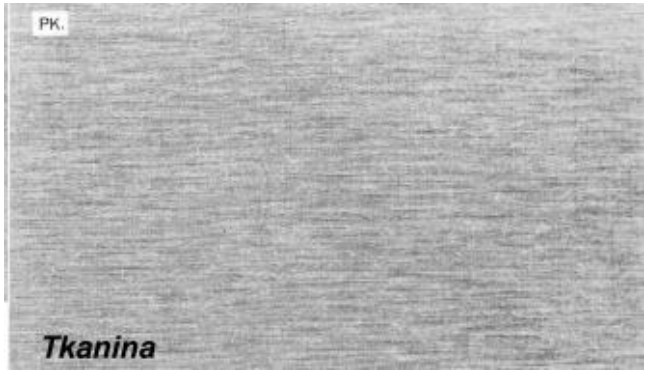
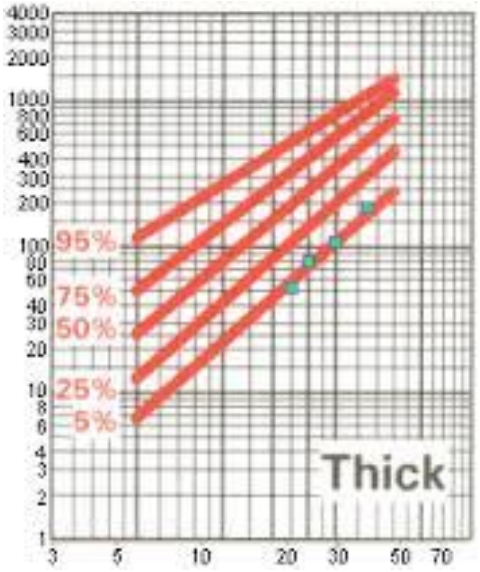
# Linear and area unevenness




- Definition of mass unevenness
- Causes of mass unevenness
- Uneveness measurement
- The relation of the uneveness of longitudinal fabrics (yarns) to the unevenness of woven or knitted fabrics




# Unevenness

- **Fluctuation of a random variable**
  - Coefficient of variation

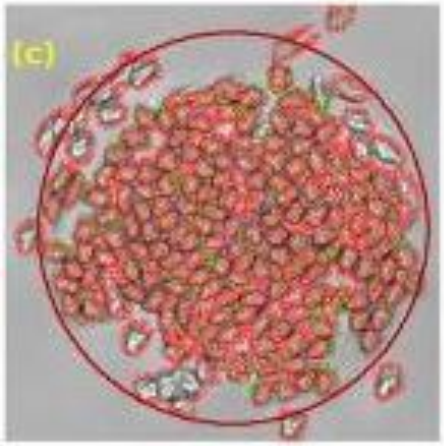
$$v = \frac{s}{\overline{x}} \cdot 10^2 \ [\%]$$

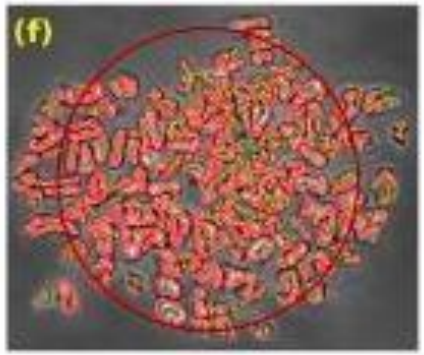
  - Standard deviation

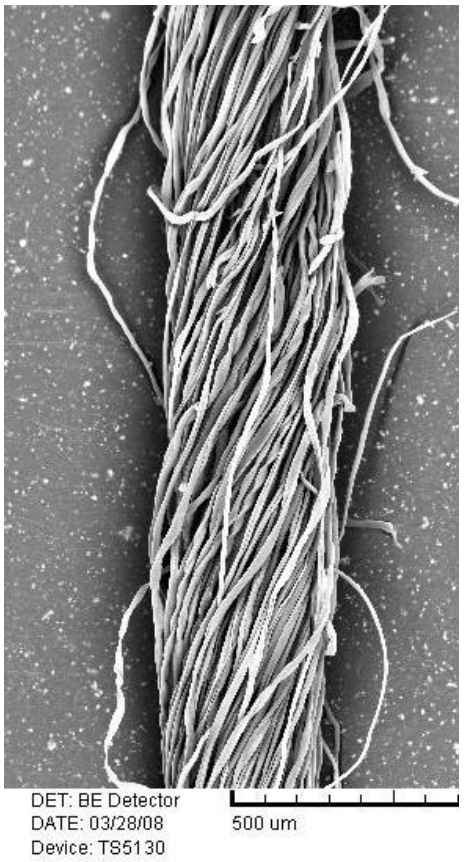
$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \overline{x})^2 \qquad s = \sqrt{s^2}$$

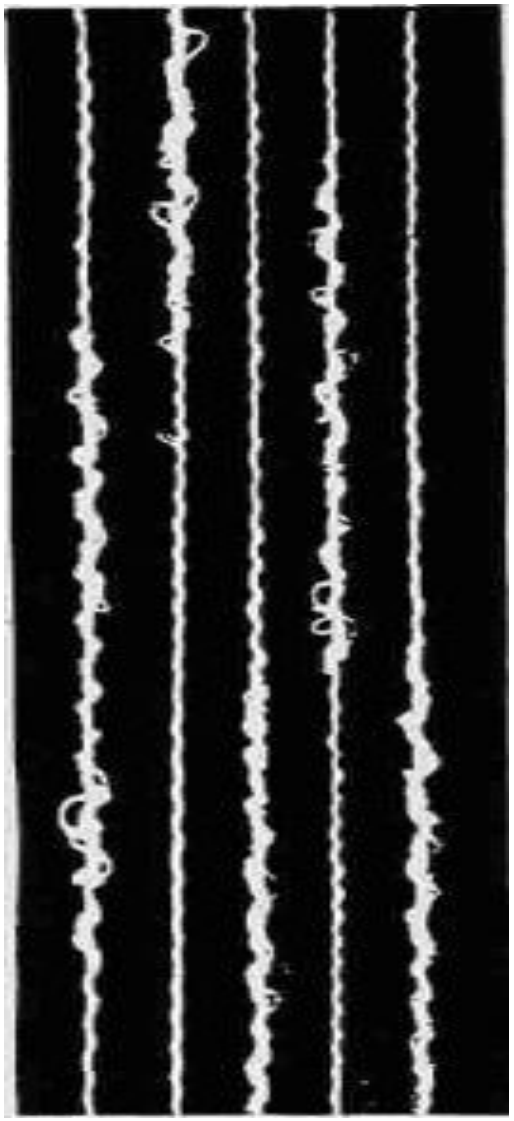
# Mass unevenness (ME)

- **fluctuations in fiber mass** in the yarn cross-section or in other longitudinal sections of the fiber product



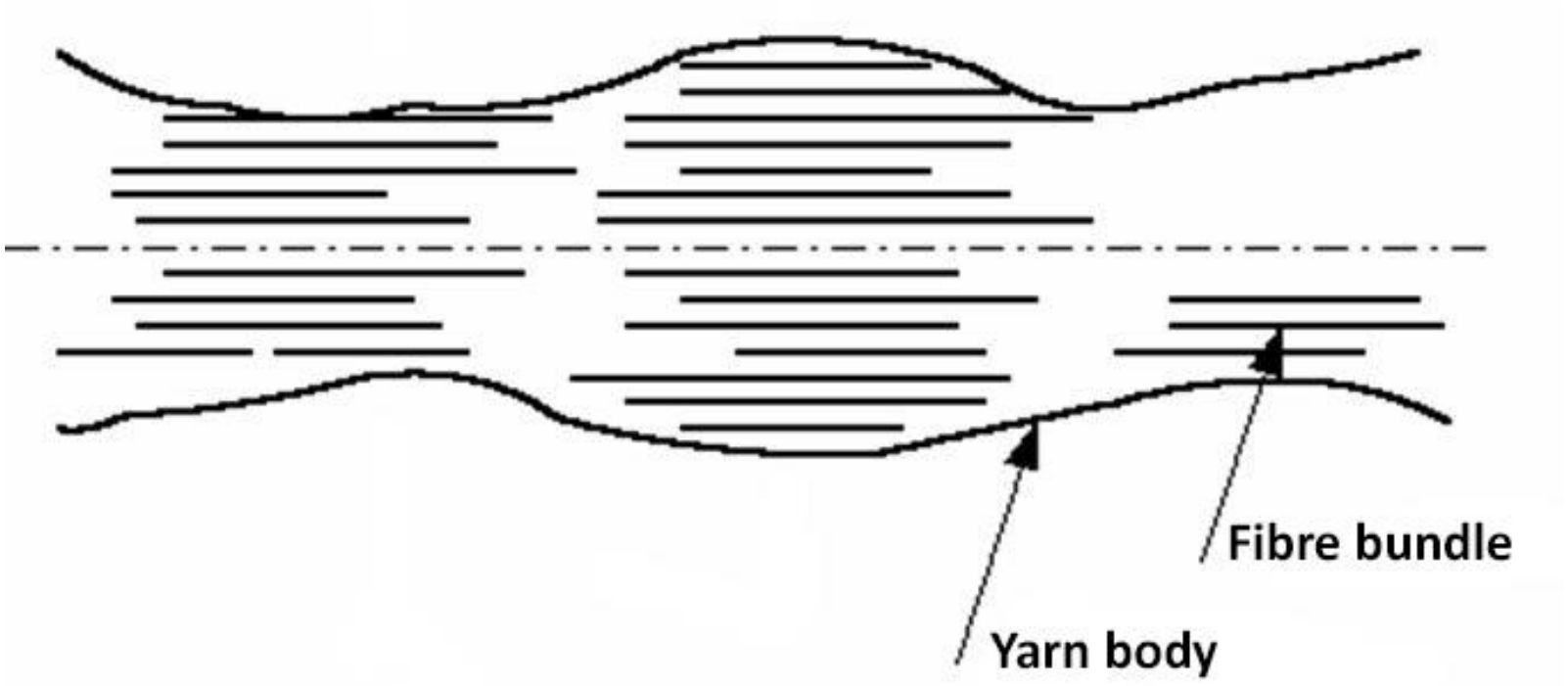



# Development of ME I.

1. Unequal number of fibers in various yarn cross-sections and their assemblies in the yarn structure
   ***intrinsic unevennes of yarn - limit unevennes***



# Limit unevenness

## Minimum unevennes of product - inherent

**random number of fibers** in product, depends on variability of fibres

Poisson‘s distribution $\lambda = \bar{x} = \sigma^2$

**n-fibers in yarn cross-section** $\bar{x} = \sigma^2 = n;\ \sigma = \sqrt{n}$

**n** ... average number of fibres:

**Martindales expression**

$$CV_{lim} = \frac{\sigma}{\bar{x}} \cdot 100 = \frac{\sqrt{n}}{n} \cdot 100\ [\%]$$

