Latest evolutions of the CIVA simulation platform & applications

EXTENDE CIVA

cea list
energie atomique • energies alternatives

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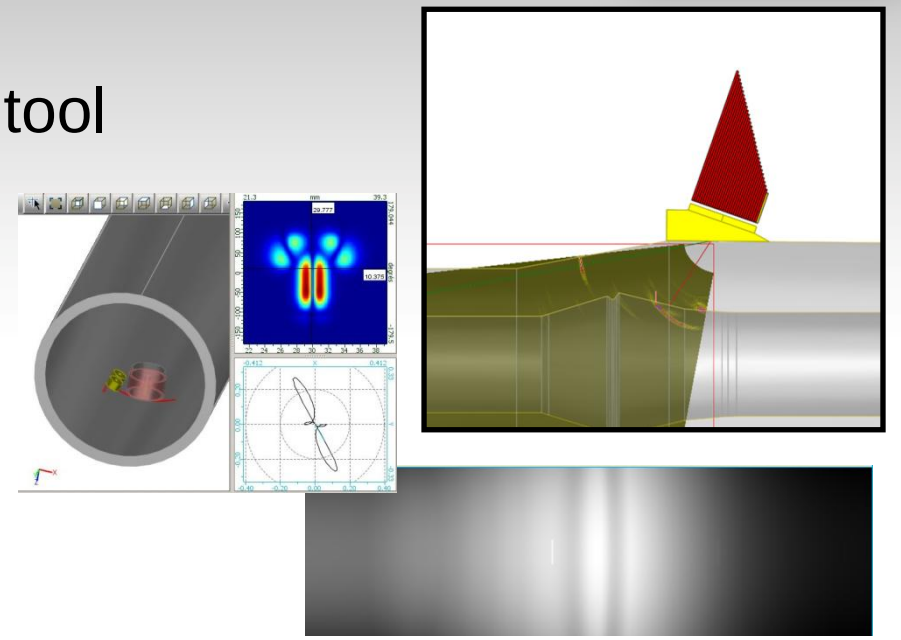
Contents

- CIVA, version 10.0
- Benefits of simulation:
  - UT: Applications to performance demonstration
  - ET: Introduction of innovative process
  - RT: Design of inspection method
  - POD: Towards more efficient POD campaign

CIVA

- Dedicated NDE modeling tool



- Multi-techniques :
  - UT : Ultrasounds
  - ET : Eddy Current
  - RT : Radiography

- Developped by CEA (French Atomic Energy commission: Research center)
  - NDT department: 100 people
  - Development & validation CIVA: 30 people
- Semi-analytical models
- Distributed by EXTENDE from 2010

License

EXTENDE activities

- **CIVA Distribution:**
  - Extende Inc. (based in NY, USA) for US and CANADA:
  - Our representative: Erica SCHUMACHER

- **Technical support**

- **Training courses**

- **Consulting:**
  - Software used: CIVA, Flux

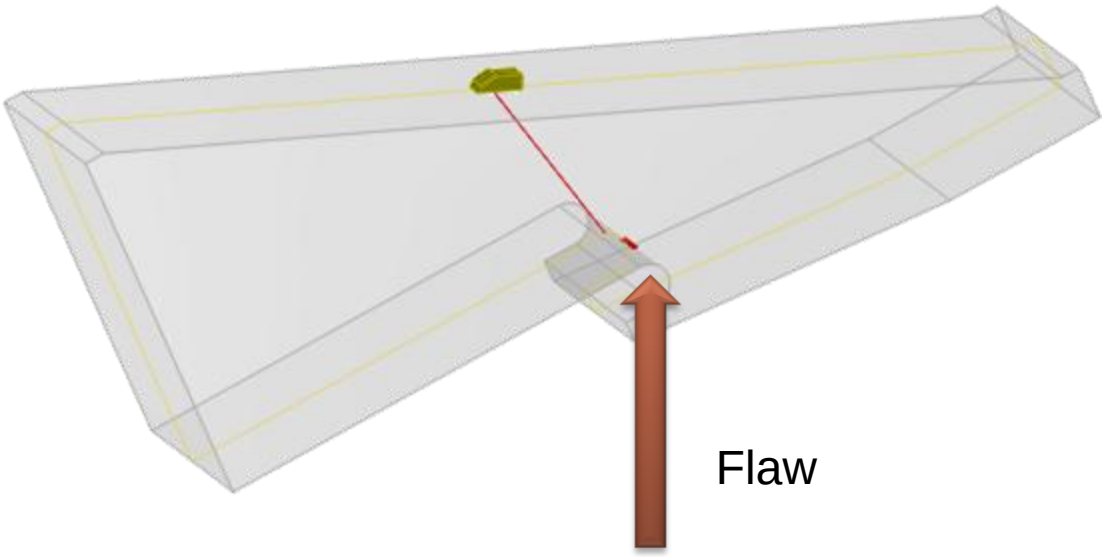
- **Research & Development:** Collaborative projects

CIVA v10.0

- CIVA V10, **user oriented:** Re-organized environment
  - More intuitive, more interactive, results “integrated” in one analysis window, etc.
- CIVA V10, numerous **new capabilities:**
  - UT: Defect response calculations availble in 3D CAD work piece geometries, branched defects, specific models for cast steels, multi-skips accounted for, Total Focusing Method, etc.
  - ET: Multiple defects, New sensors (GMR, Arrays,…)
  - RT: Dramatic improvement of the ergonomy and the computation performance, accounts for detector granularity
  - Computation of POD (Probability Of Detection) curves
  - Etc.

