On-board measurement of ultrafine non-exhaust particulate emissions from a battery-electric vehicle

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EFCA International Symposium
Ultrafine Particles – Air Quality and Climate
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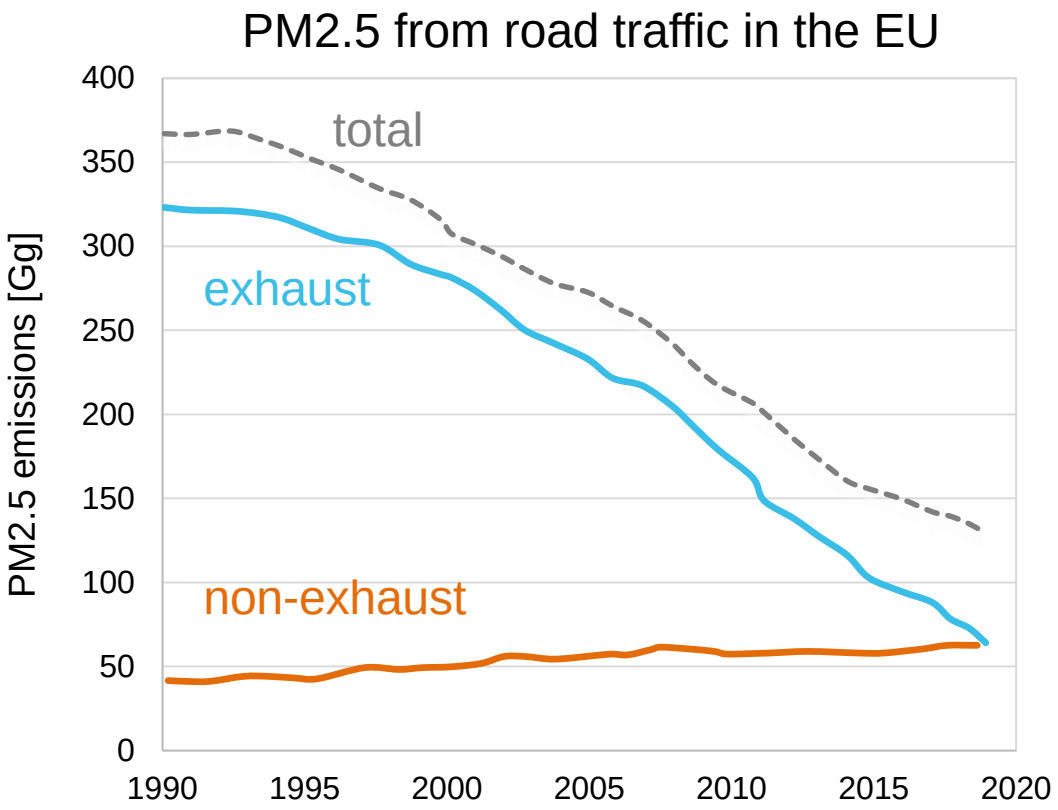
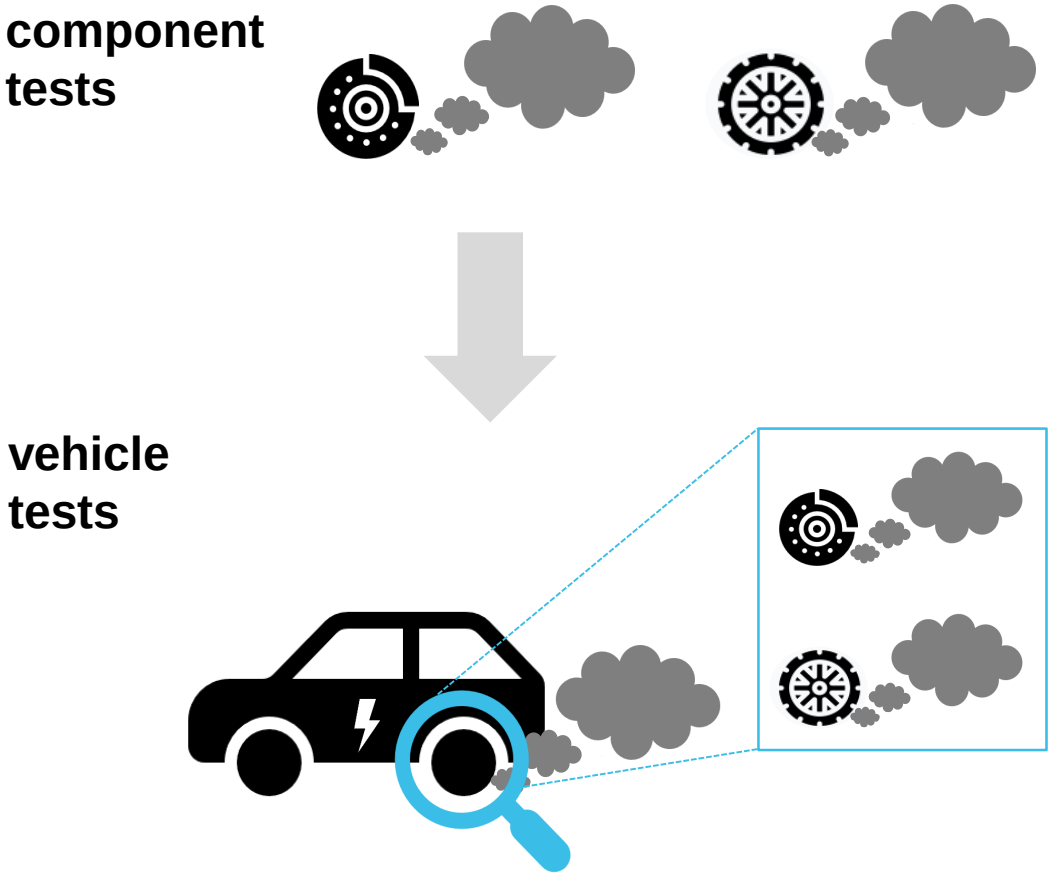
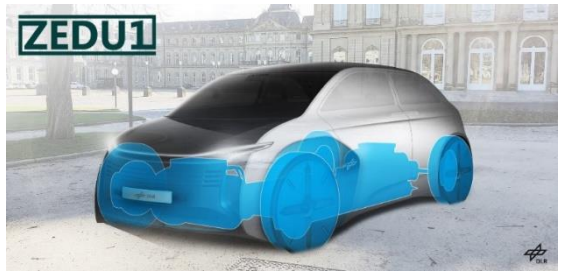
Non-exhaust particulate emissions: Relevance & Measurement



Eionet Report - ETC/ATNI 2020/5 .



Zero Emission Drive Unit Generation 1



Goal: Reduction of brake and tyre emissions
Duration: 03/2020 – 12/2022
Projekt partners: DLR-FK, DLR-VT, HWA AG, ARS GmbH
Sponsor: Baden-Württemberg Ministry of Economics, Labour and Housing

Test vehicle (BMW i3)

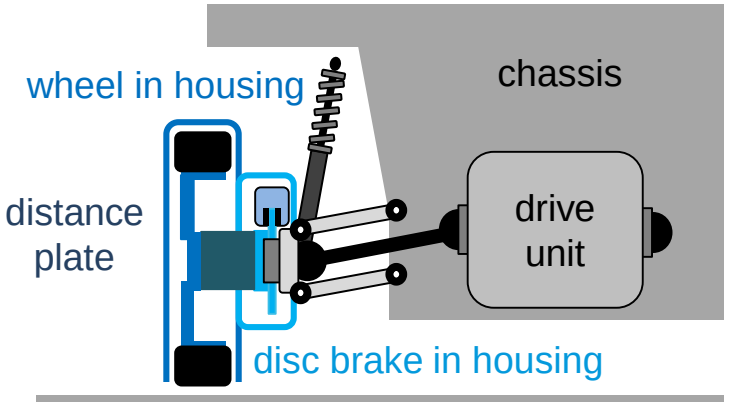
- Determining the particulate emissions of current electric vehicles
- Development of measurement methods

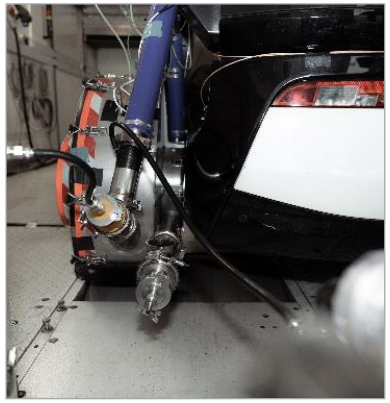
ZEDU1 – Demonstrator

- Demonstration and evaluation of novel technologies for zero-emission driving
- Completion in 2022

