NPL National Physical Laboratory

Ensuring the comparability of nanoparticle measurements by the international metrology community

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Overview

(1) International measurement comparability

(2) CCQM-K185 international comparison: particle number concentration and particle charge concentration: overview and results

(3) Ongoing aerosol science activities of National Measurement Institutes and Designated Institutes

CCQM-K185 participants

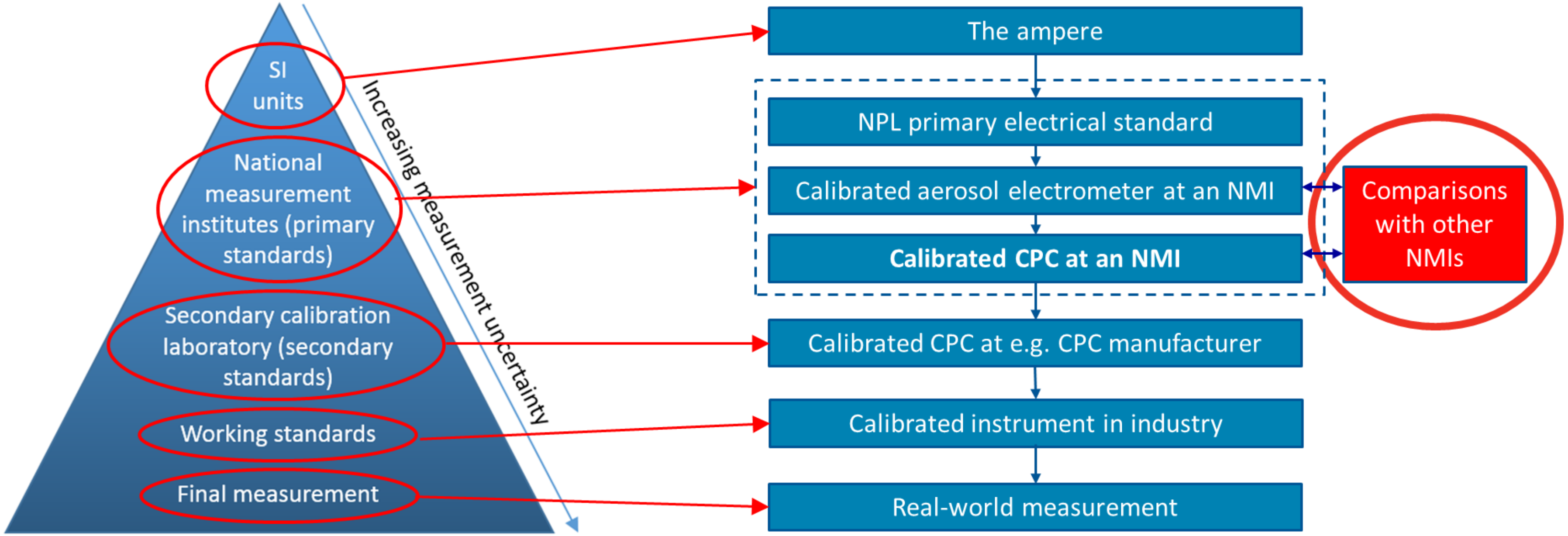
NPL: coordinator, PTB: hosts - Andreas Nowak, Anza Waheed, David Godau, Ferris Fromme & Johannes Rosahl

CCQM-P237 participants

International comparability of measurements

- Ensuring that all measurements around the world are comparable is essential to support international trade and compliance to legislation.

- Measurement primary standards are maintained by National Measurement Institutes (NMIs) who compare their measurement capabilities via formal comparison exercises



CPC = condensation particle counter

International comparisons - summary

Comparison	Year performed	Scope
EURAMET 1027	2008	Particle number concentration: 1 000 to 1 000 000 cm^{-3} Particle size distribution: 70, 100, 140 & 170 nm
EURAMET 1244	2013	Particle charge concentration: 0.15 to 3 fC cm^{-3} [Using particle sizes from 6 to 200 nm]
EURAMET 1282	2013	Particle number concentrations: 100 to 20 000 cm^{-3} [Using particle sizes from 6 to 100 nm]
CCQM-K150	2017	Particle number concentrations: 100 to 20 000 cm^{-3} Particle charge concentration: 0.15 to 3 fC cm^{-3} [Using particle sizes of 40 & 50 nm]
CCQM-K185	2024	Particle number concentrations: 1 000 to 500 000 cm^{-3} Particle charge concentration: 0.15 to 16 fC cm^{-3} [Using particle sizes of 30, 50 & 80 nm]

General trend of increasing level of challenge

[1] https://doi.org/10.1088/0026-1394/60/1A/08014

CCQM-K185 international comparison

Test	Instrument	Particle type and size	Particle number concentrations / cm^{-3}	Particle charge concentrations / fC cm^{-3}
1	Condensation particle counter	Monodisperse soot 30 nm & 50 nm	1 000, 4 000, 10 000, 20 000, 50 000 & 100 000	-
2	Condensation particle counter	Polydisperse soot 80 nm	50 000, 100 000, 250 000 & 500 000	-
3	Faraday cup aerosol electrometer	Monodisperse soot 30 nm & 50 nm	-	0.16, 0.64, 1.6, 3.2, 8.0 & 16.0

