Schweizerische Eidgenossenschaft
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Swiss Confederation

Swiss Federal Office of Metrology METAS

International comparisons of national standards for particle counting and sizing

13th ETH-Conference on Combustion Generated Nanoparticles, june 22nd to 14th 2009

Outline

- **Introduction**
  Motivation – range of concentrations and sizes
- **National metrology Institutes (NMI)**
  role – traceability
- **Project EURAMET 1027**
  scope – procedure – participants – instrumentation
- **EURAMET 1027 – Comparison**
  aerosols – procedure – results number – results size
- **Summary and Outlook**

Motivation for Metrology

ambient measurements

clean-room monitoring

emission measurements

human protection / security

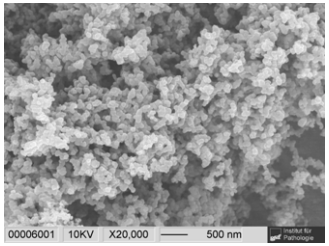
Number concentration and size range

Examples of number concentrations:

Diesel exhaust fumes:	1 000 000 000 cm^{-3}
Urban air:	1 000 000 cm^{-3}
Rural air:	10 000 cm^{-3}
Mountain air (Jungfraujoch):	100 cm^{-3}
Clean room class 9 (> 0.5 μm):	35 cm^{-3}
Clean room class 6 (> 0.1 μm):	1 cm^{-3}

Examples of particle sizes:

Water molecule	0.1 nm
Viruses	1 nm – 5 nm
Tobacco and Engine smoke	10 nm – 1000 nm
Bacteria	0.5 μm – 50 μm
Coal dust	1 μm – 100 μm



Role of a metrology institute (NMI)

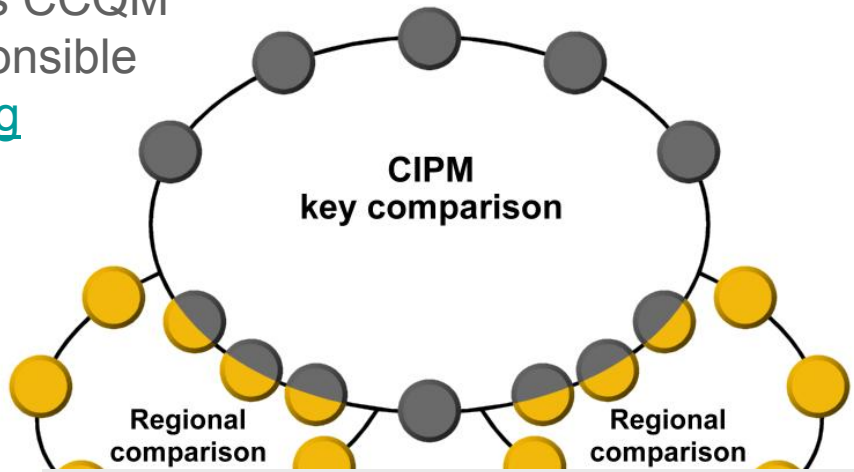
NMI must cover the need for correct measurements:

- Trading units:
  Mass, electrical current, volume, length …
- Public health of human, animals (production and wild) :
  contamination of food, air pollution, soil pollution, noise …
- Public security:
  radioactivity, speed of cars, …
- Administrative measures:
  Homologation of vehicles, exhaust measurements, …

NMI may delegate the responsibility to a designated body.

Traceability on level of NMIs

e.g. for gas analytics CCQM from CIPM is responsible
www.bipm.org



e.g.. EURAMET "Metrology in Chemistry" TC-MC
www.euramet.org

Process is necessary for declaration in BIPM-database: ***Calibration and measurement capabilities (CMC)*** ***http://kcdb.bipm.org/***

Calibration and Measurement Capabilities

Amount of substance, gases, Switzerland, METAS (Federal Office of Metrology)

KCDB

Note: No ranges of certified values in reference materials declared by Switzerland.

