C⦾teq

12ª Conferência sobre Tecnologia de Equipamentos

18 a 21 de junho de 2013

Enotel Resort & SPA
Porto de Galinhas - PE

New Applications of the NDT Simulation Platform CIVA 11
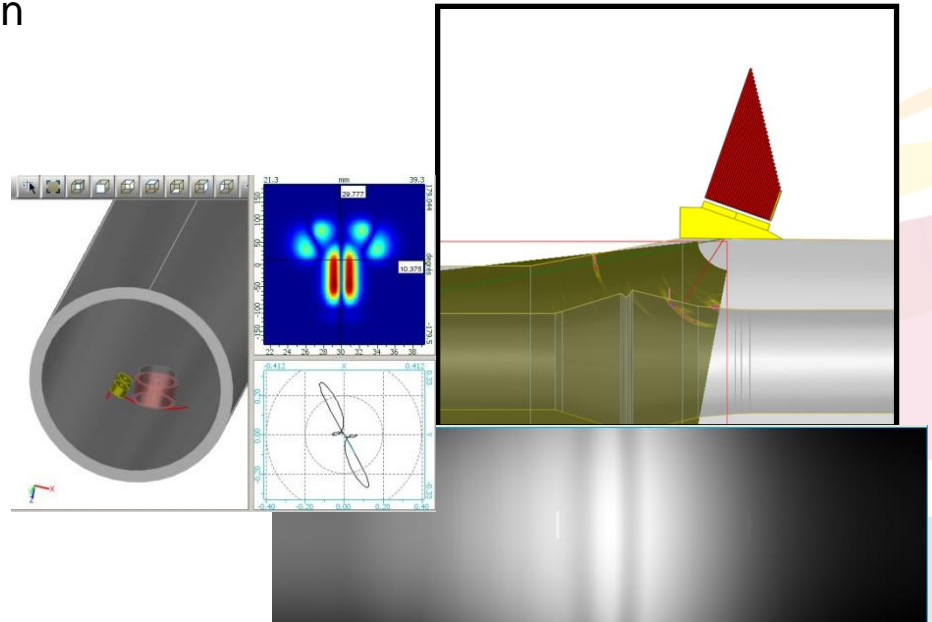
CIVA
N·D·E | 11

Contents

- Introduction
- CIVA UT
  - ✓ Capabilities
  - ✓ New features in CIVA 11
  - ✓ Applications
- CIVA ET
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- CIVA RT
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CIVA

- Software dedicated to NDE simulation

- Multi-techniques:

  - ✓ UT : Ultrasounds

  - ✓ GWT: Guided Waves

  - ✓ ET : Eddy Current

  - ✓ RT : Radiography

  - ✓ CT: Computed Tomography

  - ✓ Analysis tools

- Developped by CEA
  (French Atomic Energy commission: Research center)

  - ✓ R&D NDT department: >100 people

  - ✓ Development & validation of CIVA: 30 people

- Based mostly on semi-analytical models (fast calculation times)

- Distributed by EXTENDE since 2010

- A users community with more than 200 companies in 37 countries

EXTENDE

- CIVA Distribution

- Technical support

- Training courses

- Consulting

- Involved in collaborative R&D projects

Benefits of modeling in NDT

- Help for methods and probes design:
  - ✓ Time and cost savings: less prototypes
  - ✓ Improve performances and firm up choices
  - ✓ Help with introducing new innovations
  - ✓ Check controllability : Help in designing components

- Expertise:
  - ✓ Comparison between acquisitions and simulation
  - ✓ Better understanding of physical phenomena
  - ✓ Support for the detection / characterization

- Support qualification documentation (parametric studies)

- Technical and visual tool to share knowledge:
  - ✓ Illustrate to convince (bid proposal)
  - ✓ Explain to colleagues, suppliers, customers, etc.
  - ✓ Train operators or students

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- CIVA RT
  - ✓ Capabilities
  - ✓ New features in CIVA 11
 - ✓ Applications

CIVA UT

- CIVA UT includes:
  - ✓ Beam Calculation tool
  - ✓ Inspection Simulation tool
  - ✓ Phased-array settings calculations (delay laws, etc.)
  - ✓ POD simulation

