Modelled and Visualised Sound-Fields of 1.5D Phased-array Probes

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Historic Ultrasonic Inspection of Course Grain Materials

Manual (Still applies)

- Low frequency dual longitudinal probes applied (hand scanning)
- Options then: TRL – VSY – SLIC - all around 2.25MHz up to 4MHz

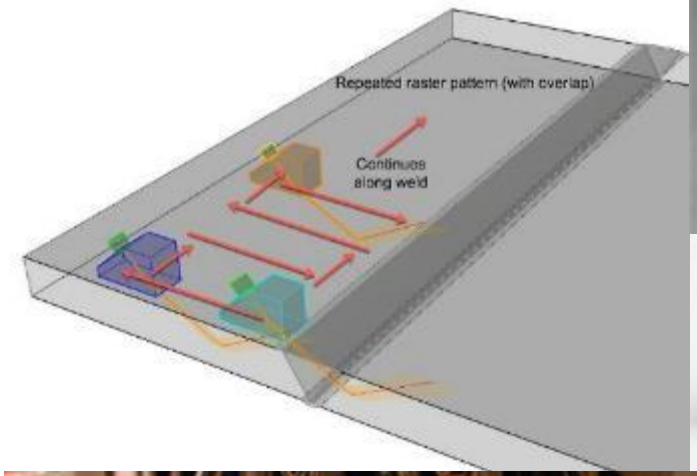
Historic Automated

- Multiple probes applied (large probe tray with many transducers applied to achieve coverage)
- Raster scan pattern applied using one probe at a time or gang of probes

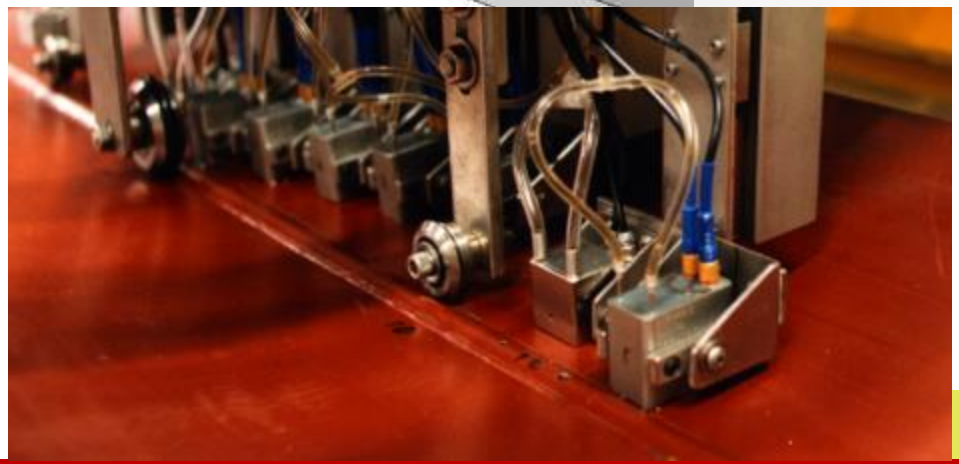
Options Today for Automation

- Single lateral scan or multiple pass lateral scan: Group of transducers applied, shear with S-Scan longitudinal dual PA

Historic Approach
Raster or Numerous Probes



Todays Option - *4 probe
Plate/weld coverage
2 shear
2 dual PA – S-scan



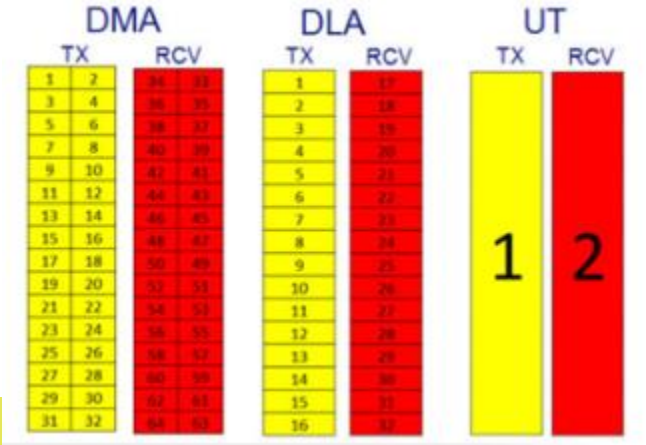
Left – 8 probes per side to cover weld.

- Multiple probes
- Combined housing
- Raster scanning

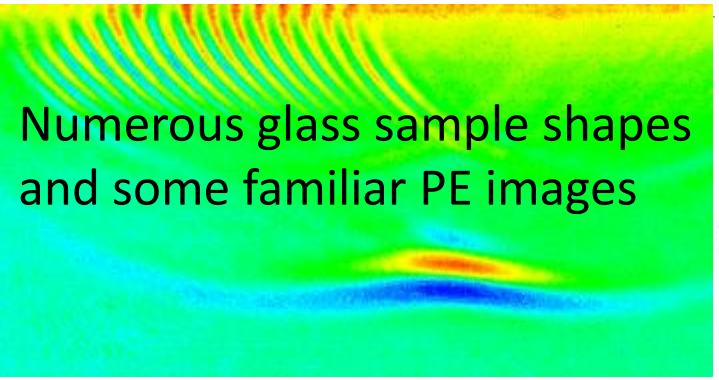
* 4 probe – prior normal beam scans performed // AUT – add additional probes (0 degree)

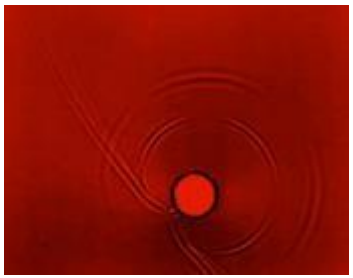
DMA – DLA – UT Probes Dual Element Configurations

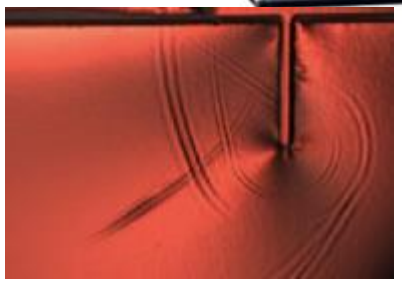
- Principles of the DMA - DLA are founded on TRL (Transmit-Receive Longitudinal)
- Shear and longitudinal co-exist - multi-mode ultrasound
- Old Names Include: TRL, Direct Long, 30-70-70, Creep, VSY and many other historic labels….
- Founded on dual element and longitudinal refracting wedges.

