Laboratory Intercomparison in Germany: Calibration of particle counters for the national periodical technical inspection

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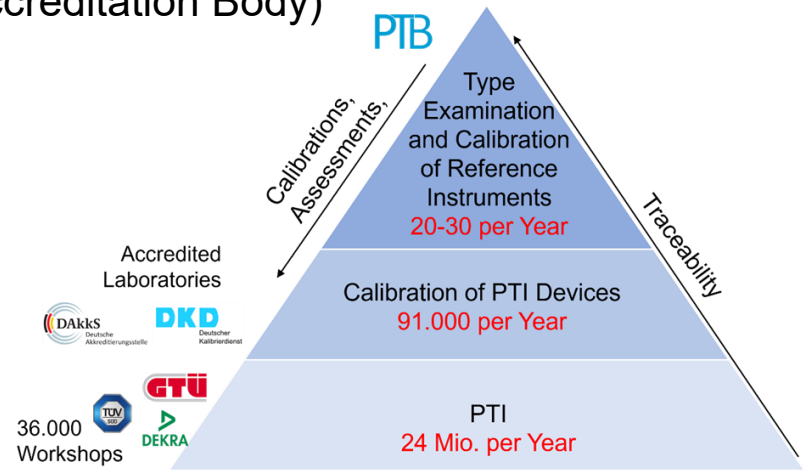
NPTI in Germany - Calibration

Backround

- 10 type examinations currently in the field (DCs and CPCs)
- 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)
- > 30 000 calibrations per year

Calibration guideline is binding
and provides a rough framework:

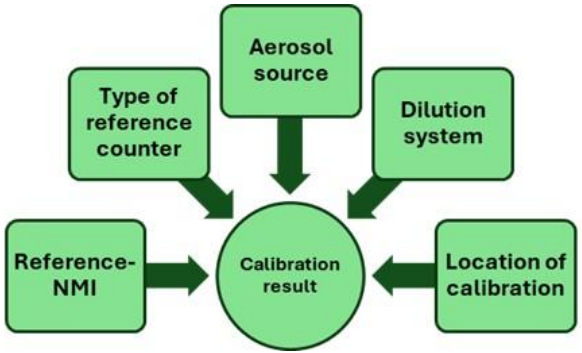
- QM according to ISO 17025
- Interlaboratory comparisons required



Including Exhaust analysers and opacimeters

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

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

- German Calibration Guideline published by ministry of transport:
  - Polydisperse, thermostable aerosol (soot or salt)
  - 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}
  - Types of Reference Counter: DC or CPC

- Calibration either on-site or in their permanent laboratory, depending on accreditation

- A calibration certificate is created for each calibration object and submitted to PTB
- PTB provides the reference value for the comparison, including transport and long term stability of devices

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

Participating Laboratories

12 different Laboratories

- Calibration Aerosol: 8 salt, 1 soot, 3 salt + soot
- Reference Counter: 4 CPC, 6 DC, 2 CPC + DC
- Accredited measurement uncertainty: about 6% up to 21%

Comparison time scale:

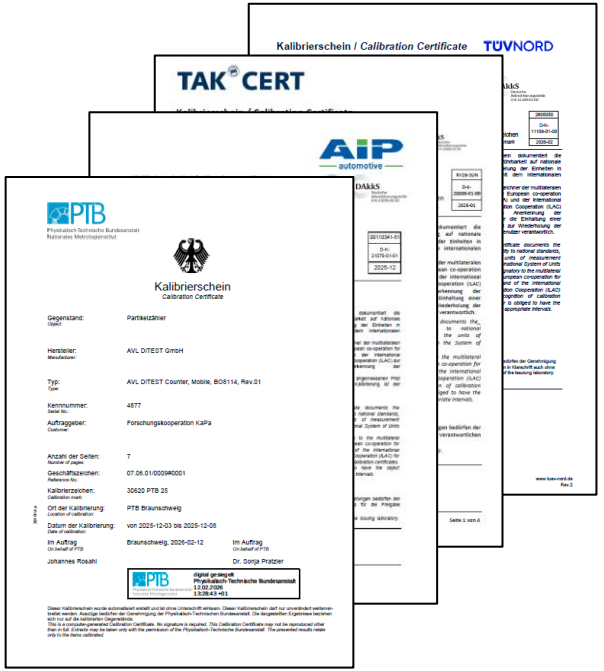
- 10/2025 – 03/2026
- 3 Measurements at PTB, beginning, middle, end of comparison

