



Long Term Monitoring of Ultrafine Particles in the Urban Atmosphere

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Cambridge Particle Meeting May 2008





Outline

- **Background**
- **The Challenge**
- **The Solution**



What are Ultrafine Particles?

- Ultrafine particles (UFPs) are airborne particles with diameters $< 0.15 \mu\text{m}$
- UFPs occur in large numbers, but essentially have no measurable mass
- Most common source in urban environment is vehicle exhaust
- UFPs make a significant contribution to urban smog

Why Monitor UFPs?



- UFPs not only degrade visibility, they also affect human health
- Current estimates of exposure to UFPs are hampered by our lack of knowledge of the spatial and temporal variability within urban areas
- To understand the exposure/response relationship to UFPs, it is essential to complement traditional measurements (PM_{10} and $PM_{2.5}$) by establishing networks to routinely monitor UFPs

Why Monitor UFPs?



“ While there is considerable toxicological evidence of the potential detrimental effects of UF particles on human health, the existing body of epidemiological evidence is insufficient to conclude on exposure/response relationship to ultrafine particles”

- World Health Organization, 2005



Why Monitor UFPs?

The European Perspective



- In 2005, European Union adopted the *“Thematic Strategy on Air Pollution”* as a consequence of the “Clean Air for Europe (CAFE)” program
- This strategy calls for member countries to increase their research activities, in the fields of atmospheric chemistry and the distribution of pollutants, and to identify the impact of air pollution on human health and the environment.
- It is therefore necessary to collect comparable data on UFPs at various European locations by adding UFP measurements in more and more air pollution monitoring stations

What is UFIPOLNET?



- UFIPOLNET: **U**ltra**F**ine Particle Size Distributions in Air **P**ollution Monitoring **N**ETworks
 - **EU-Life** sponsored project (2004-2008)
- UFIPOLNET's goal was to develop and field test an affordable, low maintenance UFP monitoring instrument
 - Partners include TSI, TOPAS GmbH, IfT, GSF, Saxon State EPA, University of Stockholm & Czech Hydro-meteorological Institute.
 - 4 prototypes are monitoring UFPs at 4 European locations since beginning of 2007 (project ends in April 2008)



UFIPOLNET Design Criteria

- **Long-term, unattended operation**
- **Low start-up and operating costs**
- **No working fluids; no radioactive source**
- **Efficient data management with remote access via the Internet**
- **Covers the size range of greatest relevance (20-500 nm)**
- **Six channels of size distribution data gives added detail**
- **Continuous monitoring with output every 10 minutes**
- **Accredited environmental sampling system**



So what is it?

- The UFP Monitor is designed for long-term, unattended monitoring of ultrafine particle concentration and size distribution in urban air and remote locations
 - Size range: 20 to 500 nm
 - Six channels of size resolution:
 - 20-30 nm, 30-50 nm, 50-70 nm, 70-100 nm, 100-200 nm and 200- 500nm
 - Provides continuous monitoring with reporting every 10 minutes



