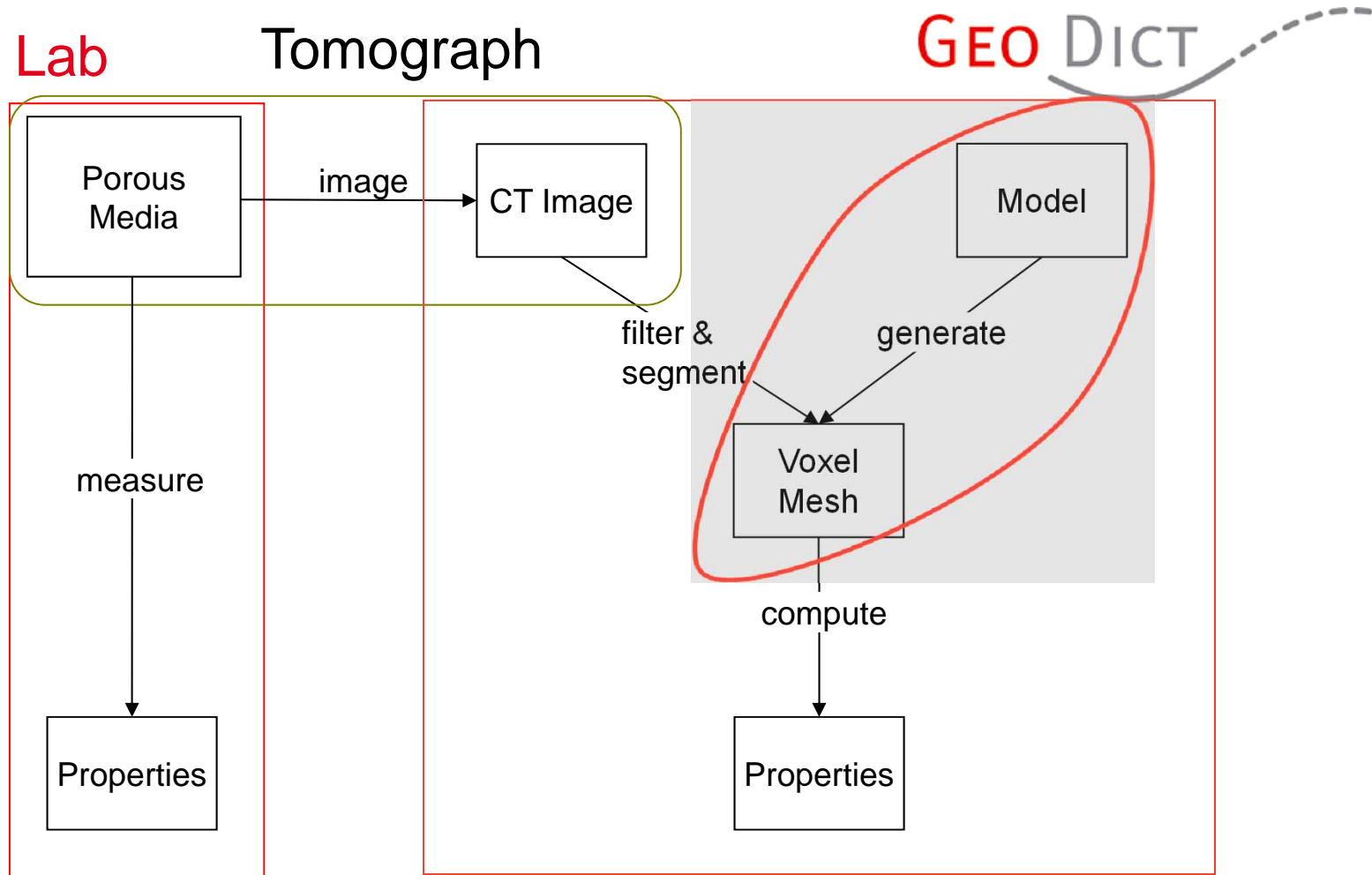

Synthesis of Virtual Nonwoven, Cellulose Material and Patterned Structures

Jürgen Becker

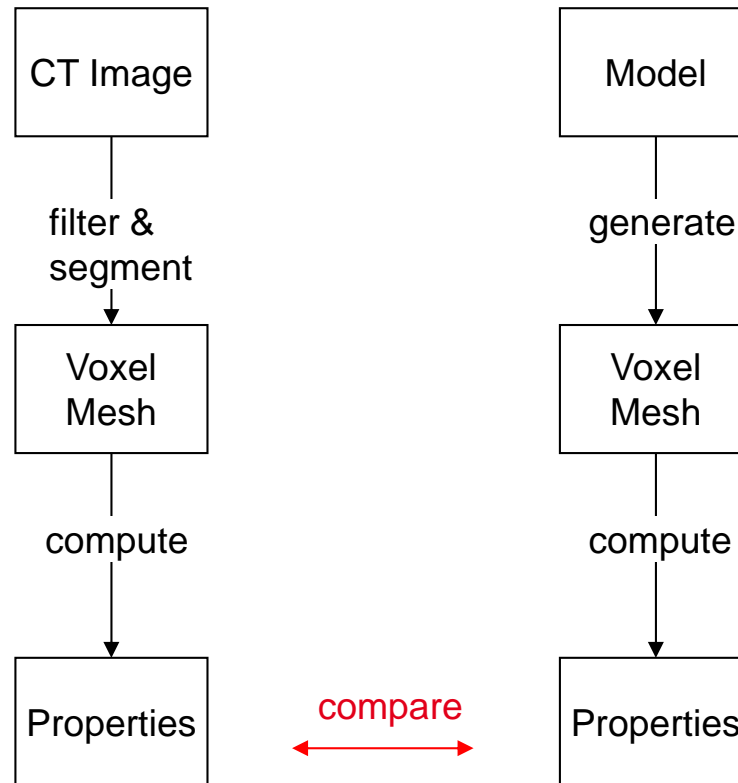
GeoDict User Meeting 2012

Computer Aided Material Engineering

