

Christof Asbach



Tiered approach for assessing risks at work places

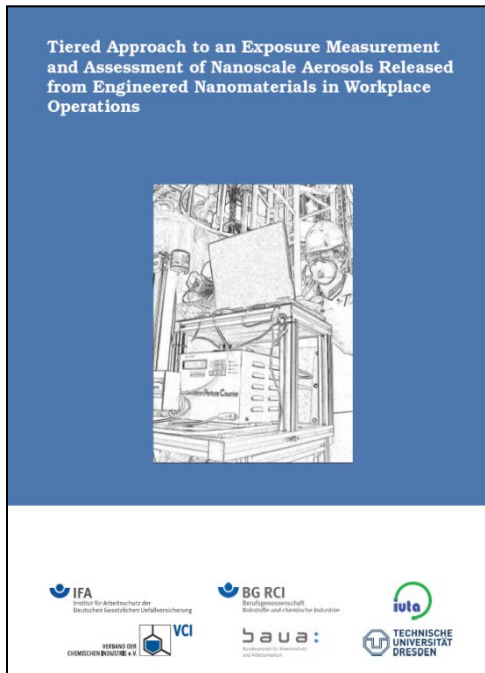
*Institute of Energy and
Environmental Technology e.V.*

*Air Quality & Sustainable
Nanotechnology*

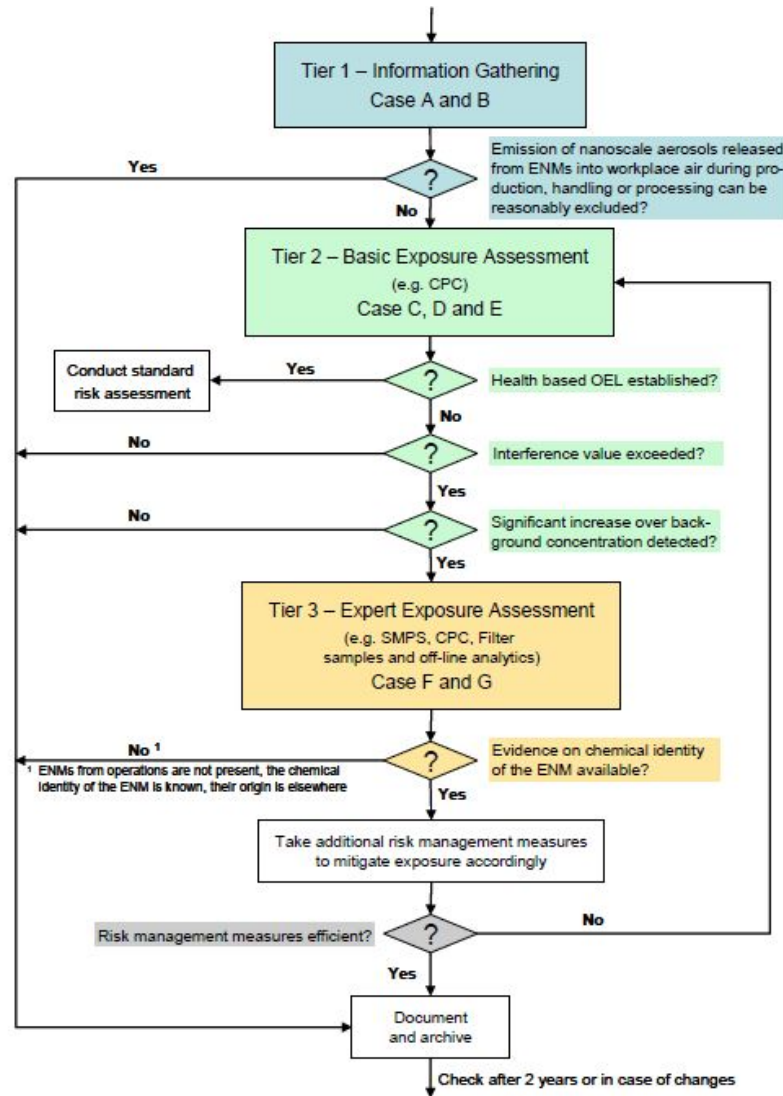
nanoValid Workshop
Berlin, November 27th, 2012

UNIVERSITÄT
DUISBURG
ESSEN

- Introduction – the „VCI concept“ in the nanoGEM project
- Description of the nanoGEM SOP-framework
- Above background? („Tier 2“)
- Expert Assessment! („Tier 3“)
- First measurement results
- Conclusions and outlook



