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Application of Laser-Based Ultrasonic Inspection to Some SNL, NM Components

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Laser Ultrasonic NDE - Characteristics

Similar to conventional Ultrasonic NDE, except:

- Non-contact (no coupling gel)
- Non-immersive (no water bath)
- Can operate in adverse environments:
  - in a furnace (950 C),
  - in a factory production line (tubing mfr.)

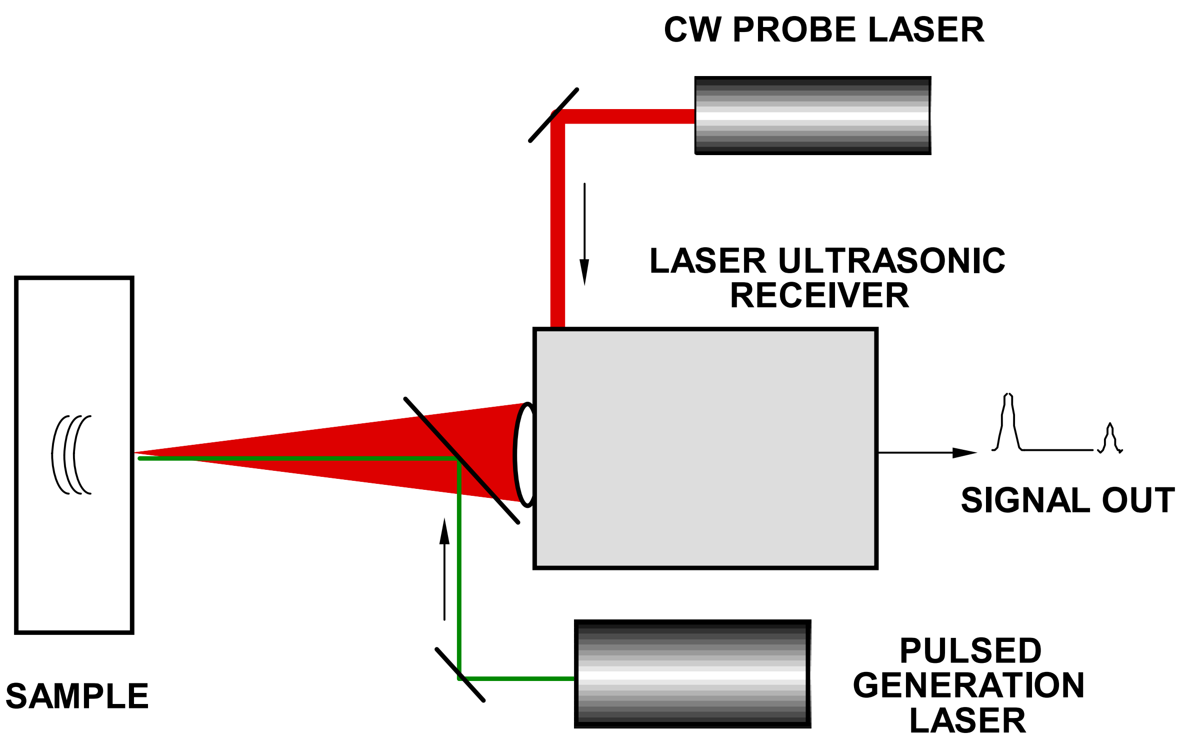
Automated process

However:

- Needs to have line-of-sight to surface
- For best SNR need to lightly ablate surface with probe laser
- Needs development of data processing procedures to extract features of interest

L-US-NDE Schematic

Pulse echo geometry



This and 3 other slides kindly provided by Marvin Klein of Intelligent Optical Systems

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L-US-NDE: Contemporary Interest

Literature search

- Many facilities are investigating this process
  - USAF / NASA / INEL
  - L-M / SwRI
  - Canadian National Research Council
  - Universities (many)

Domestic Vendors

- Intelligent Optical Systems, Torrance, CA (contract placed)
- Karta Technologies, San Antonio, TX

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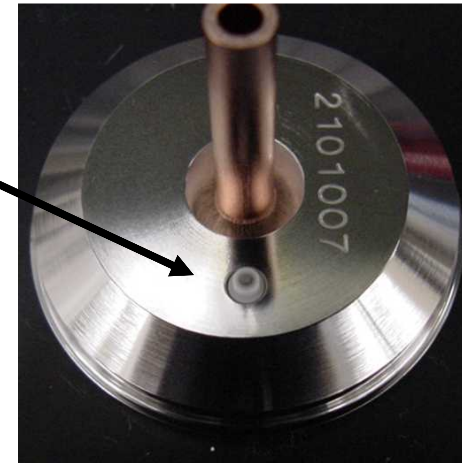
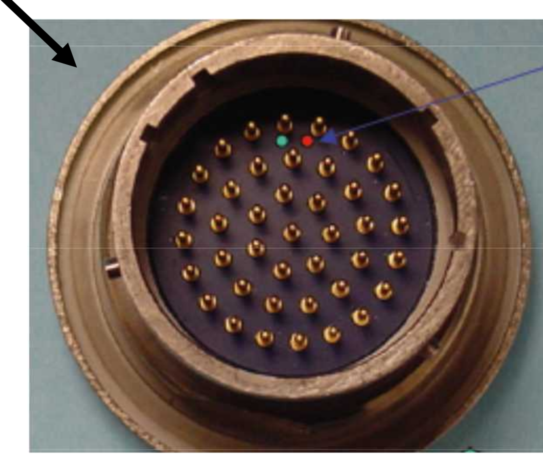
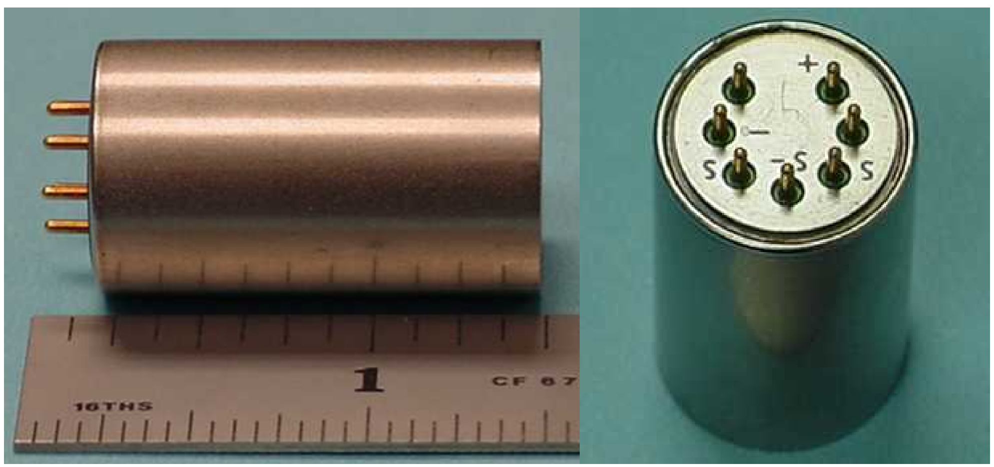
Specimens Evaluated

