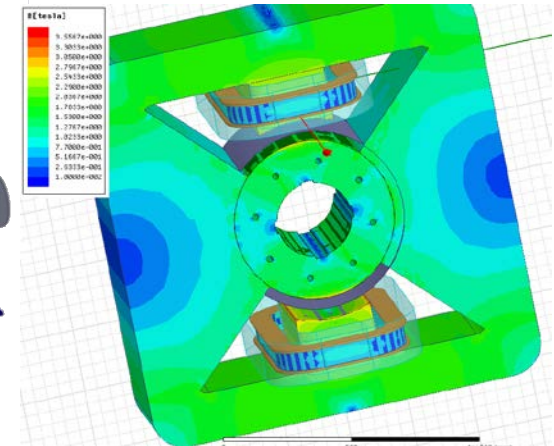
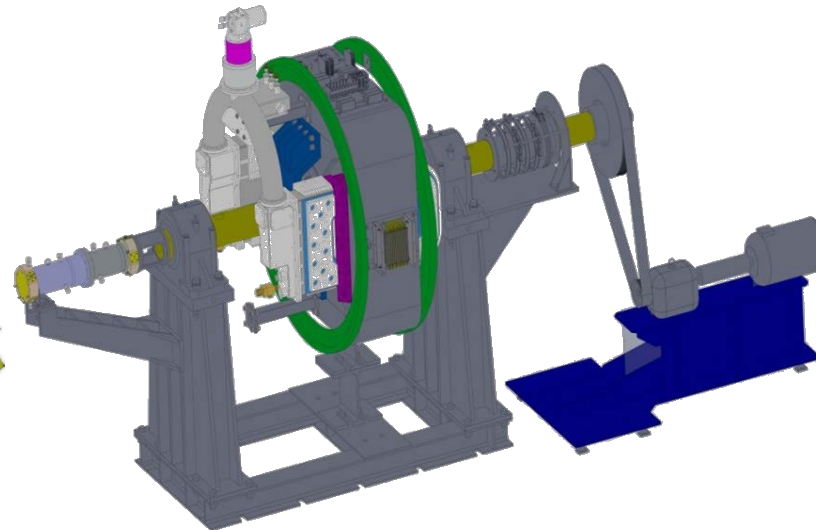
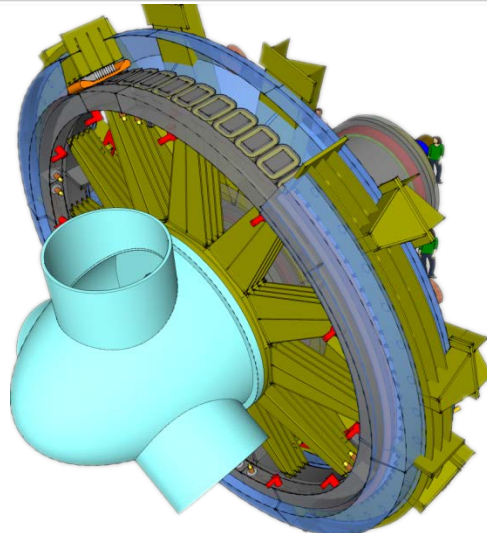
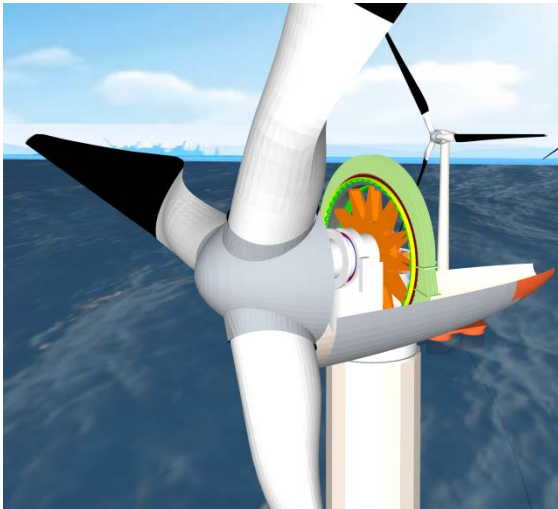


Design and Construction of the Cryogenic Cooling System for the Rotating Magnetic Validator of the 10 MW SUPRAPOWER Offshore Superconducting Wind Turbine

Jiuce Sun, Holger Neumann, Santiago Sanz, Gustavo Sarmiento, Matteo Tropeano, Iker Marino and Ainhoa Pujana
25th International Conference on Magnet Technology, Amsterdam, Nederland

INSTITUTE FOR TECHNICAL PHYSICS (ITEP) | CRYOGENICS



Outline

- 1. Overview of the SUPRAPOWER
 - Suprapower project
 - Cryogenic system layout
 - Rotating magnetic validator (RMV)

- 2. Cryogenic design for RMV
 - MgB₂ coil architecture
 - Cryostat system
 - Rotating cryocooler system

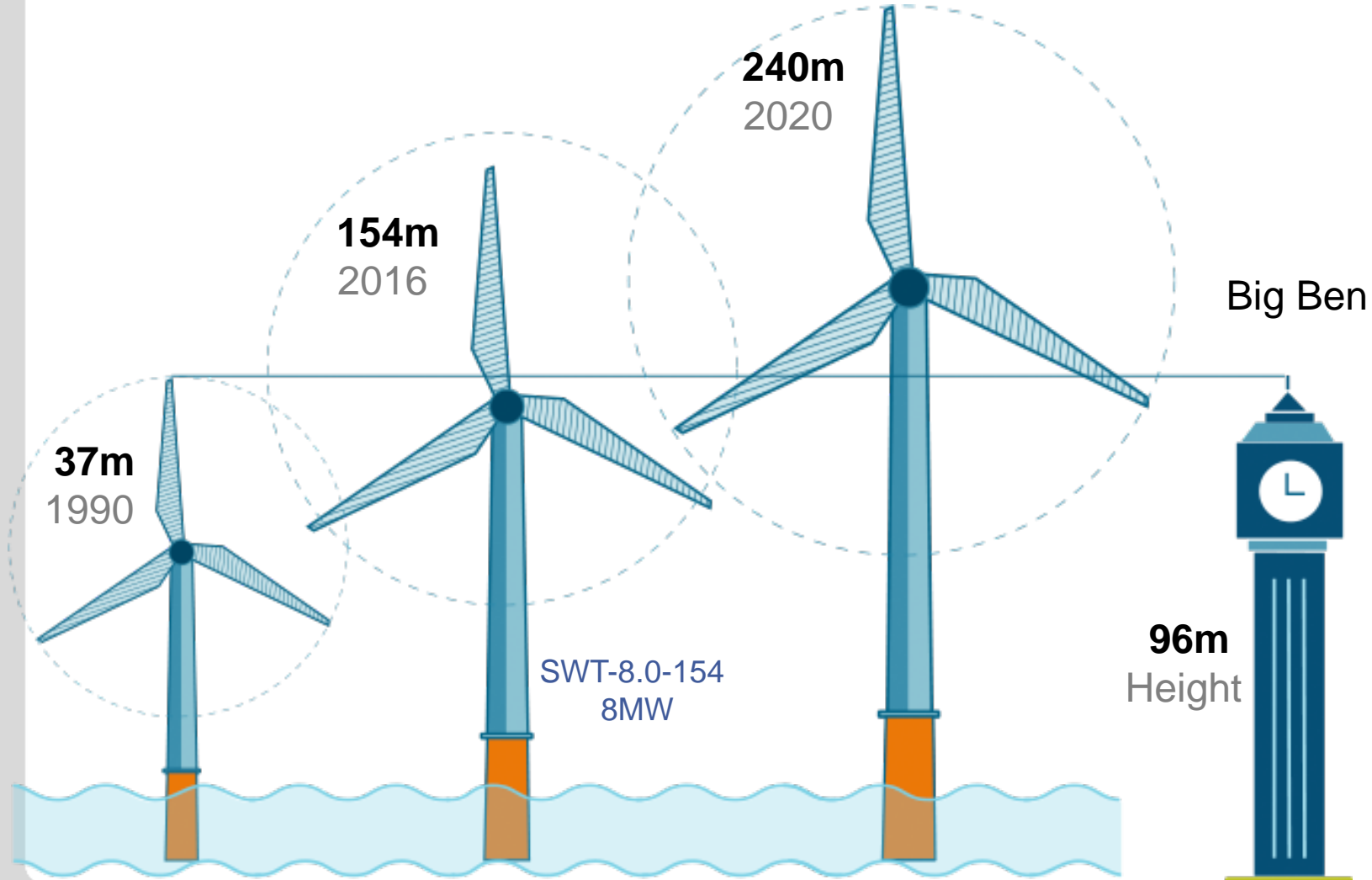
- 3. Construction and assembly
 - Manufacturing
 - Assembly

