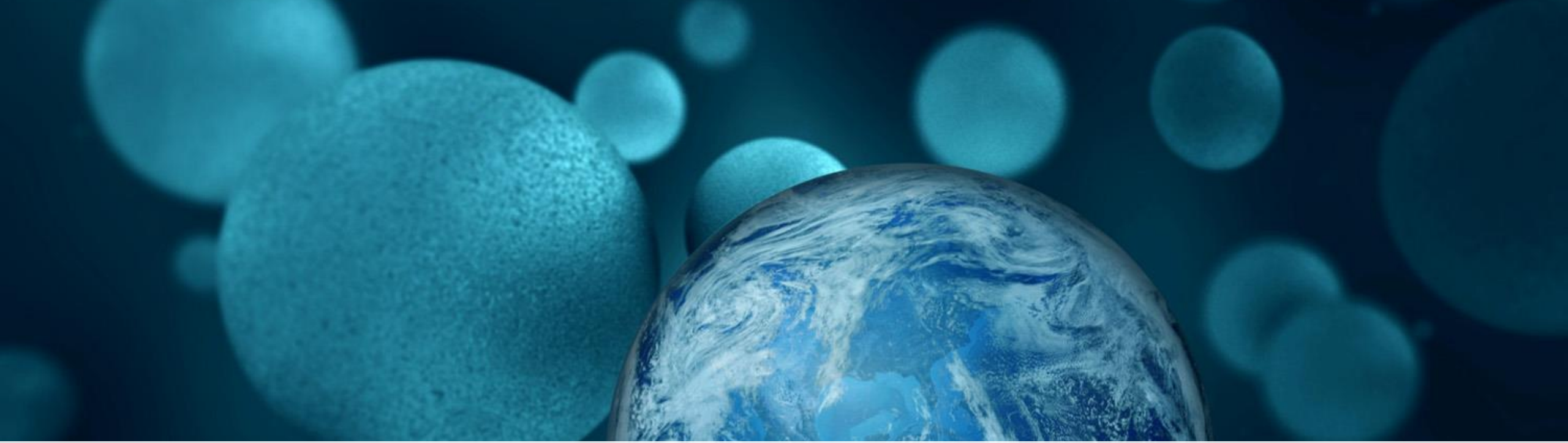


ThermoFisher SCIENTIFIC

Fiber Length/Orientation/Density Analysis via CT Images
断层扫描解析Fiber长度和强度的应用案例

Mar 2018
Eric Ho 何沛霖
Eric.Ho@Thermofisher.com

Amira/Amira Verification Workflow

Data Acquisition

Any material
any size
any scale
any imaging modality

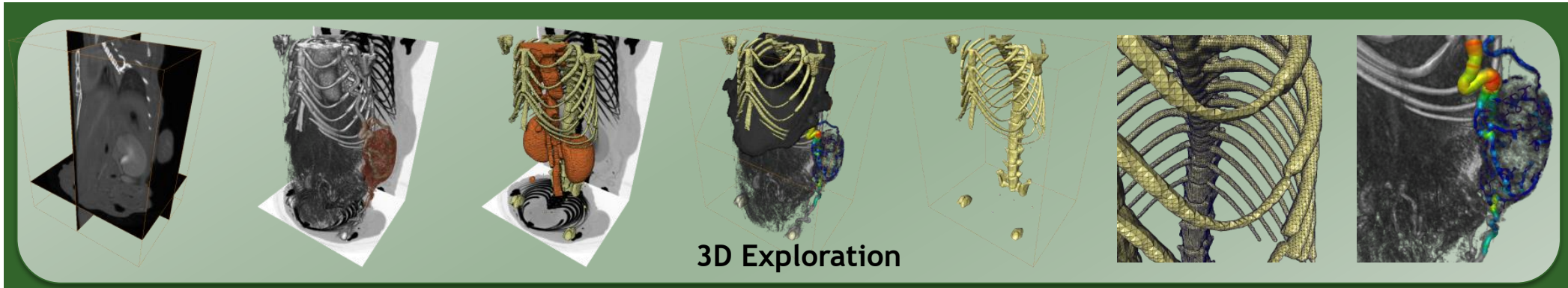
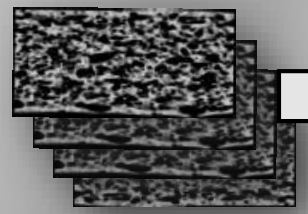
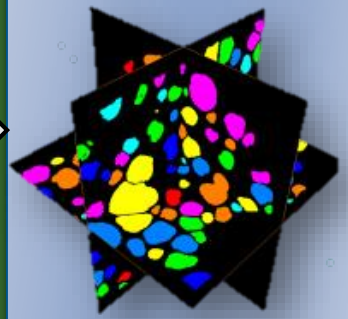


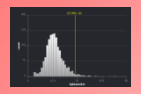
Image Processing



Segmentation

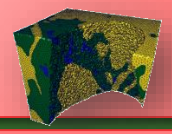


Quantification
- Defect/Porosity
- Fiber etc

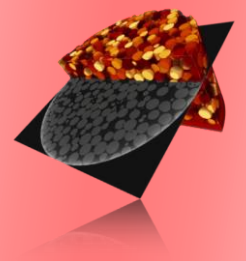


Actual / Nominal Analysis

3D model Reconstruction



Communication



Customization, automation, extension
(workflows, scripting, MATLAB, C++)

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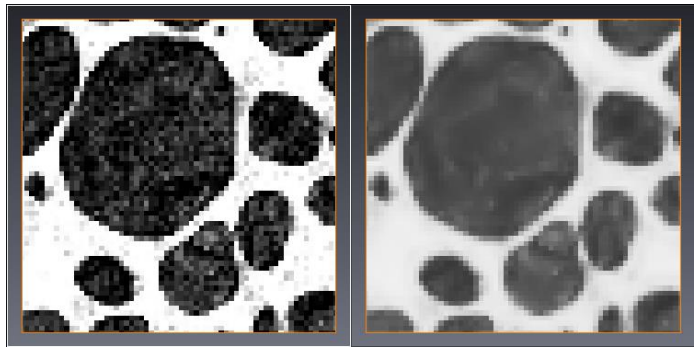
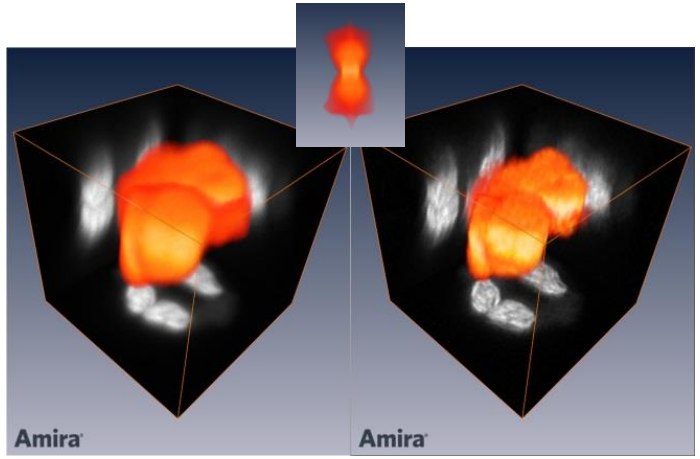
Image Enhancement

Noise reduction

- Gaussian, Median, …
- Anisotropic diffusion
- Non-Local Means
- Deconvolution





Background correction

- Flatfield
- Shading correction
- Block-Face correction

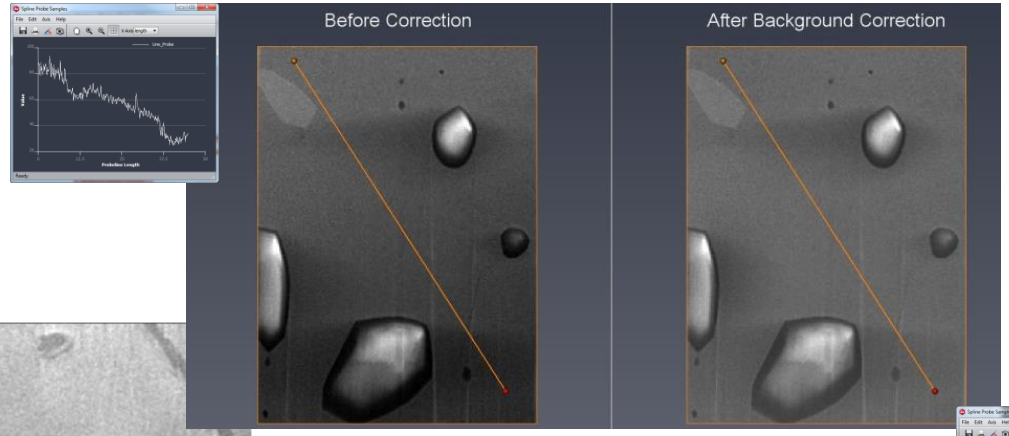
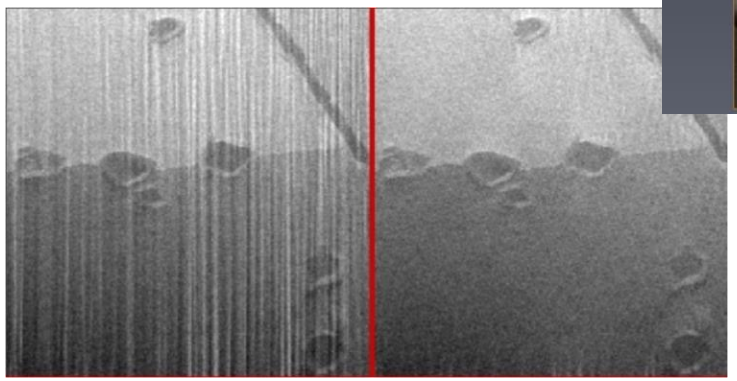


Image artefacts reduction

- Curtaining
- Pore-back / shine-through



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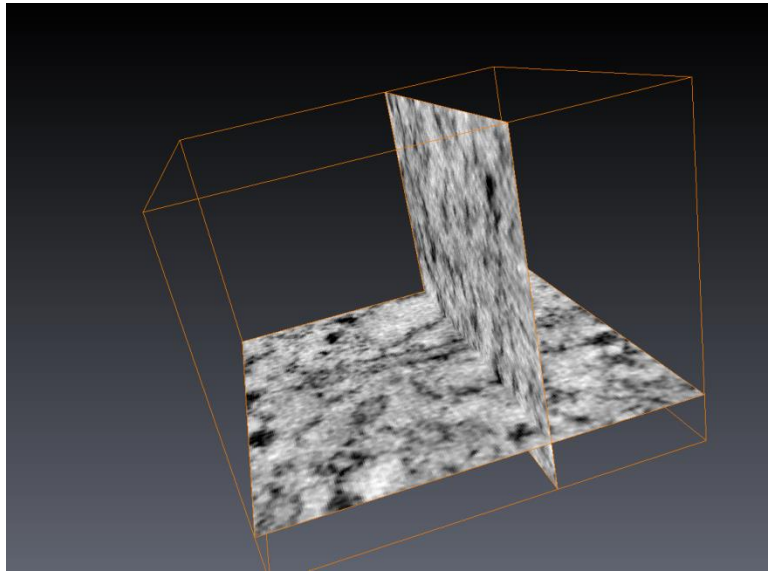
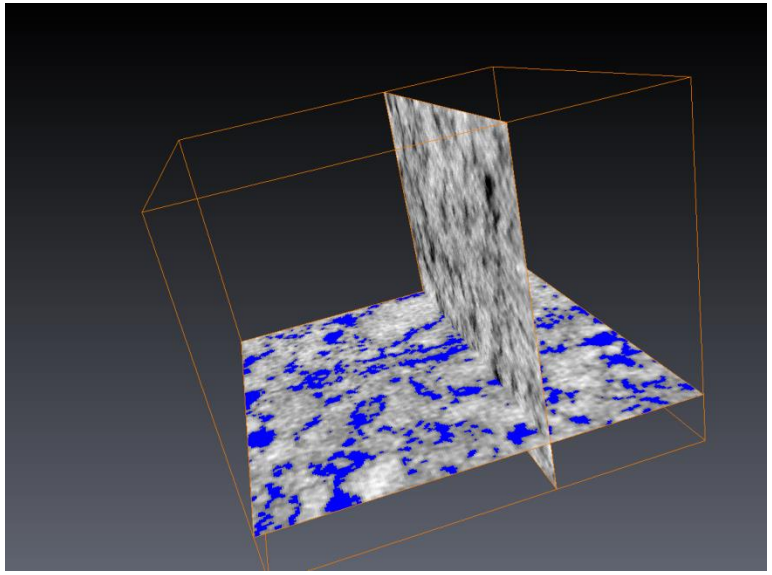
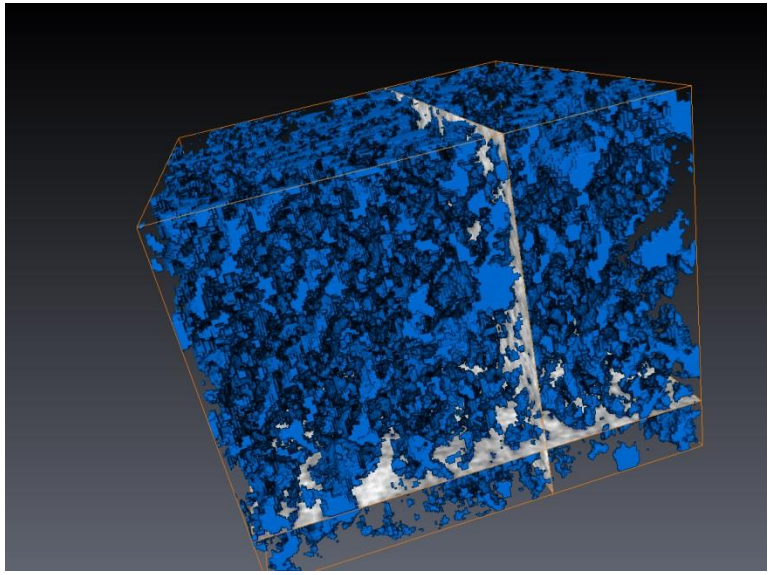
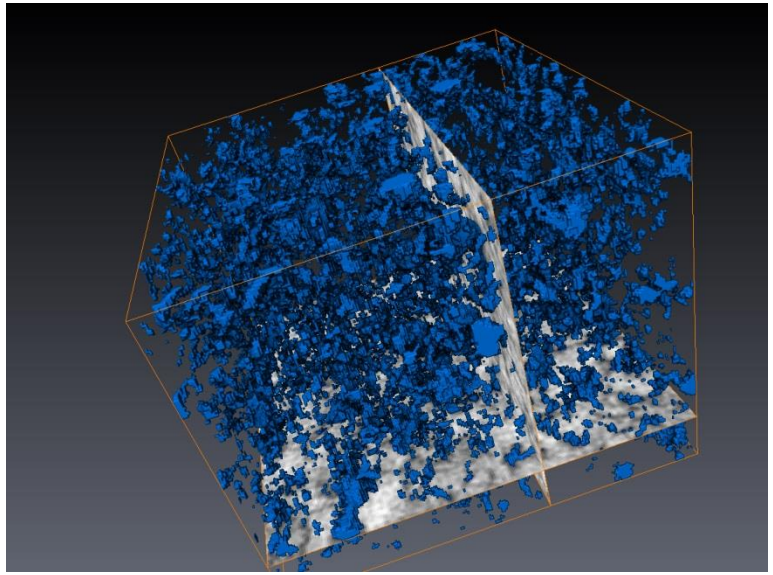
Fiber Analysis via Segmentation (Most Likely Impossible)



