



Drexel University  
Department of  
**Physics**  
*College of Arts and Sciences*



# LAr Scintillating Bubble Chambers for Rare Event Searches

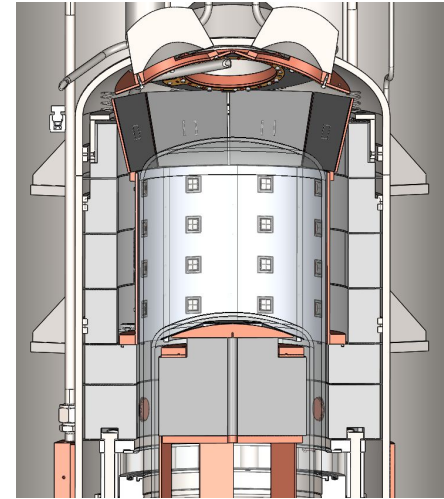
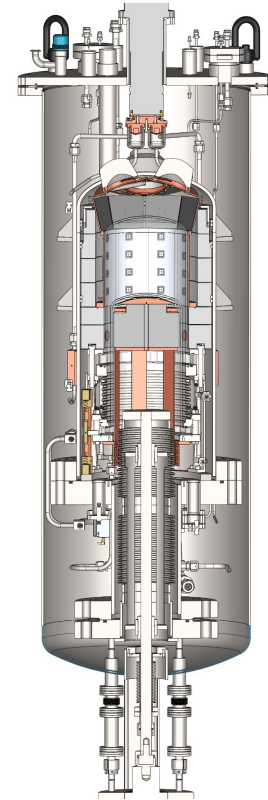
CPAD 2025 - Penn - Oct 7-10, 2025