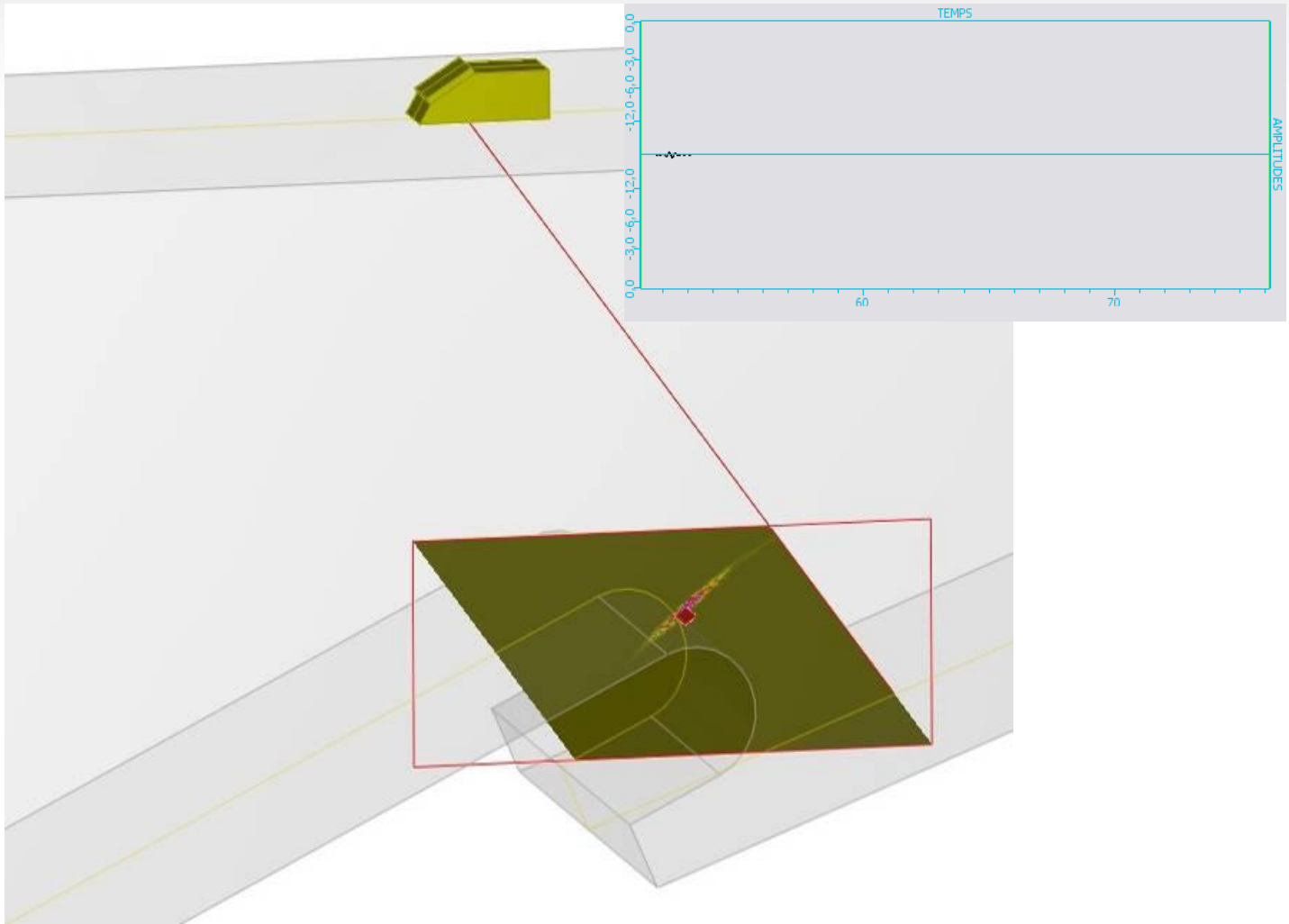
UT : Design and qualification of inspection methods

- Inspection of a steam generator thermal sleeve
- Contact probe SV 45



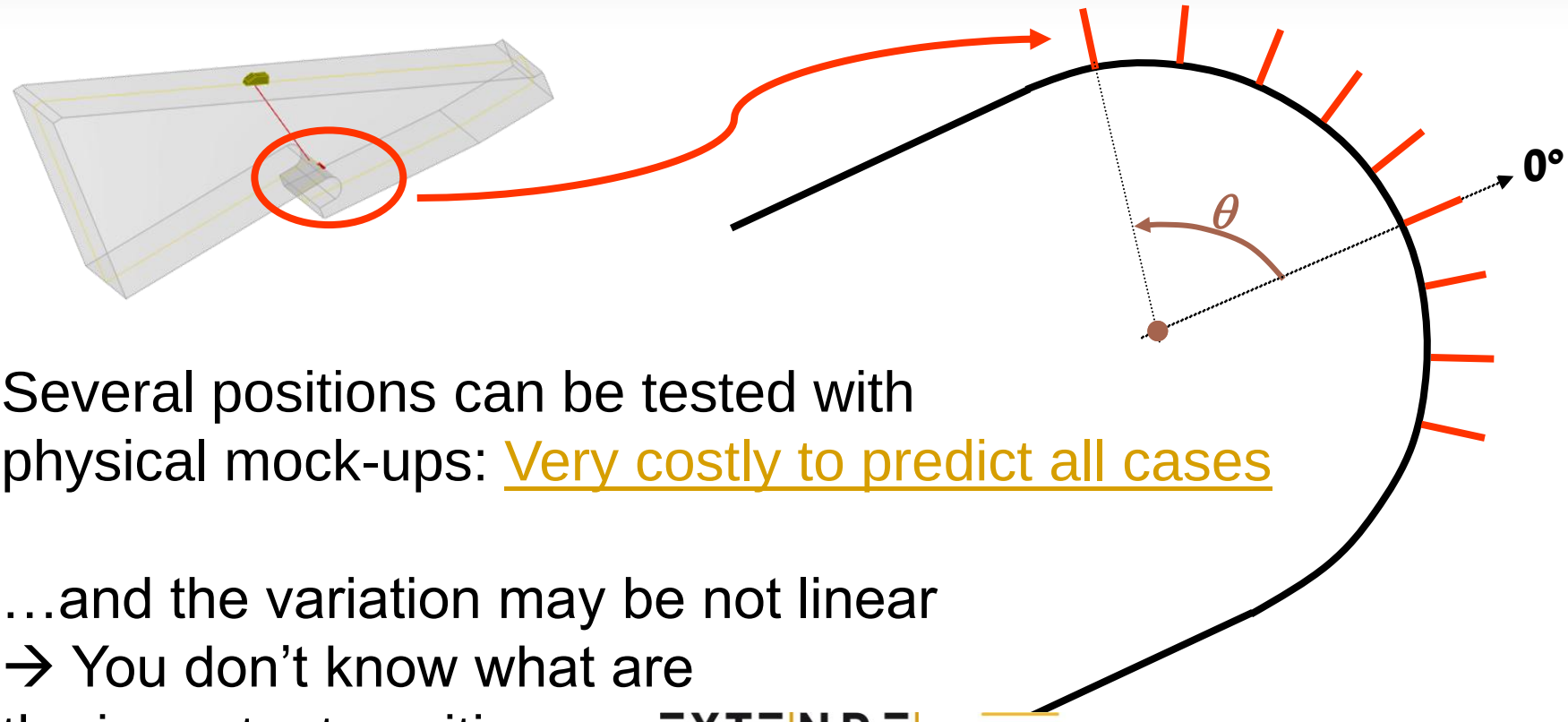
UT : Design and qualification of inspection methods

