New Possibilities of Simulation Tools for NDT and Applications

CIVA N·D·E 2016

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Outline

- Introduction
- Applications and new simulation capabilities in:
  - UT
  - ET
  - RT-CT
  - GWT
- Conclusion

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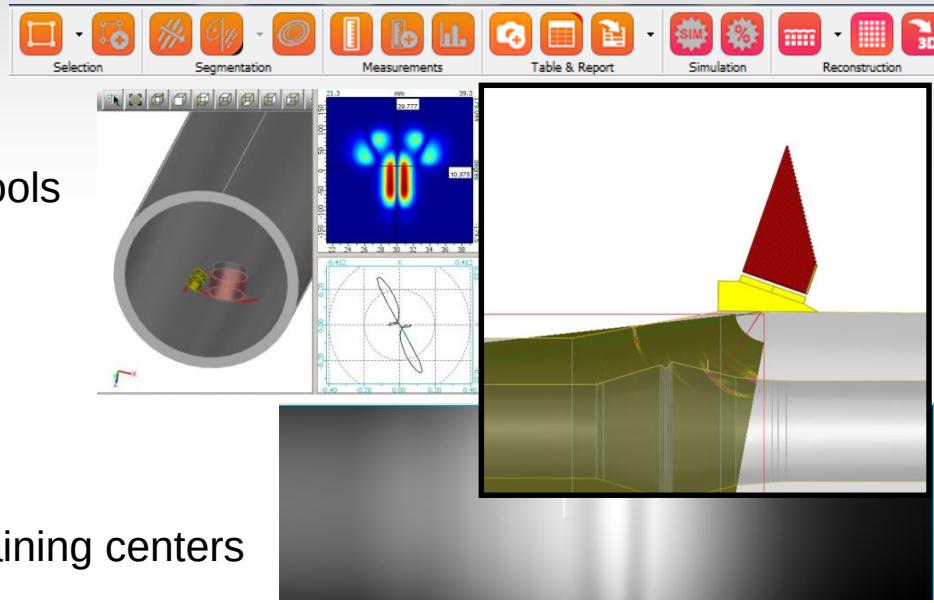
CIVA

- Leading industrial software dedicated to NDE Simulation & Analysis
  (more than 250 customers in 41 countries)
- Multi-techniques:
  - ✓ UT :
    - ○ Ultrasounds Testing modelling
    - ○ UT Acquisition Data Analysis tools
  - ✓ GWT: Guided Waves
  - ✓ ET : Eddy Current
  - ✓ RT : Radiography
  - ✓ CT: Computed Tomography
- CIVA Education: For universities and training centers
  - ○ Help to understand the physics behind NDT



- Mostly based on semi-analytical models (fast) and connection with numerical ones
- Developed by CEA (French Atomic Energy commission):
  25 years of experience with models & validations
- Distributed by EXTENDE

Context

- **Why Simulating a NDE process ?**
  - **To help for the design, optimization and implementation of the testing method:**
    - Better understanding, easy variation of parameters : a wide range of testing scenario to converge to the optimal solution
    - Better mastering of a technique and less iterations
    - Less mock-ups, less trials
    - Save time and money
  - **Expertise: Reproduce field results to understand a complex situation and confirm/disprove a diagnosis**
  - **To ease technical discussions** between all “players” (inspector, manufacturer, end user, etc.) and **convince**
  - To support performance demonstrations with study of influential parameters by simulation (and reduce mock-up tests) : Predict the worst case scenario
    An element of technical justification in qualification stage

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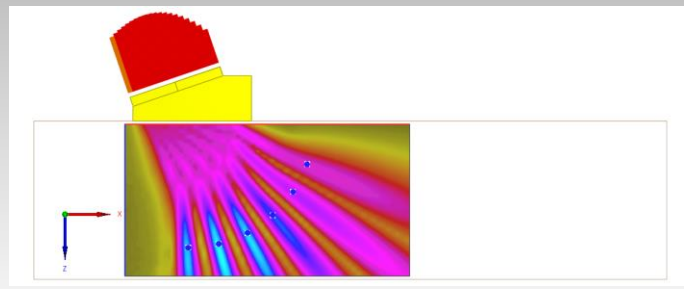
CIVA UT

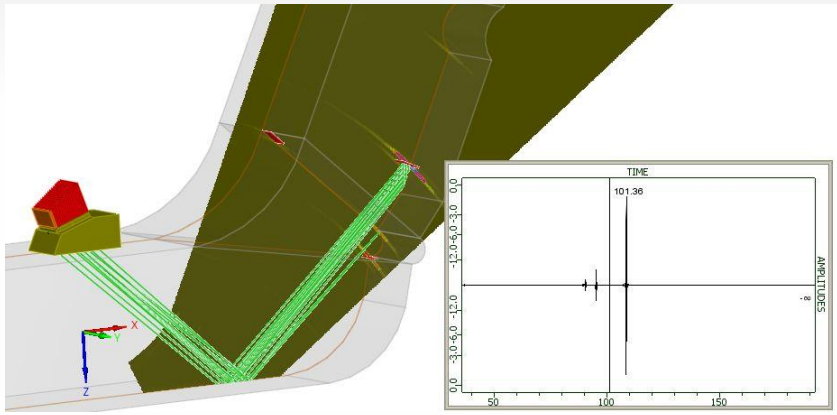
CIVA UT includes:

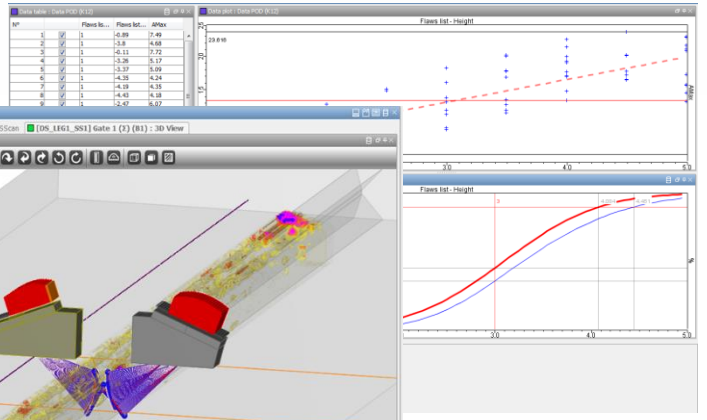
- Beam Calculation tool
- PA settings calculations (delay laws, etc.)
- Inspection Simulation tool (predict echoes)
- POD curves computation
- UT data analysis : M2M data files, Olympus data file, “PlugIn” available to import other data format

