Vibration Measurement

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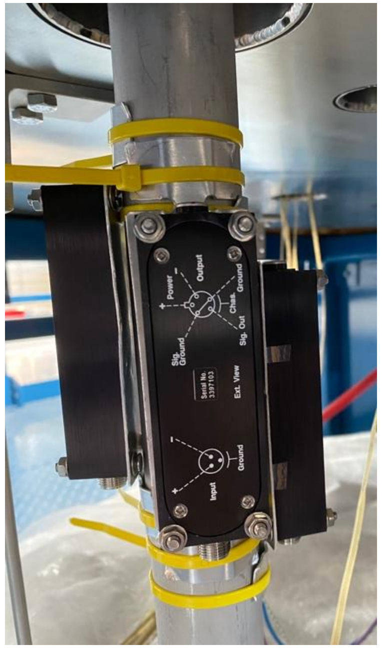
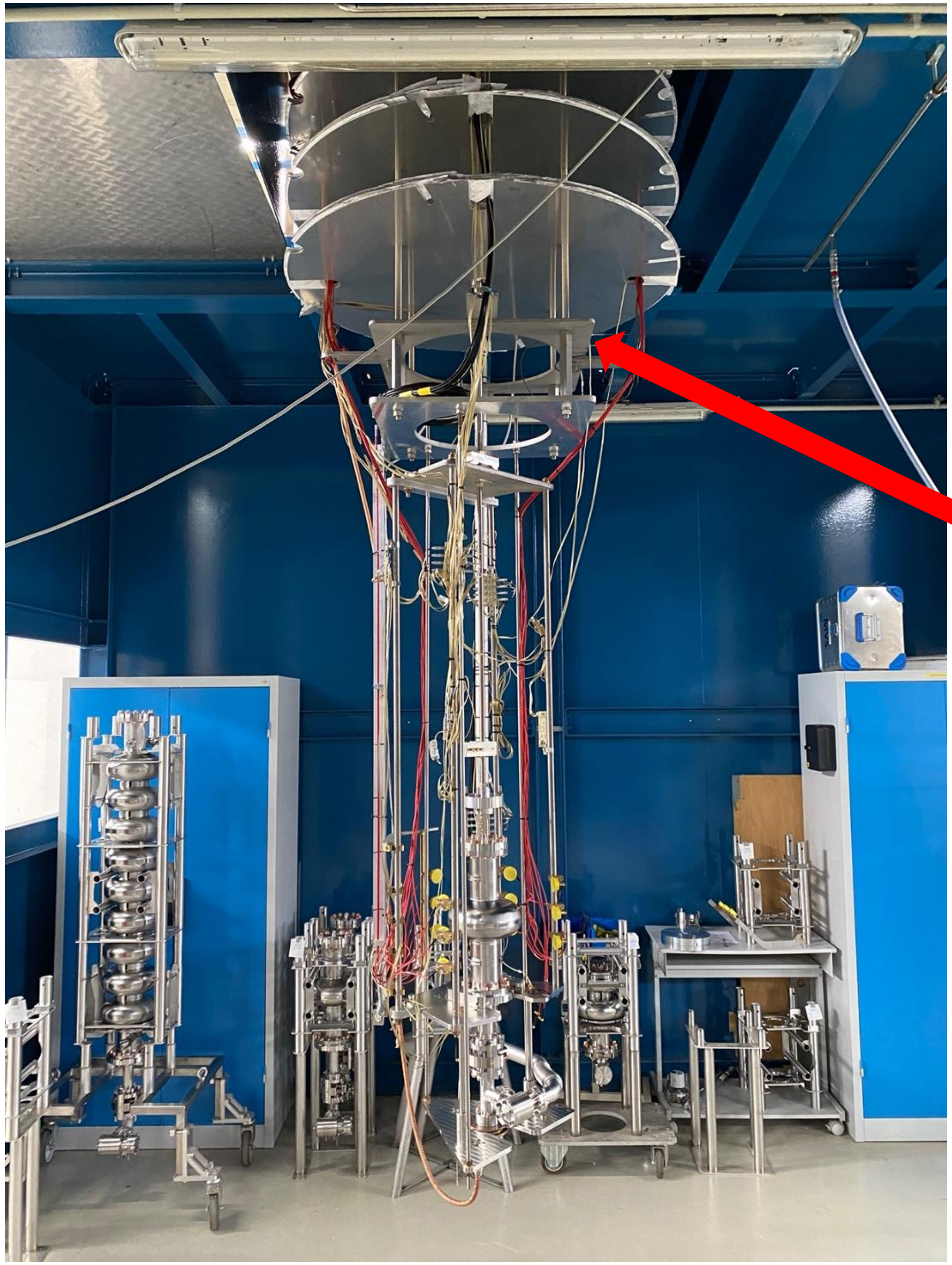
Setup

