Babcock Noell GmbH

JÜLICH FORSCHUNGSZENTRUM

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Design, Manufacture and Testing of a Pair of Superconducting Solenoids for the Upgrade of the NSE Spectrometer J-NSE at the Research Reactor FRM II

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Outline

Introduction to NSE

Design concepts

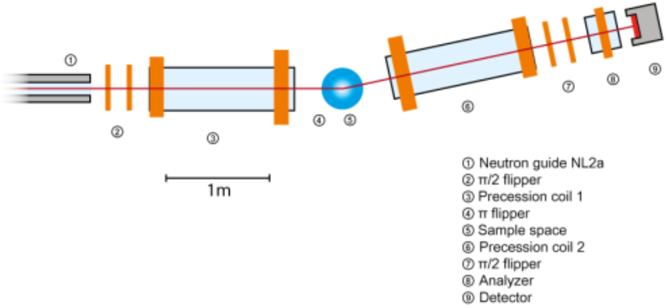
Manufacturing

Performance

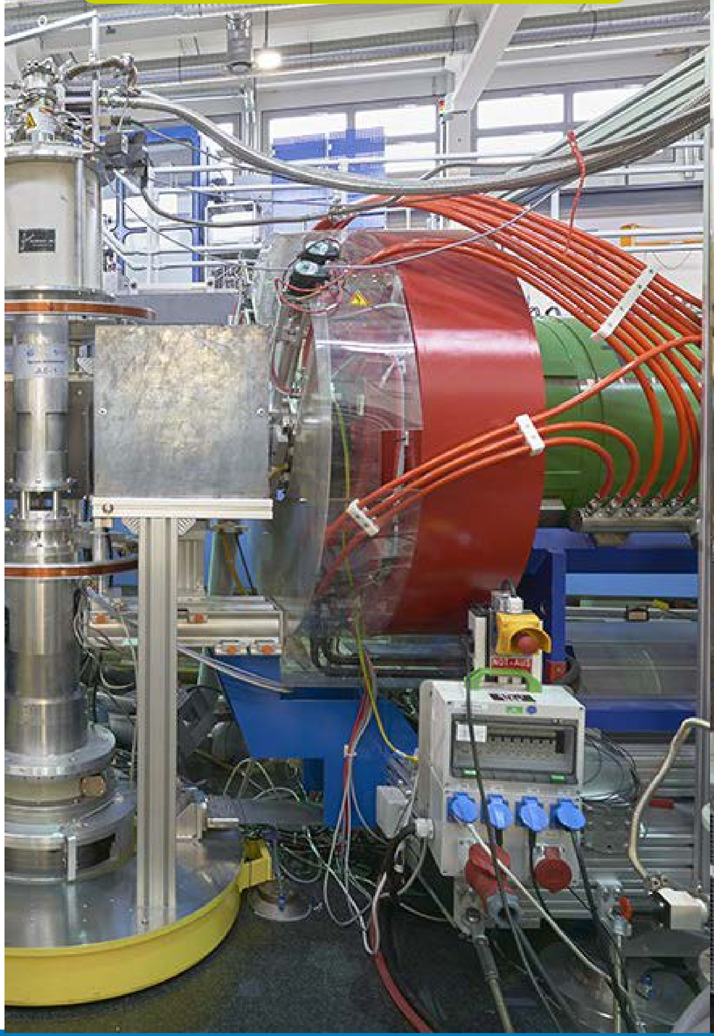
Conclusion

Introduction

Neutron Science



J-NSE at MLZ in Garching
1996-2016



SC NSE at SNS in Oakridge
2008-2017

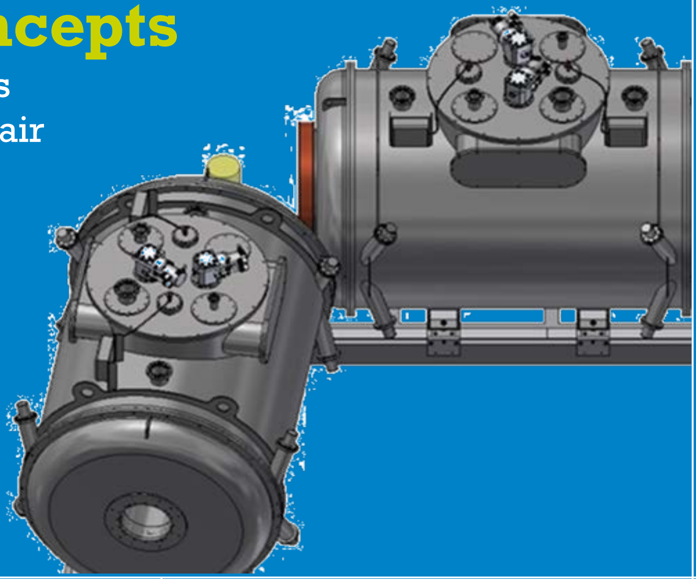
Typical applications*:

- Thermal fluctuations of surfactant membranes in microemulsions
- Polymer chain dynamics in melts
- Thermally activated domain motion in proteins

*O. Holderer et al., J-NSE: Neutron spin echo spectrometer, Journal of large-scale research facilities, 1, A11 (2015)

Design Concepts

Special requirements
For a NSE magnets pair



Low vibrations

Use of Pulse tube cryocoolers with weak connection to the coils to minimize the impact of vibrations on field stability thus on the experiments.

Low permeability

Minimize the impact of magnetization on the experiment. Use of aluminum formers and low permeability steel for cryostat.

Conduction Cooled

The use of cryocoolers allows operation in absence of a cryoplant.
This is a major feature when operating in a radiation controlled area

Identical twins

The two magnets must provide the same field integral and profile for the experiments to be successful.

Active shield

Active shielding is required to magnetically decouple the two magnets.