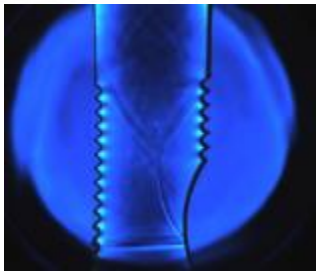


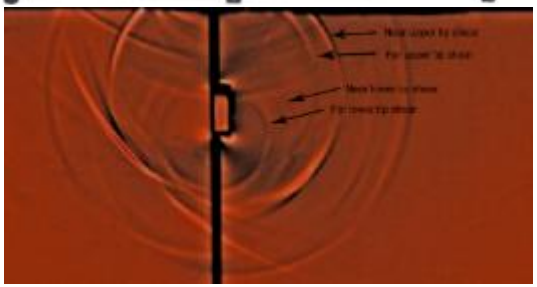
How To See Sound PhotoElastic Visualization





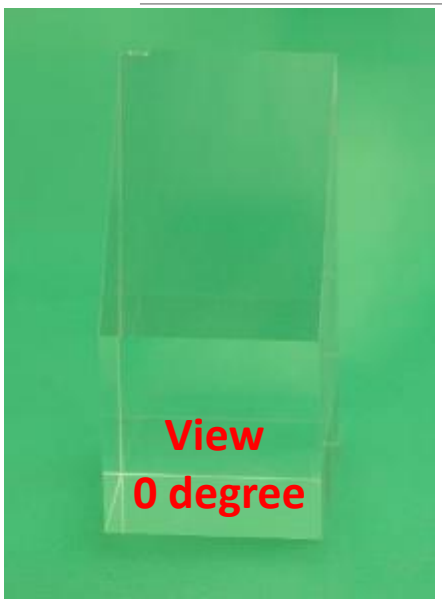


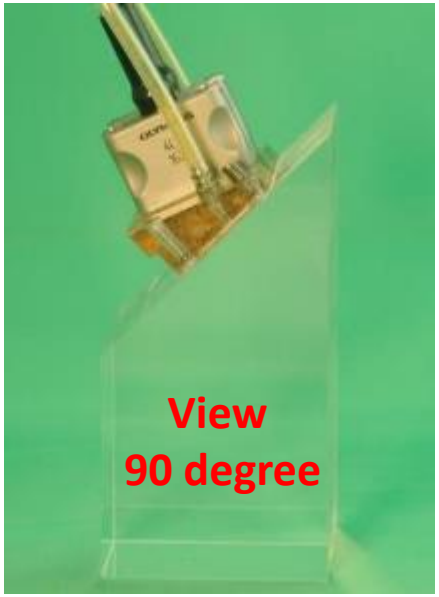


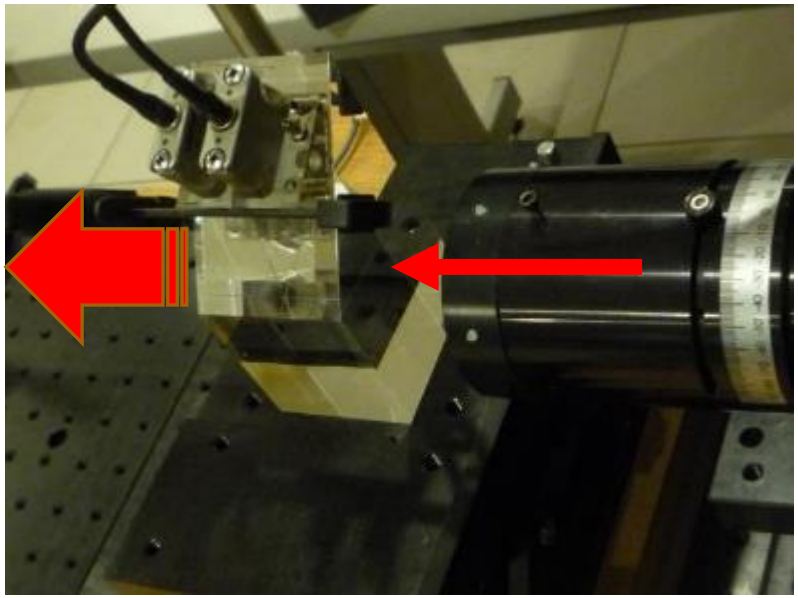


Visit ndt.net to view other examples of PhotoElastic Visualization

Our Set-up
PhotoElastic Test Sample



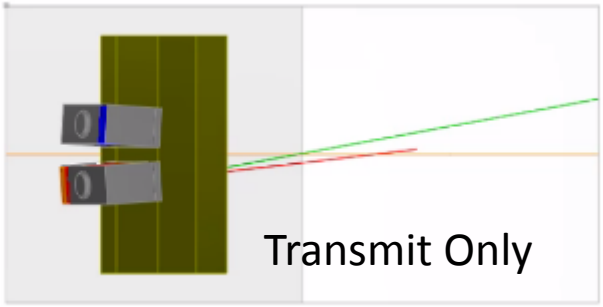




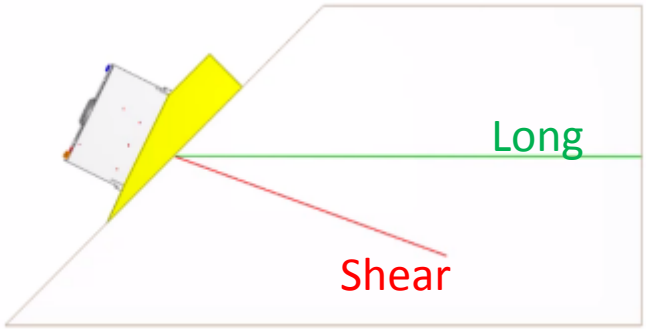
Light passes through the glass sample influenced by the induced stress from the ultrasonic pulses which are then observed.
The glass exhibits the property of birefringence and the system images the ultrasonic waves in volume.

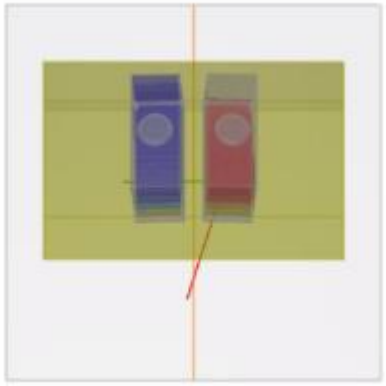
Model and PhotoElastic Glass - View Orientation

Top View
(0 Degree View)



Side View
(90 Degree View)

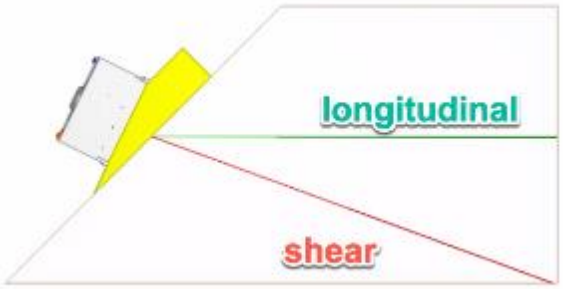




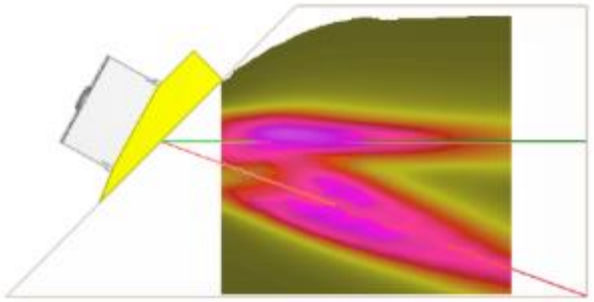
End On-View

Model of Mono, DLA & DMA

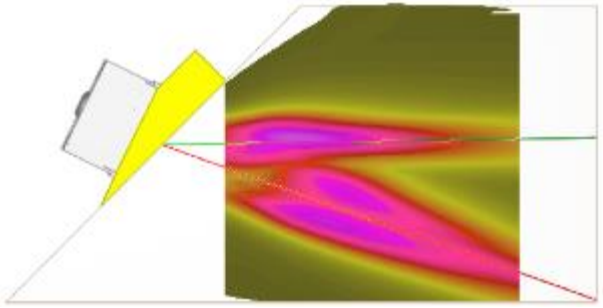
At the selected angle sound fields have very similar characteristics