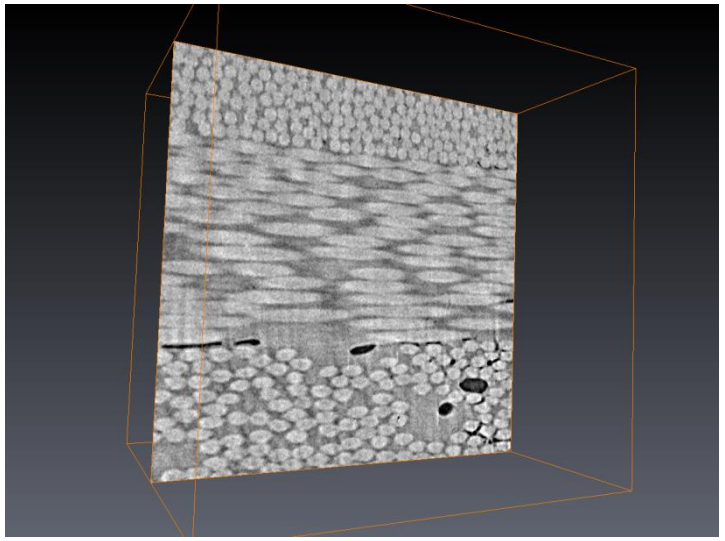


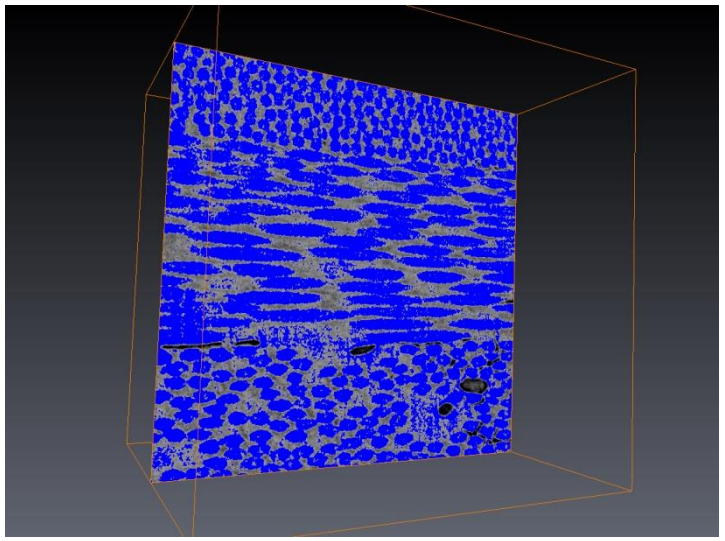


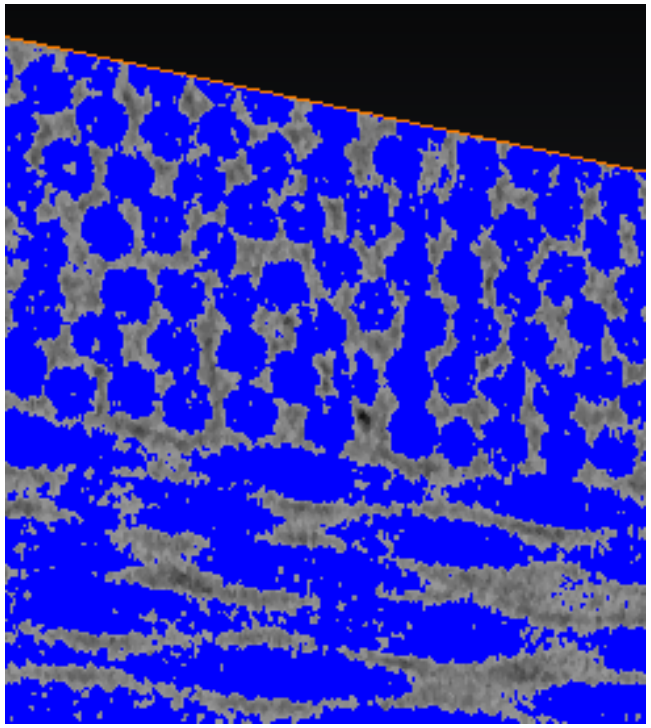


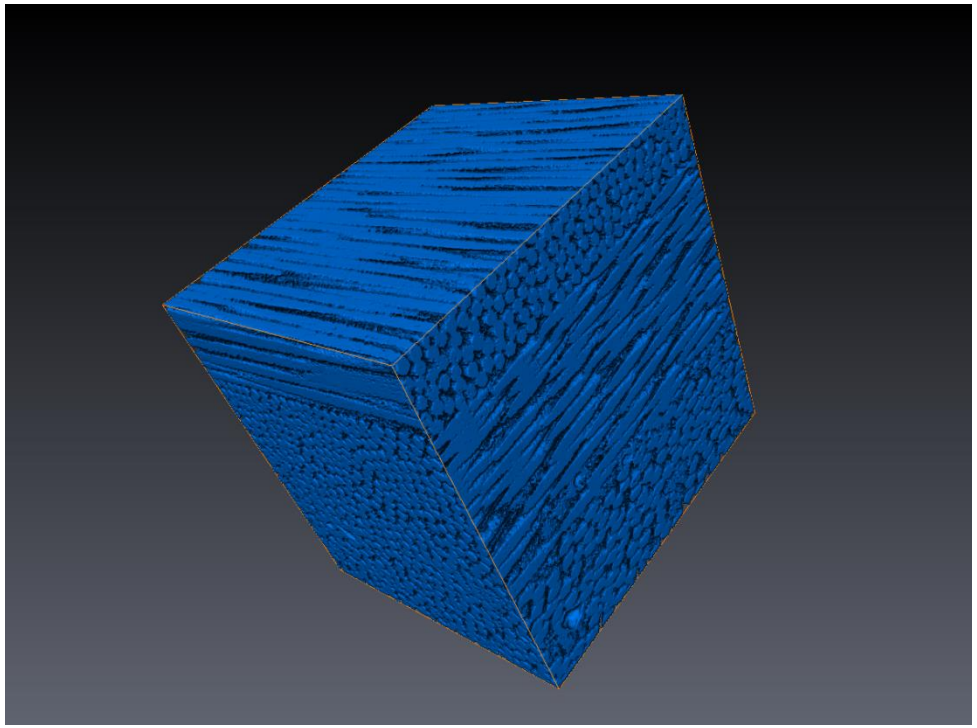
ThermoFisher SCIENTIFIC

Fiber Analysis via Segmentation (Most Likely Impossible)









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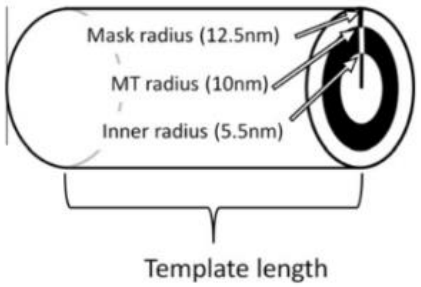
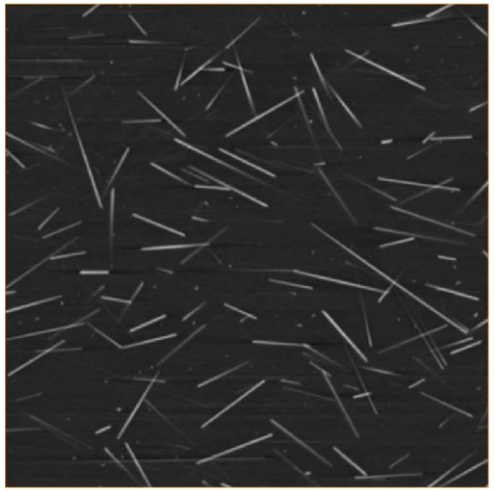
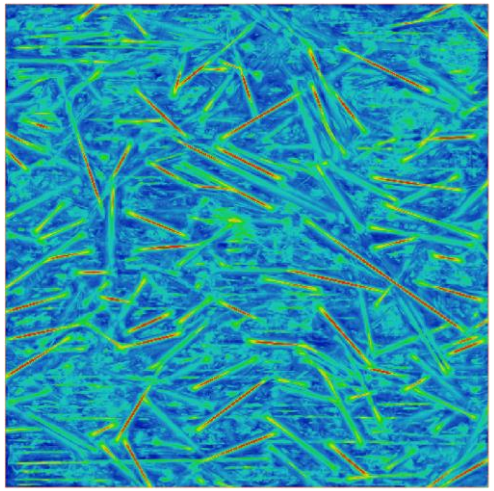
Cylinder Correlation

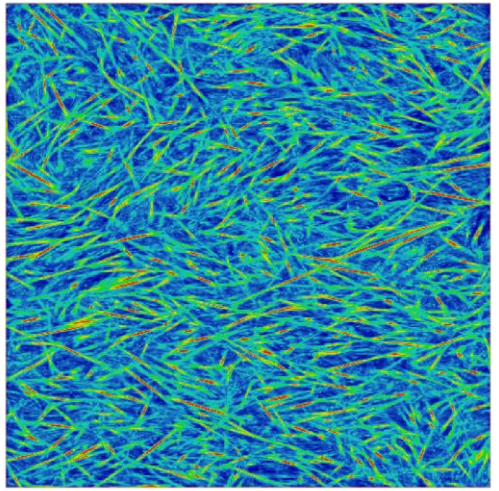
- Correlation-based detection
  - Correlation map
  - Orientation map







Avizo® Inspect



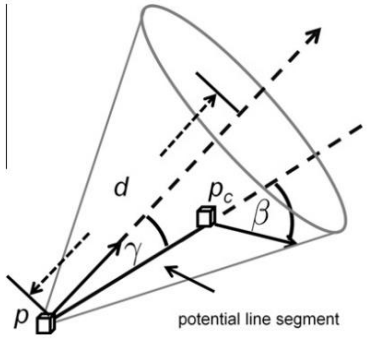
Avizo® Inspect

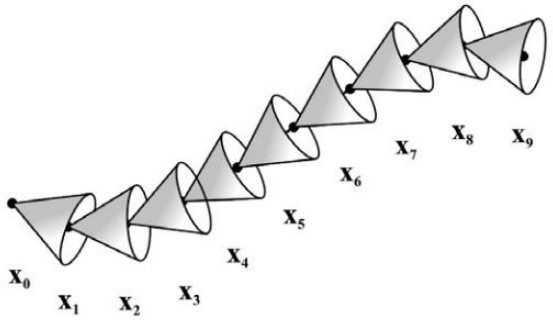
[Roseman et al., Ultramicroscopy 94, 2003], [Rigort et al., J. Structural Biology, 2012], [Weber et al., JSB, 2012]