- Simulation allows to predict the probe performance:



UT : Design and qualification of inspection methods

- What will be the influence of the flaw position on the signal? Limits of performance ?

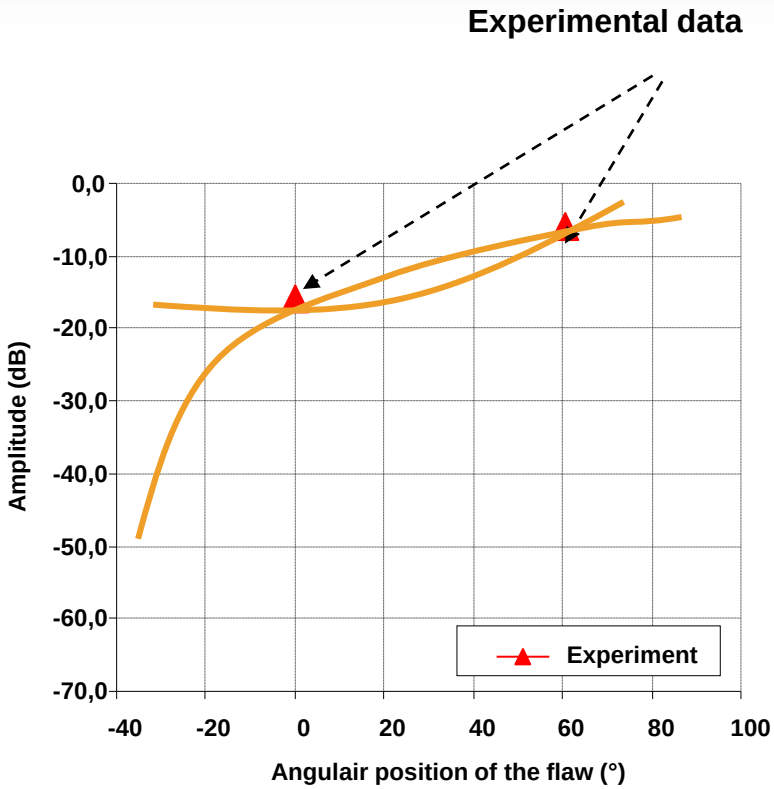


Several positions can be tested with physical mock-ups: Very costly to predict all cases

…and the variation may be not linear
→ You don't know what are the important positions

UT : Design and qualification of inspection methods

- Proposed methodology:
  - Acquisition for 2 (or 3) flaws positions with mock-ups
  - Measurements gives some elements but does not give the full variation curve



UT : Design and qualification of inspection methods

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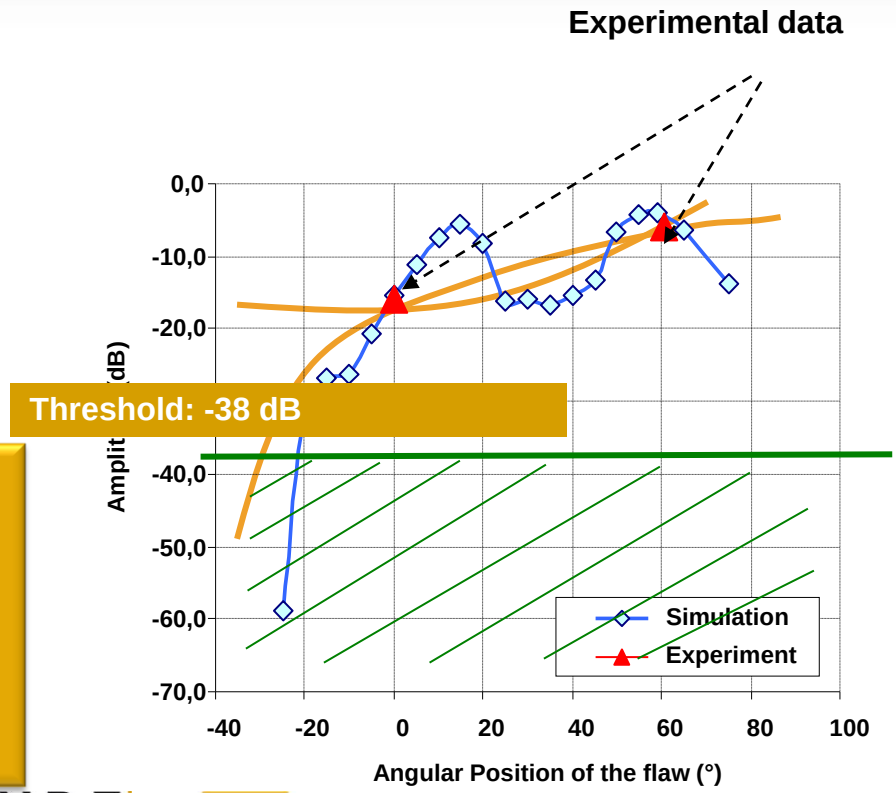
Parametric study with simulation

