

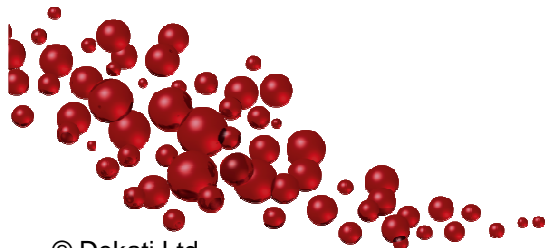
ELPI+™

Electrical Low Pressure
Impactor



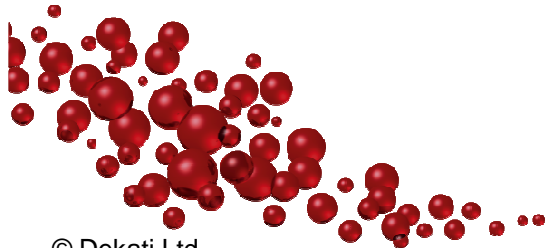
ELPI+™: Electrical Low Pressure Impactor

- Number size distribution and concentration
 - Real-time, 10 Hz
- 6 nm - 10 µm
 - 14 size fractions
- Particles are collected
 - Enables subsequent chemical analysis on the collected samples
- Wide dynamic range
 - From outdoor air to power plant stack concentrations

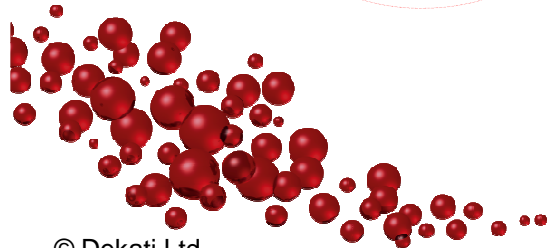
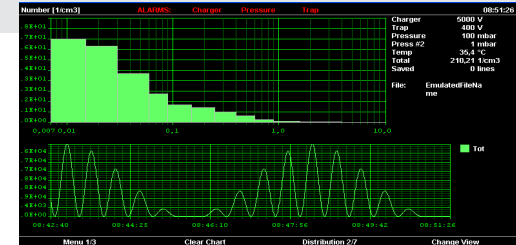
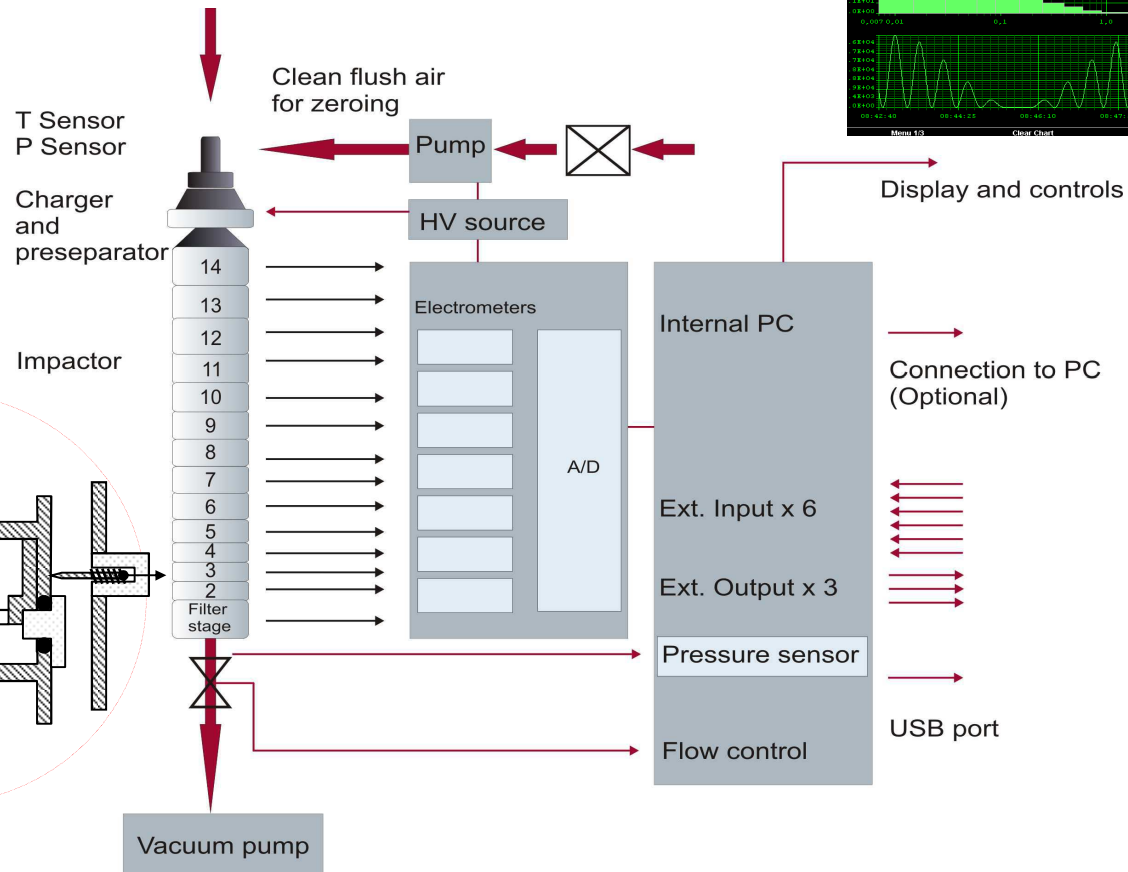
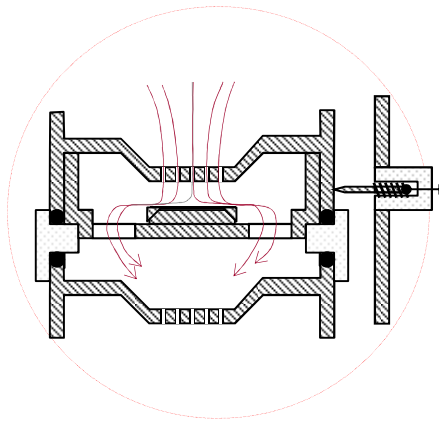
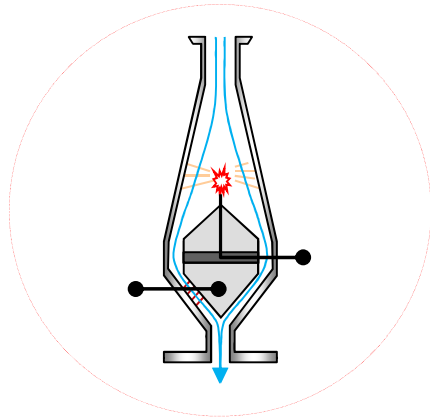


ELPI+™ Operating Principle

- Operation based on three main components:
 1. Impactor
 - Particle size fractionation
 2. Charger
 - Particle are charged before fractionating
 3. Electrometers
 - Current distribution - directly proportional to number distribution
 - Fast, sensitive



ELPI+™ Operating Principle



ELPI+™ Charger

- Corona charger

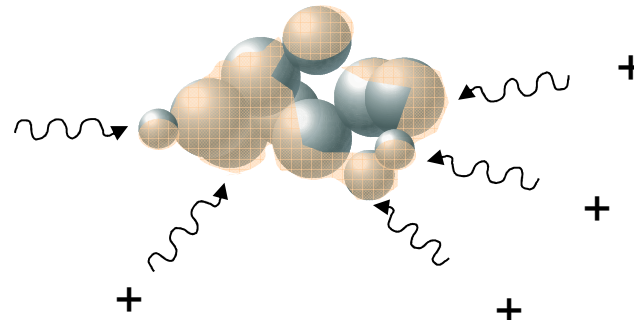
- Unipolar (+)
- Diode-type

- Charging

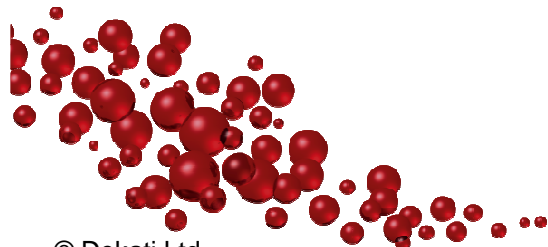
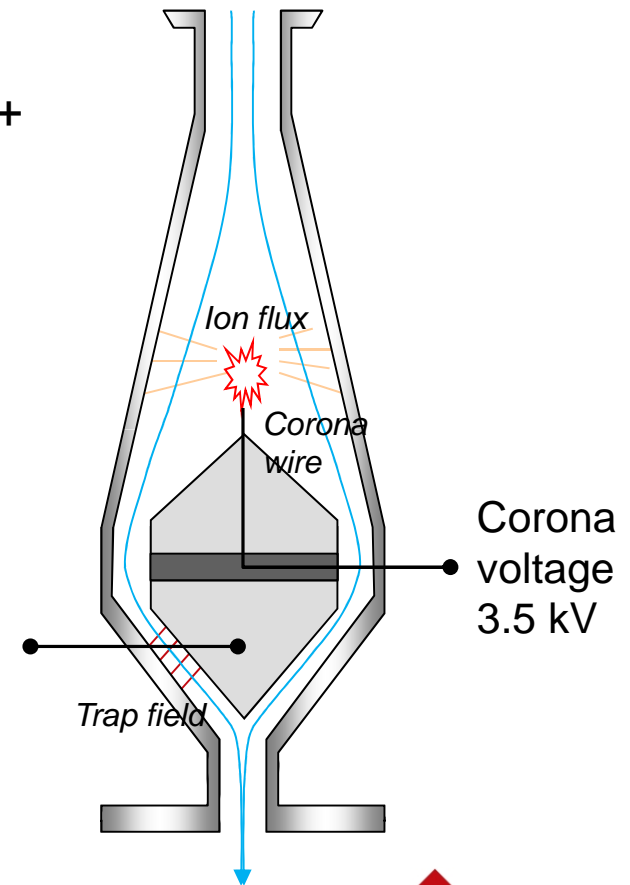
- Corona discharge
- Diffusion charging

