

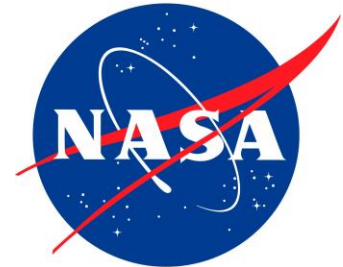
The Lunar Explorer Instrument for space biology Applications (LEIA) pre-flight tests: Mechanical Considerations

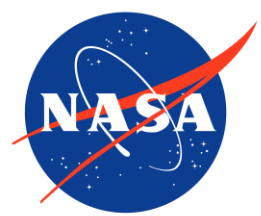
Chinmayee Govinda Raj, Lauren C. Liddell, Earl T. Daley, Kris Vogelsong, Matthew McKay, Diana M. Gentry, Jessica A. Lee, A. Mark Settles, Sergio R. Santa Maria

NASA Ames Research Center, CA

Session: Microbes 2

Date: Dec 6, 2024 Time: 2:00 - 3:30 PM

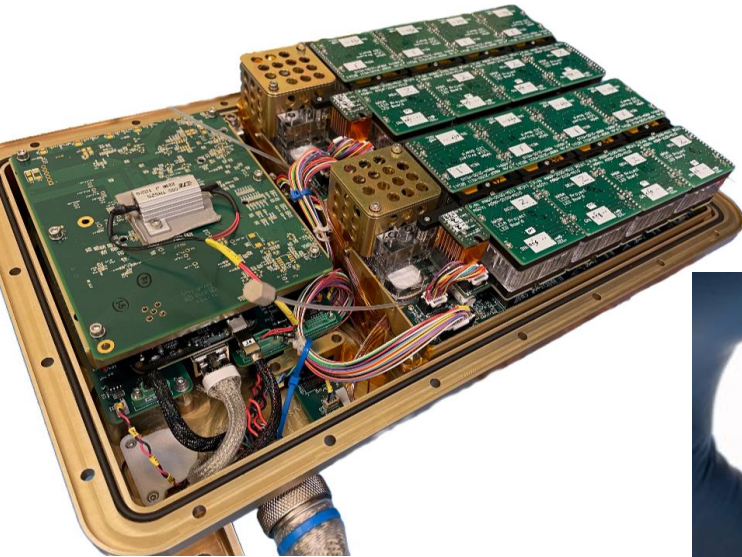




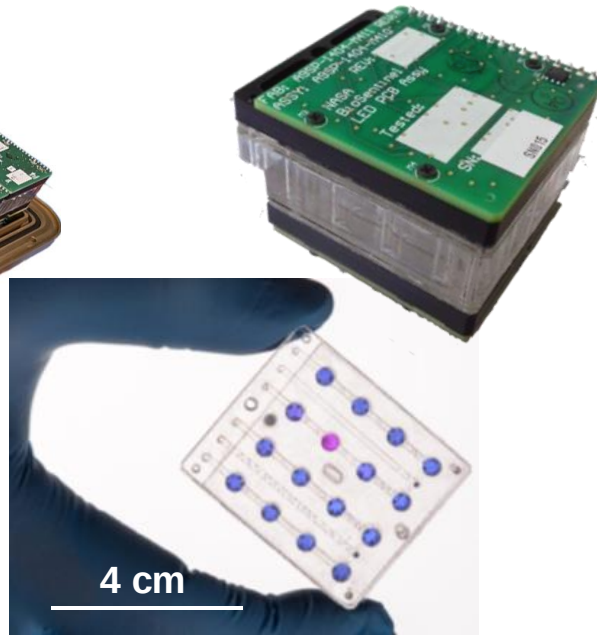
BioSensor monitors cell growth in microfluidic culture wells



