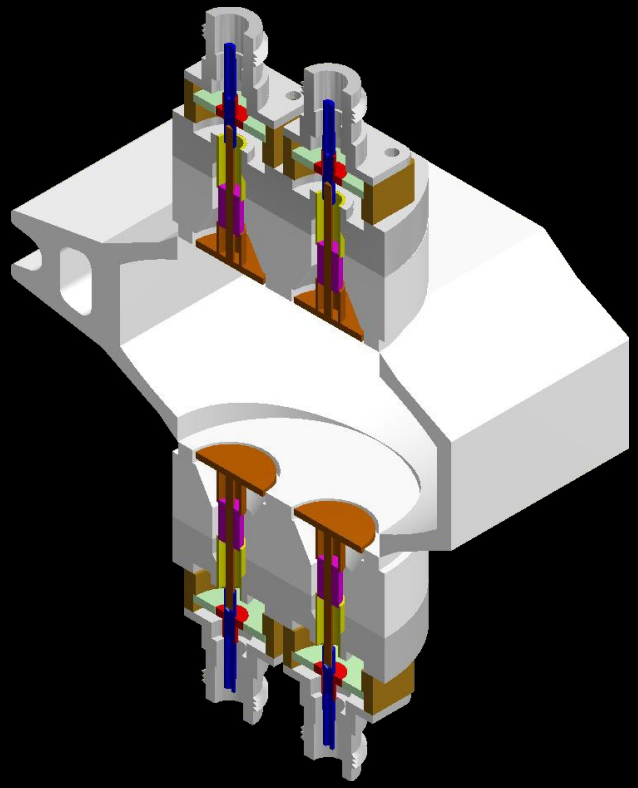
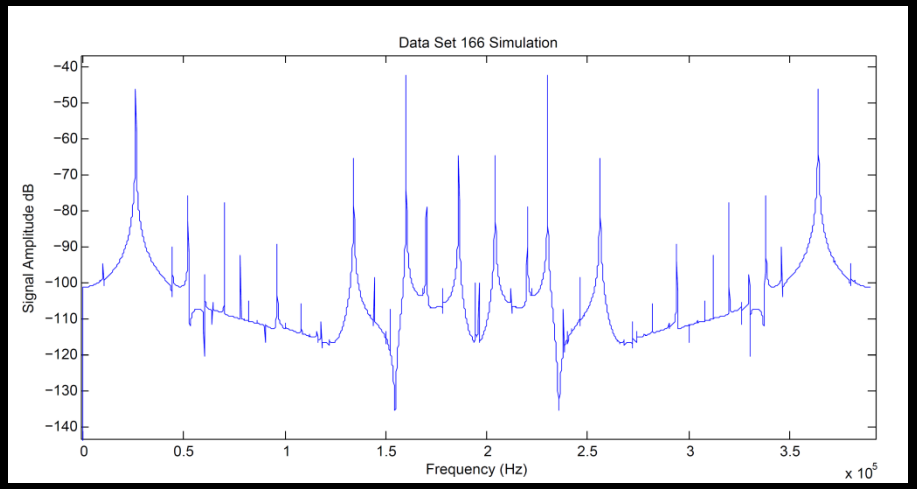
Cornell University
Laboratory for Elementary-Particle Physics