- ELPI+™ charger generates ion plume and particles are charged based on (mainly) diffusion charging:

- Charge of particles is directly related to ion- and condensation sinks and active surface of particles



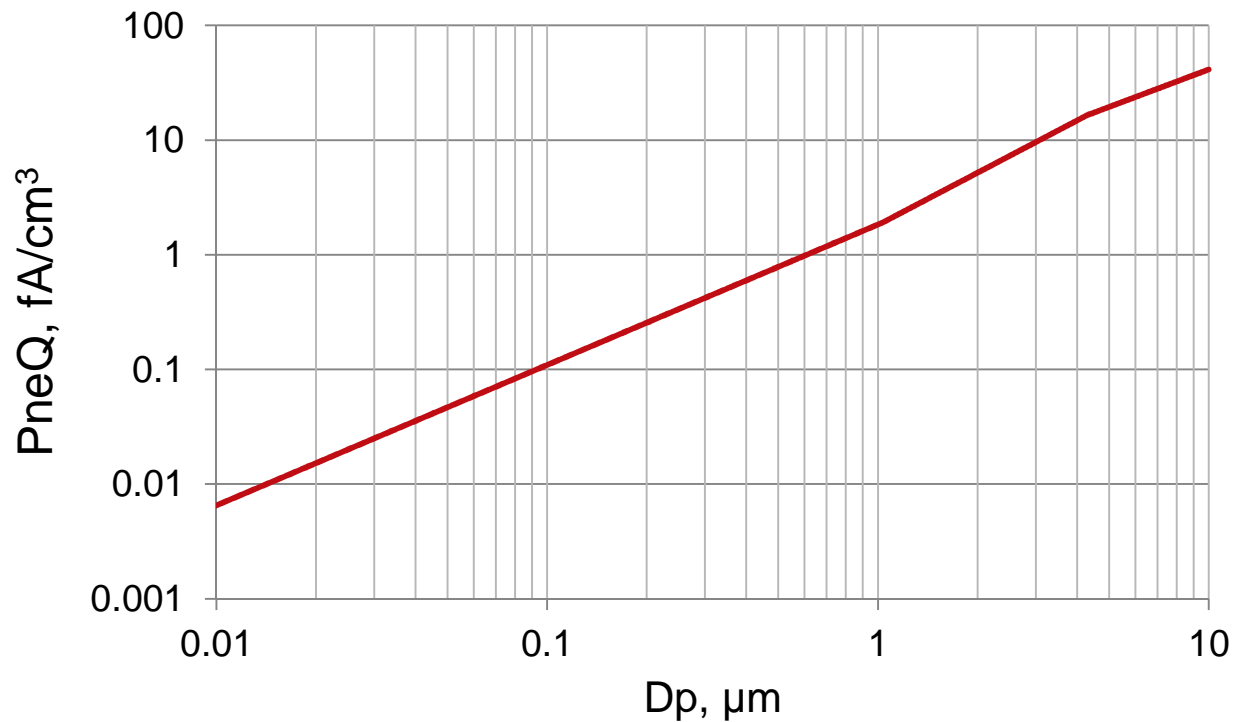
Trap voltage
20 V



Charger Calibration

Järvinen, A., Aitomaa, M., Rostedt, A., Keskinen, J., and Yli-Ojanperä, J., Calibration of the new electrical low pressure impactor (ELPI+), *J. Aerosol Sci.* 69, 150-159, 2014

ELPI+™ Charger Efficiency



$$P_n = \begin{cases} 68.531 \cdot D_p^{1.225}, & D_p < 1.035 \mu\text{m} \\ 67.833 \cdot D_p^{1.515}, & 1.035 \mu\text{m} \leq D_p \leq 4.282 \mu\text{m} \\ 126.83 \cdot D_p^{1.085}, & D_p > 4.282 \mu\text{m} \end{cases}$$

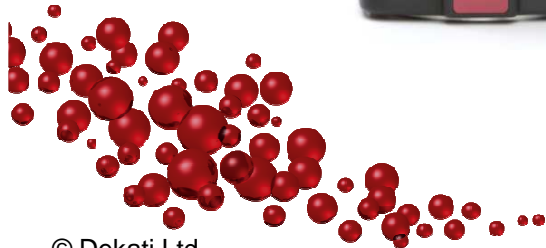


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ELPI+™ Impactor

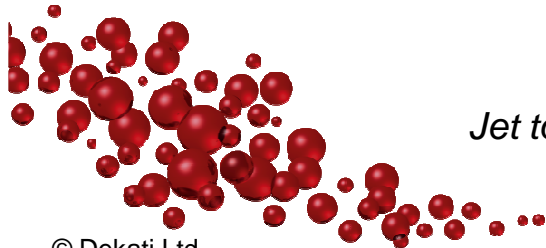
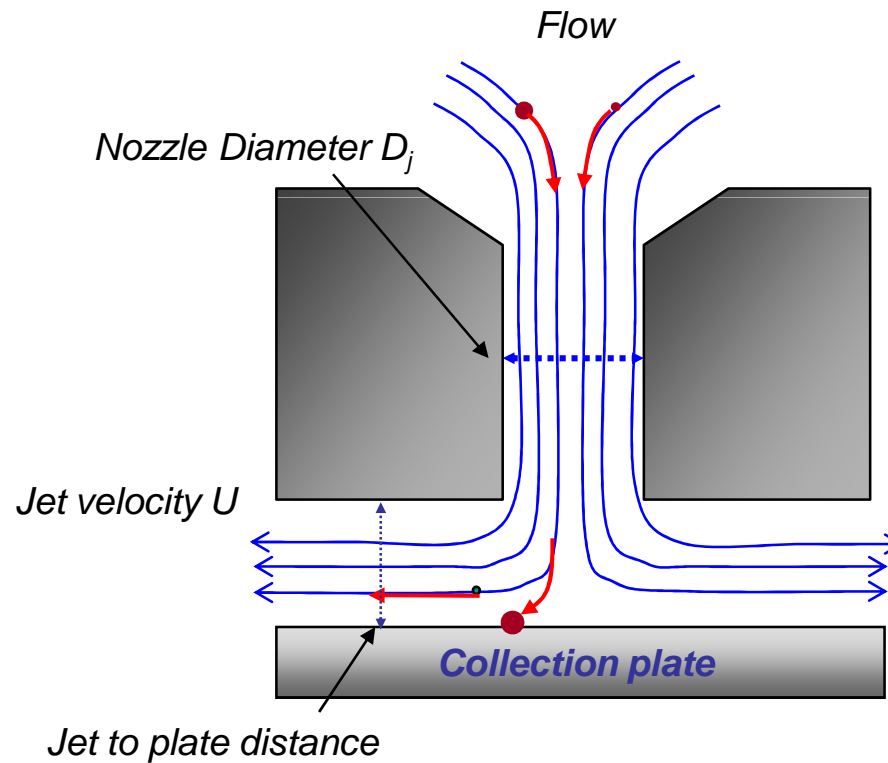


- 15 stage SS cascade low-pressure impactor
- Small deposit area, 25 mm
- 40 mbar low pressure
- 6 nm – 10 µm
- Stage 1 (6-16 nm) integrated filter

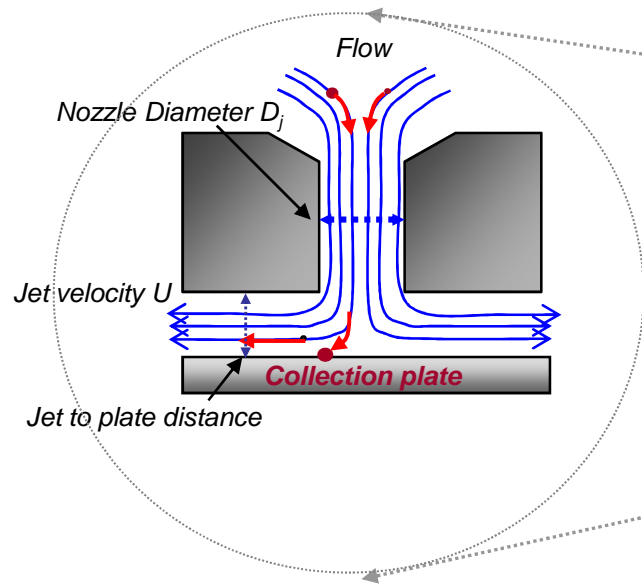


Impactor

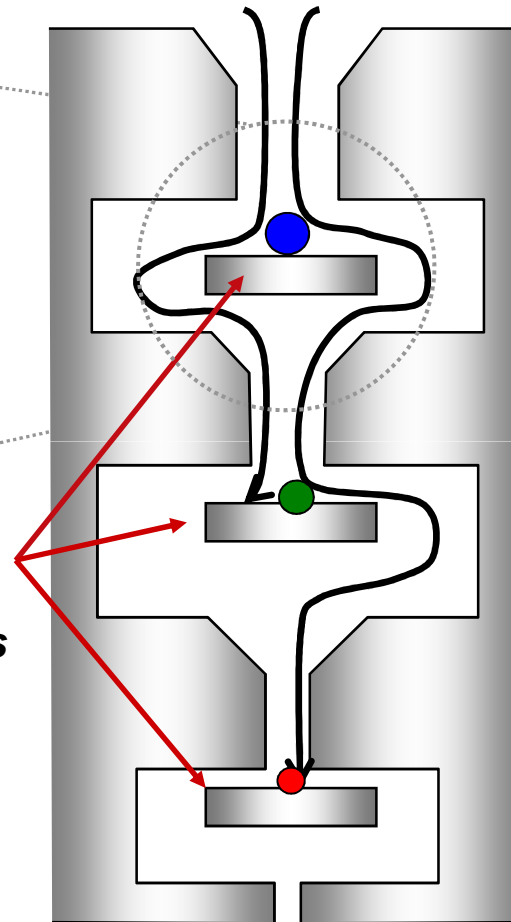
- Aerodynamic diameter
- Gas velocity and dimensions different in different stages