- Techniques covered:
  - ✓ Pulse-echo conventional UT
  - ✓ Phased-Array
  - ✓ Tandem
  - ✓ TOFD
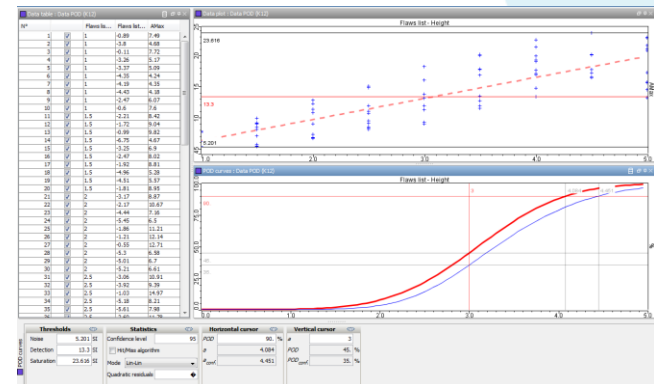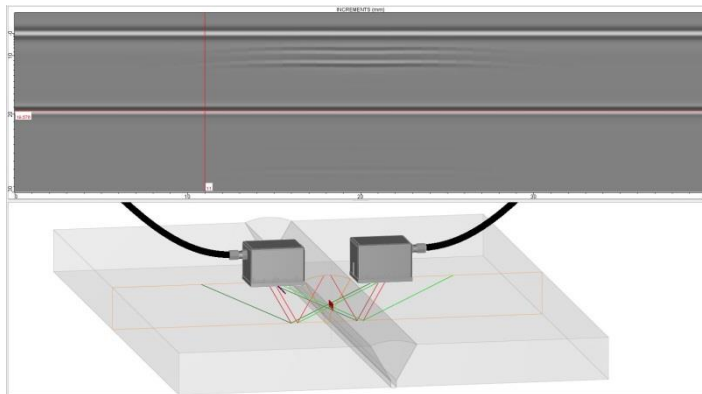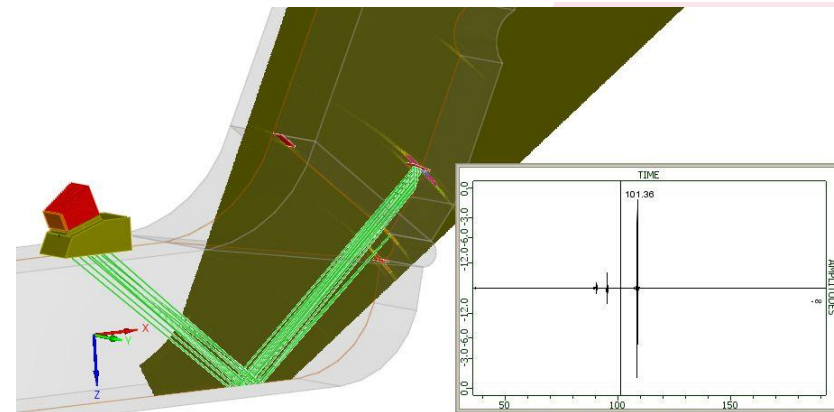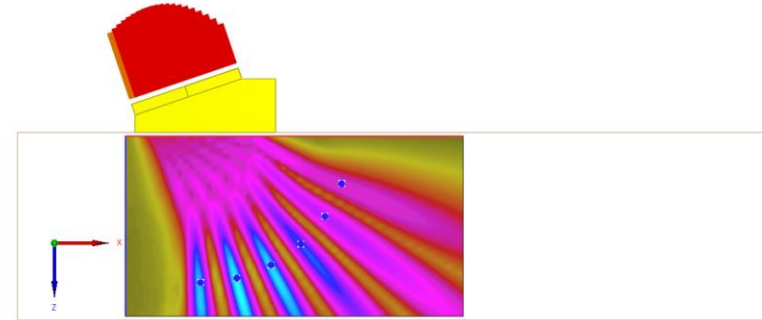
Main new features in CIVA11

- **3D CAD heterogeneous specimens:**
  - ✓ Complex geometries
  - ✓ Assembled structures
  - ✓ Simulation with several solids
  - ✓ Welds
  - ✓ Cladding
  - ✓ Change of acoustic properties due to heat-treatment, etc.
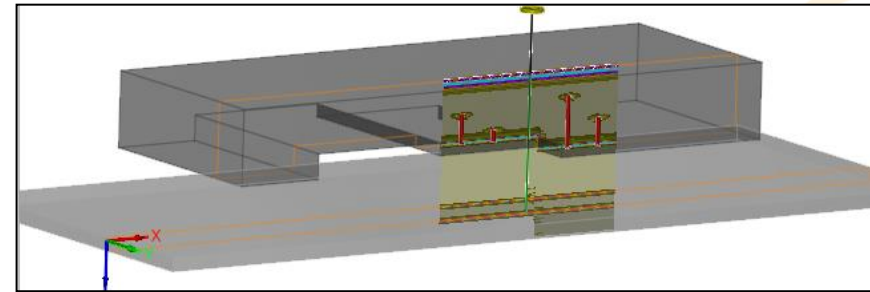
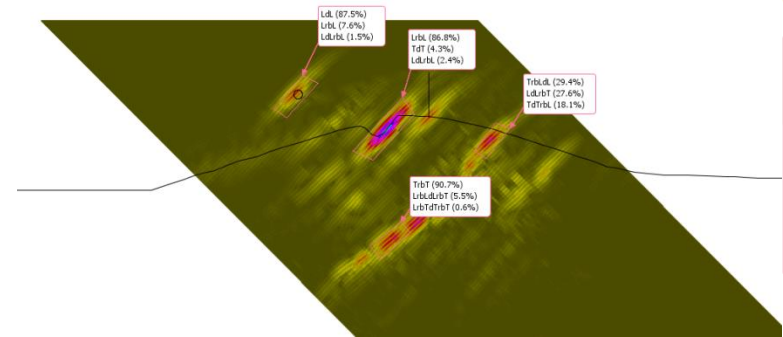- **Templates of various weld profiles defined according standards**
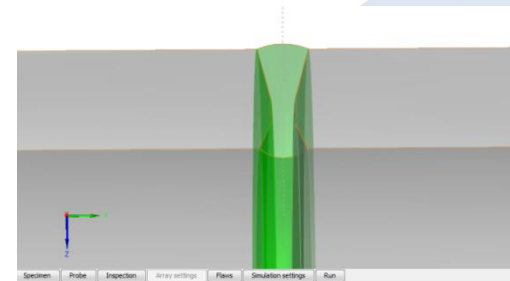
- **Polycristalline materials**
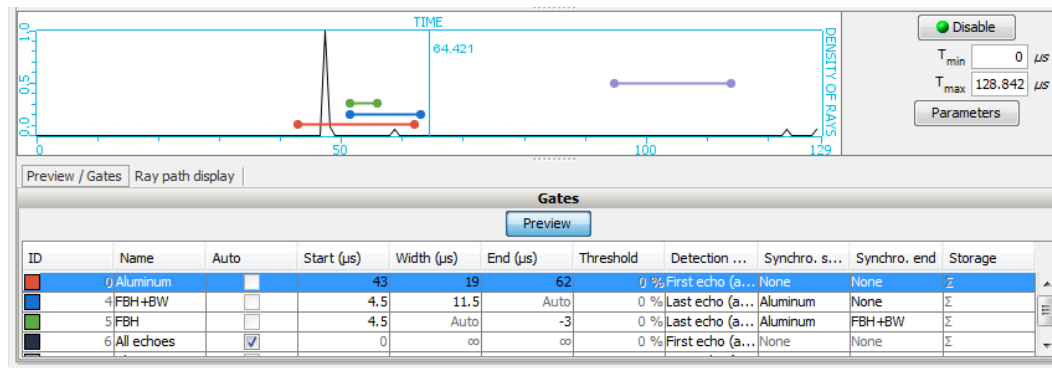 - ✓ Account for structural noise & attenuation vs grain size