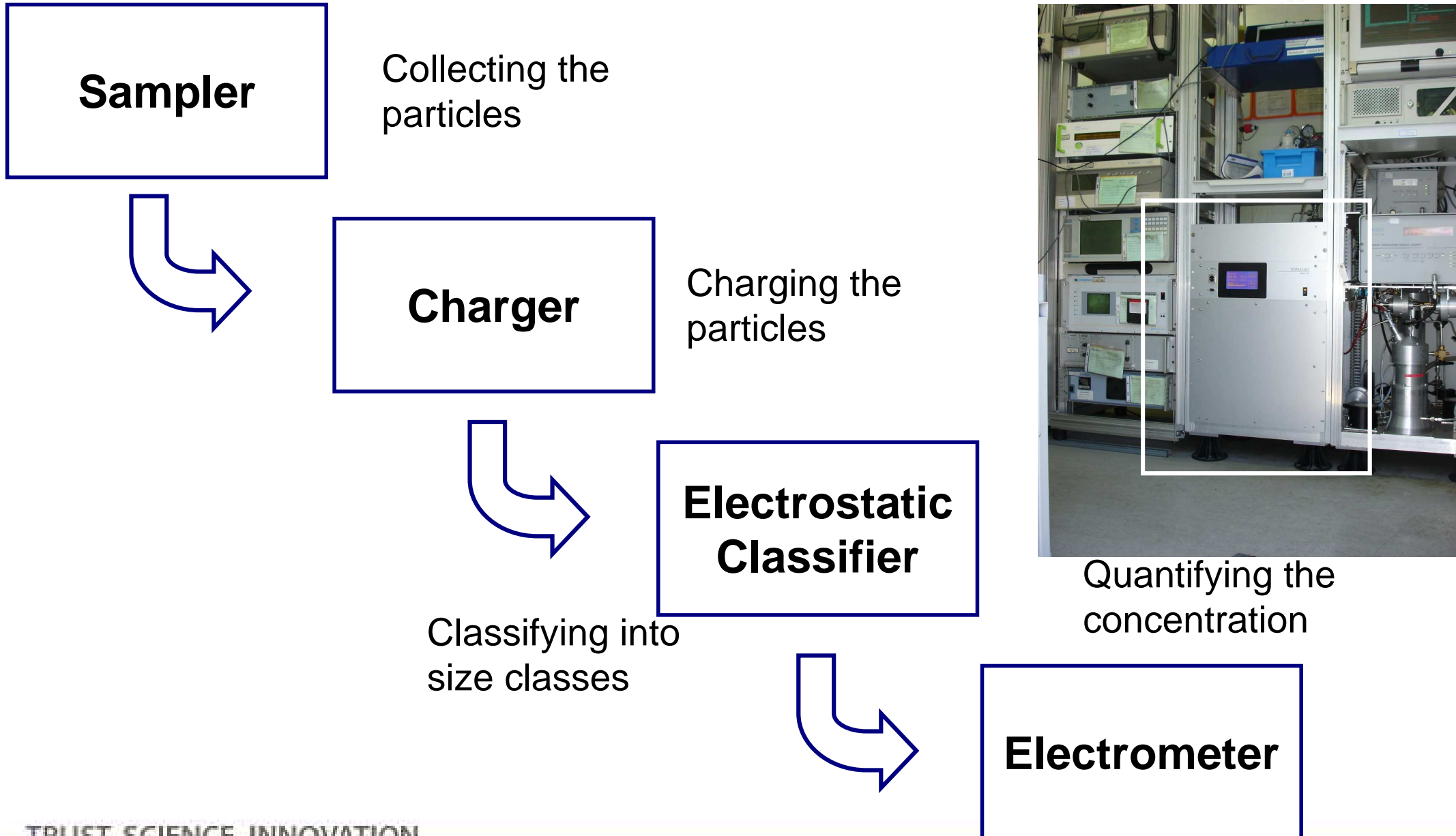
Ultrafine Particle Monitor



The UFP Monitor capitalises on existing TSI core technologies

- Unipolar particle charger (as used in the EAD 3070A)
- Long DMA column with recirculating flow system (as used in the Electrostatic Classifier Model 3080)
- Aerosol electrometer for particle detection (as used in the EAD 3070A)
- Accredited sampling systems are available

