HORIBA

Explore the future

HORIBA Scientific

Particle Analysis

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Sieving Without Sieves

March 15th 2016

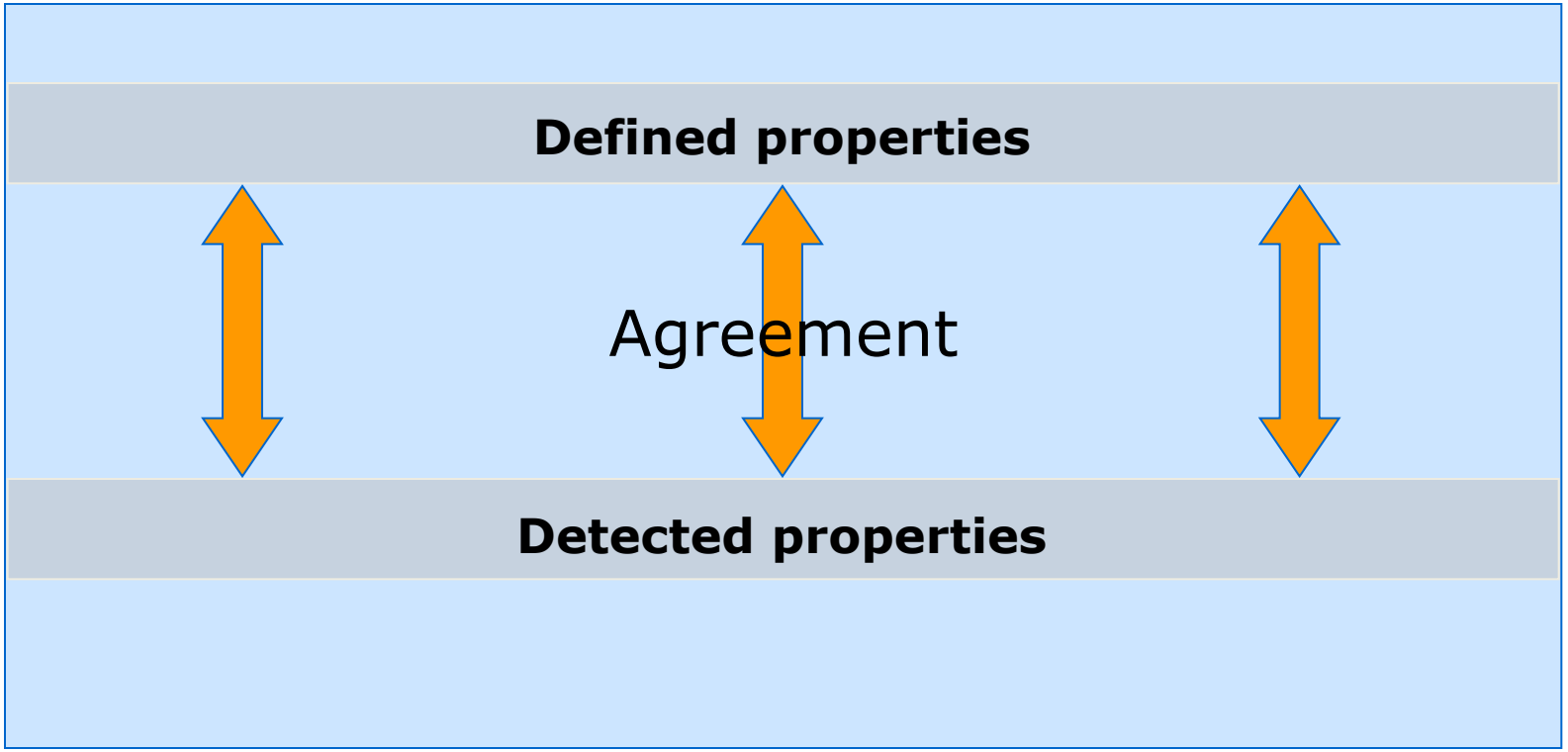
Topics

Particle analysis

Sieving

Sieve replacement with image analysis and the CAMSIZER

Motivation for particle sizing



Certain properties are to be achieved when **products** are manufactured.
These depend on the **particle size** and the **particle distribution**.

Particle size/distribution = product property

Motivation for particle sizing

Example 1: Coffee

The particle size determines important taste properties
Too coarsely ground coffee: a watery cup of coffee

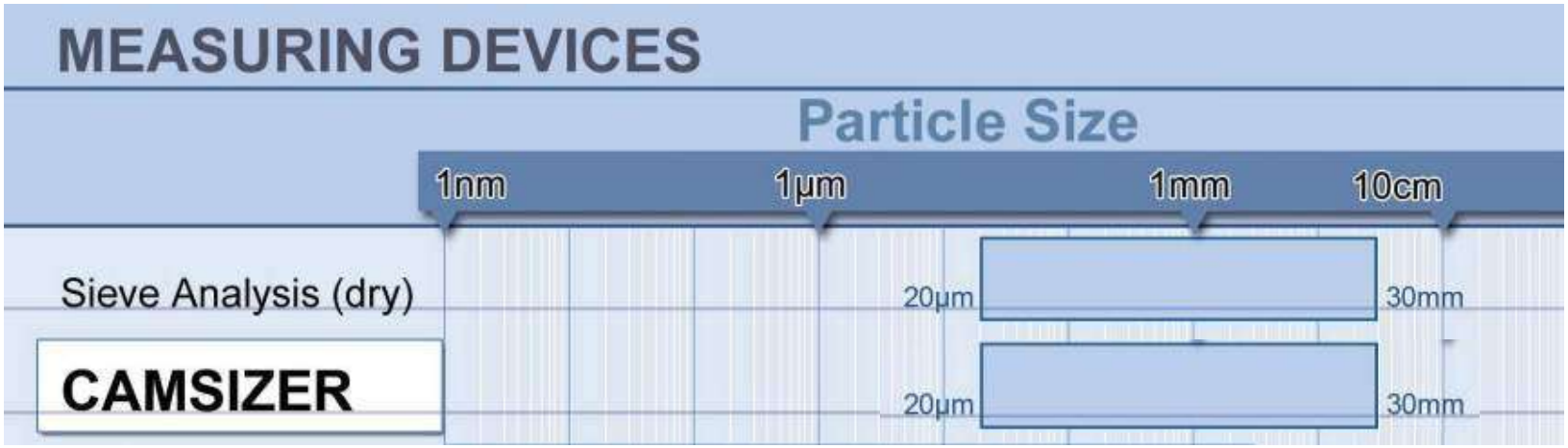
Too finely ground coffee: too many aromatics, acids and bittering agents are dissolved, the filter could be blocked or fines arrive in the coffee cup

Motivation for particle sizing

Example 2: Sandpaper

The quality of the sanding result is always determined by the particle size distribution of the abrasive.
Incorrect Size wrong surface finish
Too wide particle size distribution:
Generates grooves and rills on the surface.

Measuring systems



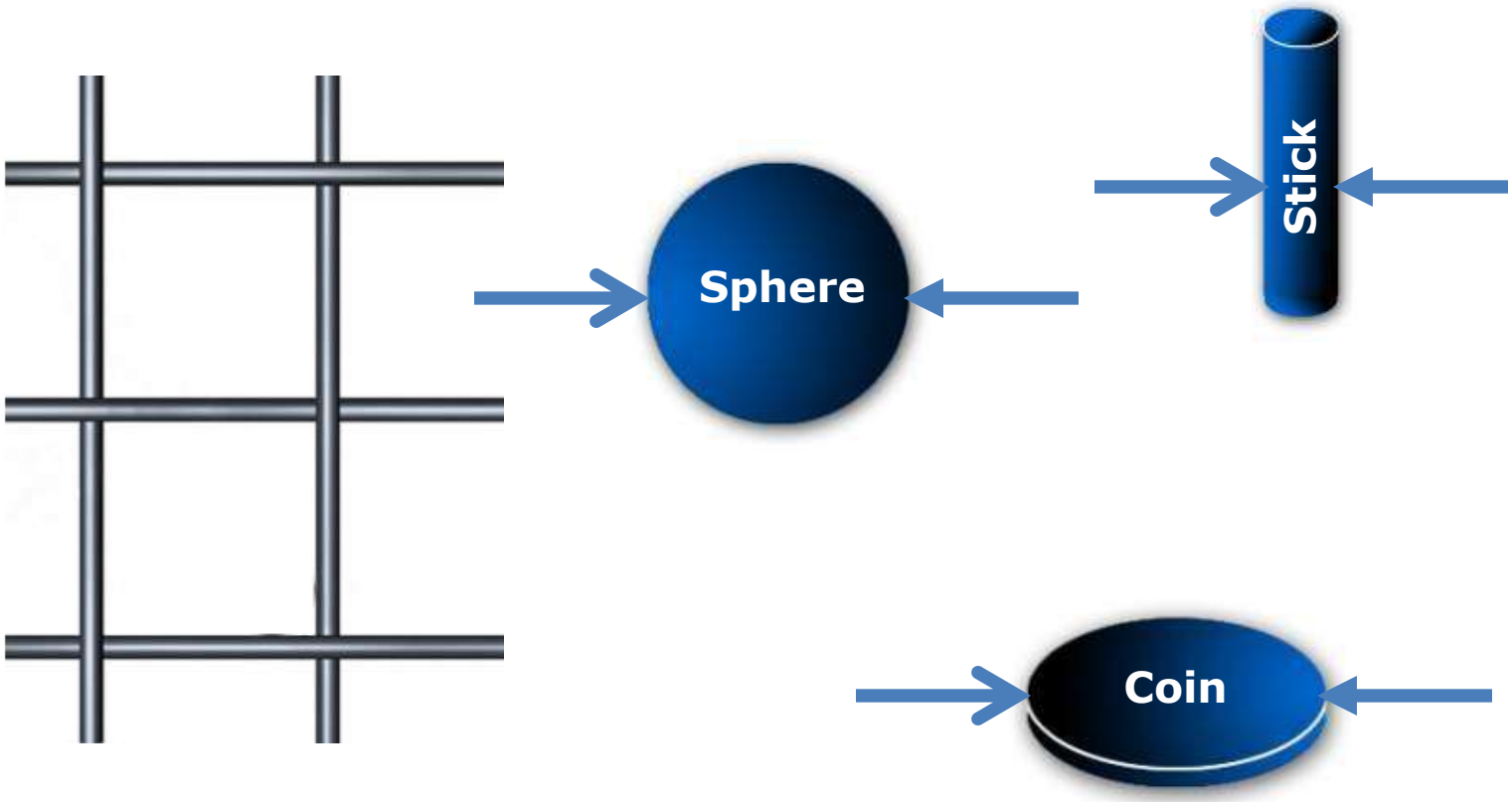
Sieving

Traditional measurement:

- Sieve analysis 0.02mm – 30mm
- Sufficient statistics in a short time
  until now: older optical systems had poor statistics

Measuring principle: sieving

What size particle passes through a two dimensional (often square) hole?

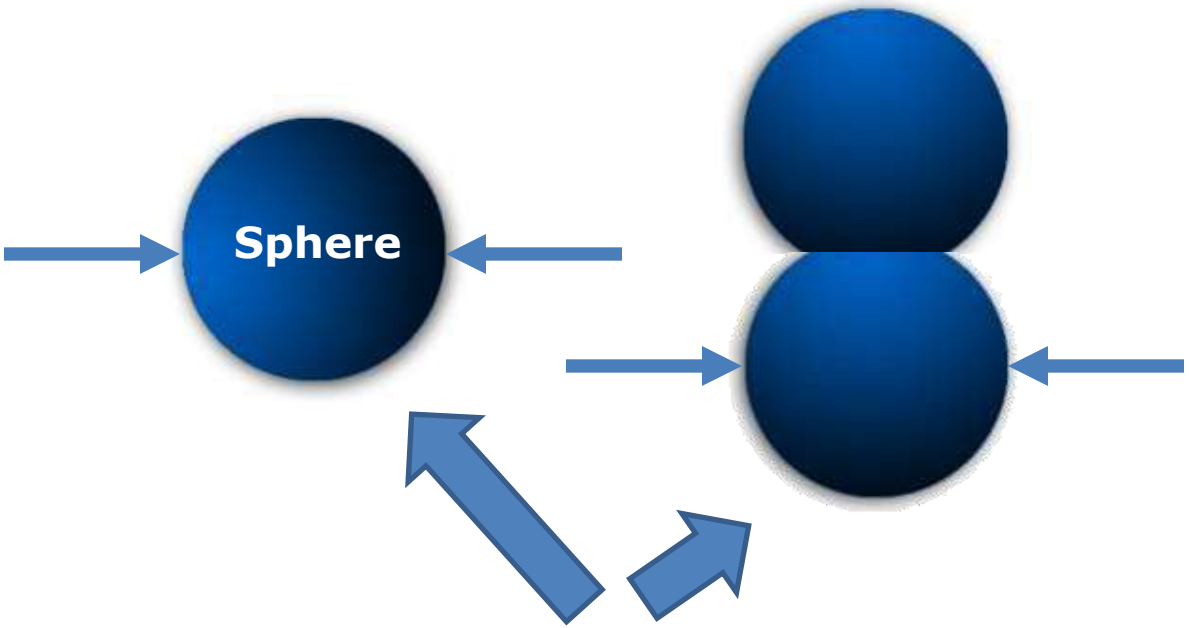


Measuring principle: sieving

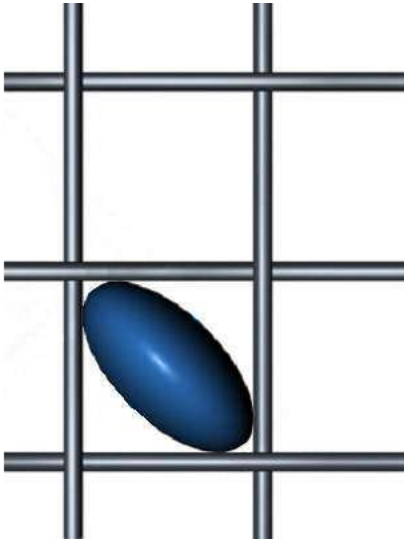
What size particle passes through a two dimensional (often square) hole?

Surprises!

Doublet from Spray Drying



Same size in sieve



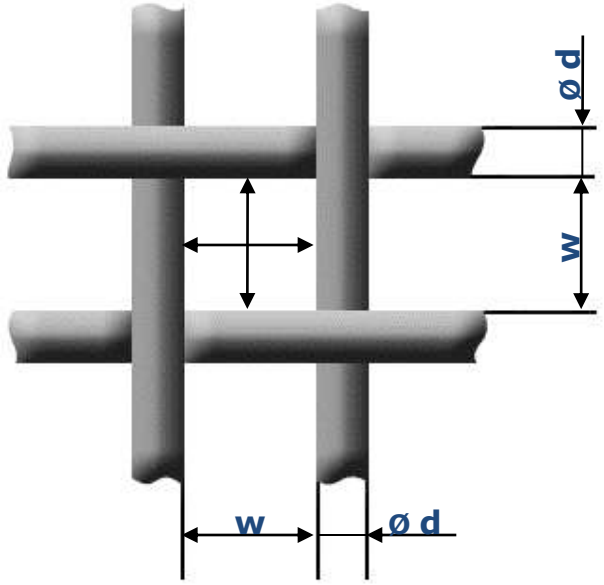
Lenticular particle (e.g., pill)… no simple dimension

Standards for sieving

If sieve analysis is used for quality control within the context of DIN EN ISO 9000:2000 then both the ***sieve shaker*** and the ***test sieves*** must be subjected to test agent monitoring.

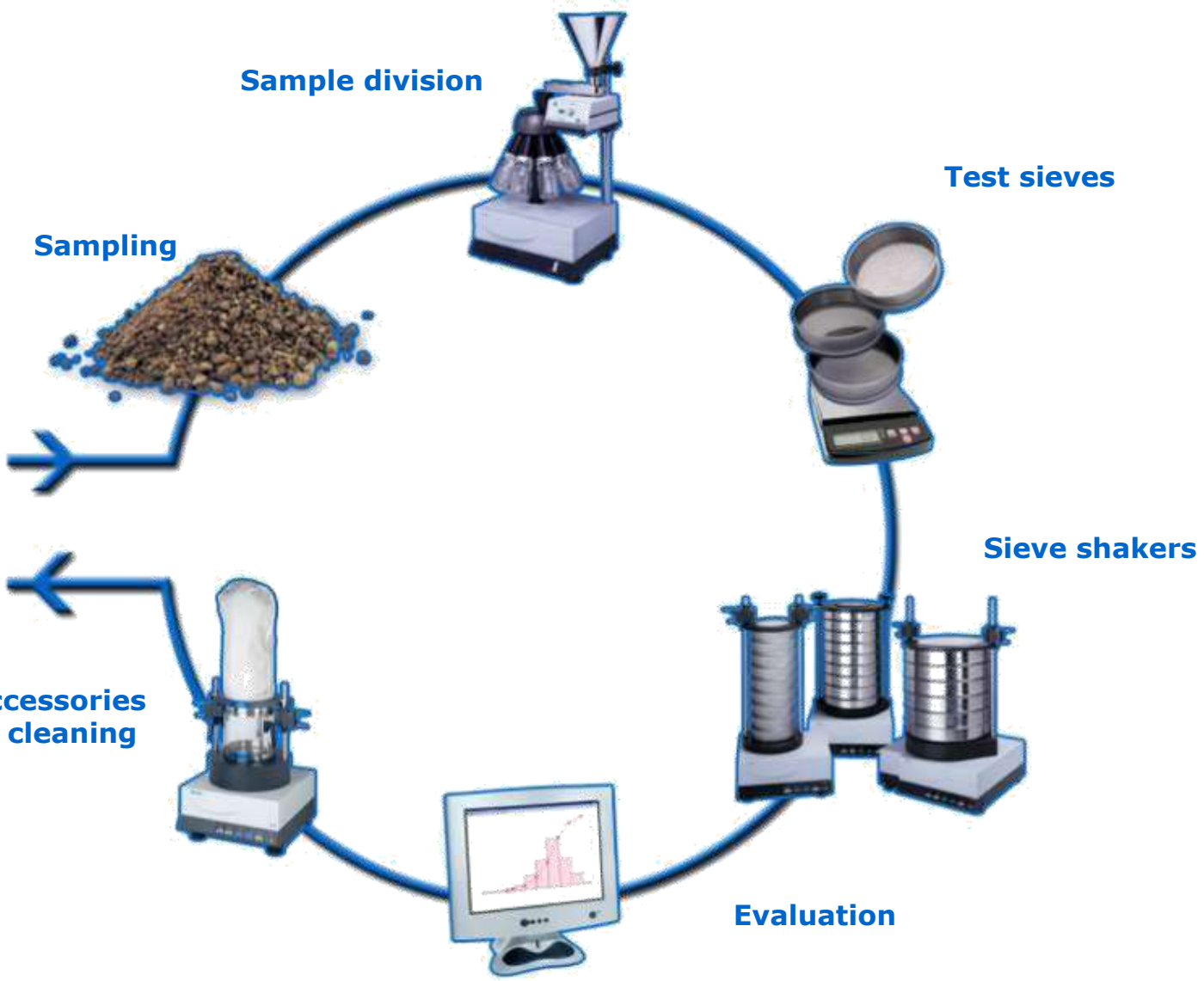
Technical requirements & testing according to ISO 3310

Tolerance for mean value (*Y*):
The mean value of the mesh width must not differ from the nominal value *w by more than* the *tolerance* ± *Y*.



w = mesh width
d = wire diameter

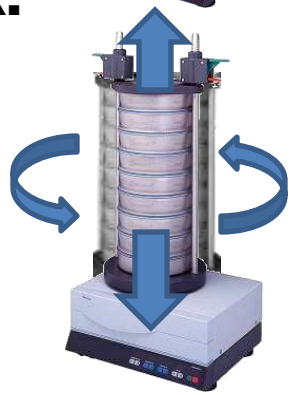
Sieve analysis: workflow



Measurement

Add known mass of sample to top of sieve stack.

