AirMonTech

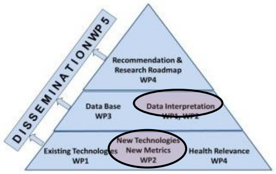
Trends in Instrumentation for Urban Air Quality Monitoring: New Devices and Metrics

U. Quass, T.A.J. Kuhlbusch, and AirMonTech Consortium

Current and future air quality monitoring
Barcelona, 25/26.04.2012

www.airmontech.eu

NEW TECHNOLOGIES – NEW METRICS & PROXIES



Approach:

- Science based reviews of metrics, detection principles and instrument performance
- Collection of manufacturer's and developer's information
- Input into the database

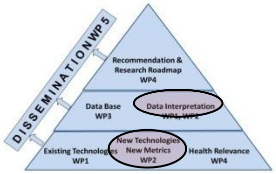
Metrics in AirMonTech database

- MBI: Metric Basic Information
- MMTO: Metric Measurement Technology Overview
- MMTI: Metric Measurement Technology Information

PM	PM	Gases	Gases
Number concentration	Ammonium	NO	Benzene
Size distribution	Mineral Ions (Ca, Mg, K, Na, Cl)	NO2	VOCs
Surface concentration	Elemental carbon	NOx	PAHs
Shape, morphology	Organic carbon	SO2	Mercury
Mass concentration	Light absorbing aerosols	O3	MultiGasAnalysers
Non-C-elemental composition	Reactive oxygen species	NH3	
Molecular composition	Macrophage mobility decrease	HNO2	
Mercury	Polycyclic aromatic hydrocarbons	HNO3	
Sulfate	Primary biological aerosol particles	CO	
Nitrate			

AirMonTech WP2

NEW TECHNOLOGIES – NEW METRICS & PROXIES



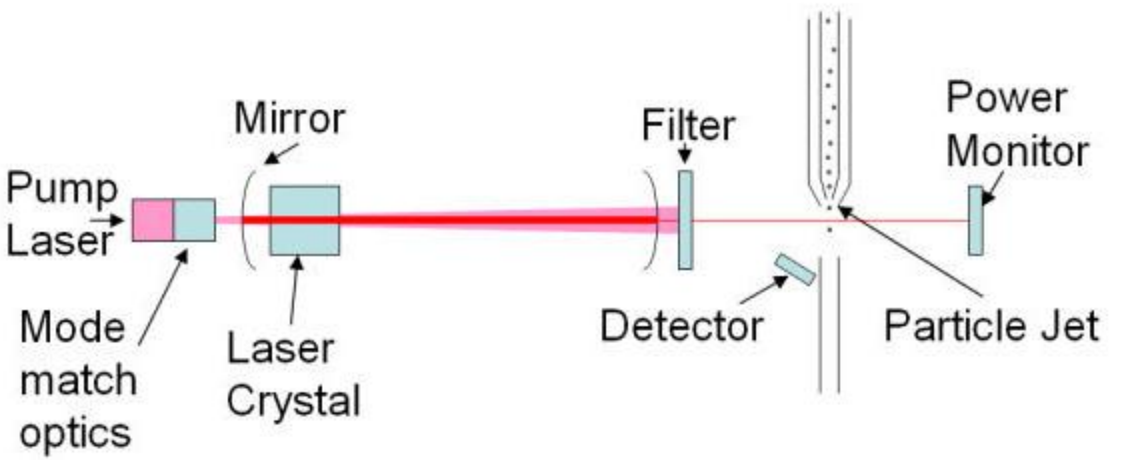
Approach:

- Science based reviews of metrics, detection principles and instrument performance
- Collection of manufacturer's and developer's information
- Input into the database
- Evaluation of trends and options

