Pushing CW beam current limit of TESLA SRF Cavities with Nb3Sn and NbTiN Coating of the HOM Antennas

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Thin Films SRF 2022, 19-23.09.2022

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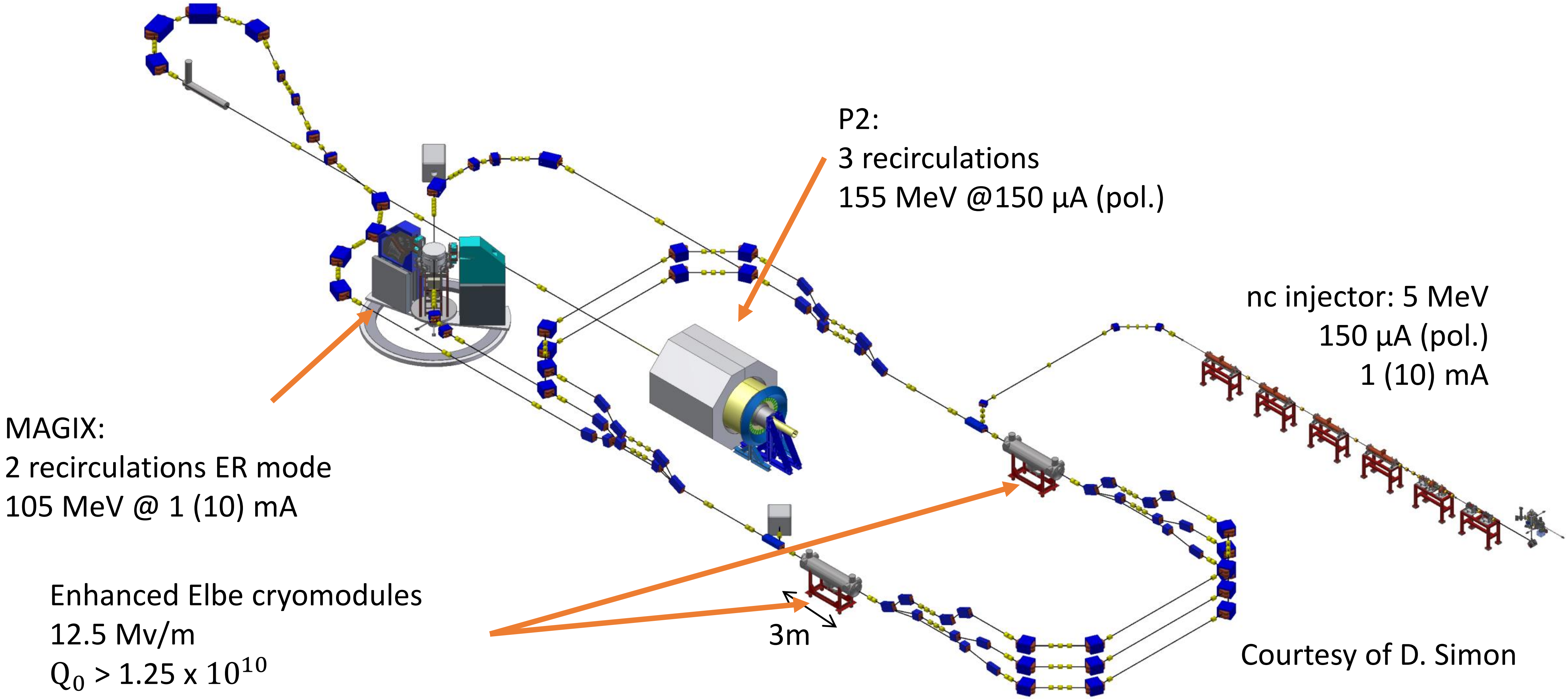
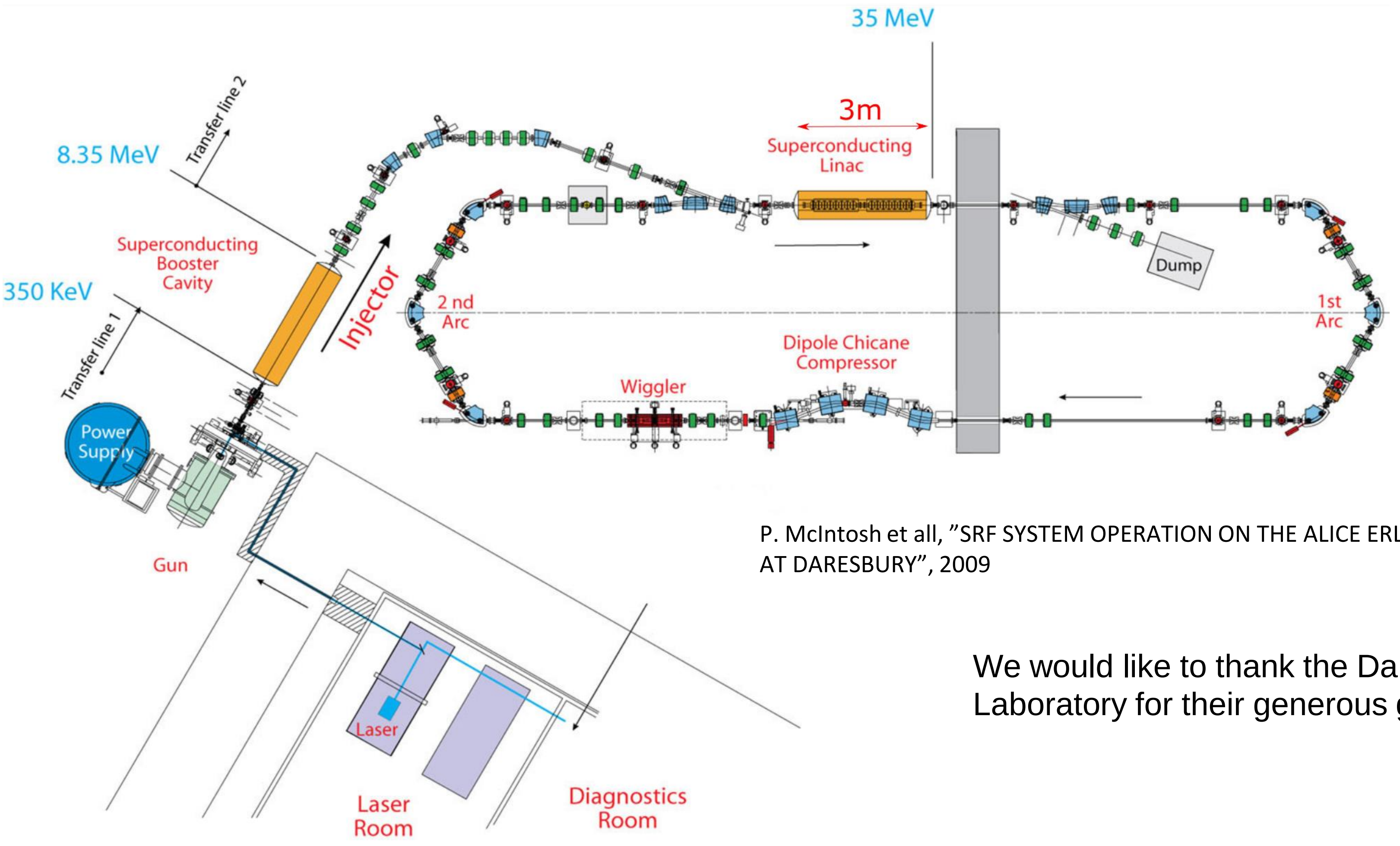
- MESA & ALICE using ELBE-type cryomodules
- Refurbishment of SRF cavities at HIM
- Coated HOM antennas for MESA
- Summary & Outlook