Analysis of BPM Signal Non-Linearities in CESR Vacuum Chamber



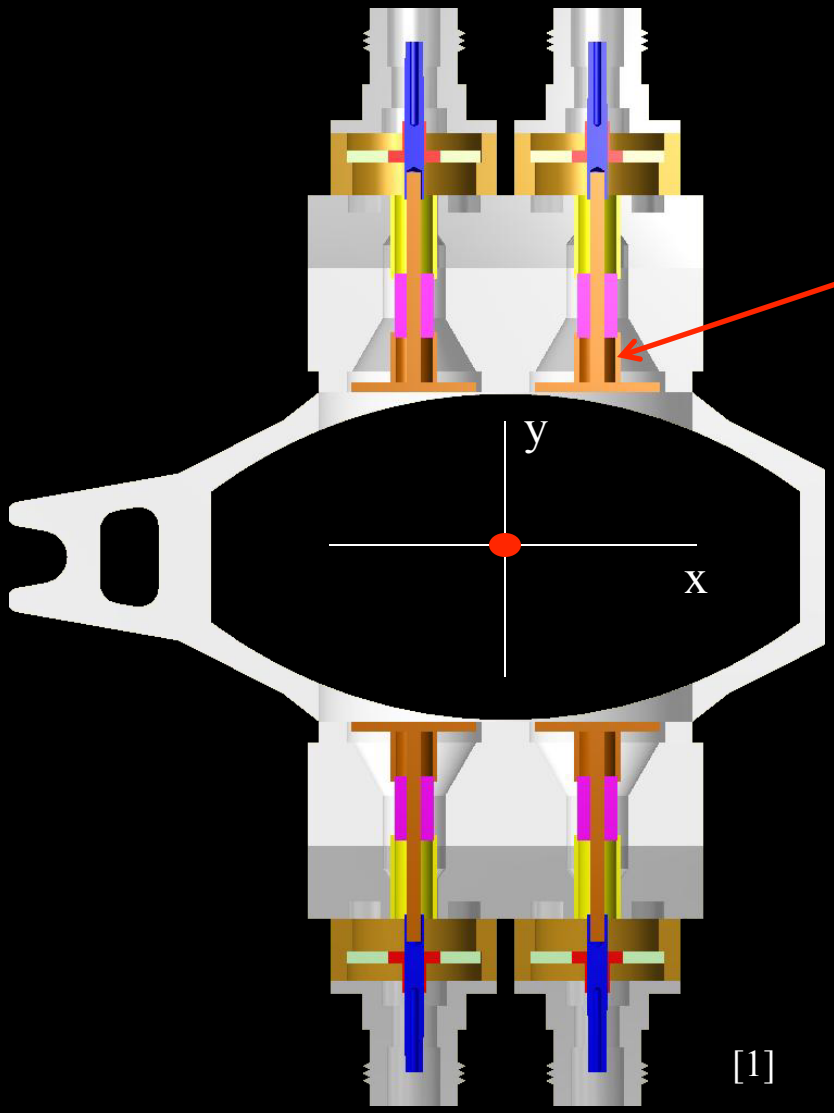


Johan Bonilla

CLASSE/LEPP REU 2012

M. Billing

CESR Vacuum Chamber

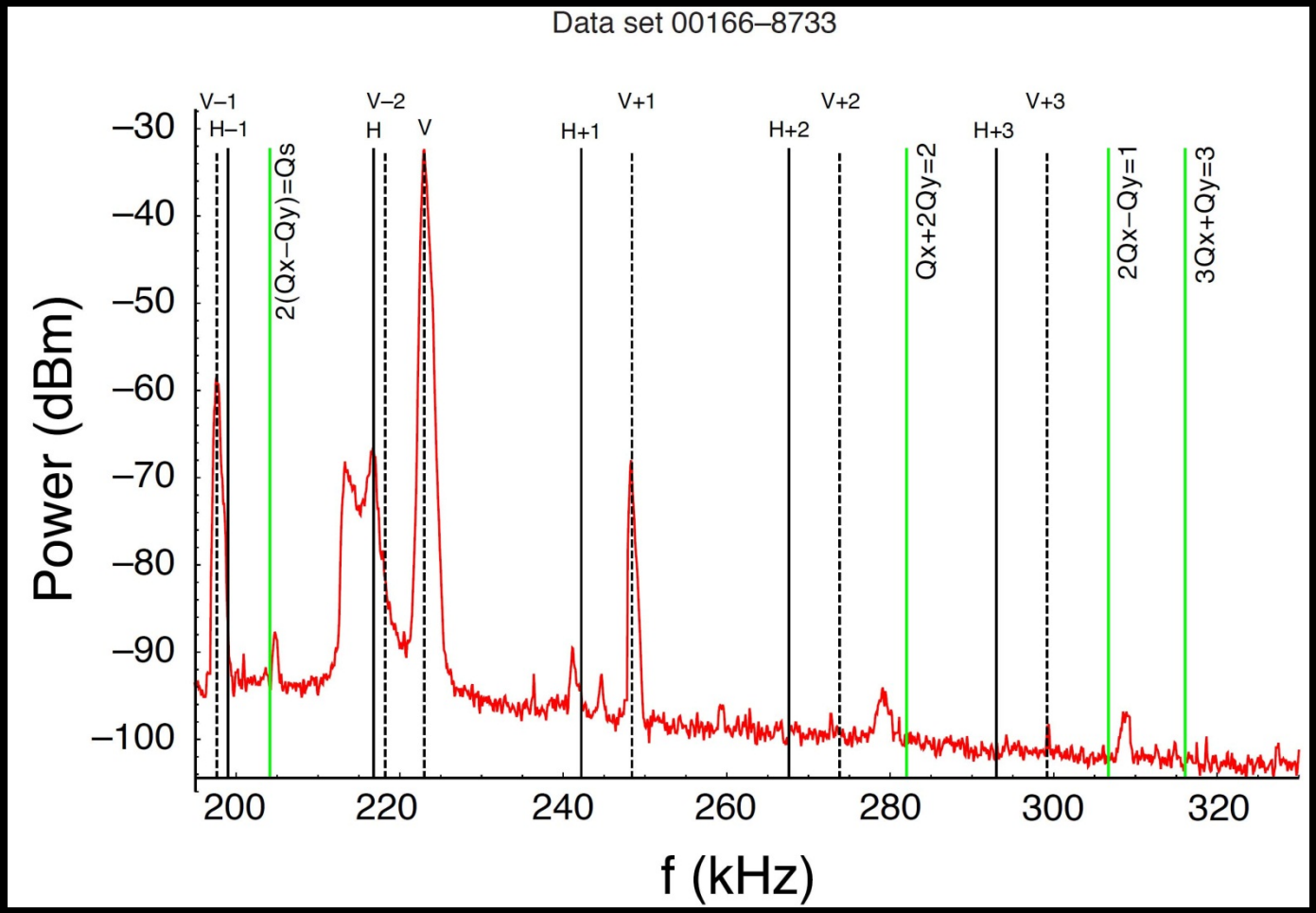


Beam Position Monitors (BPM)

[1]

