CIVA UT VALIDATION IN SEPARATED T/R CONFIGURATIONS

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EXTENDE CIVA

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OVERVIEW

- Introduction
- 1) Dual Element transducer
  - Description of the configuration
  - Acquisitions performed
  - Comparison Simulation / Experiment
- 2) Tandem PA configuration
  - Description of the configuration
  - Acquisitions performed
  - Comparison Simulation / Experiment
- Conclusion

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Introduction: EXTENDE activities

- CIVA Distribution

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Introduction

- Simulation in NDT more and more used industrially, particularly to support qualification or design process
- Allows to study a wide scope of configuration at low cost, complementary to real trials
- Model reliability is of first importance
- Validation works (UT, ET and RT) are performed in the frame of a collaboration EXTENDE / CEA, then published on EXTENDE website:

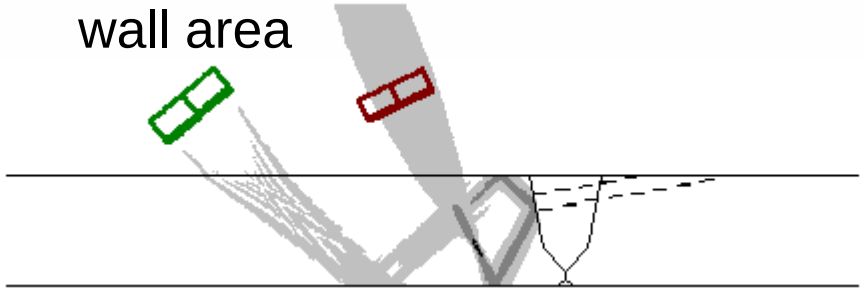
  www.extende.com

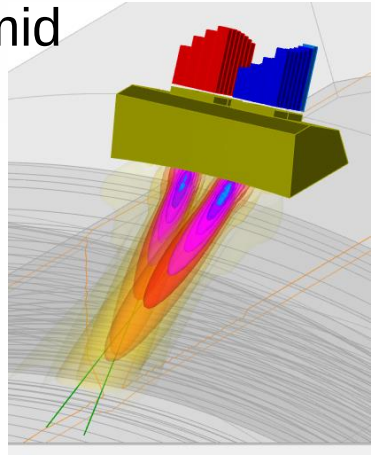
Introduction

- The process involves several stages:
  - To define and perform trials, check and improve repeatability and reproducibility of measurements
  - To describe precisely input data in CIVA
  - To perform CIVA computations, analyse results and compare with experiments
- This presentation deals with 2 types of separated Transmit/receive UT transducer:
  - Dual Element probe
  - Tandem Phased-Array set up

Introduction

- 1) Dual Element Probe:
  - Can inspect sub surface area thanks to a very short dead zone
  - Good performance in attenuating materials such as bimetallic weld
- 2) Tandem Configuration:
  - Widely used for pipe girth welds inspection (such as Zonal Discrimation technique) especially for the mid wall area





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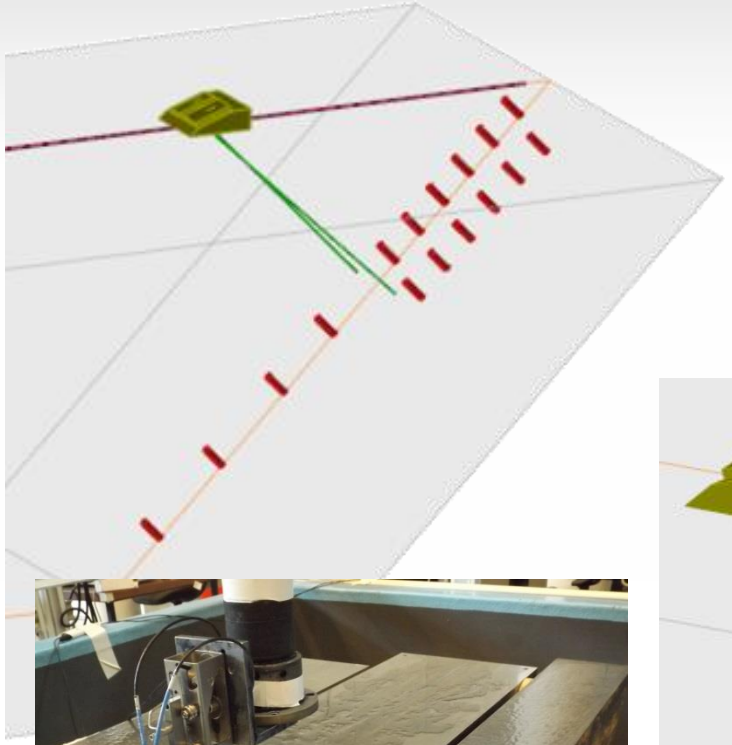
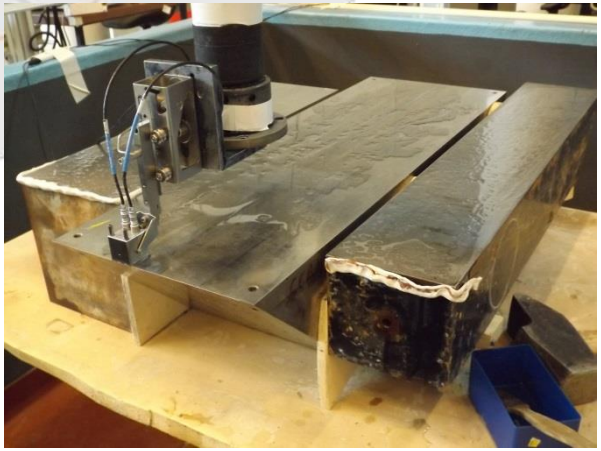
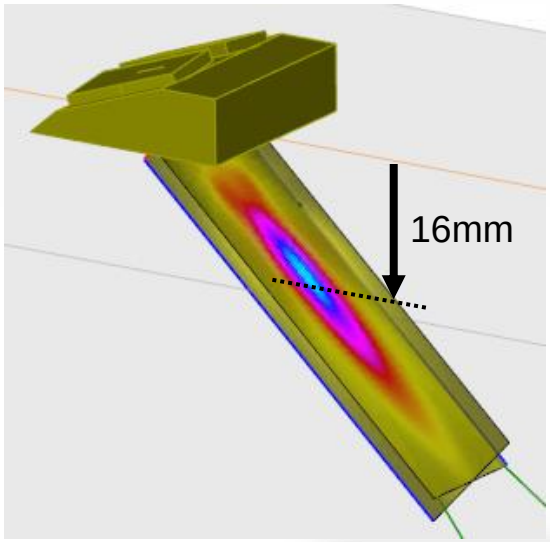
Dual Element Probe

