Ultrafine Particles in Urban Air, Dresden 23 – 24, 2007, Session 2

A new particle measurement system for environmental ultrafine particles

A. Zschoppe [1], L. Hillemann [2], A. Rudolph [1], C. Peters [1] and R. Caldow [3]

[1] Topas GmbH, Wilischstr. 1, D-01279 Dresden, Germany
[2] Umweltbetriebsgesellschaft, Altwahnsdorf 12, D-01445 Radebeul, Germany
[3] TSI Incorporated, 500 Cardigan, MN 55126 Shoreview, USA

Environmental measurement of ultrafine particles - Motivation

- Ultrafine particles have an impact on human health !
- It's necessary to monitor the exposure in cities and urban areas.
- Commercially available instruments: SMPS, DMPS or FMPS.
- But utilization in air pollution monitoring networks ?

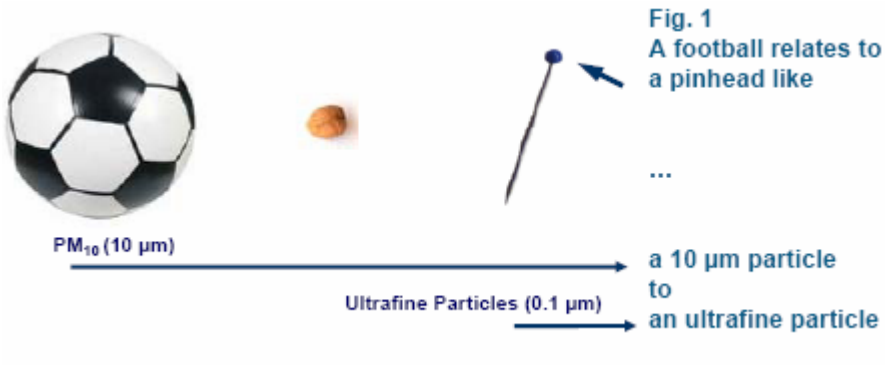


Fig. 1
A football relates to
a pinhead like
...

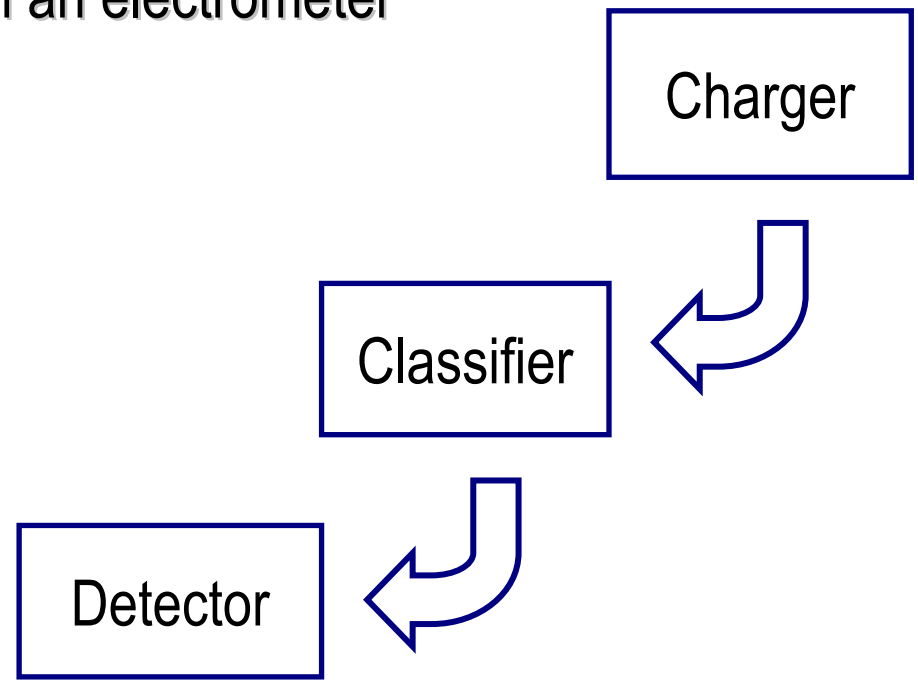
Objectives - demands for using inside monitoring networks

- Affordable and easy to use under routine measuring network conditions
- No butanol or other consumables
- No radioactivity due to regulatory limits
- Reduced data amount per time
- Lower service effort

Conception for a new instrument setup - Measurement principle

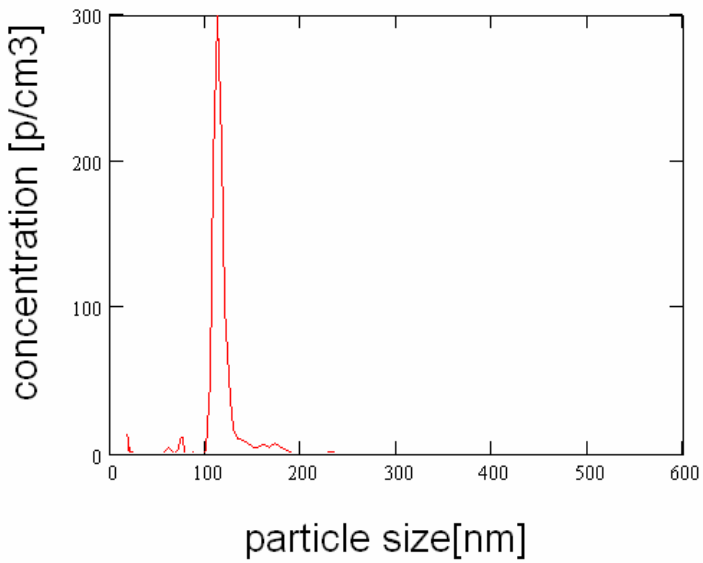
- Electrical charging of the particles
- Separation of charged particles with a DMA
- Measuring of the charge with an electrometer

