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SRF Activities at HIM and JGU Mainz

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IFAST
AMICI ACCELERATOR AND MAGNET INFRASTRUCTURE FOR COOPERATION AND INNOVATION
Cluster of Excellence PRISMA+ Precision Physics, Fundamental Interactions and Structure of Matter
Federal Ministry of Education and Research

Outline

- Introduction
- MESA Overview
- MESA Cryomodules
- HOM Antenna Research (TOSCA project)
- HELIAC
- Testing needs

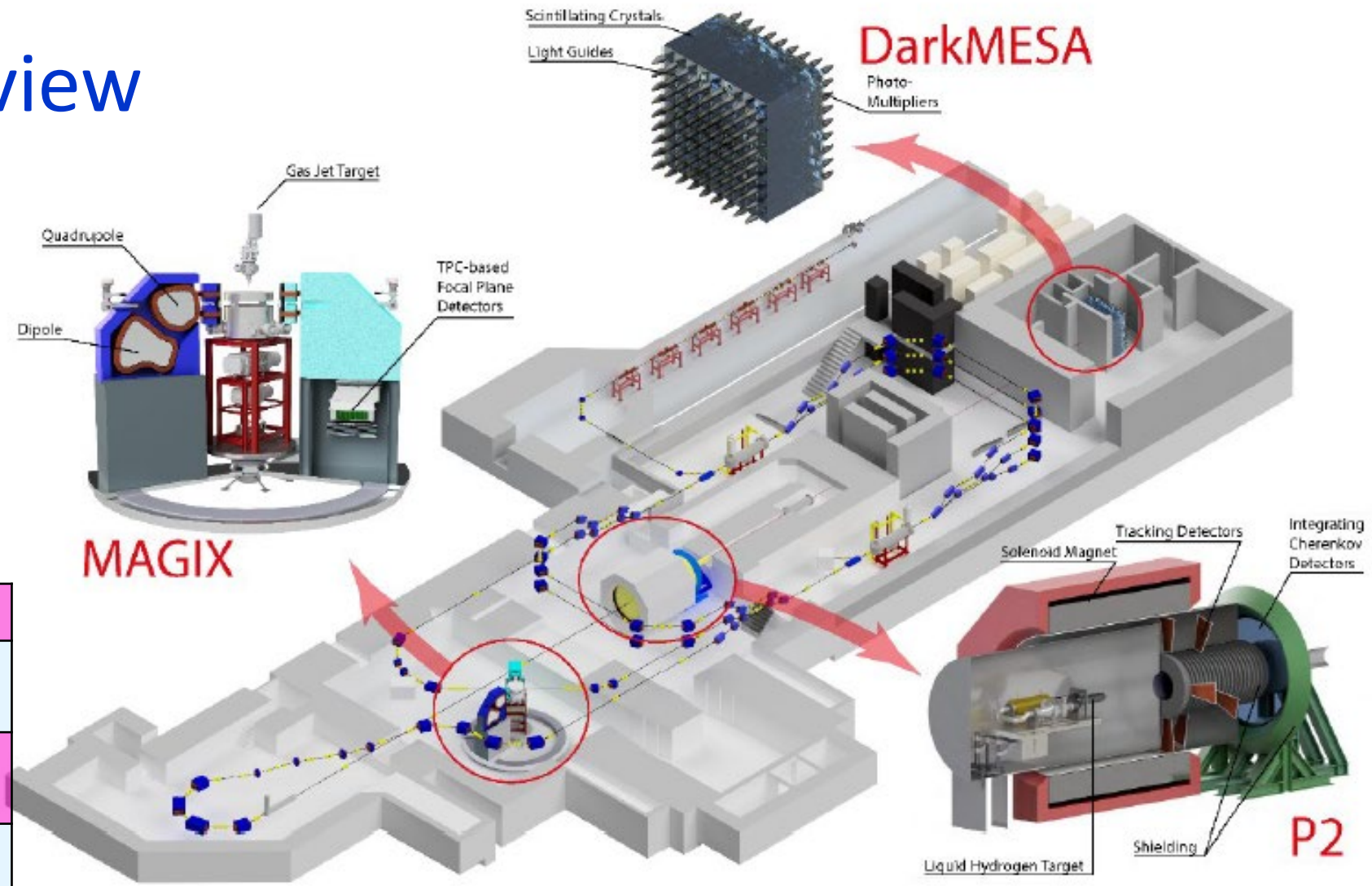
Introduction

At HIM two groups are working with SRF cavities at present:

- ACID: testing of CH-cavities for ion acceleration and cryomodule assembly for the future HELIAC accelerator at GSI

- MESA: cryomodule tests for the MESA ERL currently under construction at JGU Mainz and research on coated HOM antennas within the TOSCA BMBF project

MESA Overview



Operational Parameters

	Basic Parameter
max. beam energy	105 MeV (ERL mode) 155 MeV (external beam)
max. current in ERL operation	1 mA (later 10 mA) (0.77-7.7 pC/bunch)
Number of recirculations	2 (ERL mode) 3 (external beam)

