



Development of a thermal-hydraulic model for the dynamic simulation of the EU DEMO breeding blanket cooling loops. Part I: HCPB

A. Froio¹, C. Bachmann², F. A. Hernandez Gonzalez³, G. Federici², L. Savoldi¹, R. Zanino¹

¹NEMO Group, Dipartimento Energia, Politecnico di Torino, Torino, Italy

²EUROfusion Consortium, PPPT Department, Garching, Germany

³Karlsruhe Institute of Technology, Karlsruhe, Germany

AIM OF THE WORK

Development of a global thermal-hydraulic model of the **EU DEMO tokamak**

composed of several modules

1st module

Breeding blanket cooling loops

4 different BB concepts:

DCLL
WCLL
HCLL

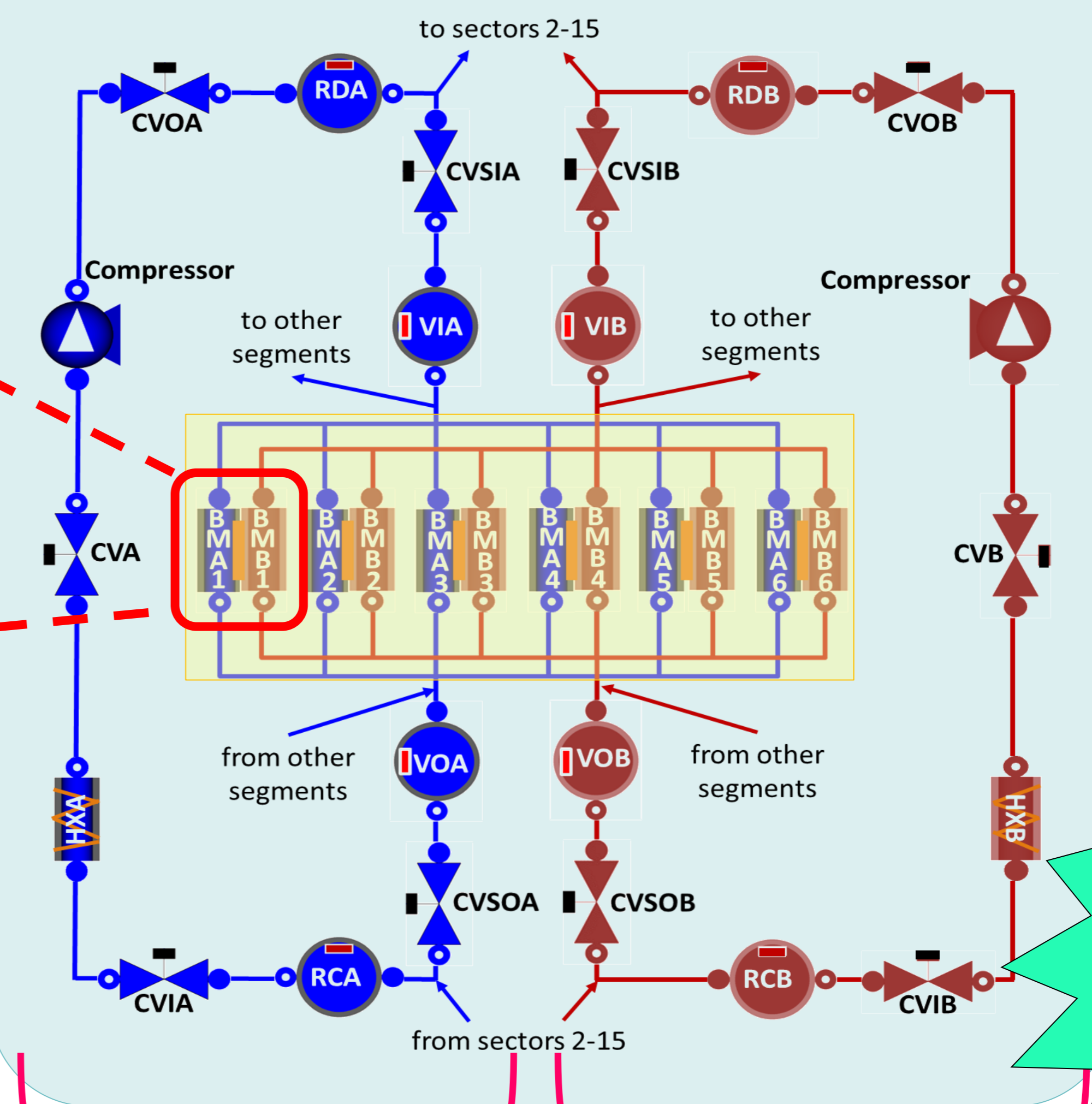
HCPB

2014 Design

- 16 sectors
- 3 OB + 2 IB segments per sector
- 6 BMs per segment

Model written in Modelica language → modular, object oriented

HCPB cooling system



2 independent circuits

1D finite volume fluid flow in each cooling channel

$$A \cdot l \cdot \frac{d\rho}{dt} = \dot{m}_{in} - \dot{m}_{out}$$

$$\frac{l}{A} \frac{\partial \dot{m}}{\partial t} = p_{out} - p_{in} + \Delta p_{friction}$$

$$A \cdot l \cdot \rho \cdot c_v \cdot \frac{\partial T}{\partial t} + \dot{m} \Delta h = \dot{Q}_{in}$$

