CRYOMODULES FOR MESA

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

F. Hug for the MESA team

ERL Workshop 2022

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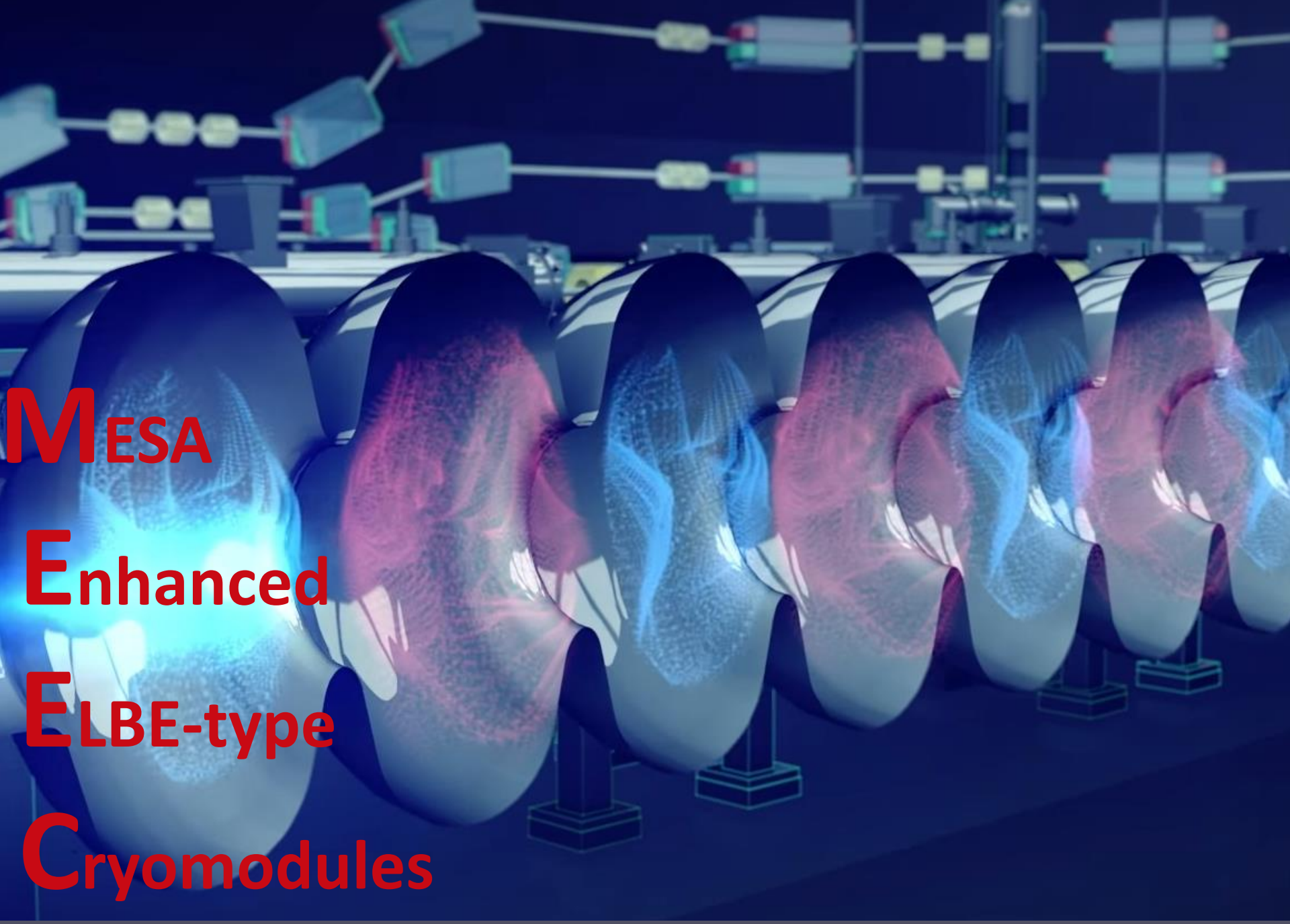


