CAI FATIGUE TESTING IN CFRP: IS THE TEST REPRESENTING WHAT HAPPENS IN REAL STRUCTURES?

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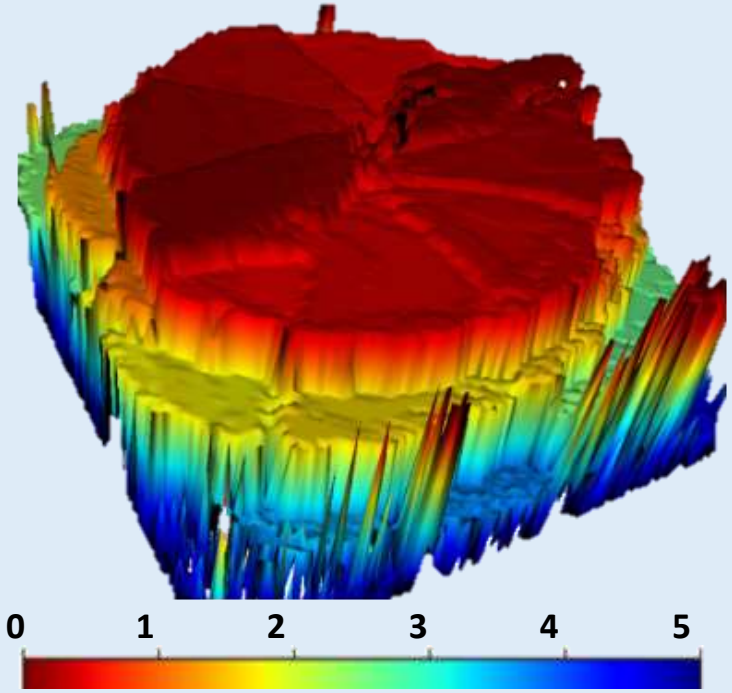
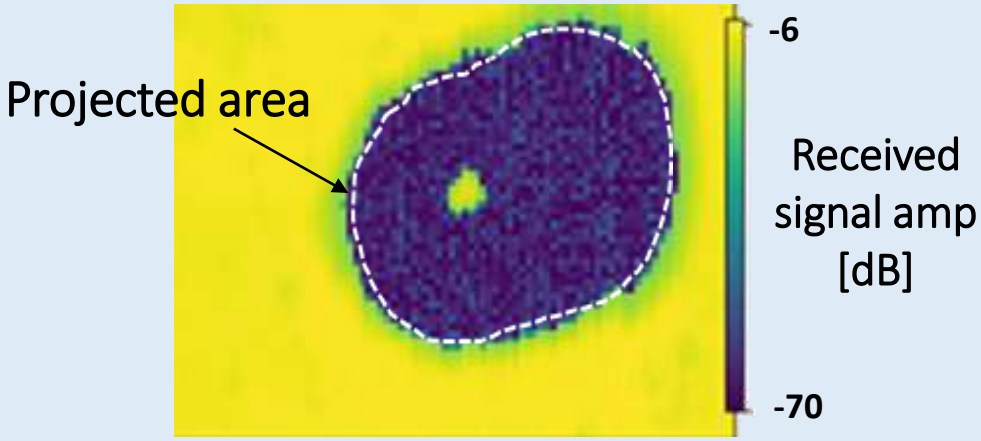
Impact delamination in CFRP

Staircase 3D shape



Non-delaminated central cone



Delamination: plateau or gradual growth?

1. No-growth of projected area

Fatigue behavior and lifetime distribution of impact-damaged carbon fiber/toughened epoxy composites under compressive loading

Toshio Ogasawara , Sunao Sugimoto , Hisaya Katoh & Takashi Ishikawa

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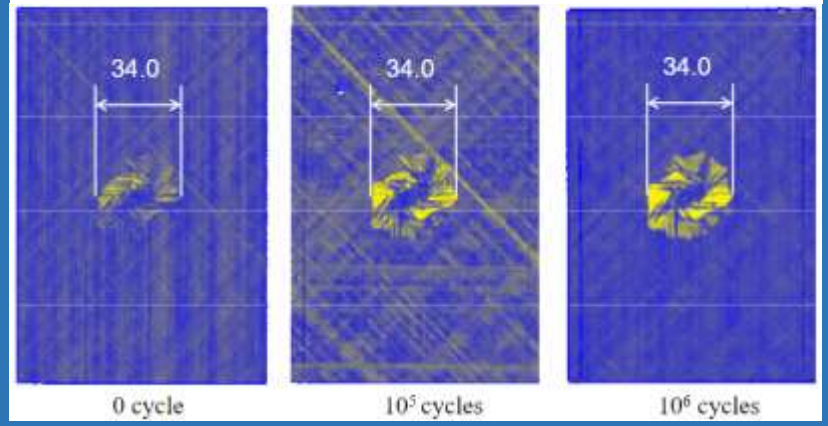

