European Commission

European Metrology Research Programme

Emerging requirements for measuring pollutants from automotive exhaust emissions Progress update

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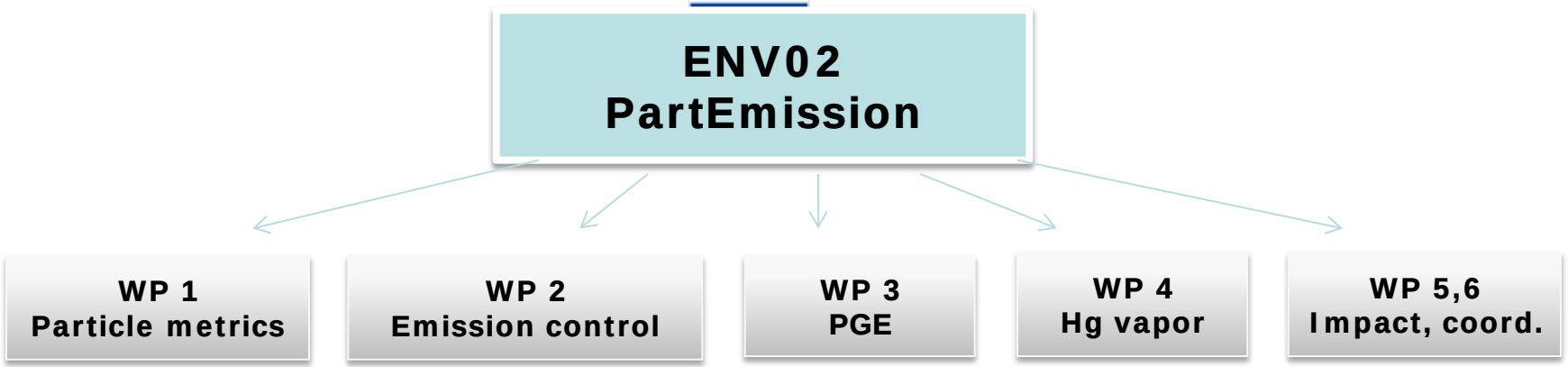
Institute for Energy and Transport
Joint Research Centre

PMP meeting
DG ENTR Brussels
21 November 2013



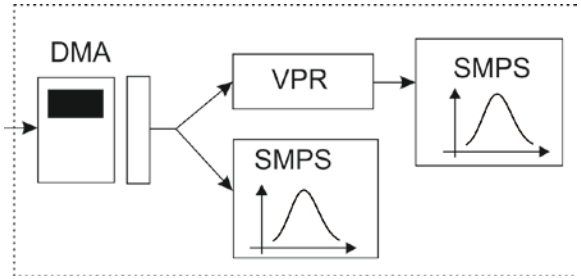
- **WP 1: Automotive combustion particle metrics**
  - **Task 1.1: Generation of automotive combustion calibration aerosols**
  - **Task 1.2: Number concentration traceability**
- **WP 2: Methods for periodic emission control of modern diesel vehicles**
- WP 3: Quantification of Platinum Group Elements (PGE) in automotive emission
- WP 4: Traceability for Hg vapor measurement
- WP 5,6: Management and creating impact

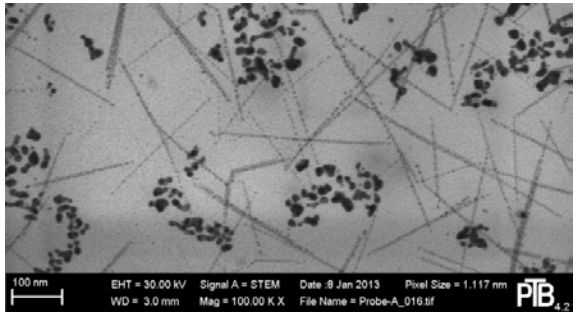
Participants: mainly National Metrology Institutes > PTB, METAS, NPL, MIKES, DFM, VSL, IJS, LNE, BAM, JRC

