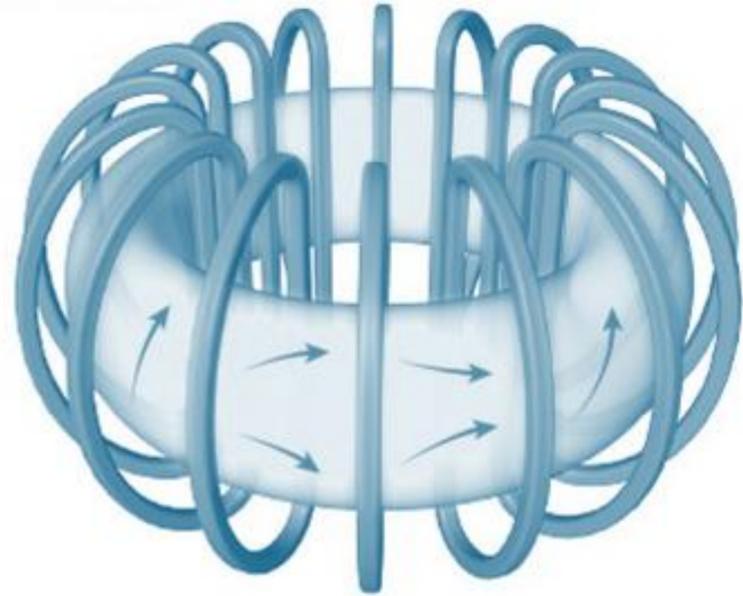


Skyfall 2: A 1.2m diameter HTS pseudo- Helmholtz magnet for liquid metal MHD studies

Goal:
Stellarator with
laser engraved
HTS (High Temperature Superconductor)



Tokamaks vs Stellarators

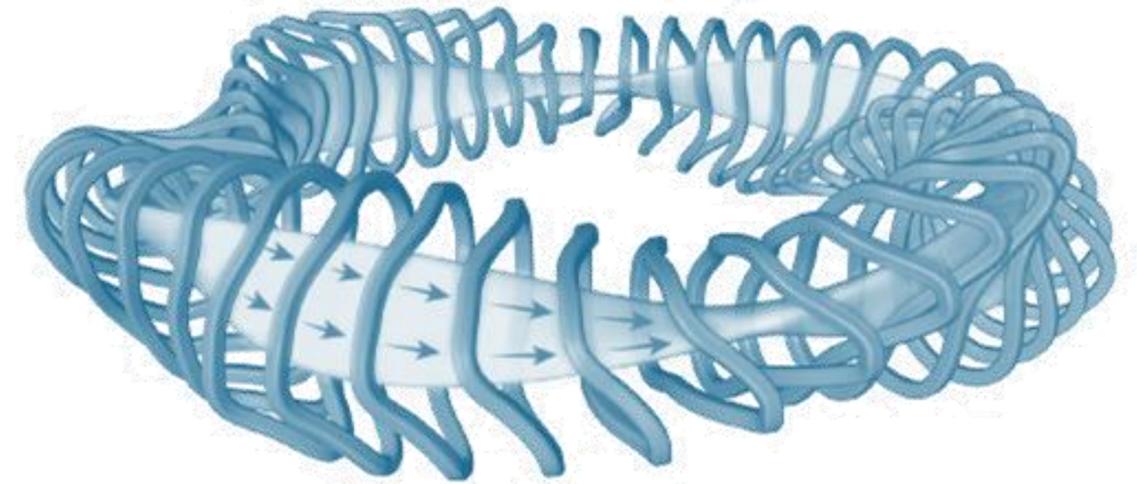


✓ Simple to build
All coils are planar (2D)

✗ Difficult to operate

The plasma current **is pulsed, unstable, subject to disruptions**, and most coils are pulsed too. This introduces losses, operational and regulatory difficulties.

Renaissance fusion propose to use laser engraved HTS to ease the manufacturing



✗ Difficult to build

Intricate 3D coils are computed, built and positioned with mm precision.

✓ Simple to operate

Magnetize, evacuate, inject gas, ionize, heat. Leave it on. **Continuous operations**

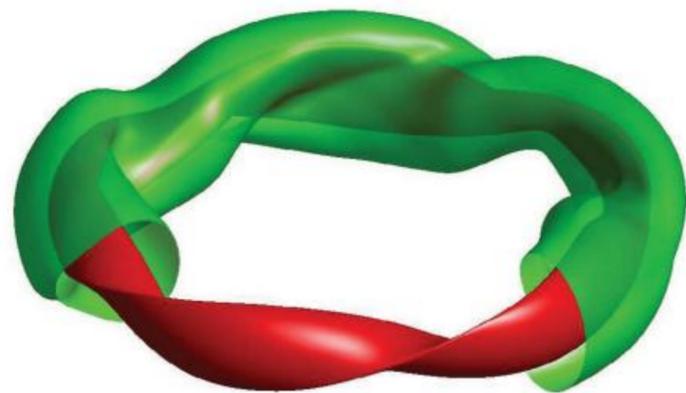




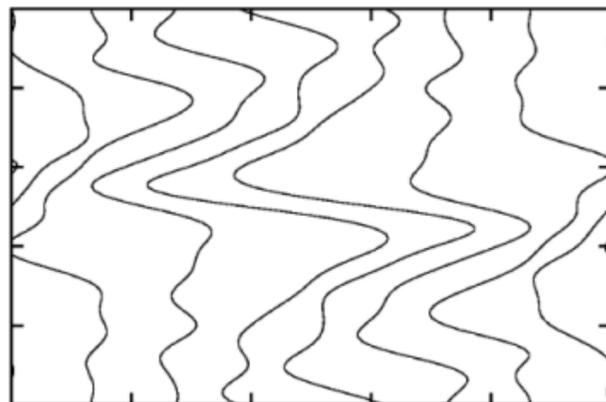
Simplifying the design of stellarator magnets

