Status of the CM4 repair work

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ICCC meeting- 1 July 2019

Outline

- HIE ISOLDE SC linac in 2018
- CM4 refurbishing plans and changes occurred
- Work done so far (January - June 2019)
- Next steps
- Projected energy reach of HIE ISOLDE SC linac at the restart

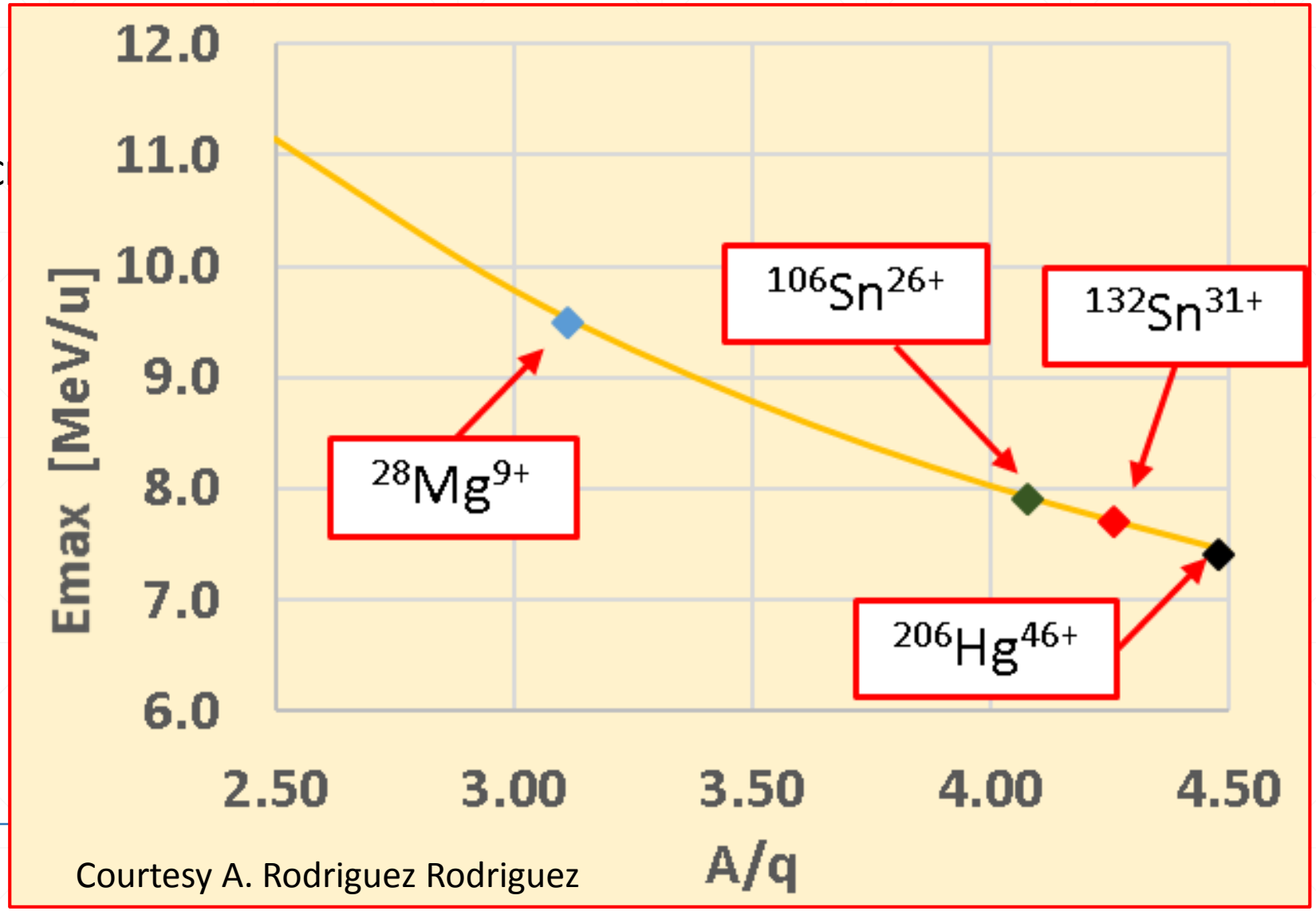
Reminder: HIE ISOLDE in 2018

- During hardware commissioning a non conformity was evidenced on Cavity 3 of CM4: faulty contact at the input coupler
- We decided not to put power in this cavity: the risk was to contaminate the whole cryomodule in case of release of material in the common vacuum.
- A few cavities are limited by field emission (in CM1 and CM2), it was decided to downgrade their settings rather than re-condition them in situ.
- Upon initiative of BE-RF, the LS2 committee gave green light to exchange CM4 in 2019
- No resources to intervene on more than one CM
- Detailed analysis confirmed that CM4 exchange offered the highest potential for improving the performance of the machine (by recovering one full cavity)

