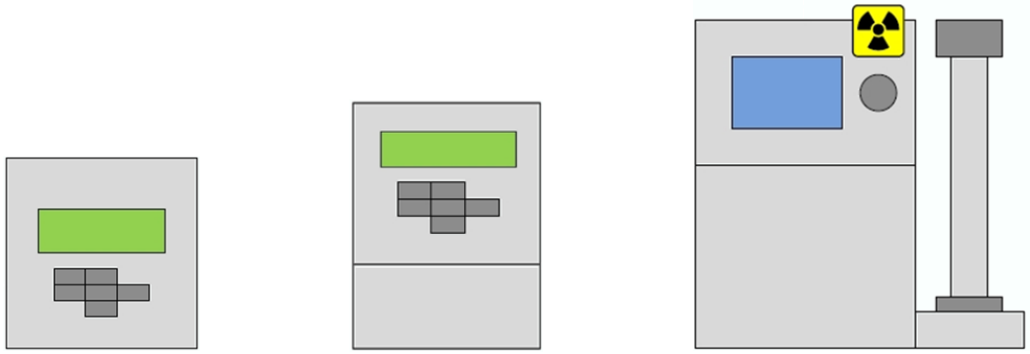
Inter-Laboratory Comparison Exercise
CPC CALIBRATION

CALIBRATION AEROSOLS AND LABORATORY SETUPS

Intermediate Status Report

2016-10-12
Alexander Terres



MOTIVATION

- **Comparison of Calibration Aerosols**

- Comparison of Laboratory Setups

- Suitability for Calibration sub-23nm ?

CPC CALIBRATION ROUND ROBIN SCHEDULE

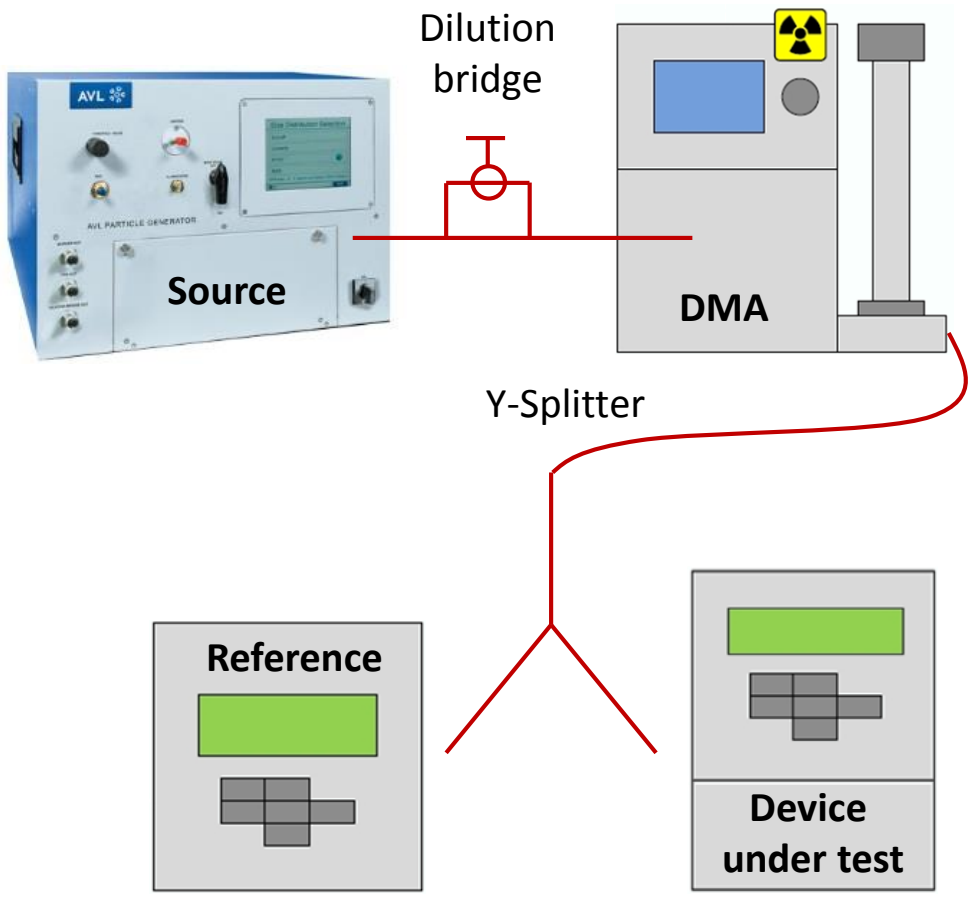
TIME	LABORATORY	Type
02 / 2016	TSI Germany	Instrument Manufacturer
03 / 2016	JRC	Research Institute
04 – 05 / 2016	AVL Austria	Instrument Manufacturer
06 – 07 / 2016	PTB	National Metrological Institute
07 – 08 / 2016	BMW	Vehicle Manufacturer
09 – 10 / 2016	Ricardo Energy & Environment	Calibration Service
11 / 2016	VW	Vehicle Manufacturer
12 / 2016	TSI Germany	Instrument Manufacturer