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

Calibration Certificate

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

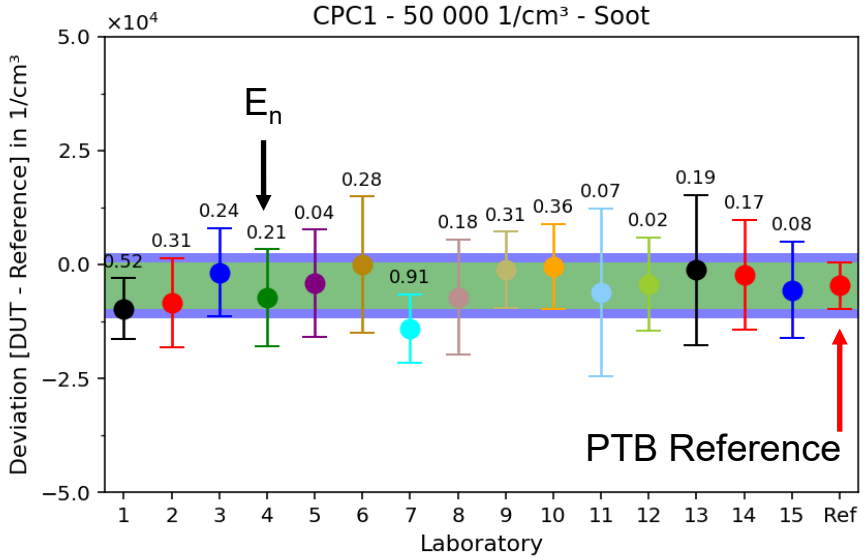
Typical results of PTB calibration



Results - Example

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

| En | ≤ 1 passed
| En | > 1 failed

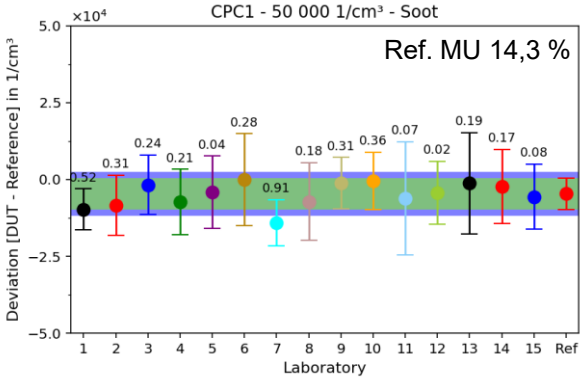


MU PTB Reference incl. Standard deviation Device Under Test (DUT)

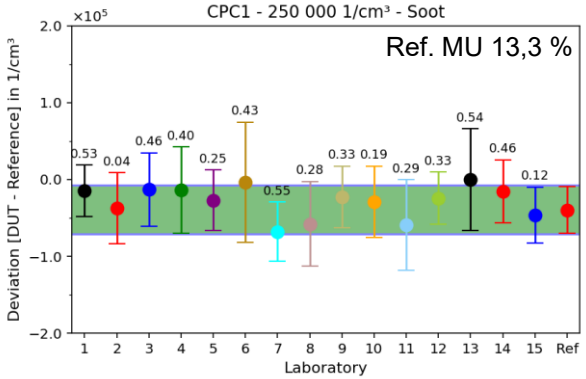
Comparison Reference MU incl. Transport Instability

x_i: Measured value by the participant
x_{ref}: Comparison Reference value
U_i: Expanded measurement uncertainty of the measured value (k=2)
U_{ref}: Expanded measurement uncertainty of the reference value (k=2)

