



Influence of Injection Pressure on Particle Size Distribution (PSD) and Number Concentration (N)



Goal

- Public discussion on ultrafines in Diesel exhaust. Accusation: "Low soot mass, but high number of ultrafine particles in exhaust of a modern Diesel engine"

--> Investigation at the Robert Bosch GmbH

Test engine

- 3.0 l, 6 cylinder, direct injection diesel engine with a 1600 bar common rail injection system from Bosch
- Test bench, stationary measurements

Particle size measurement

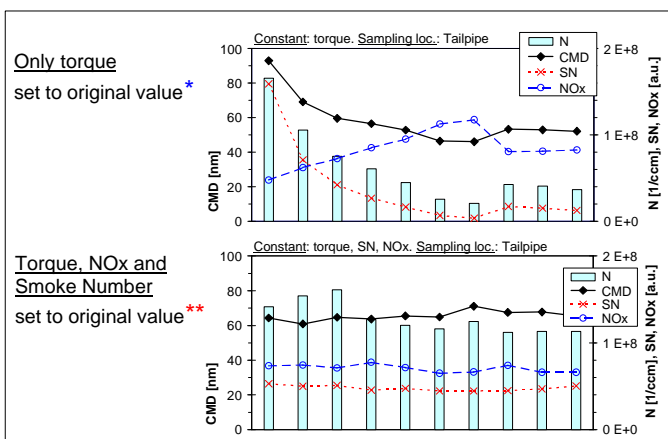
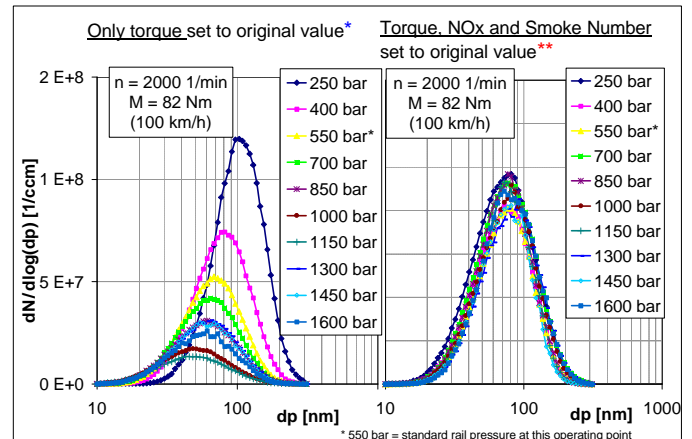
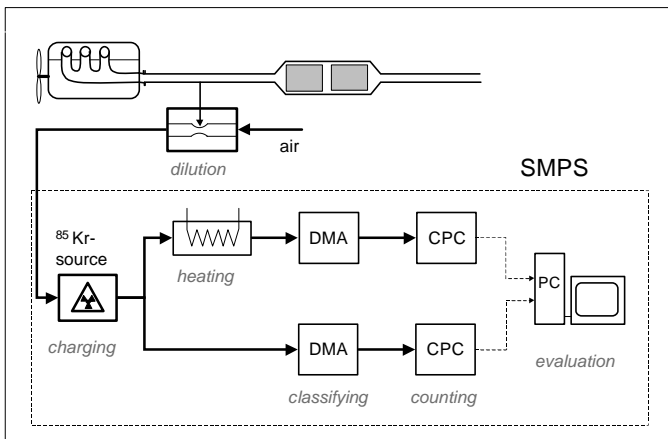
- Dual-path DMPS
- One stage ejector dilution

Question

- Is a simple variation of the injection pressure useful?
- or isn't it more realistic to set other parameters (like the NOx emission) to their original values after changing the rail pressure?