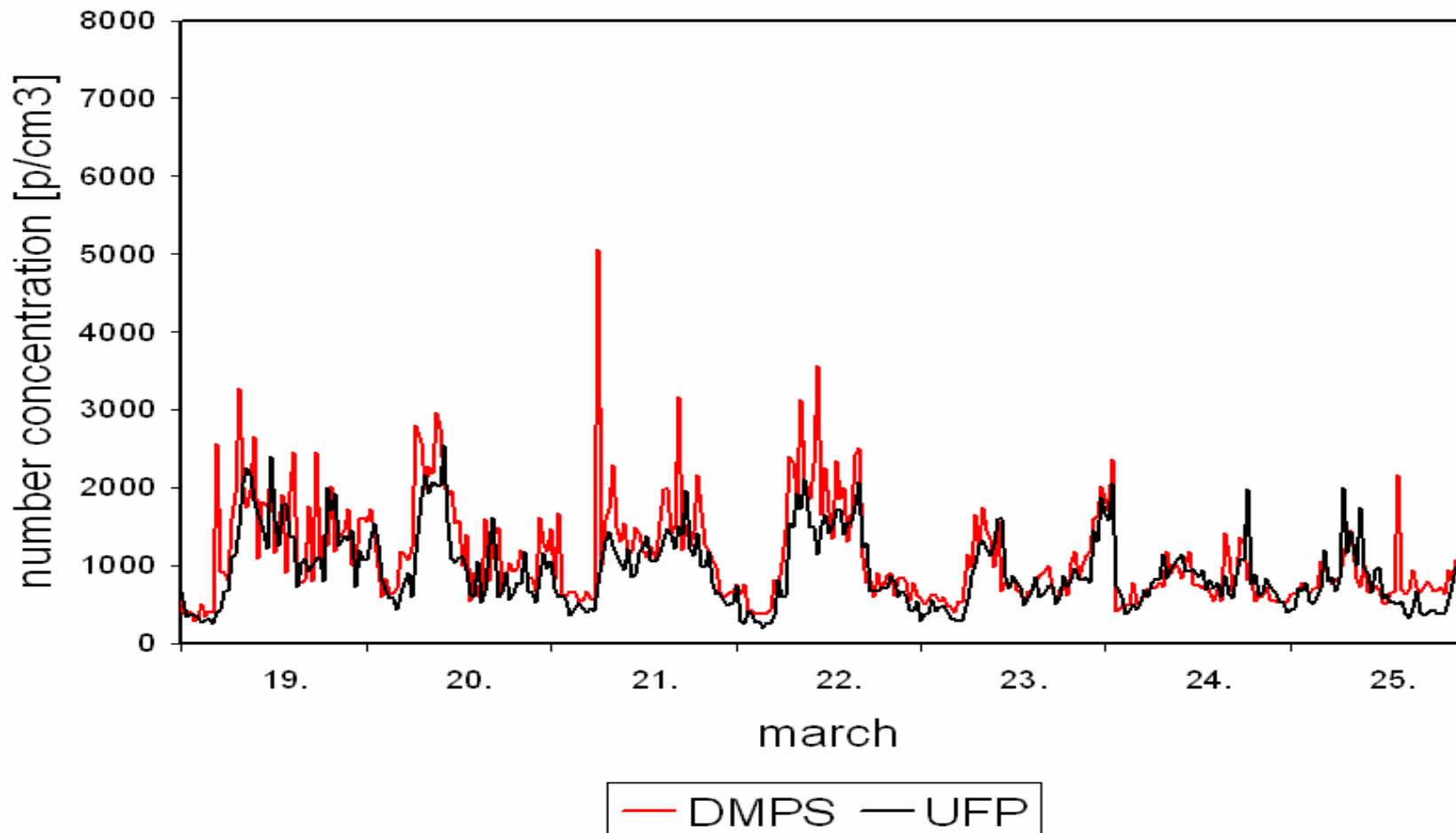
Principle of Operation





UFP Monitor Field Validation Data

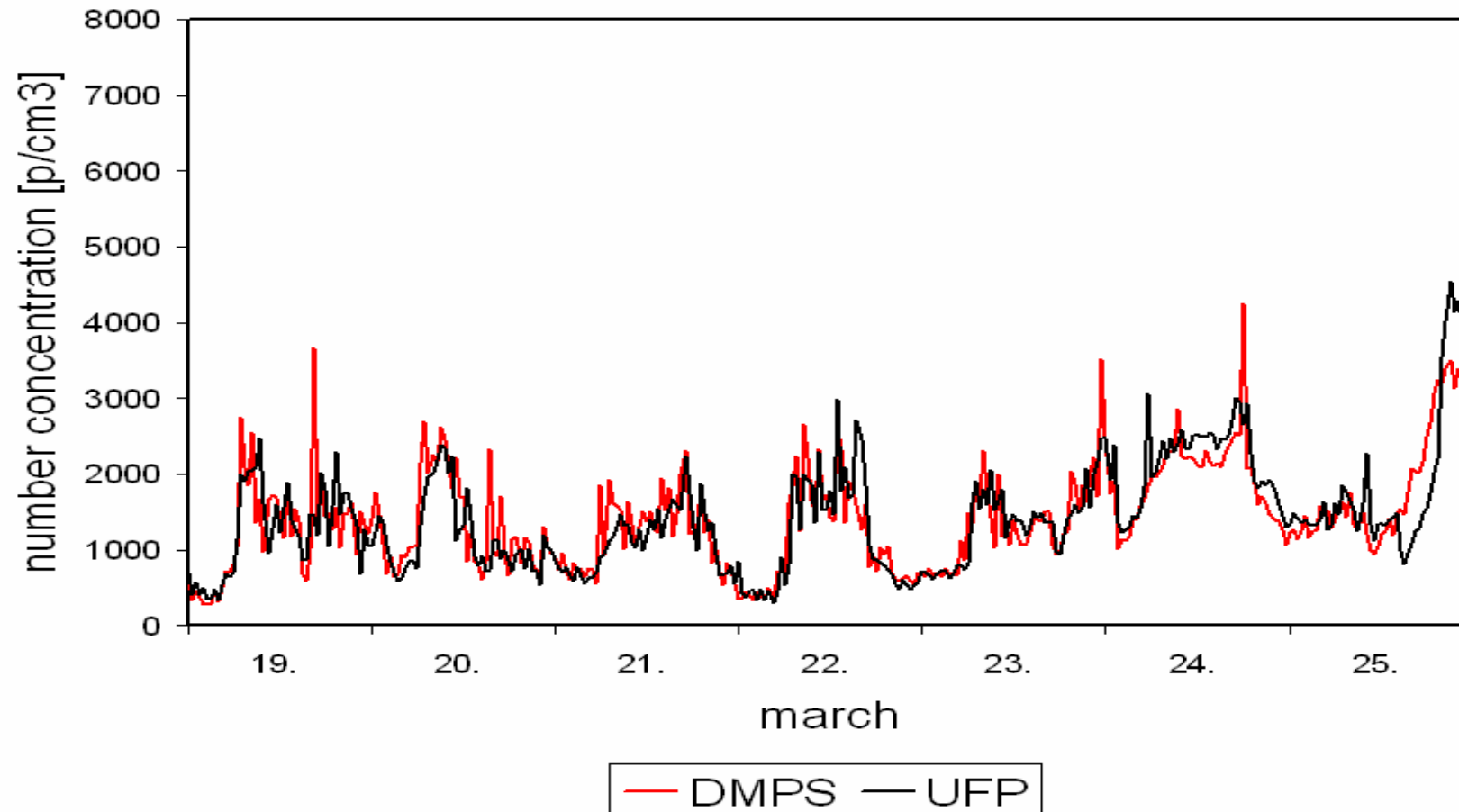
50 - 70 nm



UFP Monitor Field Validation Data