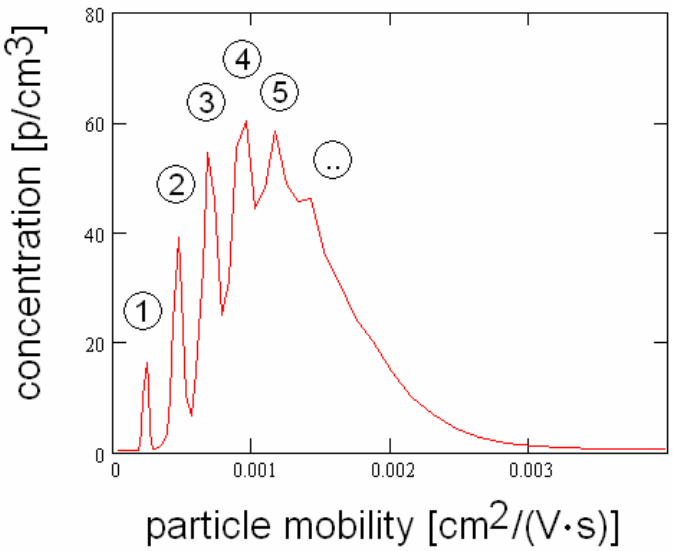
- Advantages:
  - no butanol like CPC
  - no radioactive source
  - less expensive
- Disadvantages:
  - multiple charged particles
  - limited sensitivity



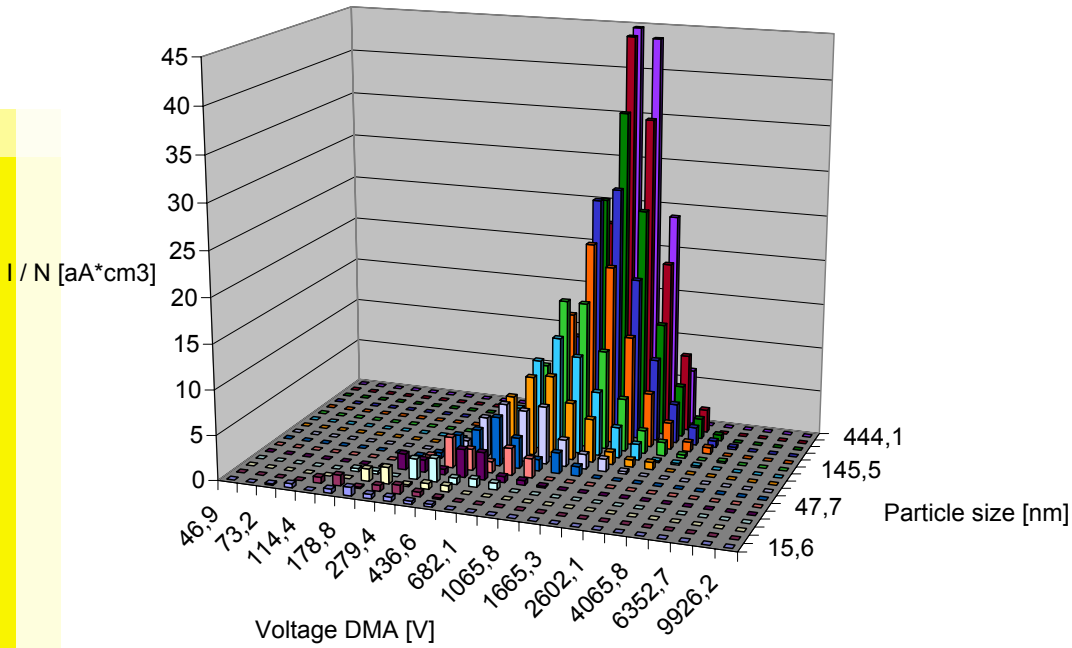
Unipolar charging and mobility distribution

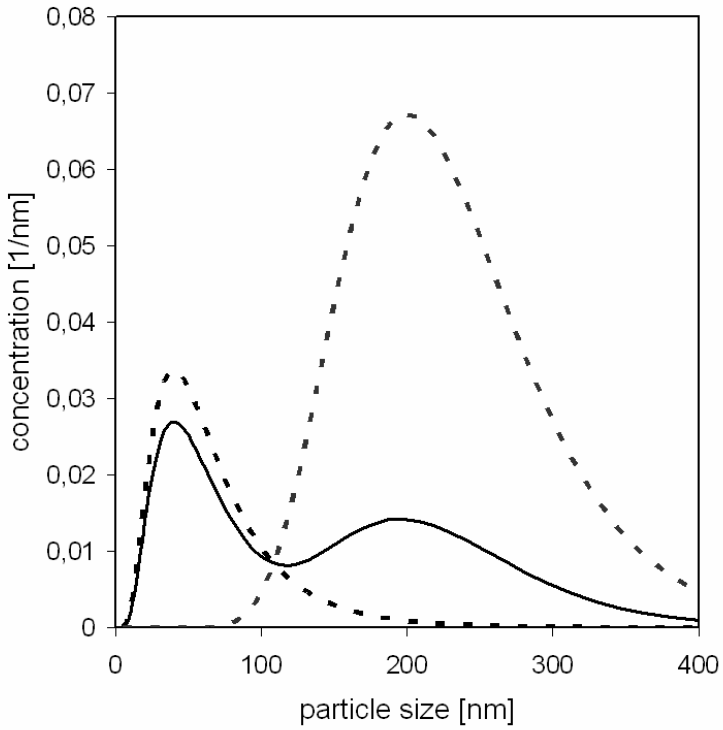
monodisperse aerosol ≠ monomobile aerosol