BioSensor Prototype

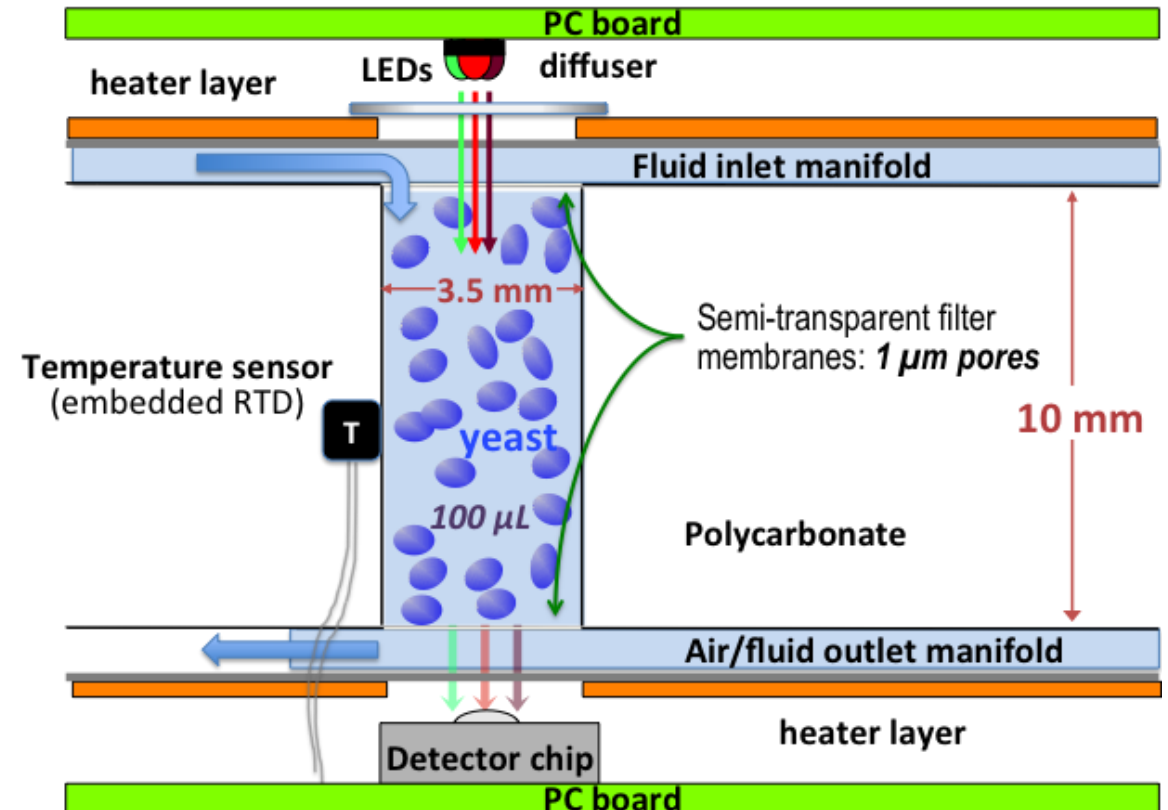


Microfluidic Card

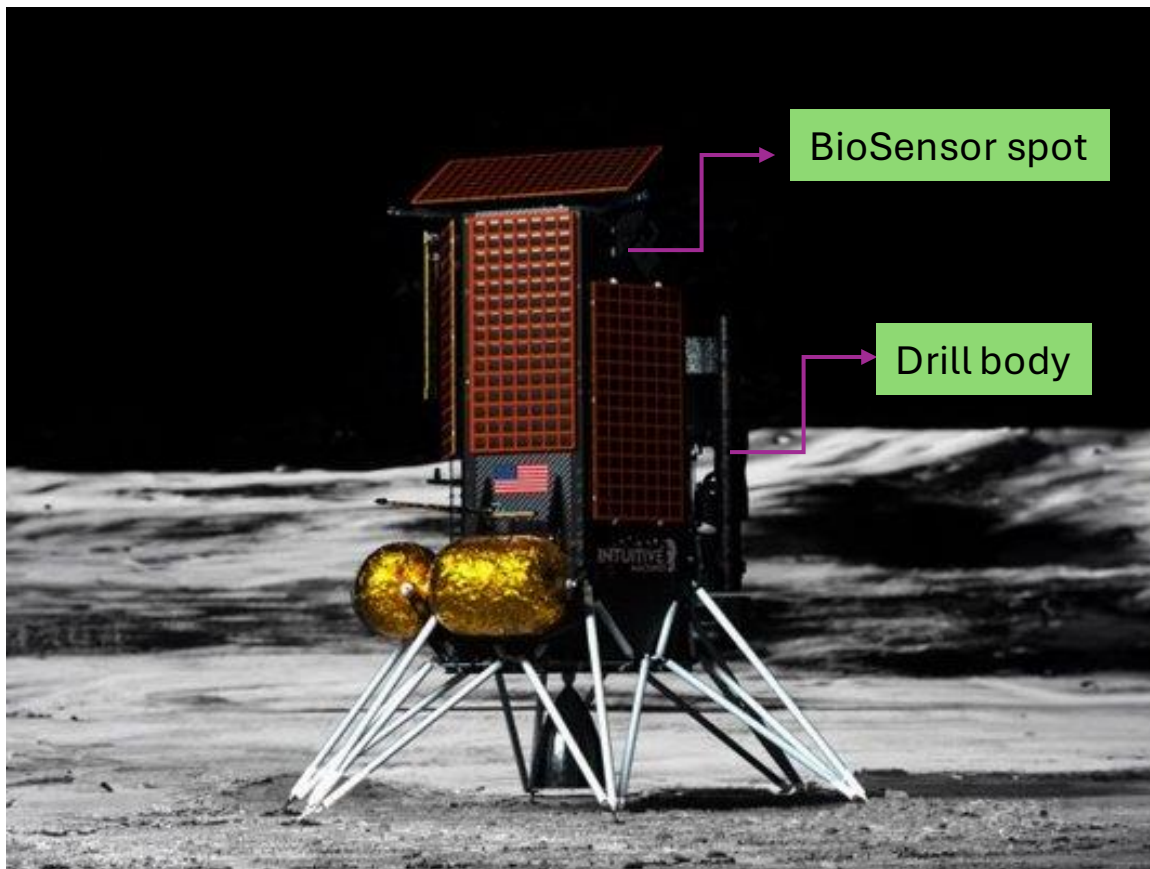


- BioSensor contains 16 microfluidic cards
- Pumps and valves control medium addition through 2 separate manifolds
- Each card has 16 culture wells (256 wells total)
- Autonomous rehydration on the Moon
- Optical absorbance measurements at four wavelengths -- Red, Blue, Green, and IR

Individual Cell Culture Well



Potential BioSensor Mounting Spot



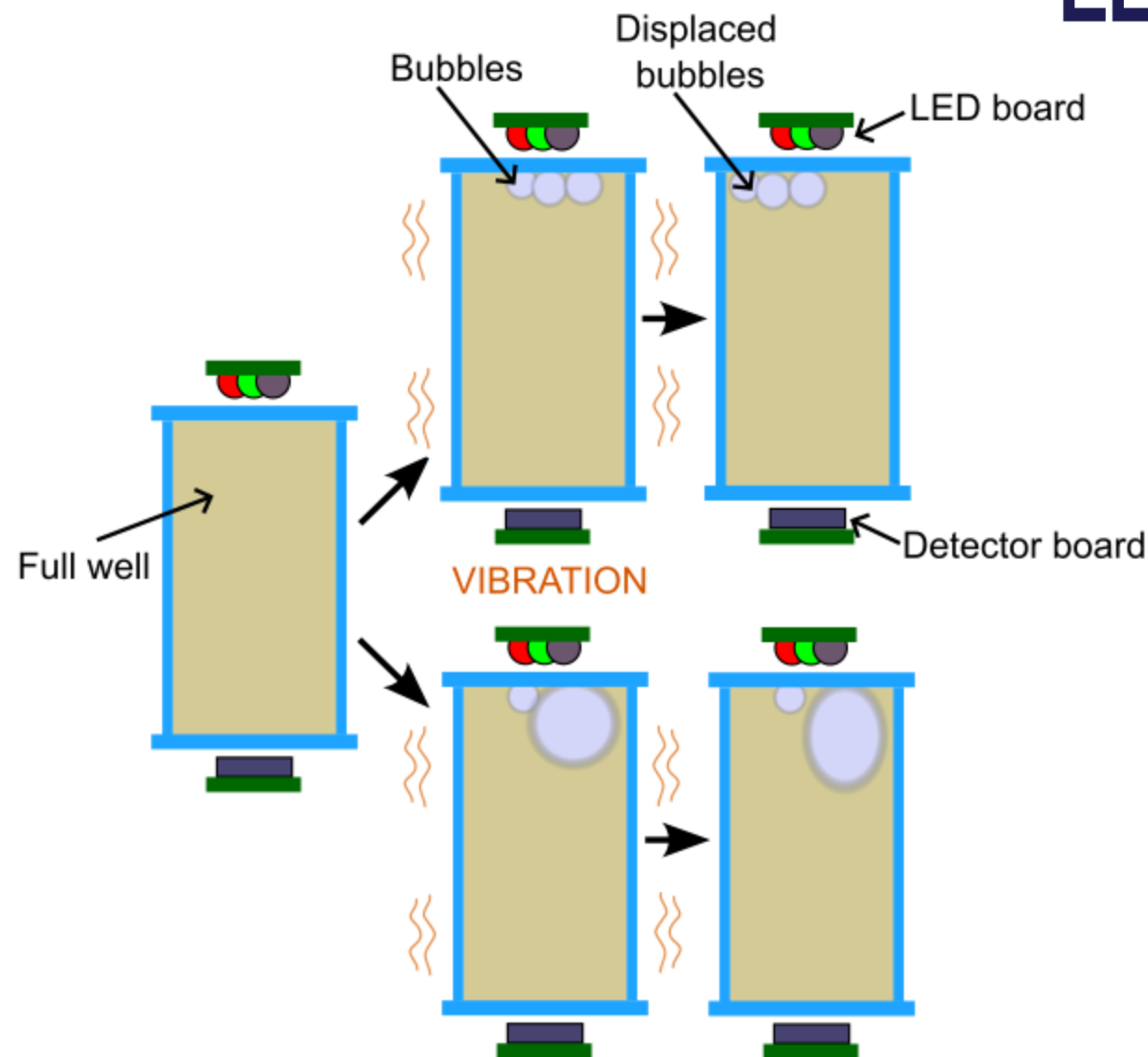
- LEIA's BioSensor and PROSPECT's ProSEED drill co-located on the lander

(BioSensor location notional only.)

