SAND2019-14294C

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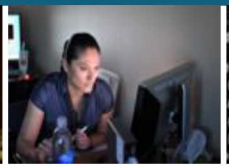
Bubble Bifurcation in a Vibrated, Closed, Liquid-filled Cylinder



Engineering Sciences Center – Sandia National Laboratories

Dayna Obenauf, Benjamin Halls, and John Torczynski

72nd Annual Meeting of the American Physical Society Division of Fluid Dynamics

Seattle, Washington, Nov. 23-26, 2019

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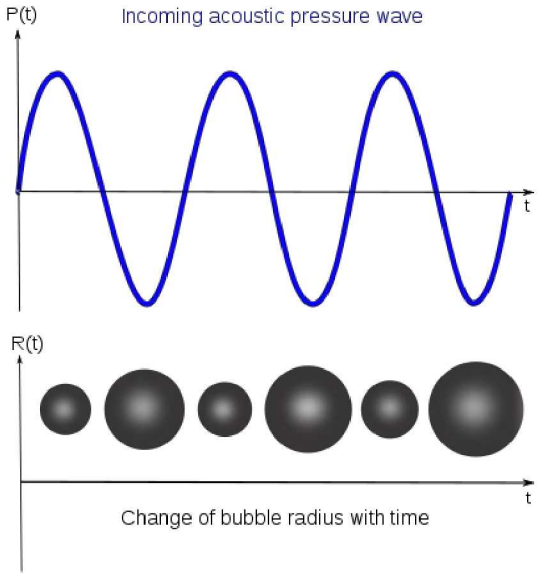
Multi-phase flows and vibration

- Breakup of interface – entrains bubbles below surface
- Complex physics from forces acting on bubbles

- $F_{Bjerknes} = \langle -V(t)\nabla P \rangle$
  - $V(t)$ = bubble volume
  - ∇P = pressure gradient

Primary Bjerknes – bubbles move down

Secondary Bjerknes – bubbles attract/repel



Multi-phase flows and vibration

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- $F_{Bjerknes} = \langle -V(t)\nabla P \rangle$
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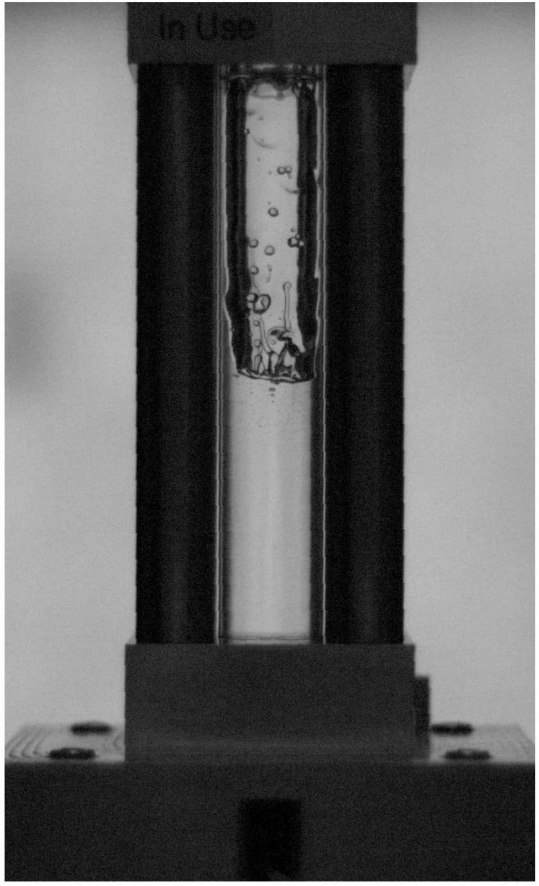
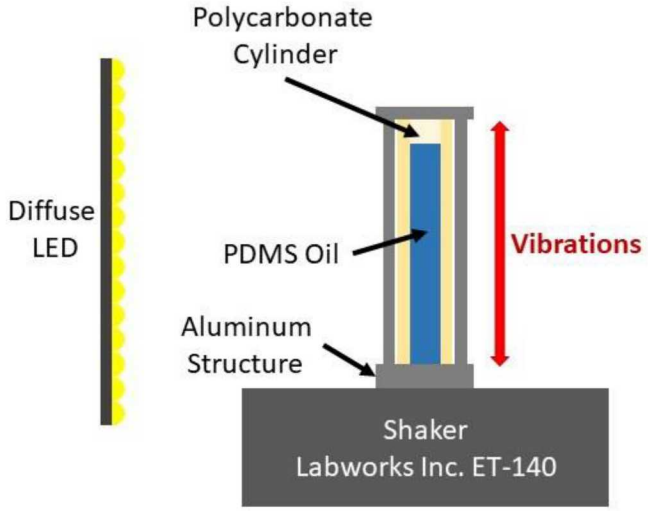
Primary Bjerknes – bubbles move down

