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Laser Ultrasonic NDE of Small Component Braze and Weld Joints

(A non-contact, non-immersion ultrasonic NDE technique)

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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 S/N ratio, surface ablation by probe laser needed**
- **Each case needs development of data processing procedure to extract features of interest**

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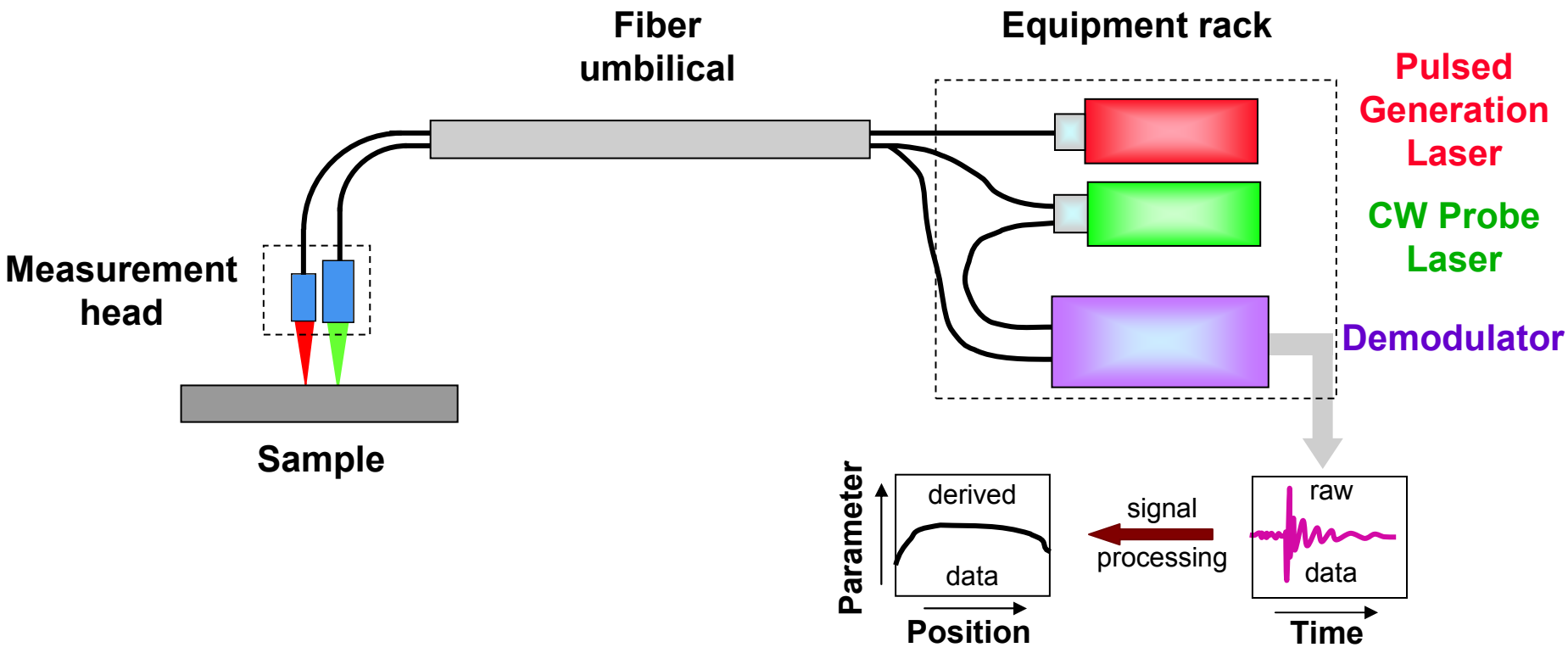
L-US-NDE Schematic



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L-US-NDE: Contemporary Interest

Literature search

- Many facilities are investigating this process
  - USAF / NASA / Idaho National Engineering Laboratory
  - Lockheed-Martin / Southwest Research Institute
  - Canadian National Research Council
  - Universities (many)

Domestic Vendors

- Intelligent Optical Systems, Torrance, CA
- Karta Technologies, San Antonio, TX