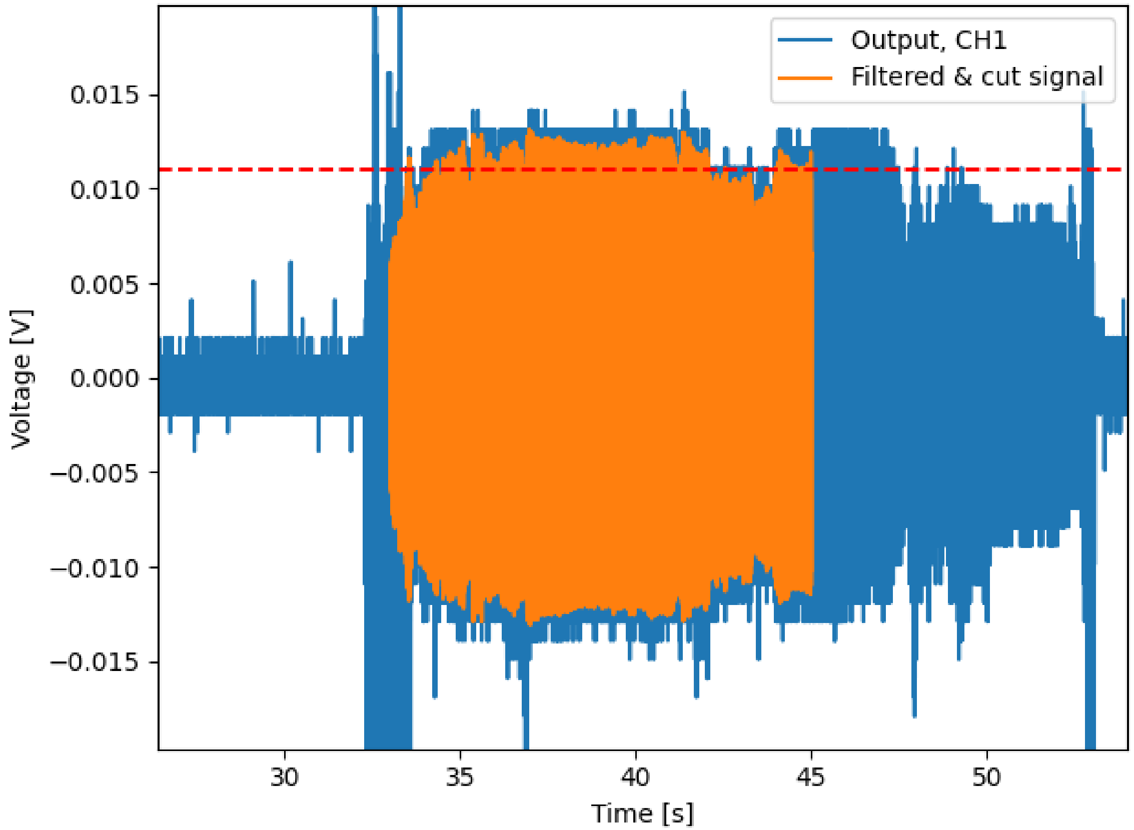
3 x (Accelerometers + Amplifier) → Readout

