R100/C100 Cryomodule Microphonics

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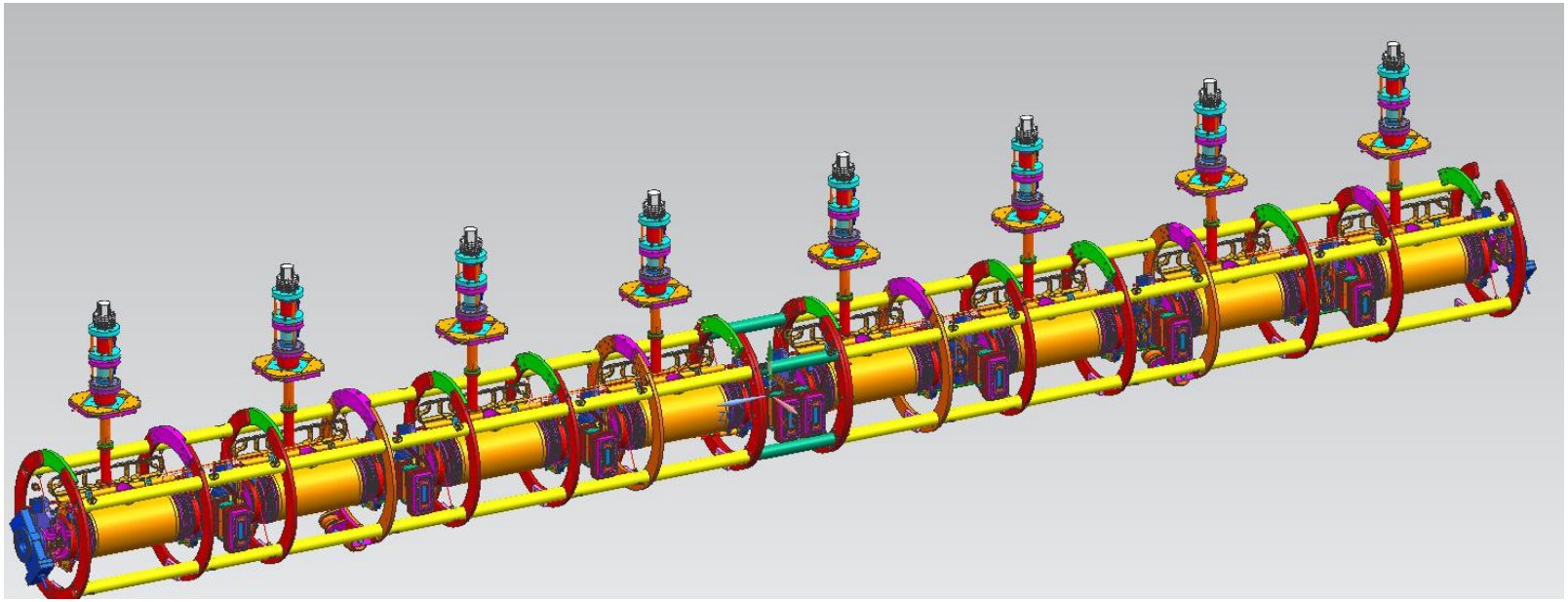
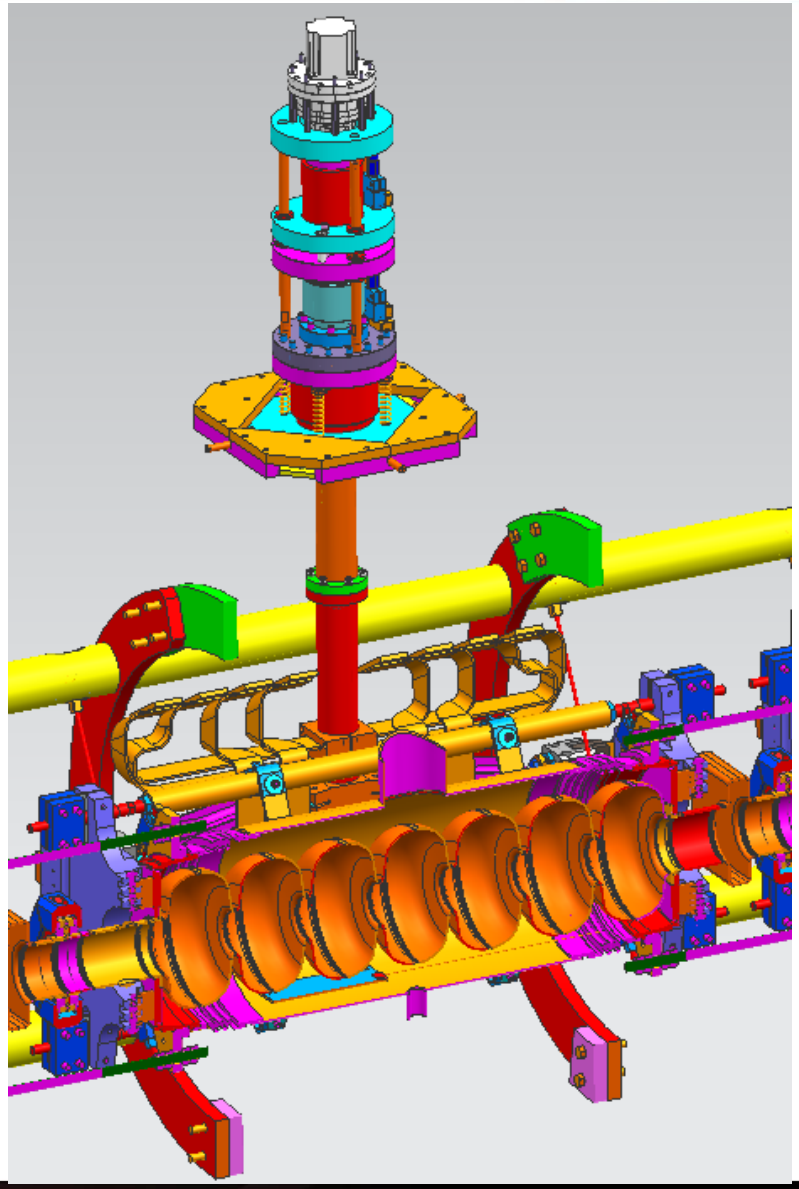
C100 Cryomodule Space Frame

