ILI Innovation in UT Technology

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Agenda

1. Brief Introduction
2. Small Diameter EMAT ILI
3. Gas-coupled Ultrasonic ILI

“Innovation, like evolution is a process of constantly discovering ways of rearranging the world into forms that are unlikely to arise by chance – and that happen to be useful.”
- Matt Ridley, How Innovation Works

A Mini History Starting in 1991

MICROLINE → mears A QUANTA SERVICES COMPANY

→ Q-INLINE Quanta Inline Devices →

Qi2 Superior Inspection Intelligence ELEMENTS PIPELINE RESOURCES

Doing a lot with a little

- Personnel
  - Highly trained technicians
  - More Level 3 Analysts than Level 1
- Insight Analysis Software
  - Fast, accurate reporting
  - Client interface is very user-friendly
- Advanced Technology

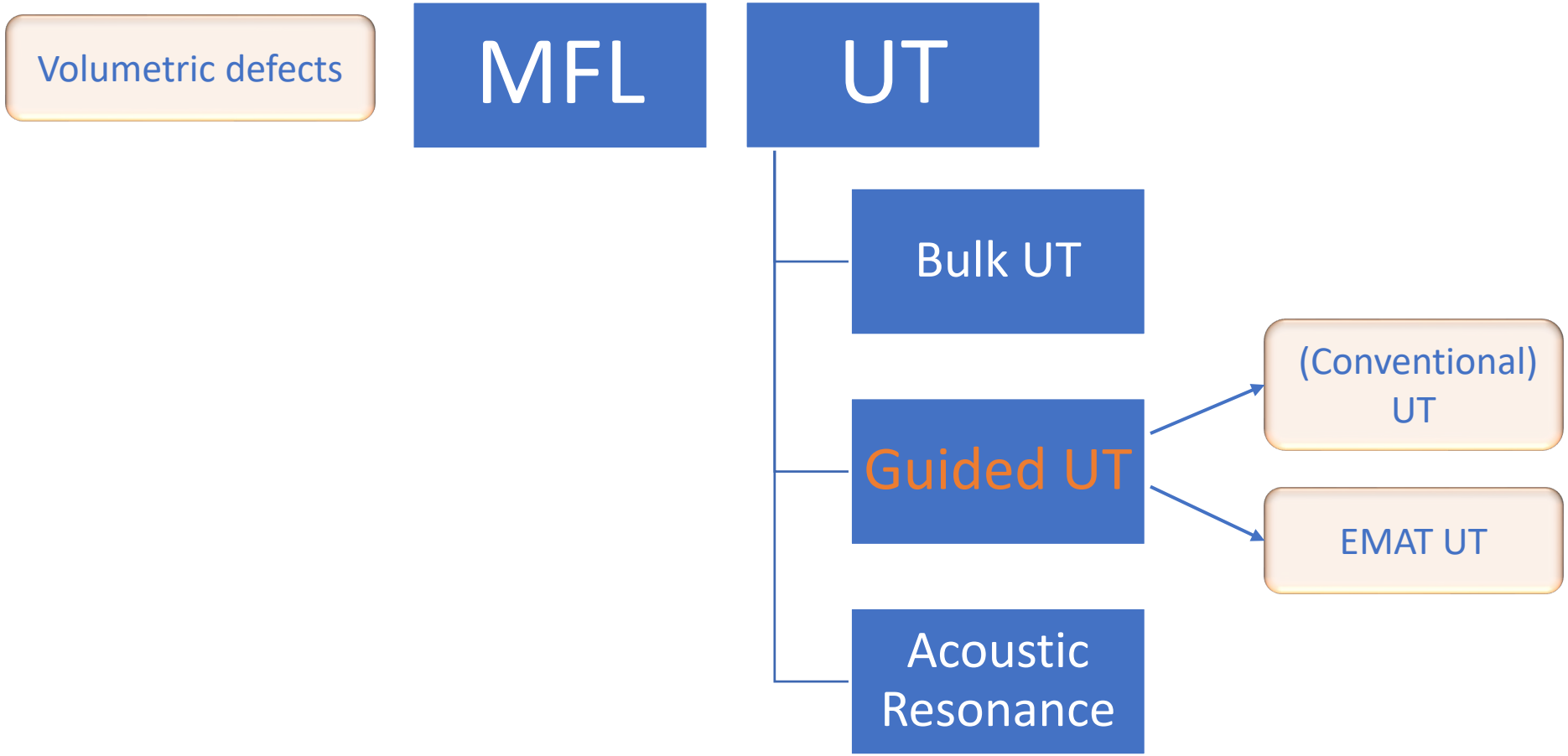
Small Diameter EMAT

Crack Detection

What's the problem?

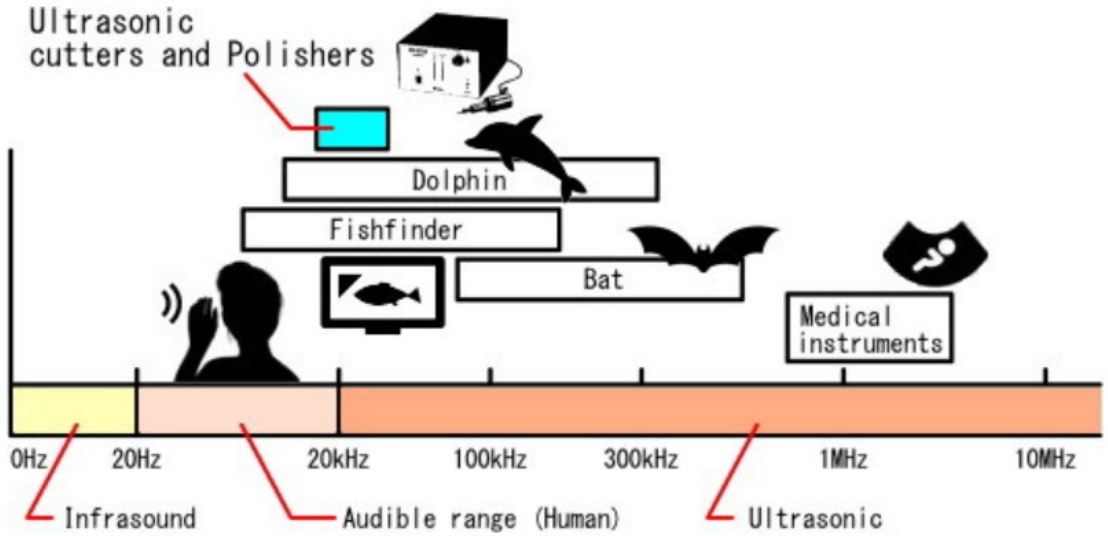
We need a reliable ILI system for assessing gas pipelines for cracks.

