Do particle emissions of municipal waste incinerators pose a threat?

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Regulations

Stringent limitations as a political reaction on public concern about adverse health and environmental effects of waste incineration

Consequences: multi-stage, highly efficient, complex flue gas cleaning devices

~ 2/3 of the investment for a waste incineration plant

Limits for hazardous emissions of MSWI plants in Germany

Pollutant	Limit (daily mean, mg/m³) TA Luft (1986)	Limit (daily mean, mg/m³) 17. BImSchV (1990)
Organics (C_{tot})	20	10
CO	100	50
HCl	50	10
HF	2	1
SO_2	100	50
NO_2	500	200
Dust	**30**	**10**

Techniques for reducing particulate emissions

Selection of gas cleaning equipment mainly determined by:

- particle load in the flue-gas flow
- average particle size
- particle-size distribution
- flowrate of flue gas
- flue-gas temperature
- compatibility with other components of the entire FGT system (overall optimisation)
- required emission concentration

Types of devices for flue-gas dust removal

- dry electrostatic precipitator (**dry ESP**)
- wet electrostatic precipitator (**wet ESP**)
- bag house filter (**BF**)

- wet scrubbers (venturi scrubber)
- cyclone or multi-cyclone (pre-deduster)

in several cases (mainly in NL and D) combination of these tools in use,

some recent new plants relying on baghouse filters only

Dust emissions

Normal operation

Dust emission considerably below limit value

Transient operation due to fuel inhomogeneity, during start and shutdown ⇨ increased emission of dust

⇒ real mean dust loads < legal limits

Level of annual averages	Number of plants/lines
> 50 mg/Nm^3	3
> 30 < 50 mg/Nm^3	1
> 10 < 30 mg/Nm^3	8
> 5 < 10 mg/Nm^3	29
< 5 mg/Nm^3	103

Dust emissions survey of European MSWIs, FEAD 2002

Reduction efficiency

Particle reduction measures with high efficiency concerning total particulate mass

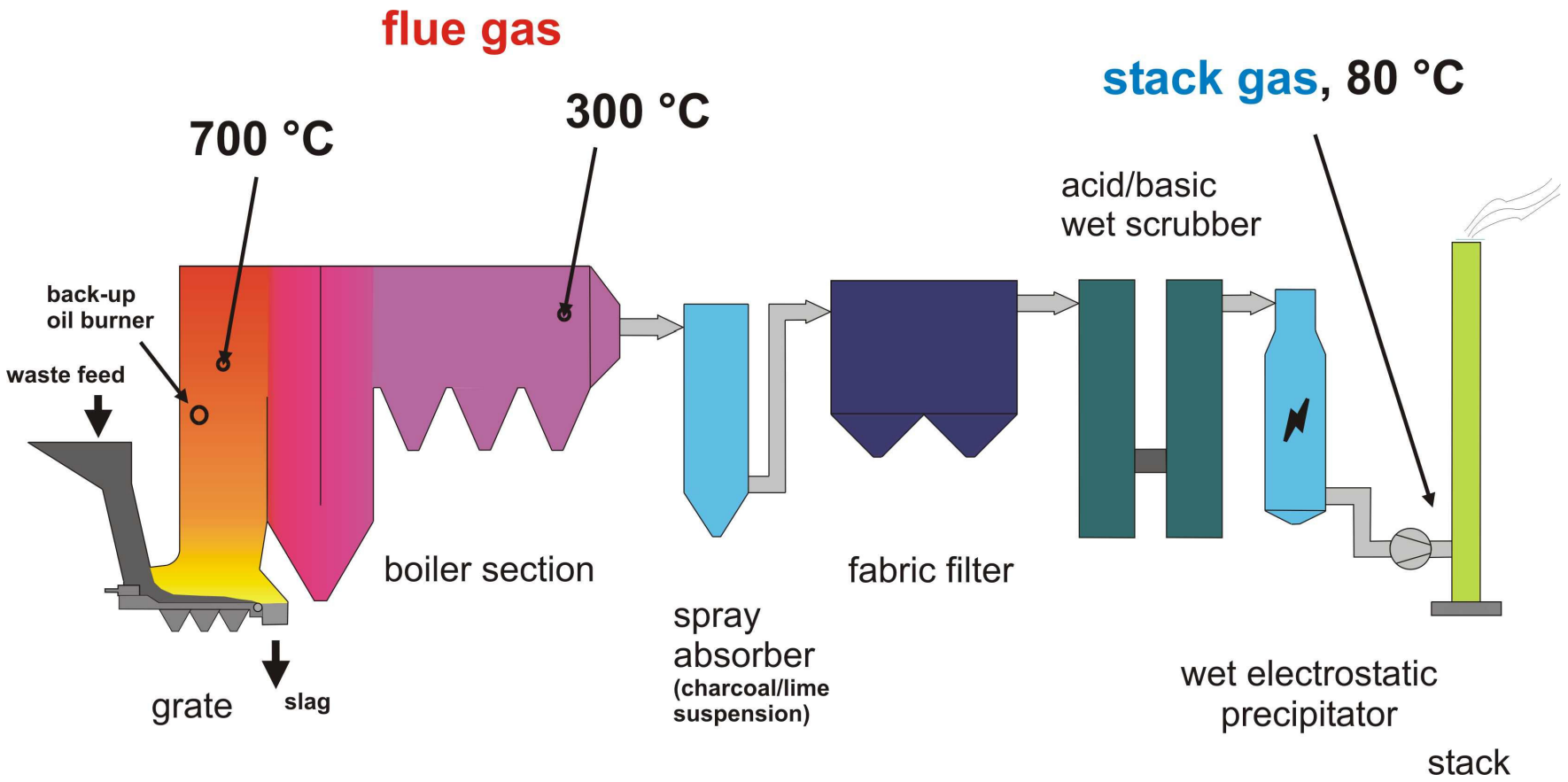
Decreasing collection efficiency at small particle sizes

