EMPIR EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

METROPEMS

Improving counting efficiency and linearity beyond the on-road emission measurement regulations for Portable Emissions Measurement Systems (PEMS)

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26th ETH Nanoparticles Conference

PTB Physikalisch-Technische Bundesanstalt Braunschweig und Berlin

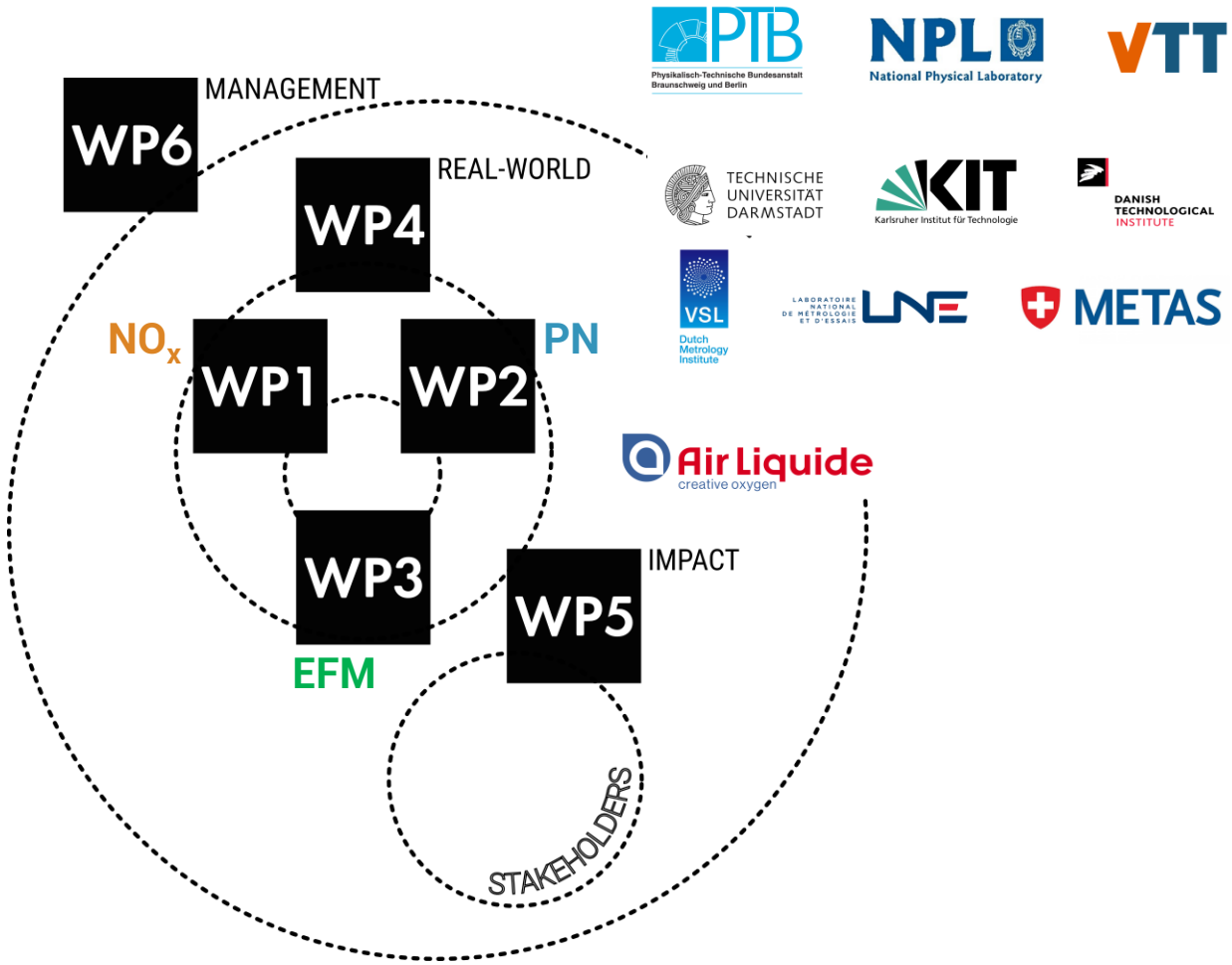
NPL National Physical Laboratory

LNE Laboratoire National de Métrologie et d'Essais

VTT

METAS

Overview: MetroPEMS Project



6 NMIs, 1 DI, 2 academic partners, 1 industry partner
2.1 M€ budget, 3-year project started September 2020

SCIENTIFIC GOLS

WP1: Extending amount fraction capabilities of high accuracy primary reference materials of NO_2

WP2: Metrological validation and performance tests of PN-PEMS devices

WP3: Application-oriented PEMS EFM calibration procedures and uncertainty budgets

