FibreCube - an innovative approach to measure fibre size

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In fibreboard industry the size distribution and morphology of the wood particles and fibres is of importance for both production and the resulting panel properties. Despite the importance of fibre quality for medium-density and high-density fibreboard (MDF and HDF) production, its evaluation continues to be carried out at a technically low level because no adequate measuring devices are available on the market.

With the aim of solving the limitations of the currently available measuring systems, the Thünen Institute of Wood Research, Hamburg University (Department of Wood Science and the Cognitive Systems Laboratory, KOGS) and Fagus-GreCon Greten GmbH & Co KG (GreCon) commenced the development of an image-based fibre analysis system: The FibreCube proved its system stability and usability in practical application already within a first 100 days industrial trail. Currently, one major wood-based panel manufacturer applies the prototype at a German MDF production site for process optimization.

The innovative engineering of the FibreCubs hard- and software solves major challenges in fibre characterization. Woolly-felted fibre samples are automated dispersed on a very high extent and, thus, adequately prepared for image acquisition and fibre characterization at greater amounts. Any touching fibres are post-separated by software, which also determines fibre dimensions by tracing the fibres flow line at sub pixel precision.

Based on the results of laboratory and industrial experiments, various interrelations of process parameters and fibre quality could be confirmed and quantified on the basis of measured values first. For example, the grinding gap distance has been documented as a major determinant of fibre quality. Further, fibres made from different types of wood were found to be significantly different in terms of fibre size distribution. The intentional modification of fibre quality for product conversion in industrial production could be clearly traced through fibre measurement. Fibre length was found correlating very well with well-known parameters like refiner energy consumption and bulk density.

In sum, the FibreCube seams to meet industrial requirements and provides a suitable tool for fibre characterization and process optimisation.

FibreCube
an innovative approach to measure fibre size

Martin Ohlmeyer • **Jan T. Benthien** • **Sabrina Heldner** • **Benjamin Seppke**
Thünen Institute of Wood Research

9th EWBPS, Hannover
9 October 2014

Welcome to the Thünen Institute

THÜNEN → science and research based policy advice → Federal Ministry of Food and Agriculture

Rural Areas	Forestry	Fisheries
• Organic Farming • Market Analysis • Agricultural Technology • and other	• Forest Ecosystems • Forest Economics • **Wood Research** • and other	• Fisheries Ecology • Sea Fisheries • Baltic Sea Fisheries

University of Hamburg
Department of Wood Science

THÜNEN
Institute of Wood Research

Our motivation

- Fibre quality for MDF production is a „black box"

- Determined visually and haptically based on experience

- Available systems on the market may not meet major requirements of the industry

Motivation

Software

Hardware

Performance

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Our conclusions & tasks

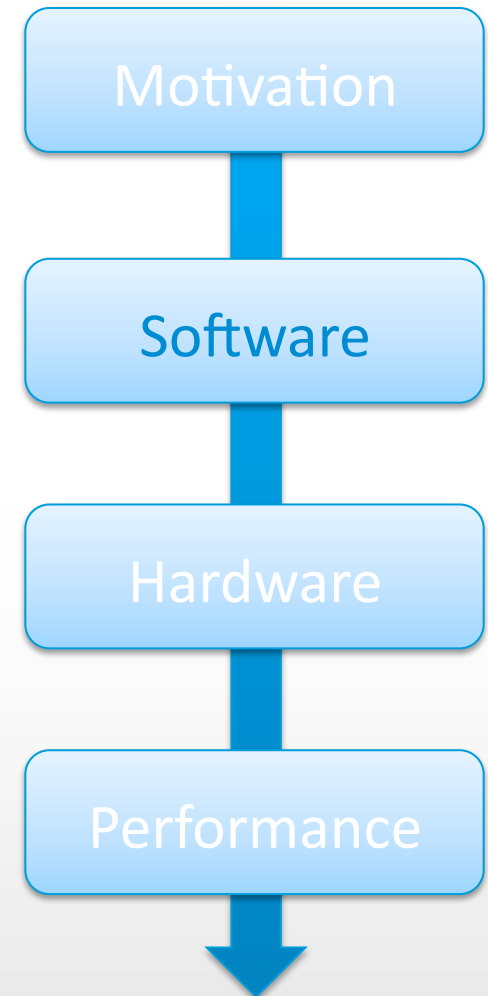## Handling & measurement of dry fibres:

- Hardware
  - simple sampling procedure
  - fibre separation
  - dispersion in air
  - data acquisition
- Software
  - handle overlapping fibres
  - fast analysis
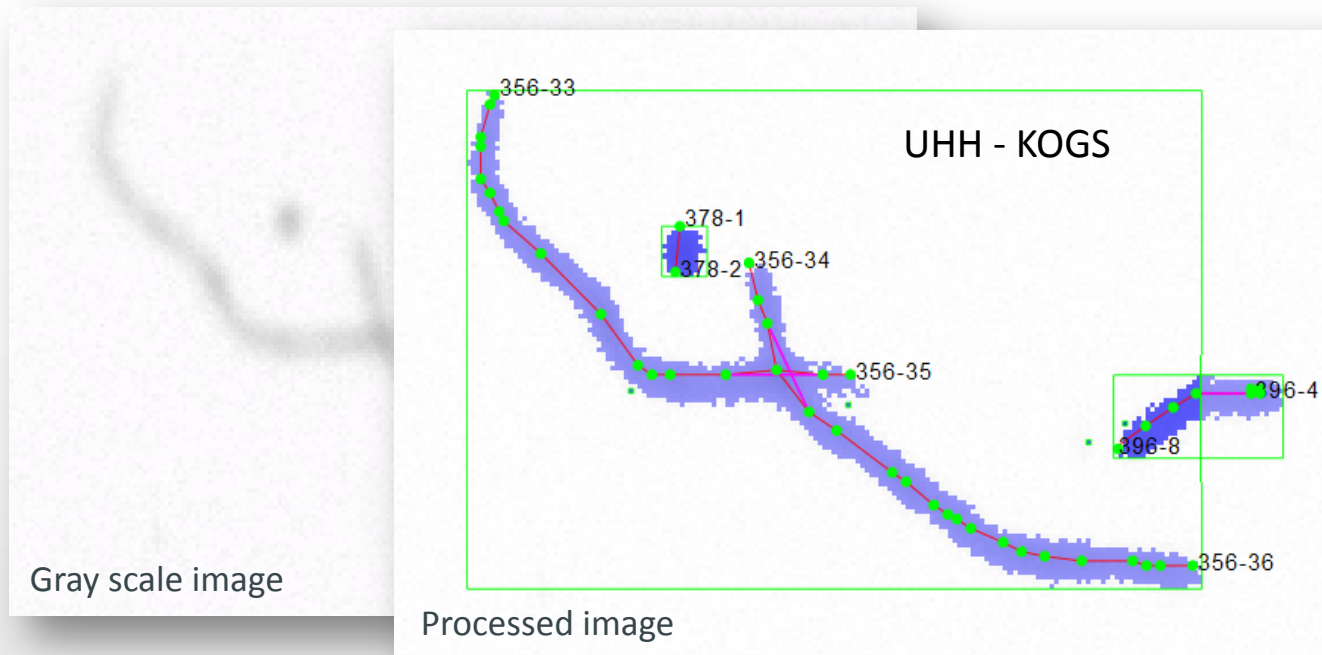
UH

