A method to estimate the size of corrosion patches with guided waves in pipes.

R. Carandente and P. Cawley

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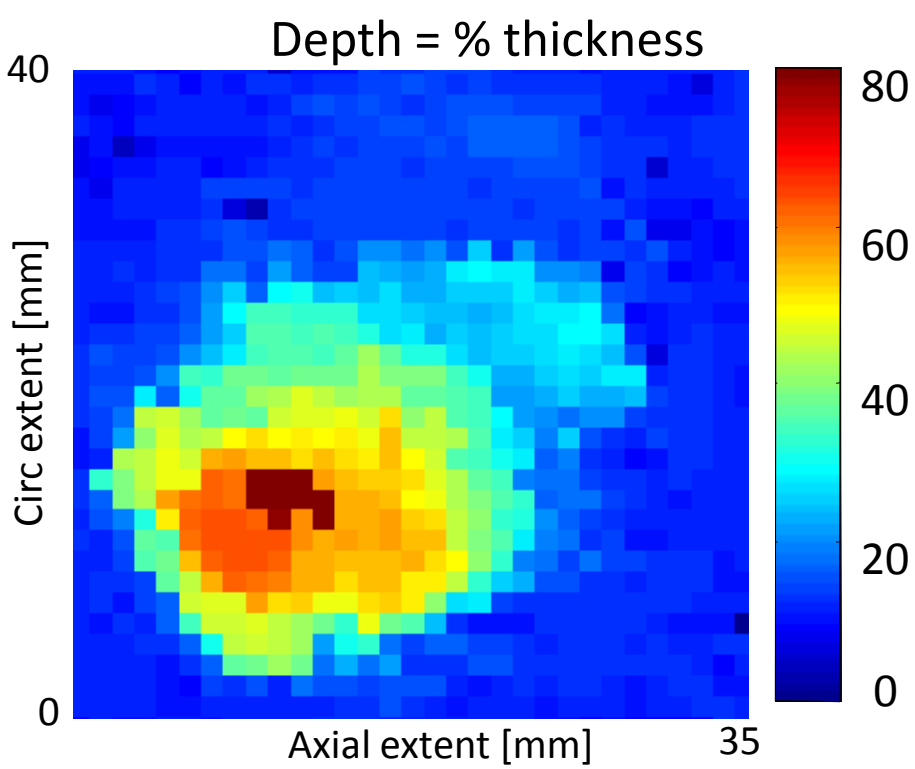
MOTIVATION

A crucial issue in the Oil & Gas industry is to size corroded areas (the maximum depth is a crucial parameter), especially if located in inaccessible sites.

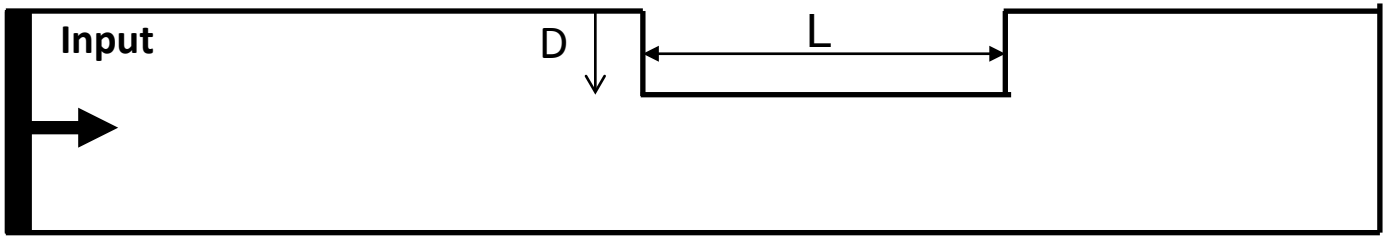


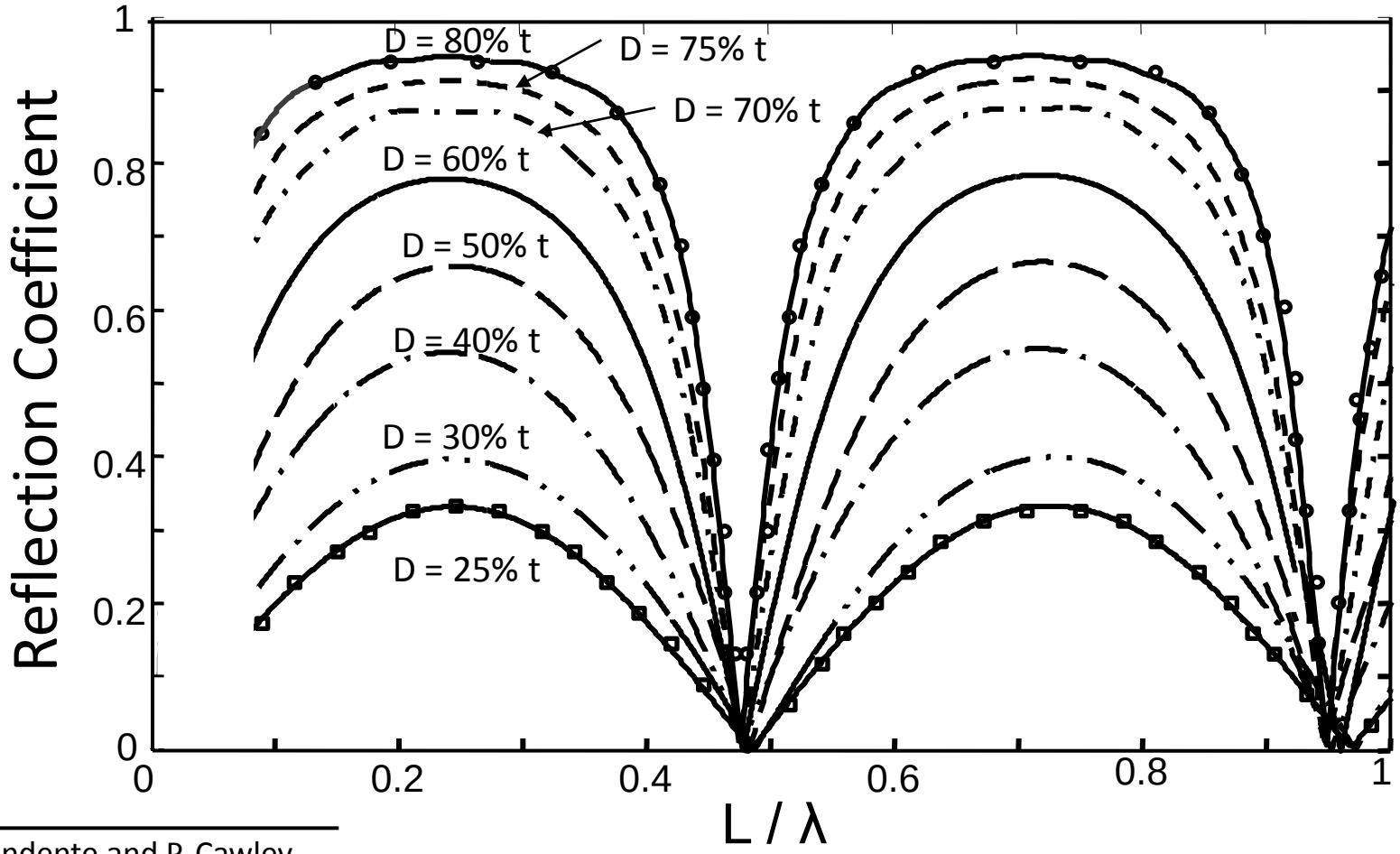
The purpose of this work is to analyze the effect of the shape of a defect on the Reflection Coefficient (RC) spectrum to find a method for remote sizing of defects.