Derived for ideal fiber tow

Fibres are straight, parallel to yarn axis, and equal in cross-section

Fibres are randomly distributed and their distribution corresponds to Poisson‘s distribution

# Martindale expression

$$CV_{lim} = \frac{100}{\sqrt{n}}\ [\%] \qquad n = \frac{\bar{T}[tex]}{\bar{t}[tex]}$$

- Martindale extension:

$$CV_{lim} = \frac{100}{\sqrt{n}}\sqrt{1 + \left(\frac{v_p}{100}\right)^2}$$

  - $v_p$ ... coefficient of variation of fibre cross-section [%]

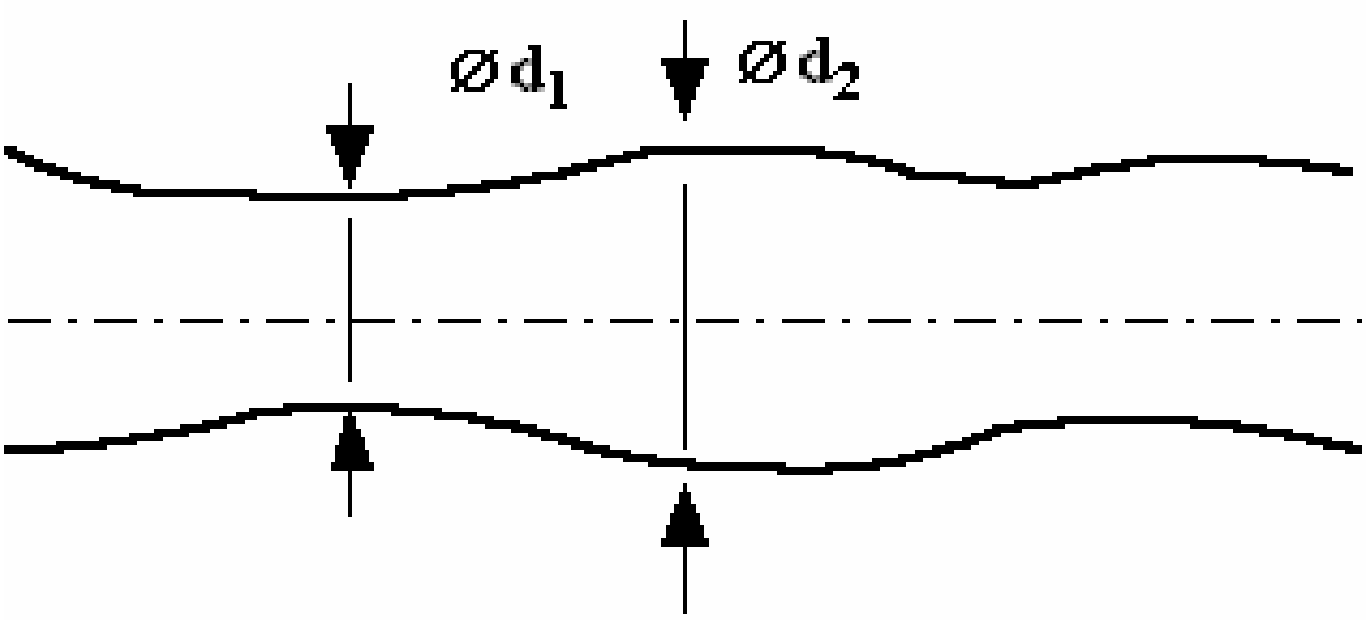
$$CV_{lim} = \frac{100}{\sqrt{n}}\sqrt{1 + \left(\frac{v_d}{100}\right)^2}$$

  - $v_d$ ... coefficient of variation of fiber diameter[%]

| Fibres | t [tex] | $v_p$ [%] |
|---|---|---|
| VS – cotton type | | 19 |
| VS – wool type | | 15 |
| PAD | 0,39 | 26 - 28 |
| | 0,67 | 30 - 33 |
| | 1,3 | |
| PES | 0,28 | 25 - 27 |
| | 0,31 | |
| | 0,33 | |
| | 0,36 | |
| | 0,44 | |
| PAN | 0,34 | 16 - 20 |
| | 0,44 | |
| POP | 0,28 | 29 - 32 |
| | 0,39 | |
| | 0,67 | 32 - 33 |

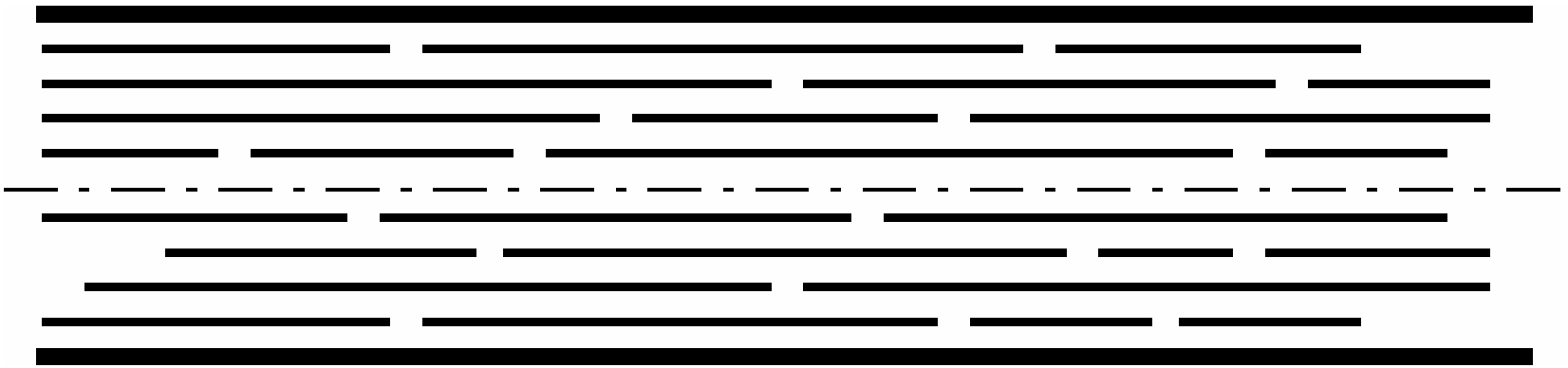
# Development of ME II.

2. Variable fibre cross-section, resp. linear density of individual fibers ⇒ Random behavior of fibres



# Development of ME III.

3. Imperfections of staple fibre ends due to uneven fibre length



!!! *Manufacturing errors – we can modify it*

# Parameters of ME

linear mass unevenness **U [%]**

**quadratic mass unevenness CV [%]**

CV, U – var. coeff., standard deviation of unevenness

level of unevenness is standardized

**limit mass unevenness $CV_{lim}$, $U_{lim}$ [%]**

deviation rate **DR (x,y) [%]**

index of irregularity **I**

production unevenness **$CV_f$, $U_f$ [%]**

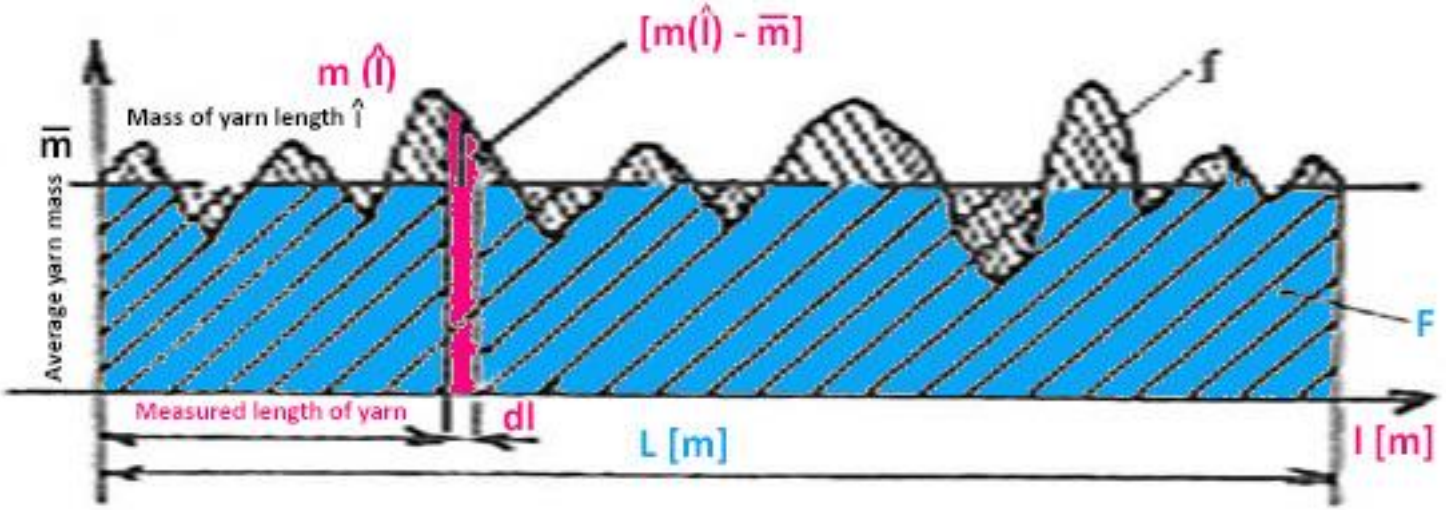
machine unevenness **$CV_m$, $U_m$ [%]**

# Linear unevenness

- standard deviation of average mass

$$U = \frac{f}{F} \cdot 100 = \frac{\int_0^L |m(l) - \bar{m}| dl}{\bar{m} \cdot L} \cdot 100 \quad [\%]$$

$$U = \frac{100}{\bar{m}} \cdot \frac{1}{L} \int_0^L |m(l) - \bar{m}| dl \quad [\%]$$