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Software solution

Image analysis

(1) Flow line tracing and separation of overlapping fibres

(2) Image moment method

Gray scale image

Motivation

Software

Hardware

Performance

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Software solution

Image analysis

(1) Flow line tracing and separation of overlapping fibres

(2) Image moment method

Gray scale image

Processed image

UHH - KOGS

356-33
378-1
378-2
356-34
356-35
396-4
396-8
356-36

Motivation

Software
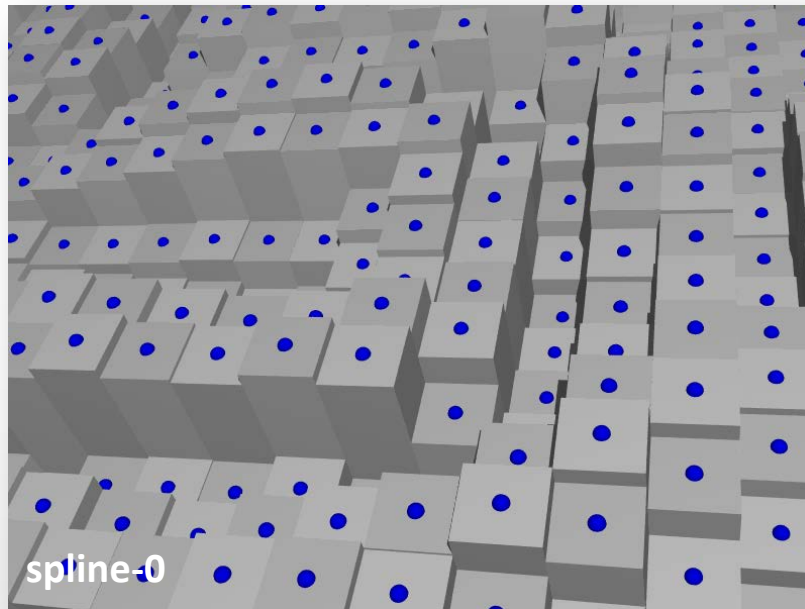
Hardware

Performance

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Software solution

Image analysis

- Sub-pixel image analysis

spline-0

Meine (2008): The GeoMap Representation: On Topologically Correct Sub-pixel Image Analysis
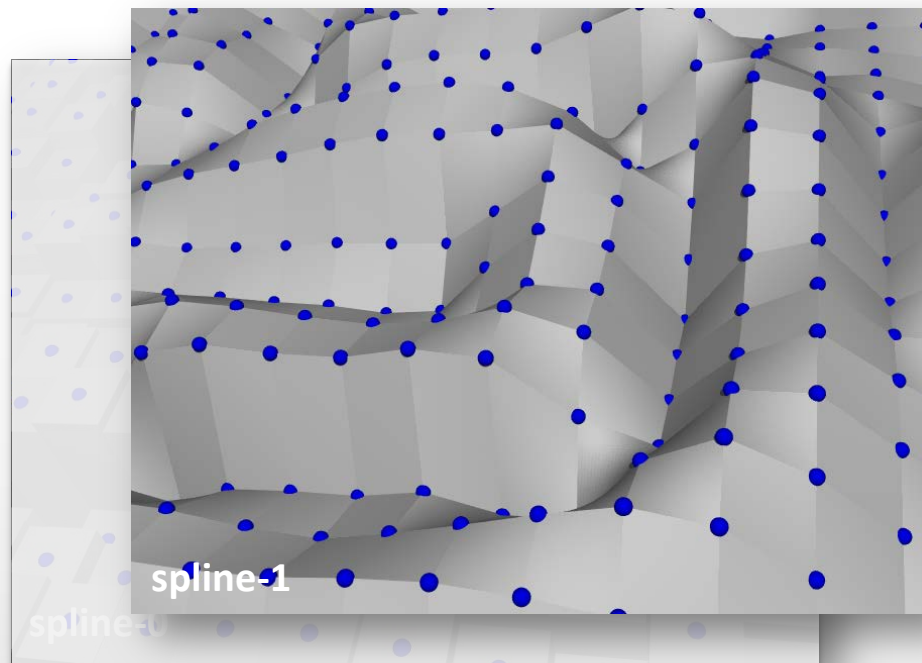Dissertation, University of Hamburg