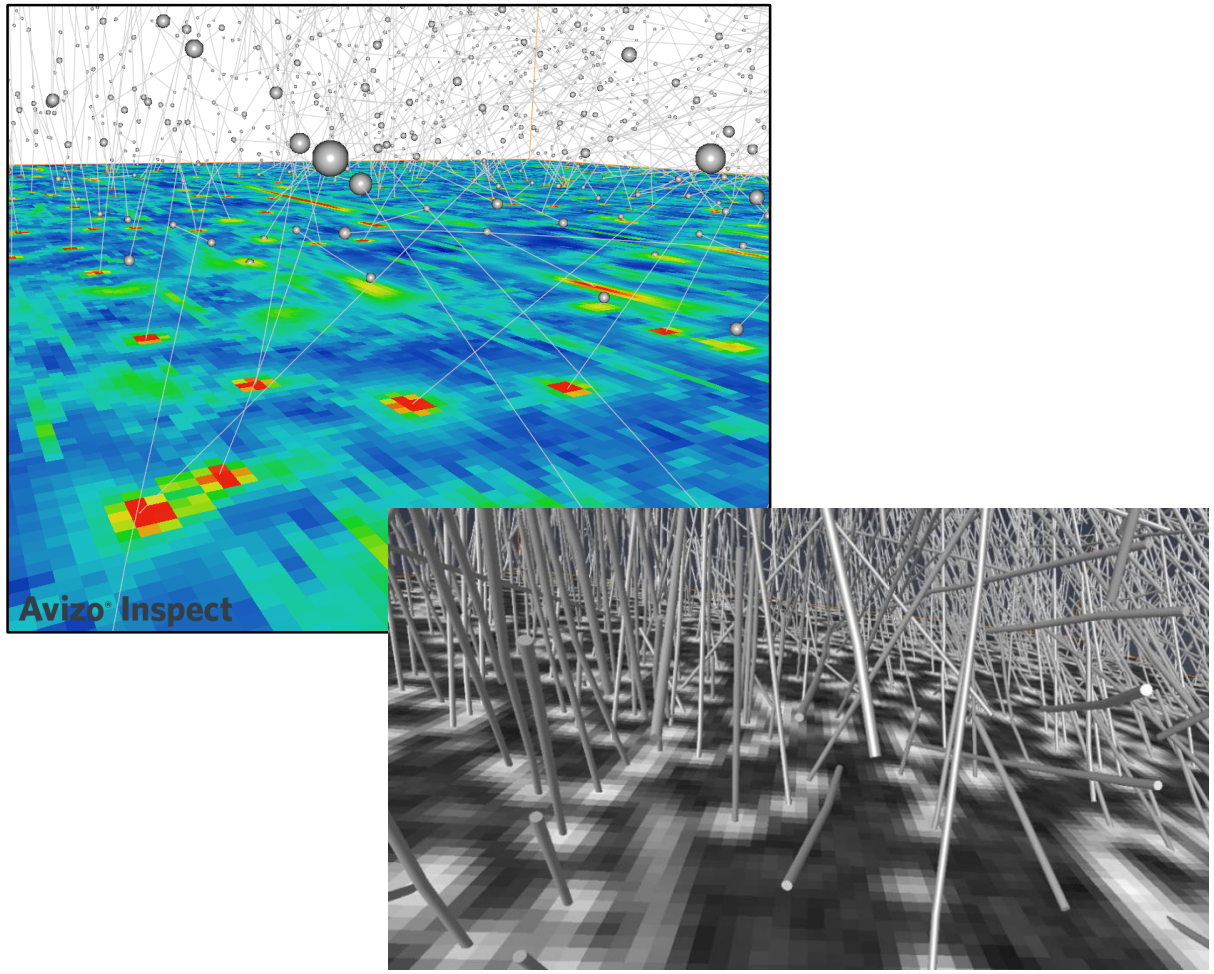
ThermoFisher SCIENTIFIC

Correlation lines tracing

- Fiber centerline tracing
  - Iterative fiber extraction







[Roseman et al., Ultramicroscopy 94, 2003], [Rigort et al., J. Structural Biology, 2012], [Weber et al., JSB, 2012]

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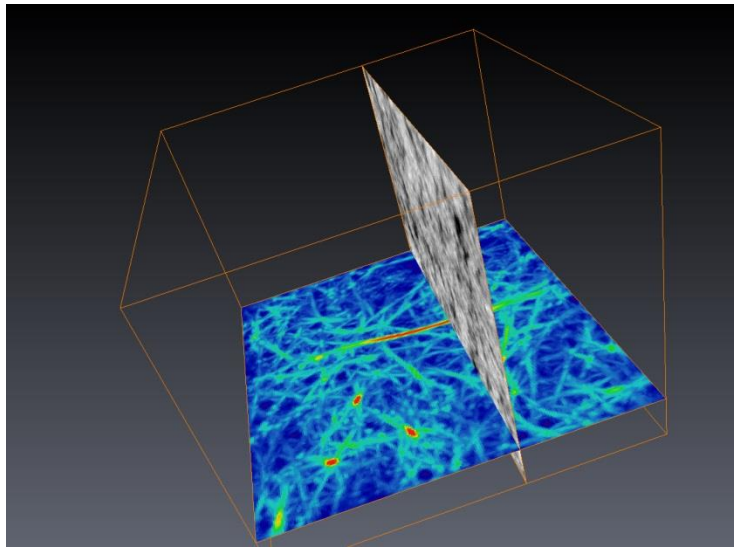
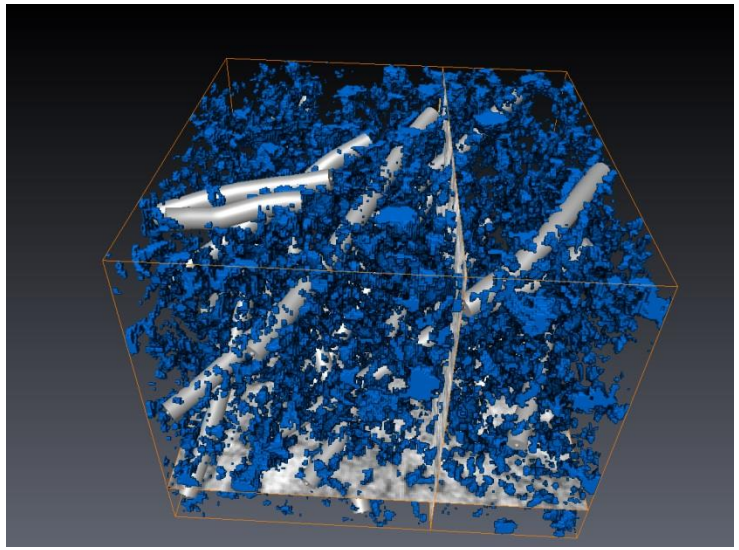
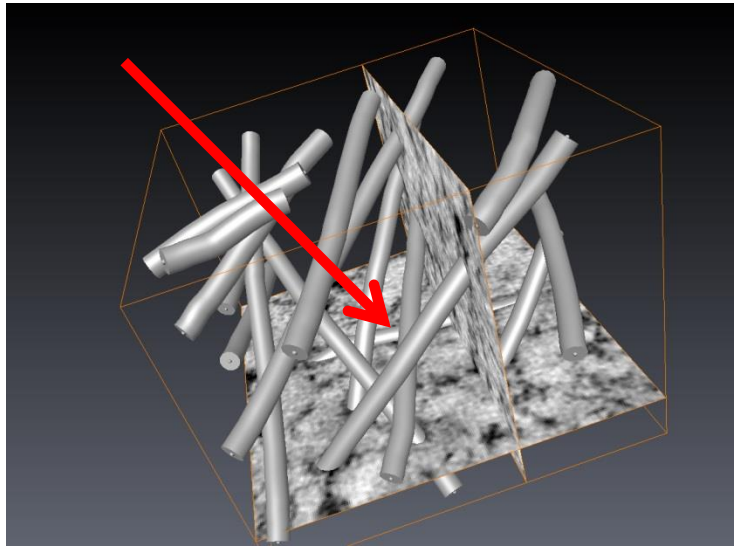
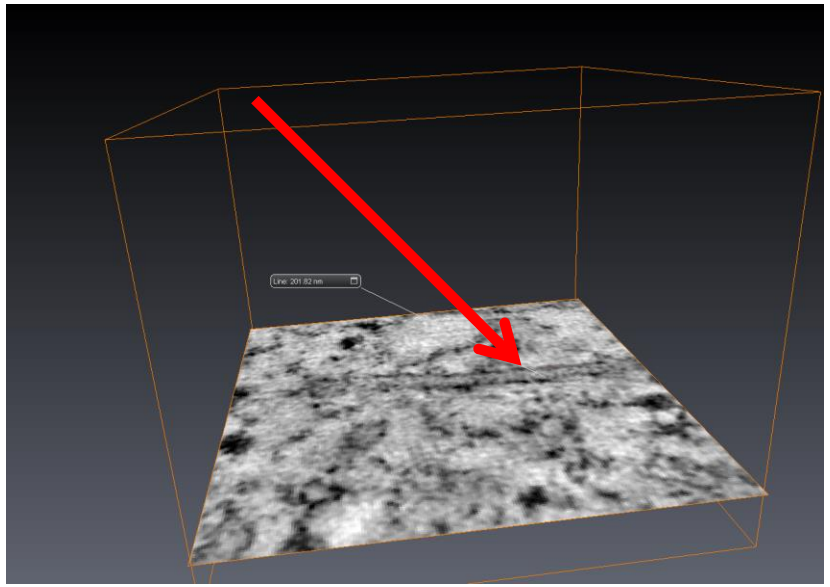
Cylinder Correlation - Result