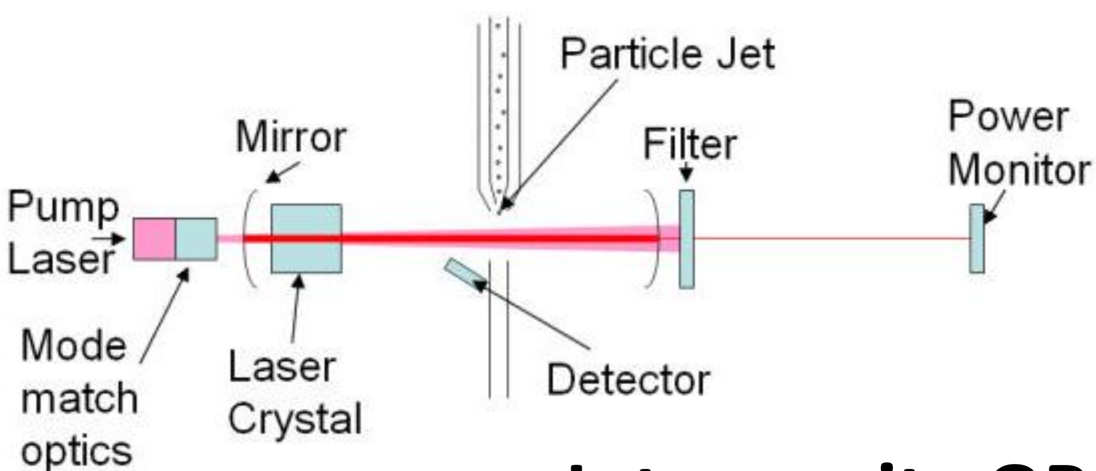
Major trends in instrumentation

- Improved performance by
  - new techniques
  - higher time-resolution

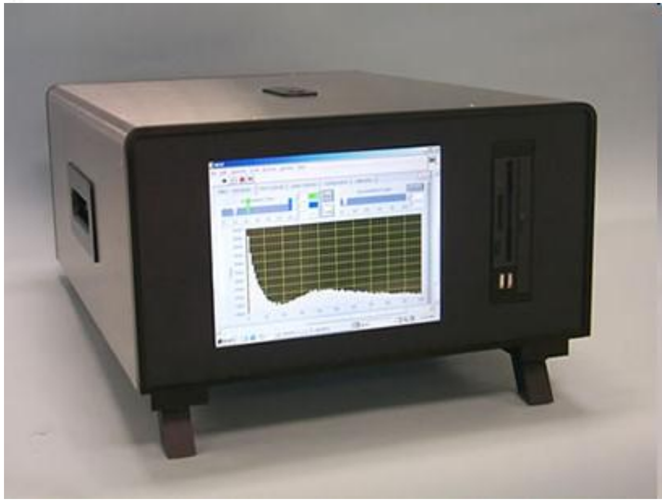
Improved performance: New technique



Standard OPC



Intra-cavity OPC



http://www.dropletmeasurement.com/

Sketches from http://www.cas.manchester.ac.uk/restools/instruments/aerosol/opc/

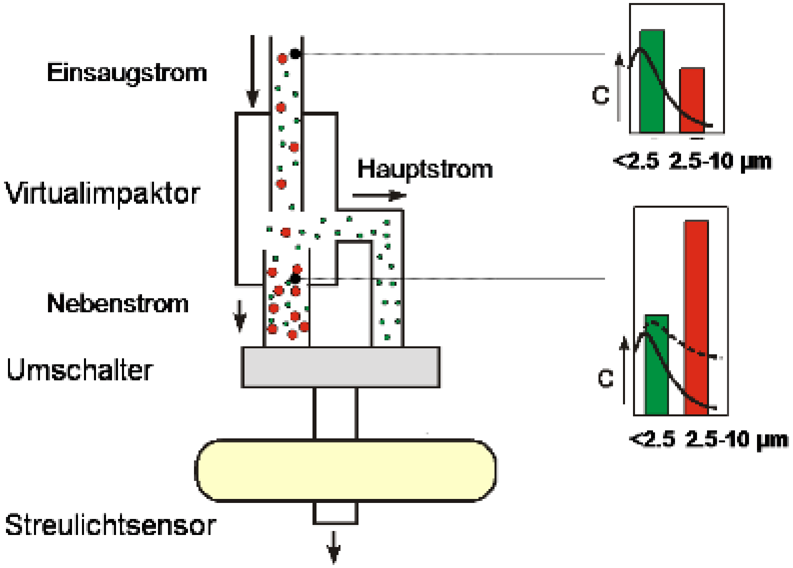
Improved performance: Real-time data

SHARP (Thermo)
Mass
Nephelometry + ß-Absorption

EDM 180 (Grimm)
Mass, size distr. 31 ch.
Light Scattering
(Nephelometer)

FIDAS (Palas)
PNC, Mass
(PM1, 2.5, 4, 10, TSP)
LED light scattering

APM2 (COMDE)
Mass PM2.5/10
Light Scattering
(Nephelometer)



Major trends in instrumentation

- Improved performance by
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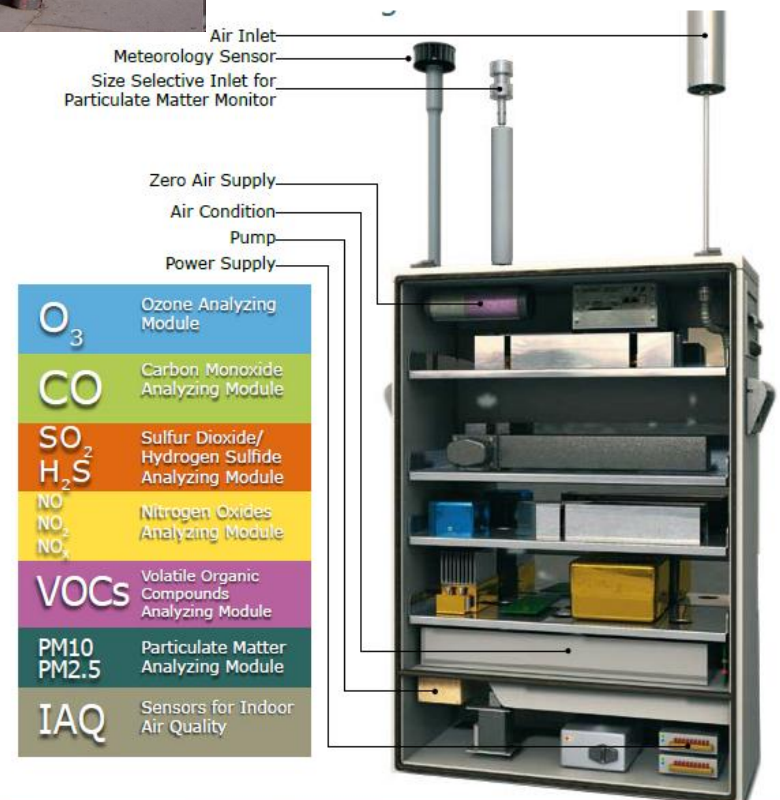
  - higher time-resolution
- Miniaturisation
  - Compact monitoring „stations“
  - Handheld detectors and microchip sensors

Compact Monitoring Stations

AirPointer

http://www.recordum.com



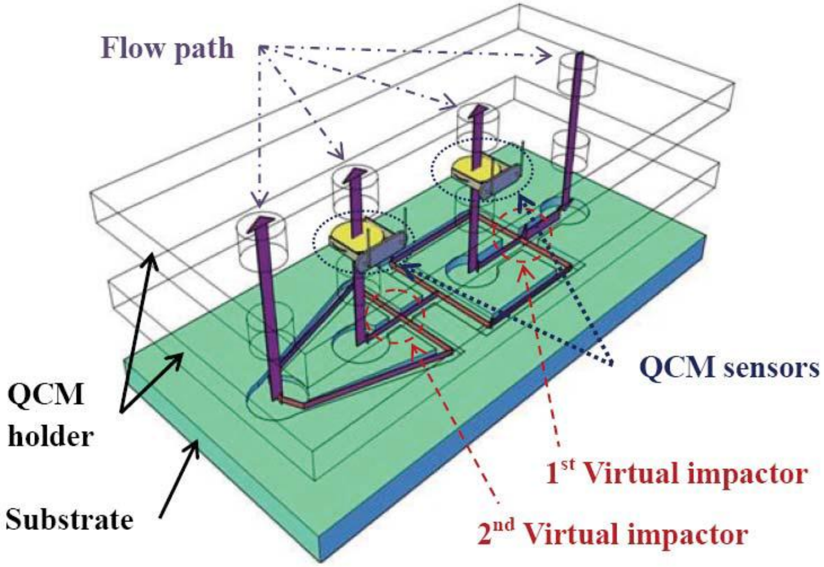
Aeroqual
AQM 60

http://www.aeroqual.com/

Miniaturisation

NanoTracer (Philips)
PNC, av. dp

MicroAeth (Magee)
BC in TSP, PM2.5



Quartz Crystal
Microbalance
Sensor
PM mass
Liang et al.
Sensors **2010**:3641-3654