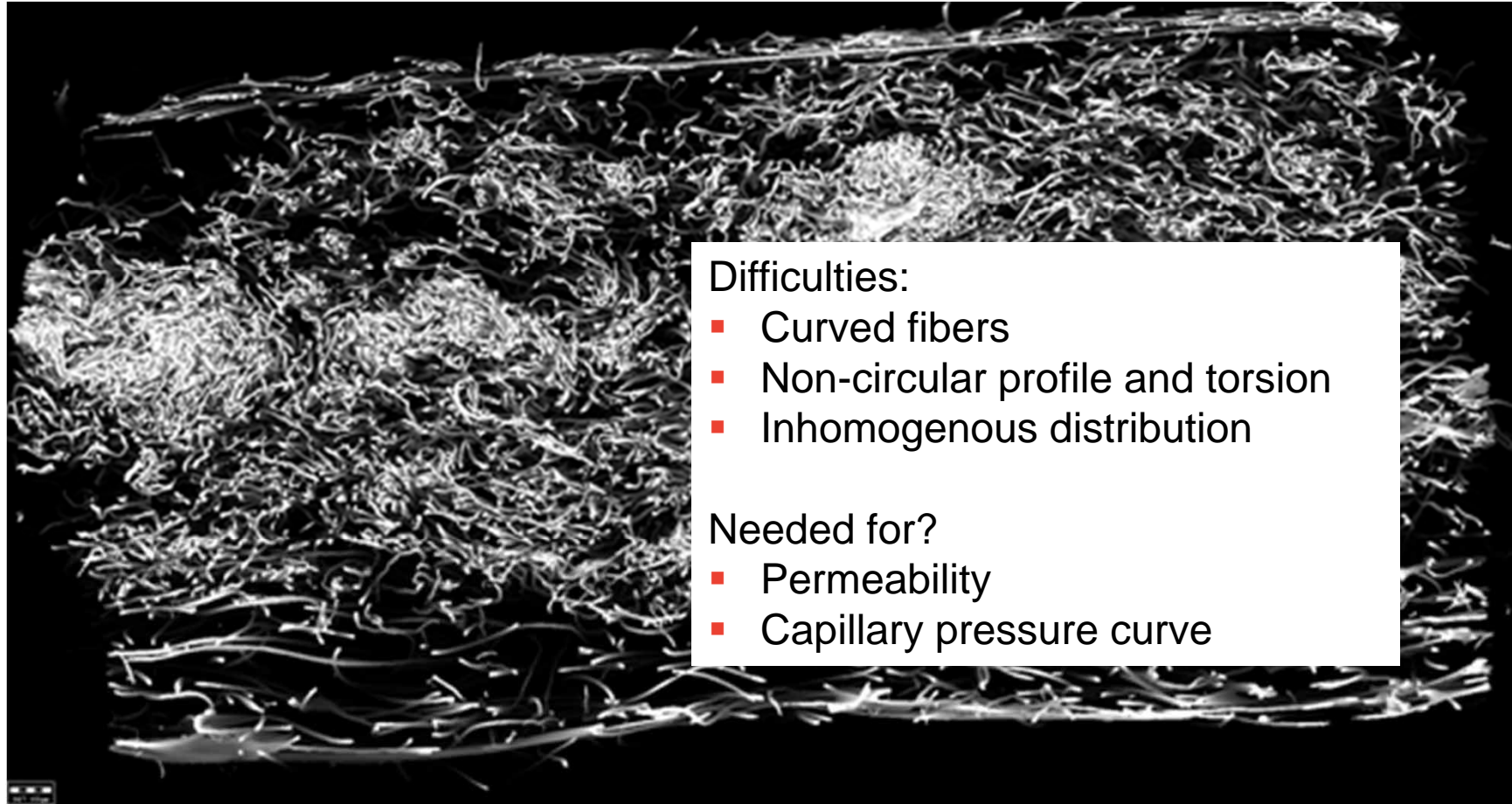


Computer Aided Material Engineering

1. Validation:
Model should mimic existing material
2. Virtual Lab:
Create new materials



Cellulose Material (3D Tomography)



Difficulties:

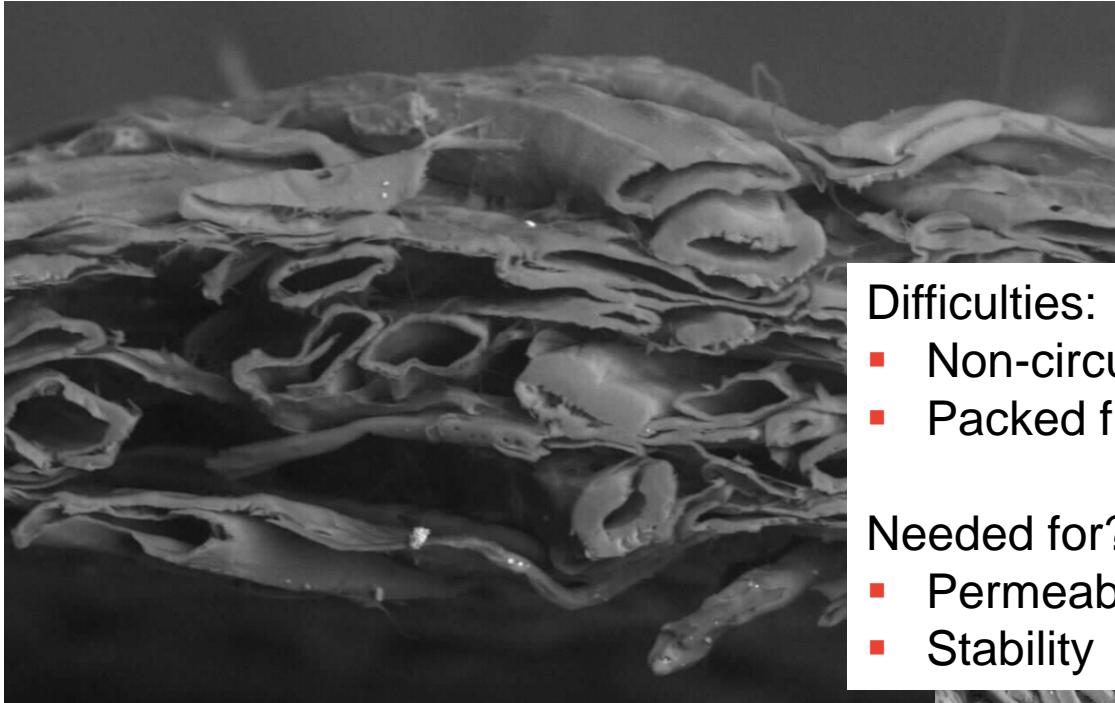
- Curved fibers
- Non-circular profile and torsion
- Inhomogenous distribution

Needed for?

- Permeability
- Capillary pressure curve

Annual Report ITWM, 2011

Paper (SEM Images)



- Grammage: 60 g/m²
- Paper height: 200 μm

Difficulties:

- Non-circular profile
- Packed fibers

Needed for?

