

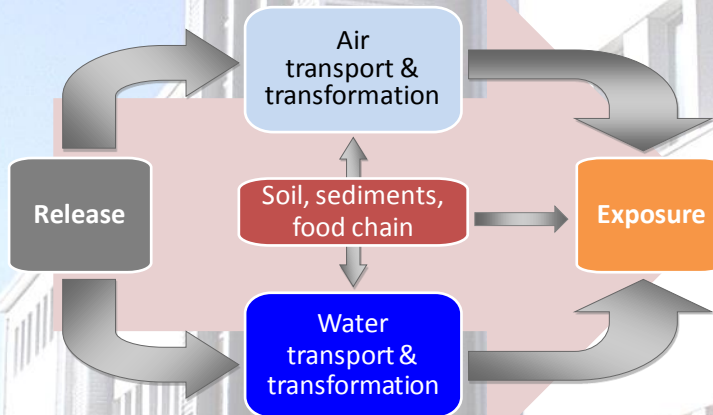
Thomas A.J. Kuhlbusch

Metrology and metrics for exposure assessment throughout the life cycle



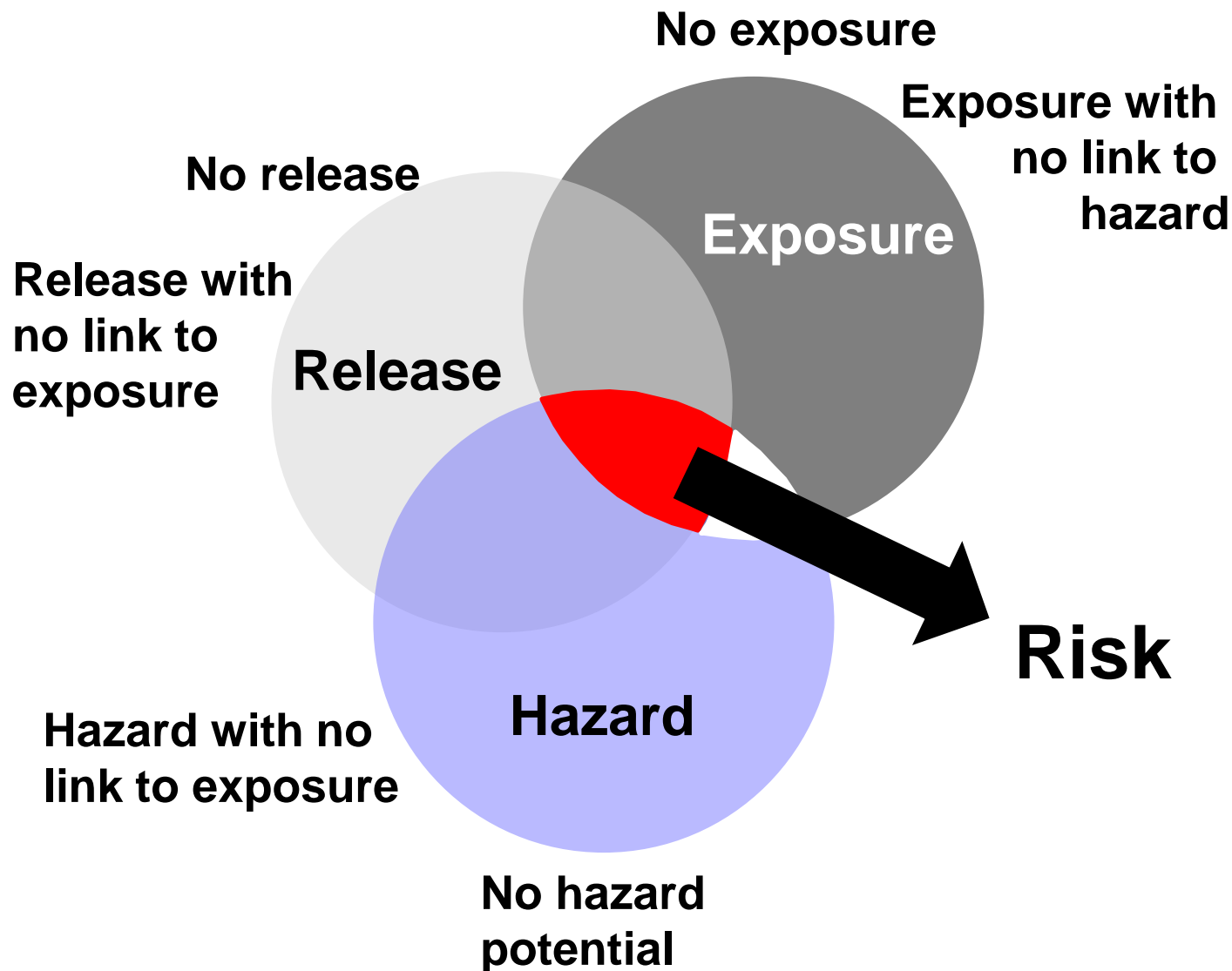
Institute of Energy and Environmental Technology e.V.

