



**CEREUS**  
*ULTRASONICS*



## Ultra-High Fidelity Downhole Ultrasonics

SPE Well Decommissioning – 6<sup>th</sup> June 2023

# Downhole Ultrasonic Inspection

## Introduction

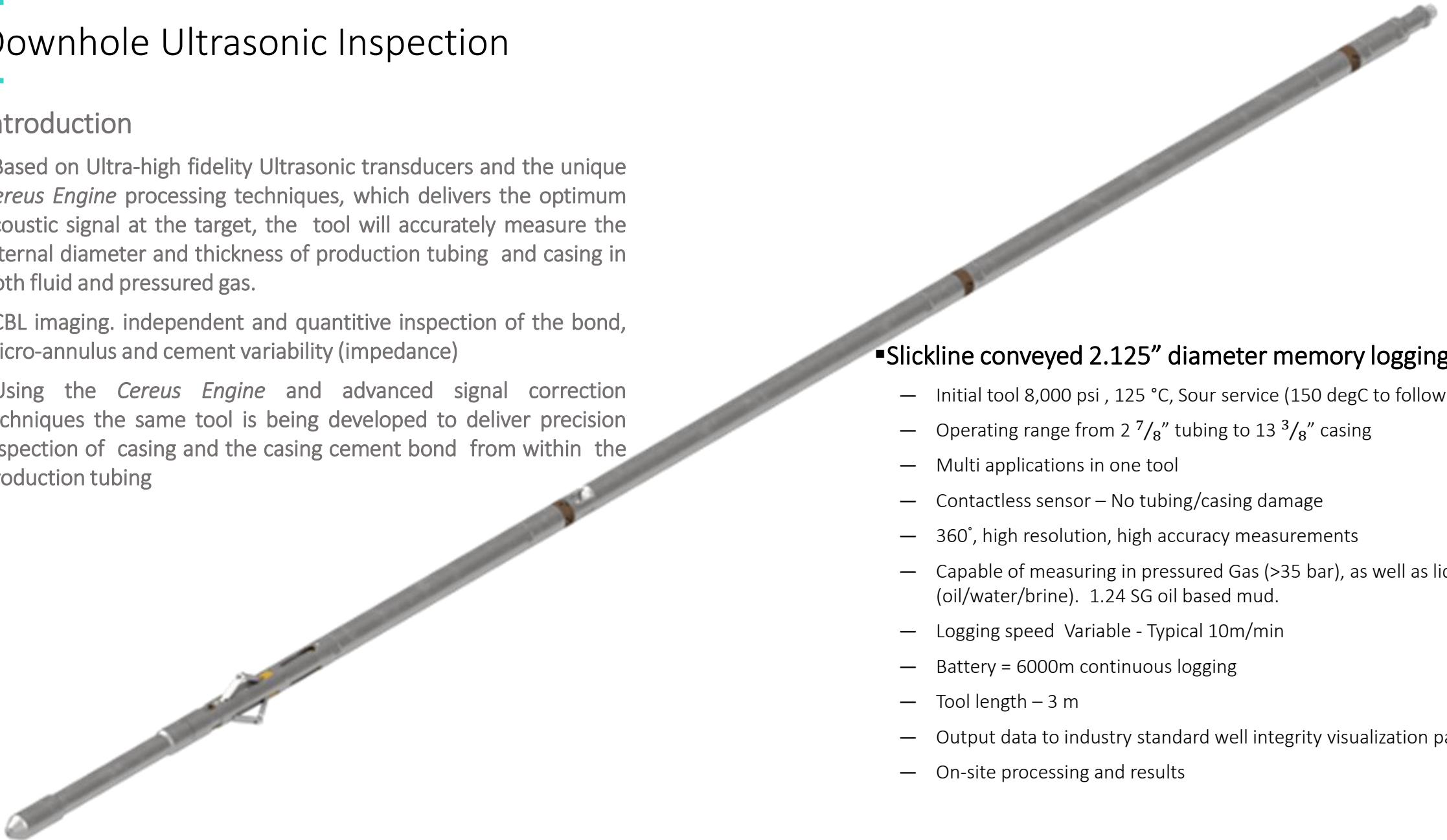
▪Based on Ultra-high fidelity Ultrasonic transducers and the unique *Cereus Engine* processing techniques, which delivers the optimum acoustic signal at the target, the tool will accurately measure the internal diameter and thickness of production tubing and casing in both fluid and pressured gas.

▪CBL imaging. independent and quantitative inspection of the bond, micro-annulus and cement variability (impedance)

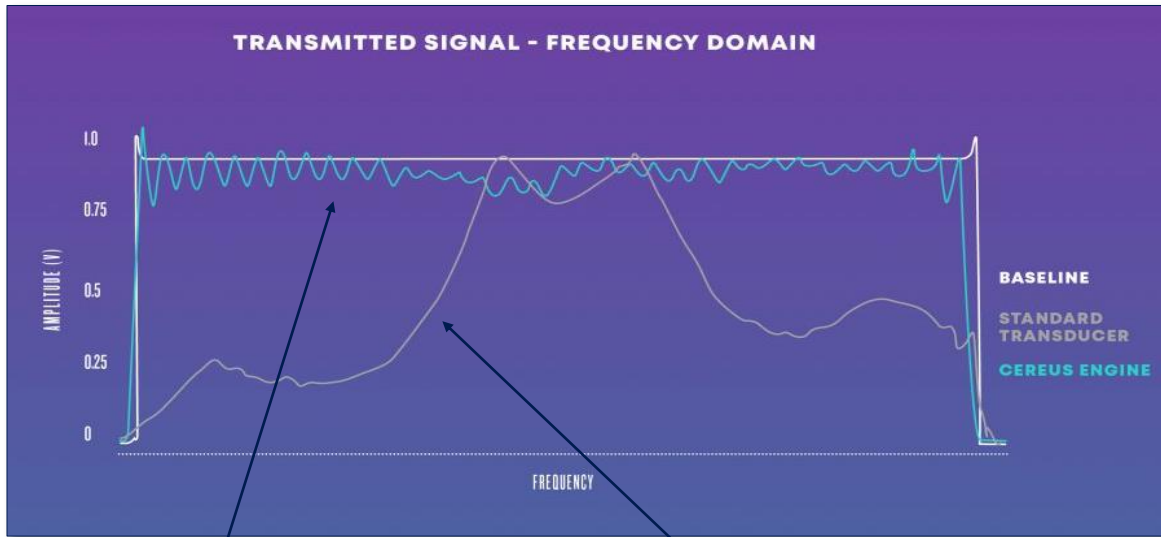
▪Using the *Cereus Engine* and advanced signal correction techniques the same tool is being developed to deliver precision inspection of casing and the casing cement bond from within the production tubing

## ▪Slickline conveyed 2.125" diameter memory logging tool:

- Initial tool 8,000 psi , 125 °C, Sour service (150 degC to follow)
- Operating range from 2 7/8" tubing to 13 3/8" casing
- Multi applications in one tool
- Contactless sensor – No tubing/casing damage
- 360°, high resolution, high accuracy measurements
- Capable of measuring in pressured Gas (>35 bar), as well as liquids (oil/water/brine). 1.24 SG oil based mud.
- Logging speed Variable - Typical 10m/min
- Battery = 6000m continuous logging
- Tool length – 3 m
- Output data to industry standard well integrity visualization packages.
- On-site processing and results



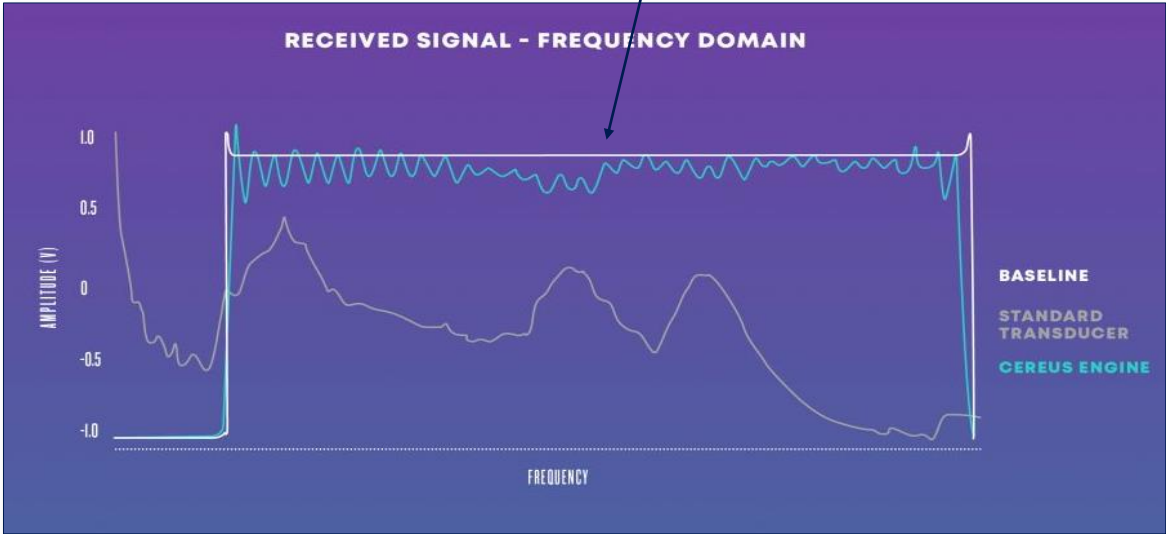
# Disruptive equalisation technology - Cereus Engine



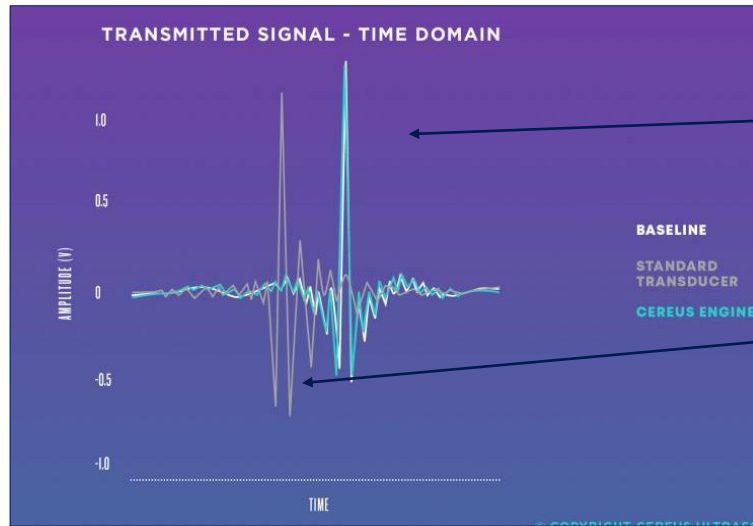
Ultra-high frequency bandwidth with Cereus Engine that more closely mirrors optimum frequency (Baseline)

