Particle Characterization of Trona

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More Information

- Best Practices/Training
  - Setting Attainable Size Specifications TR007
  - Understanding Laser Diffraction PSA Results TR008
  - Troubleshooting Laser Diffraction Data TR010
  - Help! How Can I Trust My Size Results? TR015
  - Refractive index selection, sampling, dispersion, system verification, method development and more

- Technology
  - BET Flowing Gas Surface Area TE005
  - Find the Best Analyzer for Your Application TE006
  - Intro to Laser Diffraction TE010

What is trona?

Why are power plants using trona?

Impact of size and surface area

Featured technologies

Interpreting particle size results

Q&A

What is trona?

- Google says…

What is trona?

- Naturally formed sodium sesquicarbonate
- $Na_2CO_3 * NaHCO_3 * 2H_2O$

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Why is trona useful?

- EPA regulates SO_X emissions
- Multiple strategies to remove SO_X
- Dry Sorbent Injection attractive option
- Trona
  - Capital cost low relative trad. scrubbers
  - Operational cost proportional to sorbent cost
  - SO_X removal proportional to reactivity
    - Reactivity directly proportional to surface area
    - Surface area directly prop. to particle size

Balance SO_X removal vs. cost

- Unmilled trona
  - Coarser PSD → Smaller SSA
  - Need to inject more sorbent to hit removal target
- Milled trona
  - Finer PSD → Larger SSA
  - Need to inject less sorbent to hit removal target
    - Added cost → either material cost or on-site milling
    - Finer powders typically bring flow and handling challenges

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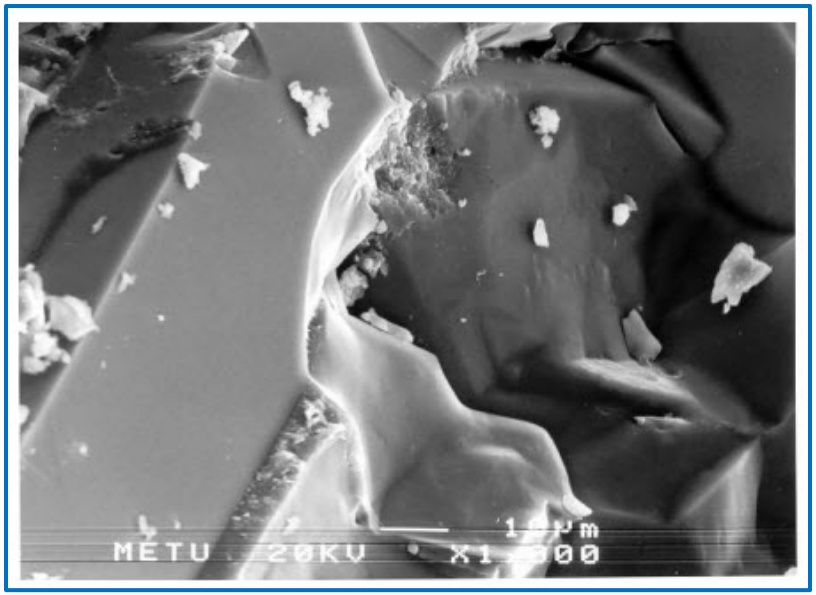
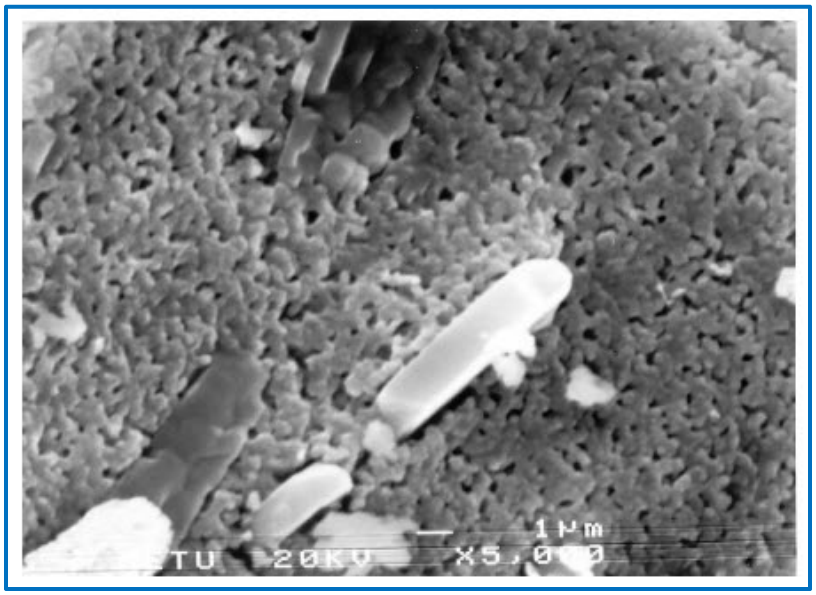
Calcination aids removal

- Trona has low natural SSA
- Trona injected into flue gas undergoes calcination and produces sodium carbonate with higher SSA
- $2(Na_2CO_3*NaHCO_3*2H_2O)$ + heat → $3Na_2CO_3 + 5H_2O + CO_2$
- Evolution of water and CO_2 creates micropores → higher SSA

