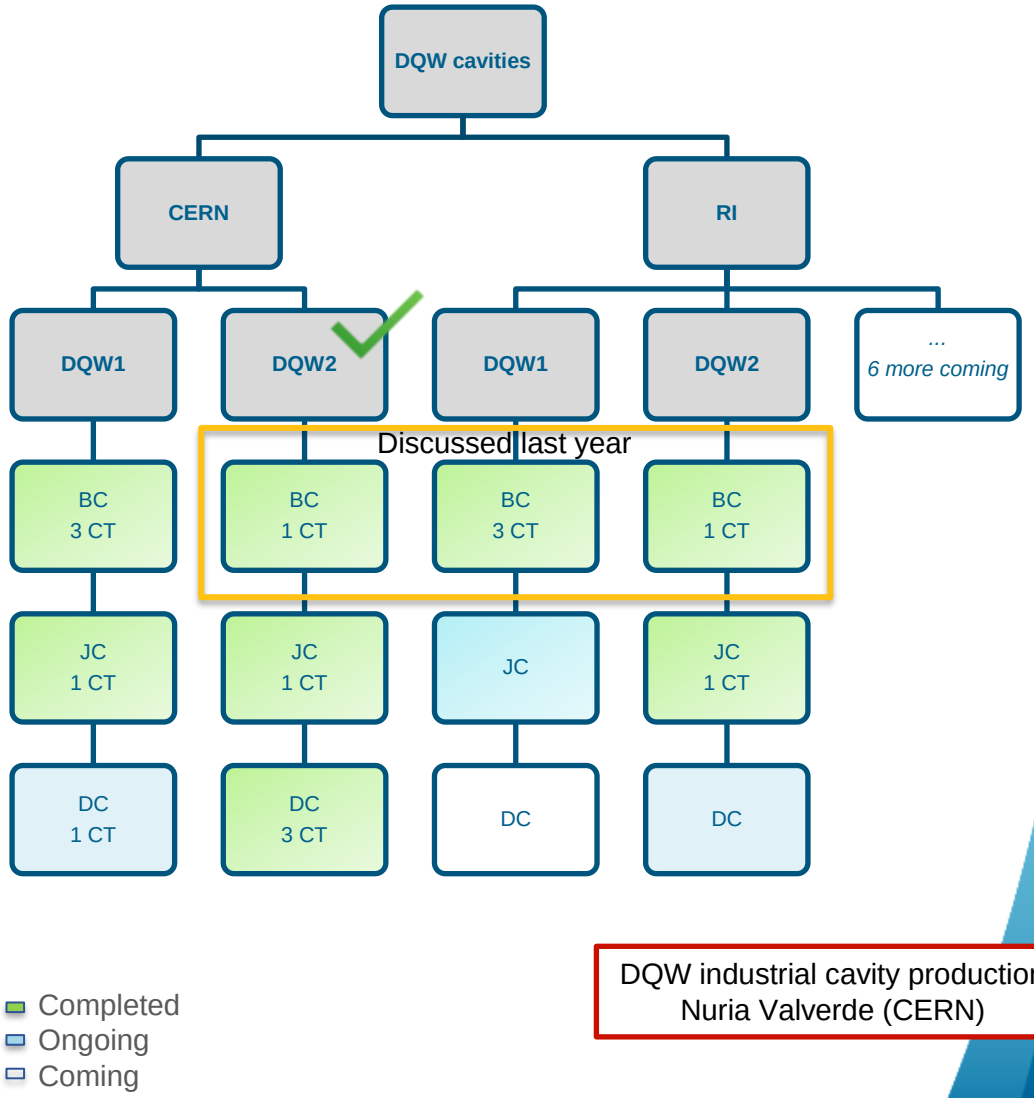
DQW CERN cavity tests

Katarzyna Turaj on behalf of WP4 and SY-RF-SRF

13th HL-LHC Collaboration Meeting Vancouver, 25-28 September 2023

Status

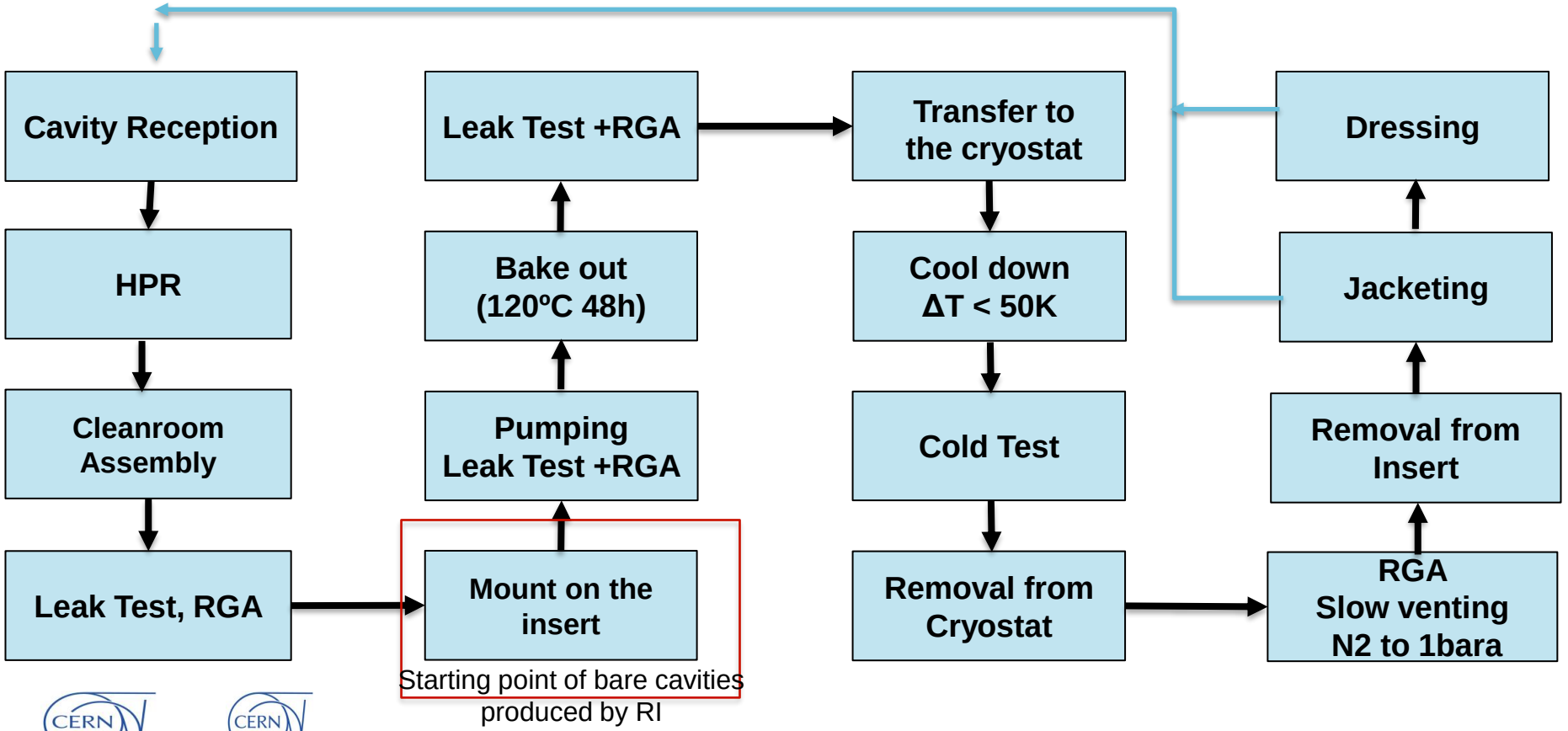
- 10 RF cold test since last year
- 1 cavity ready for a string assembly ✓
  - DQW2 CERN
    - 1 CT in JC
    - 3 CT in DC
- 2 more ready for testing in dressed configuration
  - DQW1 CERN
    - 2 (3) CT in BC
    - 1 CT in JC
    - 1 CT in DC → retest in October 2023
  - DQW2 RI
    - 1 cold RF test in JC
- 1 cavity ready for testing in jacketed configuration
  - DQW1 RI



DQW industrial cavity production
Nuria Valverde (CERN)

Simplified process flow of DQW cavities

- Similar preparation and testing process.
- RF tests performed in V3 and V4 cryostat in SM18.
- Inspection and frequency measurement between each step.

