Title: Investigation of low-level PM emissions of a modern European Diesel particle filter equipped vehicle

Abstract: (min. 300 - max 500 words)

The abstracts for papers and posters should contain unpublished information on the research subject, the investigation methods and results obtained so far. Graphs and references are very welcome. During your presentation at the conference you may expand on this with additional data and results. General information on products which are already commercially available are not the focus of the presentations but are very welcome at the exhibition.

Modern DPF systems are very effective to reduce particle emissions from Diesel vehicles. In this work low-level PM emissions from a DPF equipped EURO-4 vehicle were studied in the emission test laboratory and during real-world chasing on a high-speed test track. Concurrent measurement of CO2 allows the calculation of the dilution factor.

When the vehicle was driven under normal acceleration conditions PM emissions were close to background levels. Real-world PM emissions were studied during full-load acceleration conditions, different DPF loading status, and under DPF regeneration conditions. Size and time resolved data obtained from EEPS and particle counter are presented and real-world dilution during exhaust chasing is compared to in-situ tailpipe dilution and sampling.

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Investigation of low-level PM emissions of a modern European DPF equipped Diesel vehicle

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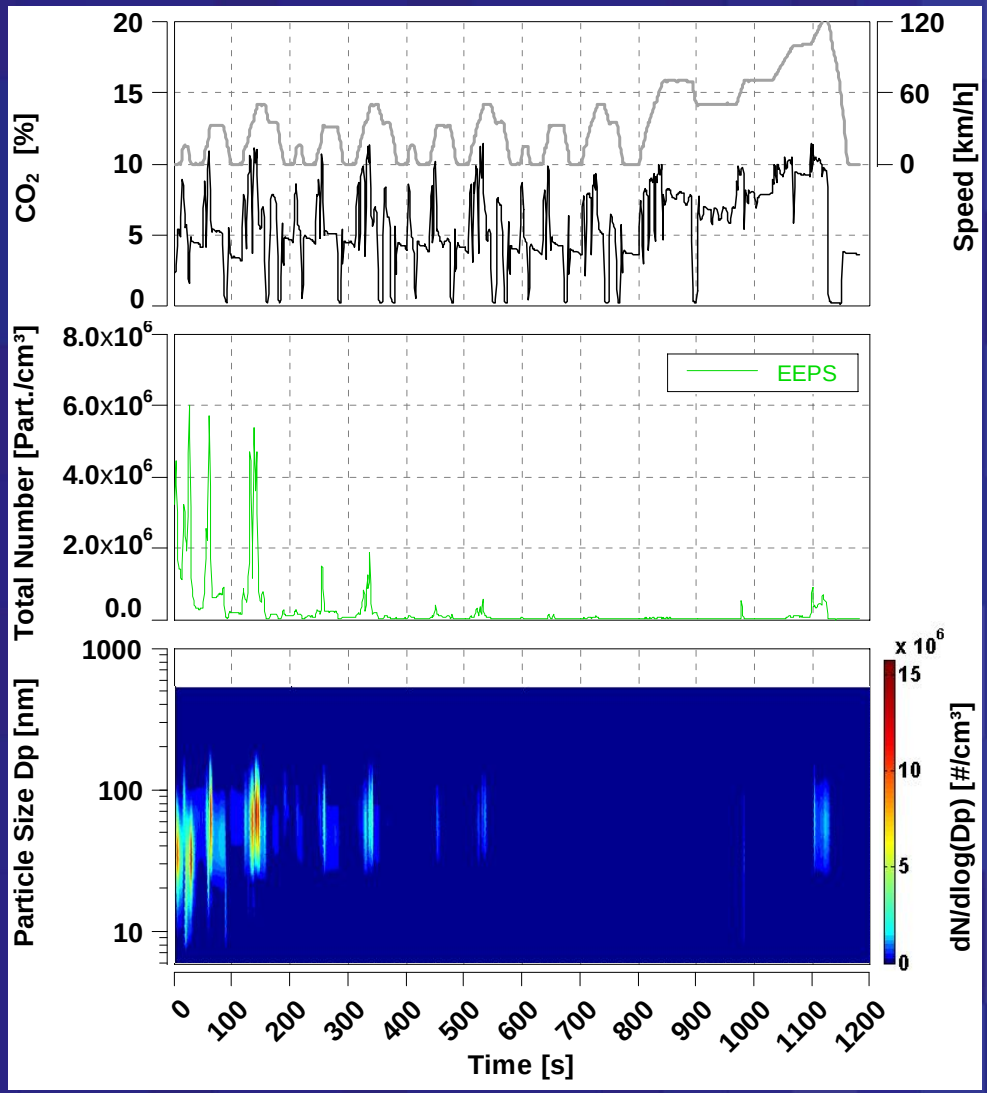
- Particles and DPF efficiency measured during emission laboratory test cycle (NEDC)
- Full load acceleration/deceleration investigation
  - real atmospheric dilution
  - laboratory tailpipe dilution
- DPF regeneration
- Summary