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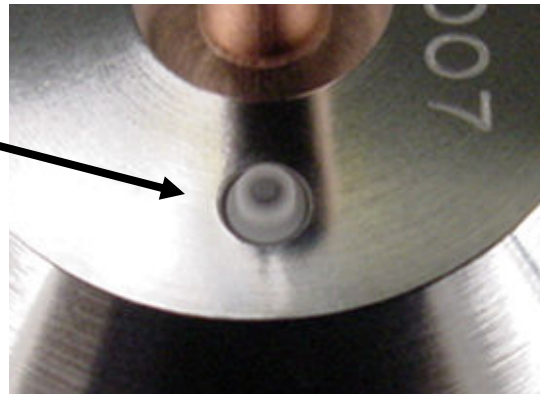
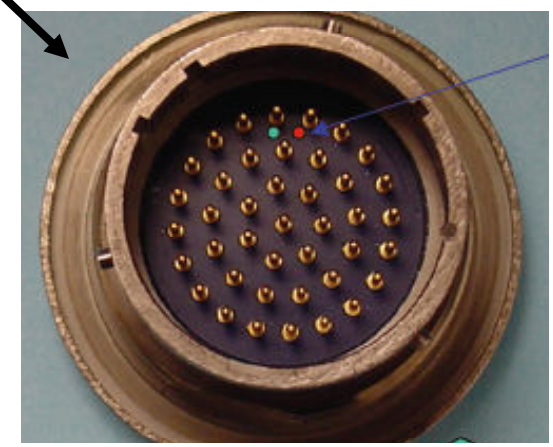
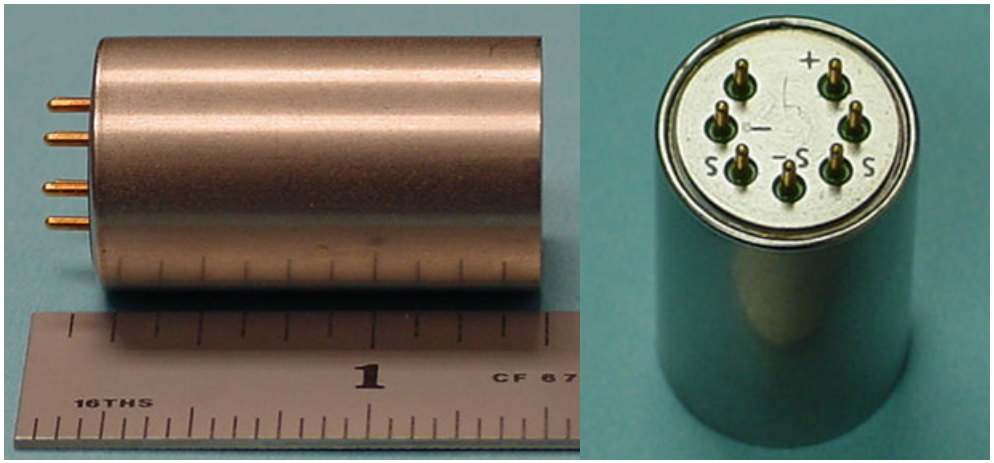
Specimens Evaluated

- 3 types of samples:
  - Braze: ceramic-to-metal seal
  - Glass-to-metal seal: connector
  - Weld: Small container header







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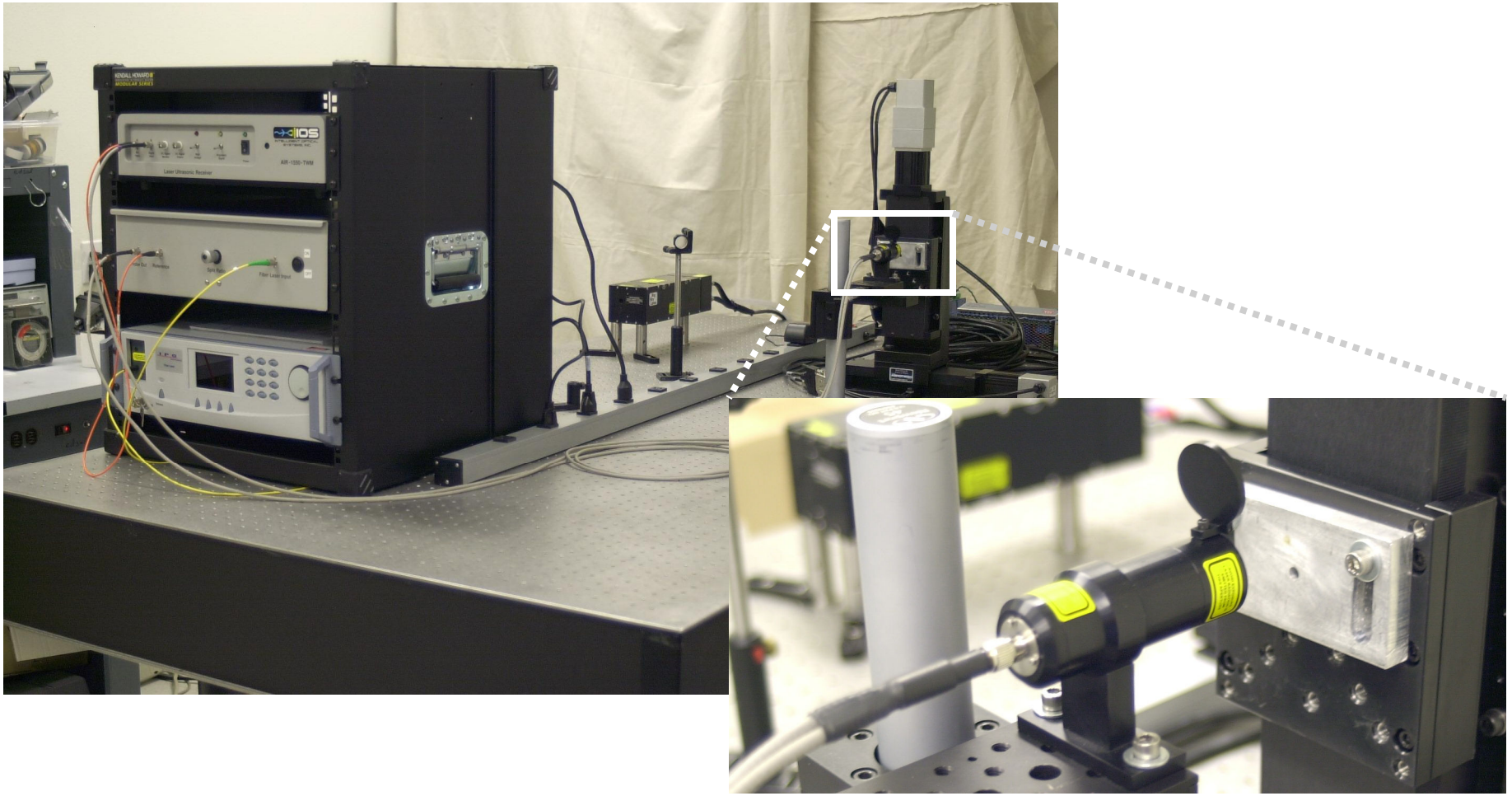
Experimental Set-Up



