

Feasibility of Diffusion Chargers for Particle Emission Measurement in Periodical Inspection

Topi Rönkkö¹, Heino Kuuluvainen¹, Laura Salo¹, Liisa Pirjola², Kimmo Teinilä³, Hilikka Timonen³,
Erkka Saukko⁴, Ville Niemelä⁵, Mikko Moisio⁵, Panu Karjalainen¹

¹Tampere University; ²Metropolia University of Applied Sciences; ³ Finnish Meteorological Institute; ⁴Pegasor Oy; ⁵Dekati Oy

Content

- Motivation
- Experiments
- Results
- Conclusions

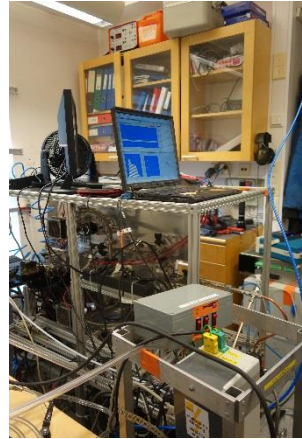
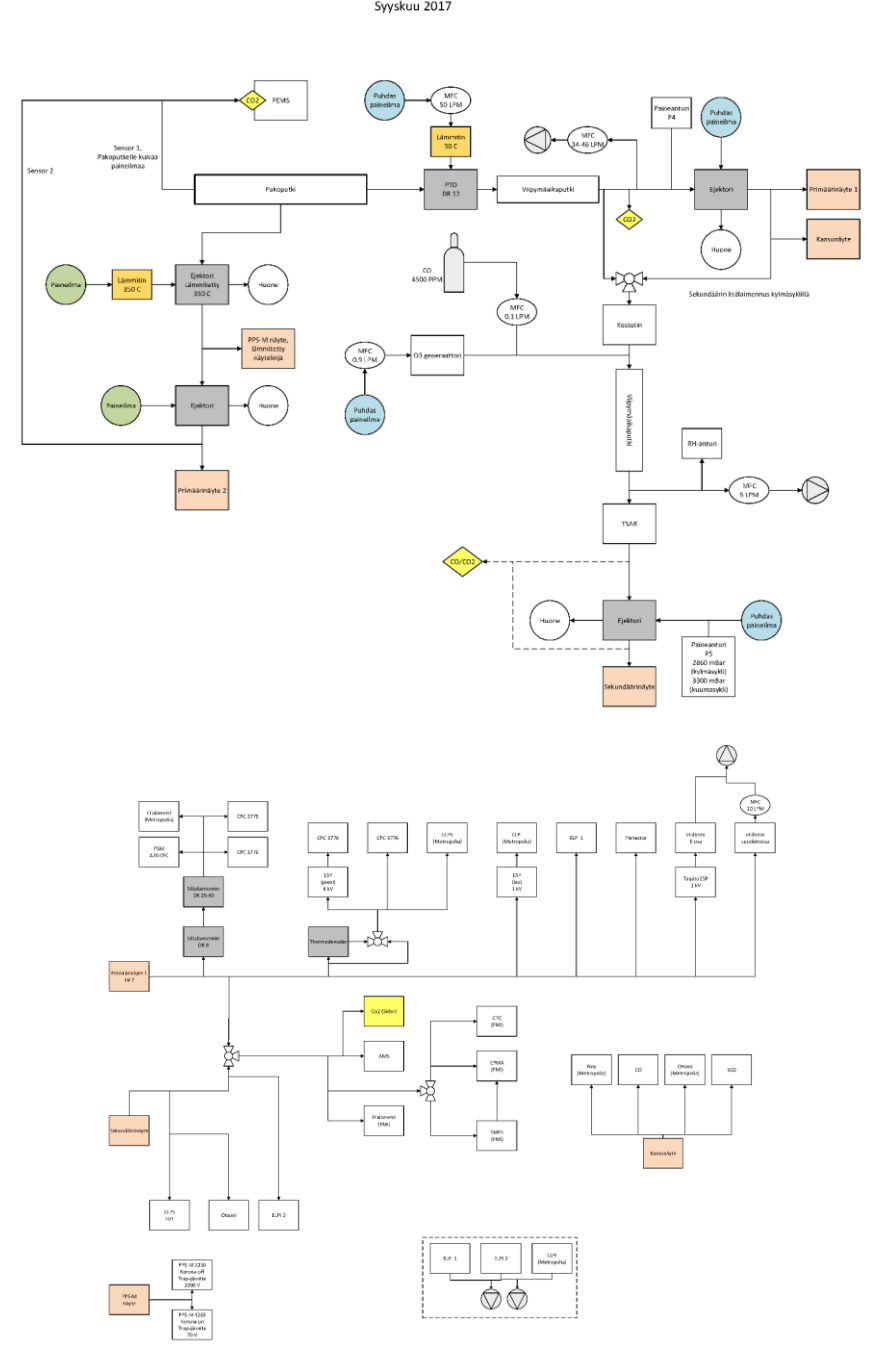
Motivation

- Periodic Technical Inspection (PTI) of vehicles is very thoroughly implemented in Europe
- Current PTI measurement of exhaust cannot detect DPF removal – Opacimeter is obsolete
- Soot emission increases 100-1000 –fold if DPF is removed
- Air quality predictions, air quality modelling and city level planning are ideally done based on type approval limits and fleet emission profile
- Cities and countries face very hard pressure to improve air quality

