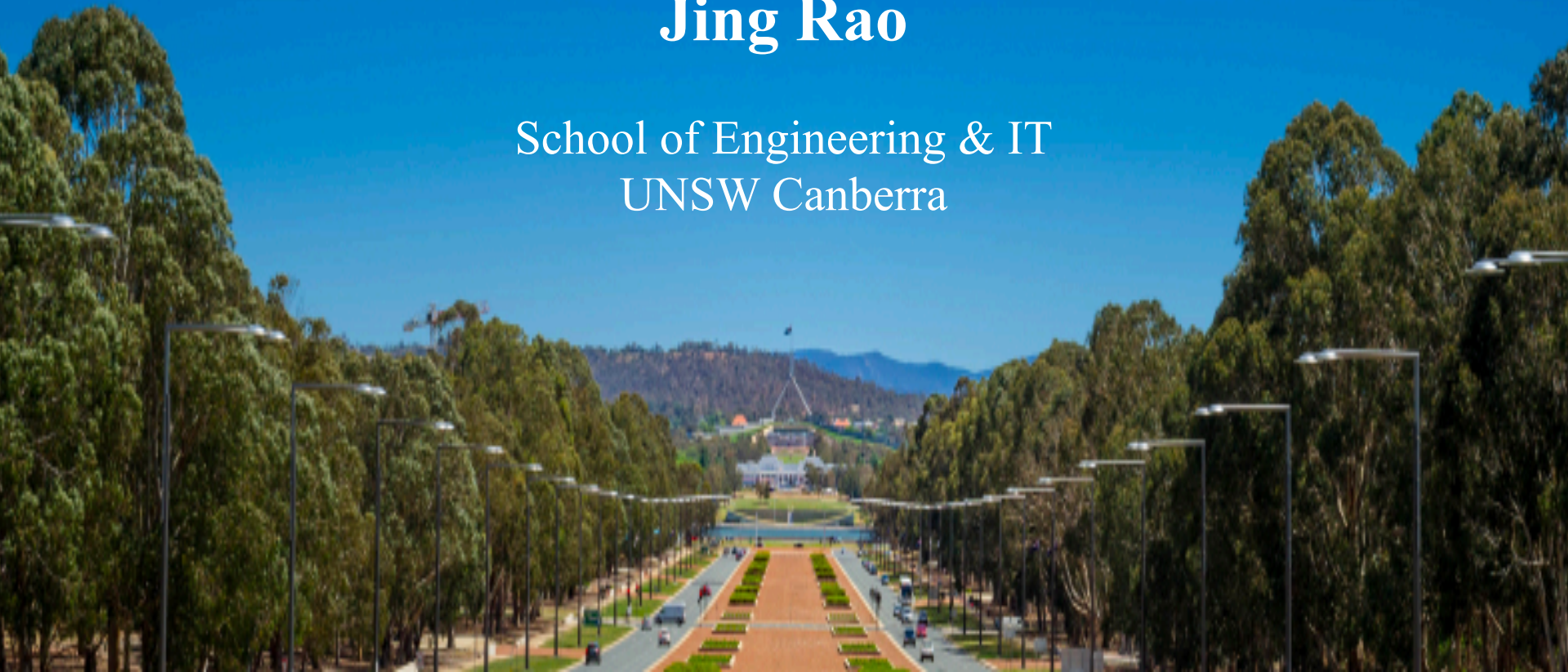


Tomographic Reconstruction of Structural Defects by Ultrasonic Waves

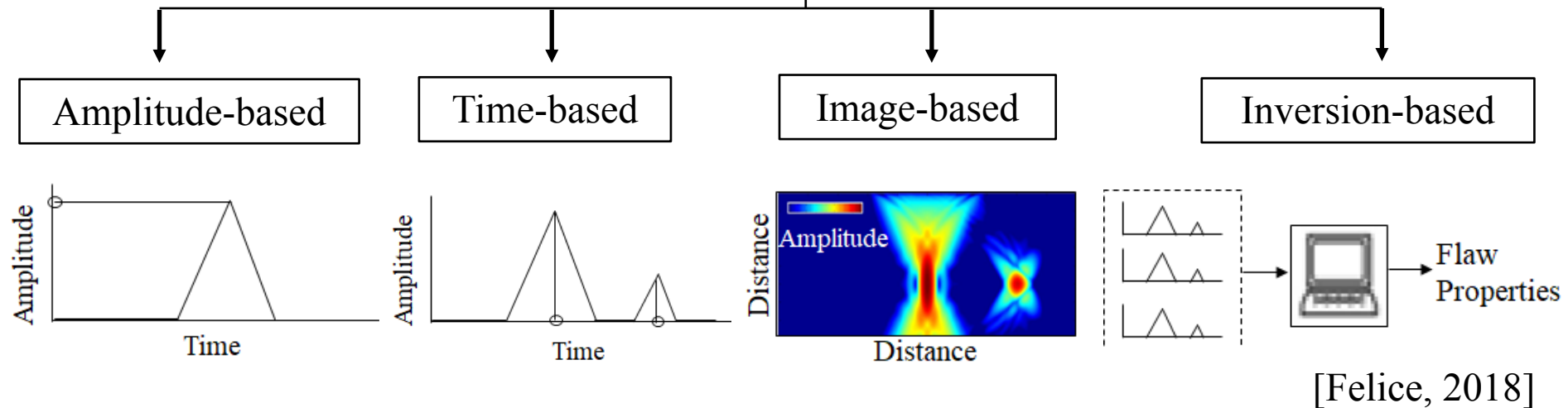
Jing Rao

School of Engineering & IT
UNSW Canberra



Ultrasonic defect characterisation methods