Coordinator:

NPL National Physical Laboratory

Host:

PTB

- Participants: KRISS (Korea), METAS (Switzerland), NIM (China), NMC (Singapore), NMIJ/AIST (Japan), NPL (UK), NRC (Canada) & PTB (Germany)

- High particle number concentrations (up to 500 000 cm^{-3}) relevant to legislation for the periodic technical inspection of road vehicles

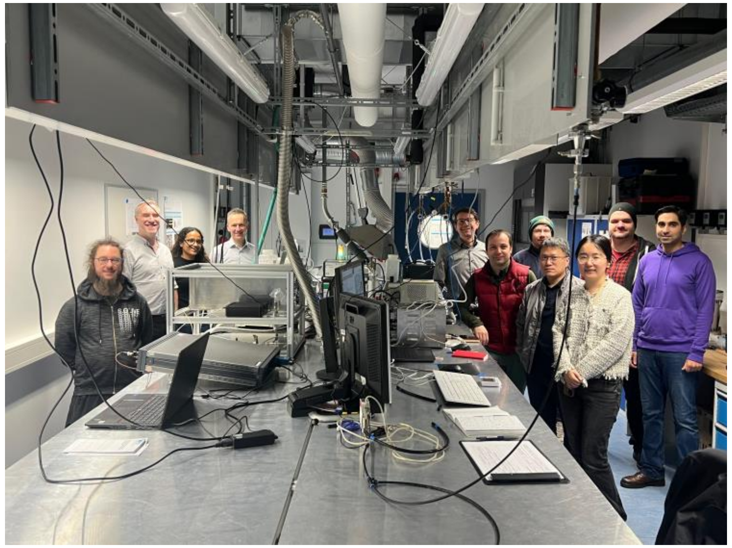
- *A plot study (CCQM-P237) was performed the week before K185. Participants were TROPOS, UBA (Germany), PTB, NPL & NIM. Results from P237 are not discussed in this presentation*

Comparison protocol

- Comparison operated according to a detailed protocol.
  Two days of FCAE tests; three days of CPC tests.

- 30 nm, 50 nm and 80 nm soot particles generated by Mini-CAST 5303C instrument and sampled from a 20-port chamber

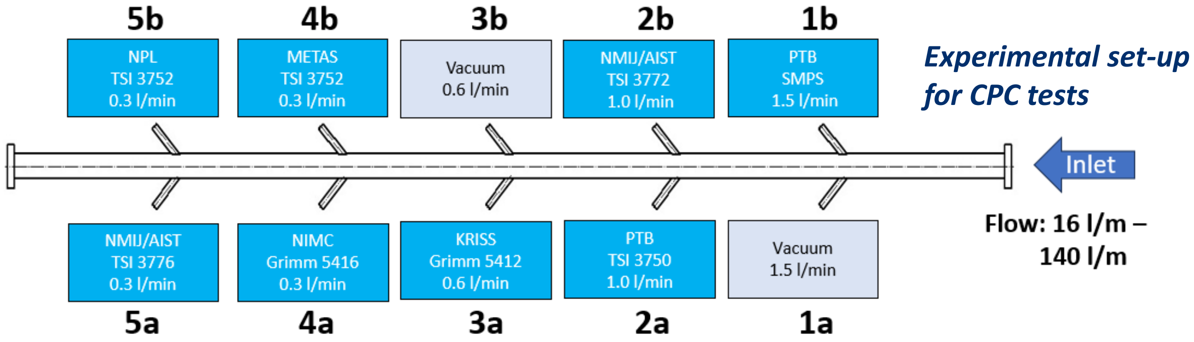
- Flow rates: 16 L min^{-1} to 140 L min^{-1} (CPC tests) and 21 L min^{-1} to 170 L min^{-1} (FCAE tests), depending on the particle size and number concentration used



