusion manufacturing square finger (W square tile & Ta-10W thimble)

- Mock-up design done. ✓
- Individual parts of a 1-finger module manufactured. ✓
- First CFD thermohydraulics simulations done. ✓
- Jointing and assembling of Ta-10W cooling fingers completed. ✓
- Post examination of 2 fingers performed. ✓

- Future plan:
  - Production of further cooling fingers for detailed HHF tests and optimisation.
  - First series of HHF tests in HELOKA to be started from 2nd Half of 2014.

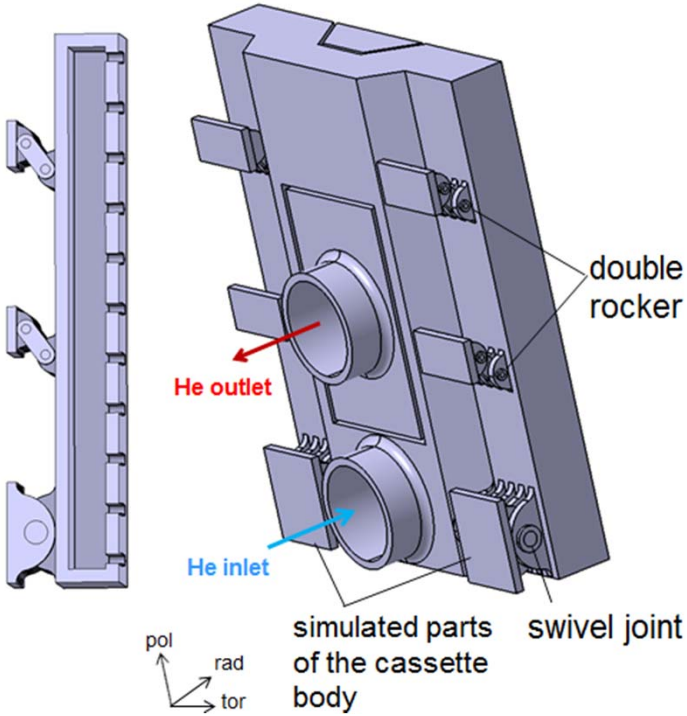
Integration of 9-finger modules to an OB target plate

[P. Norajitra et al., Final Report WP12–DAS02–T05-D1, EFDA_D_2LDRJW, v.1.2, 2012]



Target plate ring duct cooling system with 3 header/manifold levels

[L. Spatafora]



Target plate attachment design

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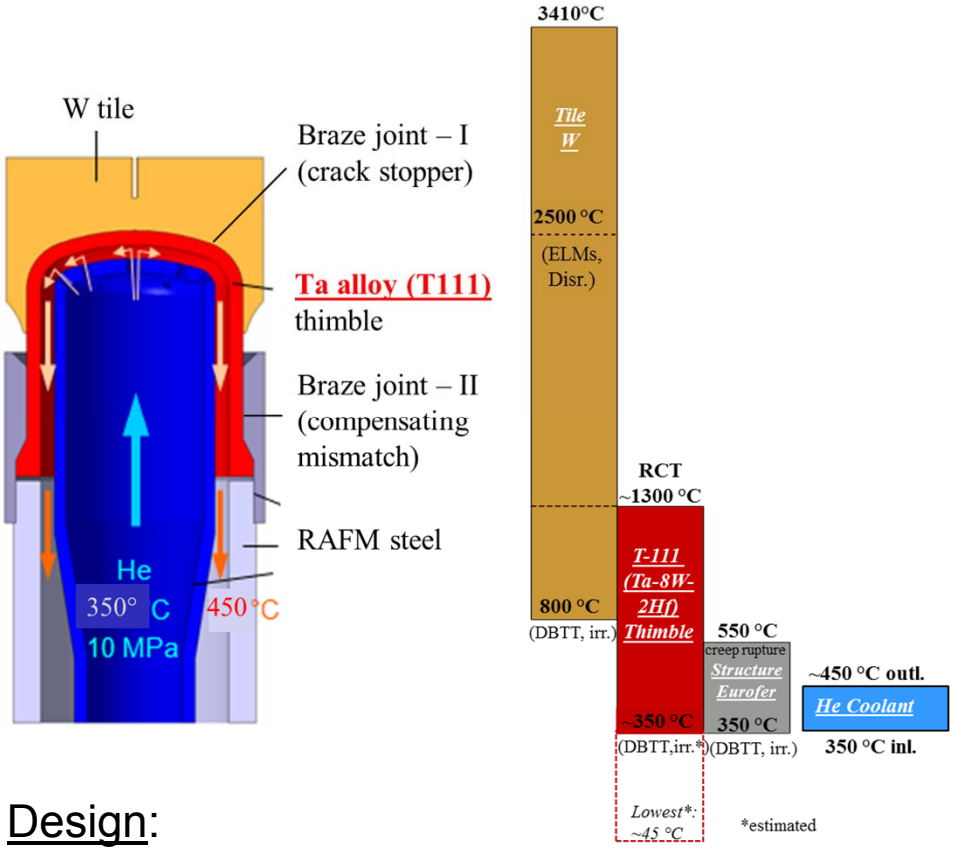
Study on alternative Low-Temp. Design using Ta Alloy as Thimble Material

[P. Norajitra et al., proc. SOFE-25, San Francisco, USA, 2013]

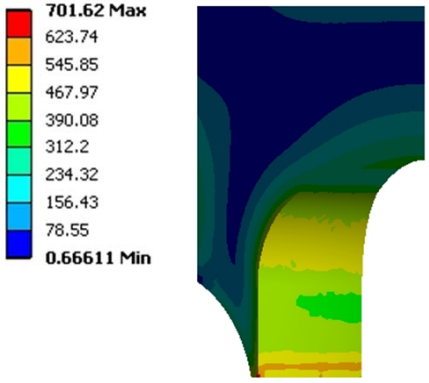


Motivation:

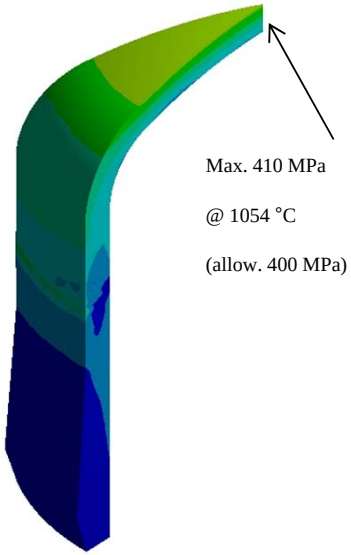
- Unknown irradiated data for W materials
- T111(Ta-8%W-2%Hf): extremely low DBTT (-196 °C) and high creep resistant at 980 – 1310 °C,
- → may satisfy the requirements on the ductility of thimble structure.
- Working temp. 350 °C allows for the simplistic use of Eurofer instead of ODS version.

Design:

- T111 as thimble material
- q = 10 MW/m^2
- p_{He} = 10 MPa
- $T_{in/out}$ = 350/450°C
- He mfr = 6.8 g/s



Tile



Check of T and stresses

→ design is useful

[W. Basuki, B. Koncar]