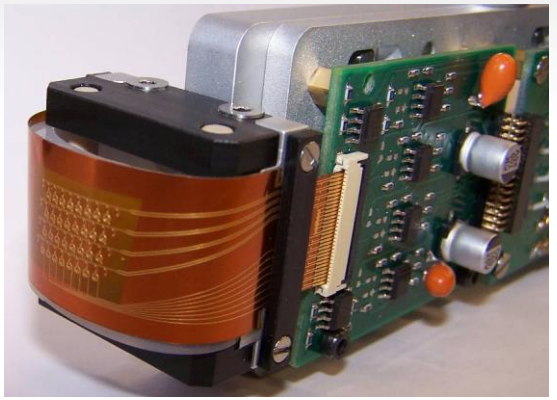


Threshold: -38 dB

- Allows to complete the results vs procedure criteria
- Crossed validation : Measurements / Simulations
- Cost efficient

ET : Introduction of innovative process

- Example: ET array sensor
  - Example of a sensor development made at CEA*:
    - 2 sets of 32 microcoils
    - Printed on a flexible kapton film
    - Silicone Roll to ensure good contact with the workpiece during scanning



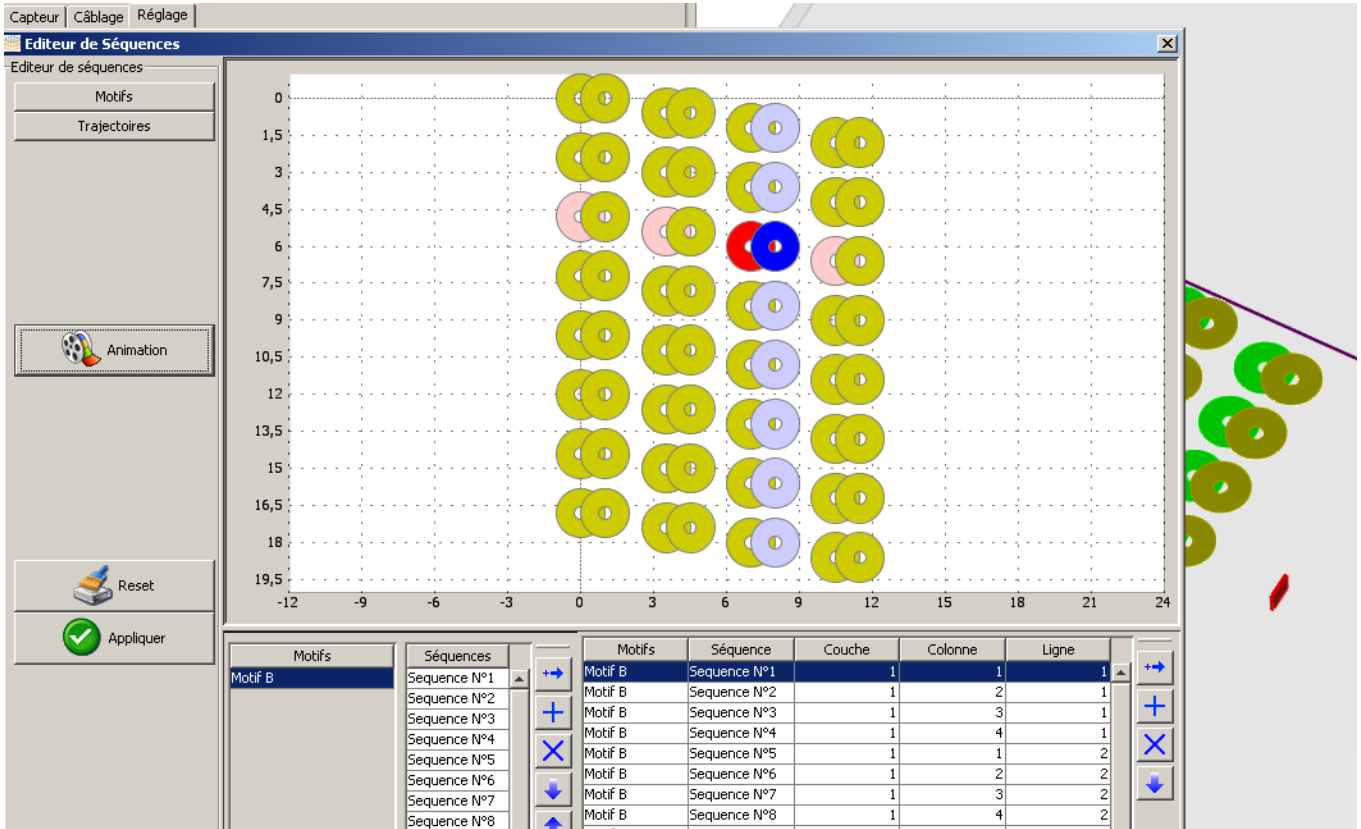
  - Advantages :
    - Good resolution for the detection of small cracks
    - Flexibility provided by the multi-elements monitoring
    - Limitation of disturbing effects due to lift-off variation