We are here

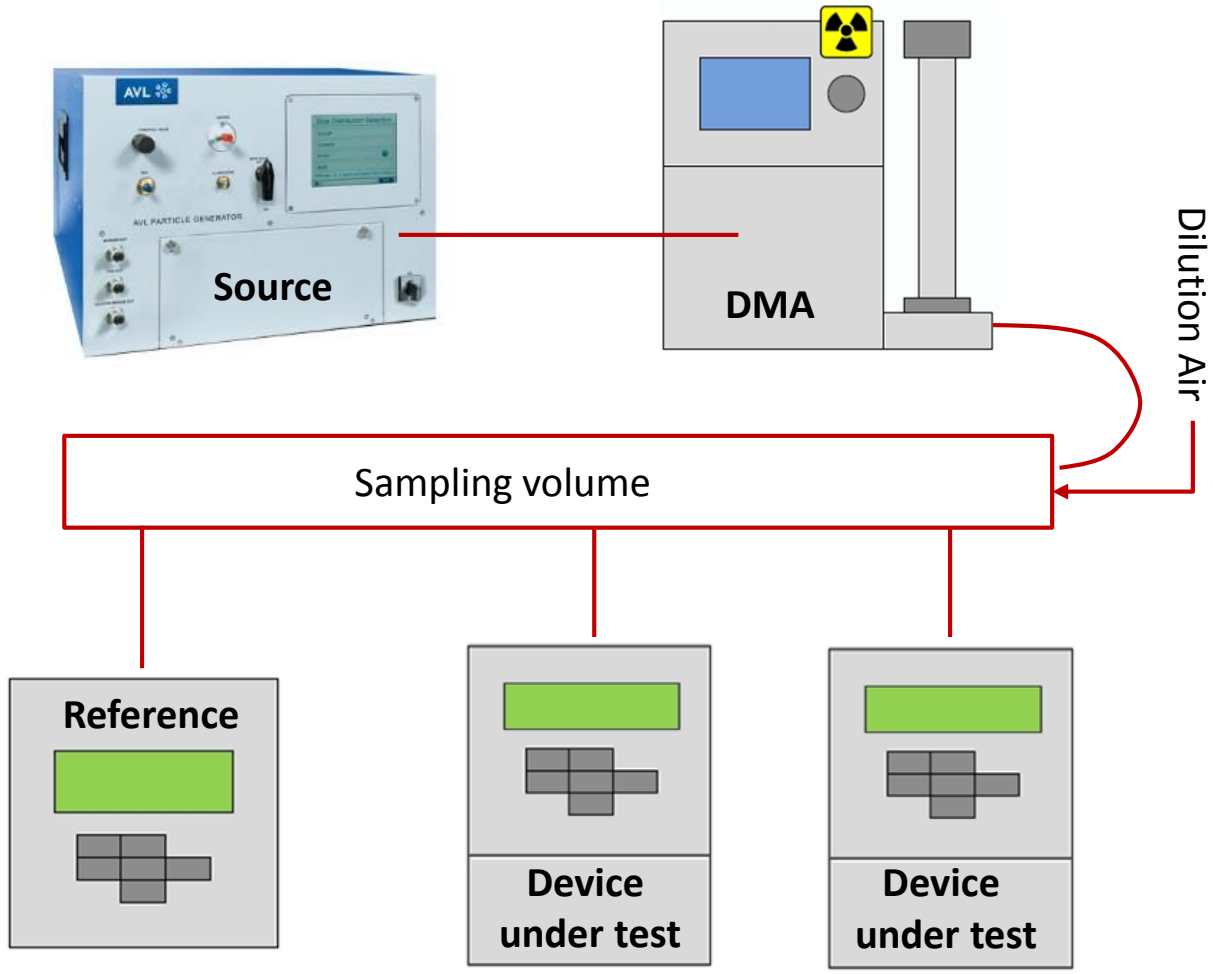
REFERENCE DEVICES & CALIBRATION

LABORATORY	REFERENCE INSTRUMENT	CALIBRATION TYPE
TSI Germany	Aerosol Electrometer	National Metrological Institute
JRC	Aerosol Electrometer CPC	Manufacturer Calibration In-house
AVL Austria	Aerosol Electrometer	Manufacturer Calibration
PTB	Aerosol Electrometer	In-house
BMW Germany	Aerosol Electrometer CPC	Manufacturer Calibration Manufacturer Calibration
Ricardo Energy & Environment	CPC	National Metrological Institute
VW Germany	Aerosol Electrometer CPC	Manufacturer Calibration In-house

