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# **Observations of Long-Range Wakefield Effects Downstream of an Off-resonance TESLA-type Cavity**

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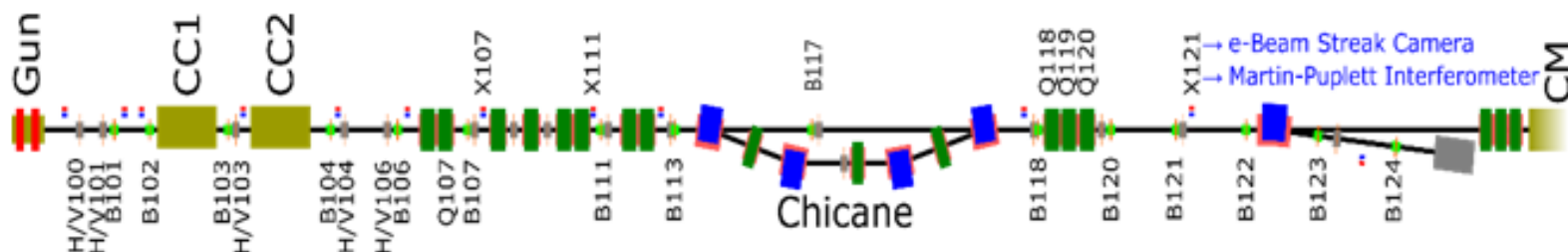
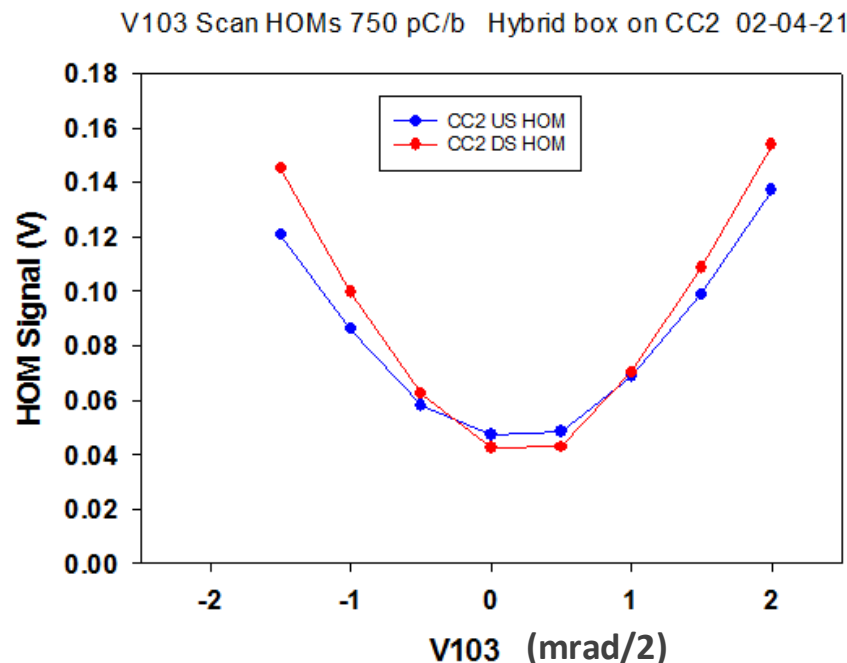
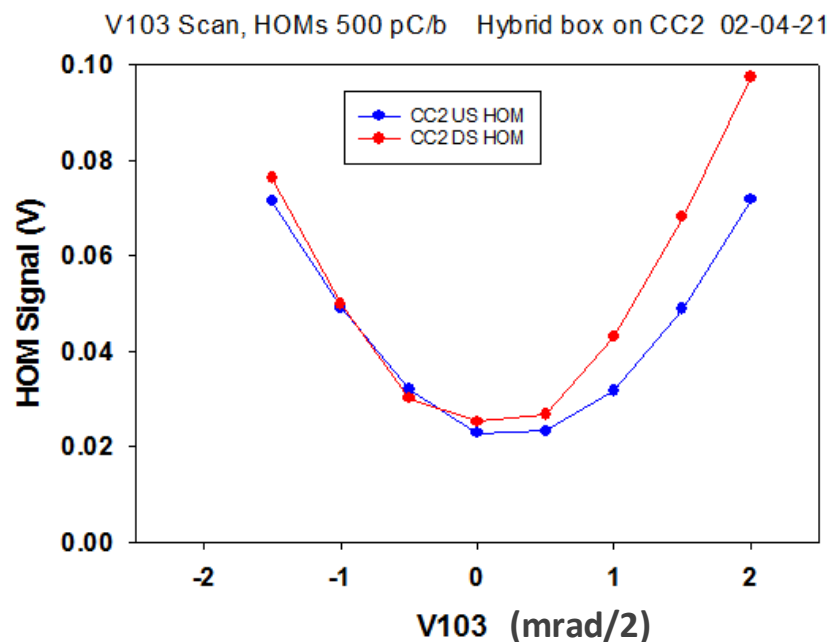
# Motivation: Assessment of LRW Effects on Beam Dynamics