The notation Q[a, b] stands for the root-sum-square of the terms between brackets: $Q[a, b] = [a^2 + b^2]^{1/2}$

NMI Service Identifier	Measurement Service Sub-Category	Matrix	Measurand		Dissemination Range of Measurement Capability			Range of Expanded Uncertainties as Disseminated						Mechanism(s) for Measurement Service Delivery
			Analyte or Component	Quantity	From	To	Unit	From	To	Unit	Coverage factor	Level of confidence	Is the expanded uncertainty a relative one?	
232-1	Environmental	nitrogen	carbon monoxide	Amount-of-substance fraction	40	200	µmol/mol	0.8	0.8	%	2	95%	Yes	Calibration of gases
232-2	Environmental	nitrogen	carbon monoxide	Amount-of-substance fraction	1	50	mmol/mol	0.4	0.4	%	2	95%	Yes	Calibration of gases
232-3	Environmental	nitrogen	carbon	Amount-of-substance	50	150	mmol/	0.4	0.4	%	2	95%	Yes	Calibration of

Project EURAMET 1027 – framework

Goal:

- Degree of equivalence for particle number concentration of national standards
- Degree of equivalence for particle sizing (equivalent mobility diameter) of national standards
- Exchange of knowhow between NMIs
- Assessment of measurand (especially size distribution parameters) for future comparisons

Method:

- Experimental work
- Comparison with combustion aerosol (CAST): unimodal and quasi monodisperse particles
- Measurement at same moment the same aerosol

Project EURAMET 1027

Participants	Measurand		
• AIST (JP)	Number	------	----------
• DFM (DK)	----------	------	Structure
• FORCE (DK)	----------	Size	----------
• METAS (CH)	Number	Size	----------
• NPL (GB)	Number	Size	----------
• UBA (DE)	Number	Size	----------

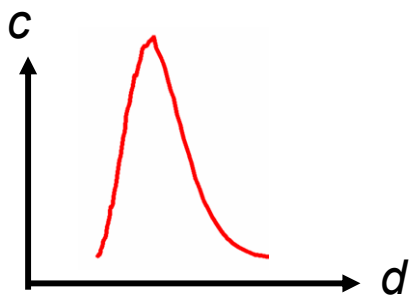
Instrument types

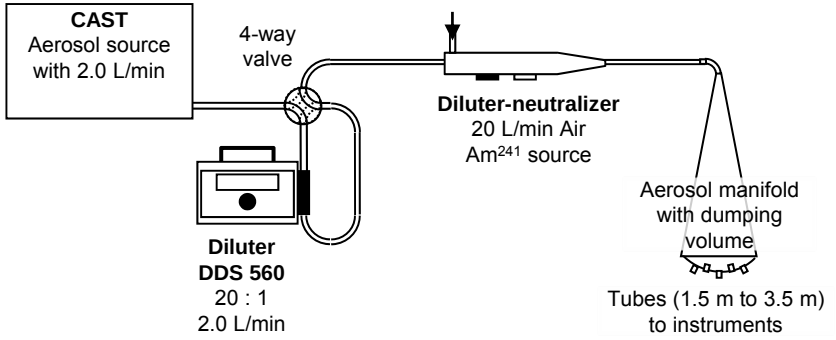
- Number: Condensation Particle Counter (CPC)
- Size: Scanning Mobility Particle Sizer (SMPS)
  Electrical Low Pressure Impactor (ELPI)
- Structure: Atomic Force Microscope

EURAMET 1027 – aerosol generation

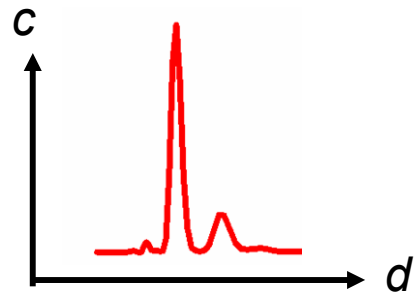
Particle generation:

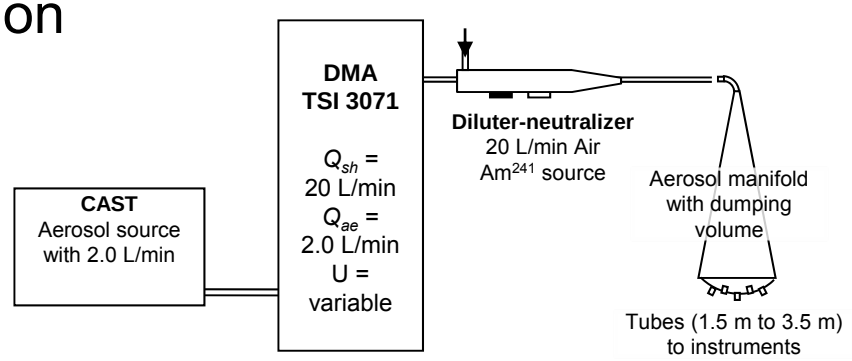
"natural" size distribution





monodisperse size distribution





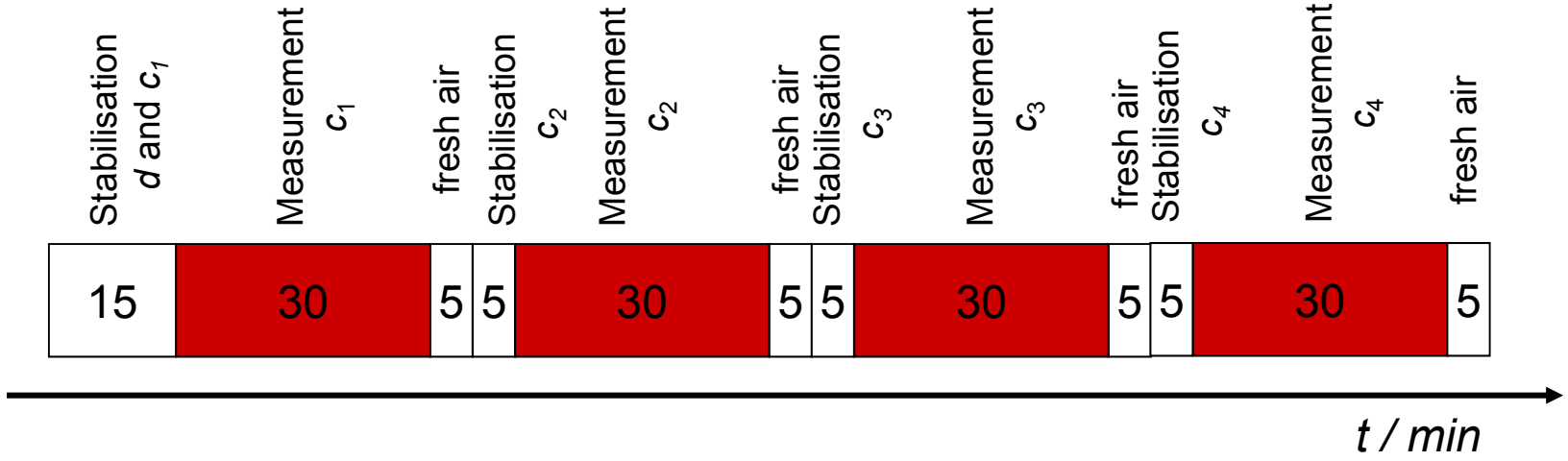
EURAMET 1027 – comparison routine

Particle number and concentrations

„natural“ size distribution $\sigma_g \approx 1.6$
d_i: 70 … 170 nm at c_i: 10^3 cm^{-3} … 10^6 cm^{-3}