Conventional operational frequency bandwidth

Significantly improved resonance return signal across a broad frequency



# Disruptive equalisation technology - Cereus Engine



Short duration Sync pulse with the Cereus Engine

Long-duration 'Sync' pulse with conventional systems

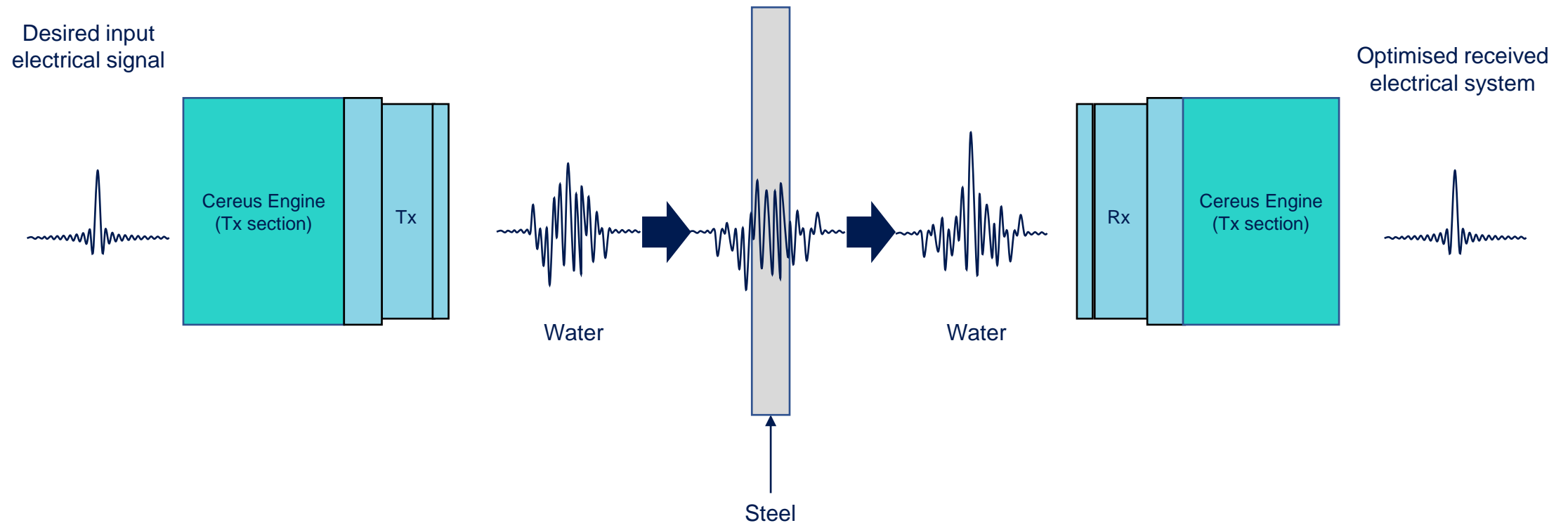


Integrity of original signal retained through Tx/Rx electronics, Tx/Rx transducer and medium, yielding a compact high amplitude peak with reduced noise and improved interpretation

- Software optimised “transmit” waveforms with the widest bandwidth and constant amplitude across this bandwidth in tight timeframe.
- Wider bandwidth, consistent signal and time bound response facilitates improved interpretation.
- Enables analysis of both resonance signals over time **and** frequency modulation.

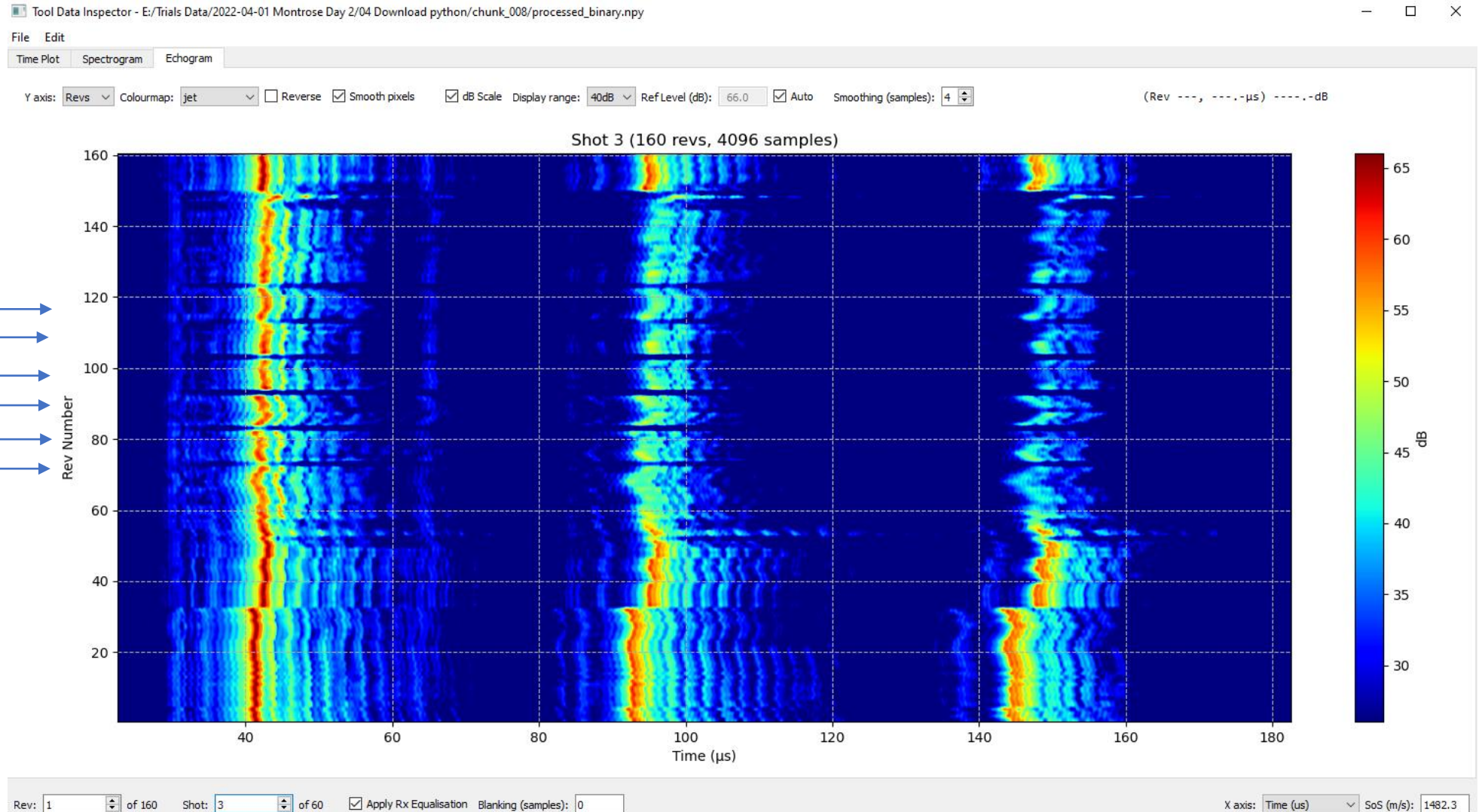
# Disruptive equalisation technology - Cereus Engine

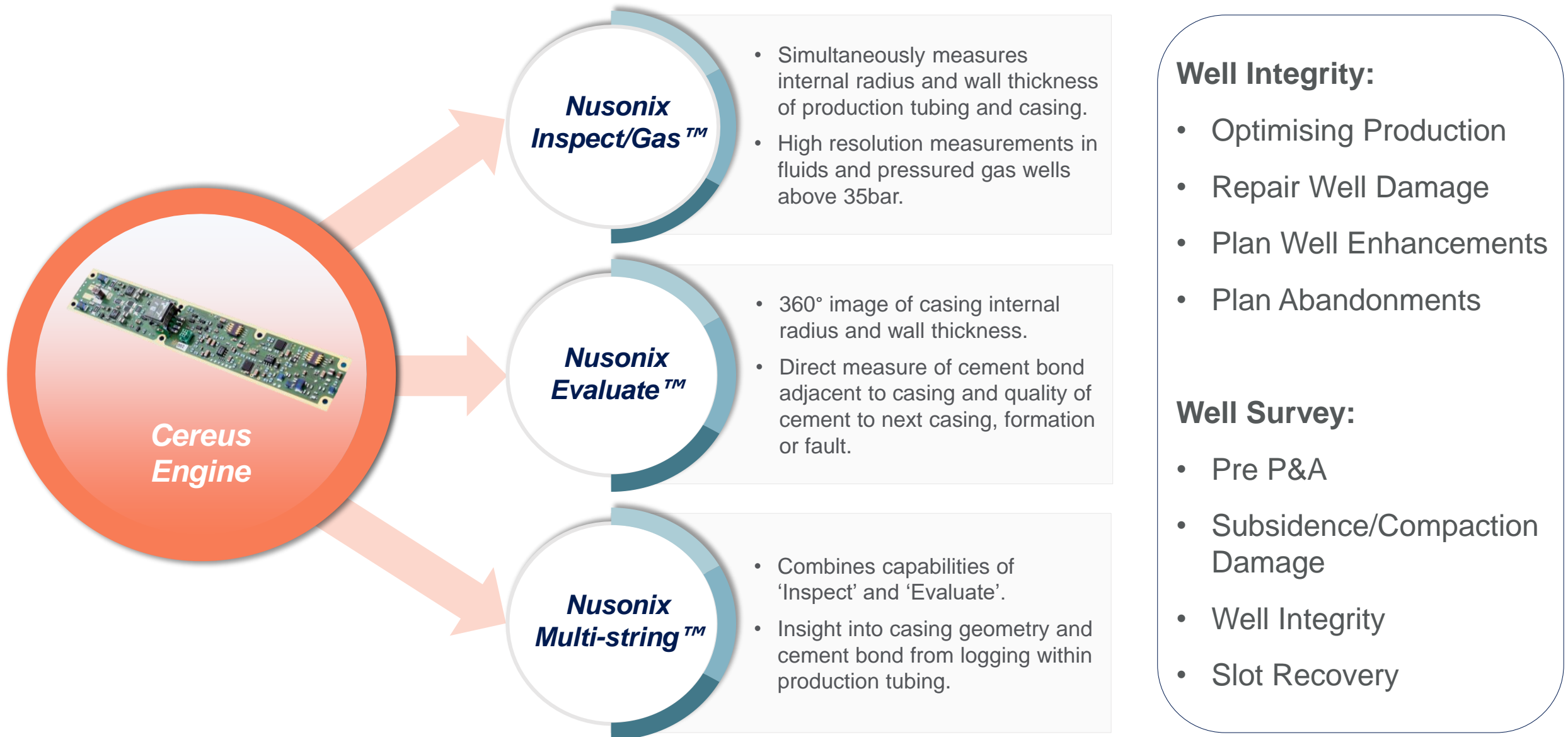
- Creative use of the Cereus Engine can provide various solutions such as cancelling out structures within a medium.
- Without the techniques employed within the Cereus Engine, no system will accurately reproduce the electrical signal applied to it.