Handheld CPC (TSI)
PNC 10->1000 nm

DiSCmini (Matter Engineering)
PNC/LDSA(alveo.)
10-300 nm modal

FIDAS mobile (Palas)
PNC, size-distr. (32ch/decade)
0.2-18 µm
PM10/4/2.5/1

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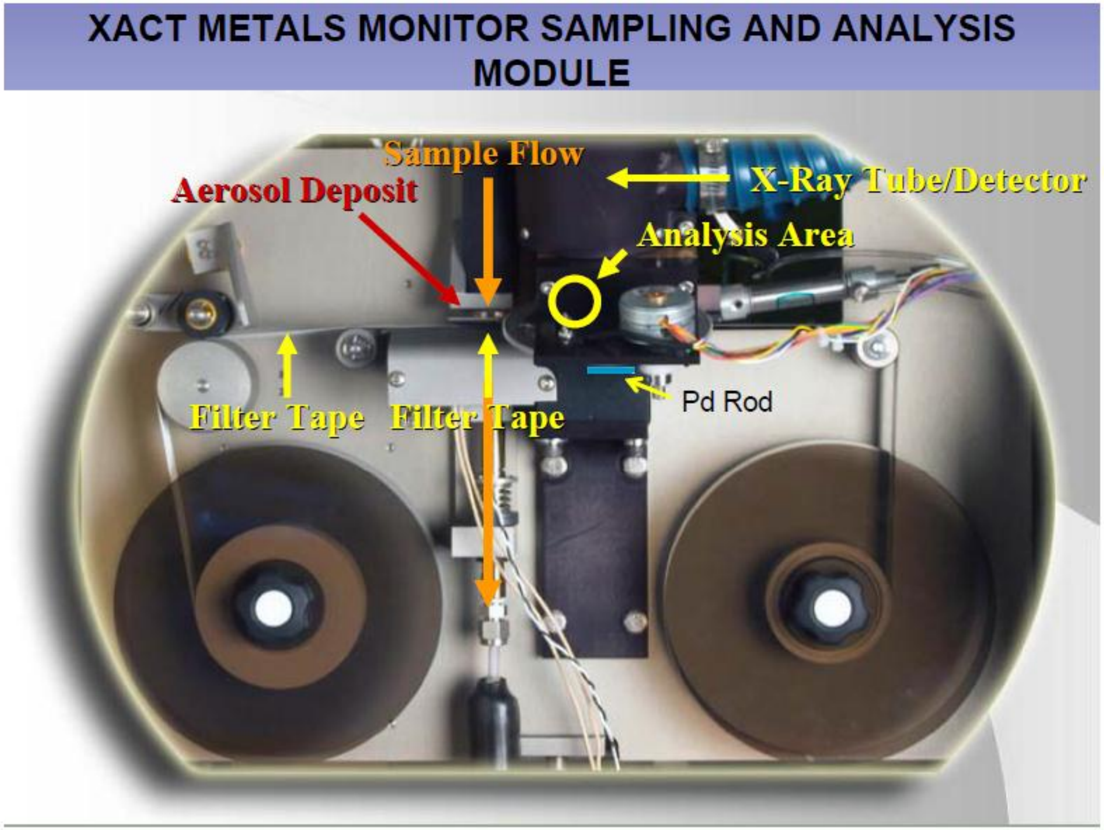
  - for particles (elements, organic matter, solubles) and gases