Cryomodule 4 layout

2018 settings (locked) and E/u versus A/q reachable in 2018 run

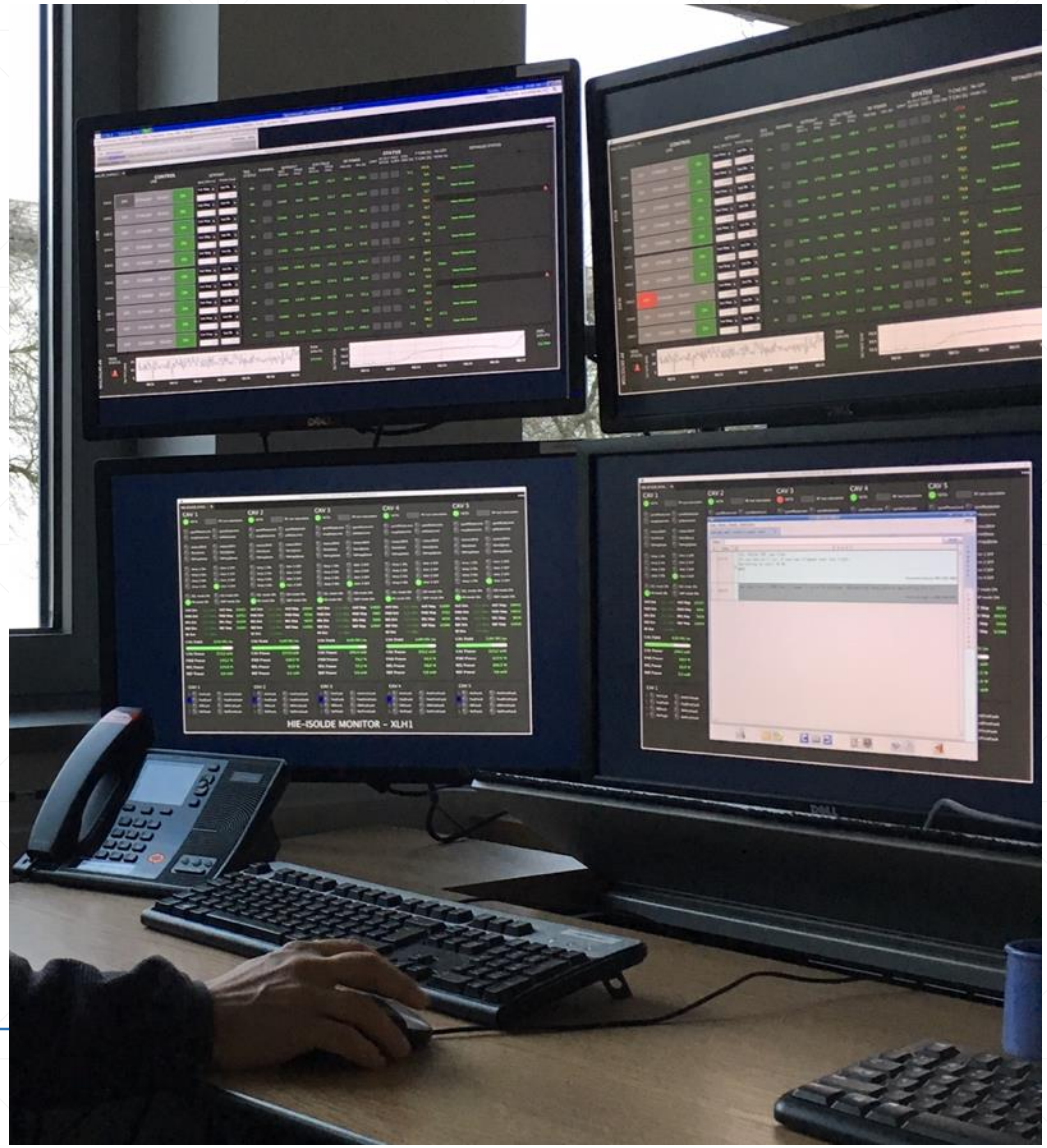
cavity	proposal [MV/m]	Achieved [MV/m]
XLL2.1	5	5
XLL2.2	5	5
XLL2.3	5	5
XLL2.4	5	5
XLL2.5	2	2
XLH1.1	5.5	4
XLH1.2	5.5	4.5
XLH1.3	5.5	5.5
XLH1.4	5.5	4
XLH1.5	5.5	5
XLH2.1	5	5.5
XLH2.2	4	5.5
XLH2.3	5	5.5
XLH2.4	5	5.5
XLH2.5	5	5.5
XLH3.1	5	4.2
XLH3.2	5	4.2
XLH3.3	0	0
XLH3.4	5	4.5
XLH3.5	5	4



Courtesy A. Rodriguez Rodriguez

Stress test after physics run on 7 December 2018: cavities locked for a few hours to higher fields

cavity	proposal [MV/m]	Achieved [MV/m]	Stress test [MV/m]
XLL2.1	5	5	**6**
XLL2.2	5	5	**5**
XLL2.3	5	5	**5.5**
XLL2.4	5	5	**5**
XLL2.5	2	2	**2.5**
XLH1.1	5.5	4	**5.5**
XLH1.2	5.5	4.5	**6**
XLH1.3	5.5	5.5	**6**
XLH1.4	5.5	4	**6**
XLH1.5	5.5	5	**5**
XLH2.1	5	5.5	**5**
XLH2.2	4	5.5	**6**
XLH2.3	5	5.5	**5.5**
XLH2.4	5	5.5	**6**
XLH2.5	5	5.5	**5**
XLH3.1	5	4.2	**4.5**
XLH3.2	5	4.2	**4.5**
XLH3.3	0	0	**0**
XLH3.4	5	4.5	**5.2**
XLH3.5	5	4	**5.2**



Foreseen steps for CM4 refurbishment

- Re-deployment of “logistic area” in the extension building (available in Jan 2019)
- Disconnection of CM4 just after the winter stop (Jan. 2019)
- Transport to SM18 (March. 2019), in front of the HIE ISOLDE clean room
- Finalize set of spare cavities (at least with QSS3 fully qualified), prepare them and store for installation (Nov 2018-March 2019)
- Open CM4 in clean room, remove all cavities, rinse 2, replace the others (window between April- August 2019- no scheduled power cuts when CM is open!)
- Closure, cold test in M9 (September-December 2019)
- Re-install CM4 in the HIE ISOLDE linac (as from January 2020)

