Dekati® High Temperature ELPI+™

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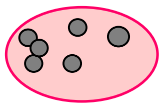
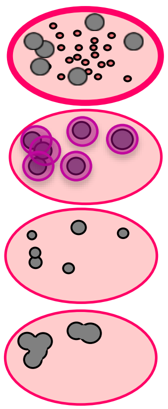
DEKATI

Hot particle sample

Sample conditioning





Sampling dynamics

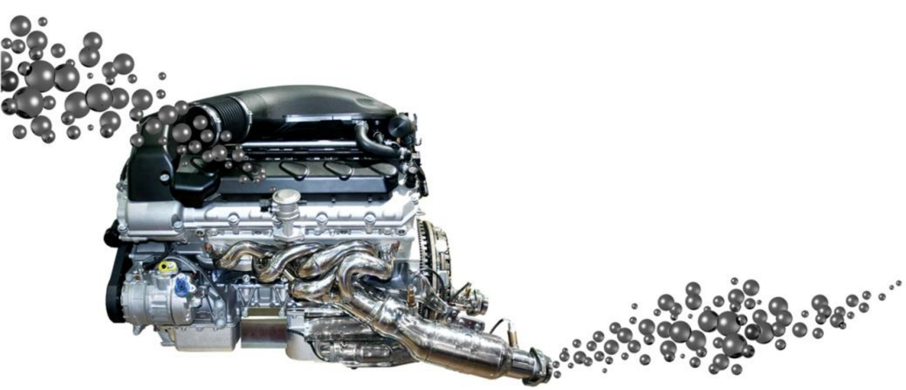
- Nucleation
- Condensation
- Evaporation
- Coagulation

Effect of dilution parameters

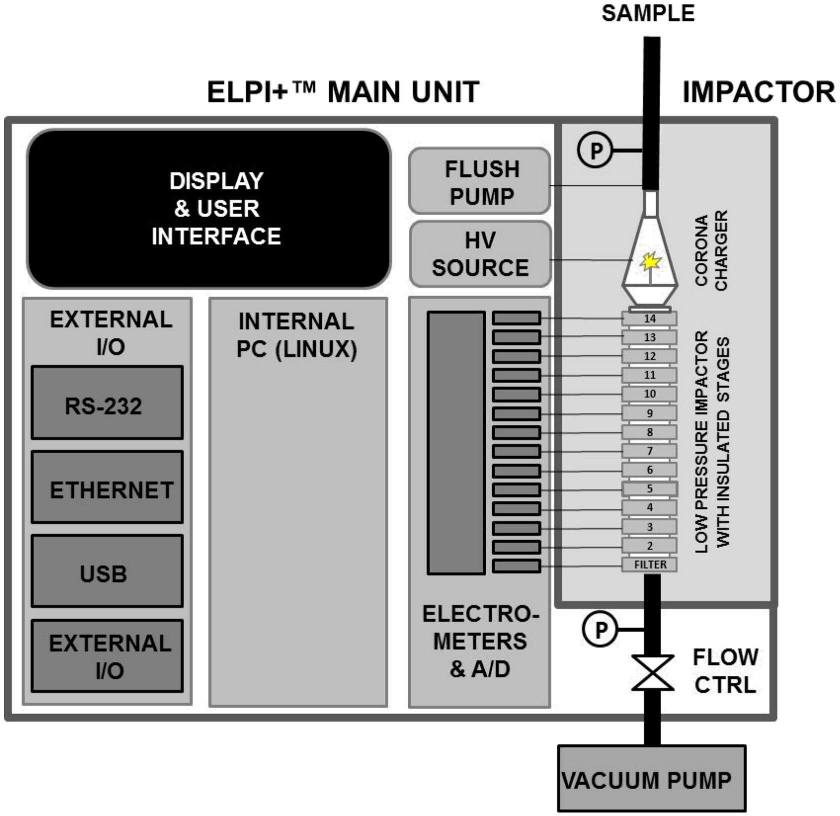
- Temperature
- Residence time
- Humidity
- Dilution ratio

Particle Losses

- Inertial
- Gravitational
- Turbulent
- Diffusion
- Thermophoretic
- Electrophoretic

