Optimal use of wood for papermaking based on wood microstructure

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What is the ”optimal use”? Why should SilviScan help?

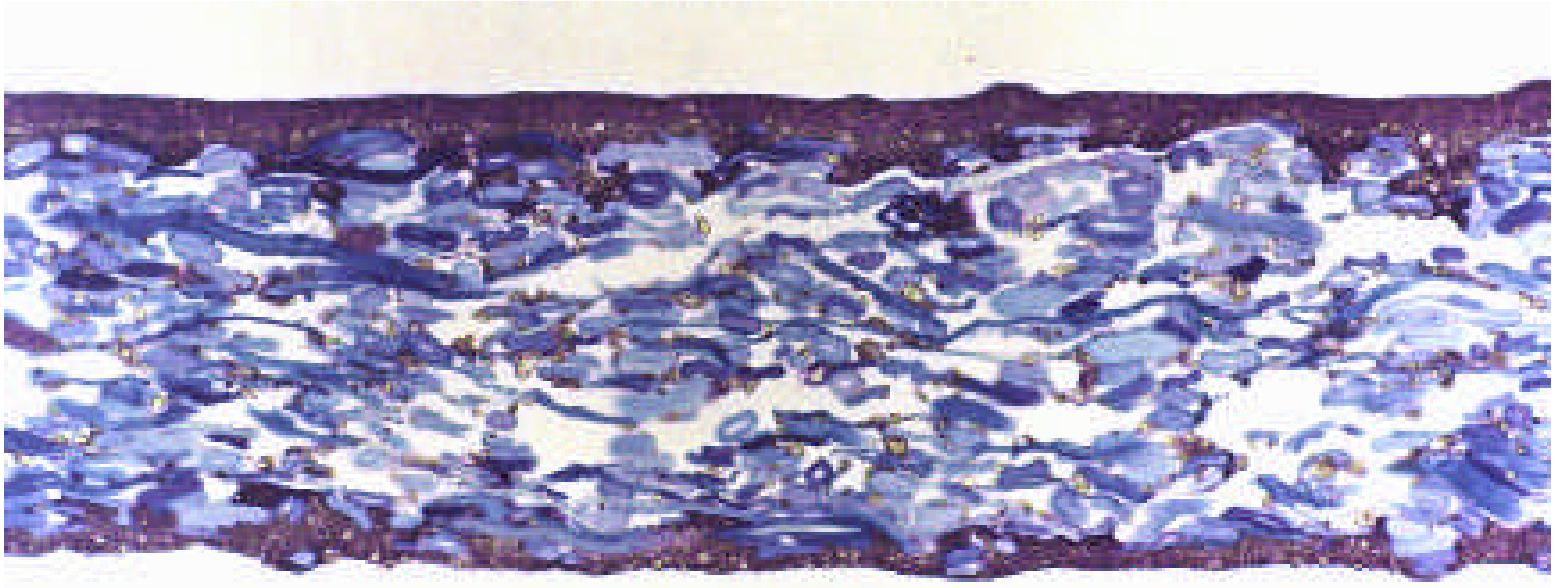
- **Uniformity in product**
  - **Control best when it starts from wood properties**
  - **Tradition: measure furnish (CSF, fiber length, …)**
  - **Perspective: huge variability in wood fiber properties**
- **Lean and low-cost products**
  - **Reduce grammage, use wood more efficiently**
  - **Use cheaper wood raw material, or cheaper fibers**
  - **Focus on proper geometric, physical and chemical characteristics of the fibers**

So SilviScan is great!

- ***SilviScan*** **measures wood raw material**
- ***SilviScan*** **gives statistically representative sample size**
- ***SilviScan*** **produces well-defined geometric and structural characteristics for fibers**

What is the best fiber?

- **Common – and bad! – question**



LWC cross-section

What is the best fiber?

- **Common – and bad! – question**

- **All the short answers are trivial**
  - **Fiber length for strength**
  - **Low coarseness for opacity, smoothness**
  - **High coarseness for bulk, bending stiffness**
  - **et cetera**

What is the best composition of paper?

