Update on EU procurement regarding the W transition

PSD Meeting on the transition of JT-60SA to W

V. Tomarchio

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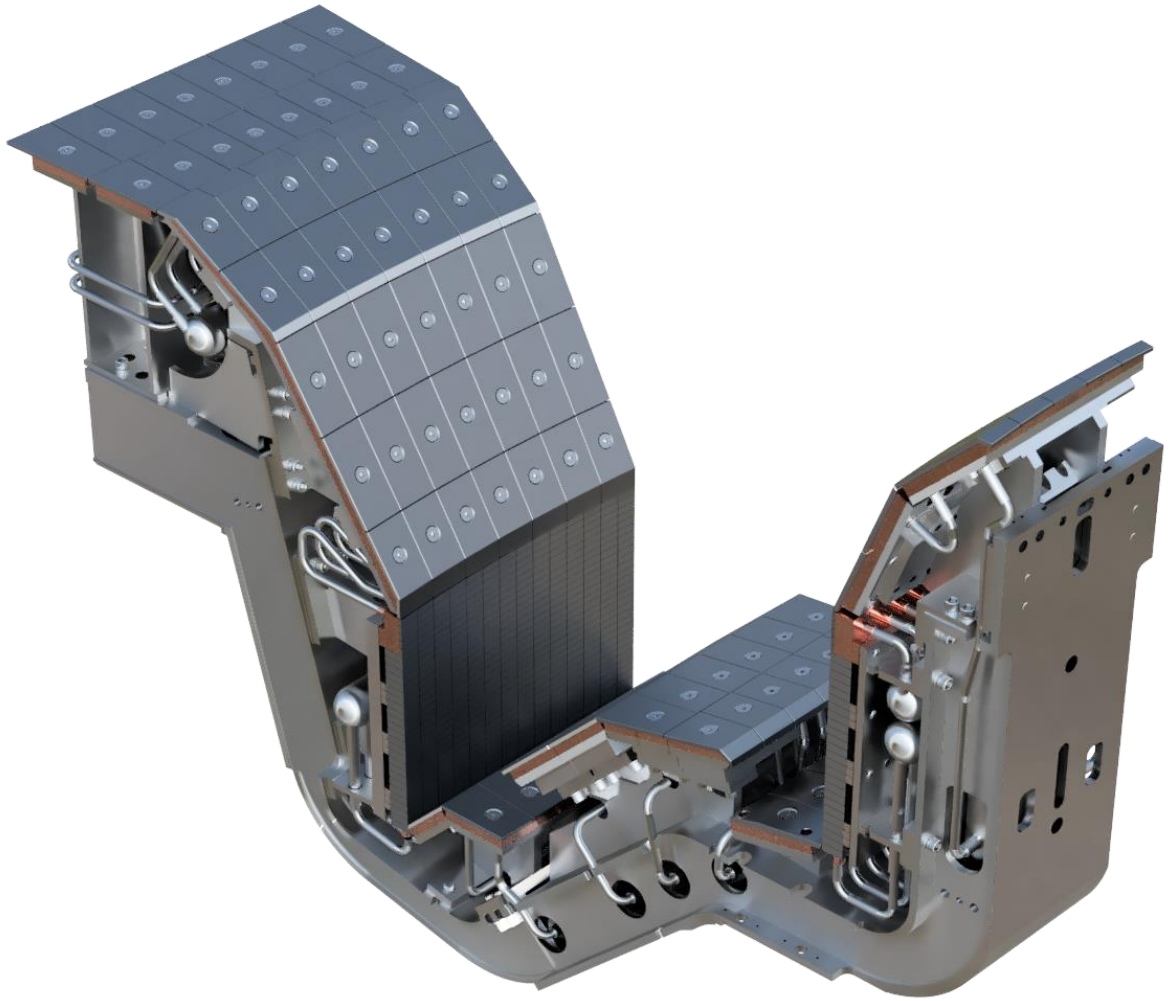
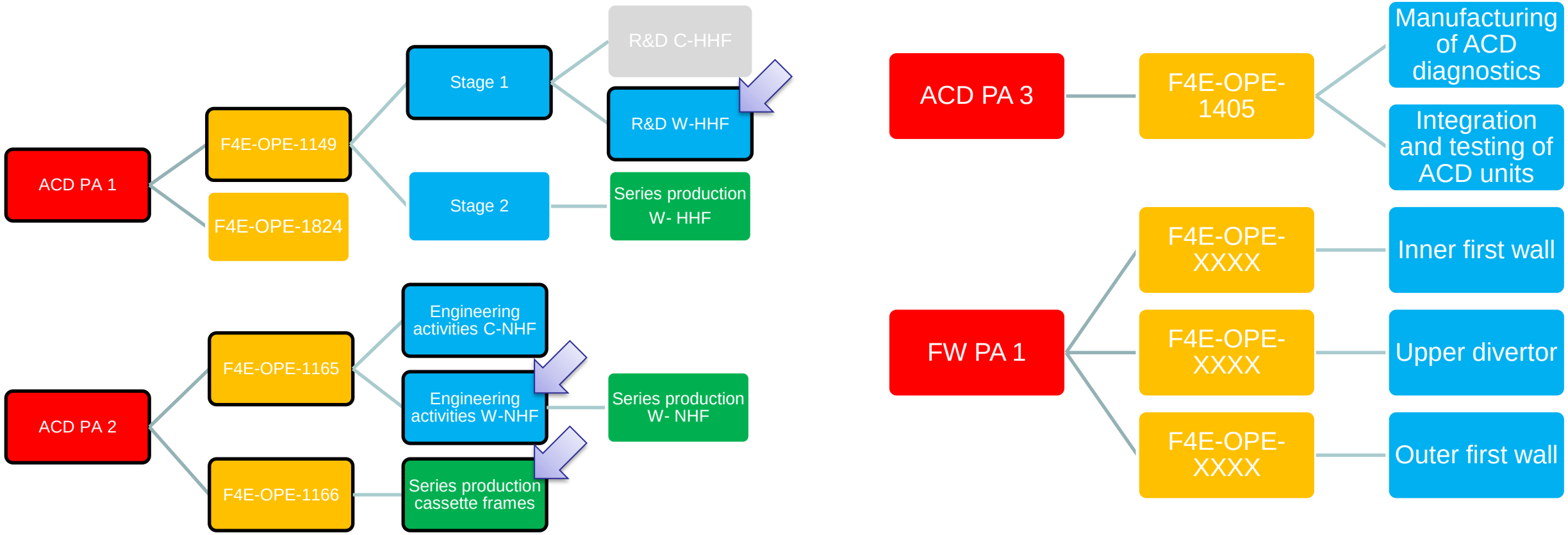


PA strategy


ACD PA 1
F4E-OPE-1149
F4E-OPE-1824
Stage 1
Stage 2
R&D C-HHF
R&D W-HHF
Series production W- HHF
ACD PA 2
F4E-OPE-1165
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Engineering activities C-NHF
Engineering activities W-NHF
Series production cassette frames
Series production W- NHF
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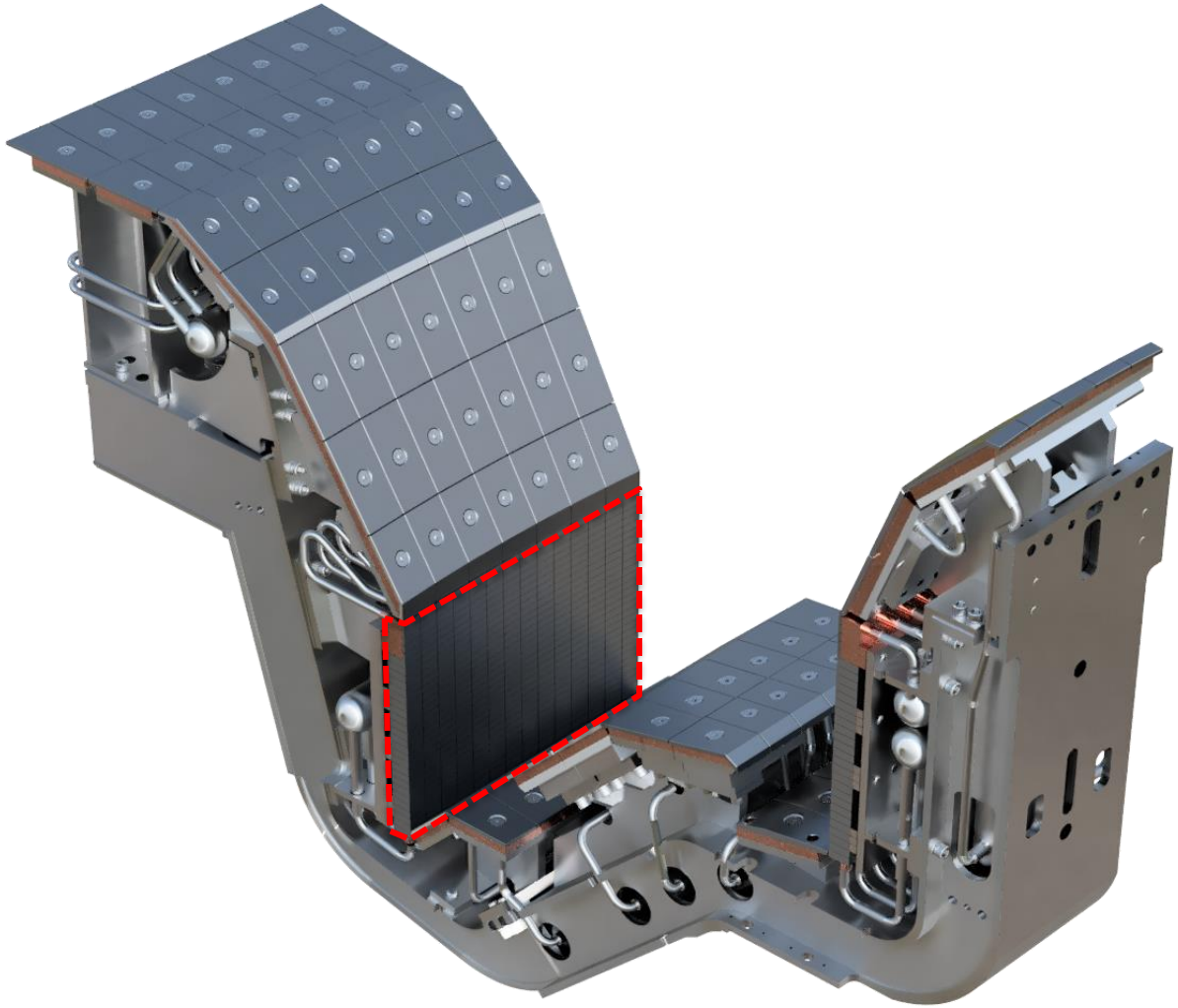
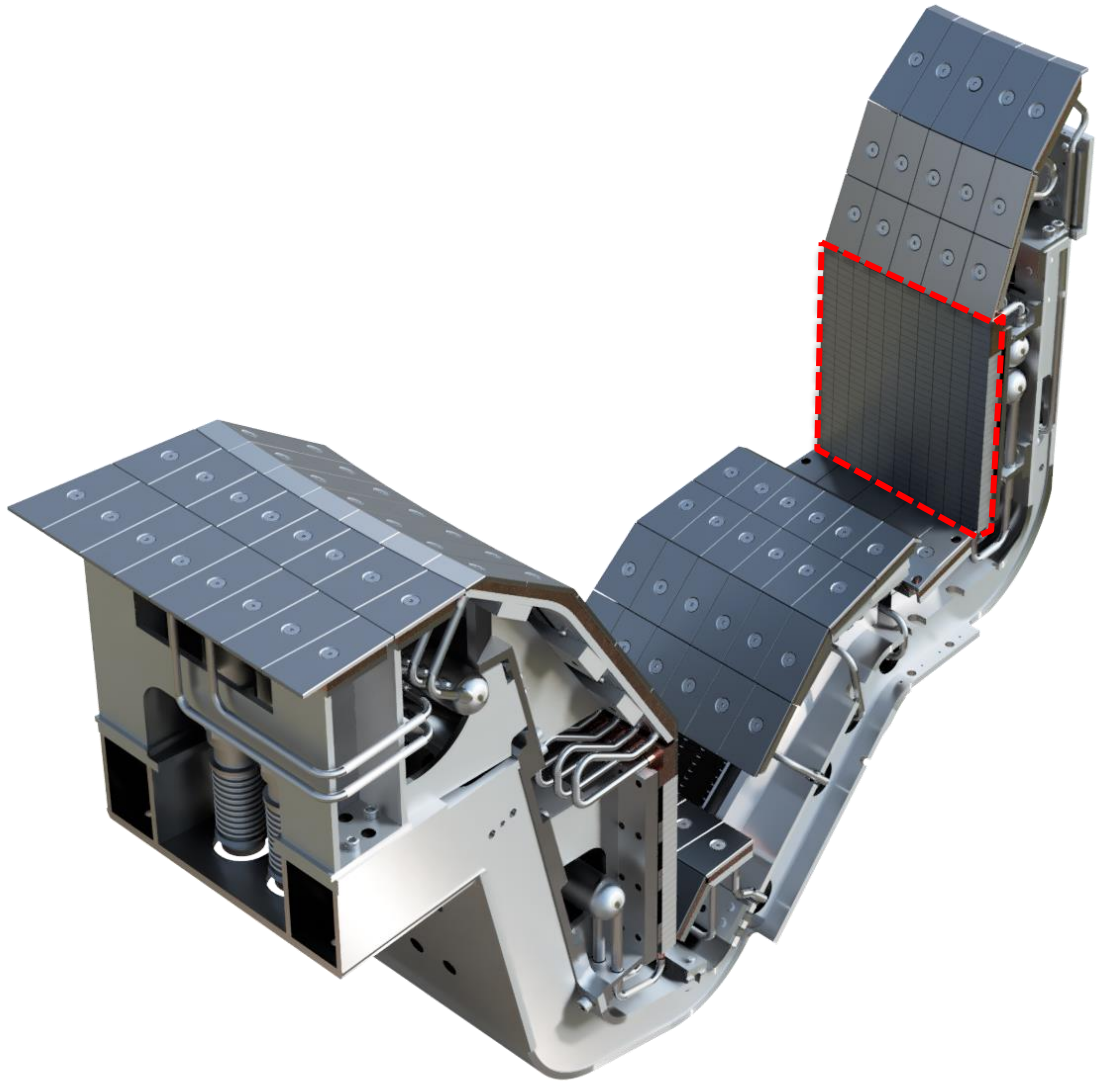
Manufacturing of ACD diagnostics
Integration and testing of ACD units
FW PA 1
F4E-OPE-XXXX
F4E-OPE-XXXX
F4E-OPE-XXXX
Inner first wall
Upper divertor
Outer first wall

