

Development of Meter-Scale Large W/Cu Divertor Components for Fusion Reactor at ASIPP

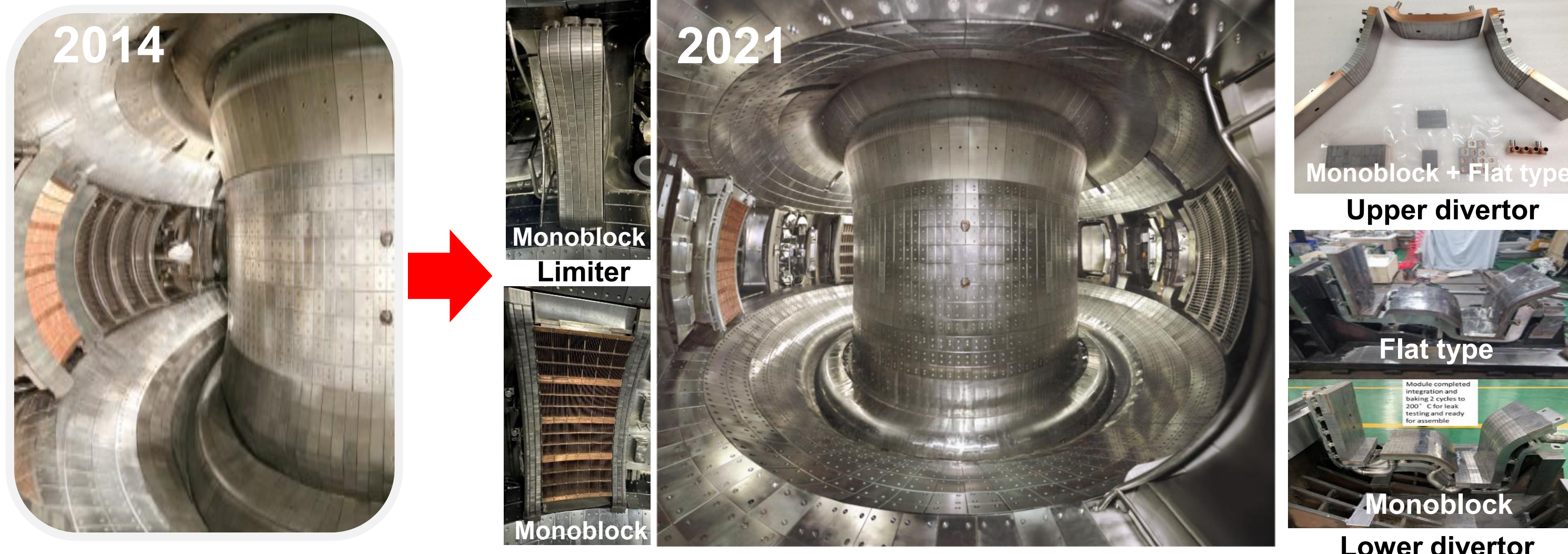
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Development and achievement of W/Cu components

- EAST 's plasma-facing components evolution: non-actively cooled stainless steel → water-cooled heat sinks → molybdenum first wall → W/Cu monoblock upper divertor → **fully upgraded W/Cu monoblock lower divertor**.
- 2025, EAST achieved **1,066 s stationary H-mode** plasma at approximately 70 million °C.