WP4: Real-world assessment of PEMS performance

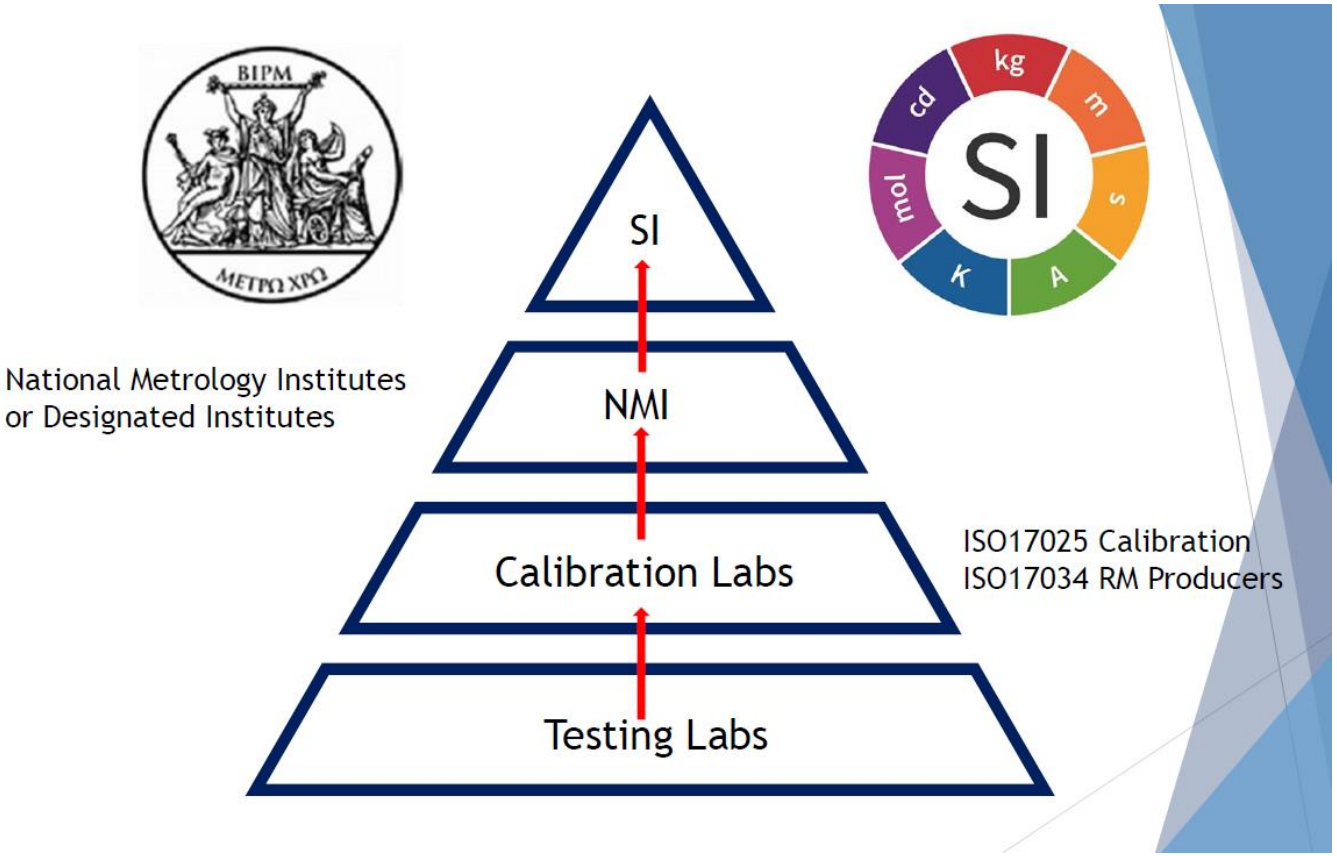
WP5: Creating impact

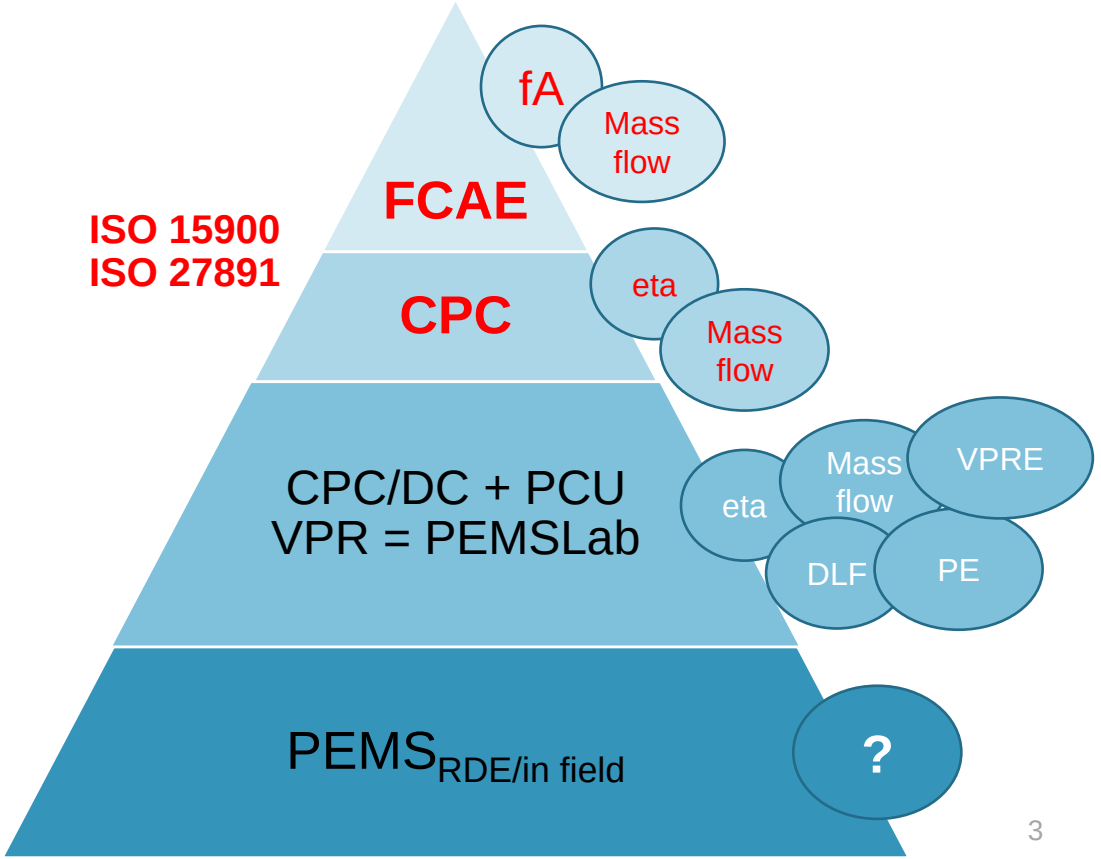
WP6: Management and coordination

PN-Legislation and Traceability

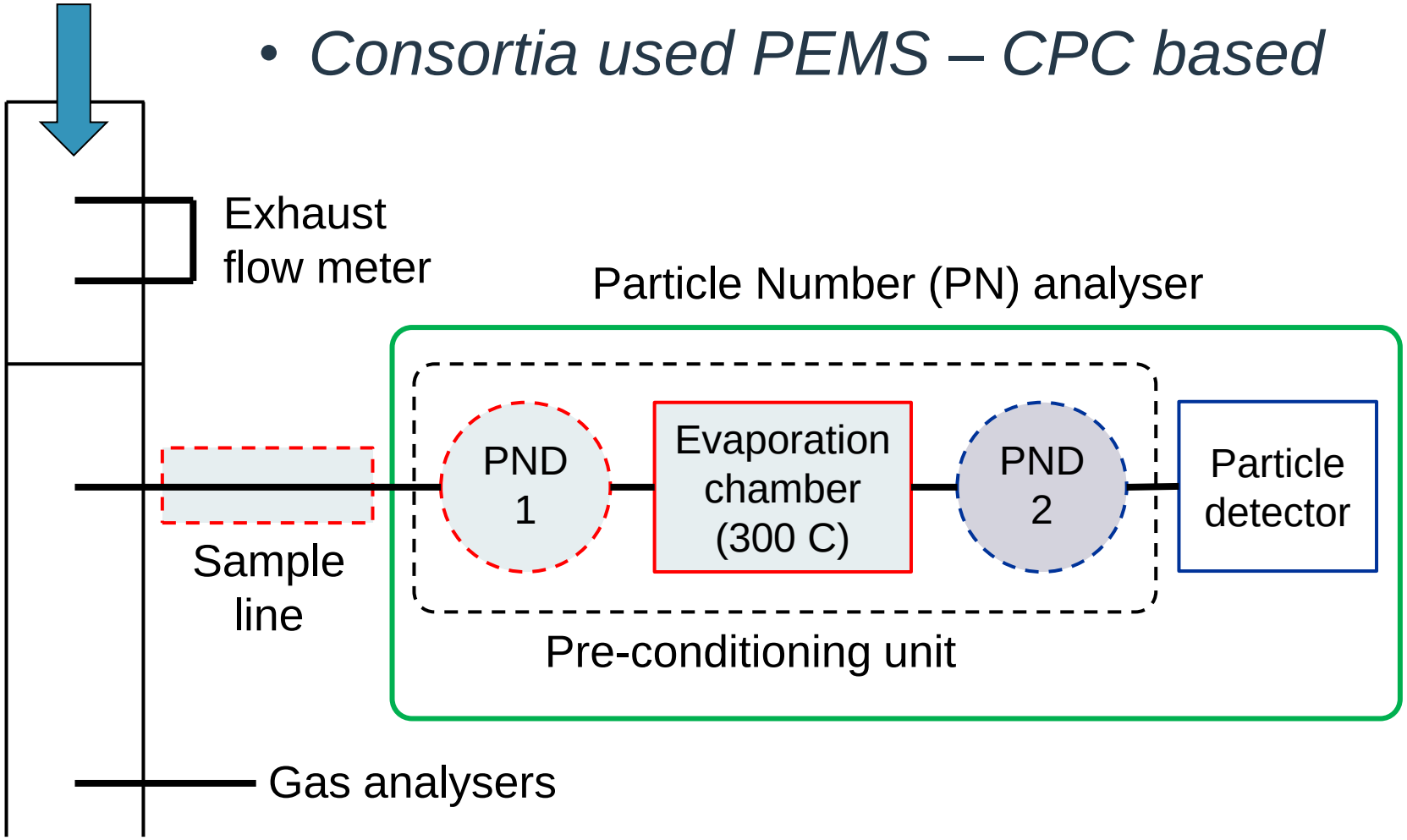
- The specifications and requirements for particle number (PN) portable emissions measurement systems (PEMS) are described in European Commission Regulation (EU) 2017/1151 and its amendment (EU) 2017/1154.

- Traceability scheme for PN – RDE - counter (ISO - NMI – approach)