- The cavity string is suspended within the space frame by nitronic rods (think bicycle spokes)



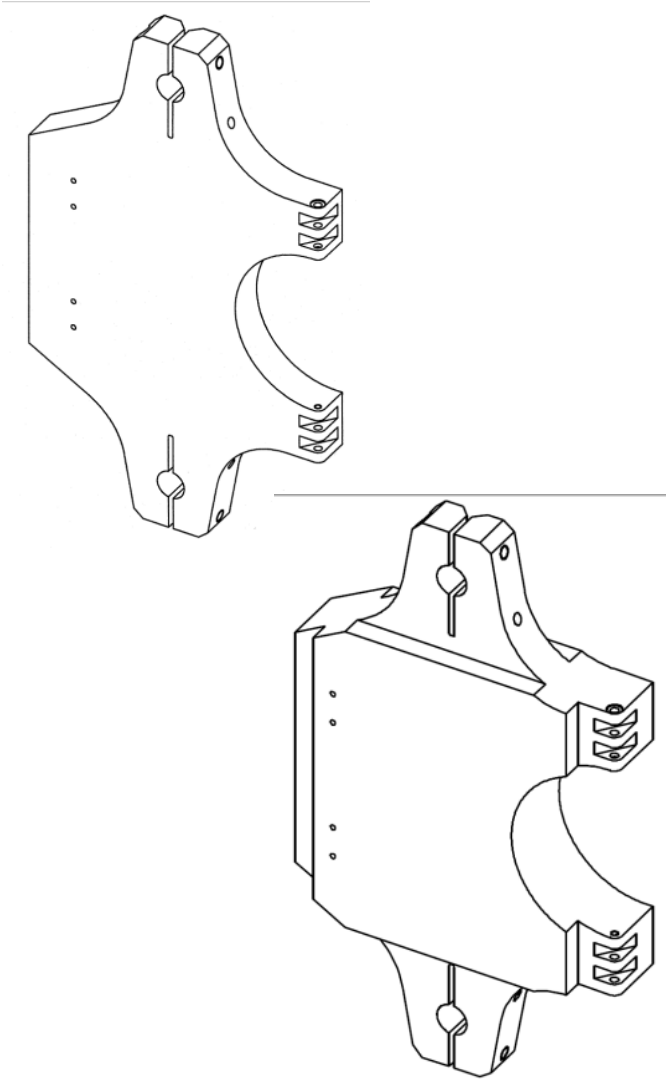
NOTE: C100 space frame is bolted to the vacuum vessel; R100 is not. R100 cavities were built in-house.

