Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

NPTI Introduction in Germany - Interlaboratory Comparison of Accredited Calibration Laboratories

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NPTI in Germany - Overview

Regulatory Framework

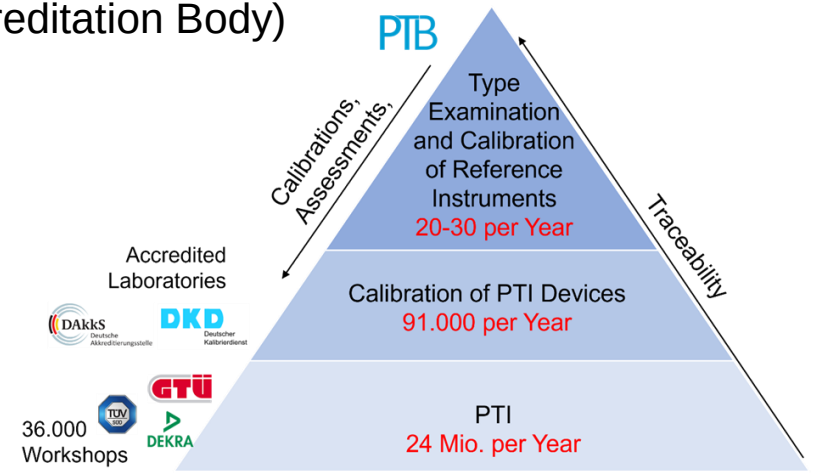
- Mandatory particle number (PN) measurement in PTI for Euro 6 diesel vehicles since July 2023
- Legal basis: German PTI Directive and German Measurement and Verification Act (aligned with the European Measuring Instruments Directive – MID)
- Technical requirements for particle counters defined in PTB-A 12.16 (2021)

Devices in Operation

- 10 type examinations currently in the field (DCs and CPCs)
- Extensions for all instruments to date after proof of long-term stability
- Regular revisions for design or software changes

NPTI in Germany - Calibration

- Subsequent Verification is replaced by calibration
- Calibration Laboratories are independent and responsible for procedure and traceability
- Accreditation is granted by the DAkkS (German Accreditation Body)



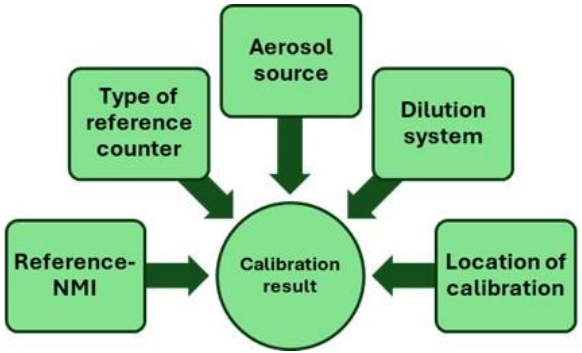
Including Exhaust analysers and opacimeters

Calibration guideline is binding
and provides a rough framework:

- Polydisperse, thermostable aerosol
- 70 nm ± 20 nm
- Monomodal Size Distribution (GSD) of 1.5 to 2.1
- Calibration points: 50 000 cm^{-3}, 250 000 cm^{-3}, 350 000 cm^{-3} - 500 000 cm^{-3}
- QM according to ISO 17025 (interlaboratory comparisons required)

German Interlaboratory Comparison

- PTB-ASA research cooperation for calibration of particle counters in PTI
- Particle counters from various manufacturers and types calibrated by different calibration laboratories
- Calibrations according to individual calibration procedure