- Simulation: Helps the design

*See : "Flexible and array eddy current probes for fast inspection of complex parts", B.Marchand, J. M. Decitre, and O. Casula, QNDE 2010

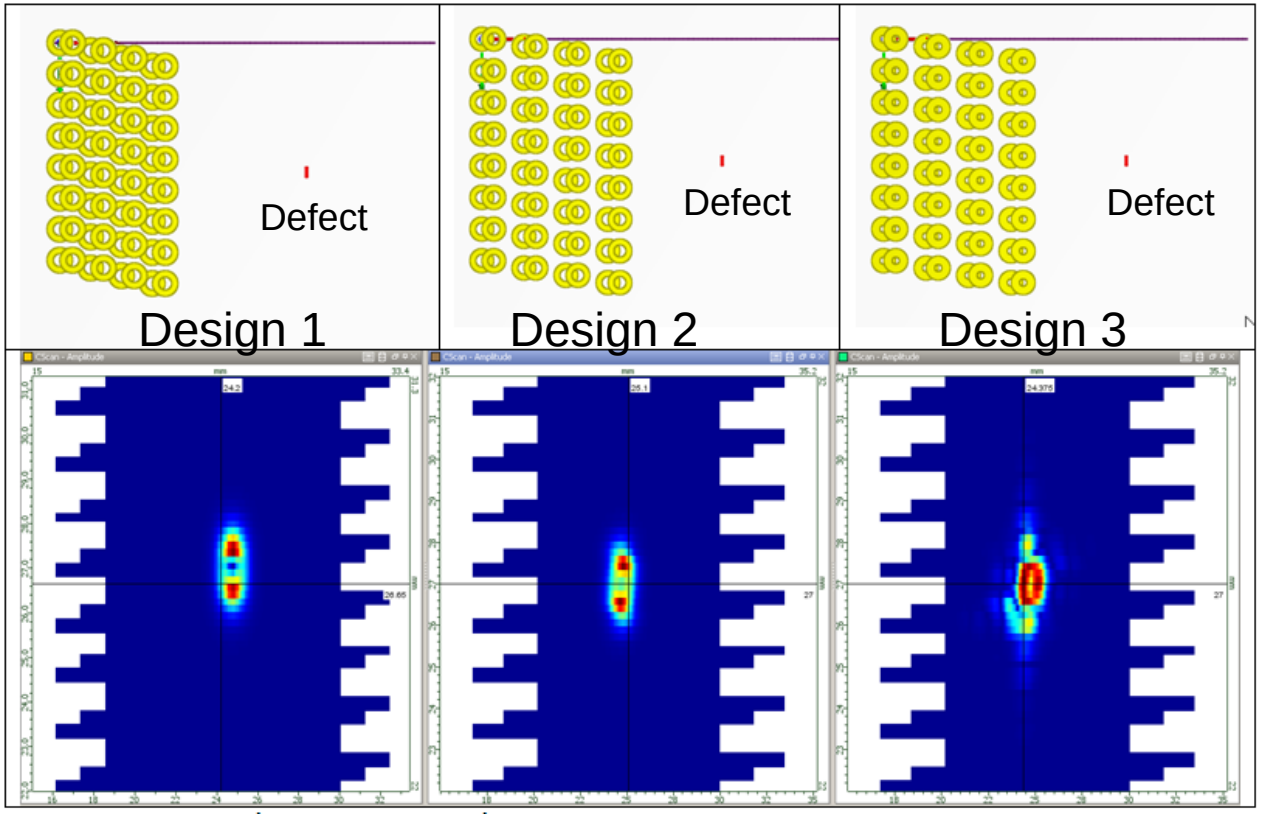
ET : Introduction of innovative process

- CIVA10: Built-in tools for ET arrays:
  - Geometrical description of winding layers
  - Definition of wiring
  - Definition of channels: “Patterns “and electronic “trajectories”



ET : Introduction of innovative process

- Comparison of 3 designs (defect 0.4*0.2*0.1mm^3)
  - 1 mechanical scanning axis / Acquisition 1Mhz
  - Design 2 vs Design 1: Variation of inter-coils distances
  - Design 3 vs Design 2: Variation of coils sizes



ET : Introduction of innovative process

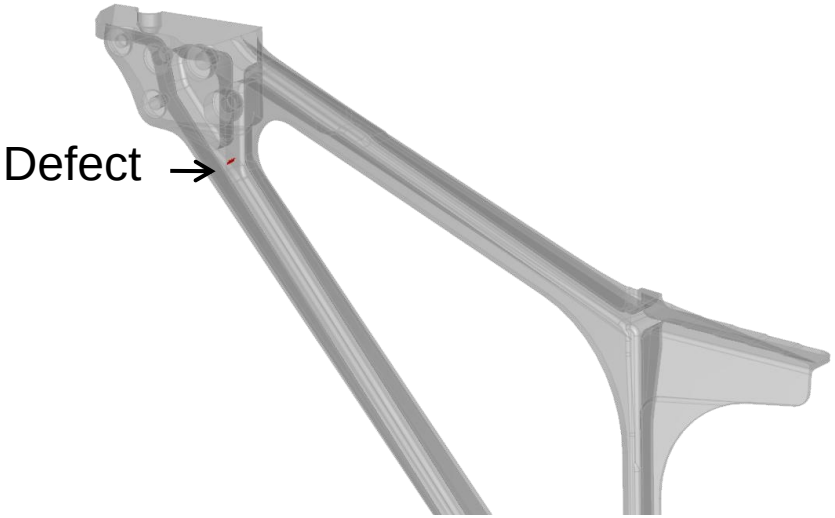
- Benefits of simulation:
  - Virtual prototyping allows to test numerous solutions before creating a physical prototype :
    - Time & cost saving: Less prototypes
    - Enhanced performances
  - Evaluate before investing: Virtually compare an existing conventional technique with an innovative one
  - New Technologies: It means by definition few feedback. Simulation allows to better understand and handle a new technique at low cost