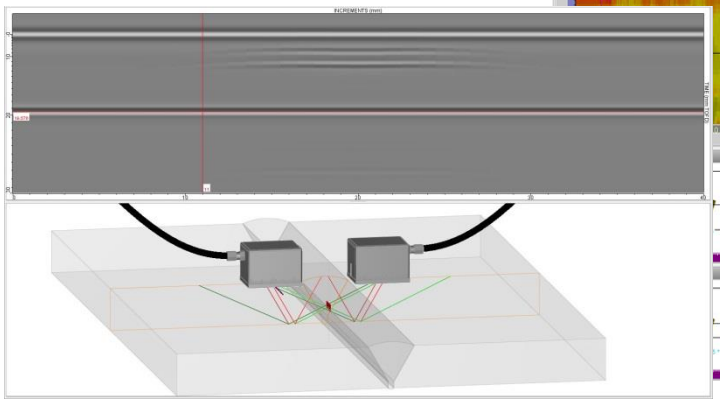
Techniques covered:

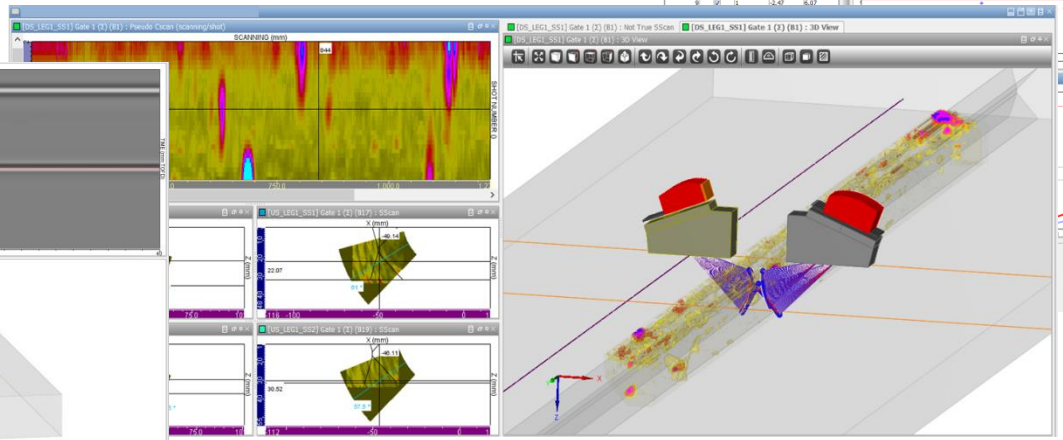
- Pulse-echo conventional UT
- Phased-Array
- Tandem
- TOFD







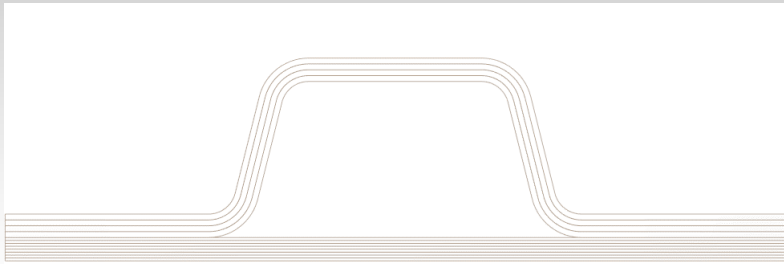


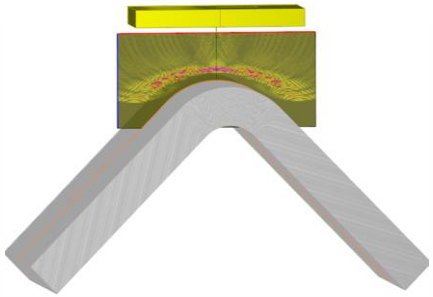


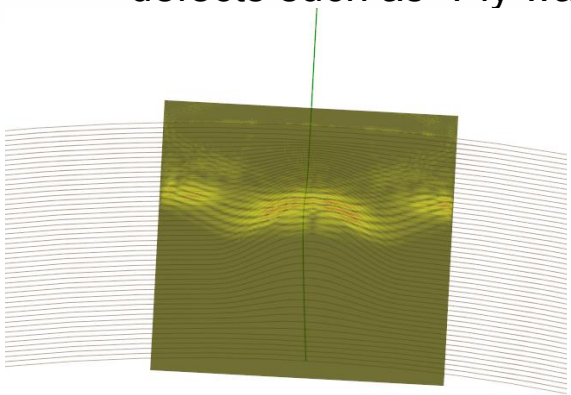
New capabilities for UT modelling

New Tools for composite structures simulation:

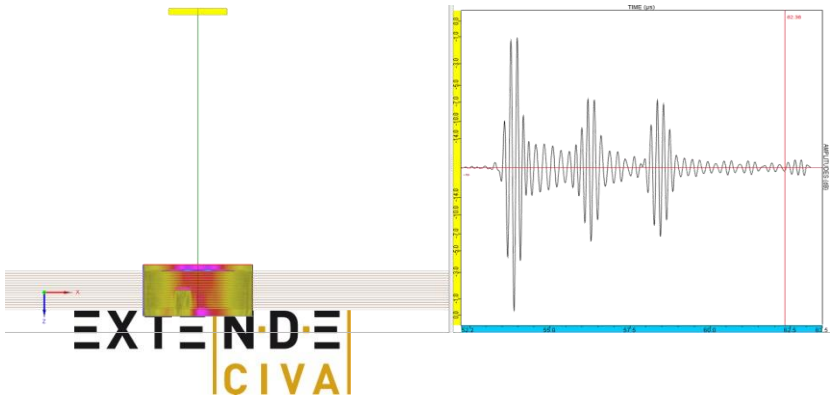
- Easy input structures such as:
  Flat panels, Cylindrical shapes,
  bended area, stiffener
- Can simulate delamination in flat or curved composites with semi-analytical models thanks to a **continuously variable** model
- Implemented SAUL algorithm for Phased-Array probes:
  Adaptive focal laws to optimize beam for complex shapes
- **Connection with a numerical tools FIDEL2D** from Airbus Group Innovation to account for additional phenomena (Inter-plies resonance, typical composite defects such as “Ply waviness”)