Shake and allow smaller particles to pass through stack.



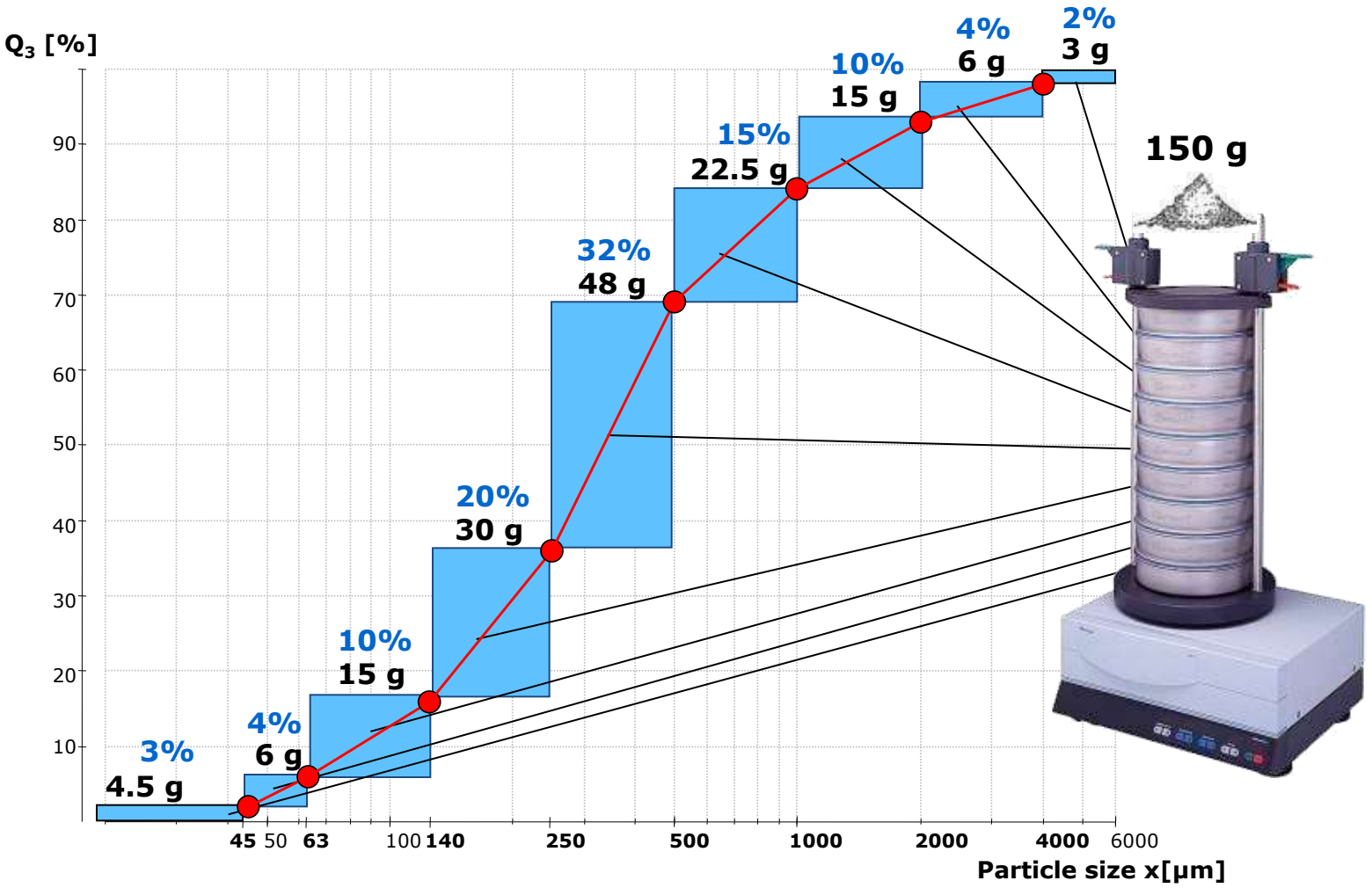
Remove each screen and weigh particle fractions on screen.

Analyze Data.

Clean sieves for the next user.