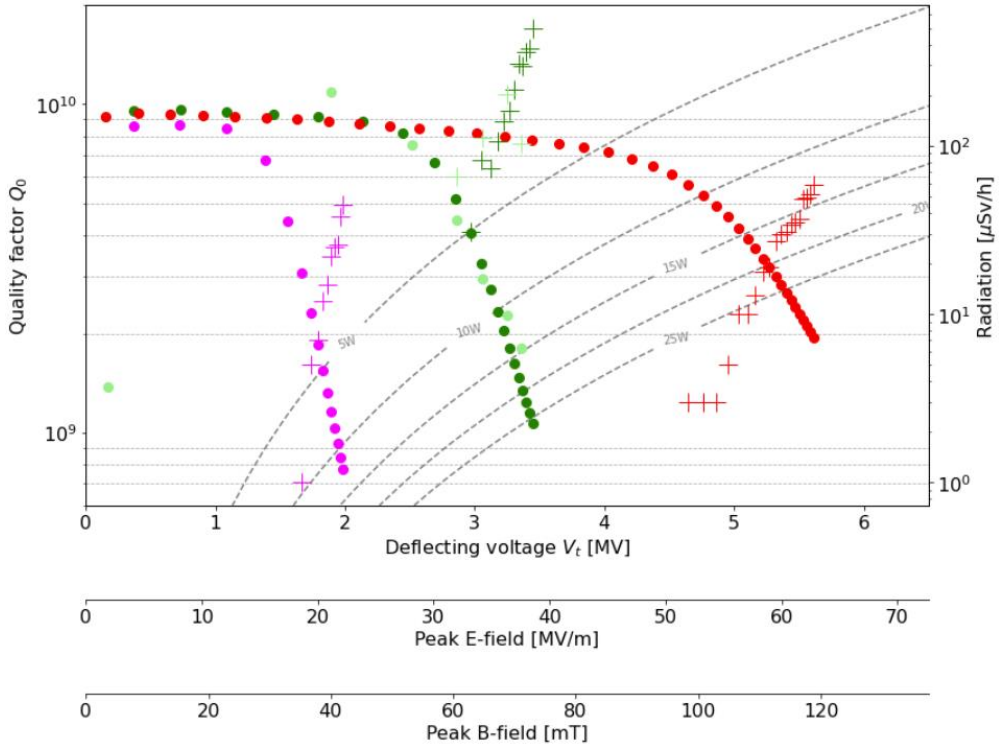


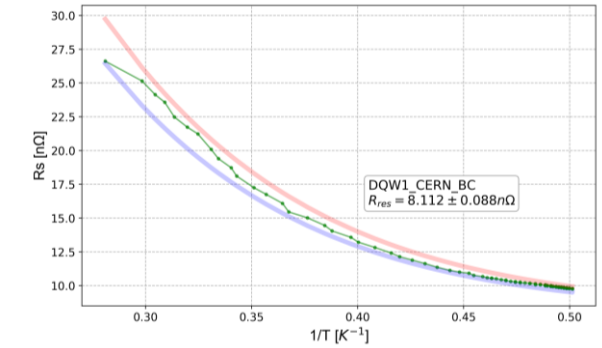
Cold test set-up

- Test temperature: 2K
- Sensors used during the tests:
  - Temperature sensors: CERNOX.
  - 3 single-axis magnetic flux probes.
  - Radiation monitors (different position depends on the cryostat).
- Cryostats equipped with magnetic field compensation coils - set at ~0.5μT (BC).
- Stiffening frame for bare cavities.
- JC and DC tested fully immersed in the LHe bath.
- Cavity vacuum actively pumped by turbo and ion pump, then only cryopumping.

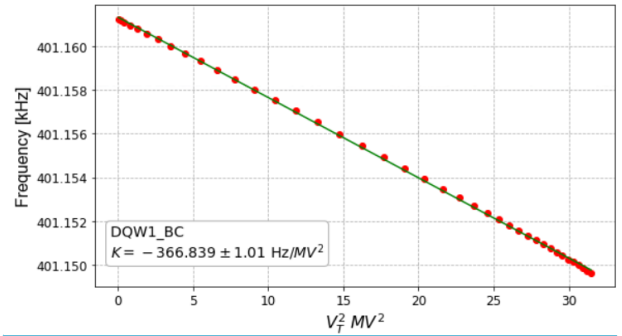
Bare Cavity Test Results – DQW1-CERN-BC

- Tested three times:
  - **1st CT** poor RF performance test stopped (*)
  - **2nd CT** after light BCP (~30µm): poor RF performance test stopped.
    - Before He processing
    - After He processing
  - **3rd CT** after additional light BCP (~30µm): met specification
    - **5.6MV** (Q_0=2e9), Epeak~63MV/m and Bpeak~119mT