Motivation

Software

Hardware

Performance

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Software solution

Image analysis

- Sub-pixel image analysis

spline-1
spline-0

Meine (2008): The GeoMap Representation: On Topologically Correct Sub-pixel Image Analysis
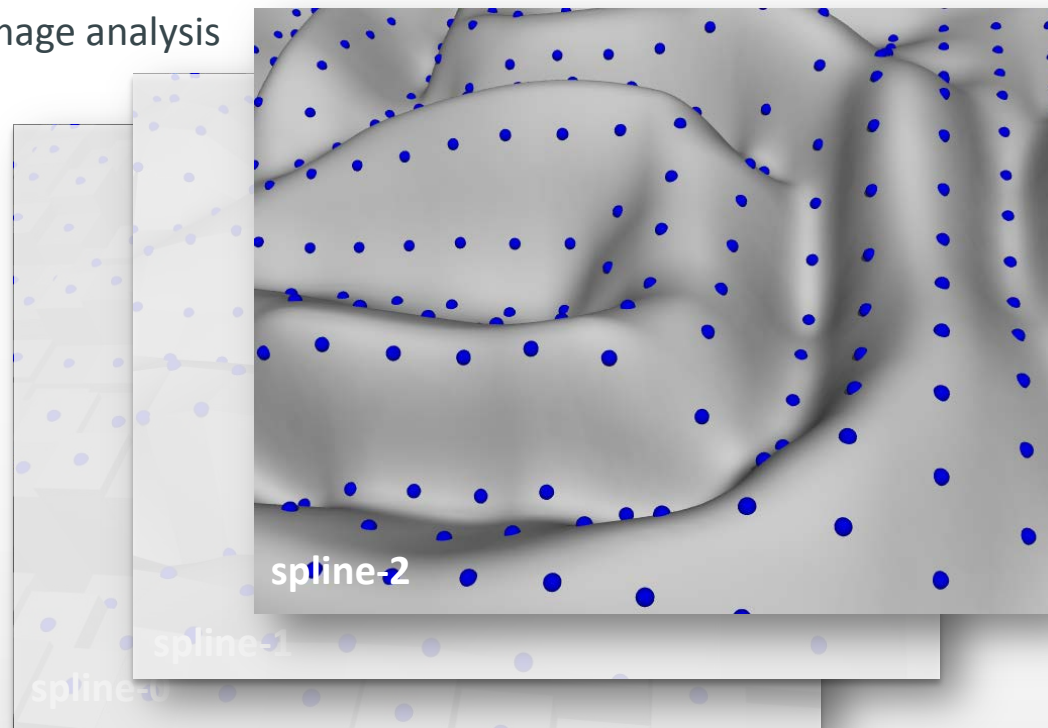Dissertation, University of Hamburg

Motivation

Software

Hardware

Performance

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Software solution

Image analysis

- Sub-pixel image analysis

spline-2

Meine (2008): The GeoMap Representation: On Topologically Correct Sub-pixel Image Analysis
Dissertation, University of Hamburg

Motivation

Software
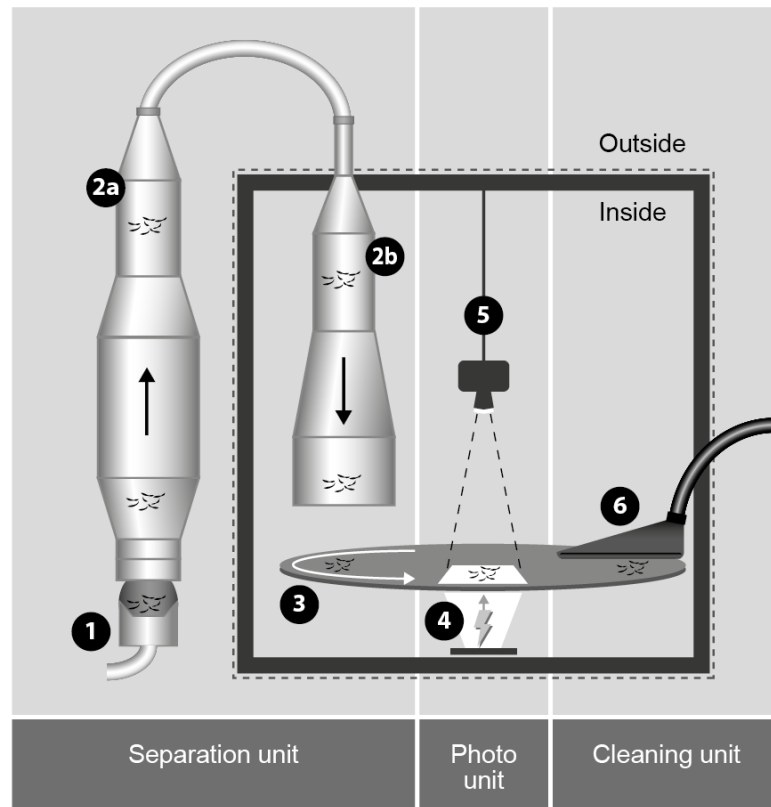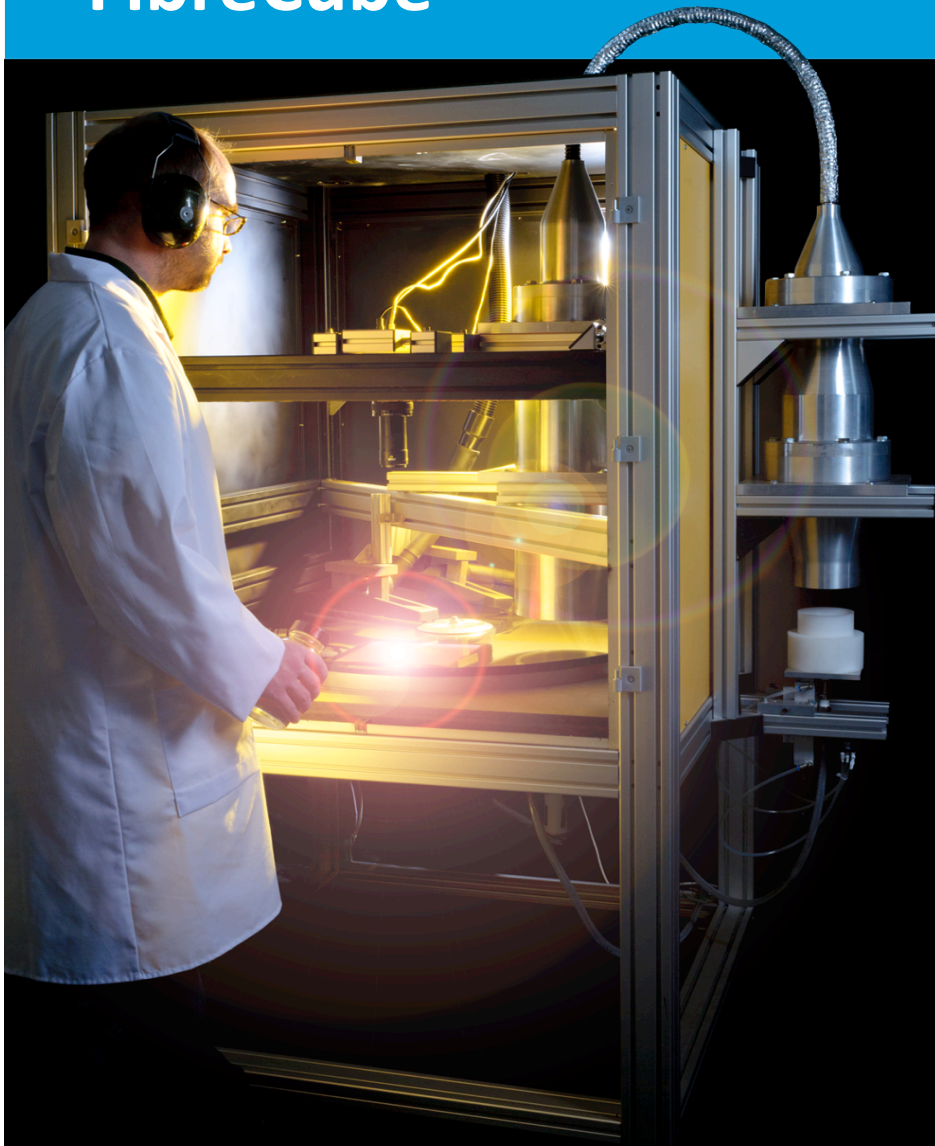
Hardware

