AMAP-Colloquium January 31st, 2019

Ultrasonic Inspection of aluminum components

Conventional to phased array, manual to automatic

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KARL DEUTSCH Prüf- und Messgerätebau GmbH + Co KG
Wuppertal

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- Introduction to KARL DEUTSCH
- Basics of UT inspection
- Distinctiveness of UT testing on aluminum
- Inspection of welds on thin plates with complex geometries
- Inspection of casted aluminum plates
- Integrated precision measurement of wall thickness
- Inspection of spotwelded aluminum plates
- Different types of automatic testing machines

Introduction to KARL DEUTSCH

Ing. Karl Deutsch & LEPTOSKOP

Hannover Messe
(1951)

LEPTOSKOP

coating thickness
measurement
since 1948,
founding of company
May 13th 1949

KARL DEUTSCH

KARL DEUTSCH

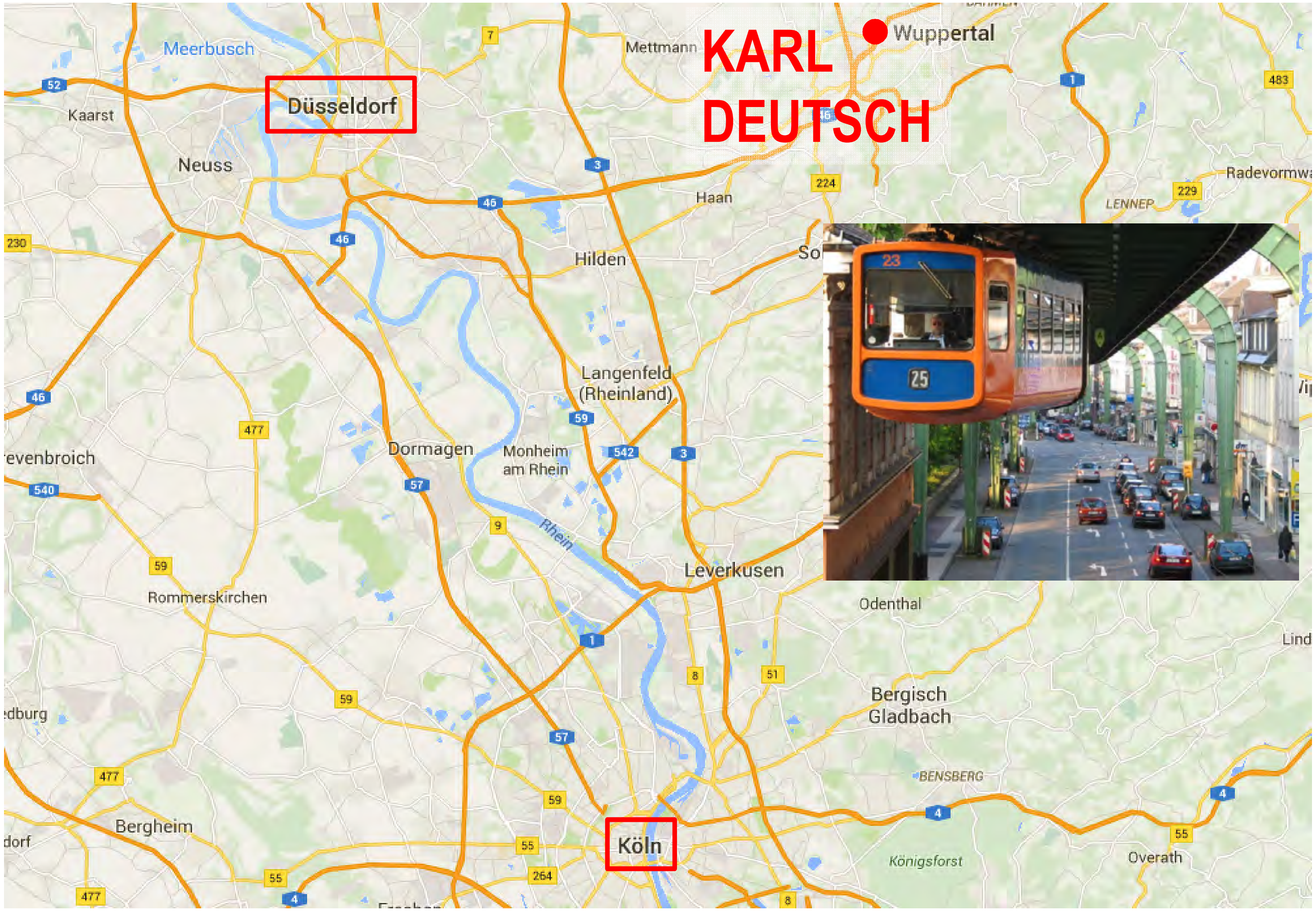
- Founded in 1949, family business in 3rd generation
- Two locations in Wuppertal
- 130 employees in Wuppertal +20 more worldwide

Ing. Karl Deutsch
1900 - 1975

Prof. Dr. Volker Deutsch
* 1932, KD 1961-2001

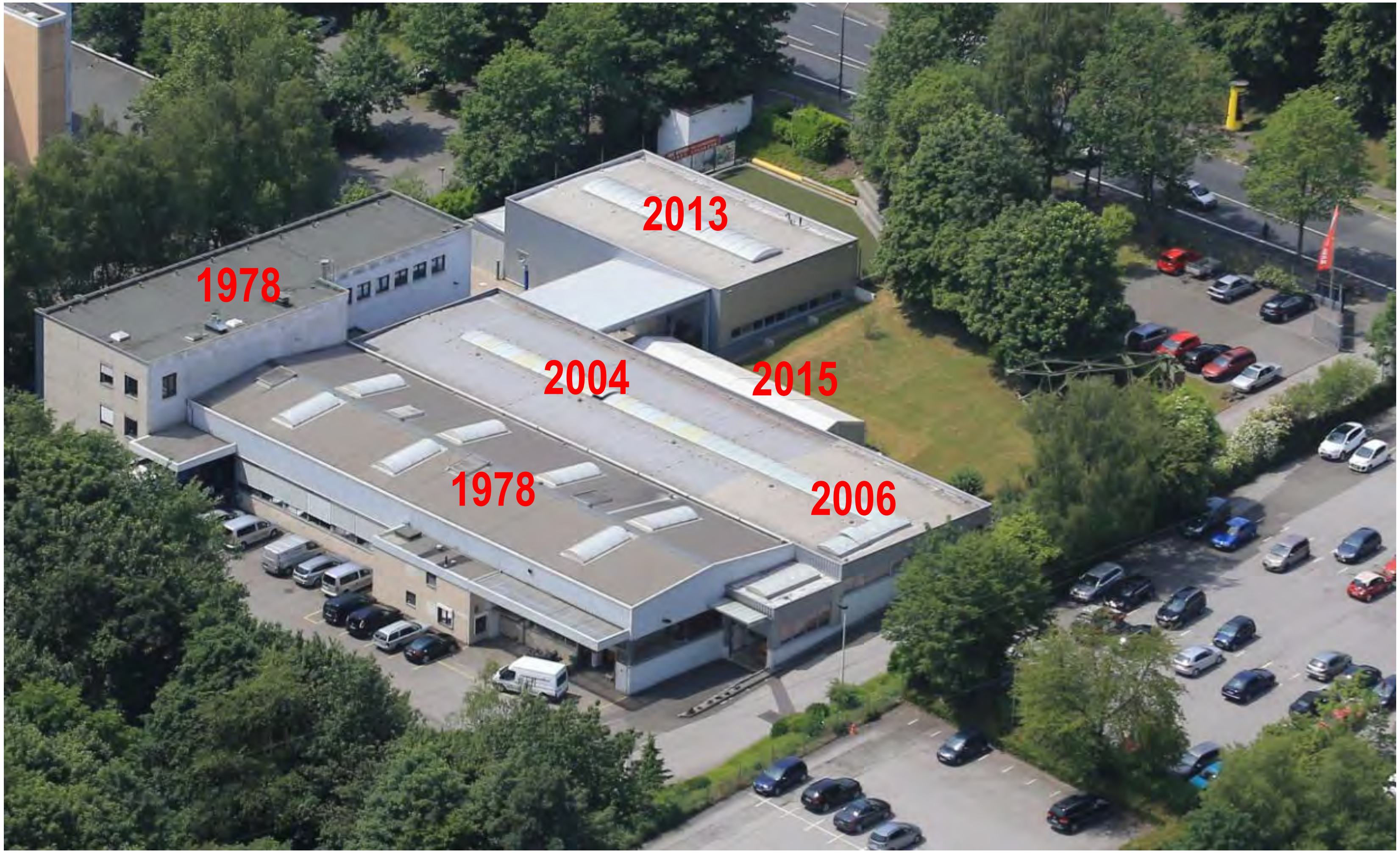
Dr. (USA) Wolfram Deutsch
KD 1998 - ...

KARL DEUTSCH in Wuppertal



Works 1: Portables, R&D, Administration

Works 2: Testing Systems Production




Works 1

KARL DEUTSCH Product Range

- Machines, instruments and equipment for PT, MT and UT
- UT probes development and manufacturing
- Portable units for coating- and wall-thickness measurement
- Portable units for measurement of magnetic fields

Application-Laboratory

- Consulting
- Tests on customer specimens
- Instrument-Training
- Application development

Dr. rer. nat. Helge Rast
(Laboratory head)

Dr.-Ing. Volker Schuster
(QM, Standards)

Stefan Kierspel
(Productmanager PA/UT)

Contakt:
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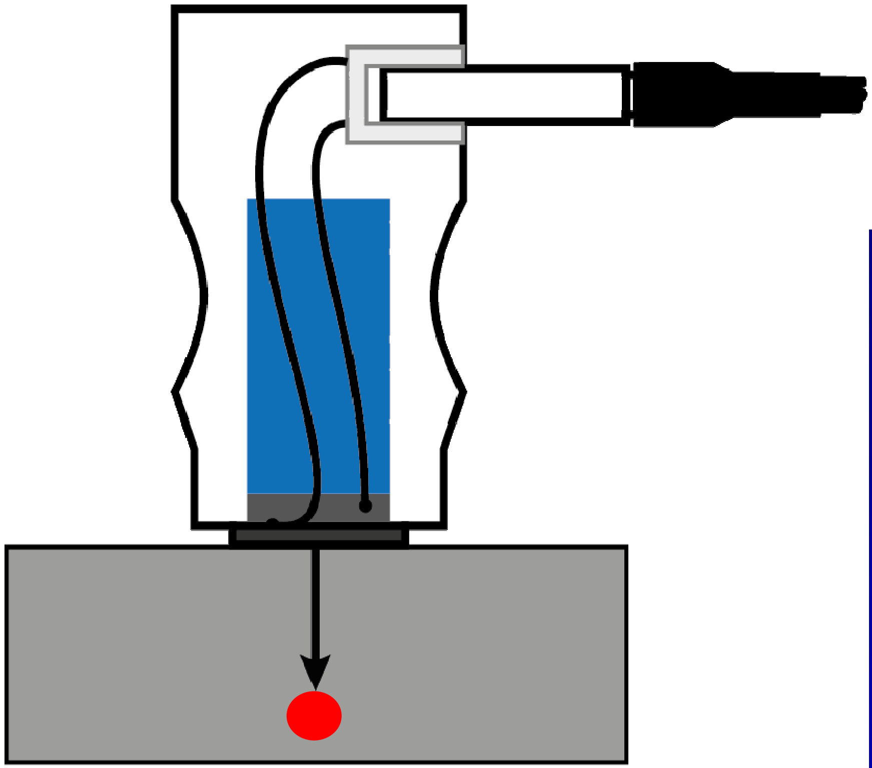
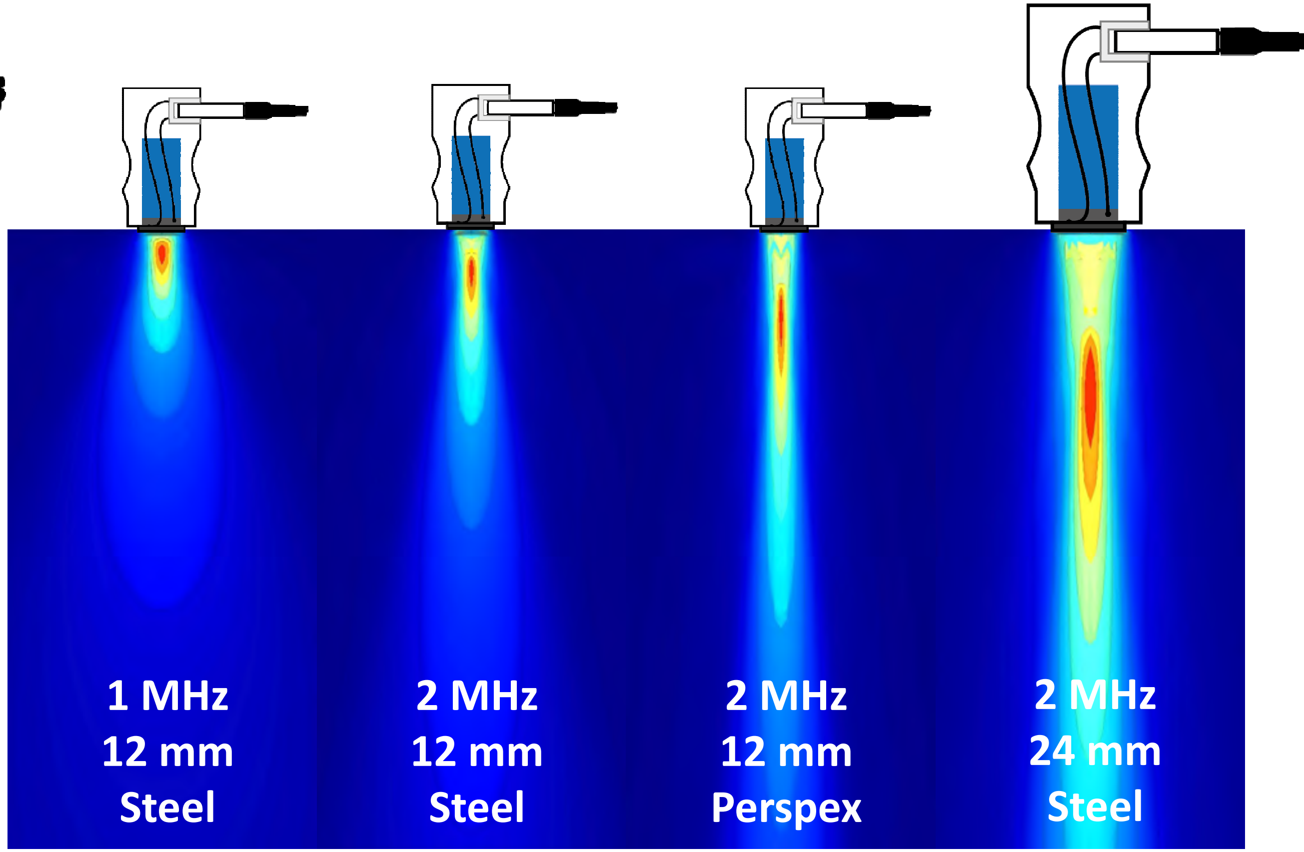
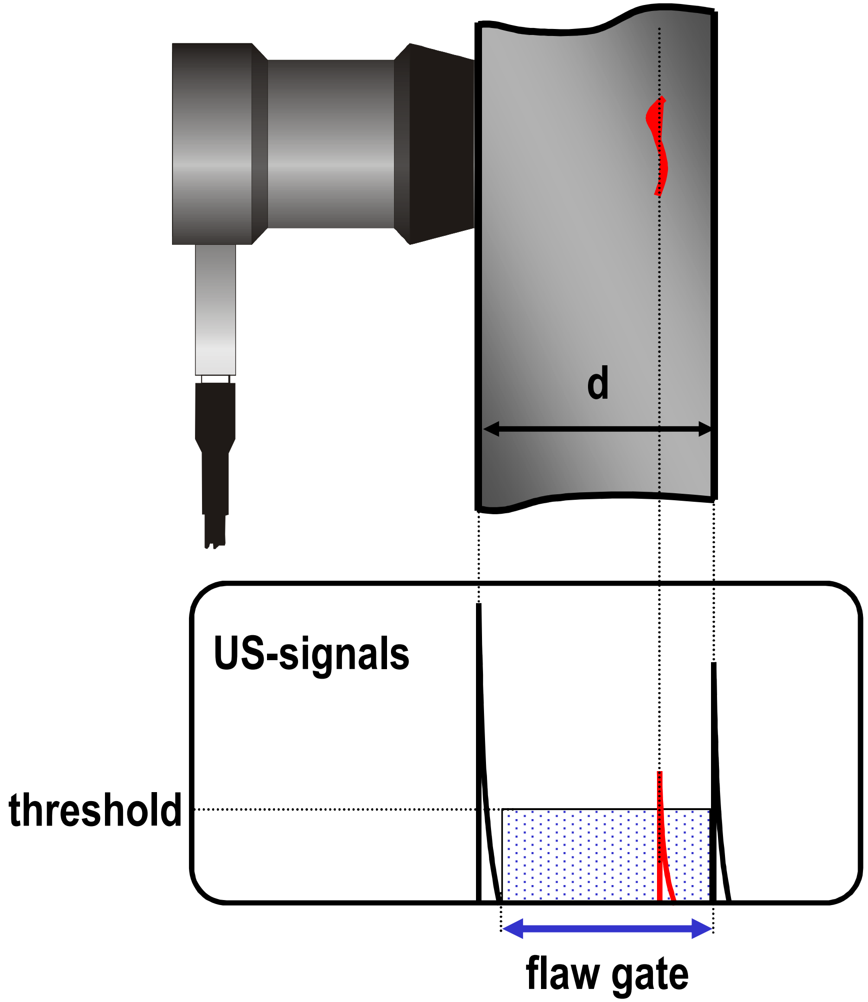
Basics of UT inspection

