Design of the W wall and Update on procurement

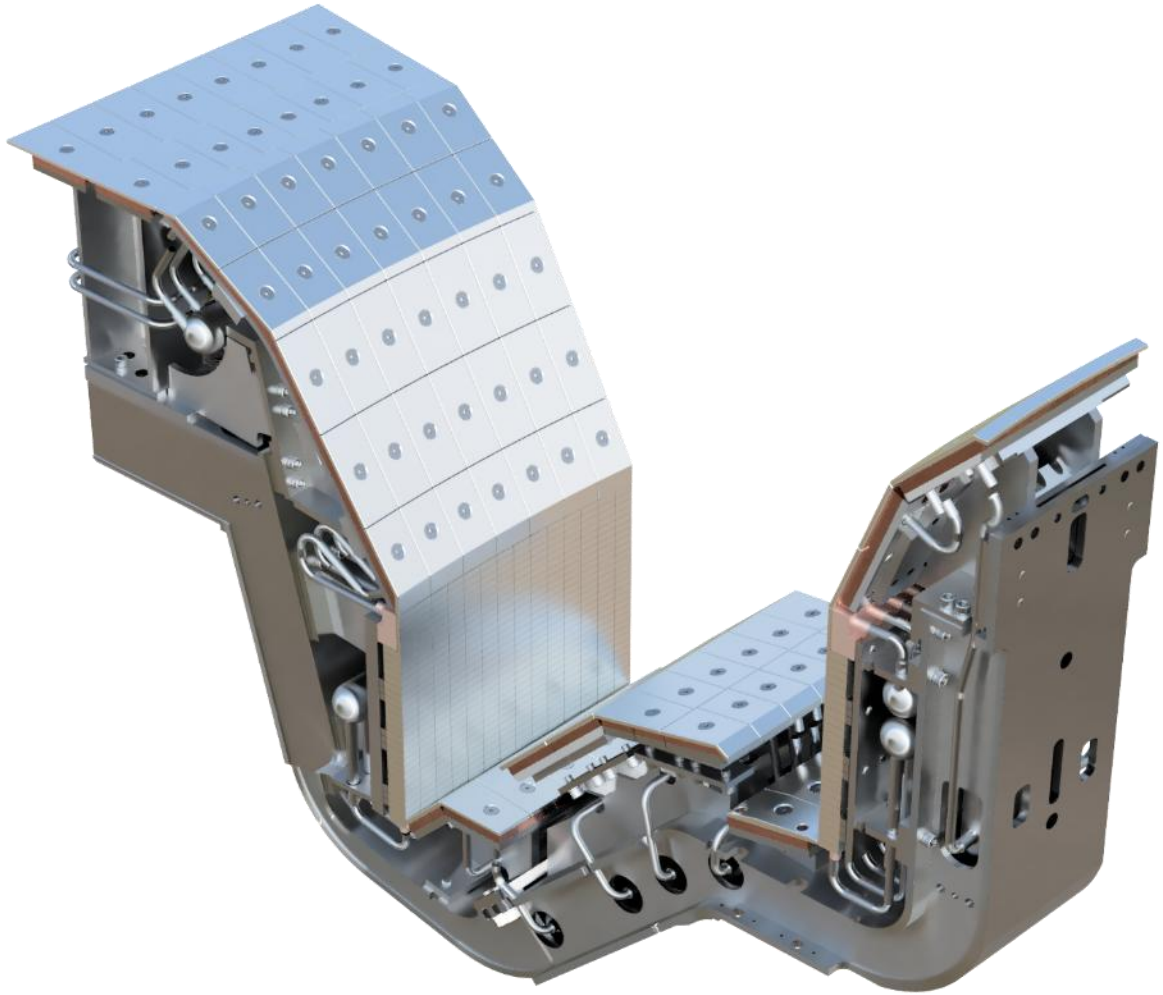
PSD Meeting

28/04/2026

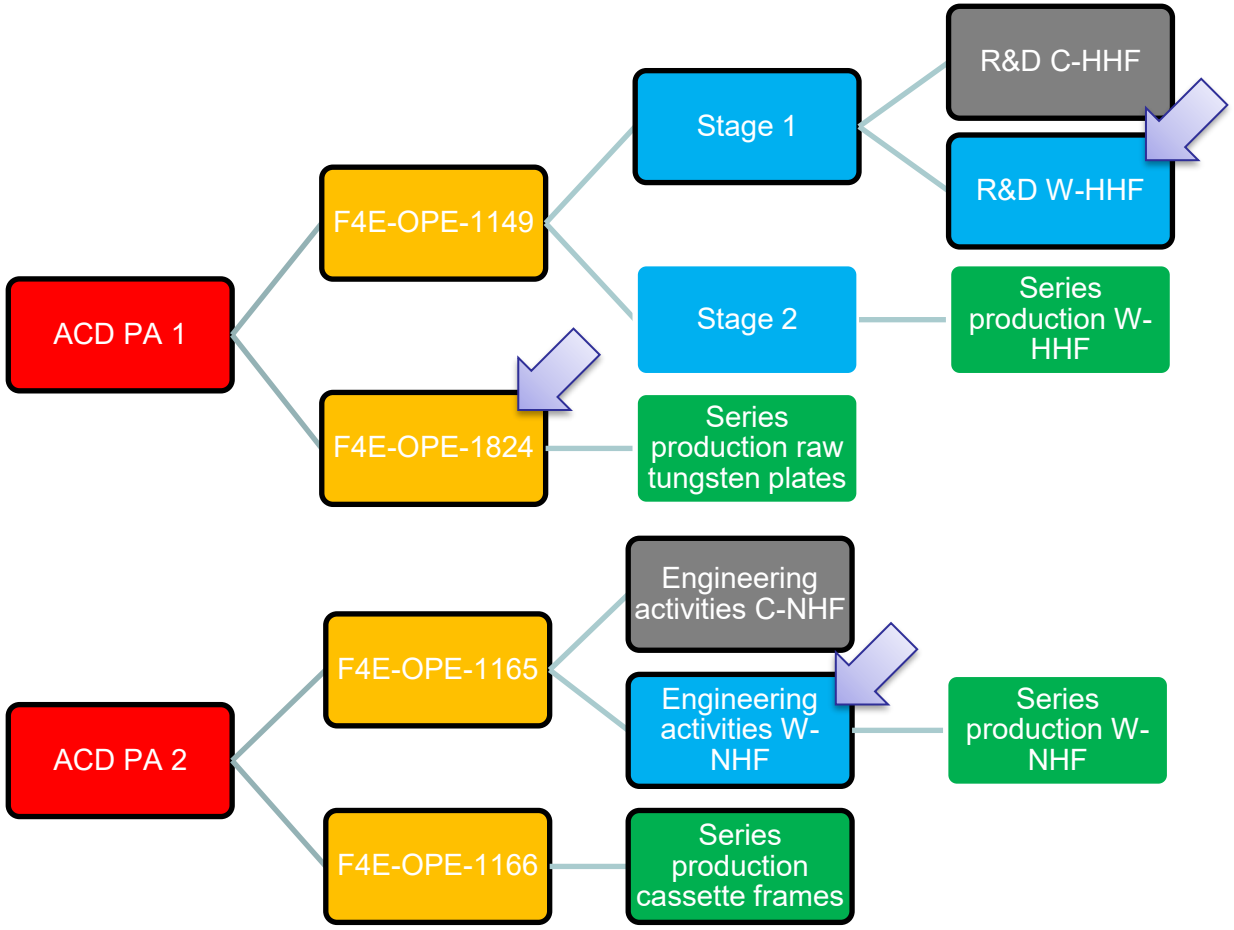
JT-60SA
Advanced Superconducting Tokamak
BA-Satellite Tokamak Program

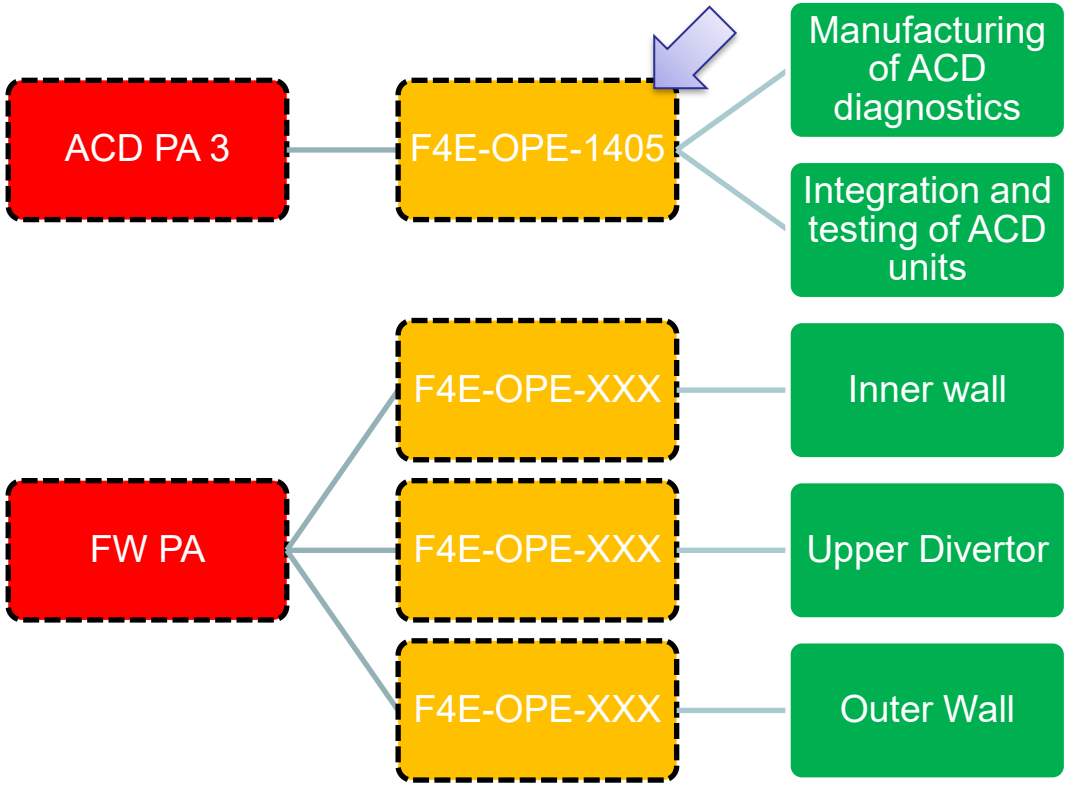
Status of W divertor and first wall technology development

- PA strategy
- Contracts implementation
  - HHF
  - NHF
  - CF
- Tungsten first wall



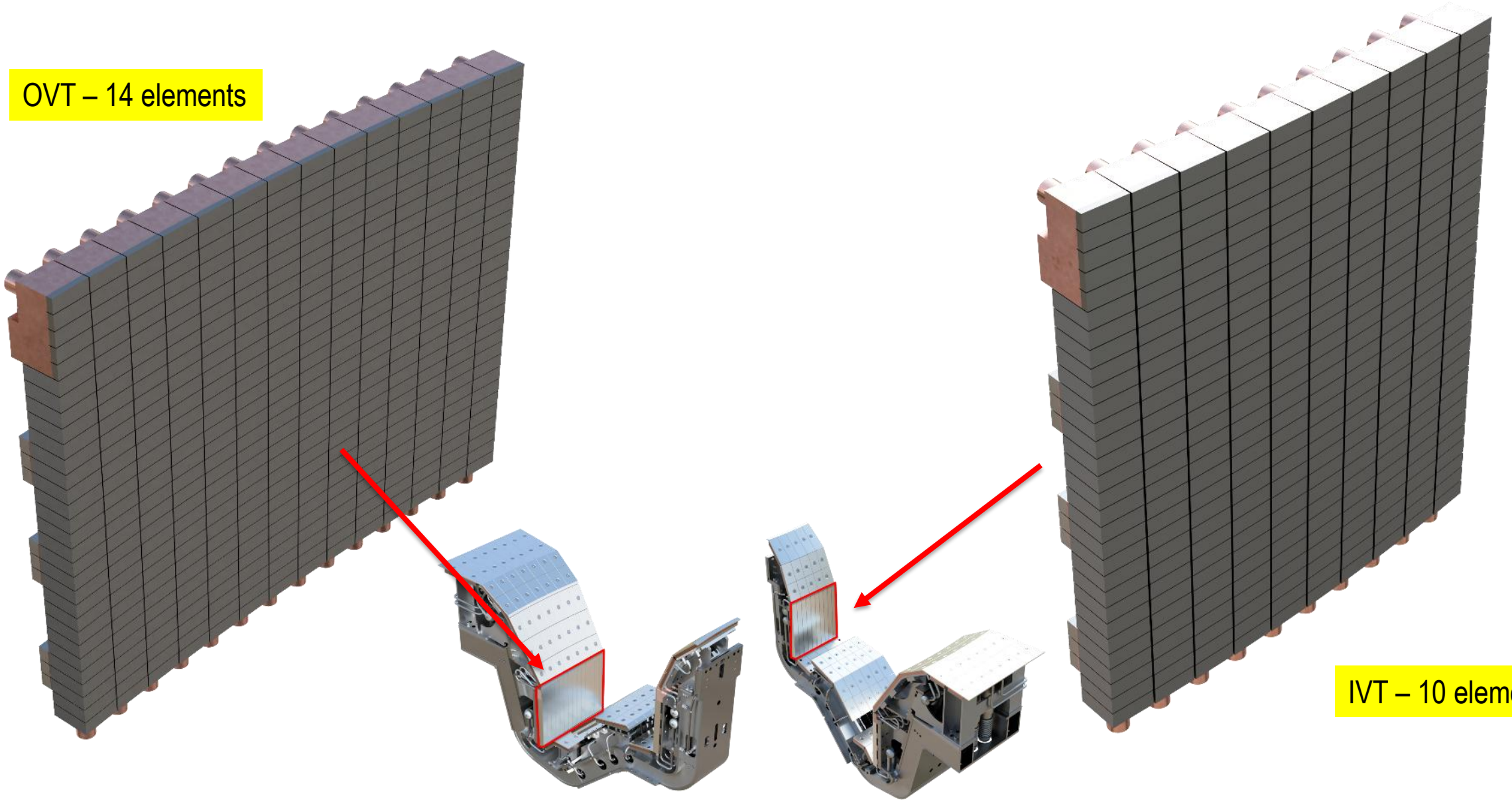
PA strategy


ACD PA 1
F4E-OPE-1149
Stage 1
R&D C-HHF
R&D W-HHF
Stage 2
Series production W-HHF
F4E-OPE-1824
Series production raw tungsten plates
ACD PA 2
F4E-OPE-1165
Engineering activities C-NHF
Engineering activities W-NHF
Series production W-NHF
F4E-OPE-1166
Series production cassette frames


ACD PA 3
F4E-OPE-1405
Manufacturing of ACD diagnostics
Integration and testing of ACD units
FW PA
F4E-OPE-XXX
Inner wall
F4E-OPE-XXX
Upper Divertor
F4E-OPE-XXX
Outer Wall