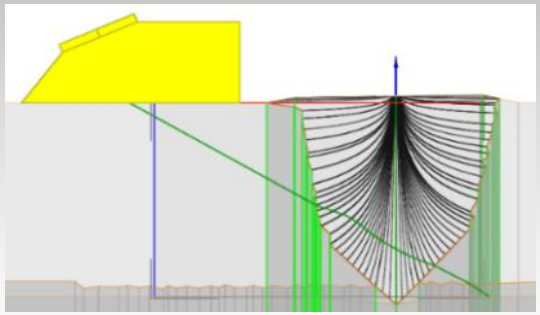


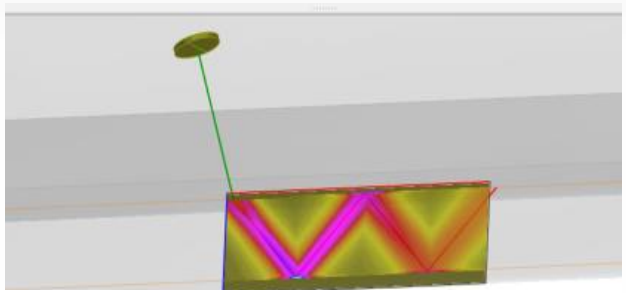
Snapshots/videos of beam/composite scattering

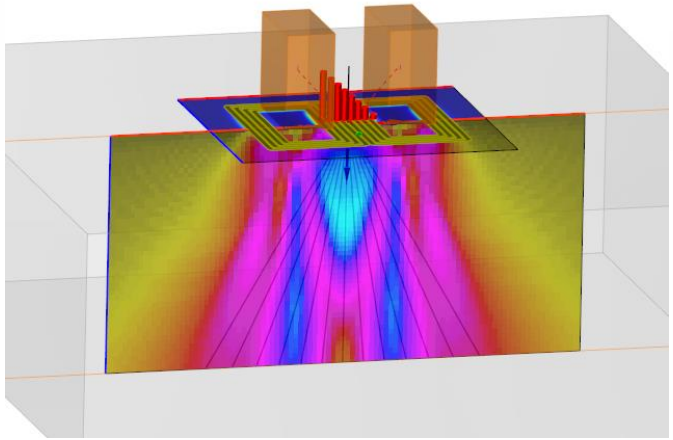


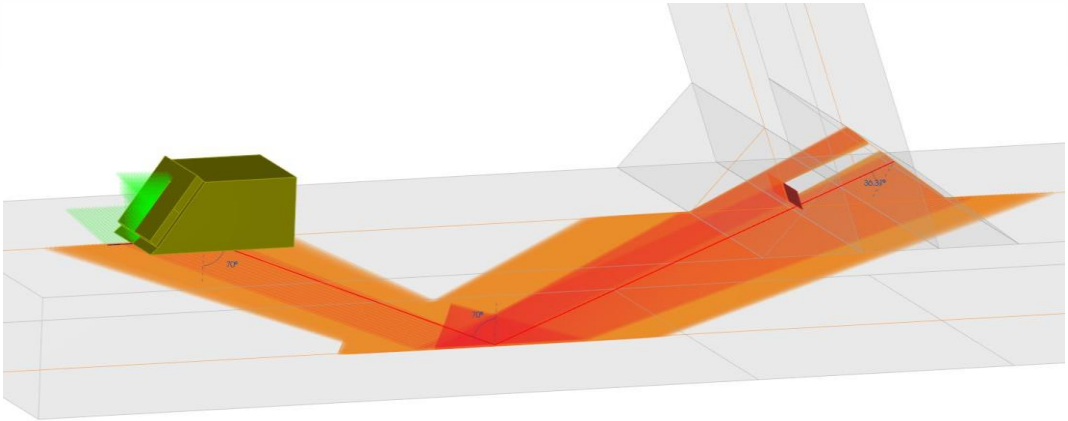
New capabilities for UT modelling

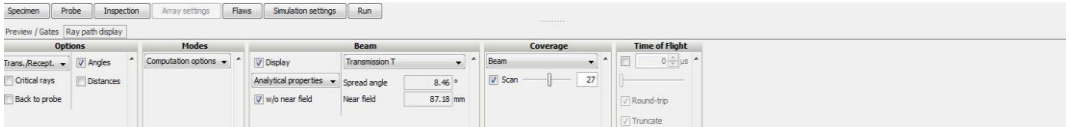
- **Some of the other new features:**
  - “Ogilvy” based continuously variable model to account for dendrite orientation change in **austenitic weld**
  - **Multi-skips** UT paths display in beam module
  - **EMAT Phased-Array** probes
  - New ray based **zone coverage tools**