Conventional way

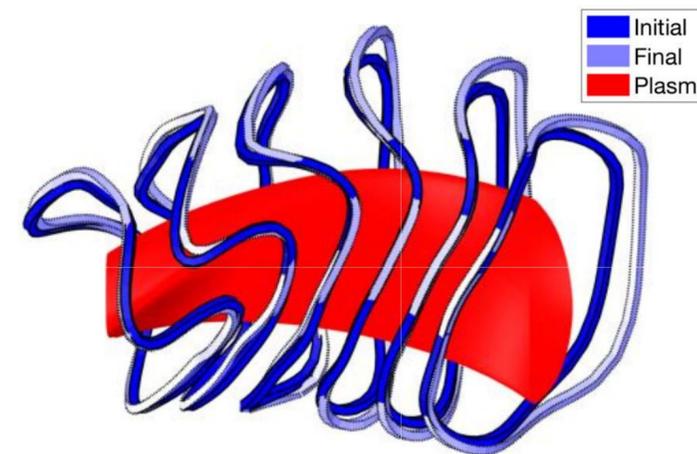
Conformal surface



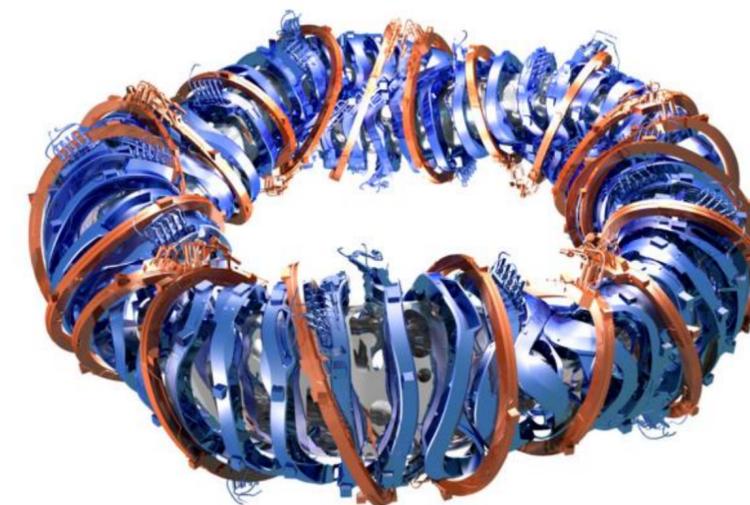
Electric current solution



Coil spatial optimization

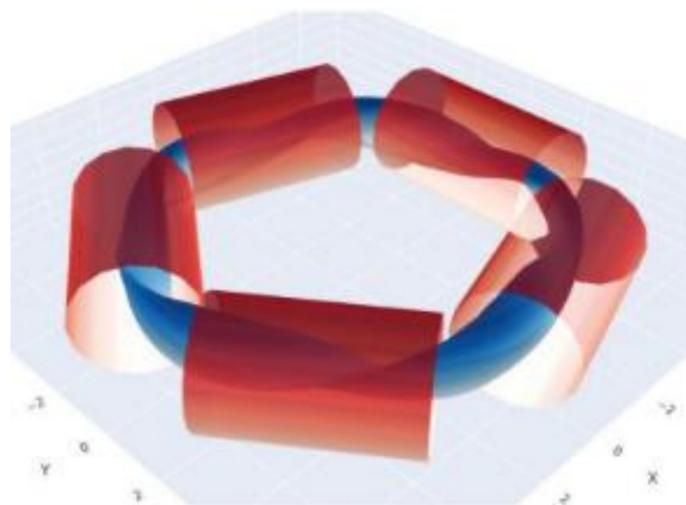


Magnet design

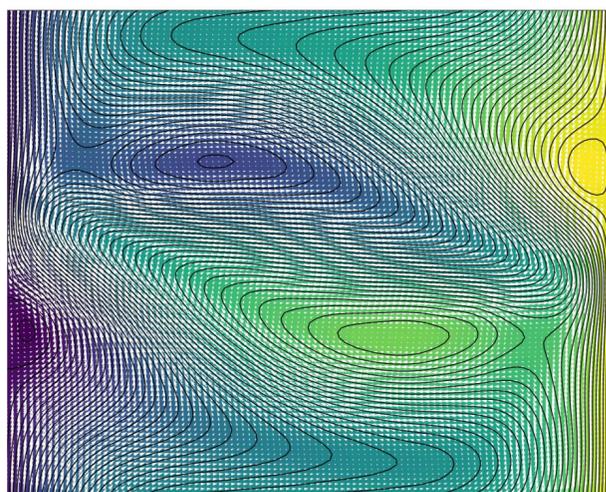


Renaissance Fusion way

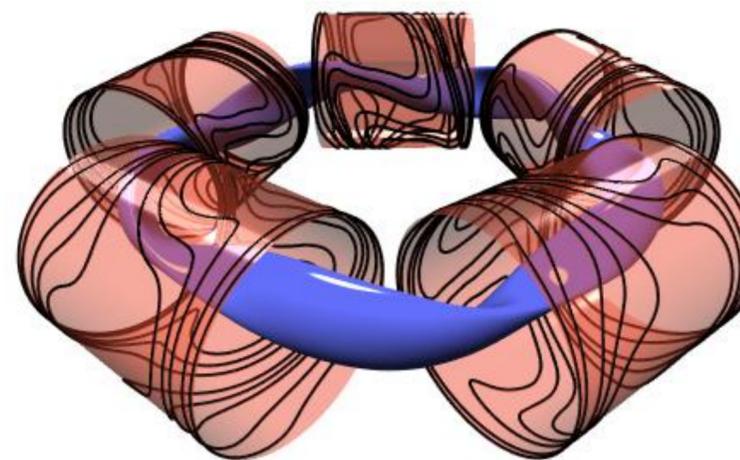
Cylindrical surfaces



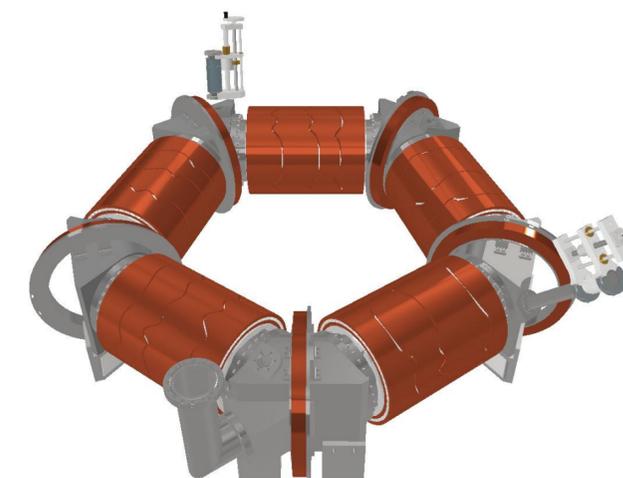
Electric current solution



Engravings optimization



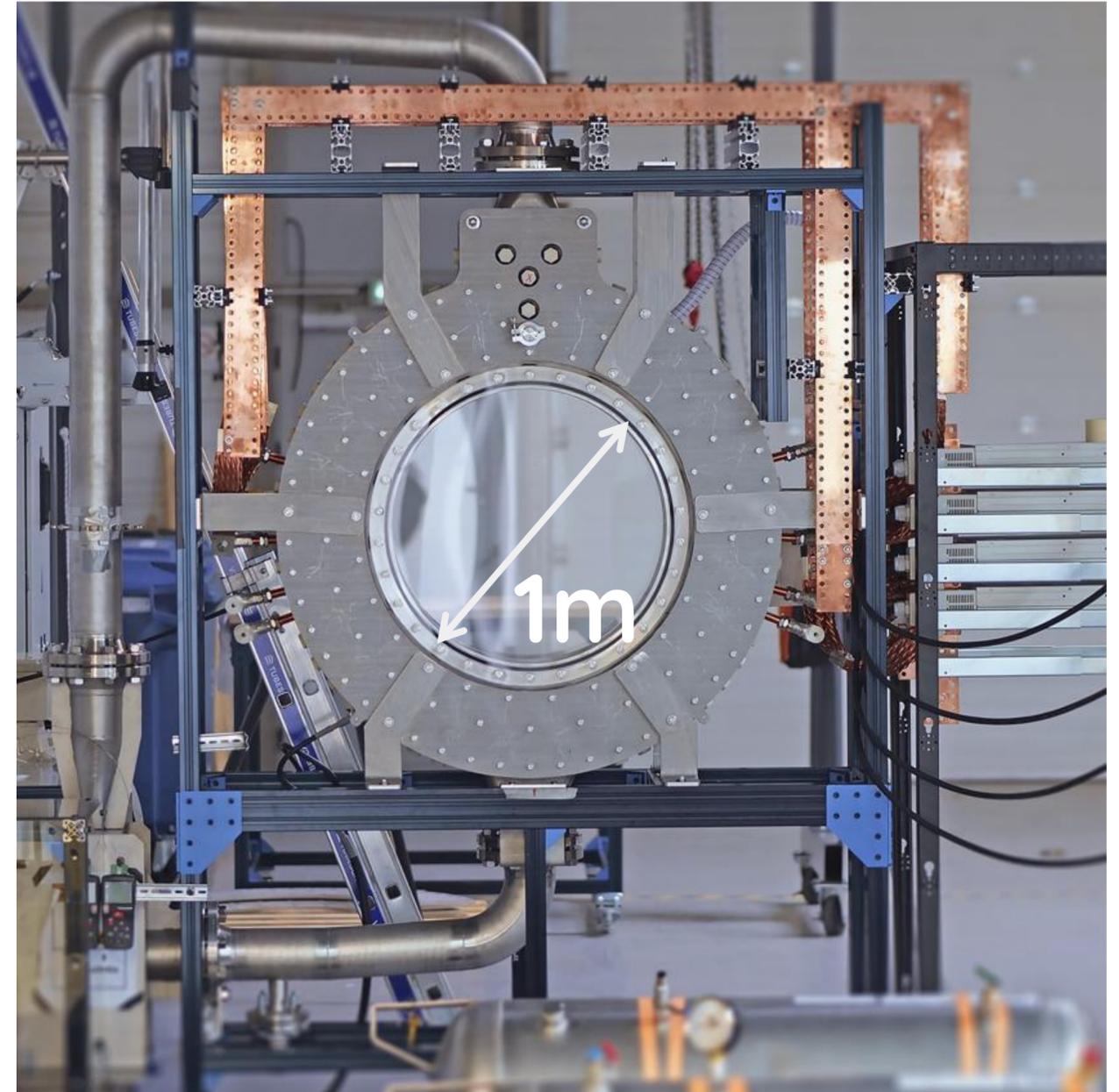
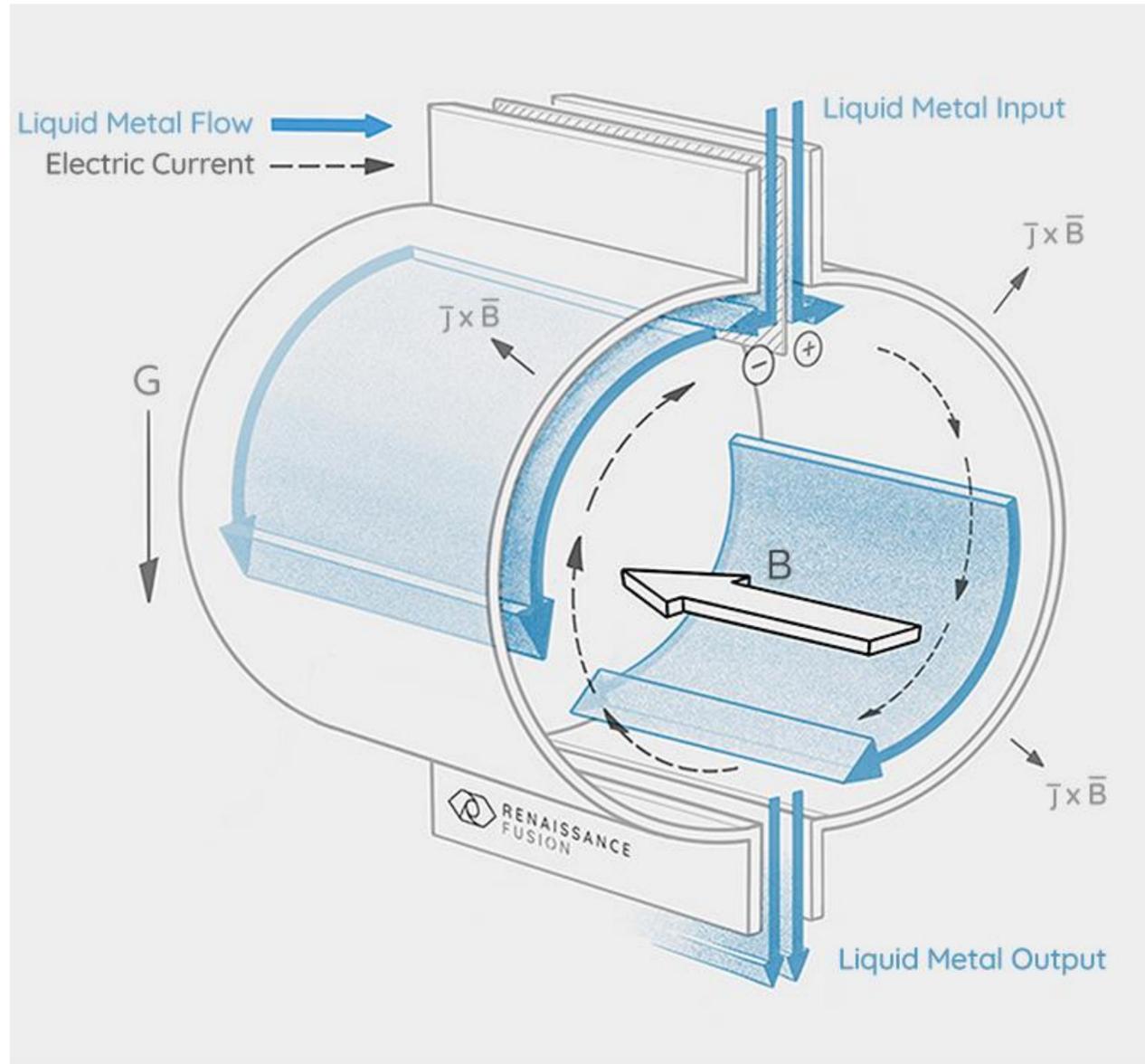
Magnet design