- Furnish is always mixture
- Components interact through all papermaking phases
- Grammage is often very important

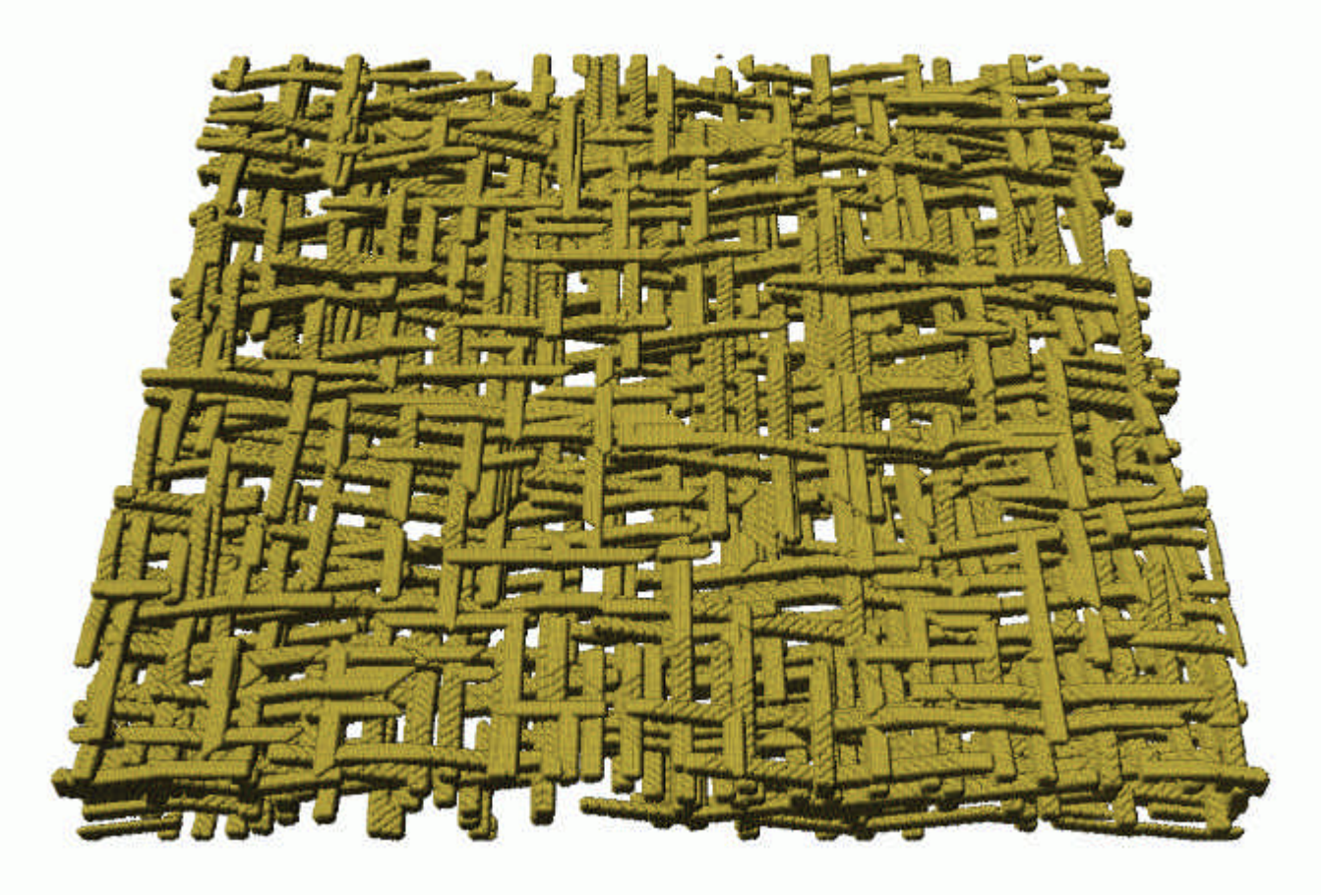
Three ways to find answers

- **Experiments**
- **Theories**
- **Computations**

Three ways to find answers

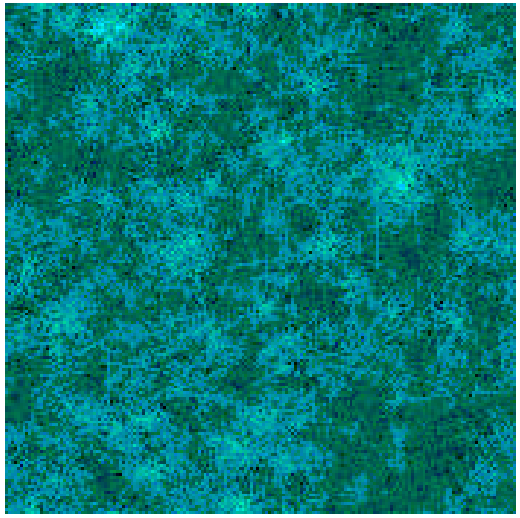
- **Experiments**
  - **Development by small steps, from lab to mill**
- **Theories**
  - **Predictions limited to ”simple” cases**
  - **Often impractical or unmeasurable concepts**
- **Computations**
  - **Any number of furnish components**
  - **Need a lot of numbers as input**
  - **Need real experiments for ideas, verification**