Air Quality & Sustainable Nanotechnology



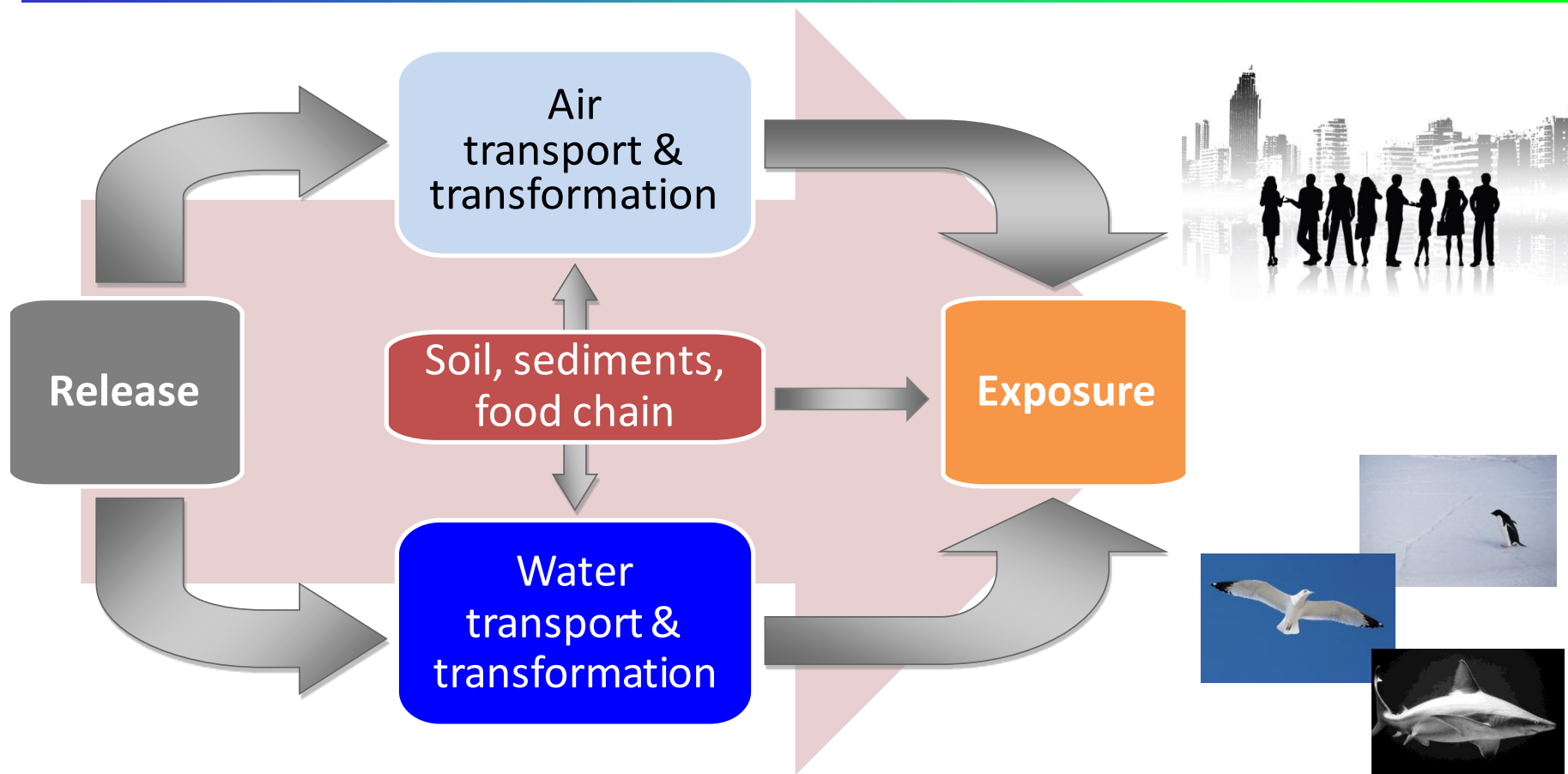
**ECHA Topical Scientific Workshop
Regulatory Challenges in Risk Assessment of Nanomaterials
Helsinki, 23 - 24 October 2014**





- **Metrics for exposure**
- **Tiered approach for exposure assessment**
- **Release**

Which metric?



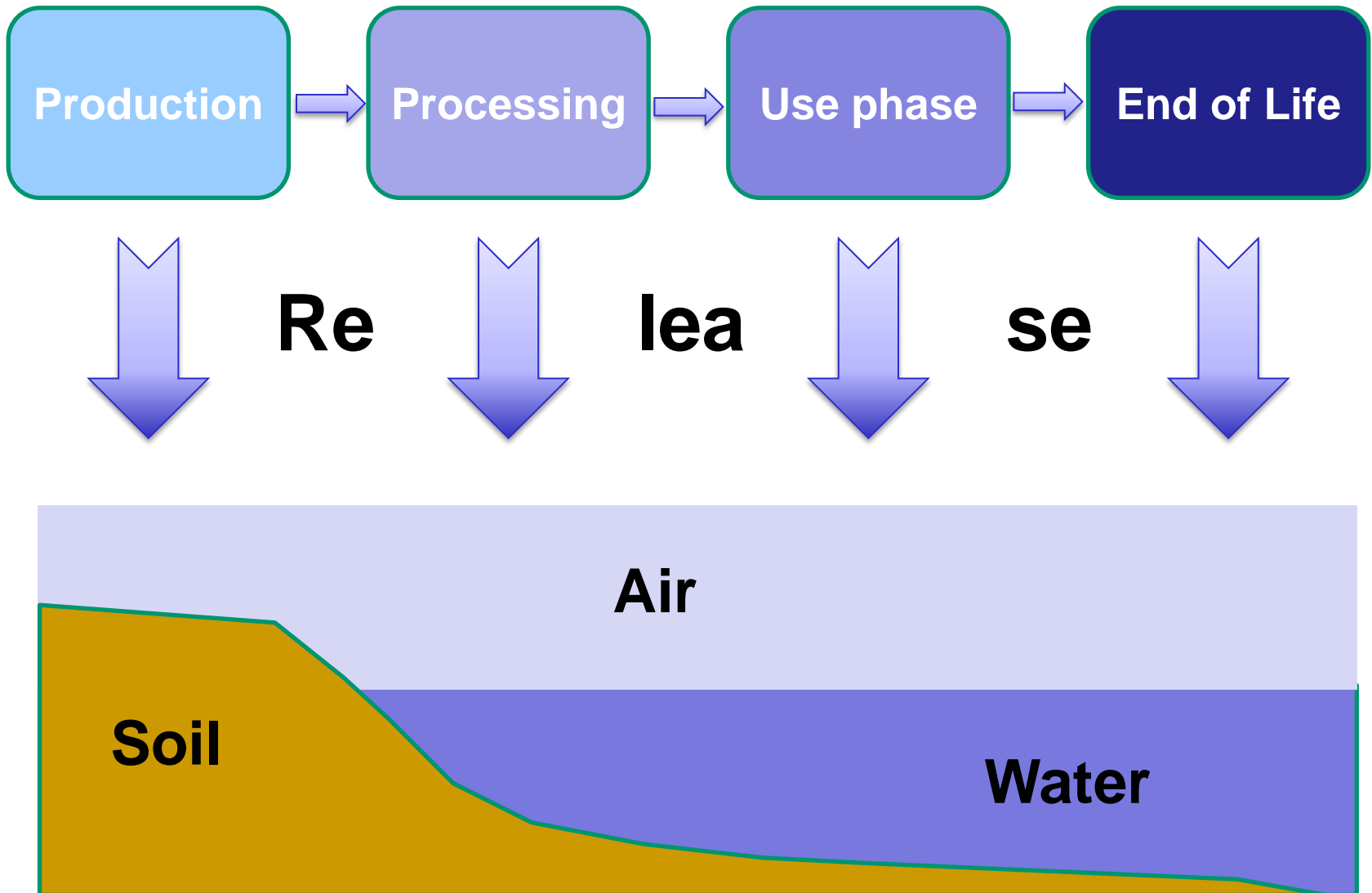
Mass?
Number?