DLR
HWA ENGINEERING SPEED
Baden-Württemberg
MINISTERIUM FÜR WIRTSCHAFT, ARBEIT UND TOURISMUS

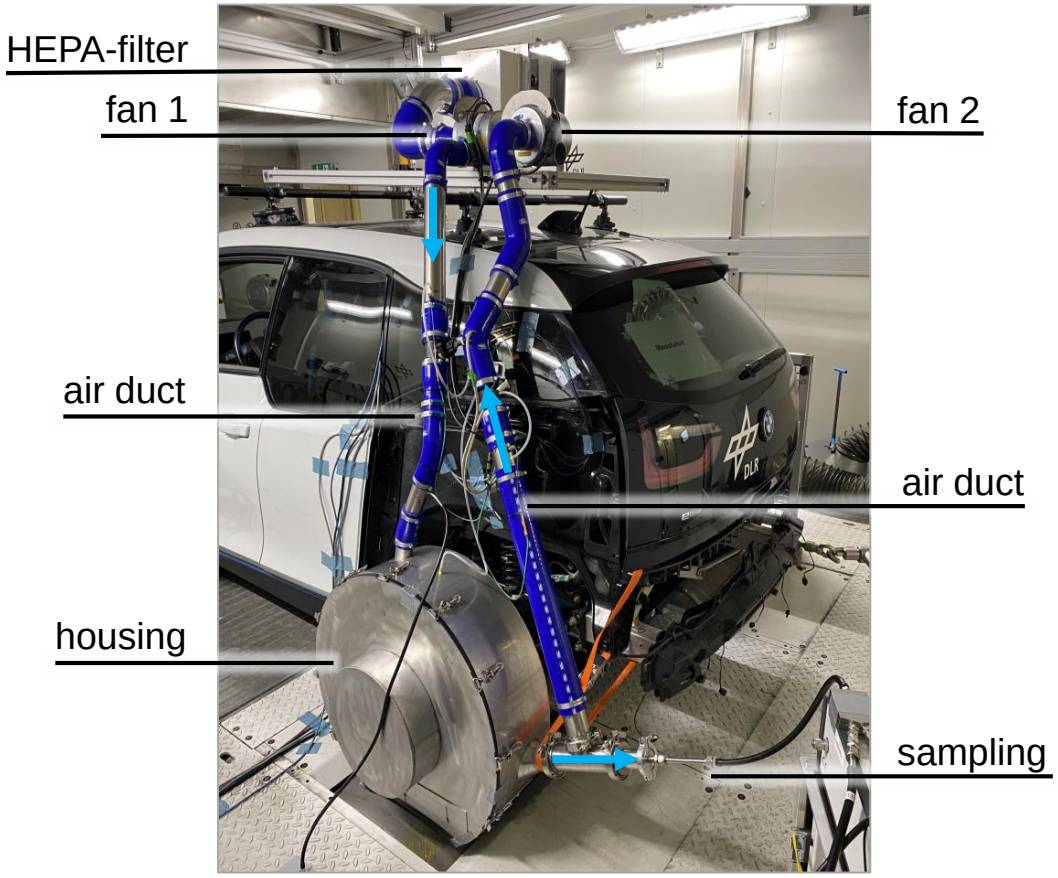
Setup on the test vehicle





Sampling system:

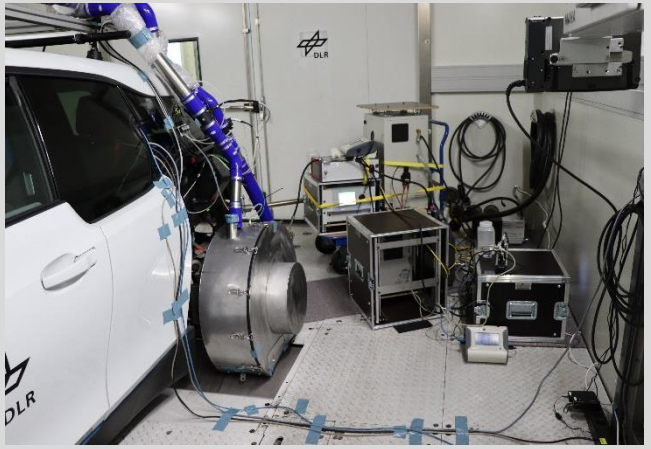
- separate enclosures for brake and tyre
- ventilation with adjustable, filtered air flow
- isokinetic particle sampling