Problematic size range: < 0.1 … 0.5 µm → **ultrafine particles**, UFP

very low mass contribution – high number concentration

inhalable into the lung ⇨ health effects (respiratory and cardio-vascular diseases)

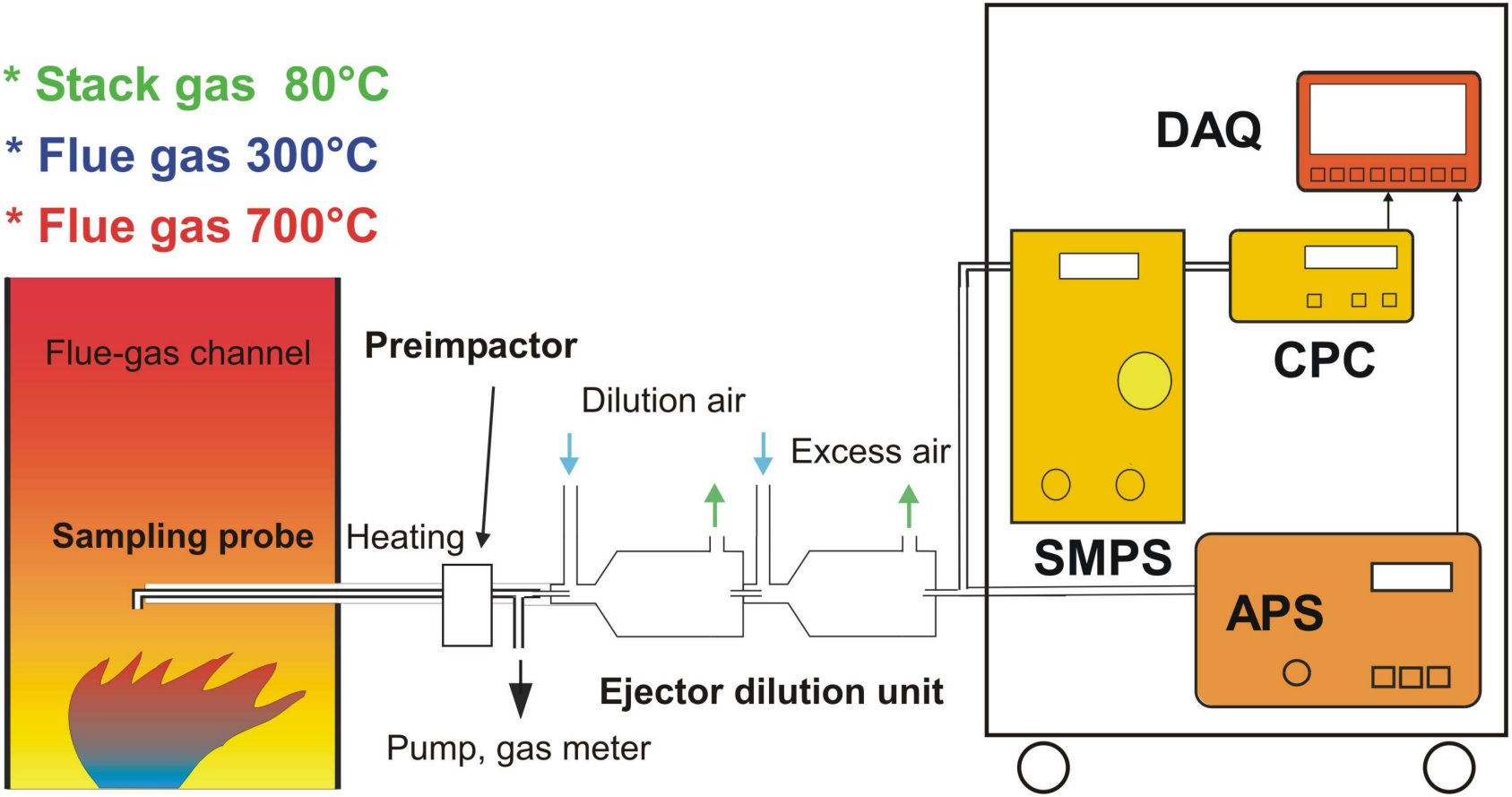
MSWI power plant



2 lines, 7 t/h each, P_{el} = 2 x 5.3 MW, P_{th} = 2 x 18.3 MW, T ~ 1000 °C

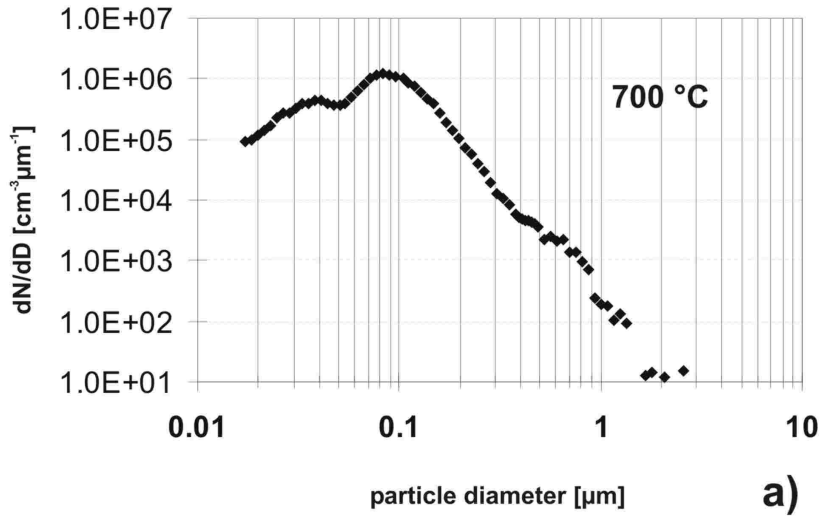
Online particle analysis

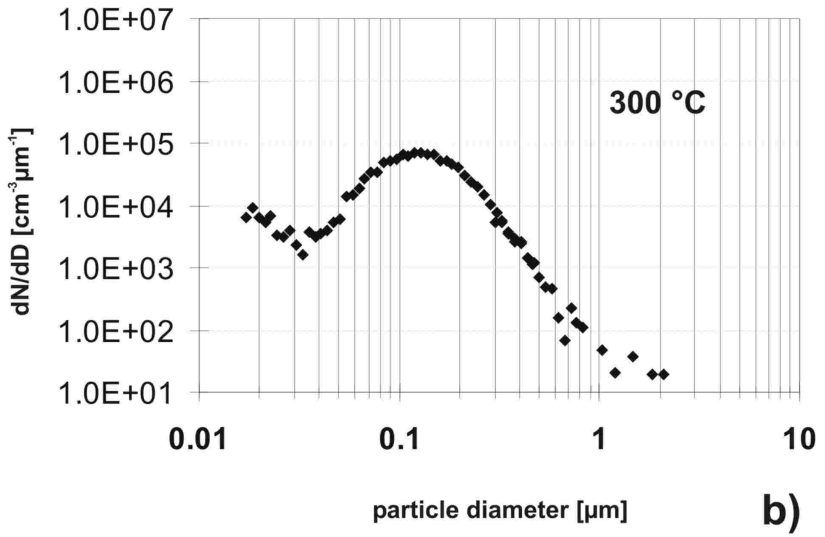
* Stack gas 80°C
* Flue gas 300°C
* Flue gas 700°C