- **3 types of samples:**
  - **Braze: Neutron tube ceramic-to-metal seal**
  - **Glass-to-metal seal: connector**
  - **Weld: Small thermal battery**







Experimental Set-Up

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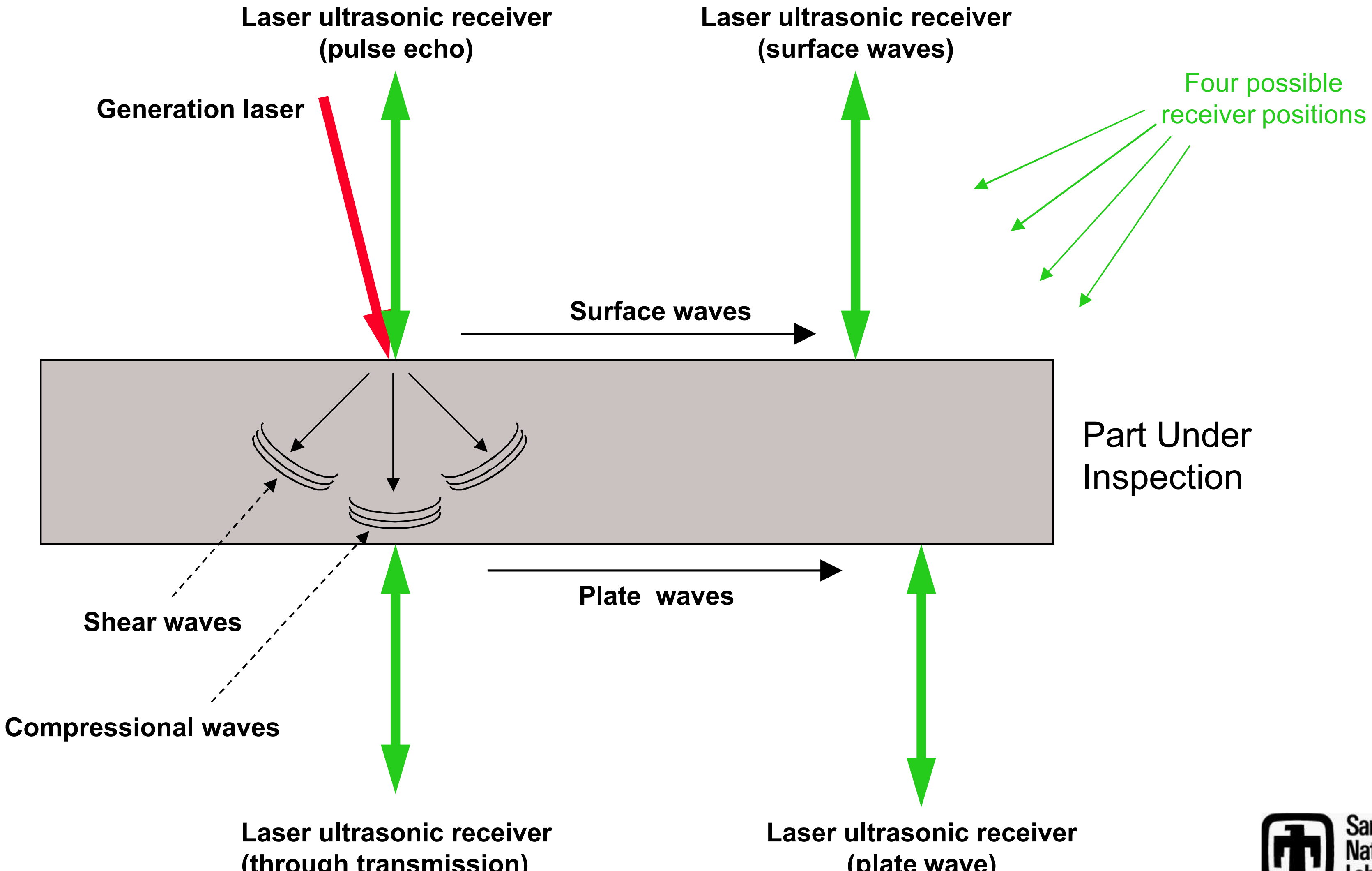
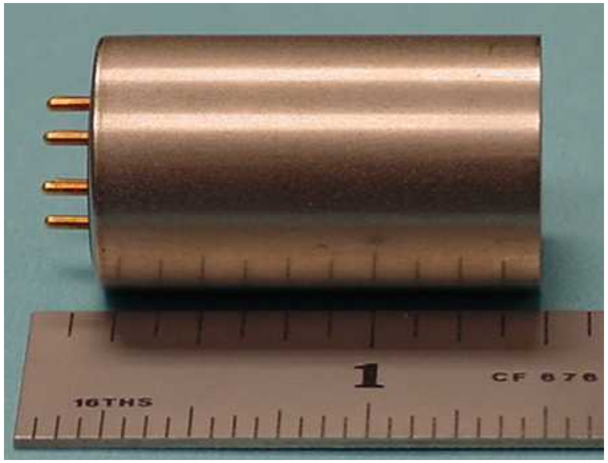
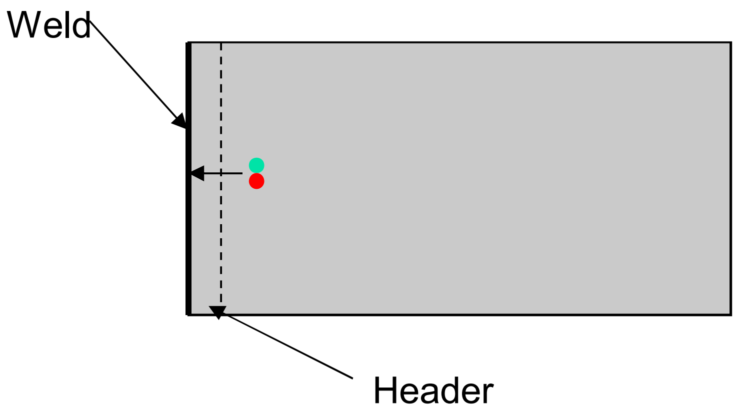
L-US-NDE: Wave Geometries