Axisymmetric flat bottomed defects

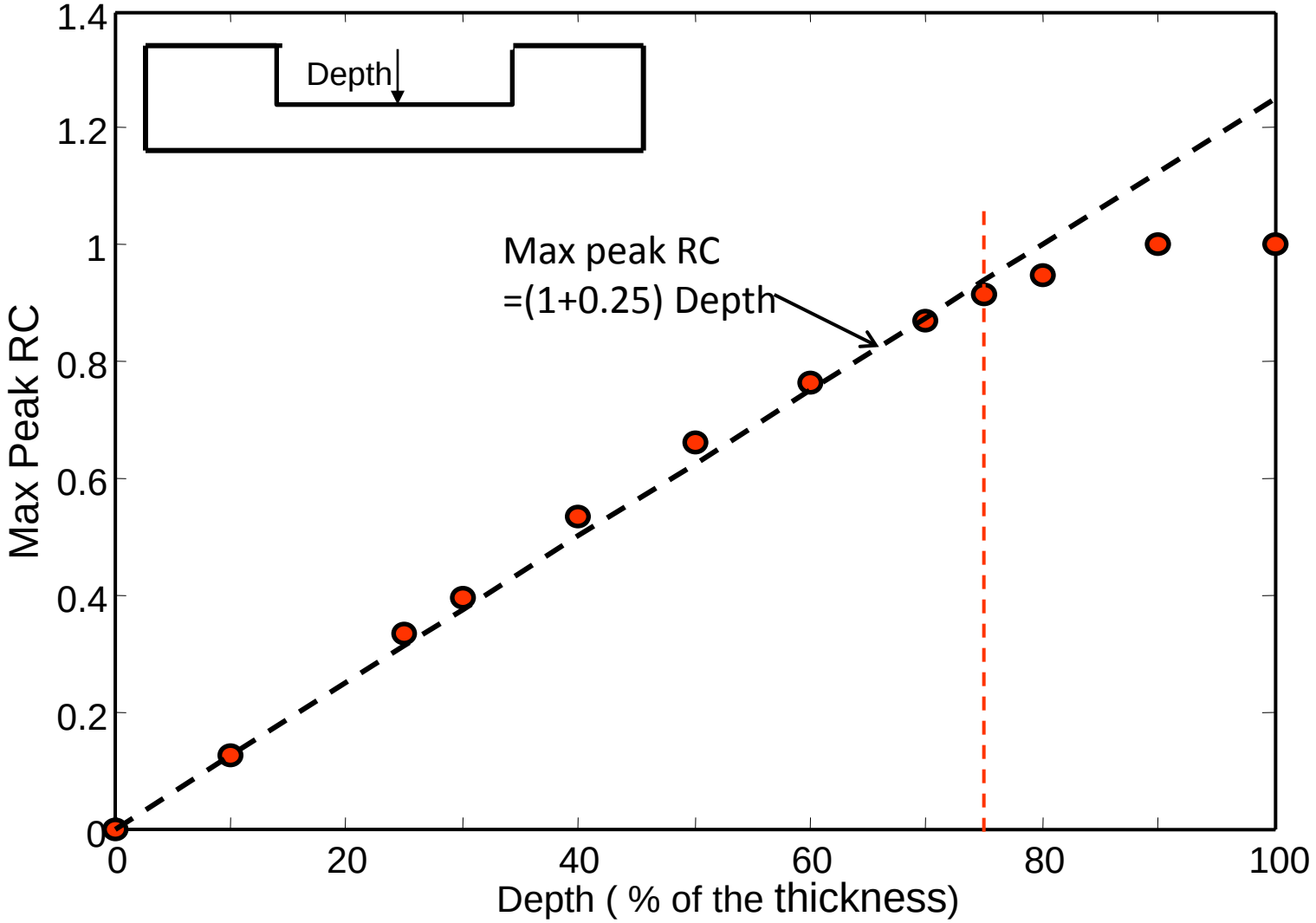
Imperial College London

Section of pipe

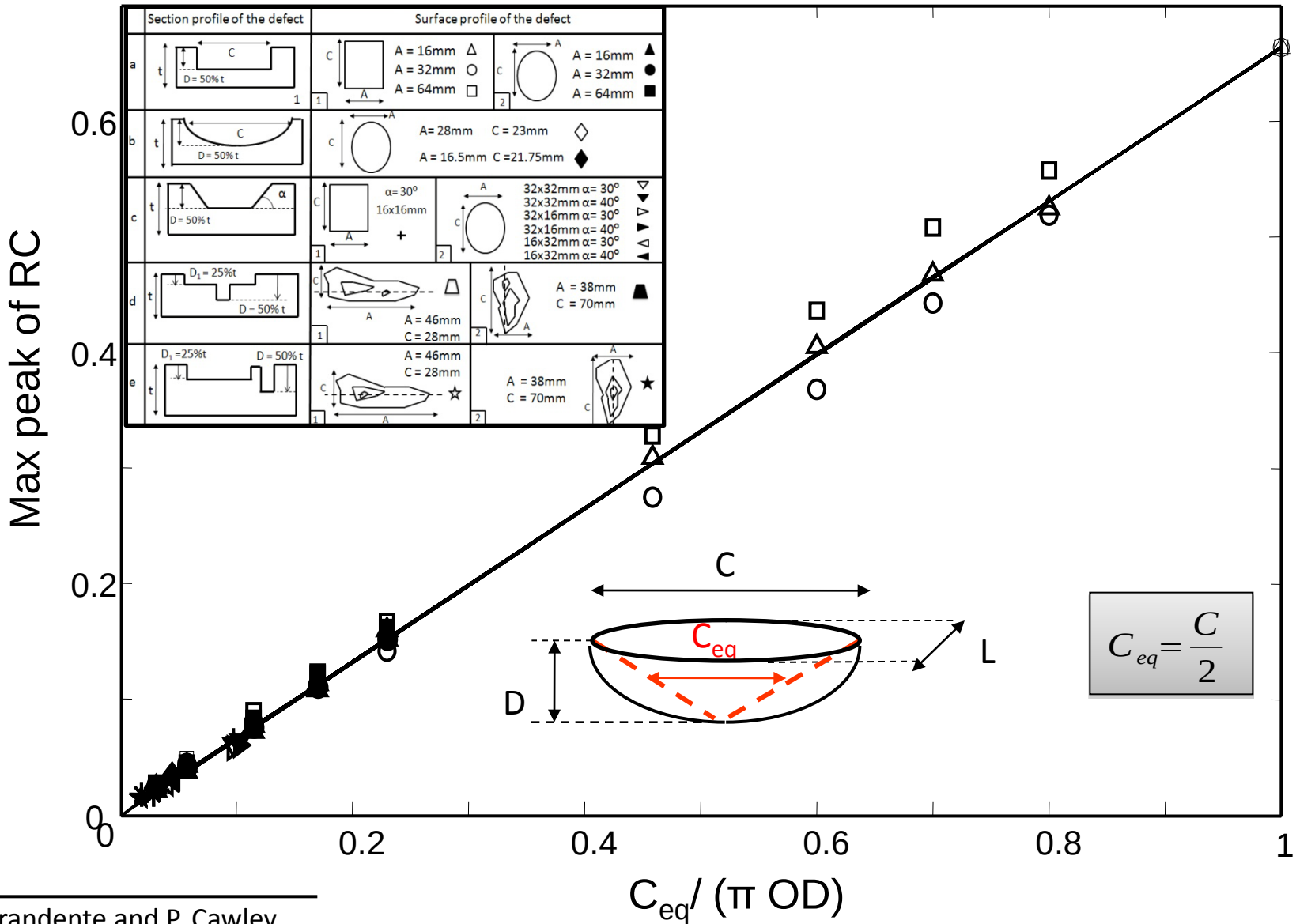




Axisymmetric flat bottomed defects



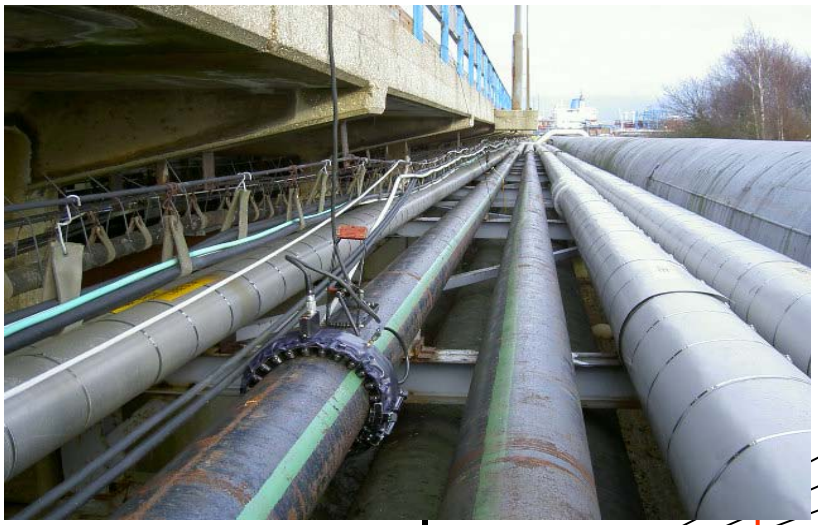
Maximum depth = 50% of the thickness

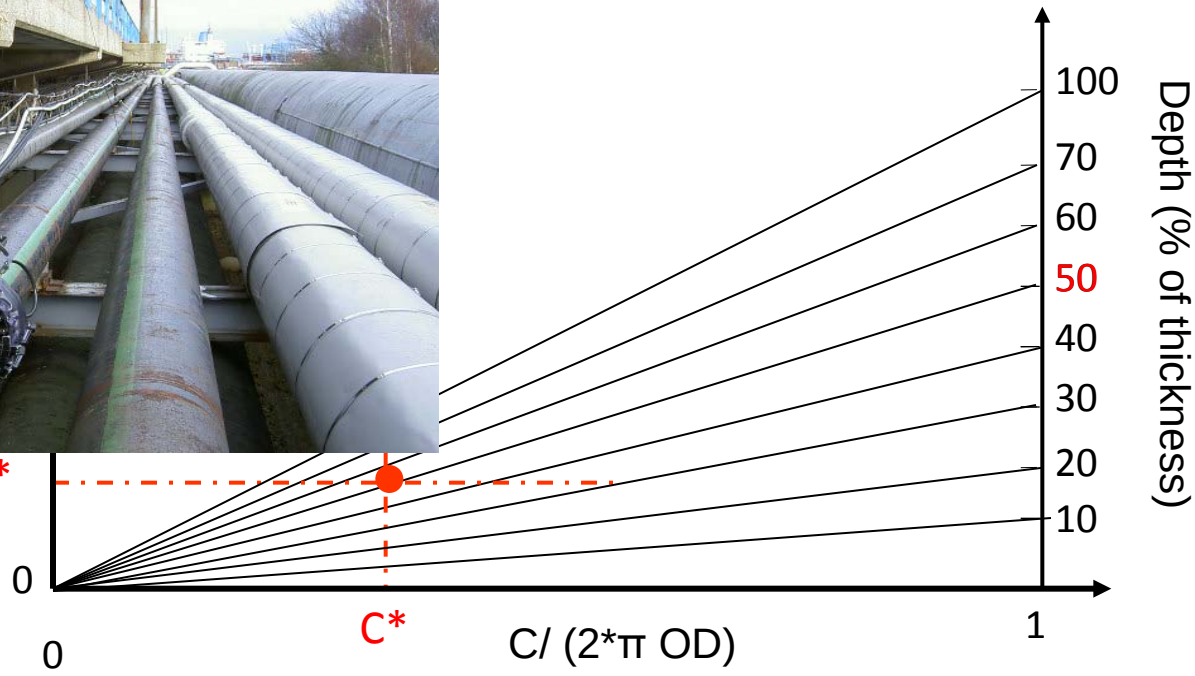


Numerical depth estimation

Method

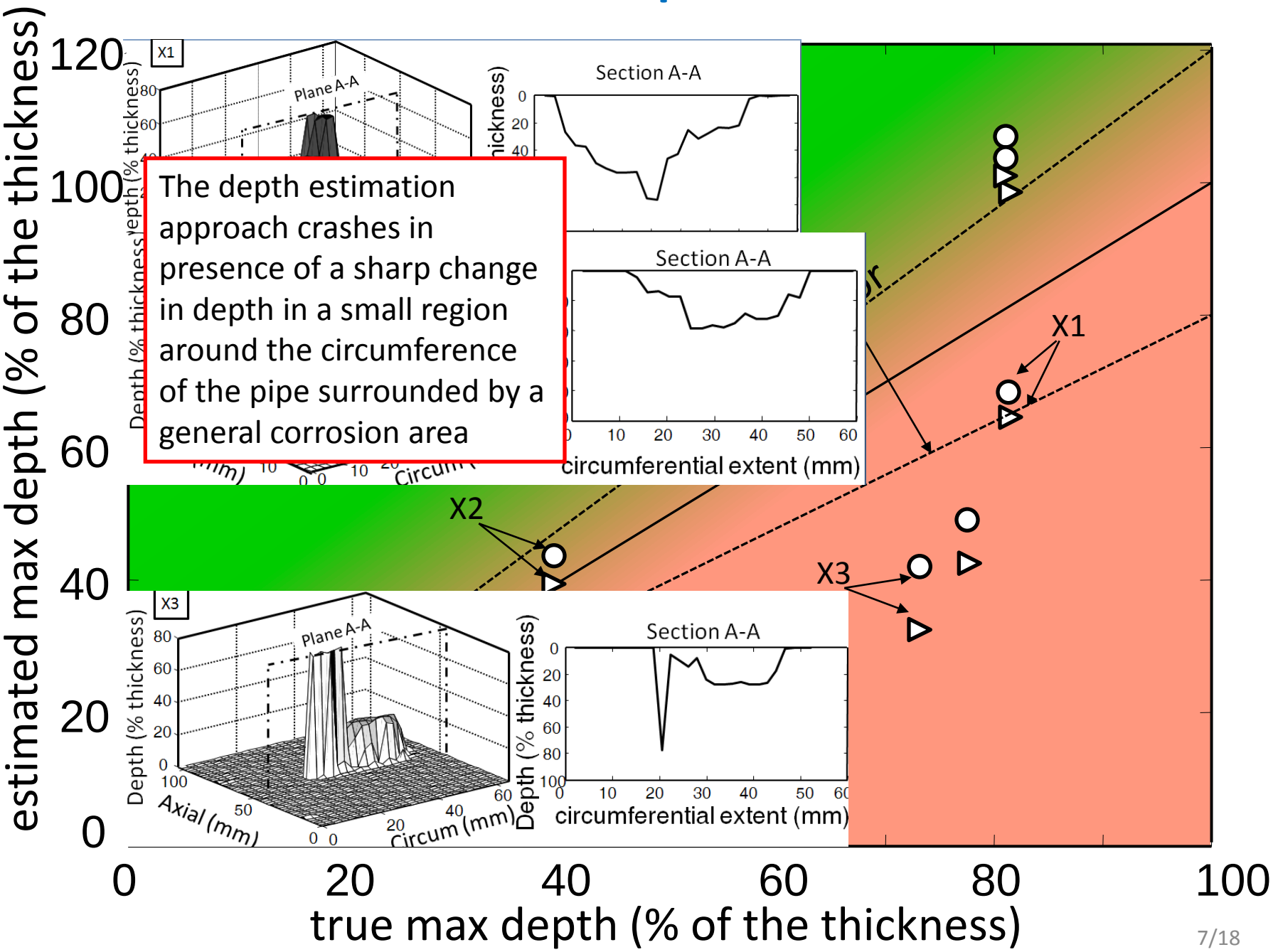
Assuming linear relation between the maximum peak of the RC and depth of an axi symmetric defect (valid for D<75% t)



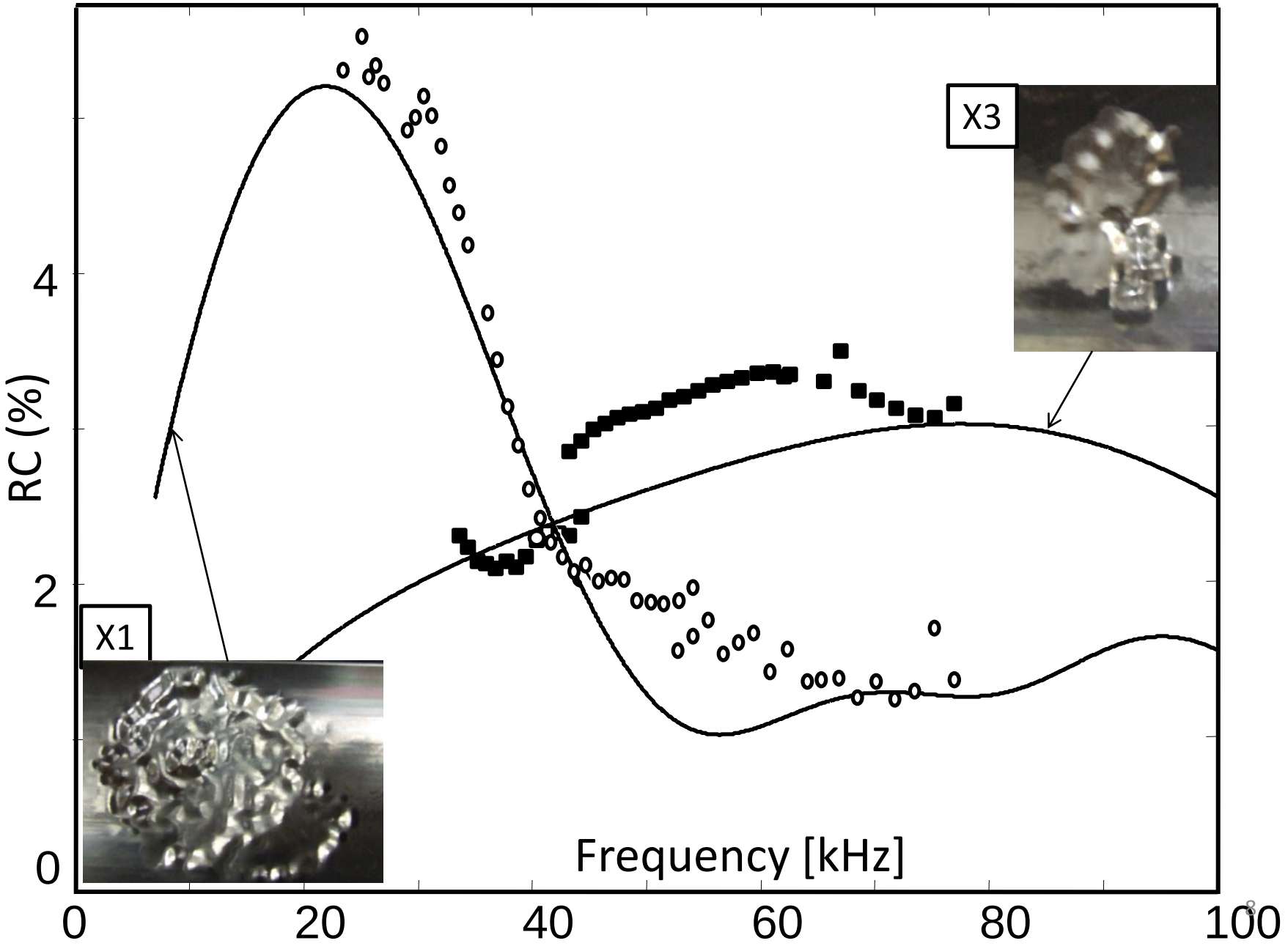