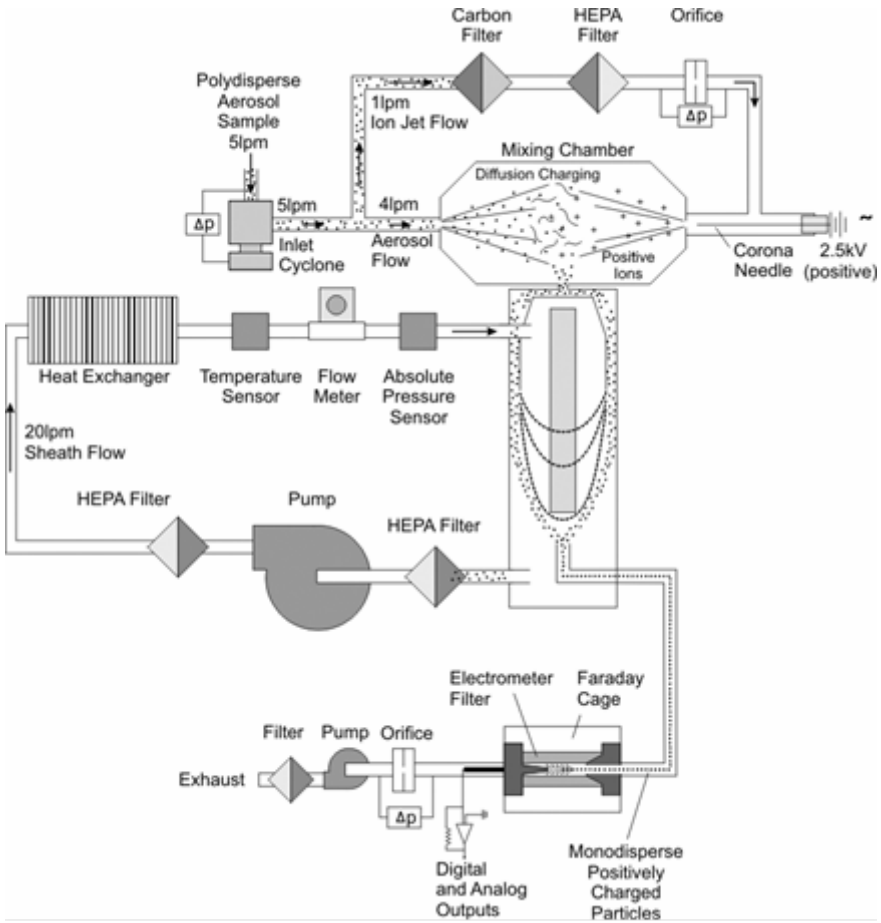


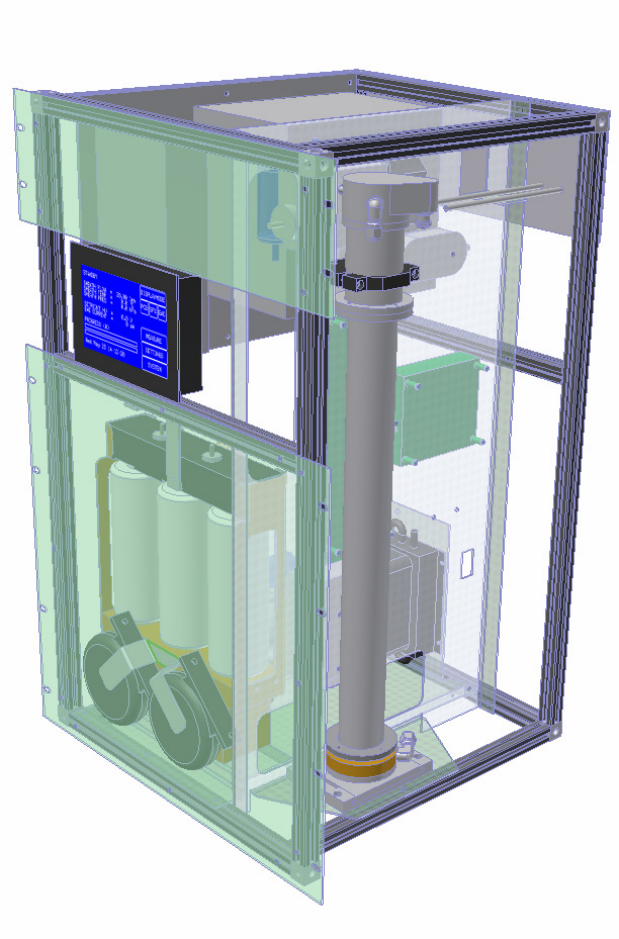
Calibration and inversion





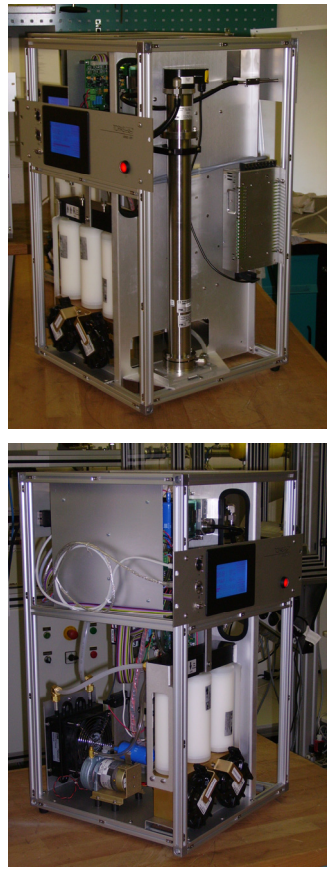
Conception for a new instrument setup





Instrument setup and details

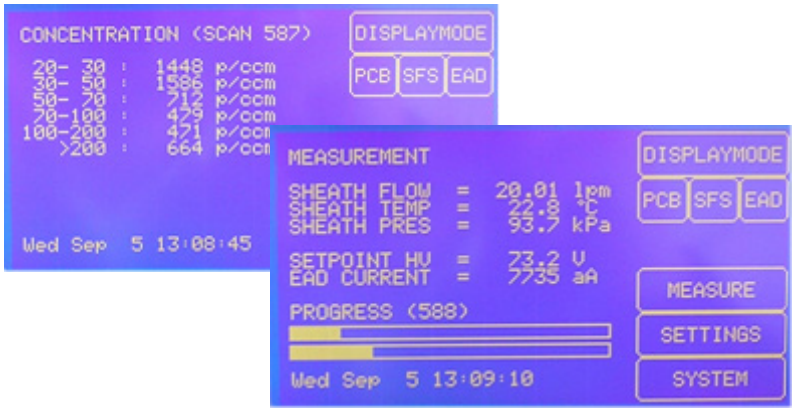
- Sampling inlet with cut-off at 500 nm
- Corona-based diffusion charger
- Long DMA (TSI 3081) with sheath air circuit
- Electrometer with control unit
- Central control unit (PCB) and single board computer for hardware control and data processing
- Database driven data storage

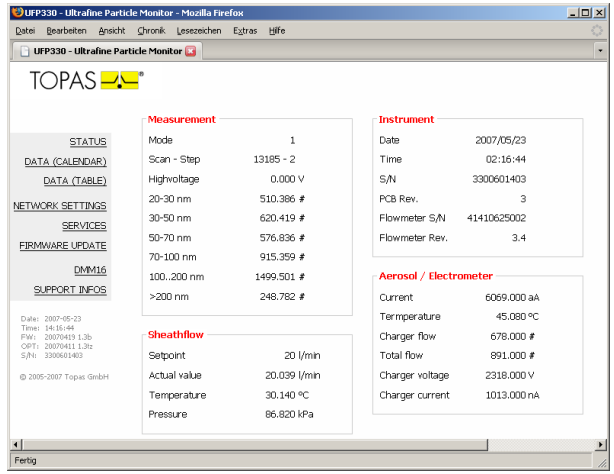


Instrument prototype with removed housing

Instrument control and data access

- Setup and information via touch panel
- Access via network
- Data exchange into customized spreadsheets
- Communication module for routine networks
- Individual protocols possible





Specifications

Dimension	16 SU 19" frame rack Height 710 mm, Depth 410 mm
Weight	32 kg
Power supply	88...264VAC 47-63Hz
Size range	20 - 500 nm
Size classes	>20 | >30 | >50 | >70 | >100 | >200
Min. conc. @ 20 nm	500 #/cm³
Min. conc. @ 200 nm	50 #/cm³
Ambient temperature	10 - 40 °C
Ambient humidity	0 - 90 % r.H., not condensing
Aerosol pressure range	900 - 1100 mbar
Time resolution	approx. 11 min
Sample flow rate	5 lpm
Sheath flow rate	20 lpm
Ports	Serial / Ethernet / USB