Cascade Impactor



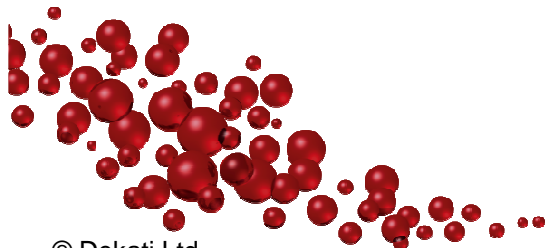
Collection substrates



Stage 3: $>10 \mu\text{m}$

Stage 2: $>2.5 \mu\text{m}$

Stage 1: $>1.0 \mu\text{m}$



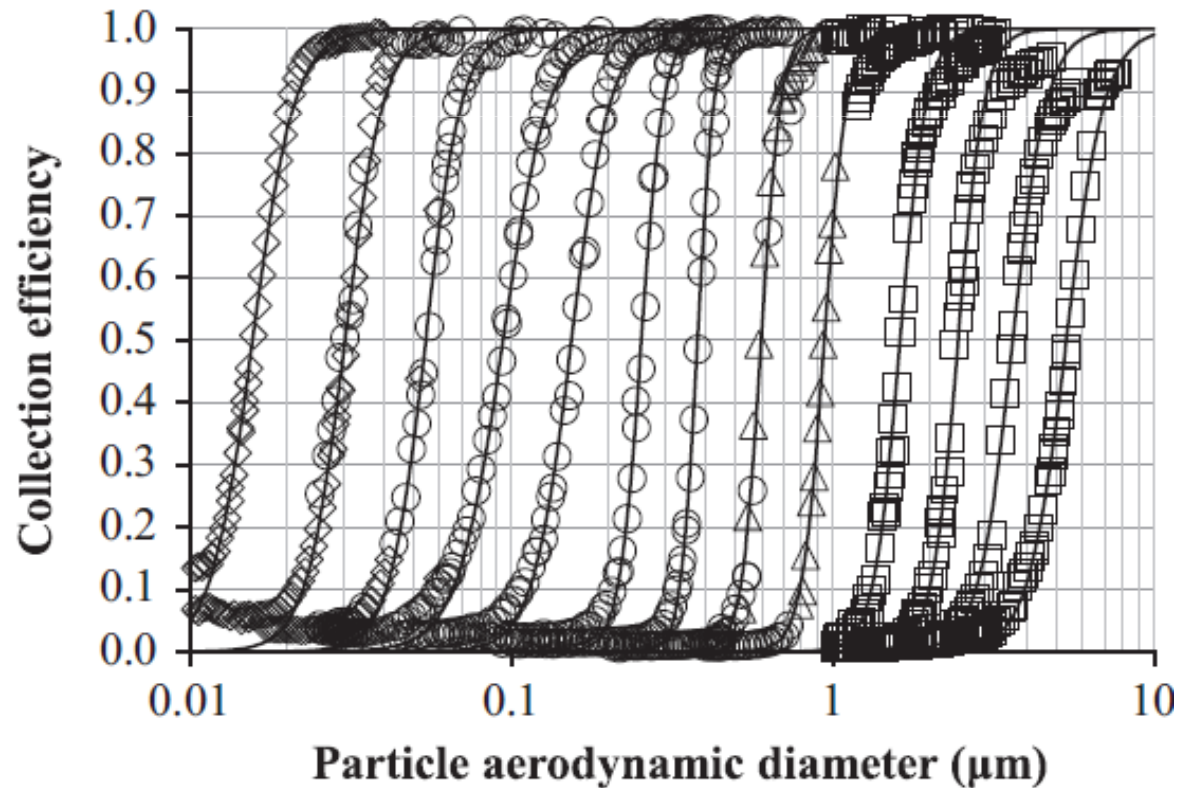
ELPI+™ Impactor Calibration

Good calibration information and low losses

Calibration of the new electrical low pressure impactor (ELPI+)

A. Järvinen*, M. Aitomaa, A. Rostedt, J. Keskinen, J. Yli-Ojanperä

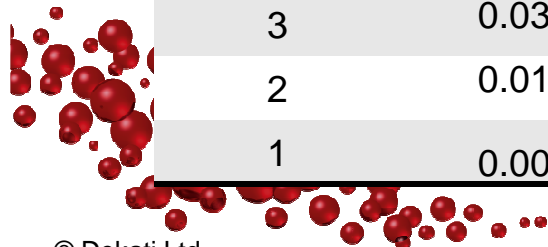
Tampere University of Technology, Department of Physics, Aerosol Physics Laboratory, P.O. Box 692, FI-33101 Tampere, Finland



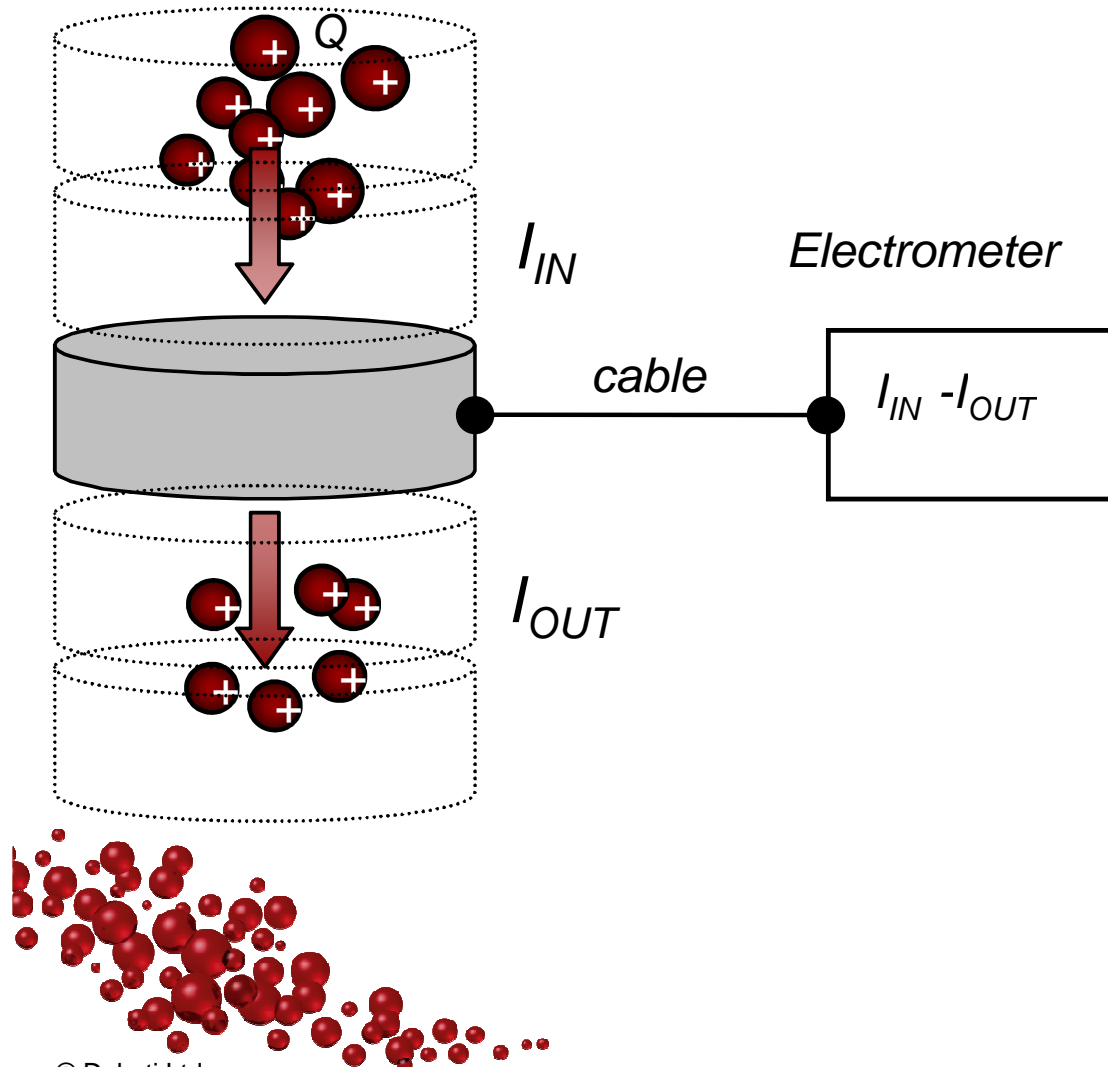
ELPI+™ Impactor

Stage	D50	Di
15	10	
14	5.34	7.31
13	3.63	4.40
12	2.46	2.99
11	1.62	2.00
10	0.94	1.23
9	0.60	0.75
8	0.38	0.48
7	0.25	0.31
6	0.15	0.19
5	0.094	0.12
4	0.054	0.07
3	0.030	0.04
2	0.016	0.02
1	0.006	0.01

- 14 size fractions
- New stage at 16 nm
- "Filter stage" standard in all units
- See correct values in the data sheet