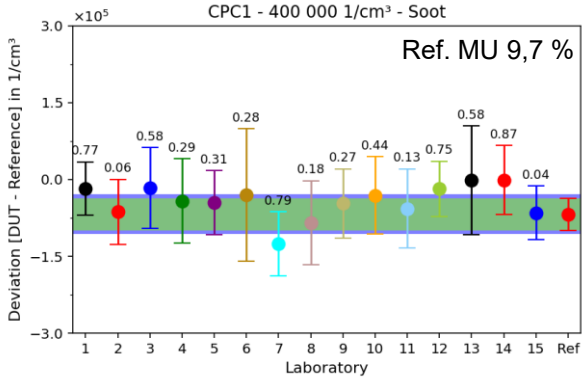
Results CPC 1



pass	fail
15	0



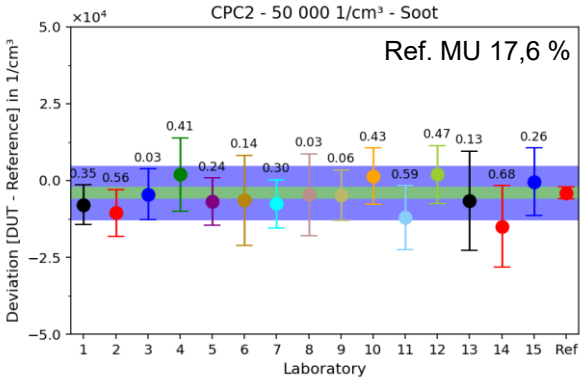
pass	fail
15	0



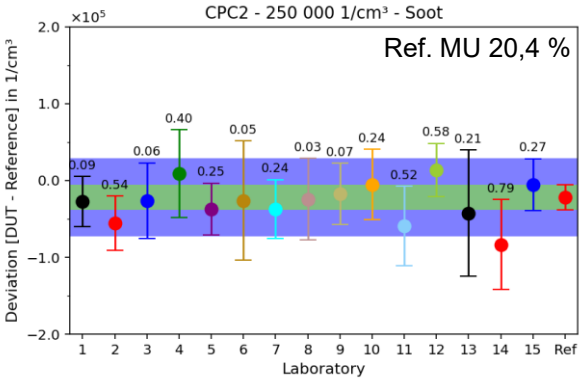
pass	fail
15	0

Higher standard deviation, low transport uncertainty

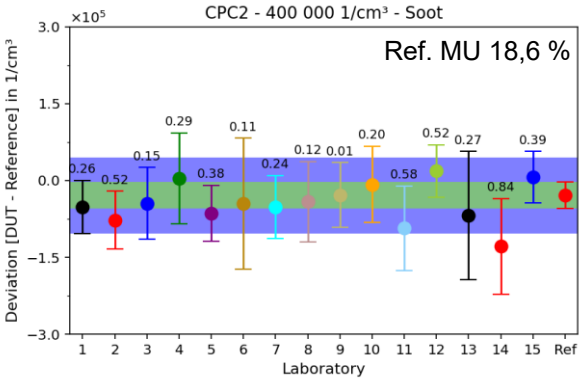
Results CPC 2



pass	fail
15	0



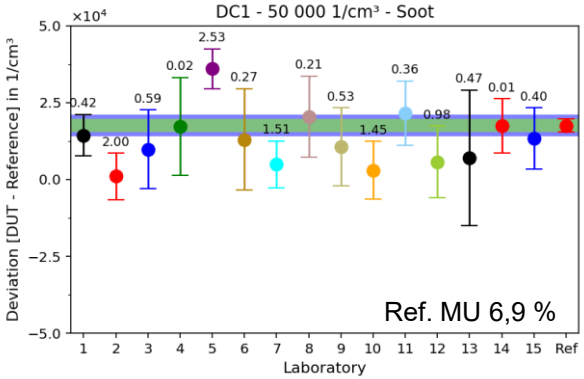
pass	fail
15	0



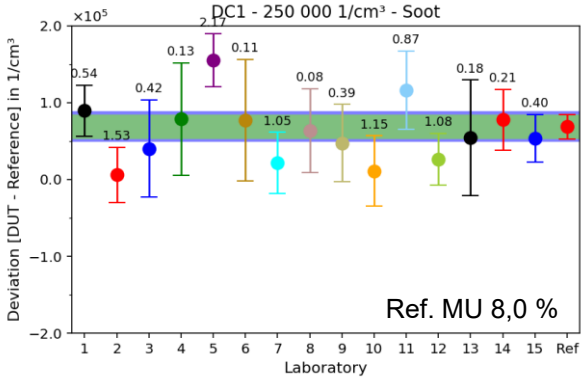
pass	fail
15	0

- Measurement uncertainties of the participants are smaller than the uncertainty of the reference
- Problems with the significance