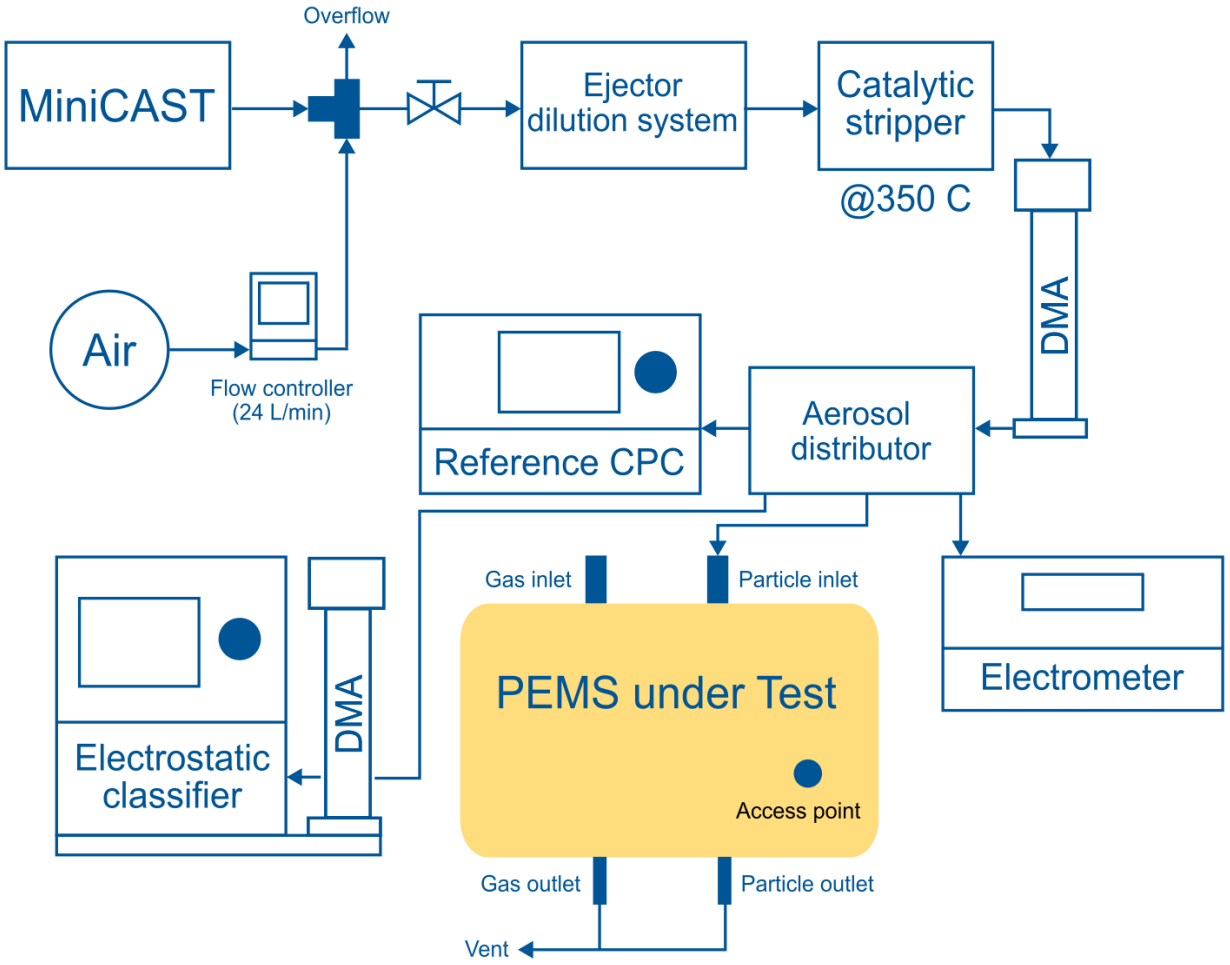


PN - PEMS device: General Setup



- *Consortia used PEMS – CPC based*

Harmonization strategy at NMI



RECOMMENDATION for LAB-Setup:

- **CAST + Predilution + VPR-Setup: Thermostable soot**
- **<u>Lambda approach = 1</u> for all Operation Points (OP) at CAST**
- **A DMA Tandem / Approach by 2U + 3U – Setup for Counting efficiency up to 200 nm**
- **Multiple charge correction (MCC) for particle > 50 nm, ratio < 5%**
- **Linearity for mono- and polydisperse soot particles (up to 800k)**

→ **Deliverable as guideline for stakeholders**

Round Robin metric

- Counting efficiency of PN analyser
- Linearity of PN analyser in PEMS:
  - Monodisperse particles
  - Polydisperse particles

ETH by PTB

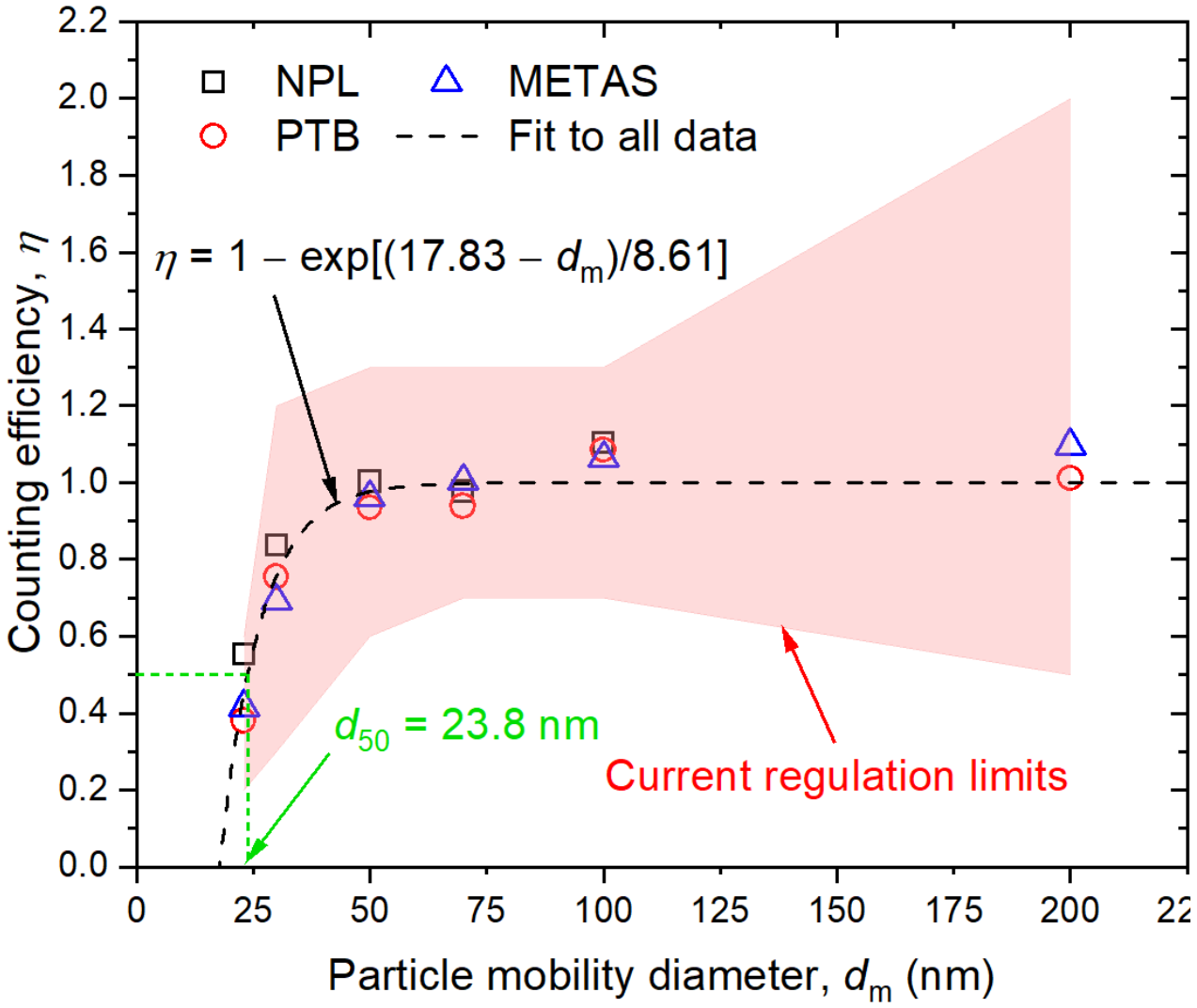
GOALS for RR:

- **Validation of NMI capabilities with PEMS-CPC based**
- **To ensure high quality measurements**
- **Important step to harmonize and to minimize measurement uncertainties**

- Particle concentration reduction factor (PCRF)
- Dilution factor of PN analyser
- Particle Penetration efficiency
- Volatile Particle removal efficiency

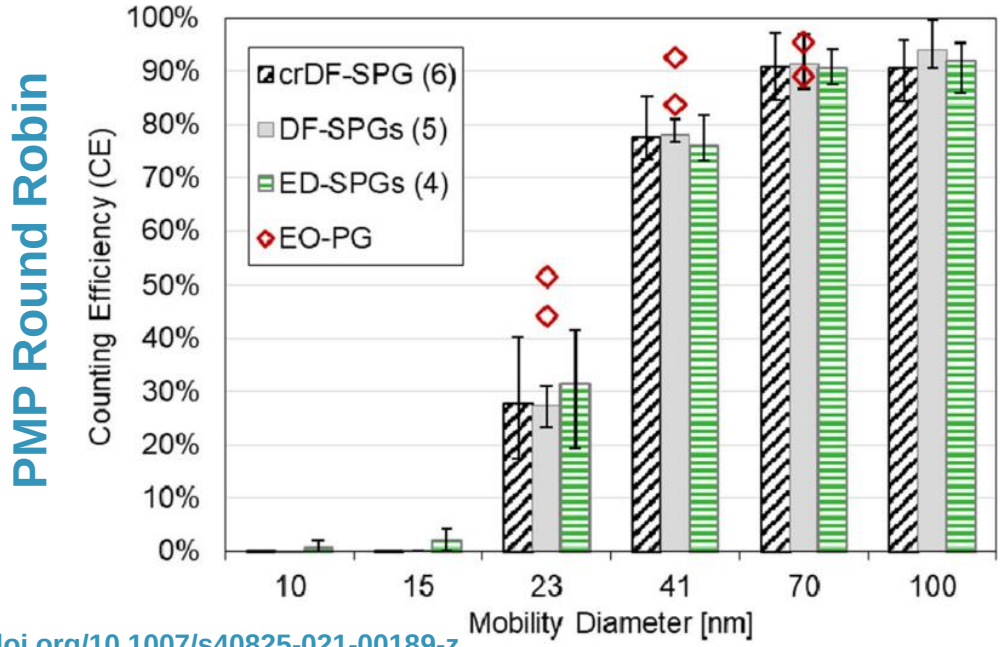
Cambridge Particle meeting by NPL, Mohsen Kazemimanesh