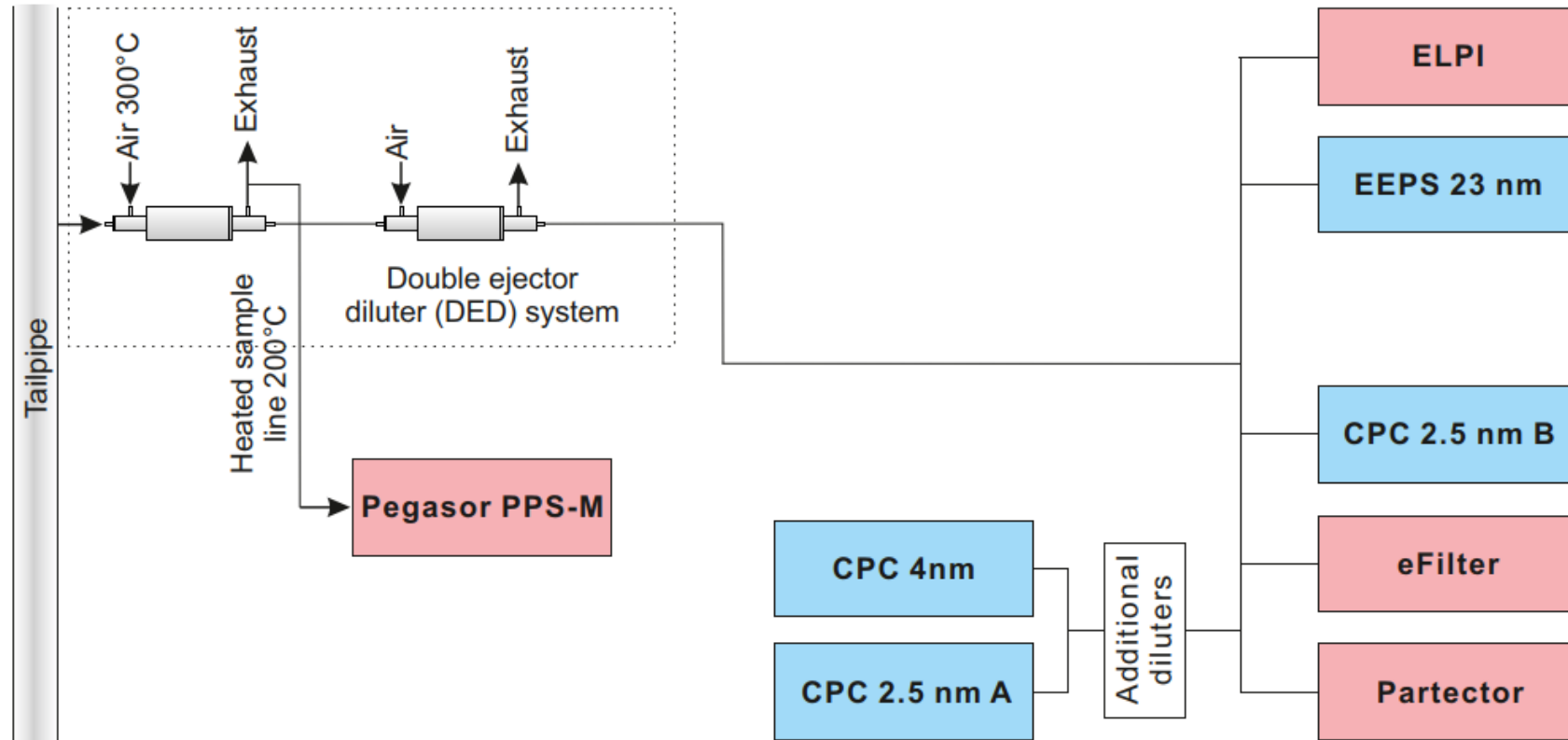
Fixing broken DPFs is a low cost – high reward way to improve air quality with existing PTI infrastructure

Measurements

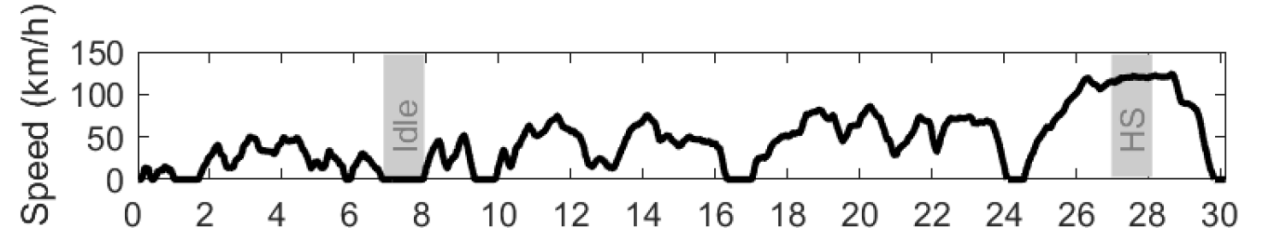
- Measurements were not initially designed for the purpose of this presentation but, instead, to study
 - the emissions from vehicles typical for Indian car fleet
 - physical and chemical characteristics of particles
 - the functioning of particle sensors
 - the effects of fuels and lubricant oils
 - emissions during NEDC and WLTC
 - primary and fresh exhaust
 - the SOA potential of exhaust
- First manuscript, focusing on the effects of fuels, has been submitted Applied Energy
- Anyway, lot of data regarding the functioning of diffusion chargers were generated -> focus of this presentation



