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Electro-Mechanical Properties of Spoke-Loaded Superconducting Cavities

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Collaborators

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- **AES**
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Cavity RF Power Requirements

- **In many applications superconducting cavity RF frequency variations are on the level of or greater than the loaded-cavity bandwidth.**

- **Mechanical deformations drive RF eigenfrequency variations.**

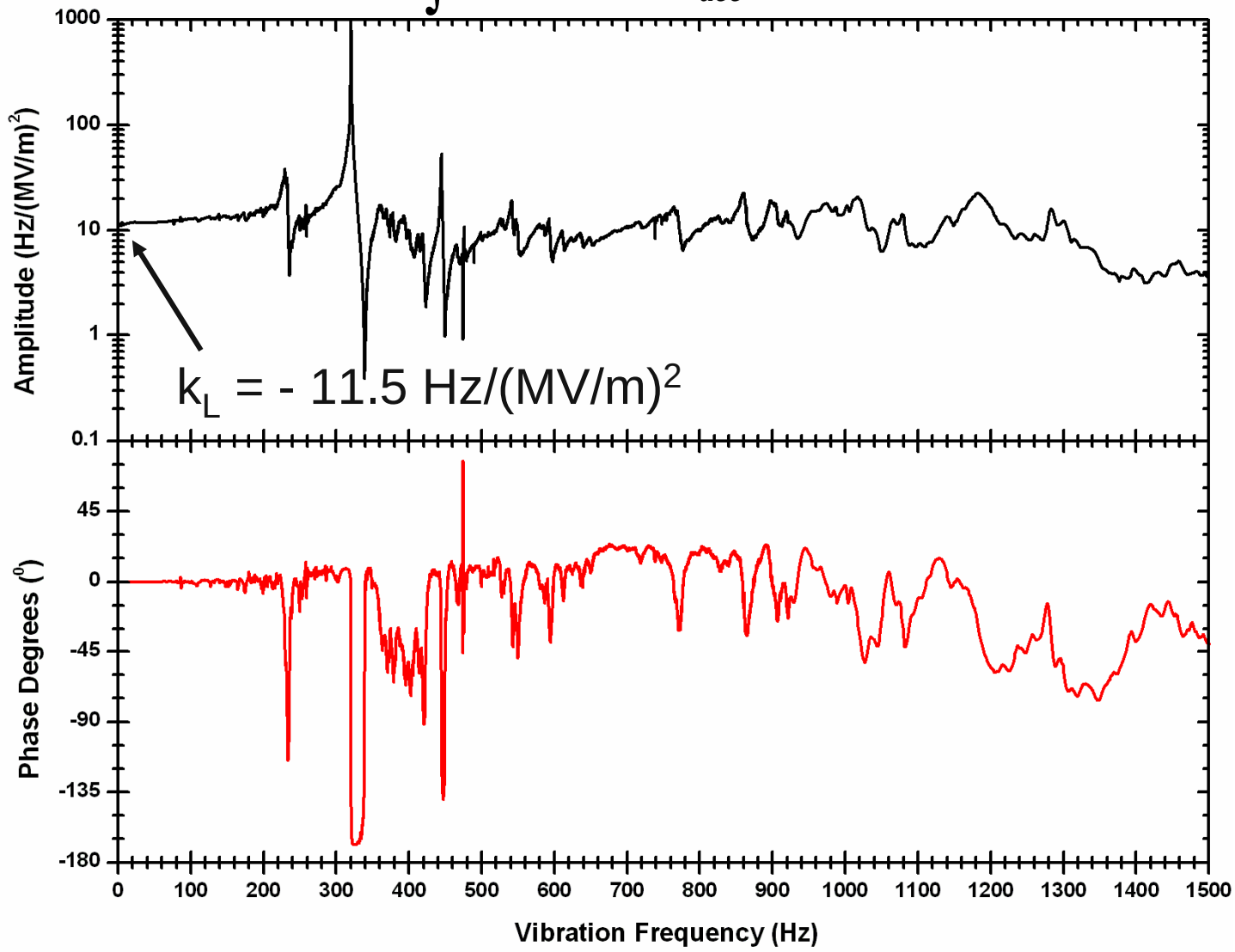
- **Reactive RF power required to control the cavity RF phase is given by [J.R. Delayen, Ph.D Thesis, Cal-Tech, 1978]:**