Circumferential extent of the defect has to be determined by another technique (especially for defects of sub-wavelength size , C≤ λ)

Numerical depth estimation

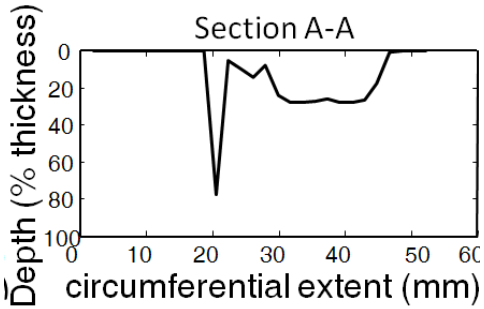


Validation of the model



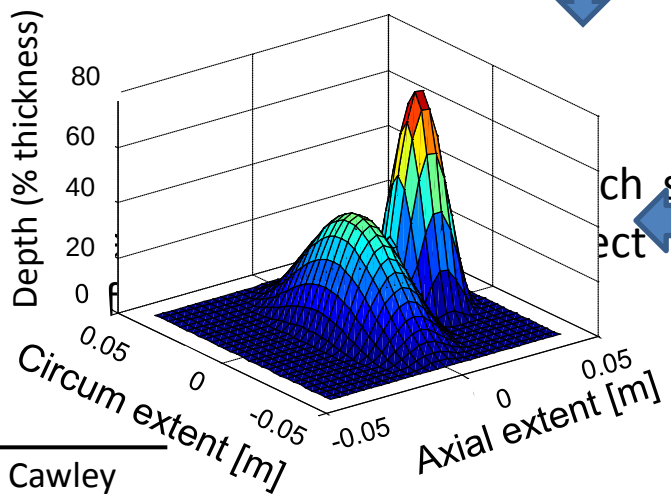
Limitation of the method

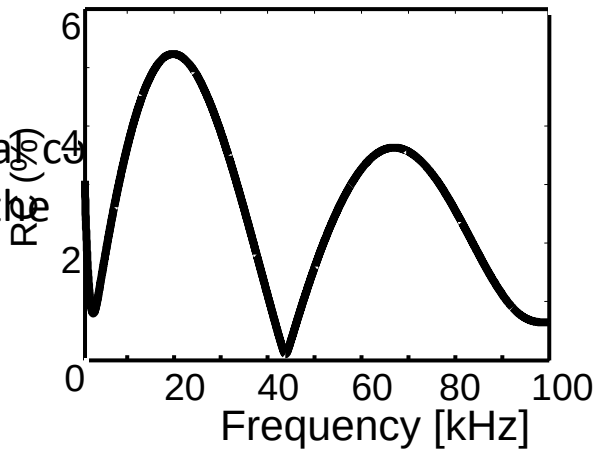
PROBLEM : The depth estimation approach crashes if a sharp change in depth is present within a small region around the circumference of the pipe surrounded by a general corrosion area.



IDEA: Try to diagnose the presence of this kind of defect in order to adapt the method to such cases.