C100 Tuner Detail

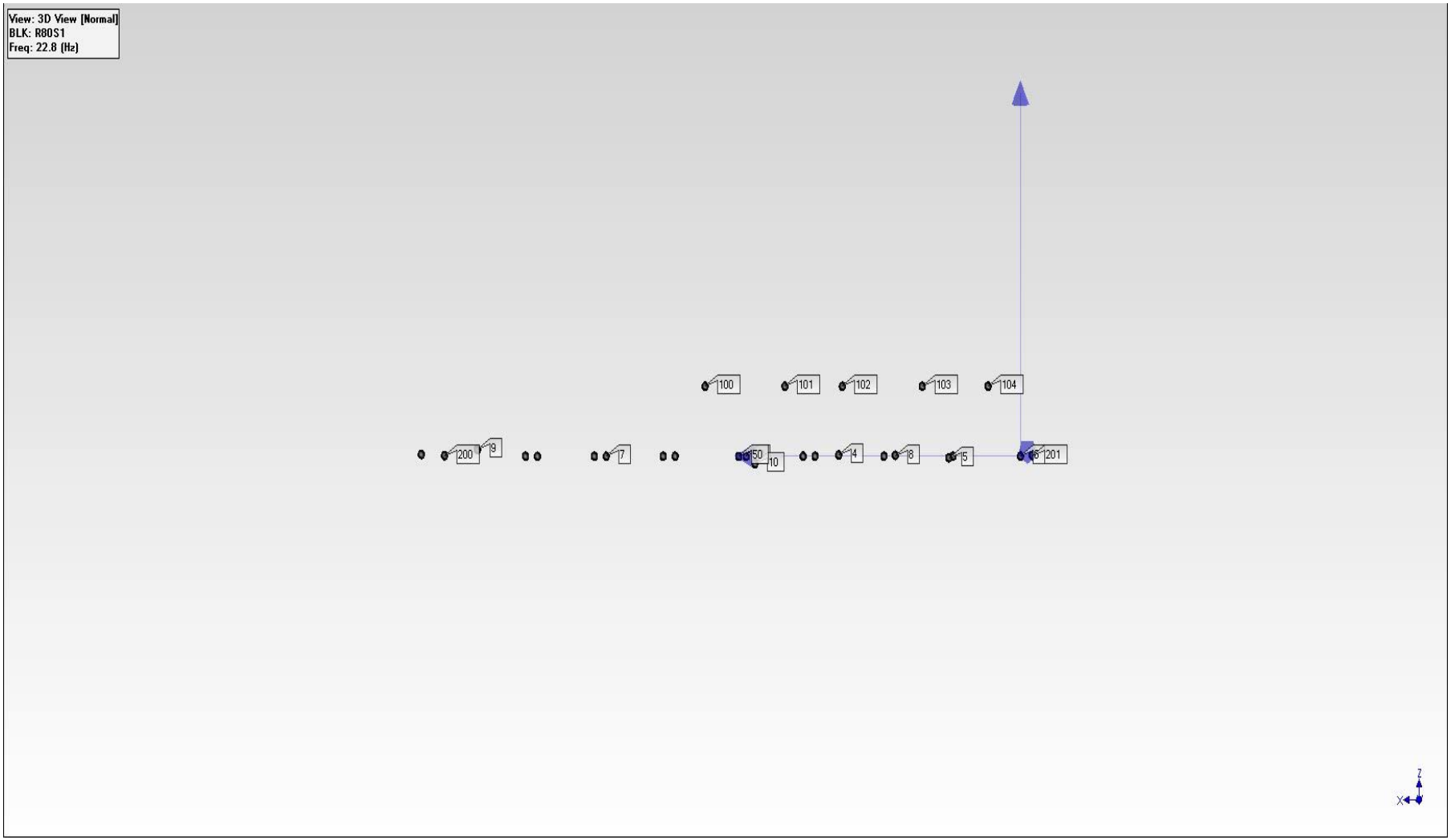


Modal Response Testing

- A warm cavity and a cryomodule were instrumented with triaxial accelerometers.
- A series of warm impulse hammer response tests were performed on structures ranging from bare cavities to a fully assembled cryomodule.
- This data was used in combination with finite element analysis to improve the design. The tuner pivot arms were stiffened.



Modal Test Animation, C100-5 at 23Hz



