CRYOMODULES FOR MESA

A quick overview about the experiences with turn-key cryomodules for CW operation at Johannes Gutenberg-Universität Mainz

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and the MESA team

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in cooperation with

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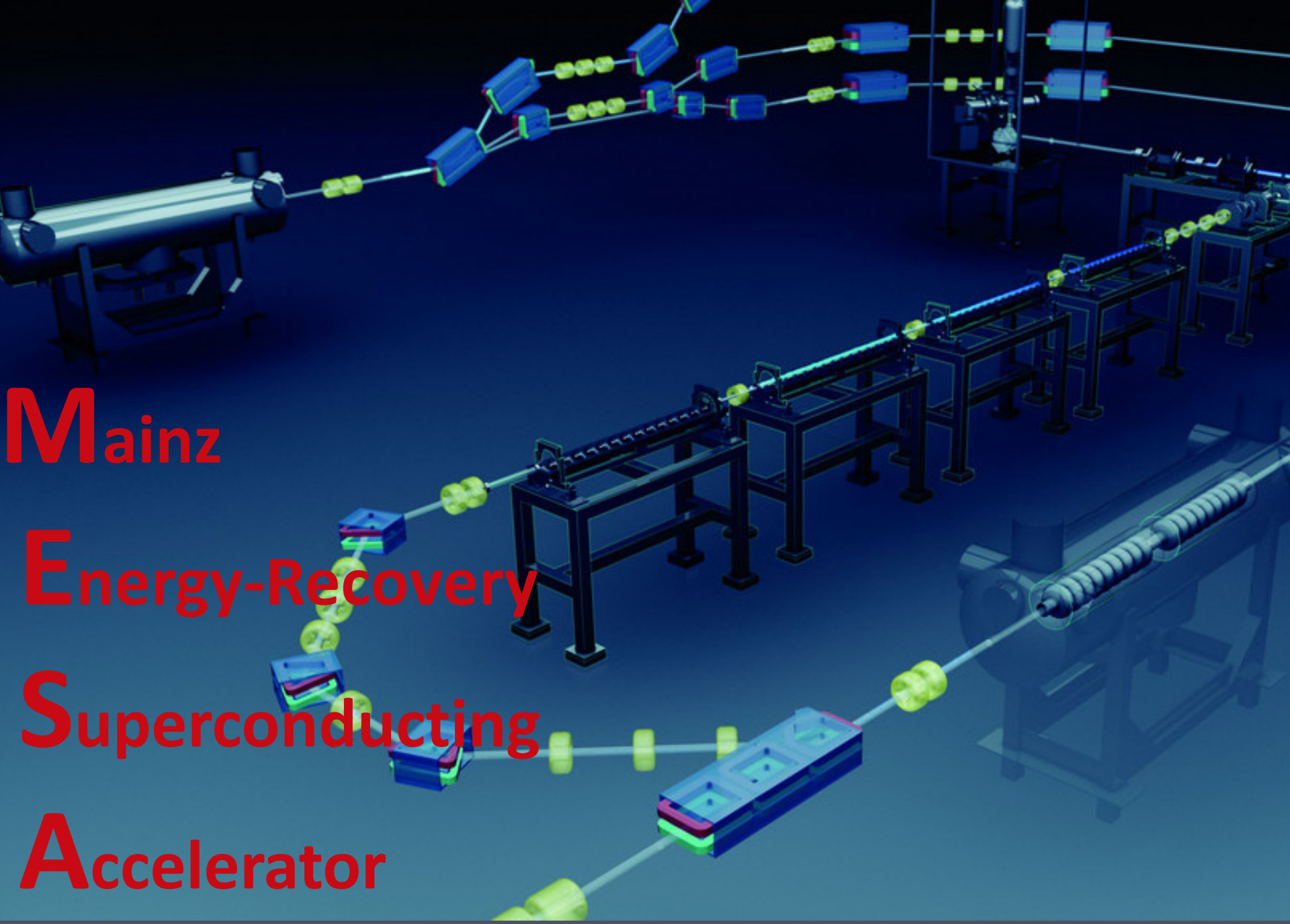
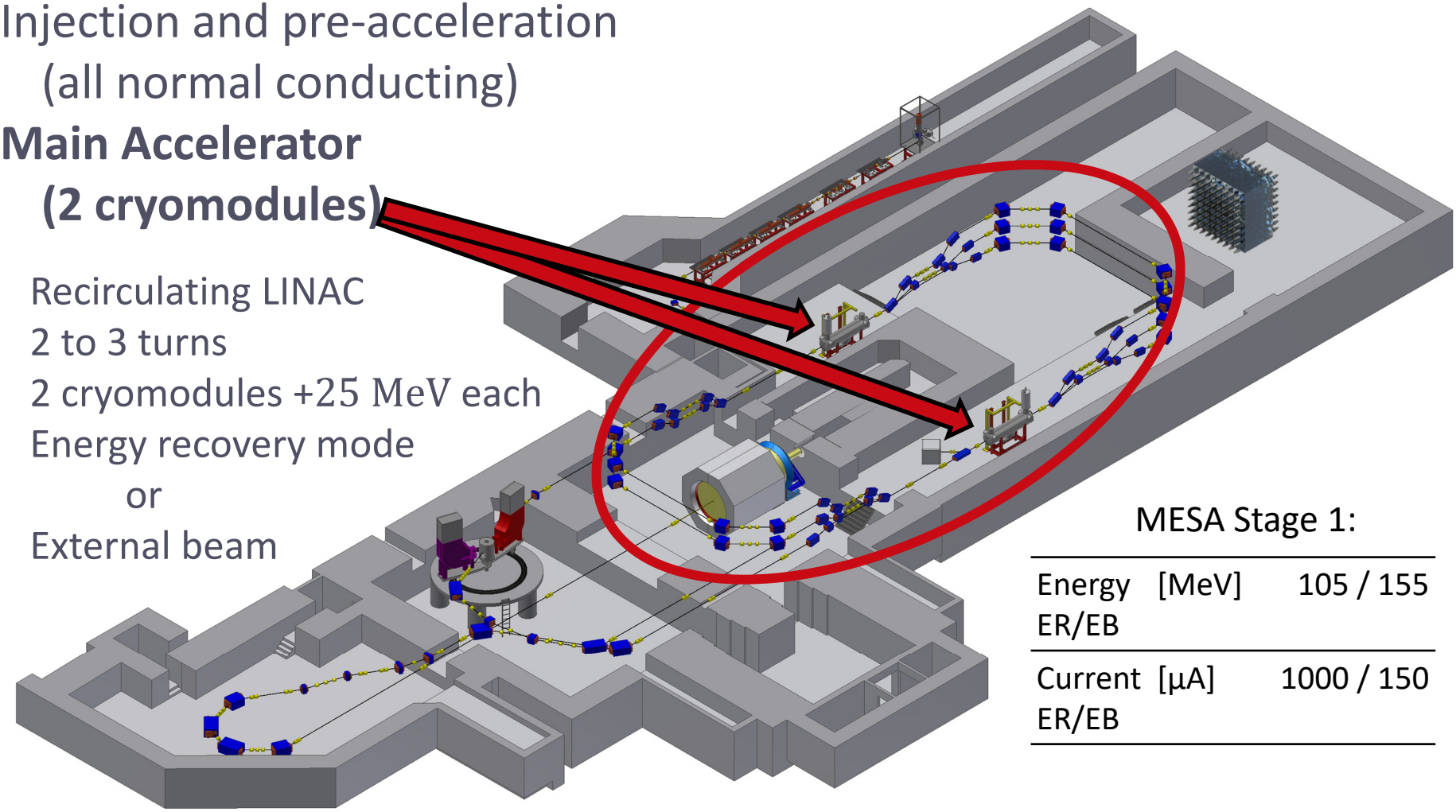

