Prevention of Dual-Mode Excitation in 9-Cell Cavities

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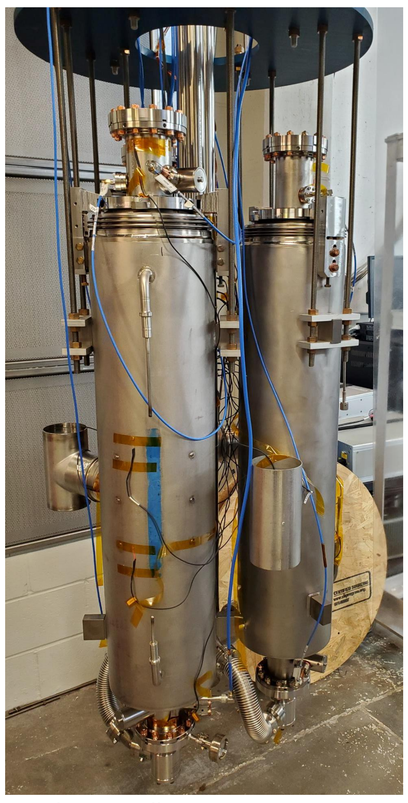
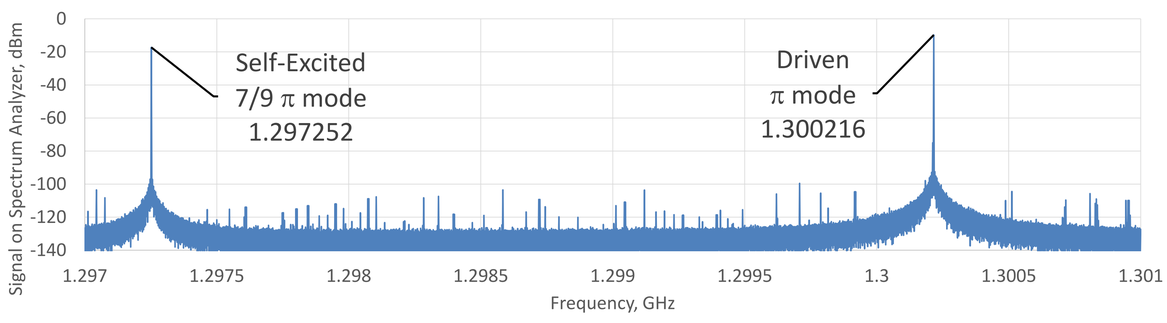
Jefferson Lab
Exploring the Nature of Matter

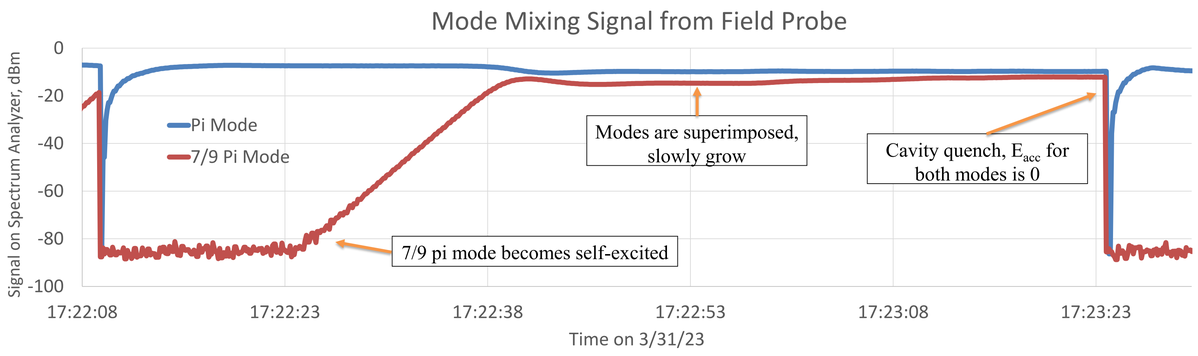


Three 9-cell cavities awaiting 2K vertical test

The Phenomenon of Mode Mixing

- Observed in many 9-cell TESLA design cavities during qualification vertical test:
  - Cavity style used at XFEL, LCLS-II, ILC
  - Observed on nearly every cavity for LCLSII-HE
- Occurs at high gradients, > 17 MV/m
- 7/9 π mode becomes self-excited due to multipacting, modes are superimposed
- Unable to measure E_{acc}, Q_0, reliably
- Could lead to premature quench of cavity below maximum gradient
- Possible source of field emission from Bremsstrahlung