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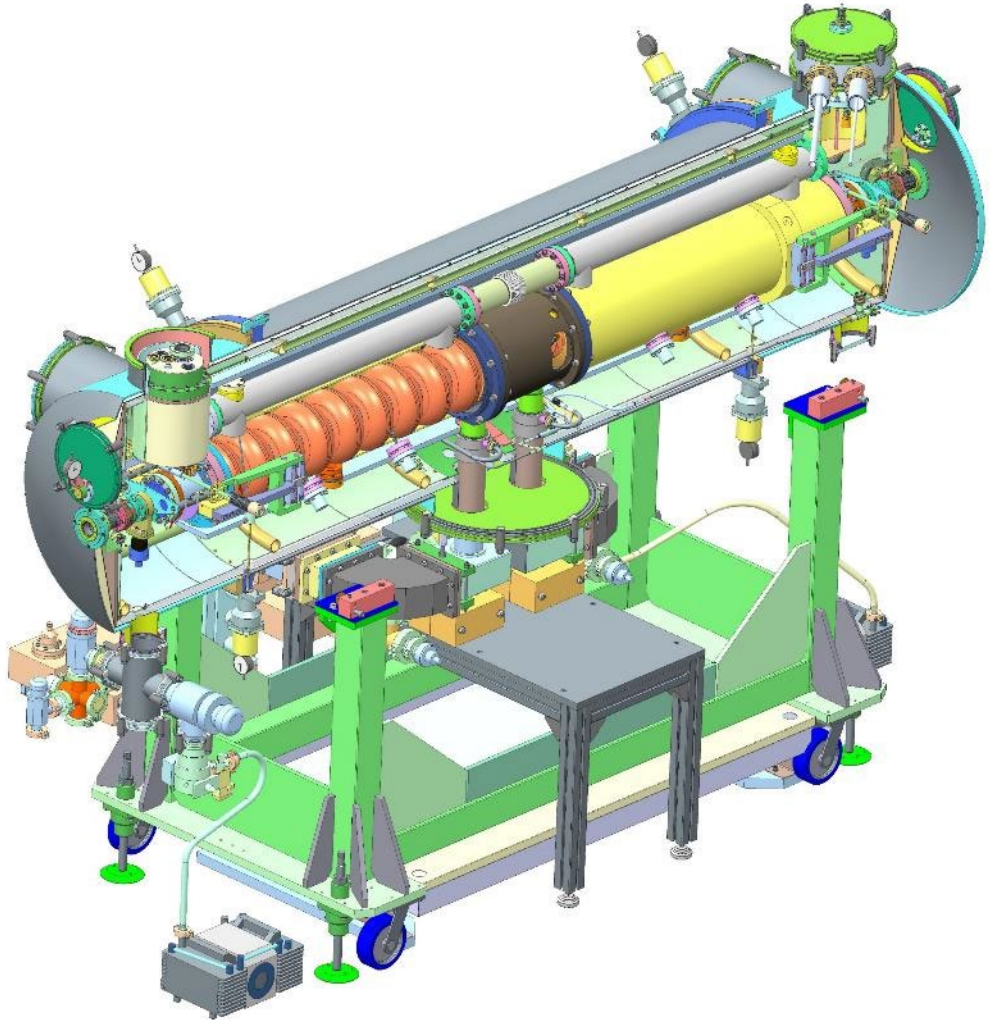
MESA Cryomodule

- MESA uses an enhanced version of ELBE cryomodules (added XFEL piezo tuners and improved HOM damping)
- 2 cryomodules each containing 2 TESLA/XFEL cavities