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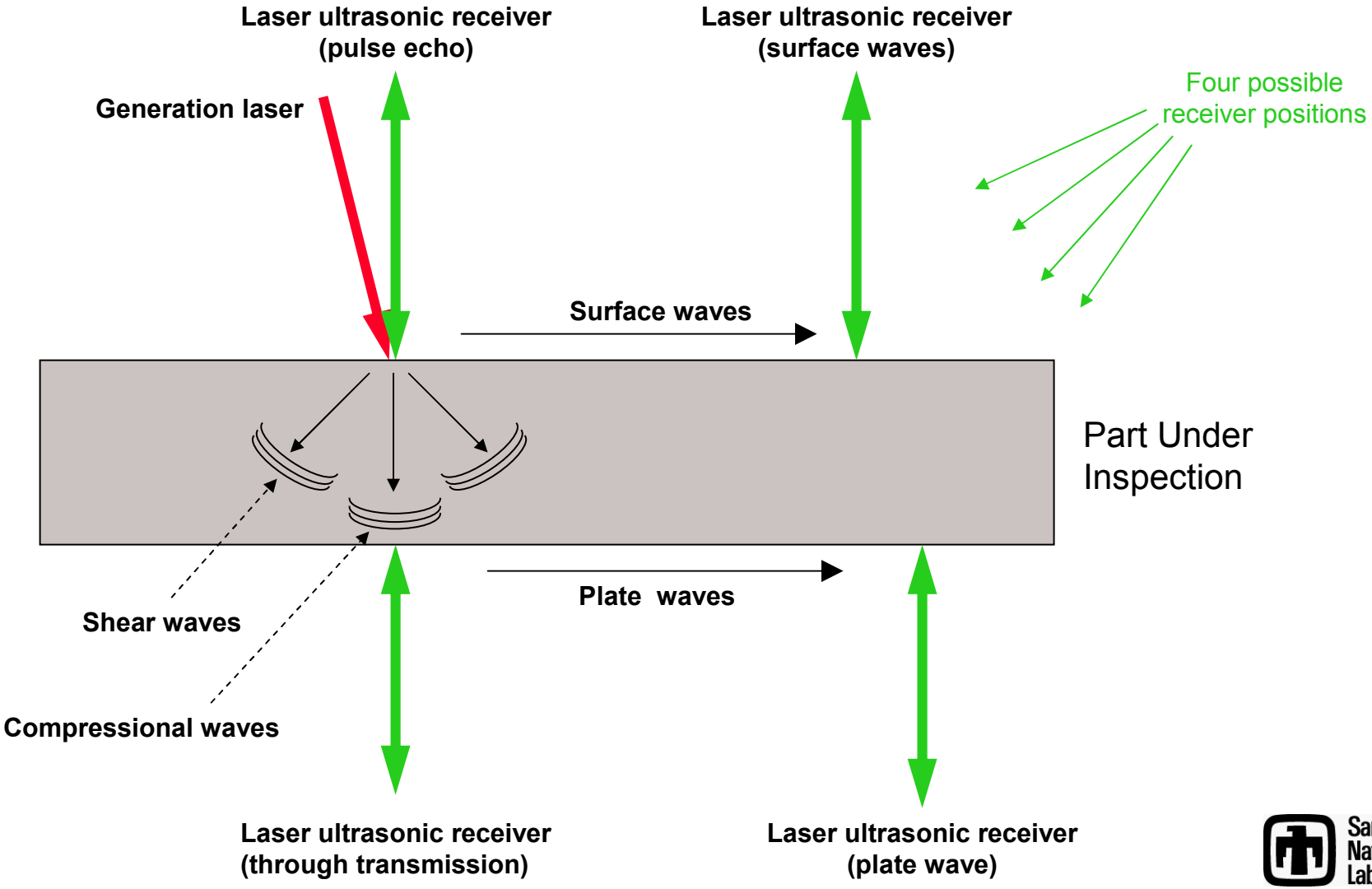
L-US-NDE: Wave Geometries



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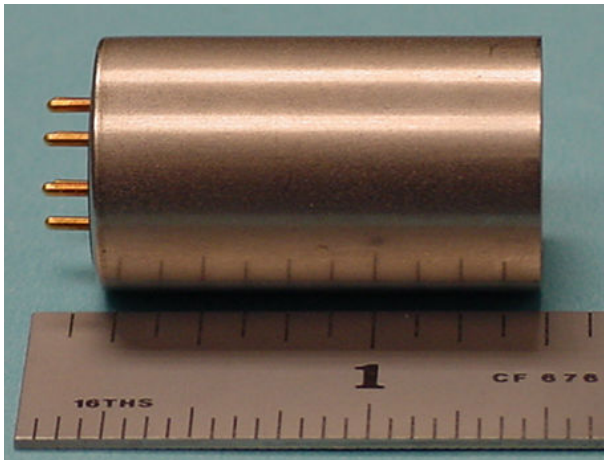
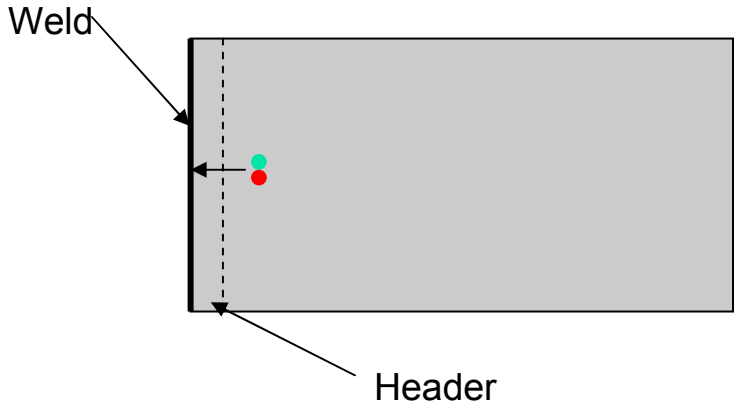
Weld Examination Geometry: Initial





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.