<https://www.vci.de/Downloads/Tiered-Approach.pdf>



The nanoGEM Concept

Monitoring strategy added

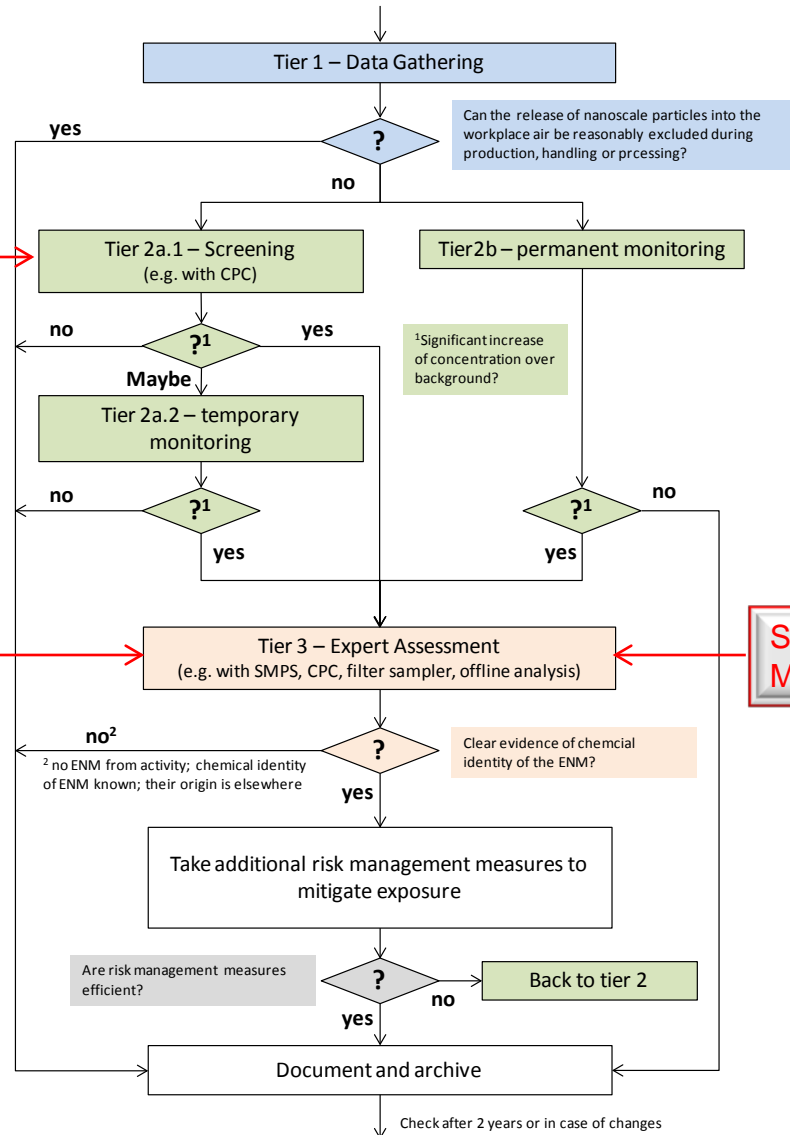
SOP M Tiered Approach

SOP S Instruments

SOP M Screening

SOP M Sampling

SOP M Expanded Measurements



Complete set of SOPs written

- Tiered approach
- All measurements (main SOPs)
- For all routinely used instruments (Sub-SOPs)

All SOPs are freely available
through the nanoGEM
website

www.nanogem.de



Standard Operation Procedures

For assessing exposure to nanomaterials, following a tiered approach

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Main SOPs

- SOP-M-Tiered Approach: Tiered Approach for the assessment of exposure to airborne nanoobjects in workplaces
- SOP-M-Screening: Performance of Orientation Measurements („screening-measurements”) for Nano-scale Aerosols (Tier 2)
- SOP-M-Expanded Measurement: Measurements of the inhalation exposure to nanoscale product materials and ultrafine aerosols at workplaces including the background concentration (Tier 3)
- SOP-M-Sampling: Sampling of Airborne Nanoobjects for Consecutive Microscopic Analysis (Tier 3)

Sub-SOPs – Instruments

- SOP-S-SMPS(TSI): Procedure of particle measurements with the Scanning Mobility Particle Sizer (TSI Model 3936)
- Etc....(for a total of 12 instruments currently – expandable)
- Sub-SOPs on data analysis and SEM sample preparation and evaluation

Basic Rationale:

„A **decision** whether an Expanded Measurement **(Tier 3) is necessary** or whether emission of nanoscale aerosols released from ENMs into workplace air during production, handling **or** processing **can be reasonably excluded!**”

Means:

- Detailed **description of the conditions** (workplace, measurement techniques etc)
- **Background determination** and description (average, standard deviation etc) at either the (located) **emission source** or in the **worker’s breathing zone**
- **Determination** of either **emission concentration** or the **exposure concentration**
- **Comparison** to background (including their uncertainties)
- **Decision** whether the necessity of tier 3 measurements **can be reasonably excluded**
- A detailed **data form** to be filled during investigations

Background determination (source or breathing zone):

- Use identical measurement time for background determination AND the following emission or exposure concentration (suggestion currently: 45 min)
- Divide it into time periods of equal lengths to be used for the determination of standard deviation of the background (example 9x5 min)
- Calculate average background and its standard deviation
- Specify the conditions of work (possibly with a reference to the industrial workplace to be investigated)

Emission or exposure concentration determination (signal concentration):

- Follow the processes described for background using identical measurement parameters

Net emission or exposure (net signal)

- Difference to background

Comparison of standard deviations of background and signal concentrations

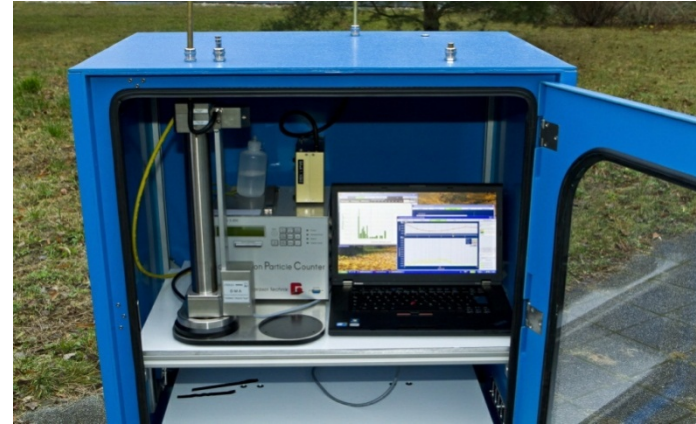
Document otherwise significant sources of ultrafine particles

Significance check:

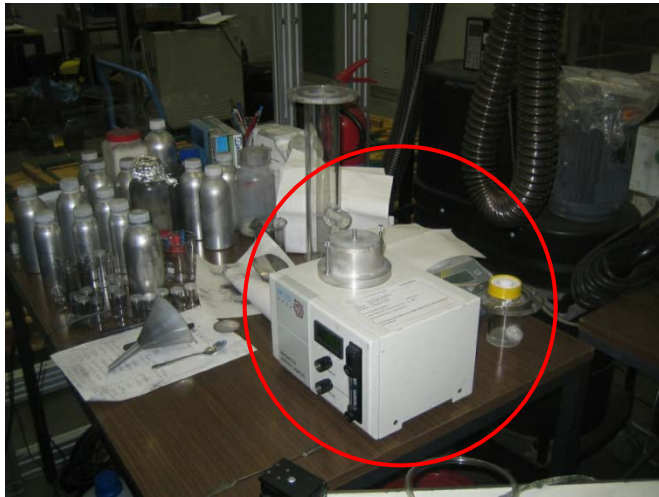
- If the net signal is higher than the threefold standard deviation of the background, then the signal is significant (tier 3 is necessary)

Under which conditions will tier 3 measurements be recommended?

