

Experimental study of the performances of various Condensation Particle Counters challenged by steady-state airborne DEHS particles

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Motivation & objectives (1/2)

- Number concentration
 - the most frequent characteristic used for
 - > airborne nanoparticle monitoring,
 - > task emission classification,
 - > protective equipment performance evaluation against nanoparticles.
 - of great interest in the context of characterization of diesel exhaust
 - has been proposed as a relevant metric for airborne nanoparticle exposure assessment (IFA)
- CPC have been developed and widely used for a long time
 - few is known about their performance when multiple models are simultaneously challenged by an identical aerosol

Motivation & objectives (2/2)

- The use of CPC for aerosol monitoring when nanomaterials are produced or handled has been recommended by several institutes (e.g. NIOSH, INRS)
- CPC calibration relies on a specific setup which involves a DMA and an electrometer (ISO 27891, 2015)
- This study aims at providing a methodology for checking CPC to ensure reliable lab or field measurement campaigns
 - The objectives are to:
 - > develop a setup suitable for checking CPC
 - > allow a wide range of concentrations and particle sizes to be investigated and reproduced
 - > provide intercomparison data

Outline

- 1 Description and performances of the generation device (calibration tool)

- 2 Description and performances of the Device for Counter Check (DCC)

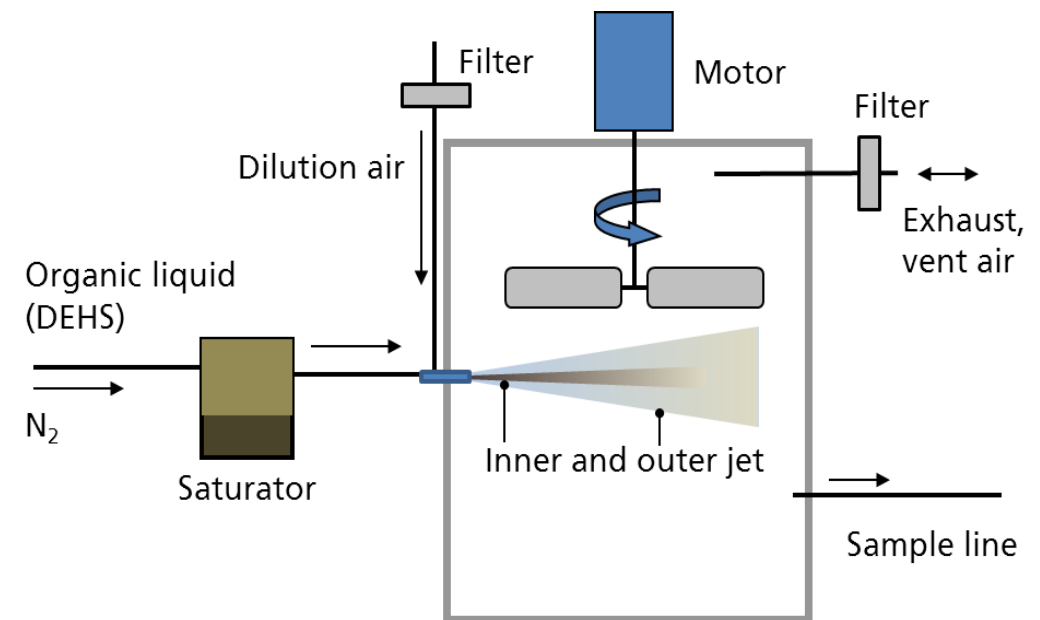
- 3 Application to a set of CPC
 - 3a • Results for handheld CPC
 - 3b • Results for stationary CPC

- 4 Conclusions & perspectives

Description and performances of the generation device (calibration tool)