Setup in this study



Vehicles and cycle



- Vehicles on chassis dyno
- WLTC
- Diesel vehicle:
 - Toyota Corolla, model year 2007, displacement 2.2 dm³
 - DOC but not equipped with DPF (Euro IV))
 - Conventional diesel fuel EN590
 - Lubricant oil: Neste city pro LL5W-30
- Gasoline vehicle:
 - Suzuki SX4, model year 2005, displacement 1.6 dm³
 - MPI, TWC
 - Conventional 98E5 gasoline
 - Lubricant oil Neste City Pro C2 5W-30

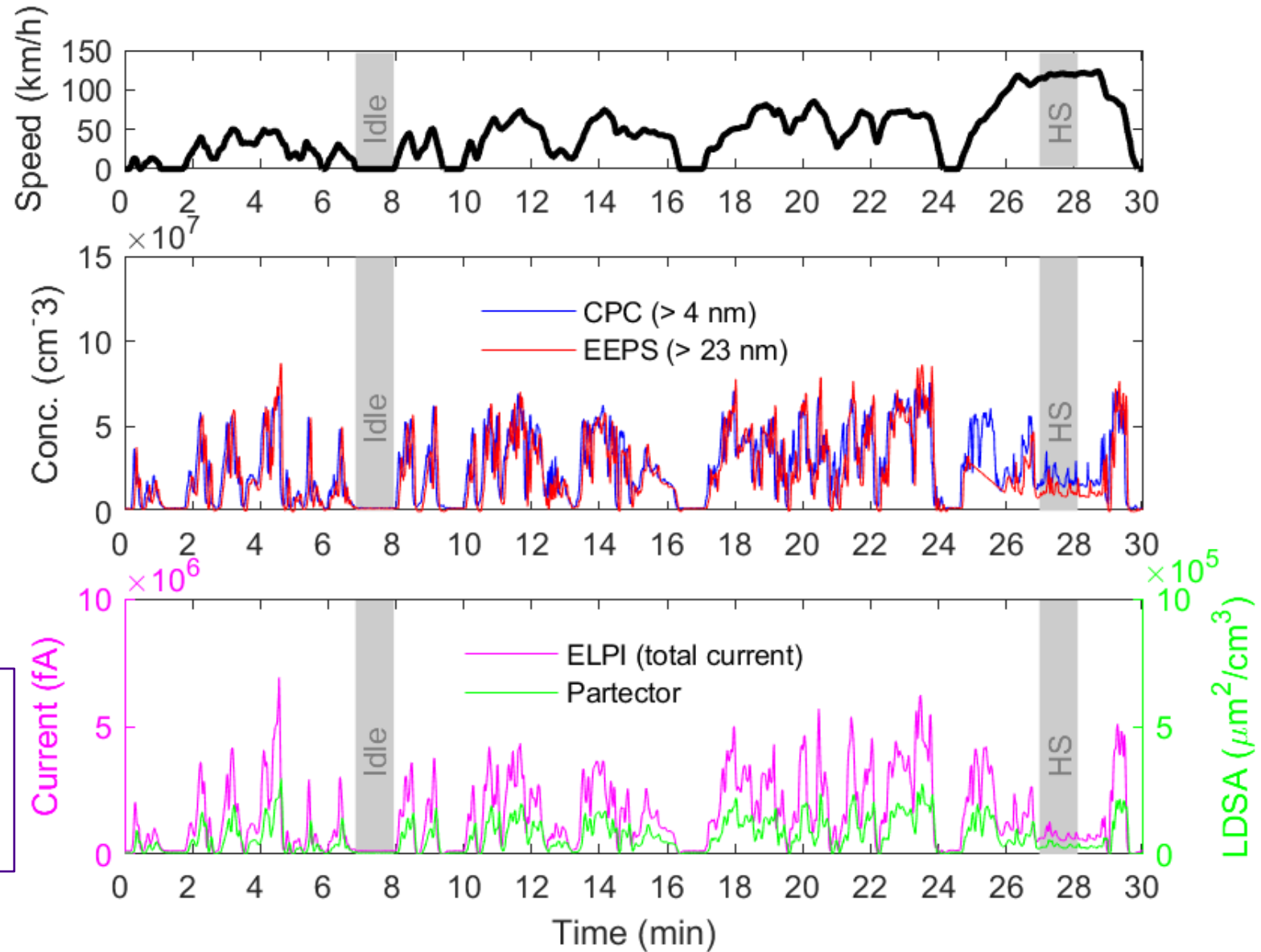


Diesel passenger car (Toyota Corolla, 2007)

Note: dilution ratios were not corrected!

DR $\sim 2.5 \times 10^4$ for CPC 4 nm
DR ~ 77 for EEPS, ELPI, Partector

Total current from diffusion charger of ELPI, Partector, CPC and EEPS ($> 23\text{nm}$) produce nearly identical time series patterns



Diesel passenger car (Toyota Corolla, 2007)