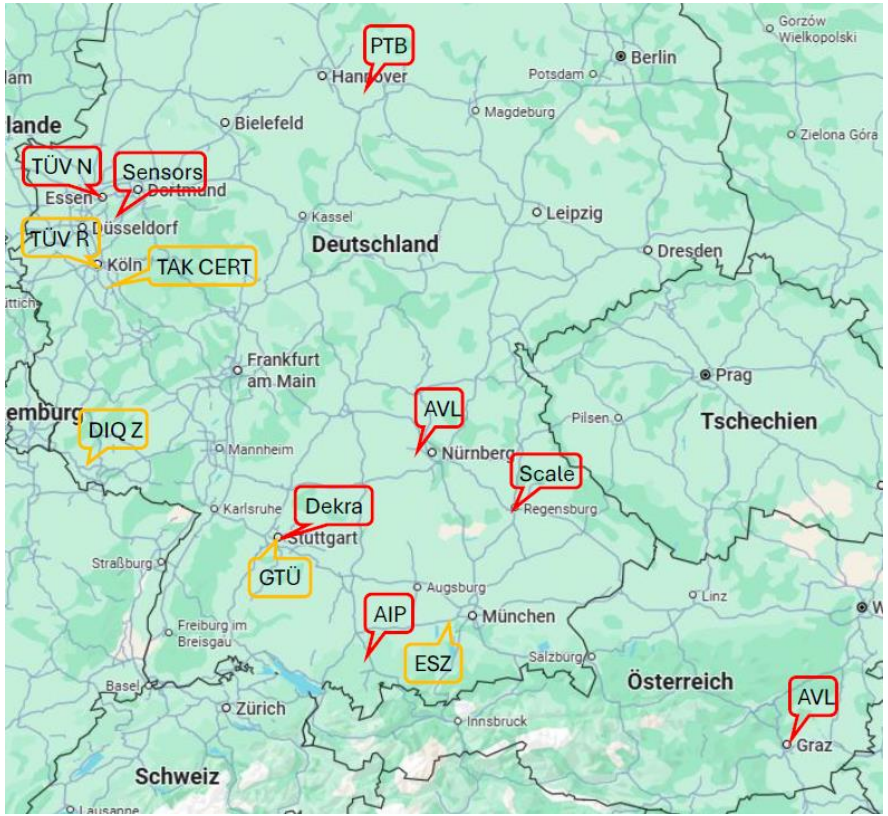


- ➢ Scientific basis for assessing the comparability of different calibration methods
- ➢ Evidence for ensuring validity of results according to DIN EN ISO/IEC 17025:2018, 7.7

Participating Laboratories

KW 41	06.10.2025 - 12.10.2025	PTB
KW 42	13.10.2025 - 19.10.2025	PTB
KW 43	20.10.2025 - 26.10.2025	Scale MT
KW 44	27.10.2025 - 02.11.2025	AVL DE
KW 45	03.11.2025 - 09.11.2025	GTÜ
KW 46	10.11.2025 - 16.11.2025	DEKRA
KW 47	17.11.2025 - 23.11.2025	AIP
KW 48	24.11.2025 - 30.11.2025	AVL AT
KW 49	01.12.2025 - 07.12.2025	
KW 50	08.12.2025 - 14.12.2025	PTB
KW 51	15.12.2025 - 21.12.2025	PTB (ESZ, AIP)
KW 52	22.12.2025 - 28.12.2025	
KW 01	29.12.2025 - 04.01.2026	
KW 02	05.01.2026 - 11.01.2026	
KW 03	13.01.2026 - 18.01.2026	Sensors
KW 04	19.01.2026 - 25.01.2026	TAK CERT
KW 05	26.01.2026 - 01.02.2026	DIQ ZERT
KW 06	02.02.2026 - 08.02.2026	TÜV Rheinland
KW 07	09.02.2026 - 15.02.2026	TÜV Nord
KW 08	16.02.2026 - 22.02.2026	
KW 09	23.02.2026 - 01.03.2026	PTB

Transport Stability and Drift



Devices and Manufacturers

Hella Gutmann,
HG4-PCK, DC

AVL DiTEST,
Counter Mobile, DC

Mahle,
PMU 400, CPC

TEXA,
NP 01, DC

Snap-on,
DSS-PN, CPC

Calibration Procedure

- Each laboratory using their own accredited calibration procedure and measurement uncertainty
- Calibration either on-site or in their permanent laboratory, depending on accreditation