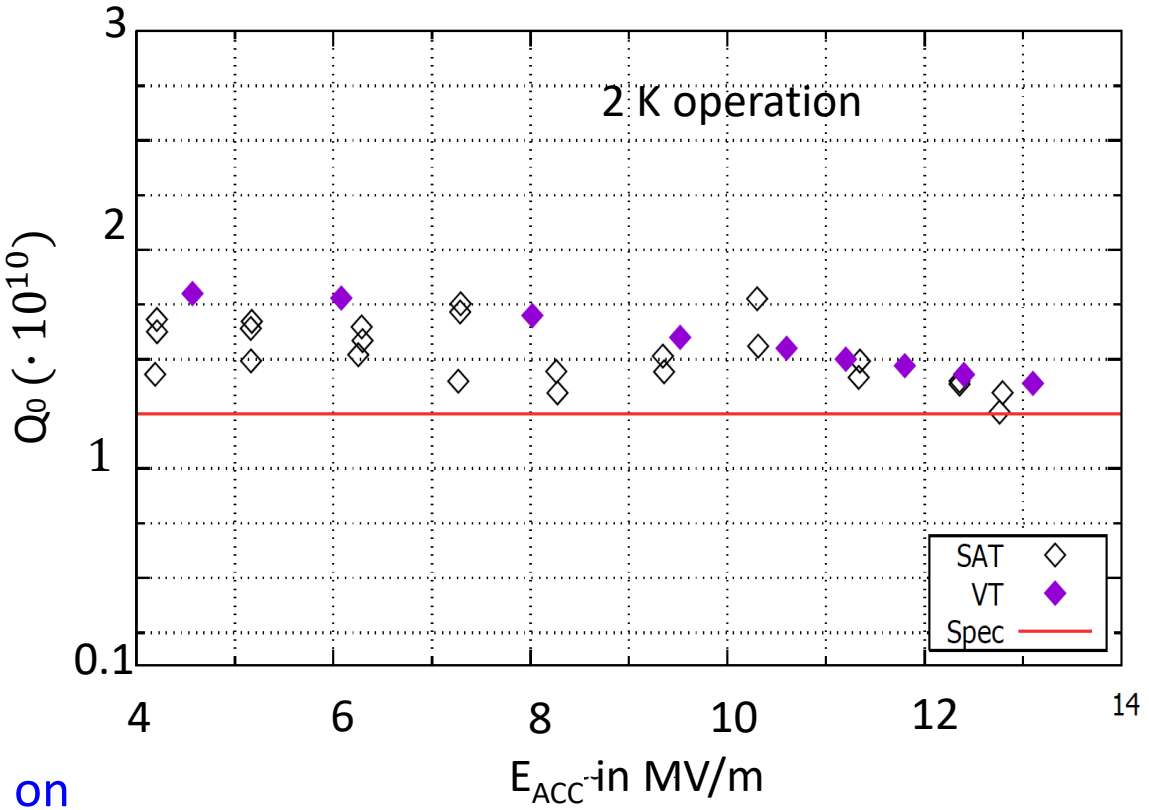
- 12.5 MV/m operating gradient
- total losses per module < 40 W static and dynamic)
- Quality factor: $Q_0 > 1.25 \times 10^{10}$



Picture: HZDR

Production of 2 Cryomodules for MESA

- 2015: 2 MEEC's ordered at RI Research Instruments GmbH
- Until 2017 SRF testing infrastructure became available at HIM
- 9/2018: First cryomodule does not meet specs at HIM → refurbishment by vendor
- 3/2019: Second tested cryomodule achieves specs during test at HIM/Mainz
- 8/2020 :refurbished cryomodule tested and fulfills specs



→ JGU built up an SRF group from scratch from 2013 on (now operating very successfully)

Further Optimizations on HOM Antennas (TOSCA project)

Goal: Test small Nb_3Sn and NbTiN systems for existing cavities
here: Nb_3Sn and NbTiN coated HOM antennas for MESA cavities

→ Coated antennas can sustain higher temperatures without quenching and may allow higher c.w. beam current

Cavities and cryomodule used within this task origin from the decommissioned ALICE ERL (Daresbury, UK). The complete module has been gifted to JGU Mainz, which we highly appreciate.

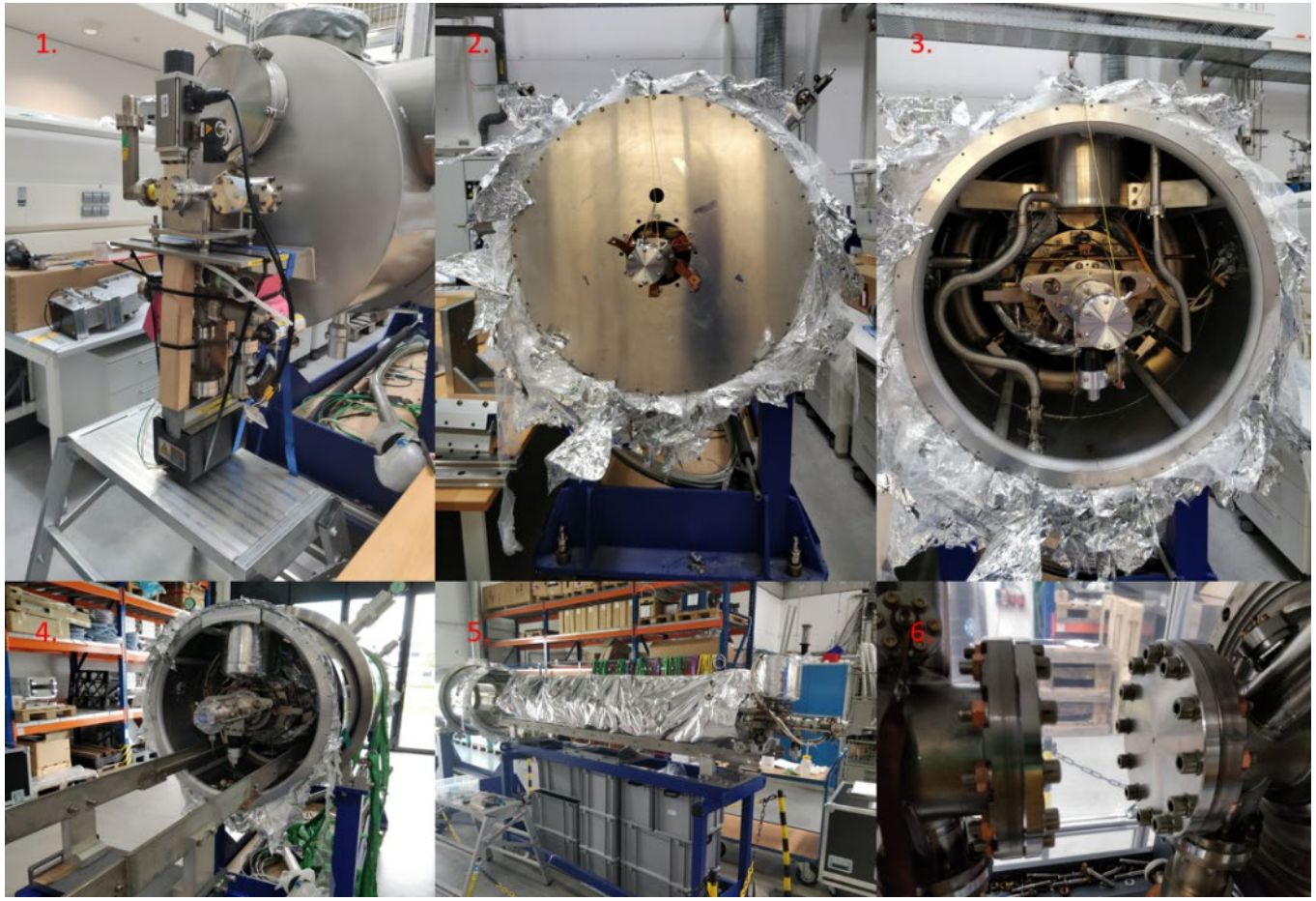
The ALICE module suffered strongly from field emission at very low accelerating fields already (< 7 MV/m)
Refurbishment by (at least) HPR needed