2. Plateau phase projected area

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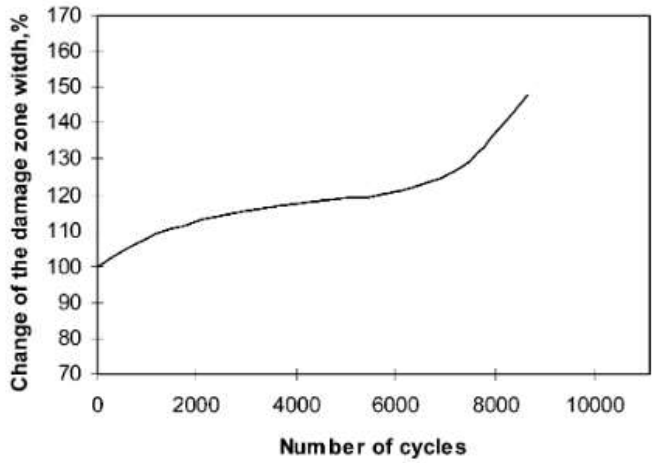
International Journal of Fatigue

Impact damage growth in composites under fatigue conditions monitored by acoustography

A.S. Chen, D.P. Almond *, B. Harris



3. Gradual growth projected area

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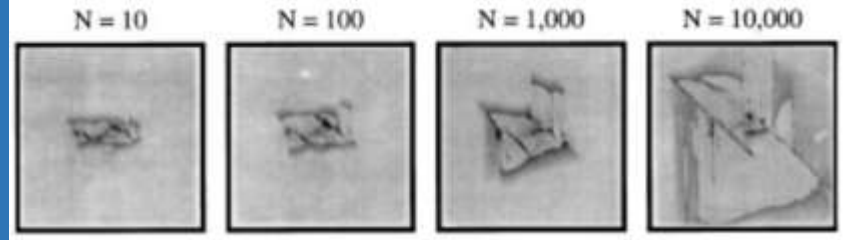
Effect of loading parameters on the fatigue behavior of impact damaged composite laminates

Milan Mitrovic [a], H. Thomas Hahn [a,*], Greg P. Carman [a], Peter Shyprykevich [b]