Counting efficiency, mono



- **Generator: Triple flame miniCAST 5303C**
- **Thermostable soot at 23, 30, 50, 70, 100, 200 nm**
- **MCC approach implemented**

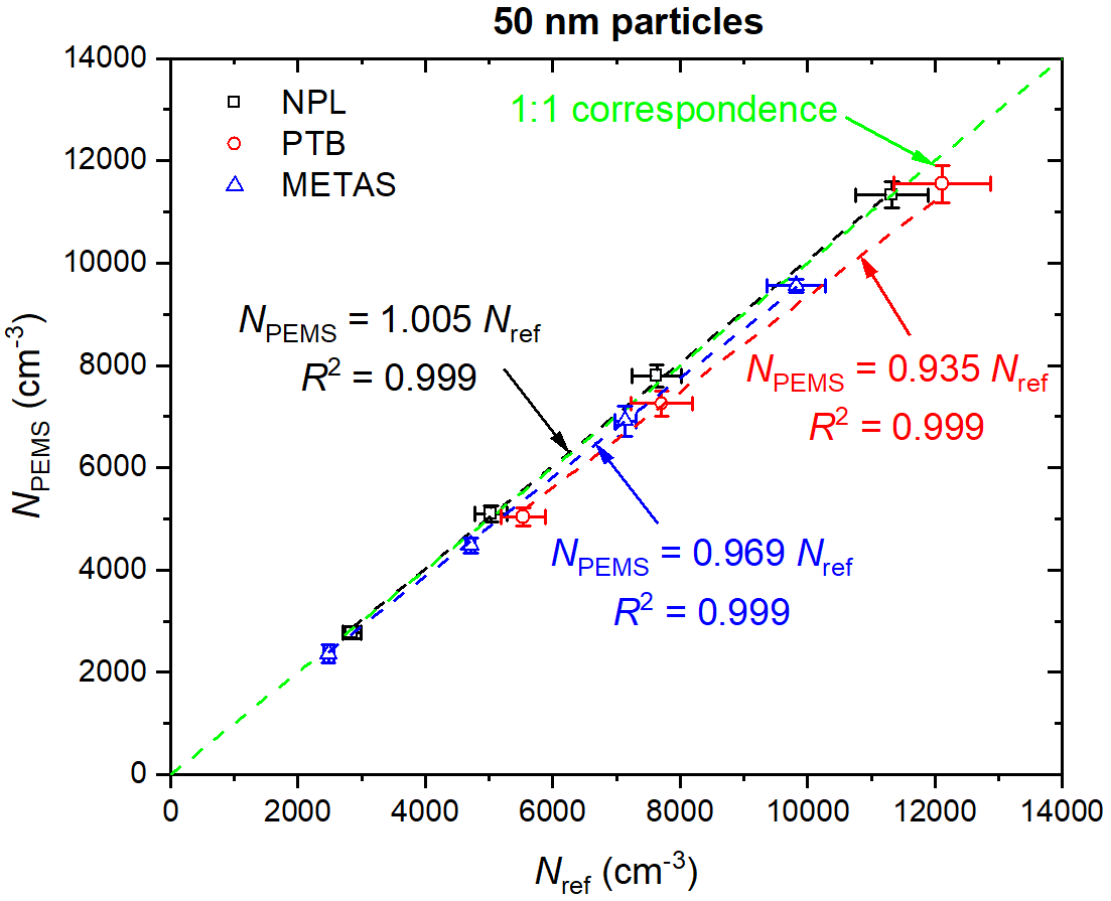
→ ***Good agreement by partners***

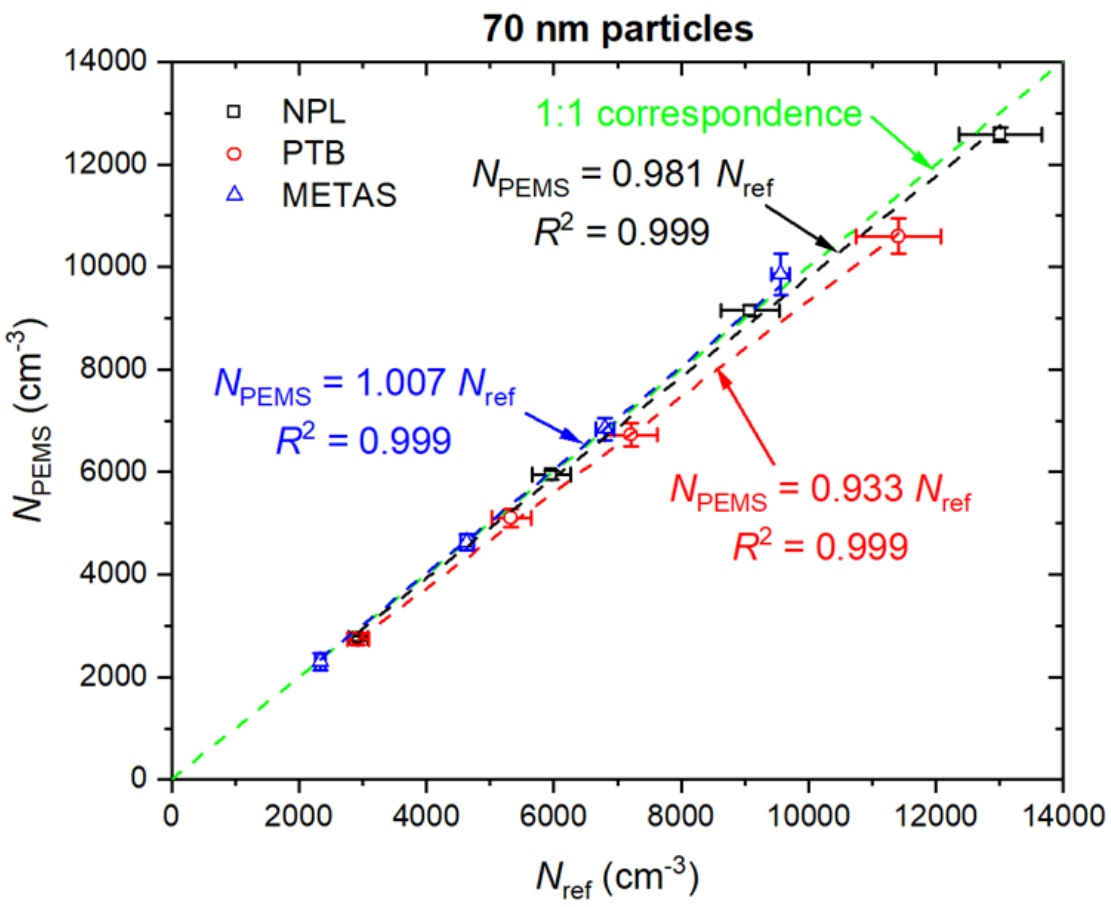


DOI: https://doi.org/10.1007/s40825-021-00189-z

Linearity, mono

- 10 min. each concentration level for 2500, 5000, 7500, > 10 000 cm-3