- Calibration aerosol: soot or salt, polydisperse particle number size distribution (~70 nm)
- Types of Reference Counter: DC or CPC
- Calibration points: 50 000 cm^{-3}, 250 000 cm^{-3}, about 400 000 cm^{-3}

- A calibration certificate is created for each calibration object and submitted to PTB
- PTB provides the reference value for the comparison

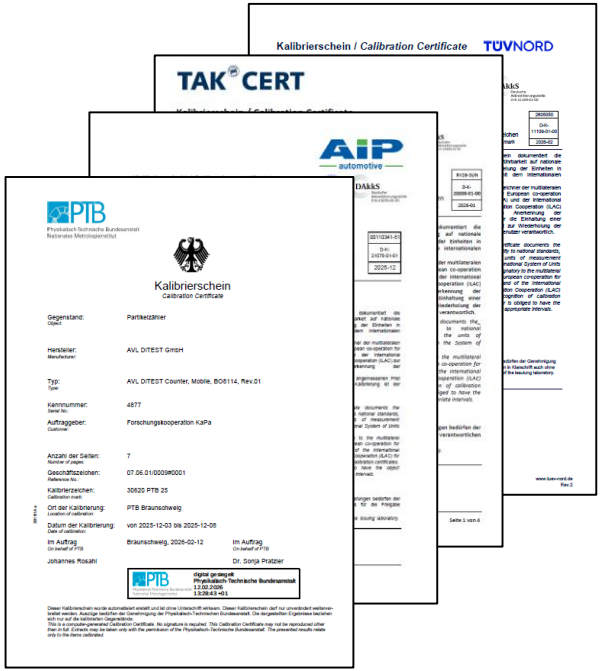
- Exchange or coordination of results between laboratories before submission is prohibited

Calibration Certificate

- PTB reference with soot aerosol
- Additional measurements with salt (2 calilbrators provided by Scale MT and Knestel)

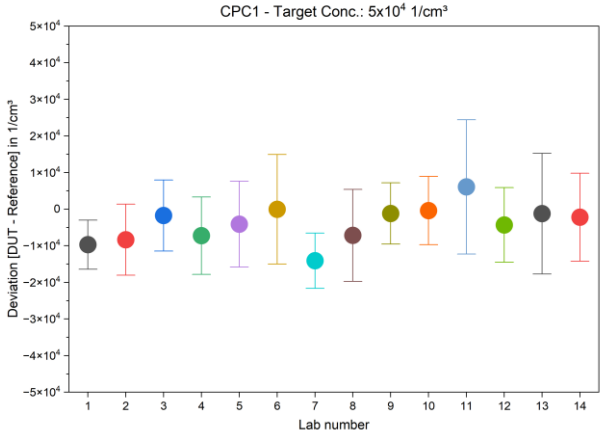
Dp	PNC Reference	PNC DUT	Deviation DUT - Reference	Exp. Measurement Uncertainty (k=2)		Counting Efficiency DUT / Reference
nm	1/cm³	1/cm³	1/cm³	1/cm³	%	%
70	51 300	40 700	-10 600	1 700	3,3	79,4
70	256 000	196 000	-60 000	16 000	6,0	76,5
70	408 000	326 000	-82 000	25 000	5,9	79,9