1. If the emission or exposure concentrations are significantly above background **OR**
2. If standard deviations of background are significantly larger than the signal (i.e. conditions of background determination are not representative e.g.) **OR**
3. If the methodological approach was found to be not suitable (a mandatory discussion of this aspect is included in the data form) e.g. because the instrumentation was not suitable or the exposure conditions (cross sensitivities) could not be appropriately investigated



- Measurement of concentration and size distribution with SMPS, CPC, NSAM and/or aerosol-spectrometer, APS
- Background has to be taken into account
 - Activities with and without nano-materials, parallel measurements outside the facility and in the workplace, or
 - Background determination during activities by „far-field“ measurements, or
 - Background determination before and after activity in the workplace
- Additionally sampling of particles by NAS or TP for imaging techniques



- Sampling for morphological and chemical characterisation of ENMs
 - Qualitative separation from background
- Sampling systems (ESP, TP)
- Choice of substrate materials (a.o. Si-Wafer, TEM-grid)
- Performance of representative sampling

- Measurements were carried out at a pilot plant at IUTA (Duisburg, Germany) for the gas phase synthesis of nanoparticles



Measurement locations

- Measurements were conducted according to Tier 2 (screening and monitoring) and Tier 3
- Measurement locations were (besides background measurement outside enclosure):
 - At the reactor/control room during synthesis