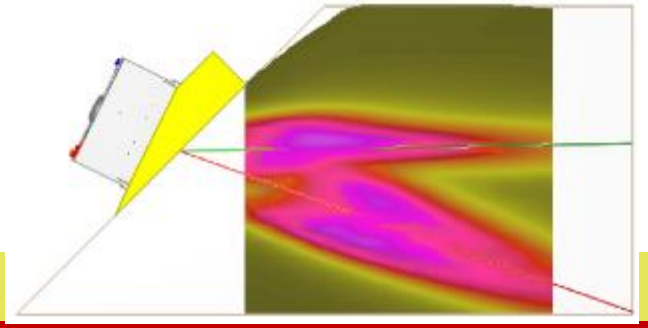
Mono-element Dual



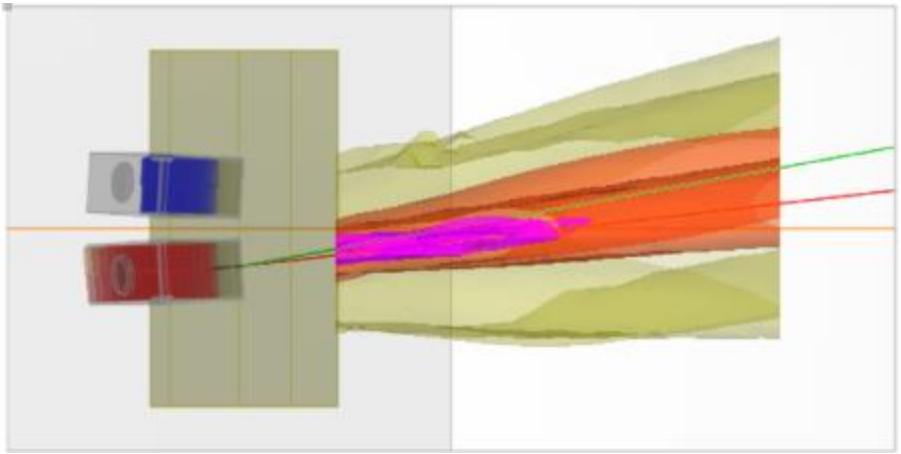
Dual Linear Array

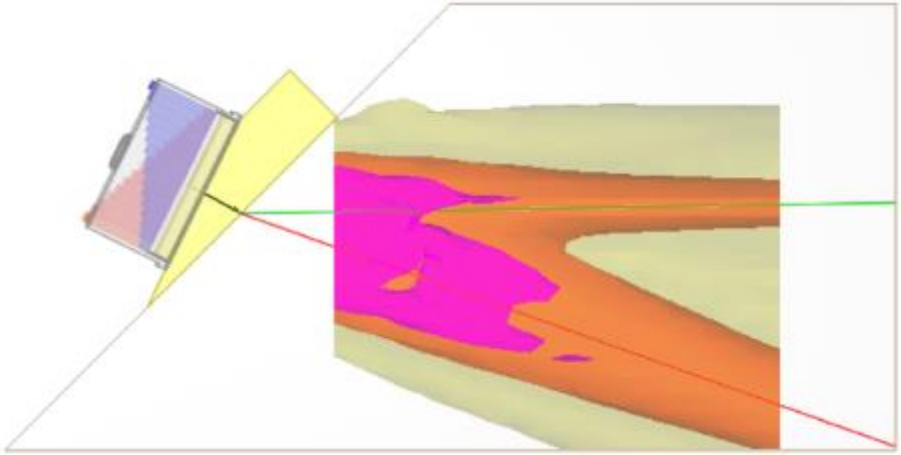


Dual Matrix Array

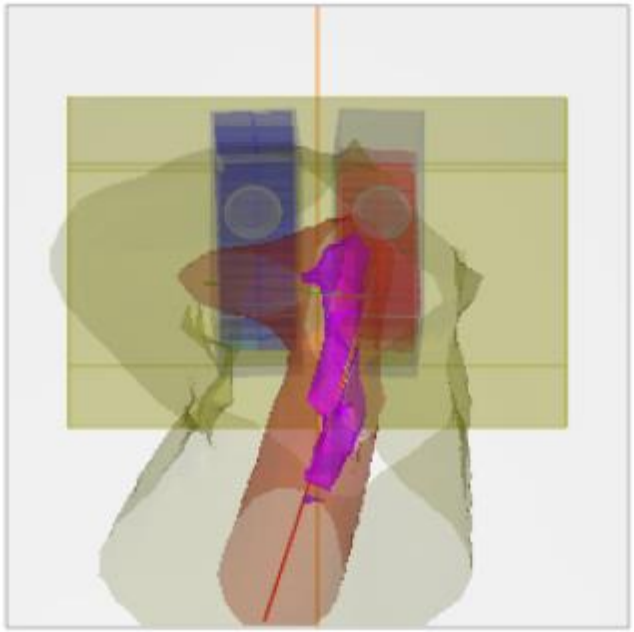


Modelling Glass Sample

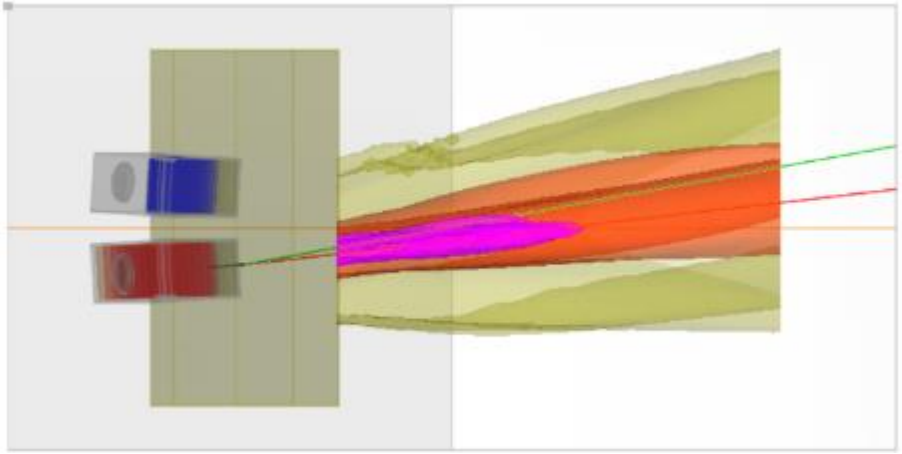


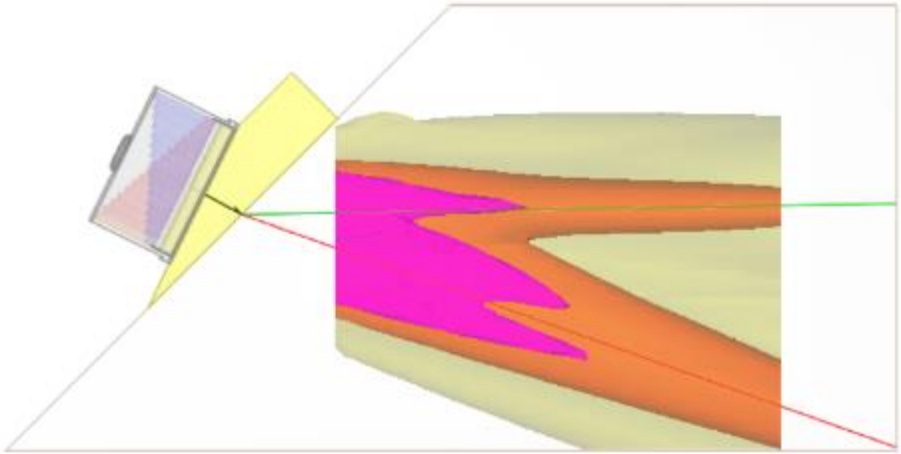


Dual Matrix Array

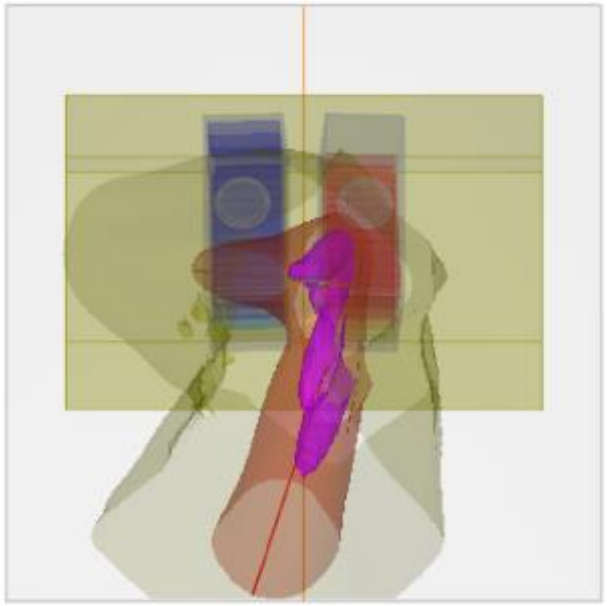


Modelling Glass Sample

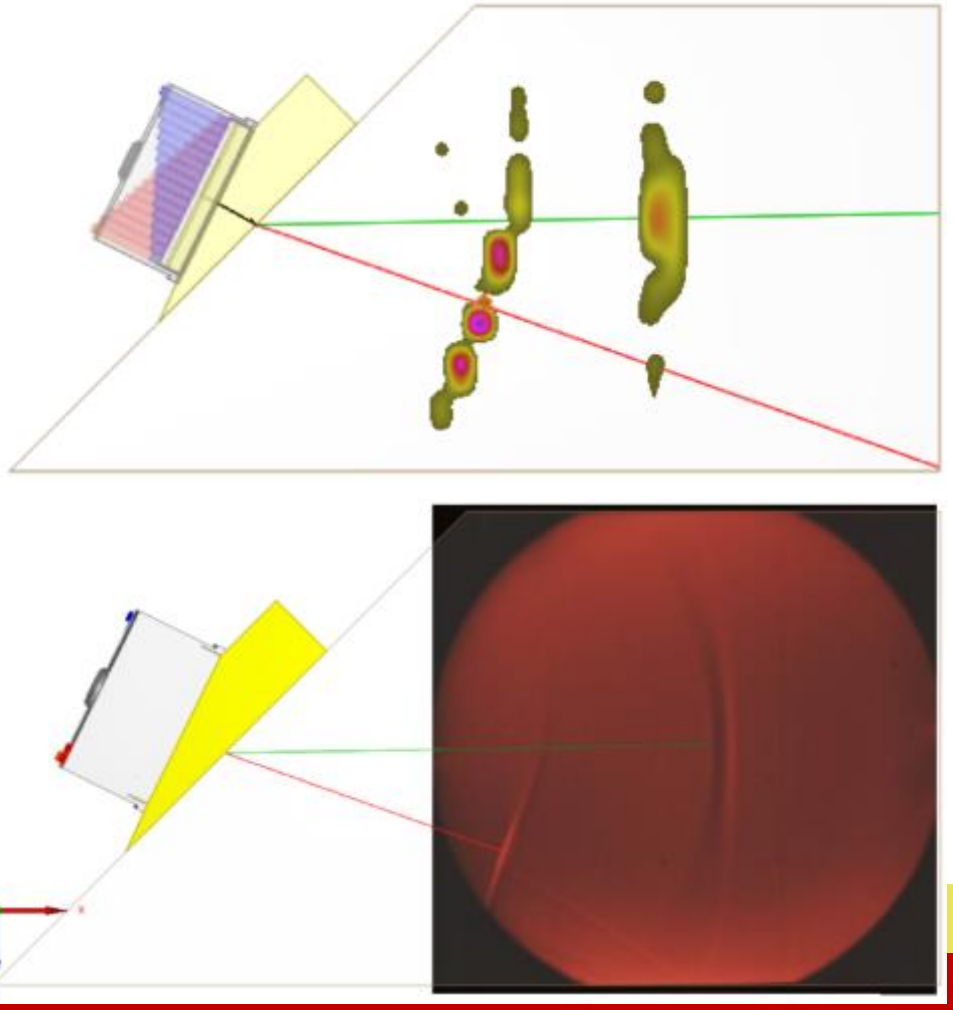




Dual Linear Array

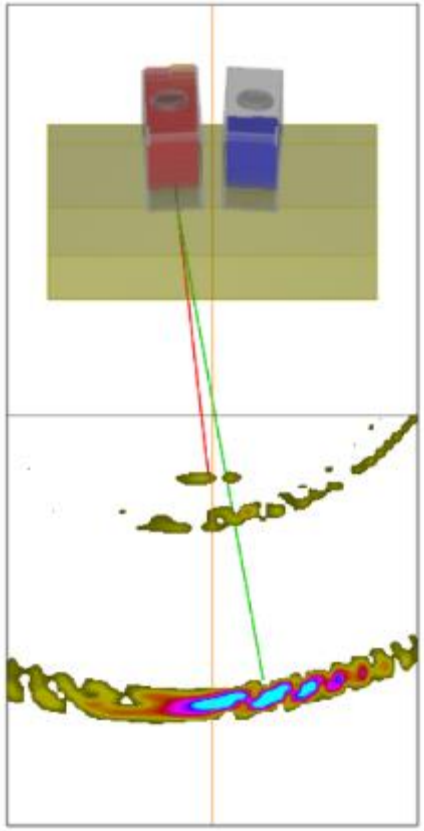


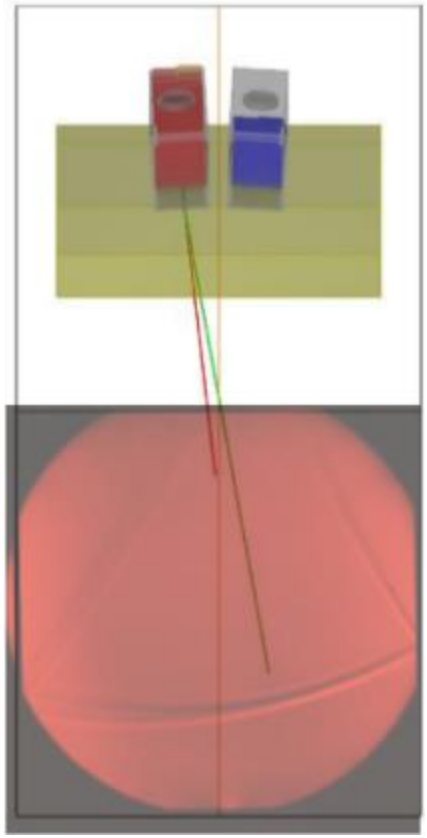