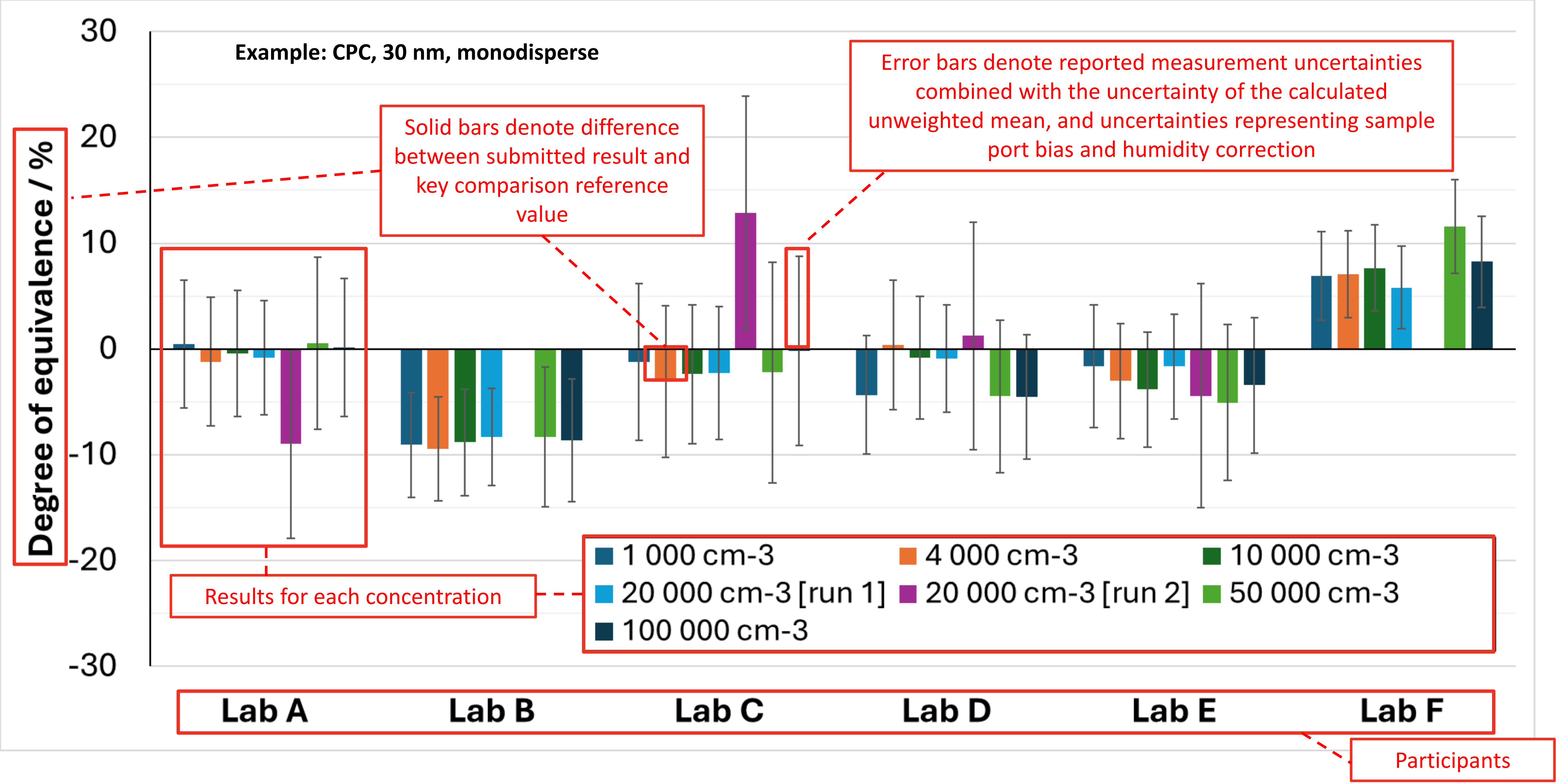
- Comparison of mass flow meters performed at the start and end of CPC and FCAE tests

- Daily dilution factor measurements performed during CPC tests

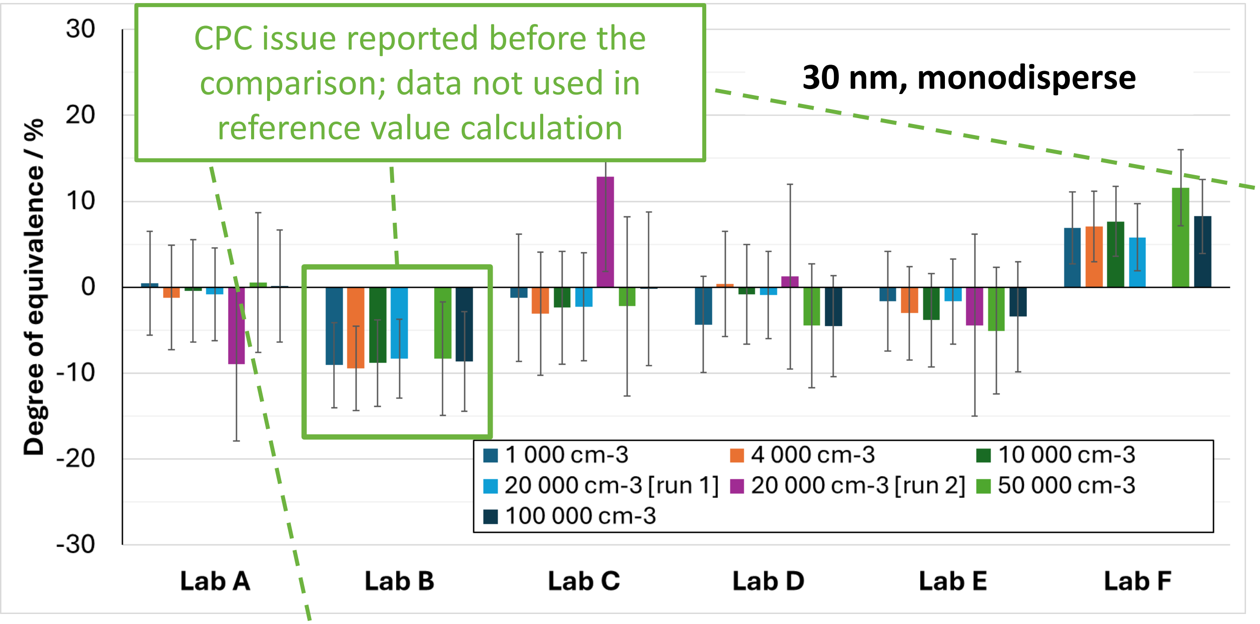
- *Each lab submitted results (measured mean concentrations, uncertainties and metadata) to NPL for independent processing*