Proofs of concept are necessary

Proof en concept : Skyfall2

Skyfall 1 : Liquid metal interest & Proof of concept 2024



Triple interest of liquid metal concept for stellarator

- Neutrons **out**
- Tritium **in**
- Heat **extraction**

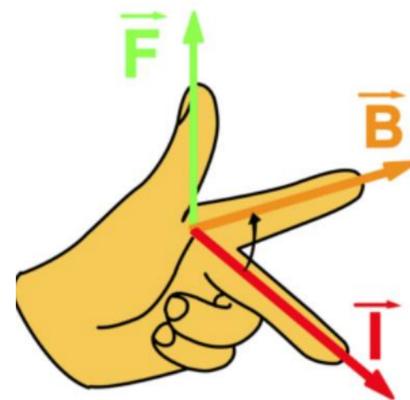
Skyfall 1 experiment (ambient T)

- **Liquid Galinstan (Gallium, Indium & Tin)**
- **Permanent Magnets**

Skyfall 1 : Current in liquid metal

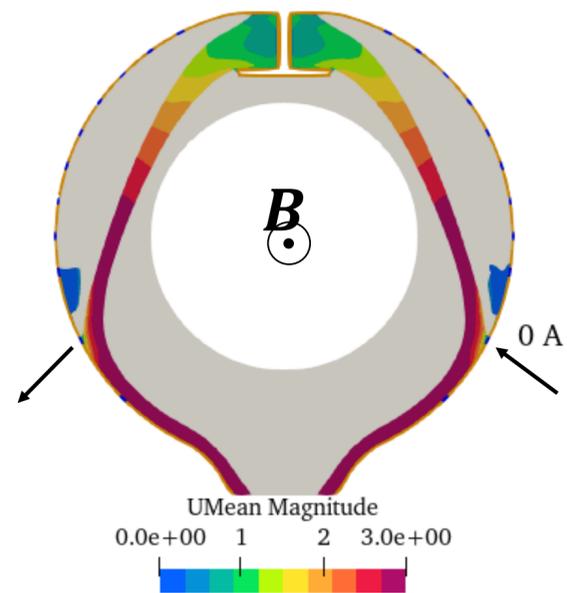
Validated MHD numerical models for plasma facing thick liquid walls