$$\delta\omega \cdot U$$

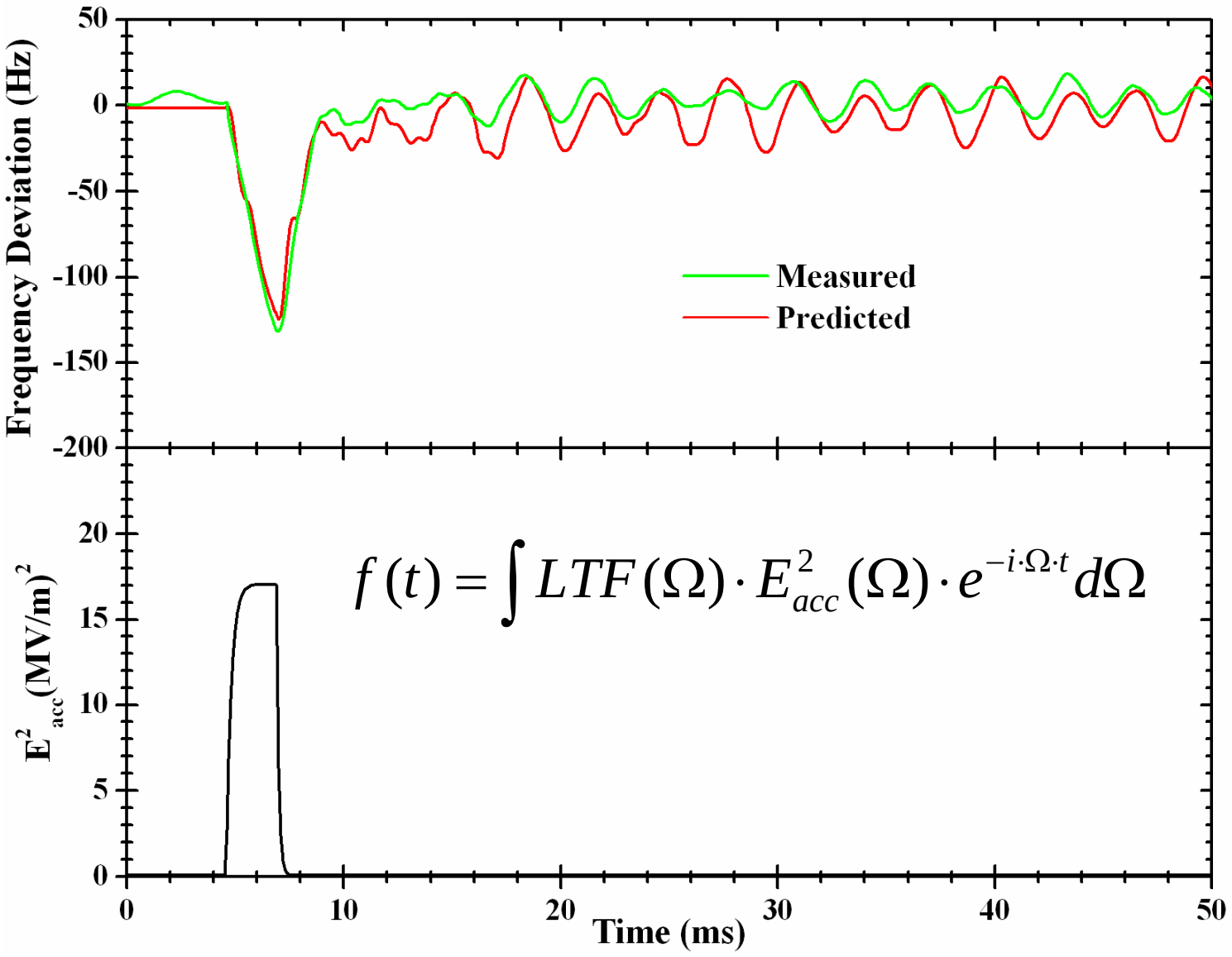
- **Mechanical Properties of Triple-Spoke-Loaded Cavities**
  - **Pulsed operation ↔ Lorentz detuning of a β = 0.5 triple-spoke-loaded cavity**
  - **Continuous-Wave operation ↔ Microphonic-noise of a β = 0.5 triple-spoke-loaded cavity**