APPROACH : ch spatial c
ect on the





Defect diagnostic- Complex defects

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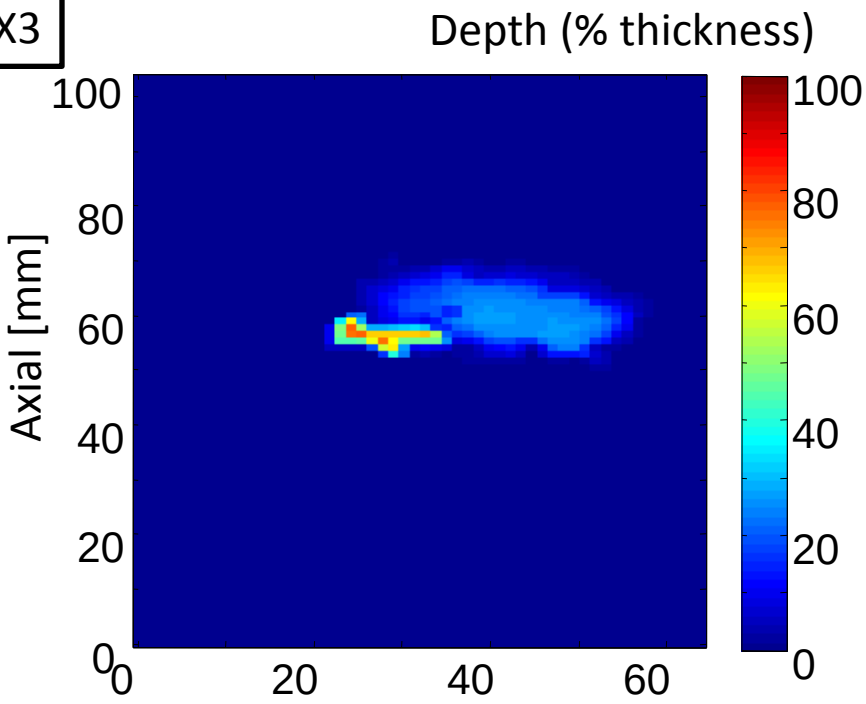
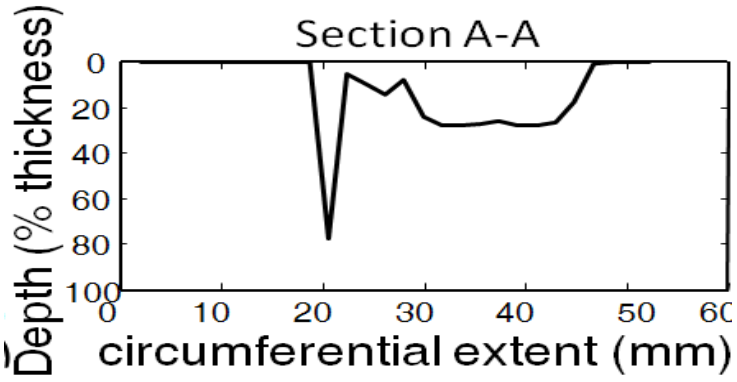
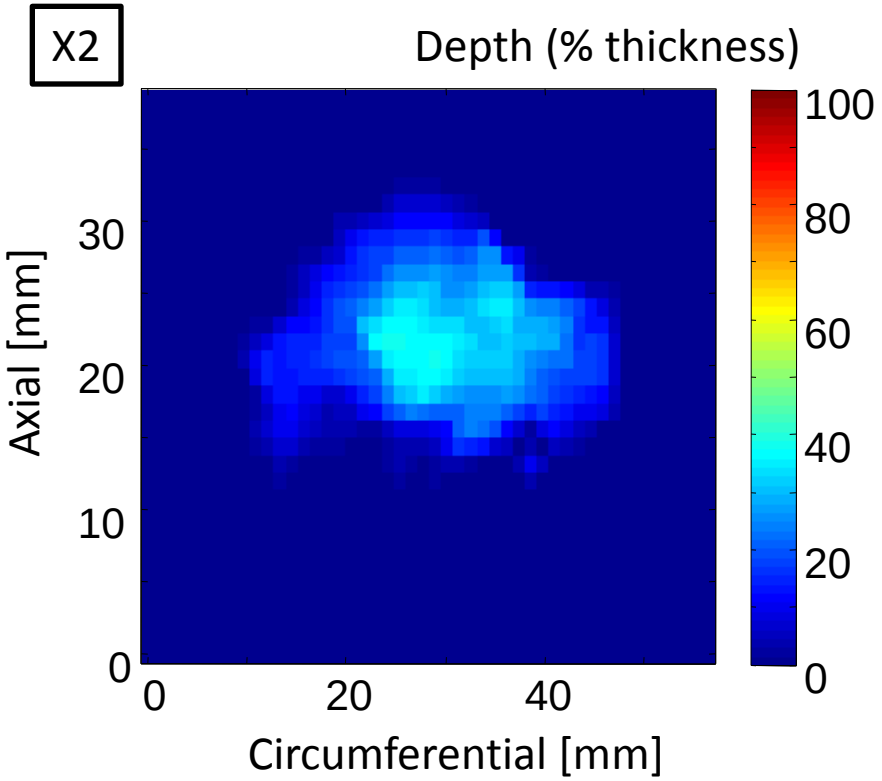
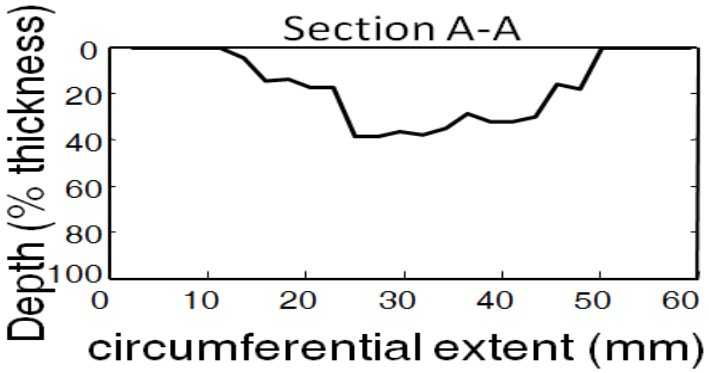
X3