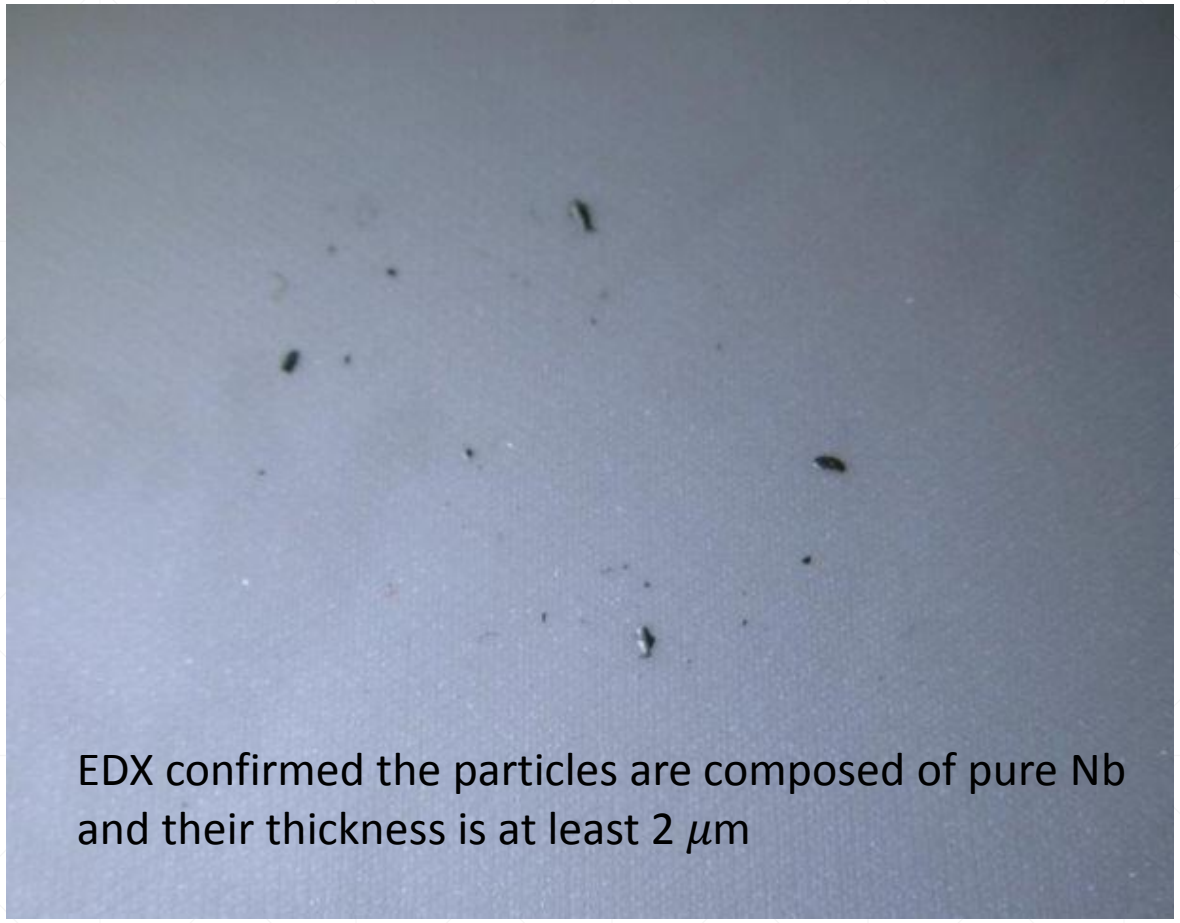
Changes occurred and new baseline

- Of the three spare cavities available
  - QSS3 did not perform well at vertical test. The reason is now understood (foreign macro-particle on Nb)
  - QSS2 and QS18 had excellent performance in vertical test, but…
- In both cases, after final rinsing particles were found in the filter of the exhaust water
- A careful investigation (optical inspections, SEM/EDX analysis of particles) was conducted
- We can’t exclude these particles be fragments of the Nb film detached from the cavity surface
- Consequently, and in order to minimize the risk for the users,
  BE-RF-SRF and TE-VSC-CC agreed on the following actions:

  - Reinforce mesures for slow venting, and avoid re-rinsing of already installed cavities
  - Limit the intervention to the repair of the RF line, wihtout replacing working cavities*
  - Re-test the spare cavities in vertical cryostats (in second half of 2019)

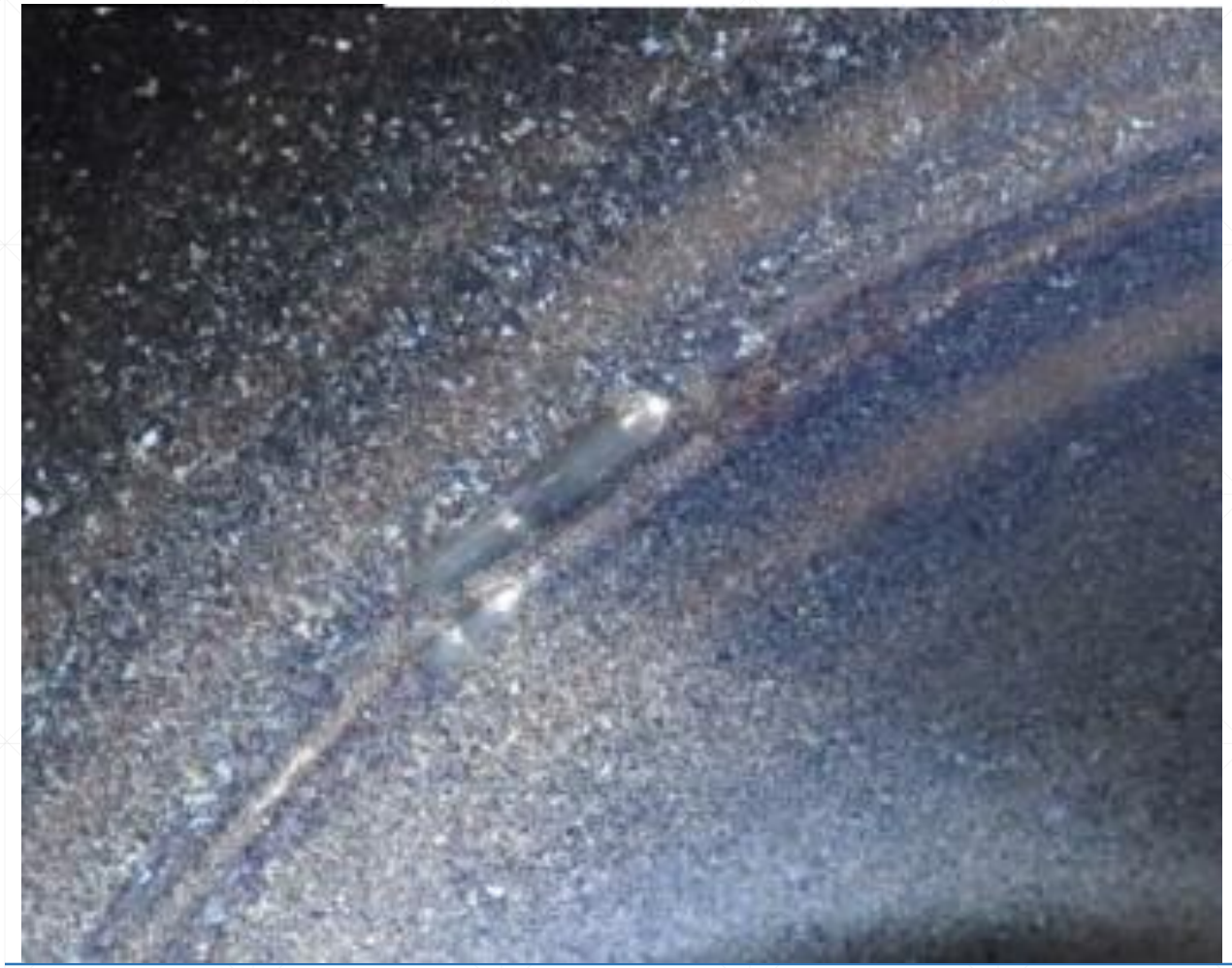
*N.B.: spare cavities would have offered lower cryogenics consumption, not higher fields, with respect to the installed ones. Howevere operations in 2018 were not limited by cryogenics power

Case of QS18 and QSS2



EDX confirmed the particles are composed of pure Nb and their thickness is at least 2 μm

Case of QS18 and QSS2



Work done on CM4 so far (main points)

- CM transport to SM18 (14 March)
- RF measurements
- Slow venting
- CM opening and RP inspection, shutters closure
- Survey
- Diagnosis and repair of RF line of CAV3
- Inspection and re-soldering of RF cables where needed
- Re alignment
- Closure, slow pump down, leak checks under pressure
- Transport and positioning in M9 (26 June)