# Example of the principles

## Acoustic returns over a perforated joint





# Nusonix – Inspect



Ultrasonic multi purpose downhole inspection tool

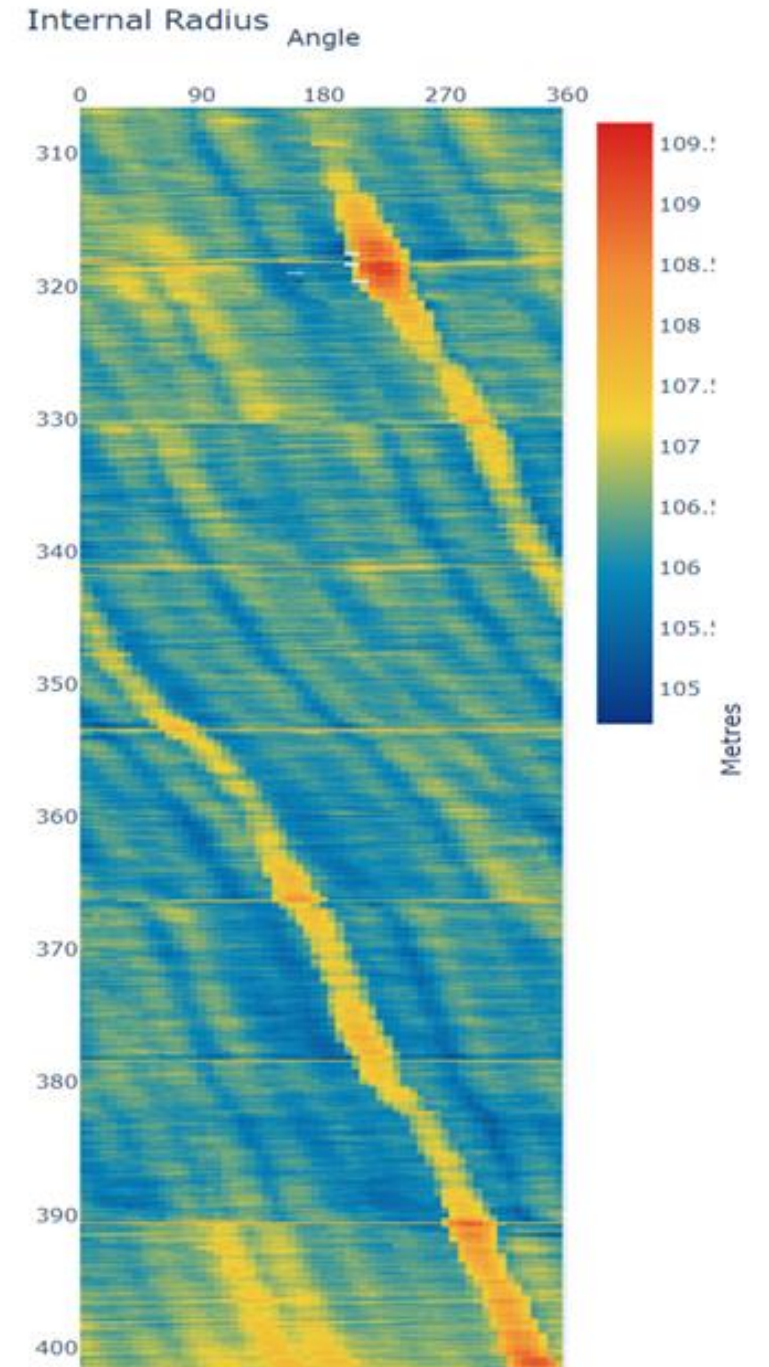
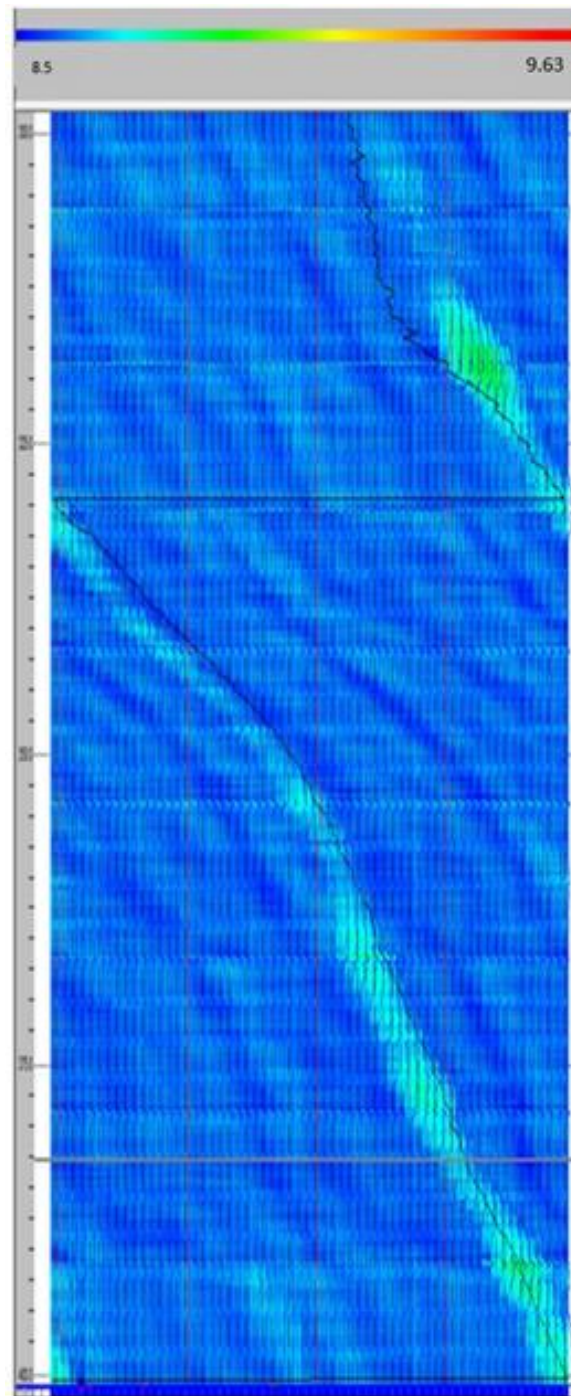
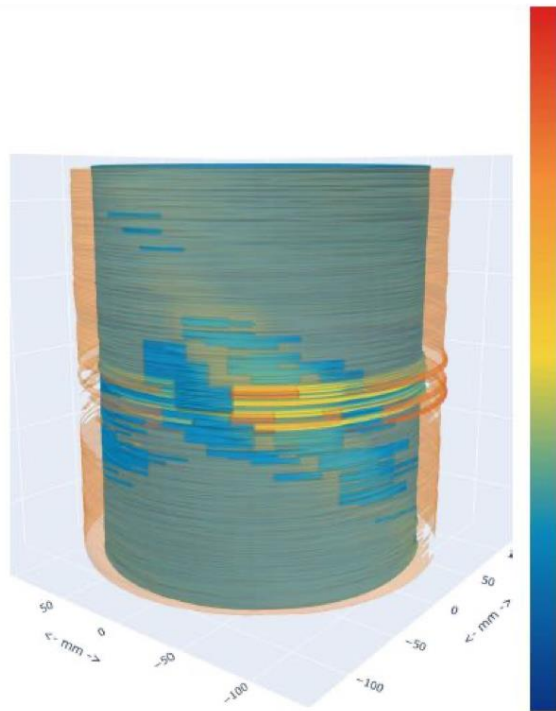
- Slickline memory
- Compact and simple to rig-up – 3m long
- PC based set-up and reporting software
- Slim hole integral centraliser to suit tubing size
- Minimum applied contact force to tubing
- Requires additional bow-spring above tool