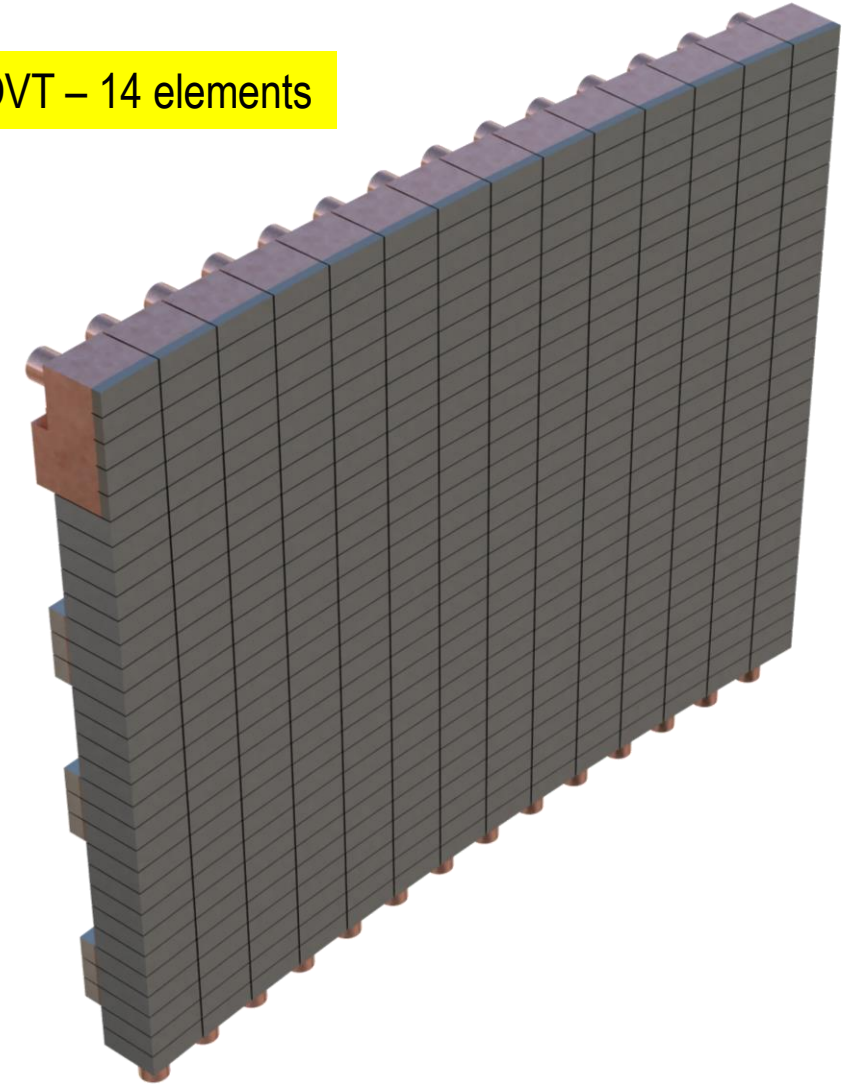
High Heat Flux Elements – HHF

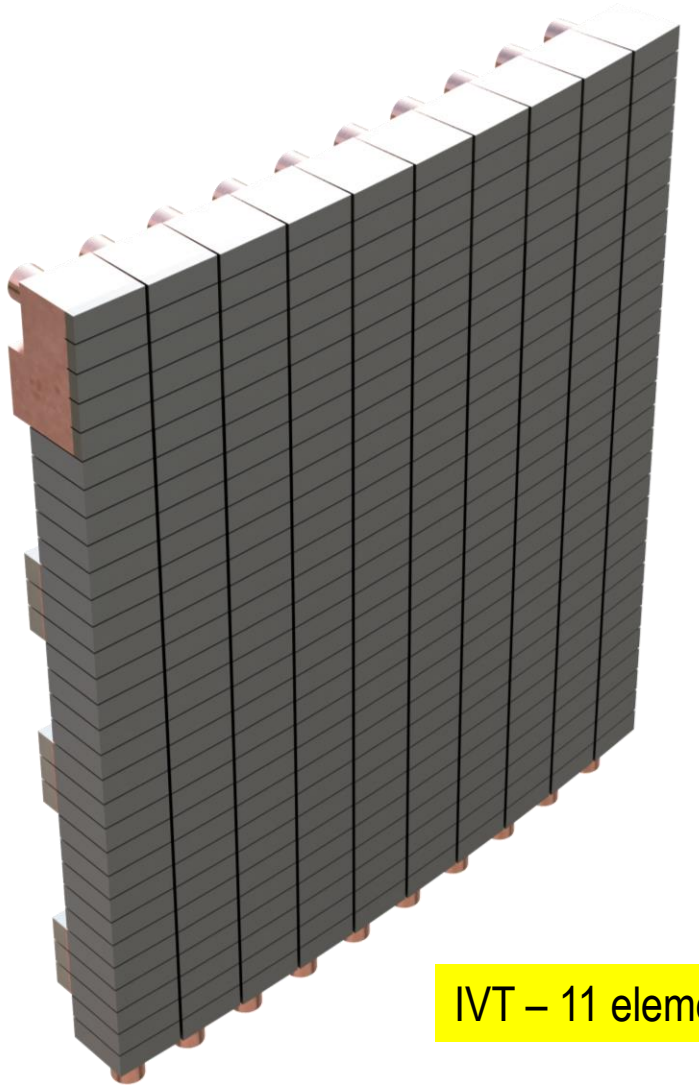




High Heat Flux Elements – HHF

OVT – 14 elements





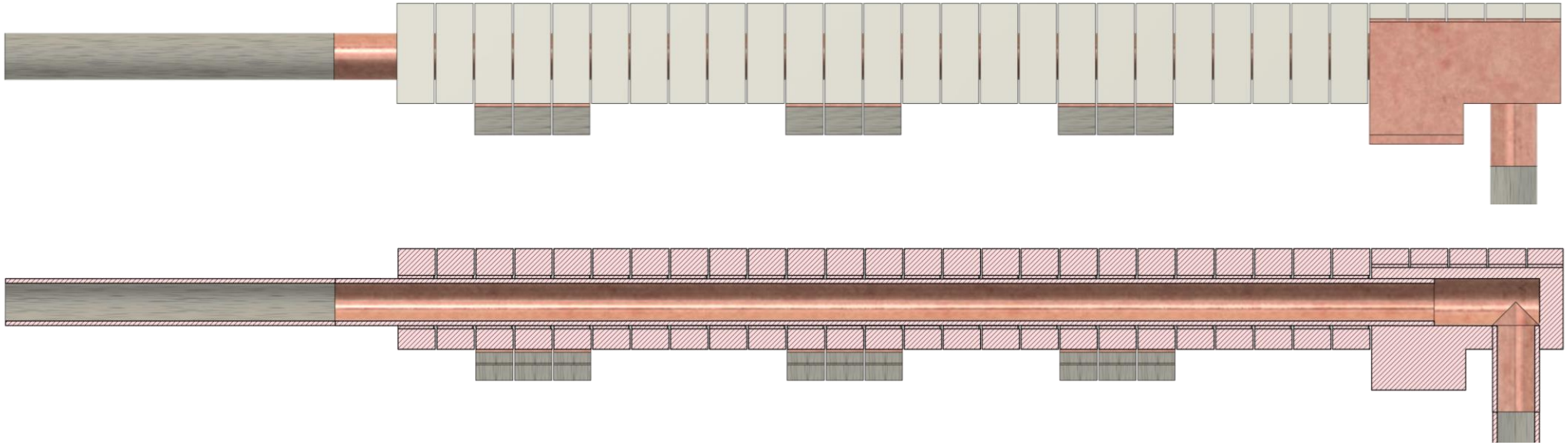
IVT – 11 elements

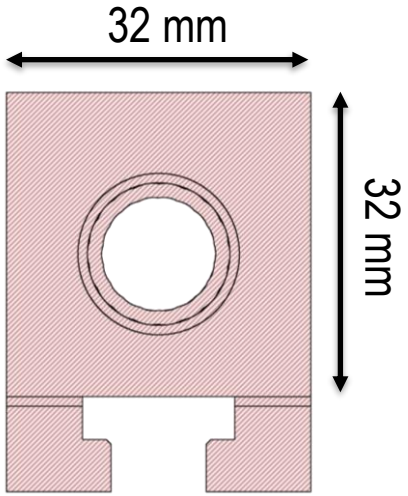
HHF – tungsten monoblock

- The efforts are now focused on the well-known monoblock design

- ITER-grade tungsten plates and complete monoblocks have been sourced to manufacture small scale mockups
- The hot radial pressing (HRP) technique has been chosen to simplify the post-processing of the bonded material, sparing the heat treatment to recover the CuCrZr mechanical properties

HHF – tungsten monoblock

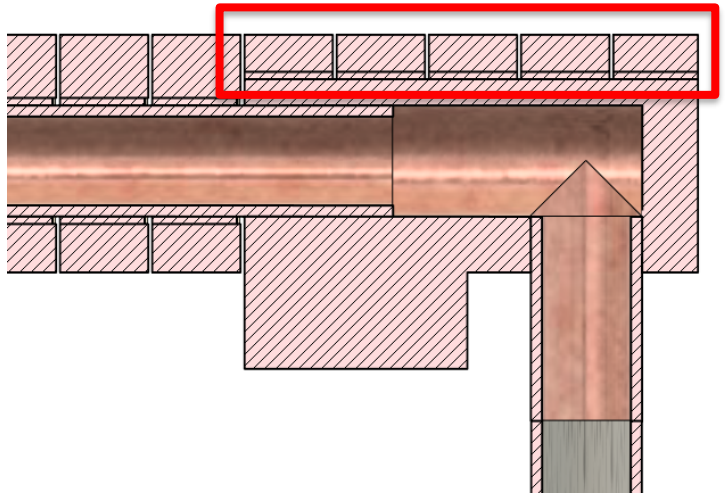




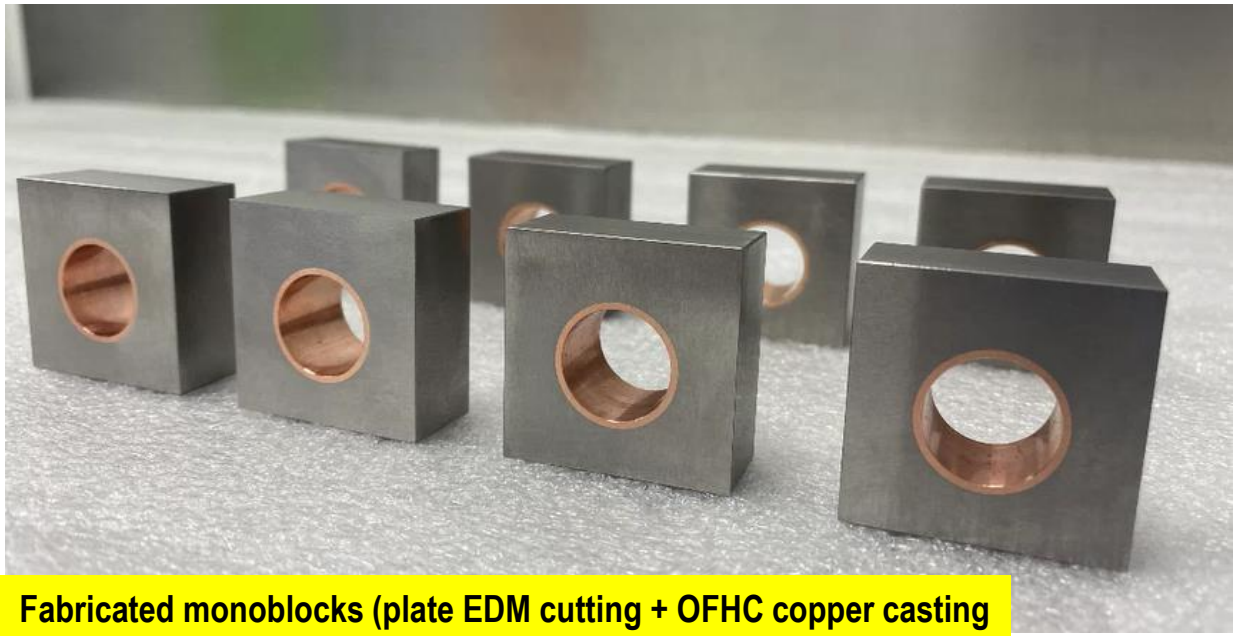
11.9 mm thickness

- Monoblock design (well known design)
- Hot radial pressing (experience in EU)
- ITER grade tungsten (proven material)
- Same shape as active carbon elements