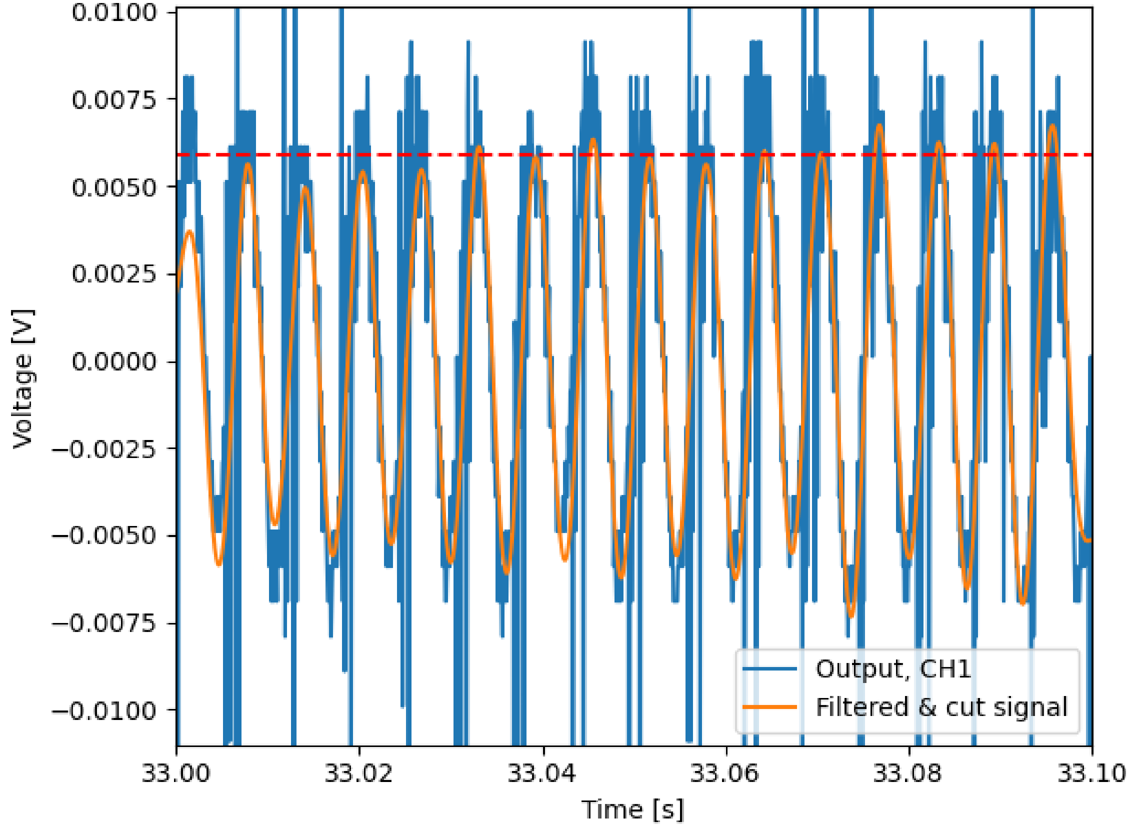




Sensors at 26 K for cavity at 2K
(Producer specifies > 77 K)

Calibration





shaker acc. amp.

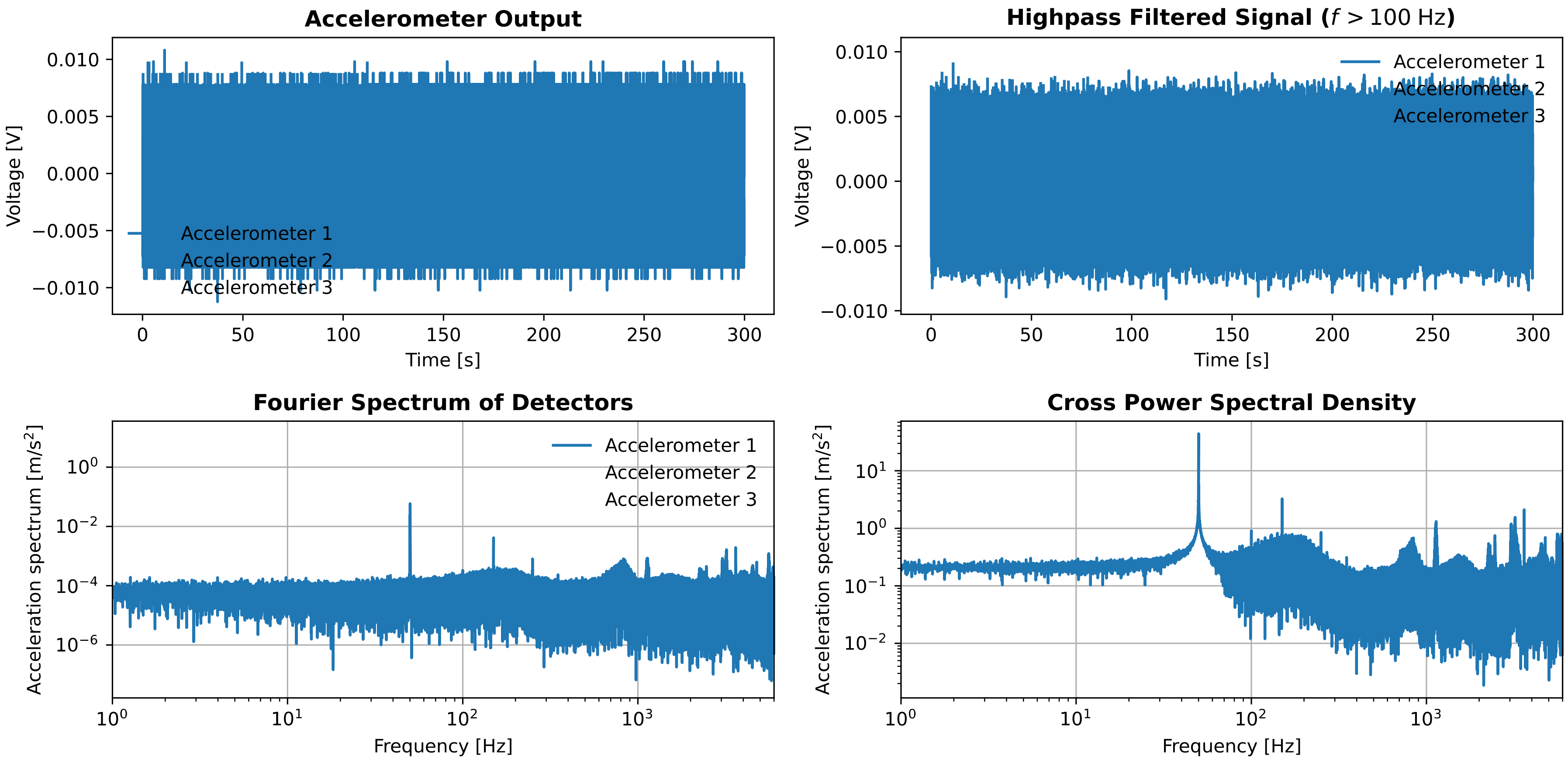
Expect: $U_{out} = 10\ m/s^2 \cdot \frac{1pC}{m/s^2} \cdot \frac{10\ mV}{pC} = 0.1\ \text{V}$