KCL PAKKA – a computational tool



KCL PAKKA

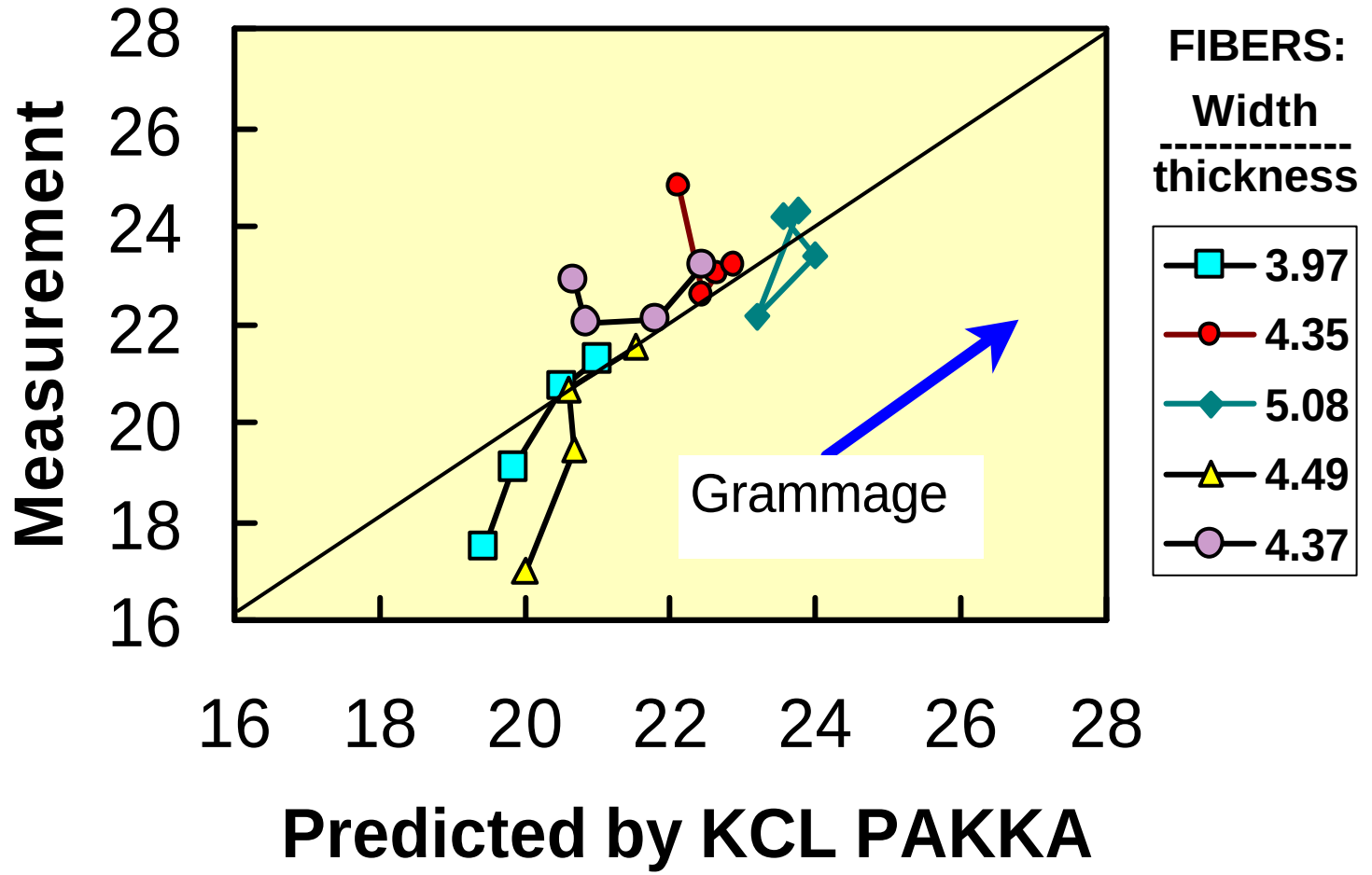
- **Simplified, yet realistic 3D network structure**
- **Predicts paper properties as a function of**
  - **furnish (pulp mixtures, hypothetical pulps, etc.)**
  - **layered structures, etc.**
- **We use it, e.g., to test interaction mechanisms**



Definition of a fiber:

- Dimensions
- Coarseness
- Conformability (flexibility, collapsability)
- Refractive index, optical surface area
- Shrinkage potential (↙ fiber swelling)
- …

Light scattering for grammage range 20 – 100 g/m²



Biggest obstacles to making full use of computations

- **Fiber property measurements are still very few: SilviScan is very welcome!**
- **R&D lacks competent people to develop computation tools**

What about theoretical relationships between paper properties and fiber properties ?