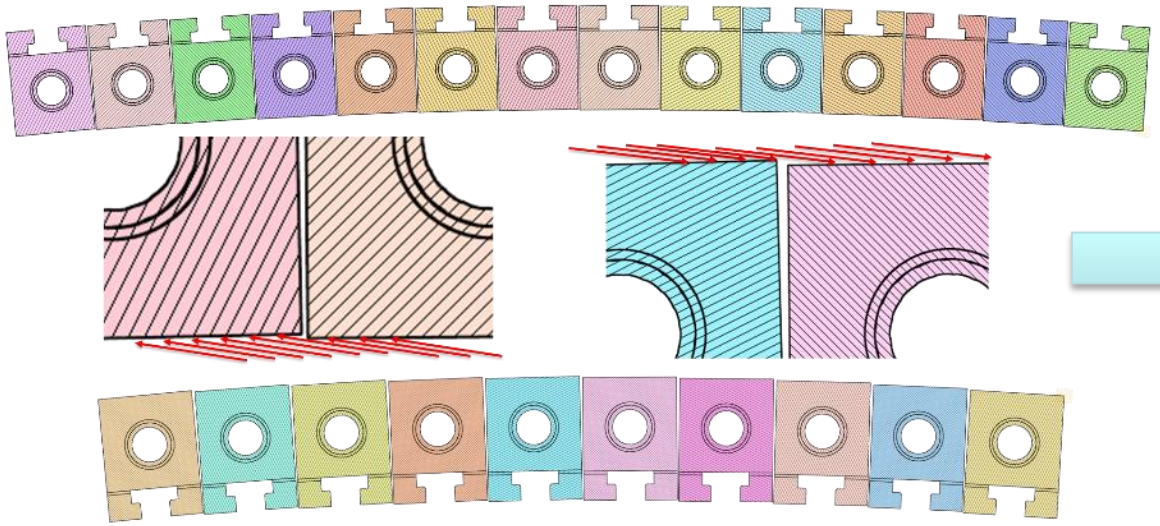
High Heat Flux Elements – HHF

OVT – 14 elements

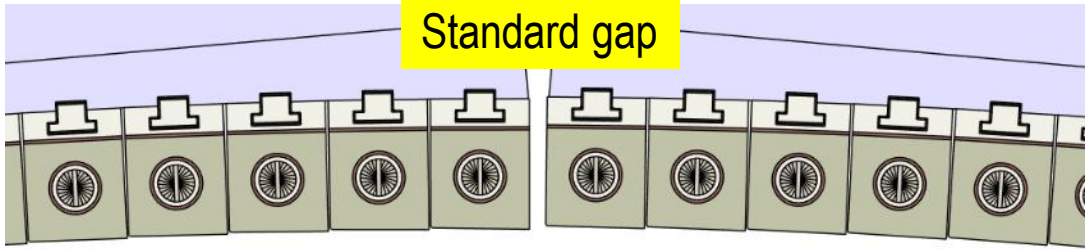


IVT – 10 elements

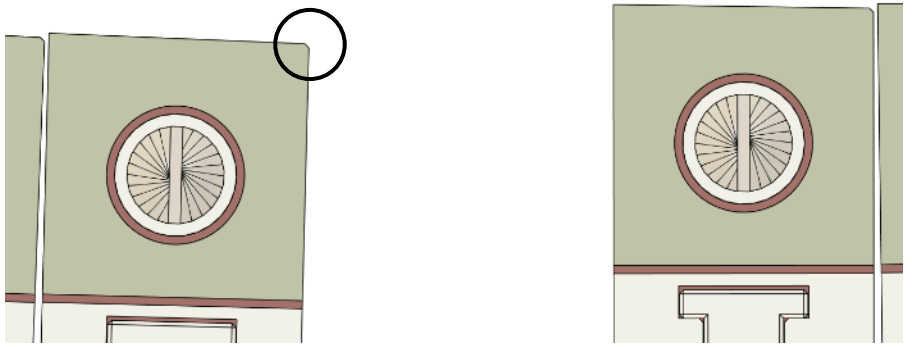
High Heat Flux Elements – HHF



Standard gap

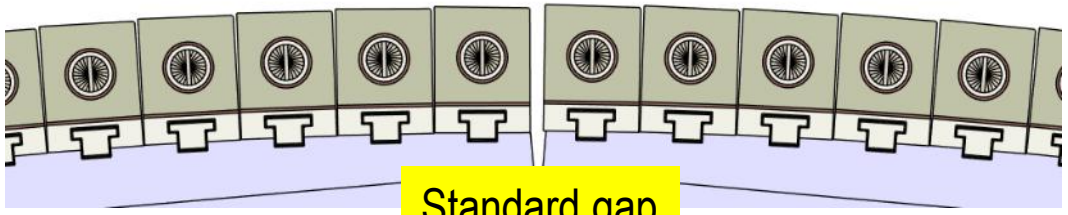


OVT



Diagnostic opening

IVT



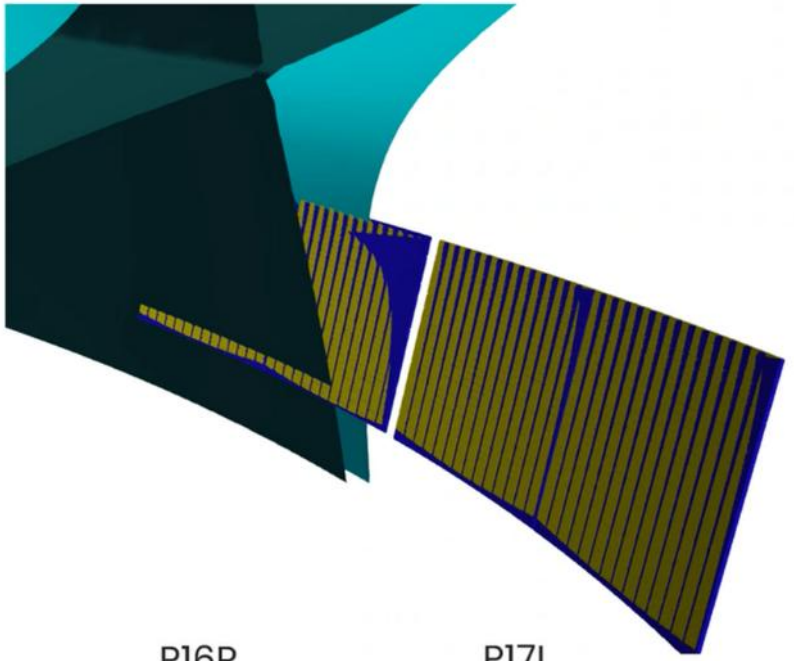
Standard gap

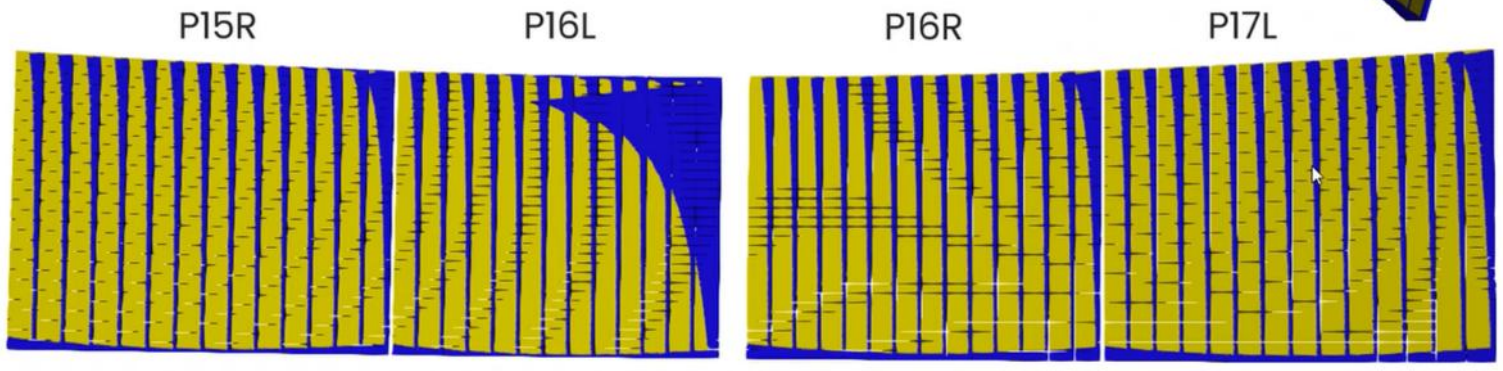
Shaping principle – rotation plus translation to protect leading edges – **including tolerances**

High Heat Flux Elements – HHF

Shadowing – LFS

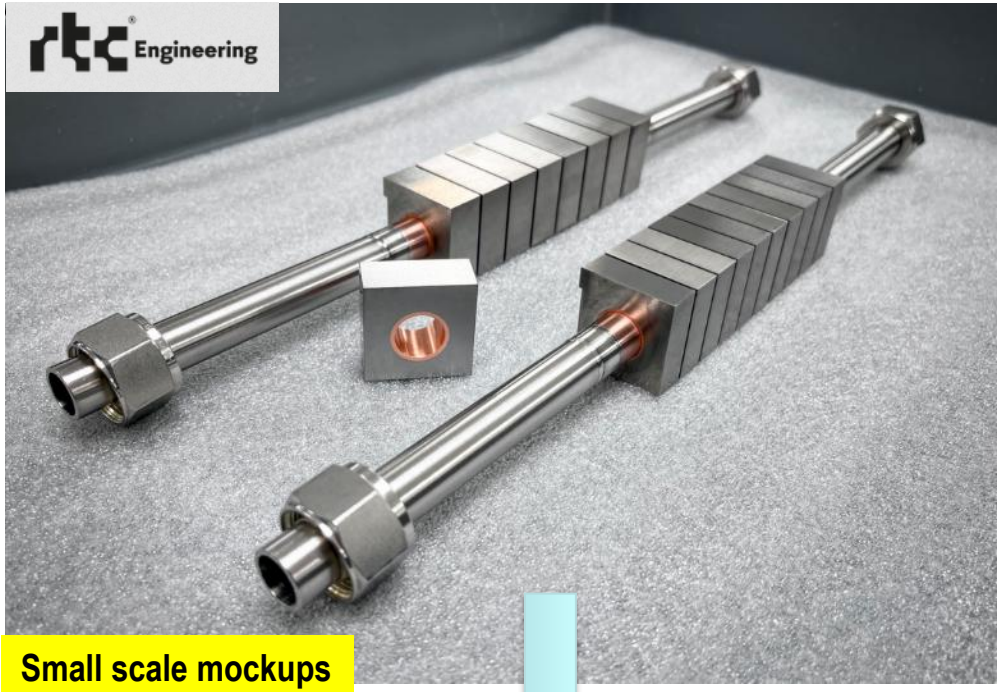
Analysis in progress



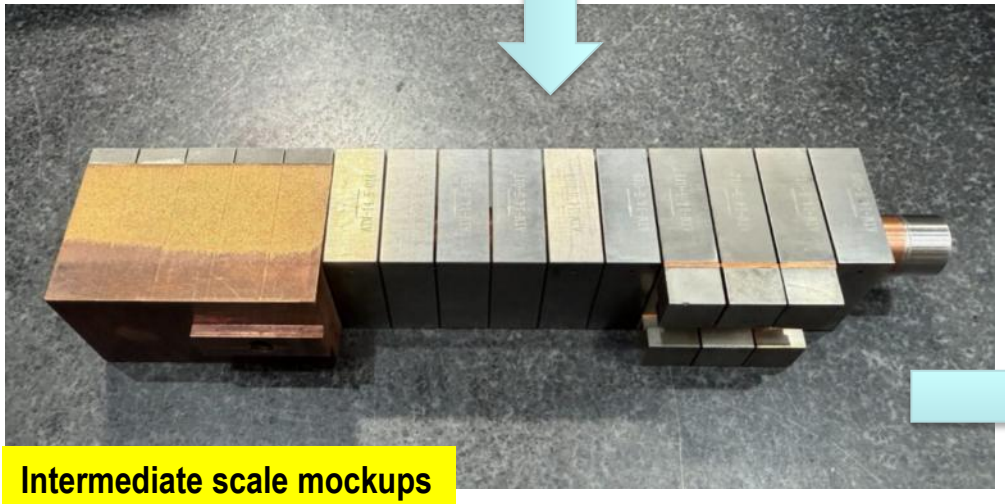


Shaping principle – rotation plus translation to protect leading edges – **including tolerances**