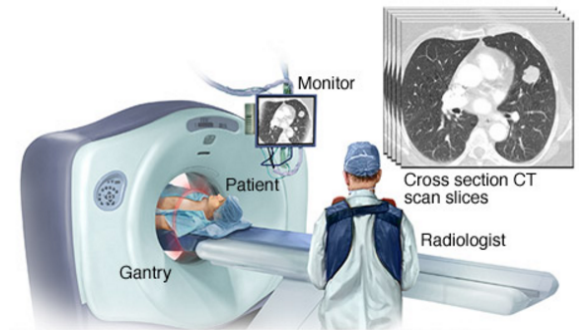
Defect Characterisation techniques



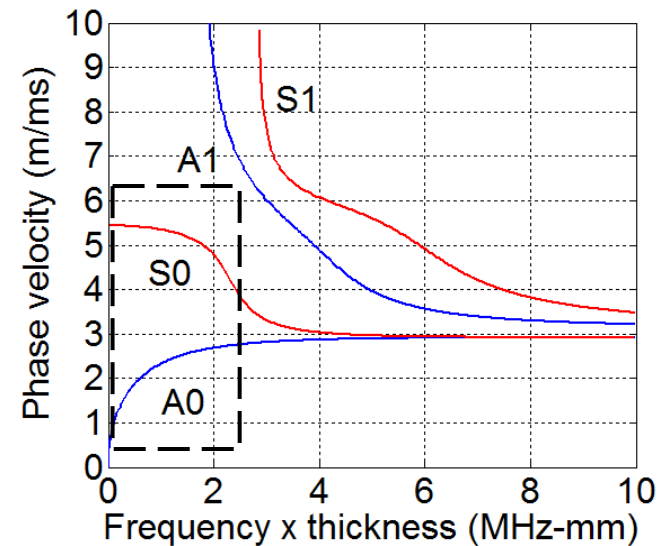
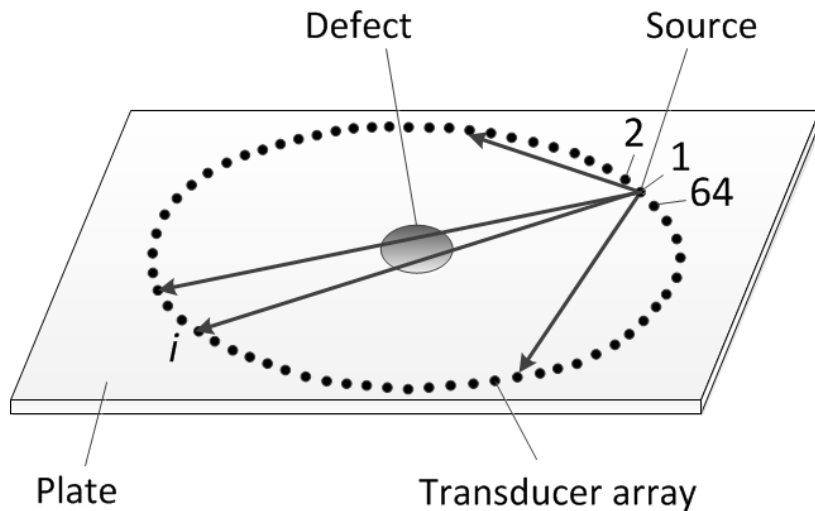
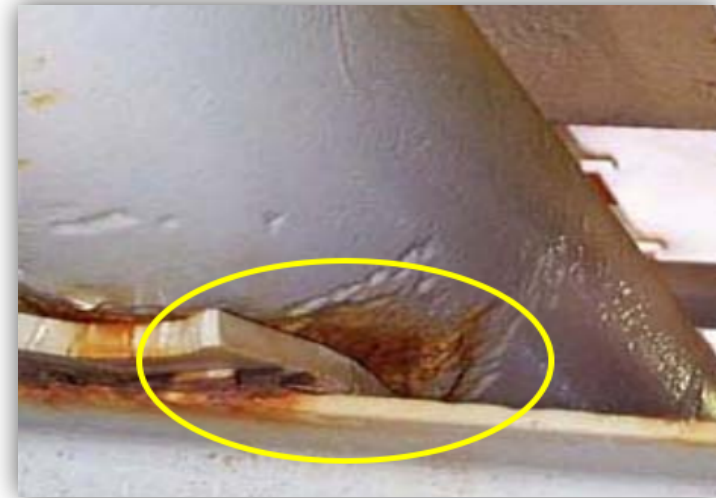
How to accurately characterise real defects?