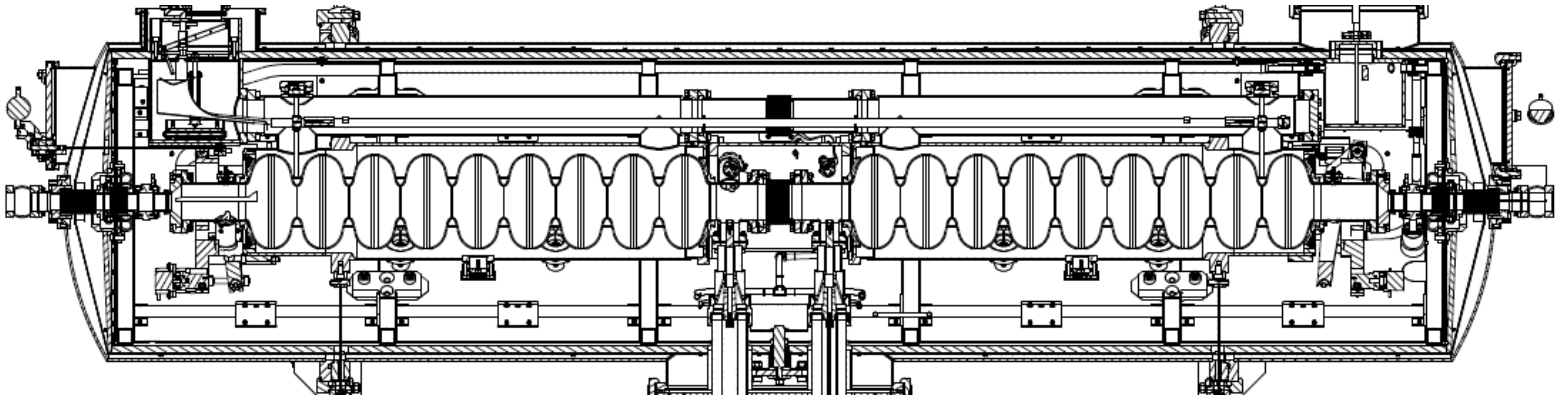
MESA

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}

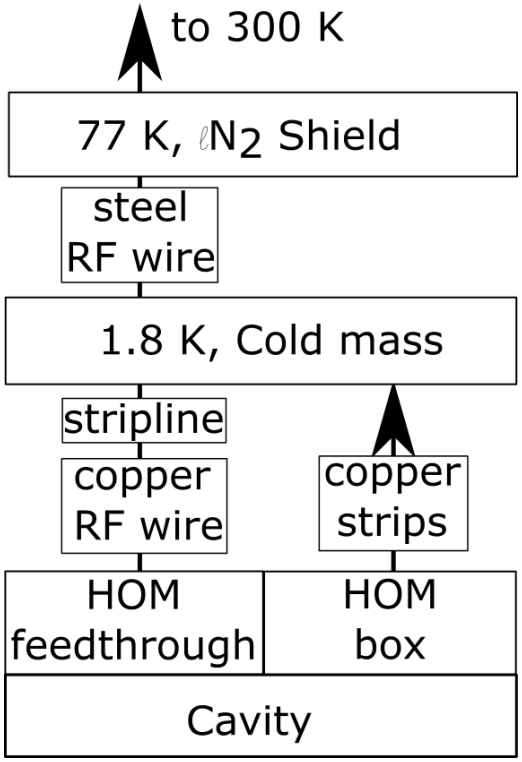
- XFEL/Saclay Piezo tuner added
- BBU simulations ongoing ($I_{\mathrm{th}} \leq 12$ mA)

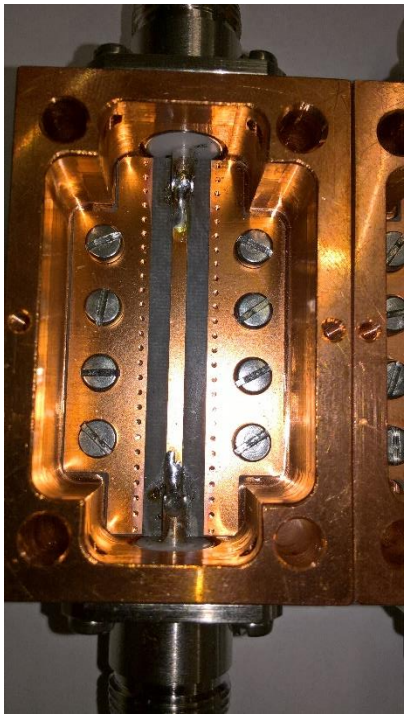
MESA Enhanced ELBE-type Cryomodules

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)

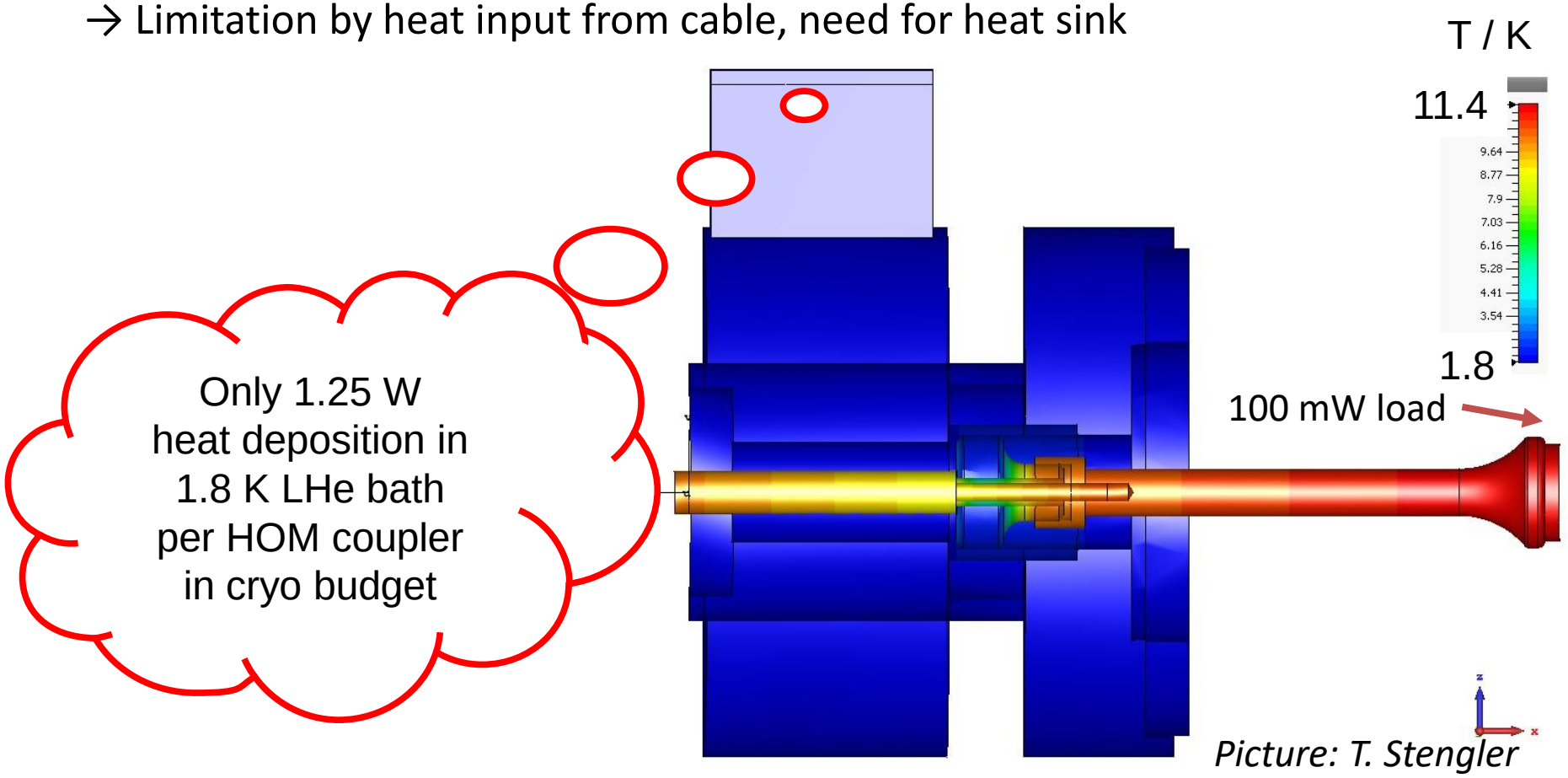
„Entwicklung eines supraleitenden Beschleunigermoduls für den rezirkulierenden Betrieb am Mainz Energy-Recovering Superconducting Accelerator (MESA) “, PhD. Thesis of T. Stengler