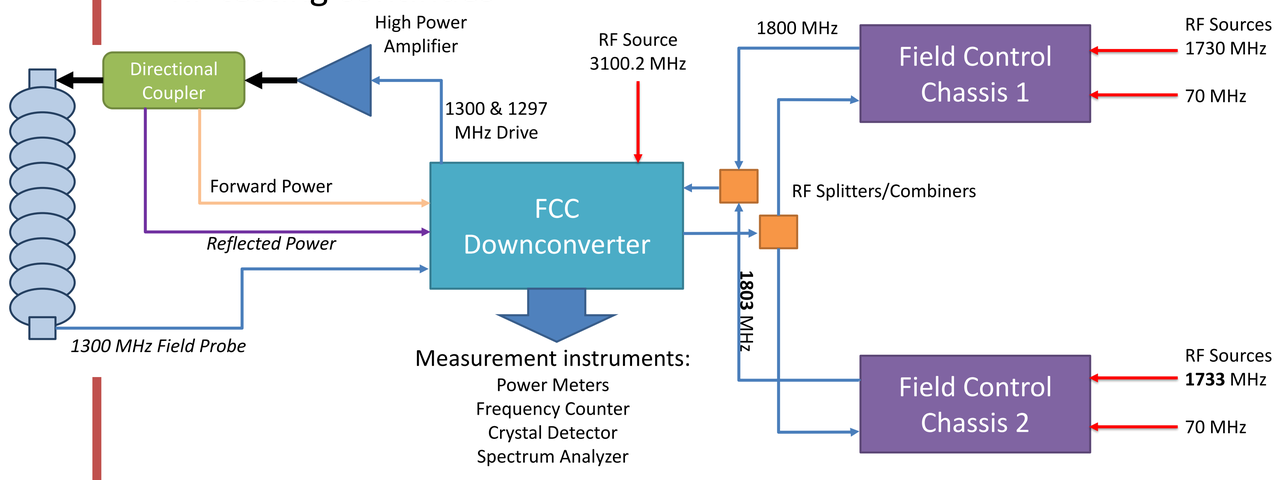


Effects on Cavity Testing

- Only appears in single-cavity vertical tests, when cavity is near critical coupling: $Q_0 \approx Q_{fpc} \approx 10^{10}$
- Does not occur in cryomodules, cavities are strongly over-coupled
- When mode mixing occurs during testing, must turn off power to the cavity to let 7/9 π mode decay
- Dwell time is several seconds, takes time to decay and refill the cavity
- When mode mixing, reflected and transmitted power see increased energy from the undesired mode, invalidates any data taken
- Can be time consuming, only a short window to take accurate data in each power cycle
- Prevents stable measurements when at high-gradient, important for measuring field emission and processing other multipacting barriers

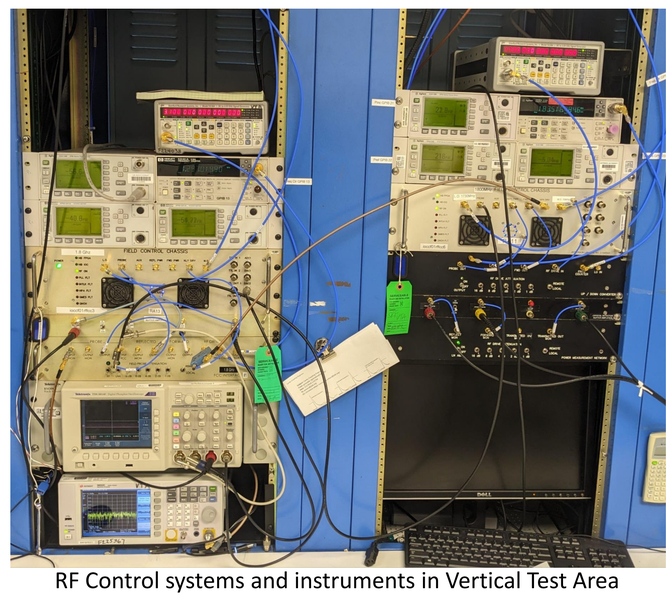
Novel Control Scheme to Prevent Mode Mixing

- Turn off power at 1300 MHz, π mode is no longer excited
- The second Field Control Chassis (FCC) is turned on, exciting the 1297 MHz 7/9 π mode
- Optimize phase for 7/9 π mode by minimizing reflected power
- Reverse phase by 180°, causing the mode to die away
- The output power at 1297 MHz set to < 10 mW at the cavity in order to reduce interference
- Power from FCC 1 is restored to drive the π mode
- RF testing continues



