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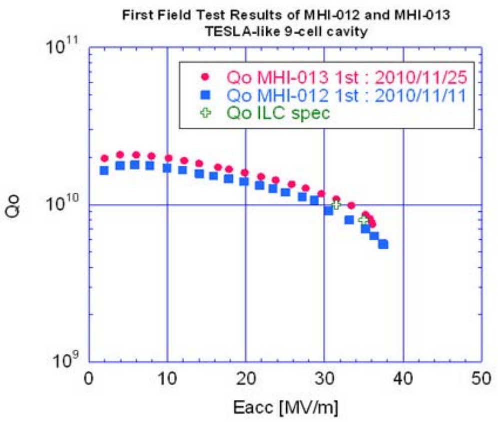
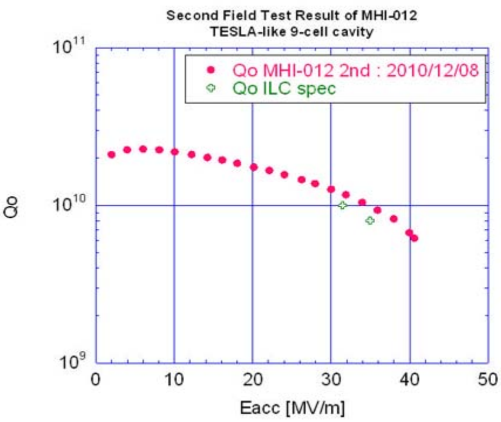
Japanese 9-cell SCRF cavity meets ILC specifications

Designing and fabricating an optimal accelerating cavity is not so simple. There are two important parameters scientists are looking for: the gradient of 35 megavolts per meter (MV/m) and the quality factor (Q_0) of greater than 0.8×10^{10}. A Japanese cavity now fulfilled those requirements for the first time at a test which took place at the Superconducting radiofrequency Test Facility (STF) at KEK, adding momentum towards future mass production.

Accelerating gradient and an unloaded quality factor (Q_0) are two important parameters for realizing the ILC. The accelerating gradient is a measure of how much an accelerator can increase the energy of a particle over a given stretch, typically indicated by the unit MV/m. The higher the gradient, the shorter the accelerator, and hence, the cheaper the system can be built. The quality factor, Q_0, is a qualifier of how well the cavity can sustain the stored RF power. A higher Q_0 means a lower rate of power loss relative to the stored energy.



<Fig1>Vertical test result of MHI-012 and MHI-013. MHI-013 fully met the ILC cavity production specifications.



<Fig2>MHI-012 second vertical test result which exceeded 40MV/m accelerating gradient.

On 25 November, scientists at STF performed a vertical test on MHI-013, the 13th in a series of nine-cell cavities fabricated by Mitsubishi Heavy Industries Co. Ltd. It showed a result that fulfilled the production specifications for the ILC and demonstrated the accelerating gradients of 31.5 MV/m with Q_0 greater than 1×10^{10}, and of 35MV/m with Q_0 greater than 0.8×10^{10}. The cavities in the main linacs of the ILC will operate at 31.5MV/m and $Q_0 > 1\times10^{10}$, and prior to installation these cavities are supposed to clear the performance goal of 35MV/m with Q_0 over 0.8×10^{10} in vertical testing.

"We have conducted the surface-treatment and the vertical test on two cavities, MHI-012 and MHI-013, fabricated for the Quantum Beam Project," said Ken Watanabe, assistant professor at KEK. "This good result is backed by our accumulated know-how on the quality assessment and attributed system improvement. Also, the good communication with the developer greatly helped the improvement of cavity fabrication technique," he said.

The one-meter-long niobium cavities each consist of nine cells. The inner surfaces of those cells are polished to provide micrometer-level smoothness, and are made free of impurities. Tiny surface blemishes or dust could cause cavities to lose the superconductivity, and prevent the cavities from sustaining the electric field needed for accelerating particles. To ensure the smoothness, a series of cavity inner surface treatment processes for cavities including electro-chemical etching, high-pressure water rinsing and dust-free assembly, were carried out at the electro-polishing facility at the STF of KEK.

They also have gone through on optical inspection process using the so-called Kyoto camera, a high-resolution inspection device. "Using the optical inspections after the delivery and at each step of treatment, we have confirmed that there were no geometric defects before final electro-polishing process," said Watanabe.

From the test results, both MHI-012 and MHI-013 demonstrated the accelerated gradients over 35MV/m, and seemingly both cavities have met the ILC specifications. But MHI-012 didn't reach that level. Despite the record of 38.2MV/m maximum gradient, it lost the Q_0 due to field emission. For MHI-013, the KEK team used slightly different processing parameters based on the procedure they used for MHI-012. "That change worked well for preventing field emission to occur. I believe that the field emission can be controlled by adjusting the parameters, working conditions, or procedure to the infrastructure," Watanabe said.

The KEK team conducted a second surface treatment and vertical test on MHI-012 on 8 December, and it also cleared ILC specifications. "It demonstrated over 40 MV/m for the first time: 40.7 MV/m with Qo equal to $6.12x10^9$," Watanabe said. MHI-012's gradient could go higher since it did not lose its superconductivity at 40.7 MV/m. Scientists stopped testing as they were planning to install MHI-012 into a cryomodule for the quantum beam project right after the vertical test. "We didn't want to mess with the cavity," Watanabe said. "We need to keep working hard to maintain good cavity qualities for the ILC."

<Fig3>Scientists working on cavity vertical test at STF. Image: Akira Yamamoto

- JACOW Mirror at KEK

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