High Order Modes

Monopole mode: Amplitude first order independent of beam position
Phase of mode determined by bunch arrival time

Dipole Modes: Each mode has 2 polarizations
Frequencies degenerate for ideal cavities
Frequency degeneracy broken by power coupler and fabrication errors

If frequency splitting is < line width, Need both couplers to separate polarizations

Nathan Eddy, Fermilab Instrumentation
Broadband Measurements

- Digitize signal with high bandwidth (>2.5GHz), fast scope (>5GS/s)
- Spectrum provides a means to measure cavity response under real operating conditions
- Able to provide phase measurement by comparing HOM monopoles to 1.3GHz fundamental
  - Both signals present on one cable
  - Able to achieve 0.1° rms relative phase measurement
Narrow-band Measurements

- ~1.7 GHz tone added for calibration purposes.
- Cal tone, LO, and digitizer clock all locked to accelerator reference.

- Dipole modes exist in two polarizations corresponding to orthogonal transverse directions.
- The polarizations may be degenerate in frequency, or may be split by the perturbing affect of the couplers, cavity imperfections, etc.
- May be difficult to determine their frequencies.
HOM Narrowband Electronics

• RF Systems
  - Downmix electronics require LO with very stable phase with respect to the RF
  - Can we build a system to explore multiple modes?

• Digitizer Electronics
  - Implement signal processing directly in FPGA based digitizer
  - Prototype was tested successfully at DESY
Finding the electrical center of the EEX TM110 5-Cell cavity.

Scanned the beam through horizontal plane of warm cavity (3.887 GHz) & monitored induced Ptrans signal. Plotted peak signal. Linear fits give electrical center at 1.6 mm.
Thanks!

Nathan Eddy, Fermilab Instrumentation
Analysis of Monopole Data

• Lines are singlets - frequencies are easy to find
• Find real and imaginary amplitudes of the waveform at the line frequency
• Find phase angle for each HOM mode
• Convert phases to times
• Weight the times by the average power in each line
• Correct the scope trigger time using this weighted average of the times
• Calculate the phase of the 1.3GHz fundamental relative to this new time

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