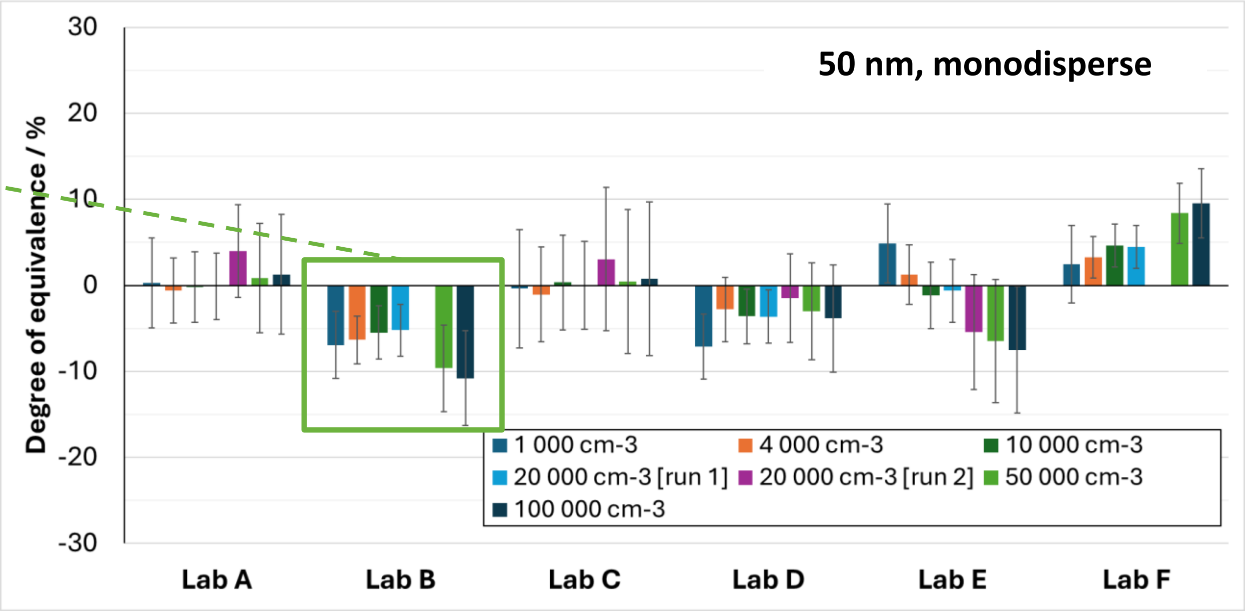


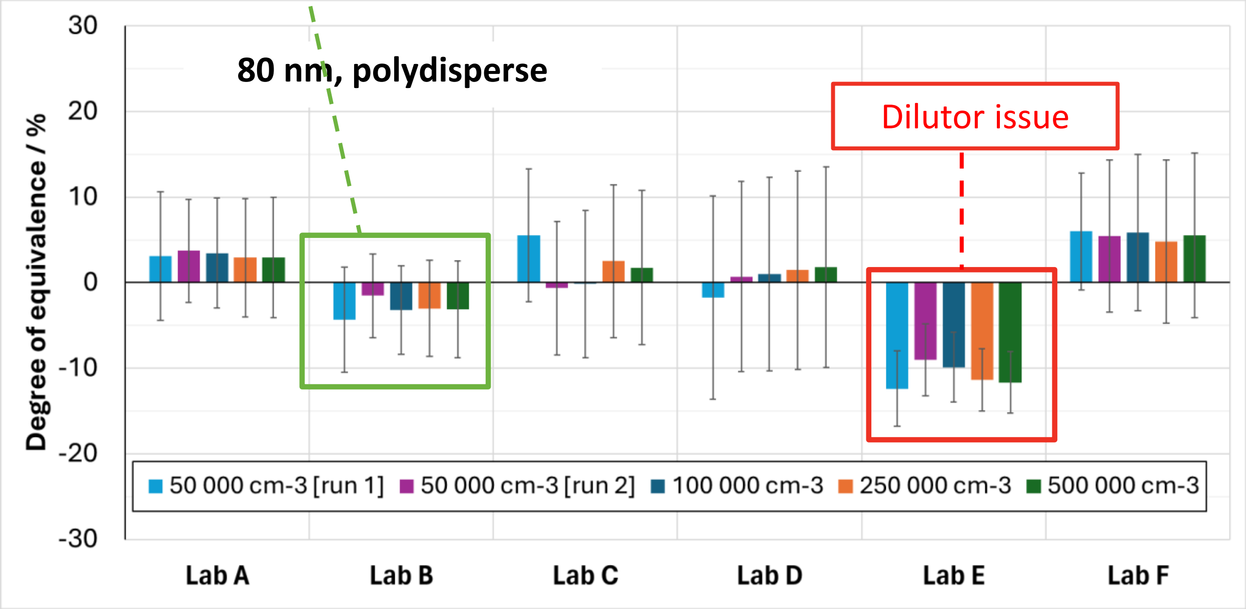
Understanding how the results are presented



