Large Grain Cavity R&D

TTC 2022

2022/10/11

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3-cell LG Cavity R&D

Courtesy H. Araki, KEK

- Motivation
  - ILC cost reduction R&D

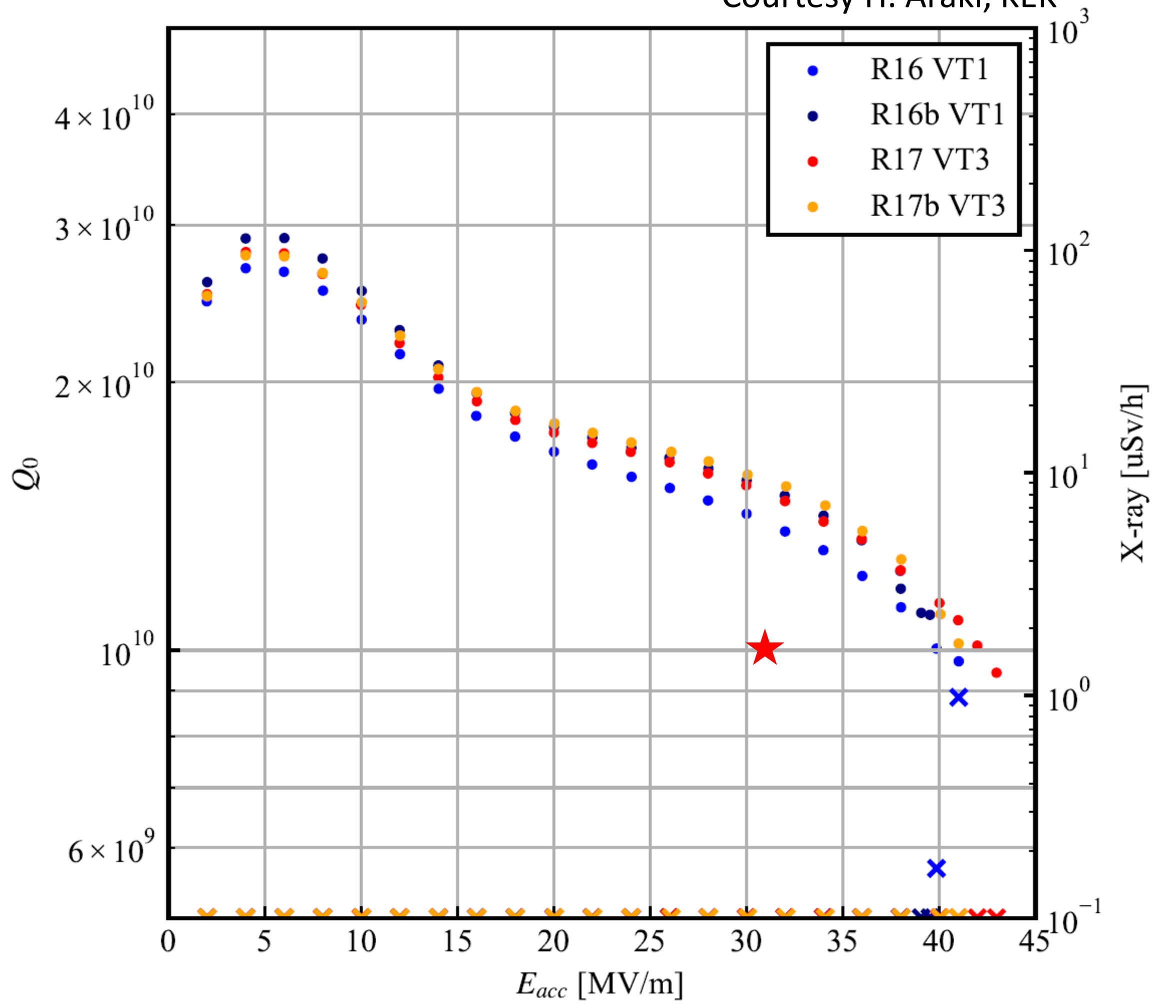
- Properties
  - TESLA-shape 3-cell cavity
  - High-RRR
  - Large-Grain Nb
  - Manufactured at KEK CFF

	RRR	Ta (ppm)	Cavity
ILC TDR	≥ 300	≤ 500	-
High RRR, Low Ta	500	20	R16, R16b
High RRR, High Ta	363	1390	R17, R17b