Measurement scenarios

Chassis dynamometer





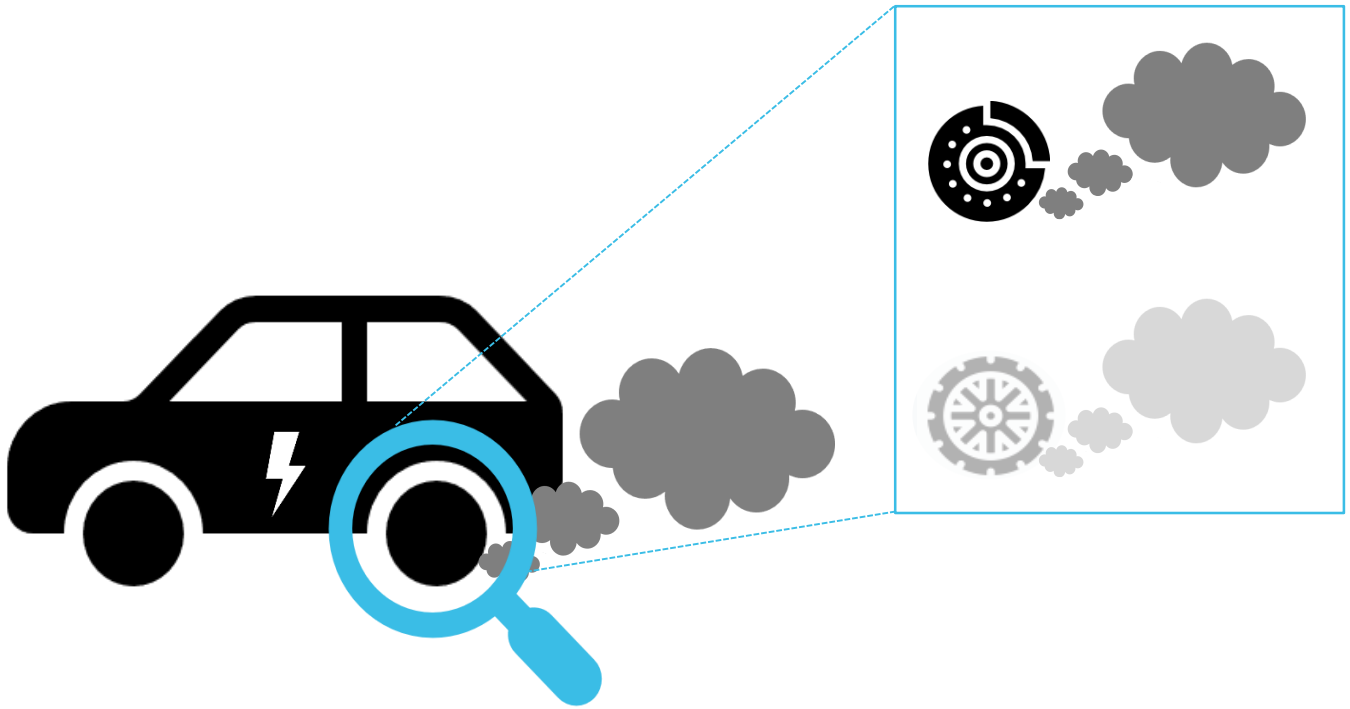
Road drive

Total	46.2 km
Urban	22.5 km
Rural	14.5 km
Motorway	9.2 km

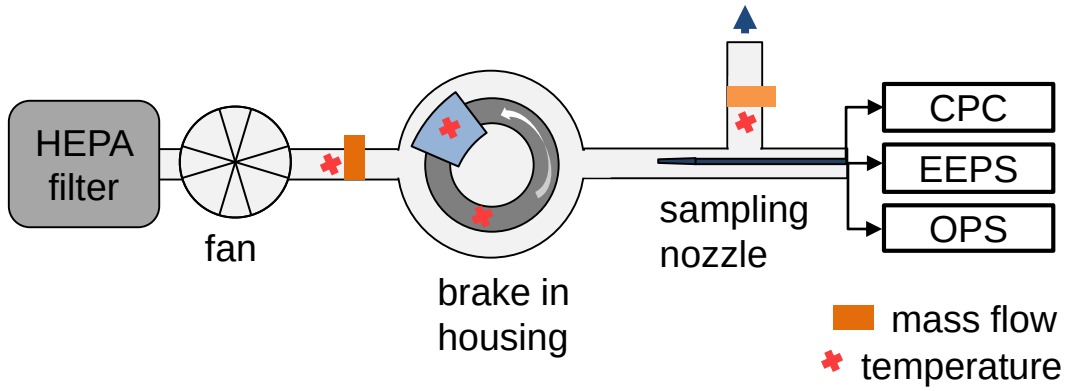
Proving ground

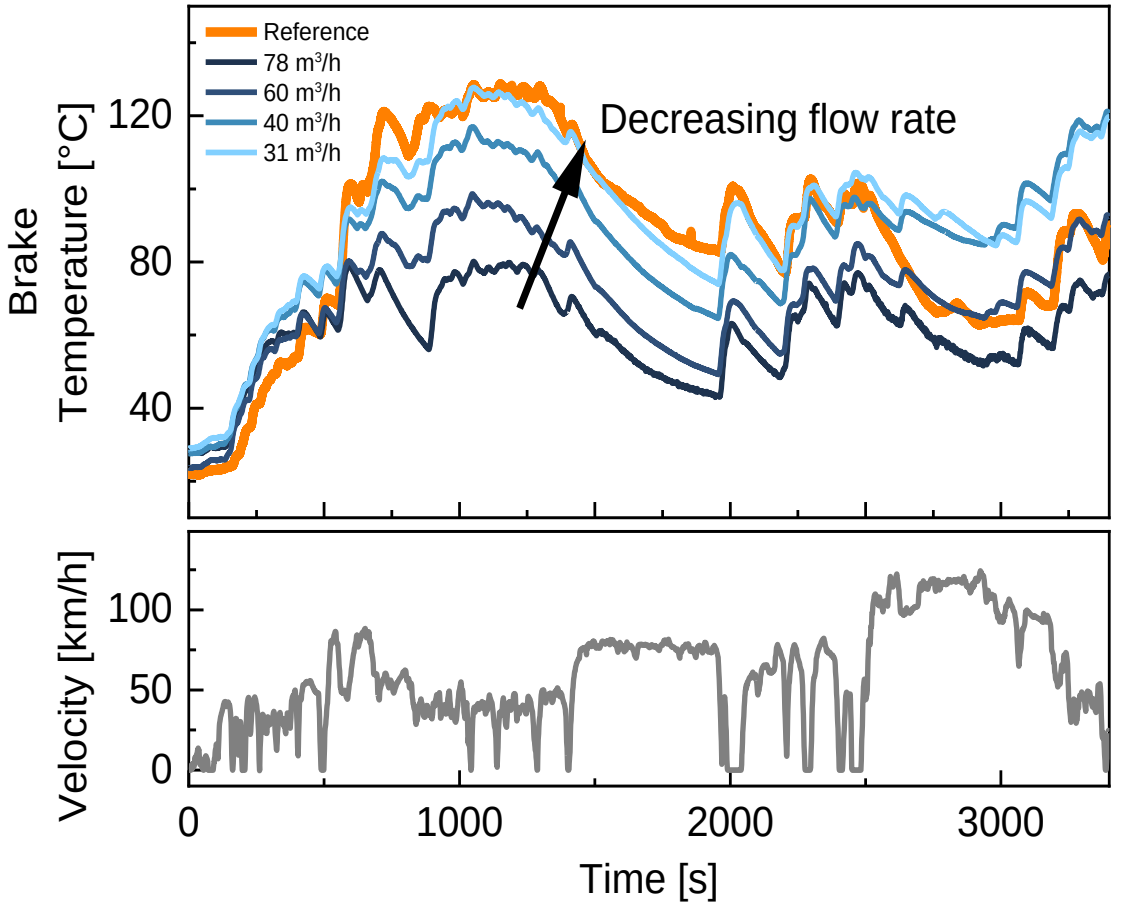


Measurement of brake emissions



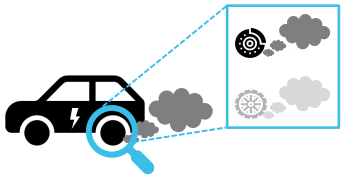
Measurement of brake emissions

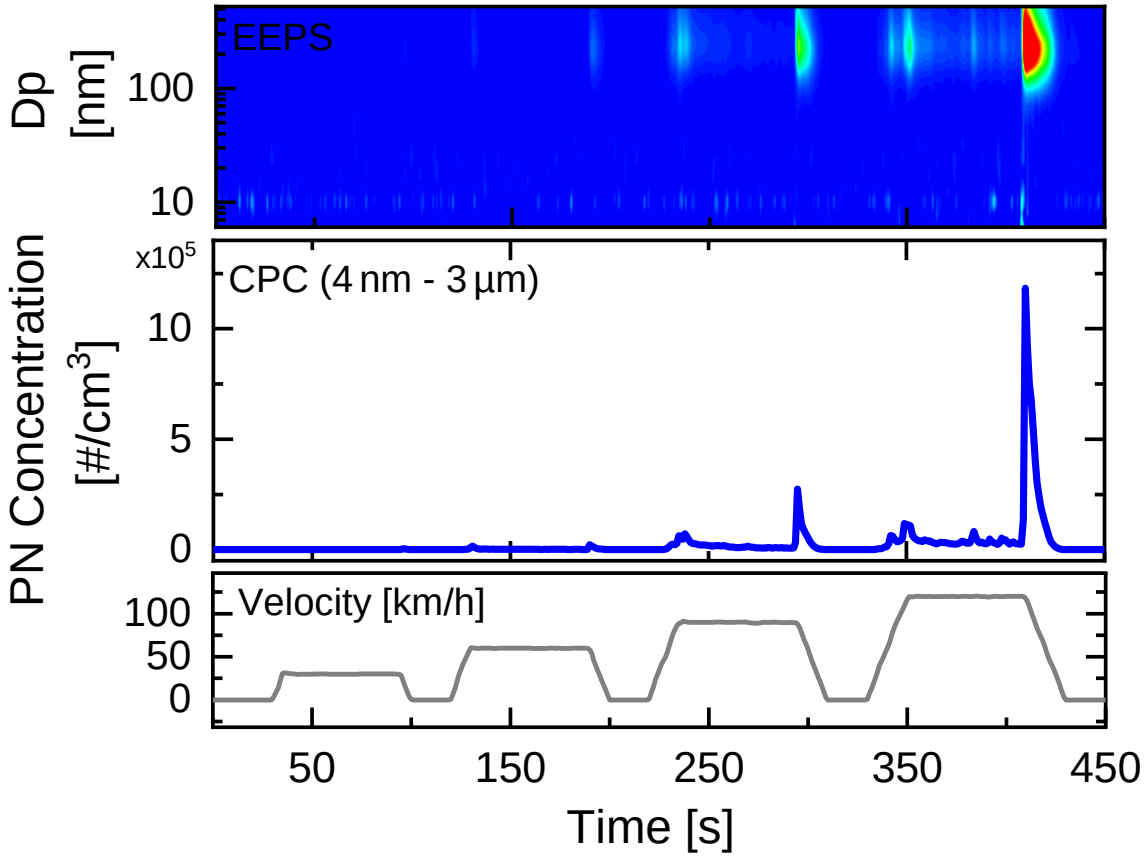


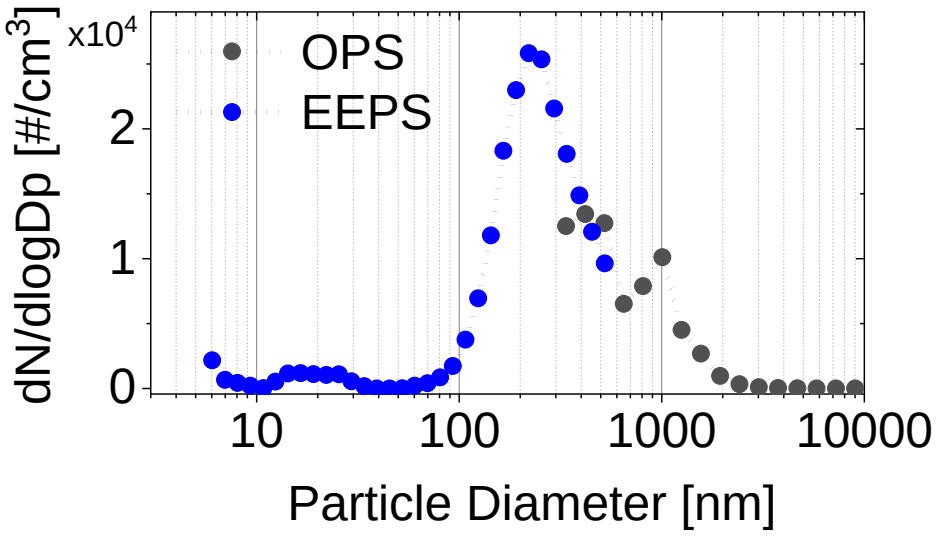


- original cast iron brake disc
- closed ventilation system with HEPA-background
- adjustment of the (constant) cooling air flow with real driving reference (without brake housing)