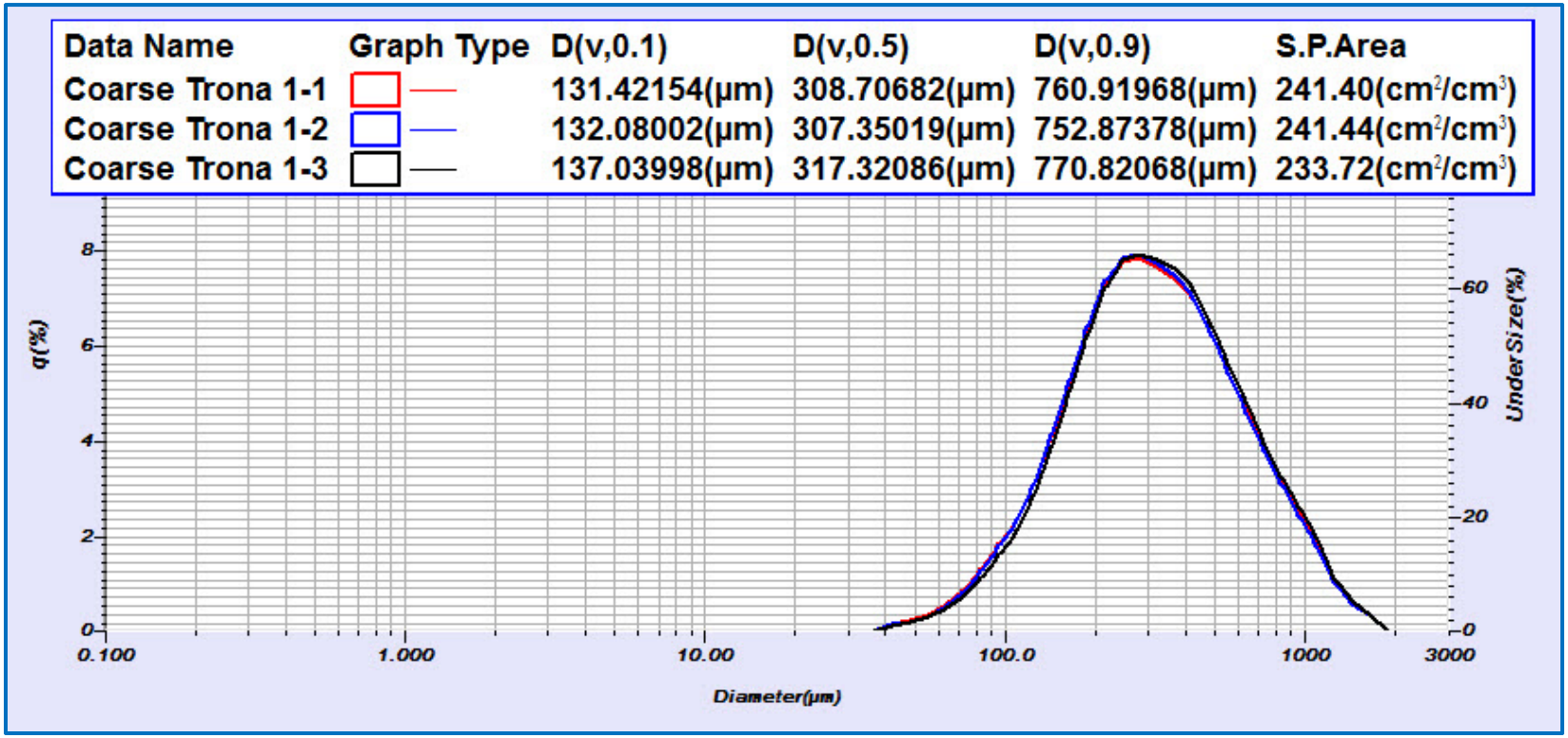
Effect of Calcination





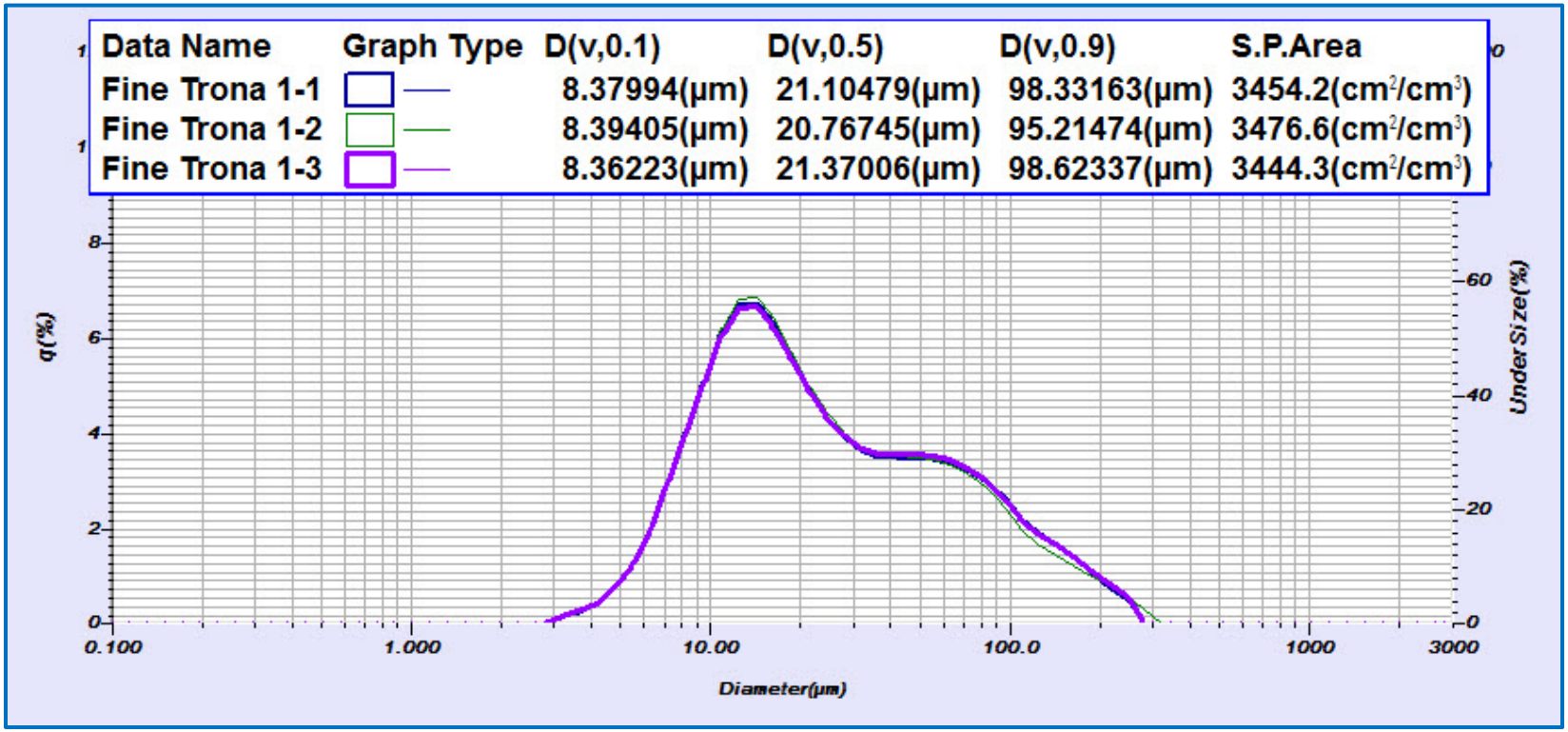
Measure surface area to screen incoming material

Unmilled trona



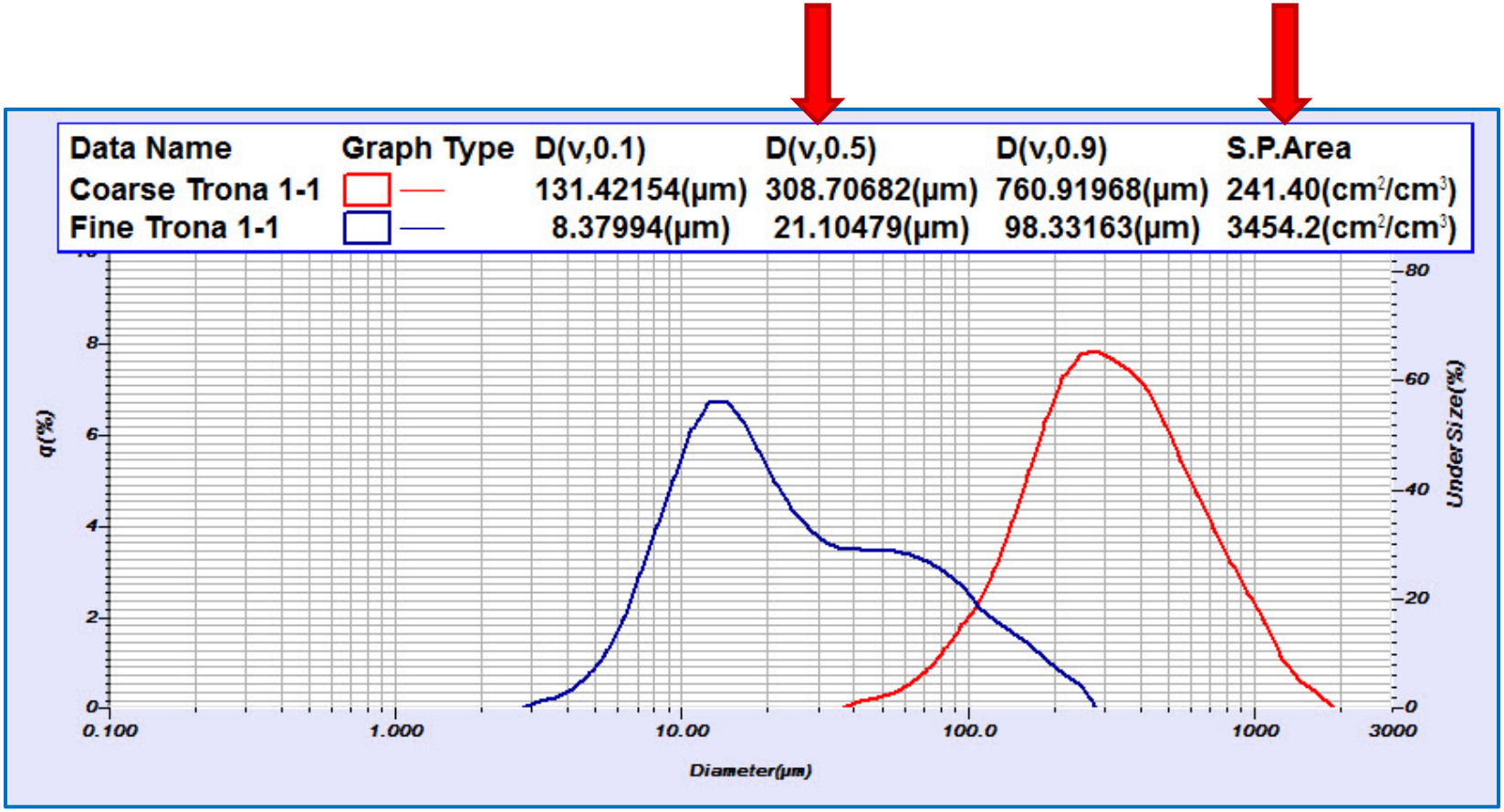
Measure particle size to screen incoming material

Milled trona



Measure particle size to screen incoming material and monitor milling end point, efficiency, etc.

