TIMBER MEASUREMENTS SOCIETY
CENTRAL MEETING 2016

Options of 3D-scanning measurements for logs: differences and relevance

Udo Hans Sauter
Jörg Staudenmaier

Department of Forest Utilisation

Forest Research Institute of
Baden-Wuerttemberg

Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg

Forest Research Institute of Baden-Wuerttemberg (FVA)

- Located in Freiburg (Black Forest)
- Research institute of the forest administration
- Regional, national and international research and consulting tasks and projects

FVA - Department of Forest Utilisation

Harvesting, logistics

Roundwood measurement, grading

Applied wood science

Bioenergy from forests
short rotation agroforestry

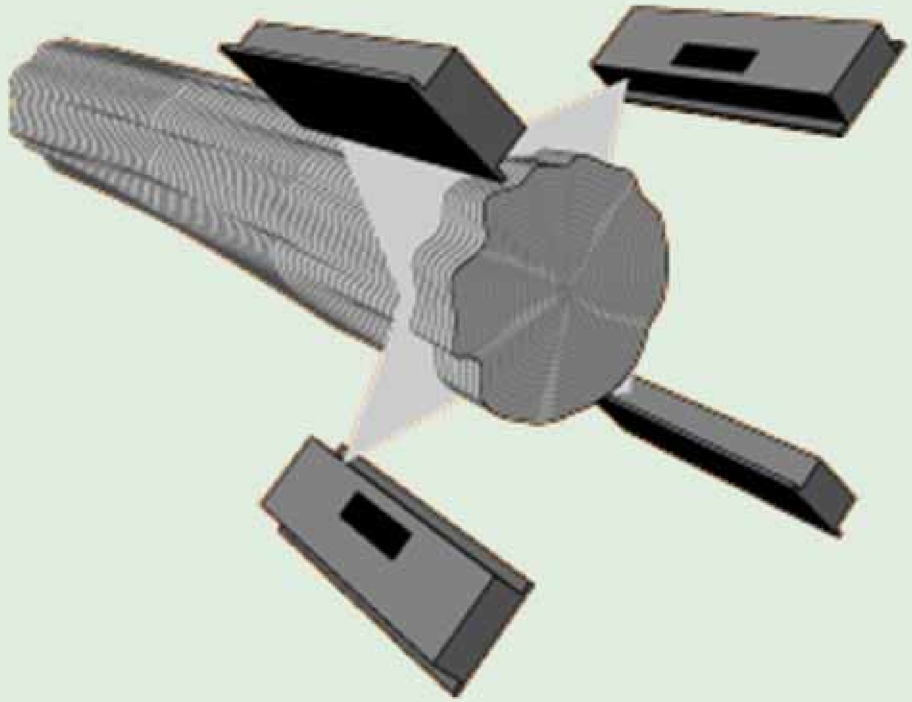
Electronic measurement: technology

Electronic measurement: technology

- 2D Measurement Systems
  - infrared or / and ultrasound
  - normally 2 perpendicular diameters
  - fixed measuring directions (geometry of the system)

Electronic measurement: technology

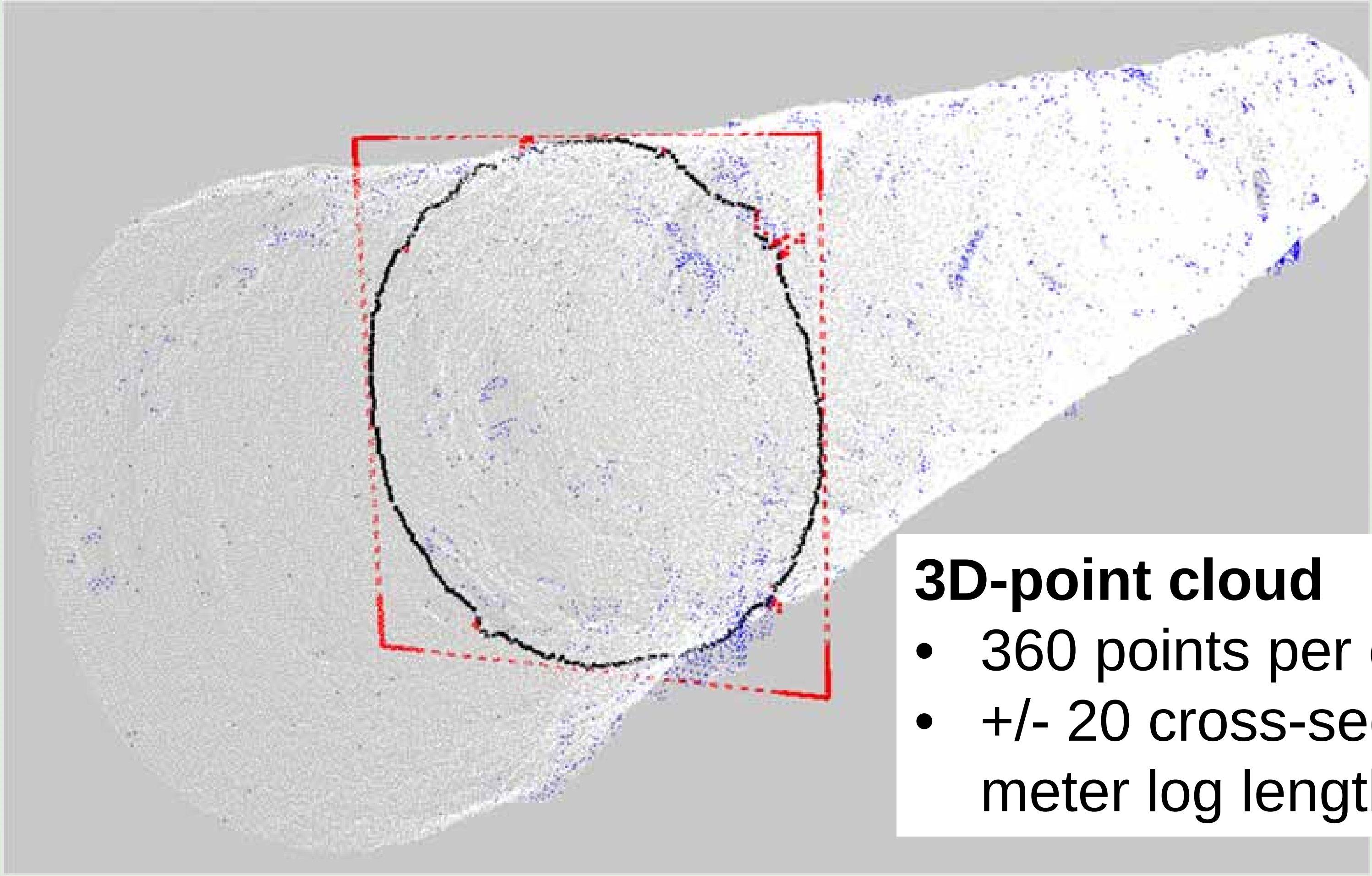
- 3D Measurement Systems (Laser-Triangulation)
  - Normally 4 laser sources / sensor devices
  - Full contour scan



Electronic measurement: raw material

- Only softwood:
  - Spruce
  - Pine
  - Fir
  - Douglas fir
  - Larch
- Short logs (< 6 m)
- Long logs (6 – 20 m)

Electronic measurement: data processing



3D-point cloud

- 360 points per cross-section
- +/- 20 cross-sections per meter log length

Electronic measurement: data processing

Preprocessing of data

- Smoothing the measured data of all cross sections:

