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Cavity performance in STF from 2008-2012 summarized

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Achieving high gradient performance of 9-cell cavities at KEK for the international linear collider

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ABSTRACT

Since 2008, vertical tests of 1.3 GHz 9-cell cavities at the superconducting RF test facility (STF) in KEK have been carried out for the International Linear Collider (ILC). The tested cavities are mainly KEK-05 through KEK-22. Test results showed that KEK-12, KEK-13, KEK-17, and KEK-21 attained the unloaded Q value (Q_0) of 0.8×10^{10} at the accelerating gradient (E_{acc}) of 35 MV/m (ILC specification) only by the electro-polishing (EP) process. These four cavities had no problematic defect on any electron beam welding seams at their equators; however, field emission was still observed in the vertical tests. This paper reports on the recent progress of the cavity performance at KEK-STF, along with a detailed analysis of problematic defects and the effect of the local mechanical grinding.

1. Introduction

The eighteen 9-cell cavities for S1-Global [1], Quantum Beam Project [2], and STF-2 (Phase-2) have been fabricated, measured, and assembled into cryomodules since 2008 as part of R&D for the ILC [3]. From the Quantum Beam Project, every cavity complied with the Japan High Pressure Code [4], because of the legal requirements for accelerator operation in the STF [5] tunnel.

Over the past five years, various useful techniques for evaluation and improvement of the cavity performance have been developed and used at the STF. For example, the *T*-mapping/X-ray-mapping system [6] is necessary for the identification of heating locations and X-ray emission sites. The optical inspection (Kyoto camera) system [7] is useful for the observation of defects on the inner surface of the cavity. The replica method [8] using laser microscopy is useful for the analysis of the defect shape. The local mechanical grinding method [8] is effective in the improvement of the cavity performance. Application of this method to the iris region results in a drastic reduction in field emissions.

At the STF, various kinds of problematic defects have been observed, analyzed, and categorized into four types (Type-I to Type-IV). Consequently, it is clarified that there is a correlation between the quench field and the shape of the problematic defect observed on the equator (Type-I).

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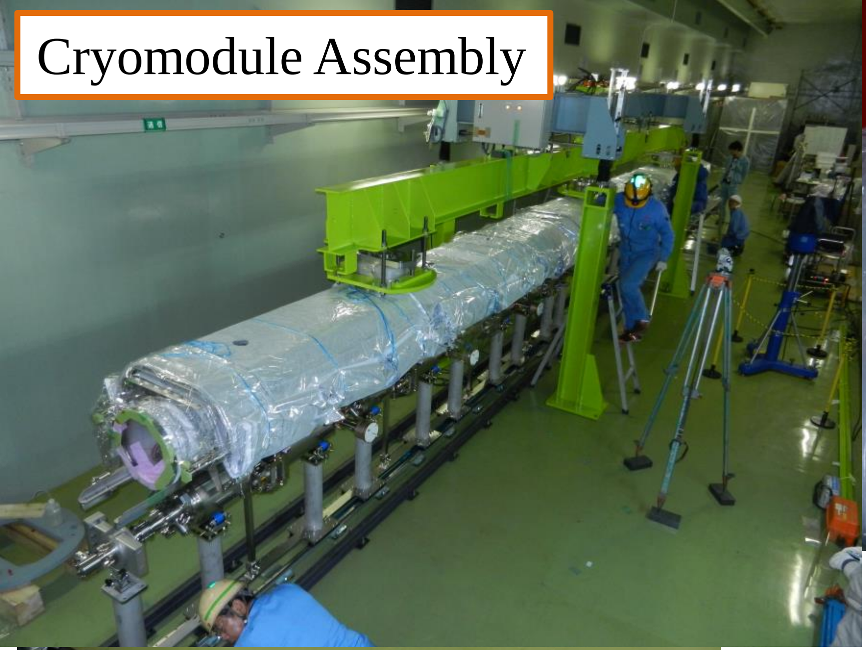
2. Results of vertical tests