Lorentz Force Law



$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$$

Electric force
Magnetic force



Q=5.9 L/s



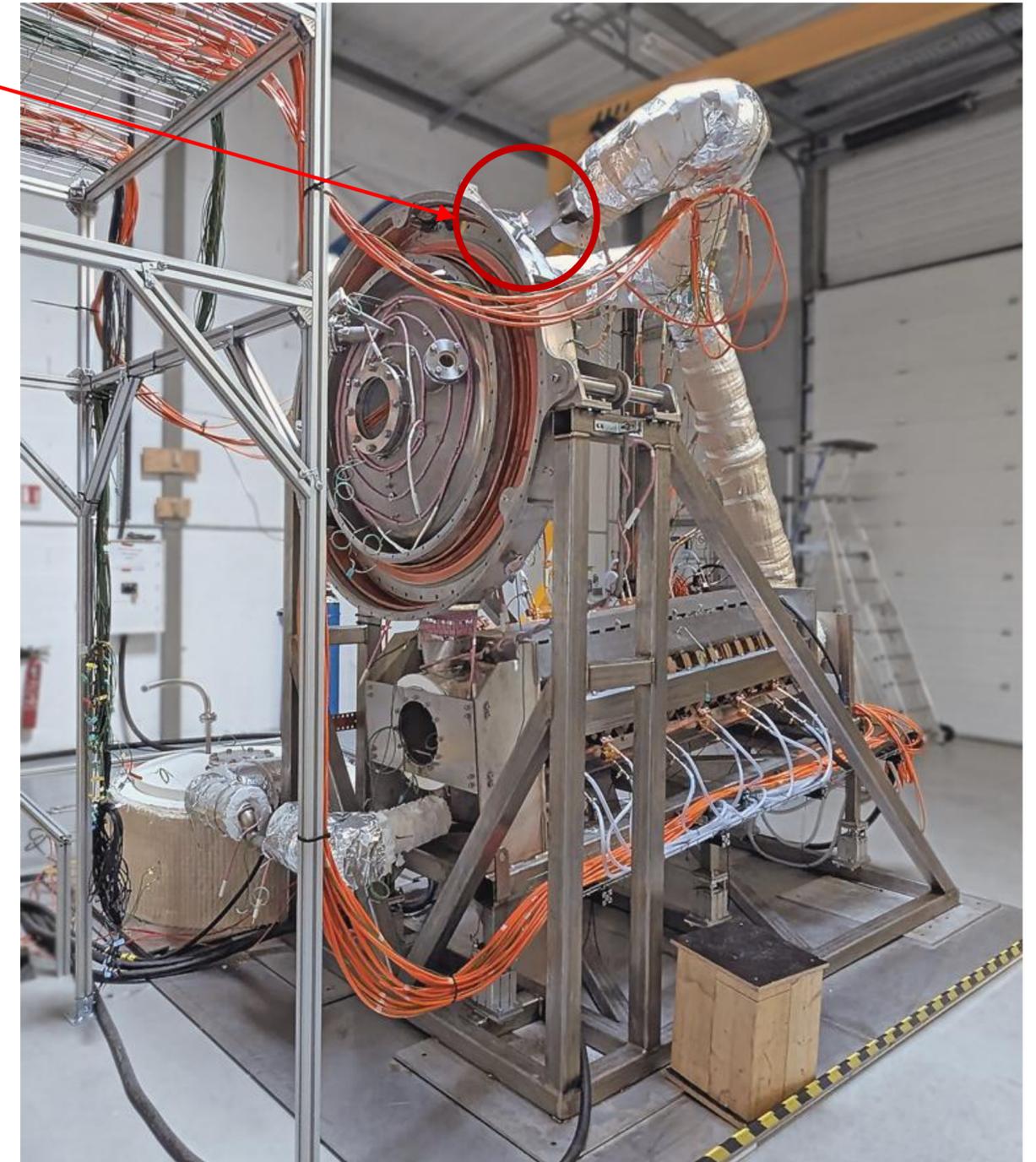
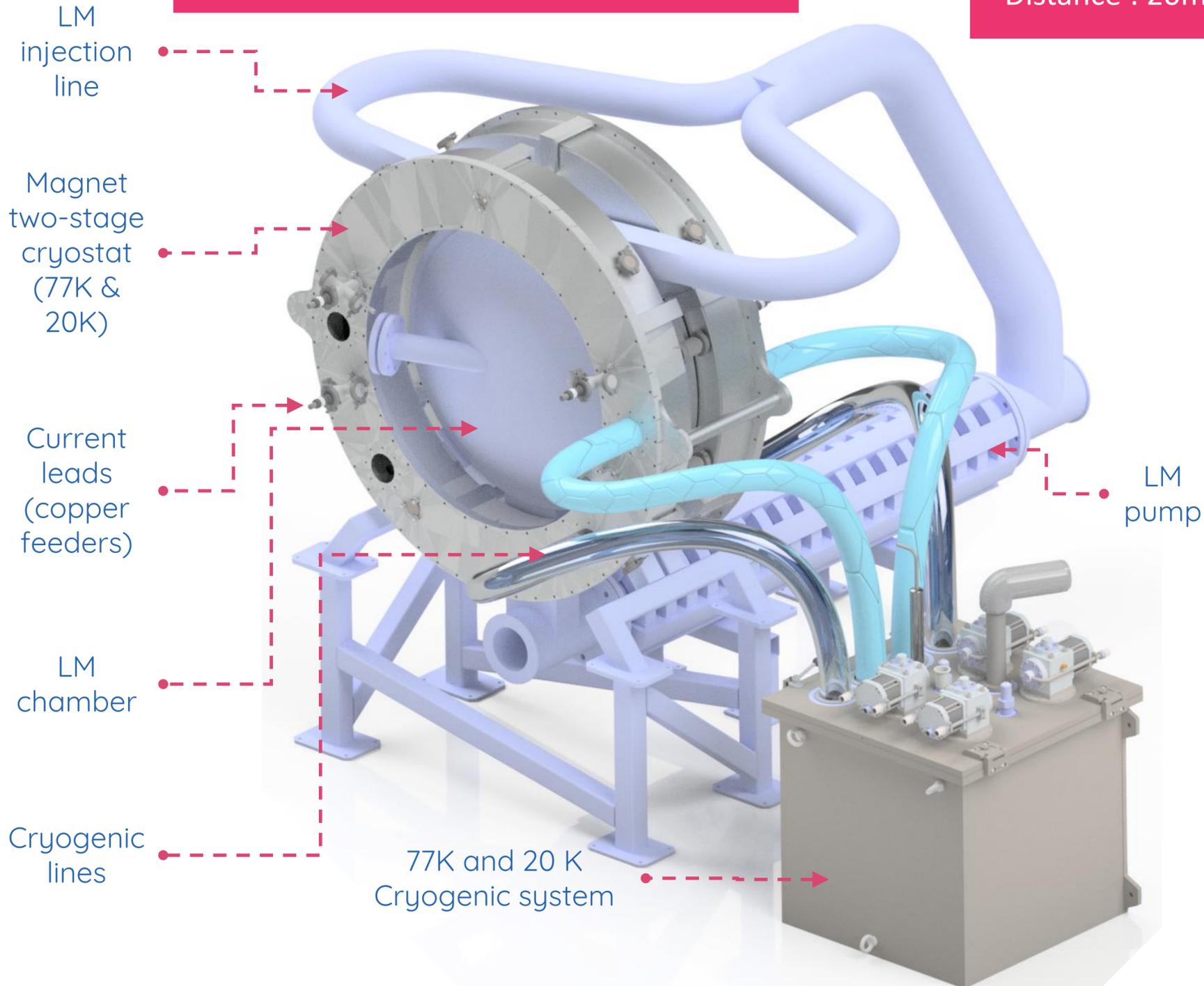
Now we ready for Skyfall#2

Skyfall 1 experiment (ambient T)

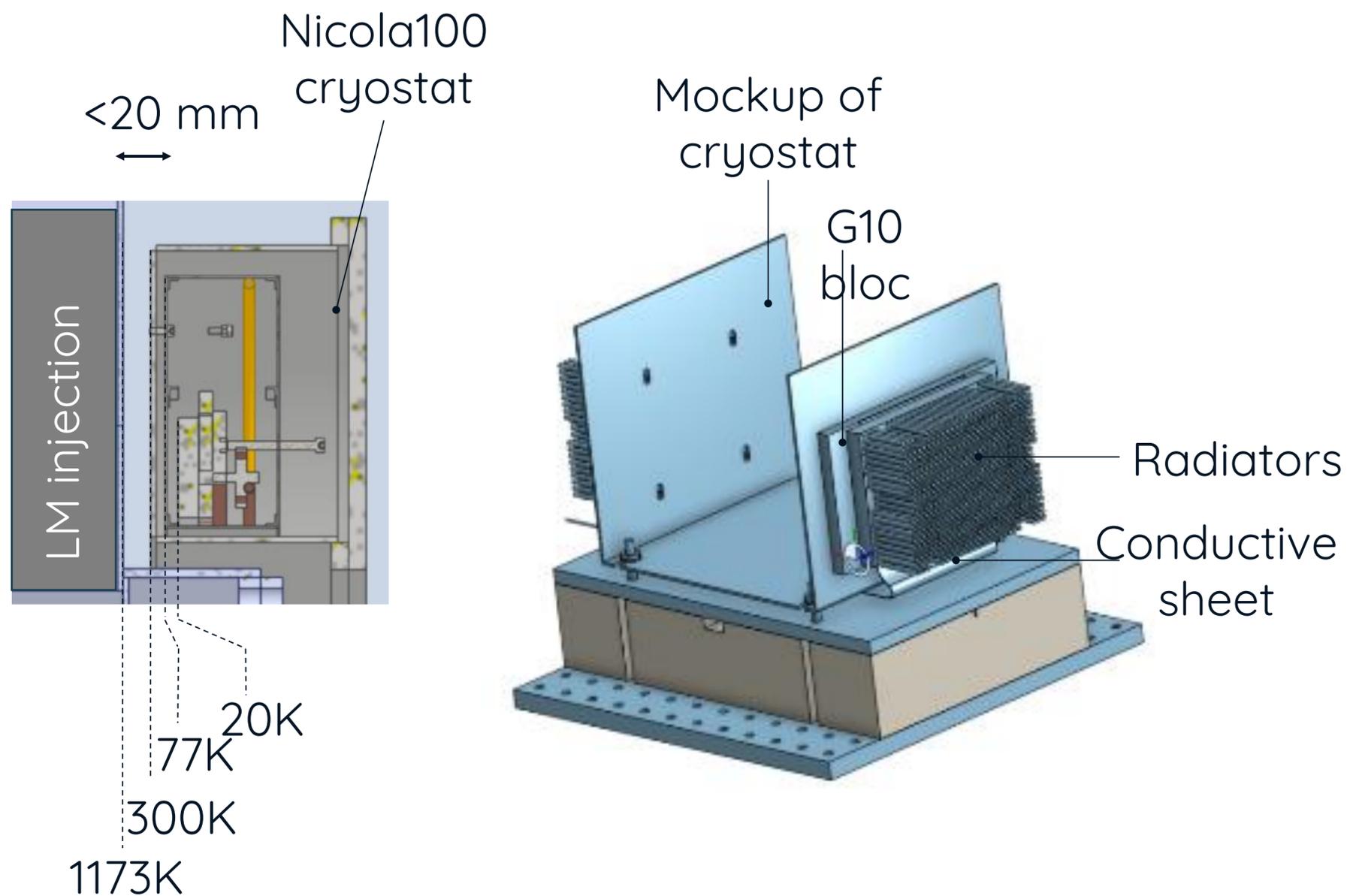
Skyfall 2 : Liquid Sn or Li up to 850°C - 2025

Flowing, in a 1 m diameter chamber, a 10 cm thick layer of liquid Sn (then Li) up to 850°C under a 1 T magnetic field