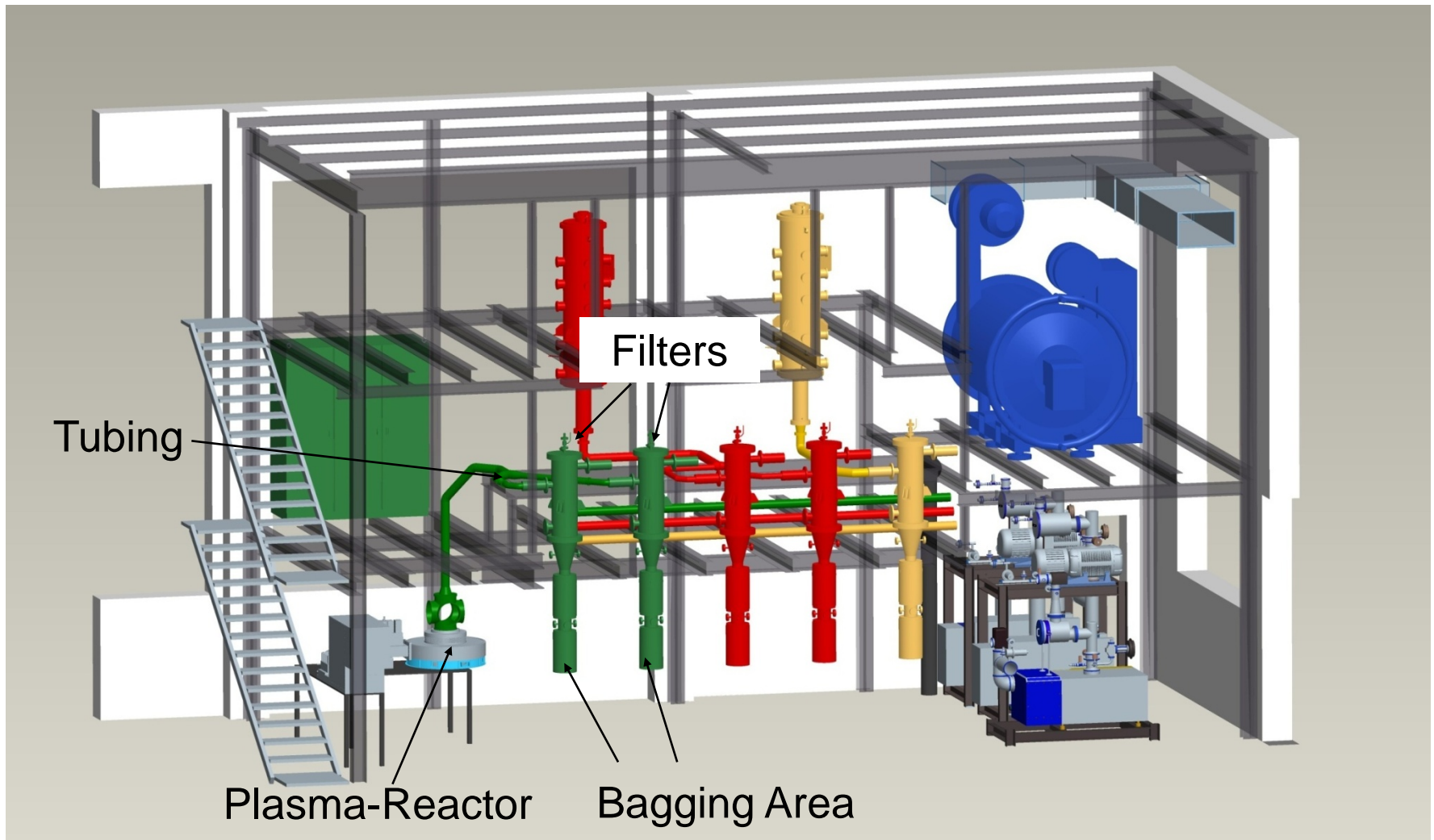


- In the bagging area during filter cleaning and bagging

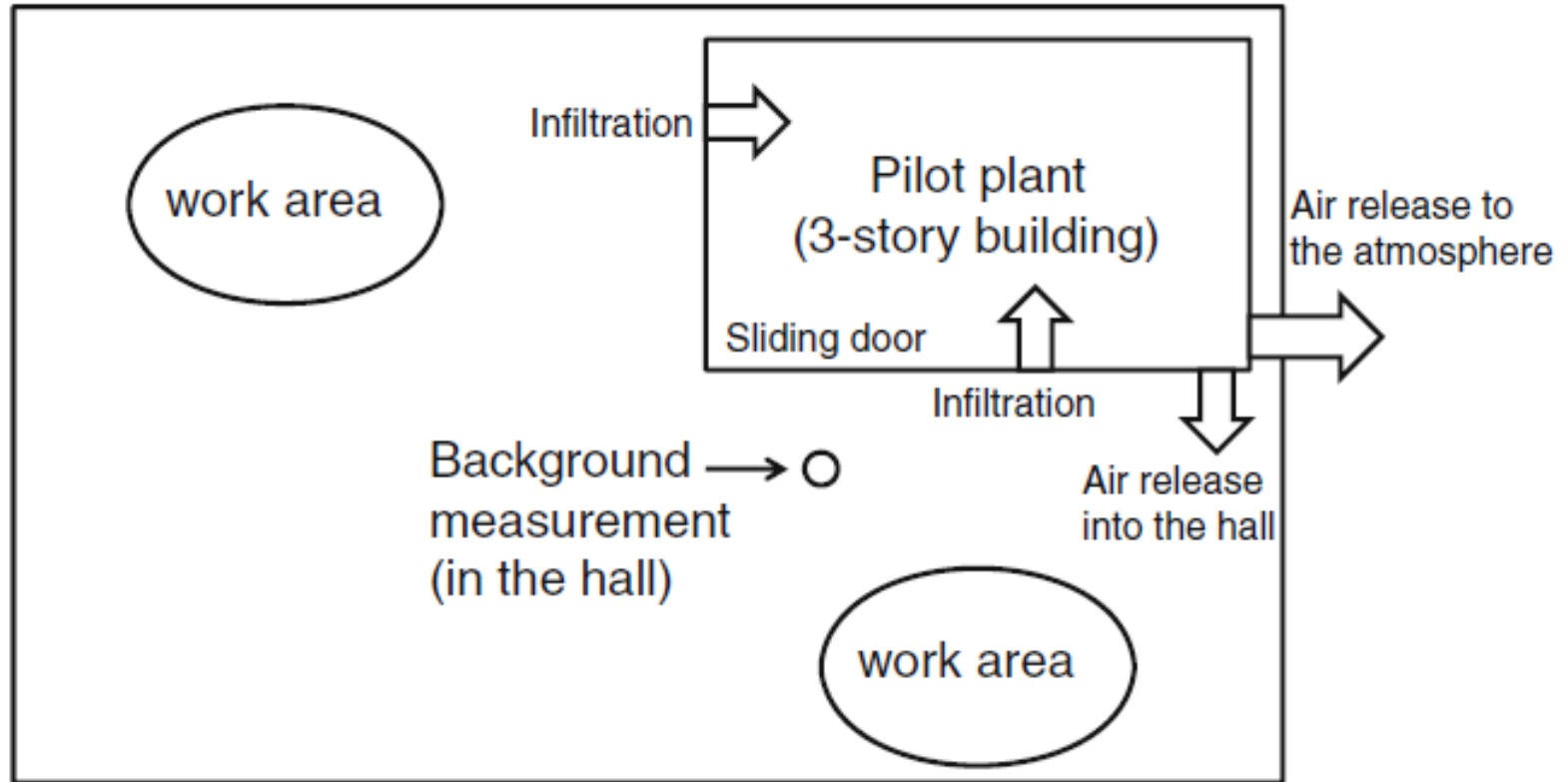


- Near the open tubing during cleaning



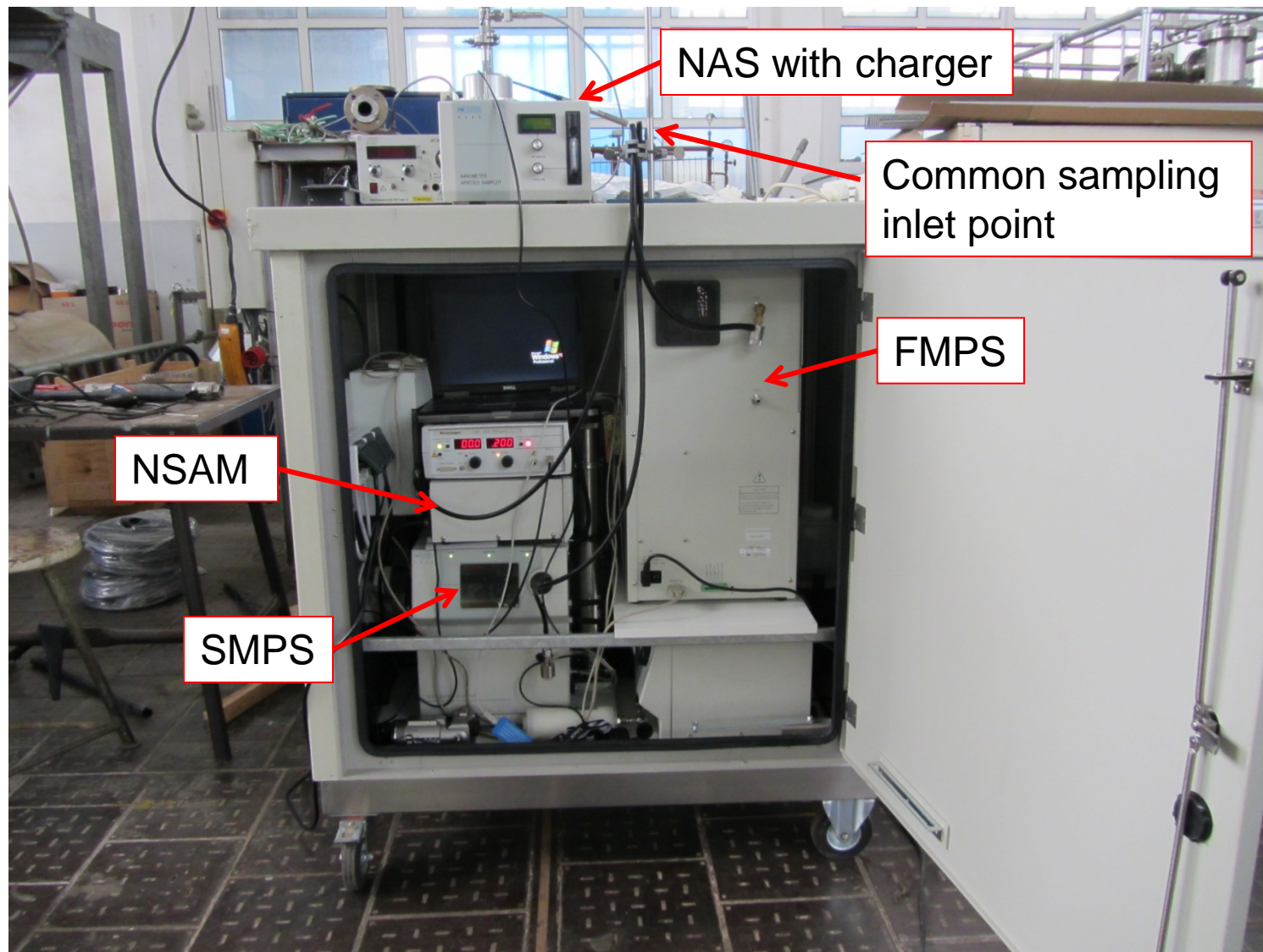


- Tier 2 (Screening)
handheld CPC (TSI model 3007)
(number concentration, 1 s time res.)
- Tier 2 (Monitoring)
miniDiSC (FH North Western Switzerland)
(number concentration and mean diameter,
1 s time res.)
- Tier 3
SMPS (TSI model 3936)
(number size distribution < 1 μm , 2 min time res.)
FMPS (TSI model 3091)
(number size distribution, 5.6-560 nm, 1 s time res.)
APS (TSI model 3321)
(number size distribution > 1 μm , 20 s time res.)
NSAM (TSI model 3550)
(lung deposited surface area concentration, 1 s time res.)
NAS (TSI model 3089) with homebuilt charger