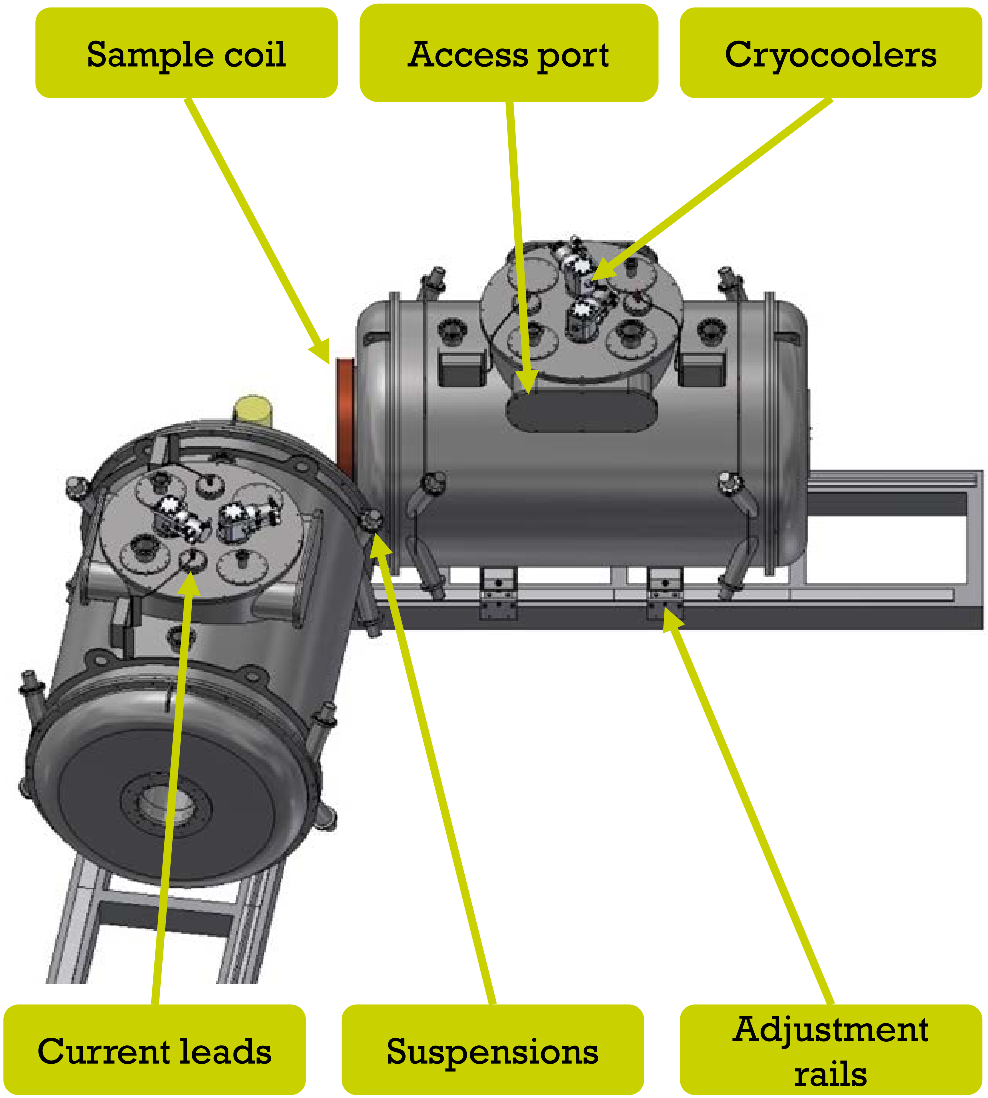
Quench safe

With 10 coils per system in series, a proper quench concept is required to minimize mechanical stresses.