Fig. 1 shows the results of vertical tests conducted for evaluating the performance of the 9-cell cavities KEK-12 through KEK-22 in the Quantum Beam Project and STF-2. Three important items (*T*-mapping/X-ray-mapping, Kyoto camera and local grinding machine) were systematically used for these eleven cavities. The KEK-12, KEK-13, KEK-17, and KEK-21 cavities met the ILC specification of accelerating gradient [9] only upon application of the EP process in one or two vertical tests. However, all other cavities, except KEK-16, attained an accelerating gradient higher than 35 MV/m after application of the local mechanical grinding method. The KEK-16 cavity was limited by heating at the higher-order mode (HOM) coupler at the quench field of 33.8 MV/m. Fig. 2 shows the maximum accelerating gradient in all (26) performance tests for KEK-12 to KEK-22. Table 1 presents a summary of the best results of these performance tests. The average maximum gradient in Table 1 is 36.8 ± 1.8 MV/m. At S1-Global, the average maximum gradient for KEK-05, KEK-06, KEK-07, and KEK-09 cavities was 28.9 MV/m with heavy field emissions, however local mechanical grinding was not carried out. On the other hand, KEK-08, KEK-10, KEK-11 and KEK-T2 were fabricated and tested for the R&D. KEK-T2, which was made by another vendor, has no HOM couplers.

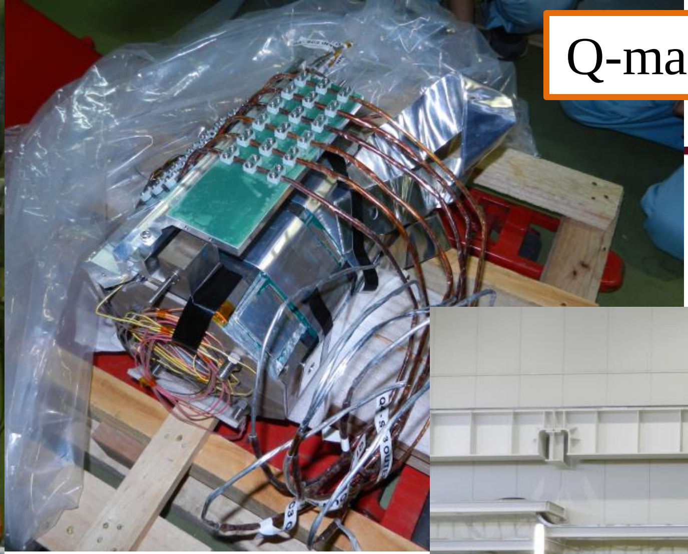
In the following sub-sections, two typical examples of the problematic defect, which certainly limits the cavity performance, are explained in detail on the basis of the *T*-mapping/X-ray-mapping and optical inspection results. One (observed on the equator) causes the thermal quench (case of KEK-15), and the

STF Status

- STF-2 Cryomodule (CM-1, 8 cavities & Q-magnet)
  - Assembly working on going
  - CM-2a (half size) assembly will start from next year
- Cavity
  - MHI-23~-26 cavities for CM-2a vertical testing as 1st pass
- Others
  - New Lab. Construction (COI) will finish in F.Y. 2014 in north area of STF
  - In-house cavity (KEK-01) to be fabricated in CFF
  - Seamless & Large Grain single cell cavities to be fabricated in CFF



Cryomodule Assembly



Q-magnet for CM-1

Cavity String Installation

MHI-23 & -24 Cavities

Area for New Lab.

