

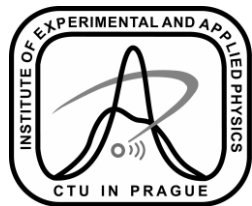
Direction of Acoustic Analysis Efforts

William Woodley

Derek Cranshaw

Shane Meister

Emery Pattison



PICO Collaboration Meeting

22 August 2024

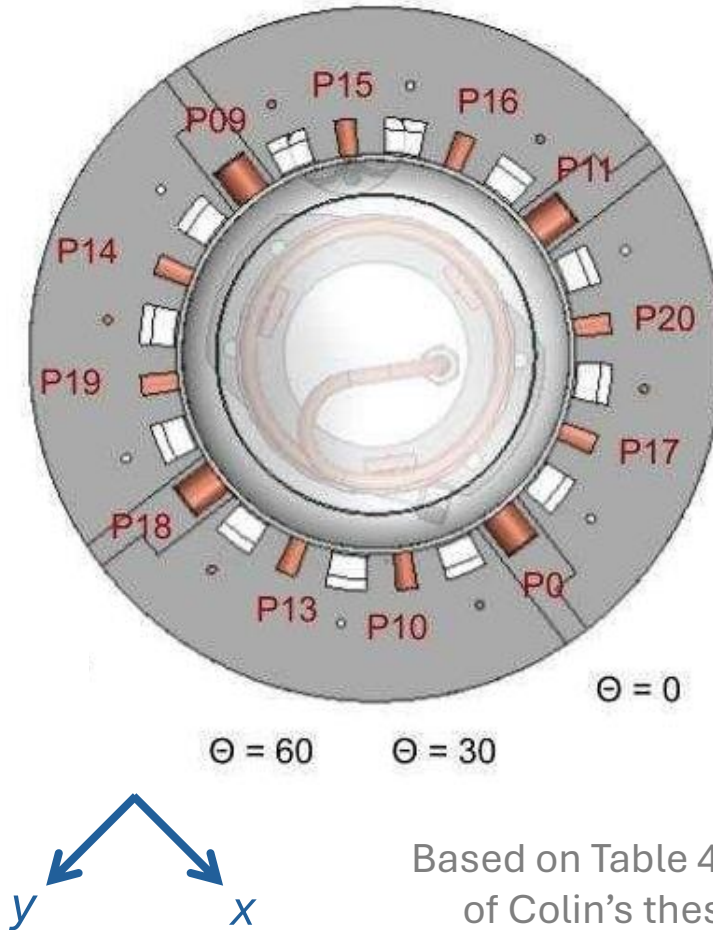
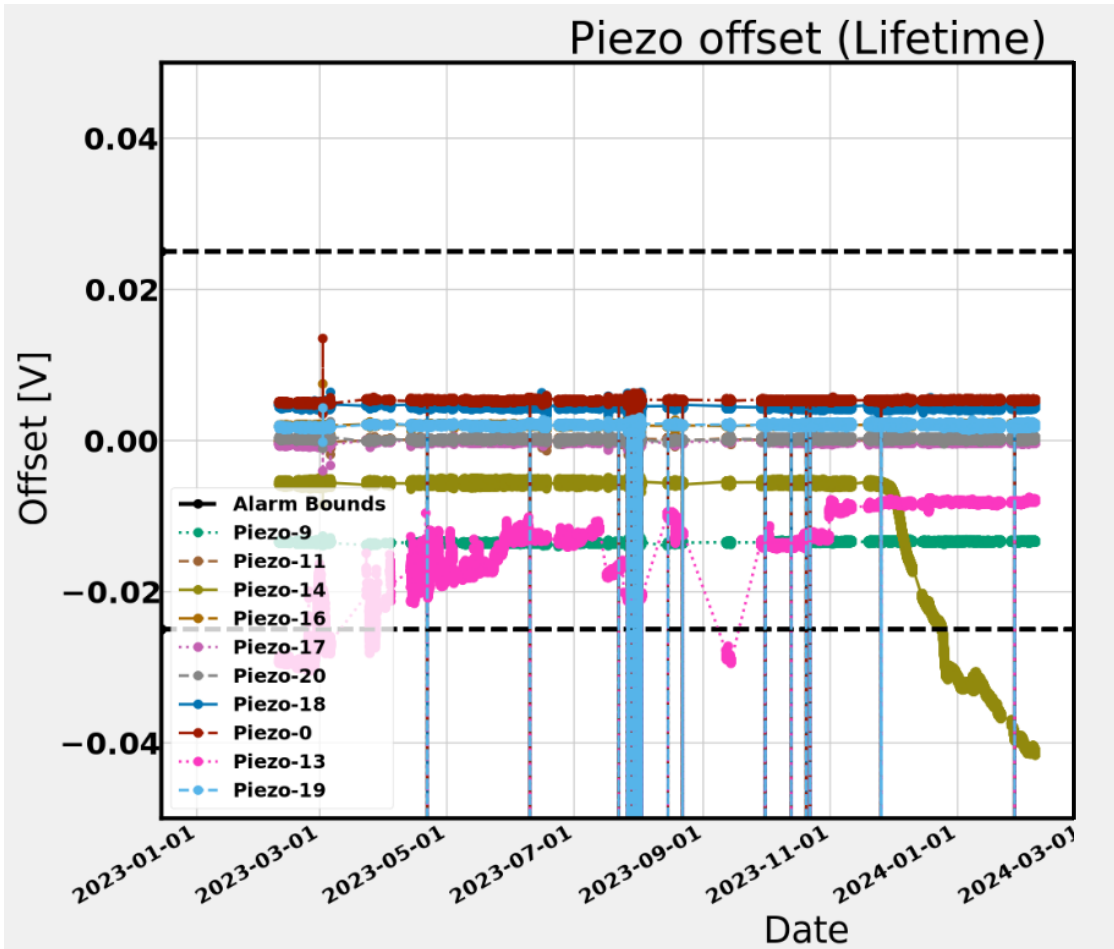
Prague