Principles of UT inspection

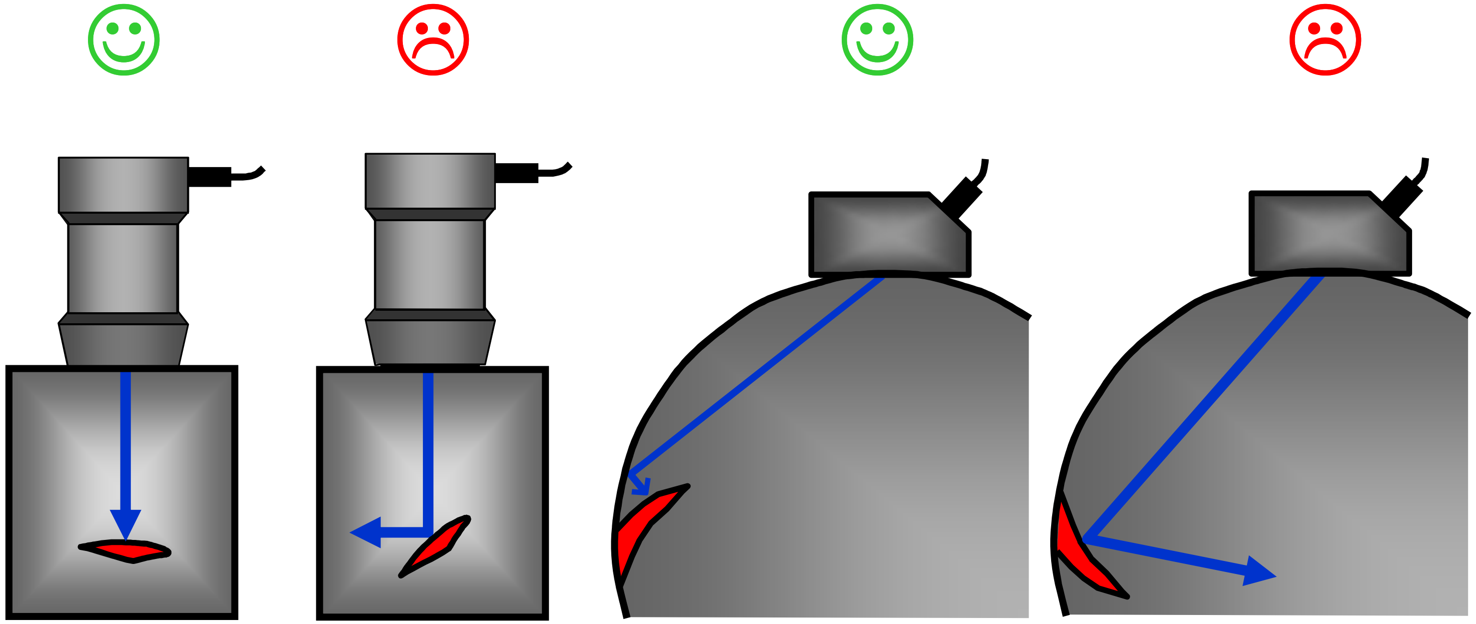




Principles of UT inspection



Ultrasonic Reflection from Defects

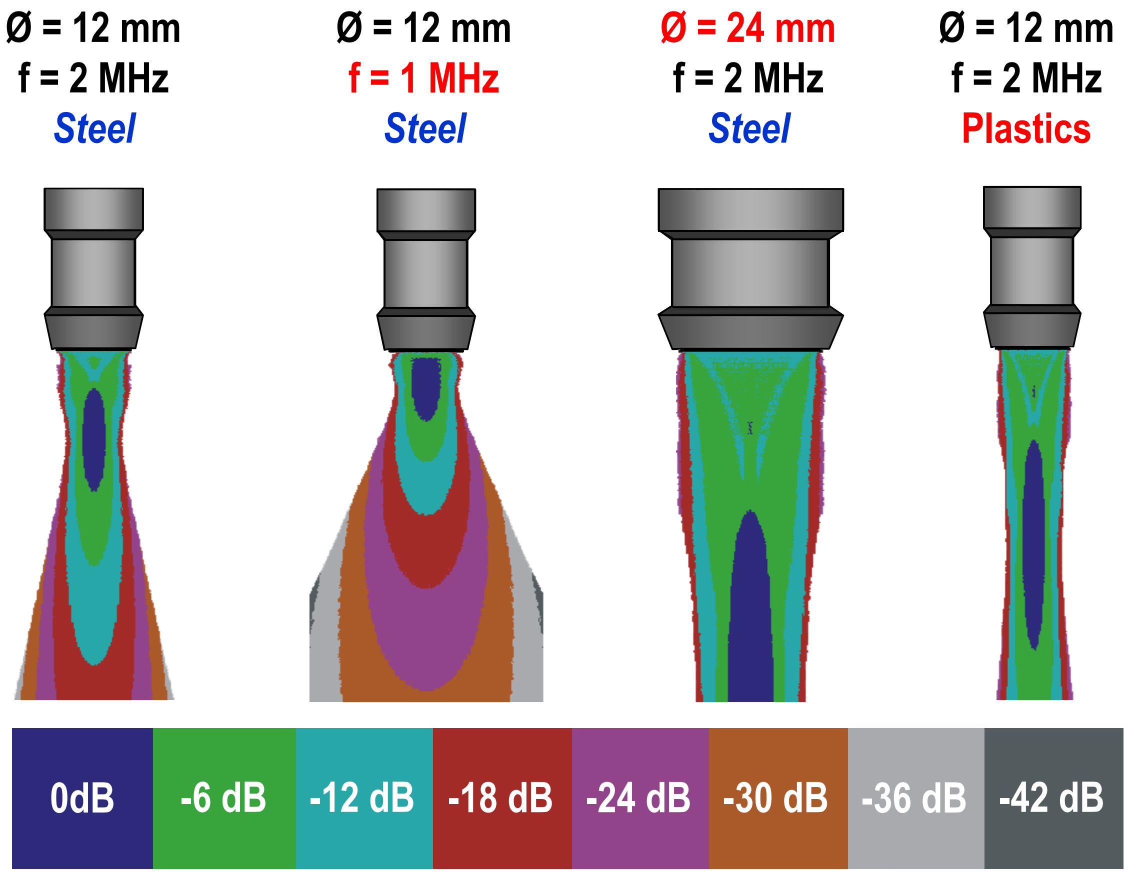


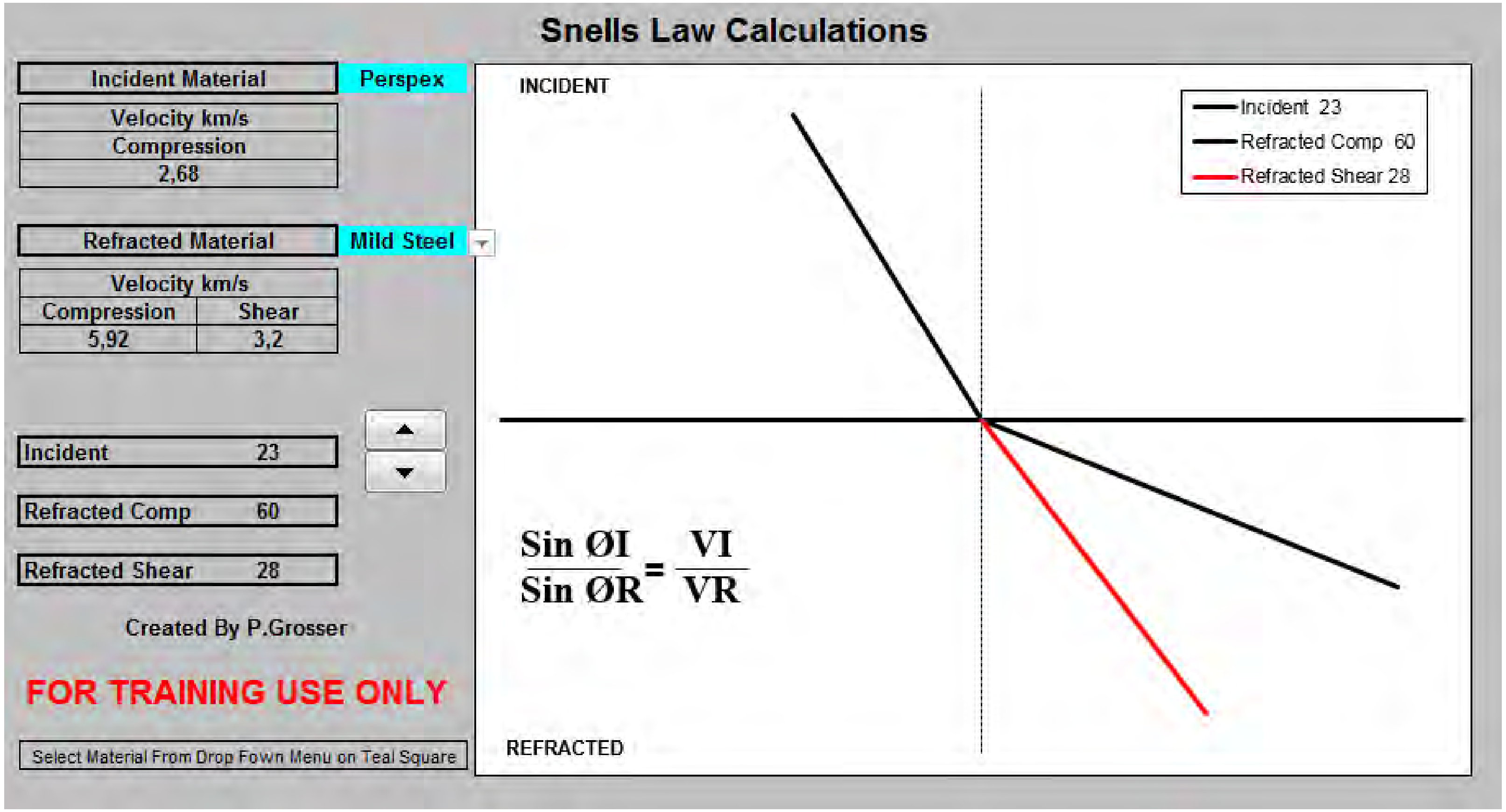
ECHOGRAPH Ultrasonic Probes

<u>Criteria of Choice:</u>

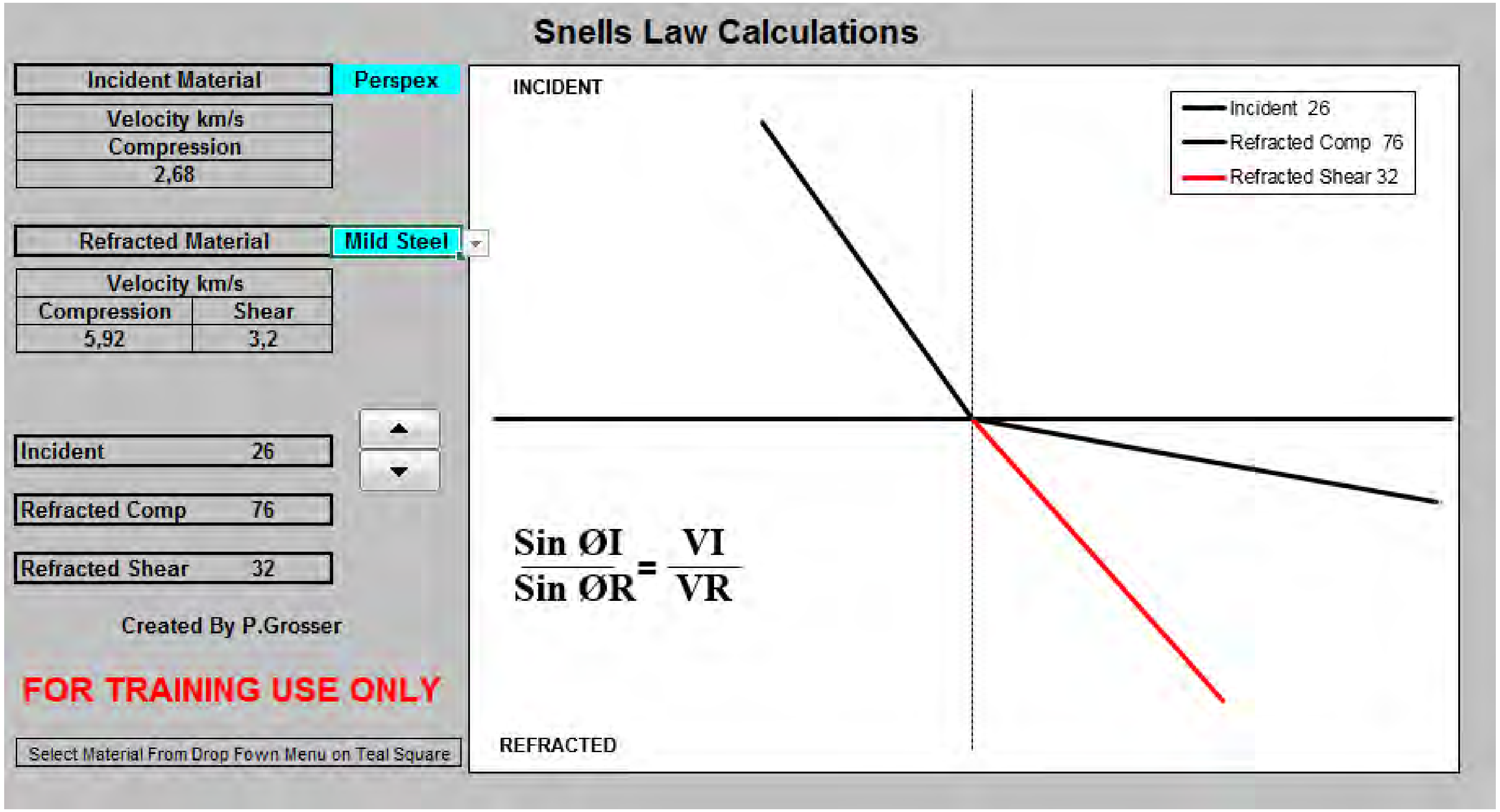
- **frequency (material, penetration depth, sensitivity)**
- **probe size (intensity)**
- **incidence angle (application)**
- **width of sound field, focus**

Sound Field Characteristics

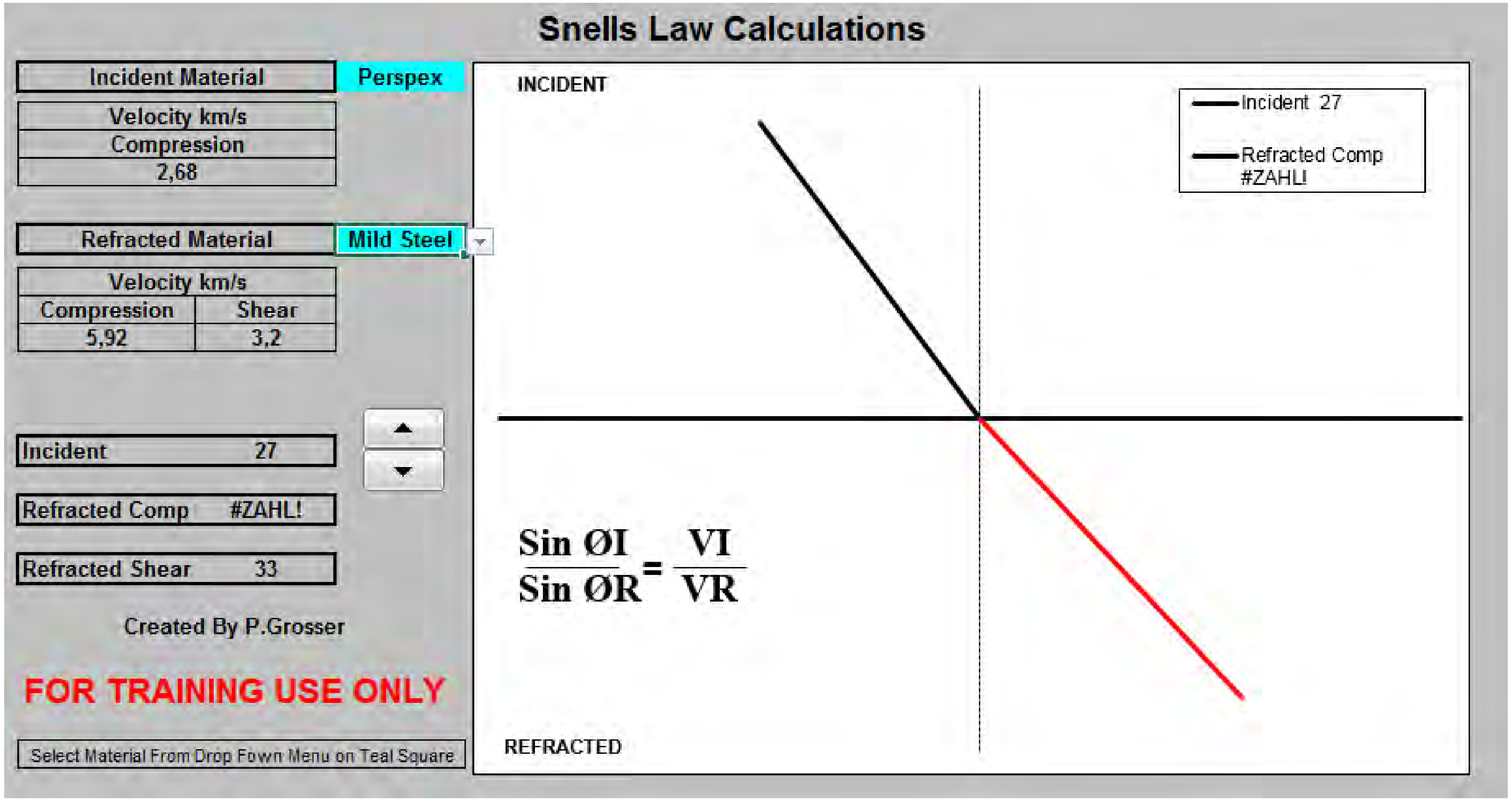



Snells Law Calculations
Incident Material
Perspex
Velocity km/s
Compression
2,68
Refracted Material
Mild Steel
Velocity km/s
Compression
Shear
5,92
3,2
Incident 23
Refracted Comp 60
Refracted Shear 28
Created By P.Grosser
FOR TRAINING USE ONLY
Select Material From Drop Fown Menu on Teal Square
INCIDENT
REFRACTED
Incident 23
Refracted Comp 60
Refracted Shear 28
Sin ØI / Sin ØR = VI / VR

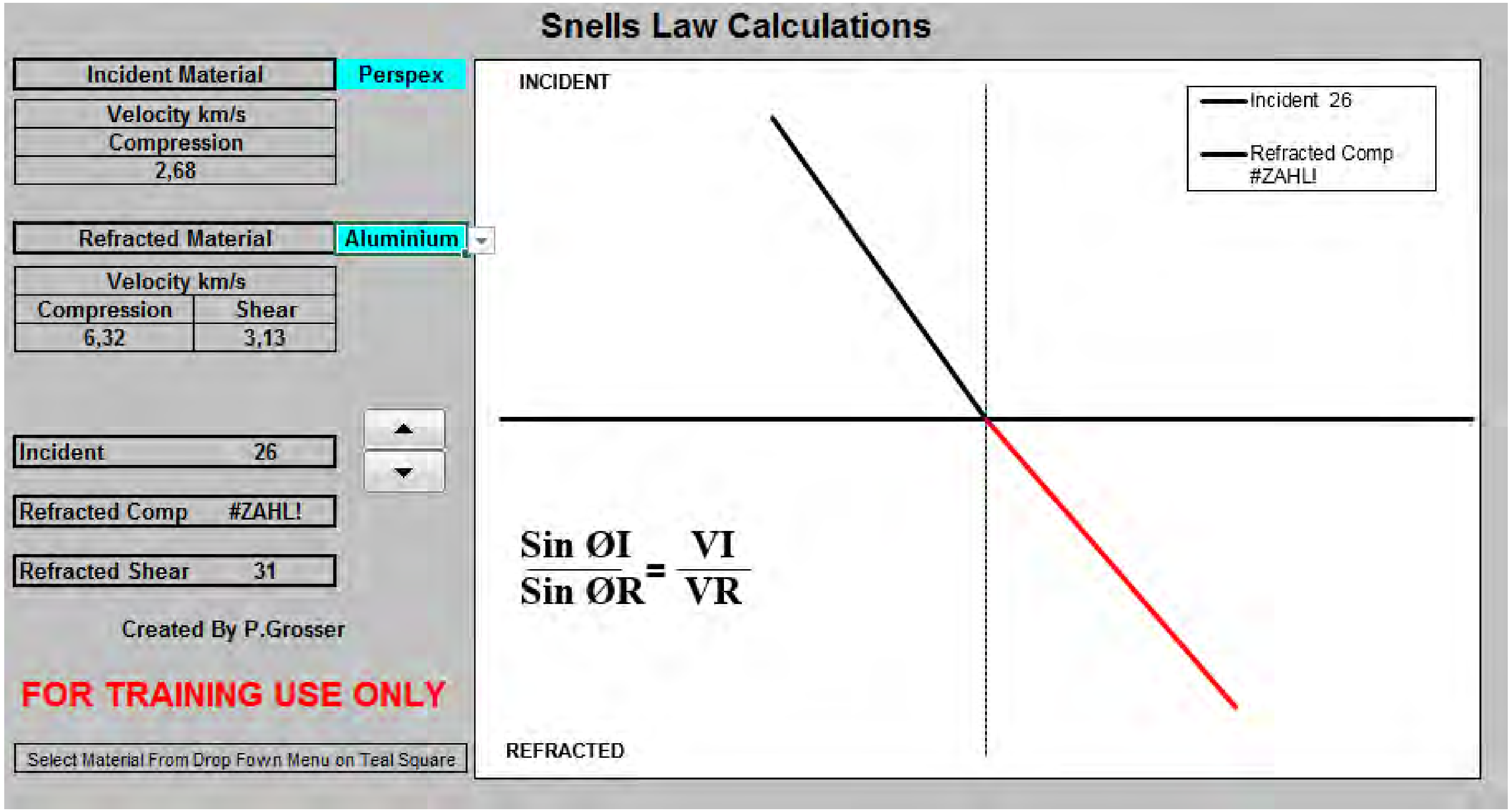
Reflection and Diffraction



Reflection and Diffraction



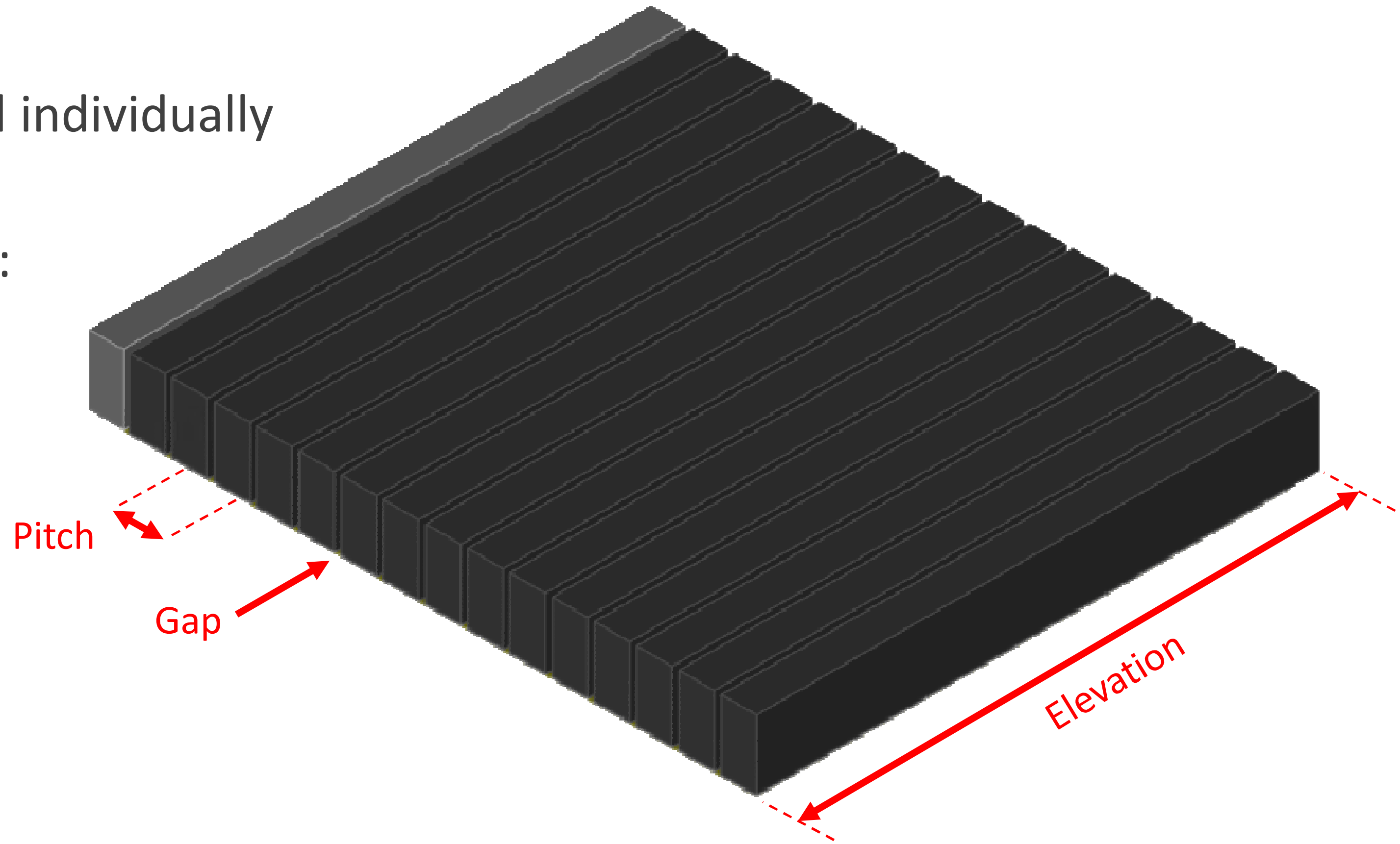
Reflection and Diffraction



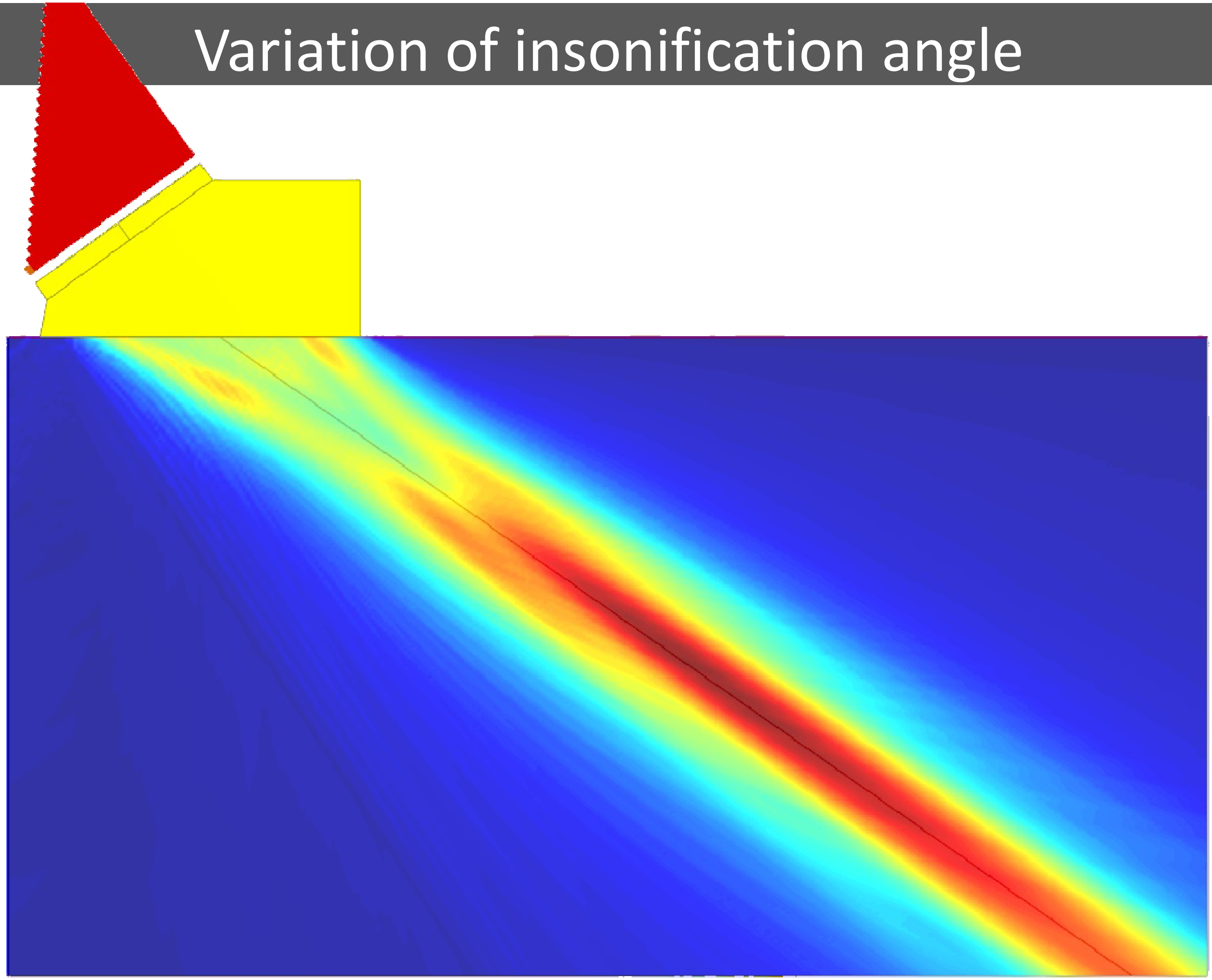
Phased-Array Probes

- Probe divided into small strips => elements (linear array)
- Every element can be excited individually