Sensor Types



Ultrasonic Technology

- A sound wave is a vibration that is transmitted through a medium.
- An ultrasonic wave is defined as an “inaudible sound wave, which humans cannot hear.”



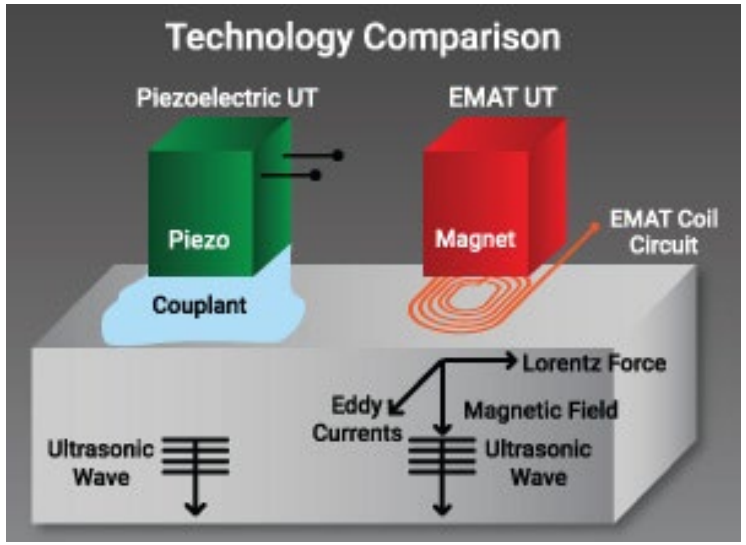
What sound does a pipeline make?

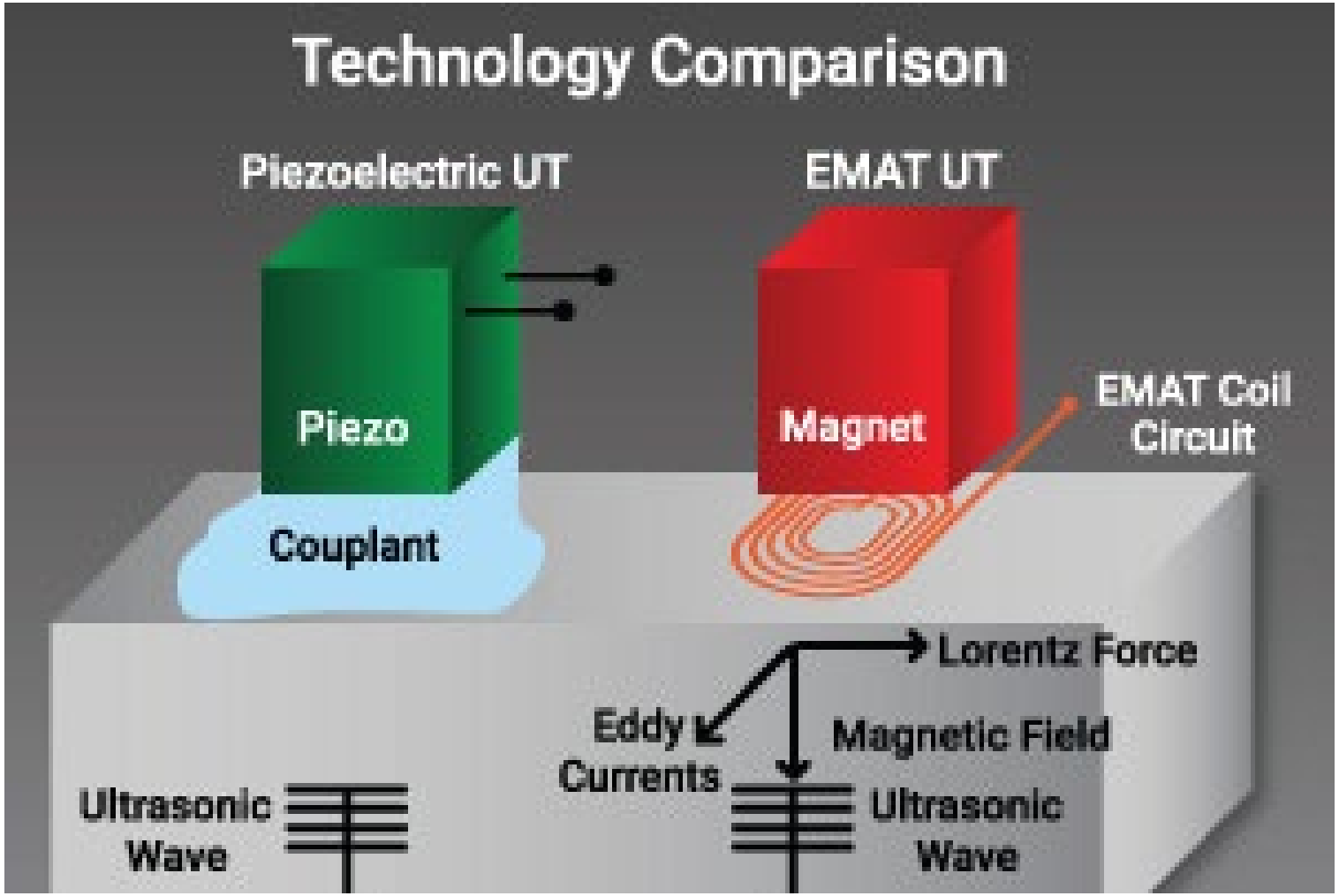
Although hammering the pipeline will generate sound within the pipe wall… the signal response is not going to tell you much!

Propagating ultrasonic waves

- Piezoelectric UT
  - A signal is produced by the transducer and transmitted into the pipe wall and back through a liquid medium.