Initial Battery Examination Geometry



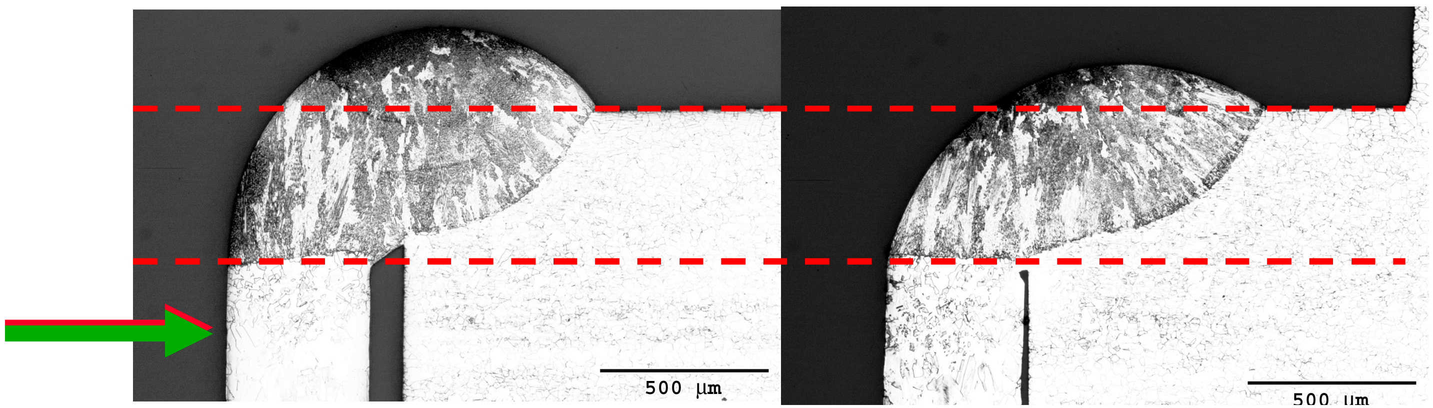


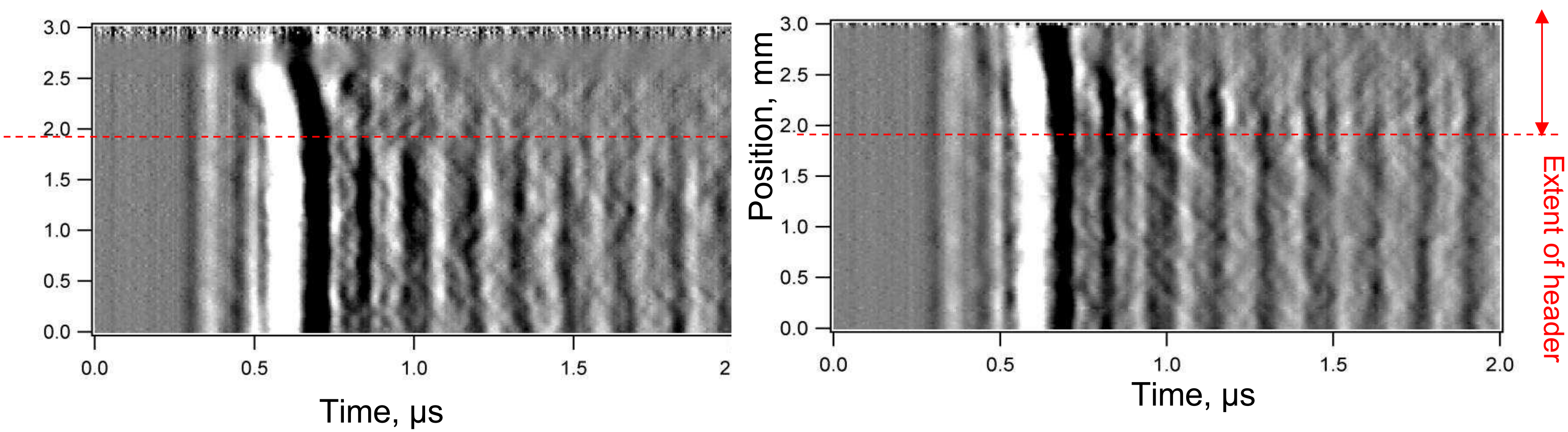
Initial weld penetration measurement configuration.

Beams are scanned side by side toward the top edge (2 locations).

The red dot and the green dot mark the initial locations of the generation and probe lasers.