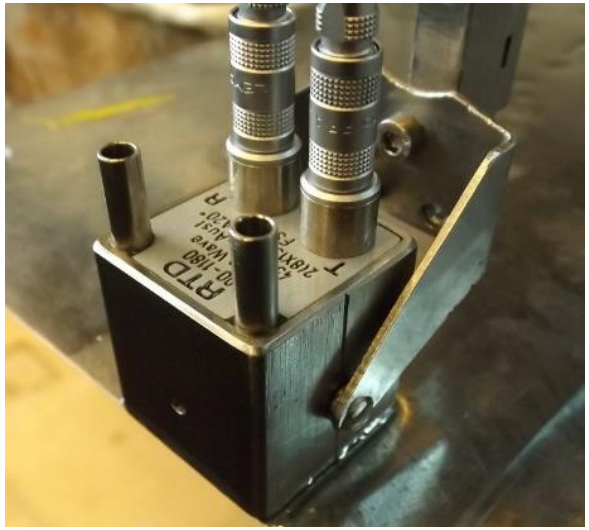
- Description of the configuration



- Carbon Steel Mock-up
- FBH, 3mm diameter
- Range of depths, from 5 to 150mm
- TRL 45° probe, 4MHz







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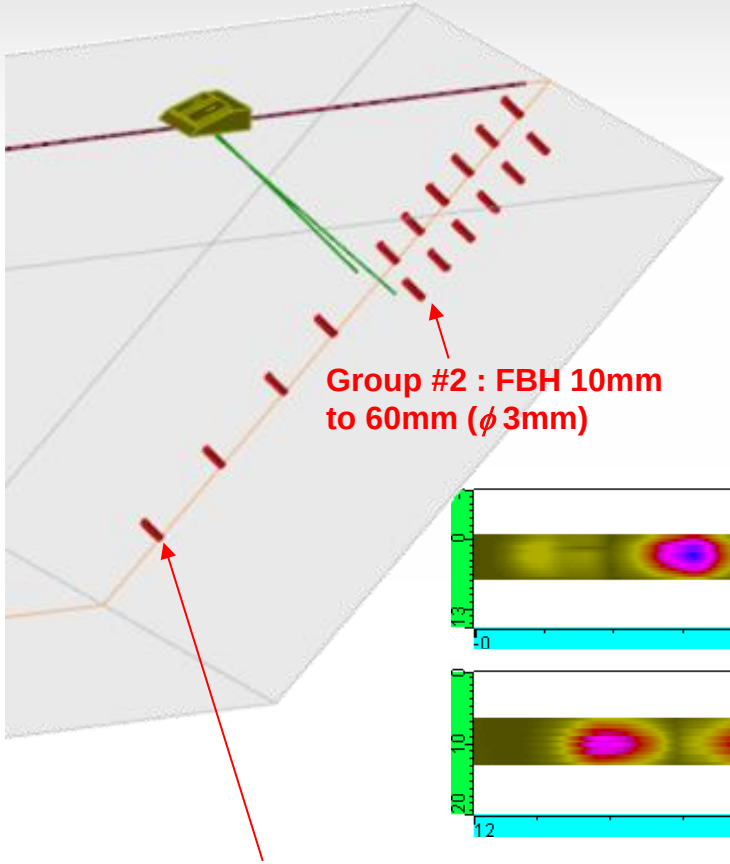
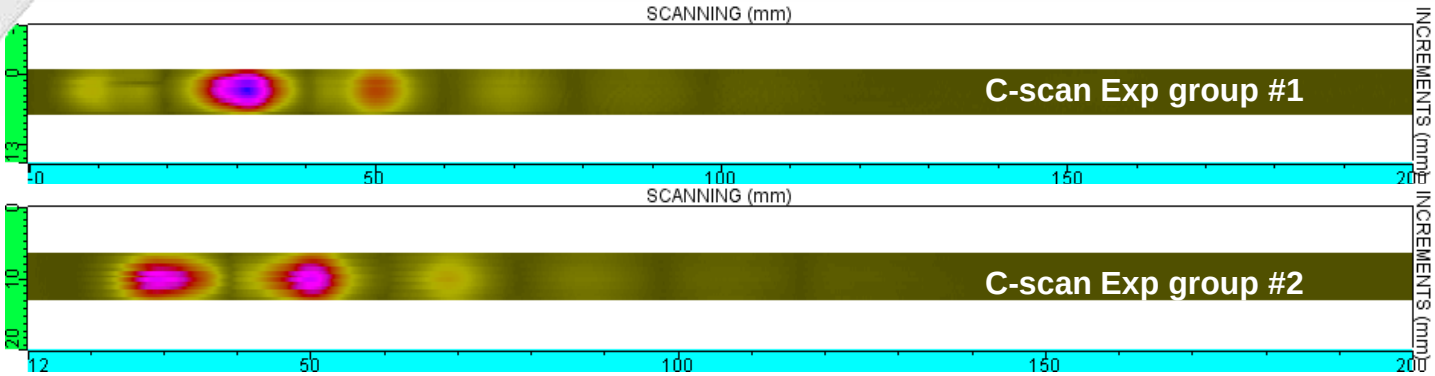
Dual Element Probe

- Acquisitions performed:



- Exemple of obtained Cscan
- FBH, 3mm diameter
- Range of depths, from 5 to 150mm

