



## Segmentation of individual fibres in a uni-directional composite from 3D X-ray computed tomography data

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# Segmentation of individual fibres in a uni-directional composite from 3D X-ray computed tomography data



Emerson M. J., Jespersen K. M., Dahl A. B., Conradsen K., Mikkelsen L. P.

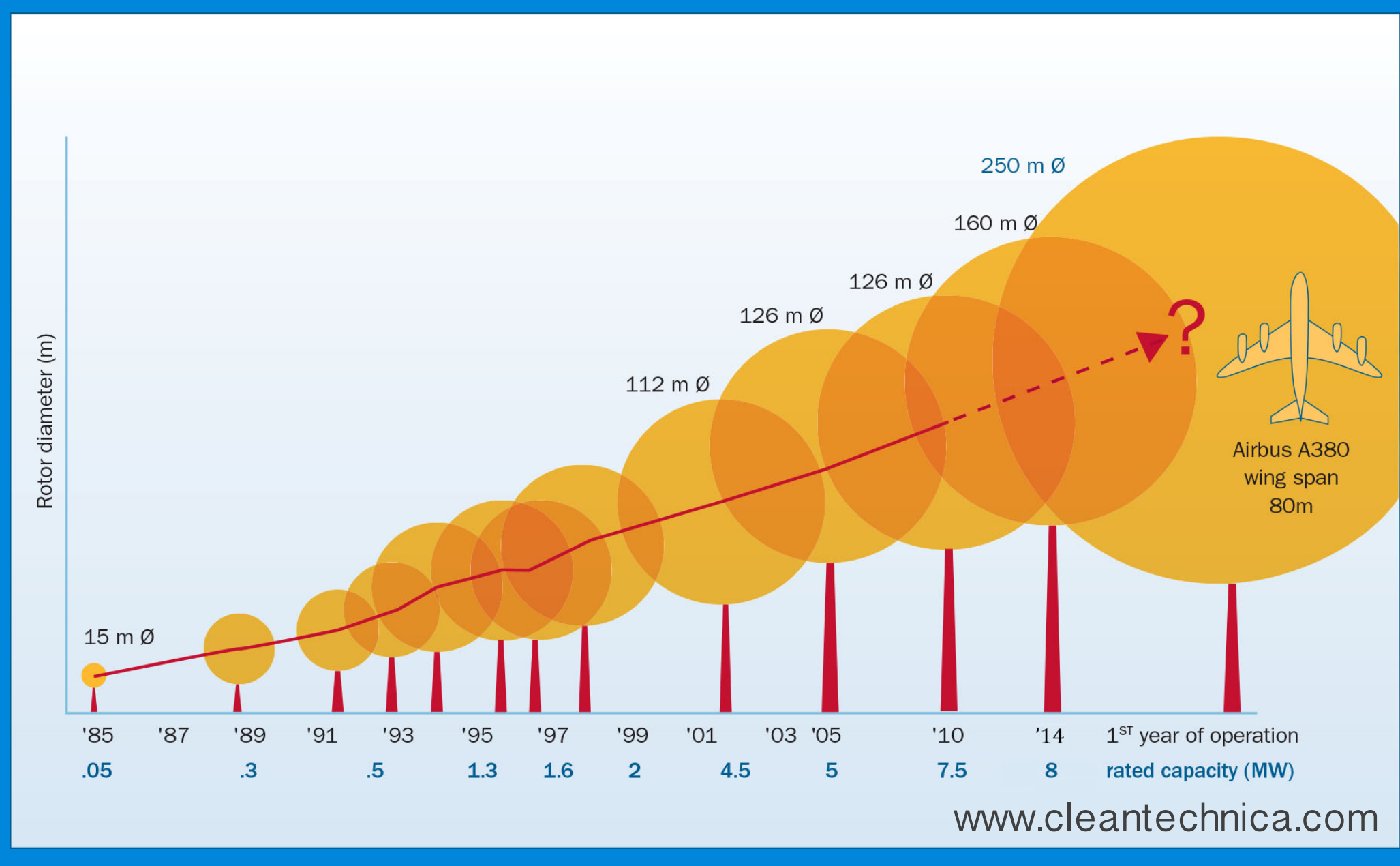
monj@dtu.dk

## MOTIVATION

Wind turbine blades are becoming **longer** to decrease the **cost of energy**.