Multi-component detection 1: XRF

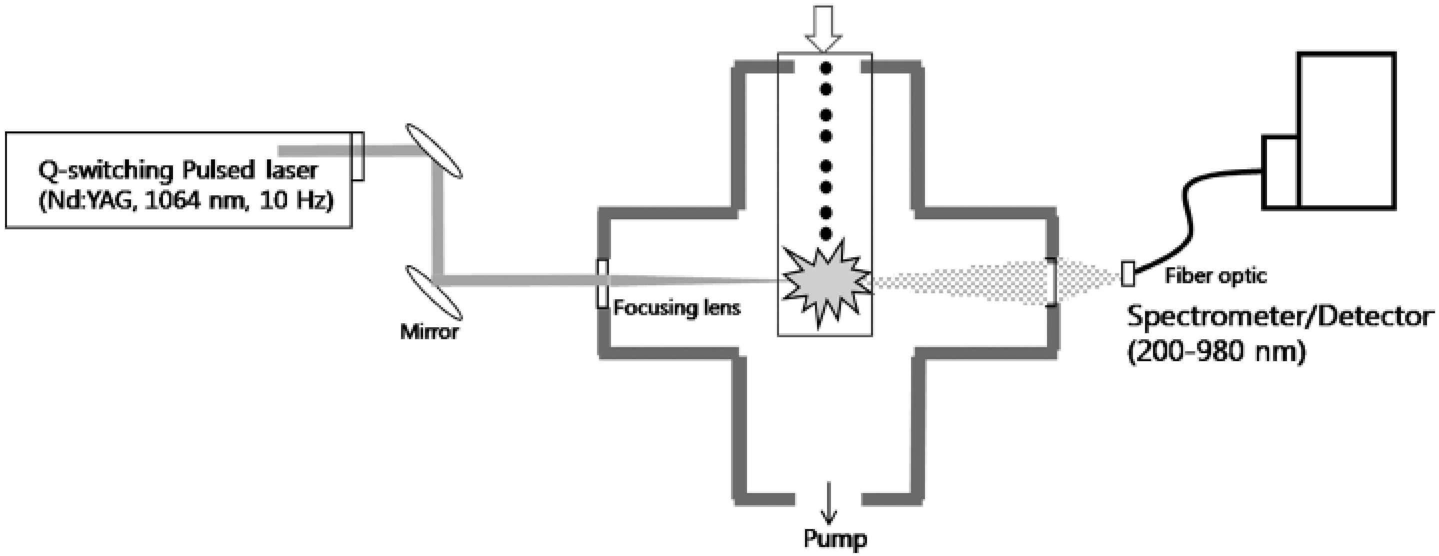
1 m³/h,
PM10, 2.5, TSP

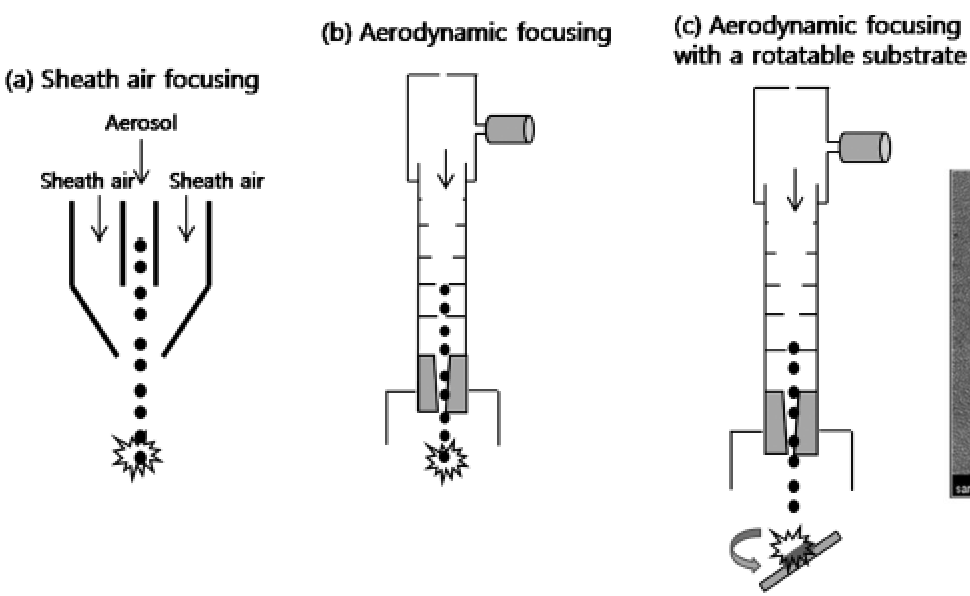


XAct 620 Ambient Metal Monitor (**Pall Corp.**)
Up to 36 elements, 15-240 min., DLs down to <<1 ng/m^3