Find: $U_{out} \approx 0.01\ \text{V}$

i.e. $a = 100 \frac{m}{s^2} \cdot \frac{U_{out}}{V} \Rightarrow q_{rms} = \frac{1}{(2\pi f)^2} \cdot 100 \frac{m}{s^2} \cdot \frac{U_{out}}{V}$ (nominal)

i.e. $a = 1000 \frac{m}{s^2} \cdot \frac{U_{out}}{V}$ (calibrated)

Spectrum at 2K (Sensors still work)



Inferred average displacement

$$q^2_{rms\,(full)} = \lim_{T\to\infty} \frac{1}{T} \int dt |q_T(t)|^2 = \int df\, S_q(f) \qquad q^2_{rms\,(BW)} \approx \frac{f_m}{Q_m} S_q(f_m)$$

with $S_q(f) = \int d\tau \left\langle R_{ij}(\tau)\right\rangle_{i\neq j} e^{-i2\pi f\tau}, \quad i,j = 1,2,3$

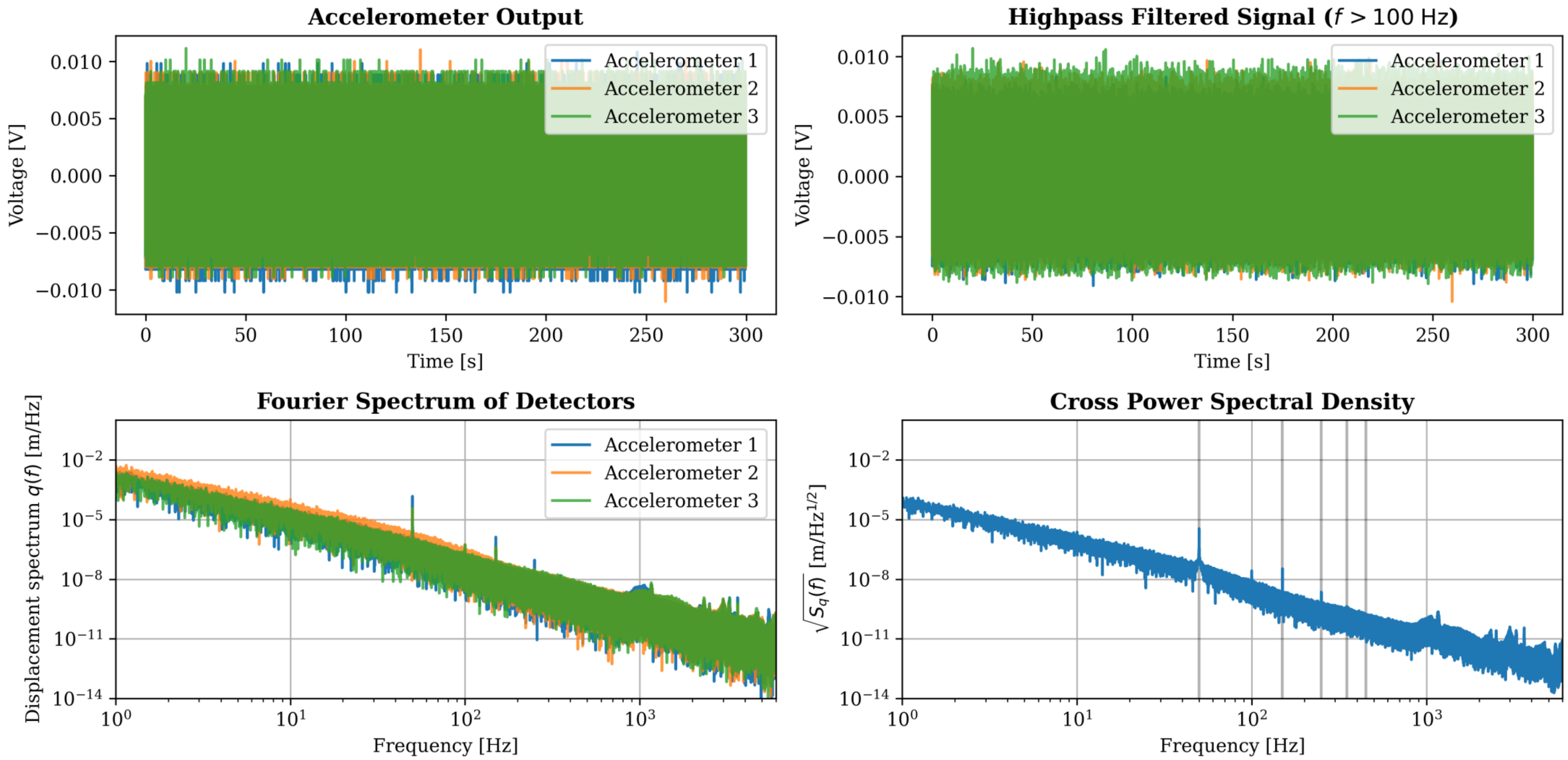
and $R_{ij}(\tau) = \lim_{T\to\infty} \frac{1}{T} \int dt\, q_i(t-\tau)\, q_j(t)^*$