Unmilled vs. milled trona



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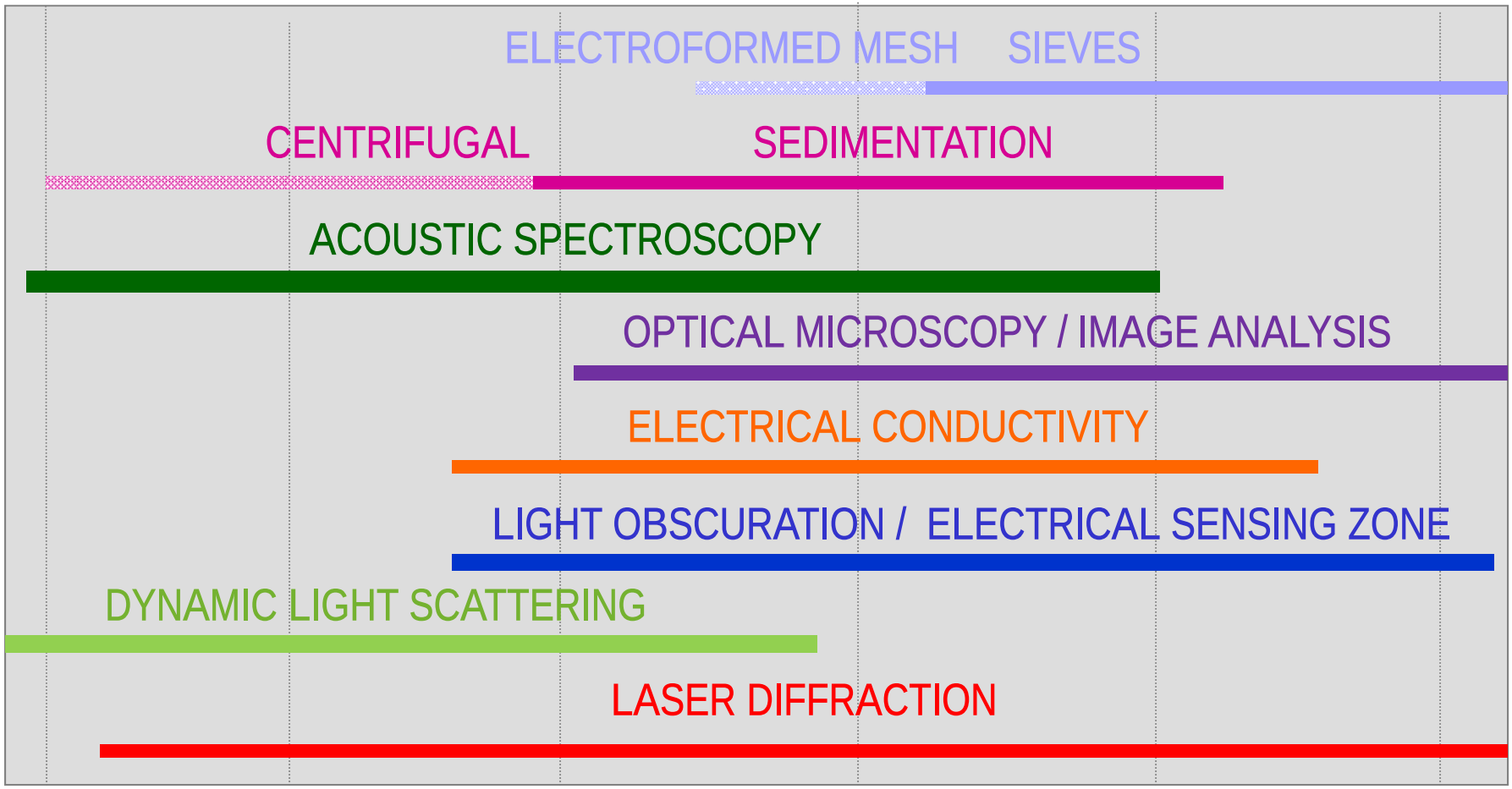
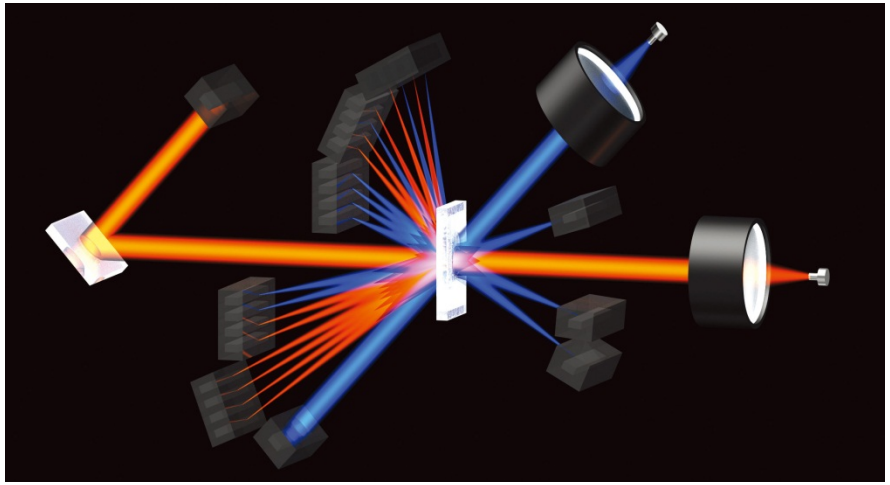
Featured technologies

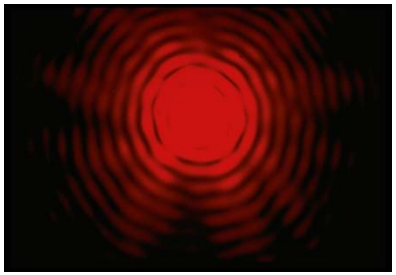
- **LA-950 & LA-300**
  Laser Diffraction
- **SZ-100**
  Dynamic Light Scattering & Zeta Potential
- **CAMSIZER & CAMSIZER XT**
  Dynamic Image Analysis
- **PSA300**
  Static Image Analysis
- **SA-9600**
  Flowing Gas BET Surface Area

Size Range by Technique



Laser Diffraction





- Converts scattered light to particle size distribution
- Quick, repeatable
- Powders, suspensions
- Most common technique

LA-950: Laser Diffraction

- Lowest total cost of ownership
- Measures in less than 60 seconds
- One-button operation
- Wet and dry measurement
- Ultra durable
- Ninth generation
- 10 nanometer – 3 mm

LA-300: Laser Diffraction

- Unique portable design
  - Shippable in Pelican case
- Ultra durable
- One-button operation
- Wet measurement
- 100 nm – 600 µm

SA-9600 Surface Area Analyzer

- 0.1 - >2000 m^2/g
- Single or multi-point analysis
- One or three station systems
- Single point: up to 30 analyses per hour
- High value route to quick and easy surface area analysis

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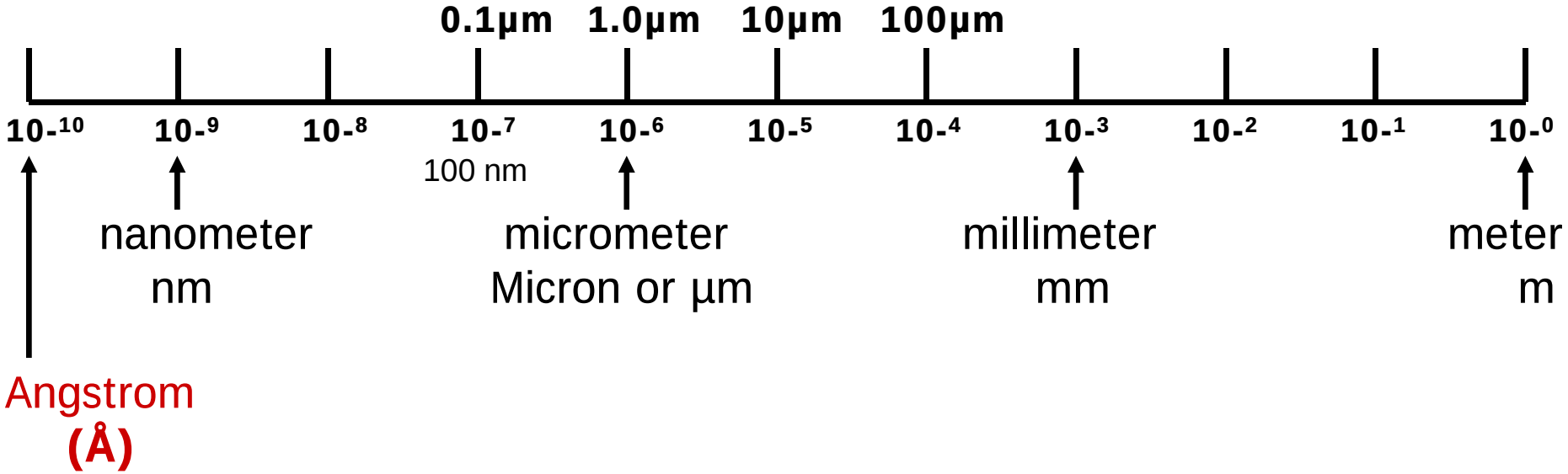
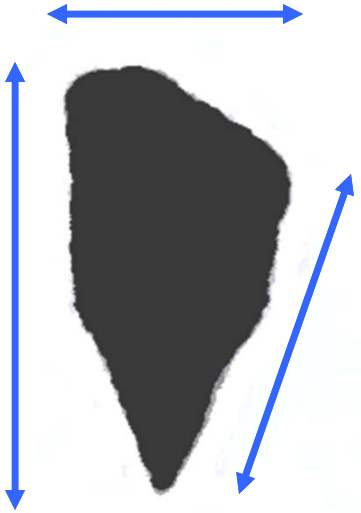
Size Terminology



The most common designation is micrometers or microns. When very small, in colloid region, measured in nanometers, with electron microscopes or by dynamic light scattering.