Main new features in CIVA11

- Custom Phased-Array probes
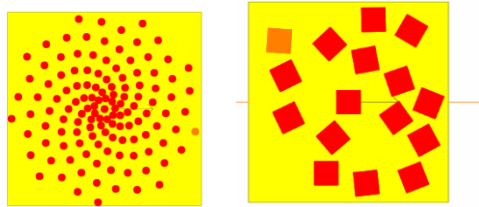
- Modes automatic identification


- Acquisition gates definition

- Compatible with Omniscan® data files for analysis and signal processing in CIVA

Applications (1/2)

- Acquisition gates can be tested by simulation:
  - ✓ Defined versus time of flight
  - ✓ Defined versus other signals (synchronized gates)
- Applications: Step wedge block (carbon steel) with FBH
  - ✓ Inspected with a dual element 4MHz
  - ✓ Results without gate:
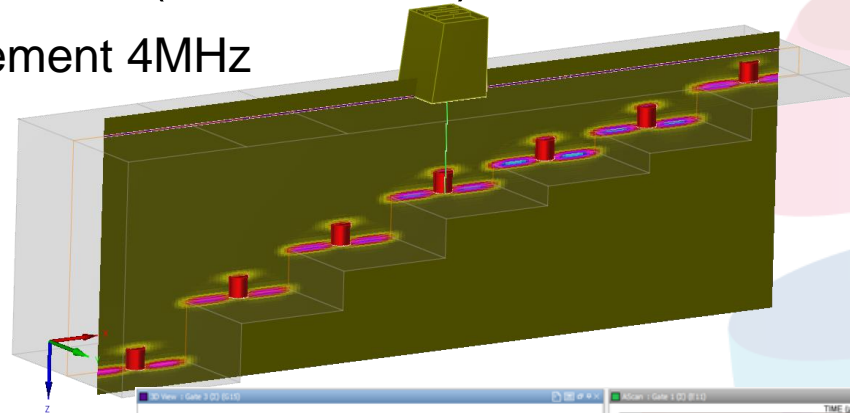
  - ✓ Gates synchronized versus backwall echo (last peak):

 - ✓ Capability to keep only FBH echoes and plot easily DGS curves
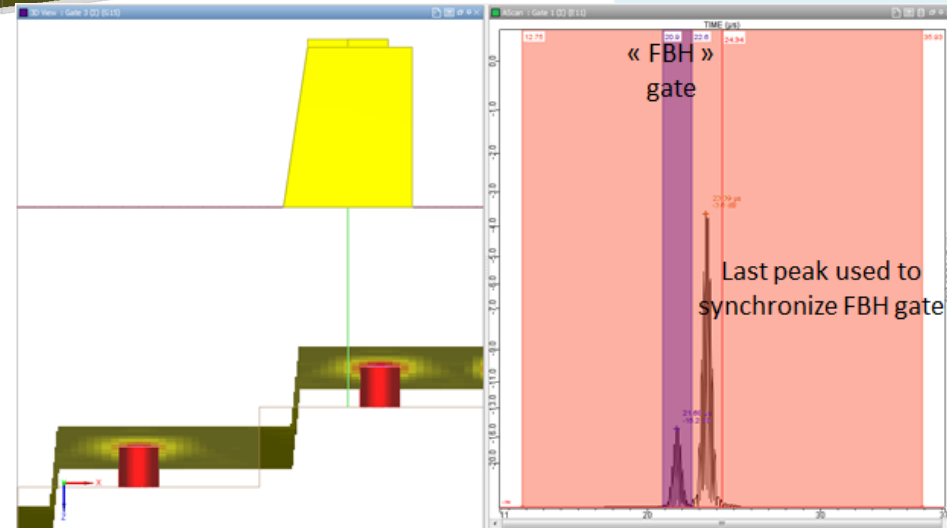
« FBH » gate

Last peak used to synchronize FBH gate

Applications (1/2)

- But at some positions, 2 backwall echoes can "overlap":

  ✓ Depends on the beam size

  ✓ One backwall echo is trapped
    in the "FBH" gate: Unexpected signal

  ✓ Unstable gate

  ✓ Can happen in "real life"