Tungsten upper divertor

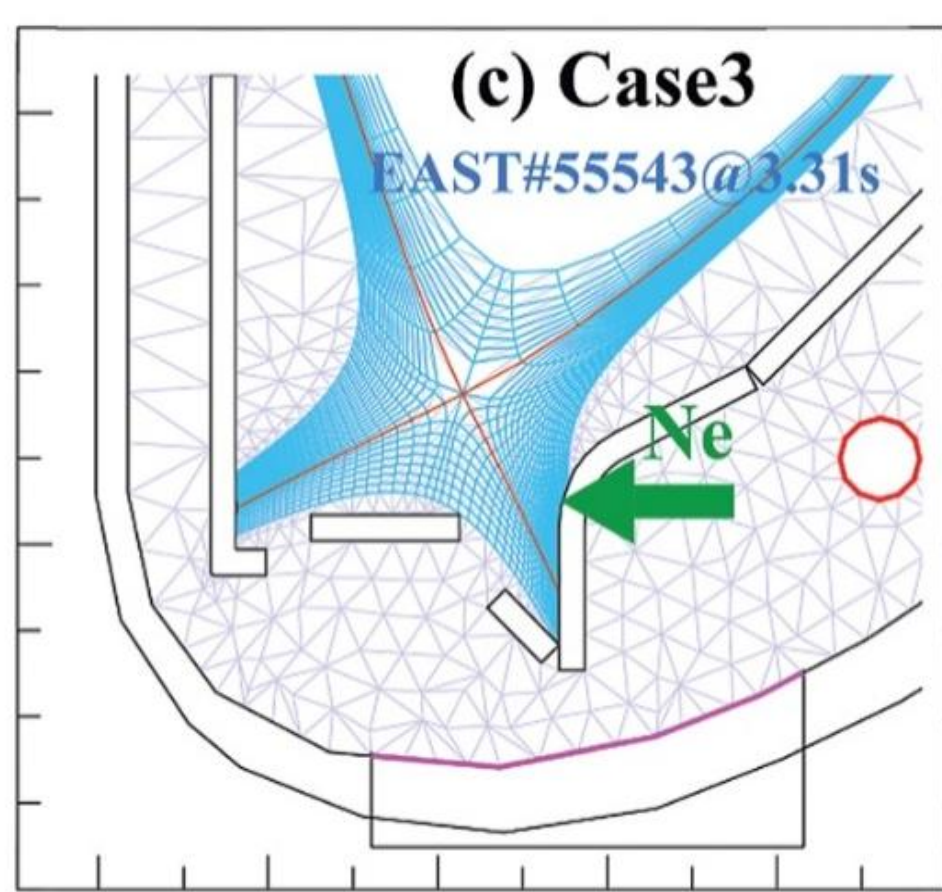
Full tungsten divertor and limiter (10 MW/m²)

- Lots of R&D work has been done to explore the design and technology of W/Cu components oriented to the DEMO and future fusion reactor in ASIPP.