Daniel Pyda, Drexel University  
7 October 2025

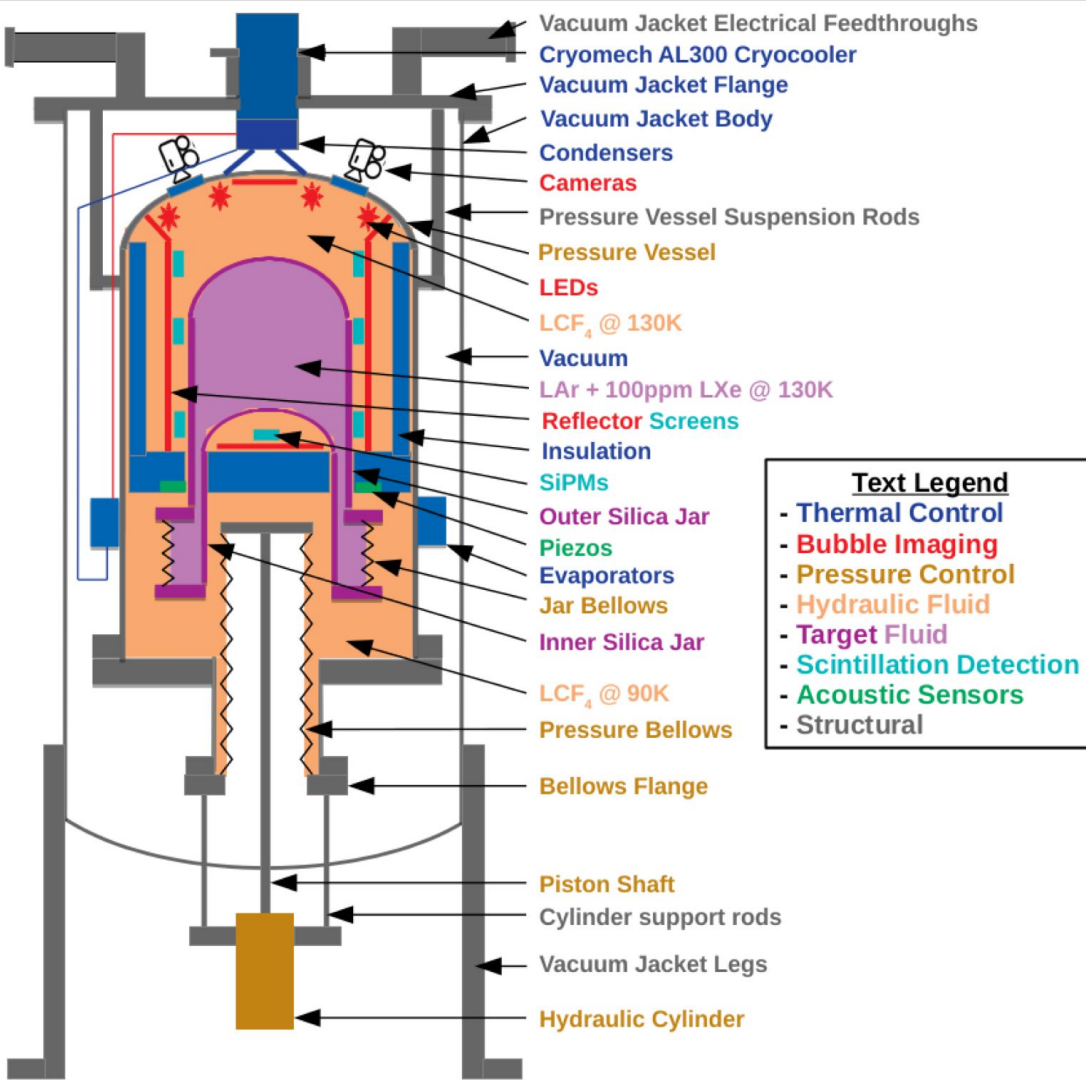
# Scintillating Bubble Chamber



- 10 kg liquid argon (LAr)
- First stage - Calibration - Current Stage (almost)
  - SBC-LAr10, FNAL MINOS Tunnel (~100m)
- Second stage - Dark Matter Search
  - SBC-SNOLAB (~2km)
- Third stage? - Neutrinos
  - Reactor site



- 10kg LAr
- 100 eV nuclear recoil bubble threshold
- Electron recoil blindness



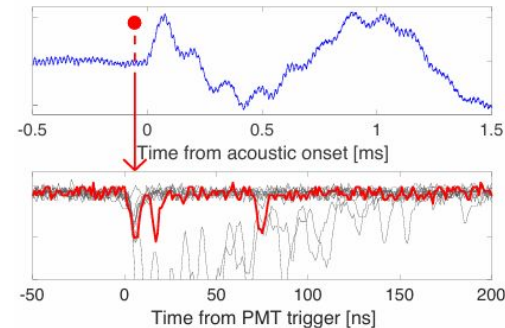
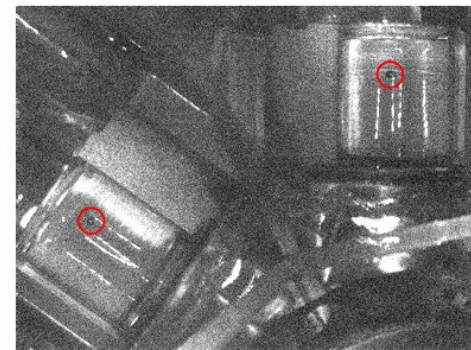
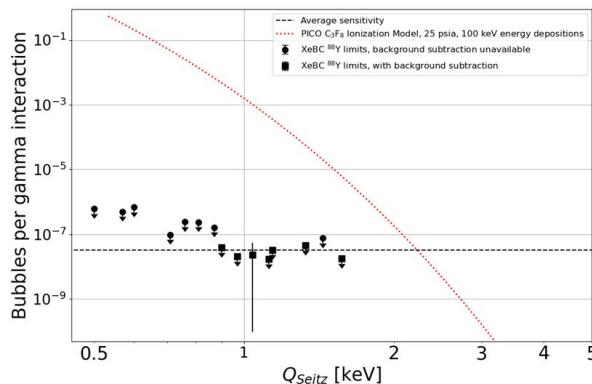
# Why LAr?