- 4. Summary and outlook



Why superconductivity meets wind energy?

■ Offshore wind turbine is getting larger and larger



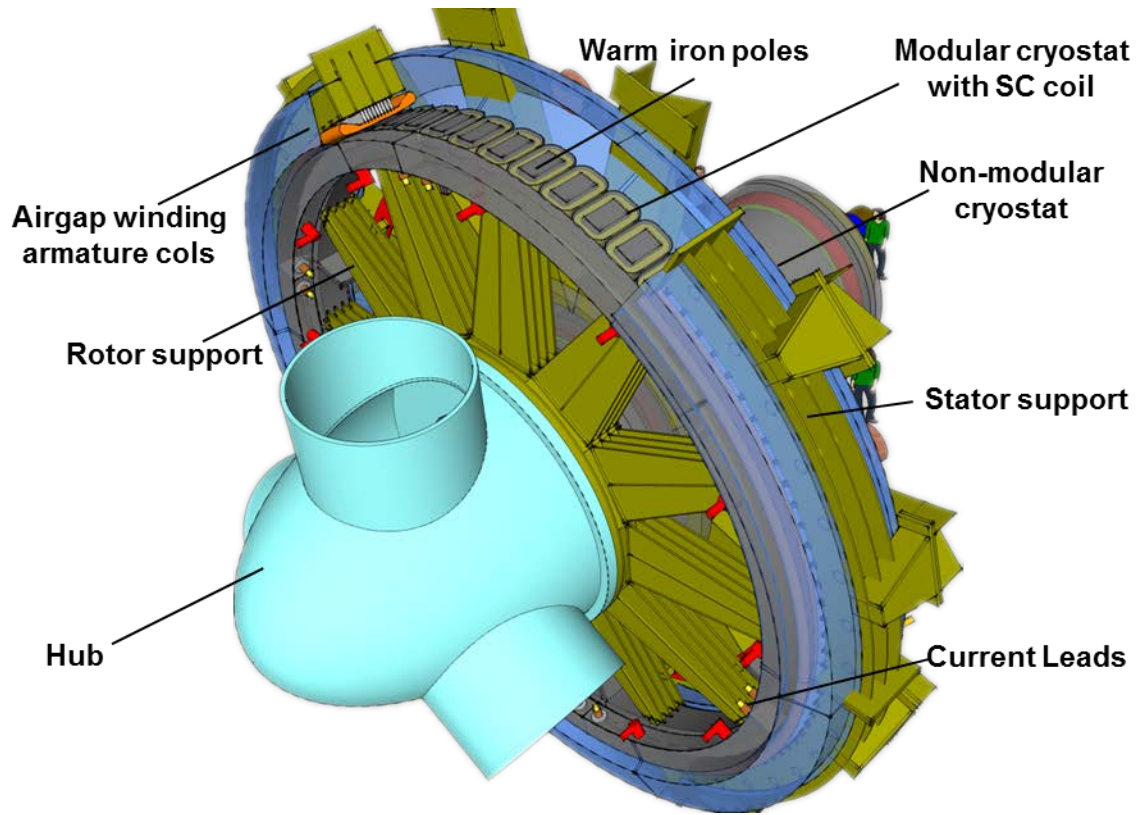
Adwen AD-180, 8MW, 180m Rotor



MHI Vestas V164, 9MW, 164m Rotor

SUPRAPOWER – 10 MW Superconducting offshore wind turbine

■ **Superconductivity** maybe the feasible technology to scale up offshore wind turbine to 10 MW+ due to high magnetic field and low loss