Mainz
Energy-Recovery
Superconducting
Accelerator

Mainz Energy-Recovery Superconducting Accelerator

1. Injection and pre-acceleration
   (all normal conducting)
2. **Main Accelerator**
   (2 cryomodules)

- Recirculating LINAC
- 2 to 3 turns
- 2 cryomodules +25 MeV each
- Energy recovery mode
  or
- External beam

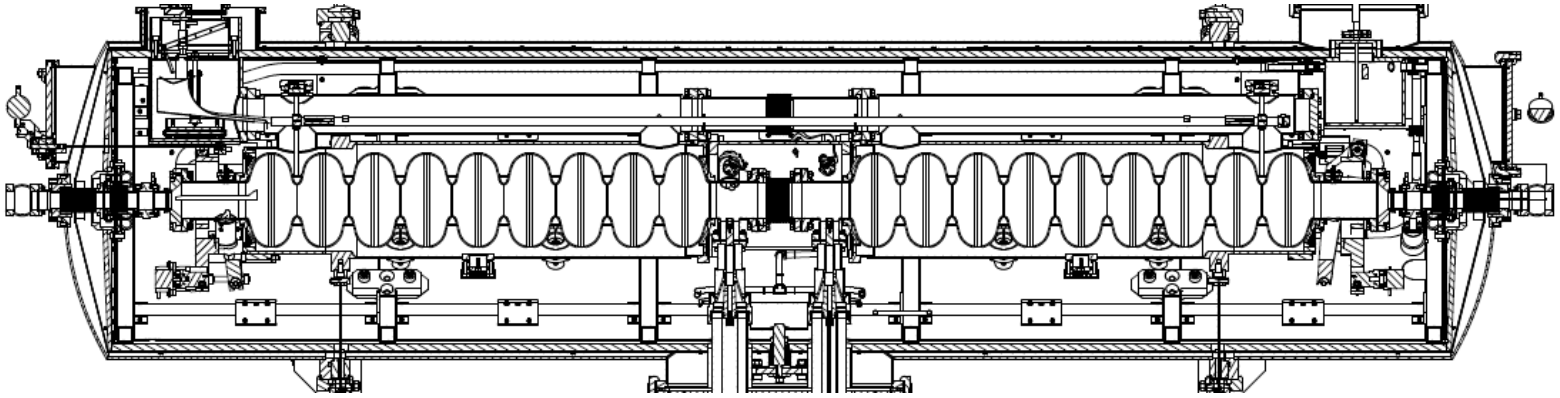


MESA Stage 1:

Energy [MeV] ER/EB	105 / 155
Current [µA] ER/EB	1000 / 150


MESA
Enhanced
ELBE-type
Cryomodules

MESA Enhanced ELBE-type Cryomodules



Variable	Specification
energy gain per CM	> 25 MV
static losses	<15 W
dynamic losses @25 MV (CW)	<25 W
$\propto Q_0$ @12.5 MV m^{-1}	>1.25 × 10^{10}

- XFEL/Saclay Piezo tuner added
- BBU simulations ongoing ($I_{\mathrm{th}} \leq 12$ mA)
- Tests with beam at bERLinPro

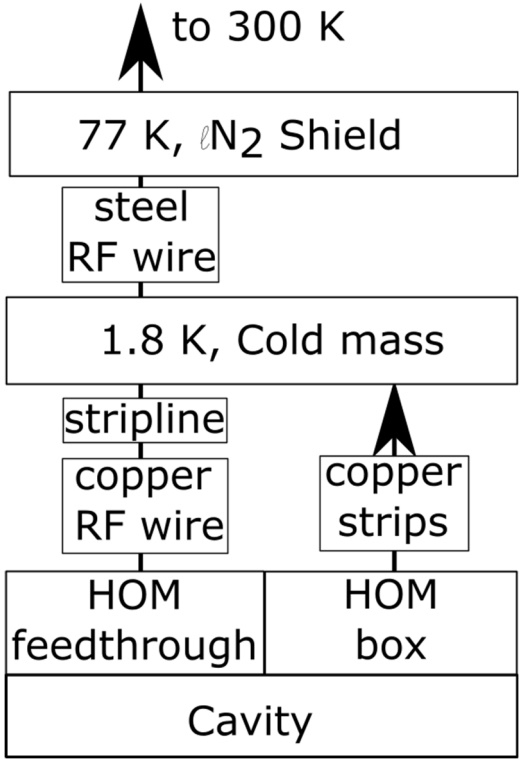
B.C. Kuske *et al.*, "Incorporation of a MESA Linac Modules into BERLinPro", in *Proc. IPAC'19*