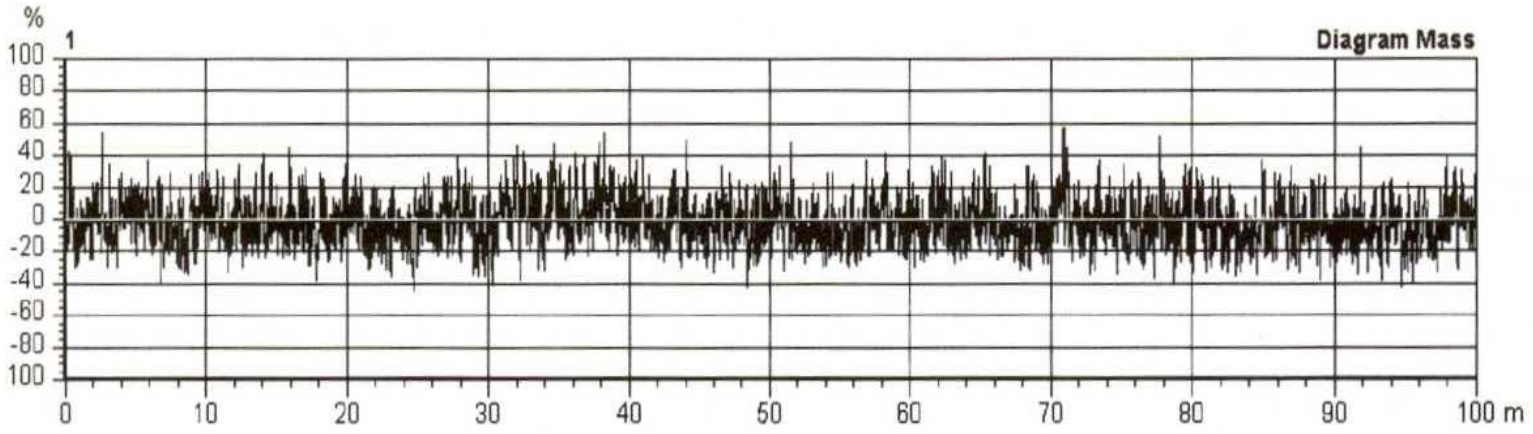


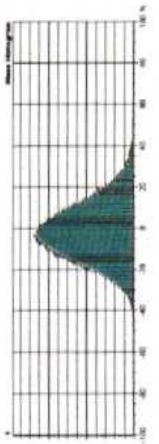
# Quadratic unevenness

- variation coefficient of mass
  - mostly practically used

$$CV\,[\%] = \frac{100}{\bar{m}} \cdot \sqrt{\frac{1}{L}\int_0^L (m(l) - \bar{m})^2 dl}$$

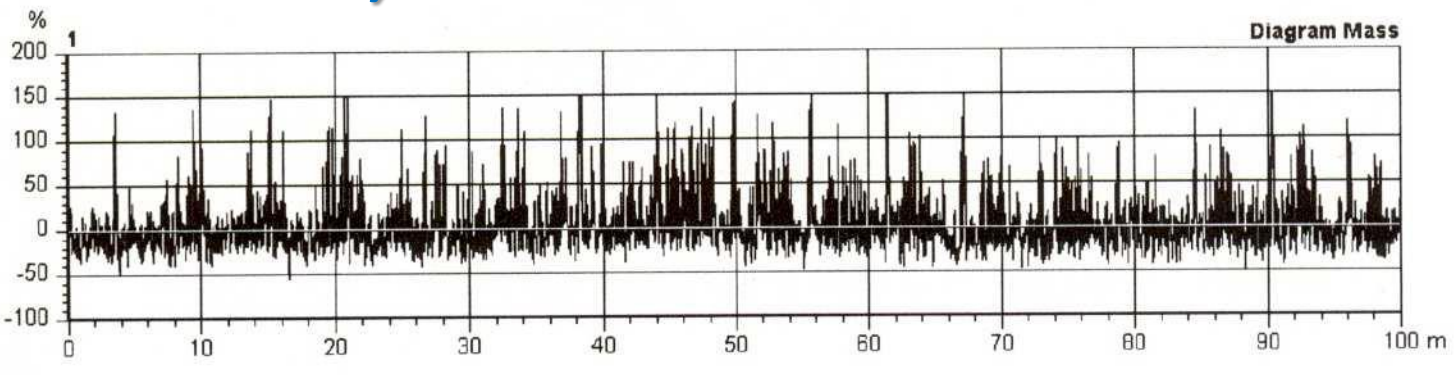
$$\frac{CV}{U} = \sqrt{\frac{\pi}{2}} \cong 1,25$$ valid for normal distribution

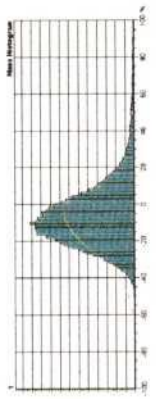


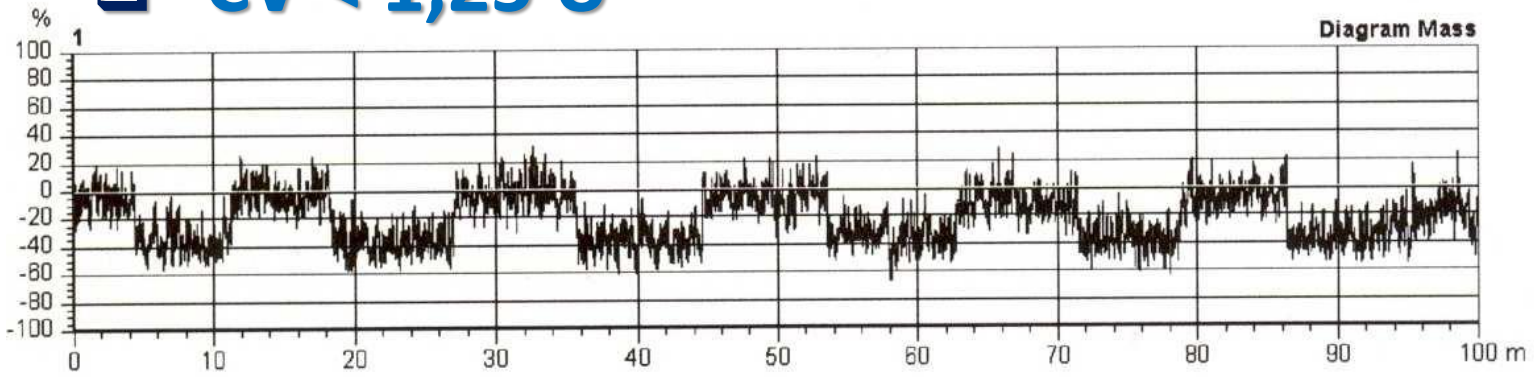
# Quadratic unevenness

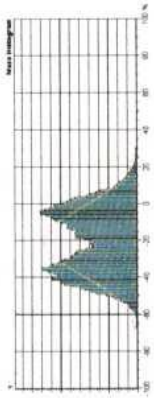
- CV > 1,25 U



- CV < 1,25 U



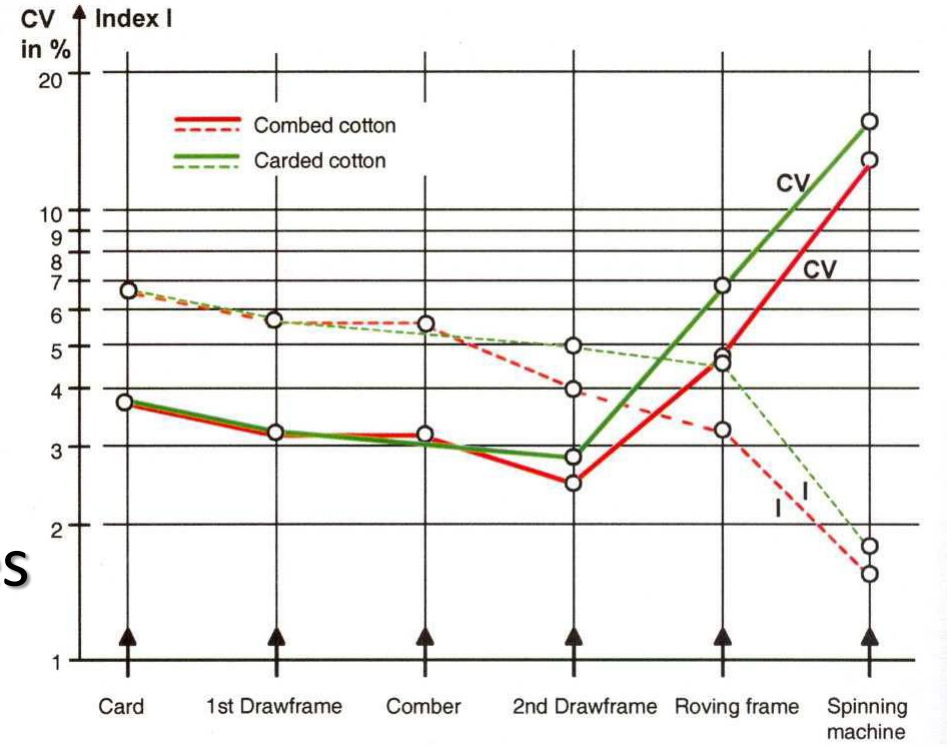
# Index of irregularity

- ratio between measured $CV_{ef}$ a limit $CV_{lim}$ unevenness
- deviation of product from ideal assembly (I=1)