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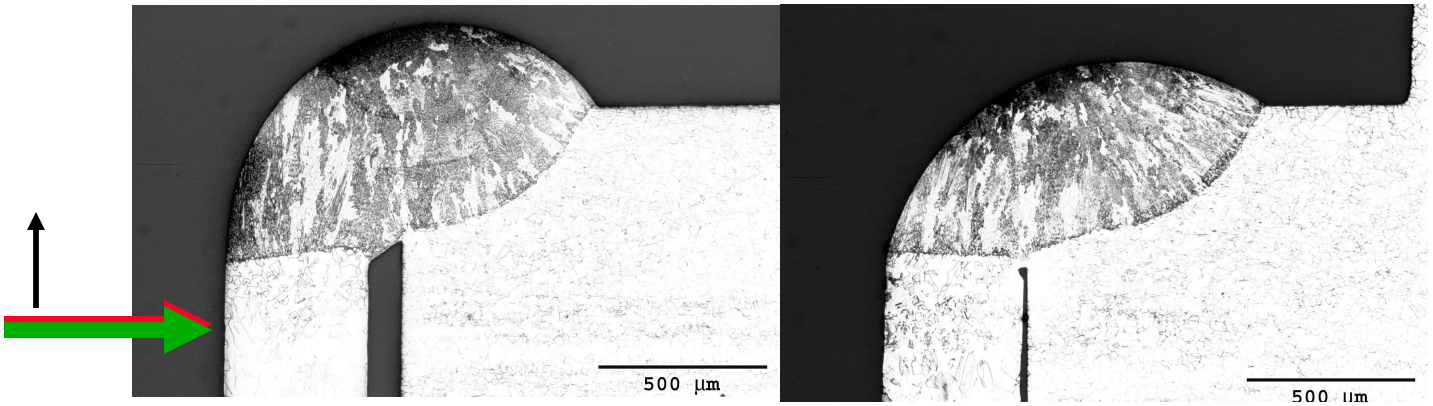
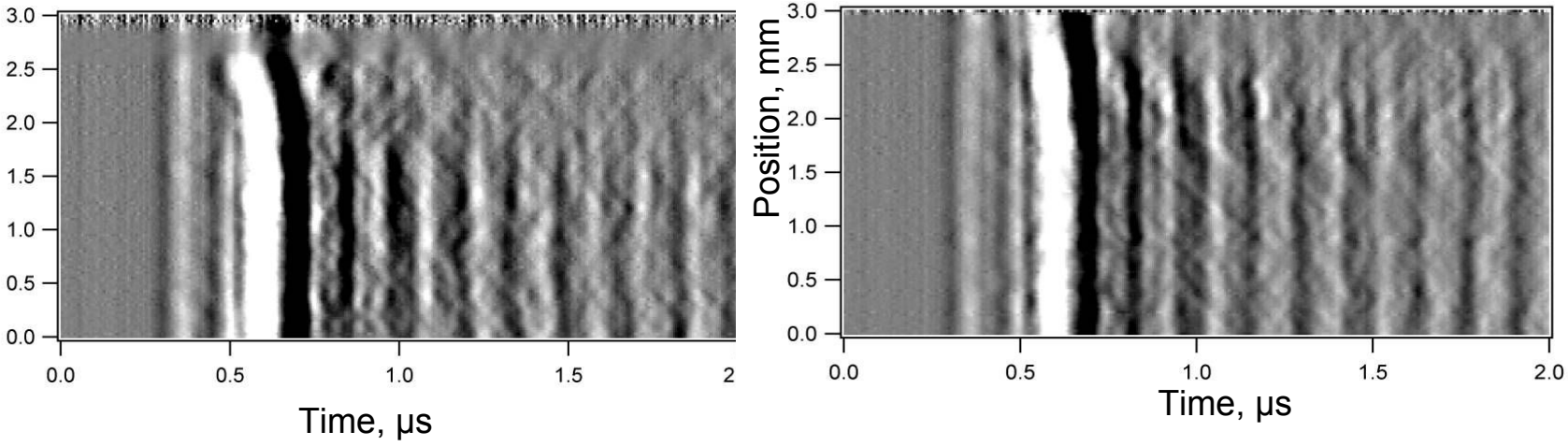
Weld Metallography & Scan Results