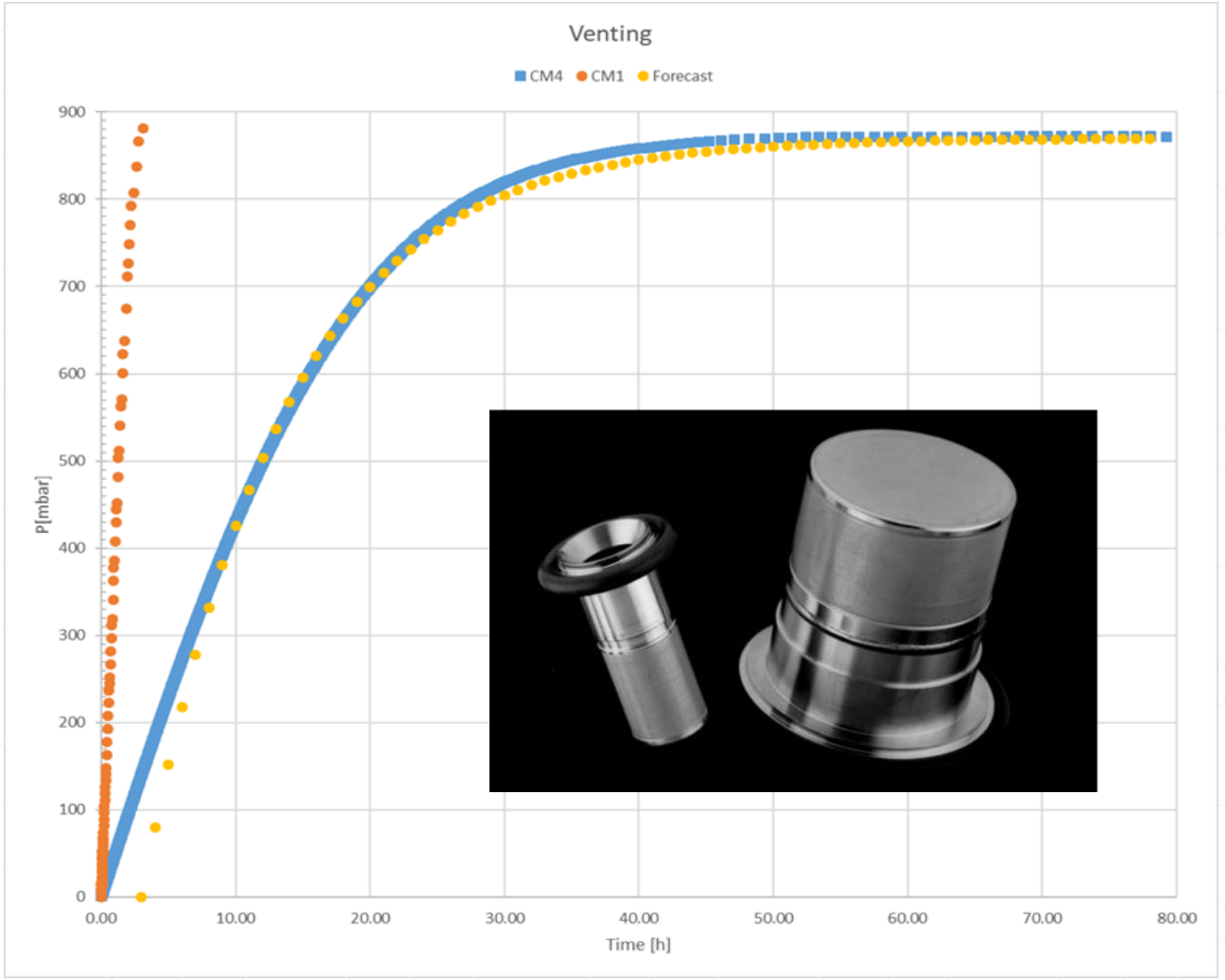
Slow venting of CM4

Improvements respect to CM1:

Venting from the top has the advantage the flow goes in same direction as gravity.

A diffuser filtering particles ≥ 0.003 µm was installed in the clean room. The space between the filter and the shutoff valve was assembled in clean conditions

Dosing valve to control the flow. This time we have targeted a venting time of maximum 2 mbar/min, final value was set to 0.8 mbar/min.



Courtesy J A. Ferreira Somoza

So, what was the matter with CAV3?

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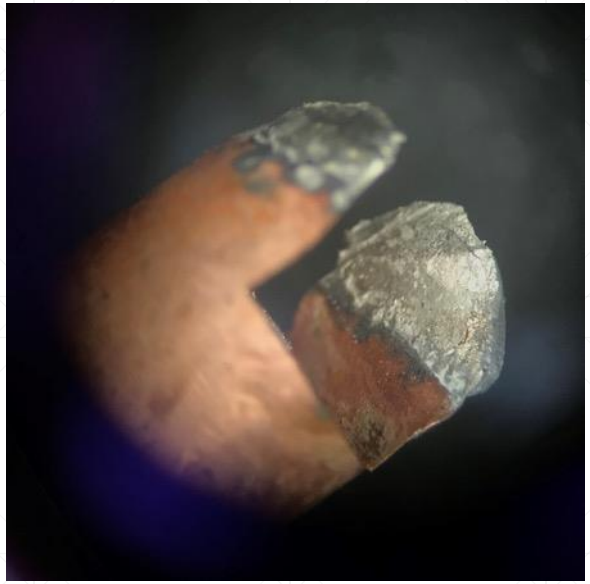
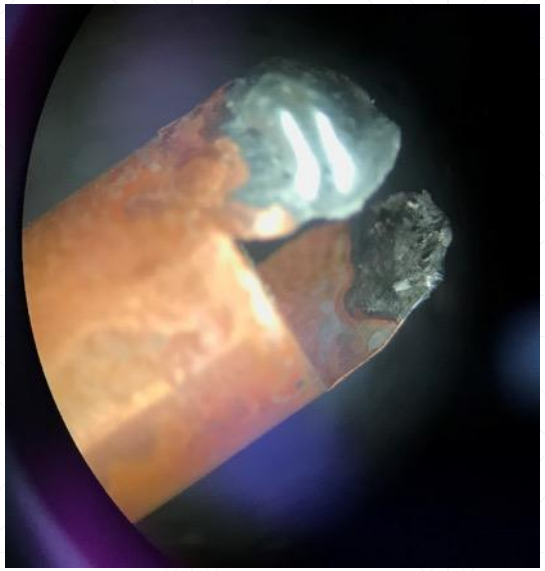
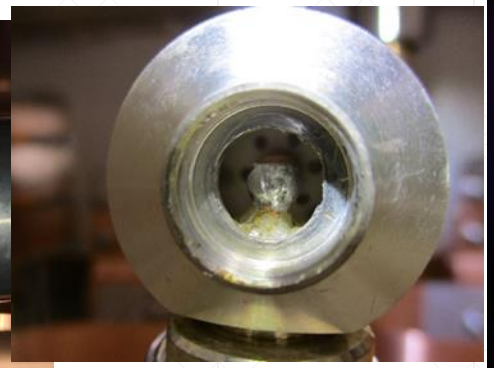
The soldering of inner conductor of the coax cable to coupler antenna was damaged after the first cool down.