- Probes are flexible according:
  - Oscilator size
  - Insonification angle
  - Focussing



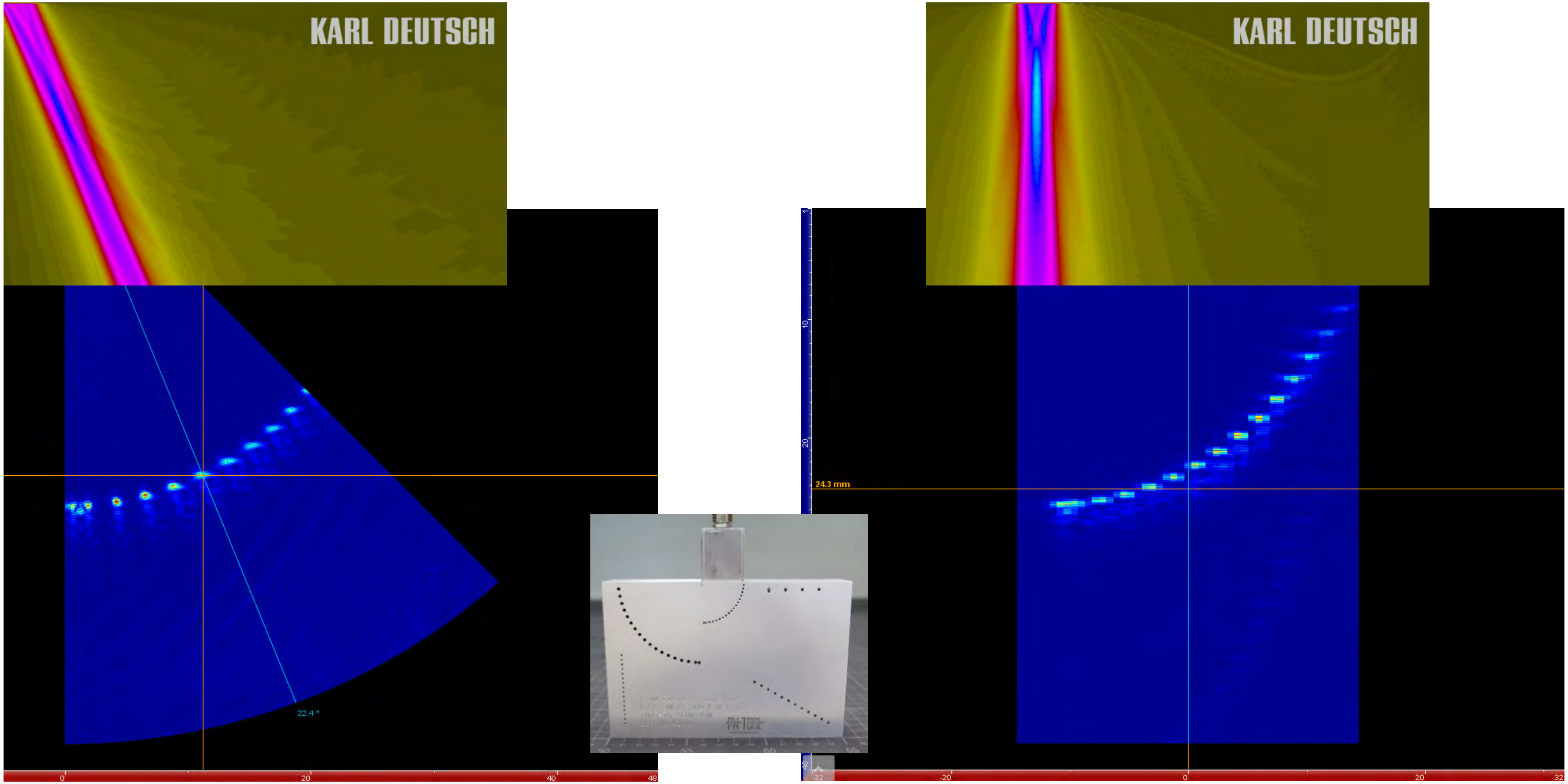
Variation of insonification angle



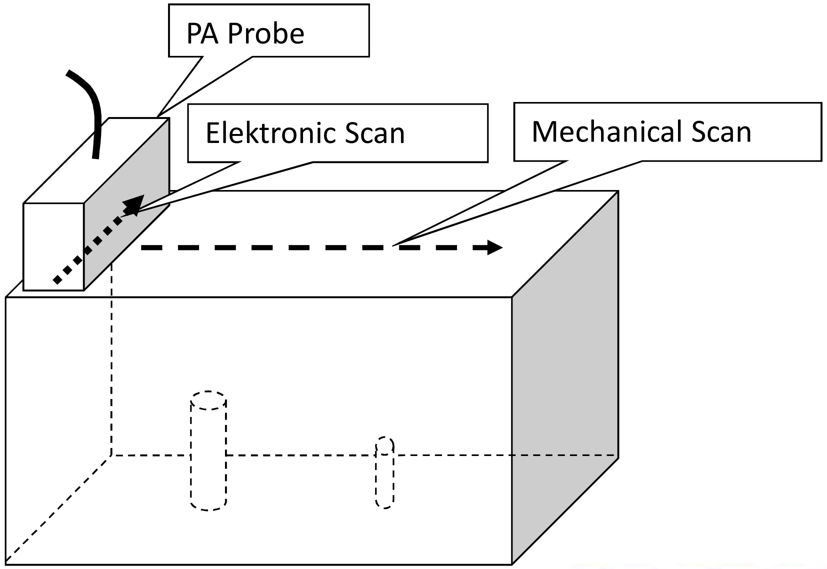
Standard PA-UT methods

Sector-Scan

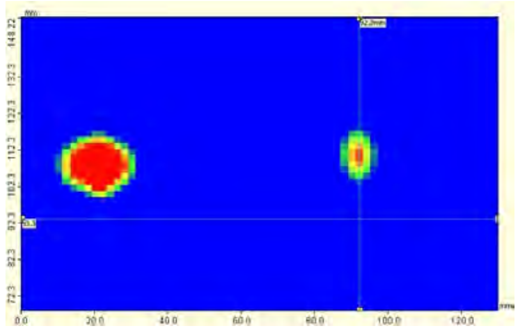
Linear-Scan



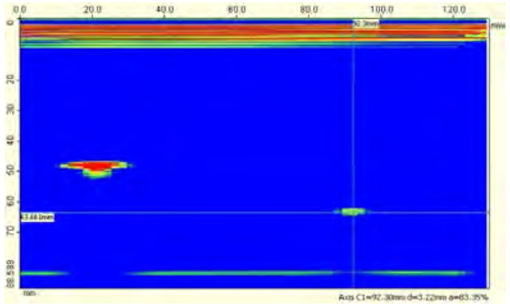
Display of results



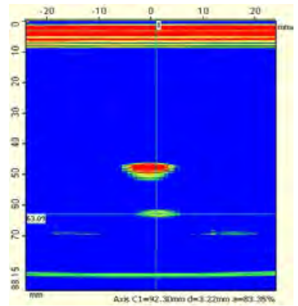
Top view (C-/P-scan)

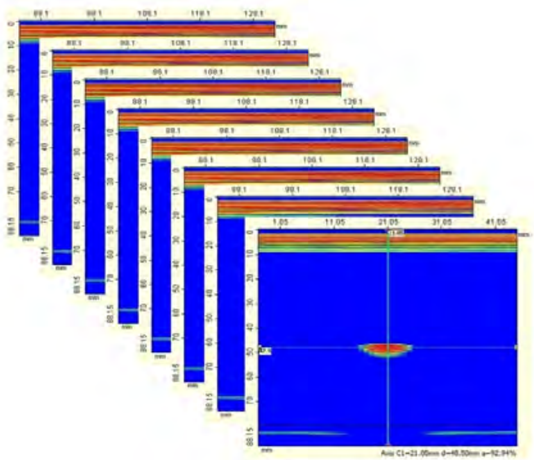


B-Scan



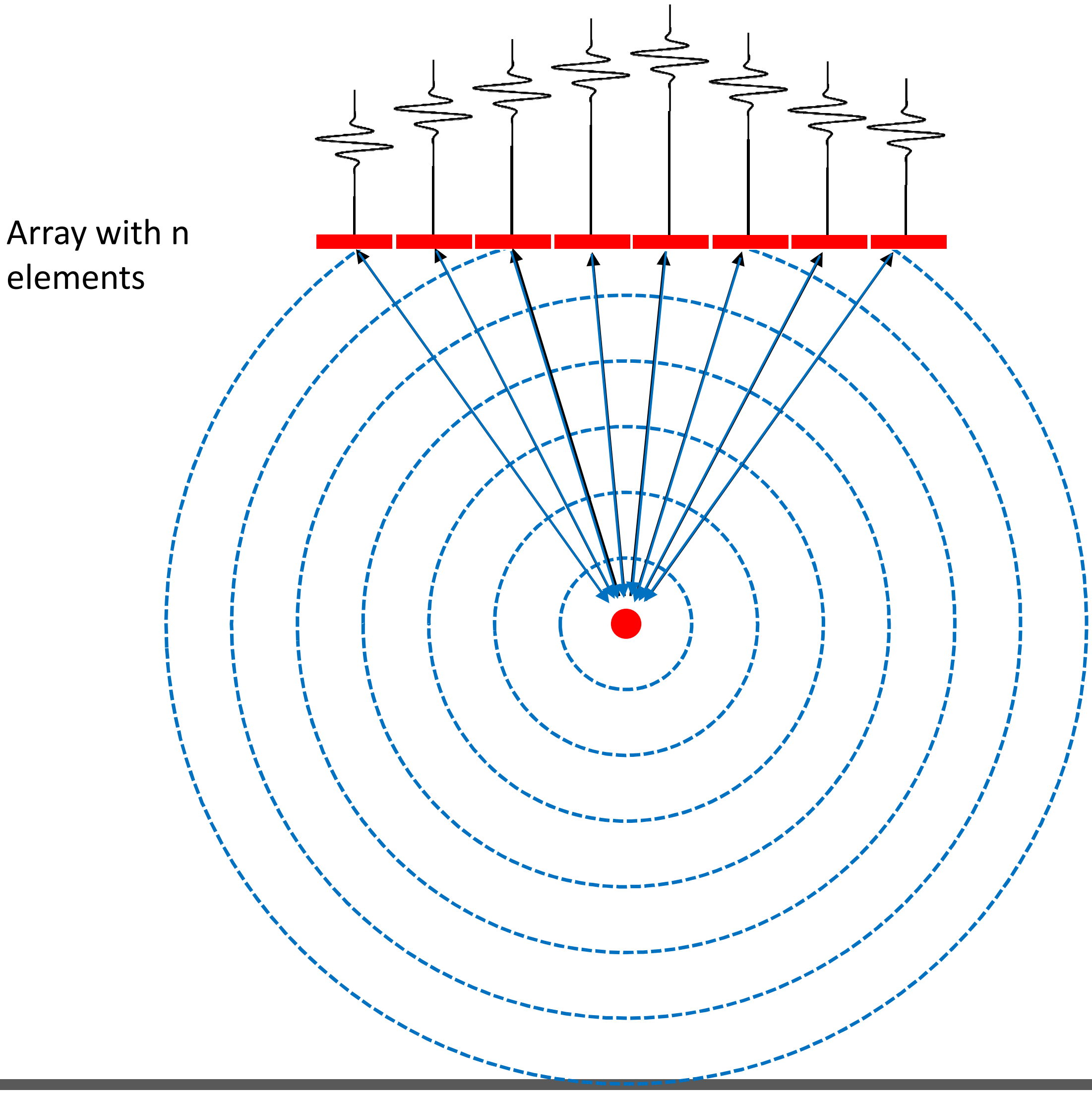
Side View(E-Scan)





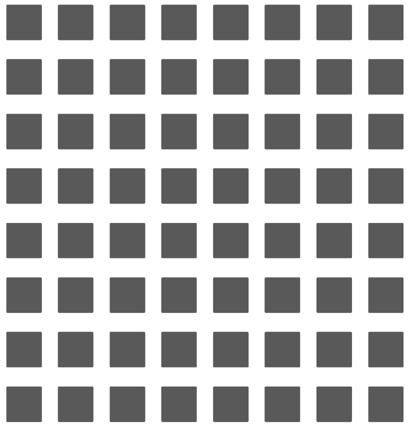
Elektronical B-Scans (E-Scan)

Full Matrix Capture (FMC)

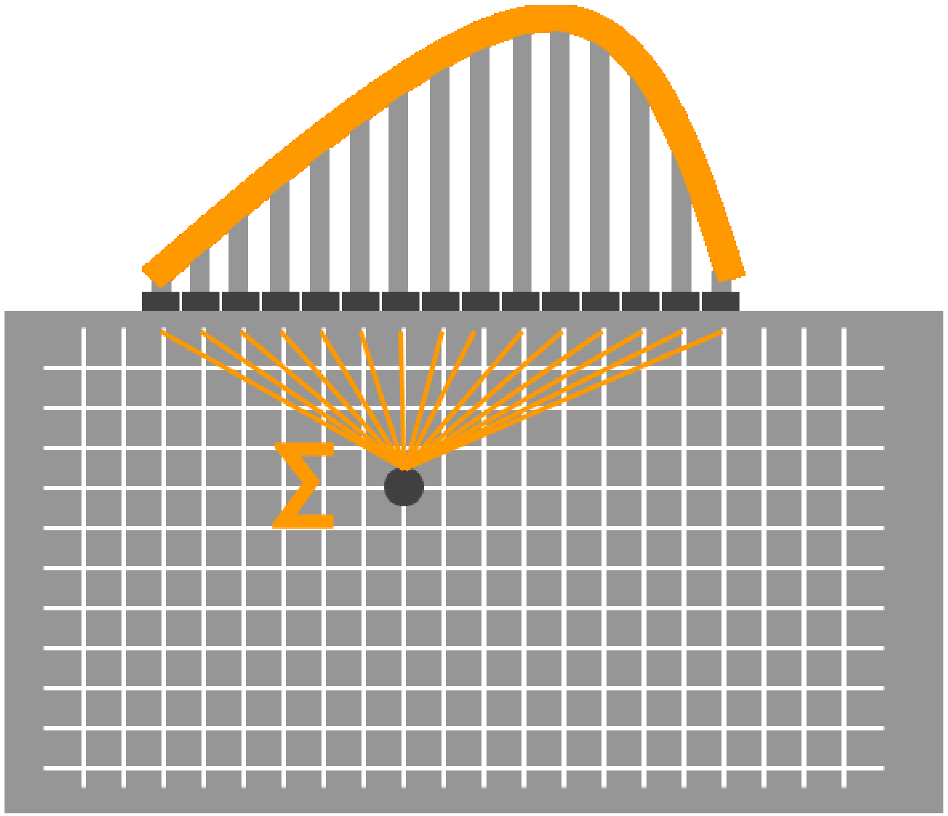


- Recording of a complete set of A-scans
- Each element is excited one by one while all elements are receiving

- Result: n x n Matrix of A-scans



Principle of the Total Focusing Method (TFM)



TFM is a post-processing algorithm for FMC data.

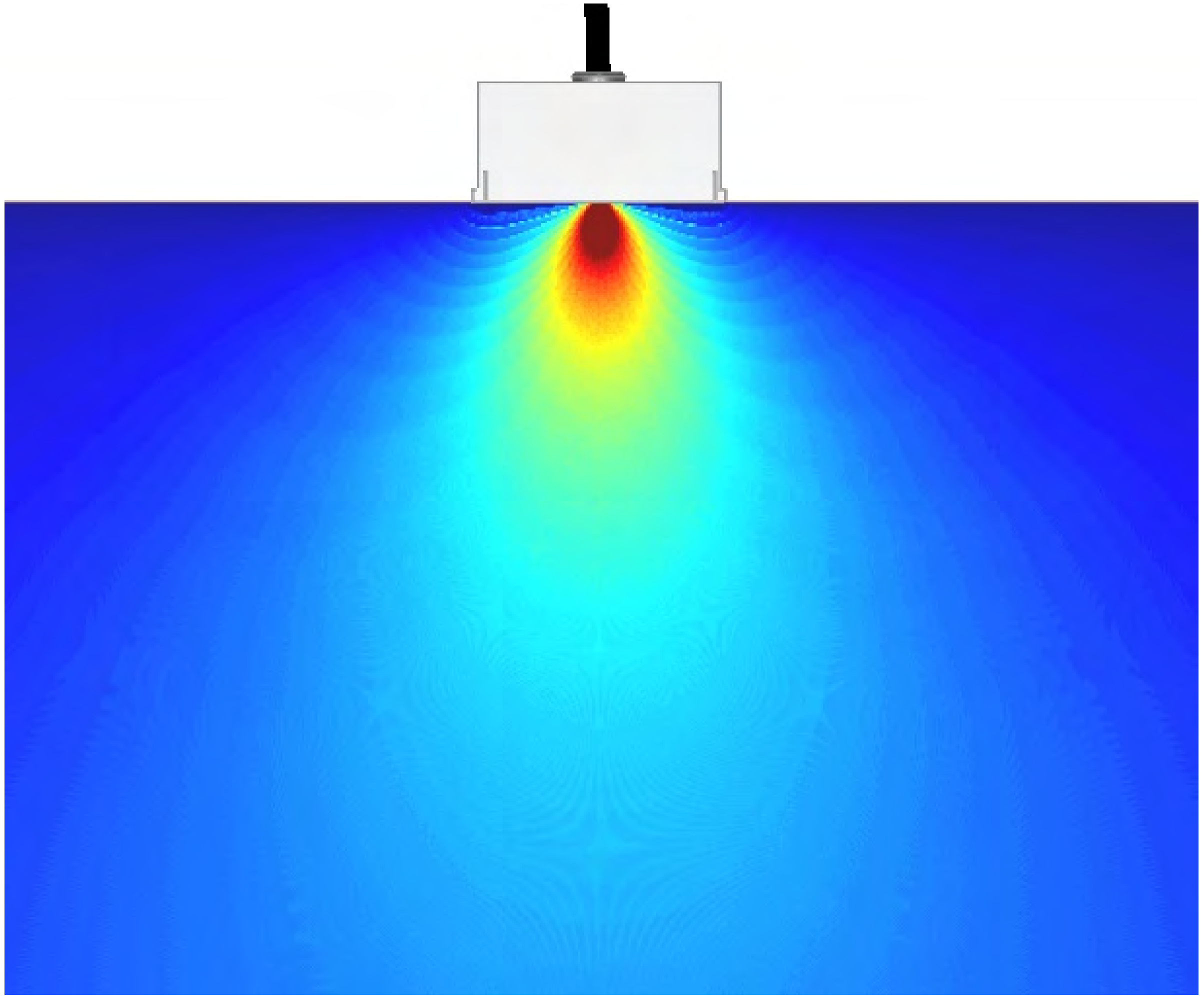
- Discretion of an inspection area to a grid
- Creation of an artificial focus at all points of the grid by summation of the FMC data

Advantage:

- Inspection area may be wider than the probe
- Focussation within the complete inspection zone

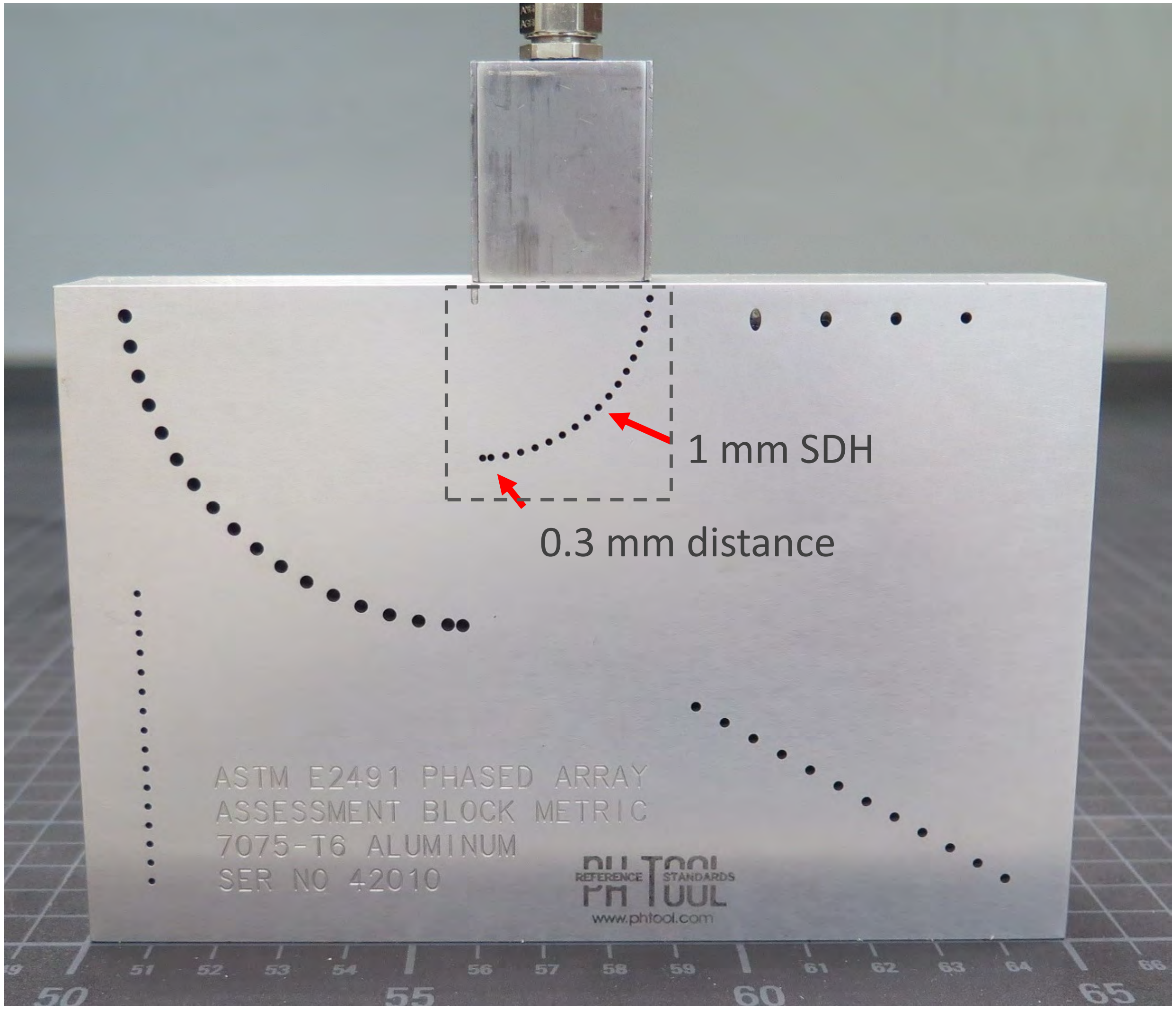
Soundfield of a single element

- CIVA simulation of a probe with 10 MHz, 64 elements, 0.3 mm pitch, 0.05 mm gap
- Wide soundfield
- Probe „looks“ into all directions