HOM Antenna simulations

- Thermal calculations at HOM antenna:

  → Provide optimised thermal connection design to RI

  → Limitation by heat input from cable, need for heat sink



Picture: T. Stengler

HOM Antenna simulations

Goal:

Reduce heating of HOM Antenna

→ Prevent quench of whole CM

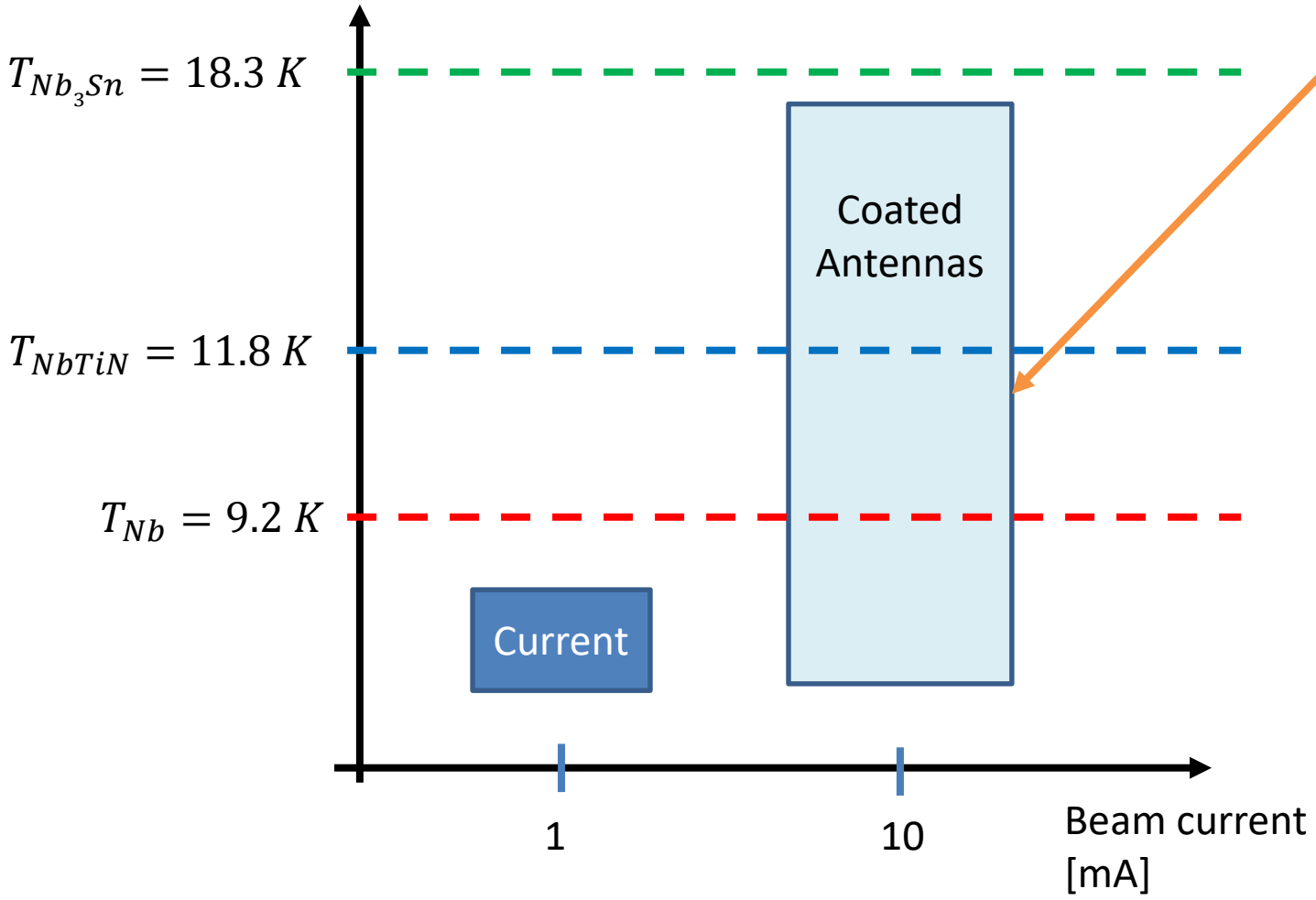
How: Antenna coating with Nb3SN/NbTiNon Nb/Cu Antennas