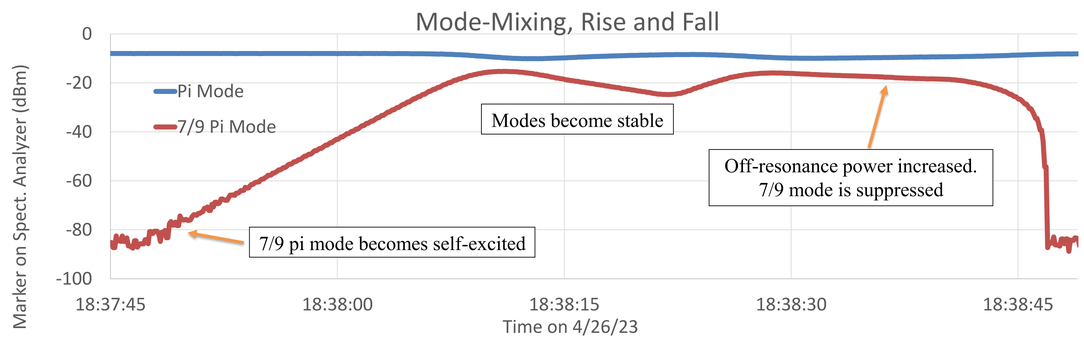
Design of RF System for Cavity Test

- Field Control Chassis sets amplitude and phase, locks onto cavity frequency
- Two Field Control Chassis (FCC) connected in parallel, one for each mode
- Now a regular part of testing L2-HE cavities
- Possible extension to other R&D cavity testing with multiple modes



RF Control systems and instruments in Vertical Test Area

System Performance



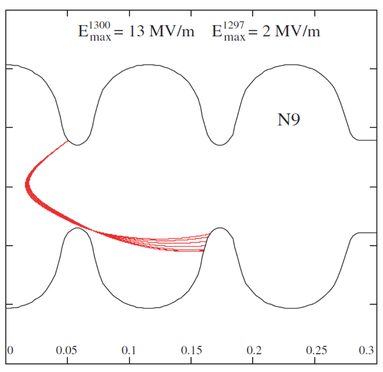
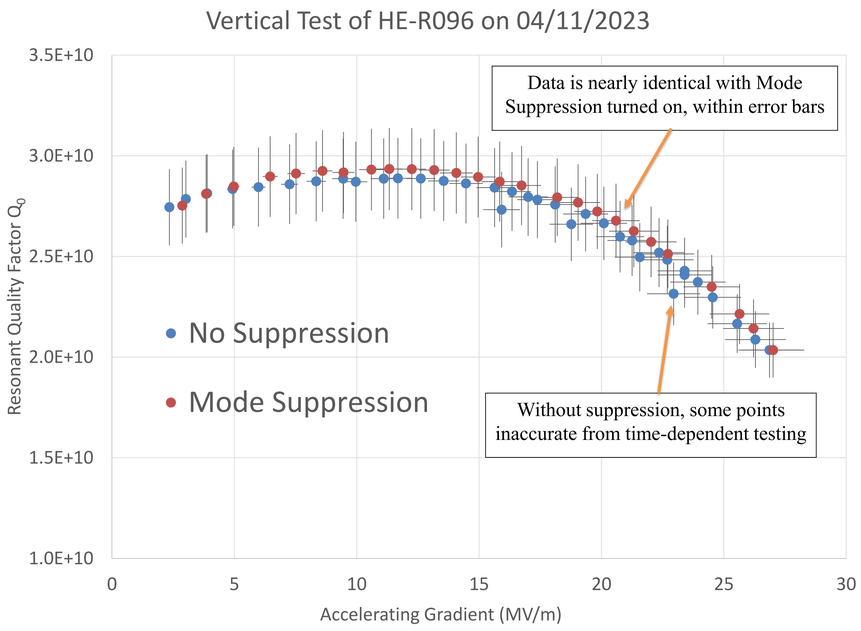


FIG. 4. (Color) Trajectories terminated in the neighboring cell ($15 < E_{max} < 20$ MV/m, for emission in the 3rd and 7th cell $E_{max} \sim 13$ MV/m). Passband-mode excitation occurs.

Figure from V. Volkov [1]

References

1. V. Volkov, J. Knovloch, A. Matveenko, "Monopole passband excitation by field emitters in 9-cell TESLA-type cavities", DOI: 10.1103/PhysRevSTAB.13.084201
2. G. Kreps, A. Gössel, D. Proch, W.-D. Möller, D. Kostin, K. Twarowski, "Excitation of parasitic modes in CW cold tests of 1.3 GHz TESLA-type cavities", SRF2009, Berlin, Germany, TUPPO036
3. Zhenghui Mi *et al.*, "Parasitic modes suppression in CW cold tests of 1.3 GHz"



- Once off-resonance power is applied, 7/9 π mode does not grow, stopped feedback loop
- Off-resonance power is small, <10mW
- Power in the π mode is > 20 W when testing cavity
- Errors on measurement of Q_0 are small, < 1%
- Error bars are already 8-10%
- No effect on measurement of gradient (E_{acc}) through FP, no field is excited by off-resonance power

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