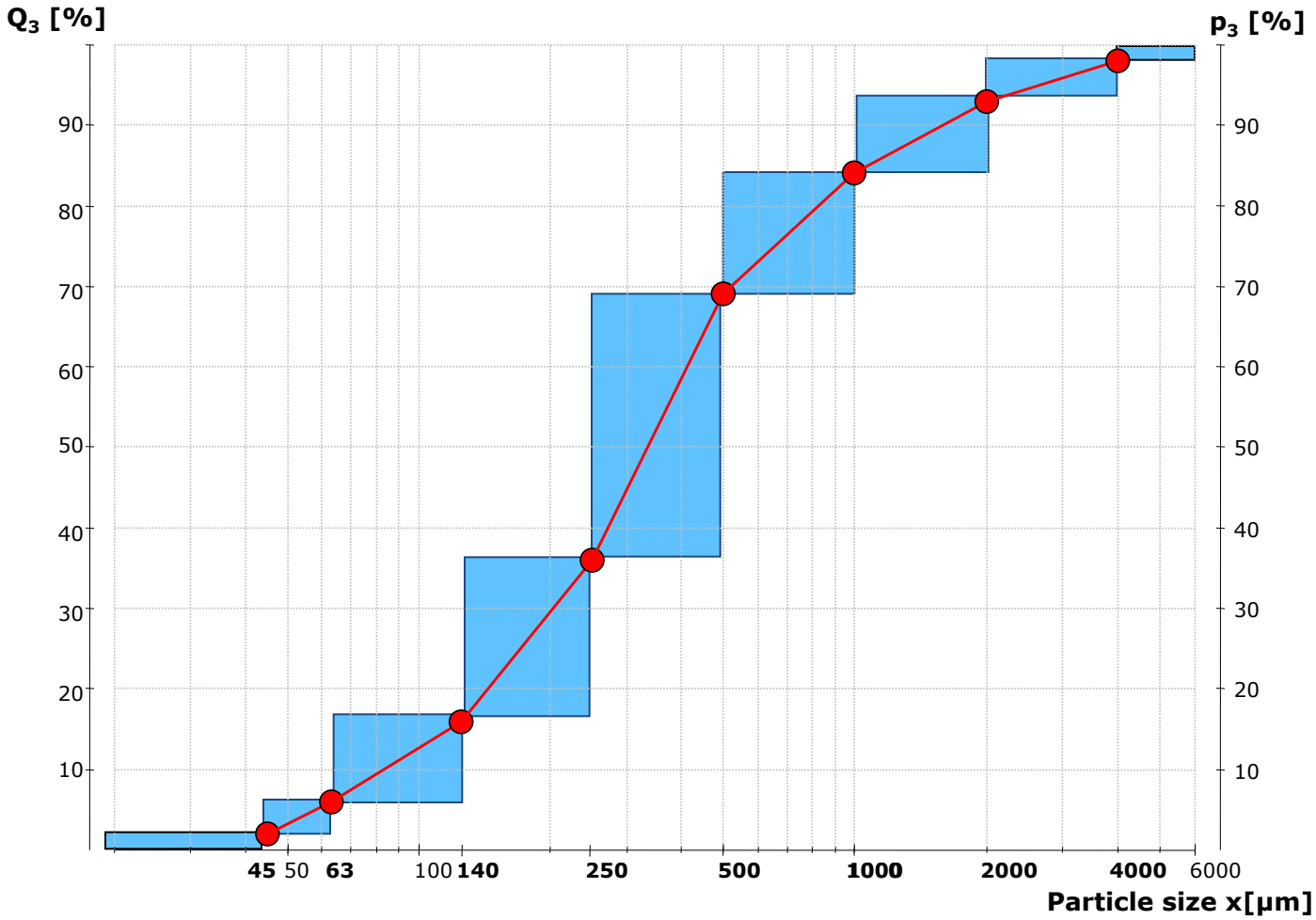
Visualization

Cumulative distribution



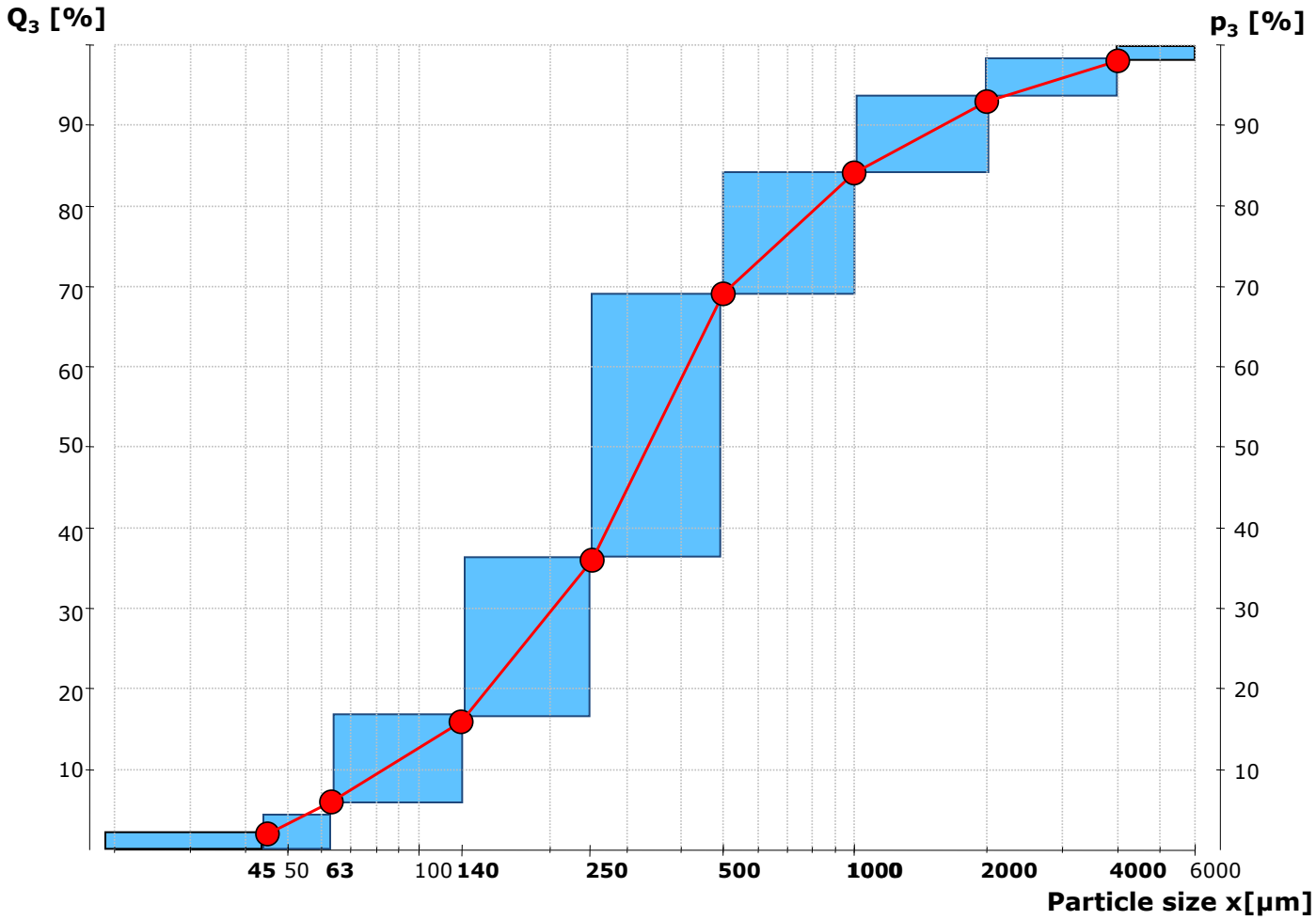
Visualization

Cumulative distribution



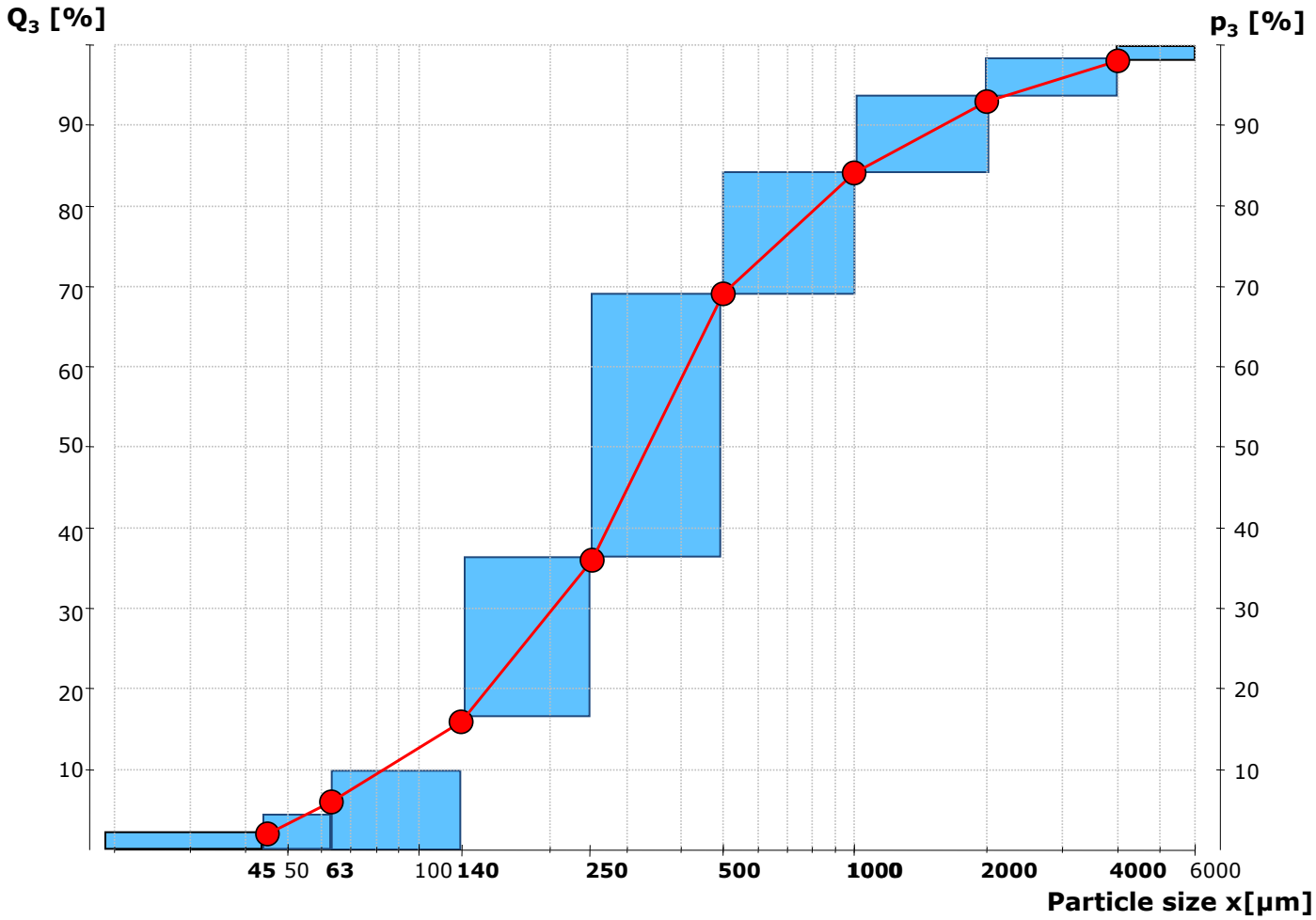
Visualization

Cumulative distribution



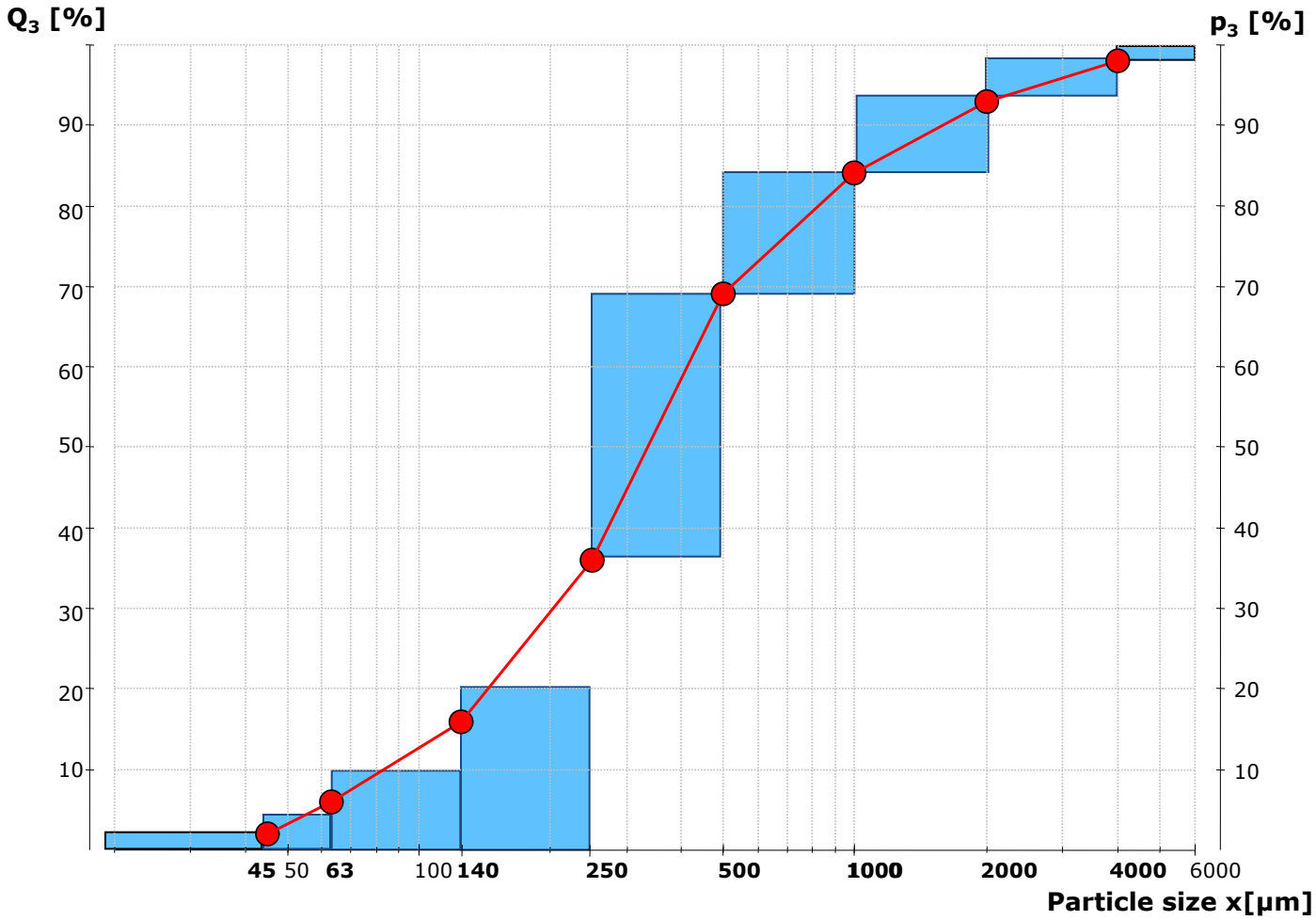
Visualization

Cumulative distribution



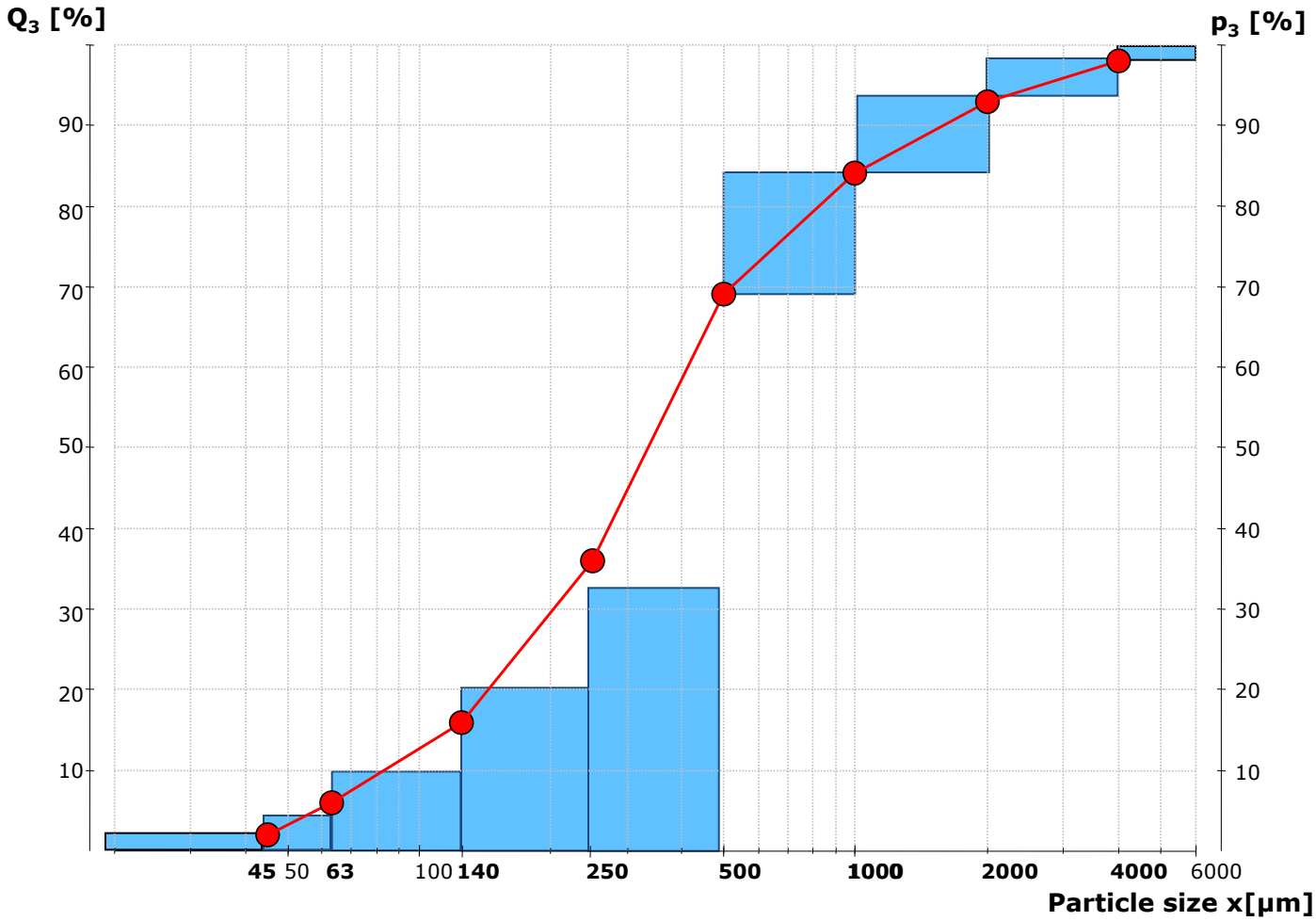
Visualization

Cumulative distribution



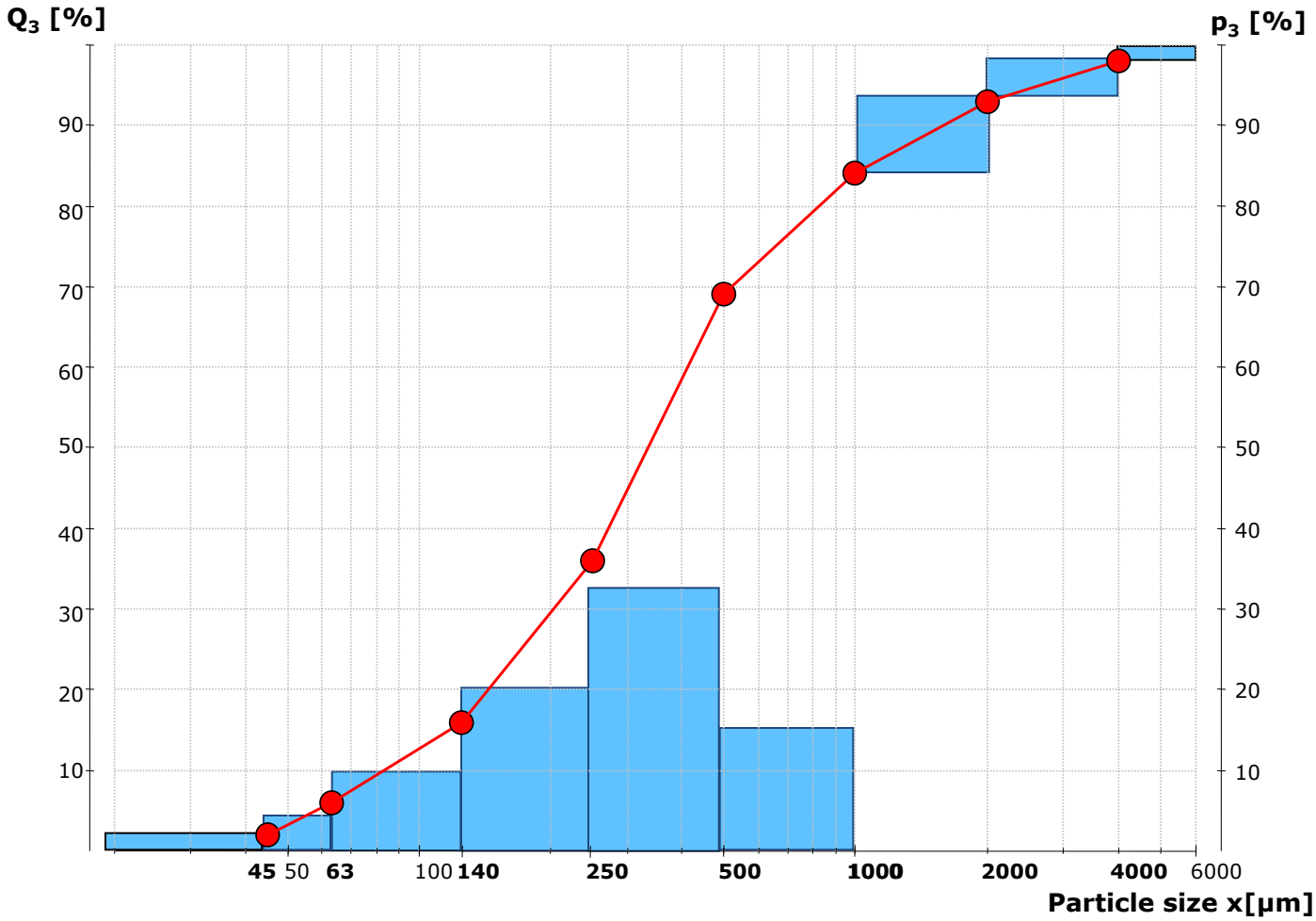
Visualization

Cumulative distribution



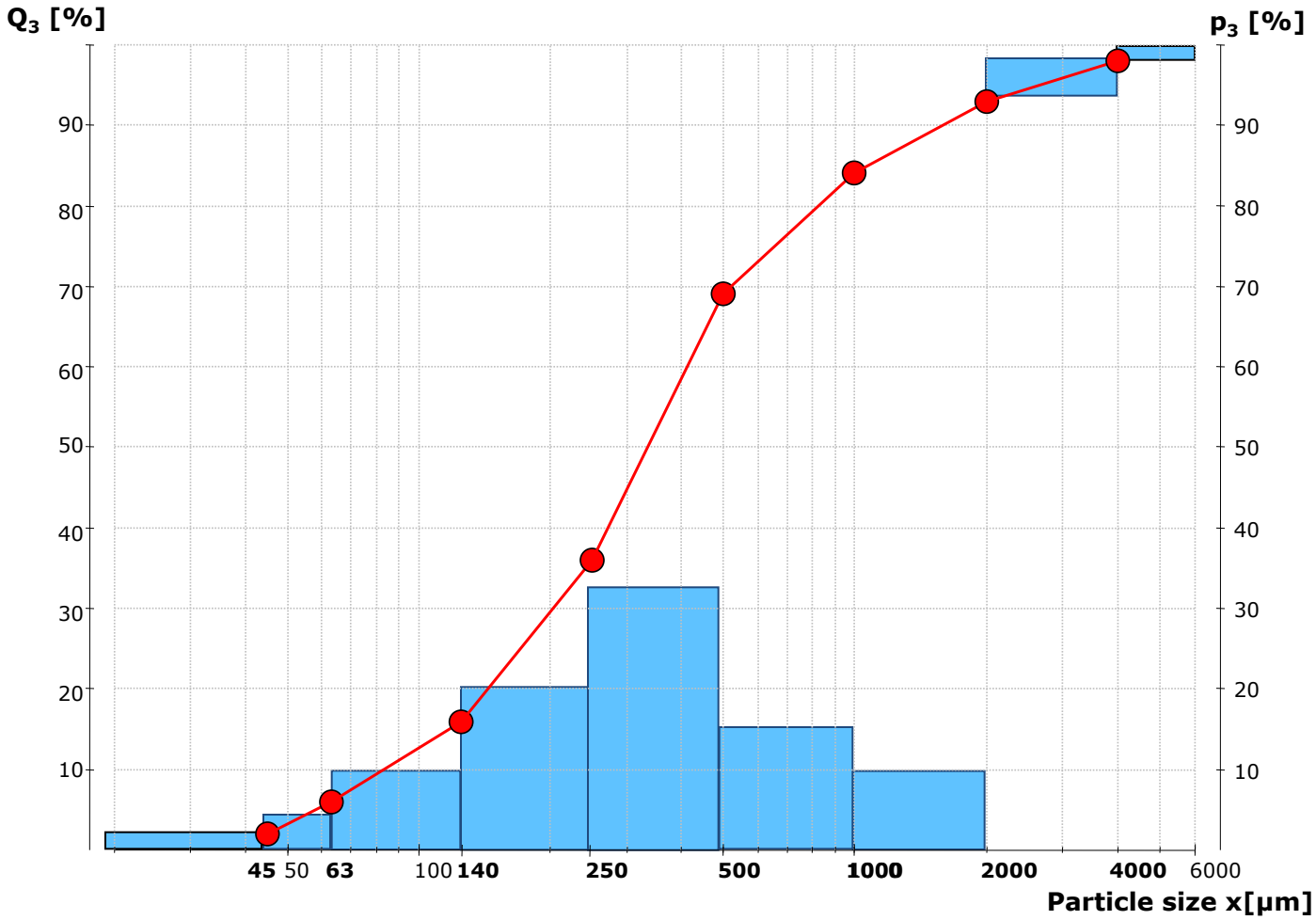
Visualization

Cumulative distribution



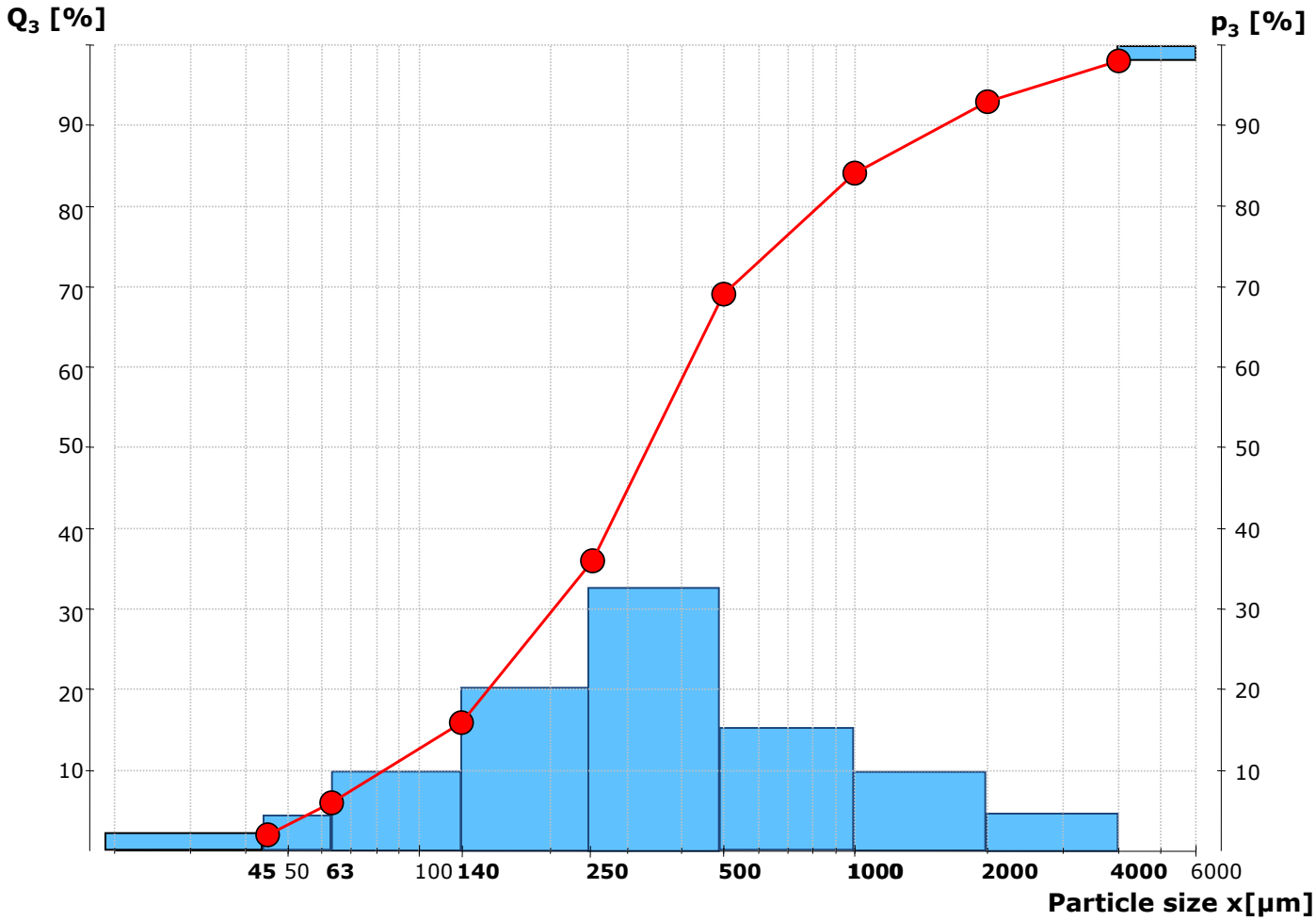
Visualization

Cumulative distribution



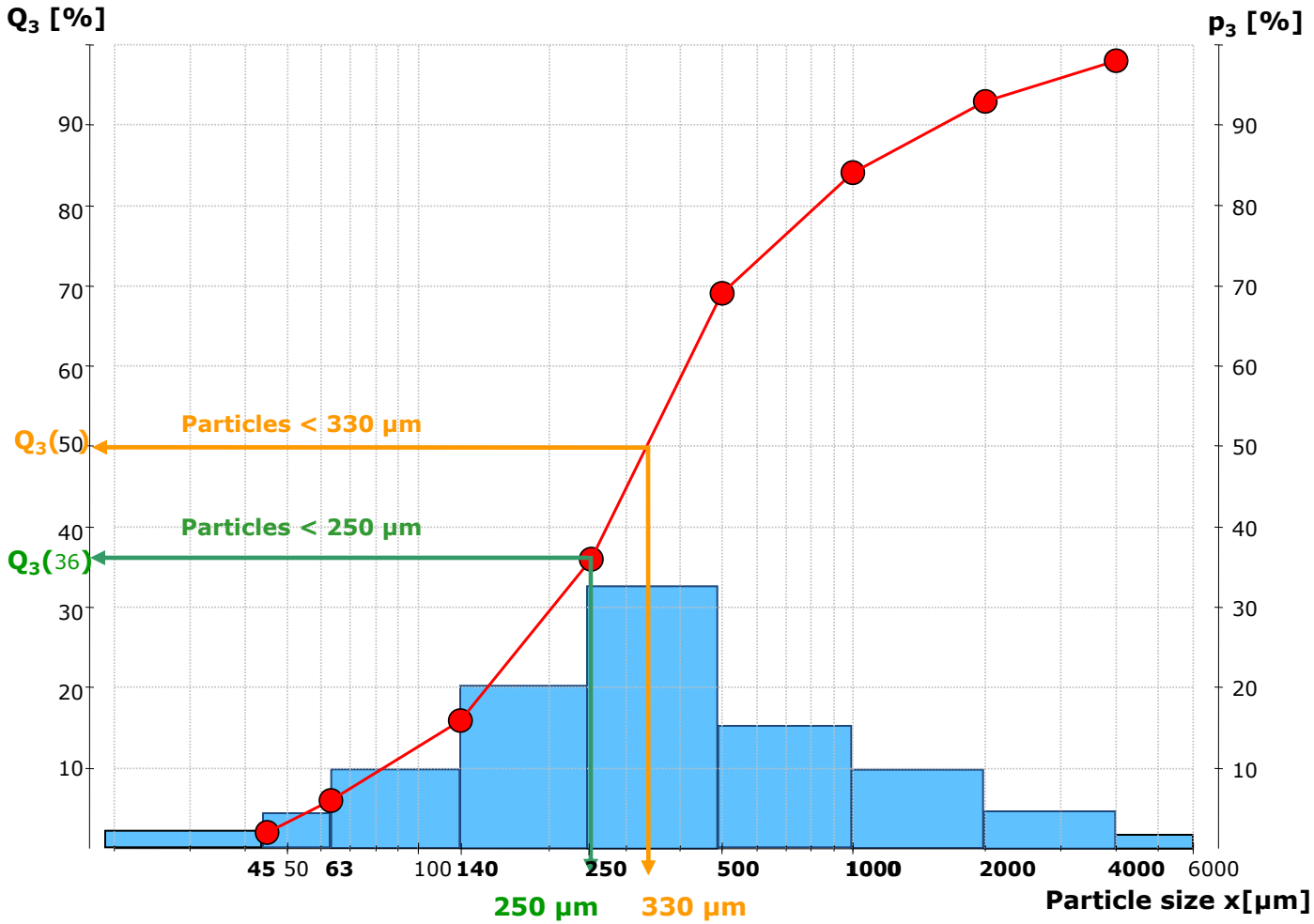
Visualization

Cumulative distribution



Visualization

Cumulative distribution

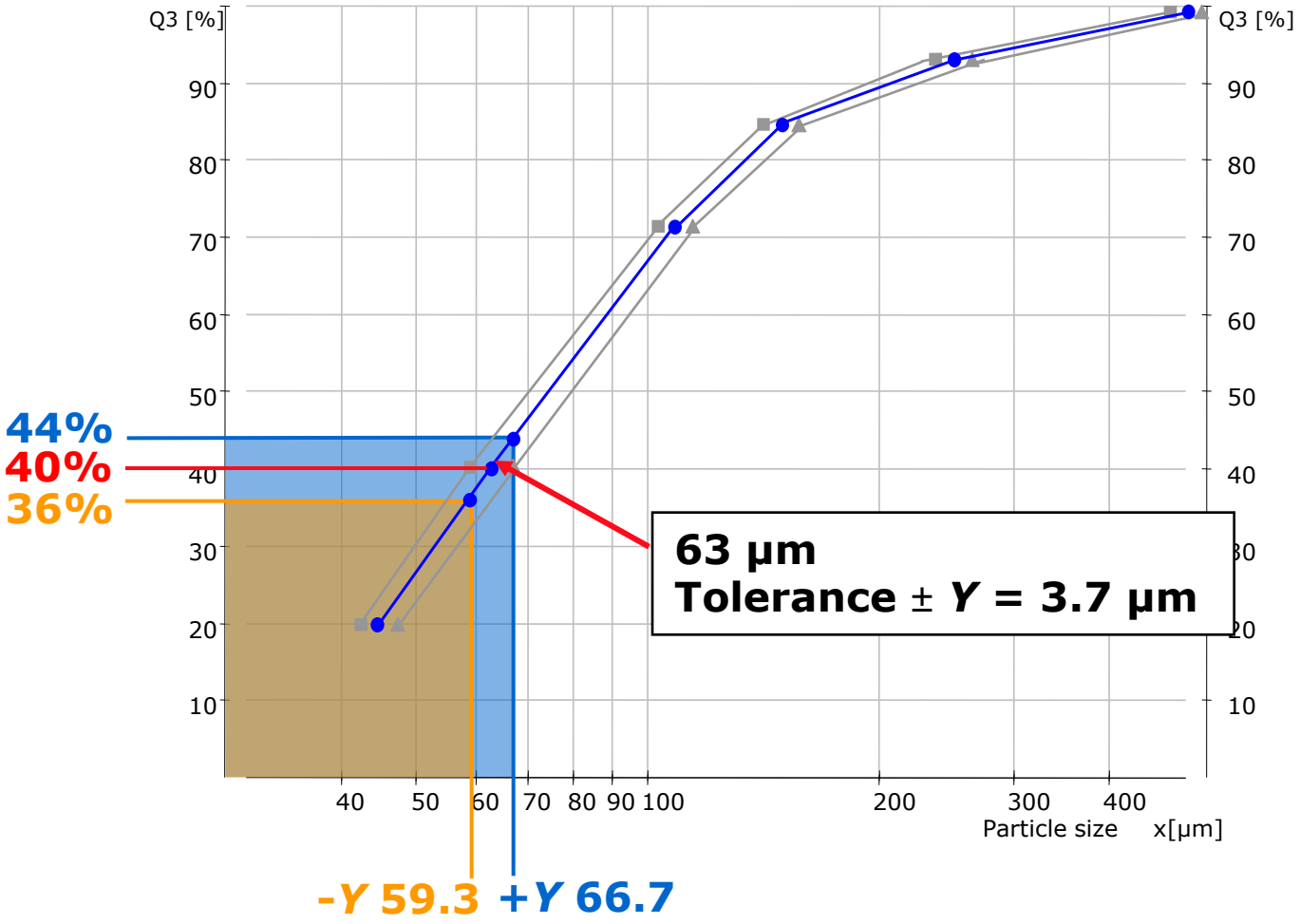


Quality monitoring problems (size)

