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Performance of the Novel Cornell ERL Main Linac Prototype Cryomodule

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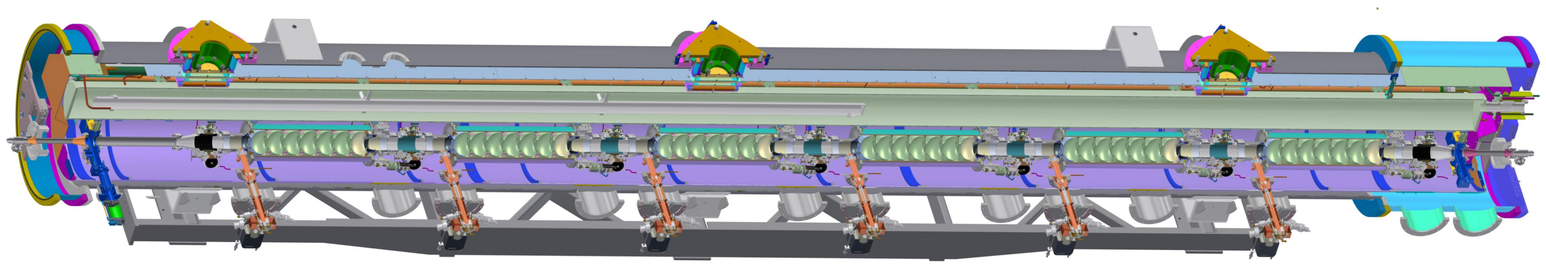
Introduction

The main linac cryomodule (MLC) for the future energy-recovery linac (ERL) based X-ray light source at Cornell has been designed, fabricated, and tested. It houses six 7-cell SRF cavities with individual higher order-modes (HOMs) absorbers, cavity frequency tuners, and one magnet/BPM section. Cavities have achieved the specification values of 16.2MV/m with high-Q of 2.0e10 in 1.8K in continuous wave (CW) mode. During initial MLC cavity testing, we encountered some field emission, reducing Q and lowering quench field. To overcome field emission and find optimal cool-down parameters, RF processing and thermal cycles with different cool-down conditions have been done. Here we report on these studies and present final results from the MLC cavity performance.

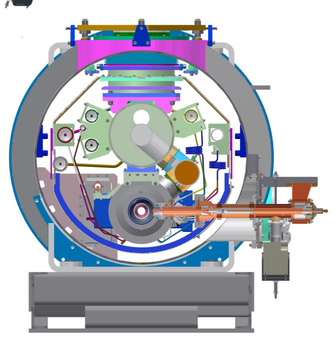
Image; moving MLC to Wilson lab, Mar2015.