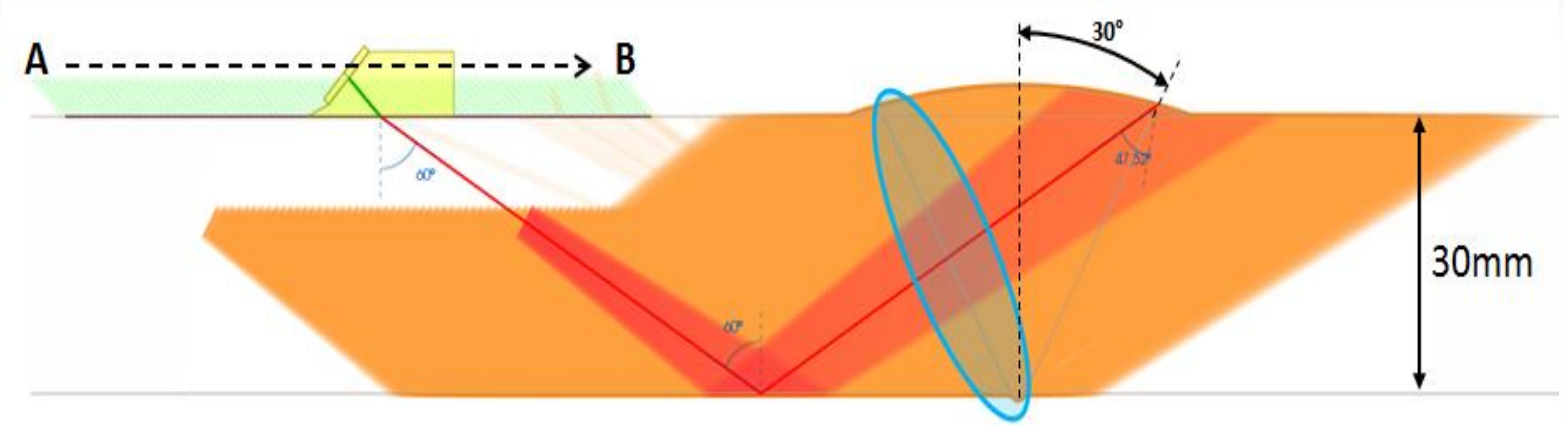






Application Example

- **Preparing a UT inspection scan plan with simulation**
  - **Quickly evaluate your scan plan with a zone coverage image:**
    - Based on ray tracing and real-time field simulation of beam aperture and main characteristics : Near field distance, incidence angles, spread angle, time of flight tracking, coverage on the full mechanical or electronic (PA) scan



  - **Fast and easy analysis…but a real prediction of detection sensitivity needs:**
    - Beam amplitude information
    - Influence of defect location, nature and orientation

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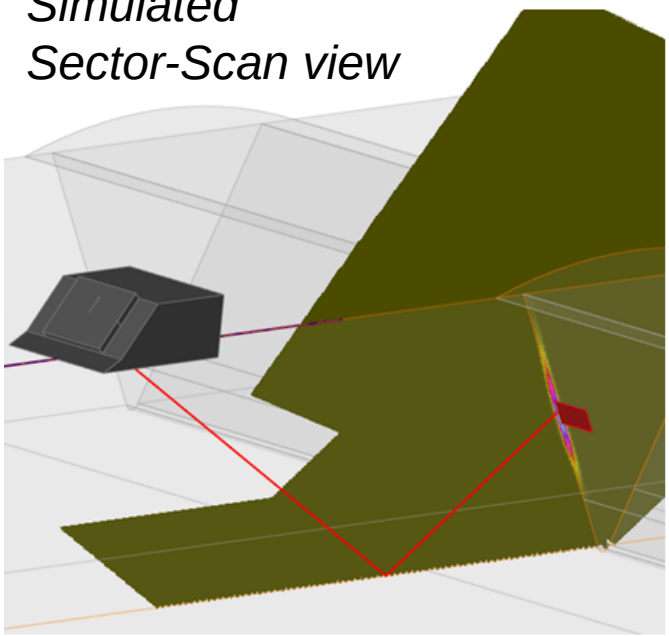
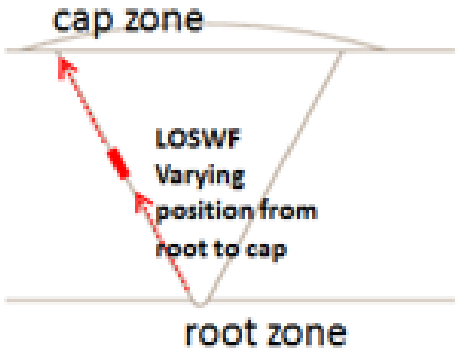
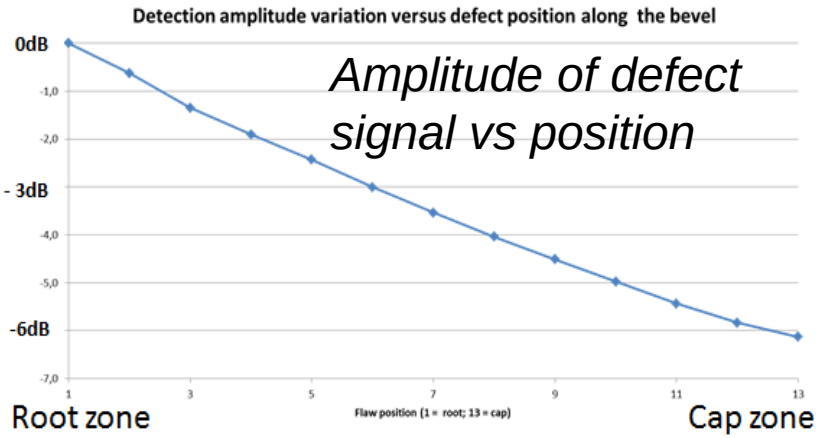
Application Example

- **Preparing a UT inspection (scan plan) with simulation**
  - **Inspection Simulation:**
    More quantitative analysis of LOSWF defect response
    - Case 1: Planar back wall : 6dB drop for defect response depending on its location (root or cap). Can be compensated by an adapted TCG