# MFC vs Ultrasonic

Alwyn platform Slot recovery

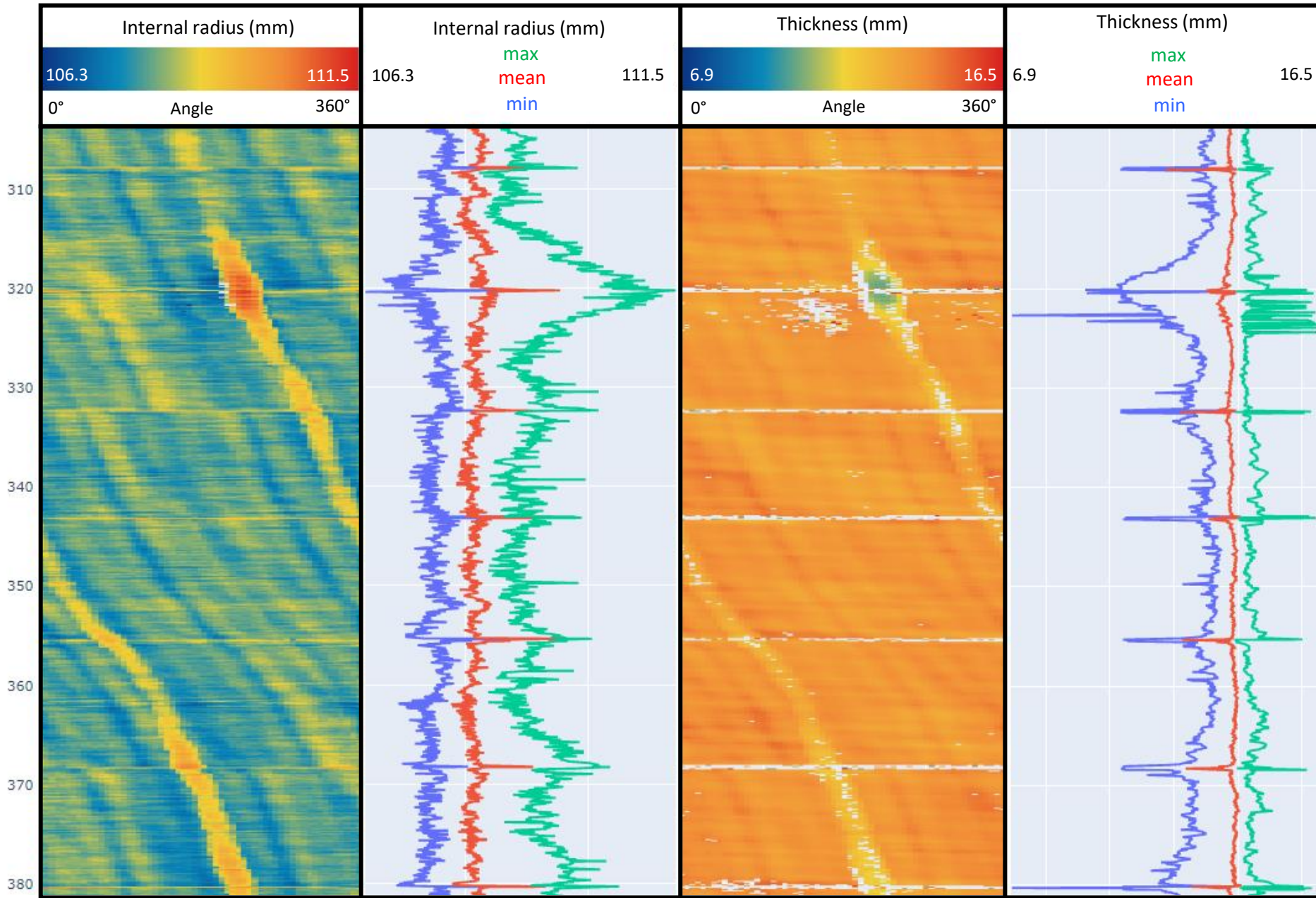
- 9 5/8" casing field trial
- Full range MFC 28.7mm
- Full range Ultrasonic 4.0mm
- Logging speed 9m/min



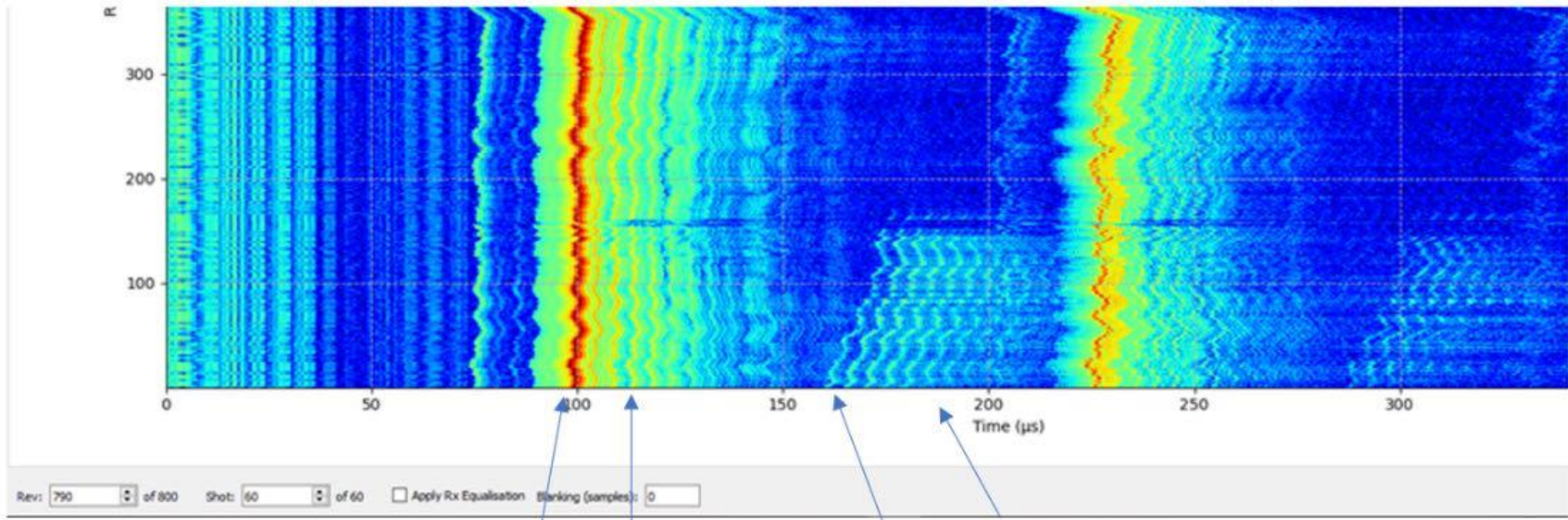
# Field trial results

## Hi-resolution results

9 5/8" casing inspection



# Multi-casing detection



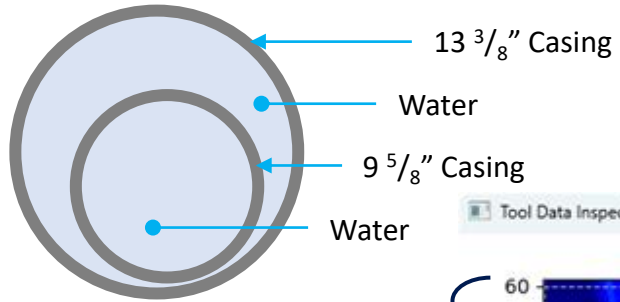
9 5/8" casing ID

9 5/8" casing thickness resonances

13 3/8" casing

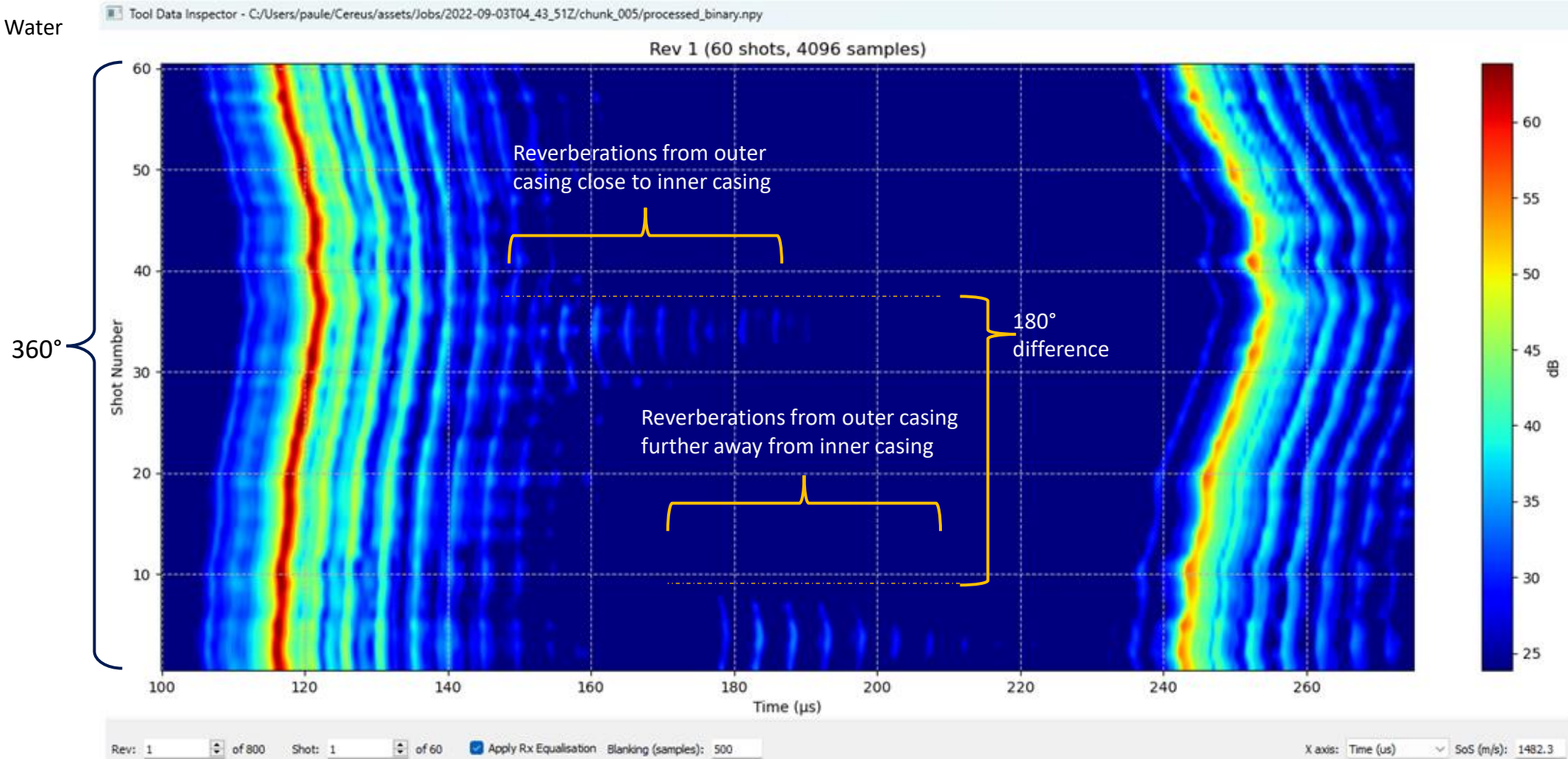
From some of the CBL modelling and experiments this could be 13 3/8<sup>th</sup> return creating resonances in the 9 5/8<sup>th</sup> tubing as it passes through.