Characterisation of brake emissions

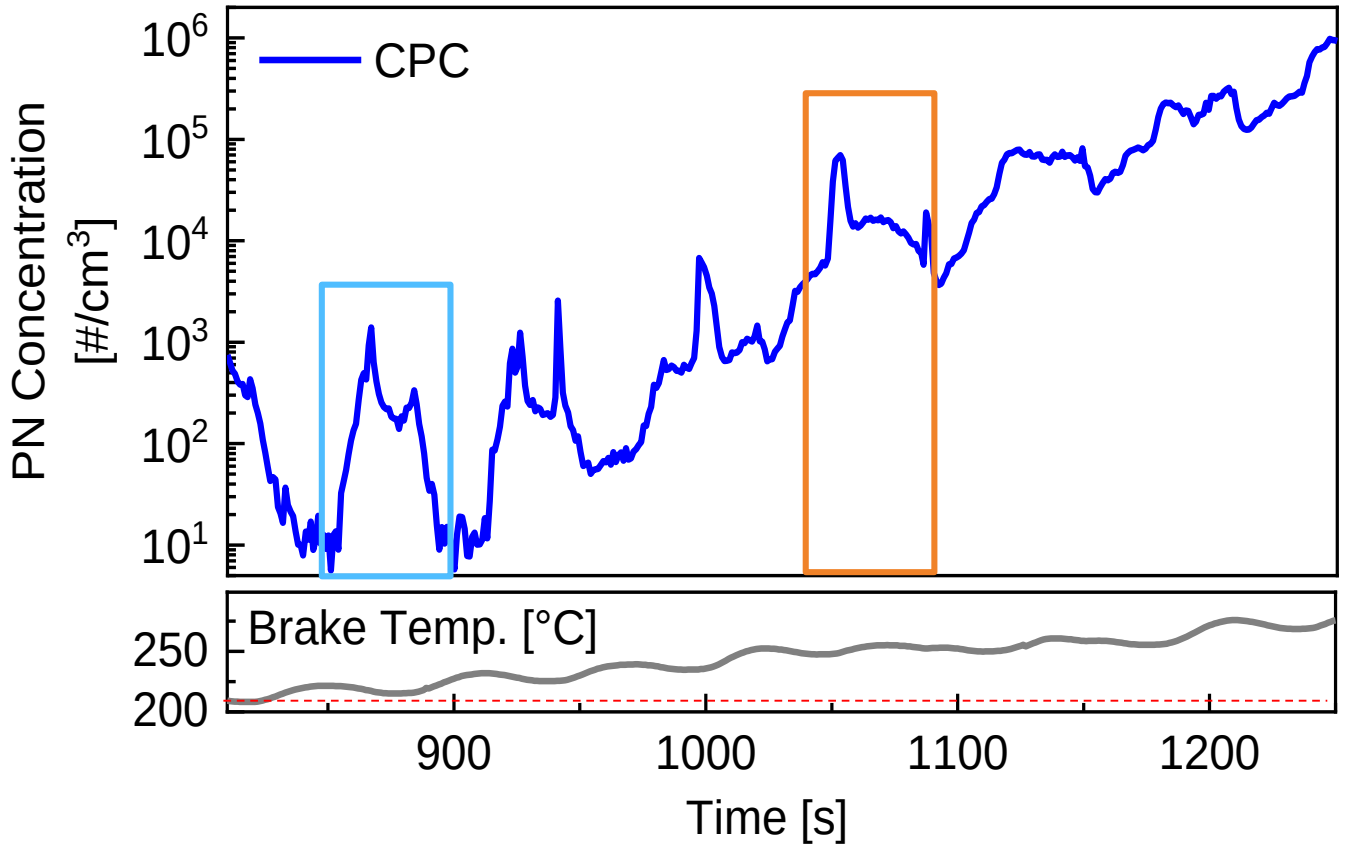


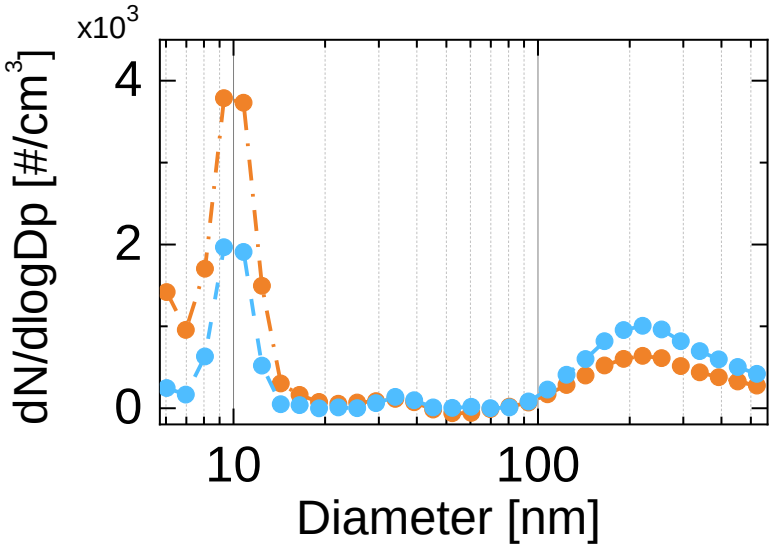




- particles diameter of about 220 nm
- ultra-fine particles at heavy braking and at high temperatures

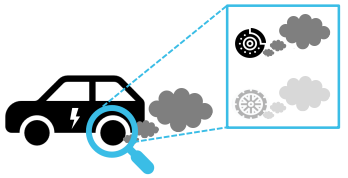
Temperature dependence of brake emissions