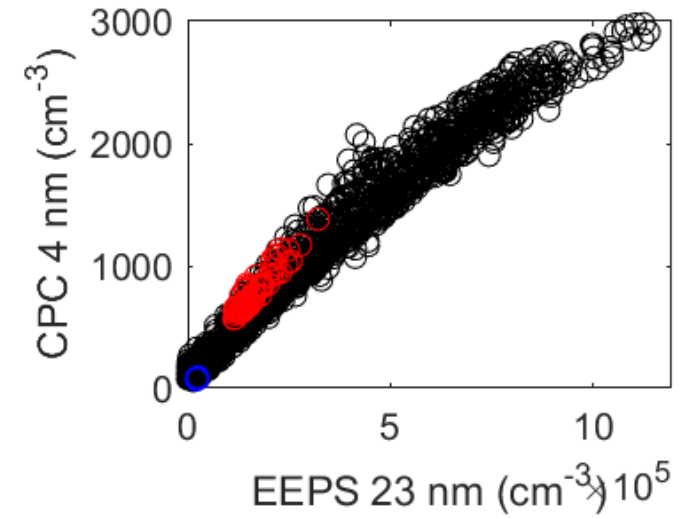
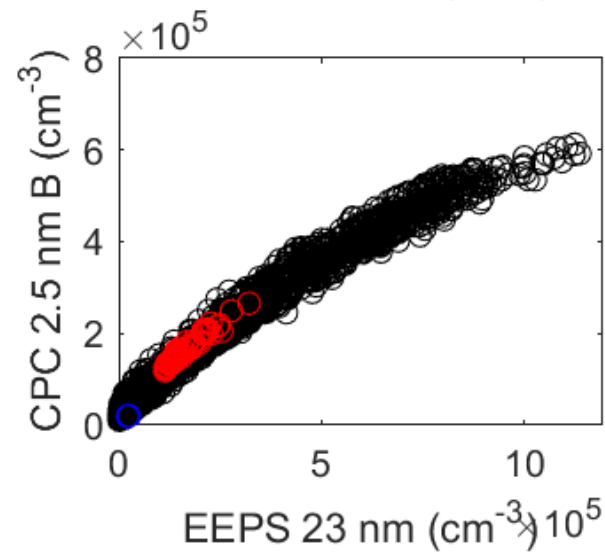
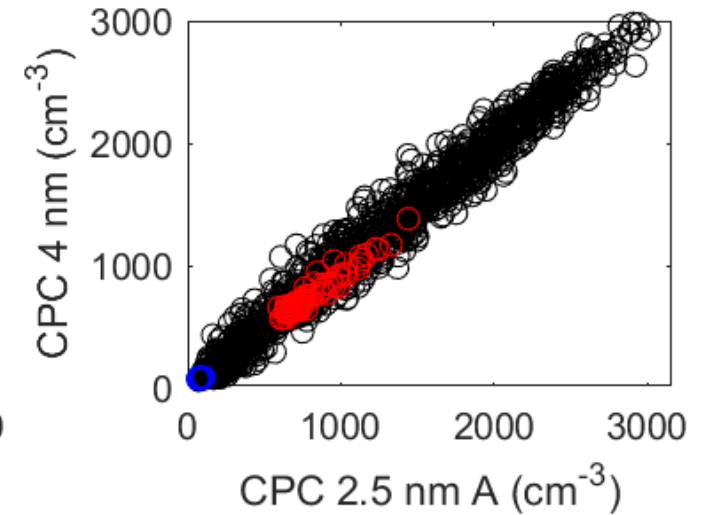
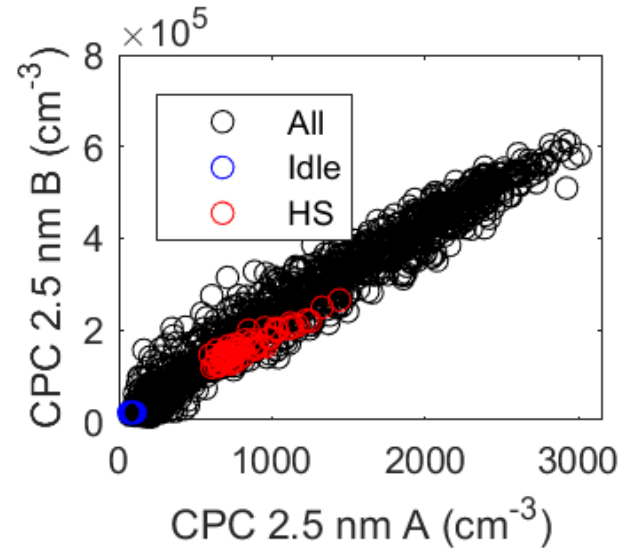
Good correlation despite
different dilution

Concentrations very low
at idle

N_{tot} does not correlate
fully linearly with $PN >$
23nm

Note: dilution ratios were not corrected!

DR $\sim 2.5e4$ for CPC 4 nm, CPC 2.5 nm A
DR ~ 77 for CPC 2.5 nm B, EEPS



Diesel passenger car (Toyota Corolla, 2007)