- Investigate higher-order-modes (HOMs) in a TESLA-type cavity (CC2) and their effects on beam dynamics using bunch-by-bunch rf BPM data taken downstream of CC2.
- It is known that off-axis steering in accelerator cavities can lead to long-range wakefields (LRWs) and dipolar HOMs that can cause submacropulse centroid slewing and oscillations. (A.H. Lumpkin *et al.*, PRAB 2018).
- CC2 is tuned off-resonance and powered off in Run 3 data so this is a special case.
- Beam dynamics downstream that lead to emittance dilution were observed, but residual submacropulse centroid oscillations present even with on-axis steering unlike the cavity tuned case.

# CC2 HOMs Probed with V103 Scan

02-04-21

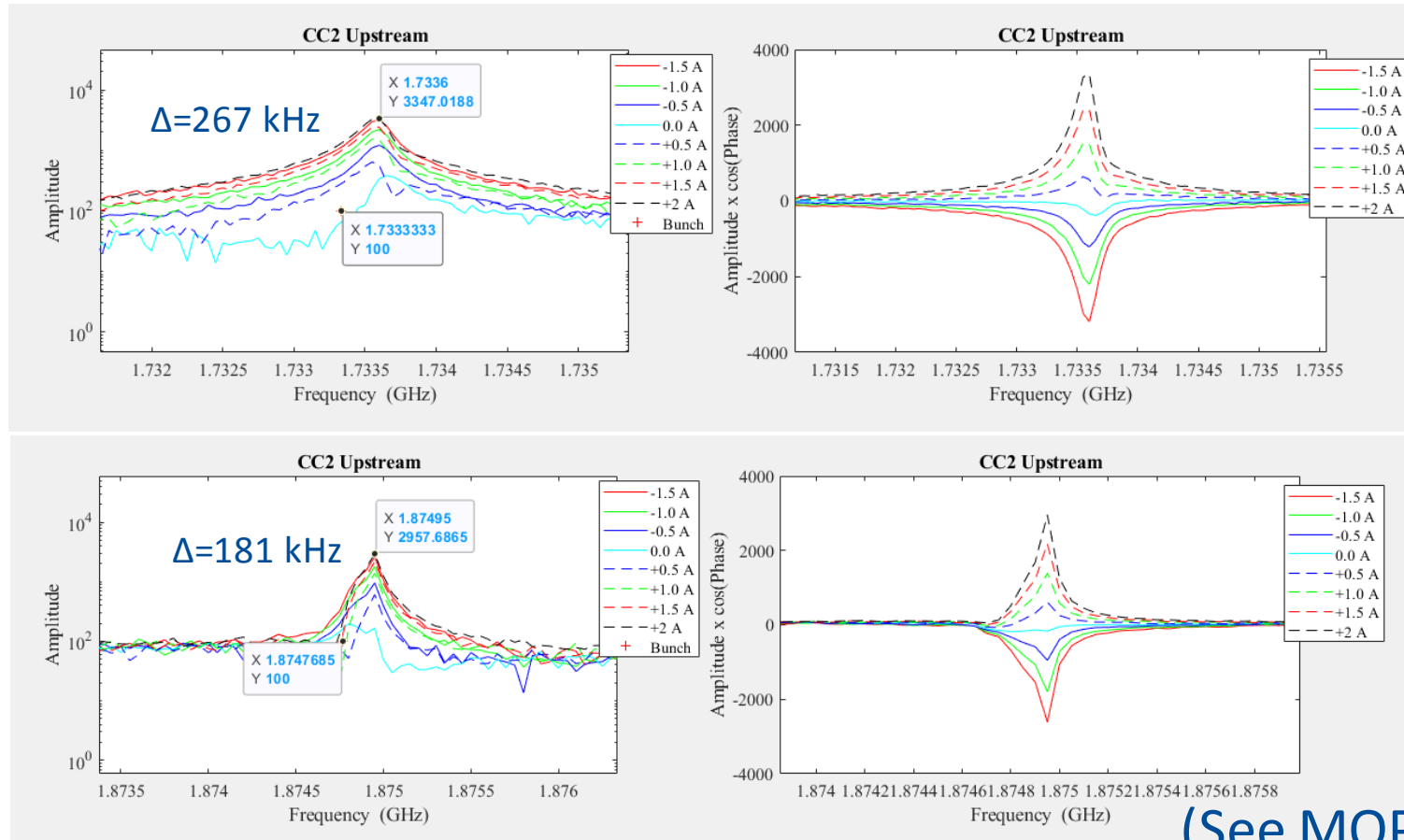
- HOM signals for different charges, 500 pC/b and 750 pC/b.
- 1.75-GHz band. Open iris above 500 pC/b. Double VC spot.