Purpose of this Session

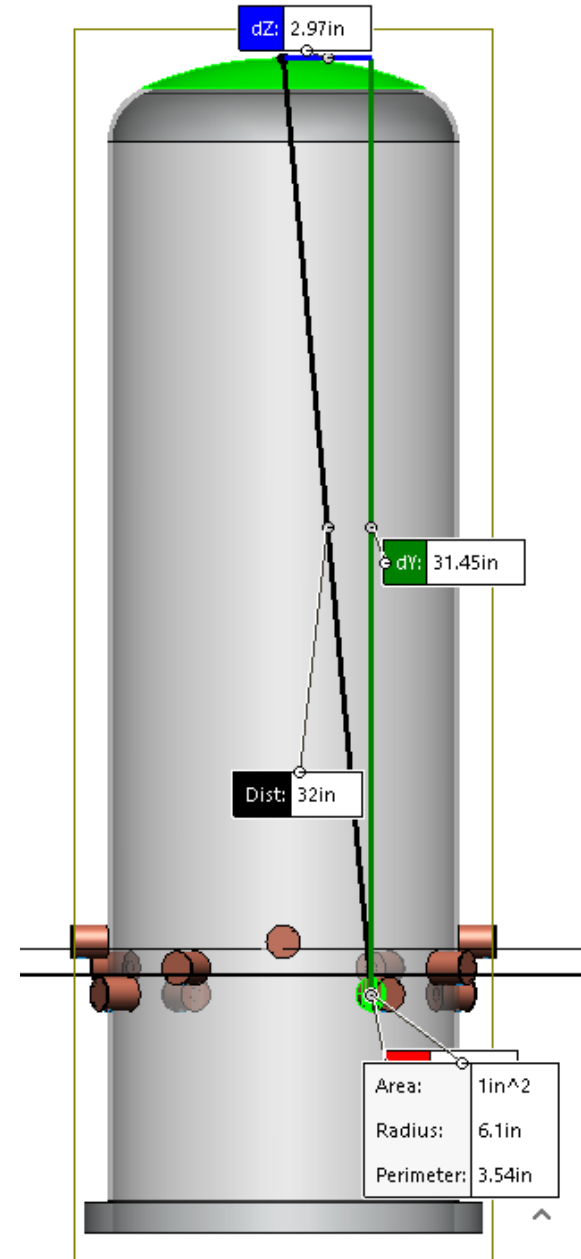
- 1 Brainstorm and discuss ideas.
- 2 Gain knowledge and understand the history of acoustic analyses so we don't waste time doing pointless or already-done work.
- 3 Set hard goals for highest priority analyses to prevent getting lost following random rabbit holes.
 - Then update the list on GitHub.

Piezos

- Originally 12 piezos in PICO-40L. 10 still work.



Based on Table 4.2 of Colin's thesis



Anatomy of an Acoustic Signal

- 1 A bubble is formed.
- 2 The sound wave hits the quartz.
- 3 The sound wave echos.