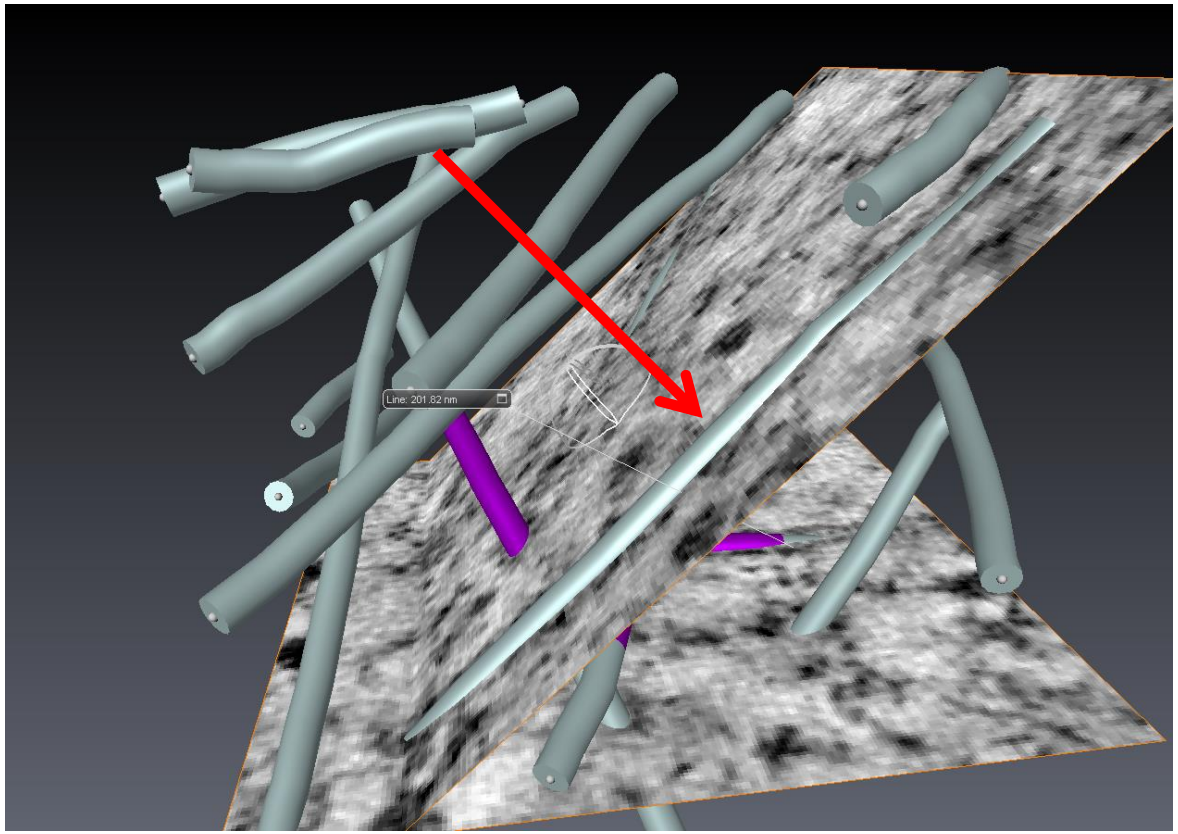


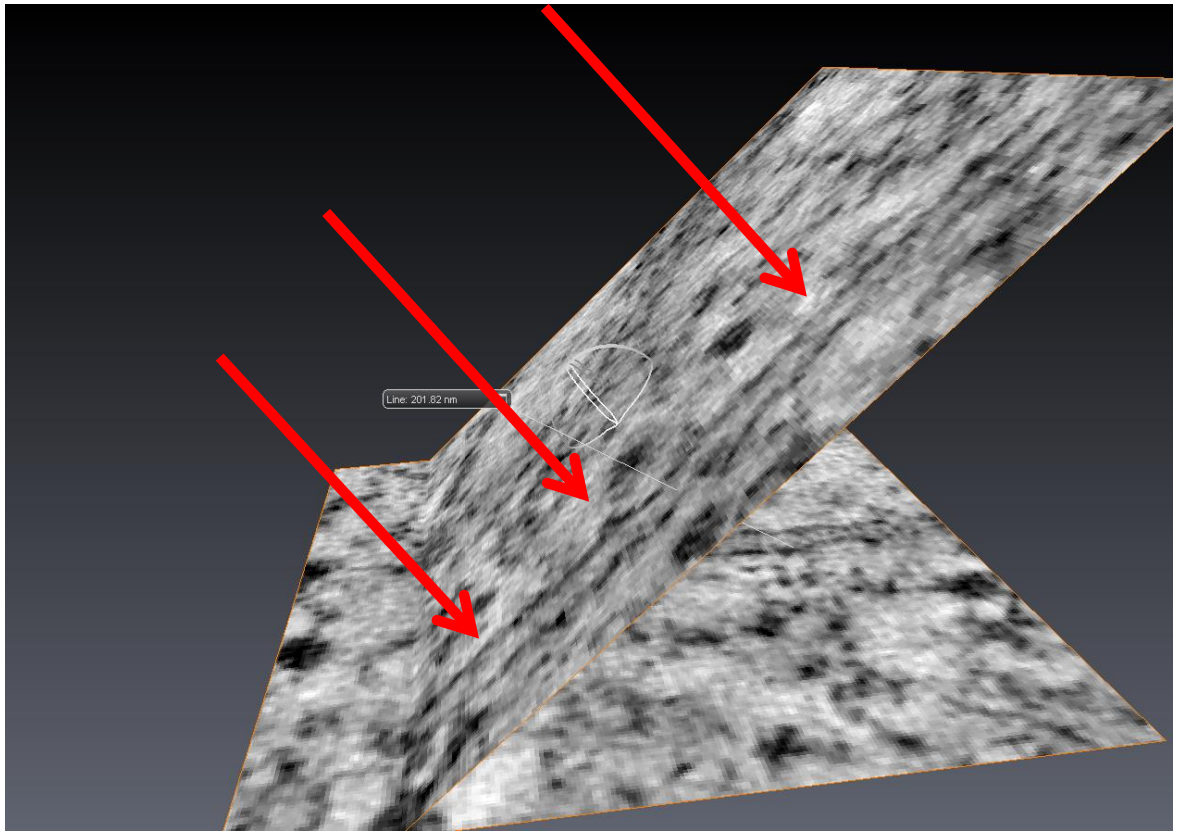




ThermoFisher SCIENTIFIC

Cylinder Correlation - Result





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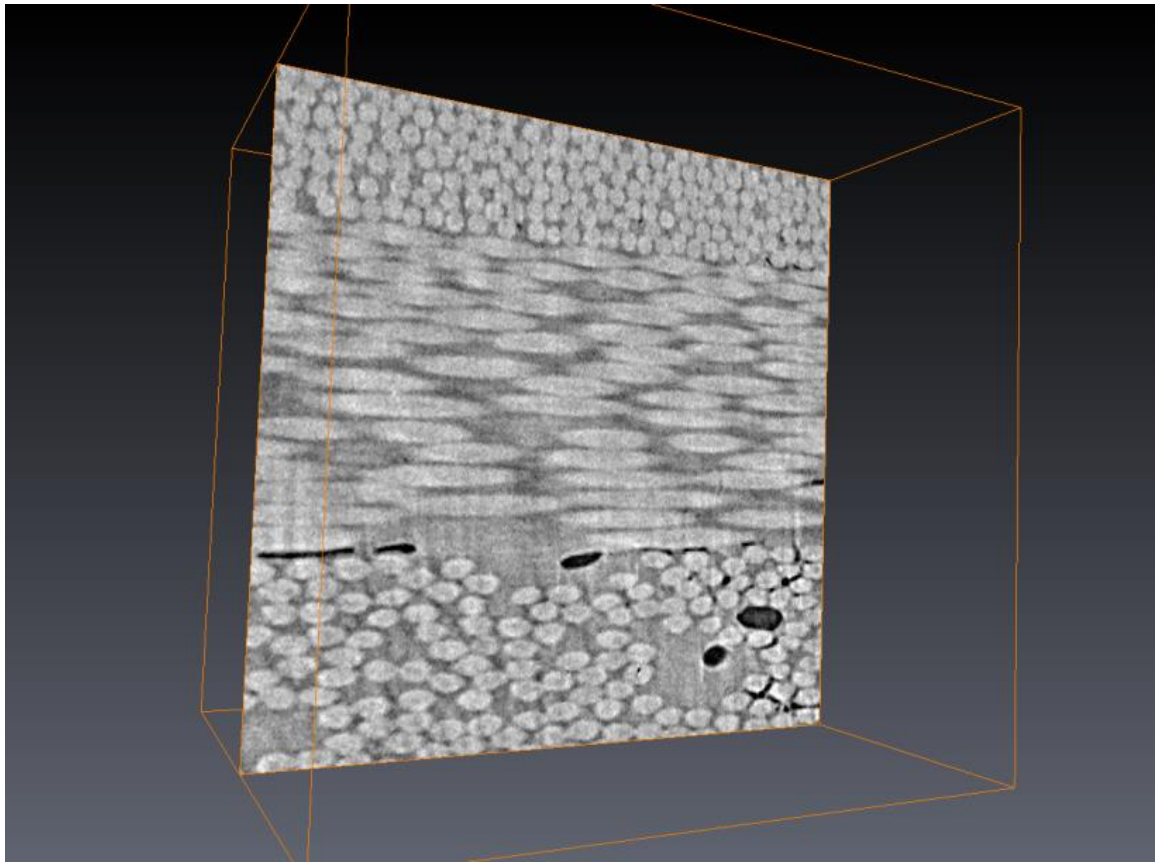
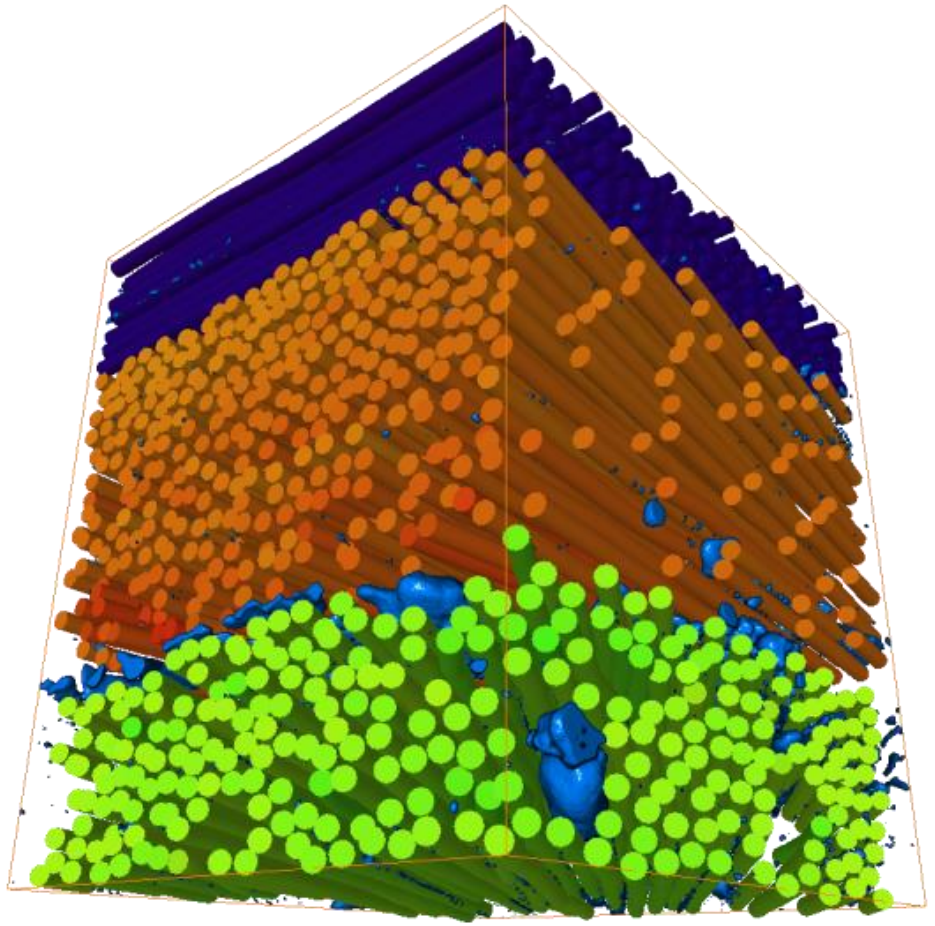
Cylinder Correlation - Result





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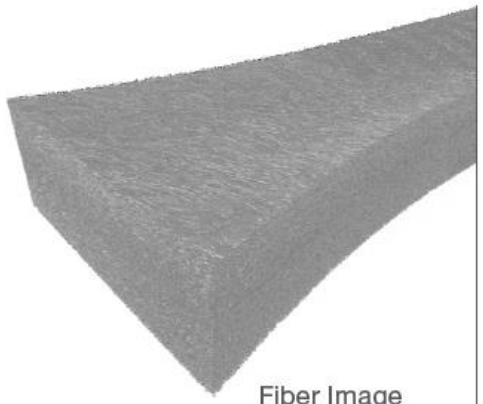
Fiber Verification

Single Fiber Extraction From CT Image

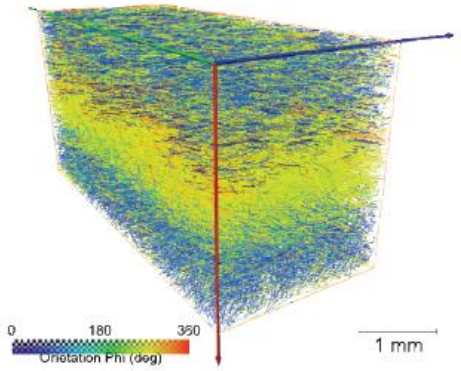
Test Piece of GFRP

Avizo XFiber Extension
Geometrical Template
Fiber Centerline Tracing

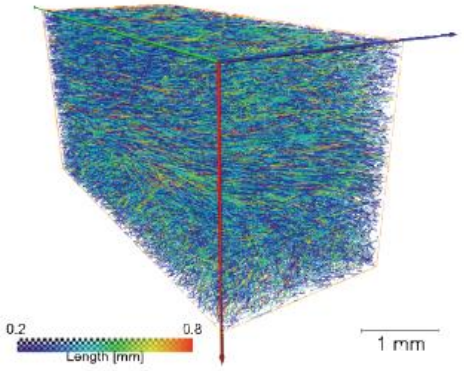


Fiber Image

Tracing and Visualization of Each Fiber



Fiber Orientation Colormap



Fiber Length Colormap

Measurements for Quantitative Analysis

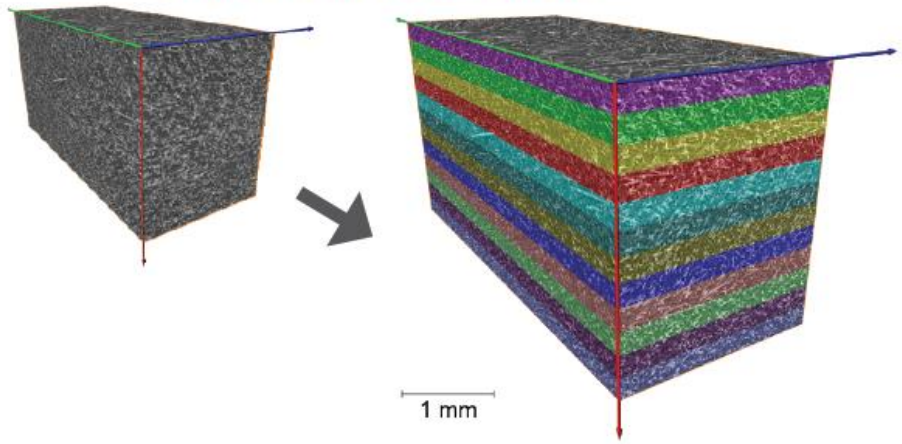
Each Fiber

- Length
- Orientation
- Diameter
- Volume
- Surface Area
- Tortuosity…

Full/Sub-Volume

- Total Fiber Volume
- Total Fiber Surface Area
- Orientation Tensors
- Main Orientation Vectors
- Fibers Density…