Modelling & PhotoElastic Glass Sample



DMA 45 degree
90 degree view

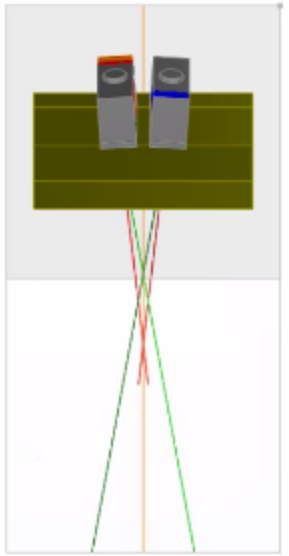
Modelling & PhotoElastic Glass Sample



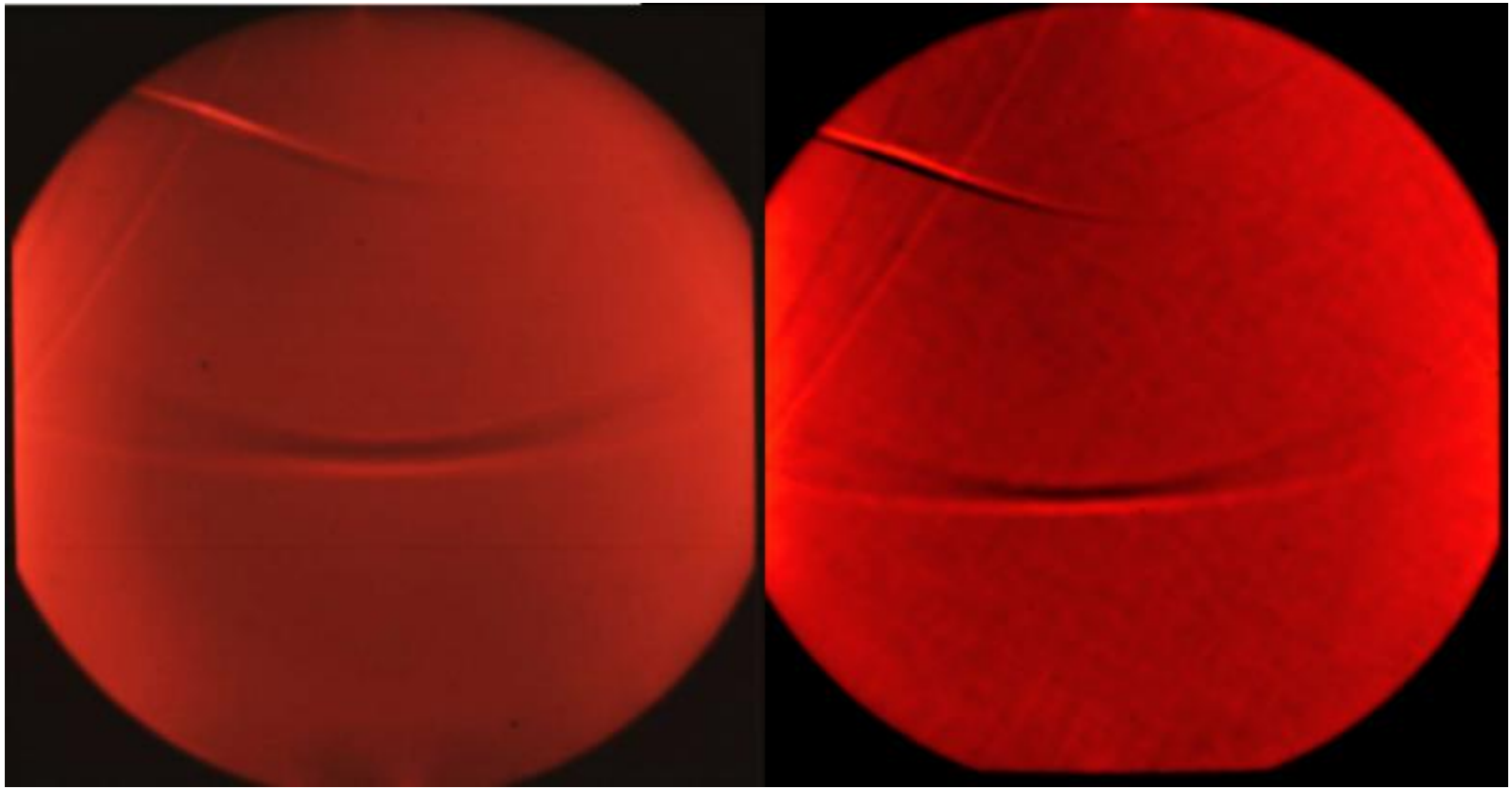


DMA 45 degree
0 degree view

Shear does not show well in photoelastic image due to the angle (out of focal plane)



Photoelastic Comparison



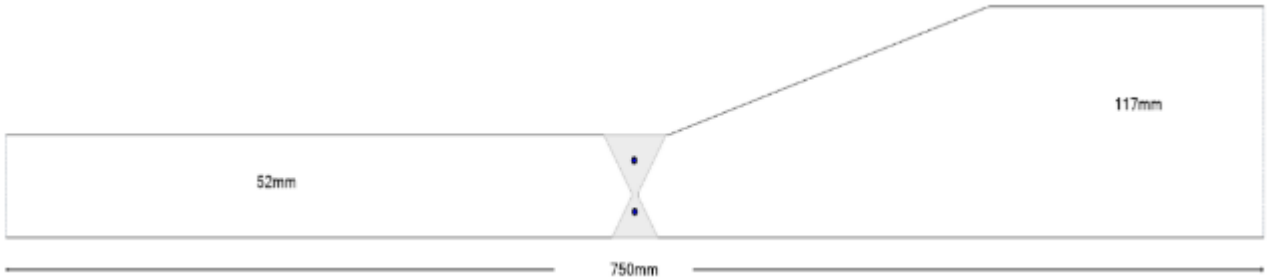
DMA 45 degree
90 degree view

DLA 45 degree
90 degree view

DMA for Weld, with Plate and Fusion Longitudinal & Shear

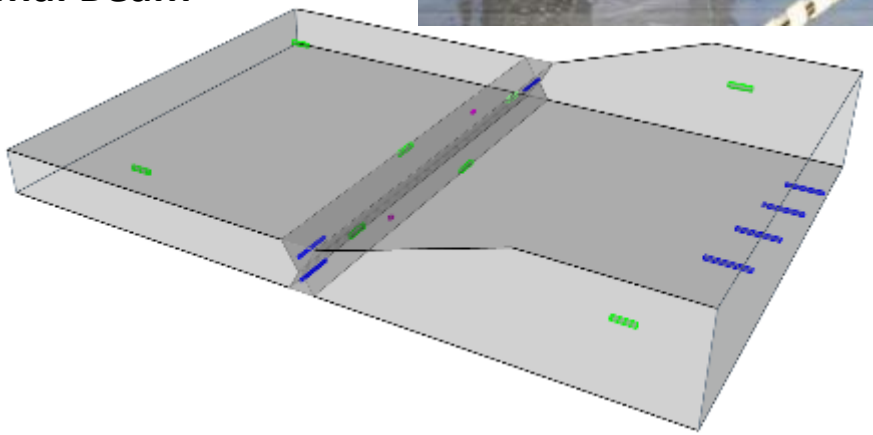
- Combination of transducers and modes are applied for inspection
- Normal beam scan performed for plate and over weld
  (cap removal or flat-topped weld is ideal)
- Parent material and fusion zone can be inspected using shear
- DMA or DLA applied to weld volume
- Coverage achieved using extensive S-scan angle range
  (our angle range applied, 30 to 89 degrees)
- Calibration is required for plate and a separate calibration is used for weld region
- Awareness of the attenuation is required
  (Cal/test block vs actual weld and parent materials)