- Past bubble chambers - freon-based COUPP, PICO
  - Electron recoil insensitivity  $\sim 1$  keV
  - High energy vs. low energy events? Acoustics:  $\sim$ MeV energy resolution
- LAr - scintillation
  - $\sim$ keV energy resolution
  - DM expectation - bubble without scintillation
  - $<100$  eV electron recoil insensitivity
- SBC prototype - XeBC

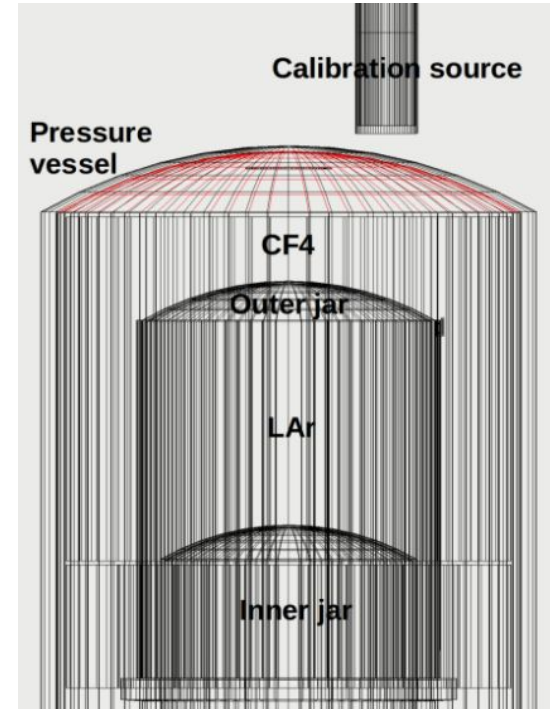
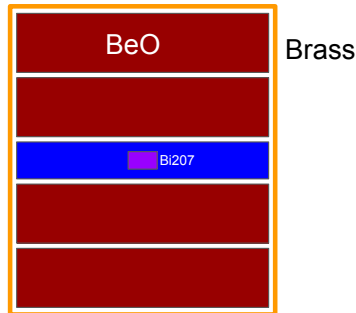
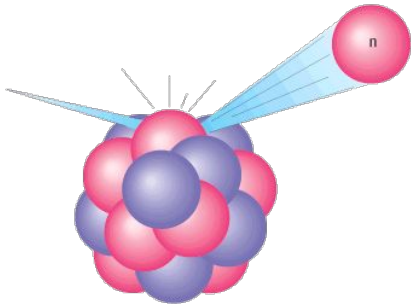
Baxter, D., et. al. (2017). First Demonstration of a Scintillating Xenon Bubble Chamber for Detecting Dark Matter and Coherent Elastic Neutrino-Nucleus Scattering. *Physical Review Letters*, 118(23).

Alfonso-Pita, E., et. al. (2025). Low-threshold response of a scintillating xenon bubble chamber to nuclear and electronic recoils. *Physical Review D*, 111(3).