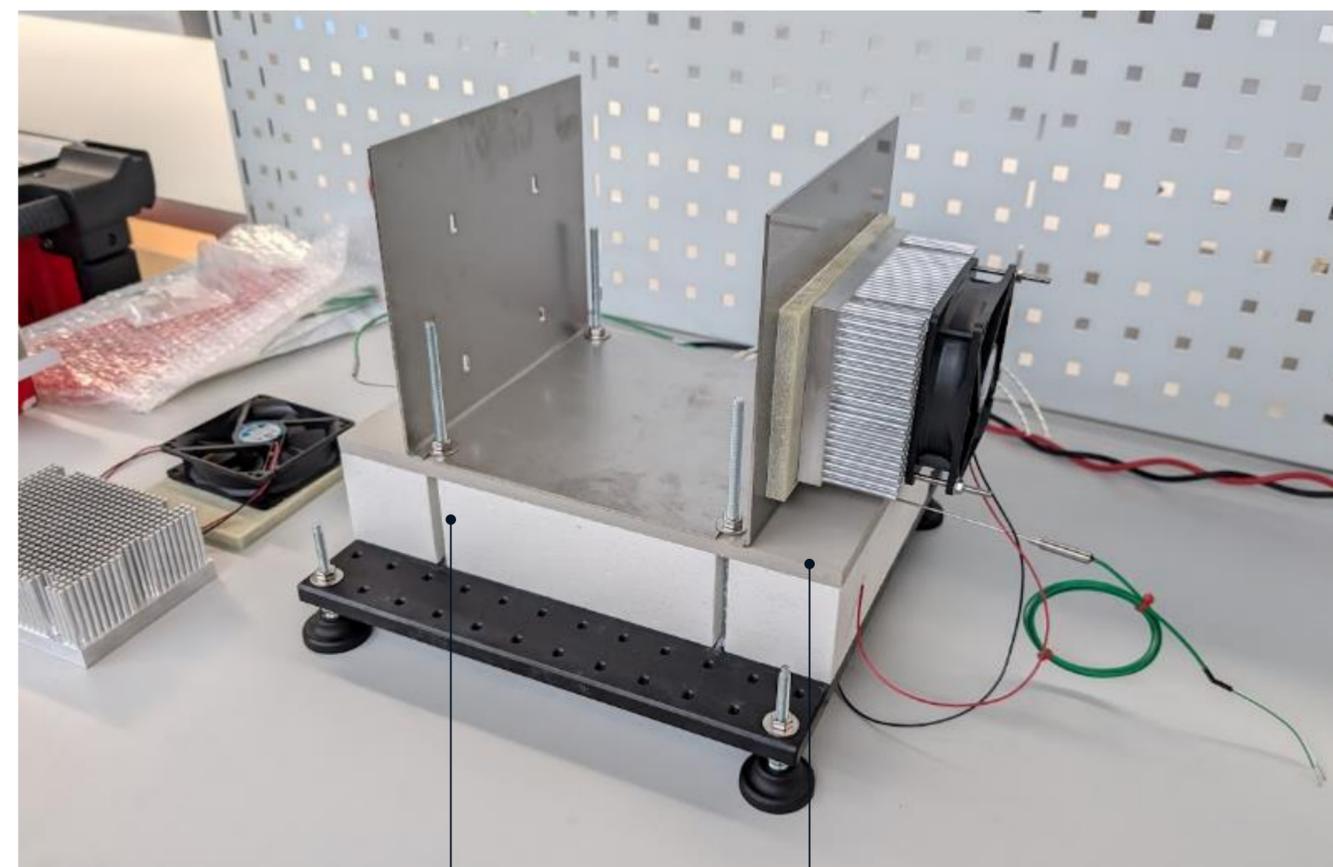
Thermal gradient : 1000K
Distance : 20mm



Experimental thermal insulation bench in construction to validate 900°C to RT insulation design in than 10 mm



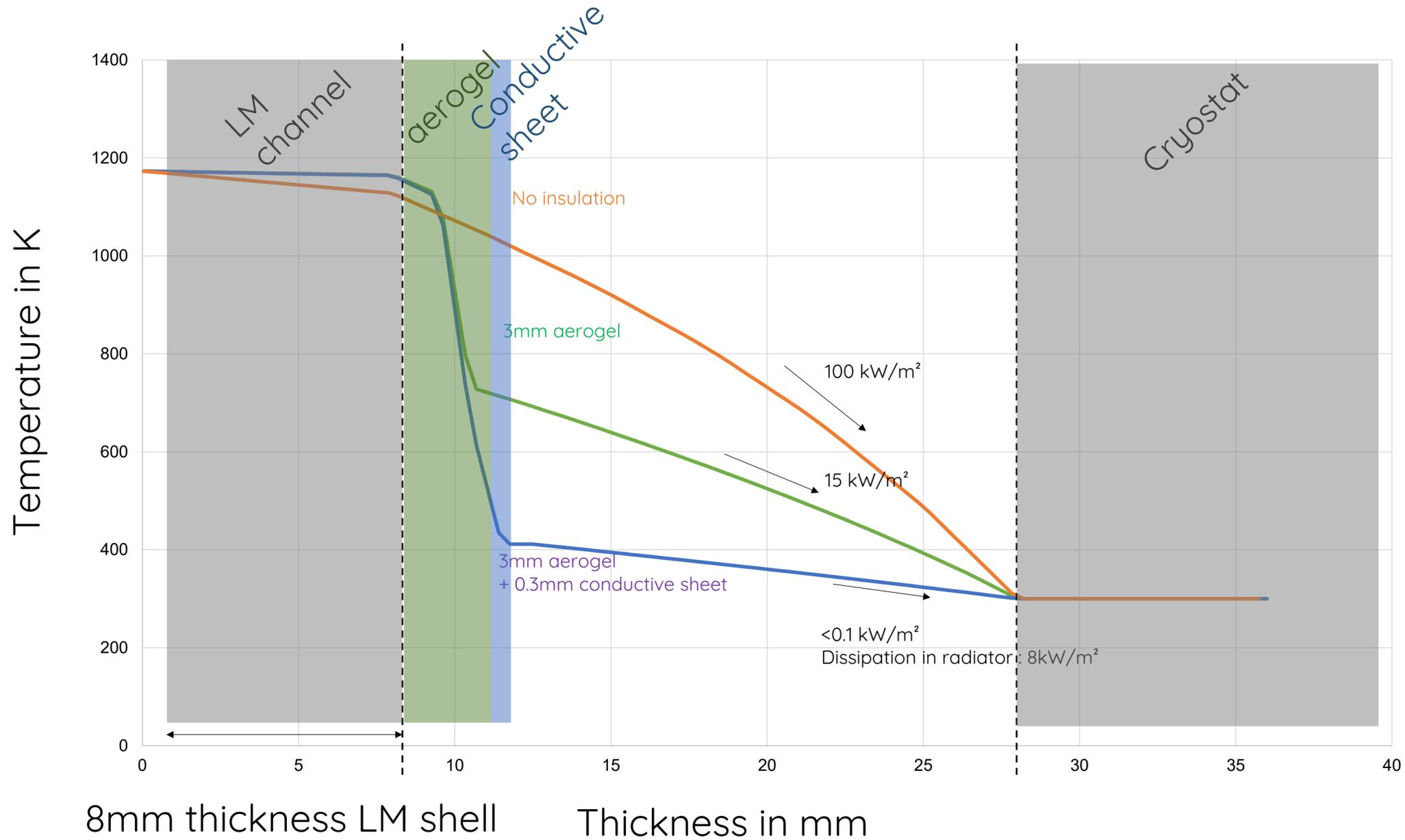
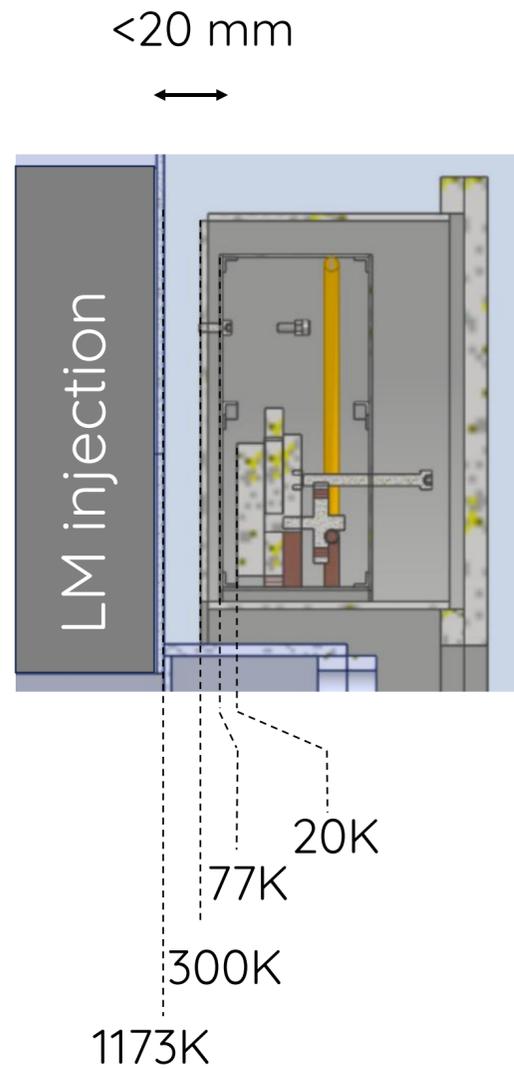
Thermal insulation test bench