LABORATORY SETUPS

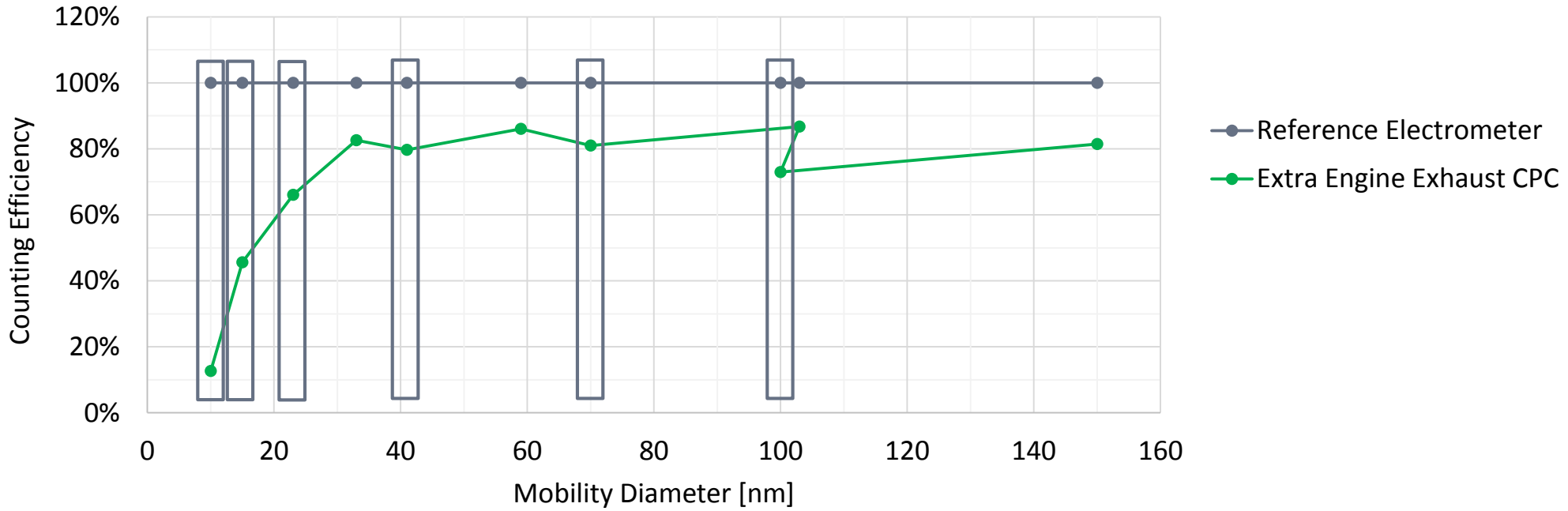


Splitter-type: ISO 27891 compliant setup



Sampling volume-type: not ISO 27891 compliant

TESTING PROCEDURES: COUNTING EFFICIENCY



Mobility Diameter	10	15	23	41	70	100
Corresponding Diameter, Double Charges	-	-	33	59	103	150
Burner Operating Point	A	A	B	C	D	E
Motivation	Sub-23	Sub-23	PMP	PMP	Linearity	PN-PEMS

TESTING PROCEDURES: COUNTING EFFICIENCY

Measurement
- Recording uncorrected **Raw Data**
- No K-factor on devices under test
- Averaging time: 60-240 seconds

Flow
- Correction: **Nominal / actual Flow**
- Flow measurement: Volume or Mass

Charges
- Correction for **double charges**
- Charge distribution: Wiedensohler
- No correction for triple charges
- No correction <23nm

Critical when using reference **Electrometer**

Influenced by:
Aerosol characteristics
e.g. size distribution, chemistry etc.

Splitter Bias: Only corrected in certain labs required in ISO 27891

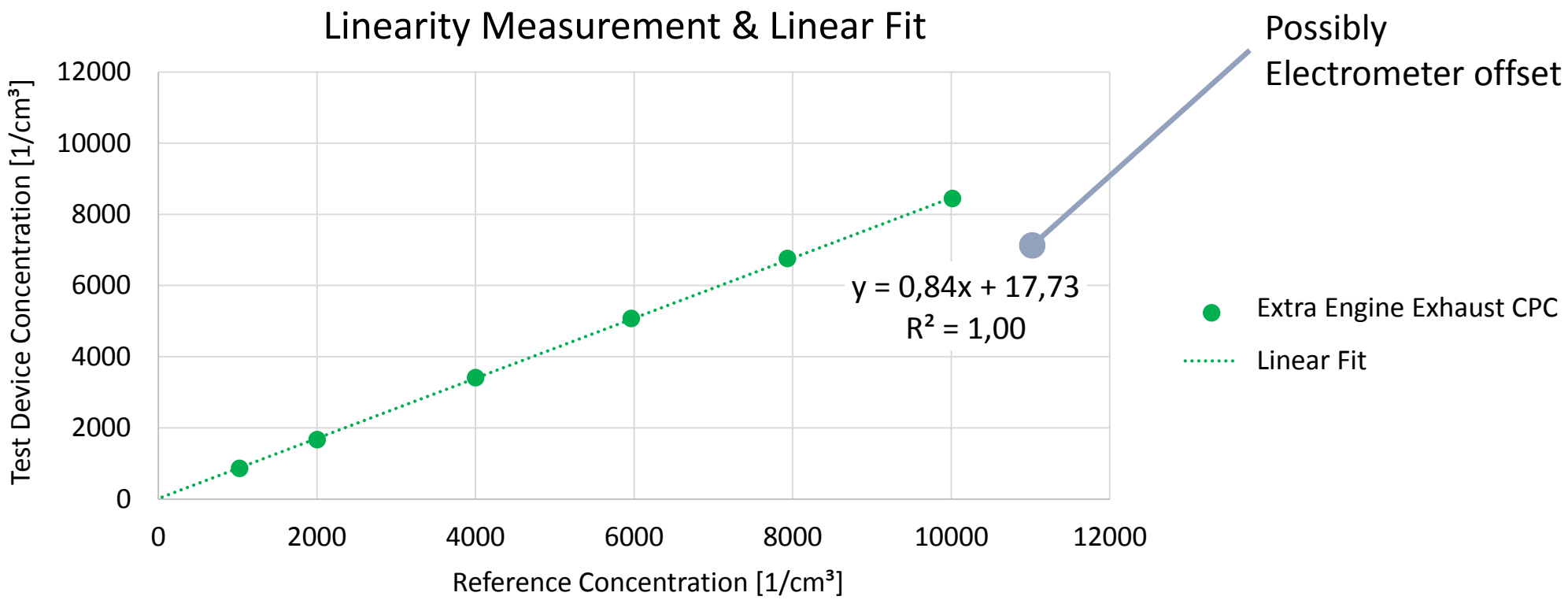
Electrometer Zero: Not corrected
To be applied in the future?