Backwall echo contained in the « FBH » gate

Last peak used to synchronize FBH gate
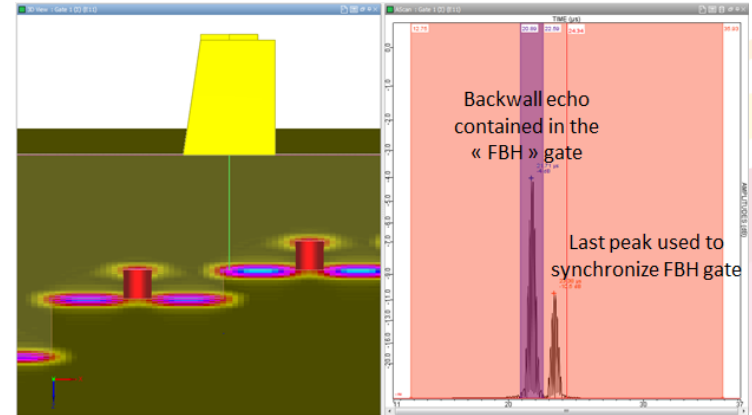
- Simulations can be used to identify such problems and optimize the gate or the block

- Results with a step wedge having smoother steps at some positions:

  - Only FBH echoes kept,

  - Plotting of DGS curve
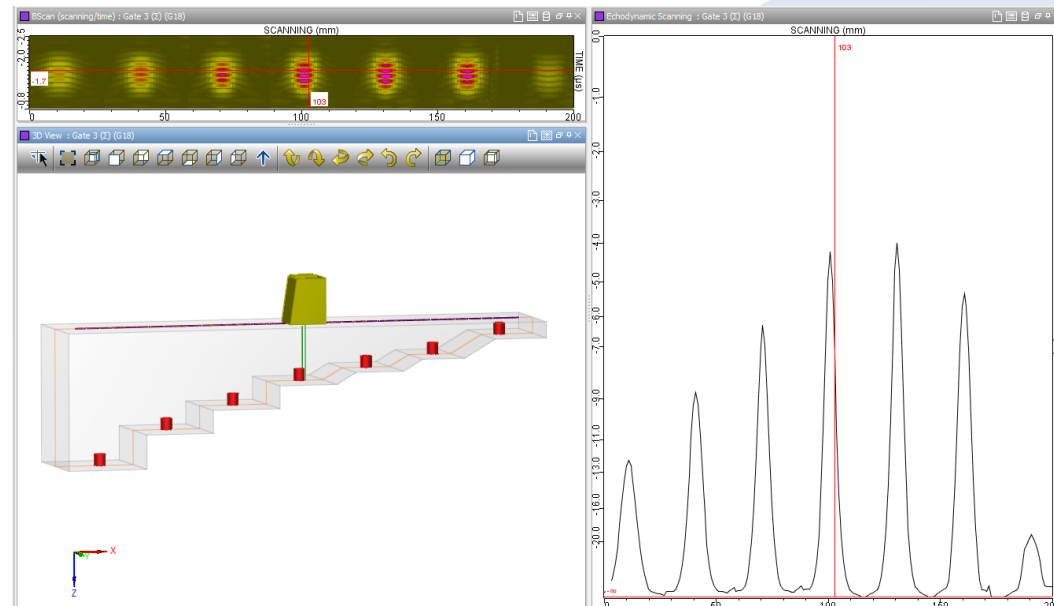
Applications (2/2)

- Simulate Weld Inspection by PA UT

- Examples: Modeling qualification tests of pipeline girthwelds inspection made with PipeWizard, Rotoscan, etc.

- Inspections rely on zonal discrimination approach
  - ✓ Weld divided into different area of 3mm height maximum
  - ✓ Each channel of the probe is dedicated to inspect one area
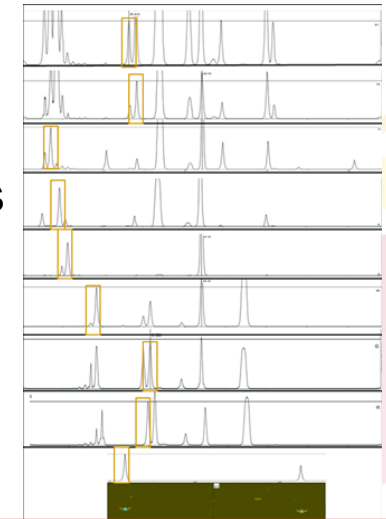 - ✓ Relies on higly focused beam
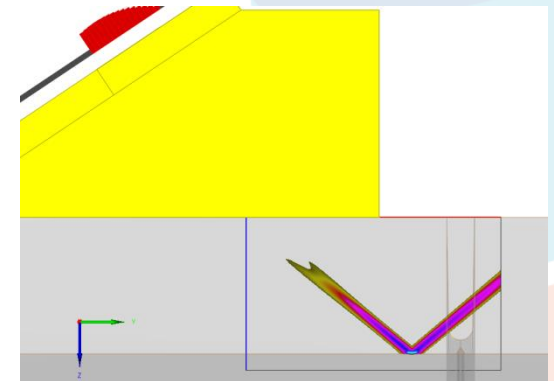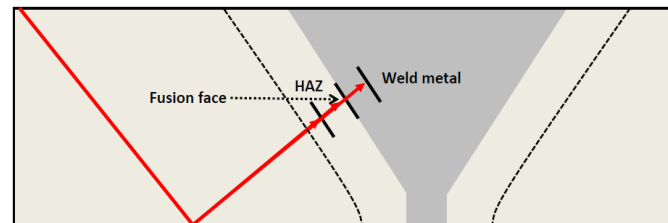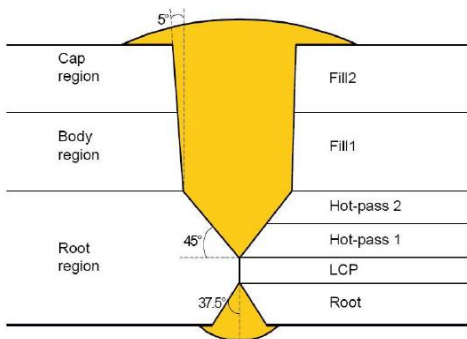
Applications (2/2)