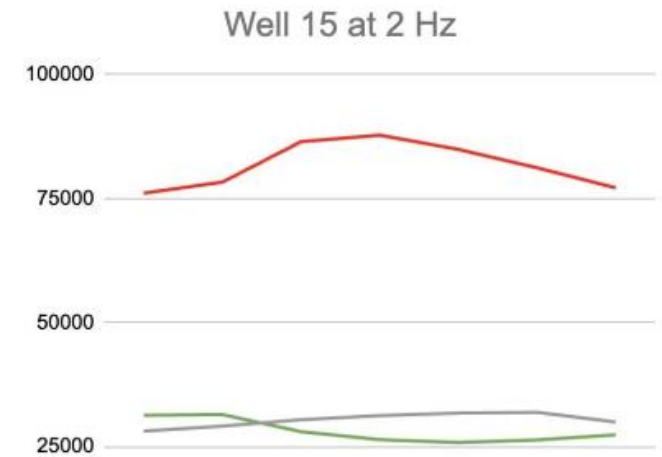
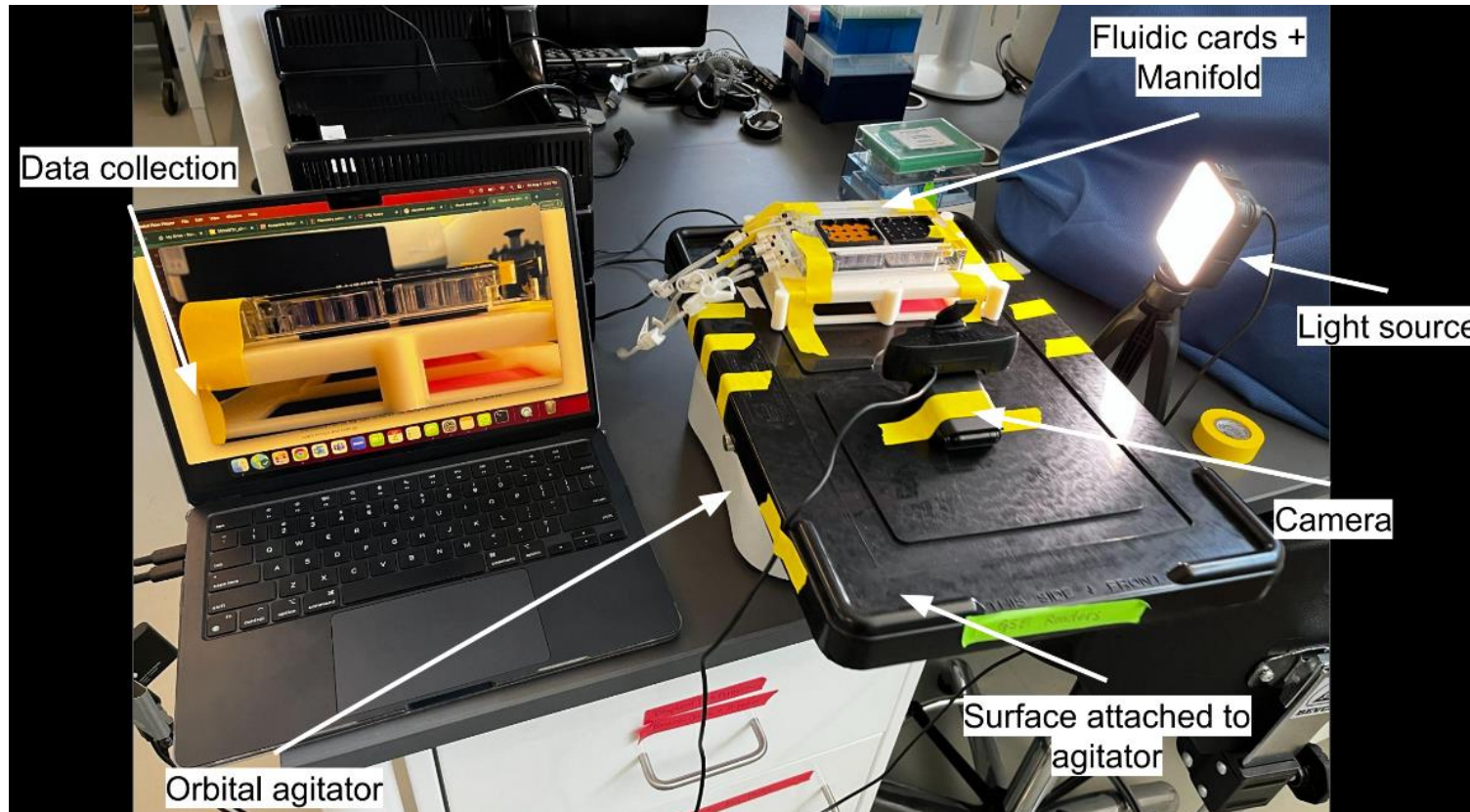
Image credit: Intuitive Machines

Optical Measurement Considerations

- Absorbance measurements noise and artifacts due to bubble formation during well rehydration and yeast growth.
- Significant data anomalies by vibrations from PROSPECT's ProSEED drill
- Anticipated drill ON duration: ## hrs
- Number of drilling cycles: ##

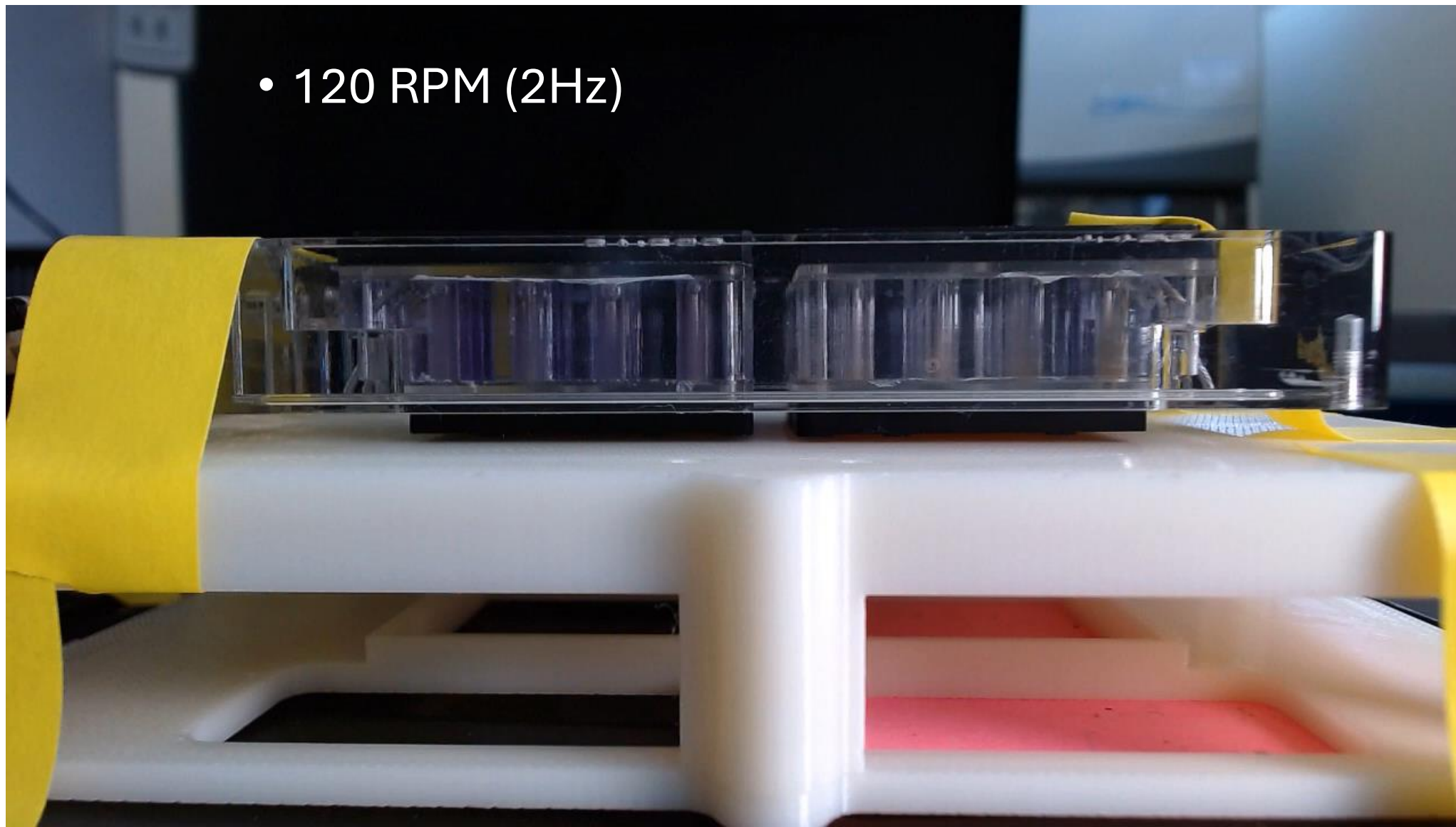


Preliminary Vibration Testing



Preliminary Vibration Testing

- 120 RPM (2Hz)

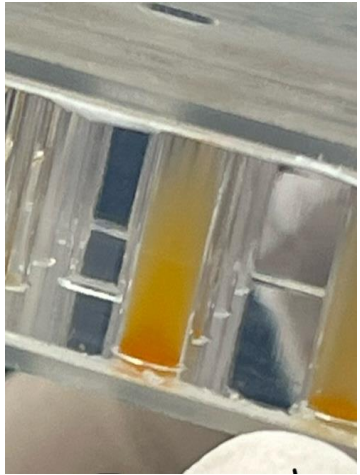


Test Methodology

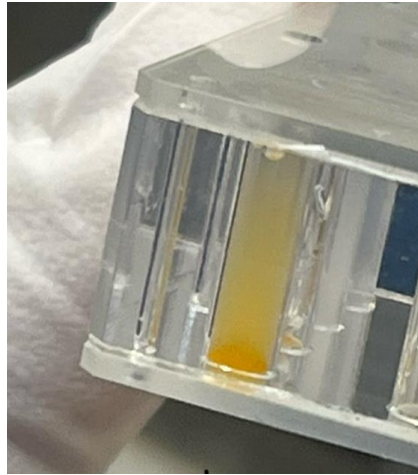
- Sine sweep signals -> drill vibration
- Axes: x, y and z
- Frequency: 5 - 2560 Hz
- g-load: 0.25 and 0.5
- Accelerometer for localized vibration measurement