TESTING PROCEDURES: EXEMPLARY EVALUATION

Example: Calibration at 41nm

	Reference Electrometer	**Device under Test (CPC)**
Raw Concentration	8255/cm³	6904/cm³
Zero Offset	116/cm³	0/cm³
Nominal Flow : measured Flow	3 l/min : 2,87 l/min	1 l/min : 1,01 l/min
Flow correction	1,045	0,99
Flow corrected concentration	8629/cm³	6836/cm³
Flow corr. concentration **@59nm**	3170/cm³	2864/cm³
Double charge ratio (Theory)	5,7%	5,7%
Double charged particles	181/cm³	163/cm³
Double Charge Correction	8629-2*181	6836-163
Charge corrected concentration	8267/cm³	6673/cm³
CPC Counting Efficiency	6673 : 8267 = 80,7%	

TESTING PROCEDURES: LINEARITY



Target Concentration Reference Device	0	1.000	2.000	4.000	6.000	8.000	10.000

Reference Device: Aerosol Electrometer or CPC

TESTING PROCEDURES: COUNTING EFFICIENCY

Measurement

- Recording uncorrected **Raw Data**
- No K-factor on devices under test
- **70nm** mobility diameter
- Averaging time: 60-240 seconds

Flow

- Correction: **Nominal / actual flow**
- Flow measurement: Volume or Mass

Charges

- Correction for **double charges**
- Charge distribution: Wiedensohler
- *Derived from Counting Efficiency test*