The Basics

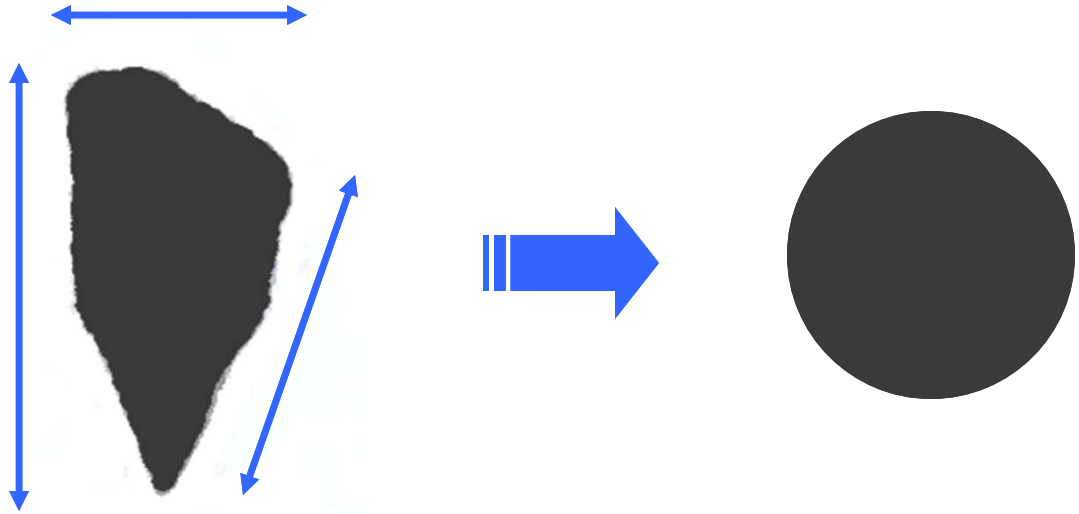
Which is the most meaningful size?



different size definitions ⇒ different results

The Basics

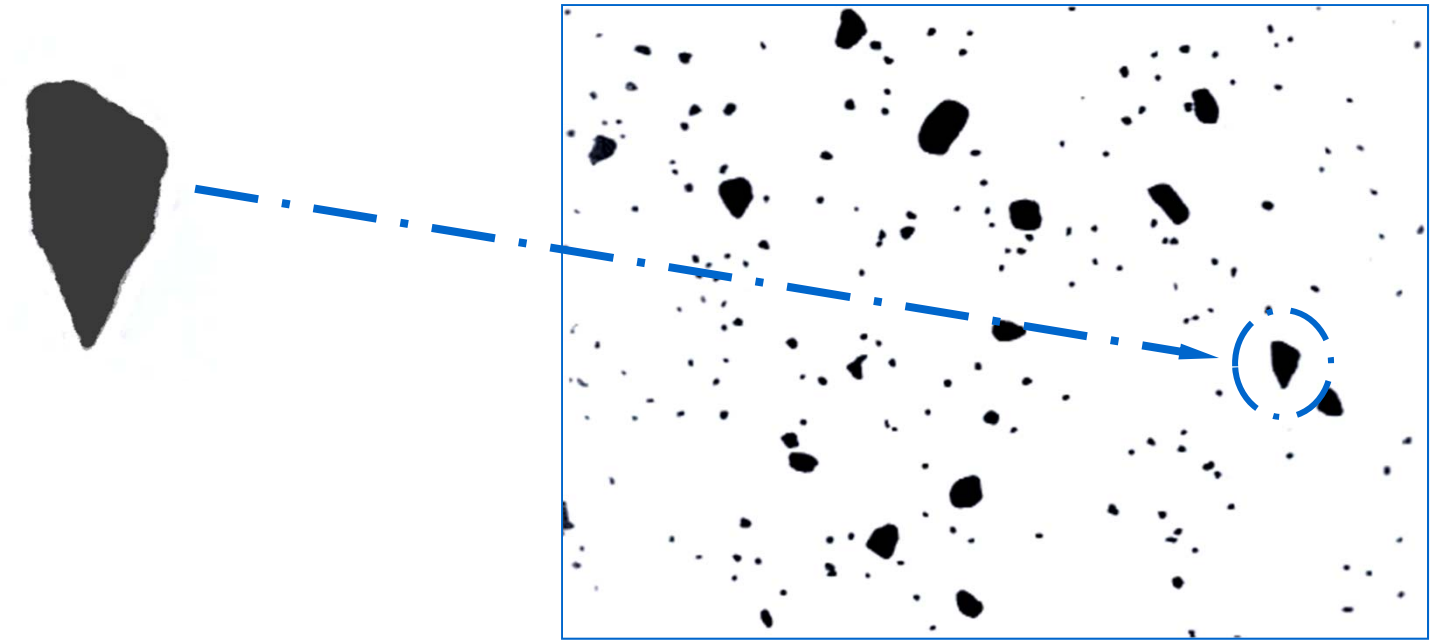
What sizes can be measured?