Measurement procedure

- Setting the engine operating point and waiting for stationary conditions. The operating point was chosen to match a vehicle speed of 100 km/h: speed = 2000 1/min; torque = 82 Nm; $Q_{air} = 100 \text{ m}^3/\text{h}$; $p_{rail} = 550 \text{ bar}$ - Measuring the particle size distribution.
- Changing the pressure in the rail. The adaptation of the torque is done automatically by the EDC 16 by changing some parameters, esp. the end of injection. - Measuring the particle size distribution.*
- Changing the EGR rate, until the Bosch Smoke Number (SN) equals the value of the standard setting. Changing the start of injection to set the NOx level to the standard value. - Measuring the particle size distribution.**
- Switching from the sampling probe in the tailpipe position to the one behind the transfer line. - Measuring the particle size distribution.



Results

- If only the torque is kept constant after changing the injection pressure, there is a slight shift to smaller mobility diameters with increasing rail pressures, but at the same time the number concentration is reduced quite significantly.
- These two phenomena are probably coupled by diffusion driven agglomeration.
- If other engine parameters like the NOx emission level are also kept constant, the dependence of the aerosol properties from the injection pressure vanishes.
- With a test procedure of practical relevance, no correlation between particle size and injection pressure of a modern, direct injection diesel engine was identified.**

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→ Particle size measurement

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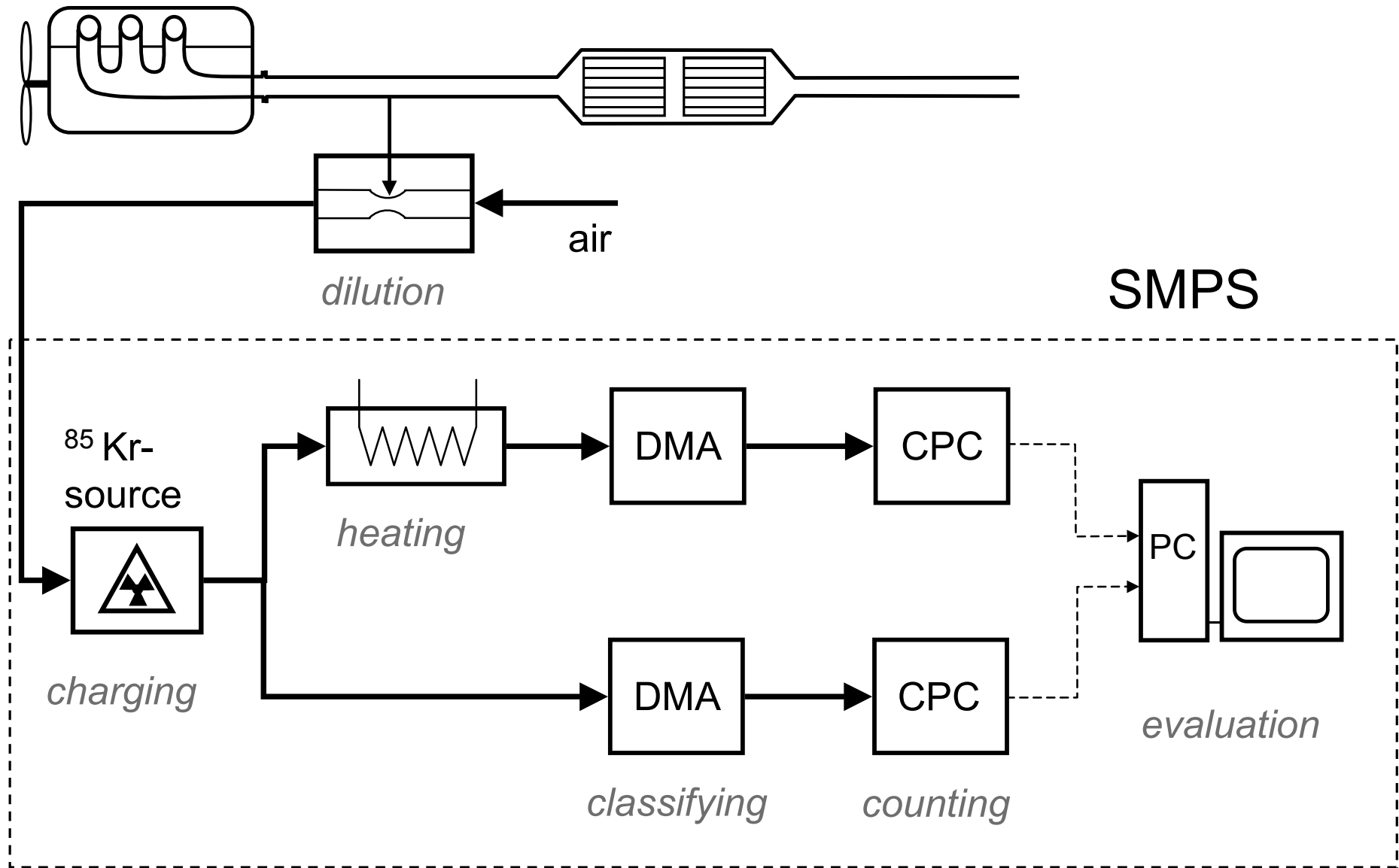
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→ Measurement procedure

