



**EAST  
/HT-7**

**ASIPP**

# **Progress of W/Cu Divertor Project for EAST**

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**2nd Sino-German Workshop on Plasma Wall Interactions**

**Max-Planck Institute of Plasma Physics, Garching, Dec.6-8, 2010**

**— Sponsored by Sino-German Center for Research Promotion**





- **EAST PFMC Plan**
- **R & D of W/Cu PFCs**
- **New Possibility of W/Cu PFCs**
- **EAST W/Cu Divertor Project**
- **Summary and Outlook**



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## Missions of EAST

- ↳ steady-state high-performance plasma
- ↳ physics research and technology development

## PFMC plan for EAST

- **Initial phase** (2006-2007), PFM was SS plates bolted to the support w/o active cooling
- **First phase** (2008-2013) with limited heating (max. heat flux onto divertor  $\sim 2\text{MW/m}^2$ ), PFM is mainly SiC-coated doped graphite tiles bolted to Cu heat sink
- **Second phase** (2014-) with more heating ( $>10\text{MW}$ ), PFC will be changed into actively-cooled W/Cu-PFC gradually (max. heat removal from divertor  $7\sim 10\text{MW/m}^2$ )

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G. -N. Luo, et al., *Phys. Scr.*, T128 (2007) 1

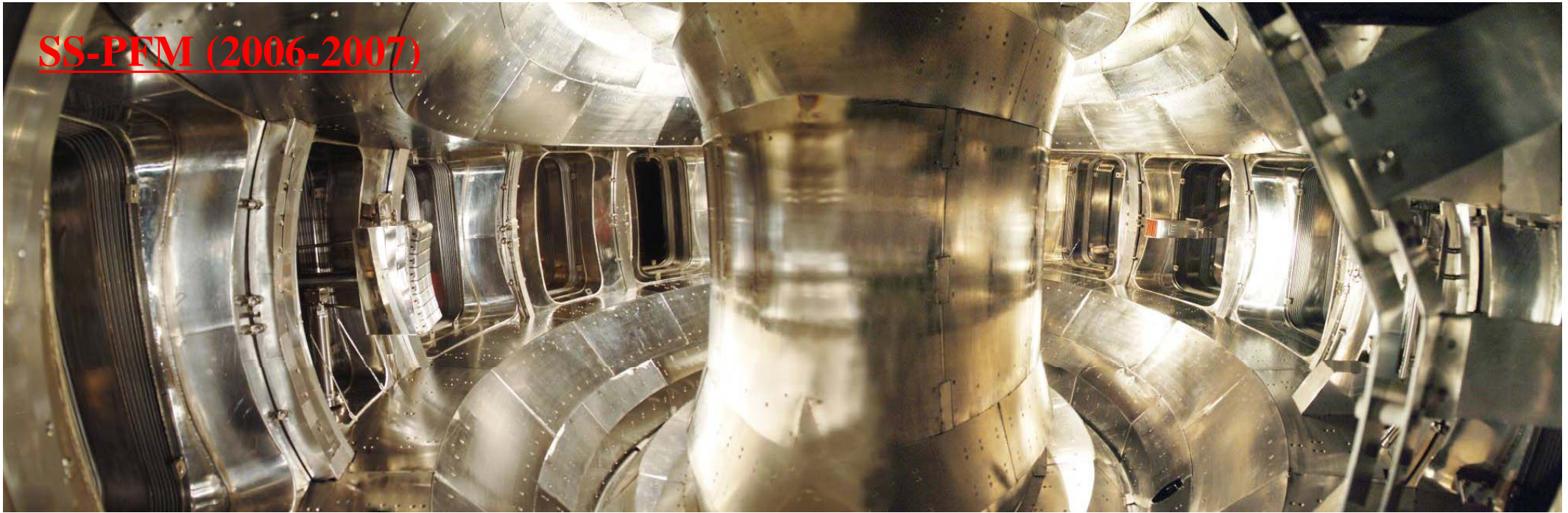


# PFMC for EAST

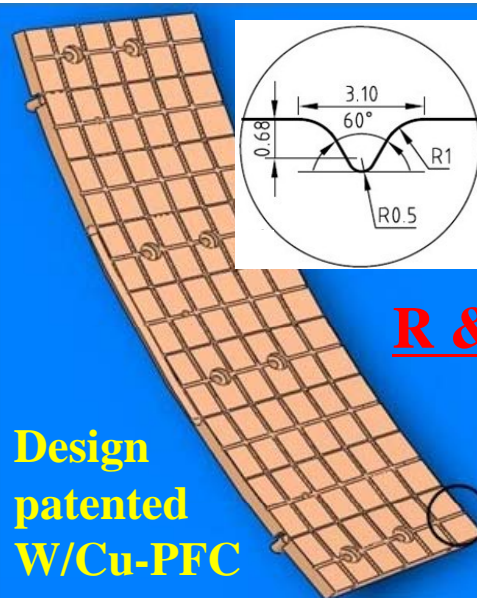
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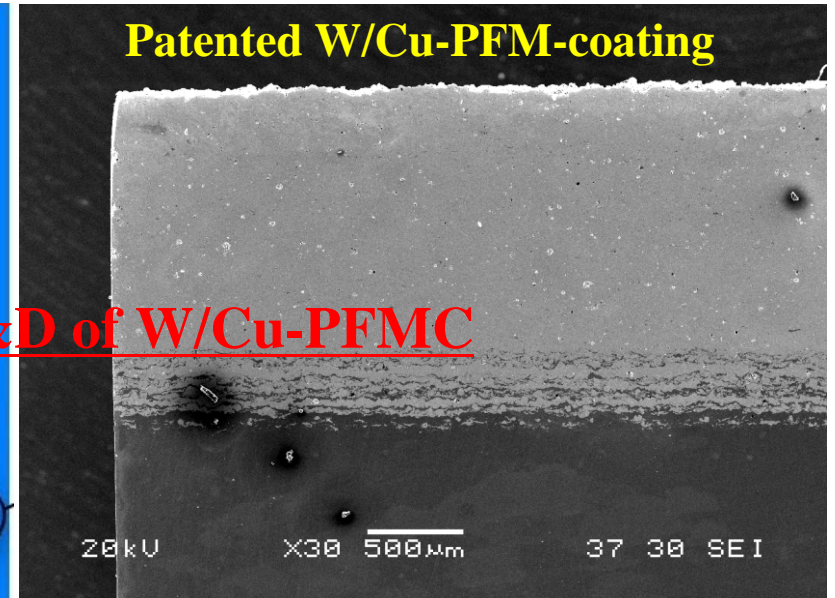
SS-PFM (2006-2007)