- More information from defects
- Better imaging algorithms

Tomographic methods

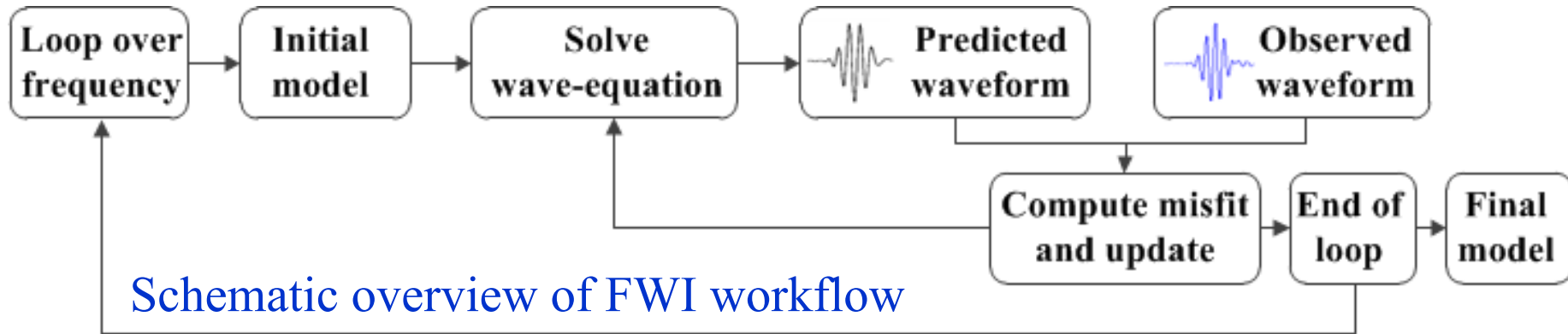


Guided wave tomography for corrosion mapping



Full Waveform Inversion - FWI

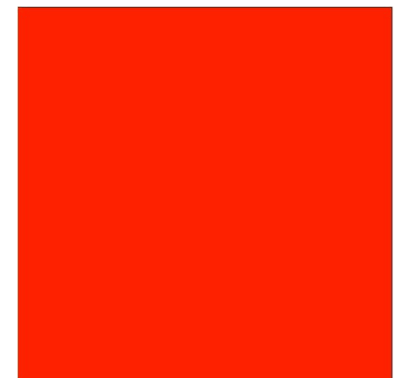
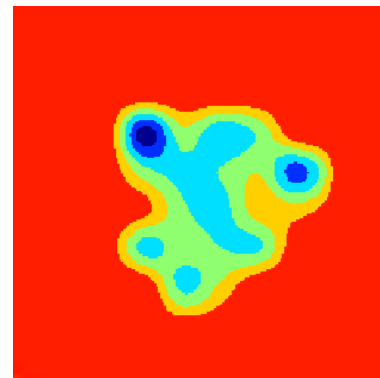
Full Waveform Inversion derives from the goal of fitting the whole waveform by the end of the inversion so that all available information is used.



Novel contributions

- ❖ Higher order scattering effect
- ❖ Multiple frequencies

Original Reconstruction

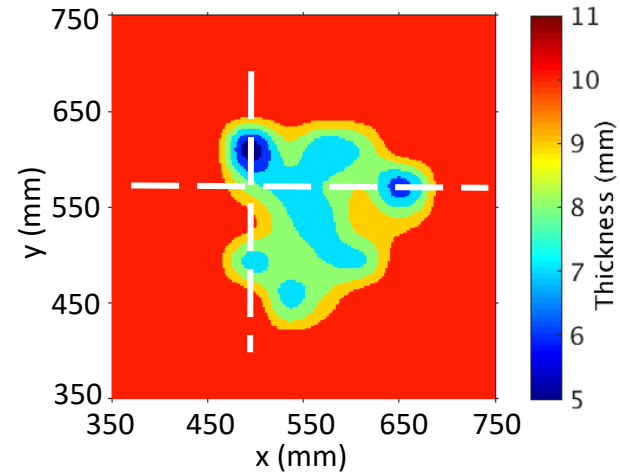


@35kHz

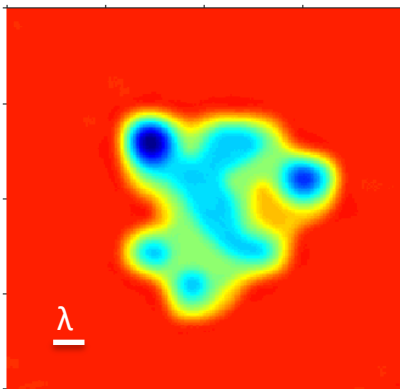
Validation of complex-shaped defect



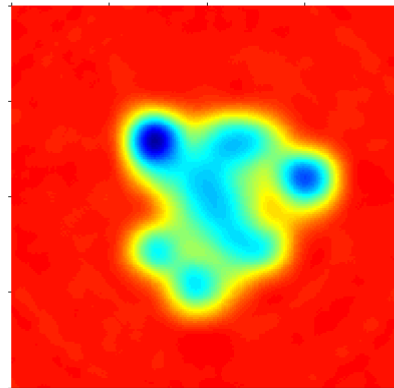
Original thickness map



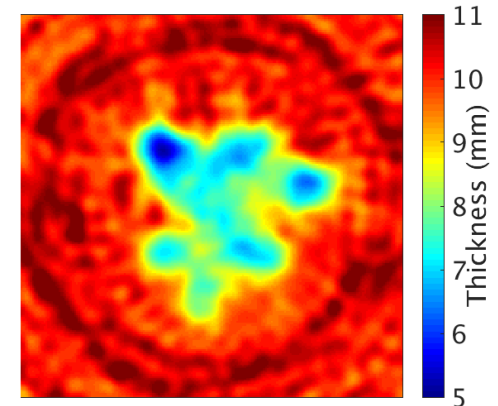
Finite difference (FD)



Finite element (FE)