⟶ Bubble motion in a vibrating enclosed cylinder



Experimental Apparatus

- Partially-filled cylinder undergoing vertical vibration
  - Cylinder height: 100 mm
  - Cylinder diameter: 12.5 mm
  - Liquid: PDMS Oil (20 cSt)
  - Fill: 50-90%
- Frequencies: 40-70 Hz
- Acceleration: 30 g



Effects of frequency variation (with 70% fill)

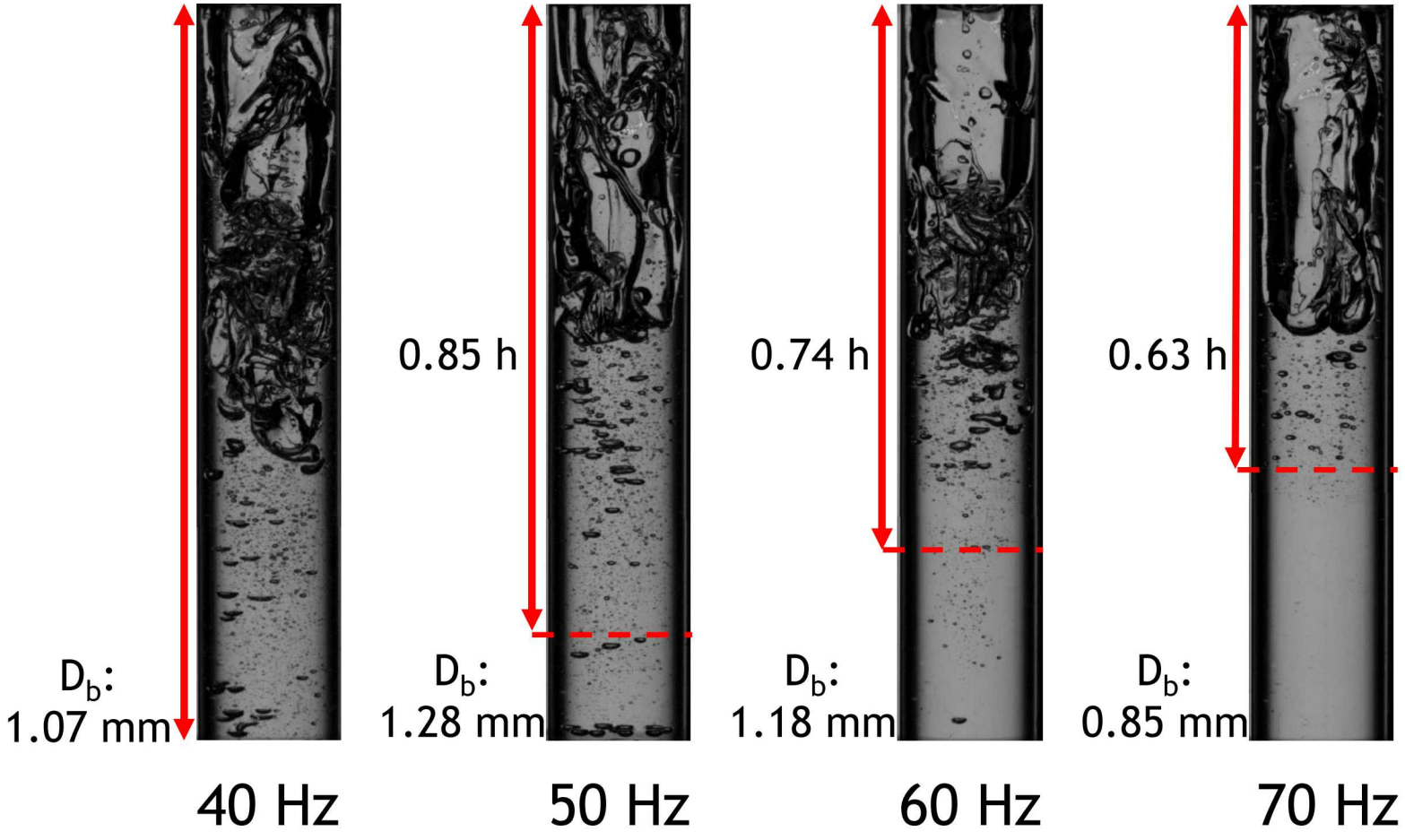
40 Hz

50 Hz

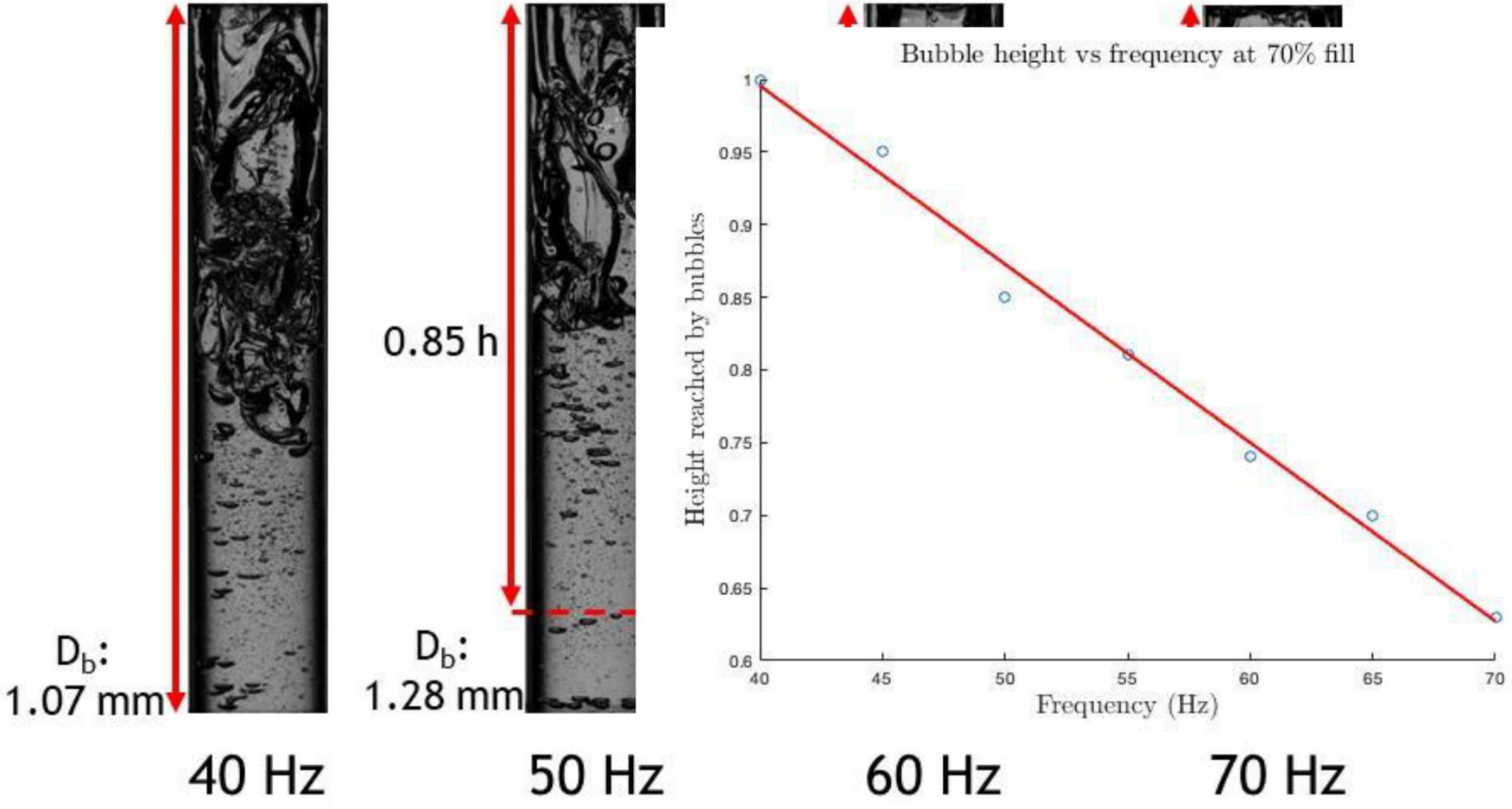
60 Hz

70 Hz

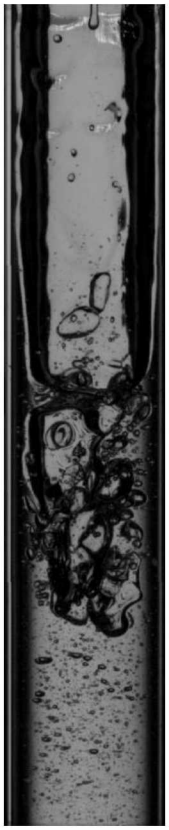
Effects of frequency variation (with 70% fill)



Effects of frequency variation (with 70% fill)



Effects of void fraction (at 50 Hz)