RT : Preparing an inspection

- Stiffener inspection with an X-ray source

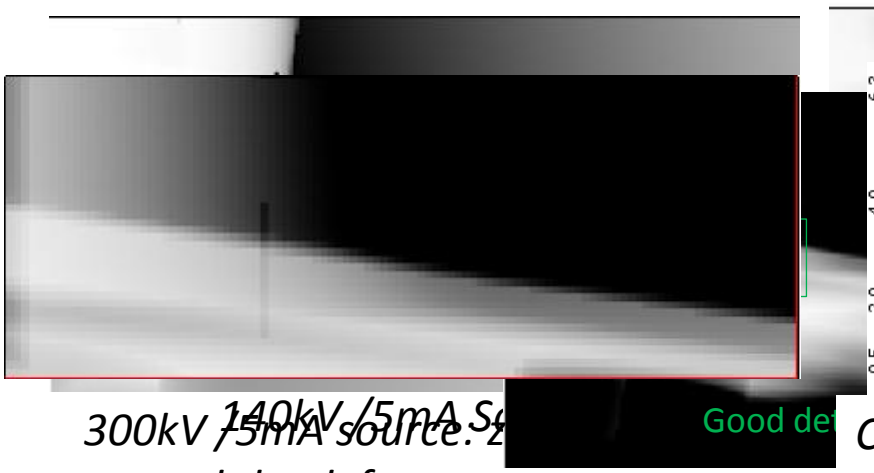
- Problematic: Select the best settings before inspection:
  - Limit the number of shots
  - Limit the operation time

- Parameters:
  - Which source to select among 3 available?
  - Which film?
  - Ideal positionning & source/film distance ?
  - Which exposure time ?

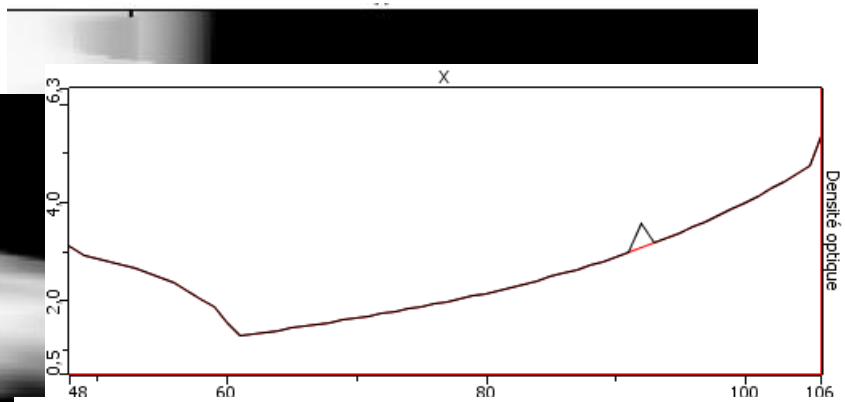


RT : Preparing an inspection

- Performance comparison with 3 different sources:
  - Source at 140 kV/5mA
  - Source at 200 kV/5mA
  - Source at 300 kV/5mA



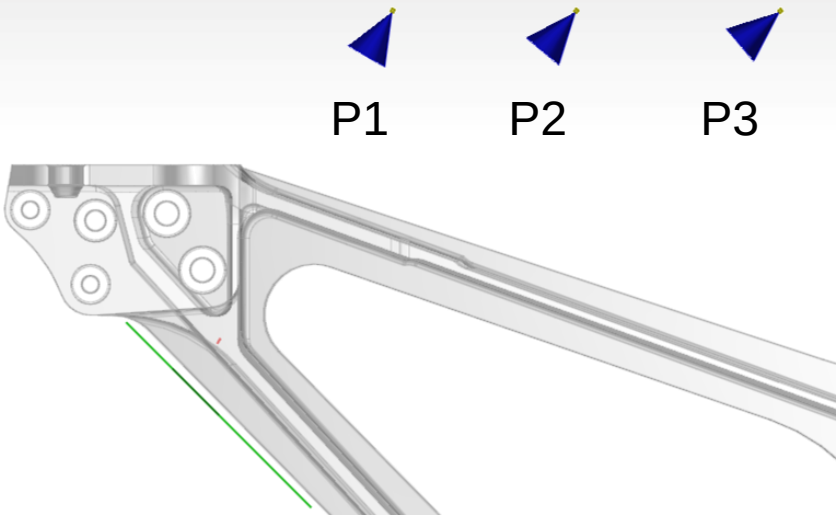
300kV /5mA source: 2
around the defect

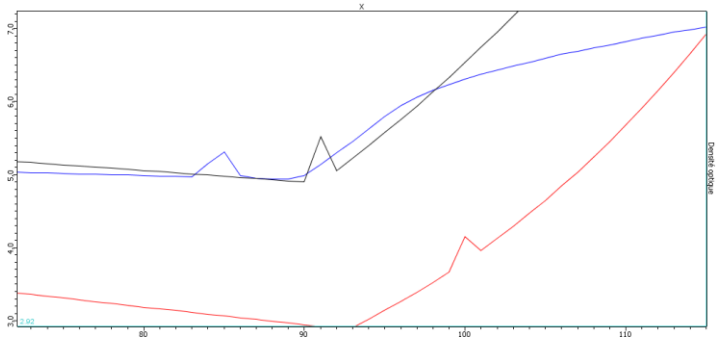


Curve of the optical density extracted at a cross-section nearby the flaw

RT : Preparing an inspection

- With the selected source : Optimization of the position of the source:
- Comparison with 3 positions
  - P1: X = 300 mm / orientation -30°
  - P2: X = 500 mm / orientation -40°
  - P3: X = 700 mm / orientation -50°