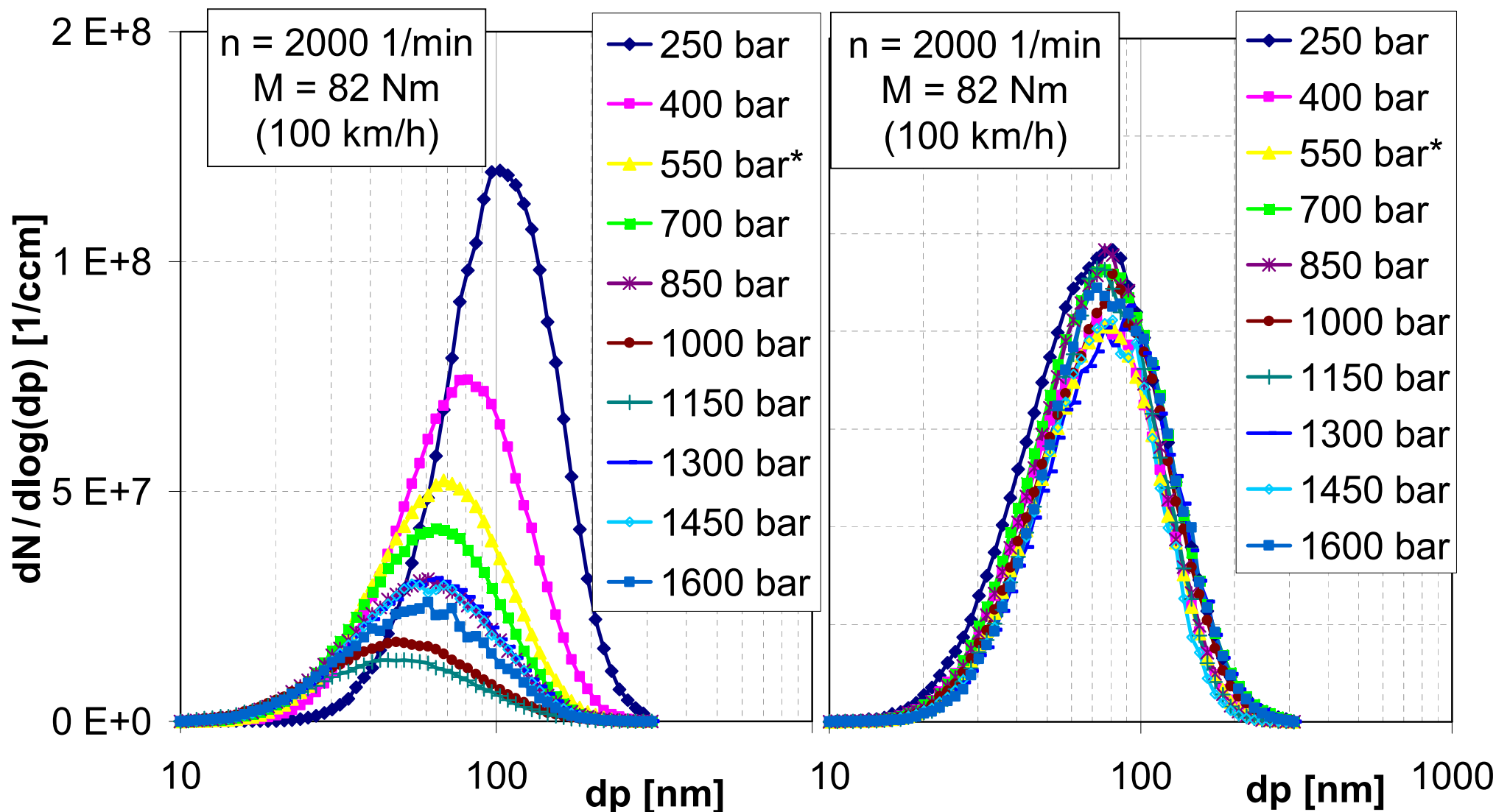
- **1**: Setting the engine operating point and waiting for stationary conditions. The operating point was chosen to match a vehicle speed of 100 km/h: speed = 2000 1/min; torque = 82 Nm; Q_{air} = 100 m³/h; p_{rail} = 550 bar.
- Measuring the particle size distribution.
- **2**: Changing the pressure in the rail. The adaptation of the torque is done automatically by the EDC 16 by changing some parameters, esp. the end of injection.
- Measuring the particle size distribution.*
- **3**: Changing the EGR rate, until the Bosch Smoke Number (SN) equals the value of the standard setting.
Changing the start of injection to set the NO_x level to the standard value.
- Measuring the particle size distribution.**
- **4**: Switching from the sampling probe in the tailpipe position to the one behind the transfer line.
- Measuring the particle size distribution.