Performance

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Hardware

Separation unit | Photo unit | Cleaning unit

1 Sample feeding
2a Riser pipe
2b Gravity pipe
3 Rotating glass table
4 Flash-light
5 High-resolution camera
6 Exhaustion
⤙ Fibers
▬ Housing

Outside
Inside

Motivation

Software

Hardware

Performance

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FibreCube

- Sampling dry fibres

- Characterisation of the entire fibre size range

- 0.5 g of fibres

- ca. 650 images with > 250.000 fibres

- Image size: 93 x 62 mm^2

- Resolution: 1094 dpi

- Pixel size: 23.2 µm

- Data acquisition: 8 min per run

- Evaluation of data: 3 - 5 min

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FibreCube

Results

- Histogram / frequency polygon

- Box-Whisker-Plot

- Specific values

  - Number of fibre per mg

  - Fibres > 6 mm

  - Fibre length / width / slenderness ratio

  - Fibre fineness

  - Fibre classification
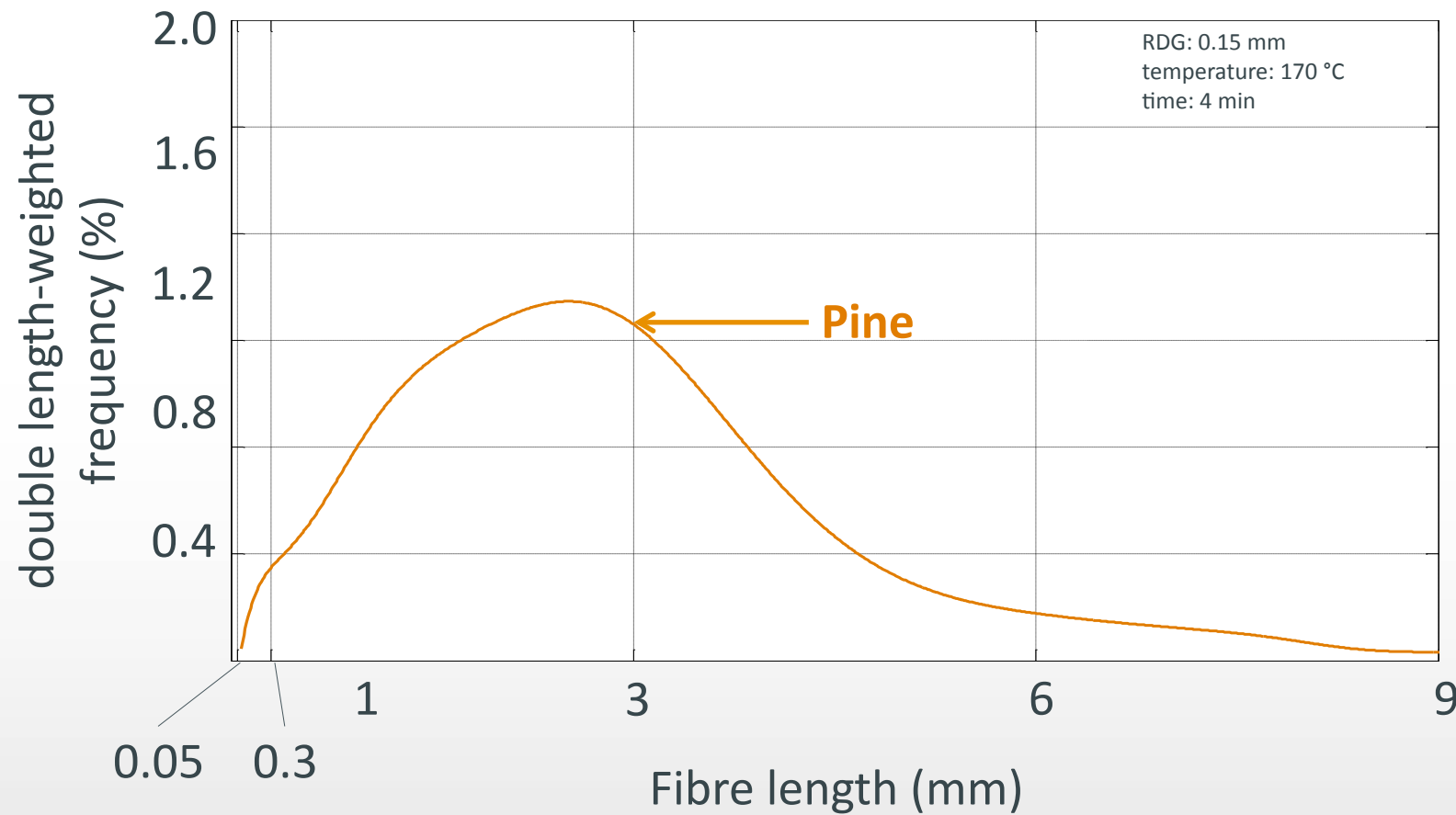   (dust, fines, shives...)