# Multi-casing detection

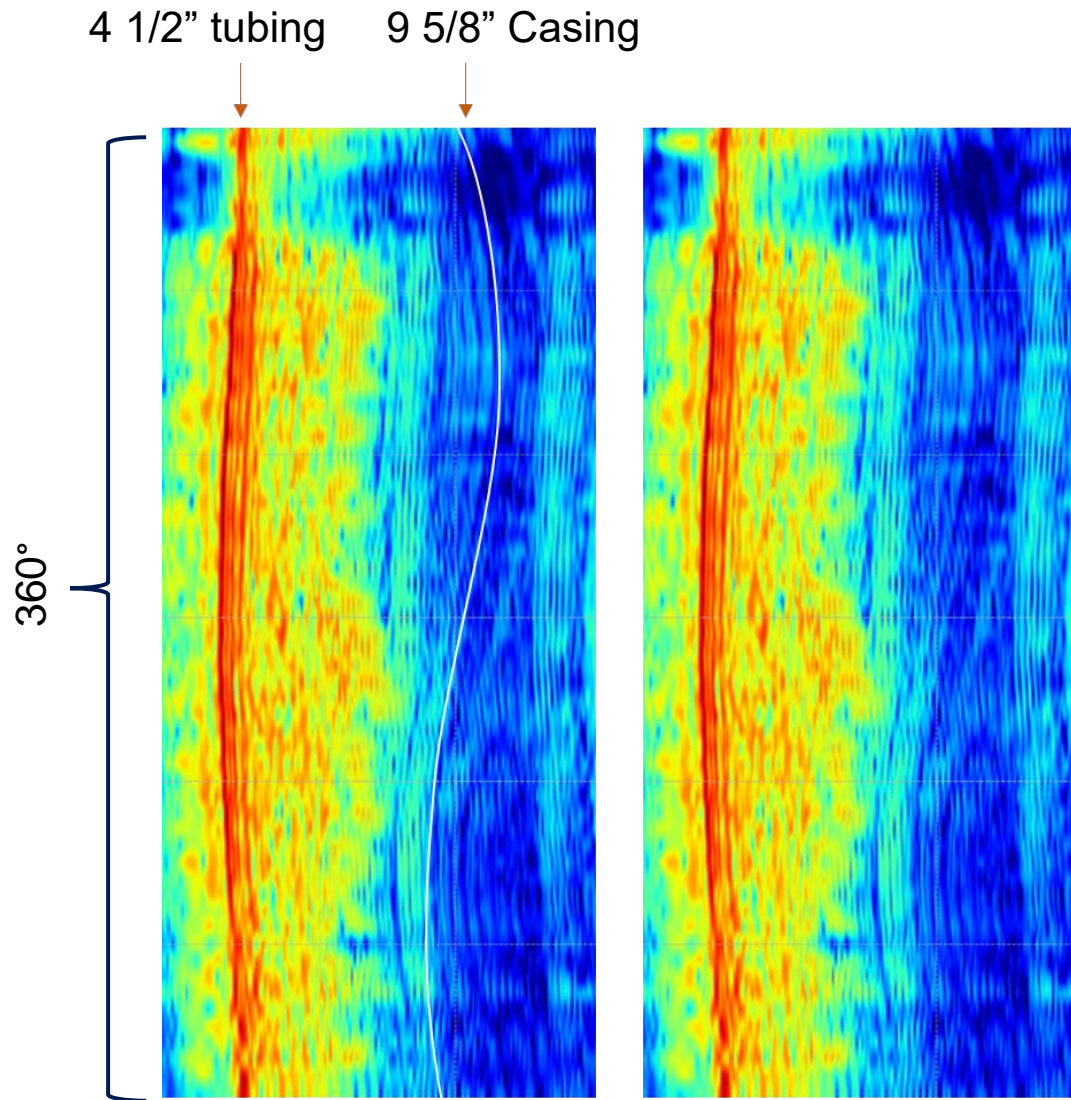


Observation of 2<sup>nd</sup> casing at Alwyn, North Sea.

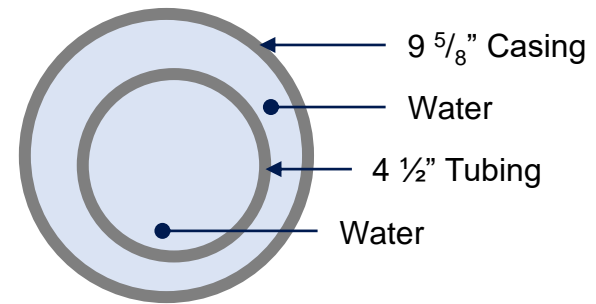
Single revolution of the transducer



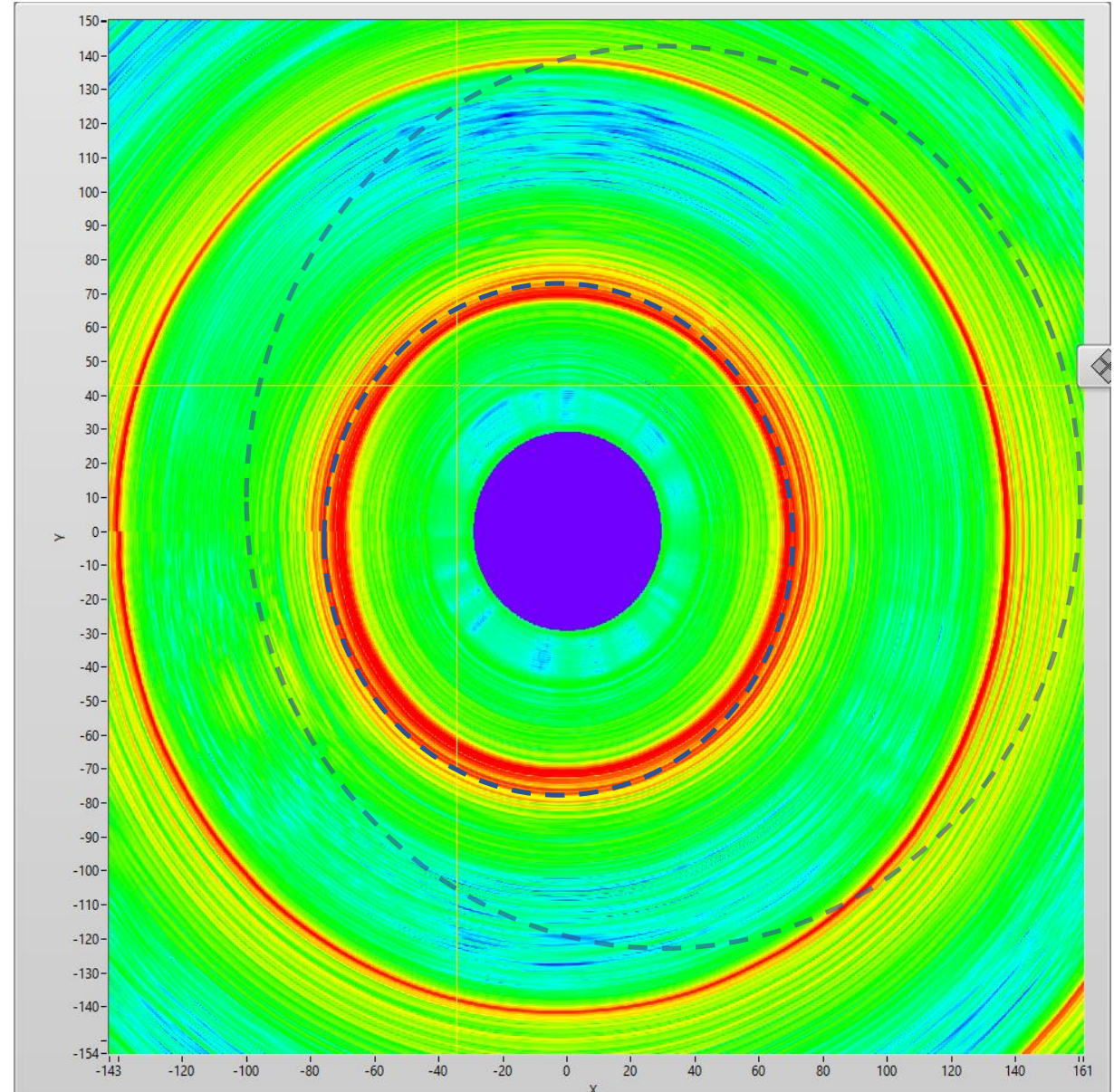
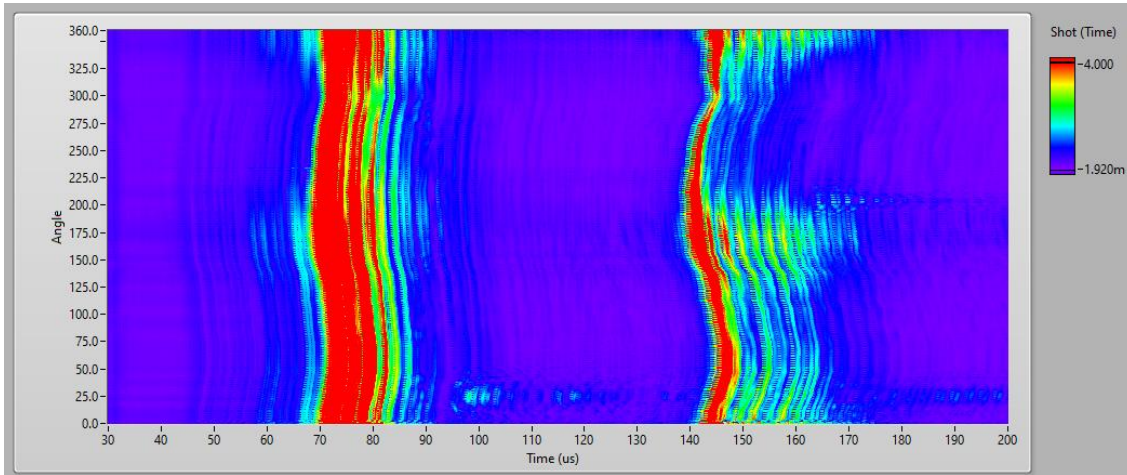
# Nusonix Evaluate™ – Multi-casing detection