http://www.pall.com/main/OEM-Media-Membranes-and-Materials/Product.page?id=54499

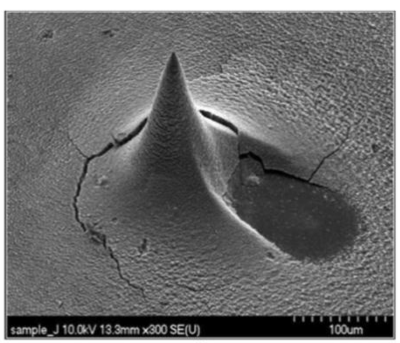
Multi-component detection 2 : LIBS

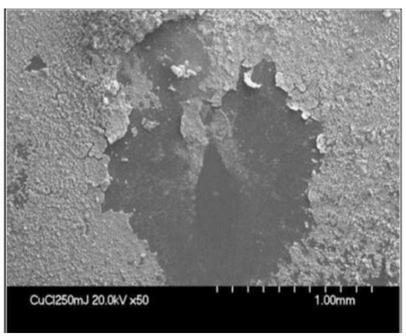




5 min sampling, dp(min) ~ 60 nm

LOD (Cu, dp ca. 100 nm): ~ 80 ng/m³

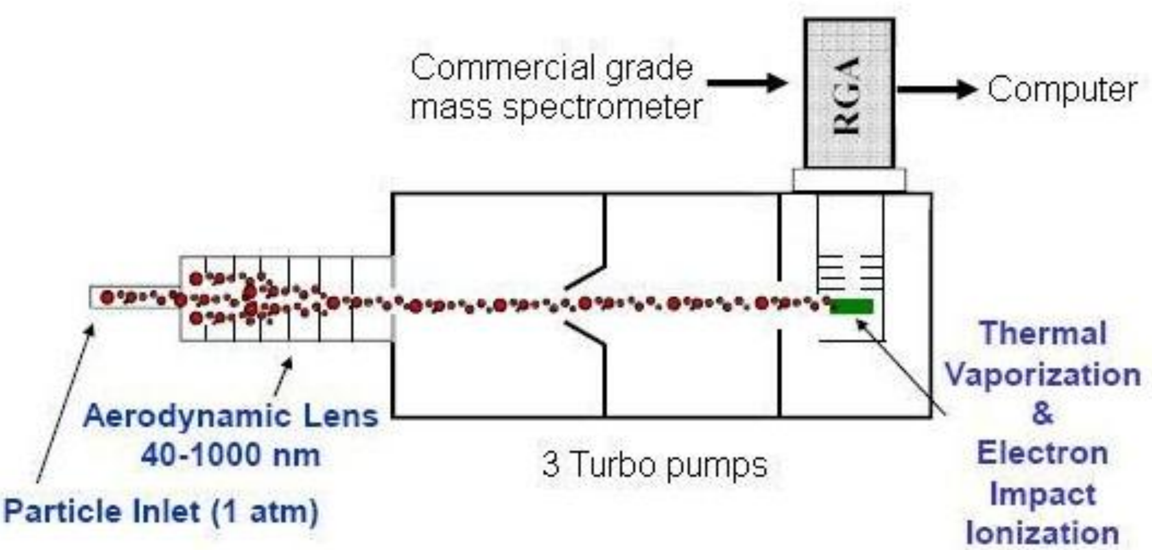


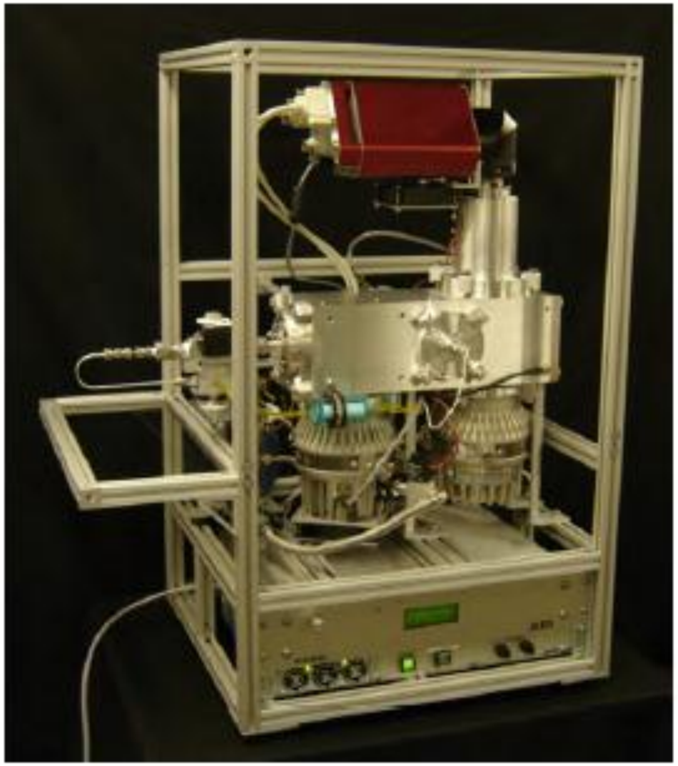


Park, K. et al., Aerosol Science and Technology, 43:375–386, 2009

Multi-component detection 3: ACSM

http://www.aerodyne.com/products/aerosol-chemical-speciation-monitor
http://cires.colorado.edu/~jjose/ams.html





L.N. Ng et al.: Aerosol Science and Technology, Volume 45 (2011) , pp. 770-784(15)

No size data as in AMS, with Quadropole: 0-200 amu range

In development:
ccTOF-ACMS with higher mass range, higher time resolution, higher sensitvity

Example for ACSM field Data:

Y. L. Sun et al., Atmos. Chem. Phys. Discuss., 11, 25751–25784, 2011

Multi-component detection 4: IC

Water soluble gases and/or particle compounds

PILS-IC

Taken from Metrohm web site

URG 9000 IC

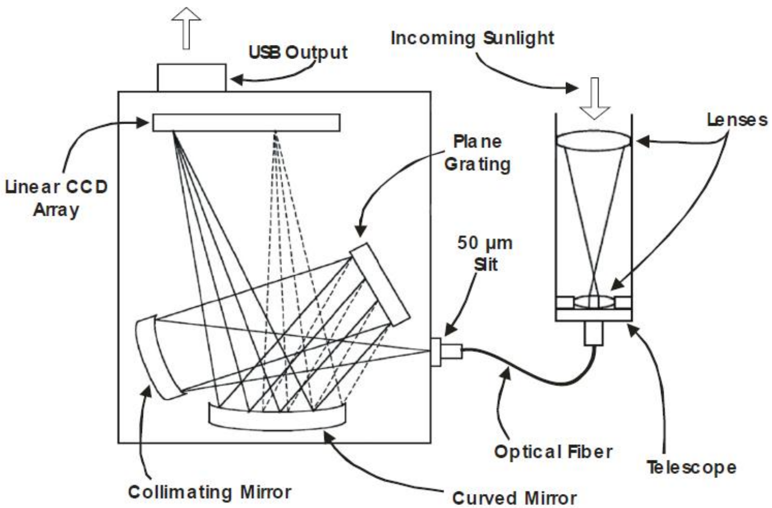
Taken from URG web site

MARGA

Taken from Applikon web site

Multi-component detection 5: DOAS

MINI-DOAS (open path)



Galle et al. J. Volcanology and Geothermal Research, 119:241-254.

COMPUSS (open path)

Mori et al., Bull. Volcanol. Soc. Japan 52:105-112

MOBILE- UV-DOAS (cuvette)

http://www.duvastechnologies.com/

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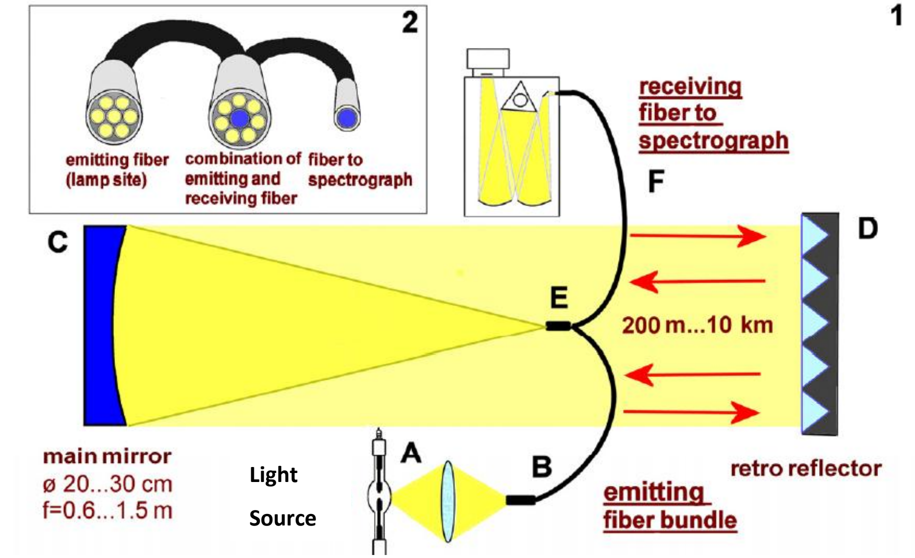
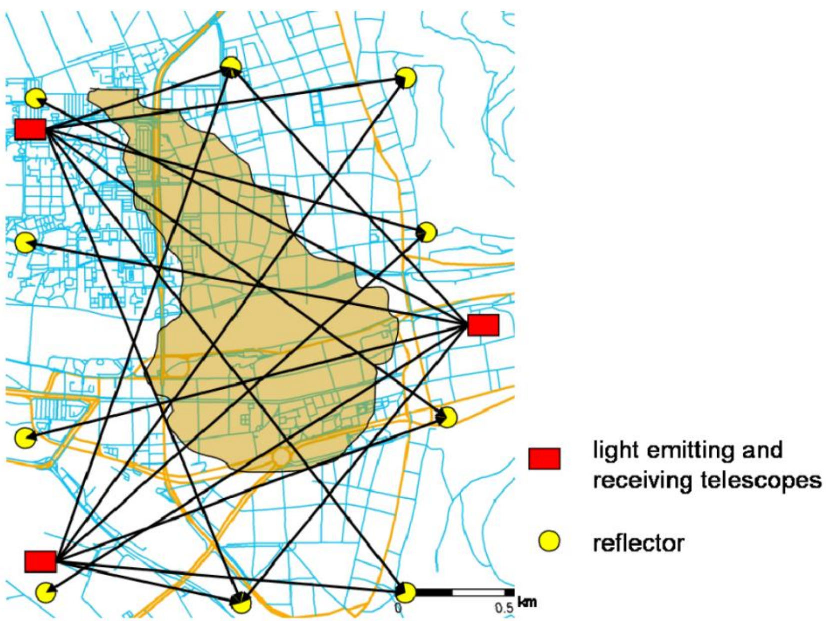
  - mapping the air quality of a city