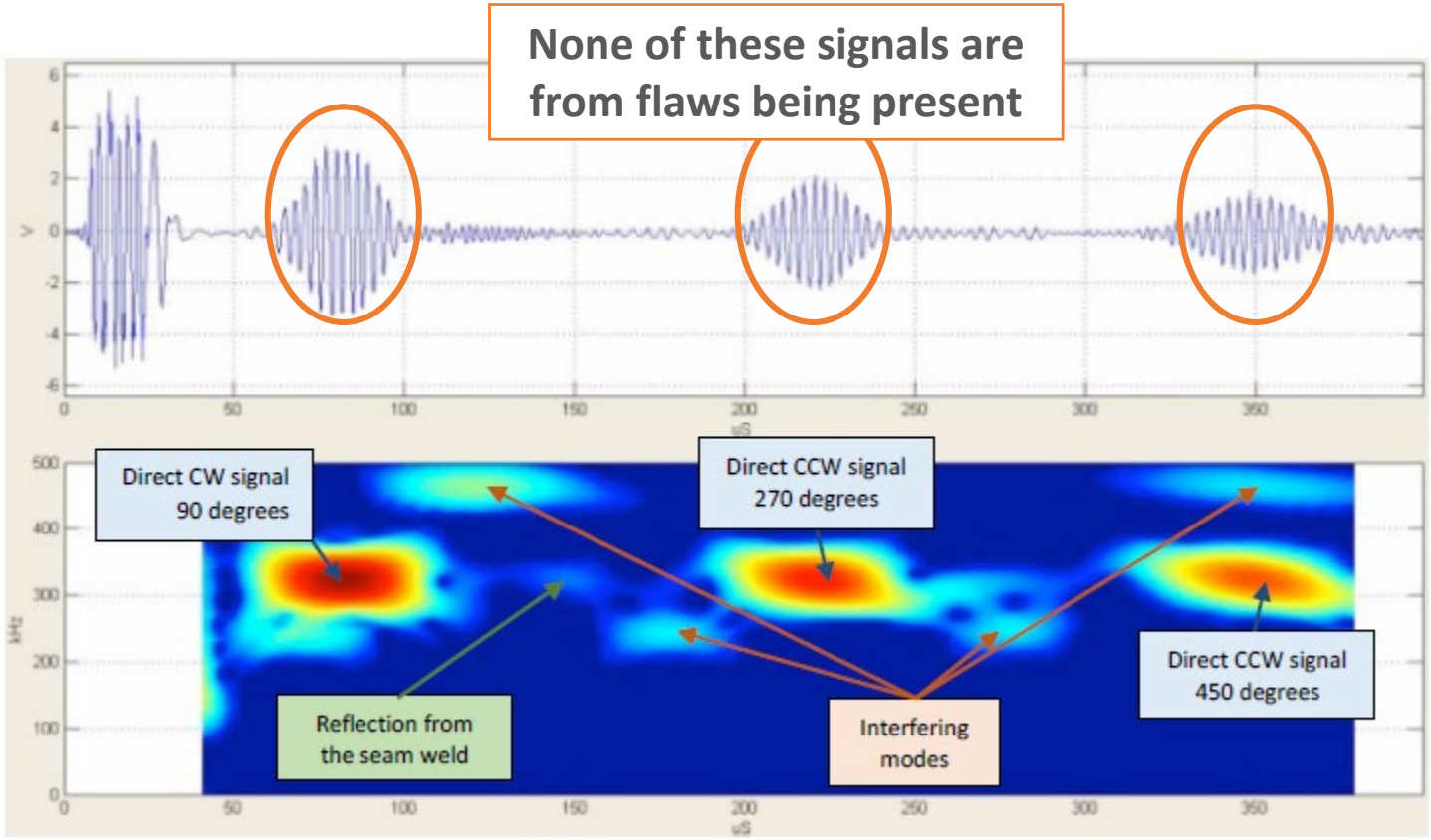
- EMAT UT
  - Uses electromagnets to generate that sound wave within the pipe wall itself.





Piezo-electric UT and EMAT are the most preferred ultrasonic method as they can be electrically manipulated to realize the generation and reception of complex but controlled acoustic phenomena.

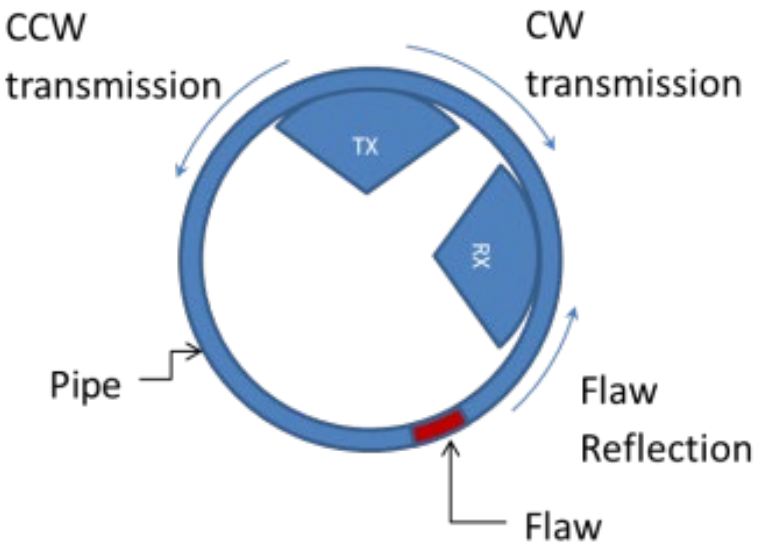
What's the EMAT Problem?



Signal noise!