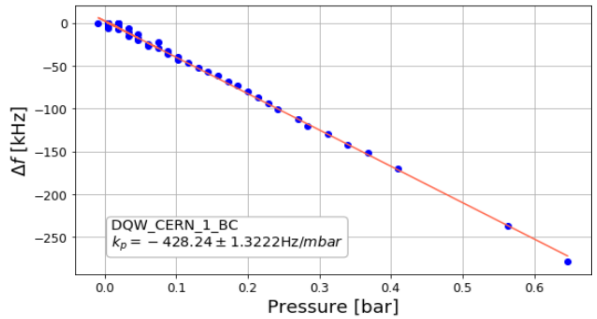




Residual resistance: ~8.1nΩ



Lorentz Force Detuning

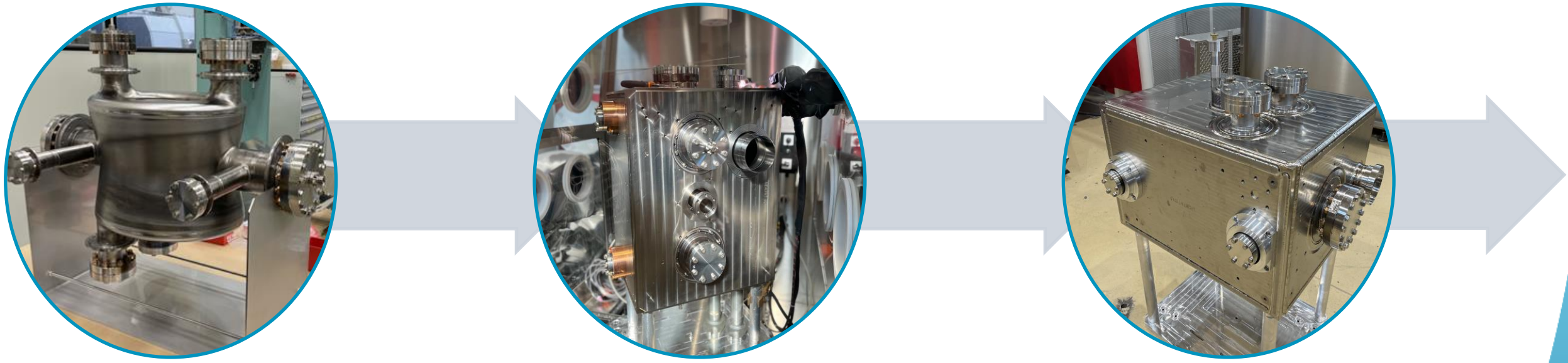


Pressure sensitivity

(*) reported last year

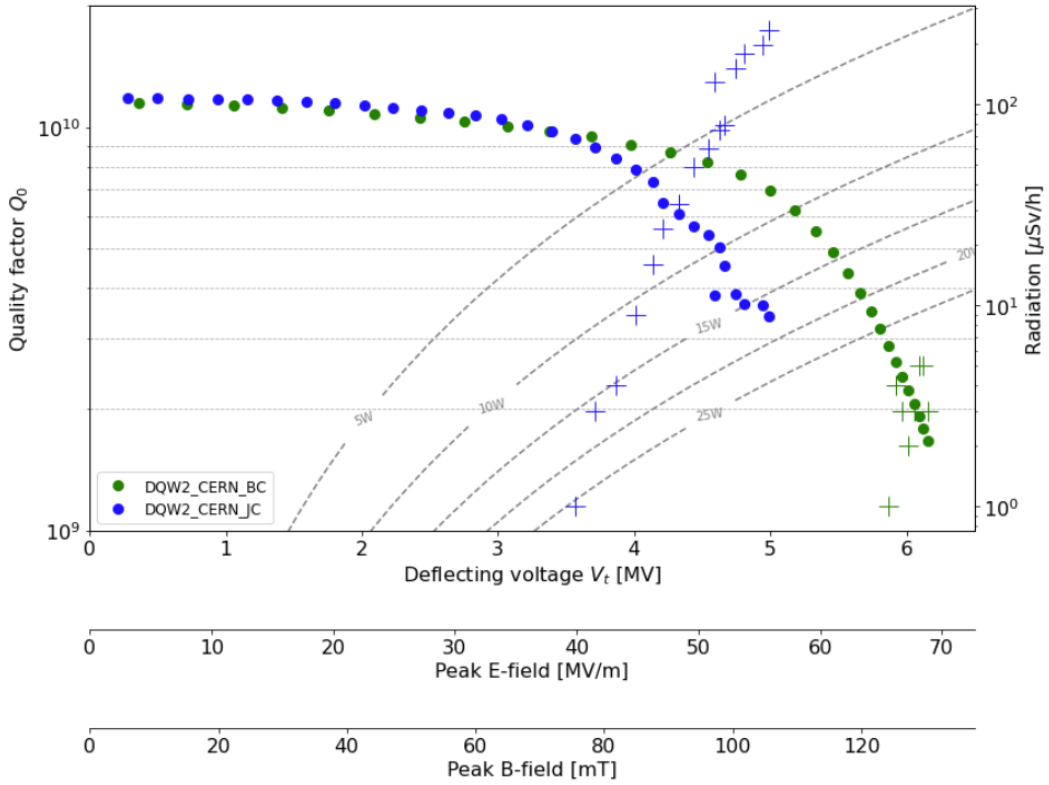
Jacketing

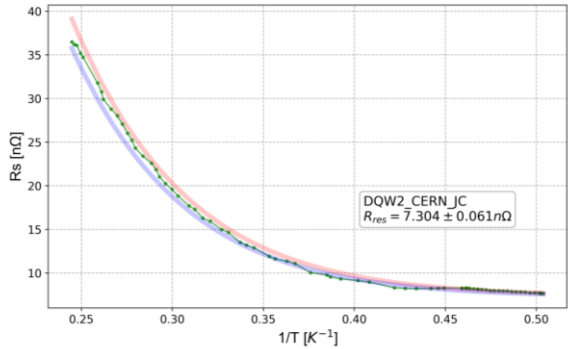
- Cold Magnetic Shield + Helium tank assembly (bolted) and TIG welding



