

Observation of particle size distributions in diesel exhaust under ambient and laboratory dilution conditions

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Introduction

- Road transport emission, especially from diesel engines, is known as one source of particulate matter
- Large uncertainties still exist in the following areas:
 - Measurement reproducibility of particle number and size
 - Lack of a calibration source
 - Formation of nucleation particles (10-20 nm)
 - Performance of laboratory dilution and sampling systems vs. real world dilution



Purpose of the study

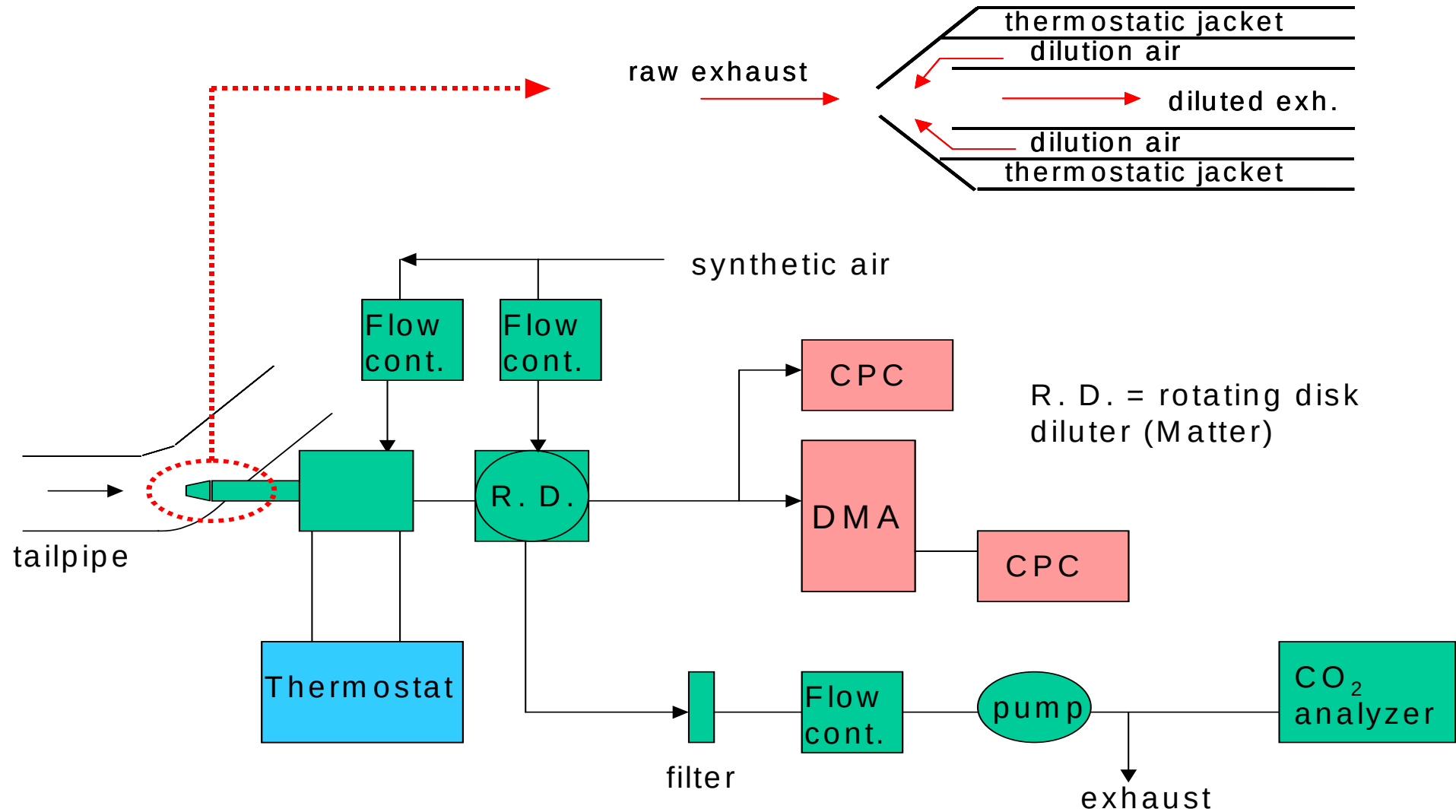
- Test performance of the new FFA in-situ diluter in comparison with real world dilution (on-road chasing of exhaust plume)
- Investigate effects of dilution air temperature and relative humidity
- Assess how diesel exhaust particle number size distributions are influenced by vehicle parameters (load, fuel sulfur, history, ...)