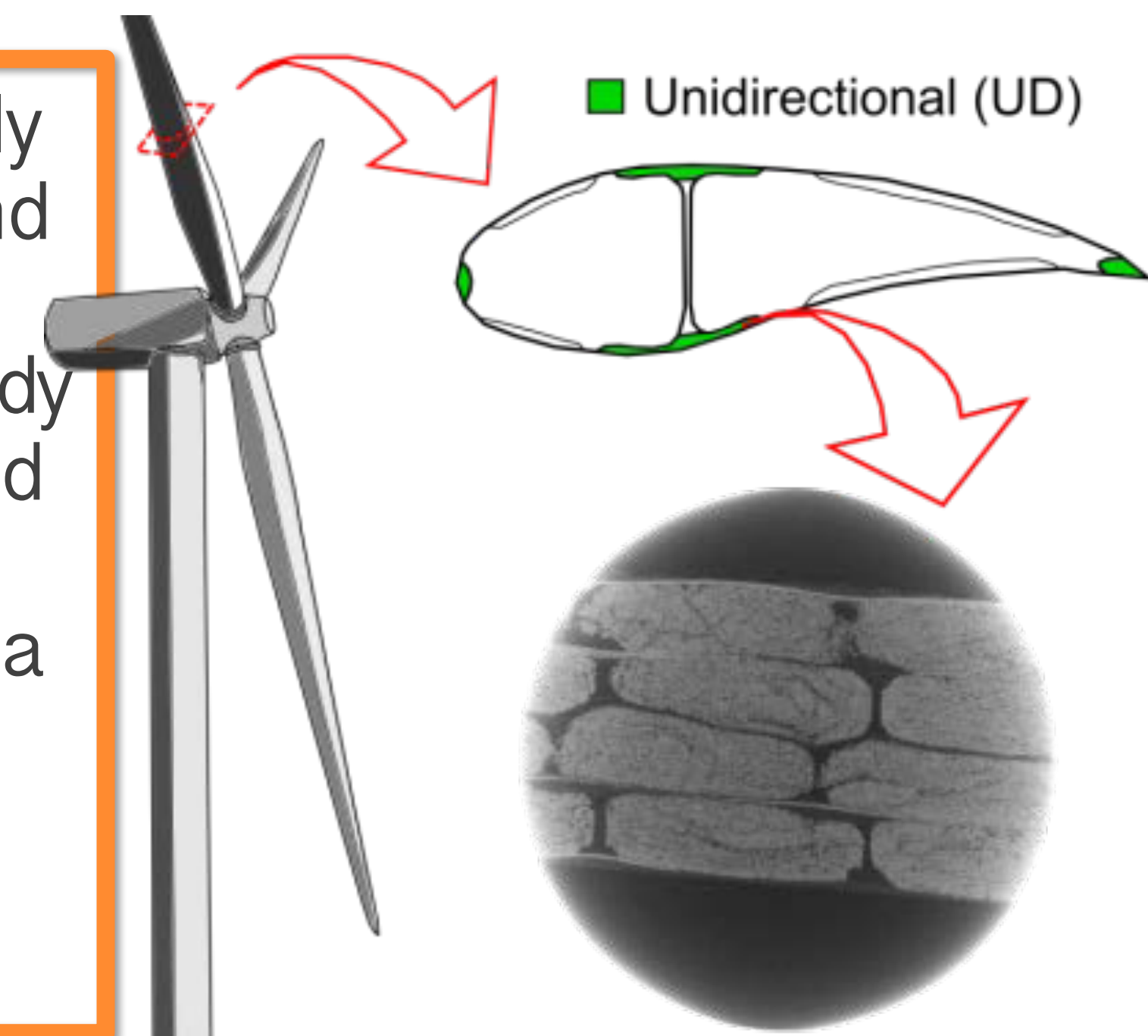
They need to stand higher stresses.



## TASK

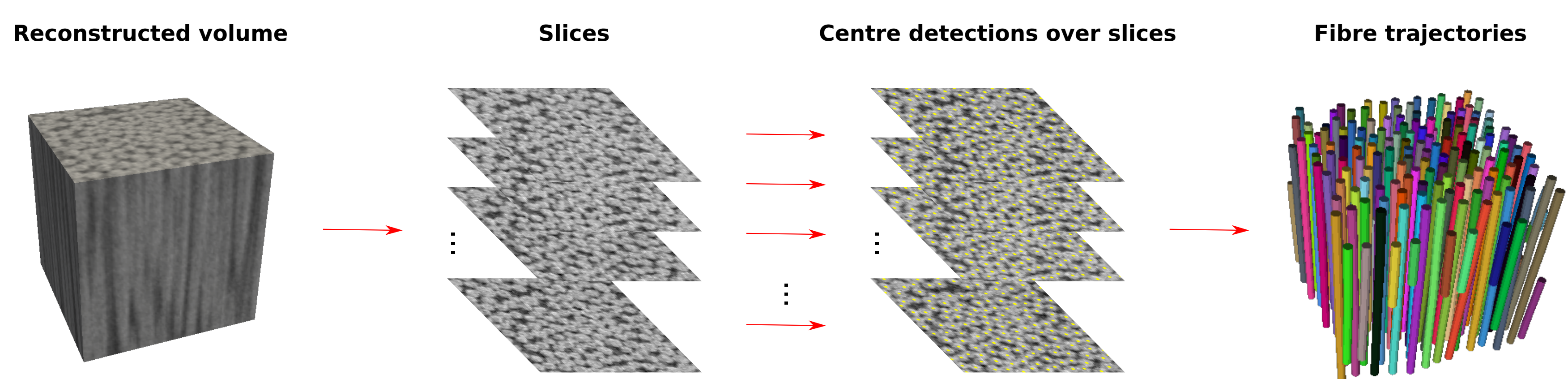
We segment individually uni-directional glass and carbon fibres from tomography data to study the **fibre orientation** and relate it to the **compression strength**, a key parameter when designing the blade's **load carrying parts\***.