d2m Engineering
KNOWLEDGE, INNOVATION, SERVICE

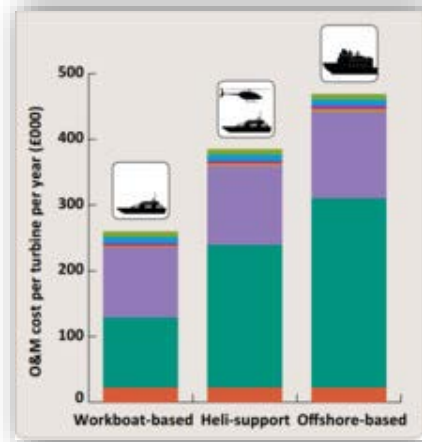


Characteristics of offshore wind turbine

■ Harsh Environment and Very Limited Time Window

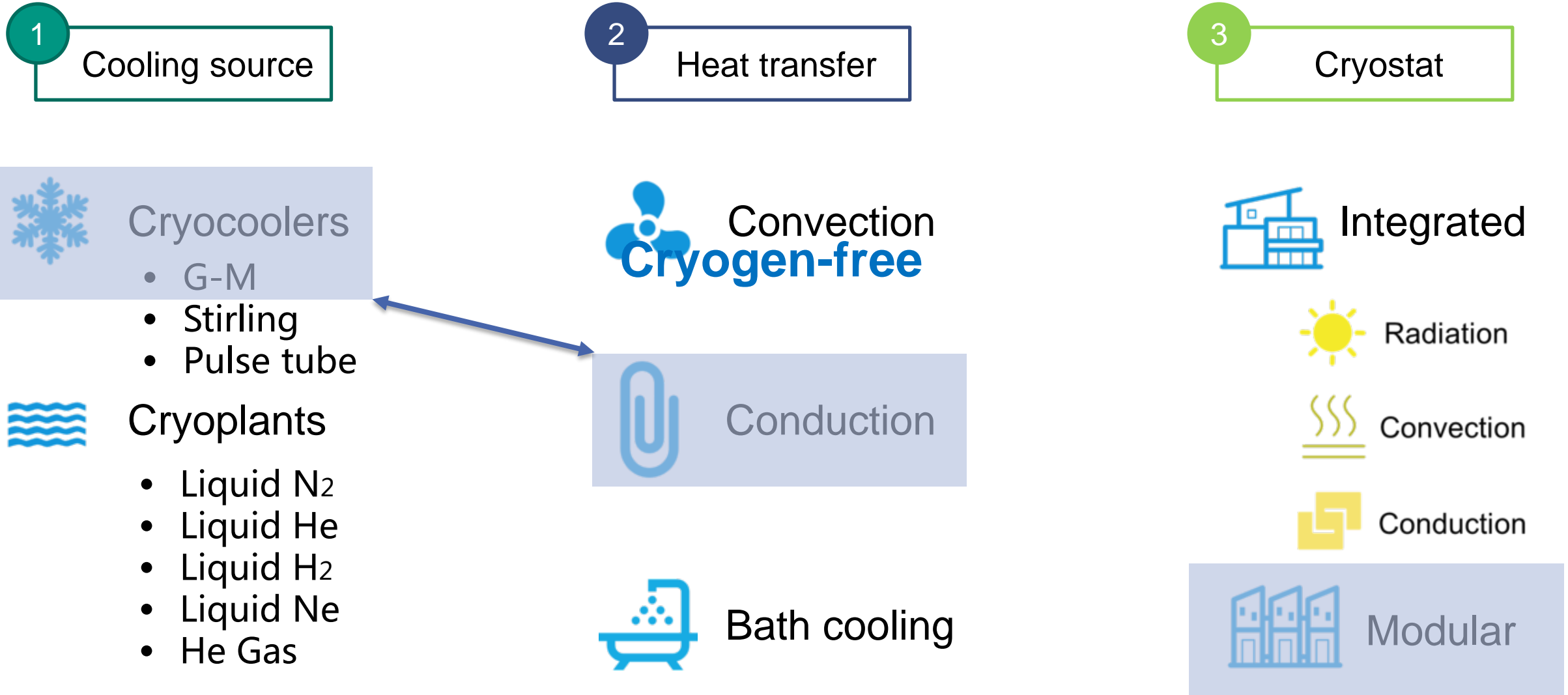


■ Costly Access of Installation and Maintenance



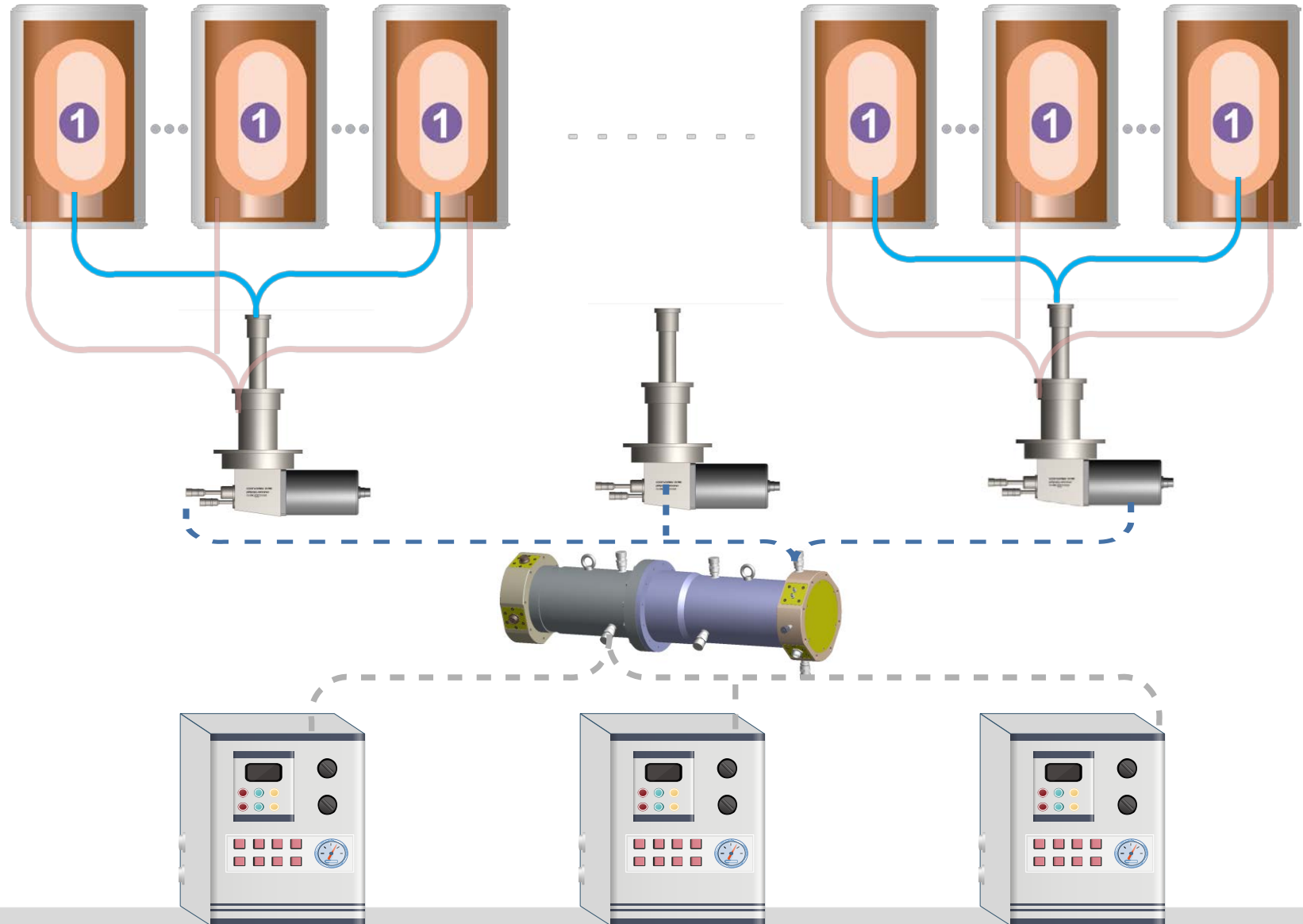
“Invisible or at least plug in and play” Cryogenic system with simple structure, high availability and reliability is dramatically required

What we choose for SUPRAPOWER Cryogenic cooling



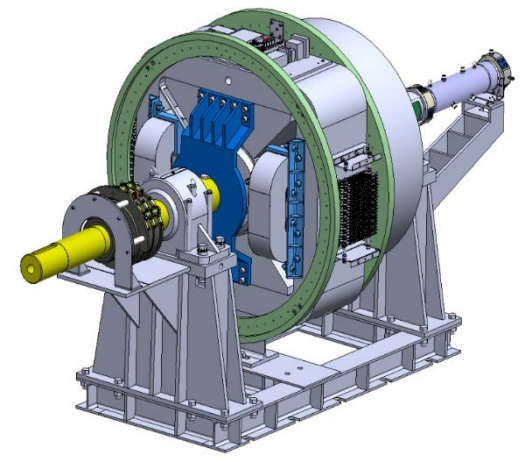
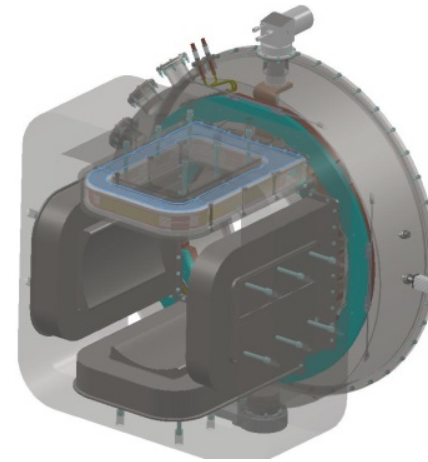
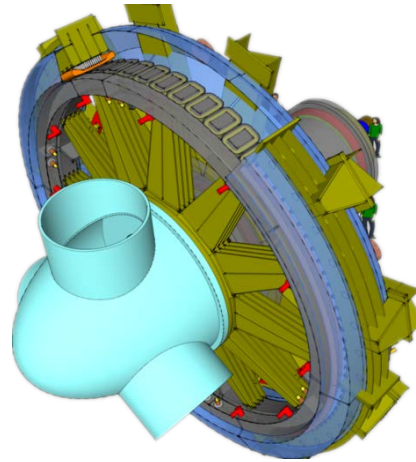
SUPRAPOWER Cryogenic Layout

- 1** Modular Cryostat
- 2** Distributing cryostat
- 3** Cold head
- 4** Rotary joint
- 5** Compressor



Rotating magnetic validator (RMV)