Ceramic bed with 900 °C electric heater
10 mm aerogel insulation



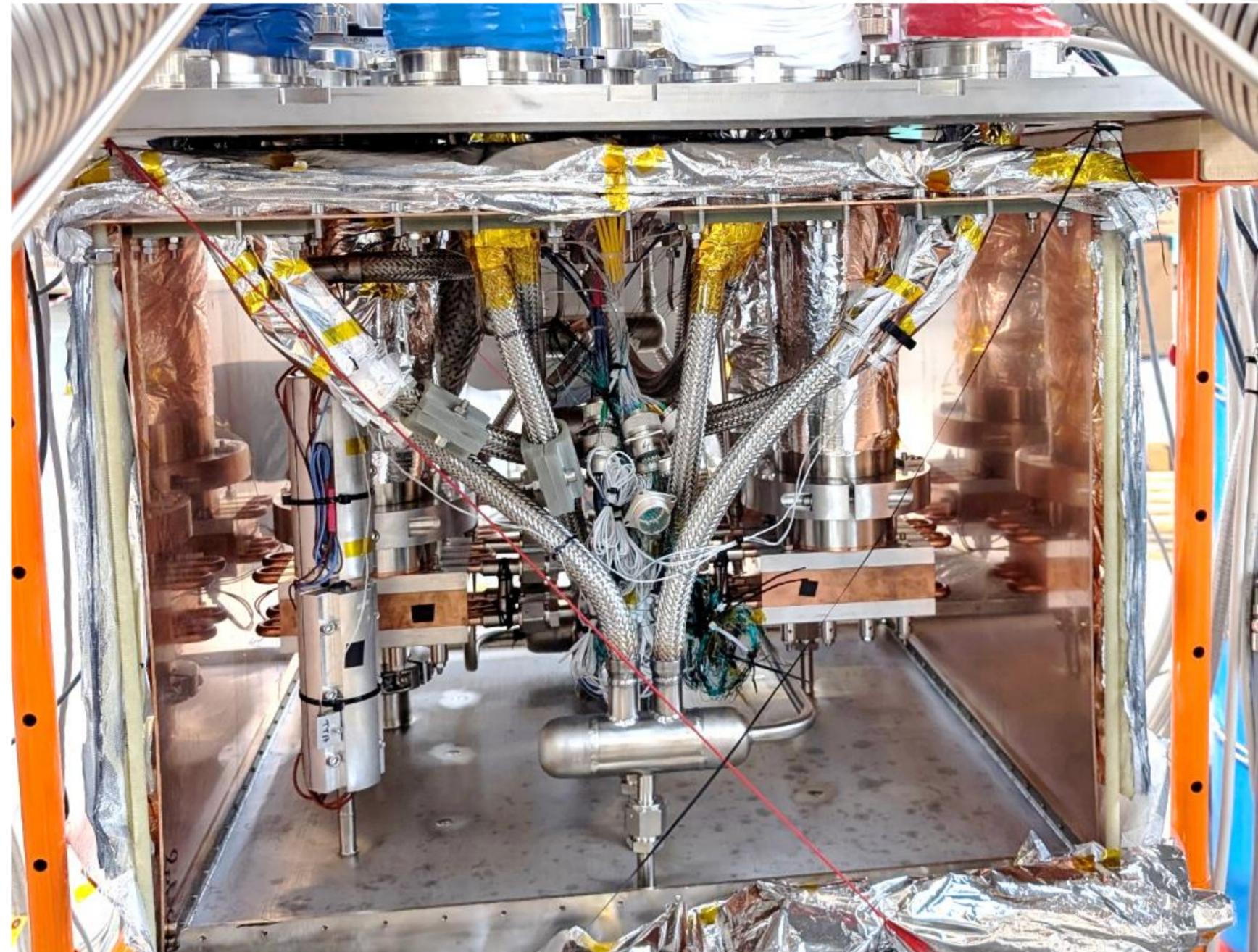
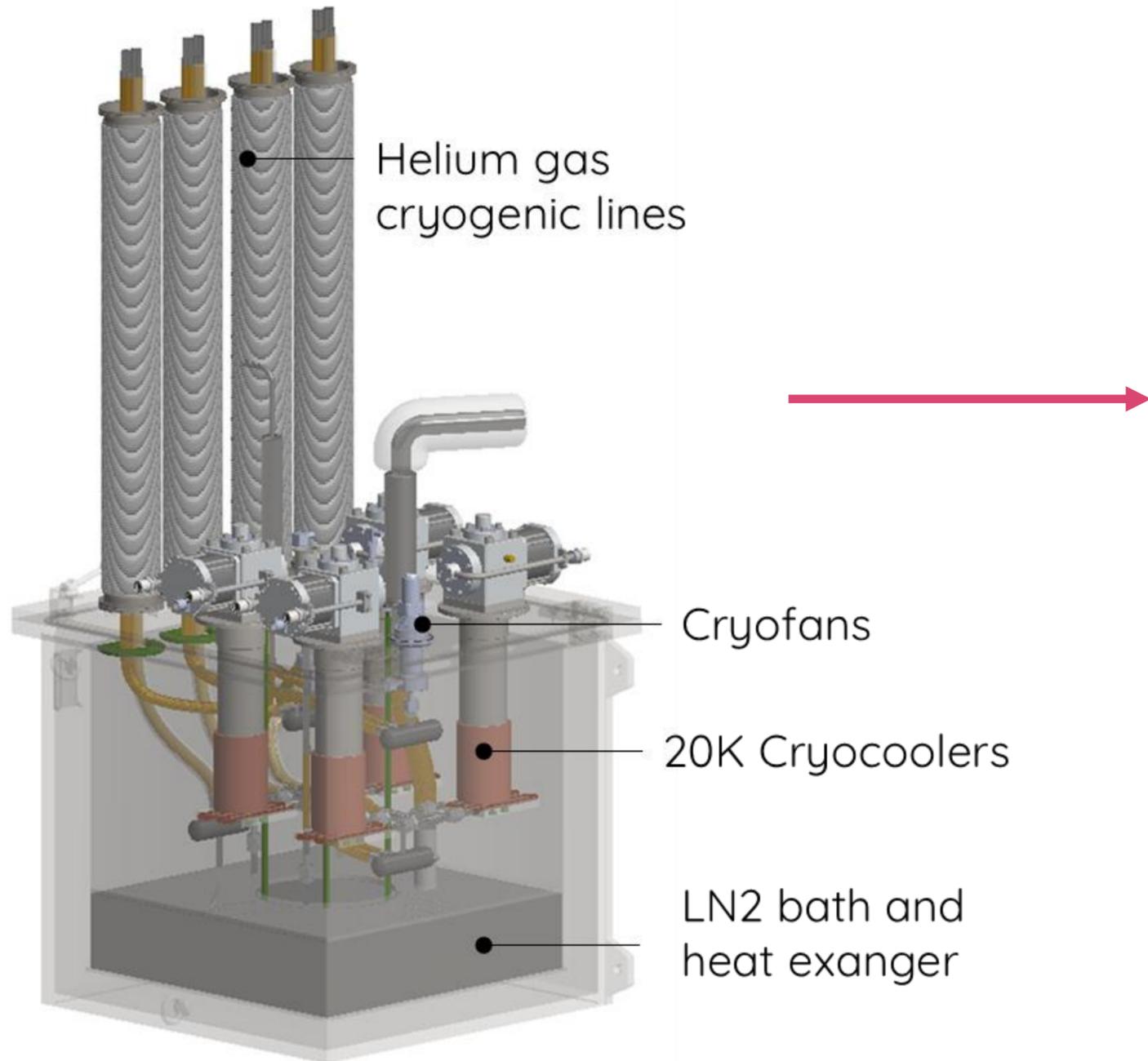
Designed insulations could reduce heat from 900°C to RT in less 20 mm