$$I = \frac{CV_{ef}}{CV_{lim}} \qquad I = \frac{U_{ef}}{U_{lim}}$$

**I >1**

- Disadvantage:
  - strong influence of number of fibres

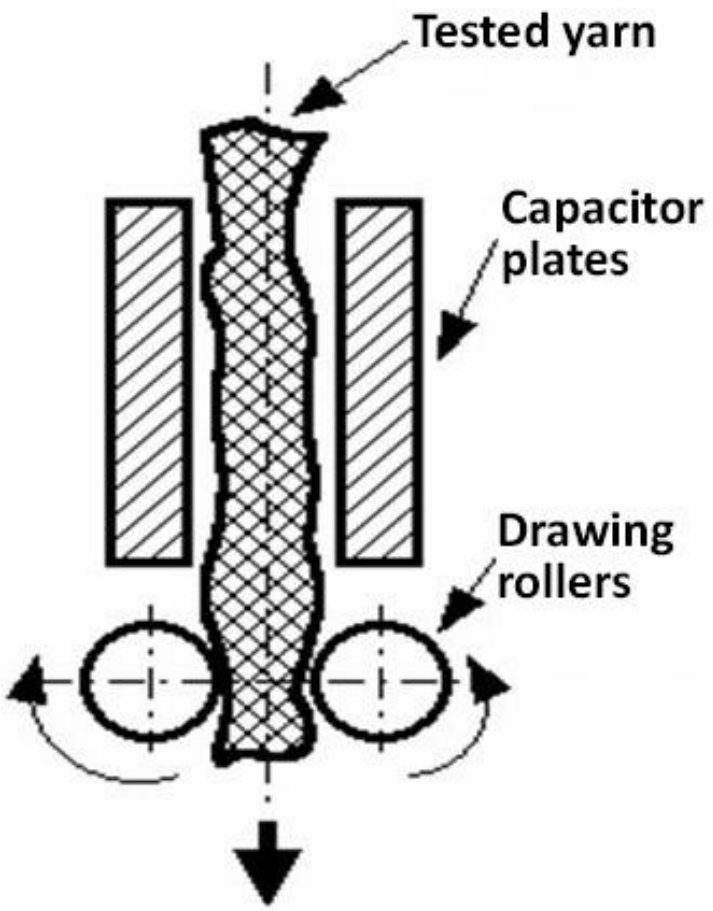


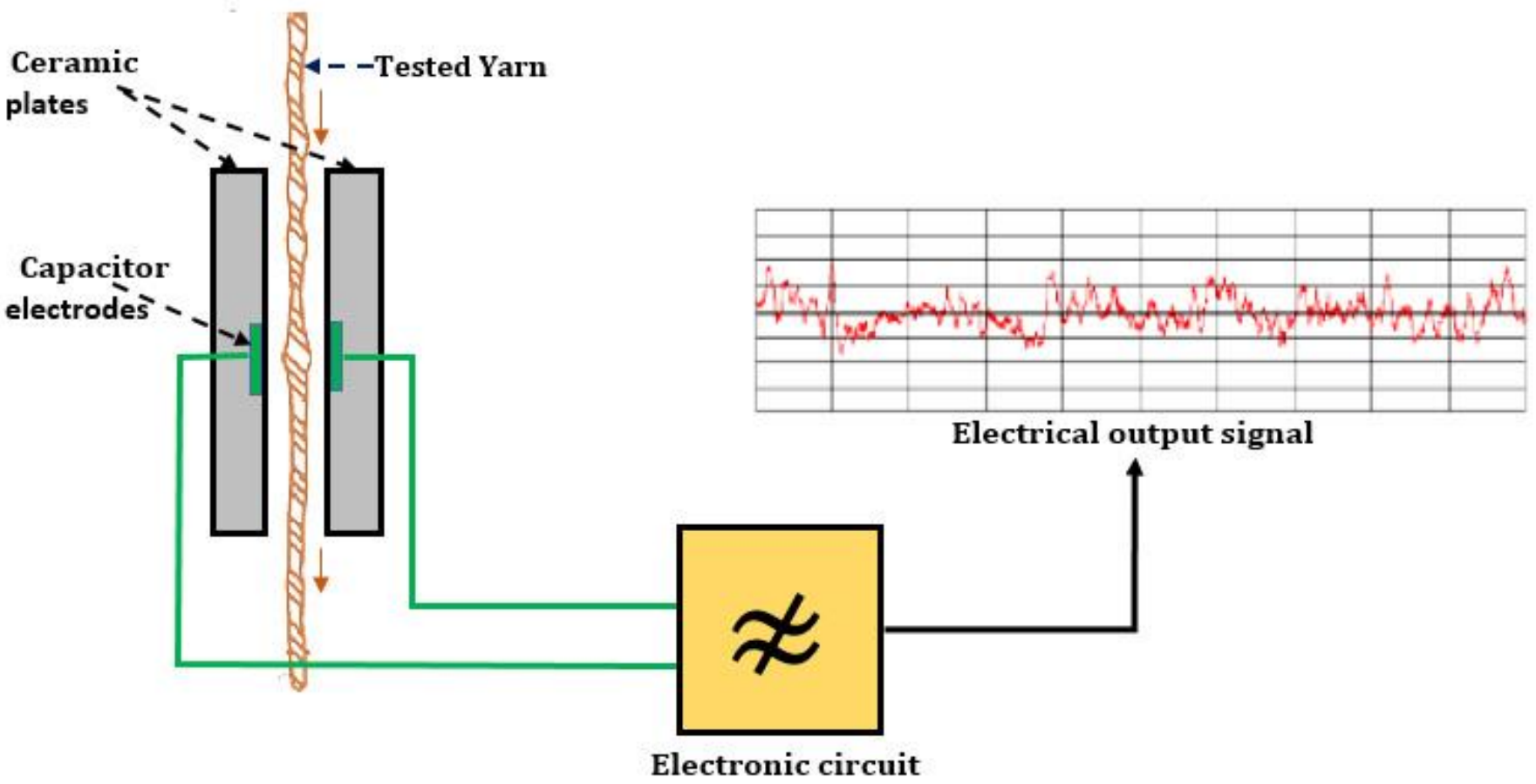
# Measurement of ME

- **Discrete:**
  - Linear textile (yarn, tow) divided on **p**-number of similar length of Yarn, that are weighed
  - Result - mean, variance, standard deviation and **variation coefficient**
- **Continuous:**
  - Mostly used method change of capacitor capacity
  - ZELLWEGER – přístroj Uster Tester
- **Mehtods for non-direct measurement:**
  - Capacity – e.g. Uster Tester
  - Optical – e.g. Zweigle, QQM-3

# Continuous measurement of ME

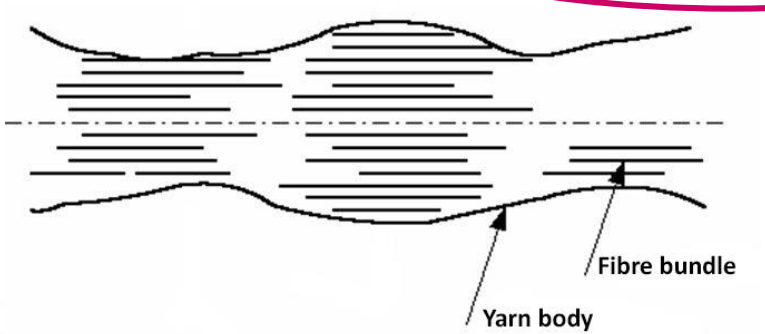
- **ZELLWEGER USTER**

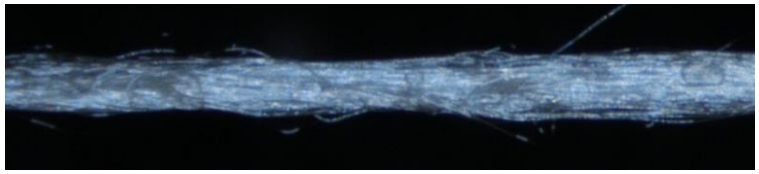


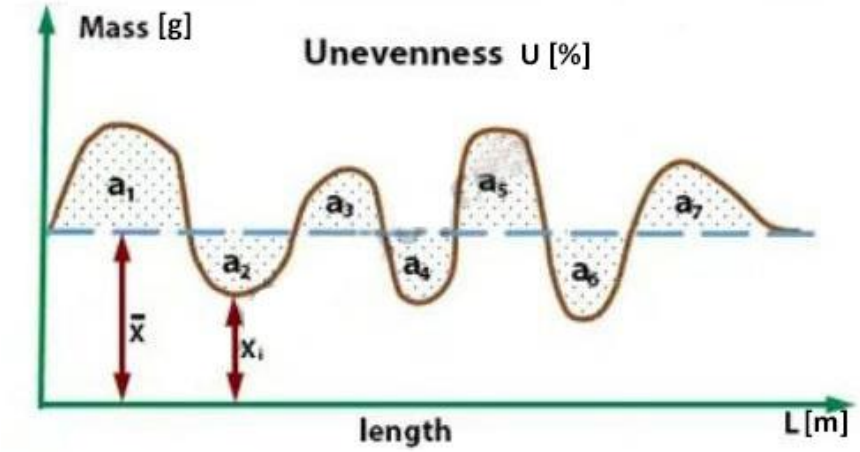


Ceramic plates
Tested Yarn
Capacitor electrodes
Electrical output signal
Electronic circuit

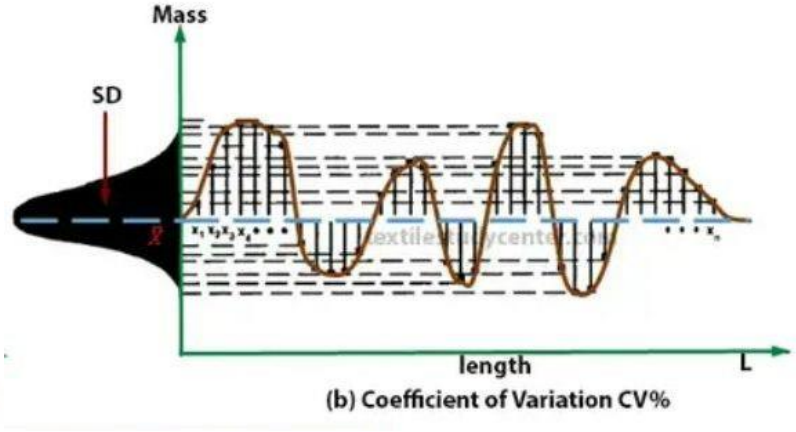
# Outputs I.