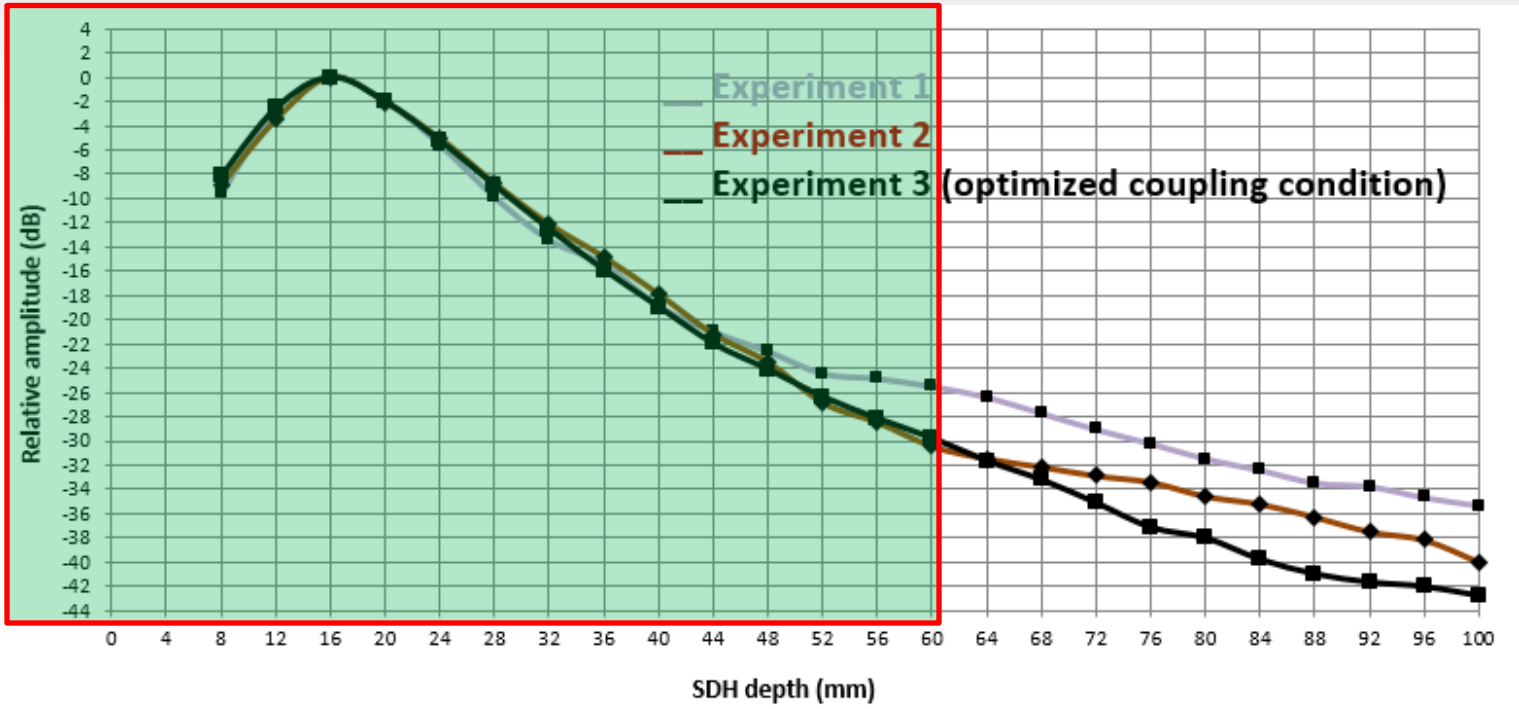


Dual Element Probe

- Acquisitions performed: Repeatability/Reproducibility
  - Contact and coupling conditions may change during mechanical scan (variation of adhesion, change of orientation,…)
  - Impact on reflector responses can be very strong
  - Necessity to optimize the mechanical holding device to ensure good coupling and reach a repeatability / reproducibility at +/-2 dB.

Dual Element Probe

- Acquisitions performed: Repeatability/Reproducibility



- Comparisons vs. simulation have been done until 60 mm depth (good reproducibility and action zone for this transducer)

Dual Element Probe

- Comparison simulation vs. measurements
  - To accurately model such transducer, necessary of good and accurate knowledge of input data.
  - Not easy to get with such Dual Element Probe (incidence angle, roof angle, crystal separation distance, etc.)
  - Without precise and clear data, RT or CT can be performed.
  - CIVA can be used to find out relevant parameters by inverse process
  - Principle: Variation of probe parameters in a relevant range, then computation of DAC curves, compared to experimental ones, and selection of the « best fit »

Dual Element Probe

- Comparison simulation vs. measurements
  - To accurately model such transducer, necessary of good and accurate knowledge of input data.
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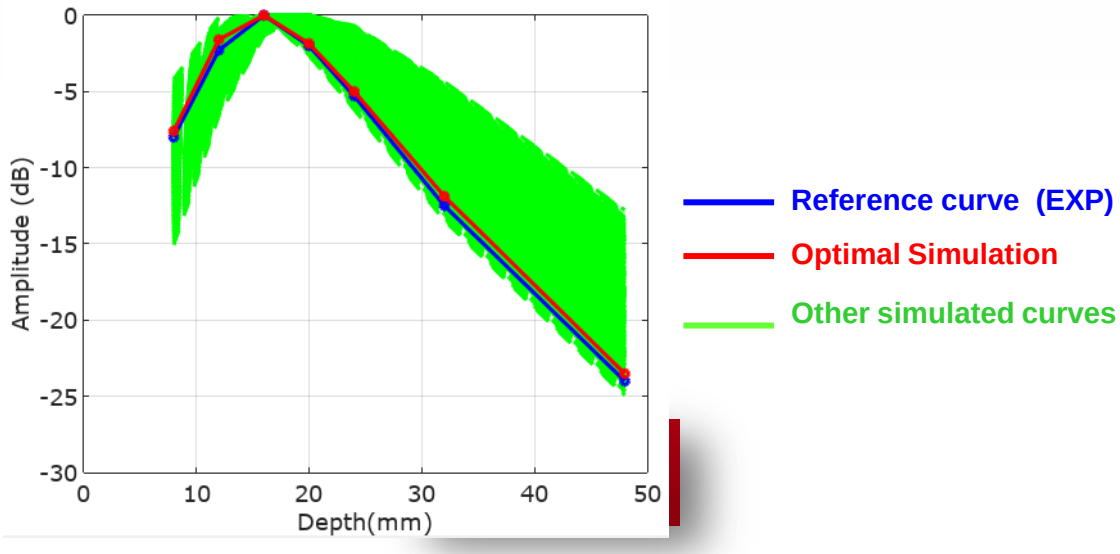
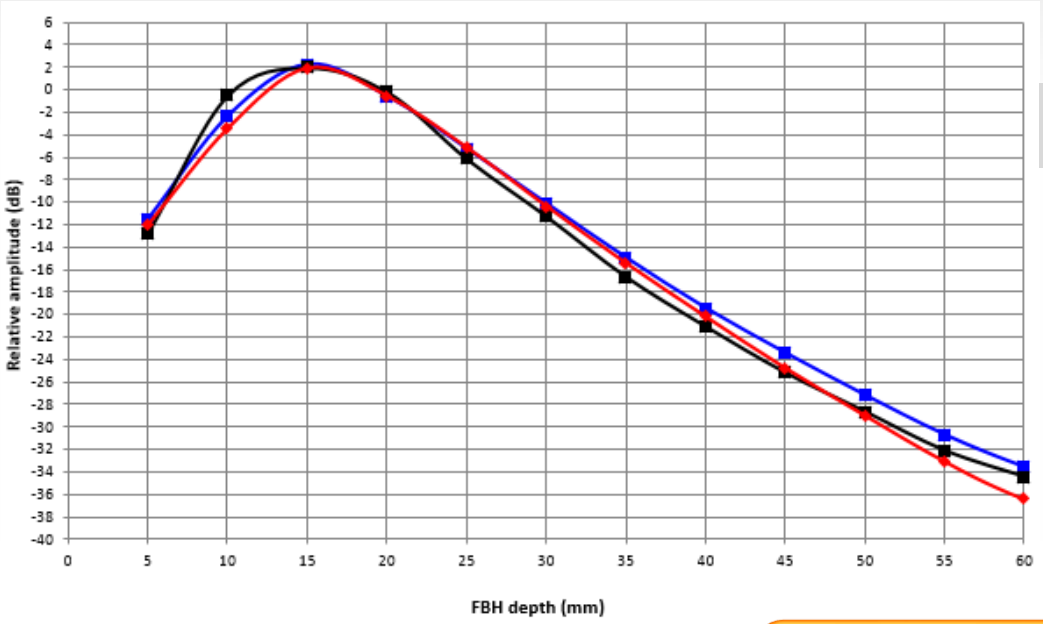