SiC/C-PFM (2008-2013)



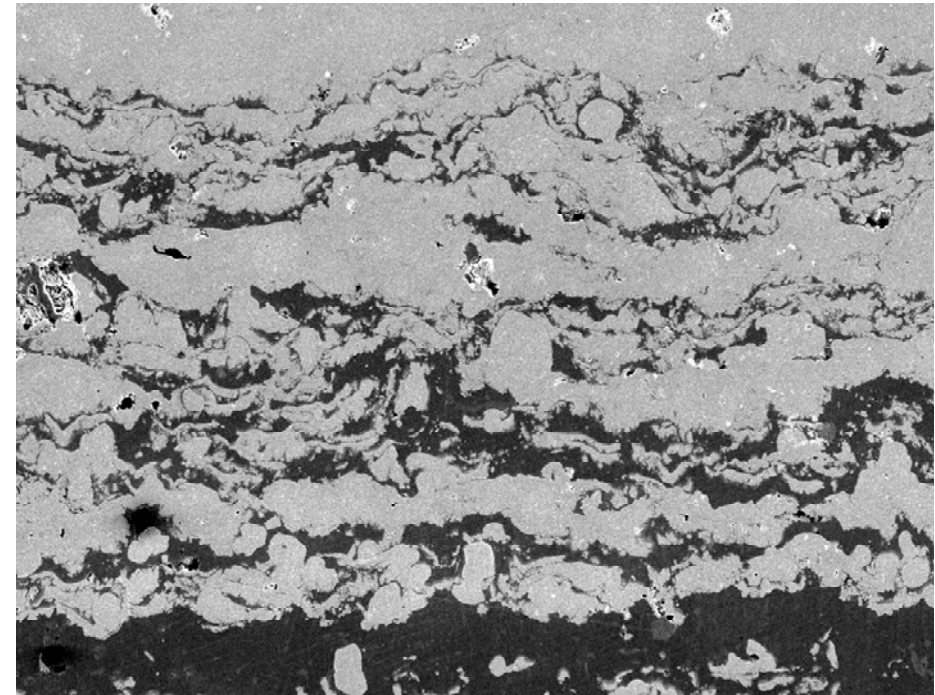
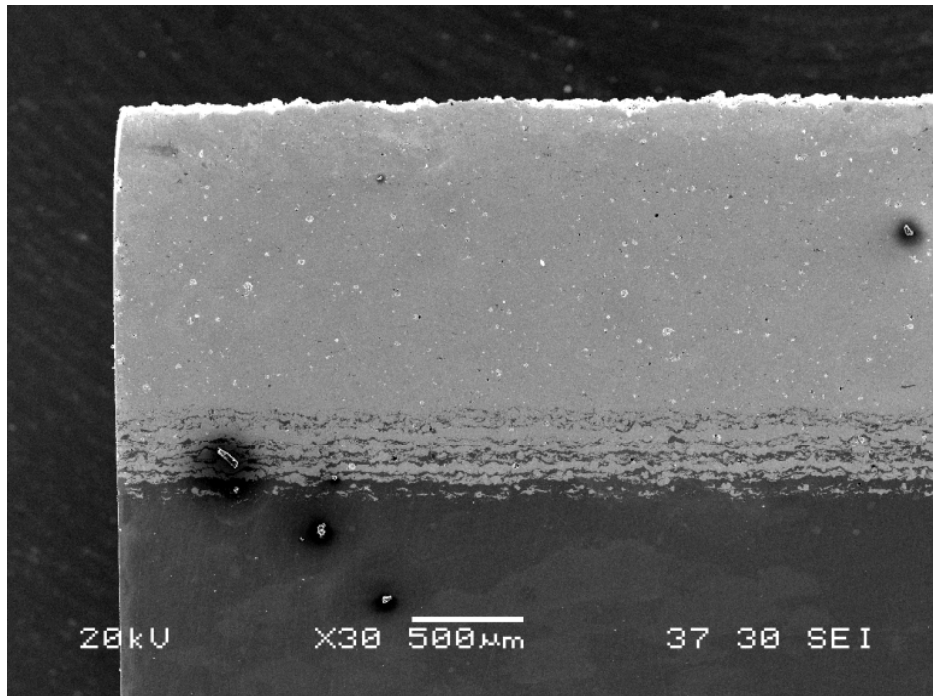
**Patented W/Cu-PFM-coating**