- Permeability
- Stability

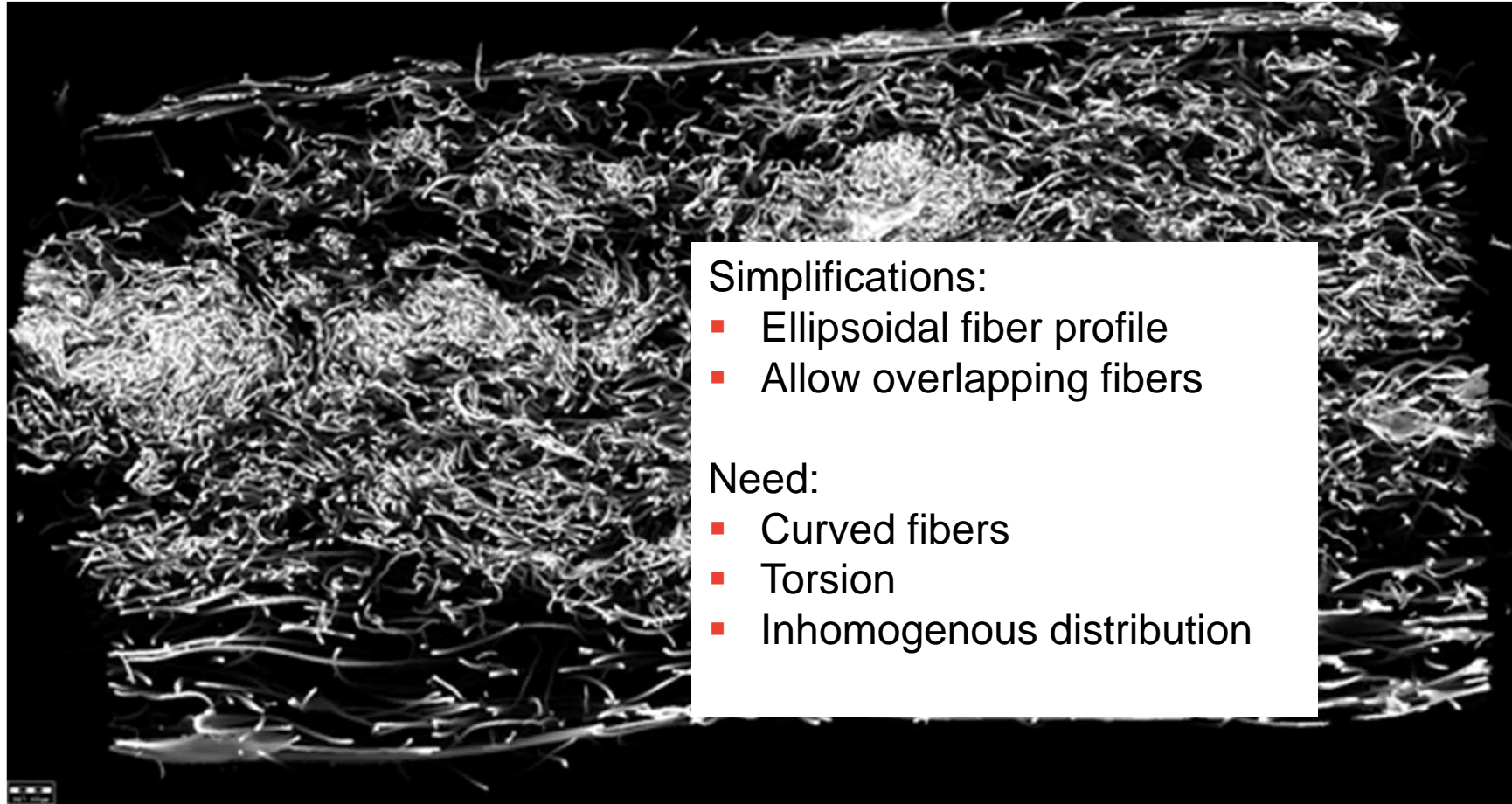


Occam's Razor

What is an acceptable structure model, which simplifications are allowed?

- Accept overlapping fibers in the model?
Permeability, Diffusivity: Yes
Elastic properties, Conductivity: No
- Fill hollow fibers?
- Use mean value for fiber diameter or size distribution?
- Ignore inhomogeneities?

Cellulose Material (3D Tomography)



Simplifications:

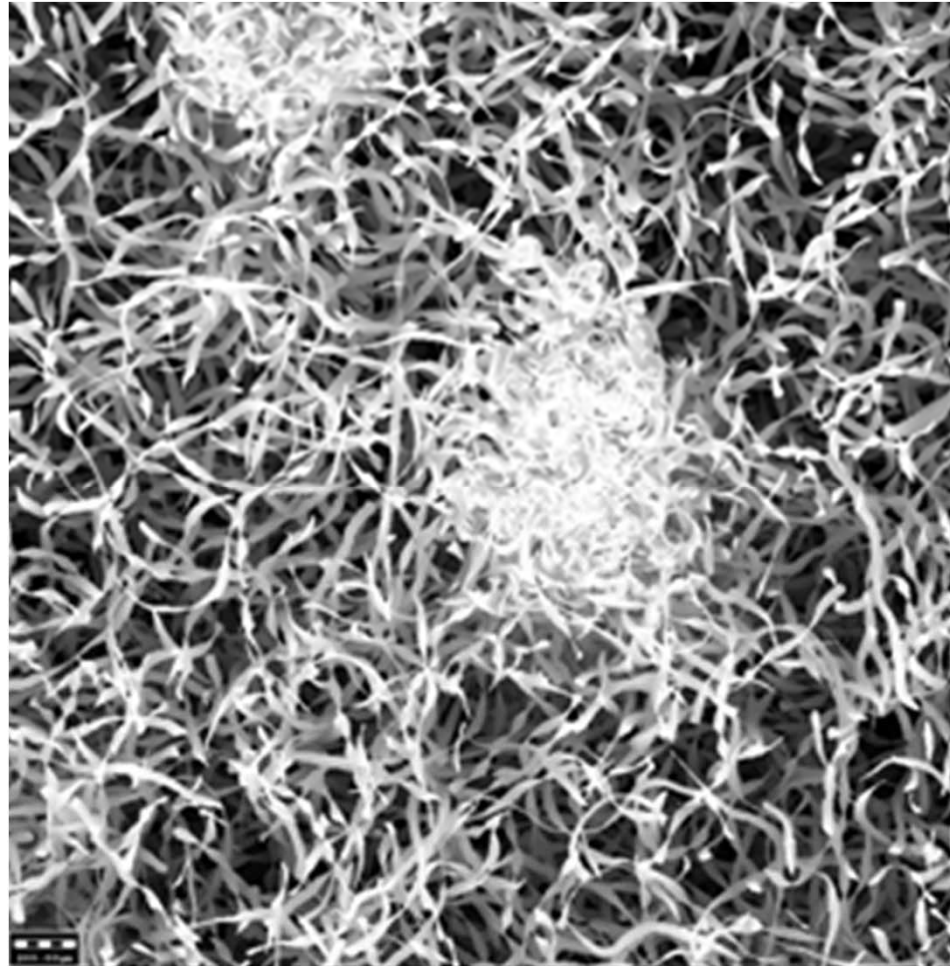
- Ellipsoidal fiber profile
- Allow overlapping fibers

Need:

- Curved fibers
- Torsion
- Inhomogenous distribution

Annual Report ITWM, 2011

Resulting 3D Model



Annual Report ITWM, 2011

Curved Fibers

Idea: create curved fibres out of straight segments

Algorithm:

1. start with one segment
2. add segments until desired fibre length is reached



Curved Fibers

How to determine the direction of the next segment?