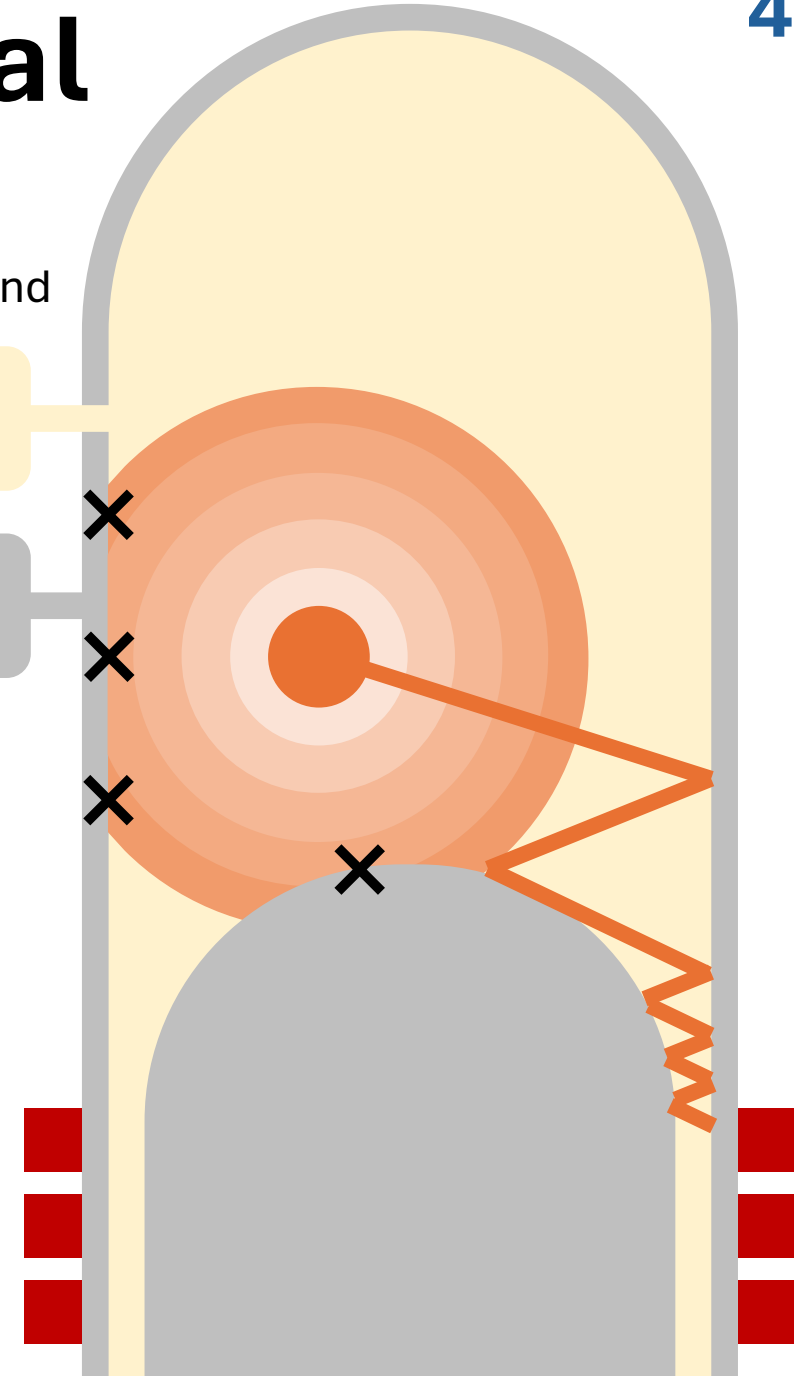
Constant noise from pumps, air handlers, people talking, etc.



Speeds of Sound

100 ms⁻¹

5800 ms⁻¹