High Heat Flux Elements – HHF

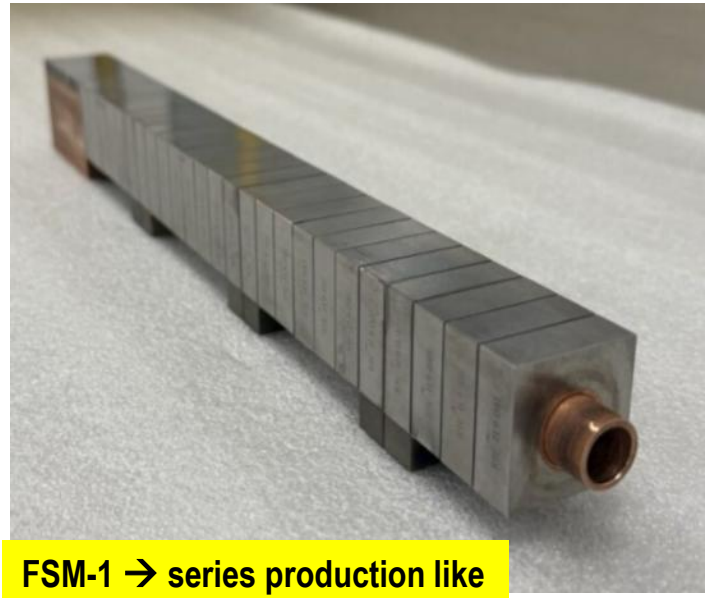


Small scale mockups

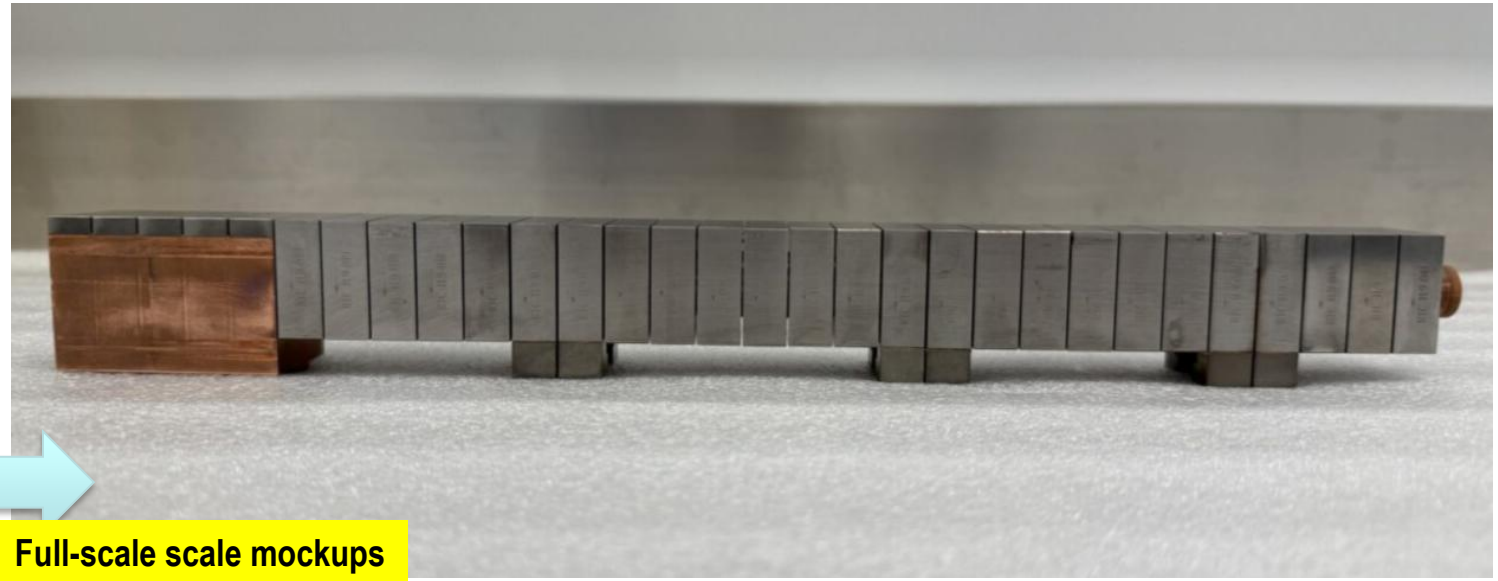


Intermediate scale mockups

FSM-0 → embedded defect qualification



FSM-1 → series production like



Full-scale scale mockups

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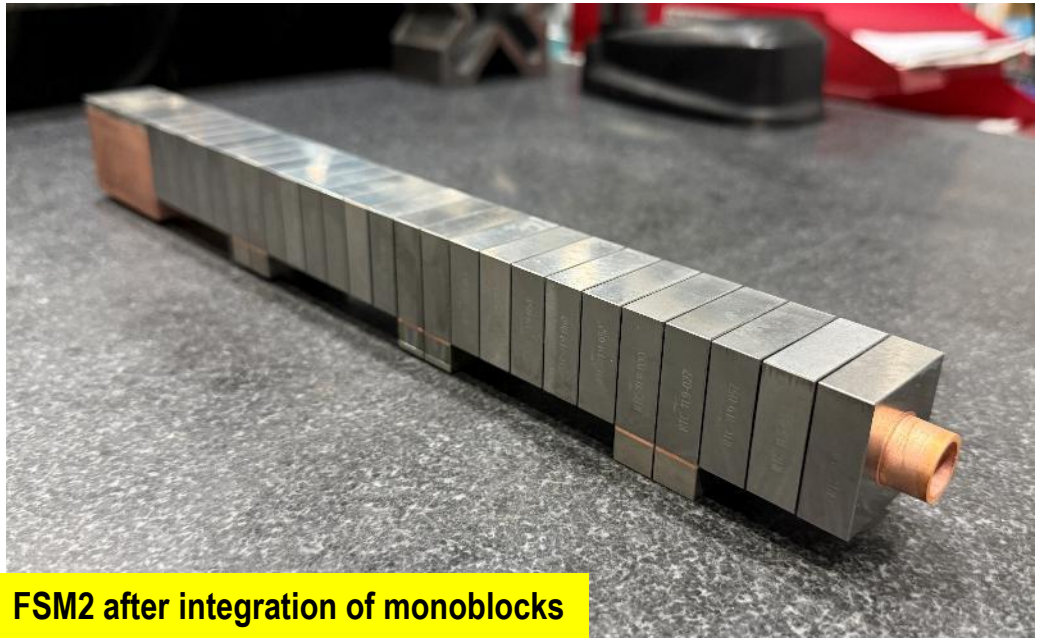
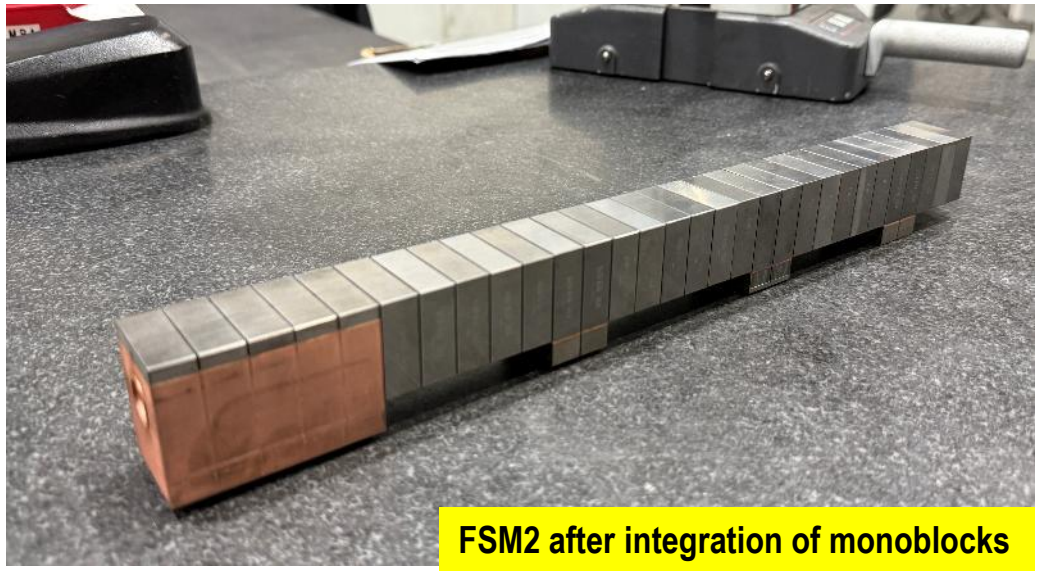
High Heat Flux Elements – HHF

FSM0 + FSM1 ready for pipe integration



FSM2 after integration of monoblocks

FSM0 + FSM1 ready for shipment



FSM2 after integration of monoblocks

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BA-Satellite Tokamak Program

NEW

High heat flux tests

JT-60SA
Advanced Superconducting Tokamak
BA-Satellite Tokamak Program

NEW

High heat flux tests

10 MW/m²

~2600 pulses

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Advanced Superconducting Tokamak
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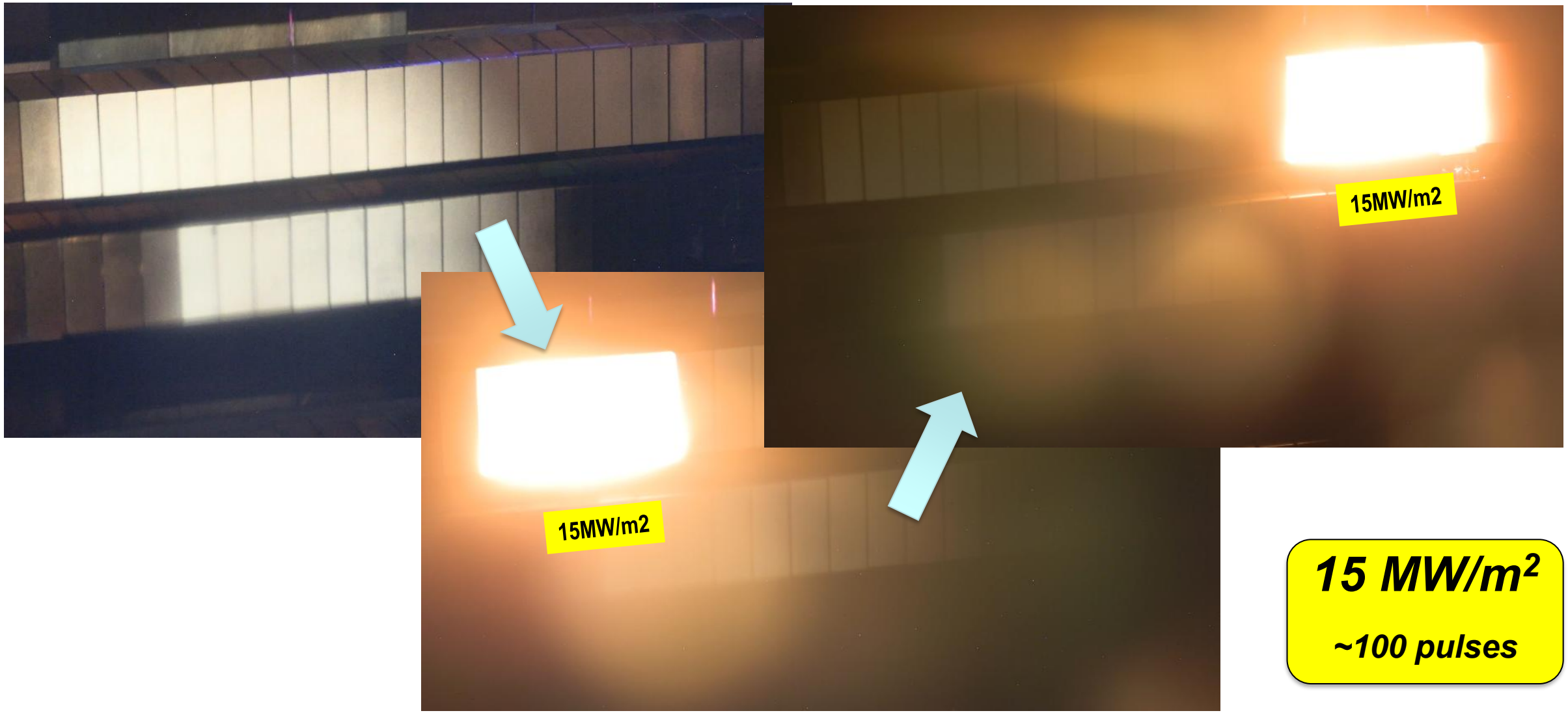
NEW

High heat flux tests



15 MW/m²

~100 pulses

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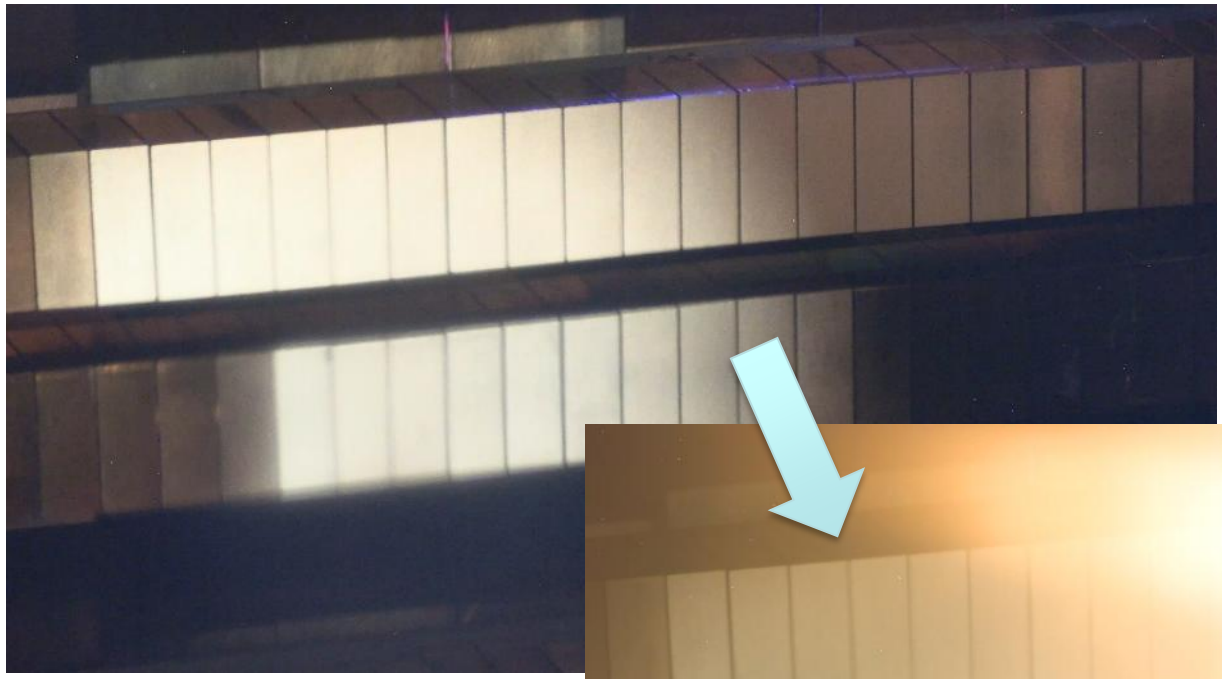
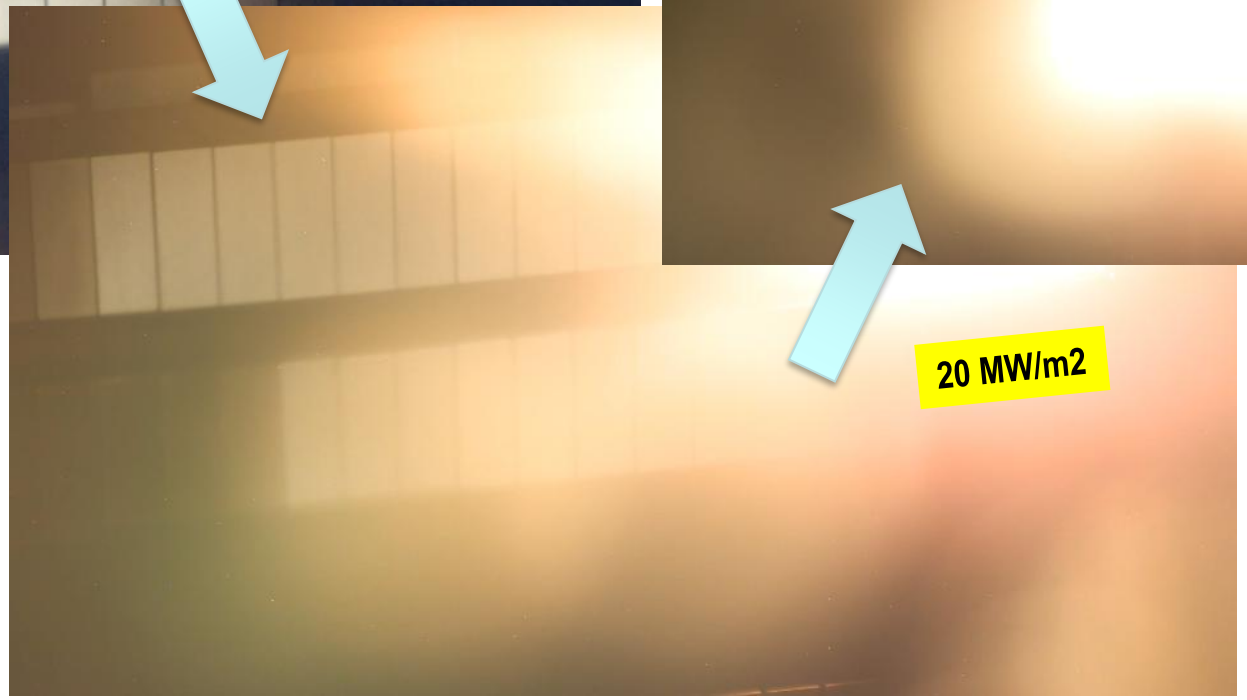
NEW