ANL $\beta = 0.5$ Triple-Spoke Cavity Lorentz-Detuning

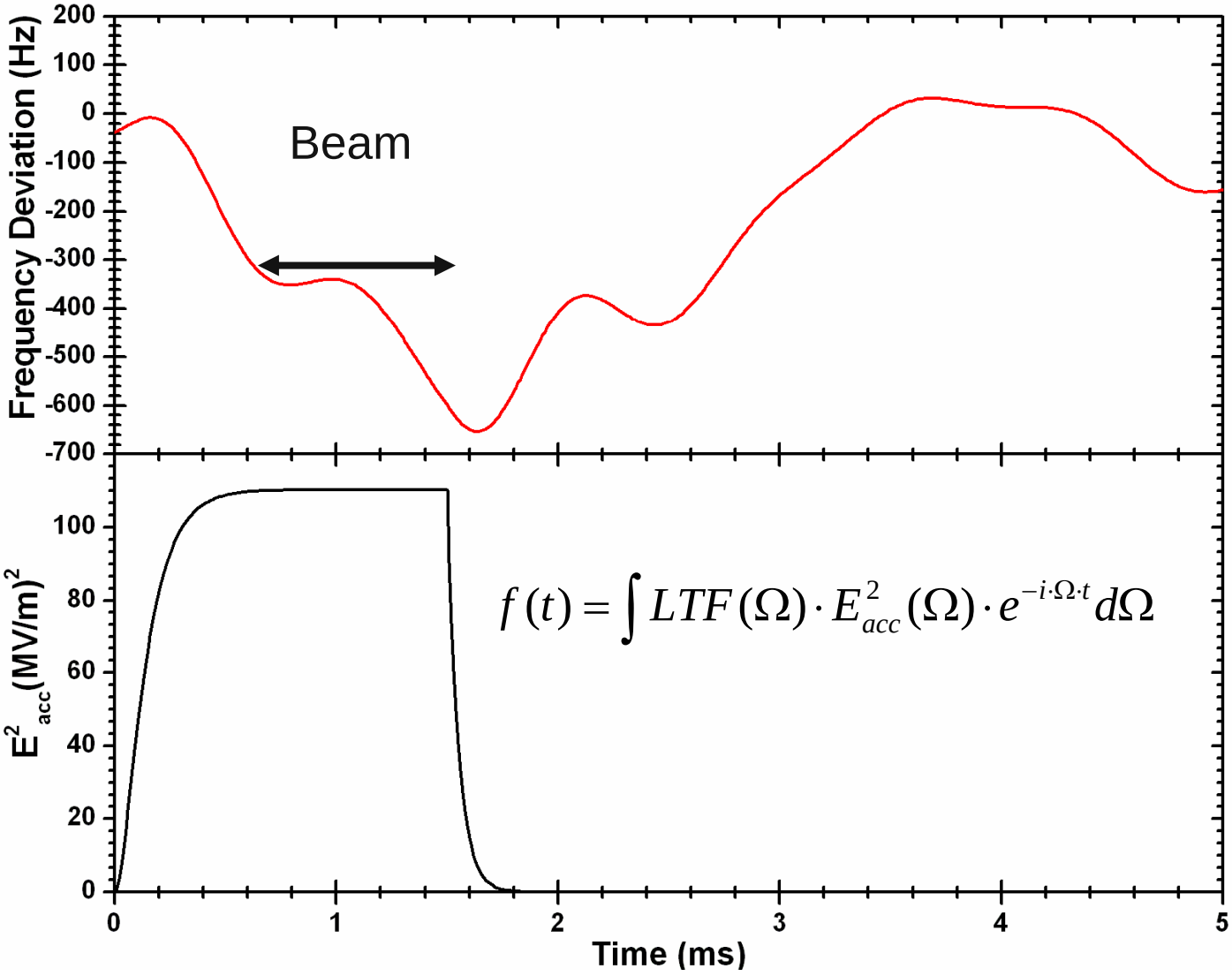
$$f(t) = \int LTF(\Omega) \cdot E_{acc}^{2}(\Omega) \cdot e^{-i \cdot \Omega \cdot t} d\Omega$$