\* green parts in the blade on the right



## PIPELINE AND CHALLENGES

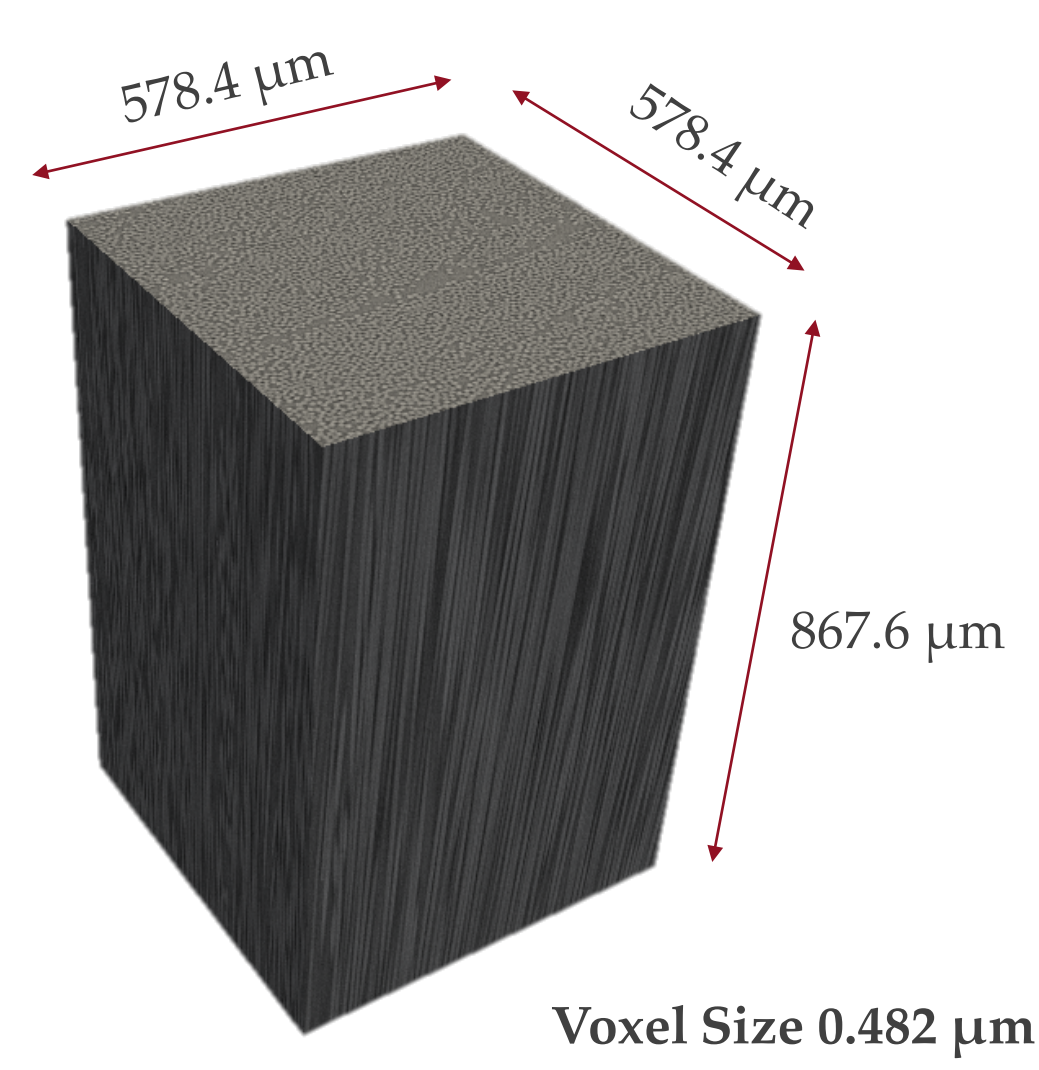
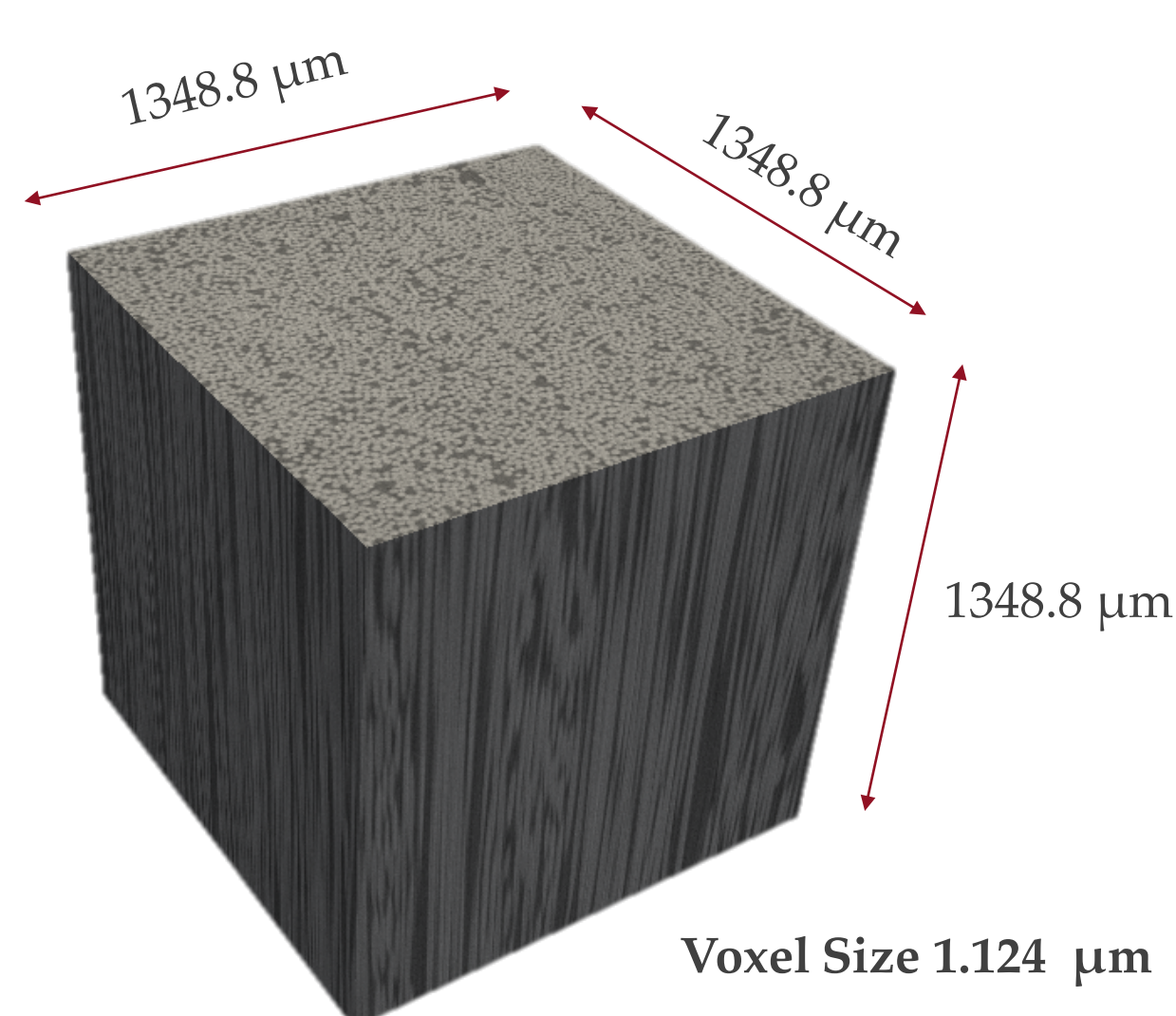
- Low quality scans to avoid a long acquisition time.
- Composite materials with high fibre volume fraction.
- Large data sets.