Ongoing CST simulations

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

HOM Antenna simulations



Expectation

Current HOM Antennas fulfill ERL at 1 mA

10 mA need improved HOM decoupling

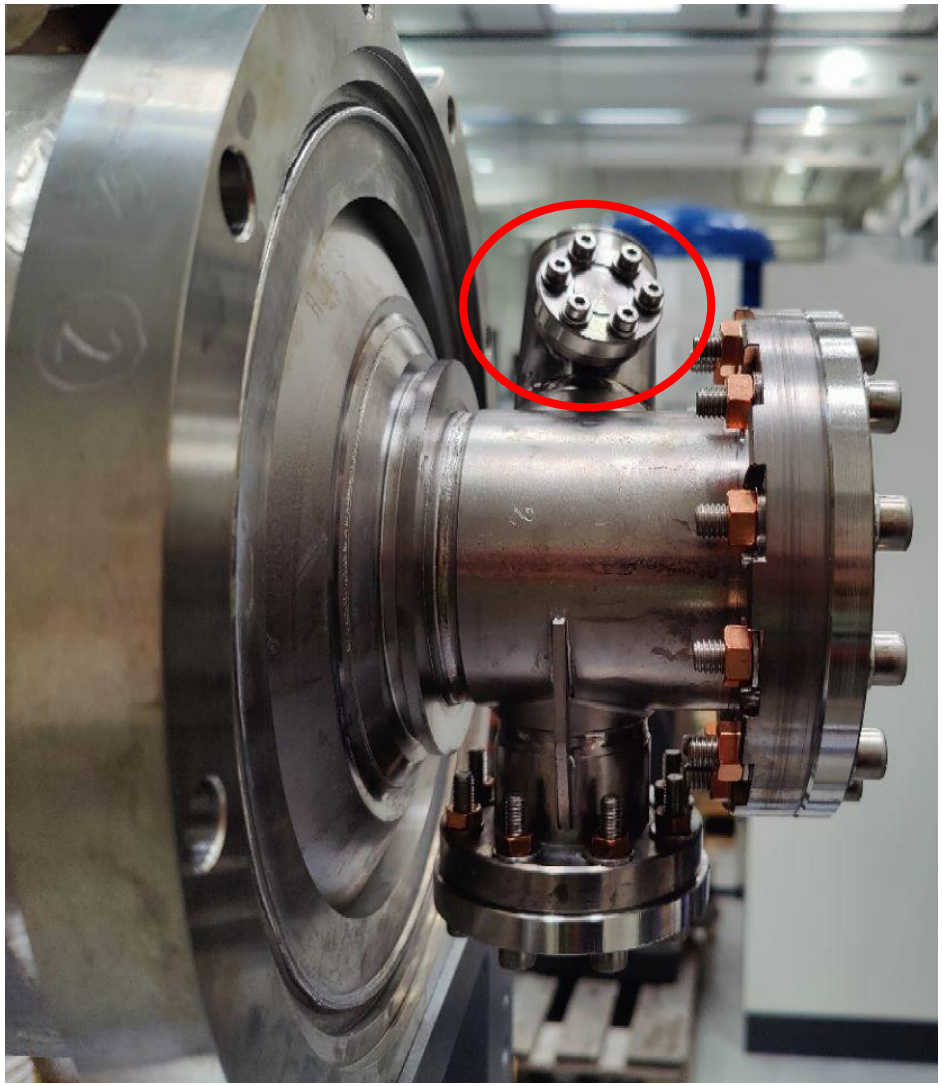
Refurbishment of a decommisioned ALICE module for antenna research (and as future spare module for MESA)

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



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

Production of 2 Cryomodules

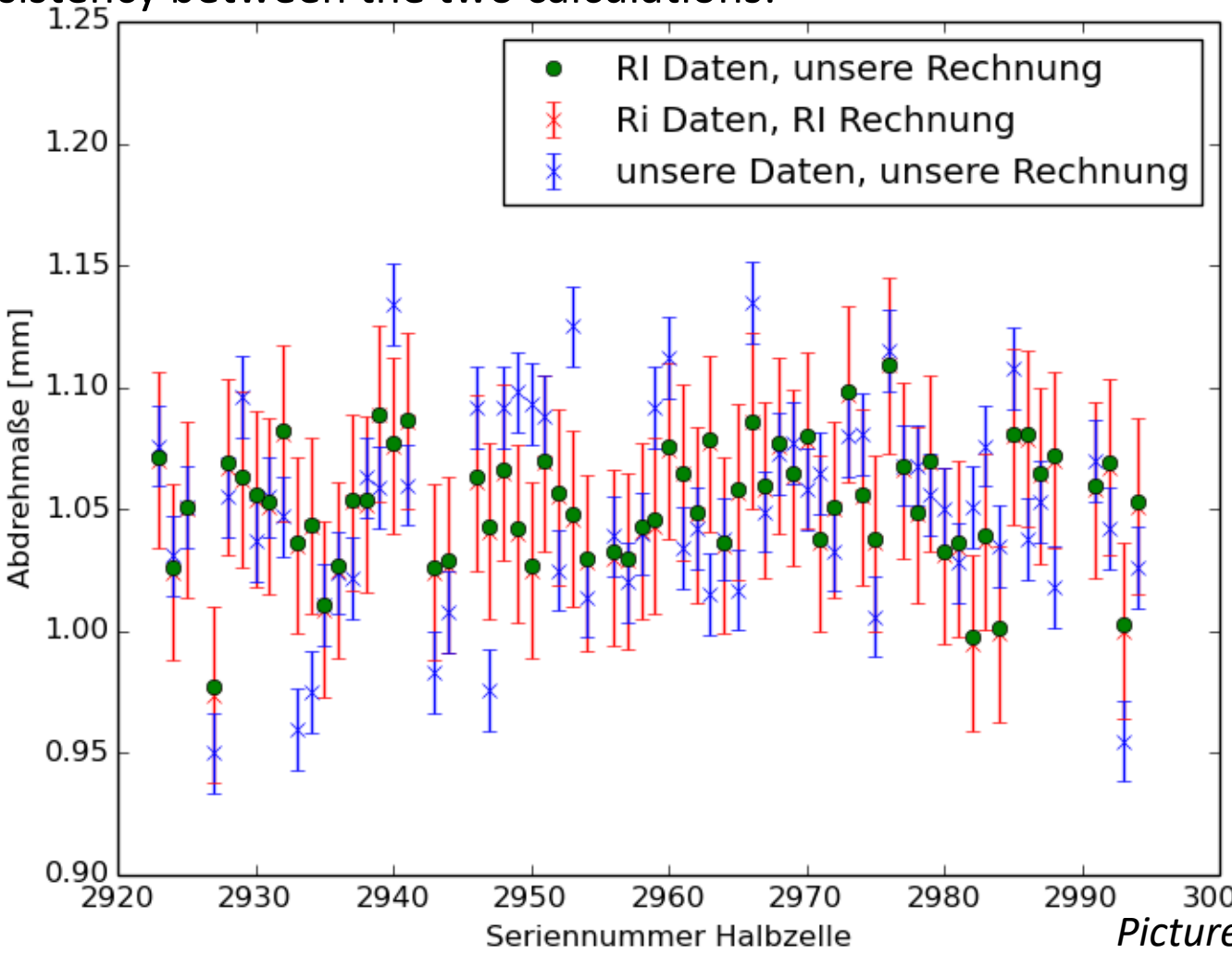
- Close cooperation between RI and Mainz University
  - Weekly **conference calls**
  - **Personal meetings** if necessary approx. **3 per year**
  - **Approval** of all changes
  - Quality control: All RF **measurements** verified by JGU