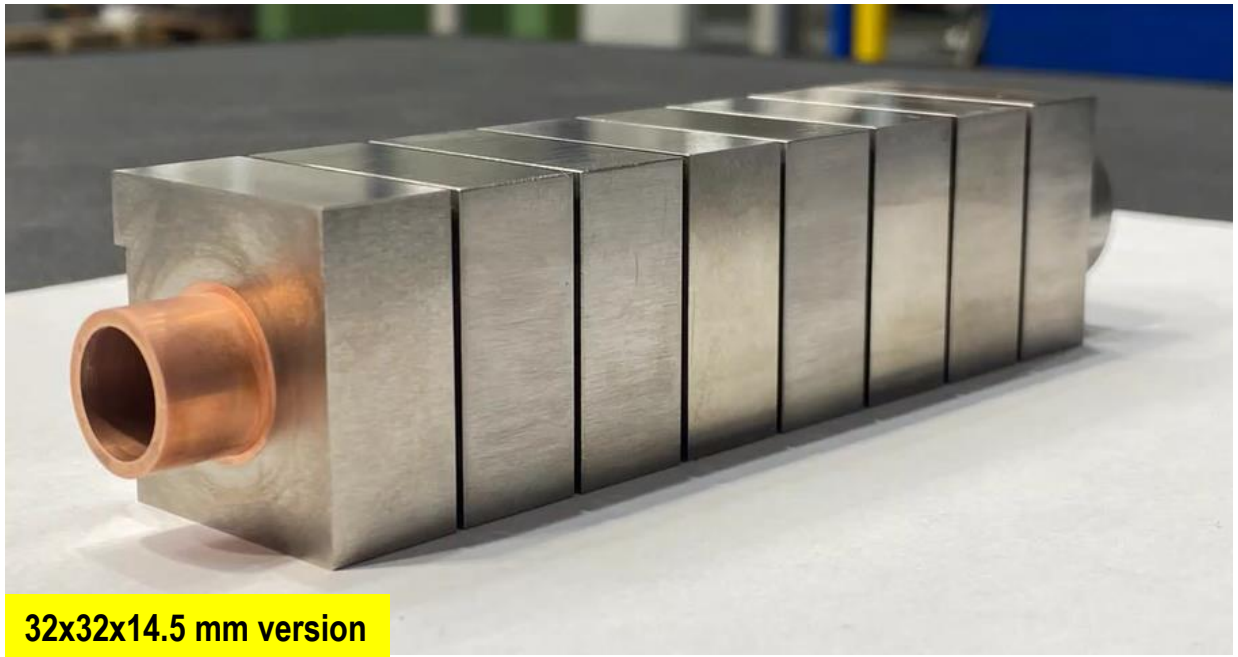
Tungsten tiles for low heat flux region



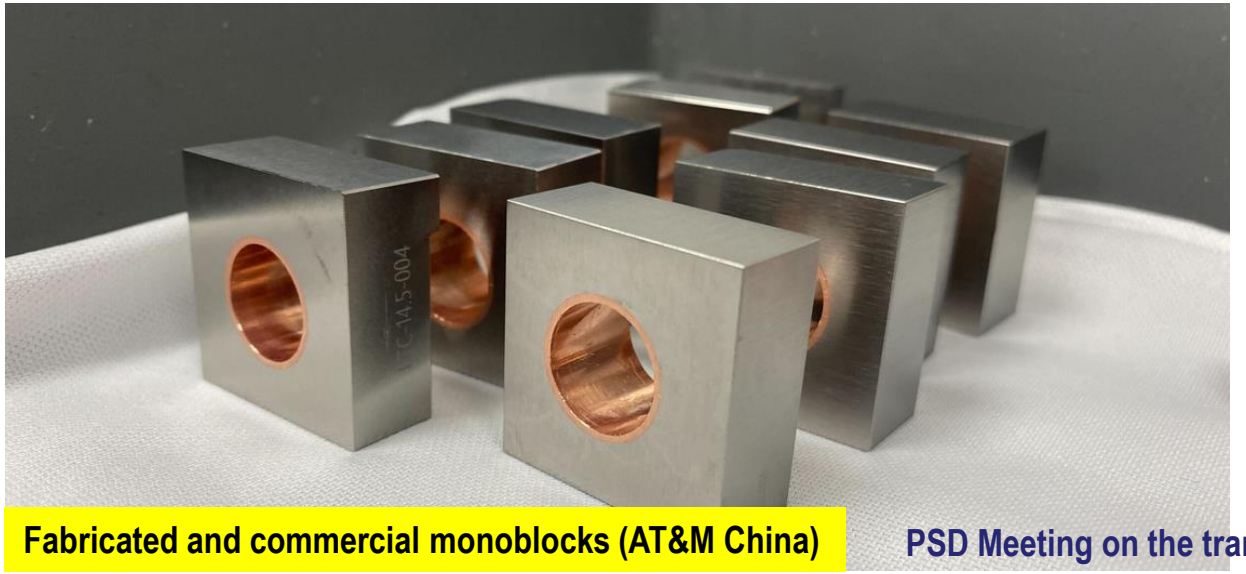
HHF – tungsten monoblock



Fabricated monoblocks (plate EDM cutting + OFHC copper casting



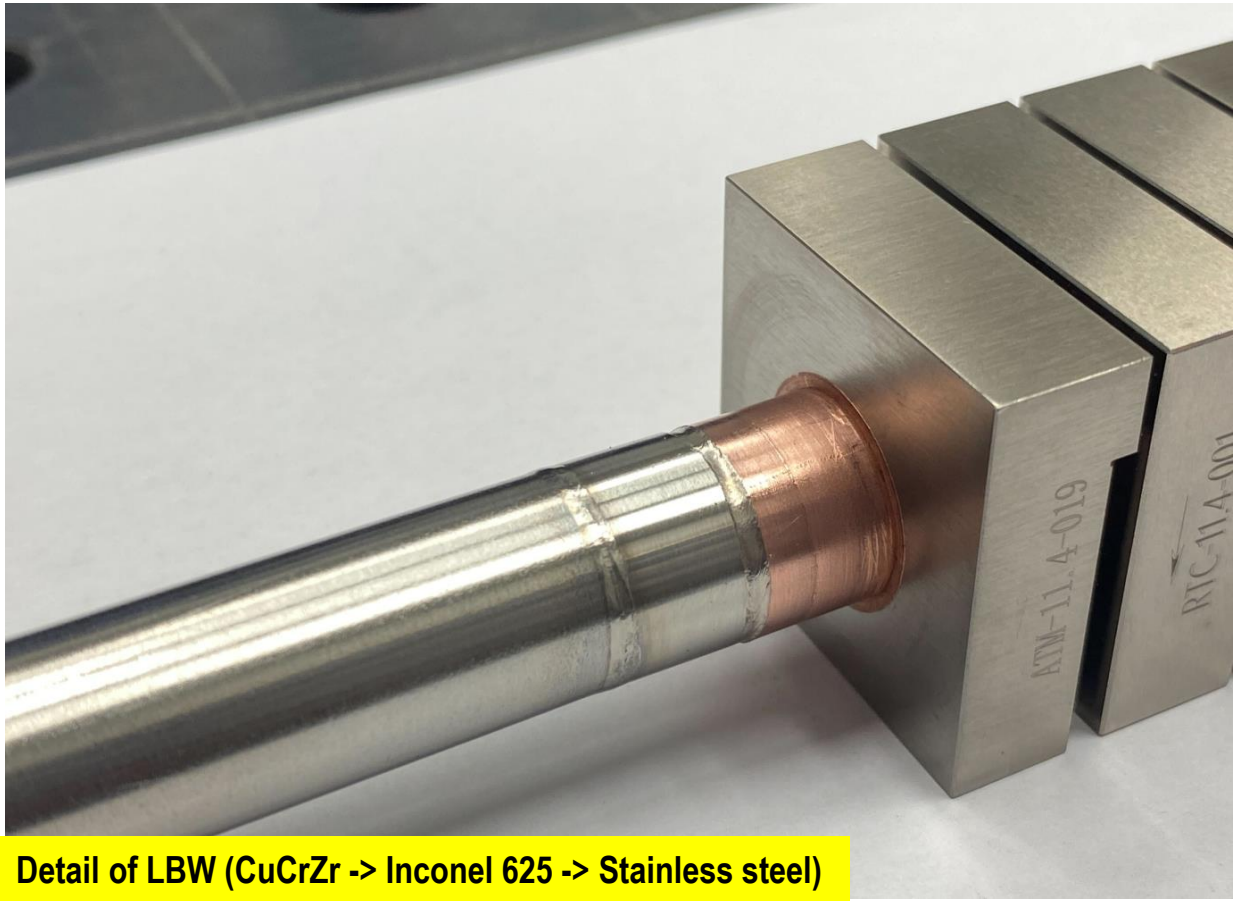
32x32x14.5 mm version



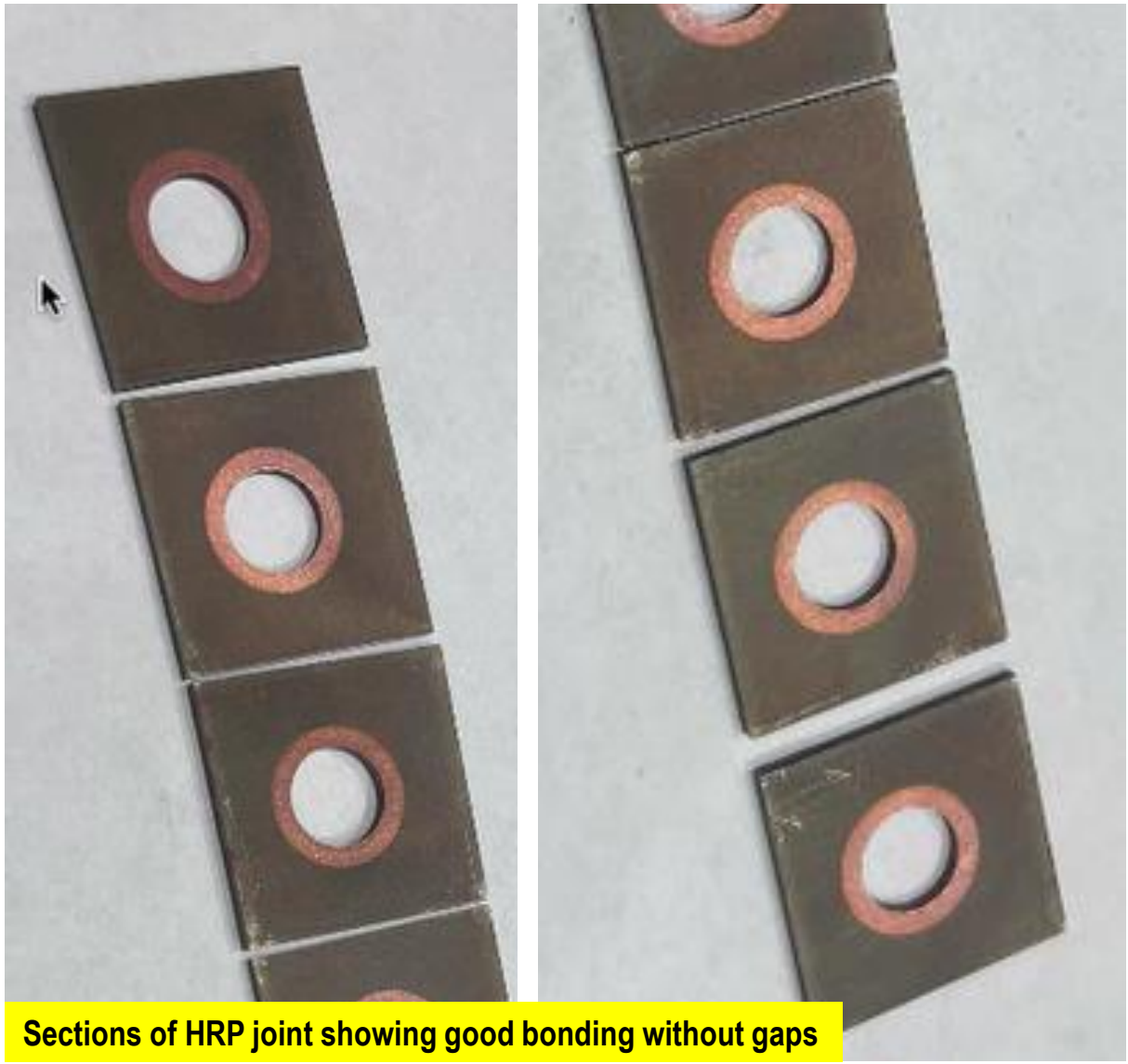
Fabricated and commercial monoblocks (AT&M China)