R & D of W/Cu-PFMC



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## The major goals of the VPS-W/Cu PFC being developed at ASIPP

- Large scale of VPS-W/Cu PFCs with active cooling and castellation structures
- Cooling capability up to  $10\text{MW/m}^2$
- Bonding strength  $\sim 30\text{-}50\text{MPa}$
- Porosity  $< 5\%$
- Thermal conductivity  $> 85\text{ W/m/K}$
- Oxygen content of  $< 1\text{at}\%$



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## HHF testing-Upgrade

Evaluation of PFC integrity and lifetime; NDT calibration

Max. power: 10 kW  $\Rightarrow$  30 kW

Cooling: 0.4 Mpa, 2 m<sup>3</sup>/h  $\Rightarrow$  ITER

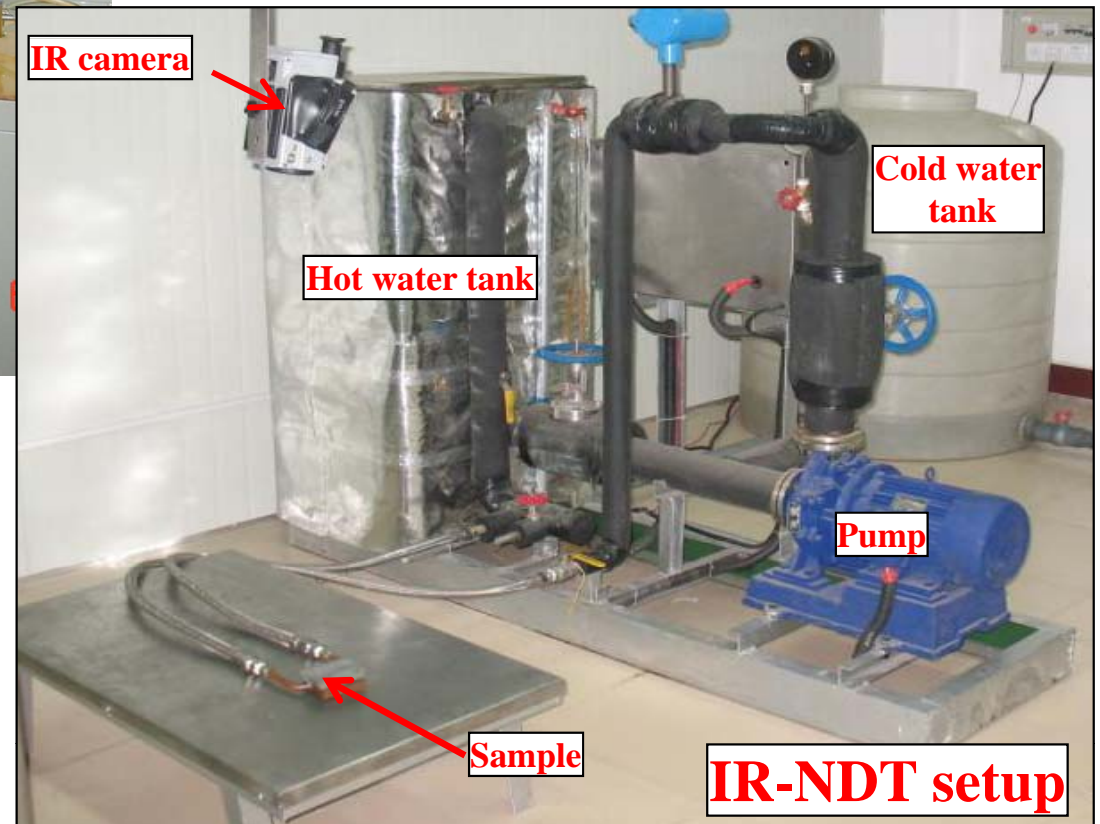
Max. area: 3  $\times$  3 cm<sup>2</sup>  $\Rightarrow$  10  $\times$  10 cm<sup>2</sup>

## Non-destructive Testings (NDTs)

Establish acceptance standards

Quality control at batch reception

Ultrasonic and IR thermography inspection methods (hard/software) are being developed for EAST PFCs





