Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

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Performance of the Cornell Main Linac Prototype Cryomodule for the CBETA Project

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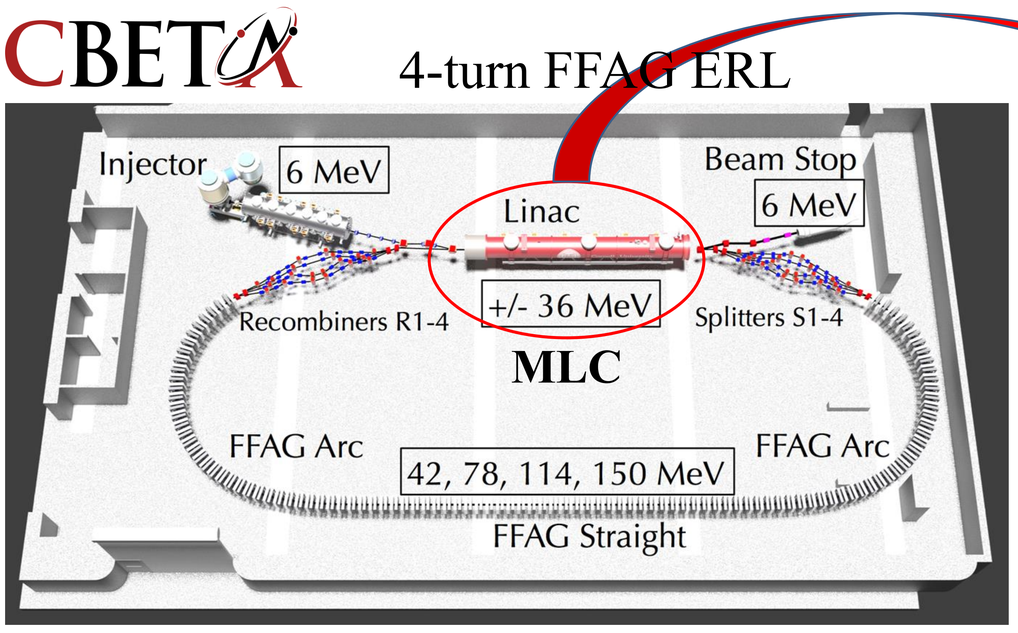
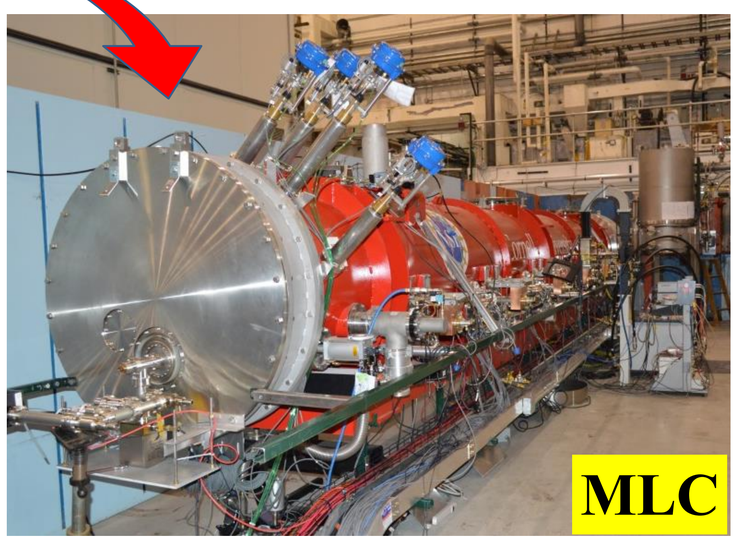
MOPOB60

Introduction

The Cornell Main Linac Cryomodule (MLC) is a key component in the Cornell-BNL ERL Test Accelerator (CBETA) project, which is a 4-turn FFAG ERL under construction at Cornell University. The MLC houses six 7-cell SRF cavities with individual higher order-modes (HOMs) absorbers, cavity frequency tuners, and one magnet/BPM section. Here we present final results from the MLC cavity performance and report on the studies on the MLC HOMs, tuner, and microphonics.