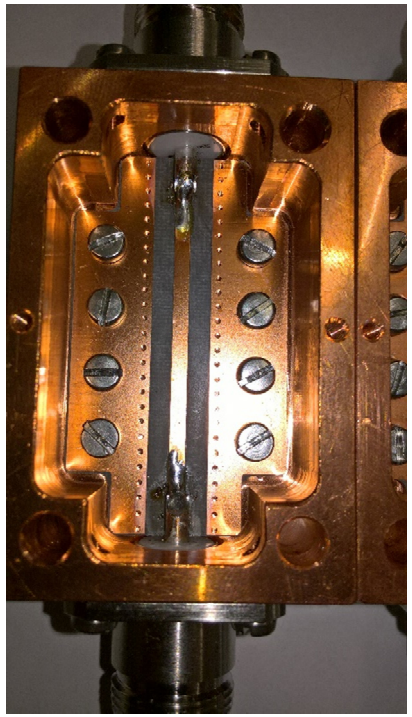
MESA Enhanced ELBE-type Cryomodules

Concern: Heating of the HOM-Antenna

Changes:

- Sapphire windows at HOM feedthrough
- Strip line in HOM cable for cooling



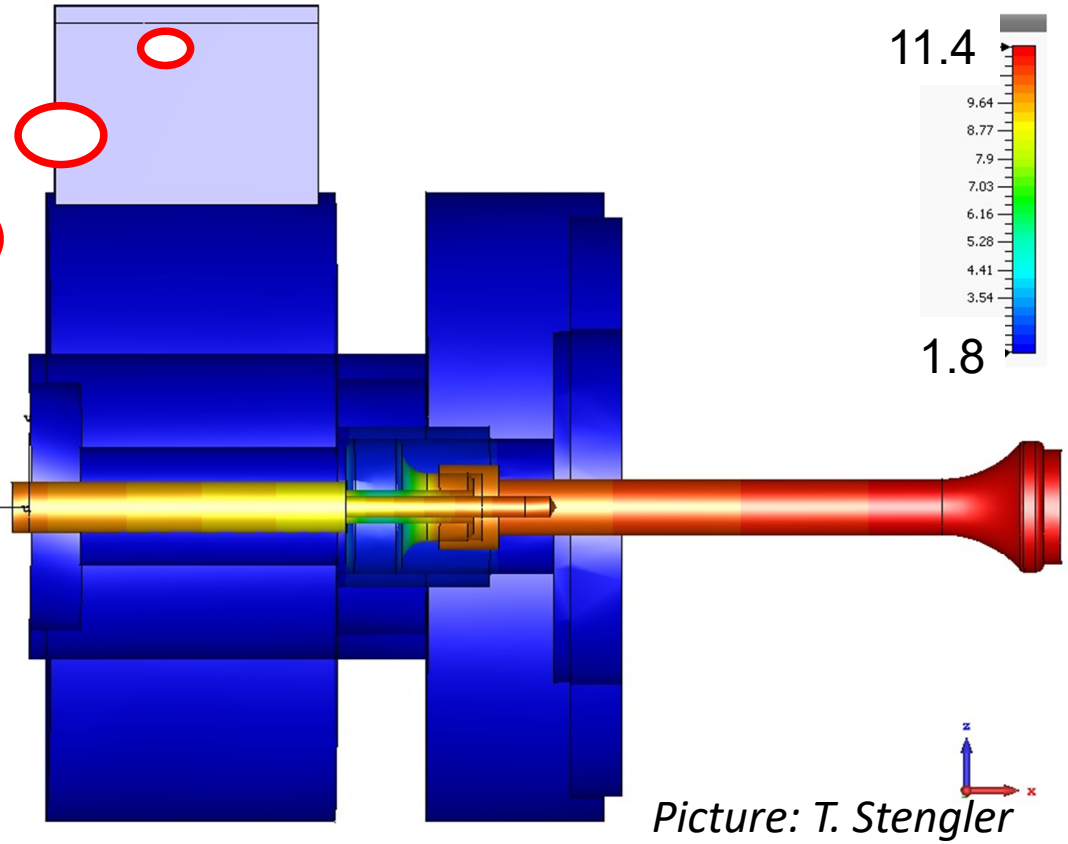


Cryomodule (2 XFEL Cavities @ 12.5 MV/m)

HOM Antenna calculations

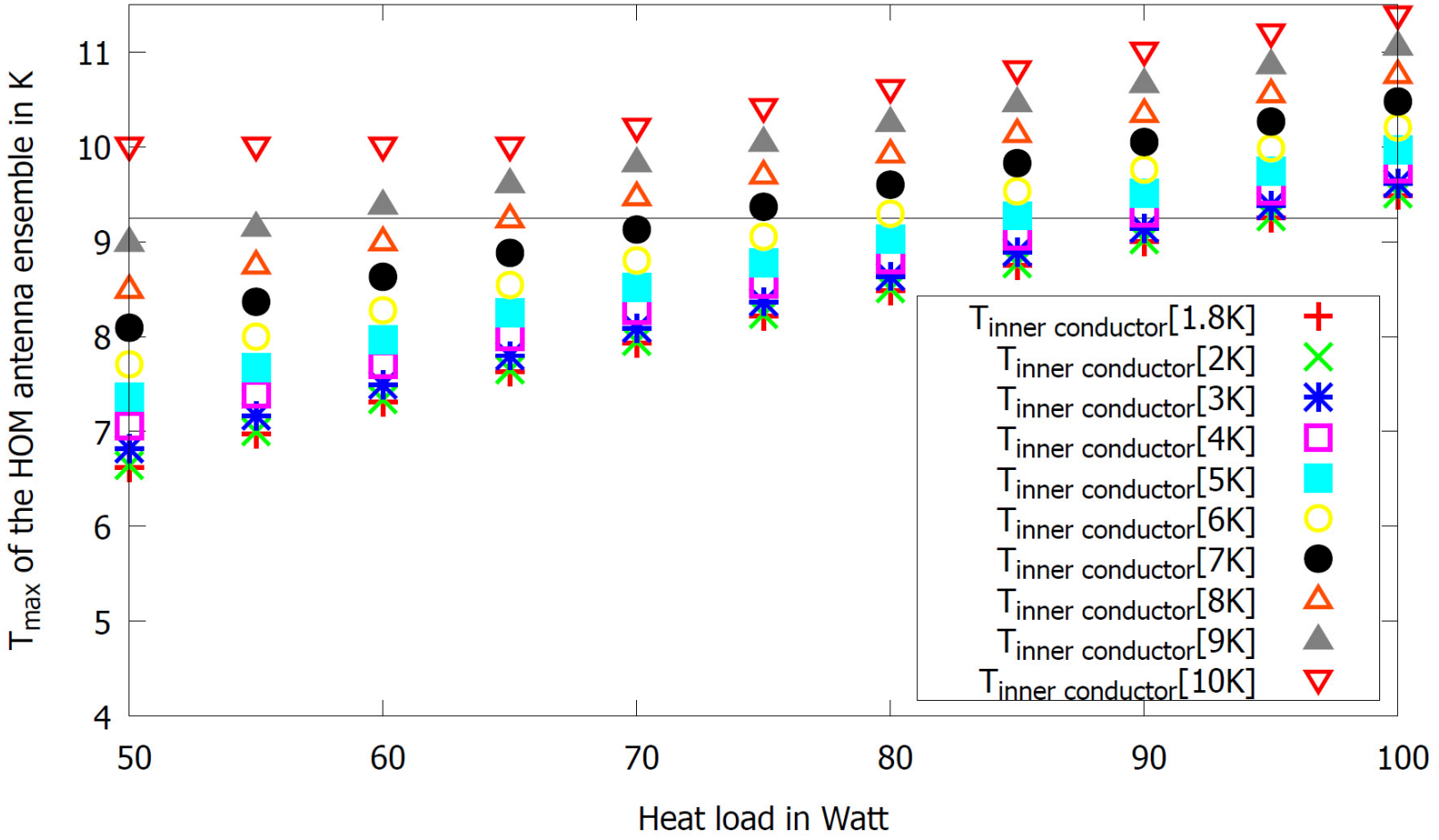
- Thermal calculations at HOM antenna:
  - → Provide optimised thermal connection design to RI
  - → Limitation by heat input from cable, need for heat sink