Background Microphonics Testing

Testing in the CEBAF tunnel showed that:

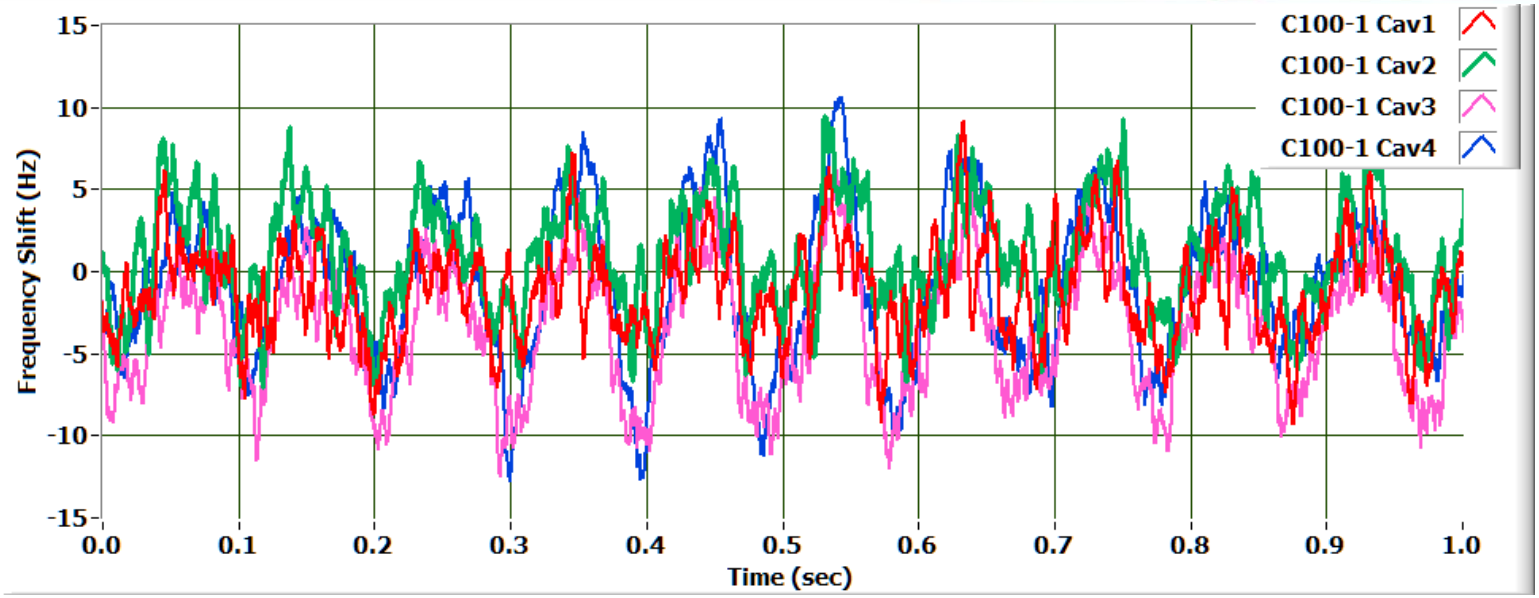
1. Cavity microphonics spectra were similar, with peaks at about 10.5, 20-25, and 40-45 Hz. Matching peaks were identified in the modal test data.
2. Cavities at the center of the CM were noisier, getting quieter towards the ends.
3. Cavity microphonics amplitude was not always repeatable with respect to time and/or cryomodule position (construction activity?)