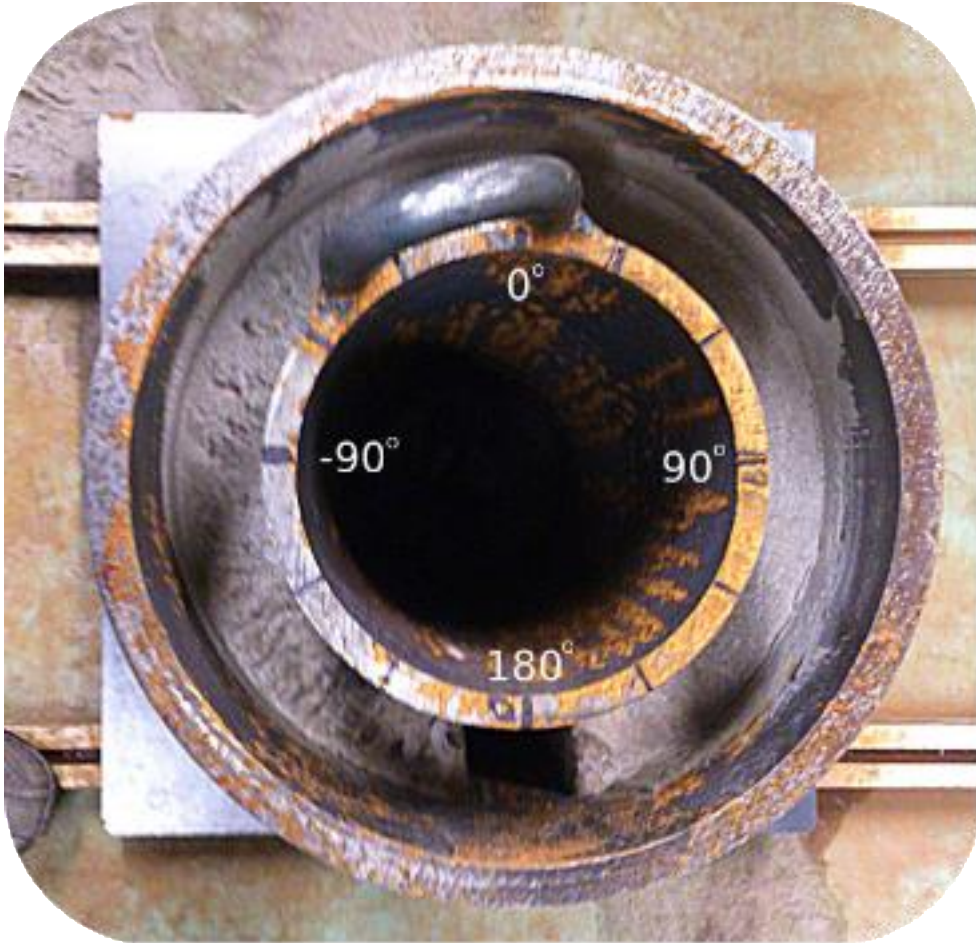


- Observation of 2nd casing.
- Single revolution of the transducer



# Nusonix Inspect™ – Eccentricity plots

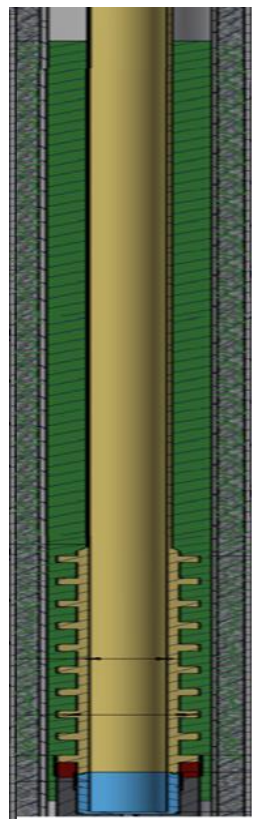




## *Possible Capabilities:*

- ✓ Direct wall thickness measurements
- ✓ Internal geometry mapping
- ✓ Dis-bonding of internal casing
- ✓ Cement annulus cavities
- ✓ Bond to next casing/formation
- ✓ Cement quality

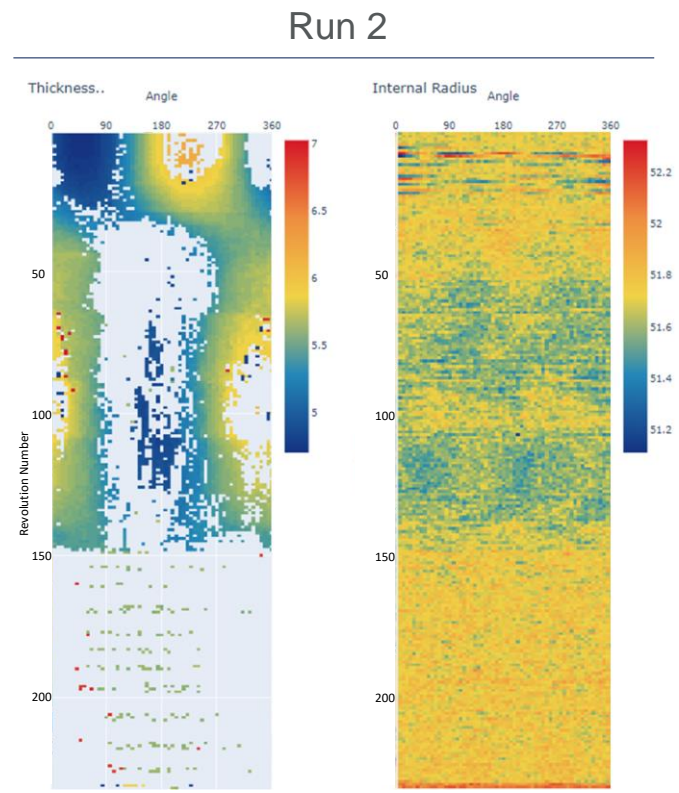
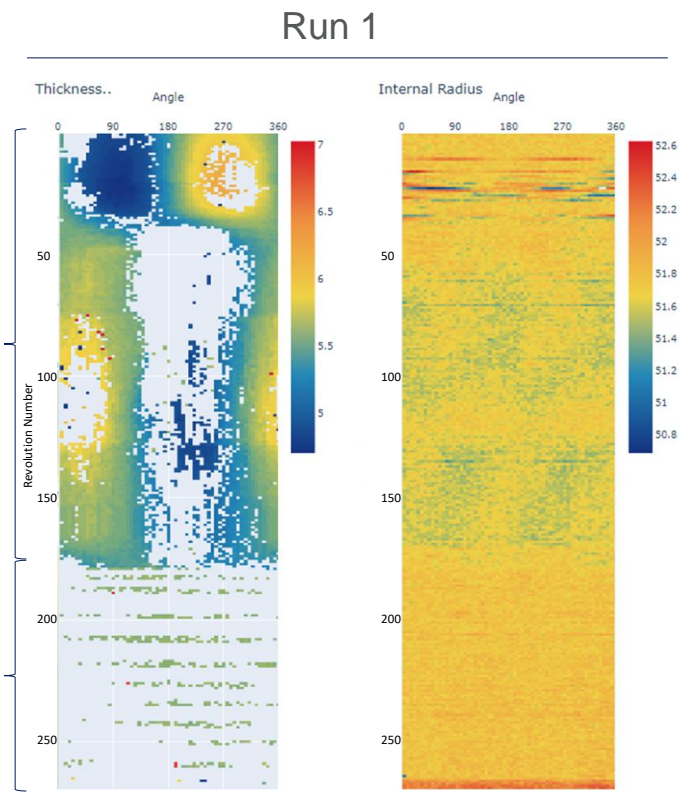
# Nusonix Evaluate™ – Bismuth plug verification



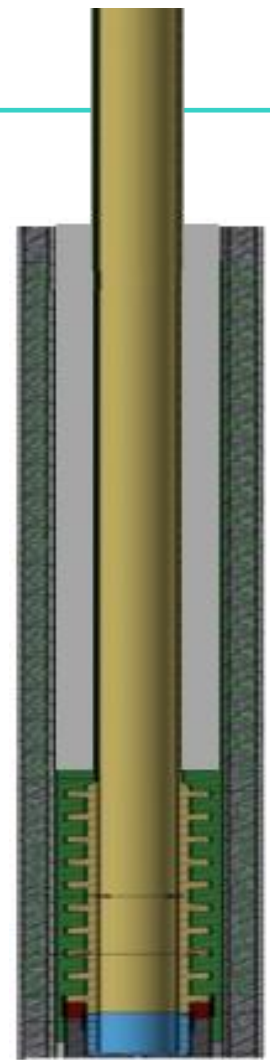
Weaker bond across 360° profile in test well with set process for Bismuth impacted by test conditions

Verified strong bond quality and consistency on Bismuth in this section

Before Setting



Demonstrated highly repeatable measurement and conclusions driven by direct measurement and response