The Basics

Particle

Particle Distribution

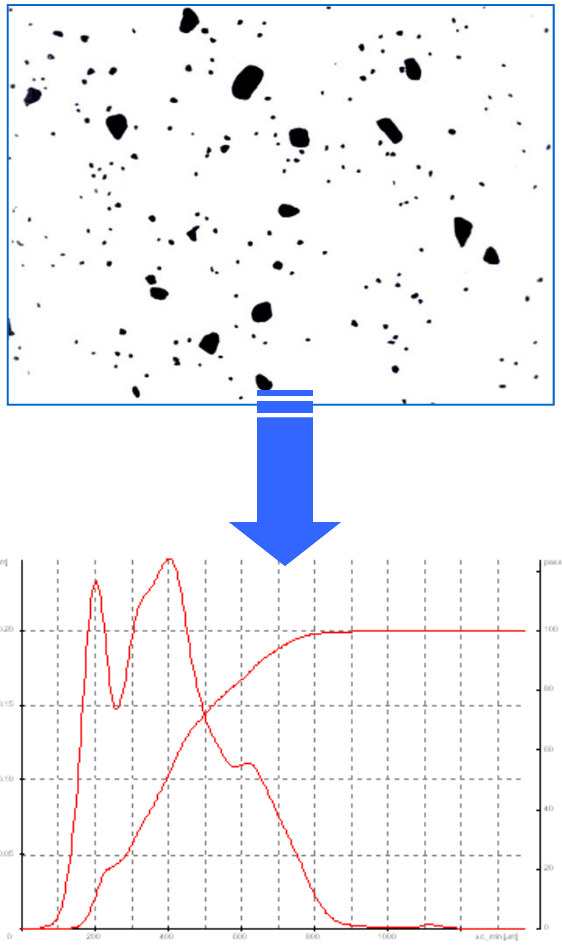


The Basics

Particle Size

4 µm

Particle Size Distribution

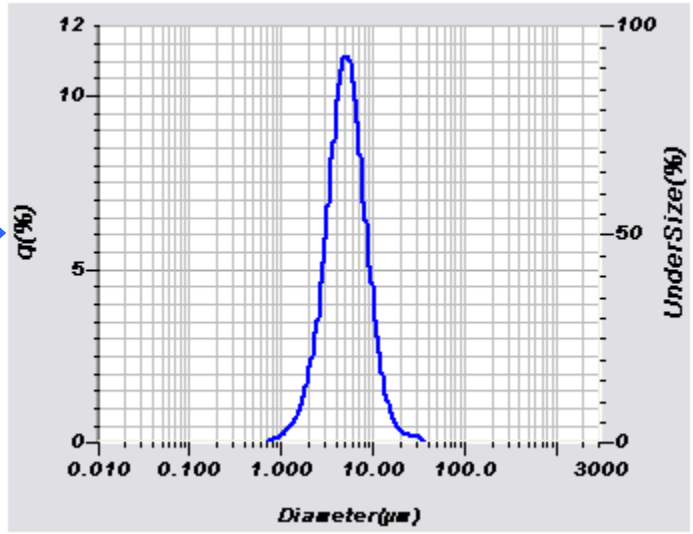


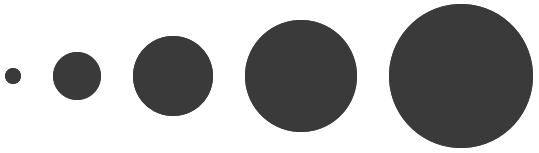
The Basics

Laser Diffraction

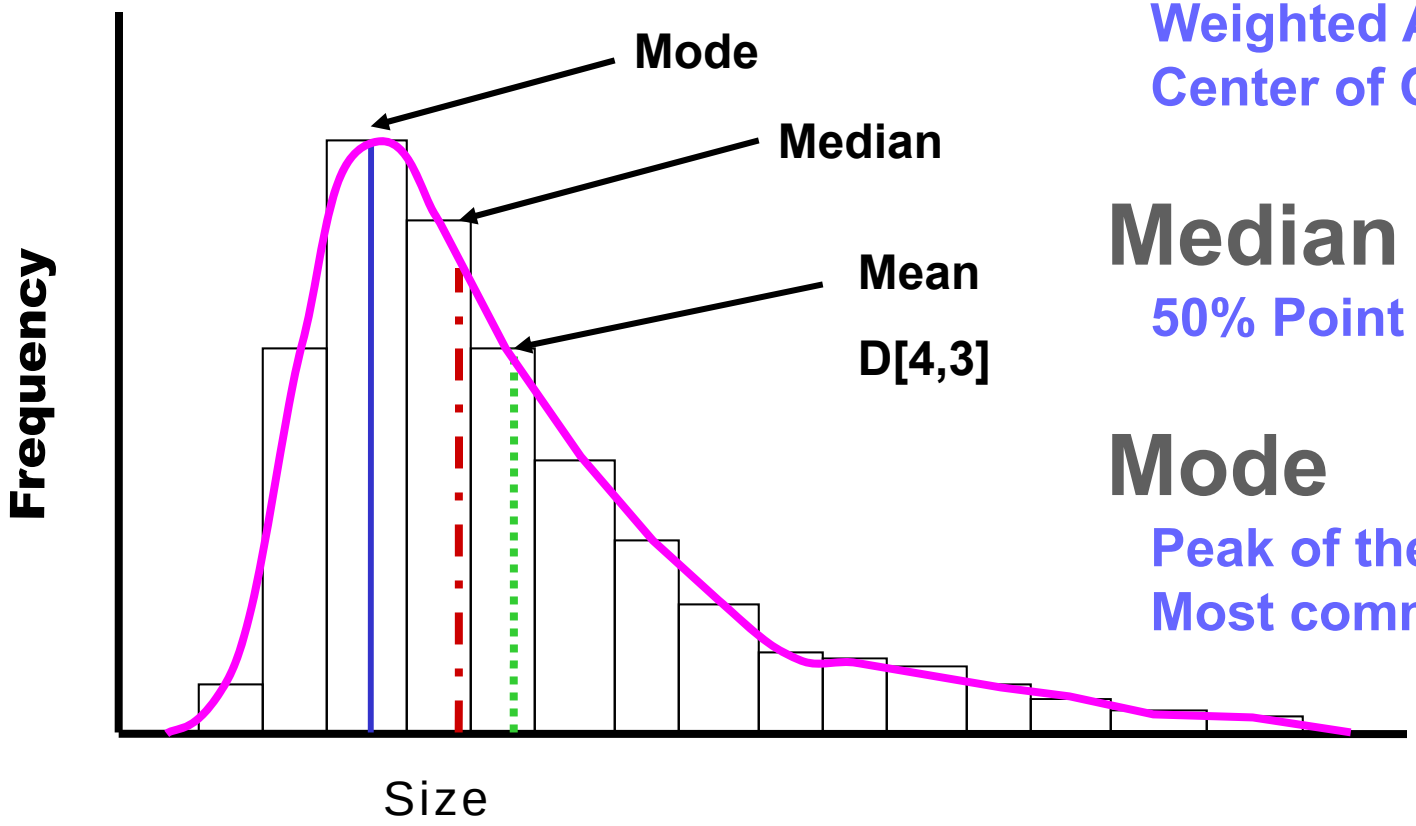
Assumes hard, spherical shape model

q% = amount of each size by volume





Central Values



Mean

Weighted Average
Center of Gravity

Median

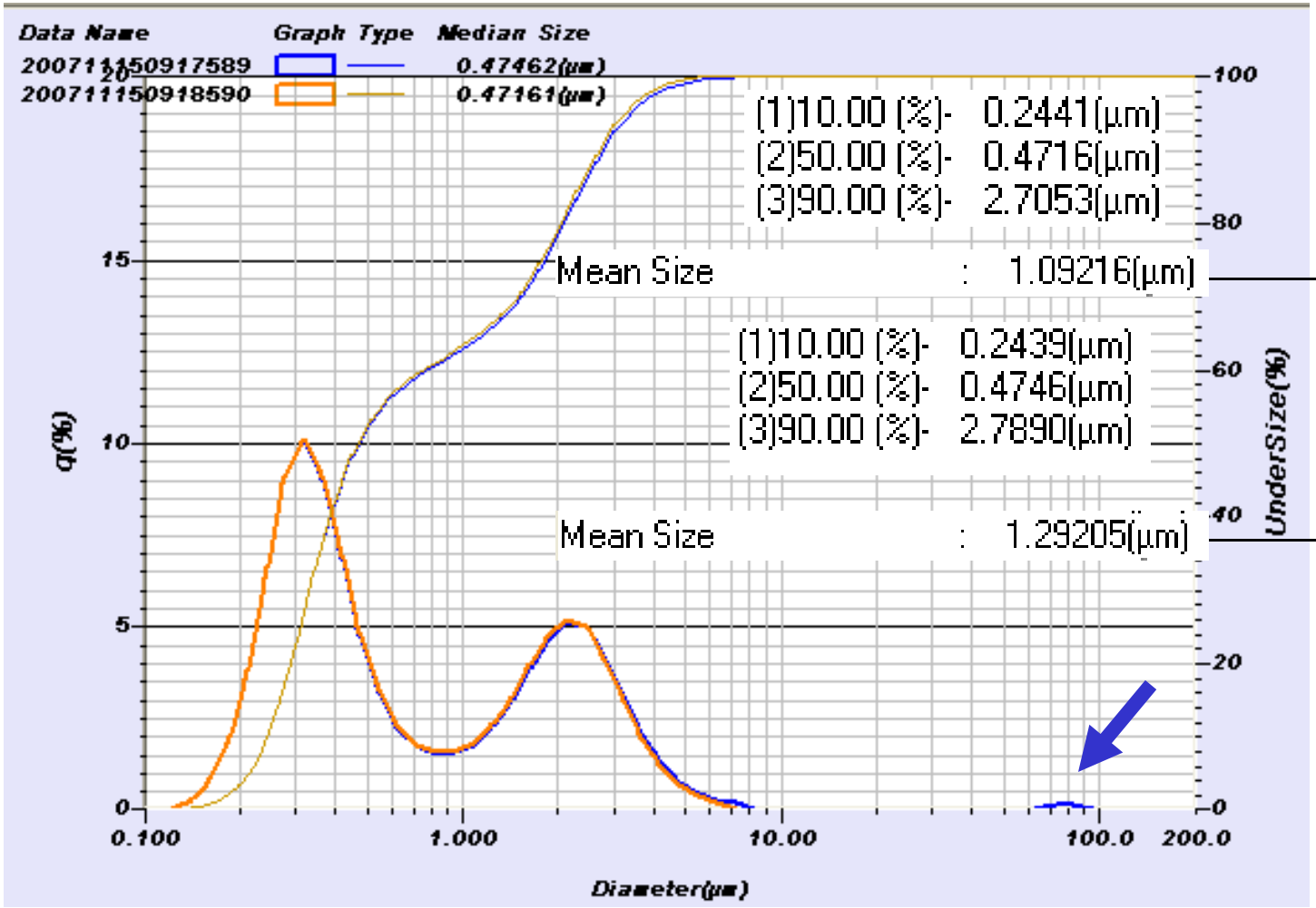
50% Point

Mode

Peak of the distribution
Most common value