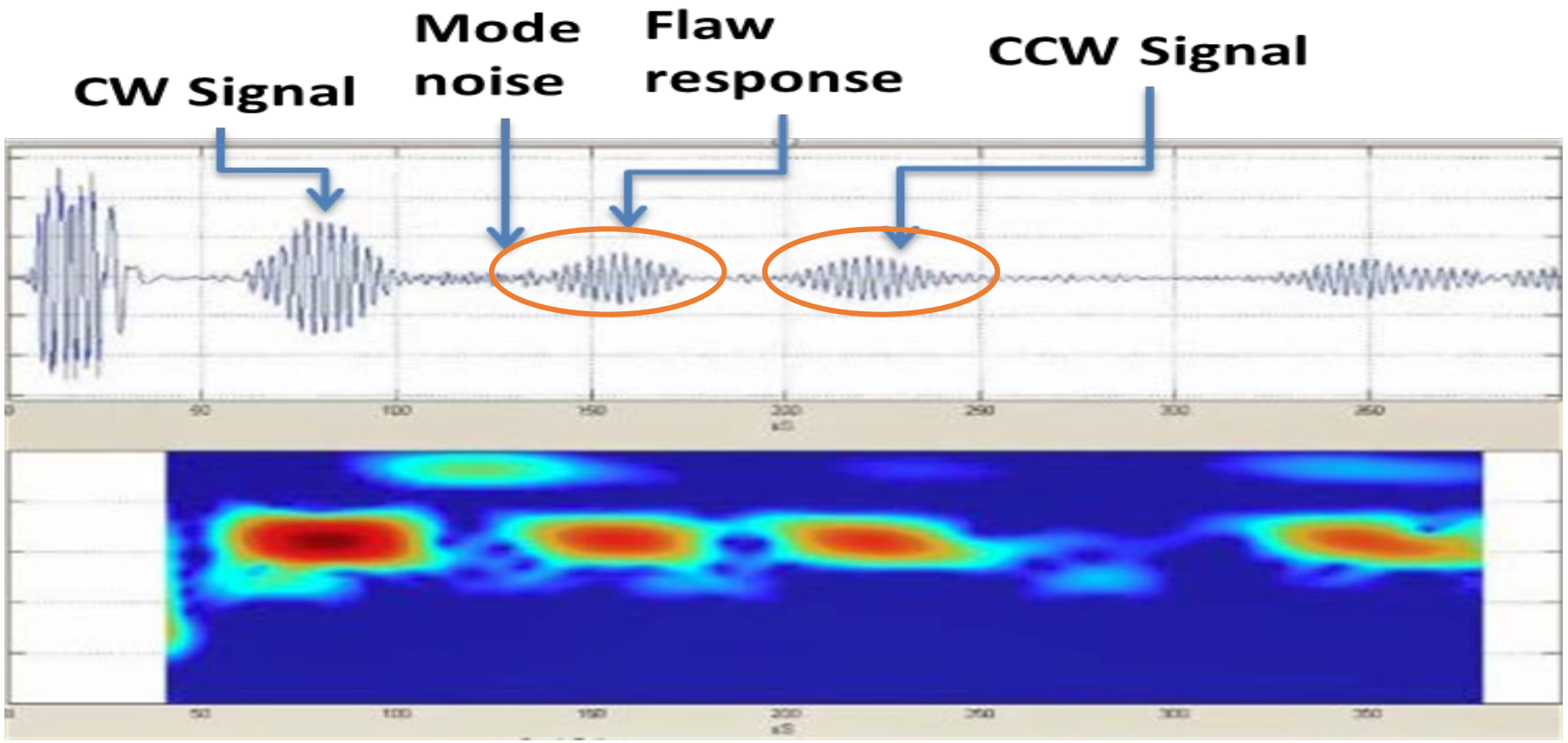
“Noisy” Data

- Small diameter = multiple reflections = signal congestion
- Difficult to discern what is a reflection and what is a flaw signal



“Failure is only the opportunity to begin again more intelligently.”
– Henry Ford

Flaw Response is difficult to discern



What's the Solution?

Un-Constrained

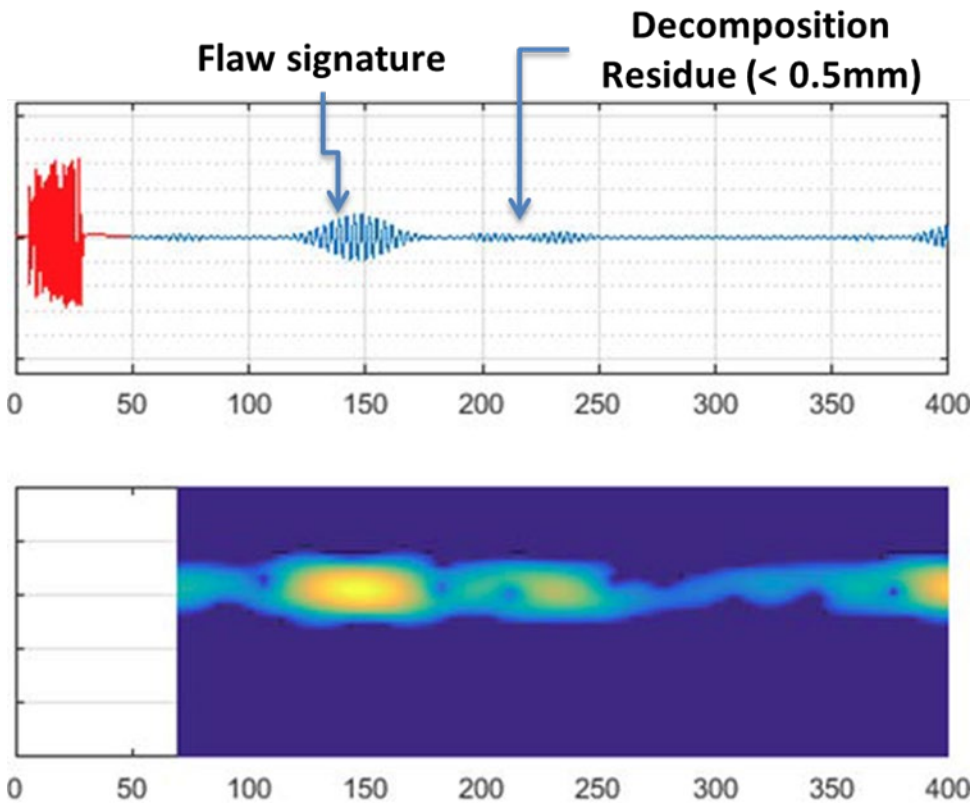
- Creating v sophisticated algorithms by analyzing lots of actual vs. predicted data to filter out noise (read: so many digs!)