J-NSE Specs

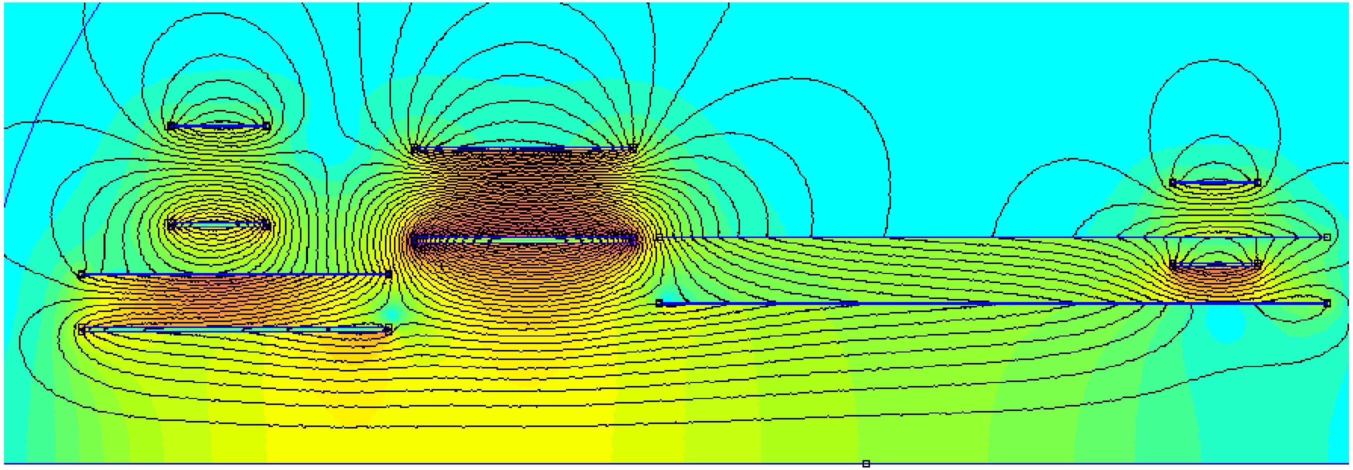
Main Parameters

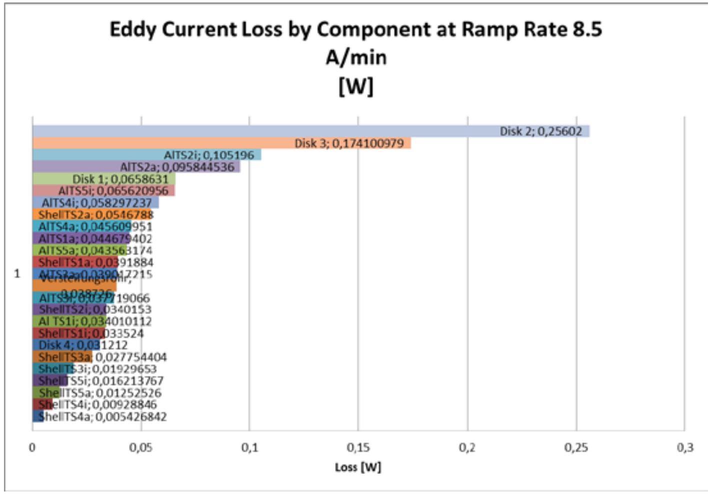
	NC	SC	Units
Warm bore diameter	310	320	mm
Cold mass length	-	2.2	m
Cold mass diameter	-	1.2	m
Device length	2.2	2.5	m
Maximum current	440	220	A
B Field on axis	0.3	1.2	T
B Field integral	0.5	1.5	Tm