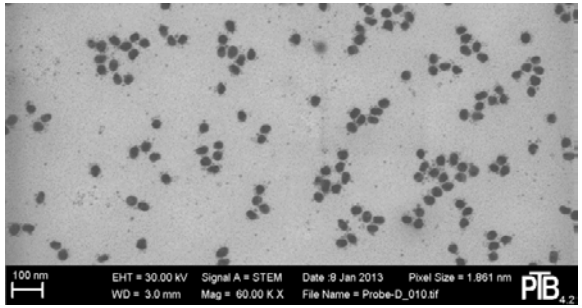
Automotive particle emission metrics

suitable calibration aerosols – temperature stability

- Thermal stability assessed via comparing size distribution upstream and downstream a VPR
- Graphite spark aerosol (JRC) does not need thermal treatment
- CAST combustion aerosols (METAS) need thermal treatment to be thermally stable
- Silver particle aerosols (TROPOS) need sintering at 600°C for thermal stability; upper size limited to 50 nm



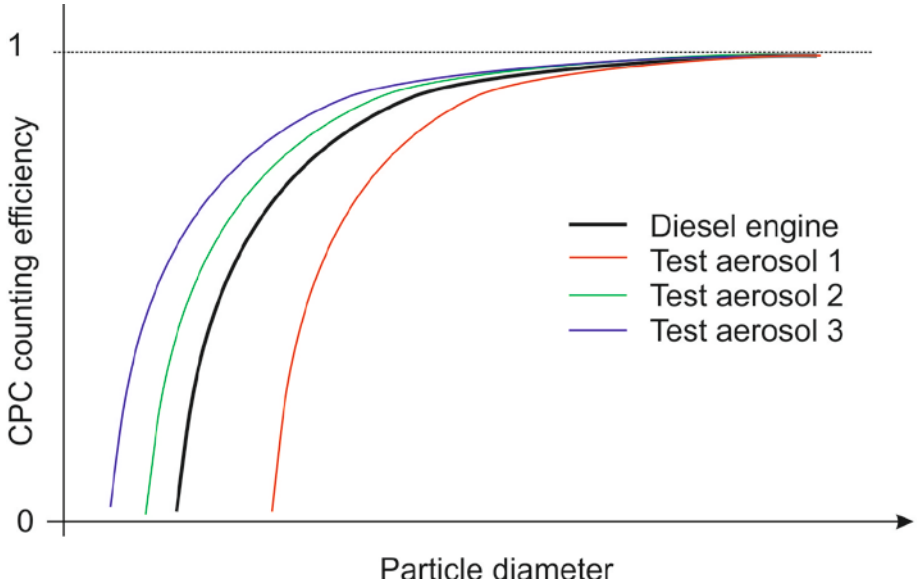




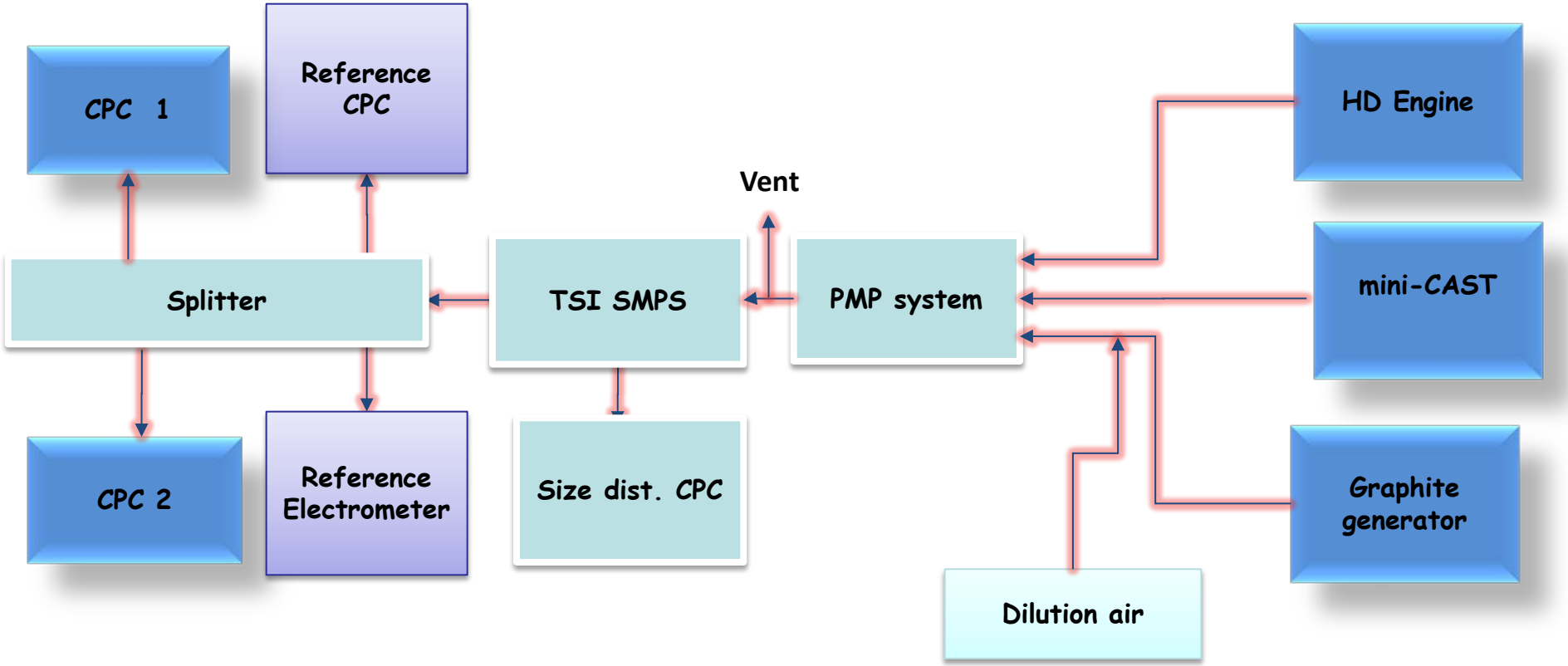