Dual Element Probe

- Comparison simulation vs. measurements



Reference: SDH Ø2mm
16mm depth

Experiment

Simulation « Kirchhoff » model

Simulation « Kirchhoff Full Beam » model (available since 2016)

- 2 CIVA models evaluated:
  - Kirchhoff (fast)
  - Kirchhoff – Full Beam: More accurate when « complex » fields

Both models give good prediction (within +/-2dB experimental uncertainty)

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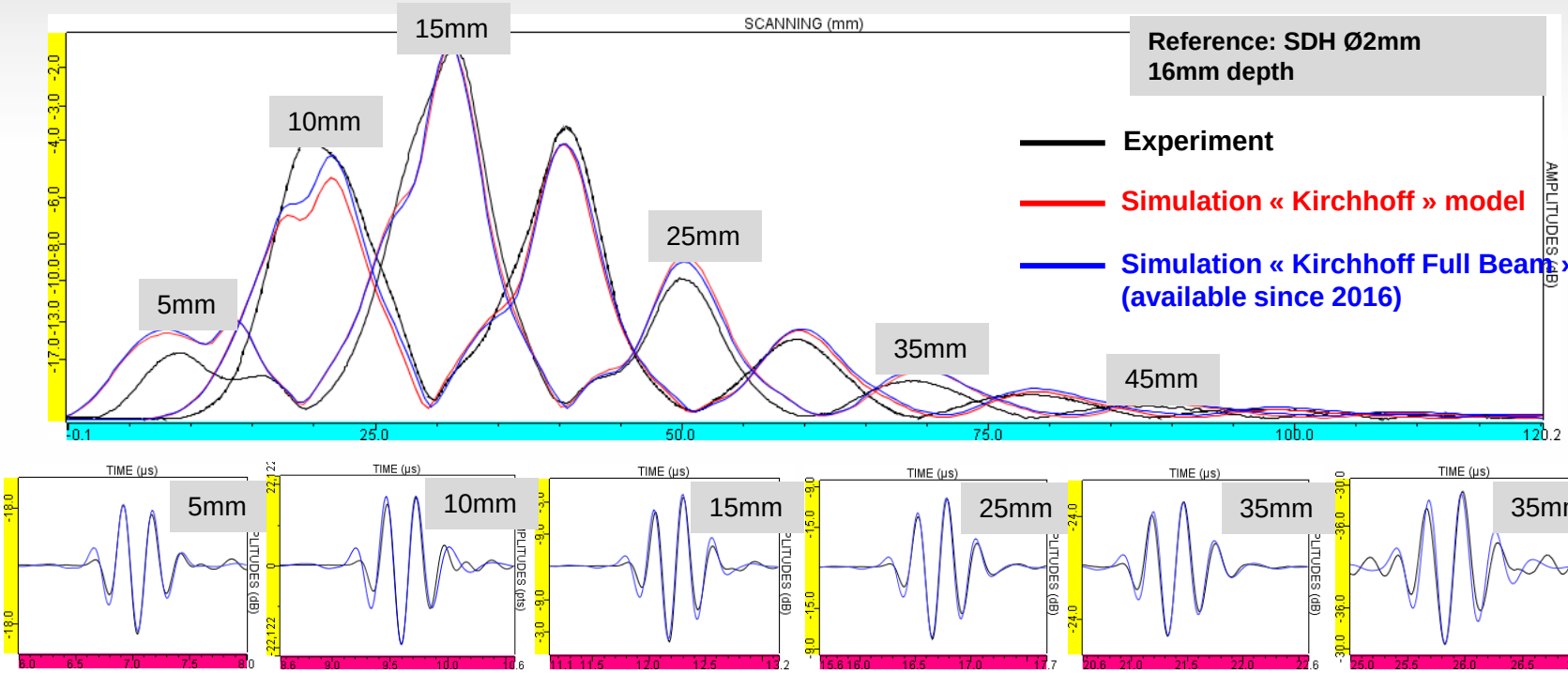
Dual Element Probe

- Comparison simulation vs. measurements



- Very good agreement simulations vs. Measurements both on waveforms and echodynamic curves