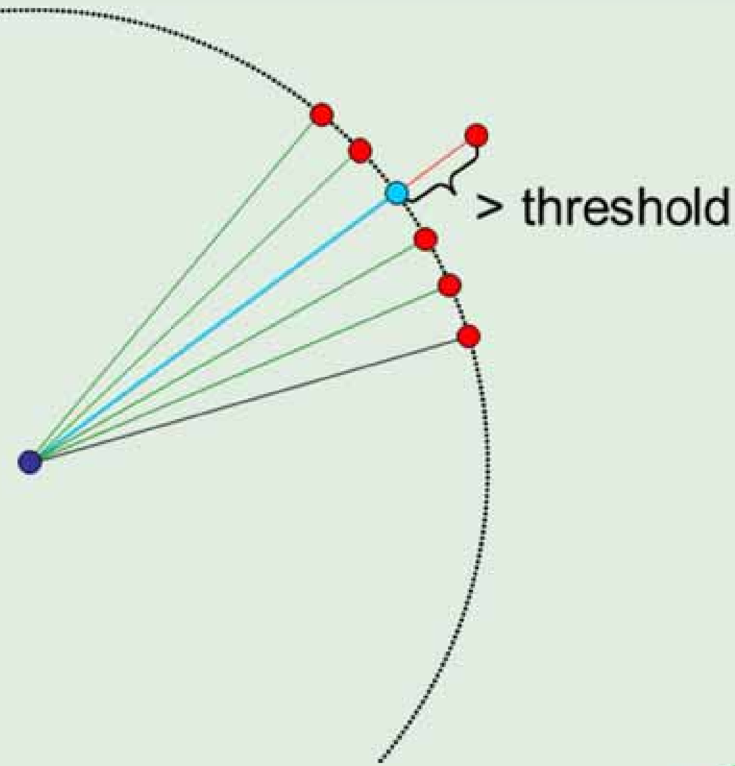
  Detection of errors and outliers

  → looking at the radii of two adjacent points

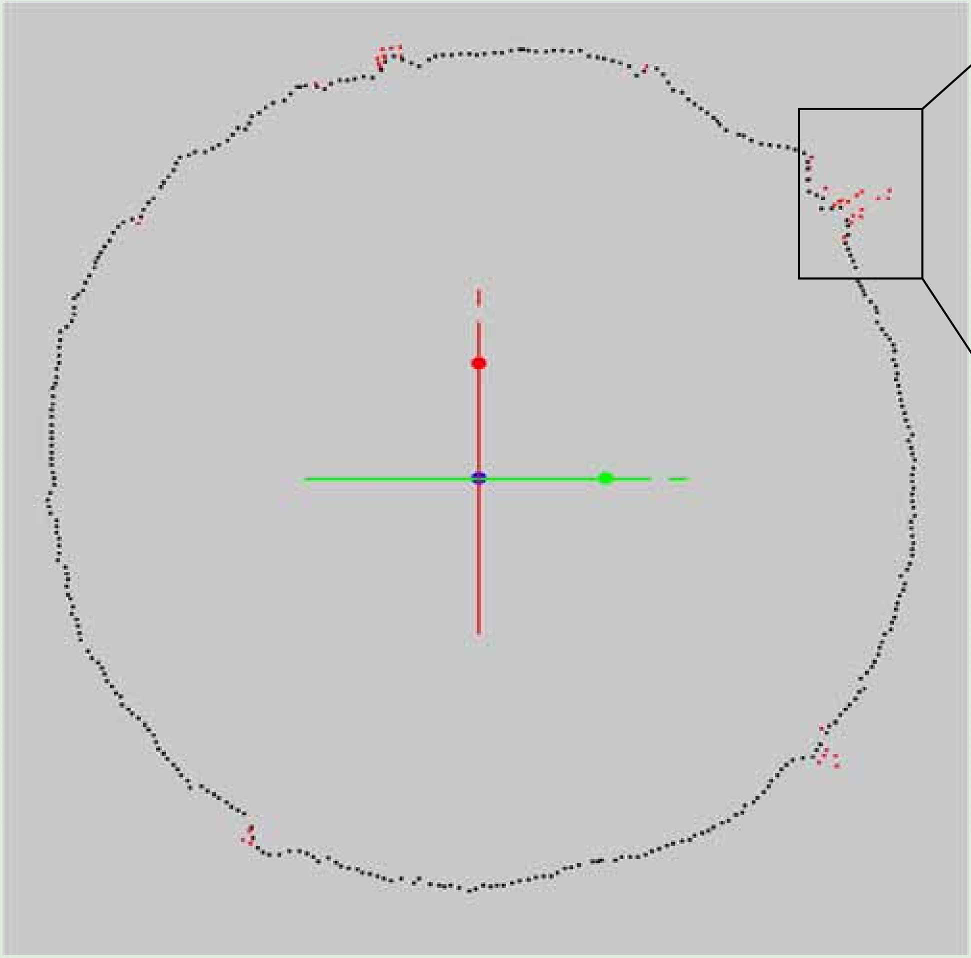
  → if the difference between the two radii is bigger than X% of the mean radius

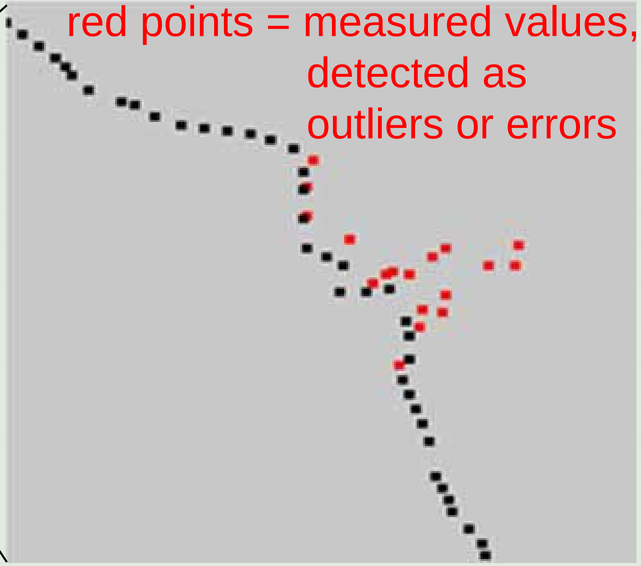
  → computing of new values

  → iterative method
  (repeated computation until all points are inside the limits)