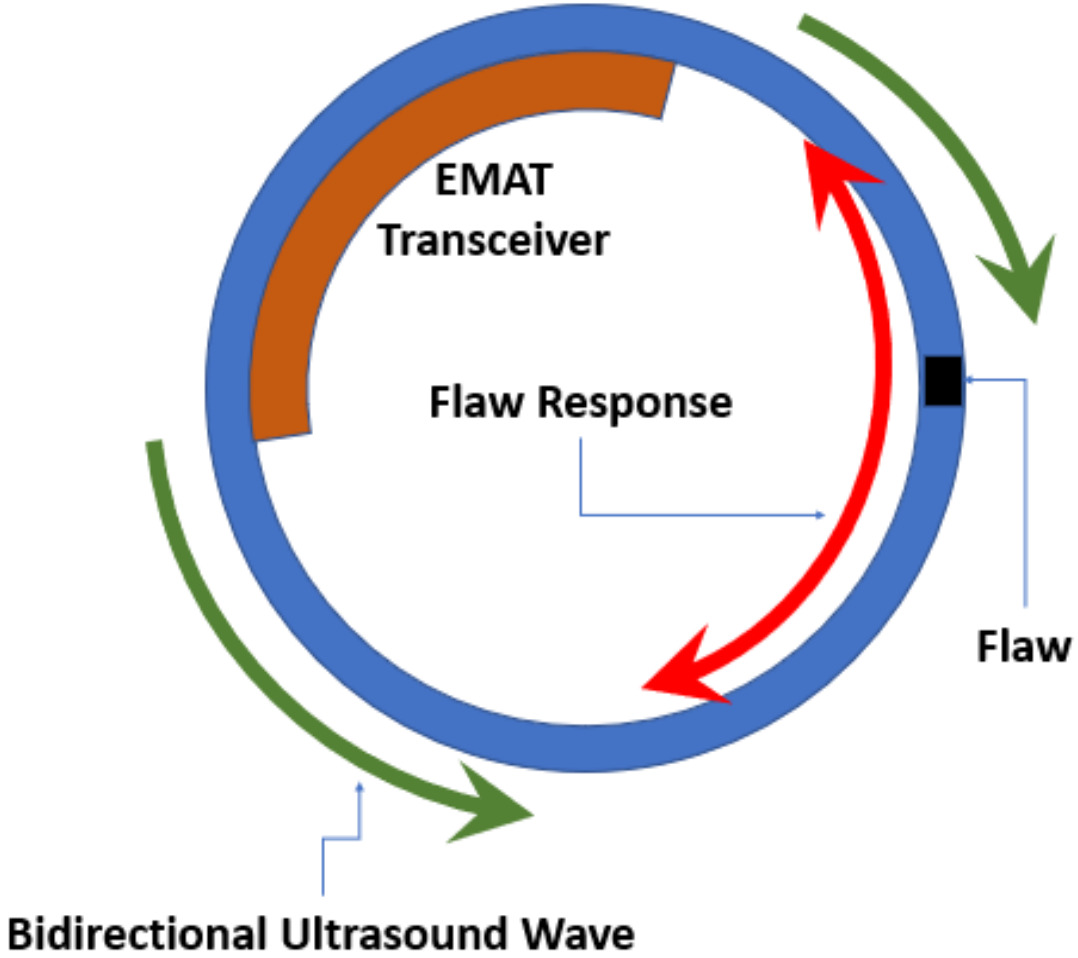
Constrained by Diameter

- Redesign the transducer to eliminate unnecessary noise on the front-end.

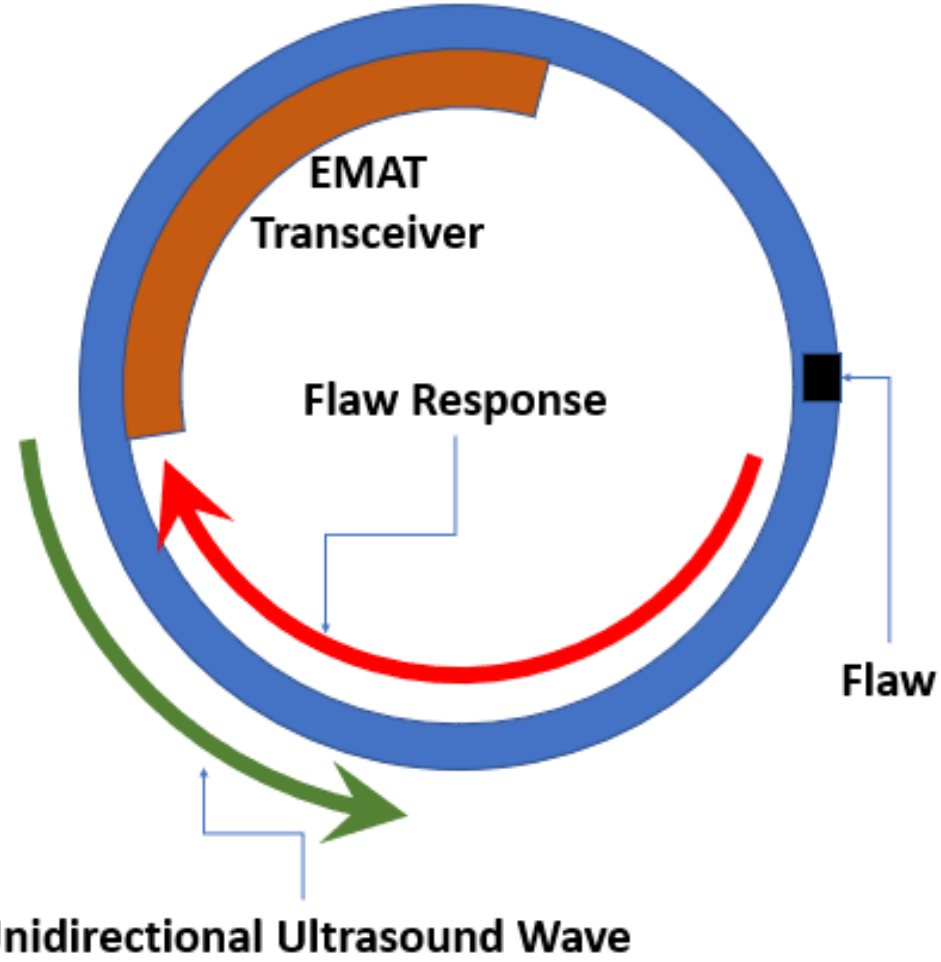
Unidirectional Ultrasound

- Send out one wave in CW direction
- CW wave is the interrogation signal
- CCW wave contains only flaw information