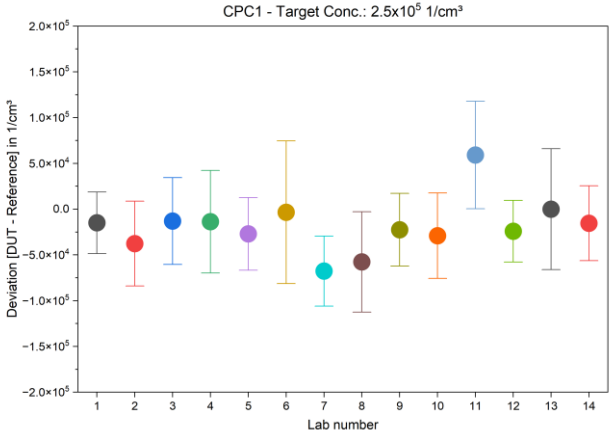
Typical results of PTB calibration

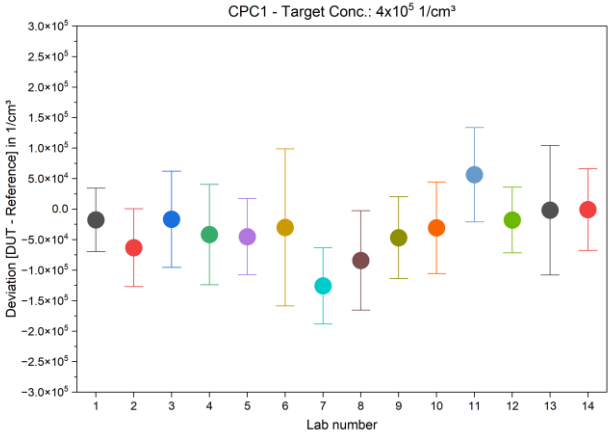


Results CPC 1

- Preliminary results, comparison of the participating laboratories with each other
- Without reference value of PTB

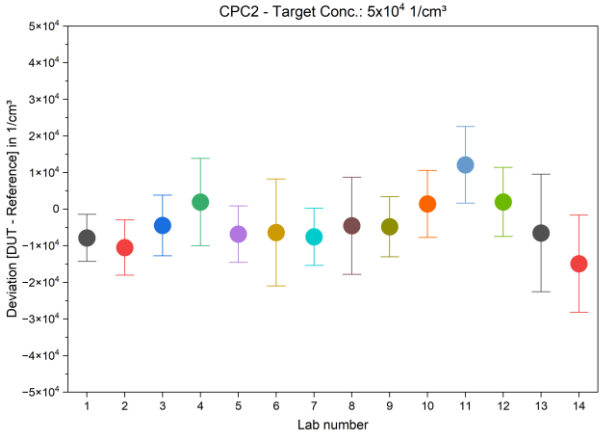


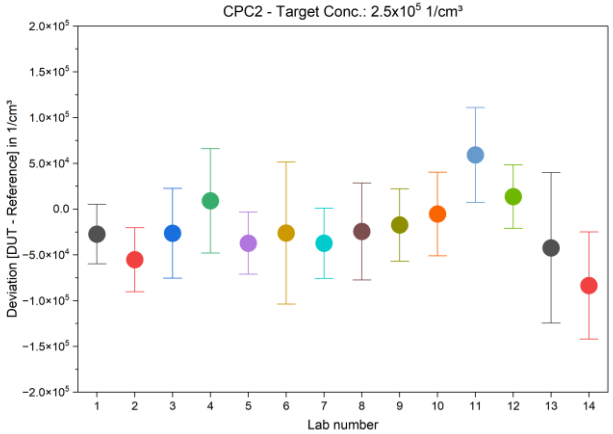


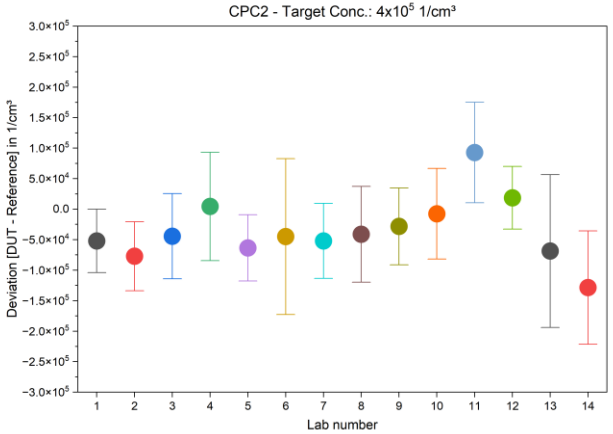


- Deviation display DUT – reference of the participant
- Including individual uncertainty