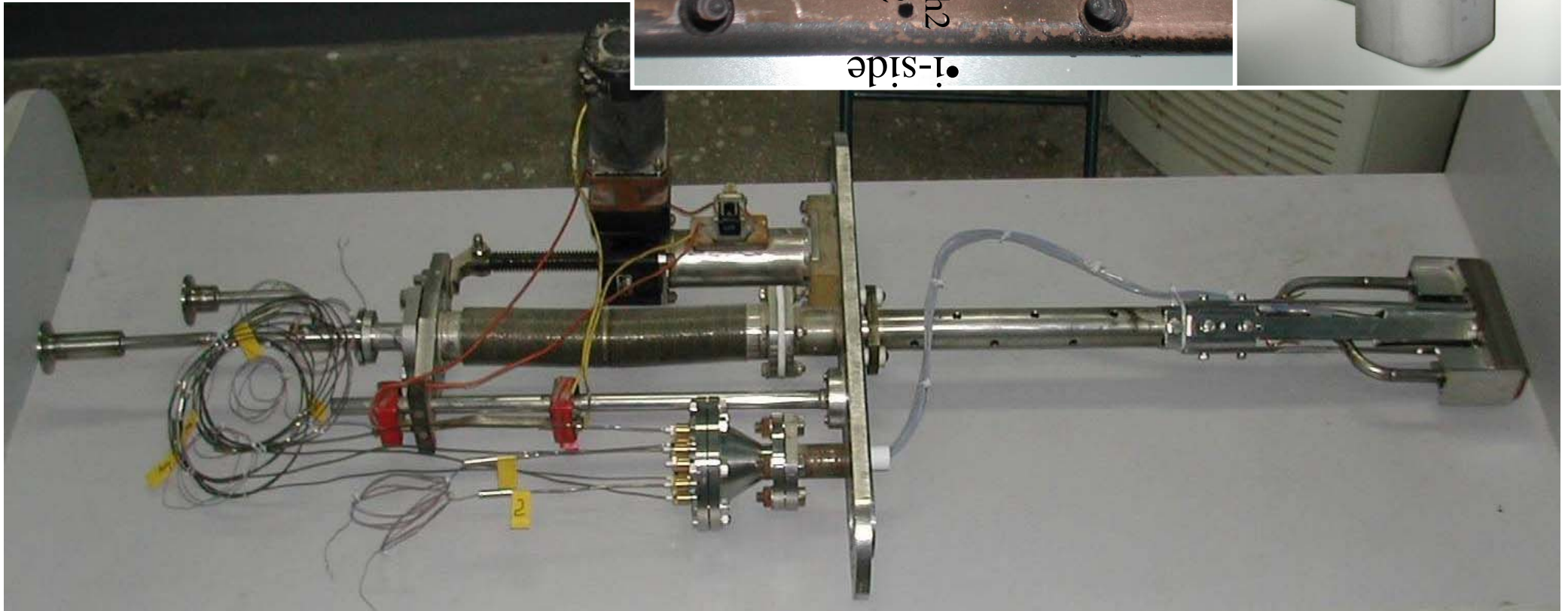
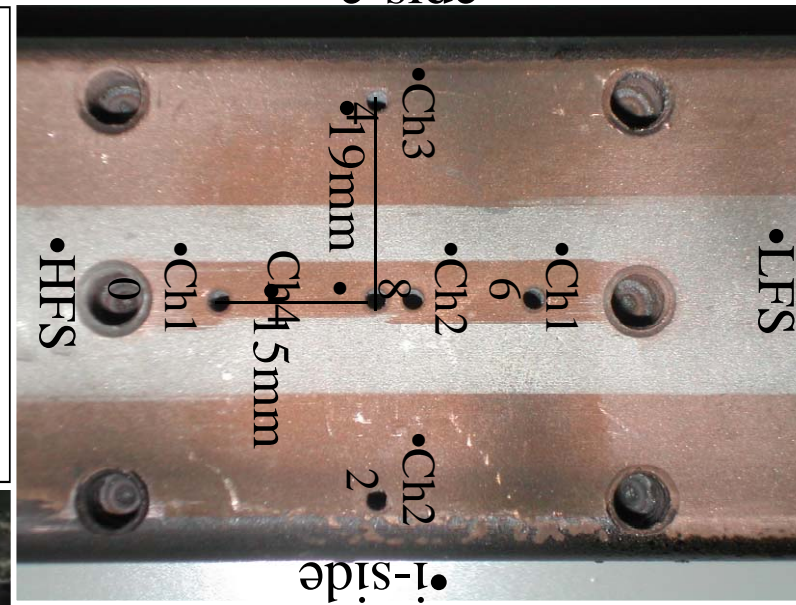


# Testing of W/Cu-PFC on HT-7

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- Movable limiter on HT-7
- $150 \times 50 \times 40$  mm
- 1 mm thick W coating
- $2\text{m}^3/\text{h}$  cooling water
- IR camera
- Thermocouples