Automotive particle emission metrics suitable calibration aerosols – “soot-like”

Assess which calibration aerosol is more “soot-like”.

- Obtain a calibration with real soot (at 23 and 41nm).
- Compare it with the calibration obtained with lab aerosol.
- Collect AFM samples to compare aerosol physical properties.



Soot-likeness - Experimental setup



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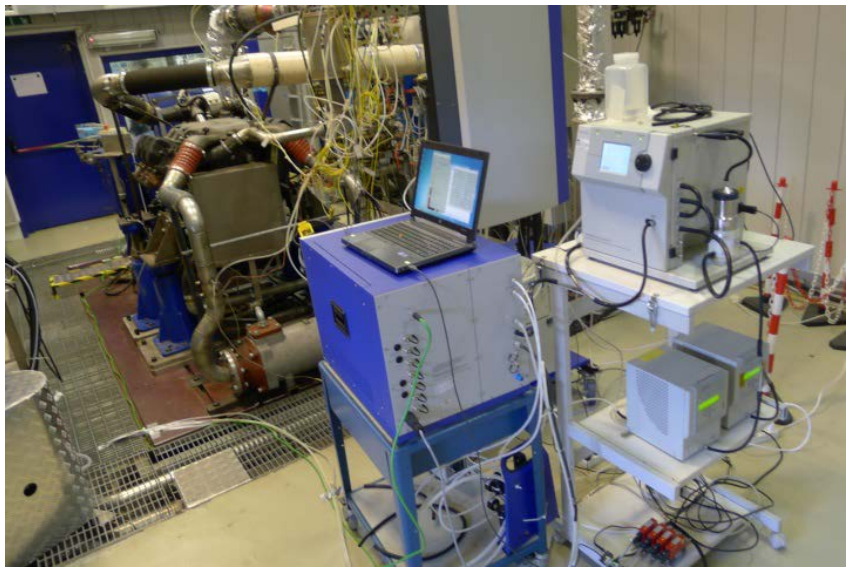
- Counting efficiencies of a test CPC were simultaneously measured with CAST combustion, graphite and “real-soot” (Daimler V6 HD engine)



