Karlsruhe Institute of Technology

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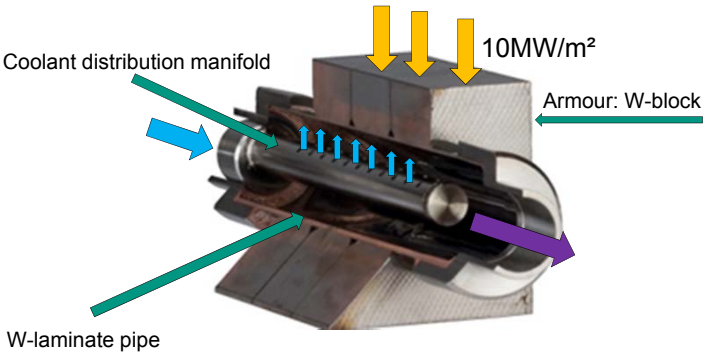
# Helium-cooled Divertor: Design and DEMO Integration Studies

Bradut-Eugen Ghidersa[1], Jens Reiser[1], Yuming Chen[1],
Joon-Soo Lim[2], Namkyu Lee[2], Hyung Hee Cho[2]

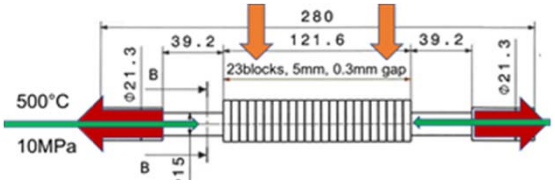
[1]Karlsruhe Institute of Technology (KIT), Institute for Neutron Physics and Reactor Technology (INR), Karlsruhe, Germany
2Heat Transfer Lab. Dep. of Mechanical Engineering, Yonsei University, Republic of Korea

## KIT Helium-Cooled Divertor

- High temperature solution: $T_{He}$ > 500°C
- Designed for 10MW/m² peak heat flux
- Uses tungsten laminates as structural material
- Simple geometry: W-blocks (armour) installed on a W-laminate pipe (similar to ITER divertor)
- Jet-impingement cooling: Helium flow is distributed through a inner manifold along the W-laminate pipe



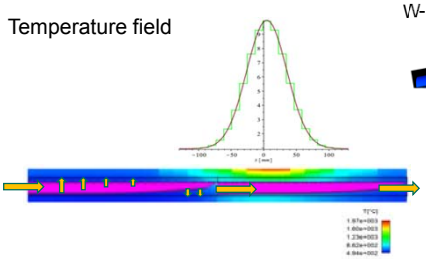

He-cooled Divertor mock-up



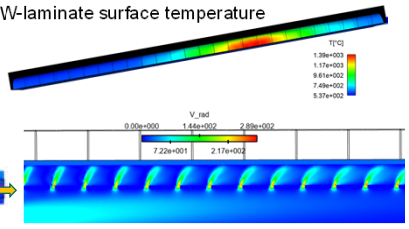

## Target integration studies

- The length of the DEMO outboard vertical target is 645mm; applying the jet cooling scheme for the full length (1 module) would require ~1kg/s per row:
  - large pressure losses
  - non-uniform jet-flow rates distribution
  - Low coolant temperature increase (~7°C)
- Most of the target length see loads around 1MW/m²
- Only near the strike point the surface heat load is large
- Use a cooling scheme with several segments in series:
  - Lower flow rate needed (~65g/s per row)
  - Better jet flow rate distribution
  - Higher coolant temperature increase (~100°C)

Temperature field



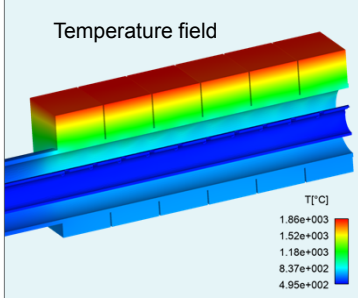
W-laminate surface temperature

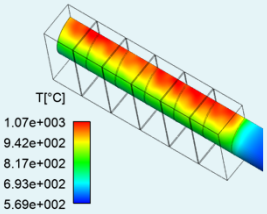


Jet velocity under the high heat flux area

## CFD Analysis of the He-cooled mock-up

Temperature field

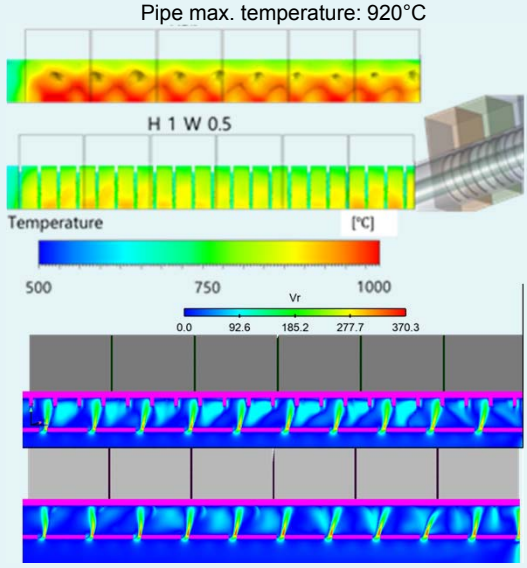



W-laminate surface temperature

Cooling performance enhancement: pipe with ribs

Pipe max. temperature: 920°C




Impingement jet pattern for the reference case (bottom) and a configuration using inner ribs (top)

## Summary and Conclusions:

- Evaluation of the thermal-hydraulic performances of the new helium-cooled divertor concept
- Proposal of a target integration concept using 5 modules in series as well as an experimental plan for the validation and qualification of the concept
- Manufacturing of 1 divertor module mock-up and evaluation of the thermal performance via CFD
  - W-laminate pipe max. temperature around 1070°C
  - It is possible to decrease further this value through heat transfer enhancement techniques, for instance , ribs on the pipe inner surface
- CFD of 2 modules in series with concentrated heat flux
  - Higher temperature values in the solid parts (pipe) than for the mock-up
  - Jet tilting (~60°) could account for 20% HTC reduction
  - Further optimization for a better flow distribution and reduced jet tilting is needed
- Experiments planned for 2018 will look into evaluating experimentally the new concept performance and validate the numerical models



EUROfusion

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