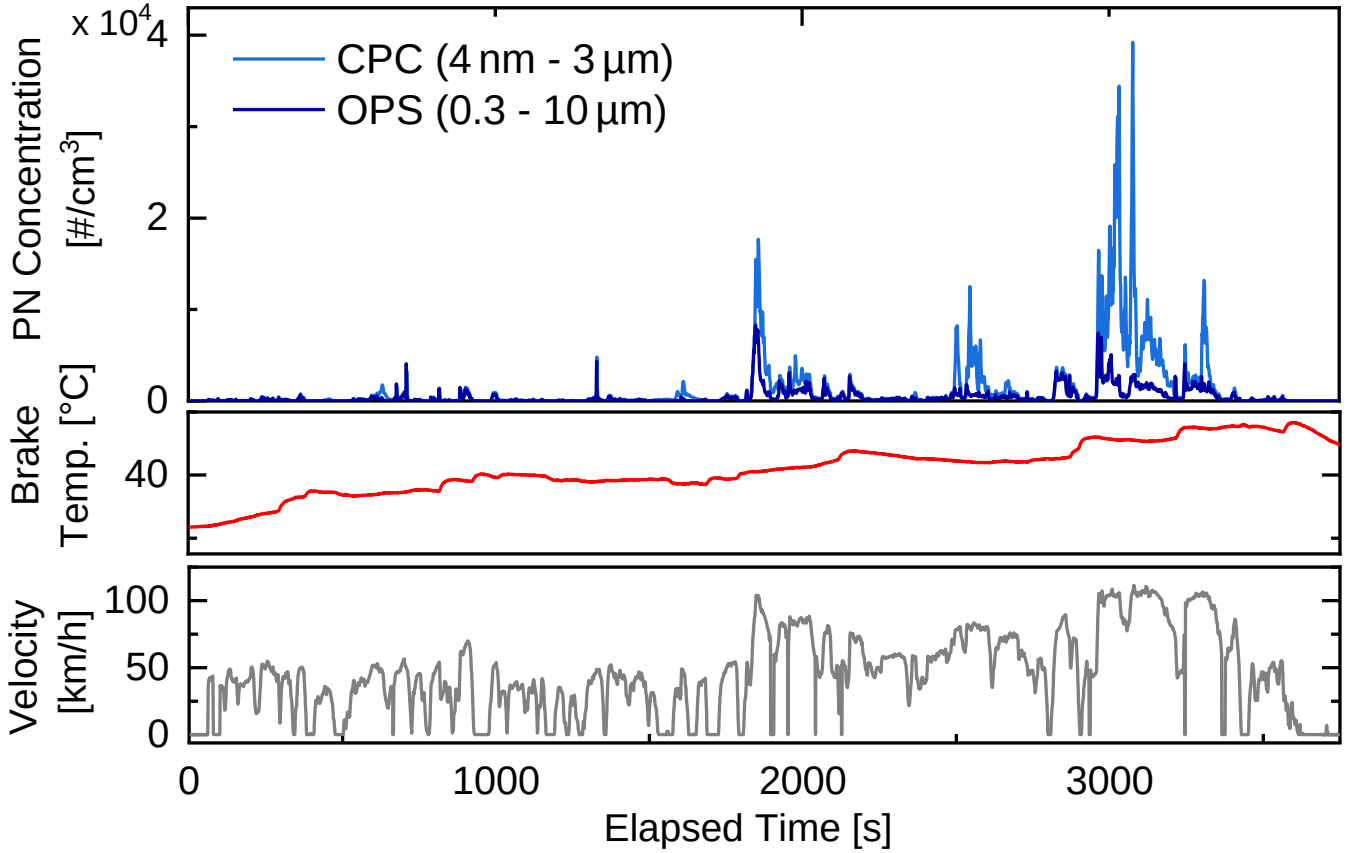


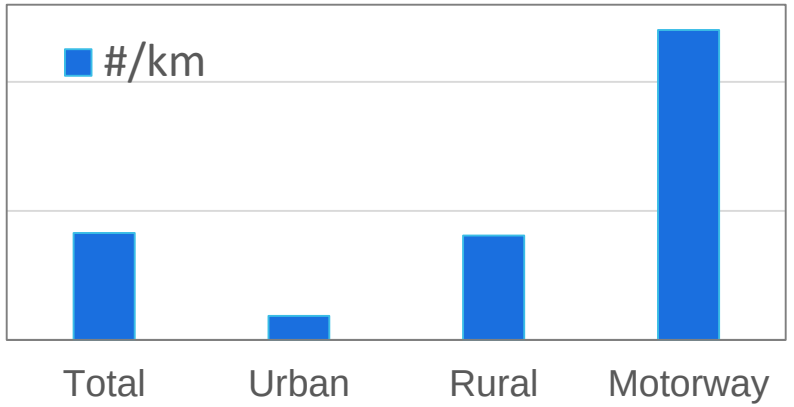


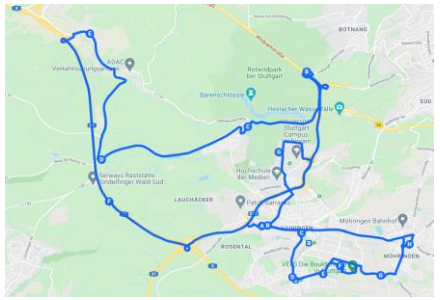
- exponential increase of particle number concentration above the critical temperature
- mainly ultrafine particles (10 nm)