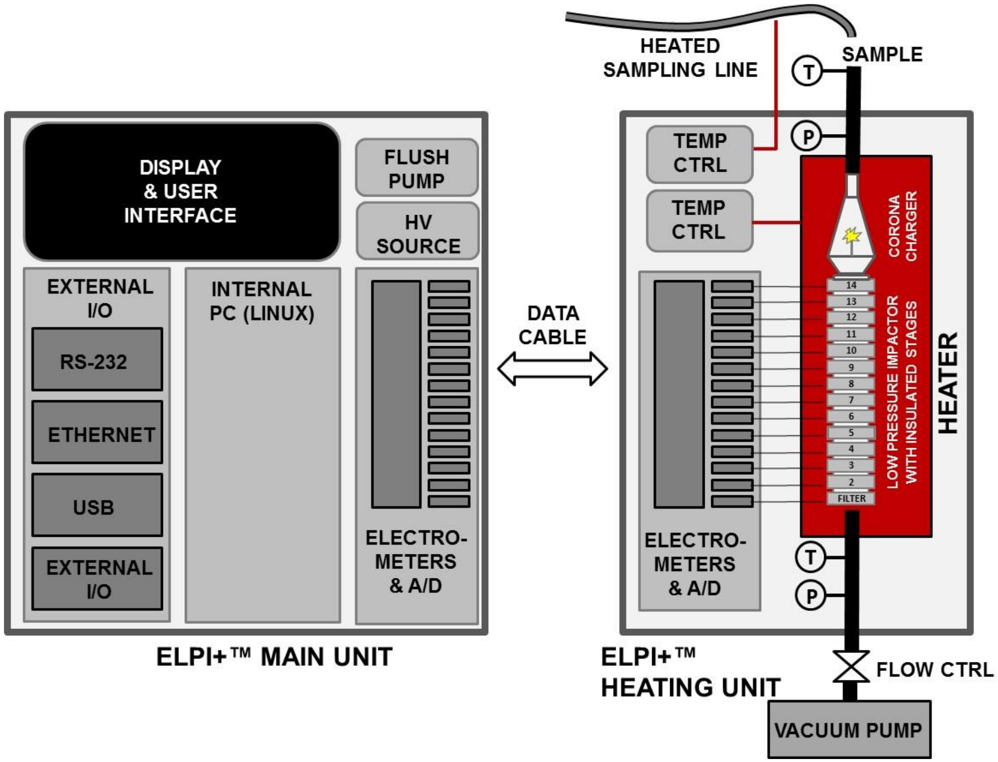


ELPI+™



- Real-time particle size distribution
- 6 nm – 10 µm
- Operation
  - Charger: particle charging
  - Impactor: particle size classification
  - Electrometers: electrical detection of charged particles

High Temperature ELPI+™



- Same operating principle as ELPI+™
- Charger+Impactor moved to external heating unit, max 180 °C
- Allows hot aerosol size and charge distribution measurement in real-time

High Temperature ELPI+™

- 6 nm – 10 µm
- 10 lpm
- 10/1 Hz
- Max 180 ºC !
- Heater power 500 W
- Max. 1000/500 W for External heater (230V/110V)
- Temperature measurements
  - Sample inlet
  - Impactor outlet
  - Heater
- Pre-set calibration values 60, 120 and 180 °C
  - Calculation sheet provided for other temperatures

HT-ELPI+™ Collection Foils

- Aluminium foils
- Greased aluminium foils, max 100 °C
- Apiezon-L grease, max 100 °C
  - Same for Dekati® Collection Substrate Spray
- Apiezon-H grease, max 200 °C
- Polycarbonate collection foils, max 140 °C
- HT-ELPI+™ not yet compatible with sintered collection plates

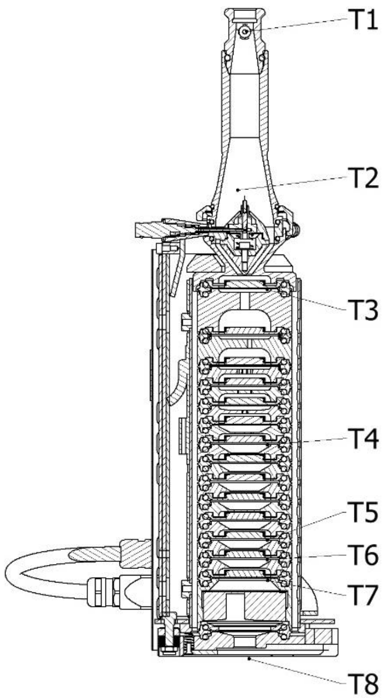
Effect of Temperature on ELPI+™ Calibration