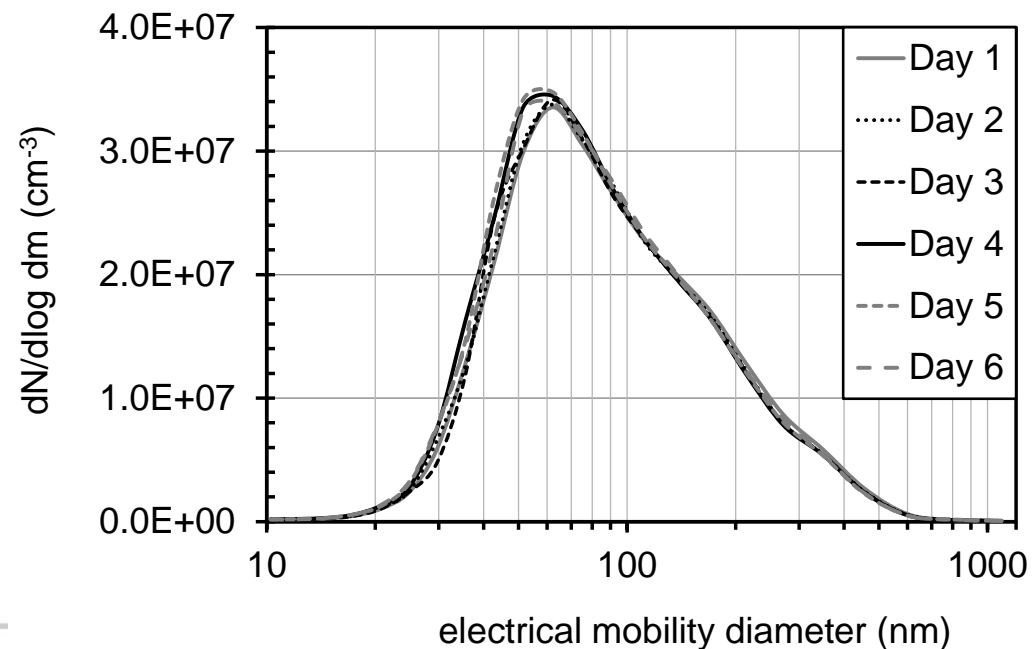
The Calibration Tool

- Developed by W. Koch / ITEM Fraunhofer (Hannover, Germany) in the framework of the Nanodevice European Project (Koch *et al.*, J. Aerosol Sci. 39, 2008, Koch *et al.*, J. Aerosol Sci. 49, 2012)
- Working principle of the “calibration tool”
 - Generation of liquid DEHS droplets by evaporation / condensation processes
 - Brownian coagulation in a continuously fed well-stirred tank reactor (~ 60 L in volume)
- A reproducible aerosol source
 - Self-preserved particle number size distribution



The Calibration Tool

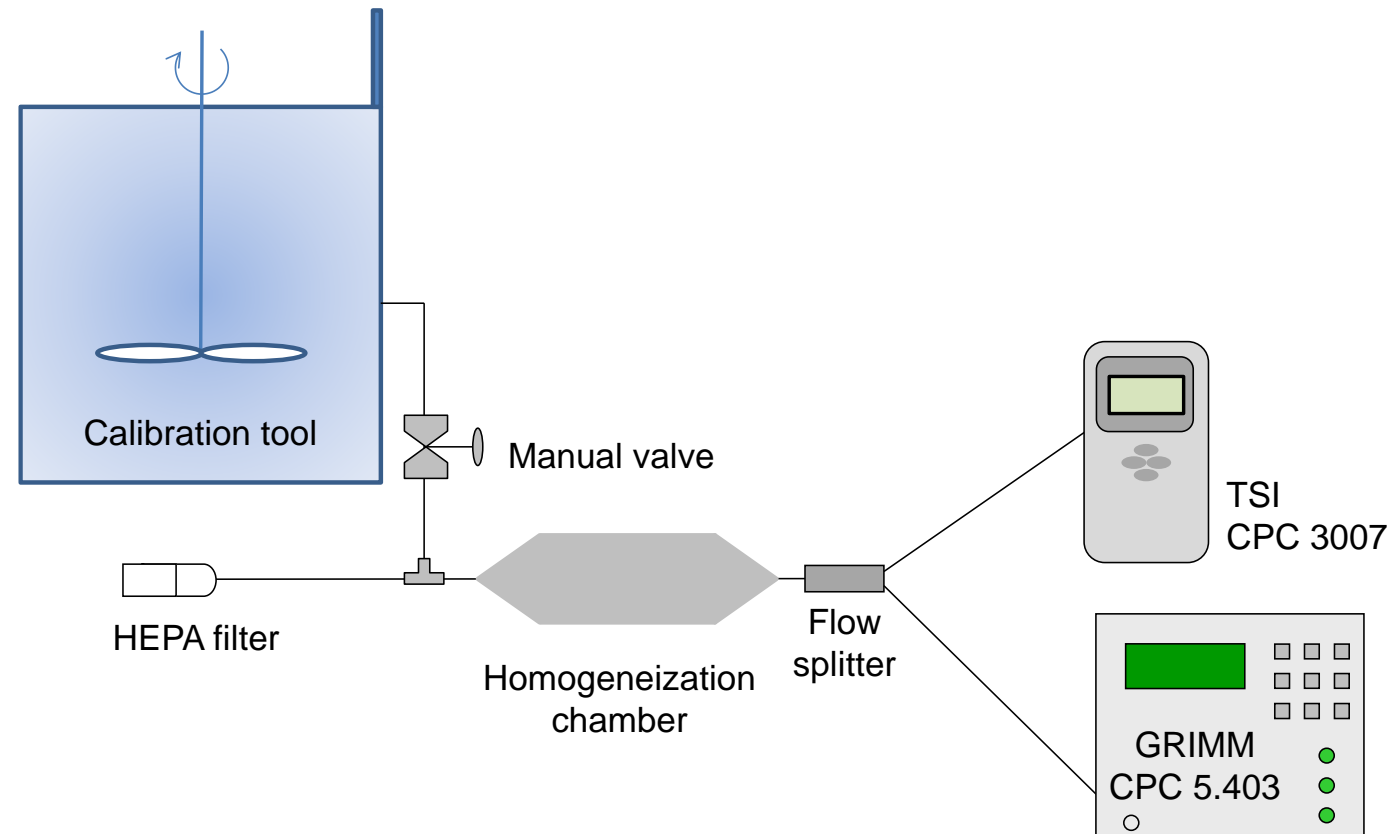
- Aerosol characterization
 - Number concentration
 - > $C_N \approx 2 \times 10^7 \text{ cm}^{-3}$
 - > $CV_{7 \text{ hours}} < 2 \%$; $CV_{6 \text{ days}} < 3 \%$
 - Size distribution
 - > $d_{\text{mode}} \approx 60 \text{ nm}$
 - > $CV_{7 \text{ hours}} < 7 \%$; $CV_{6 \text{ days}} < 7 \%$