PM measurement at FFA



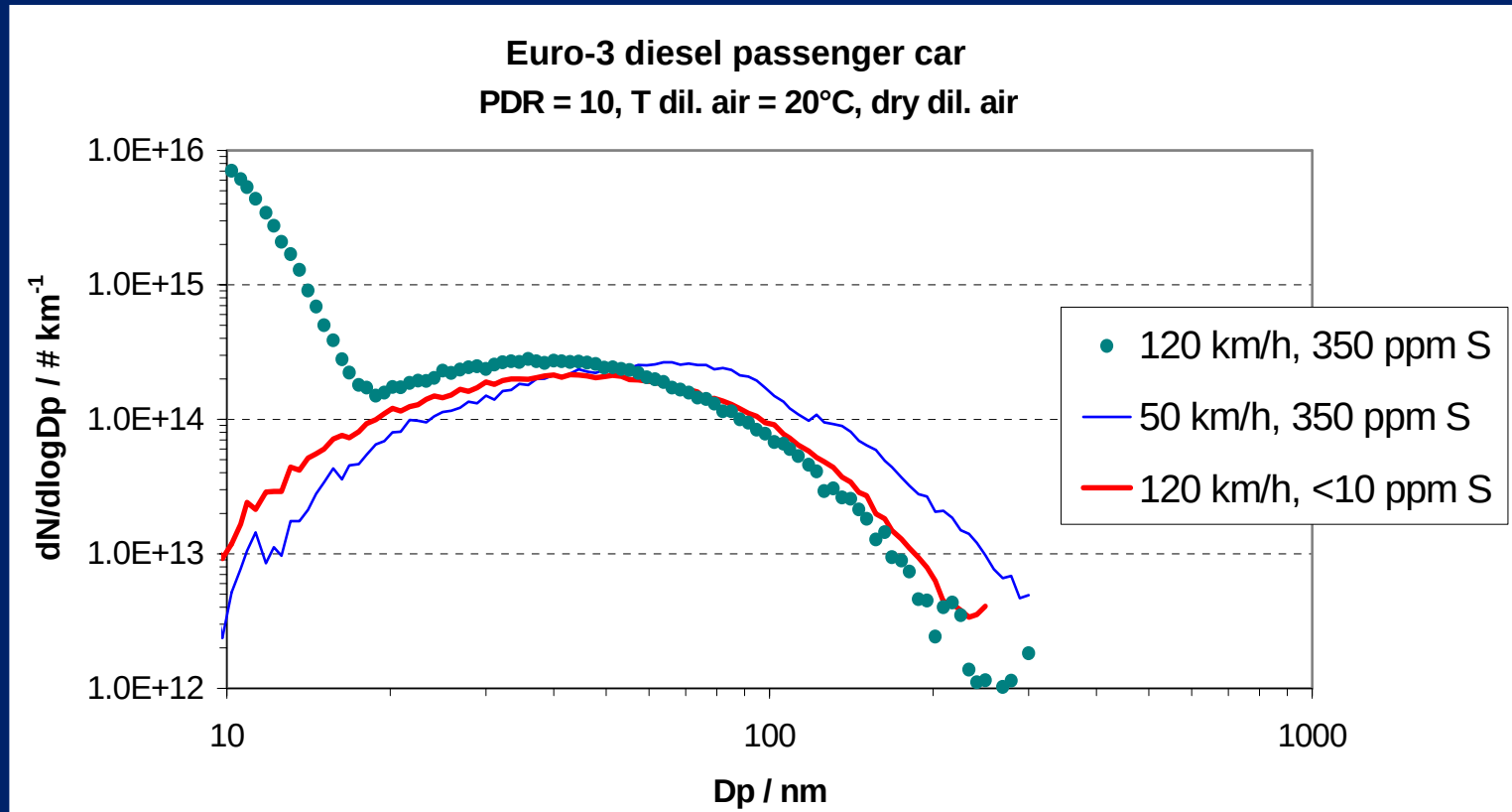
FFA in-situ diluter and sampling (1)



FFA in-situ diluter and sampling (2)