sampling analysis

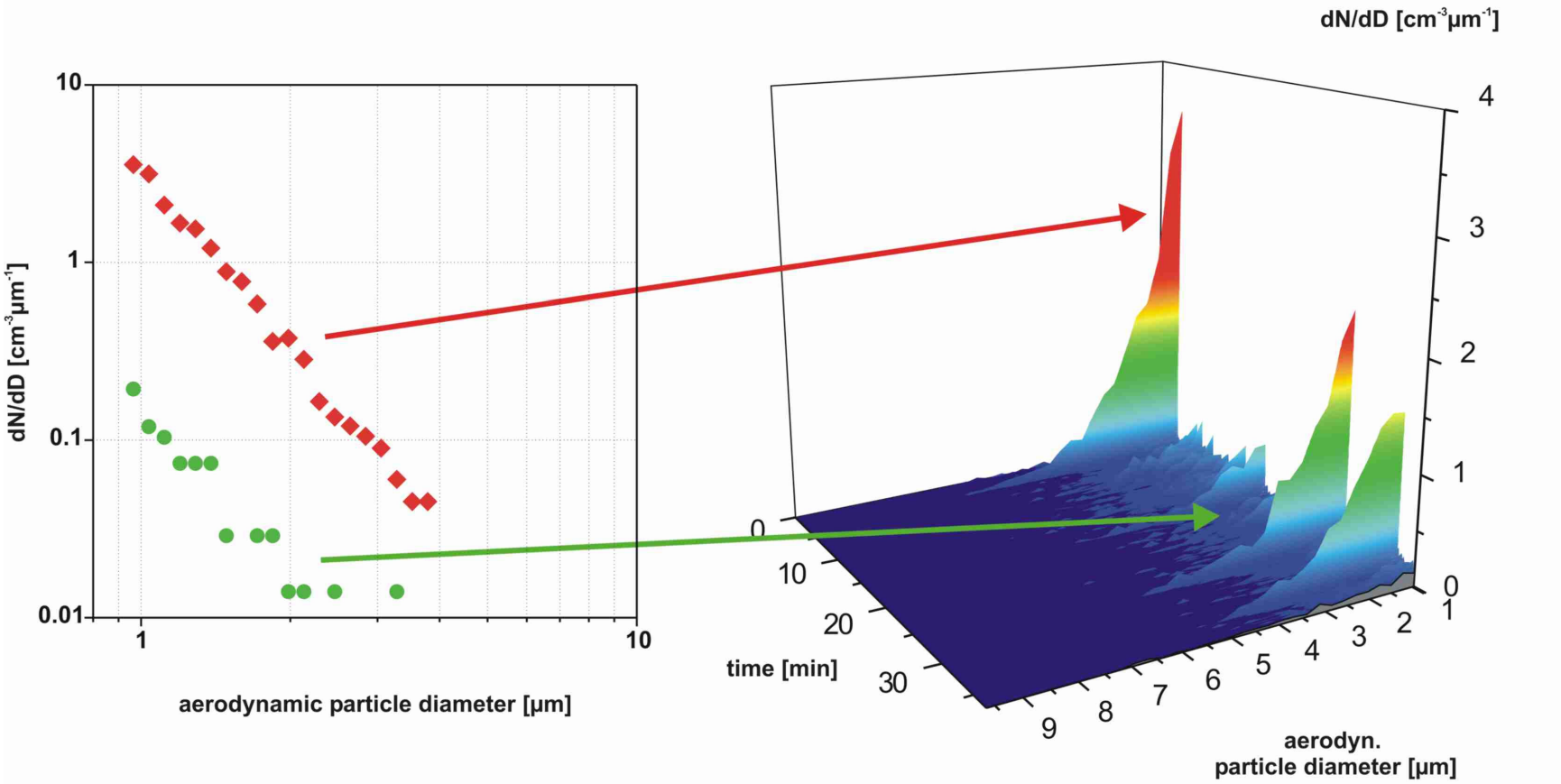
Particle growth



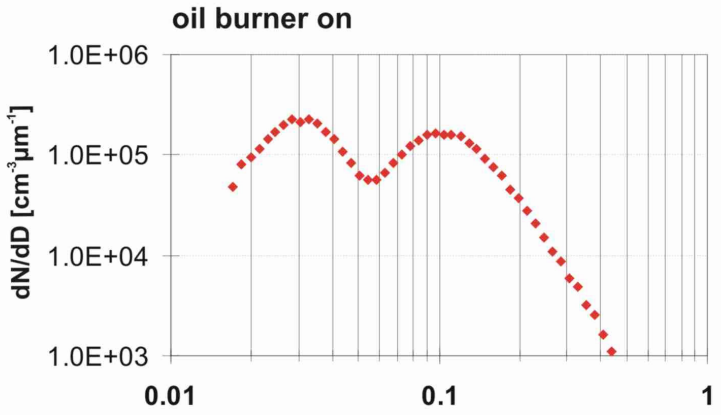


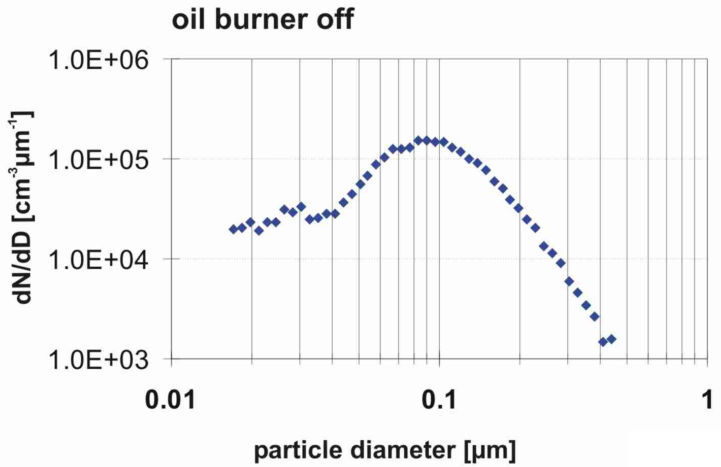
Growth of particles inside the boiler with decreasing flue gas temperature