Differentiated signal

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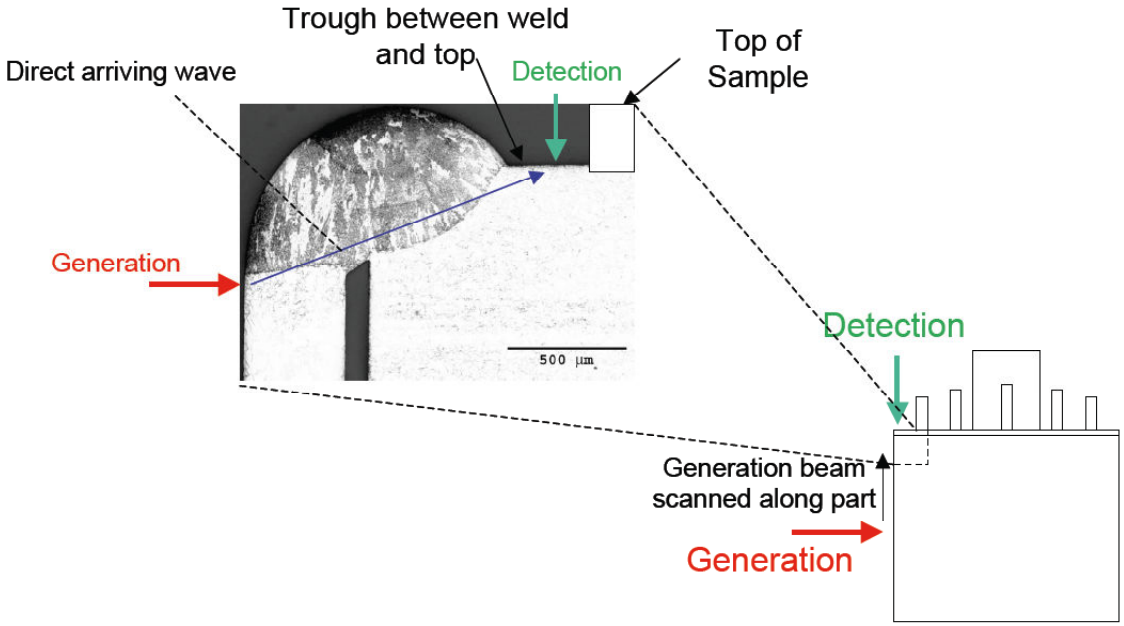
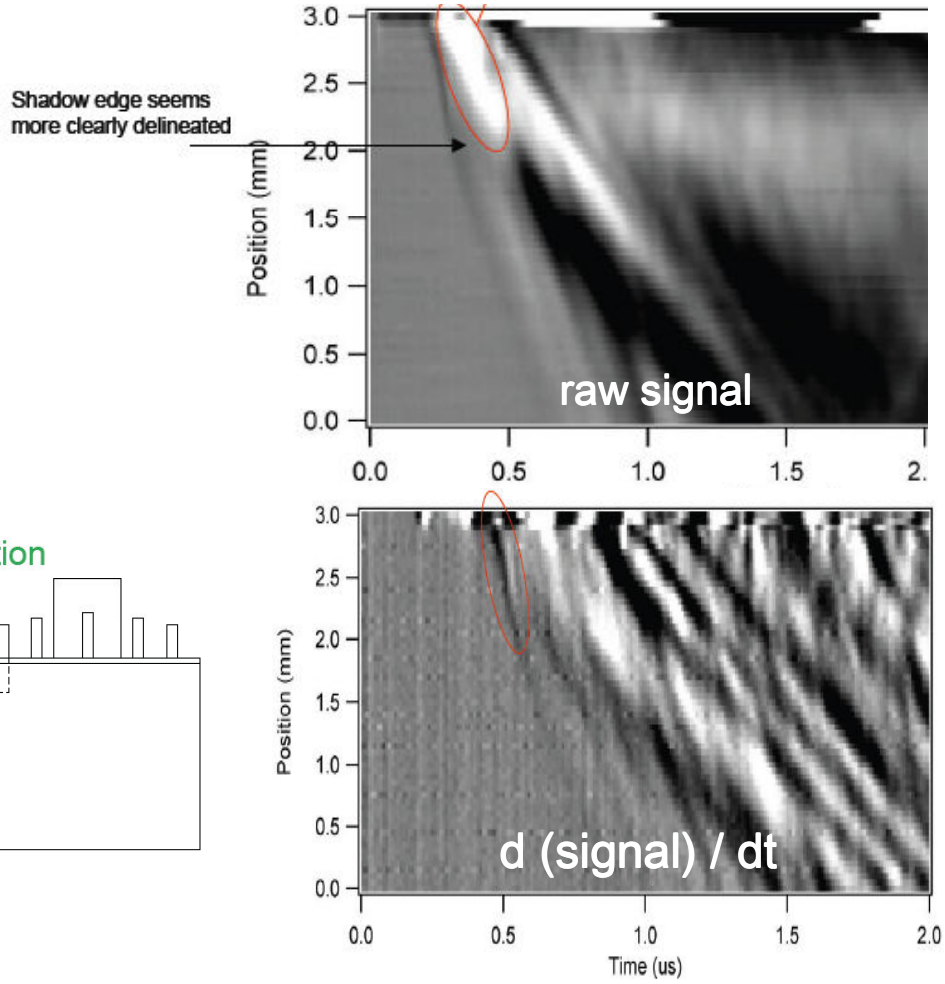
Second Attempt at Weld Scan





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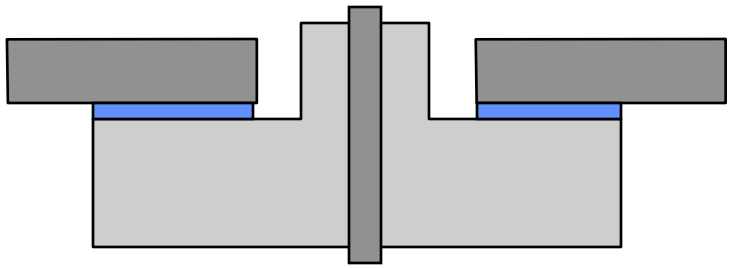
Brazement:
Alumina Insulator to Kovar Header



Several assemblies have leaked through the braze.