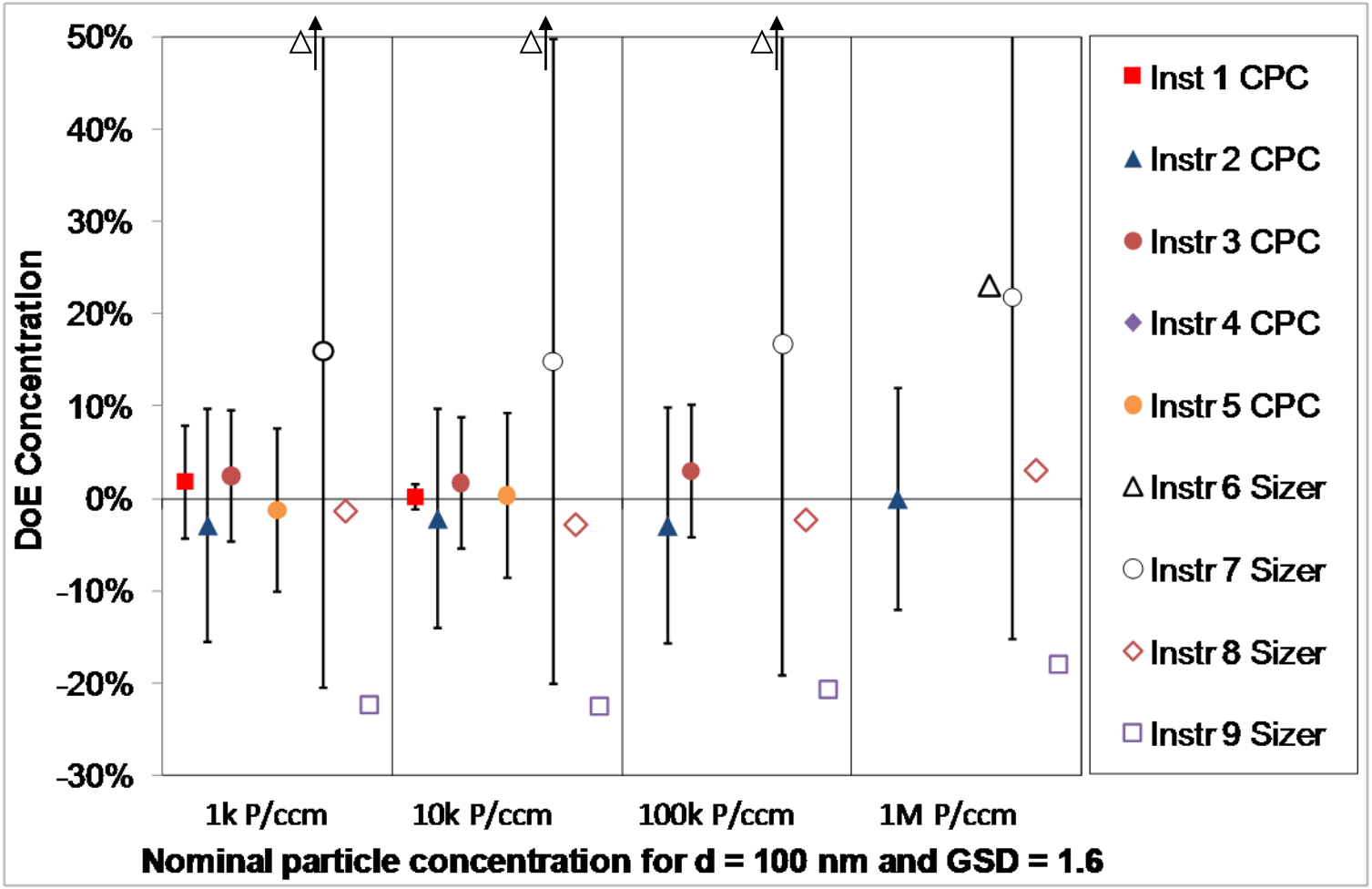
„monodisperse“ size distribution: $\sigma_g < 1.1$
d_i: 50 … 180 nm at c_i: 10^3 cm^{-3} and 10^4 cm^{-3}

Cylce per particle size:



EURAMET 1027 – results 1/5

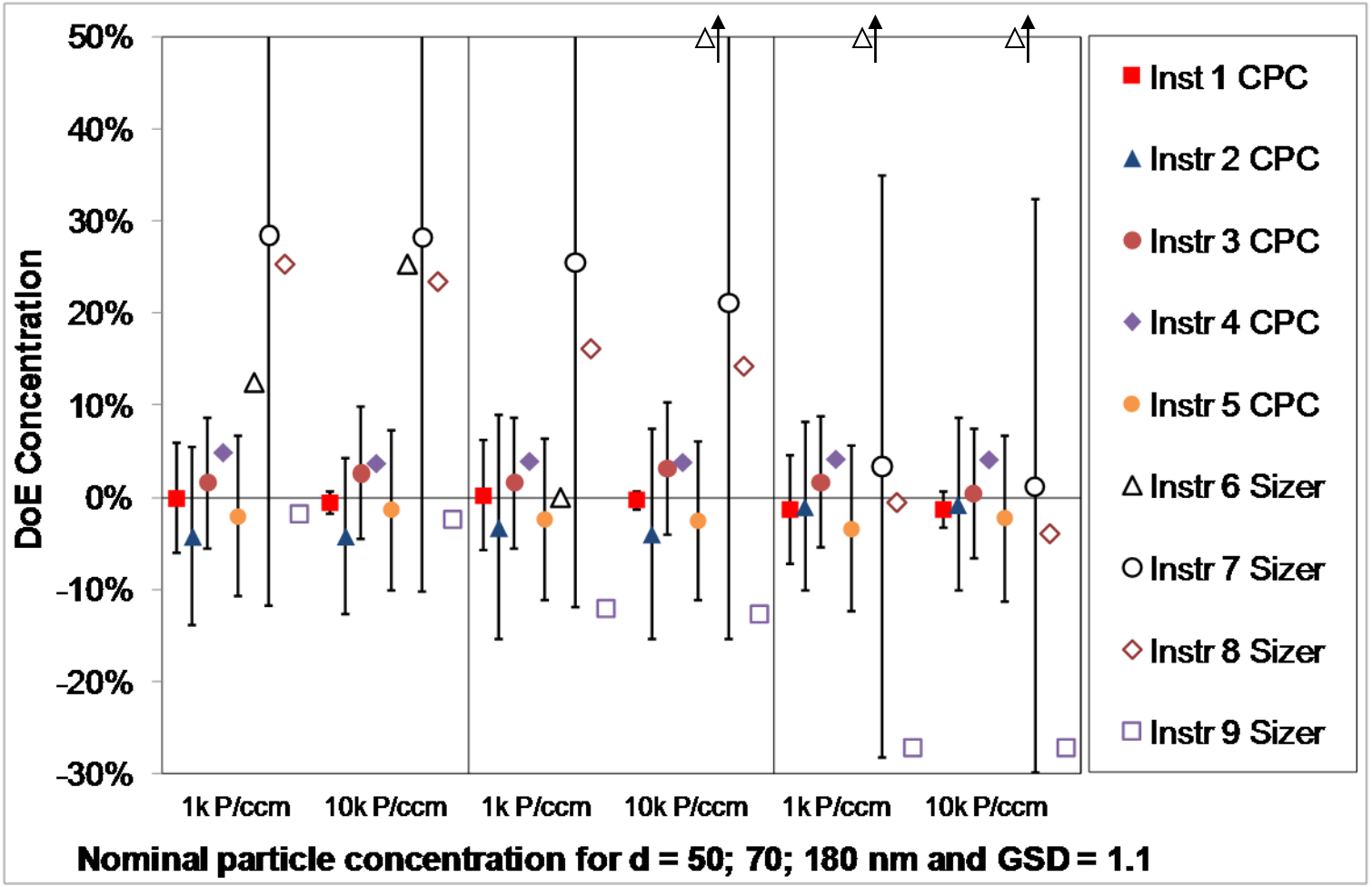
Number concentration – “natural” size distribution