- Simulation allows :

    - Simulate and optimize beam and delay laws

    - Predicting defect responses for the different channels
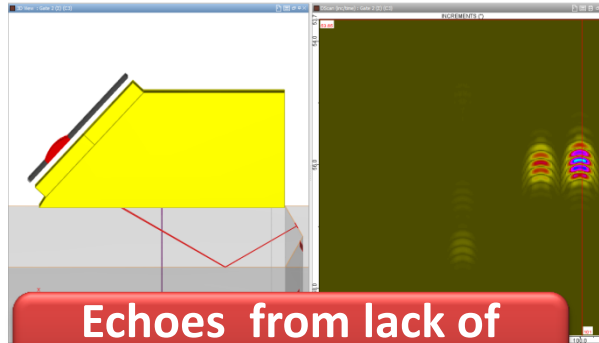

**Echoes from lack of fusion (B-Scan view)**

Charts of the different channels

- Interest of using simulation:

    - ✓ Can replace some part of the qualification tests (costly process)

    - ✓ Reach more reliable qualification: Easy to obtain additional data in order to cover more possible situations (defects, system position, probe parameters, etc.)

- ✓ Validation study of CIVA for Pipeline GirthWelds inspection published at ASNT2012

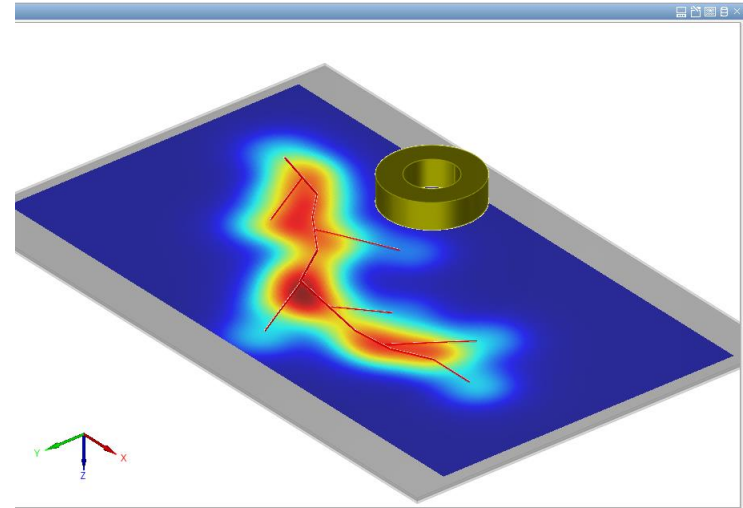# Contents

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
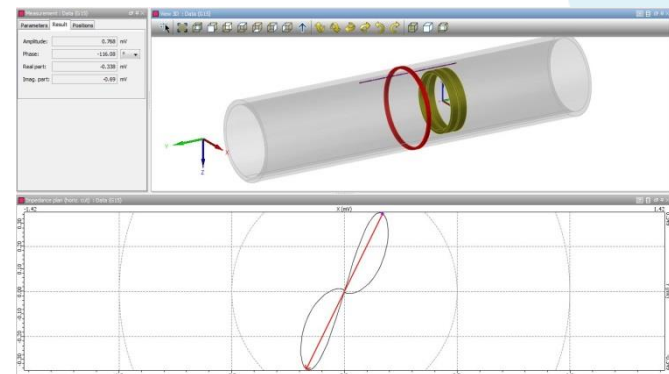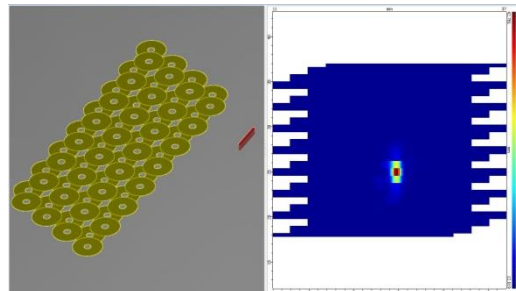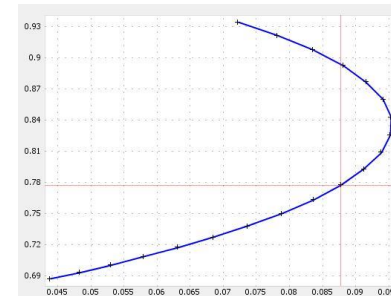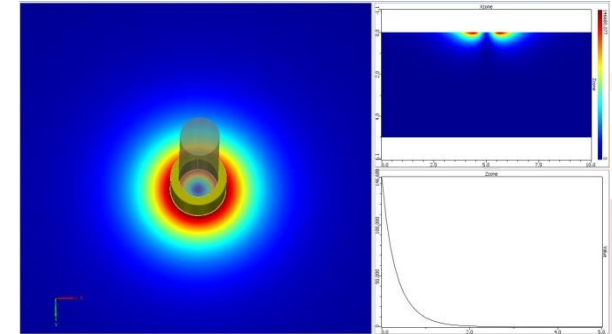
Main new features in CIVA11

- New "BEM" model adapted for thin flaw

 $\rightarrow$ more realistic simulation
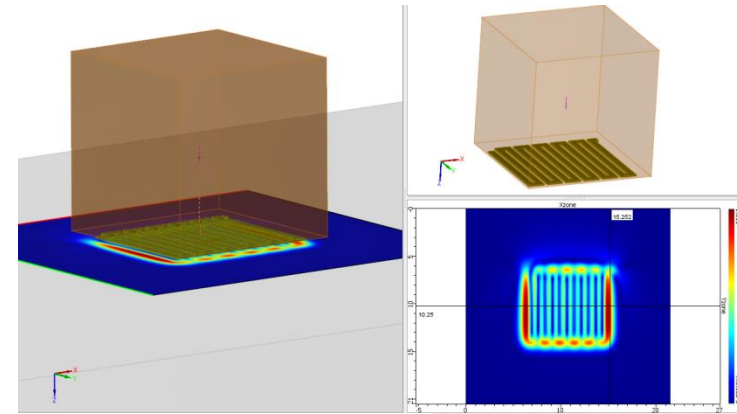 of complex cracks

- Extension of coil libraries (D, meander, pancake, etc.)