Further Optimizations on HOM Antennas

Decommissioning of the module is completed

HPR planned after maintenance of HPR cabinet at Mainz

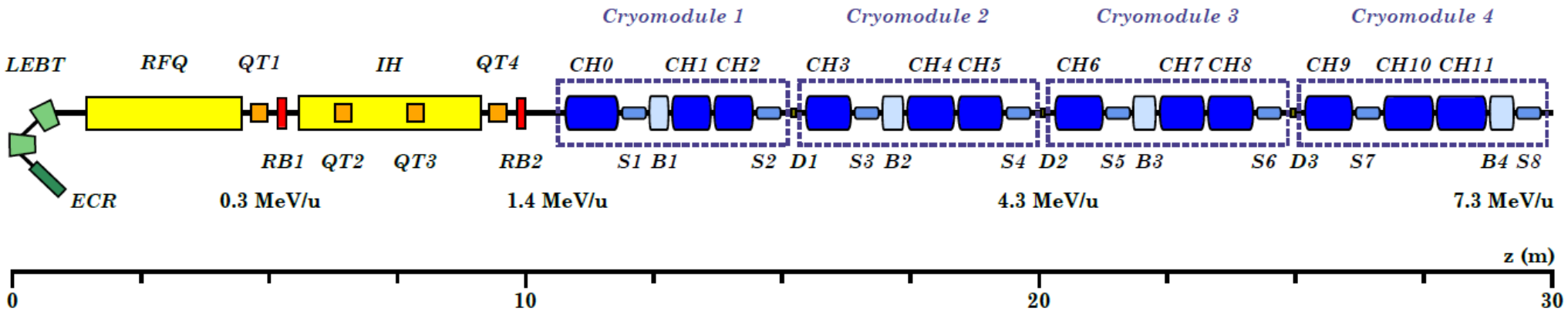
Afterwards: first vertical baseline tests before antenna modification at AMTF



HELIAC

HELIAC: HElmholz LInear Accelerator

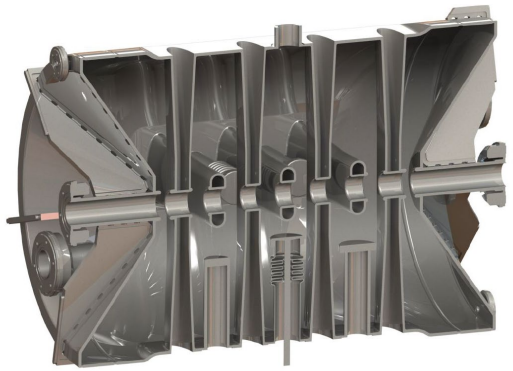
- cw SRF linac for heavy ions
- High intensity beams for future synthesis of (new) super-heavy elements
- First cavity tested with beam in July 2017
- First complete cryomodule for 4 cavities in preparation for beam test within 2022/2023