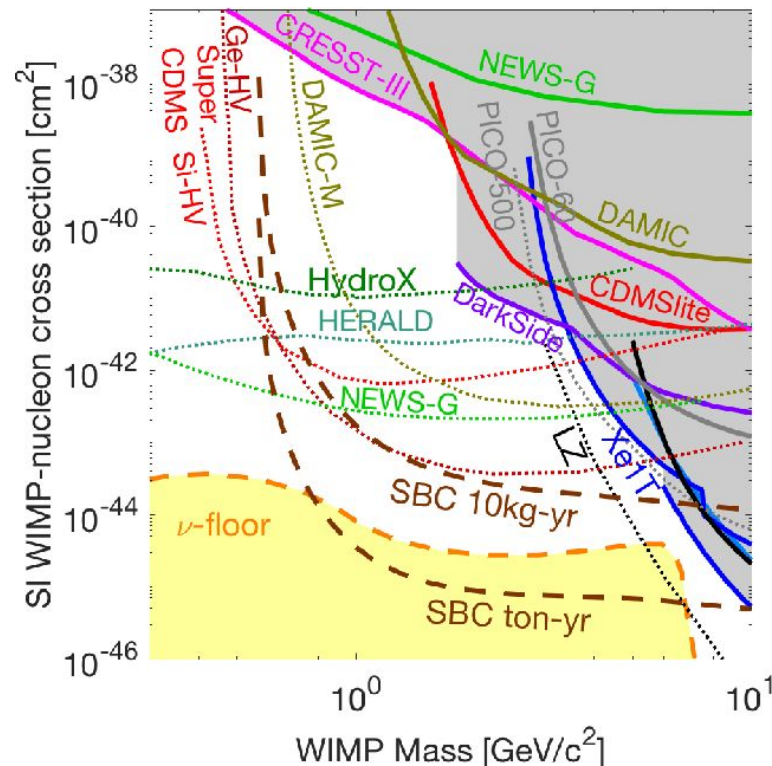
- Detector performance and recoil sensitivity
- Calibration campaign:
  - Backgrounds
  - ER blindness
    - Gamma sources - Cs137
  - Bubble nucleation efficiency
    - Photoneutron sources - Bi207, Sb124 w/ BeO
    - Thomson scattering sources - Co60, Sb124, Th228



# Dark Matter Search



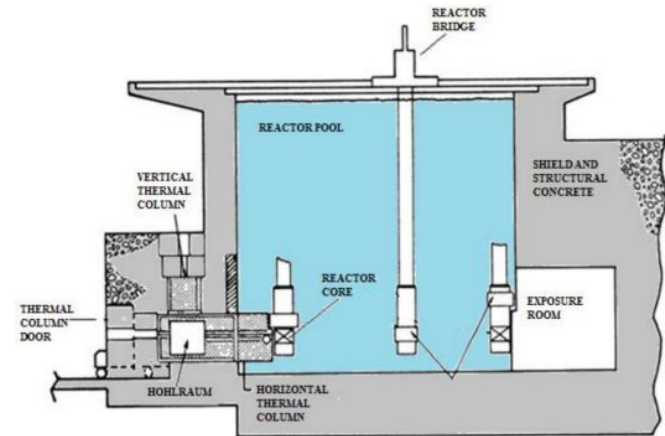
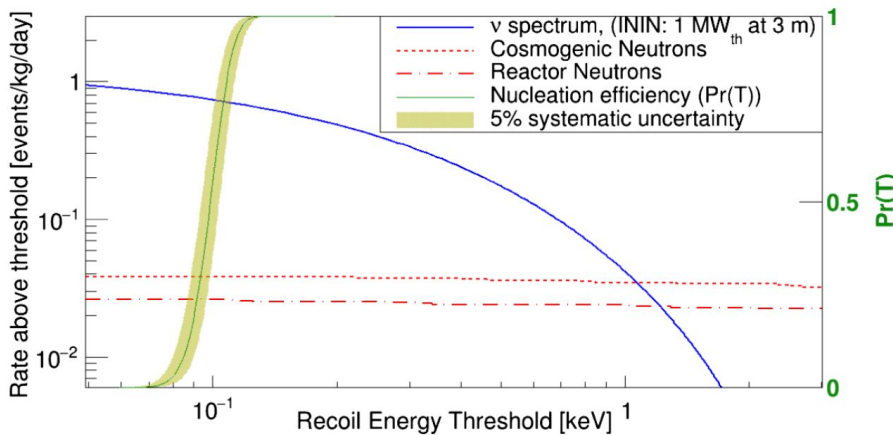
- Low mass ( $< 10$  GeV) WIMPs
  - New parameter space
- Near background free
- Improvements from calibration stage?