  - ➢ 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

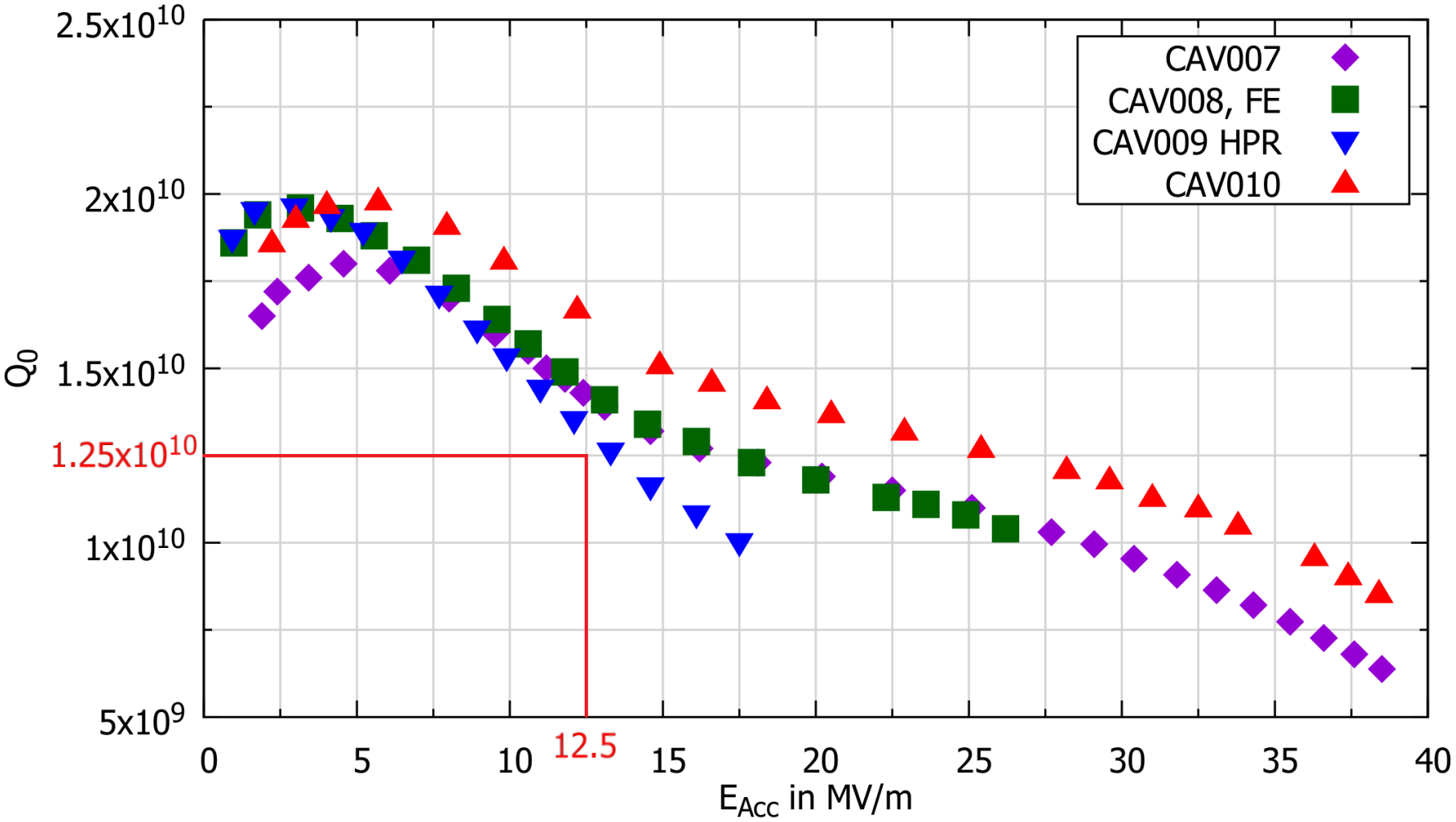
Quality Control of Cavity Production by JGU