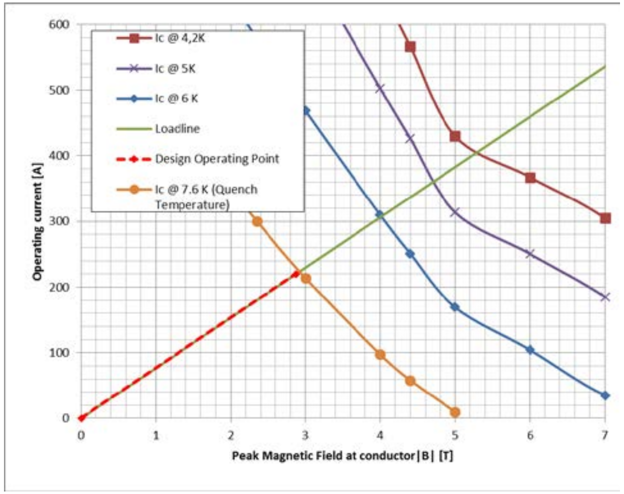


J-NSE Design

Electromagnetic



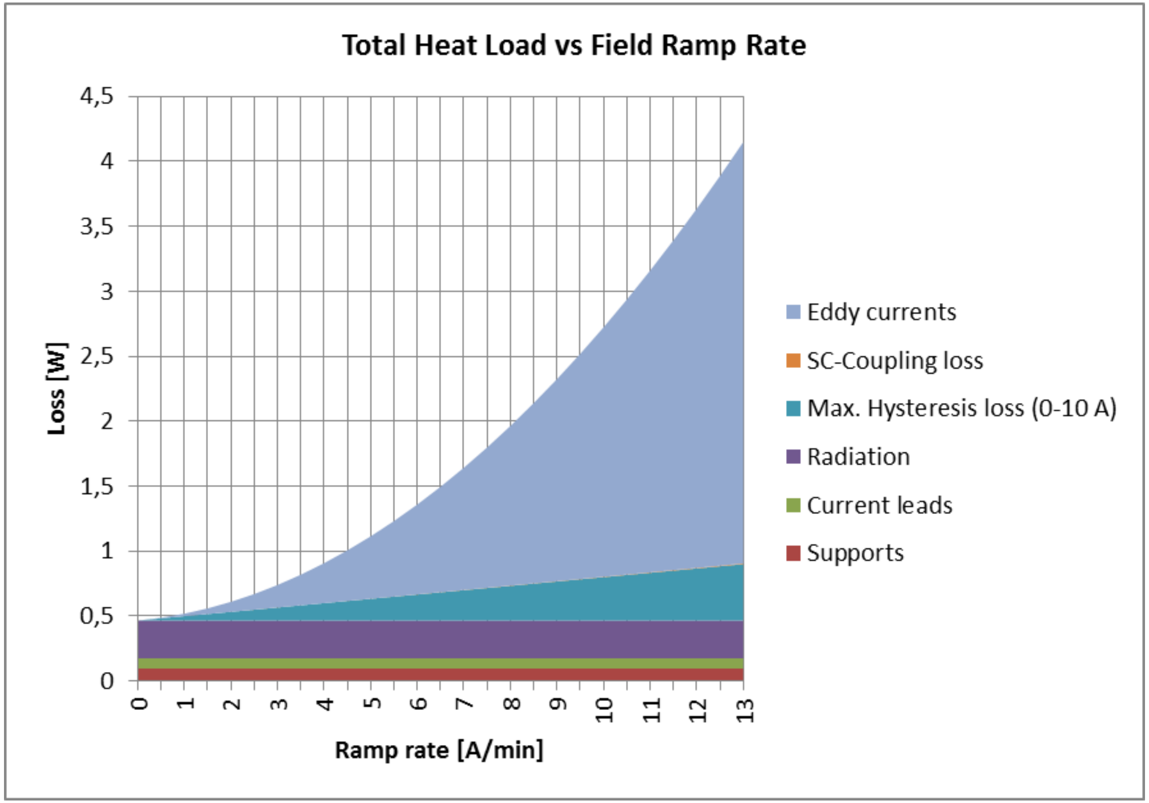




- 5 couples of field and shield coils
- 0.8 mm diameter SC wire with 6 μm filaments to minimize hysteresis effects
- Peak field on conductor 2.87 T at 220 A
- Loadline percentage of 54% at 4.2 K
- Al formers required accurate eddy current analysis to minimize heat loads during ramps