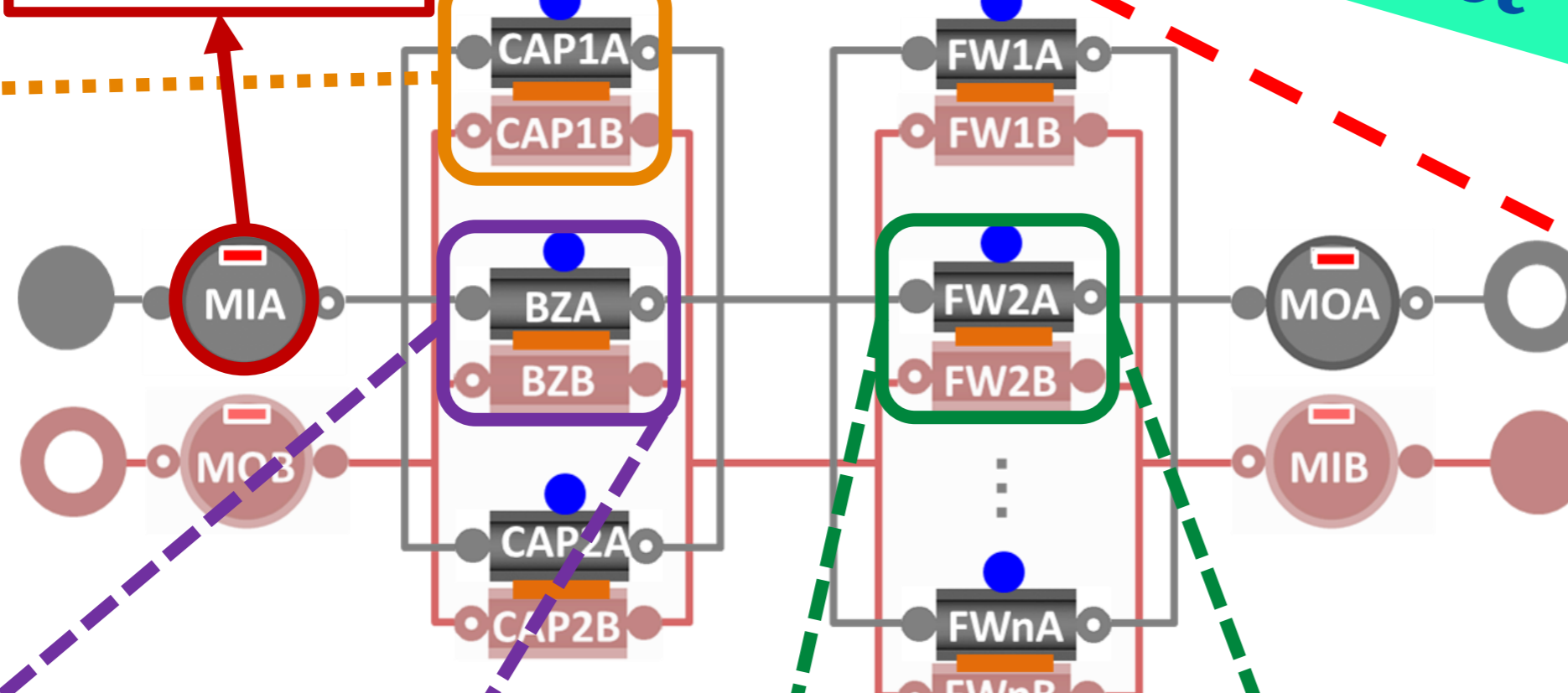
MODEL

Parameters

- Geometrical data
- # of FW channels
- # of CPs in BZ
- # of cooling channels in CPs and caps
- Coolant and material properties
- Correlations for Nu and f