Emission laboratory PM sampling

- In-situ dilution (Casati et al. Atmos. Env. 2007)

Post-DPF PM during NEDC



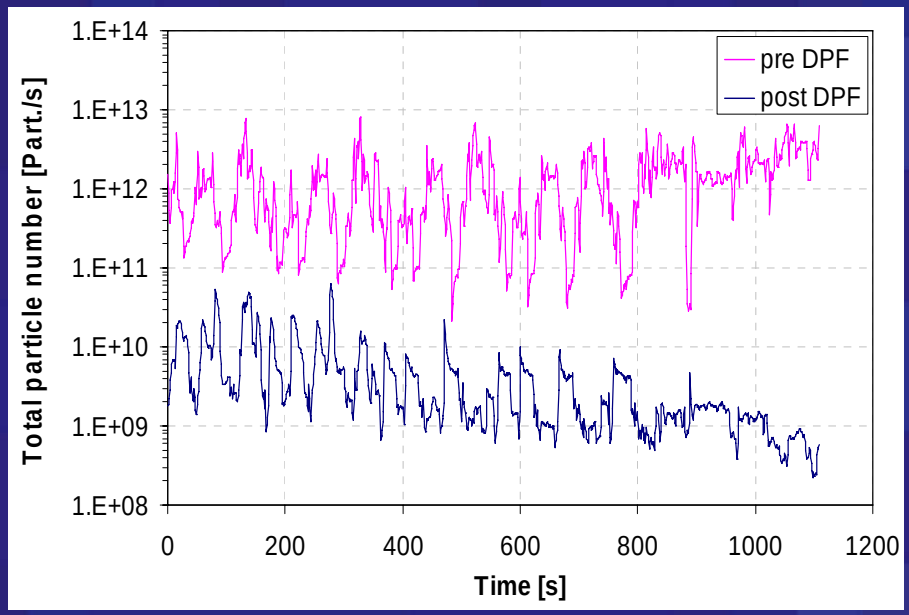
- Euro-4 DPF vehicle
- tailpipe sampling with FPS and EEPS

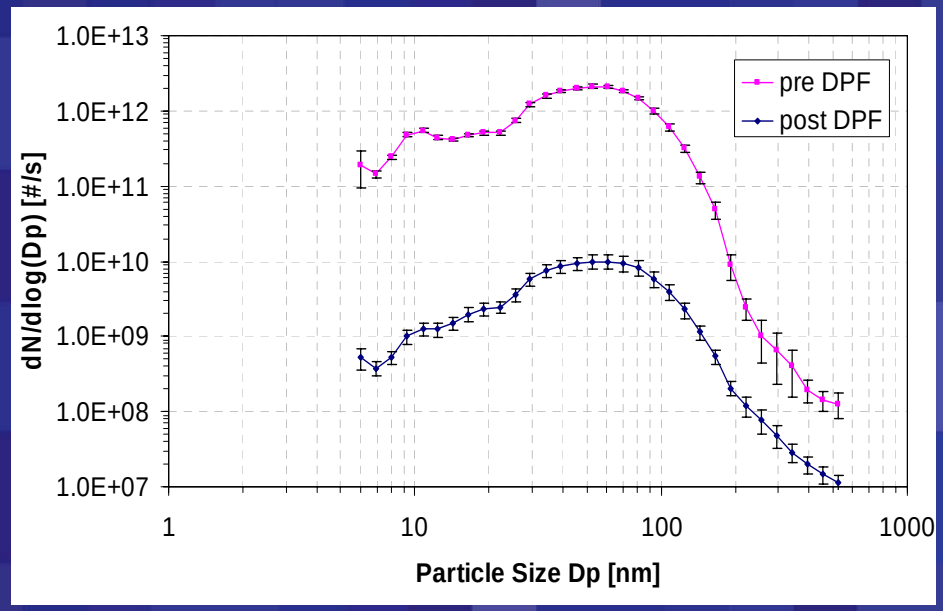
=> some PM measurable during cold start

=> very low PM during remainder

=> [PM] = 0.3 mg km^{-1}; [PN] = $5x10^{11}$ km^{-1}

DPF Efficiency during NEDC





=> [PM] efficiency = 99.3%

=> [PN] efficiency = 99.5%; efficient performance including ultrafine particles

On-road chasing of exhaust plume

Test vehicle:

Euro-3 Diesel
speed, fuel consumption
exhaust temperatures

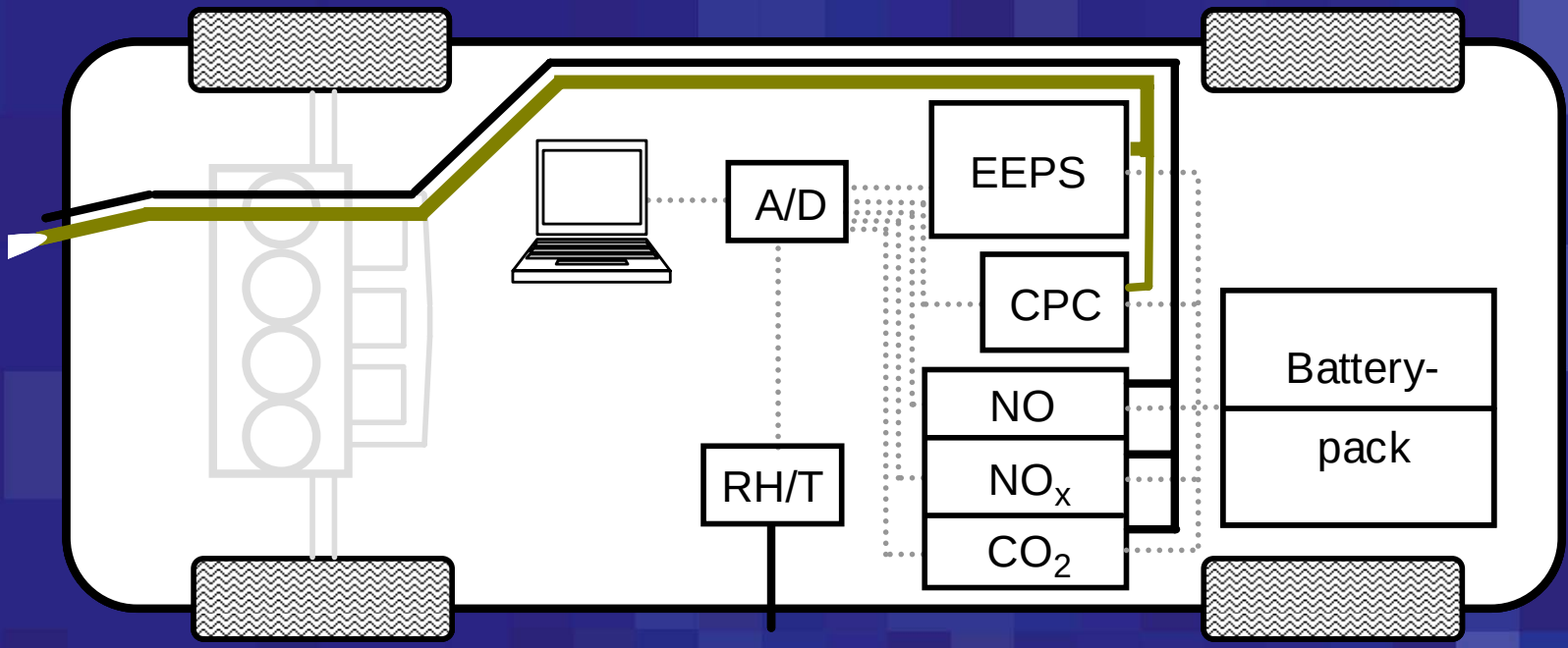
Ford Mobile Lab:

EEPS, CPC, NOx, CO_2,
T and RH

Test track:

high speed oval,
4 km/lap
Distance: 10-100 m

Test vehicle for exhaust chasing

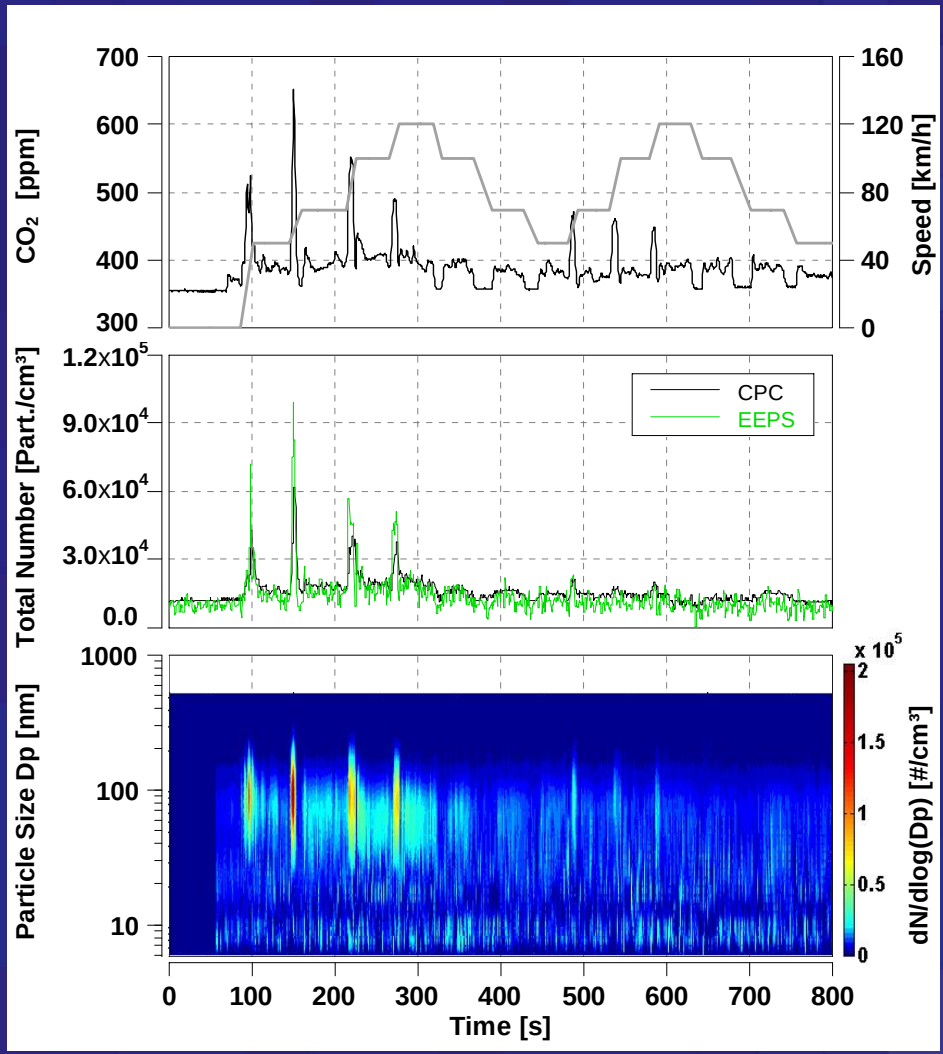


Test vehicle for exhaust chasing

Measurement equipment

- Particles: EEPS, CPC
- Gases: CO_2, NO, NO_x
- Temperature and rel. humidity

Full load acceleration/deceleration exhaust chasing with regenerated DPF

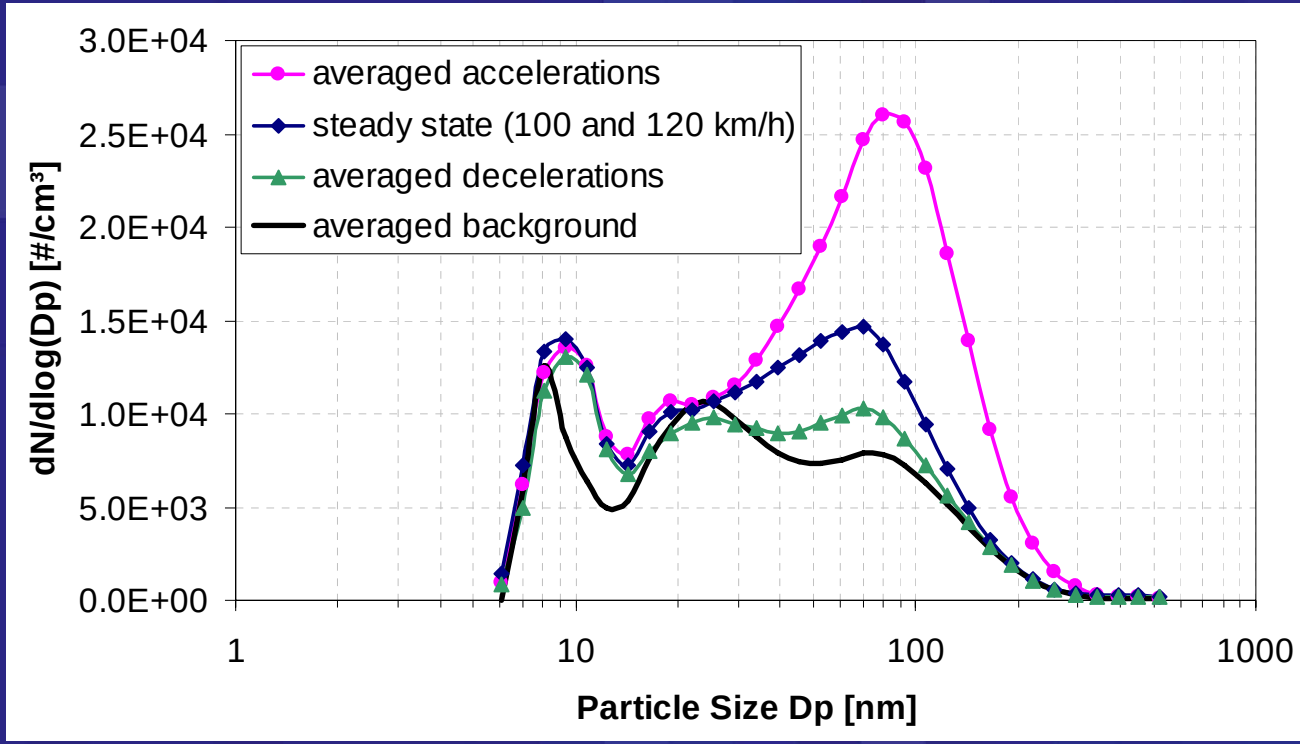


- full load acceleration, Euro-4 DPF vehicle
- freshly regenerated DPF
- Exhaust chasing on test track at 10-20 m distance