32x32x11.4 mm version

HHF – tungsten monoblock

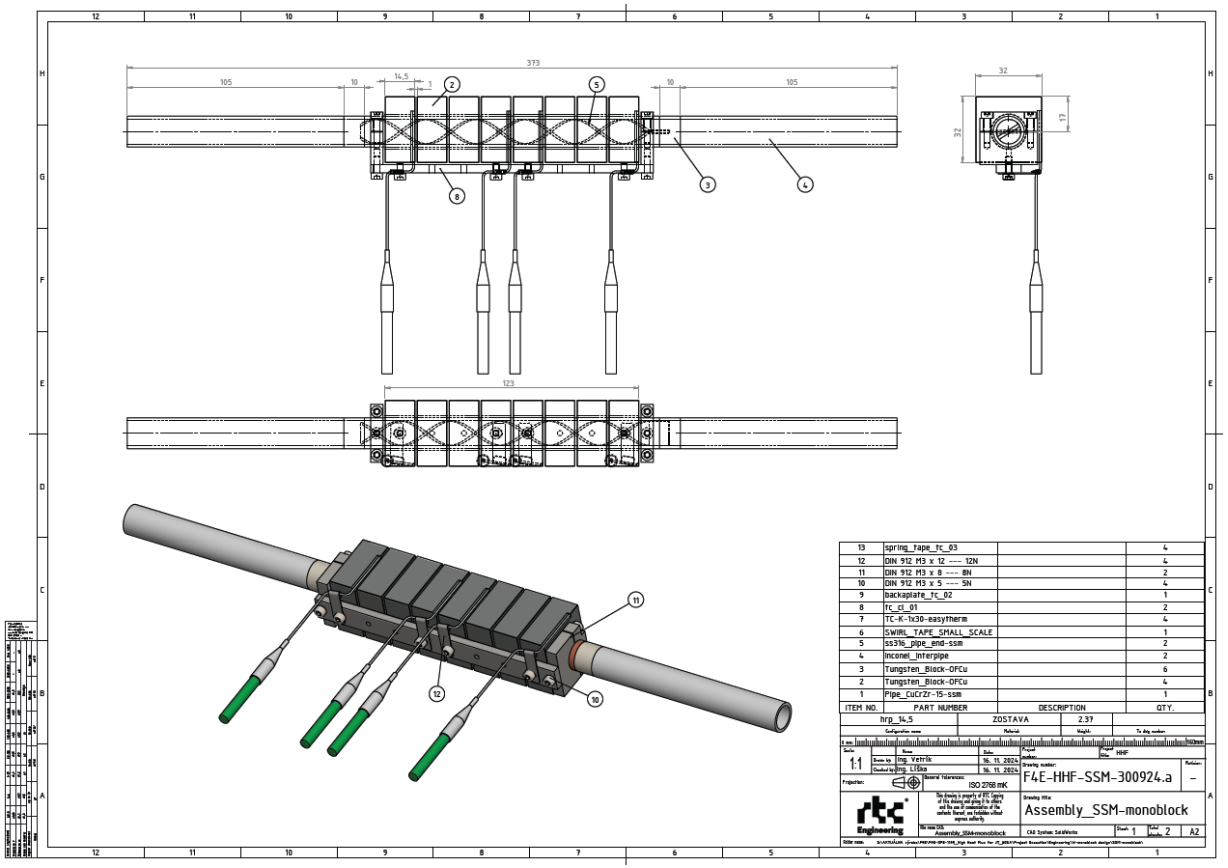


Detail of LBW (CuCrZr -> Inconel 625 -> Stainless steel)

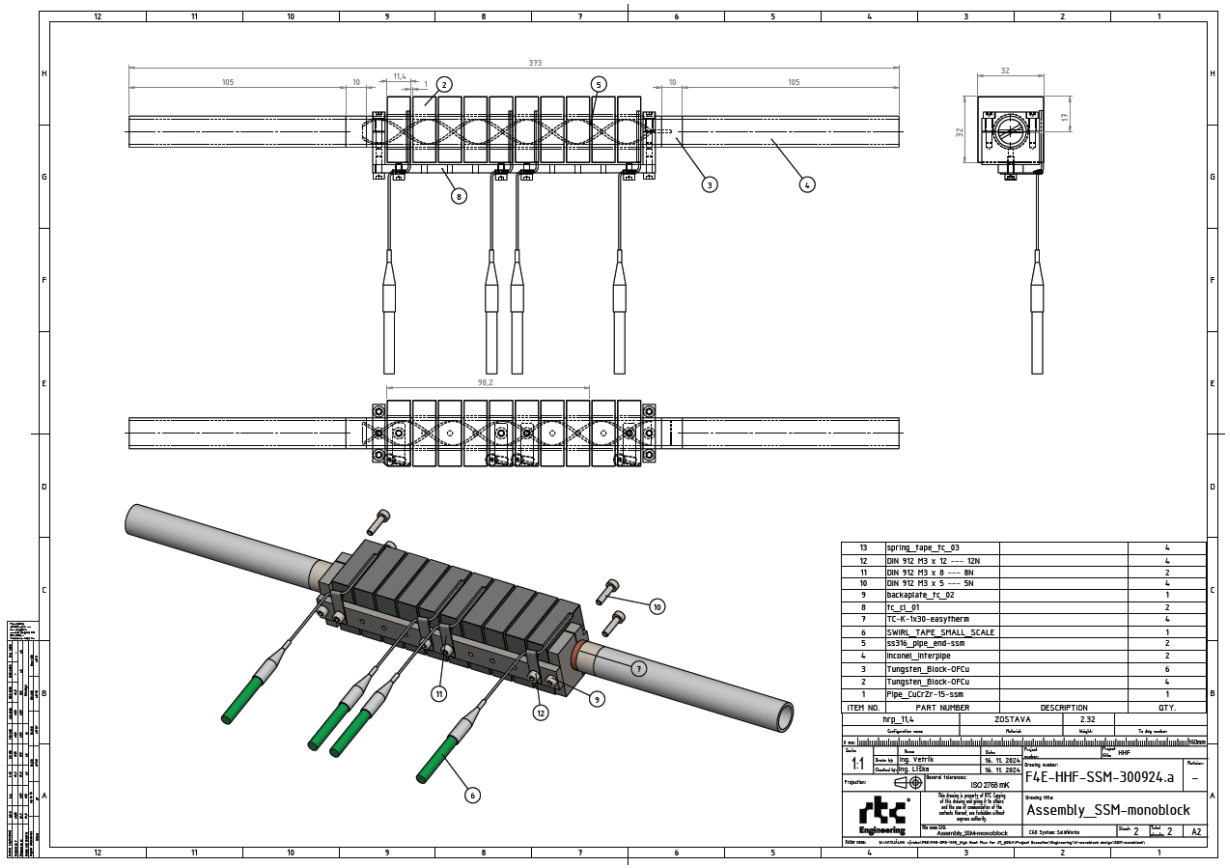


Sections of HRP joint showing good bonding without gaps

HHF – tungsten monoblock



32x32x14.5 mm version – manufacturing drawing



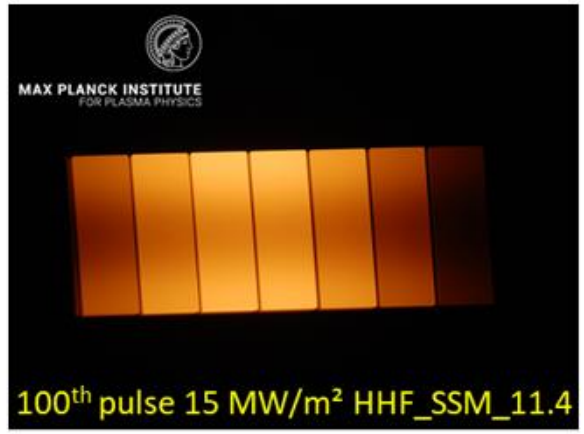
32x32x11.4 mm version – manufacturing drawing

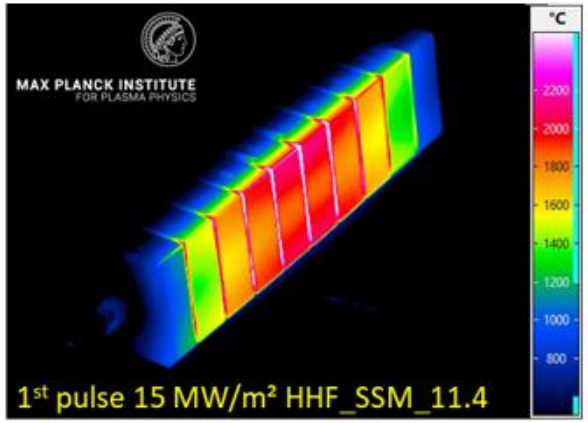
HHF – tungsten monoblock testing

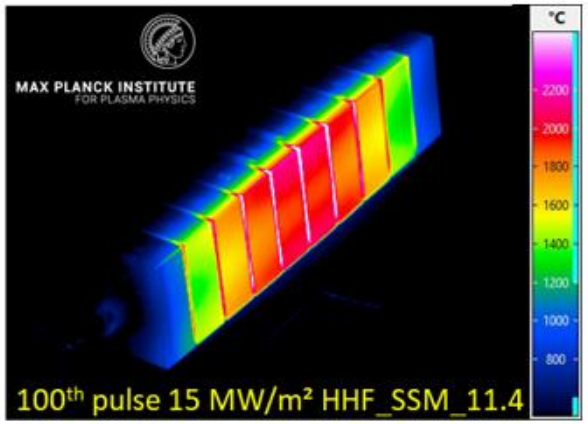
Performed GLADIS loading of JT-60SA monoblock mock-ups

Mounting of JT-60 SA mock-up. The beam maximum is between center blocks.

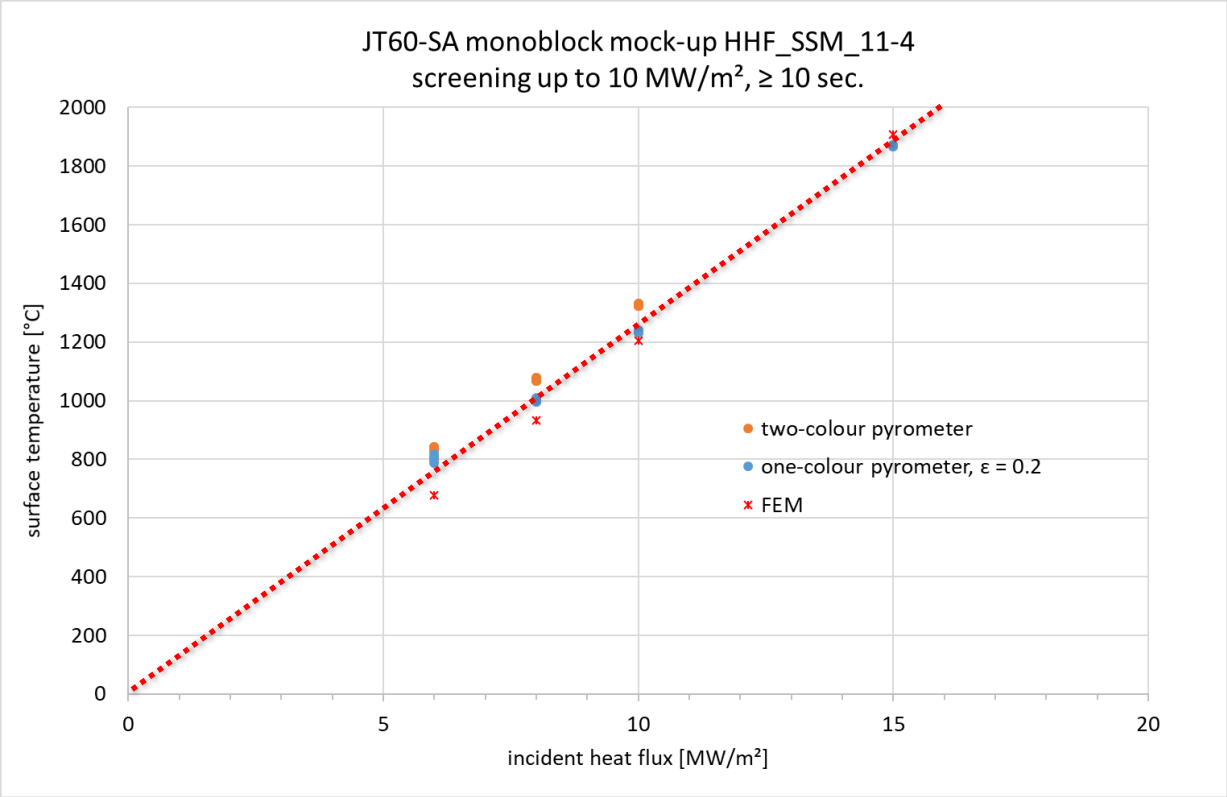
1. screening: 6 – 10 MW/m², up to 15 sec., followed by 15 MW/m², 5sec.
2. cyclic loading: 100 x 10 MW/m², 10 sec.
3. screening of pulse duration: 15 MW/m², 5…12 sec.
4. cyclic loading: 100 x 15 MW/m², 10 sec
5. high power transient loading: 3 x 20 MW/m², 2 sec.