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



Pictures: P. Weber

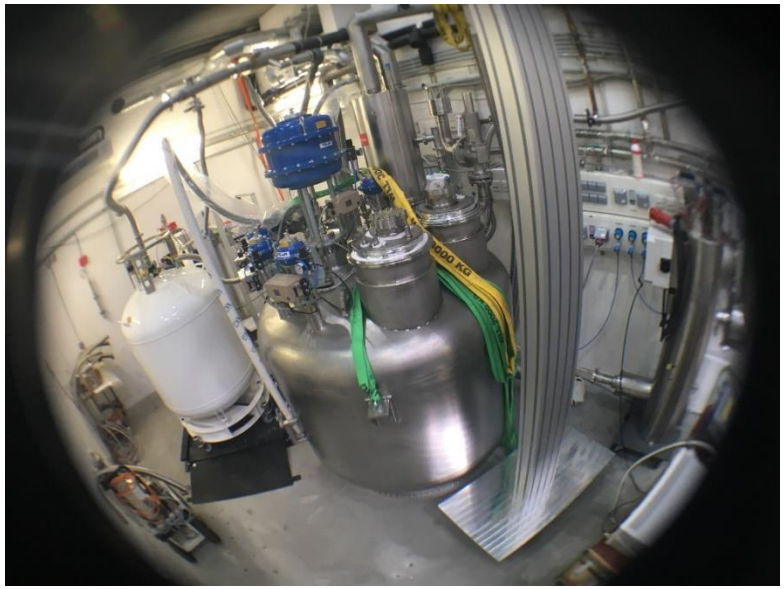
Vertical Test Results @ DESY AMTF

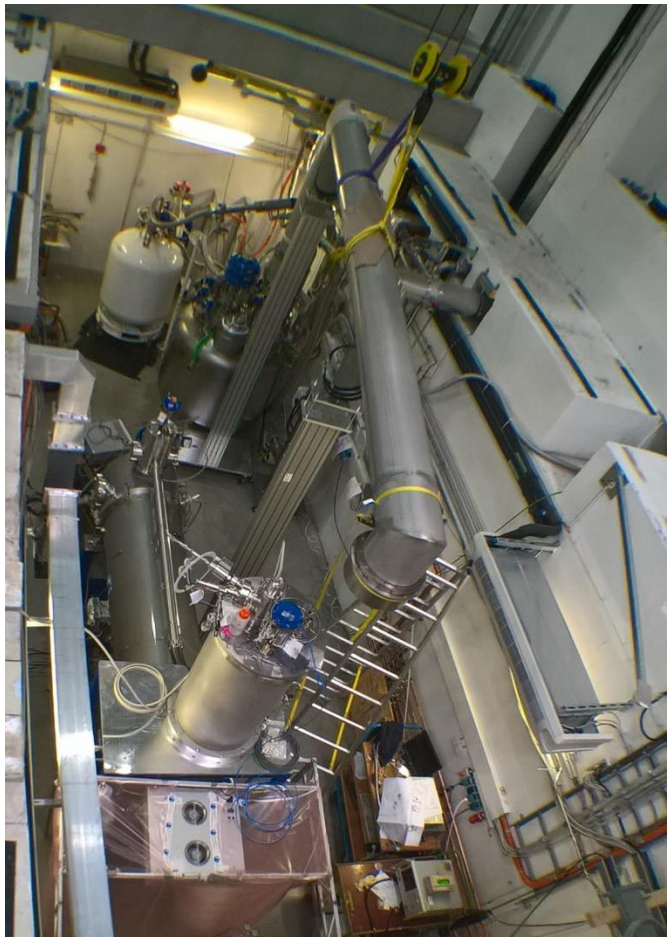


Site Acceptance Test at HIM

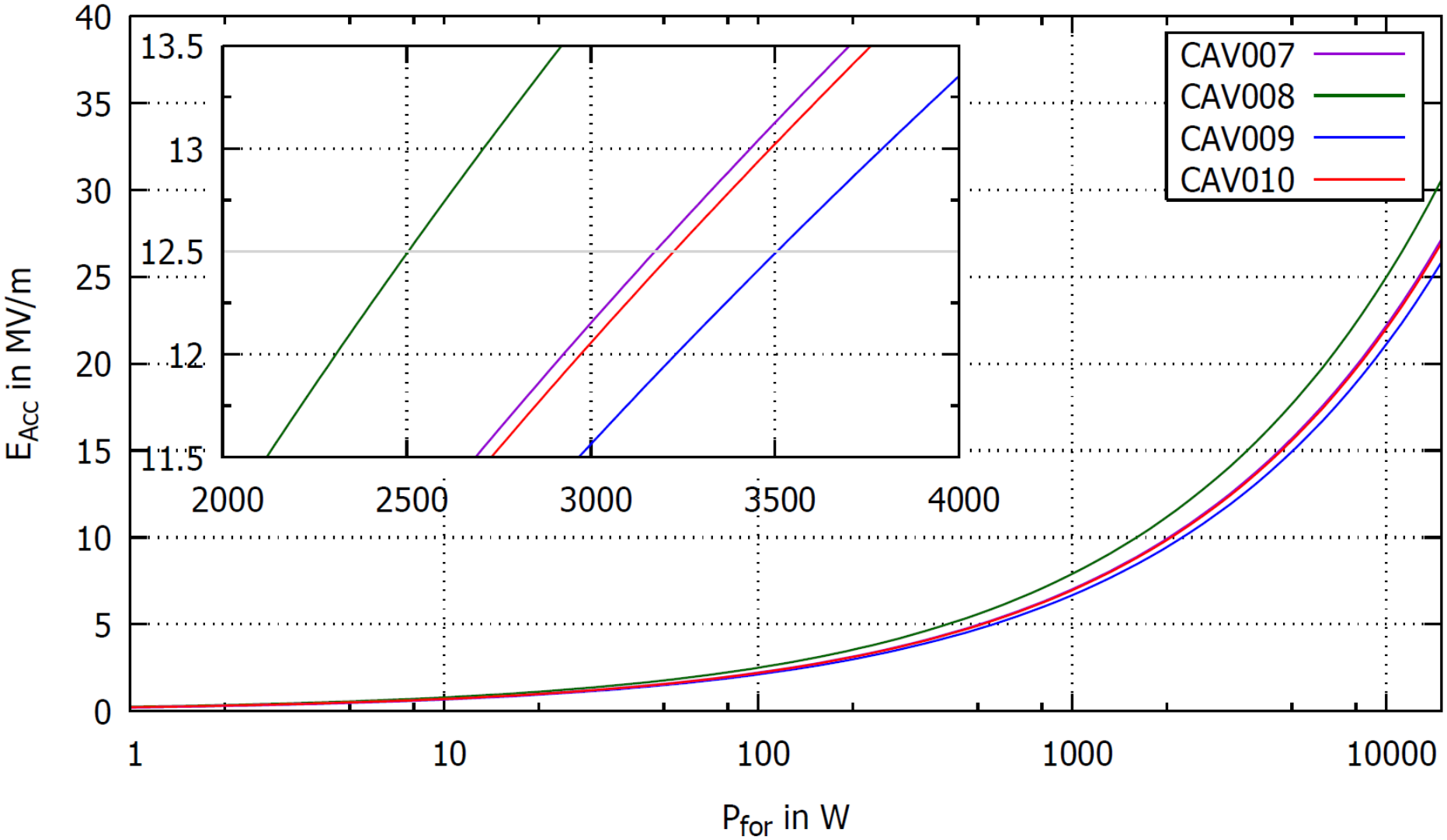
HELMHOLTZ GEMEINSCHAFT
Helmholtz-Institut Mainz

