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Title: Applied Acoustics Lab Overview

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Los Alamos NATIONAL LABORATORY

Applied Acoustics Lab Overview

Cristian Pantea & Troy Semelsberger
Materials Physics and Applications, MPA-11

FCIC Task Lead Meeting
webex

LA-UR-21-XXXXX

Applied Acoustics Team

http://www.lanl.gov/orgs/mpa/mpa11/AcousticsAndSensorsTeam

Cristian Pantea

Applied Acoustics Team Leader

Troy Semelsberger

Research Scientist
Catalyst Synthesis & Testing
Reaction Engineering
Materials Characterization
Aging & Lifetime Analyses
Weapons and Non–Weapons work

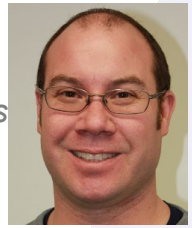
Vamshi Chillara

Research Scientist
Electric Imp Spectroscopy (Chevron)
Well Integrity Monitoring
CO_2 sequestration (DOE)
µarchitected Waveguides

John Greenhall

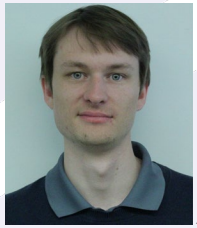
Research Scientist
Machine Learning
3DHEAT
Defects Thermoel Wafers
NDE weapons components
Electronics design

Craig Chavez:



Research Technologist
Mechanical and Electronics Design, and System Configuration

Eric Davis



Postdoc
Well Integrity Monitoring
CO_2 sequestration (DOE)
D_2O content in heavy water
3DHEAT
Acoustic Monitoring of Pu
NDE of weapons components

Dipen Sinha

Visiting Scientist
Defects Thermoel Wafers
Welding inspection
NDE of weapons components
Electronics design

Christopher Hakoda

Postdoc
µarchitected Waveguides
Well Integrity Monitoring

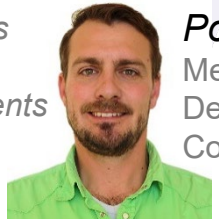
Hung Doan

Postdoc
Corn stover acoustics sensor
Well Integrity Monitoring

Alan Graham

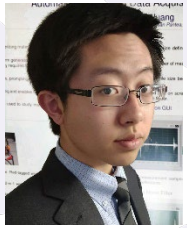
Research Associate
Defects detection in wafers
Welding inspection
NDE of weapons components

Pavel Vakhlamov



Post-Master
Mechanical and Electronics Design, and System Configuration

Sincheng Huang



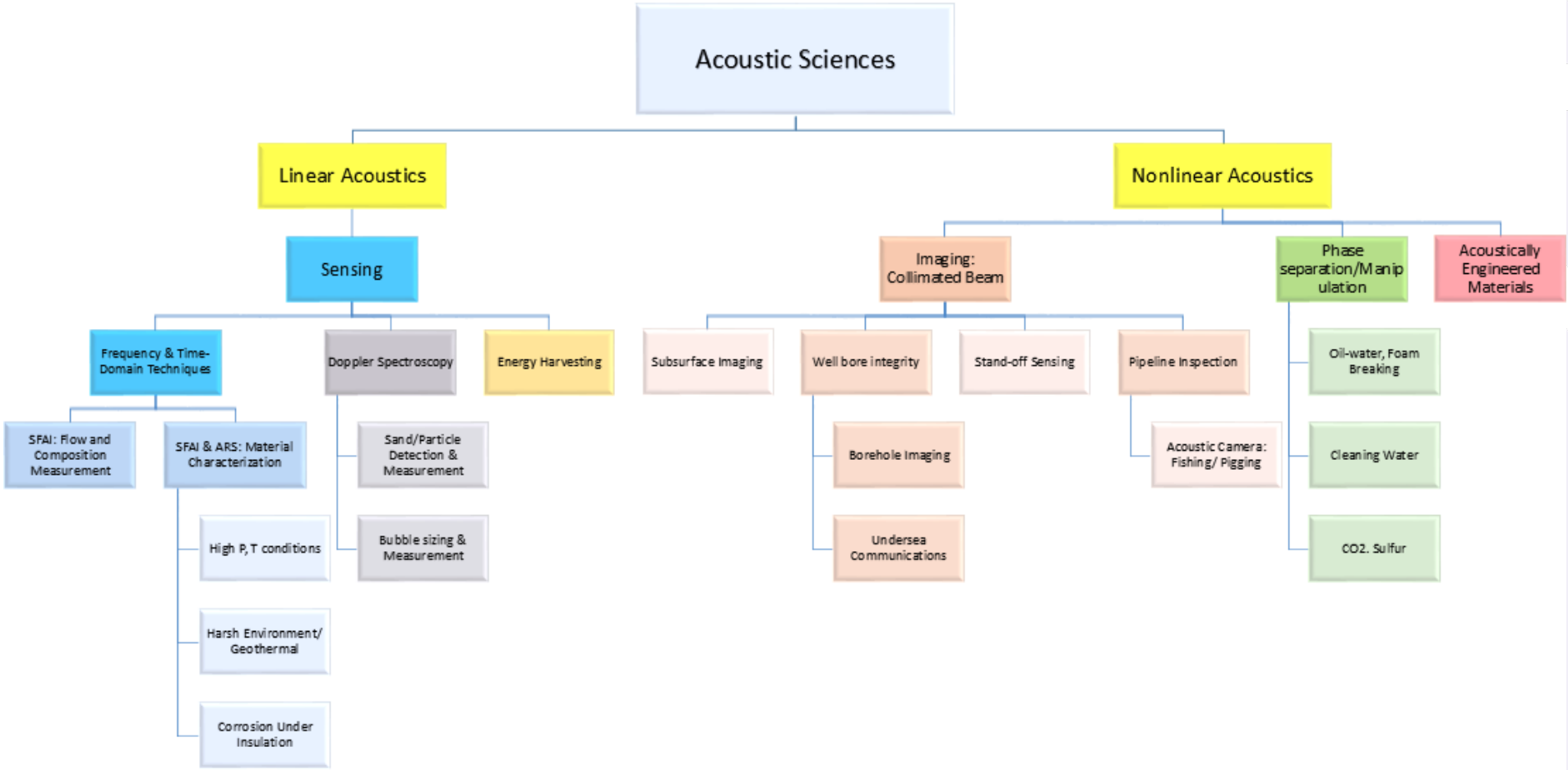
Grad Student
Instrumentation development
LabView programming
D_2O content in heavy water

Our research - Applied Acoustics

Development of instrumentation, methods and sensors with a focus on difficult and challenging conditions (high pressure, high temperature, corrosive media, radiation, etc.)