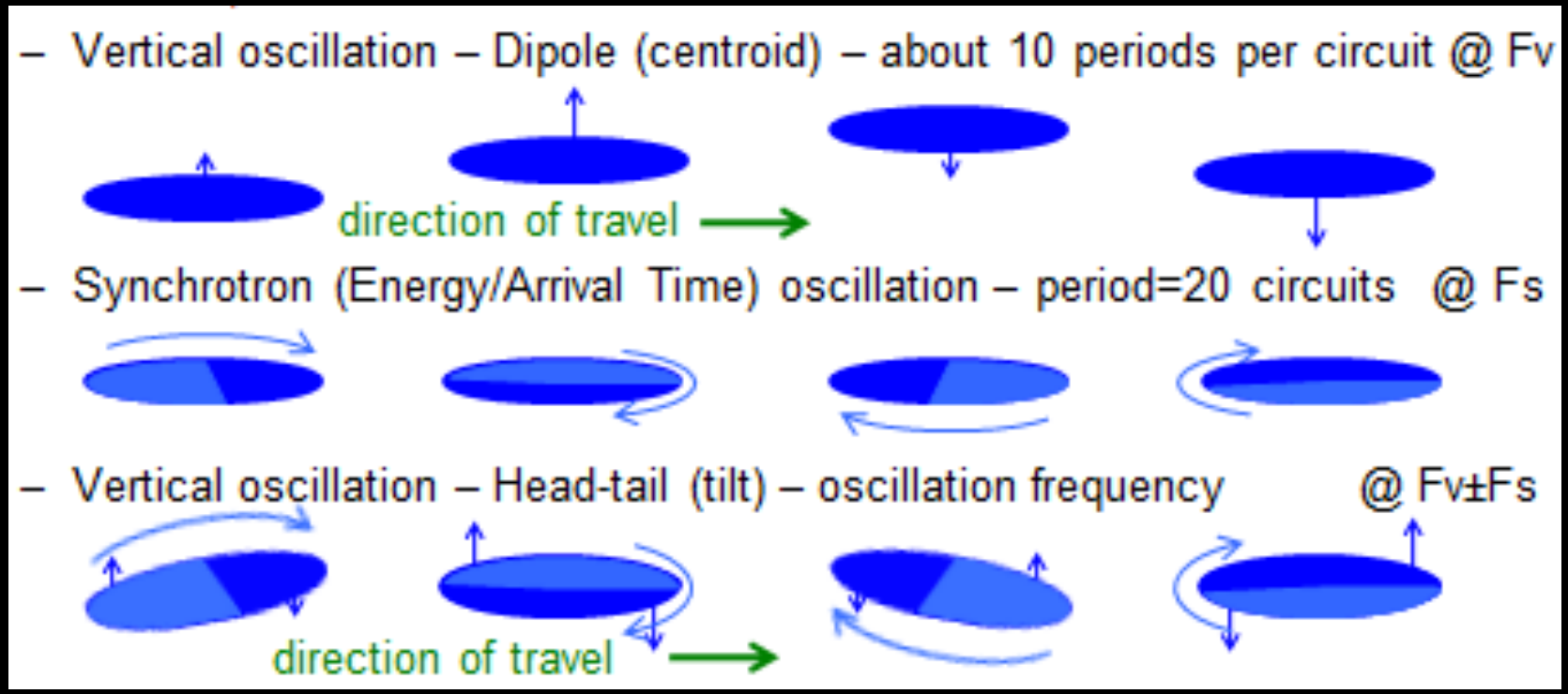
Experimental Example: CESRTA Project

30 Bunch Train: Observed Spectral Motion for 30th Bunch



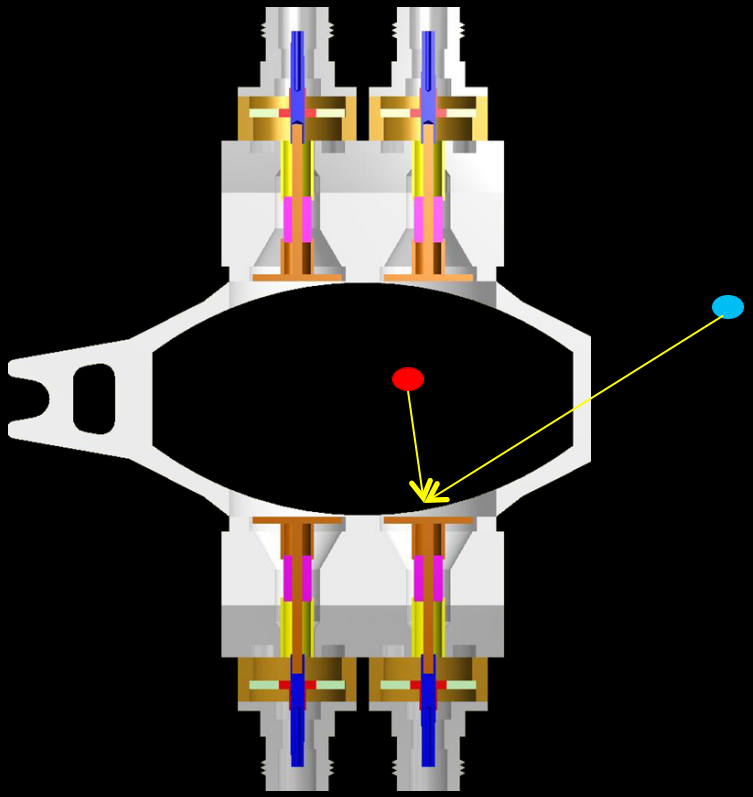
[2]

Head-Tail Motion



[3]

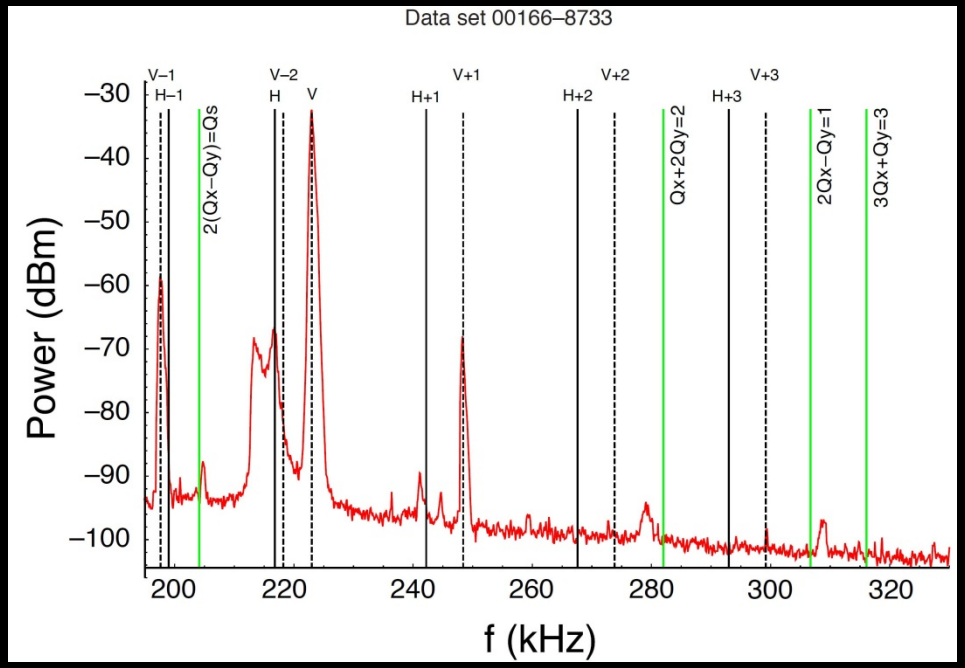
Calculating BPM Signal



Signal:

All Roads Lead to Non-Linearities

- BPM Signals



Simulation of Bunch Position

- Two Independent Functions Describe Motion

  - $\omega_h = 220\ kHz$
  - $\omega_v = 230\ kHz$
  - $\omega_s = 26\ kHz$
  - $\phi_{0x} = \phi_{0s} = \phi_{0y} = 0$

Simulation of Data Set 166

$I\downarrow b =$ 0.73 mA

= 81.3mm

-67 dB (fh)

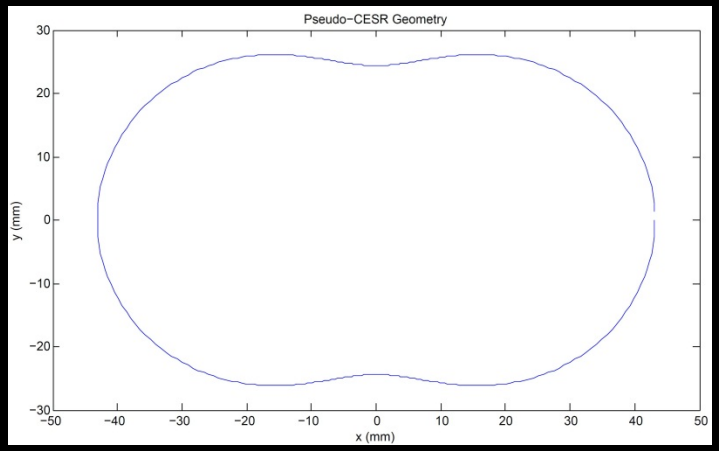
= 45.3mm

-32 dB

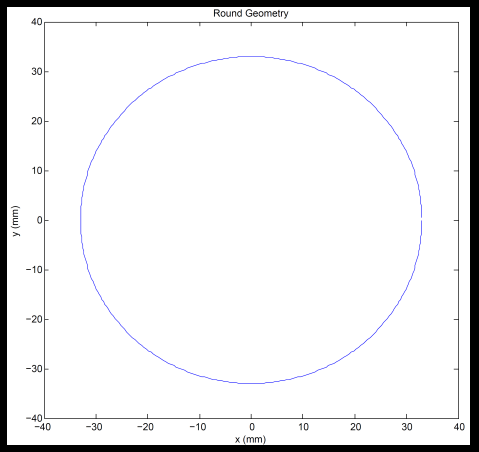
(fv)