J-NSE Design

Thermal



2 PT cryocoolers with 1.5 W q 4.2 K each

HTS leads to minimize heaload at 4.2 K

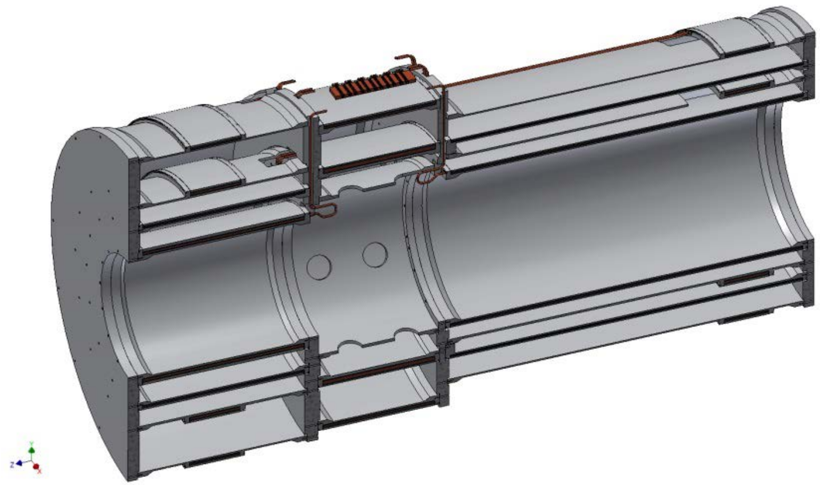
Al5N used to transport the heat from coils to cold heads while minimizing gradients

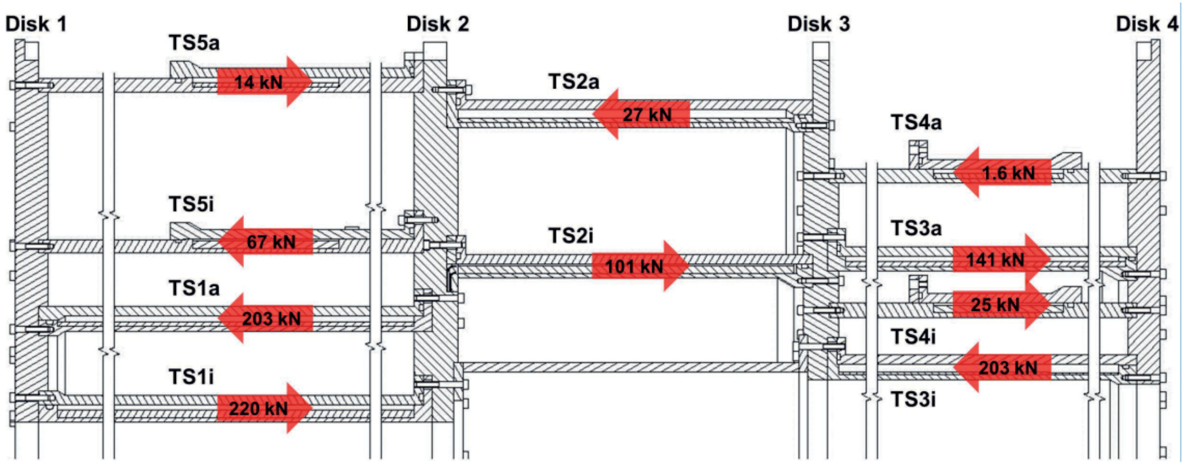
25% margin on the heat load at nominal 8.5 A/min ramp rate