Accelerometer

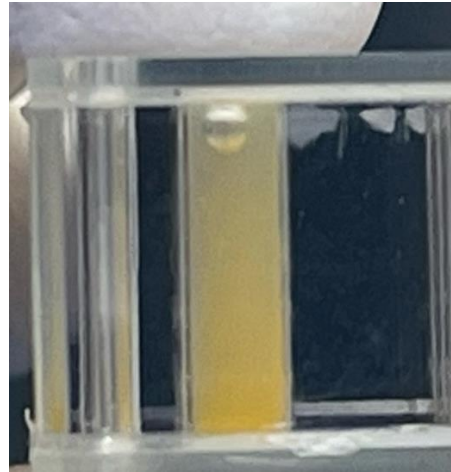
2x Fluidic cards sandwiched between emitter board (top) and detector board (bottom, not shown)



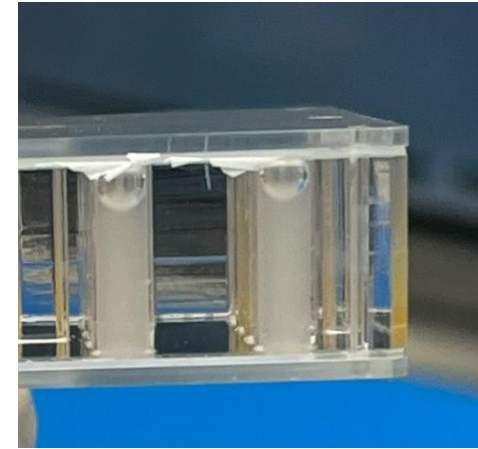
1. Fully filled



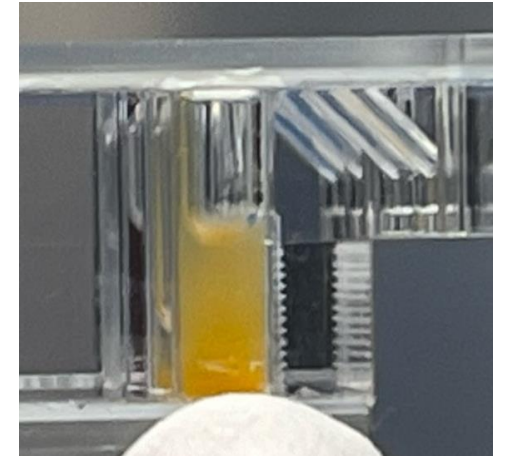
2. Small bubble



3. Medium bubble



4. Large bubble



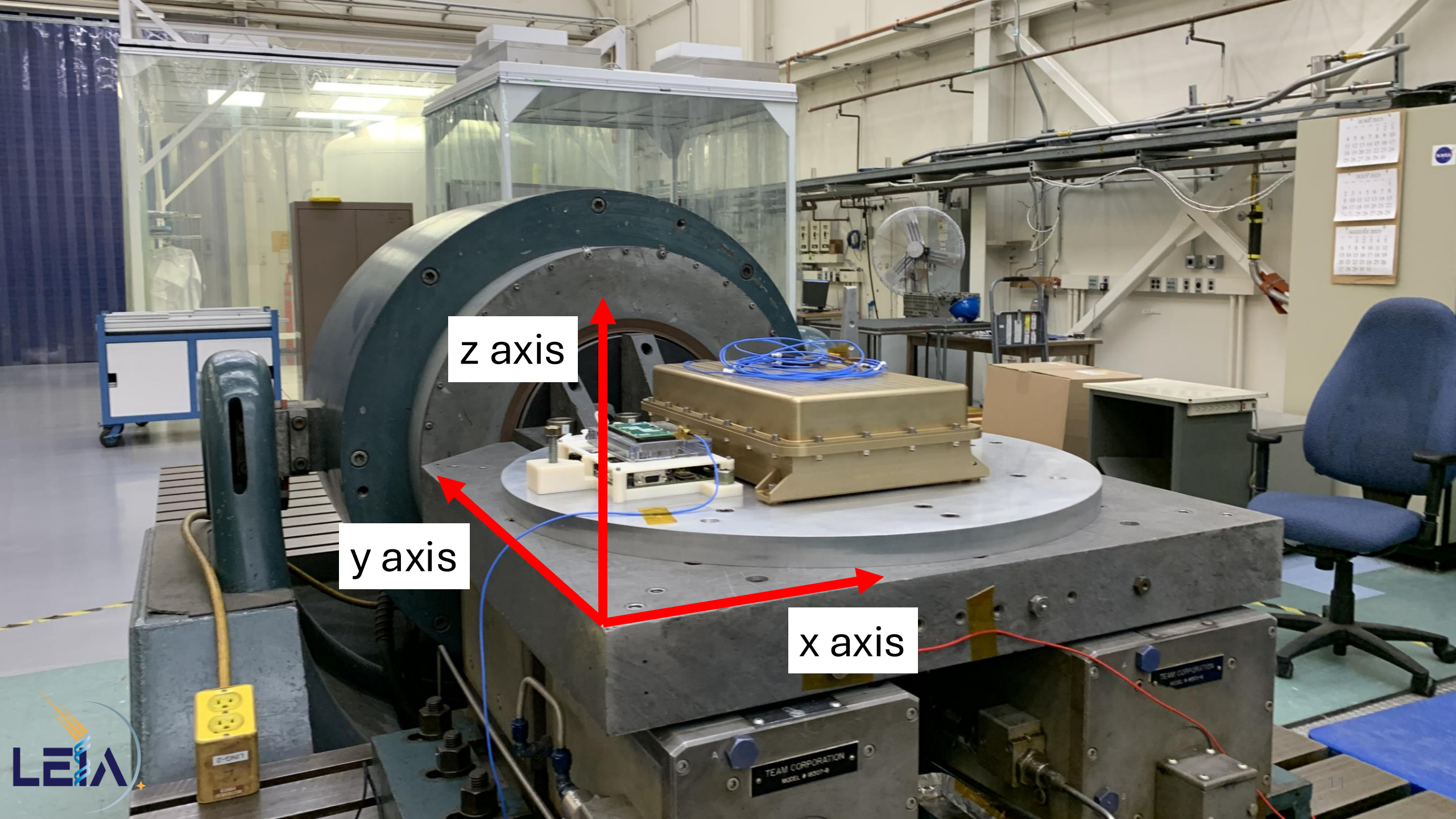
5. Partial fill

Fluidic Wells with Five Most Likely Fill Conditions

- Entire unit placed inside a dark bag to avoid stray light pollution