=> during first acceleration cycle PM above background measurable

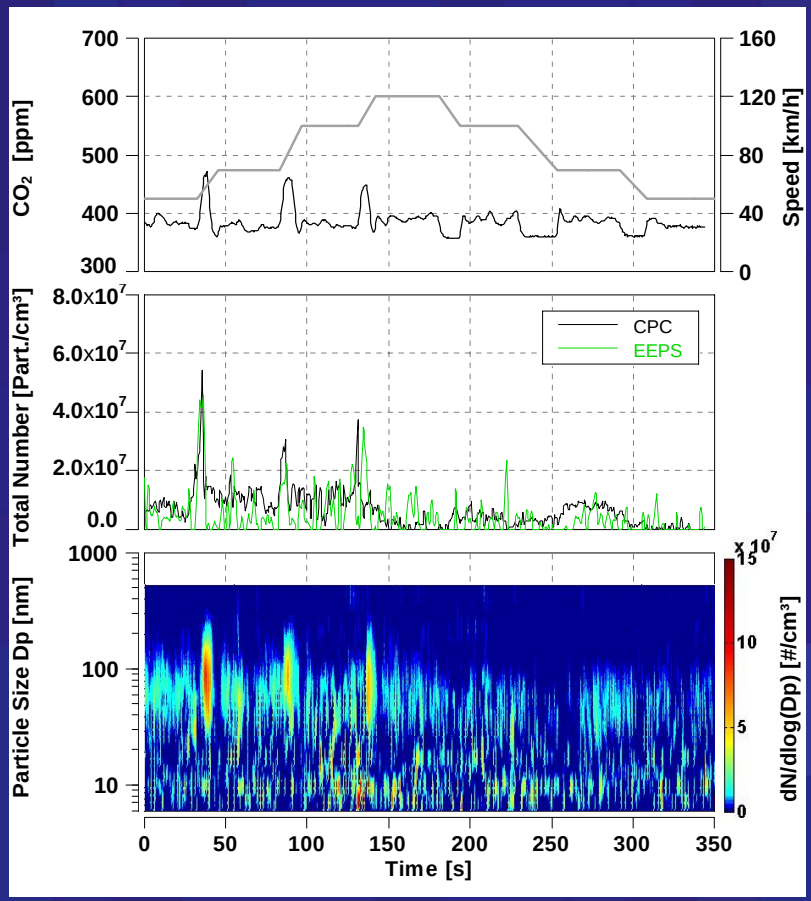
=> second acceleration cycle: barely above background, due to increased filtration efficiency

Averaged PM size distributions during exhaust chasing

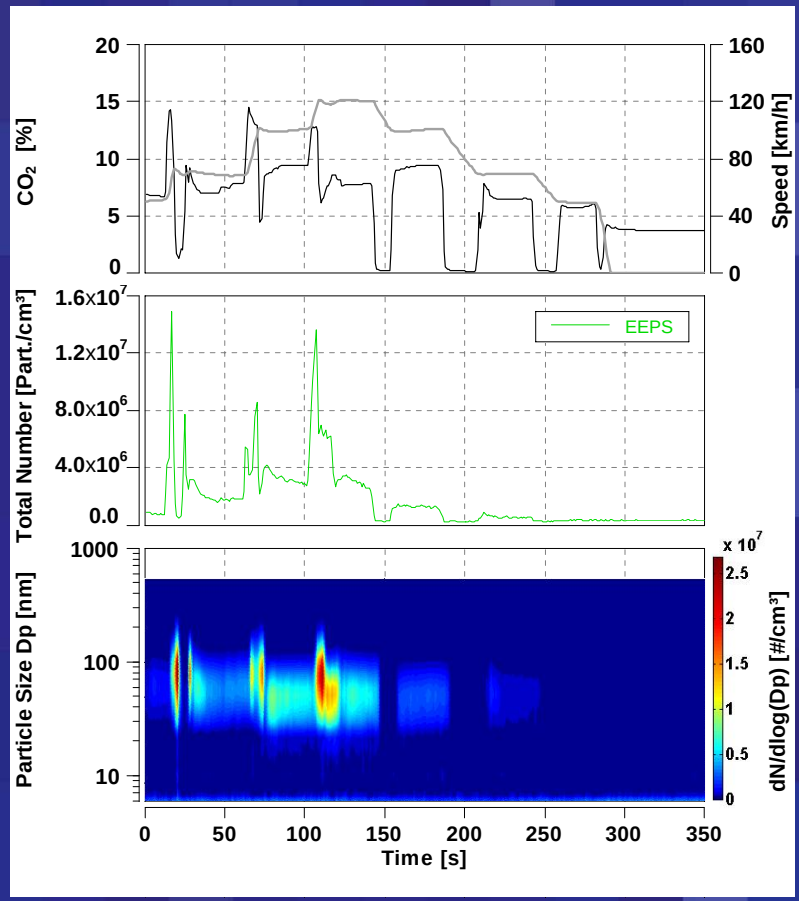


Acceleration/deceleration w loaded DPF[1]