Sensing **Manipulation with sound**

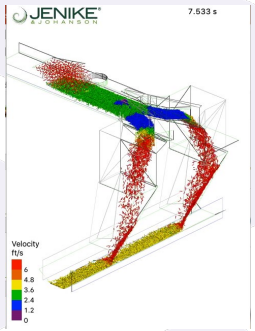
Applied Acoustics Lab Capabilities



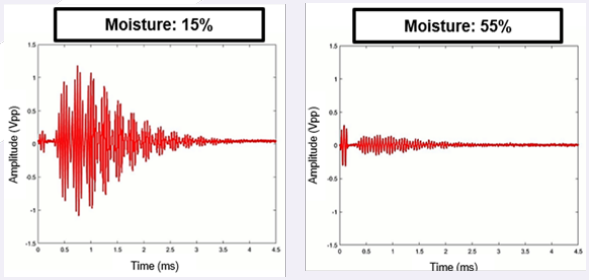
“Smart” Transfer Chutes with In-line Acoustic Sensors for Bulk-Solids Handling Solutions

- **Objective:** Develop innovative solids handling equipment (1) and unique in-line acoustic measurement sensors (2, 3) that improve operational reliability, safety, throughput, and yield of biorefineries.
- **Current limitations:** for moisture sensing: cost, durability, complexity, reliability, sampling volume, and continuous monitoring. There are no known commercial sensors for real-time monitoring of plug-screw feeder wear or commercial chutes with the ability to change configuration to discard problematic feedstock.
- **Relevance:** This project directly aligns with the long-term goal of FCIC, and the challenges identified in the ADO and Biorefinery Optimization Workshops by developing novel bulk solids handling equipment specifically designed for biomass material, and developing novel acoustic sensors addressing the long-standing, well-known IBR bulk solids handling challenges

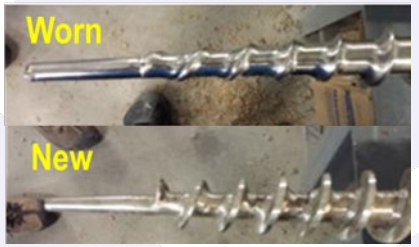
1. “Smart” Chute

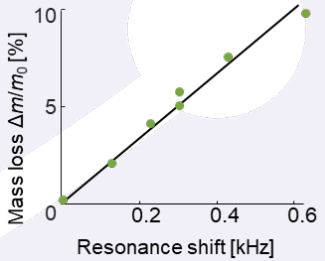


2. Moisture Sensor (corn stover)

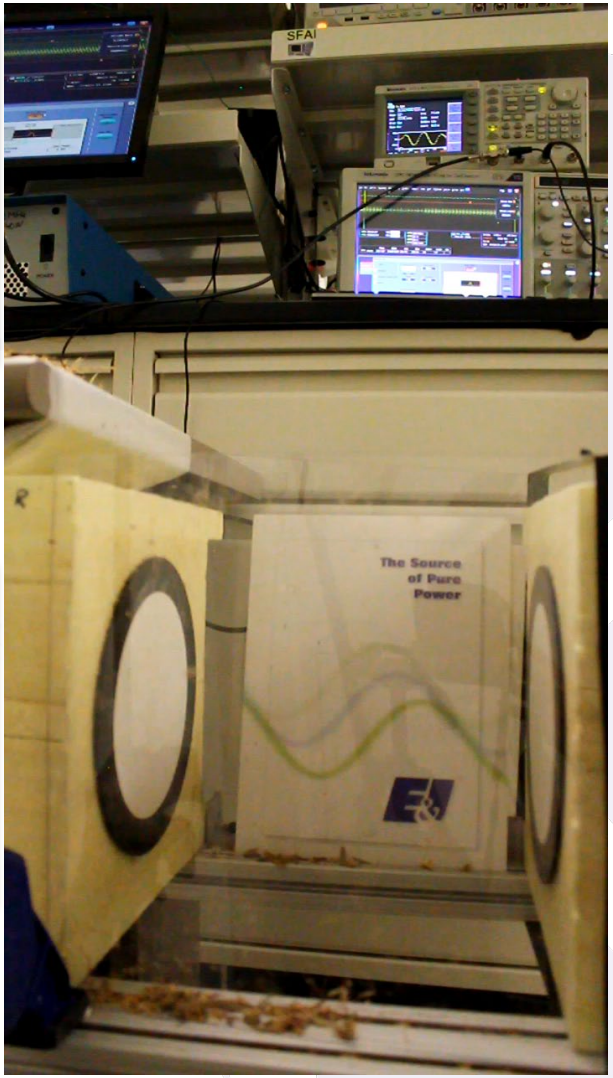


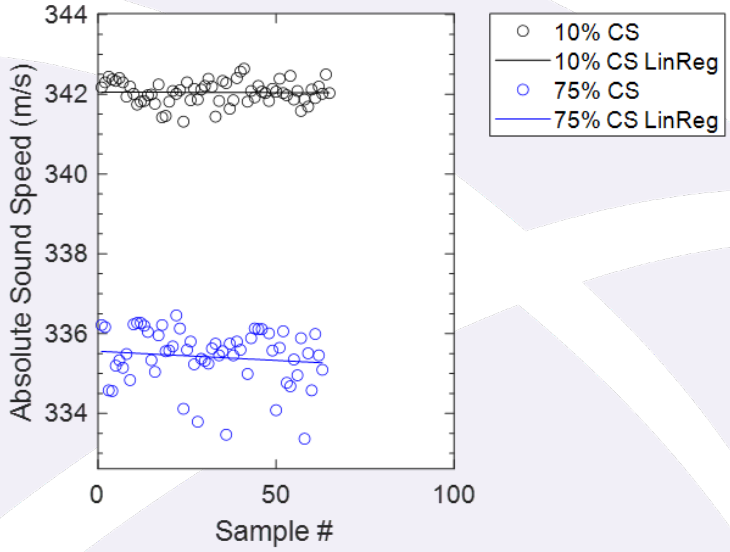
3. Wear Sensor

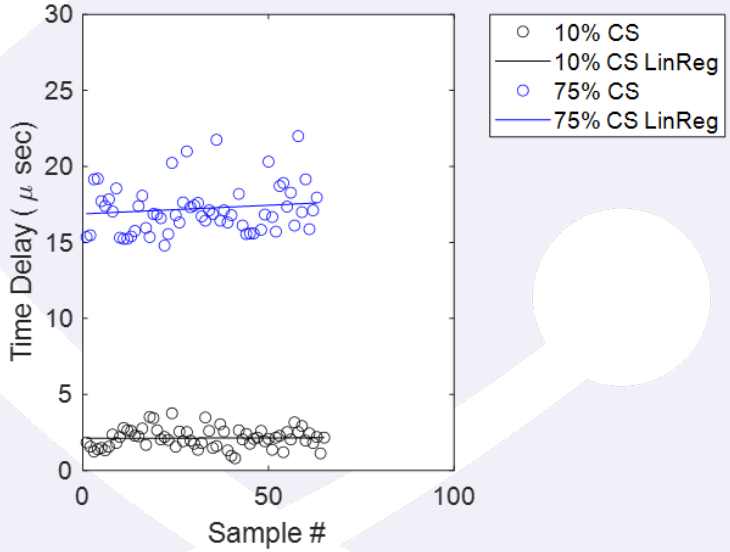




Acoustic moisture sensor







Acoustic wear sensor for plug-screw feeder

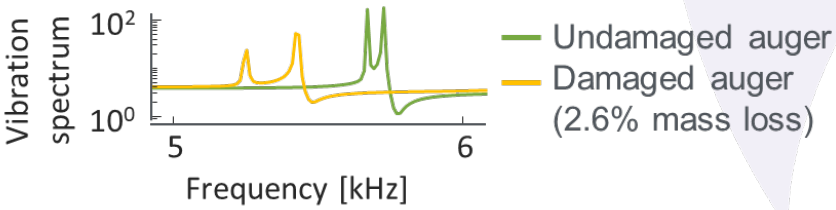
***In operando* monitoring of plug-screw feeder wear state**