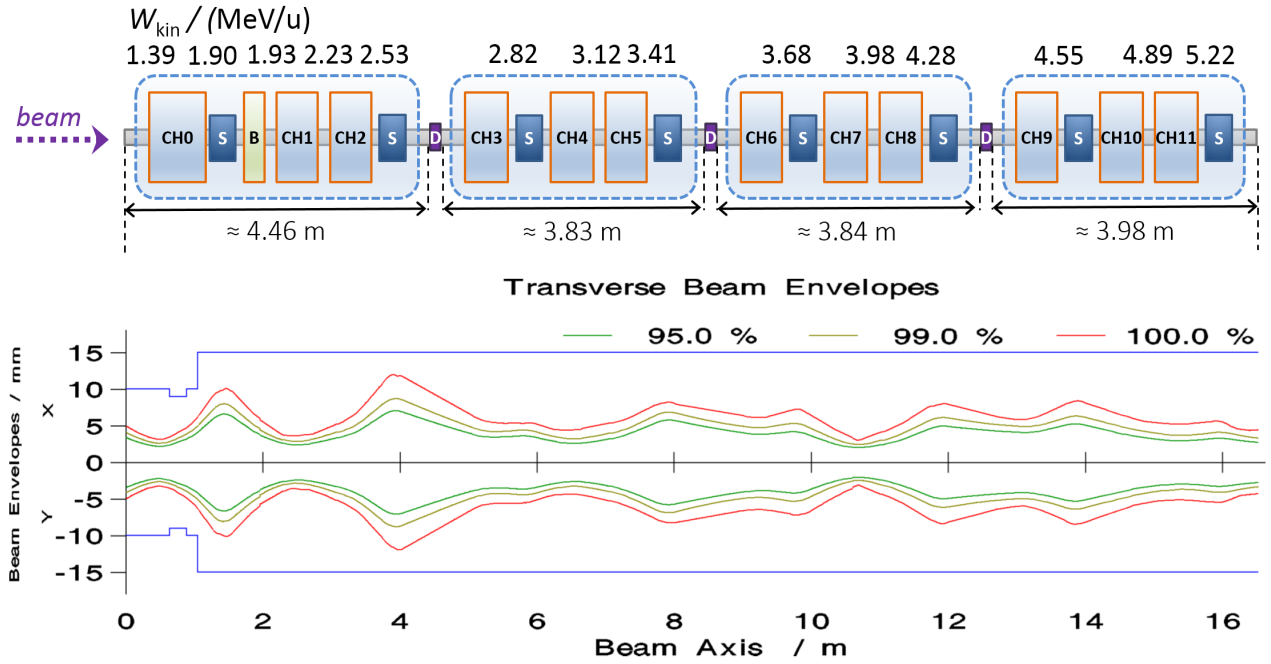


HELIAC

Ion Linac using superconducting CH-mode cavities

- 5.5 MV/m operating gradient
  (achieved in horizontal tests: 9.6 MV/m)
- Quality factor: $Q_0 > 5 \times 10^8$
  (achieved in horizontal tests:
  8.1×10^8 @ 9.6 MV/m)





HELIAC

Current Status

- Assembly of the first cryomodule containing 4 cavities at Mainz ongoing
  “Advanced Demonstrator Module”
- Beam tests at GSI planned afterwards
- Note: every cavity in the complete linac is unique due to the changing ion velocity!

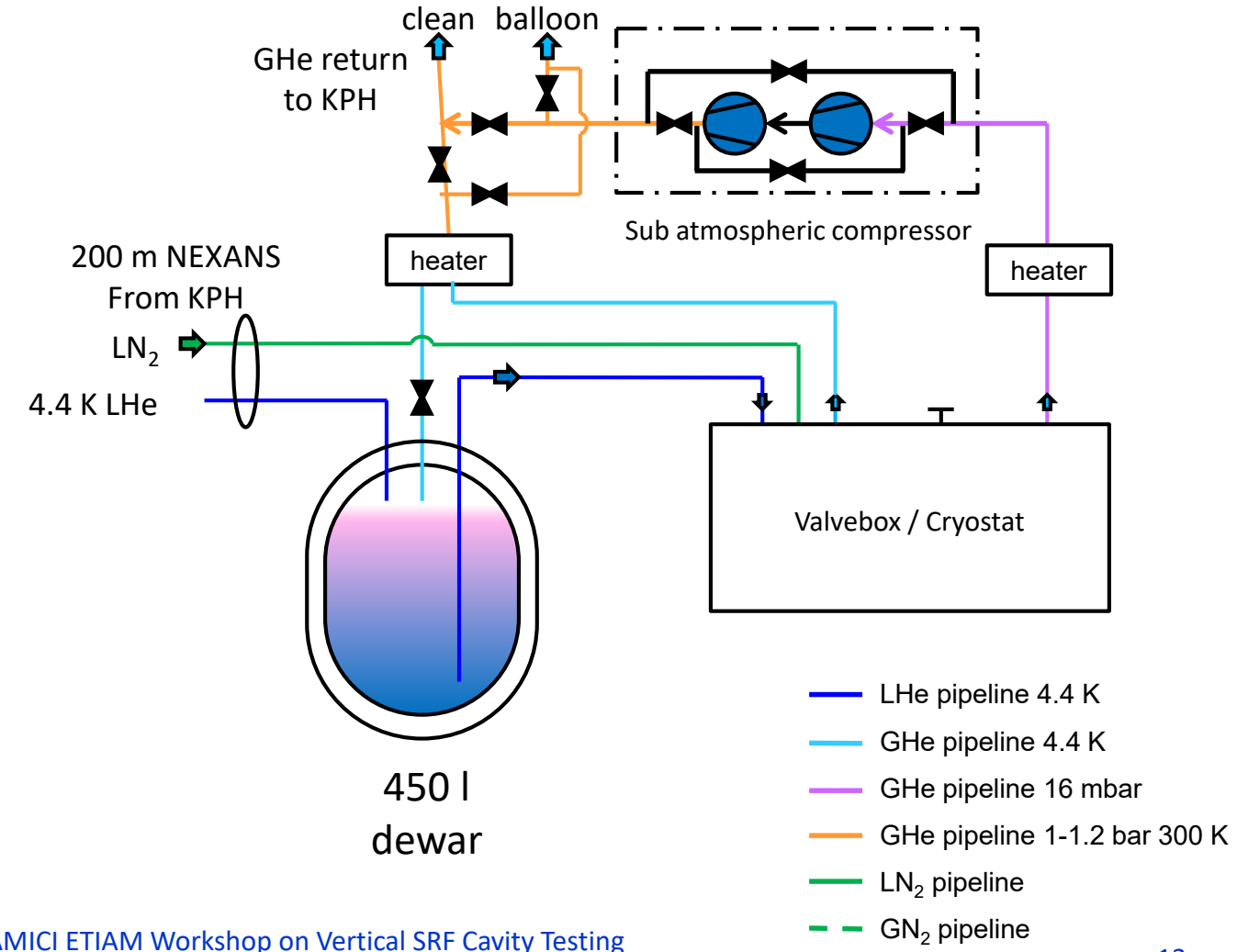
→ A lot of design work and cavity testing needed