Good correlation between diffusion charger and PN

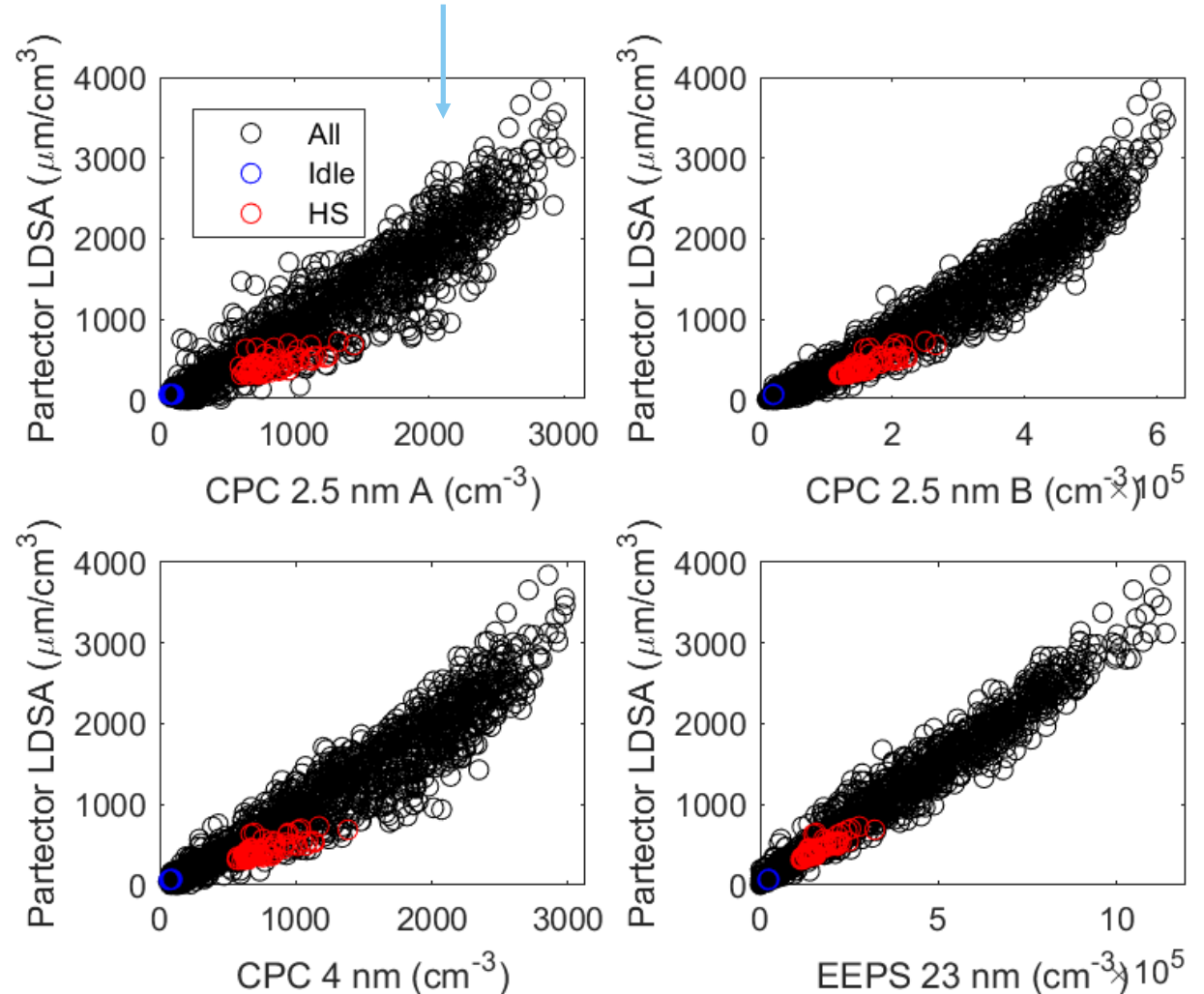
Even excellent correlation between the diffusion chargers and PN >23 nm calculated from EEPS

Concentrations low at idling

Note: dilution ratios were not corrected!

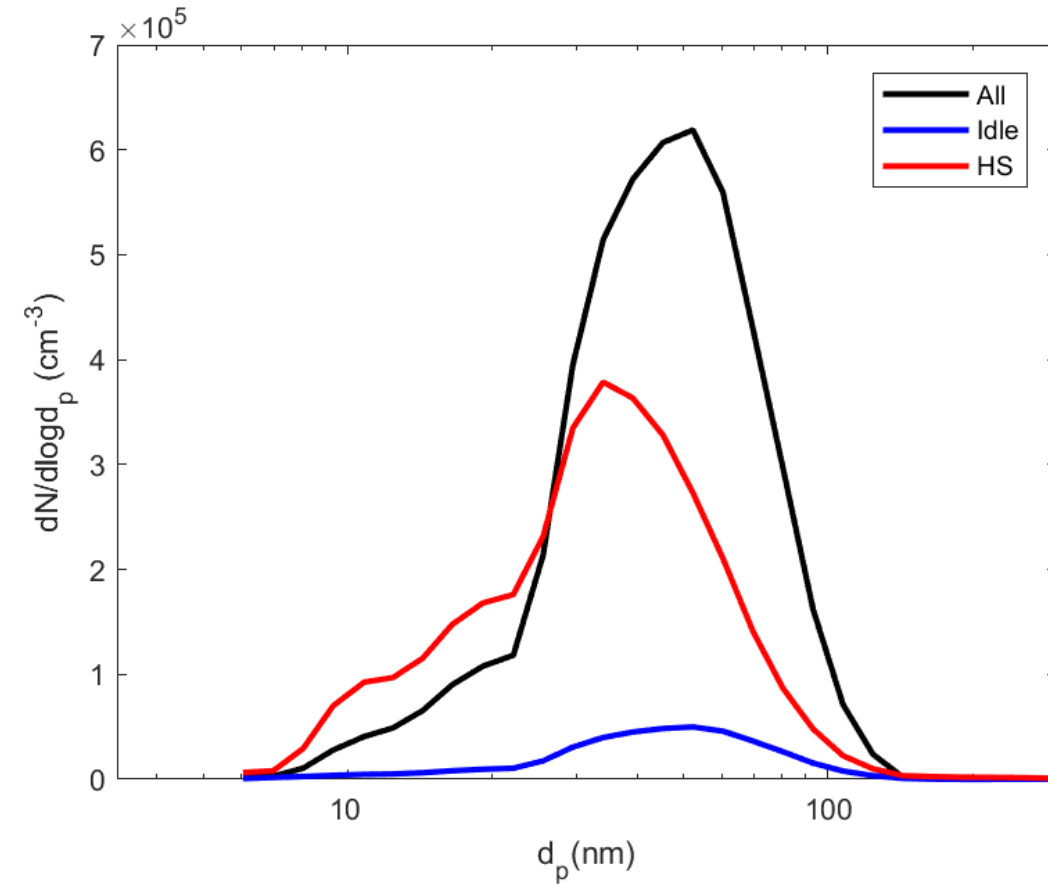
DR $\sim 2.5 \times 10^4$ for CPC 4 nm, CPC 2.5 nm A
DR ~ 77 for CPC 2.5 nm B, EEPS, Partector