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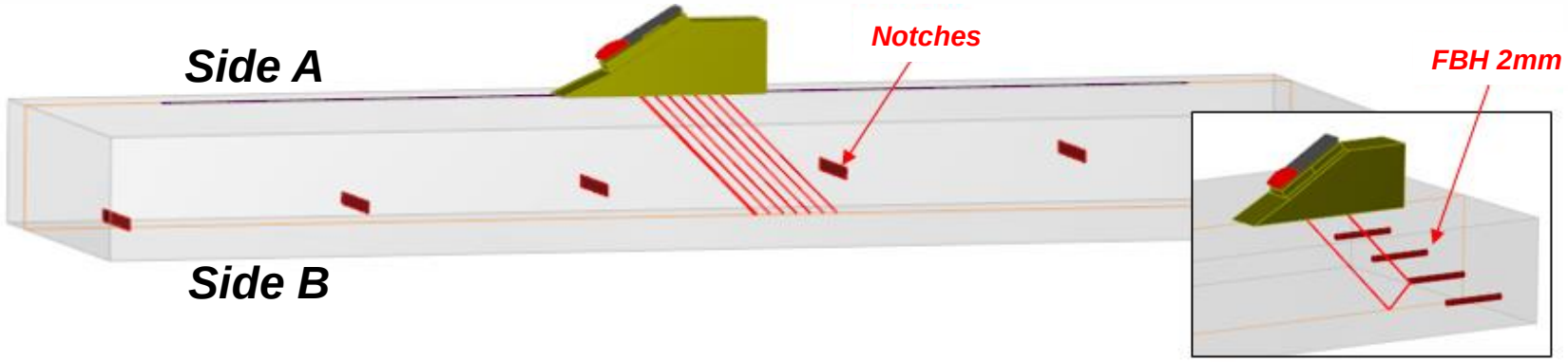
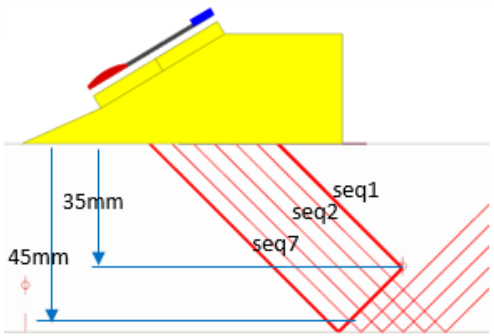
Configuration TANDEM

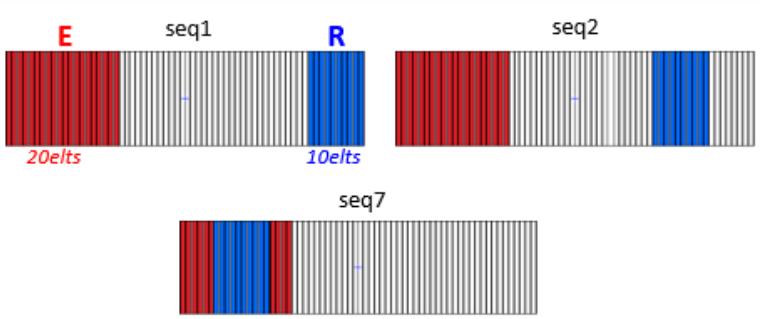
- Description of the configuration
  - Carbon Steel Mock-up , thickness 50mm
  - Notches (planar defects) 5mm height, at different depths (each 5mm)
  - Inspection from both sides A and B, notches depths from 7.5 to 47.5 mm
  - Calibration on FBH 2mm diameter



Configuration TANDEM

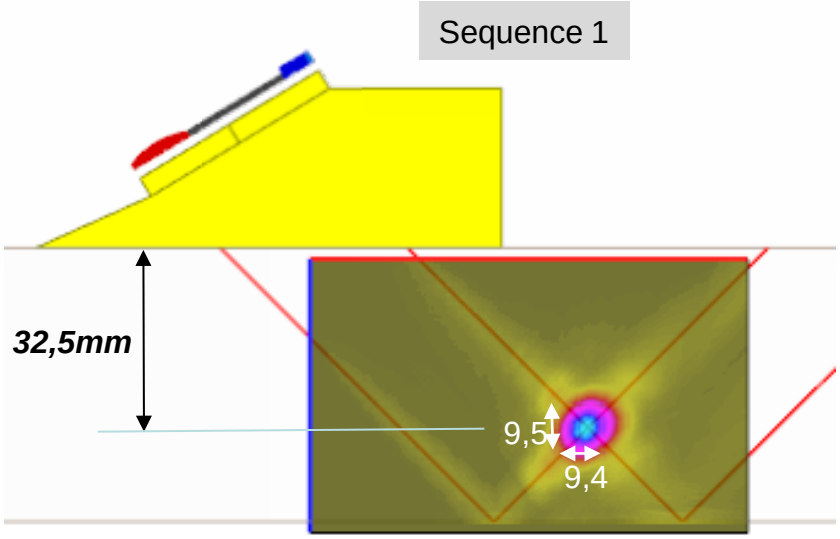
- Description of the configuration
  - Linear PA probe 64 elements, frequency 5MHz, on a wedge refracting shear waves 45°
    - Pitch & frequency given by probe manufacturer
    - Experimental characterization for the wedge (geometry, incidence angle, sound velocity)
    - Transmission pattern: 20 First elements of the array
    - Reception: Electronic scan, group of 10 elements, 7 sequences