Conformal Mapping

52mm X 86 mm

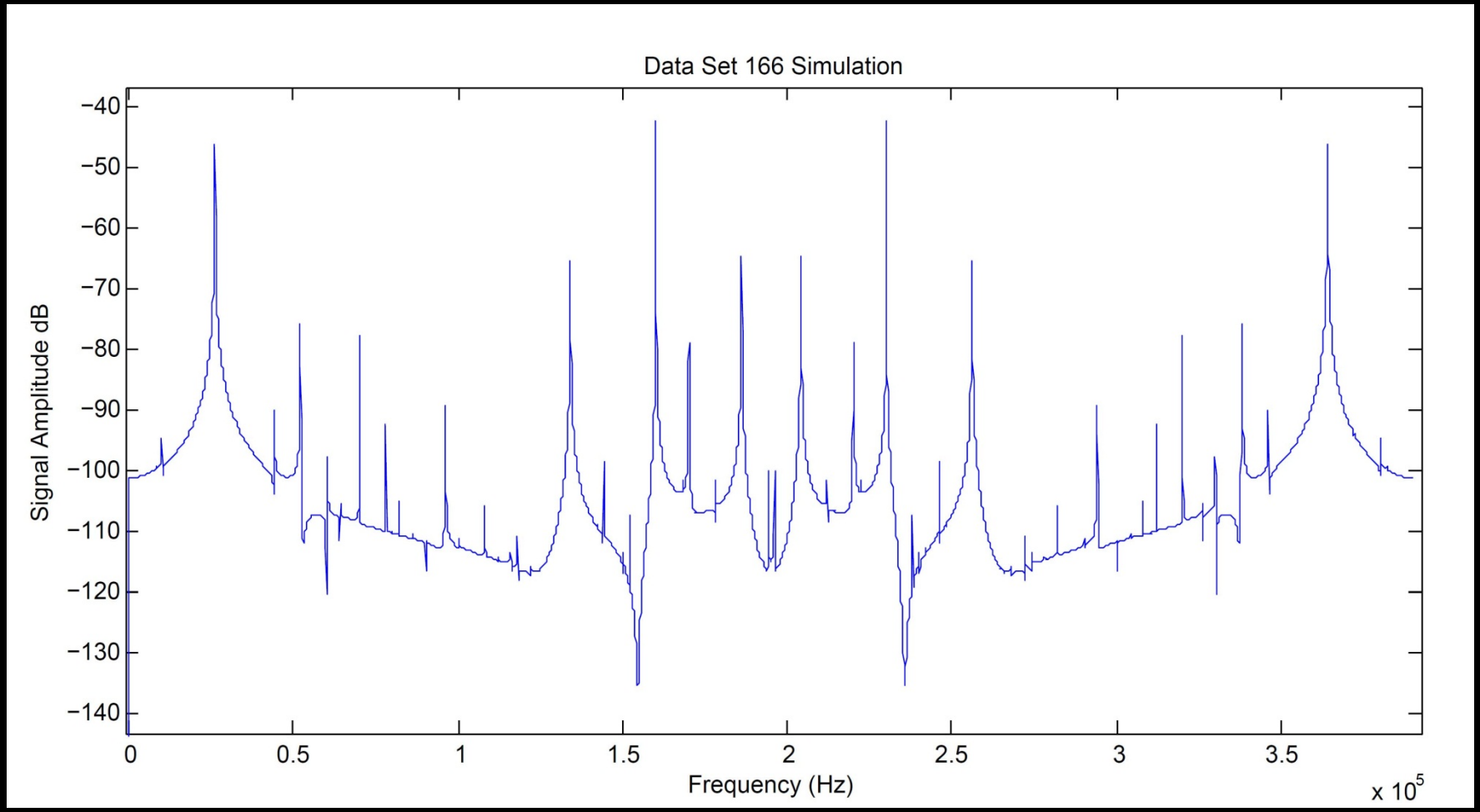


Diameter: 66 mm



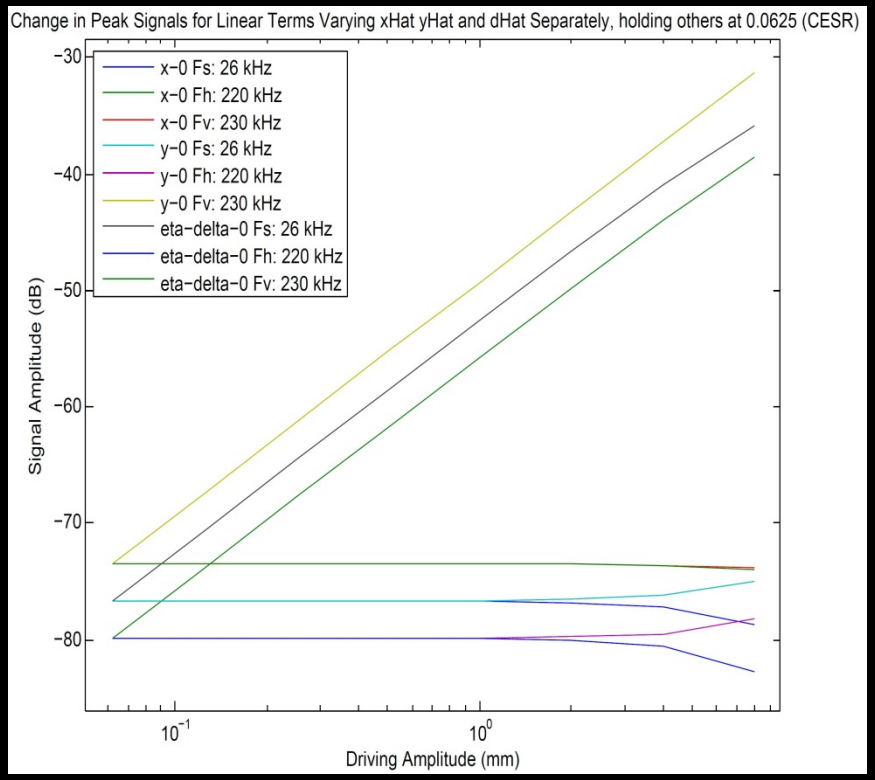
- Transform 1:
- Transform 2:
- Transform 3:

Position FFT of Data Set 166

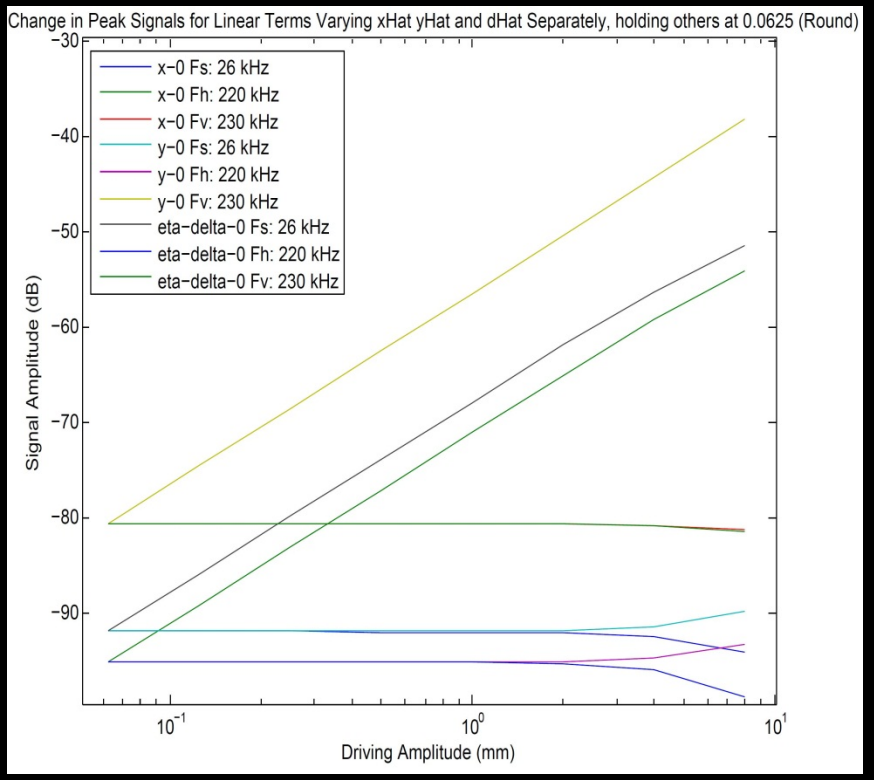


Overall Signal Strength

CESR



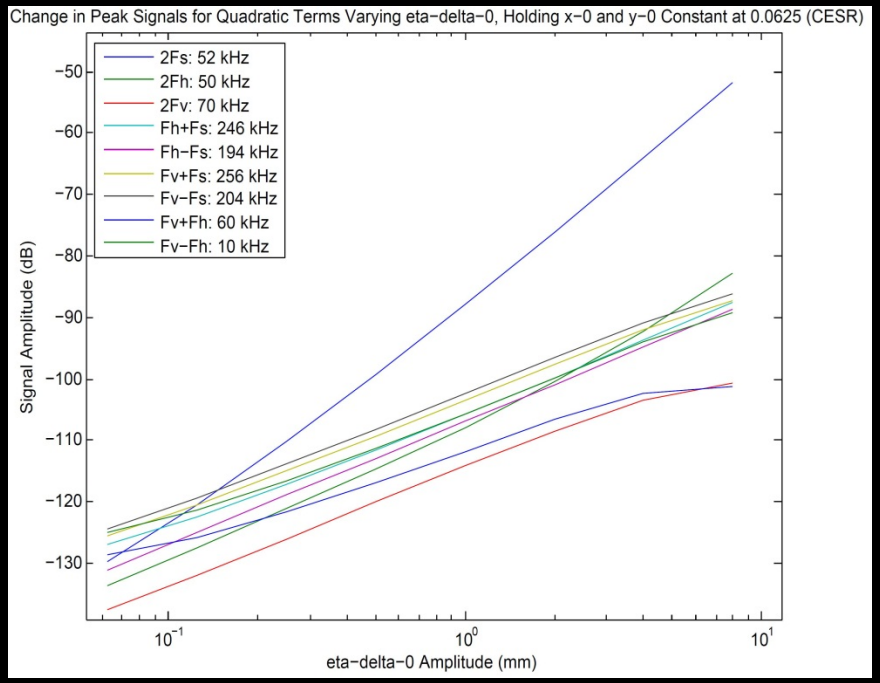
Round



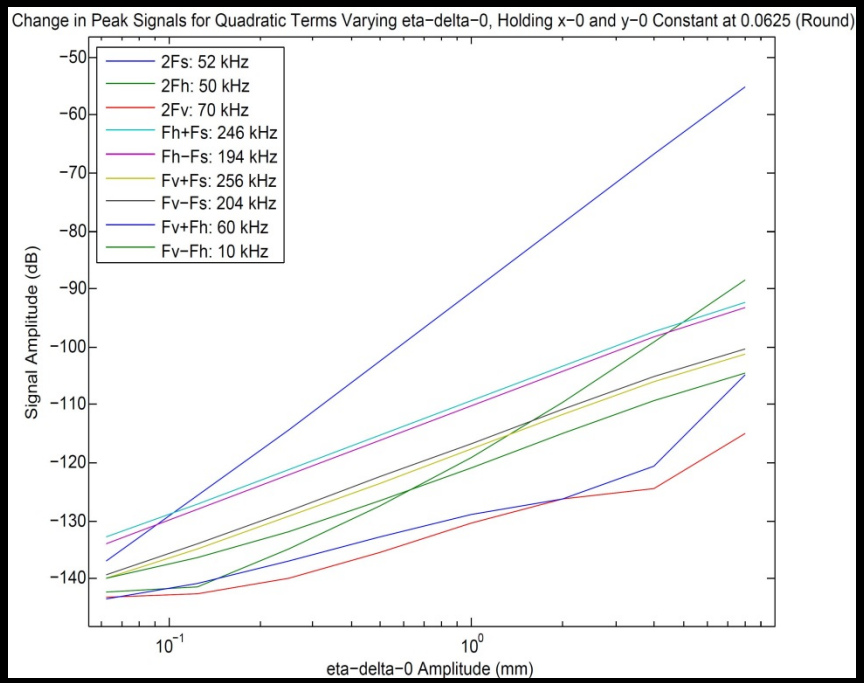
Higher Signal Strength Overall
Specially the Horizontal Frequencies