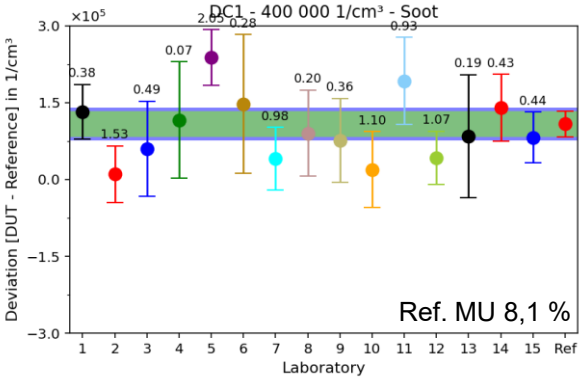
Results DC 1



pass	fail
11	4



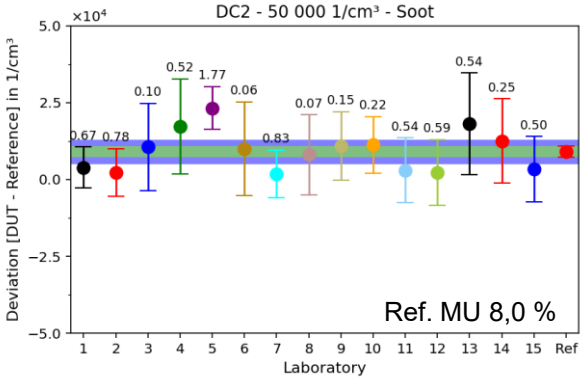
pass	fail
10	5



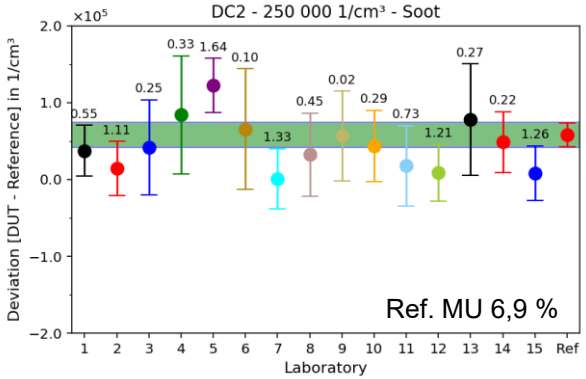
pass	fail
11	4

- Lower reference uncertainty: More difficult to pass

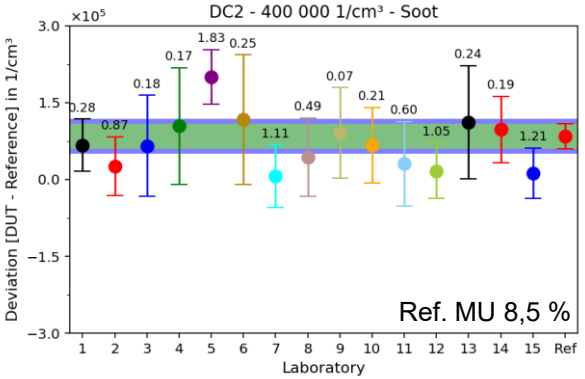
Results DC 2



pass	fail
14	1

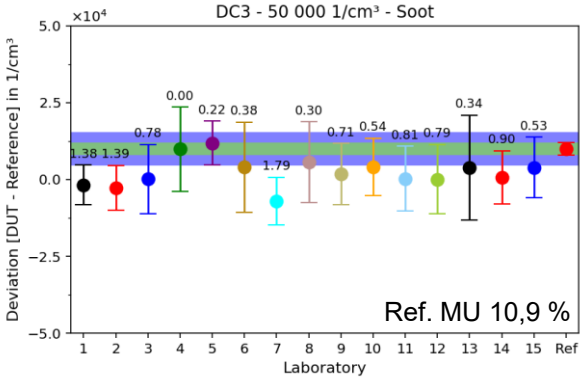


pass	fail
10	5

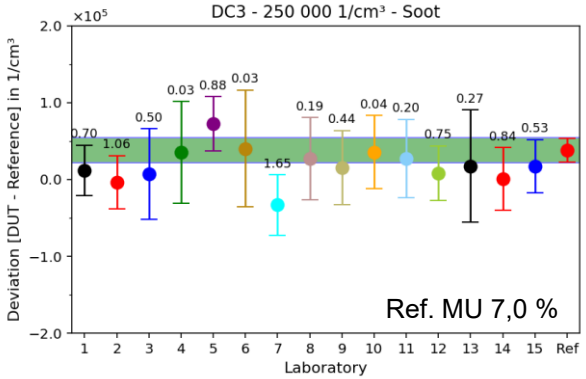


pass	fail
11	4

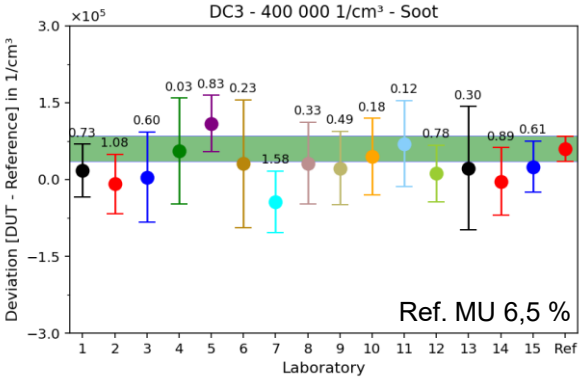
Results DC 3



pass	fail
12	3



pass	fail
13	2



pass	fail
13	2

Summary and Outlook

All measurements have been completed on schedule. **Many thanks to all participants!**

- 8 Laboratories pass all 15 Points
- 4 Laboratories pass 11-14 Points
- 3 Laboratories pass 8-9 Points

Lessens learned: **Reduce Transport MU,**

- Measurements at PTB if possible
- More measuring Points for PTB
- Additional CPC from PTB as DUT

Next steps:

- Test report for use in accreditation, for internal use (Focus on En values)
- Paper on extended results, Focus on conclusions of different calibration methods

Questions?

Accuracy

Objectivity

Passion

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The National Metrology Institute

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