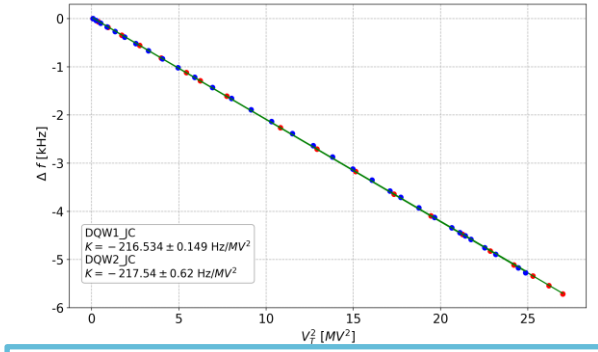
Jacketed Cavity Test Results – DQW1-CERN & DQW2-CERN

- **DQW1: 5.1MV** (Q_0=5e9), Epeak~57MV/m and Bpeak~108mT
  - Better Q but higher radiation compared to the **bare cavity** but tested in a different cryostat.
- **DQW2: 5 MV** (Q_0=3.4e9), Epeak~56MV/m and Bpeak~106mT
  - Higher radiation (degradation of Q_0 at high field) compared to the **bare cavity** but tested in a different cryostat.
- Tests stopped purposely at ~5MV.
- The cavities were sent for dressing at CERN.