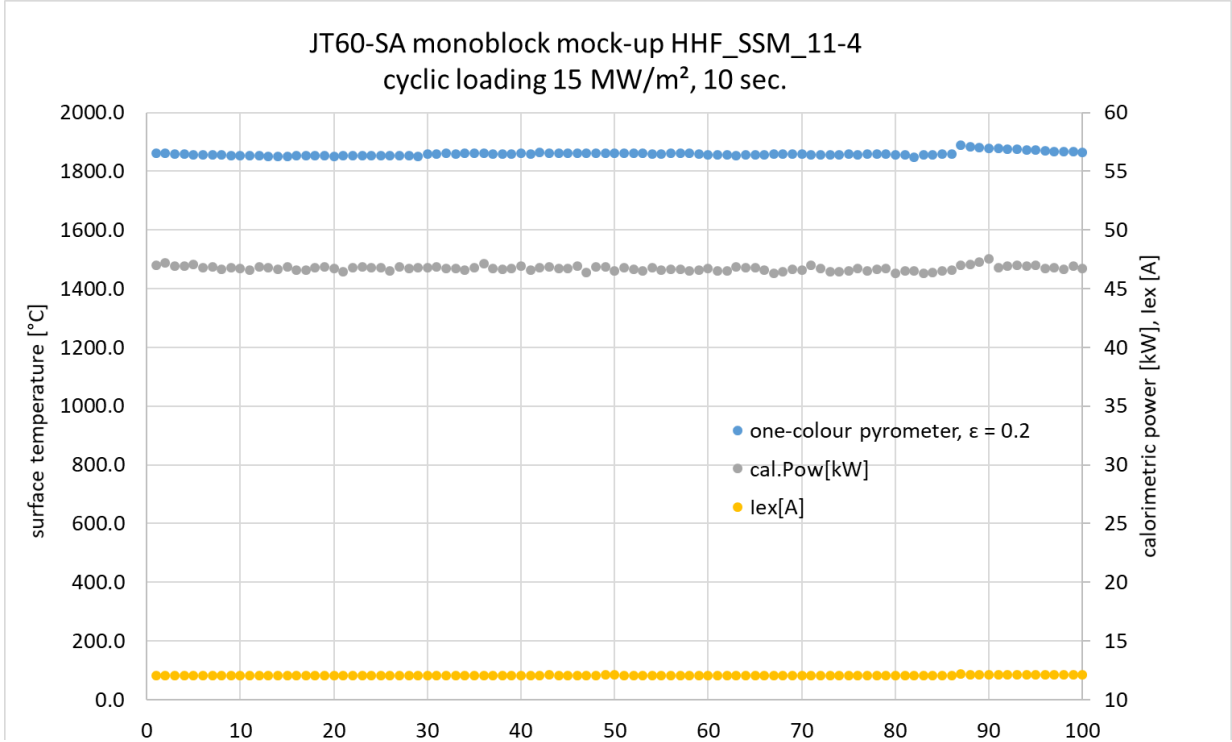




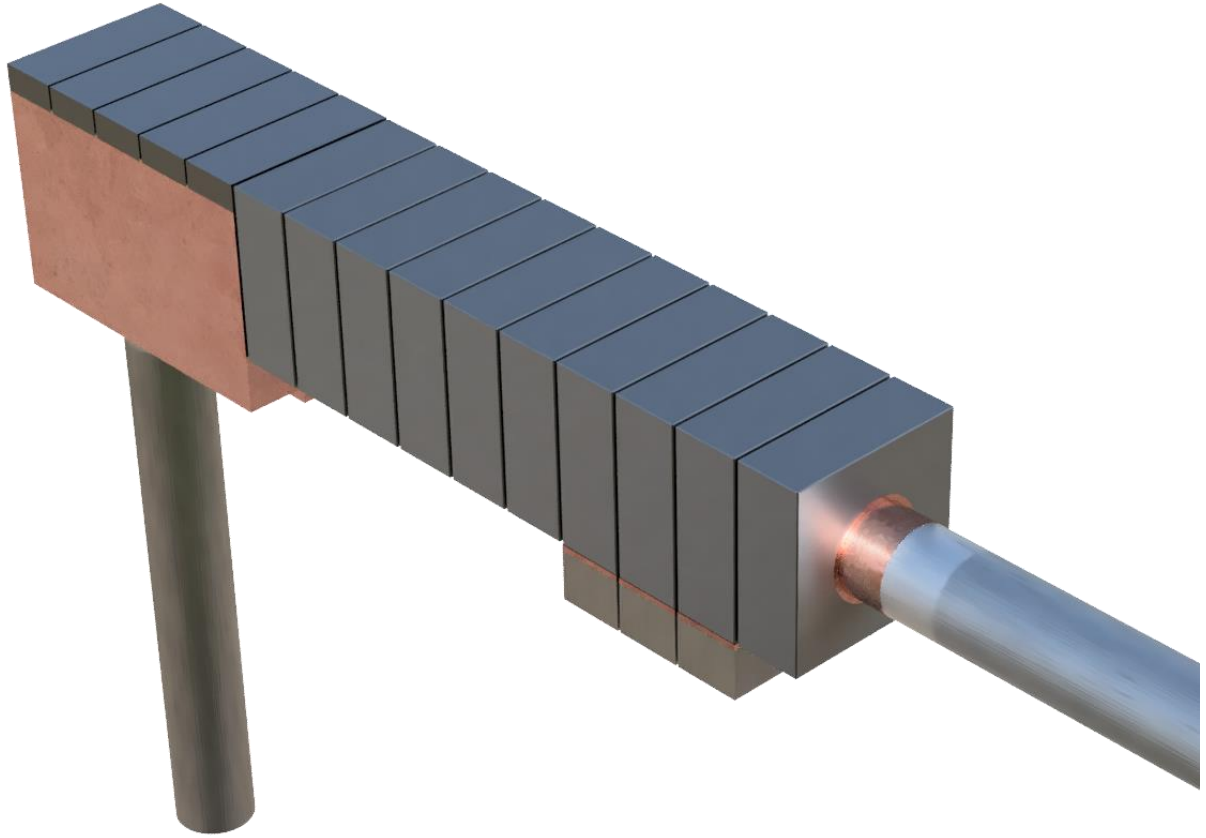


HHF – tungsten monoblock testing

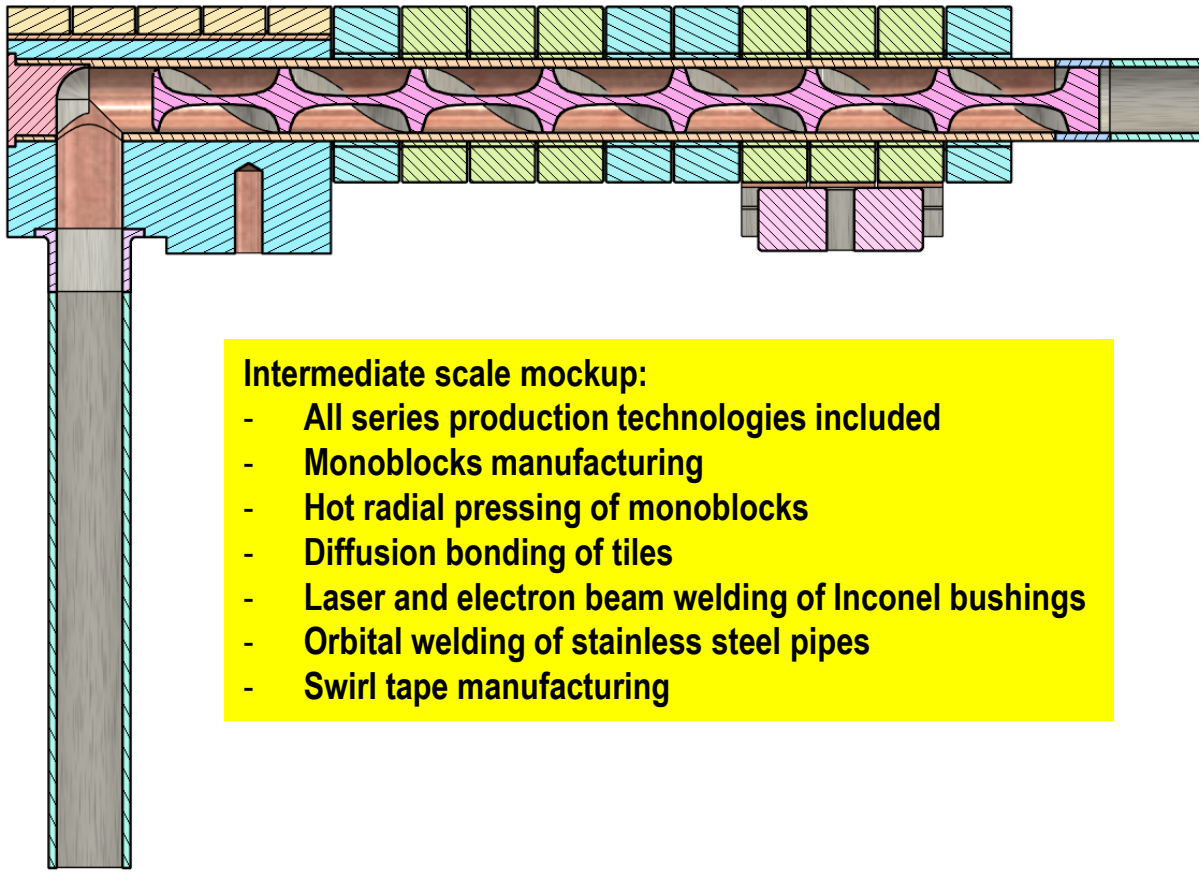




HHF – tungsten monoblock – next steps

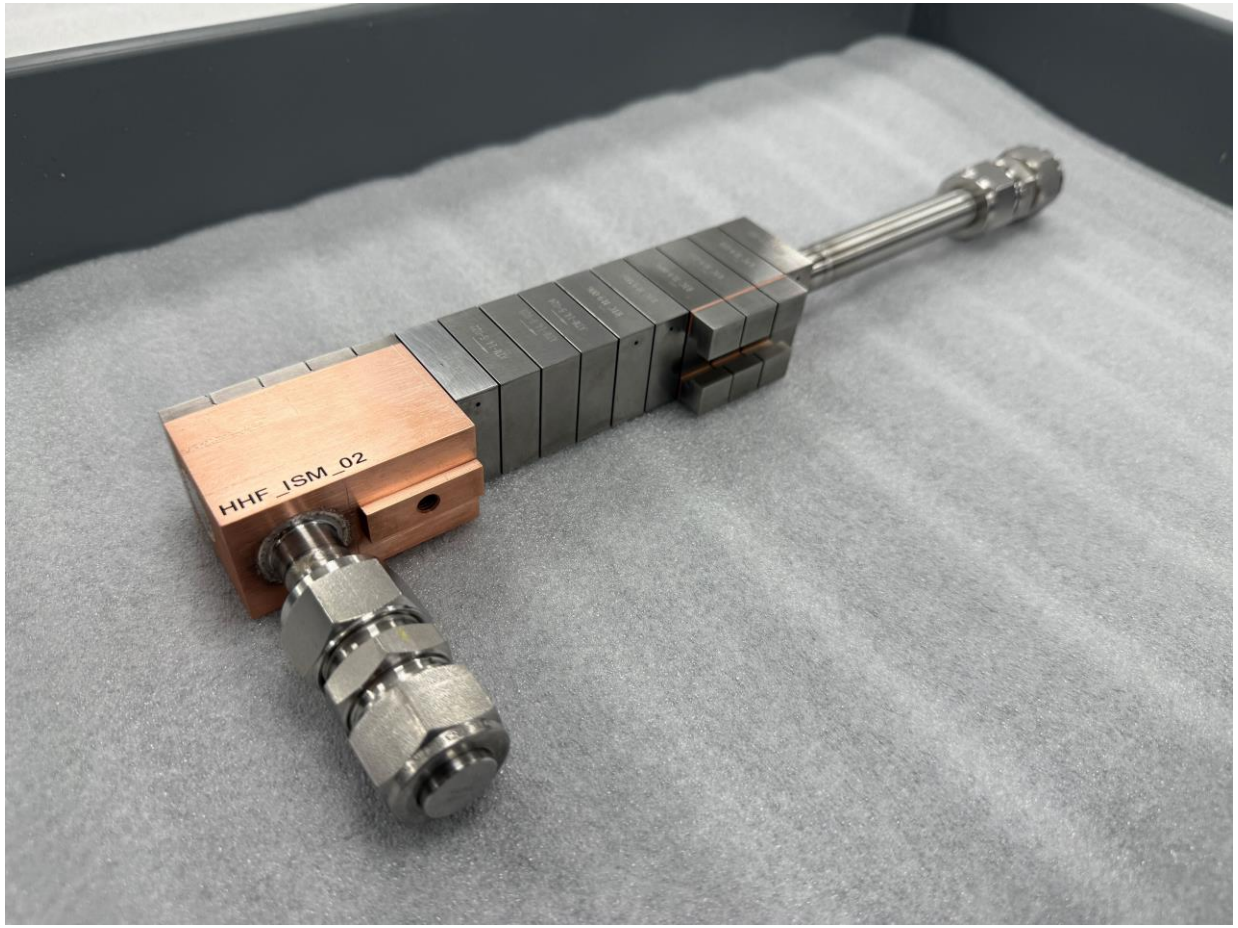


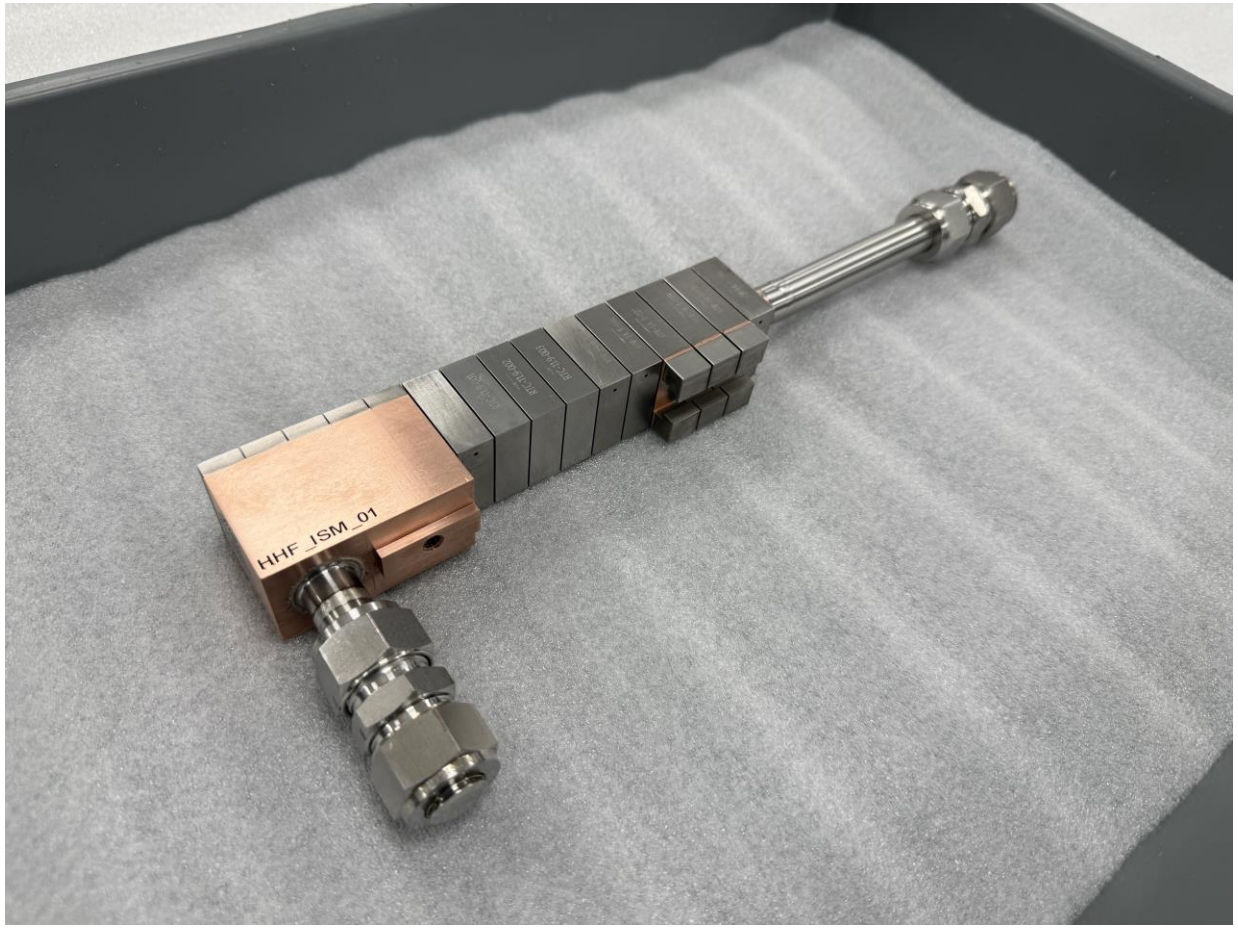
Intermediate scale mockup



Intermediate scale mockup:
- All series production technologies included
- Monoblocks manufacturing
- Hot radial pressing of monoblocks