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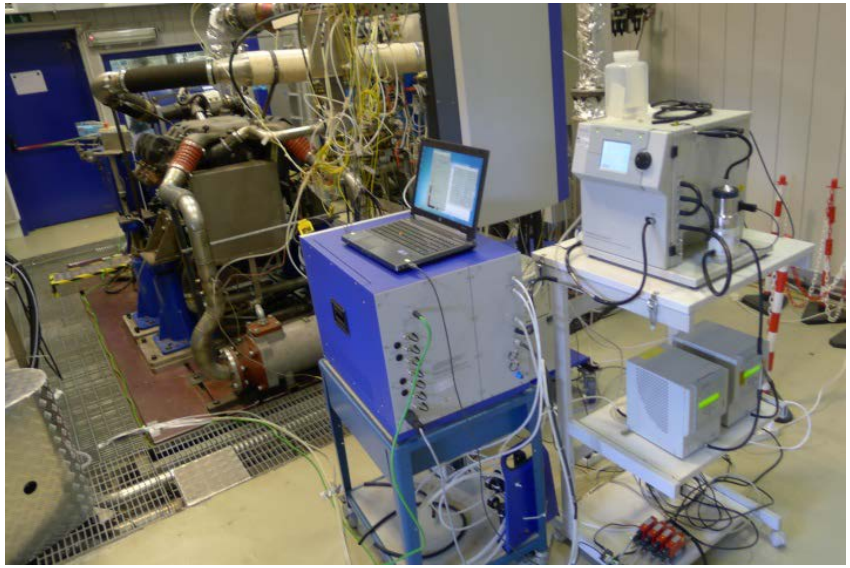
- Counting efficiencies of a test CPC were simultaneously measured with CAST combustion, graphite and “real-soot” (Daimler V6 HD engine)
- Counting efficiency variability due to different engine conditions are of the same order of the variability due to different aerosol materials



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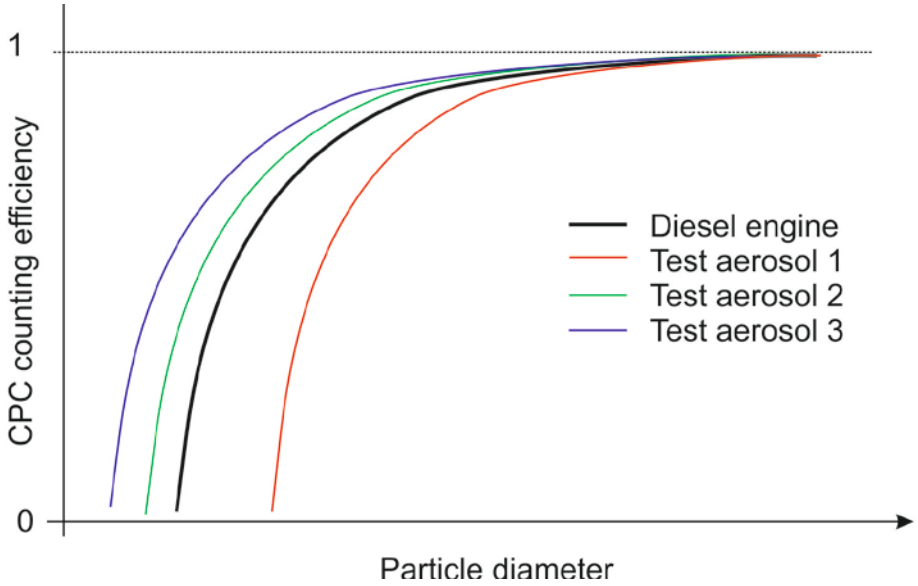

