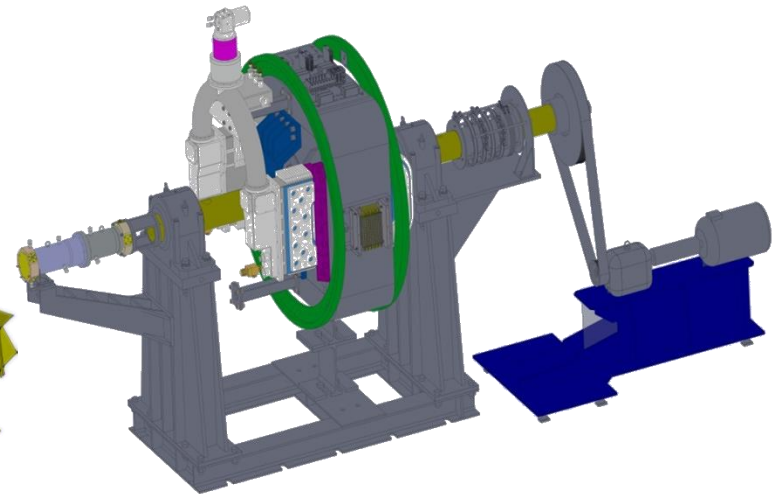
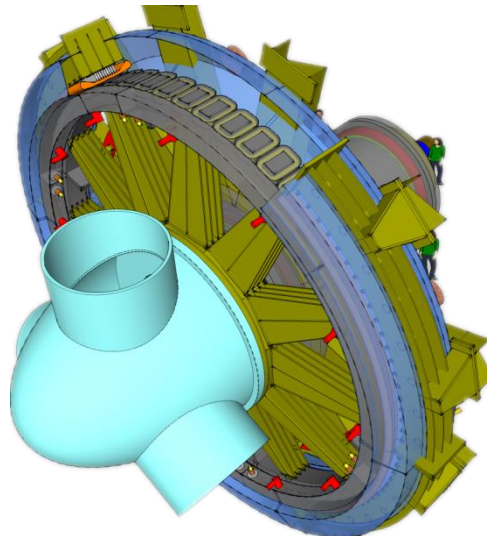
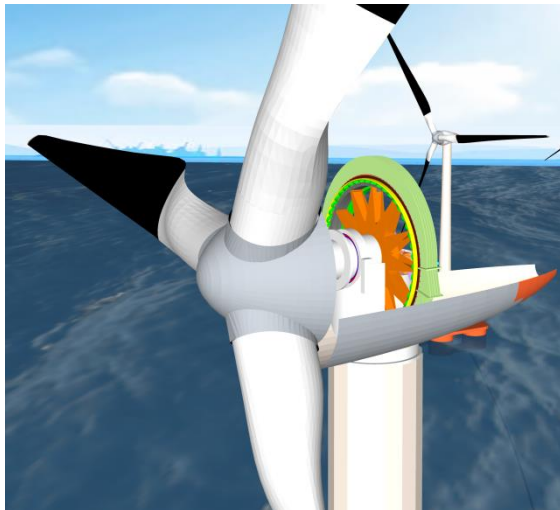


Compact cryogen-free modular cooling system for large scale offshore superconducting wind turbines

Jiuce. Sun, Ralf. Müller, Sanz. Santiago, Holger. Neumann

The European Cryogenics Days & 2nd IWC-HTS, Karlsruhe, Sep 14, 2017

INSTITUTE FOR TECHNICAL PHYSICS (ITEP) CRYOGENICS



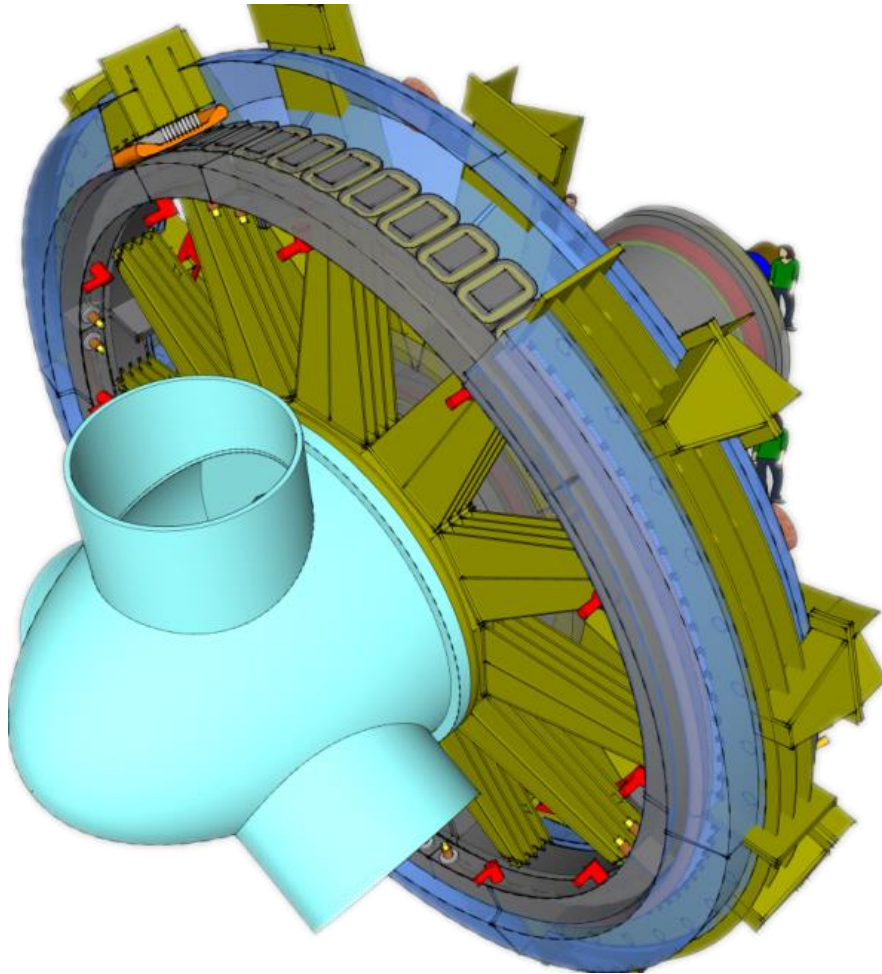
Outline

- 1. Overview of the cryogenic system
 - Object-oriented Requirements
 - Modular and cryogen-free concept
 - Roadmap of cryogenic development
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 - Modular cryostat
 - Distributing cryostat
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 - Full Modular cryostat
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SUPRAPOWER project