Only 1.25 W heat deposition in 1.8 K LHe bath per HOM coupler in cryo budget



Picture: T. Stengler

HOM Antenna calculations



Picture: T. Stengler

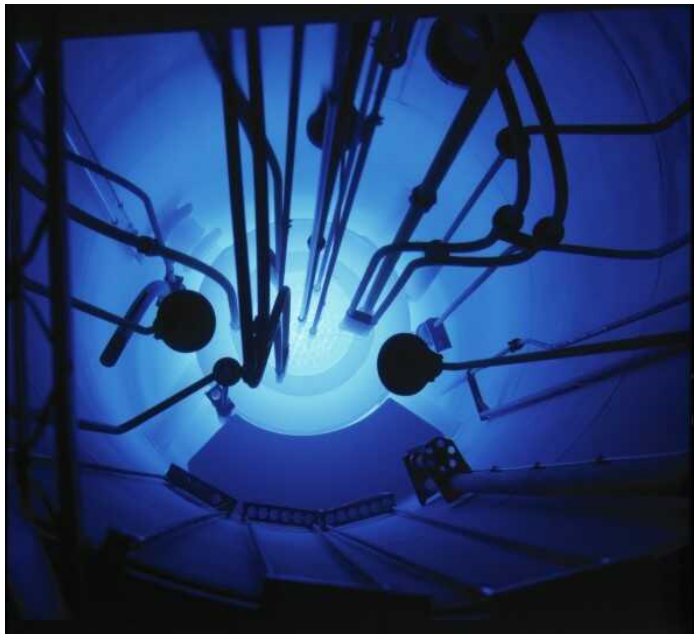
Production of 2 Cryomodules

- 2015: Ordered at RI Research Instruments GmbH
- All changes incl.
  - **Cryogenic Components** (valve box, 2K heat exchanger and JT valve, transfer line)
  - Stand alone **control system** (and connectable to EPICS)
  - With expertise of DESY, HZDR and industry partners
- Milestones
  - VT at DESY AMTF
  - FAT at Mainz
  - SAT at Mainz

Further Investigations by JGU

Analysis of the Niobium used for Cavity Production:

- Neutron activation analysis at TRIGA
- X-ray fluorescense analysis at geo-science department at JGU
- Mass spectrometer analysis at MPI for Chemistry