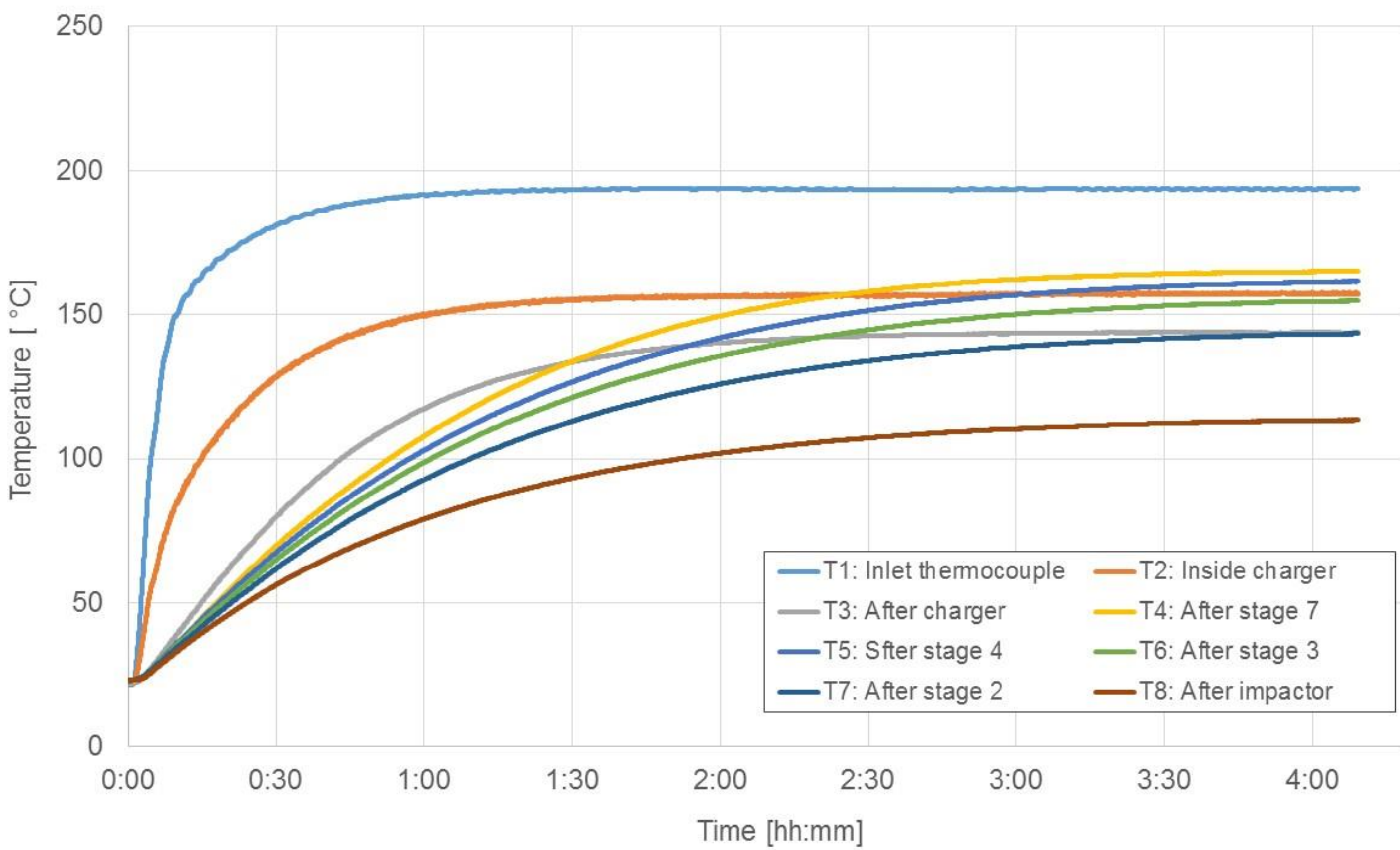
- Impactor cutpoint calculation is based on pressure measurement and known (calibrated) Stokes numbers
  - Järvinen, A., Aitomaa, M., Rostedt, A., Keskinen, J. & Yli-Ojanperä, J. 2014. Calibration of the new electrical low pressure impactor (ELPI+). 2014 J. Aerosol Sci. 69, pp. 150-159.
  - Hillamo, R. E., & Kauppinen, E. I. (1991). On the performance of the Berner low pressure impactor. Aerosol Science and Technology, 14(1), 33-47.
- Temperature changes gas flow rate, jet velocity in the impactor nozzles, gas viscosity and mean free path
- Charger efficiency assumed to remain constant