- 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)**

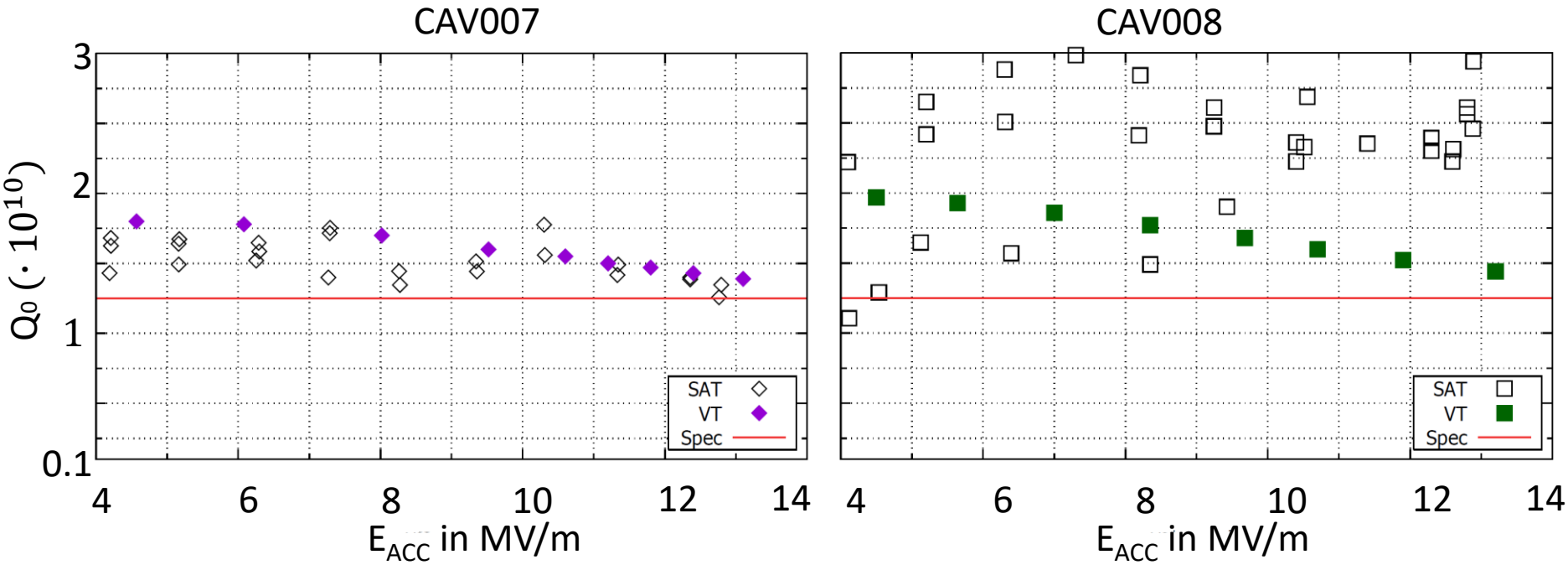




RF Generator and Possible Gradients



Site Acceptance – Cryomodule 1

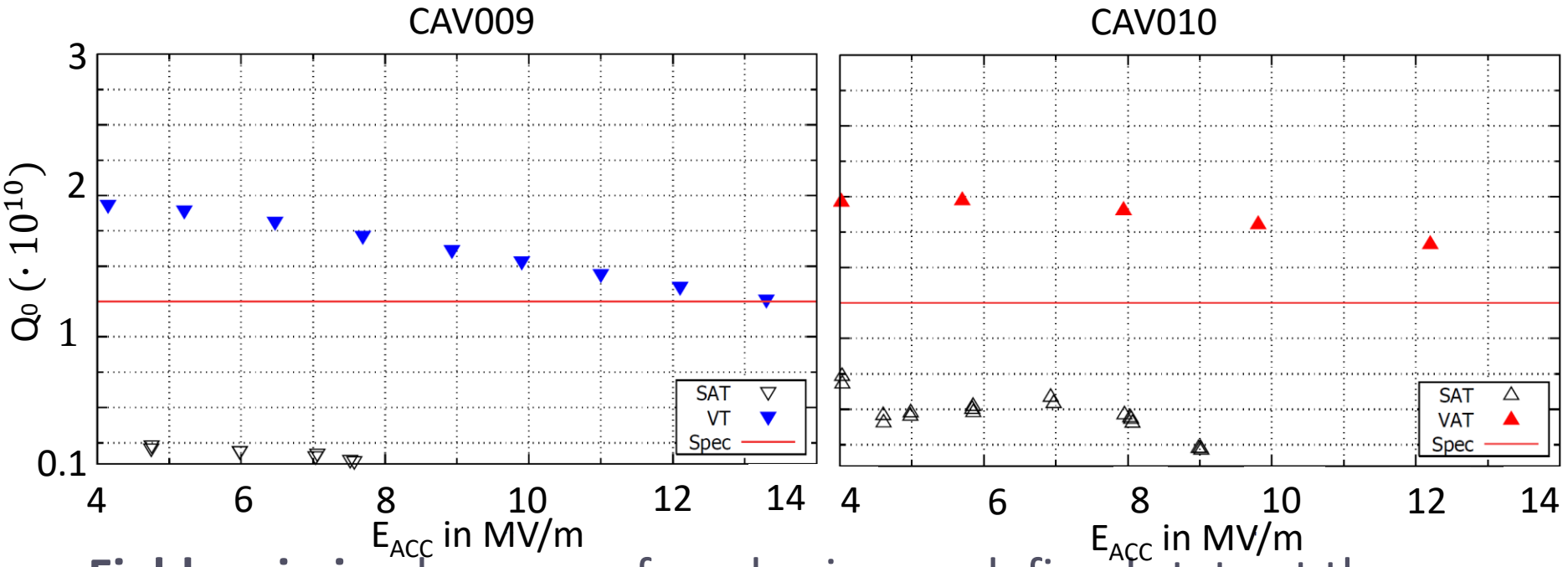


CAV008:

- **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…

1st Site Acceptance – Cryomodule 2

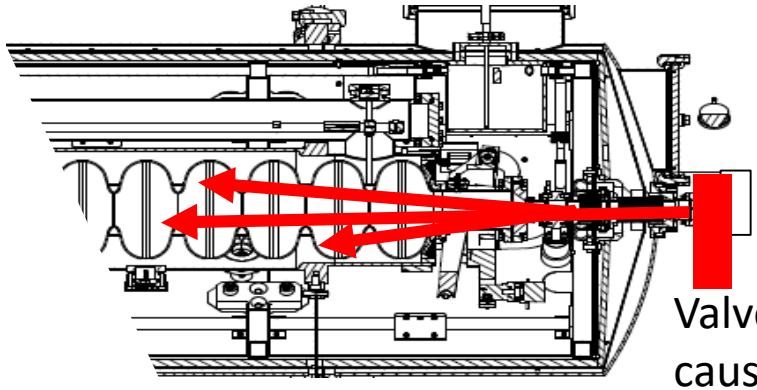


Field emission because of a valve in a undefined state at the beam pipe

Particles could float in N_2 atmosphere

CM received **refurbishment**

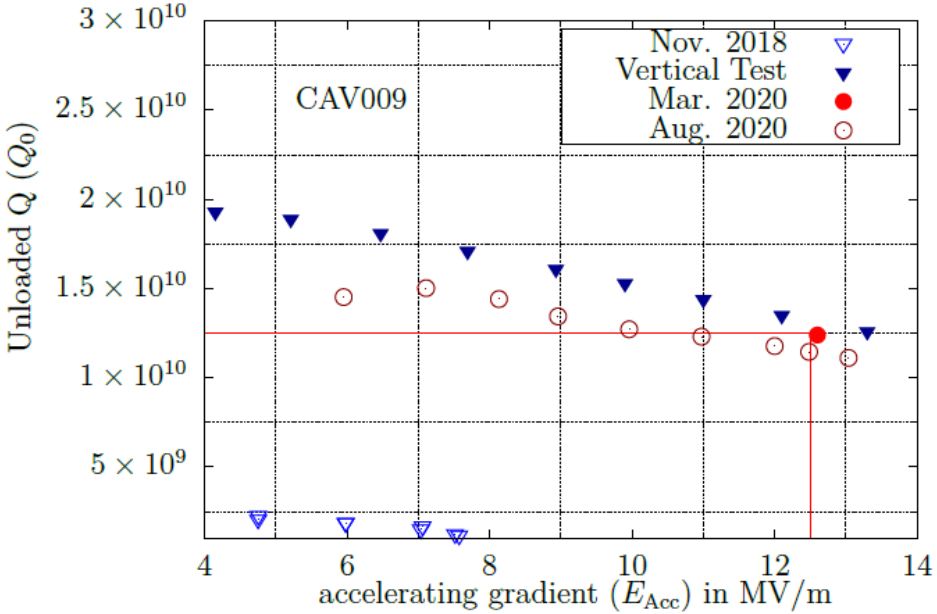
Re-Test in **2020**



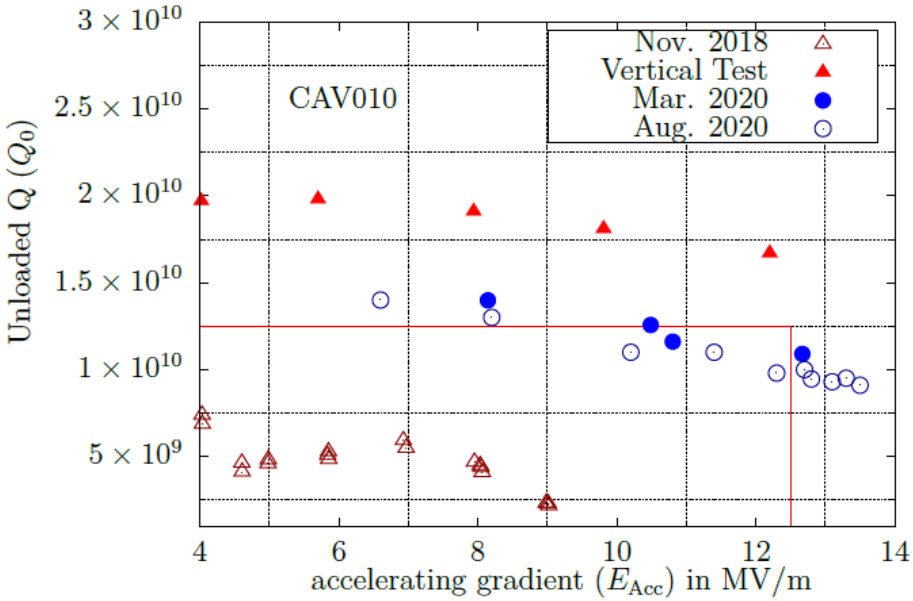
Valve movement caused particles

2nd Site Acceptance – Cryomodule 2

CAV009



CAV010



Increased performance close to design value

Still some degradation with respect to vertical test

→ Module accepted as full cryogenic losses within specification

Summary and Outlook

Cryomodule production:

- Successful „turn key“ CM production by industry
- CM1 with 2x 12.5 MV/m @ $Q_0 = 1.2 \cdot 10^{10}$
- CM2 successfully refurbished and accepted
- CM transport under vacuum

Cryomodule future:

- Clean integration into the accelerator
- Performance tests at final position and with beam
- Refurbishment of a spare module ongoing
  → future maintenance, hands on experience

Summary and Outlook

„Turn key“ experience:

- Need of close contact to vendor
- Successful project in the MESA case
- Modules and cavities might not be the ultimate ERL devices but good compromise for universities/small labs

HOM research:

- We would like to thank the Daresbury Laboratory for their generous gift
- Module and cavity preparation is ongoing, first tests in 2022