3-cell LG Cavity VT Test Results

- All cavities were treated according to the ILC TDR
  - Pre-EP (5 µm) & EP-1 (100 µm)
  - Annealing (800°C 3h)
  - Local grinding
  - EP-2 (20 µm)
  - Baking (120°C 48h)
  - R17 and R17b received additional local grinding and EP-2
- All achieved ILC TDR specifications (★)

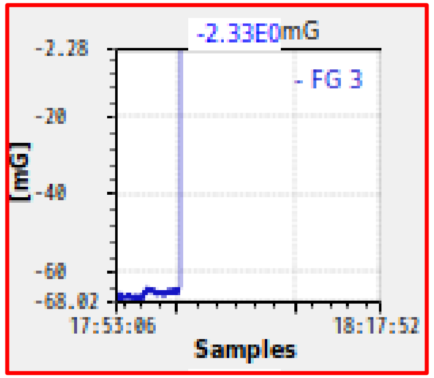
Courtesy H. Araki, KEK



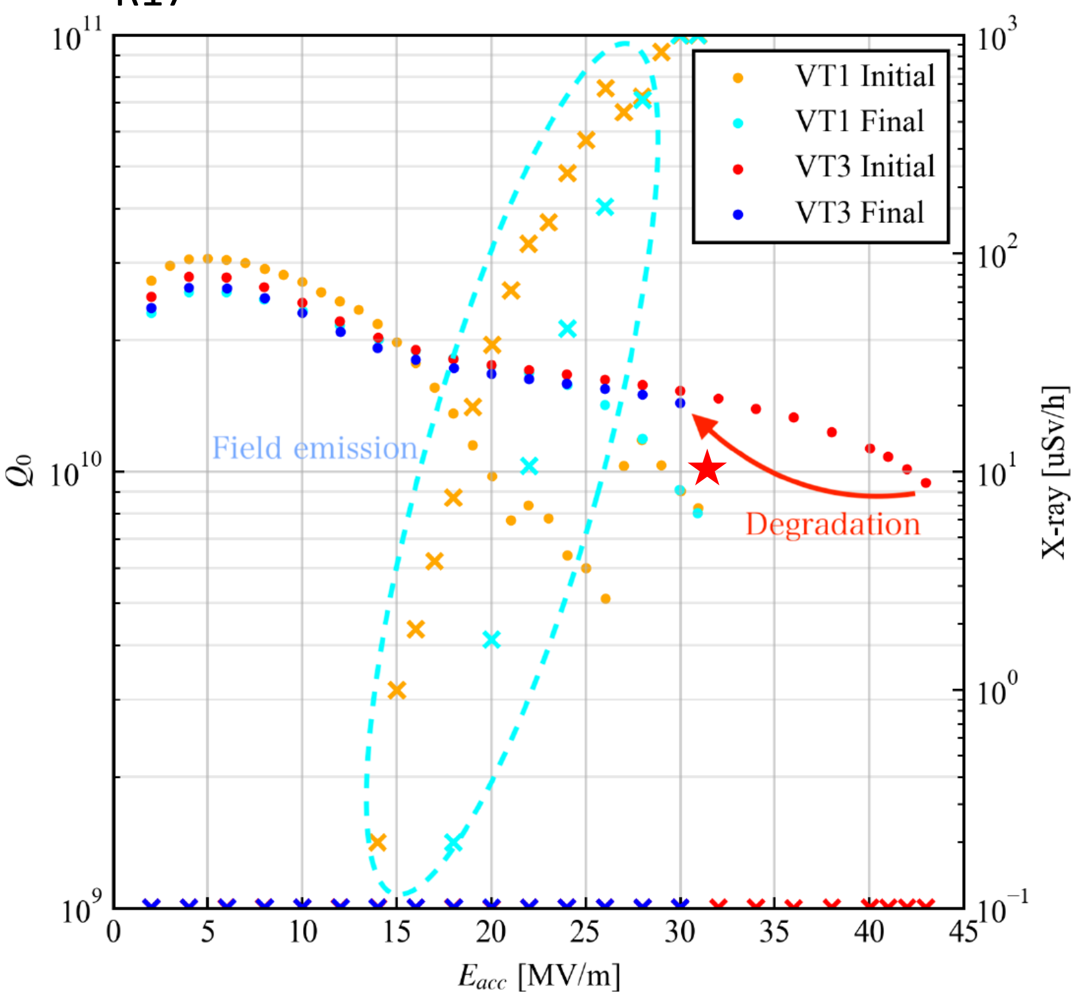
Large Degradation Observed in 3-cell LG Cavities