Description and performances of the Device for Counter Check (DCC)

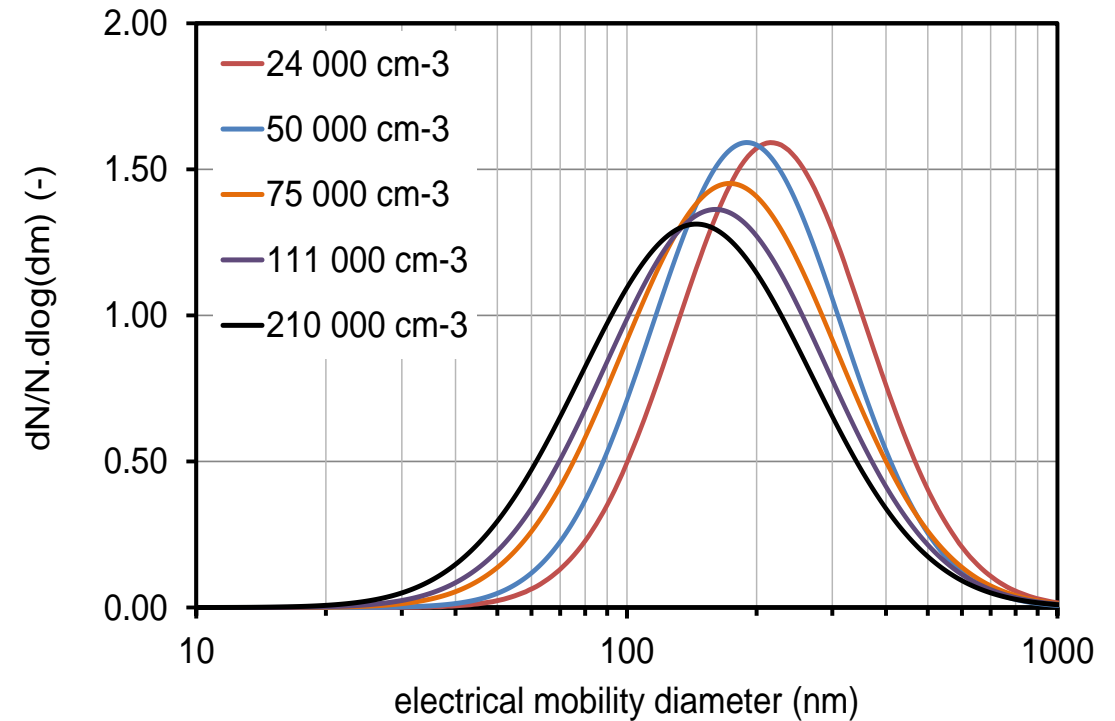
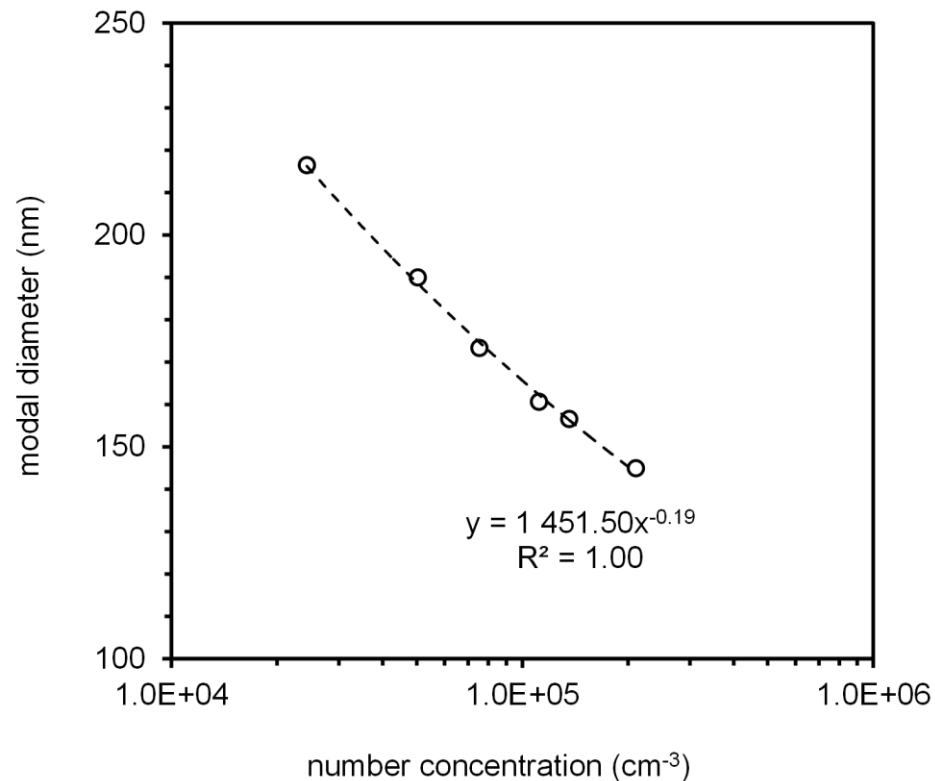
The Device for Counter Check (DCC)