Split Volume to 12 Layers



Example of 12 Layers

- Simulation Vs Actual
- Single and Multiple Layers
- Improve Simulation for more accurate predictions
- Export data to other software

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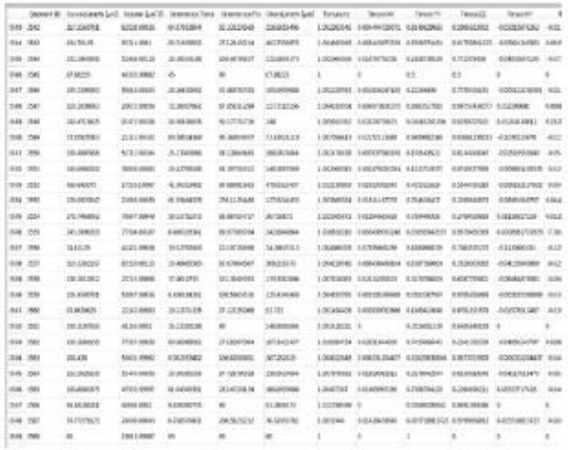
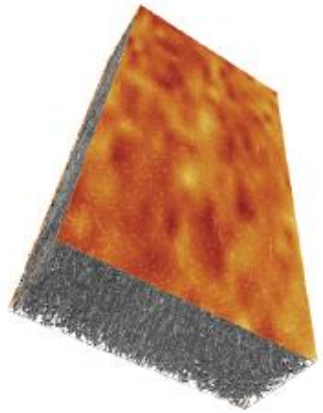
Fiber Verification

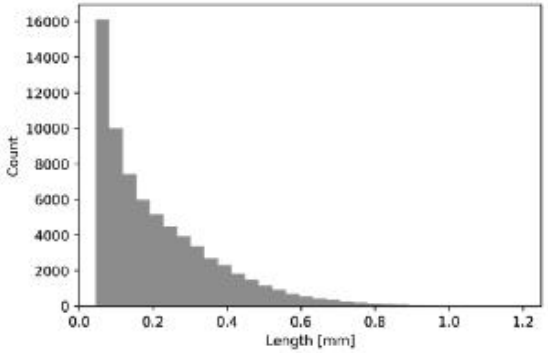
Full-Volume Analysis



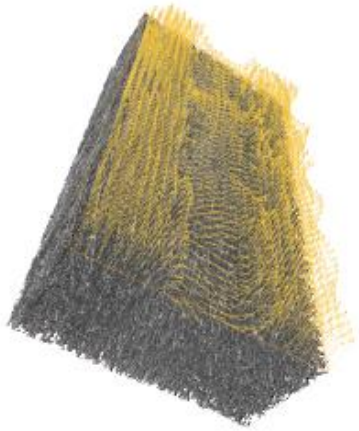
Analysis Report for Each Fiber



Visualization of Orientation Vectors

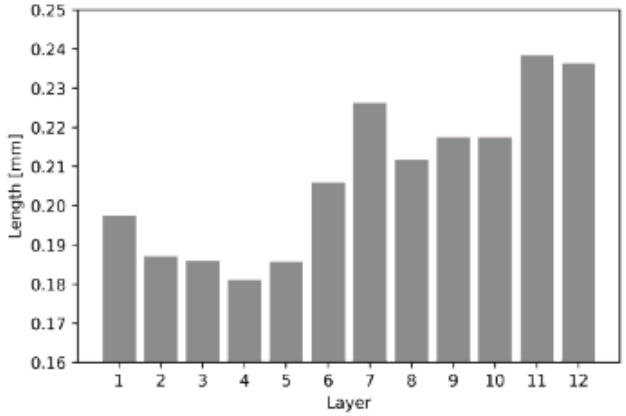


Distribution of Length

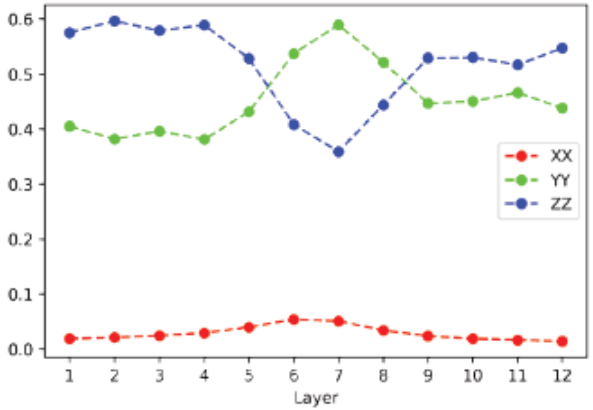


Visualization of Density of Fibers

Layerwise Volume Analysis



Distribution of Mean Length



Distribution of Orientation Tensor
Trend Analysis of fiber orientation in core and skin layers under injection molding

Data courtesy of EMS Grivory

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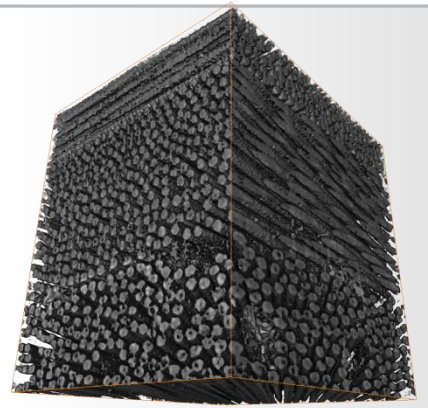
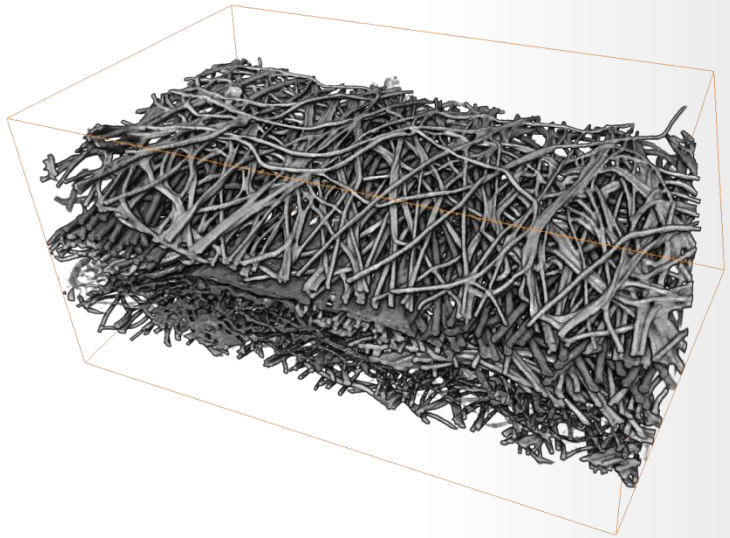
Fiber Analysis Use Cases - Datasets

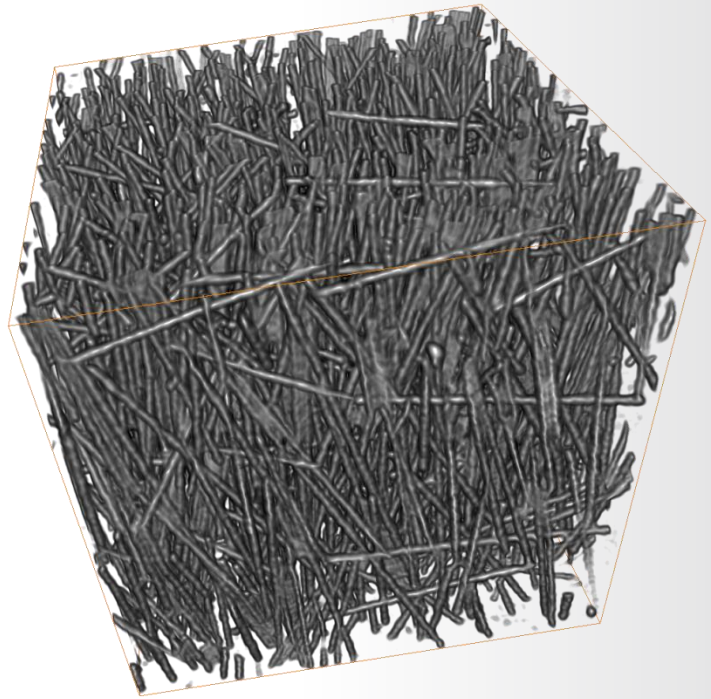
- CFRP Bike 0.27um



- Mask Filter Fiber 1.07um



- CFRP 1.25um



Avizo

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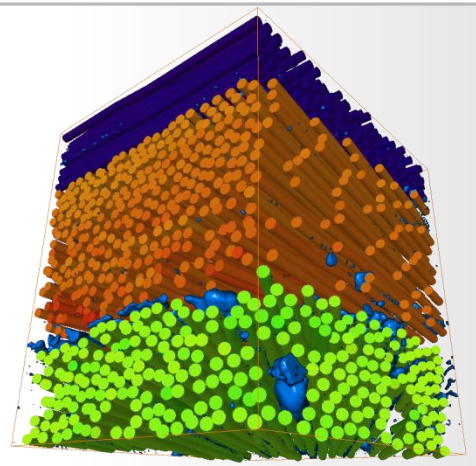
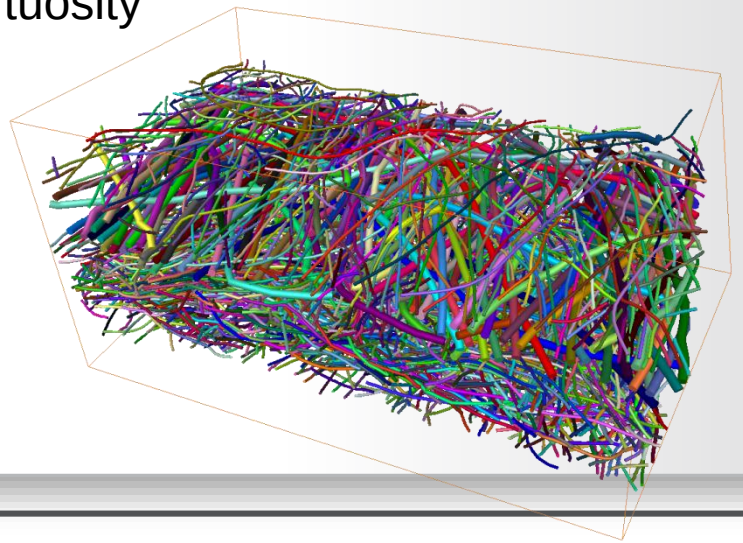
Fiber Analysis Use Cases - Results

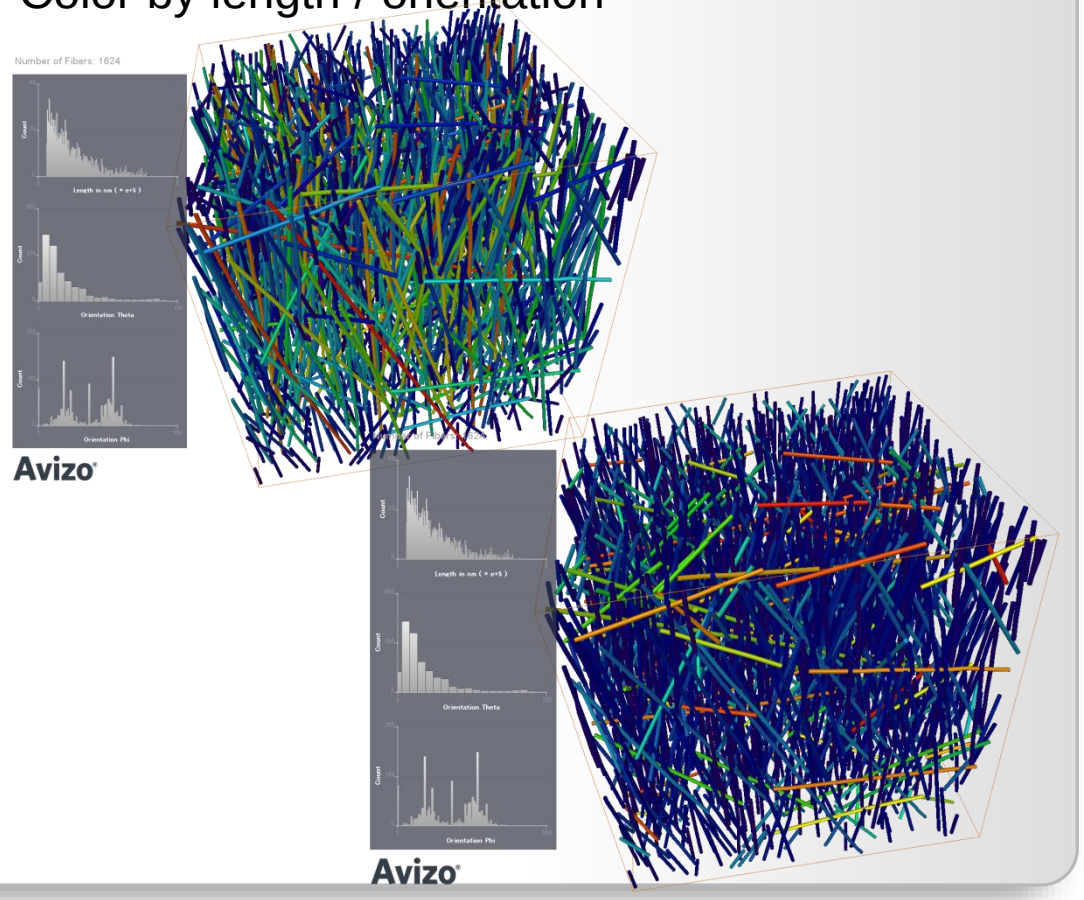
- CFRP Bike 0.27um
  - Color by Orientation
  - Defect ID