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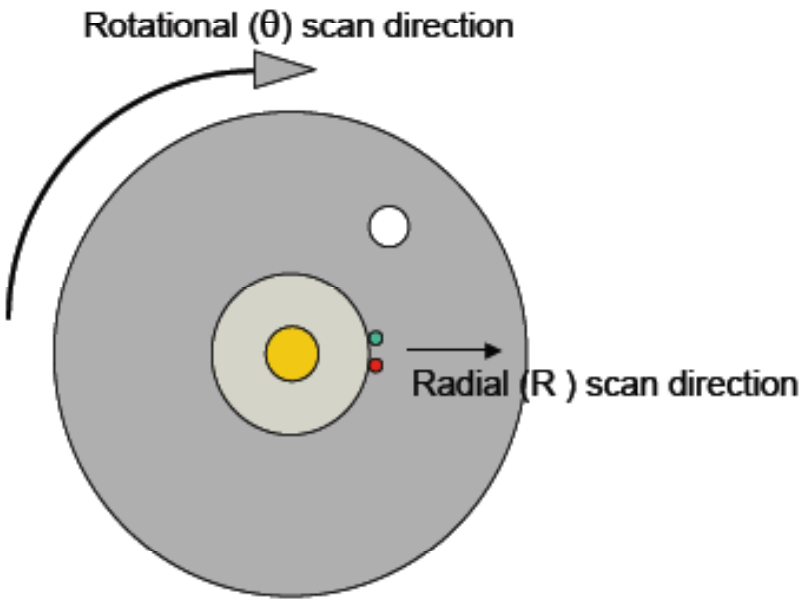
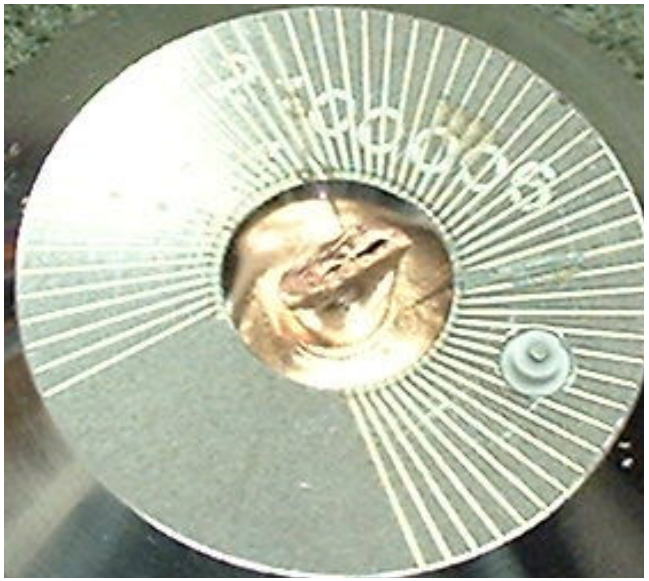
Geometry of Braze Scan