- The DCC consists of the coupling between:
 - the aerosol generation (calibration tool)
 - a specific sampling and dilution line



The Device for Counter Check (DCC)

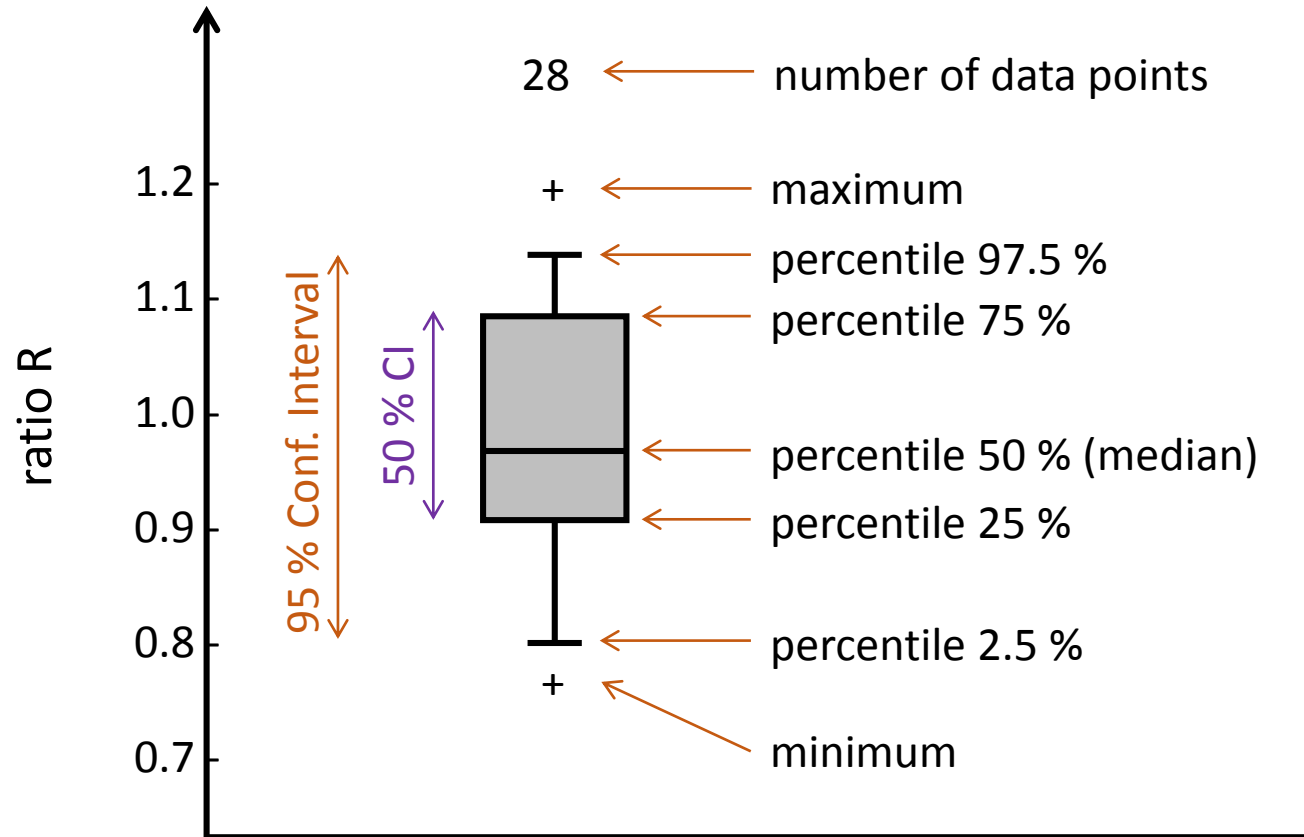
- The DCC consists of the coupling between:
 - the aerosol generation (calibration tool)
 - a specific sampling and dilution line