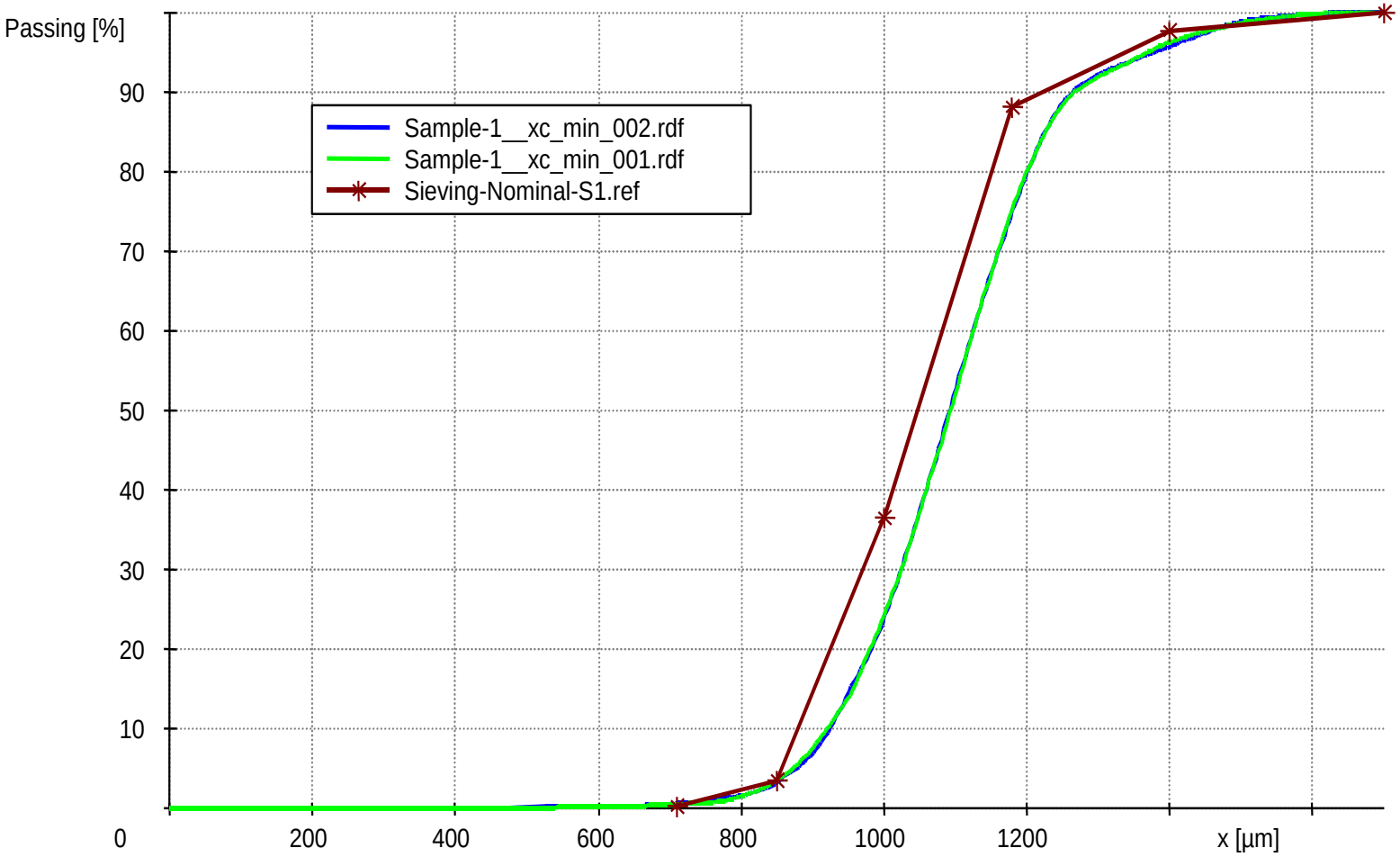
Cross contamination and weighing problems

Importance of mesh width

consequences of tolerances



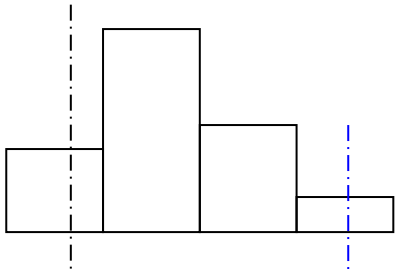
Spherical particles



In theory these curves should match. Why don't they?
Hint: Look at the detailed sieve specification!

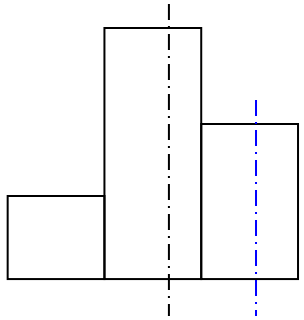
Influence of mesh width

Mesh sizes warp

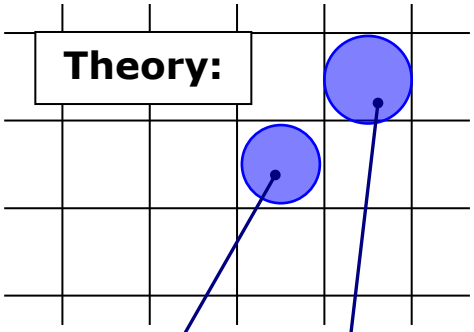


1400µm

Mesh sizes weft



1400µm **1429.5µm**

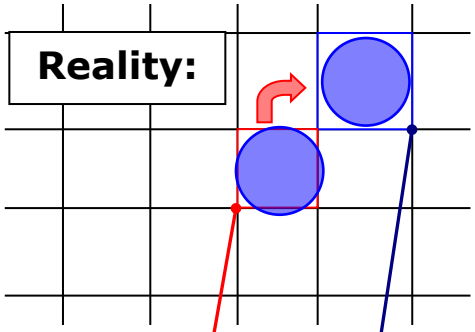


Nominal Sieve Mesh = 1400µm

only beads < 1400µm

will **pass** the sieve mesh

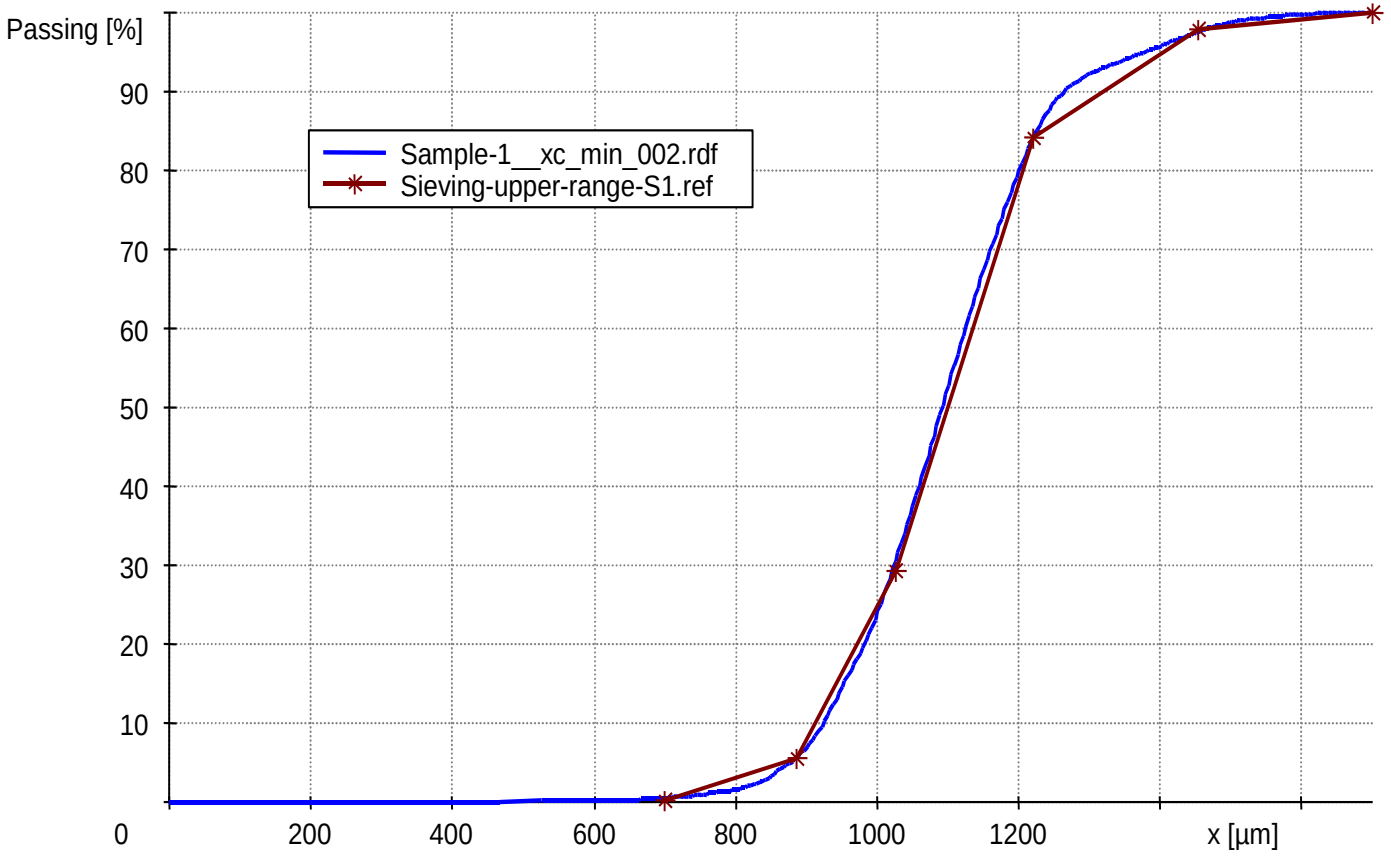
beads > 1400µm will **not pass** the sieve mesh



Real Sieve Mesh **>1400 = 1455**

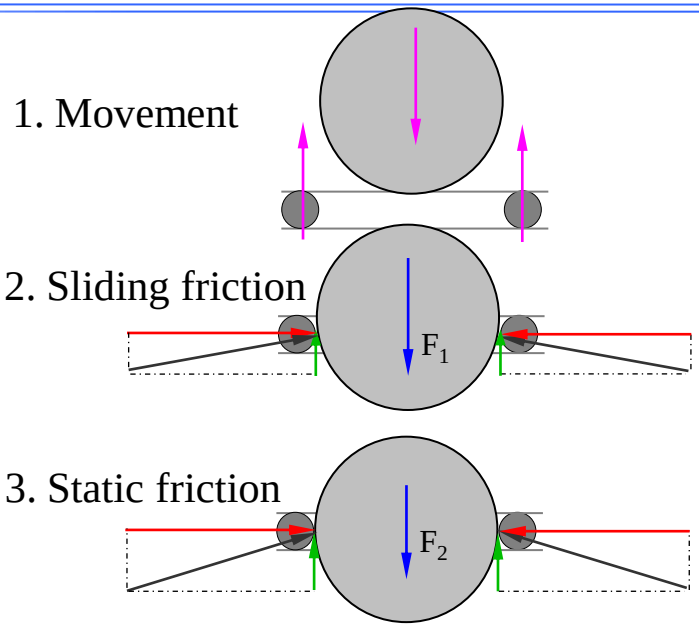
Upper mesh size range ~1455µm sieve No. 03033531 (nominal 1400µm)