- Two poles
- No armature winding
- Identical air-gap
- Identical cryostat



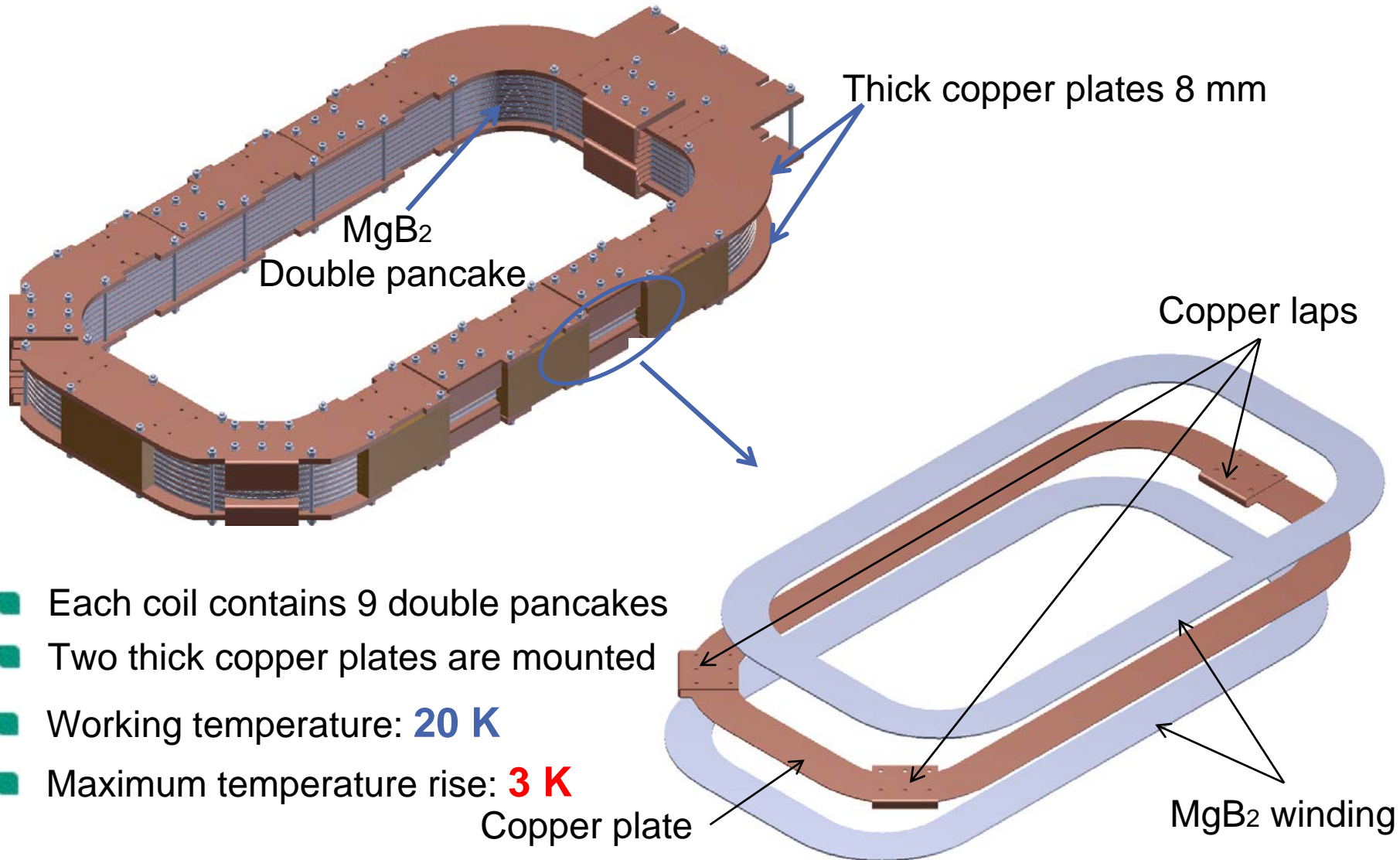
Parameter	10 MW generator	Scale generator	RMV
Power	10 MW	550 kW	-
Speed	8.1 rpm	121.5 rpm	30 rpm
Torque	11.8 MN·m	43.2 kN·m	-
Number of poles	48	4	2
Rotor winding	MgB2	MgB2	MgB2
Induction peak value in airgap	1.5 T	1.5 T	1.5 T
Operating temperature	20 K	20 K	20 K

Outline

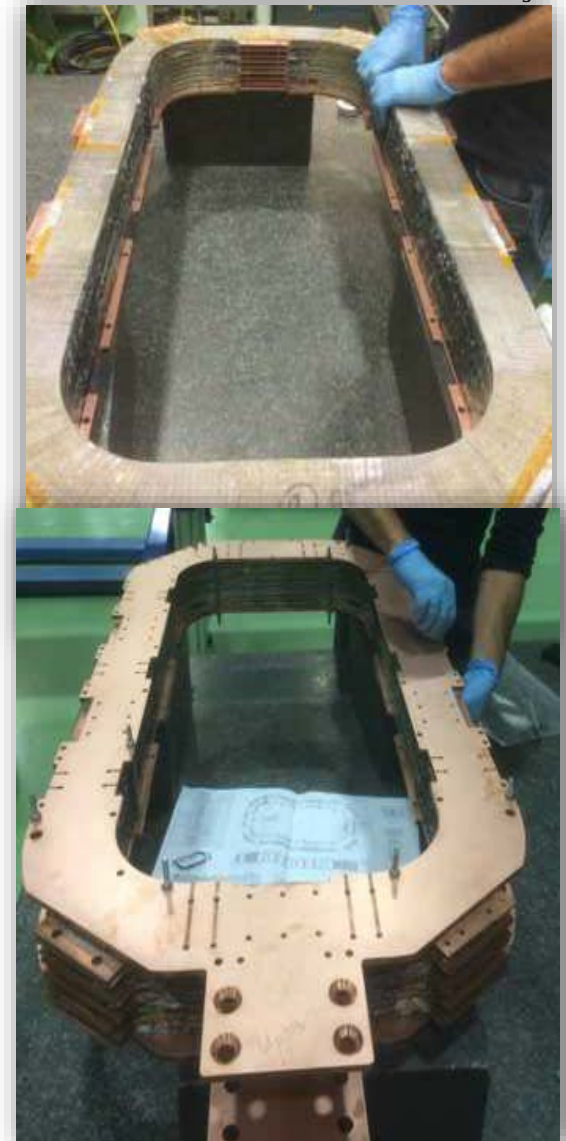
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 - **Cryostat system**
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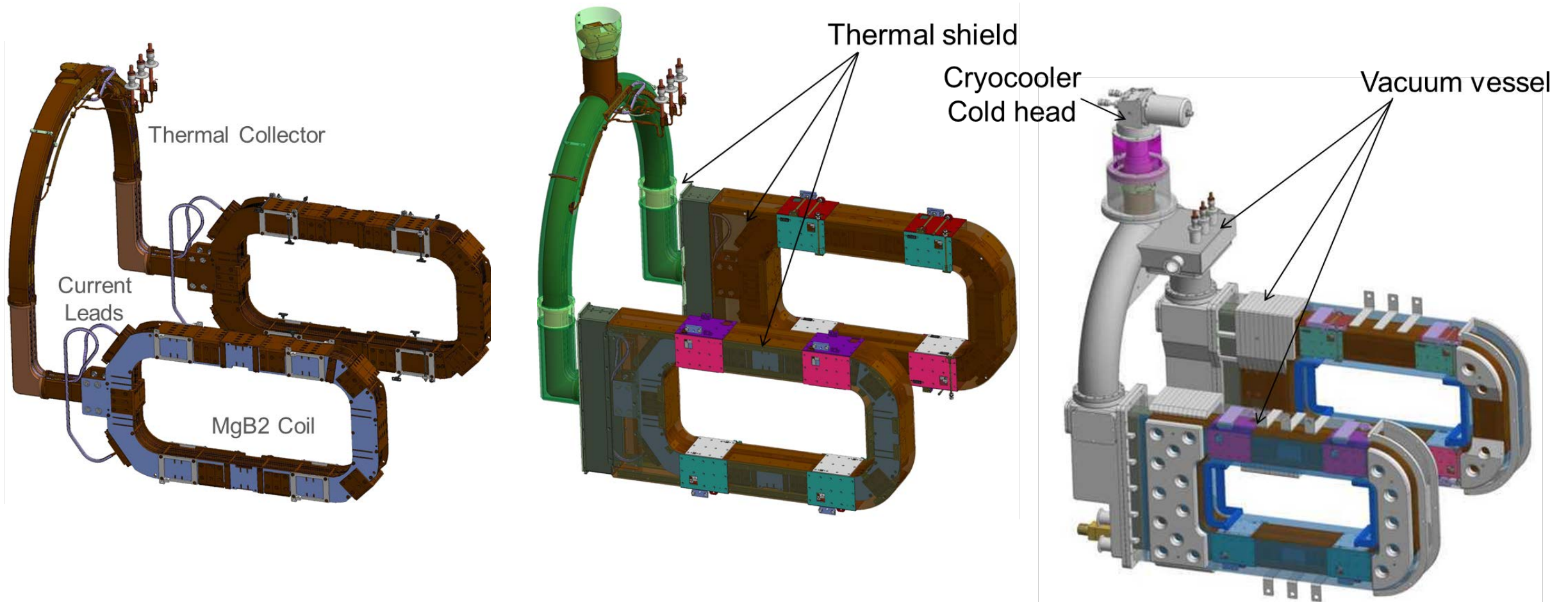
Race-track SC coil for conduction cooling