Simulated Sector-Scan view



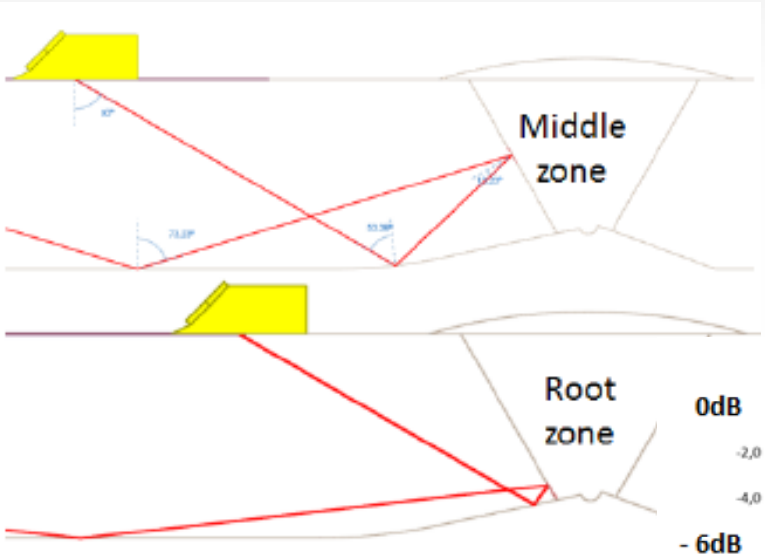




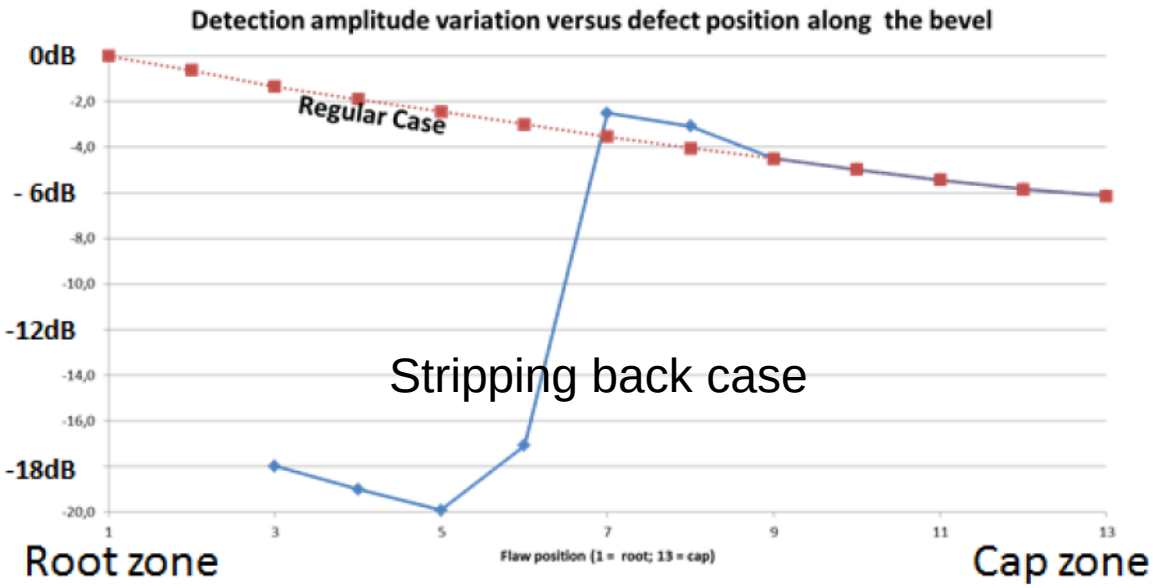
Amplitude of defect signal vs position

Application Example

- **Preparing a UT inspection (scan plan) with simulation**
  - **Additional Inspection Simulation for more quantitative analysis of the response of a Lack Of Side Wall Fusion defect**
    - Case 2: Irregular back wall with a stripping back



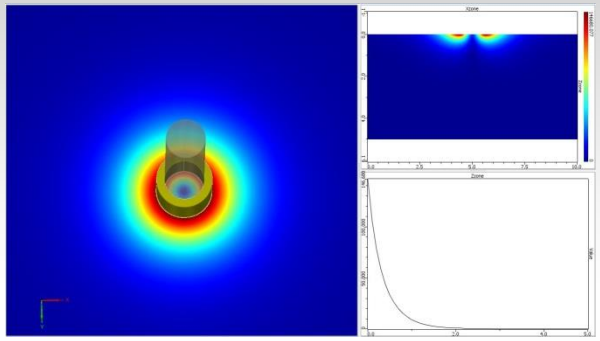
- Different beam path Transducer –Defect vs position
- Very strong sensitivity change for detection



CIVA ET

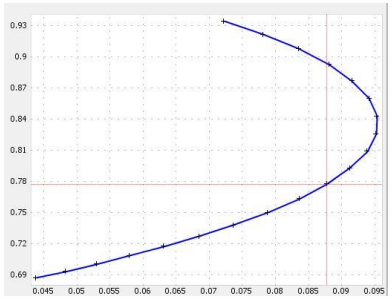
CIVA ET includes:

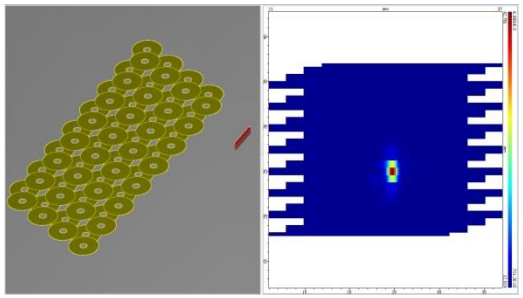
- Field Calculation tool
- Probe response
  (impedance diagram, lift-off signal)
- Inspection Simulation tool
- POD simulation

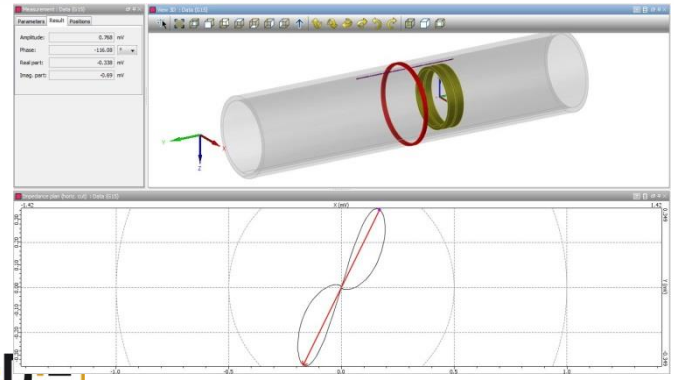


Techniques covered:

- Conventional ET
- Eddy Current Array
- Remote Field Technique

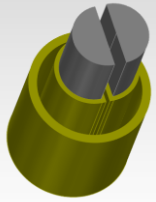


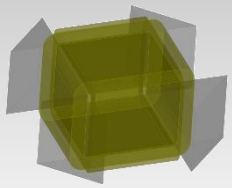




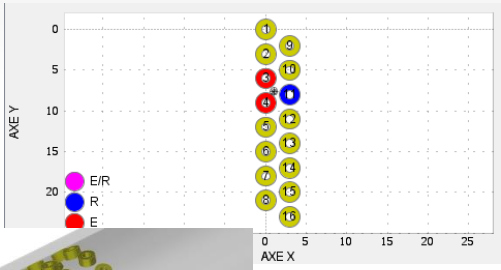
New capabilities for ET modelling

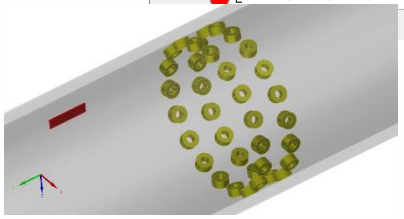
- **Some of the new capabilities:**
  - **New built-in complex probes with their ferrite cores:**
    - Orthogonal wound “+Point like” probe
    - “Rototest-like” probe