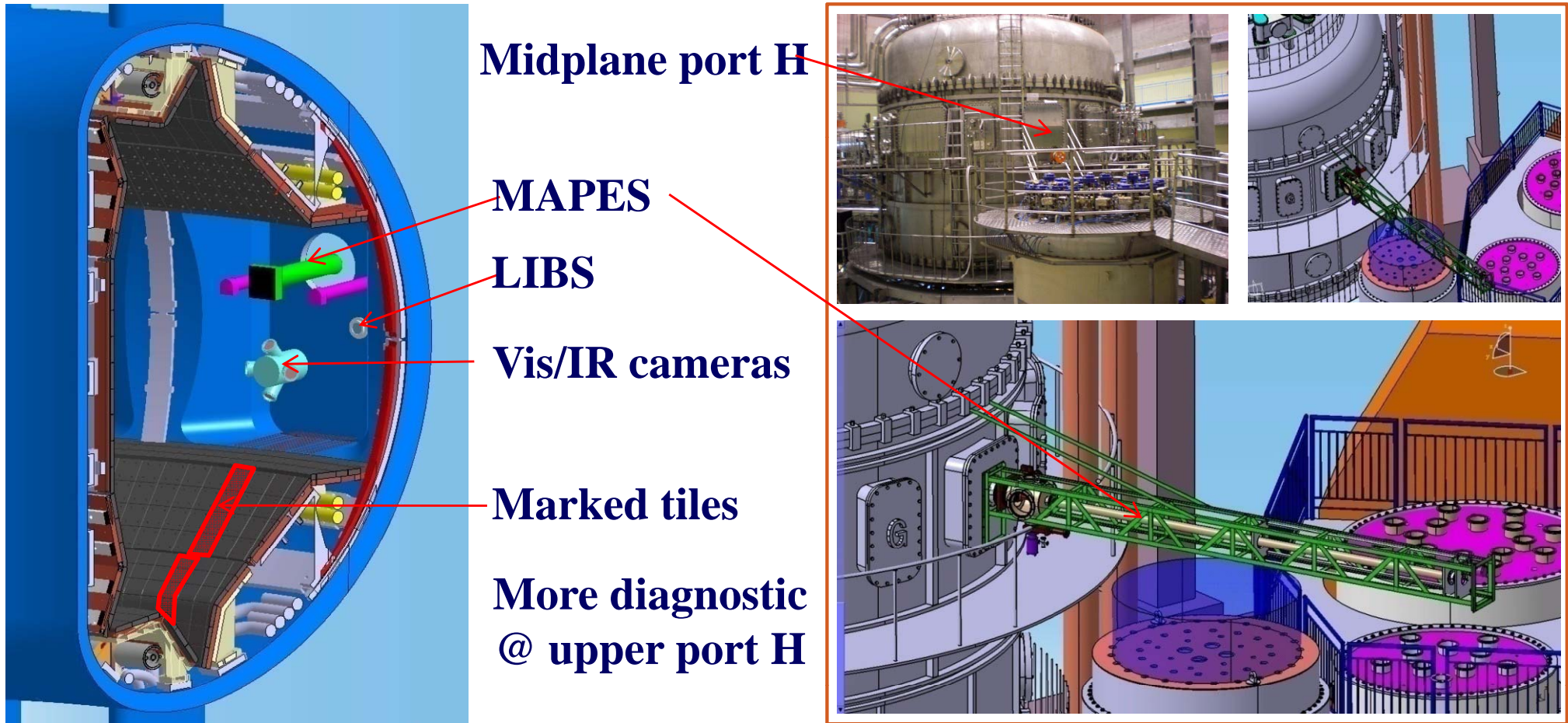


# Future testing on EAST

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- Materials and Plasma Evaluation System (MAPES) under construction on EAST for material testing and edge plasma studies
- Testing with fixed marker tiles (comprehensive platform for PWI studies)