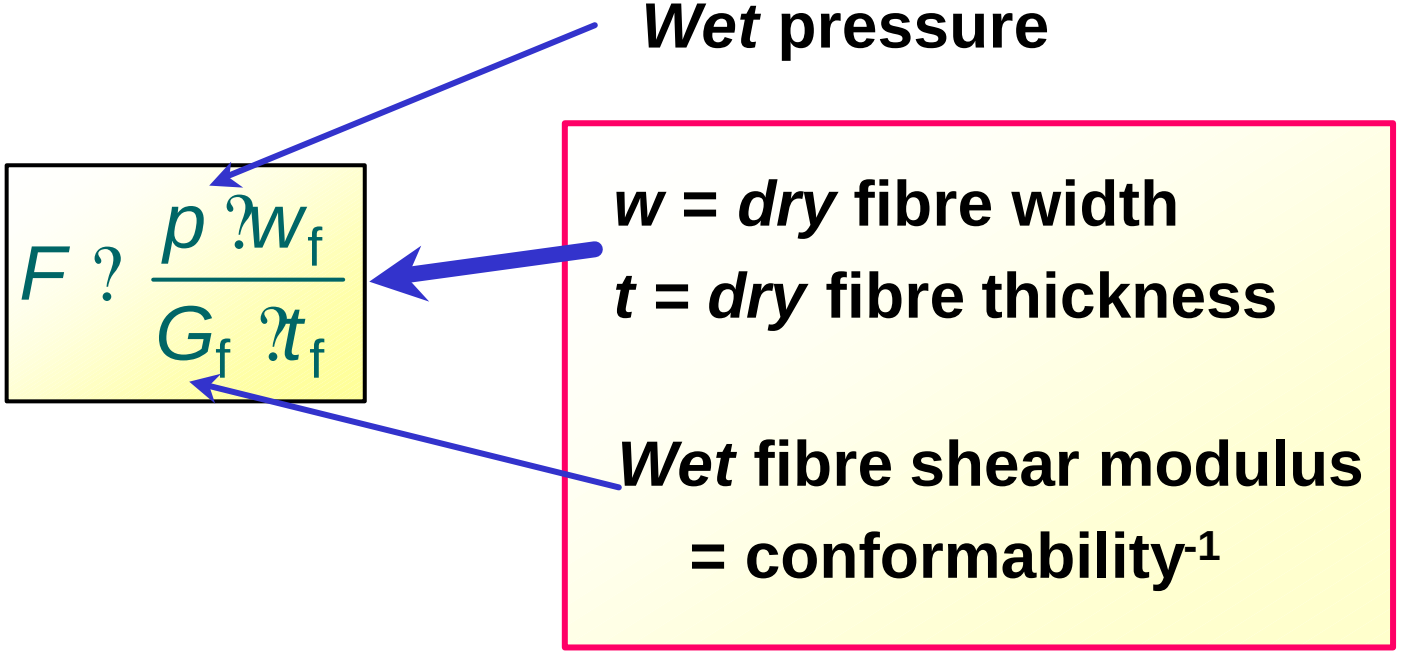
Paper properties – fiber properties Fundamentals

- **Sheet structure is simple (!), universal, except for**
  - **Small details (fines, fillers, fiber fragments)**
  - **Formation (inhomogeneity in sheet plane)**
- **Mechanical properties**
  - **Fiber length crucial when grammage low**
  - **No quantitative description for the effects of refining, wet pressing, drying**

Porous sheet structure

- ***Fibrous "backbone"*, determined by**
  - **wet pressing (integrated pressure pulse, permeability)**
  - **fiber processing: cell wall stiffness and swelling**
  - **cross-dimensions of fibers**
- **Smaller particles either fill or expand the backbone**