Anatomy of an Acoustic Signal

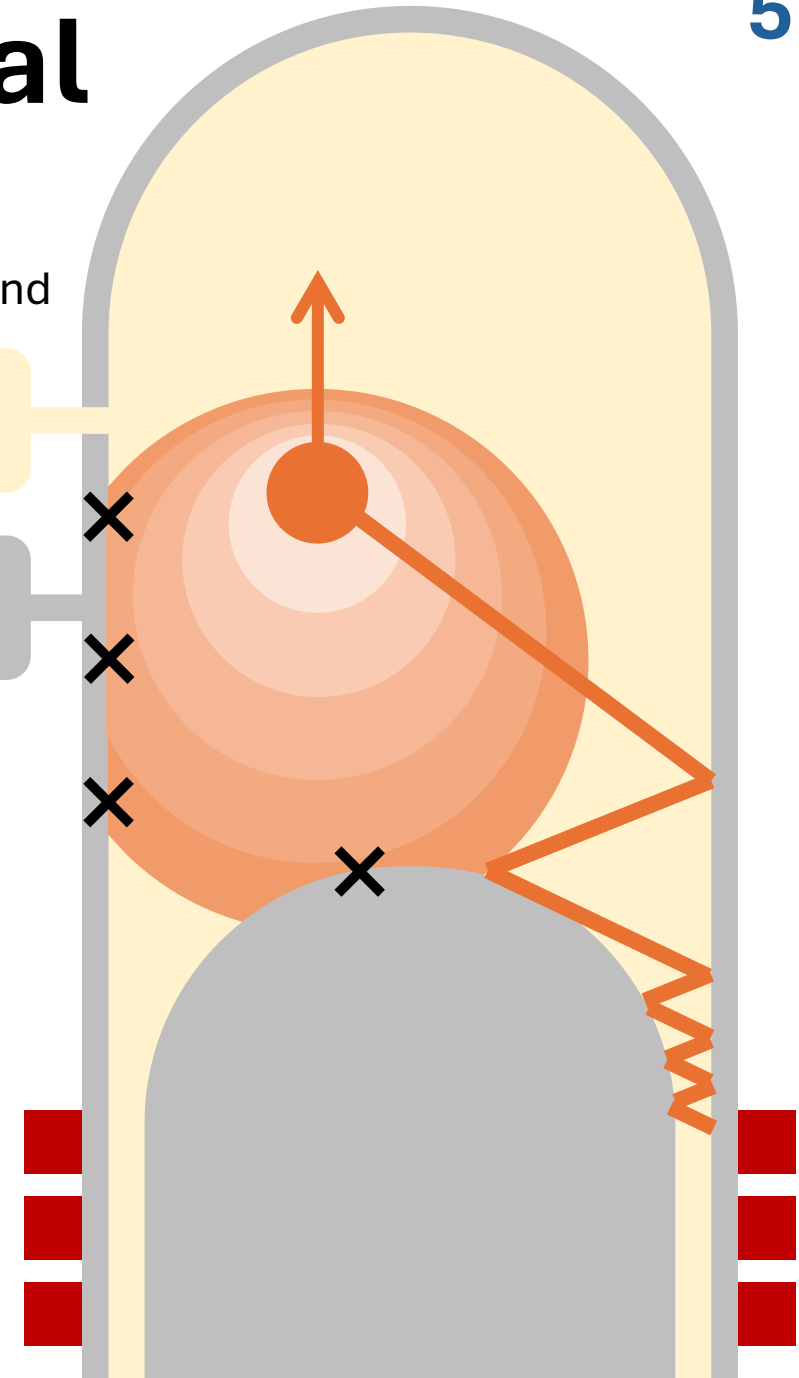
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- 4 The bubble ~~moves~~ (Doppler effect).