50%

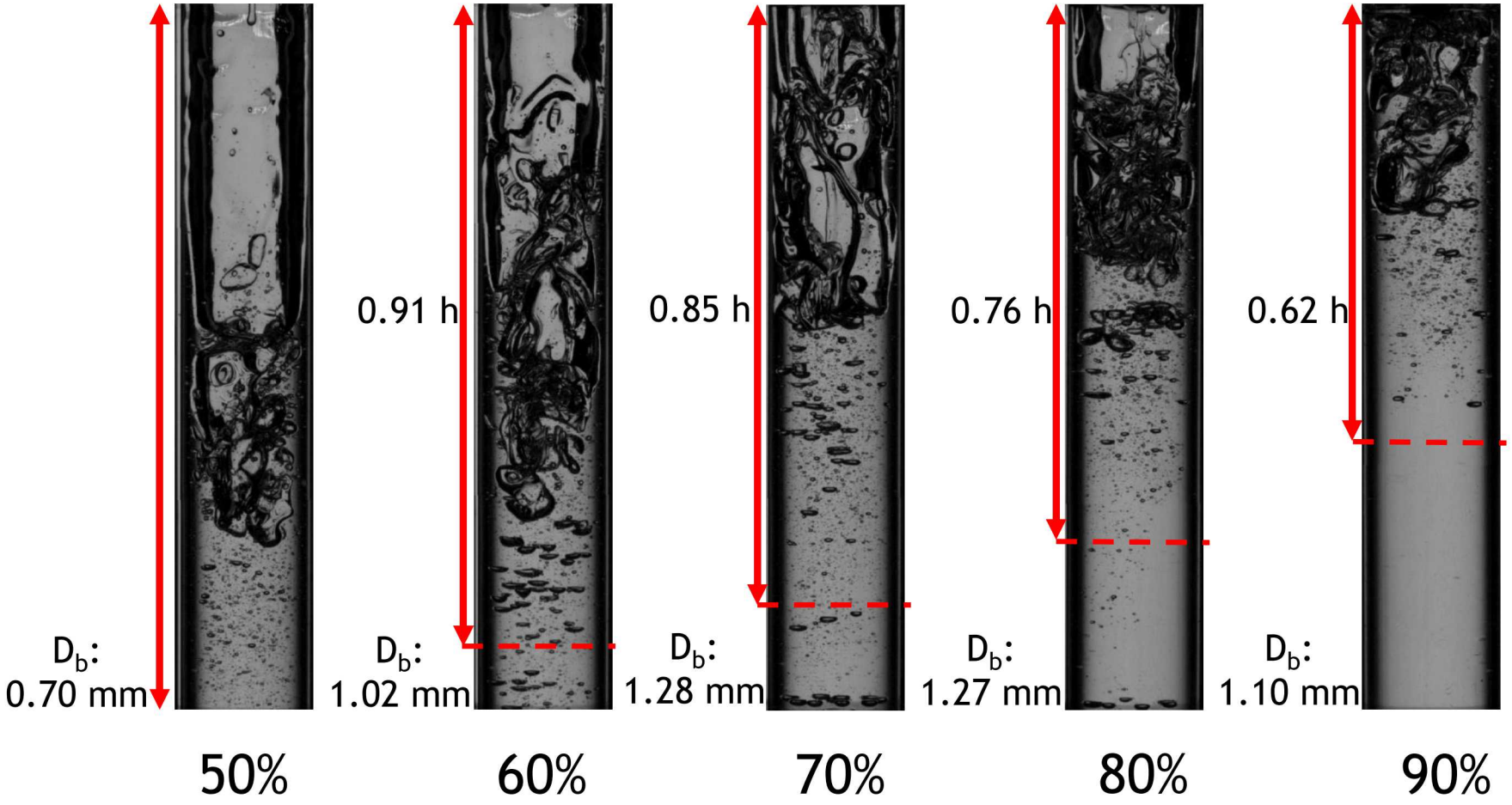
60%

70%

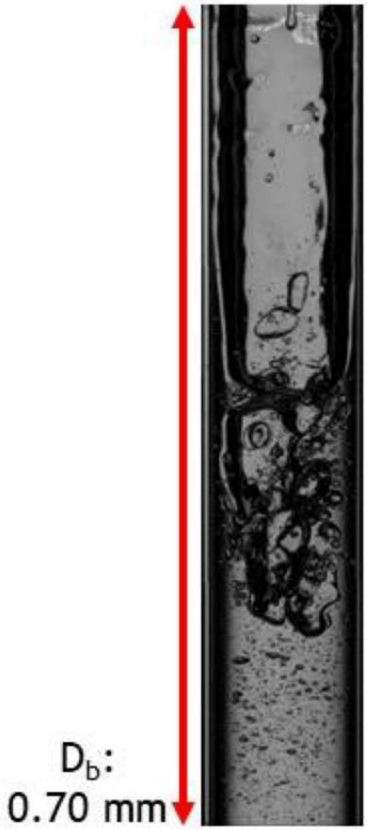
80%

90%

Effects of void fraction (at 50 Hz)

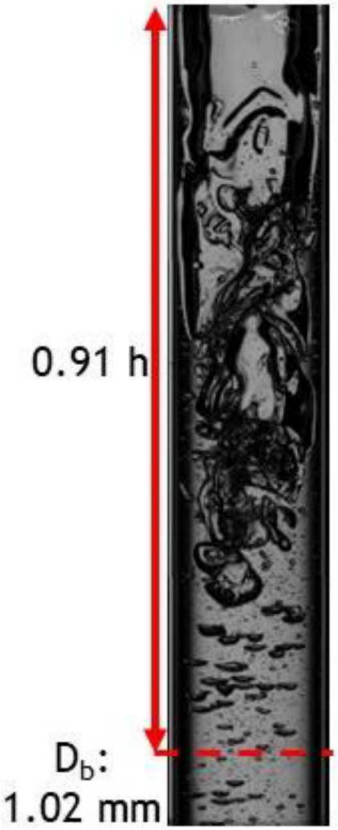


Effects of void fraction (at 50 Hz)