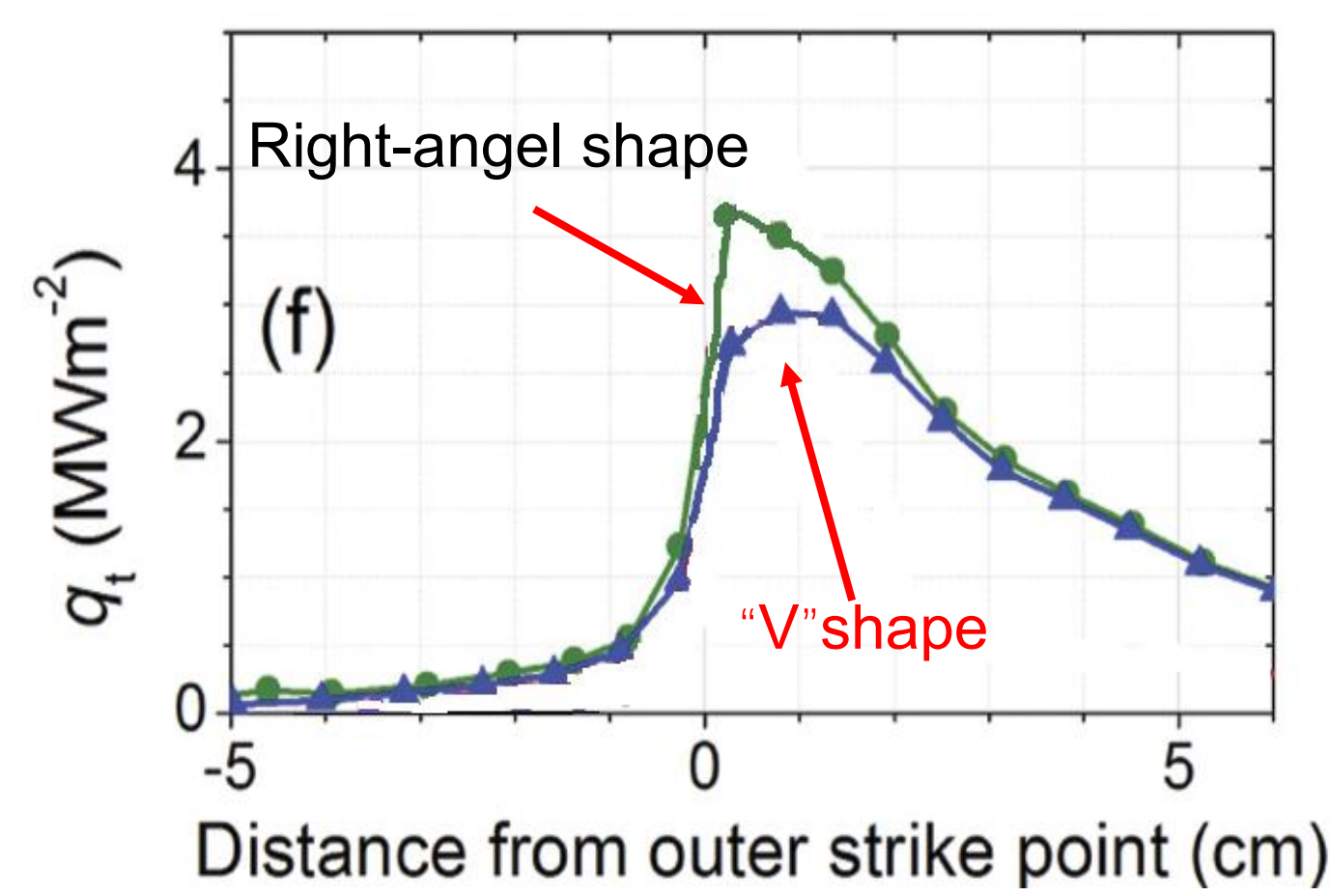
PFC design with a closed V-shape

● V-shape divertor configuration

According to the simulation on EAST lower: the **"V" shape closed** structure can significantly reduce the maximum heat load at the strike point than the **right-angle structure**. [2021 Nucl. Fusion, 61, 126070]



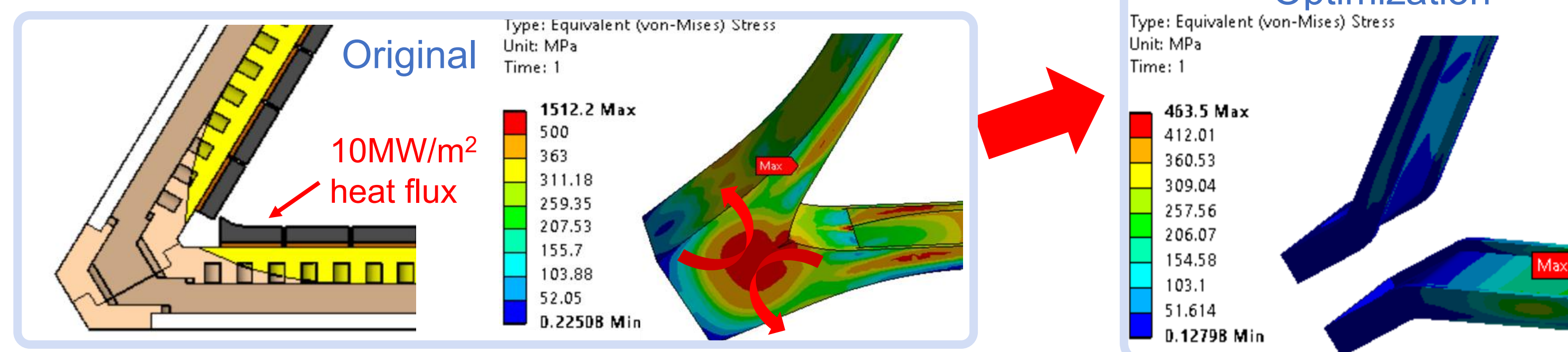
case 3: V-shape corner



The Distributions of q_t along the outer target

● Optimization for PFC

Under a **10 MW/m²** heat flux, all materials meet the temperature design criteria. A stress peak occurs at the V-shaped slot due to space constraints, though it is significantly reduced by **structure "decoupling"**



● Manufacture and test for mock-up

- PFU: explosive welding + brazing and Hot Isostatic Pressing.
- Composite Plate : solution → bending → brazing → solution → aging.
- Non-destructive testing (**defect < φ2mm**), pressure, baking, leak detection.
- PFU passed **1000-cycles + 15 MW/m²; without visual damage**.