- Performance degradation due to quenching was observed in all 4 cavities
- We believe the environmental magnetic field is locally trapped at the quenching site
- R17 VT3 showed the largest degradation
  - 43.1 MV/m to 30.0 MV/m
  - A change of over **60 mG** on the outer surface

	Before	After	Delta
R16 VT1	41.4	37.2	-4.2
R16b VT1	39.7	39.5	-0.3
R16b VT2	41.7	35.4	-6.3
R16b VT3	40.6	34.7	-5.9
R17 VT3	43.1	30.0	-13.1
R17b VT3	41.9	36.6	-5.2



Courtesy H. Araki, KEK



- We could demonstrate that a thermal cycle to above the transition temperature releases the trapped flux, reverting the degradation

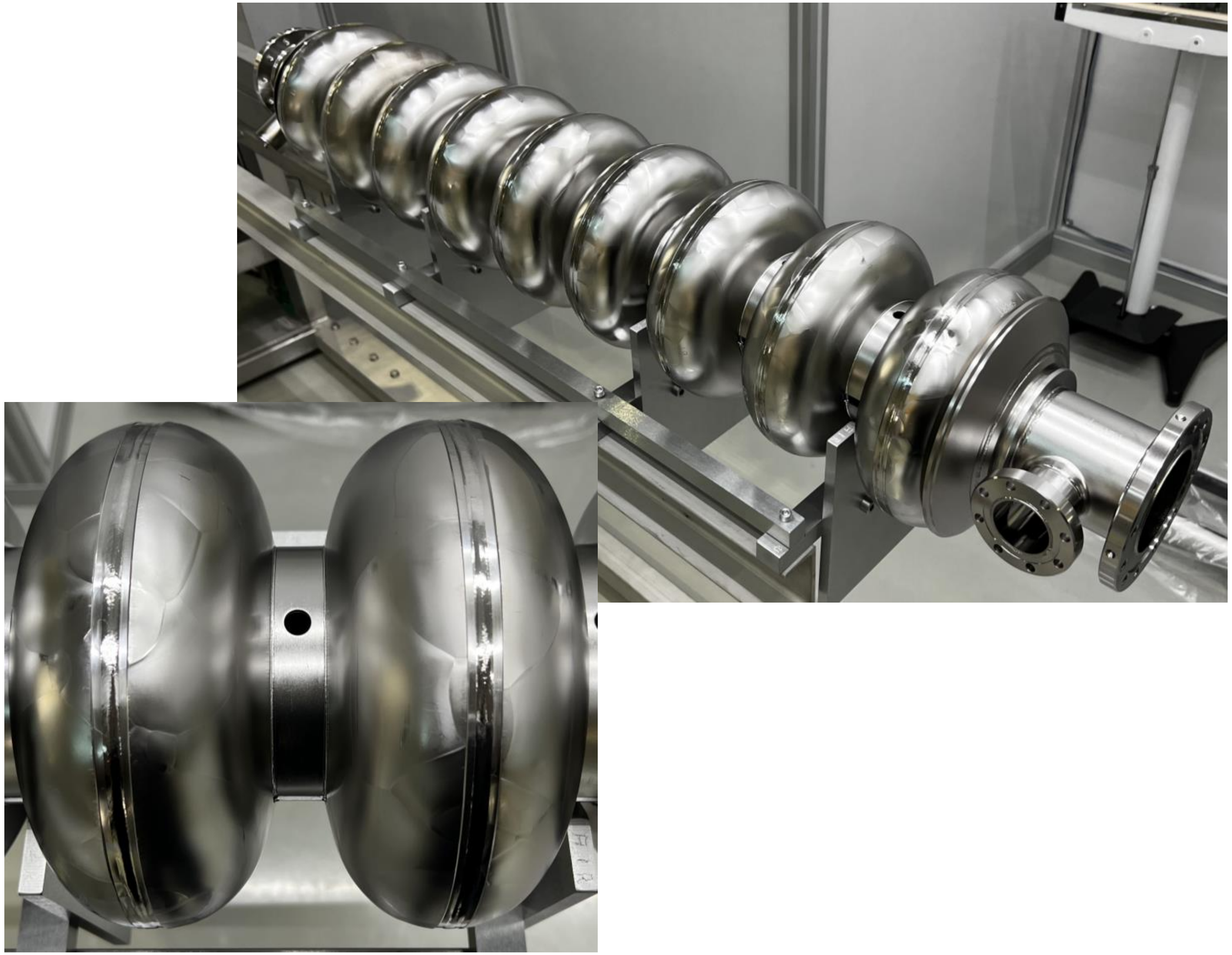
- For more on 3-cell LG cavity R&D see also the contribution at 加速器学会 2022:
  H. Araki *et al.*, “Performance Measurement of Superconducting Cavities Using New Niobium Material”, WEP031