SRF Infrastructure @ HIM

- Clean room
  - 40m² ISO 6 and ISO 4
  - USB and rinse
  - HPR for CH and XFEL Cavities
  - 180°C bake out
  - Rail system for string assembly
- Module assembly space in front of the clean room

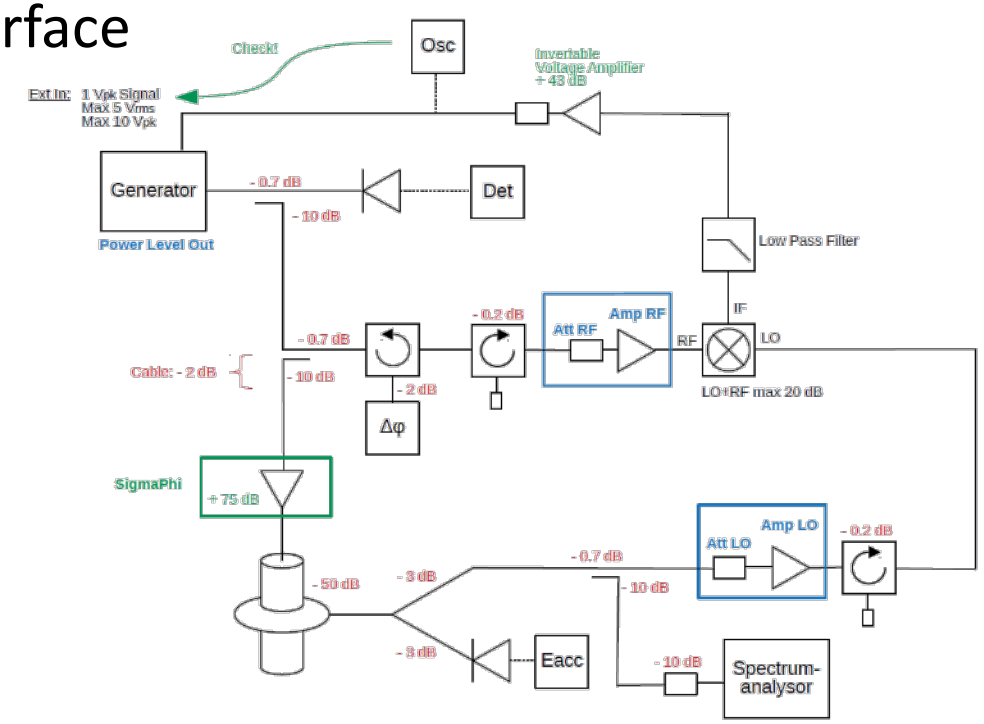
SRF Test Infrastructure @ HIM

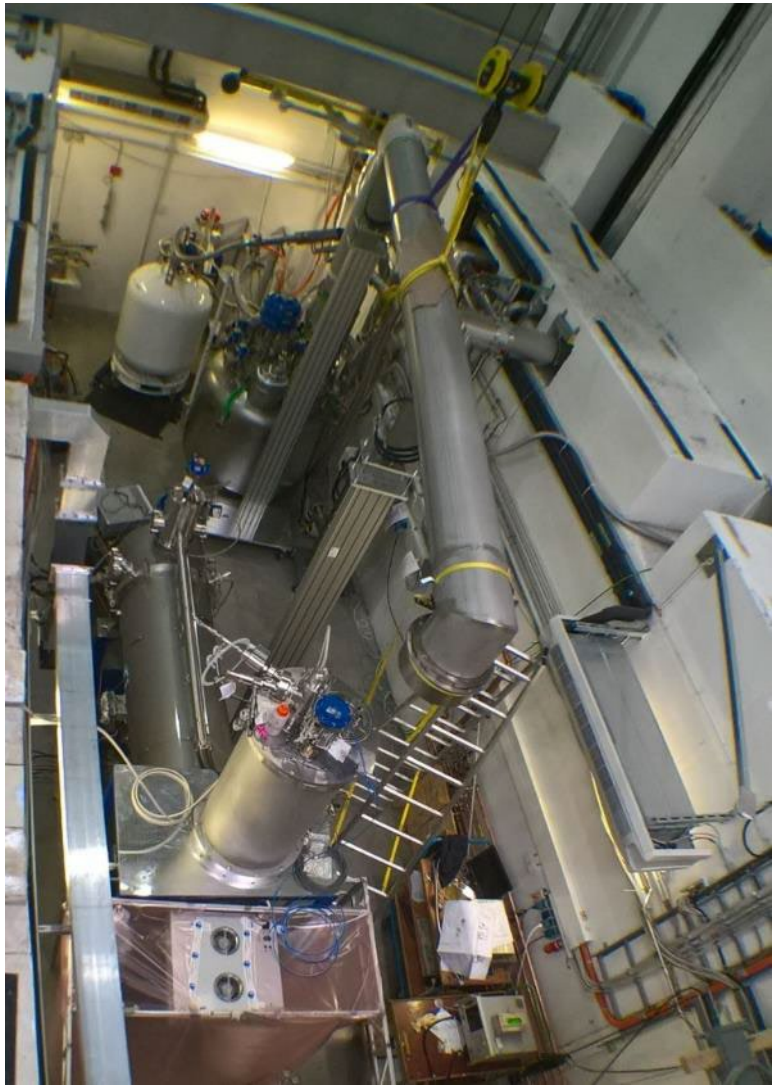
- Bunker for up to 15 MV/m testing
- Recovering He circuit
- 140 L/h (avg.) LHe
- 1.8 K possible (up to 4 g/s LHe)