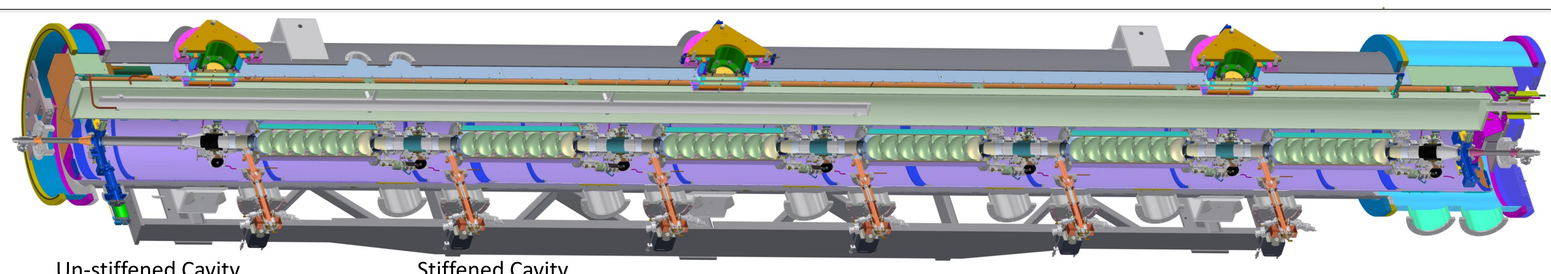




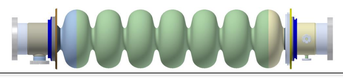
Main Linac Cryomodule (MLC) prototype

- 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

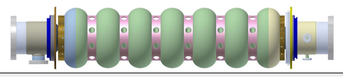
☆ Three un-stiffened cavities and three stiffened cavities.



Un-stiffened Cavity



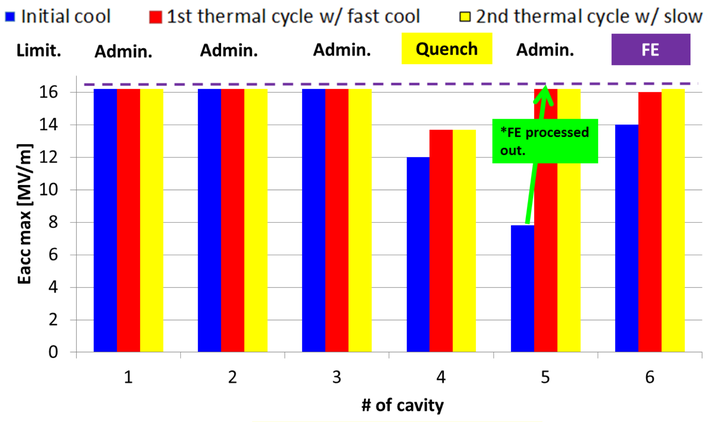
Stiffened Cavity



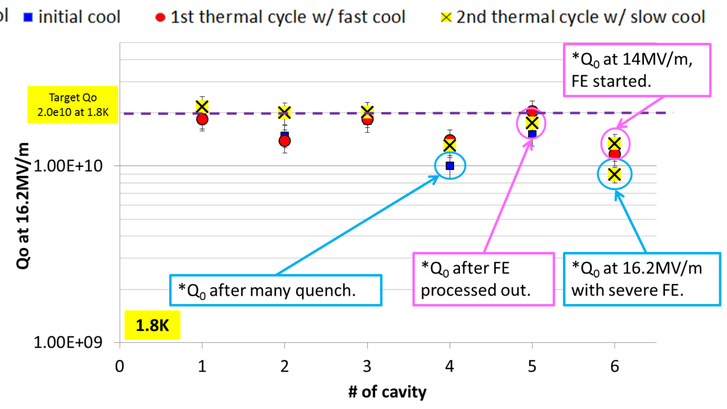
Cavity preparation:
bulk BCP, 650C outgassing, final BCP, 120C bake, HF rinse

RF test achievements at 1.8K

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.

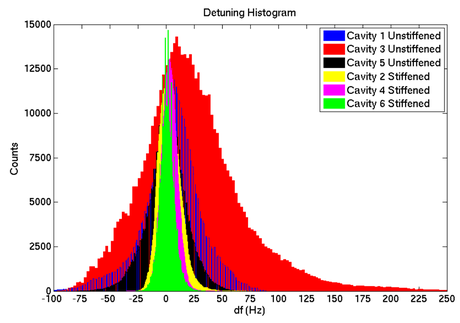


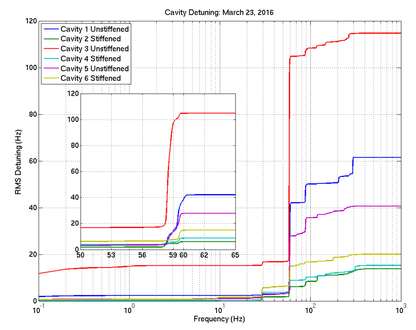
Achieved field gradient



Q_0 of cavity at 16.2MV/m, 1.8K

Microphonic measurements





- Average detuning of stiffened cavity: ~40Hz, un-stiffened cavity: ~100Hz.
- Integrated detuning gains dramatically at 60Hz.
- No optimization or fast tuner compensations were done yet.