# CC2 V103 Scan Show HOM Near Resonances

02-04-21

- CC2 HOM amplitude and phase information. Dipole Modes 7, 14 with diff. frequencies of 267 and 181 kHz with beam harm..

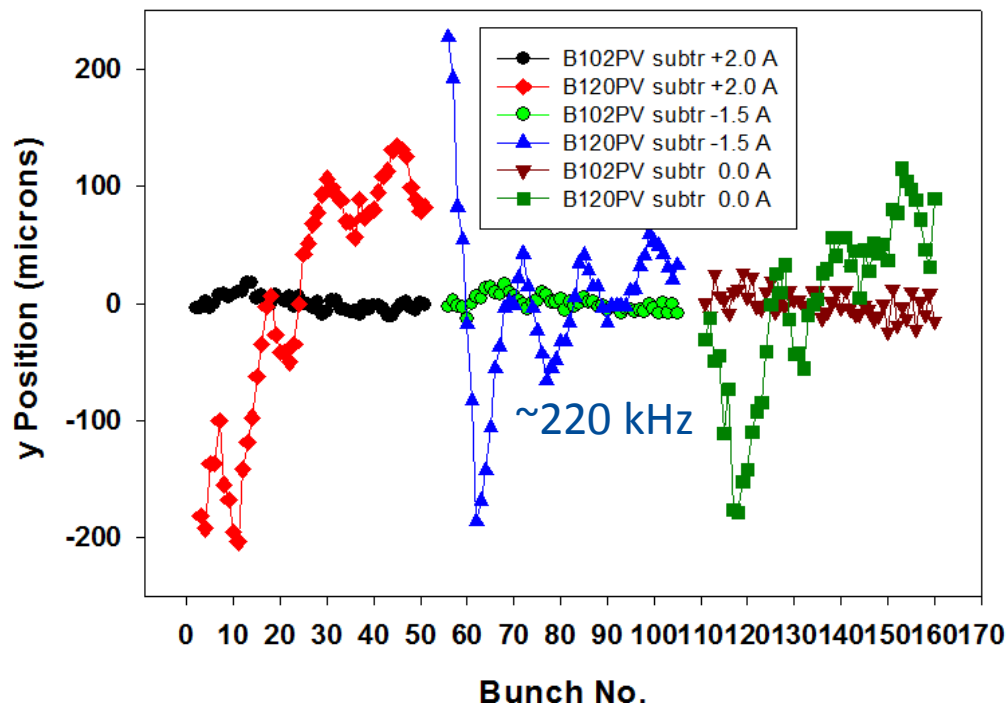


(See MOPAB232)  
Fermilab

# Submacropulse Centroid Oscillation and Slew at B120V

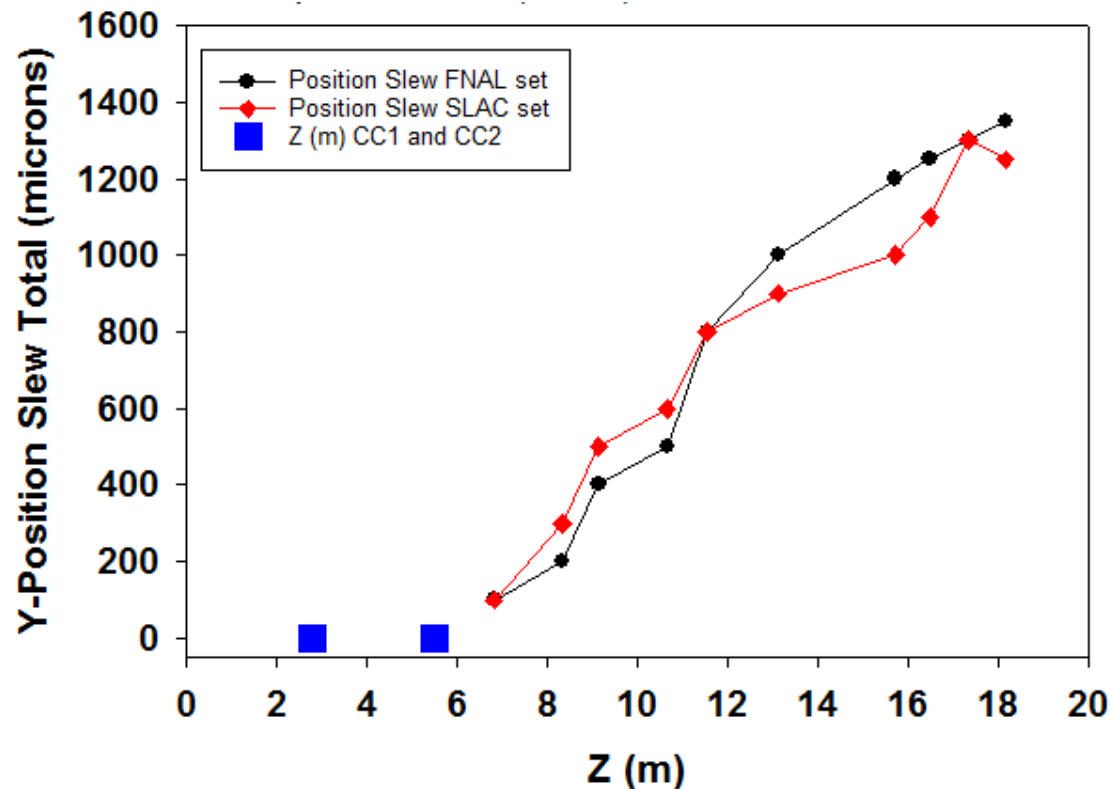
- Beam submacropulse centroid oscillation observed at B120PV 10 m downstream in comparison to B102 located before CC1.
- Residual Oscillation of  $\sim 220$  kHz (Green data) seen even with on-axis steering at  $V103=0.0$ A.