- Diffusion bonding of tiles
- Laser and electron beam welding of Inconel bushings
- Orbital welding of stainless steel pipes
- Swirl tape manufacturing

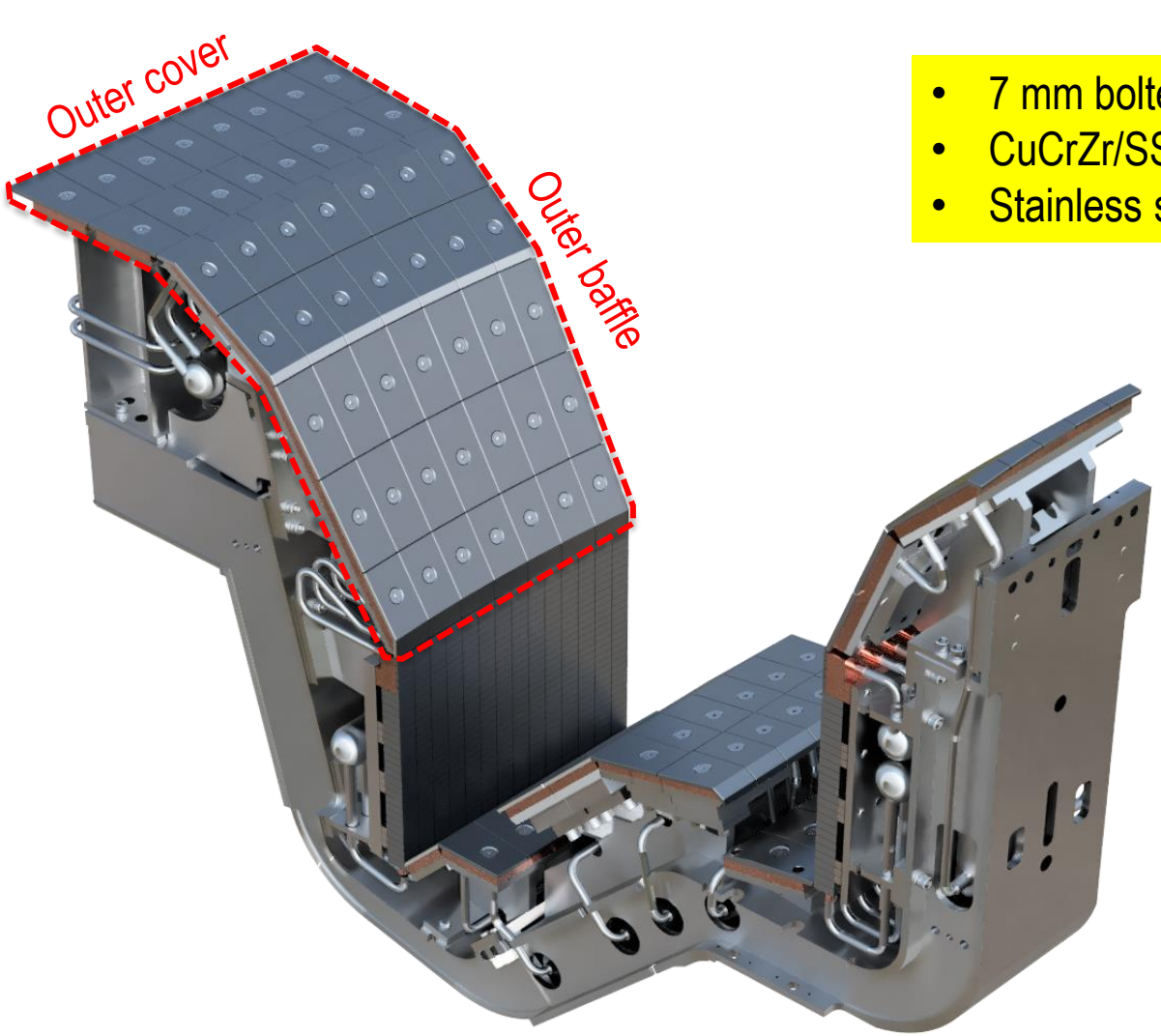
HHF – tungsten monoblock – next steps

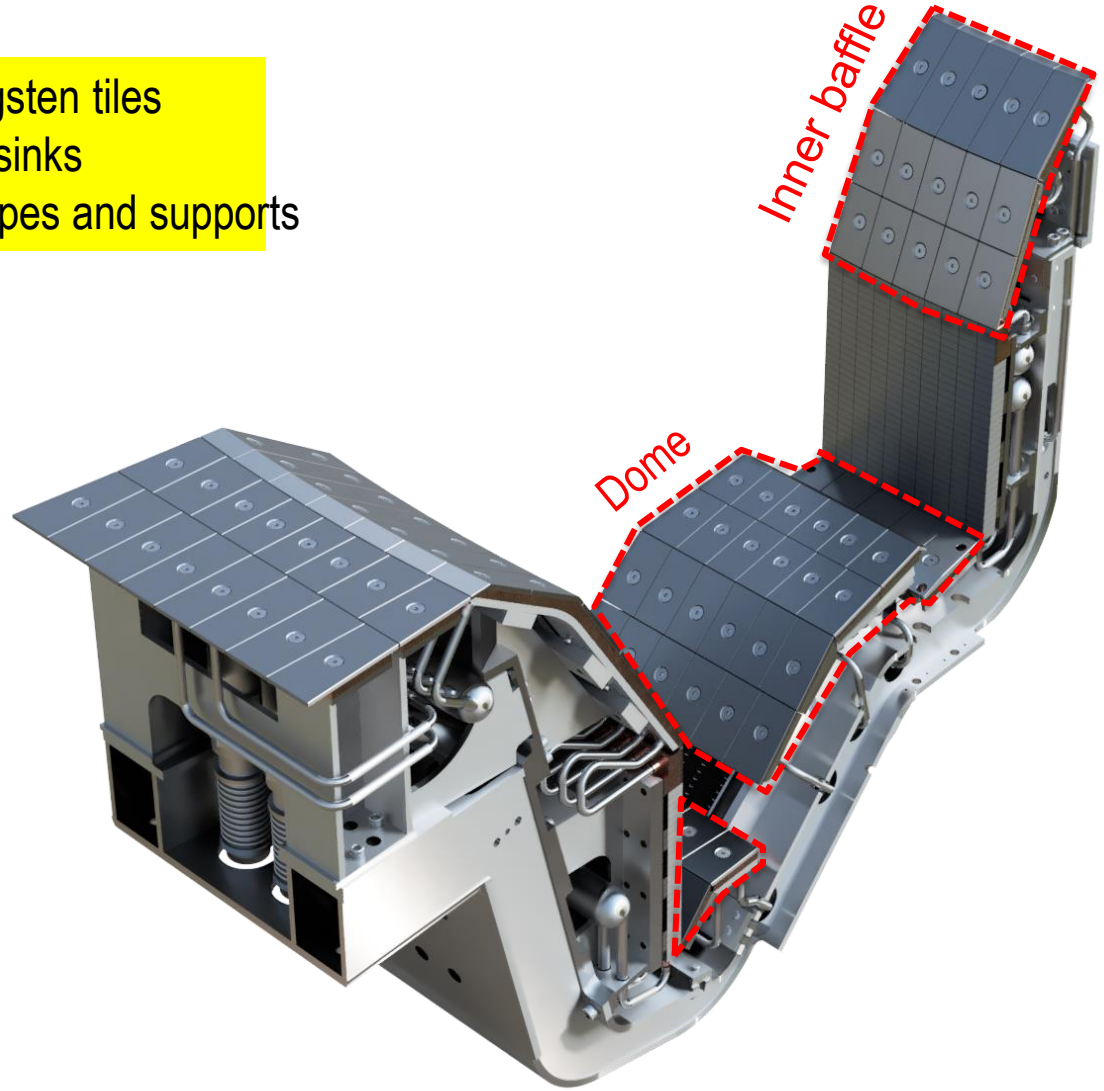




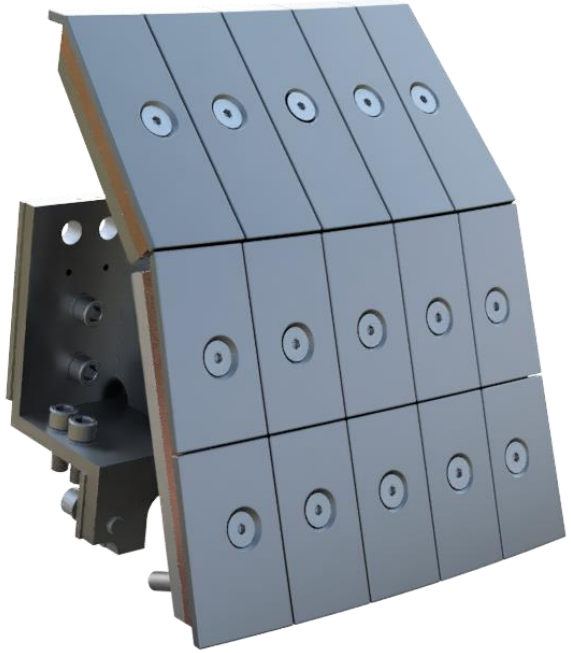
Normal Heat Flux elements – NHF

- 7 mm bolted tungsten tiles
- CuCrZr/SS heat sinks
- Stainless steel pipes and supports