	21 °C	100 °C	180 °C
Stage	D50, µm	D50, µm	D50, µm
2	0.016	0.013	0.011
3	0.028	0.024	0.022
4	0.056	0.044	0.037
5	0.094	0.080	0.068
6	0.155	0.138	0.123
7	0.262	0.242	0.224
8	0.382	0.371	0.355
9	0.613	0.599	0.587
10	0.948	0.955	0.950
11	1.60	1.66	1.67
12	2.39	2.53	2.55
13	3.99	3.75	3.80
14	6.68	5.52	5.60
15	9.91	10.18	10.37

	21 °C	100 °C	180 °C
Flow [lpm]	9.92	11.17	12.31

Impactor internal temperatures during heating

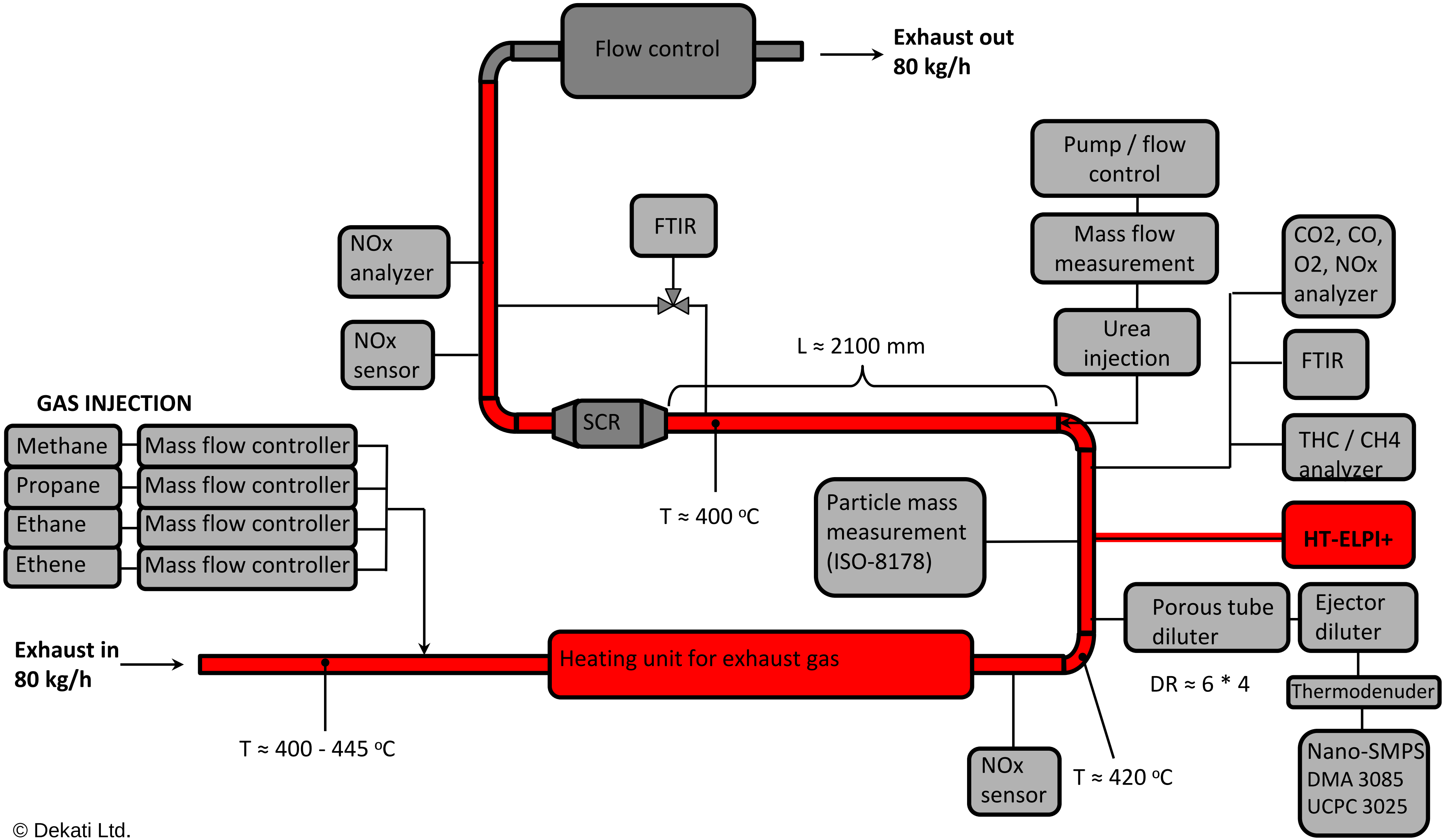




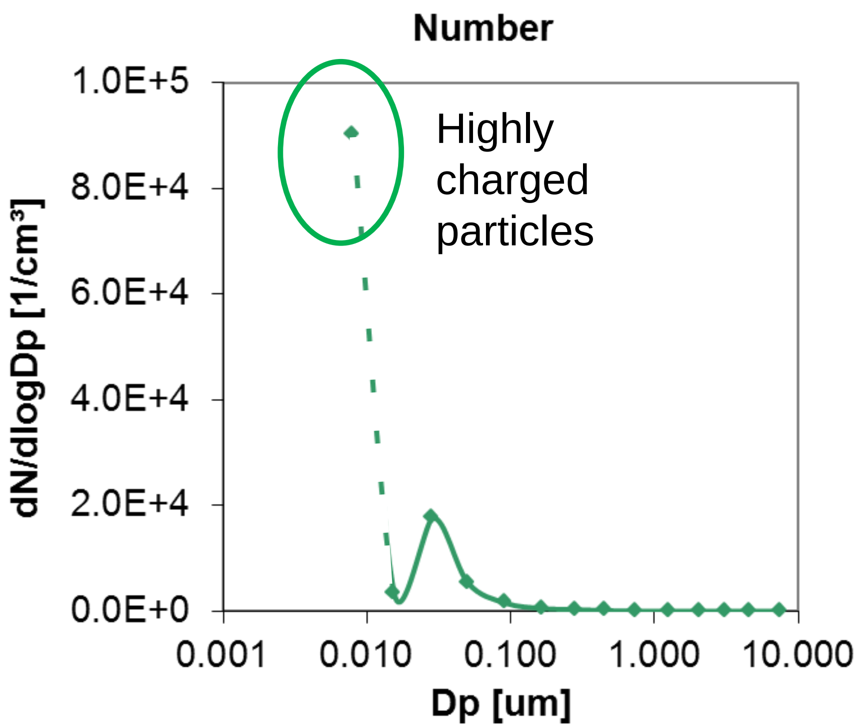
Test engine

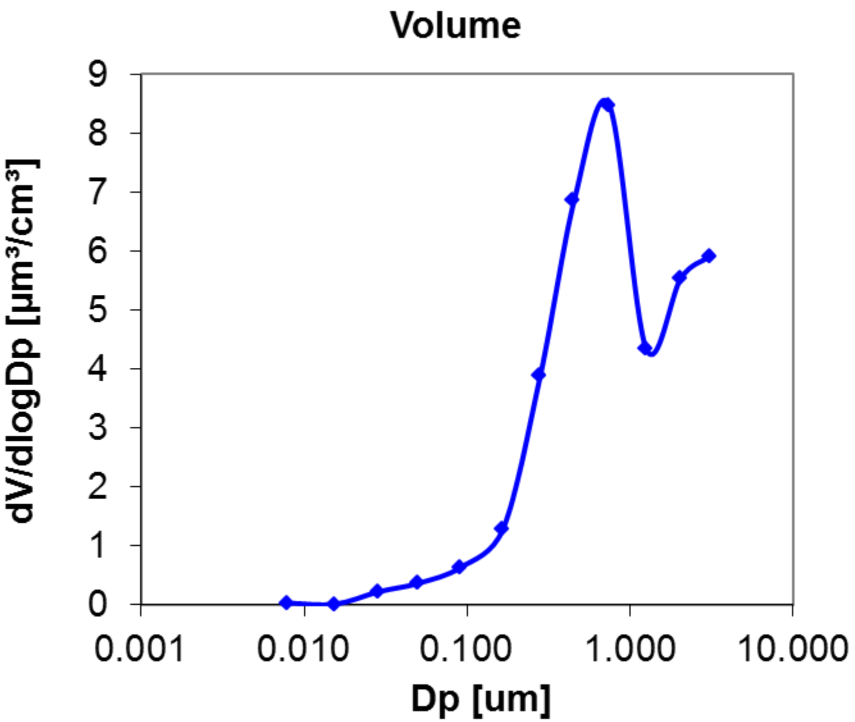
- MY 1999, 2 liter MB W124 Gasoline engine, converted for natural gas use, VTT engine dynamometer
- Exhaust gas synthesizer to mimic large bore natural gas engine exhaust composition
- Tests at 11-22 kW