High heat flux tests

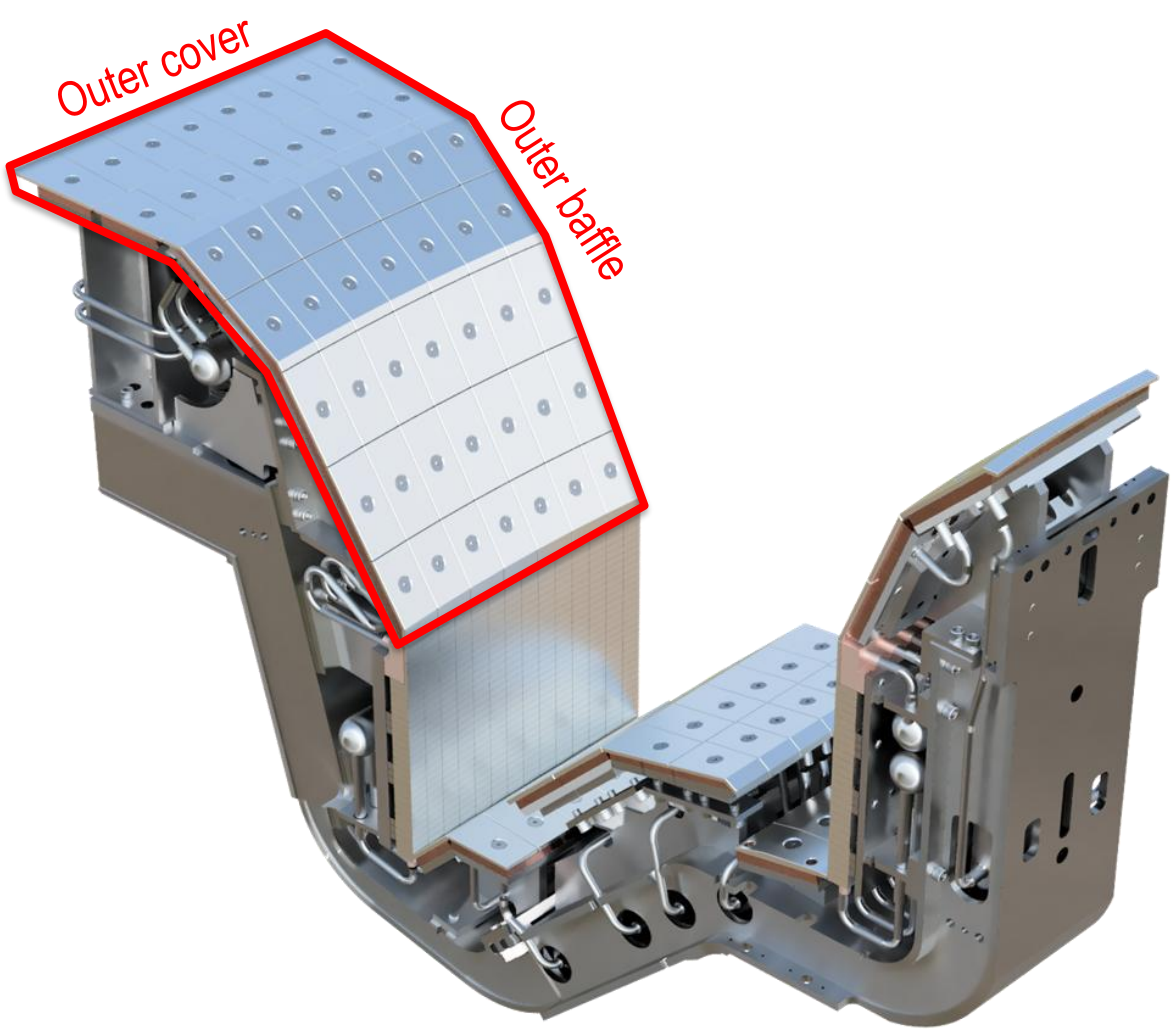


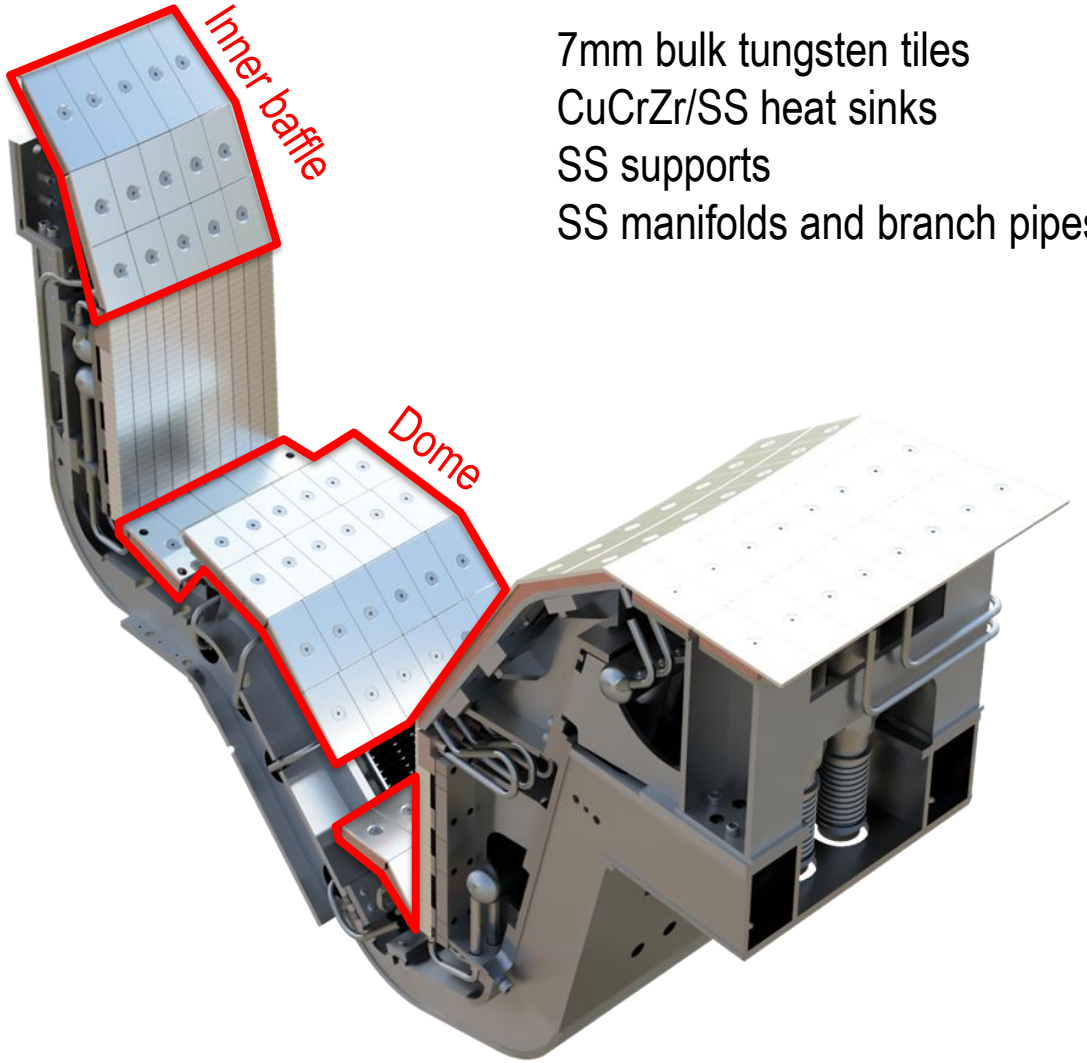


20 MW/m²

15 pulses (2s)

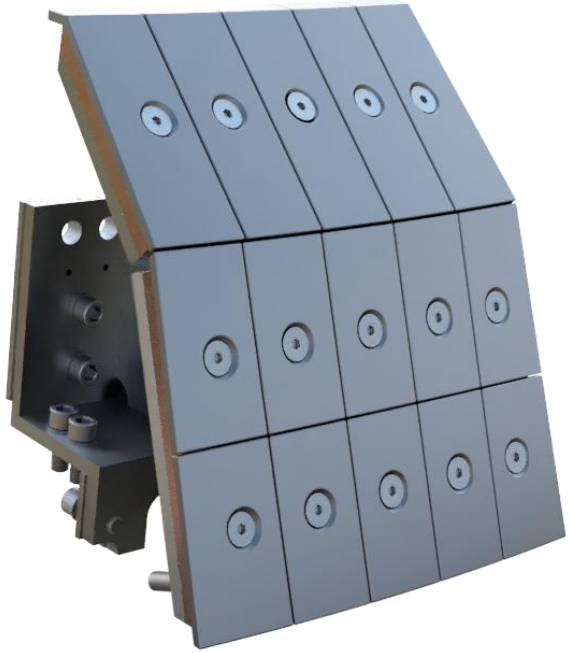
Normal Heat Flux elements – NHF



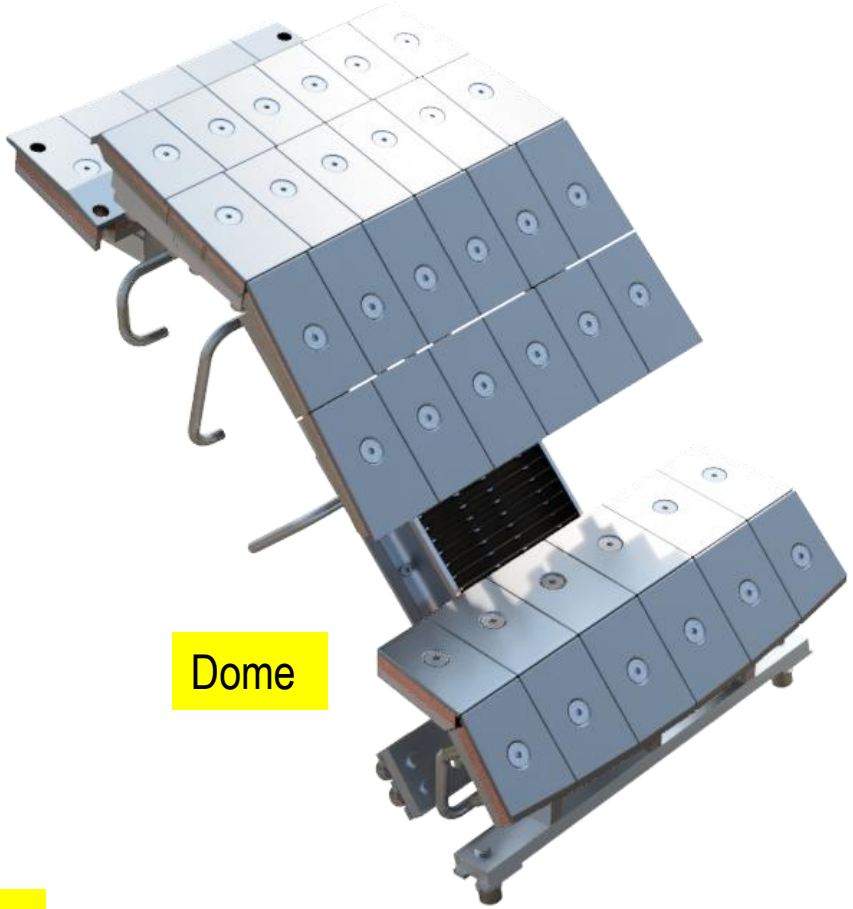


7mm bulk tungsten tiles
CuCrZr/SS heat sinks
SS supports
SS manifolds and branch pipes