Speeds of Sound

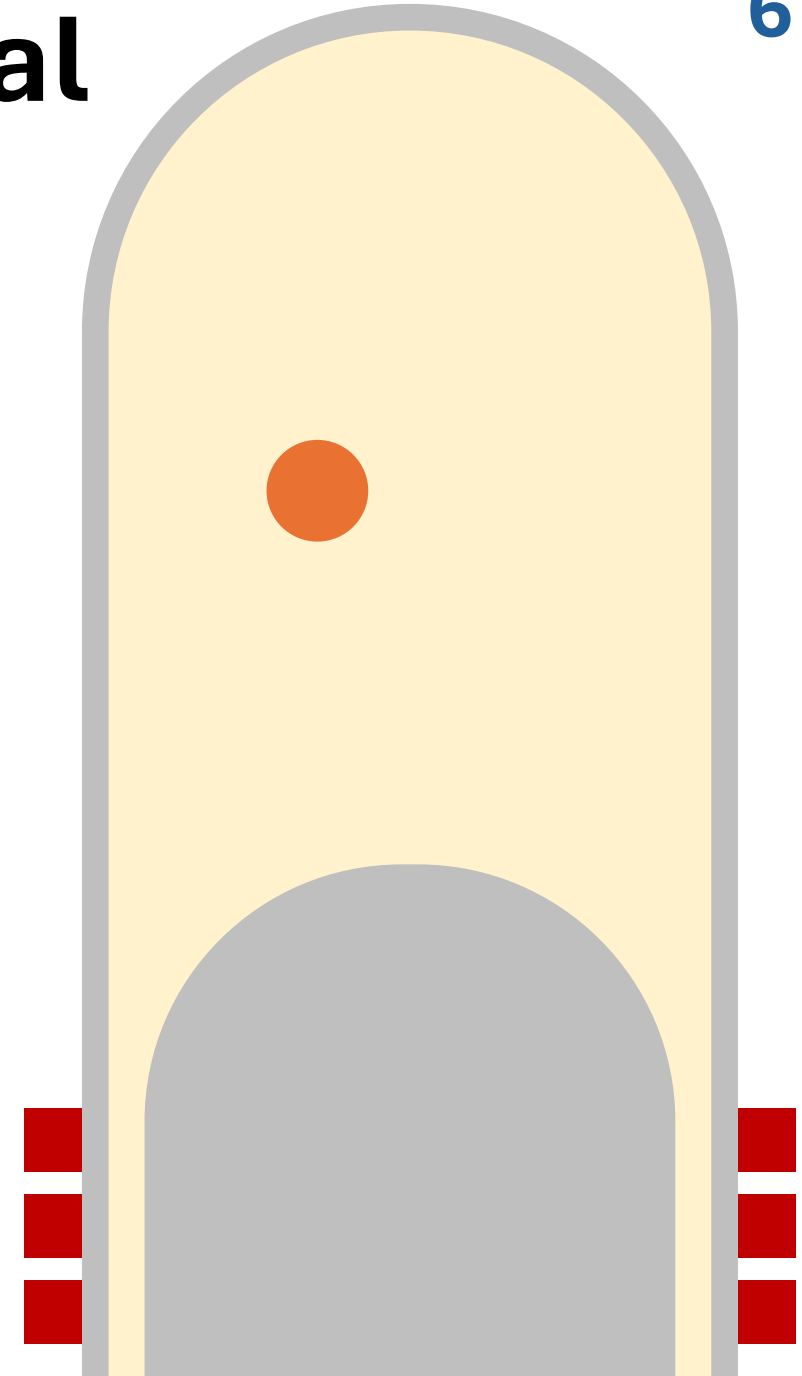
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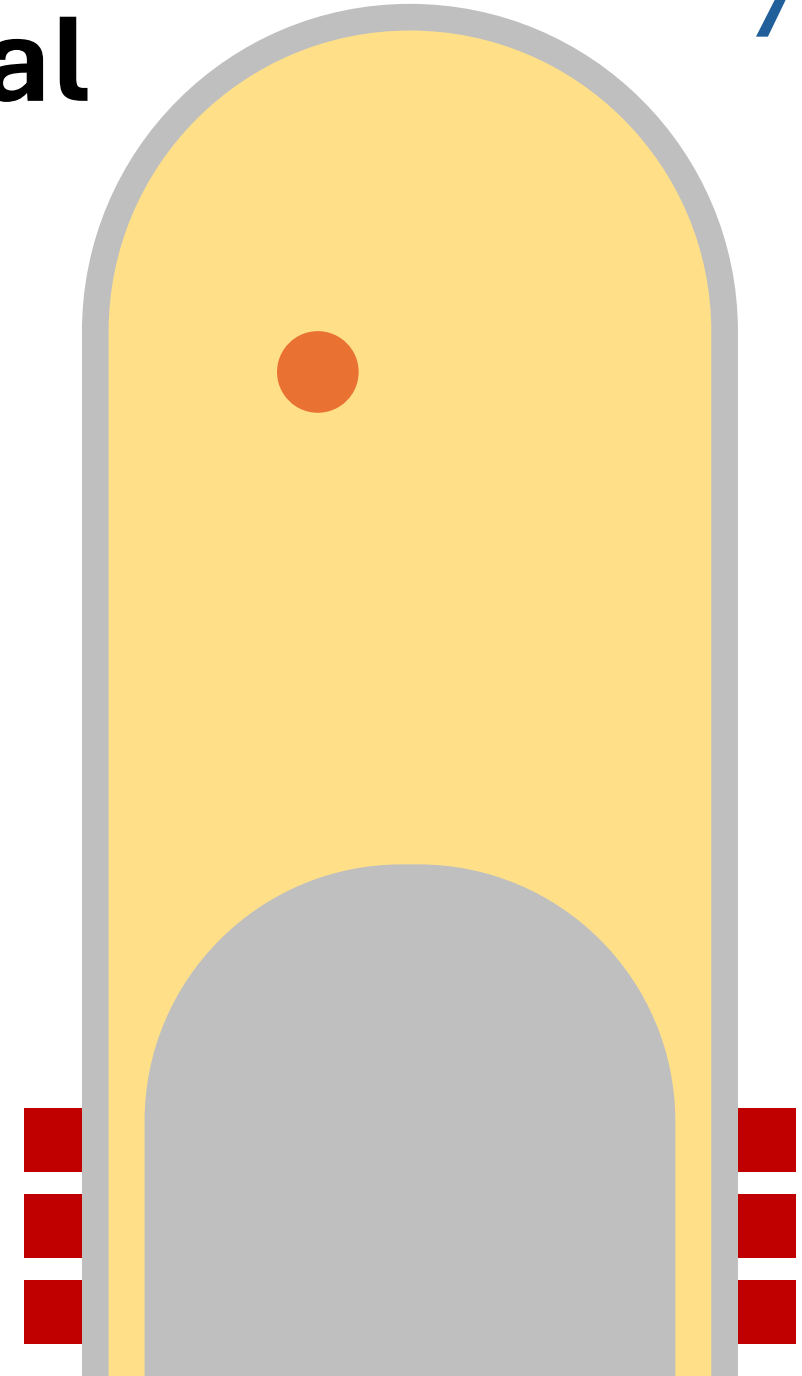