Road drive: Brake emissions under realistic conditions

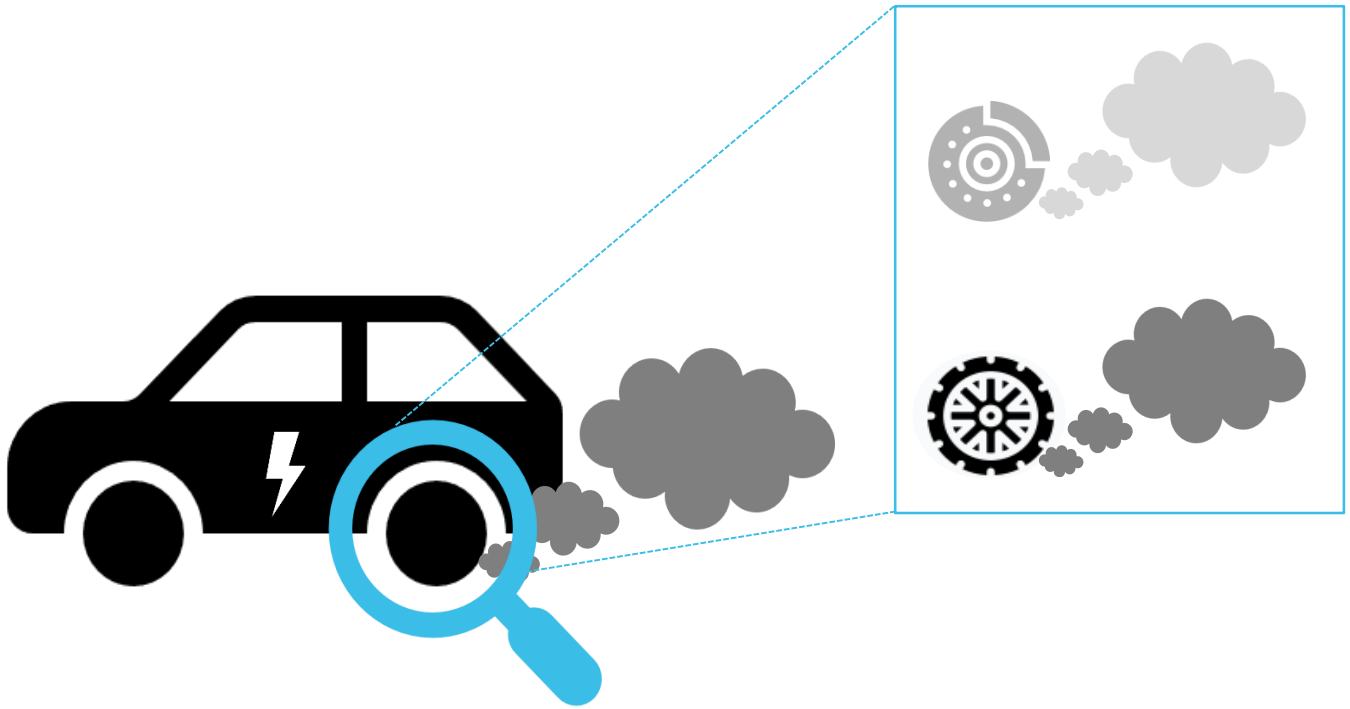




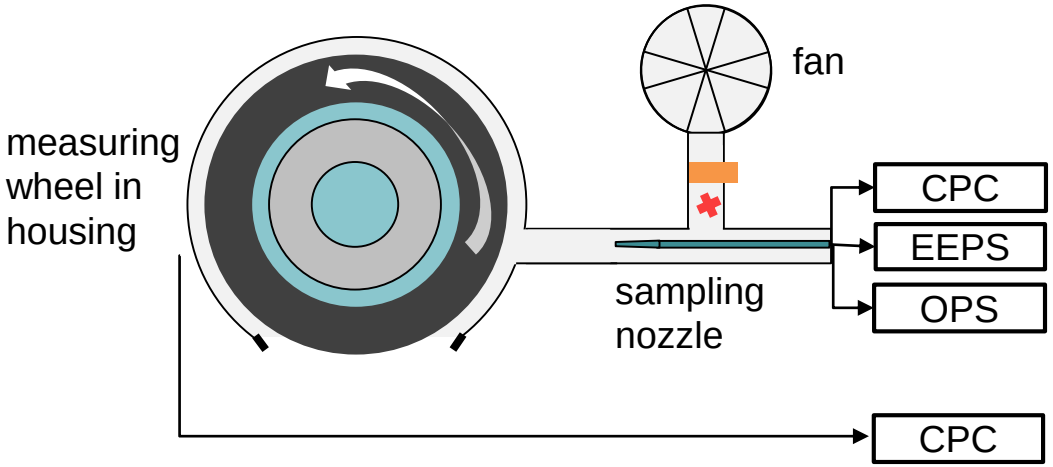


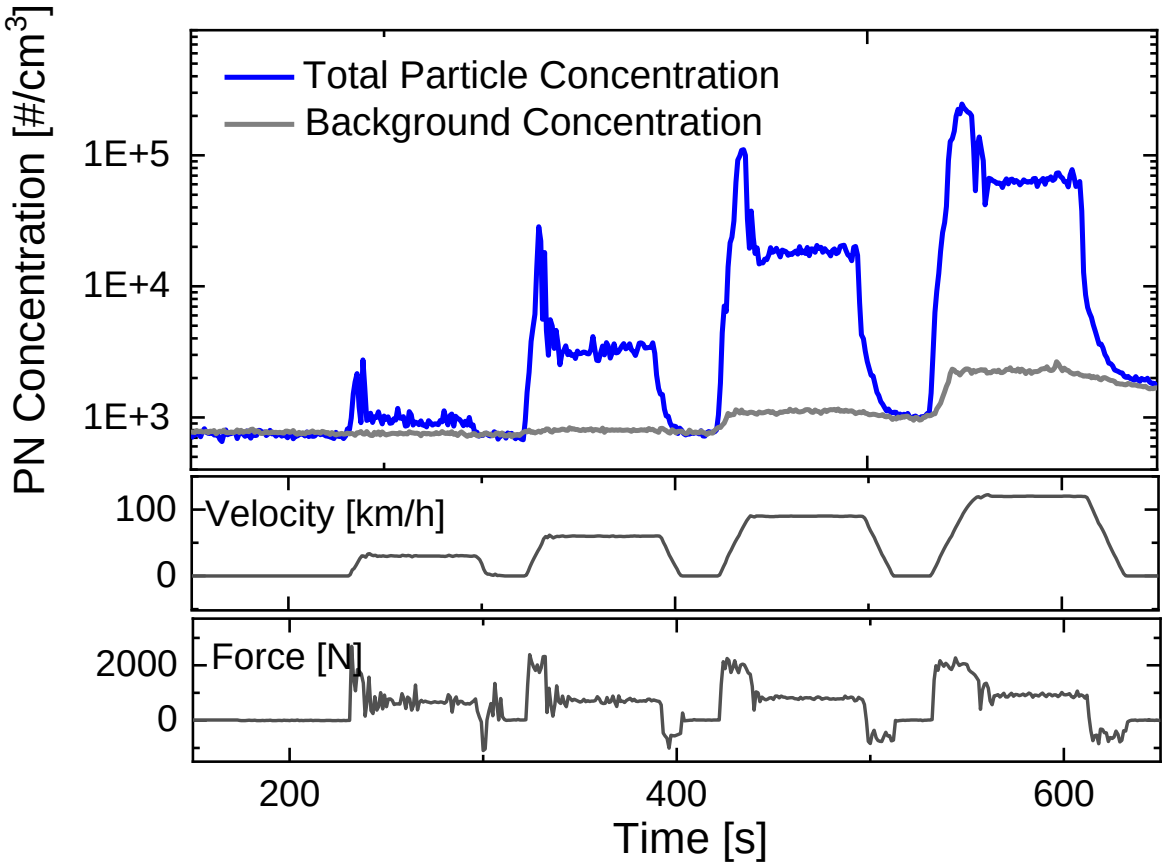


Measurement of tyre emissions



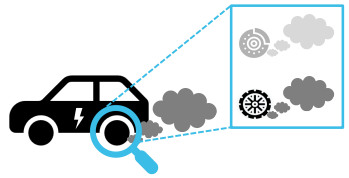
Measurement of tyre emissions

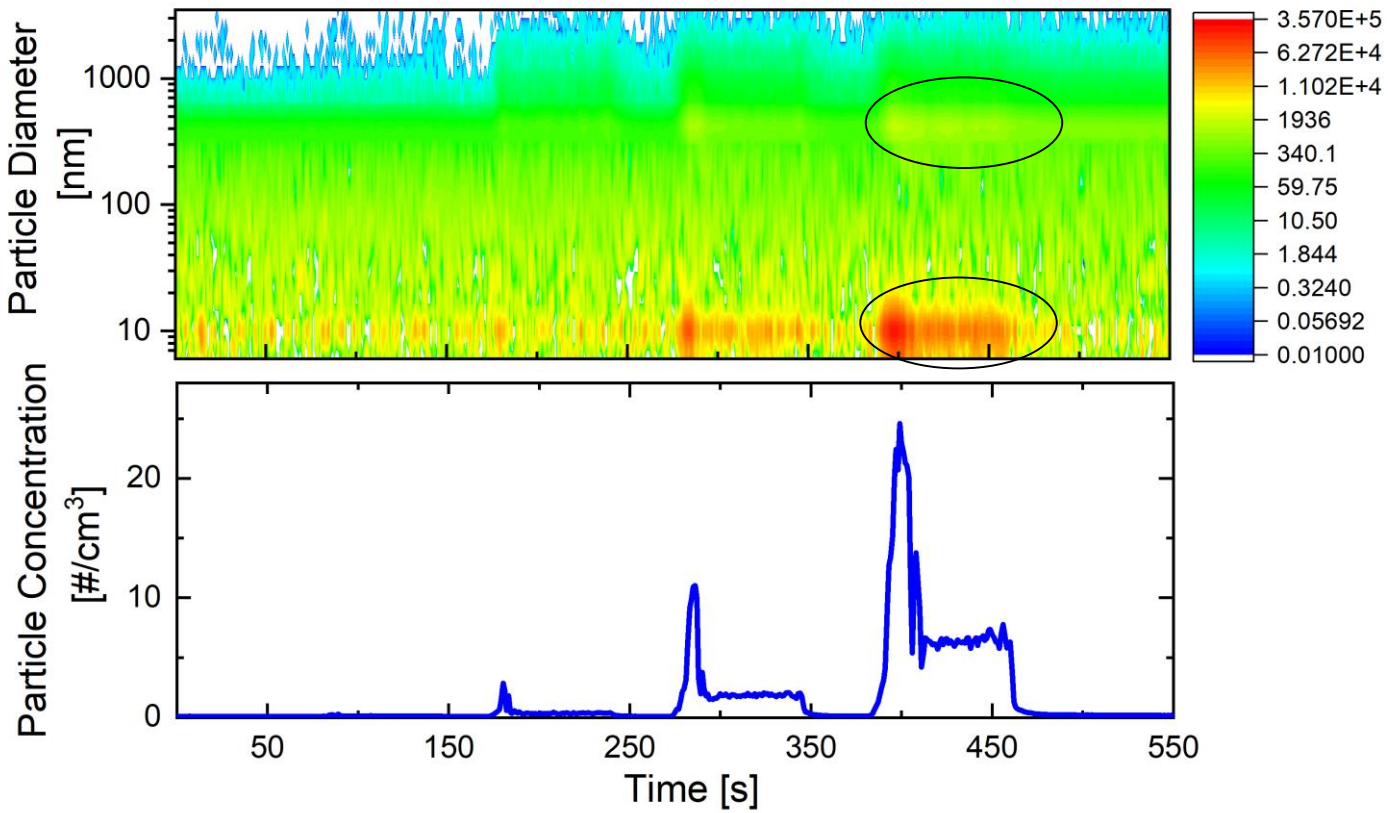


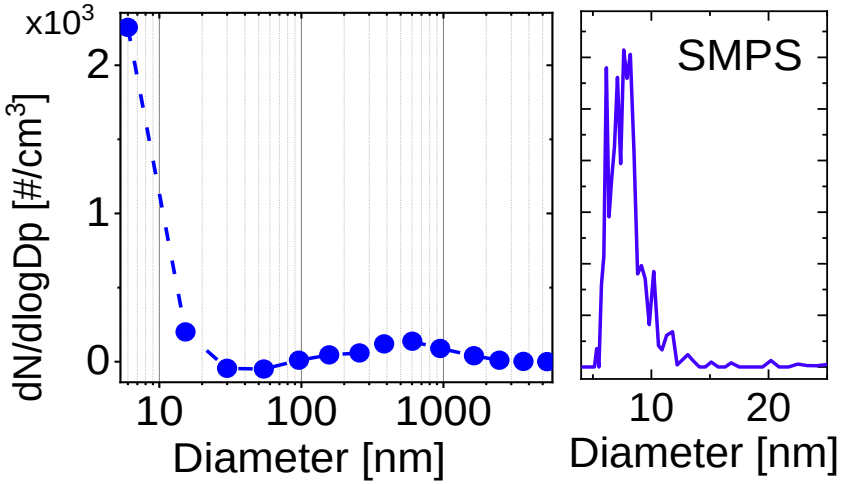


- open sampling system due to the contact area between tyre and road
- monitoring of the background concentration with additional CPC