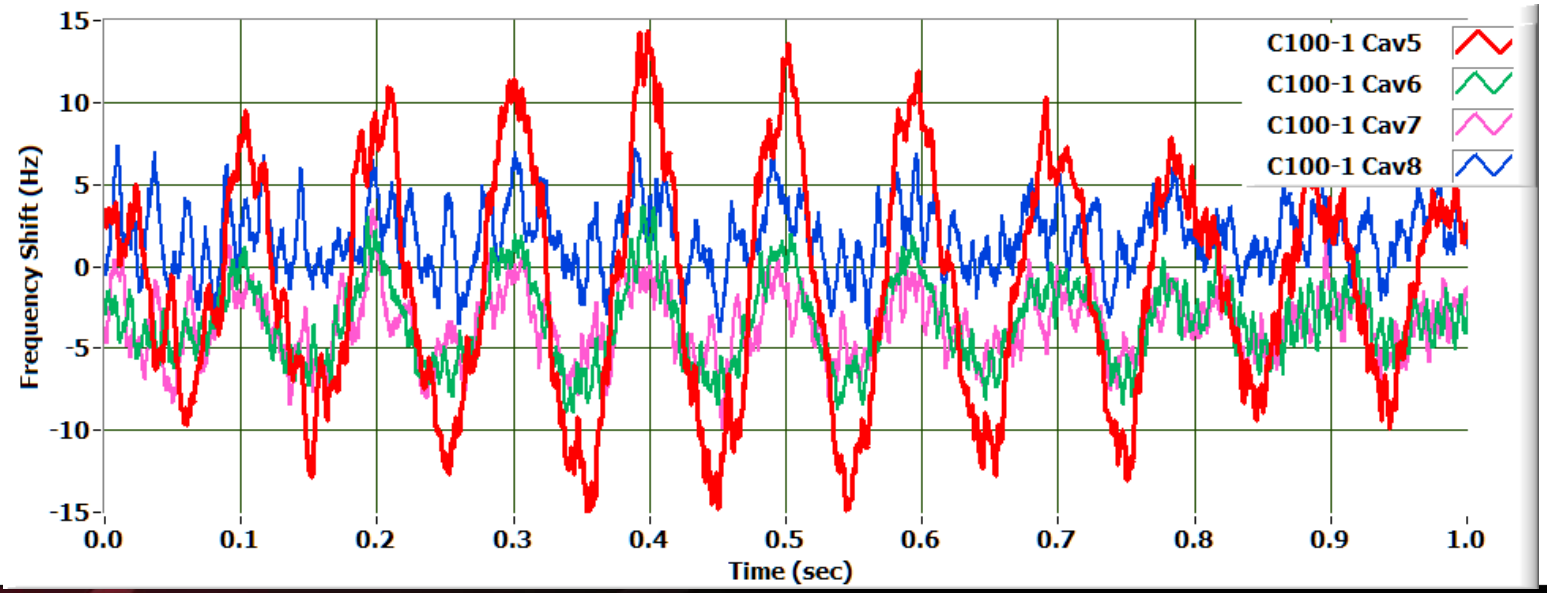
Background Microphonics Testing (cont.)