- FFS: Fibre Fact Sheet

Thünen Institute of Wood Research

FIBER FACT SHEET

Sample:	F13
Sampling location:	Thünen Institute of Wood Research, Hamburg
Responsible person:	Benthien, Heldner
Date of sampling:	2013
Date of analysis:	16–Apr–2014

Basic data

Initial sample weight (g)	4.9
Number of fibers (pcs)	2.221e+06
Number of replicates	10
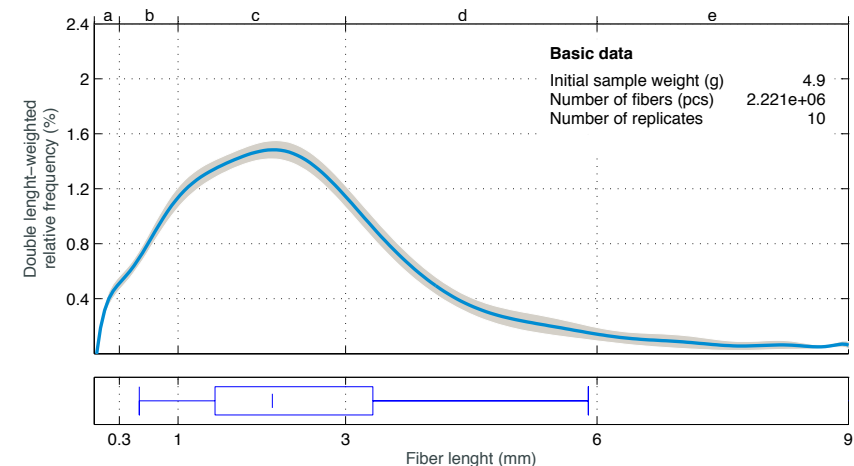
Relative fiber number	mean	std	cov (%)
NoF – Number of fibers (pcs/mg)	456	21	5
NoF 6 – NoF >= 6mm (pcs/g)	323	38	12
NoS – Number of shives (pcs/g)	27	5	19

FW – Fiber width (mm)	mean	std	cov (%)
Unweighted	0.08	0	5.41

FL – Fiber length (mm)	mean	std	cov (%)
Unweighted	0.53	0.04	6.74
Single lenght–weighted	1.51	0.06	3.83
Double lenght–weighted	2.64	0.07	2.78

SL – Slenderness ratio (mm)	mean	std	cov (%)
Unweighted	6.32	0.28	4.42

FCV – Fineness characteristics value

	mean	std	cov (%)		mean	std	cov (%)
FLm – Mean fineness (mm)	2.45	0.07	2.92	FL 16 (mm)	1.09	0.04	3.99
delta FL – Finess interval (mm)	2.87	0.09	3.29	FL 50 (mm)	2.31	0.07	2.89
				FL 84 (mm)	3.96	0.12	2.98
CF0.315 – Finest fiber content (%)	2.31	0.25	10.89				
CF1.0 – Fine fiber content (%)	13.85	0.98	7.08				

Boxplot				Fiber lenght classes a – e			
FL 5 (mm)	0.54	0.03	5.45	a 0.0–0.3 (%)	2.16	0.24	11.12
FL 25 (mm)	1.44	0.05	3.57	b 0.3–1.0 (%)	11.69	0.8	6.82
FL 75 (mm)	3.33	0.08	2.55	c 1.0–3.0 (%)	54.48	1.15	2.11
FL 95 (mm)	5.89	0.18	3.02	d 3.0–6.0 (%)	26.99	1.41	5.23
				e > 6.0 (%)	4.68	0.52	11.12
Peak height (mm)	2.14	0.11	5.17				
Peak height (%)	1.49	0.03	2.11				

Performance of FibreCube

Effect of wood species

RDG: 0.15 mm
temperature: 170 °C
time: 4 min

Pine

double length-weighted frequency (%)