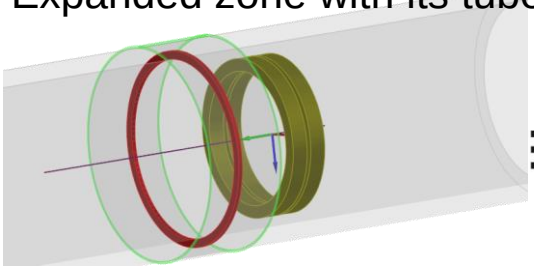


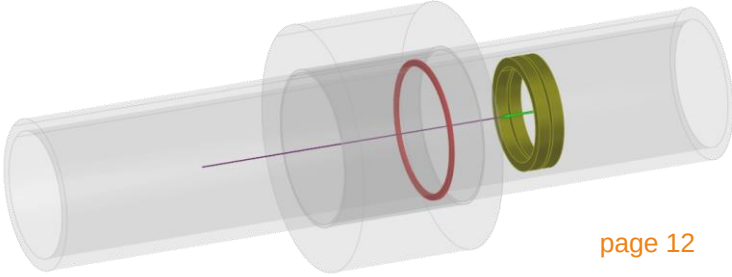
  - **Eddy current arrays :**
    - New editor to define ECA with their acquisition modes
    - “X-Probe” like built-in probe for tube inspection





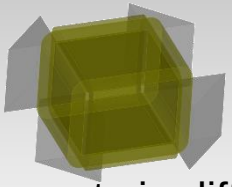
  - **2D CAD heterogeneous axisymmetric configurations:**
    - For instance possible to simulate typical steam generator inspection issues:
      - Influence of support plate
      - Influence of local parasitic deposit (copper, magnetite, etc.)
      - Expanded zone with its tube sheet



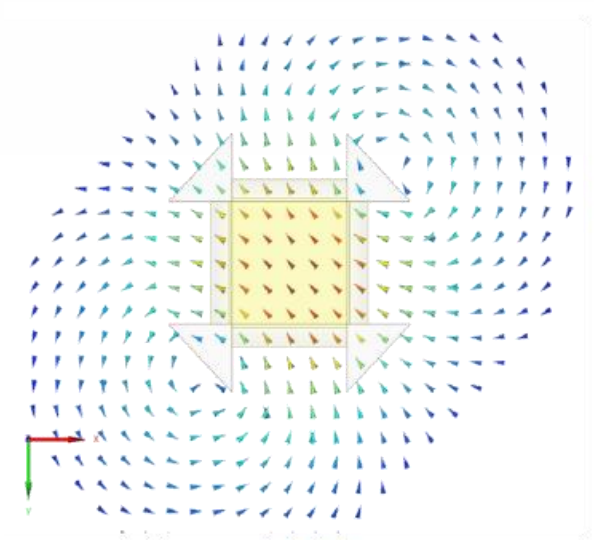


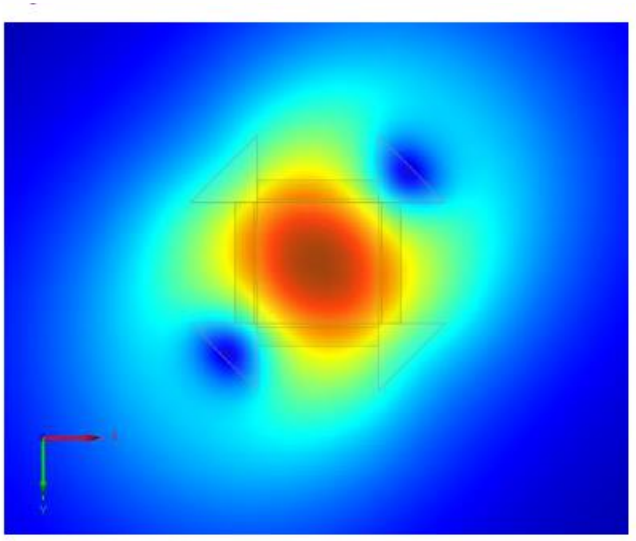
Application examples

- **Evaluate +Point Probe performances:**
  - **Orthogonal wound “+Point like” probe**
    - 2 interlaced coils with a “+” ferrite shape
    - Naturally less sensitive to lift-off noise as both elements in differential modes are closely linked



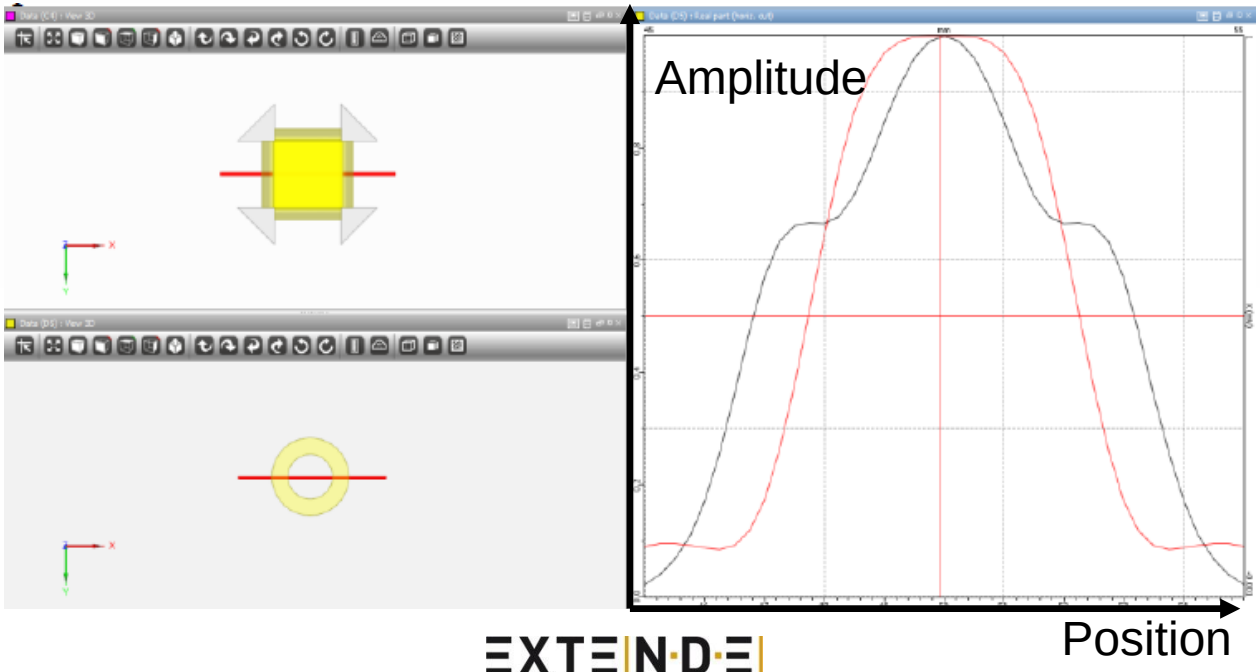
  - **Field Computation:**
    - Field concentration below probe centre, “no hole” at coil centre
    - Highly directional eddy currents direction: sensitive to longitudinal and transverse direction, less at 45°