So a test was performed with a baseline (C100-1) and a modified (C100-5) cryomodule in adjacent zones (SL23, SL24) with all sixteen cavities measured simultaneously and while operating at the same gradient

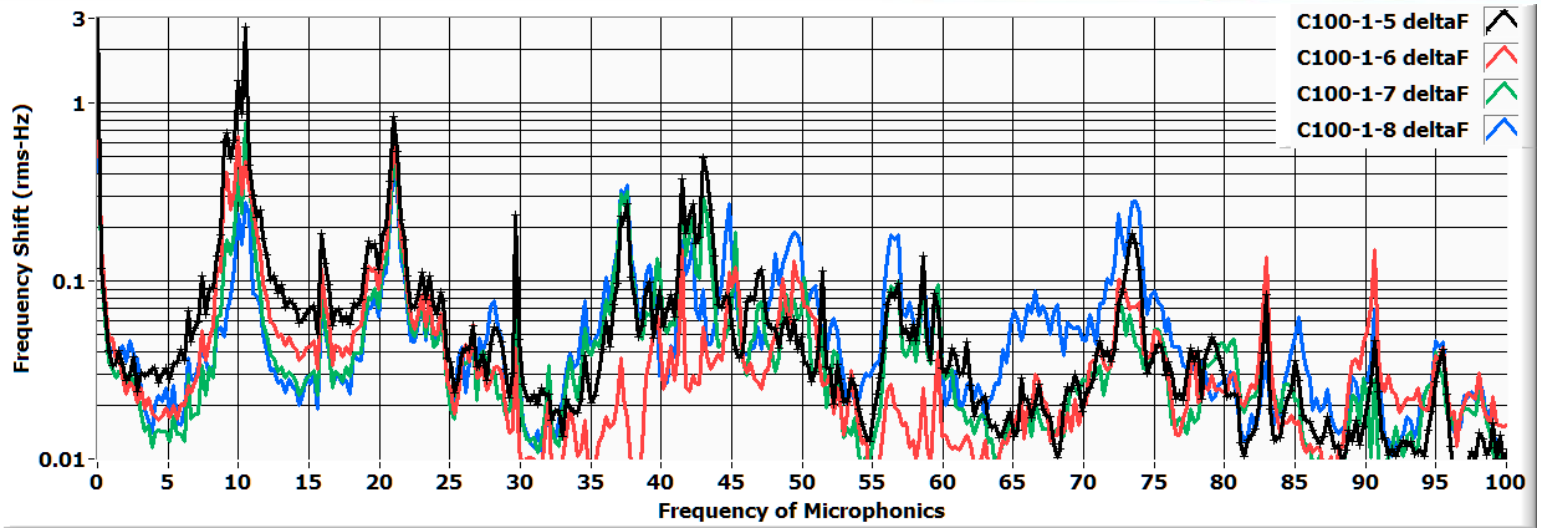
- Data taken using digital low level RF system operated in a fixed frequency mode (GDR) at 1497 MHz and 10 MV/m.
- The RF phase angles between the incident power and the cavity field probe readings (DETA) were recorded at 1kS/sec for 100 seconds.
- Phase angle and cavity loaded-Q used to calculate the detune frequency
- 16 channels of data (2x8 cavities) acquired synchronously.