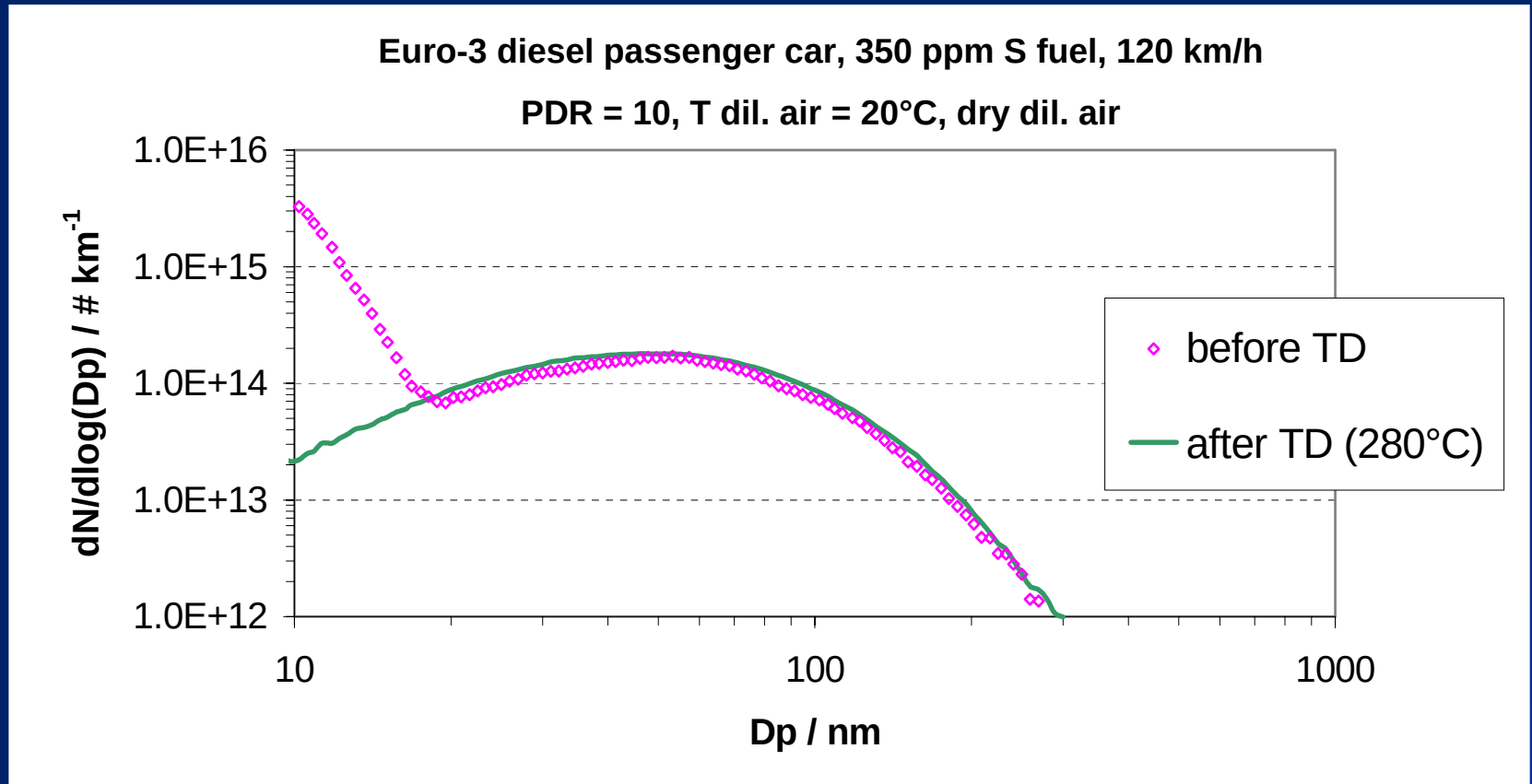


Effect of engine load and fuel sulfur



High load and high S fuel lead to the formation of a nucleation mode.