Installation and sampling system

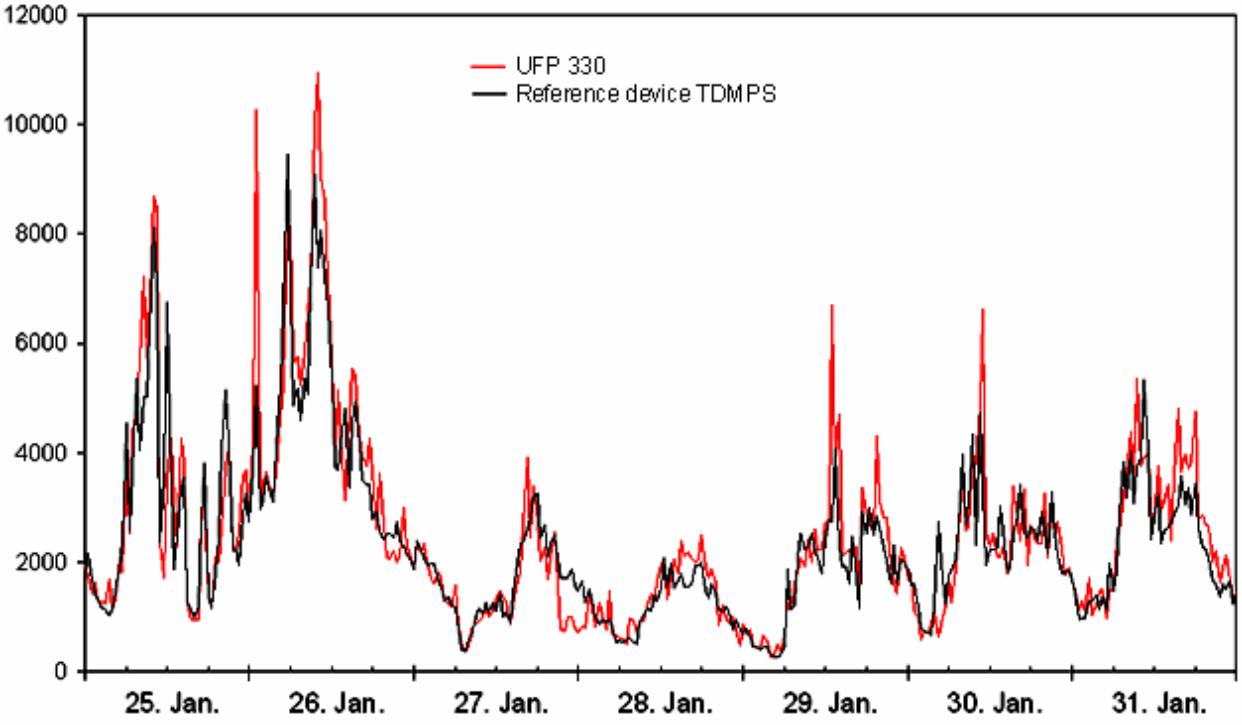
- Particular attention has to be paid to the sampling system
- PM1-inlet, a membrane dryer and an equalizing tank
- Membrane dryer requires no maintenance
- Induces only small particle losses

Size Class	%
20 - 30 nm	15.1
30 - 50 nm	8.6
50 - 70 nm	5.3
70 - 100 nm	3.5
100 - 200 nm	1.9
200 - 500 nm	0.9

Dryer particle loss

Some measurement results - comparison measurements

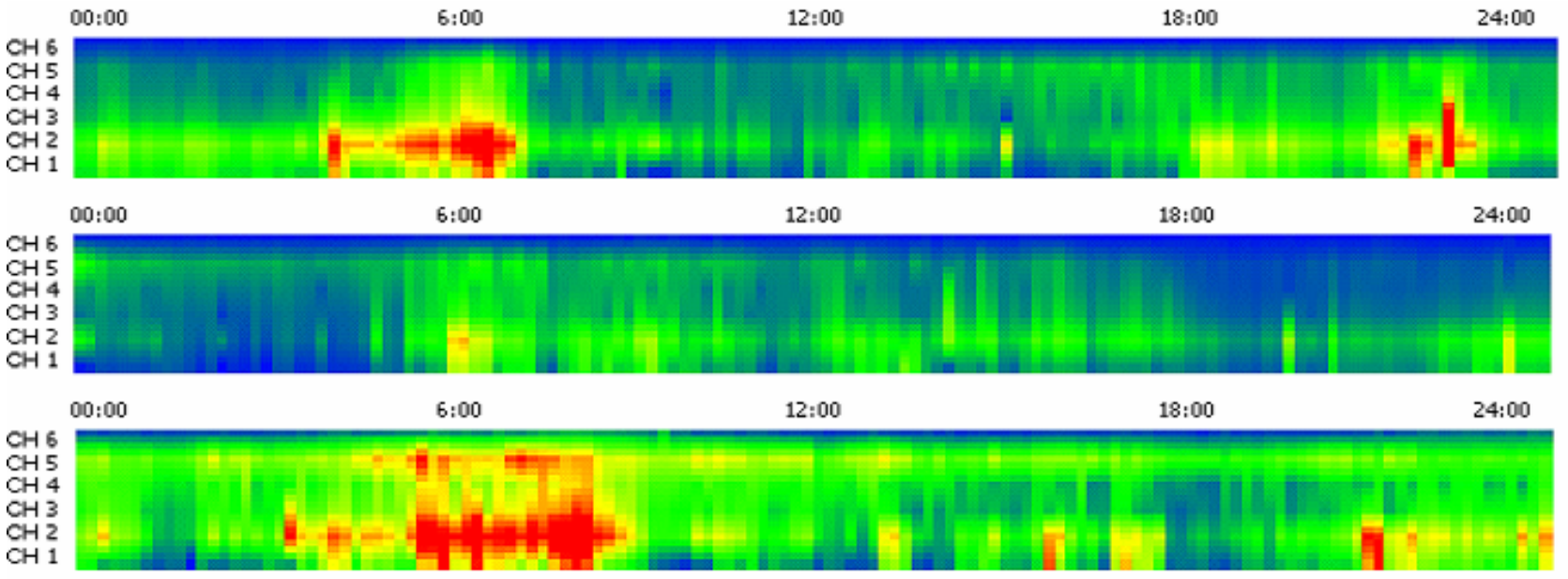
- Comparison with a twin DMPS in Dresden



Comparison measurement (particle size 50 – 100 nm)

Some measurement results – longterm measurements

Daily ultrafine particle distribution



User experiences from user view

- Long time periods without necessity of service
- Maintenance procedures are easy to perform
- High data availability
- High stability of measurements

- Reasonable correlation with reference devices
- Expected correlation with NO_x
- Same max and min with NO_x, soot concentration and traffic

Summary

- A new particle measurement system for environmental ultrafine particles has been designed.
- Four prototypes have been successfully set up and tested.
- They are working in different routine measurement networks all over Europe.
- Within the project UFIPOLNET the results will be compared and discussed.
- The current results show the applicability of measuring of environmental ultrafine particles in urban areas.