P1: Orientation - 30°

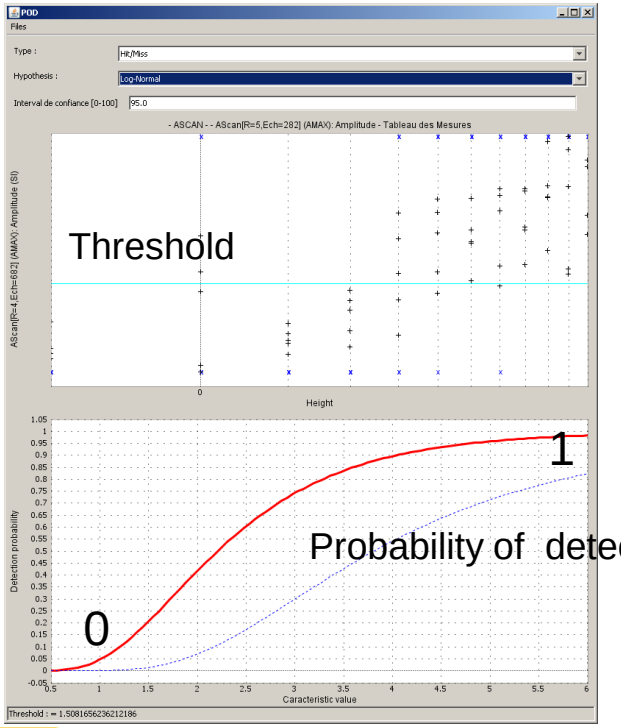
P2: Orientation - 40°

P3: Orientation - 50°

Position/orientation	Δ DO (with & without flaw)
300mm/-30°	0,29
500mm/-40°	0,54
700mm/-50°	0,31

POD in a few words

- A POD curve links the defect detectability to its size
- For 1 defect size, lthe POD gives the probability of this flaw to be detected for a given threshold
- This probability depends on influential and uncertain parameters



POD in a few words

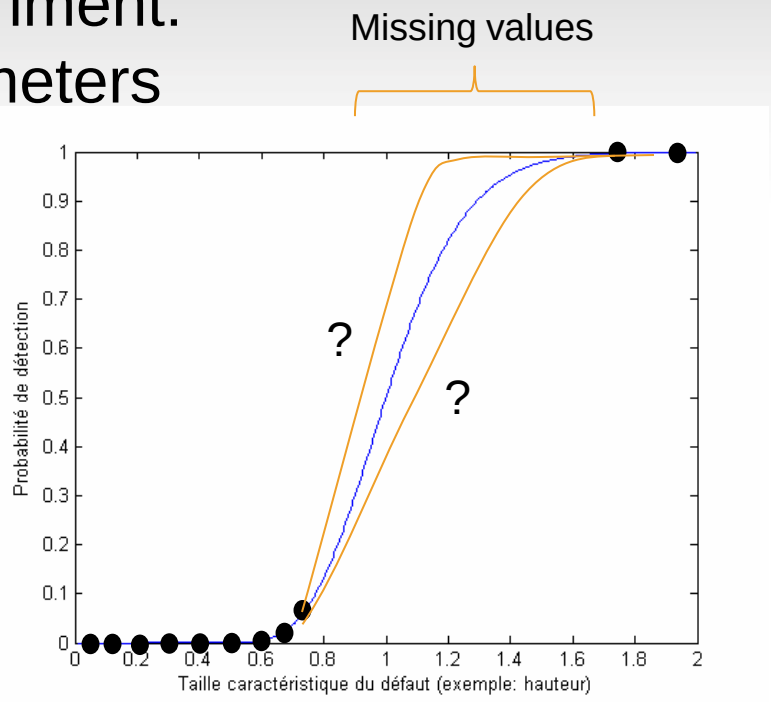
- Methods that have to be applied and rules that have to be respected to have a reliable POD are **heavy and cost consuming**.
  - MIL-HDBK-1823 (aeronautics)
  - DNV-OS-F101 Appendix E (oil & gaz)
  - …

- Building a POD implies **many** mock-up, most finally **destructed** to have references, many acquisitions, analysis...

Benefits of simulation POD

- Optimize design of experiment: Find the influential parameters

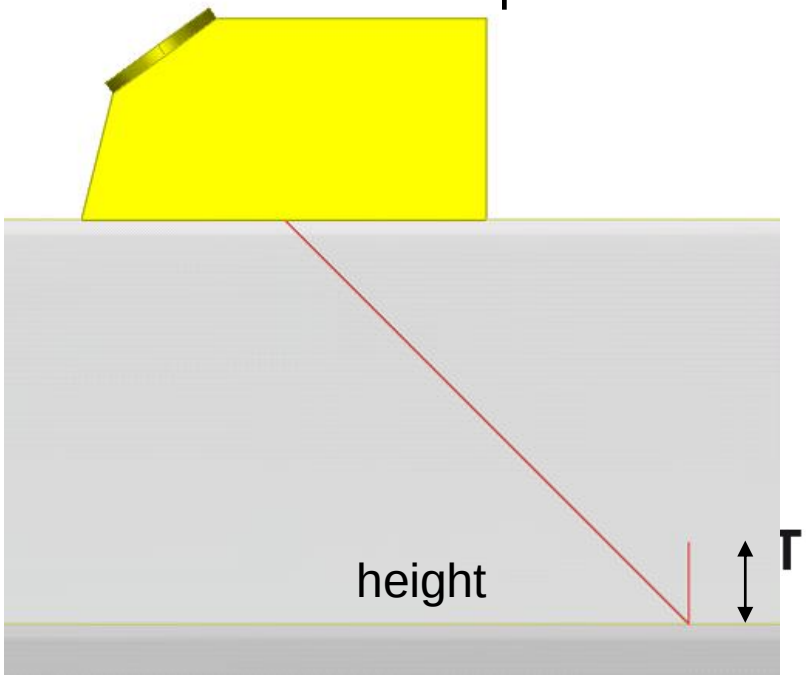
- If measurements are not in the **interesting area of uncertainty**, the result obtained with mock-ups does not give satisfaction and **cost is increasing**.