Main new features in CIVA11

- EMAT probes (coupling with CIVA UT):
  - Electric field computation in CIVA ET
  - Defect response in CIVA UT

- Accounting for electrical parameters of ET system and probe by circuit coupling (stray capacitances, etc.)


- Heat exchanger tube expansion zone
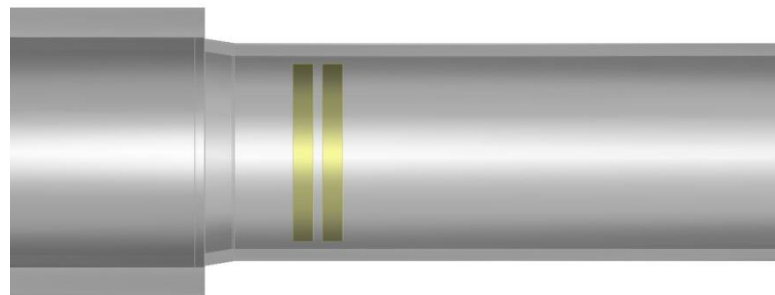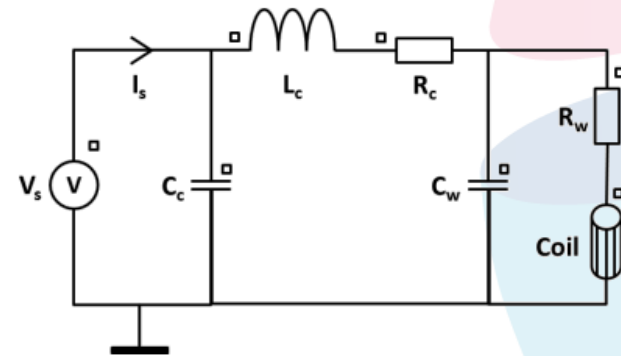
Applications

- Steam generator tube inspection by bobbin probe

  - ✓ Inconel tube of 9.84mm IR and 1.27mm thickness

  - ✓ Expanded radius (δr=0.6mm) to fit with a ferromagnetic tubesheet at its basis