- Each coil contains 9 double pancakes
- Two thick copper plates are mounted
- Working temperature: **20 K**
- Maximum temperature rise: **3 K**



Cryostat system for RMV



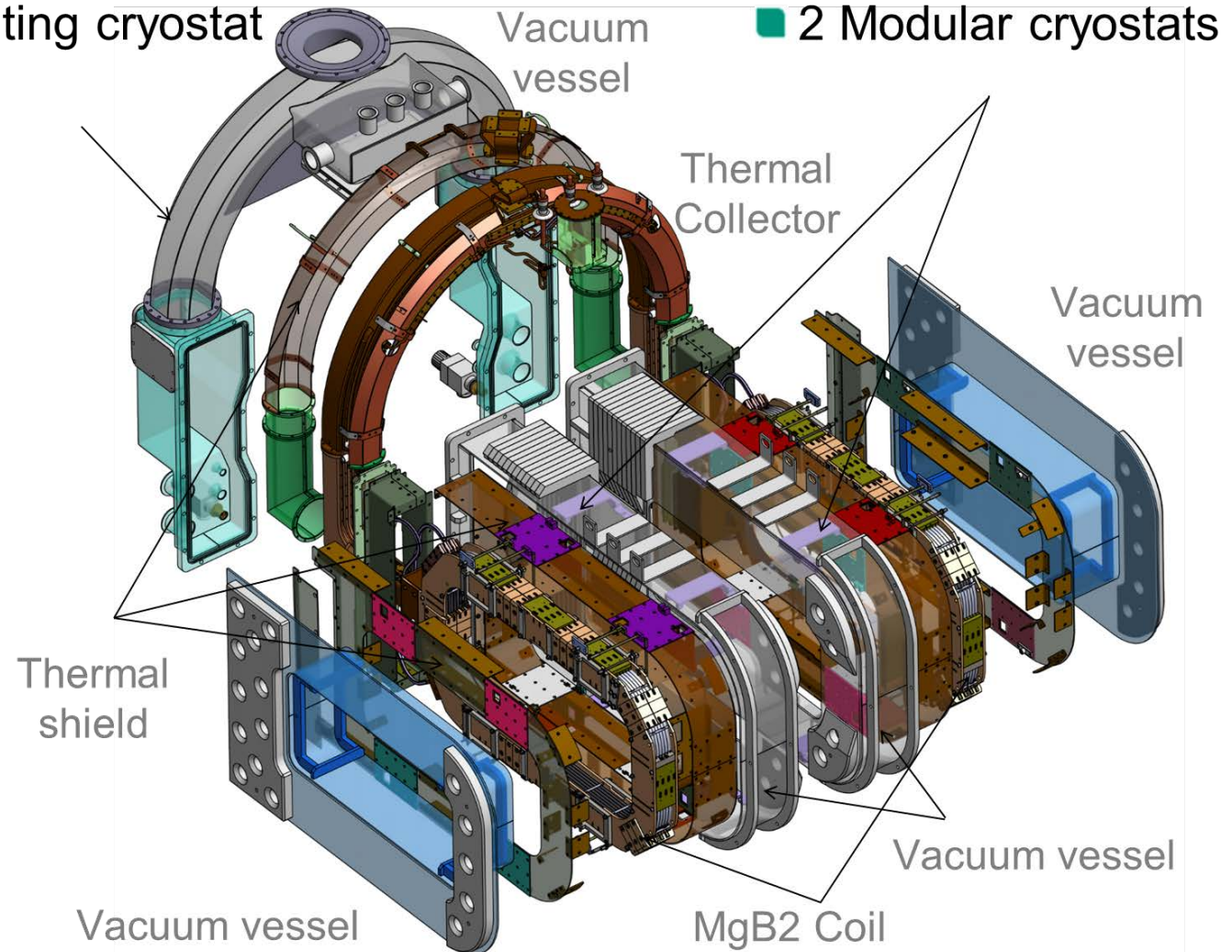
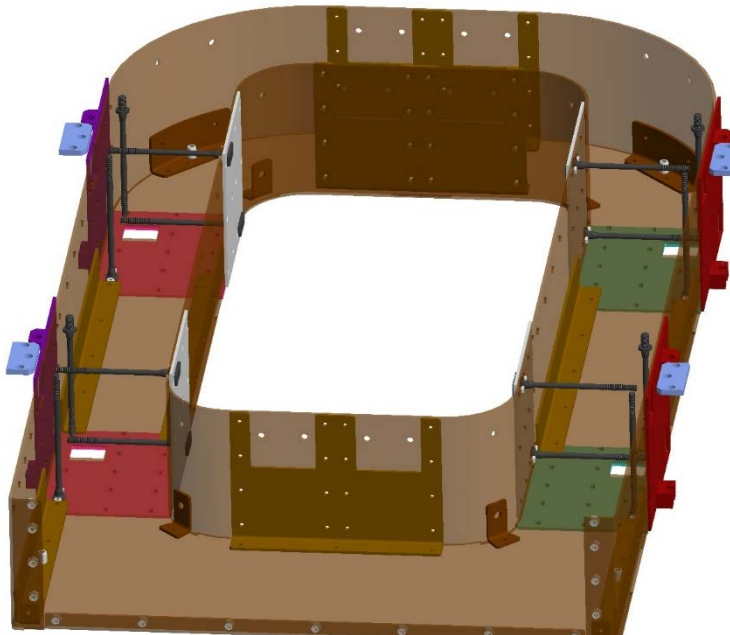
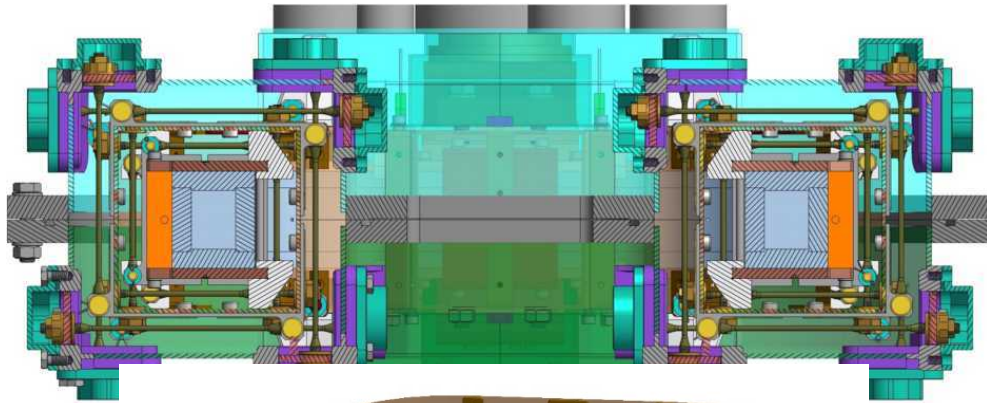
- Multi-layer-insulation (MLI) will be applied on the outer surface of the thermal shield
- Vacuum vessel made of SS304 will envelop the superconducting coil and shield