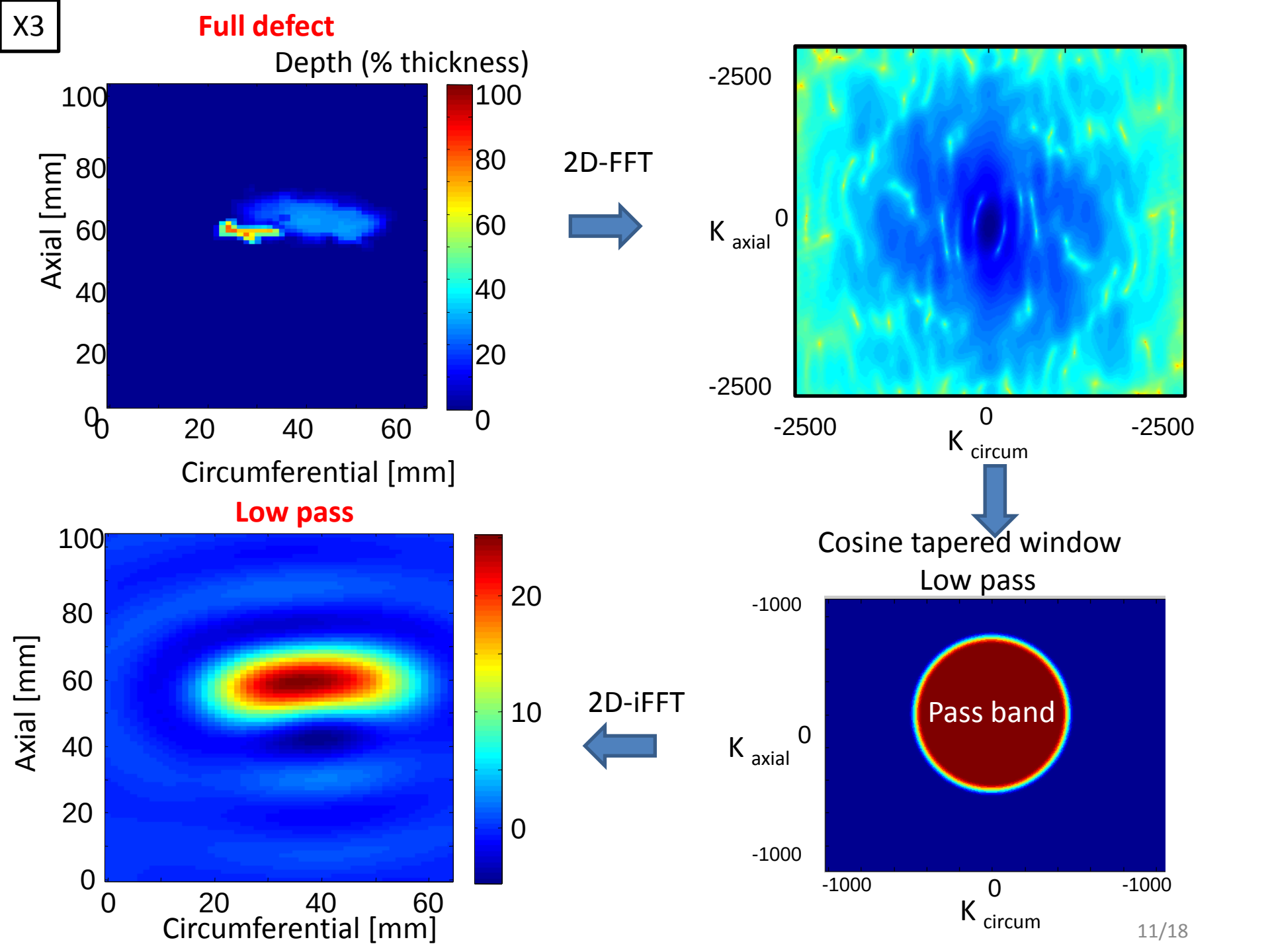


X2



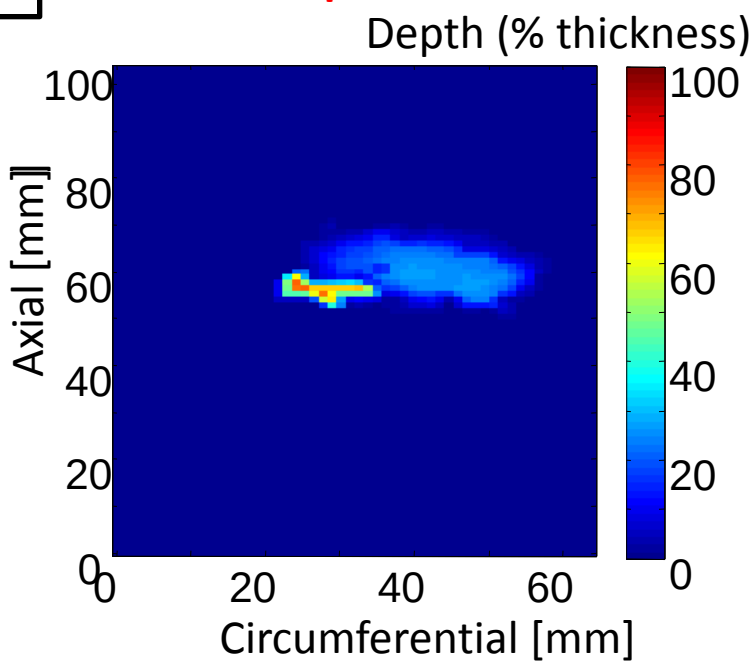


X3

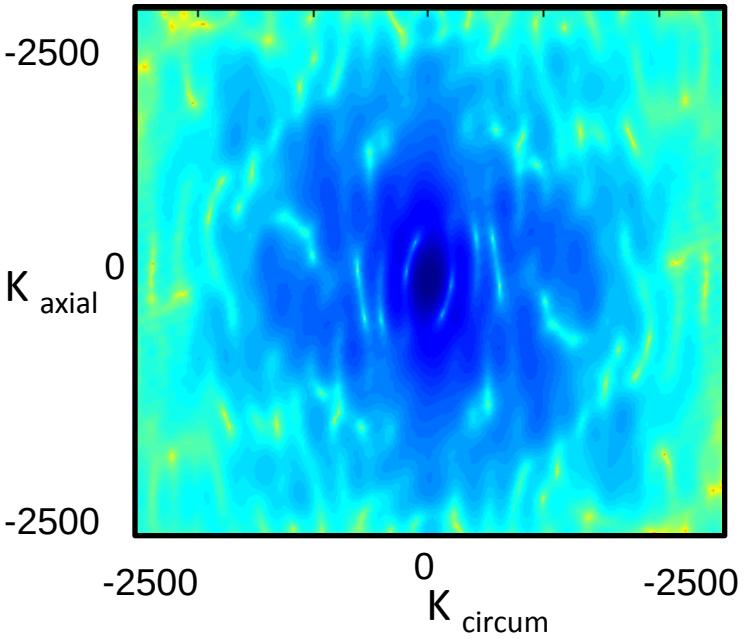

Full defect
Depth (% thickness)
Axial [mm]
Circumferential [mm]
2D-FFT
K axial
K circum
Cosine tapered window
Low pass
Pass band
2D-iFFT
Low pass
Axial [mm]
Circumferential [mm]

X3

Full profile

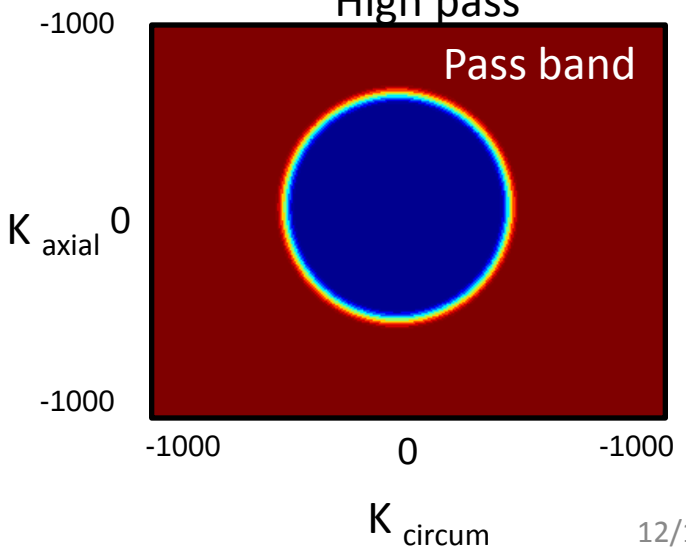


2D-FFT



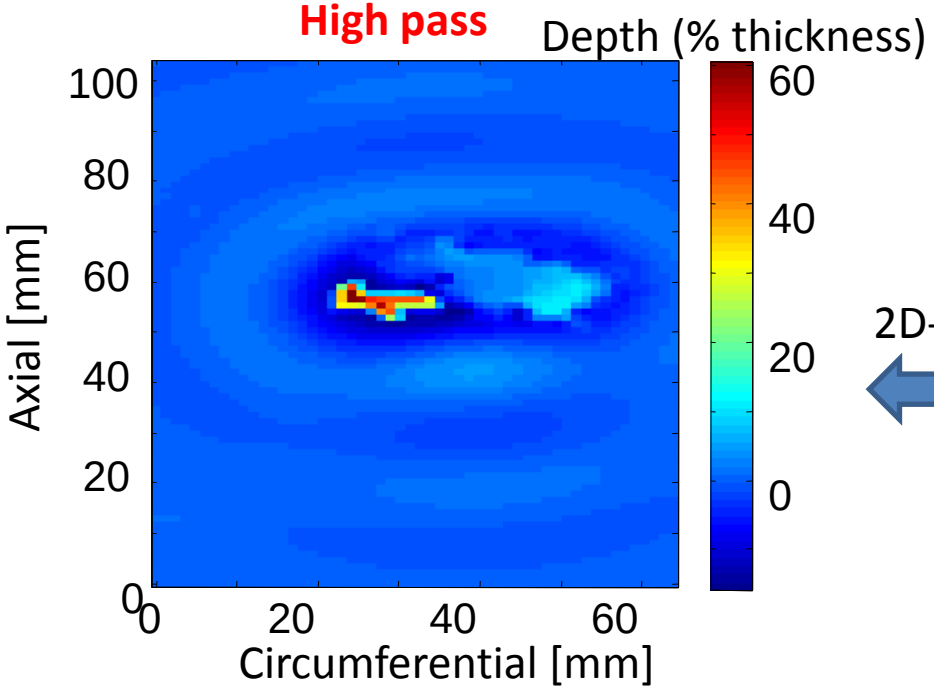
Cosine tapered window

High pass



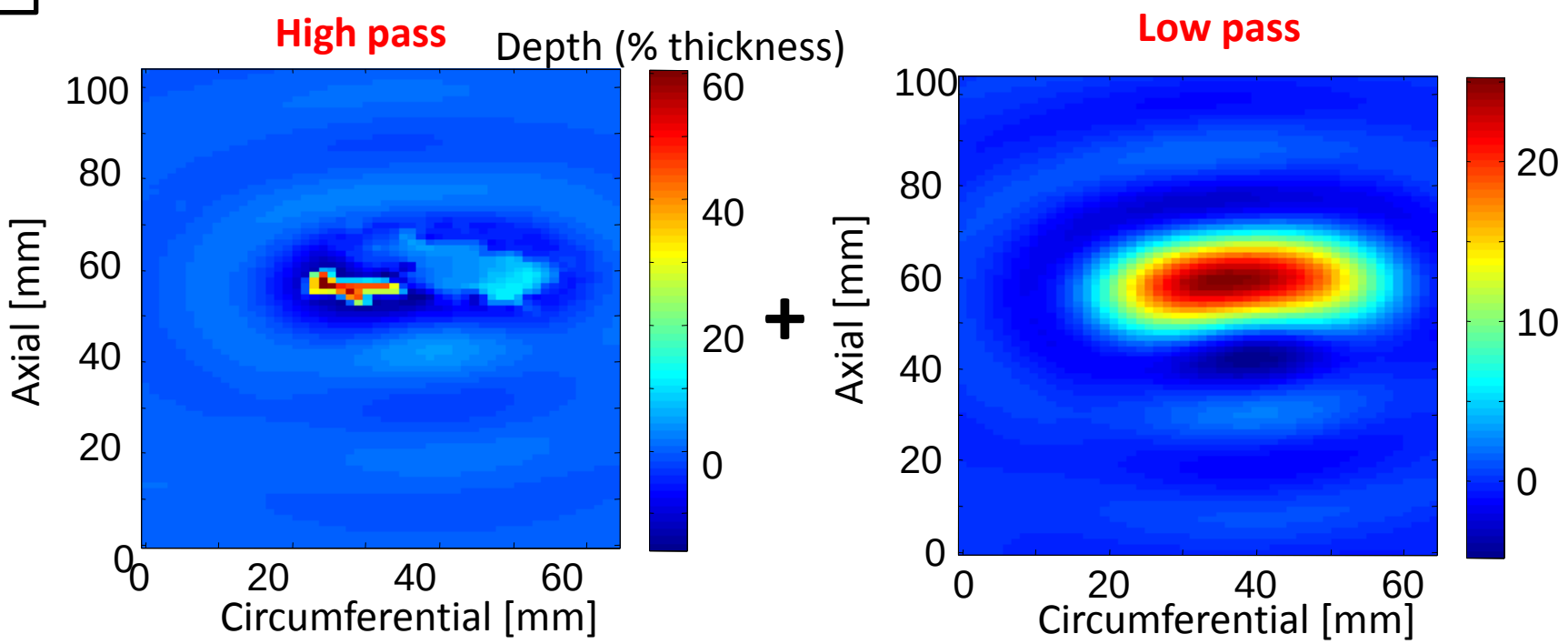
2D-iFFT

High pass

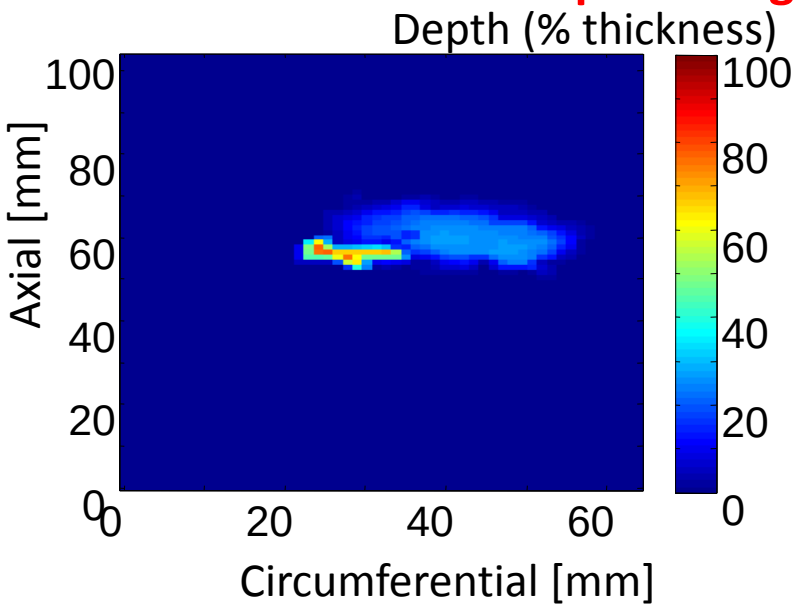


X3

The original profile can be reconstructed by the superposition of the two defect matrices