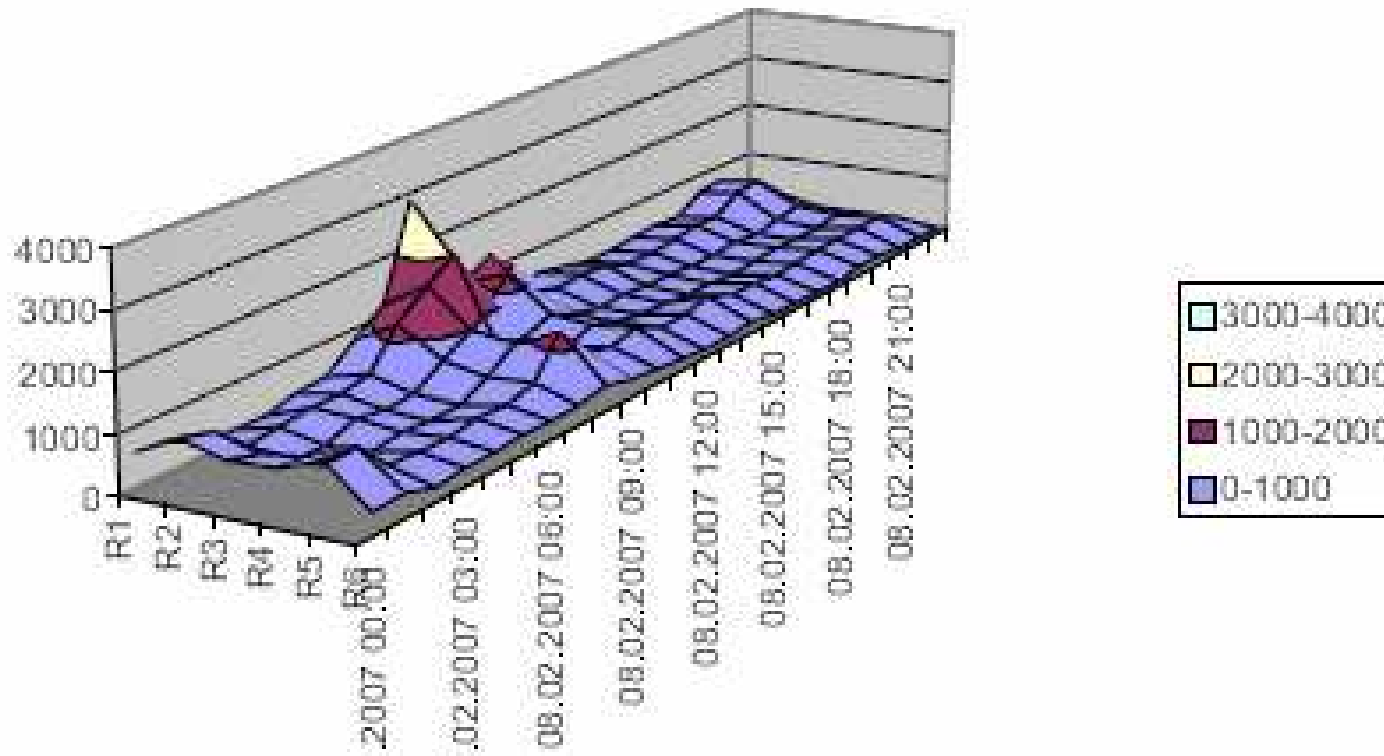
100 - 200 nm





Augsburg Data

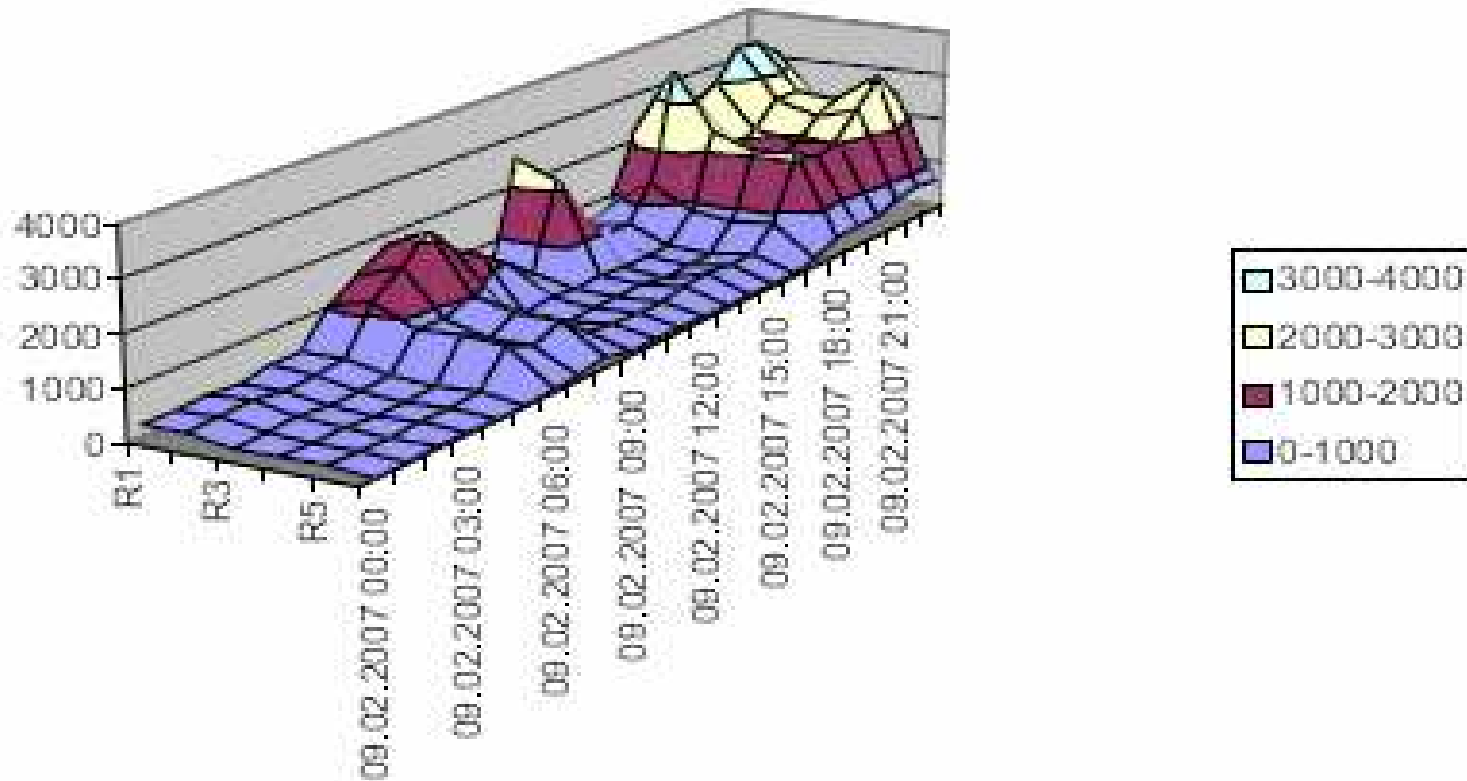
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Augsburg Data