Current Measurement



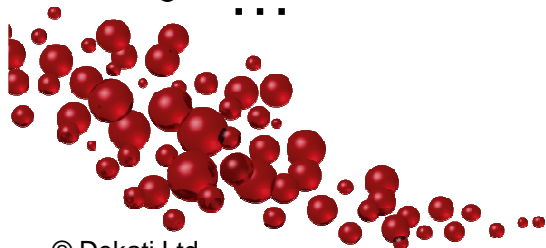
- Current measurement from outside the stage
- Whole Impactor stage acts as Faraday's cage
- Collection material does not matter

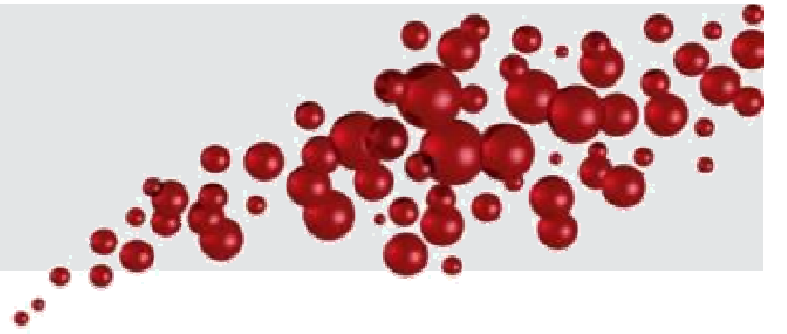
ELPI+™ applications

- Combustion research
- Outdoor air quality measurements
- Indoor air
- Automotive testing and research
- Blow-by gas
- Brake wear debris
- Pharmaceutical studies
- Welding fumes

- ...

- Wide variety of applications
- Application notes/papers available
- Publications list at www.dekati.com





High Temperature ELPI+™ High Resolution ELPI+™

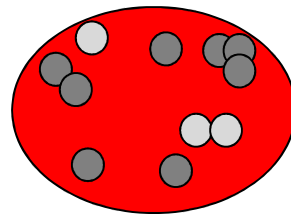


High Temperature ELPI+™



Measurement from difficult conditions

Hot Sample,

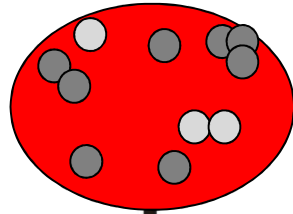


but low particle concentration

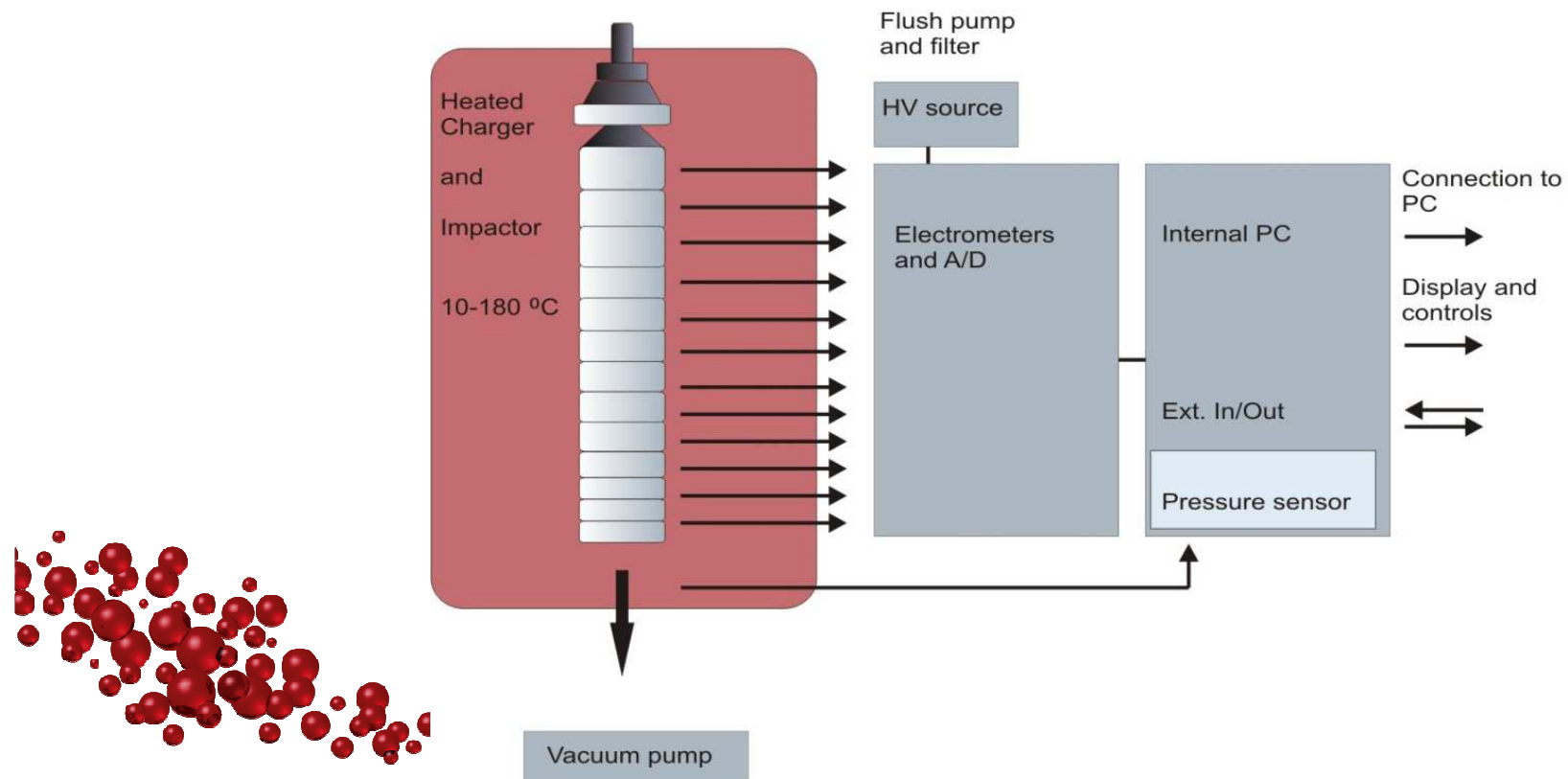


High Temperature ELPI+™

Hot Sample



Can be measured without dilution



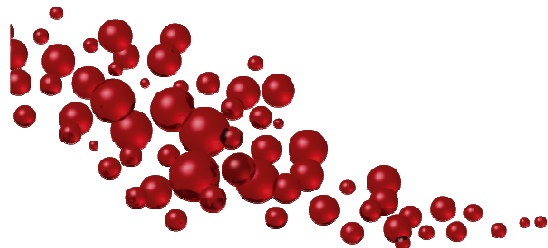
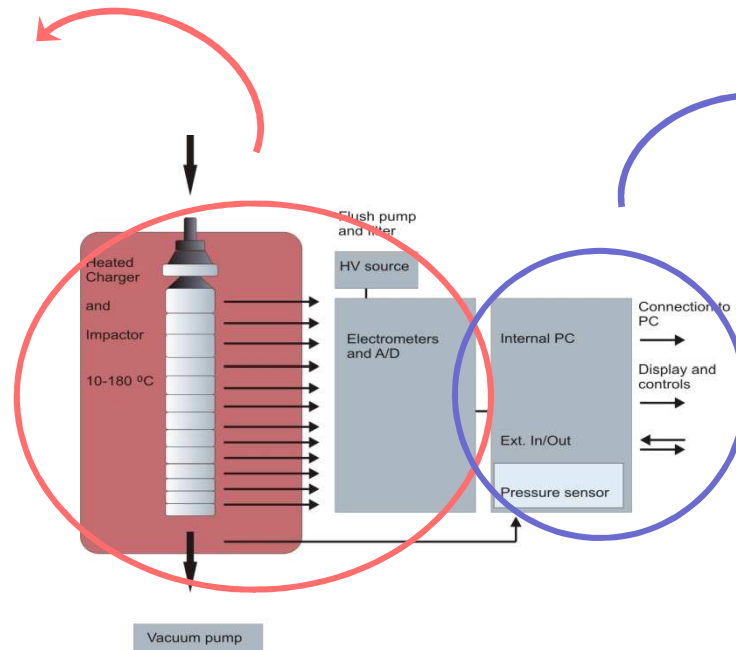
Jonna Kannosto

High Temperature ELPI+™

Heating unit



ELPI+™ main unit

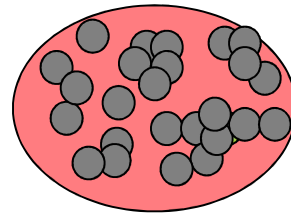
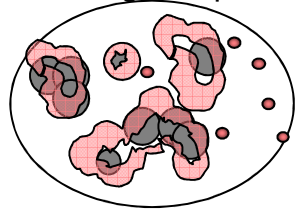


Dilution solutions

Solid particles are measured

Uncontrolled dilution

Vapors on particle surfaces or forming new particles



No dilution no unwanted condensation or nucleation

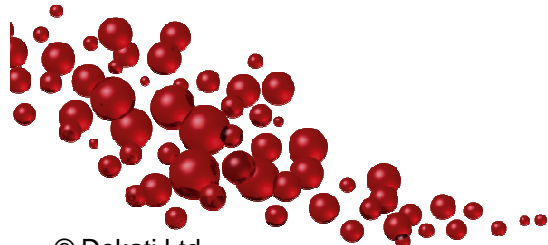
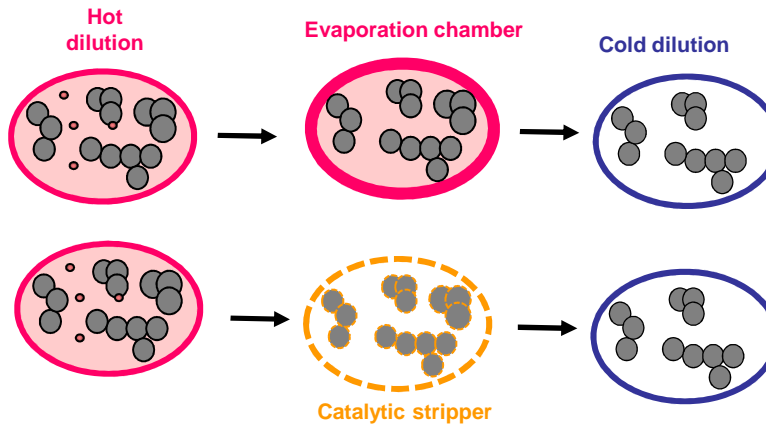