Natural gas engine test bench



HT-ELPI+™ results: size distribution



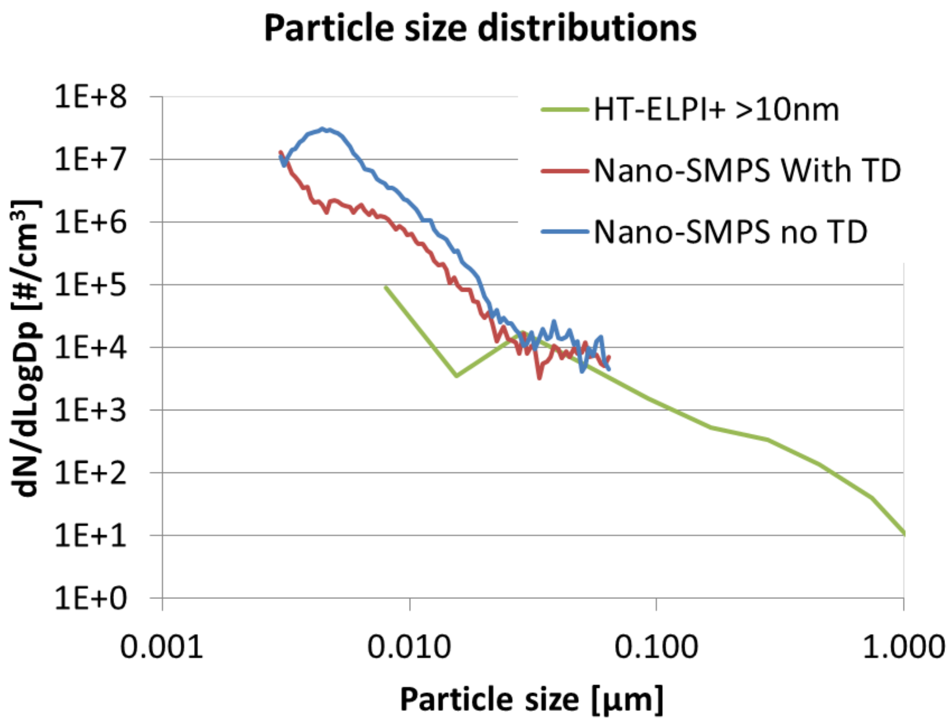


30 000 # / cm^3

(7000 #/cm^3 for >10 nm)