Explosive view of the cryostat for the RMV

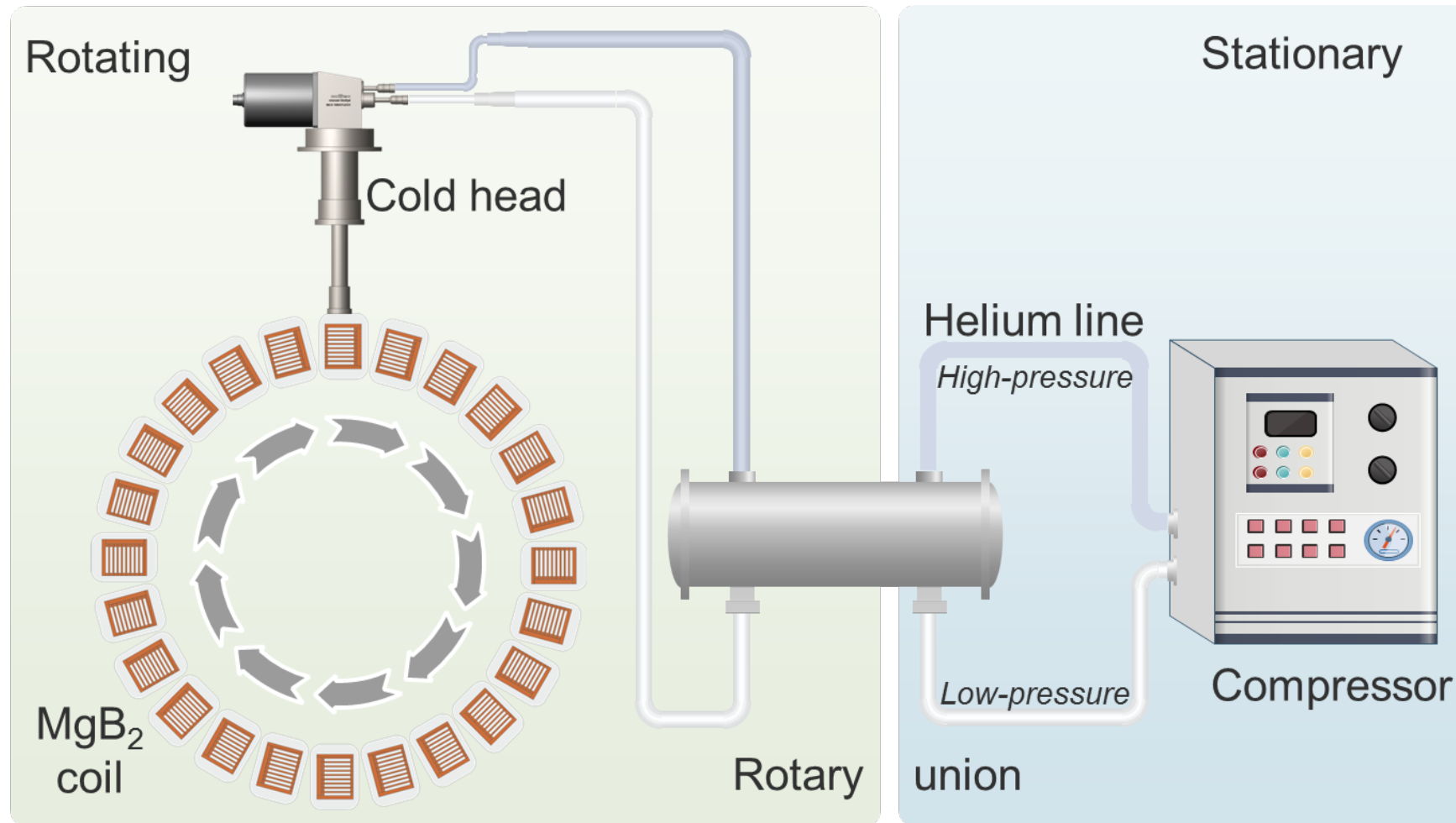
■ Supporting

■ 1 Distributing cryostat

■ 2 Modular cryostats

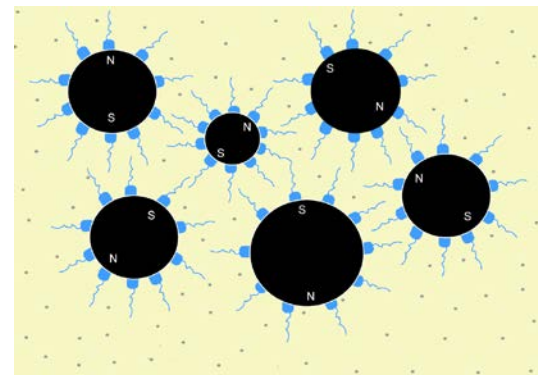
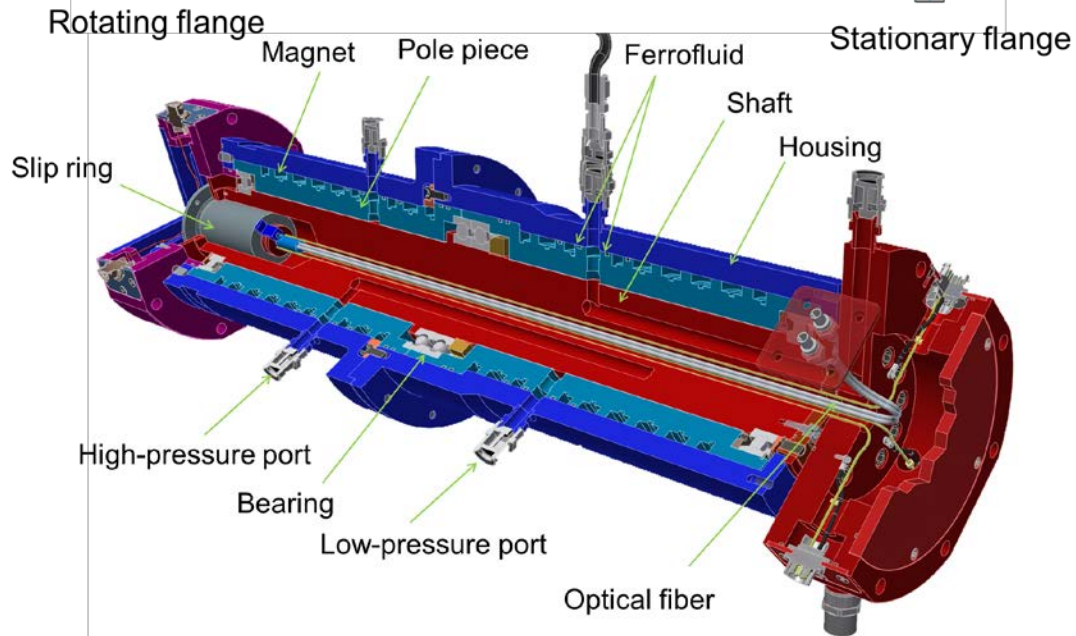