  - ✓ Circumferential inner flaw of 1mm extension and 25% thickness

  - ✓ Inspection at 200 kHz
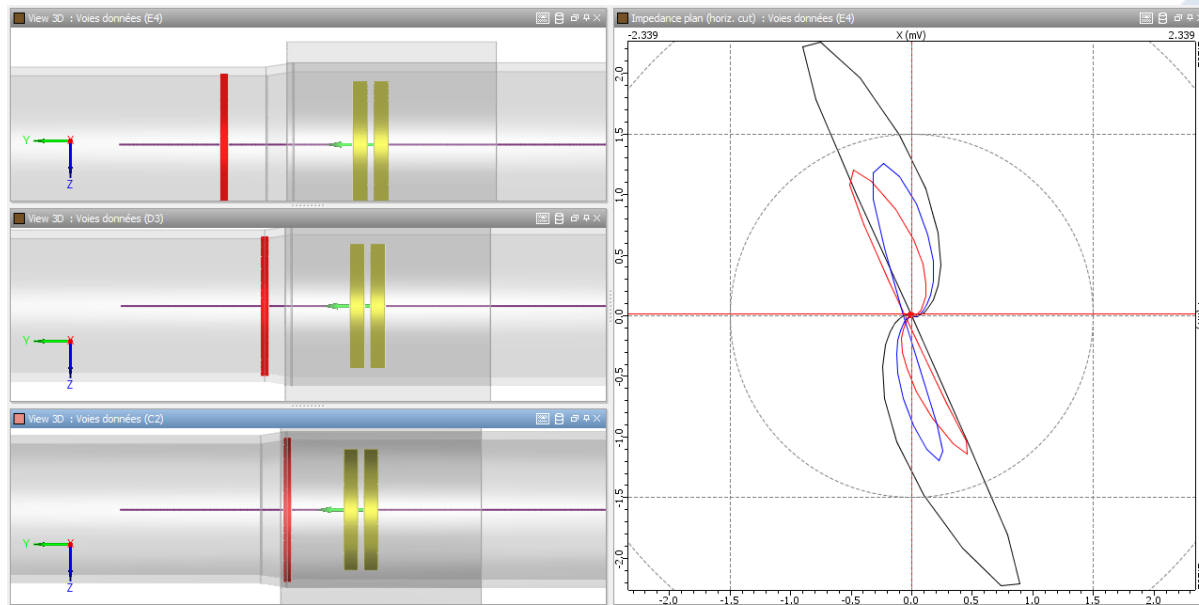
- Signal of the absolute channel:
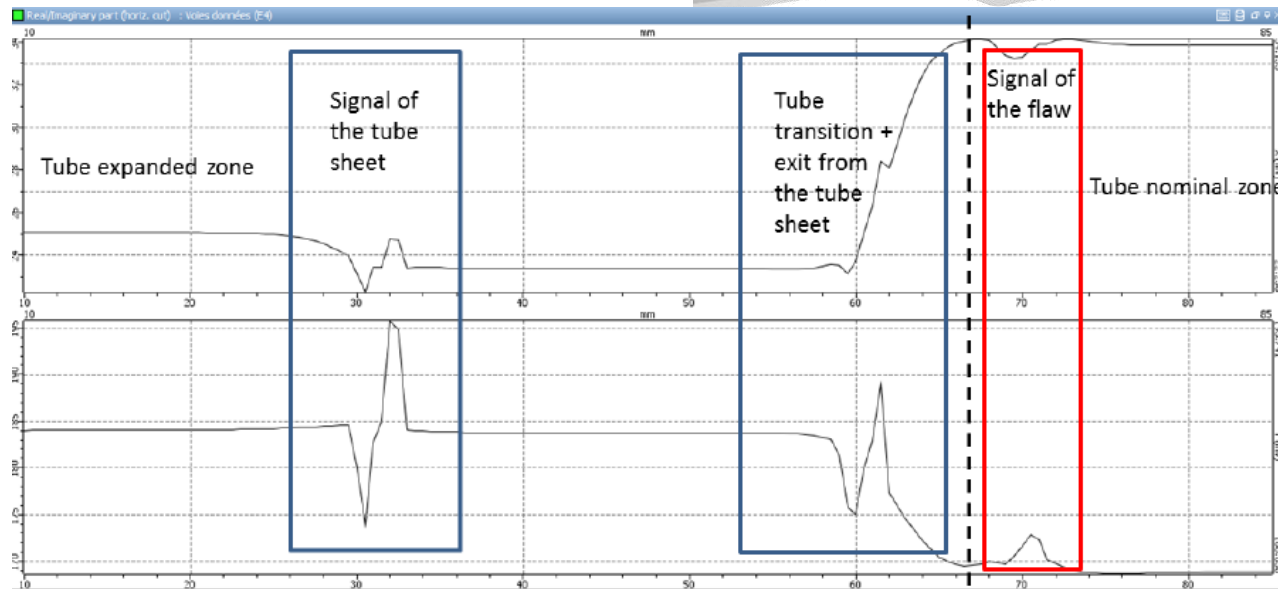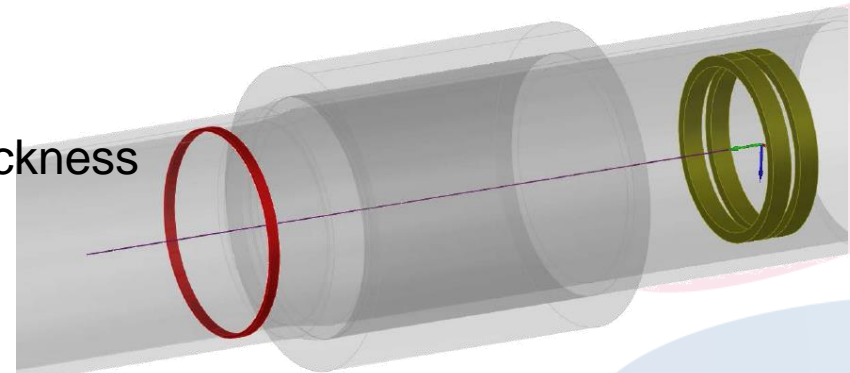
Applications

- Study of the influence of the transition zone on the flaw signal

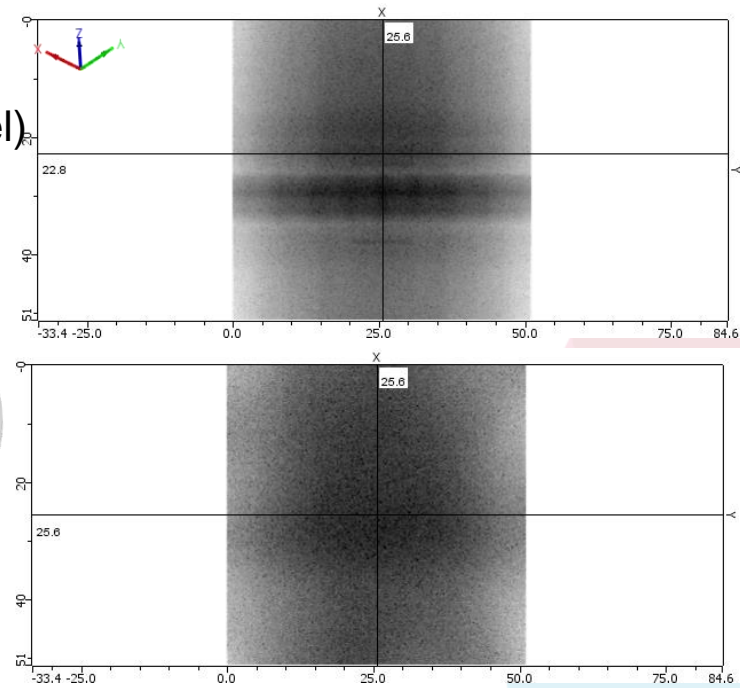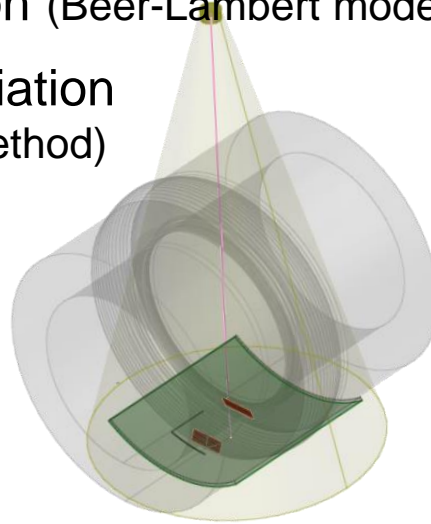 - ✓ Differential channel: Flaw in the nominal part
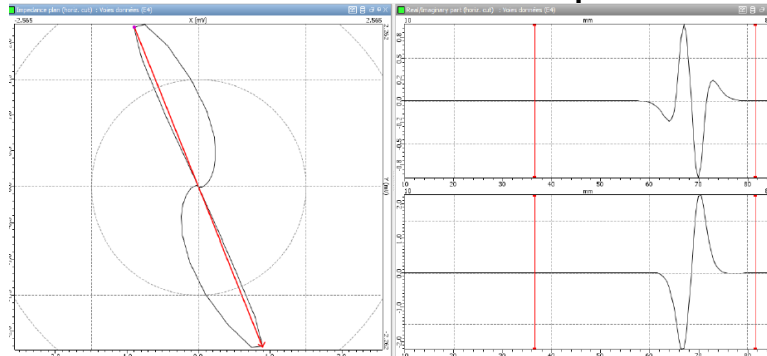
  - ✓ Flaw located in the transition zone (red and blue curves) :
    Decrease of the flaw signal amplitude
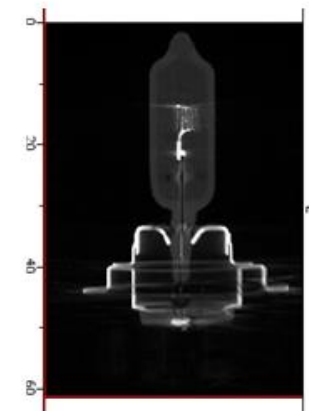
CIVA RT-CT