Only torque set to original value*

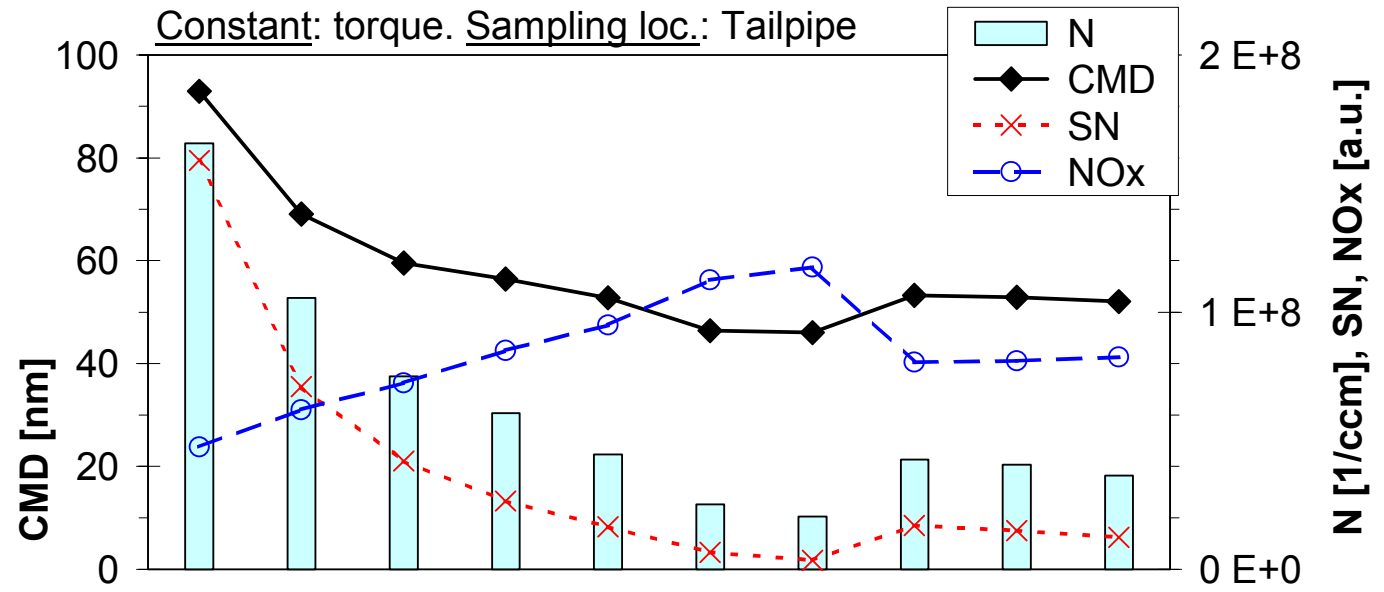
Torque, NOx and Smoke Number set to original value**