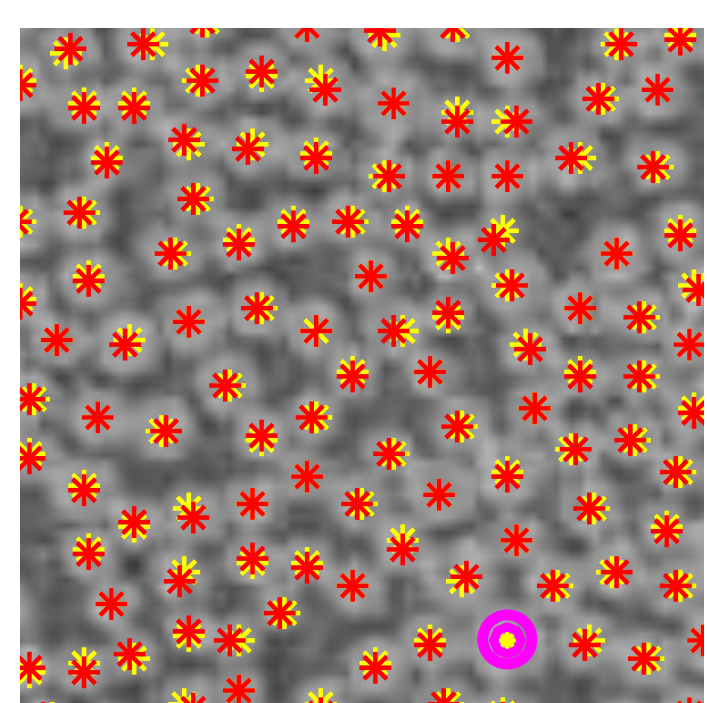
## SEGMENTATION AND TRACKING

1. Glass Fibre Reinforced Polymer (GFRP)

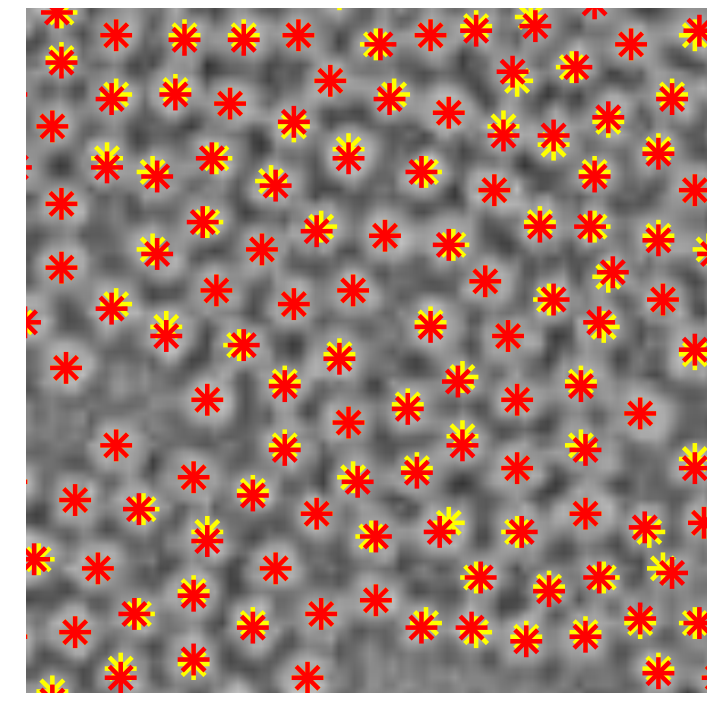
2. Carbon Fibre Reinforced Polymer (CFRP)



Detected centres in red and reference centres in yellow.