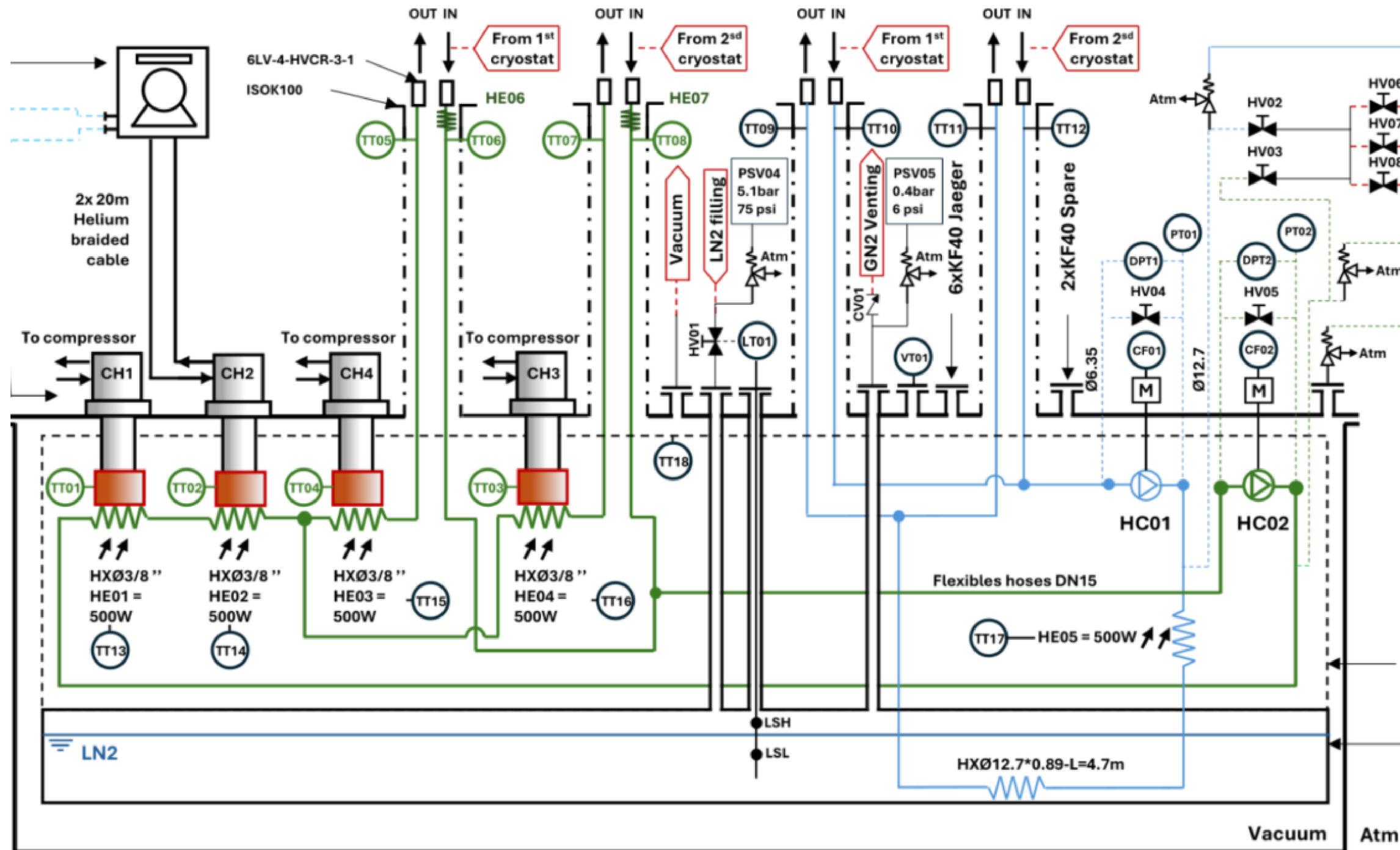
Cyostat can work in standard condition

Custom cryogenic system for magnet cooling

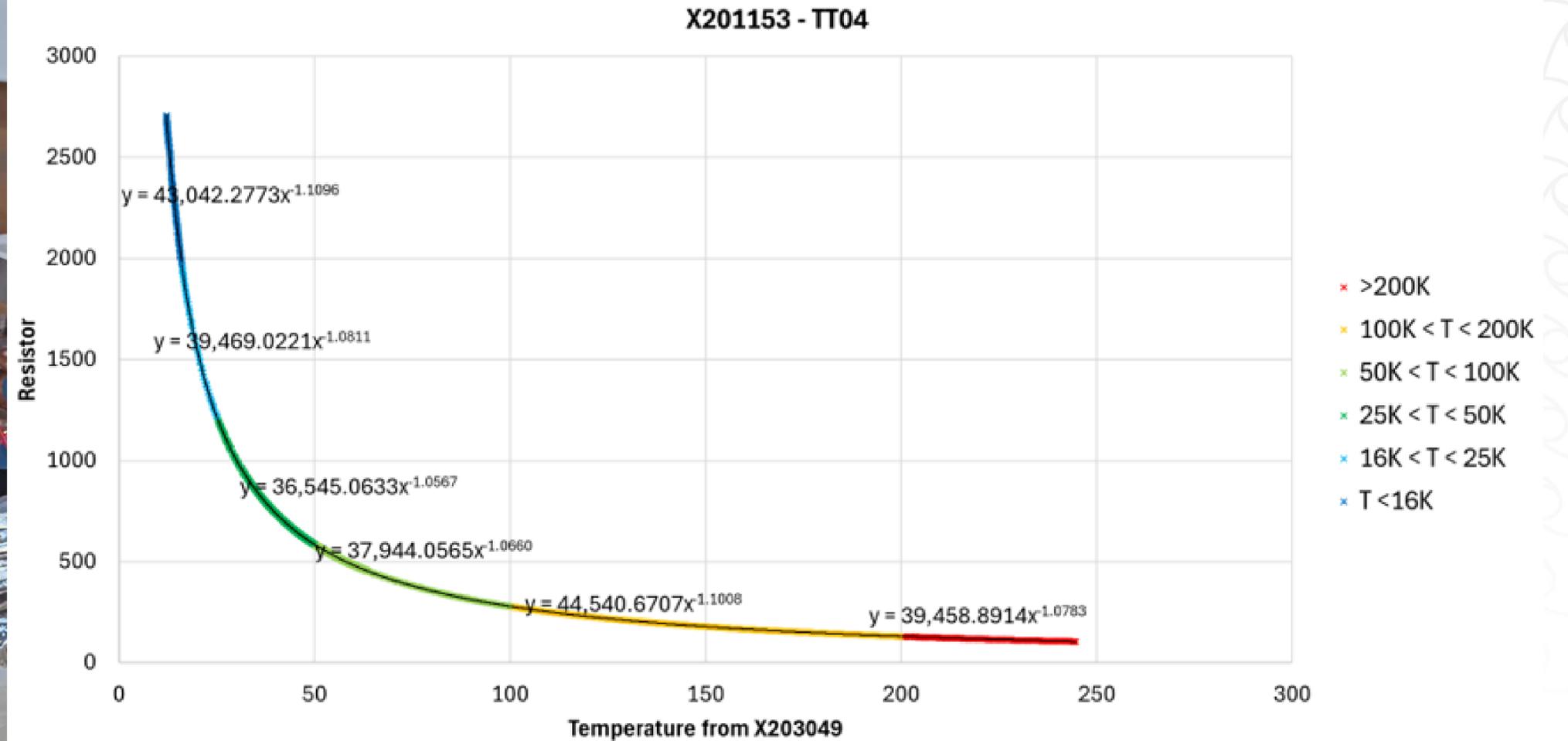
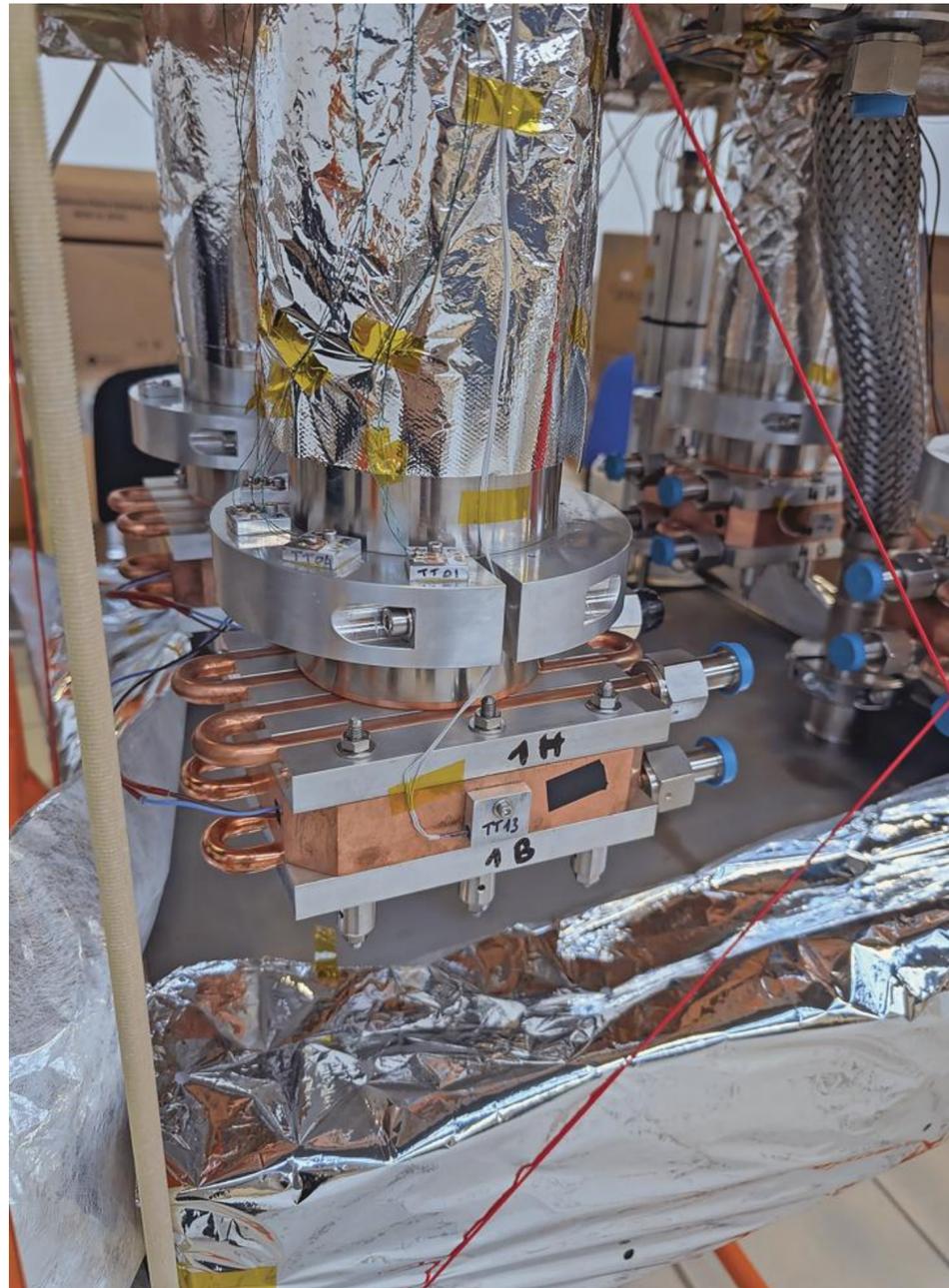
CRYOBOX : Main principle