Real and simulated augers

Undamaged auger

Damaged auger

Simulated vibration spectrum



Description

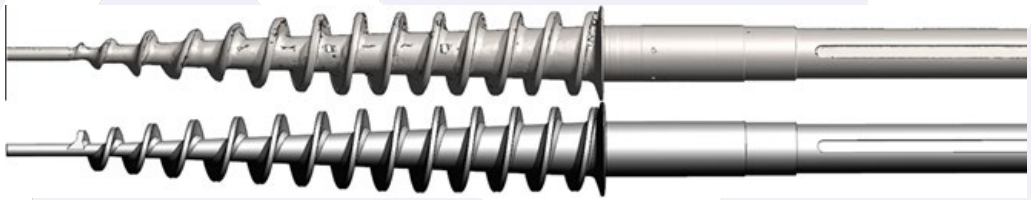
- Continuous real-time wear monitoring of plug-screw feeder

Value of new tool

- Offers advanced process control strategies
- Increases IBR plant operational safety
- Increases IBR time-on-stream
  - Decreases maintenance downtime & costs (i.e., failures)

Potential Customers & Outreach Plan

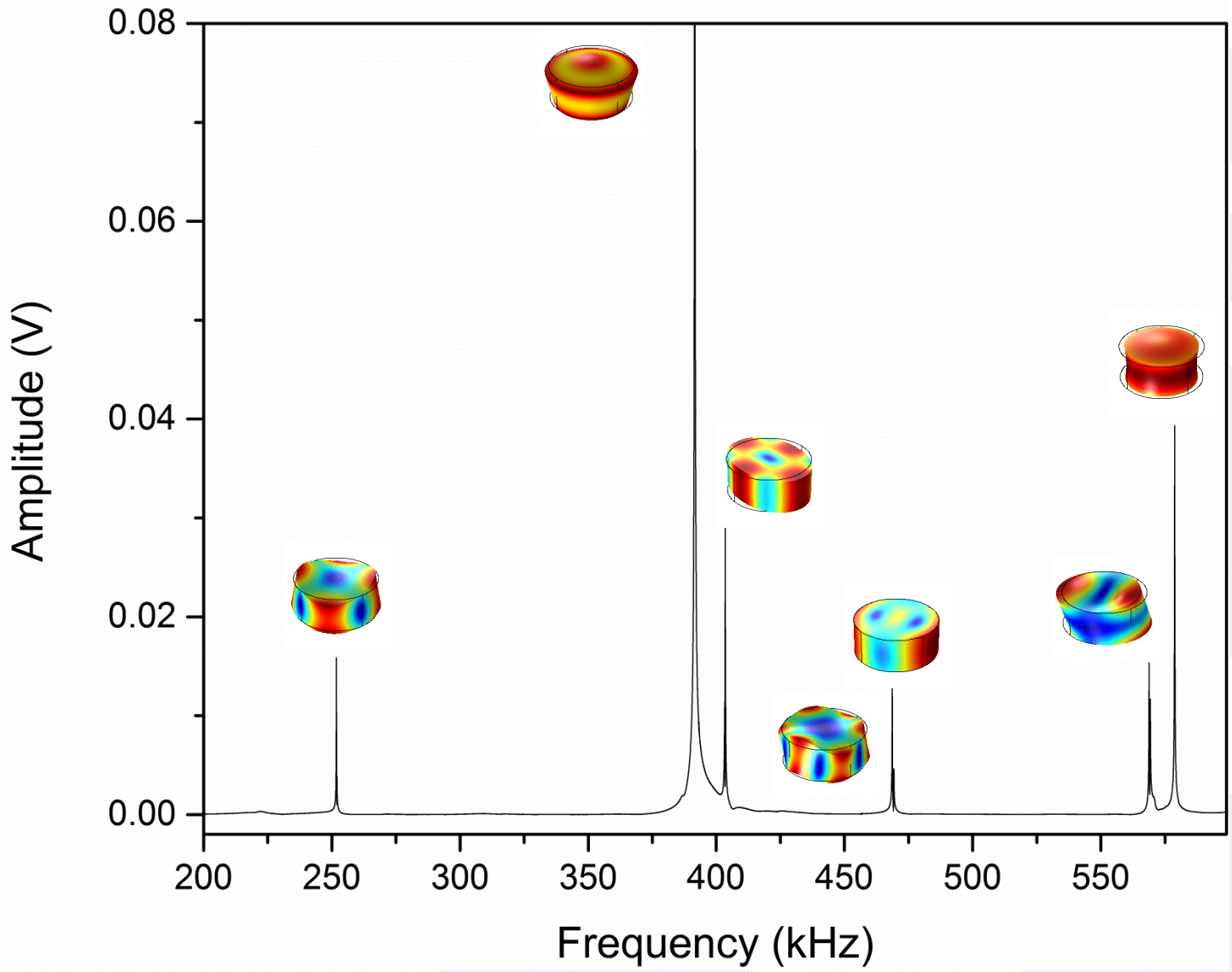
- IBR plants, additive manufacturing, mining,
- Tech transfer and commercialization



Applications of Acoustic Techniques

Observe mechanical resonances of objects to determine physical properties of fluids and elastic properties of materials

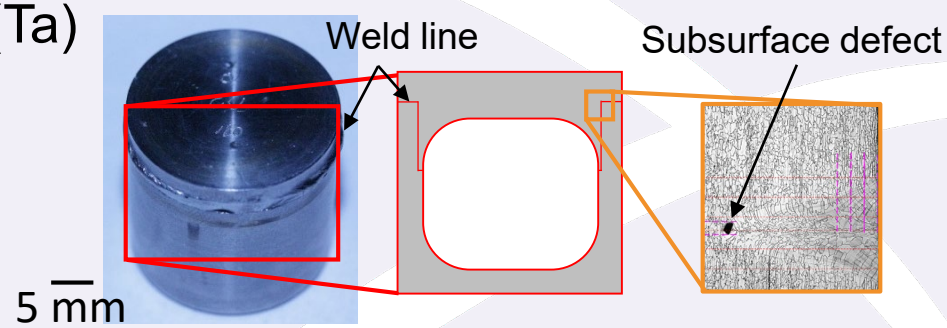
Fluid inside pipe



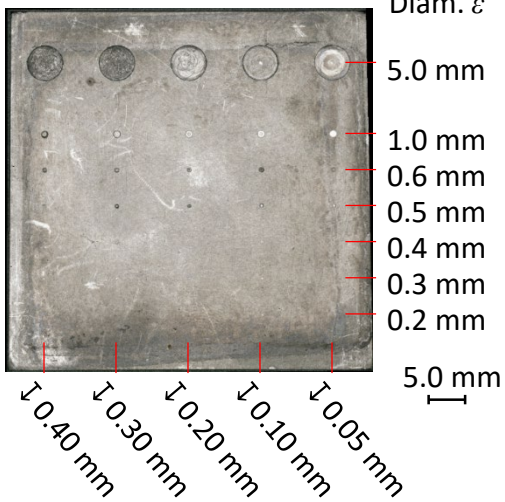
Applications of Acoustic Techniques

Acoustic weld defect detection

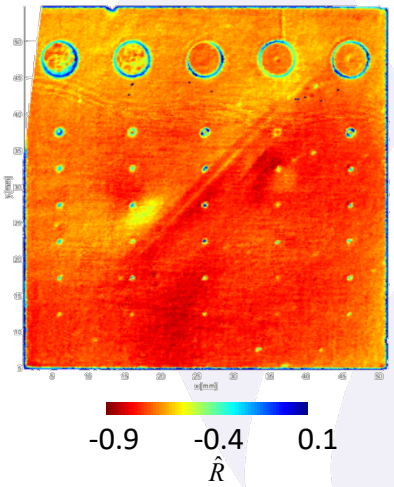
- Weld detection in dense materials (Ta) challenging for radiography
- Solution: scanning acoustic microscopy