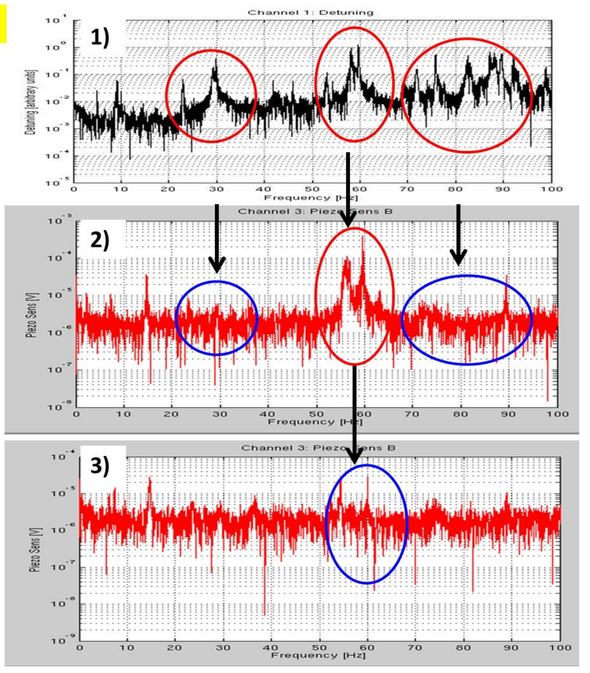
Microphonic source analysis and control

Measured with Cavity#2 (stiffened)

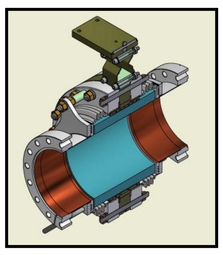
1) Pump Skid ON
80K flow was 7.5 g/s (high flow)
5K flow was 1.8 g/s

2) Pump skid Off
80K flow was 2.425 g/s (low flow)
5K flow was 1.6 g/s
Insulation vacuum turbo pumps ON
Valve Open.

3) Pump skid Off
80K flow was 2.425 g/s(low flow)
5K flow was 1.6 g/s
Insulation vacuum turbo pumps off, Valve closed.

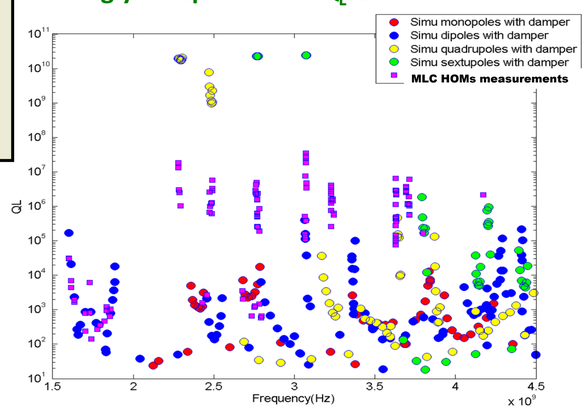


MLC HOMs summary

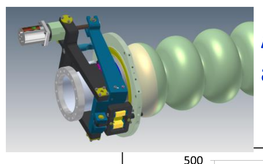


Silicon Carbide SC35 Absorbing cylinder

Dipole HOMs in the MLC cavities are strongly damped below Q_L~10^4.

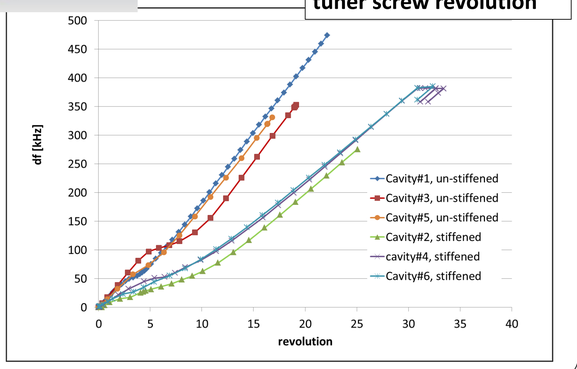


MLC tuner test



All cavities were tuned to resonance at 1.8K.

Tuning range vs. tuner screw revolution

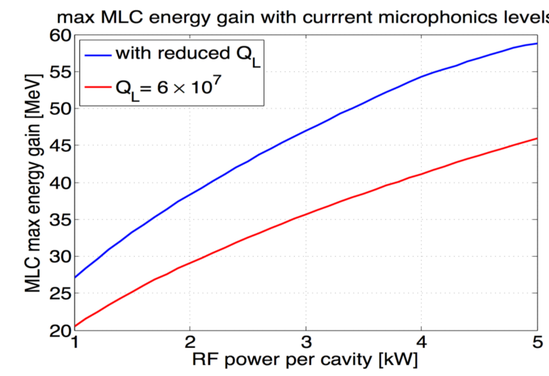


Conclusion

- **The 7-cell cavities in the MLC can provide enough voltage and cooling for 76MeV per ERL turn (36MeV are needed for the CBETA project).**
- **Q_L of dipole HOMs of the MLC cavities are strongly damped below the target value of ~10^4. The higher Q modes measured in the MLC are very likely from quadrupole and sextuple modes. These mode types are not a concern for causing beam break up (BBU).**
- **Slow tuner worked as designed and tuned cavities to resonance at 1.8K. Piezo fast tuner test is planned for the future.**
- **The nominal energy gain of 36 MeV per pass for the CBETA project may be reached with the available RF power at the current level of microphonics.**

RF Power Requirements

With the current detuning level the MLC can provide the design 36MeV energy gain for the CBETA at 2-3kW RF power per cavity without beam loading.



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