Volatility of nucleation particles

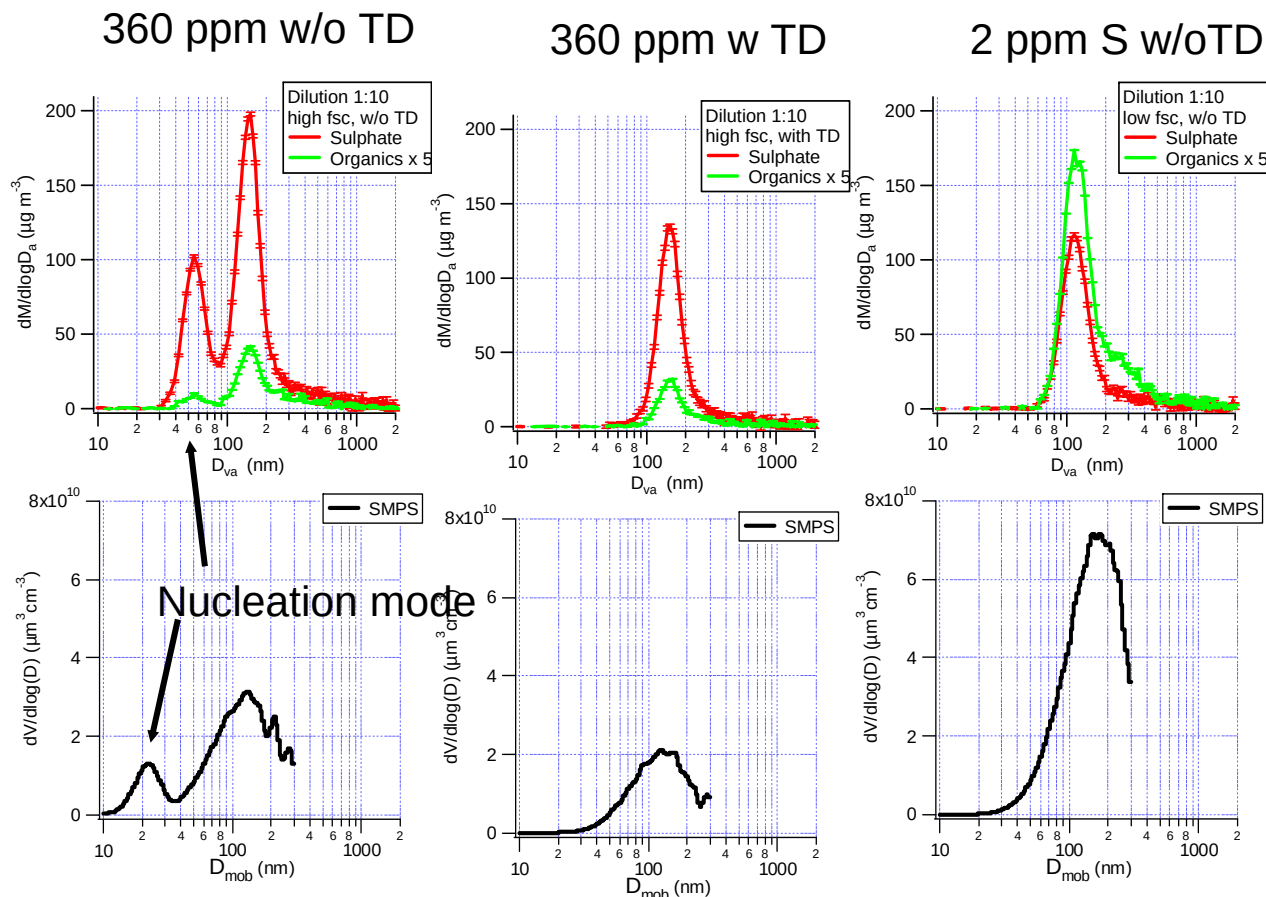


The nucleation particles are composed of semivolatile material.

Nucleation particles composition at 120 km/h

AMS

SMPS



Mainly sulfate, only minor organics

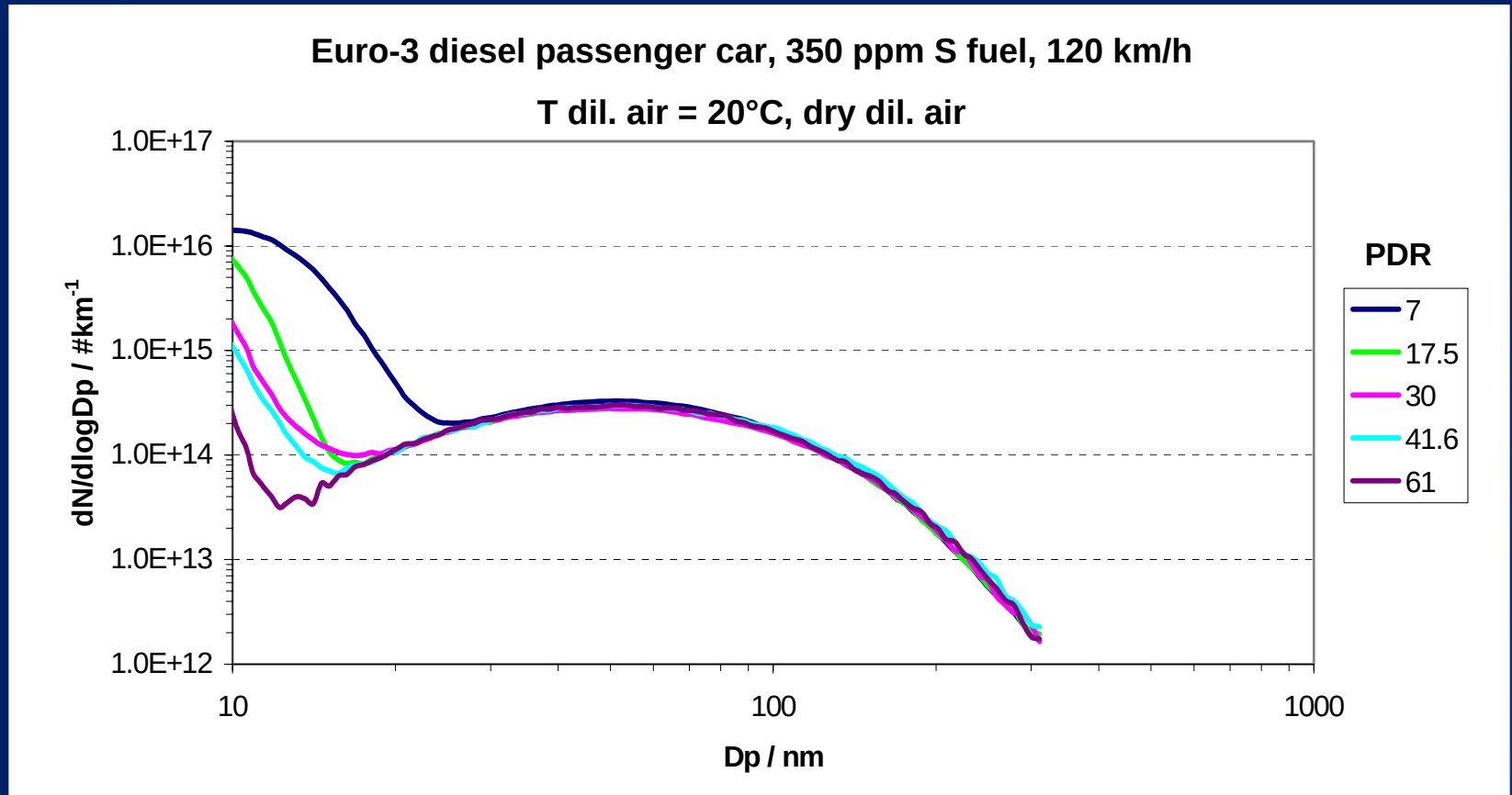
Schneider et al., MPI Mainz/Ford,
submitted ES&T 2004