## U [%], CV [%]

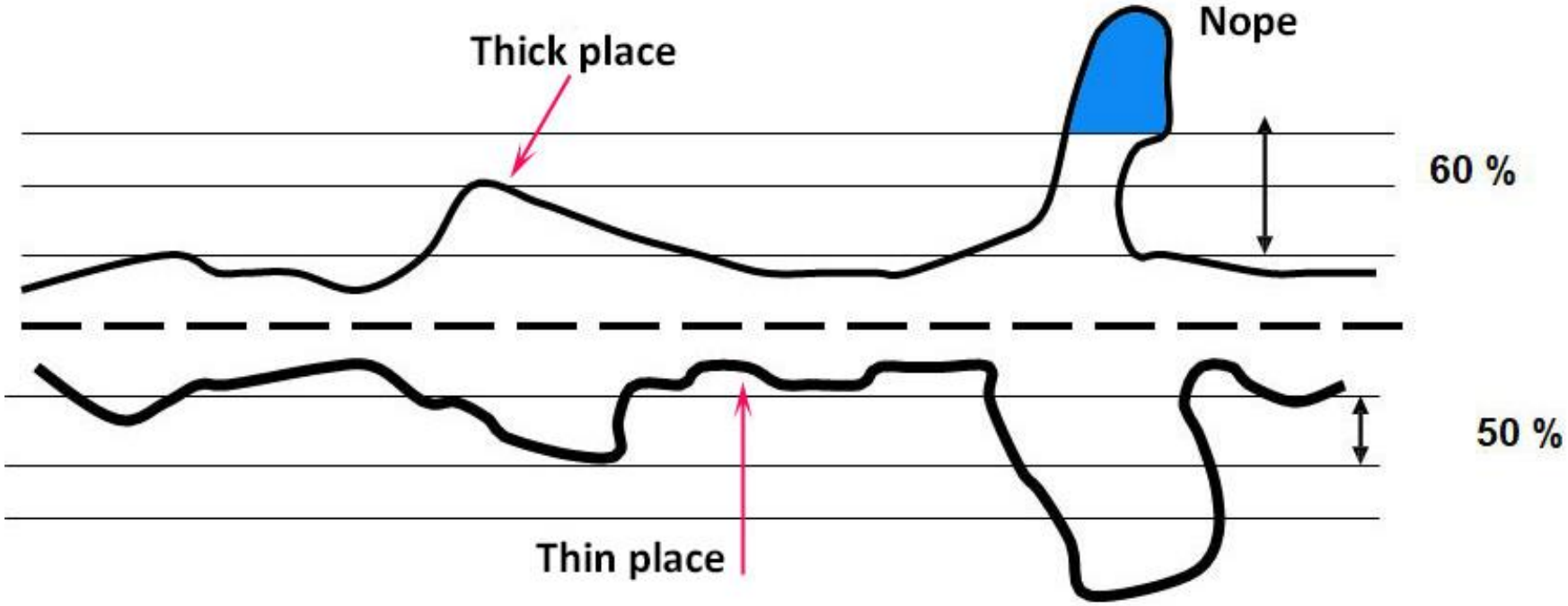




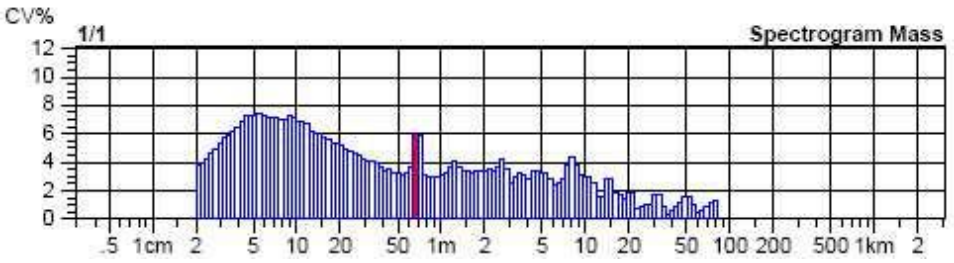



# Outputs II.

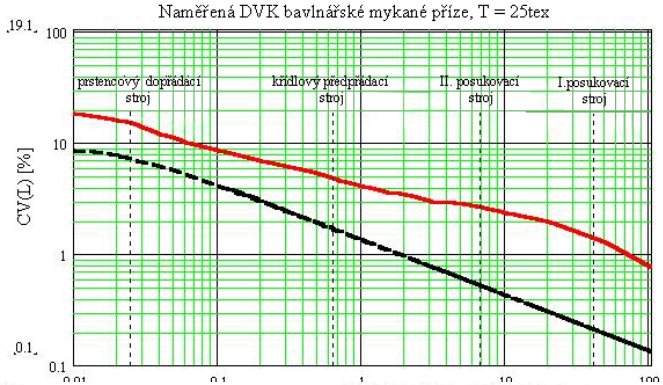


# Graphical presentation of ME

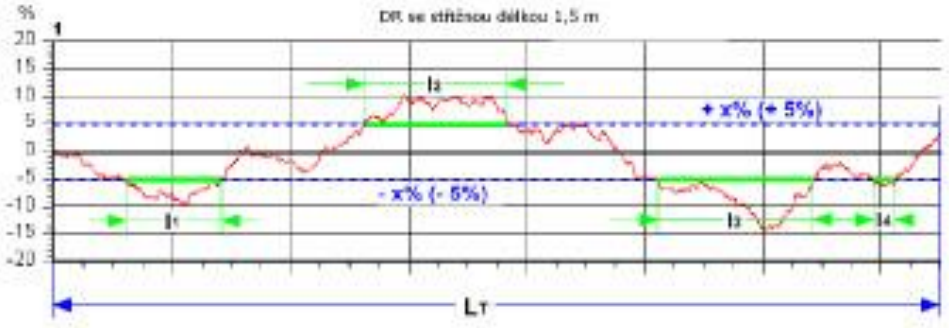
Spectrogram (CV)



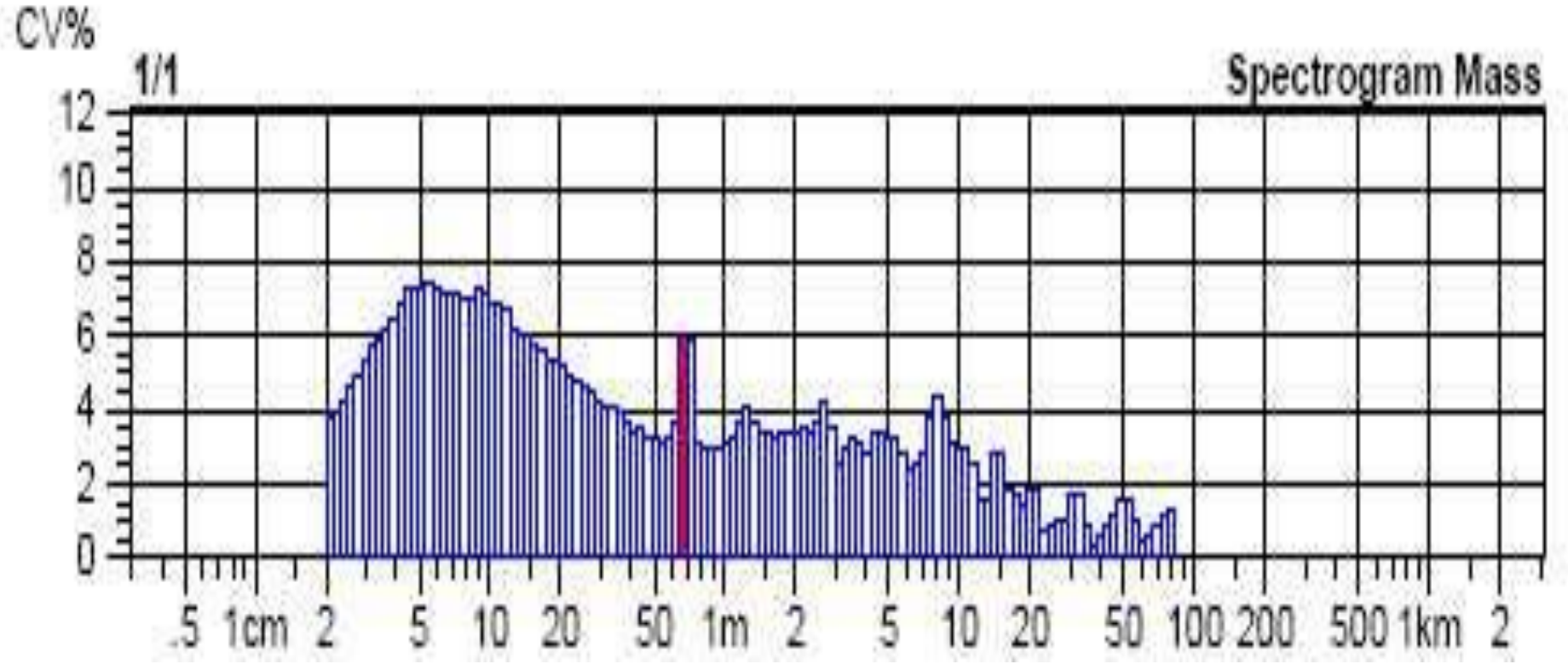

Variance-length curve (VLC)



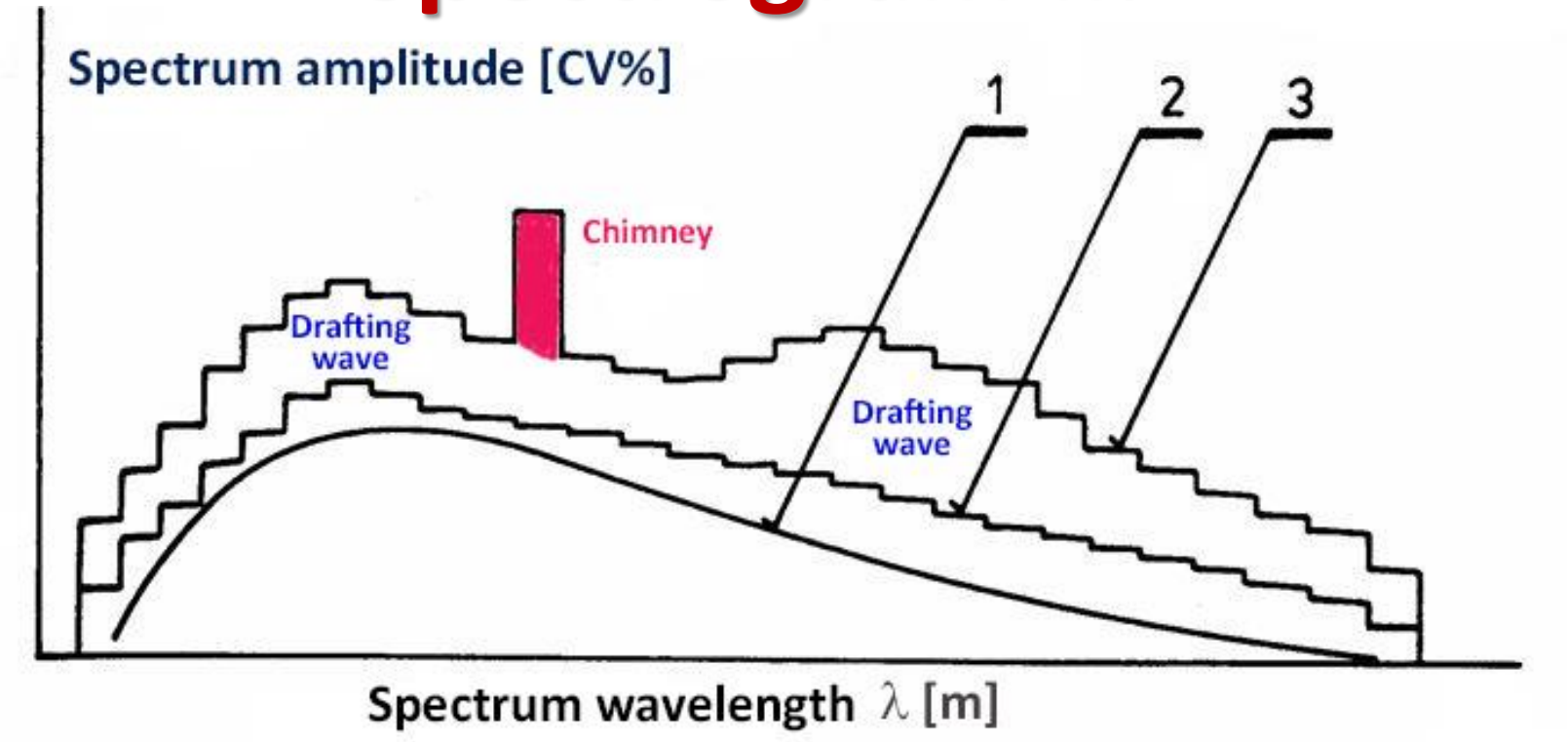

Deviation rate (DR) curves (U)