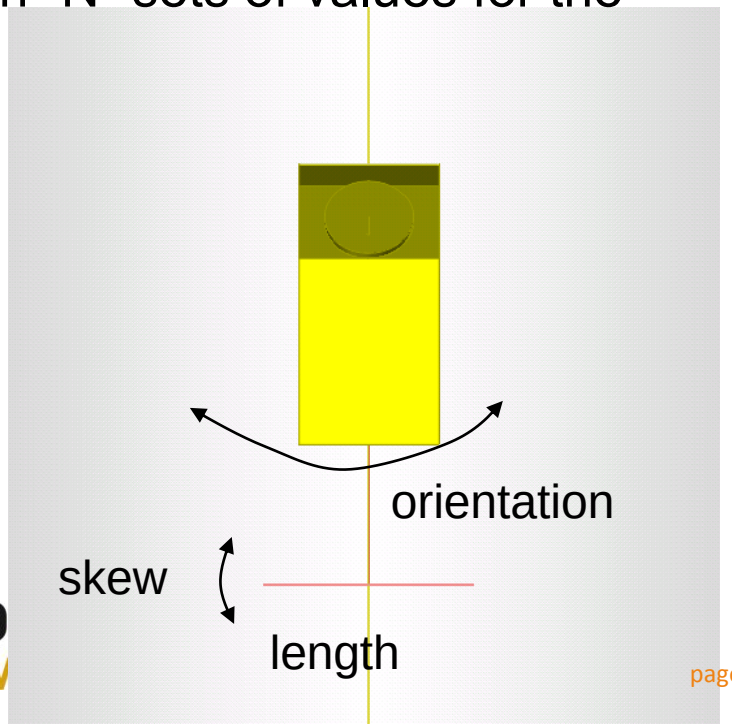


- **Adapted domains of uncertainties** may be find thanks to simulation **before** making mock-up.

POD in CIVA software

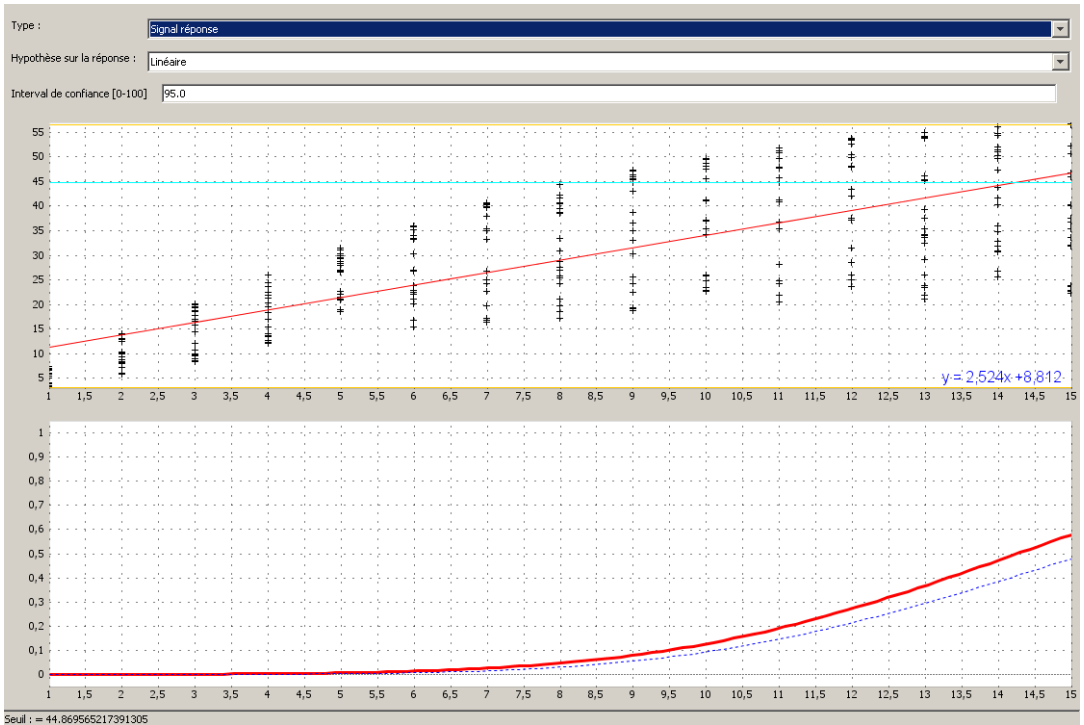
- User defines:
  1. Nominal configuration”
  2. Characteristic quantity→e.g. Defect height
  3. Uncertain parameters and their statistical distribution →e.g. Defect skew, probe orientation
  4. Run the “N” computation with “N” sets of values for the uncertain parameters





POD : Application

- CIVA gives:
  - The whole set of results for each case (Ascan, Bscan, etc.)
  - The POD curve and associated parameters
    - Inspection procedure **thresholds** (detection, noise level, saturation)
    - Type of data: Signal Response/Hit-Miss
    - Confidence bound



Conclusion

- CIVA V10.0 : A reorganized environment & enhanced simulation capabilities
- Simulation can now also help to support a POD campaign: More reliable curves at low cost
- Numerous applications available for 3 techniques: UT,ET,RT
  - Design and qualification of inspection methods
  - Innovation
  - Preparation of inspection
  - Expertise
  - Training