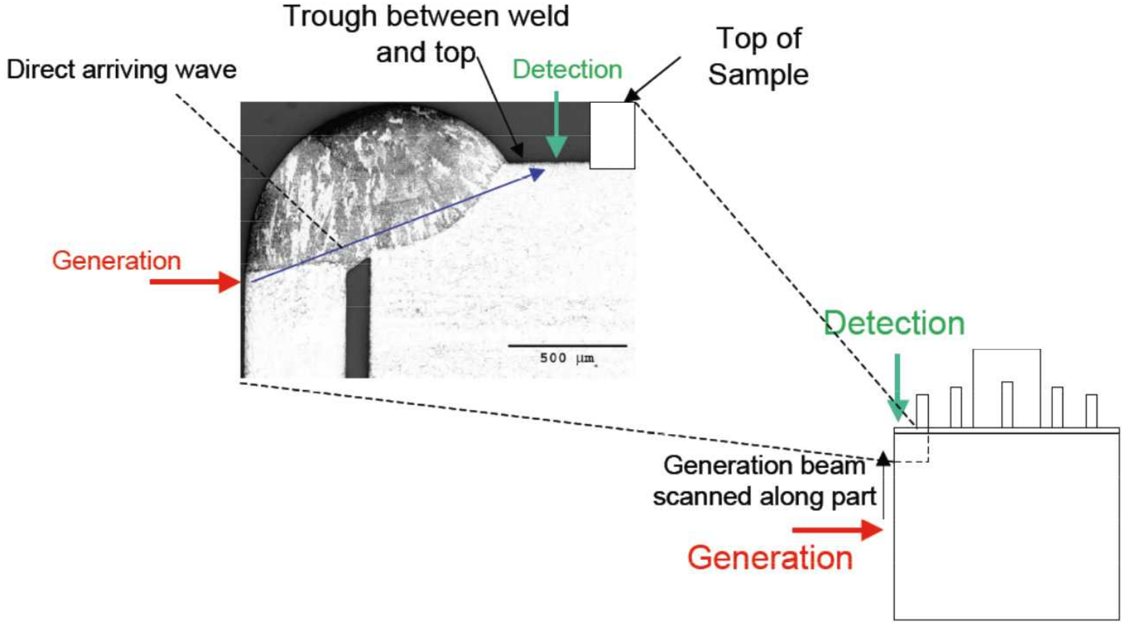
Weld Metallography & Scan Results

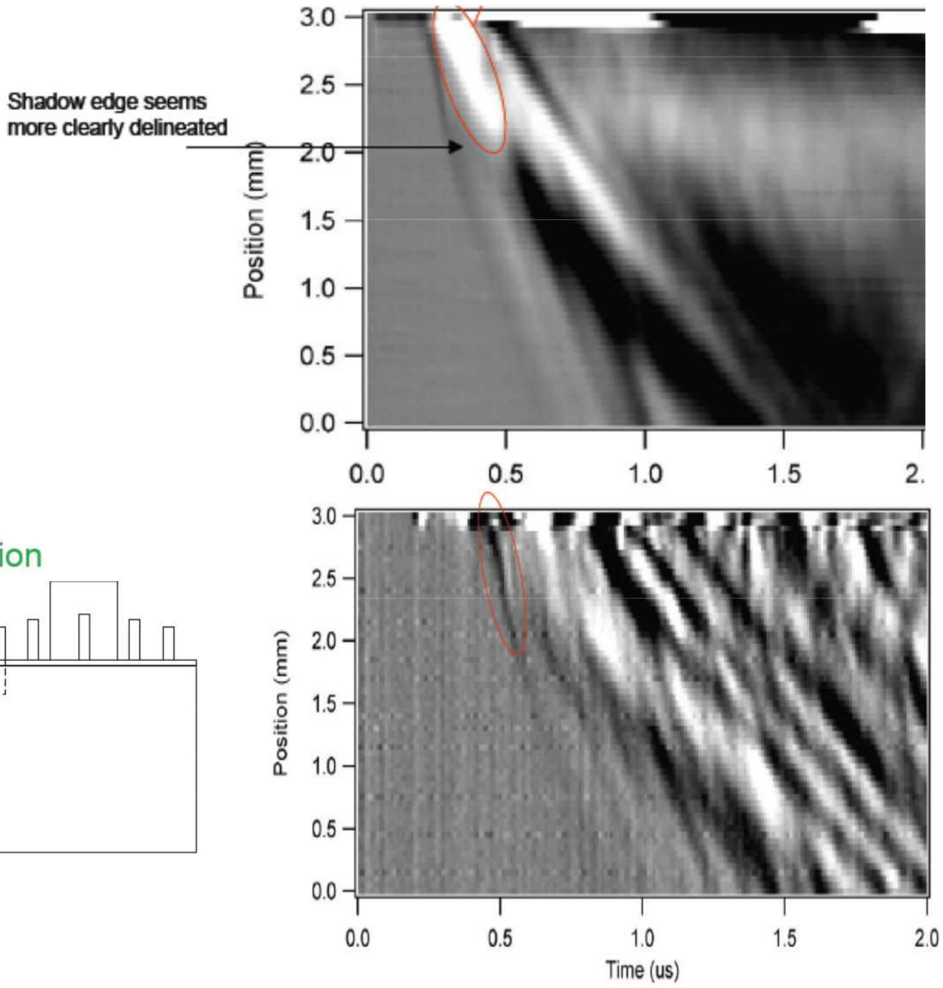




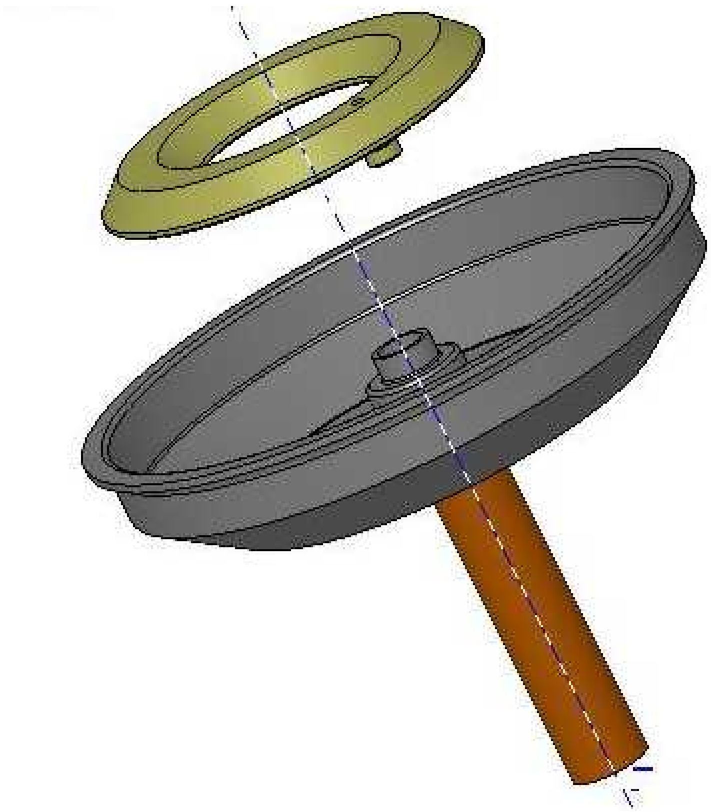
Differentiated signal

Second Attempt at Weld Scan





Brazement:
Alumina Insulator to Kovar Header



Several assemblies have leaked through the braze.