CPC operated at very low concentrations



Diesel passenger car (Toyota Corolla, 2007)

Particle size distribution dominated by soot
mode in 20 – 100 nm



Note: dilution ratios (DR ~77) were not corrected!

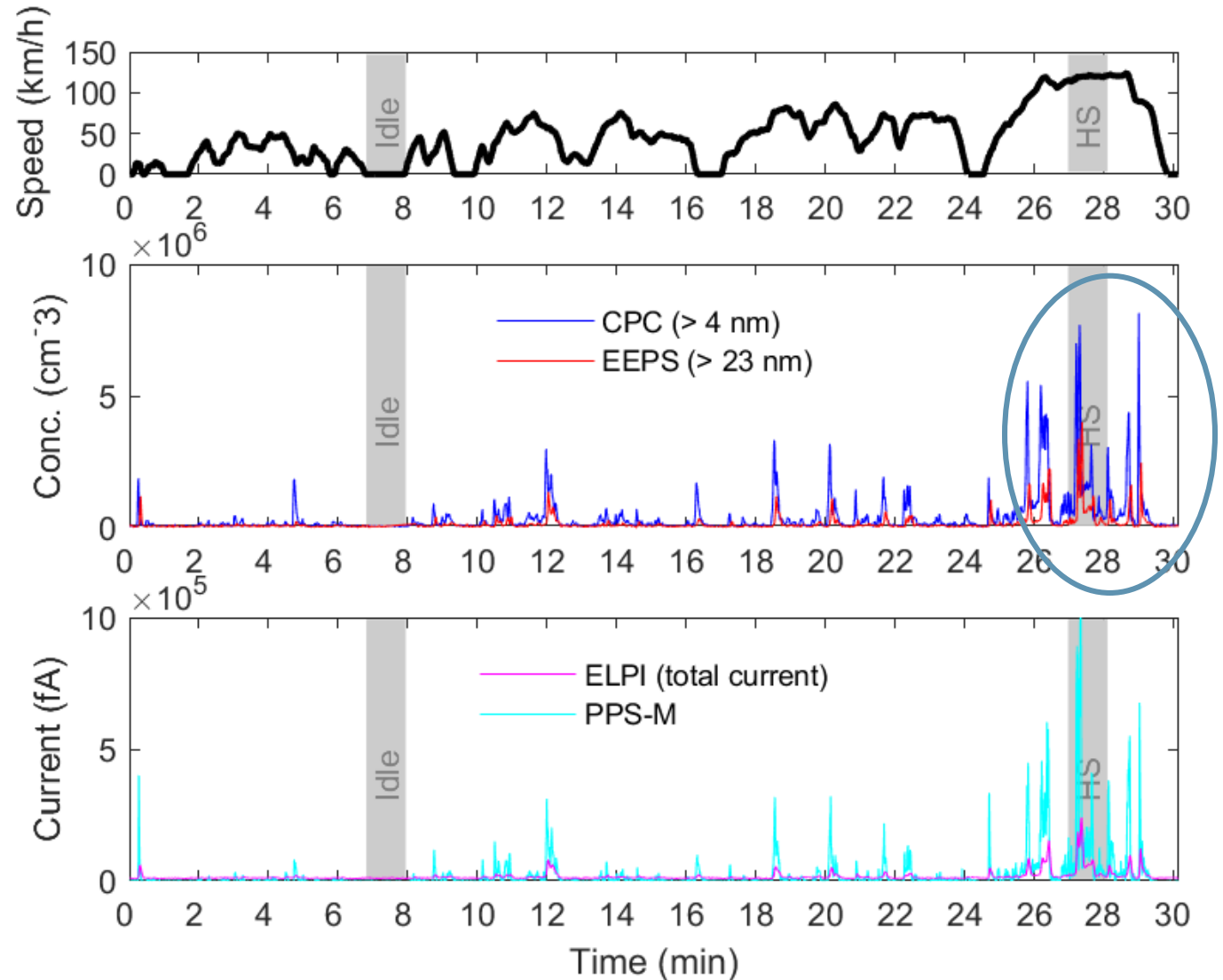
Gasoline passenger car (Suzuki SX4, 2005)

Note: dilution ratios were not corrected!