Electronic measurement: data processing



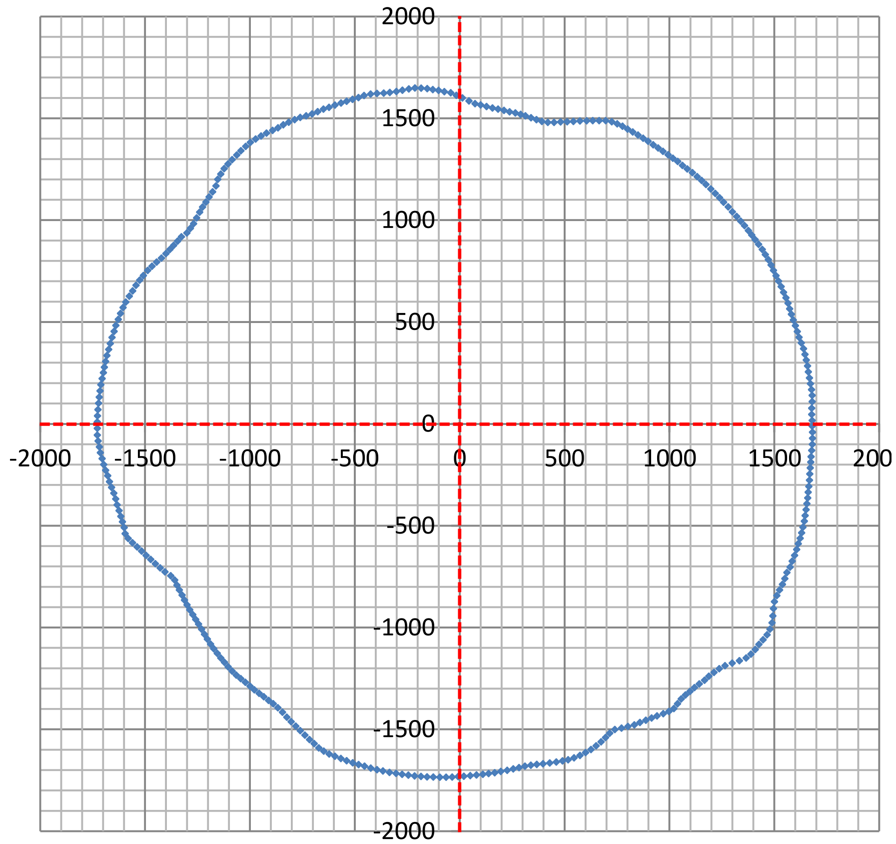


Example:
slice no. 85,
mean radius: 132,4 mm
threshold: 2 % → 2,648 mm

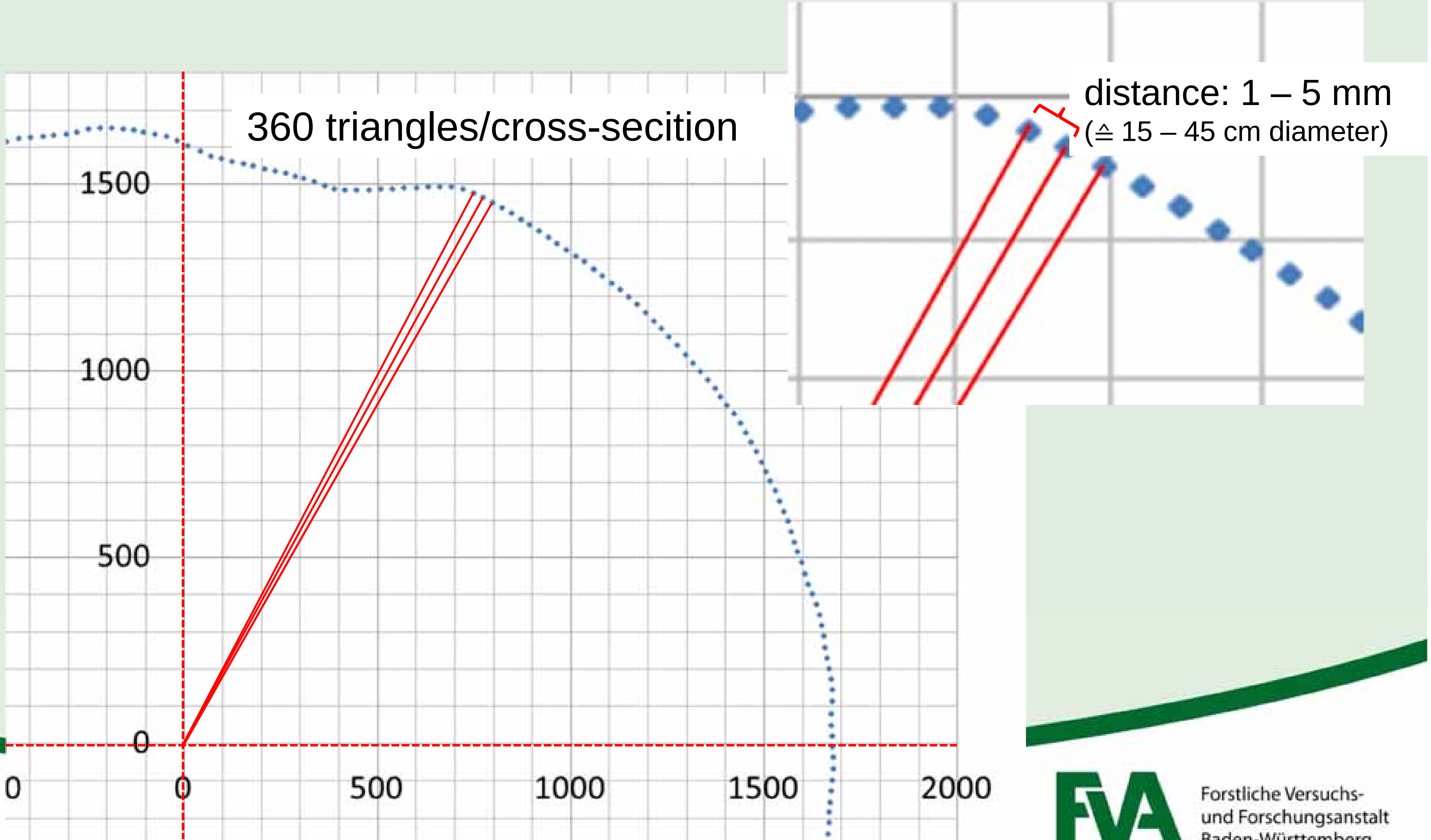
Calculating cross-section areas

- polygon based on 360 contour points
- calculating the real area (Gauss quadrature, based on triangels)

$$A = \frac{1}{2}\sum_{i=1}^{360}(y_i + y_{i+1}) \times (x_i - x_{i+1})$$



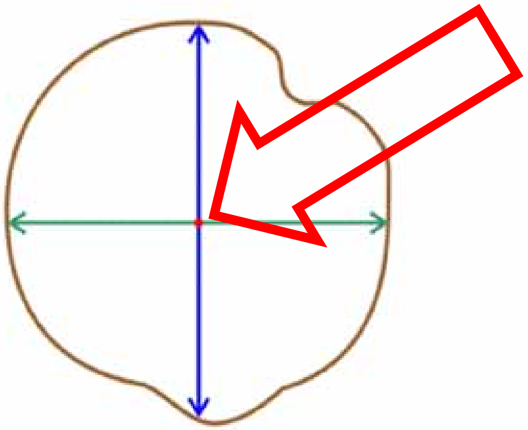
Calculating cross-section areas



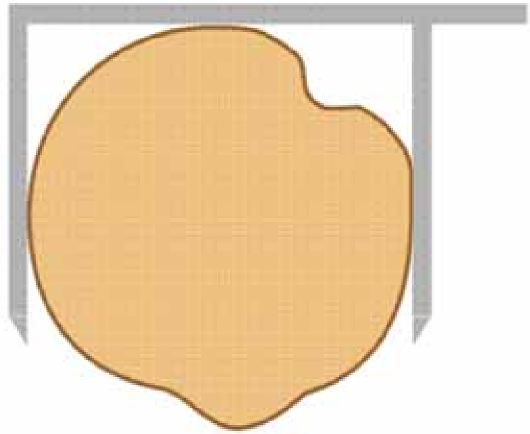
Electronic measurement

Diameter: different approaches

Definition of the centre point?



determining the real **contour**



Simulating a mechanical **caliper**

Definition of the centre point

Premise: All diameters intersect in one common point

→ different approaches to define this intersection / centre point

arithmetic centre point	
Mean value of all measurend points *(m)*: $$m_x = \frac{1}{360}\sum_{i=1}^{360} x_i$$ $$m_y = \frac{1}{360}\sum_{i=1}^{360} y_i$$	