- Key technology development and validation of 10 MW SCG



d2m Engineering
KNOWLEDGE. INNOVATION. SERVICE

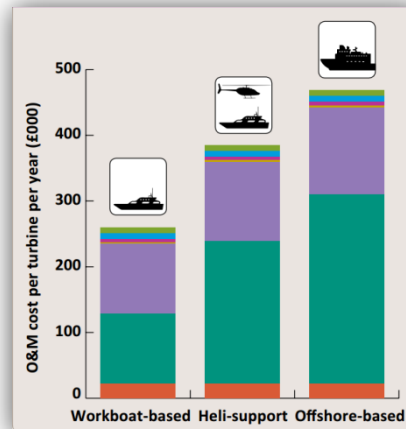


Characteristics of offshore wind

■ Harsh Environment and Very Limited Time Window



■ Costly Access of Installation and Maintenance



“Invisible” Cryogenic system with simple structure, high availability and reliability is required

SUPRAPOWER cryogenic cooling

1 Cooling source

2 Heat transfer

3 Cryostat



Cryocoolers

- G-M
- Stirling
- Pulse tube



Cryopumps

- Liquid N₂
- Liquid He
- Liquid H₂
- Liquid Ne
- He Gas



Convection Cryogen-free



Conduction



Bath cooling



Integrated



Radiation



Convection

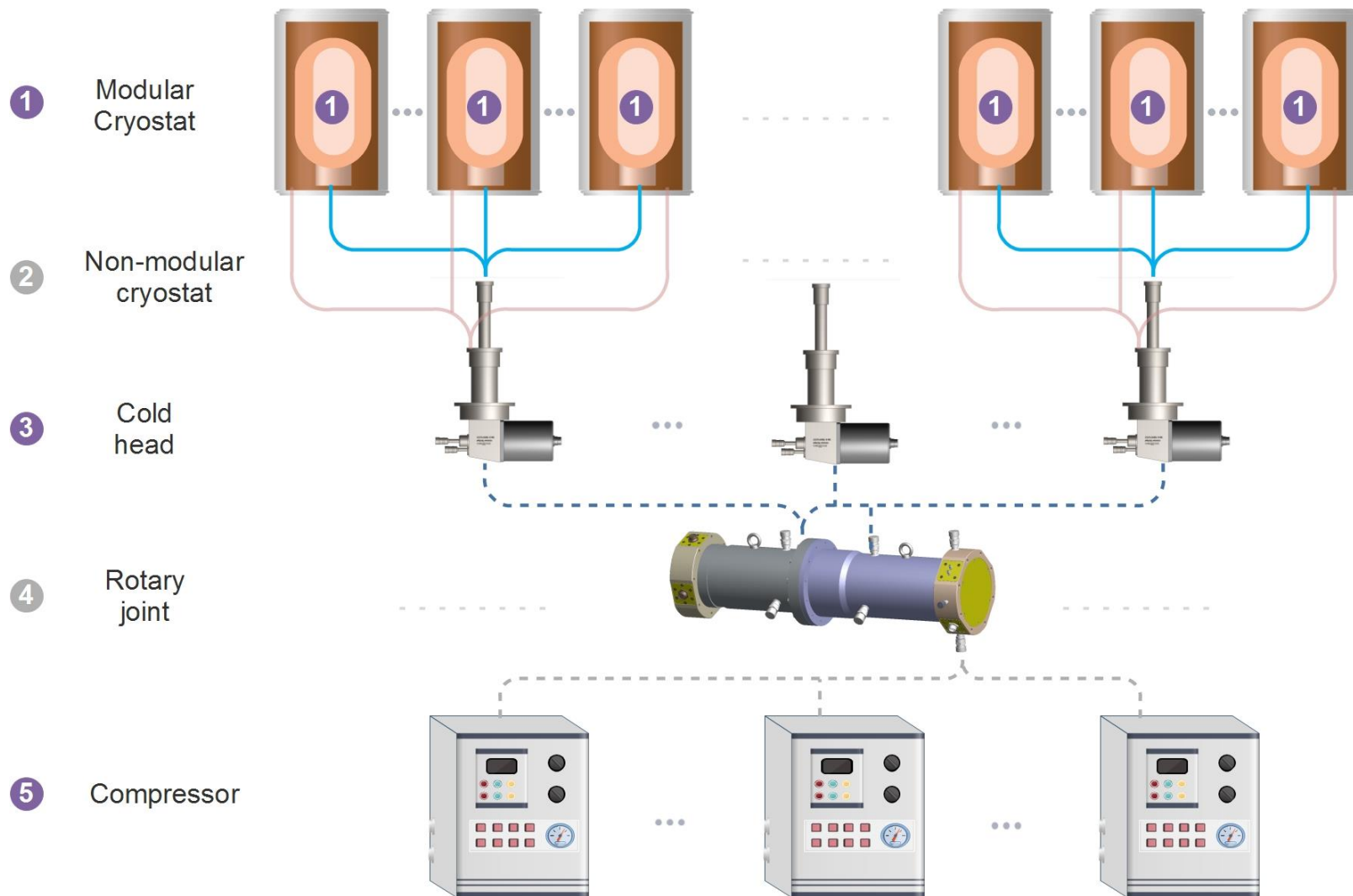


Conduction

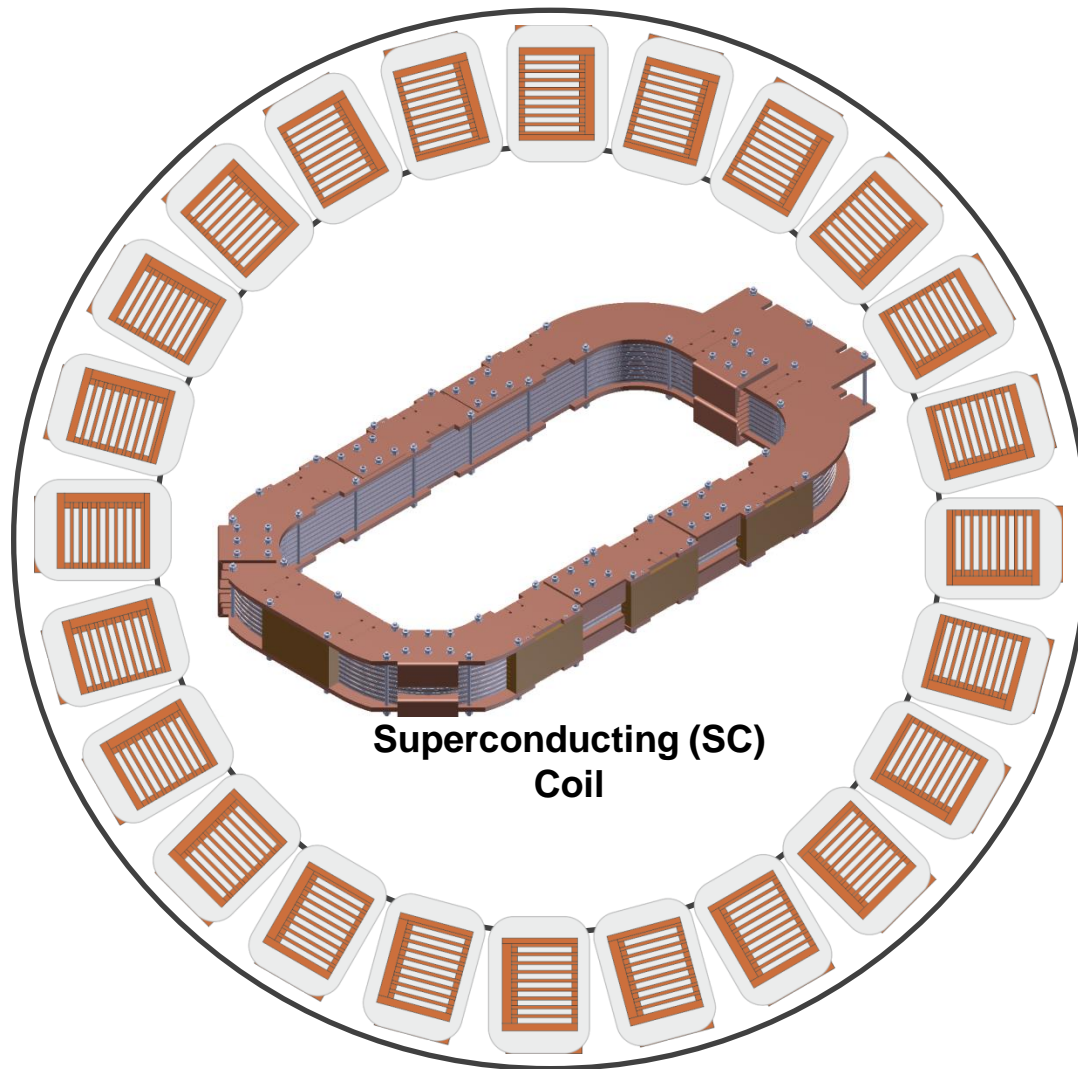


Modular

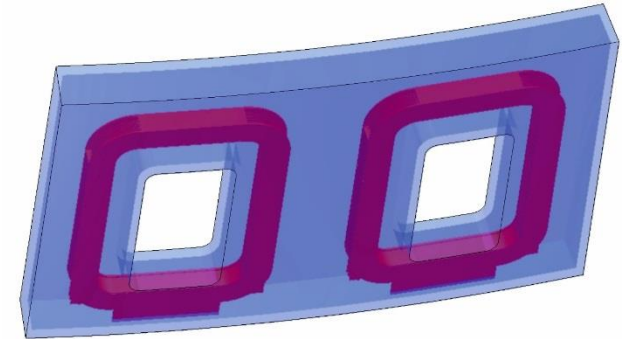
SUPRAPOWER cryogenic cooling system



Cryostat system for SCG