- Exhaust chasing on test track in real atmosphere



- Laboratory: tailpipe in-situ dilution w synthetic air

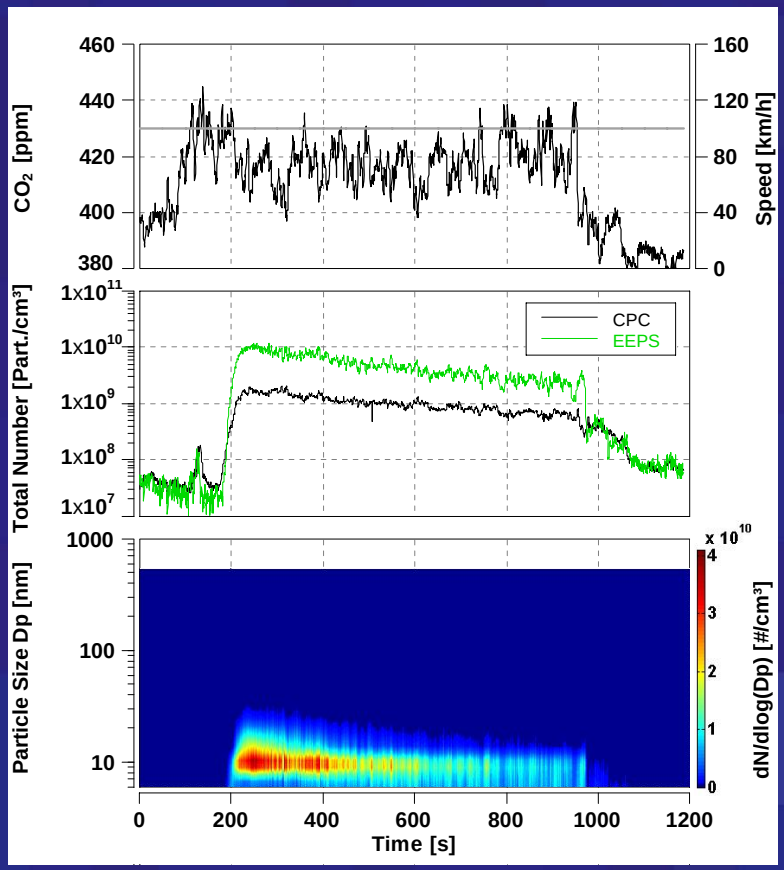


=> data from real atmosphere chasing need to be corrected for ambient background

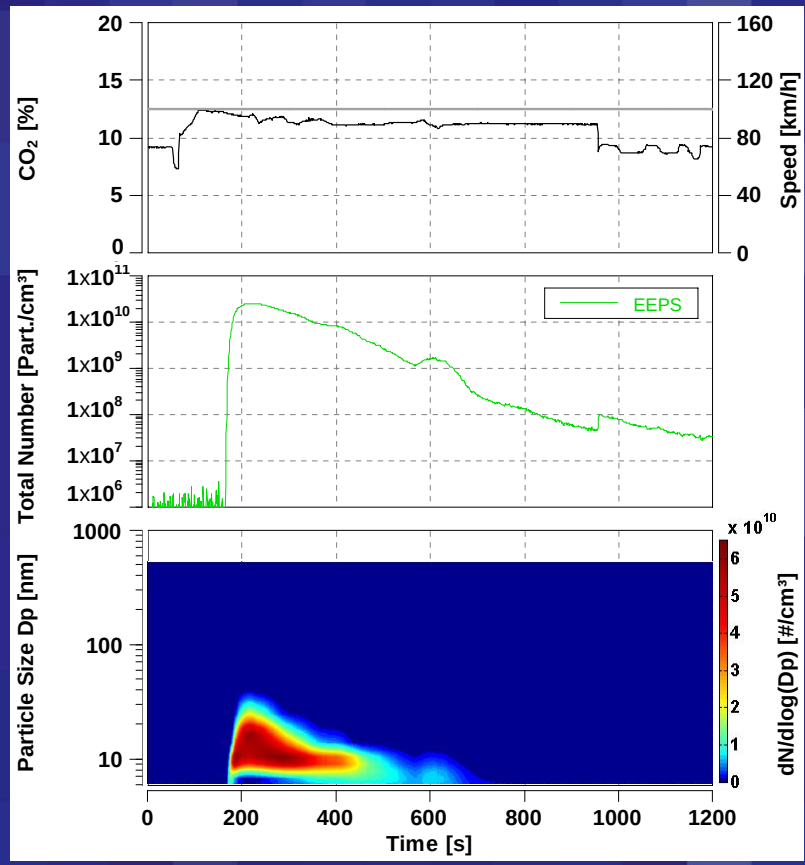
=> good agreement of laboratory and atmosphere measurement