- Mask Filter Fiber 1.07um
  - Color by Tortuosity



- CFRP 1.25um
  - Color by length / orientation



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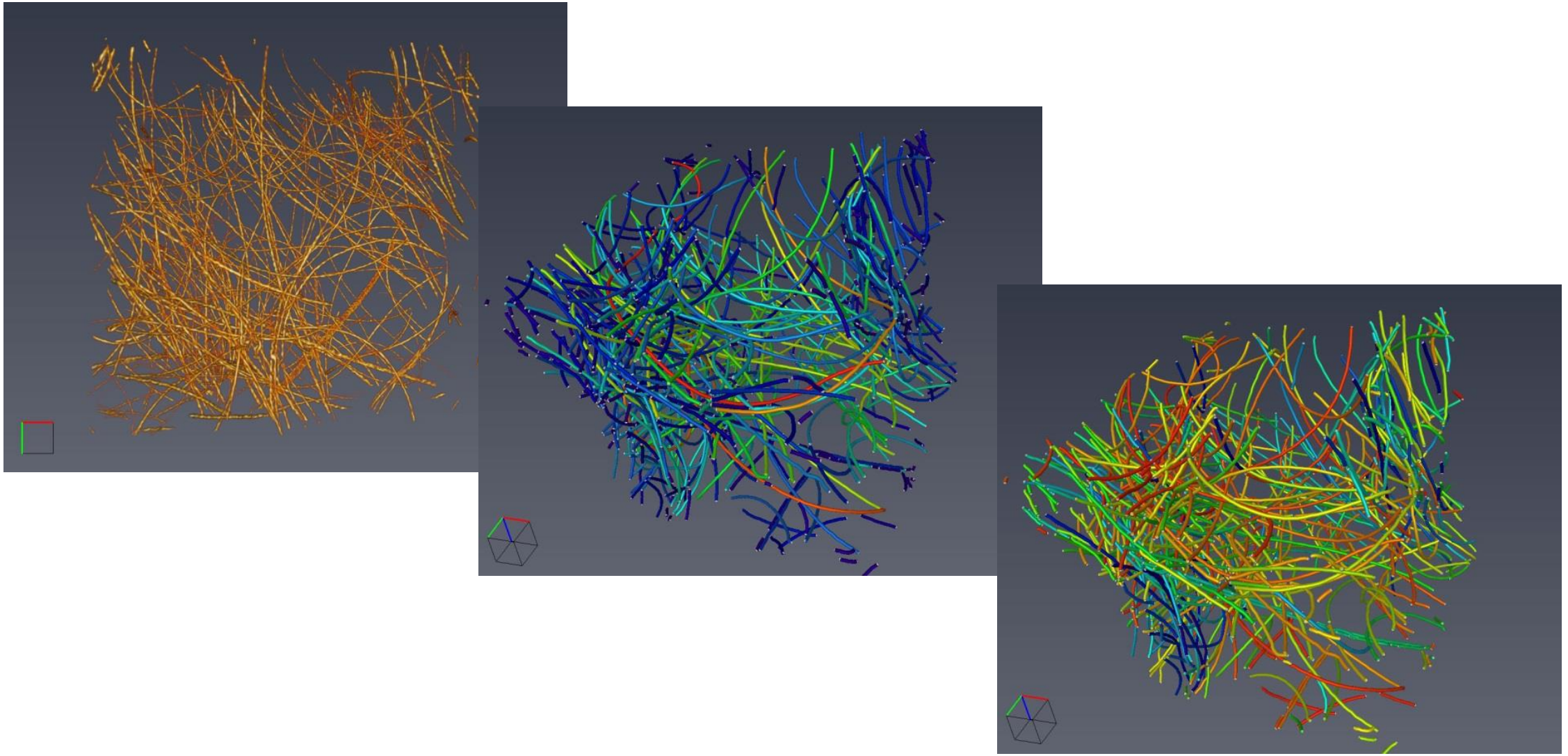
Color by Length / Tortuosity



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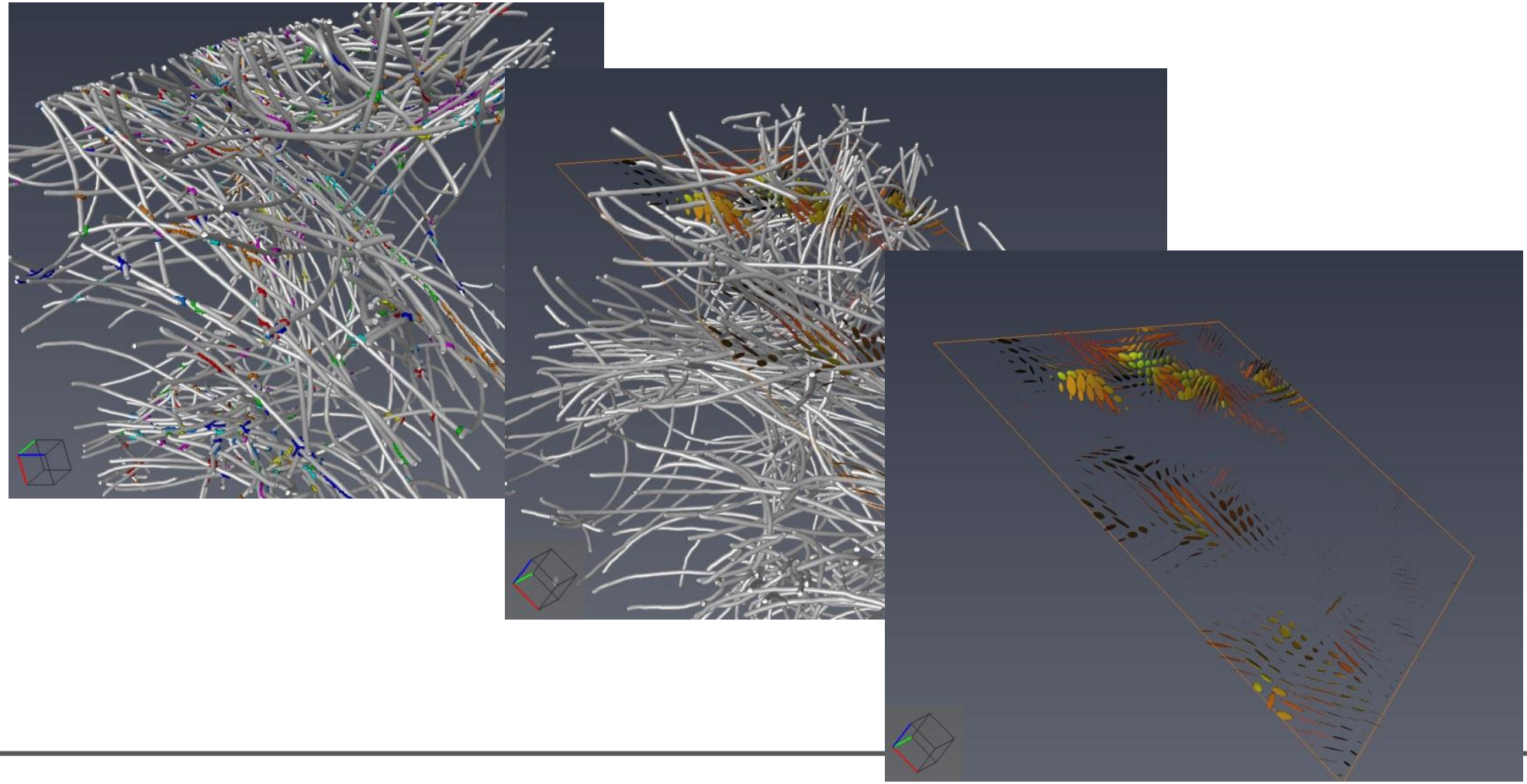
Color by Length / Tortuosity

- Contact points and local orientation



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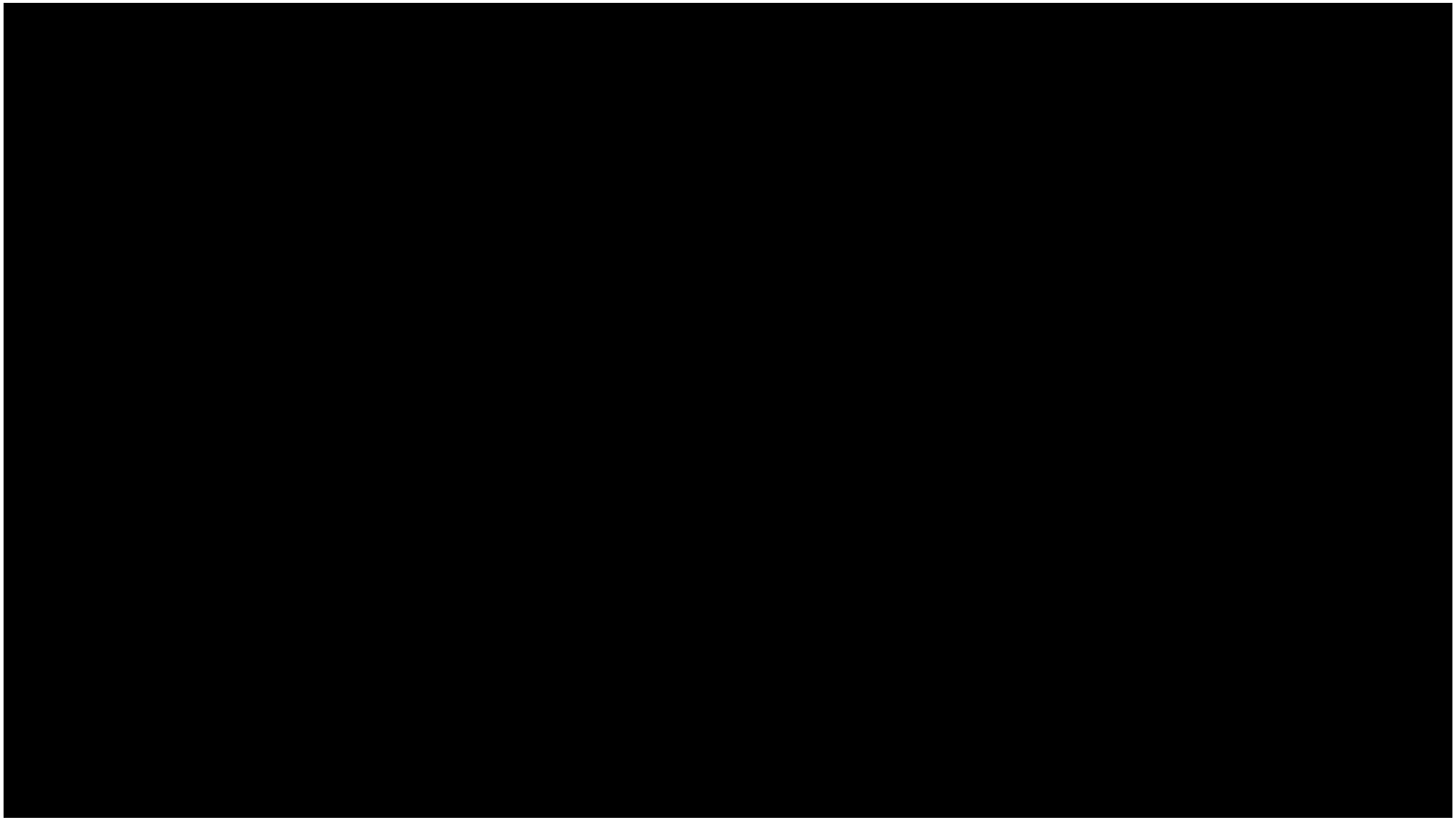
Fiber Cases Video – CFRP/ GFRP DVC / FR Concrete