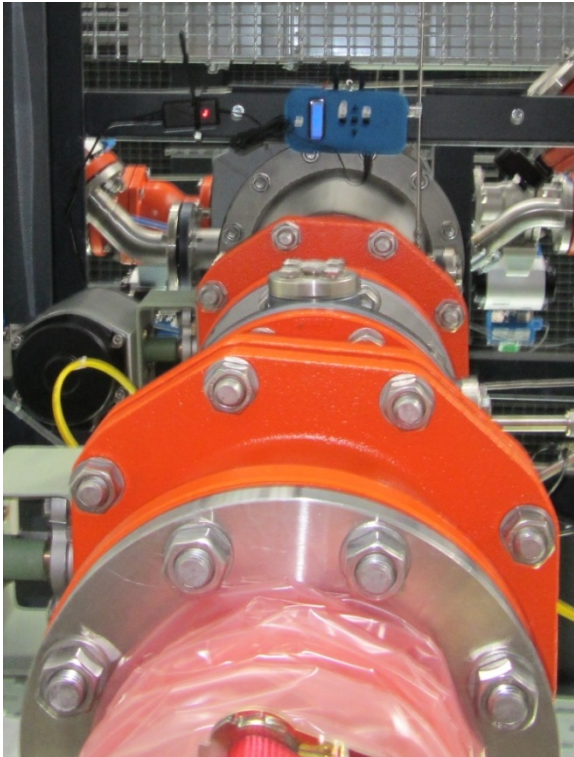


From: Wang et al., *J. Nanopart. Res.* **14**: 759

Background Measurement Station



- Monitors (miniDiSCs) were mounted under the ceiling (mesh floor) above potential leaks as well as in the closest ventilation inlet