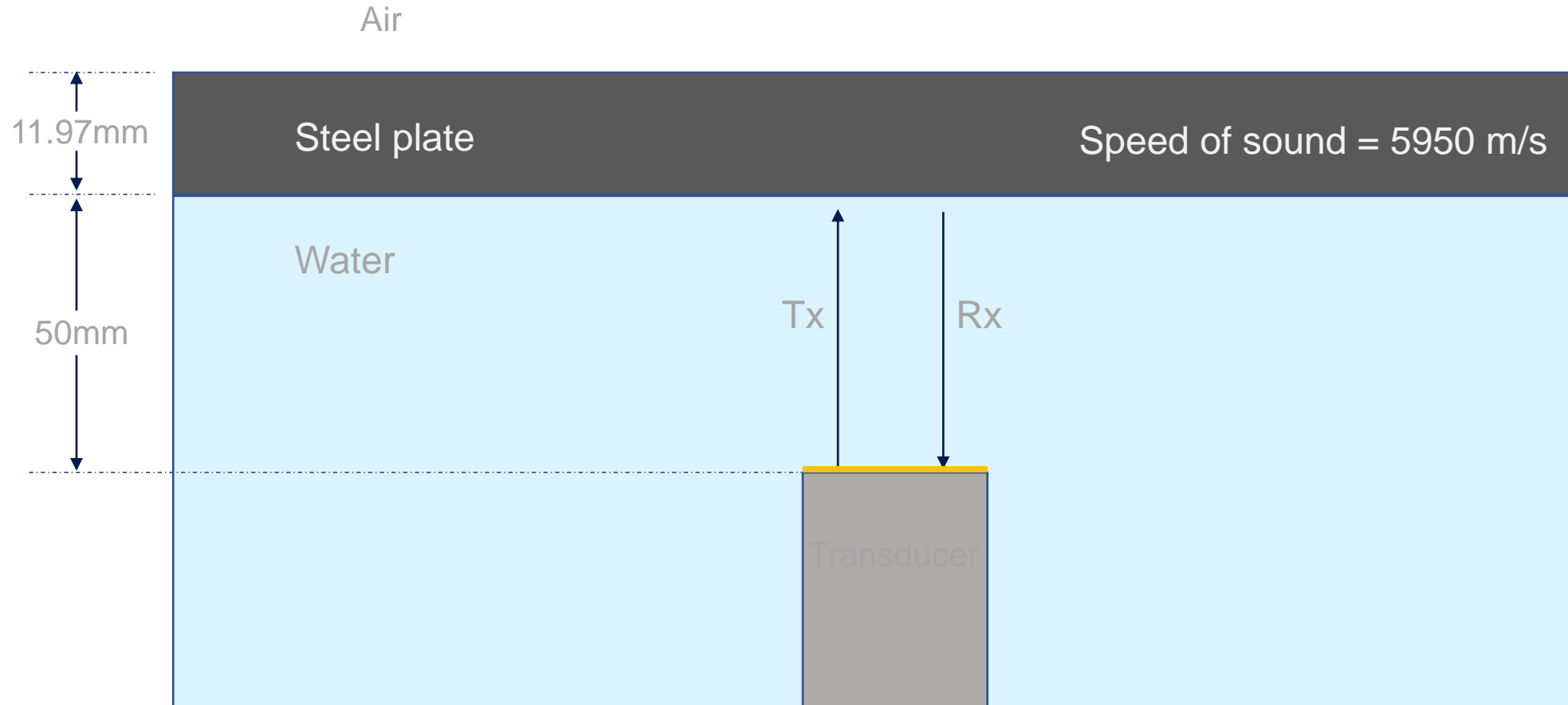
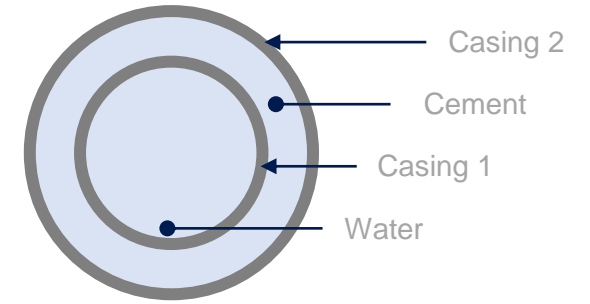
After Setting



# Casing to Cement CBL – Introduction of casing 1

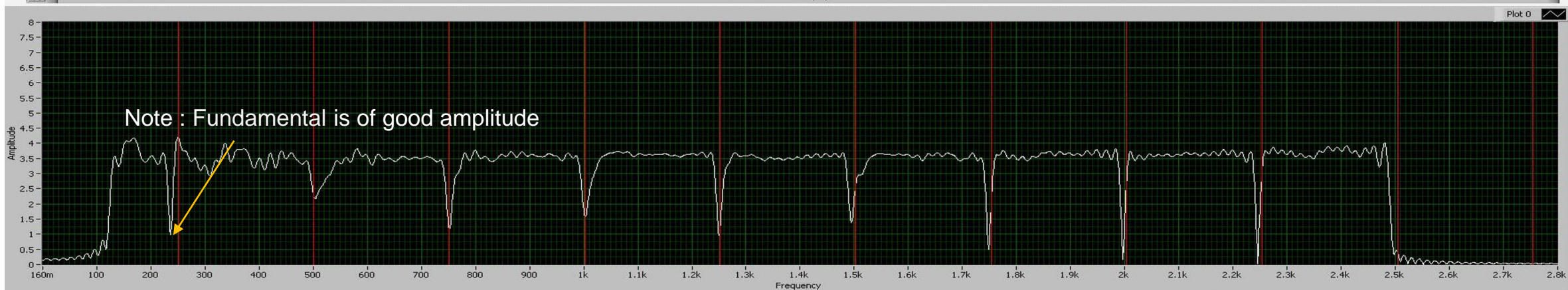
Steel plate is placed above the transducer on the water surface to emulate casing 1 with a gaseous backing (*dis-bonded, gas* in the micro-annulus).

Steel plate dimensions: 150mm x 100mm x 11.97mm.



# Casing 1 to cement (Bad Bond (Gas))

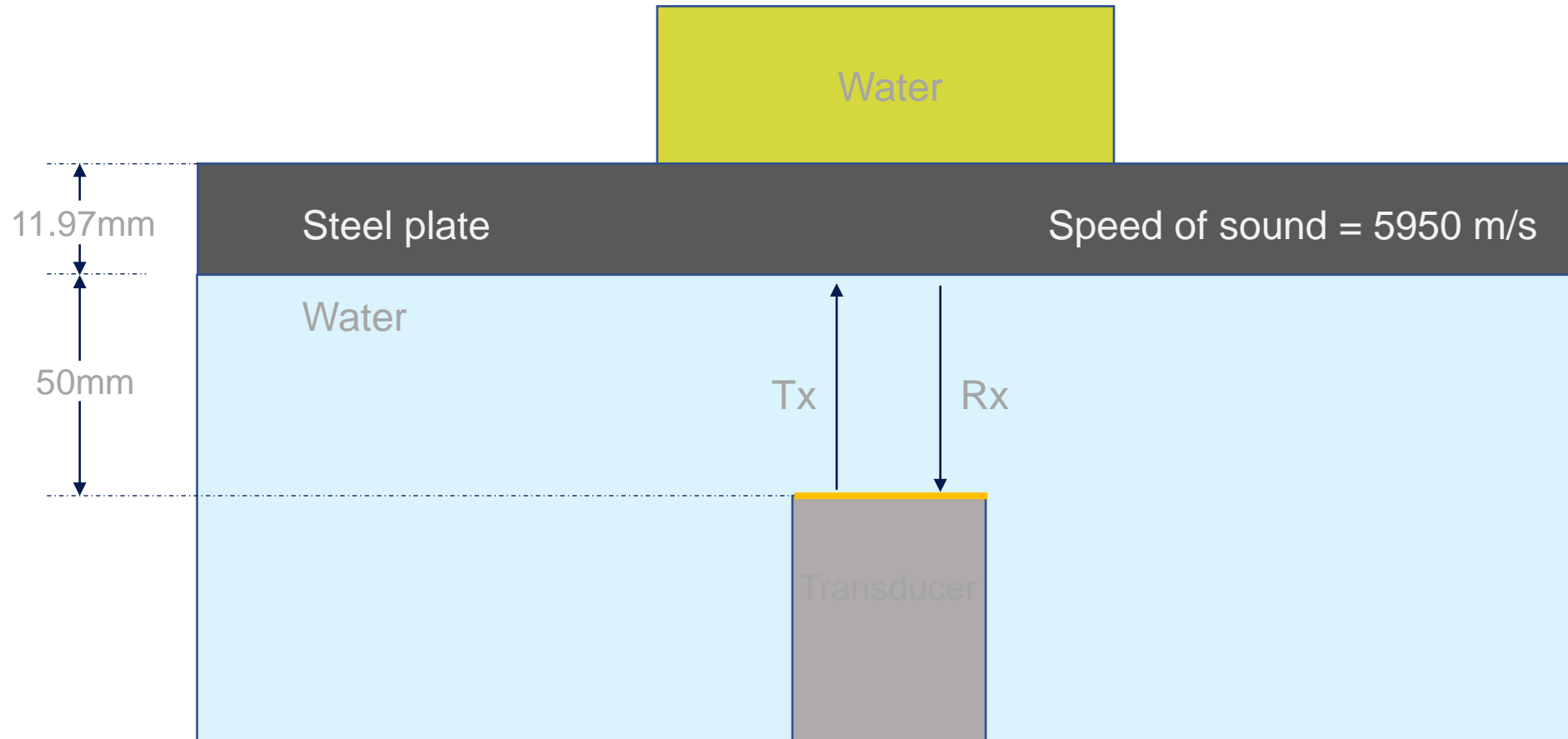
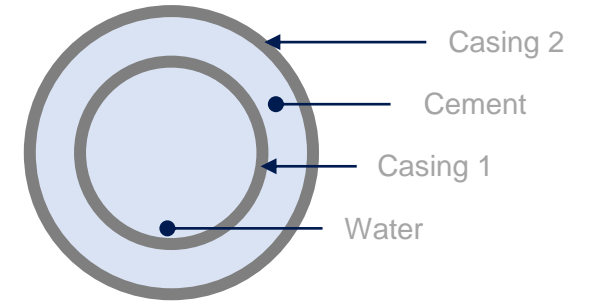
Water/steel/*air* interfaces: *Dis-bonded* with *gas* between casing and cement