0.0078 mg/m^3

Comparison to diluted measurements

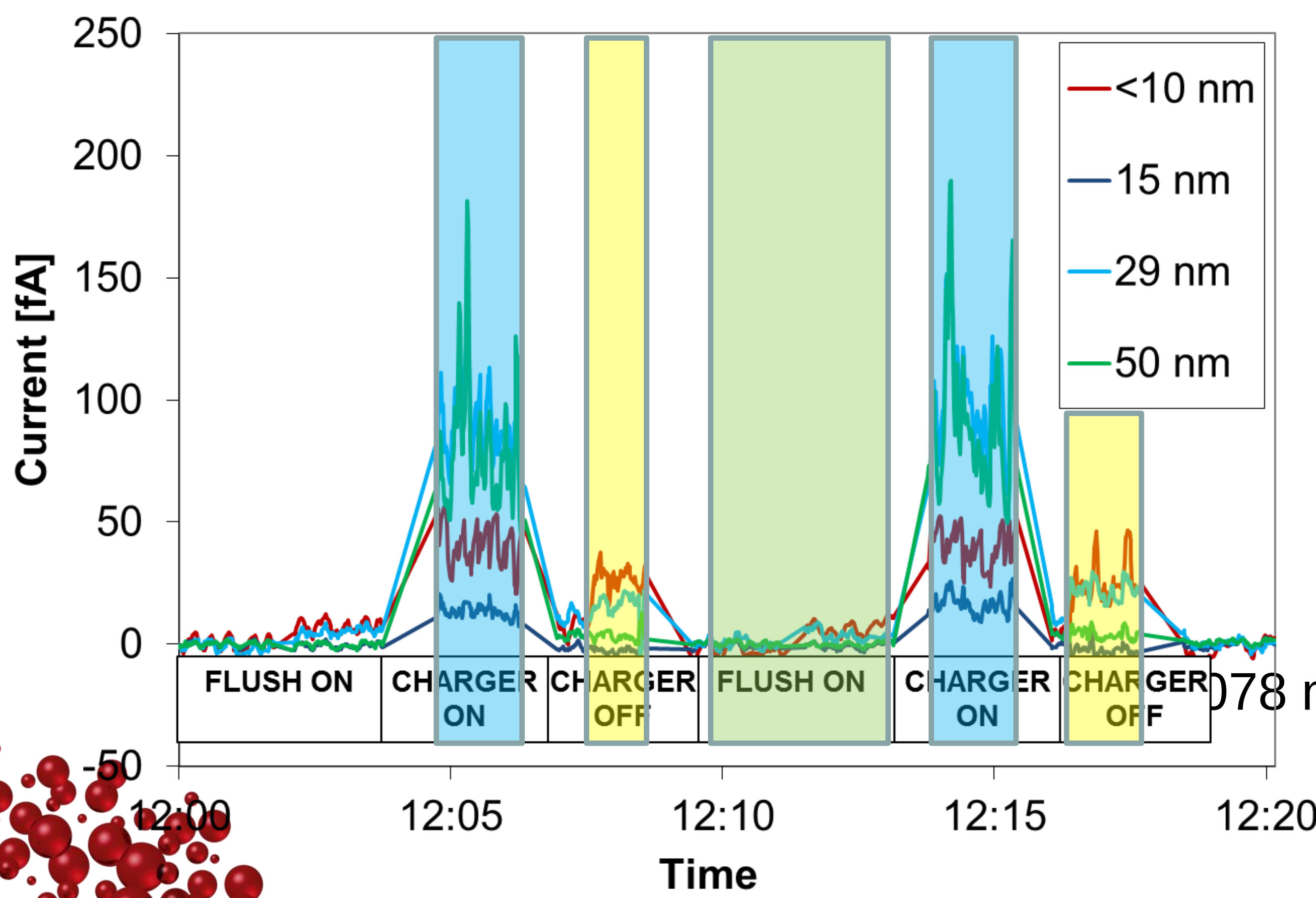


Number [#/cm3]	
HT-ELPI+	3.0e+4
HT-ELPI+ >10 nm	7.0e+3
SMPS Without TD	3.5e7
SMPS With TD	2.7e6
Mass [mg/m3]	
HT-ELPI+ (dens=1)	0.0078
ISO 8178 (AVL SS)	7000

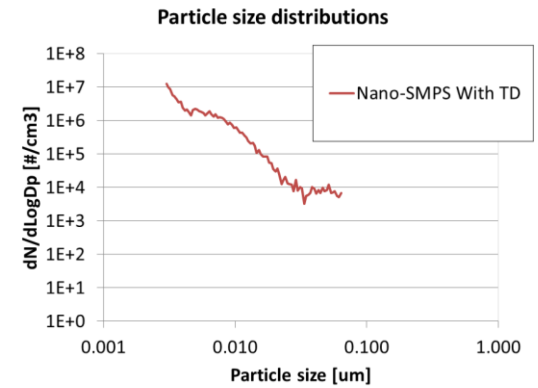
Result: Charge levels

3093 rpm, 33 Nm, 11 kW, Ethene + Propane injection

HT-ELPI+ Electrometer currents



078 mg/m3



HT-ELPI+™

- Same advantages as with ELPI+™
- Direct measurement of sample in source conditions
  - High Temperature measurement, up to 180 °C
  - No dilution required
    - No uncertainties or particle transformations caused by dilution
    - Improved sensitivity
    - Low concentration measurements
- Diluted measurements may provide different results
- Things to consider
  - Sample concentration
  - Sample temperature
  - Heating time (stainless steel impactor)
  - Collection foil material (max temperature)
  - Connection to the pump (max temperature)