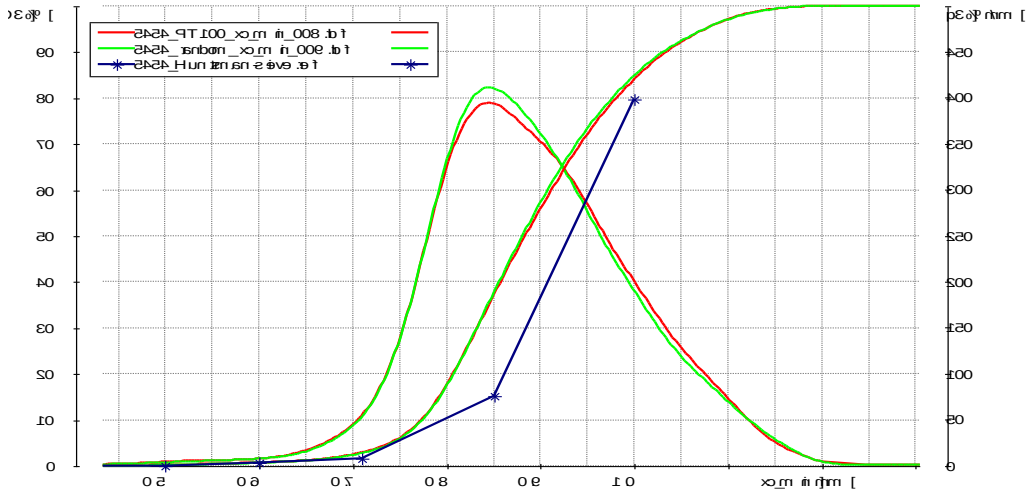
Real mesh width



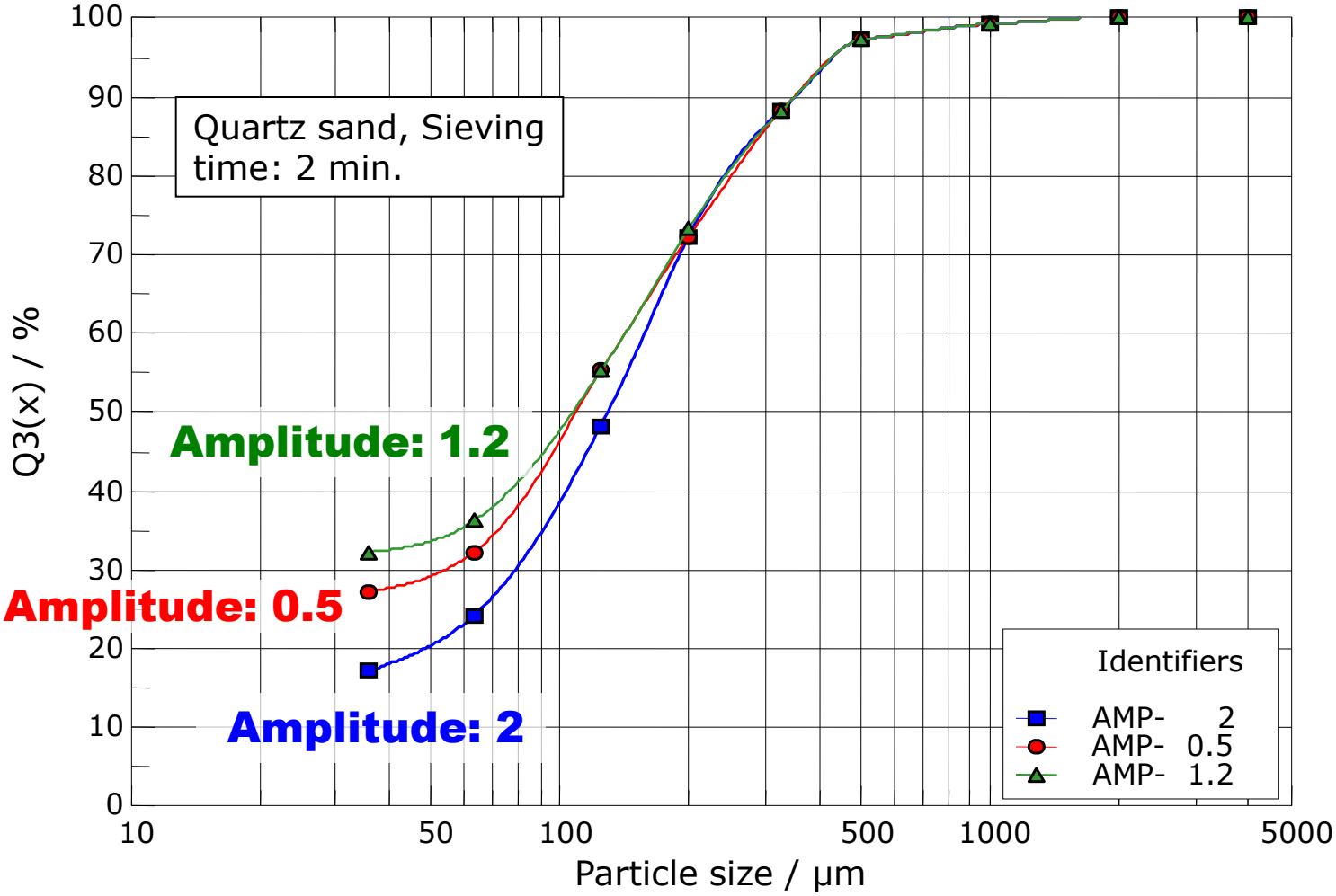
Particles get stuck in sieves

Round particles are easily captured but hardly released





Different shaking amplitude

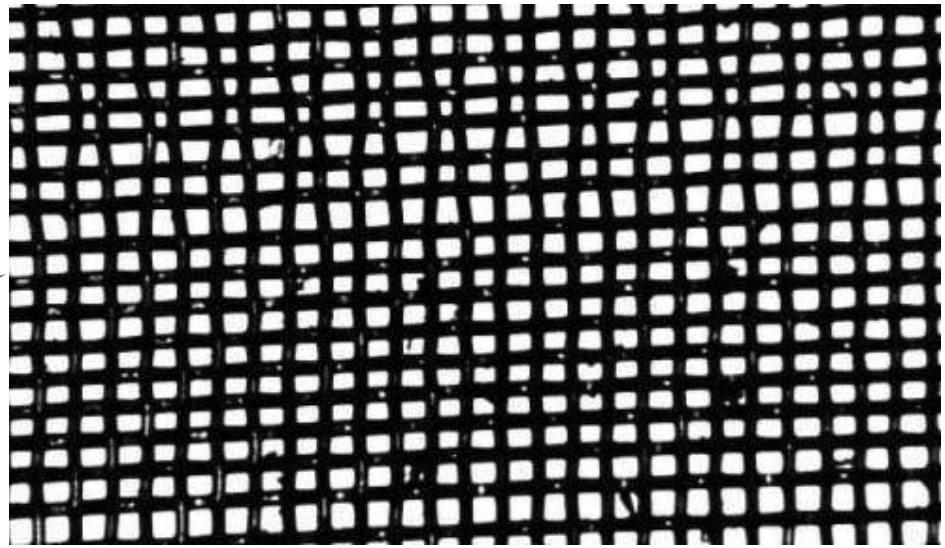


Watch out for wear!

“Beating” on sieves with particles (sieve analysis), or careless cleaning is going to wear out the sieves!

It requires a lot of work to monitor sieve condition.

Worn out sieves



Sieving advantages

- Robust and industrial-suited
- Easy handling
- Long history
- Low cost

Sieving disadvantages

- Low resolution,
  small number of ascertainable classes
- Limited sample amount
- High operation costs (labor, replacement)
- Hard to confirm correct operation
- Cannot see change in size of some particles (e.g., rods)
- No shape analysis possible

Dynamic Image Analysis (DIA)

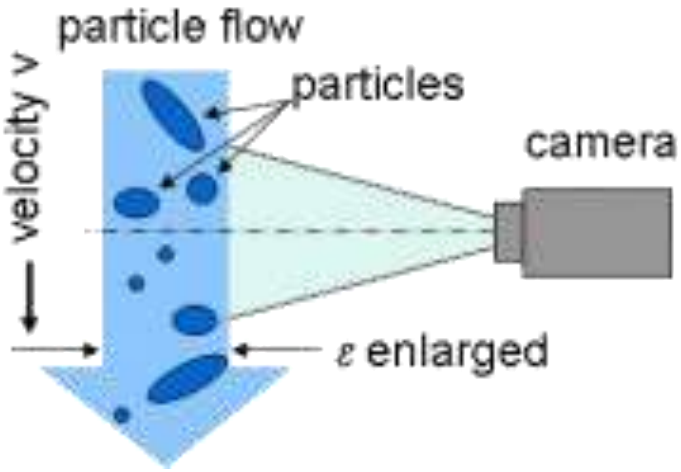
- **Particles flow through the measurement volume of the instrument and the field of view of the camera.**

- **Particles images are captured during movement, no other moving parts necessary.**

CAMSIZER

- **Capturing of many particle images in a short time interval**

- **Particles are projected in random orientation (3D)**



Data analysis

Raw image

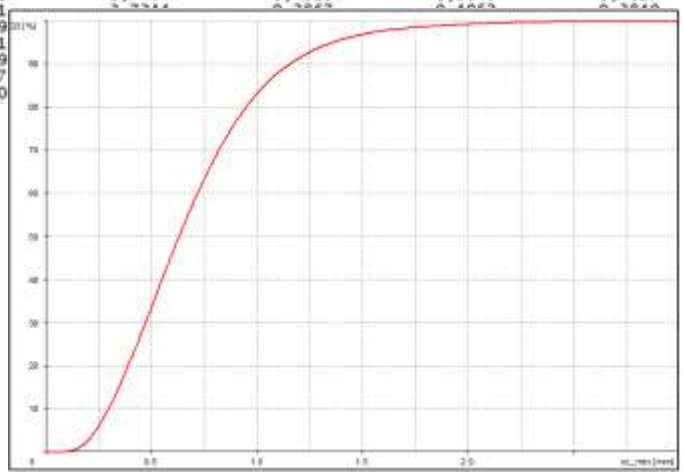
Binarize

Find edges

Analyze each particle

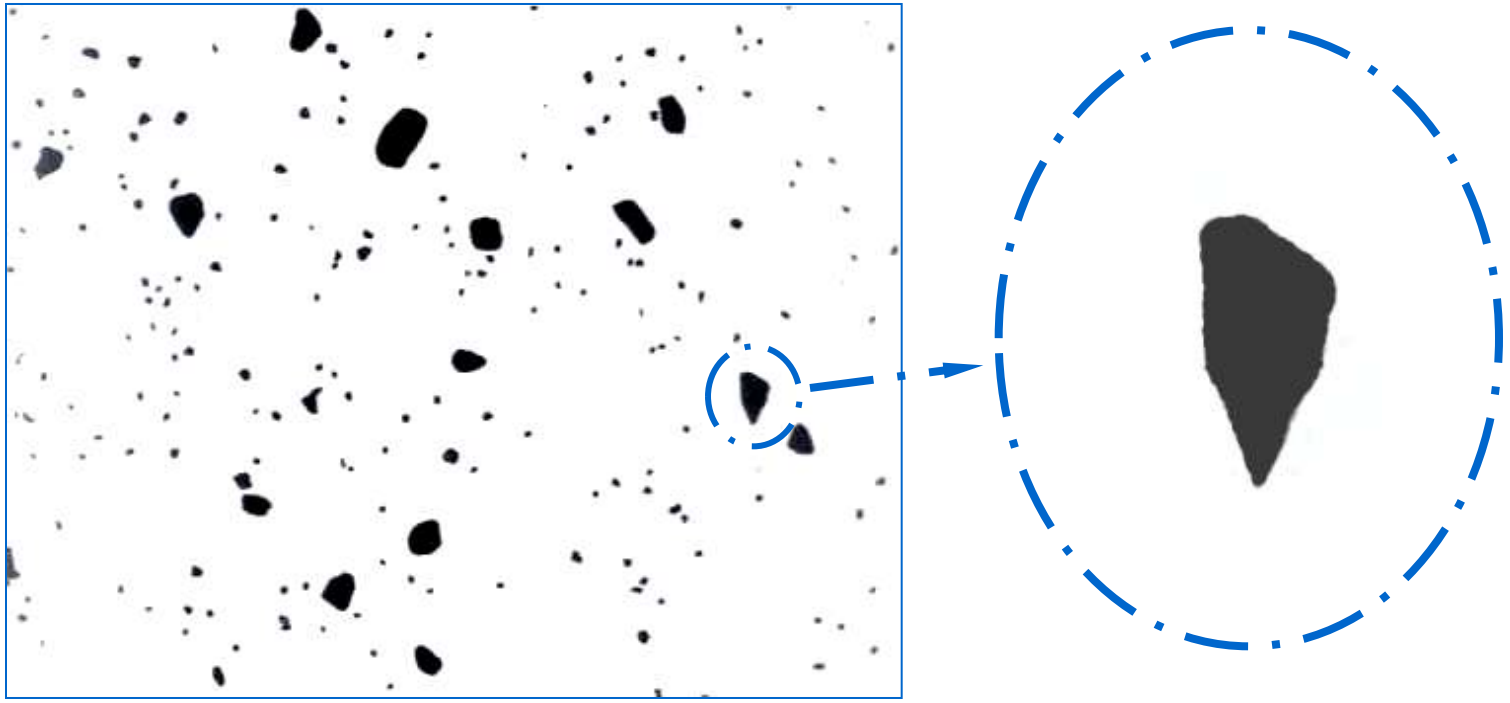
Particle No.	xs	ys	x_area	xFe	xMa
1	10,9028	0,3489	0,1219	0,1269	0,1186
2	13,0800	0,4677	0,2176	0,2234	0,2156
3	9,8570	0,6081	0,4872	0,5260	0,4746
4	12,8006	0,8691	0,3937	0,4154	0,3894
5	13,2663	0,7529	0,2767	0,3113	0,2720
6	3,0971	1,2902	0,5874	0,6104	0,5833
7	0,9952	1,1762	0,2226	0,2342	0,2194
8	7,6237	1,2215	0,1609	0,1668	0,1594
9	1,7679	1,2251	0,1242	0,1237	0,1238
10	6,1222				
11	9,381				
12	3,828				
13	8,148				
14	7,525				
15	4,4723		3,7404	0,4829	0,3049
16	1,2791				
17	3,3809				
18	11,7481				
19	12,0319				
20	5,8967				
21	1,7070				

Output distribution



What is the size?

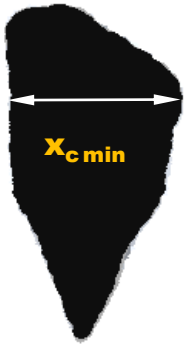
Different measurement systems provide different results.



Many size measures

$x_{c\,min}$

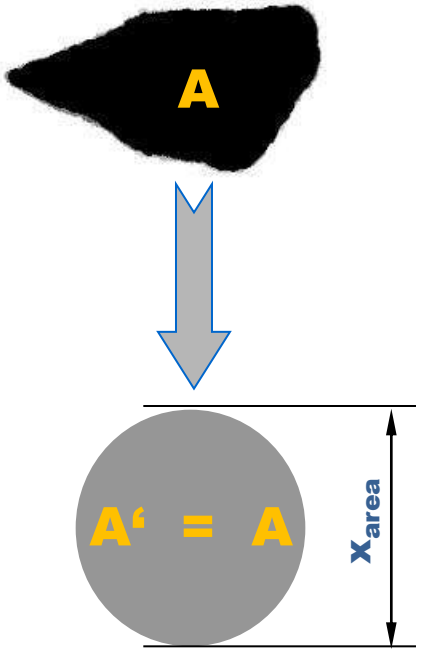
"width"



Width is best suited for comparison with sieves !

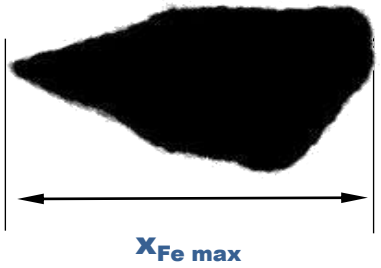
x_{area}

"diameter over projection surface"



$x_{Fe\,max}$

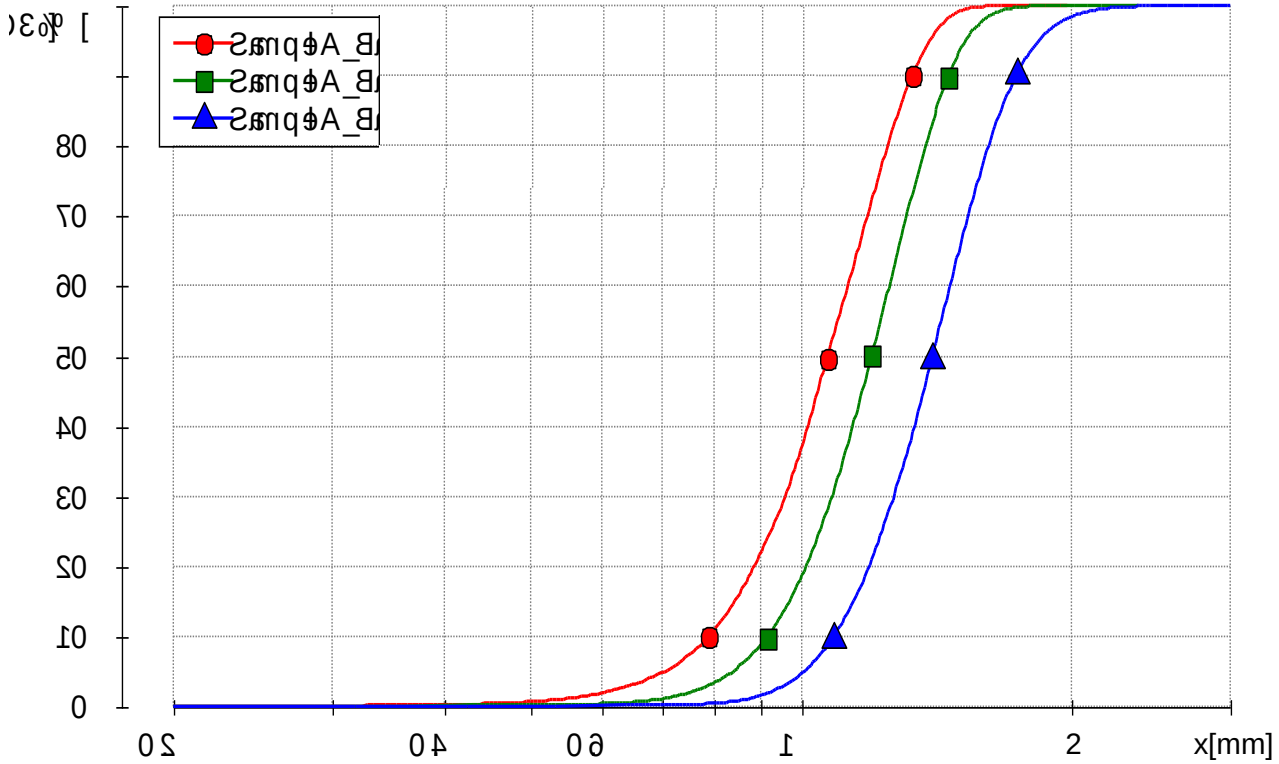
"length"



Shape parameters can be calculated!

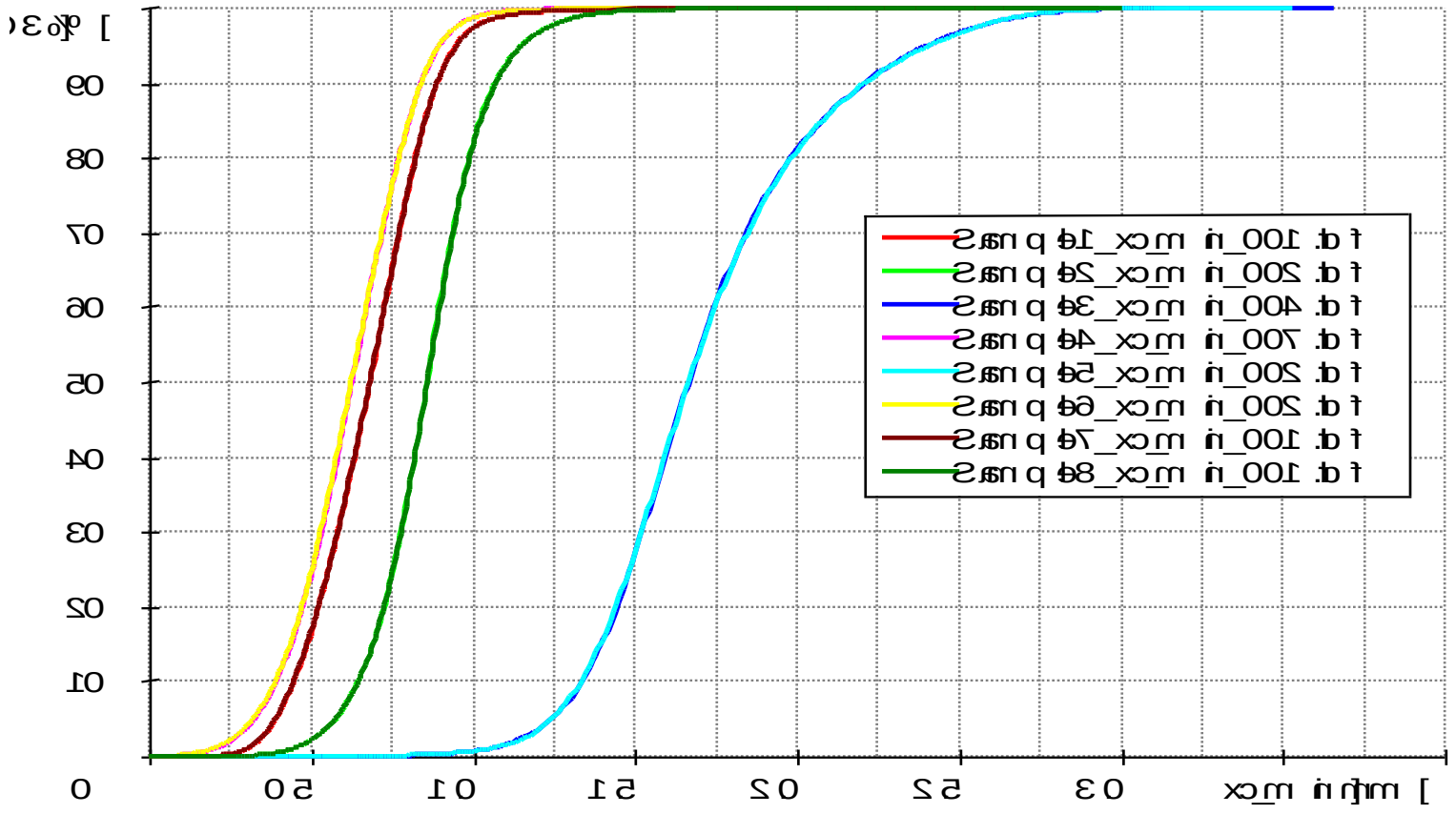
Comparison of size definitions

$x_{c\,min}$ ⇔ x_{Area} ⇔ $x_{Fe\,max}$



different size definitions ⇔ different results

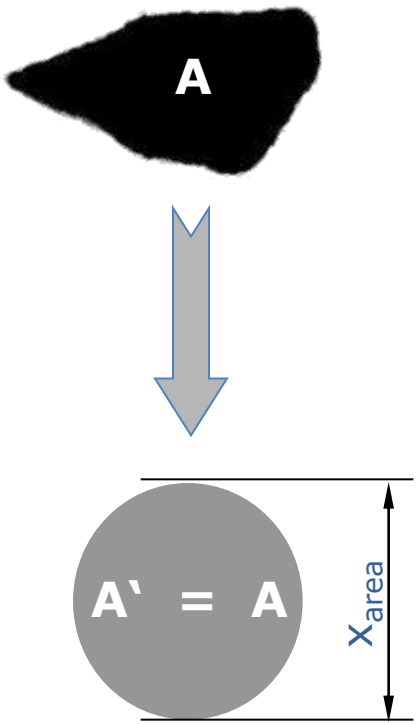
Image analysis reproducibility



Samples 1-8, the following samples show identical results .