Accuracy\*\* 99.1%

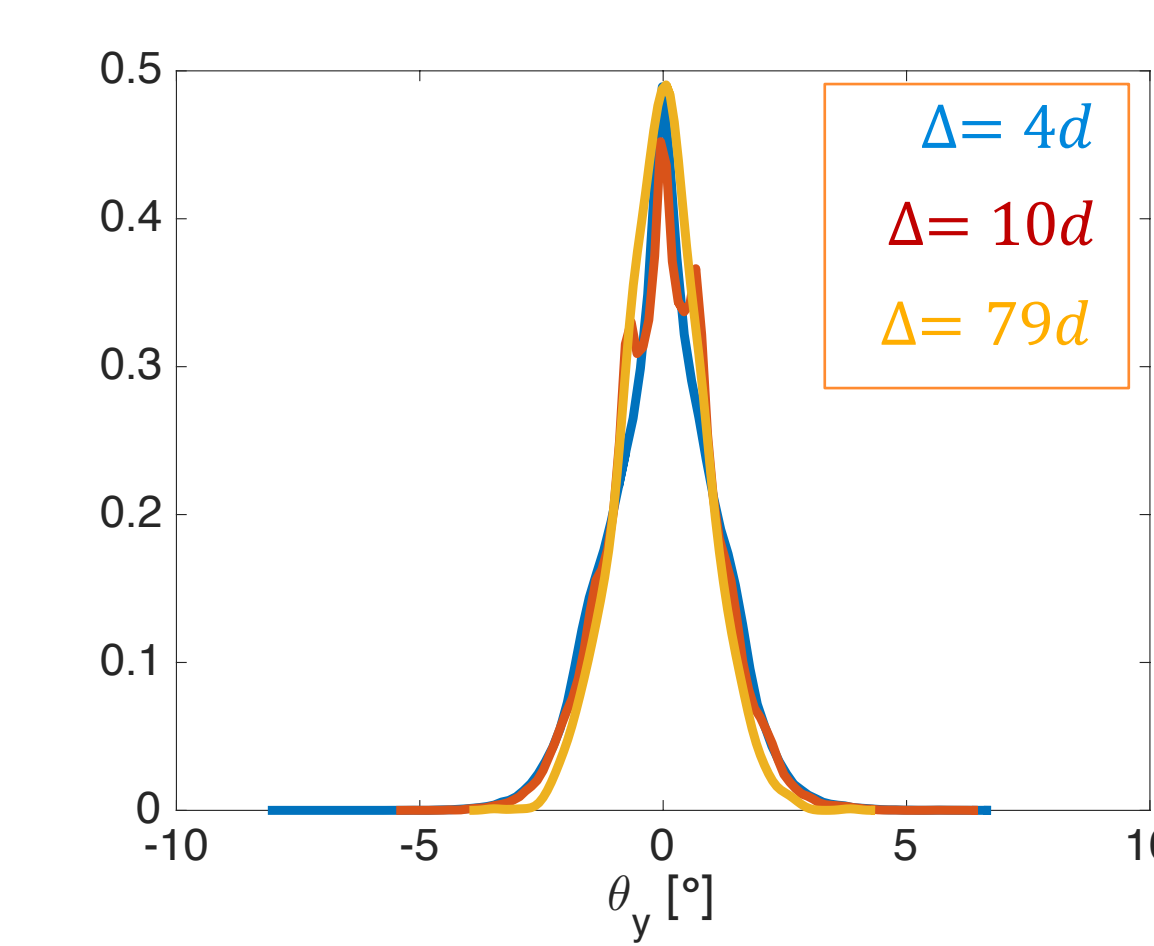
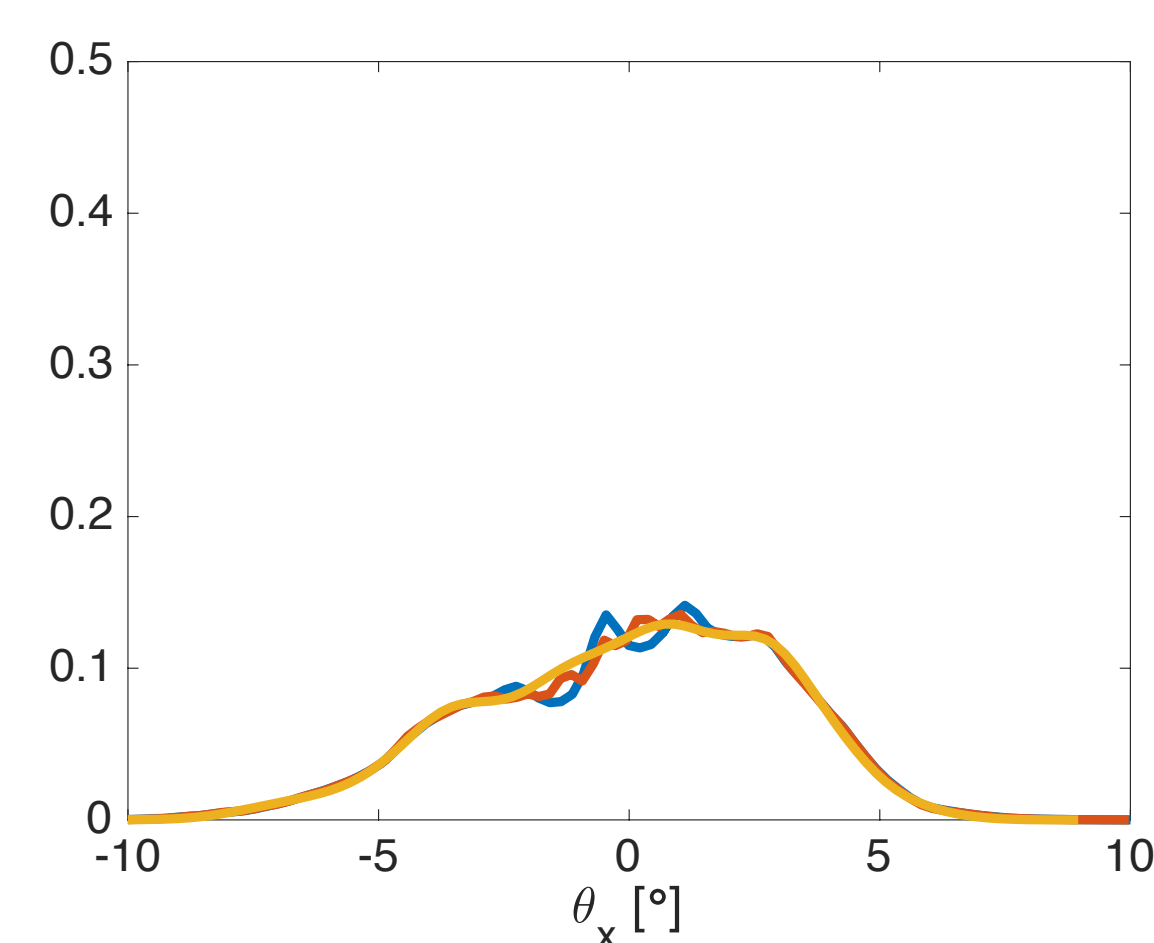