# Spectrogram I.



# Spectrogram II.




1 ⇒ Ideal spectrum **limit unevenness**

2 ⇒ Real spectrum **without non-periodic errors**

3 ⇒ Real spectrum **with periodic errors**

- **ch** – chimney, **df** - drafting wave machine caused unevenness

# Uster Statistics

USTER® STATISTICS 2001

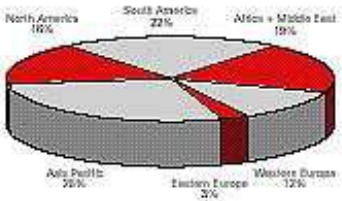
**Mass Variation**

*100% CO, carded ring-spun for woven fabrics*

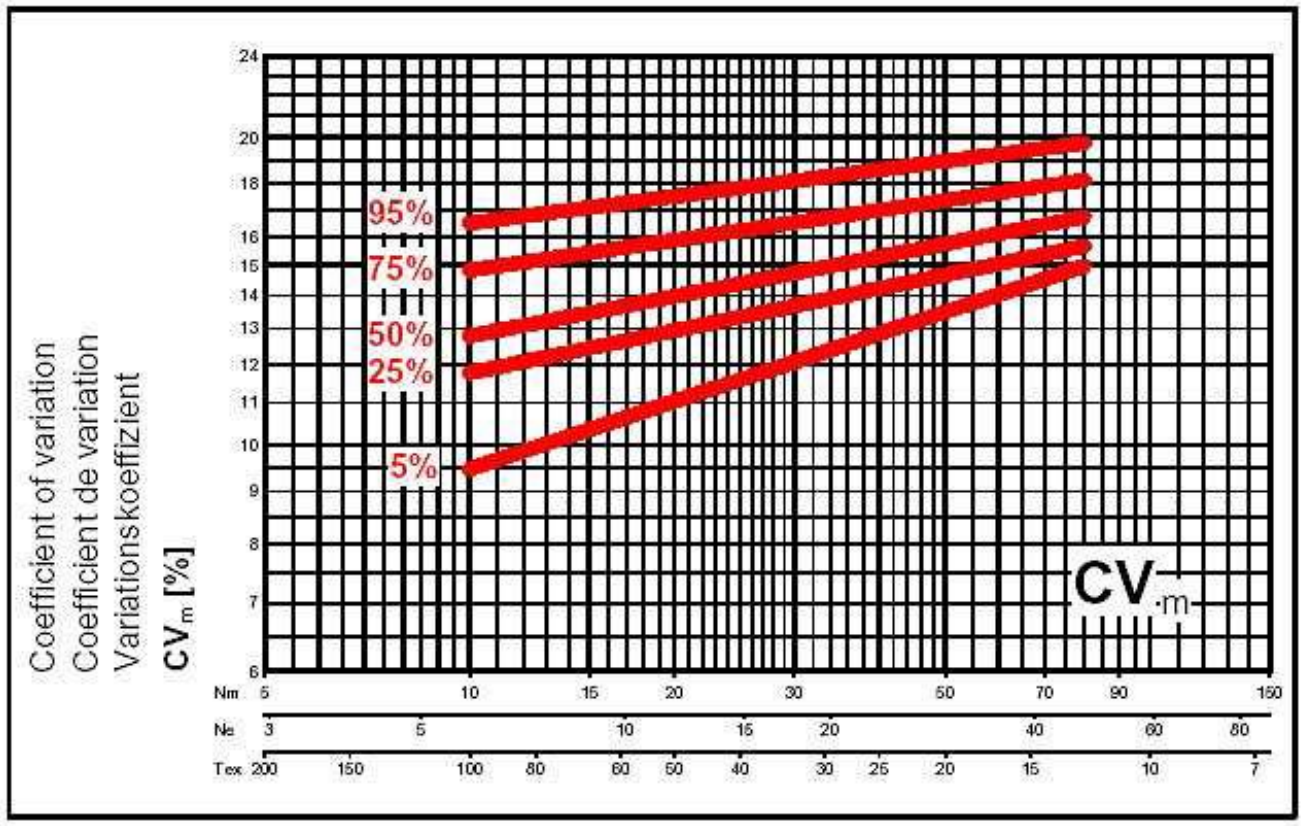
8.3

USTER® STATISTICS 2001

100% carded cotton (ring-spun)
100% coton cardé
(filé sur continu à anneaux)
100% Baumwolle, kardiert (Ringgarn)

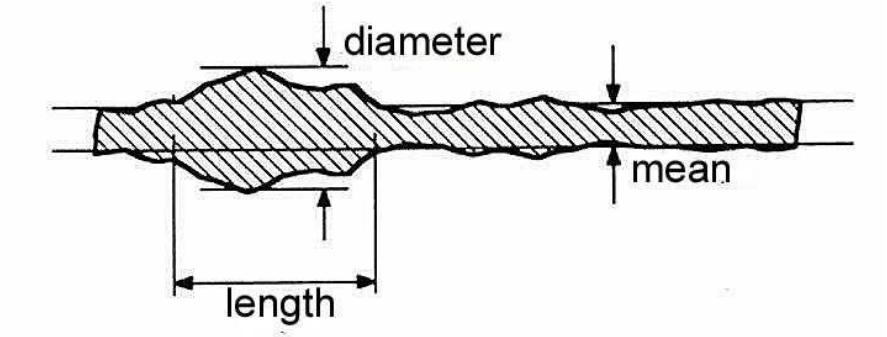


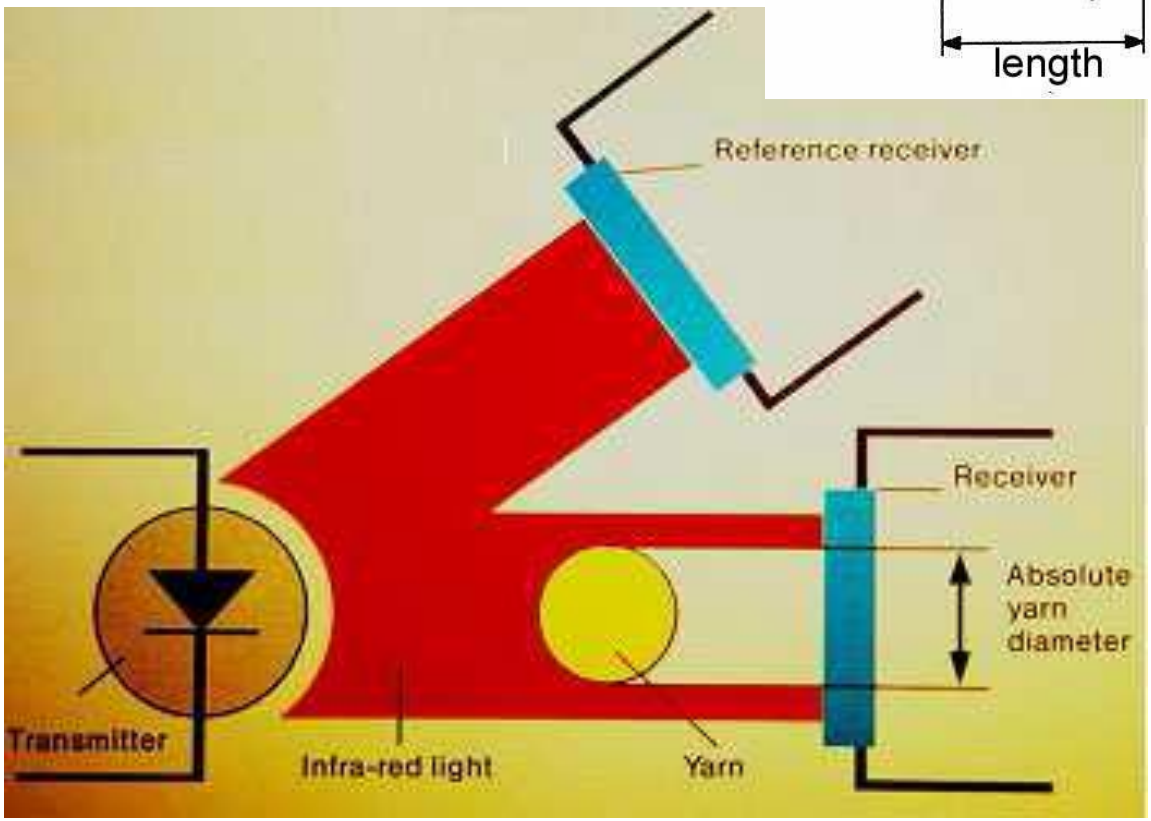

*Origin of samples*
*Origine des échantillons*
*Herkunft der Proben*

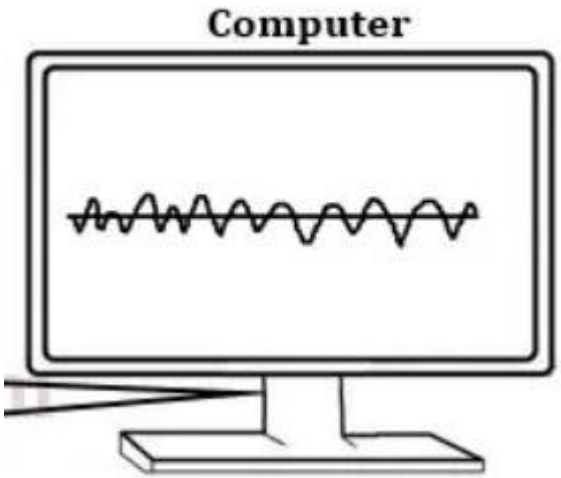



Coefficient of variation of yarn mass
Coefficient de variation de masse du fil
Variationskoeffizient der Garnmasse