DR $\sim 3.1 \times 10^4$ for CPC 4 nm
 DR ~ 95 for EEPS, ELPI
 DR ~ 10 for PPS-M

Significantly lower particle concentrations when compared to previous diesel car measurement

Total current from diffusion charger of ELPI, PPS-M, CPC and EEPS ($> 23\text{nm}$) produce nearly identical time series patterns

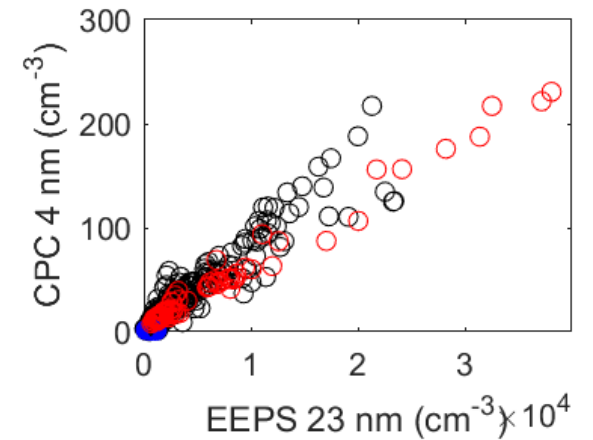
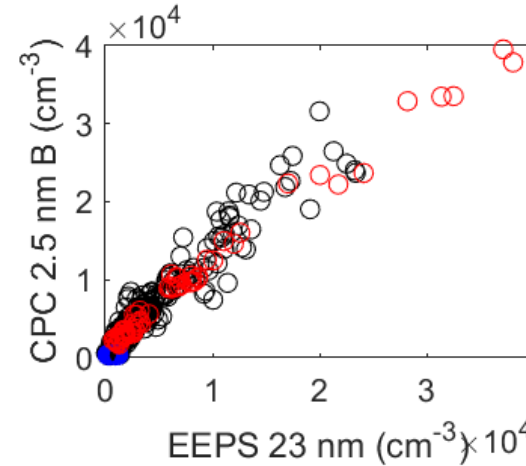
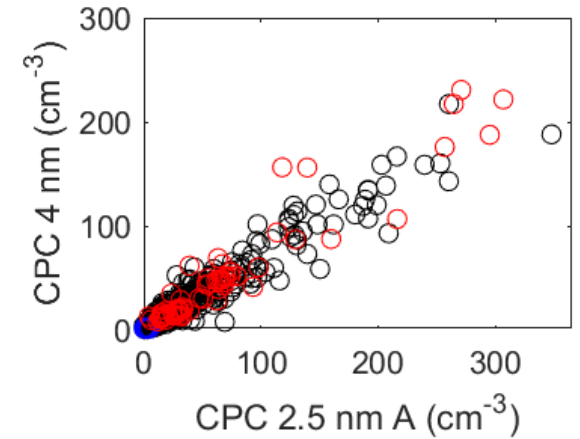
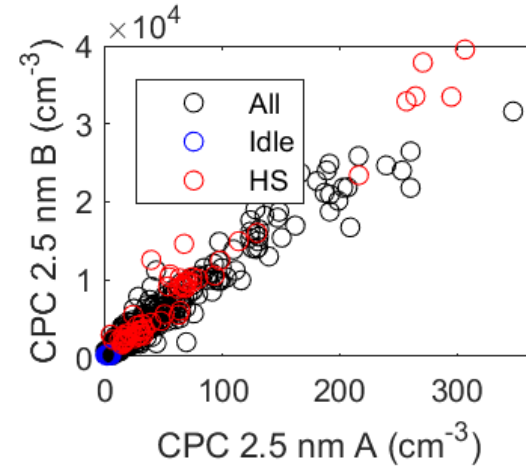


Gasoline passenger car (Suzuki SX4, 2005)

Good correlations
Concentrations very low
at idle

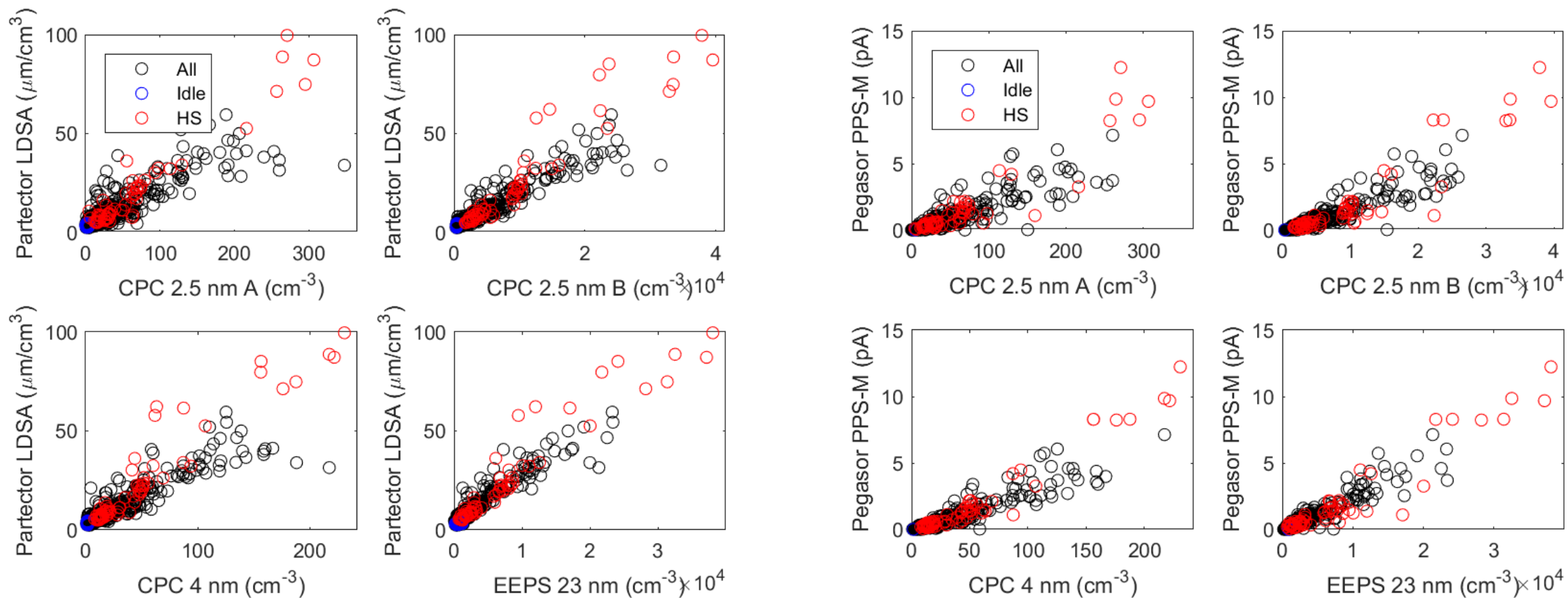
Note: dilution ratios were not corrected!