Time Domain Data for Cavities 1 to 4 and 5 to 8

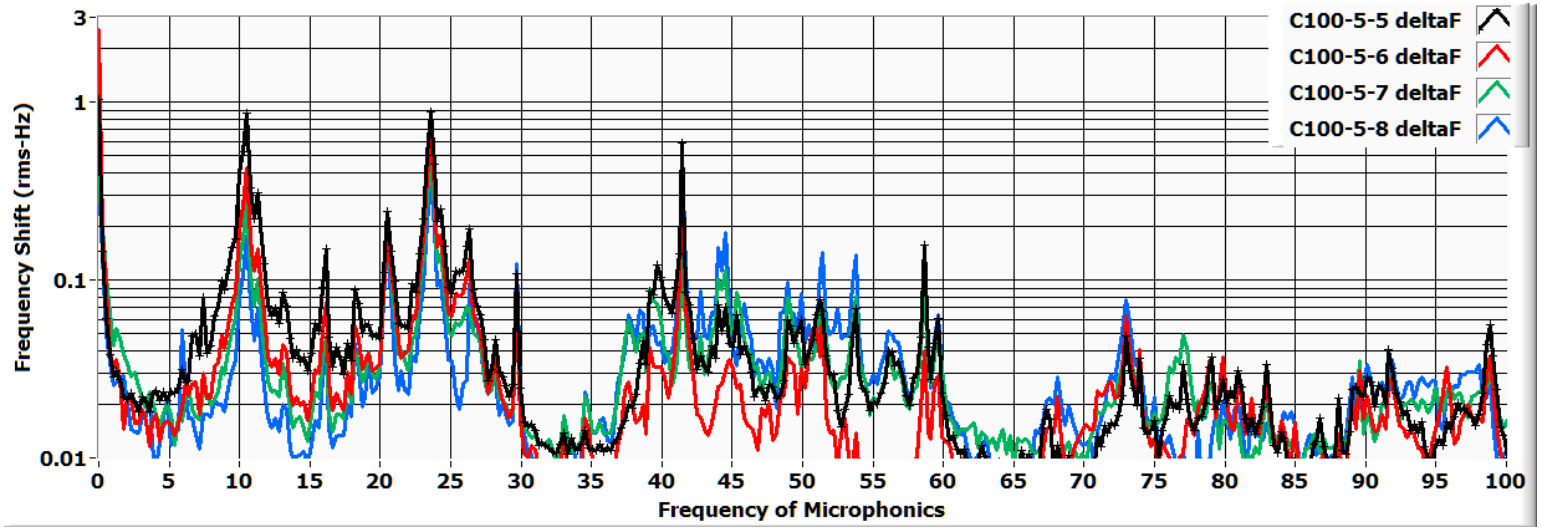




Time Averaged Microphics Spectra



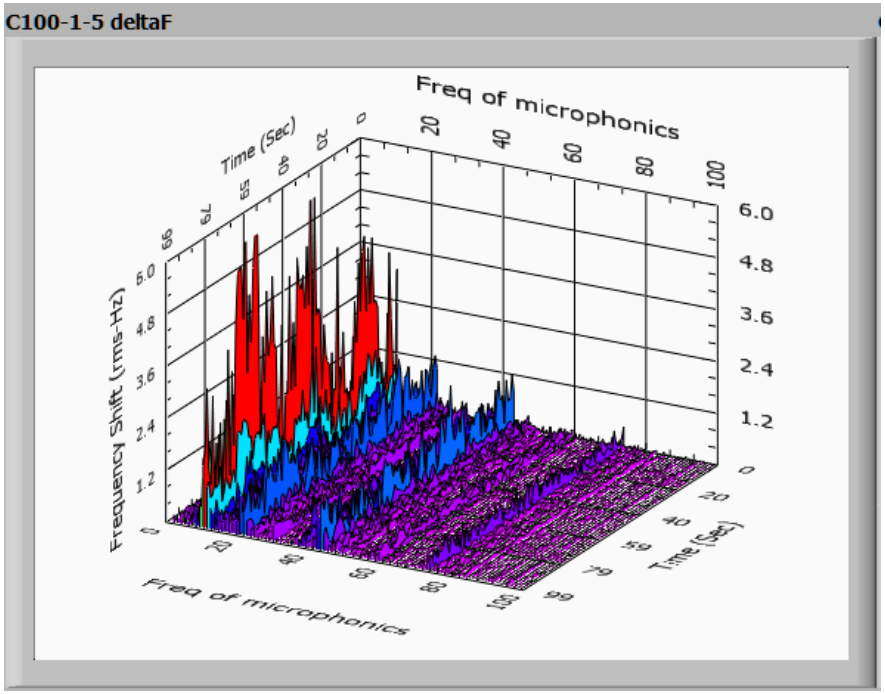
Original Tuner



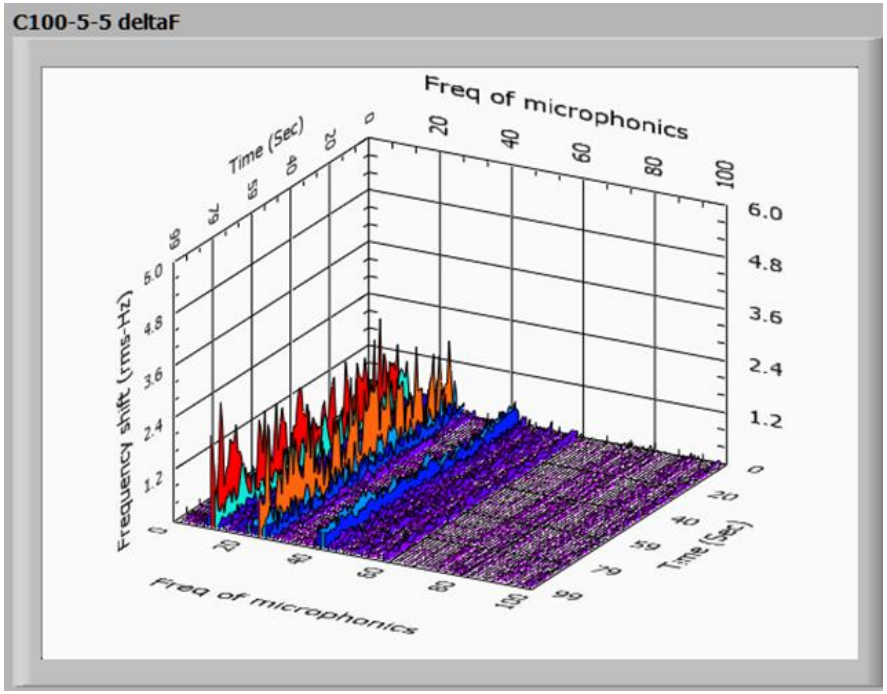
Stiffened Tuner

Microphonics Spectra vs Time

Original Tuner



Modified Tuner



Simultaneous and Adjacent Location

Peak Detuning Amplitude in Hz

Cryomodule	C100-1 (baseline)	C100-5 (modified)	% Improved
Cavity 1	11.8 Hz	5.1 Hz	57%
Cavity 2	12.8 Hz	6.7 Hz	48%
Cavity 3	13.7 Hz	5.6 Hz	59%
Cavity 4	13.5 Hz	7.4 Hz	46%
Cavity 5	18.0 Hz	9.6 Hz	46%
Cavity 6	9.1 Hz	8.5 Hz	8%
Cavity 7	9.7 Hz	5.6 Hz	42%
Cavity 8	8.9 Hz	5.8 Hz	35%

Suggestions for the Future

1. 24 Cavity (simultaneous?) measurement of baseline C100 vs modified C100 cryomodules in adjacent zones vs R100. (August, 2015)
2. Long-term accelerometer study of 0L04 (R100, late fall 2015):
   a) Trigger off of module trips, look at pre-trigger accelerometer data
   b) Trigger off of 6σ accelerometer events, look at LLRF data
3. Develop, install, test a helium pressure sensor with >50Hz bandwidth, fluid coupled to the LHe circuit.
4. Develop, install, and commission an accelerator-site continuous vibration monitoring system.

Acknowledgments

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