Remember: D[4,3] is sensitive to large particles

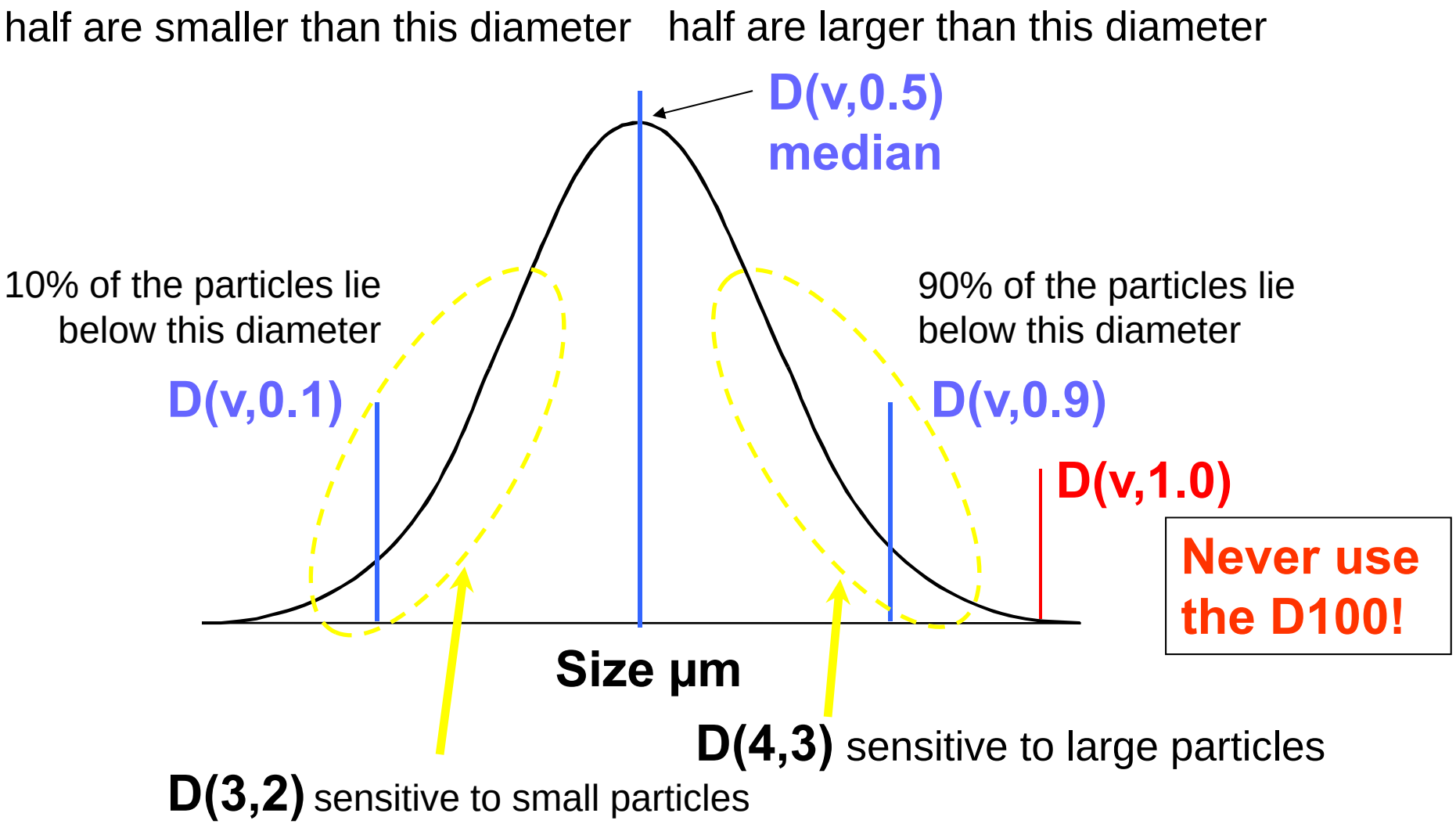
Mean vs. Median



15% difference

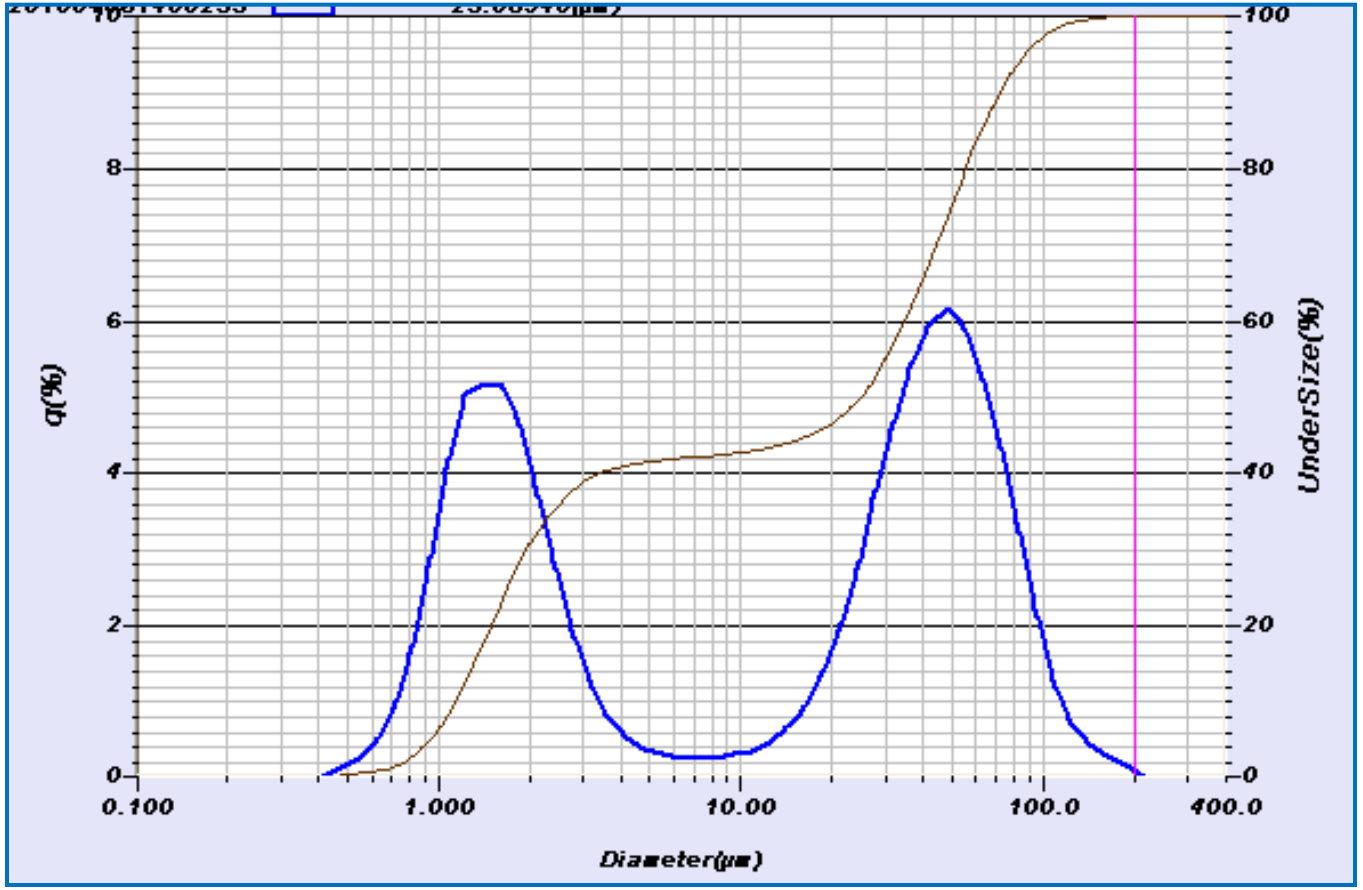
Classic example: CMP slurries

Most Common Statistics

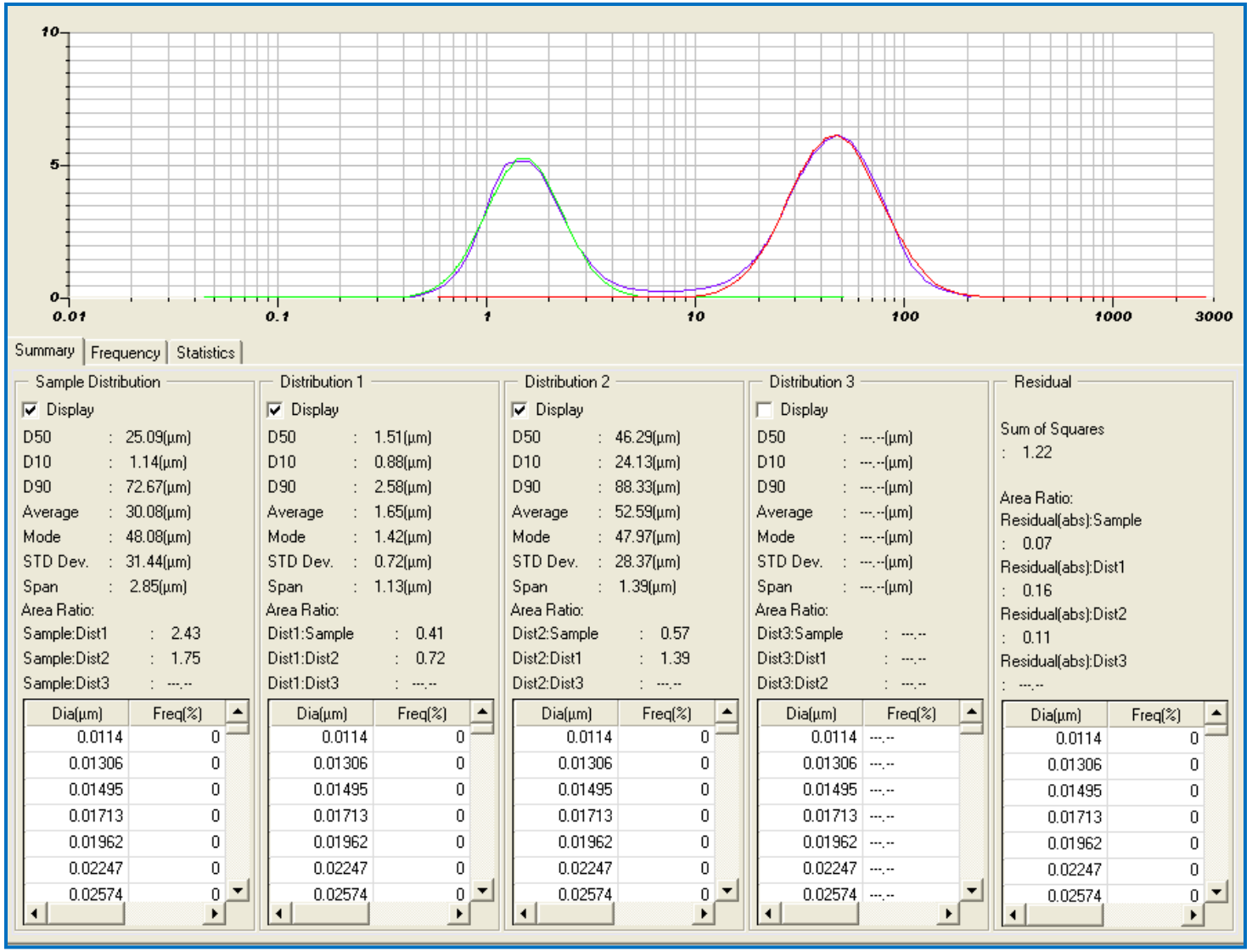


Bimodal Distribution

Which numbers to use for specifications?
D50 still an option, but some prefer finer details



Multimodal Report



Automate COV Calculation

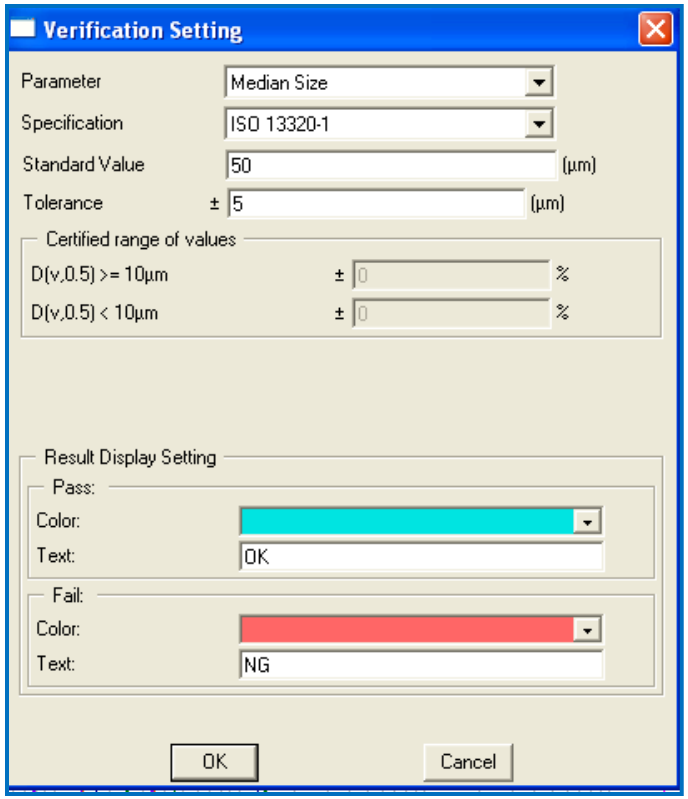
- Coefficient of Variation indicates precision of multiple measurements