# Neutrinos?



- High exposure  $\rightarrow$  neutrino fog
- CE $\nu$ NS study
- Reactor neutrinos
  - Instituto Nacional de Investigaciones Nucleares (ININ) TRIGA Mark III
  - HFIR Oak Ridge National Laboratory





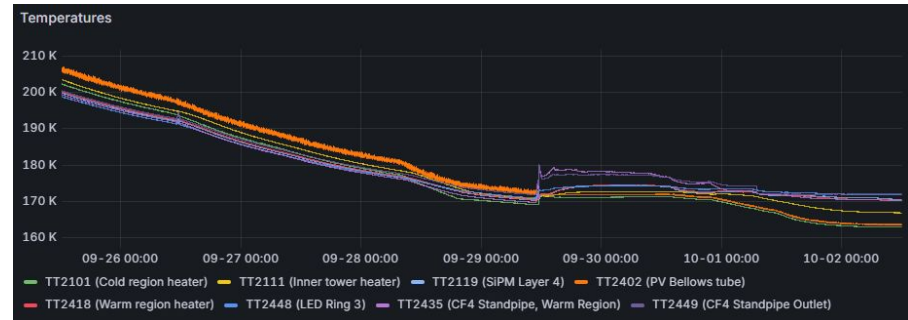
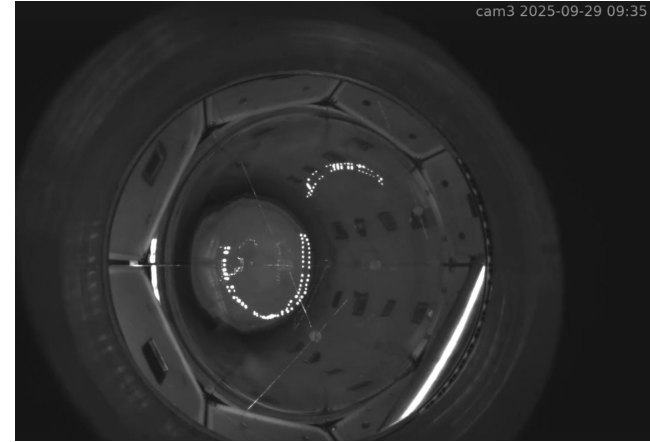
- SBC-LAr10 (FNAL) dark matter search
- FNAL/SNOLAB background rates
- LCF4 optical properties
- Instrumentation/experiment design potential



# Current Status



- Condensing: LCF4 fill, LAr fill
- First bubbles in the coming weeks!



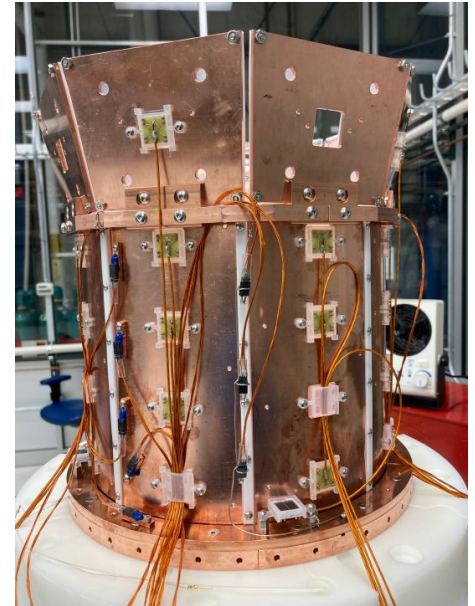
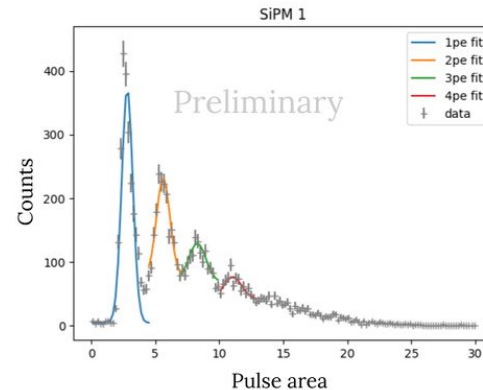
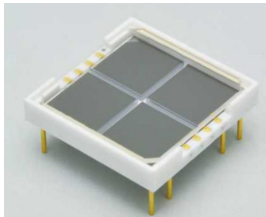
# Fill Video - gif