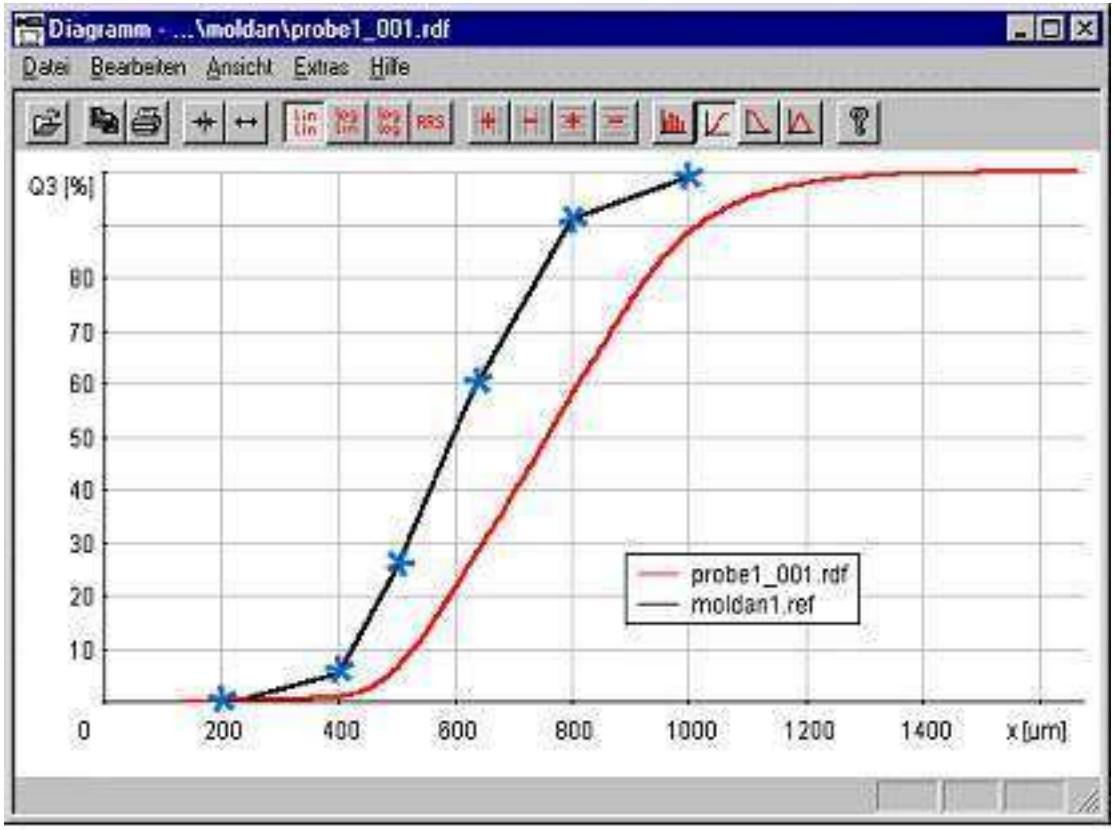
1=7, 3=5, 2=8, 4=6

Area measurement ⇔ sieving



x_{area}

"diameter
via projection surface"

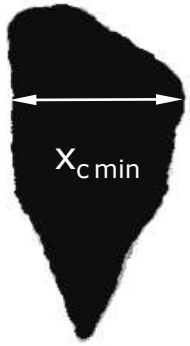


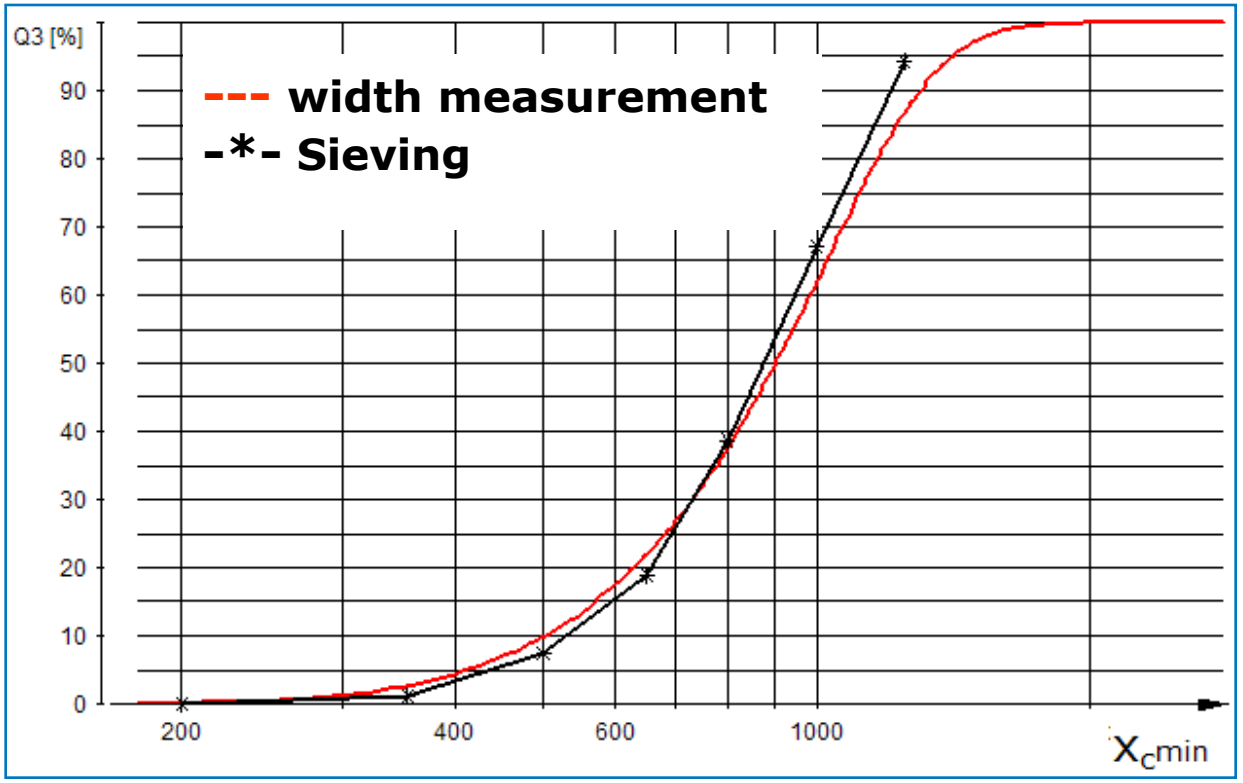
comparison

CAMSIZER-measurement x_{area} (**red**)
and sieving * (**blue**)

Measuring of width ⇔ sieving

$x_{c\,min}$ "width"

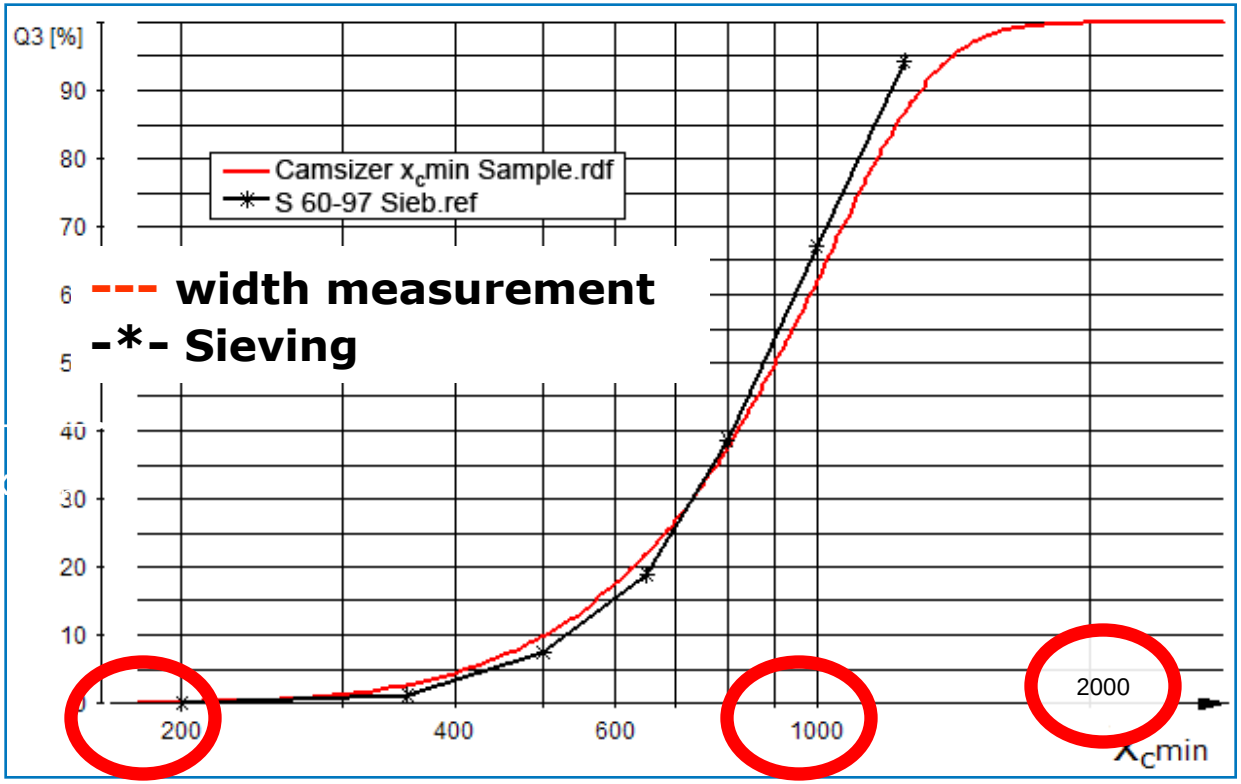




comparison

CAMSIZER-measurement $x_{c\,min}$ (**red**) and sieving * (**black**)

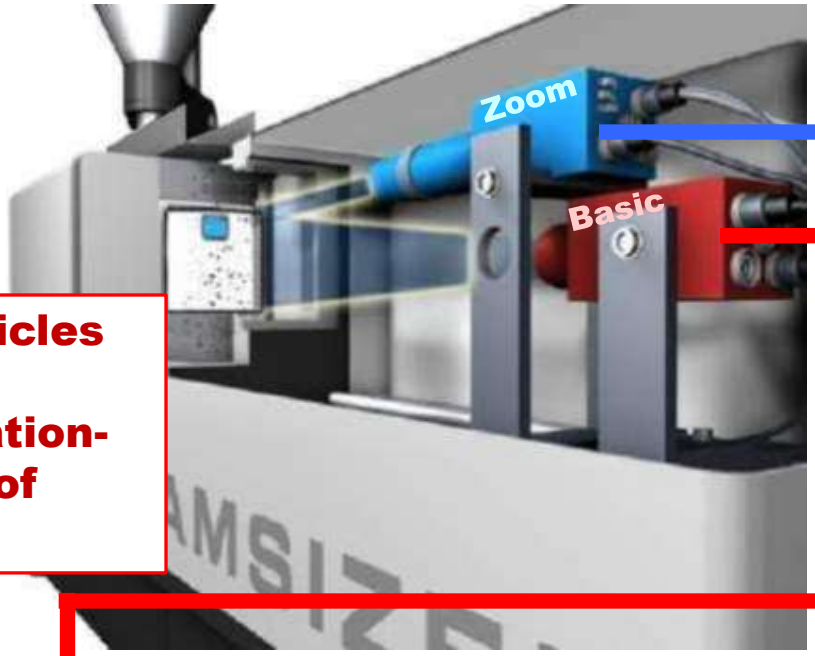
Size range



Range is 200 to 2000 microns … (factor 10)

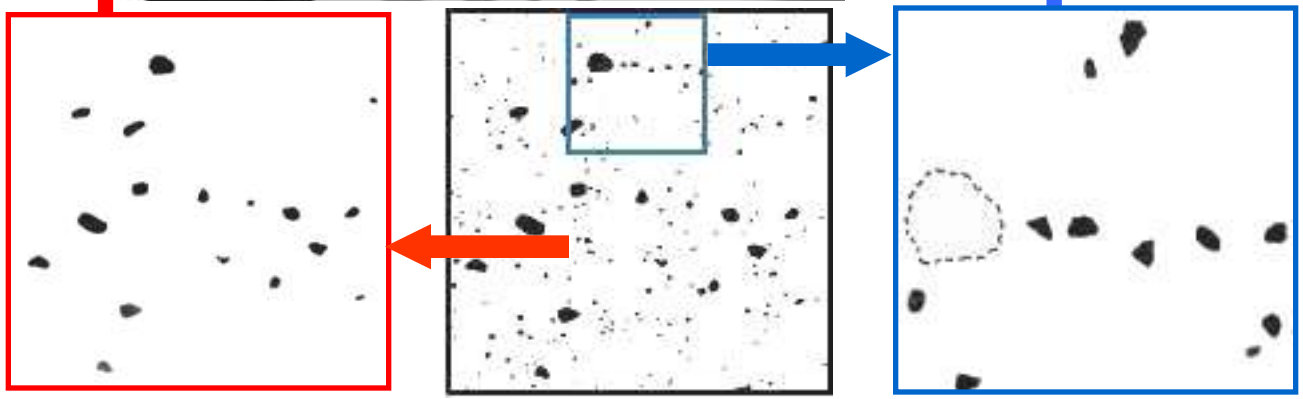
How to cover a wider range or different size products? (factor 1500)

2 Camera system for size range



Large particles in high representation-wide field of view

Small particles with high resolution (magnification)



Basic camera

Zoom camera

Calibration

Master sieve stack (that wears with use)