Mainz Energy-recovering Superconducting Accelerator



Accelerators and Lasers in Combined Experiments

Injector	8 MeV
CM	26.65 MeV
Beam	35 MeV @13 µA
Q_0	$5 * 10^9$
f	1.3 GHz
Time in operation	2005 - 2016

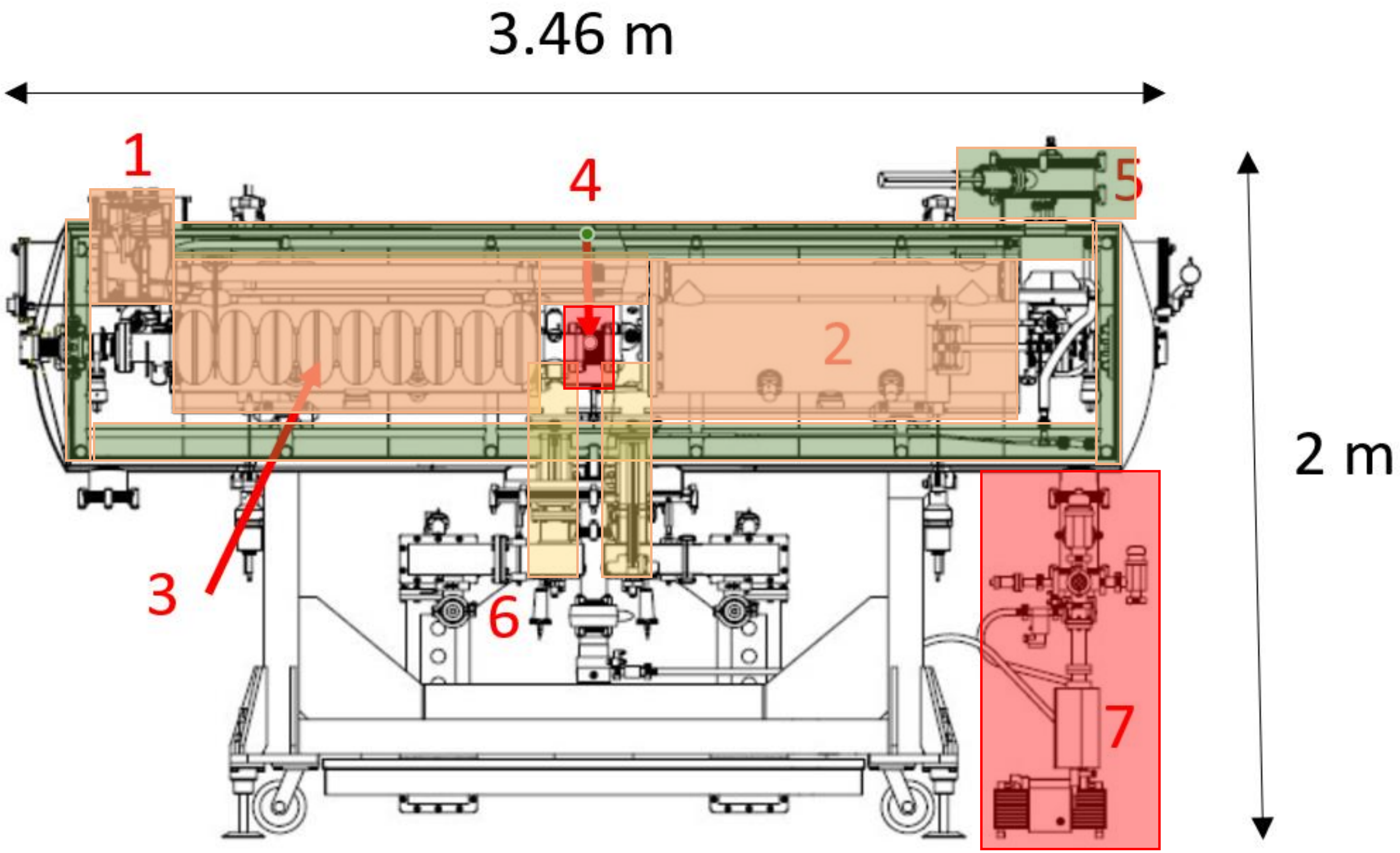


P. McIntosh et all, "SRF SYSTEM OPERATION ON THE ALICE ERL FACILITY AT DARESBURY", 2009

We would like to thank the Daresbury Laboratory for their generous gift.

ELBE-type cryomodule

1. Helium port
2. Titanium Helium tank (1.8 K)
3. 9-cell 1.3 GHz Nb TESLA cavities
4. Bellow between the two cavities
5. Nitrogen port (77 K liquid N)
6. RF couplers
7. Vacuum pump