Electronic measurement: contour diameters

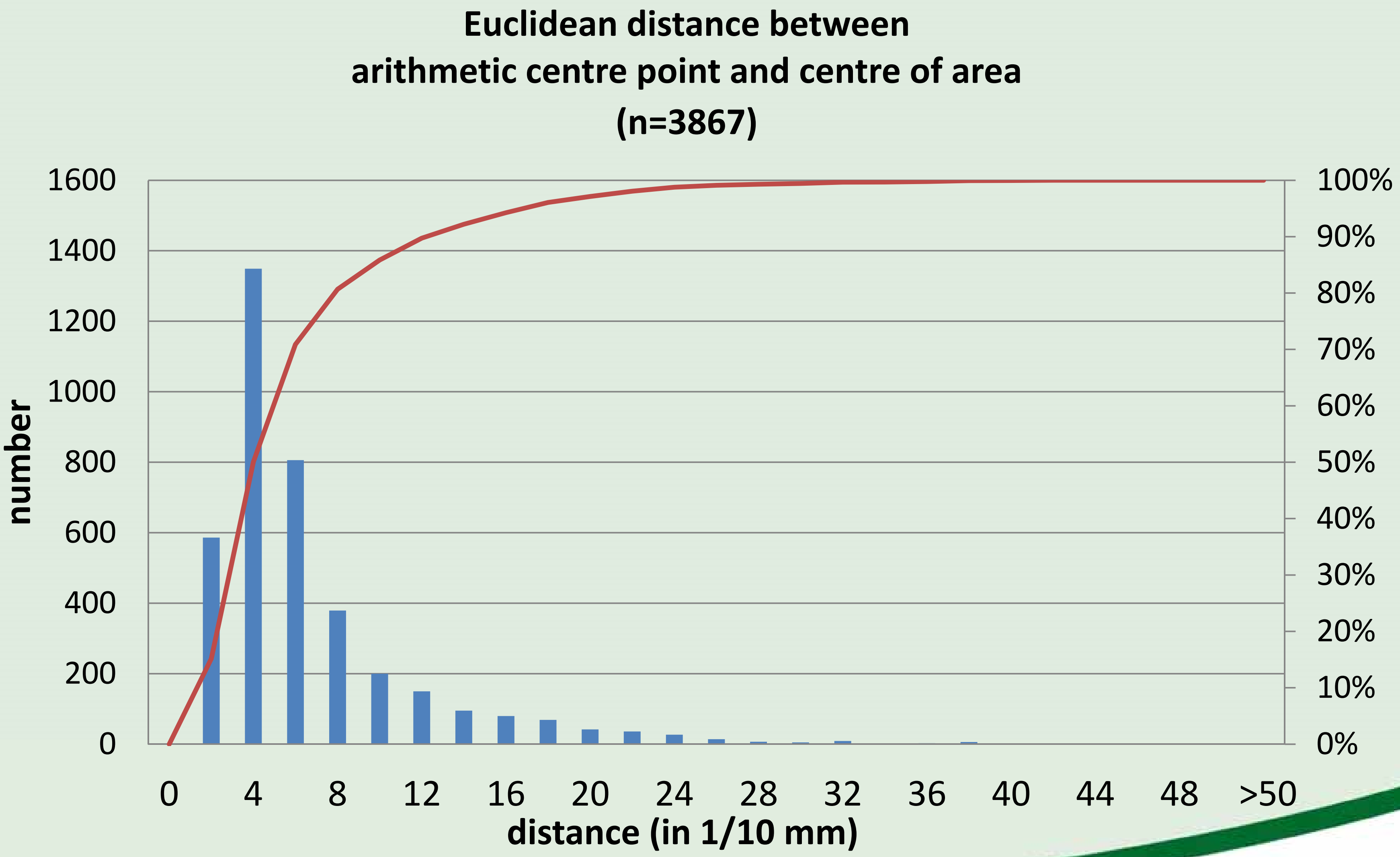
Definition of the centre point

Premise: All diameters intersect in one common point

→ different approaches to define this intersection / centre point

arithmetic centre point	***centre of area***
Mean value of all measurend points *(m)*: $$m_x = \frac{1}{360}\sum_{i=1}^{360} x_i$$ $$m_y = \frac{1}{360}\sum_{i=1}^{360} y_i$$	Calculating the centre of area*(c)*: $$c_x = \frac{1}{6A}\sum_{i=0}^{N-1}(x_i + x_{i+1}) * (x_i y_{i+1} - x_{i+1} y_i)$$ $$c_y = \frac{1}{6A}\sum_{i=0}^{N-1}(y_i + y_{i+1}) * (x_i y_{i+1} - x_{i+1} y_i)$$

Electronic measurement: contour diameters



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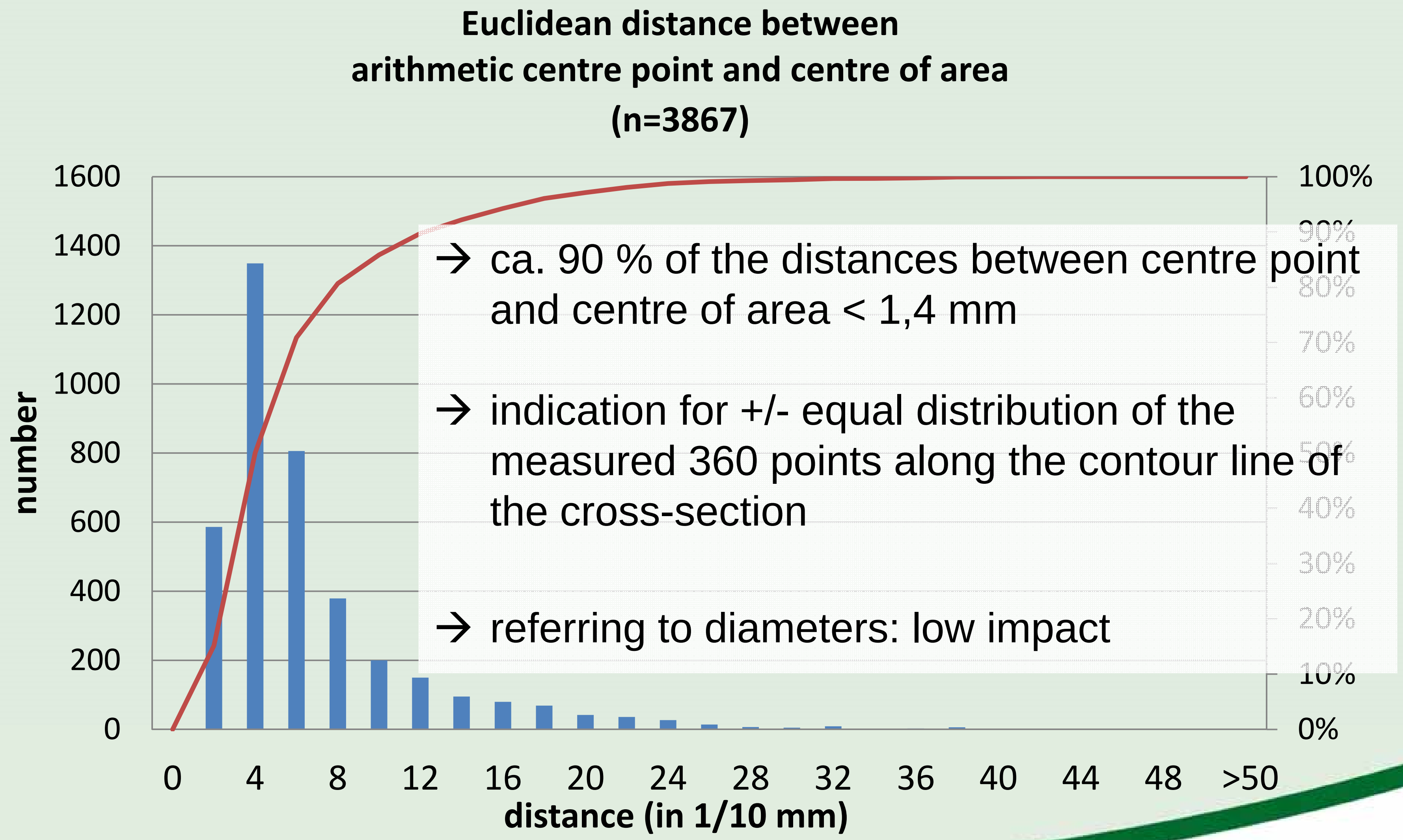
Electronic measurement: contour diameters



→ ca. 90 % of the distances between centre point and centre of area < 1,4 mm

→ indication for +/- equal distribution of the measured 360 points along the contour line of the cross-section

→ referring to diameters: low impact

Calculating diameters and circular areas

180

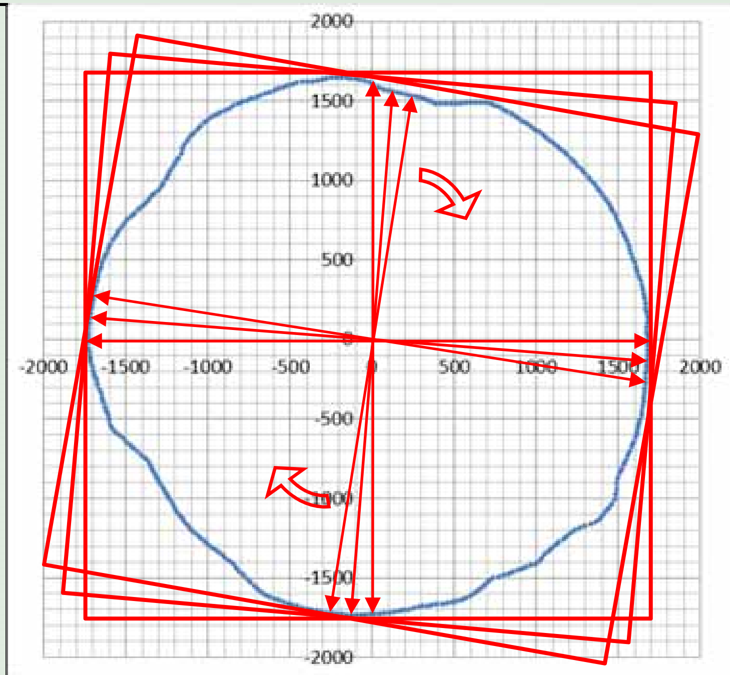
diameters

(caliper / contour)