Characterisation of tyre emissions

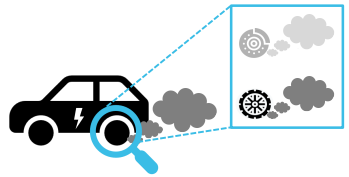


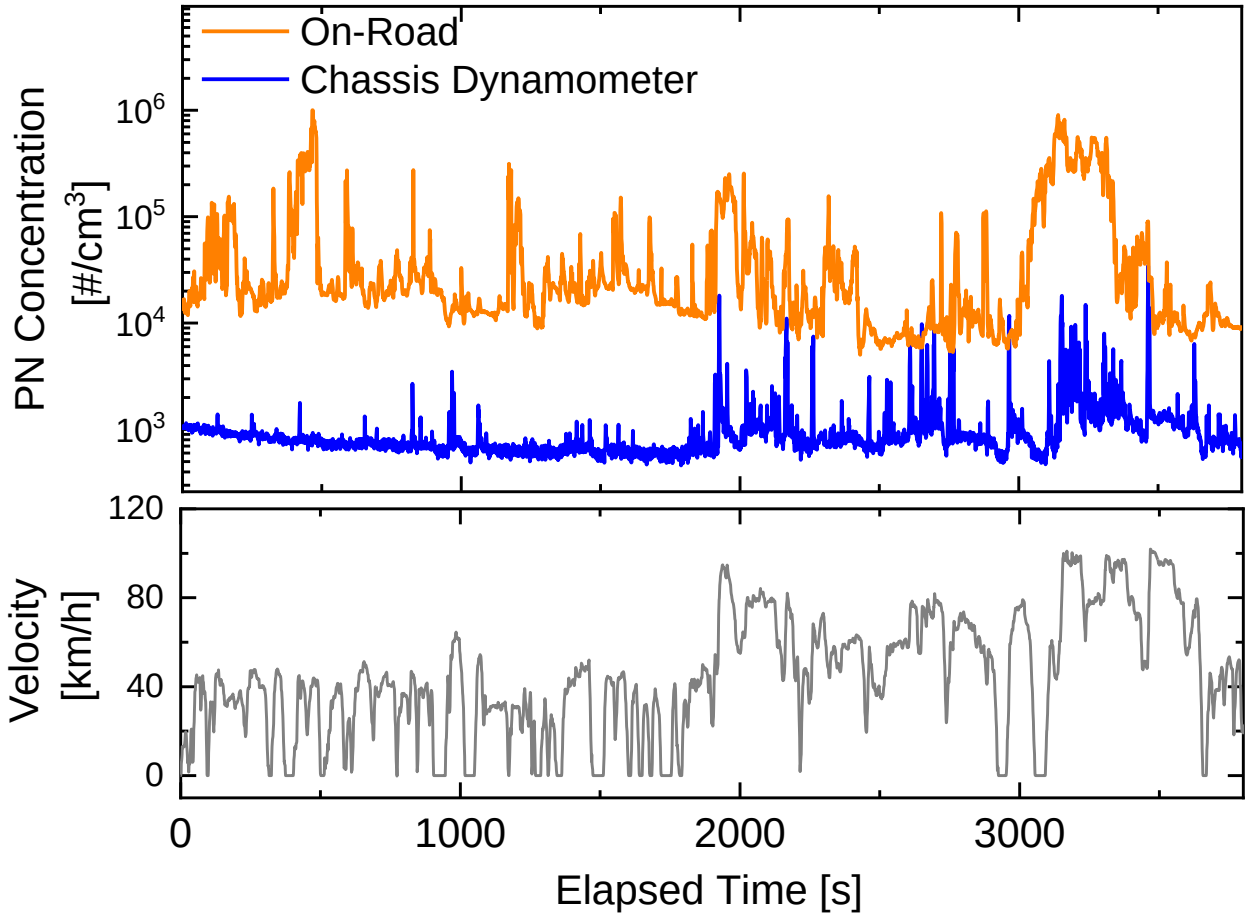


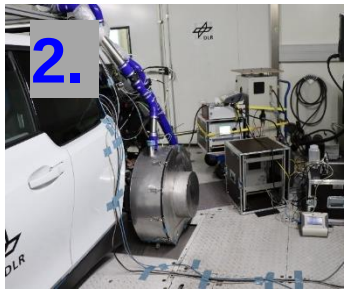


- abrasion particles
- ultra-fine particles (5 – 10 nm), determined by EEPS & SMPS

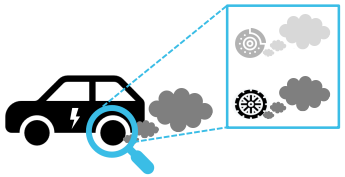
Road drive: Tyre emissions under realistic conditions