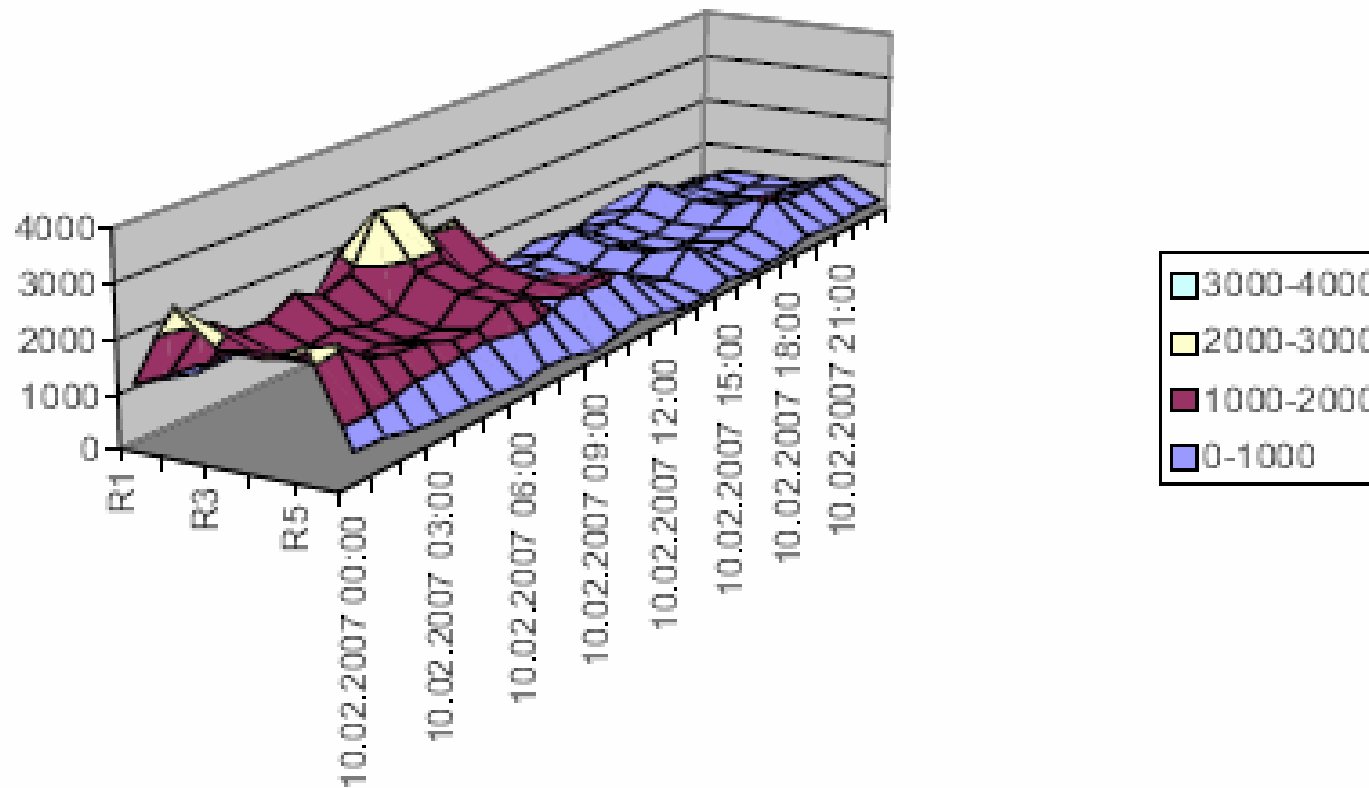
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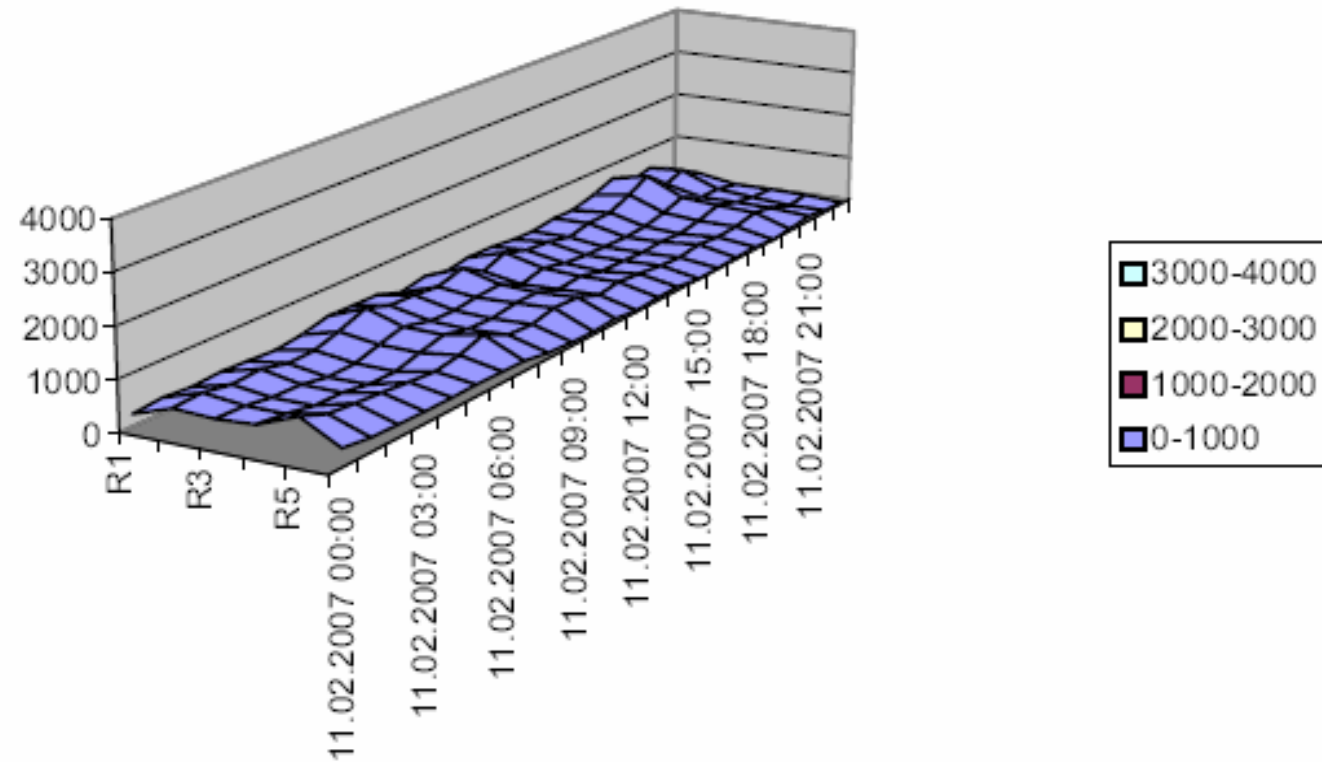
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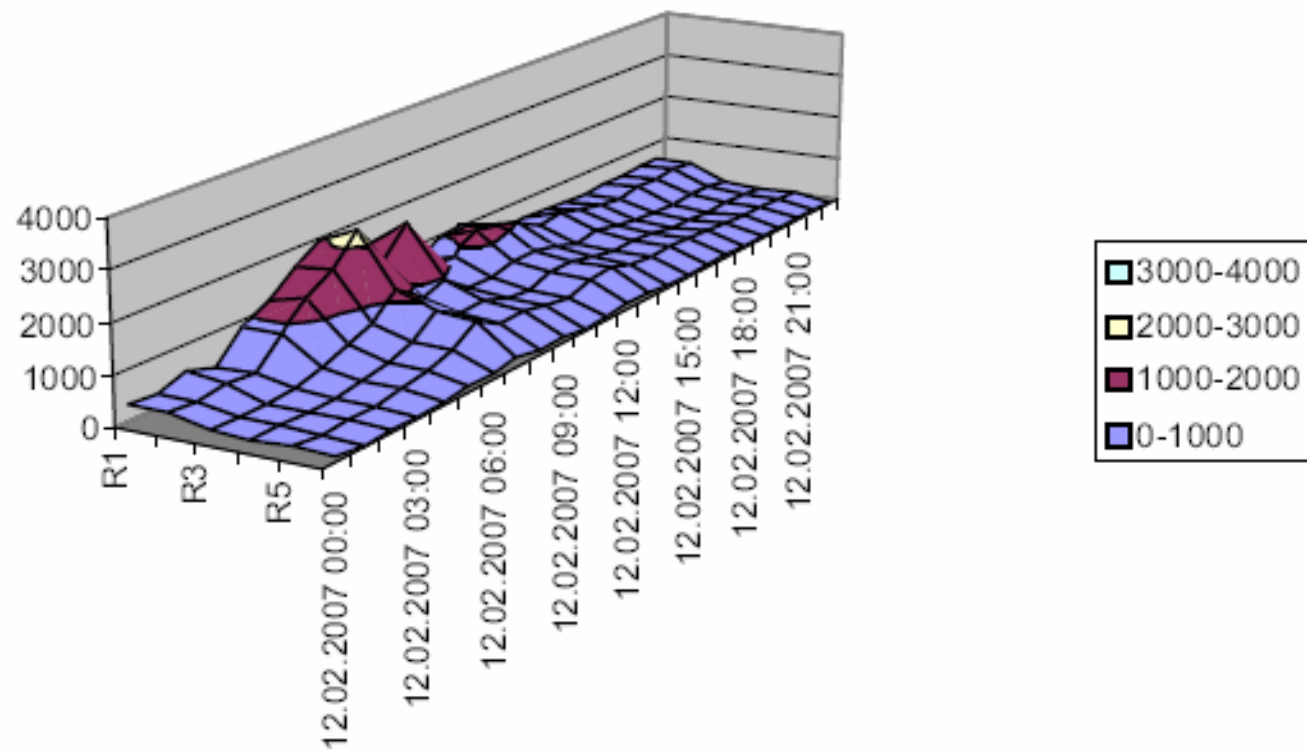
Sunday