Bagging

Later moved to 1st floor
for tube cleaning

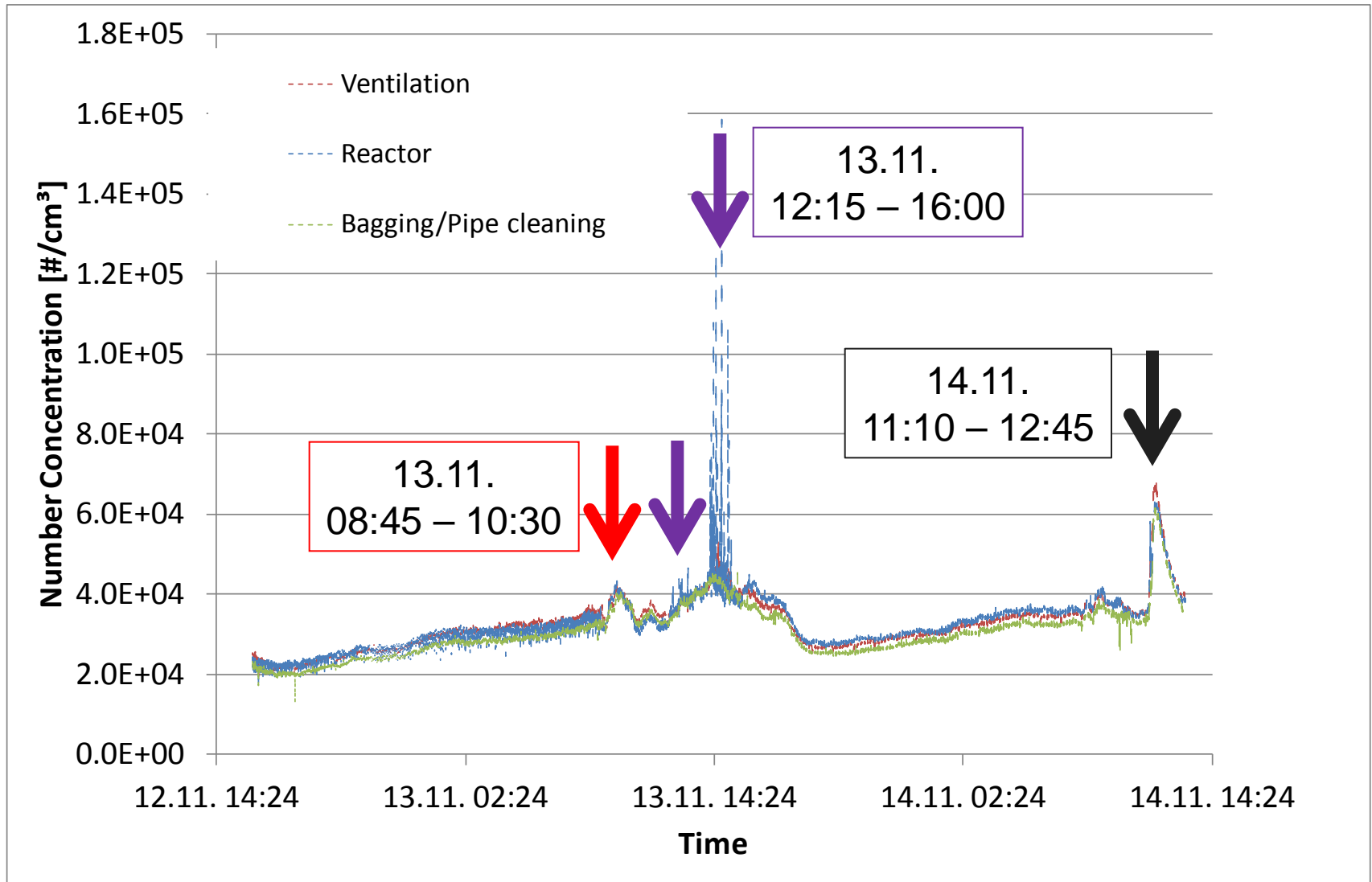


Reactor

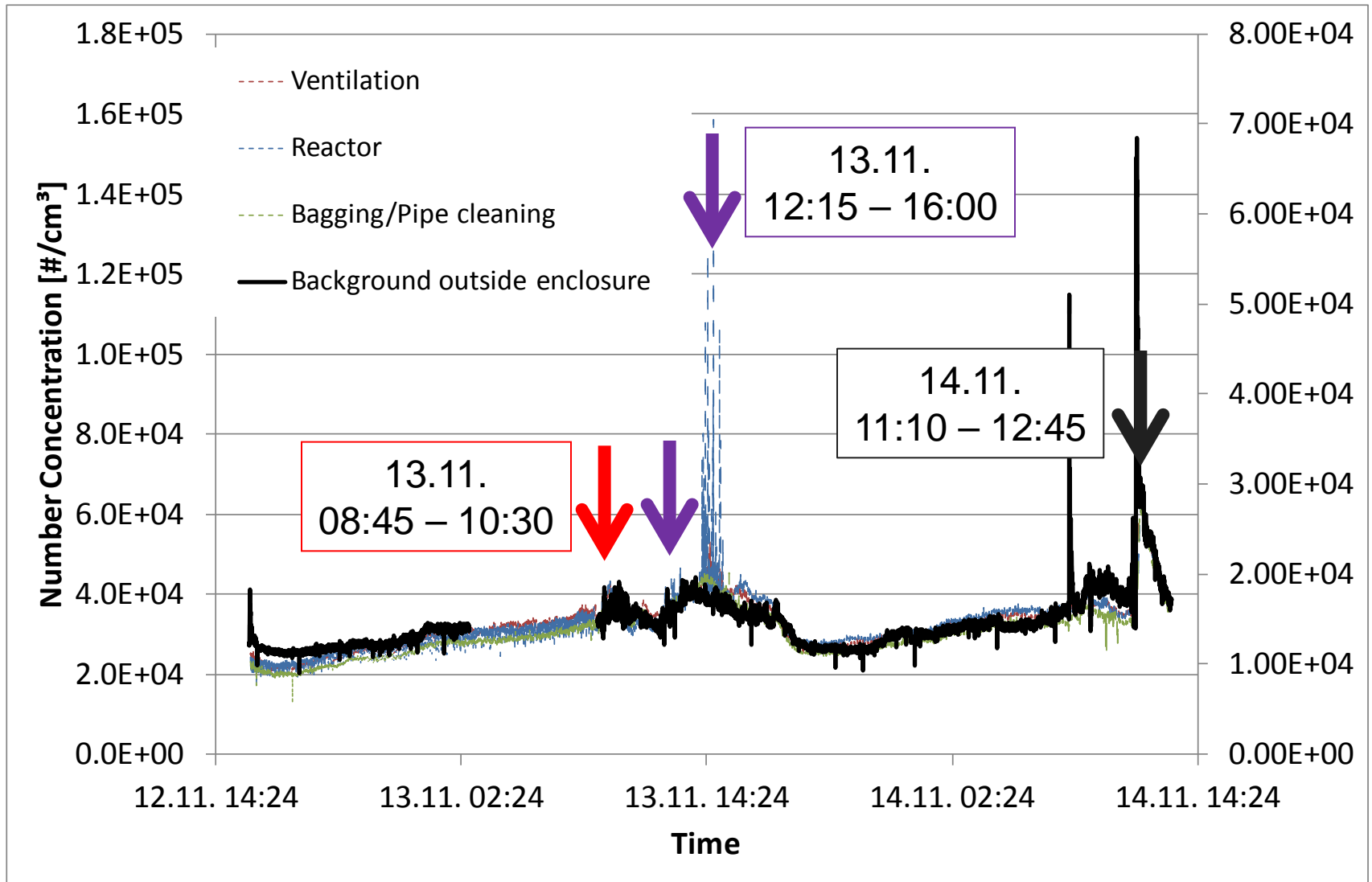


Ventilation

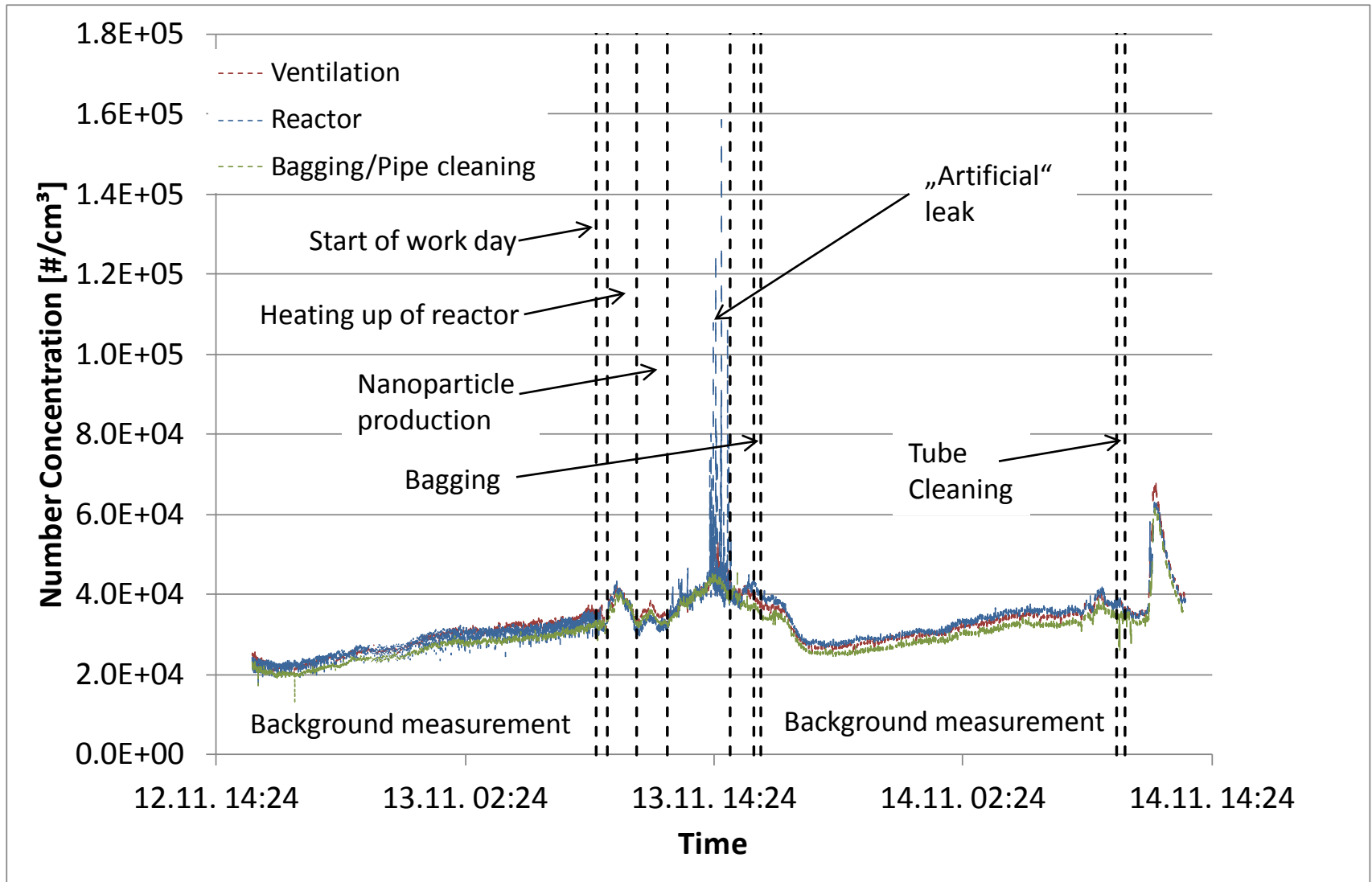
Results from monitoring (miniDiSC)