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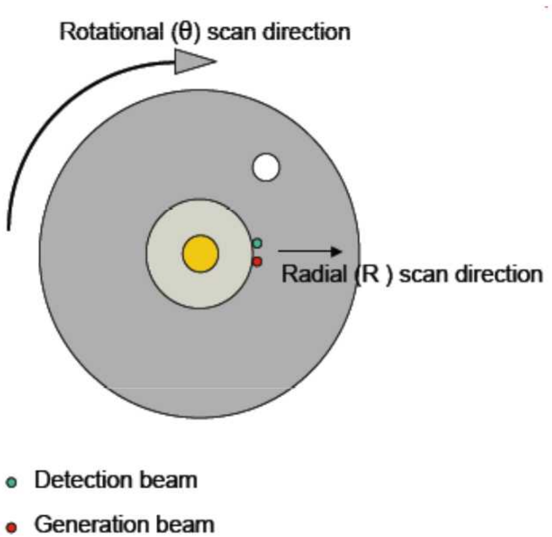
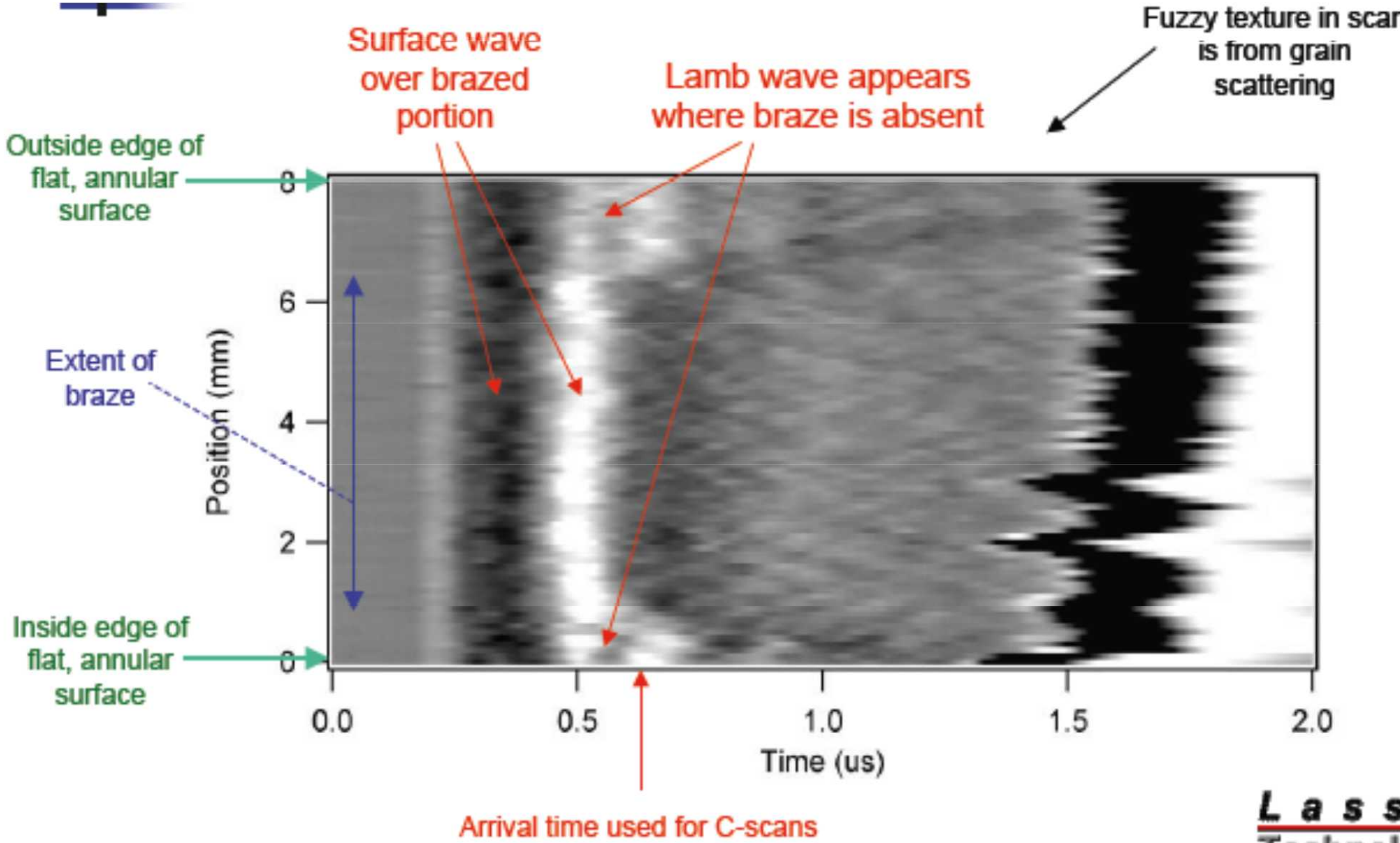
Geometry of Braze Scan