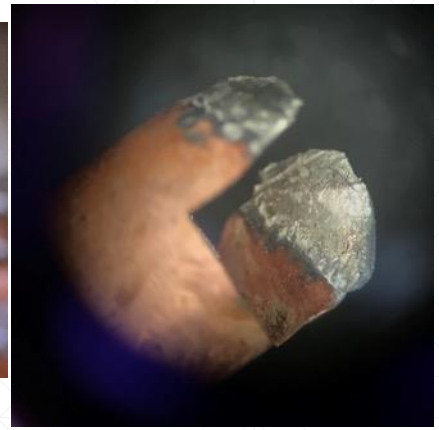



Inspection of the weak spot at all other cavities revealed similar features albeit less severe

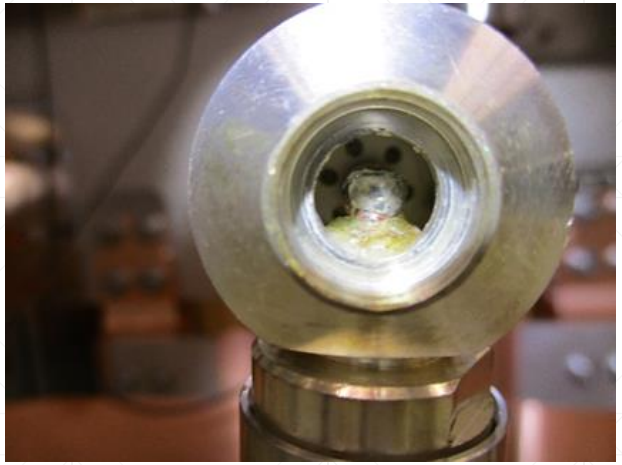
QS17



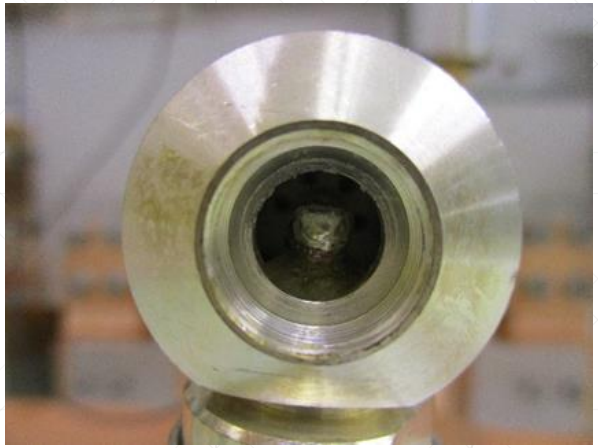
QS19



QS22



QS23



QSS1

Soldering re-done with improved technique

RF measurements at warm

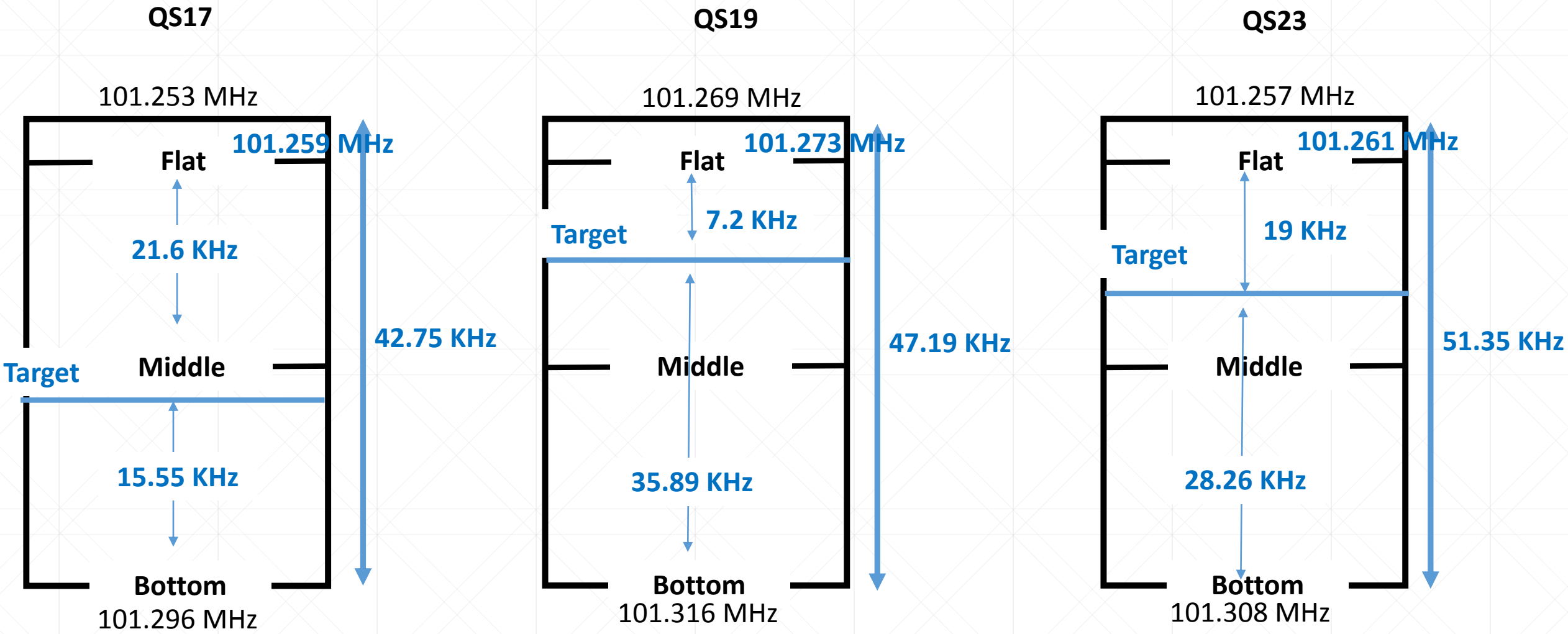
RF transmission and its relation to Qext and Q0				
CM4				
Cavity	RF trans (dB)	Q ext (pickup)	Q0	QL
QSS1	-69	6.28E+10	9.71E+03	6951
QS23	-64.6	2.82E+10	1.01E+04	6014
QS22	-64.7	2.96E+10	1.04E+04	6176
QS19	-64.2	2.51E+10	9.98E+03	6015
QS17	-63.5	2.15E+10	1.00E+04	6014

2017 measurements (EDMS 1879571 v.1)