- ISO 13320 makes recommendations using COV

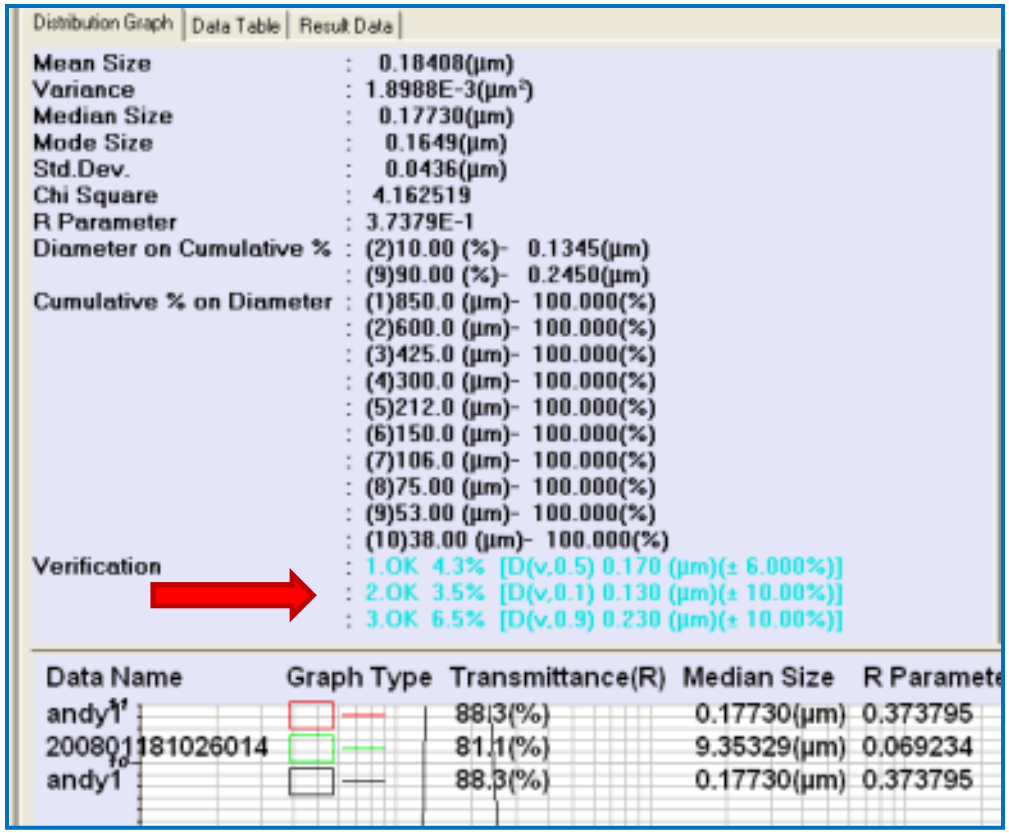
Summary Report

Export Summary | Print Summary | Edit Layout | Best Fit Columns | Hide Selected | Exit

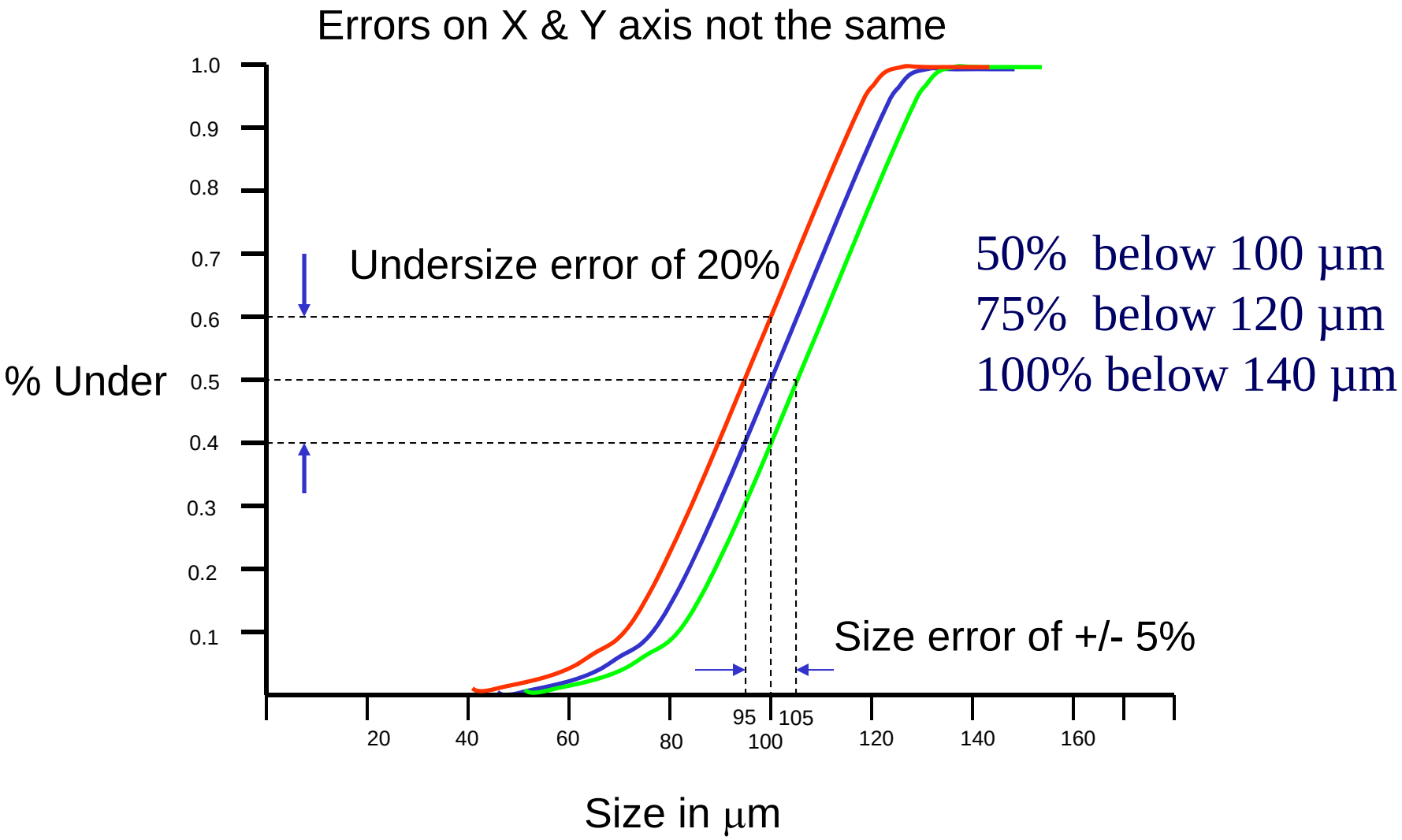
File Name	Sample Name	D(v,0.1)	D(v,0.5)	D(v,0.9)
200811061138068.NGB	Zircoa Slurry	0.065	0.107	0.185
200811061140069.NGB	Zircoa Slurry	0.071	0.145	11.896
200811061144070.NGB	Zircoa Slurry	0.069	0.129	3.838
Average		0.068	0.127	5.306
Std. Dev.		0.003	0.019	5.992
CV (%)		4.471	15.023	112.921
ISO 13320-1 (20.0, 15.0, 20.0)		PASSED	FAILED	FAILED