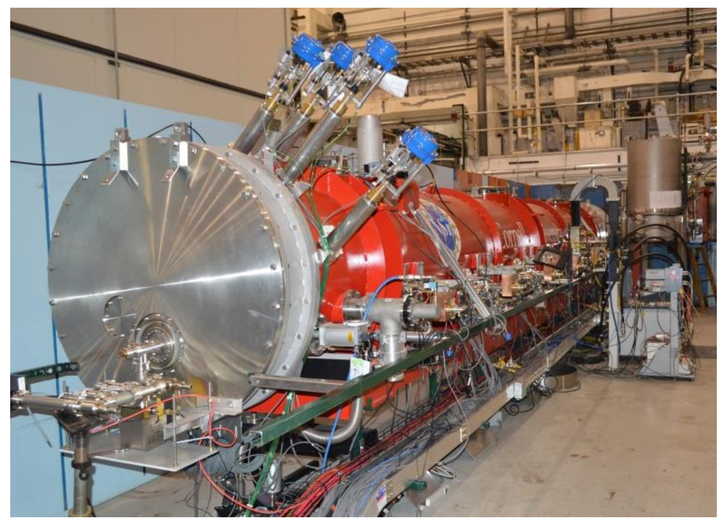
Main Linac Cryomodule (MLC) prototype



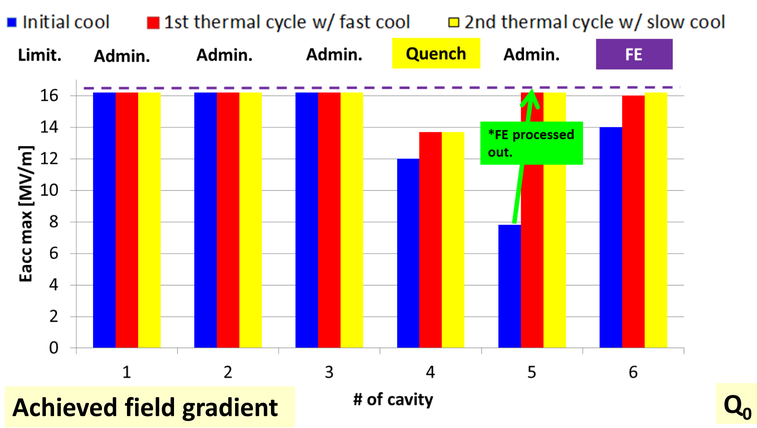
- Number of 7-cell cavities 6
- Acceleration gradient 16.2 MV/m
- R/Q (linac definition) 774 Ohm
- Qext 6.5×10^{7}
- Total 2K / 5K / 80K loads: 76W / 70W / 1500W

- Number of HOM loads 7
- HOM power per cavity 200 W
- Couplers per cavity 1
- RF power per cavity 5 kW
- Amplitude/phase stability 10^{-4} / 0.05° (rms)
- Module length 9.8 m

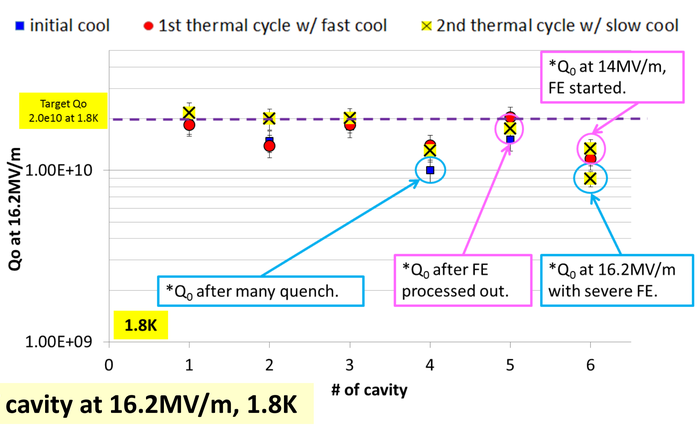



Cavity preparation: bulk BCP, 650C outgassing, final BCP, 120C bake, HF rinse

RF test achievements in 1.8K



Achieved field gradient



Q_0 of cavity at 16.2MV/m, 1.8K

- Cavity #1, #2, and #3 achieved the target gradient of 16.2MV/m in the first power rise.
- Cavity #5 had severe field emission (FE), but processed out by RF processing. Cavity #4 was FE free, but limited by quench.
- 5 of 6 cavities achieved the design spec of 16.2MV/m.

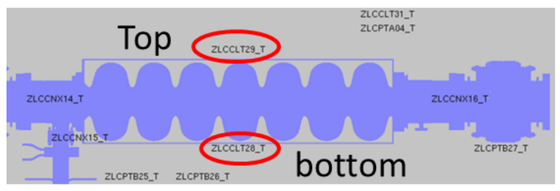
- Cavity #1, #2, #3, and #5 achieved the target Q_0 of 2.0×10^{10} at 16.2MV/m, 1.8K after thermal cycles.
- Q_0 of cavity #4, #5, and #6 were impacted by early quench or field emission, and thus the impact of thermal cycles is less visible.
- 4 of 6 cavities had achieved design Q_0 of 2.0E+10 in 1.8K.