Acknowledgements and useful links

- With the contribution of the LIFE financial instrument of the European Community: No. LIFE04 ENV/DE/000054.

- Links

http://www.ufipolnet.eu

http://www.topas-gmbh.de

http://www.tsi.com

http://www.tropos.de

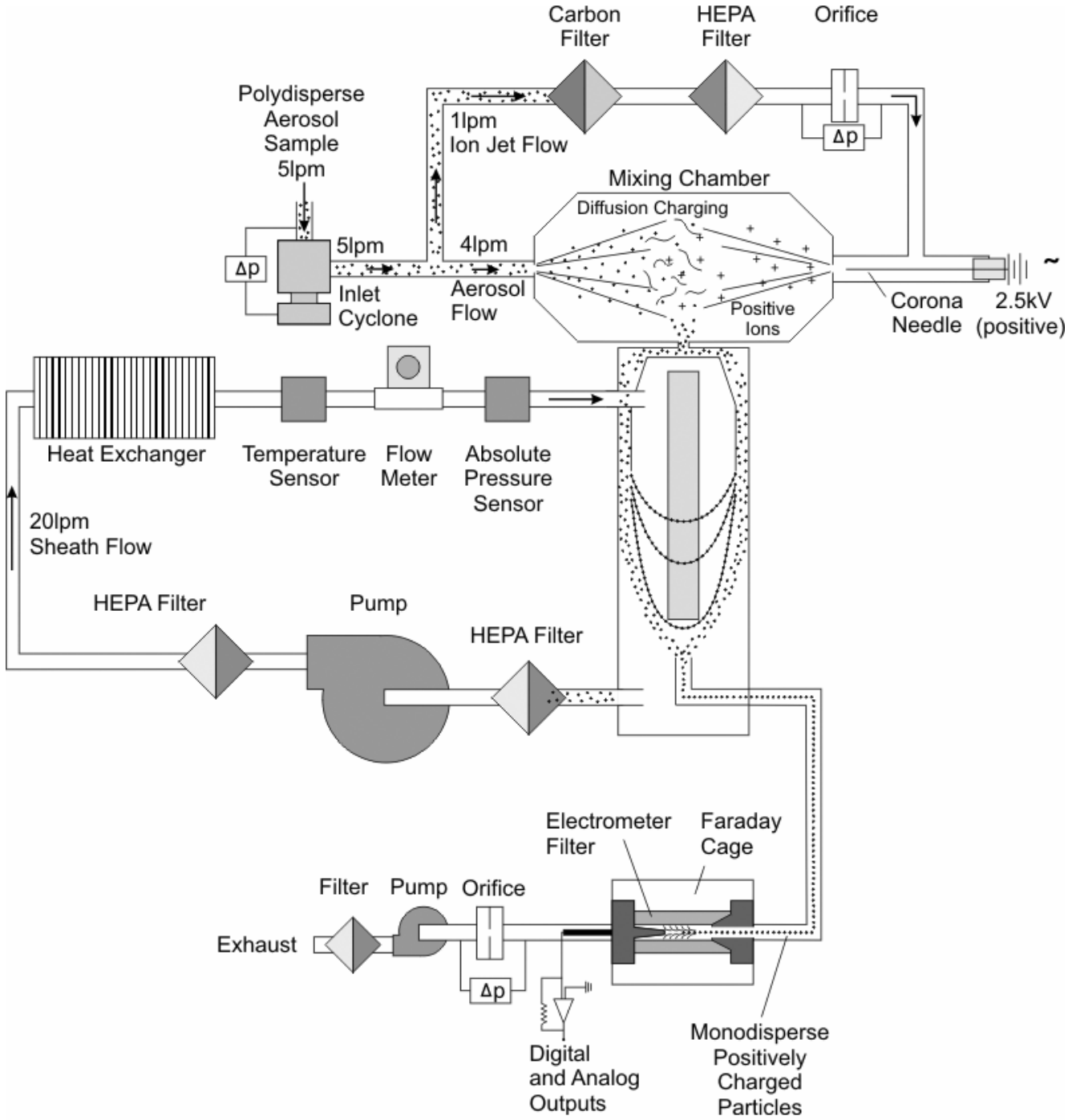
http://www.tu-dresden.de/mw/

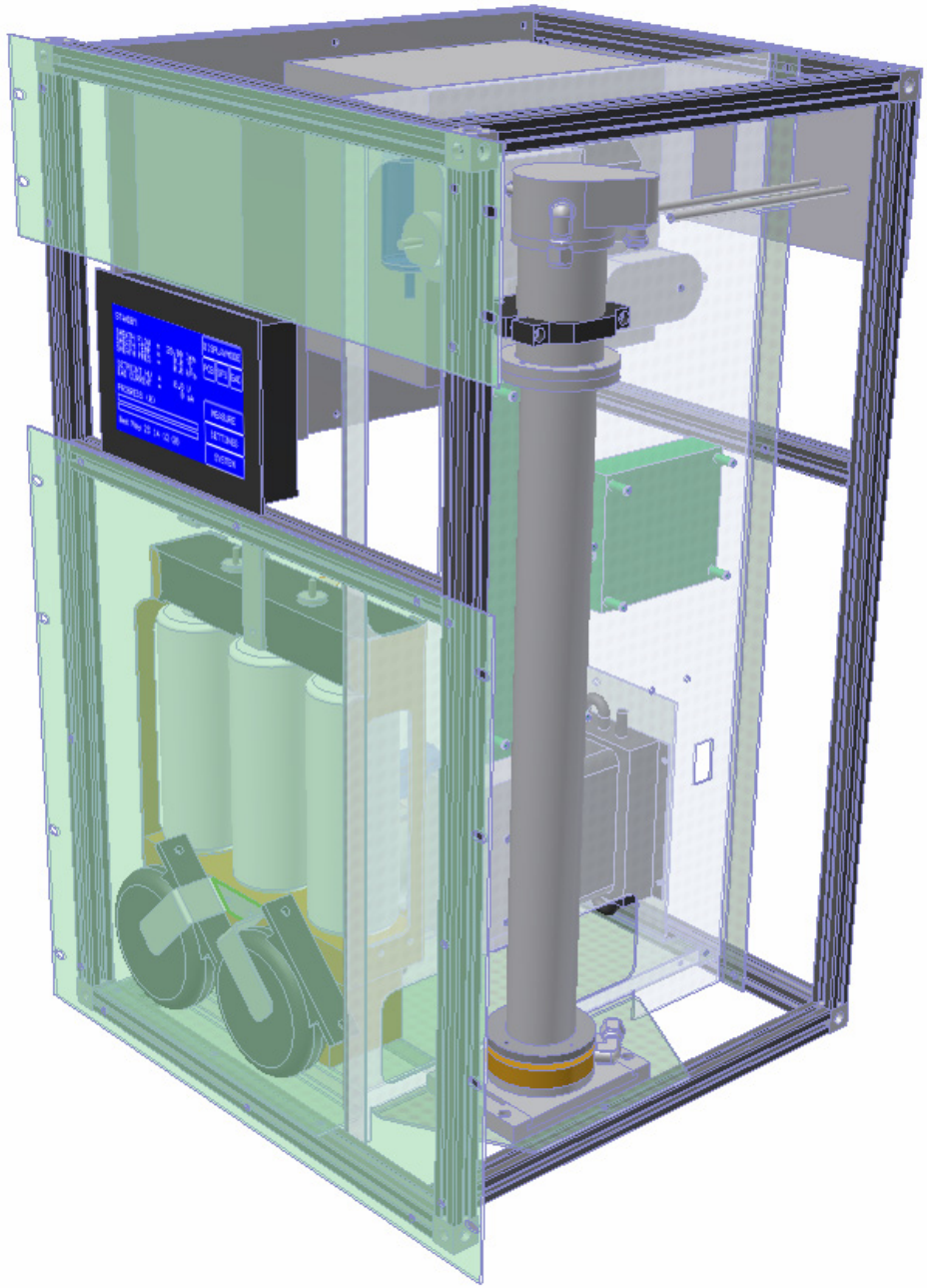
UFIPOLNET