Accuracy\*\* 100%

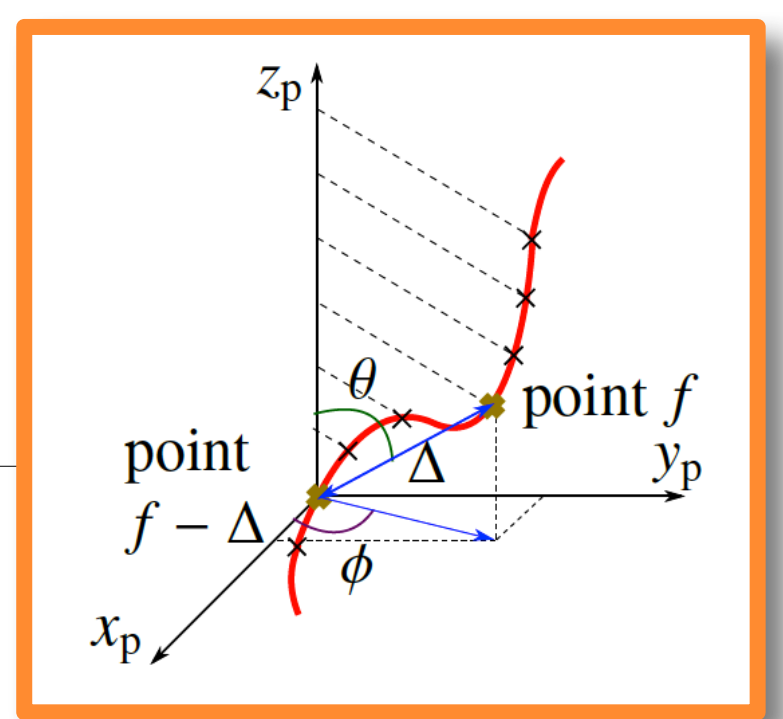
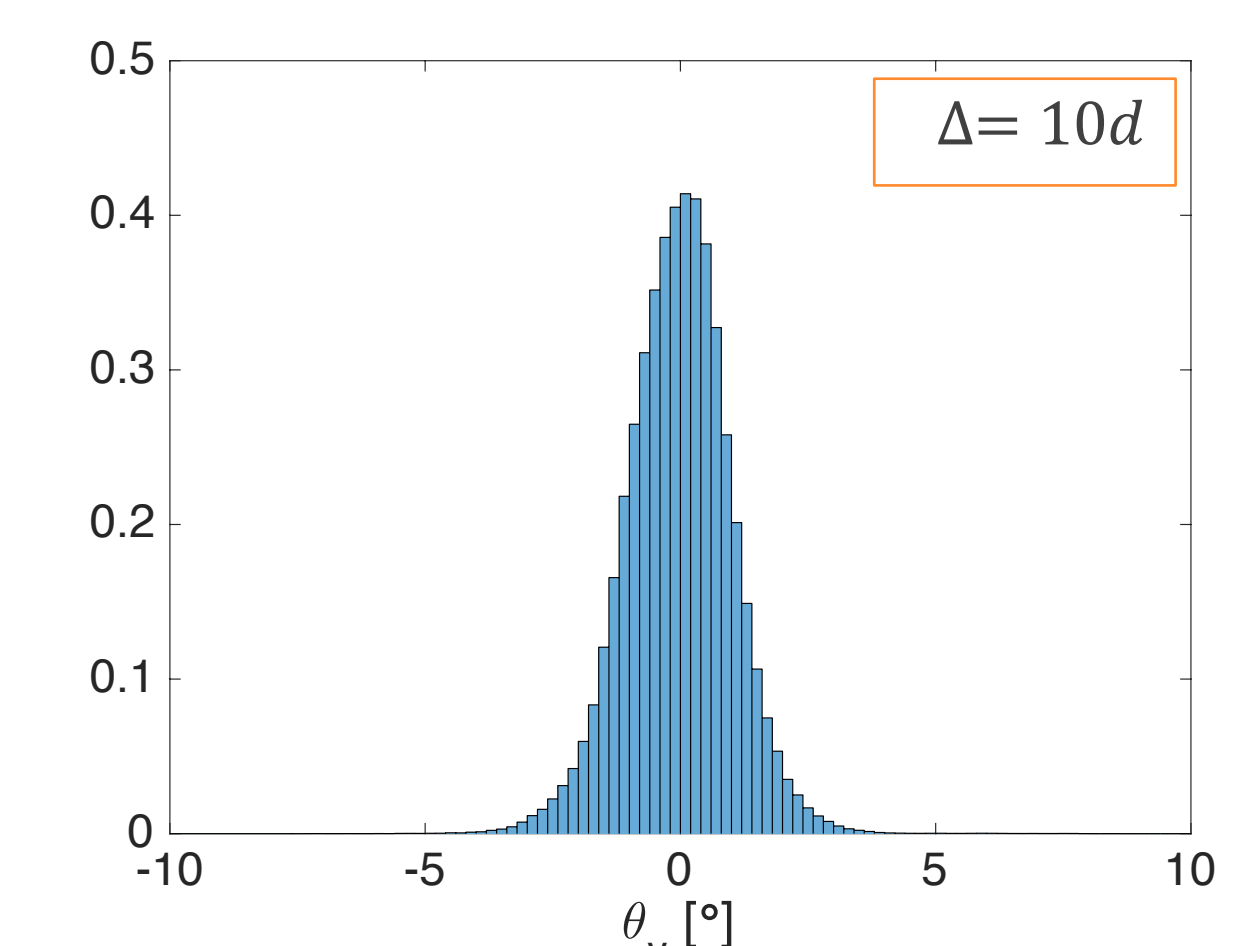