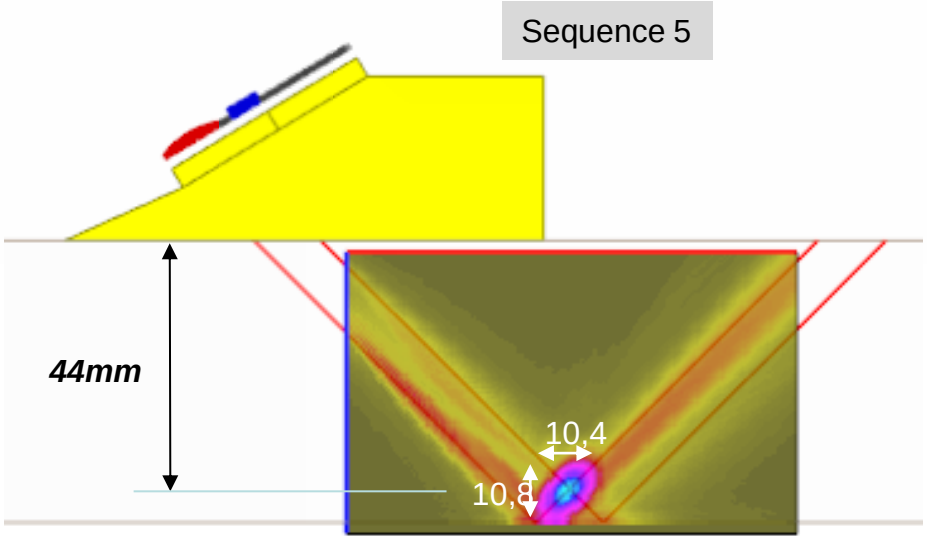




Configuration TANDEM

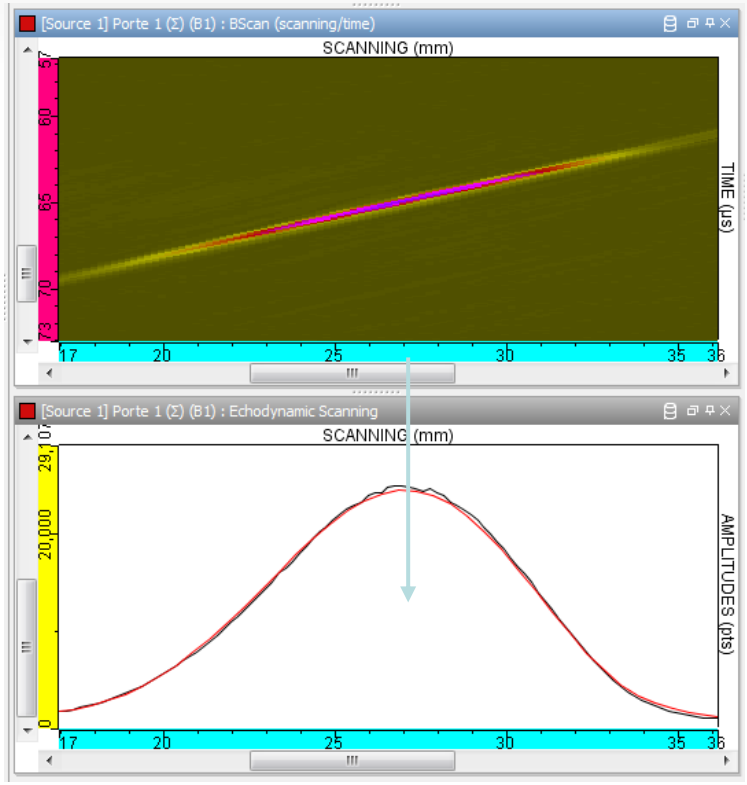
- Description of the configuration
  - Linear PA probe 64 elements, frequency 5MHz, on a wedge refracting shear waves 45°
    - Focusing S45 at 45mm depth in transmission
    - No delay law in reception