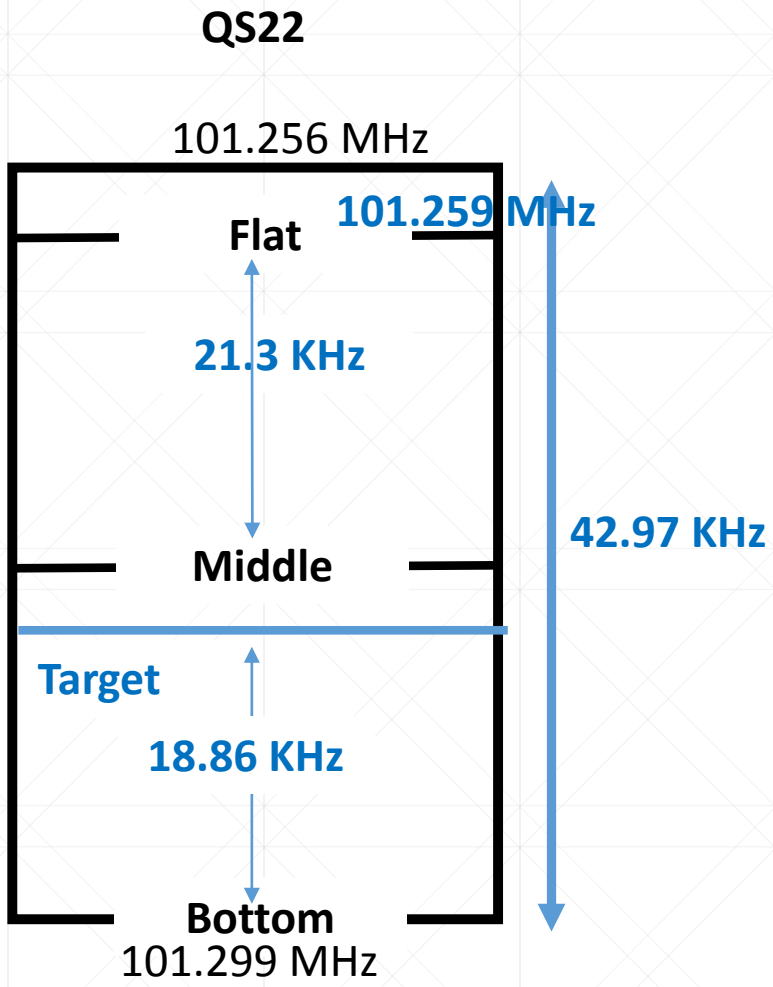
CM4				
Cavity	RF trans. (dB)	Qext (pickup)	Q0	QL
QSS1(C4.5)	-73.4	1.71E+11	9.55E+03	6800
QS23(C4.4)	-64.9	2.92E+10	9.75E+03	5700
QS22(C4.3)	-64.9	3.10E+10	1.03E+04	6000
QS19(C4.2)	-64.2	2.38E+10	9.38E+03	5540
QS17(C4.1)	-63.6	2.21E+10	9.98E+03	5900

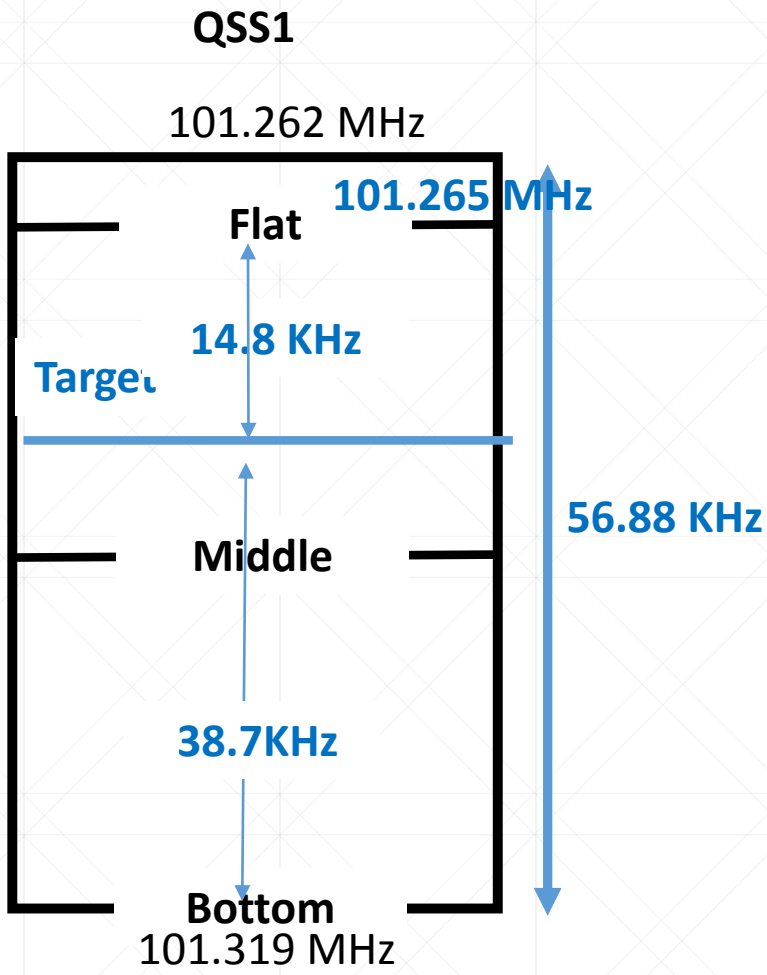
Figure 7: RF transmission and its relation to Qext and Q0