Augsburg Data

Monday





What is available?

- Two Models of Ultrafine Particle Monitors
 - Model 3031 (19-inch rack mounted cabinet)
 - For easy installation and compatibility in monitoring stations
 - TSI Model 3031-1 (bench top cabinet)
 - For laboratory or mobile applications

The specification is the same, but the box is different!



3031 Internet Access

- **From INSIDE TSI**

Address: <http://10.1.17.10/status.htm>

- **From OUTSIDE TSI**

Address: <http://208.50.115.28/status.htm>

Annual Consumables



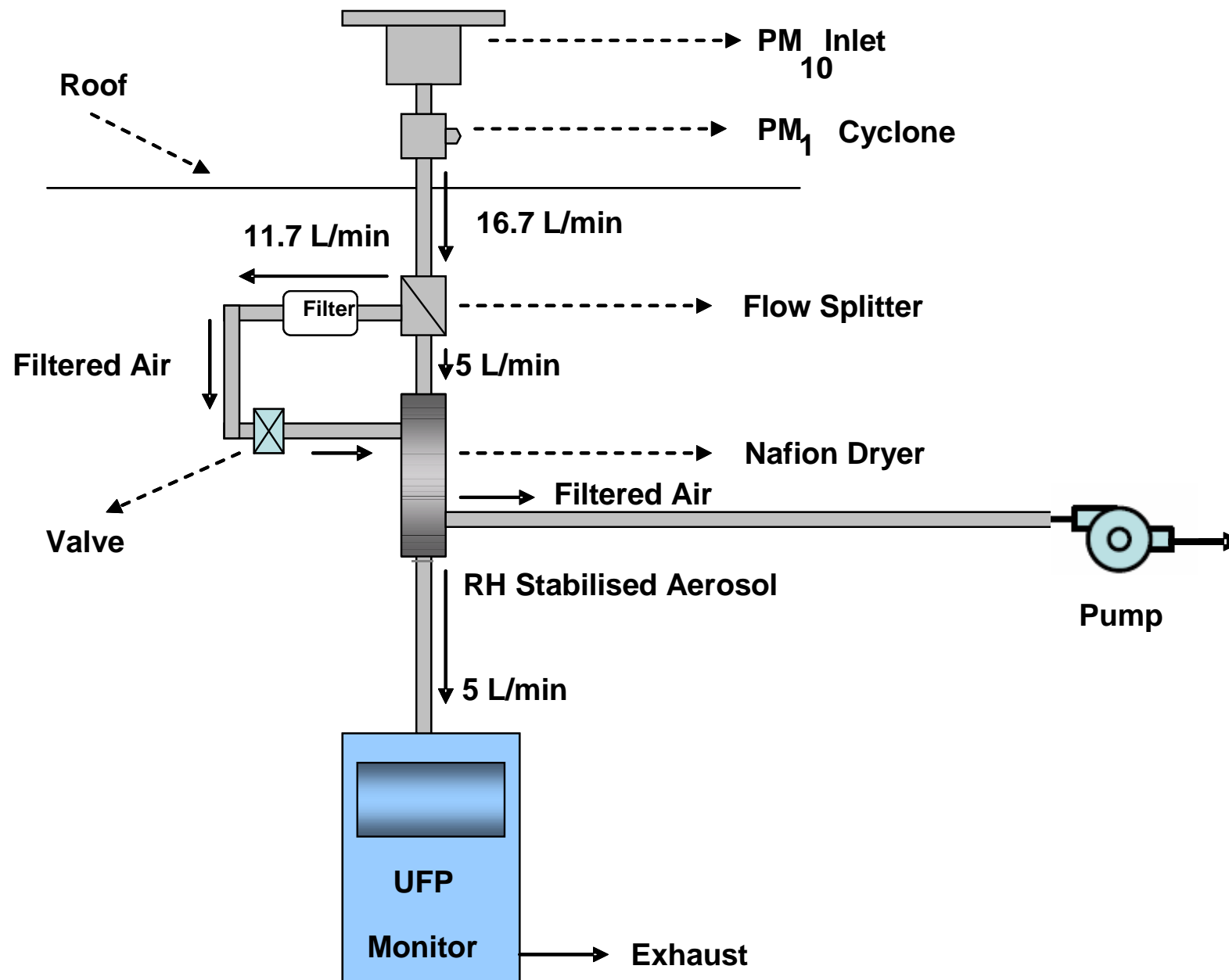
Description	Qty/instrument	Qty Annually
HEPA Capsule Filter	2	2
Balston DFU-BX Filter	2	2
Carbon Capsule Filter	1	4
Wire Core Micro-fiber Filter	1	1