# Oasys measurement system (co Zweigle)

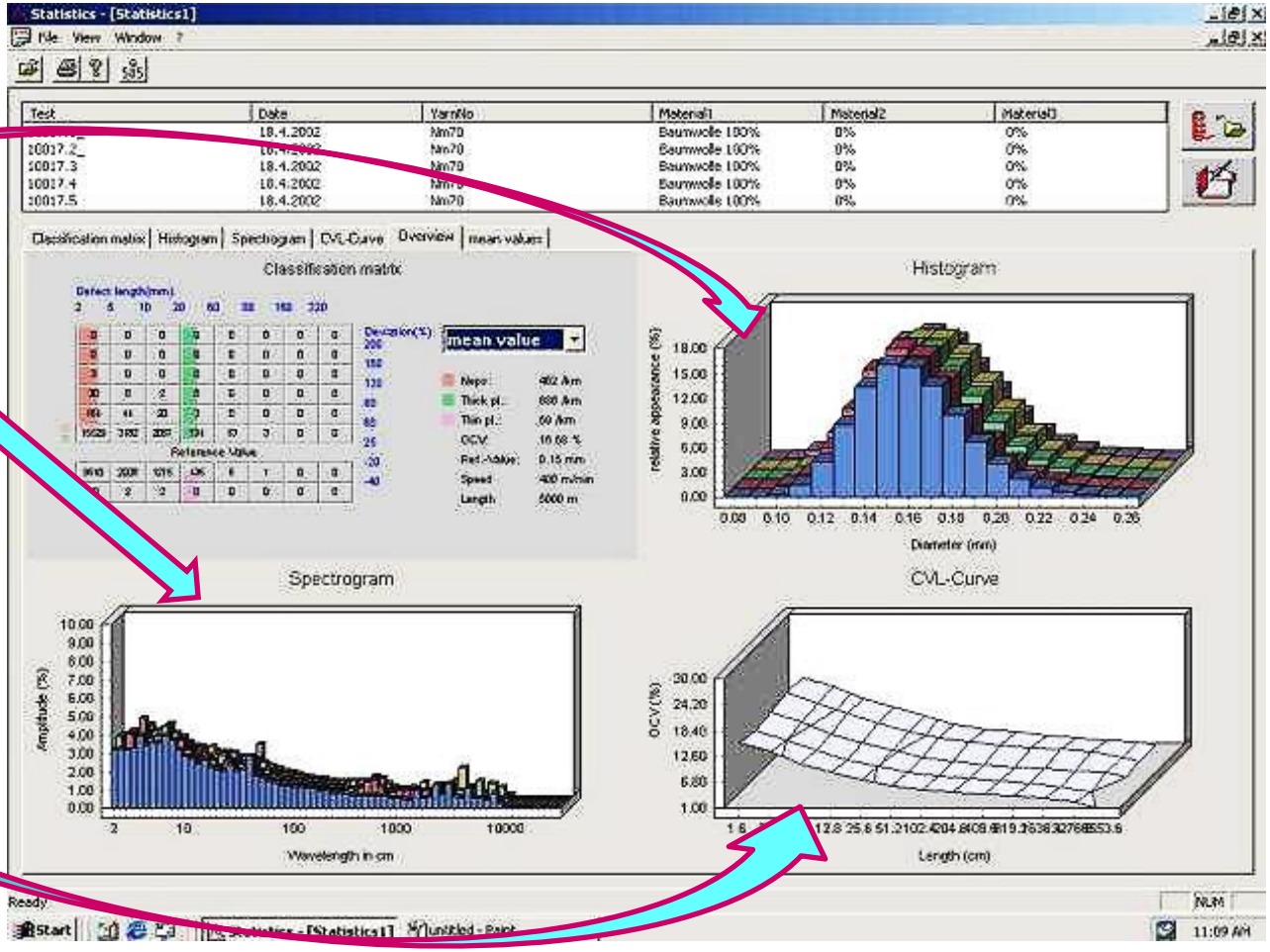


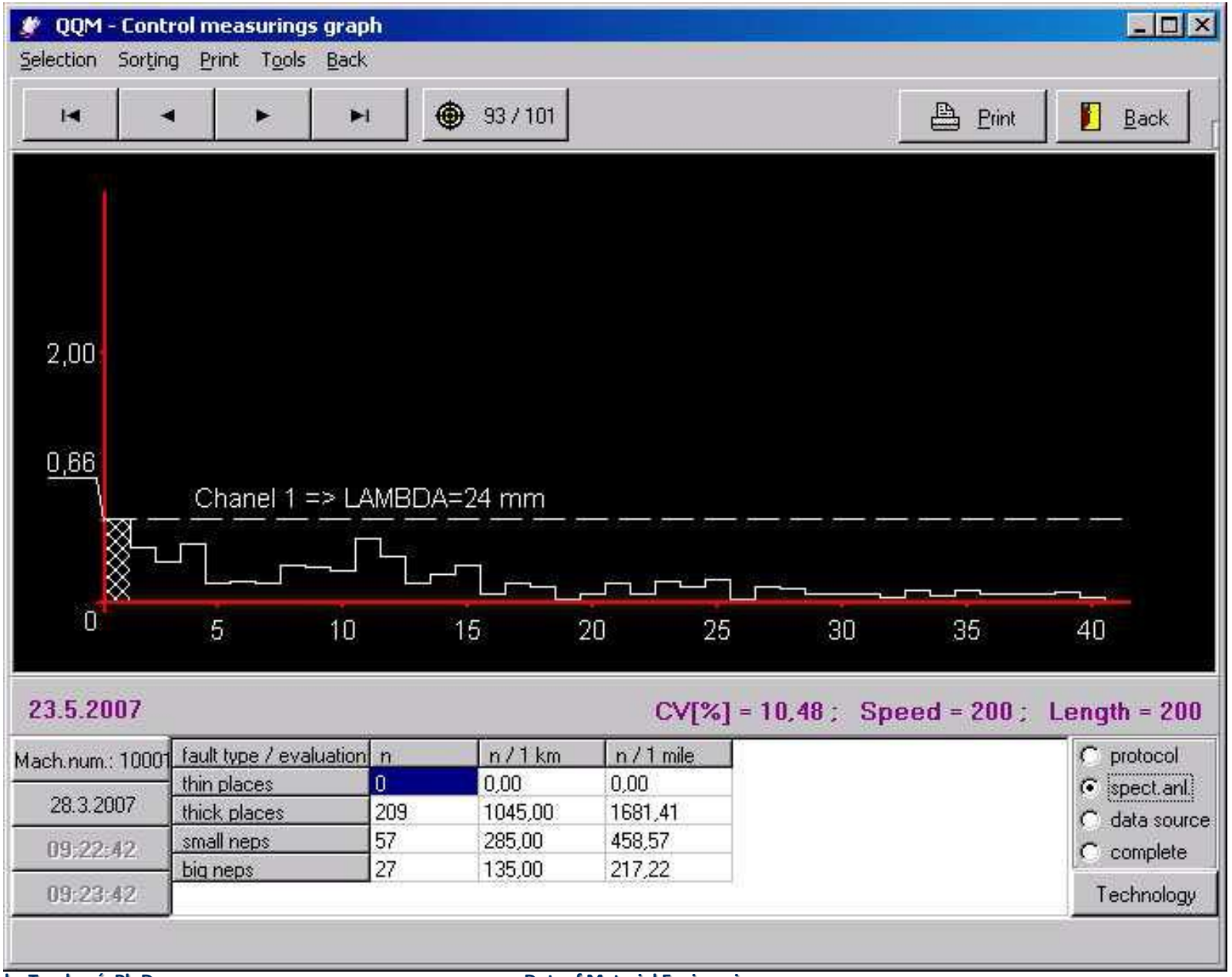
# Output from OASYS (Zweigle)

Histogram
Spectrogram
Variance-length curve



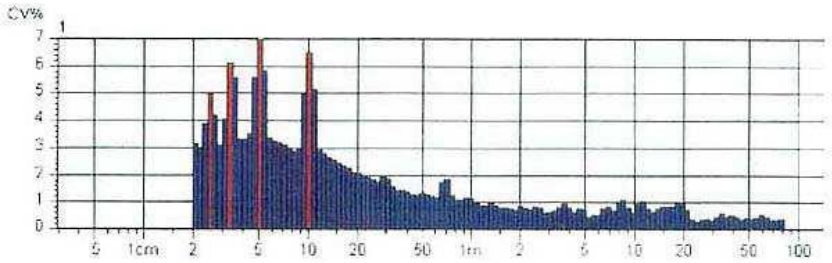
# QQM system

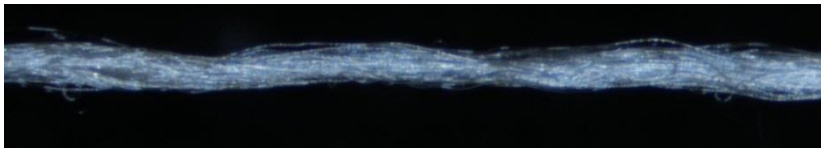
Czech cotton research institute, and OTTO STÜBER GmbH & Co KG

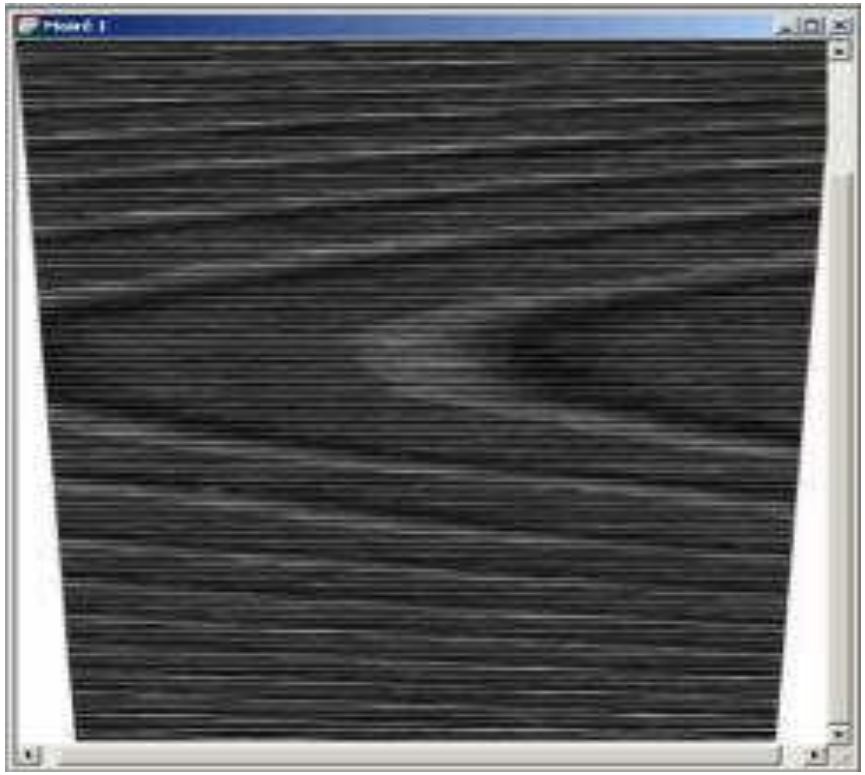

QQM - Control measurings graph
Selection Sorting Print Tools Back
93 / 101
Print
Back
2,00
0,66
Chanel 1 => LAMBDA=24 mm
0
5
10
15
20
25
30
35
40
23.5.2007
CV[%] = 10,48 ; Speed = 200 ; Length = 200
Mach.num.: 10001
28.3.2007
09:22:42
09:23:42
fault type / evaluation | n | n / 1 km | n / 1 mile
thin places | 0 | 0,00 | 0,00
thick places | 209 | 1045,00 | 1681,41
small neps | 57 | 285,00 | 458,57
big neps | 27 | 135,00 | 217,22
protocol
spect.anl.
data source
complete
Technology