Demonstration Block Targets & Weld



Shear Wave Weld Fusion

Normal Beam



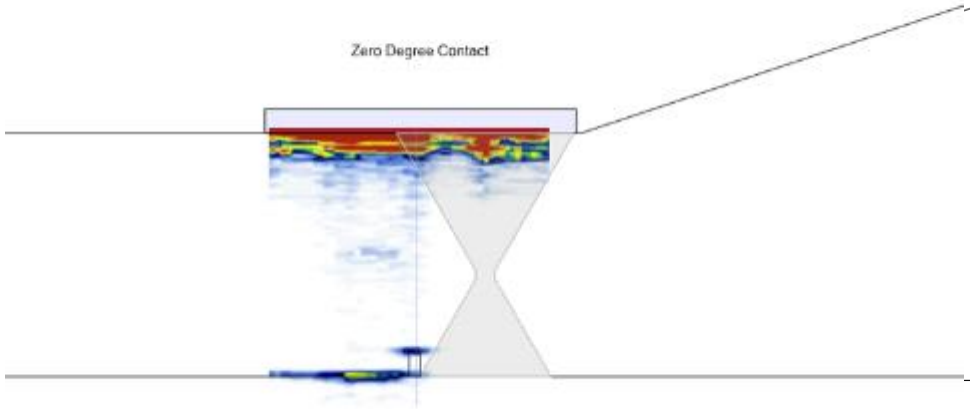
750mm (29.5 inches) x 500mm (19.6 inches) 52mm (2”) – tapered to 117mm (4.6”)

Yes - it is heavy !

Zero Contact Conventional Zero Contact Array

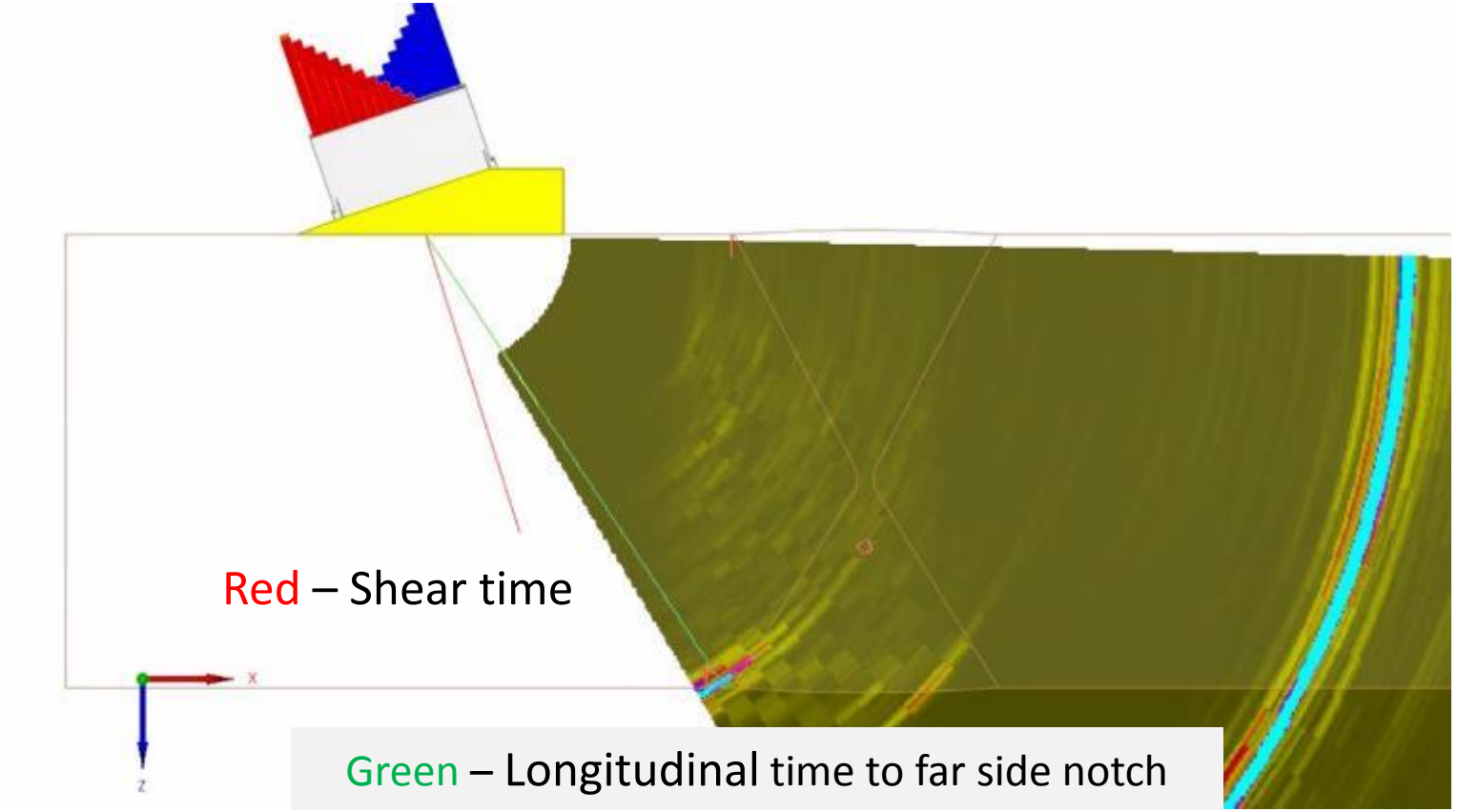
Weld cap removed – our work included conventional zero & flex array

- Contact single or dual element (PE/PC) transducer
  - manual scan was used for our work
  - Options; Semi-automated indexed or Fully automated area scanner
- Flexible ultrasonic phased-array probe for complex shape surface geometry
- Linear Array shown:
  - Note two gain levels were applied
    - Plate scan level - plate gain dB shown
    - Weld scan level +12dB