Quadratic Terms with Varying Energy Oscillation

CESR

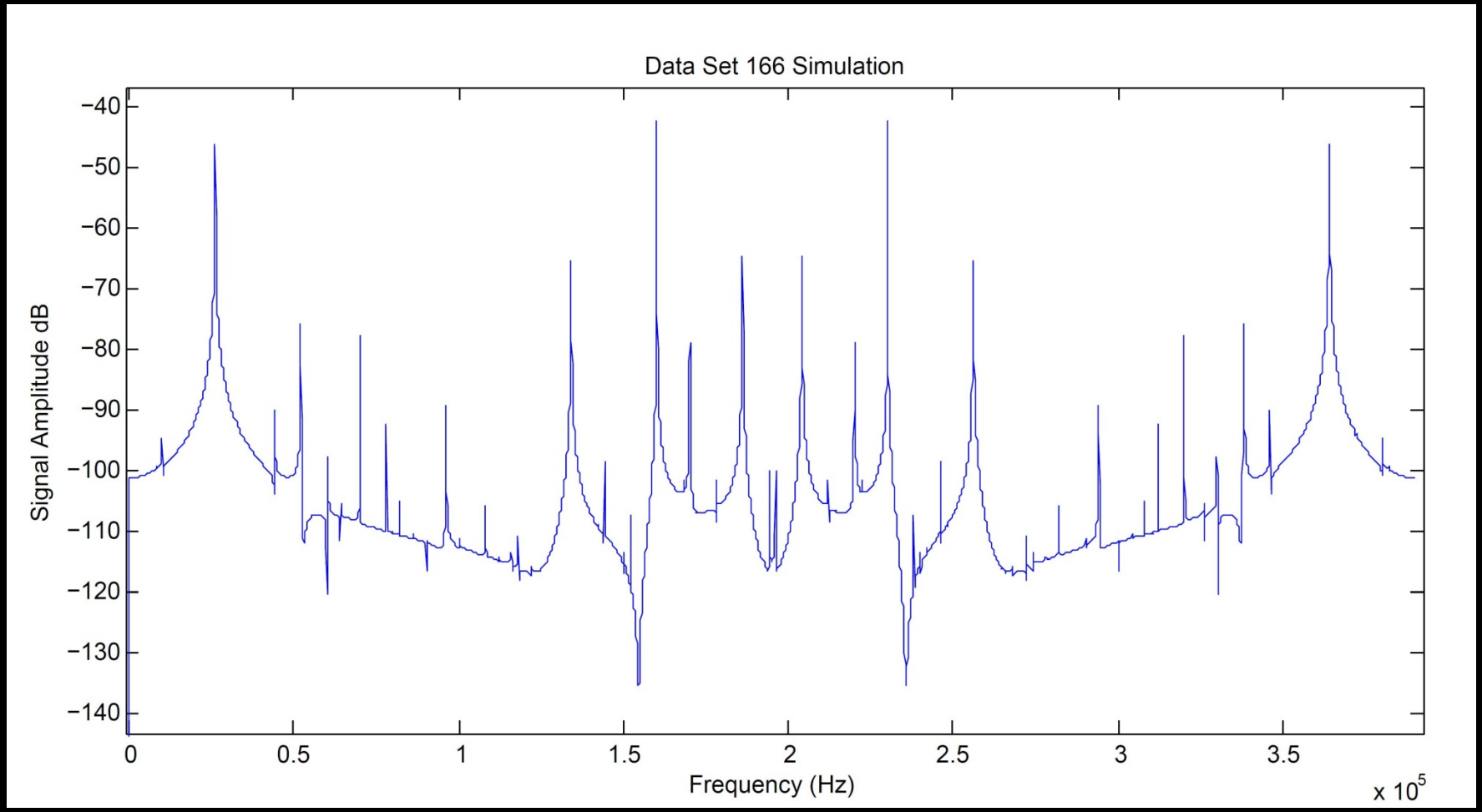


Round



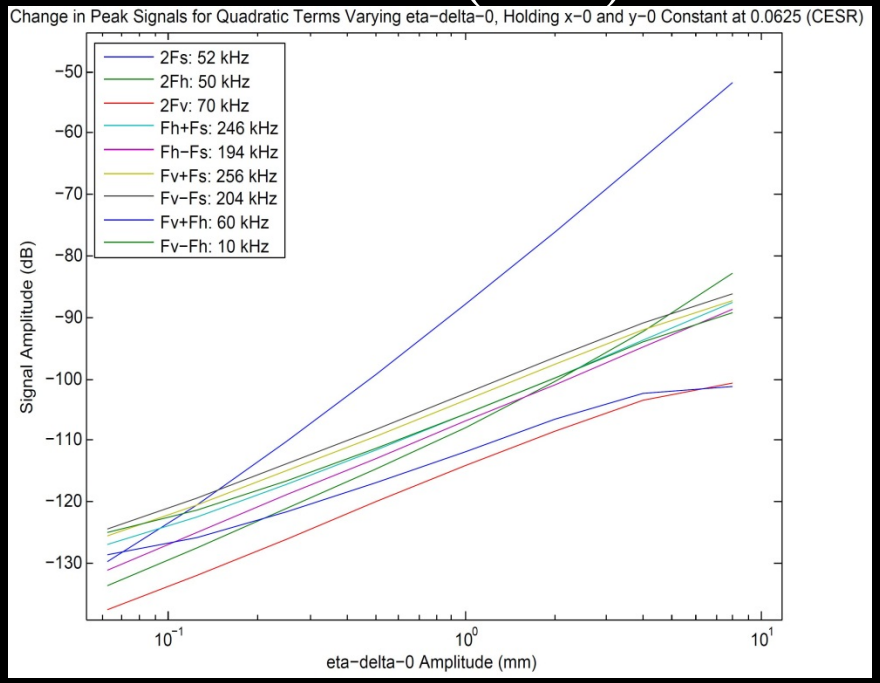
- Fv+Fs and Fv-Fs Remain Fairly Close
- In general, sign pairs converge
- Signal strength still higher in pseudo-CESR
- Overall growth largely dependent on base height growth

Look Back at Signal FFT

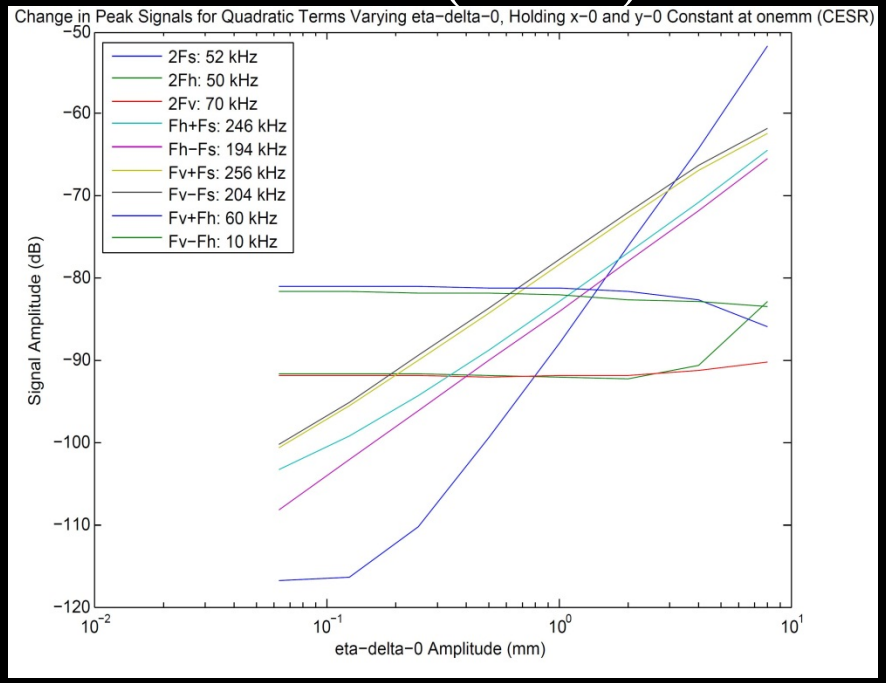


Closer Look at Quadratic Terms in CESR Varying Energy Oscillation

CESR (min)