Surface?
Reactivity?

Which metric to be used in exposure assessment?



	Personal monitors	Easiness to measure	Conservative from release to exposure	Sensitivity to detect exposure	Health relevant	Easiness to distinguish from background	Facilitates grouping	Regulatory experience	Feasibility to implement in regulation
Particle mass concentration	+++	+++	+++	+	++	+	+	+++	+++
Particle surface area concentration	+++	+++	-	++	++	+	+	+	+++
Particle number concentration	++	+++	-	+++	+	+	+	+	+++
Particle size distribution	0	+	-	+++	+++	++	+++	0	-
Particle reactivity	-	-	-	-	+++	-	+++	0	0



Similar release mechanisms for different life cycle stages possible

- Heat stress – processing / use / end of use phases
- Abrasion – processing / use / end of use phases
- Wash off – use / end of use phases
-

➔ Separation into release mechanisms?

mechanical processes

- sanding
- drilling
- sawing
- milling
- cutting
- dustiness
- mechanical shock
- wash off
-

thermal processes

- thermal stress
- incineration
- combustion
-

chemical processes

- reactive liquids / gases
- dissolution
-

mixed processes

- sanding (mechanical and thermal processes)
- wash out (dissolution and wash off)
- weathering (degradation and abrasion)
-

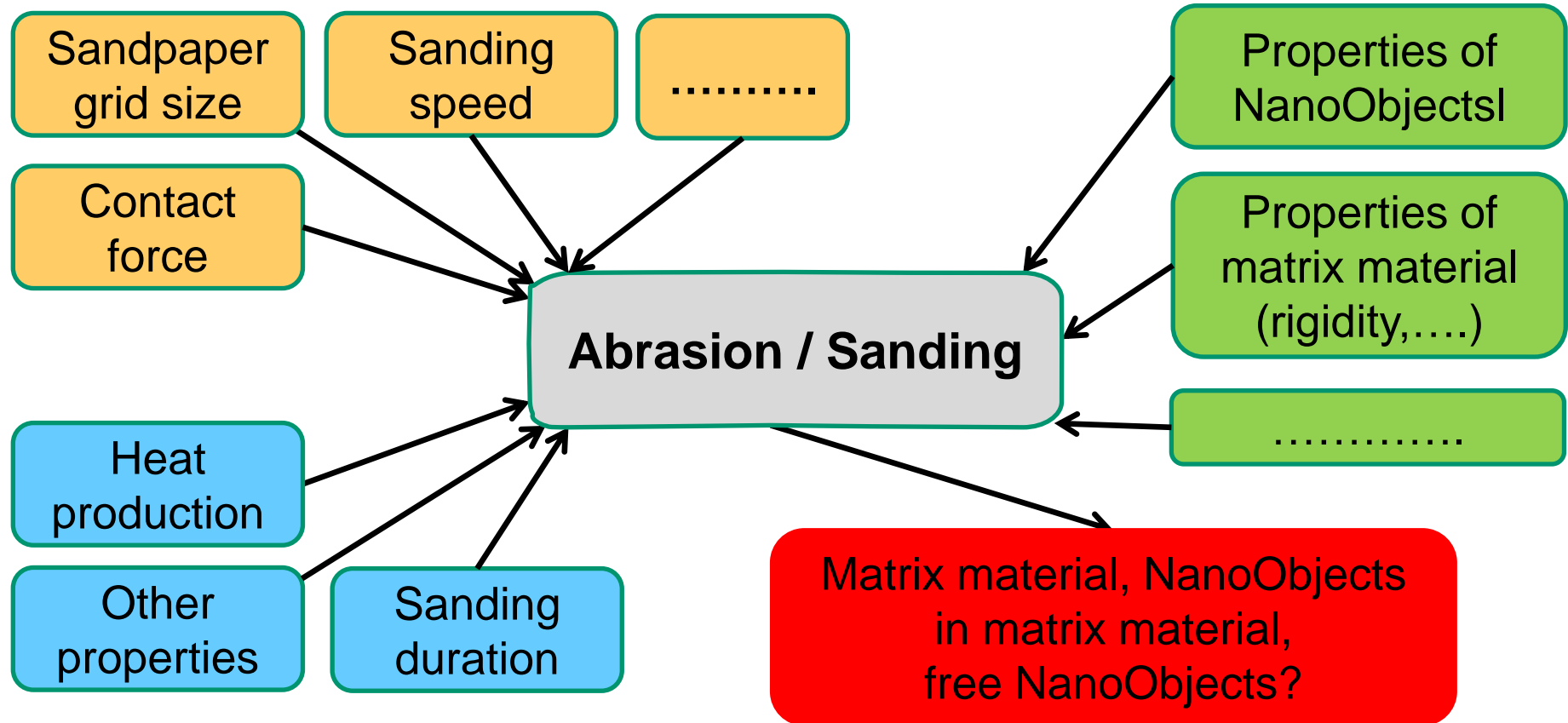
Release process - Sanding

Sanding is a process describing the dynamic friction between two surfaces.