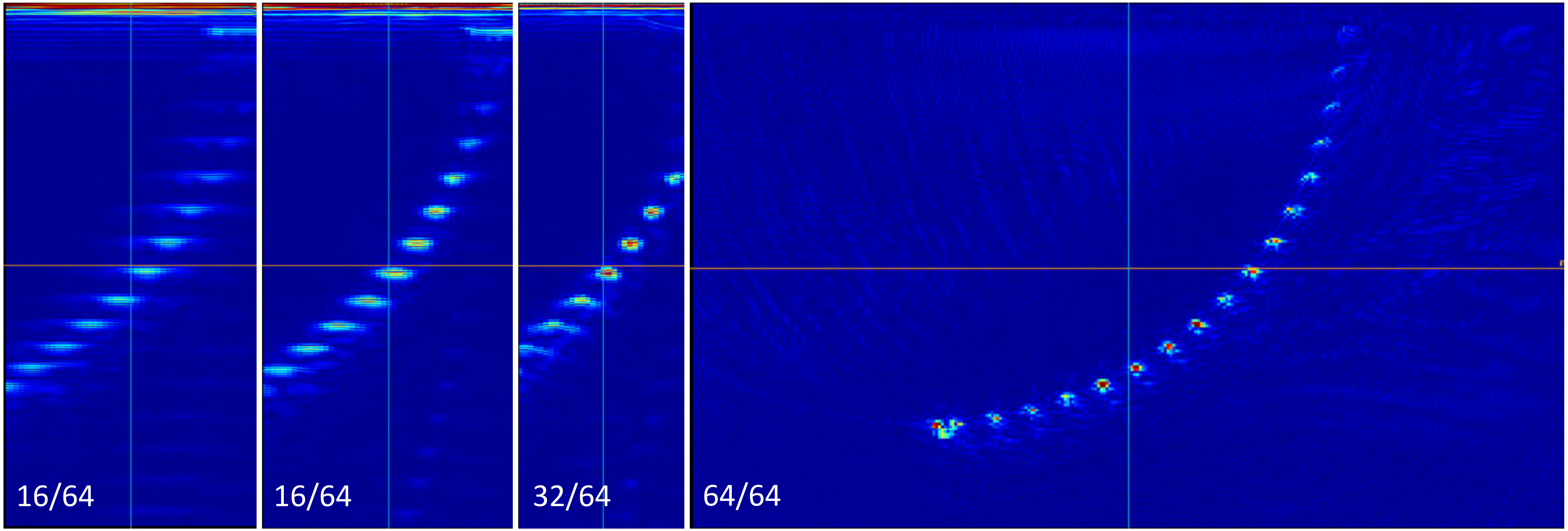
What TFM can do

- Sample: ASTM E2491 Phased Array Test Block Metric 7075-T6 Aluminum
- Instrument: GEKKO
- Probe: 10 MHz, 64 elements, 0.3 mm pitch, 0.05 mm gap



What TFM can do

B-scan	Focussed B-scan	Total Focusing Method



Distinctiveness of UT testing on aluminum

Distinctiveness

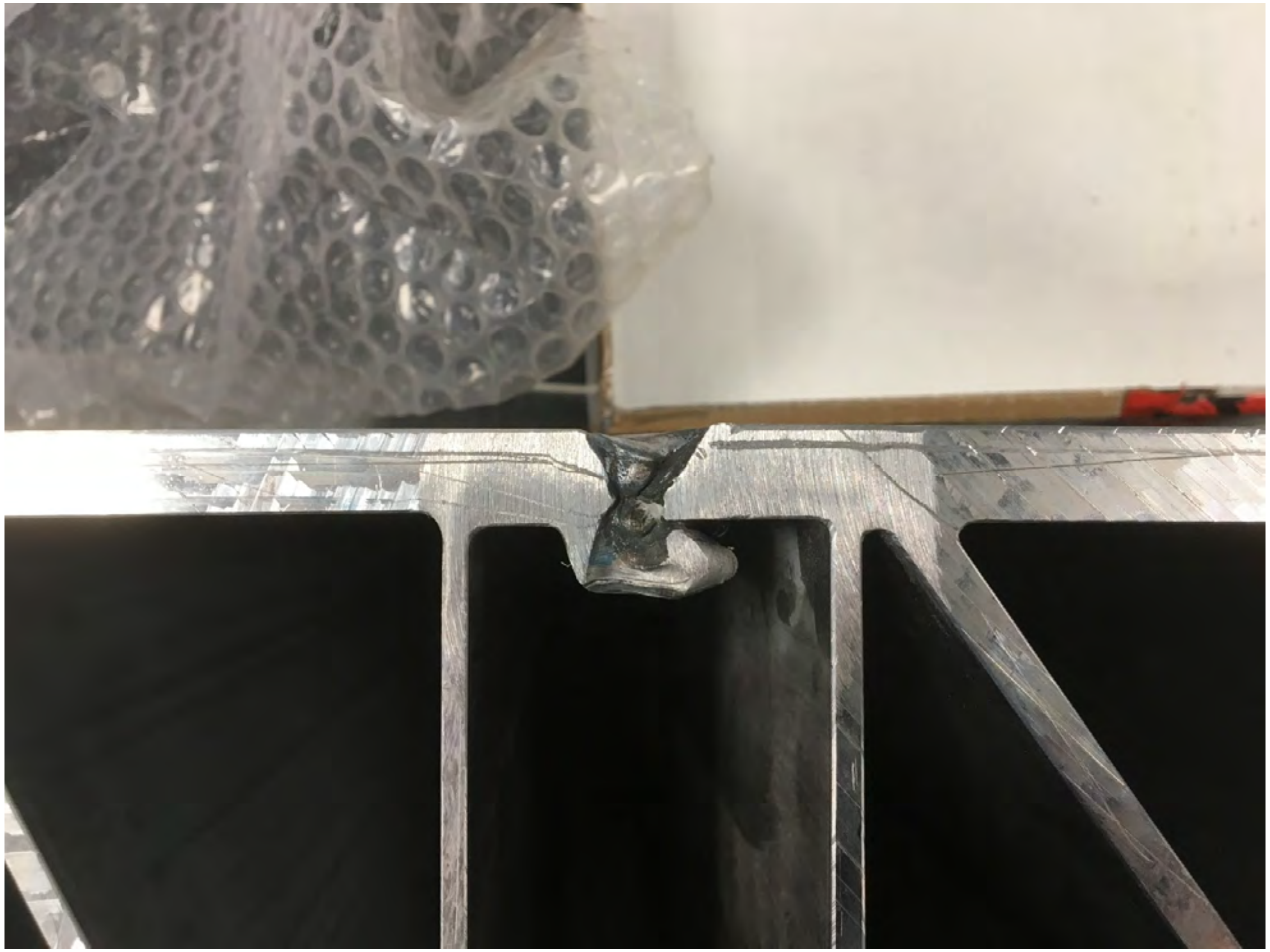
Special characteristics of aluminum in terms of UT inspection are:

- Relatively high sound velocity of L-waves (6.400 m/sec) and relatively low sound velocity of T-waves (3.100 m/sec)

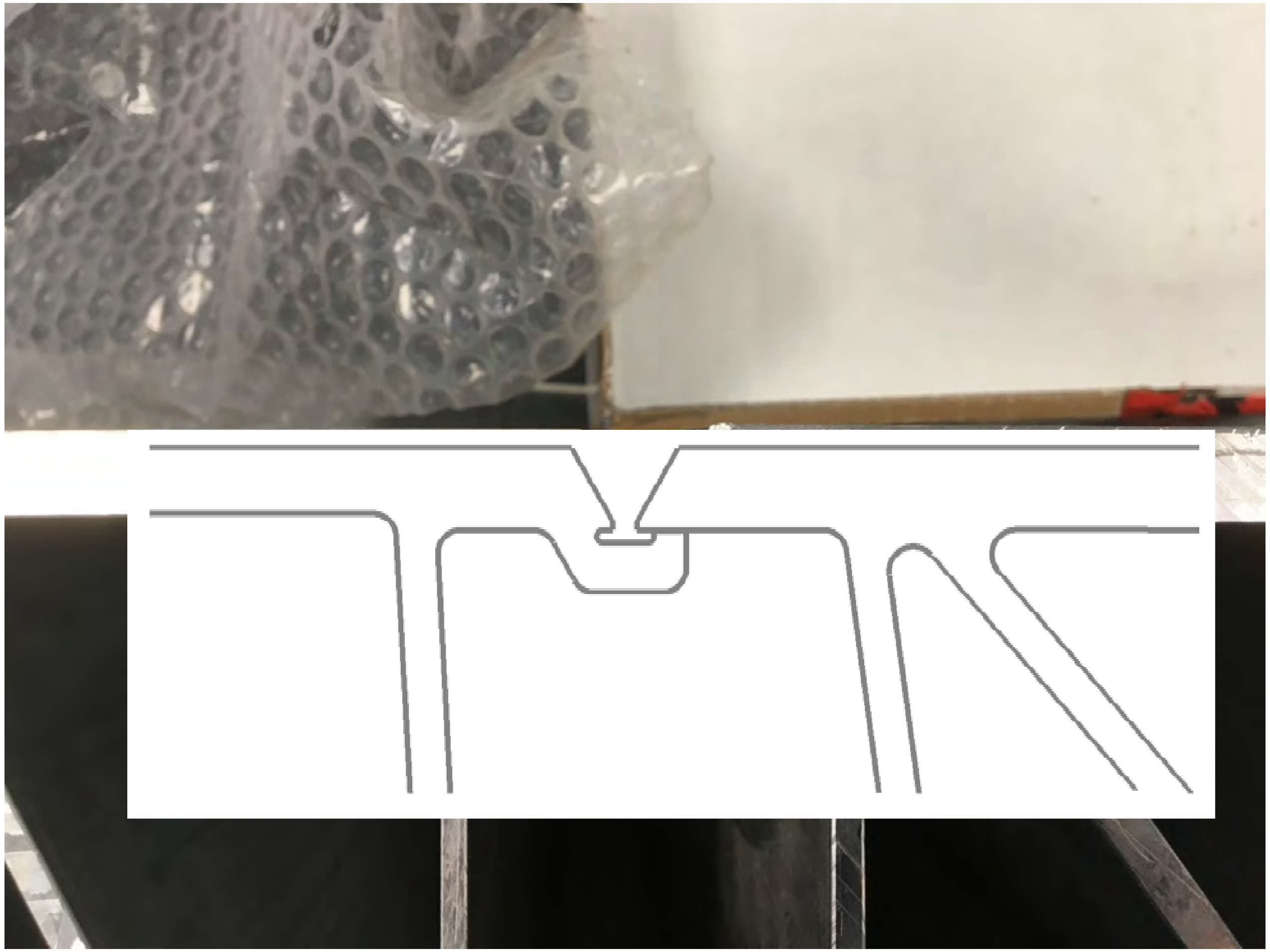
  => angle inspection with T-waves can go down to 30° without having an L-wave
- Relatively low sound attenuation => pulser voltage on steel might be ok but leads to over-saturated signals on aluminum
- Inhomogenious sound velocity on rolled parts
- Grain size influences sound attenuation

Inspection of welds on thin plates with complex geometries

Thin plates

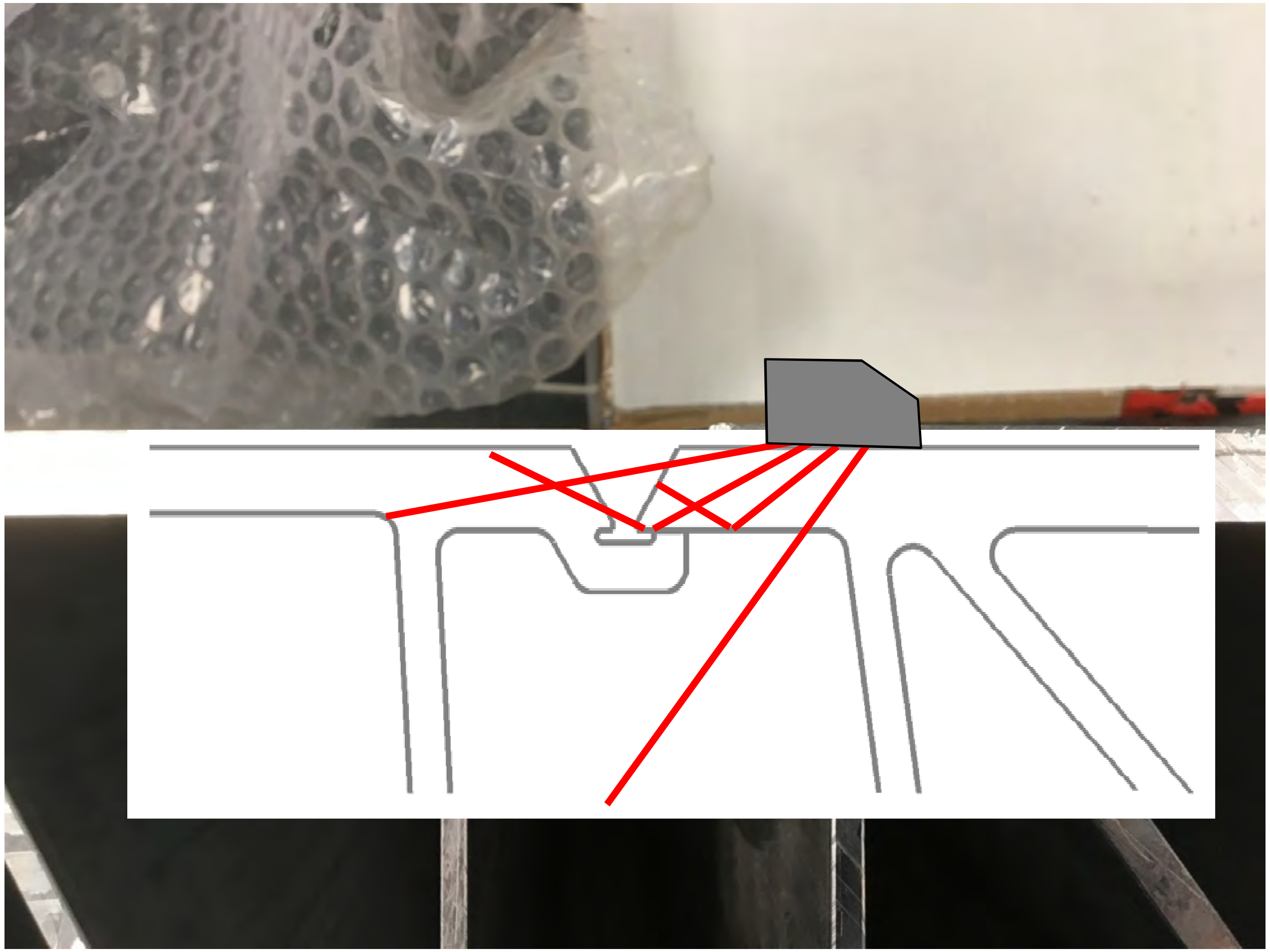


Thin plates

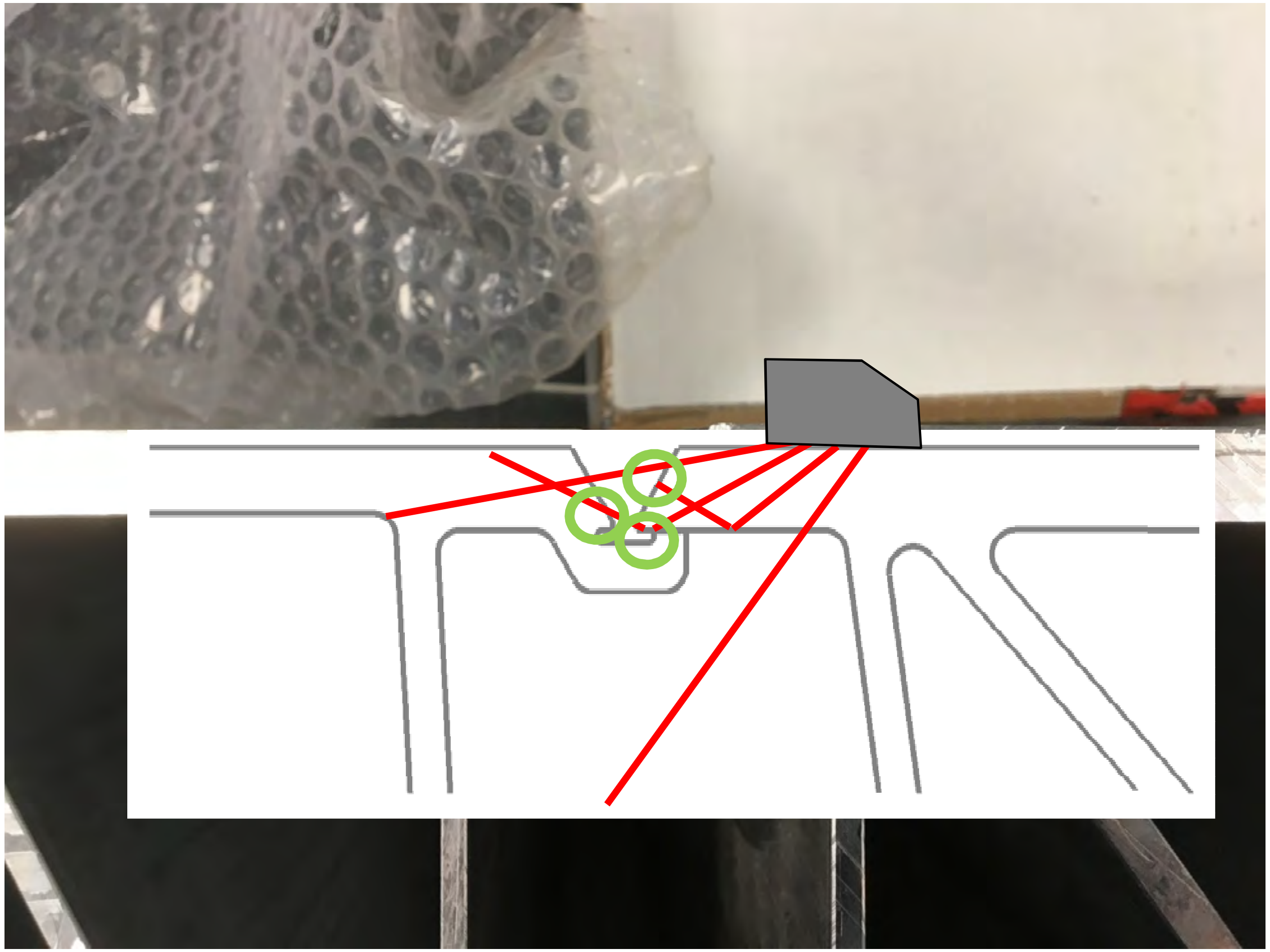


Thin plates

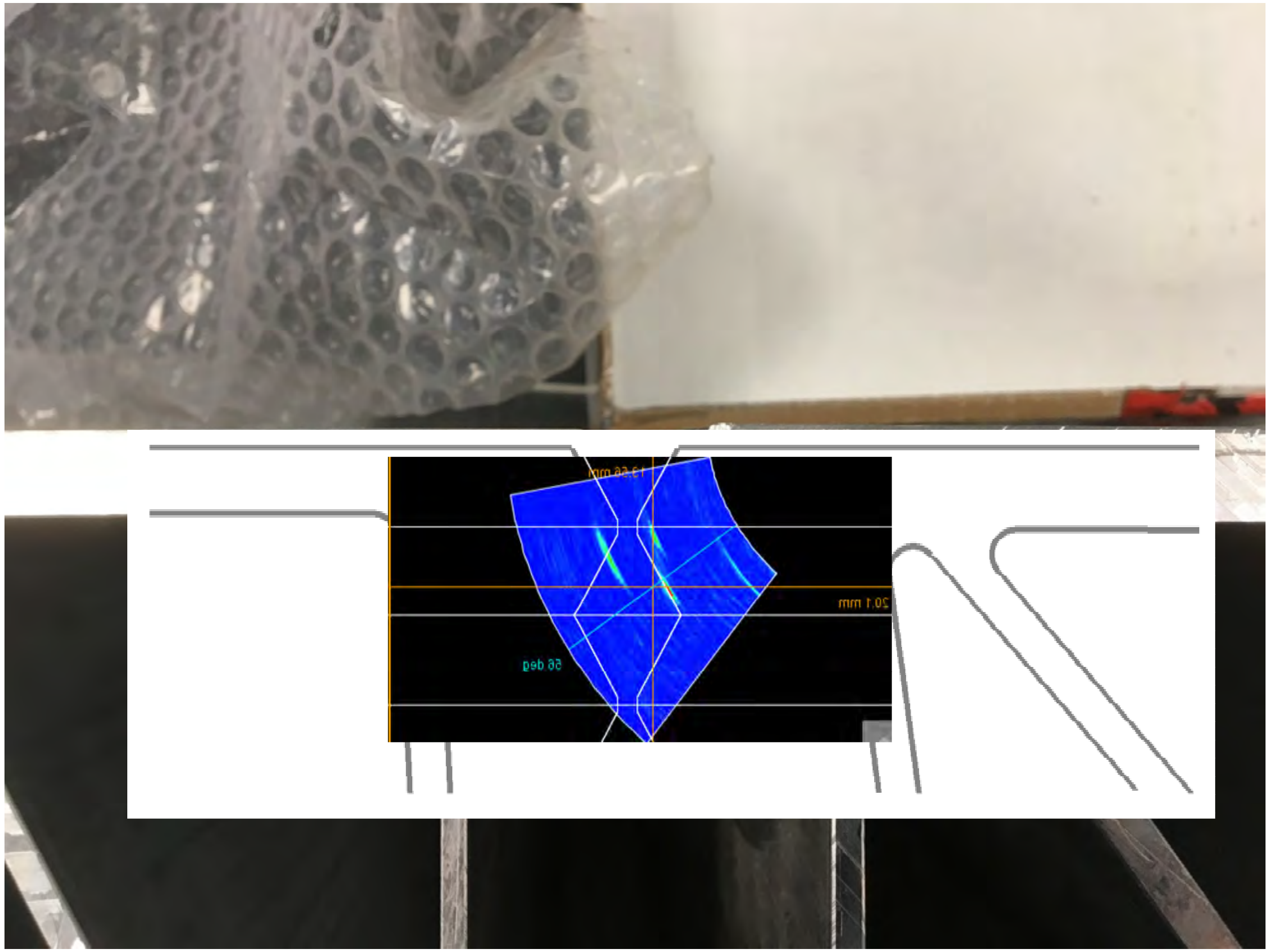
Probe 16 Elements,
10 MHz, 50° wedge
Sector-Scan 40-80 °