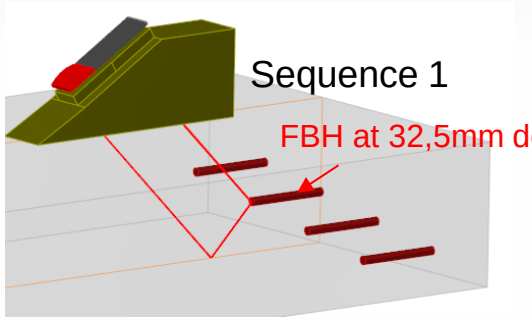


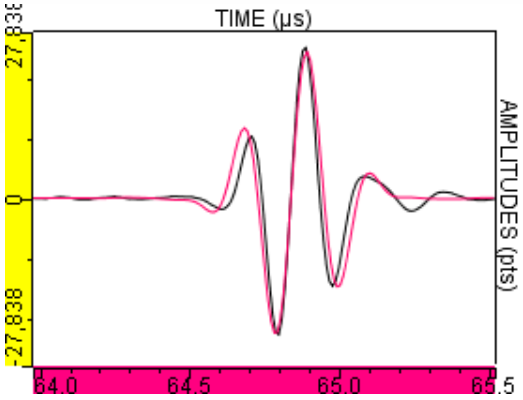


Configuration TANDEM

- Acquisitions performed:
  - Calibration: Sequence 1, FBH 32.5mm depth





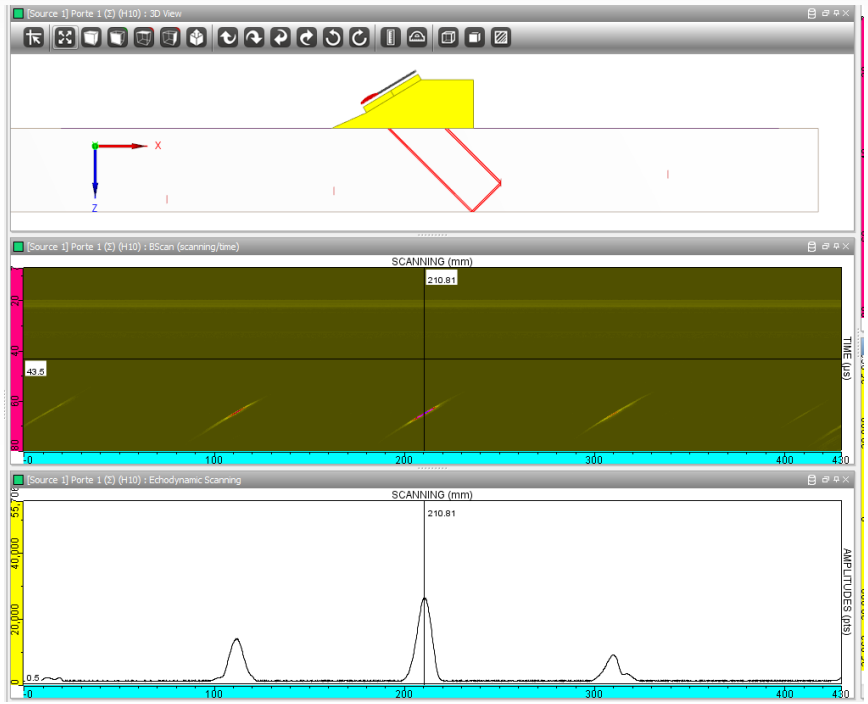


Configuration TANDEM

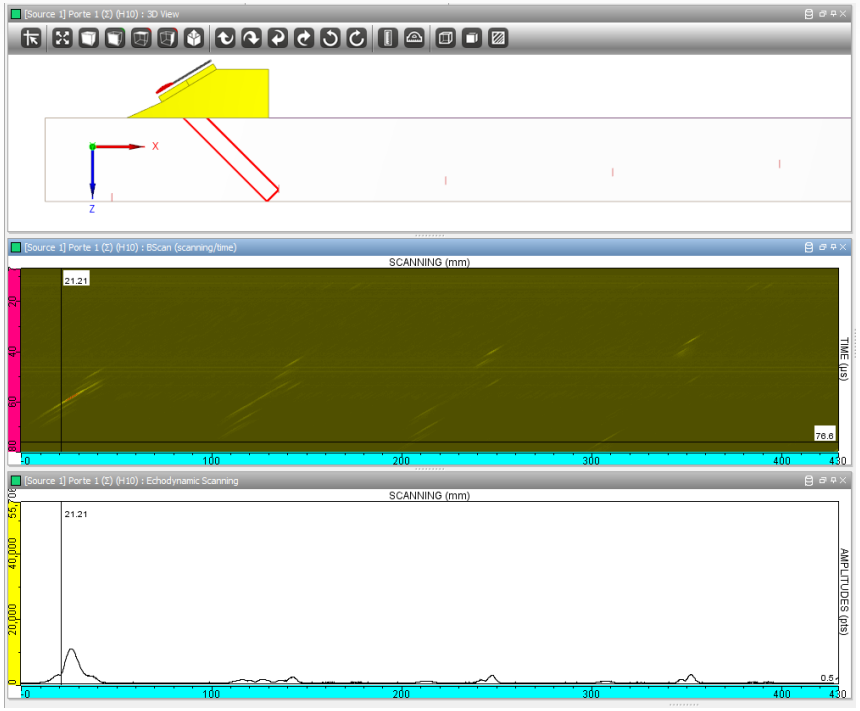
- Acquisitions performed

Reference Seq 1
FBH 32.5mm depth

Seq 1



Seq 7



Configuration TANDEM

- Acquisitions performed

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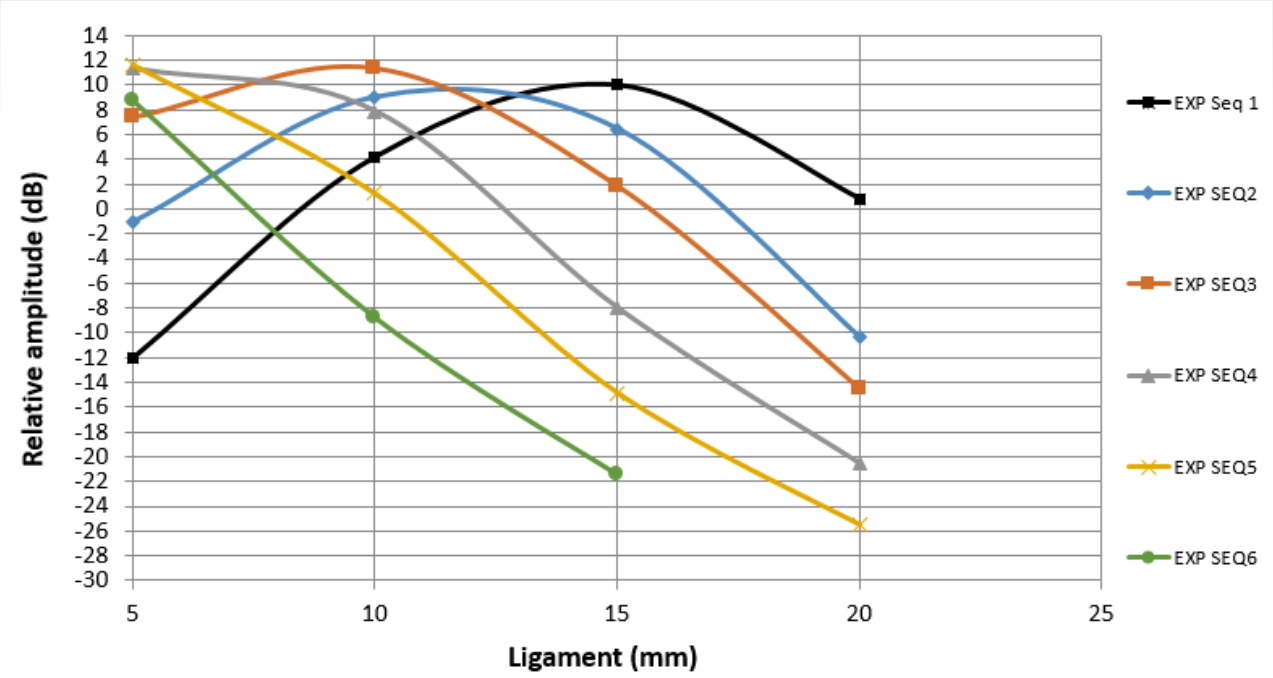

- **This graphs (defect response vs depth for all seq.) highlights advantages of Phased Array tandem: To be able to detect defects on a wide range of depths with pretty similar sensitivity, thanks to electronic scanning and multi-channels**