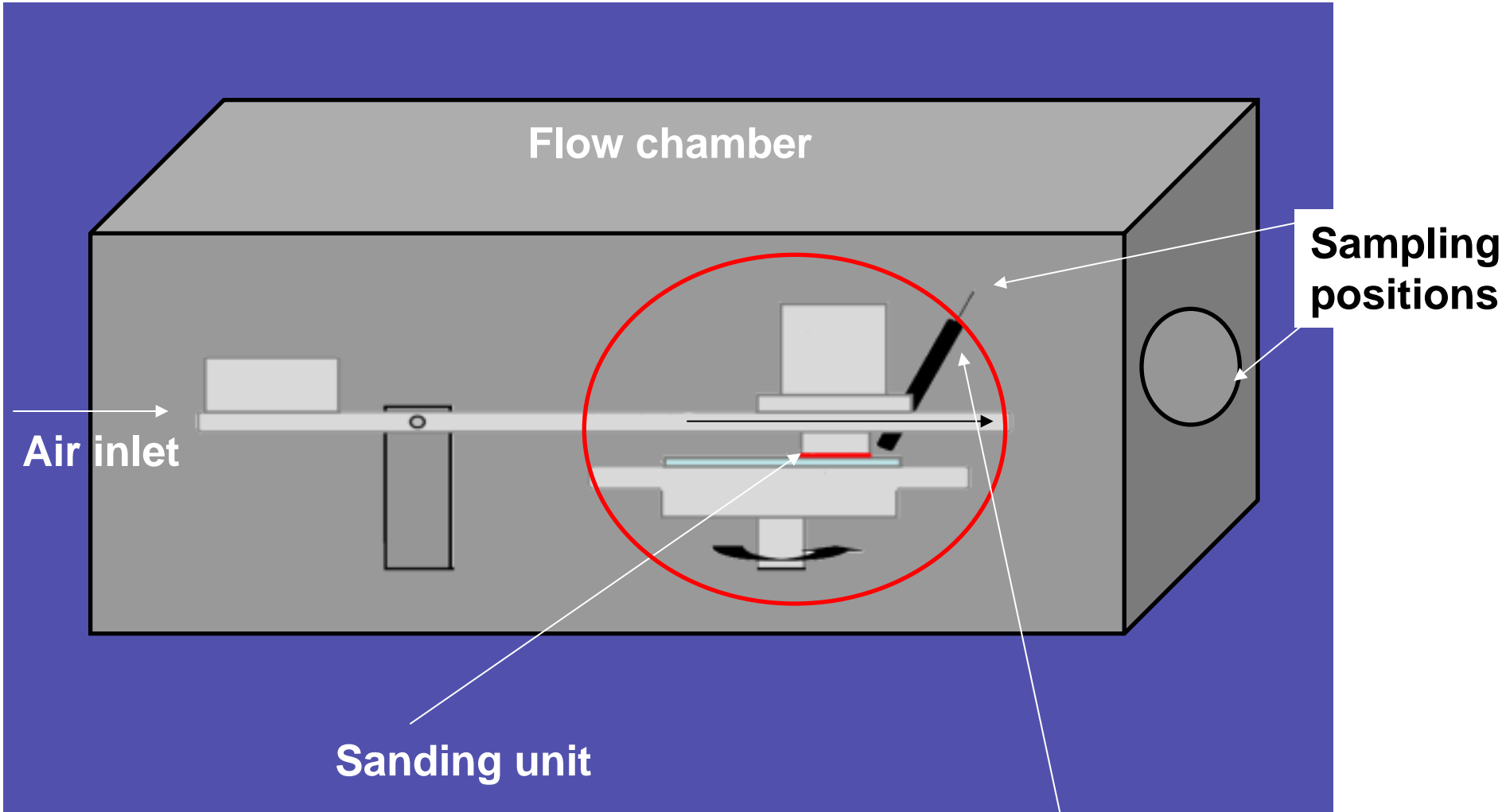
Life Cycle Stage: Manufacturing (e.g. surface treatment, grid blasting),
Consumer Use (e.g. surface treatment, ...)

Process properties

Material properties



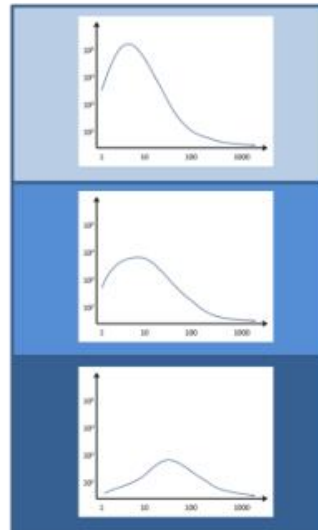
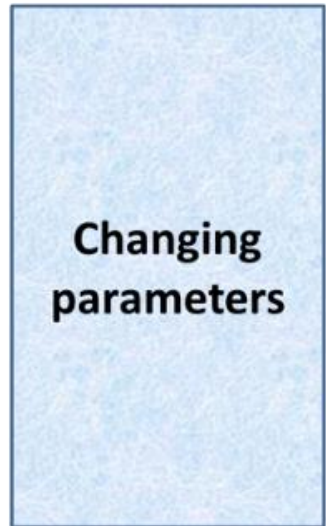
Improved sanding test stand – set-up