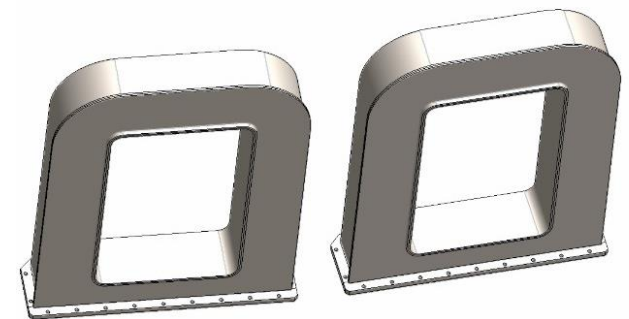


■ Integrated cryostat



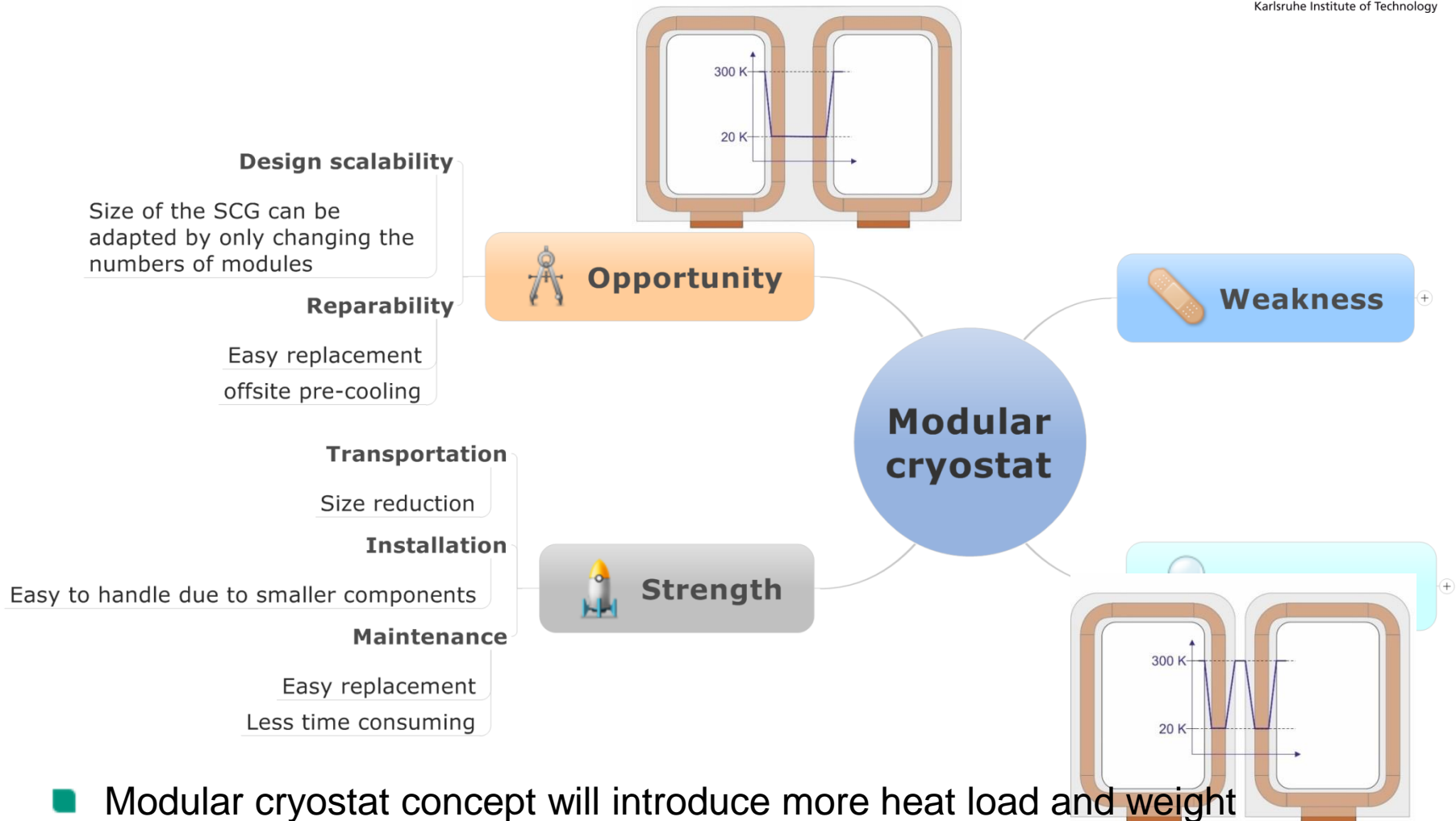
one cryostat for several coils

■ Modular cryostat



one cryostat for one coil

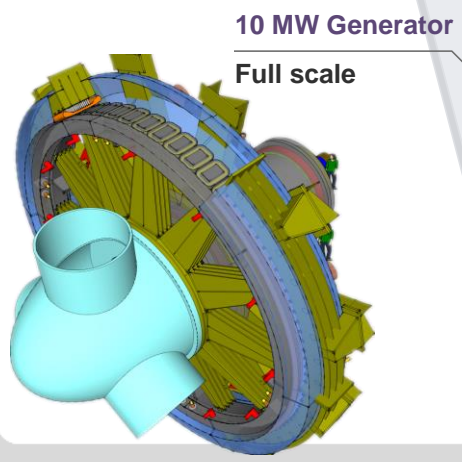
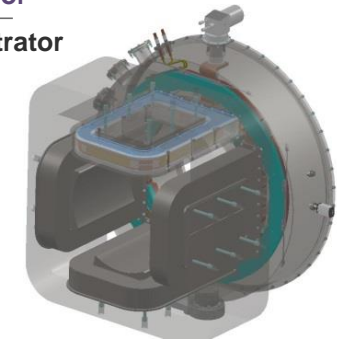
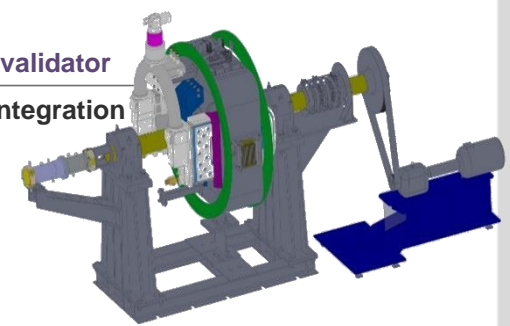
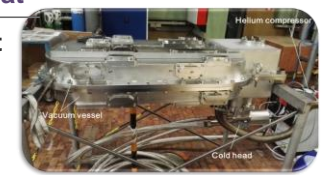
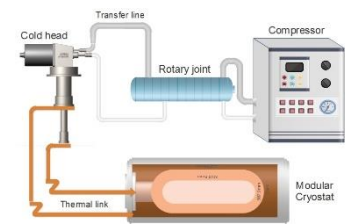
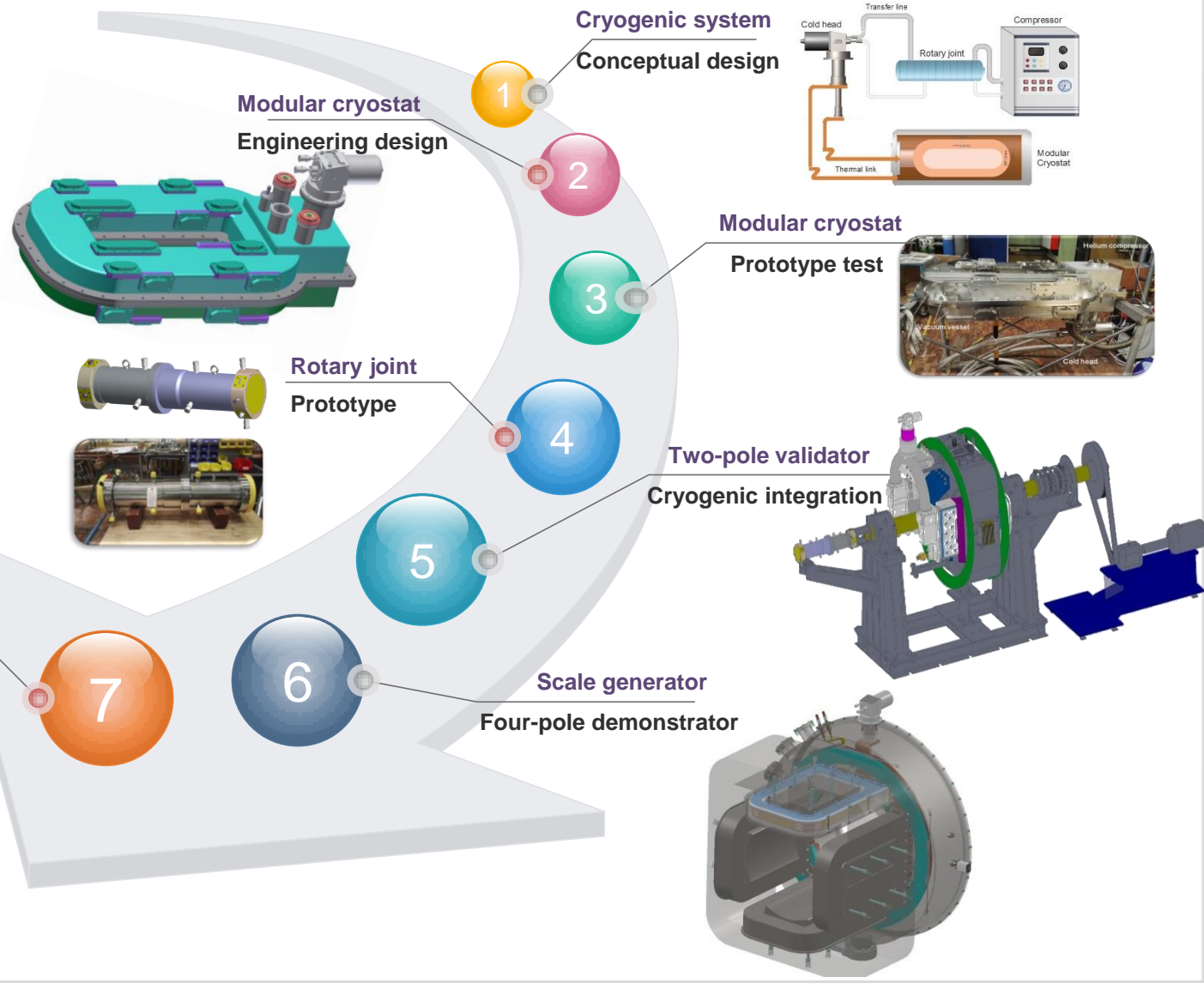
SWOT Analysis of modular cryostat