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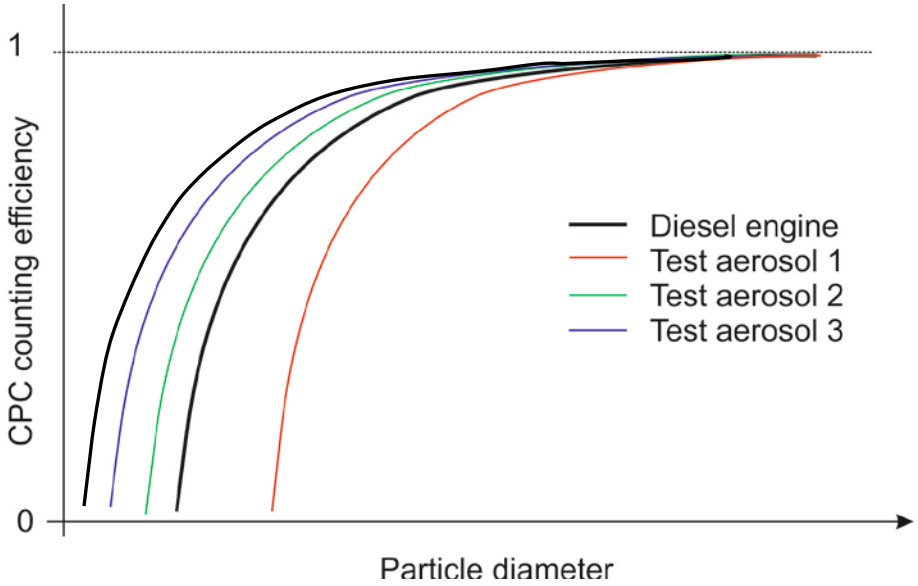

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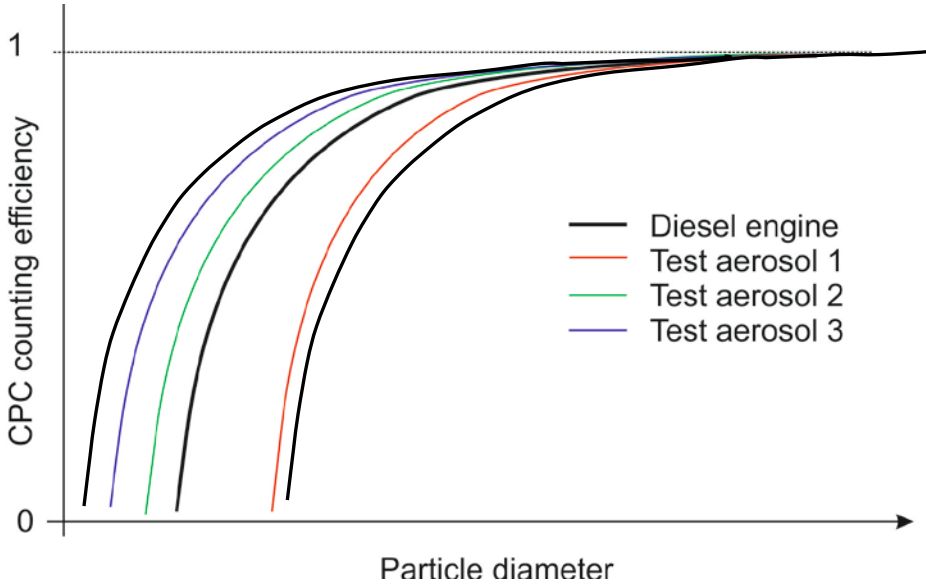