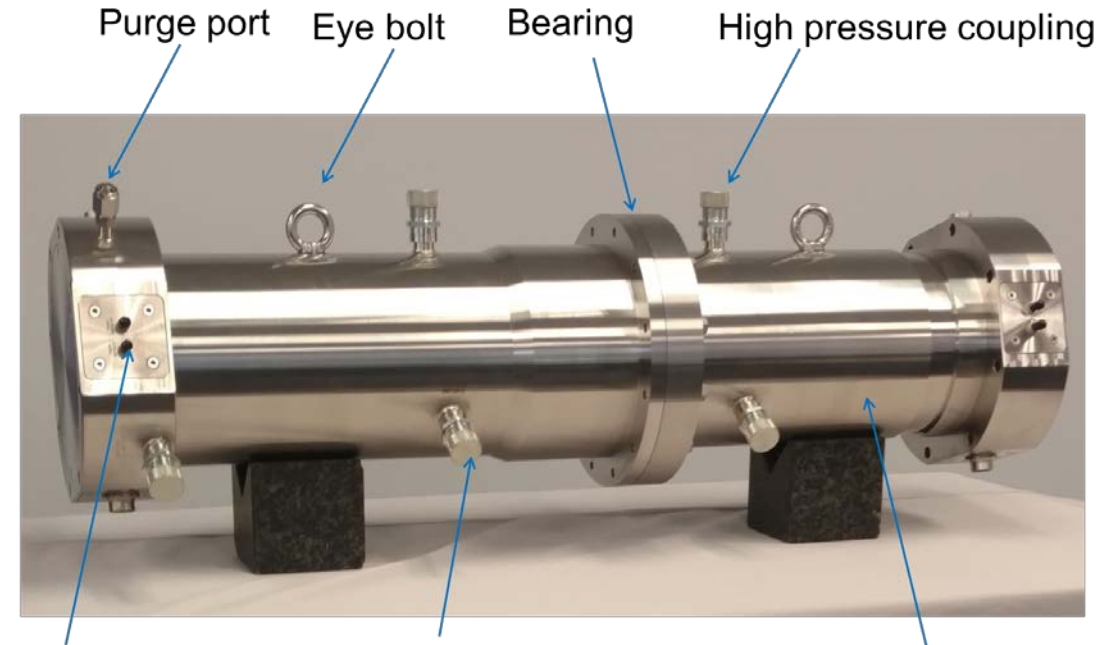
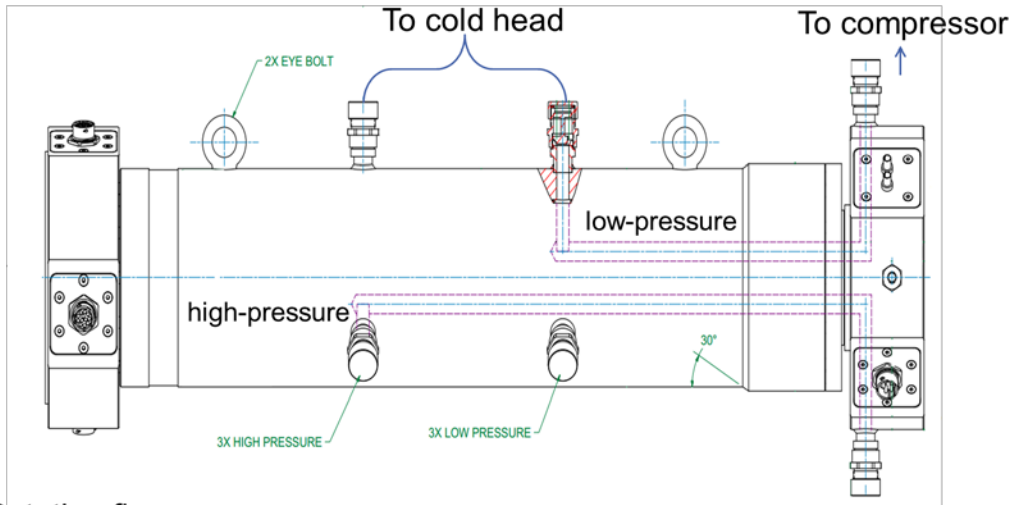


Rotating cryocooler system



- A rotary joint needs to be developed to link the stationary compressor and rotating cold head of the G-M Cryocooler