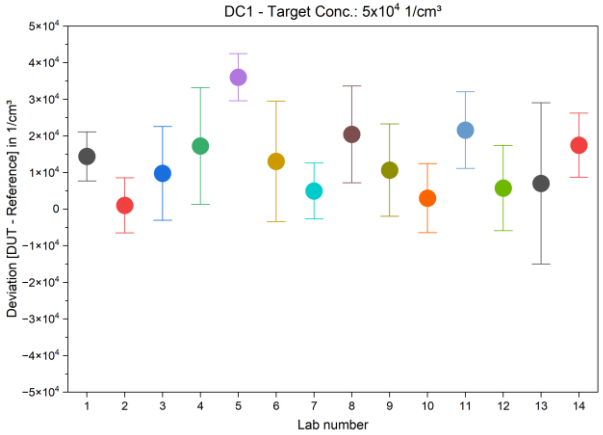
Results CPC 2

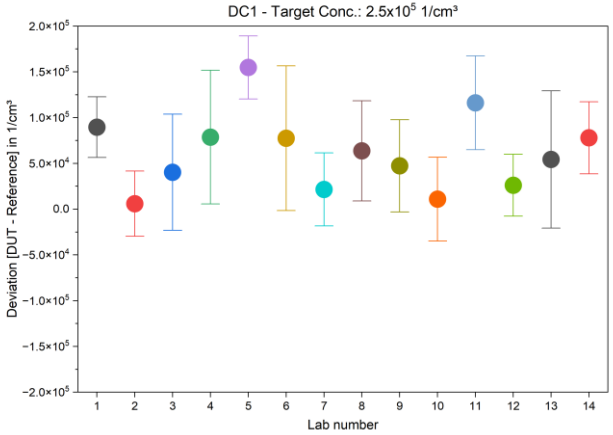


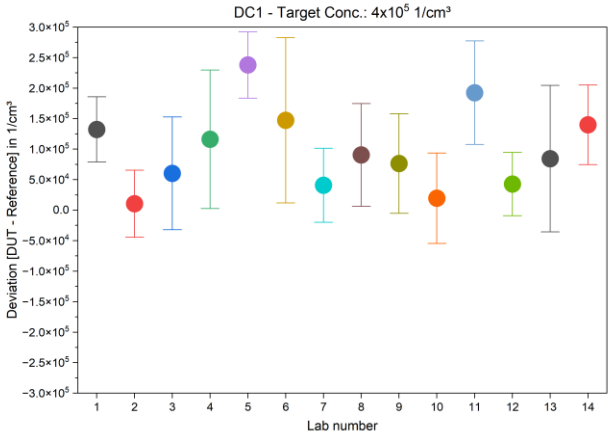




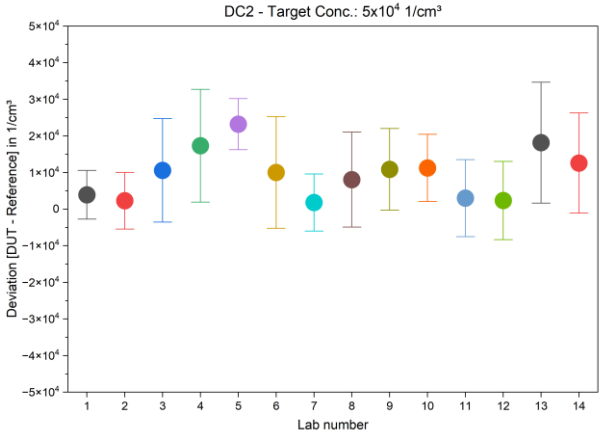
Results DC 1

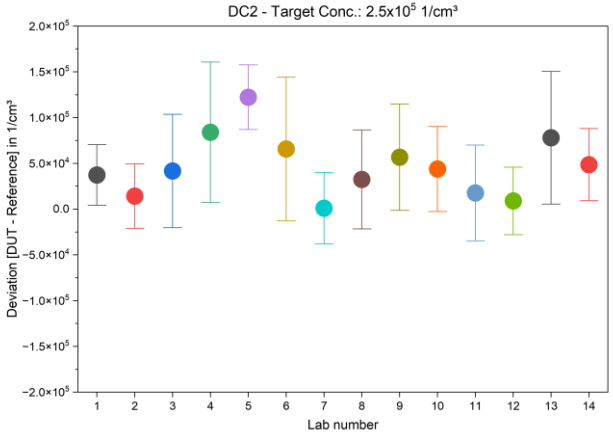

DC1 - Target Conc.: 5x10⁴ 1/cm³
Deviation [DUT - Reference] in 1/cm³
Lab number

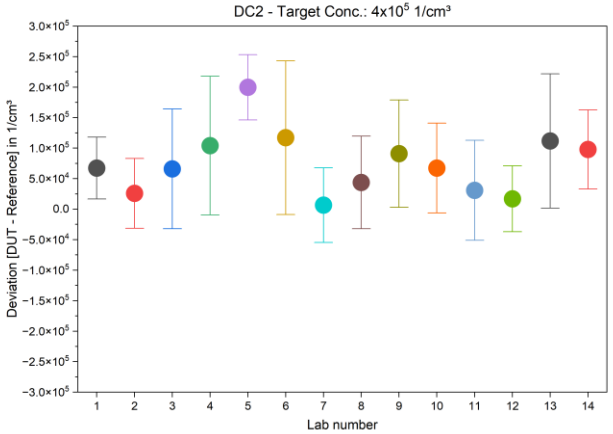

DC1 - Target Conc.: 2.5x10⁵ 1/cm³
Deviation [DUT - Reference] in 1/cm³
Lab number