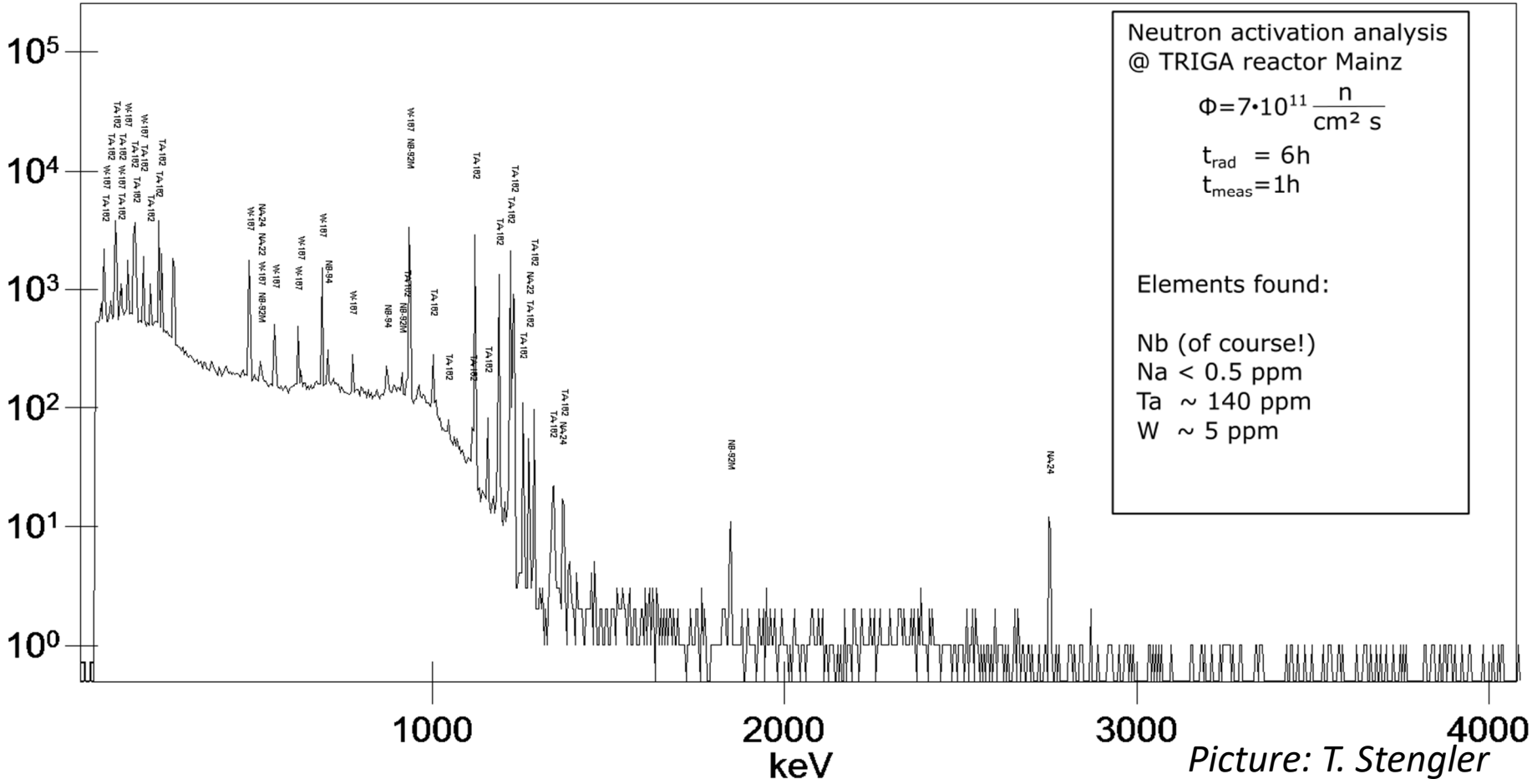


Pictures: Kernchemie, JGU Mainz

Further Investigations by JGU

First Results of Neutron Activation Measurements:

- Contamination within specification (Ta < 500 ppm, W < 70 ppm)
- Unexspected Natrium contamination due to bad water quality



Picture: T. Stengler

Production of 2 Cryomodules

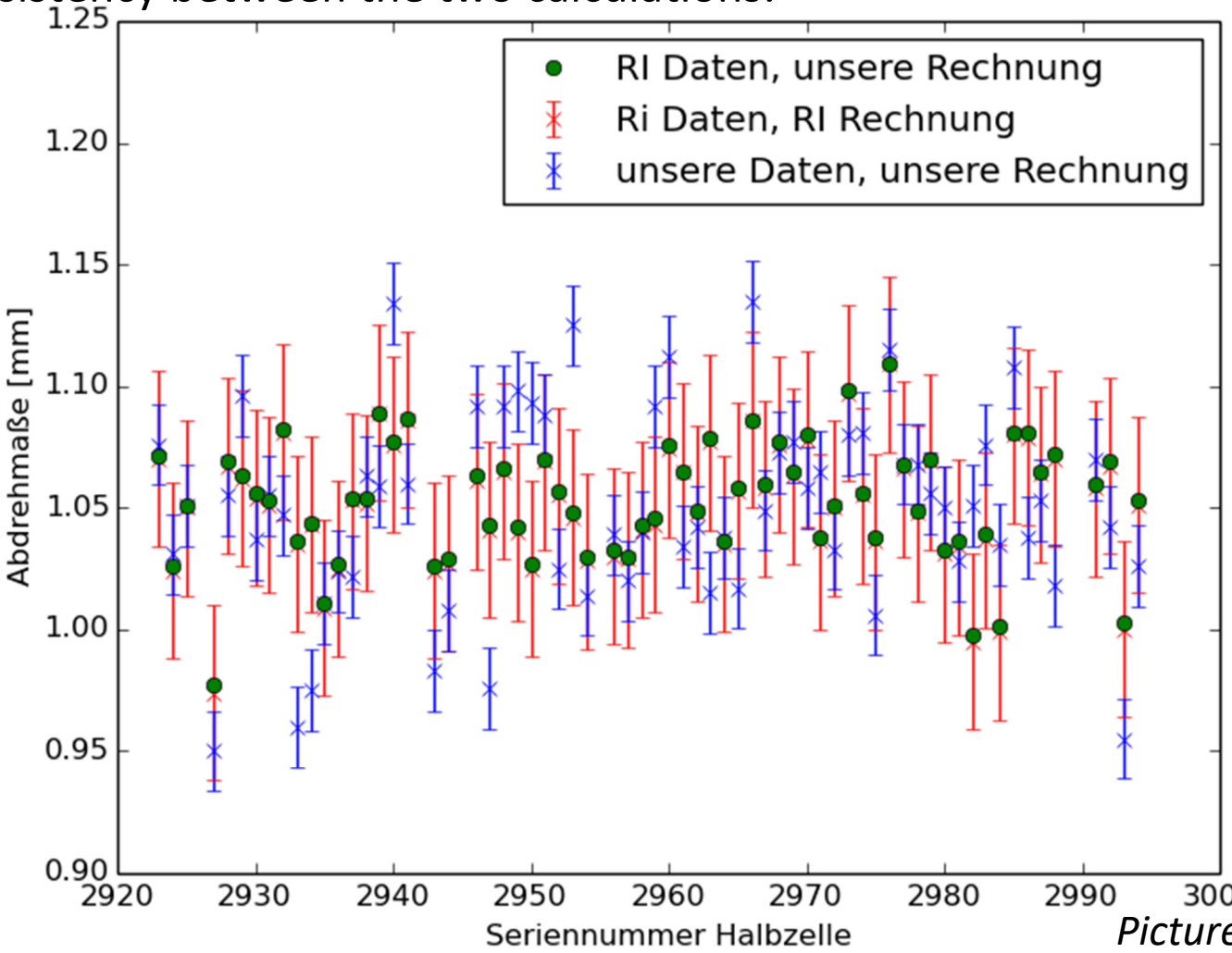
- Close cooperation between RI and Mainz University
  - Weekly **conference calls**
  - **Personal meetings** if necessary approx. **3 per year**
  - **Approval** of all changes
  - Quality control: All RF **measurements** verified by JGU

  - ➢ Effective cooperation between RI and JGU
  - ➢ Close cooperation needed for project coordination