Provisional results: Particle number concentration

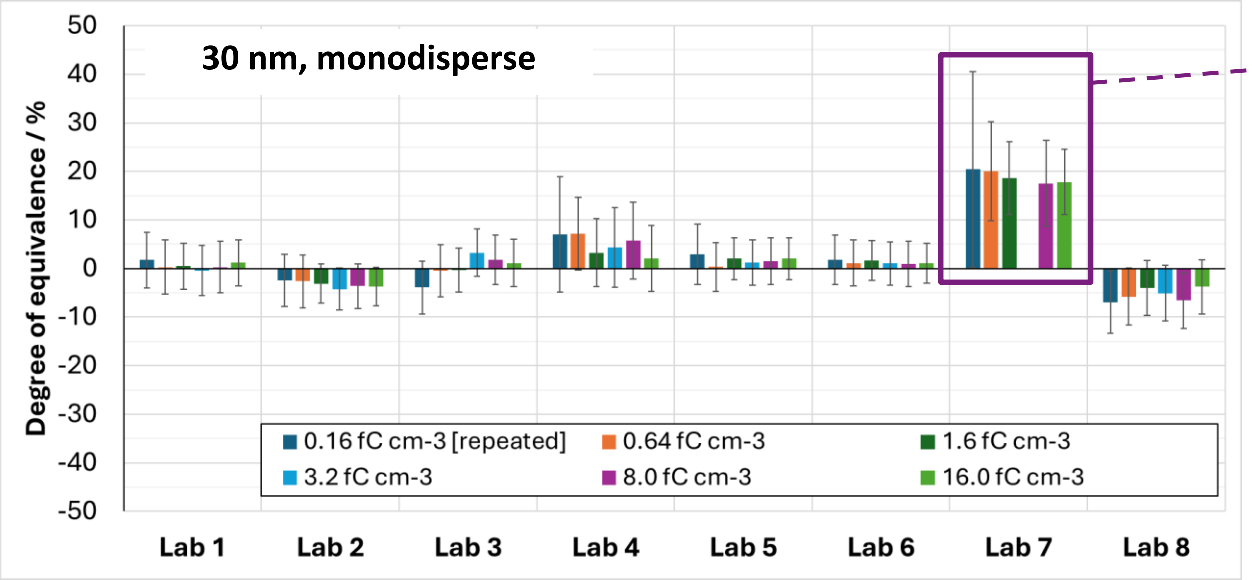


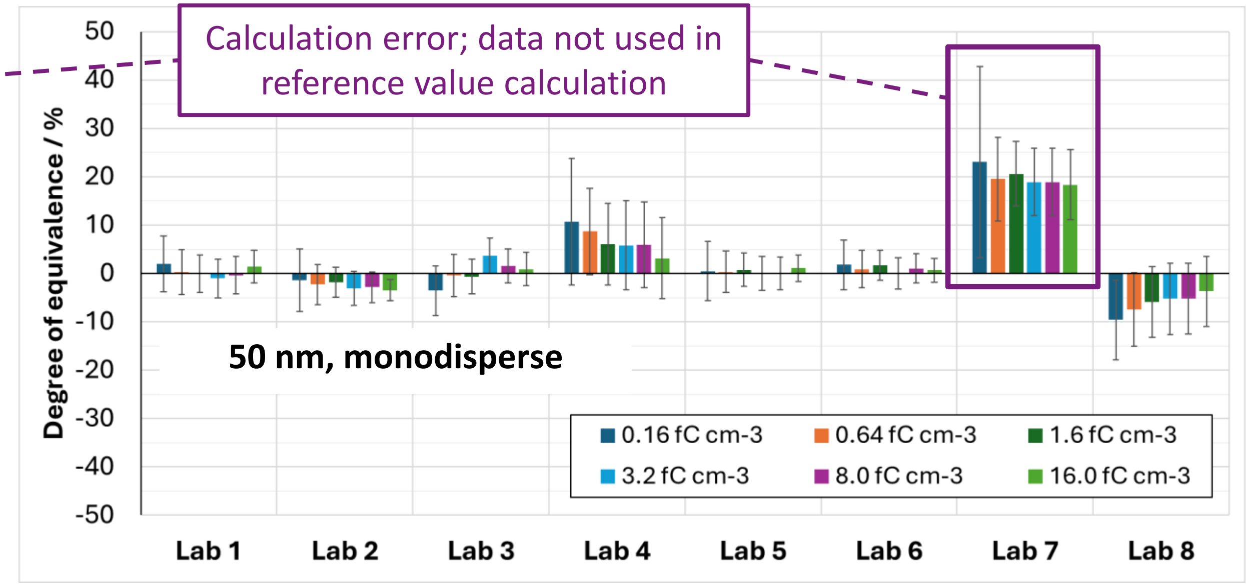




- Range of instruments and measurement approaches (with / without dilutor) used
- 30 nm and 50 nm tests: results of four of the six participants agree with the key comparison reference value for all, or all but one, concentrations
- 80 nm tests: better agreement with the KCRV was demonstrated (five out of six laboratories agreeing with the KCRV for all concentrations)