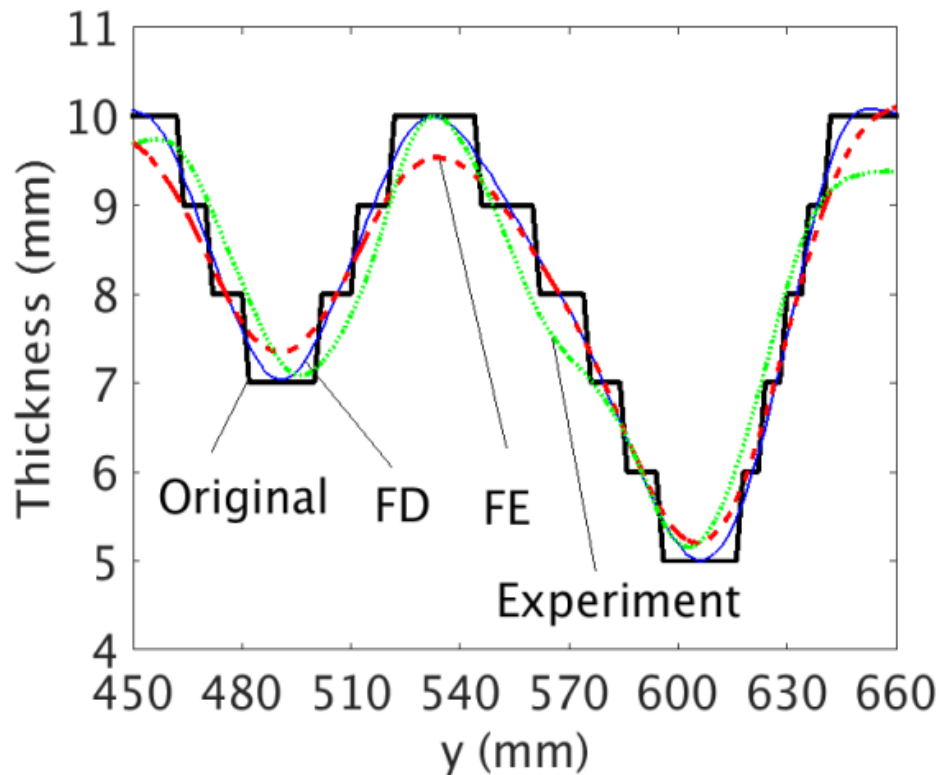


Experiment

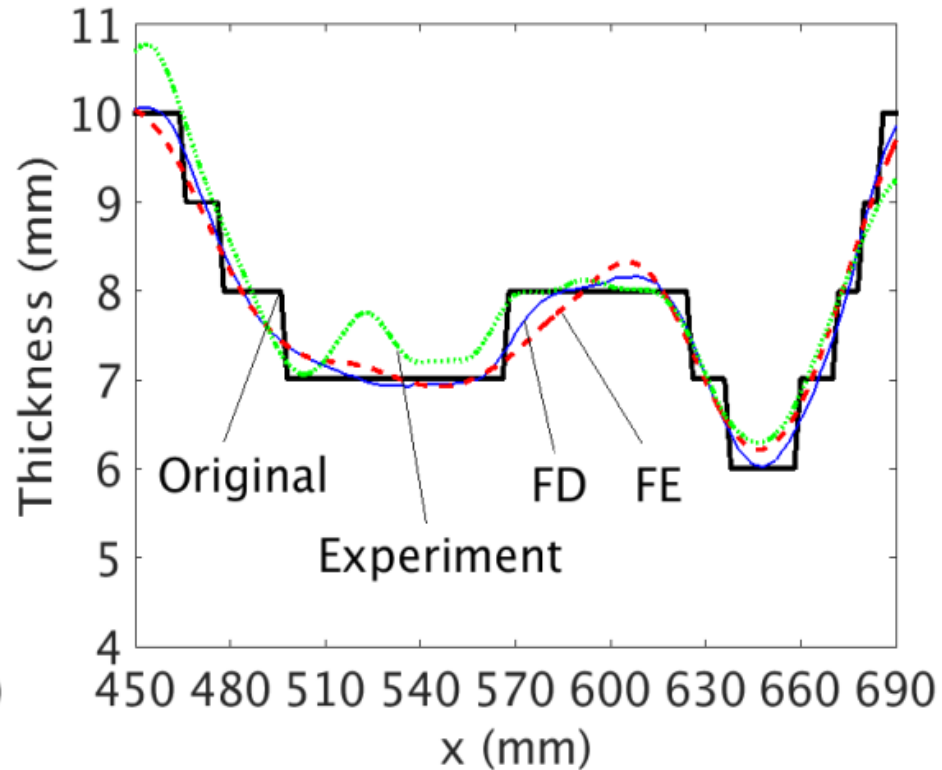


Cross-sectional thickness

Vertical cross section

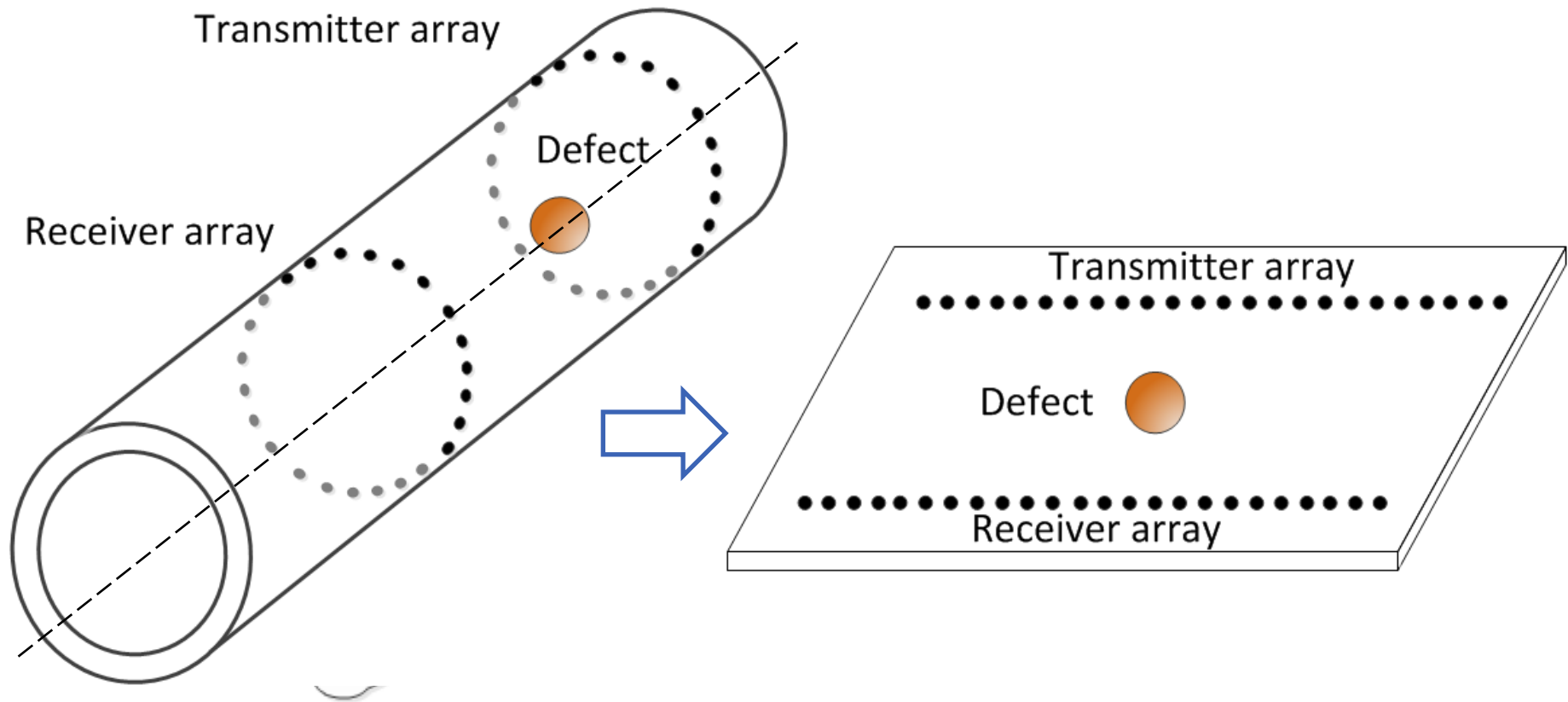


Horizontal cross section