Note that $S_q(f_c) \propto T$ for coherent signals at f_c. However, q_{rms} does not depend on T.

E.g. for a constant background $S_q(f) = S_q(f_0)$ and a mechanical bandwidth $\Delta\omega_m = 10^{-2}\, \frac{\omega_m\,/10^4\mathrm{Hz}}{Q_m/10^6}$ we find $q_{rms} = 10^{-10}\mathrm{m}\ \frac{S_q(f_0)^{1/2}}{10^{-9}\mathrm{m\ Hz}^{-1/2}} \cdot \frac{\Delta\omega_m^{1/2}}{10^{-1}\mathrm{Hz}^{1/2}}$

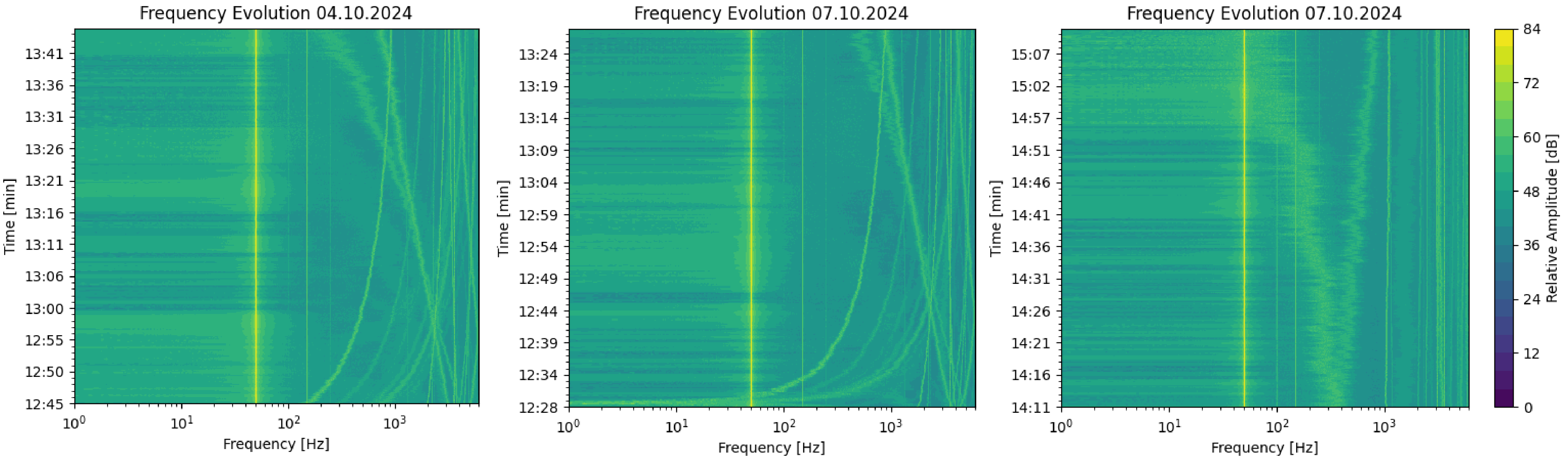
Inferred average displacement

(Cavity@2K, During Testing, nominal sensitivity)