9-cell LG Cavity: KEK7

- Motivation
  - ILC cost reduction R&D
  - Horizontal test

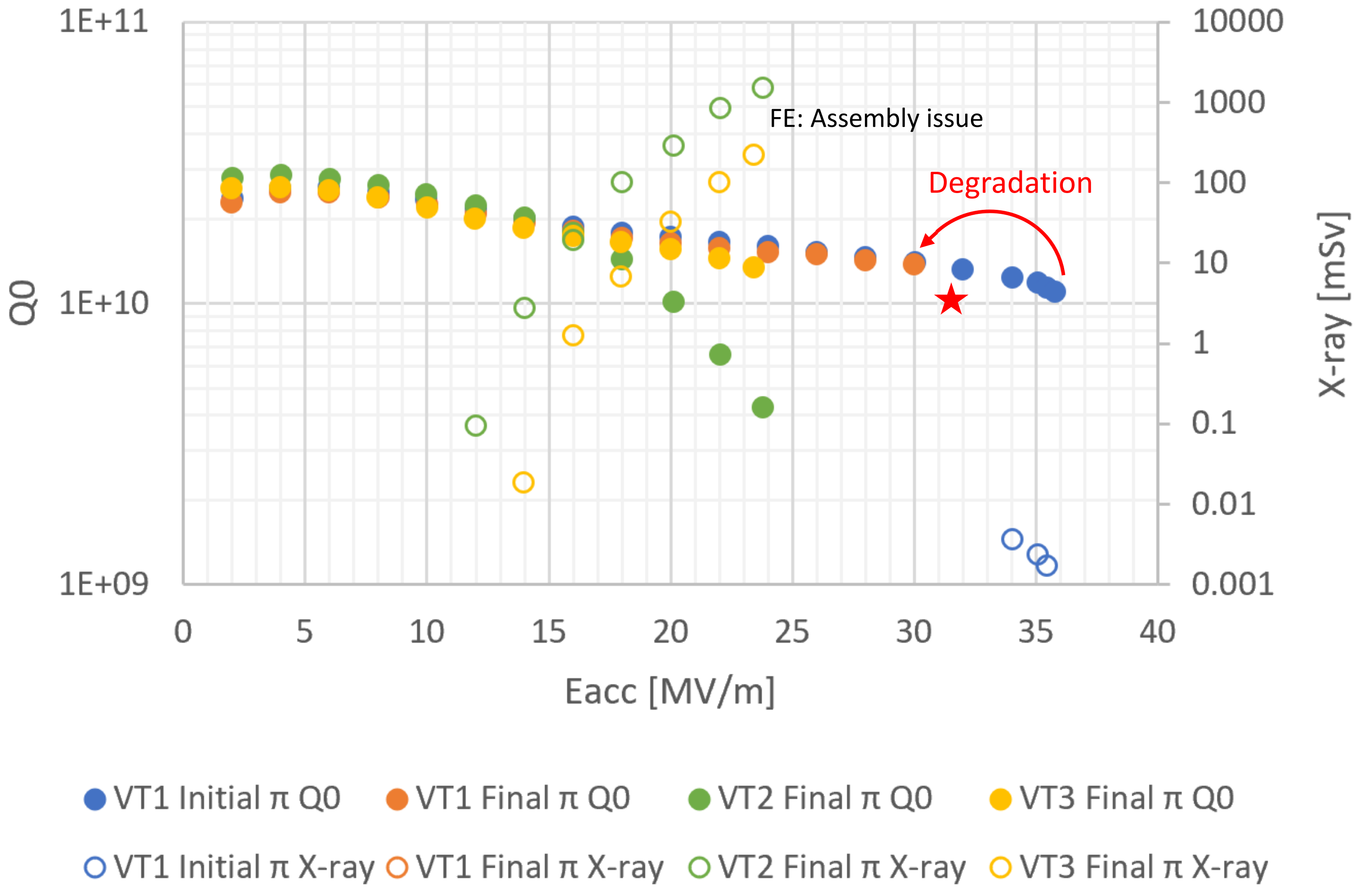
- Properties
  - TESLA-shape 9-cell cavity
  - High RRR
  - High Ta
  - Large-Grain Nb
  - Manufactured at KEK CFF