DC1 - Target Conc.: 4x10⁵ 1/cm³
Deviation [DUT - Reference] in 1/cm³
Lab number

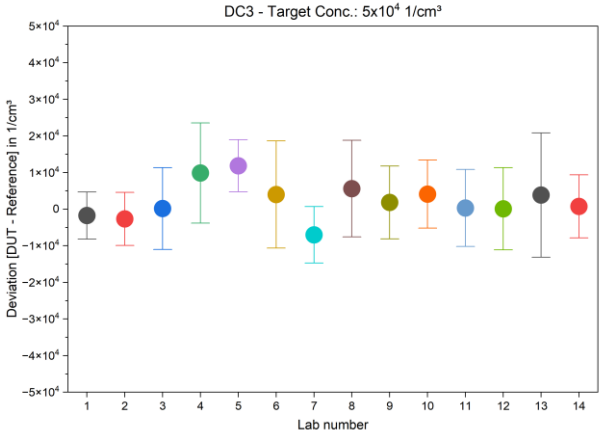
Results DC 2

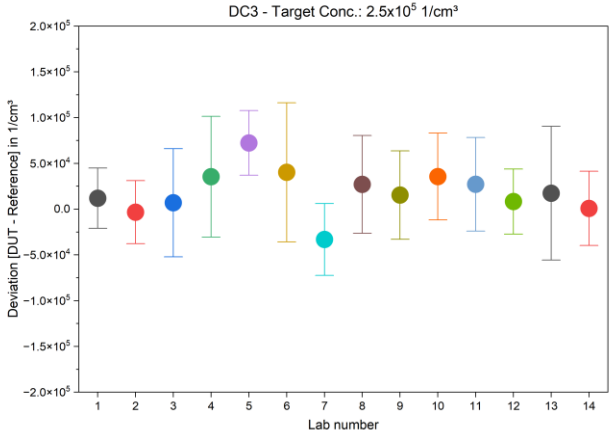

DC2 - Target Conc.: 5x10⁴ 1/cm³
Deviation [DUT - Reference] in 1/cm³
Lab number

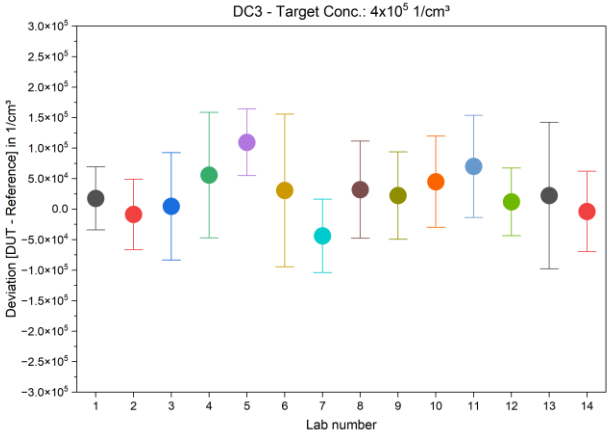

DC2 - Target Conc.: 2.5x10⁵ 1/cm³
Deviation [DUT - Reference] in 1/cm³
Lab number


DC2 - Target Conc.: 4x10⁵ 1/cm³
Deviation [DUT - Reference] in 1/cm³
Lab number

Results DC 3


DC3 - Target Conc.: 5x10⁴ 1/cm³
Deviation [DUT - Reference] in 1/cm³
Lab number


DC3 - Target Conc.: 2.5x10⁵ 1/cm³
Deviation [DUT - Reference] in 1/cm³
Lab number


DC3 - Target Conc.: 4x10⁵ 1/cm³
Deviation [DUT - Reference] in 1/cm³
Lab number

Quality Criterion En Value

- En value calculated for each individual measured value
- Difference is normalized by the expanded measurement uncertainty
- Used as the key quality criterion for the comparative measurement
- Indicates the agreement between measurement and reference value