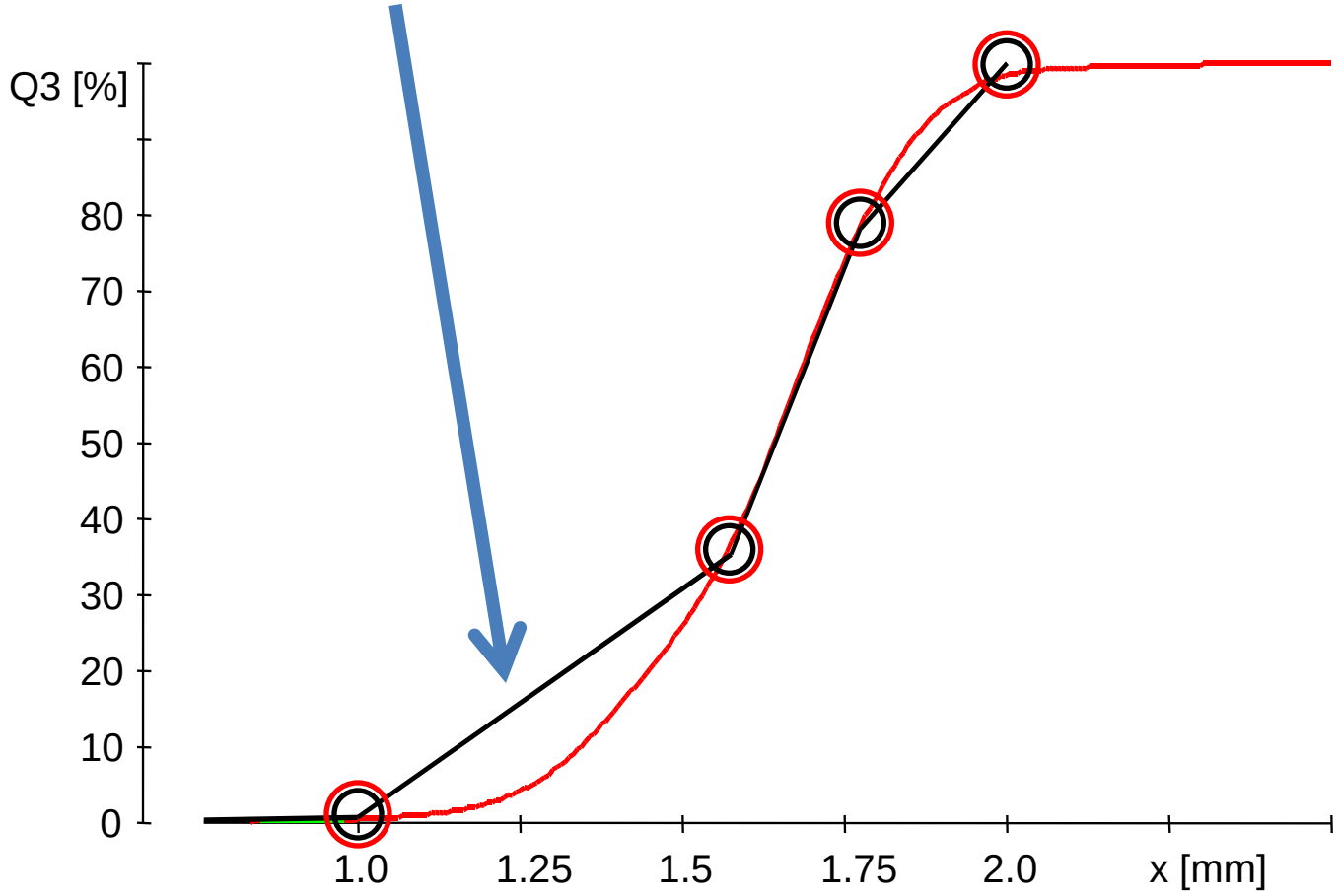
Calibration Reticle

Calibration beads

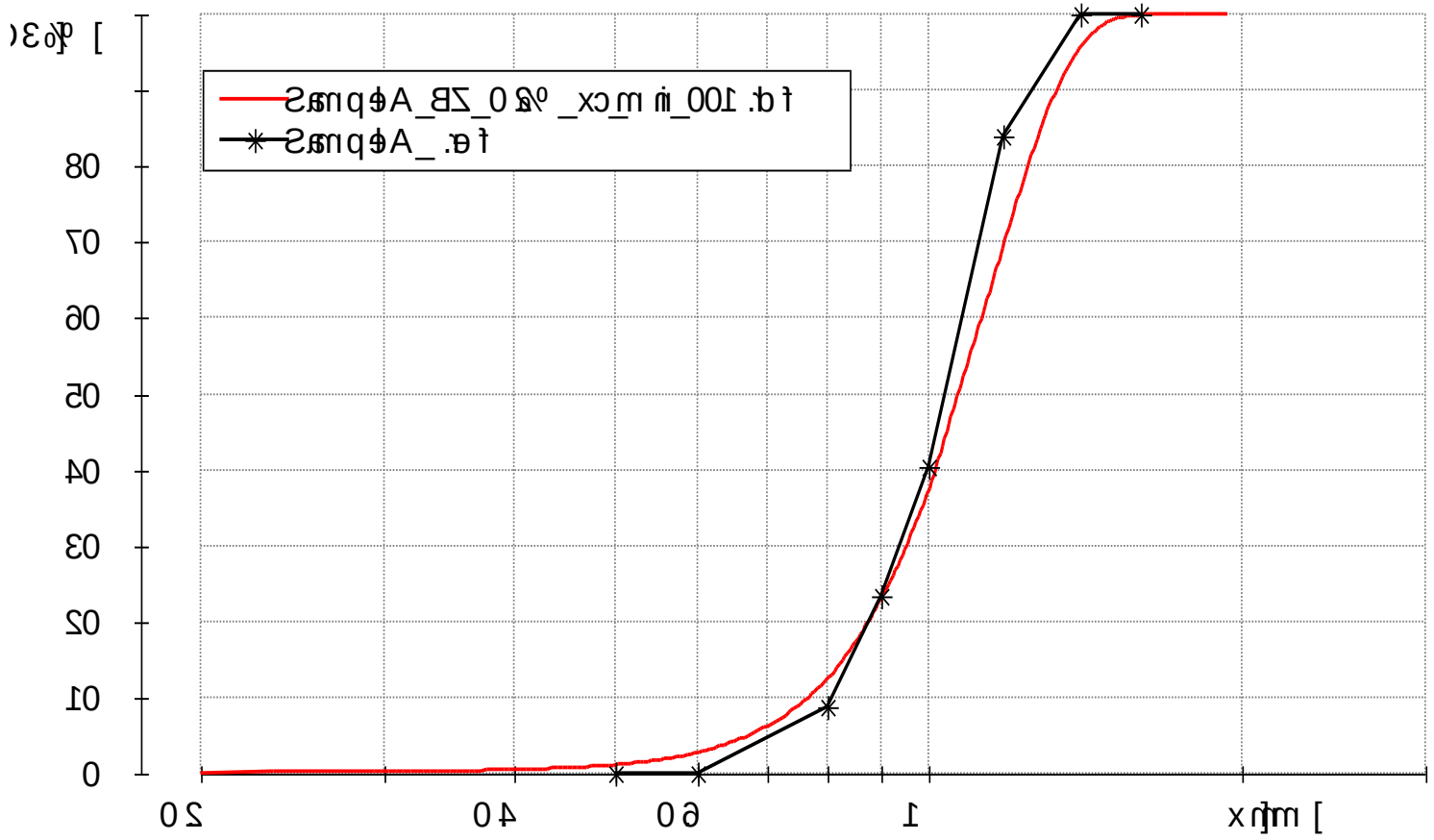
- **Traceble to an international standard**
- **Covers the whole measurement range**
- **Instrument to instrument agreement**
- **Does not wear**

Resolution and fitting

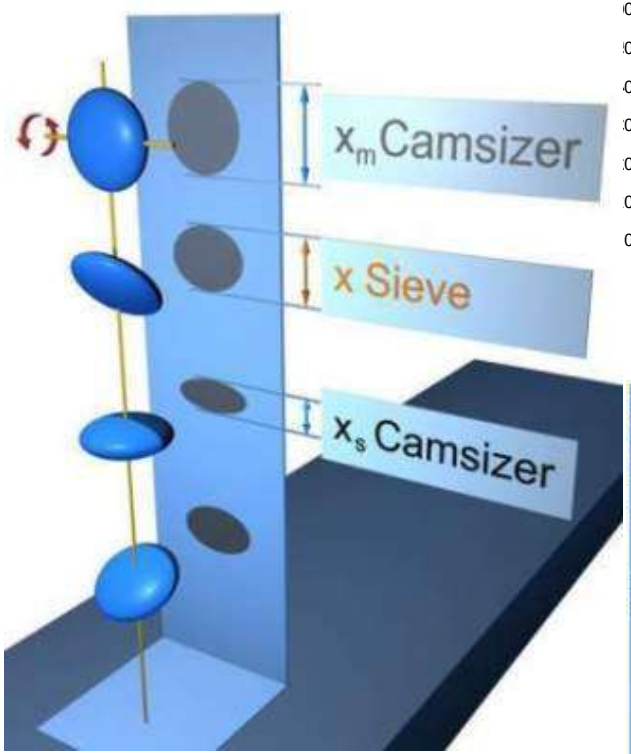
This is due to poor resolution of sieves.

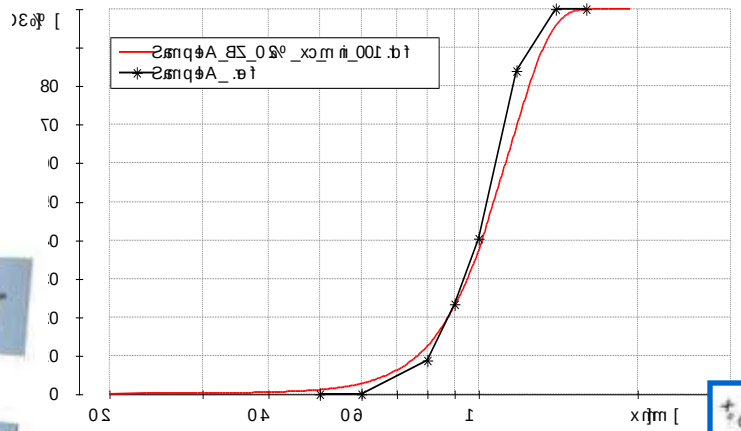


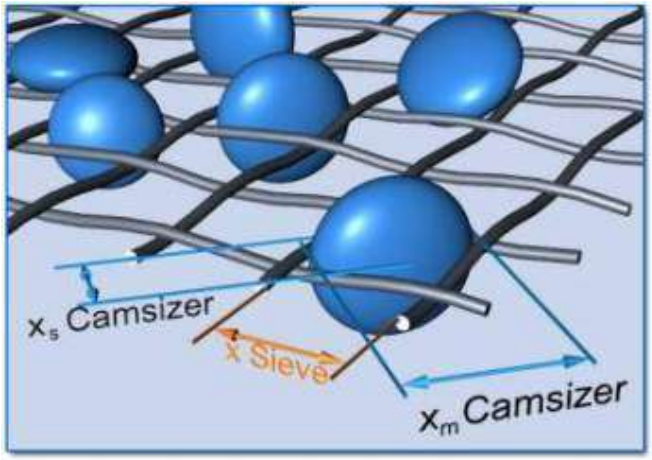
Lenticular particles

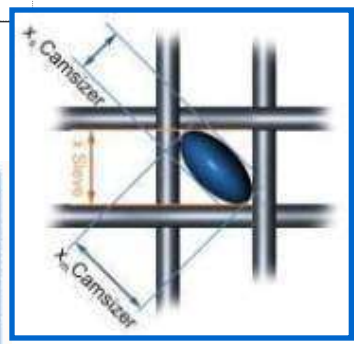


Lenticular particles



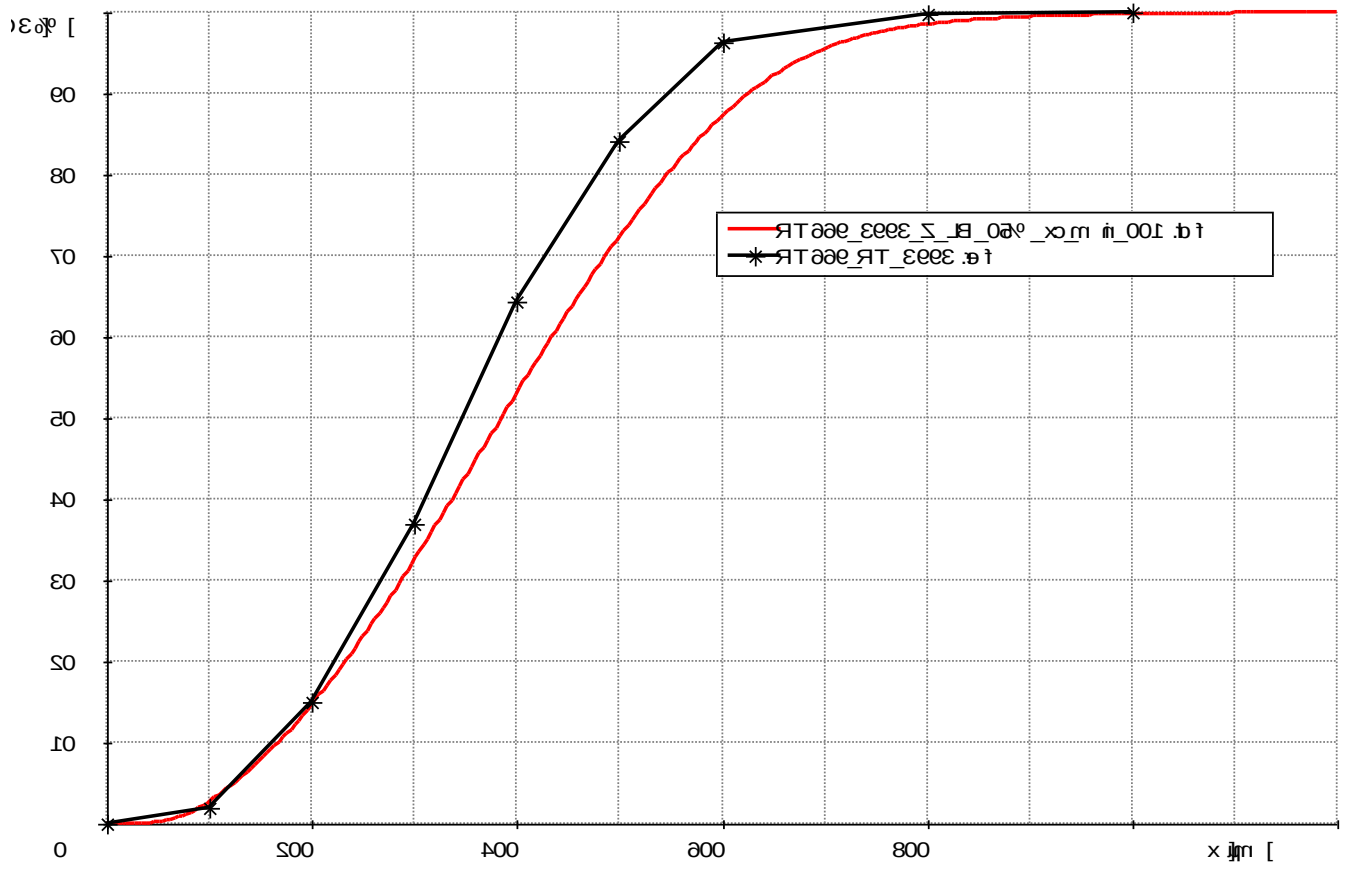




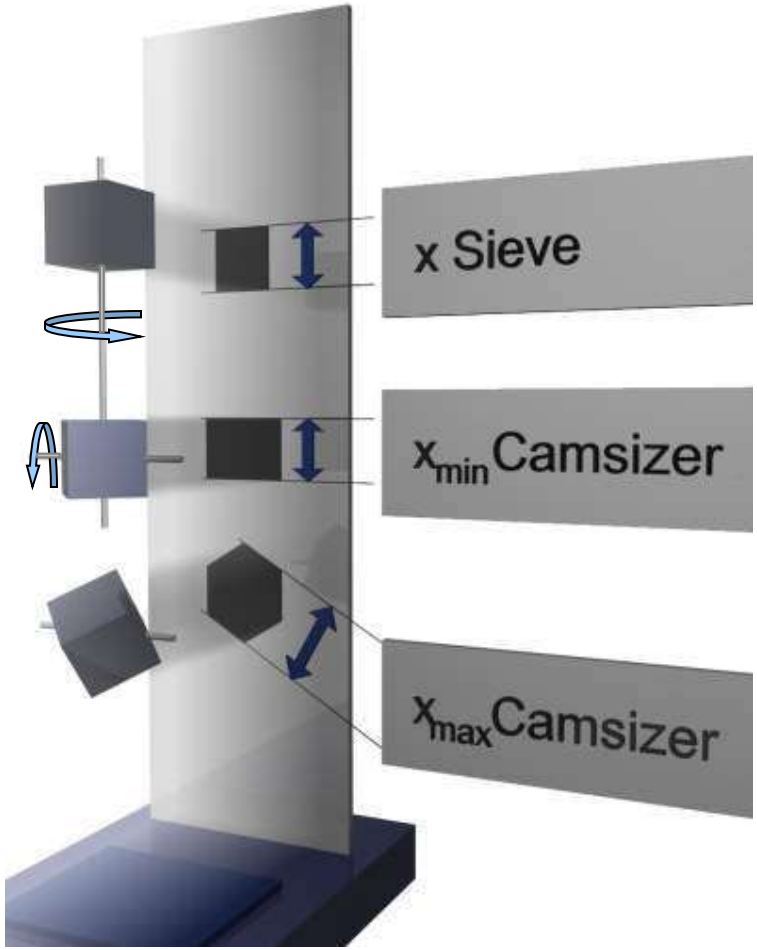


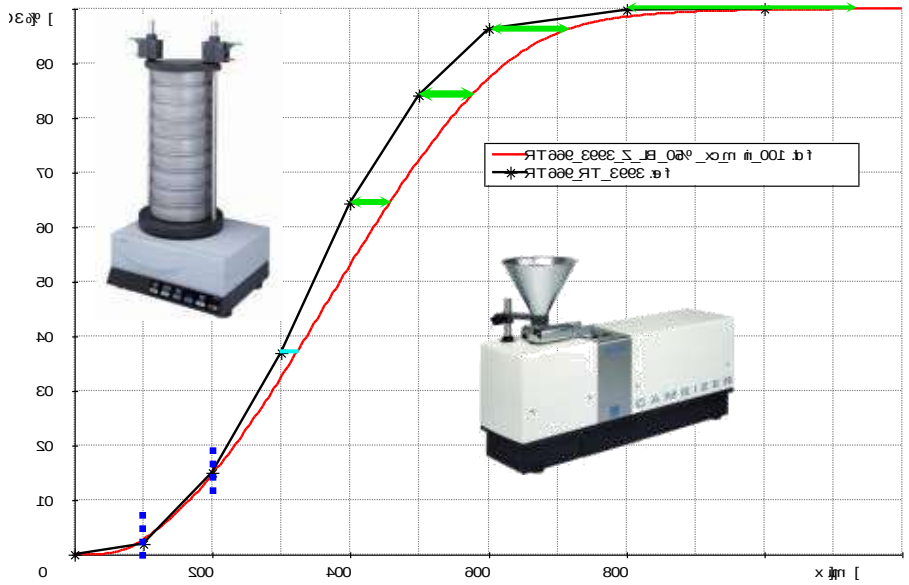
Angular particles

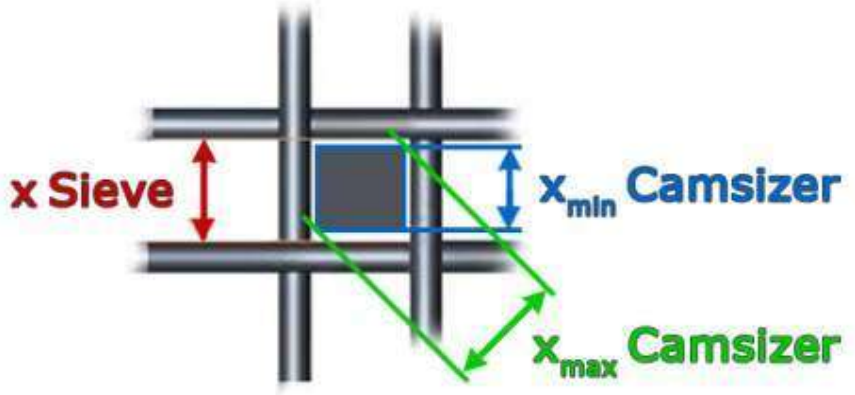
(coal, sand, sugar)