RF measurements at warm: frequency and tuning range

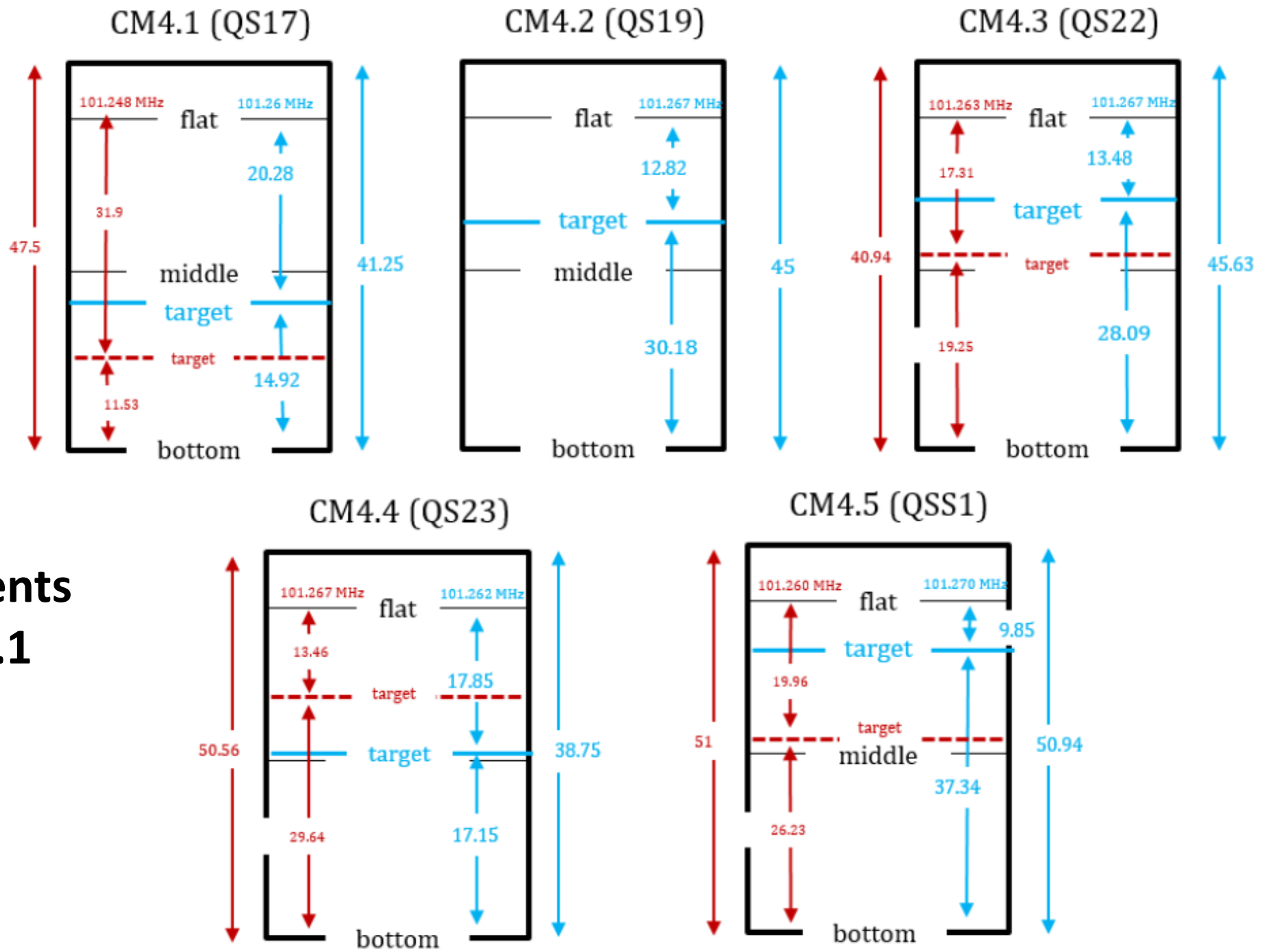


RF measurements at warm: frequency and tuning range

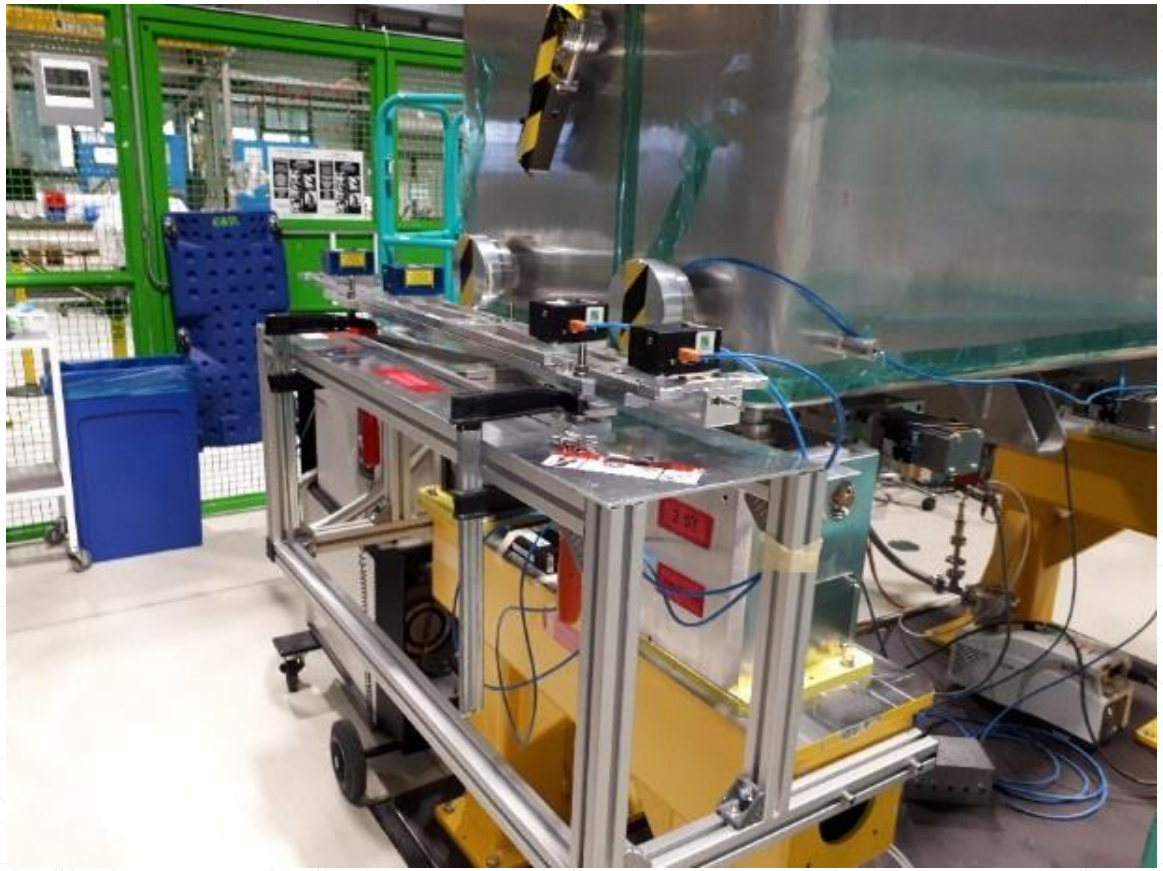


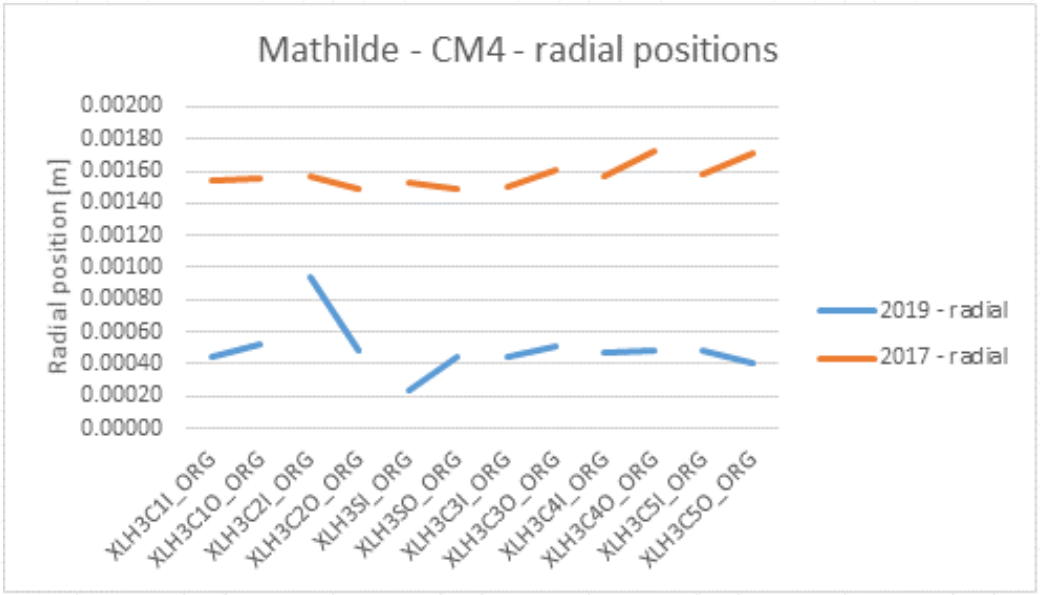


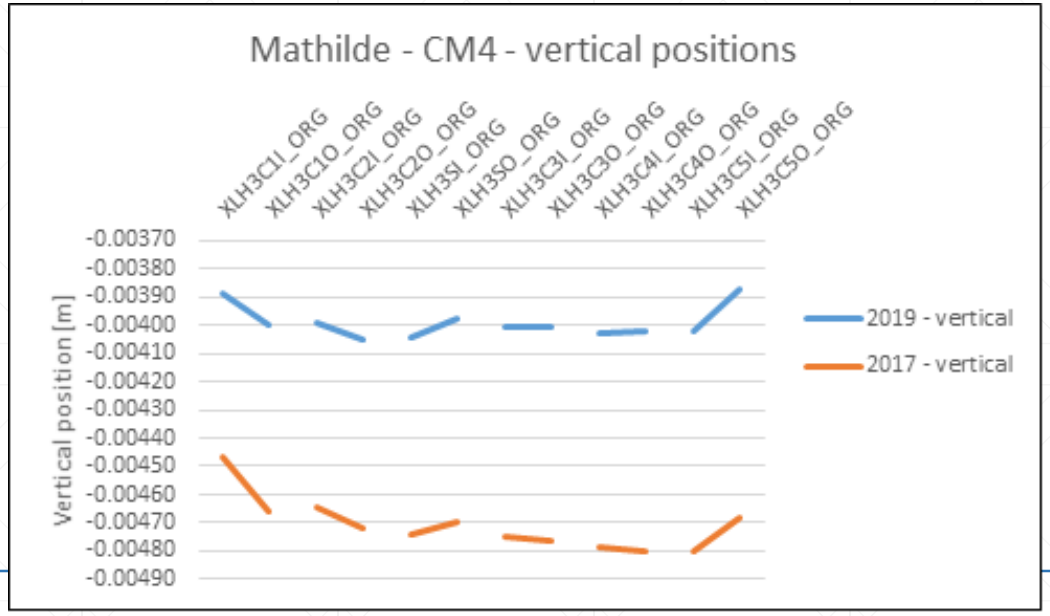
2017 measurements
EDMS 1879571 v.1



Results of the final survey







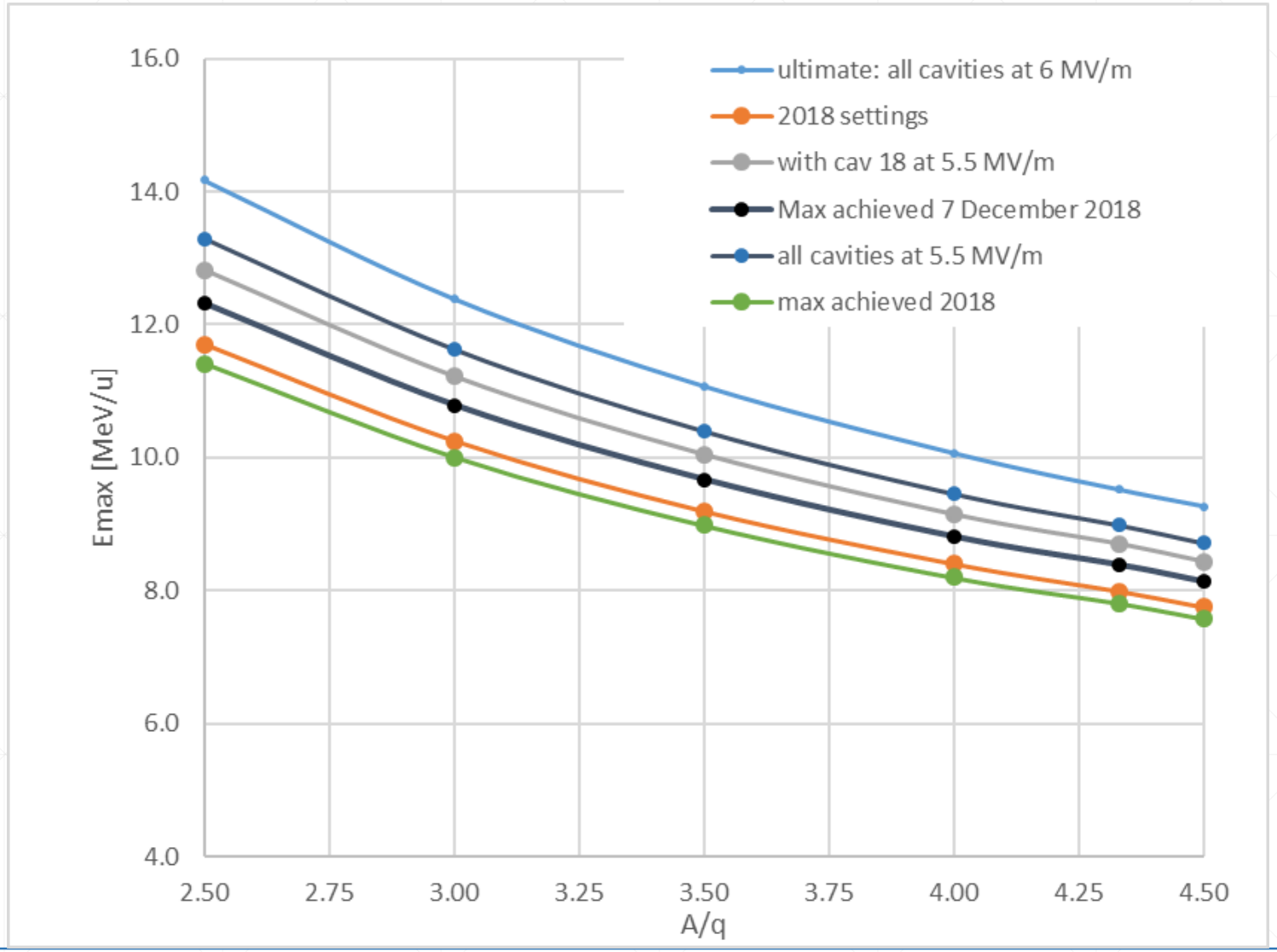
-CAV2 and Sol.: radial misalignments of +0.4 and -0.2mm.
-Beam dynamics implications checked by M. Fraser, OK

CM4 transport to the test bunker (June 26)

Next steps

- Cryogenics connections
- RF, solenoid, controls and instrumentation cabling
- Interlock checks
- Cool down start (~ 15 July onwards)
- Cavity conditioning above Tc (end July)
- Cold test (August- September)
- If cold test OK, transport to ISOLDE by end 2019

Foreseeable energy reach of the HIE ISOLDE linac after LS2



Summary

- CM4 repair work proceeding on schedule
- Issues with spare cavities (suspect delamination of Nb film)
- Technical choices dictated by minimum risk approach in terms of energy reach at HIE ISOLDE after LS2
- Main limitation to stabilize ultimate fields (6 MV/m in all cavities) comes from pressure fluctuations in the cryo-plant
- Further consolidation envisaged is to complete the set of spares with missing components to build a fifth cryomodule and install it on line
- Proposal is being considered by CERN Consolidation management