Results from monitoring (miniDiSC) and background (FMPS)



Results from monitoring (miniDiSC)

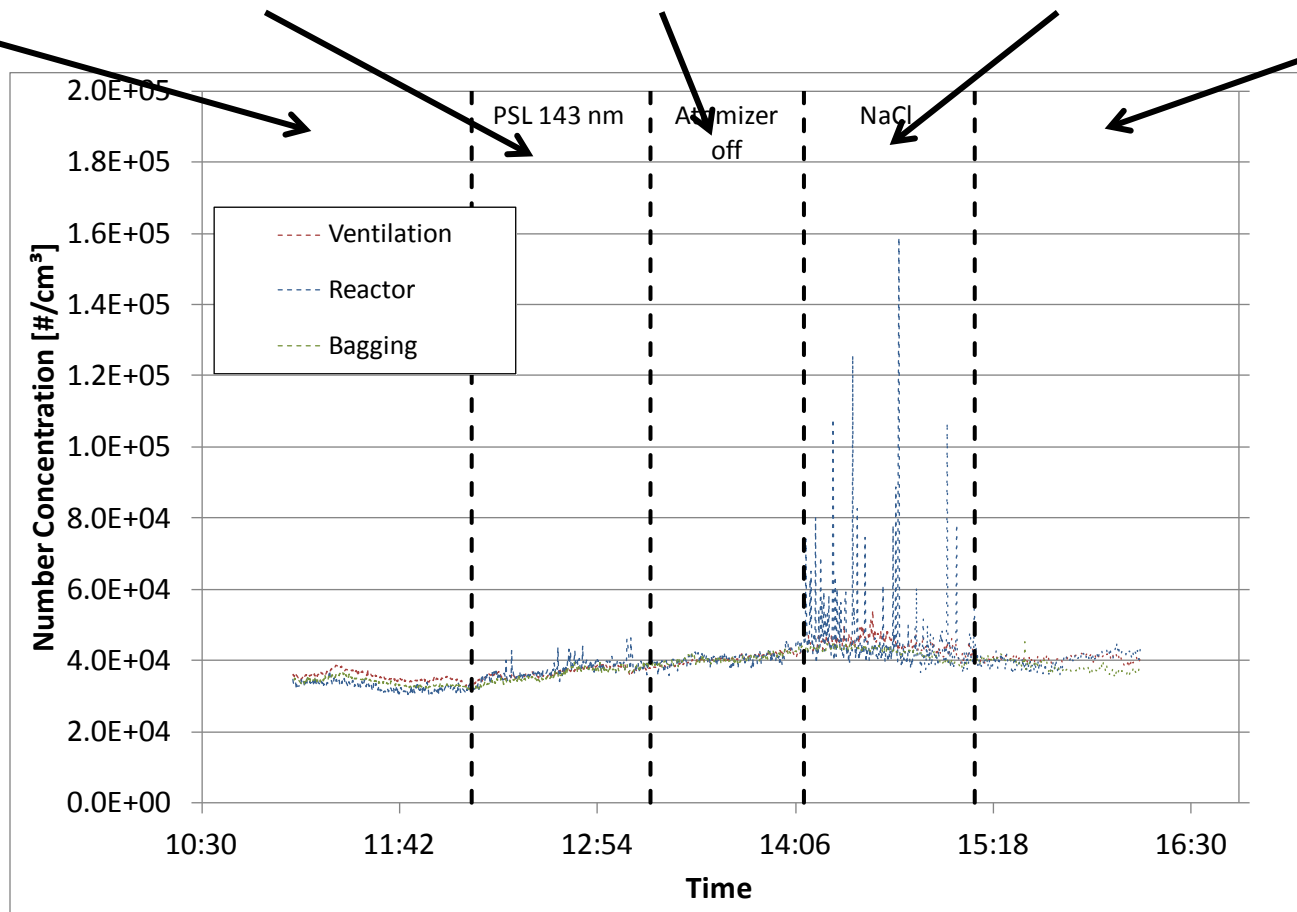


- It was expected that no particles would be emitted from pilot plant
- Therefore, a „leak“ was simulated by dispersing harmless particles (PSL and NaCl) at approximately 5 l/min into the workplace to test the measurement strategy
- 12:09 – 13:14: PSL, 143 nm, 16,000 #/cm³ ($1.3 \cdot 10^6$ #/s)
- 13:14 – 14:10: Atomizer off
- 14:10 – 15:12: NaCl, mode 195 nm, $3.6 \cdot 10^6$ #/cm³ ($3.0 \cdot 10^8$ #/s)