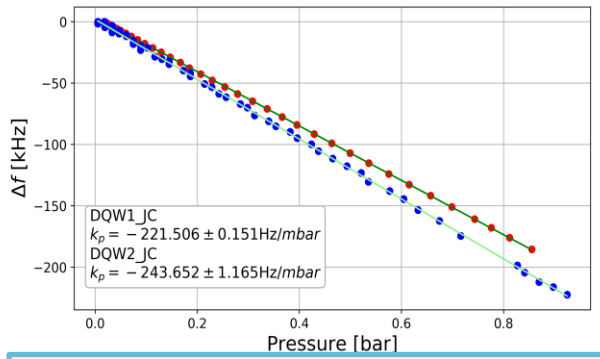




Residual resistance: ~7.3nΩ



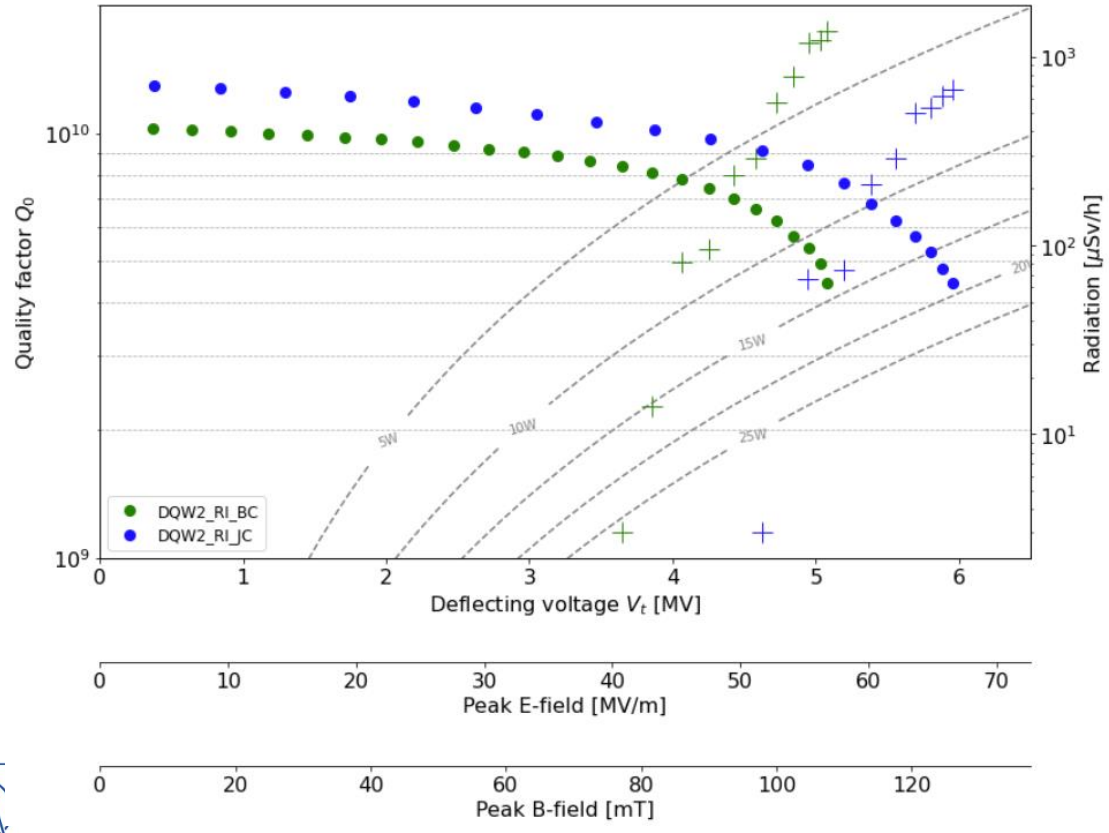
Lorentz Force Detuning

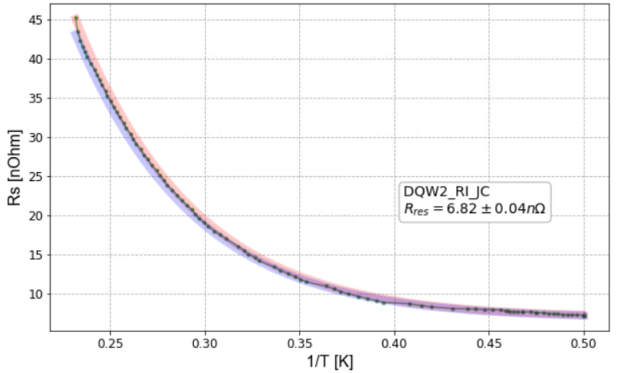


Pressure sensitivity

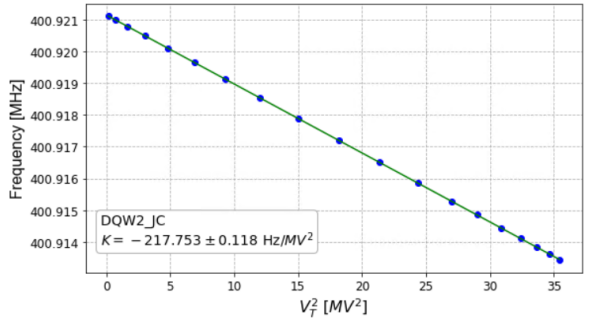
Jacketed Cavity Test Results – DQW2-RI

- **DQW2: 5.9 MV** (Q_0=4.4e9), Epeak~67MV/m and Bpeak~126mT
- Test stopped at 5.9MV due to the radiation.
- Significant improvement (Q_0 and radiation) compared to **bare cavity** tests done in the same cryostat.
- The cavity was sent for dressing at CERN.