for MARINA round robin test
CEA, BASF, IUTA

Release process

Release characteristics



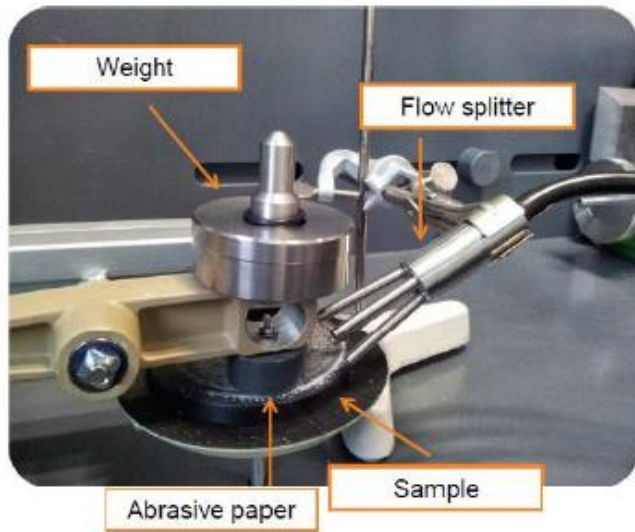
Kuhlbusch et al., 2014

Extract MARINA

- Sandpaper size: 32 mm diameter
- Sandpaper grid size: 80
- Speed between paper & material: 1.8 m/s
- Weight: 1 kg (+/- 5%)
- Size of sample disc: 11 cm diameter x 1.0 cm thickness,
- Disc time of contact: depending on material (~2- 4 min)
- Air flow: 21 l/min
-

Set up

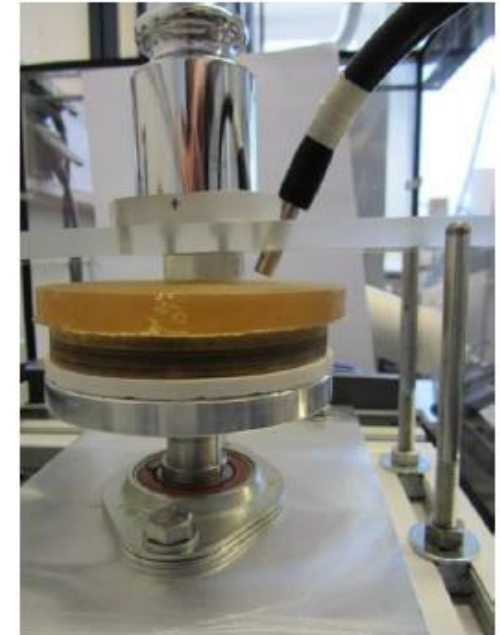
CEA



BASF

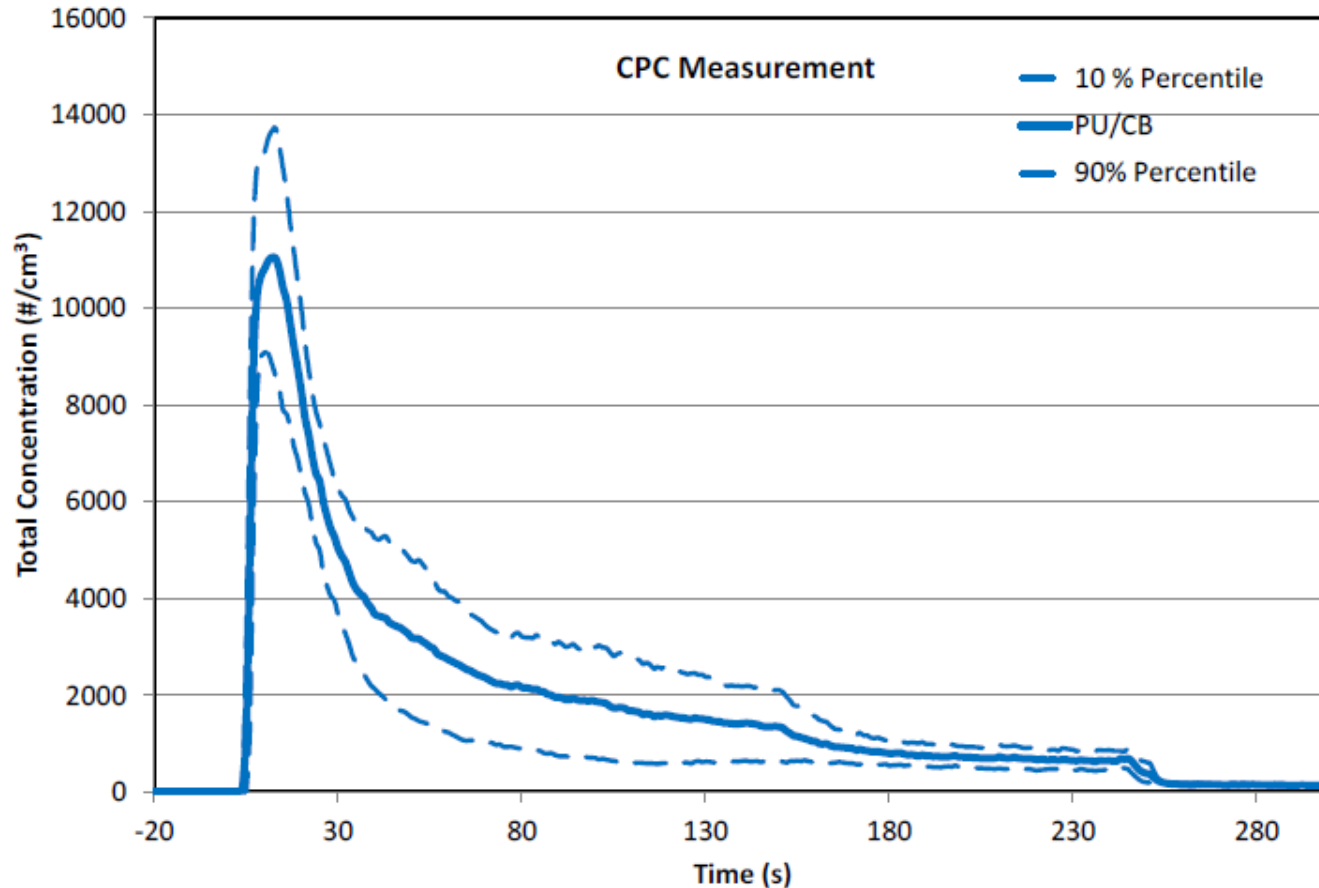


IUTA



Within Lab Variability – CPC Total Number Concentration

Average of four experiments:



→ Observed variability between experiments of mostly up to $\pm 50\%$ observed within one laboratory

mechanical processes

- sanding
- drilling
- sawing
- milling
- cutting
- dustiness
- mechanical shock
- wash off
-

thermal processes

- thermal stress
- incineration
- combustion
-

chemical processes

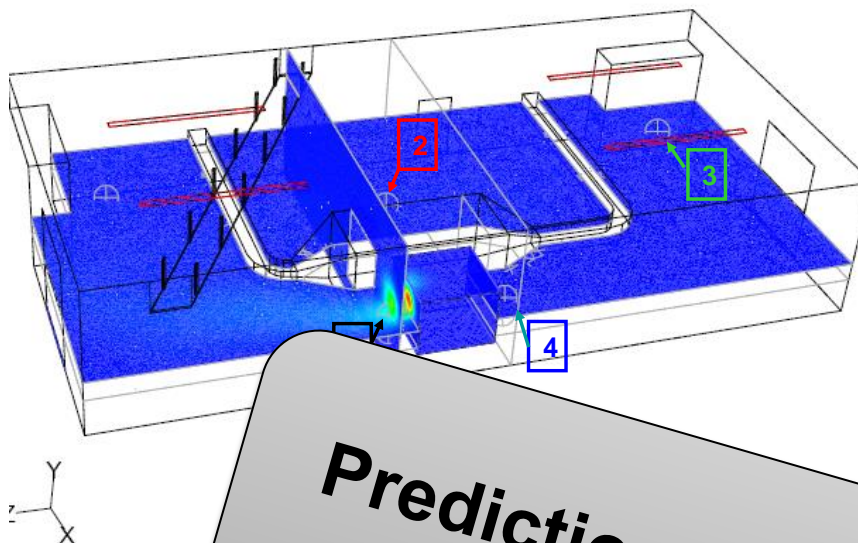
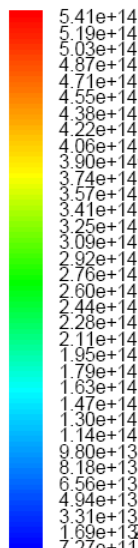
- reactive liquids / gases
- dissolution
-

mixed processes

- sanding (mechanical and thermal processes)
- wash out (dissolution and wash off)
- weathering (degradation and abrasion)
-