A. R. Goulden et all, „INSTALLATION AND COMMISSIONING OF THE SUPER CONDUCTING RF LINAC CRYOMODULES FOR THE ERLP “, 2008

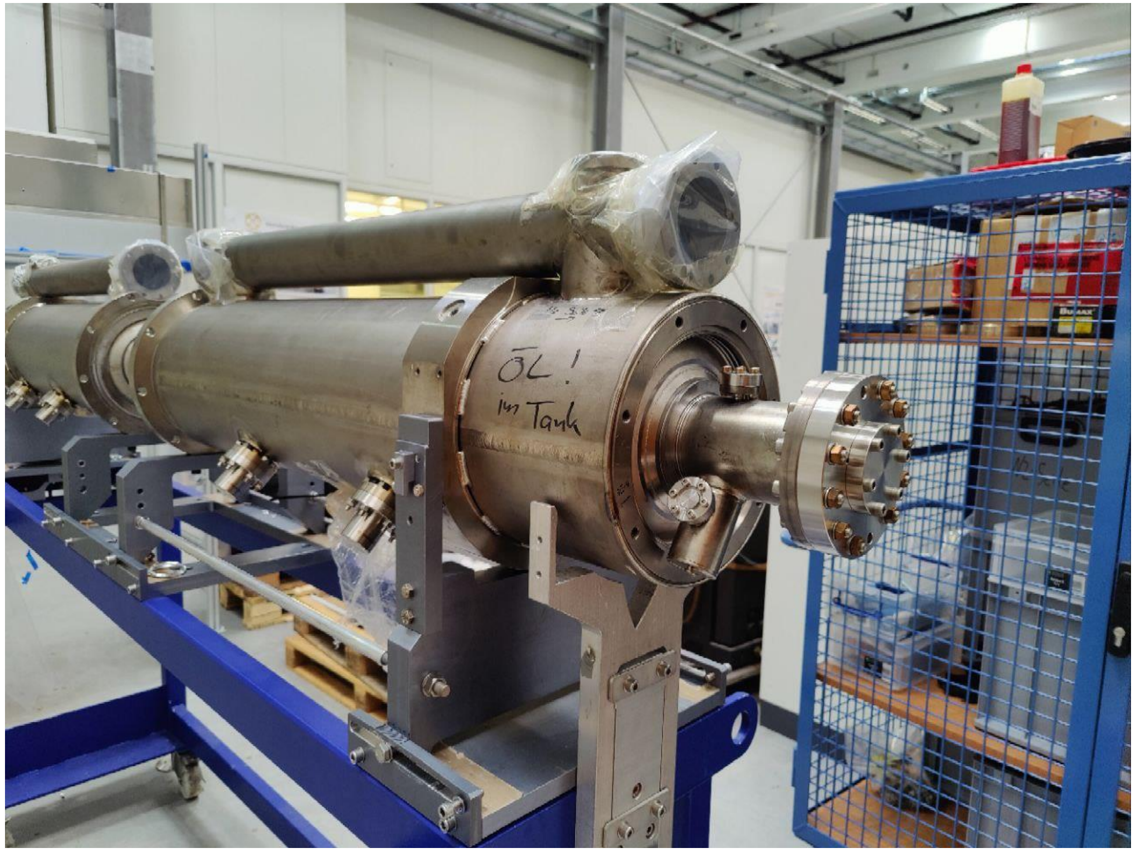
Refurbishment of the ALICE module

MESA Enhanced ELBE-type Cryomodules (MEEC):

- Helium port (Joule-Thomson valve)
- Faster DESY/Saclay tuner (higher beam currents)

  → diameter of Helium tank changed
- New HOM antennas
- Cavity contamination leads to field emission @7 MV/m

→ Clean room treatment!



Clean room infrastucture at HIM

Personal entrance (ISO 6)

Material entrance (ISO 7)

Clean room 1 (ISO 6)

Ultrasonic bath (USB) system

High pressure rinse (HPR)

Personal airlock

Material gate

Clean room 2 (ISO 4)