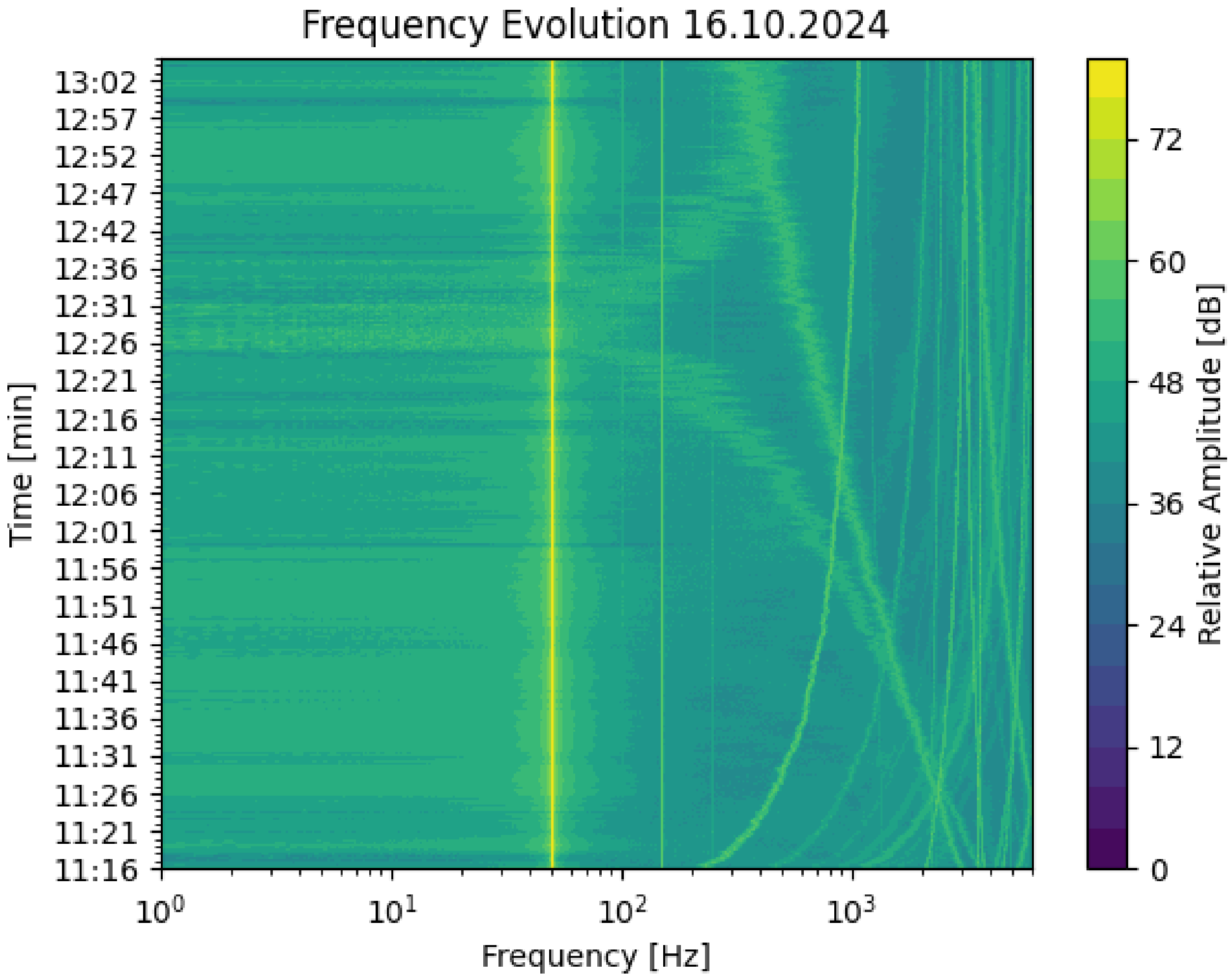
$q_{rms\,(BW)} \approx 10^{-1}\sqrt{\frac{f_m/10^3}{Q_m/10^5}S_q(f_m)} \approx 0.6 \cdot 10^{-10}$ (calibrated sensitivity) → Similar values for other datasets

Measurement at 4K (cavity resting)