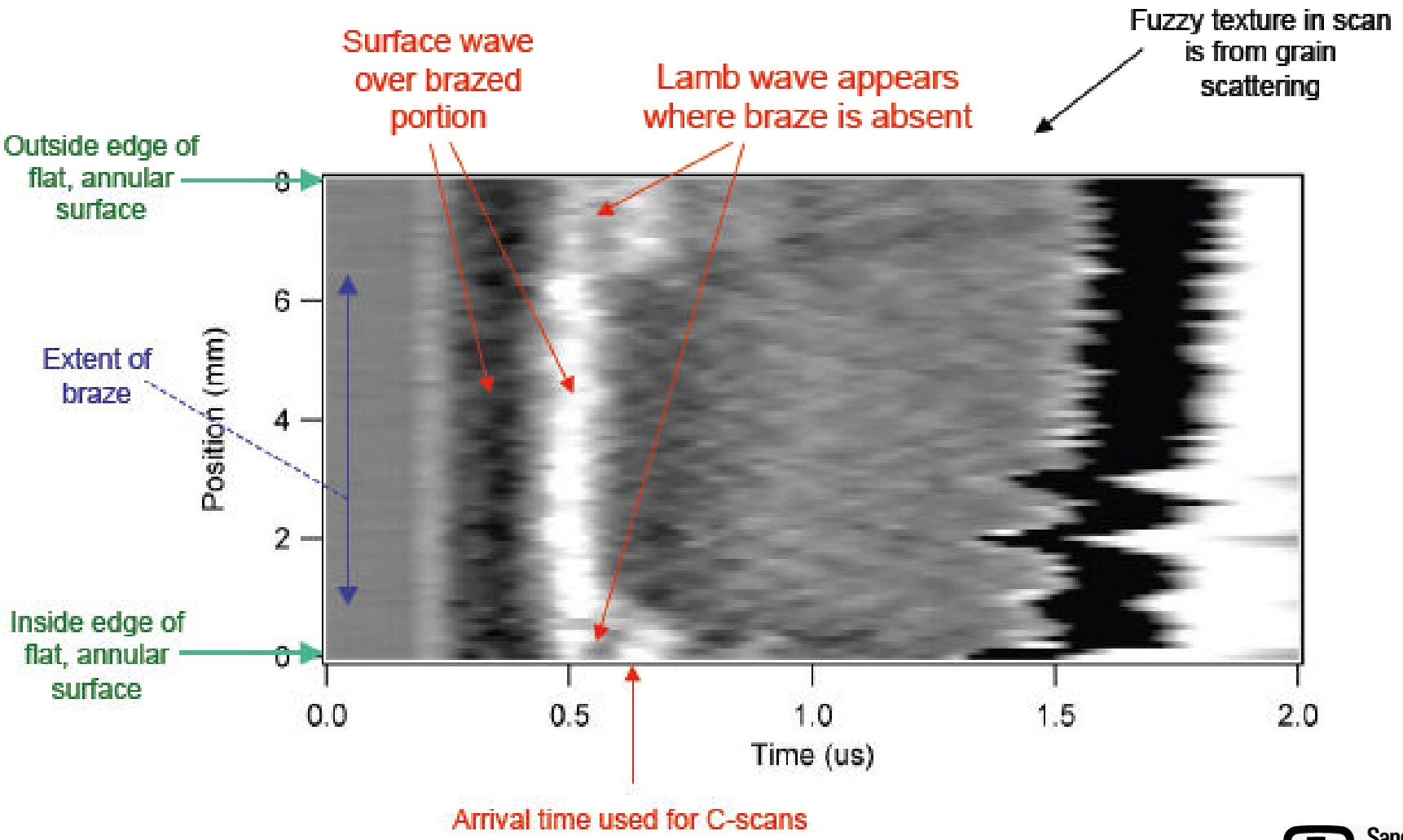


- Detection beam
- Generation beam



Ablated

Braze B-Scan "Raw" Results



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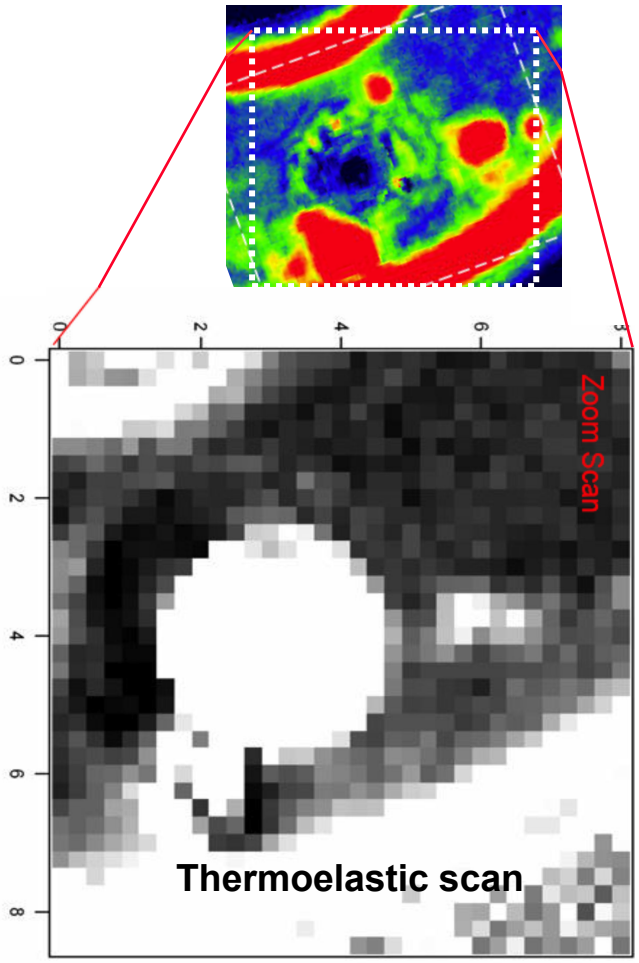
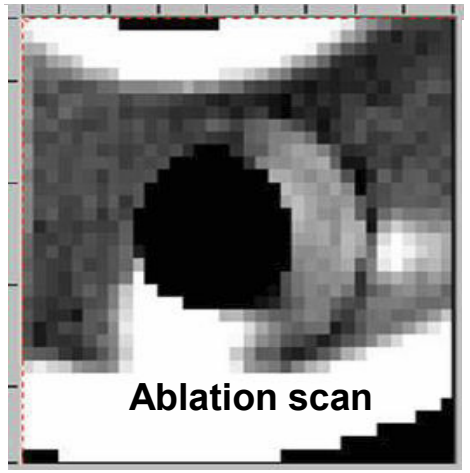
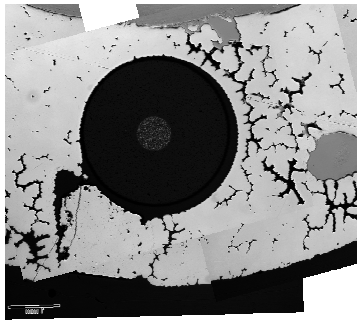
Comparison of Thermoelastic L-US, Ablation L-US, SAM & Metallography