Ablated

Not

Braze B-Scan "Raw" Results



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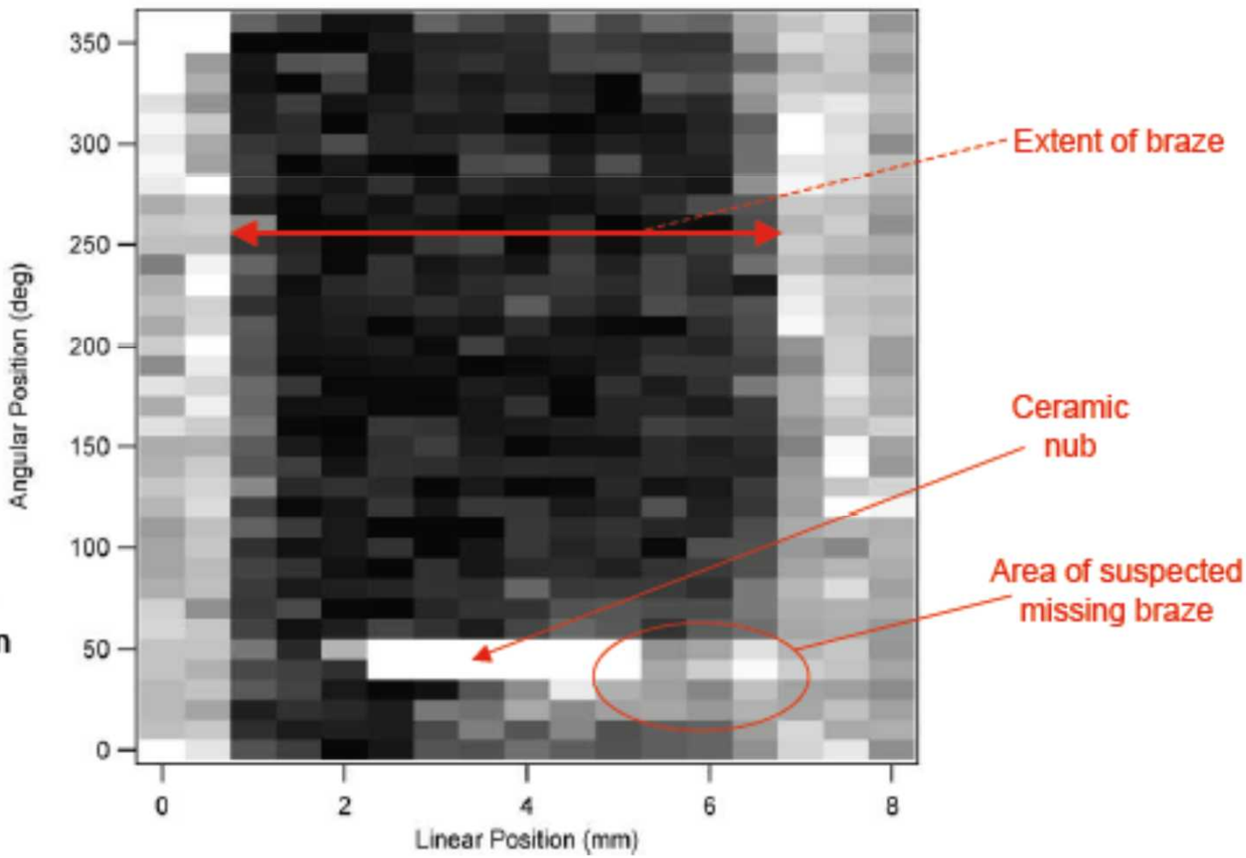
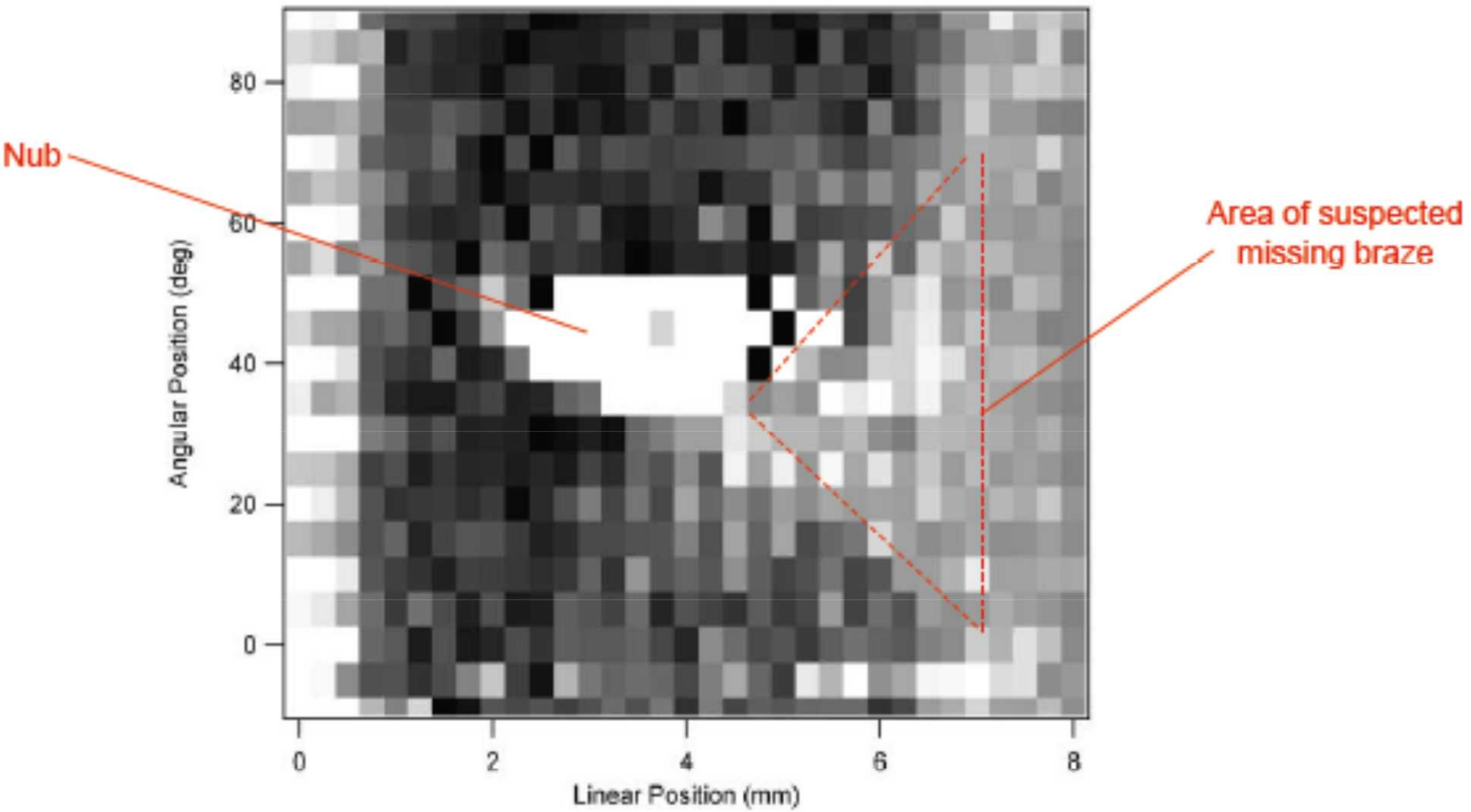
C Scan Results

Measure amplitude at arrival time of 0.65 μs (Slide 3). Plot amplitude in grey scale.