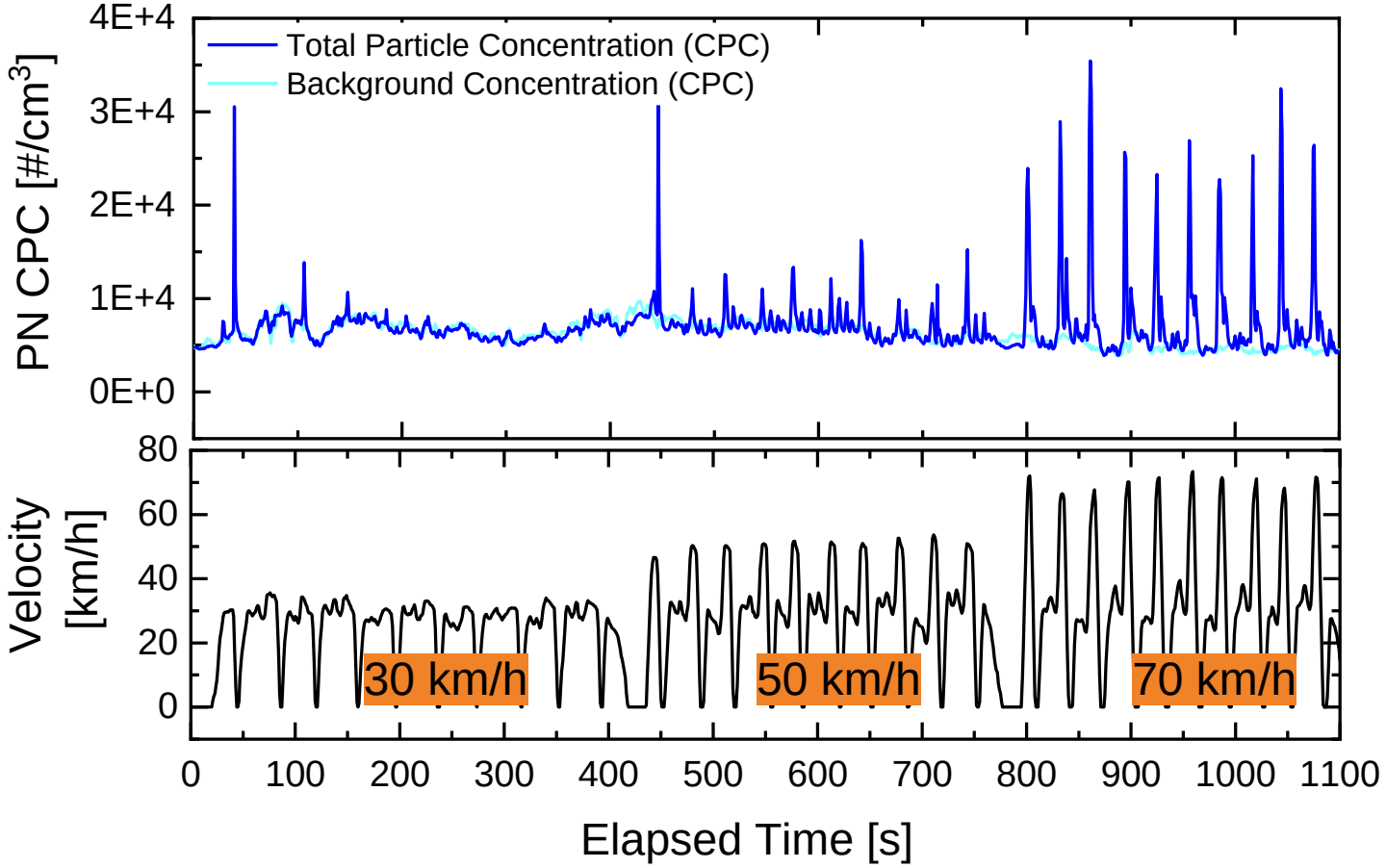






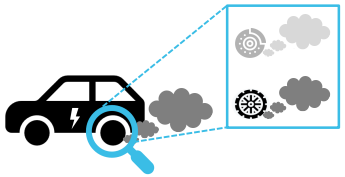
Proving ground: Tyre emissions

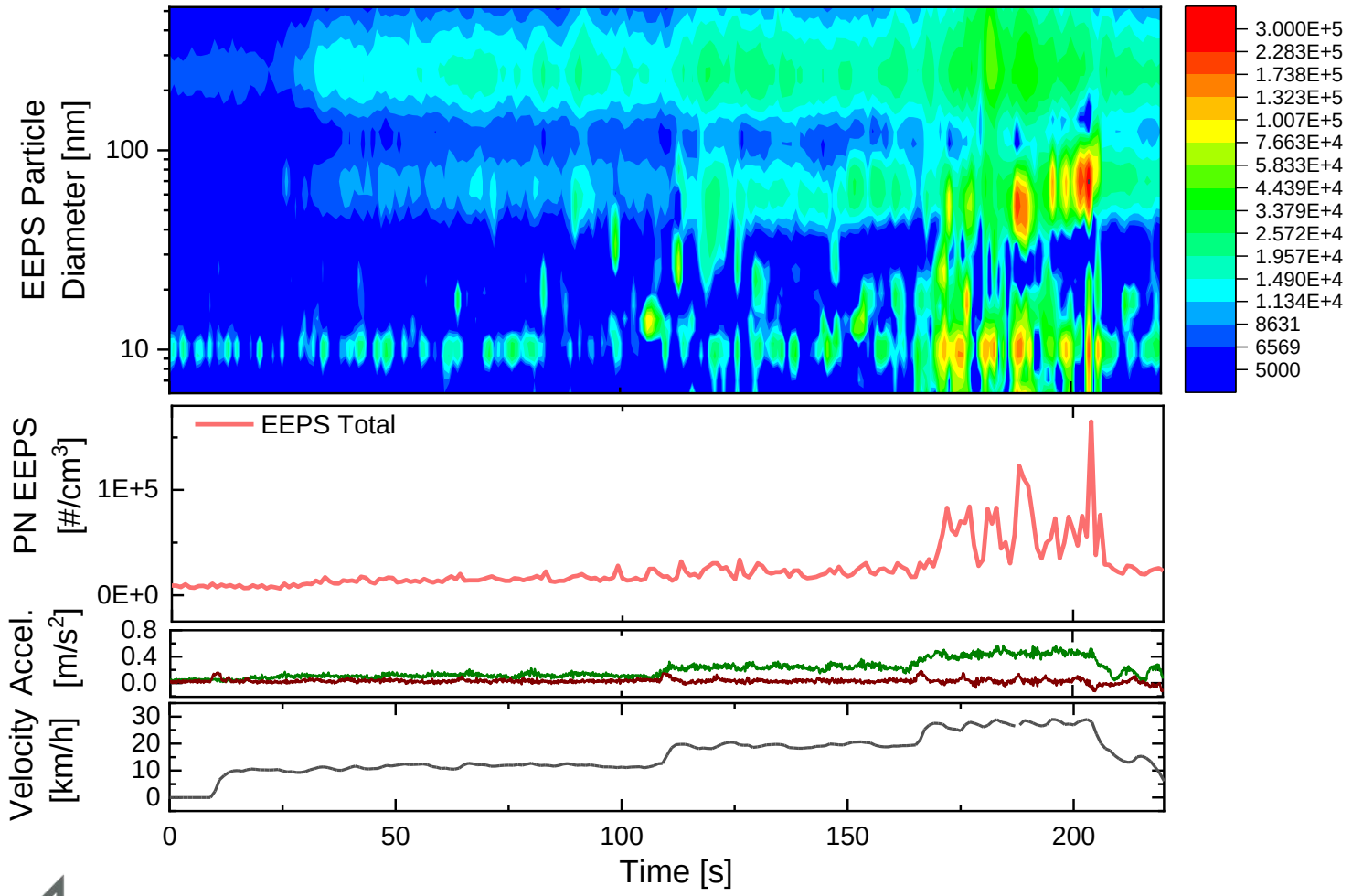


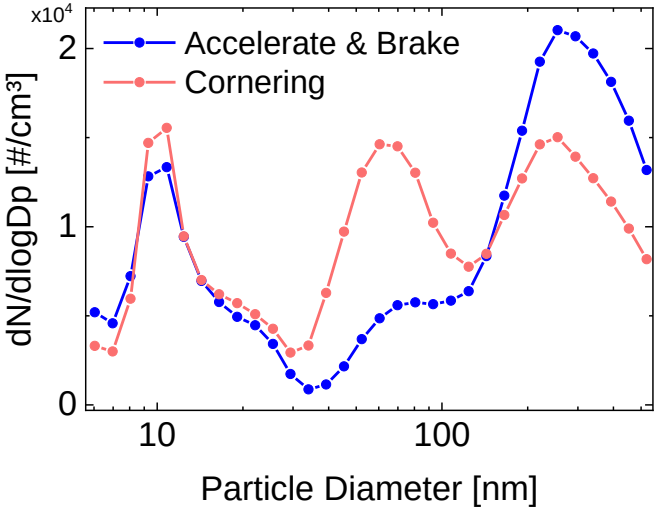


- lower and more stable background concentration
- identification of the emitted particles

Proving ground: Cornering and lateral acceleration

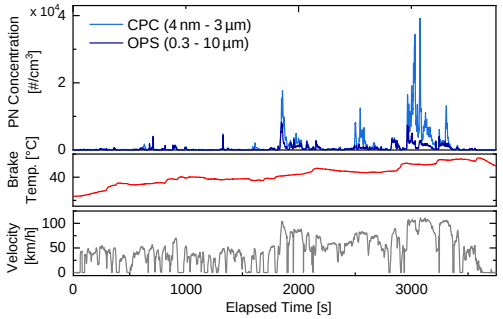


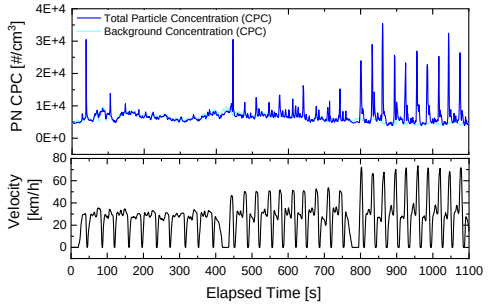




Summary

- new setup for non-exhaust real driving emissions
- characterisation of airborne tyre and brake wear particles on the chassis dynanometer
- measurement of brake emissions on the road
- measurement of tyre emissions on the proving ground



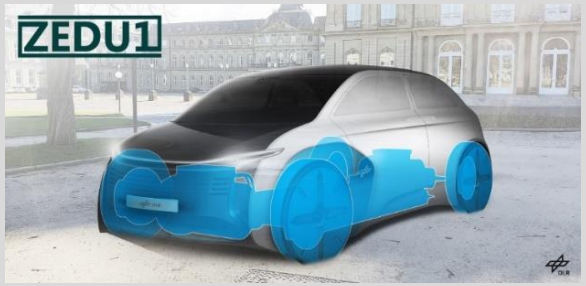


Acknowledgements

Project: Zero Emission Drive Unit Generation 1

Sponsor: Baden-Württemberg Ministry of Economics, Labour and Housing

Team: E. Deykova, F. Epple, M. Fritsch, T. Grein, L. Köhler, F. Philipps, T. Schripp



Thank you for your attention!

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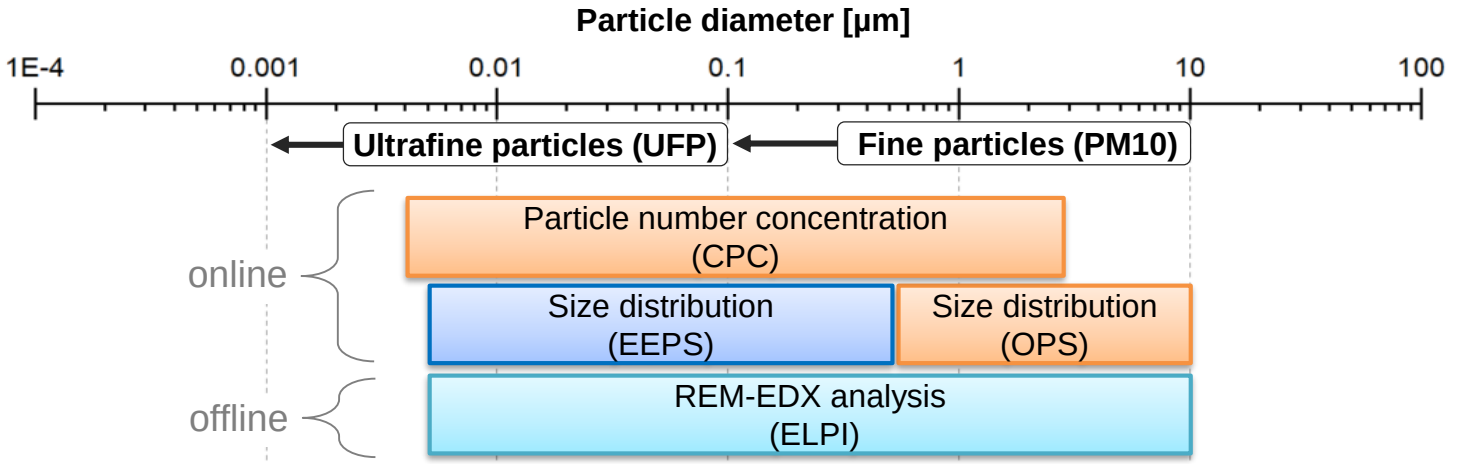
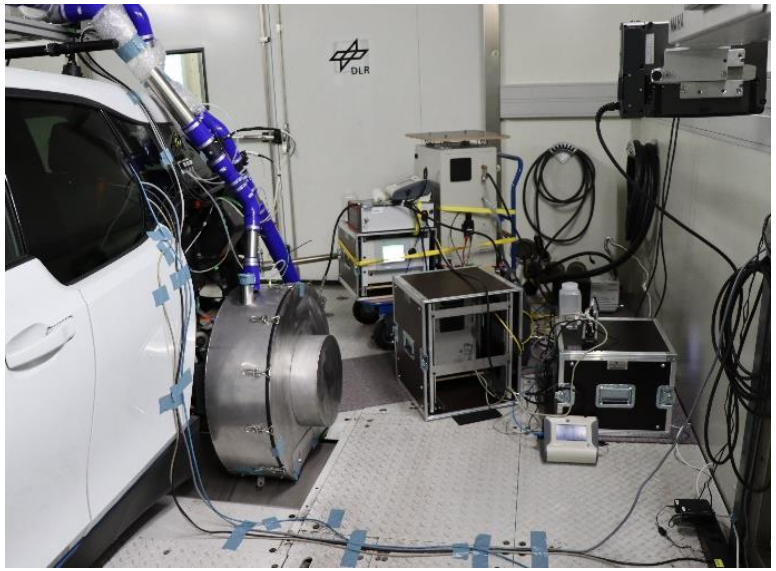
Particle measurement technology





Light Scattering

CPC

OPS

Electromobility

EEPS

Impactor & Microscopy

ELPI

REM-EDX

Particle characterisation:

- Particle number concentration
- Particle size distribution
- Morphology
- Elemental composition

Proving Ground: The influence of cornering and lateral acceleration