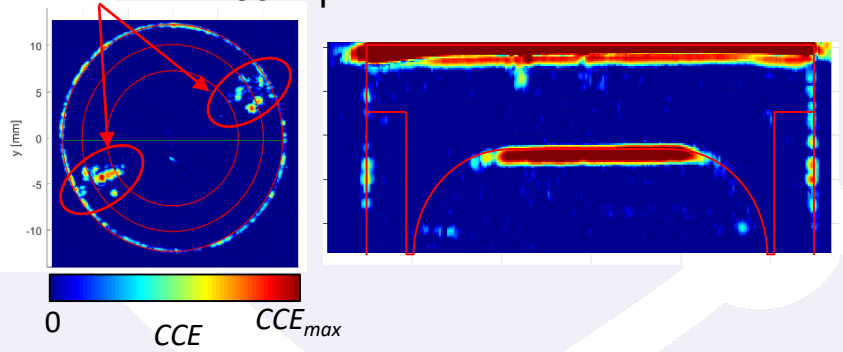
Optical microscopy of Ta plate



Acoustic microscopy of Ta plate



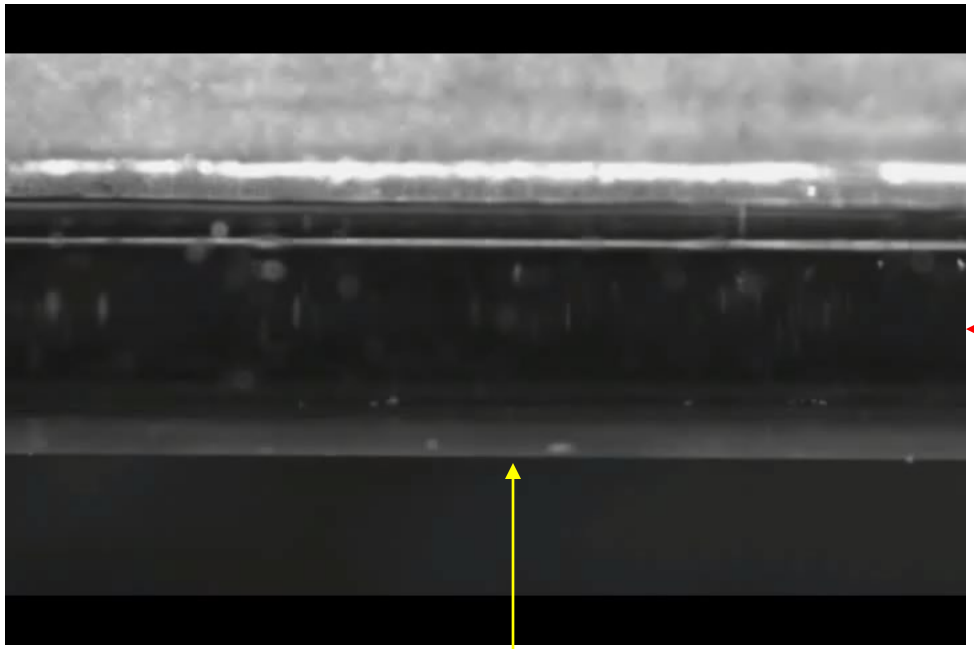
Inclusions intentionally introduced 180° apart



Concentration of Particles in a Tube

Sound field is turned ON and OFF.

Piezoelectric Transducer @ 1.5 MHz

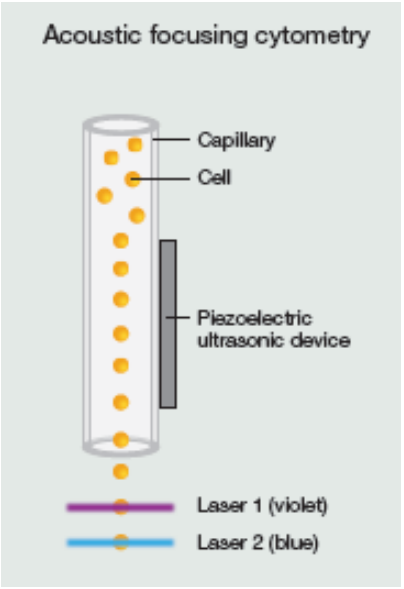


600 μm capillary, Flow~ 200 μL/min

20 μm polystyrene beads

Real Time Video

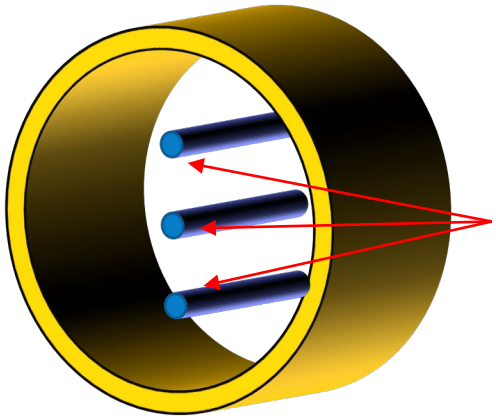
Acoustic Flow Cytometer



Biological cell analysis

Thermo Fisher Scientific

Acoustic Separation of Humidified Air



Nodal lines

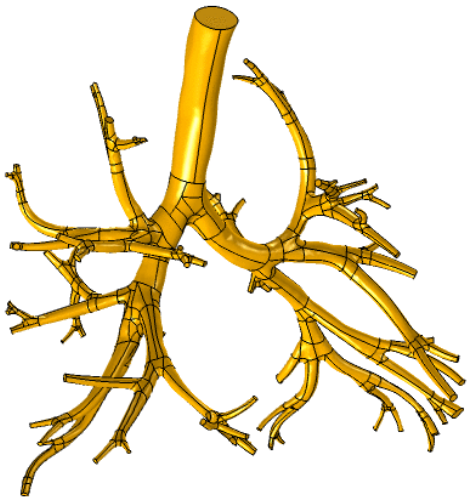
The video (real-time) shows the separation of mist from humidified air and concentrating the mist acoustically inside a hollow cylinder using sound. Once the mist is concentrated, It can be taken out of the system. Various types of implementation are possible and this is simply a proof-of-concept to show what is possible with sound.