Many possibilities:

- keep previous direction + random deviation



- keep previous curvature + random deviation



- keep main fiber direction + random deviation



- anisotropy

Curved Fibers

Determine fiber direction \vec{d}_{n+1} :

$$(\vec{d}_{n+1} - \vec{d}_n) - (\vec{d}_n - \vec{d}_{n-1}) = G_\sigma(0) - \alpha(\vec{d}_n - \vec{d}_{n-1}) - \beta(\vec{d}_n - \vec{d})$$

$\alpha = 0, \beta=0$: keep previous curvature

$\alpha = 1, \beta=0$: keep direction

$\alpha=1, \beta=1$: keep main direction: $\vec{d}_{n+1} = \vec{G}_\sigma(0) + \vec{d}$

(then normalize \vec{d}_{n+1})

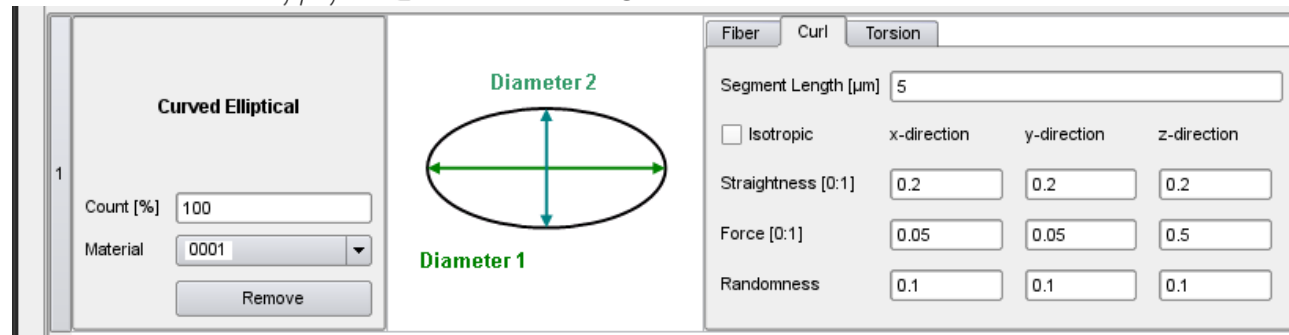
Full 3D anisotropy would be: $\alpha, \beta, \sigma \in R^{3 \times 3}$

Used in GeoDict : $\alpha, \beta, \sigma \in R^3$ (~diagonal matrices)

α : straightness

β : force

σ : randomness



Curved Fibers

Fiber **Curl** Torsion

Diameter 1 [μm] Edit ...

Aspect Ratio

Length [μm] Edit ...

Orientation Edit ...

Center [μm] Edit ...

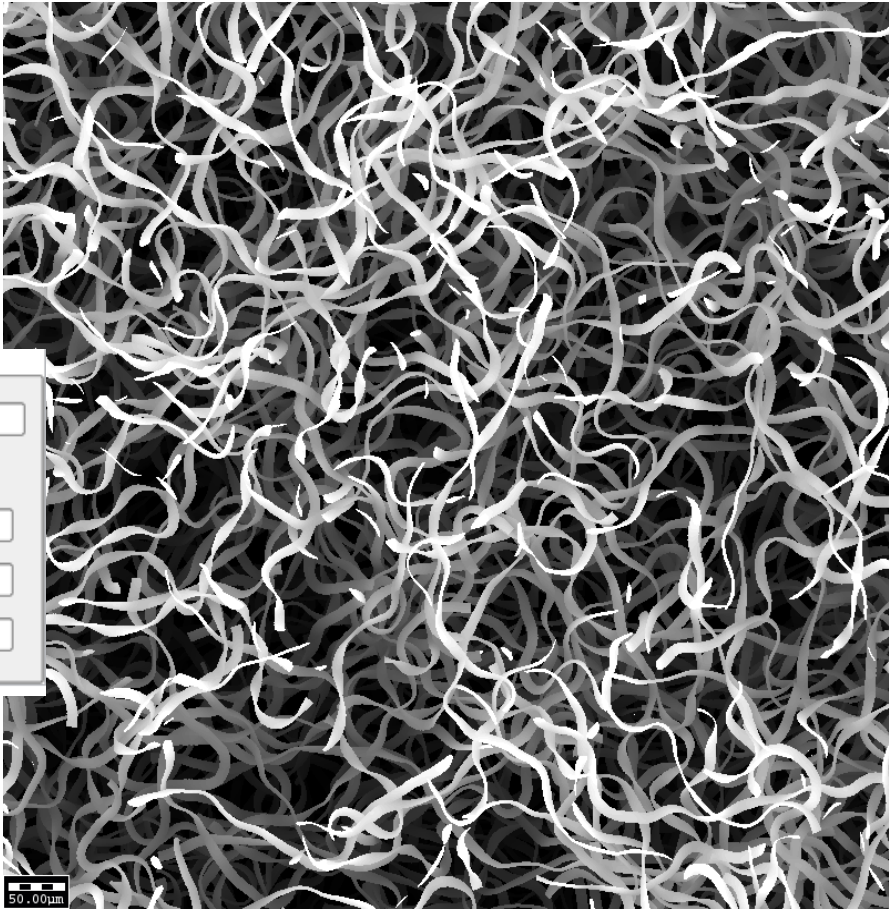
Couple Diameter 1 / Dtex and Length

Fiber **Curl** Torsion

Segment Length [μm]