FAST V103 scan, 500 pC/b, 50b 02-04-21



# Submacropulse Centroid Slew Effects are Tracked vs. z

- Estimated slew magnitude as function of z with backward extrapolation indicates CC2 is source of the submacropulse kick LRWs.



# Summary

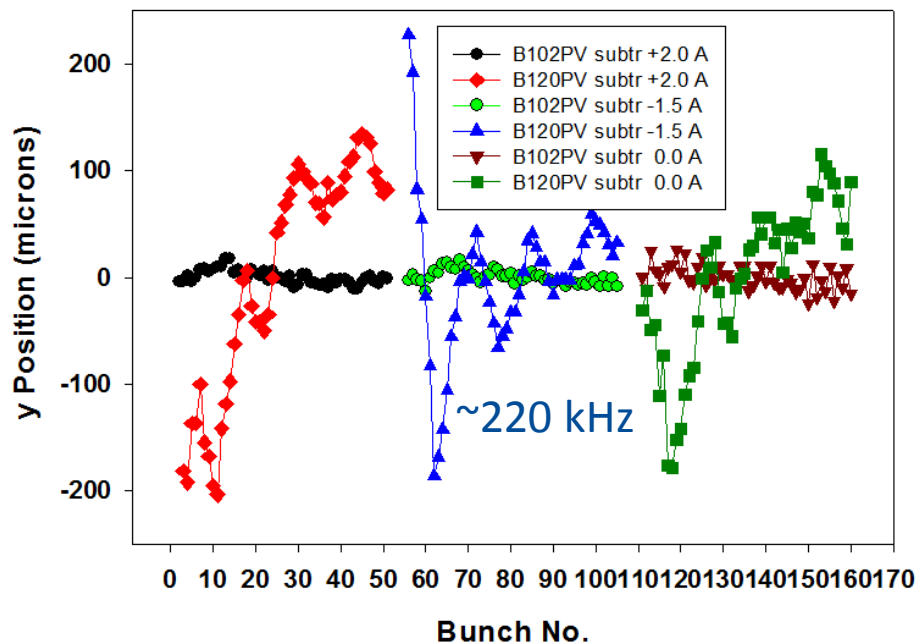
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- The HOM detectors and rf BPMs were used to evaluate off-axis steering effects and LRWs in a TESLA Cavity at FAST.
- CC1 was powered normally, but CC2 was off-resonance and unpowered so total energy was 20 MeV.
- Spectral data show clear near-resonances with a beam harmonic in dipolar modes 7 and 14 in CC2. Combination leads to submacropulse centroid oscillation at  $\sim 220$  kHz.
- Beam dynamics that lead to emittance dilution were observed, but residual submacropulse centroid oscillations present even with on-axis steering. We attribute this to CC2 being off-resonance and the excitation of dipolar modes 7 and 14.

## Q118-120 used to Focus Beam at X121 and B121

- The quadrupole focusing effect is shown in the reduced beam submacropulse centroid oscillation from B120PV to B121PV.
- This is summed over in the synchroscan streak image.

FAST V103 scan, 500 pC/b, 50b 02-04-21



FAST V103 scan, 500 pC/b, 50b 02-04-21