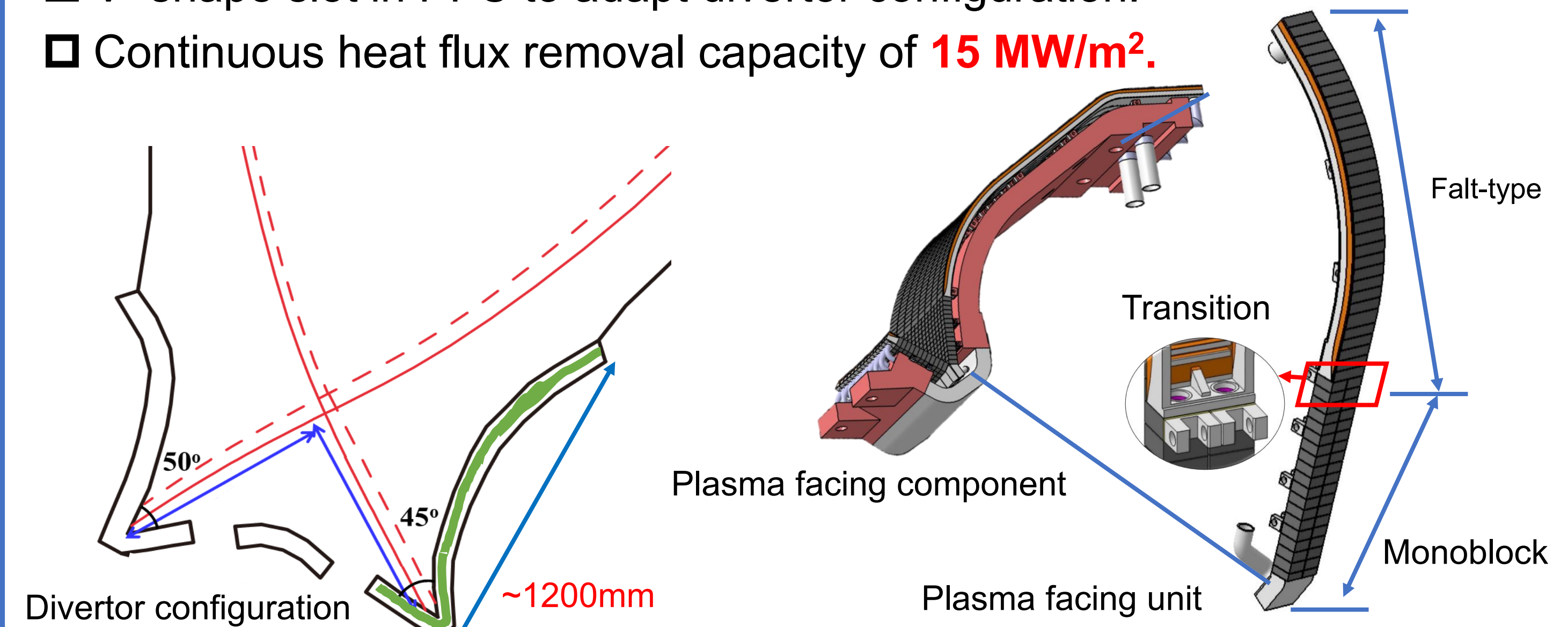
PFU mock-up after test

Surface temperature

Meter-scale W/Cu divertor components

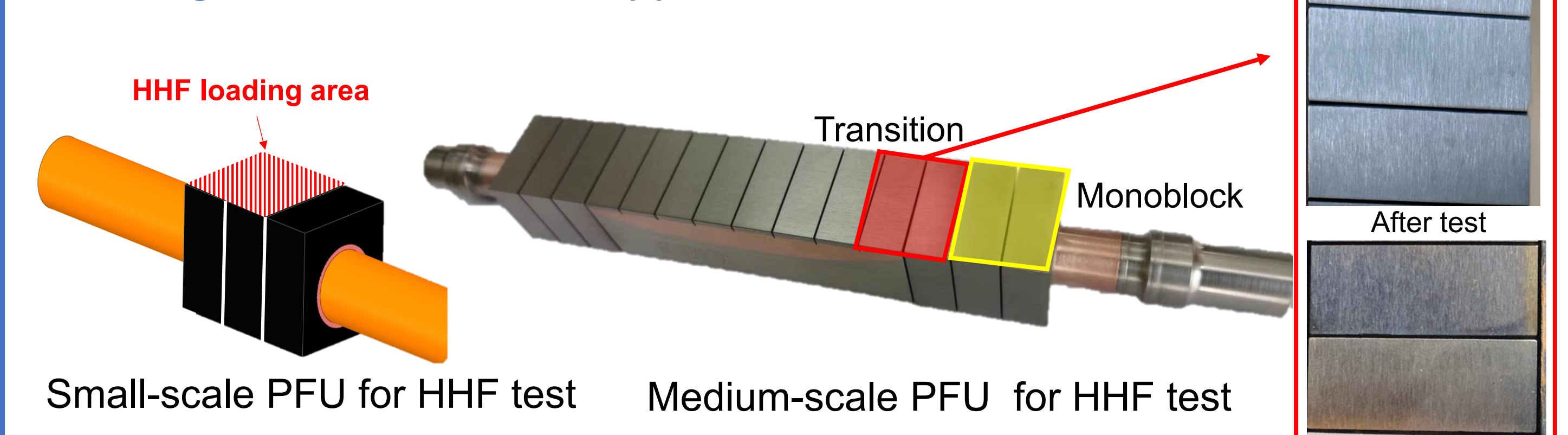
Meter-scale divertor PFC design

- V- shape slot in PFC to adapt divertor configuration.
- Continuous heat flux removal capacity of **15 MW/m²**.



● Manufacture and HHF test for mock-up

- Passed qualification for CuCrZr mechanical properties after heat treatment, CuCrZr/316L interface, monoblock support leg joint, and CuCrZr-316L tube-to-tube junction.