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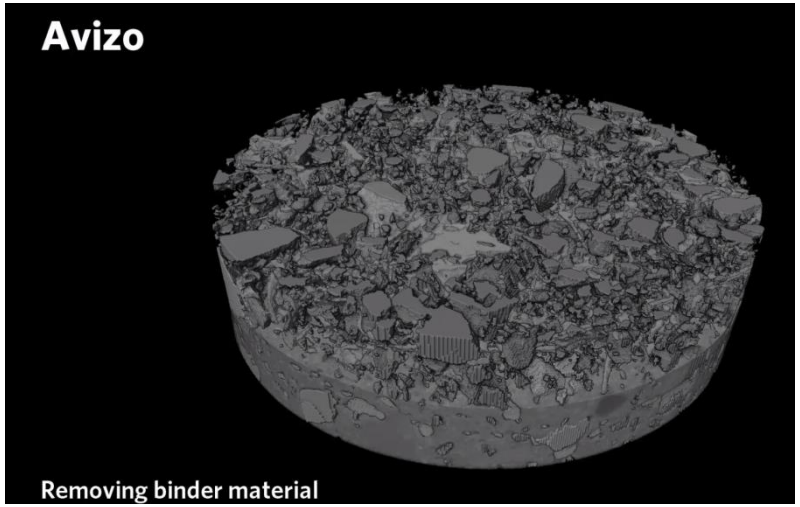
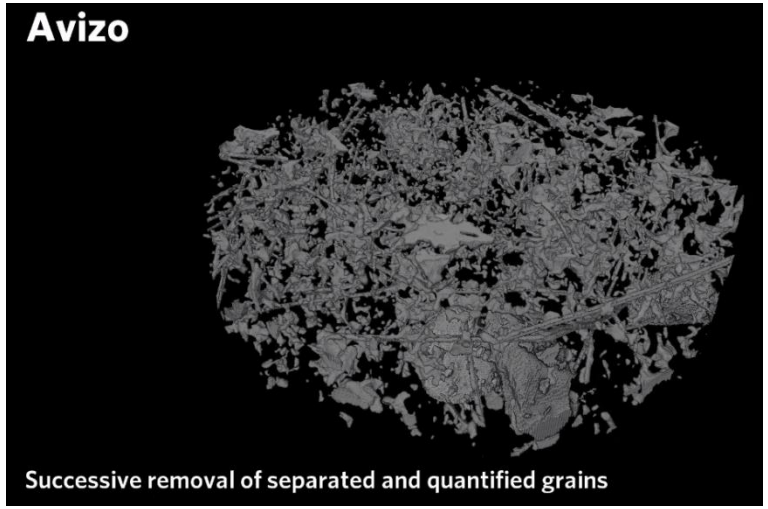
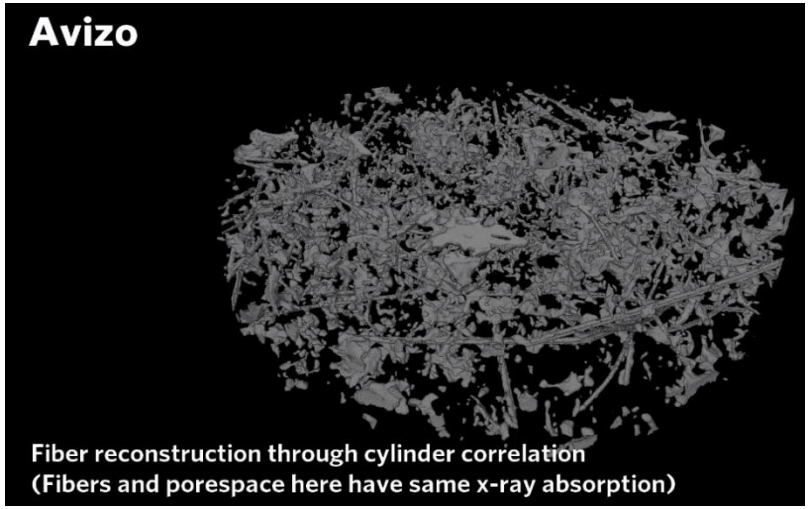
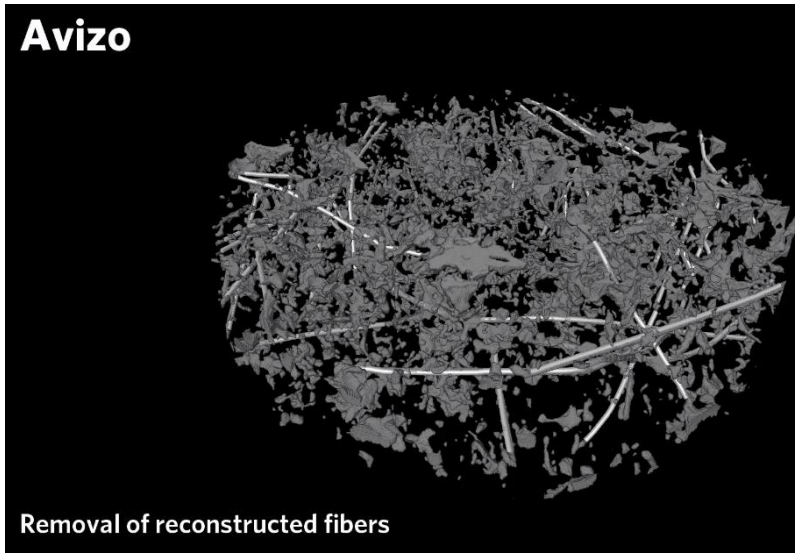
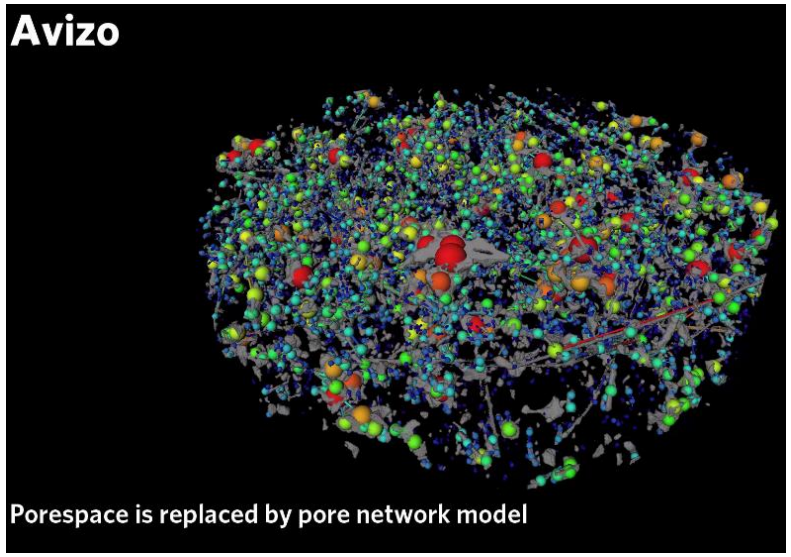
Fiber and Porosity Analysis

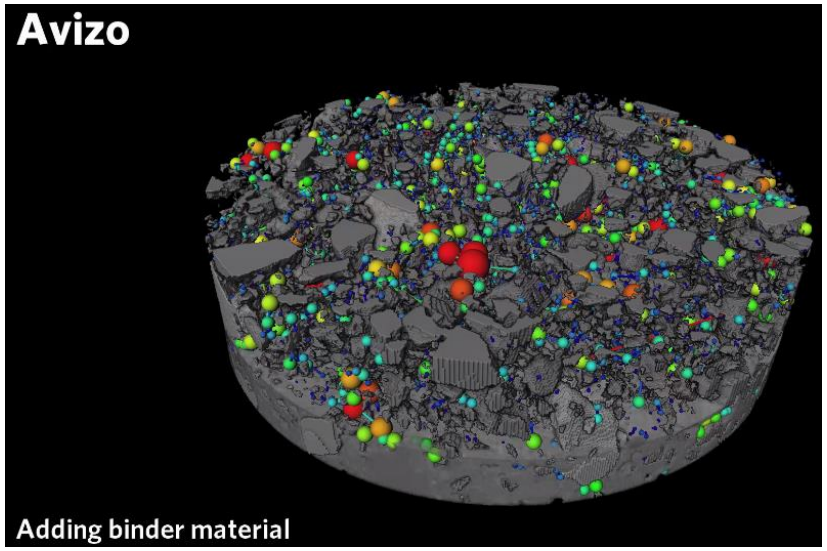












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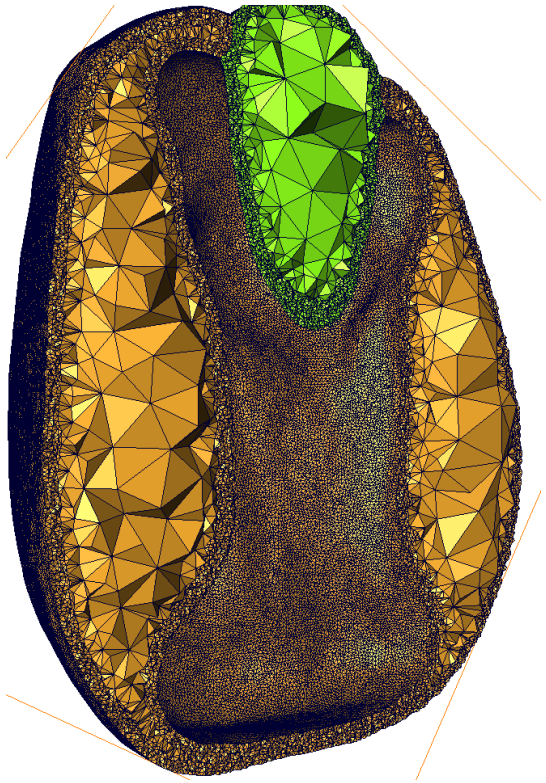
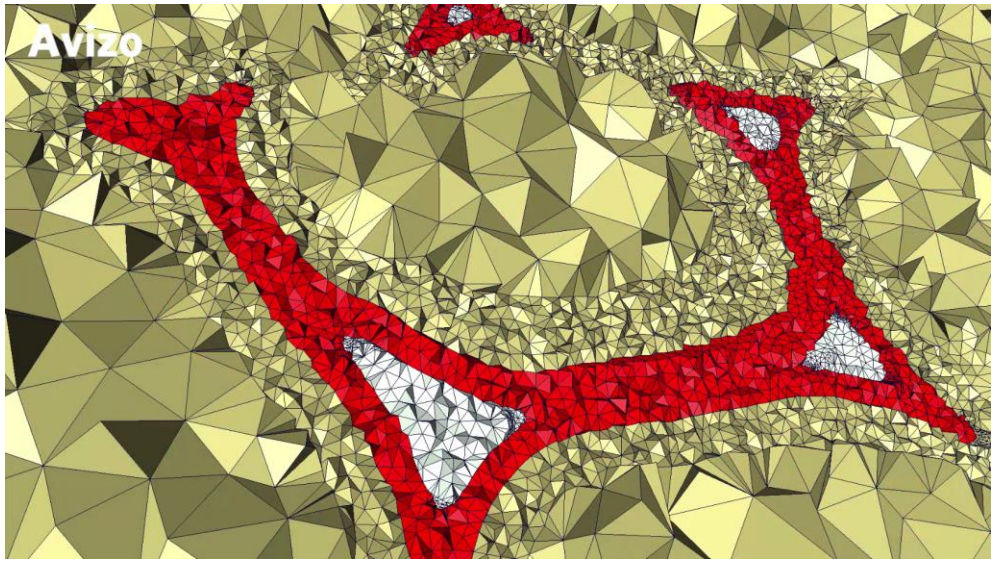
High Performance Meshing / 3D Printing

(new in Avizo 9.4/ Amira 6.4)

Direct meshing from segmentation data

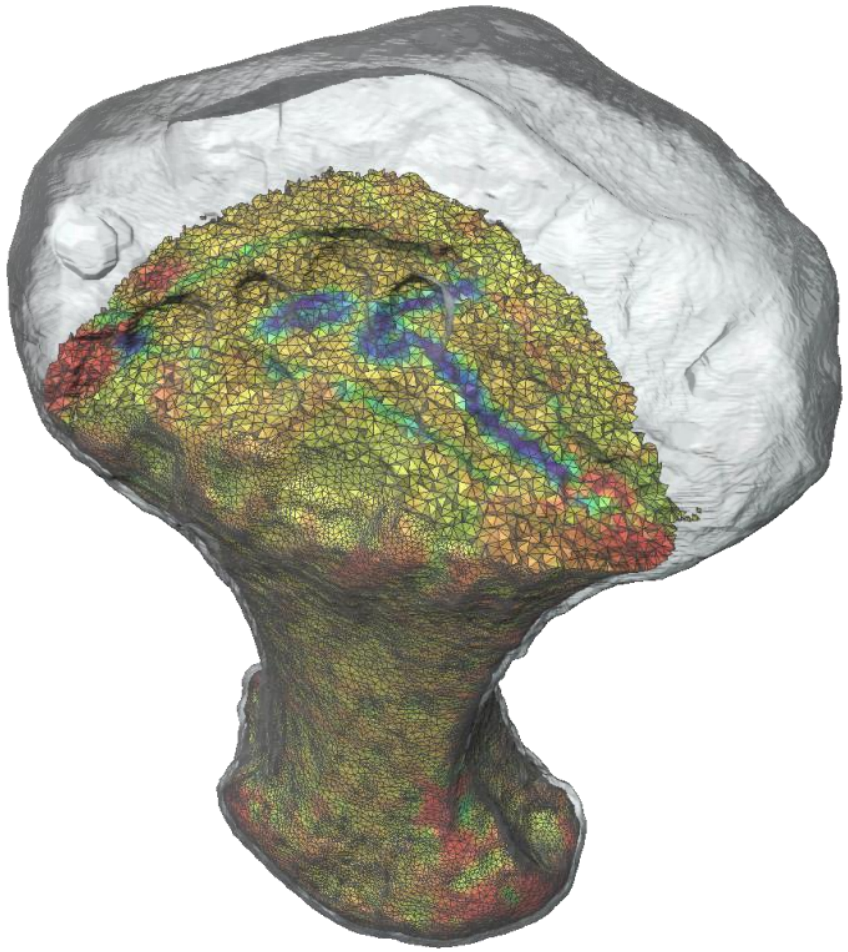
- High Quality and Fast mesh generation
- Fine control over cell size distribution
- Dedicated intuitive Meshing Workroom
- Complete set of exporters: Abaqus, Ansys, Fluent and more.