C-C load

1. LVI test

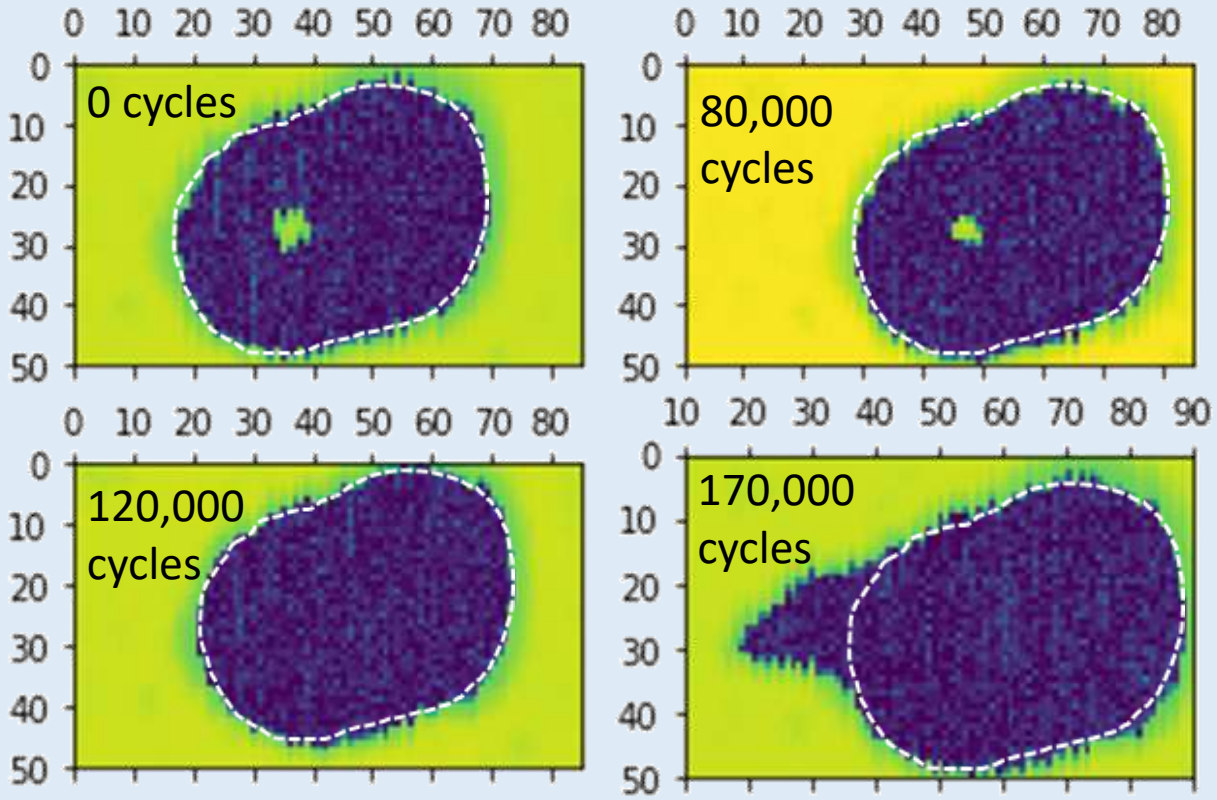
2. CFAI test

Echo-pulse ultrasound scan (Dolphicam 2)

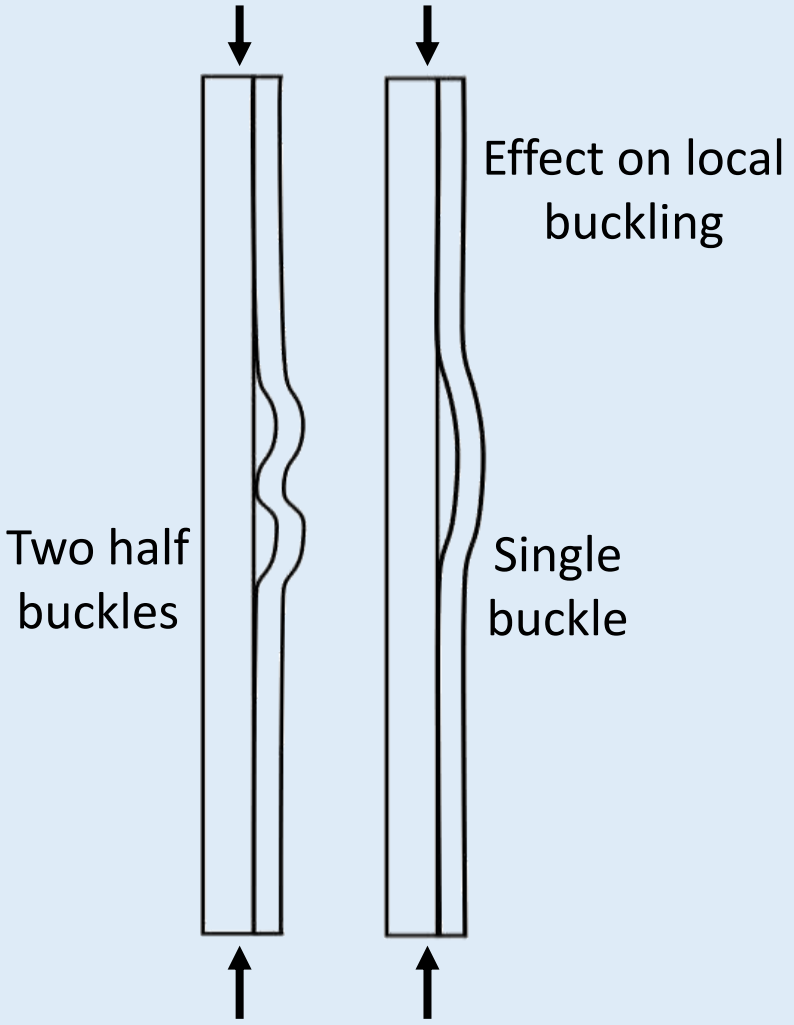
Through thickness transmission ultrasound scan