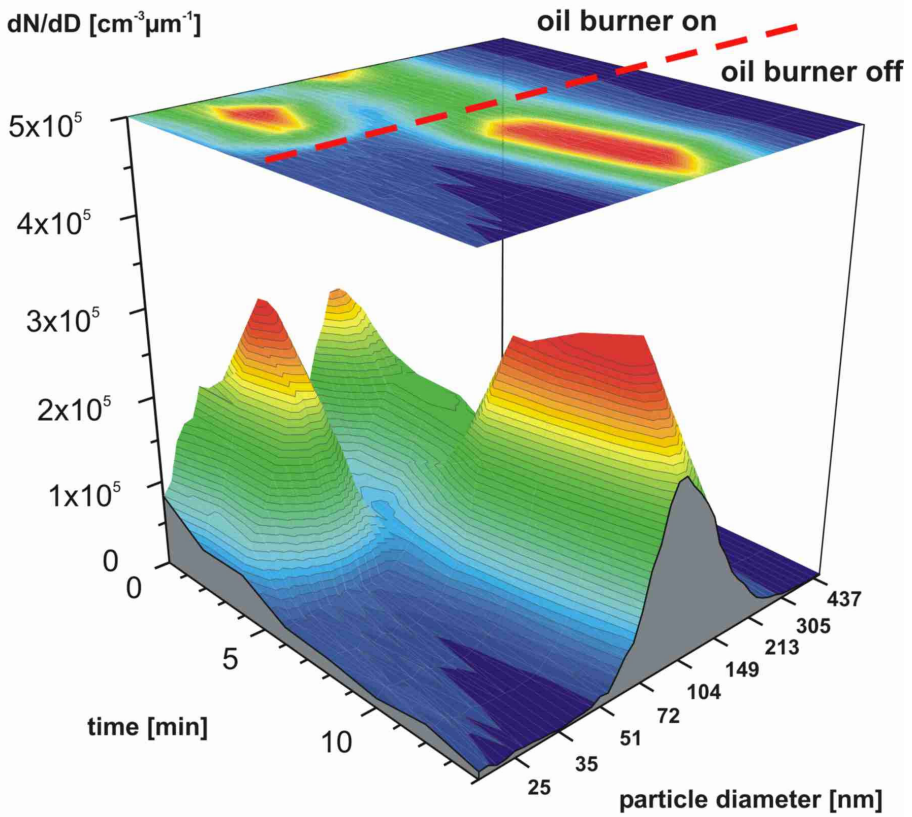
Operation of the grate cleaning flaps



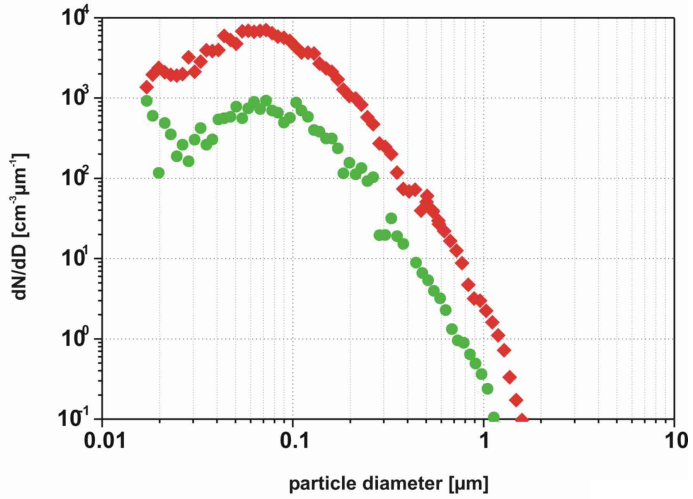
Effect of oil burner operation