- Calorimetric measurements possible



SRF Test infrastructure @ HIM

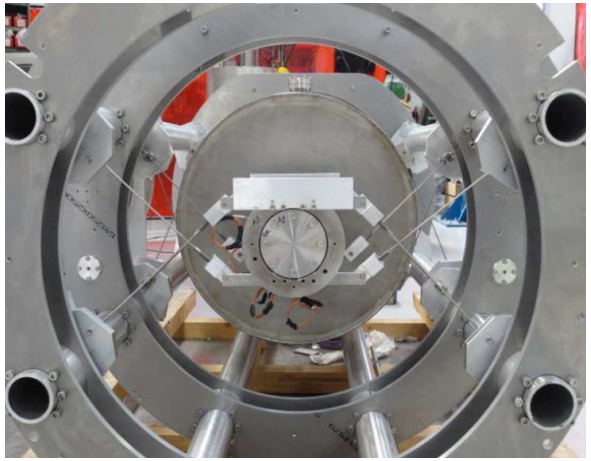
- test stand 1.3 GHz for MESA cryomodules (incl. Joule-Thomson valve)
- 15 kW SSPA (1.3 GHz)
- EPICS / Python interface
- PLL

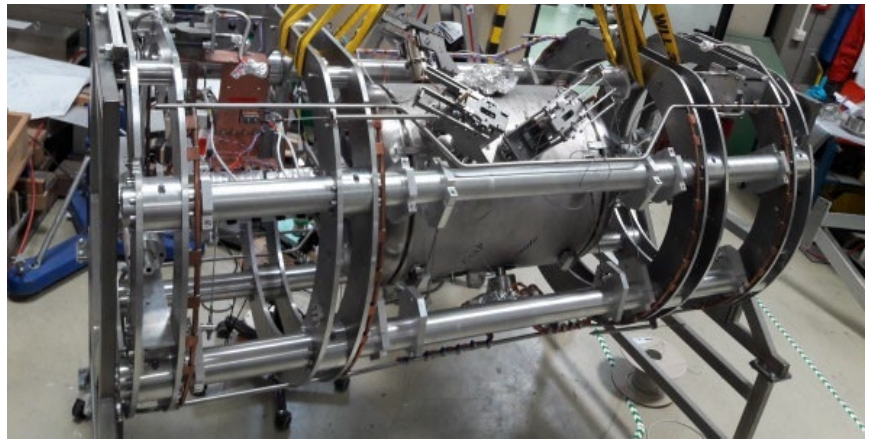




SRF Test infrastructure @ HIM

- Horizontal tests for HELIAC
- Cryostat for jackeded cavities
- Designed for 217 MHz CH cavities
- PLL
- 12 kW SSPA
- EPICS / Python interface