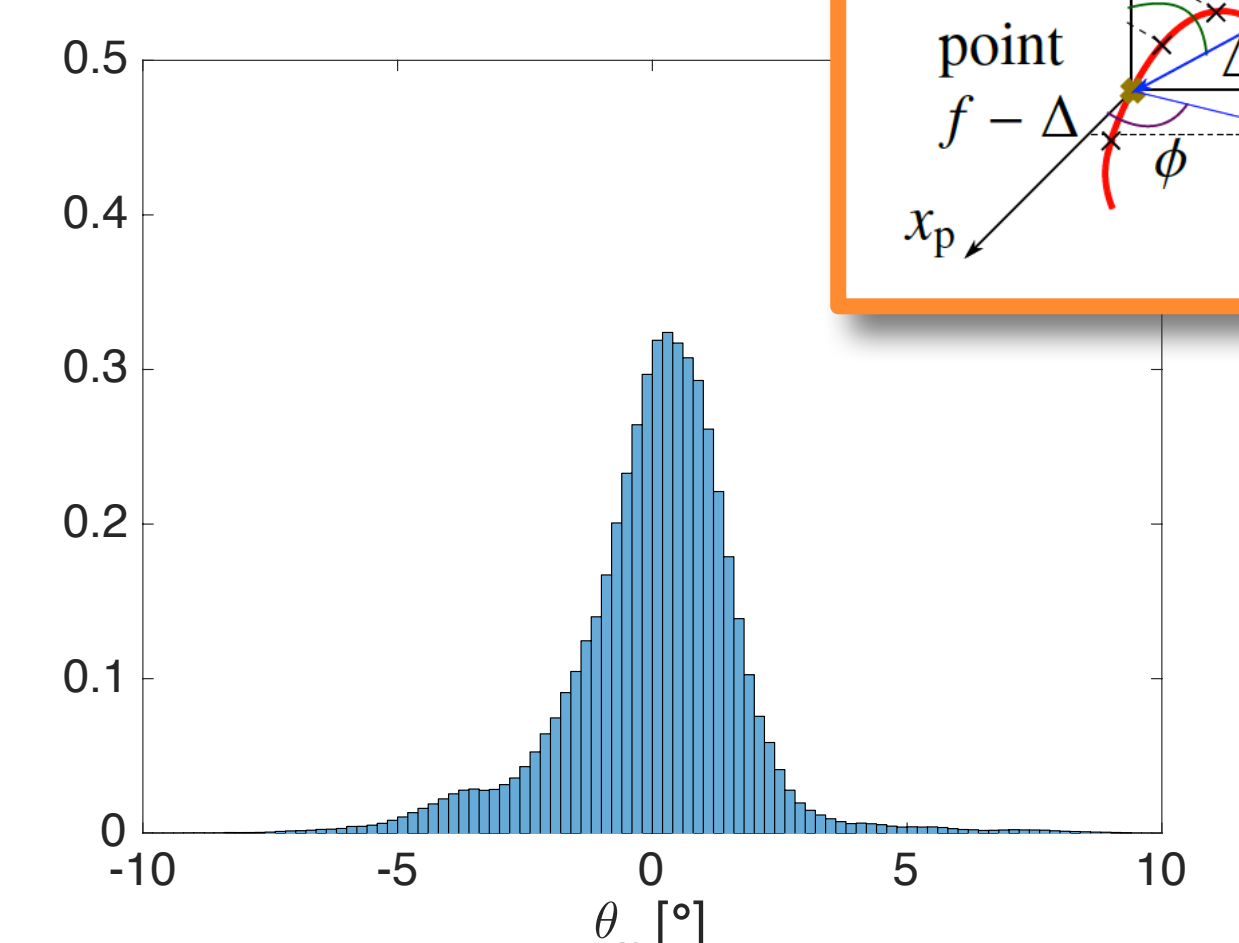
\*\*Accuracy measured as correctly found centres in a test image, of size half of a slice.