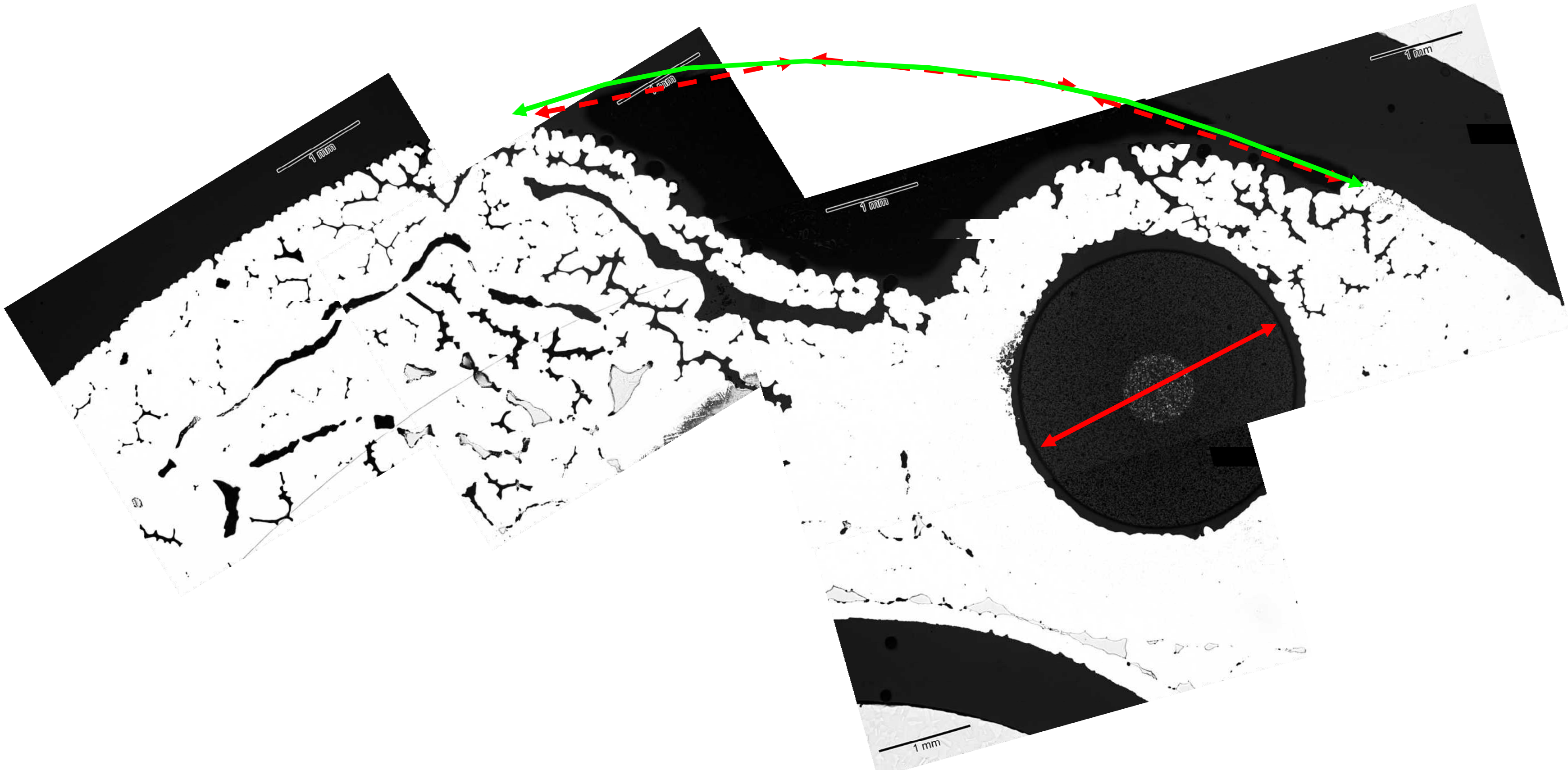


Note: pixel size is actually smaller near the ID (position 0 mm) than the OD (position 8 mm)