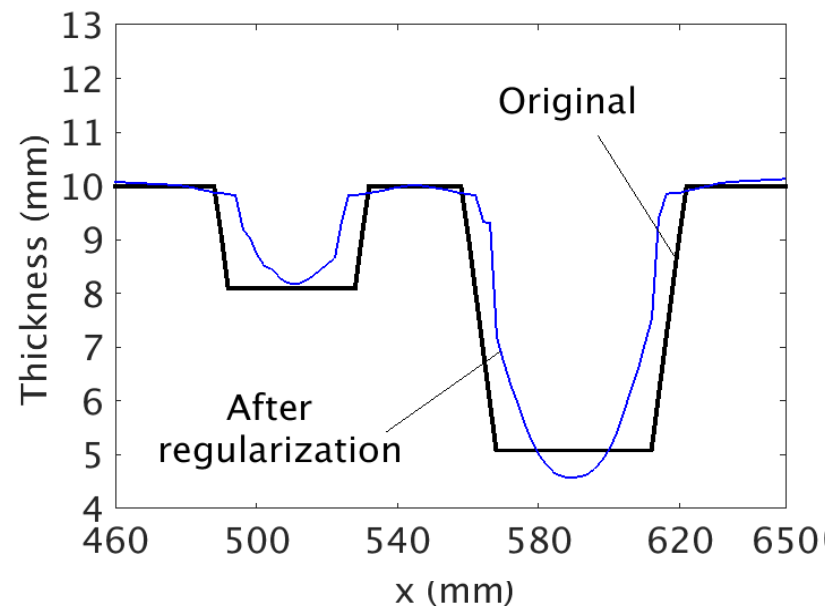
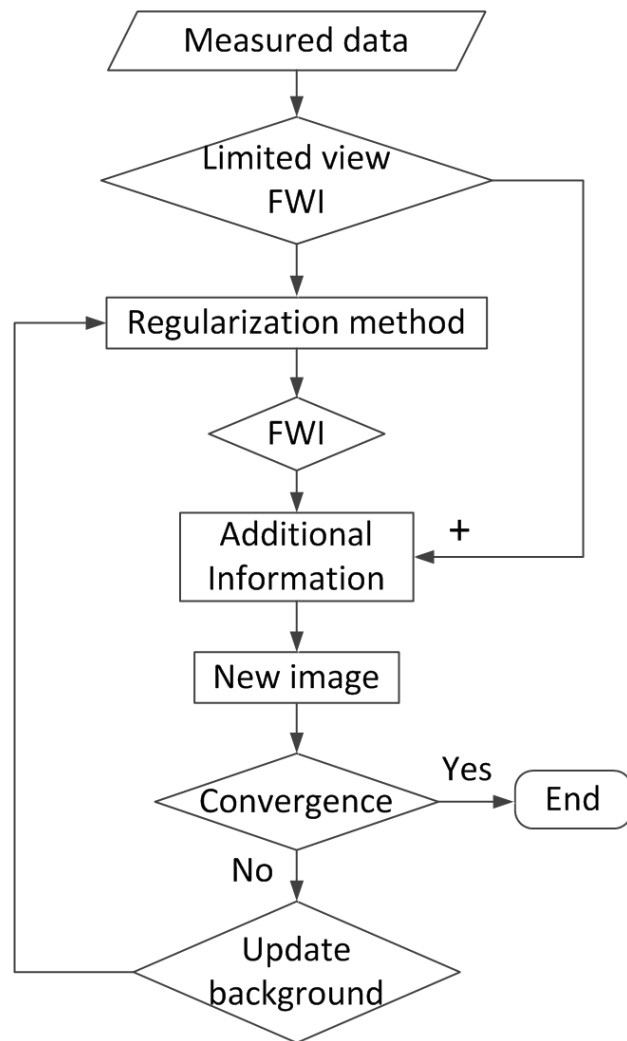
J. Rao, et al. *IEEE Transactions Ultrasonics, Ferroelectrics, and Frequency Control*, 2016, 63(5), 737-745. [**\(Highly Cited Paper\)**](#)