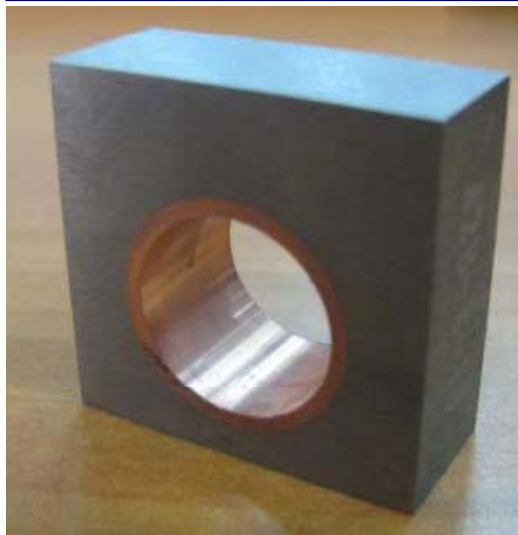




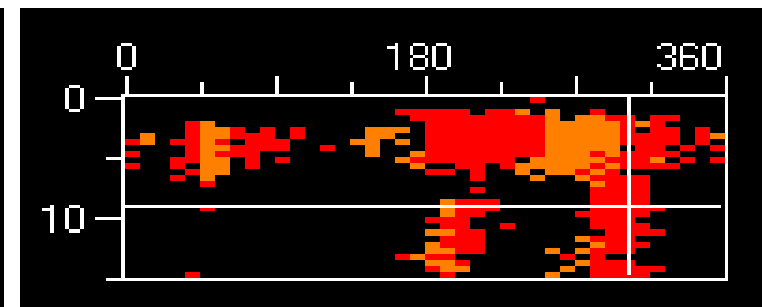
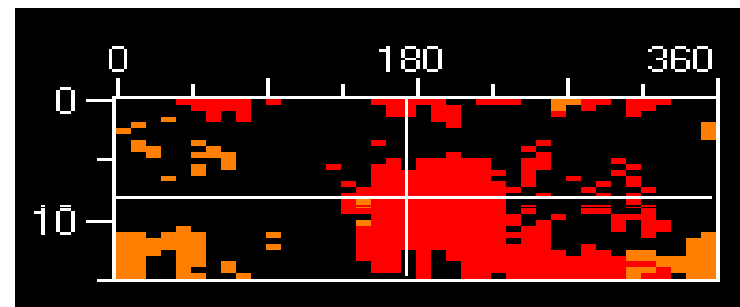
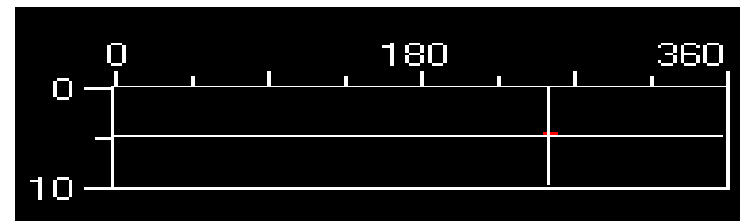
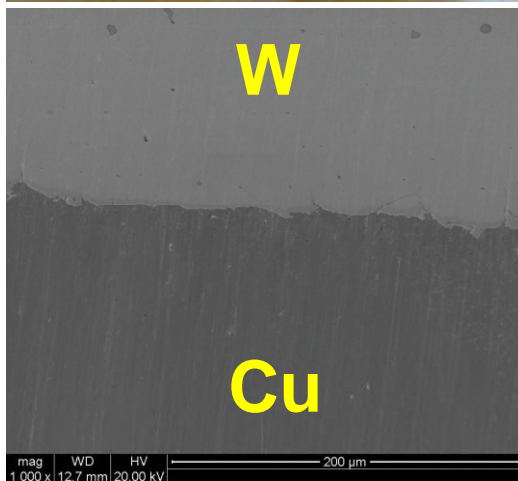
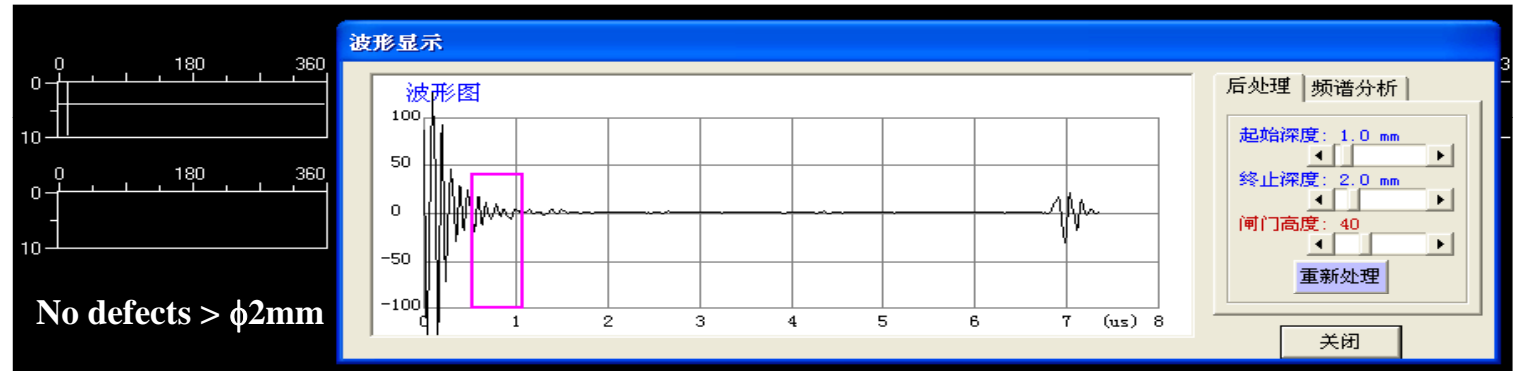
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- Recently, efforts to achieve ITER-like **Monoblock W/Cu PFC** were made in collaboration with domestic companies and universities. W/Cu monoblocks have been successfully prepared by means of HIP technology



## Spiral scanning ultrasonic NDT of W/Cu interface





- **Brazing welding R & D** of the monoblocks to the CuCrZr cooling tube is underway, and the HHF and NDT testings are under planning
- ITER-like **Flat-type W/Cu PFC** will be explored soon by means of HIP or brazing technologies