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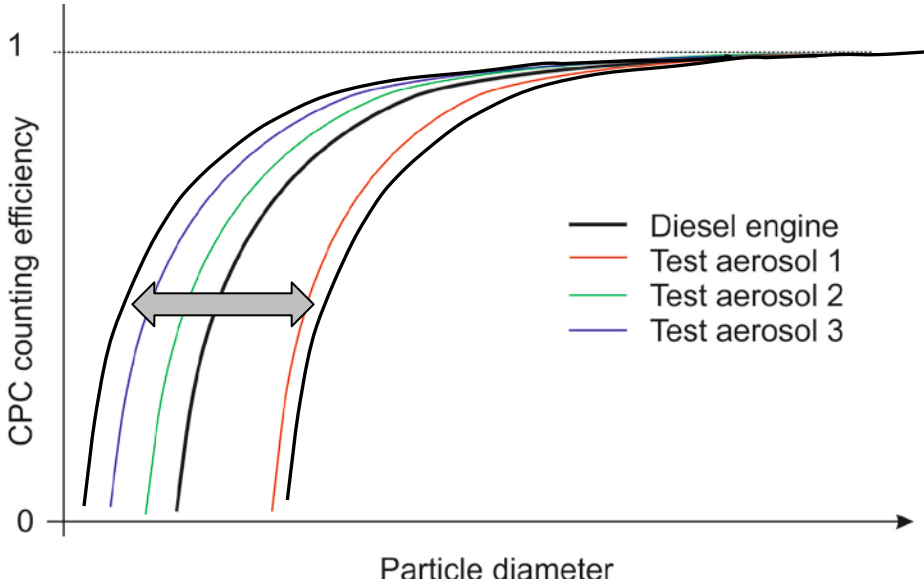
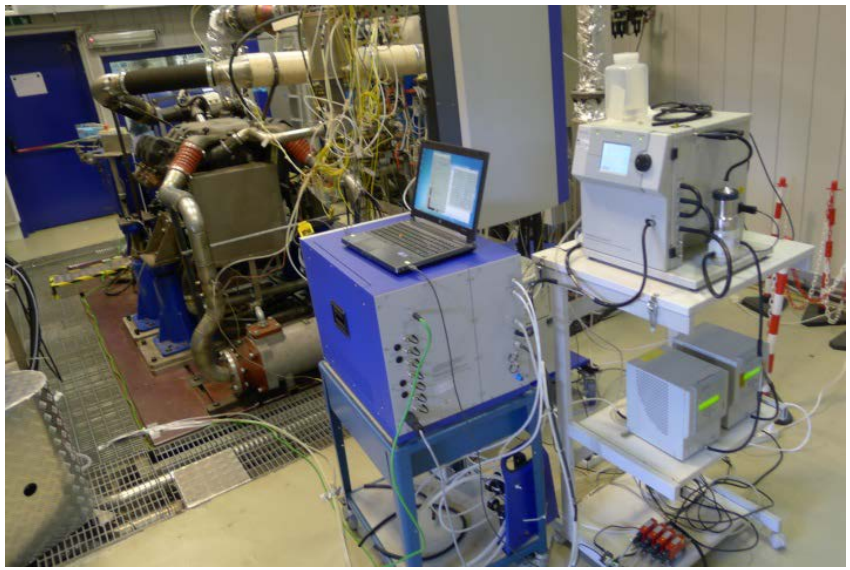


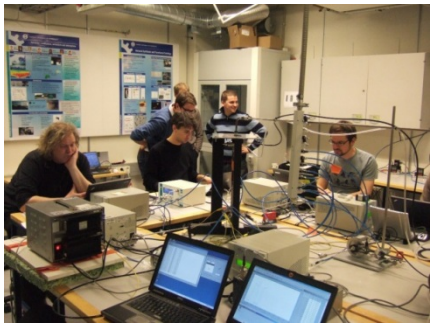
Automotive particle emission metrics suitable calibration aerosols – “soot-like”

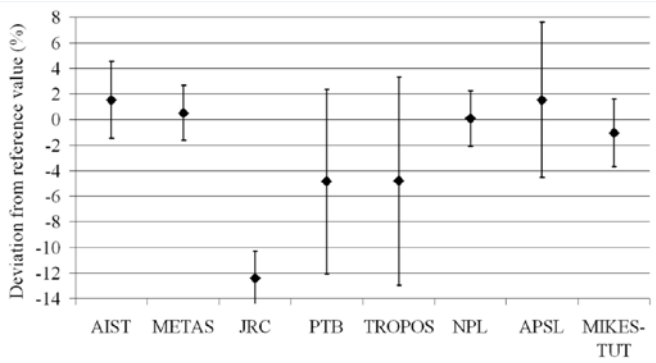
- Counting efficiencies of a test CPC were simultaneously measured with CAST combustion, graphite and “real-soot” (Daimler V6 HD engine)
- Counting efficiency variability due to different engine conditions are of the same order of the variability due to different aerosol materials
- “soot-like” seems not to be a good criteria to select the standard aerosol, **need for harmonisation**. Different criteria than “soot-likeness” has to be identified.