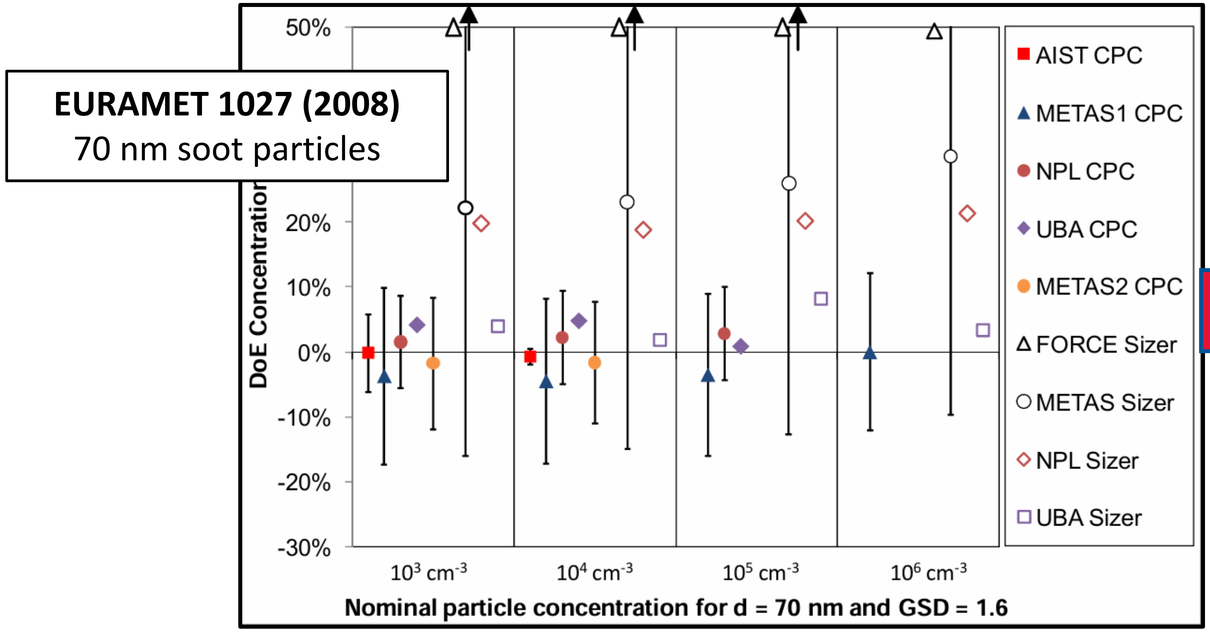
Provisional results: Particle charge concentration