- CIVA RT-CT includes:

  ✓ Direct radiation (Beer-Lambert model)

  ✓ Scattered radiation
     (Monte-Carlo method)

- Techniques covered:

  ✓ X-Ray

  ✓ Gamma-Ray

  ✓ Tomographic reconstruction
   (FDK, PixTV algo)

Main new features in CIVA11

- Heterogeneous 3D CAD geometries

- Digital radiography: Image plate detectors

- POD computation

- Scattering model accounts for pair creation
  (high energy phenomenon)

- Post-processing:
  - ✓ Detectability criteria
  - ✓ Fast Target dose/exposure computation by post-processing

- CT reconstruction algorithms available
 on experimental data

Applications

- New features: Simulate several objects in the same configuration
  - ✓ For instance: Work piece (turbine disk) + Wall (lead block)
  - ✓ Some backscattering phenomenon can be accounted for
- Inspected with Ir192 gamma ray source

- Build-up (1+scatt/direct) comparison with and without backscattering around the flaw

Build-up comparaison and evaluation of the backscattering
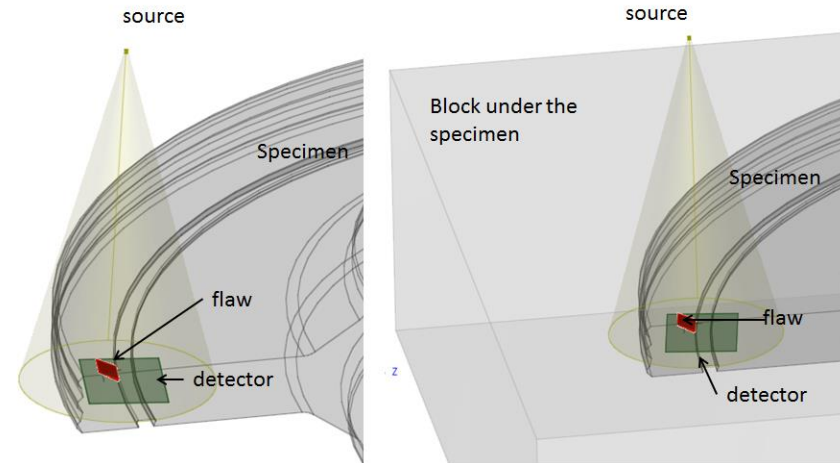
--- With backscattering:
Higher build-up = Noisy image

--- Without backscattering
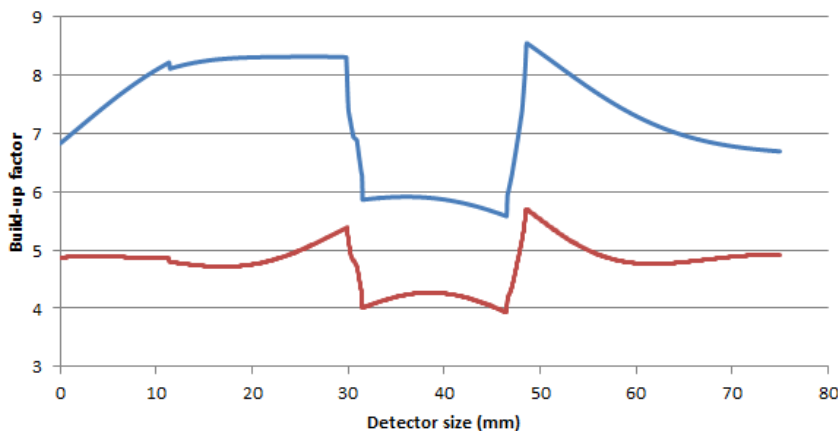
CONCLUSION

- Benefits: Improve cost-efficiency of NDT at different stages of the process
  - ✓ Design and qualification of inspection methods
  - ✓ Preparation of inspection
  - ✓ Expertise
  - ✓ Training

- CIVA 11: Numerous new capabilities in UT, ET, RT and CT
- CIVA 11 Guided Waves released soon

- A lot of potential applications

- Come to visit our booth #43

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