Controlled dilution setup



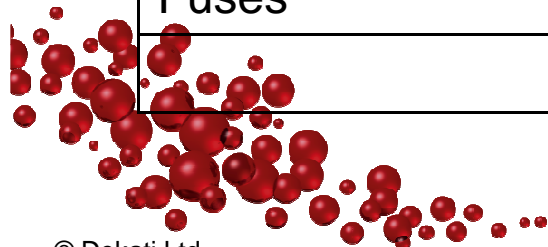
DEED

DEED Air



High Temperature ELPI+ Specifications

Temperature controller	2 x CAL-3300 PID controllers
Max. temperature	180°C for impactor 250°C for external heater (sampling line)
Heater power	500W for impactor heater Max. 1000/500W for External heater (230V/110V)
Warm-up time	Approximately 2 h
Temperature measurement	Sample inlet Heater After impactor
Pre-set calibration temperatures	60, 120 and 180°C Other calibrations can be calculated
Fuses	2 x 10A



Construction



Heating unit



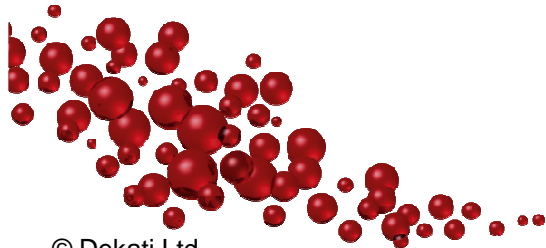
Impactor assembly with heater



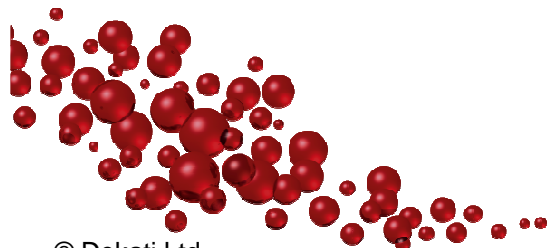
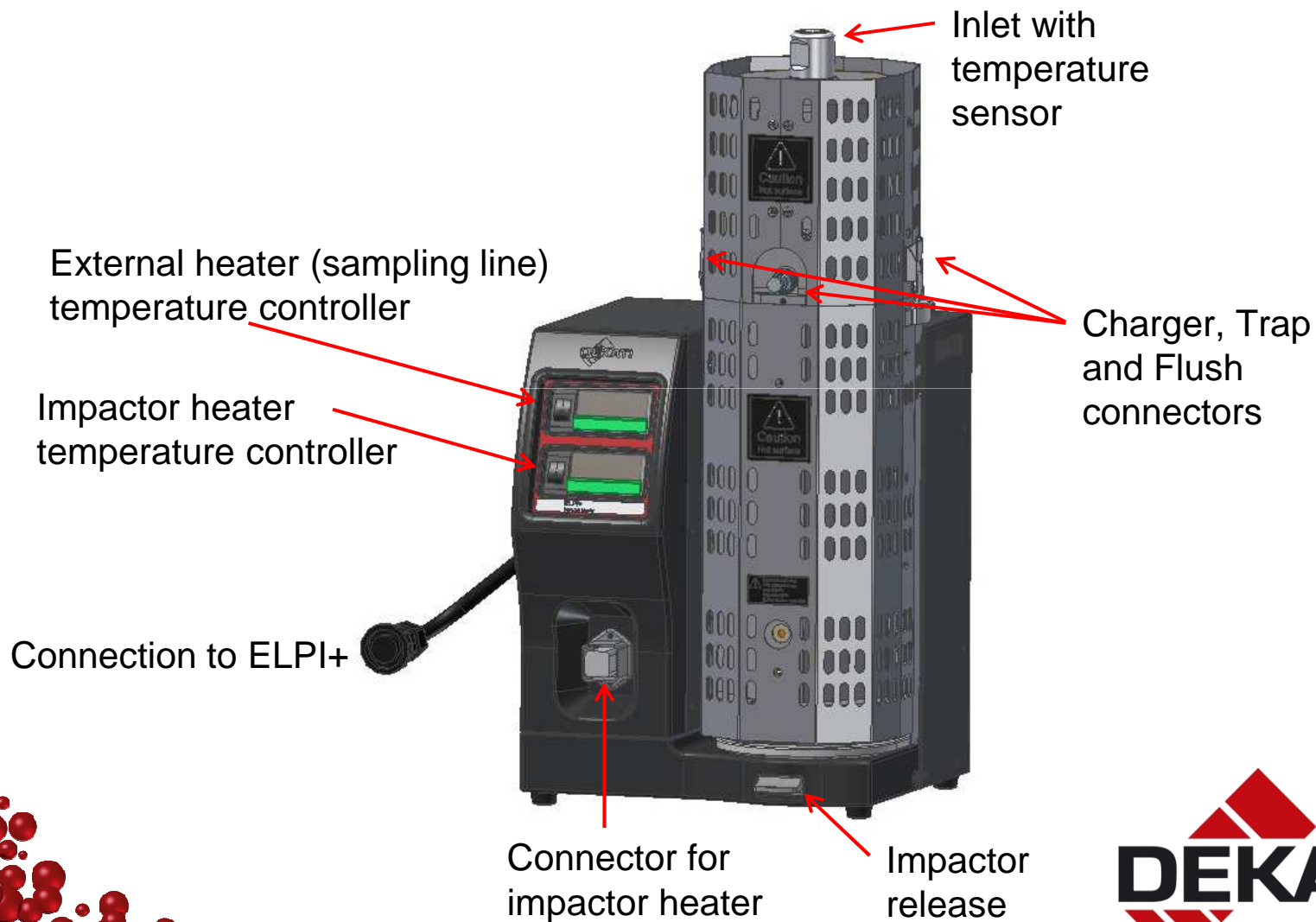
Charger insulation

Also included:

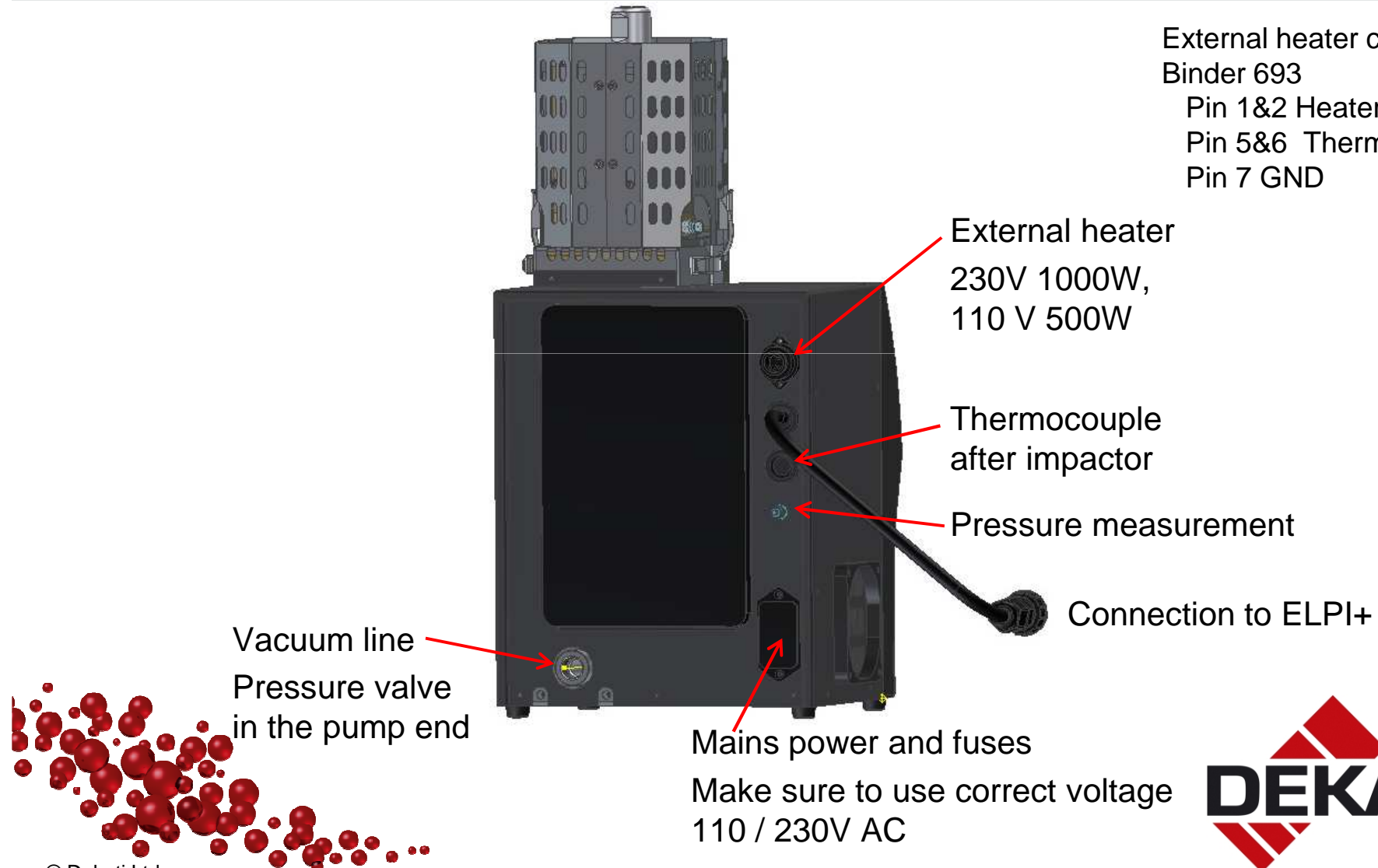
- Charger inlet with a thermocouple
- Pressure measurement hose
- Extensions for Charger, Trap and Flush
- Silicone plug to close ELPI+ vacuum line
- External ball valve for pressure adjustment