High Temperature ELPI+™: Applications

- Engine emissions
  - Tailpipe particle characterization
  - Solid particle research
  - OBD sensor studies at OBD conditions
  - Tailpipe particle charging studies
  - Particle formation studies
  - PEMS
- Stationary source emission measurements
  - Emission characterization
  - Direct measurements from wet stacks
  - After treatment device characterization studies
  - Low concentration measurements
  - Particle formation studies
  - Particle charging studies

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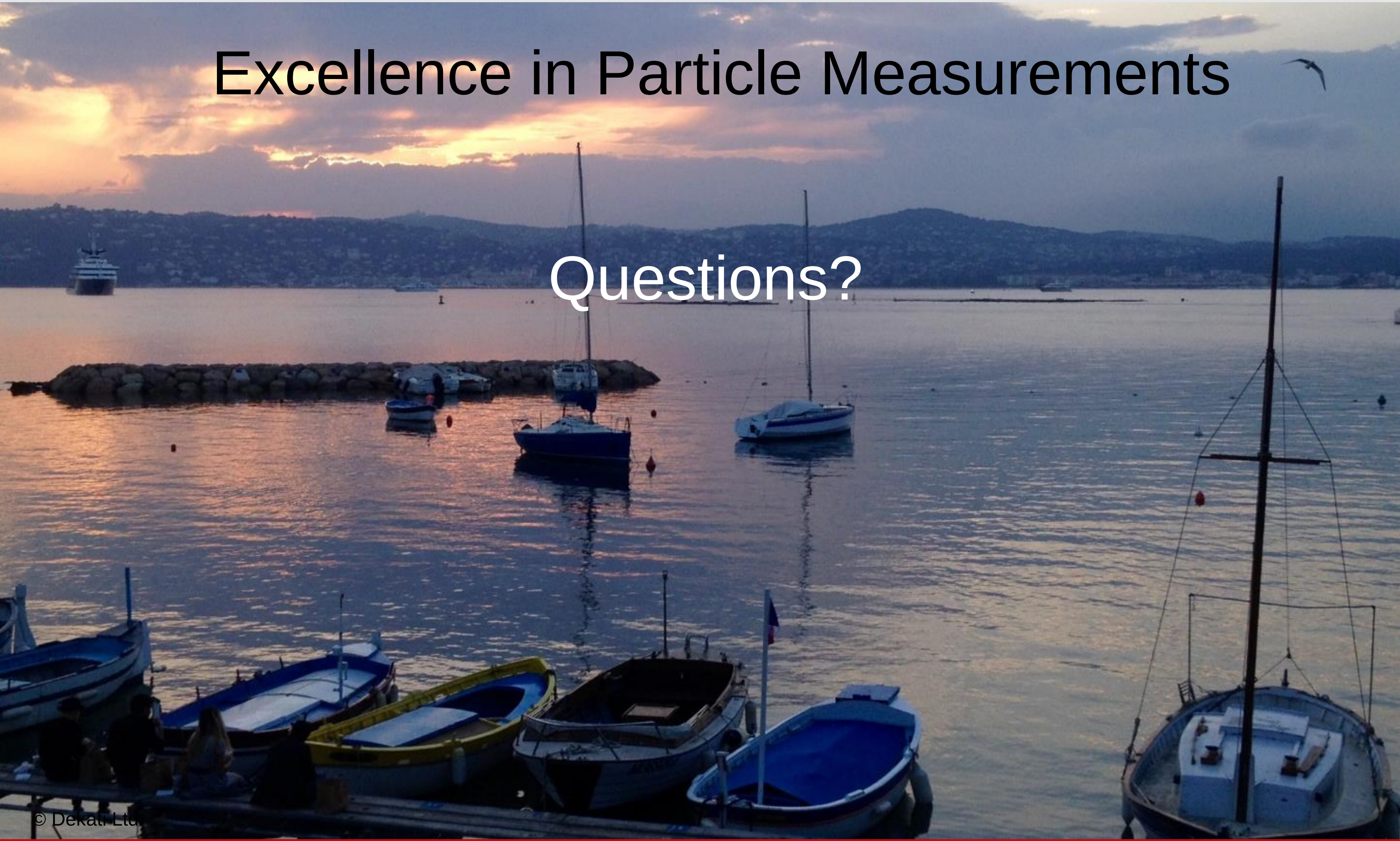

Excellence in Particle Measurements

Questions?