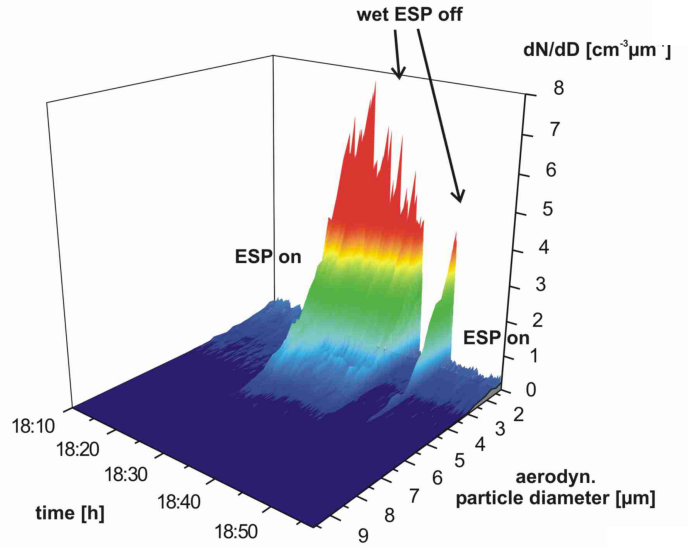




Operation of ESP



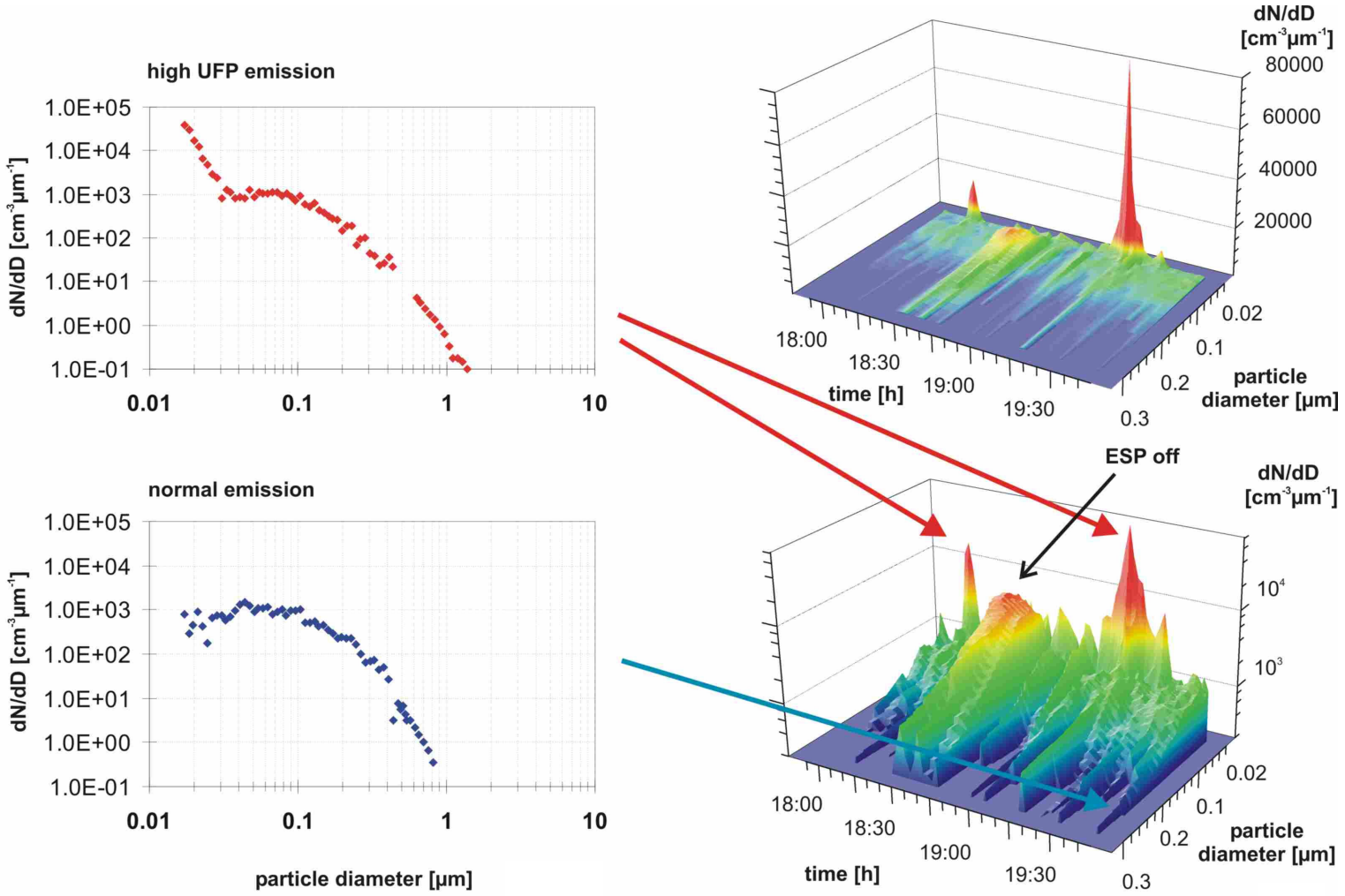
Operation of wet electrostatic precipitator (ESP)