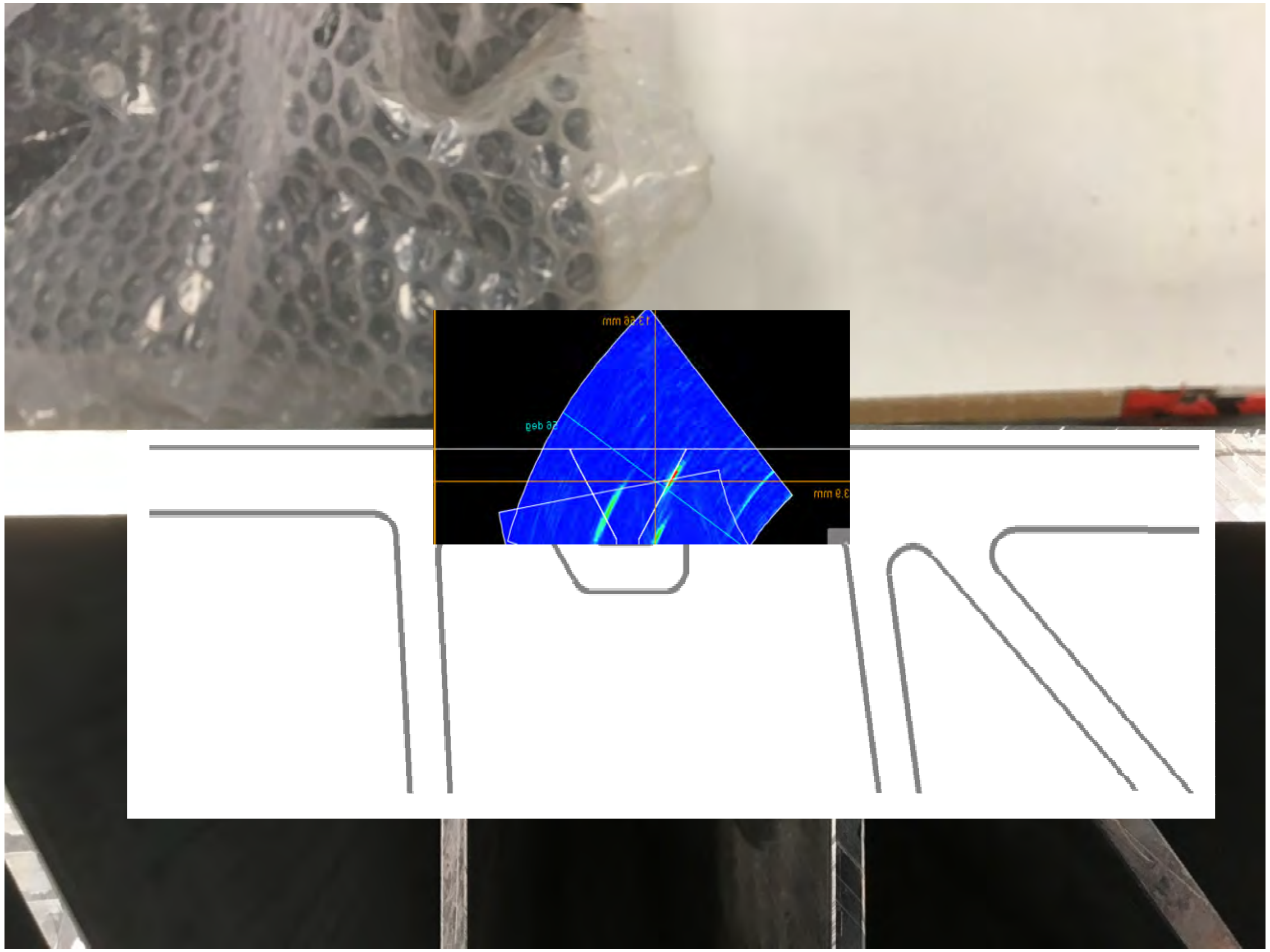
Thin plates



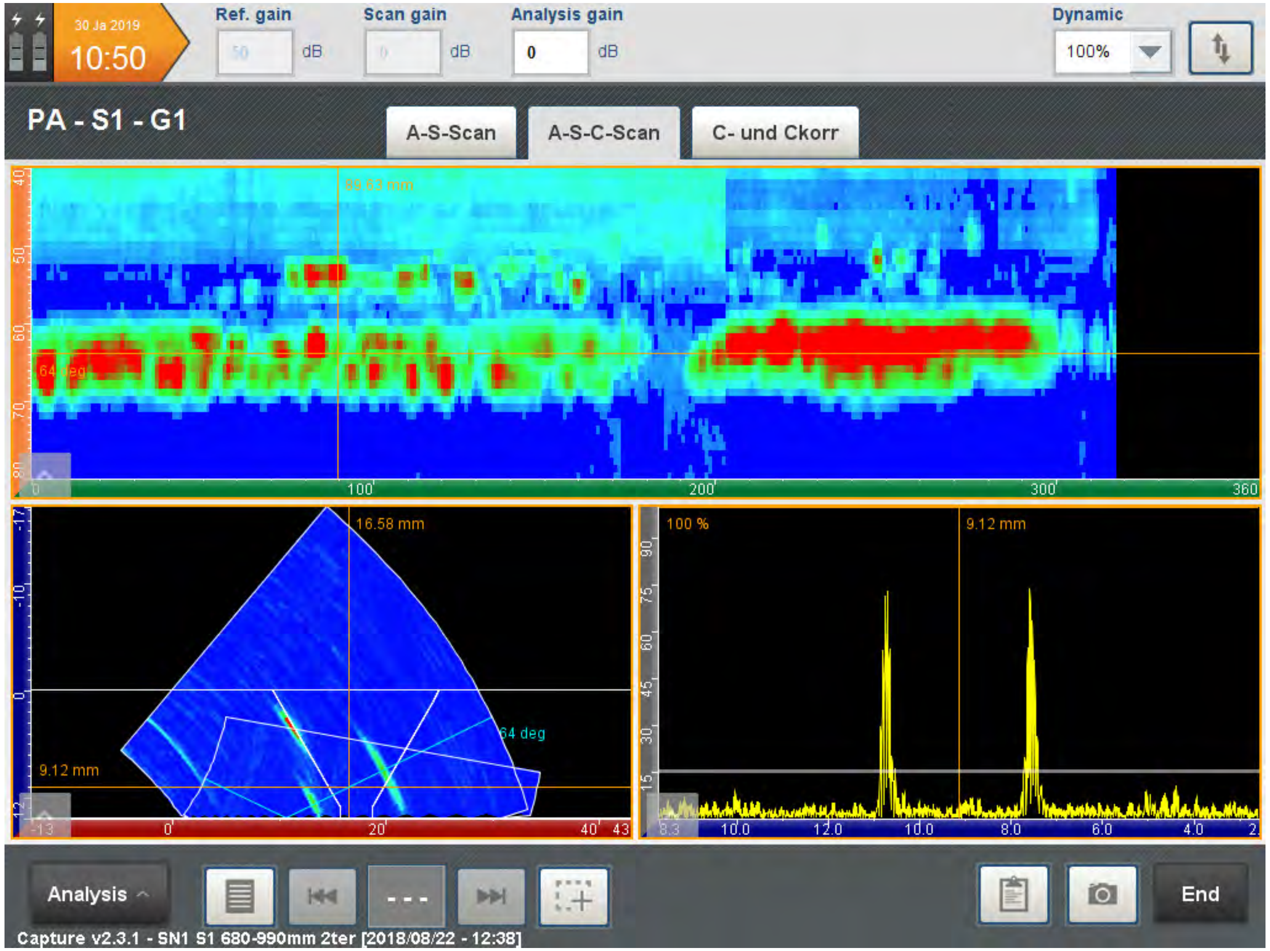
Thin plates



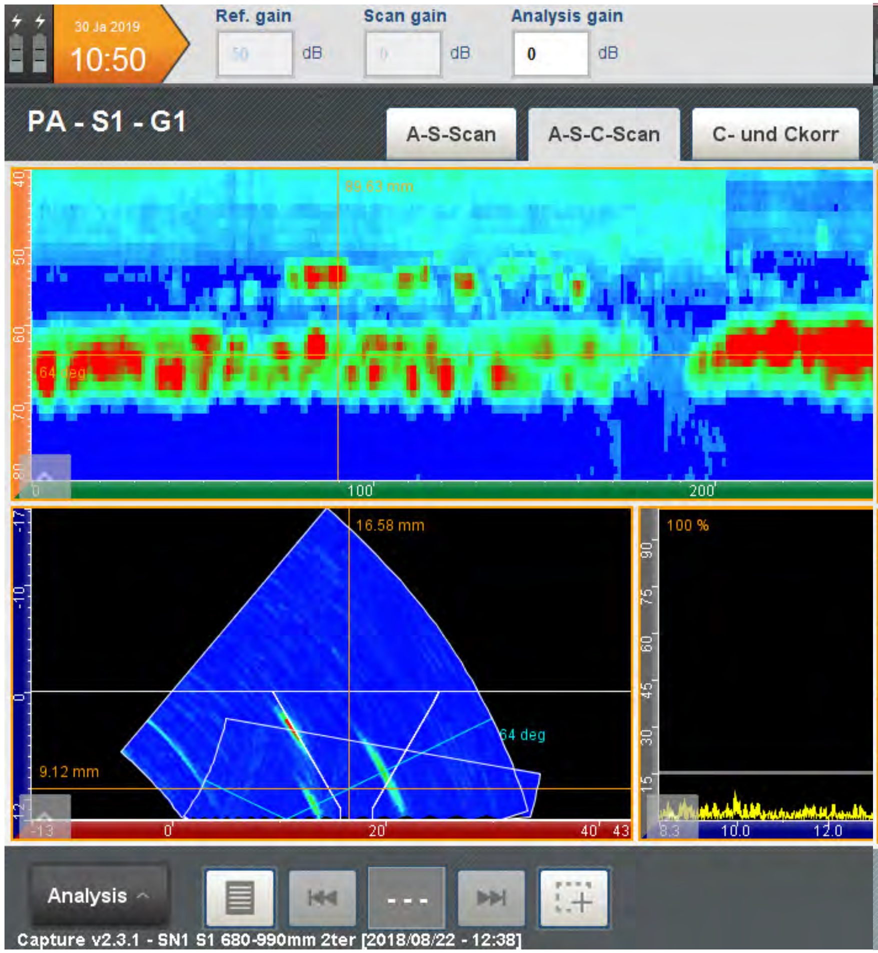
Thin plates

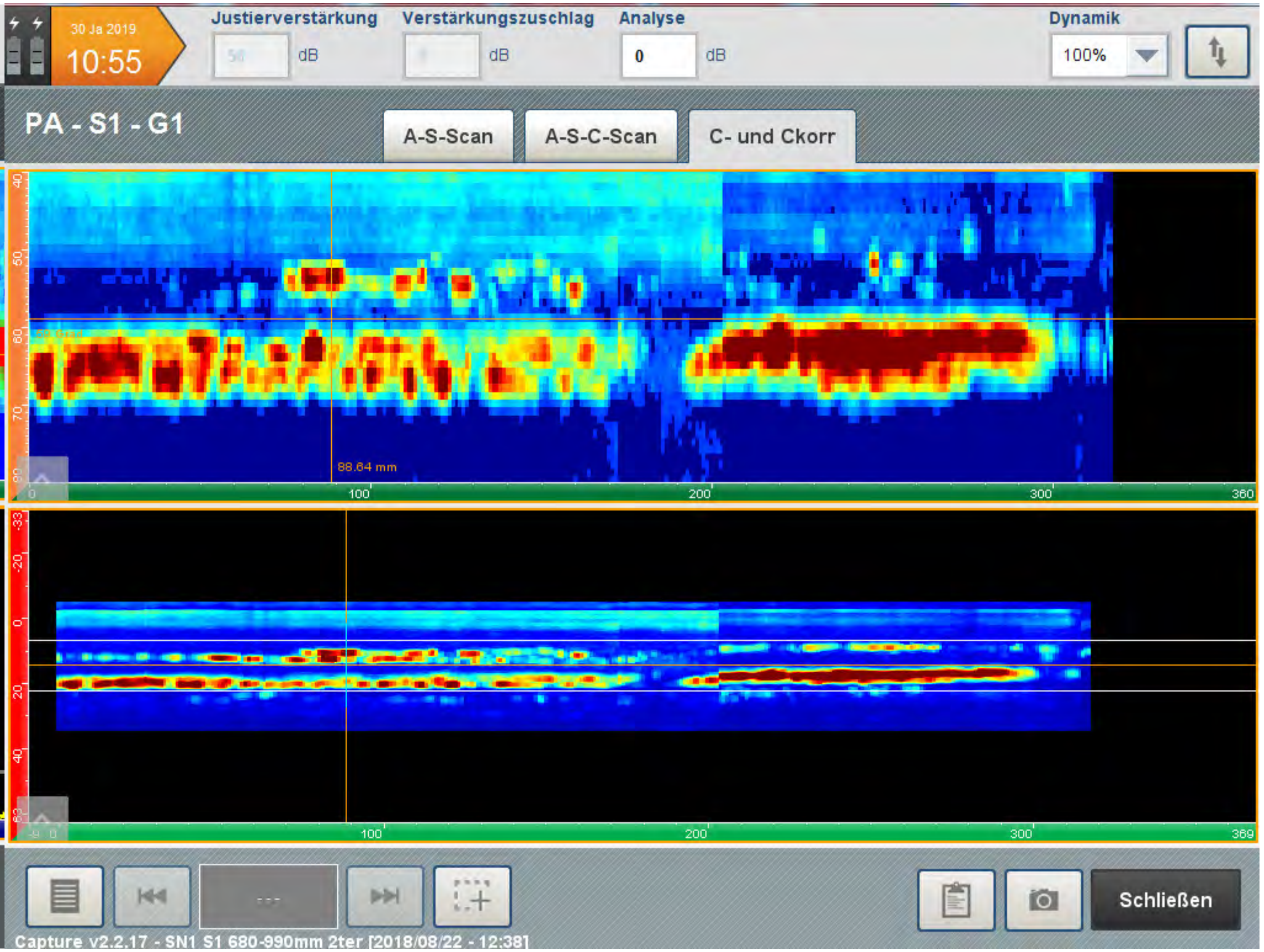


Interpretation



Interpretation

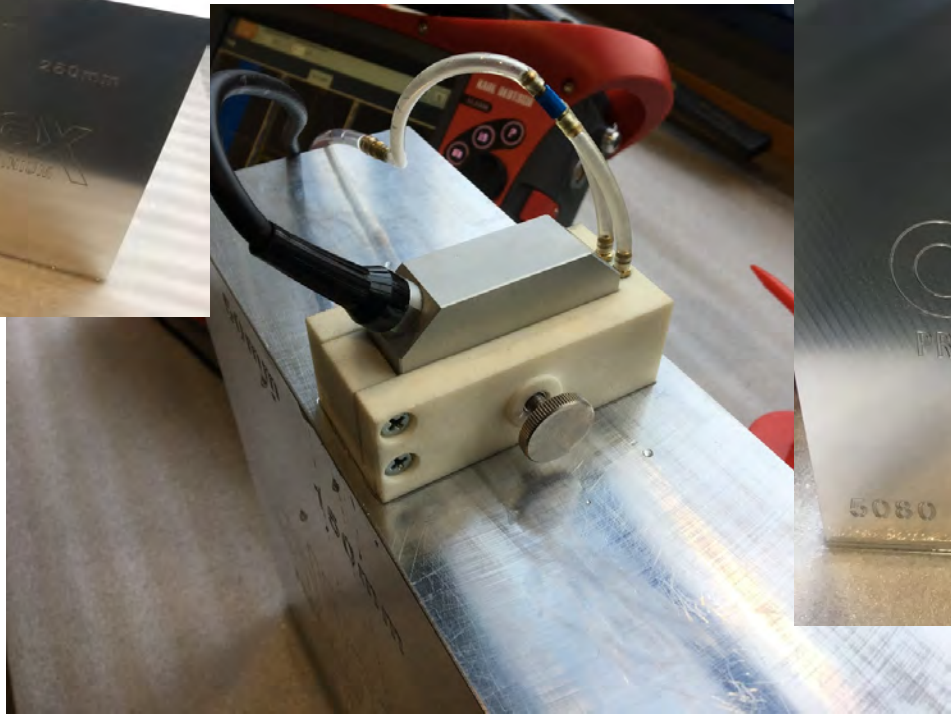




Inspection of casted aluminum plates

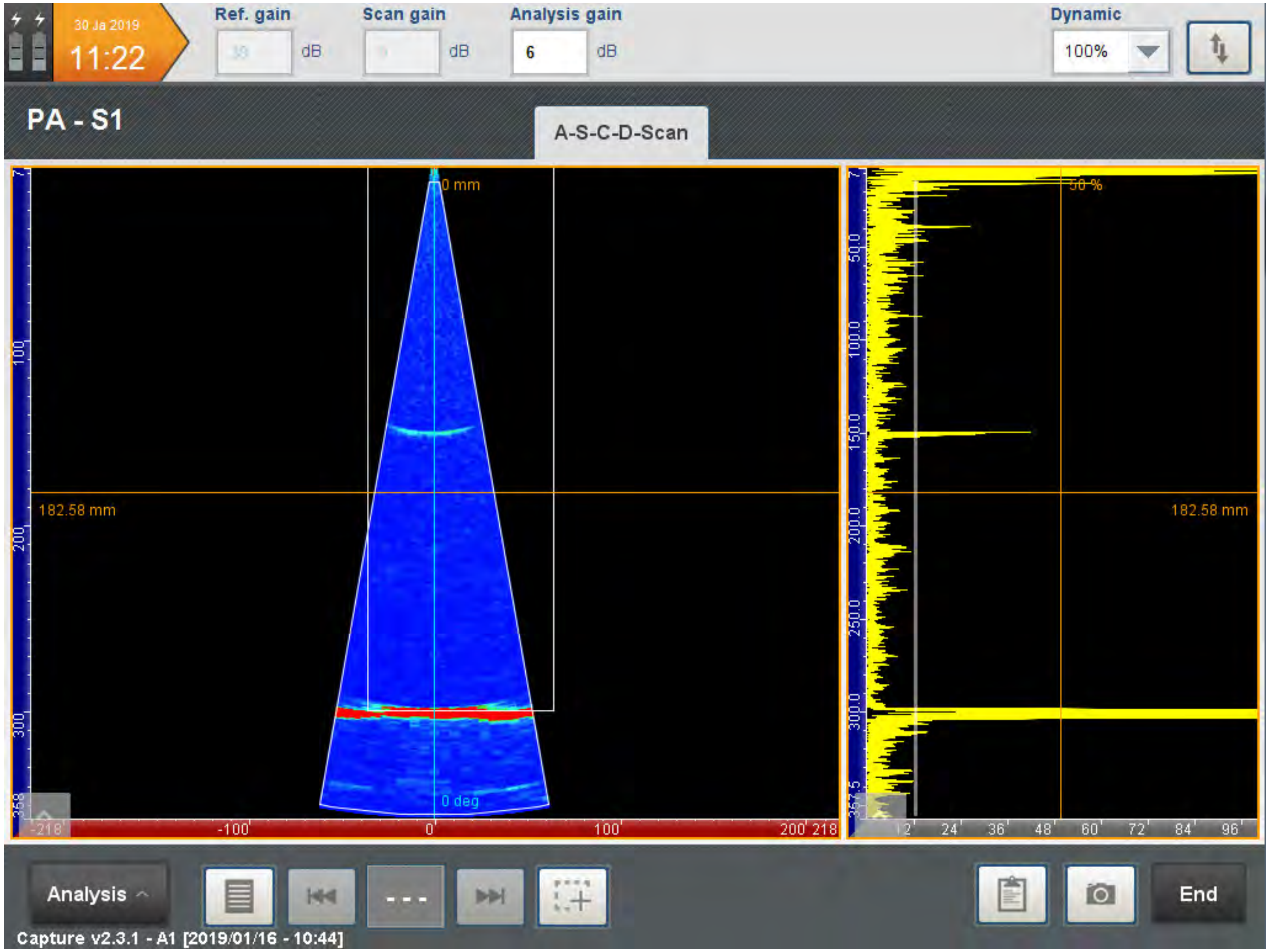
Inspection setup

Probe with 5 MHz,
0,85 mm pitch
10 mm elevation
Watergap 1 mm



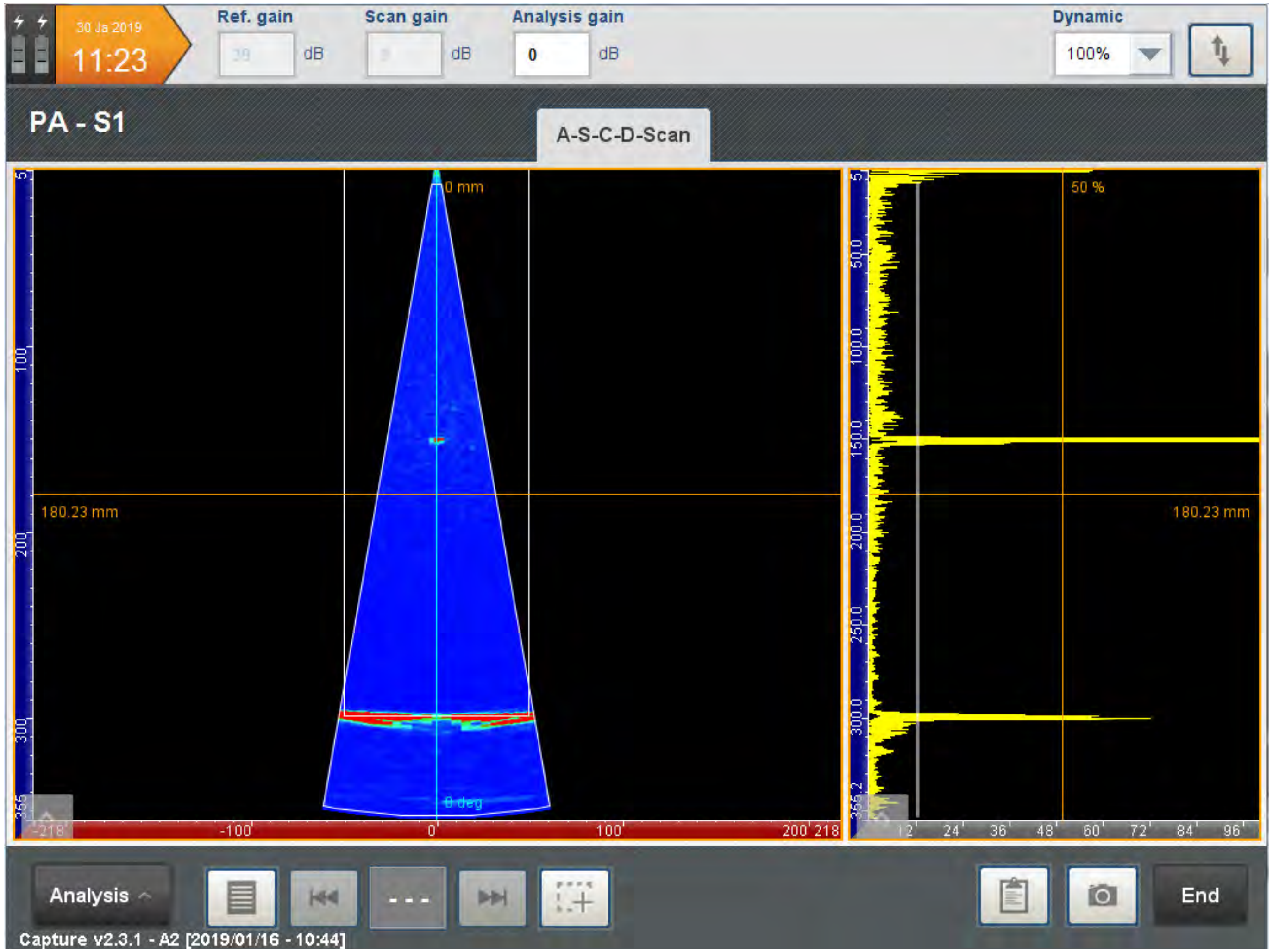
Without focussation

FBH 2,5 mm
at 150 mm
unfosussed
Sector Scan
-10° to +10°



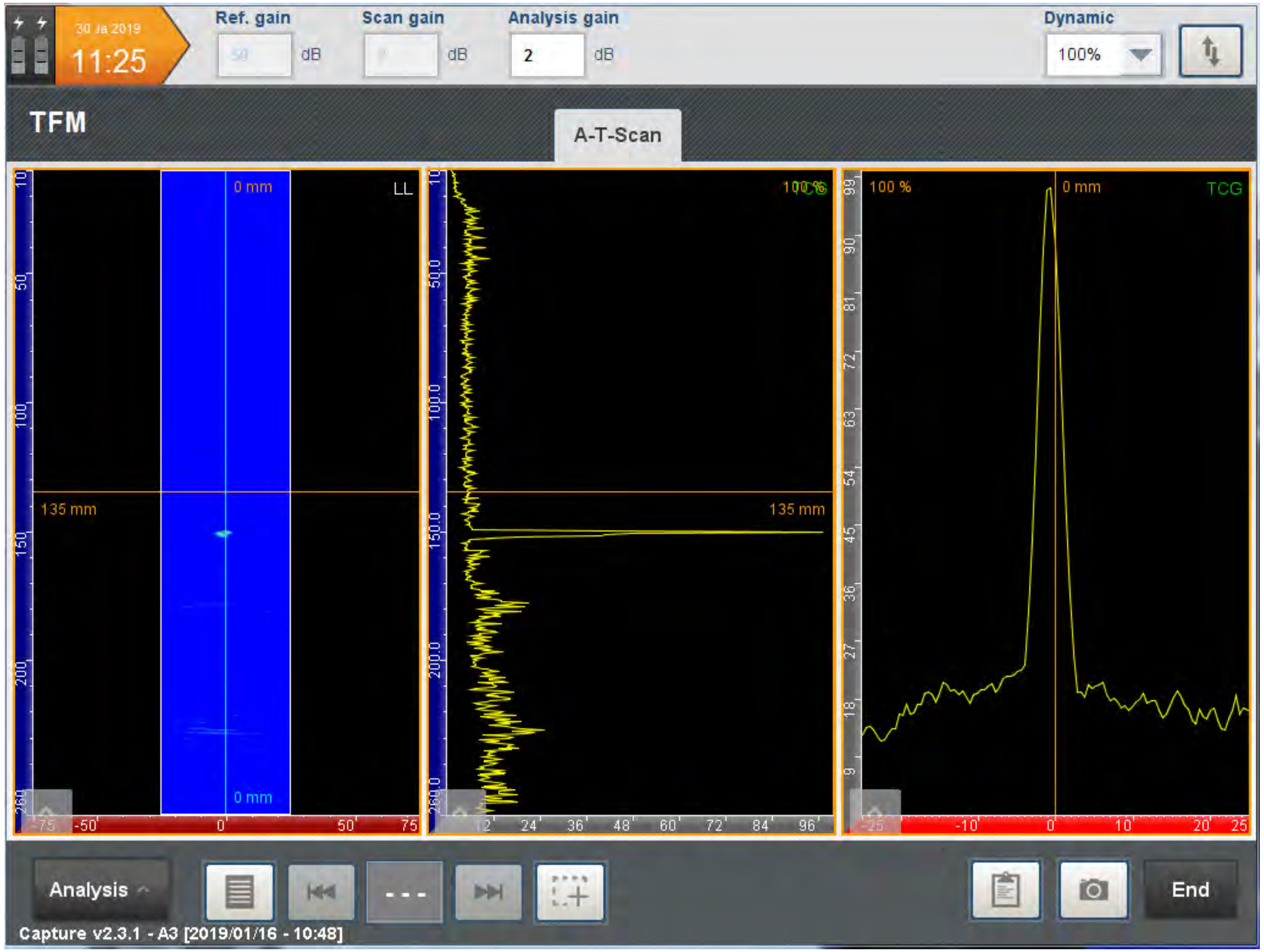
With focussation at 150 mm

FBH 2,5 mm
at 150 mm
focus at 150 mm
Sector Scan
-10° to +10°



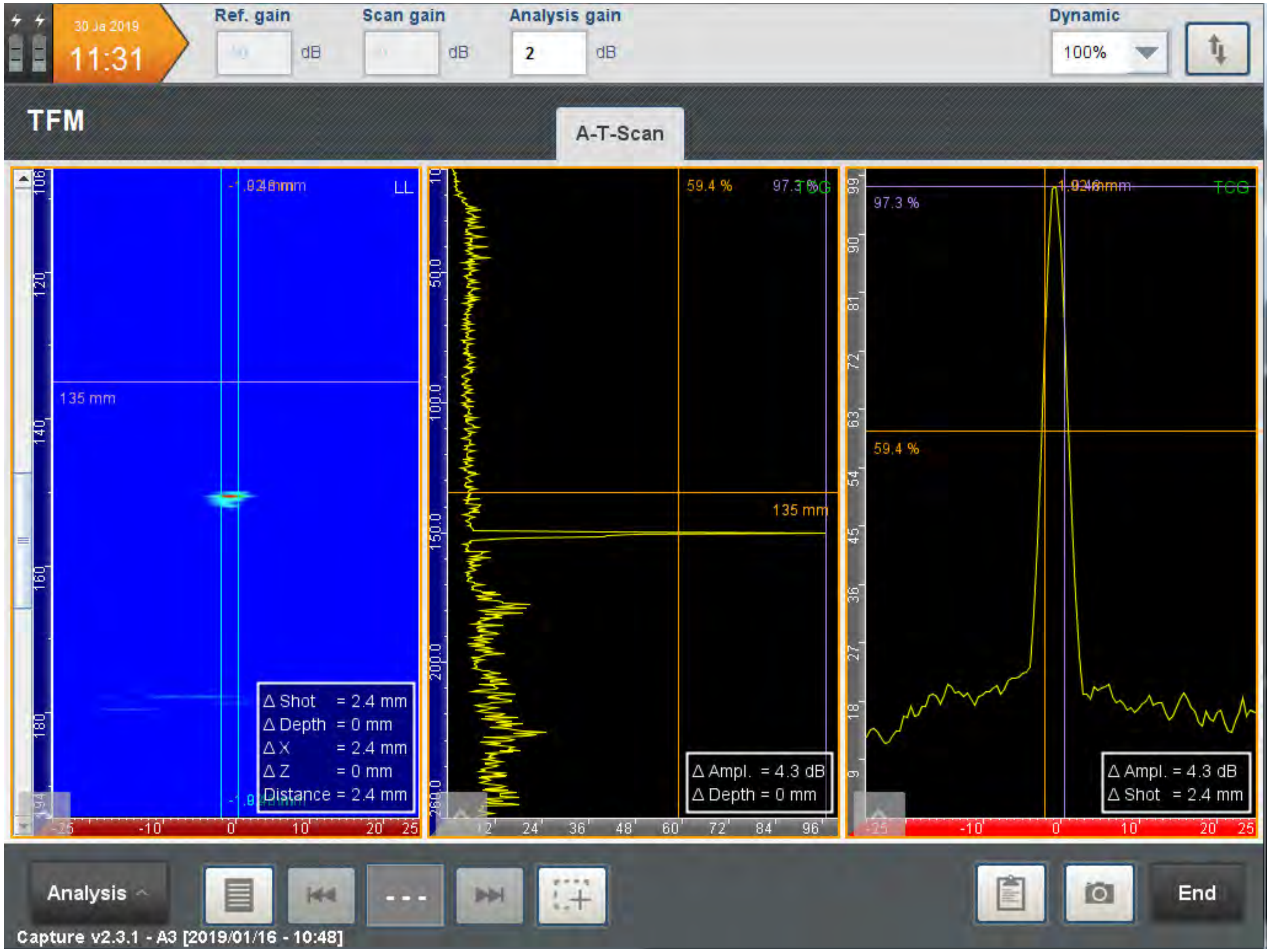
All area focus with TFM