Connections



Connections – backside



External heater connector:
Binder 693
Pin 1&2 Heater
Pin 5&6 Thermocouple
Pin 7 GND

External heater
230V 1000W,
110 V 500W

Thermocouple
after impactor

Pressure measurement

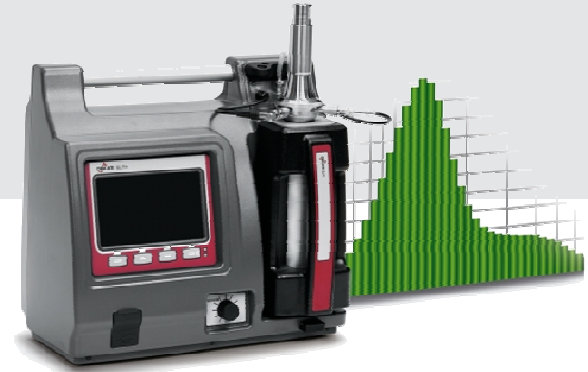
Connection to ELPI+

Vacuum line
Pressure valve
in the pump end

Mains power and fuses

Make sure to use correct voltage
110 / 230V AC





High Resolution ELPI+™



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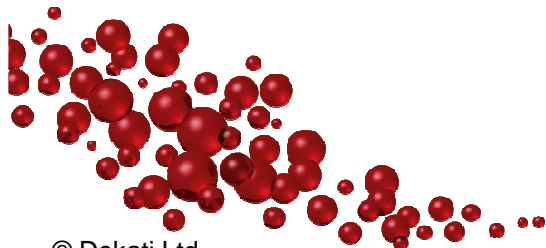
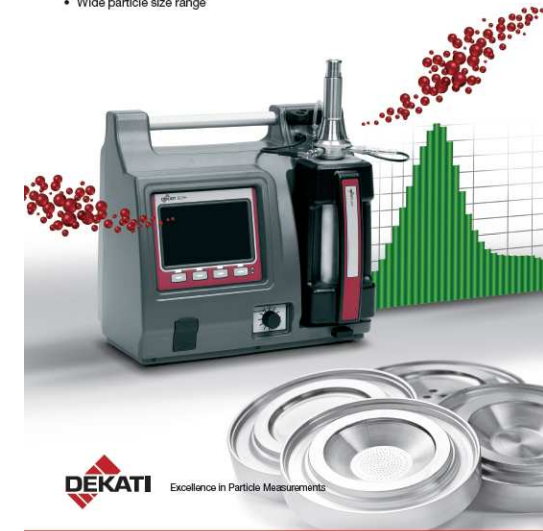


HR-ELPI+™

- Number size distribution and concentration
 - Real-time, 1 Hz
- 6 nm - 10 µm
 - 100 or 500 size fractions
- Particles are collected
 - Enables subsequent chemical analysis on the collected samples
- Wide dynamic range
 - From outdoor air to power plant stack concentrations

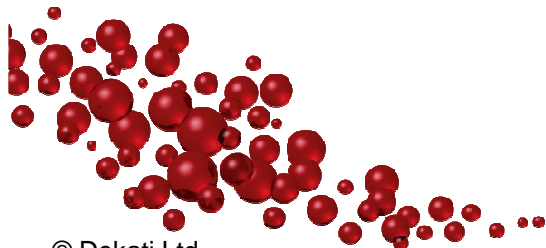
Dekati® High Resolution ELPI+™

- Real-time particle size distribution
- High size resolution
- Wide particle size range

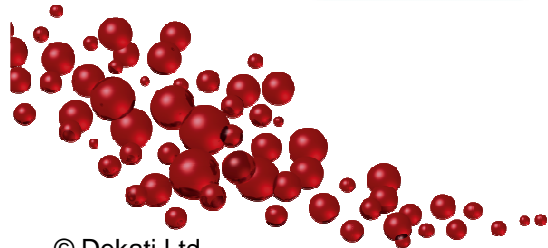
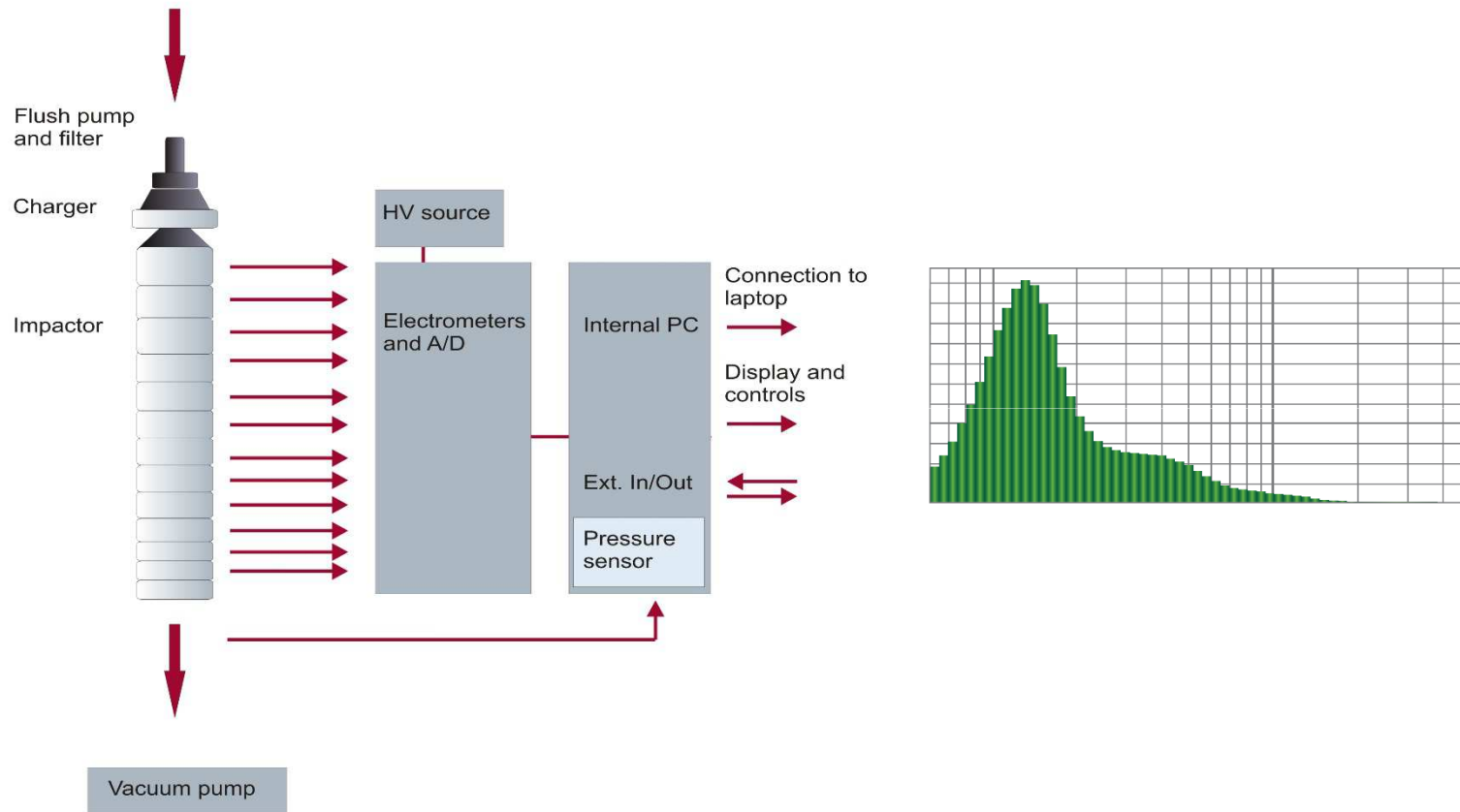


HR-ELPI+™ Operating Principle

- Operation based on:
 1. Impactor
 - Particle size fractionation
 2. Charger
 - Particle are charged before fractionating
 3. Electrometers
 - Current distribution - directly proportional to number distribution
 - Fast, sensitive
 4. Data inversion in the HR-ELPI+VI™ software
 - Data inversion based on measured impactor kernel functions and iterative calculation routine