Automotive particle emission metrics
Electrometer inter-comparison

- First inter-comparison of charge concentration measurements by faraday cup electrometers (FCAE) at Tampere University of Technology





- Participants agree within 3% in the size range 20 nm to 100 nm and number concentrations above 5000 cm^{-3} for singly charged synthetic particles. Larger deviations result at lower particle sizes and concentrations and soot particles.

Automotive particle emission metrics
CPC calibration workshop

CPC cut-off calibration workshop took place in Leipzig (TROPOS) in Octrober.

Calibration aerosol:

- Unsintered silver particles
- Sintered silver particles
- Combustion generated particles (CAST)

Instrument manufacturers participated as a first round robin test.
Results expected in the next weeks.

Methods for periodic emissions control metrological validation

- Seven prototype instruments provided by instrument manufacturer are calibrated for opacity (PTB), mass (PTB, METAS) particle number concentration (METAS, MIKES) and tested on field (JRC).

- Increased “soot”-sensitivity is attempted for by use of light scattering (3), electrical (1), ionisation chamber (1) and diffusion charging (2) sensors.

- The “soot”-sensitivity critically depends on the measurement principle. Diffusion charging sensors are particularly sensitive at low particle number concentration and insensitive to the particle size; in contrast light scattering is limited at low particle sizes.

Summary and Outlook

- Thermally treated combustion and graphite aerosol are suitable to calibrate VPRs.
- There is not a single “soot-like” aerosol suitable to calibrate counting efficiencies of PMP-compliant CPCs, still a need for harmonization. Different criteria to select the superior aerosol.
- Worldwide comparability of particle charge measurement within 3% demonstrated.
- Prototypes of instruments designed to replace today’s opacimeters in periodic emission controls exhibit a large variability at low particle number / mass concentration and sizes.
- The EMRP work on “soot”-metrology continues until mid 2014 and hopefully beyond that.

More information

http://www.ptb.de/emrp/partemission-publications.html

- **Characterization of Combustion Aerosol Produced by a Mini-CAST and Treated in a Catalytic Stripper**
  by: Athanasios Mamakosa, Imad Khaleka, Robert Giannellib, Matthew Spearsb
  (http://www.tandfonline.com/doi/full/10.1080/02786826.2013.802762)

- **Calibration and modeling of PMP compliant condensation particle counters**
  by: Athanasios Mamakos, Barouch Giechaskiel, Yannis Drossinos, Dominique Lesueur, Giorgio Martini, Alois Krasenbrink)
  (http://publications.jrc.ec.europa.eu/repository/handle/111111111/25454)

- **Assessment of pumped mercury vapour adsorption tubes as passive samplers using a micro-exposure chamber**
  by: Richard J. C. Brown , Melia K. Burdon , Andrew S. Brown and Ki-Hyun Kim
  (http://pubs.rsc.org/en/content/articlelanding/2012/em/c2em30101f/unauth)