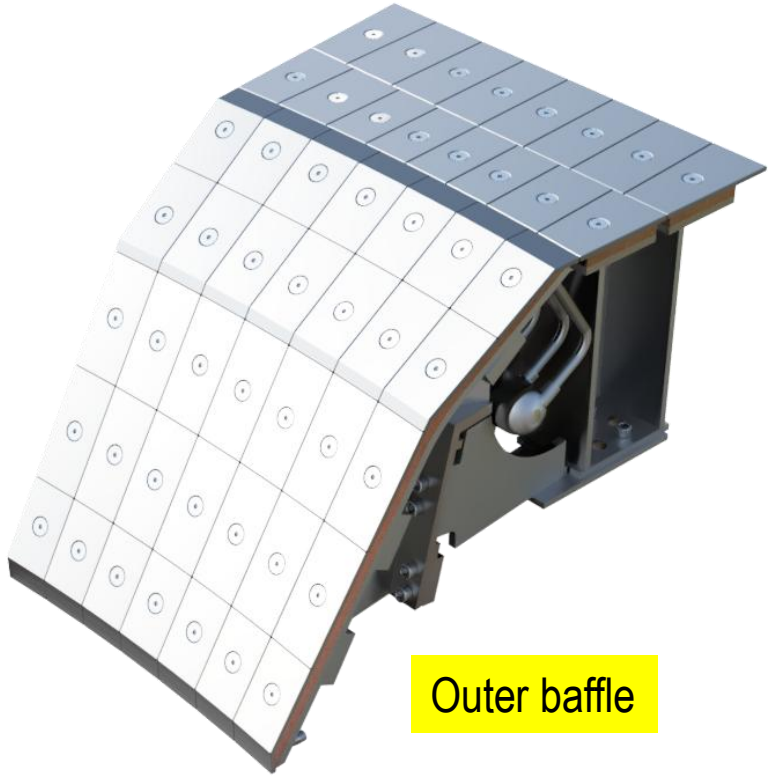
Normal Heat Flux elements – NHF



Inner baffle



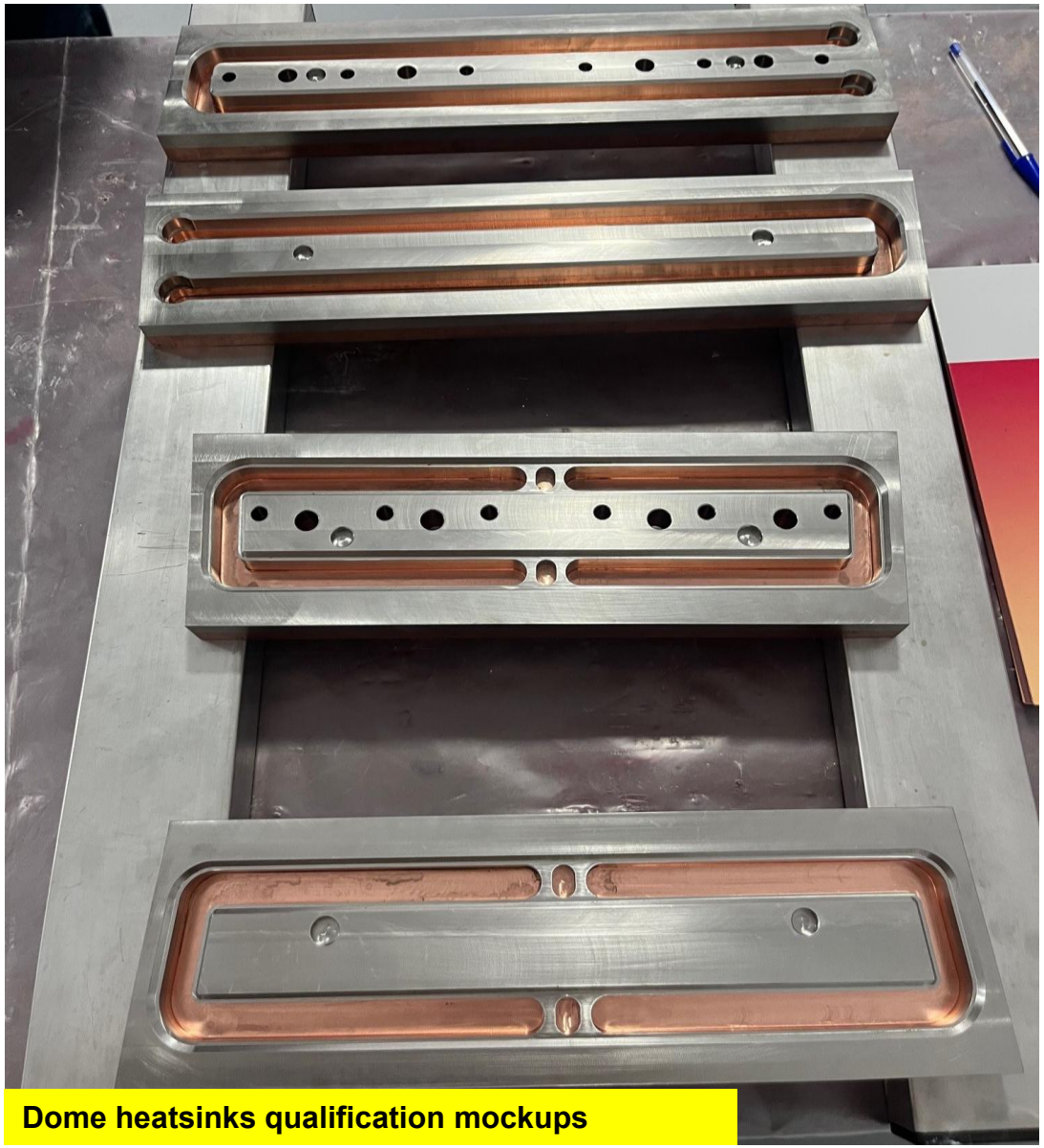
Dome



Outer baffle

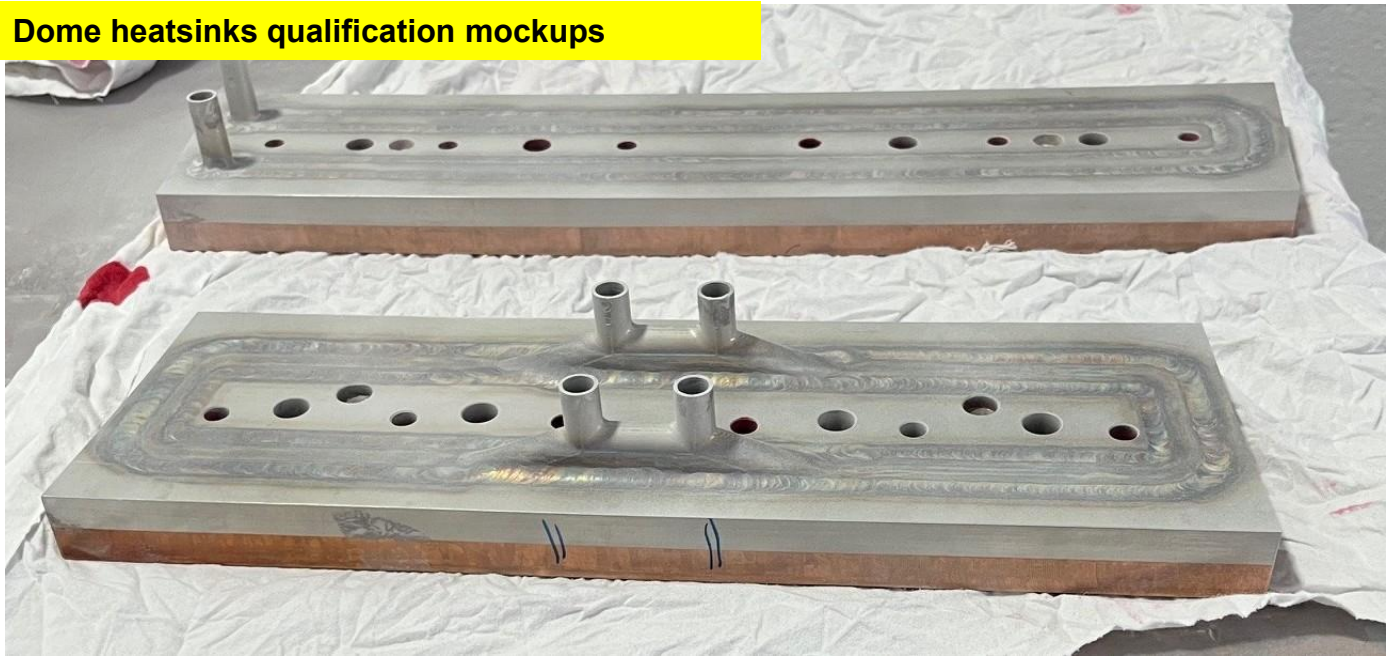
- Bolted tile design
- Bulk tungsten tiles
- ITER grade tungsten
- CuCrZr/SS heat sinks and SS supports

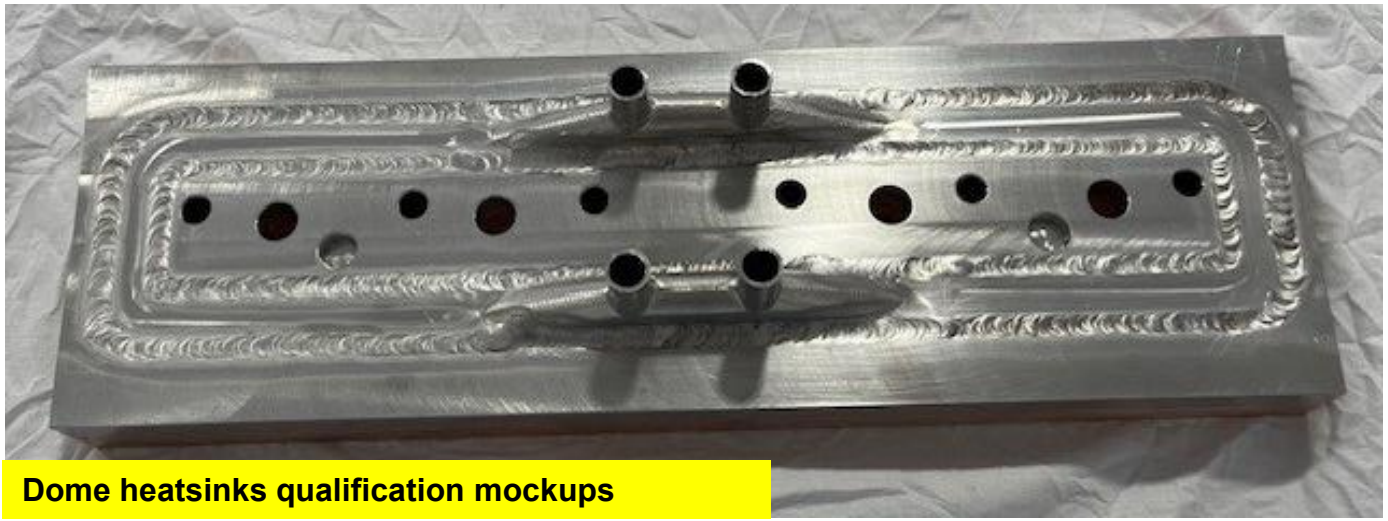
Normal Heat Flux elements – NHF



Dome heatsinks qualification mockups

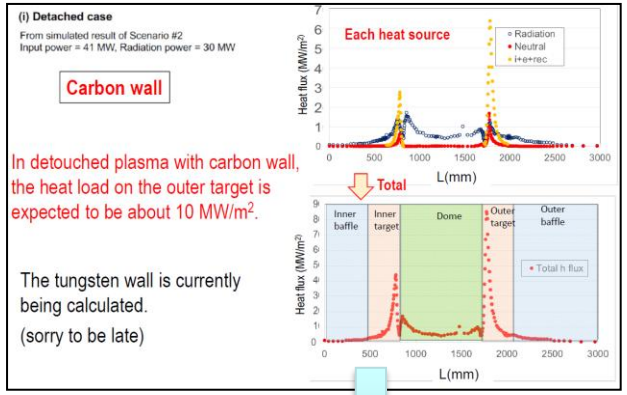
Dome heatsinks qualification mockups

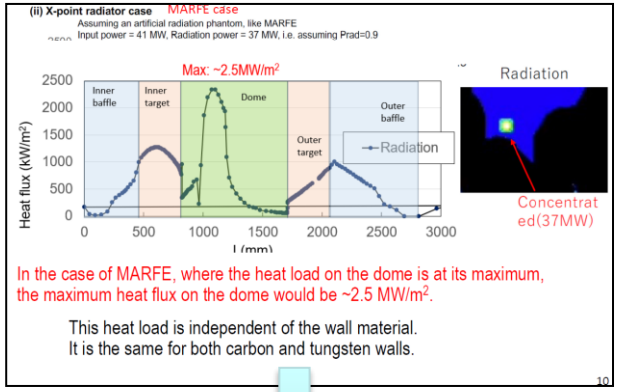


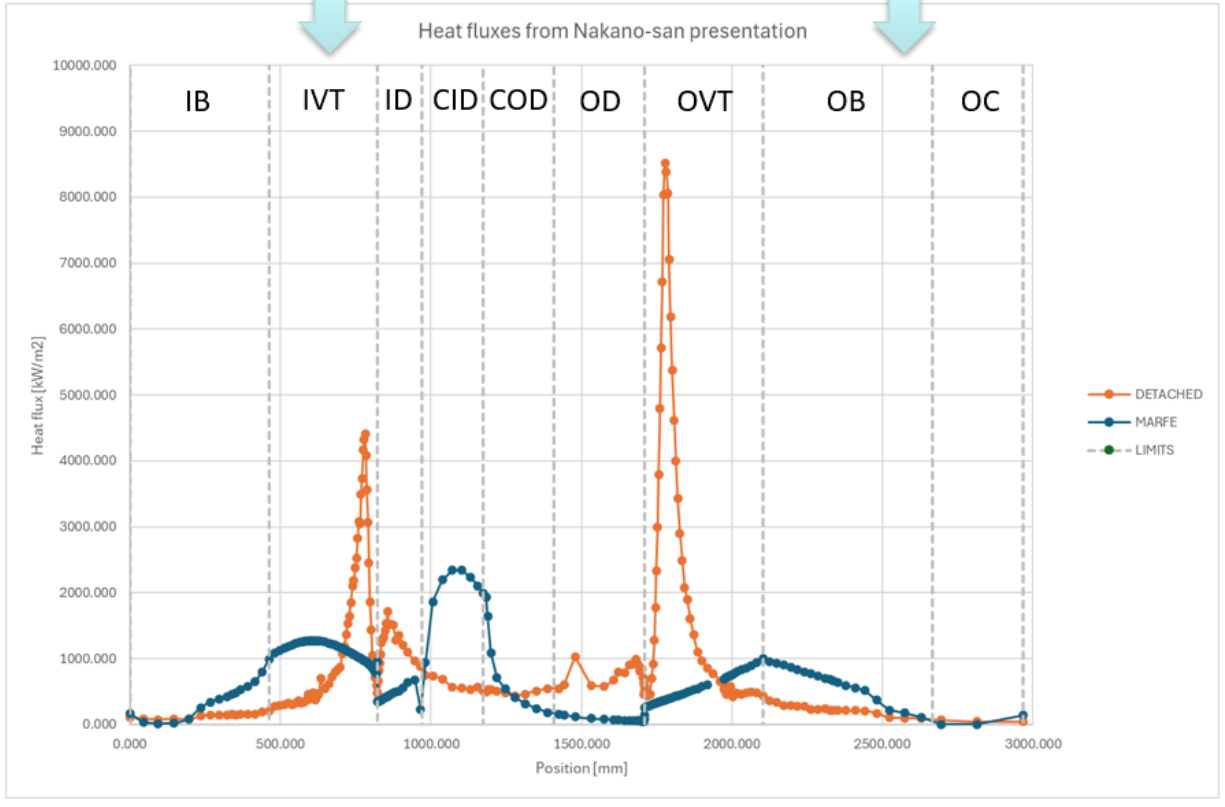


Dome heatsinks qualification mockups

Normal Heat Flux elements – NHF



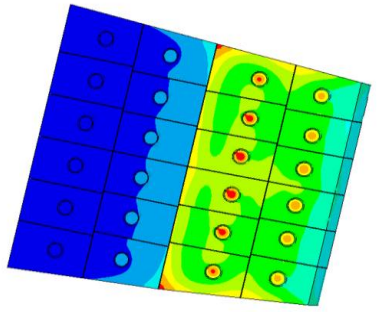


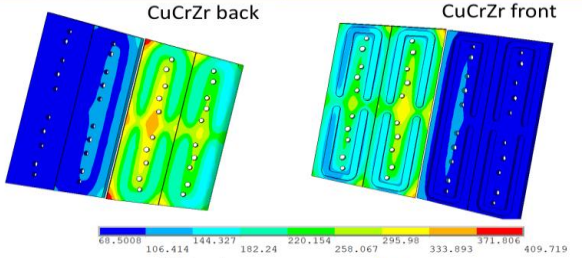


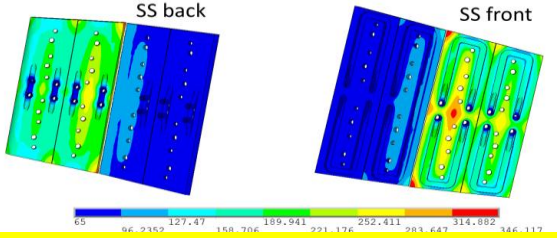
TEMPERATURE - MARFE

FUSION FOR ENERGY

CENTRAL DOME

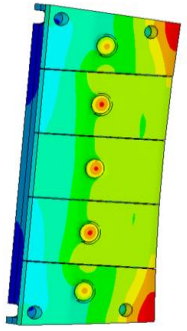


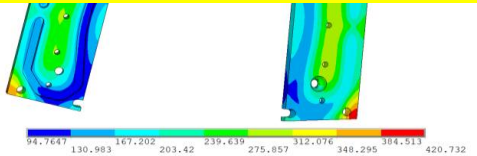


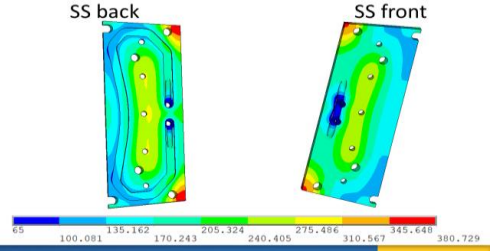


TEMPERATURE - DETACH

INNER DOME

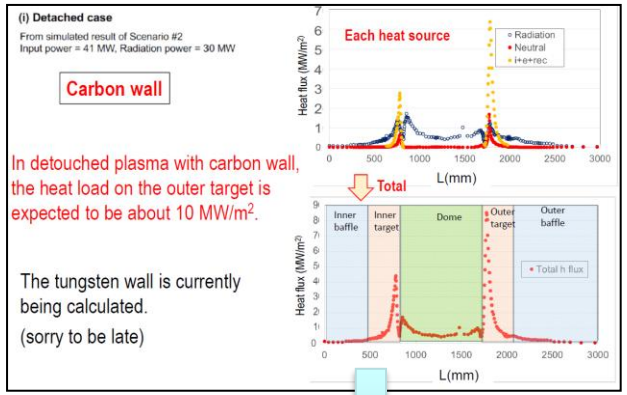


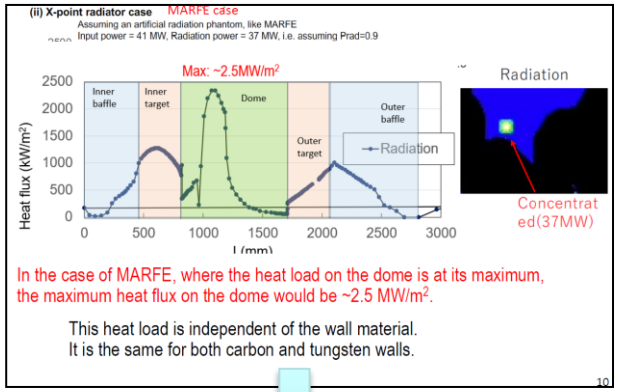


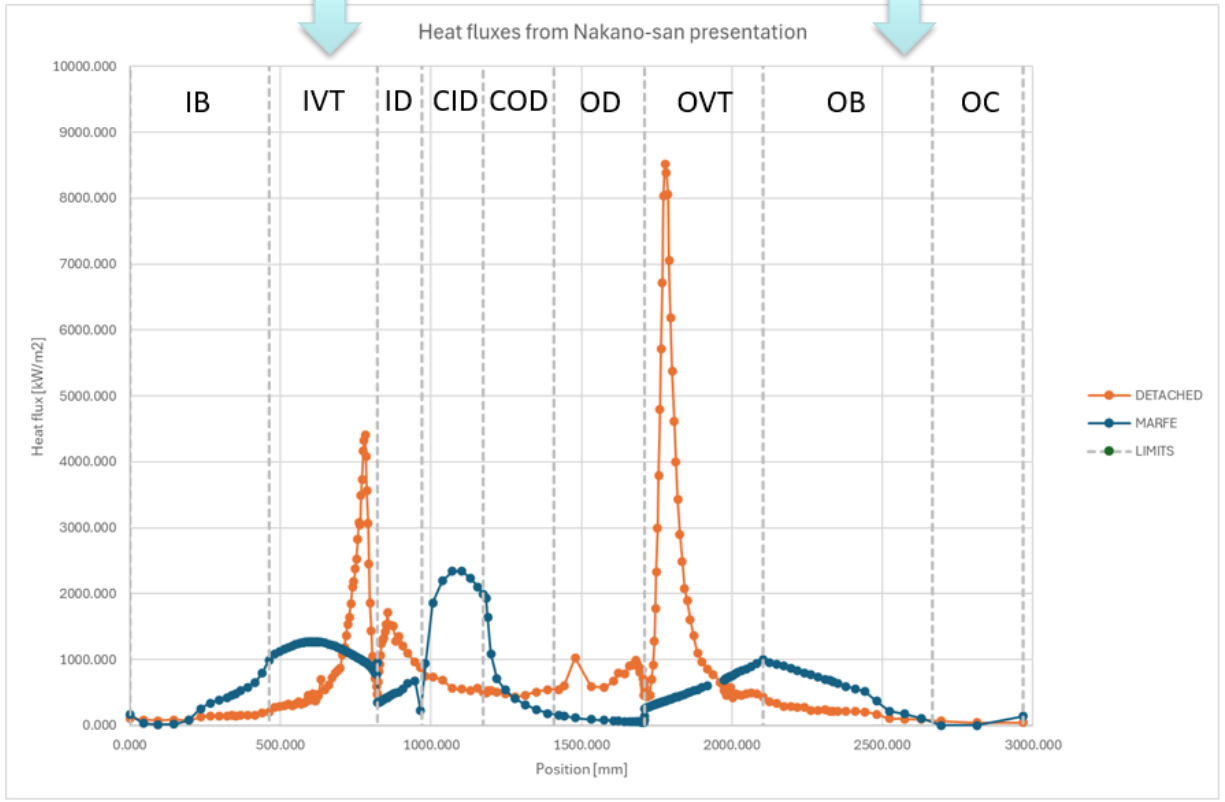


All dome components satisfy the requirements
T_{CuCrZr} < 450C
T_W < 1200C
After flow channel shape optimization