Application examples

- **Evaluate +Point Probe performances:**
  - **Response of a 5mm longitudinal notch** (100kHz) **:**
    - Comparison with +Point and cylindrical coil with the same outer diameter (2.6mm)
    - Better resolution with the +Point sensor seen on the amplitude curve:
      - Estimated to 4.5mm (red curve) for the + Point
        instead of 6.5mm for the other coil (-6dB drop from the max)
      - More precise sizing



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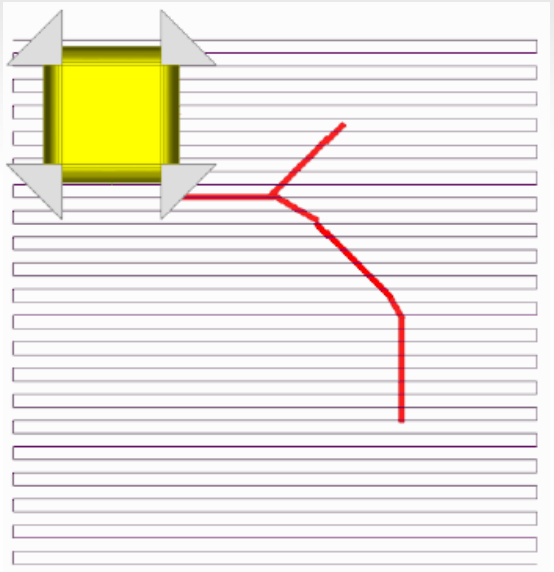
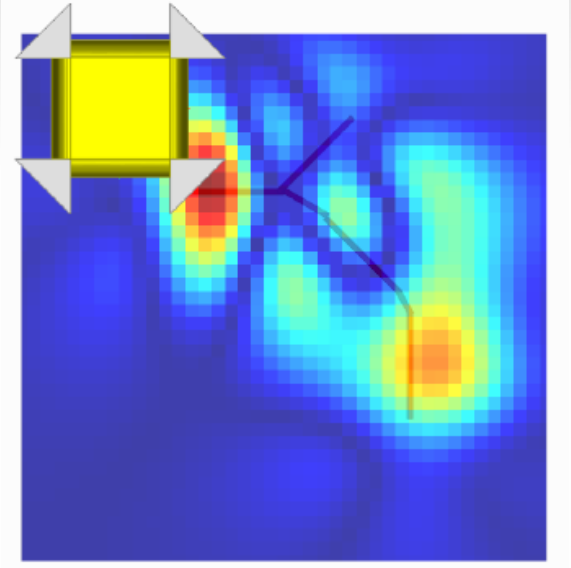
Application examples

- **Evaluate +Point Probe performances:**
  - **Raster scan over a complex flaw (“crater crack” like) :**
    - C-Scan imaging



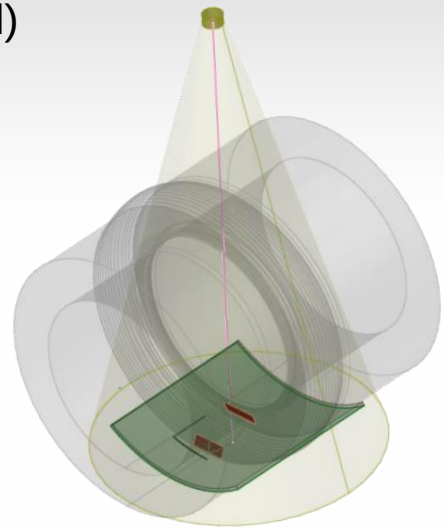


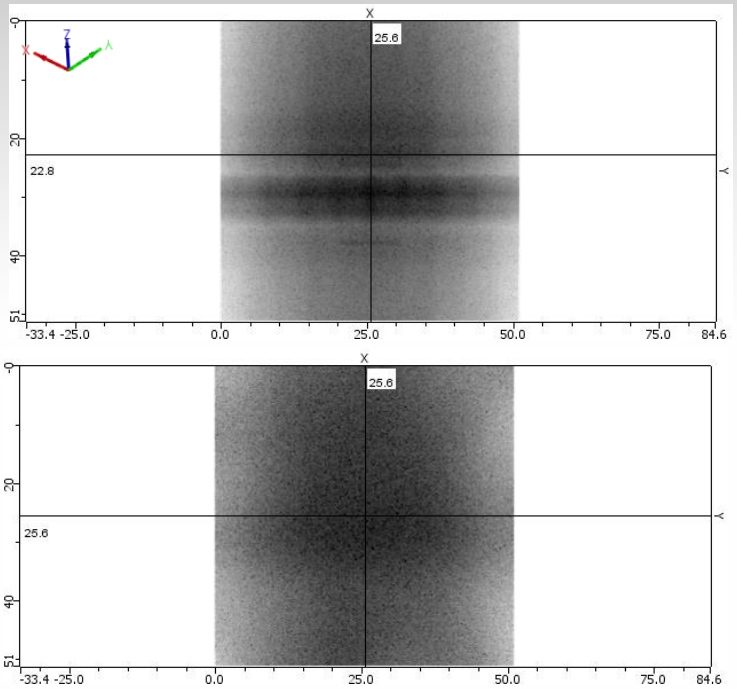
    - 0° and 90° flaw branches respond strongly, not the other ones
    - Other parts of the flaw generates signal at shifted positions
    - C-Scan image complex to interpret (several spots), not optimal resolution
    - Simulation can help predict or interpret such result