- Modular cryostat concept will introduce more heat load and weight
- More challenges comes to modular cryostat design due to limited space
- Better scalability and easy maintenance obtains from the modular design

Roadmap of cryogenic development

- 1 **Conceptual Design**
Cryogenic design for the 10 MW and scale down validator
- 2 **Key component**
Modular cryostat; Rotary joint; Thermal collector
- 3 **Cryogenic integration**
Cold head connection; Rotating validation
- 4 **System optimization**
Cryocooler distribution management

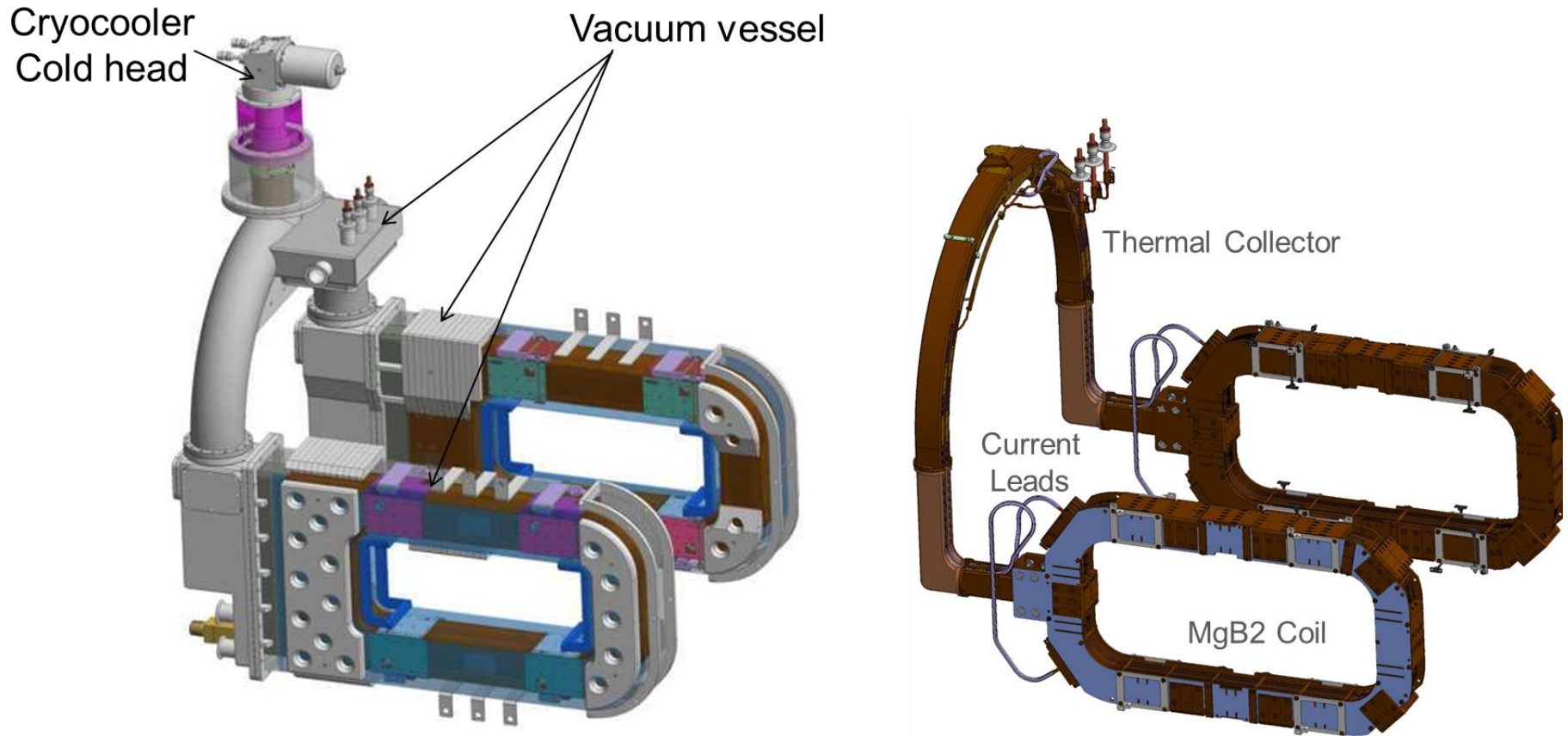