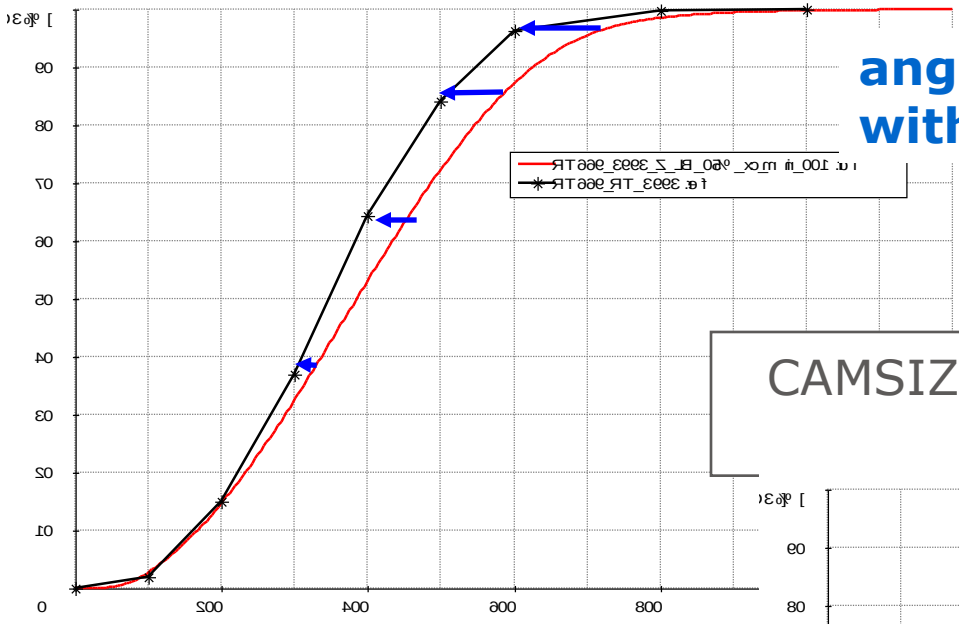
Cubes / angular particles





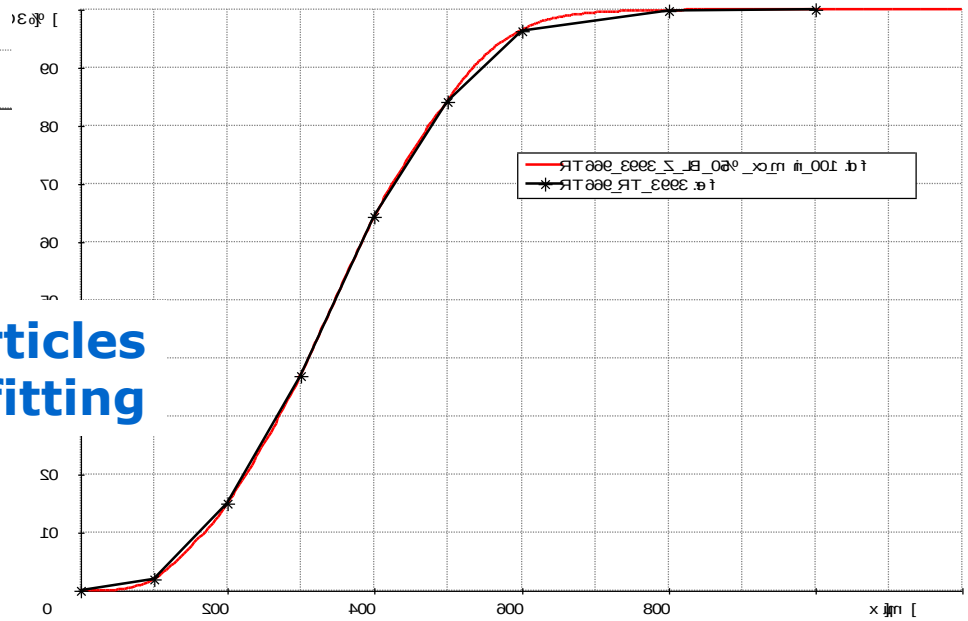


Fitting … the final adjustment



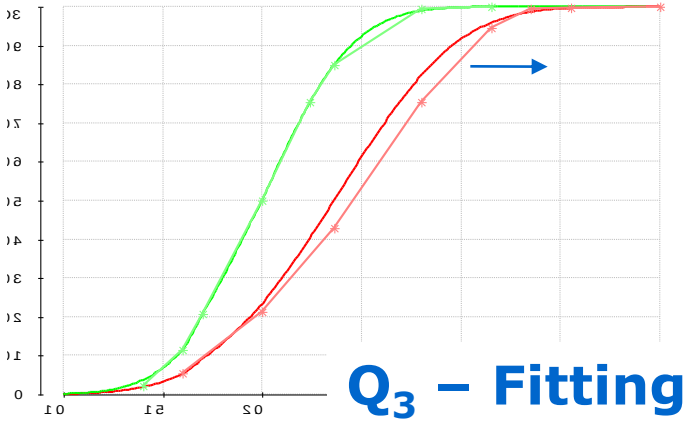
angular particles without fitting

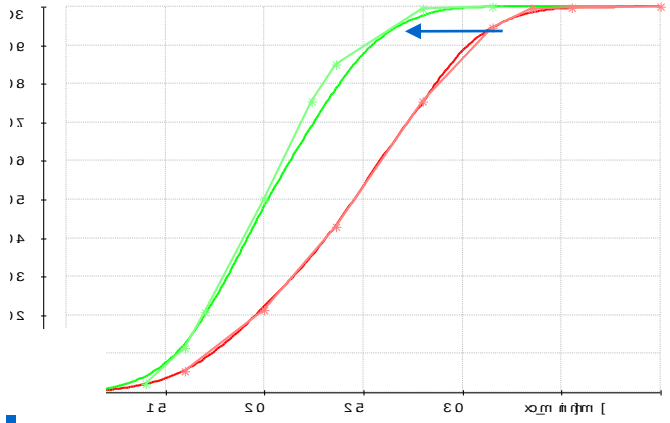
CAMSIZER-measurement $x_{c\,min}$ (**red**)
sieve analysis (**black**)



angular particles with Q_3-fitting

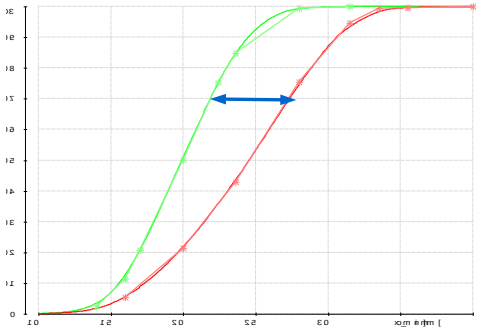
Limits of Q_3 fitting

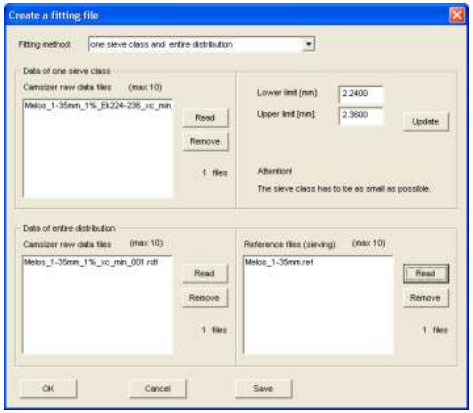




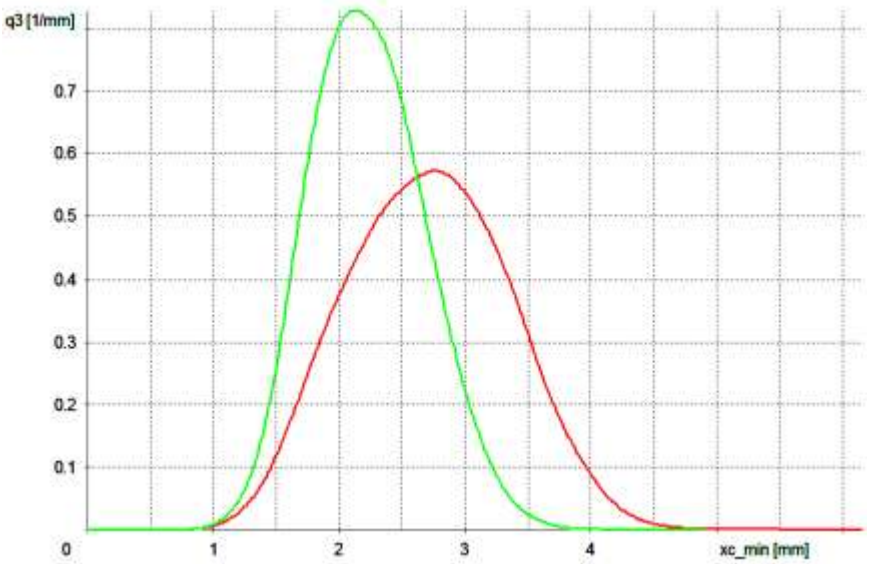
Q_3 – Fitting
Cannot fit in general.
(all sizes)

Elementary – fitting



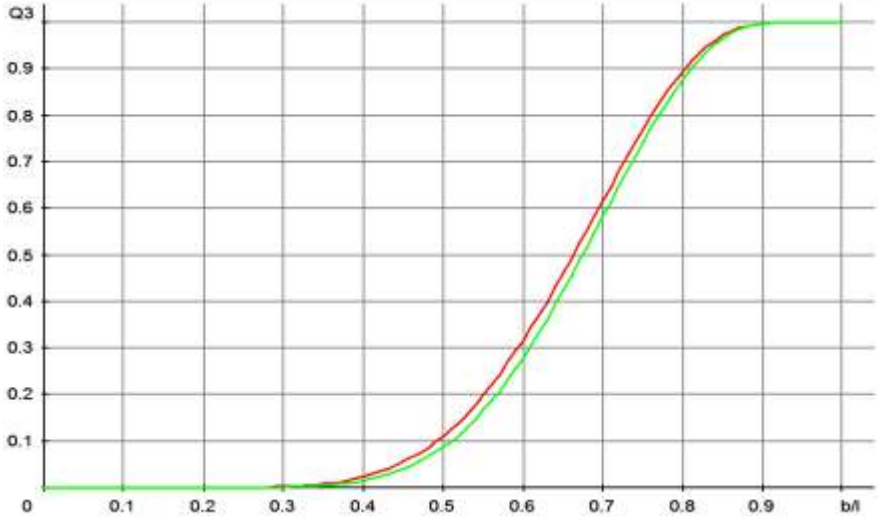


Elementary fitting



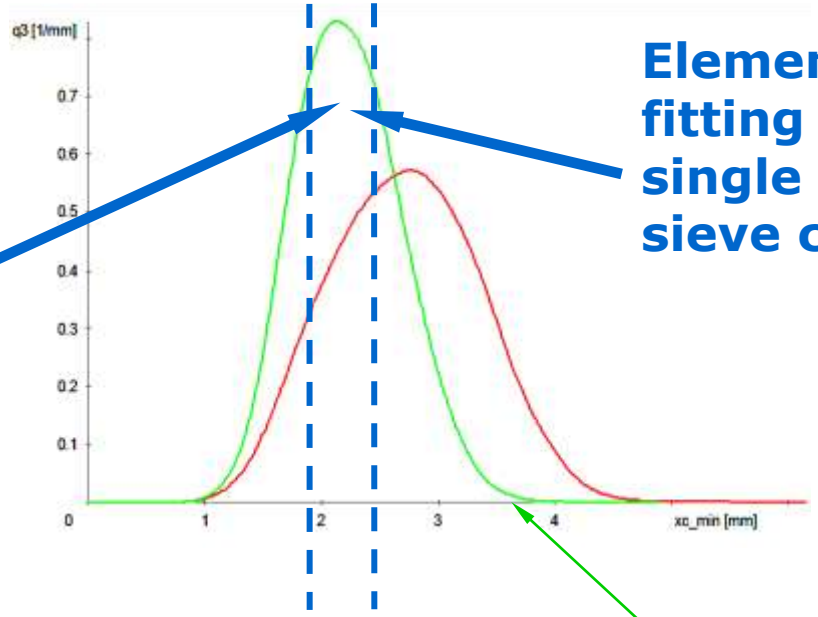
Two samples with different width of distribution but …

… with similar shape. (= same product type)



Elementary fitting

Digital imaging ⇔ sieving

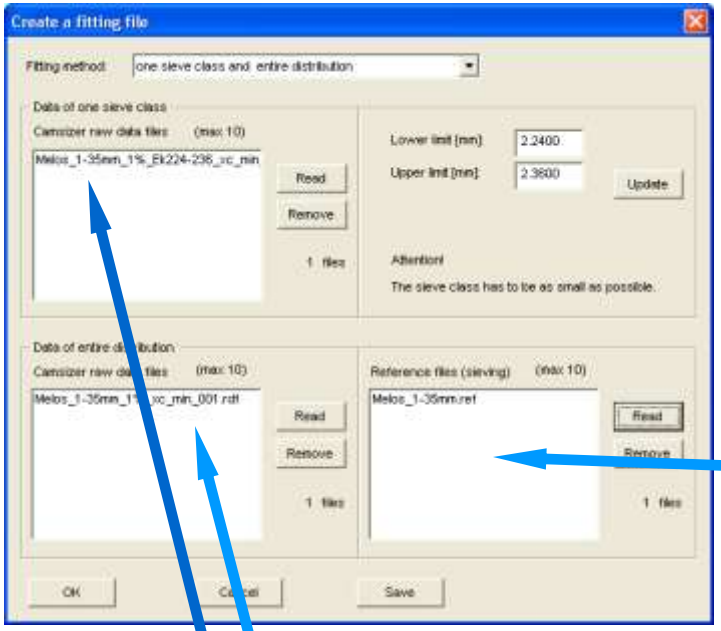


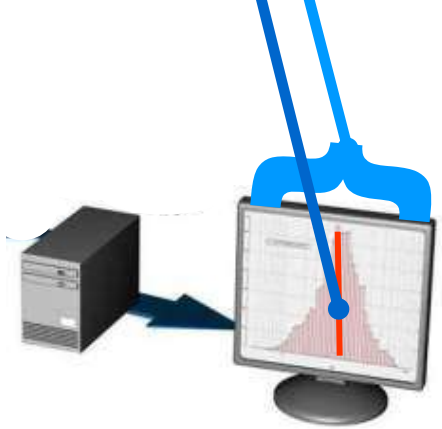
Elementary fitting with single (narrow) sieve class

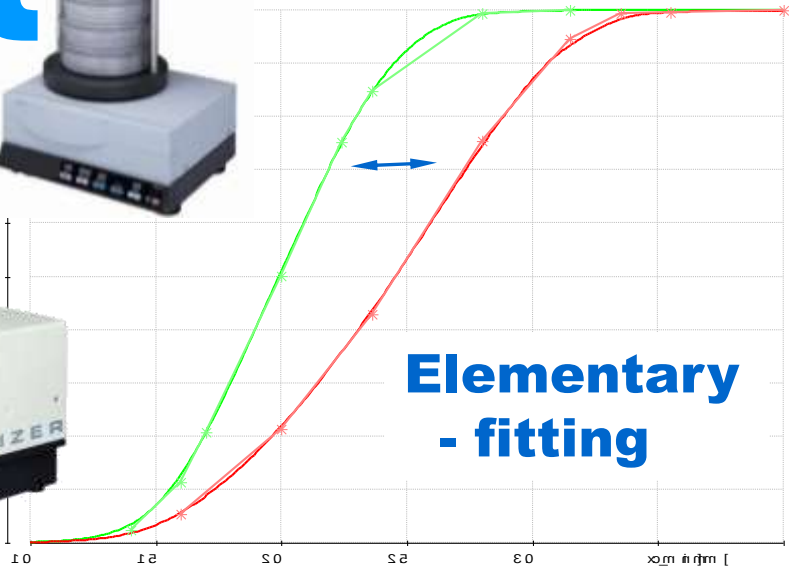
Single class (element): Taken from the sieve stack and measured in CAMSIZER

For the CAMSIZER elementary fitting use the more narrow sample

Elementary fitting







Elementary fitting with single (narrow) sieve class and entire distribution

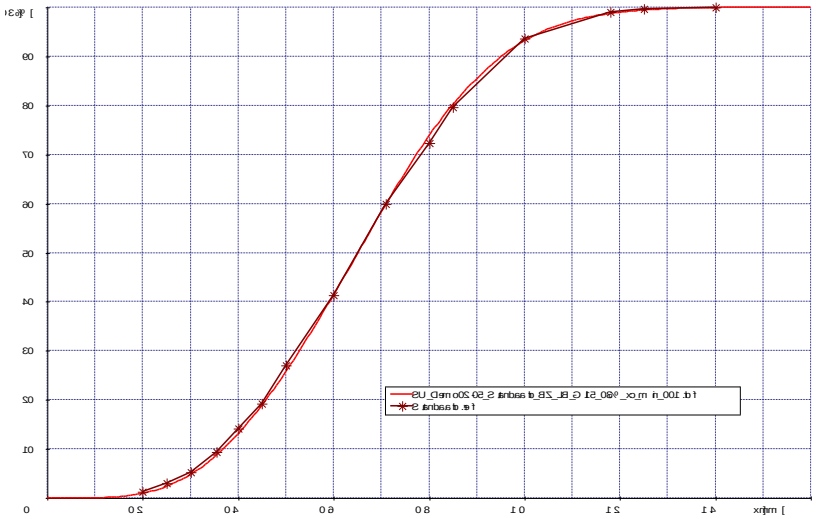
Elementary - fitting

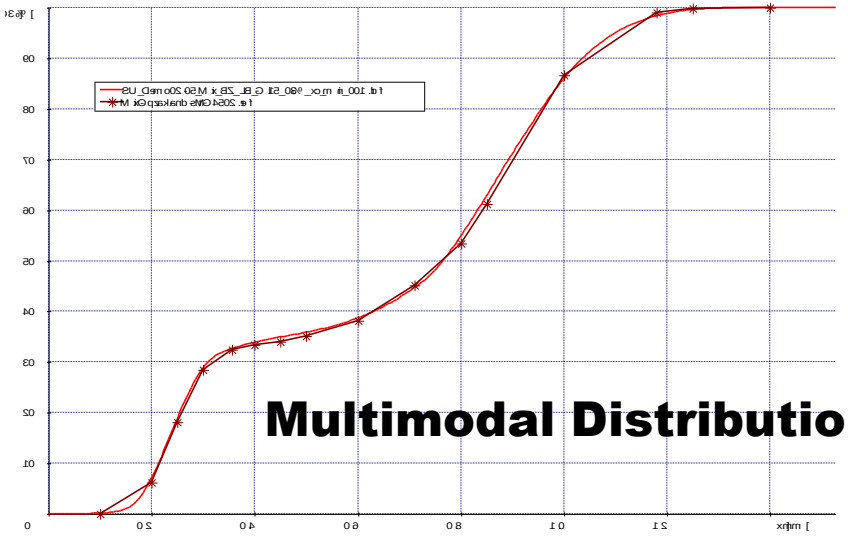
Elementary fitting results

Elementary Fitting:

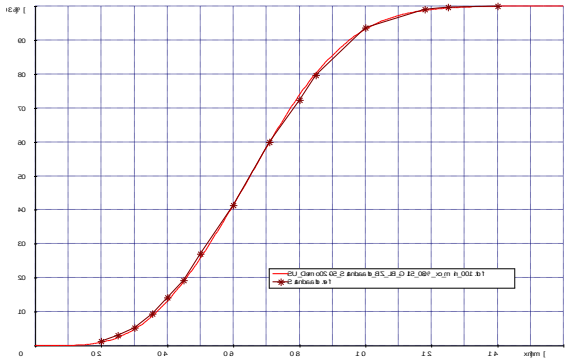
- **For samples with similar shape**
- **Fitting of different width of distribution possible (even multimodal distributions)**
- **Applications: sand, sugar, fertilizer, minerals, plastics, foodstuffs...**

➢ Samples with varying particle shape,
e. g. abrasives will need different fitting files





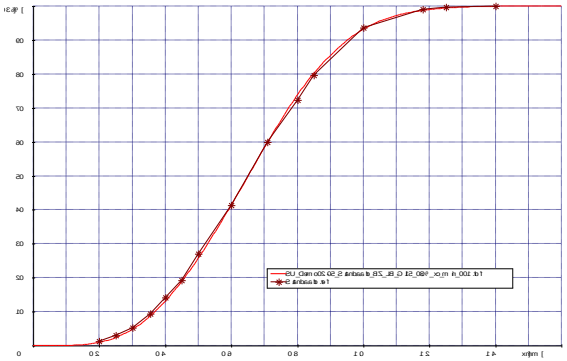
Conclusions



The Camsizer can be used in place of sieves to provide fast, easy data. It also provides shaped data.

Historical sieve data can be matched through an elementary fitting process. This requires one (good) sieving and two Camsizer measurements.

Image analysis advantages



Sieve	CAMSIZER
Low resolution	High resolution
Limited sample amount	Flexible sample amount
No shape information	Shape information included
High labor costs	Low labor costs
Hard to check accuracy	Easy accuracy check
Cannot see doublets	Easy to analyze doublets and other complex shapes

Questions?

Ask a question at labinfo@horiba.com

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P: 866-562-4698
E: jeff.bodycomb@horiba.com

Thank-you

Thank you very much for your attention.

Thank you

Omoshiro-okashiku
Joy and Fun

眞峰

감사합니다

Cảm ơn

ありがとうございました

Dziękuję

धन्यवाद

Grazie

Merci

谢谢

நன்ற

ขอบคุณครับ

Obrigado

Σας ευχαριστούμε

شُكْرا

Tack ska ni ha

Большое спасибо

Danke

Gracias