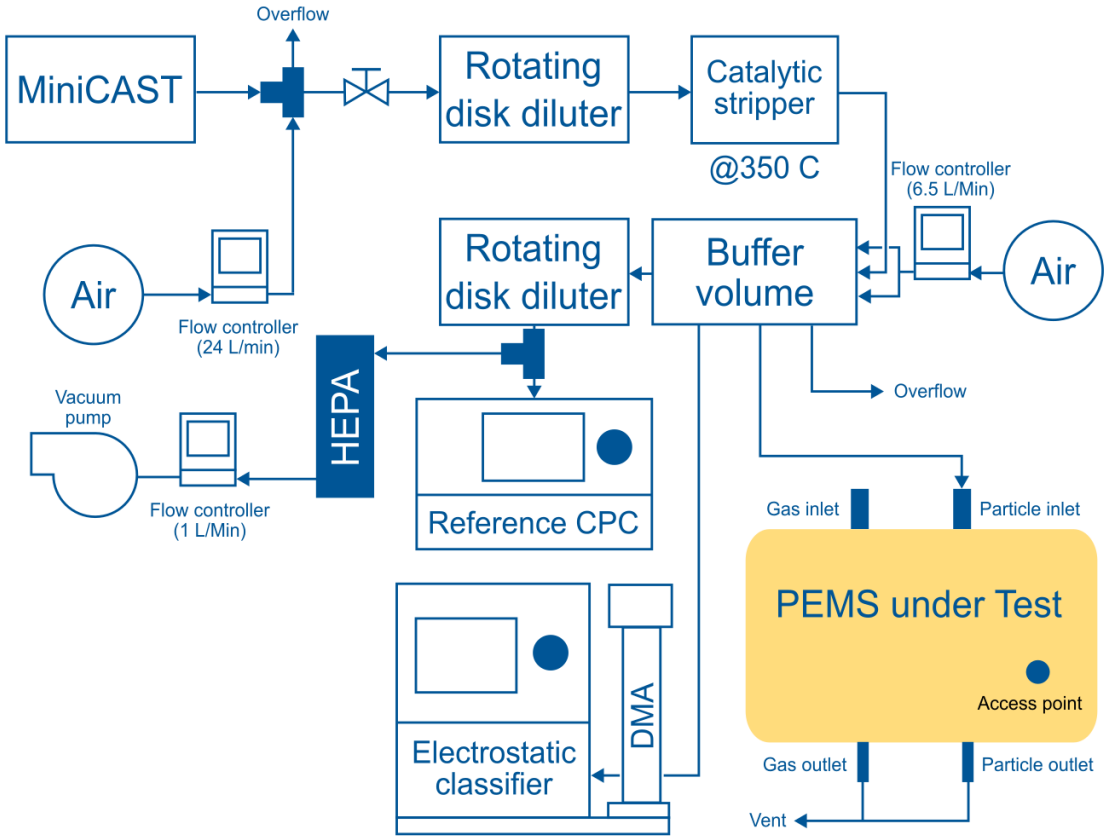


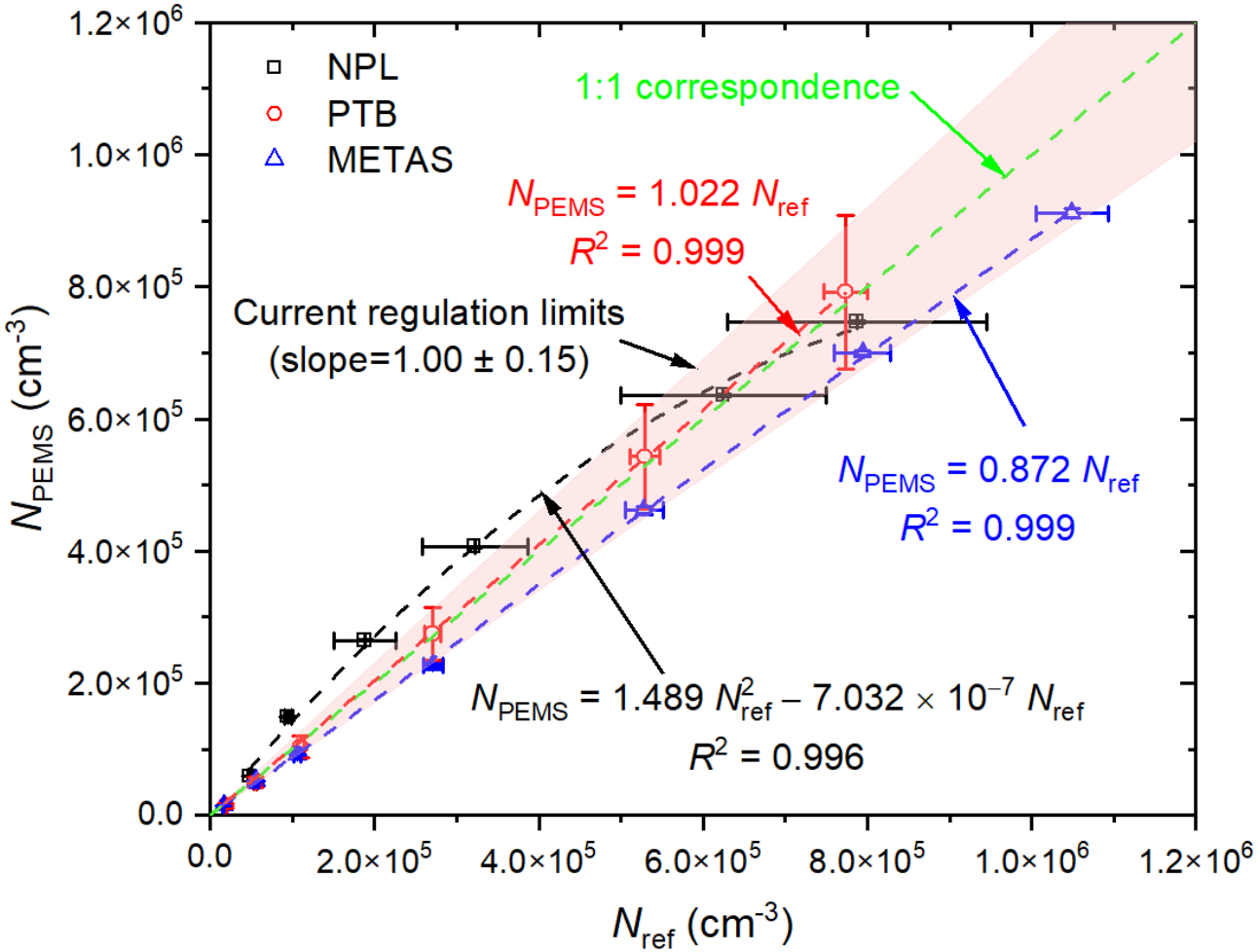


→ Fairly good agreement by partners (± 5%), especially for 70 nm

Linearity, poly - Lab

- **Check of response up to 1.1 Mio particle/cm^{-3} at 70 nm (CMD, poly)**

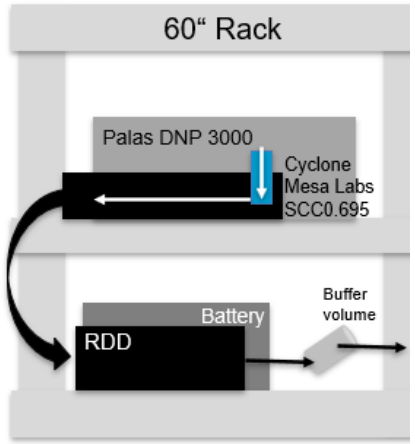




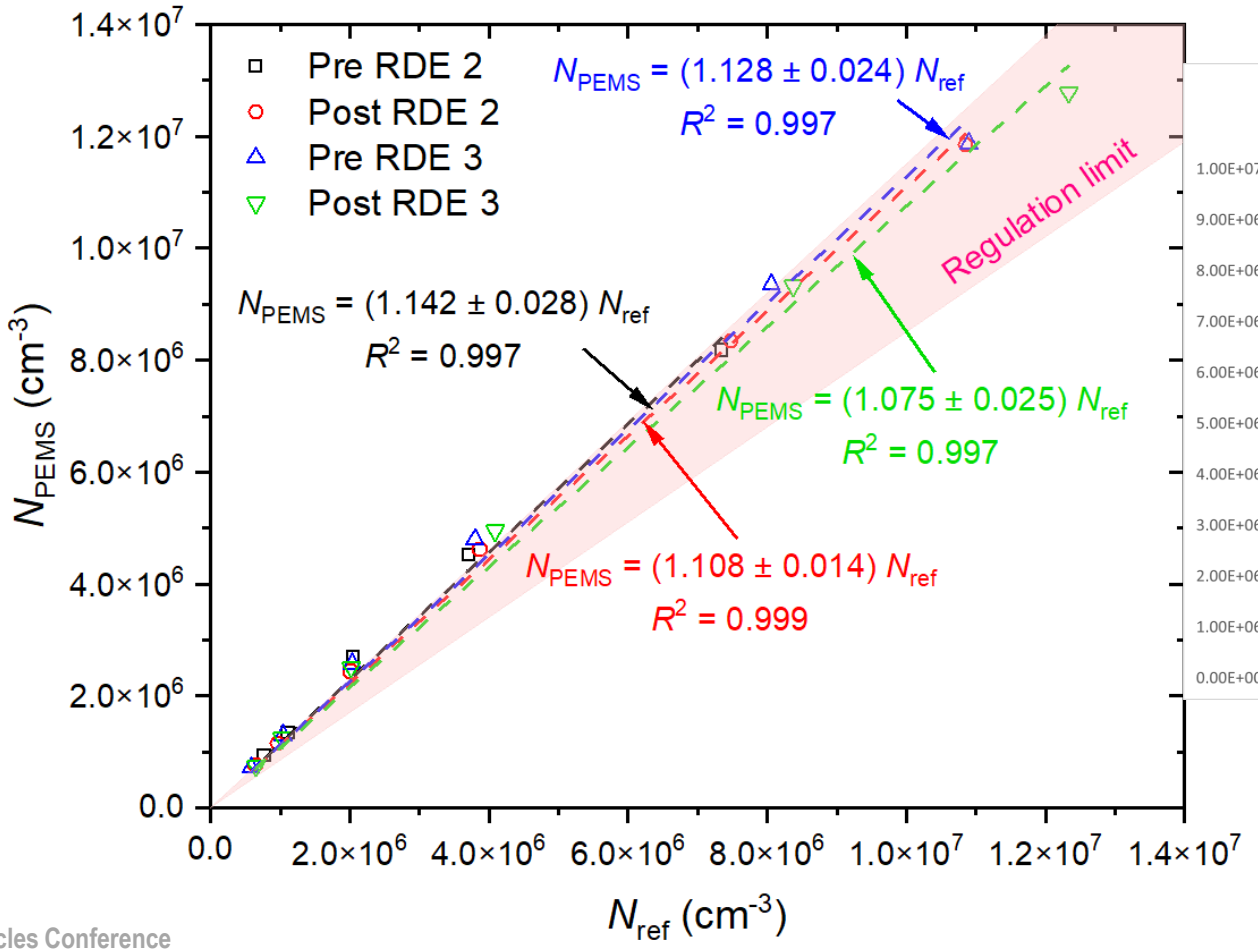
→ ***Higher variation was figured out by partners; NPL used CPC in photometric mode***