Applications of Acoustic Techniques

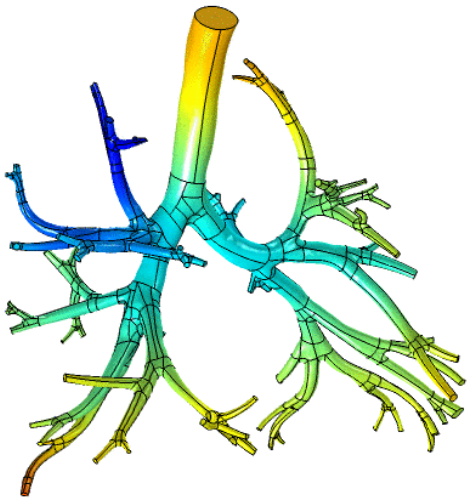
IPV – targeted excitation of lungs (1)

- Intrapulmonary percussive ventilation (IPV): Applies periodic bursts of air/aerosolized medication down the trachea to improve air absorption and mucus clearance
- Currently, no good understanding of optimal parameters (frequency)
- We simulate how frequency affects sound penetration in lung bronchi

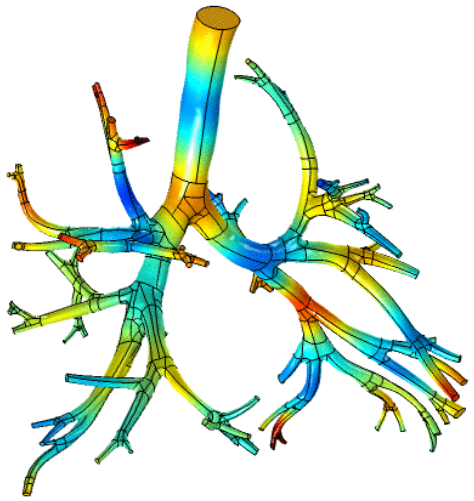
0.001 kHz (typical for IPV)



1.54 kHz



7.44 kHz

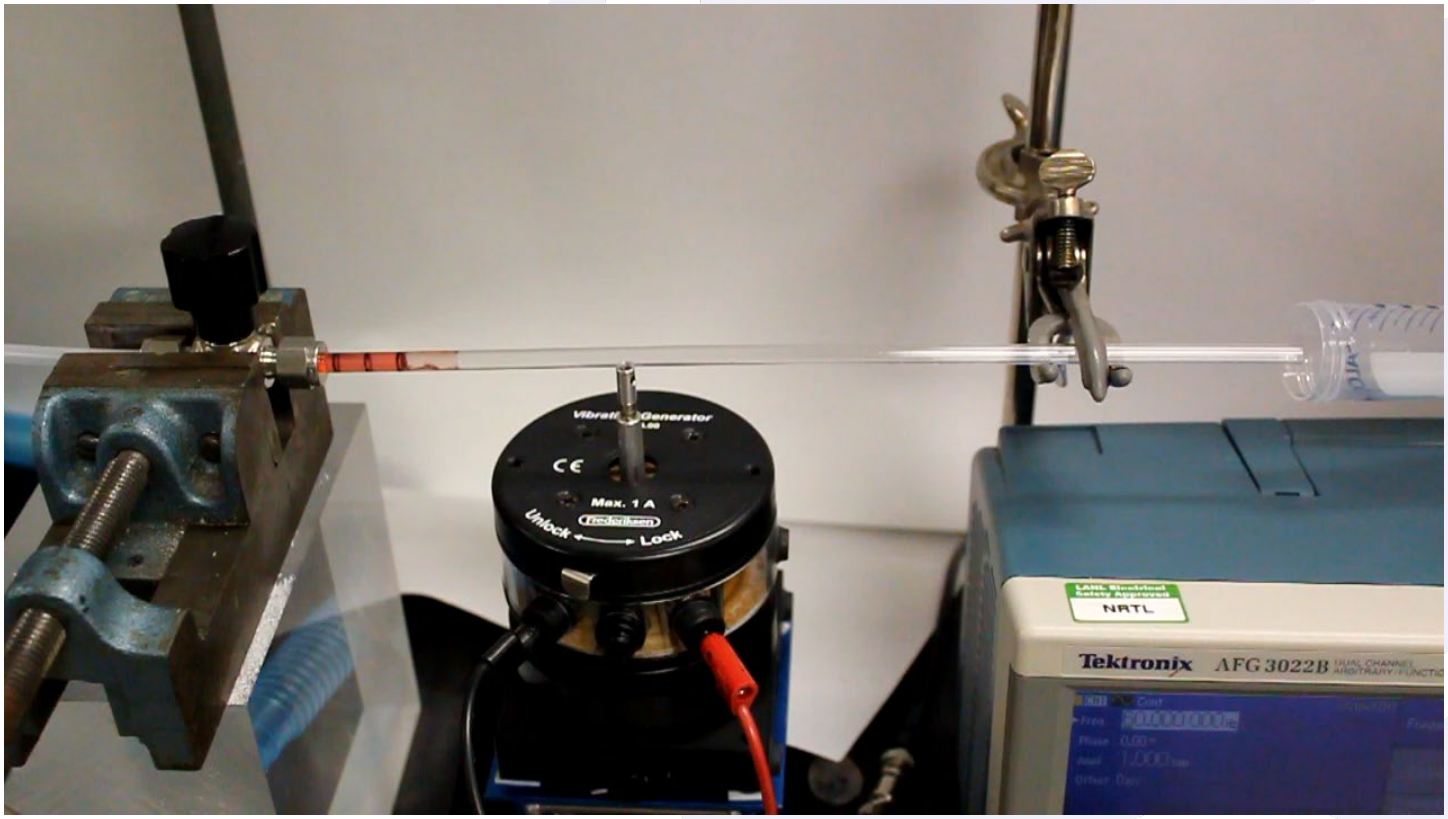


Funded by DOE Office of Science through the CARES Act (the Coronavirus Aid, Relief, and Economic Security Act)

Applications of Acoustic Techniques

IPV – targeted excitation of lungs (2)

- Proof-of-principle: use vibrations to improve mucus clearance from a channel

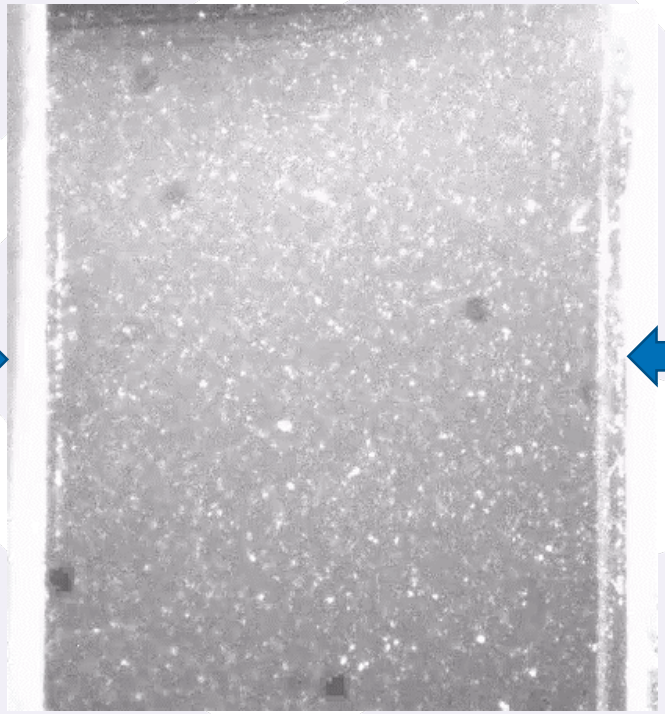


Applications of Acoustic Techniques

Non-invasive mechanical separation of any two-phase system (e.g., liquid-liquid, liquid-solid, gas-liquid, etc.,) using sound