The Device for Counter Check (DCC)

- The DCC consists of the coupling between:
 - the aerosol generation (calibration tool)
 - a specific sampling and dilution line
 - a reference CPC
- Associated with an adapted data treatment procedure
 - Data points disregarded when $\frac{\sigma(C_N)}{C_N} > 5\%$
 - Ratio calculated for each data point : $R = \frac{C_N^{\text{CPC under study}}}{C_N^{\text{reference CPC}}}$
 - Results displayed as boxplots

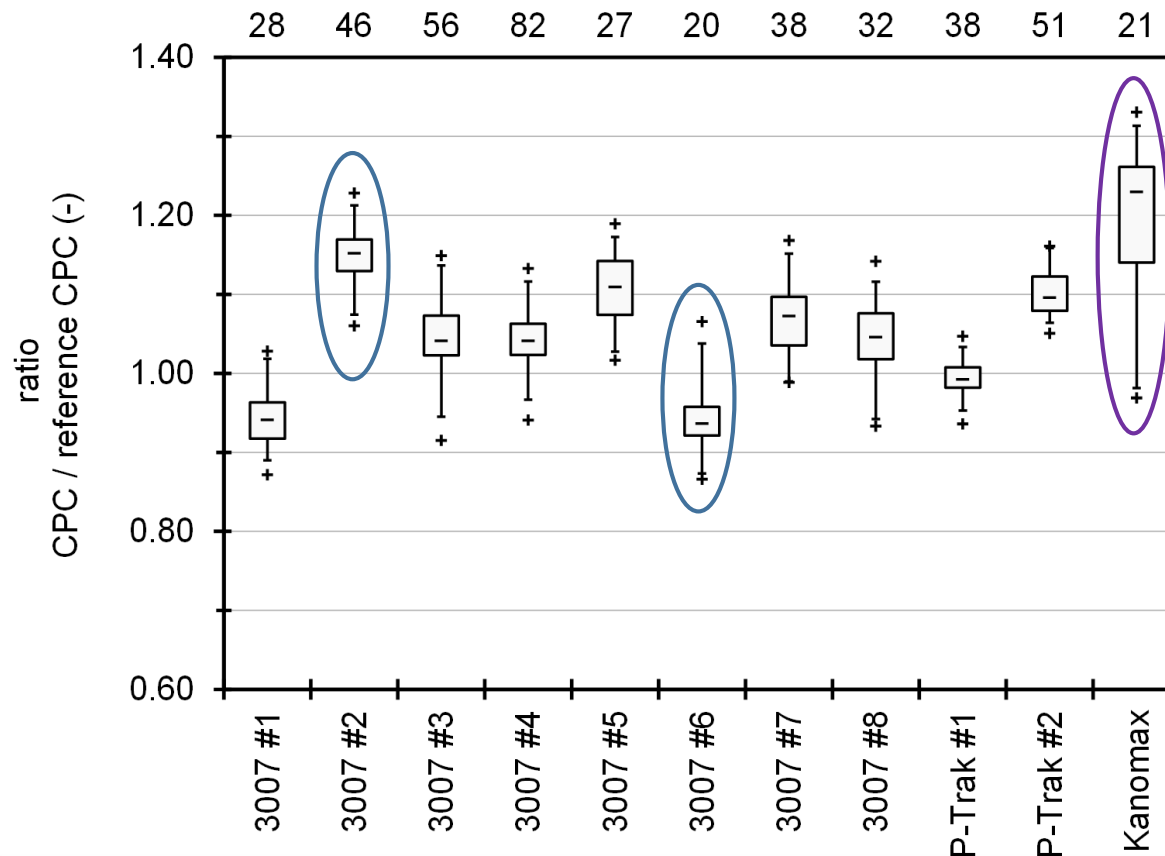
Reminder: boxplot



Application to a set of CPC

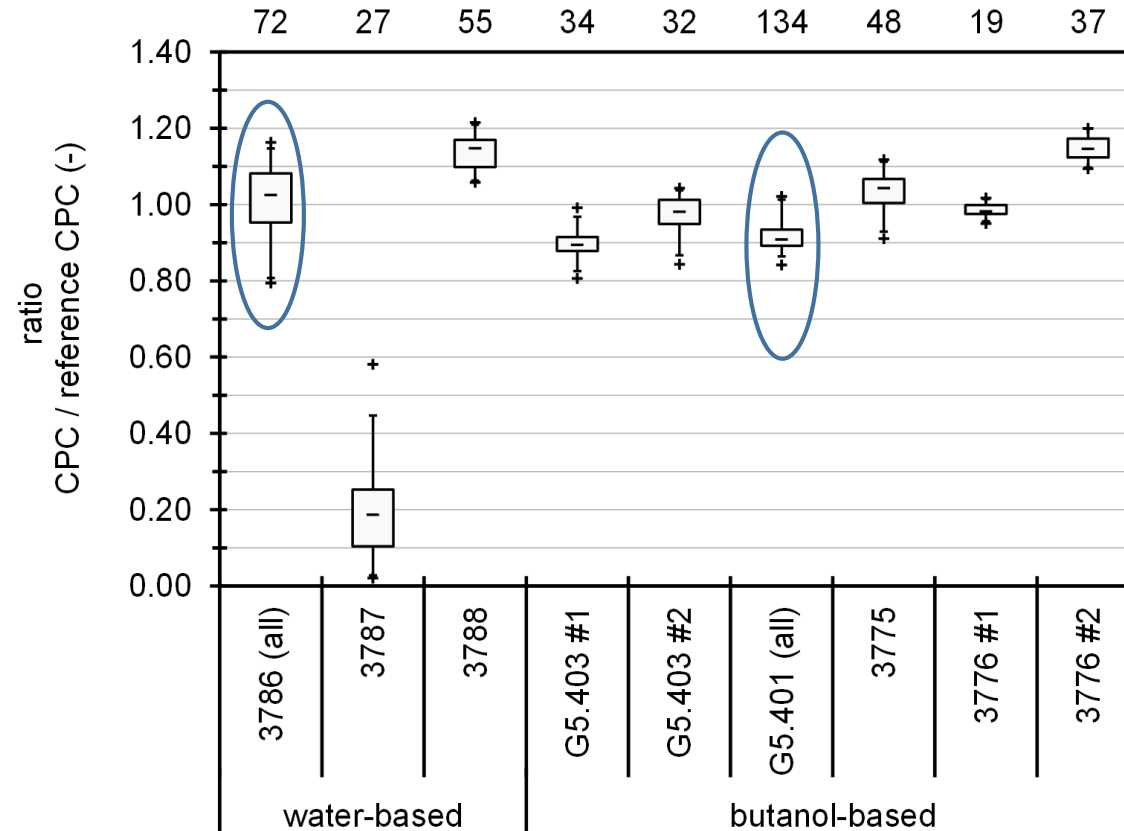
Results for handheld CPC

- > All CPC are found within $\pm 25\%$ compared to the reference...
- > ...Except the Kanomax, which presents the largest span (ratios range from 0.97 to 1.33)
- > The variability in the number concentration reported by several specimens of handheld CPC 3007 can reach up to 25% (#2 vs. #6)