- The small-scale PFU passed **5000-cycles + 15 MW/m²**, **No visual damage**, but micro-crack appeared.



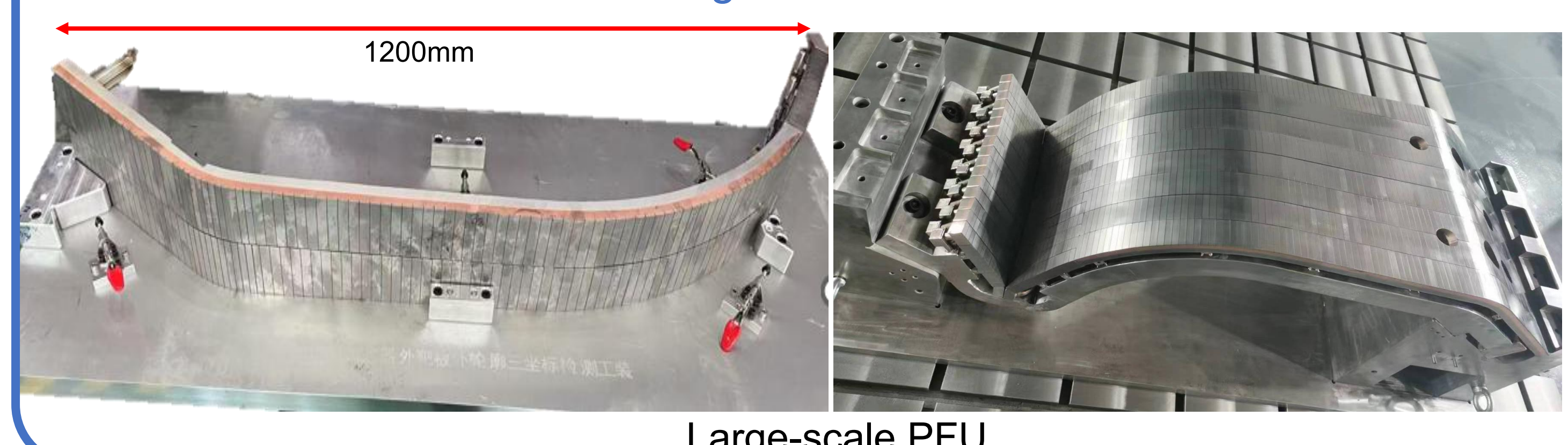
Small-scale PFU for HHF test

Medium-scale PFU for HHF test

- The medium-scale PFU transition passed **1000-cycles + 2 MW/m²** and **1000-cycles + 5 MW/m²**, **no visual damage**.
- The medium-scale PFU monoblock passed **1000-cycles + 10 MW/m²**, **no visual damage**. But when **extra 50-cycles + 20 MW/m²**, **micro-crack appeared**.