DPF regeneration

- Exhaust chasing on test track in real atmosphere



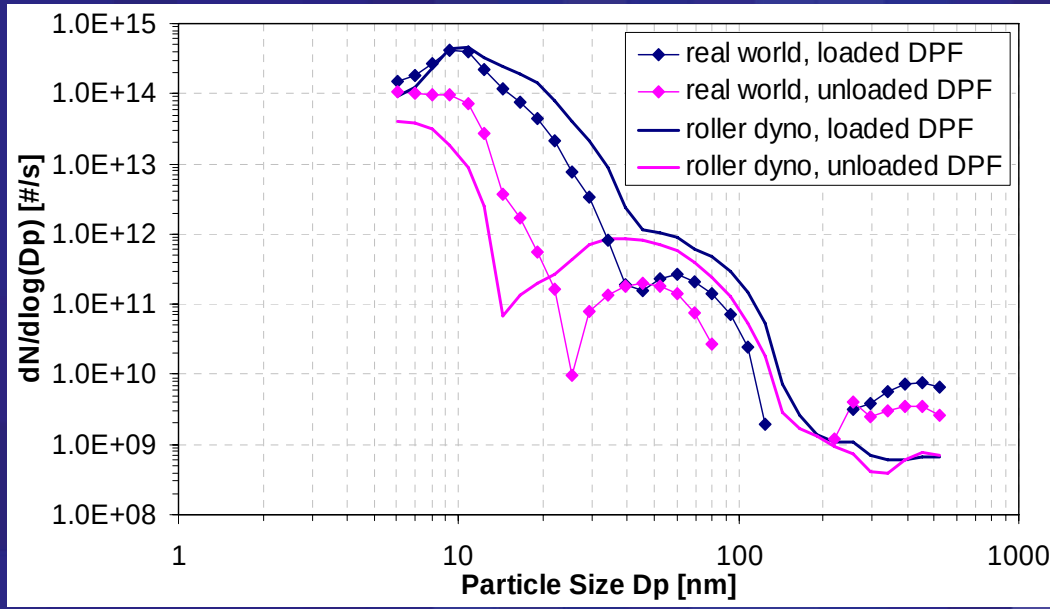
- Laboratory: tailpipe in-situ dilution w synthetic air



=> regeneration was triggered at 100 kmh-1

=> large increase of nucleation particles; reasonable agreement lab/atmosphere chasing