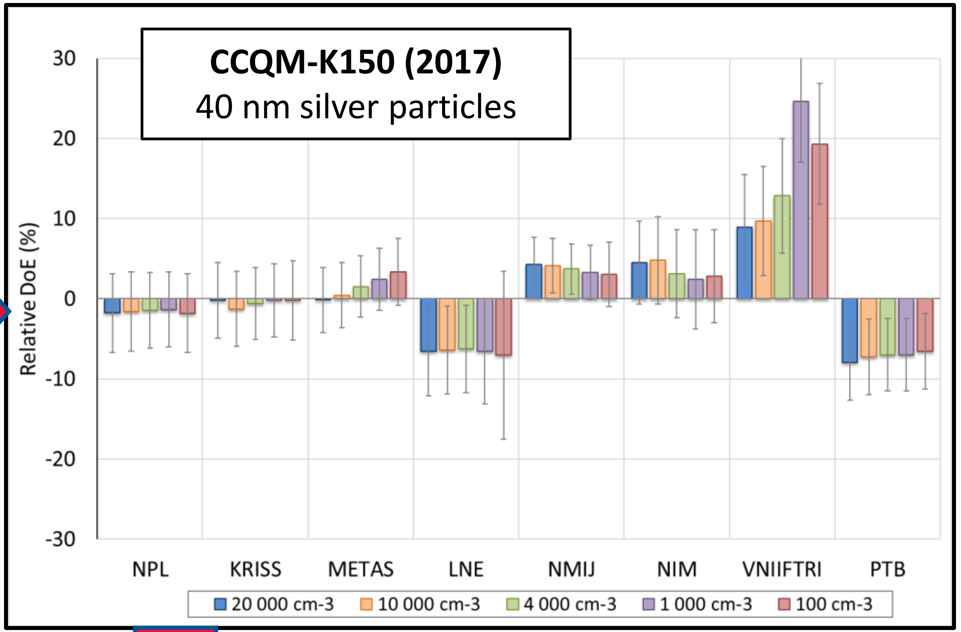


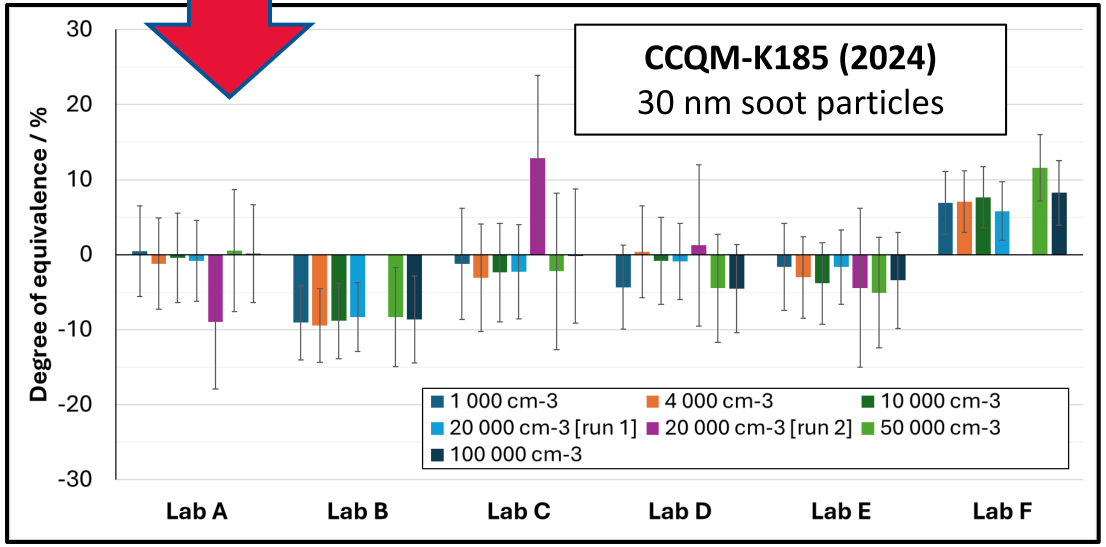


- No dilutors were used
- Similar level of agreement obtained for both particle sizes
- For both 30 and 50 nm tests: results of seven of the eight participants agree with the key comparison reference value for all, or all but one, of the concentrations

Progress from previous comparisons







- Note that example results are shown (tests and participants differ between each comparison)
- General trend of better agreement between labs and more robust uncertainty assessment

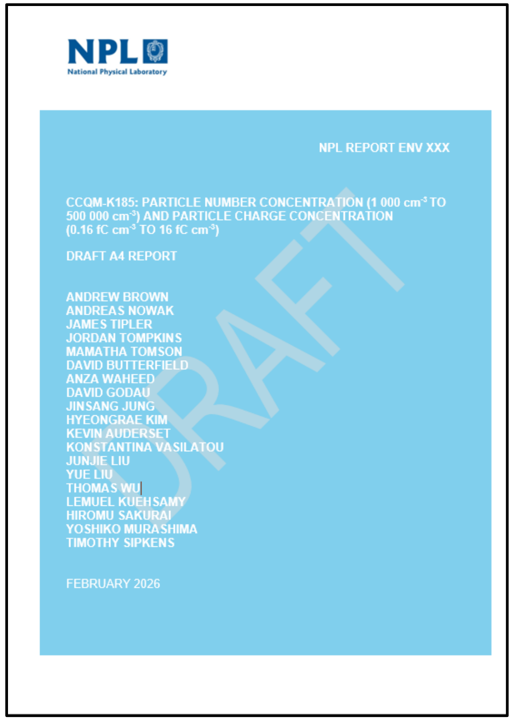
Next steps

CCQM-K185

- Finalise and publish the final report from the comparison (currently under review by the CCQM-GAWG)

- Results will be made available on on the BIPM Key Comparison Database (KCDB): https://www.bipm.org/kcdb/

- NMIs can claim Calibration and Measurement Capabilities (CMCs) of each NMI based on their performance in these key comparisons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CCQM-K185: PARTICLE NUMBER CONCENTRATION (1 000 cm^{-3} TO 500 000 cm^{-3}) AND PARTICLE CHARGE CONCENTRATION (0.16 fC cm^{-3} TO 16 fC cm^{-3})

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FEBRUARY 2026

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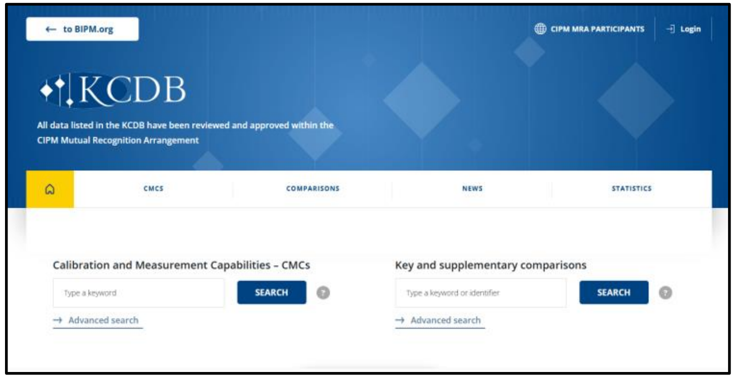
Subsequent comparisons (same measurements as CCQM-K185)

- CCQM-K185.1 (CPC only): Lab B & Lab D [April 2026]

- CCQM-K185.2: LNE (France), NPLI (India), CEM (Spain) & PTB [October 2026]



Key findings and conclusions

- Eight National Metrology Institutes have participated in the CCQM-K185 key comparison on particle number concentration and particle charge concentration. [UBA and TROPOS participated in the analogous CCQM-K237 pilot study.]
- In general, good comparability was observed between the participants, with most measurements agreeing with the consensus derived key comparison reference values (withing the measurement uncertainties)
- Most of the significant deviations from the KCRVs can be explained as instrumentation of calculation issues
- Agreement between NMIs has shown some improvement over time (across a number of comparisons), but further improvements are still possible.
- Developing a transportable 'aerosol reference material' would enable future comparisons to be performed in a similar manner to gas metrology comparisons (use of a known reference value and measurements being performed in 'home' laboratories).