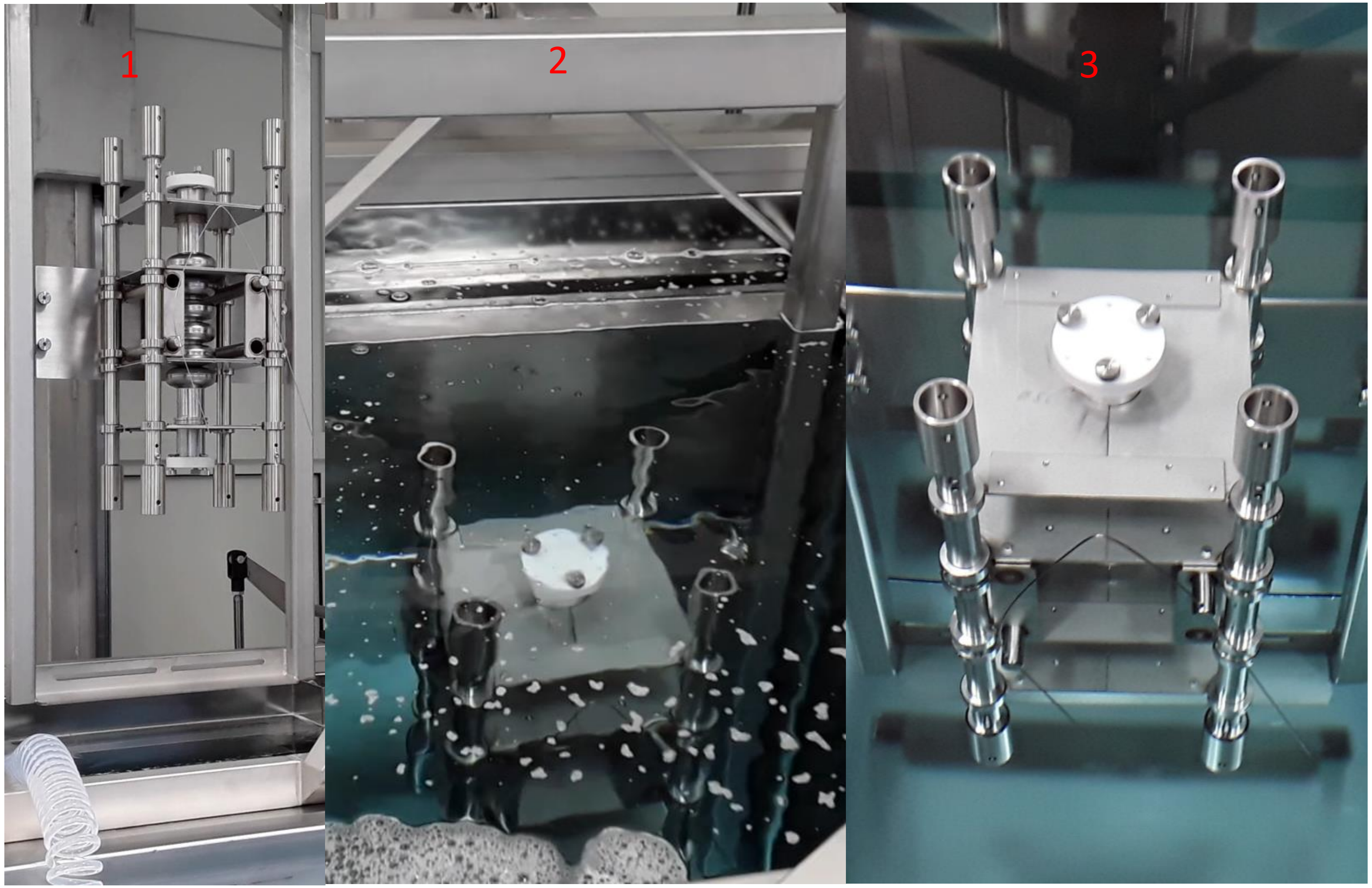
Cavity handling in the clean room - USB

(1) Cavity on the robot arm

(2) USB with 5% Tickopur and T = 40°C

(3) rinsing with ultra pure water

→ Outer surface is particle and oil free



Cavity handling in the clean room - HPR

(1) HPR setup lance moving vertically; cavity rotates around

(2)Cavity after 2 days drying in clean room 2 (ISO 4)

HPR:

- 1h duration
- up to 100 bar

→ Cavity brought to Darmstadt
→ Successful treatment!