FBH 2,5 mm
at 150 mm
TFM scan



Evaluation of the defect size

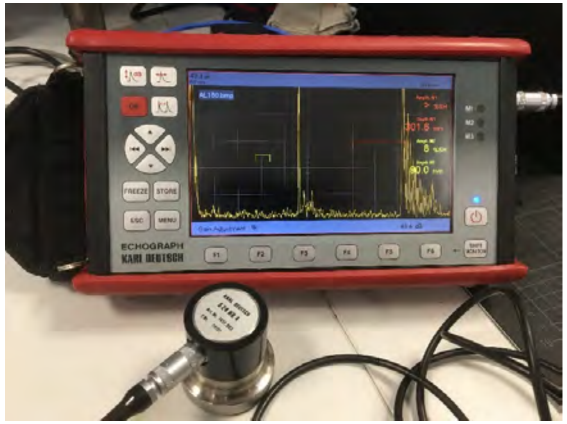
FBH 2,5 mm
at 150 mm
TFM scan

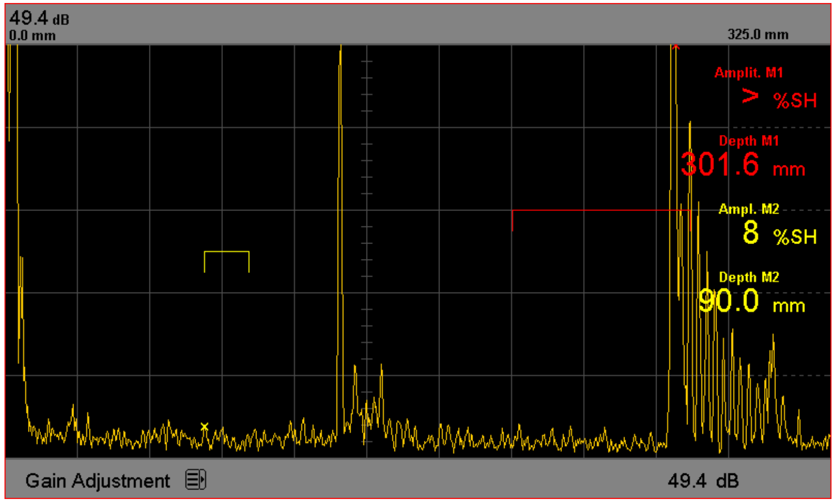


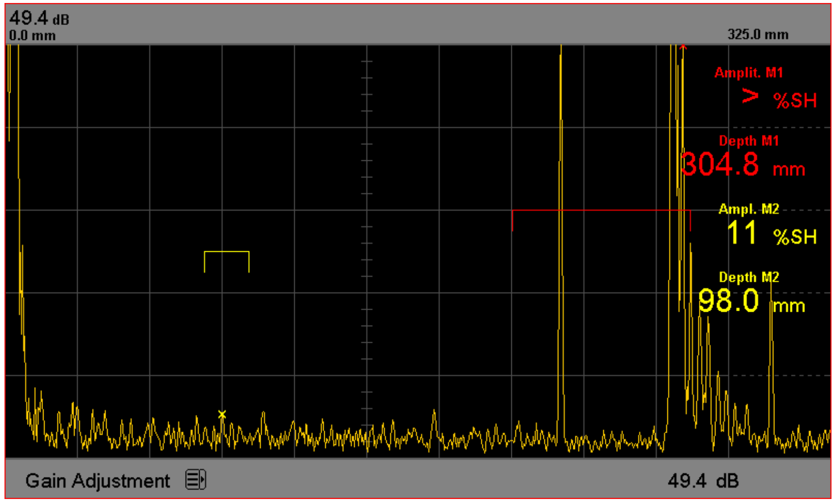
Evaluation of the defect size

Testblock with same dimensions, FBH 1,8 mm at 150 mm and 250 mm

Conventional UT with ECHOGRAPH 1095 and probe S 24 HB 4

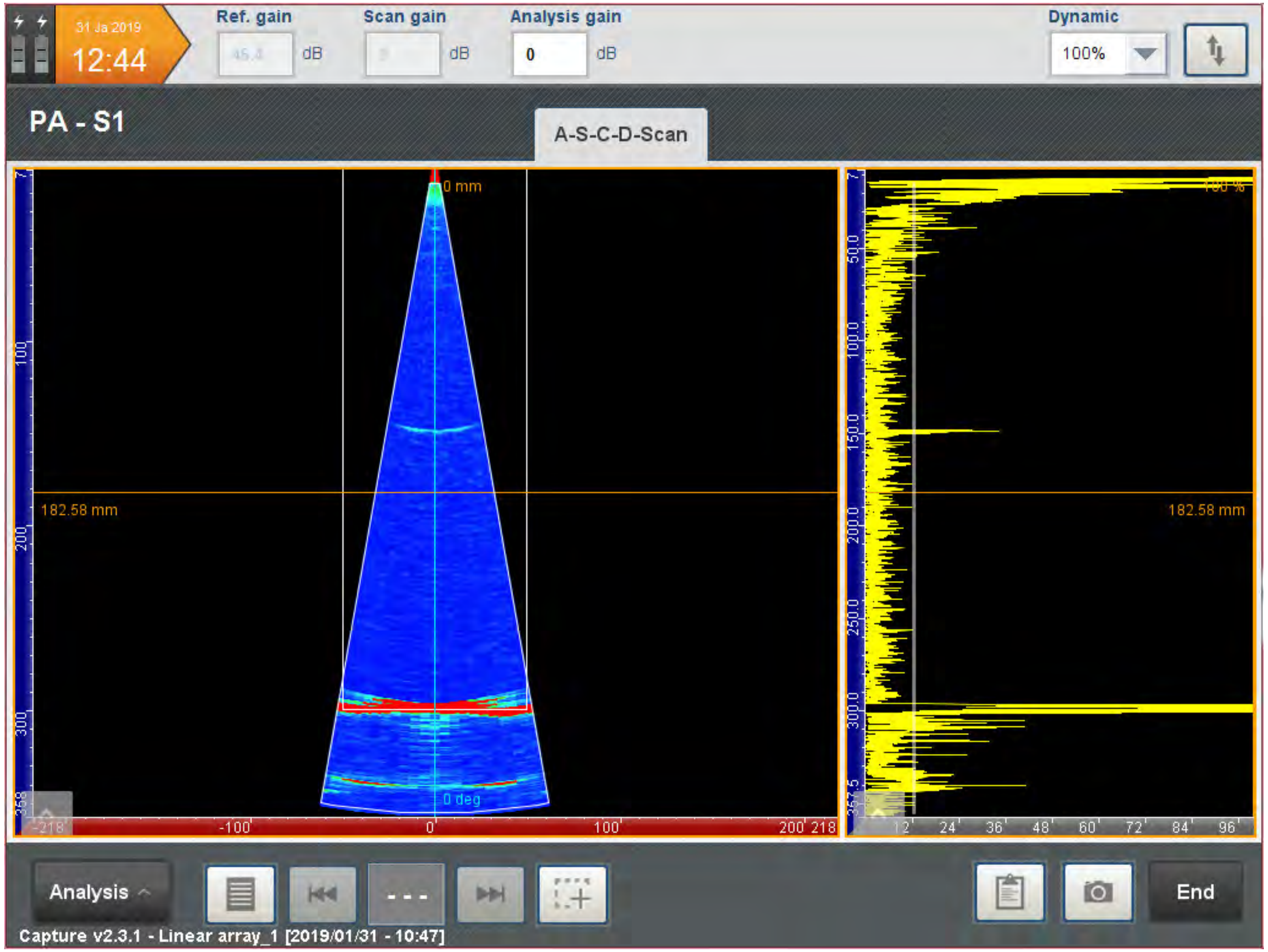






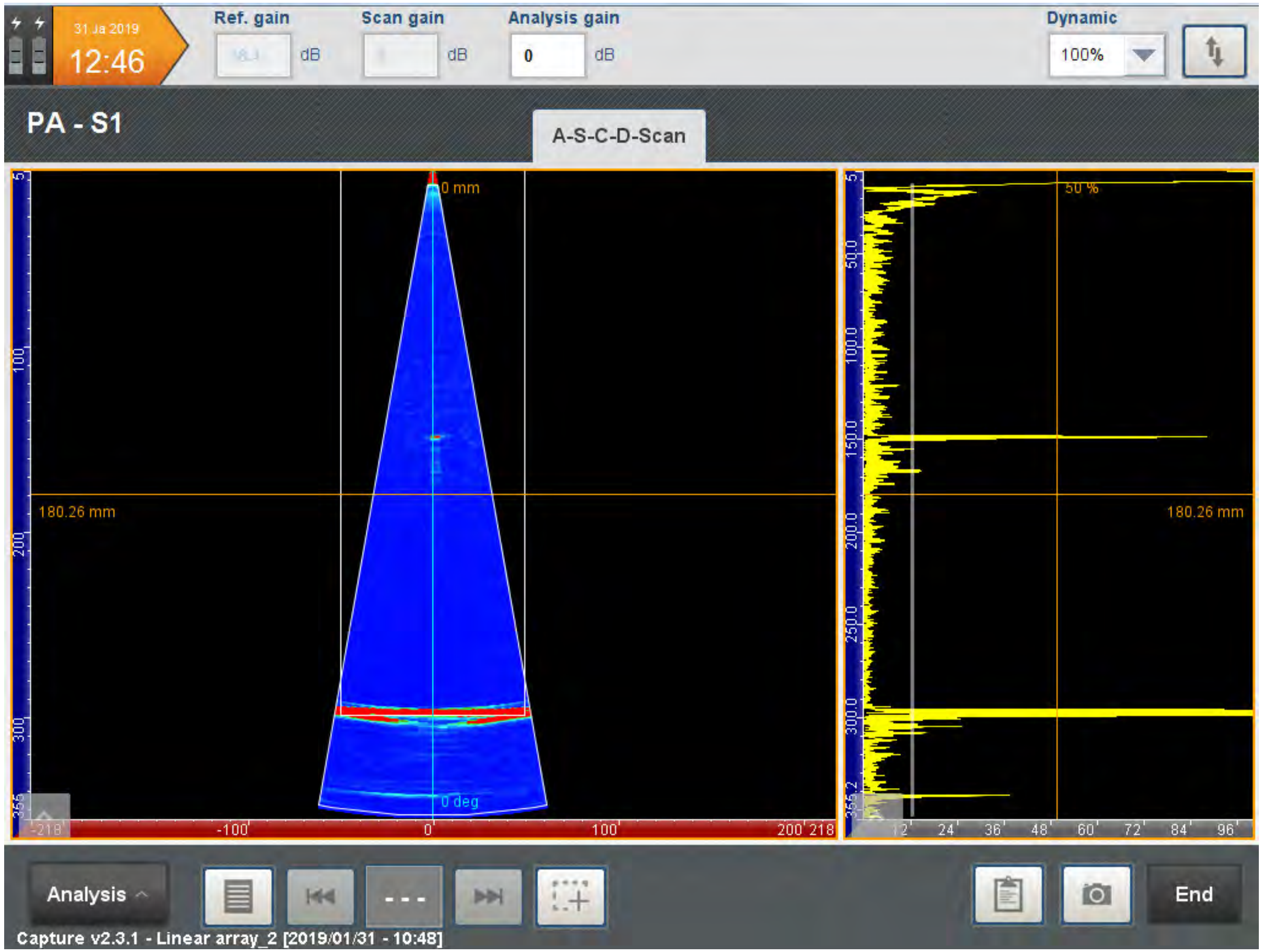
Without focussation

FBH 1,8 mm
at 150 mm
unfosussed
Sector Scan
-10° to +10°



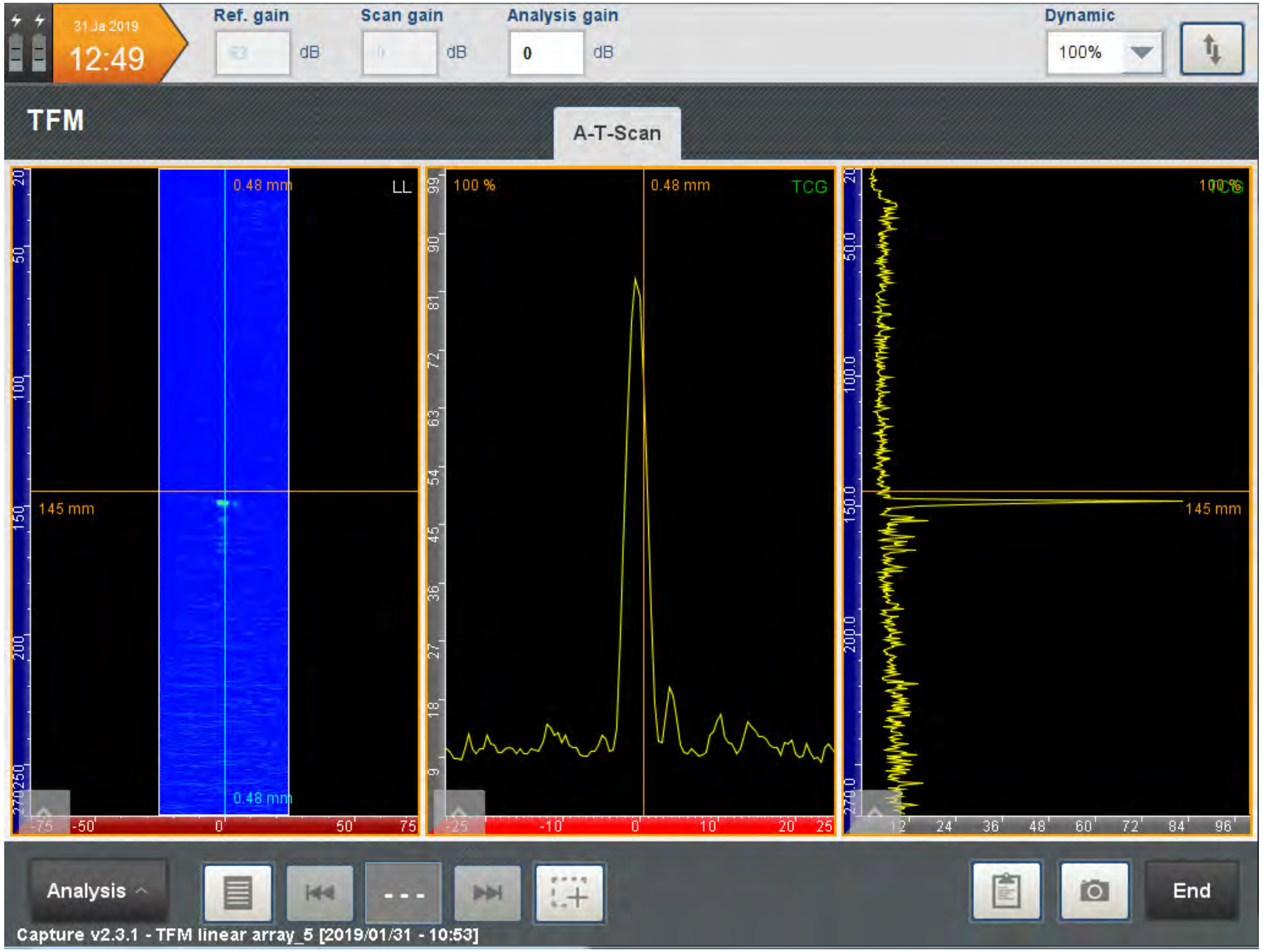
With focussation at 150 mm

FBH 1,8 mm
at 150 mm
focus at 150 mm
Sector Scan
-10° to +10°



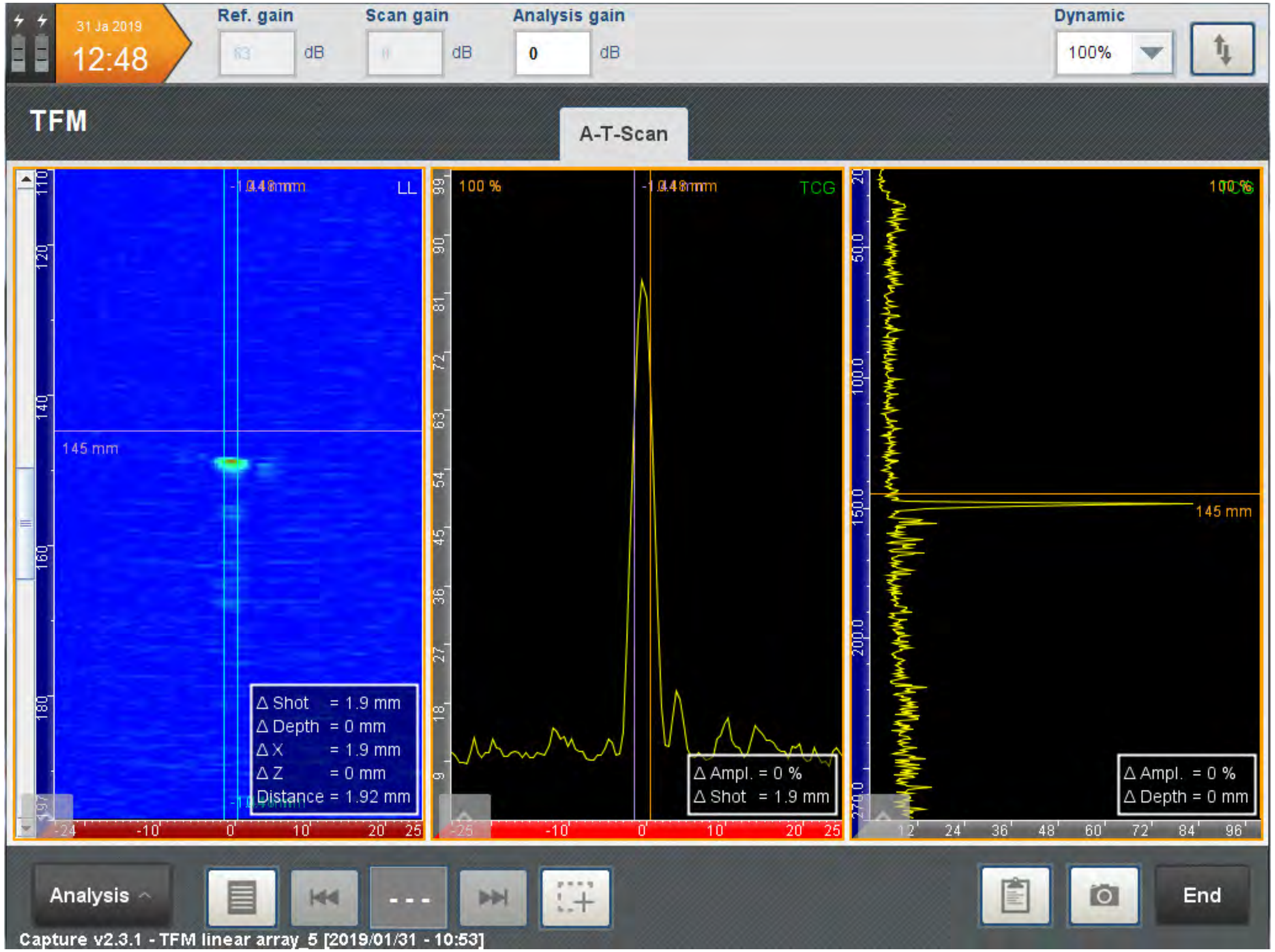
All area focus with TFM

FBH 1,8 mm
at 150 mm
TFM scan