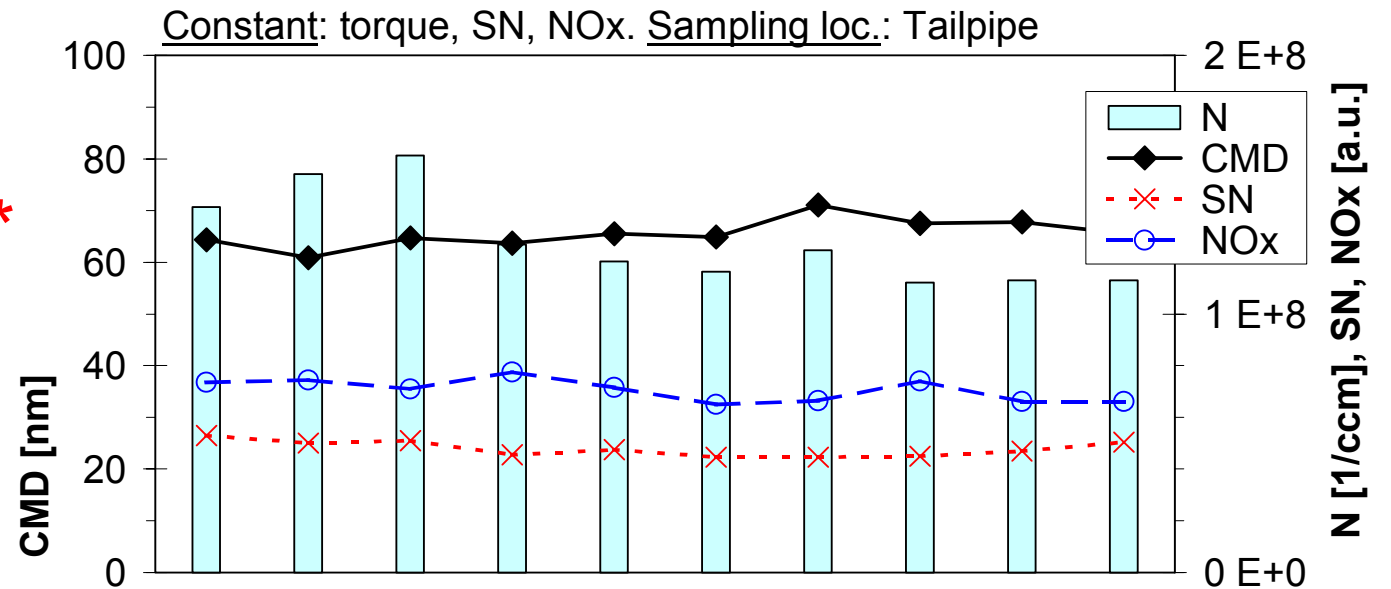
* 550 bar = standard rail pressure at this operating point



Only torque
set to original value*



Torque, NOx and
Smoke Number
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→ Results

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- These two phenomena are probably coupled by diffusion driven agglomeration.
- If other engine parameters like the NOx emission level are also kept constant, the dependence of the aerosol properties from the injection pressure vanishes.
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