ultrafine particle size distributions in air pollution monitoring networks

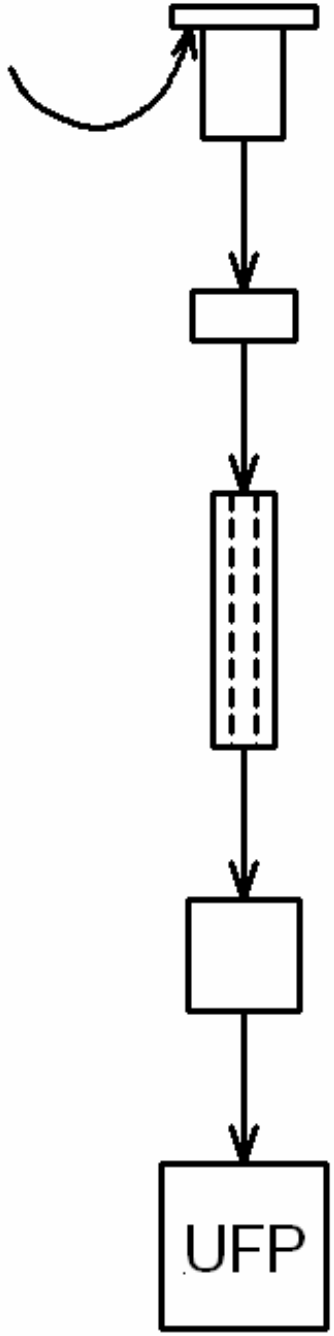
Related presentations

- L. Hillemann et al.:
  "Characterization of environmental ultrafine particles with the UFP 330, system calibration and evaluation"
- B. Wehner et al.:
  "Ultrafine particles: Comparisons UFP 330/ DMPS"

End of presentation.