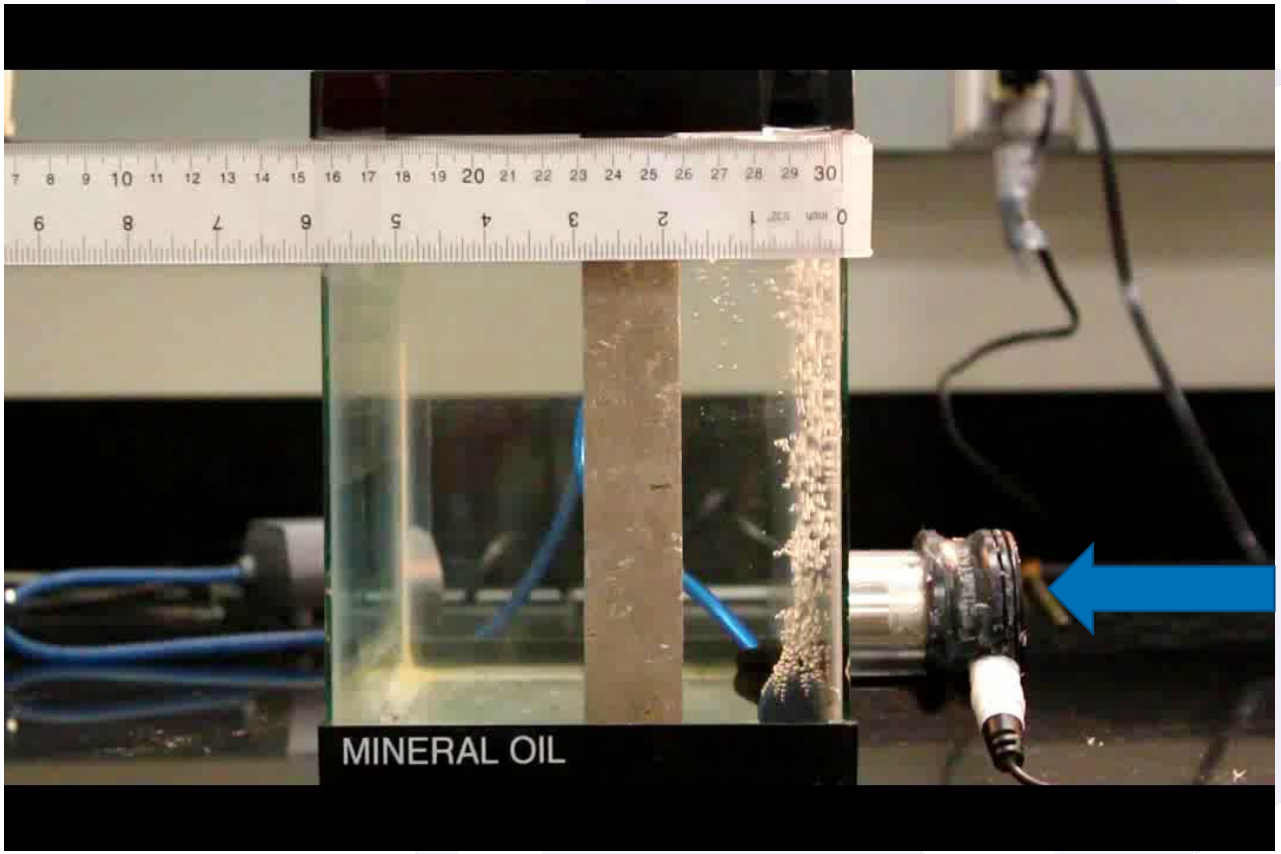
Liquid-Liquid

Solid-Liquid



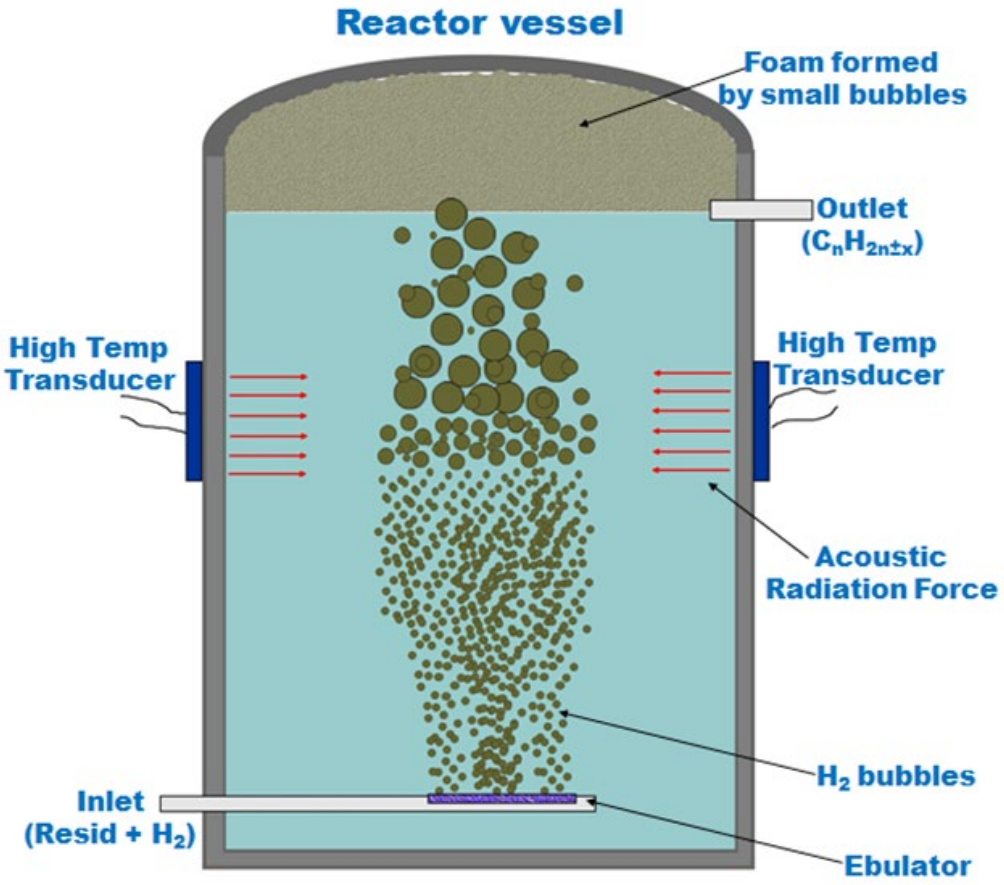
Applications of Acoustic Techniques

Manipulation of gas bubbles, liquid droplets, and solid particles with sound



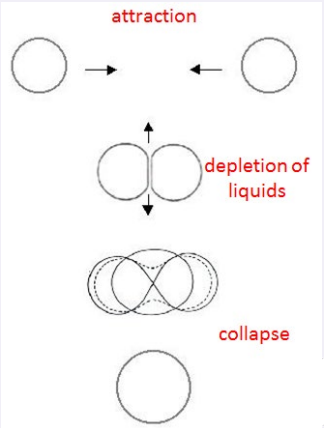
Applications of Acoustic Techniques

Ultrasonic foam mitigation



Particles/bubbles suspended in the liquid, will be moved to the nodes/antinodes of the standing waves by the **Acoustic Radiation Force**