Open-Path monitoring

Commercial DOAS
(e.g. Opsis,
Environnement SA)



New, compact long-path DOAS
(Fibre bundles, LEDs)



Tomographic DOAS measurement

Pöhler, D. Dissertation Uni Heidelberg
http://www.ub.uni-heidelberg.de/archiv/10996

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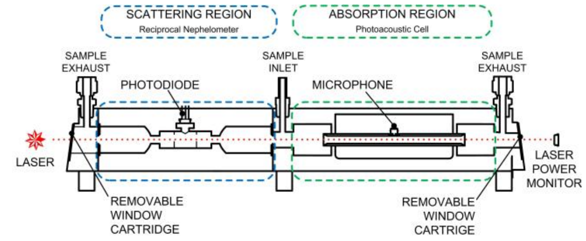
- New chemical-physical metrics

“New metrics“: Black Carbon (soot)

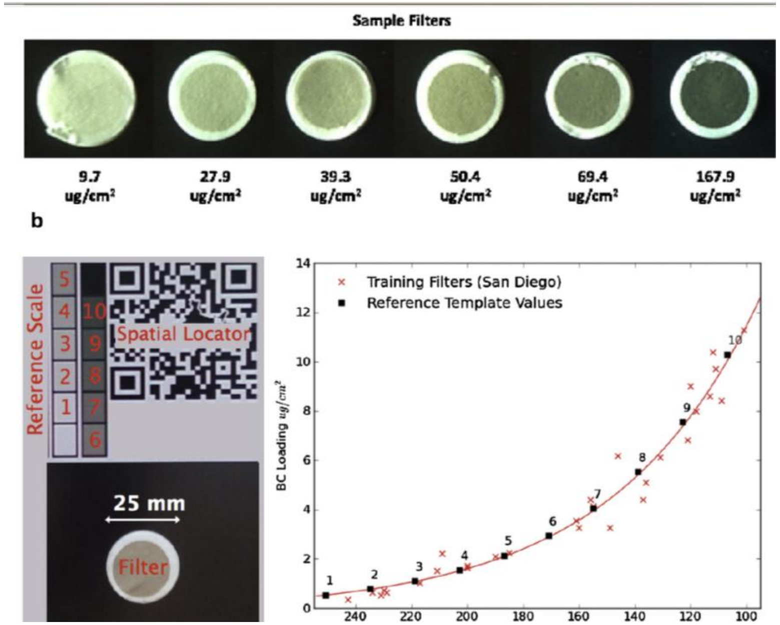


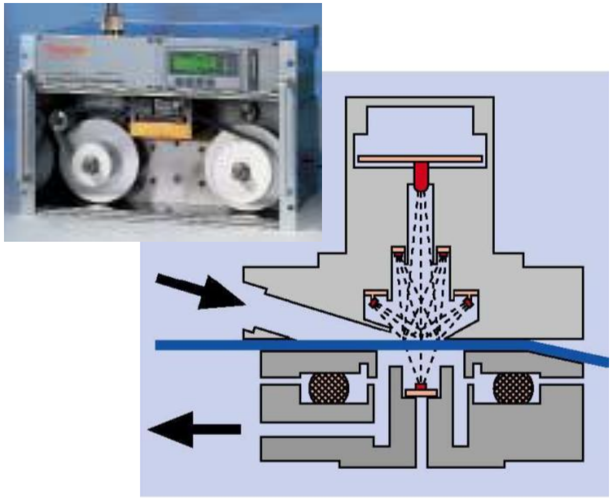
Photoacoustic Extinctiometer (DropletMeasurement)

Aethalometer AE 33 (7 WL, Magee)

Cell-Phone based BC screening

Ramanathan et al (2011) Atmospheric Environment 45, 4481-4487

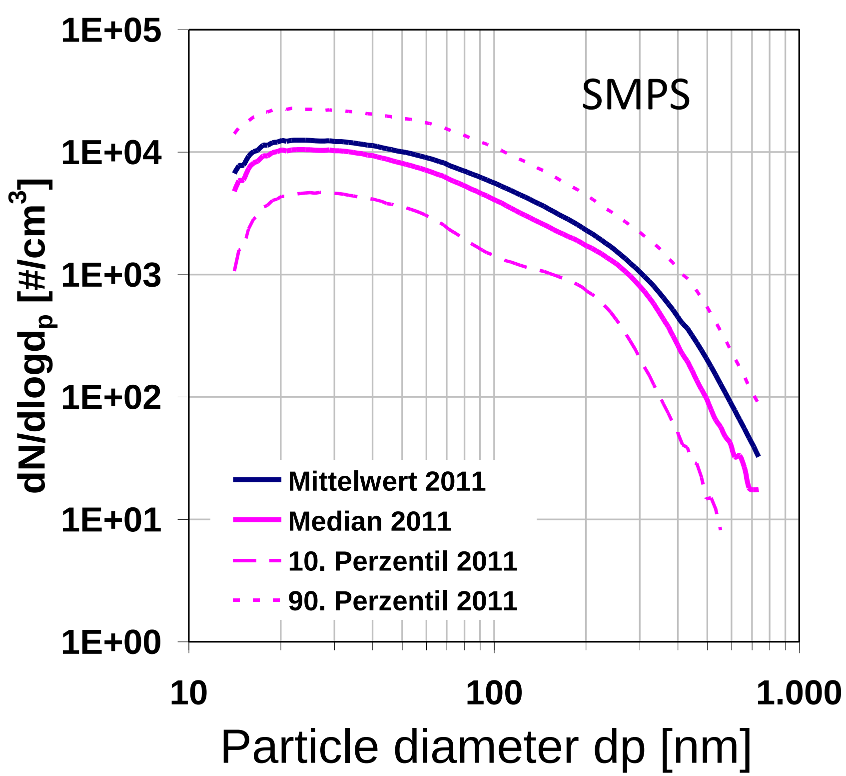




MAAP (ThermoFisher)