Summary

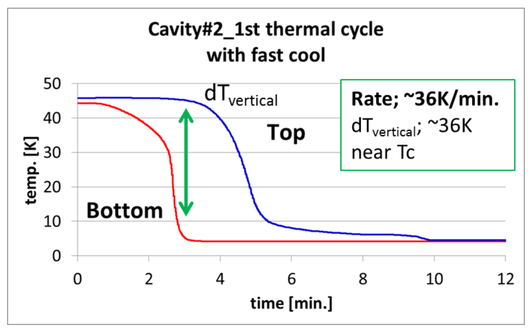
- The Cornell Main Linac Cryomodule has been cooled down from 300K to 1.8K successfully.
- The 7-cell cavities in the MLC have achieved the specification values of 16.2MV/m with Q_0 of 2.0×10^{10} in 1.8K.
- High-Q performance was maintained through cryomodule assembly to cool down and RF testing.
- Field emission caused mild Q_0 degradation in two cavities.
- Thermal cycle with small temperature gradient ("slow" cool down) gave the highest Q_0 for the cavities in the MLC prototype.

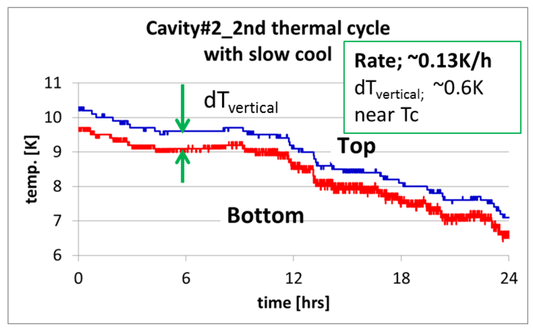
please see other posters for HOM and Microphonics.

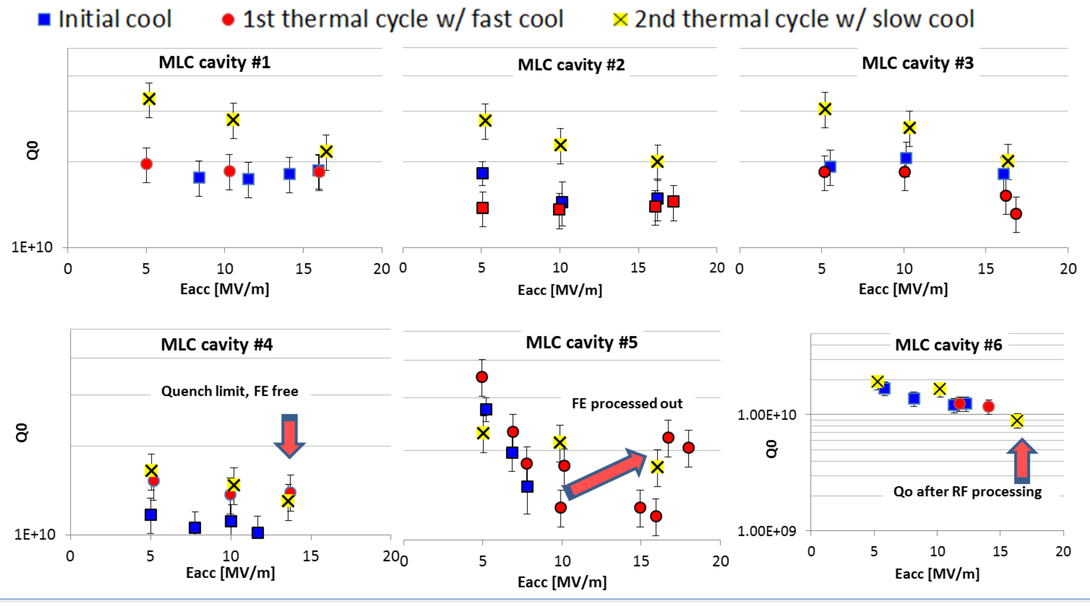
Impact of thermal cycling with different $dT_{vertical}$ on Q(E) in 1.8K



- Plot shows the temp. profiles on top and bottom of Helium tank. Not direct measurement of cavity surface temp.







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