Guided wave tomography of a pipe



Limited view guided wave tomography

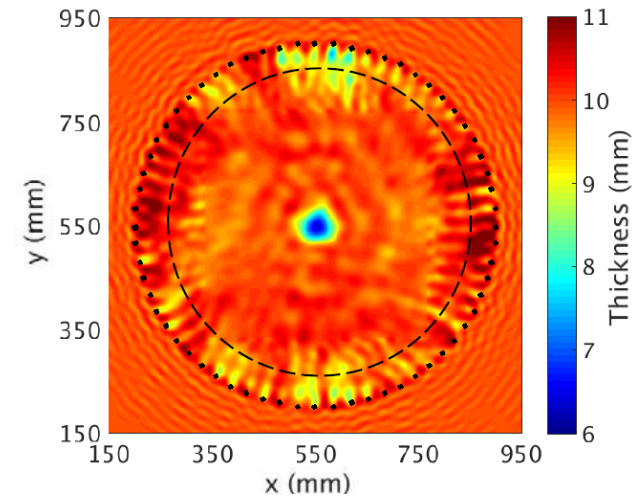
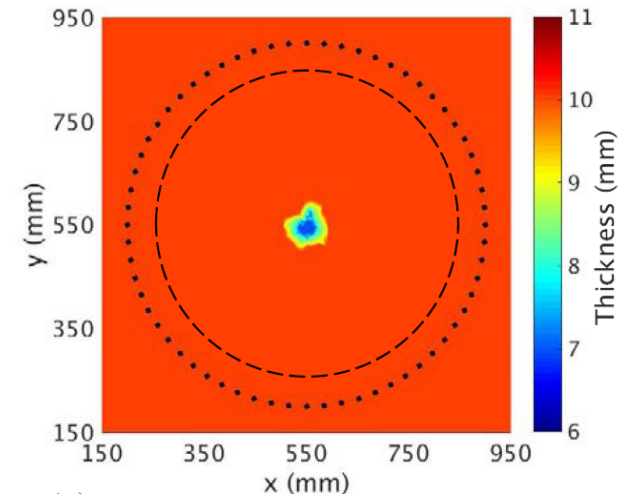
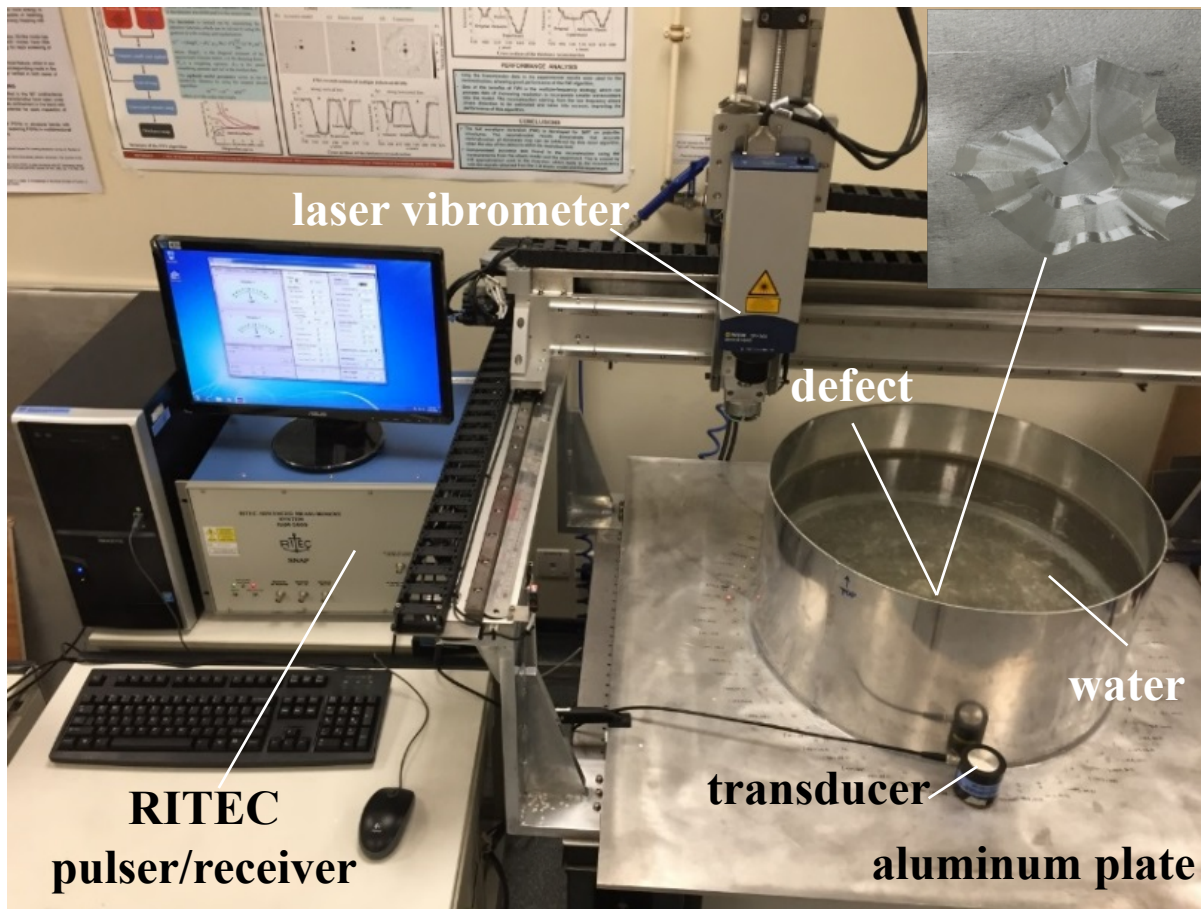
Limited view tomographic reconstruction