Normal Heat Flux elements – NHF





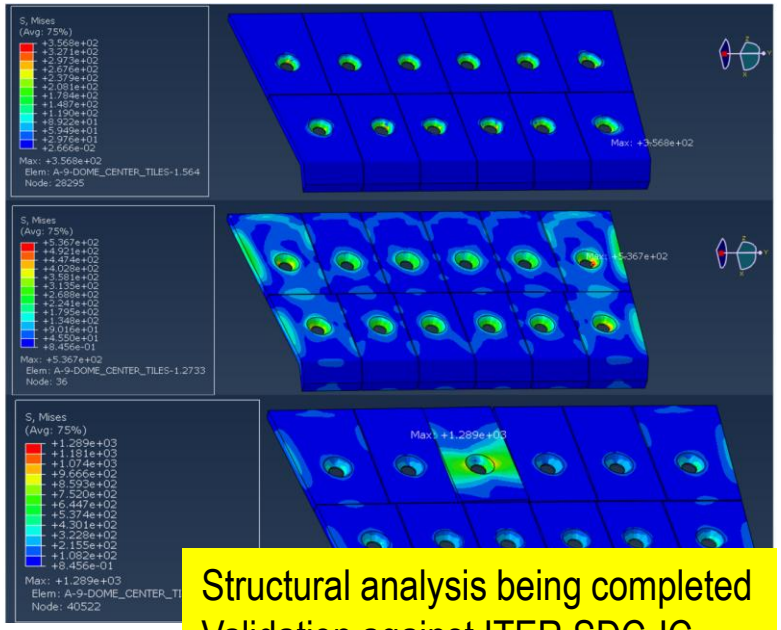


Von Mises

PRELOAD

PR + THERMAL

PR + TH + EM (1 tile)



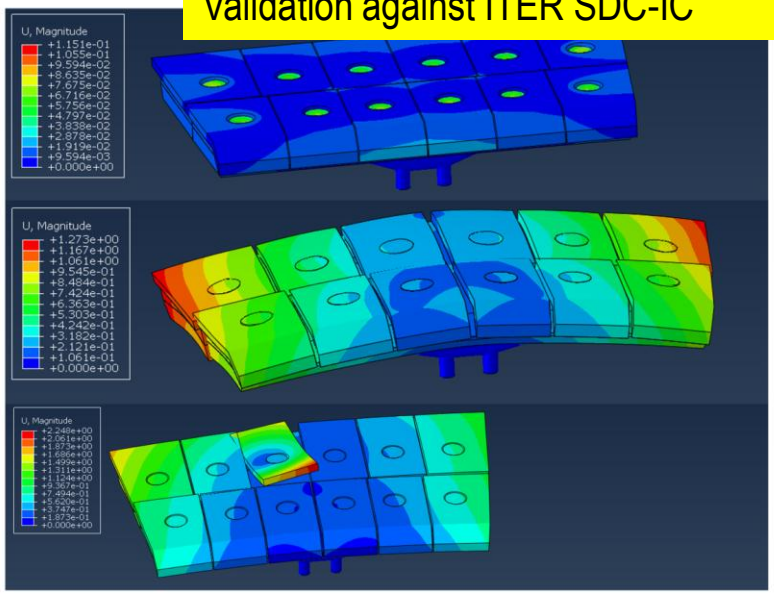
Structural analysis being completed
Validation against ITER SDC-IC

Displacement

PRELOAD

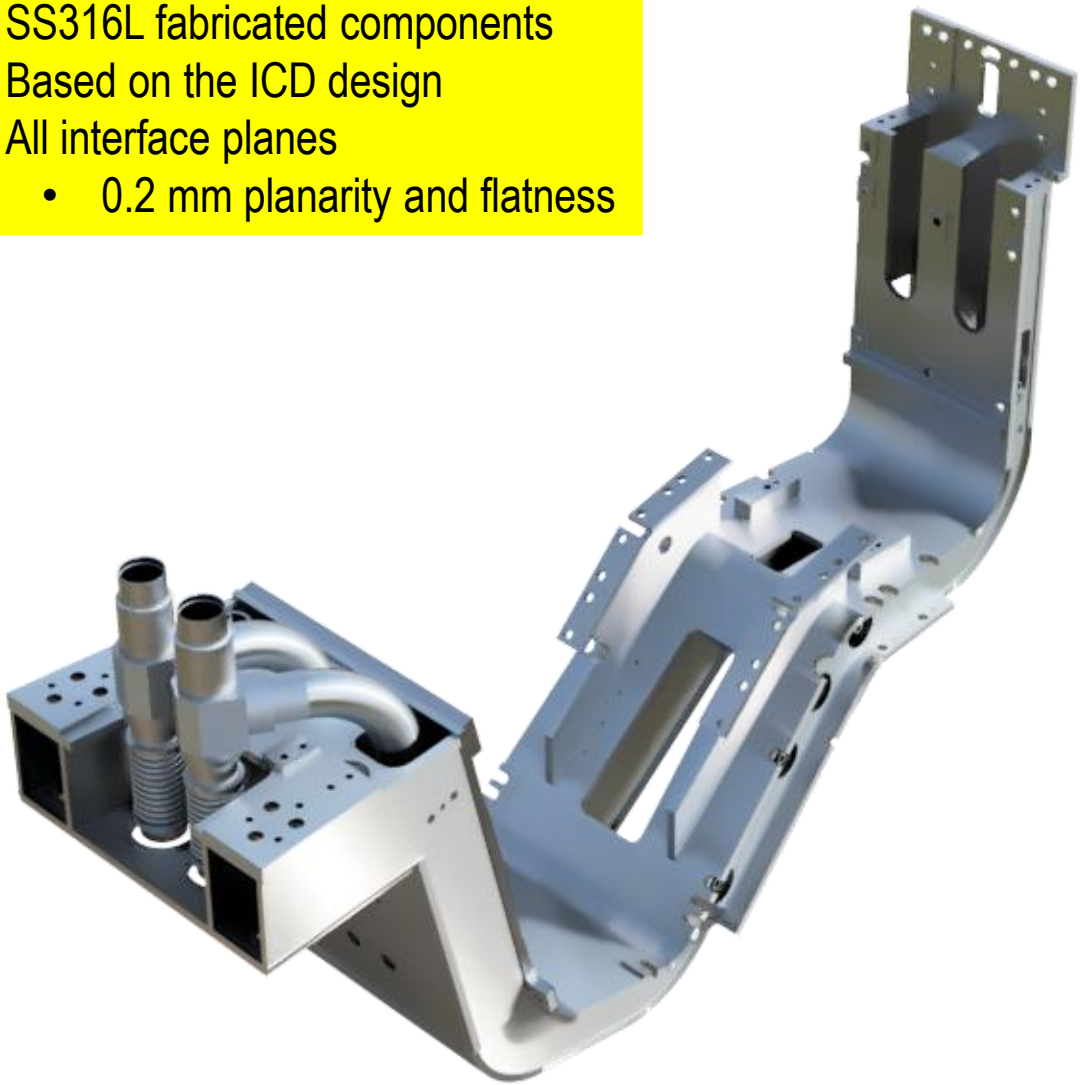
PR + THERMAL

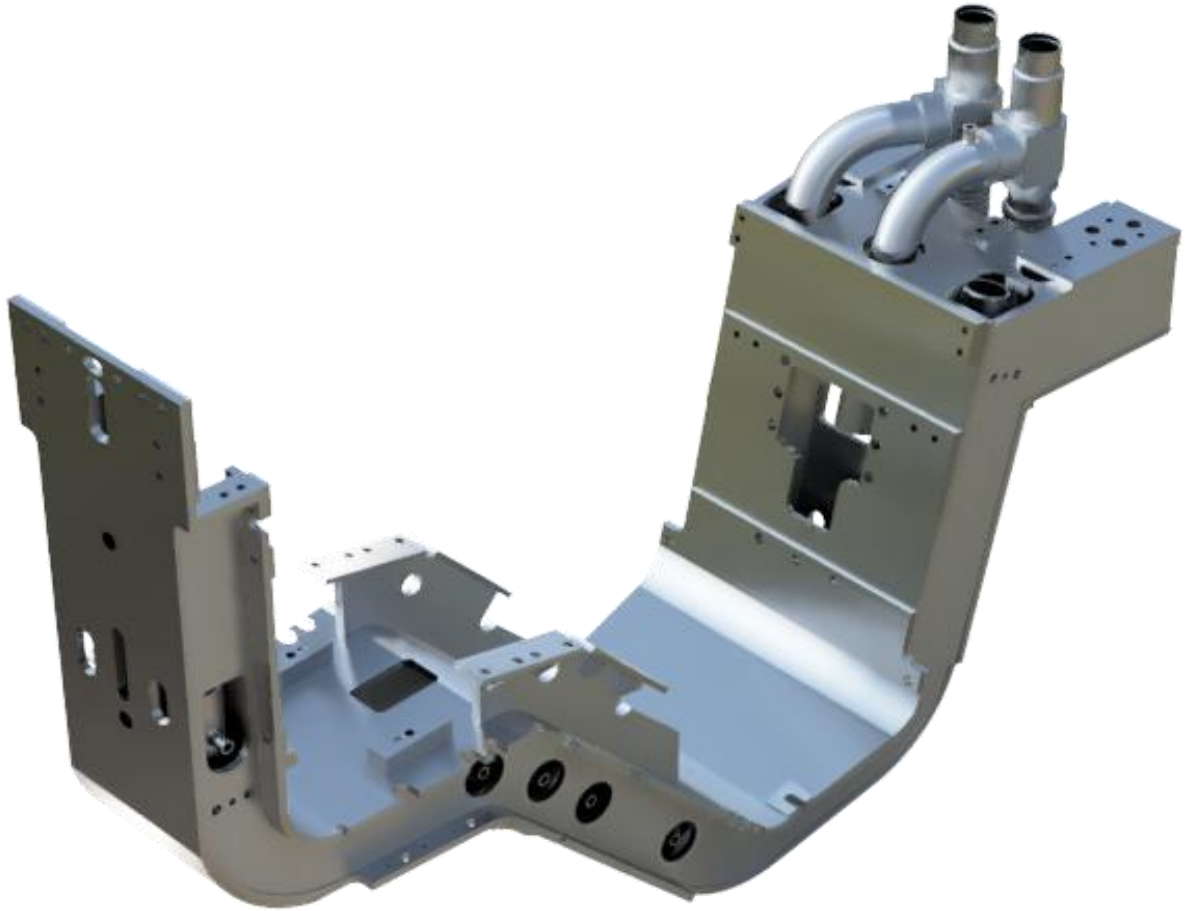
PR + TH + EM (1 tile)



Cassette Frames – CF

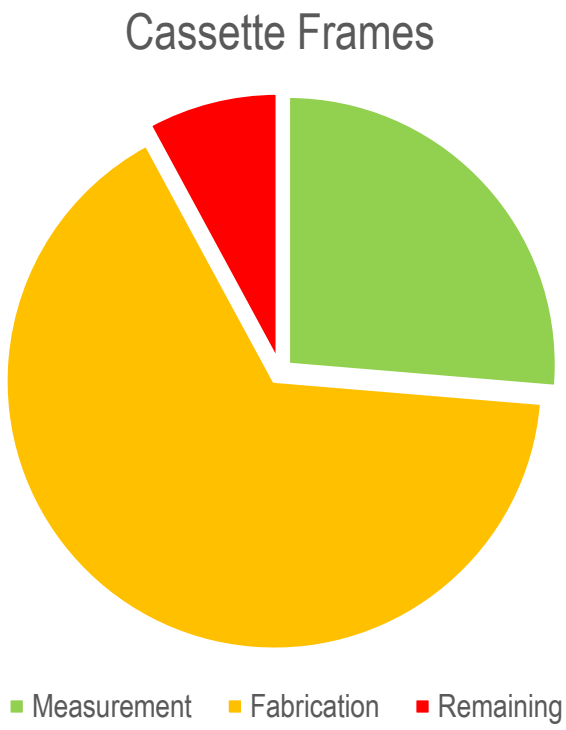
- SS316L fabricated components
- Based on the ICD design
- All interface planes
  - 0.2 mm planarity and flatness