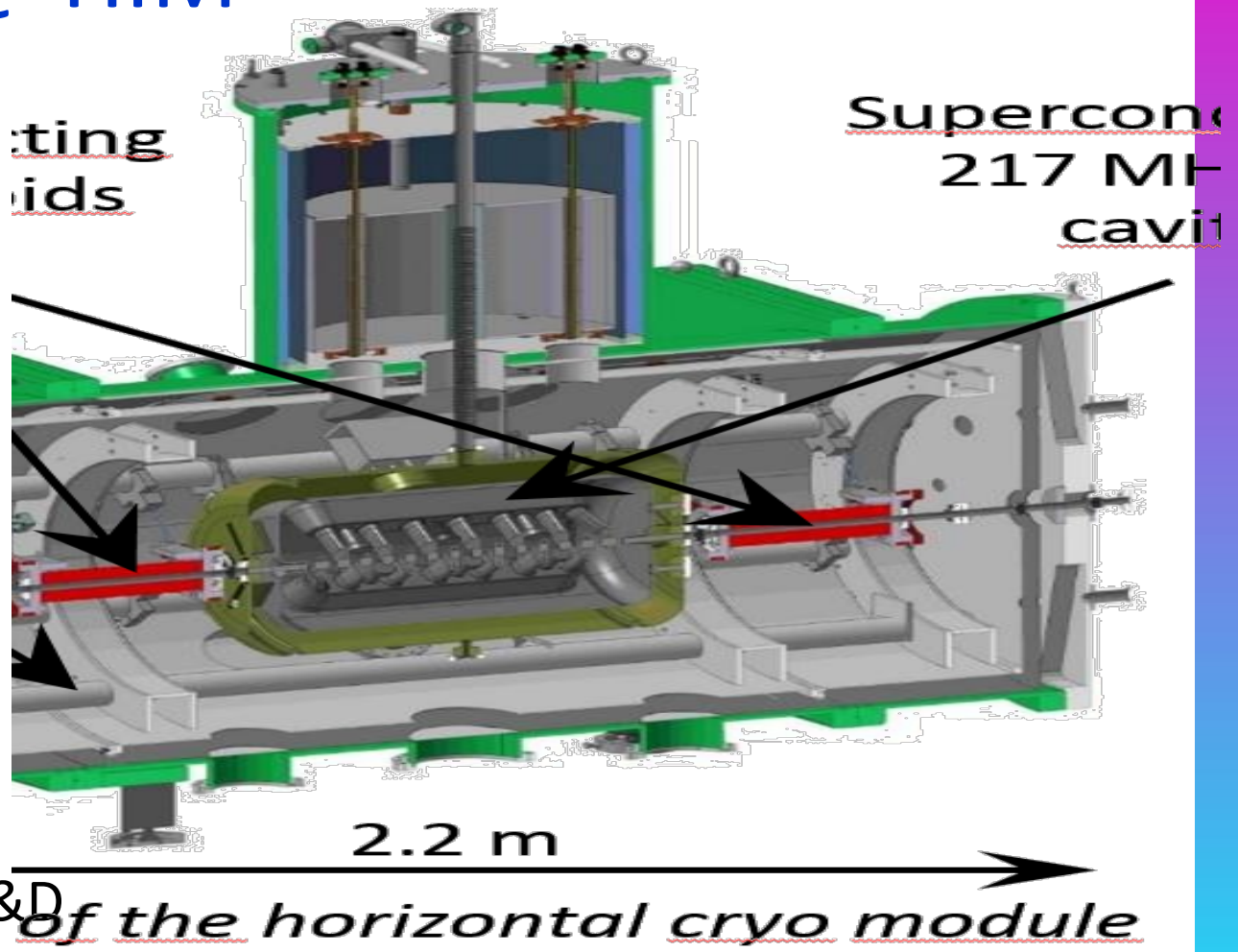


SRF Test infrastructure @ HIM

- Inner diameter 1120 mm
- Inner length 2200 mm
- Also usable by other cavity types
- 12 kW SSPA (217 MHz)
- 15 kW SSPA (1300 MHz)

- For both cavities at test bench:
  - PLL
  - Analog measurement set up
  - EPICS / Python interface

- Future Horizontal test stand for 1.3 GHz R&D



HIM SRF Horizontal Test Stand

HIM SRF Horizontal test stand				
No	Property name	Value	Unit	Comment
1	LHe volume	n/a	L	Jacketed cavities only, Depending on cavity 140 L/h Lhe production
2	Operating temperature	2	K	Max. 4 g/s He mass flow
3	Diameter / size	1,12 / 2,20	m	
4	Number of inserts	n/a		
5	RF Frequency	217; 1300	MHz	
6	Maximum Incident power	12; 15	kW	
7	Additional instrumentation	Mass flow in He return line		
8	Typical testing rate (Vts / year)	~1		Peak 2017: 6 tests
9	Possibility to test naked cavities		NO	
10	Infrastructure for small intervention		YES	Cleanroom ISO4 & 6, 40m² each, HPR, USB

Testing needs

At HIM horizontal but no vertical cavity tests can be performed at present. But there is a need for testing cavities in vertical cryostats.

- ACID: bare CH-cavities are tested vertically at Frankfurt university before Helium tank assembly. Afterwards, the cavities are tested horizontally at HIM or GSI (both at 4 K). There is a demand for vertical tests of dressed cavities down to 2 K in the future.
- MESA: complete cryomodules are tested at HIM. There is a demand of vertical testing, in particular for the ongoing work in the TOSCA project. (~4-6 VT needed)

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