D_b: 0.70 mm

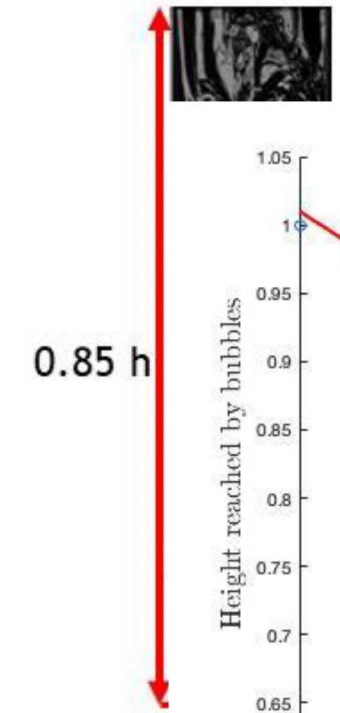
50%



0.91 h

D_b: 1.02 mm

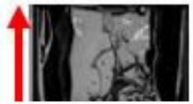
60%



0.85 h

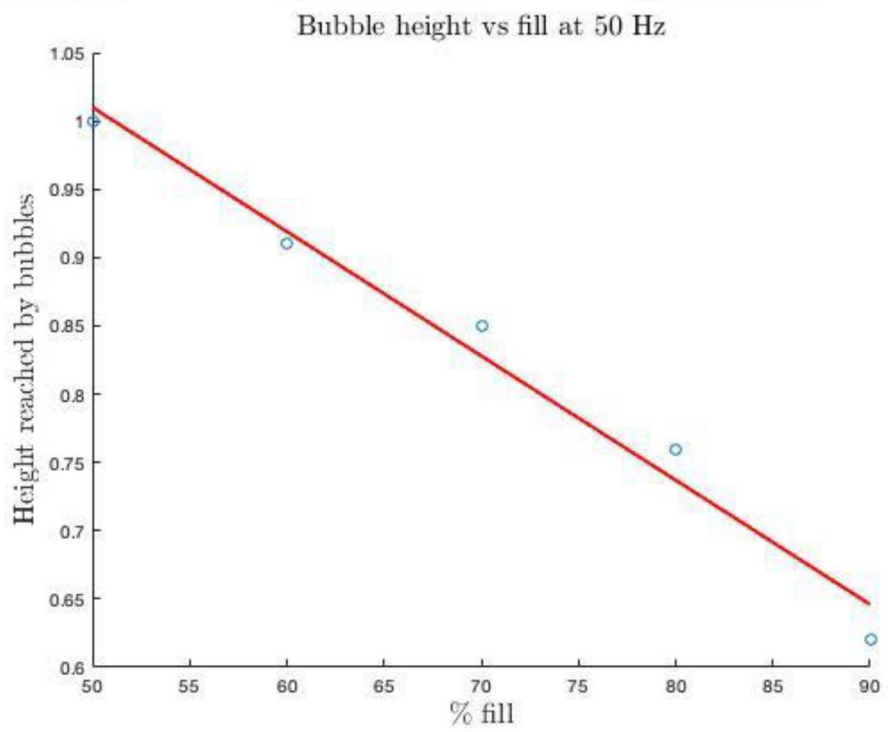
D_b: 1.28 mm

70%

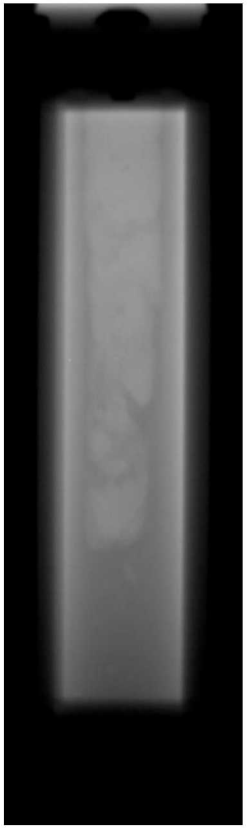


80%

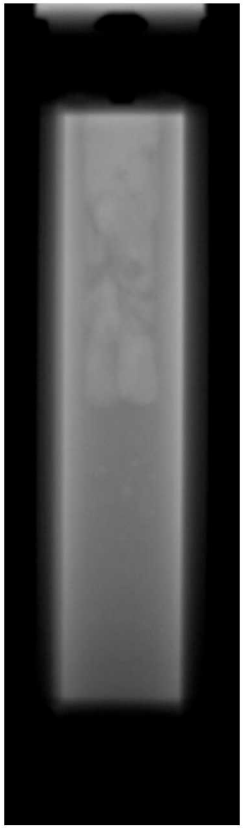
90%



Next Step: X-ray imaging

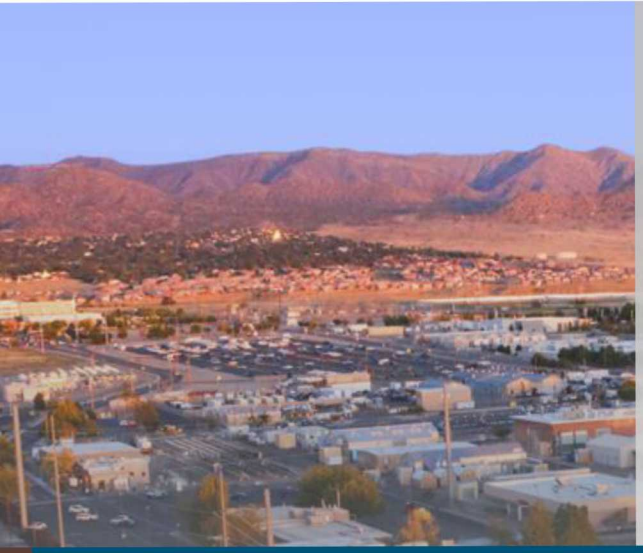


50%



70%

90%



Questions?

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