## Batch production capability

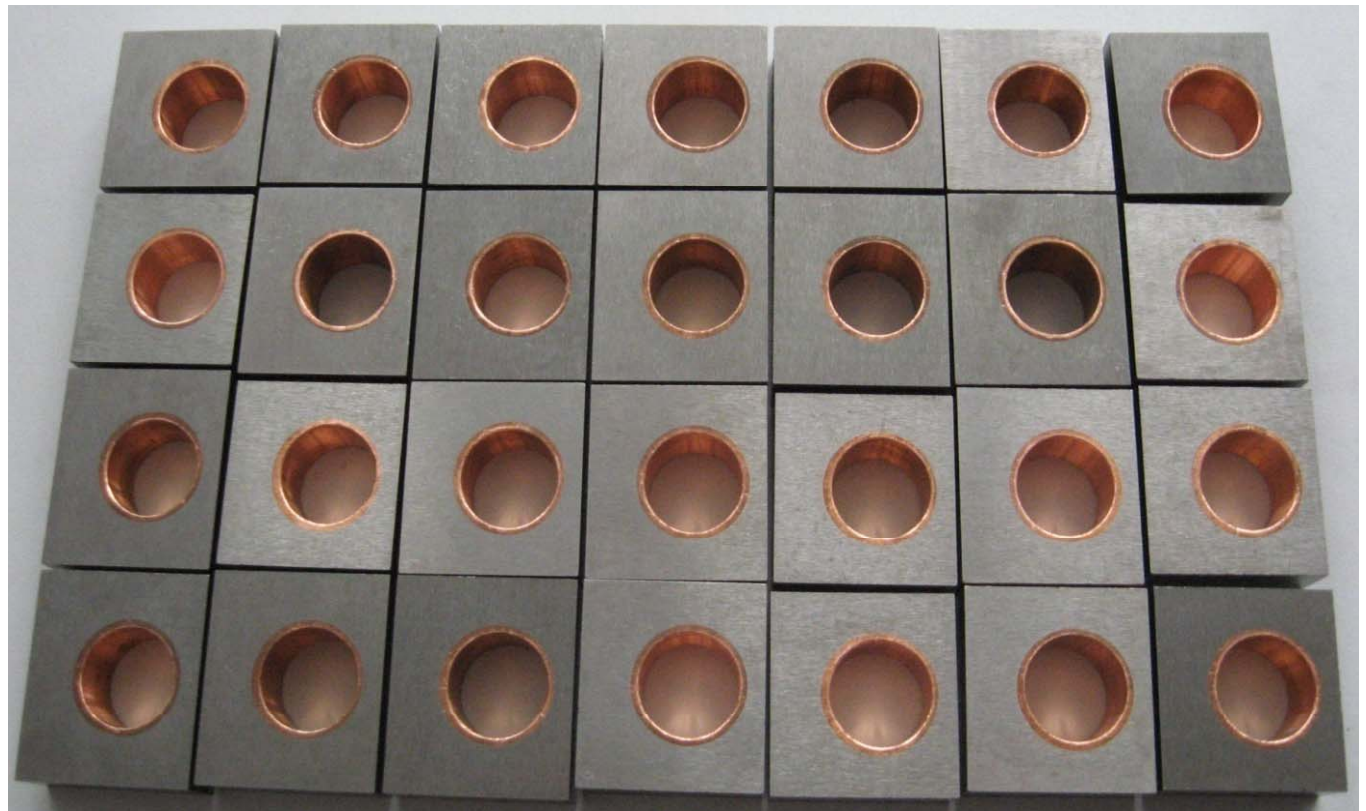


5-pieces

## Brazing Welding R & D



2-pieces





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- **To provide robust ITER-like PFC configuration and structure to withstand rapid increase in particle and power impact onto plasma-facing surfaces in EAST**
- **The EAST H-mode and attractive steady-state regimes may provide relevant plasma conditions for ITER PFC technology validation**
- **Extended plasma exposure will provide access to ITER critical issues, such as PFC lifetime (melting, cracking, etc.), tokamak operation on damaged metal surfaces, real time heat flux control, fuel retention and dust production**
- **The project could bring answers in a timely manner for ITER full W divertor for the nuclear phase**