# Instrumentation - SiPMs



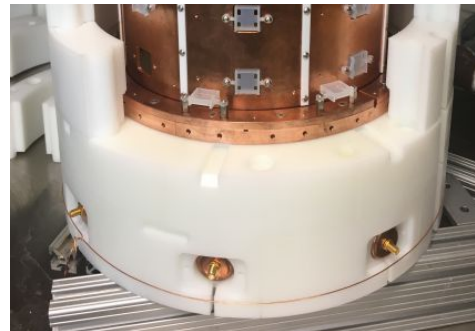
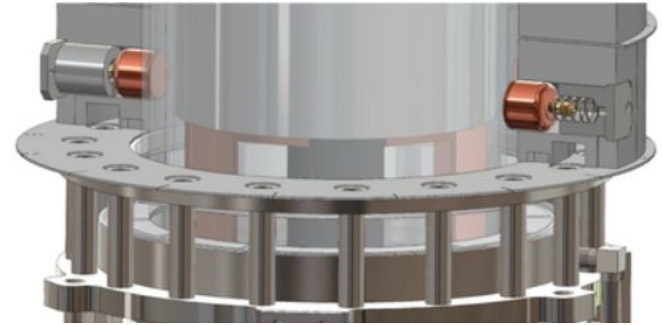
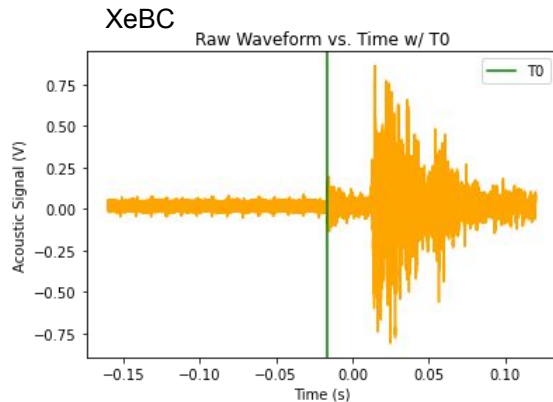
- 32 SiPMs
- Xe doped LAr - 175nm scintillation
- SBC-LAr10: Hamamatsu VUV4
  - Hawley-Herrera, H., et al. (2024). Batch VUV4 characterization for the SBC-LAr10 scintillating bubble chamber. *Journal of Instrumentation*, 19(08), T08003.
- SBC-SNOLAB: FBK VUV-HD4 (higher radiopurity)
- Scintillation light yield → event energy, background rejection
- Currently: LCF4 scintillation data