Isotropic

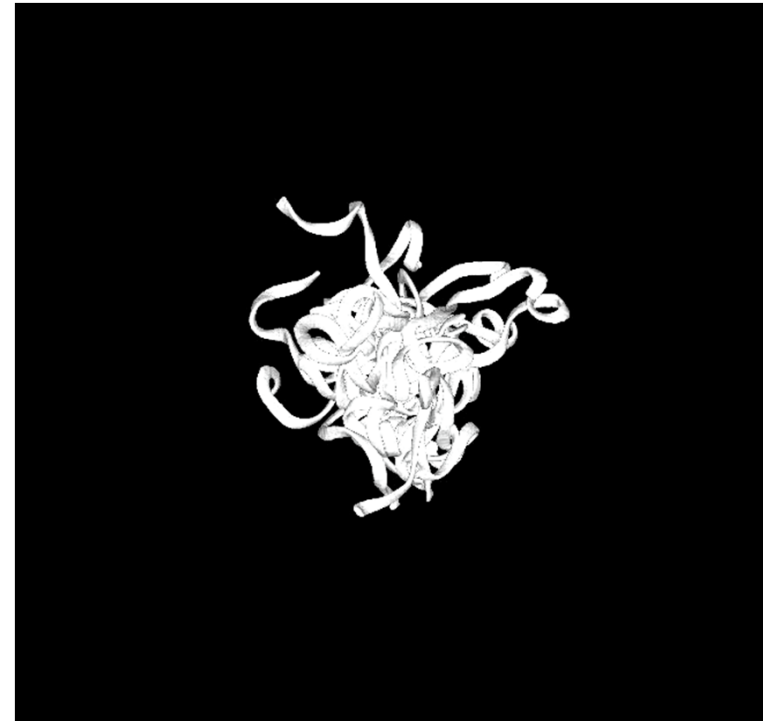
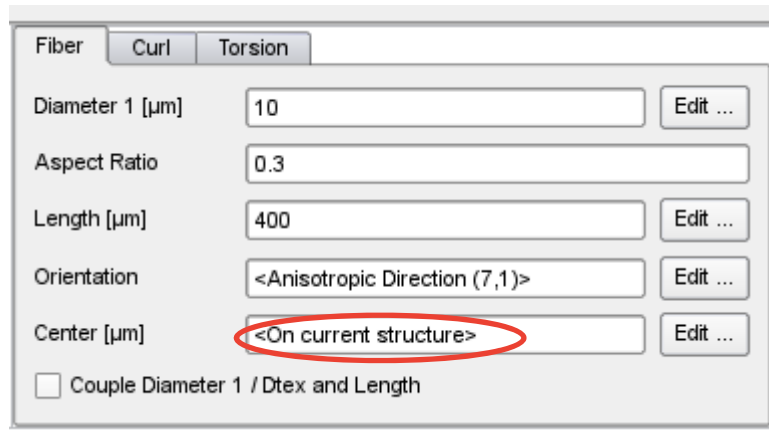
	x-direction	y-direction	z-direction
Straightness [0:1]	<input type="text" value="0.2"/>	<input type="text" value="0.2"/>	<input type="text" value="0.2"/>
Force [0:1]	<input type="text" value="0.05"/>	<input type="text" value="0.05"/>	<input type="text" value="0.5"/>
Randomness	<input type="text" value="0.1"/>	<input type="text" value="0.1"/>	<input type="text" value="0.1"/>



Inhomogeneous distribution?

Inhomogeneities

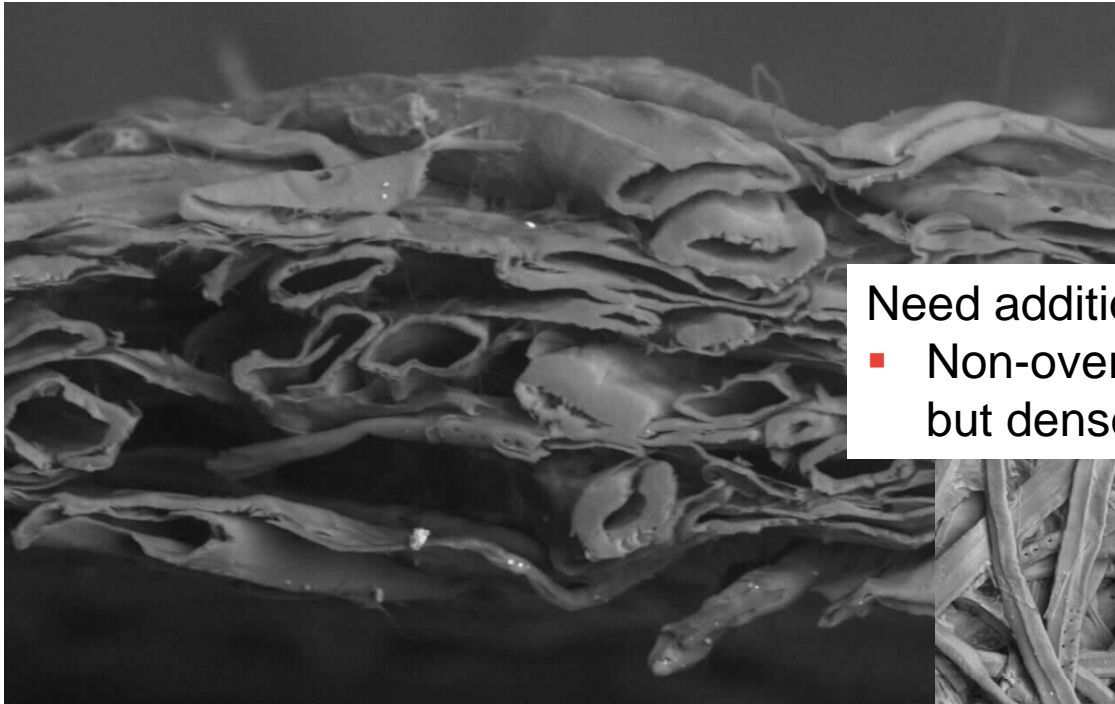
1. Create mask with SinterGeo
2. Use 'On current structure' in FiberGeo