The bars indicate the uncertainties with $k = 2$

EURAMET 1027 – results 2/5

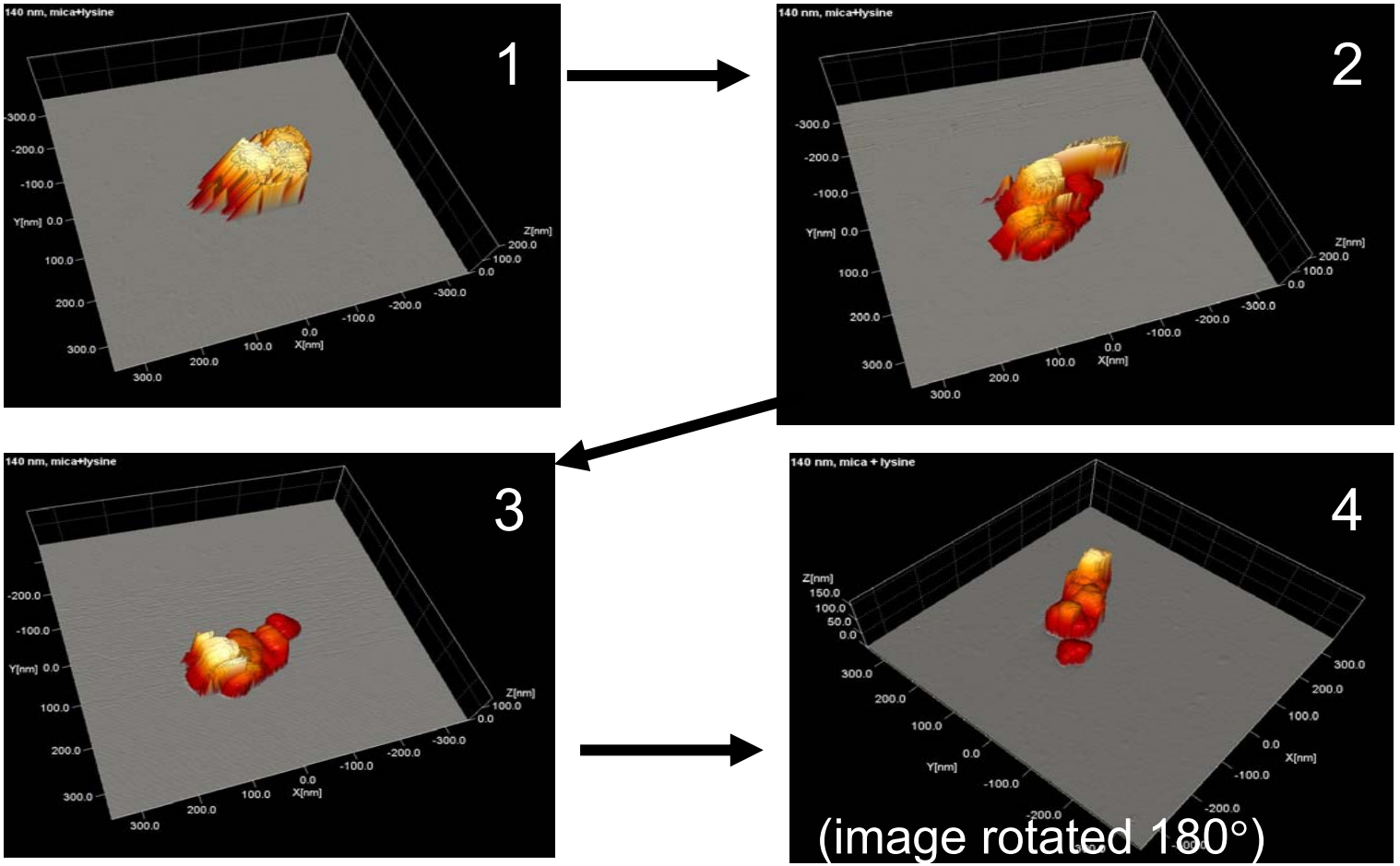
Number concentration – “monodisperse” size distribution