- Treatment
  - Local grinding
  - Pre-EP (5 µm) & EP-1 (100 µm)
  - Annealing (900 °C 3h)
  - EP-2 (30 µm)
  - Baking (120°C 48h)



Comparison Q0 vs Eacc of KEK7 VT1, VT2, and VT3

- VT1 initial π mode fulfilled ILC TDR specifications (★)
- Degradation during 6π/9-mode measurement in VT1 by 5.8 MV/m
- FT in VT2 and VT3 is an assembly issue

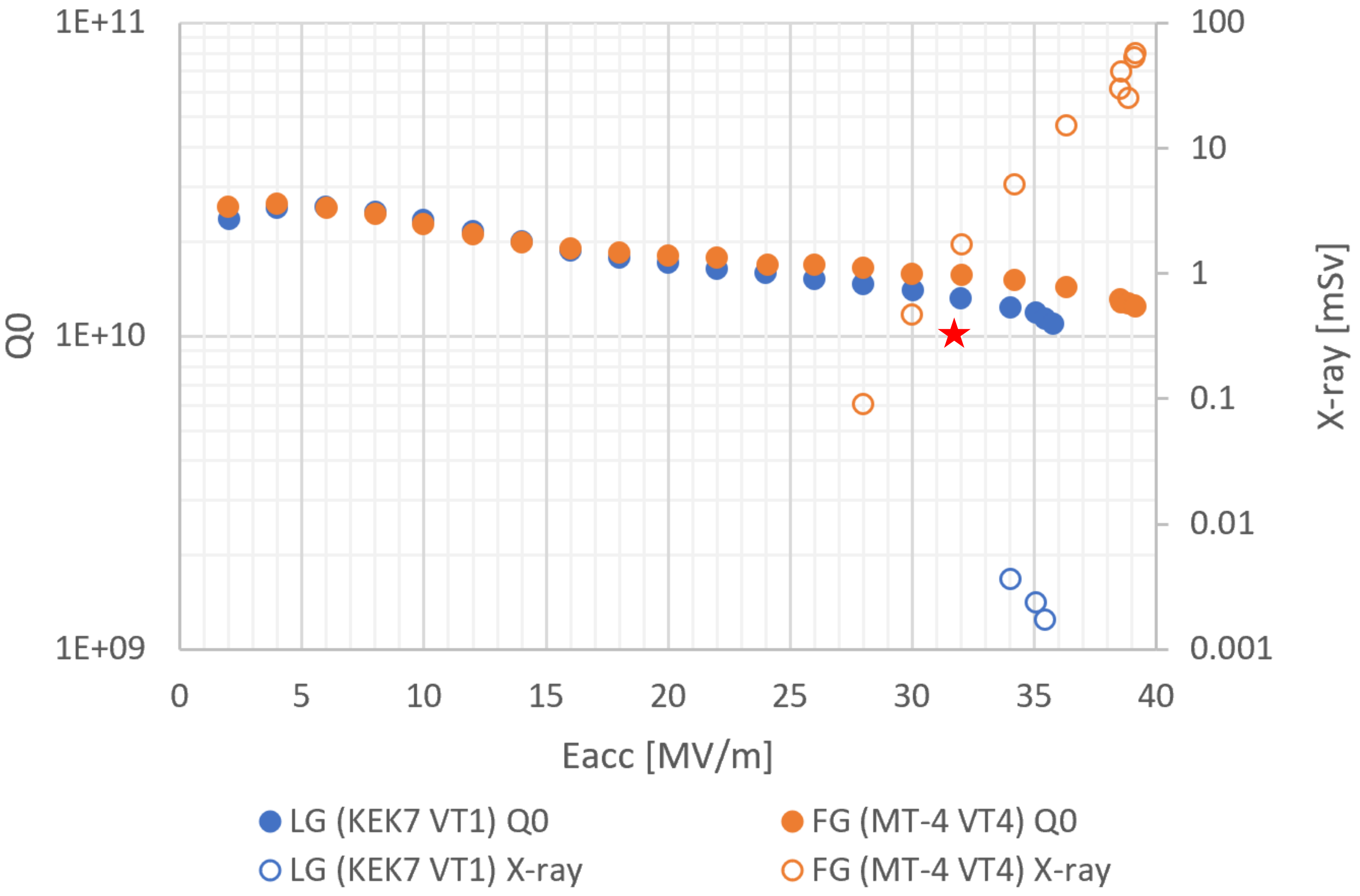


Possible explanation for FE during VT3

- Cavity was closed at within the HPR stand
- It was moved to the C1000CR and dry and clean blown
- It was moved to the C10CR