Events of ESP switched off

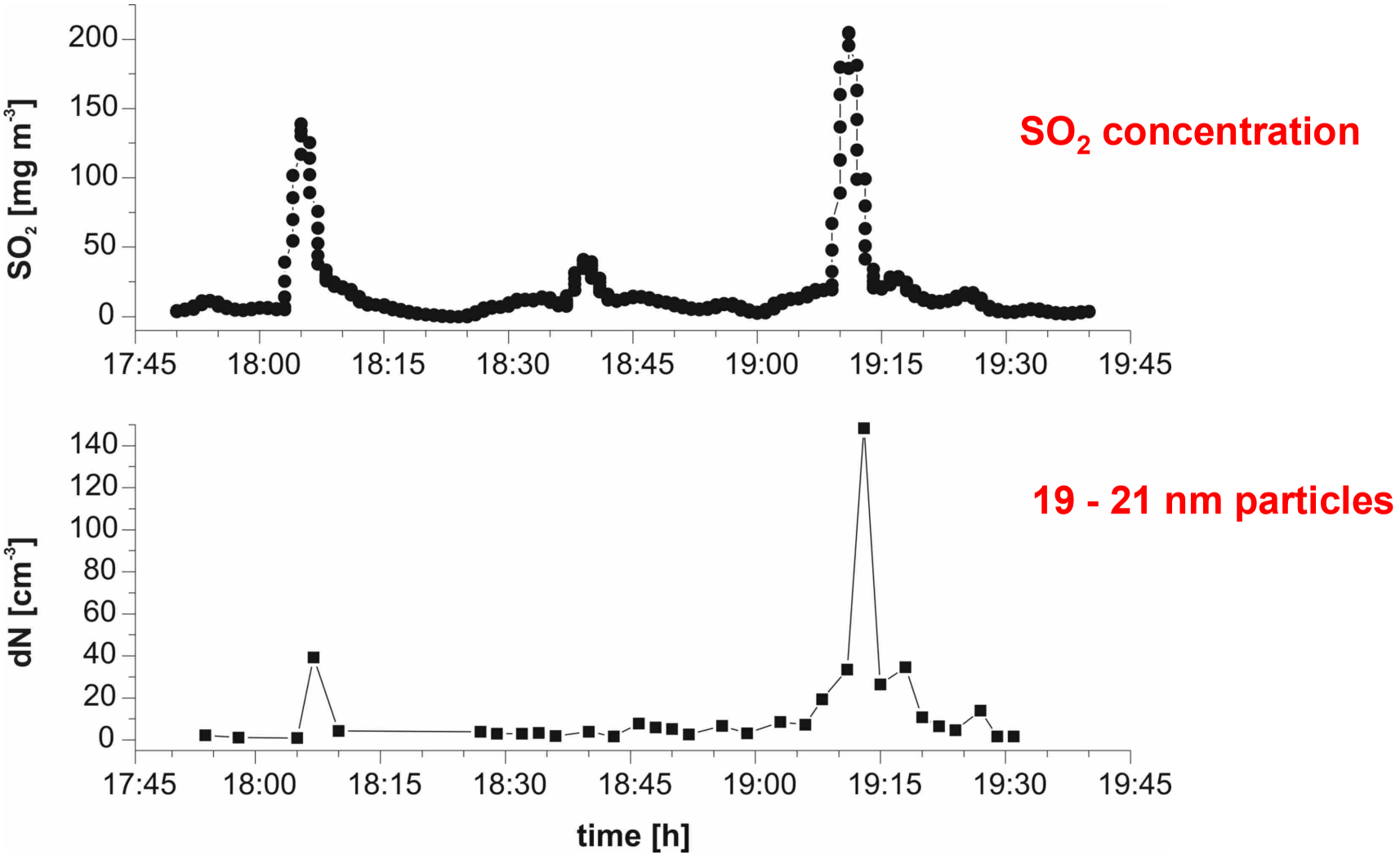
High UFP events I

Episodes of high concentrations of ultrafine particles in the stack gas

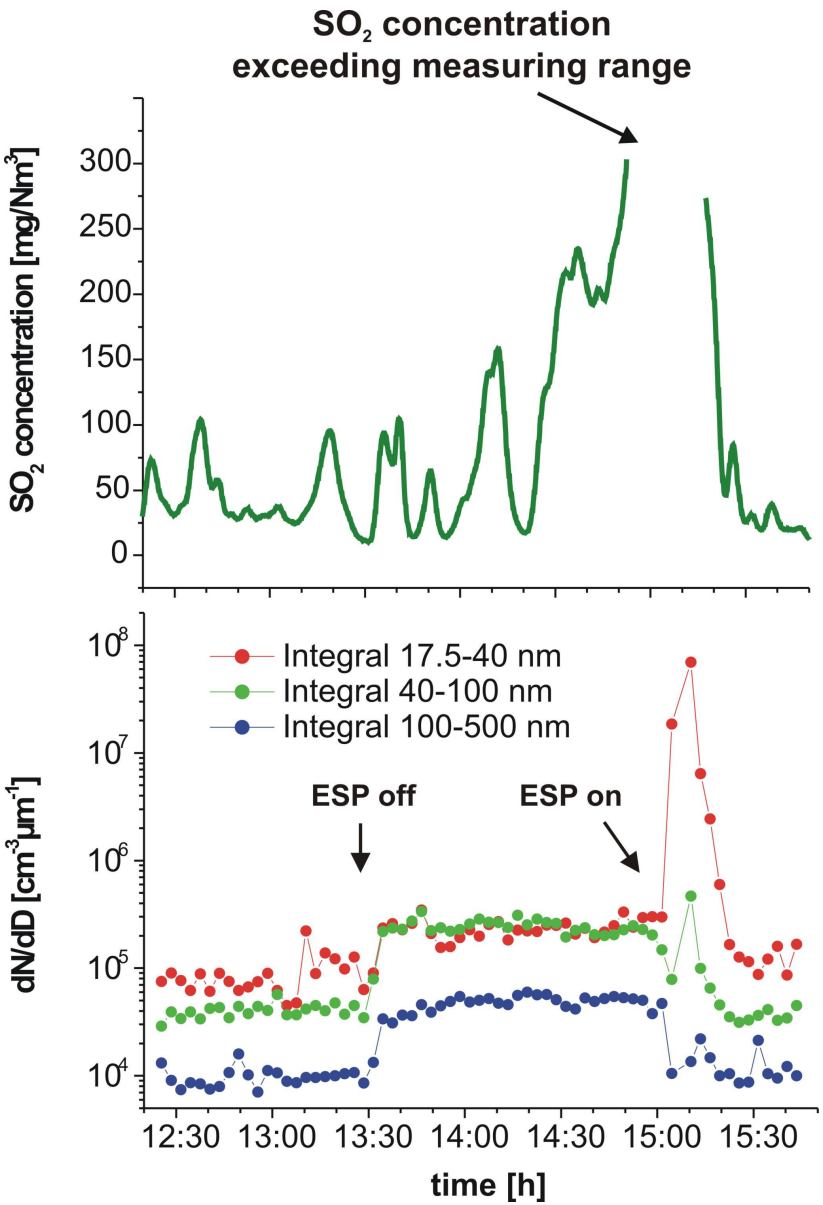


High UFP events II

Correlation of UFP and stack gas SO_2 concentration



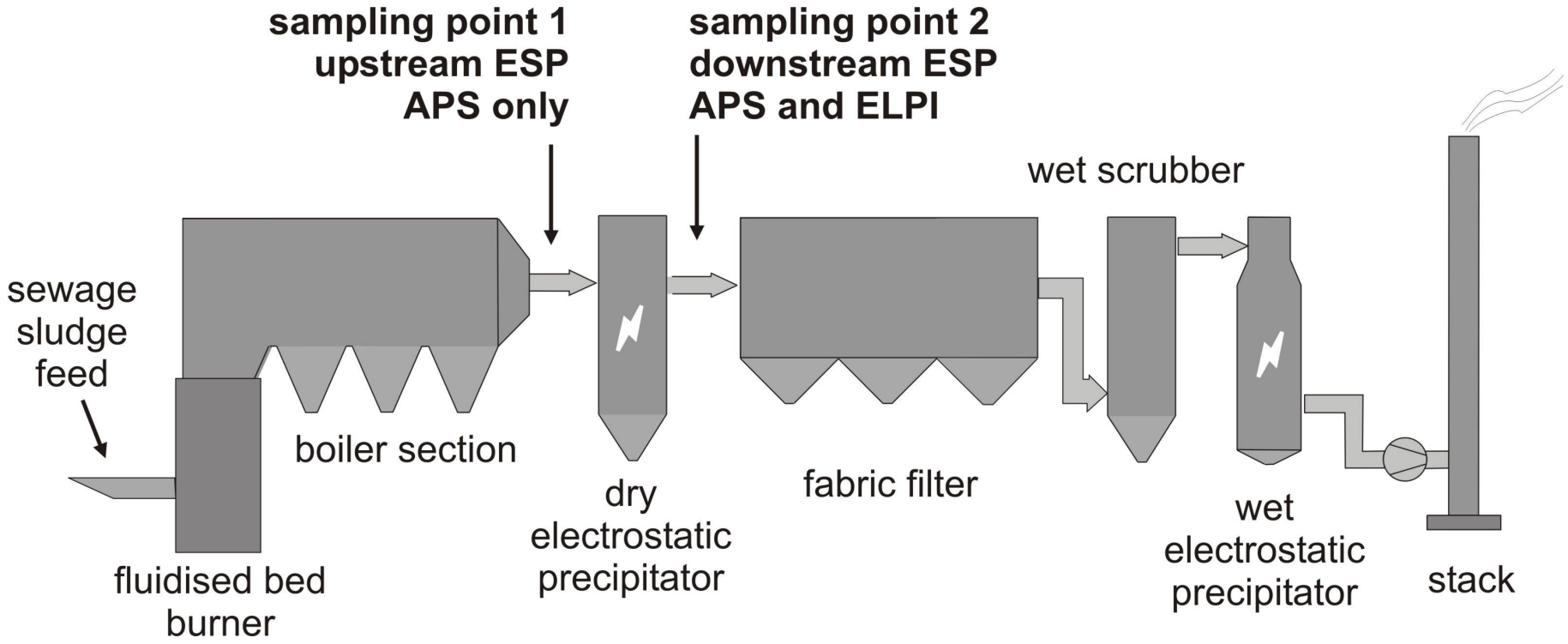
High UFP events III



Effect of ESP operation on UFP formation in the stack at high SO_2 concentration

Formation of new particles by nucleation

Municipal sewage sludge incinerator

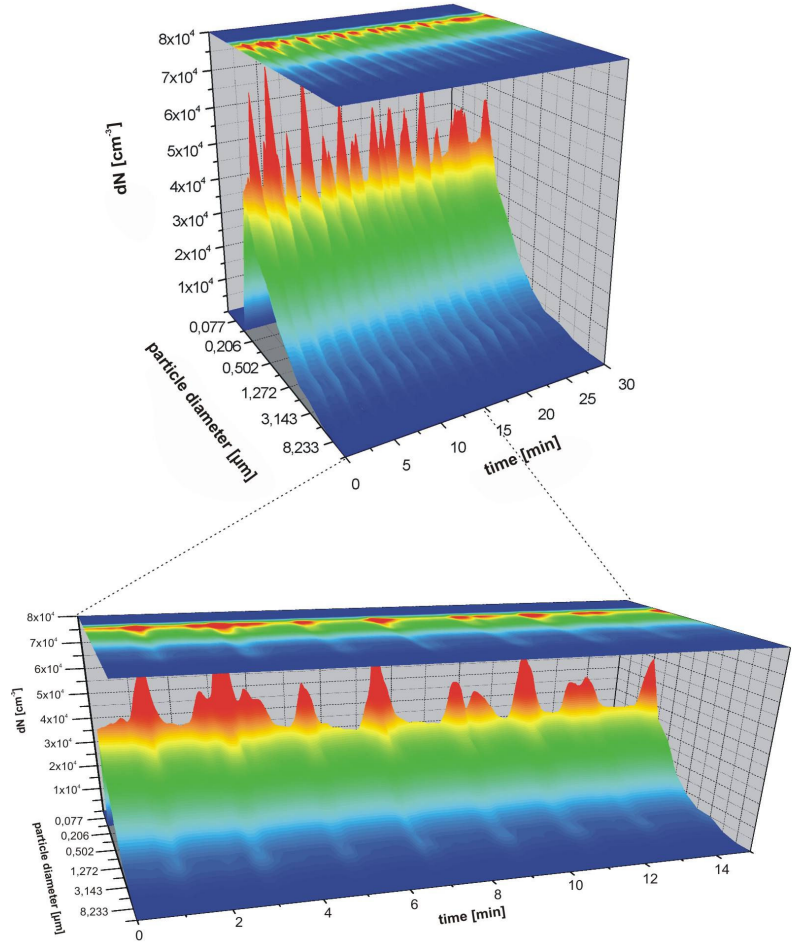


22 000 t/a, T ~ 850 °C