- 180 diameters,
- angular distance ca. 1°
- calculating the mean value of 180 diameters
- calculating the circular area

$$d = \frac{1}{n}\sum_{i=1}^{180} d_i$$

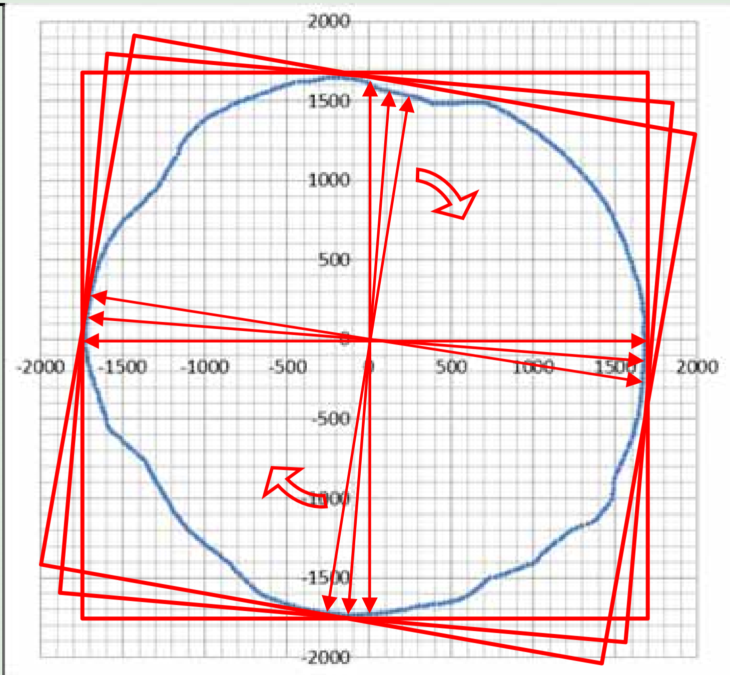
$$A = \frac{\pi}{4} d^2$$



coordinates of the arithmetic centre point:
x = 9,8
y = -30,8

Calculating diameters and circular areas

90 **diameters** (caliper / contour)	• 90 diameters, • angular distance ca. 2° • calculating the mean value of 90 diameters • calculating the circular area $d = \frac{1}{n}\sum_{i=1}^{90} d_i$ $A = \frac{\pi}{4} d^2$



coordinates of the arithmetic centre point:
x = 9,8
y = -30,8

Calculating diameters and circular areas

<table>
<tr>
<td rowspan="2">18
diameters
(caliper / contour)</td>
<td>

- 18 diameters,
- angular distance ca. 10°
- calculating the mean value of 18 diameters
- calculating the circular area

</td>
</tr>
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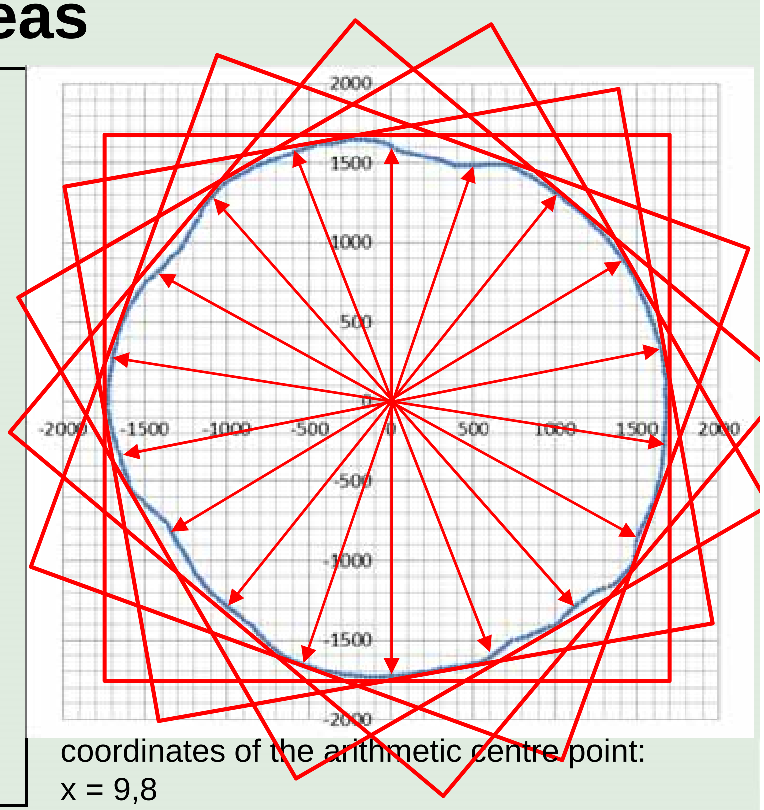
<td>

$$d = \frac{1}{n}\sum_{i=1}^{18} d_i$$

$$A = \frac{\pi}{4} d^2$$

</td>
</tr>
</table>



coordinates of the arithmetic centre point:
x = 9,8
y = -30,8

Calculating diameters and circular areas

2

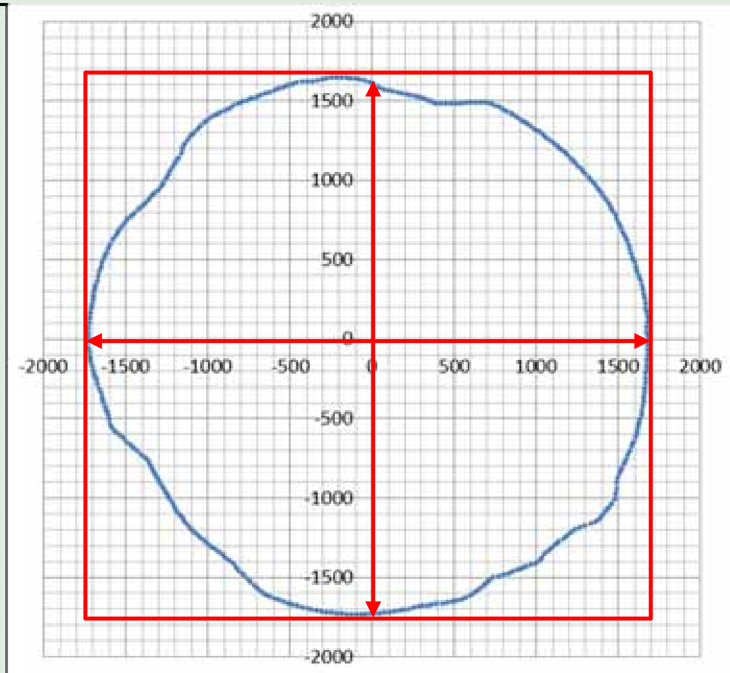
perpen-dicular diameters

(caliper / contour)

- two perpendicular diameters in fixed measuring planes (0° and 90°),
- calculating the mean value of two diameters,
- calculating the circular area