Research & Advanced Engineering

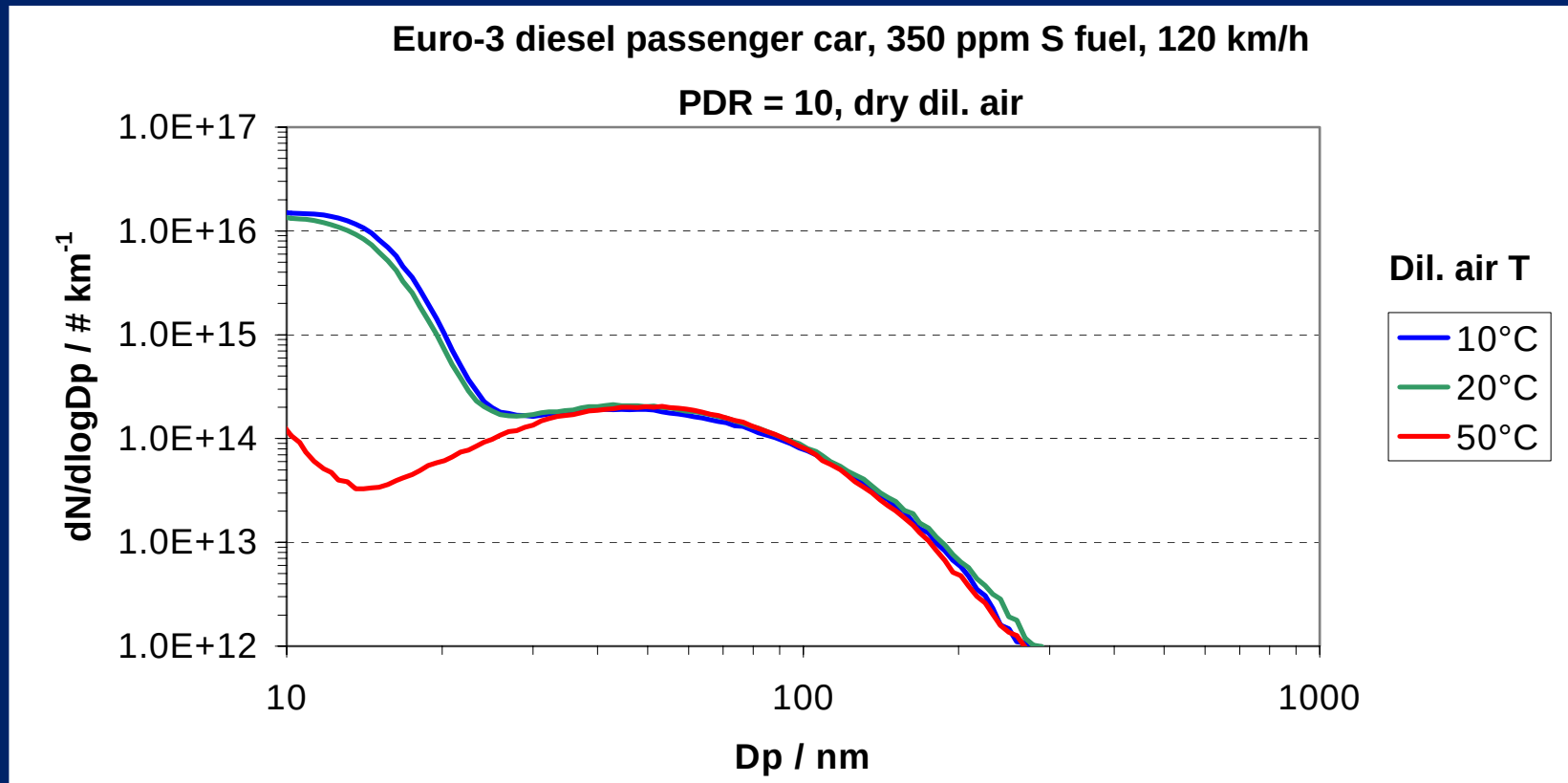


Effect of dilution ratio



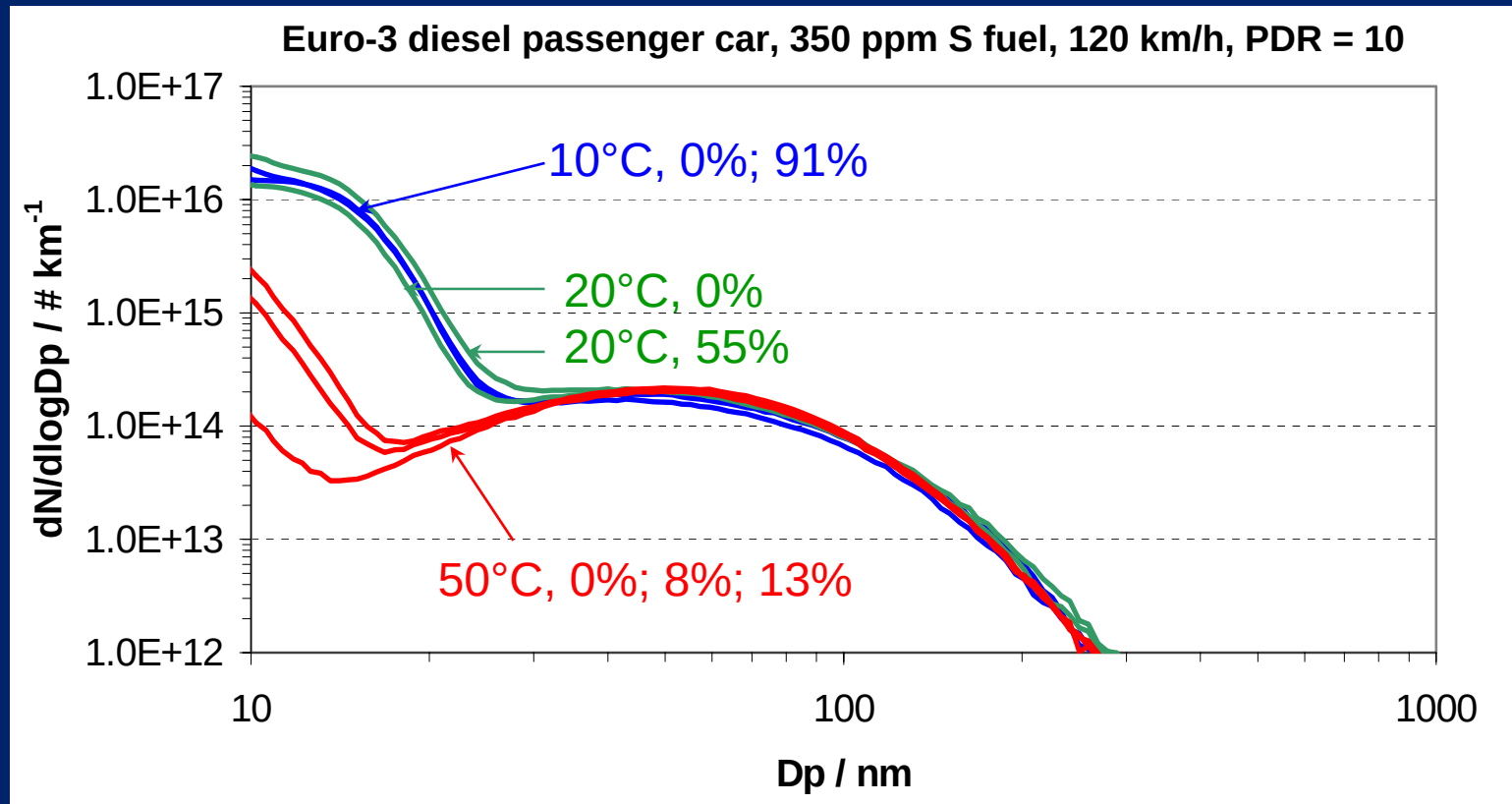
Decrease of primary dilution favours nucleation particles

Effect of dilution air temperature



Decrease of primary dilution temperature favours nucleation particles