DR $\sim 3.1 \times 10^4$ for CPC 4 nm and CPC 2.5 nm A
DR ~ 95 for EEPS, ELPI, CPC 2.5 nm B
DR ~ 10 for PPS-M



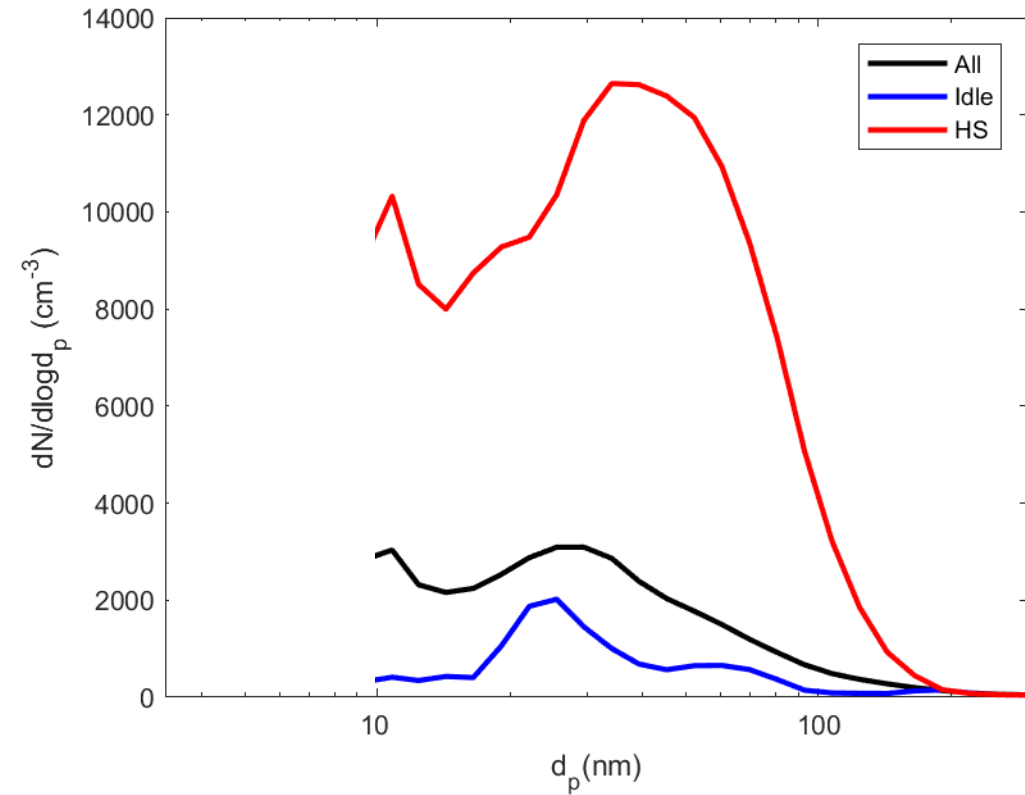
Gasoline passenger car (Suzuki SX4, 2005)

Correlations between diffusion chargers and CPCs similar than between different CPCs (see previous slide)



Gasoline passenger car (Suzuki SX4, 2005)

"Typical" soot mode at high speed, mean particle size shifted to smaller sizes in other conditions



Note: dilution ratios (DR ~95) were not corrected!

Conclusions

Based on the measurements for old gasoline and diesel cars, diffusion charger based particle measurements

- Are fast enough to detect changes in exhaust particles
- Correlate well with PN > 23nm
- Are sensitive also in low PN conditions

In our study the exhaust particle concentrations were low at idle – to be taken into account in PTI?

Results indicate that diffusion charging based instruments could be used in PTI to detect e.g. DPF removal

Thank you for your attention!

This work was a part of the Traffic and Air Quality in India: Technologies and Attitudes (TAQIITA) project funded by Business Finland, Department of Biotechnology India, Dekati Oy, Pegasor Oy, Neste, and Helsinki Region Environmental Services Authority (HSY). The authors are very grateful to Aleksi Malinen, Niina Kuittinen, Matti Lassila and Sami Kulovuori for technical expertise, operation of the dynamometer and assisting in the measurements.