$$E_n(x_i) = \frac{x_i - x_{ref}}{\sqrt{U_i^2 + U_{ref}^2}}$$

with:

x_i: Measured value by the participant

x_{ref}: Reference value

U_i: Expanded measurement uncertainty of the measured value (k=2)

U_{ref}: Expanded measurement uncertainty of the reference value (k=2)

| En | ≤ 1 passed

| En | > 1 failed

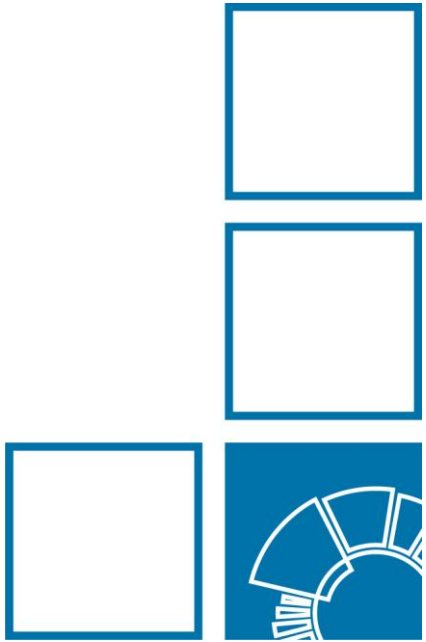
Summary and Outlook

- All measurements have been completed on schedule. **Many thanks to all participants!**
- The initial results show a good level of agreement between the participants
- Next step: Determination of the reference value
  incl. additional uncertainty contributions for stability and transport

- Test report for use in accreditation, for internal use (Focus on En values)

- Paper on extended results in Summer 2026,
  Focus on conclusions of different calibration methods
  e.g. calibration material soot or salt, type of reference CPC or DC, etc.

Questions?



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