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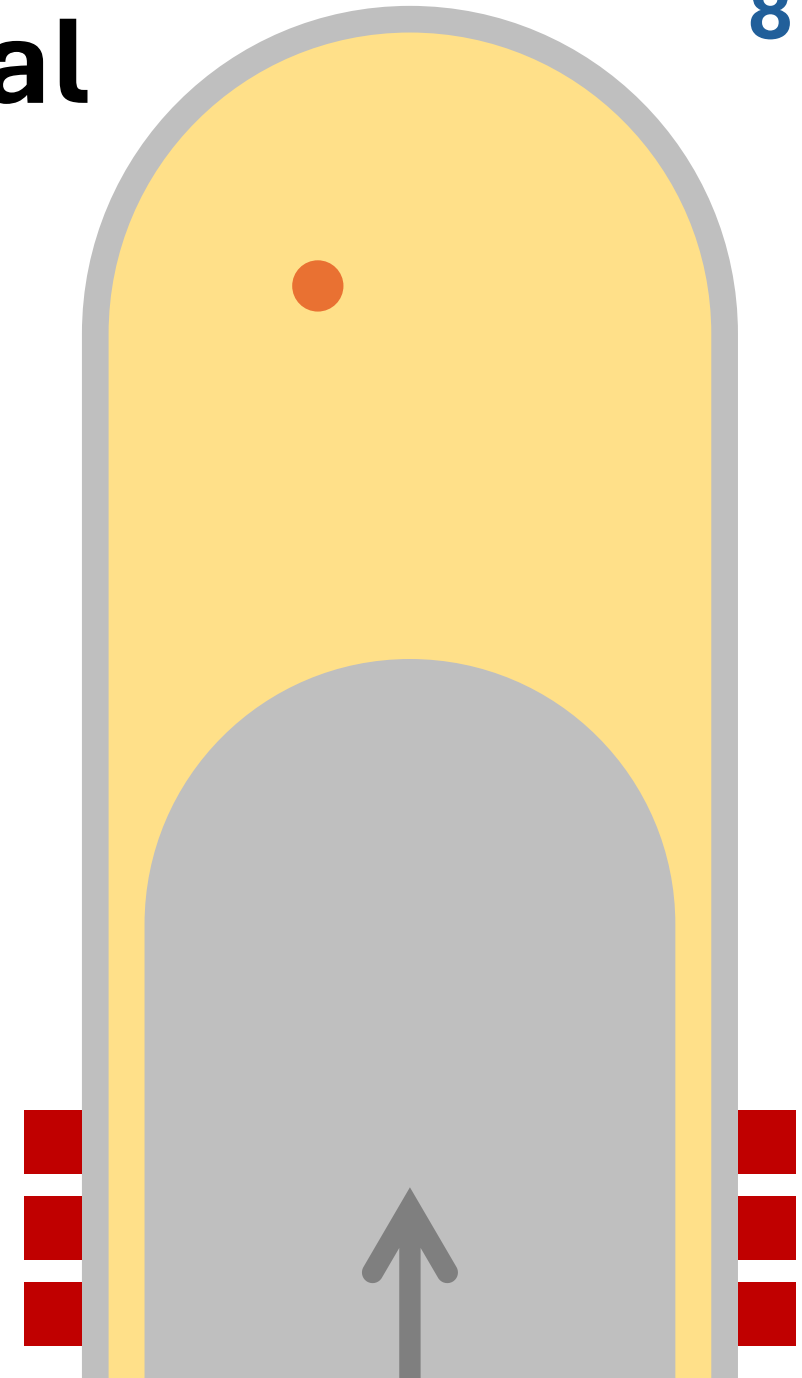
Anatomy of an Acoustic Signal