ANL $\beta = 0.5$ Triple-Spoke Cavity Pulsed Response



ANL $\beta = 0.5$ Triple-Spoke Cavity Predicted Pulsed Response



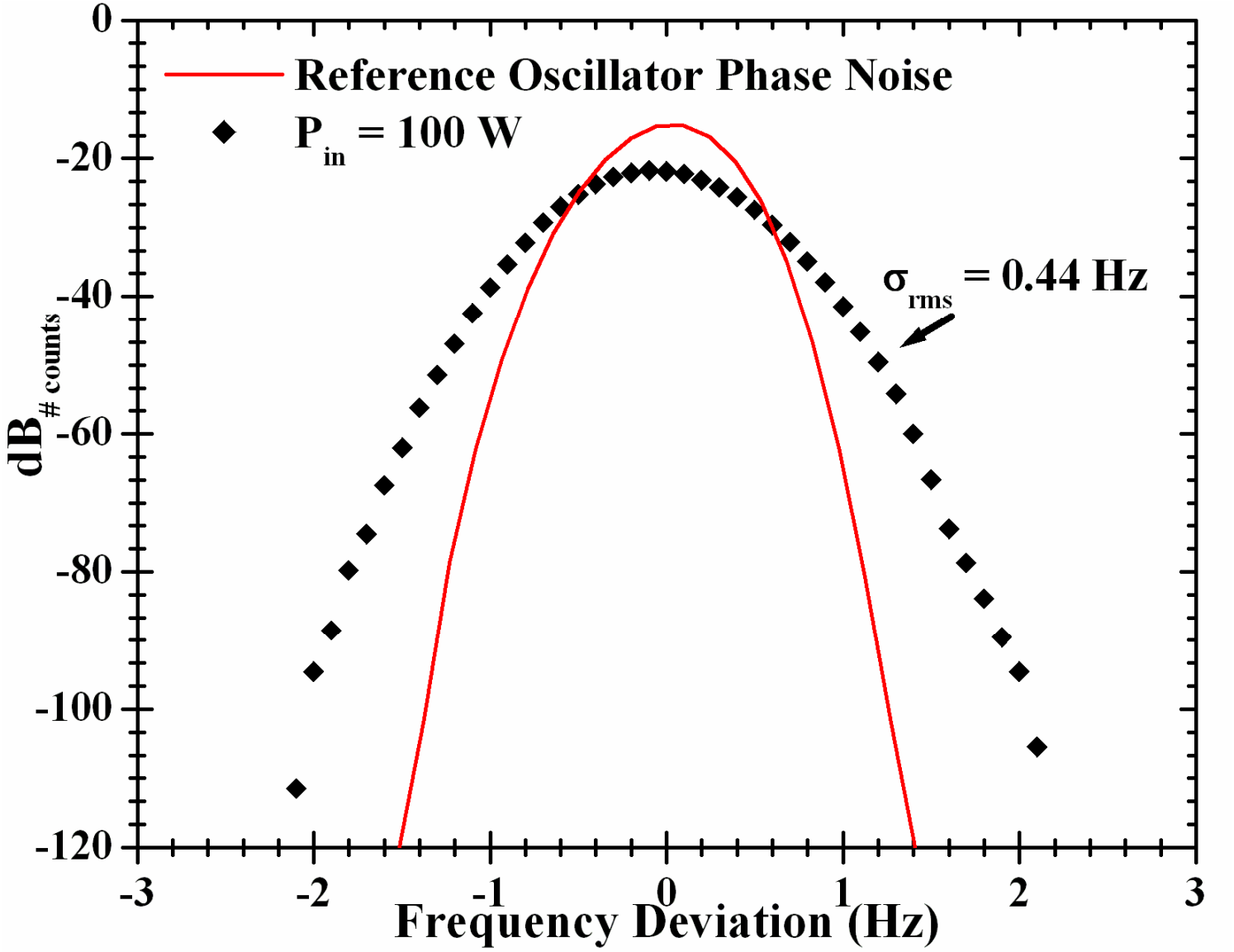
ANL $\beta = 0.5$ Triple-Spoke Cavity Lorentz Detuning

- **The Lorentz transfer function characterizes the Lorentz force driven interaction between a resonant cavity's electromagnetic field and mechanical eigenmodes.**
- **The Lorentz transfer function is a powerful tool for studying and analyzing Lorentz detuning in superconducting cavities.**
- **The Lorentz transfer function accurately characterized the pulsed response of the β = 0.5 triple-spoke-loaded cavity.**
- **The β = 0.5 triple-spoke-loaded cavity was optimized for continuous-wave operation.**
- **Mechanical changes can reduce Lorentz detuning [Apollinari et. al., IEEE Trans. Appl. Superconduct., vol. 17, no. 2, page 1322 (2007)].**