Critical when using reference **Electrometer**

Influenced by:
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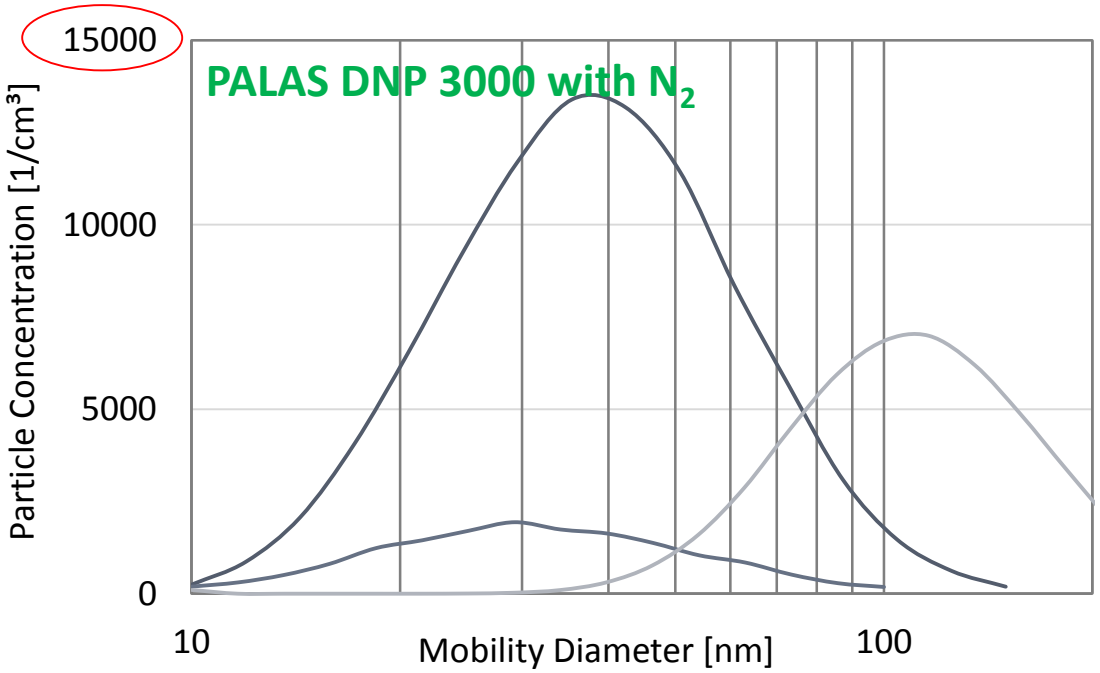
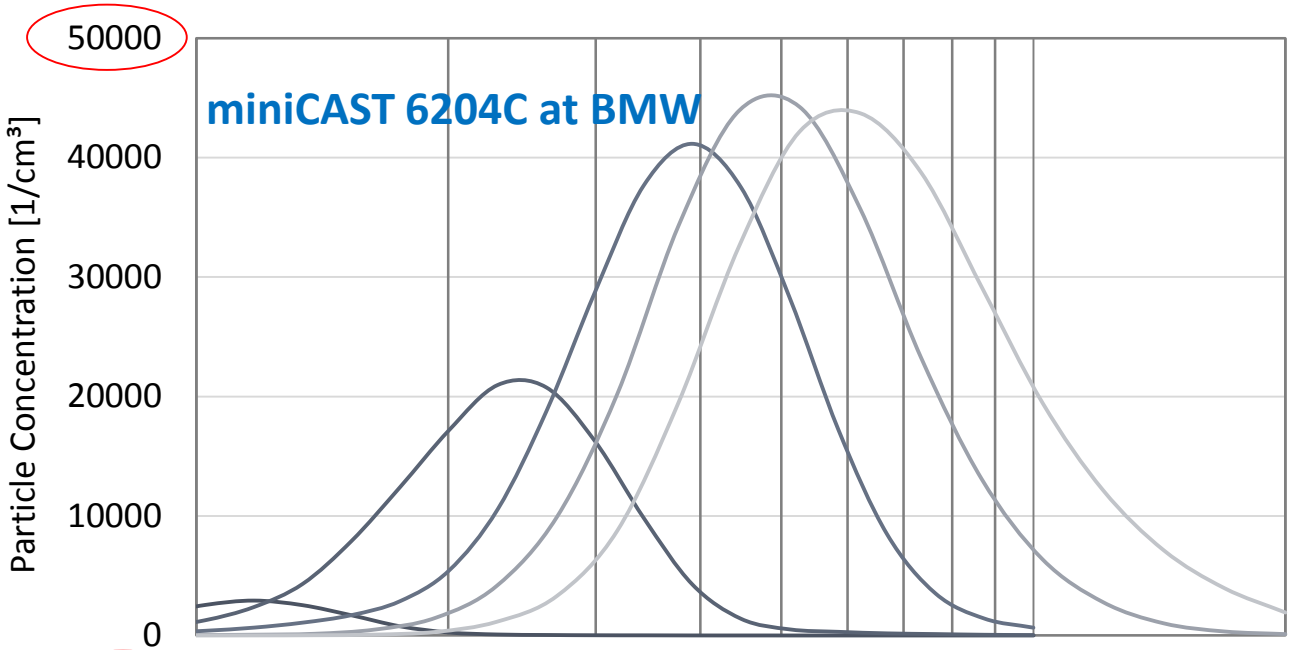
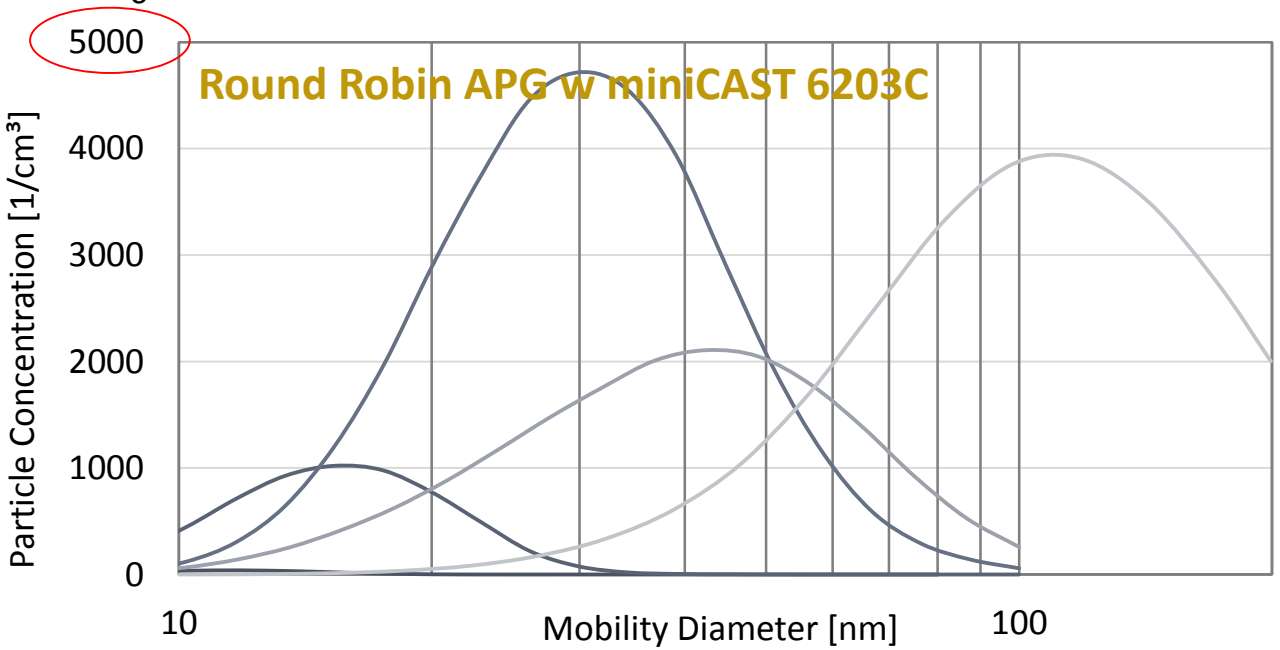
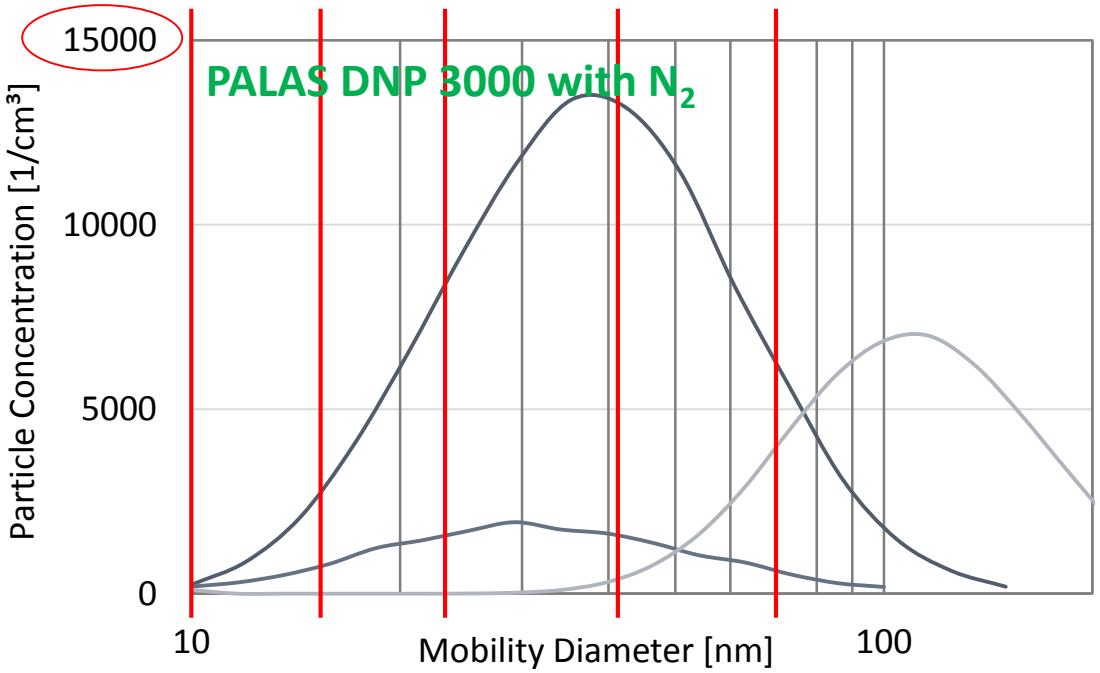
SOOT GENERATORS: SIZE RANGE