Manifolds

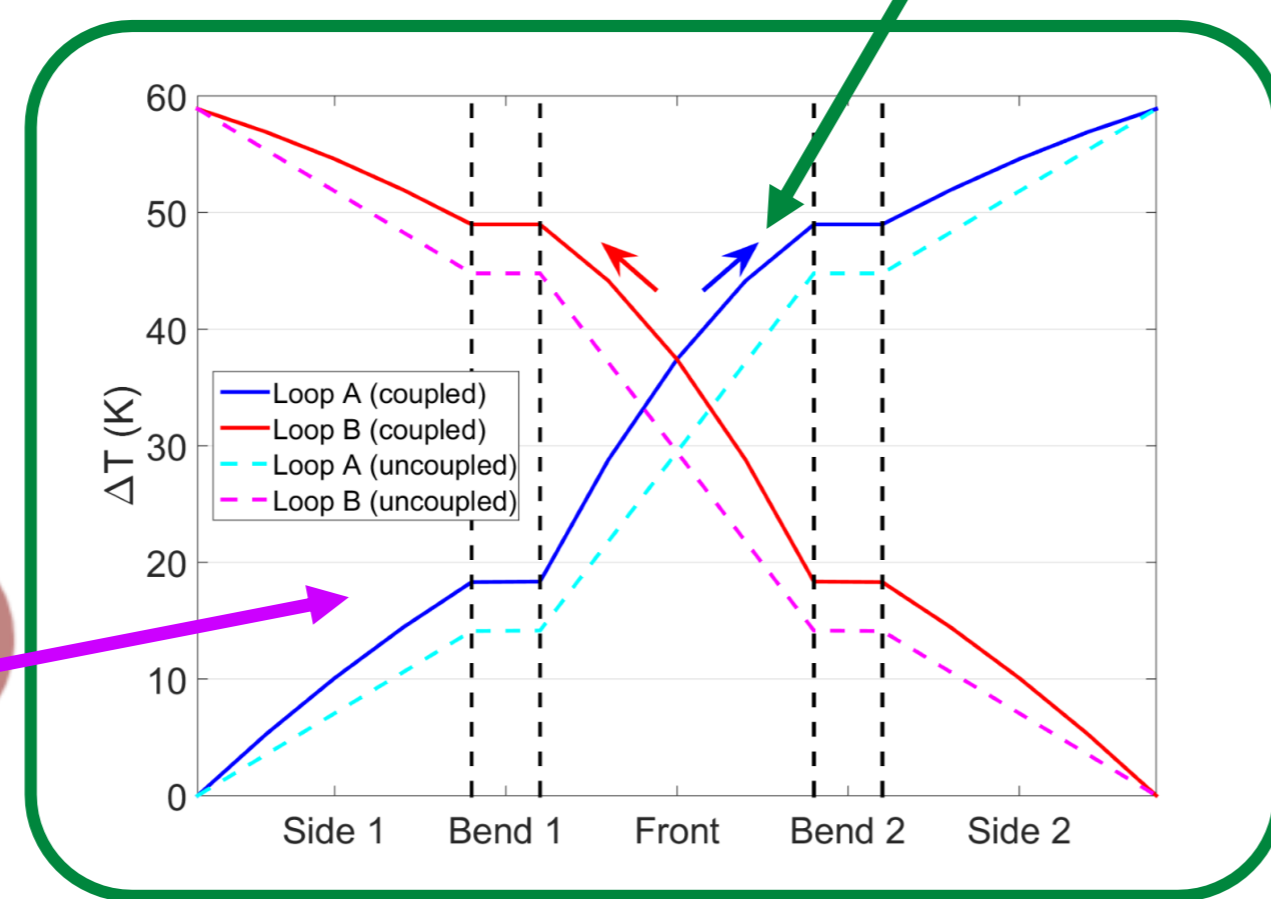
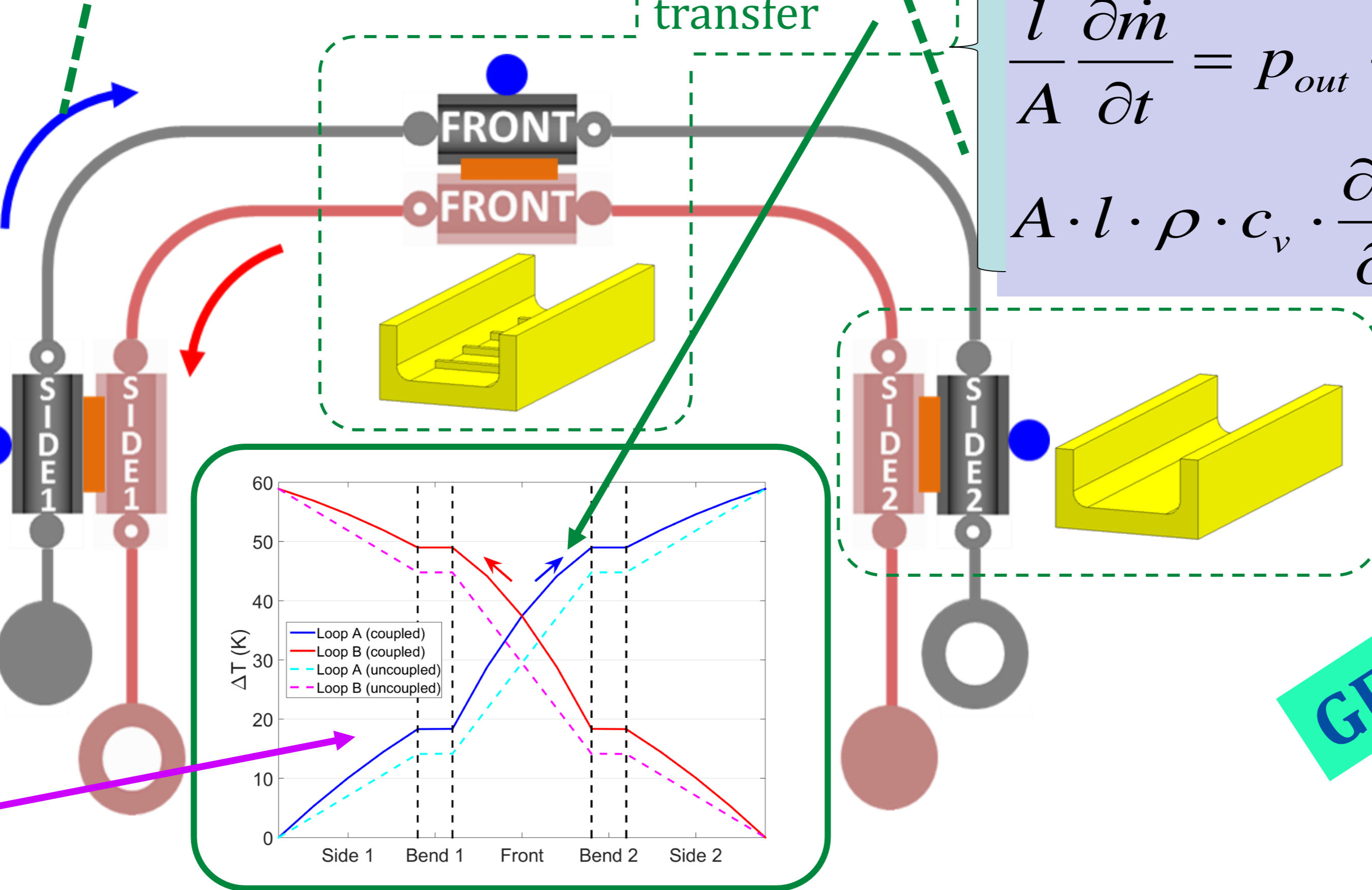
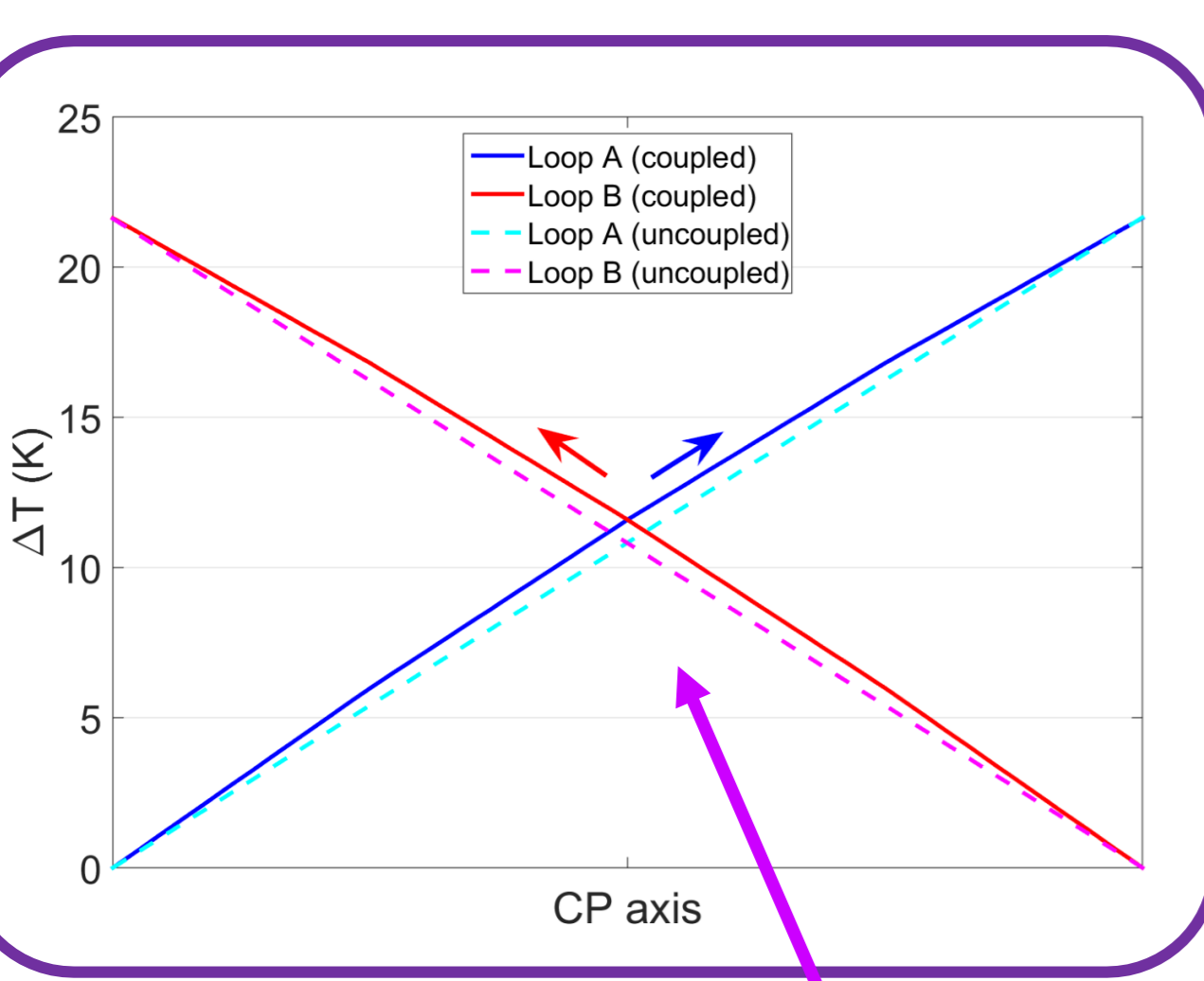
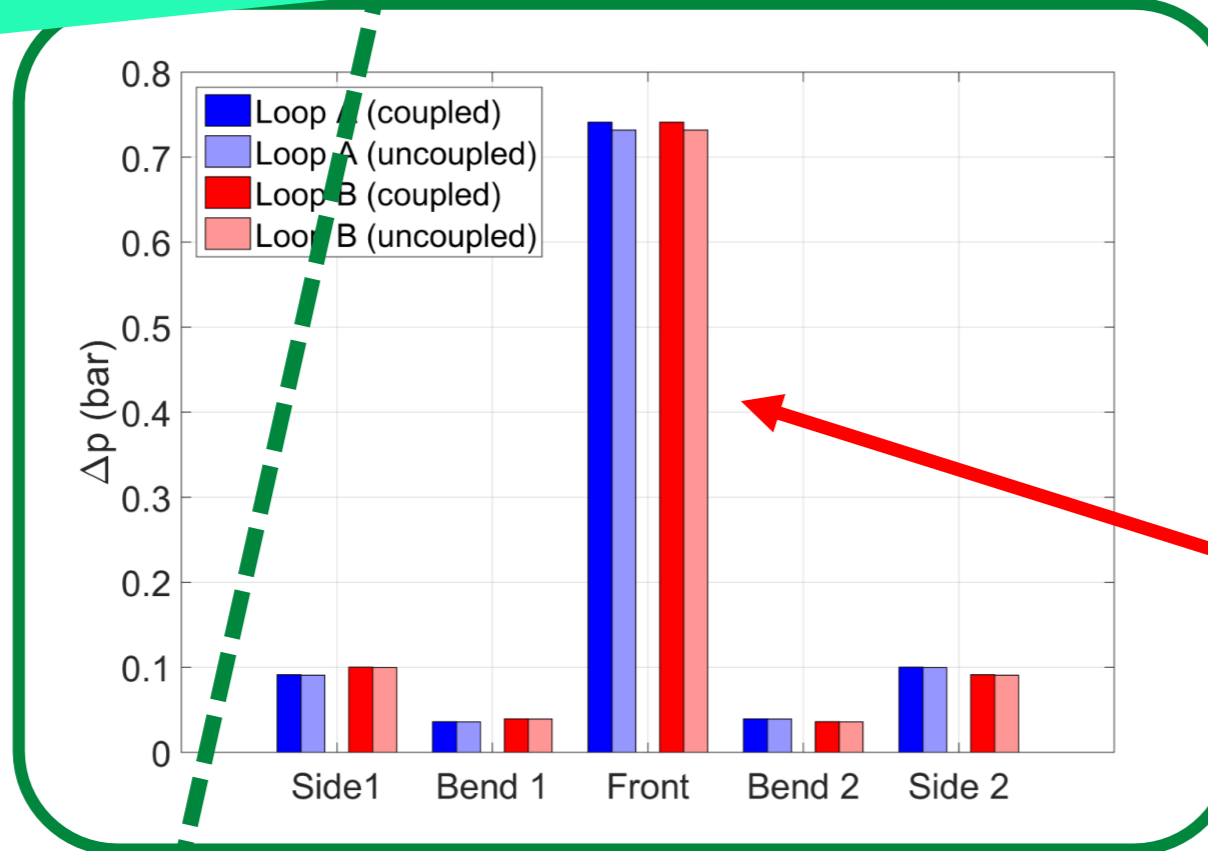
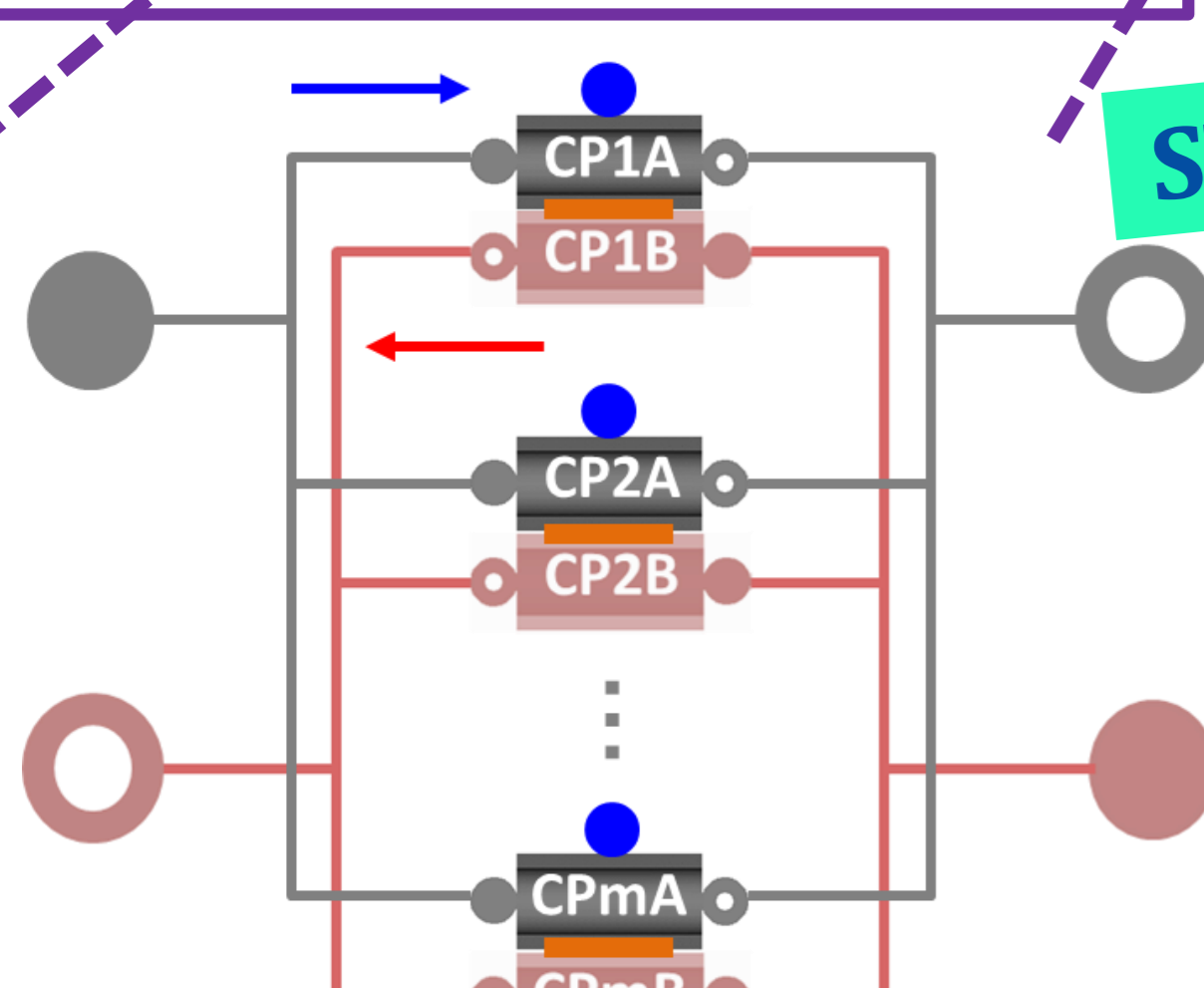
BM model object



n first wall channels

STEADY-STATE TEST CASES

Breeding zone with m cooling plates (+ 2 caps)



GEOMETRY

Component	Parameter	Value
FW channel	Length (side)	649.6 mm
	Length (front)	1120.5 mm
	Cross section	13.5×13.5 mm ²
	Bending angle	93.75°
	Wall thickness (side)	2.625 mm
	Wall thickness (front)	5.375 mm
Cooling plates	Length	1431 mm
	Cross section	5×2.5 mm ²
	Wall thickness	1 mm
BM cap	Length	1431 mm
	Cross section	13.5×6 mm ²
	Wall thickness	1 mm
Manifolds	Length	2270 mm
	Cross section (inlet)	413×274 mm ²
	Cross section (outlet)	∅200 mm

CONCLUSIONS

- Transient model of the EU DEMO HCPB BB cooling loops developed using an object-oriented modular approach
- Checked against simple steady-state cases
- Can be used to test alternative cooling concepts or loop configurations

Component	Load	Value
FW	FW surface load	300 kW/m ²
	Nuclear + Breeder unit loads	976.5 kW
BZ + caps	Nuclear + Breeder unit loads	4,7288 MW

UNIFORM HEAT LOADS