$$d = \frac{d_0 + d_{90}}{2}$$

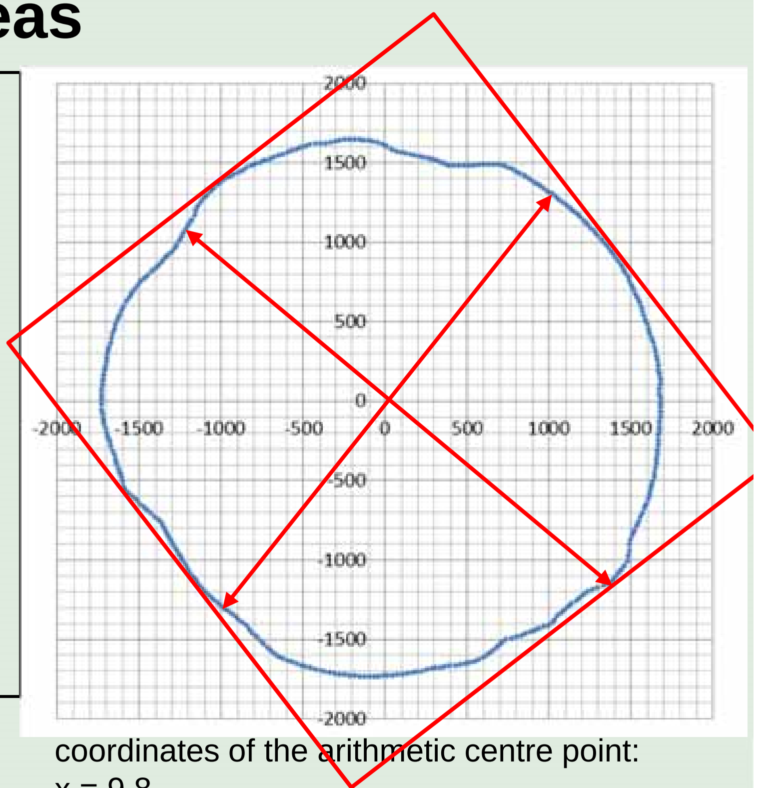
$$A = \frac{\pi}{4} d^2$$



coordinates of the arithmetic centre point:
x = 9,8
y = -30,8

Calculating diameters and circular areas

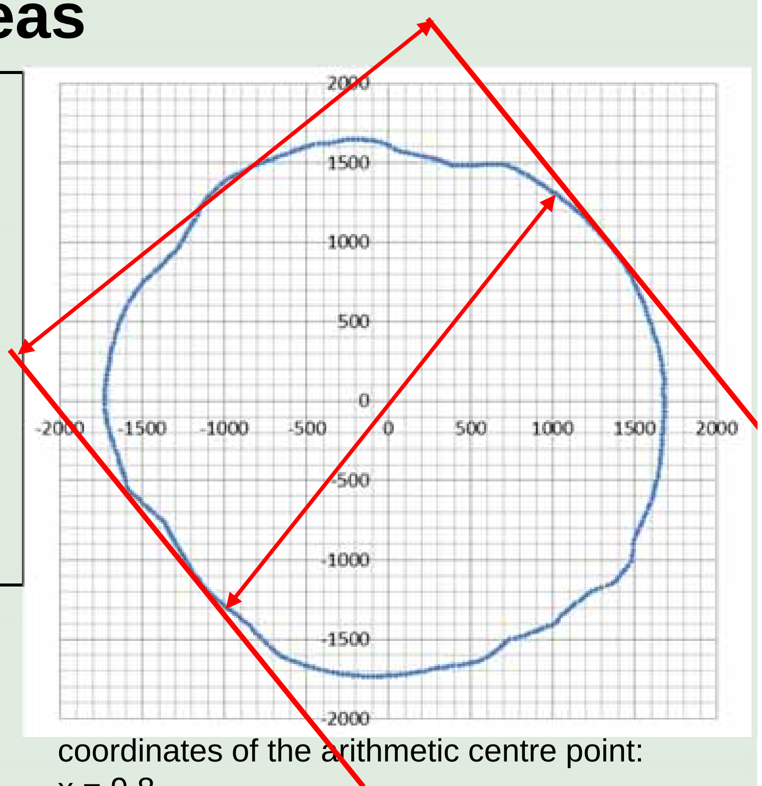
minimum diameter plus 90° (caliper / contour)	• minimum diameter (out of 180 diameters), • plus perpendicular diameter • calculating the circular area $d = \frac{d_{min} + d_{min90}}{2}$ $A = \frac{\pi}{4} d^2$



coordinates of the arithmetic centre point:
x = 9,8
y = -30,8

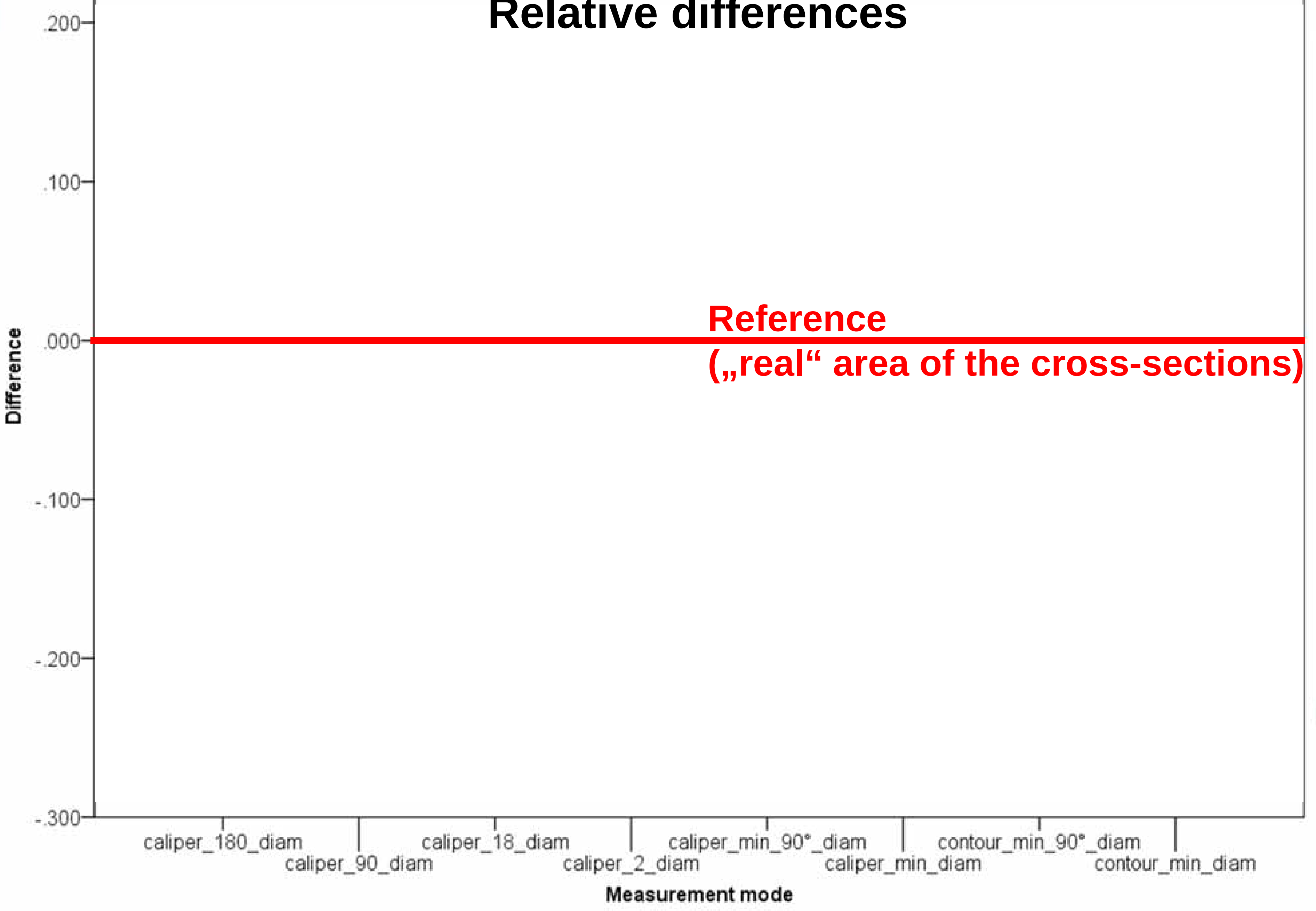
Calculating diameters and circular areas

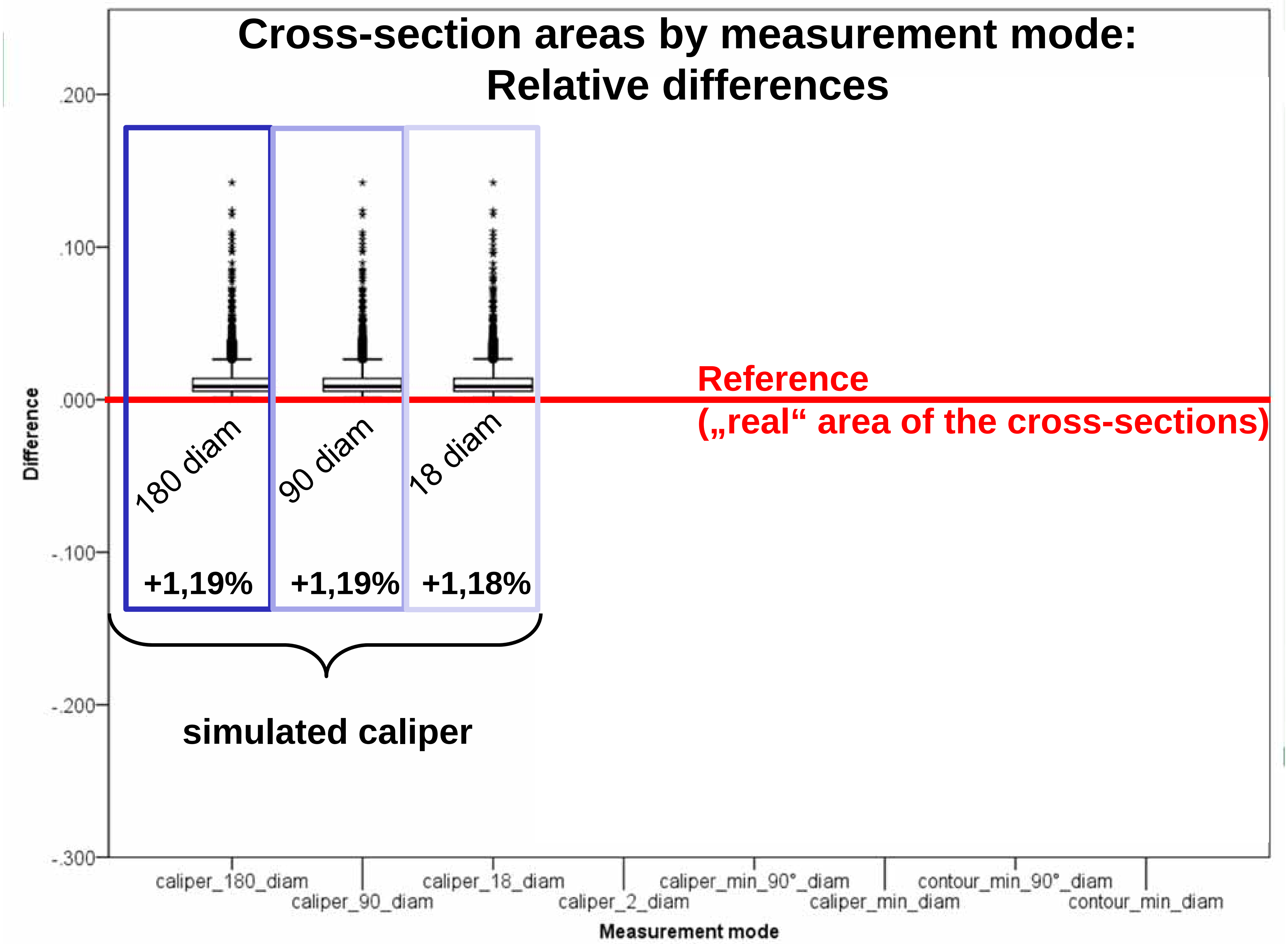
minimum diameter (caliper / contour)	• minimum diameter (out of 180 diameters), • calculating the circular area $d = d_{min}$ $A = \frac{\pi}{4} d^2$