2.0
1.6
1.2
0.8
0.4

0.05   0.3   1   3   6   9
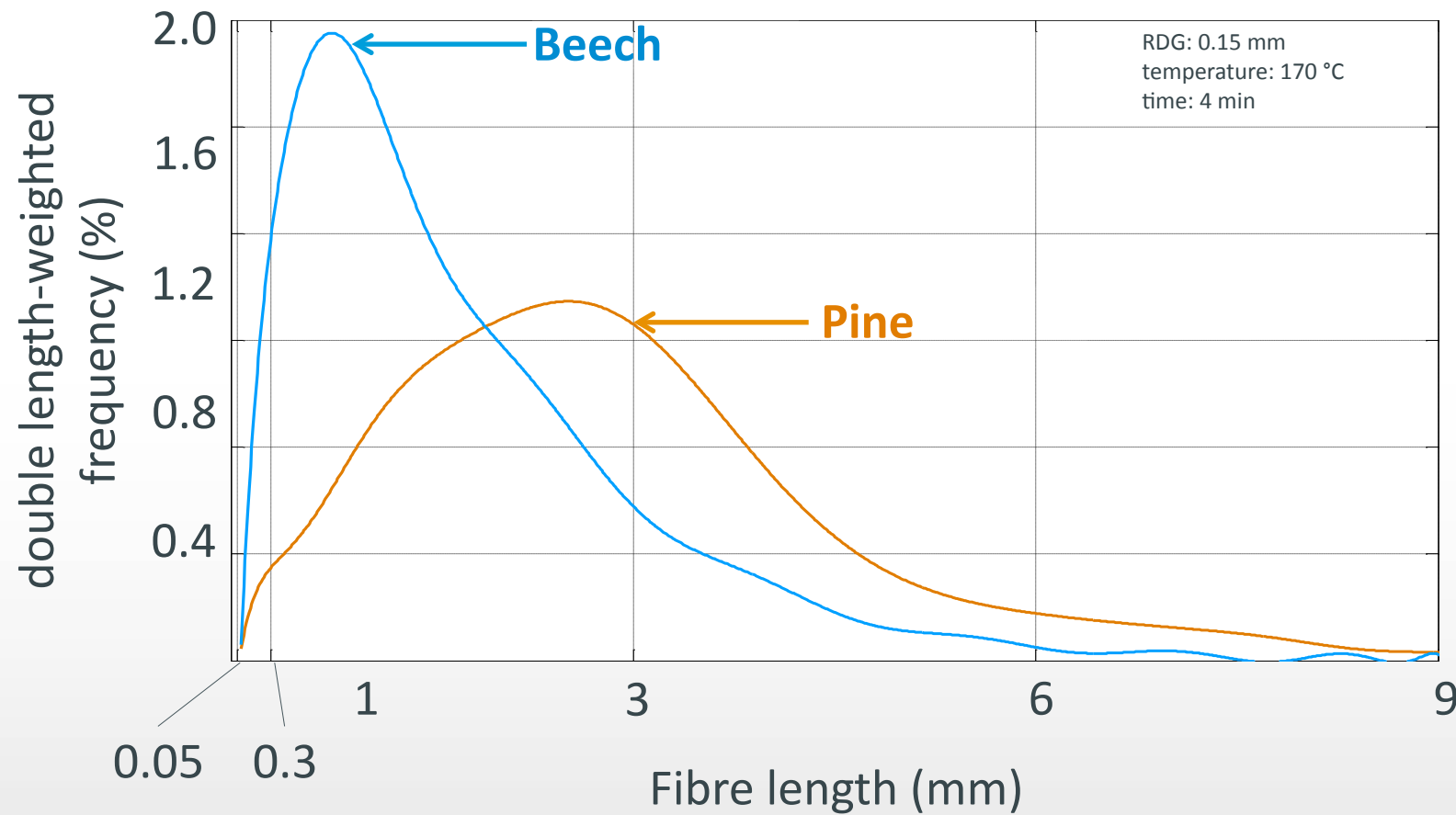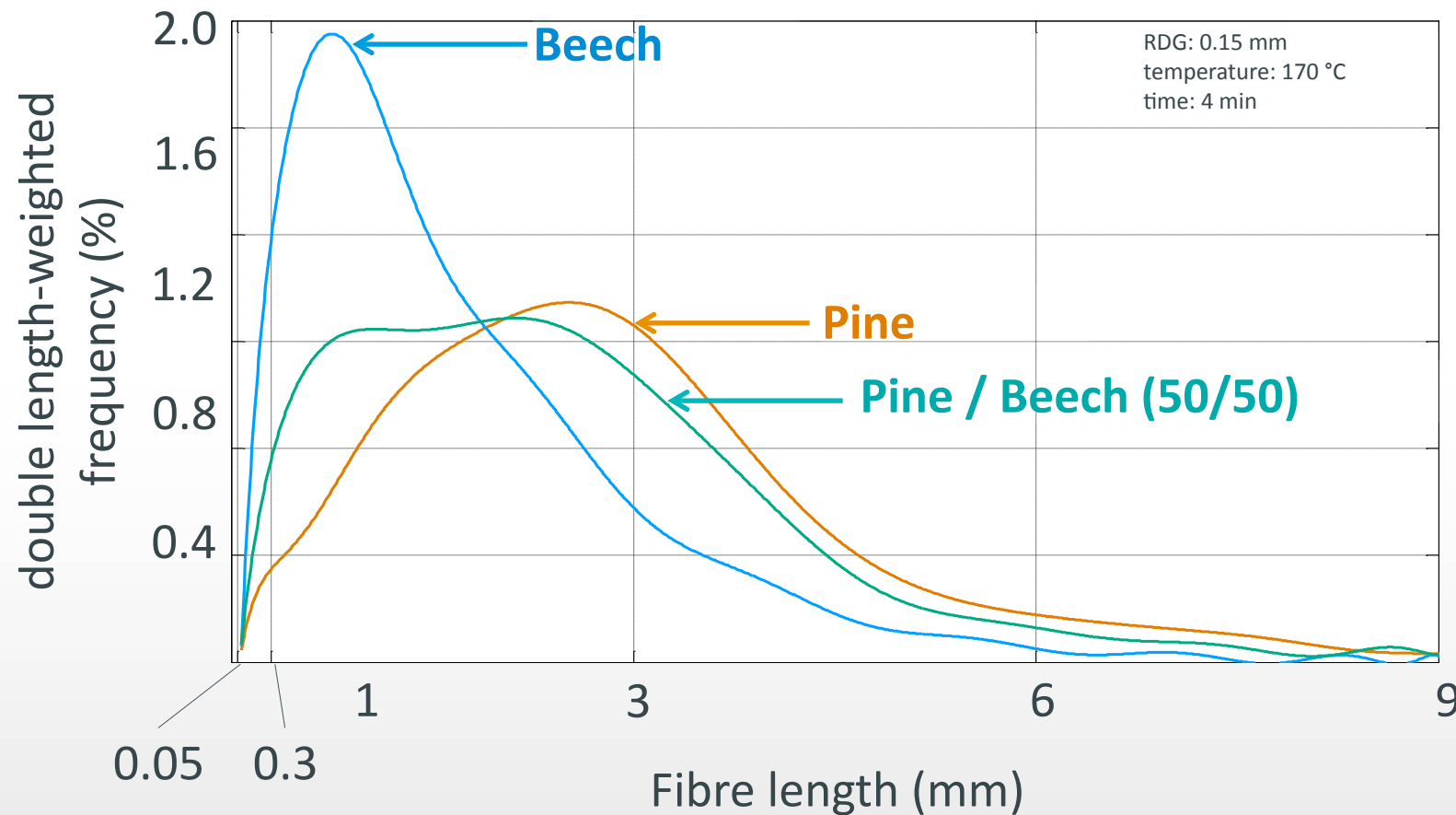
Fibre length (mm)