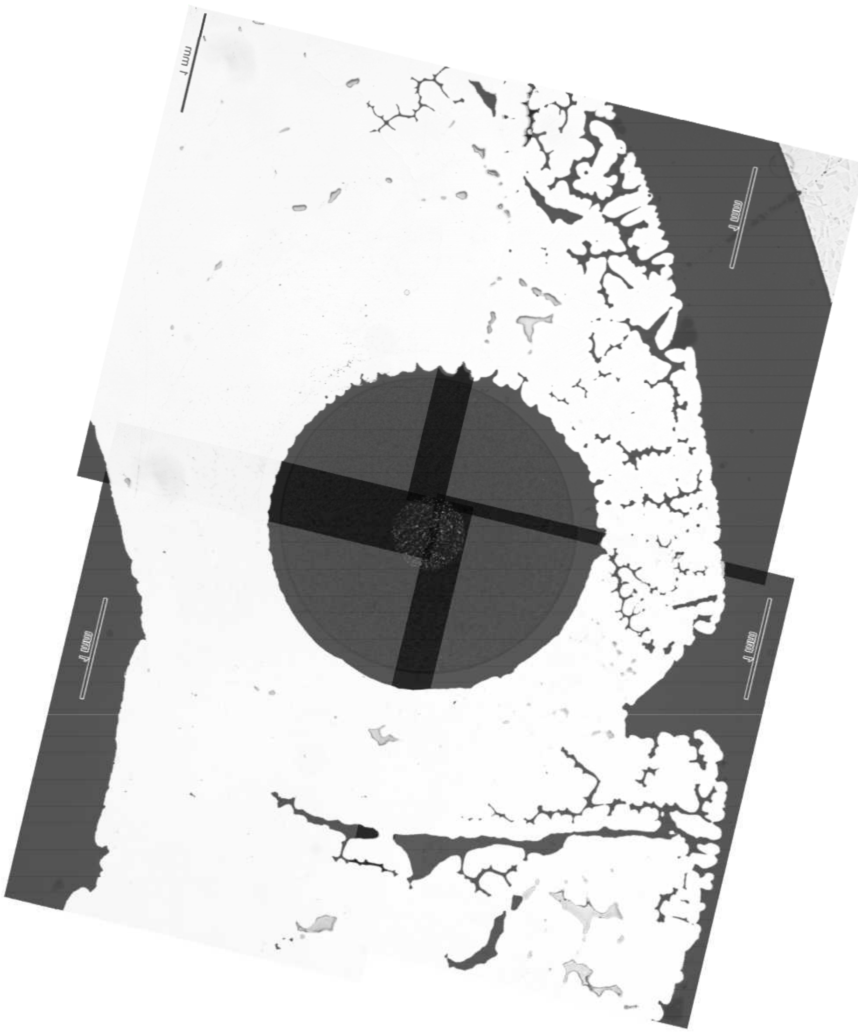
Blow-up Around Nub

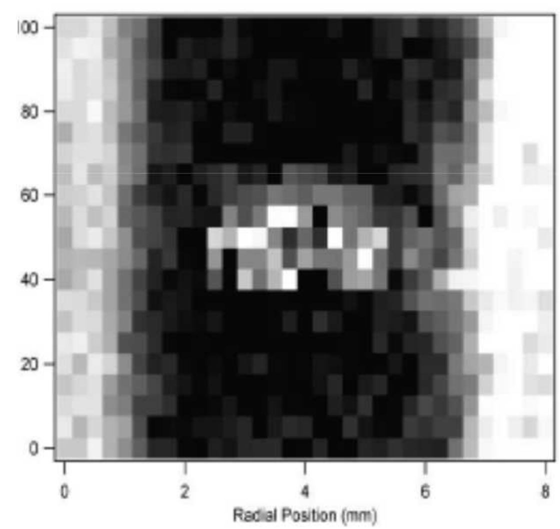


Metallography of Braze Showing Actual Defects

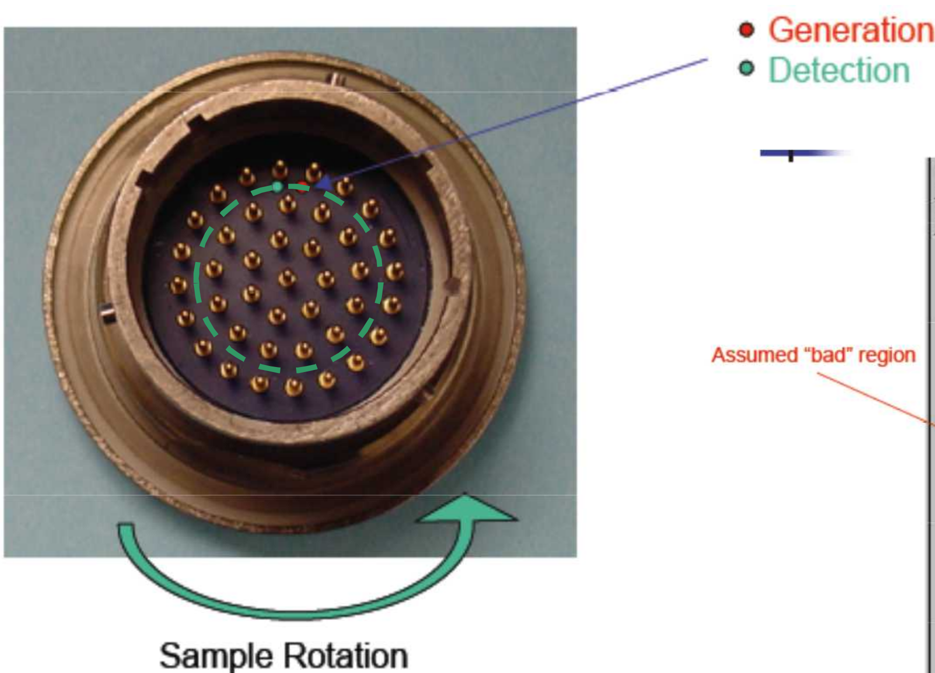


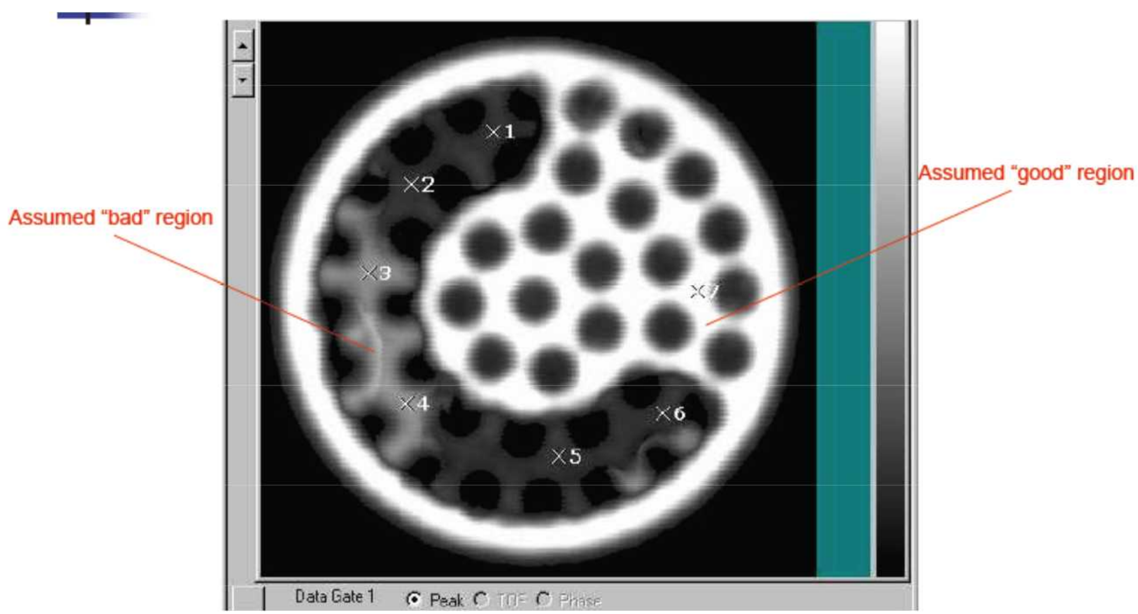
Non-Ablative Mode (aka Thermoelastic)





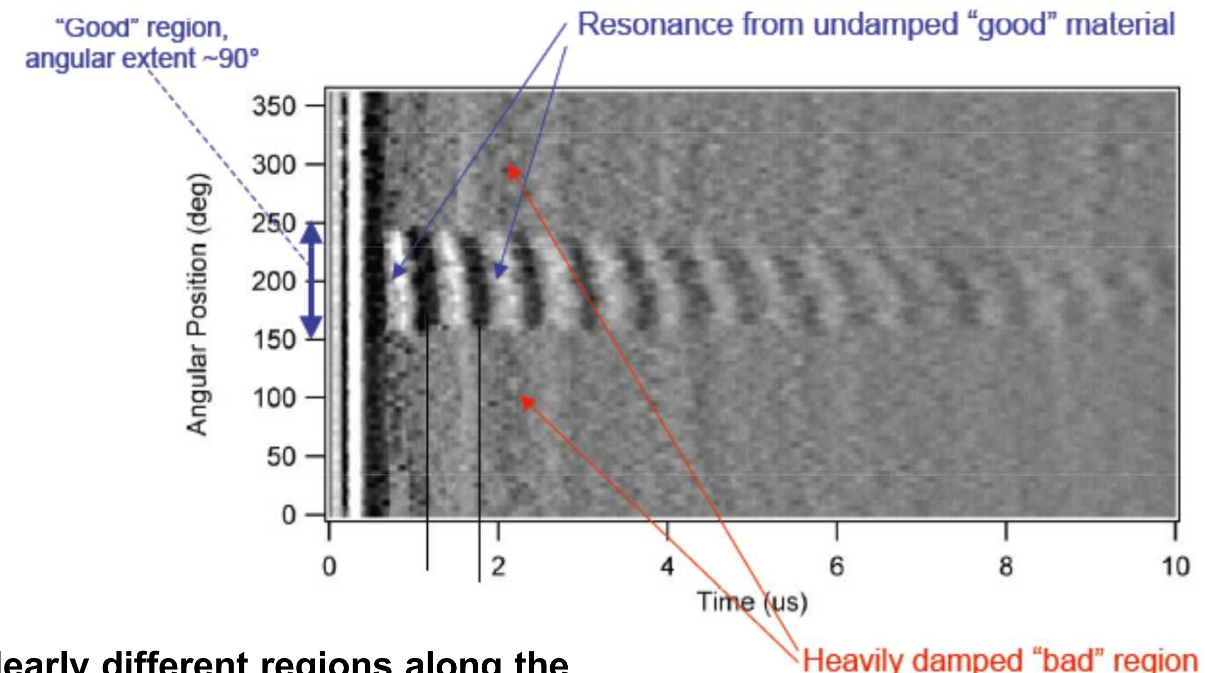
Geometry and SAM Image from Connector





Connector found to have internal glass crack via Scanning Acoustic Microscope.

Connector Circumferential Scan Dataplot



There are two clearly different regions along the scan:

Region 1: 90º wide

Region 2: 270º wide

SAM image suggests that:

Region 1 is "good"

Region 2 is "bad"

Lack of damping in B-scan Region 1 suggests this region is "good"

Conflicting evidence:

Period of resonance in Region 1 of B-scan is ~0.6 µs;

From SAM data a period of 1.5 µs was measured.

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Conclusions

- The work performed here has shown great potential for LUS NDE for implementation of quality assurance in several areas of joining.
- Included have been preliminary attempts at measurement of the depth of penetration in a cylindrical closure-type edge weld,
- Measurement of braze defects due to insufficient wetting and/or interdendritic shrinkage for a ceramic-to-metal brazement,
- Evaluation of cracked glass in a multi-pin hermetic connector.
- In each case, an alternative form of evaluation was used to correlate with the LUS data mapping.