The ramp rate is limited by eddy currents in the system

J-NSE Design

Mechanical - quench





Full aluminum former manufactured with high tolerances

Forces up to 220 kN in case of quench

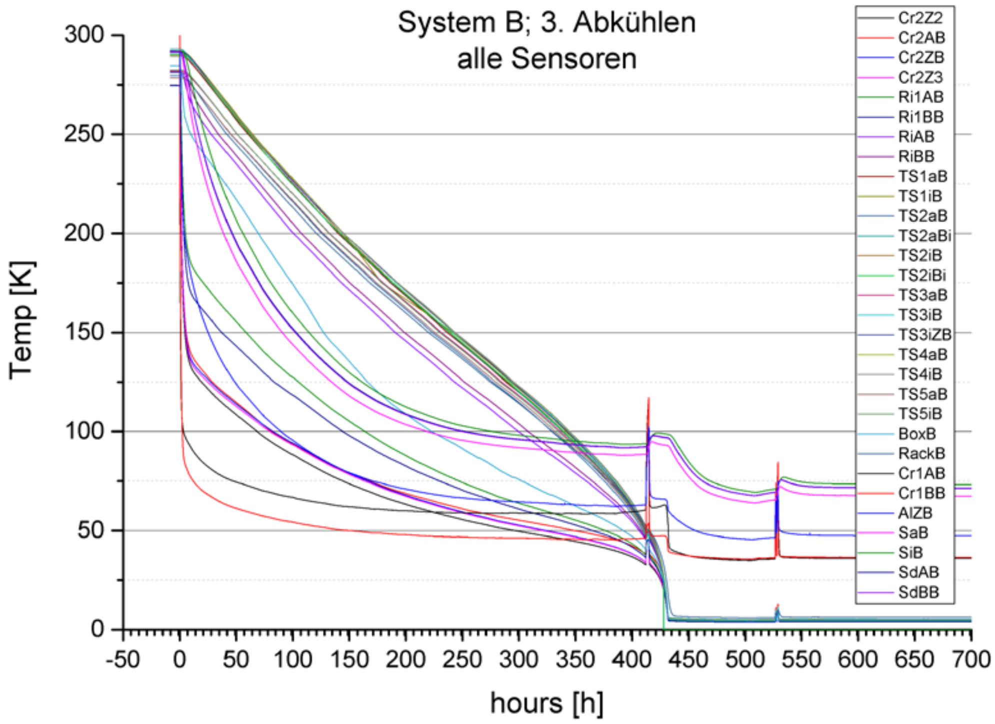
Cold diodes for quench protection

Coils vacuum pressure impregnated

Manufacturing Process

Performance

Results of the Factory Acceptance Tests



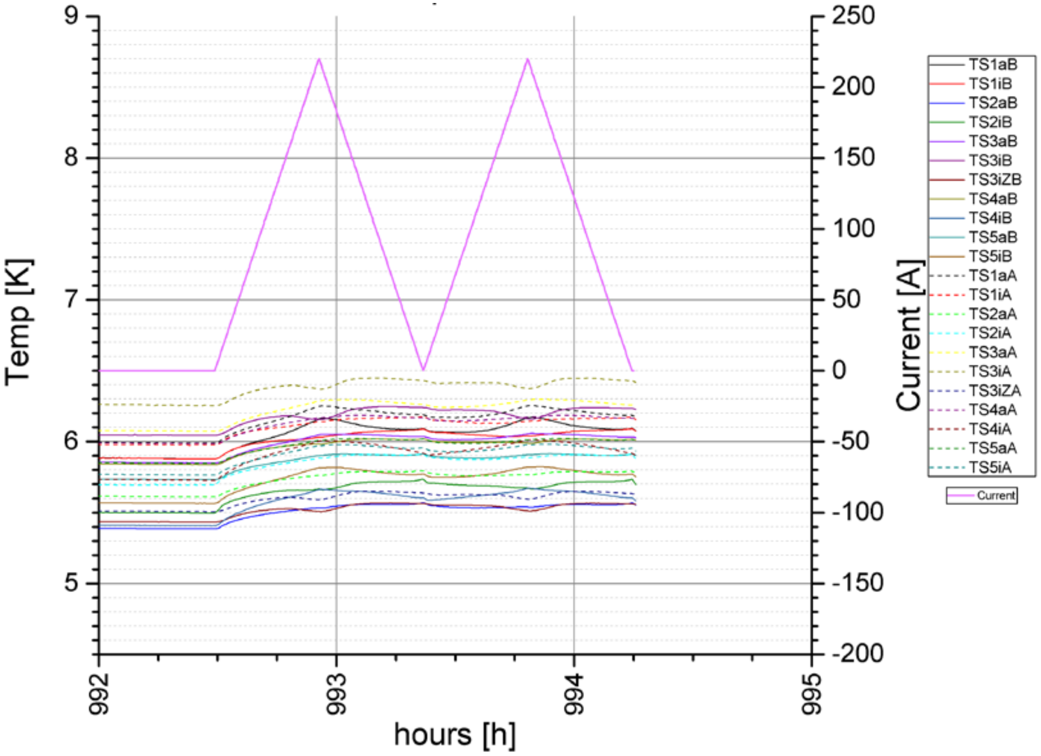
Cooldown

Minimal temperature drift during ramping

B field profile

Performance