The bars indicate the uncertainties with $k = 2$

EURAMET 1027 – results 3/5

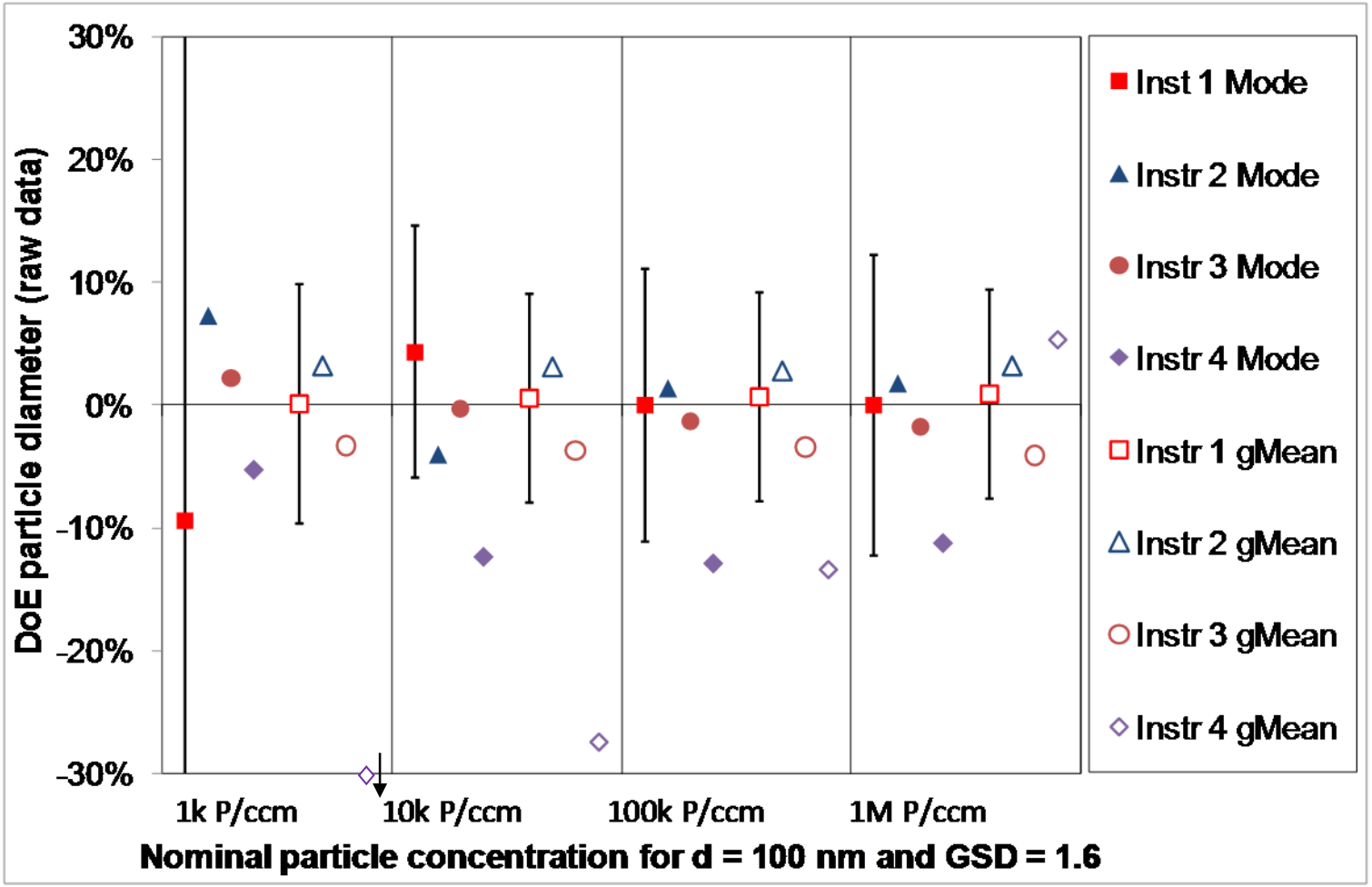
Material erosion of a particle under an AFM scan sequence