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- 4 ~~The bubble moves (Doppler effect).~~
- 5 The fast accumulator triggers.



Anatomy of an Acoustic Signal

- 1 A bubble is formed.
- 2 The sound wave hits the quartz.
- 3 The sound wave echos.
- 4 The bubble ~~moves~~ (Doppler effect).
- 5 The fast accumulator triggers.
- 6 The bellows move the inner jar.



Blip Analysis

Rajan Anderson (UNAM)

Blips

- Acoustic artefacts (“blips”) seen in piezo signals.
- Narrow frequency range.
- **Main Questions:**
 - Frequency of blips?
 - Is there a pattern?
 - Are they related to t_e ?

vs

Chirps

- Were seen in PICASSO and PICO-2L, and now again in PICO-40L.
- No pattern and broad frequency range?
- **Preliminary Hypothesis:** Failed bubbles. However, this happens on too short of timescales (ns vs 10 μ s), and the amplitude is not right.

Current Efforts

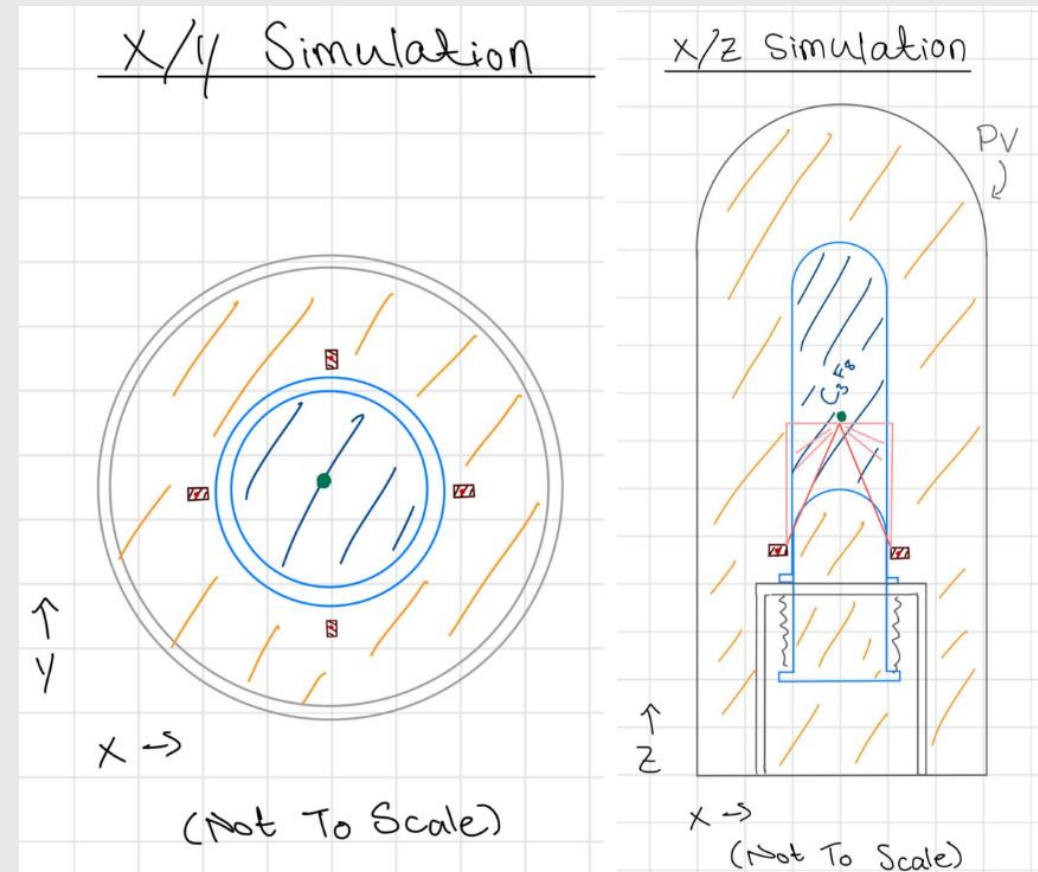
Modelling and 2D COMSOL Simulations

Emery Pattison (University of Alberta)

- Model piezo voltage with an equation used for bubble acoustics in oceanography:

$$V(t) = \sum_N A_N \cos(\omega_N(t - t_N)) e^{-\omega_N \delta(t - t_N)}$$

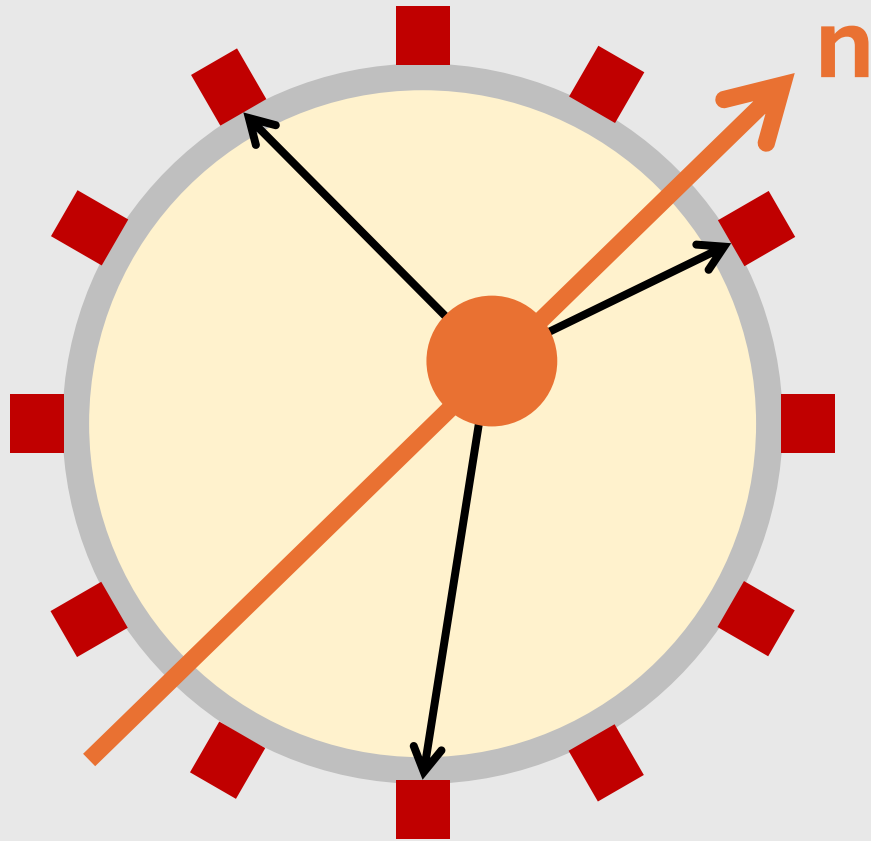
- Adapt the model to PICO.
- Potential to predict the number of bubbles based on signal shape.