3. Use LayerGeo:Add

(For realistic structure: mask should contain more than one object)

Paper (SEM Images)



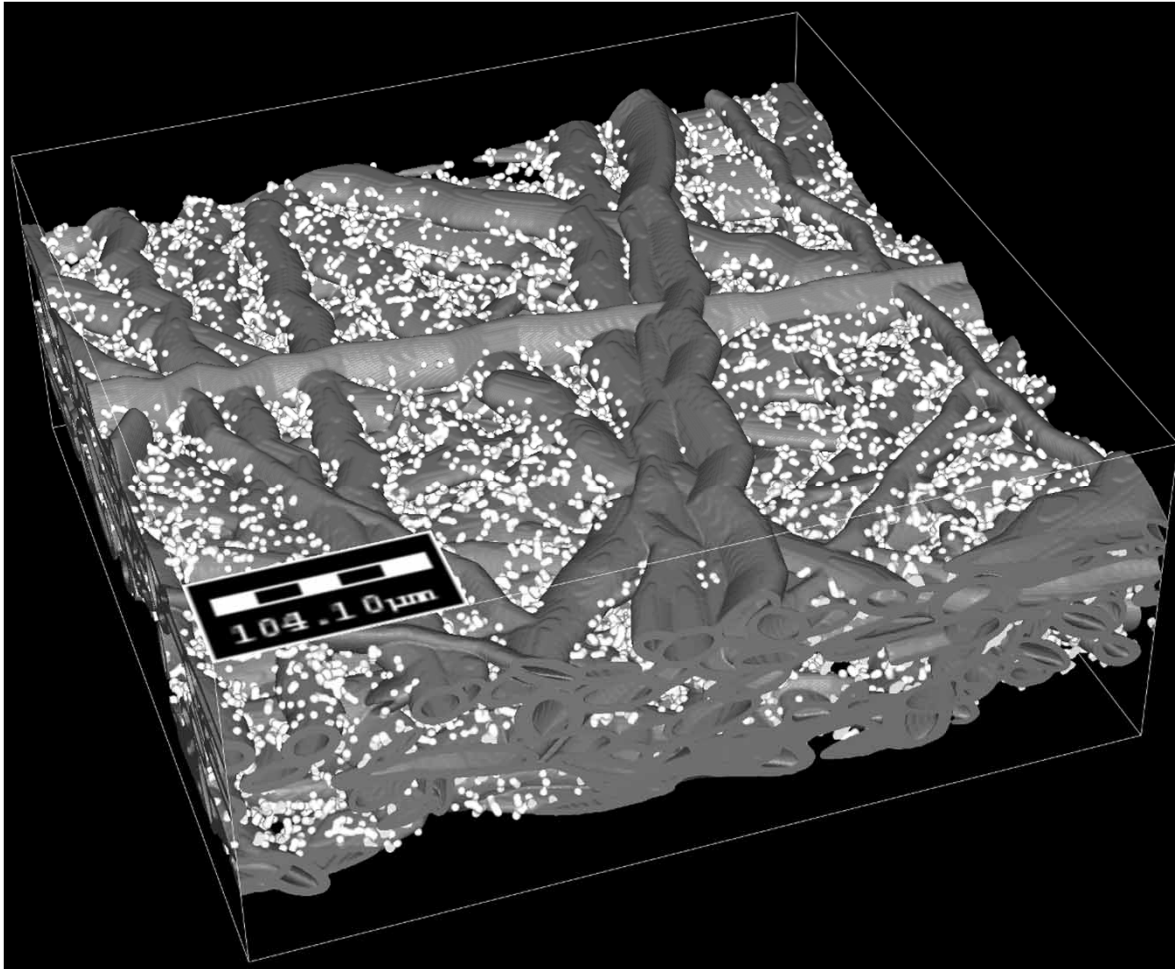
- Grammage: 60 g/m²
- Paper height: 200 mm

Need additionally:

- Non-overlapping fibers, but dense packing

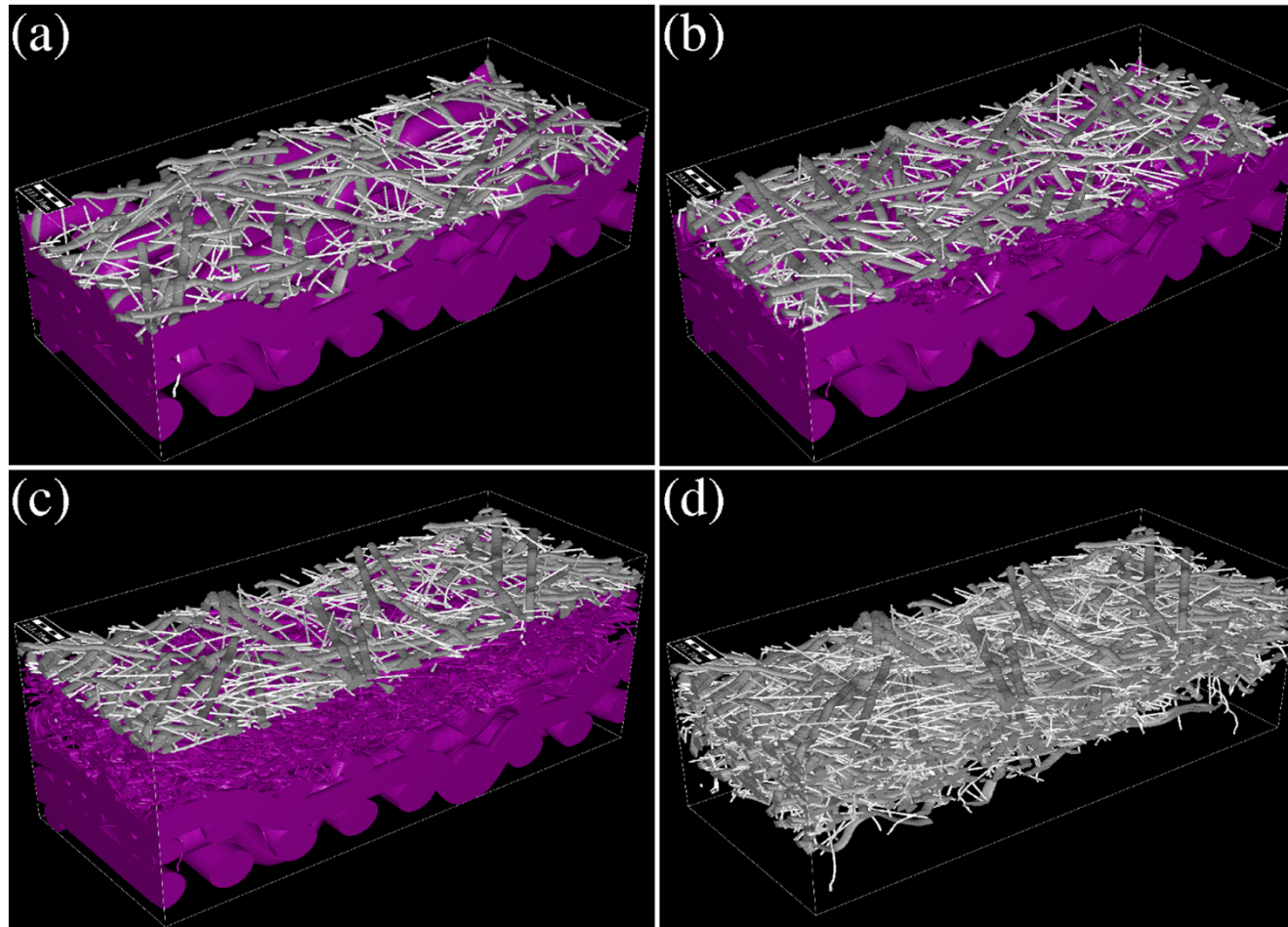


PaperGeo Model (with Overlap)



- Realistic cellulose fibers (dark gray)
- Fines attached to the fibers (light gray)
- Grammage: 50 g/m²
- Paper height: 160 mm
- Fiber Overlap

Paper Lay-Down (without Overlap)



Fiber lay-down on a forming fabric (modeled with **WeaveGeo**).

(a): 10 g/m². (b): 20 g/m². (c): 60 g/m². (d): The resulting paper-layer.

Summary

Presented features:

- Curved fibers
- Inhomogeneous structures
- Lay-down of fibers
(PaperGeo)

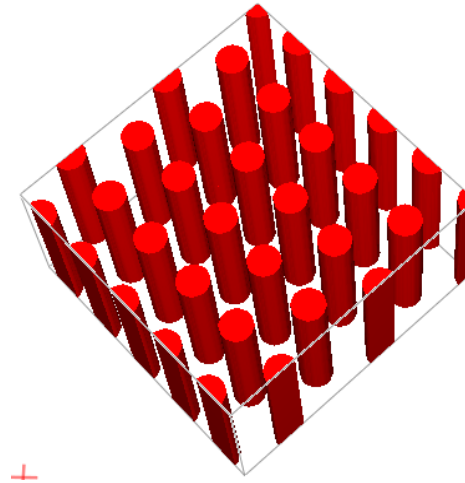
Upcoming features (2012R2):

- FiberGeo: fiber bundles
- FiberGeo: arbitrary fiber cross sections
- PaperGeo: faster lay-down algorithm
- PaperGeo: improved user interface

... and Patterned Structures

GridGeo:

- Perforated foils
- Parallel cylinders
- Predefined grid of spheres



New in upcoming 2012 R2:

- User defined grid

User Defined Grid Options

GEO DICT

Grid Options | Objects in Unit Cell

ShortCircularFiber

1 Color: 0001 Remove

ShortCircularFiber

2 Color: 0001 Remove

ShortCircularFiber

3 Color: 0100 Remove

Object Type: Sphere Create