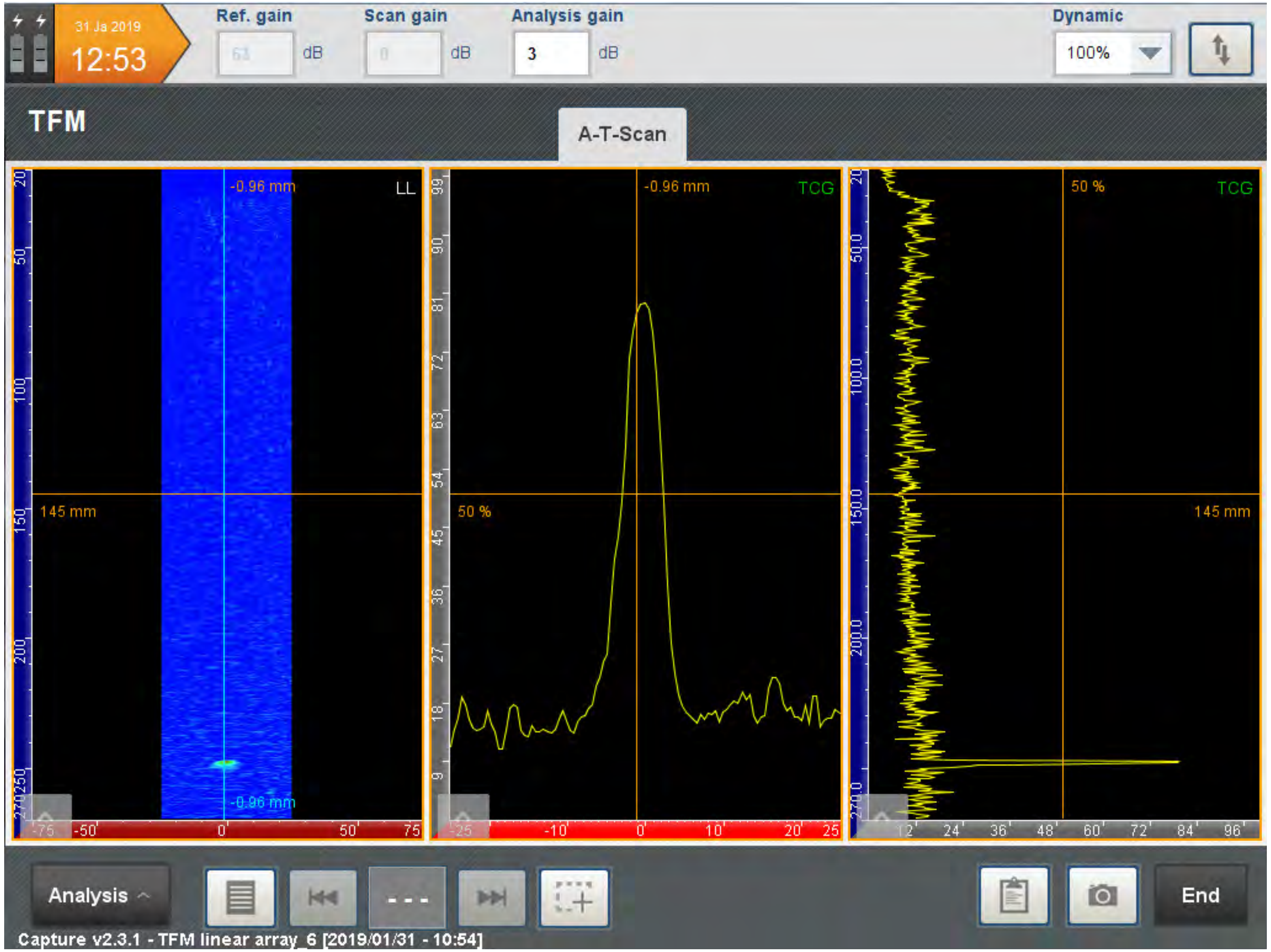
Evaluation of the defect size

FBH 1,8 mm
at 150 mm
TFM scan



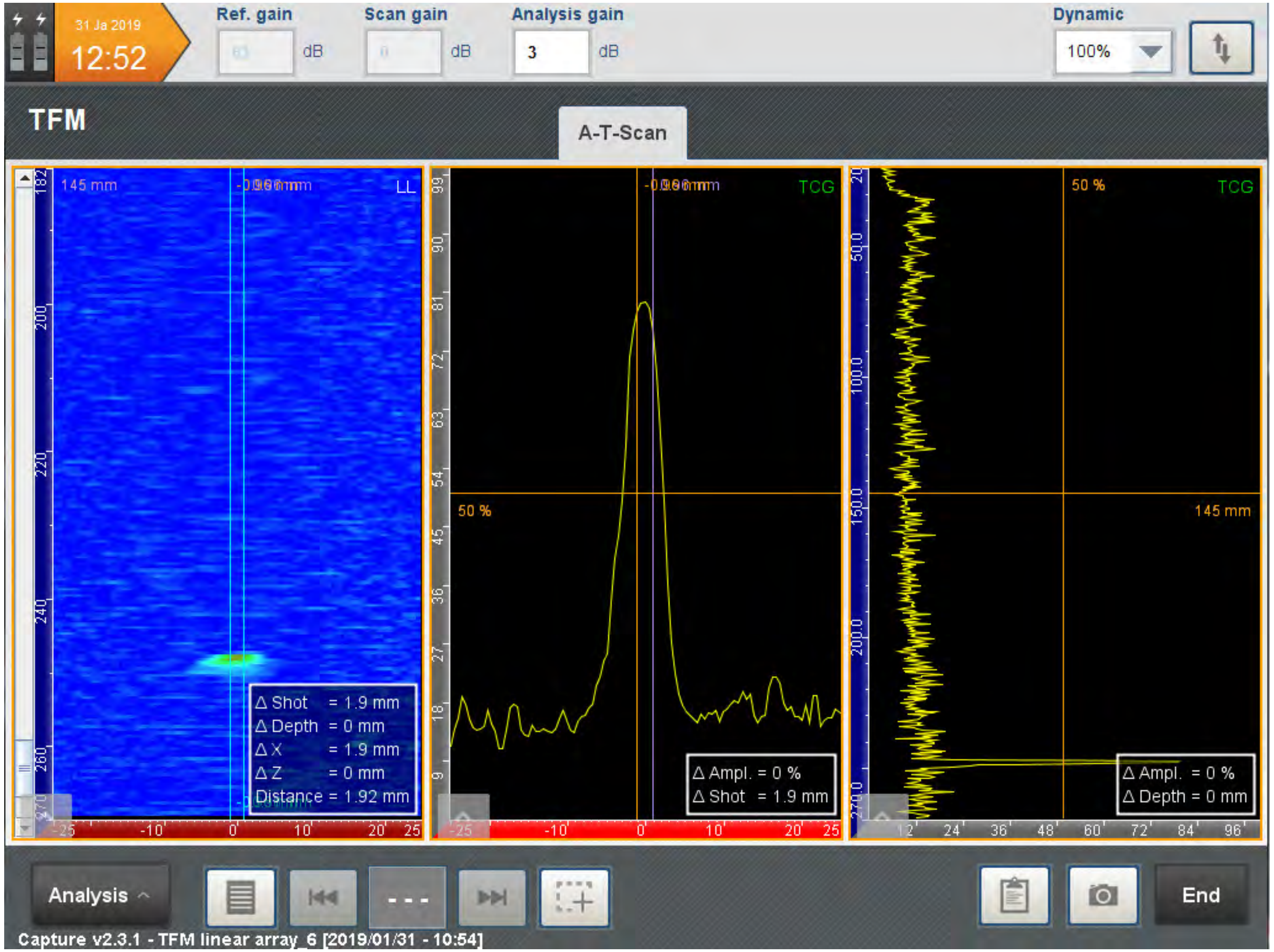
All area focus with TFM

FBH 1,8 mm
at 250 mm
TFM scan



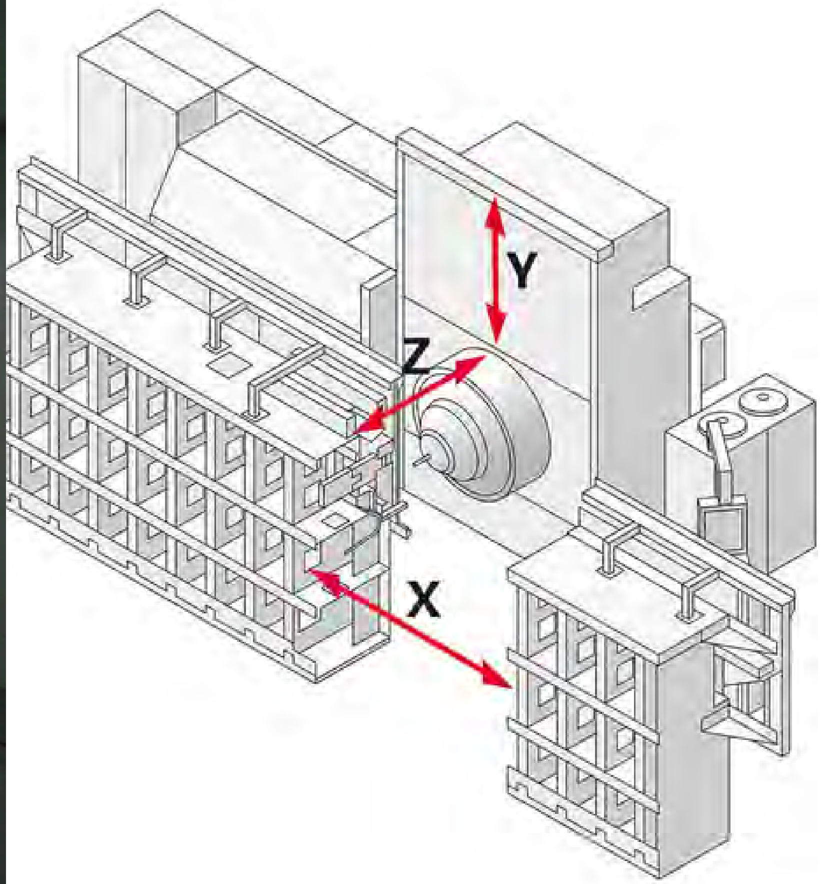
Evaluation of the defect size

FBH 1,8 mm
at 250 mm
TFM scan



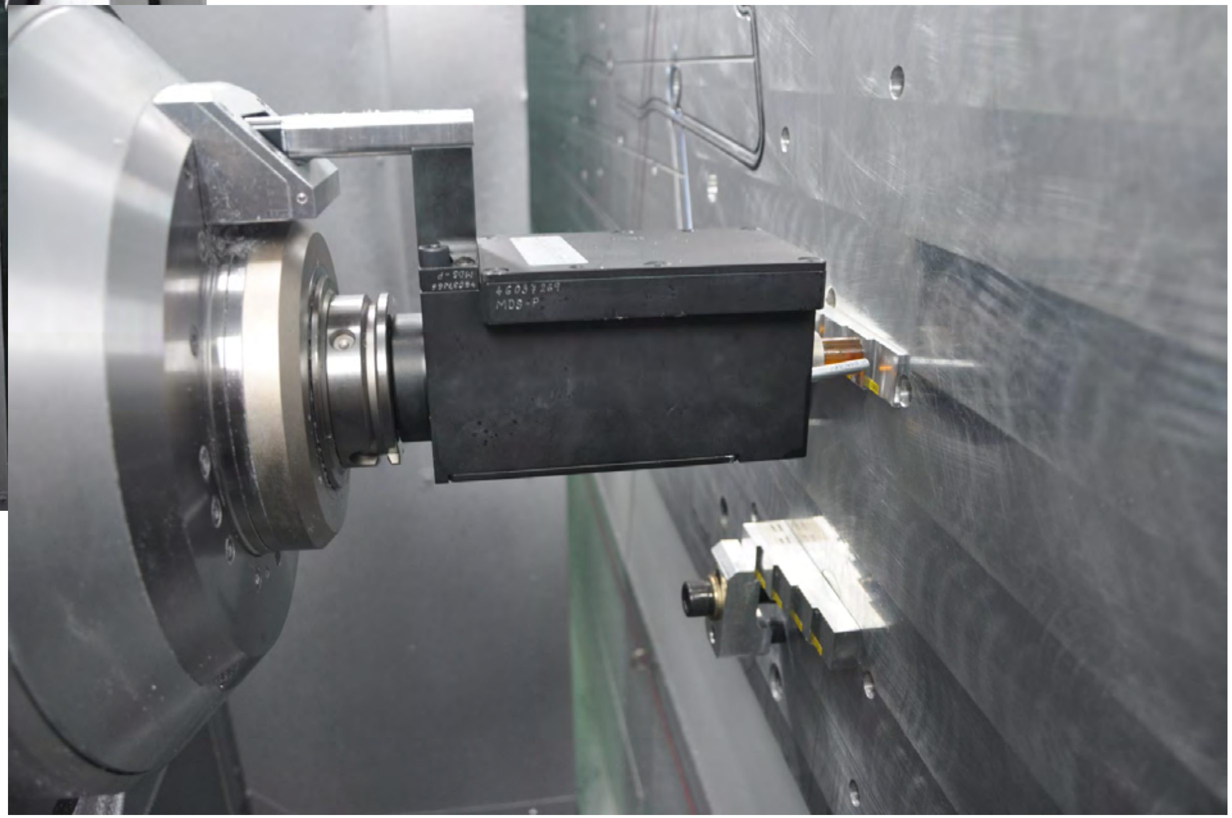
Integrated precision measurement of wall thickness

Sonic Eye by Starrag



Multi-axis grinding machine for large vertical parts

Sonic Eye by Starrag



Sonic Eye as a changing tool
Automatic thickness measurement, measured data directly influence the grinding process

Inside Sonic Eye

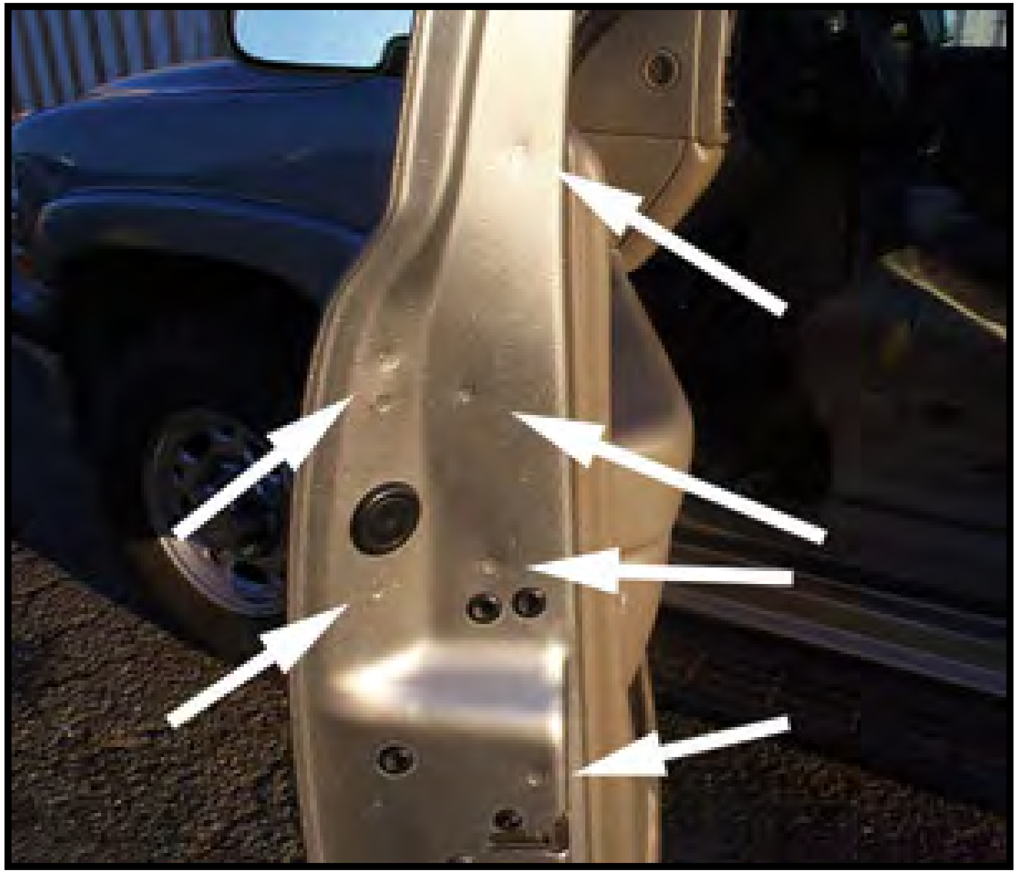
Special Version of standard precision wall-thickness gauge ECHOMETER 1077 with probe DS 12 PB 1-7