CIVA RT-CT

CIVA RT-CT includes:

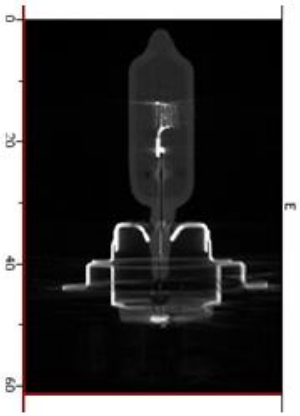
- Direct radiation (Beer-Lambert model)
- Scattered radiation (Monte-Carlo method)
- POD Computation





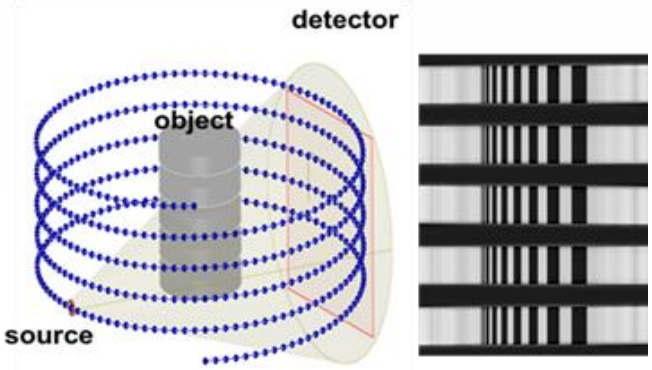
Techniques covered:

- X-Ray
- Gamma-Ray
- Tomographic reconstruction (FDK, PixTV algo)



New capabilities for RT-CT

- **Some of the new capabilities:**
  - **High energy sources:**
    - Linear accelerator
    - Betatrons
  - **Account for additional parasitic radiation due to contaminated specimen**
  - **Possibility to define multiple filters above/below the detector**
  - **Computed Tomography:**
    - Helical scanning to avoid artifacts observed on long components with circular scanning



See publication session 3.G.2 (RT modeling for NDT: Recent and future developments in the CIVA RT/CT module)

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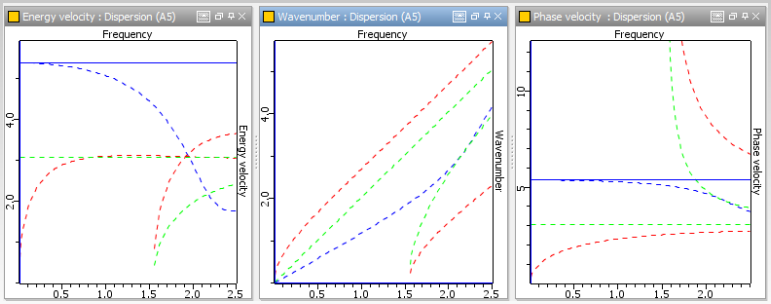
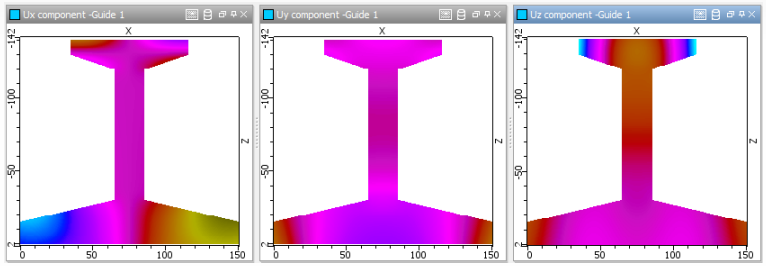
CIVA GWT

CIVA GWT includes:

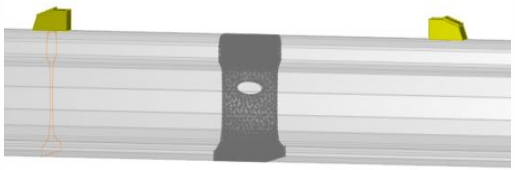
- Dispersion curves computation
- Field computation (displacement &, constrains in the cross section)
- Inspection Simulation tool

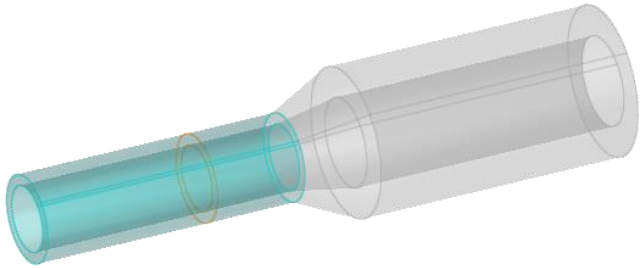


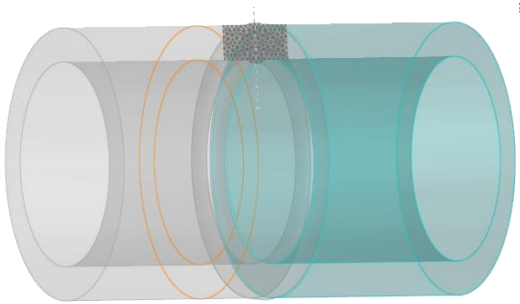


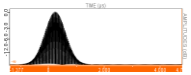
Covers:

- Various specimen geometries: Planar, tubular, weld
- And 2D CAD section (new: includes 3D FEM coupling)
- PZT or EMAT probes
- Single element or Phased-Array









CONCLUSION

- Benefits: Improve cost-efficiency of NDT at different stages of the process
  - ✓ Design and qualification of inspection methods
  - ✓ Preparation of inspection
  - ✓ Expertise
  - ✓ Training
- CIVA 2016: Numerous new capabilities in UT, ET, RT,CT and GWT
- A lot of potential applications
- Come to visit our booth #B120

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