Rotating cryocooler system – Rotary joint



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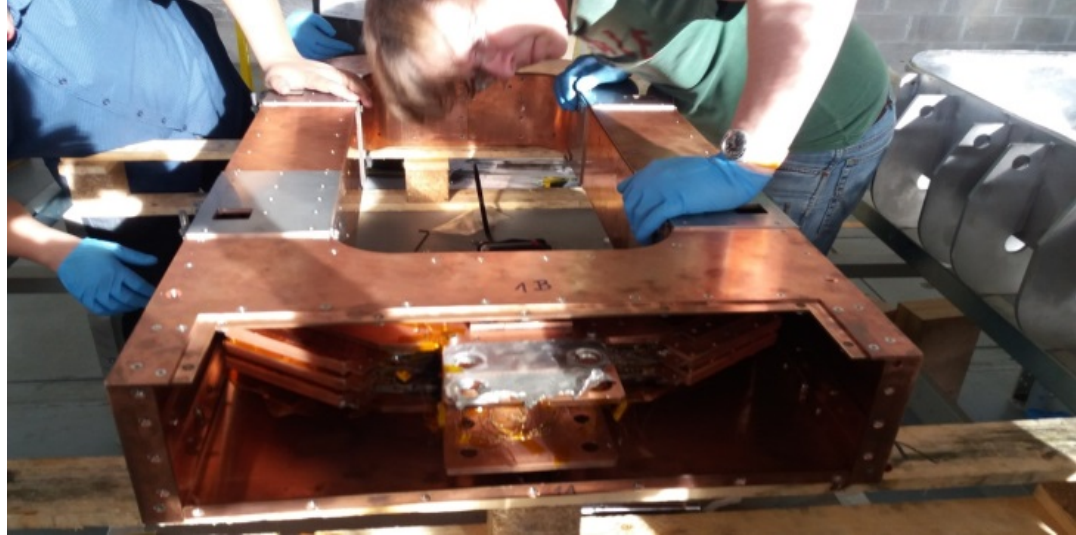
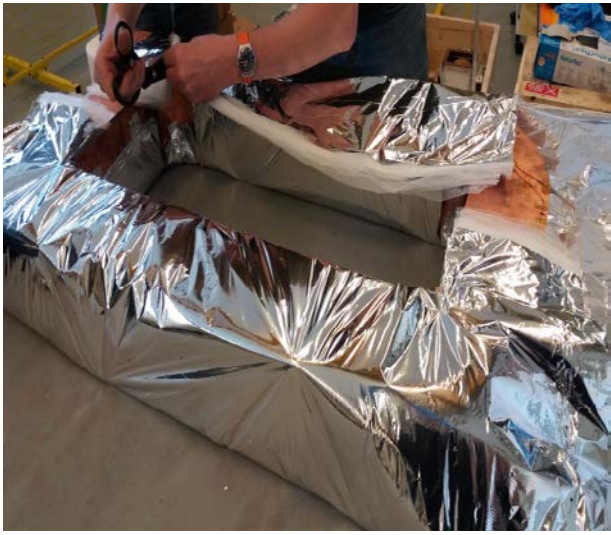
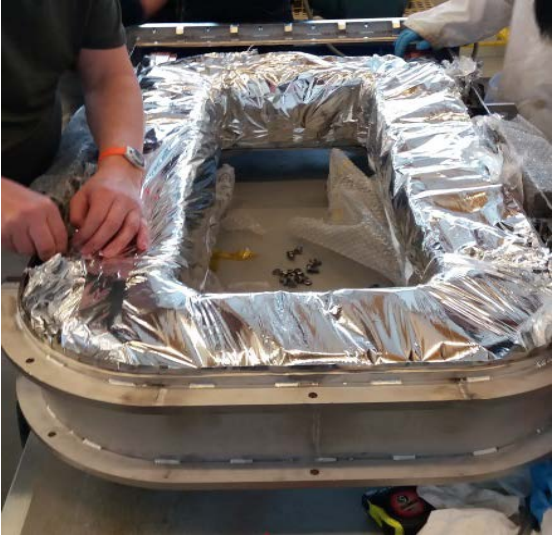
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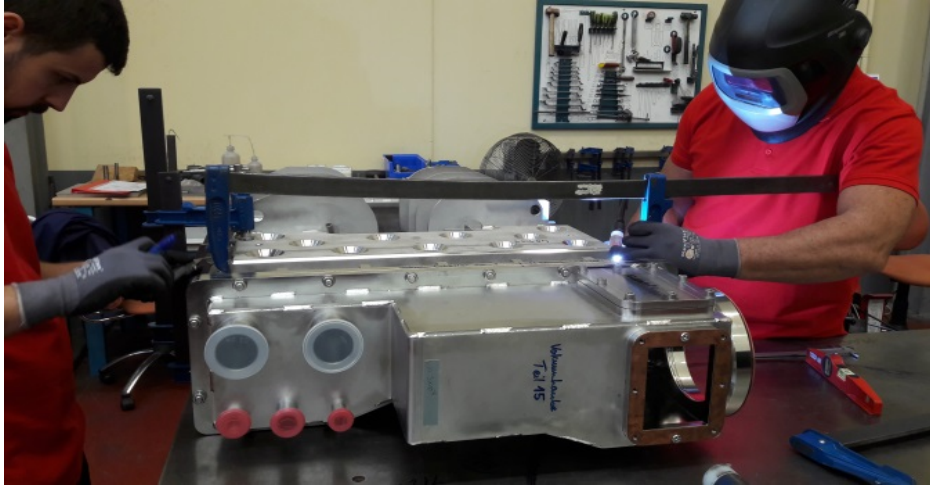
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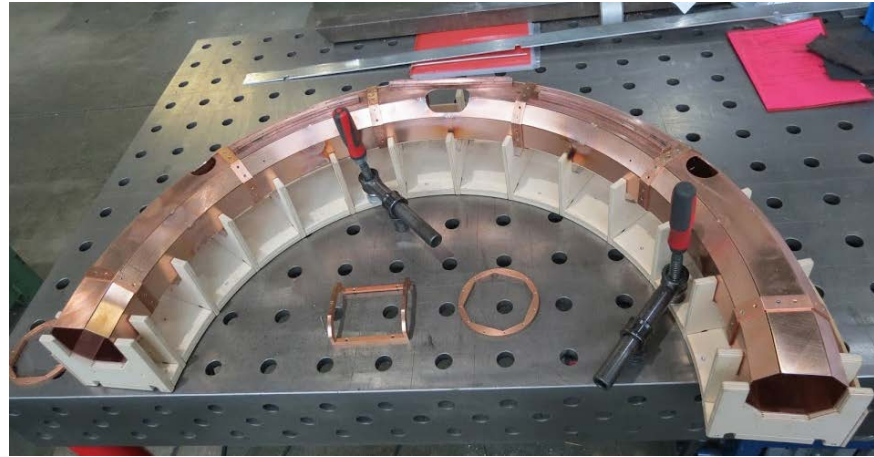
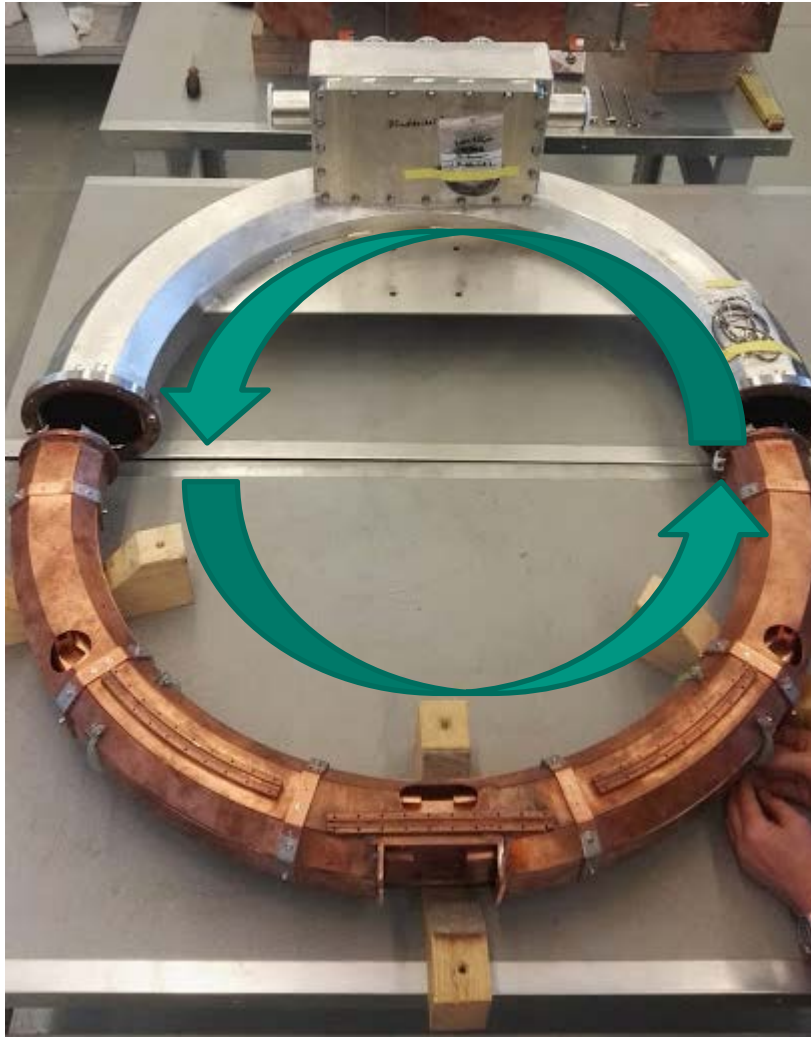
Modular cryostats assembly together with SC coil



Modular cryostats assembly together with SC coil



Distributing cryostat assembly



Cryogenic system integrated on site

Distributing
Cryostat

Cryocooler
Cold head

Drive
motor

Modular
Cryostat



Rotary Joint

Summary and outlook

- The cryogenic cooling system for the RMV of SUPRAPOWER project was successful designed and constructed.
- The superconducting coil was successfully installed in the modular cryostat
- The cryostat system and rotating cryocooler was already assembled into the RMV
- Test of the cryogenic cooling system and the RMV is to be continued

Thanks for your interest

More info at
www.suprapower-fp7.eu

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- Special thanks are extended to Andrés León, Jim Fraser and Mark Granoff of Ferrotec for the contributions to the Rotary joint, and
- Ralf Müller of KIT for his many hours dedicated to the mechanical design, manufacturing, and assembly of the cryostat system.

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