

# FWI for Ultrasonic Imaging

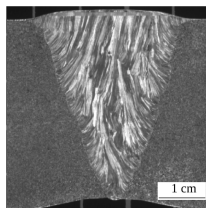
## Flaw detection in steel weld

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supervised by  
Romain BROSSIER & Ludovic MOREAU

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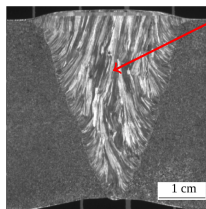
# NDT for Welds



Macrography of a weld\*

- delay and sum methods
- decomposition of covariance matrix (DORT)

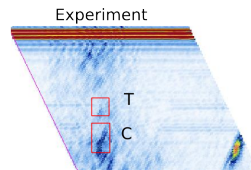
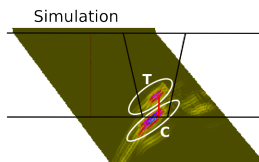
# NDT for Welds



Macrography of a weld\*

Strong unknown anisotropy

↪ distortion and splitting of the beam



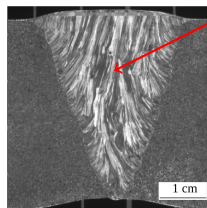
Comparison of ray based model and experiment result\*\*

- delay and sum methods
- decomposition of covariance matrix (DORT)



- ✗ need to know  $c$  in advance
- ✗ strong artefacts

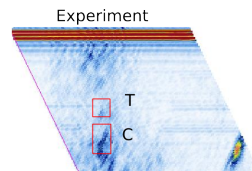
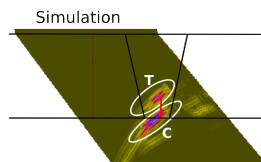
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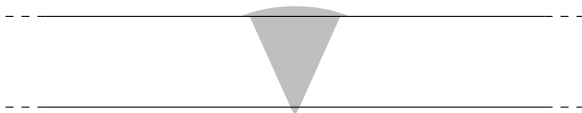


Comparison of ray based model and experiment result\*\*

- delay and sum methods → ✗ need to know  $c$  in advance
- decomposition of covariance matrix (DORT) → ✗ strong artefacts
- solving NL optimization problem →
  - contour reconstruction : *Dominguez et al., Rodriguez et al.*
  - ✓  $C_{ij}$  reconstruction : FWI

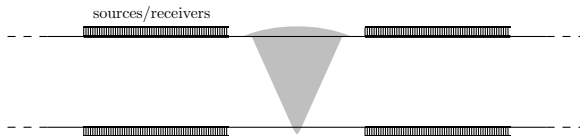
# What is specific to weld imaging ?

- ▶ 2 free surfaces : more information  $\leftrightarrow$  non-linear inversion



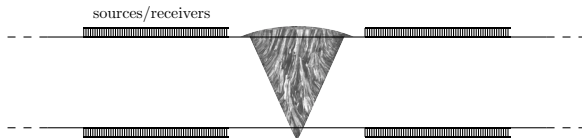
## What is specific to weld imaging ?

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- ▶ surface acquisition only



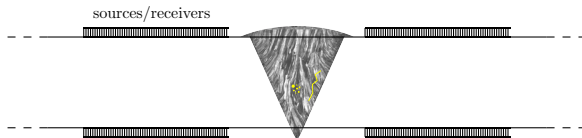
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- ▶ surface acquisition only
- ▶ anisotropy  $\rightarrow$  multi-parameter inversion ( $C_{ij}^w \times 6$ )



# What is specific to weld imaging ?

- ▶ 2 free surfaces : more information  $\leftrightarrow$  non-linear inversion
- ▶ surface acquisition only
- ▶ anisotropy  $\rightarrow$  multi-parameter inversion ( $C_{ij}^w \times 6$ )
- ▶ defects  $\rightarrow$  multi-scale inversion ( $C_{ij}^d \times 6$ )





# To do

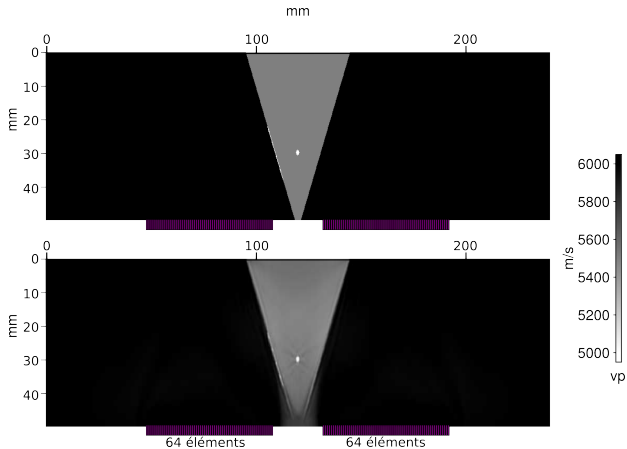
- ▶ 2D acoustic approximation (mono/multiparameter)
  - ▶ isotropic weld ( $v_p, \rho$ )
  - ▶ transverse isotropic weld ( $v_p, \rho, \epsilon, \delta, \theta$ )

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- ▶ 2D acoustic approximation (mono/multiparameter)
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  - ▶ transverse isotropic weld ( $v_p, \rho, \epsilon, \delta, \theta$ )
- ▶ 3D elastic inversion (mono/multiparameter :  $C_{ij} \times 6$ )
  - ▶ isotropic weld
  - ▶ anisotropic weld
  - ▶ real data

# Ongoing work

- ▶ 2D acoustic approximation (mono/multiparameter)
  - ▶ isotropic weld ( $v_p$ ,  $\rho$ )
  - ▶ transverse isotropic weld ( $v_p$ ,  $\rho$ ,  $\epsilon$ ,  $\delta$ ,  $\theta$ )
- ▶ 3D elastic inversion (mono/multiparameter :  $C_{ij} \times 6$ )
  - ▶ isotropic weld :  $v_p$
  - ▶ anisotropic weld
  - ▶ real data



2D isotropic case :  
monoparameter inversion of  $v_p$