# Unevenness of fabric

- **Moiré effect**
  - Unevennes in short length λ = 1 – 50 cm

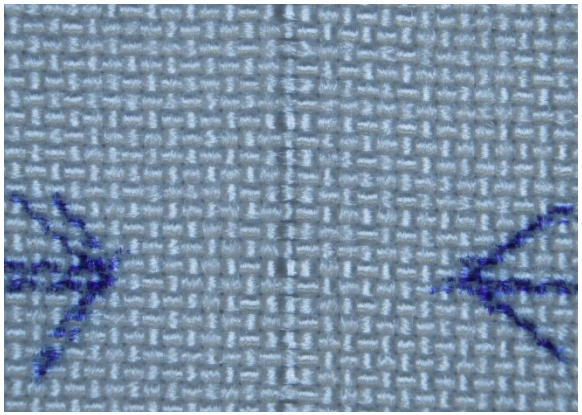


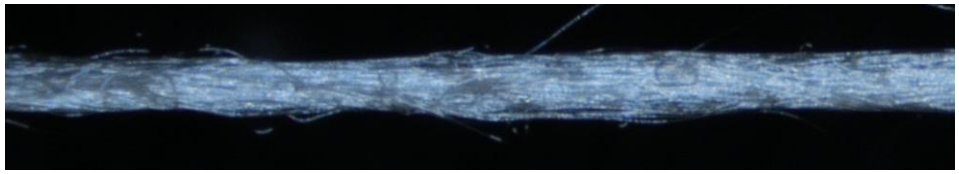



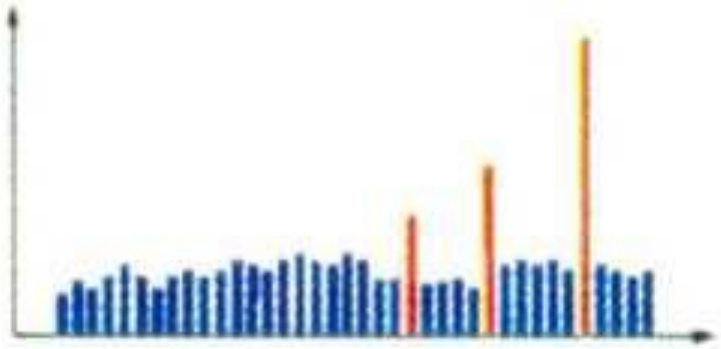


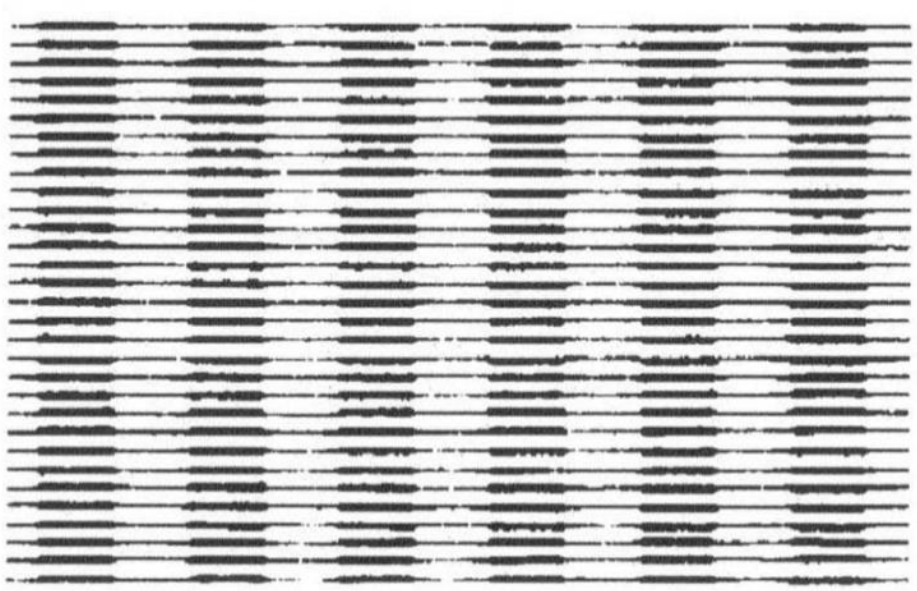
# Stripiness

- periodic unevenness in long distance l > 5m







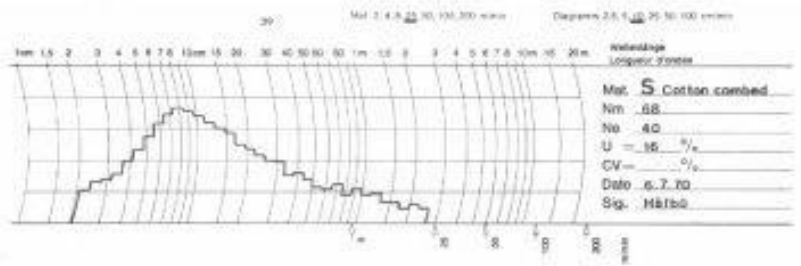


*Defects causing stripiness in yarn spektrogramm*

*Stripiness*

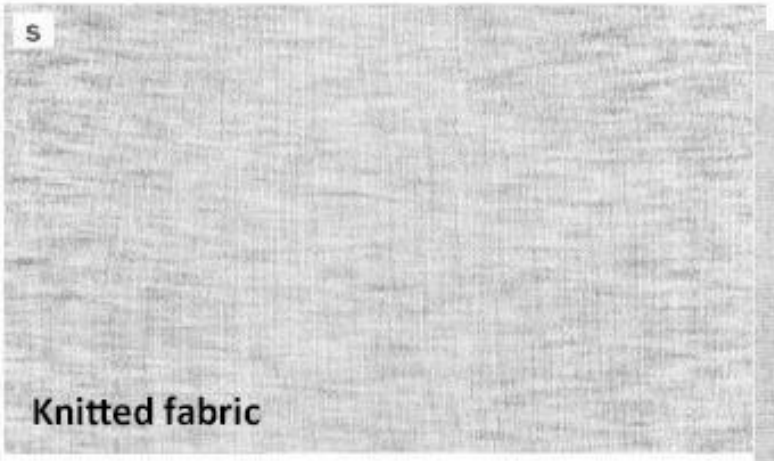
# Cloudy fabric

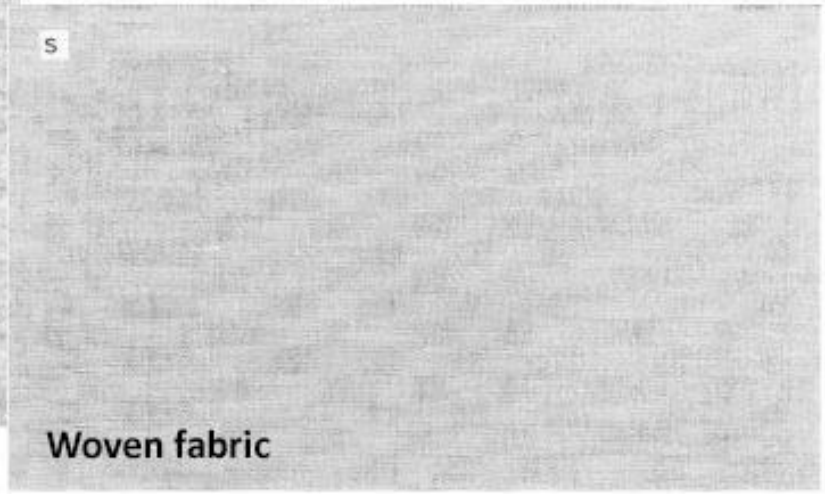
- Drafting wave

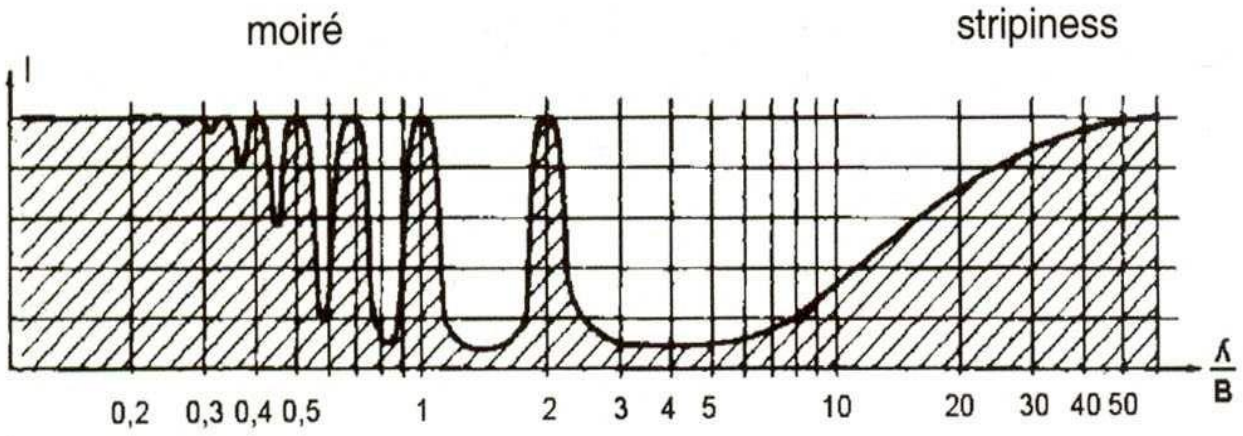
| | | T [tex] | U [%] | SPG |
|---|---|---|---|---|
| 2 | Combed Cotton | 14,5 | 10,1 | Drafting Wave - short length  |
| | | | 12.2 | |
| | | | 13.9 | |
| | | | 16 | |



Disturbing appearance - Cloudiness



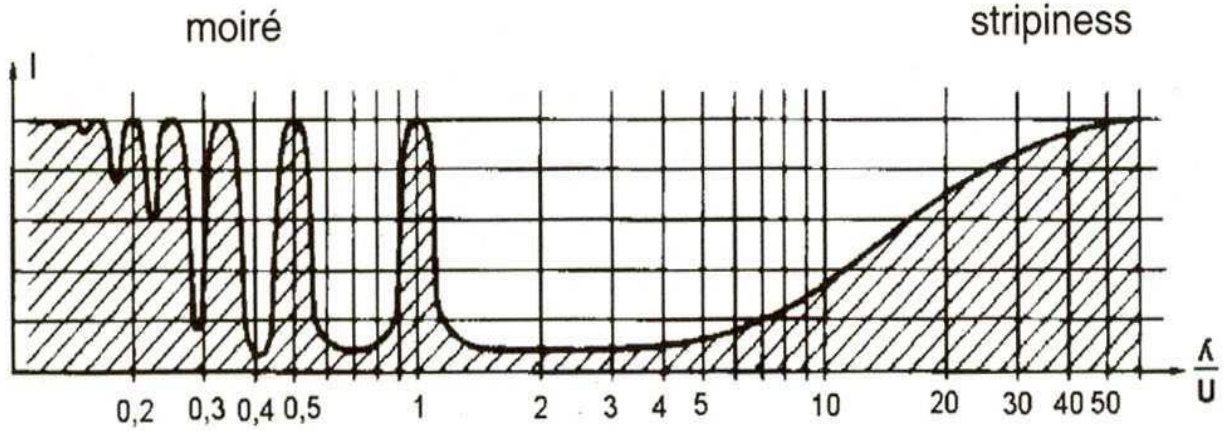



I = Intensity of the stripy or moiré appearance

λ = wave-length of the periodic fault

B = Weave width

Fig. 4-25 Woven fabric




I = Intensity of the stripy or moiré appearance

λ = wave-length of the periodic fault

U = Yarn length of the stretched out yarn with respect to the circumference of the knitted fabric.

Fig. 4-26 Knitted fabric