Result Verification



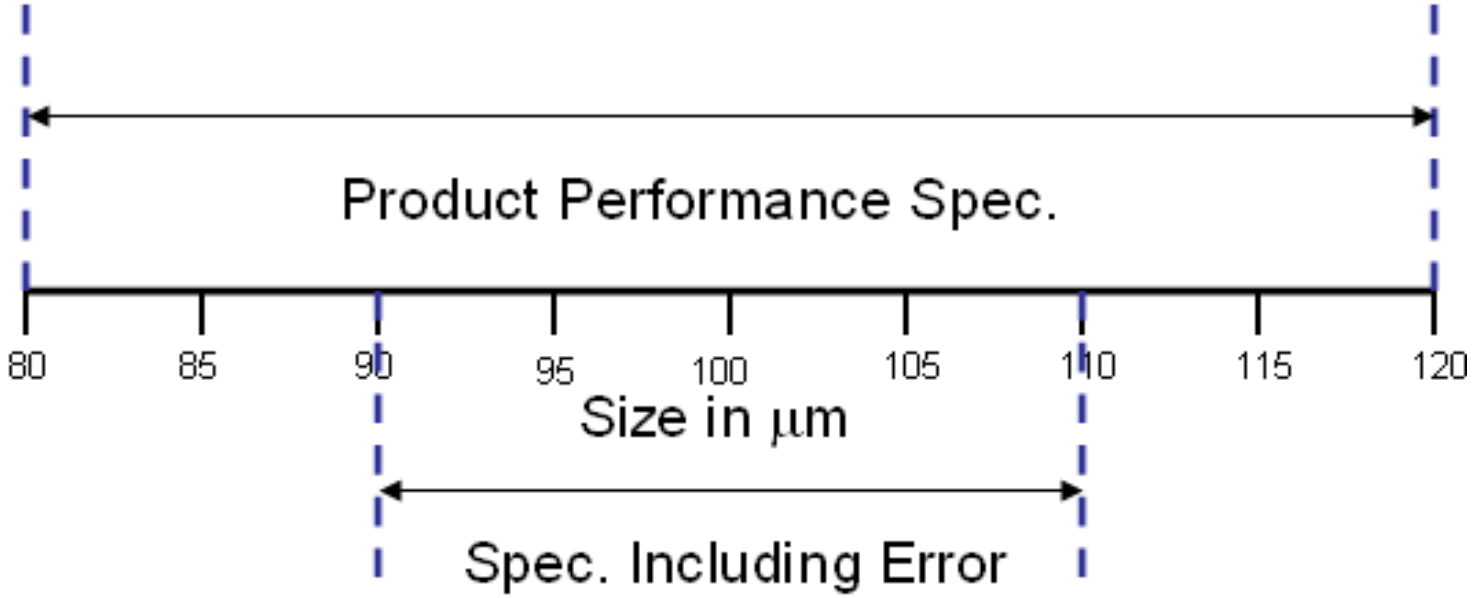


Specification on X or Y Axis



Specification with Error

Must tighten internal spec by lab error %
Then product always within performance specification



http://www.spcpress.com/pdf/Manufacturing_Specification.pdf, By David Wheeler

Specification with Error

- Must tighten internal spec by lab error
- Therefore minimize lab error makes life easier
- How to minimize error?
  - Get sampling right
  - Structured method development
  - Eye on the goal: reproducibility

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Thank you

ありがとうございました

ขอบคุณครับ

谢谢

اشكُرْ

Gracias

Grazie

Σας ευχαριστούμε

धन्यवाद

நன்றி

Tacka dig

Danke

Merci

Obrigado

감사합니다

Большое спасибо

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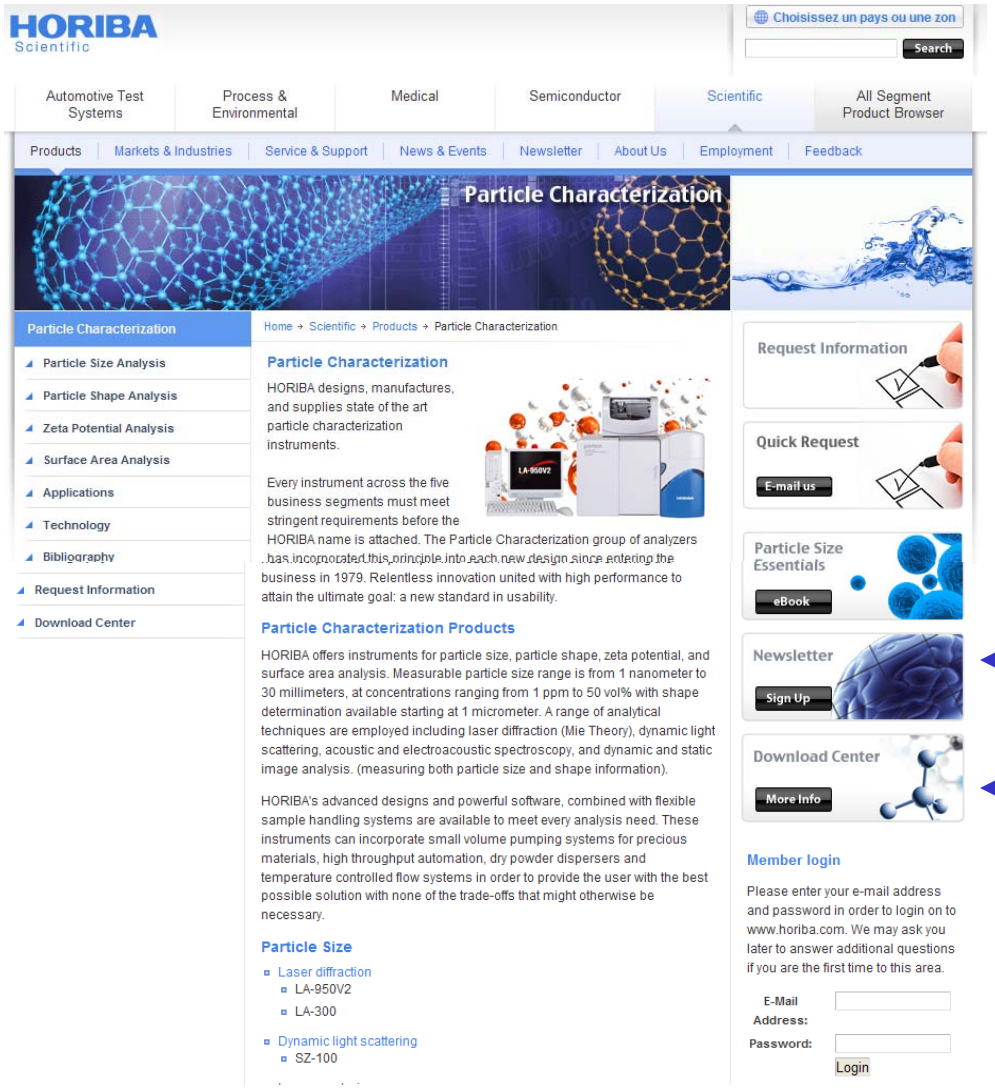

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