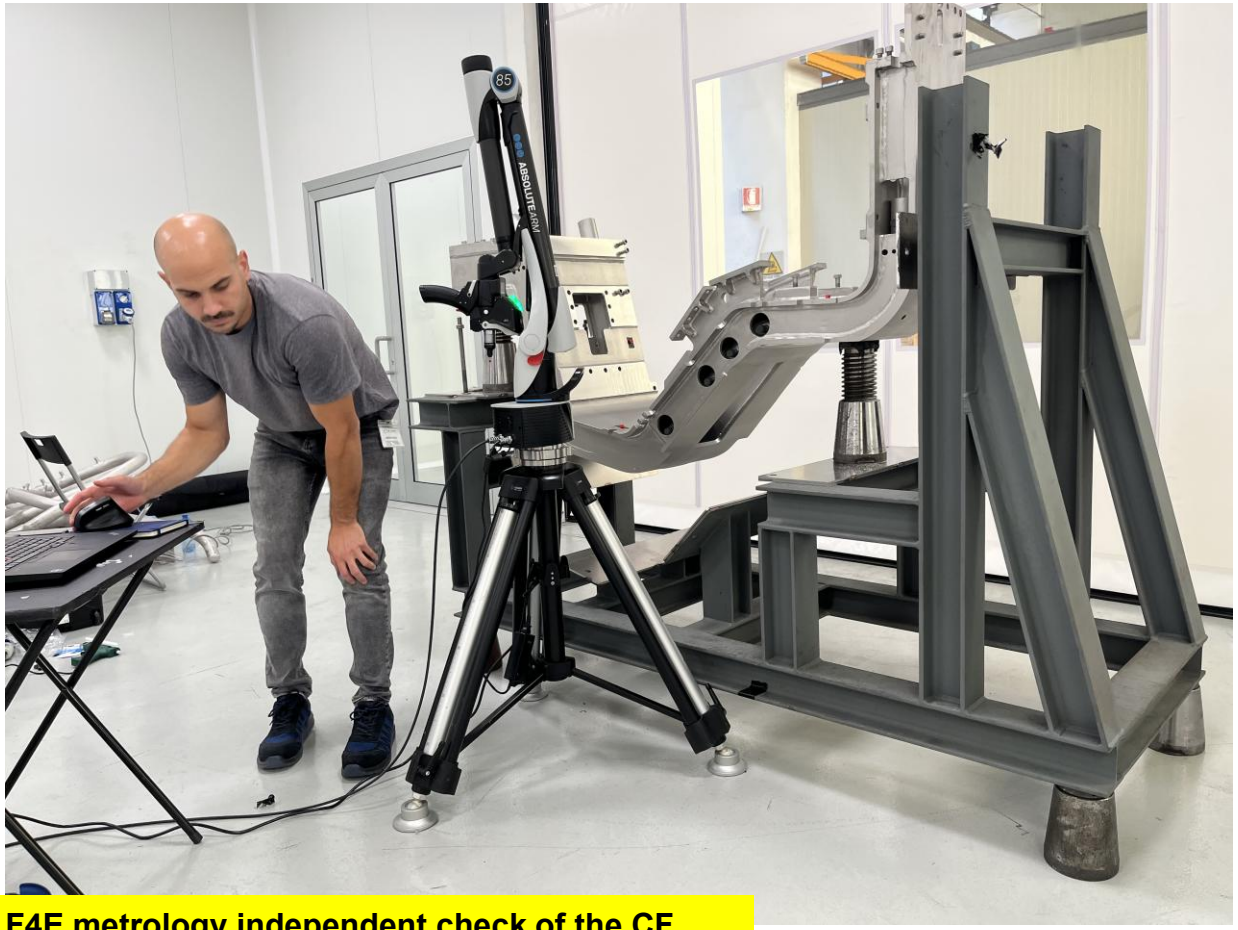




Cassette Frames – CF

- 10 cassette frames completely manufactured. Final cleaning and measurements pending
- 25 more cassette frames in various manufacturing phases

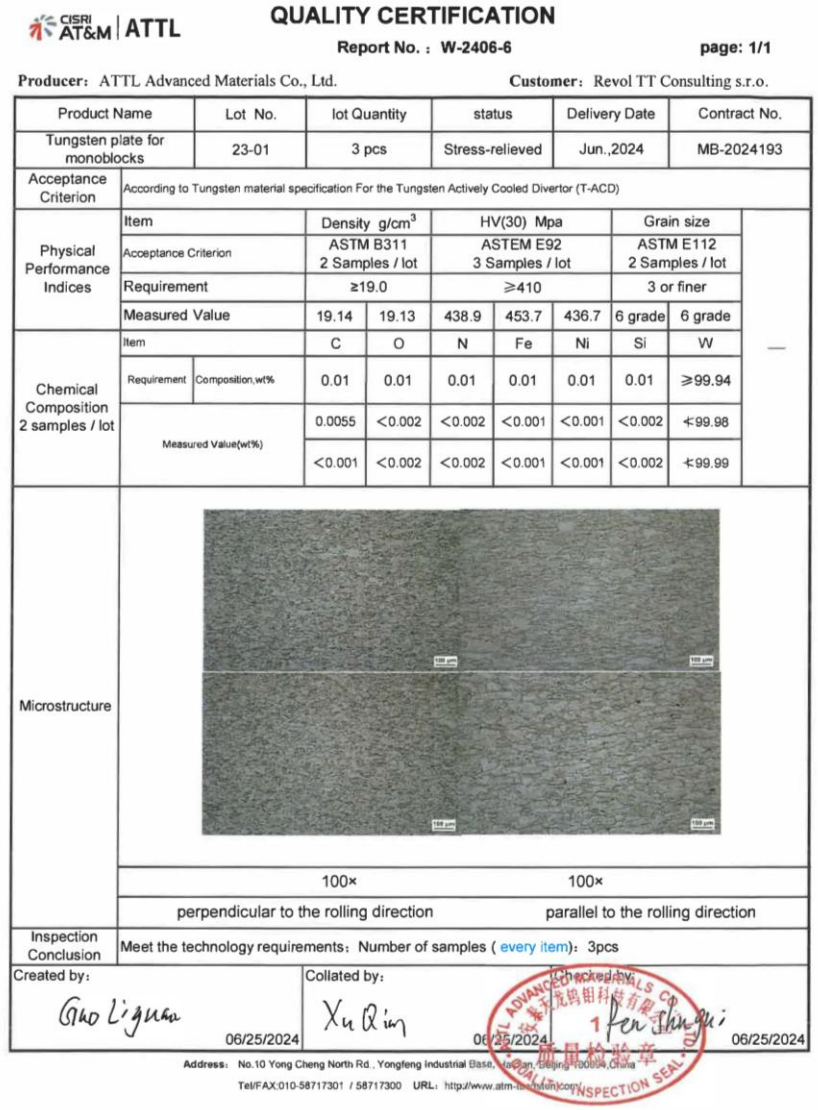




F4E metrology independent check of the CF

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
  - Options for tungsten blanks for W wall qualification trials + Divertor spares



CISRI AT&M | ATTL

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

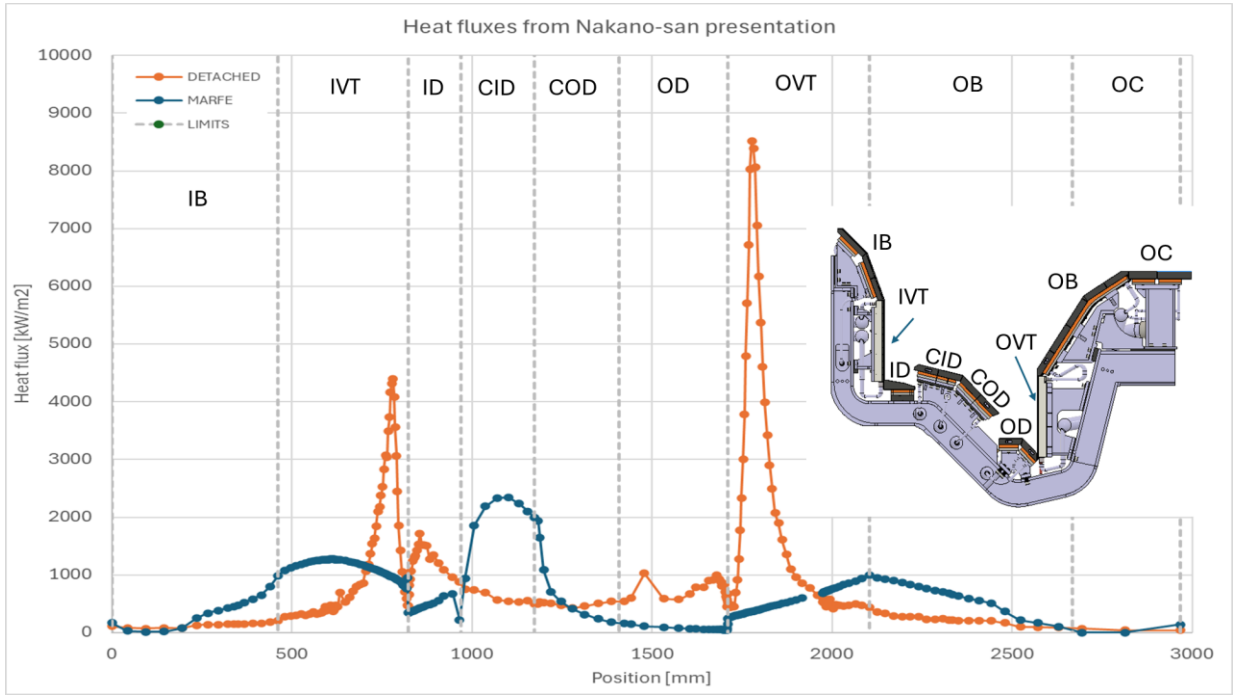
Inspection Conclusion: Meet the technology requirements: Number of samples (every item): 3pcs

Created by: Gao Liguo 06/25/2024 Collated by: Xu Qin 06/25/2024 Checked by: 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-[illegible].com

Heat loads



Heat load distribution for NHF (MARFE + detached)

Predictive modelling of JT-60SA high-beta steady-state plasma with impurity accumulation

N. Hayashi, K. Hoshino, M. Honda and S. Ide

Heat load distribution for HHF (10MW/m2 baseline + 15MW/m2)

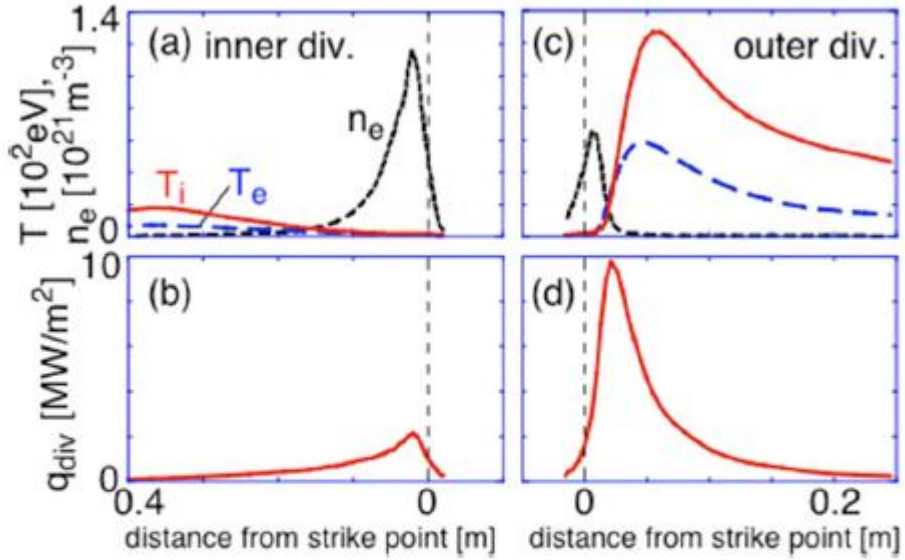
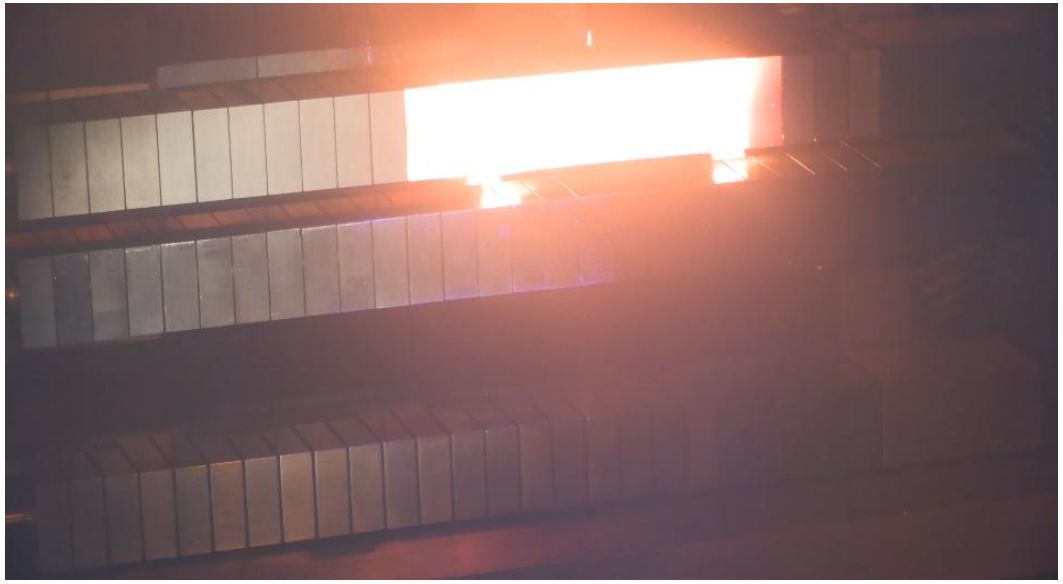


Figure 5. Profiles of (*a*) ion and electron temperatures (solid and broken lines), electron density (dotted line), and (*b*) heat load along the inner divertor plate in the same case as figure 4. (*c*) and (*d*) Profiles for the outer divertor plate.

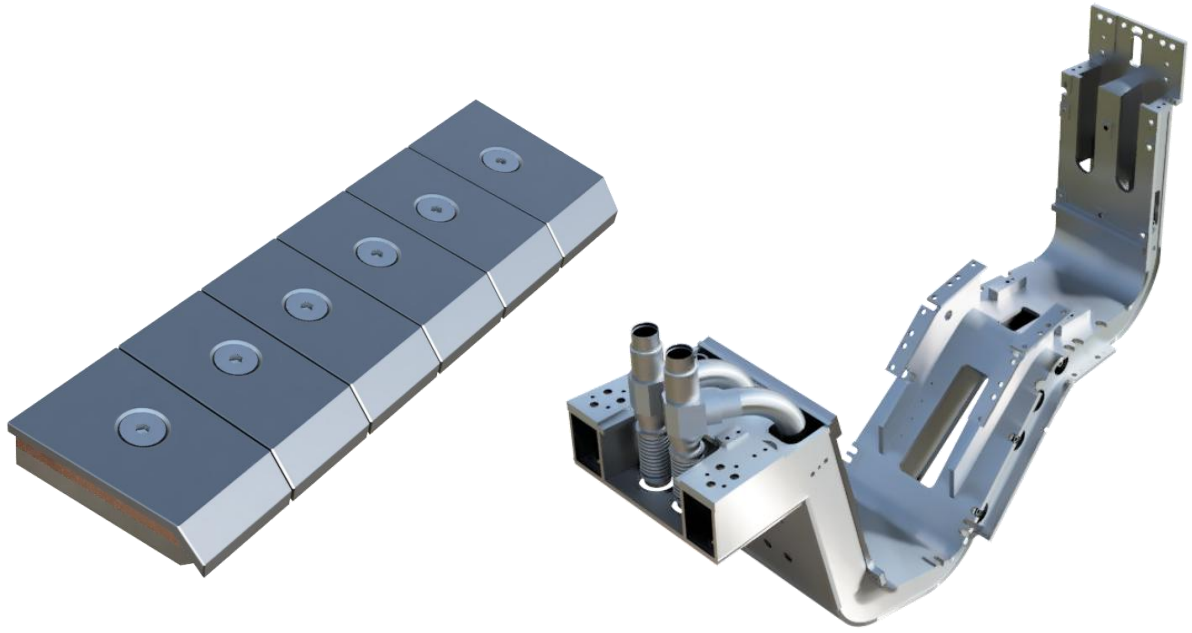
Testing

- HHF elements testing – R&D
  - IR thermography
  - Pressure test @ 25 bar
  - Hot leak test @ 25 bar, 200C
  - HHF test
    - 3000 pulses @ 10 MW/m2
    - 100 pulses @ 15 MW/m2
    - Screening test up to 20 MW/m2
- HHF elements testing – manufacturing
  - IR thermography / UT testing
  - Pressure test @ 25 bar
  - Hot leak test @ 25 bar, 200C
  - HHF testing considered x batch