2 Cryomodules, including modifications, VB, JT valve and control system built by RI

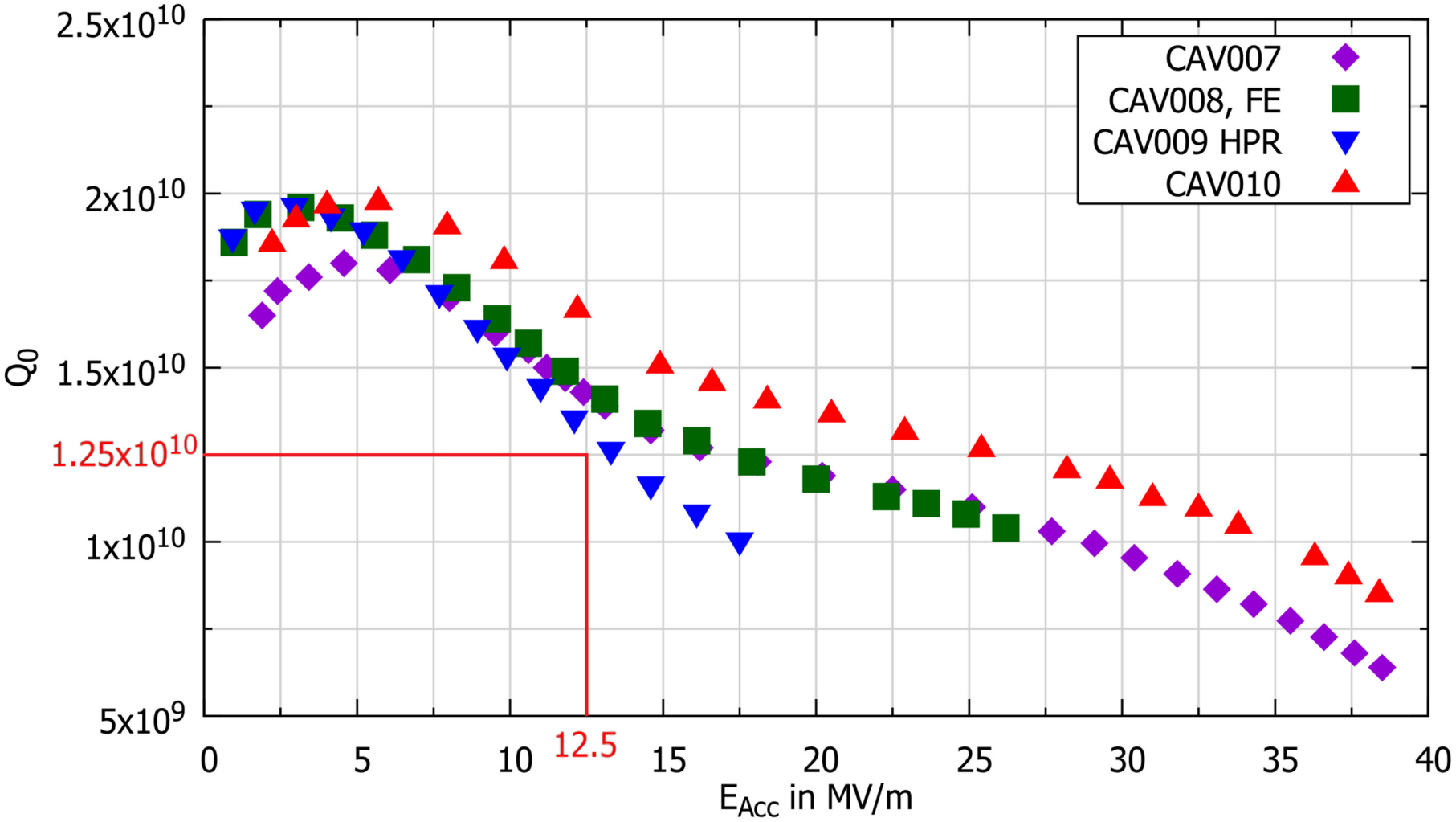
Quality Control of Cavity Production by JGU

Trimming measures calculated by using the different datasets show good consistency between the two calculations:



Pictures: P. Weber

Vertical Test Results @ DESY AMTF



Site Acceptance Test at HIM

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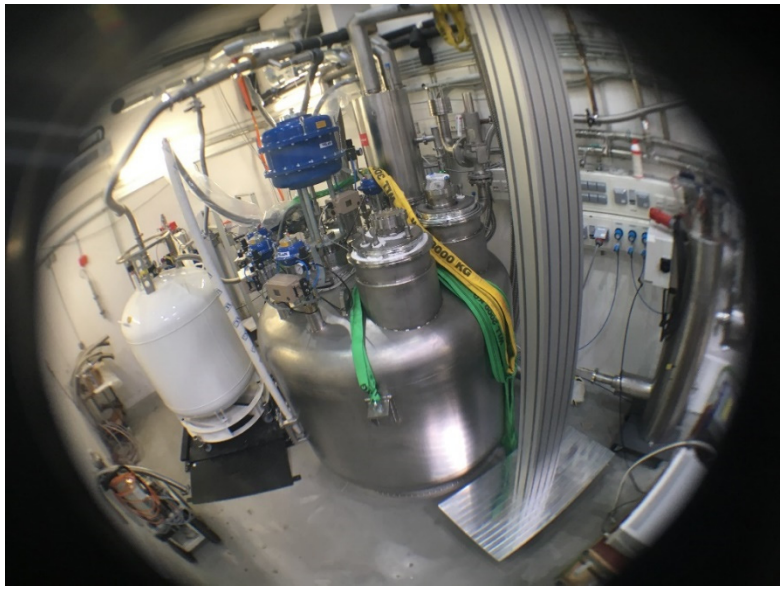
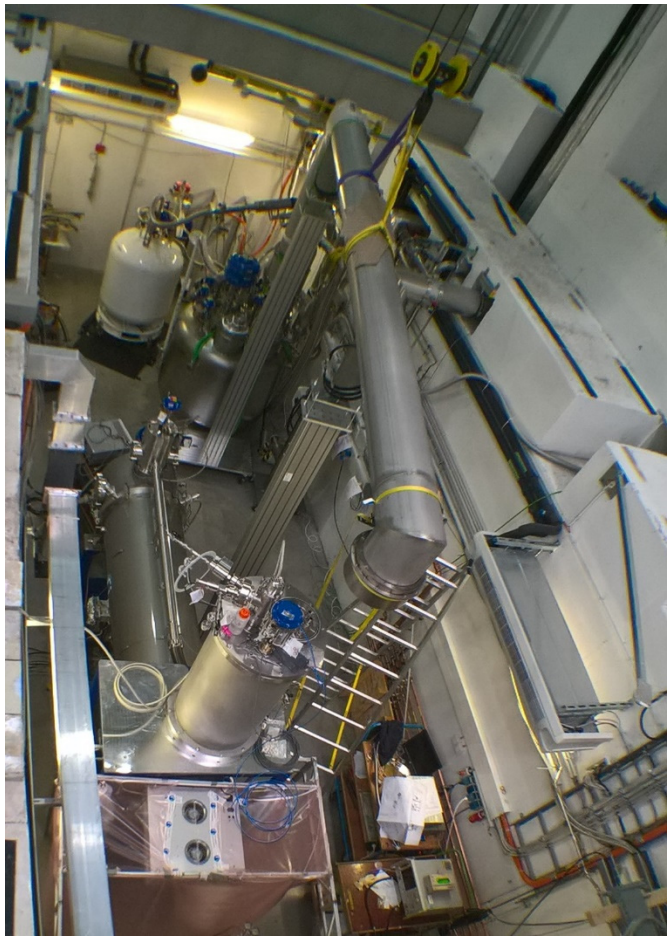
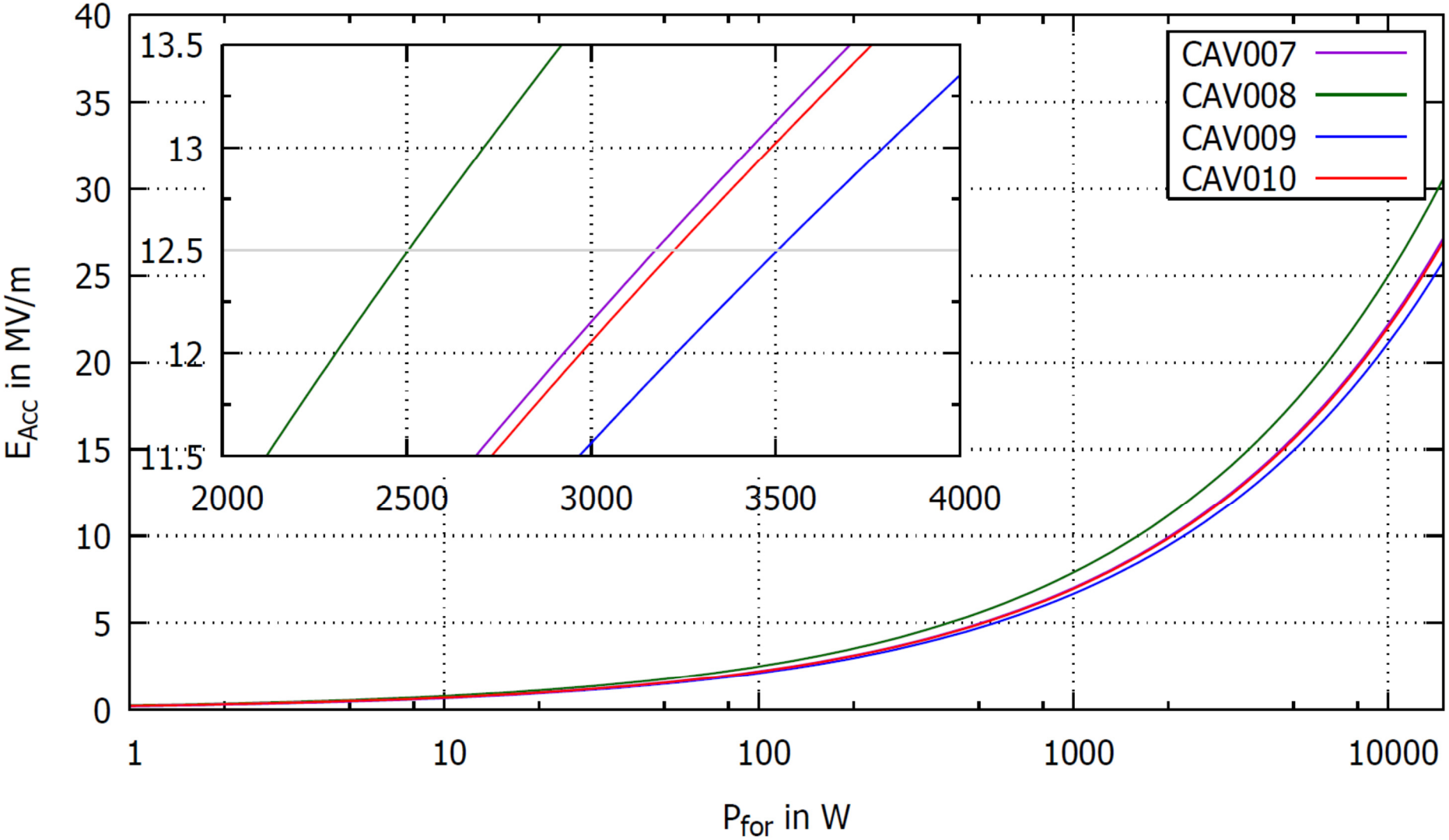
- Several successful cooldown cycles to 1.8 K at the HIM RF bunker with both cryomodules
- CW measurements up to 12.5 MV/m
- Static heat load more than 30% better than design value for both modules
- **SAT for module #1 approved recently (30.4.2019)**