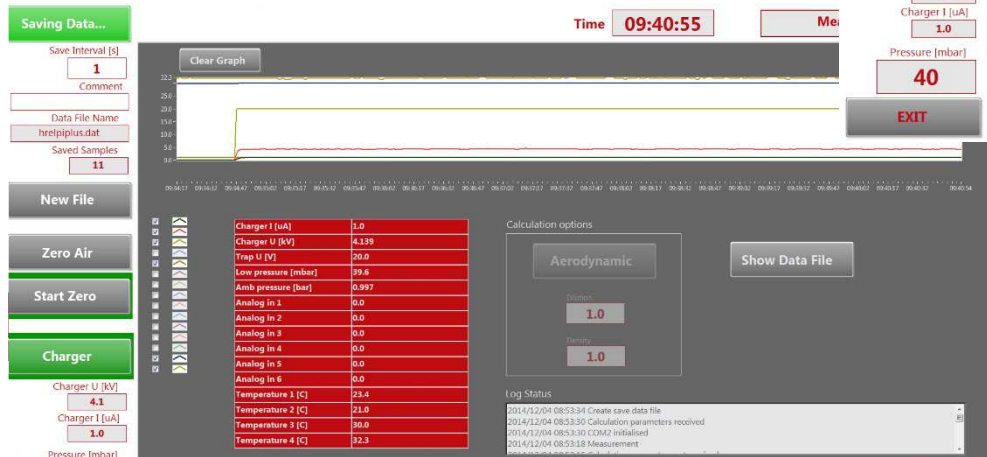
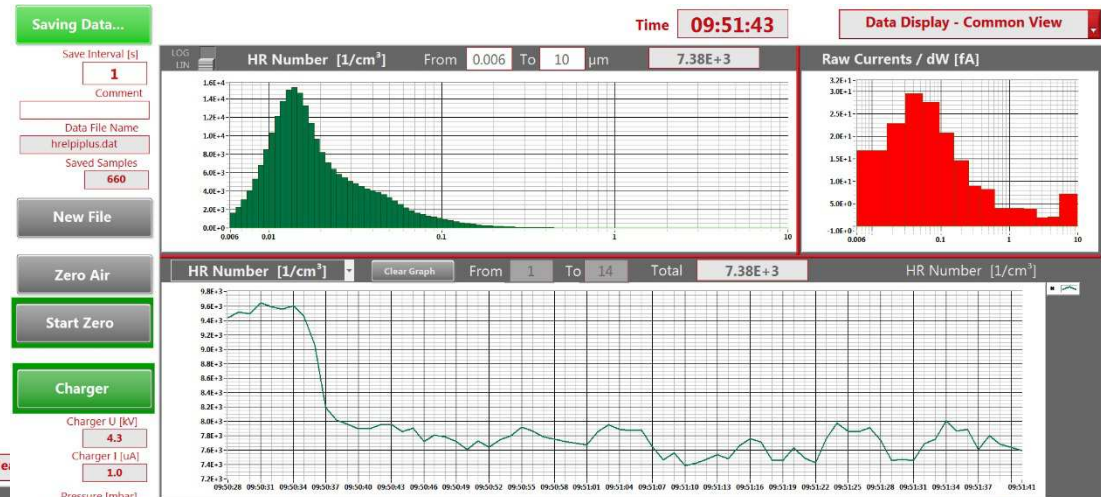
HR-ELPI+™ Operating Principle



HR-ELPI+VI™ Software

- Instrument control via HR-ELPI+VI™ software

- Runs on a laptop/PC
- See online data
- Control the ELPI+™
- Measure
- Save the data



System OK

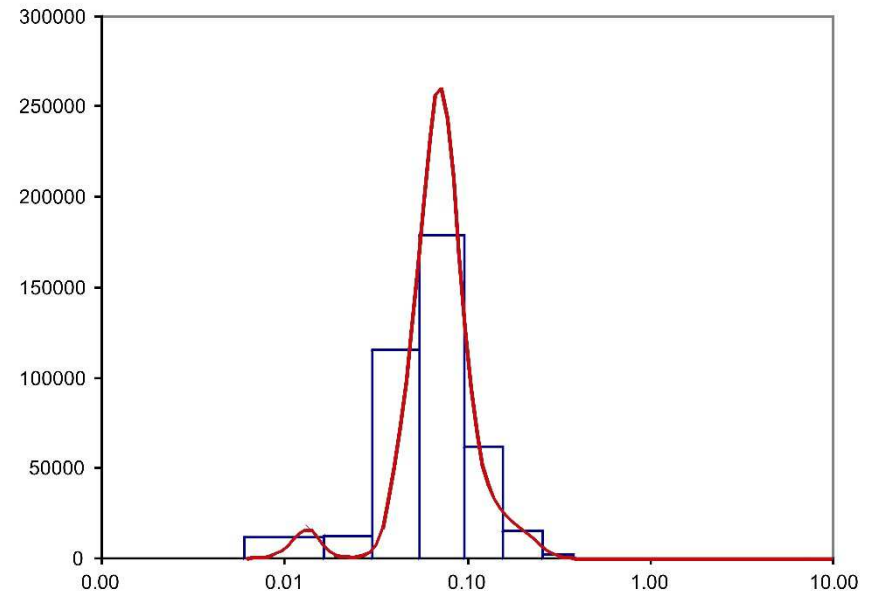
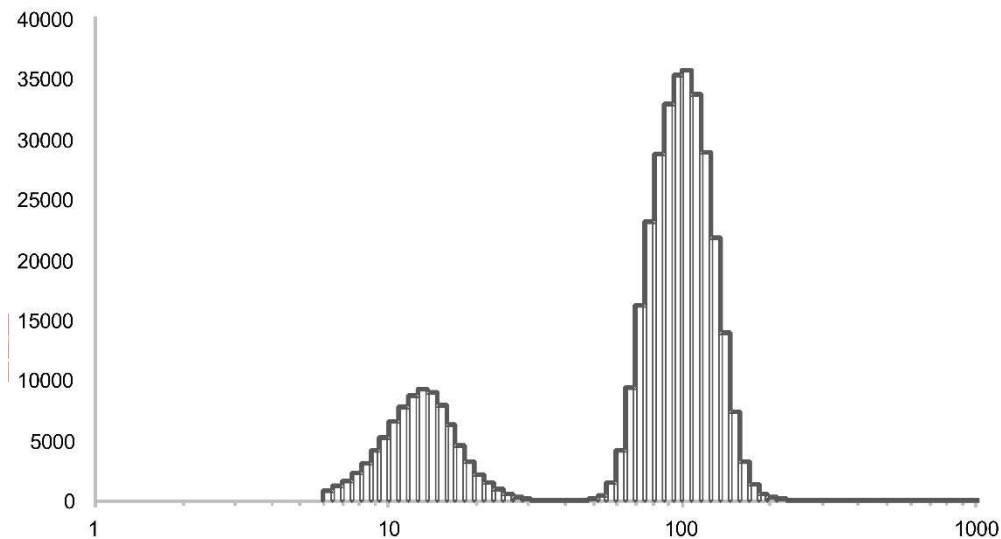


System OK



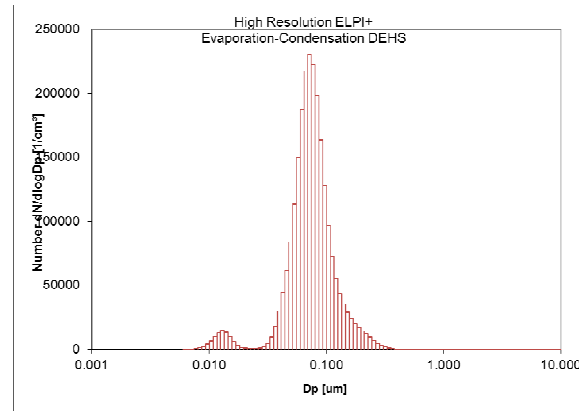
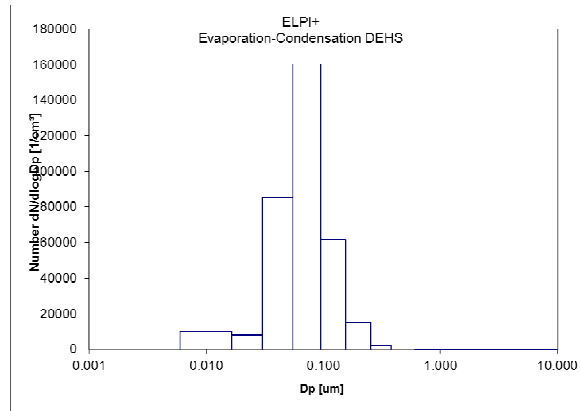
HR-ELPI+™ Calculation

- Inside HR-ELPI+VI™
- Data file format similar to ELPI+™
 - 100 or 500 size bins
- Data processing in HRELPI+.xls

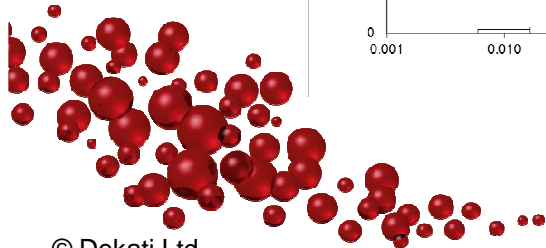
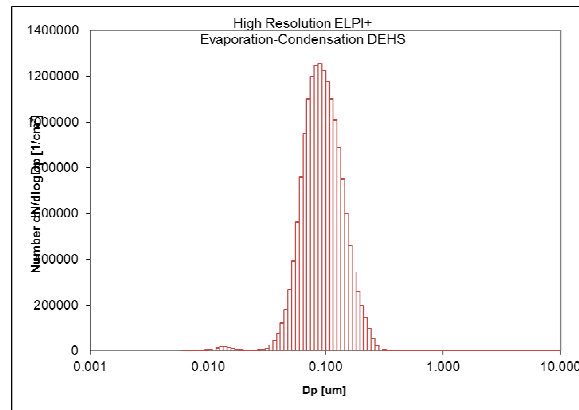
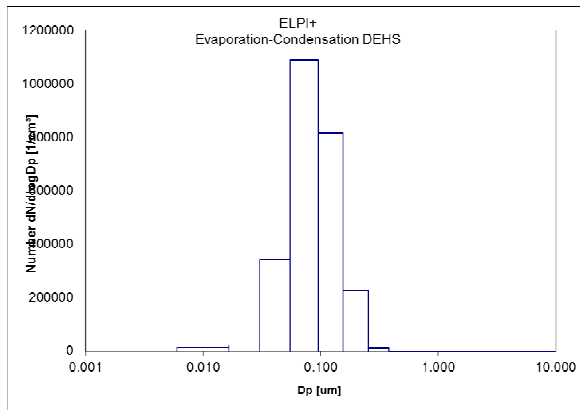