## FIBRE ORIENTATION

1. GFRP



2. CFRP



## COMPRESSION STRENGTH

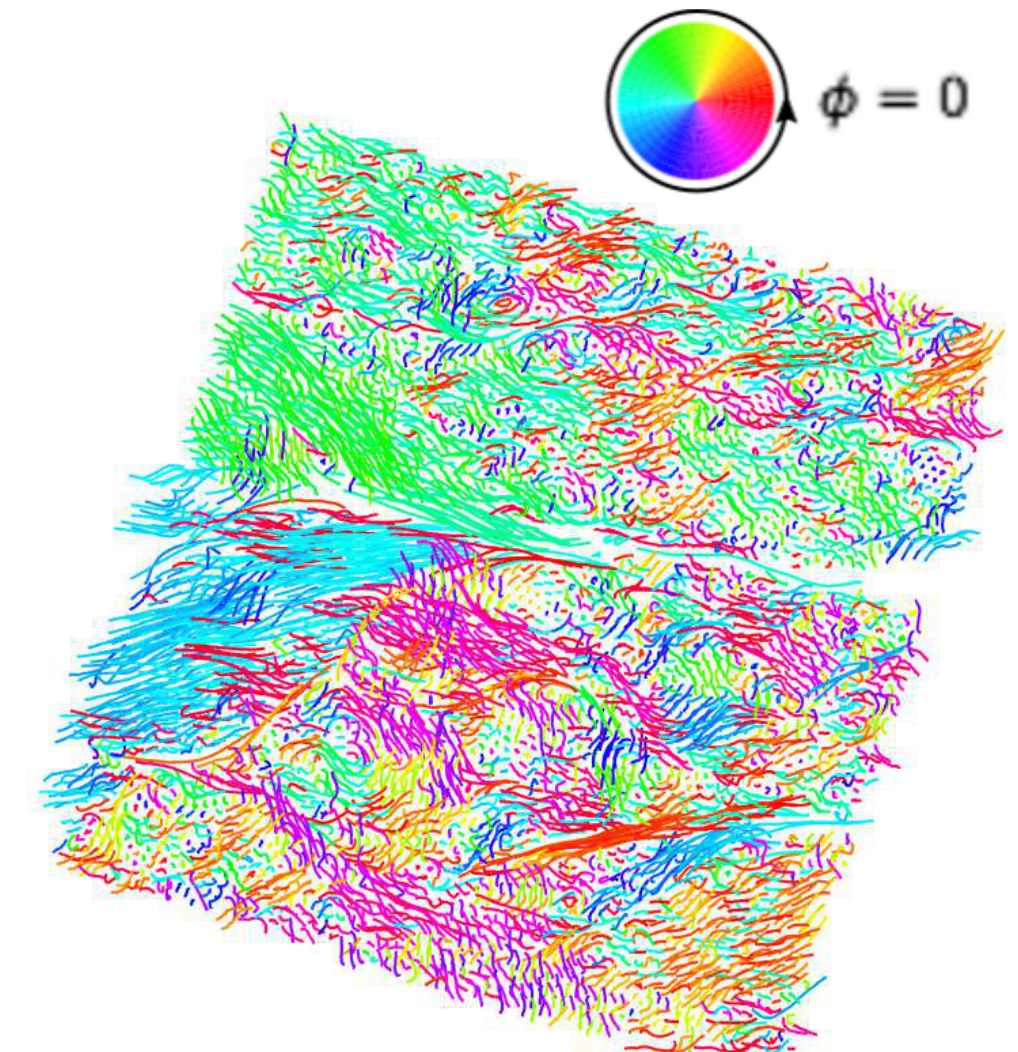
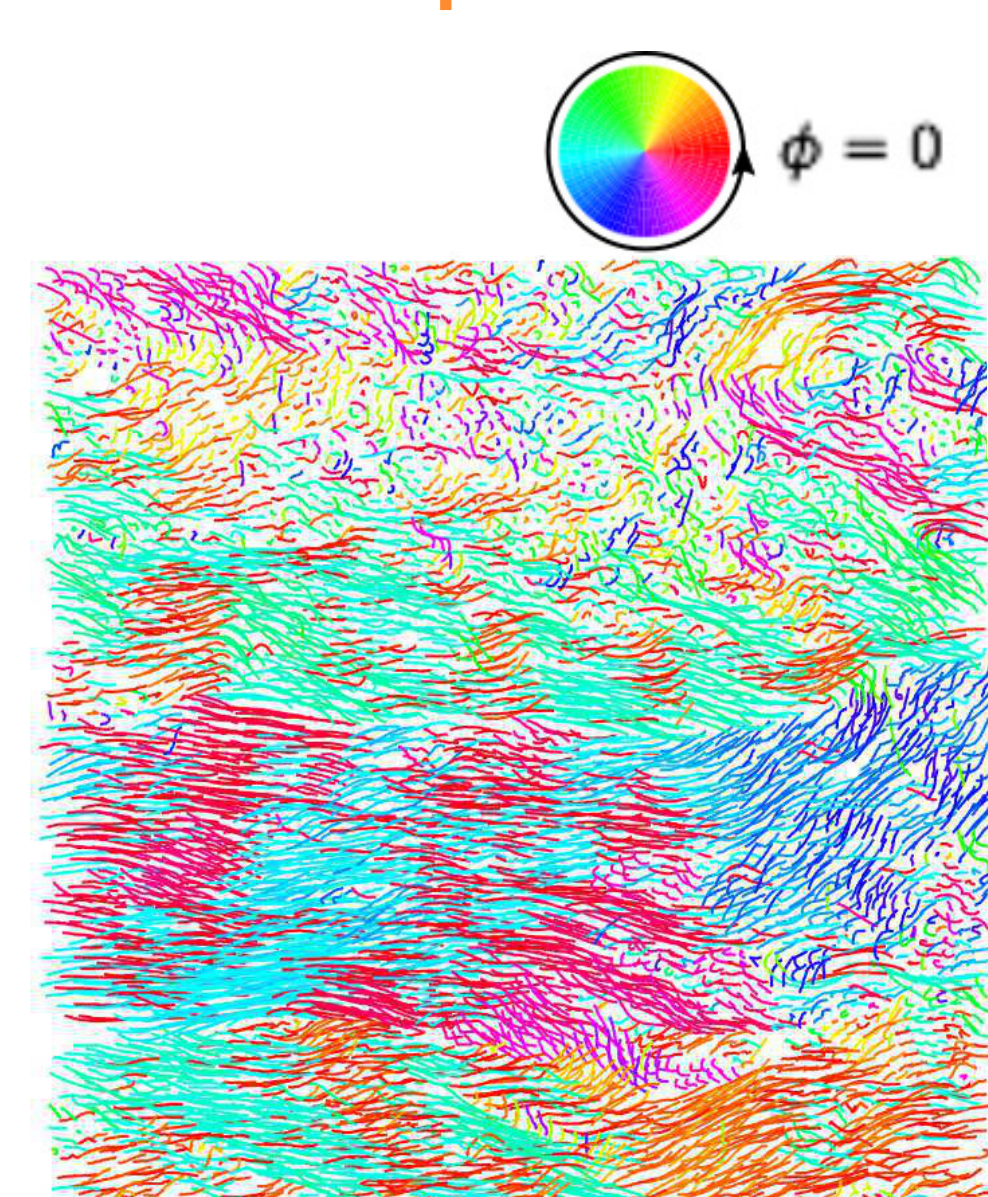
$$\hat{\sigma}_c = \frac{G}{1 + \hat{\theta}/\gamma_y}$$

(Budiansky et al., 1993)

Material	GFRP	CFRP
$\langle \theta \rangle$	2.75°	1.61°
$\langle  \theta_x  \rangle$	2.45°	1.23°
$\langle  \theta_y  \rangle$	0.86°	0.79°
$\hat{\sigma}$	0.44 GPa	0.70 GPa
$\hat{\sigma}_x$	0.49 GPa	0.87 GPa
$\hat{\sigma}_y$	1.14 GPa	1.21 GPa
$\sigma_m$	(0.82 ± 0.07) GPa	(0.90 ± 0.06) GPa

Estimated compression strength  $\hat{\sigma}$  compared to measured  $\sigma_m$  by Markussen et al., 2013

For a more precise estimate...



...add the spatial distribution

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