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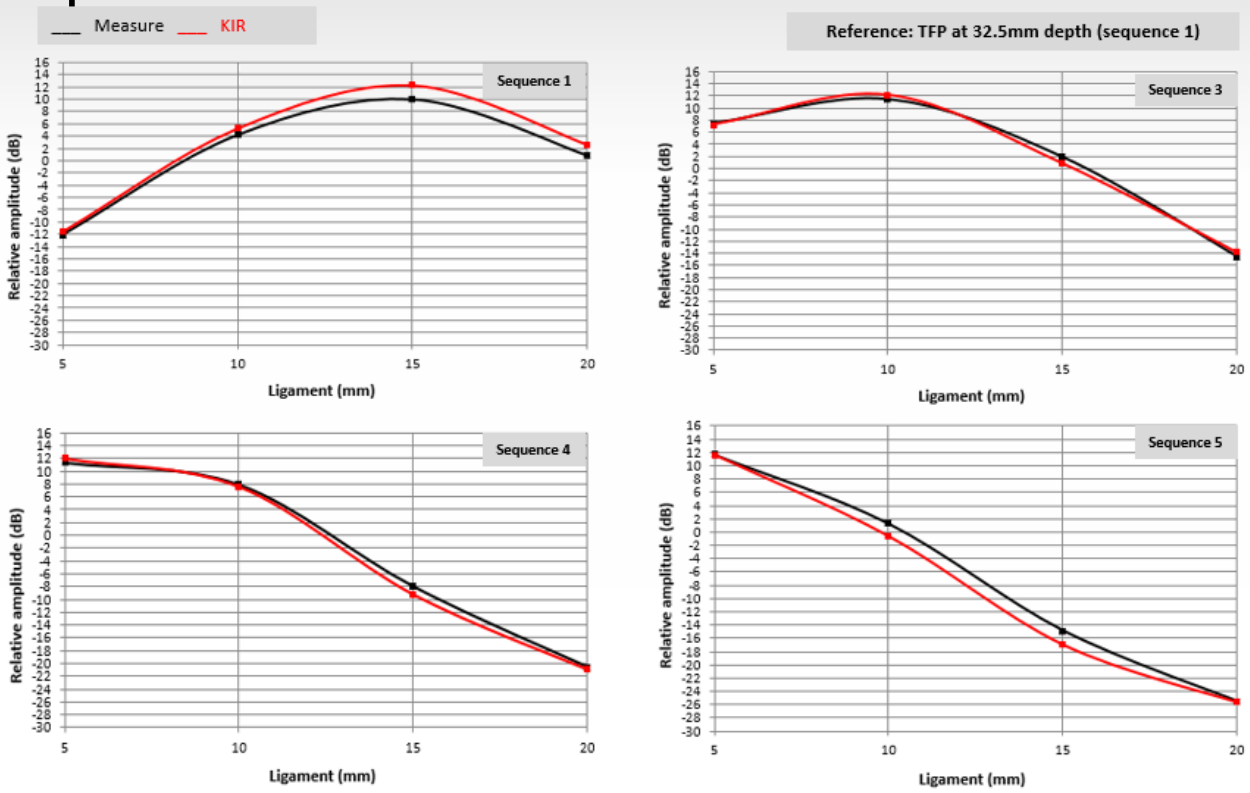
Configuration TANDEM

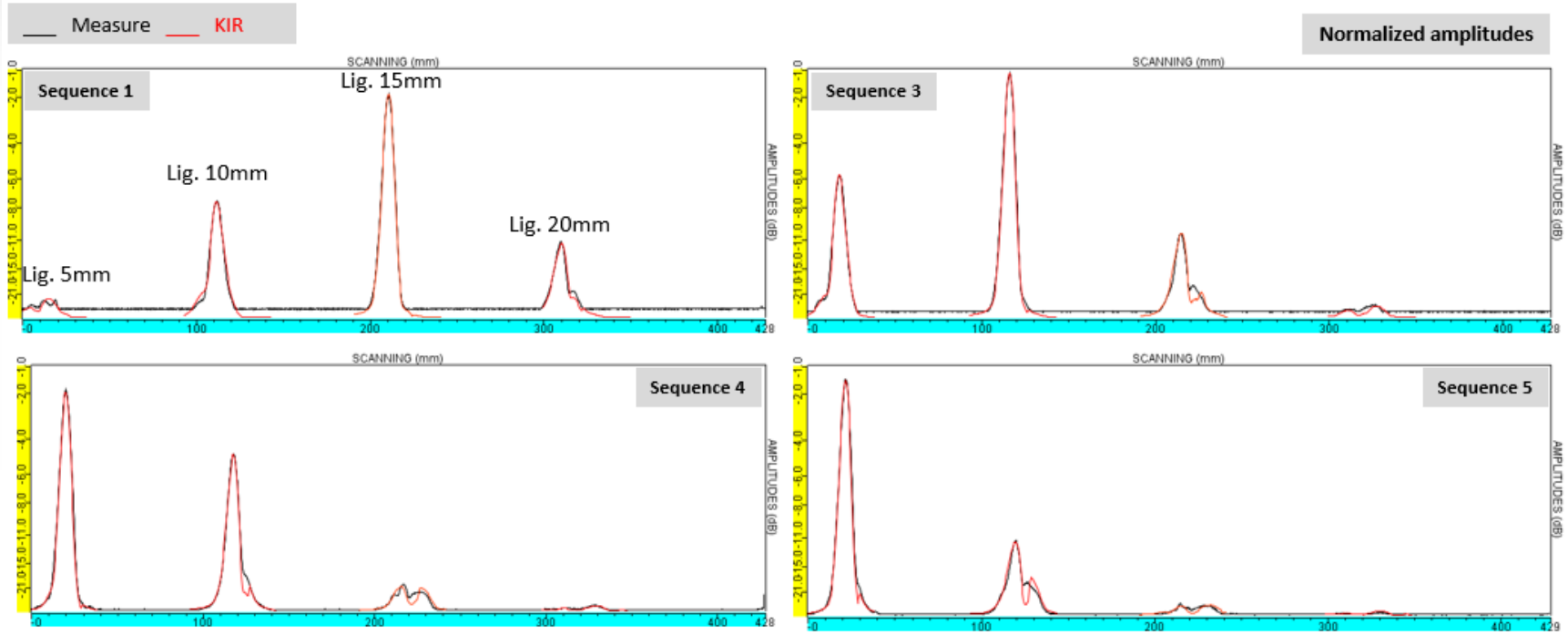
- Comparison simulation vs. measurements



- Very good agreement in amplitude, within +/-2dB difference

Configuration TANDEM

- Comparison simulation vs. measurements



- Very good agreement of echoes shape, from echodynamic curves

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Conclusion

- Comparisons simulations / experiments performed on separated T/R configurations

- In both cases, CIVA simulations validated with:
  - Very good quantitative prediction, within +/-2dB, about the experimental uncertainty
  - Very good qualitative prediction of echoes (A-Scan waveforms, echodynamic curves)

Conclusion

- Caution should be taken to perform such validation studies
- Particularly, the experimental uncertainty shall be evaluated. Repeatability/Reproducibility tests shall be performed
- More results of such experimental characterisation cases of CIVA models available on our website:

www.extende.com