Inspection of spotwelded aluminum plates

Spotweld inspection

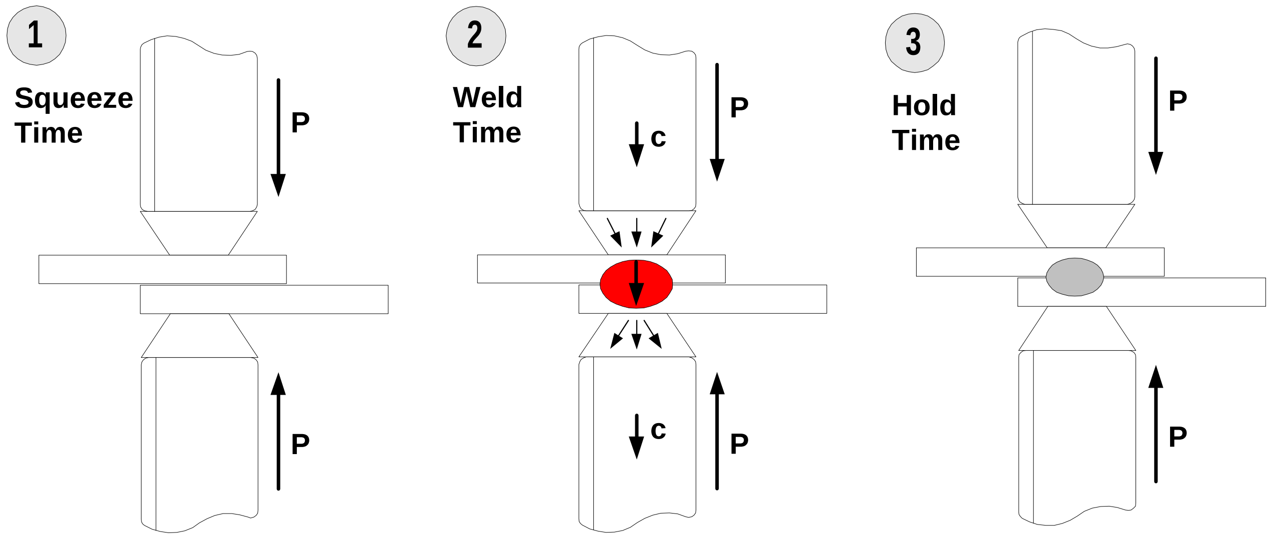
Spot welding is useful as it can produce high quality welds at a relatively low cost

About 3.000-5.000 spots on a regular car body

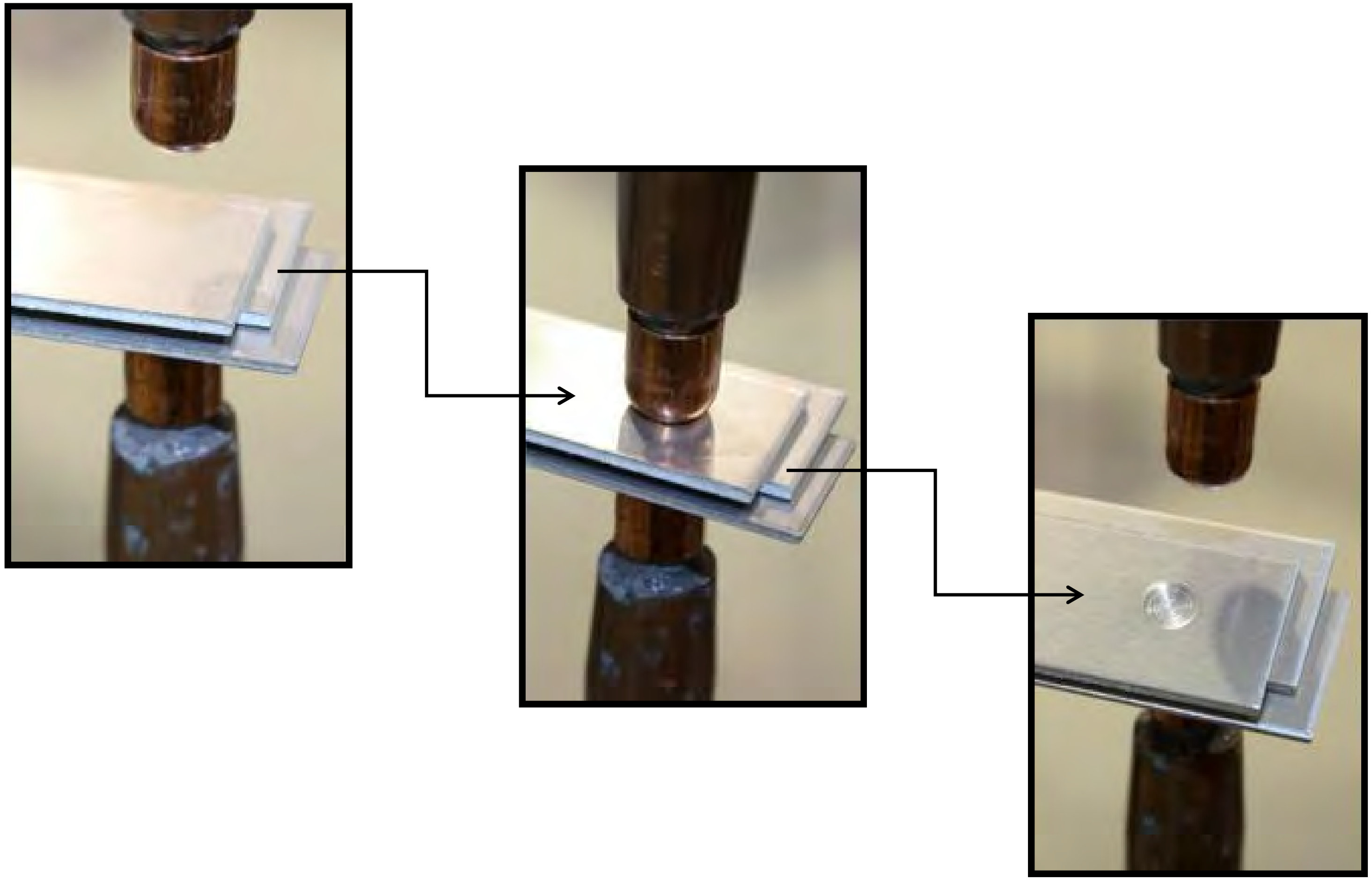


Welding Process

1. Pressure applies to assure full sheet contact
2. Heat melt the steel to form the nugget weld

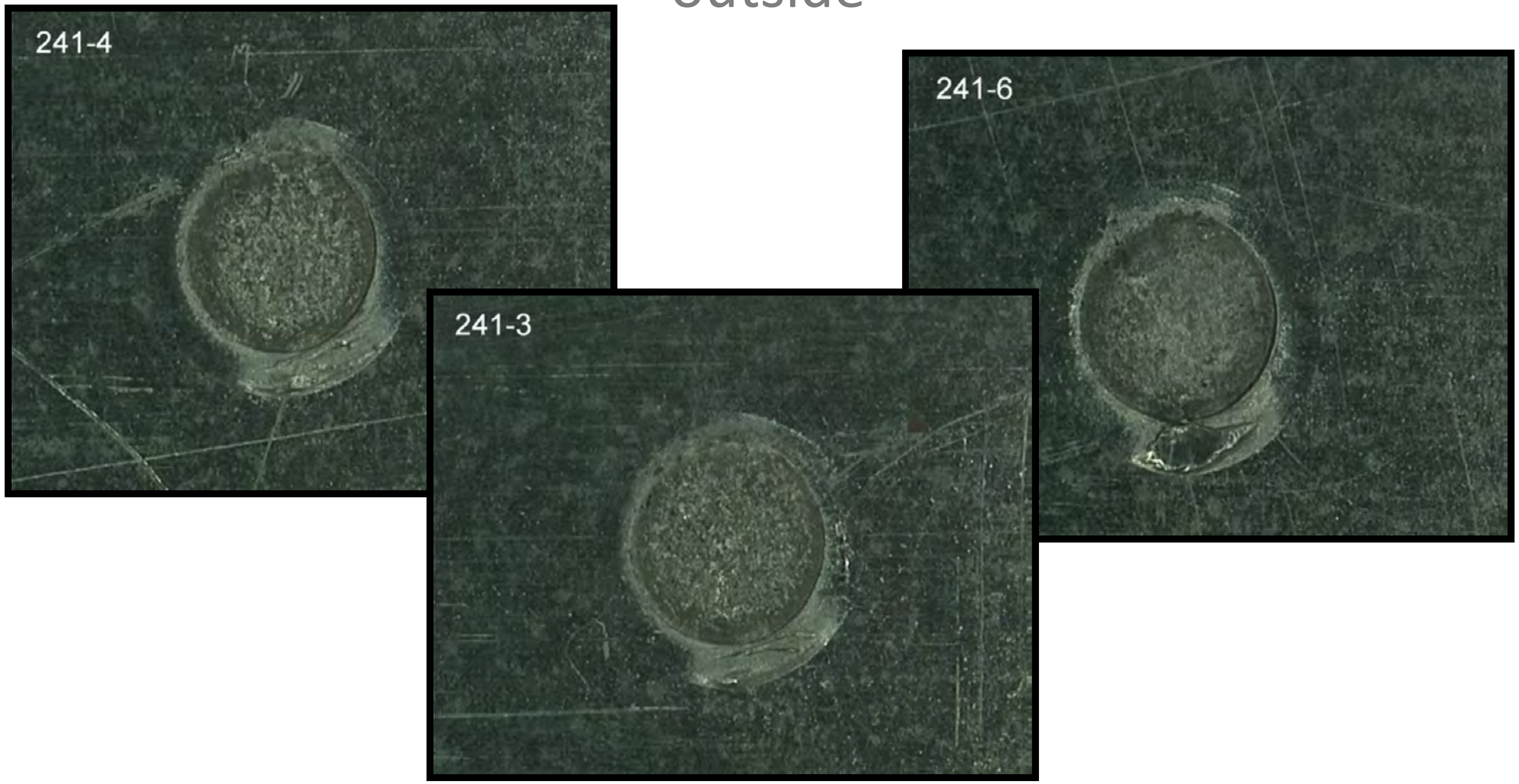


The Result



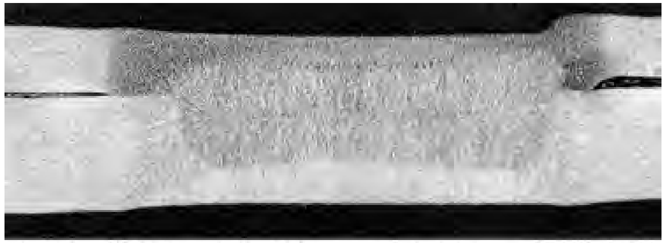
The challenge

Weld quality is impossible to predict visually from the outside

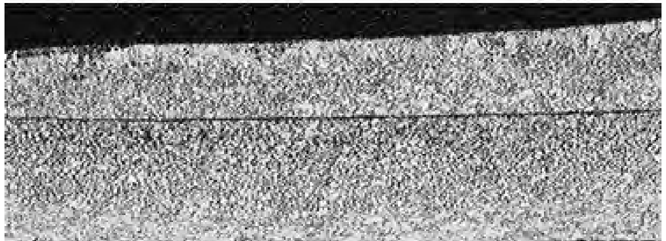


Some nugget types

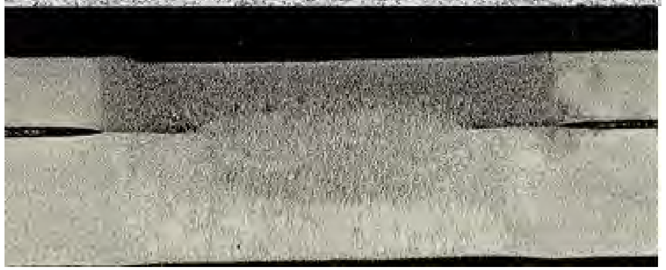
- Good



- No Weld (Loose)



- Undersized

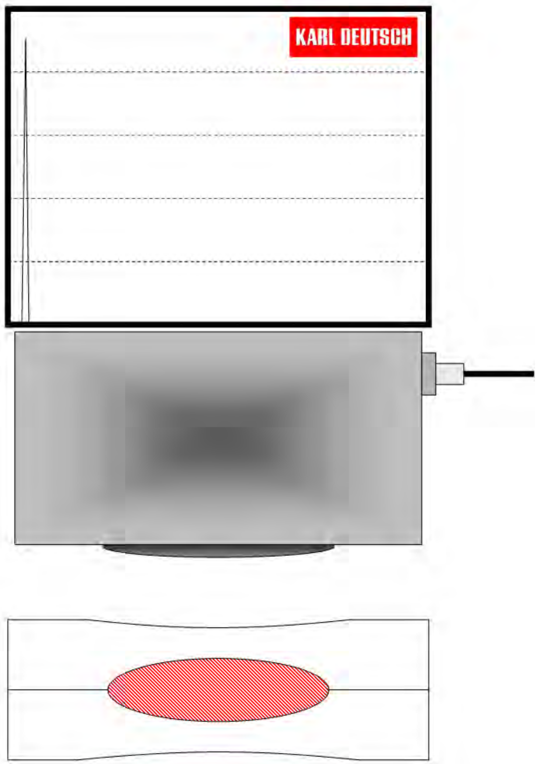


Spotweld inspection with UT/Mate

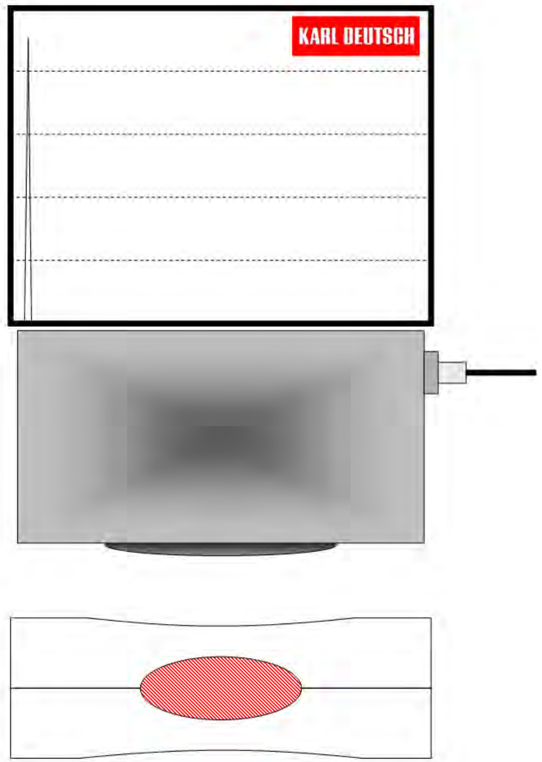
Spotweld inspection - probes

Probes have to be selected according to the nominal nugget size

Spotweld inspection – basic principle

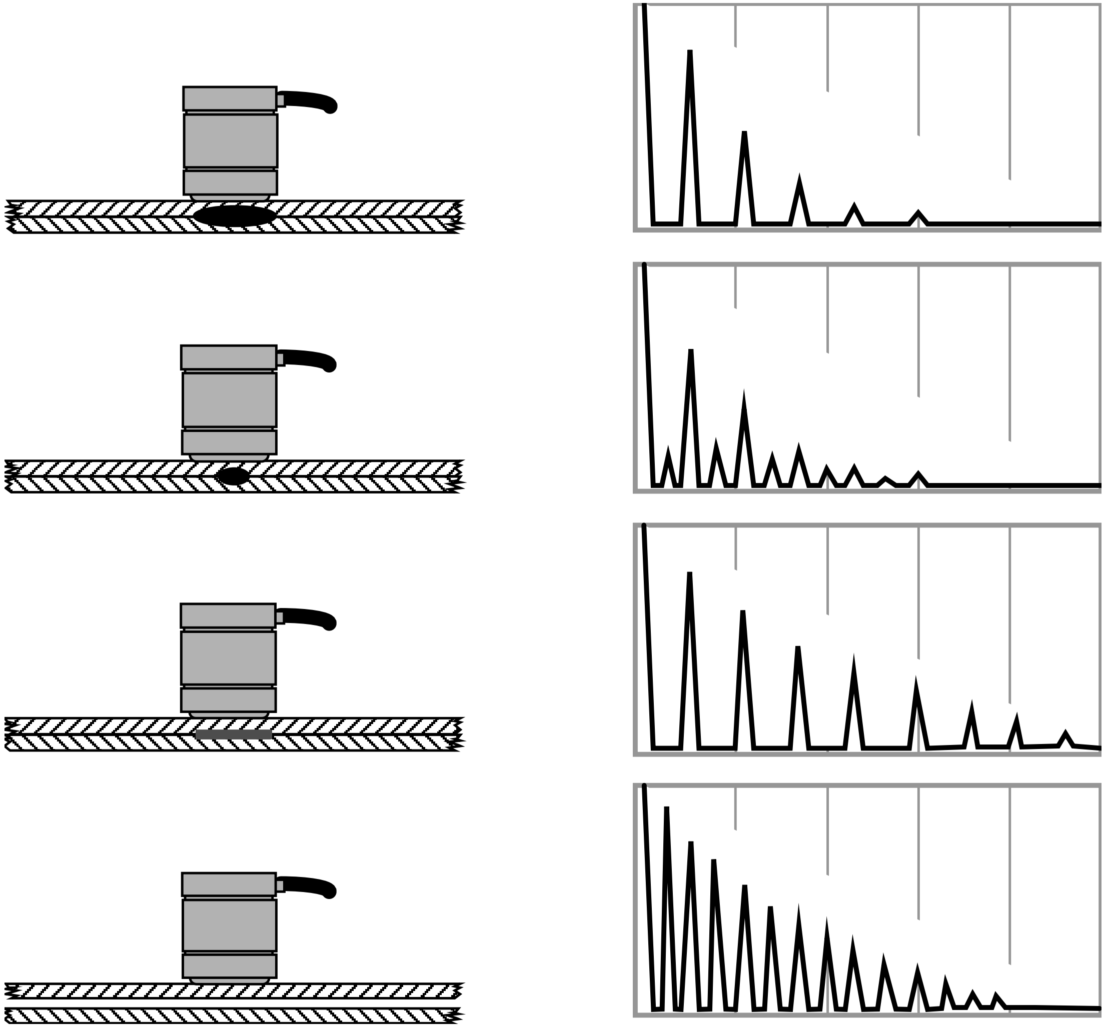


OK



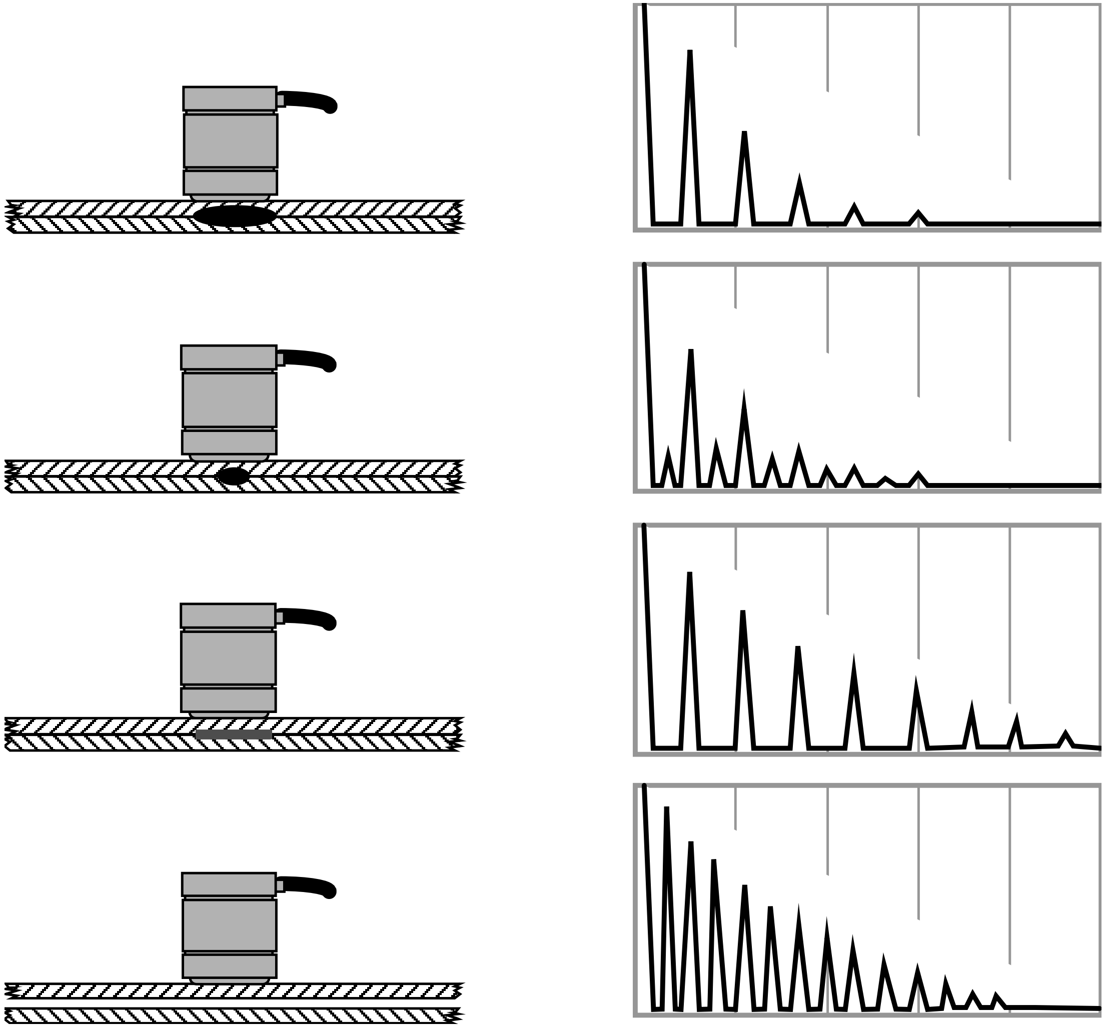
NOK

Spotweld inspection – basic principle



- Good spot
- Spot too small
- Cladding
- No weld

Spotweld inspection – basic principle



- Good spot
- Spot too small
- Cladding
- No weld

A pore in the spot center may give the same signal but is not critical

Spot welded aluminum plates often show such pores

Spotweld inspection with PA UT/X

Phased-Array-Technique is applied in UT/x

- Matrix-Probe with 61 Elements
- Only one probe required
- PA-Electronic MANTIS
- Weld nugget is evaluated
- Welded area is measured