Acoustic emissions

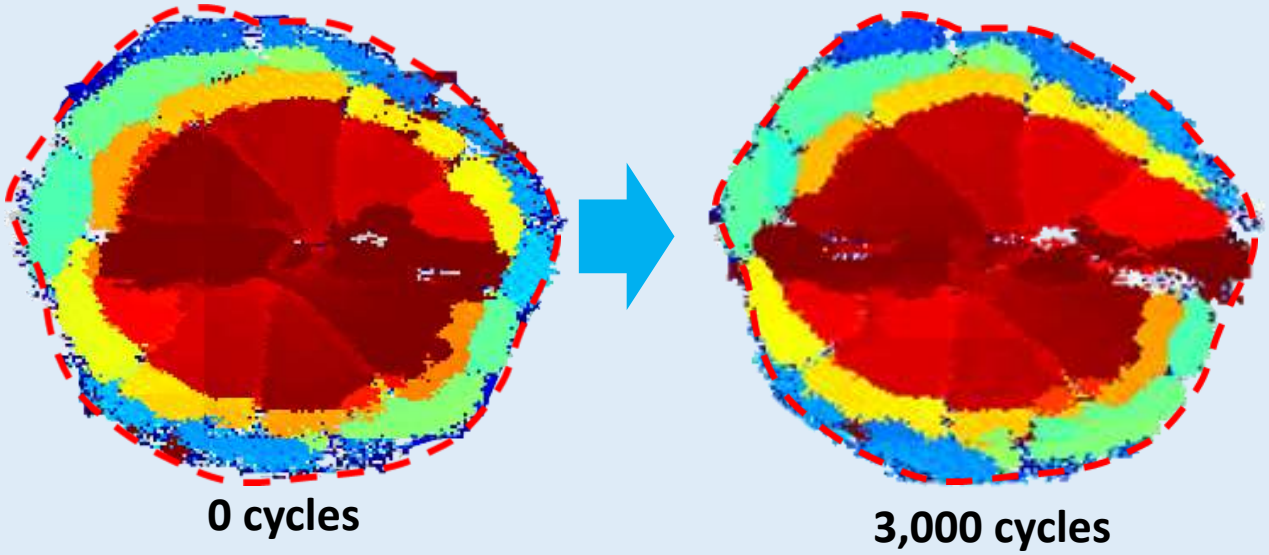
Growth inside the non delaminated cone must be considered