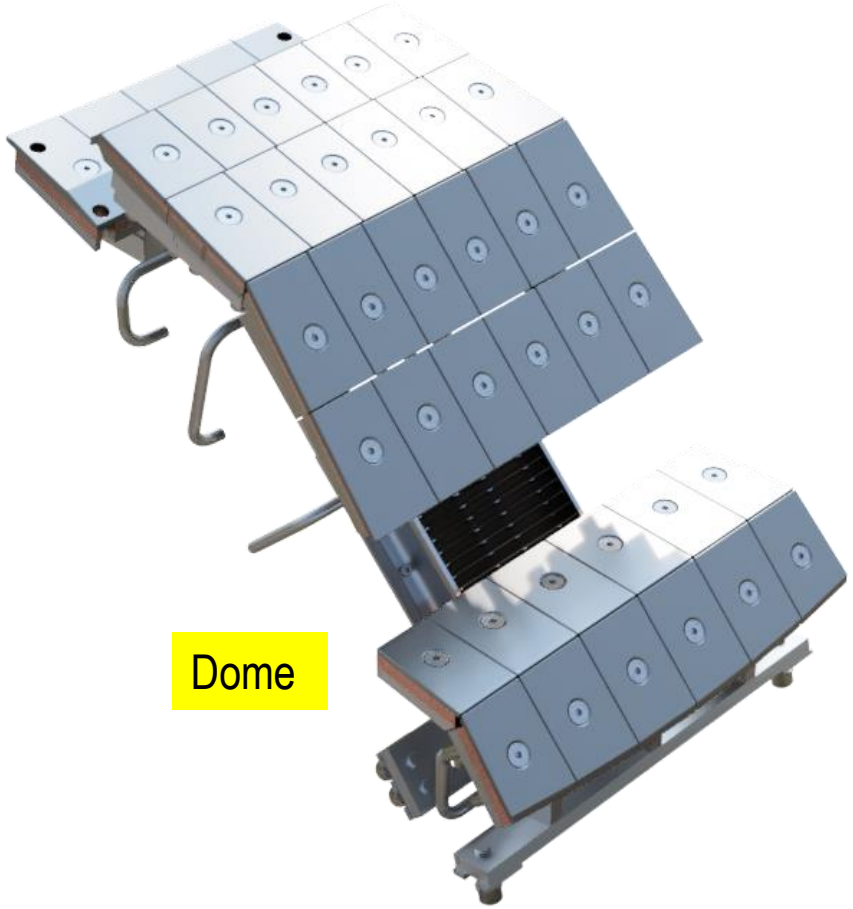




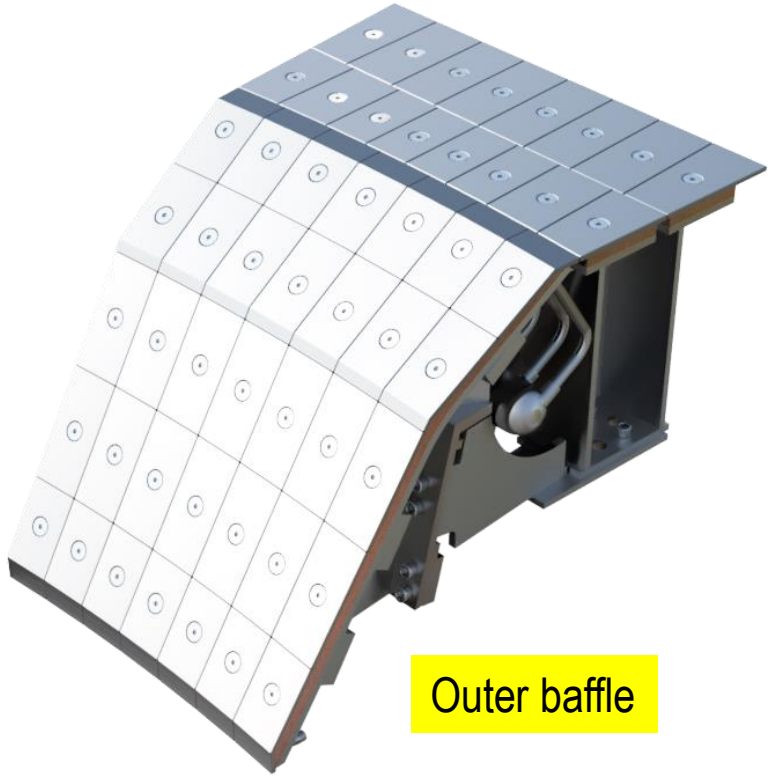
Tungsten NHF design



Inner baffle



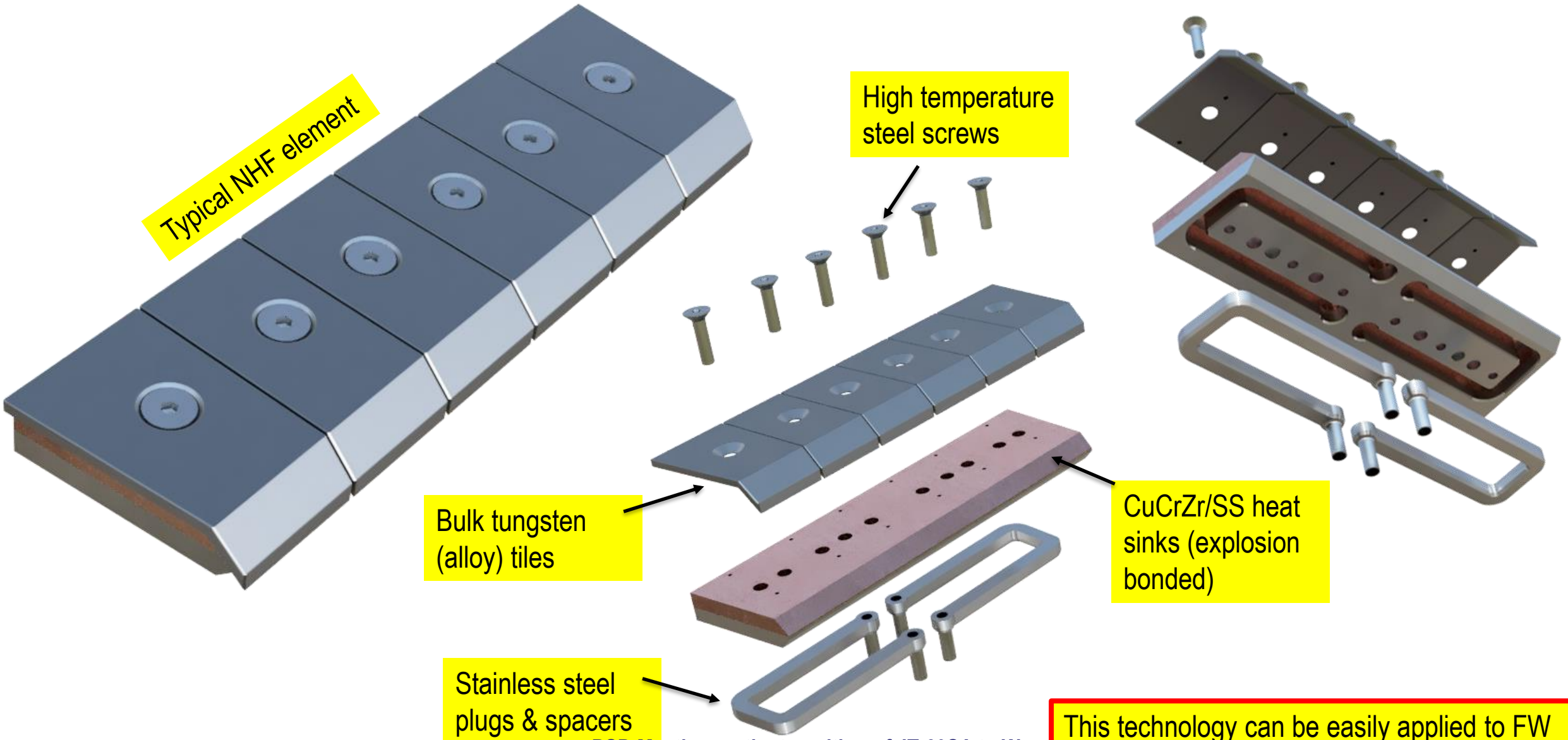
Dome



Outer baffle

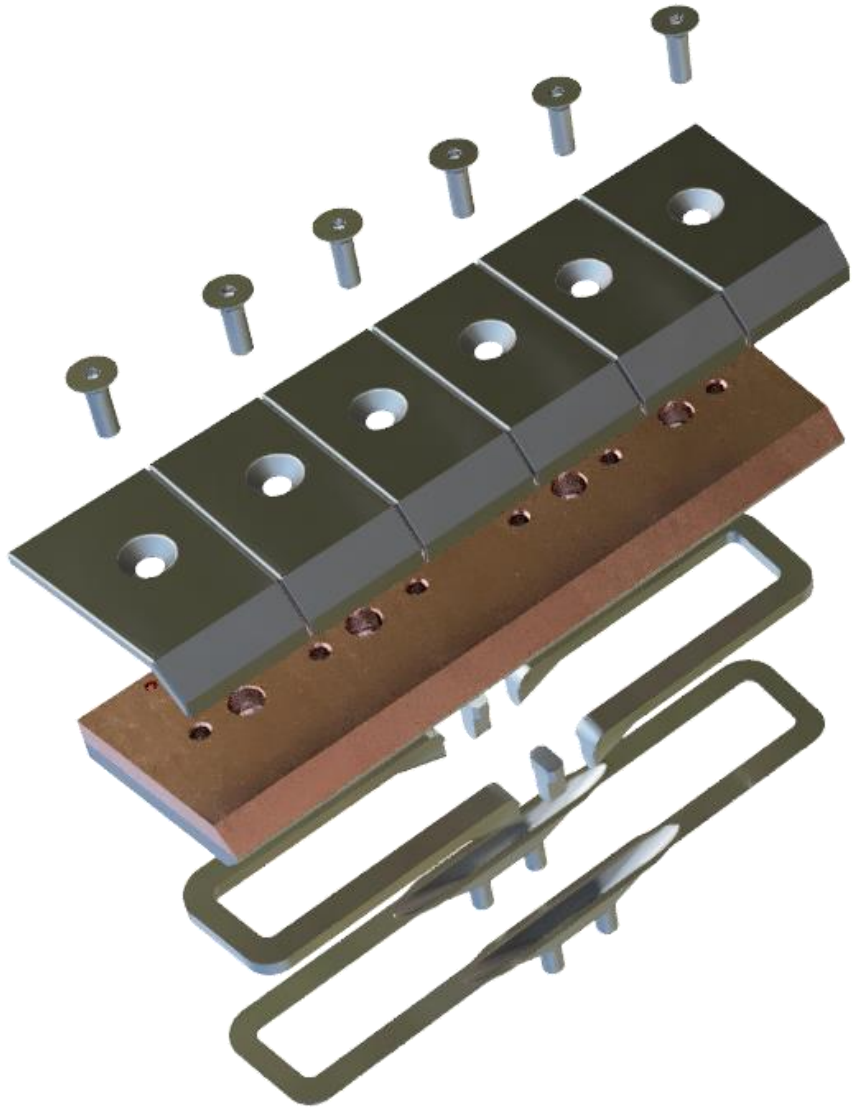
- 7 mm bolted tungsten tiles
- CuCrZr/SS heat sinks
- Stainless steel pipes and supports