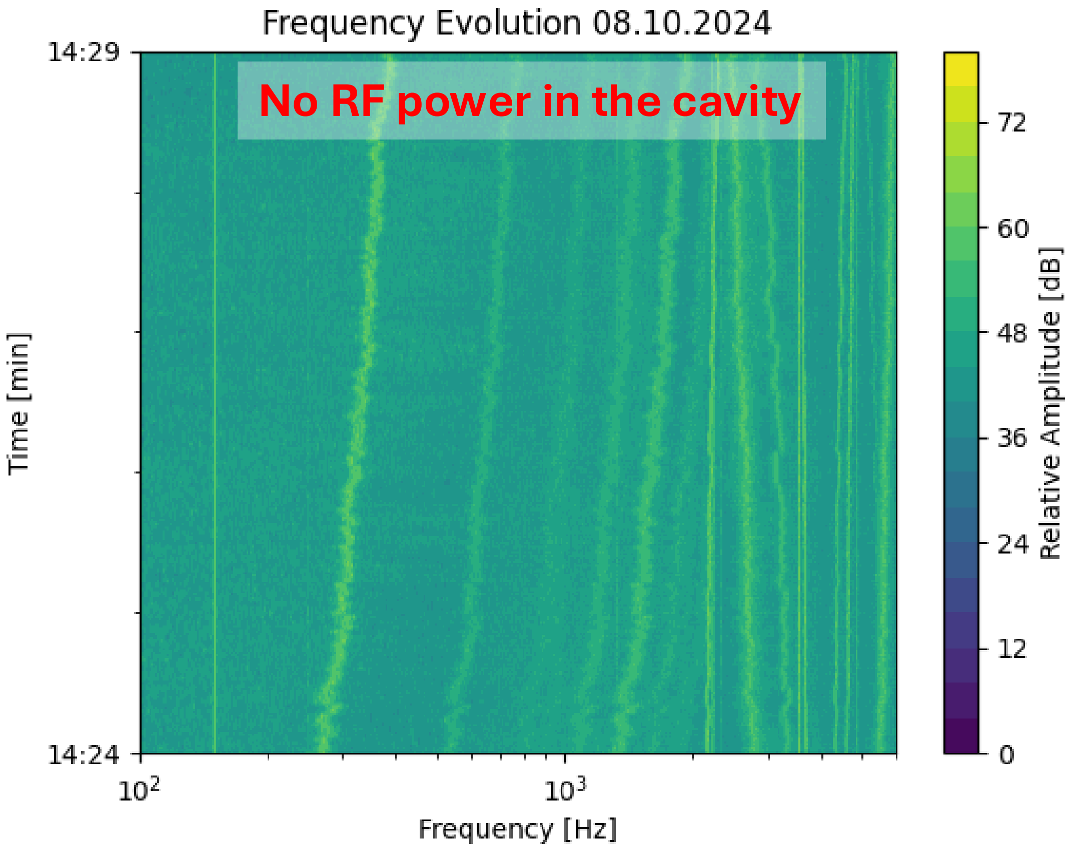


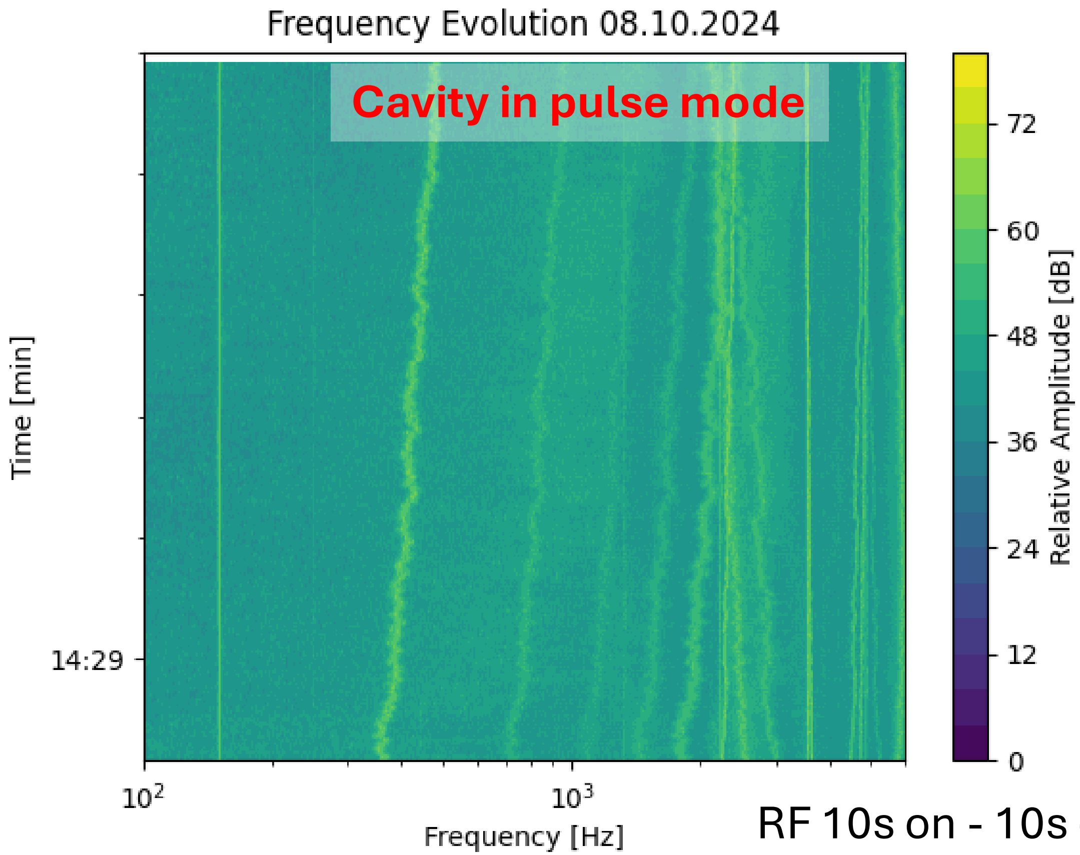
Noise sources seem to chirp

Same Measurement, slightly longer



Measurement at 2K during testing



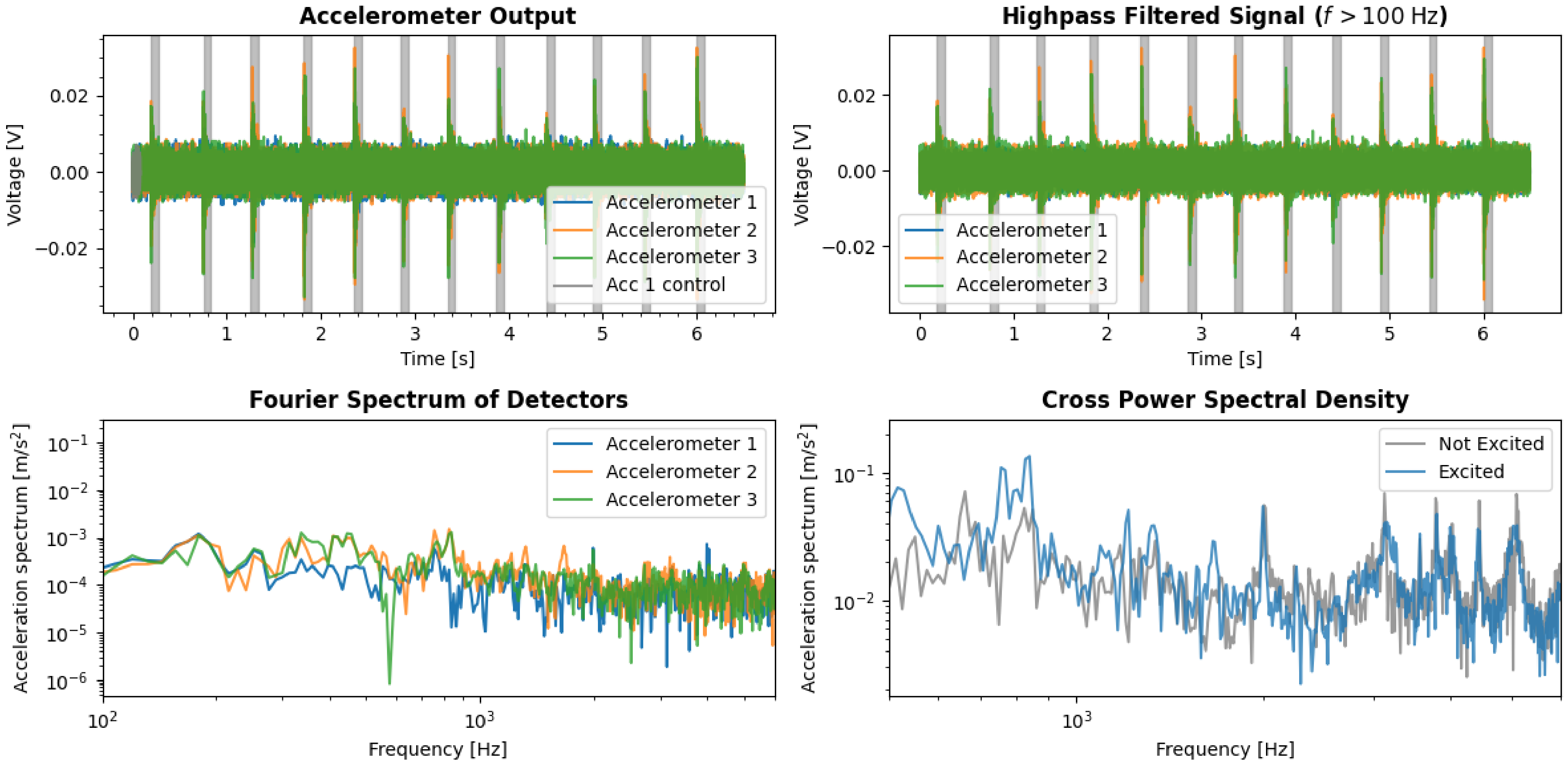


RF 10s on - 10s off

RF power does not affect vibrations **at** the measurement point

Excitation of Insert Modes (With Hammer)

Idea:
- Hammer is broadband → excites mainly resonances
- Machinery/Pumps could drive strong vibrations off-resonance



⇒ Small differences, but dominant peaks are still the same

⇒ The machinery appears to cause mostly broadband vibrations