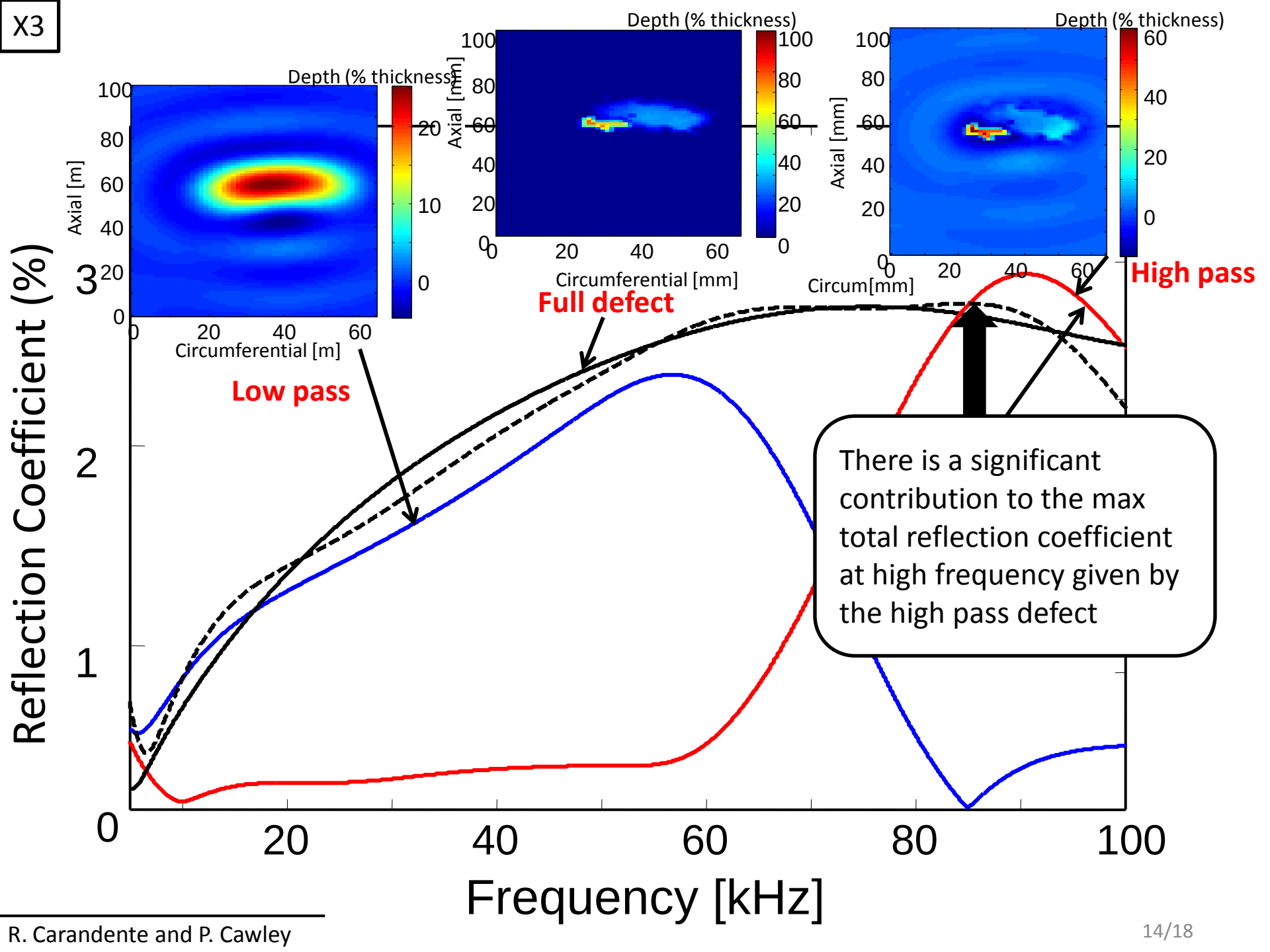


Reconstructed defect = Low pass + High pass

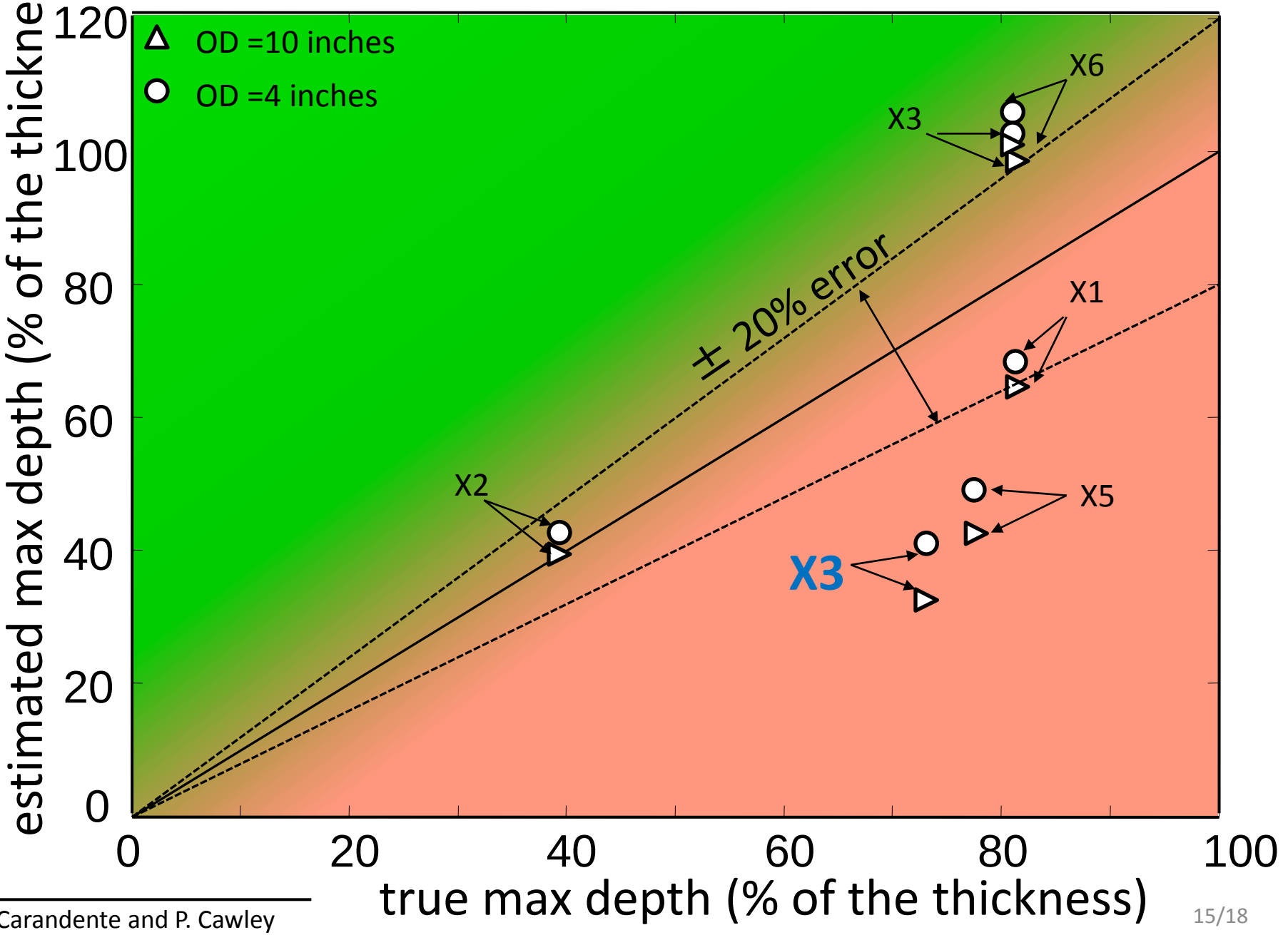


Max Error is ~ 10^{-4}

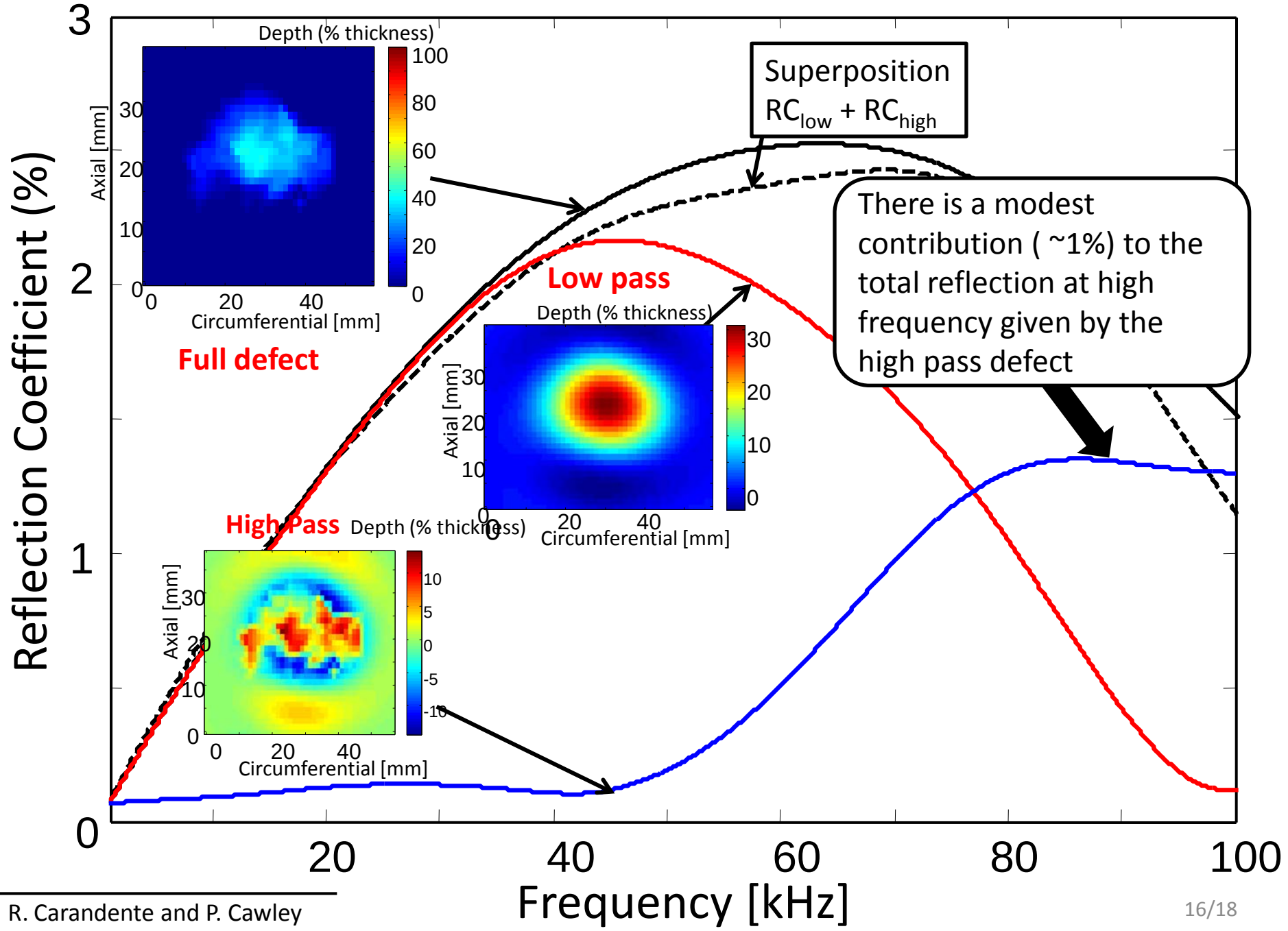
X3


Depth (% thickness)
Axial [m]
Circumferential [m]
Depth (% thickness)
Axial [mm]
Circumferential [mm]
Depth (% thickness)
Axial [mm]
Circum[mm]
High pass
Full defect
Low pass
There is a significant contribution to the max total reflection coefficient at high frequency given by the high pass defect
Reflection Coefficient (%)
Frequency [kHz]

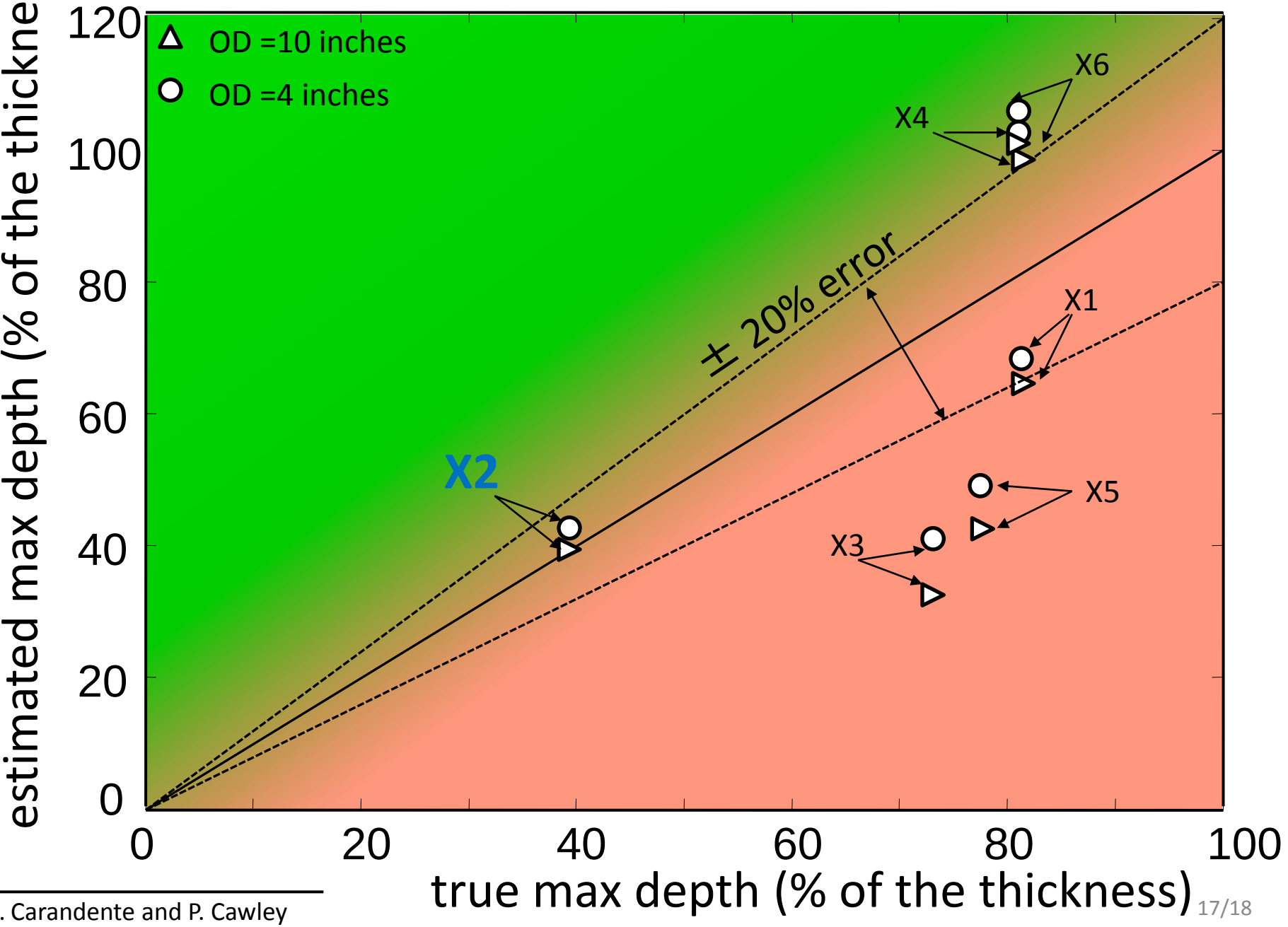
Numerical depth estimation



The superposition of the two defects works also for the reflection coefficient



Numerical depth estimation



CONCLUSIONS

The **depth estimation method**

works for defects with a gradual variation of the depth along the circumferential direction (provided the circumferential extent is known).

does not work if a sharp change in depth is present within a small region around the circumference of the pipe surrounded by a general corrosion area (problematic defect).

From the **decomposition of a defect** in the spatial frequency domain analysis:

- ❖if there is a significant *high frequency* reflection then sharp change in depth is present in a general corroded area and therefore the method is unreliable.

FUTURE

- ❖Adapt the depth estimation method for problematic defects by changing the approximation of the defect profile along the circumferential direction.

- ❖Determine a method to estimate the external circumferential extent of sub-wavelength size defects