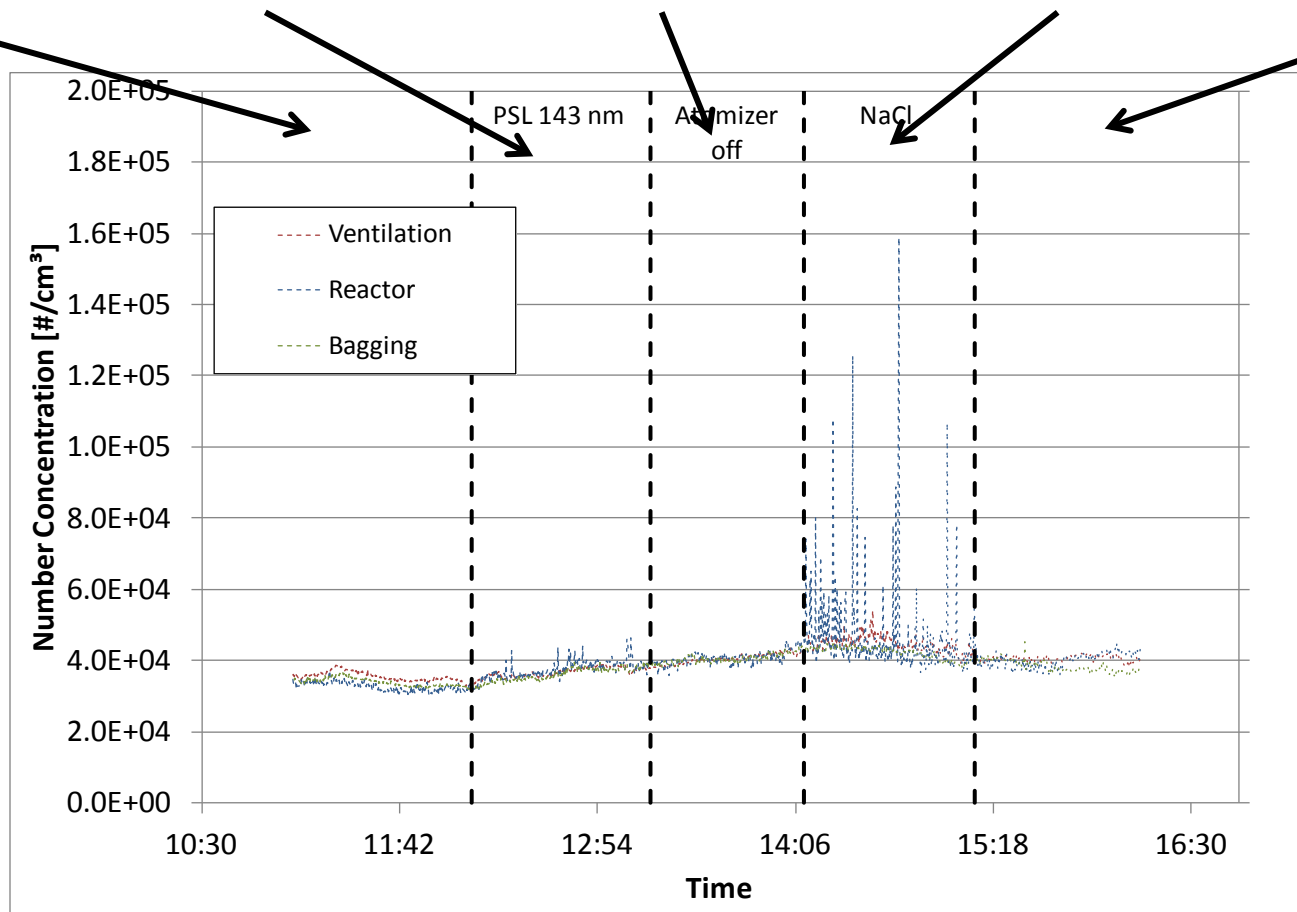
Evaluation based on reactor miniDiSC

Background before PSL	Concentration during PSL	Background after PSL/before NaCl	Concentration during NaCl	Background after NaCl
$32,794 \pm 1120 \text{ \#/cm}^3$	$37,437 \pm 2025 \text{ \#/cm}^3$	$40,897 \pm 1420 \text{ \#/cm}^3$	$46,435 \pm 4270 \text{ \#/cm}^3$	$40,244 \pm 1549 \text{ \#/cm}^3$



Evaluation based on reactor ventilation

Background before PSL	Concentration during PSL	Background after PSL/before NaCl	Concentration during NaCl	Background after NaCl
$35,556 \pm 1198 \text{ \#/cm}^3$	$36,673 \pm 1342 \text{ \#/cm}^3$	$40,446 \pm 1366 \text{ \#/cm}^3$	$46,631 \pm 1680 \text{ \#/cm}^3$	$40,533 \pm 519 \text{ \#/cm}^3$



- A proposal for a tiered approach to optimize measurement and sampling procedures for ENMs has been developed in the shape of standard operation procedures
- A first complete set of measurements according to tiered approach has just been completed (data analysis mostly still pending)
- Monitoring was shown to be a powerful tool for workplace exposure surveillance
- SOPs have been distributed to various projects and colleagues around the globe and are intended to be used in the process of standardisation within CEN and/or ISO
- SOPs are freely available through the nanoGEM webpage

Colleagues involved in development of tiered approach and measurements:

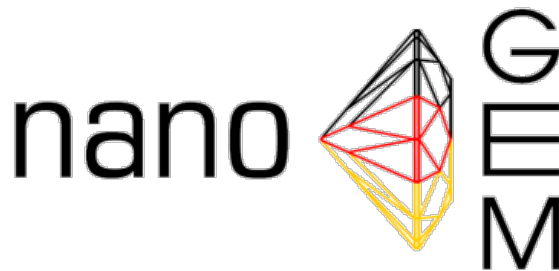
D. Dahmann, M. Voetz, B. Stahlmecke, H. Kaminski, T. Hülser, M. Spree, F. Krumpolt, U. Götz, R. Jacobs, S. Engel, T.A.J. Kuhlbusch, N. Dziurowitz, S. Plitzko



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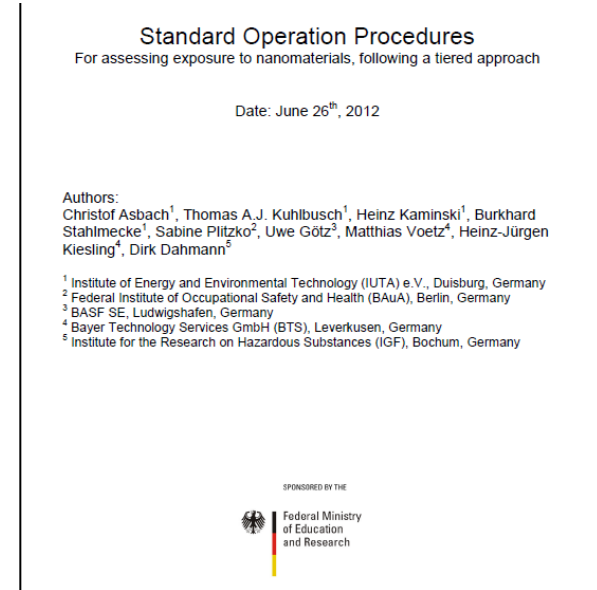


Federal Ministry
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Thank you for your attention!



<https://www.vci.de/Downloads/Tiered-Approach.pdf>



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