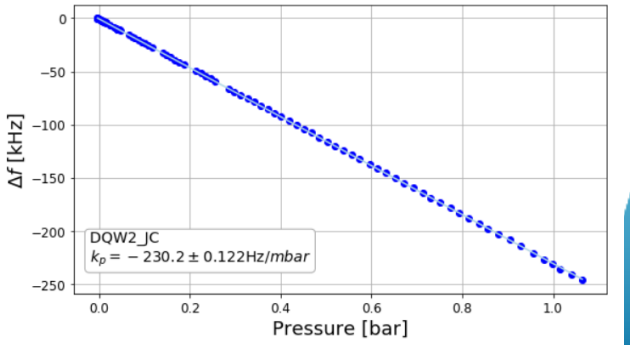




Residual resistance: ~**6.8nΩ!**



Lorentz Force Detuning



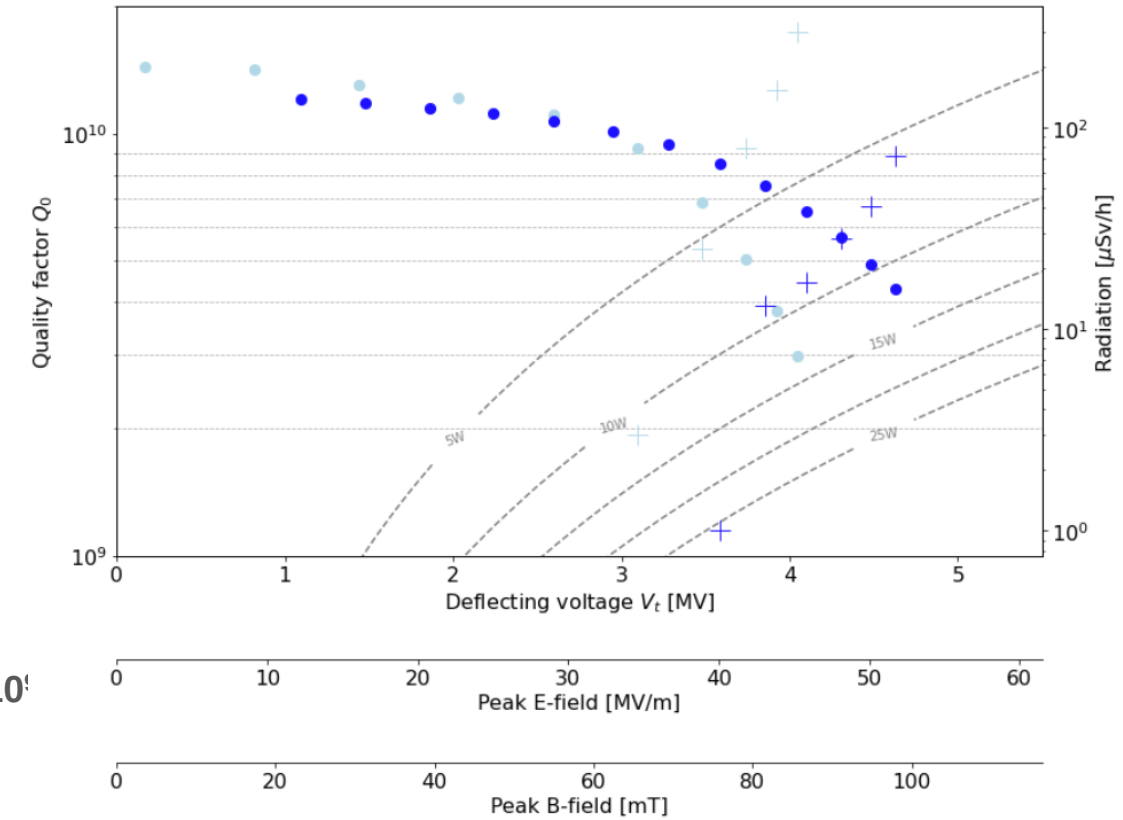
Pressure sensitivity

Dressing

- JC equipped with RF couplers (3 HOMs, 1 HF HOM, 1 FA + VT input antenna)

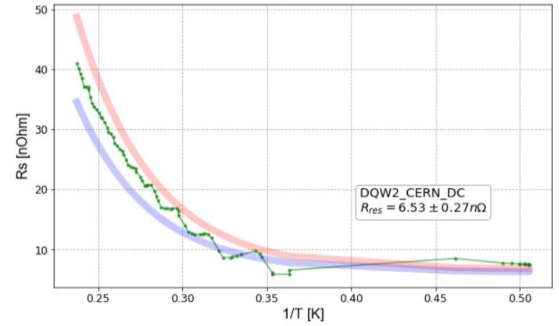
Dressed Cavity Test Results – DQW1-CERN & DQW2-CERN

- **DQW1: 3.9MV** (Q_0=2e9) , Epeak~45MV/m and Bpeak~86mT
  - Degradation observed after the high-power RF conditioning.
  - 2nd CT foreseen in October 2023
- **DQW2: 4.63MV** (Q_0=3e9), Epeak~52MV/m and Bpeak~99mT
  - 1 CT stopped due to wrong antennas and **2 CT** cavity reach 4MV (*)
  - 120℃ bakeout + 100µm oh HOMs introduced before 3rd CT

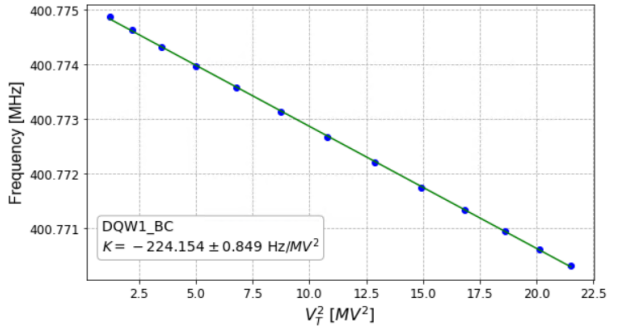


DQW CC frequency & HOM evolution during manufacture and cold testing – Amelia Edwards (Lancaster Uni)