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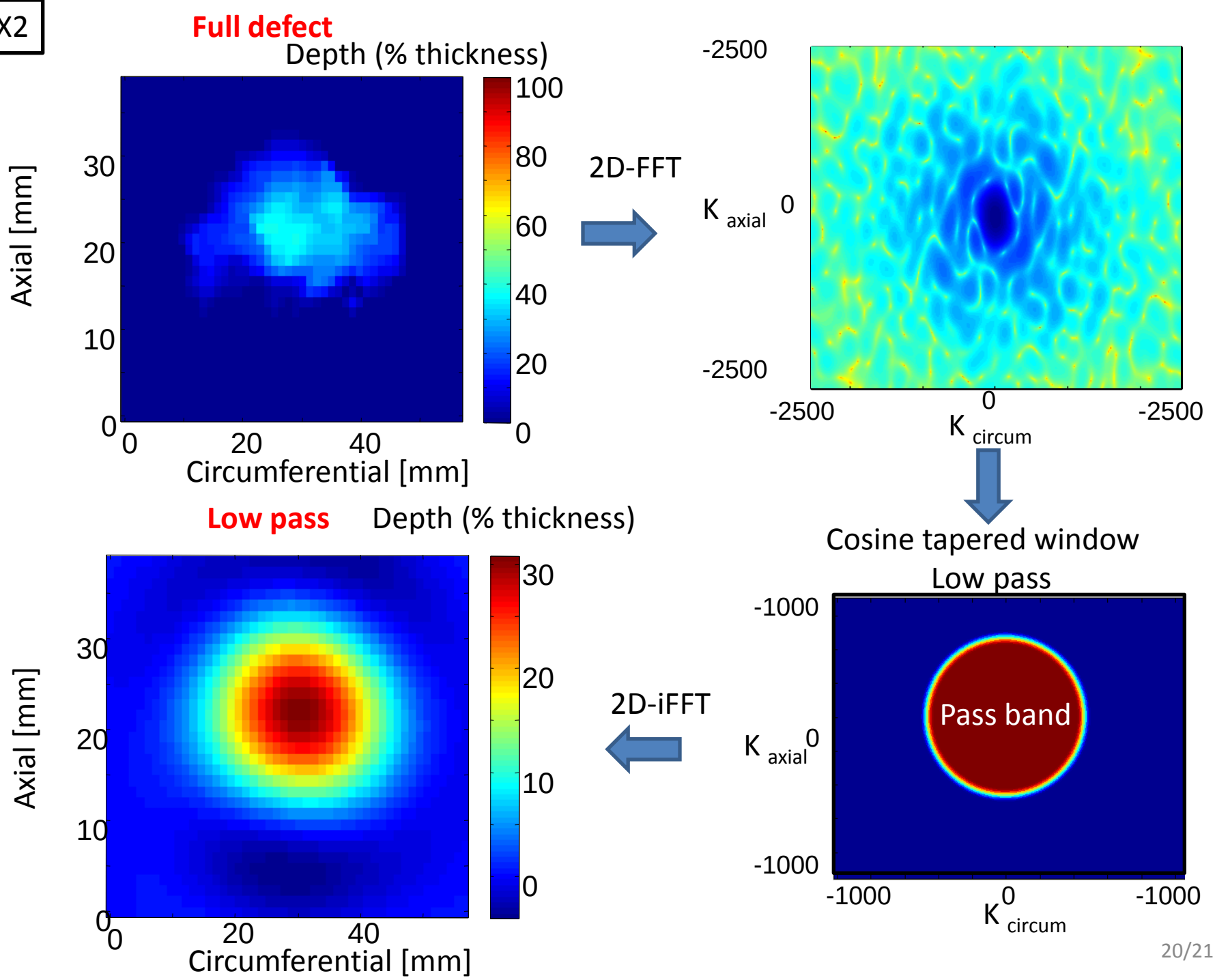
X2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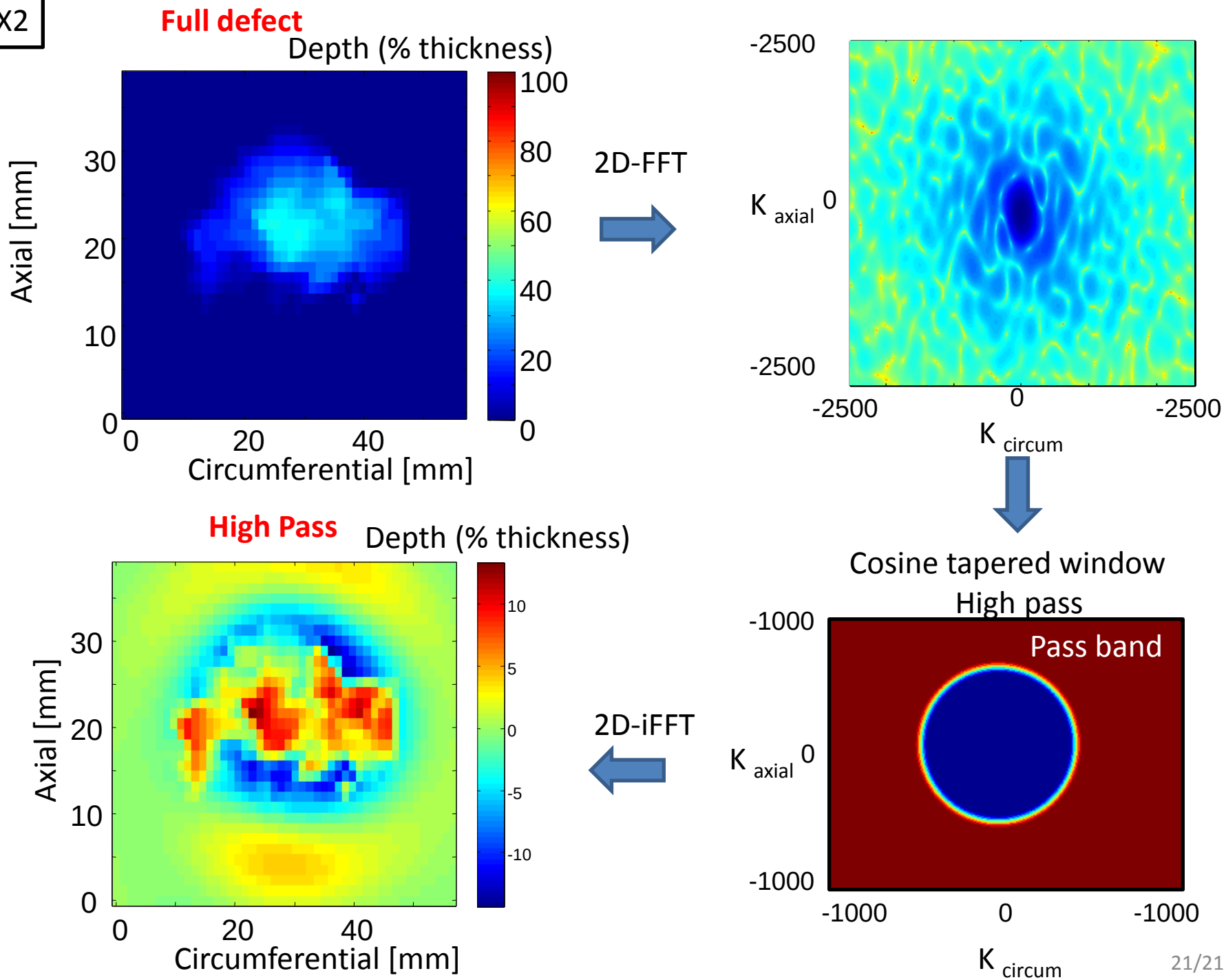
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High pass
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2D-iFFT
High Pass
Depth (% thickness)
Axial [mm]
Circumferential [mm]

X2

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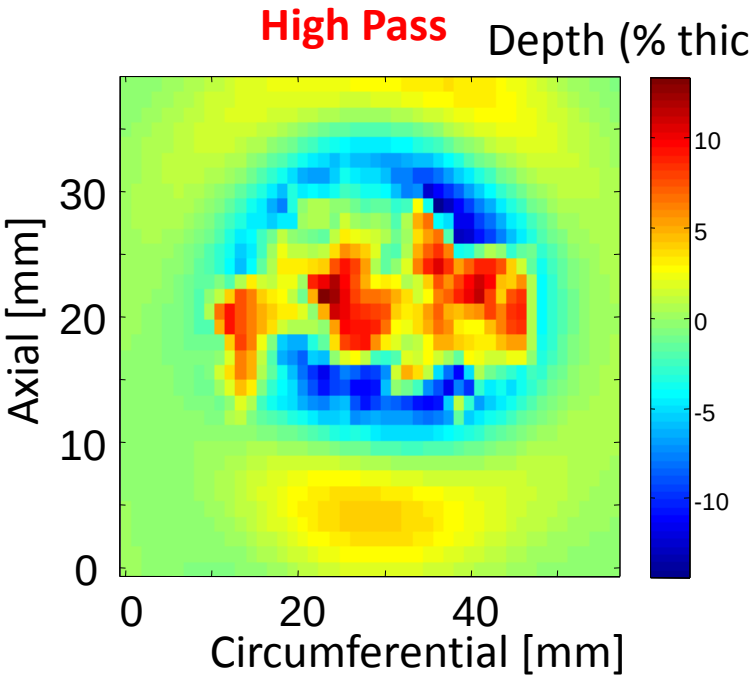
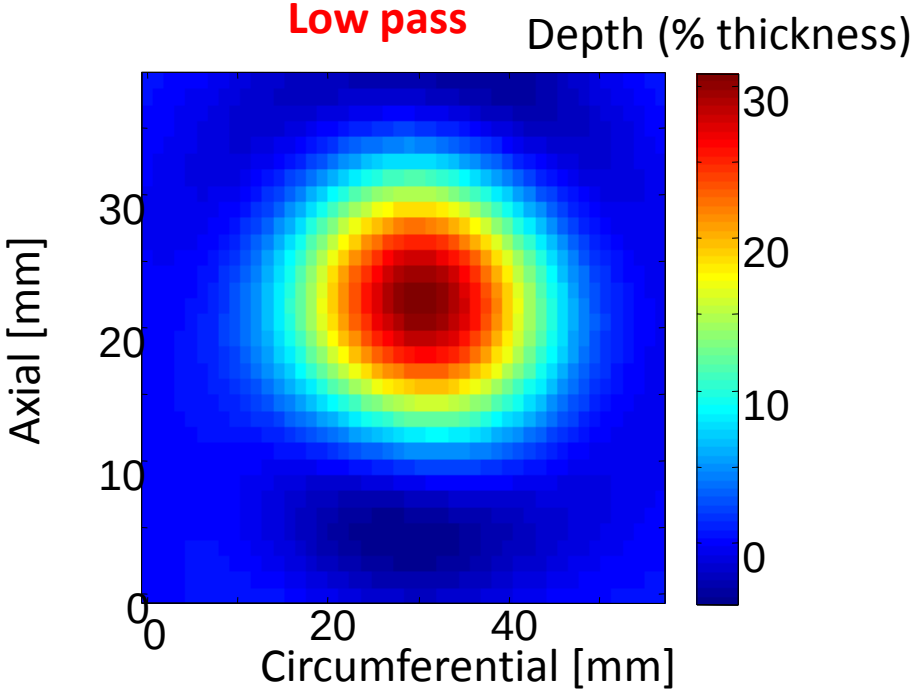
High Pass

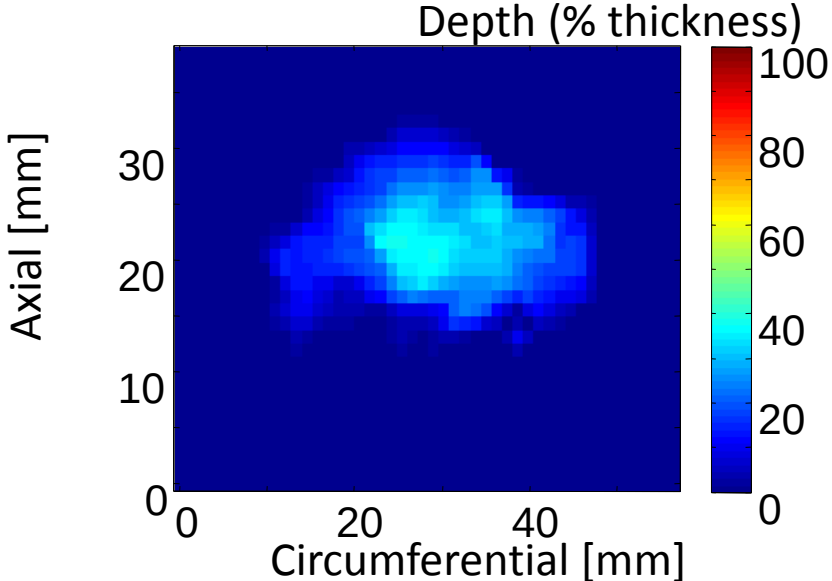


+

Low pass



Reconstructed defect = Low pass + High pass



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