Accessories

- Environmental Sampling System
 - Provides continuous sampling and conditioning of ambient ultrafine particles
 - **Standard PM10 inlet**
Provides standardised size-selective sampling of outdoor aerosol
 - **Sharp cut PM1 cyclone**
Removes large particles to avoid internal contamination of the UFP Monitor
 - **Isokinetic flow splitter**
Splits the inlet sample flow isokinetically to enable sub-sampling a portion of the flow into the particle measurement system
 - **Nafion® dryer**
Conditions the sample to remove effects of relative humidity on the aerosol
- Vacuum pump
- Flow Meter

Typical Field Setup of UFP Monitor



Everyone can download this....



The banner features a blue background with white clouds and several white stars, reminiscent of the European Union flag. In the top left corner, there is a white square containing a blue line graph and a small circle of stars, with the text 'UFIPOLNET' below it. The main text is arranged in horizontal bars: a yellow bar with '➤ ES LIEGT WAS IN DER LUFT...', a white bar with 'ULTRAFEINSTAUB - BÜRGERBERICHT DES EU-PROJECTS UFIPOLNET', a grey bar with 'THERE'S SOMETHING IN THE AIR... ⬅', and a dark blue bar with 'ULTRAFINE PARTICLES - CITIZENS' REPORT OF THE EU-PROJECT UFIPOLNET'. A small 'Life' logo is in the bottom right corner.

UFIPOLNET

➤ ES LIEGT WAS IN DER LUFT...

ULTRAFEINSTAUB - BÜRGERBERICHT DES EU-PROJECTS UFIPOLNET

THERE'S SOMETHING IN THE AIR... ⬅

ULTRAFINE PARTICLES - CITIZENS' REPORT OF THE EU-PROJECT UFIPOLNET

Life

UFIPOLNET: Concentration of Particle Number Distributions at 4 Stations in Europe



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WHY ULTRAFINE PARTICLES?

- Epidemiological studies show relationships between high concentrations of PM_{10} and adverse health effects, like heart attacks and premature deaths. It is suggested, that Ultrafine particles (UFP) are of importance in this context. The EU needs therefore more information about UFP concentrations within CAPE process and the Thematic Strategy on Air Pollution.
- Several studies show a decline of particle mass concentrations in Central Europe of TSP and PM_{10} since 1990. In contrast, particle number concentrations of ultrafine particles (< 100 nm = UFP) partly raised during winter periods 1991 – 1999 in Erfurt/Germany (Cyrus et al., 2002).
- Ultrafine particles are measured in only a few routine measuring stations in Europe.

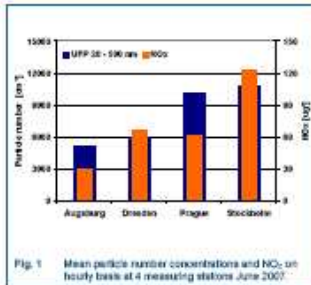


Fig. 1 Mean particle number concentrations and NCx on hourly basis at 4 measuring stations June 2007

OBJECTIVES

- Measuring Instrument for ultrafine particle size distributions (UFP 330 by TOPAS GmbH)
 - Affordable and easy to use under routine measuring network conditions
 - No butanol or radioactive wastes
 - 6 different size classes (UFP1 - UFP6)
 - >20 | >30 | >50 | >70 | >100 | >200 nm therefore reduced data amount
- Harmonisation of sampling conditions
- Measuring activities over 5 years
- Contact with interested groups, like CAPE-Working group and VDI



Fig. 2 Dresden: UFP 330, TOPAS (middle) and reference TDMPS, IPT (right)

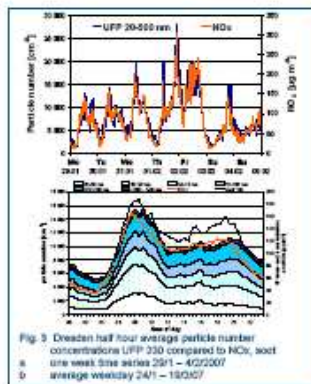


Fig. 3 Dresden: half hour average particle number concentrations UFP 330 compared to NCx, next one week time series 28/1 – 02/08/07
b average weekday 24/1 – 19/07/07



Fig. 4 The 4 Measuring sites

RESULT: UFP 330

- UFP 330 (Fig. 2) consists of a corona-jet-charger, a DMA, an electrometer (Hillemann et al., 2007)
- Same sampling system at all sites (0.5 μ m cyclone and membrane dryer), different data collecting systems and different communication protocols (Zechoppe et al., 2007).

RESULT: 4 STATIONS COMPARED

- UFP particle number concentrations + NCx (1 hour average) at 4 measuring stations in June 2007. (Fig. 1)
- Urban Background site Augsburg shows less, street canyon Stockholm shows twice as many particles as Dresden. NCx in Prague and Dresden show almost the same concentration, in Stockholm it was twice as much.