X-ray Synchrotron Nickel foam
Data courtesy: Professor Patrick PERRE, Barbara MALINOWSKA, Cyril BRETON, laboratory LGPM, Centralesupelec

https://youtu.be/KHc_w2Ot104



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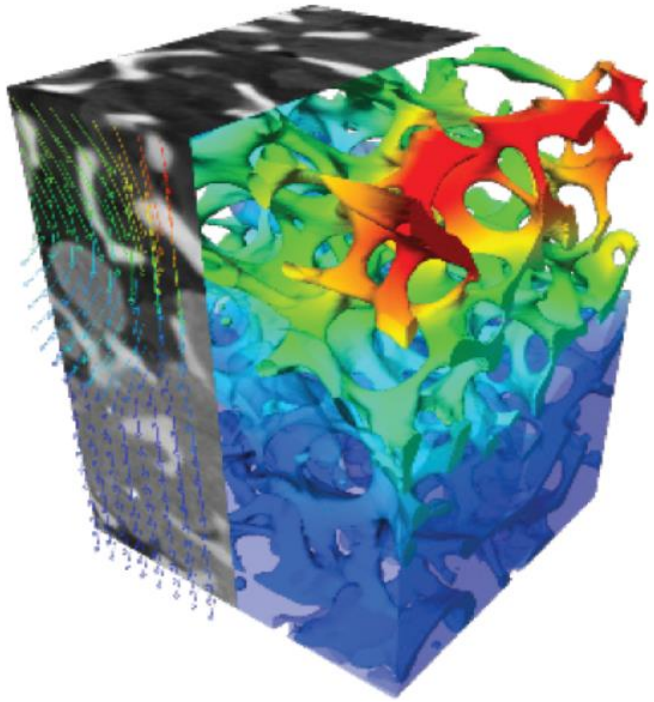
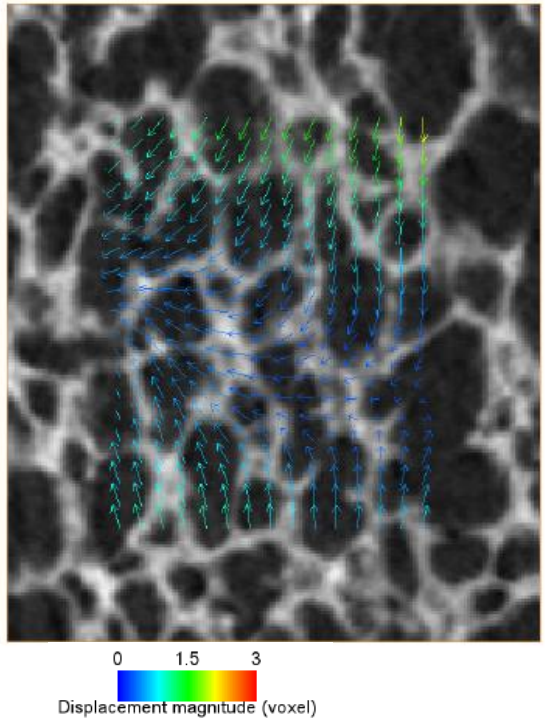
Digital Volume Correlation

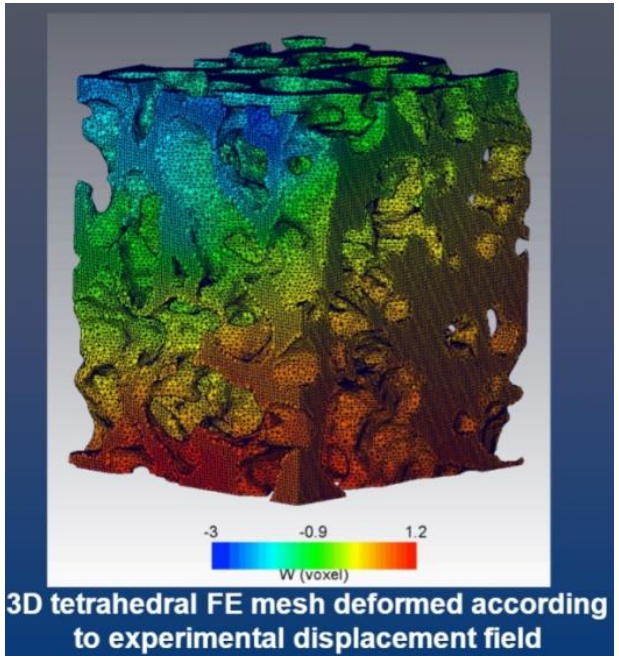
(new in Avizo 9.4/ Amira 6.4)

Displacement and Strain maps from 3D images during in-situ experiments

- Innovative, powerful, contact less, bulk-strain measurement technique
- Evaluate material response to mechanical or thermal loads, fatigue tests
- Local and Global estimation methods







Avizo XVolumeCorrelation Extension has been developed in cooperation with the companies 3Dmagination (Didcot, UK) and Eikosim (Paris, France).

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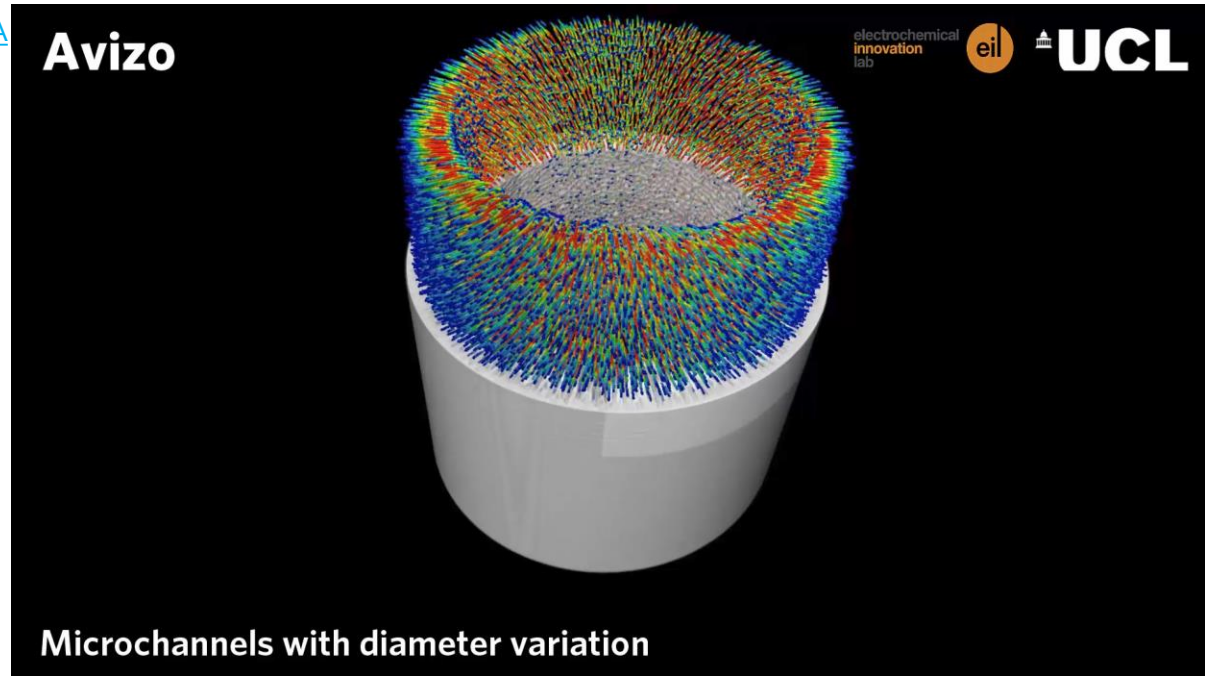
Outstanding Presentation

https://youtu.be/WHBZANpPaAA



Snapshots of any size

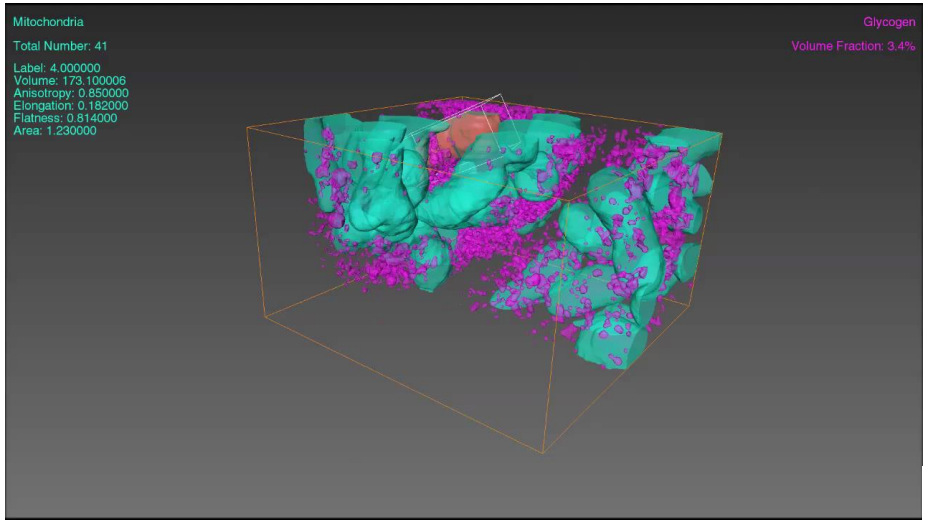
- Not limited to screen resolution

Easy animations and videos

- Create your own scenario
- Intuitive interface for generating animations

3D Stereo devices

- Display your data in real 3D
- Flat walls of any size
- Immersive environments



https://youtu.be/wFL29aD8JCc

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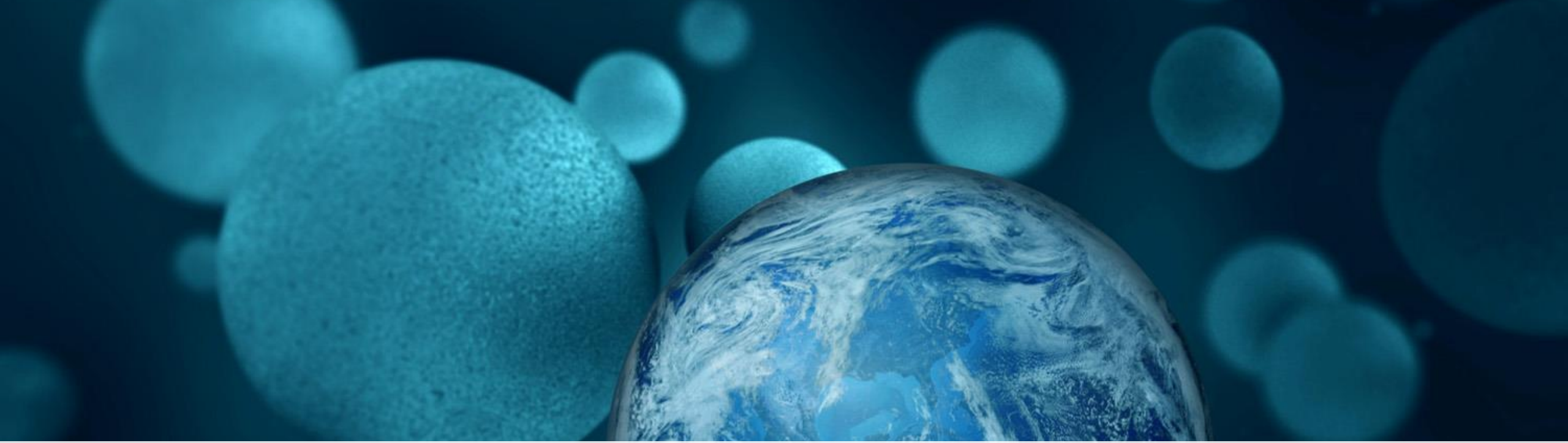

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Thank You

Eric.Ho@Thermofisher.com