Dimensionless parameter *F*

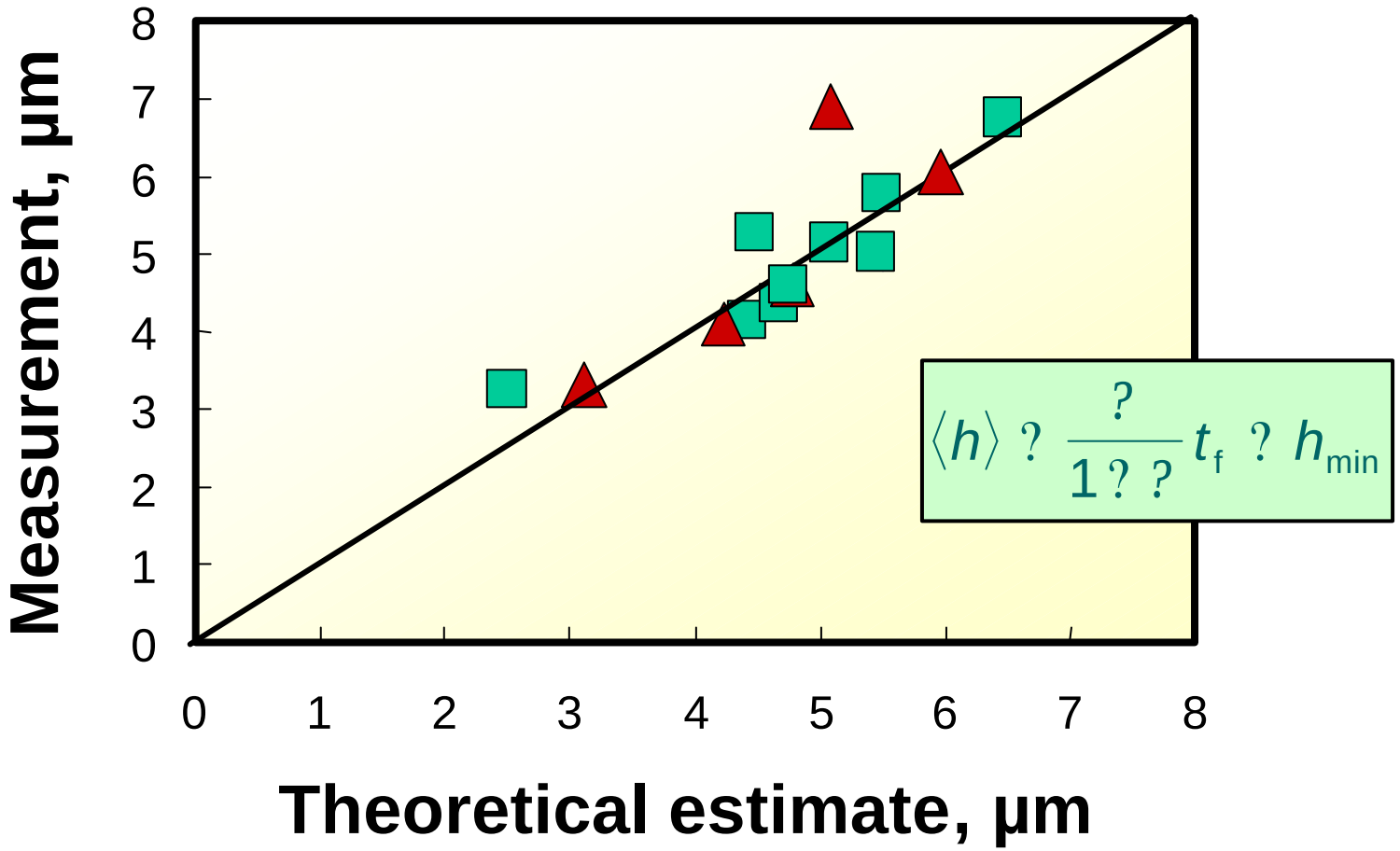


No routine measurements

Fibrous ”backbone”

- **Controlled by *F***
- **Standard handsheets:**
  - **Mechanical pulp: *F* ? 1**
  - **Kraft pulp: *F* = 3 – 4**
- **For example, porosity ? $(1 + F)^{-1}$**
  - **Valid at high grammage limit**
  - **Theoretical estimate**

Mean height of pore space



Conclusions – for the optimal use of wood fiber we need:

- **Effective measurement methods for**
  - **Width and thickness of fibers**
  - **Cell wall thickness (for fiber collapse)**
  - **Microfibril angle (for mechanical properties)**
- **Effective tools to handle the relationships from fibers to real paper**
  - **Computations offer new possibilities**

Conclusions – for the optimal use of wood fiber we need:

- **Effective measurement methods for**
  - **Width and thickness of fibers**
  - **Cell wall thickness, perimeter**
  - **Microfibril angle**

These are all properties that we get from SilviScan!