EVALUATION RESULTS

- Ongoing measurements since 12-2006 in Dresden, at the other 3 places since 02-2007.
- Comparing UFP 330 and TDMPS: In general, the correlation for the size classes UFP2 – UFP5 is higher than for the largest (< 200 nm) and smallest ($20 - 30$ nm) one. (Wehner et al., 2007)
- Correlation between total number concentration UFP 330 ($20 - 500$ nm) and TDMPS ($20 - 400$ nm) in Dresden (24/1 – 15/2/07) was good: $R^2 = 0.85$.
- Particle number concentration of UFP 330 to NCx in Dresden shows good correlation: $R^2 = 0.85$ (28/1 – 4/2/07) and therefore similar curves in a time series (Fig. 3a). A correlation with NCx indicates traffic influence (Blmll, 2006).
- The change of particle number concentration during an average weekday (24/1–19/3/07) shows the same pattern as NCx and coof (Fig. 3b).

MEASURING SITES

- Stockholm: Hornsgatan (street canyon)
 - Dresden: Schlesischer Platz (main crossing)
 - Prague: Strahovský tunnel (above tunnel exit)
 - Augsburg: Friedberger Straße (urban background)
- Three places are near busy roads, whereas the place in Augsburg is an urban background site (Fig. 4).

REFERENCES

- Cyrus, J., Heinrich, J., Peters, A., Kreyling, W., Wichmann, H. E. (2002). Umweltmed Forsch Prax., 7, 67-77.
Blmll, W. (2006). Editor: D. Batte; Forschungsbericht 203 43 257/05 UBA-FB 000943 ; UBA Texte 26 – 06, Umweltbundesamt, Berlin.

PARTNER

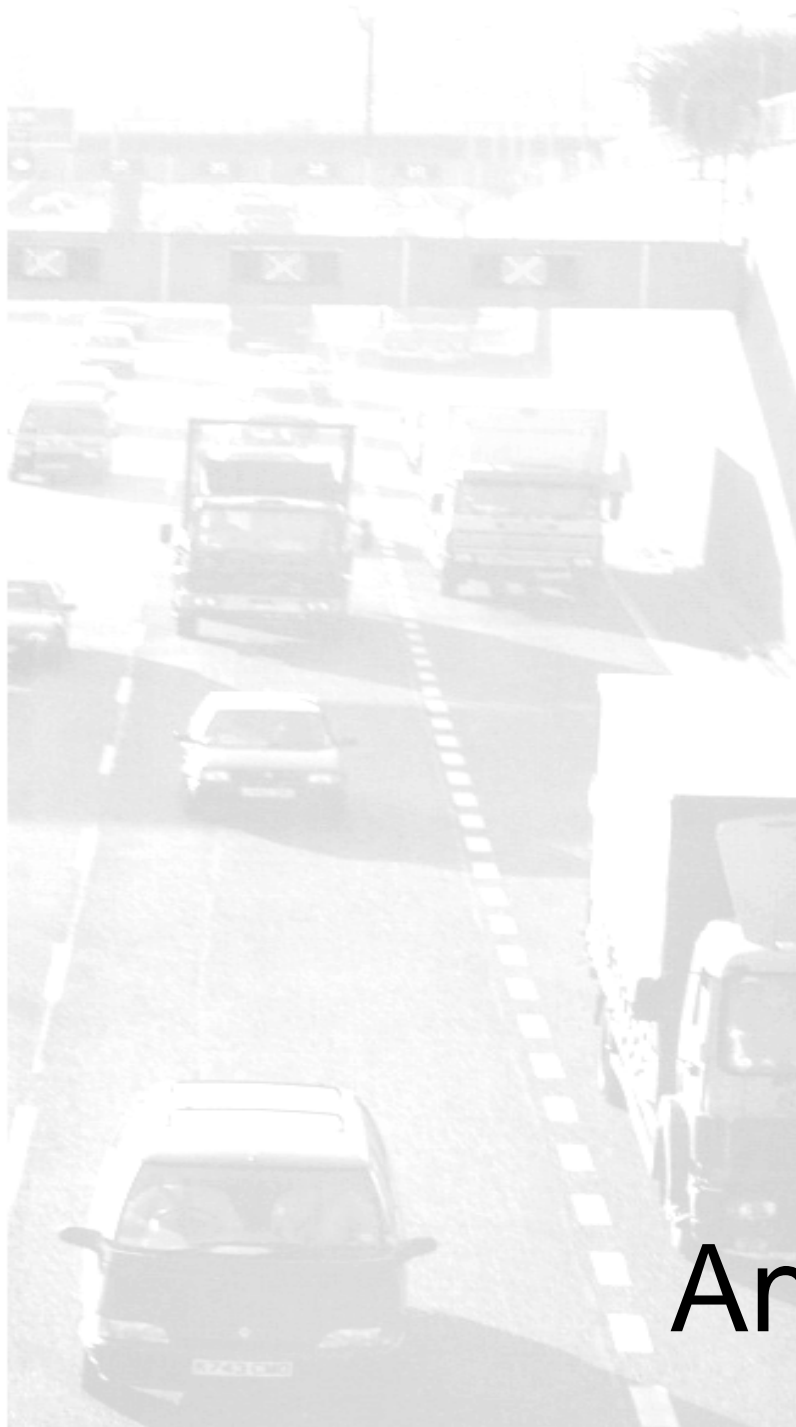


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conference: Ultrafine Particles in Urban Air 23 – 24-Oct-2007
Dresden/Germany
With the contribution of the LIFE financial instrument of the European Community – LIFE04 ENV/D/00054

RELATED POSTER + LECTURES

T18A202 B. Wehner et al., The new UFP 330: Comparison with a DMPS for ambient aerosols
T02A046, A. Zechoppe et al., A new conception for environmental measurement of ultrafine particles
T06A008 L. Hillemann et al., Aerosol mobility spectrometry based on diffusion charging



Thank you

Any Questions?