Current Efforts

Bubble Growth and Directionality

Shane Meister (Queen's University)

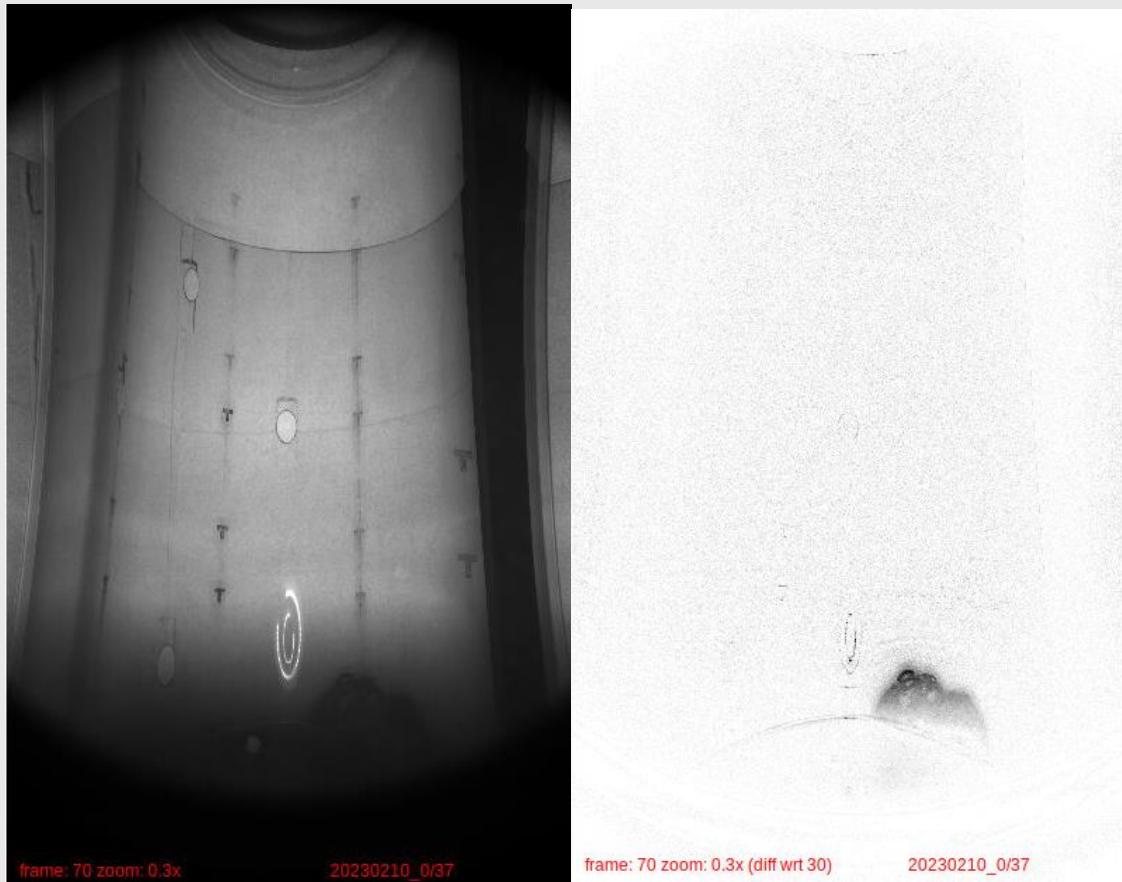


- Use the phase information and the piezo positions to triangulate bubble position.
- **How is this complicated by the quartz, piezo types, etc.?**
- This could be used to calculate bubble growth.
- It could allow for characterisation of spatial extent of bubble and get directionality of the particle that caused the bubble.
- **Is this remotely possible?**

Current Efforts

Bellows Position Reconstruction

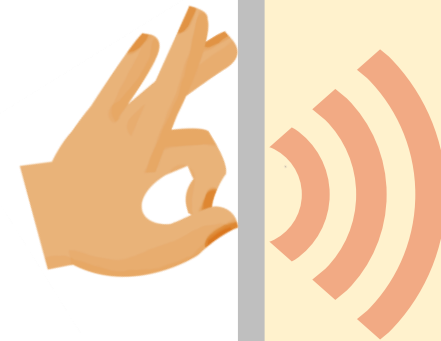
Aqeeb Ahmed (University of Alberta)



- Does the IV have a different wall rate than OV?
- Bellows events seem to occur two or three at a time, but from different areas. Are they related?
- Bellows events are difficult to see with the cameras, and position reconstruction is usually unreliable.
- Use phase shift in piezo signal to reconstruct event position independently of the optical reconstruction.

A Small Bonk?

- Is there a way to calibrate the piezos for position reconstruction by creating sounds at specific locations and looking at the responses of the piezos?
- This would likely have to be extrapolated out to the real operating conditions of the detector.
- Are there piezos on the inside and/or outside of the PV?



Roadmap

**Signal
Characterisation**

*CUTE?
Piezo inner
materials?*

**Position
Reconstruction**

*Failed bubbles?
Multibubbles?*

Directionality

*Normalisation
and offset?*

*Resonant
frequencies?*

Piezo types?

???

*Chirps?
Acoustic Trigger?
Etc.?*