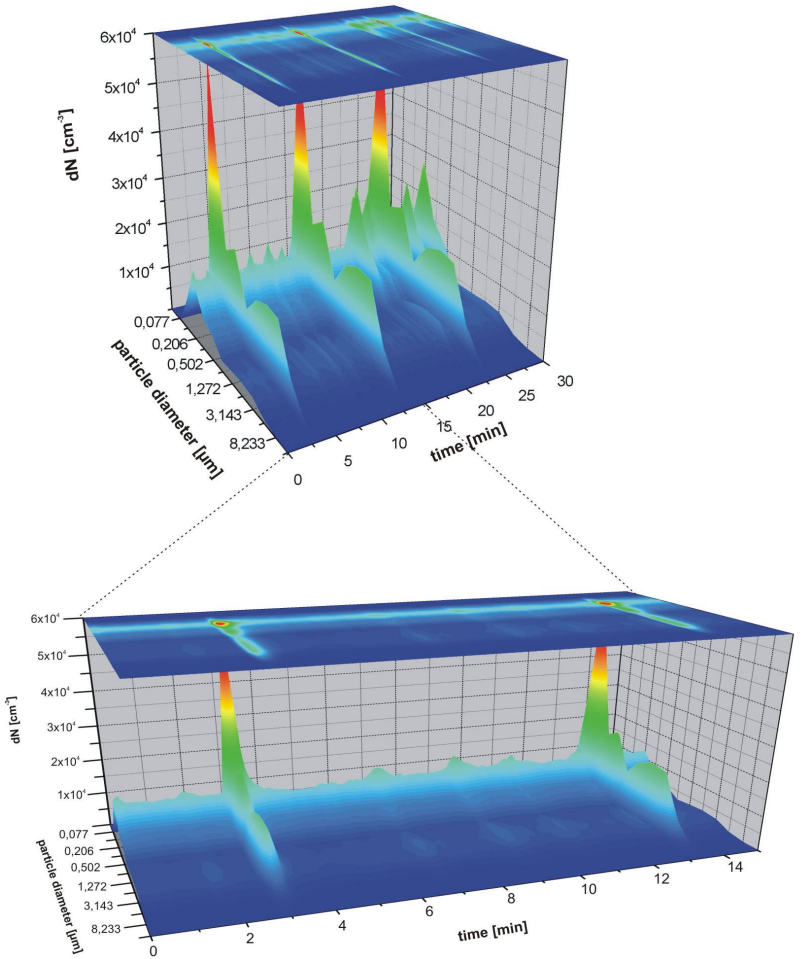
Different rapping cycles

Effect of different rapping cycles on particle size distribution time course downstream ESP

a) short cycle: 10 s rapping / 90 s intermission



b) extendend cycle: 30 s / 10 min



ESP optimization

Optimization of ESP operation

Minimum of collection efficiency between 0.1 and 1 µm

Mass collection efficiency up to > 99 %

Penetration of submicrometer particles > 10 % when calculated in terms of number concentration

Extension of the rapping cycle ⇒ more efficient agglomeration without significant loss of collection efficiency

⇒ lower reentrainment of fine and ultrafine particles

Conclusion

- Highly effective particle retention systems in MSWI plants
- Very high collection efficiency concerning mass concentration

- Decreased collection efficiency for fine and ultrafine particles
- Probably reduced efficiency during transients

⇒ **Need for investigation of collection efficiencies of particle removal devices for fine and ultrafine particles during operation at different operating conditions**

Thank you

Thank you for your attention!