Carbon Filter
HEPA Filter
Orifice
Polydisperse Aerosol Sample 5lpm
1lpm Ion Jet Flow
Δp
Mixing Chamber
Diffusion Charging
5lpm
4lpm
Δp
Inlet Cyclone
Aerosol Flow
Positive Ions
Corona Needle
2.5kV (positive)
~
Heat Exchanger
Temperature Sensor
Flow Meter
Absolute Pressure Sensor
20lpm Sheath Flow
HEPA Filter
Pump
HEPA Filter
Electrometer Filter
Faraday Cage
Filter
Pump
Orifice
Exhaust
Δp
Digital and Analog Outputs
Monodisperse Positively Charged Particles





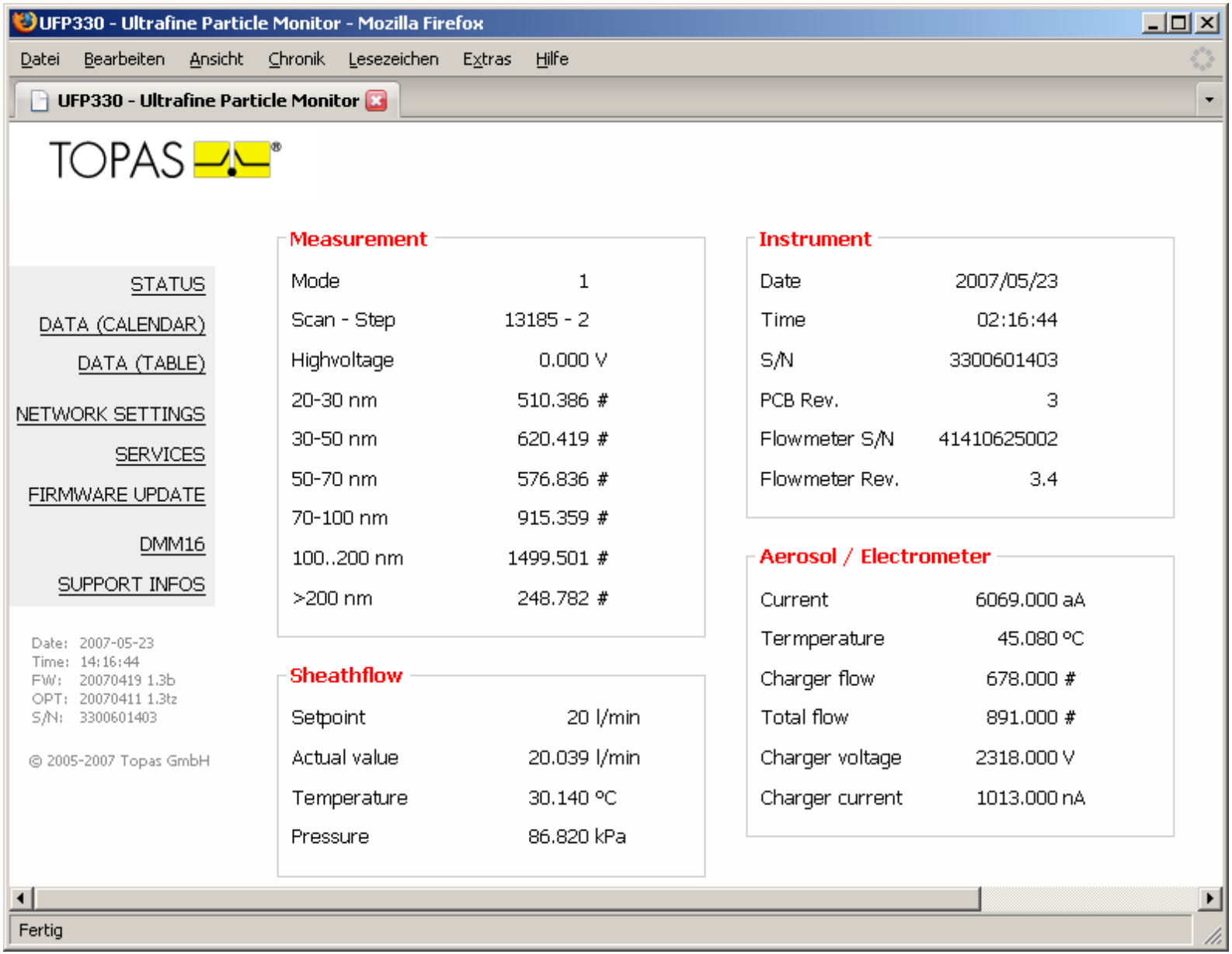
PM10-Inlet

PM1-Cyclone

Membrane dryer

Equalization tank (5 l)

Ultrafine particle sizer


UFP330 - Ultrafine Particle Monitor - Mozilla Firefox
Datei Bearbeiten Ansicht Chronik Lesezeichen Extras Hilfe
UFP330 - Ultrafine Particle Monitor
TOPAS
STATUS
DATA (CALENDAR)
DATA (TABLE)
NETWORK SETTINGS
SERVICES
FIRMWARE UPDATE
DMM16
SUPPORT INFOS
Date: 2007-05-23
Time: 14:16:44
FW: 20070419 1.3b
OPT: 20070411 1.3tz
S/N: 3300601403
© 2005-2007 Topas GmbH
Measurement
Mode 1
Scan - Step 13185 - 2
Highvoltage 0.000 V
20-30 nm 510.386 #
30-50 nm 620.419 #
50-70 nm 576.836 #
70-100 nm 915.359 #
100..200 nm 1499.501 #
>200 nm 248.782 #
Sheathflow
Setpoint 20 l/min
Actual value 20.039 l/min
Temperature 30.140 °C
Pressure 86.820 kPa
Instrument
Date 2007/05/23
Time 02:16:44
S/N 3300601403
PCB Rev. 3
Flowmeter S/N 41410625002
Flowmeter Rev. 3.4
Aerosol / Electrometer
Current 6069.000 aA
Termperature 45.080 °C
Charger flow 678.000 #
Total flow 891.000 #
Charger voltage 2318.000 V
Charger current 1013.000 nA
Fertig