Thank you for your attention!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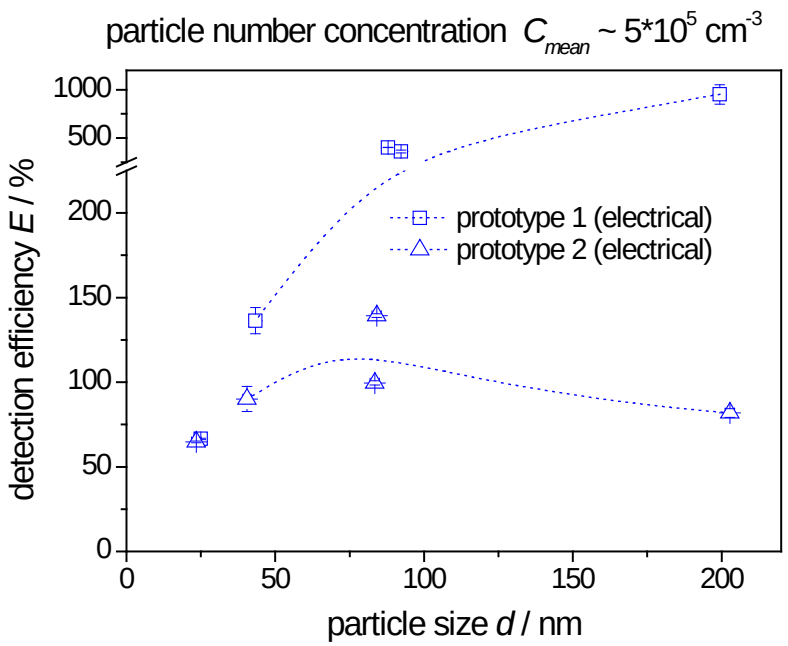
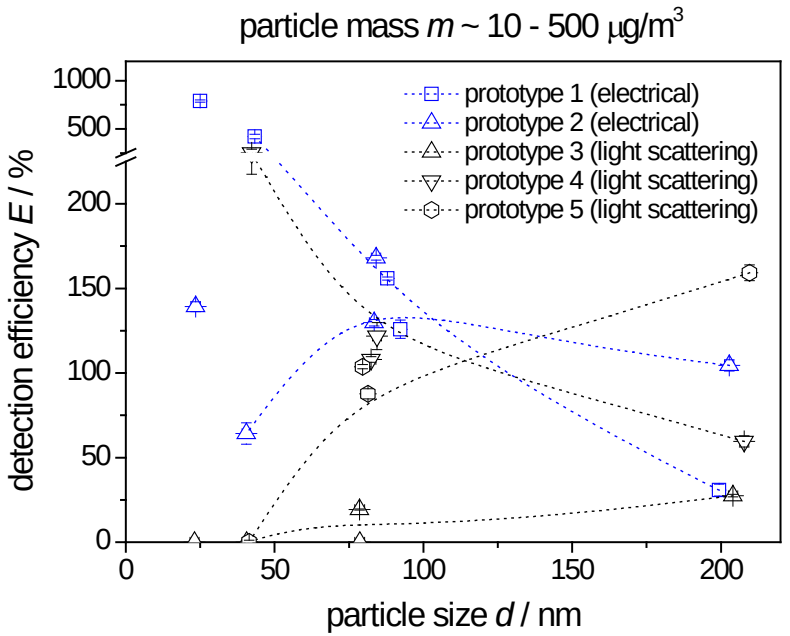
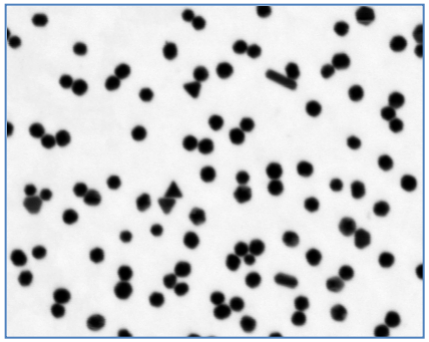
Methods for periodic emissions control particle number concentration calibration





Automotive particle emission metrics particle size standards – SI traceability

- Spherical reference gold and silver particles studied for the calibration of differential mobility analyser (DMA)
- Successful aerosolization, but systematic deviations between measured mobility diameter (DMA) and geometric diameter (TSEM)



TSEM image Au 30 nm particles

Nominal diameter	20 nm	30 nm	40 nm
TSEM mean diam	21.0 ± 1.9 nm	29.8 ± 2.0 nm	44.5 ± 2.2 nm
TSEM mode diam	20.4 nm	29.3 nm	42.9 nm
DMA mode diam	24.0 ± 0.4 nm	33.8 ± 0.6 nm	44.6 ± 1.0 nm
Factor DMA/TSEM	1.18	1.15	1.04

- Consortium issued a best practice recommendation for DMA calibration