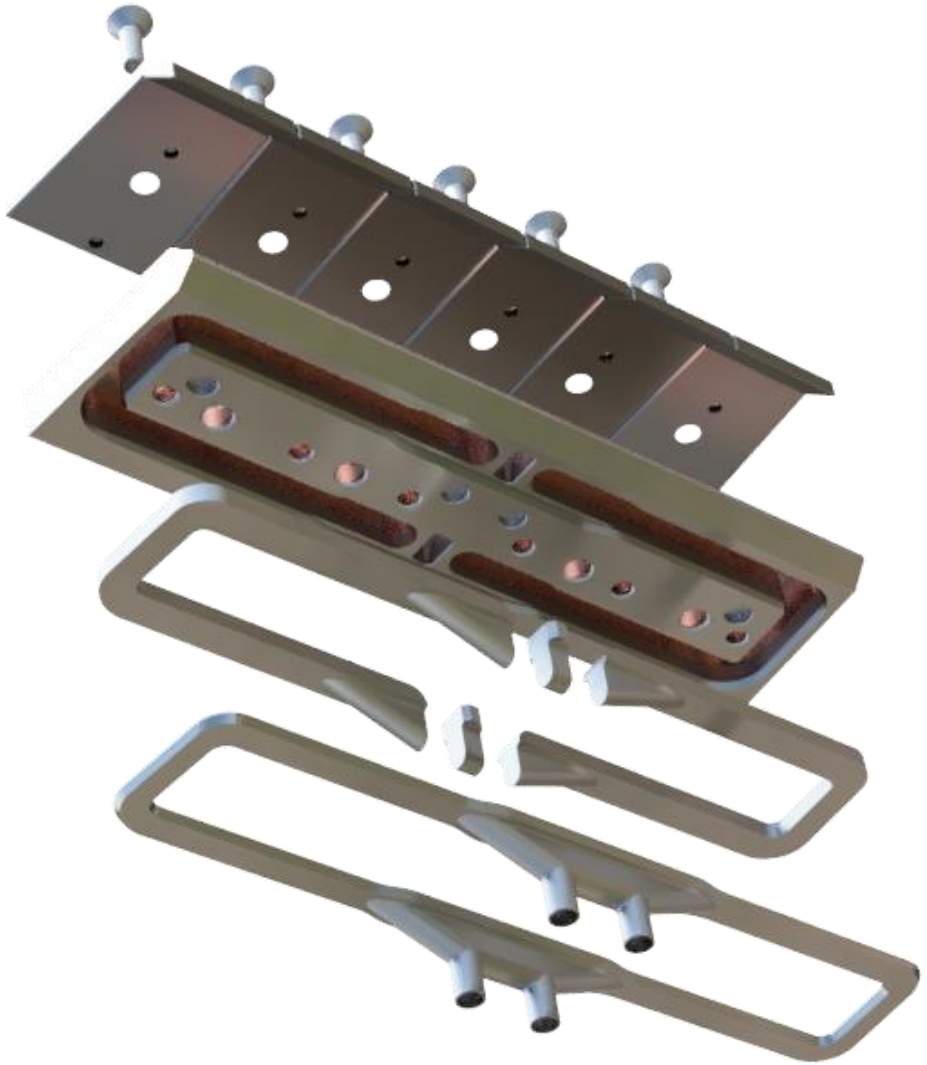
Tungsten NHF design



This technology can be easily applied to FW

Tungsten NHF design





Tungsten NHF design

About tungsten

- ITER grade tungsten
- Requirements:
  - W% > 99.94%
  - Density > 19 g/cm3
  - Grain size < 3
  - Grains aligned with heat flux direction
  - Hardness HV > 410
- Procurement:
  - Blocks and plates for IVT + OVT + 20% spares

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QUALITY CERTIFICATION

Report No. : W-2406-6 page: 1/1

Producer: ATTL Advanced Materials Co., Ltd. Customer: Revol TT Consulting s.r.o.

Product Name	Lot No.	lot Quantity	status	Delivery Date	Contract No.
Tungsten plate for monoblocks	23-01	3 pcs	Stress-relieved	Jun.,2024	MB-2024193

Acceptance Criterion	According to Tungsten material specification For the Tungsten Actively Cooled Divertor (T-ACD)								
Physical Performance Indices	Item	Density g/cm³		HV(30) Mpa			Grain size		
	Acceptance Criterion	ASTM B311 2 Samples / lot		ASTEM E92 3 Samples / lot			ASTM E112 2 Samples / lot		
	Requirement	≥19.0		≥410			3 or finer		
	Measured Value	19.14	19.13	438.9	453.7	436.7	6 grade	6 grade	
Chemical Composition 2 samples / lot	Item	C	O	N	Fe	Ni	Si	W	
	Requirement Composition,wt%	0.01	0.01	0.01	0.01	0.01	0.01	≥99.94	
	Measured Value(wt%)	0.0055	<0.002	<0.002	<0.001	<0.001	<0.002	≥99.98	
		<0.001	<0.002	<0.002	<0.001	<0.001	<0.002	≥99.99	

Microstructure

100× 100×

perpendicular to the rolling direction parallel to the rolling direction

Inspection Conclusion: Meet the technology requirements: Number of samples (every item): 3pcs

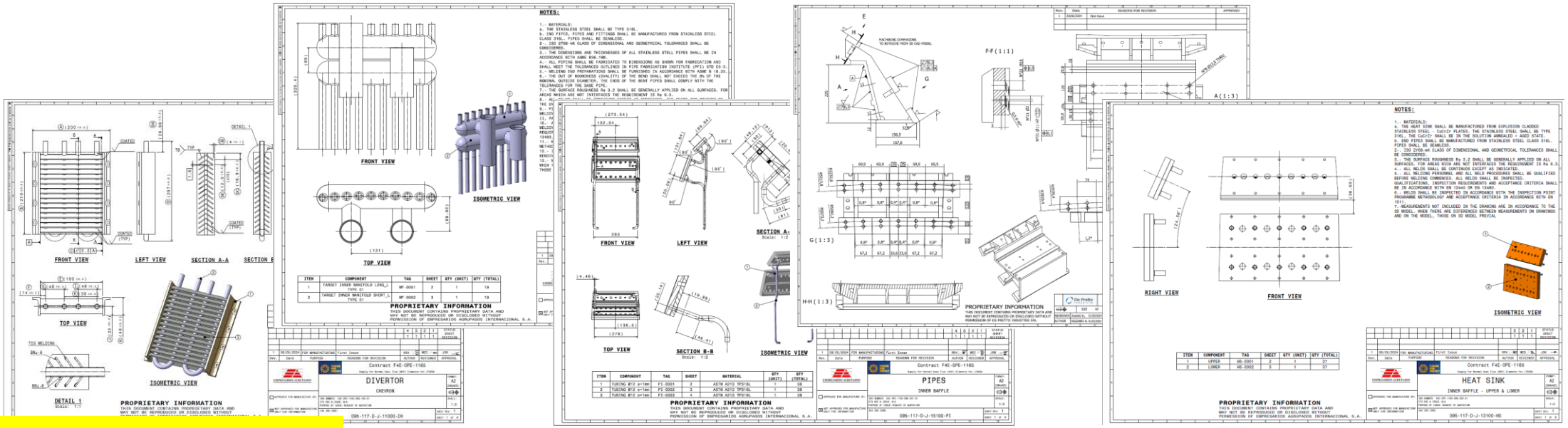
Created by: Gao Liguo 06/25/2024 Collated by: Xu Qin 06/25/2024 Checked by: 1 Fan Shengqi 06/25/2024

Address: No.10 Yong Cheng North Rd., Yongfeng industrial Base, Haidian, Beijing 100094, China

Tel/FAX:010-58717301 / 58717300 URL: http://www.atm-tech.com

NHF – bolted tungsten tiles

- Contract amendment is now in force, including:
  - Detail design of tungsten components
  - Manufacturing of technological mockups
  - Series production of all tungsten PFCs (Dome, baffles, etc.)

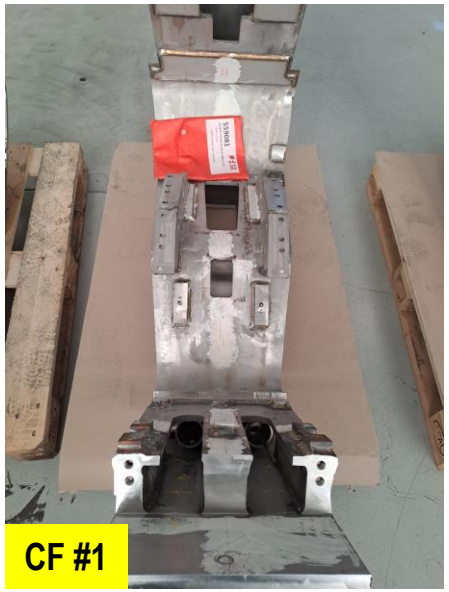


Engineering design file preparation

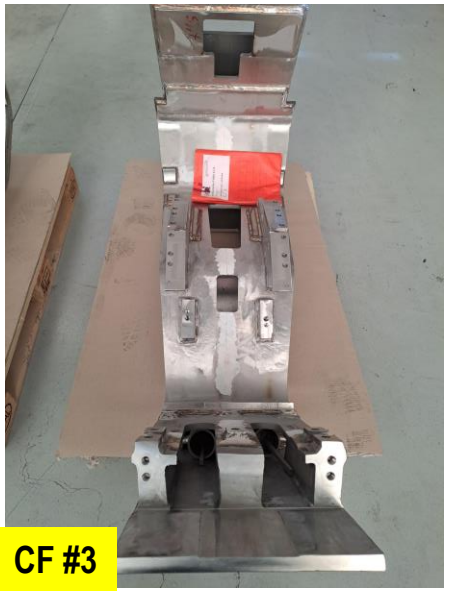
Cassette Frames – CF

- Contract in force
- Series production started
- 16 cassette frames being manufactured in parallel

Cassette Frames – CF


CF #1


CF #2


CF #3


CF #4

CF #5


CF #6

CF #7

Cassette Frames – CF

CF #8

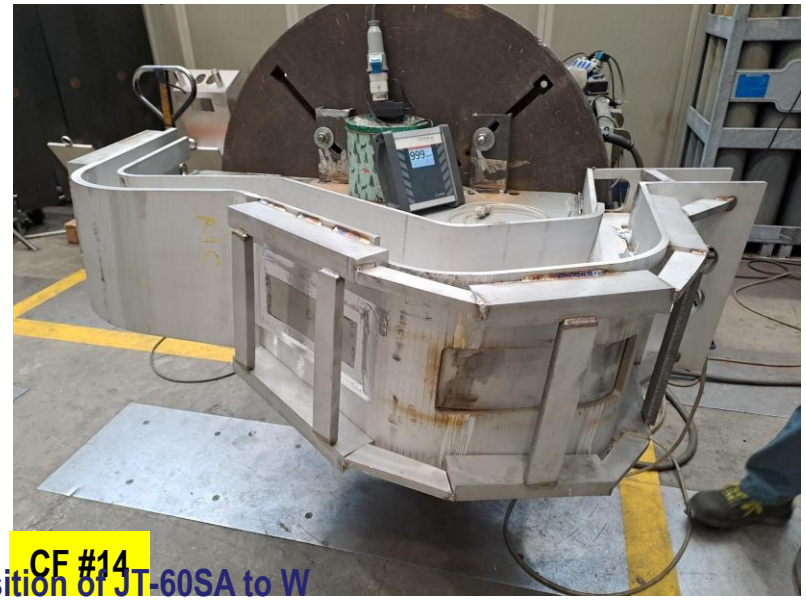

CF #9


CF #10


CF #11


CF #12


CF #13


CF #14


CF #15

Manufacturing and testing – Next steps

- HHF
  - Testing of small scale tungsten monoblock mockups in Q1/25 – DONE
  - Intermediate scale mockup manufacturing and testing by end of Q2/25
  - Finalization of full scale mockups by end of Q4/25
  - Release of series production in Q4/25 or Q1/26
- NHF
  - Design of tungsten PFCs finalized by end Q2/25
- CF
  - First 4 units in Q2/25, work in progress on 16 units

Manufacturing and testing – Next steps

- Tungsten first wall
  - Design studies have started with the review of boundary conditions, including EM loads, heat flux, water connections, mechanical connections, etc.
  - Strong requirement is to reuse most of the infrastructure already present during OP2, e.g. pedestals on vacuum vessel, location of inlet and outlet water pipes, to minimize the time for the replacement of the carbon wall.
  - Still to be verified whether we can reuse the passive stabilizing plate
  - Most likely a bulk tungsten bolted tile solution like the NHF
  - Most likely the procurement will be split up in inner wall, outer wall and upper divertor