z axis

y axis

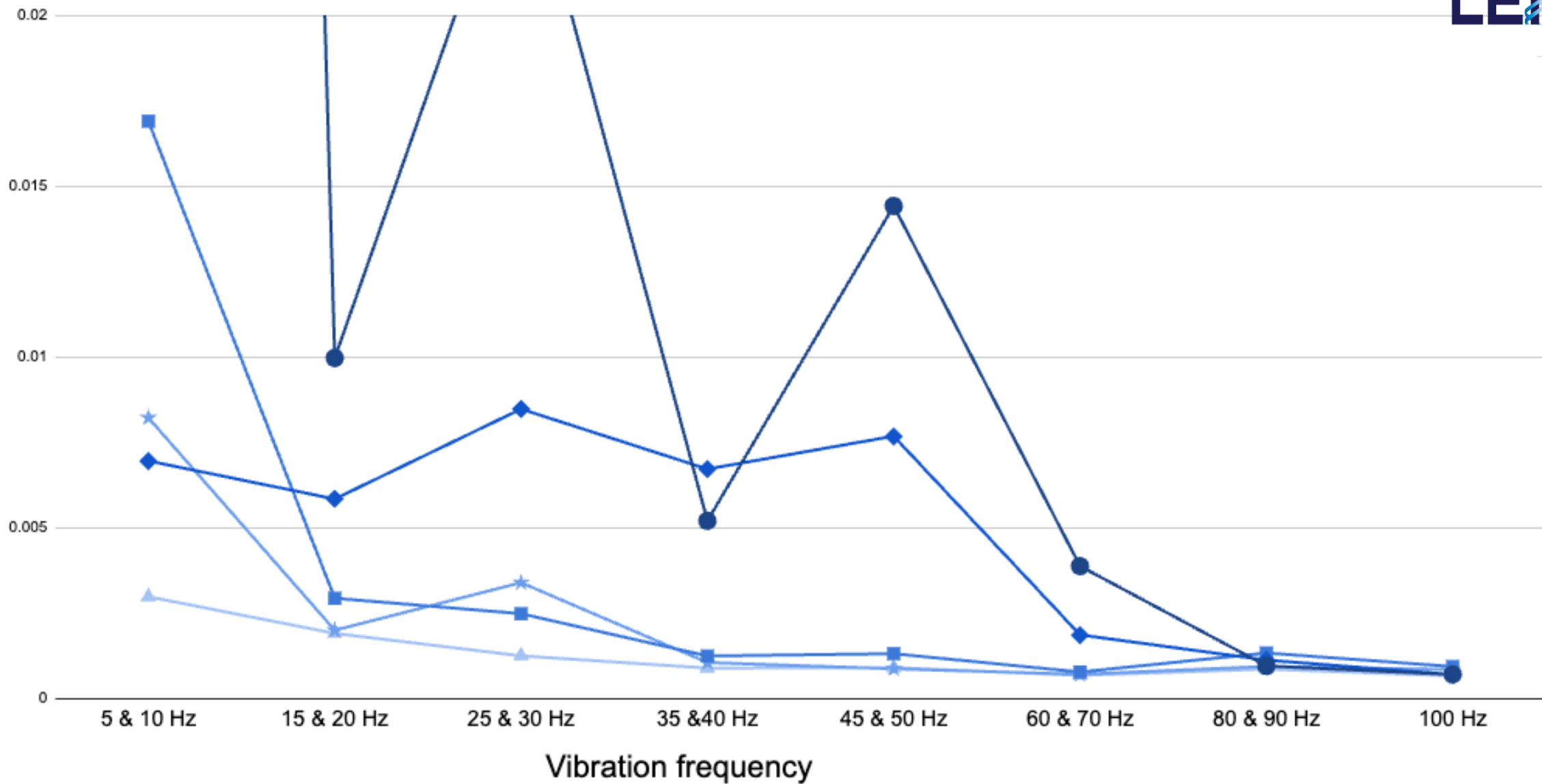
x axis

- Orientation change for z-axis vibration



Absorbance standard deviation

x-axis vibration

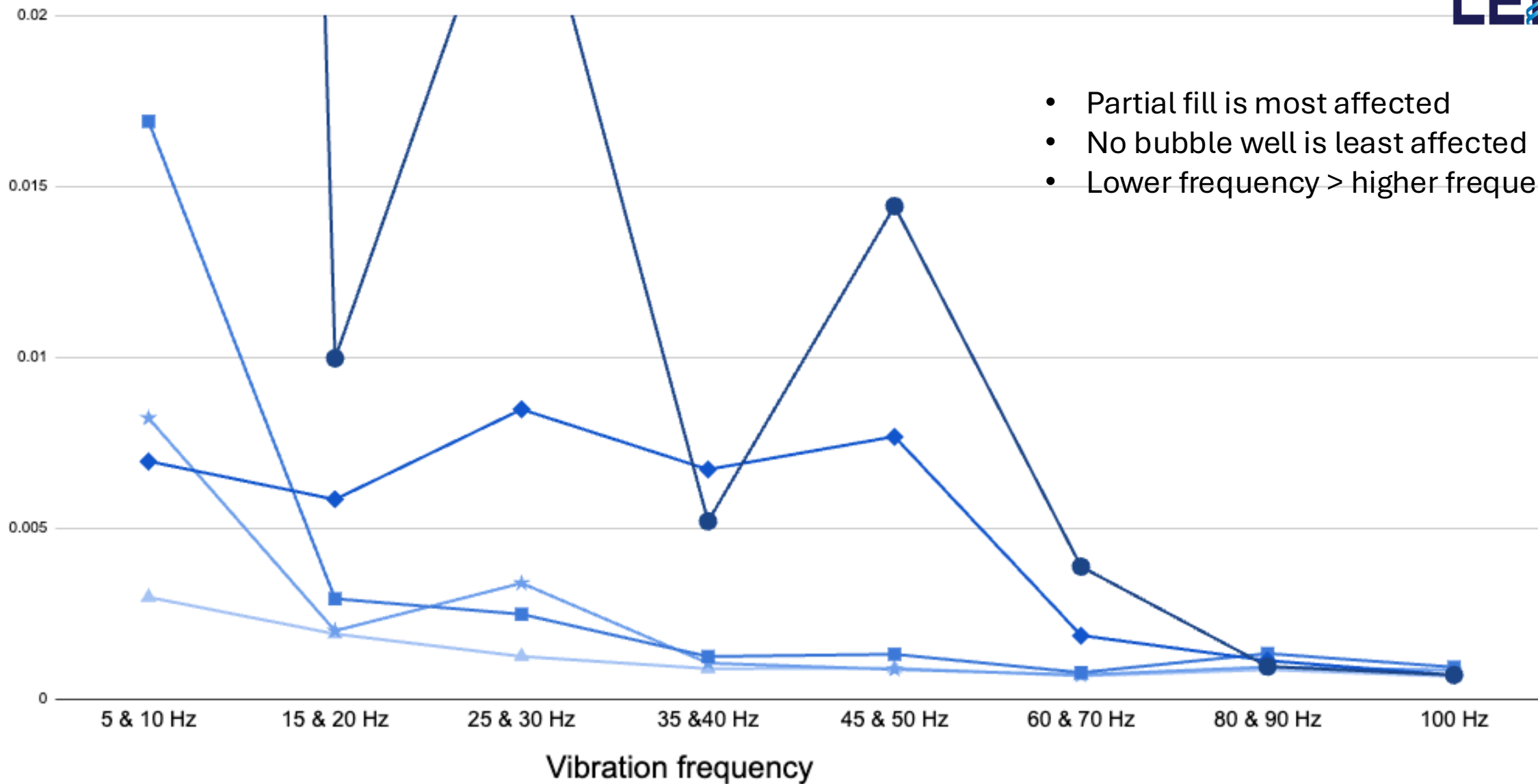


▲ No bubble ★ Small Bubble ■ Medium bubble ◆ Large bubble ● Partial fill

Absorbance standard deviation

x-axis vibration

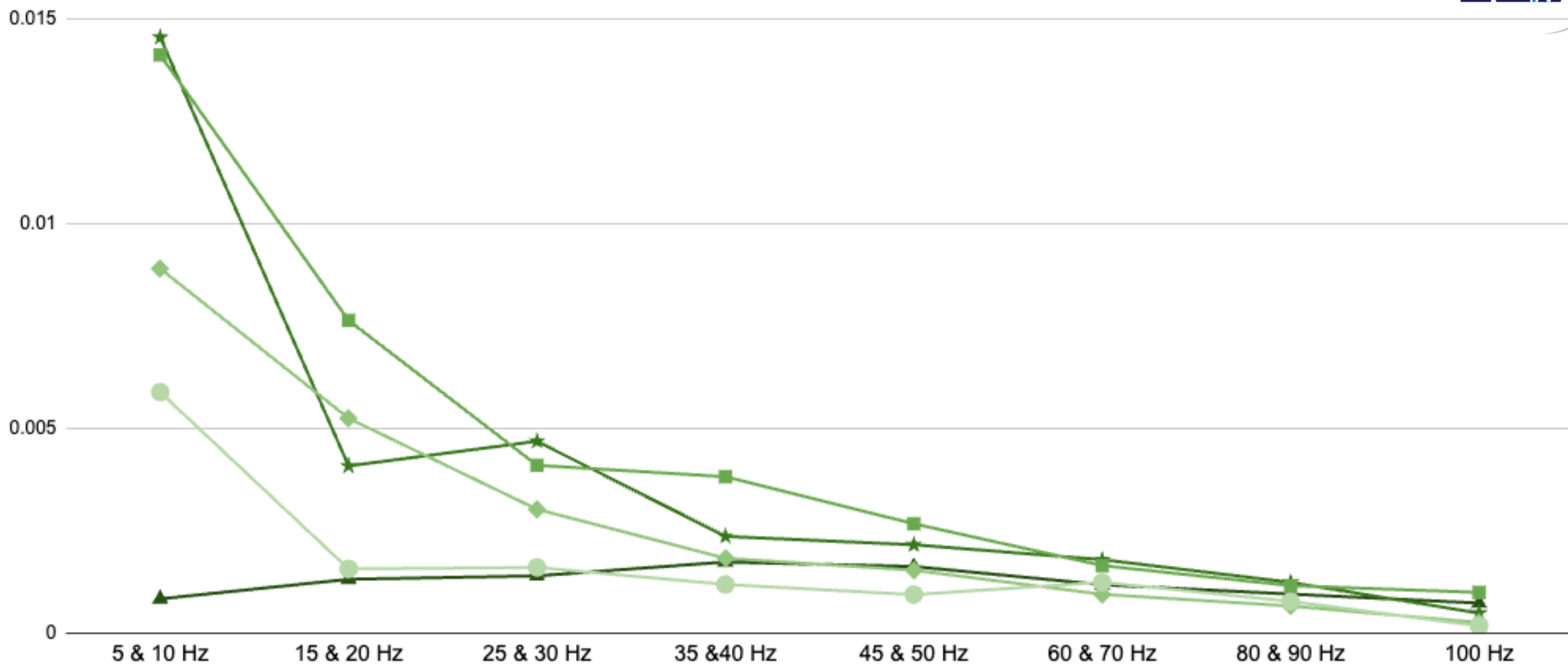
- Partial fill is most affected
- No bubble well is least affected
- Lower frequency > higher frequency