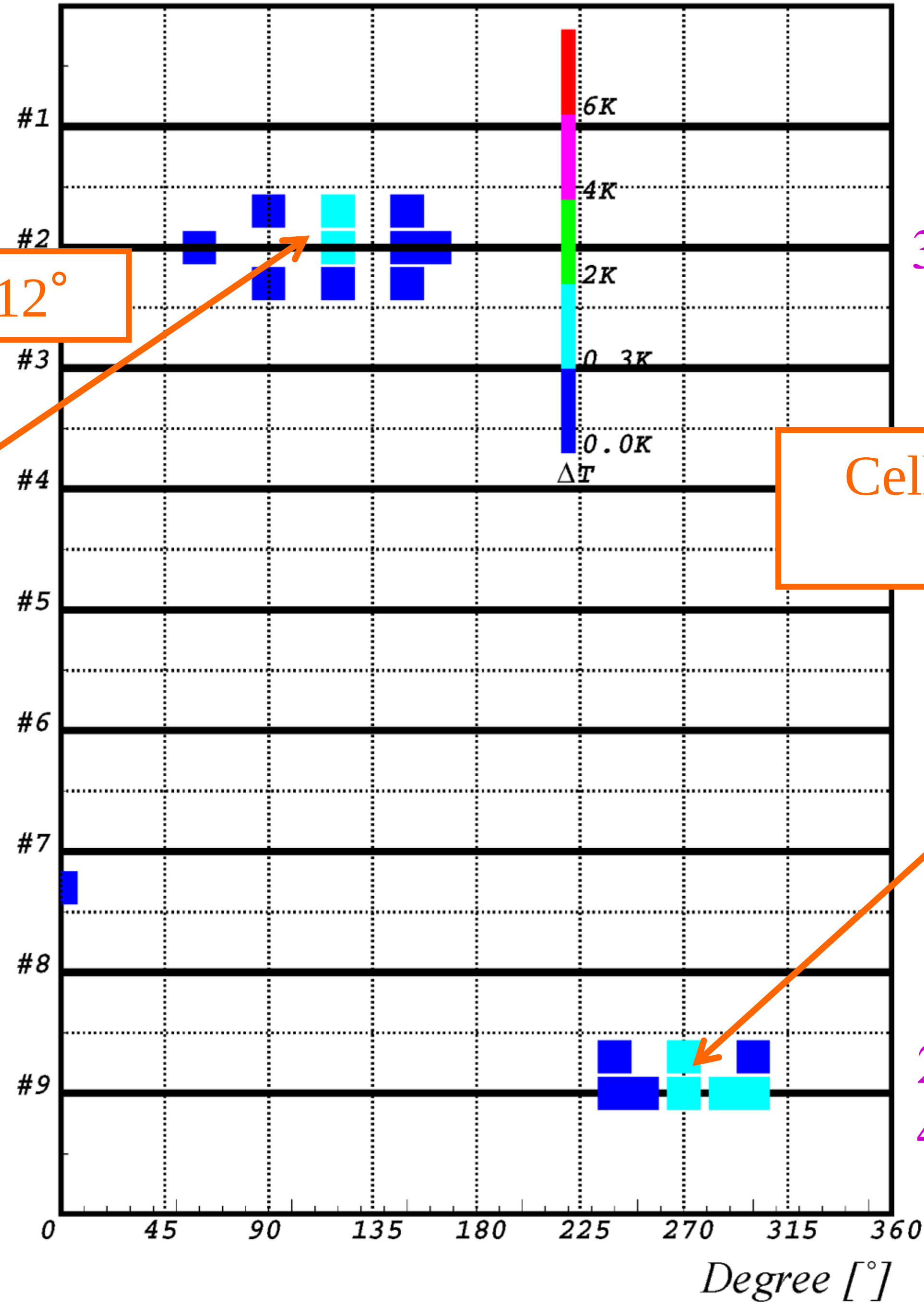
Cavity String Assembly

Cavity performance

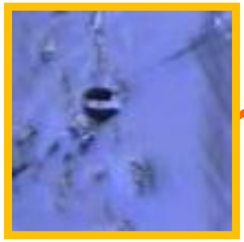
- MHI-23
  - 31.3 MV/m, 9.35×10^9, thermal quench, little X-rays
- MHI-24
  - 22.7 MV/m, 1.15×10^{10}, thermal quench, heavy field emission
- MHI-25
  - 32.8 MV/m, 8.23×10^9, thermal quench, No X-rays
- MHI-26
  - 26.1 MV/m, 3.46×10^9, administration limit (radiation), heavy field emission

⇒ Every cavity has to go to 2nd test!

T-mapping/Optical inspection of MHI-24



Cell #2 equator, θ=112°



39 MV/m @3π/9

Cell #9 equator upstream, θ=271°

23~24 MV/m @π, 4π/9, 5π/9, 8π/9

Thank you