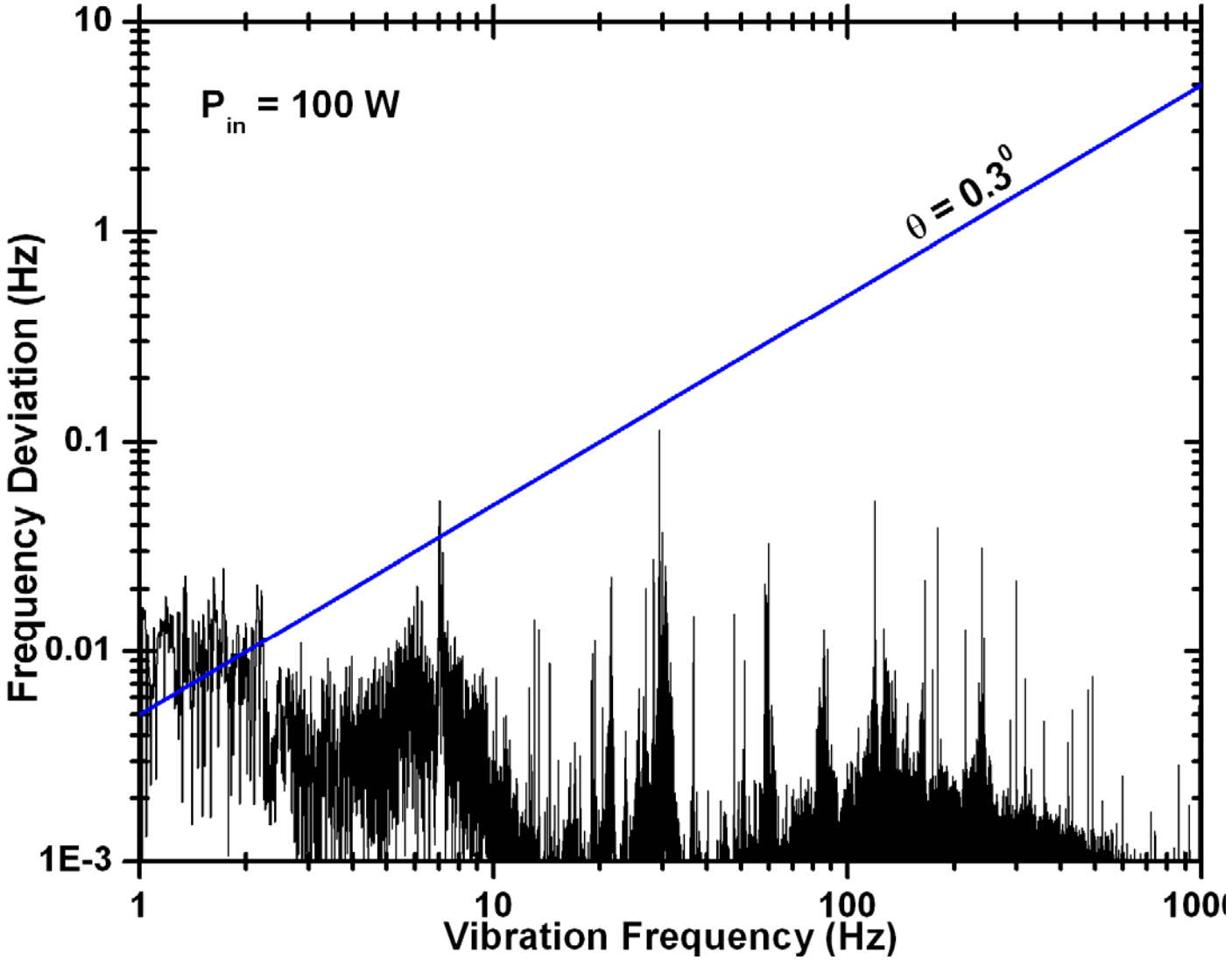
ANL $\beta = 0.5$ Triple-Spoke Cavity Microphonic-Noise

- **I am finished talking about Lorentz detuning.**
- **Now I am going to talk about microphonic-noise.**
- **Microphonic-noise for superconducting spoke-loaded cavities is mainly low-frequency non-resonant noise, 4 K liquid helium bath boiling.**

ANL $\beta = 0.5$ Triple-Spoke Cavity Microphonic Noise



ANL $\beta = 0.5$ Triple-Spoke Cavity Microphonic Noise



Conclusions

- **The bandwidth of microphonic-noise for superconducting spoke-loaded cavities is very small.**

- **The rms RF frequency deviation of the $\beta = 0.5$ triple-spoke-loaded cavity is 0.44 Hz and barely above the reference oscillator phase-noise.**

- **Mechanical fast tuners have been developed to damp the remaining microphonic-noise. See poster WEP67 and Michael Kelly's talk(WE302; today 11:20-11:40AM).**