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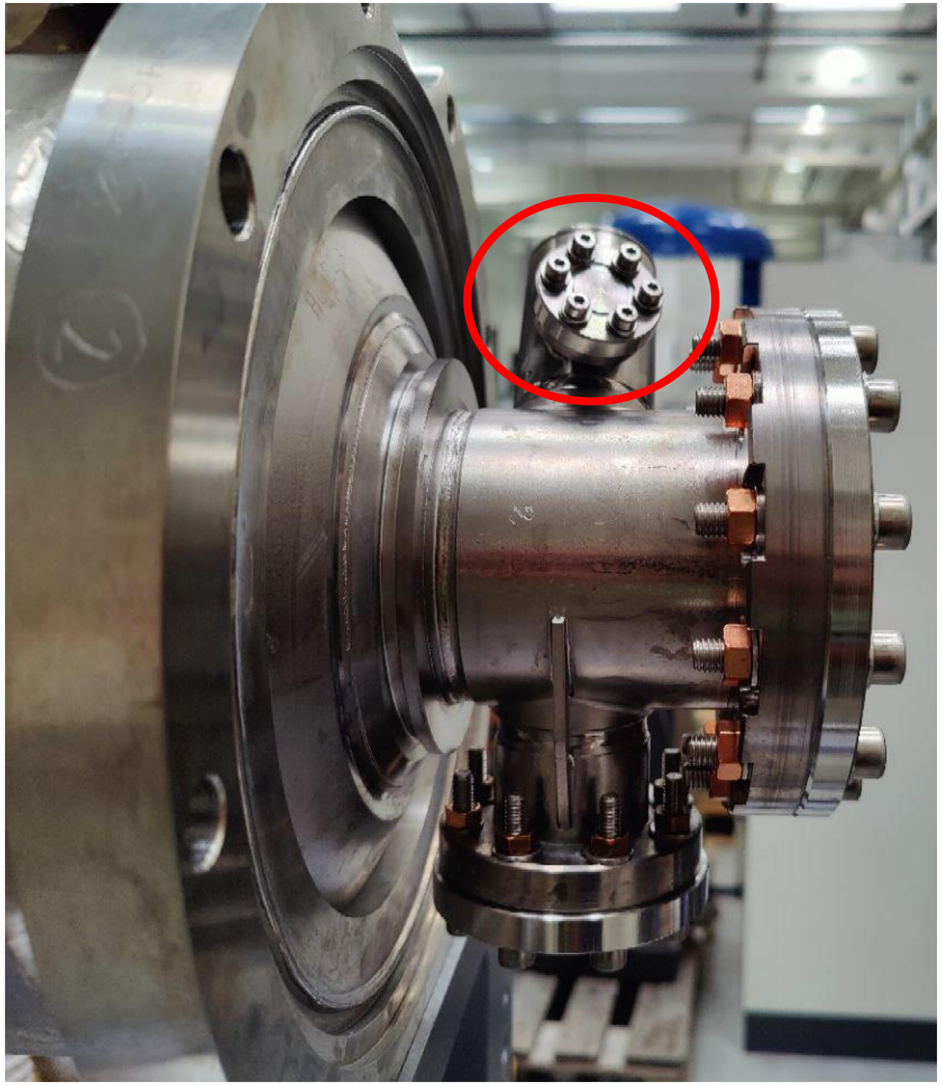


HOM Antennas

Left:

- Design from RI
- Cyocera feedthrough with flange and antenna tip
- 25 mm tip length

Right:

- DESY Design
- 29.56 mm tip length

HOM Couplers - Simulations

Power stored in HOMs:

$$P_{HOM} = N * q * k * I$$

N: #beams; q: bunch charge; k: loss factor;

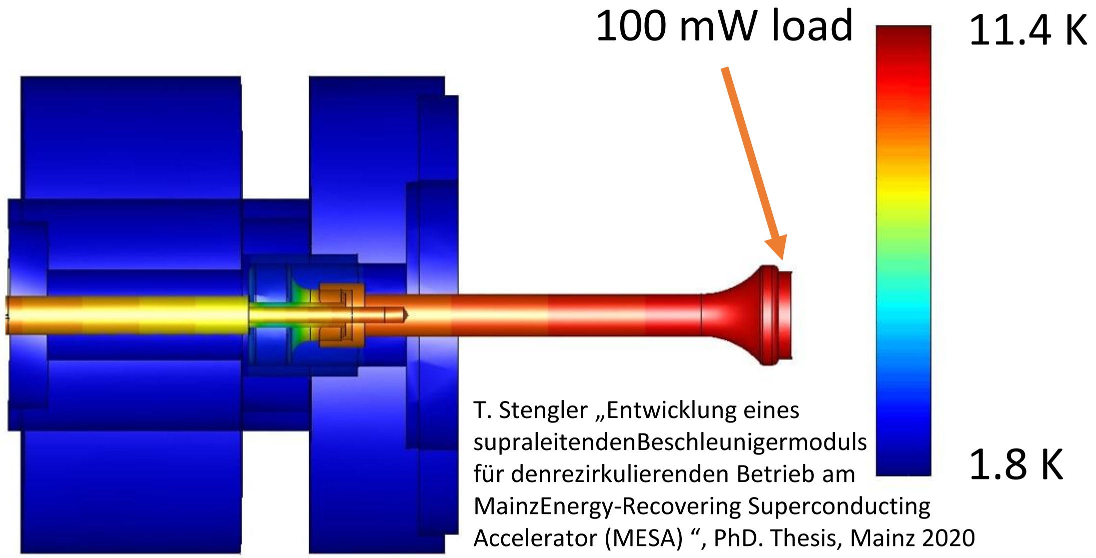
I: average beam current

→30% of P_{HOM} outcoupled by HOM feedthrough

L. Merminga, D.R. Douglas, and G.A. Krafft. High-current energyrecovering electron Linacs. *Annual Review of Nuclear and Particle Science*, 53(1):387–429, 2003.