# Instrumentation - Acoustics



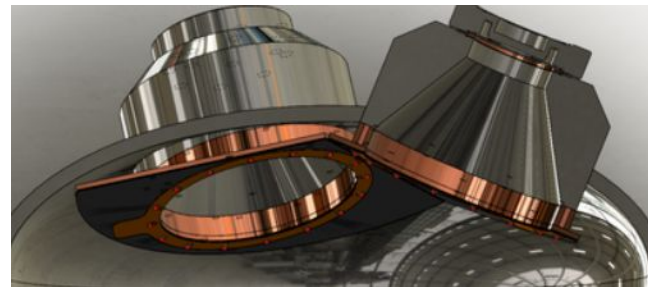
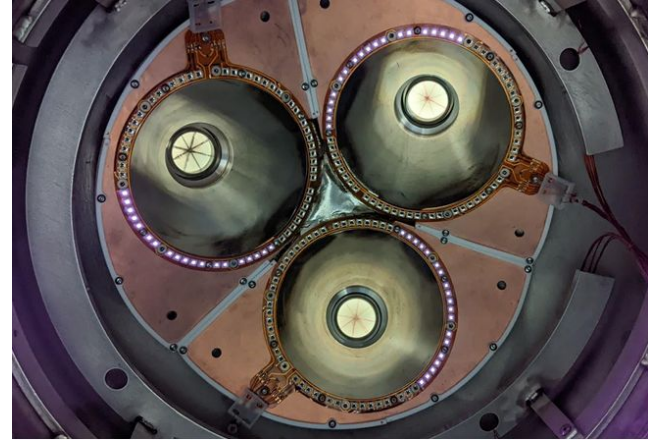
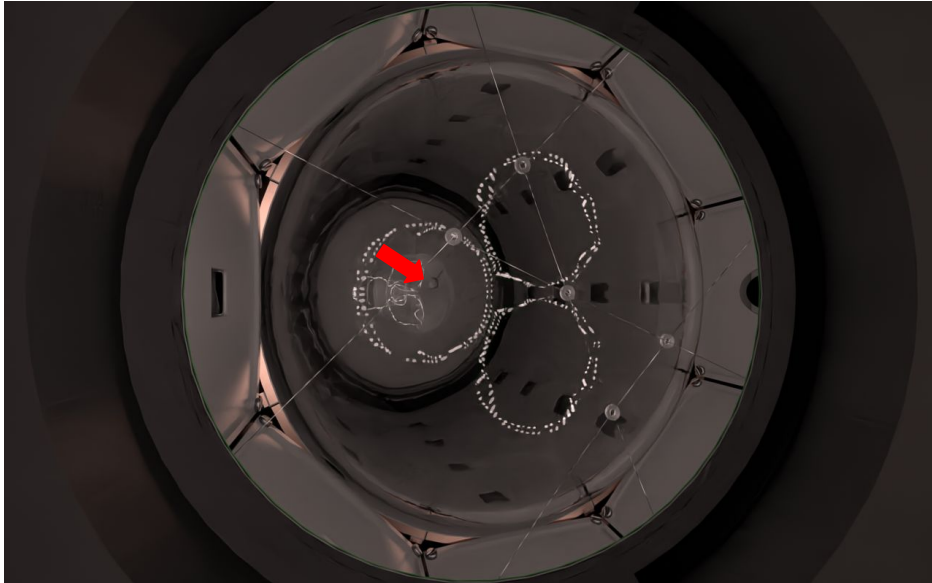
- 8 lead zirconate titanate piezoelectric transducers
- $\pm 25\mu\text{s}$  time-of-nucleation reconstruction
- Piezoelectric energy, timing



# Instrumentation - Cameras



- 3 cameras, stereoscopic imaging
- 100 fps, mm-resolution
- Bubble positions, sizes, growth



## Thanks for listening - questions?



- Eric Dahl
- Zhiheng Sheng
- Baisakhi Mitra
- Jianyu Long



- Ken Clark
- Ben Broerman
- Jonathan Corbett
- Austin De St Croix
- Koby Dering
- Hector Hawley
- Gary Sweeny
- Ezri Wyman



- Marie-Cécile Piro
- Carsten Krauss
- Mitchel Baker
- Daniel Durnford
- Youngtak Ko



- Jeter Hall
- Alex Claveau



- Pietro Giampa



- Eric Vázquez-Jáuregui
- Ernesto Alfonso-Pita



- Russell Neilson
- Julian Fritz-Littman
- Noah Lamb
- Daniel Pyda



- Ian Levine
- Ed Behnke
- Cody Cripe



- Hugh Lippincott
- Logan Joseph
- TJ Whitis
- Runze Zhang



- Gray Putnam
- Vrushank Patel



- Mathieu Laurin
- Pierre Frédéric



- Orin Harris



- Shawn Westerdale



- Shashank Priya