Conventional Tool



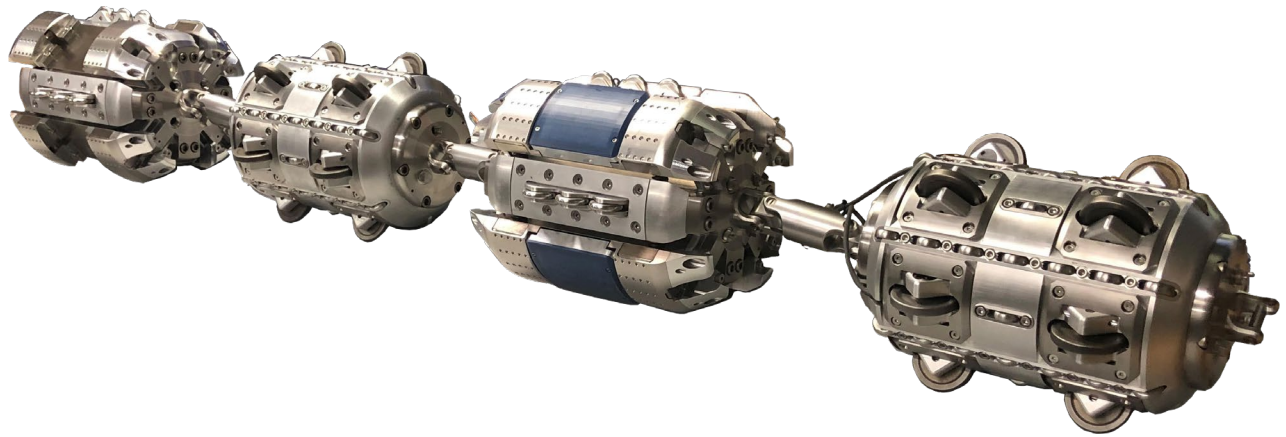
Qi2's Tool

Transciever = Transmitter + Receiver

Significant improvement in signal-to-noise ratio

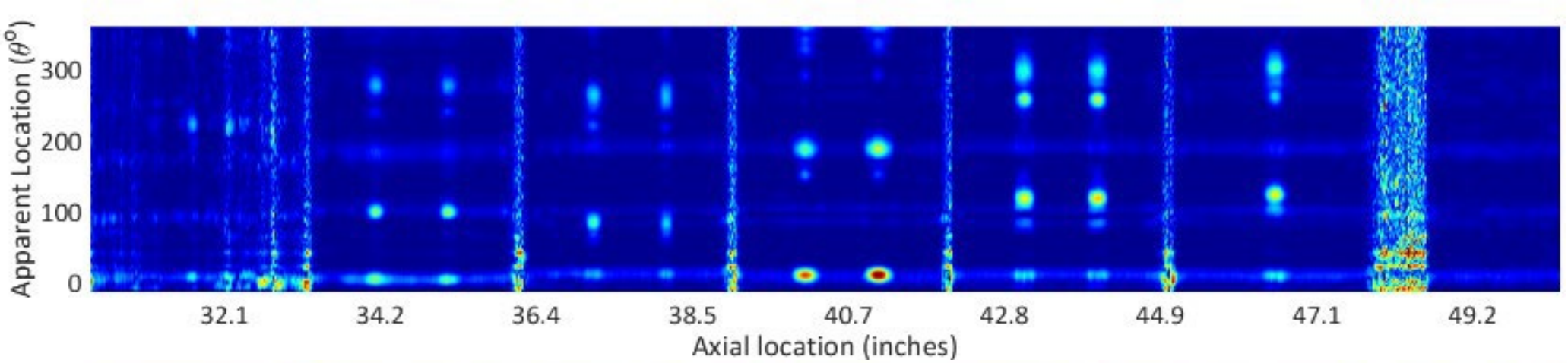
- Modified flaw sizing algorithm: wave only travels around the pipe once.
- More powerful magnets: Increases signal strength and therefore flaw signature response in relation to “noise.”
- Redundant coverage in 6’’ and 8’’: Dedicated modules interrogate flaws in each direction (CW & CCW), which will help improve POD and POI.

Creativity loves constraints!

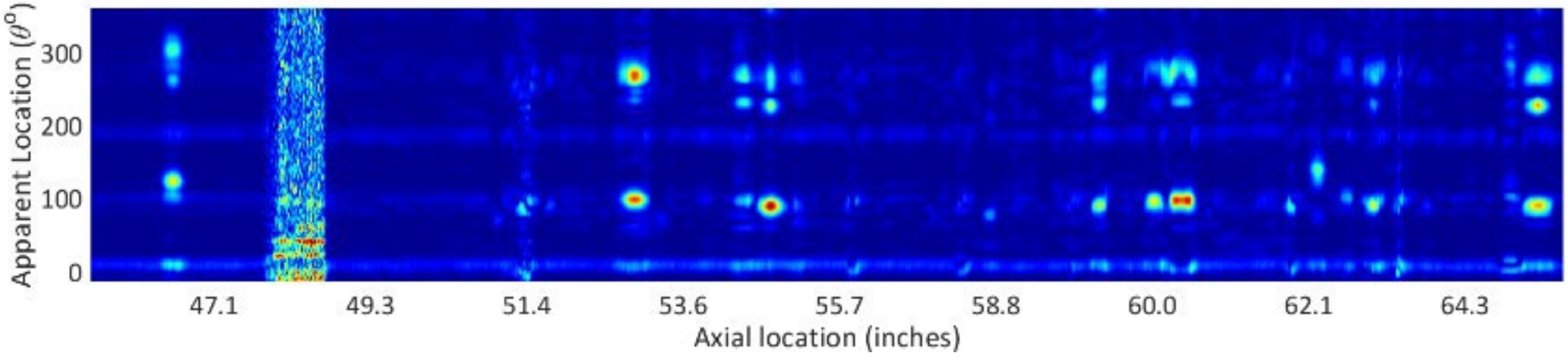


EMAT Combo Tools?