CCQM-GAWG Aerosol Metrology Task Group

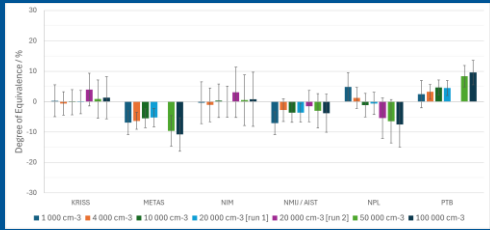
NPL

- Established in 2024 to bring the NMI & DI nanoparticle community closer together and deliver improved and coordinated engagement with the global aerosol science stakeholder community. https://www.bipm.org/en/committees/cc/ccqm/wg/ccqm-gawg-tg-aerosol

- **Current activities:**

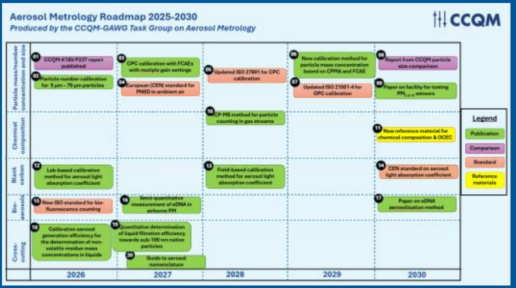
Comparability of measurement

- CCQM-K185 & P237
- Particle size down to 10nm (in planning)
- $PM_{2.5}$ cut-off size (Asian labs)



Stakeholder engagement and strategy

- Stakeholder workshop held – report in development
- Aerosol metrology roadmap



Nomenclature and standardisation

- Paper on aerosol nomenclature being drafted
- Input into European and international standardisation

ISO cen

- *For further information, please speak to me (Executive Secretary) or Konstantina Vasilatou (Chair, METAS)*

Acknowledgements

NPL

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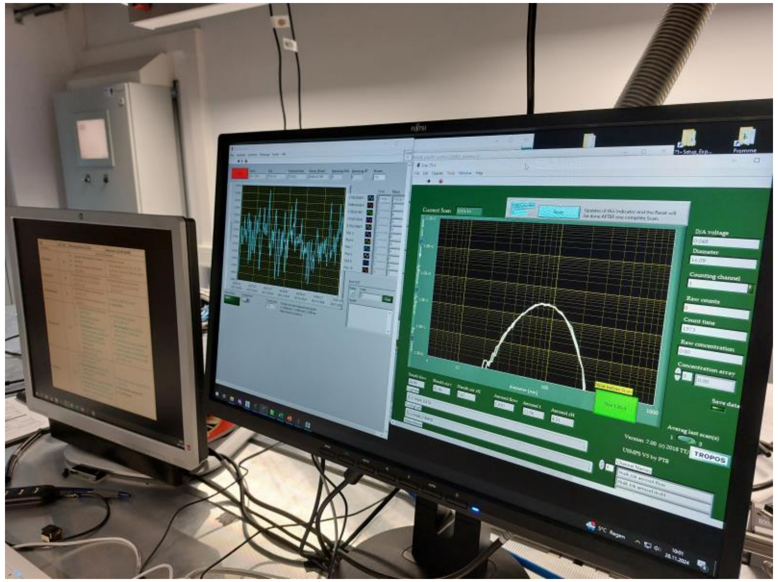
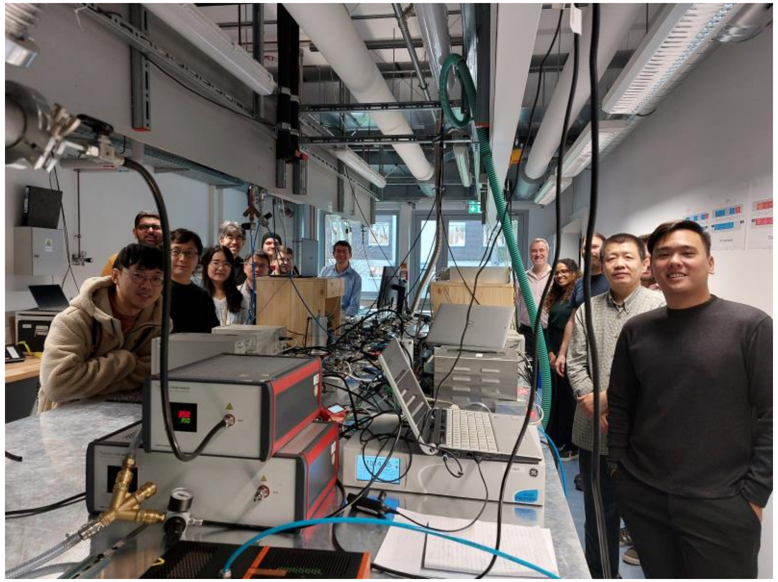
Any questions?





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