New metrics: Particle Size Distribution

Number Size Distribution at an urban site

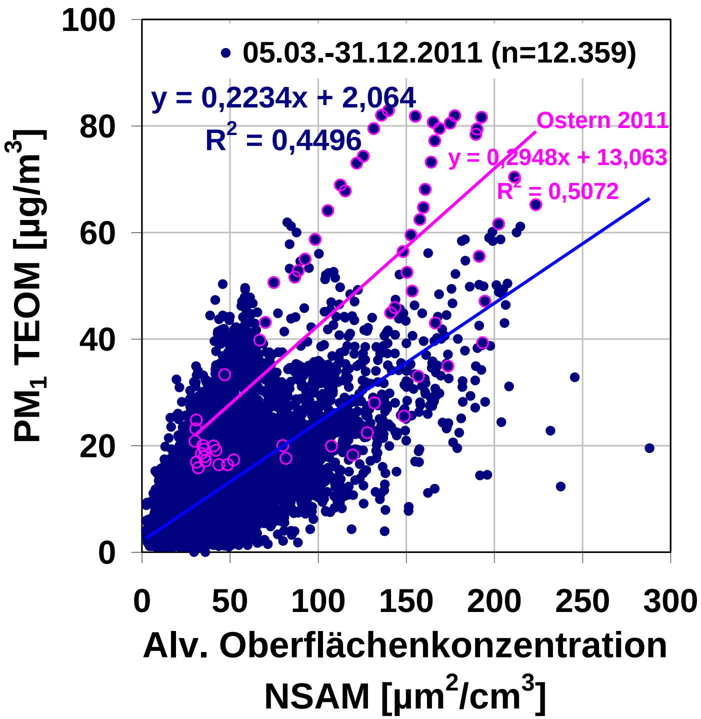


UFP (Ultrafine Particle) Monitor 3031 developed under the auspices of European Union UFIPOLNET project

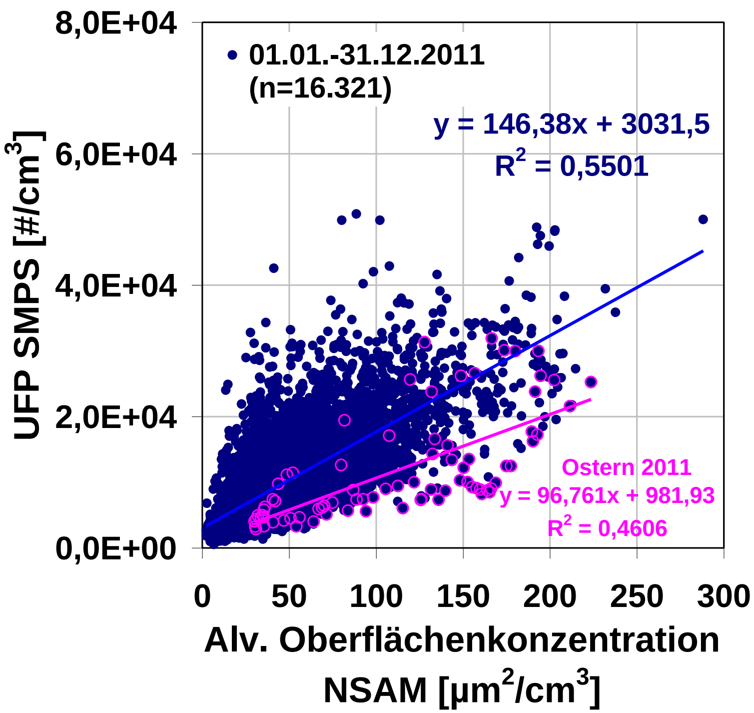
New metrics: Particle Surface

Air Pollution Monitoring Technologies for Urban Areas

Correlation Surface – PM1



Correlation Surface – UFP



New metrics: LDSA

Linear regression LDSA (NSAM)	R^2	
	2009	2010
LDSA (SMPS, berechnet)	0,94	0,98
UFP	0,34	0,56
100-750 nm Partikel	0,87	0,86
PM_{10}	0,42	0,38
PM_1 Äquivalent (Partikelvolumen SMPS)	0,63	0,61
NO gesamt	0,38	0,47
NO_2	0,48	0,49

0.44 with TEOM for 2011

UFP - NO: 0.23

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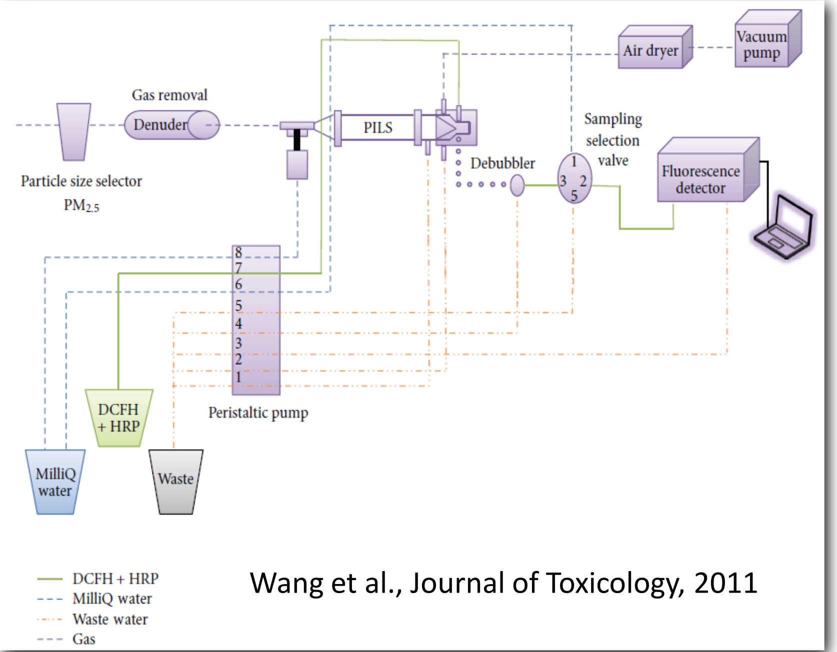
- New chemical-physical metrics
- Health effect related proxies