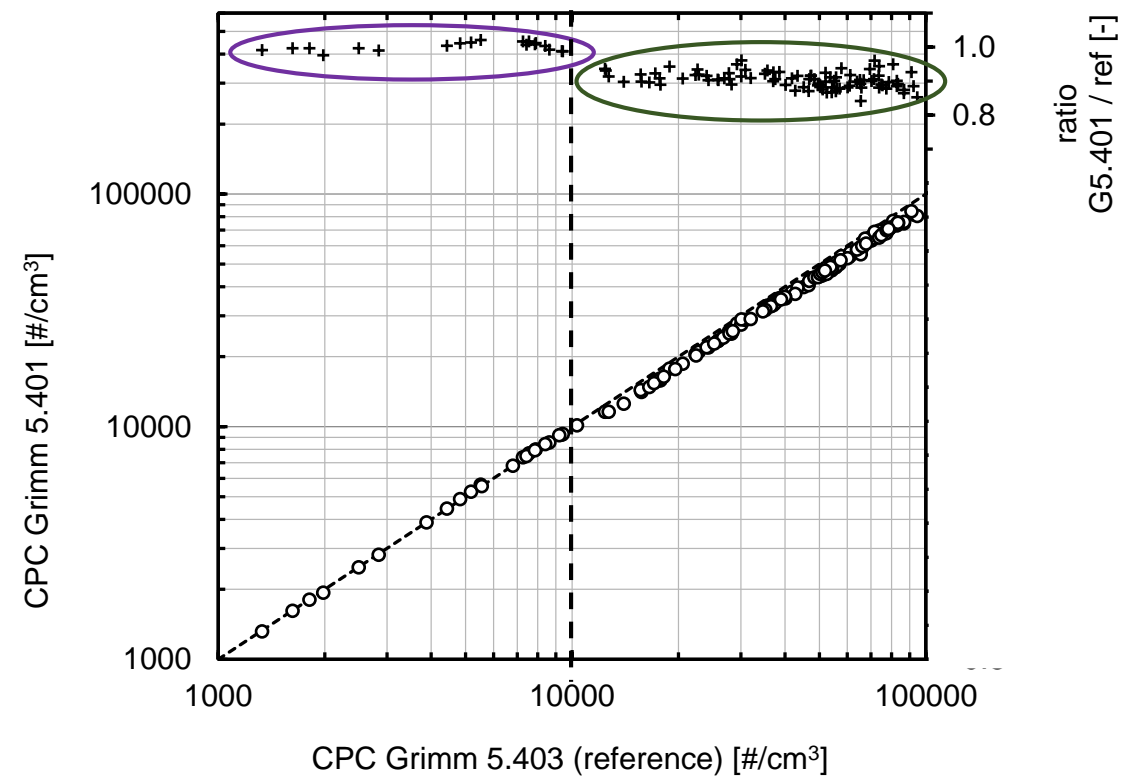
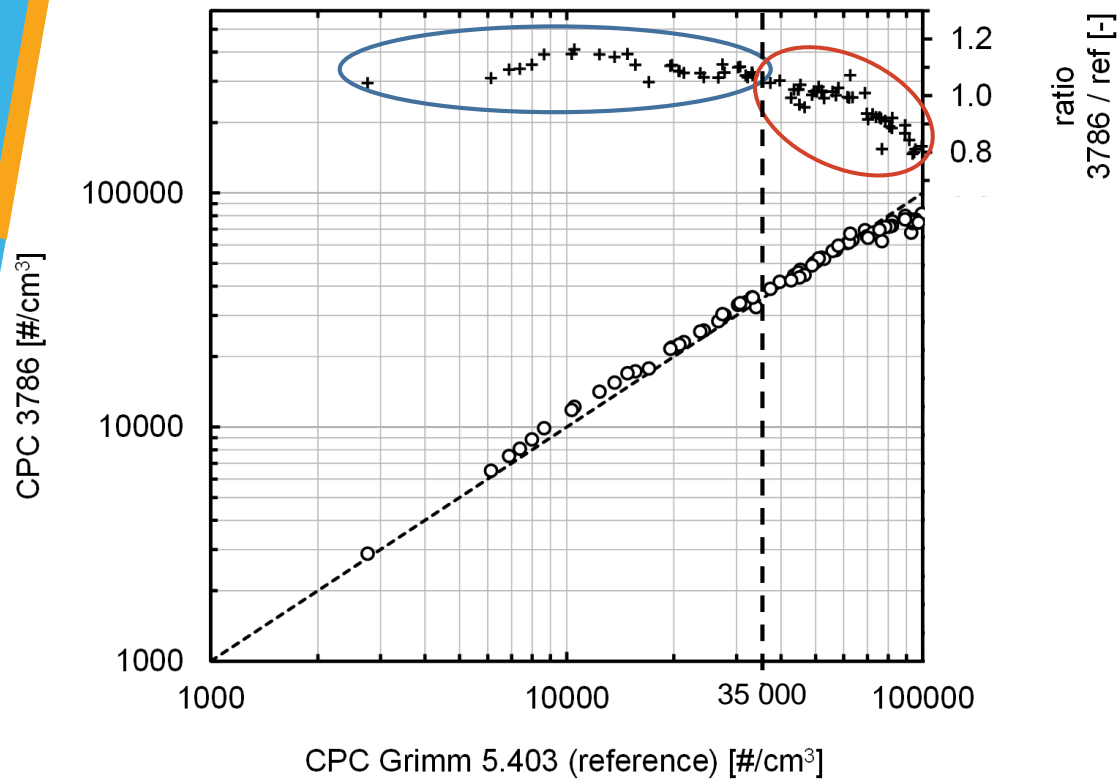
Results for stationary CPC (1/3)