# Casing 1 to cement (Good Bond)

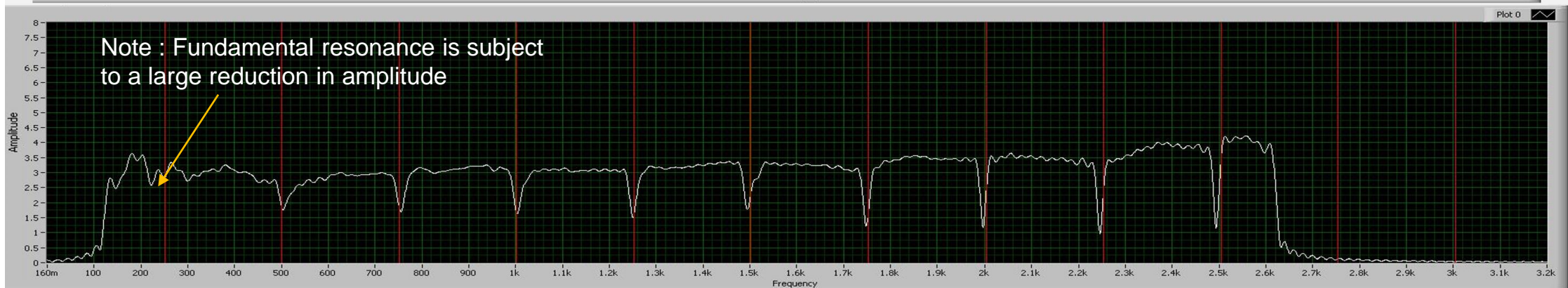
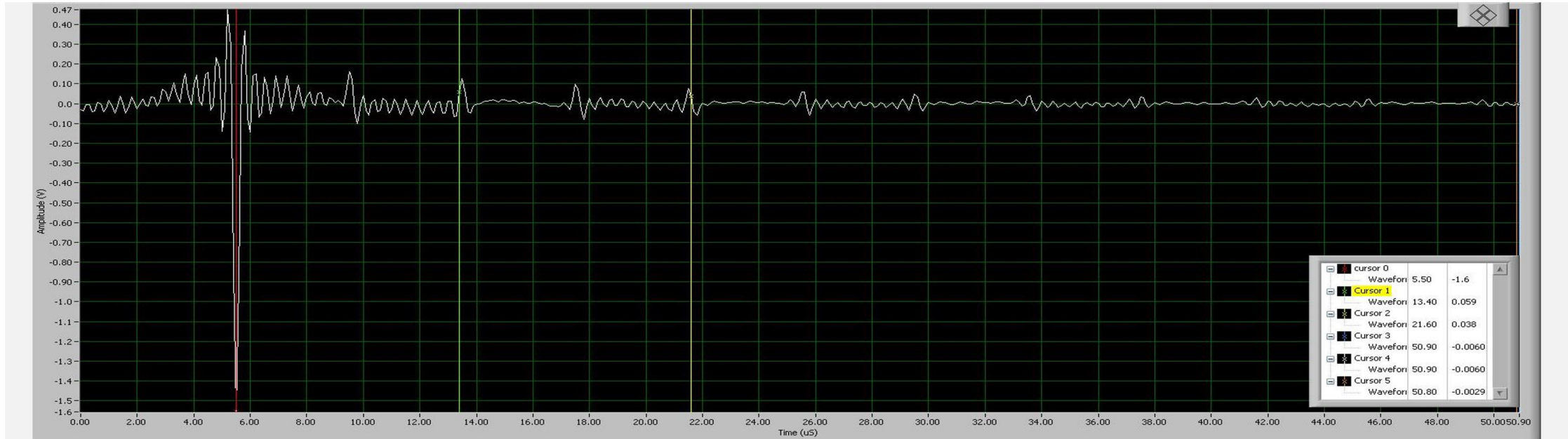
A wet sponge is placed on the top of the steel plate to emulate casing 1 with **well bonded cement**.

Steel plate dimensions: 150mm x 100mm x 11.97mm.

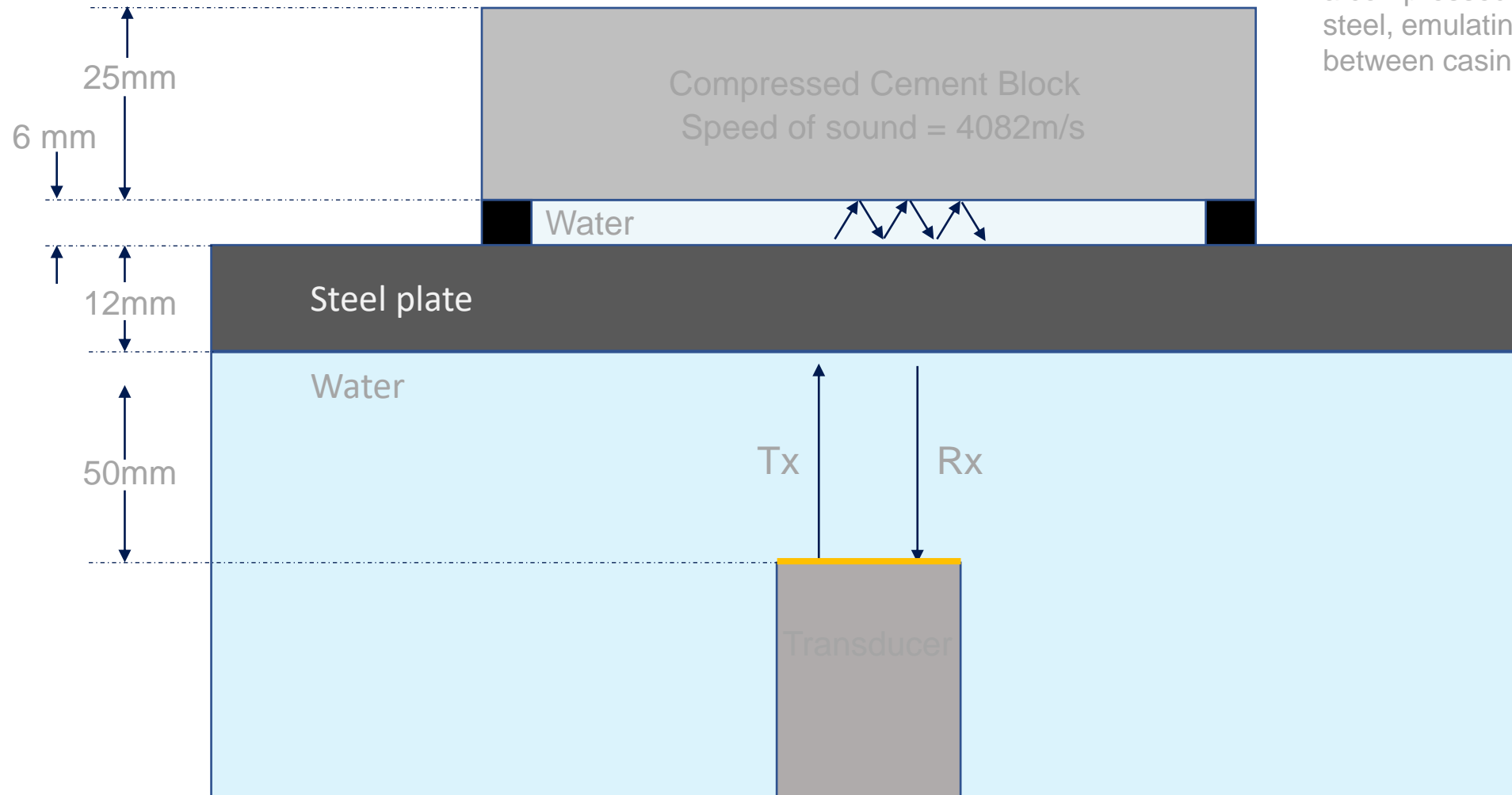


# Casing 1 to cement (Good Bond)

Water/steel/*cement* interfaces: *Well bonded* with *cement*



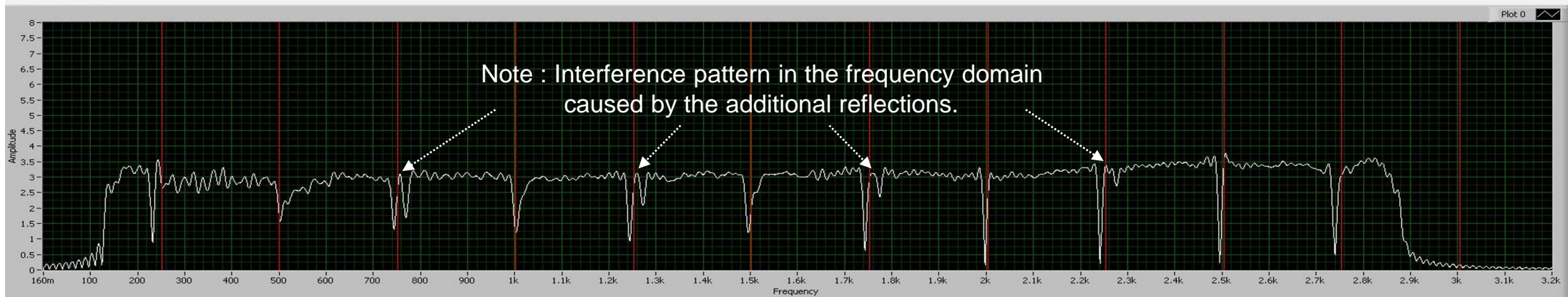
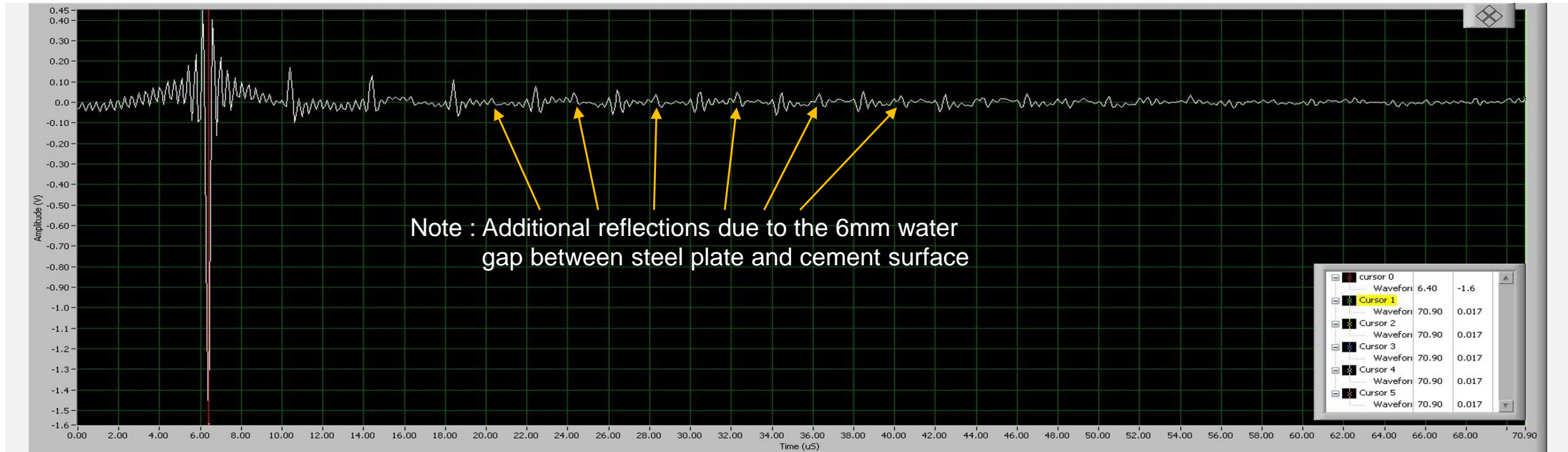
# Casing 1 to cement (Bad Bond (Water))



A water gap of 6mm is created between a compressed cement block and the steel, emulating a large dis-bondment between casing 1 and the cement.

# Casing 1 to cement (Bad Bond (Water))

Water/steel/water/*cement* interfaces: *Dis-bonded* with *water*





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