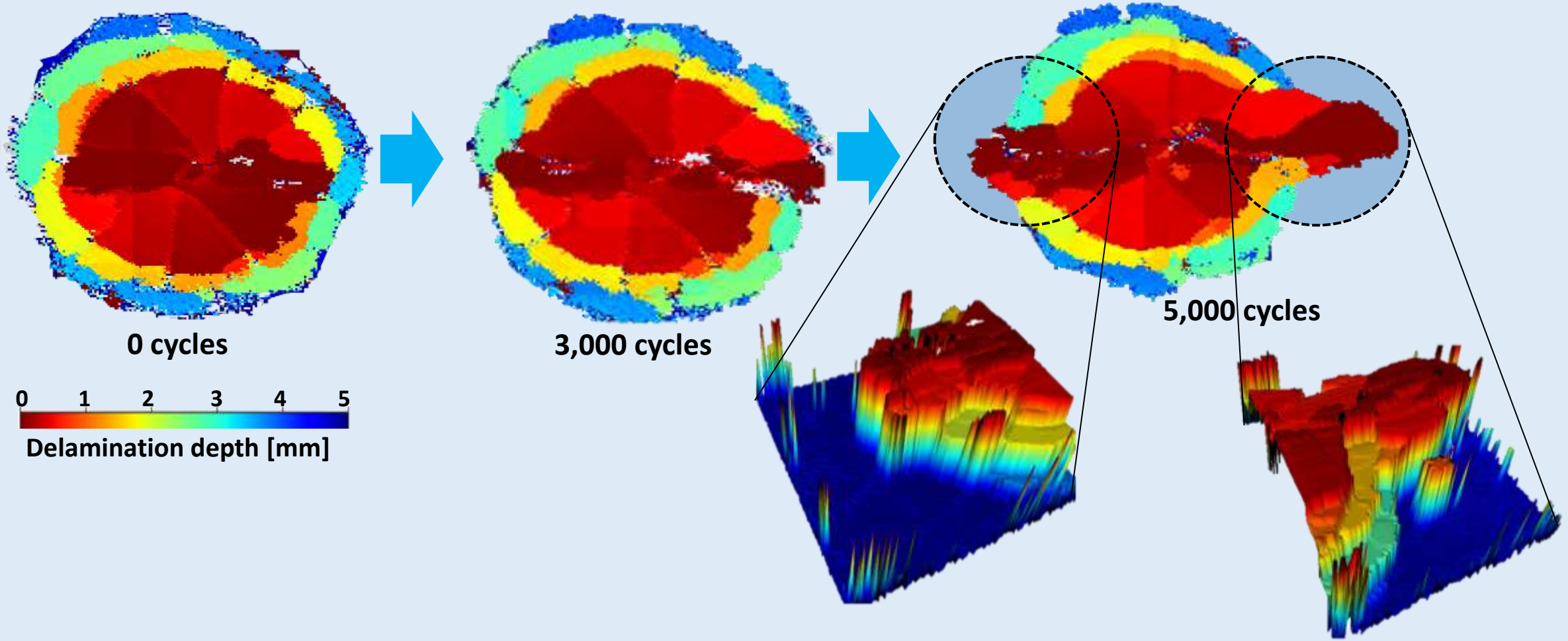
Through thickness transmission scan



Preferential growth of short delamination

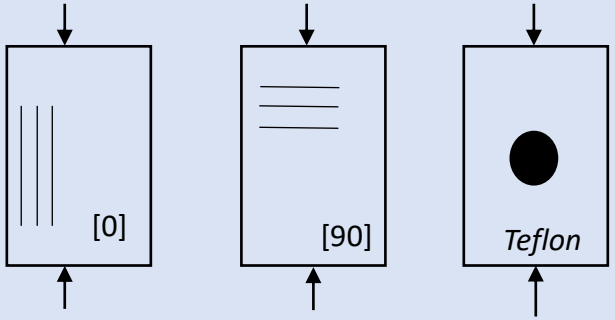