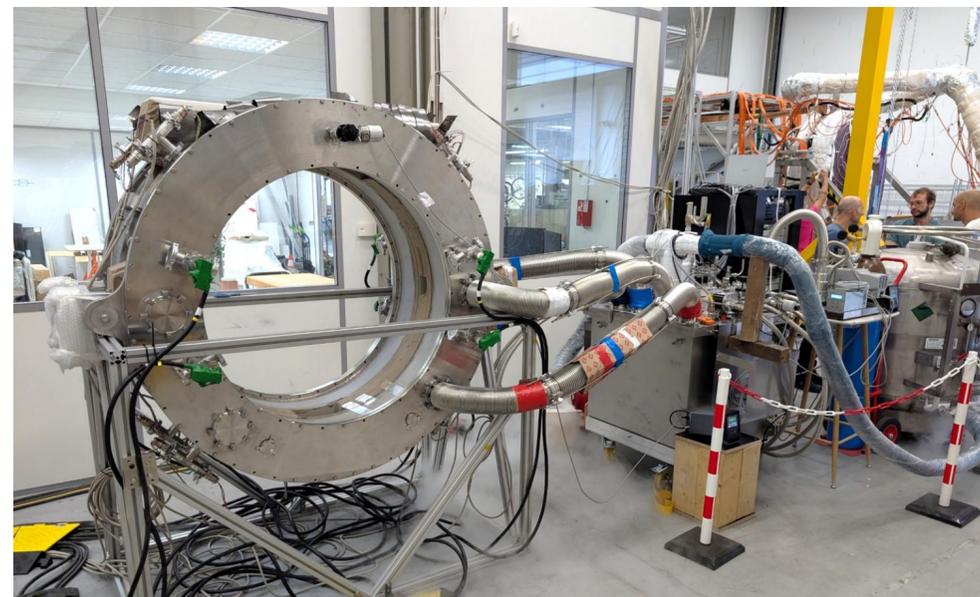
CRYOBOX : 2 helium circuits in parallel



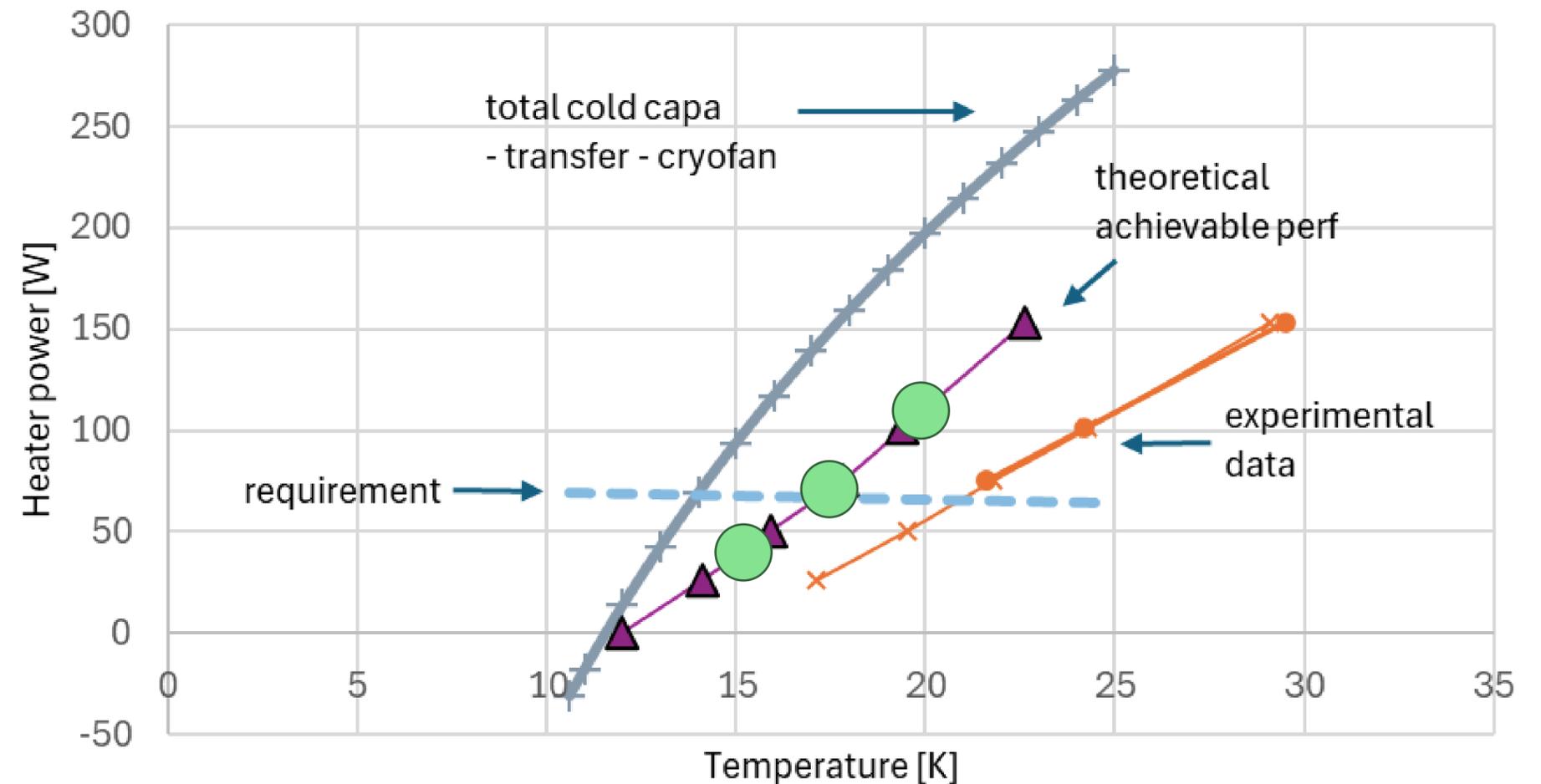
Testing of Cryobox : Calibration of sensors



Testing of Cryobox : Power curves



Cold capacity vs fan speed



Initially Measured cooling power @20K was lower than anticipated
Full cold power unlocked after improving cold head thermal contact:
120 W available at 20K
17K Achieved during magnet cooling

Thank you!



Thomas Charignon | renfusion.eu