▲ No bubble ★ Small Bubble ■ Medium bubble ◆ Large bubble ● Partial fill

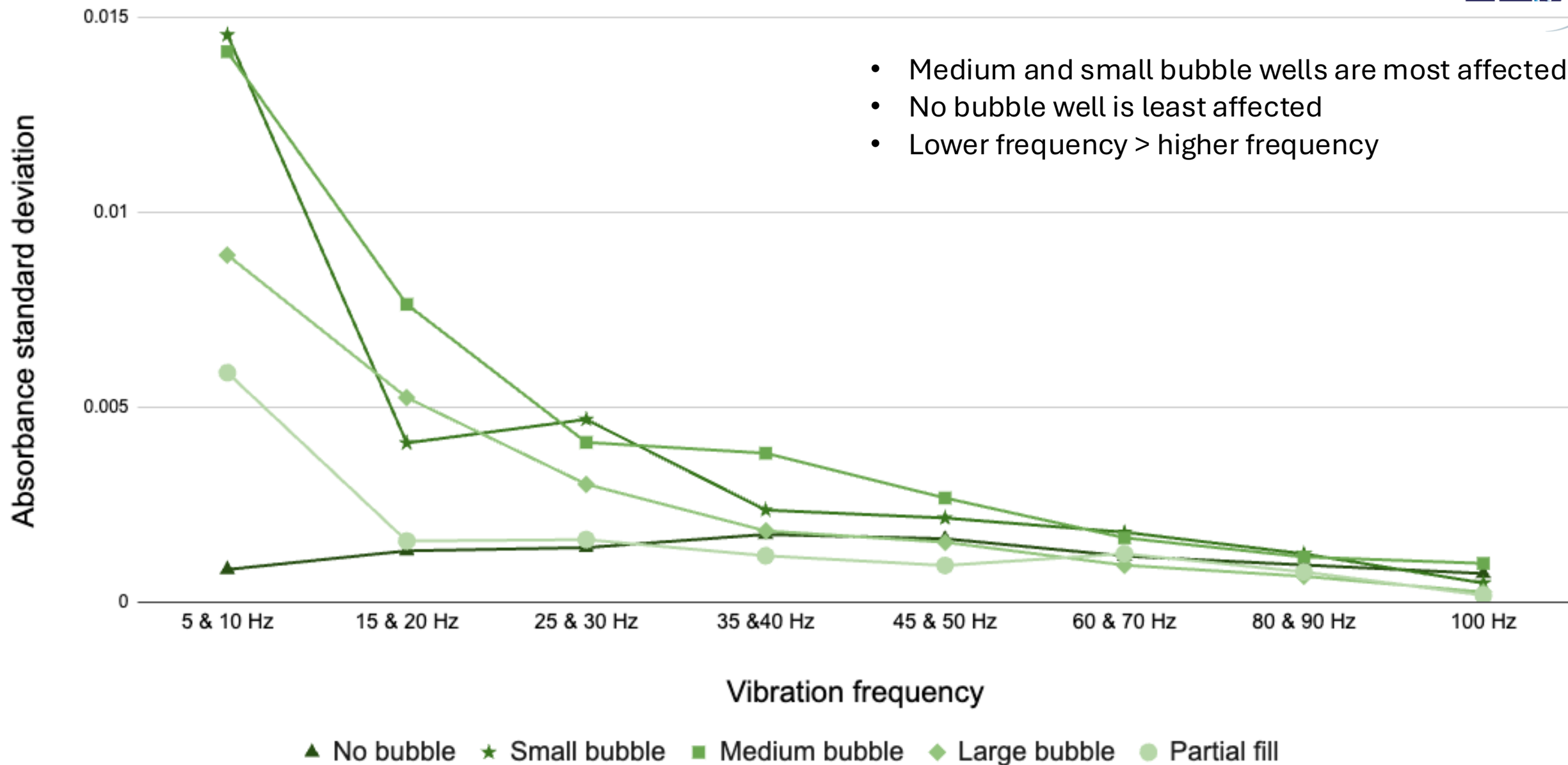
y-axis vibration

Absorbance standard deviation

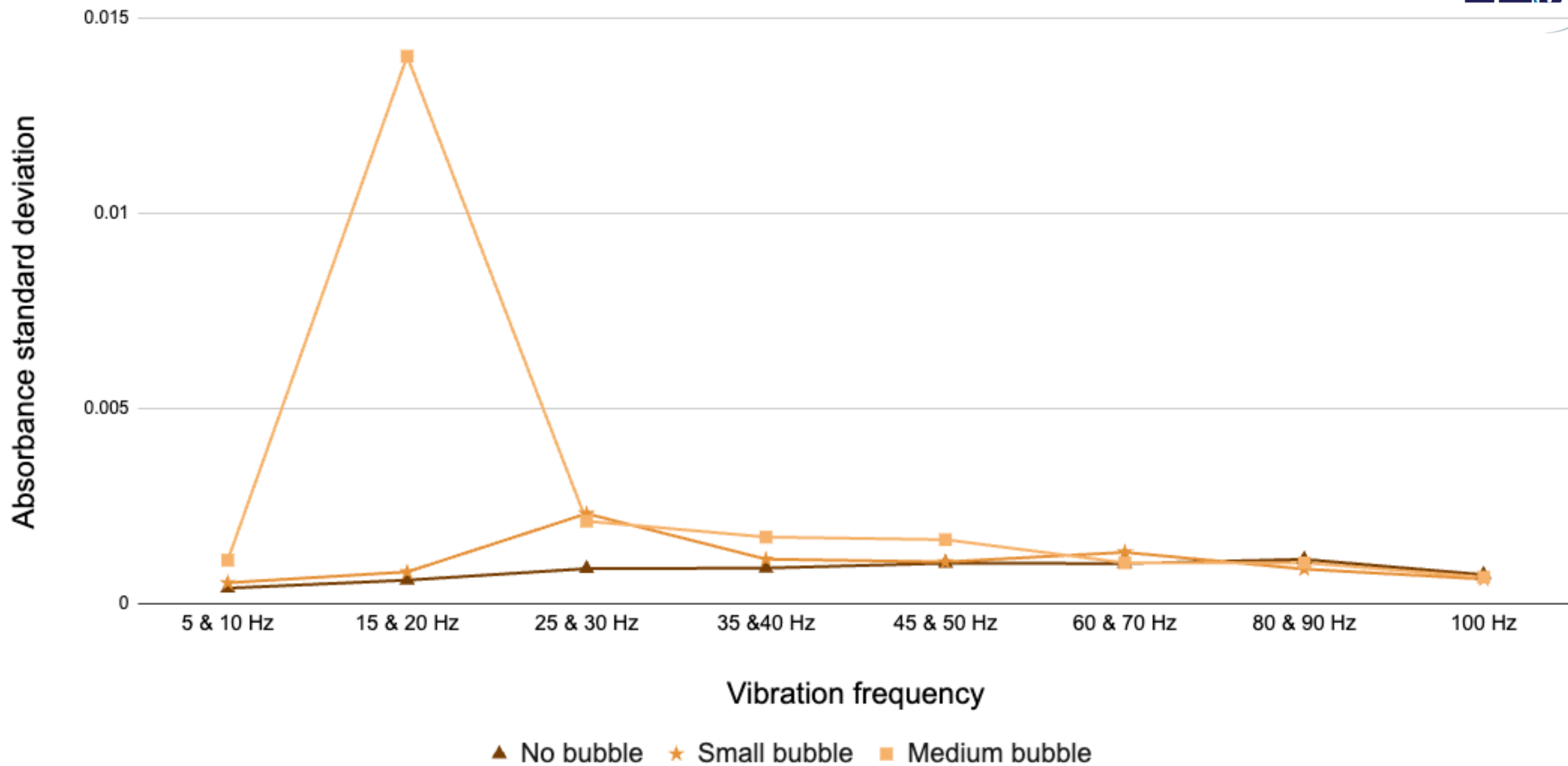


▲ No bubble ★ Small bubble ■ Medium bubble ◆ Large bubble ● Partial fill

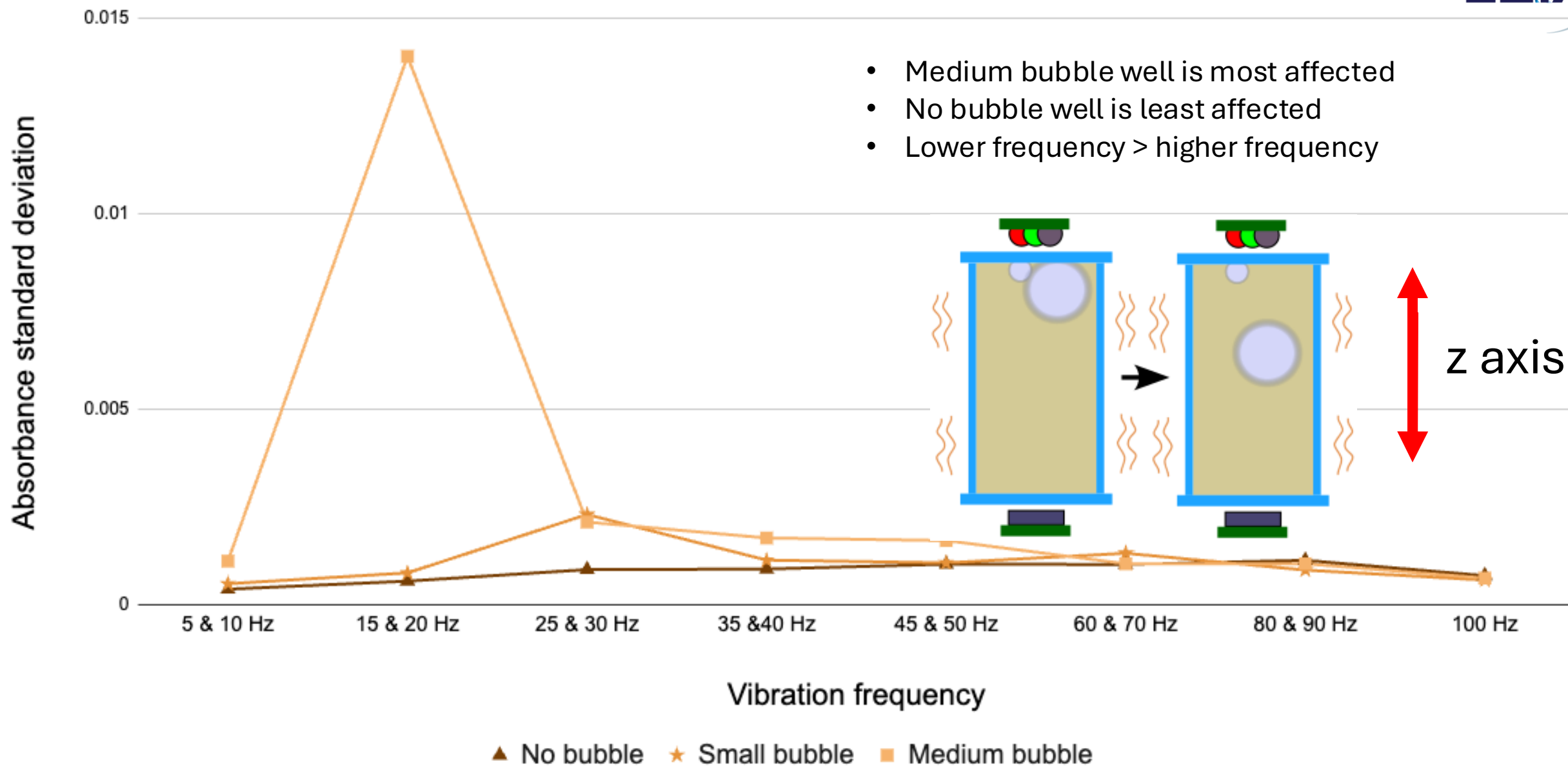
y-axis vibration

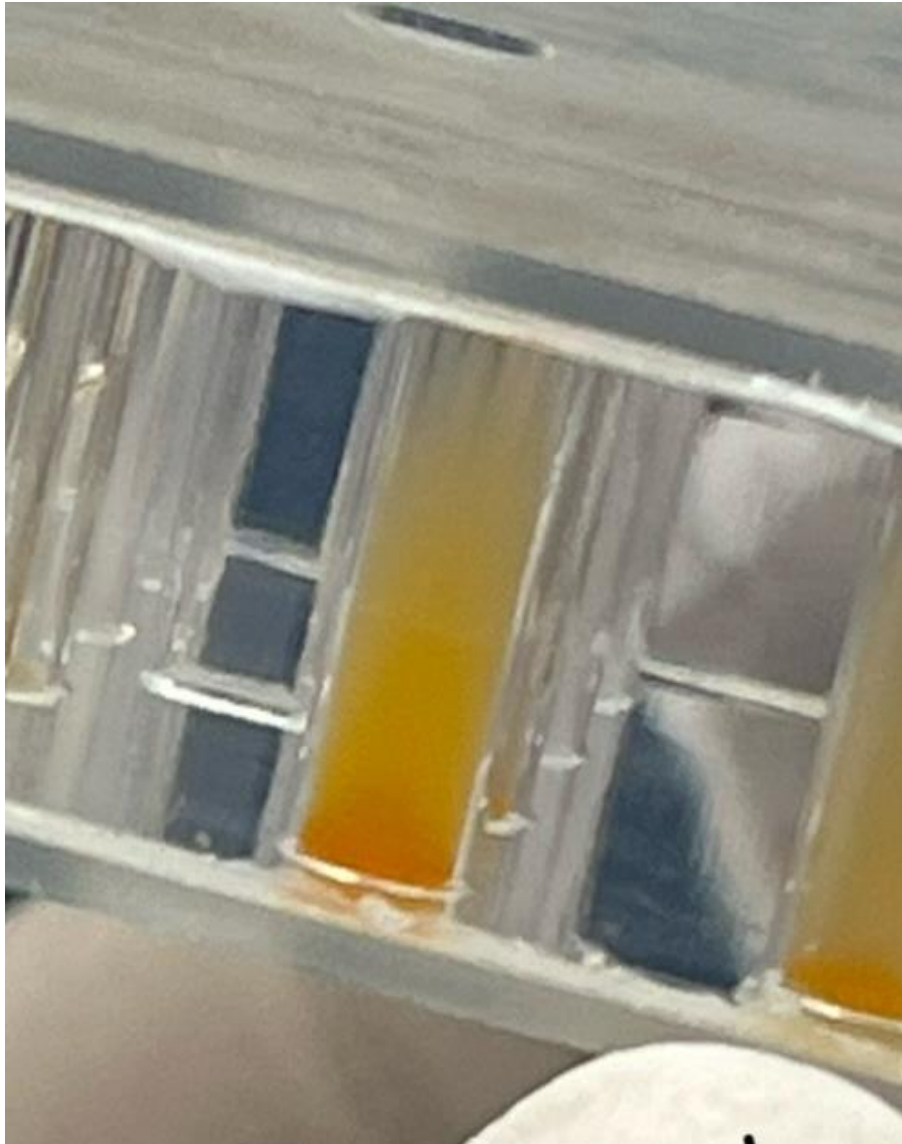


z-axis vibration



z-axis vibration

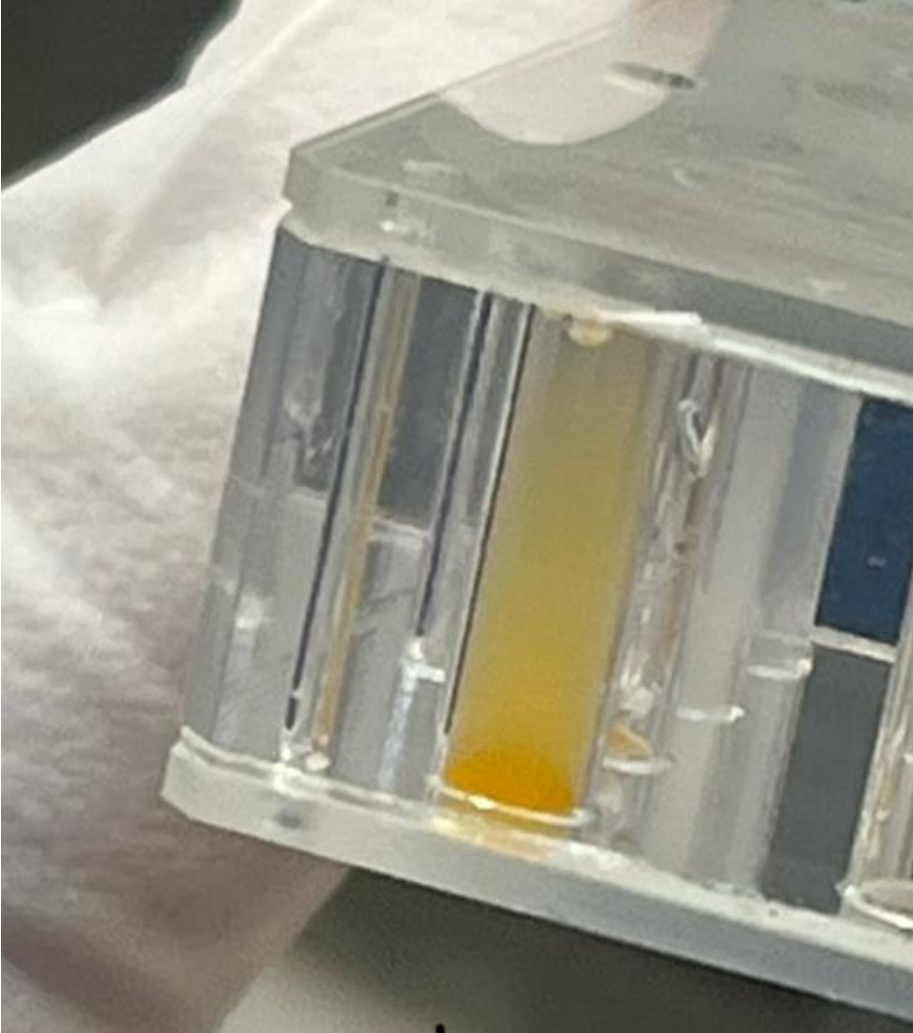




Conclusions: Fully filled

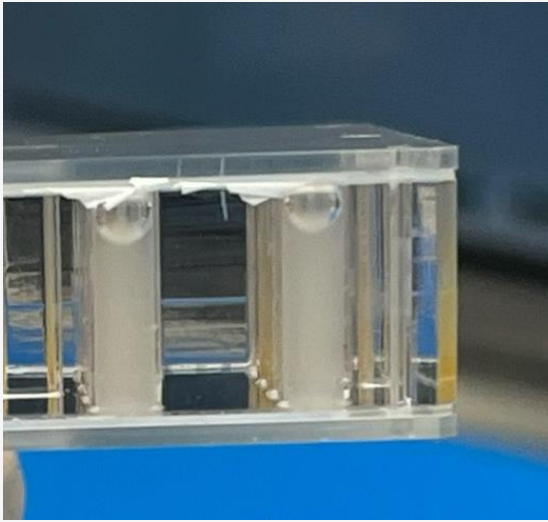
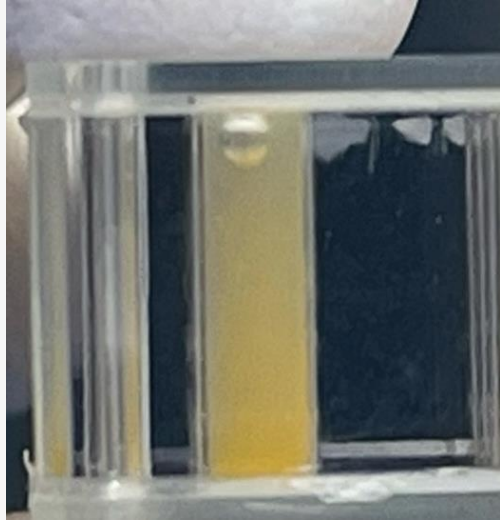
- Vibration at all frequencies has negligible effect on the optical data if the well is completely filled (fully devoid of bubbles)*

*This will not be true if there is biological growth tracking due to vibration acting as agitation for the growth media in the wells.



Conclusions: Small bubbles

- Small bubbles: Stuck to the well, yielding normal data at high freq, low translation, and may have dislodged during low freq and high translation