Preferential growth of short delamination



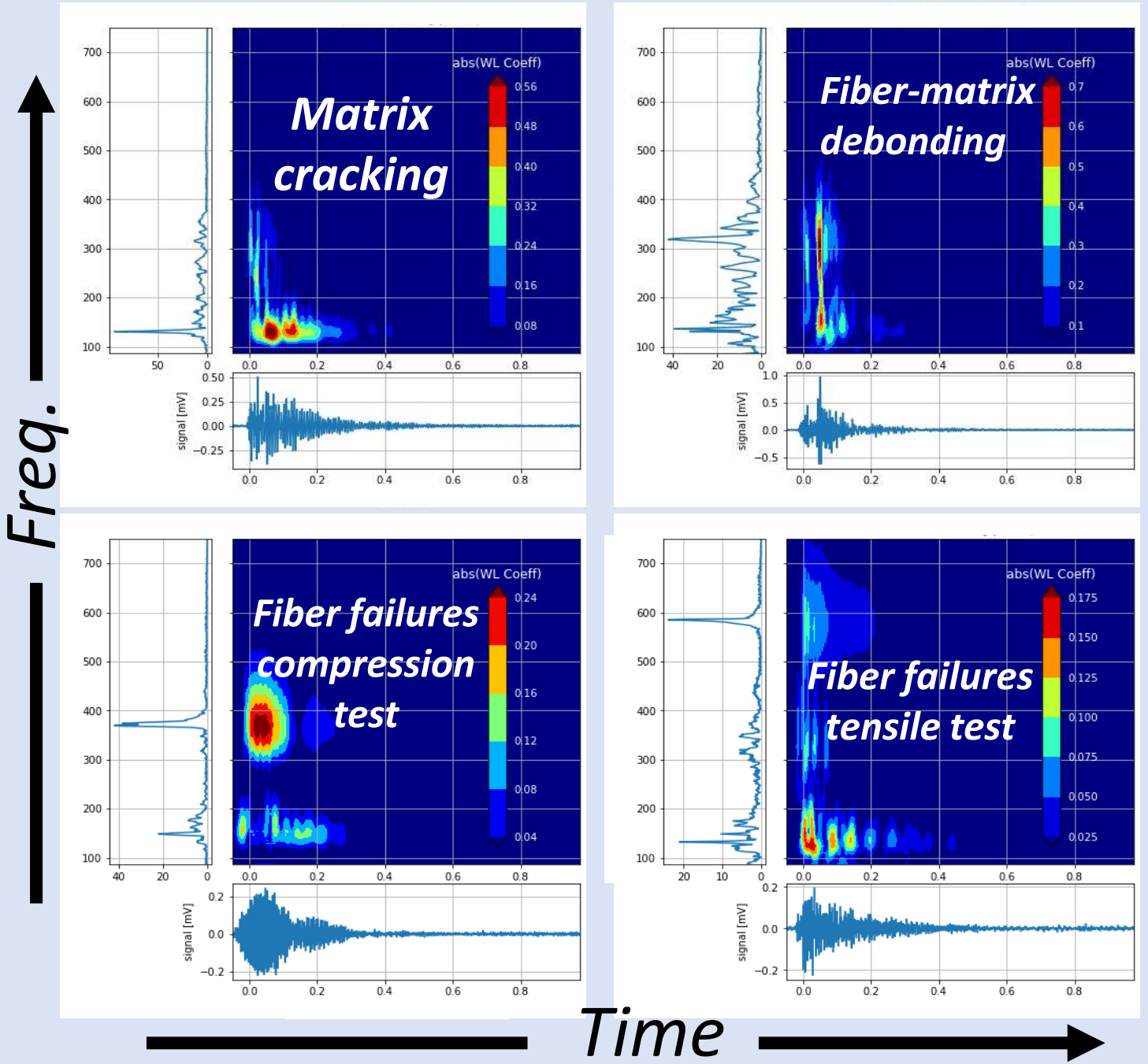
Growth of projected delaminated area is not sufficient