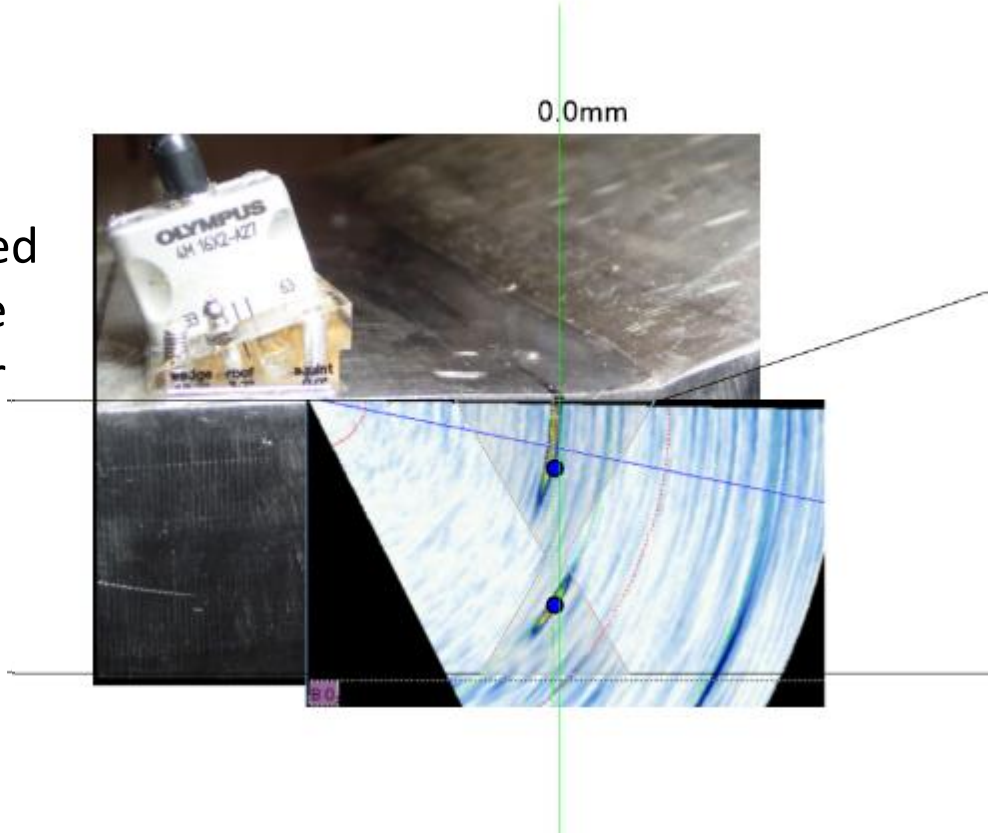
Weld cap removal is ideal to enable zero degree scan over plate and weld

S-scan 30 to 89 degrees Shear & Longitudinal time



Confirm Alignment DMA - Calibration

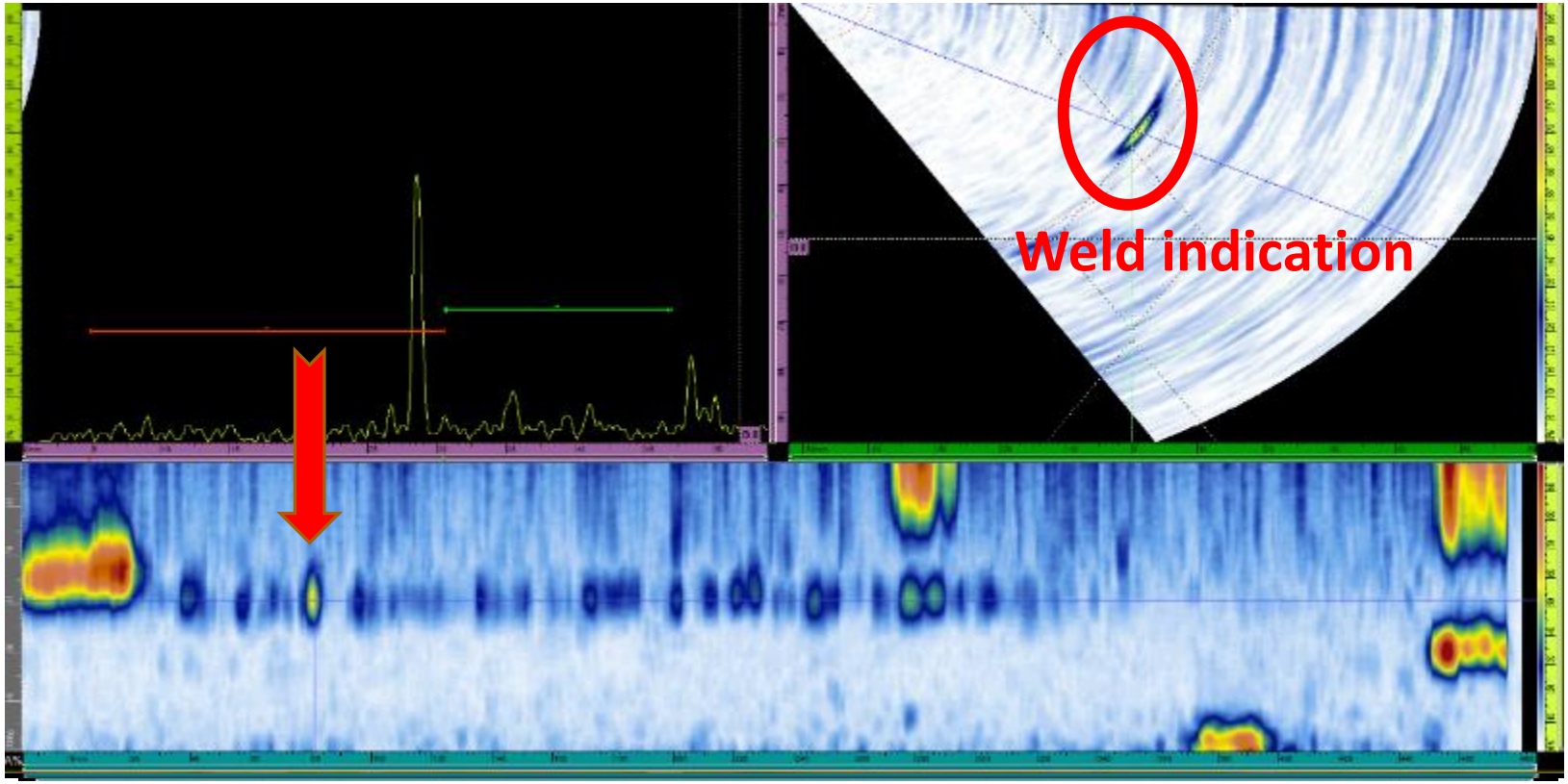
- Calibration is applied over all angles
- Two point SDH's in weld are ideal
- OD – ID notches also work well
- Response over angle sweep equalized
- Technique should optimize coverage
- Confirm index position, weld center line, affirm SDH location and other introduced targets



For our example we used SDH's

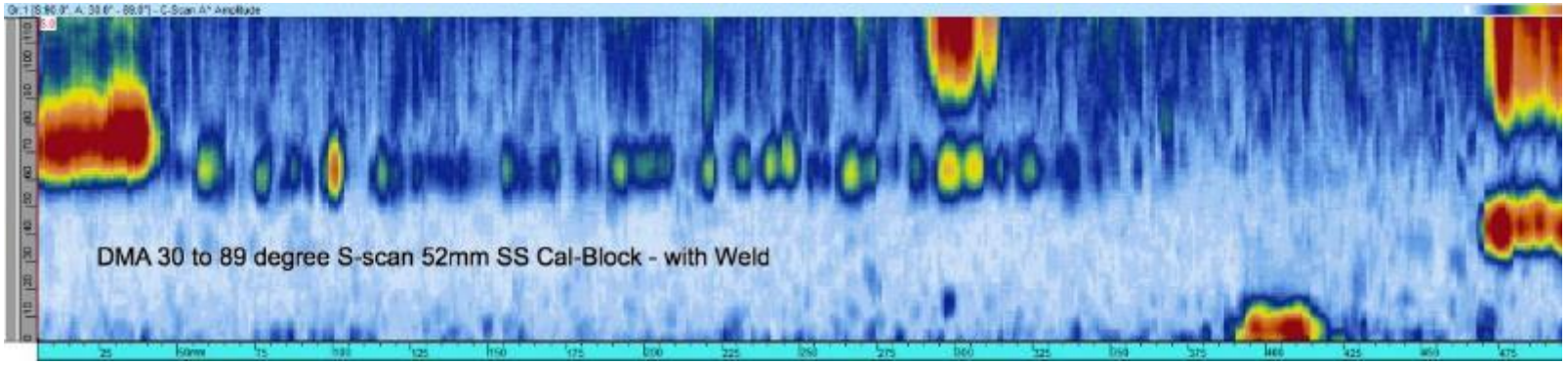
In-weld SDH calibration accommodates grain impact (boundary impedance/attenuation effects)