- Even after removing all four bolts, the bottom beam-pipe blind flange stayed put
- In order to remove the bottom beam-pipe blind flange, a little force was required
- A sucking sound occurred
- There must have been negative pressure inside the cavity
- First time observed for 9-cell cavity

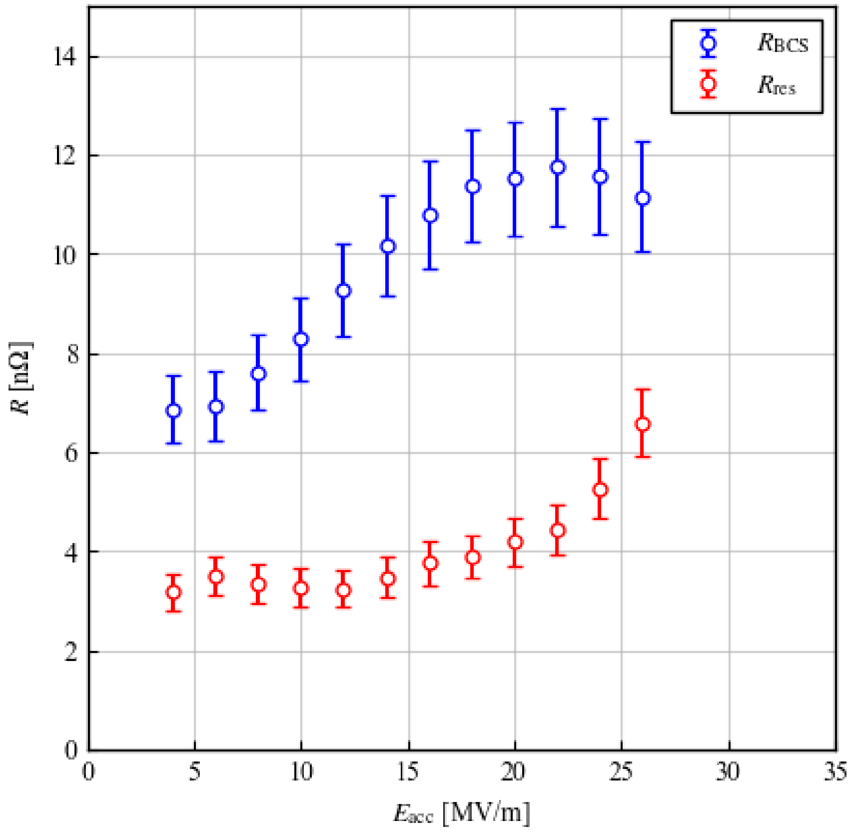
Comparison of Q0 vs Eacc for LG and FG

- Both cavities received standard treatment
  - Baking (120°C 48h)
- Both fulfilled ILC TDR specifications (★)
- Remark: Magnetic field is not controllable for 9-cell cavities