J. Rao, et al. *Journal of Applied Physics*, 120 (19) (2016) 194902. **(Featured Cover Paper)**

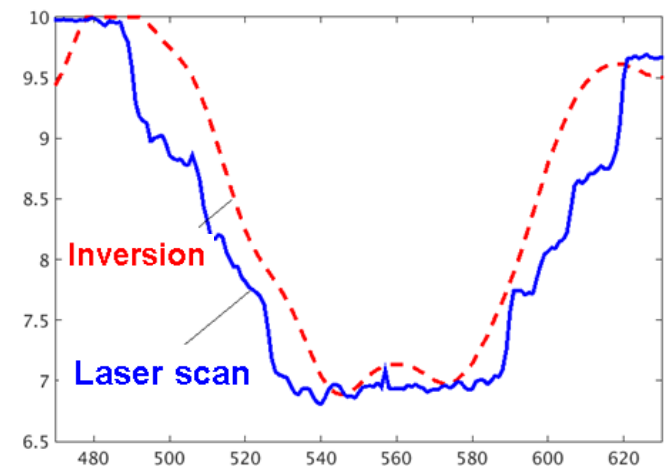
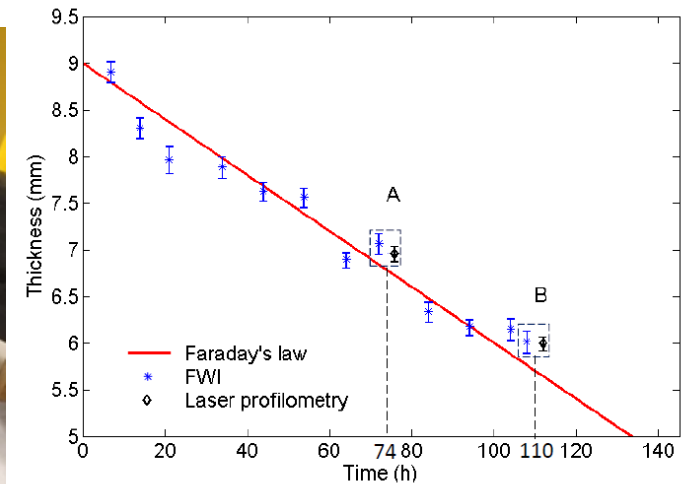
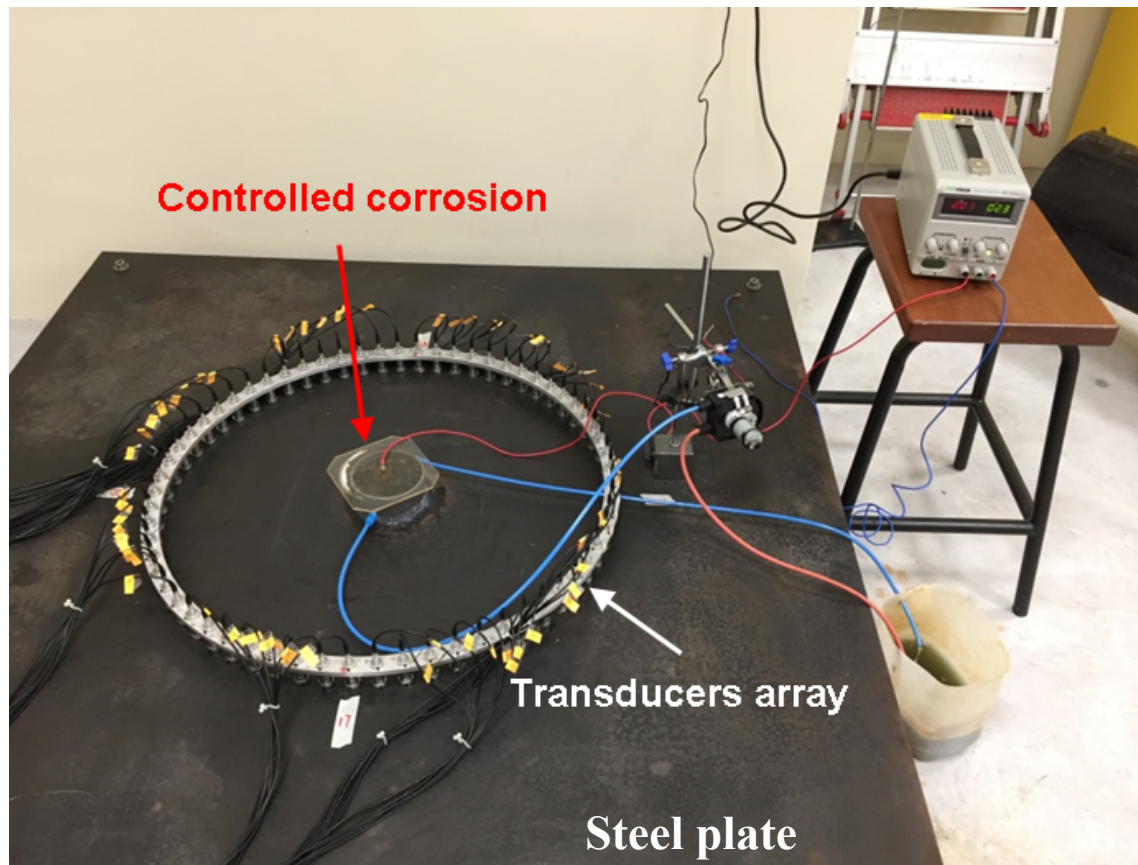
FWI for a limited view configuration using regularization

Thickness mapping of liquid-loaded plate



J. Rao, M. Ratassepp, Z. Fan. *Smart Materials and Structures* 26 (12), 125017.

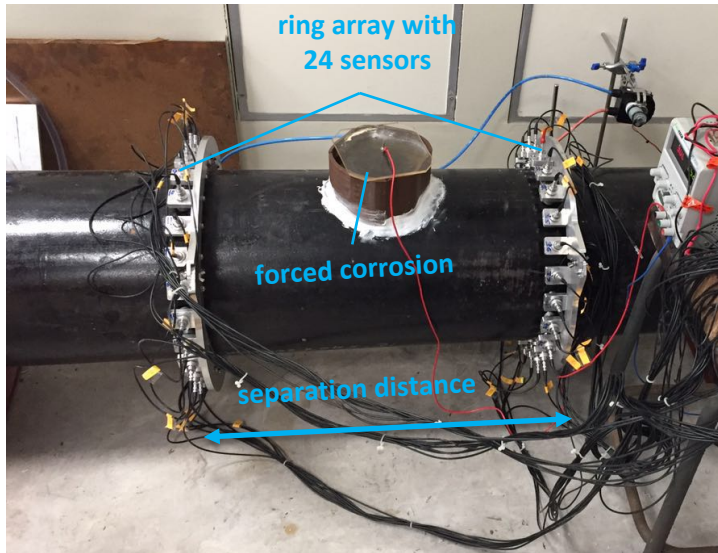
Thickness mapping of accelerated corrosion