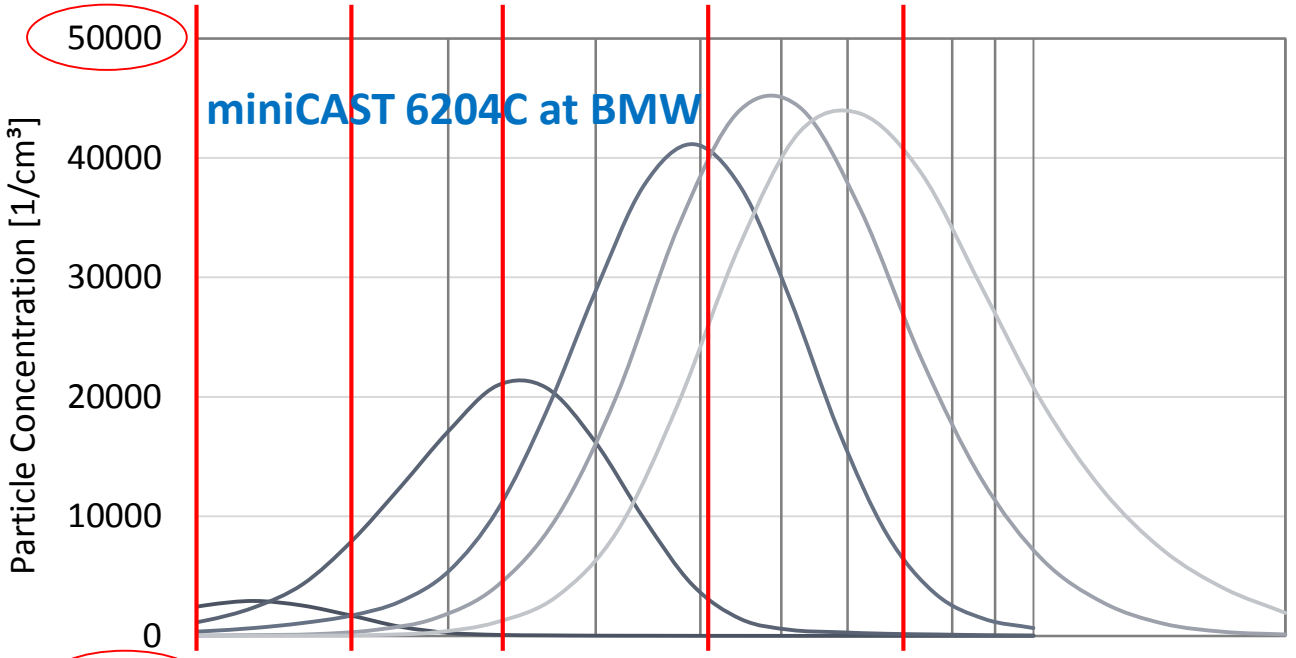


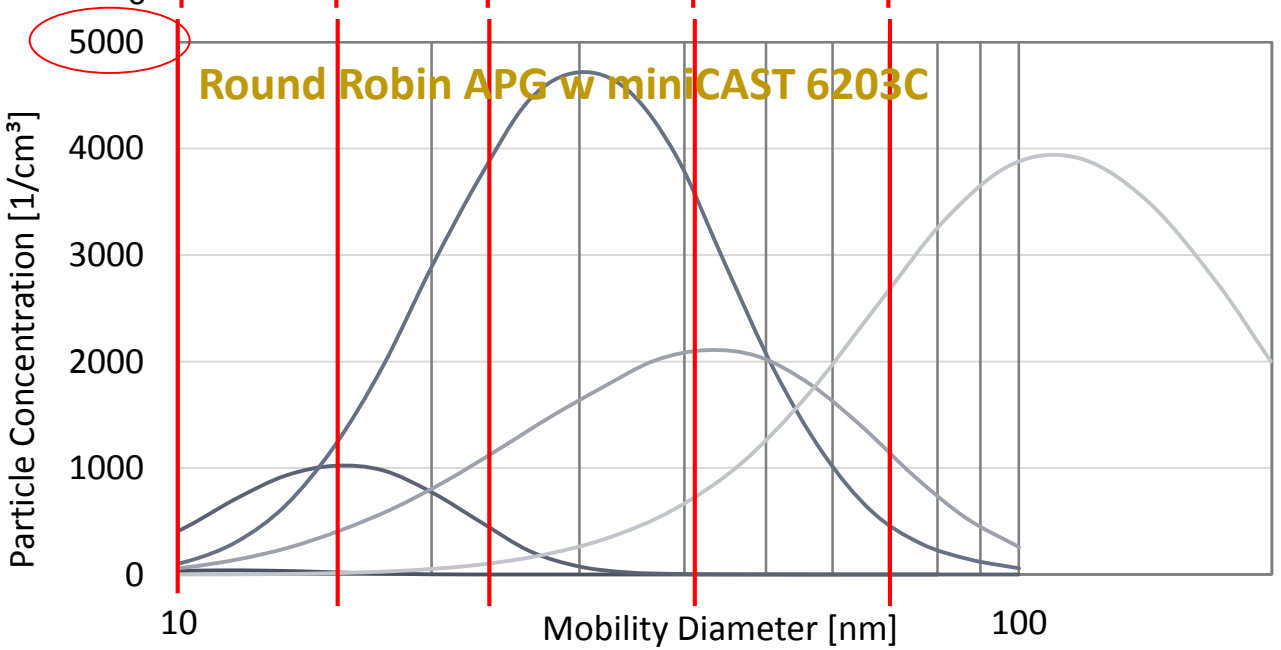




SOOT GENERATORS: SIZE RANGE







SOOT GENERATORS: MAXIMUM CONCENTRATION COMPARISON @10NM

EXAMPLE: Maximum Concentration at BMW laboratory setup (sampling volume, 15l/min dilution air)