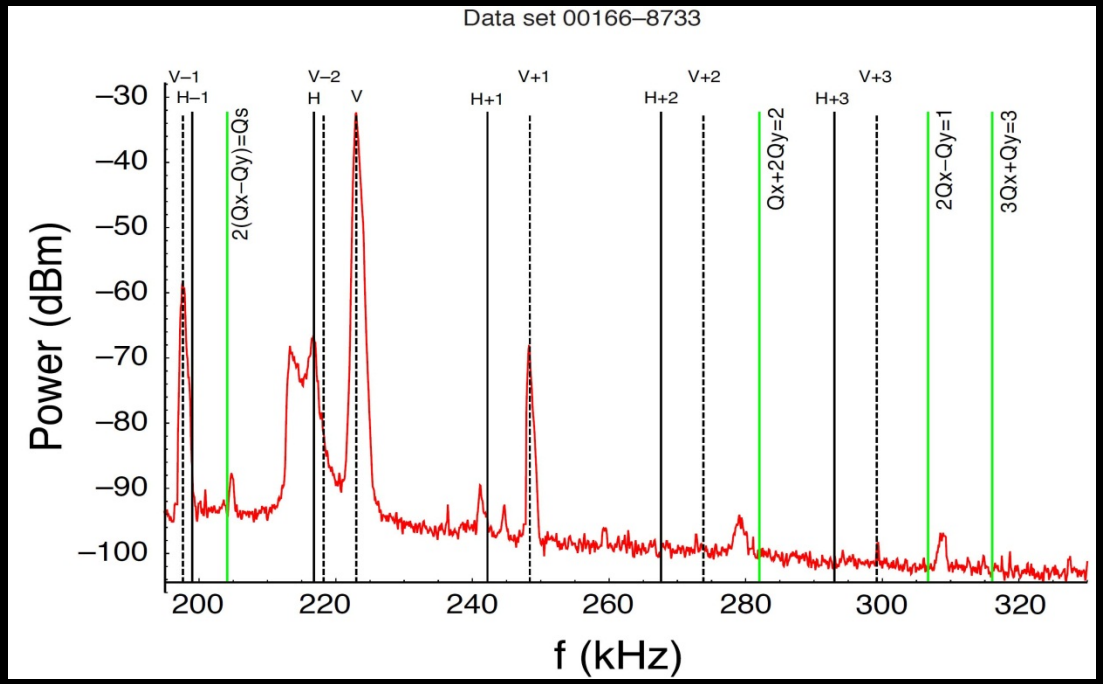
CESR (1mm)



- 2Fs grows twice as fast, expected from squaring amplitude
  - Sign pairs STILL remain convergent
  - Terms lacking Fs frequency stable
  - Prime example of “shoulder growth”

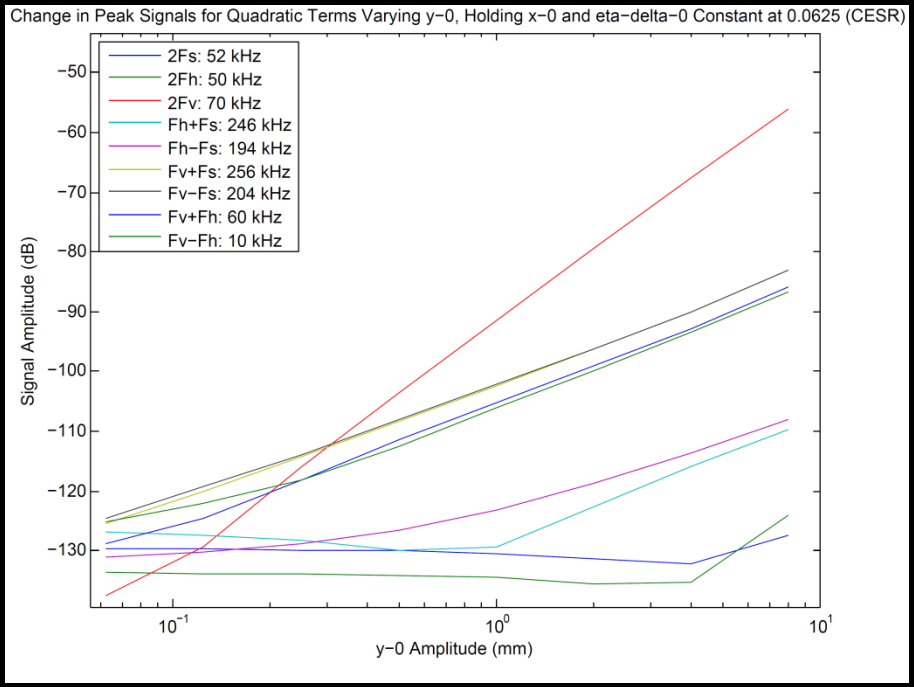
Implications

- Sign Frequency Pairs converge to equal amplitude
  - Disparities in empirical data are suggestive of additional phenomena such as head-tail motion
  - Serves as a "base" comparing side bands in CESRTA



Implications

- Round vacuum chambers have less non-linearities by ~10 dB (may serve as a better test bed for measuring Head-Tail Motion)
- Analyzing data when $\eta \downarrow x \rightarrow 0$ reduces BPM non-linearity



Acknowledgements

- [1] Li, Yulin; CESR Vacuum Chamber and BPM Figures. *Downloaded July 20, 2012*
- [2] CESRTA Project Collaboration; Electron Cloud Beam Dynamics. *Pgs. 270-315.* Draft. Printed July, 2012
- [3] Billing, Michael; CESRTA REU Presentation. June, 2012

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