Health-related proxies: ROS

Particle bound ROS (as H_2O_2 equivalents)



Wang et al., Journal of Toxicology, 2011

Potential for automation of procedure:

OH-Radical formation: DMPO/H_2O_2 spin-trap method (ESR)

Redox Activity: Dithiothreitol (DTT) consumption assay

Salicylic acid/ HPLC method

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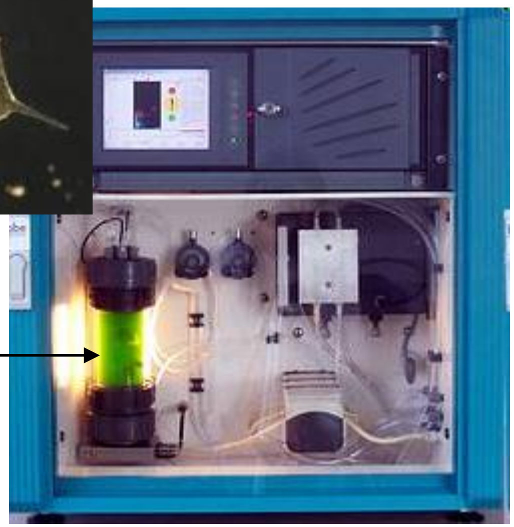
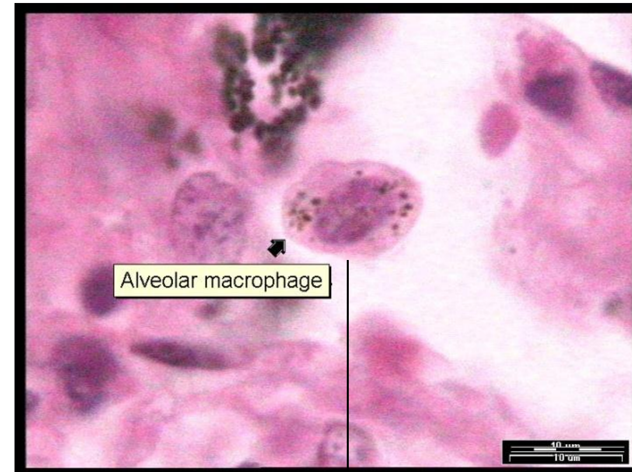
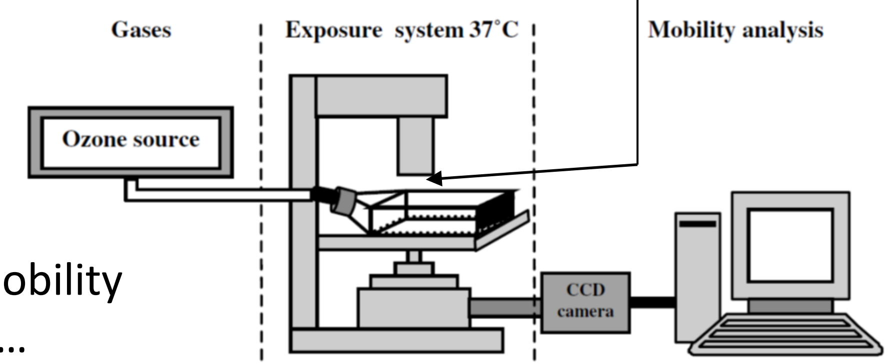
- On-line in-vitro assays

Biological AQ Monitoring?

Daphnia Magna
for test of
water toxicity







Monitoring of macrophage mobility
while exposed to polluted air…

P. Laval-Gilly et al., J. Pharmacol. Toxicol. Methods, 44:483-488 (2000)
Klestad et al., Toxicology in vitro 2:199–206 (2005)
Environmental biosensor for measuring air contaminants EPO Patent EP1058849

Conclusions 1: Gaseous pollutants

- More sensitive and selective instruments
  → enhance data quality
- Compact stations reduce spatial demands
  → ad-hoc network enlargement
- Devices for not yet regulated compounds (NH_3, VOCs)
- Multicomponent measurements, also open-path
- Microsensors with improved sensitivity and stability
  → option for dynamic sensor networks

Conclusions 2: Particulate pollutants

- Particle counters and sizers
  ➔ help identifying health-relevant fraction
- New metrics (BC, surface) can be monitored directly
  ➔ health studies, source attribution and mitigation control
- On-line elemental and molecular composition measurement possible
  => source identification and apportionment
- Automated monitoring of bioallergens
  ➔ input as confounders in epi studies?

In summary…

Monitoring technology provides a multitude of options to

- improve,
- widen,
- re-direct
- re-consider

air pollution monitoring strategies.

the goal is reduction of public health effects!

➔ Research needs

In summary…

Major **remaining challenges** and corresponding research needs are identified, comprising e. g.

- ✓ Facilitation of the use of in-situ open-path and remote sensing instruments for urban airq uality assessment
- ✓ Lowering detection limits and reliability of chip-size microsensors for health relevant gases as well as development of microsensors for particle mass and/or chemical compounds
- ✓ Development of methods that allow to better describe particle morphologies for improved discrimination of particle sources
- ✓ Lack of exposure data for many particle characteristics to identify those "silver bullets" that might be given priority in future air quality control.
- ✓ …….

The AirMonTech team
www.airmontech.eu

Thanks for your attention!

AirMonTech Consortium: (from left) J. Moeltgen (UDE), U. Quass (IUTA), K. Torseth (NILU), K. Katsouyanni (NKUA), B. Vogel (UDE), R. Otjes (ECN), E. Weijers (ECN), P. Woods (NPL), T. Kuhlbusch (IUTA, Coordinator), P. Quincey (NPL), M. Viana (CSIC), R. Gehrig (EMPA), X. Querol(CSIC,) A. Borowiak (JRC), C. Hueglin (EMPA).