Results of the Factory Acceptance Tests



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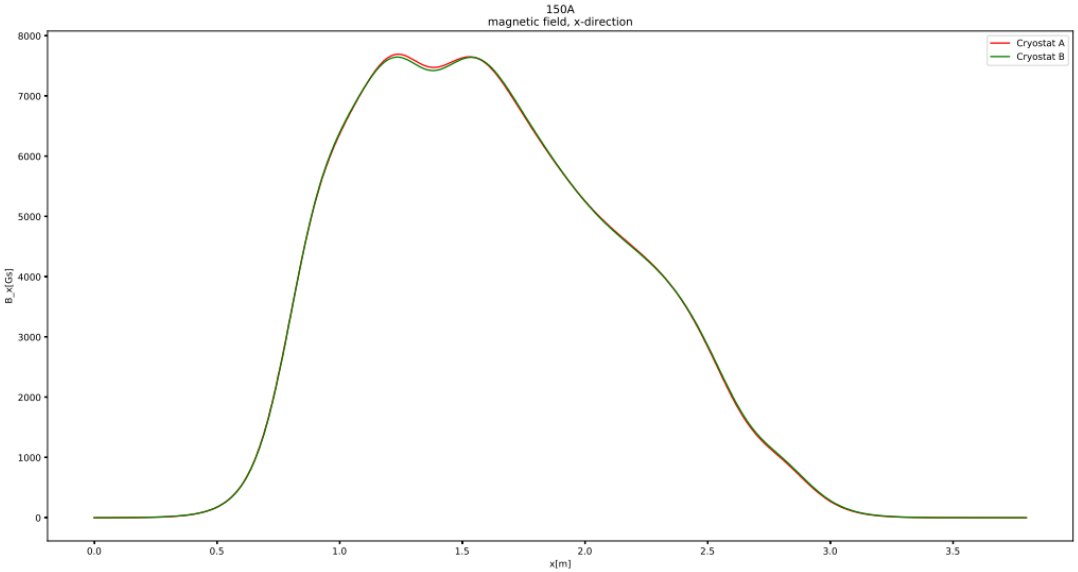

Cooldown

Minimal temperature drift during ramping

B field profile

Conclusions

HIGH PRECISION

Precisely machined aluminum formers design

LOW PERMEABILITY

Low permeability materials successfully implemented

PLUG'n PLAY

No liquid helium inventory required

QUENCH SAFE

Quenchs are easely recovered by the system

DELIVERED

The system is now installed at FRM II

Thank you for your attention