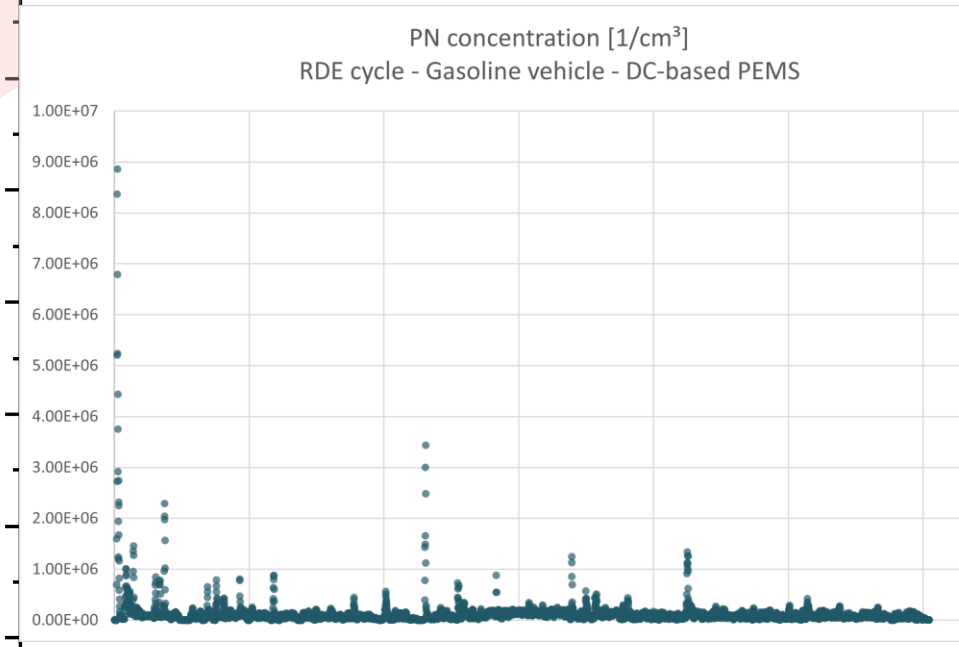
Linearity, poly - infield

- A spark discharged generator and CPC + Diluter was used as calibration setup
- Check of response up to 12 Mio particle/cm^{-3} at 70 nm (CMD, poly)

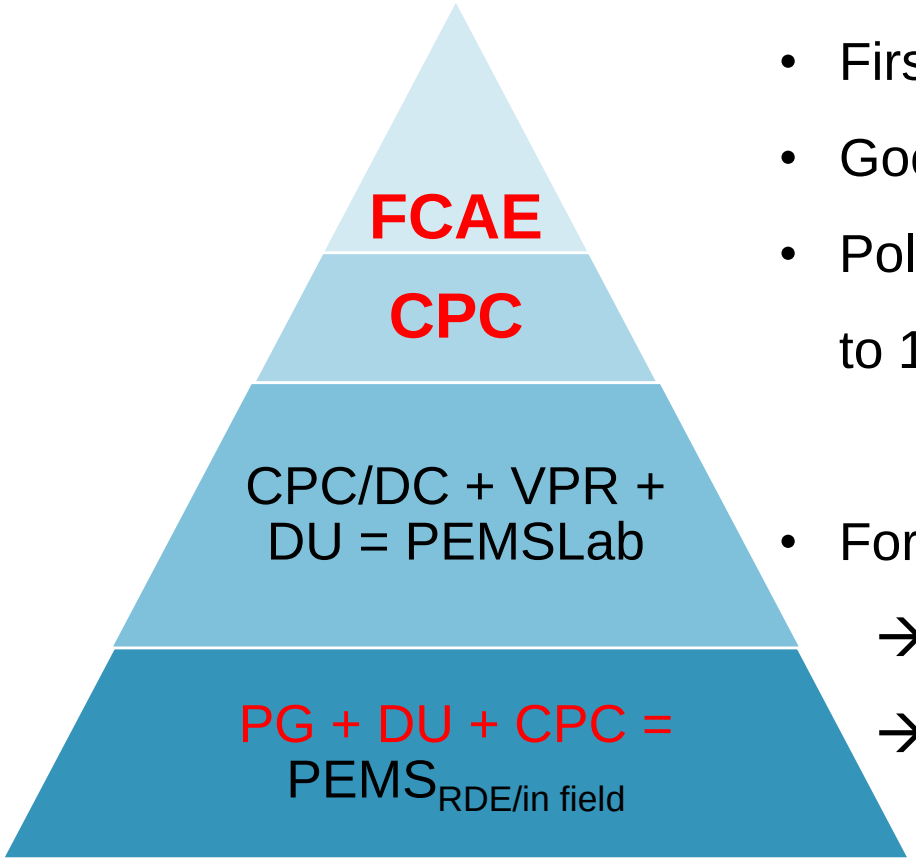


see also online presentatio last year by Angelina Del, PTB





Conclusion



- A harmonization process was established between NMIs
- First round robin between NMIs in Europe with traveling PN-PEMS
- Good agreement was figured out for monodisperse test
- Polydisperse test at high number conc- level shows higher variation up to 10 %

- For infield validation we recommended:
  - → Higher measurement uncertainties for linear response check
  - → An infield check of PN-sensors with Particle generator (PG) and reference PN setup (CPC + Dilution unit, DU), especially for gasoline cars

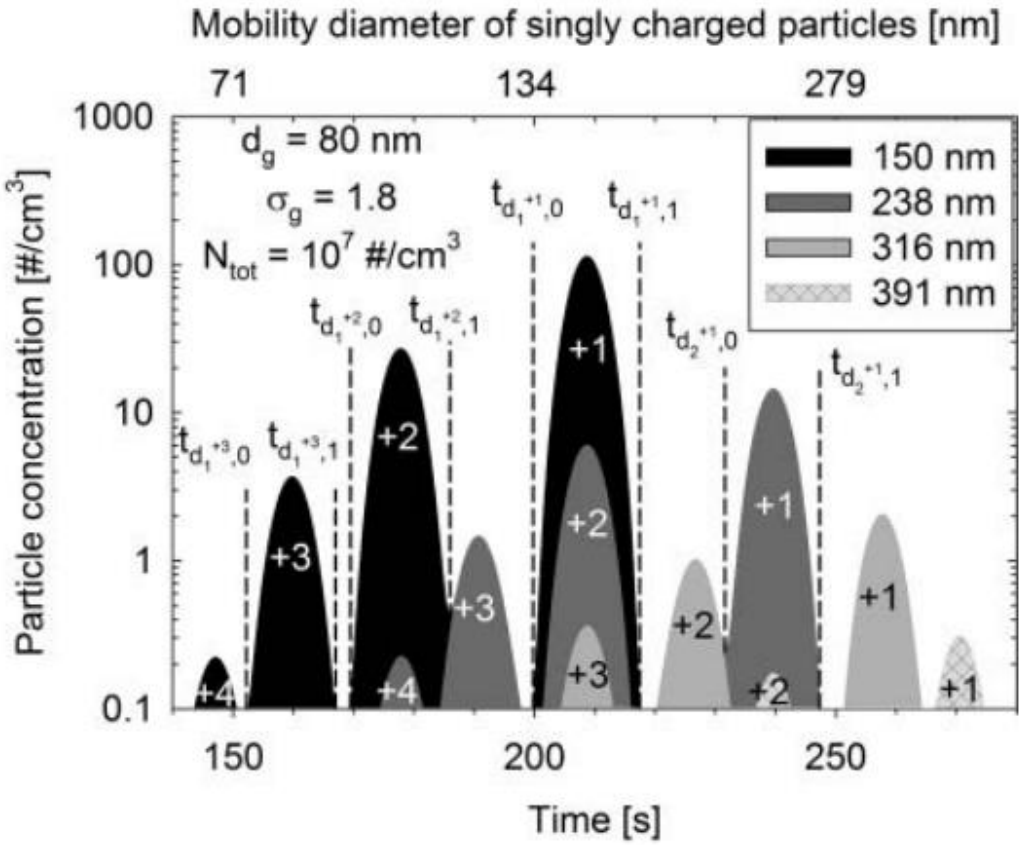
Thank you for attention, any question you may have?