C-SAM







Metallography

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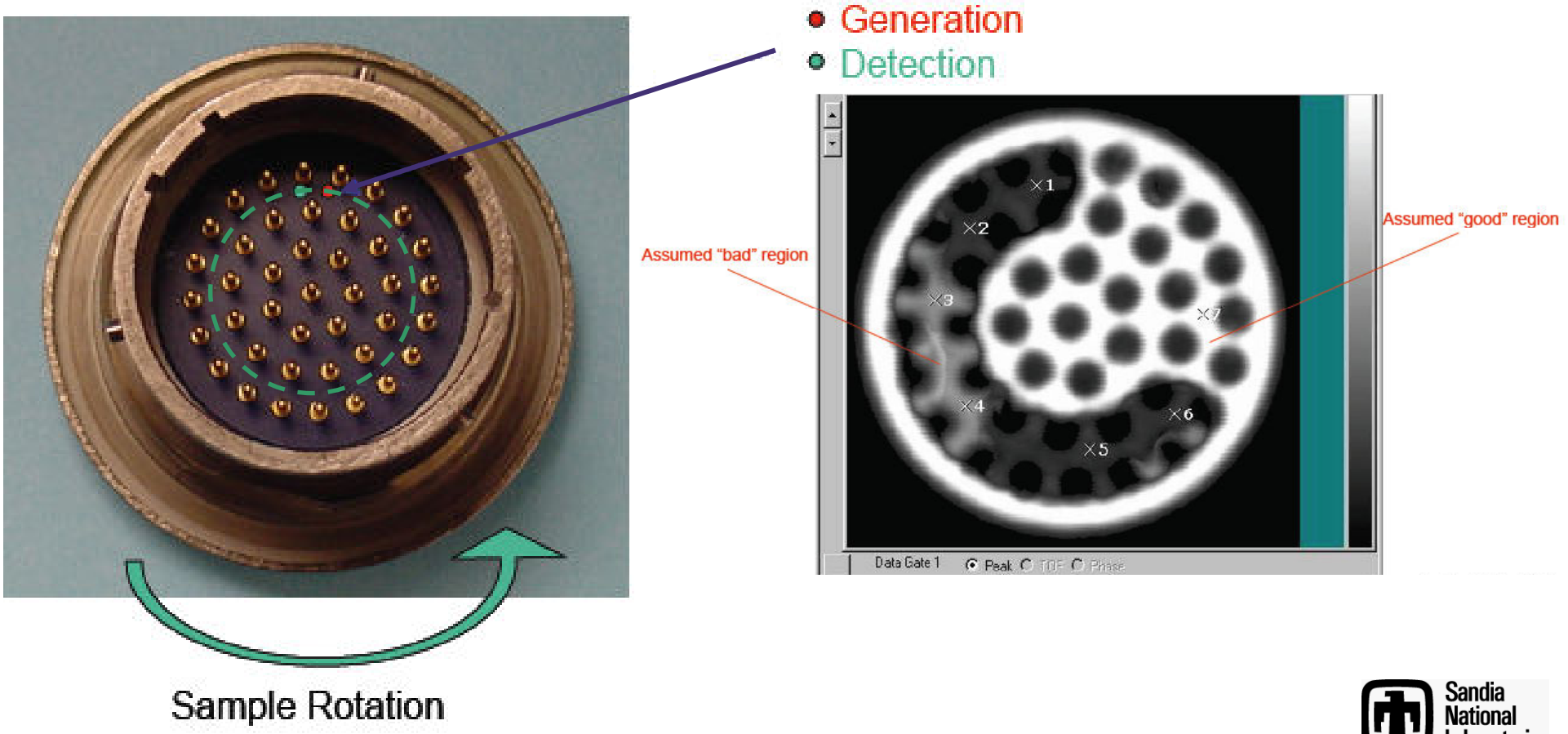
Geometry and SAM Image from Connector

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



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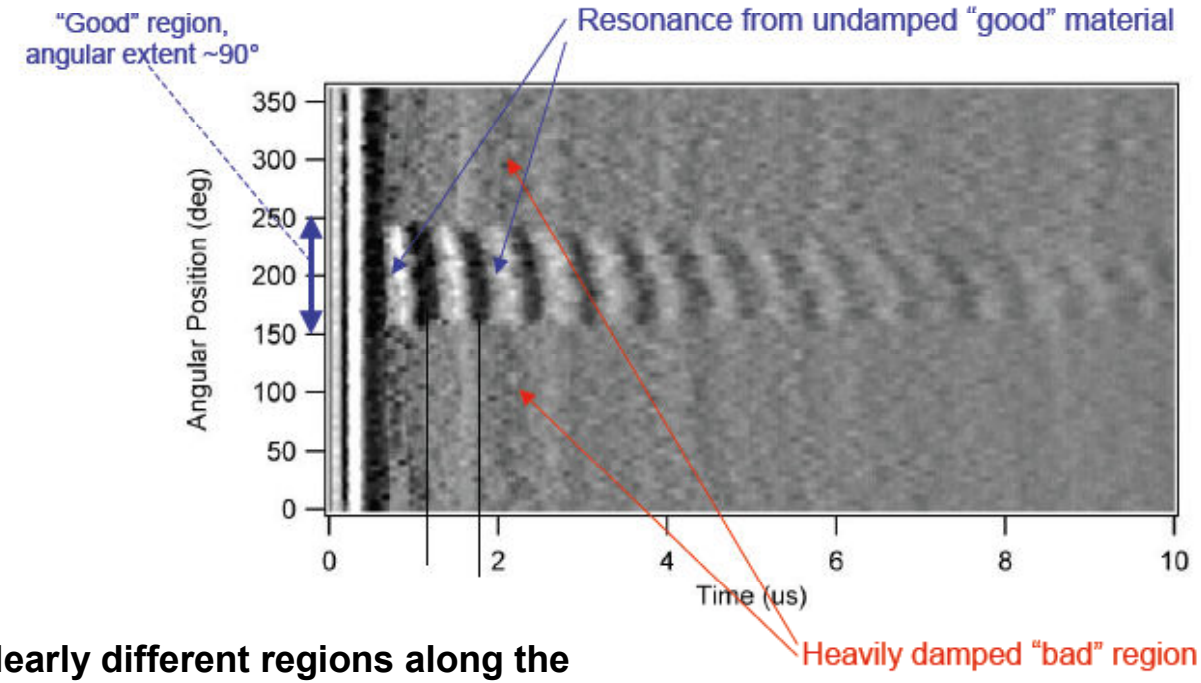
Connector Circumferential Scan Dataplot



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 of small components.
- 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, and shown good correspondence.

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