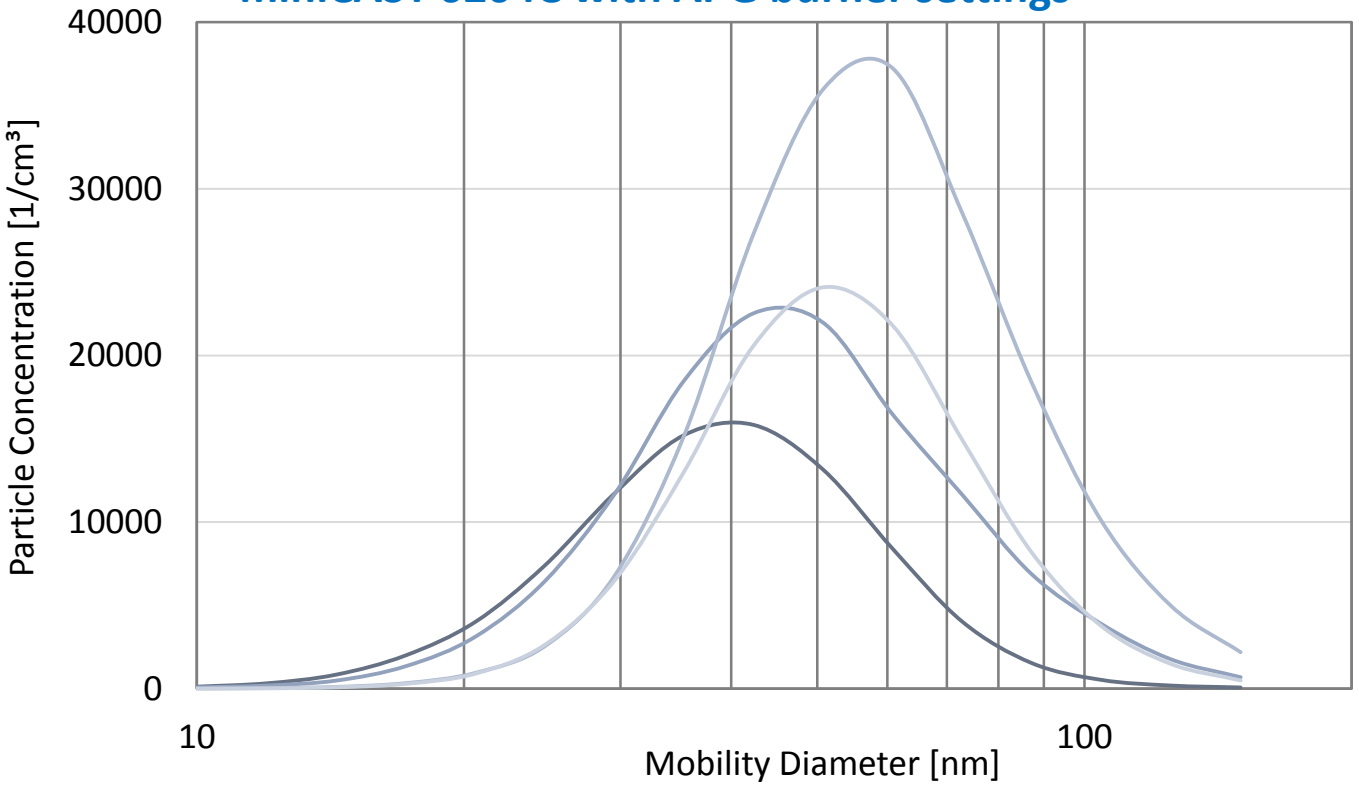
	On-site miniCAST		AVL Particle Generator		PALAS DNP 3000	
	GMD	Max. Conc.	GMD	Max. Conc.	GMD	Max. Conc.
10nm	Very small	**2500/cm³**	Very small	35/cm³		
	Small	1300/cm³	Small	**600/cm³**	Small	200/cm³
	Medium	400/cm³	Medium	180/cm³	Medium	**250/cm³**
15nm	Very small	1700/cm³	Very small	25/cm³		
	Small	7900/cm³	Small	1020/cm³	Small	700/cm³
	Medium	1700/cm³	Medium	1200/cm³	Medium	2000/cm³

Going to larger sizes (GMD 20nm – 30nm): No need to worry about multiple charges?

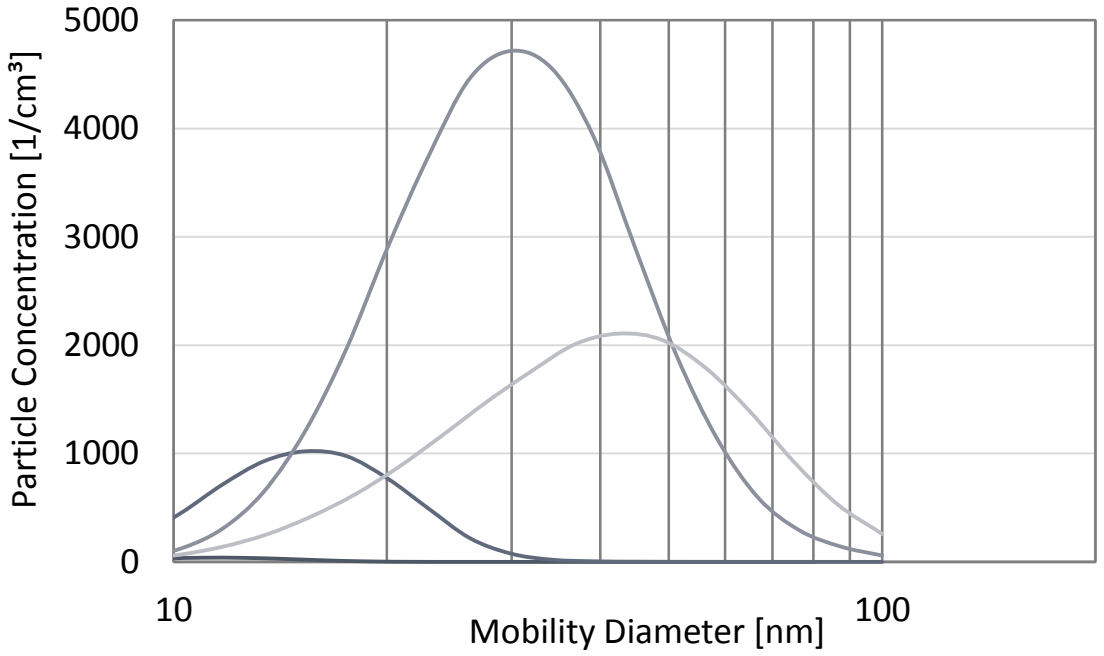
➡ 10nm: Insufficient concentration for calibration vs. electrometer with example setup