Spatial distribution of exposure

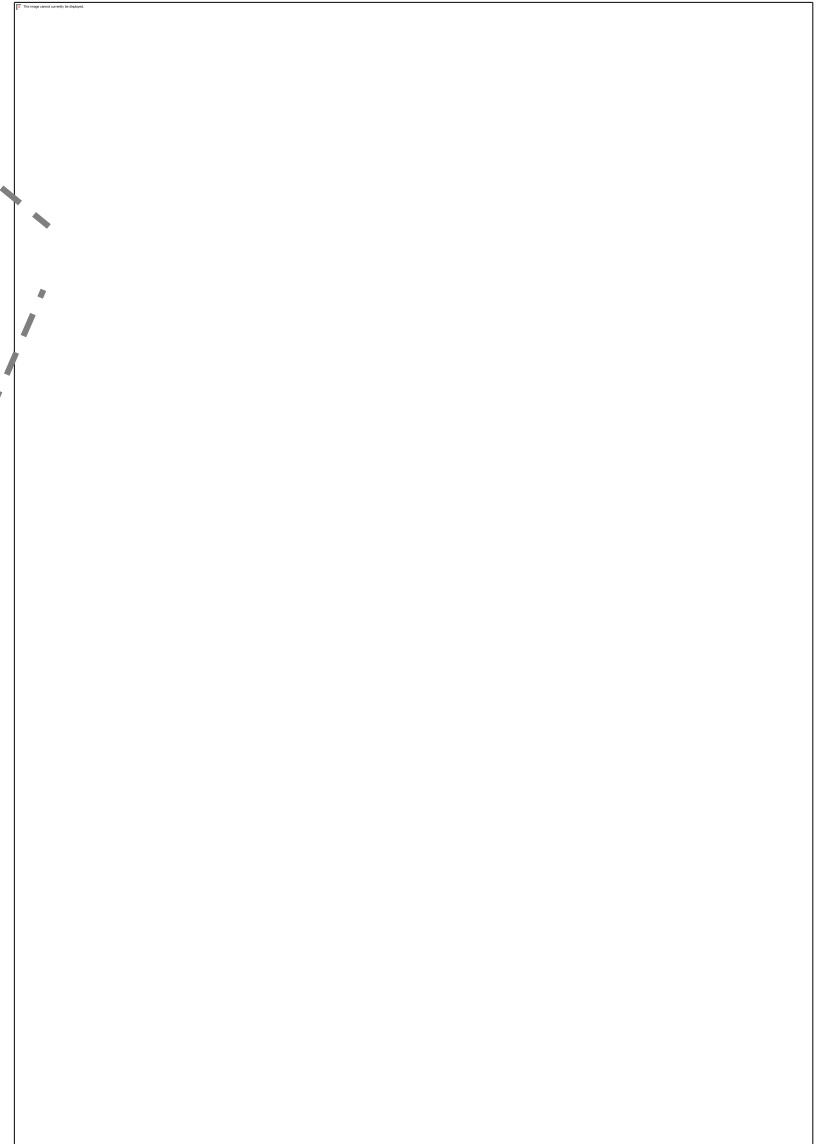
Number
Concentration




Prediction of possible
release and exposure

Mean Particle Size

Tier 2a: Screening

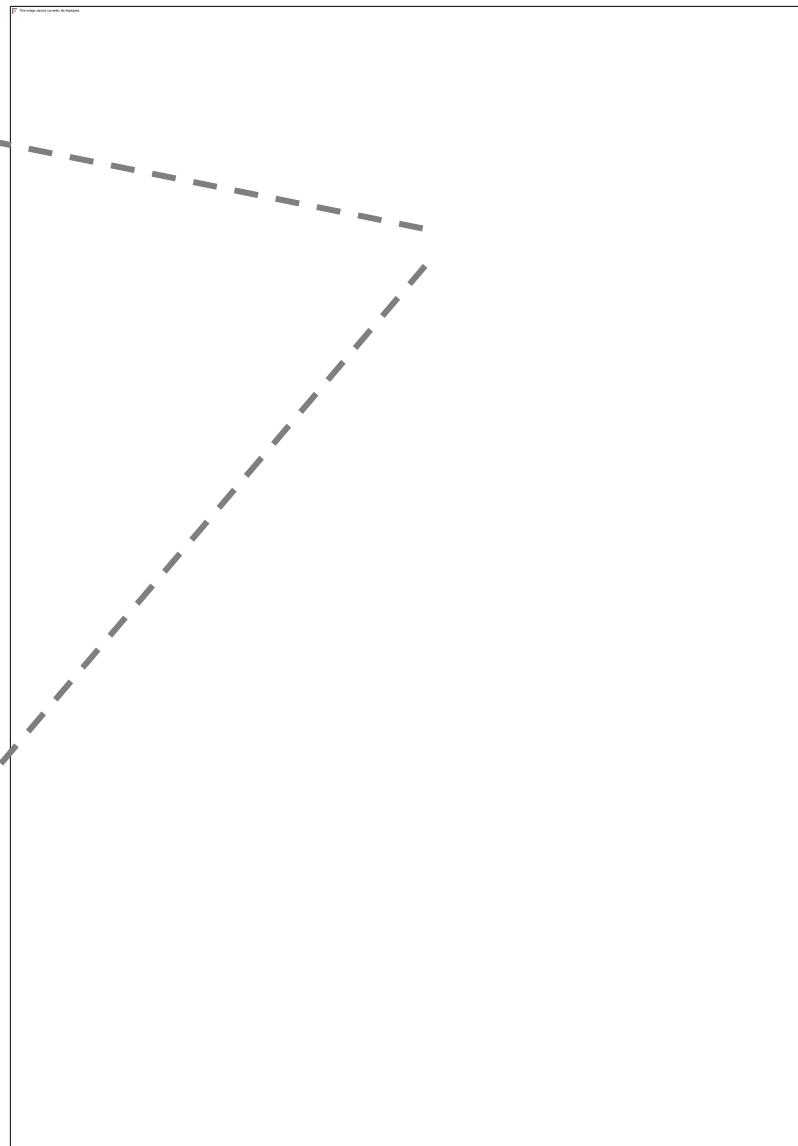


nano  **Simultaneous or consecutive measurement of background concentration**

Tier 2b: Monitoring



Simultaneous or consecutive measurement of background concentration



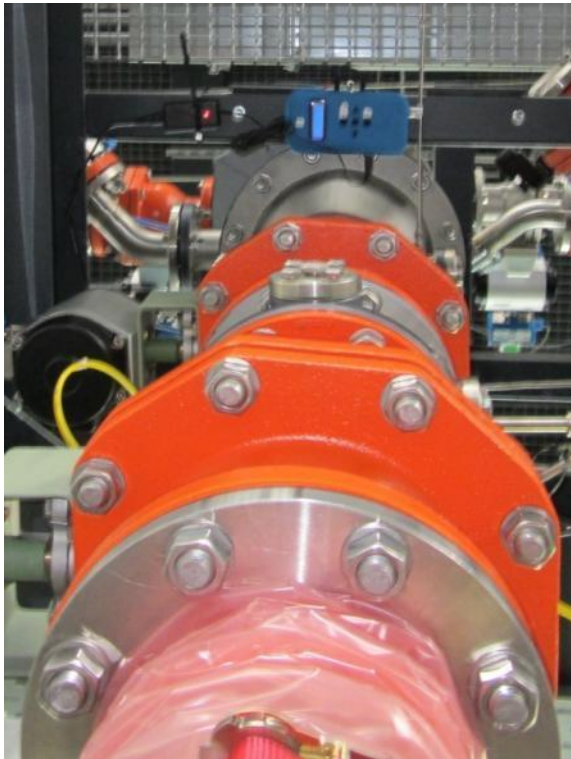
Field measurements according to the Tiered Approach