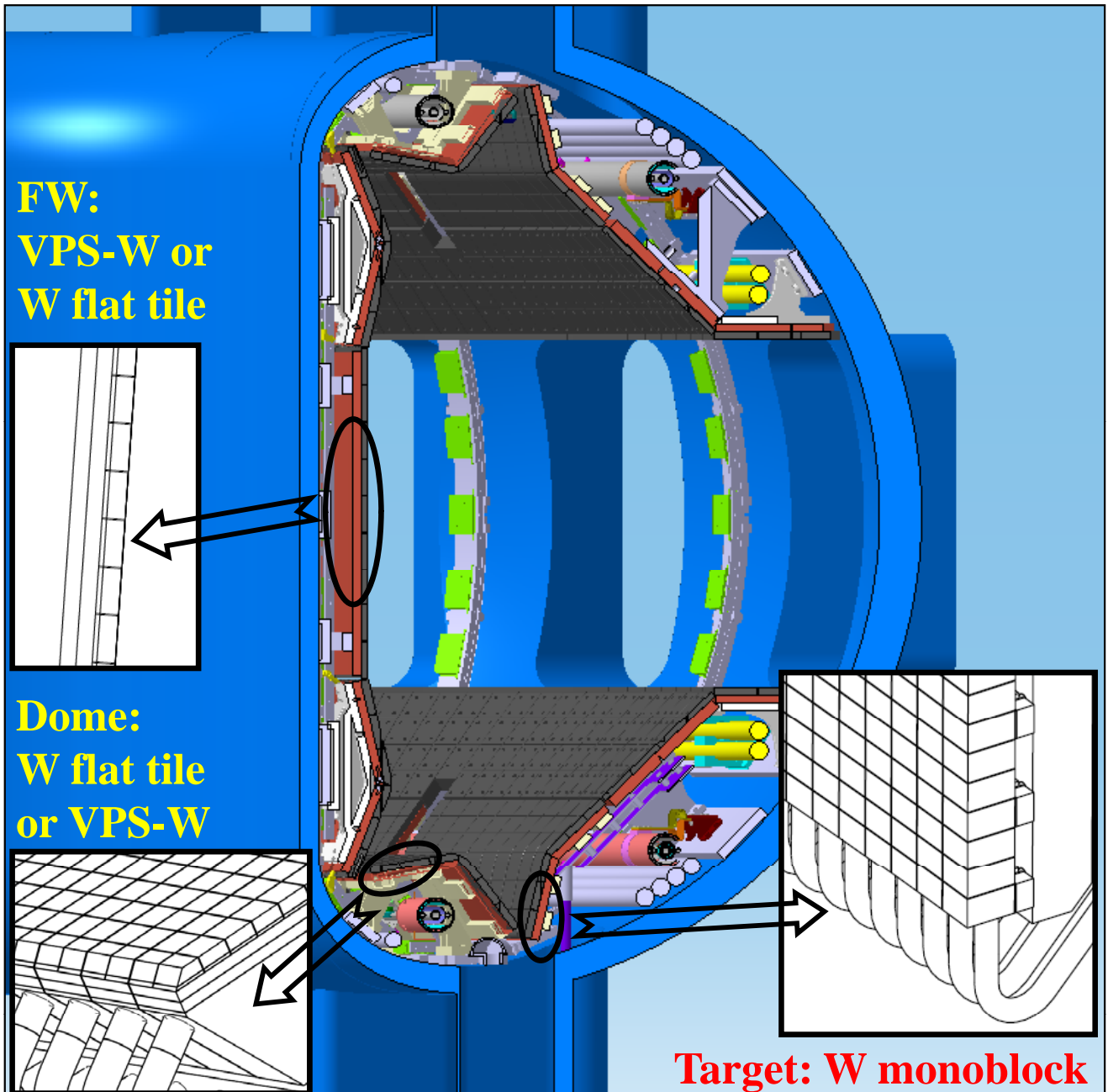


# Some details

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- **Divertor**: ITER-like configuration and structure, i.e., Monoblock targets and Flat type dome with W blocks welded to actively cooled CuCrZr heat sink (tube or plate)
- **First wall**: VPS-W coatings on actively cooled Cu alloy heat sink or the flat type PFC



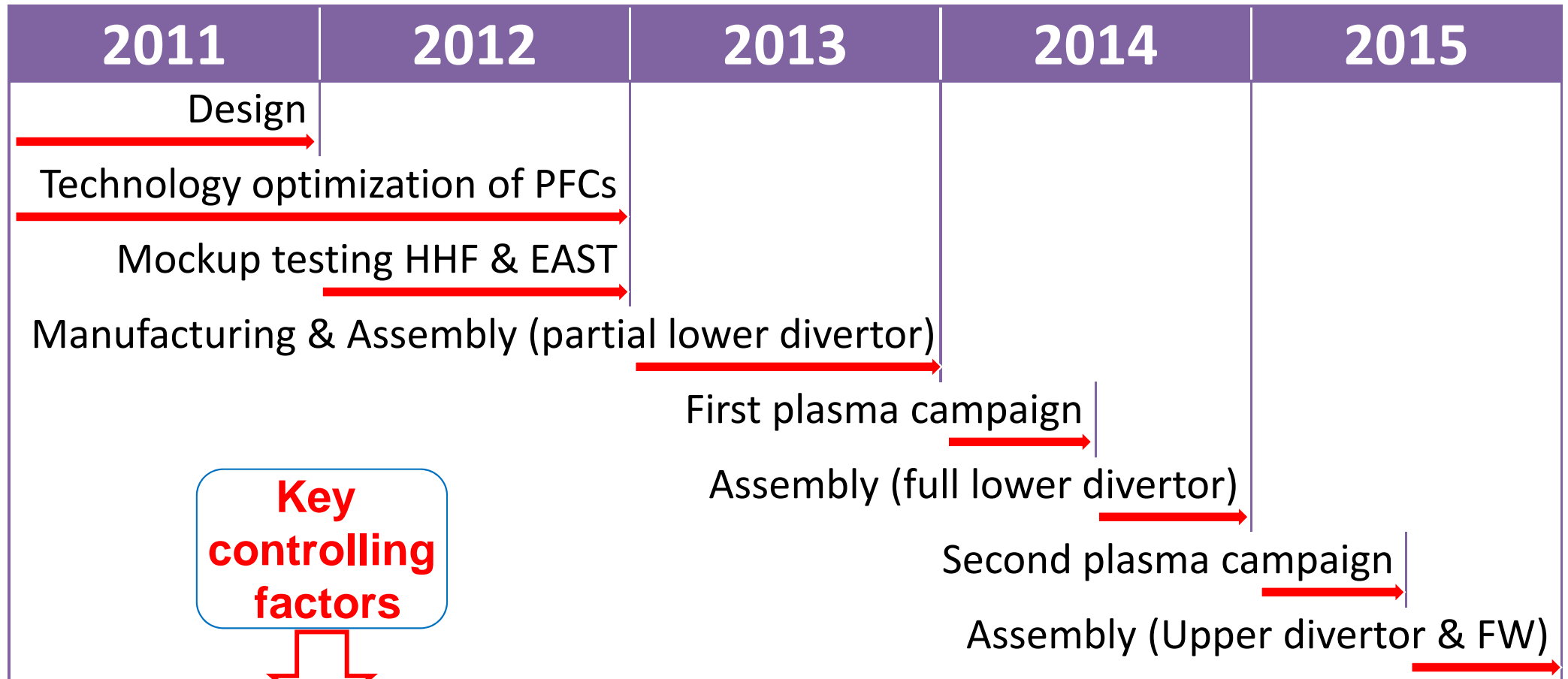




# Simplified schedule

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- **Technology optimization:** two types of W blocks welding to CuCrZr heat sink, and VPS-W coating PFC
- **Plasma optimization:** plasma heating and control, H-mode (type I ELMs) and divertor physics (particle and HHF control)



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- **W/Cu divertor plan for EAST is one of key factors to achieve its scientific missions towards steady-state high-performance plasmas, and may provide relevant plasma conditions for ITER PFC technology validation**
- **The plan aims at realizing ITER-like PFMC configuration and structure. Batch production of monoblocks has been achieved, and welding technology and flat type PFCs are under development**
- **It may take up to 5 years to achieve a full W plasma facing surfaces in EAST, depending on not only technology availability but also plasma optimization to achieve ITER relevant conditions**
- **The EAST W/Cu project may bring answers in a timely manner for ITER full W divertor for the nuclear phase**

*Welcome to collaborations  
on R & D of W-PFM/PFC  
and related PWI issues!*

*Thank you for  
your attention!*