Preliminary tests

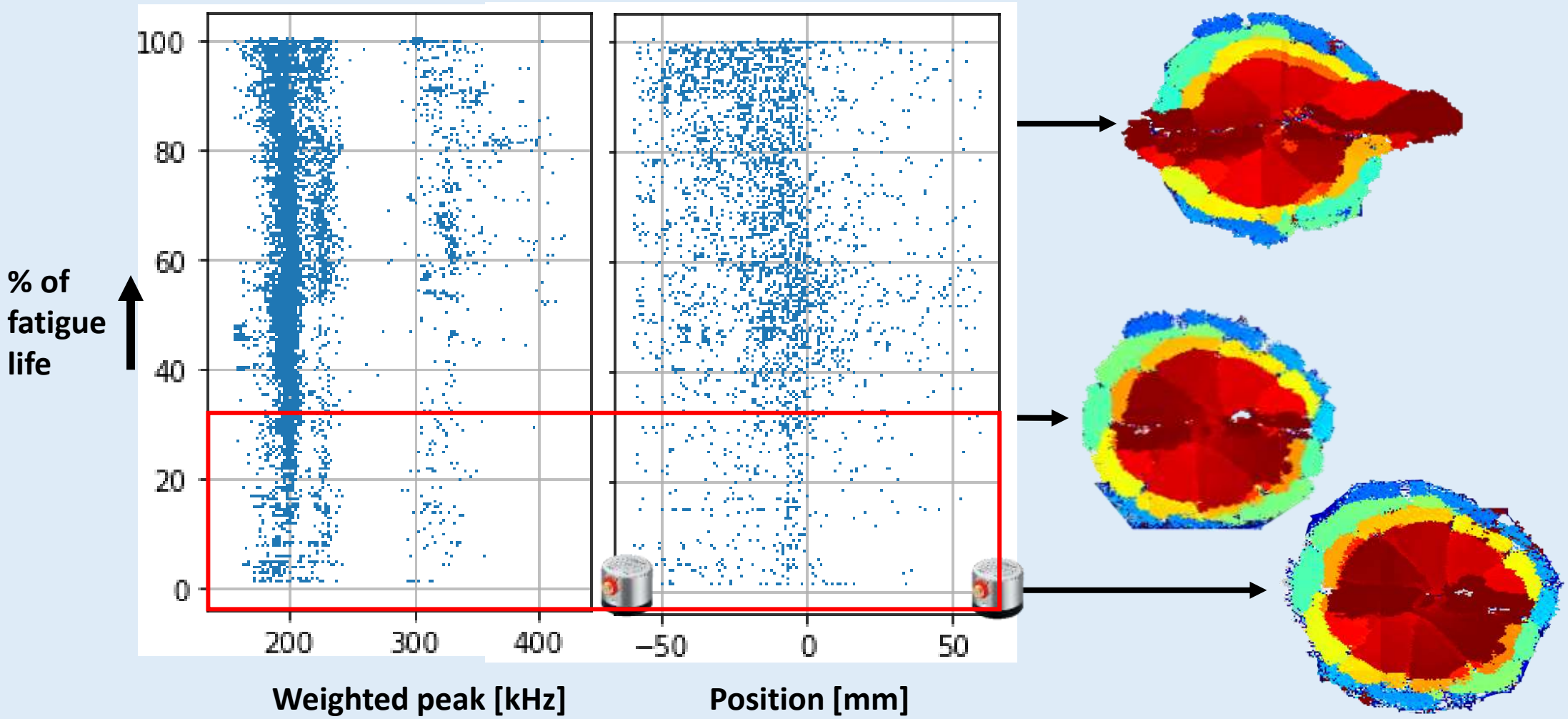


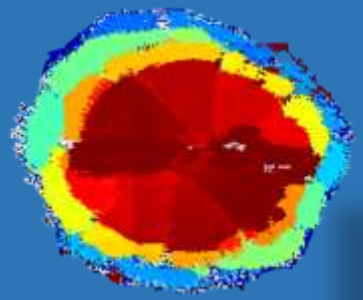
wavelet analysis

Frequency separation between *damage modes*



no growth in the C scan ≠ no damage growth



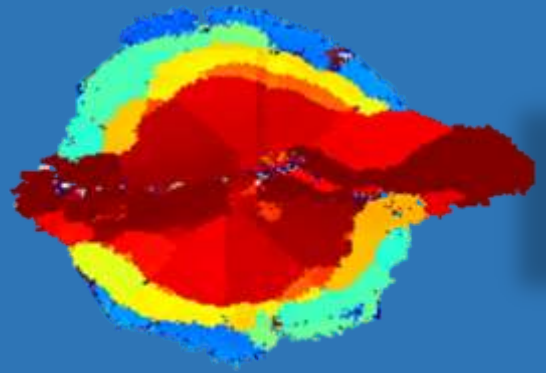


Intralaminar matrix cracking/shadowed delamination

No growth of projected delamination area

Short delamination growth

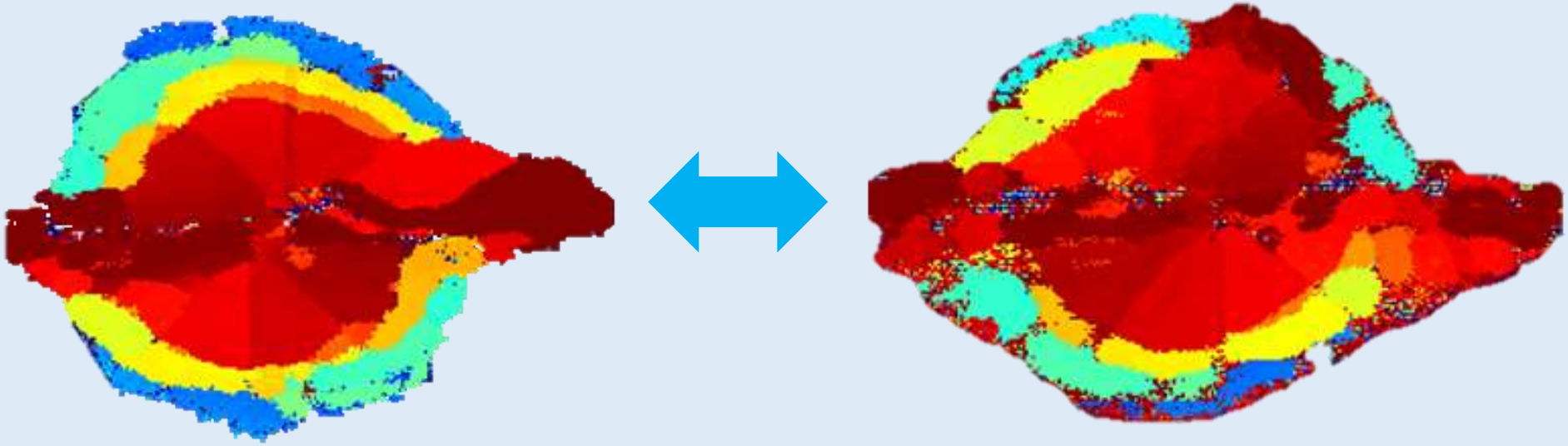
Growth inside the impact cone



Growth outside projected area

Are these results general?