Average particle size distributions during DPF regeneration

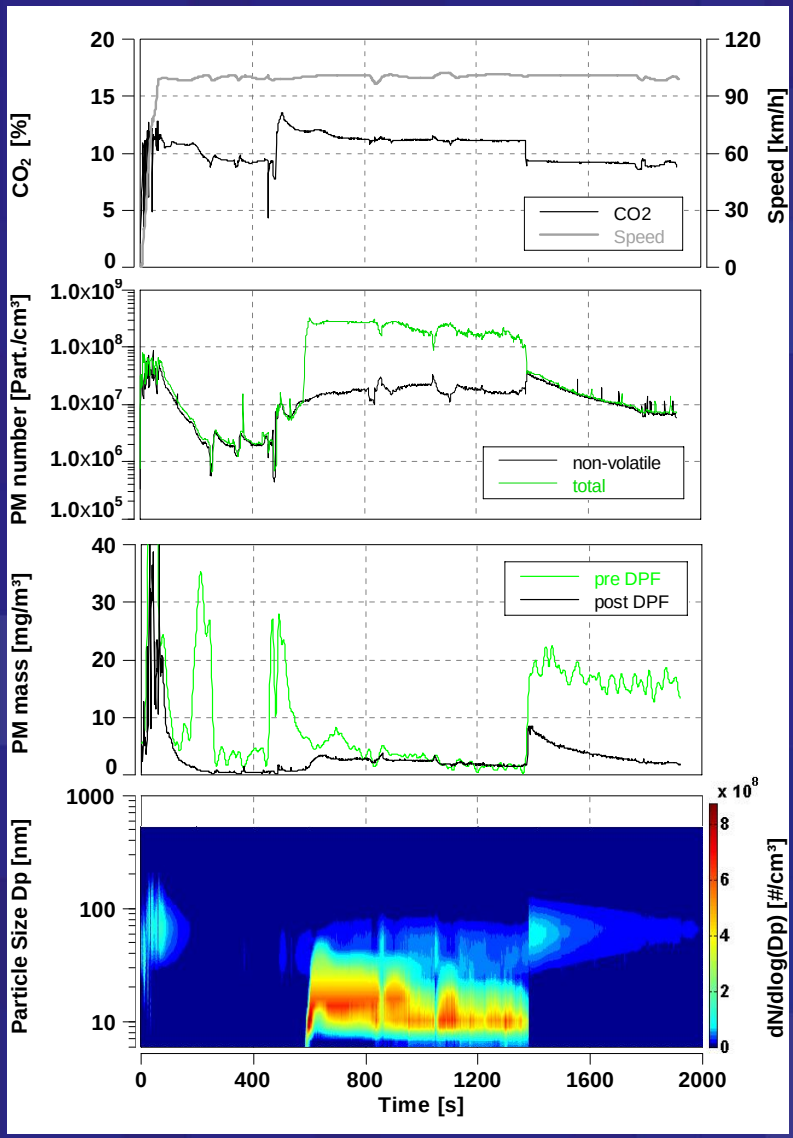


=> observed large number of nucleation particles during regeneration

=> reasonable agreement of laboratory and atmosphere measurement

=> higher number of nucleation particles during regeneration of loaded DPF

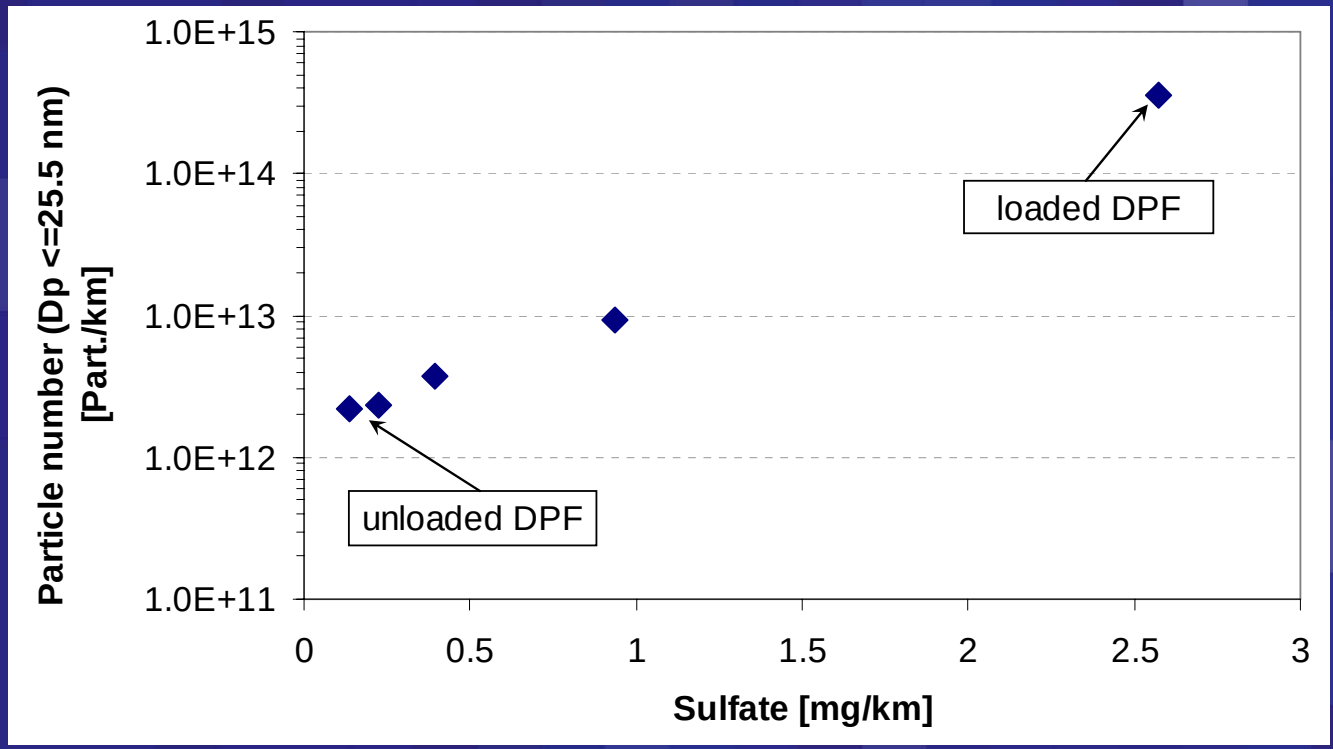
DPF regeneration: Volatility of particles



- non-volatile particles: PMP-like set-up

=> most particles during DPF regeneration are volatile

Particle number and sulfate during DPF regeneration



=> correlation of number of nucleation particles and amount of sulfate analyzed in collected PM

=> nucleation particles are likely related to stored and released sulfur in DPF

Summary & Conclusions

- The high efficiency of a wall flow diesel particulate filter was demonstrated with a EU-4 diesel passenger car. During NEDC the average filtration efficiency was [PM]=99.5% [PN]=99.3%
- Due to low emission levels on-road measurement of PM emissions is a challenging task: For constant speeds below 100 km/h or moderate accelerations the measured particle number concentrations ranged from 1 to 1.5 times background level. Only during higher speeds and full load accelerations concentrations could be observed which were above 3 times background level
- On-road tests were compared to the corresponding chassis dynamometer results: reasonable agreement was achieved
- During DPF regeneration the total number emissions of nucleation mode particles were 10^3 to 10^4 times higher while the level of the accumulation mode particles remained about the same.
- The majority of the particles emitted during DPF regeneration was found to be volatile, and is suggested to originate from accumulated sulfur compounds.