I [mA]	q [pC]	P_{HOM} [mW]	$P_{Feedthrough}$ [mW]
1	7.7	30.8	10
10	77	3080	1000

C. Stoll "Beam dynamical behaviour of the MESA SRF structures under recirculating operation" PhD. Thesis, Mainz 2020



T. Stengler „Entwicklung eines supraleitendenBeschleunigermoduls für denrezirkulierenden Betrieb am MainzEnergy-Recovering Superconducting Accelerator (MESA) ", PhD. Thesis, Mainz 2020

HOM antenna coating with Nb_3Sn and NbTiN:
→ Better HOM damping and higher T_C

HOM Couplers - Simulation

Goal:

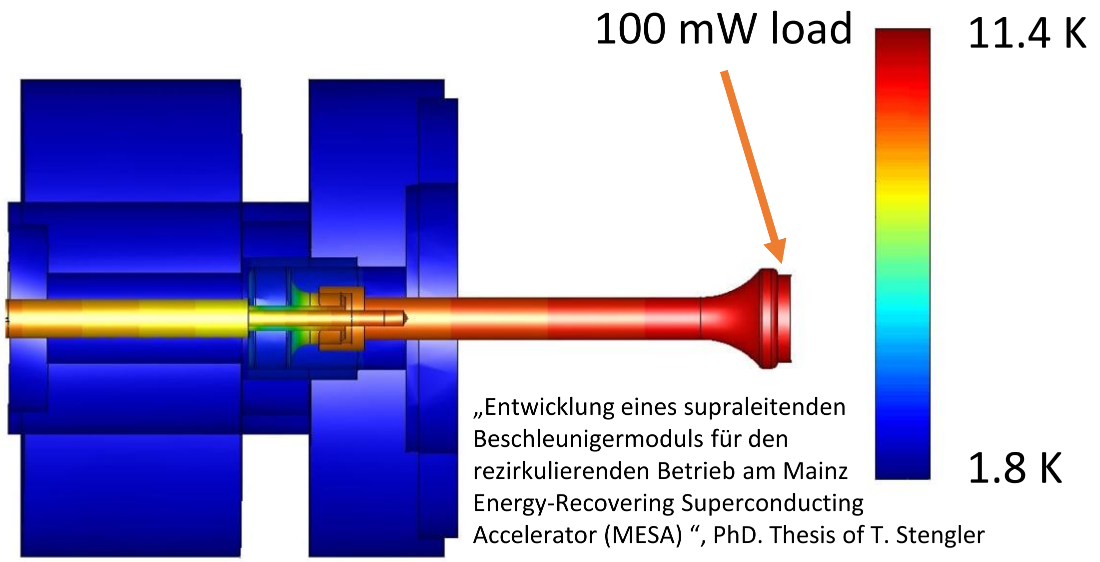
Reduce heating of HOM Antenna

→Prevent quench of whole CM

How:

Antenna coating with Nb3SN/NbTiN on Nb/Cu Antennas

Ongoing CST simulation

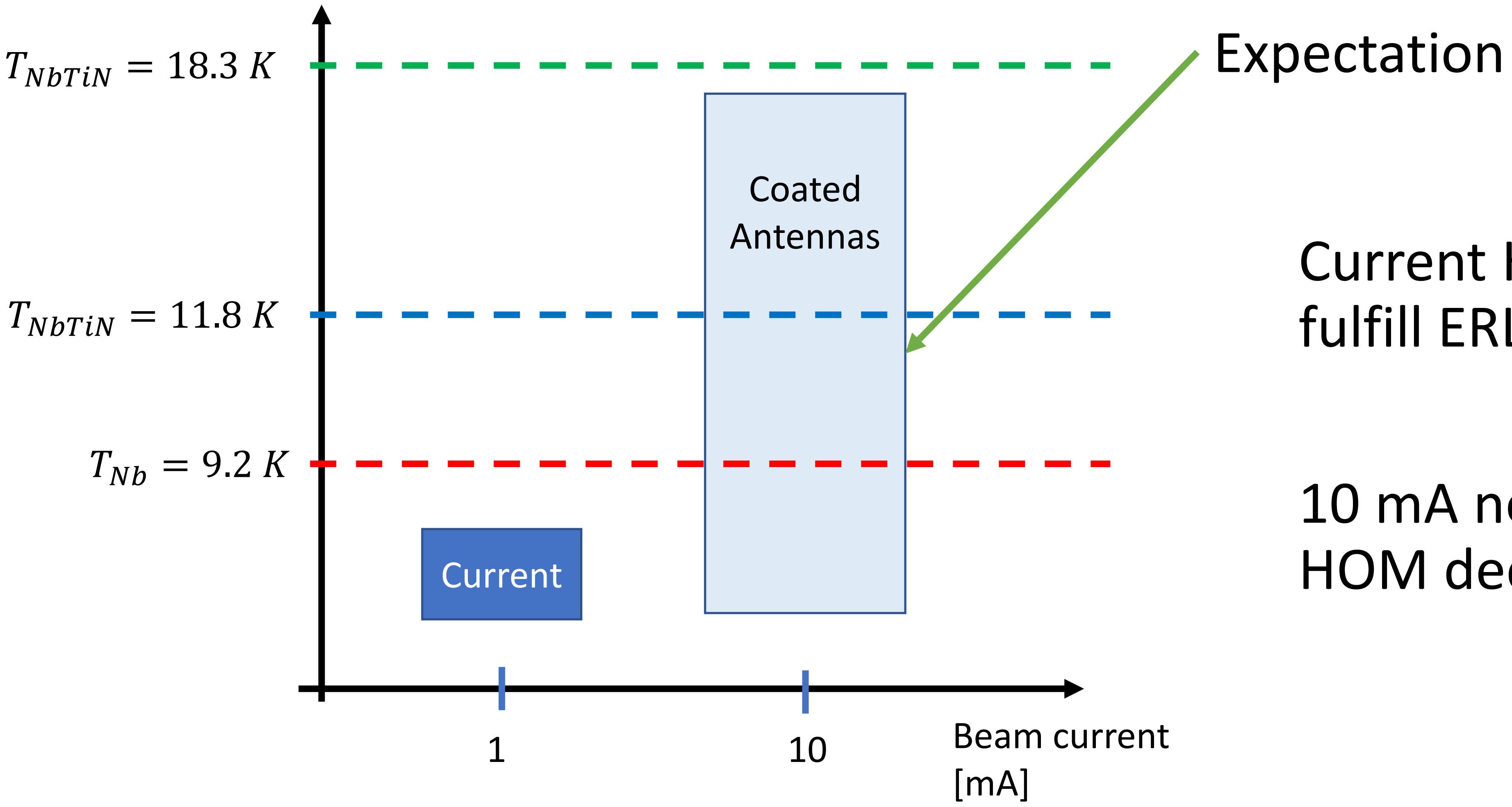


„Entwicklung eines supraleitenden Beschleunigermoduls für den rezirkulierenden Betrieb am Mainz Energy-Recovering Superconducting Accelerator (MESA) “, PhD. Thesis of T. Stengler

Property	Nb	Nb3Sn
T_C [K]	9.2	18.3
κ_0(0K)	1.4	34
ξ_0 [nm]	39	5.7
λ_L [nm]	27	65-89

S. Keckert et al 2019 Supercond. Sci. Technol. 32 075004

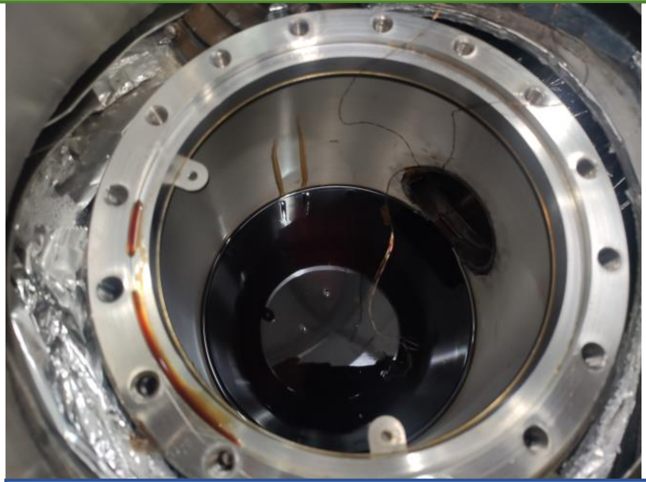
Expectation of HOM Antenna Coatings



Current HOM Antennas fulfill ERL at 1 mA

10 mA need improved HOM decoupling

Summary & Outlook



- Oil in Helium tank
- Disassembly of the ALICE Module

6 cell cavity:
- HPR treatment was successfull!

→Successfull Cavity refurbishment

2021

- HOM antennas with Nb_3Sn and NbTiN coating (Nb/Cu core)
- 2022 coated HOM antennas in Hamburg and Darmstadt

- HPR and vertical cold test in 2022
- Acetone treatment for helium tank

2022

HOM tests in ALICE module

2023+

Thank you for your attention!

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This work is supported by the BMBF through the project 05H21UMRB1

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