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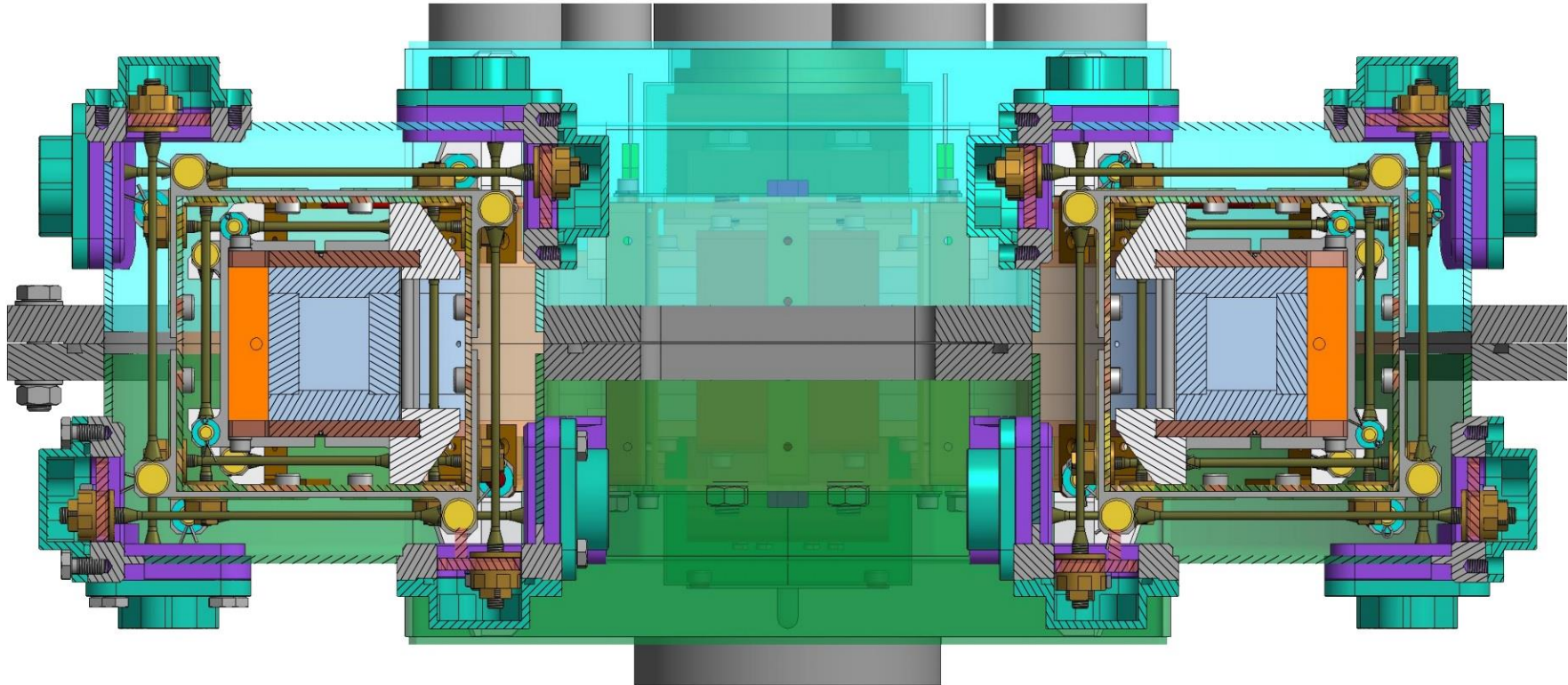
Cryogenic cooling system of the RMV



- A cryostat system was designed and manufactured for the RMV to validate the cryogenic cooling concept developed in SUPRAPOWER project

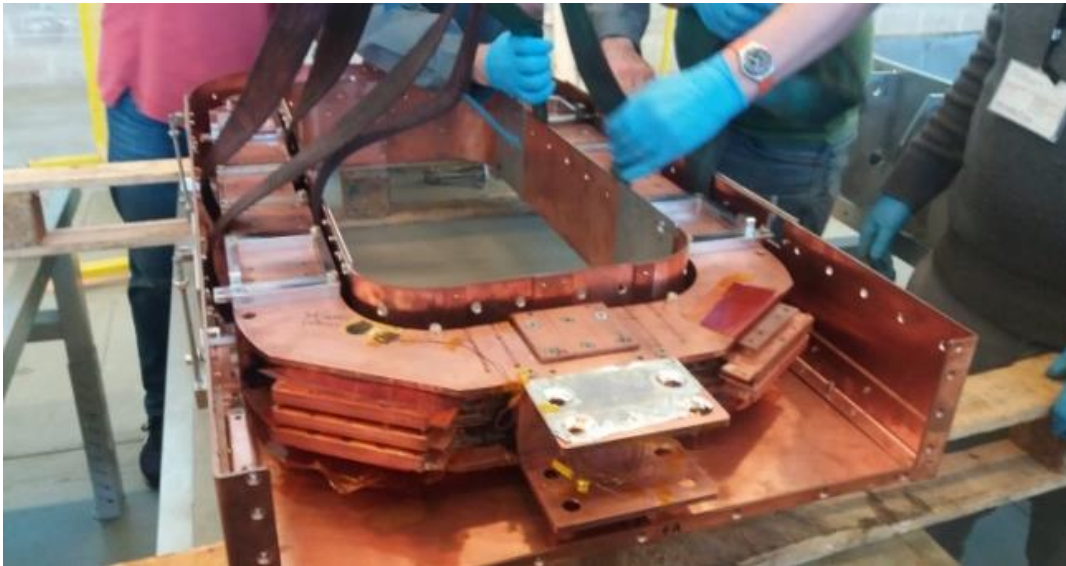
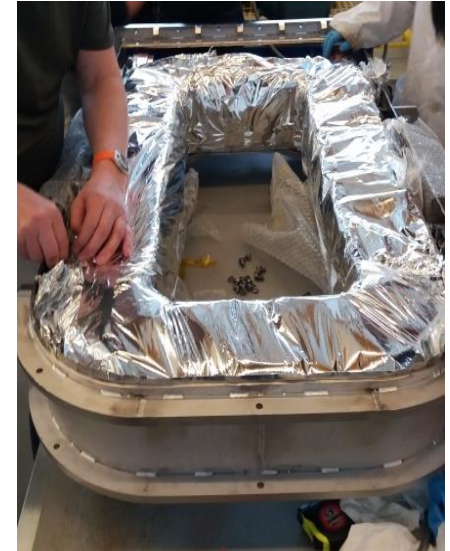
Modular cryostat -Support structures

■ Front view of the support structure

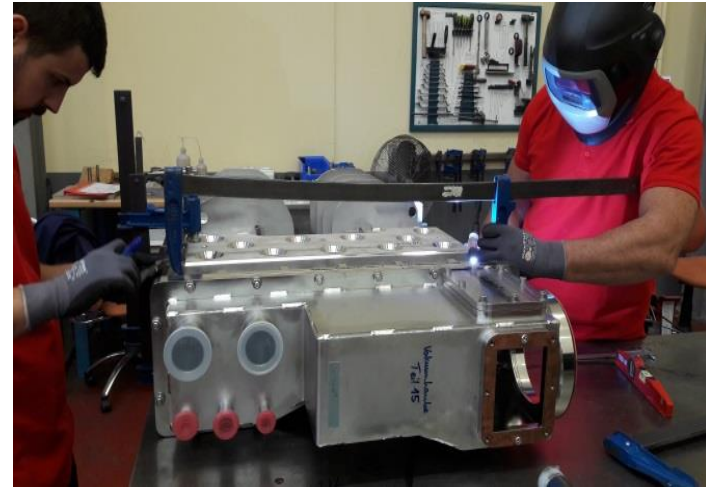


- Prototype support structure include 8 rods per coil and 8 rods per shield
- Number Reduced support structure have been applied to the modified cryostat for the RMV to save space