long and short fatigue life same qualitative growth

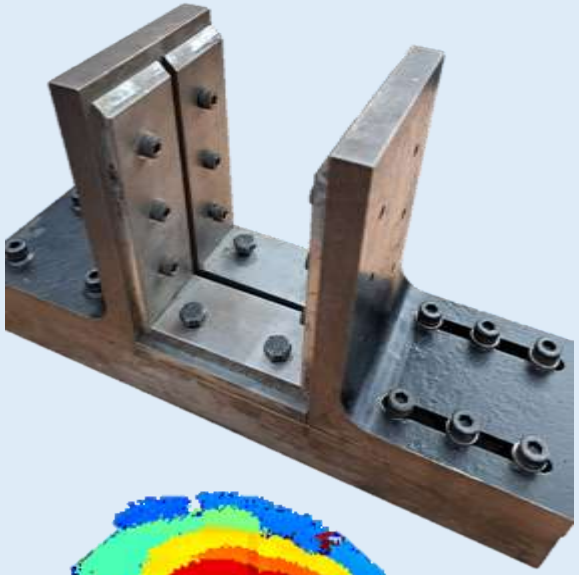


Fat. life 5,600 cycles

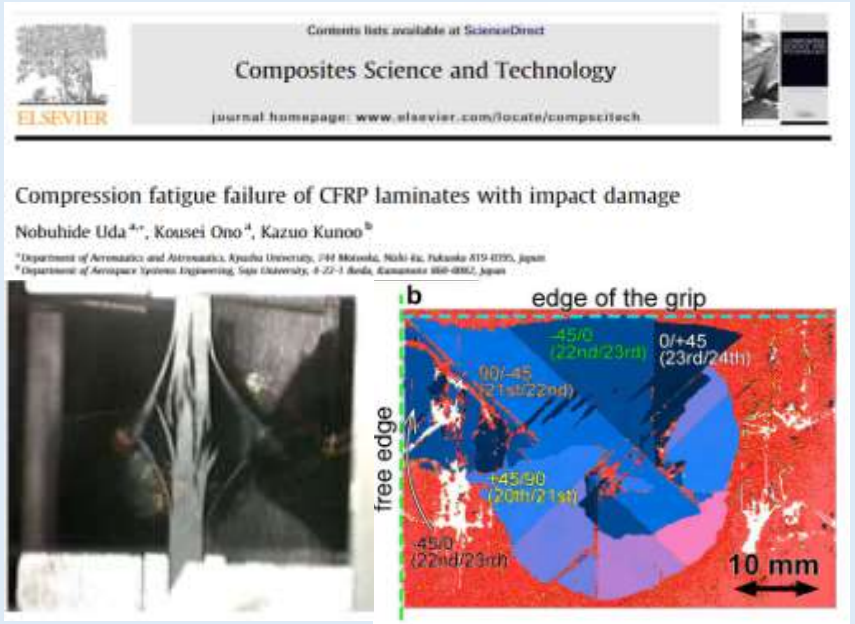
80% CAI Strength

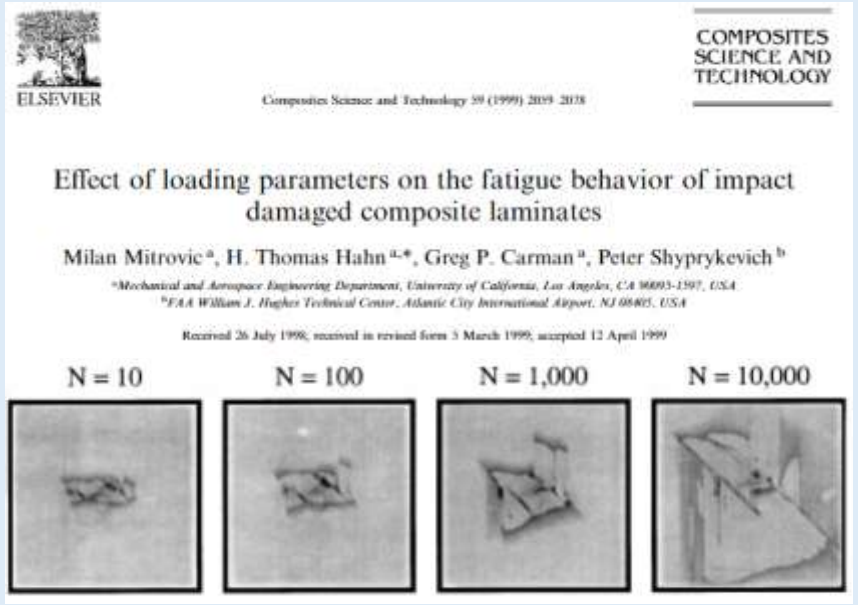
Fat. life 195,000 cycles

70% CAI Strength



≠ Setup





✗ Final growth 90 deg direction

Real structures are different from test setup

Anti-buckling guides not present

Multidirectional loading

Large structures

Conclusions

Combining multiple techniques → better understanding

growth in the non delaminate cone
growth of short delamination
low frequency AE during early stages of fatigue

Results are highly dependent on the adopted fixture

Similar monitoring strategies should be used to non/standard fixture

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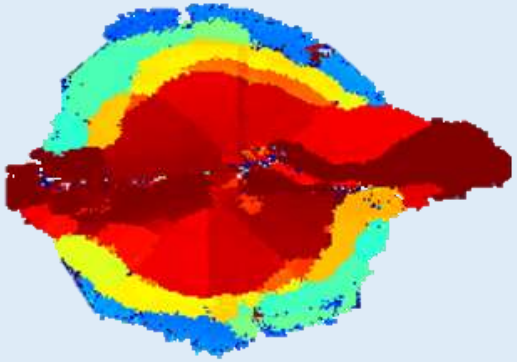
Thank you

= Setup

≠ Impact energy

≠ Layups



Final growth 90 deg direction

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Buckling behaviour and delamination growth in impacted composite specimens under fatigue load: an experimental study

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FATIGUE LIFE AND FAILURE OF IMPACT-DAMAGED CARBON FIBRE COMPOSITES UNDER COMPRESSIVE CYCLIC LOADS

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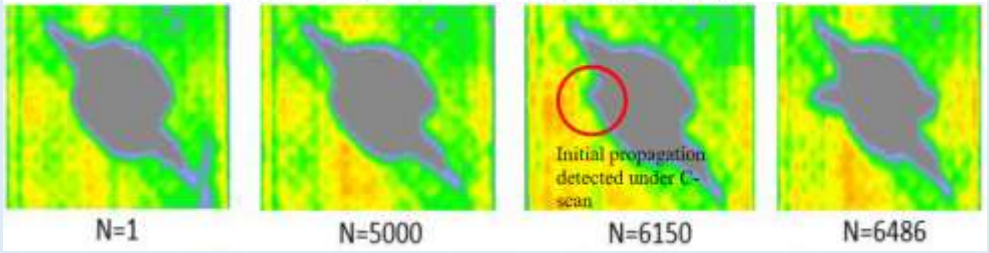

Preliminary tests