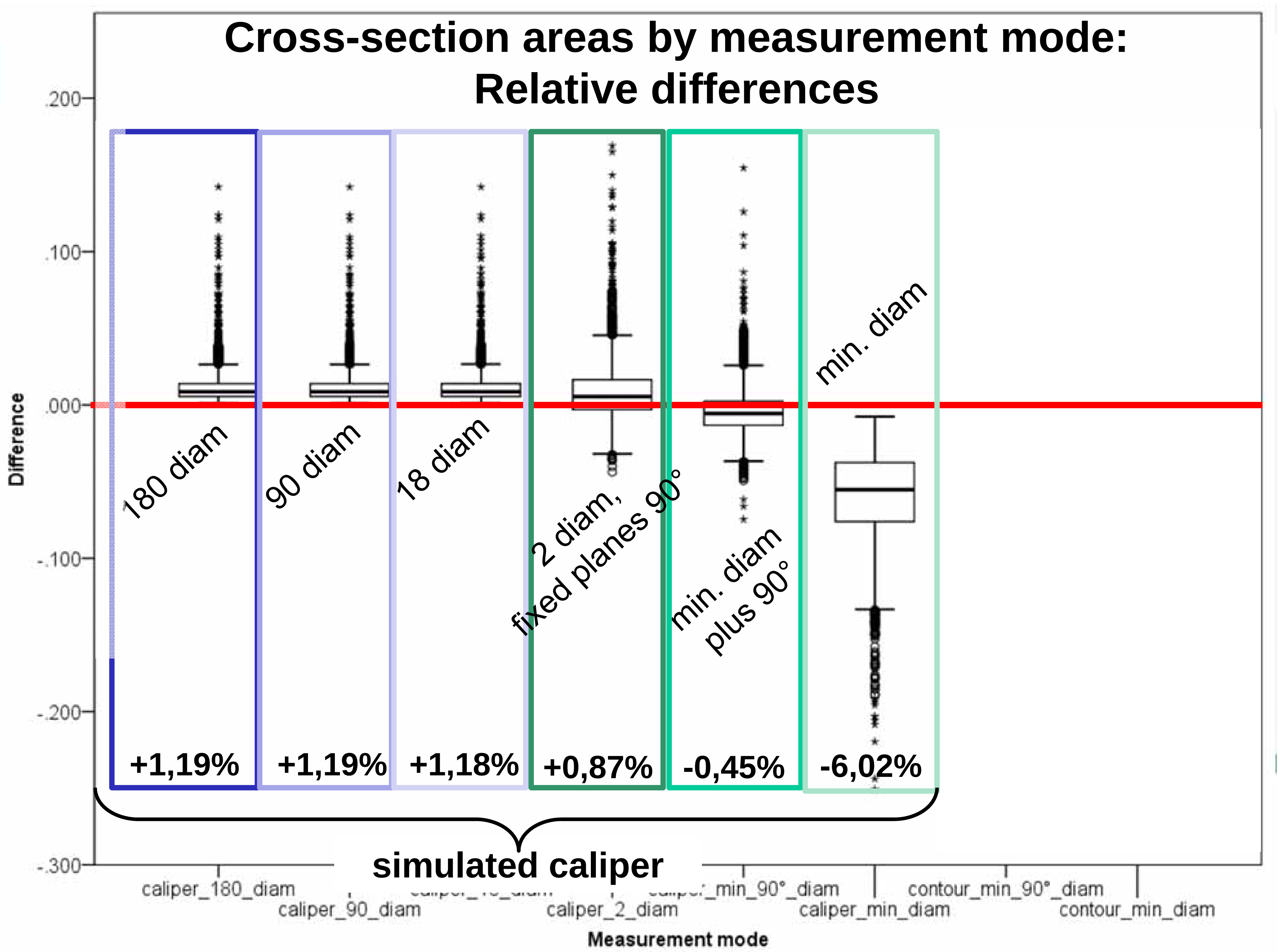
coordinates of the arithmetic centre point:
x = 9,8
y = -30,8