This project 19ENV09 MetroPEMS has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

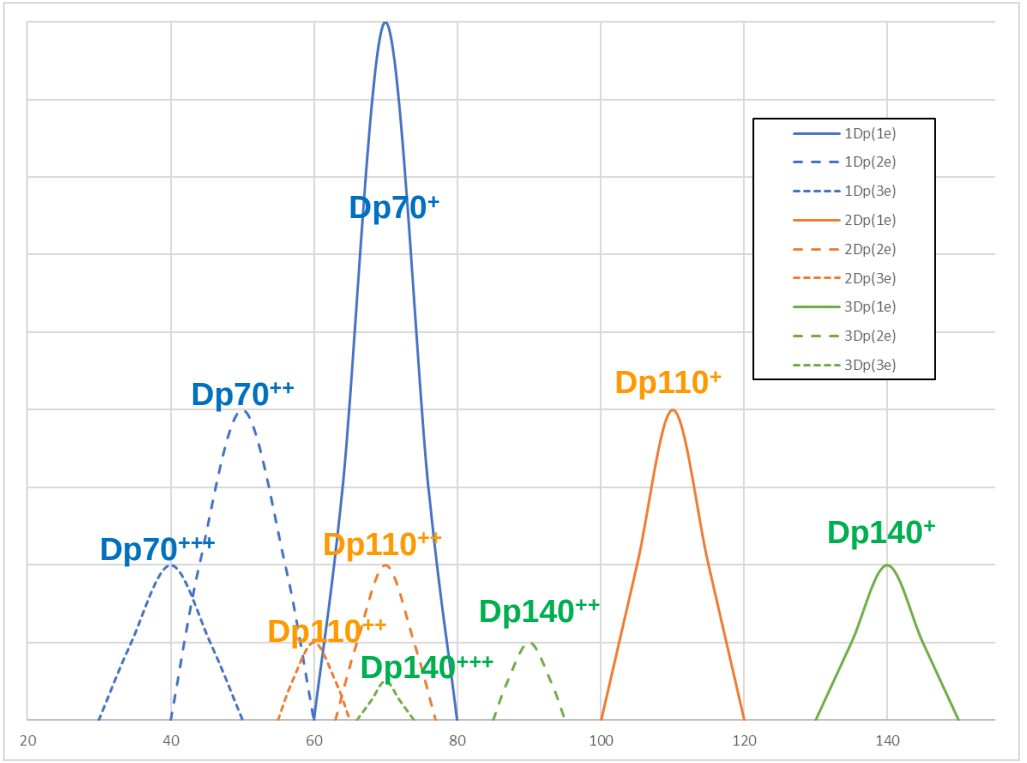
Many Thanks to WP 2 Team: Jorge, Mohsen, Alexandre, Rasmus and Tobias

Appendix 1: MCC approach

- Investigation by Mamakos, 2016 et al (DOI 10.1080/02786826.2016.1153034) for 150 nm



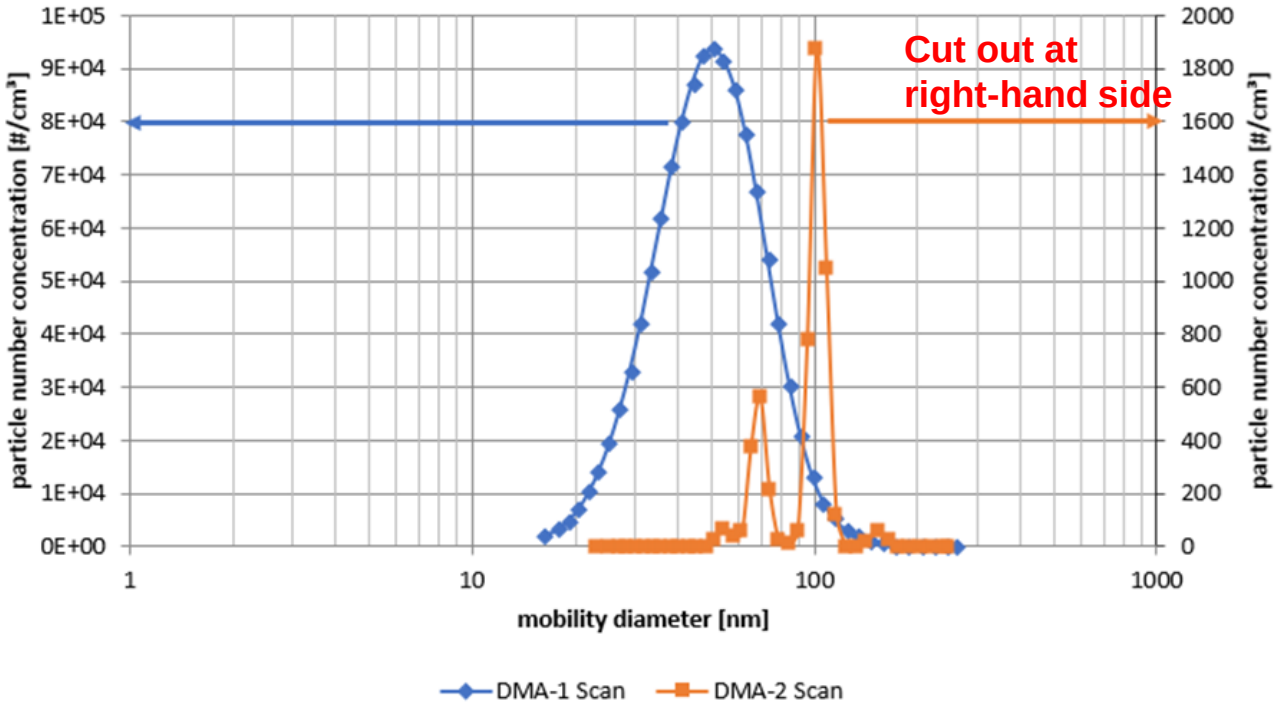
- MCC approach as example for 70 nm at Maximum of polydisperse PNSD

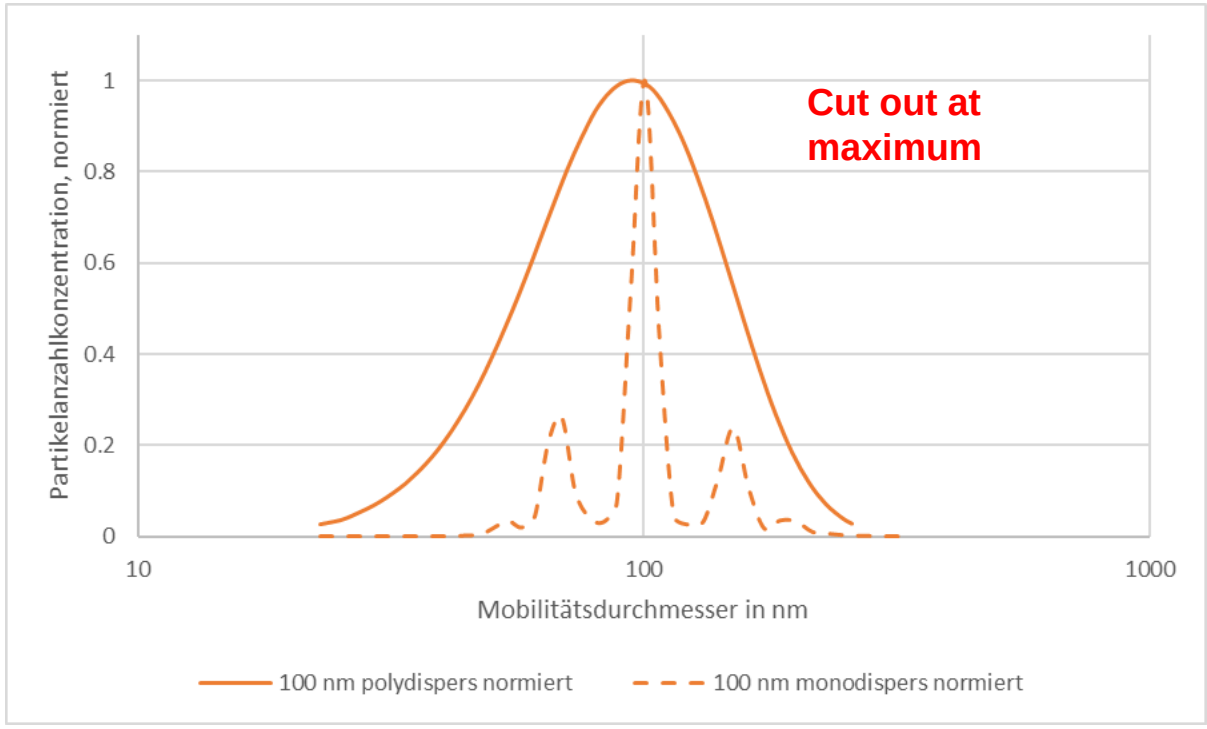


→ Charge states of each peaks have to be calculated for the right-hand side of PNSD → ISO 27891 Annex, Part D. 3, called as 2U and 3 U assumption (Approach of Multiply Charge Correction)