HR-ELPI+™ Data example: DEHS

Evaporation-condensation generator DEHS (95 °C)

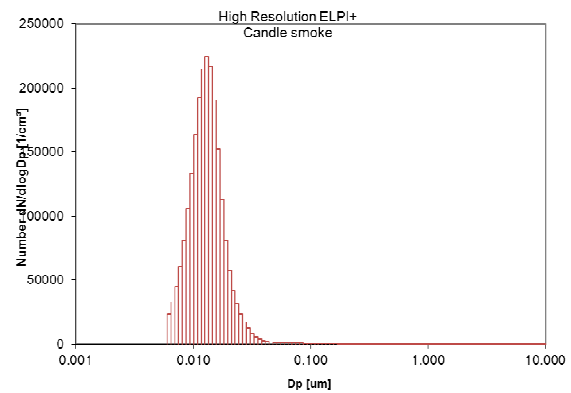
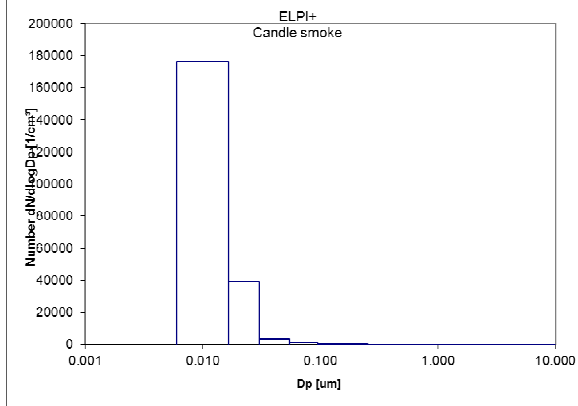


Evaporation-condensation generator DEHS (temperature 125 °C)

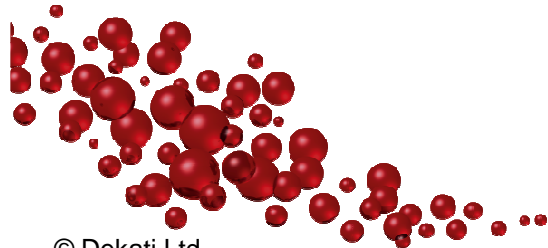


HR-ELPI+™ Data examples

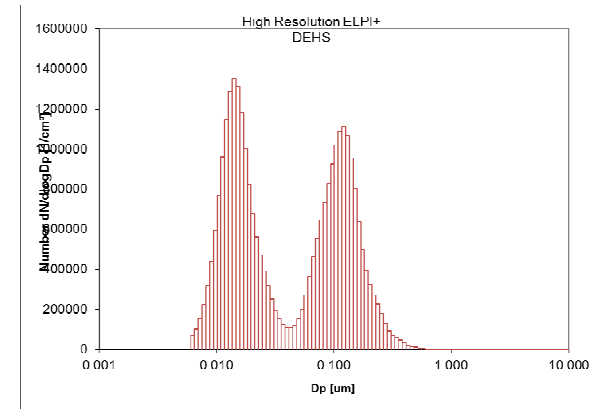
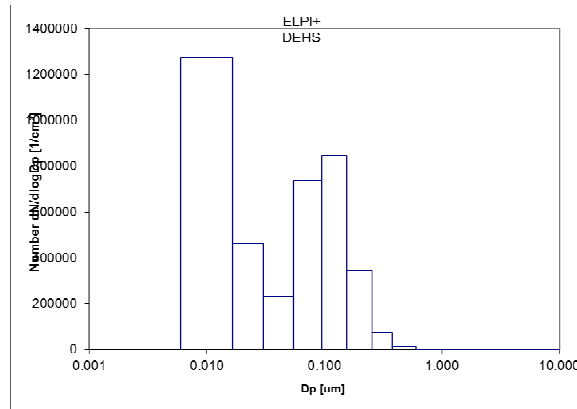
Candle smoke



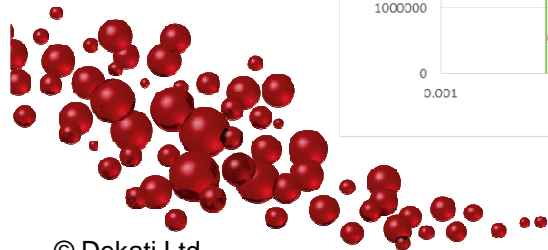
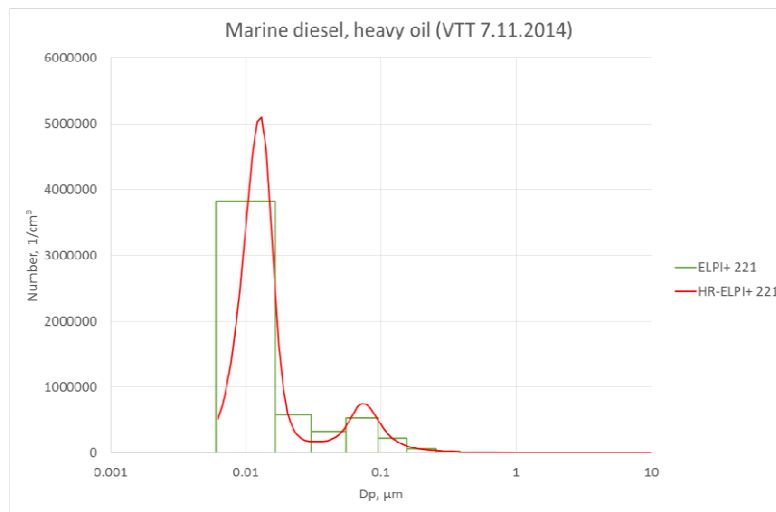
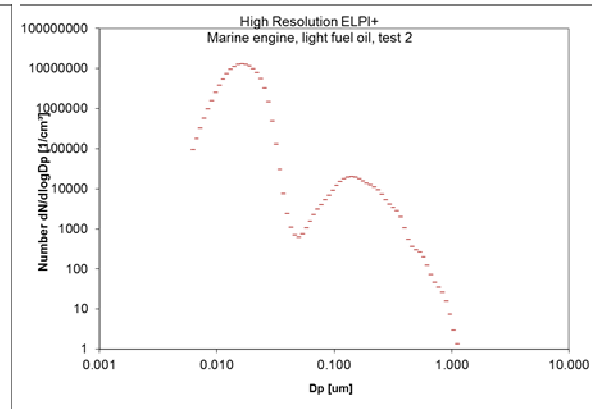
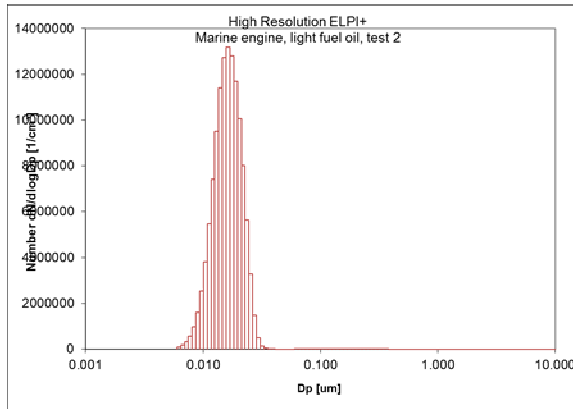
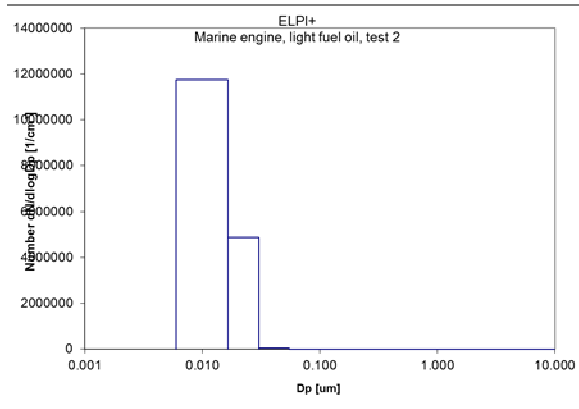
Evaporation-condensation generator DEHS (140 °C) + DeVilbiss 1:500 DEHS/isopropyl alcohol



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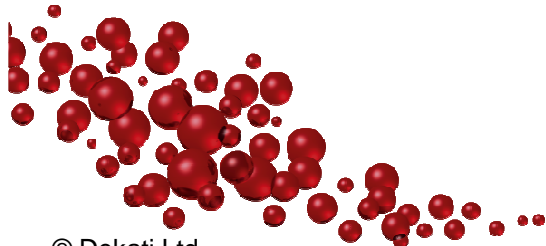


HR-ELPI+™ Data examples: diesel engine



HR-ELPI+™ Features

- 0.006 – 10 μm size range
- Number size distribution in either 100 or 500 size channels
 - 30/150 channels /decade
- Sampling rate 1Hz
- Sensitivity
 - 250 $\#/\text{cm}^3$ for 10 nm particles
 - 20 $\#/\text{cm}^3$ for 100 nm particles
 - 1.0 $\#/\text{cm}^3$ for 1 μm particles
 - 0.1 $\#/\text{cm}^3$ for 5 μm particles



www.dekati.fi

Thank you!
Questions?