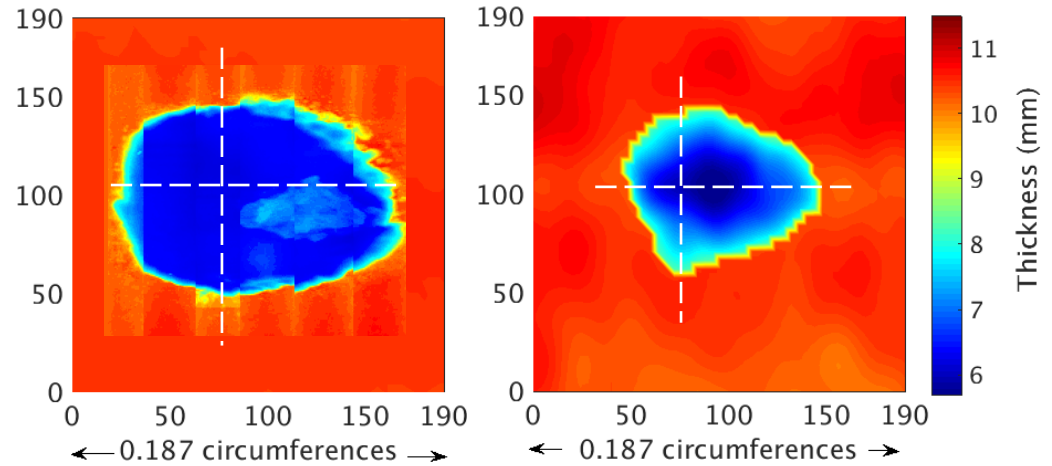
J. Rao, et al. On-Line Corrosion Monitoring of Plate Structures Based on Guided Wave Tomography Using Piezoelectric Sensors. *Sensors*, 17 (12), 2882, 2017.

Reconstruction of steel pipe corrosion

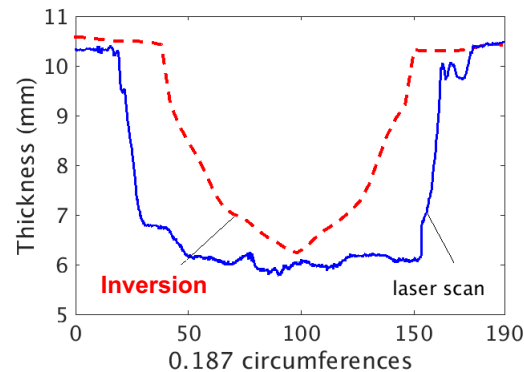
Experimental setup



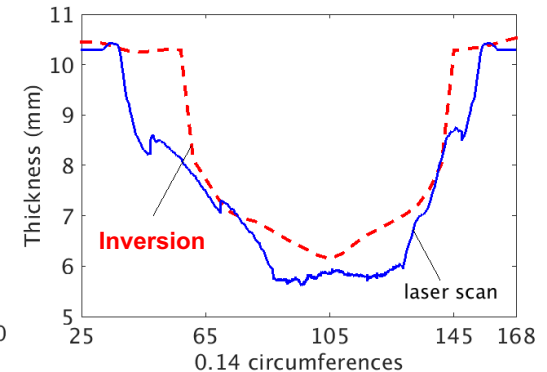
Laser measured profile Reconstructed defect



along horizontal line



along vertical line



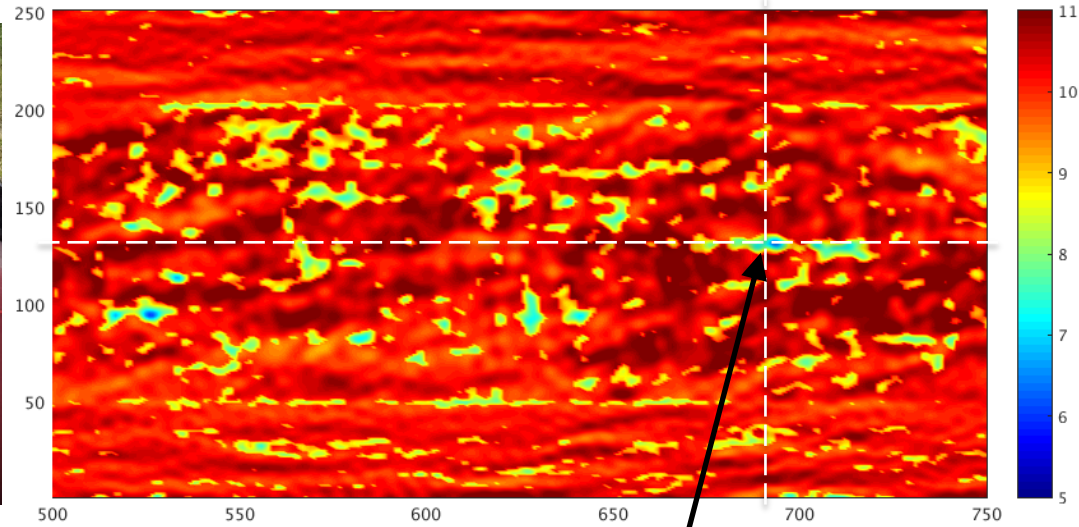
S. Dong and J. Rao, Pipeline Integrity Assessment Technology and Application, Petroleum Industry Press, 2018.

On-site testing of pipes

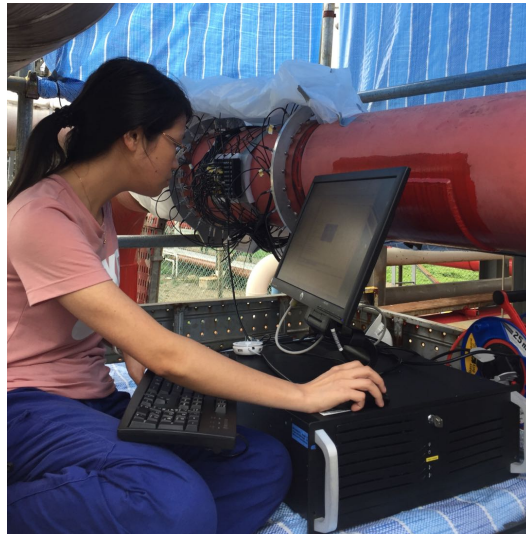
(a)



(b)



(c)



(d)



Location of the pipe support

Thank you for your kind attention!