Conclusions: Medium and Large bubbles

- Medium and large bubbles have a higher chance of interfering with the data during vibration, due to lower surface tension and a constantly flexing bubble surface

Conclusions cont...

- Lower frequencies (1-30 Hz) have a more pronounced effect on the optical data
 - bubble translation is high
 - motion is slow
- Higher frequencies (>50 Hz), have comparatively smaller effect on the optical data
 - bubble translation is low
 - motion is fast
- Most susceptible to data anomalies at all frequencies, and to a higher degree in lower frequencies
- 0-80 Hz with a 0.25 g load is the “danger zone” which has a high probability of generating data noise

Mitigation Steps

- ProSEED to BioSensor space vibration dampening
- Correlating drill schedule with BioSensor timestamps -- help identify periods when BioSensor data is unreliable,
- Accurate interpretation of the yeast response data and ensuring the validity of the BioSensor's scientific measurements on the lunar surface.

LEIA Team Presentations at ASGSR

Thursday, Dec 5

Chinmayee Govinda Raj
Lauren Liddell

Investigator poster session

MVISE: Ground mapping equipment.
Yeast strain development for radiation sensitivity.

Friday, Dec 6

Chinmayee Govinda Raj

Microbes 2

Vibration impacts on BioSensor optical readings.

Friday, Dec 6

Mark Settles
Kira Rienecker

Enabling Technologies 2

LEIA Science CONOPS.
Adapting BioSensor to diverse bioassays.

Friday, Dec 6

Katie Fisher

Microbes 3

Yeast strain development to test carotenoid production.

Saturday, Dec 7

Neha Lingam
Aidan Kihm

Undergraduate/High School Poster Session

Engineering genetic countermeasures for yeast in deep space.
Optical Density probe for MVISE.

Saturday, Dec 7

Sergio Santa Maria BioSensor deep space mission concepts.

BLISS Session

Ames Space Biosciences Booth: LEIA 3D Printed Model & Space Biomanufacturing Hardware



Questions?
Comments?
Concerns?