Cross-section areas by measurement mode: Relative differences

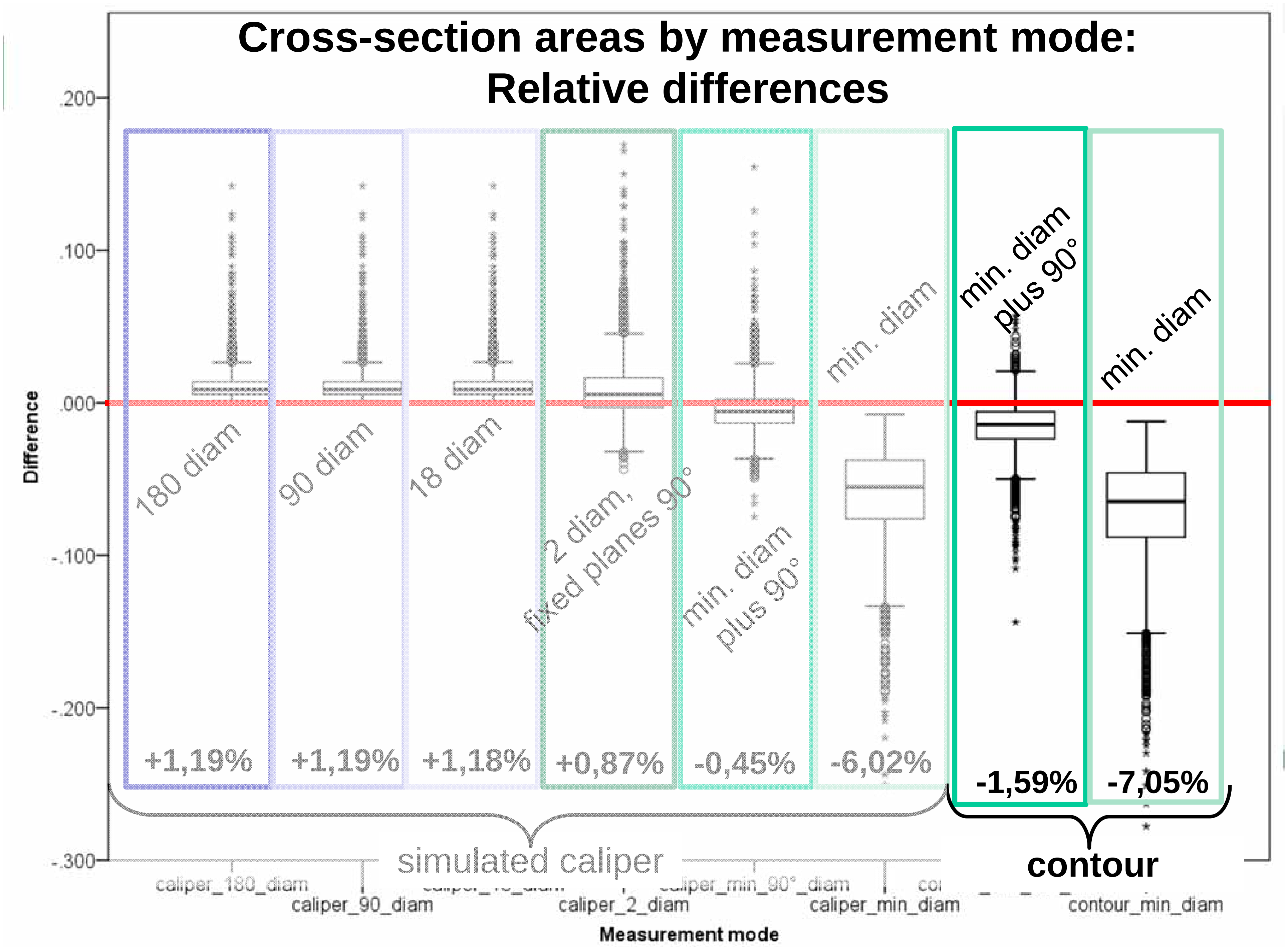




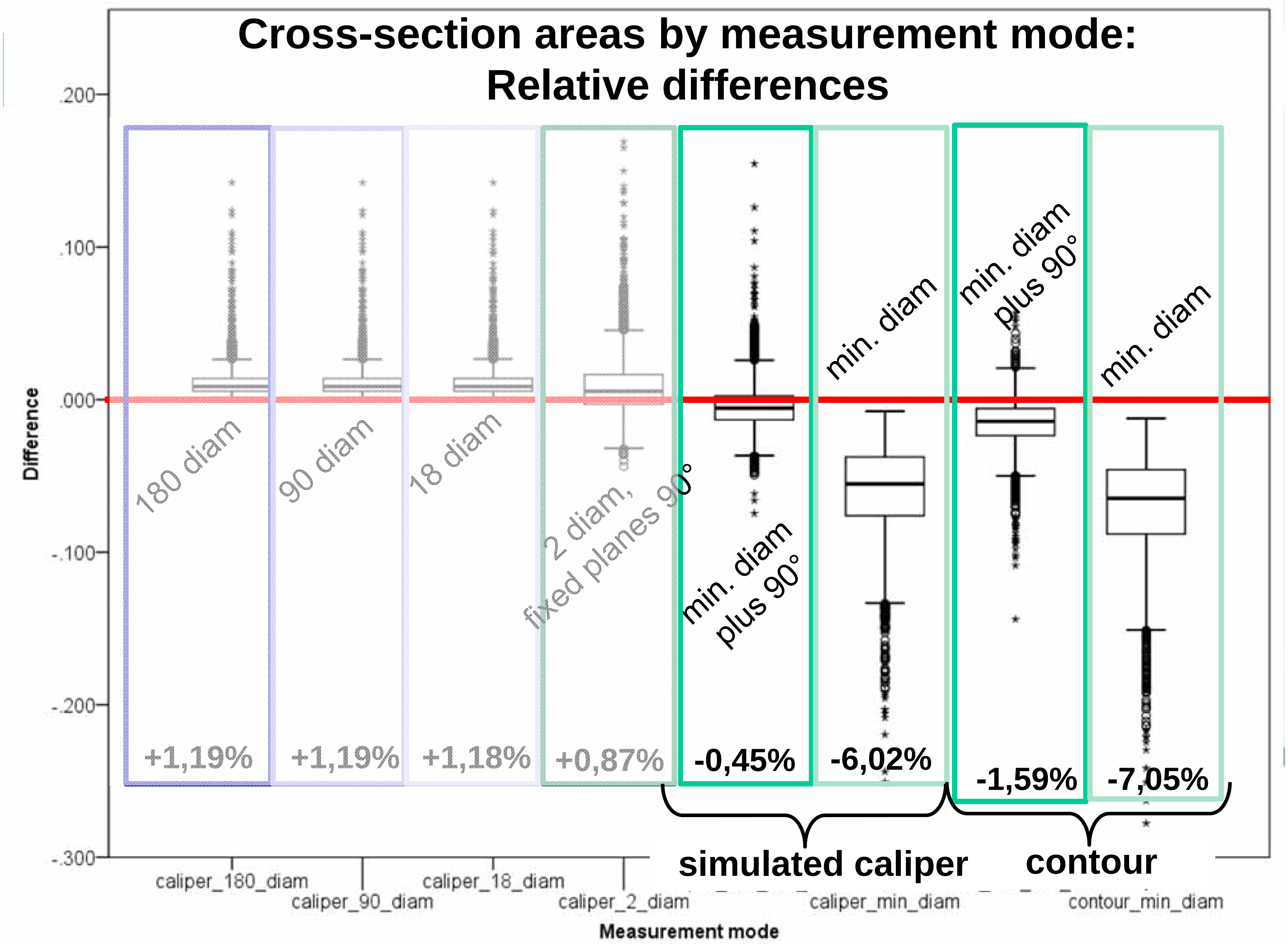
Cross-section areas by measurement mode:
Relative differences
.200
.100
.000
-.100
-.200
-.300
Difference
180 diam
90 diam
18 diam
+1,19%
+1,19%
+1,18%
simulated caliper
Reference
(„real“ area of the cross-sections)
caliper_180_diam
caliper_90_diam
caliper_18_diam
caliper_2_diam
caliper_min_90°_diam
caliper_min_diam
contour_min_90°_diam
contour_min_diam
Measurement mode



Cross-section areas by measurement mode:
Relative differences
.200
.100
.000
-.100
-.200
-.300
Difference
180 diam
90 diam
18 diam
2 diam,
fixed planes 90°
min. diam
plus 90°
min. diam
+1,19%
+1,19%
+1,18%
+0,87%
-0,45%
-6,02%
simulated caliper
caliper_180_diam
caliper_90_diam
caliper_2_diam
caliper_min_diam
contour_min_90°_diam
contour_min_diam
Measurement mode



Cross-section areas by measurement mode:
Relative differences
.200
.100
.000
-.100
-.200
-.300
Difference
180 diam
90 diam
18 diam
2 diam,
fixed planes 90°
min. diam
plus 90°
min. diam
min. diam
plus 90°
min. diam
+1,19%
+1,19%
+1,18%
+0,87%
-0,45%
-6,02%
-1,59%
-7,05%
simulated caliper
contour
caliper_180_diam
caliper_90_diam
caliper_2_diam
caliper_min_diam
contour_min_diam
Measurement mode



Cross-section areas by measurement mode:
Relative differences
.200
.100
.000
-.100
-.200
-.300
Difference
180 diam
90 diam
18 diam
2 diam, fixed planes 90°
min. diam plus 90°
min. diam
min. diam plus 90°
min. diam
+1,19%
+1,19%
+1,18%
+0,87%
-0,45%
-6,02%
-1,59%
-7,05%
simulated caliper
contour
caliper_180_diam
caliper_90_diam
caliper_18_diam
caliper_2_diam
caliper_min_diam
contour_min_diam
Measurement mode

Summary

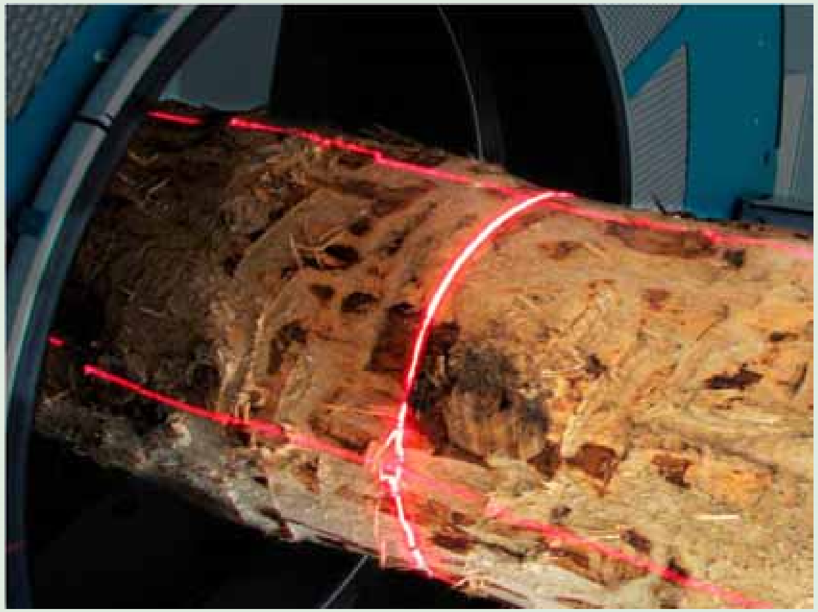
- 3D-scanning technology generates comprehensive data
- log volumes can be calculated on the basis of a cylinder model?
- log (cylinder) length is easy to determine
- there are various approaches for calculating: diameters, circular and irregular cross-section areas
- precise, reliable and transparent determination of the cross-section area can be realized by using many diameters and the principle of a caliper

Thank you!

Dr. Udo Hans Sauter
udo.sauter@forst.bwl.de

Dr. Jörg Staudenmaier
joerg.staudenmaier@forst.bwl.de

Department of Forest Utilisation
Forest Research Institute of
Baden-Wuerttemberg
Wonnhaldestrasse 4
D-79100 Freiburg



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