Cracks



Wall Loss



EMAT VS. UT

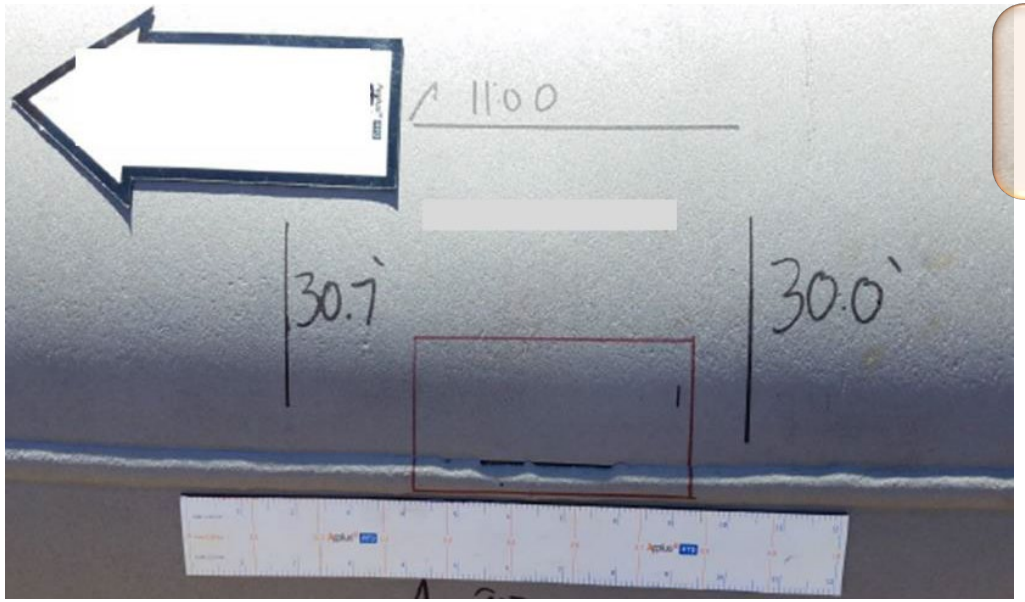
- Because the sound is generated in the part inspected instead of the transducer, EMAT is a completely non-contact technique.
  - Inspectioneering

- Advantages include less degradation of performance from:
  - Surface cleanliness
  - Speed
  - Curvature of the surface
  - Temperature of the steel

PRCI NDE 4-12 Participation

2021: Investigating crack and crack-related defects interactive with the long seam including:

- Fatigue cracks
- Hook cracks
- Lack of fusion defects
- Laminations



In conjunction with API and AOPL

Navigability for small diameter and low-flow pipelines (8’’, 10’’, 12’’)

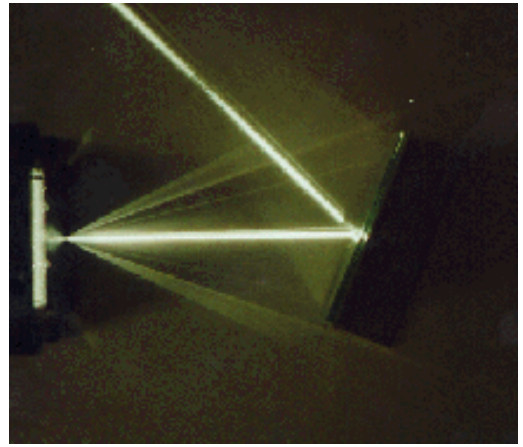
1.5D back-to-back bends: S and B2B
20% restriction: full bore and plane bore

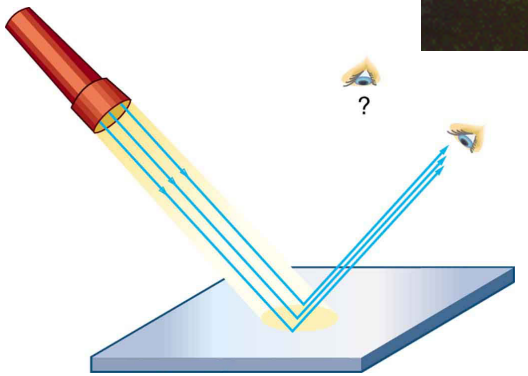
UT in Dry Gas

Metal Loss Inspection

What's the Problem?

- Gas pipeline operators need higher resolution metal loss data.
- Conventional UT only works with a liquid couplant.
- Transmitting ultrasound from a solid to a gas and back is like trying to put light through a mirror.





What's the Solution?

- Effective non-contact ultrasonic wall thickness ILI tools i.e UT tools that work in gas.
- **Piezoelectric Material**—Develop single crystal PZT
  - PZT is the dominant piezoelectric material in nondestructive testing because of its high efficiency and power capability, but it is only available as a ceramic.
- It has been impossible to grow as a crystal . . .

"Innovation in materials is vital to realizing an advance that can be conceived but not built." – Matt Ridley, How Innovation Works

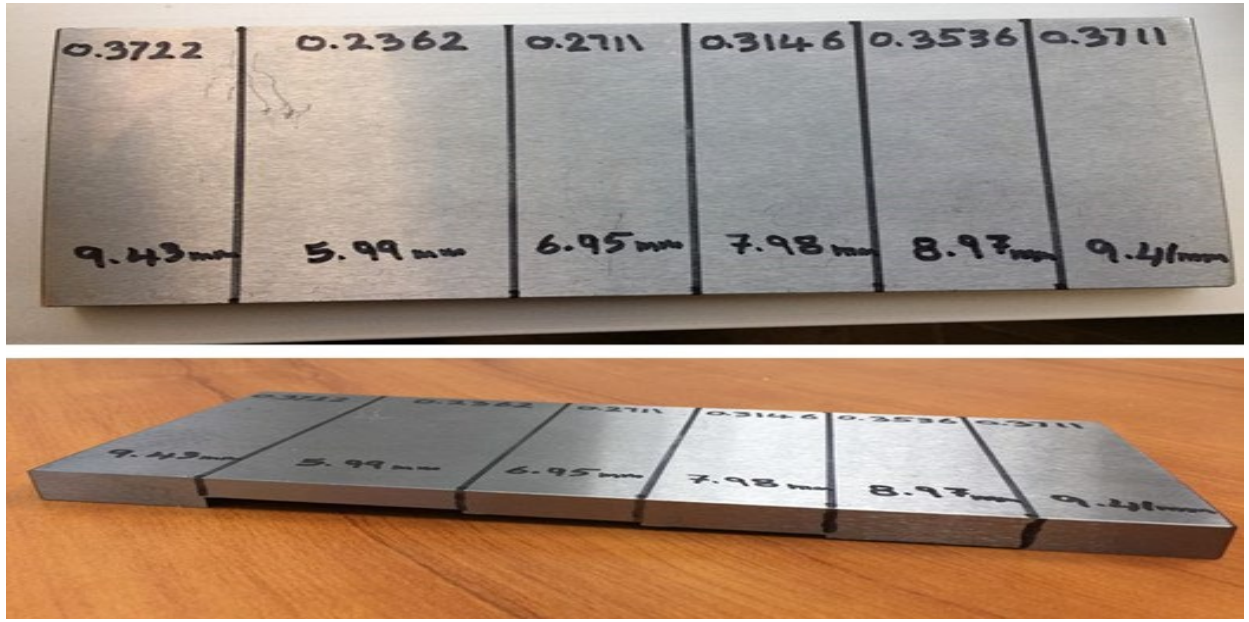
Innovative Collaboration

- Have successfully grown a single crystal PZT that when deployed in a transducer, meets desired requirements.
- This is a “First”, despite 50 years of industry effort.