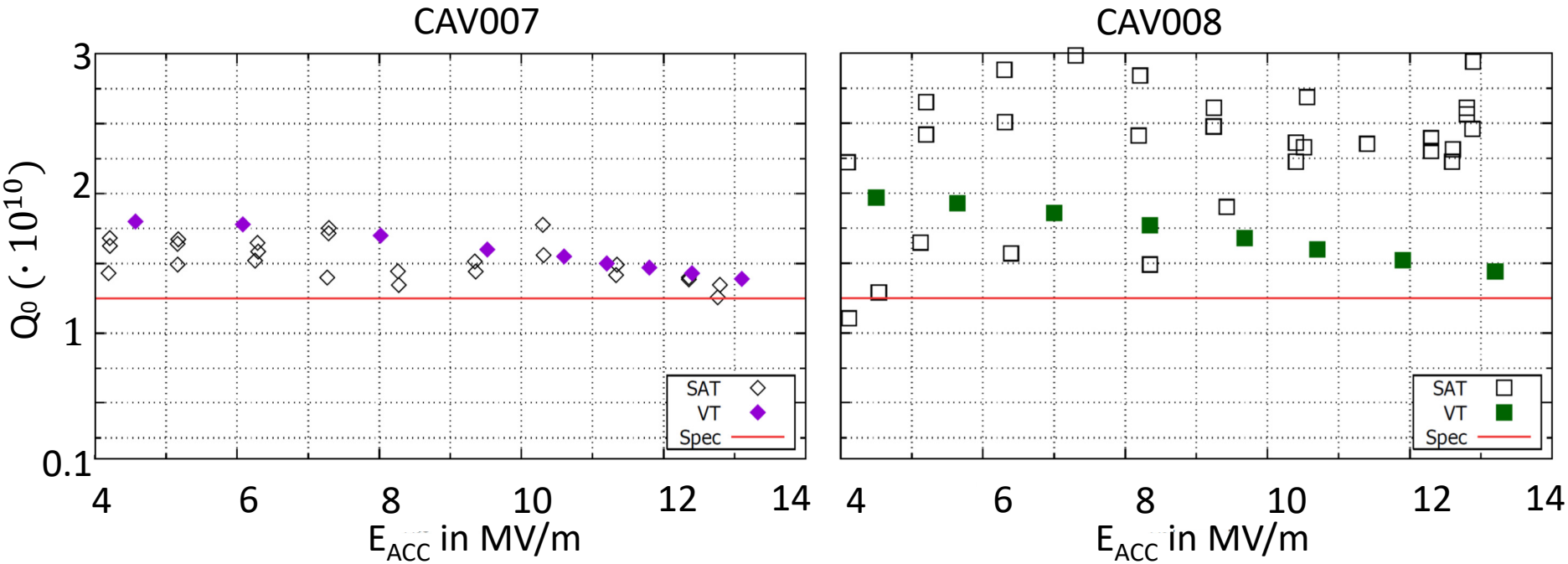




RF Generator and Possible Gradients



Site Acceptance – Cryomodule 1

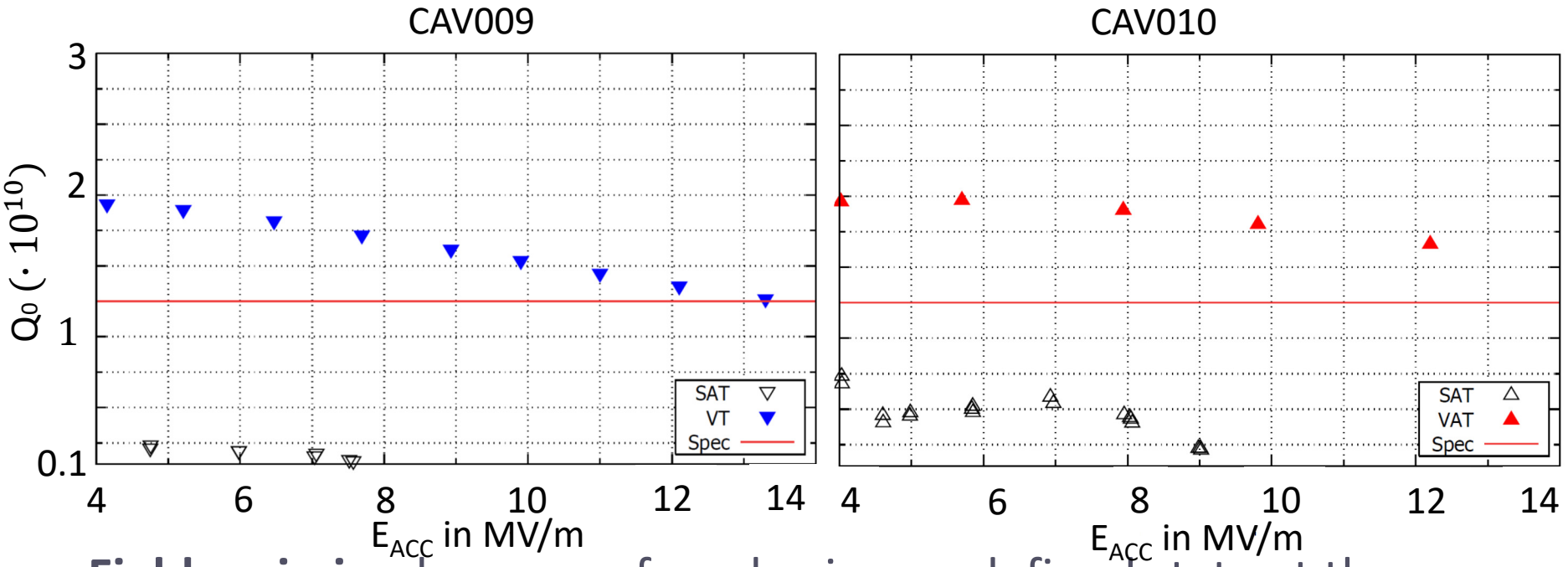


CAV008:

- **Systematic error** with **LLRF test system** occurred
- Helium flow indicates $Q_0 > 1.25 \cdot 10^{10}$ at 12.5 MV/m

To be measured again…

Site Acceptance – Cryomodule 2

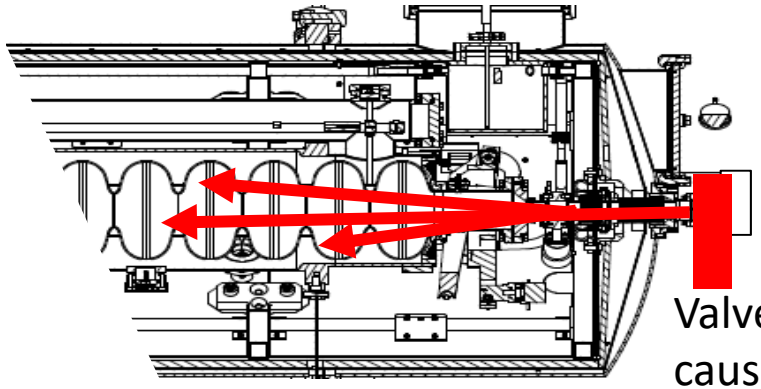


Field emission because of a valve in a undefined state at the beam pipe

Particles could float in N_2 atmosphere

CM for **refurbishment**

Re-Test within **2019**



Valve movement caused particles

Outlook and Timeline

More information: SRF '19 contributions

TUP041 – SRF Testing for MESA

THP054 – Cryogenic Installations

MESA

- User facility ERL
- At Johannes Gutenberg Universität Mainz
- Under construction (start 2022)

Cryomodule production:

- Successful turn key CM production by industry
- CM1 with 2x 12.5 MV/m @ $Q_0 = 1.2 \cdot 10^{10}$
- CM2 at refurbishment
- CM transport under vacuum
- Tests with beam at bERLinPro