AFM pictures from DFM

EURAMET 1027 – results 4/5

Mode and geometric mean – “natural” size distribution

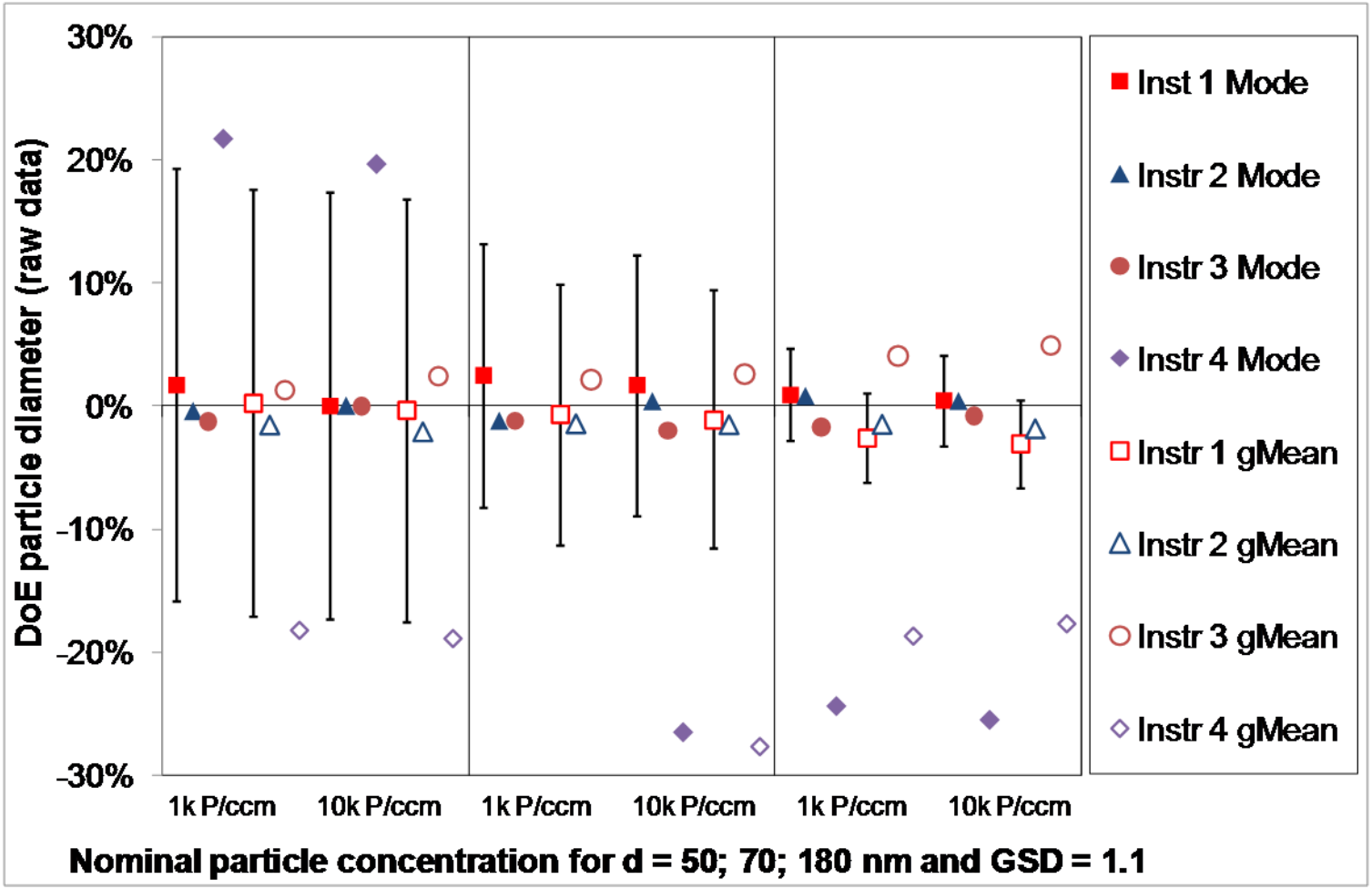


Diameter = Electrical Mobility ≠ Aerodynamic diameter

The bars indicate the uncertainties with $k = 2$

EURAMET 1027 – results 5/5

Mode and geometric mean – “monodisperse” size distribution



Diameter = Electrical Mobility ≠ Aerodynamic diameter

The bars indicate the uncertainties with $k = 2$

EURAMET 1027 – Summary

National standards for particle number concentration and particle size measurement have been established in NMIs.

Particle number concentrations:

- Equivalence of particle counters within stated uncertainties
- Equivalence of particle counters normally within ± 5 %
- Equivalence of particle sizers much better
- Lack of uncertainty statement for sizers

Particle size distributions (electrical Mobility):

- Equivalence of particle counters within stated uncertainties
- Equivalence for Mode and Geo. Mean within ± 5 %
- Equivalence of particle sizers much better
- Lack of uncertainty statement for sizers

Outlook

- Particle number concentration and particle size become important quantities in environmental protection and occupational safety.
- With EURAMET 1027 collaboration of NMIs has started; project supports future national initiatives.
- Equivalence is proved for “well-behaved” particles; NMI are willing to take over the responsibility to establish the reference for particle measurements.
- Further discussion is needed on: cropped size distributions, distribution parameters, size distributions curve fitting, uncertainty.
- Further work needed to enlarge size range

Thank you

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UBA Klaus Wirtz

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