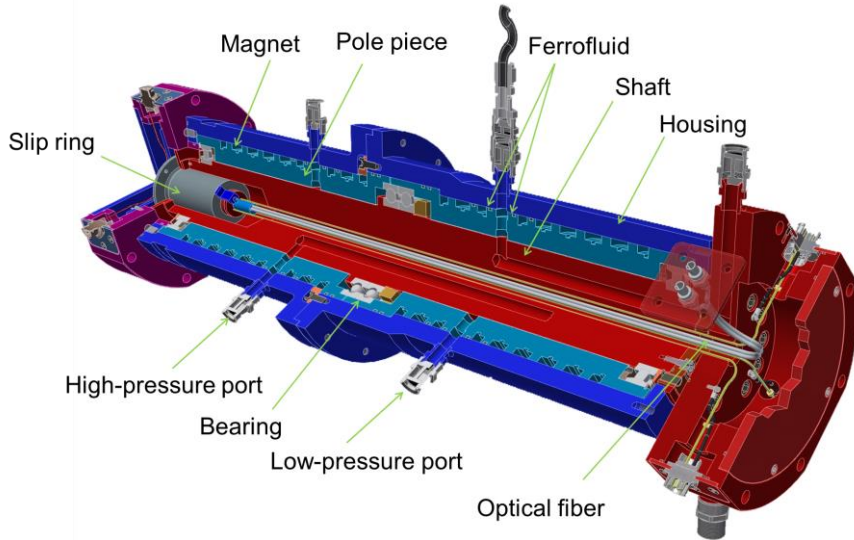
Modular cryostats assembly



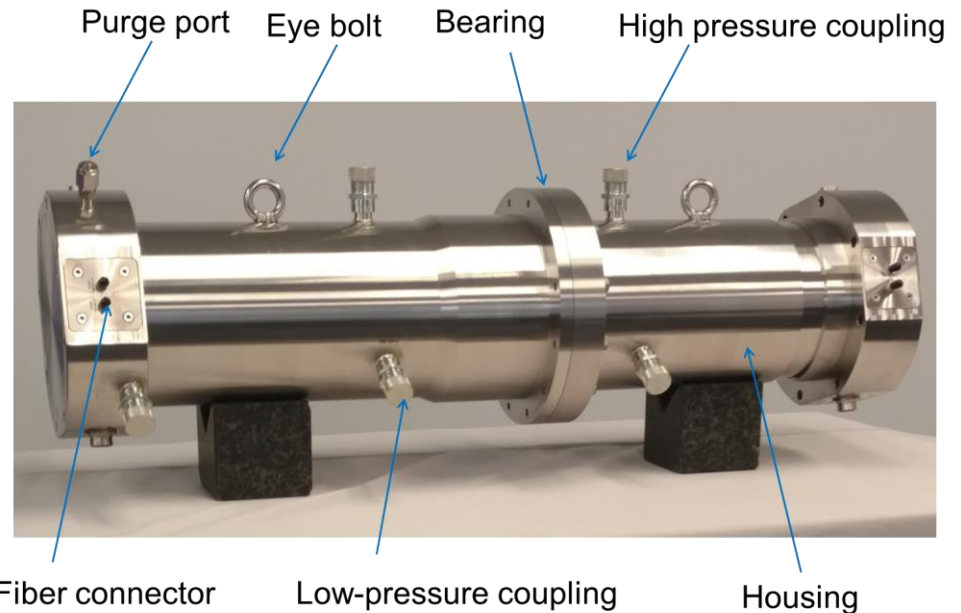
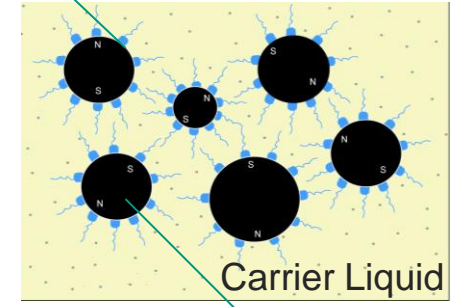
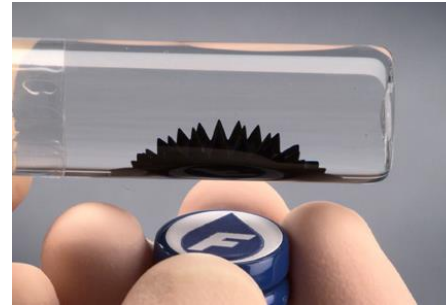
Modular cryostats assembly



Development of rotary joint



Coupling Agent "Surfactant"