Effect of relative humidity



- at 10°C no effect, at 20°C only small effect
- at 50°C: increase of nucleation by increase RH

On-road chasing of exhaust plume



Test vehicle:

Euro-3 Diesel
speed, fuel consumption
exhaust temperatures

Ford Mobile Lab:

SMPS, CPC, NO_x,
CO₂, T and RH

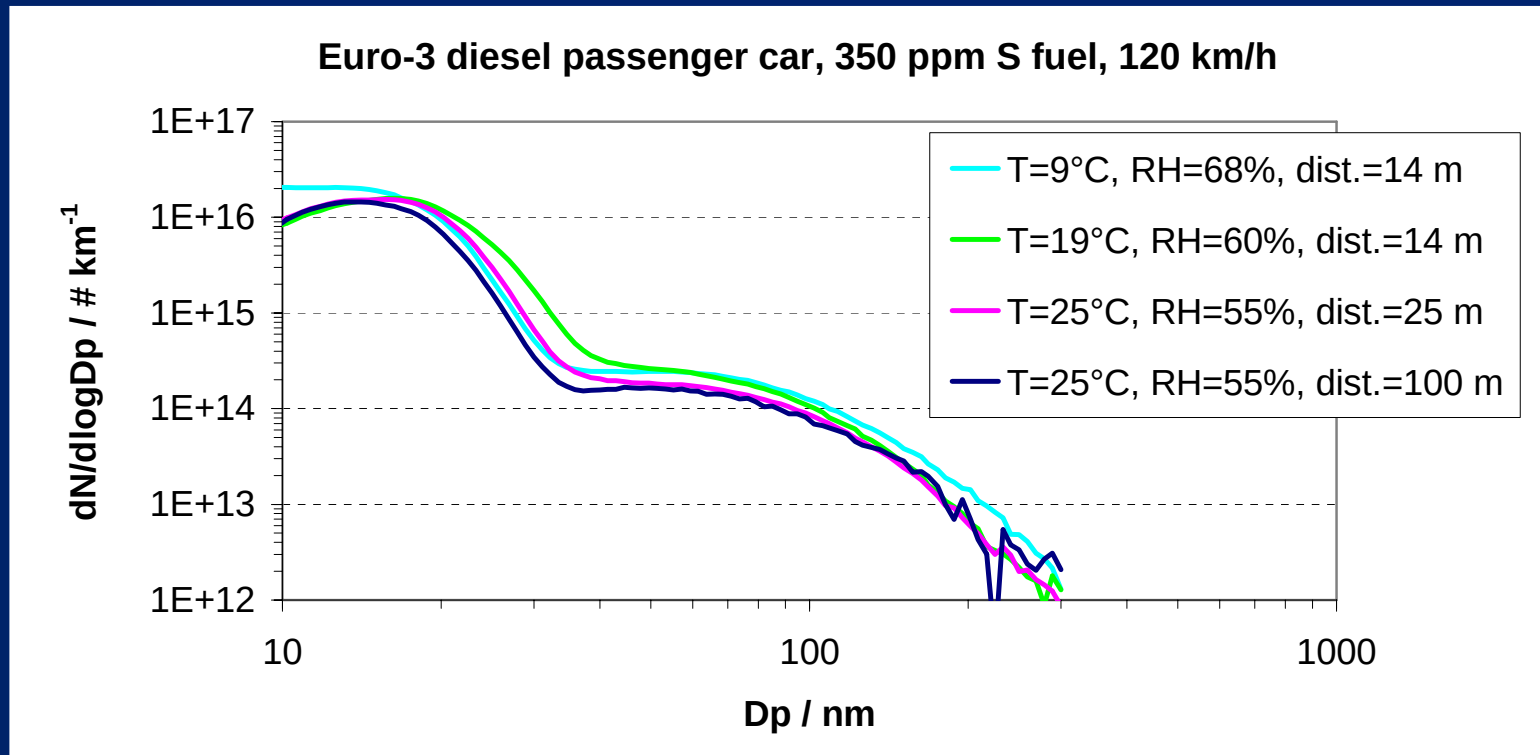
Test track:

high speed oval,
4 km/lap

Distance: 10-100 m

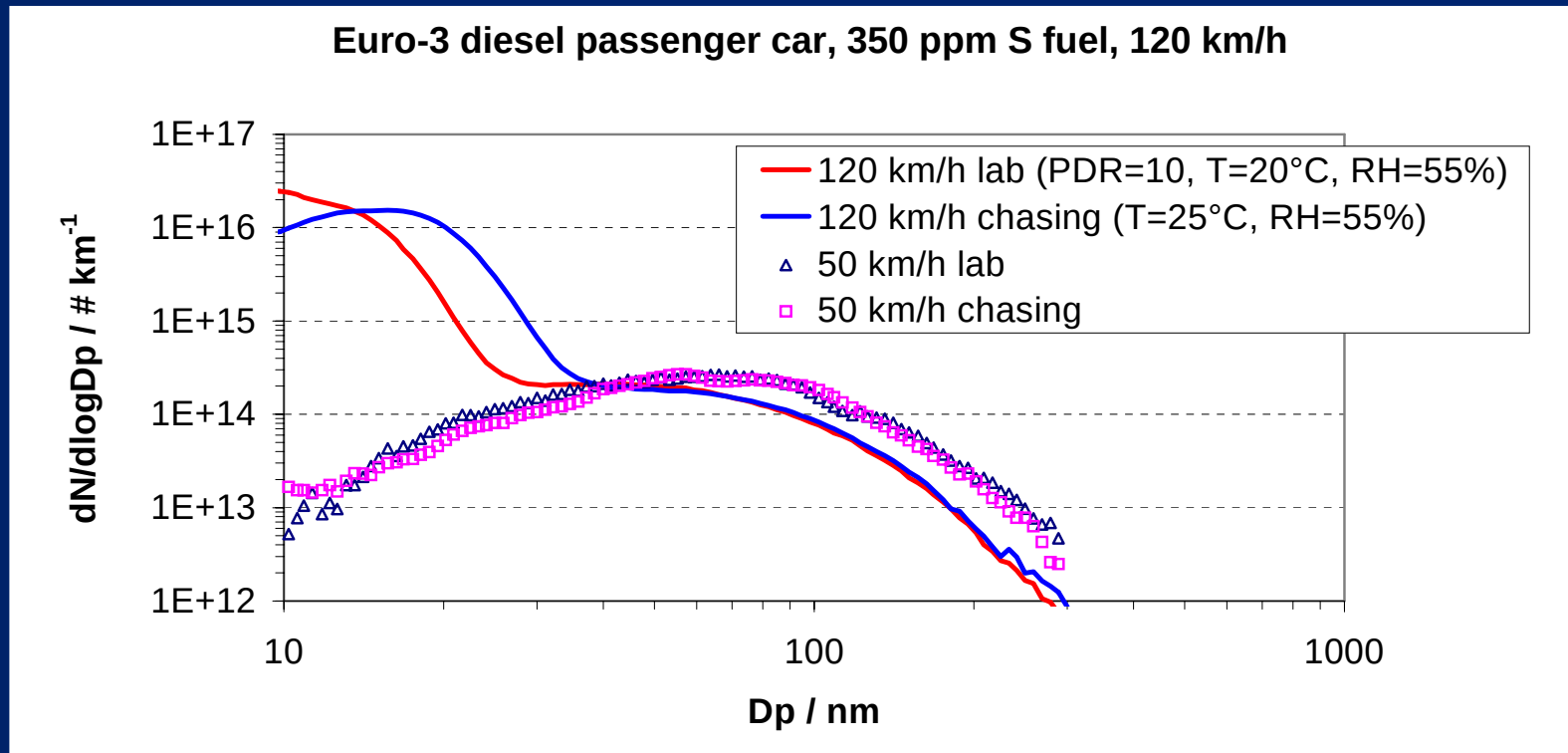


Influence of atmospheric dilution on nucleation



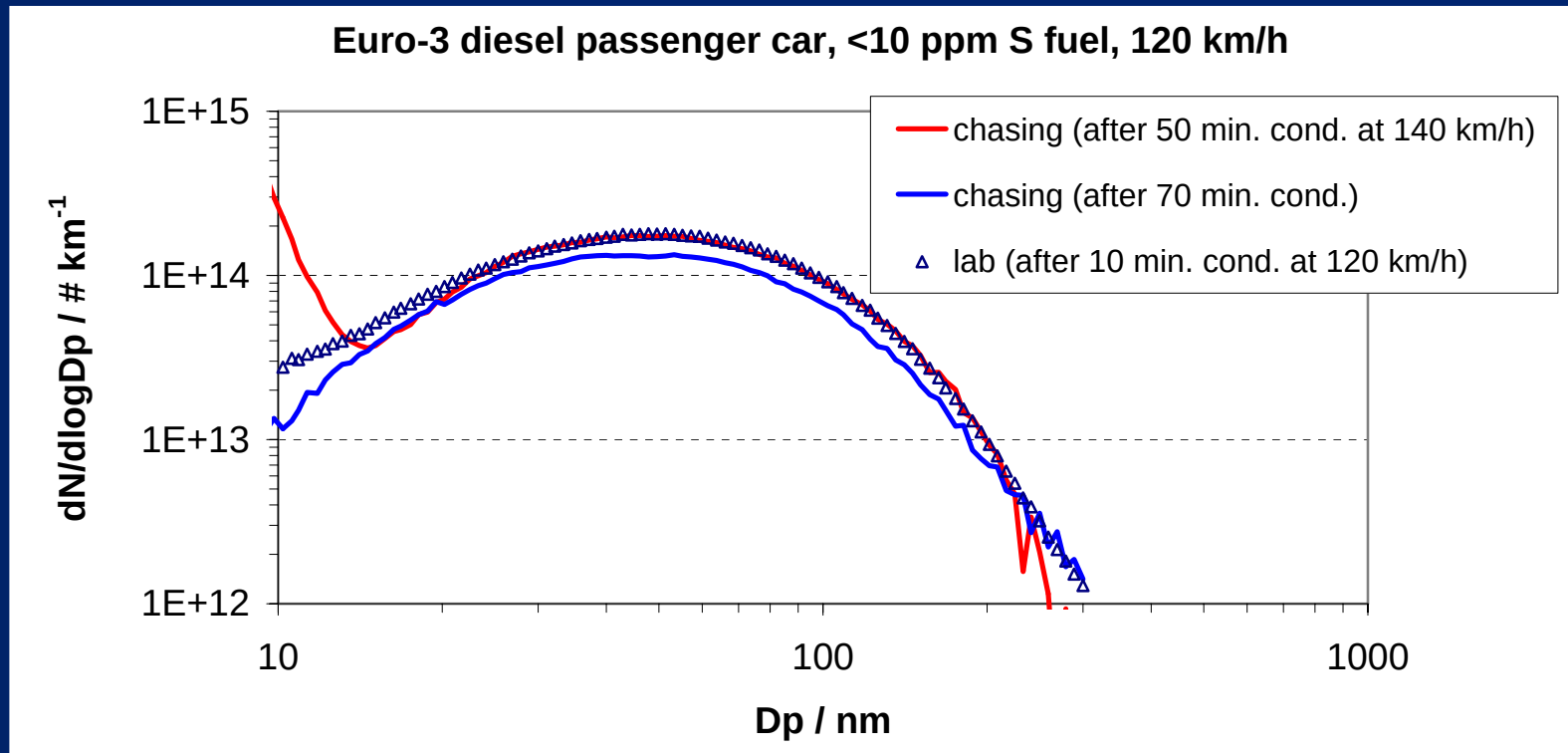
Nucleation mode is insensitive to ambient T and chasing distance.

FFA in-situ laboratory dilution vs. Real world (high S fuel) (1)



- Very good agreement of soot particle mode
- Good agreement of nucleation mode

FFA in-situ laboratory dilution vs. Real world (low S fuel) (2)



- Very good agreement of soot mode
- Small nucleation mode disappears after intensive conditioning

Conclusions

- Comparison of the soot mode region as measured using the new FFA in-situ diluter with data obtained during real world chasing results in very good agreement. The nucleation mode region is qualitatively reproduced.
- There was no temperature effect on the nucleation mode during real world dilution; nucleation was reduced at 50°C laboratory dilution.
- At ambient temperature there was only a minor effect of relative humidity.
- Nucleation is sensitive to engine load and fuel S content. When investigating low S fuel an intensive conditioning of the exhaust system is necessary to avoid artefacts.