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Performance of FibreCube

Effect of wood species

Performance of FibreCube

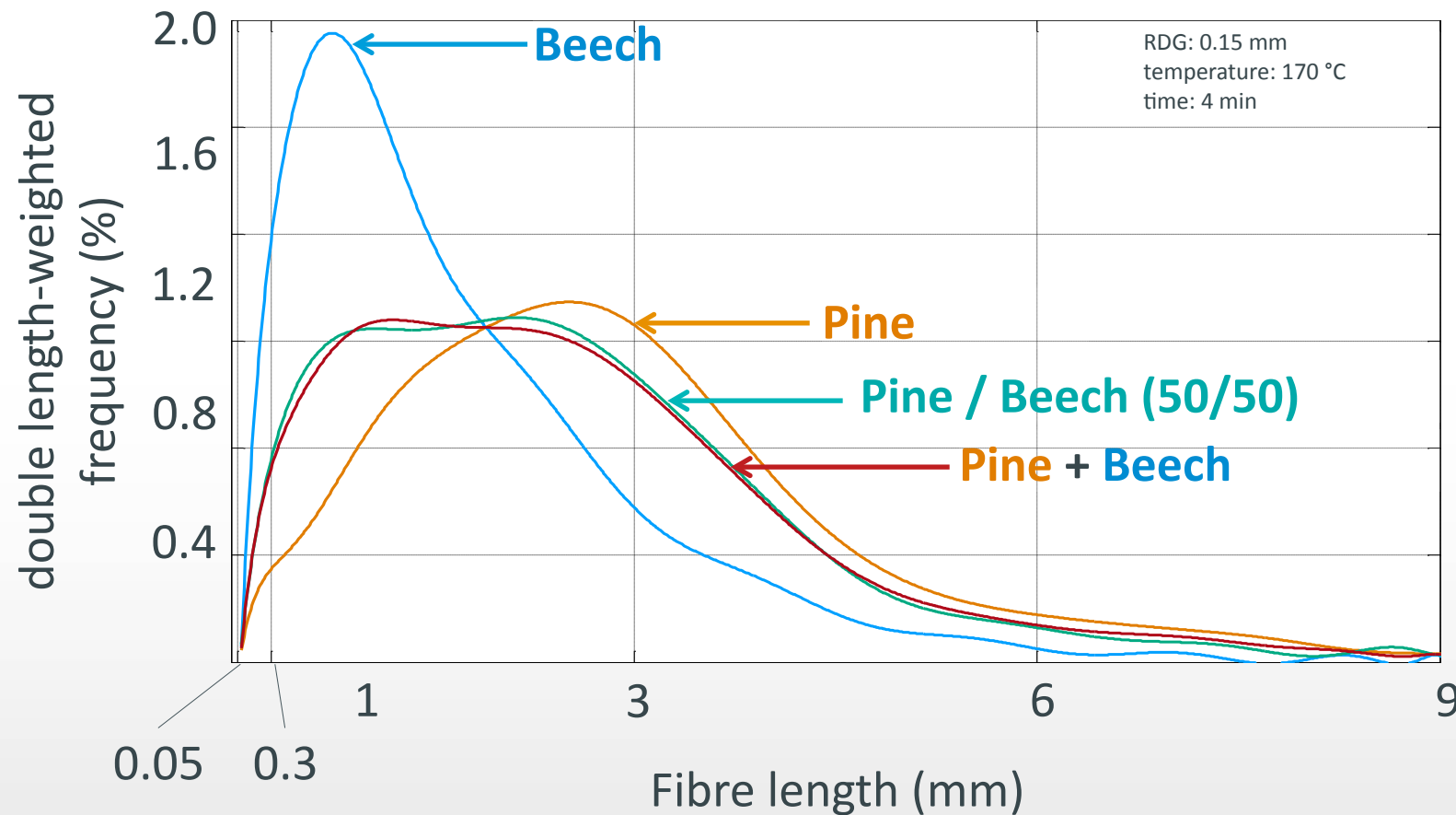**Effect of wood species**
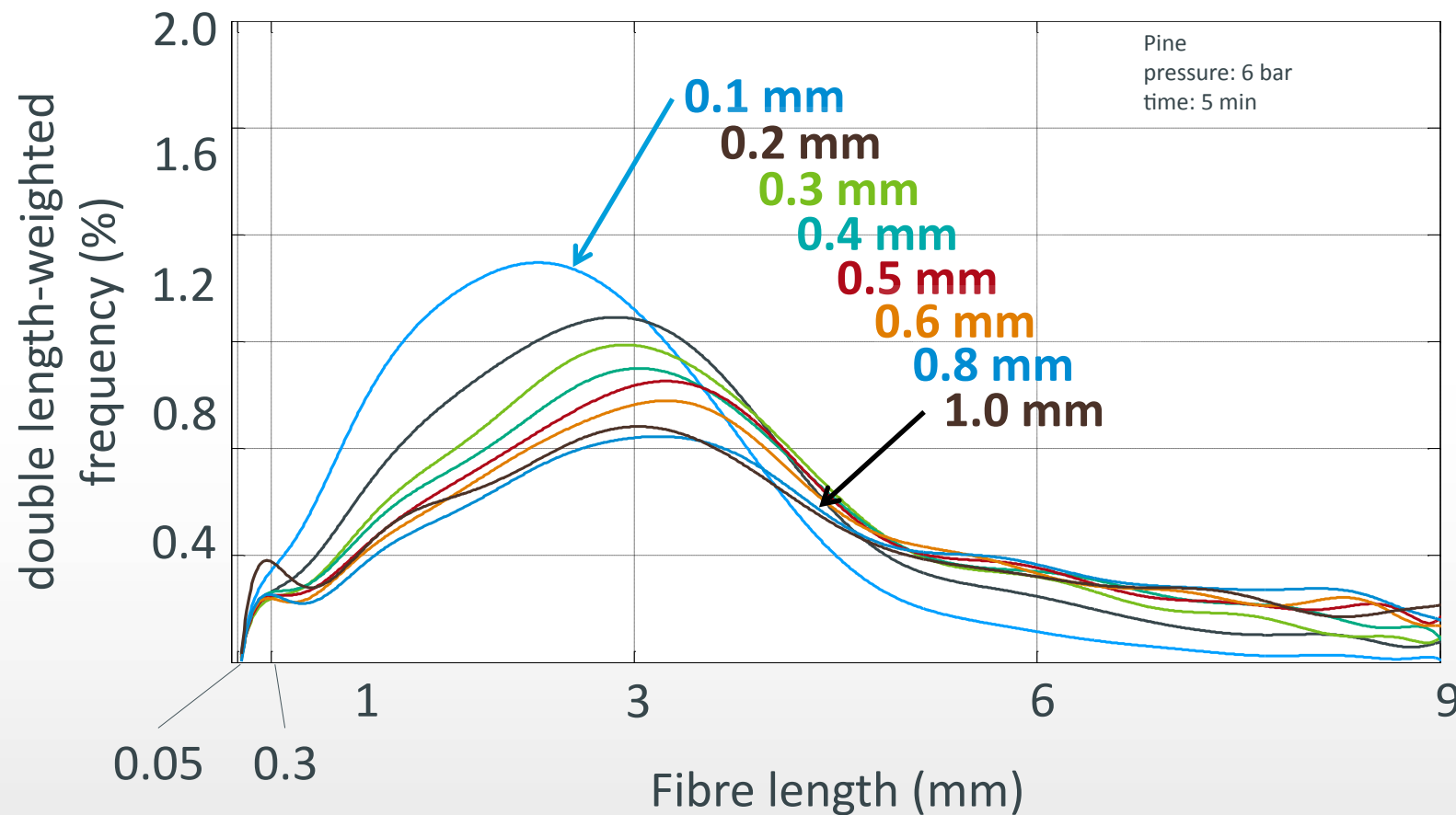
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Performance of FibreCube