SOOT GENERATORS: CAST – INTERCHANGING SETTINGS

miniCAST 6204C with APG burner settings

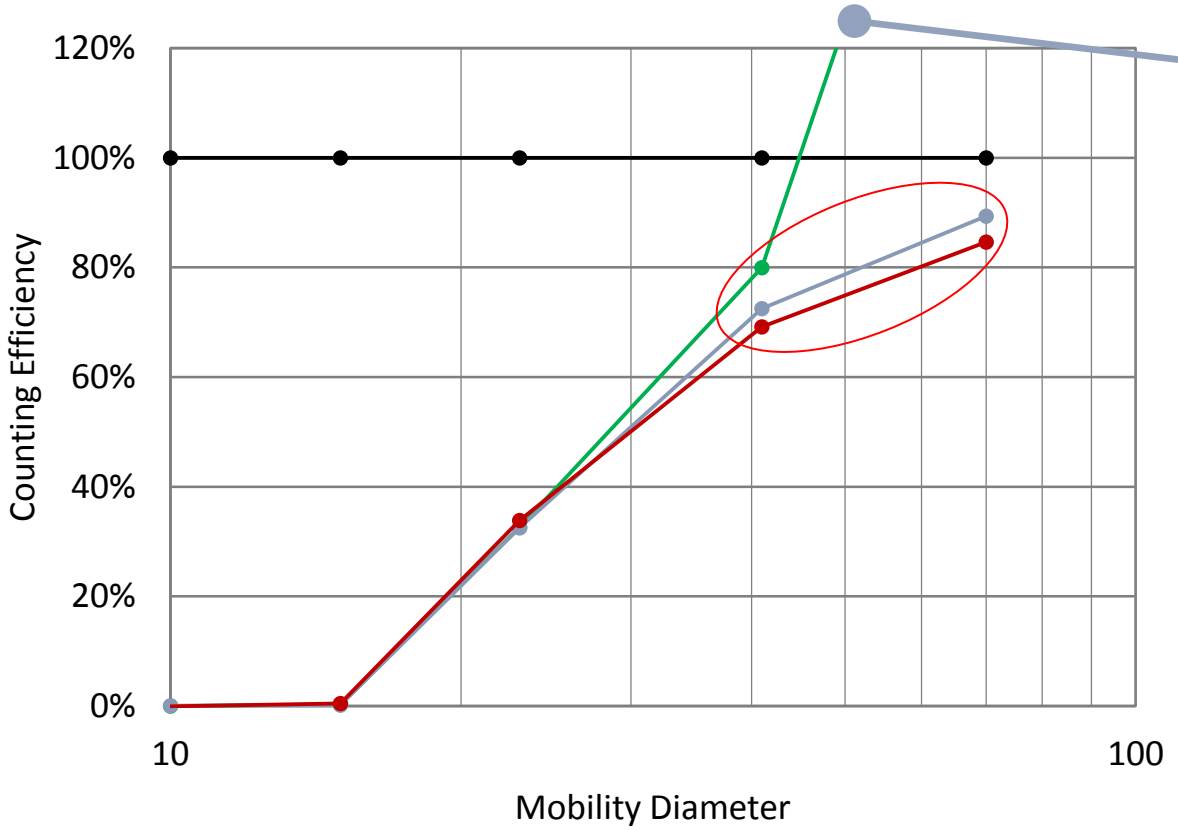


Round Robin APG w miniCAST 6203C



CAST-settings are not transferable between models!

SOOT GENERATORS: CAST – SINGLE SIZE DISTRIBUTION CALIBRATION



Electrometer Offset
Very low absolute concentration

- Reference Electrometer
- GMD 20nm
- GMD 35nm
- GMD 50nm

Calibration Aerosols

Size distribution influence
With **double charge correction** applied

Especially when comparing Electrometer & CPC

CPC CALIBRATION ROUND ROBIN
FIRST FINDINGS

– Participants from all areas of the engine exhaust PN – community

– Measurements examine **CAST soot as a calibration aerosol**
– Possible concentration issues for **sub-23nm calibration**
– No **universal burner settings** for different CAST models
– Size distribution influences measurement results

Open questions for calibration with CAST soot

(only partly covered in ISO 27891):

– Clear definition of suitable **size distributions**
– Accurate correction for **multiple charges** / Strategies to avoid multiple charges
– Zero correction and **Zero drift** of Electrometers
– Suitability of „Sample volume-type“ test setup for calibration

A big “Thank You” to all the labs that are contributing to this Round Robin!

THANK YOU FOR YOUR ATTENTION