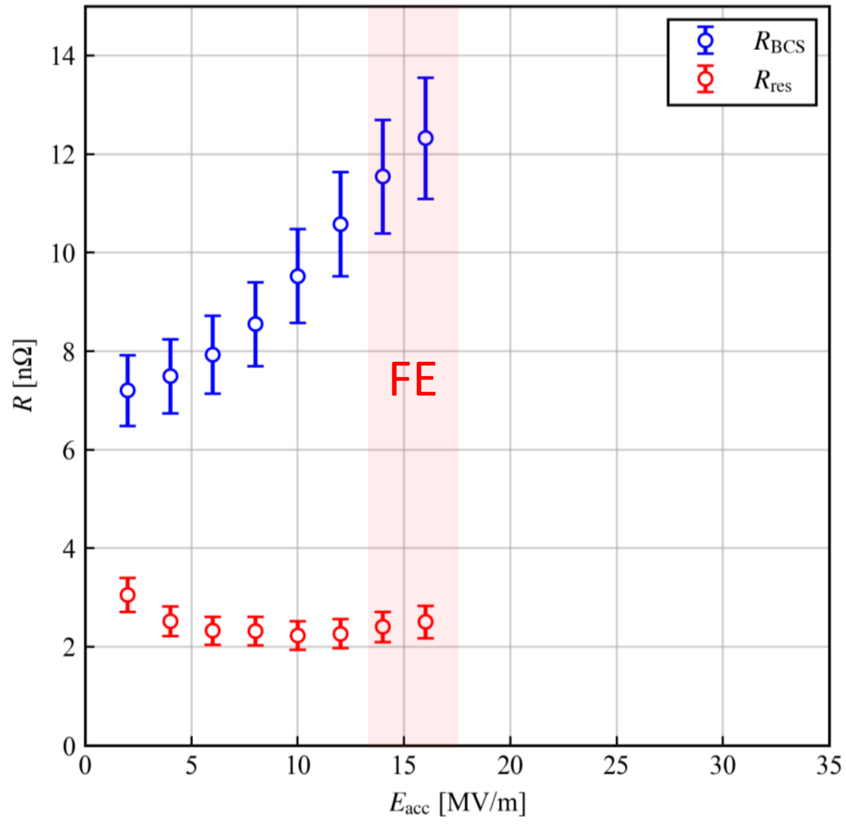


Comparison of R_{BCS} and R_{res} for LG and FG

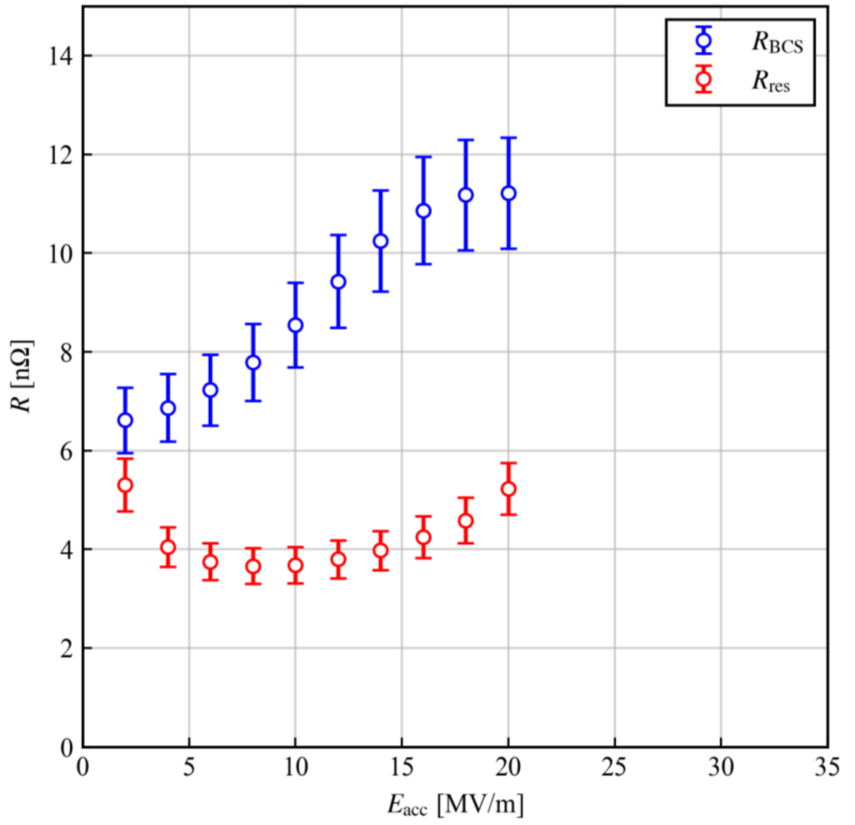
KEK7 VT1 (LG)