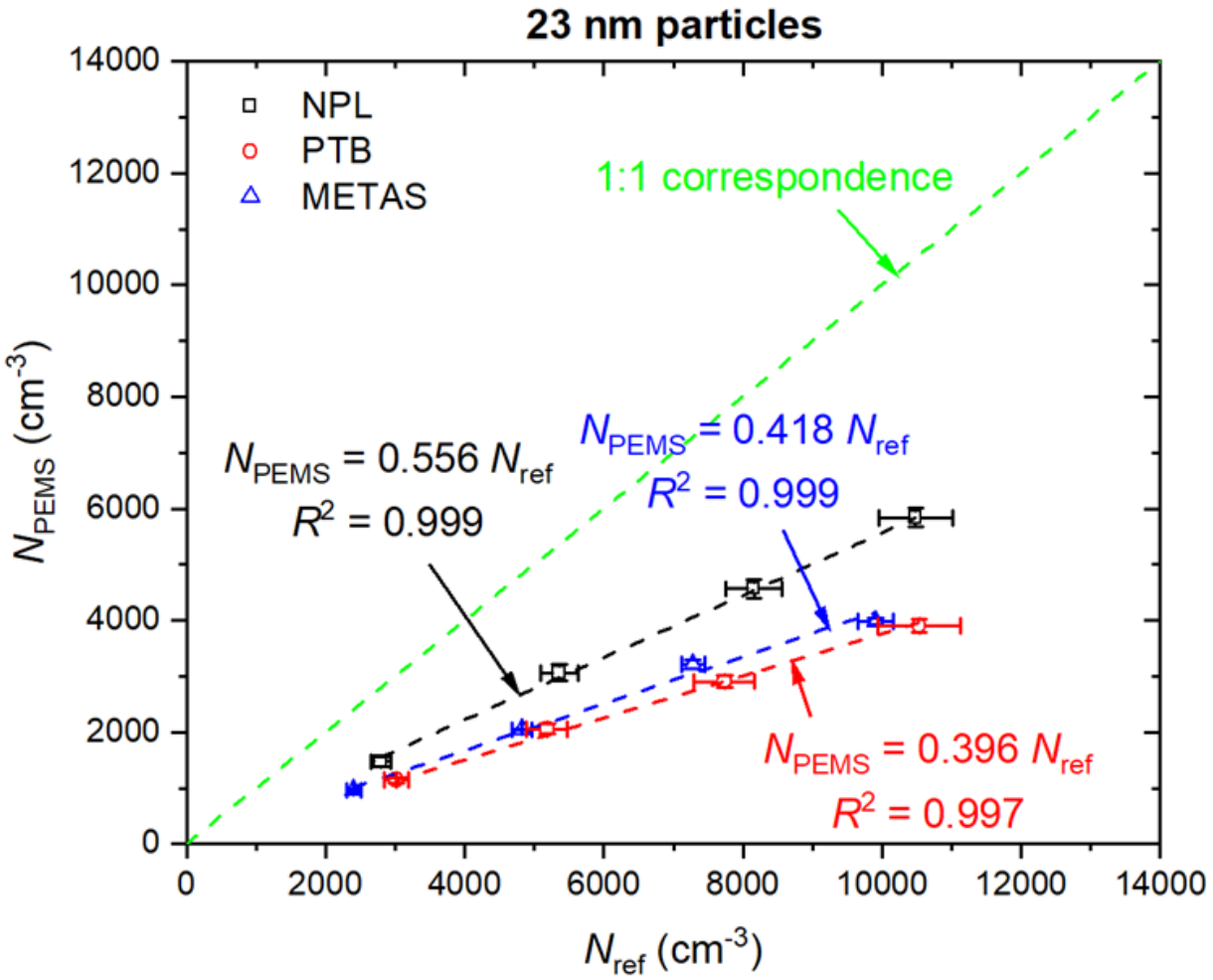
Appendix 1: MCC approach

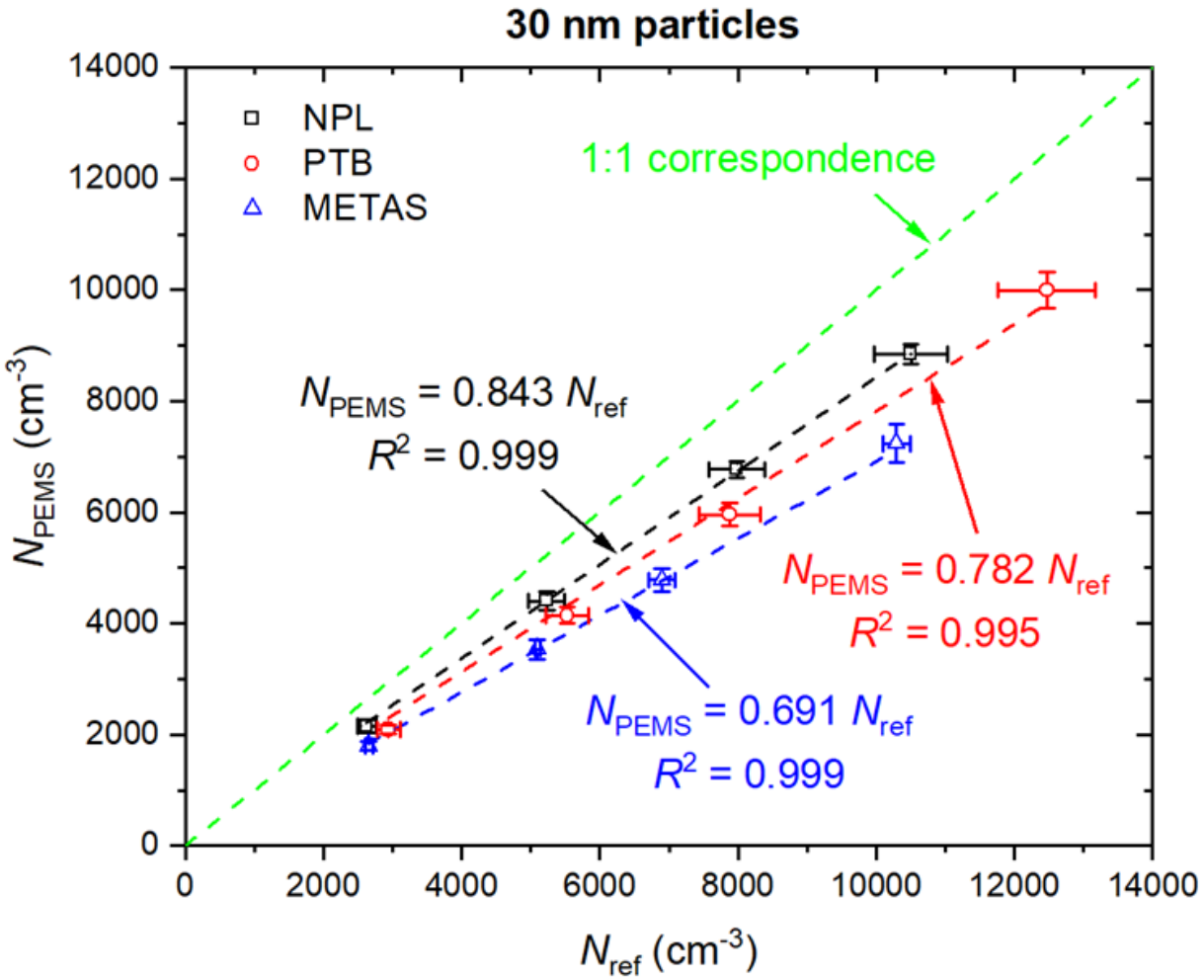
- Cut out on the right-hand side of polydisperse PNSD to avoid additional right hand side peaks for MCC spectra





Appendix 2: mono CE - additional plots





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