Effect of wood species

Performance of FibreCube

Effect of refiner disc gap

Pine
pressure: 6 bar
time: 5 min

0.1 mm
0.2 mm
0.3 mm
0.4 mm
0.5 mm
0.6 mm
0.8 mm
1.0 mm

double length-weighted frequency (%)

Fibre length (mm)

Perspectives

- Fibre length correlates very well with well-known parameters:
  i.e. refiner energy, bulk density

- Today: ongoing tests in industrial environment

- Potential for

  - enhanced knowledge of TMP

  - correlation between process conditions and fibre quality and panel properties

  - process improvement

  - new management options

  - Saving Energy

- Ask us for leasing conditions

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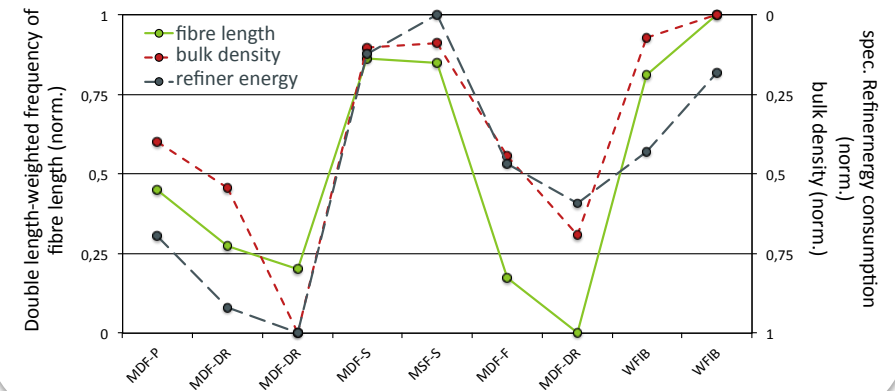
Acknowledgement – our team

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Acknowledgement – our partners

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Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG
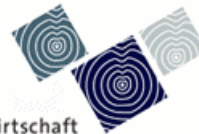
Zentrum Holzwirtschaft

KOGS
Arbeitsbereich Kognitive Systeme

SONAE
INDUSTRIA

GreCon

IHD
SCIENCE BY EXPERTS
AN-INSTITUT DER TU DRESDEN

ANDRITZ

Keep in touch @ www.ti.bund.de/fibers.html

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