This is delicious rock candy.

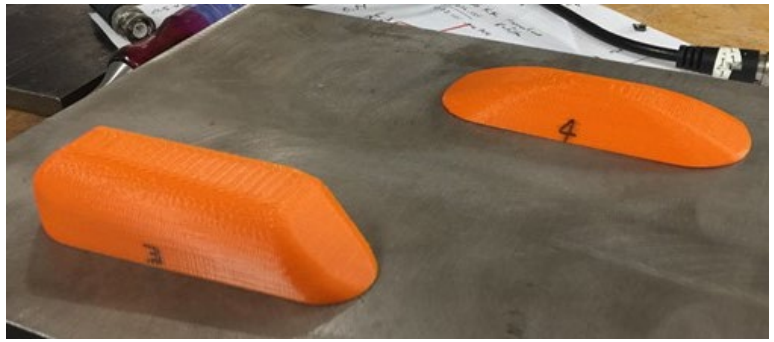
Inspection of Different Wall Thicknesses (at 250 psi)

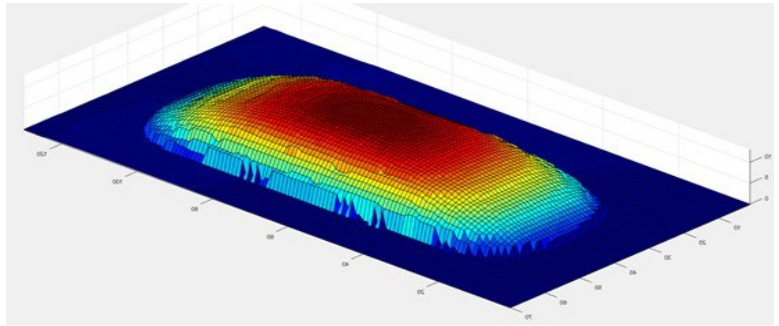
8’’ pipe nominal
0.25’’ = 6.4 mm
± 0.8%

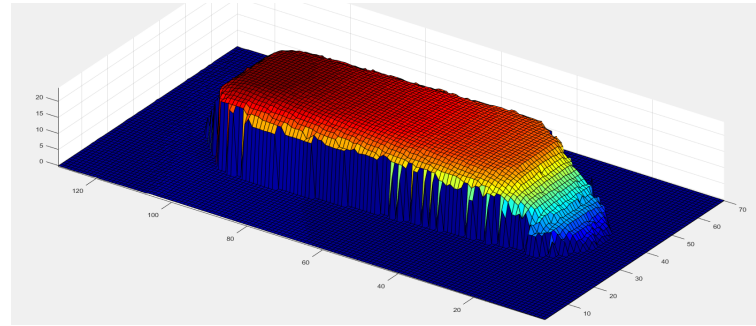


Nominal Thickness	9 mm step	8 mm step	7 mm step	6 mm step
Micrometer Measured Thickness	8.97 mm	7.98 mm	6.95 mm	5.99 mm
Gas-Coupled UT Measured Thickness	8.93 mm	7.97 mm	6.99 mm	5.96 mm

Inspection of Simulated Dents



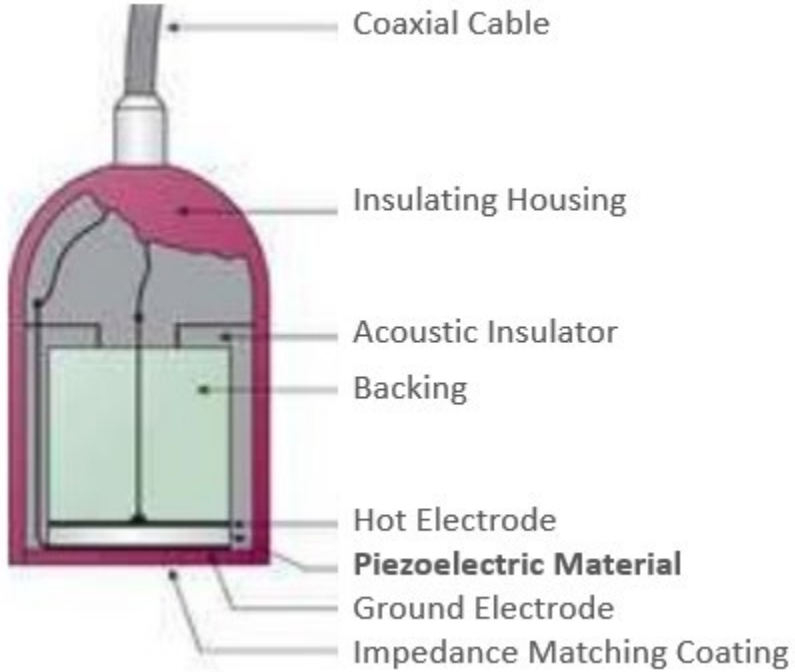




	Width		Length		Height	
	Actual	Measured	Actual	Measured	Actual	Measured
Defect 3	34 mm	38 mm	100.5 mm	98 mm	19-24 mm	18.3-24.19 mm
Defect 4	38 mm	39 mm	100 mm	101 mm	12.96 mm	13.01 mm

Deploy the Transducers!

- Metal loss: Prototypes have determined the thickness of a 6 mm steel plate to ± 0.05 mm at a standoff of 25 mm and a pressure of 250 psi.
- Deformation: Preliminary measurements surpass the capabilities of current caliper tools.



Conventional UT: ±0.5 mm
MFL: ± 1 mm

A new generation of EMAT and Gas-Coupled UT ILI

- EMAT: 8’’, 10’’ and 12’’ commercially available this year
- Gas-coupled UT: Develop an 8’’ ILI prototype tool. Completion expected in 2022.
- *We are actively soliciting co-funding and testing partners for the development, testing and deployment of these vital ILI tools.*

The more complex our problems become, the more creative our problem-solving needs to be!

THANK YOU FOR YOUR ATTENTION!

S.BAUCOM@QI2ELMENTS.COM

"Whenever you see a successful business, someone once made a courageous decision."
– Peter Drucker