KEK7 VT3 (LG)



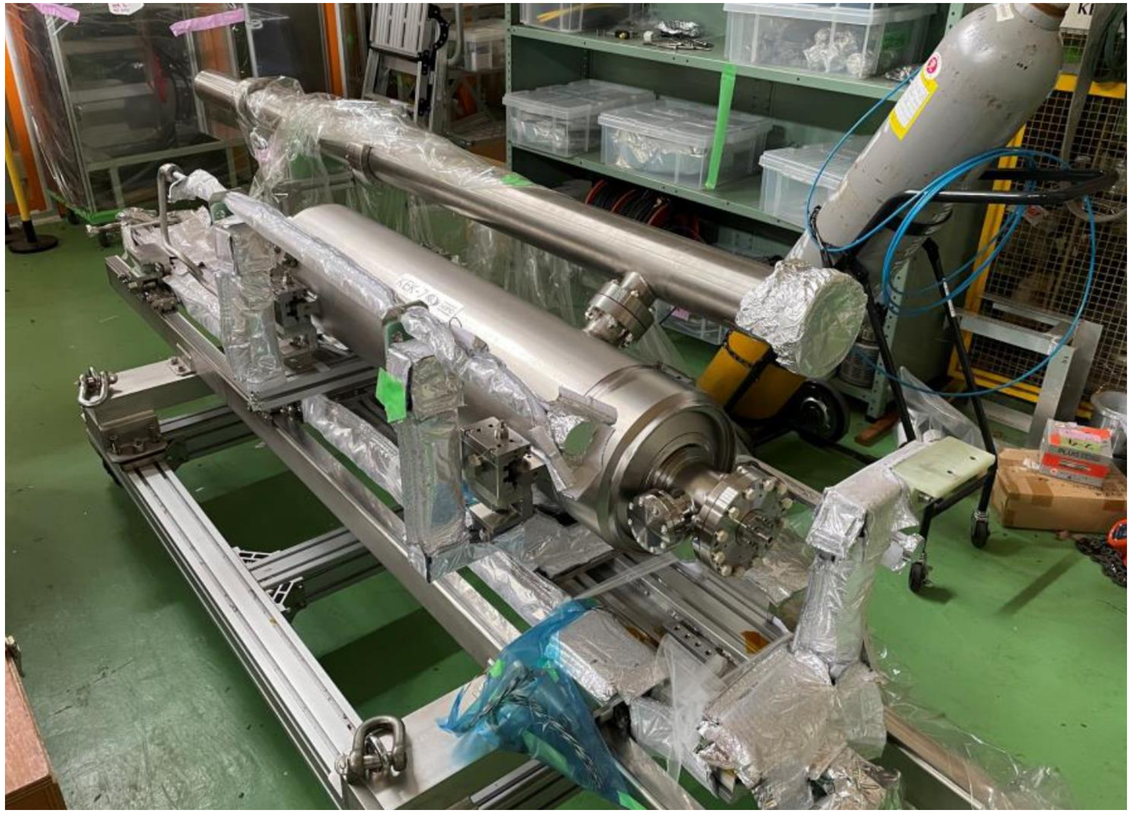
MT-6 VT9 (FG)



(all corrected for degradation)

Preparation for Horizontal Test of KEK7

- We believe FE can be overcome by additional HPR and performance as in initial π-mode measurement of VT1 can be achieved
- Proceed with preparation for horizontal test
  - KEK7 was jacketed
  - Leak check passed
  - Pressure test passed
  - Production of magnetic shield
- Plan for 1st HT in January 2023



Courtesy T. Dohmae, KEK

Summary / Discussion Points

- 3-cell LG cavity R&D
  - Four cavities produced at KEK: High RRR, low & high Ta, TESLA shape
  - All reached ILC TDR specifications
  - Degradation due to trapped flux observed, curable with thermal cycle
- 9-cell LG cavity R&D
  - One cavity produced at KEK: High RRR, high Ta, TESLA shape
  - Reached ILC TDR specifications in initial π-mode measurement of VT1, then degradation due to trapped flux
  - Q0 and Eacc performance comparable with FG (need more tests)
  - Very similar R_{BCS} and slightly lower R_{res} than FG
  - Proceeding with preparations for HT

- Why do these large degradations occur? / Why is so much flux trapped?