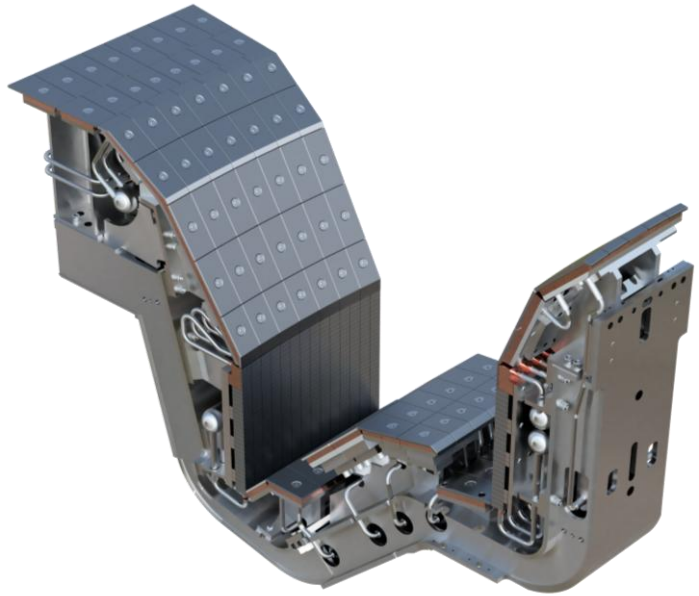


Testing

- NHF elements testing
  - Pressure test @ 25 bar
  - Hot leak test @ 25 bar, 200C
- CF main water pipes testing
  - Pressure test @ 25 bar
  - Hot leak test @ 25 bar, 160C

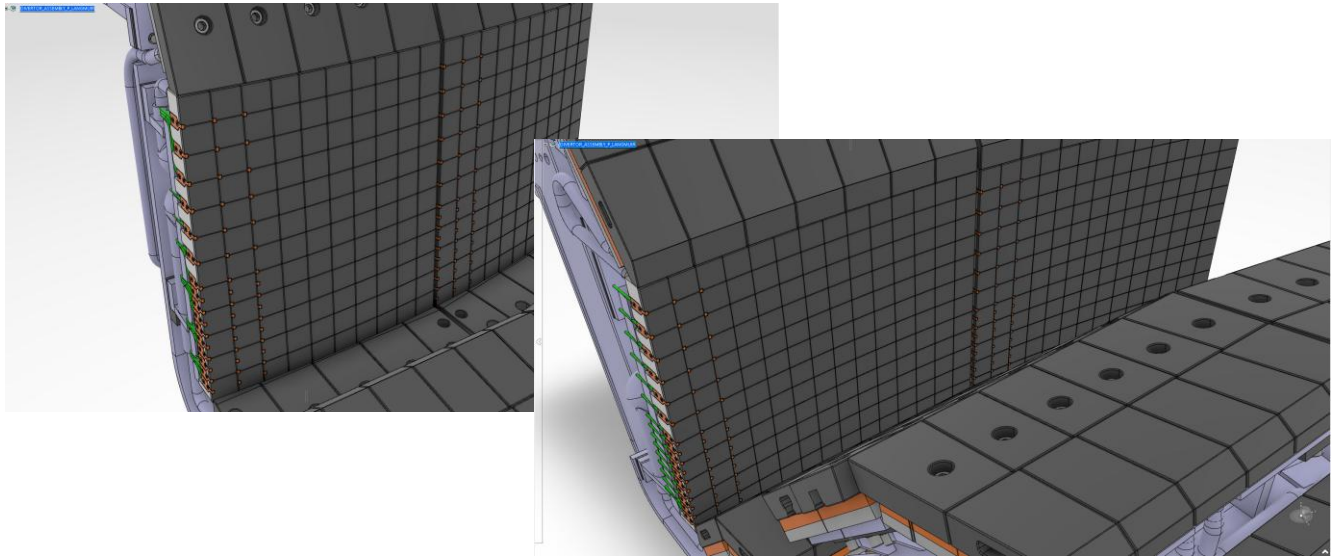


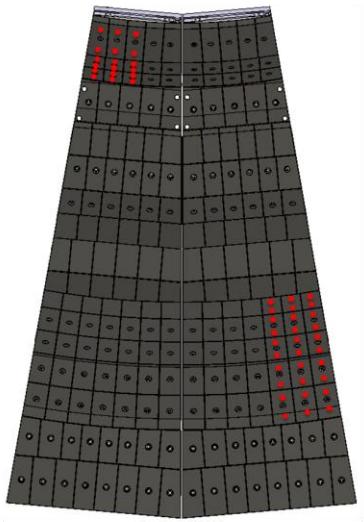
- Full divertor unit testing
  - Flow test
  - Pressure test @ 25 bar
  - Hot leak test @ 25 bar, 200C



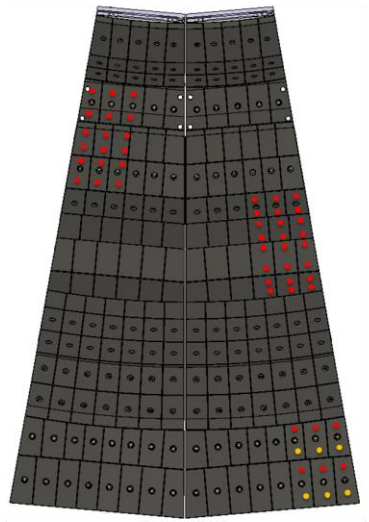
Diagnostics

- On-board divertor diagnostics:
  - Diagnostic openings
  - Langmuir probes (4 x 16 triplets)
  - Halo current coils
  - Thermocouples
  - Gas puff pipes
  - Electrical shunts (agreed)
  - Penning gauges (TBD)
  - QMBs (TBD)





P4 ➔ 16 triple probes on IB + OB



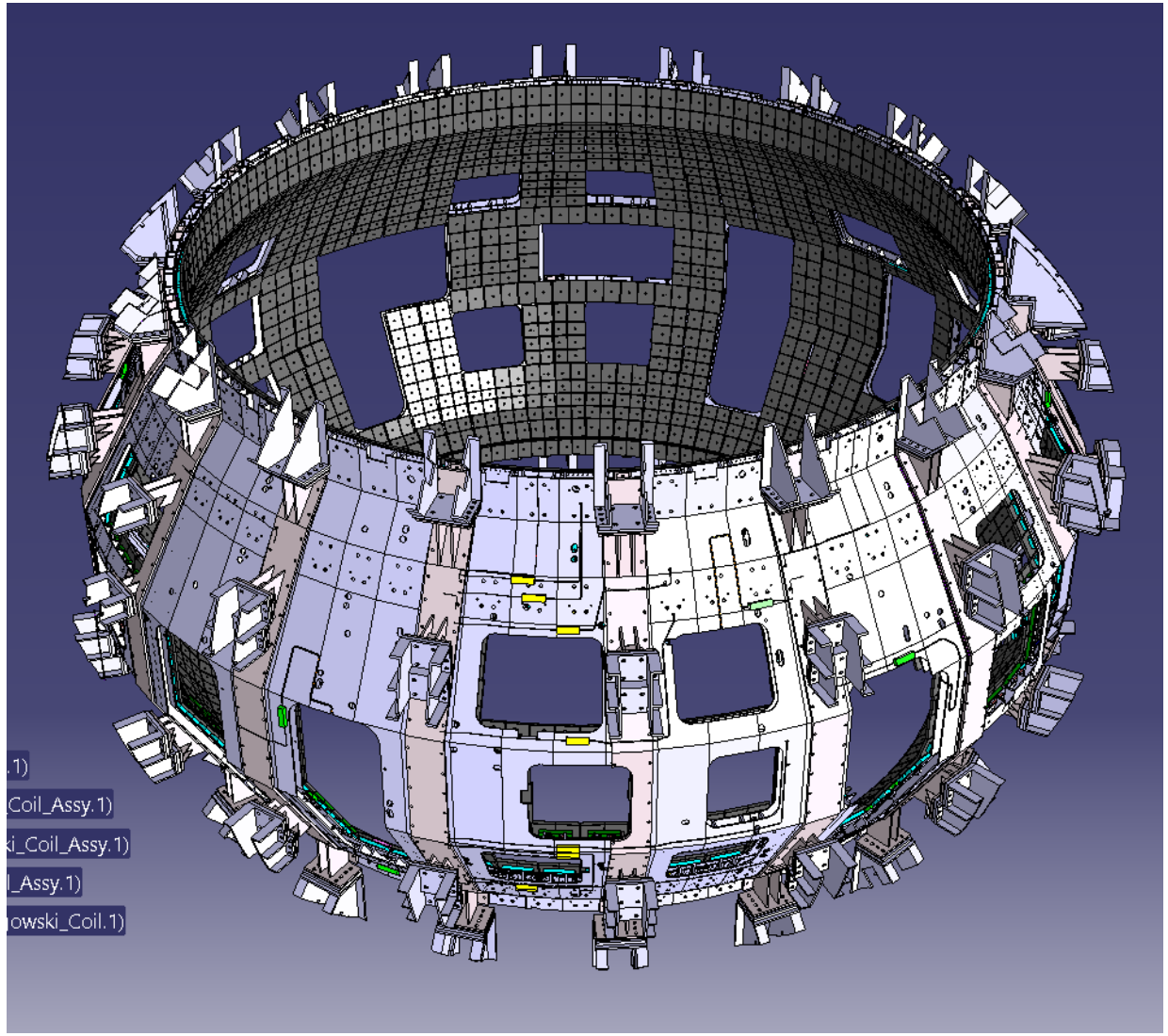
P9 ➔ 16 triple probes on DOME + OC

Next steps

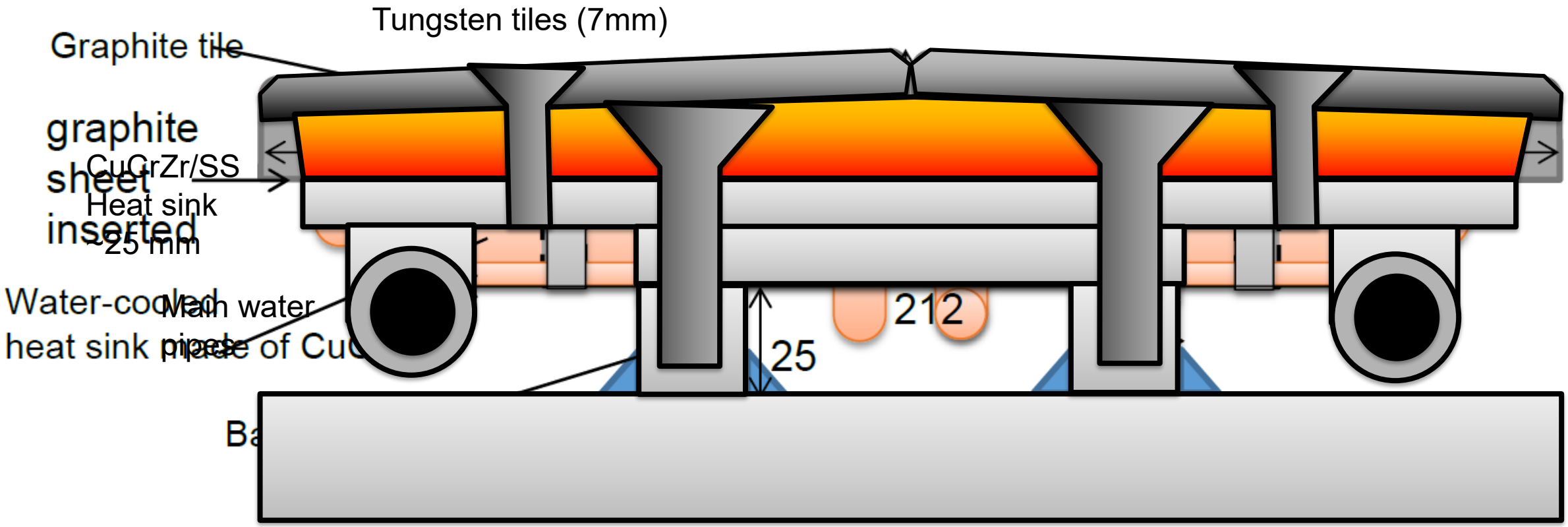
- HHF
  - Testing of small scale tungsten monoblock mockups completed in Q1/25
  - Intermediate scale mockups manufactured and tested in Q2/25
  - 3 full scale mockups manufactured and tested as Q1/26
  - Release of series production in Q3/26
  - Tungsten raw material tenders received and being evaluated as of March 2026
- NHF
  - Design of tungsten PFCs finalized in Q3/25
- CF
  - First 10 units in Q1/26
- Integration
  - PA to be signed by Q2/2026 with call for tender to start by Q1/26

Tungsten first wall

- Tungsten First wall – design activities
  - Drop-in replacement to C wall
  - Reuse of stabilizing plate → priority
  - Possible need of in-vessel work for stabilizing plate and water manifolds modification
  - Technology based on NHF design, but adapted to RE and disruption loads
  - Remote handling compatible (RH studies to be started in parallel to W wall design)
  - Conceptual design to be completed by end 2026
  - Writing of technical specification and start of call for tender for industrial contract(s) by end 2027
  - Human resources being identified in F4E Projects and Engineering departments

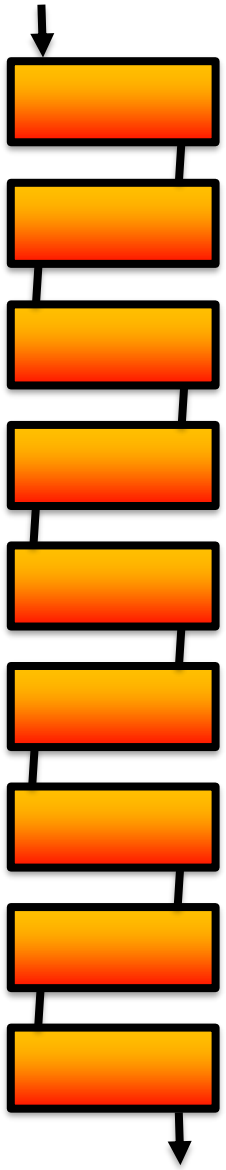


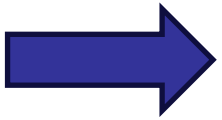
Tungsten first wall

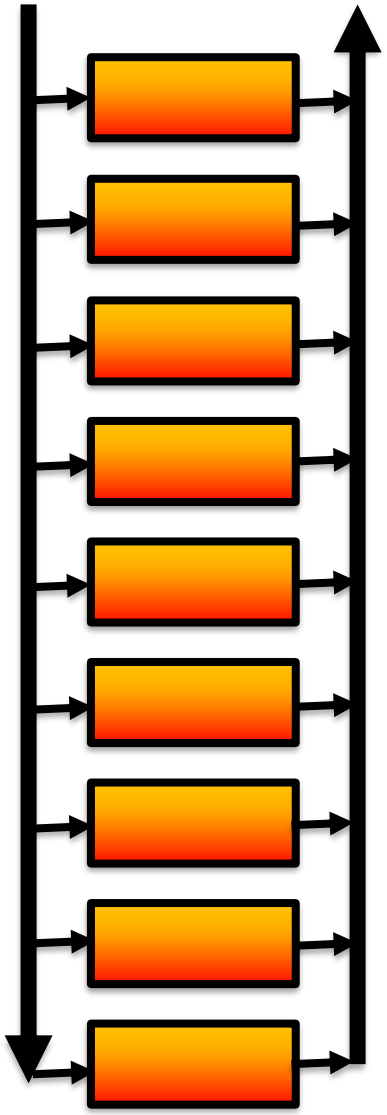


Tungsten first wall

Series flow







Parallel flow