Outcome of attracting bubbles



~ 1 MHz

Applications of Acoustic Techniques

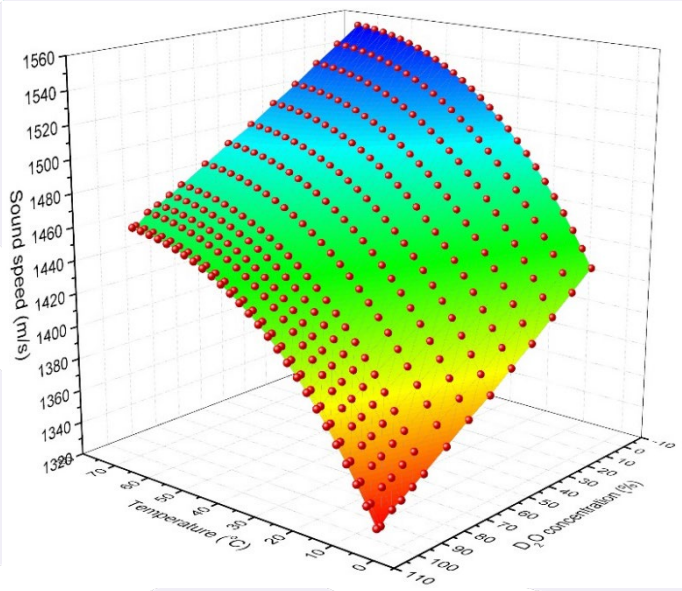
Heavy Water Production Monitoring

A New Challenge for the IAEA

Arak Heavy Water Production Facility
Girdler sulfide process + distillation

We can measure accurate and precise sound speed, to the first decimal point

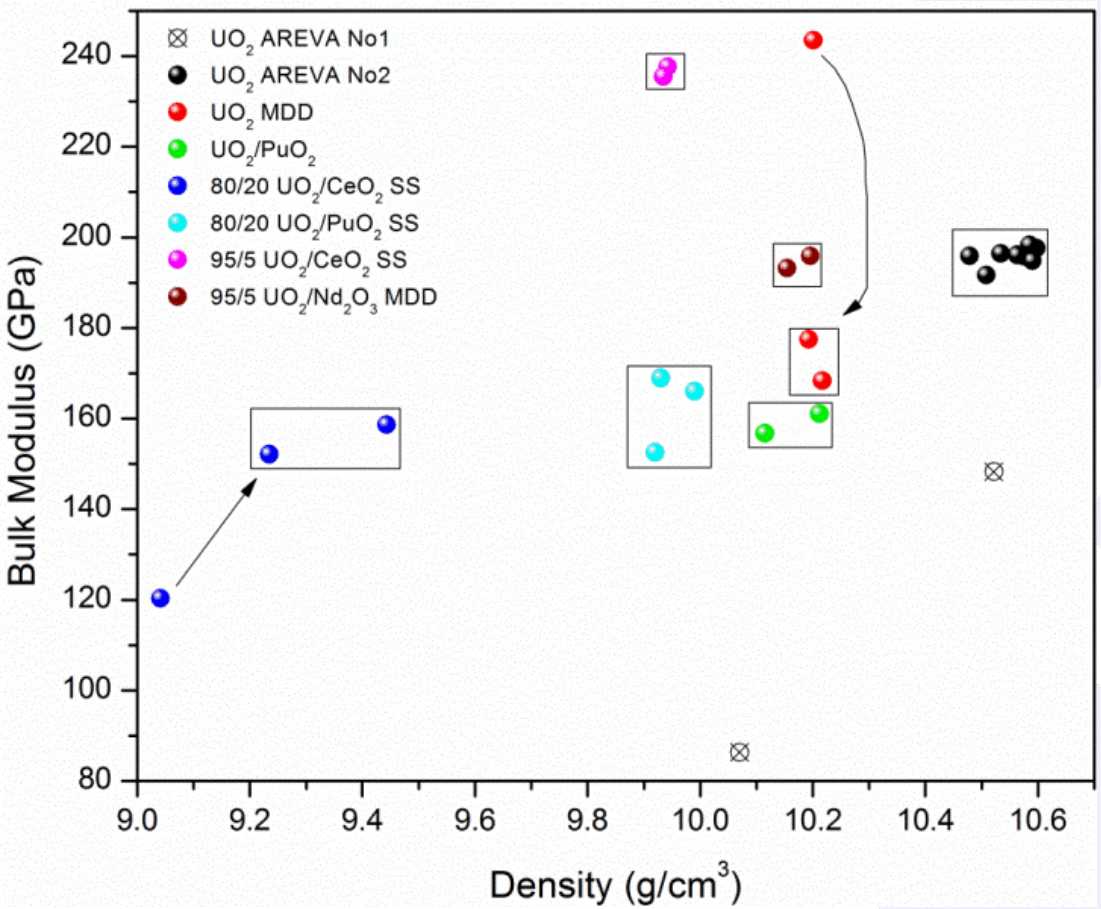
→ high precision/accuracy for D_2O concentration, ~ 0.1%



Applications of Acoustic Techniques

Nuclear materials identification

- **RUS - a nondestructive, very difficult to spoof, well-tested measurement method.**

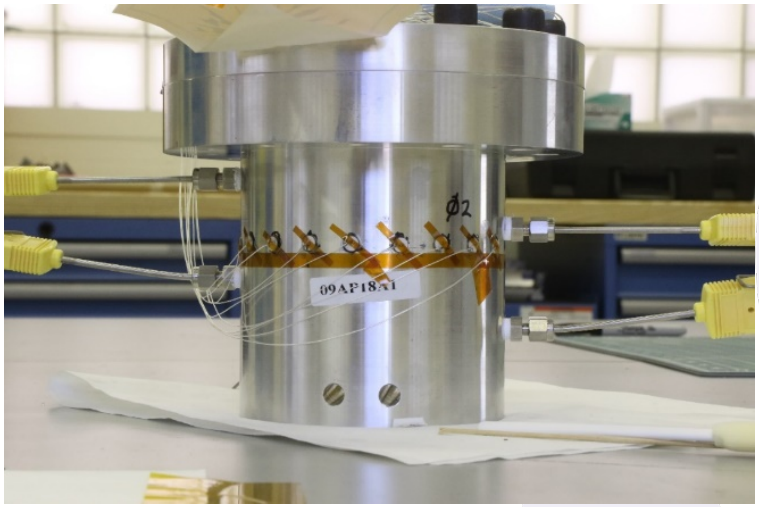


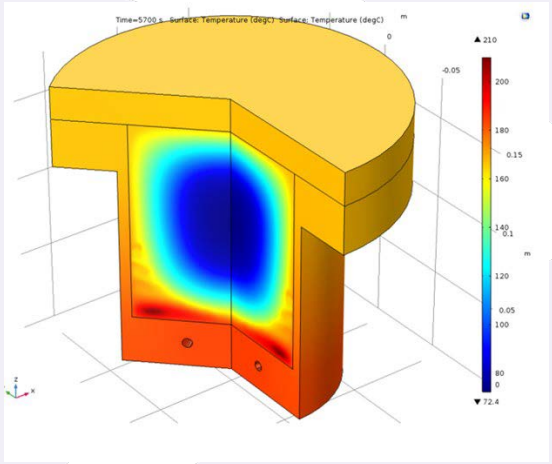
Good correlation between the elastic moduli and density for samples of different compositions/origins.