Cryostat for rotating magnetic validator

Non-modular cryostat

Modular cryostat

Rotary joint

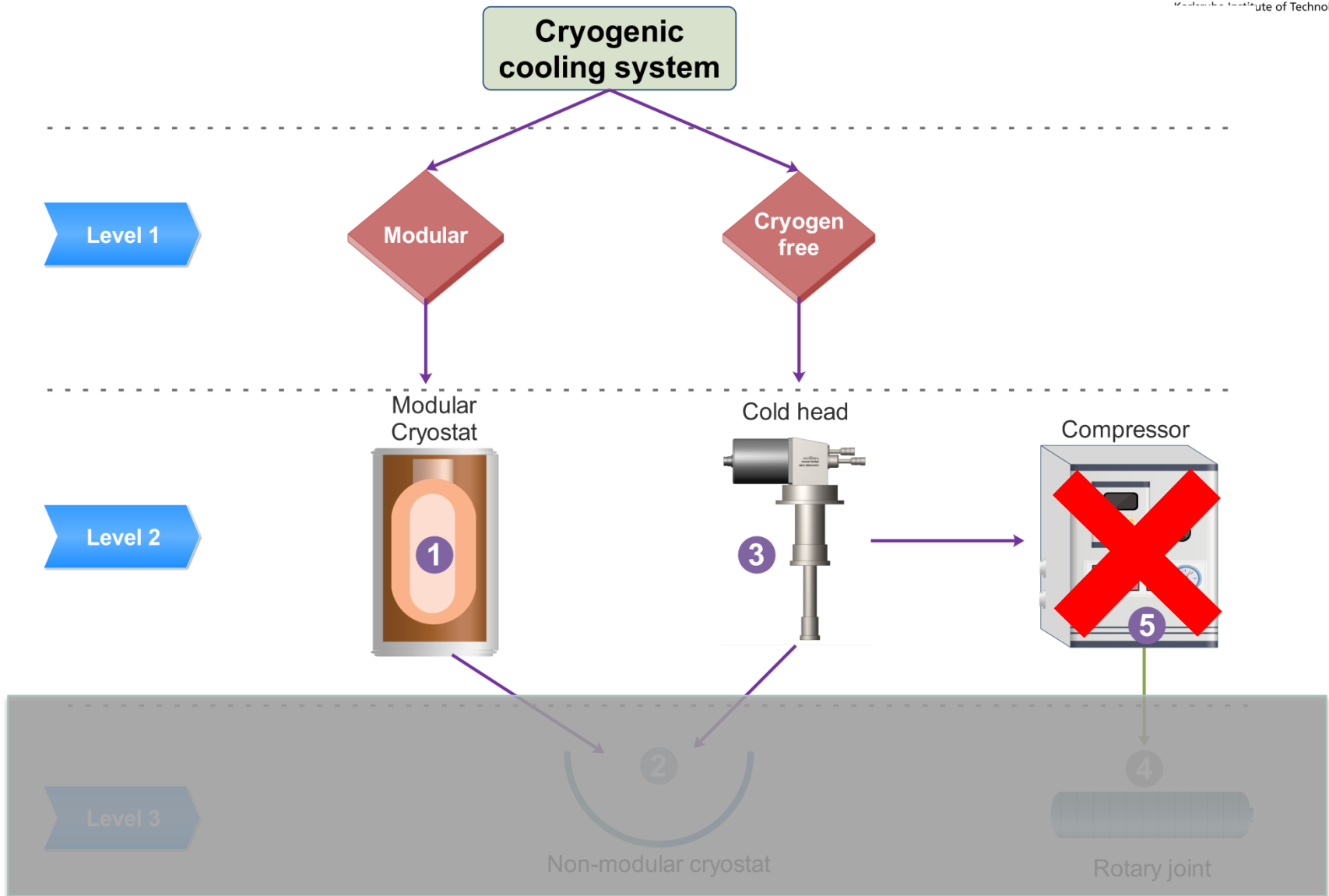


Outline

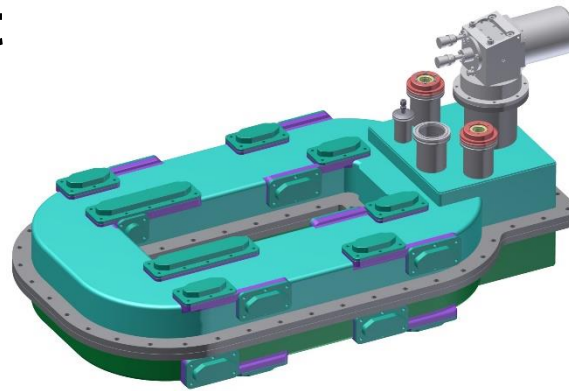
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Cryogenic optimization



Full modular cryostat



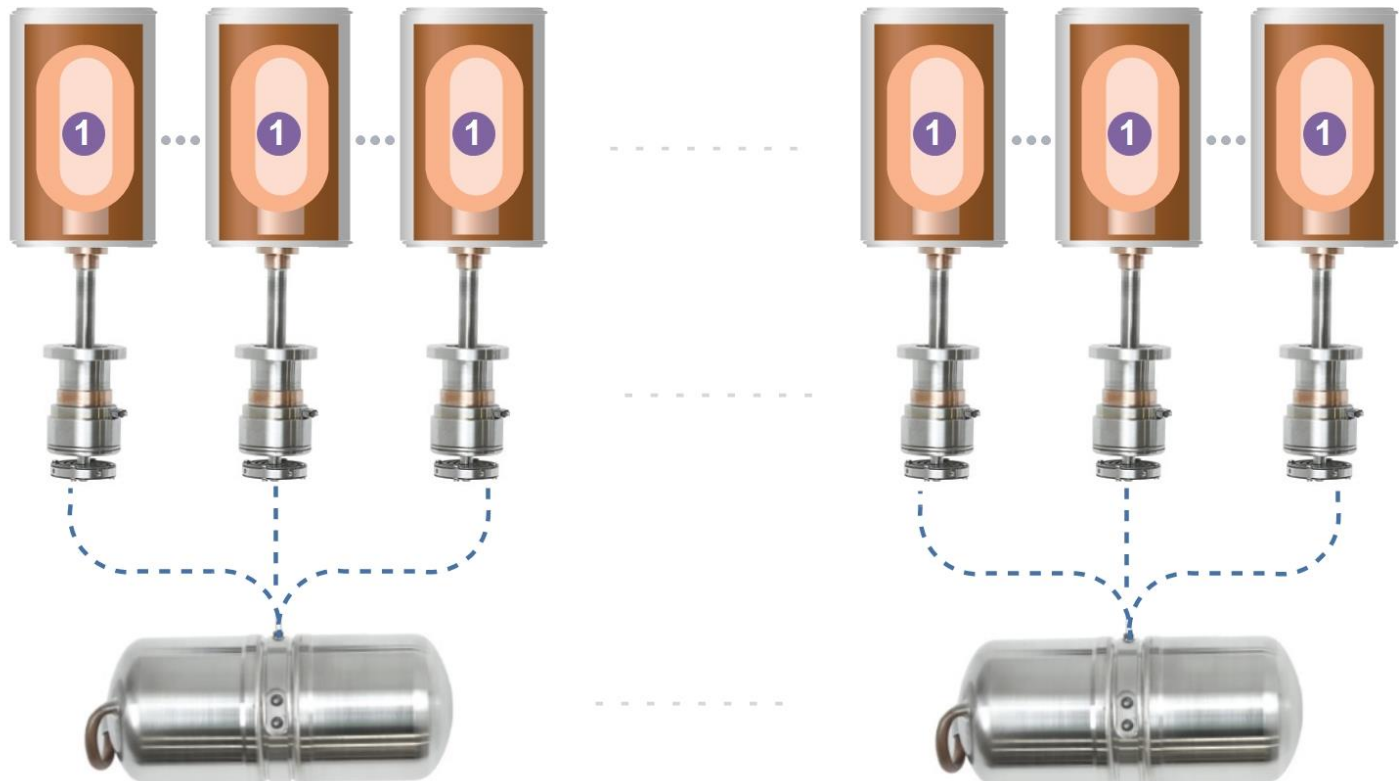
1 Modular Cryostat

2 ~~Non-modular cryostat~~

3 Cold head

4 ~~Rotary joint~~

5 Compressor



Summary

- **A compact Modular, Cryogen-free, Rotating cryogenic system has been developed in SUPRAPOWER project**
- **Modular Cryostat system for the rotating magnetic validator has been designed and manufactured**
- **Rotary joint has been developed for the G-M cryocooler used in the rotating condition**
- **A Full modular cryostat system has been proposed in consideration of maintenance and assemble**

Thanks for your interest

More info at
www.suprapower-fp7.eu

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