- > All CPC are found within $\pm 25\%$ compared to the reference...
- > ...Except model TSI 3787
 - sensitive to particle hydrophobicity?
- > Large spans are observed for some models



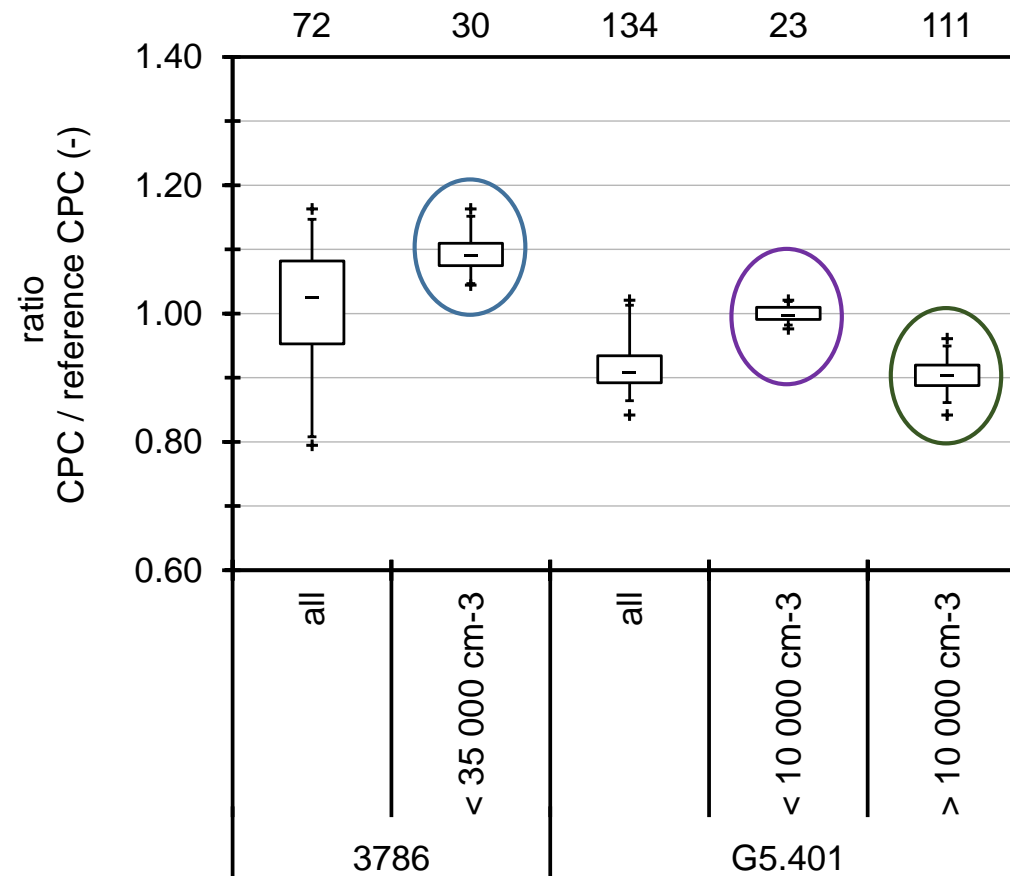
Results for stationary CPC (2/3)

- > Effect of particle concentration for water-based CPC model 3786
- > Effect of the counting mode for G5.401 (single count vs. photometric mode)



Results for stationary CPC (3/3)

- > Effect of particle concentration for water-based CPC model 3786
- > Effect of the counting mode for G5.401 (single count vs. photometric mode)



Conclusions & perspectives

- The DCC was characterized @ INRS
 - based on the calibration tool developed by W. Koch
 - produces repeatable and reproducible aerosols in a wide range of concentration
 - associated with a specific data treatment procedure
 - allows CPC to be checked prior to measurement campaigns or for periodic control
- Results highlight:
 - most CPC are found within $\pm 25\%$ compared to the reference
 - variability between different specimens of the same CPC → comparability ?
 - effect of: particle chemistry (hydrophobicity), concentration, counting mode, can exist
- Intercomparison studies are still needed
 - several specimens of the same CPC model → variability
 - once checked, CPC challenged with aerosols representative of occupational conditions



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Thanks for your attention



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