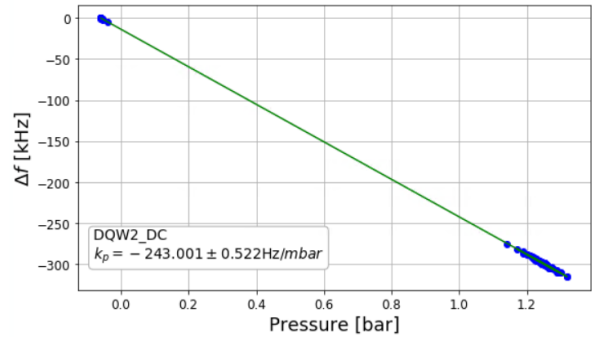
(*) Eng spec: Vt ≥4.1MV,Q0 ≥3.9×10⁹



Residual resistance: ~**6.5nΩ!**



Lorentz Force Detuning



Pressure sensitivity

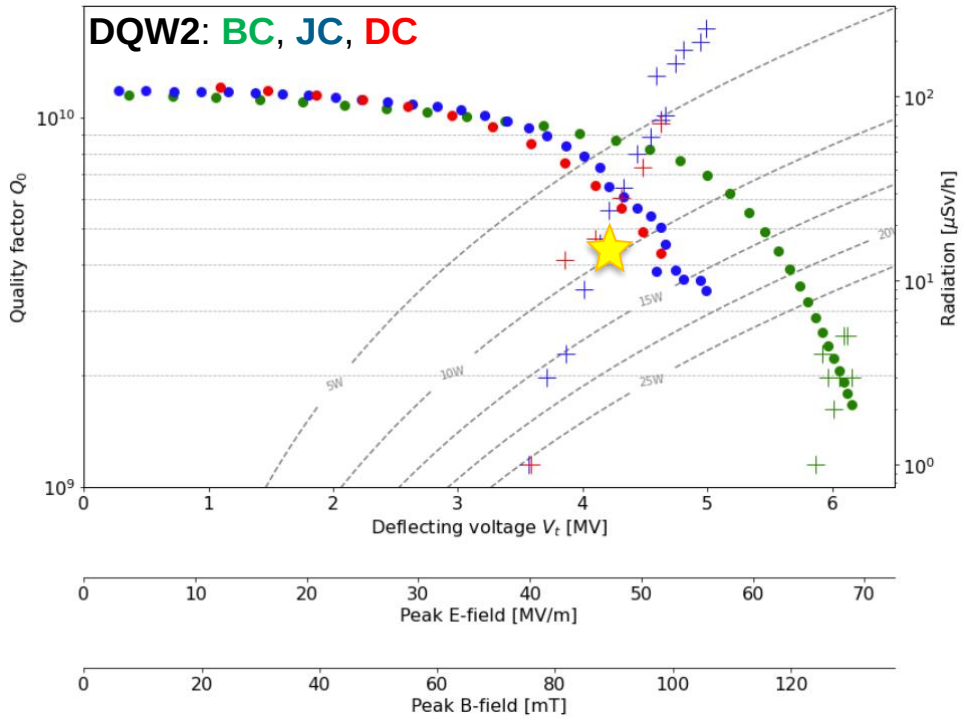
Challenges and lessons learnt

- The max fields reached are mostly dominated by the presence of field emission.
- Thermal cycle, up to ≈20 K, consistently improved Q_0 of both the jacketed and dressed cavities by ≈400%.
- As a precaution, dressed cavities are tested at 2.5K and only final measurements are made at 2K.
- 120℃ bakeout was implemented for the dressed cavity configuration.
- 25Ω feed-throughs + adapters were used and posed no issue.
- HOMs coupler treatment required several iterations.

DQW HOM couplers challenges & FPC – Simon Barrière (CERN)

Conclusions

- DQW2-CERN dressed cavity exceeded the specification target: **4.6MV**.
  - 2 more cavities (DQW1-CERN, DQW2-RI) ready for the cold test in dressed configuration: Oct ’23.
- 1st jacketed cavity (DQW2) from RI met required specification: **5.9MV**.
- Several important lessons were learned during the testing of the DQW cavities.



1st cavity ready for a string assembly

Summary table

3rd CT after light BCP

	Specification (*)	DQW1-RI-BC	DQW2-RI-BC	DQW2-RI-JC	DQW1-CERN-BC	DQW2-CERN-BC	DQW1-CERN-JC	DQW2-CERN-JC	DQW2-CERN-DC
Resonant frequency at 2K [MHz]	400.79±0.15	401.22	401.17	400.92	401.16	401.35	400.7	400.8	400.776
Max V_t [MV]	≥4.1	5.8	5.1	5.9	5.6	6.2	5.1	5	4.63
Q_0 at 4.1 MV	$\geq 3.9\times10^9$	4.7e9	7.8e9	1e10	7e9	9e9	8e9	7e9	7e9
Lorentz Force Detuning Coefficient [Hz/MV^2]	<400	365	408	218	367	358	217	218	224
Sensitivity to LHe pressure fluctuation dF/dp [Hz/mbar]	≤300	436	484	230	428	422	221	244	243
P_{diss} at 4.1 MV [W]	≤10	8	4.9	3.9	5.5	4	4.8	5.4	6

(*) EDMS1389669

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Thank you very much!