Demonstration Block 52mm (dB @ PRL – Primary Reference Level)

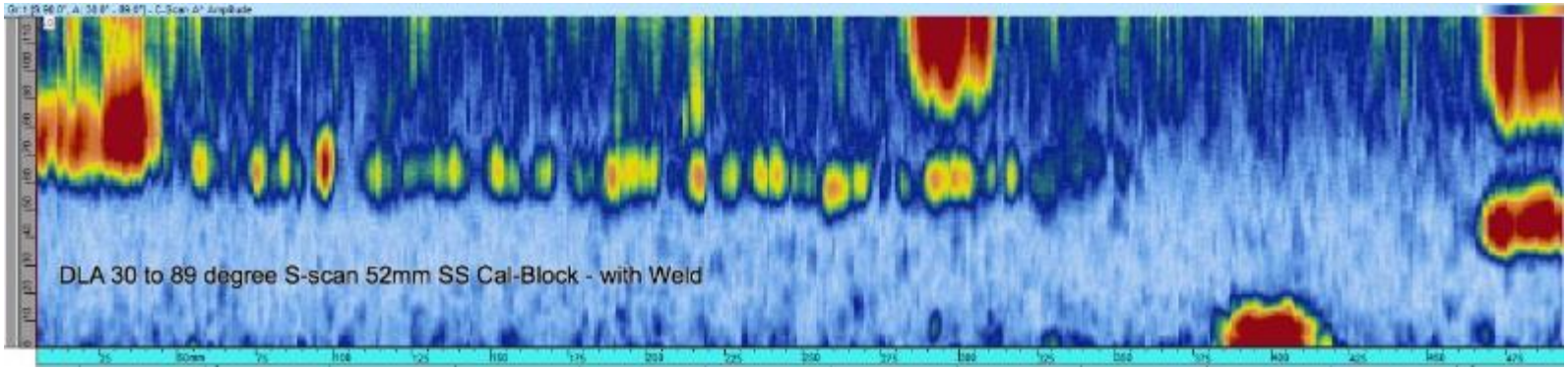


Noted: Weld indications shown further demonstrate detection levels

Calibration Block S-scan Comparison of DMA - DLA



DMA – Scan of Calibration Block SDH and Notches



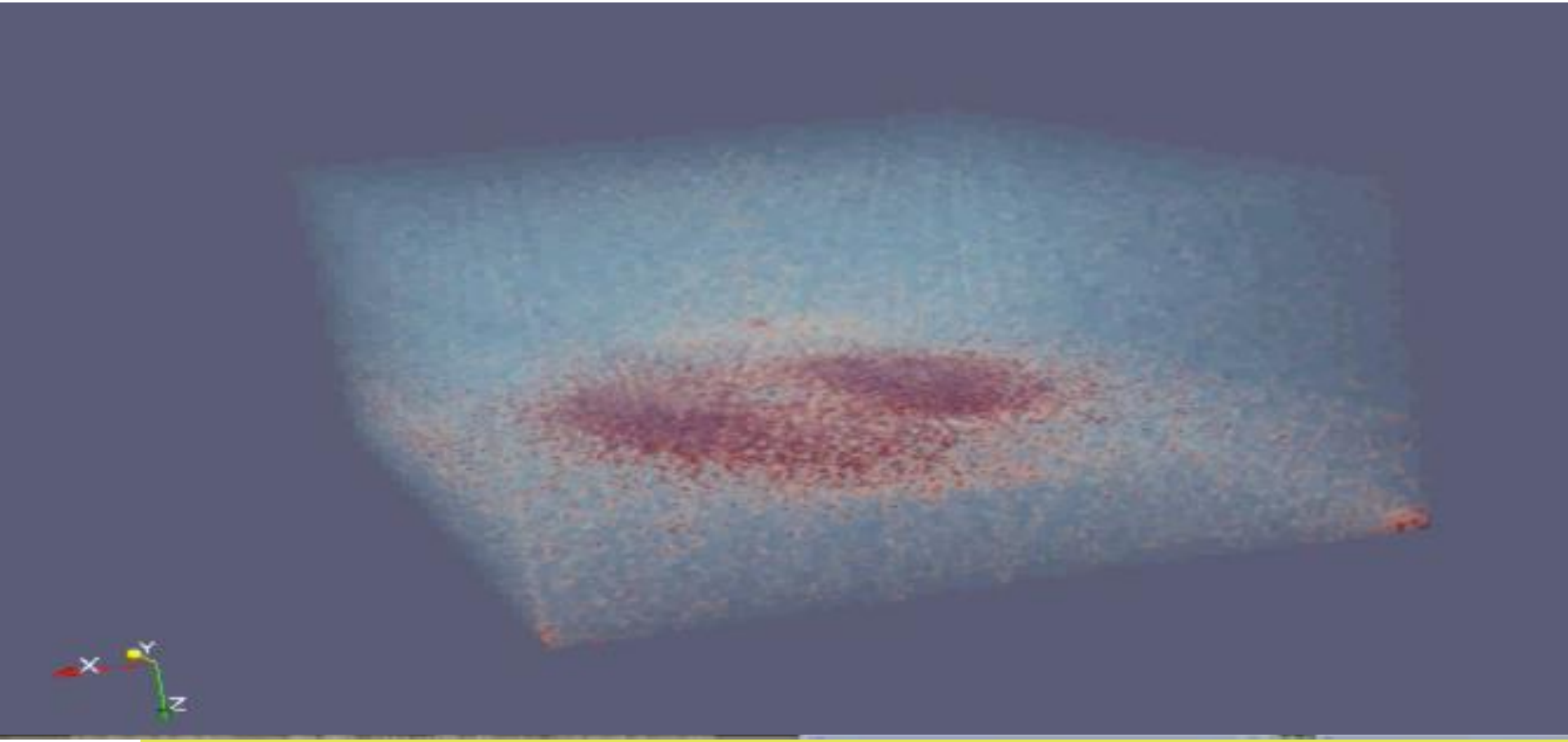
DLA – Scan of Calibration Block SDH and Notches

Conclusions

- Phased-array probes can provide improved volume coverage and offer the ability to interrogate the weld volume with multiple angles.
- In general, phased-array dual probes can provide improved signal to noise ratio for the inspection of coarse-grained materials.
- Some of the signal improvement can be attributable to the phased-array probes ability to focus in a region of interest.
- As with any focusing, the pseudo-focusing at the crossing point of a dual probe has a limited useful range. The roof angle should be carefully selected to target the region of interest.
- There is some advantage for DMA probes when a small adjustment is required to direct the beam at the pseudo-focal point to a slightly different position. Small adjustments of the focal depth can be made with the DMA probe and these could be useful when weld inspection is possible directly over the weld.

Note: The wedge used in this evaluation has a crossing point at a depth of approximately 14-15mm.

More Options for PhotoElastic



Do you have an application for PE – CT scanning – Contact Ed Ginzel

Example of PECT-UTPA

Thank you

Questions