Able to identify nuclear material composition, fabrication method and source by measuring its RUS properties.

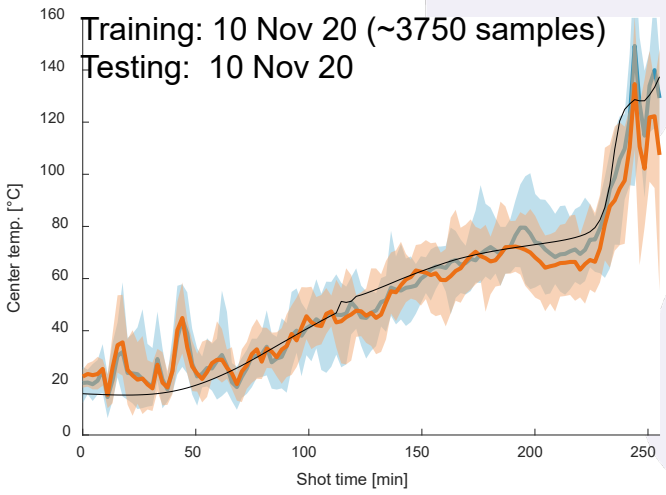
3DHEAT (3 dimensional high explosive acoustic temperature)

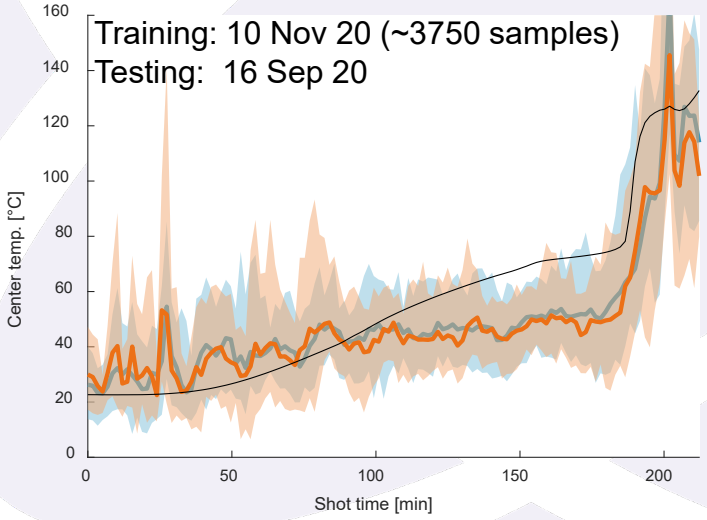
Acoustics diagnosis of thermal damage in Pentolite





Machine learning, CNN (convolutional neural network)





Thank you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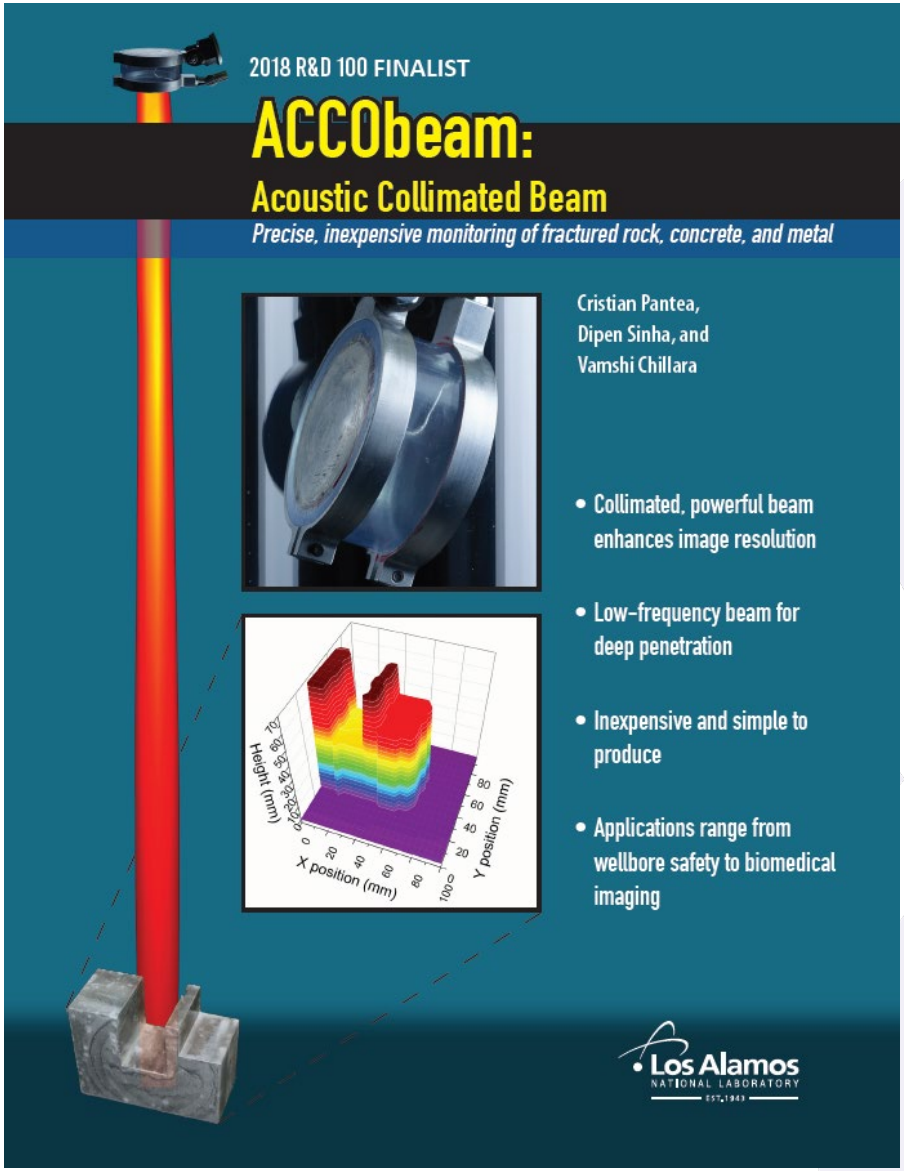
ACCObeam


2018 R&D 100 FINALIST
ACCObeam:
Acoustic Collimated Beam
Precise, inexpensive monitoring of fractured rock, concrete, and metal
Cristian Pantea,
Dipen Sinha, and
Vamshi Chillara
• Collimated, powerful beam enhances image resolution
• Low-frequency beam for deep penetration
• Inexpensive and simple to produce
• Applications range from wellbore safety to biomedical imaging
Height (mm)
X position (mm)
Y position (mm)
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