● Fabrication of Large-scale PFC

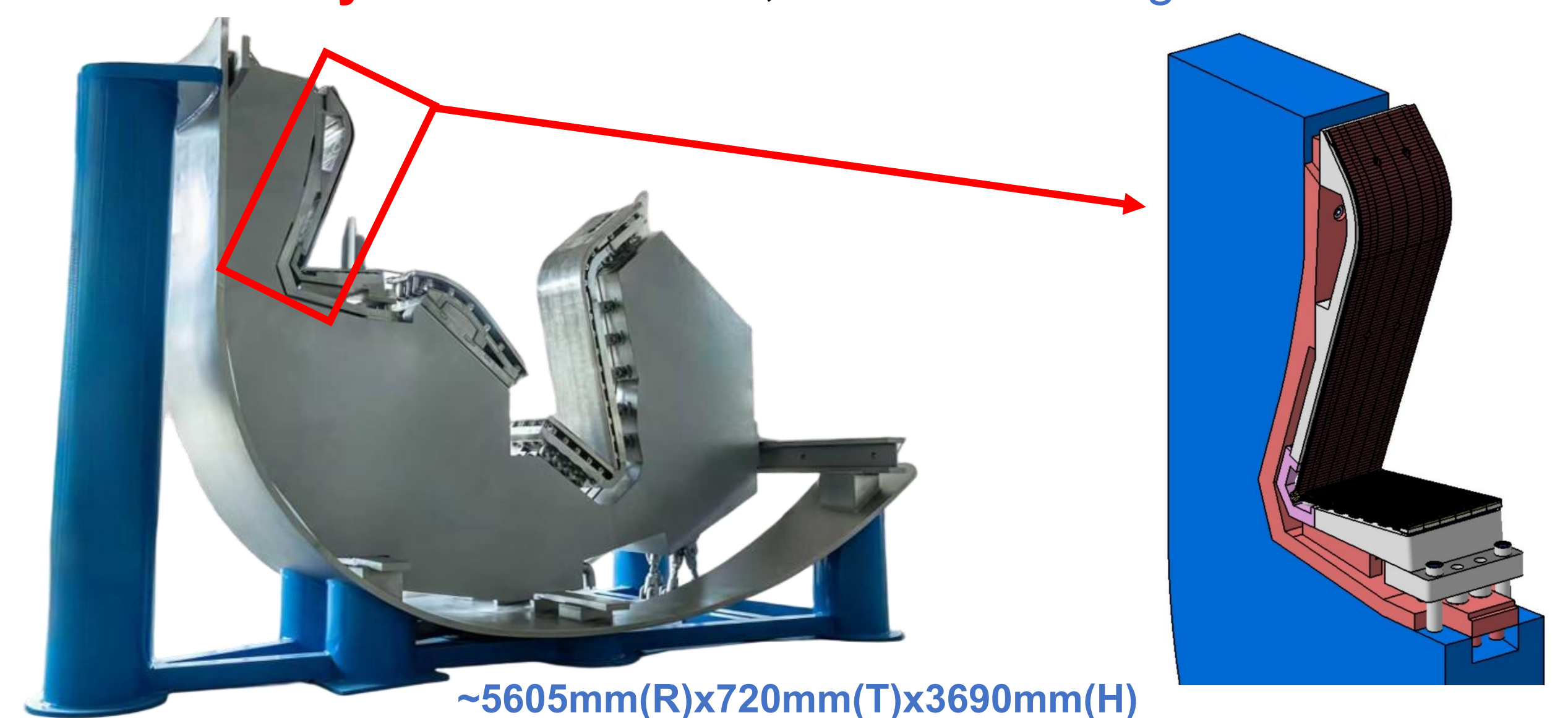
- Two PFUs **connection by water box**.
- PFC with **vertical/horizontal target** and **water-cooled steel structure**.



Large-scale PFU

PFC towards CFETR

- Potassium-doped tungsten (KW) for armor.
- Oxide dispersion-strengthened copper (ODS-Cu) alloy for heat sink.
- Passed **1000 cycle + 20 MW/m²**, **no visual damage**.



~5605mm(R)x720mm(T)x3690mm(H)
Largest target (1425mm straight and 1495mm curved target)

Summary

- Several fabrication processes for W PFCs have developed in ASIPP during past 20 years. **EAST has equipped with both upper and lower W/Cu divertor**.
- A PFC design with **closed V corner** of continuous high heat flux removal has been developed in ASIPP.
- 1.2-meter divertor components have been qualified by R&D for material, mock-up, HHF test.
- Components with **advanced materials** towards **CFETR** is under prototype phase.