- Measurements were carried out at the IUTA pilot plant



Monitoring

- 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

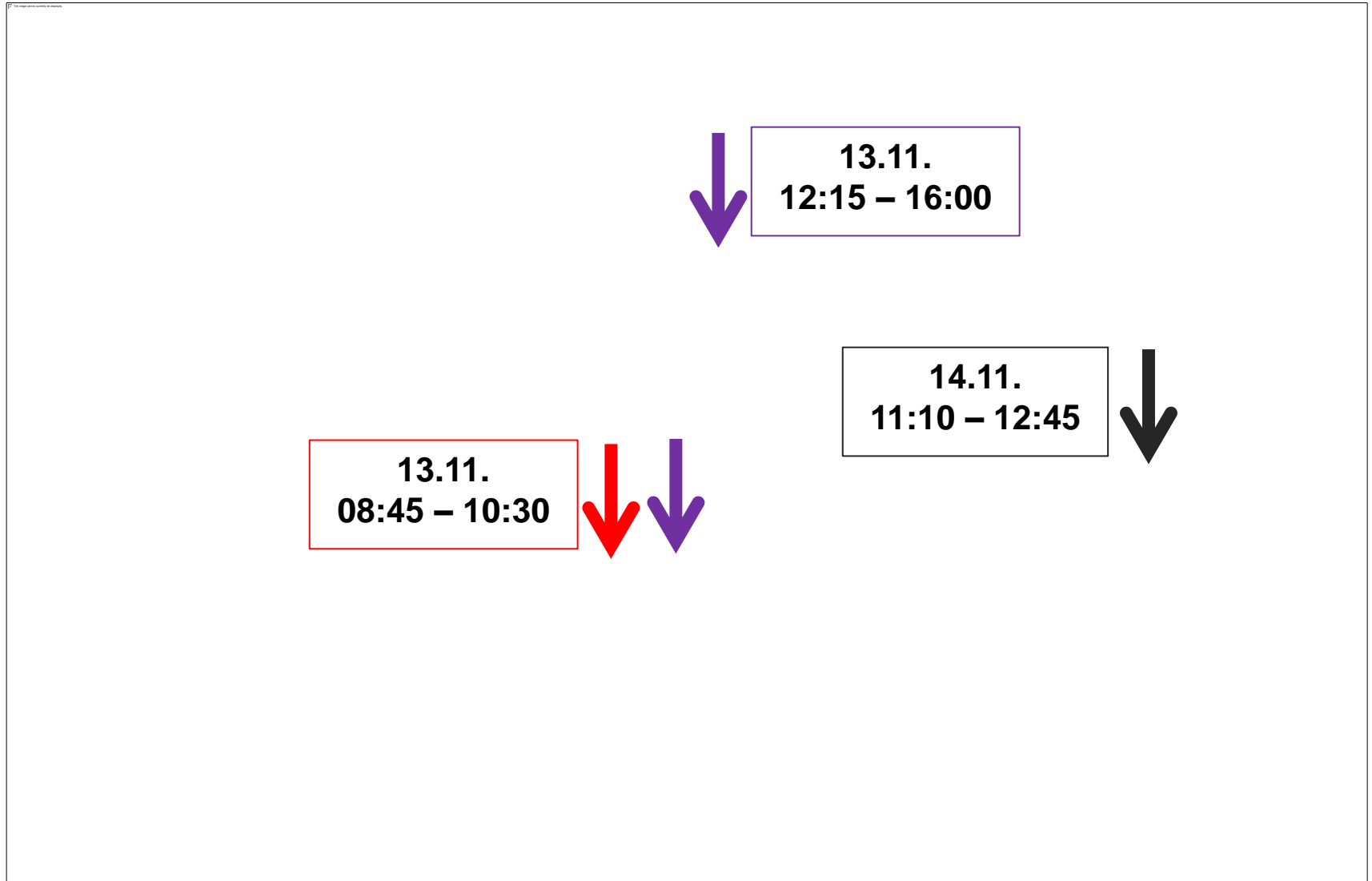


Reactor

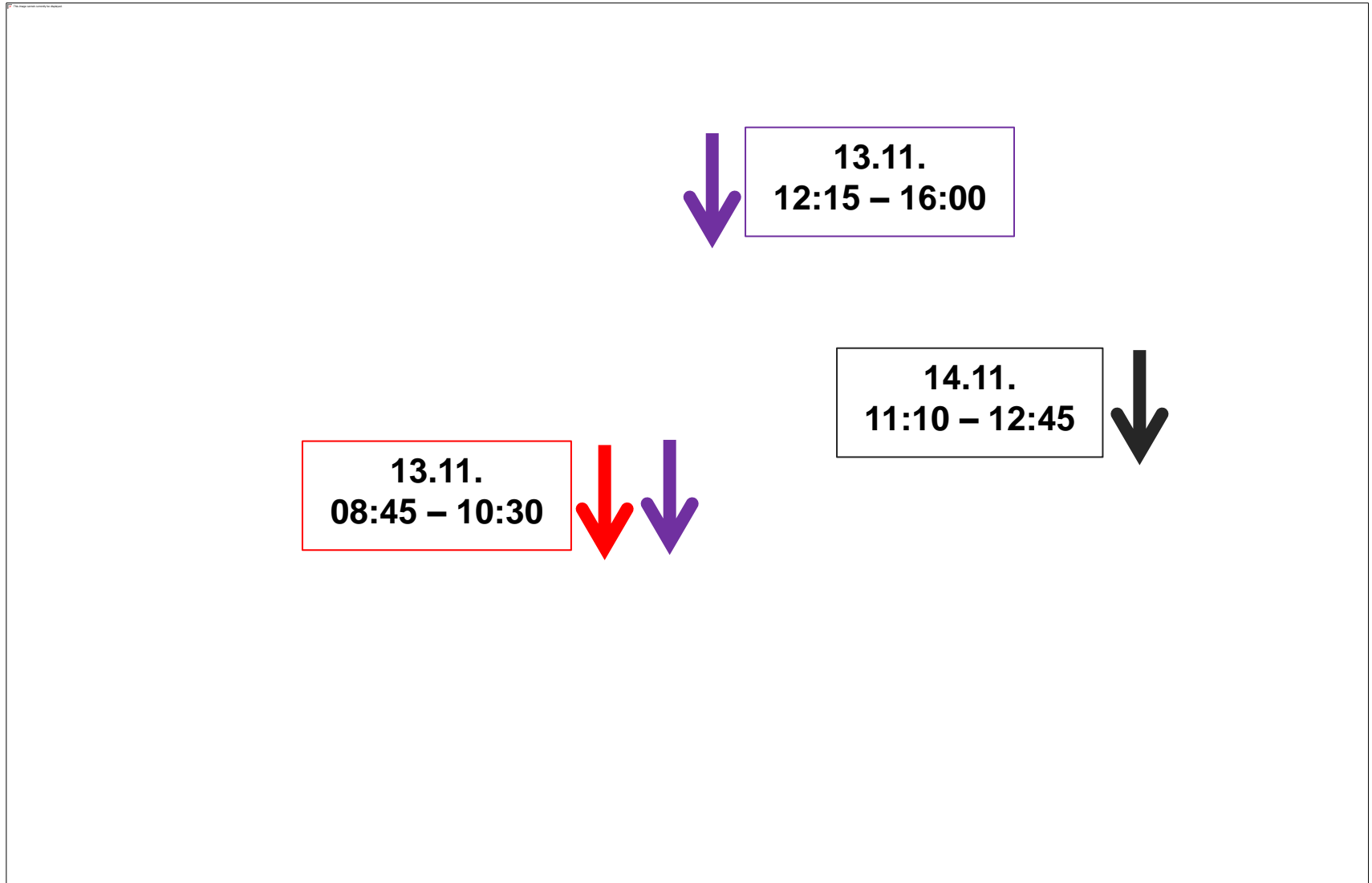


Ventilation

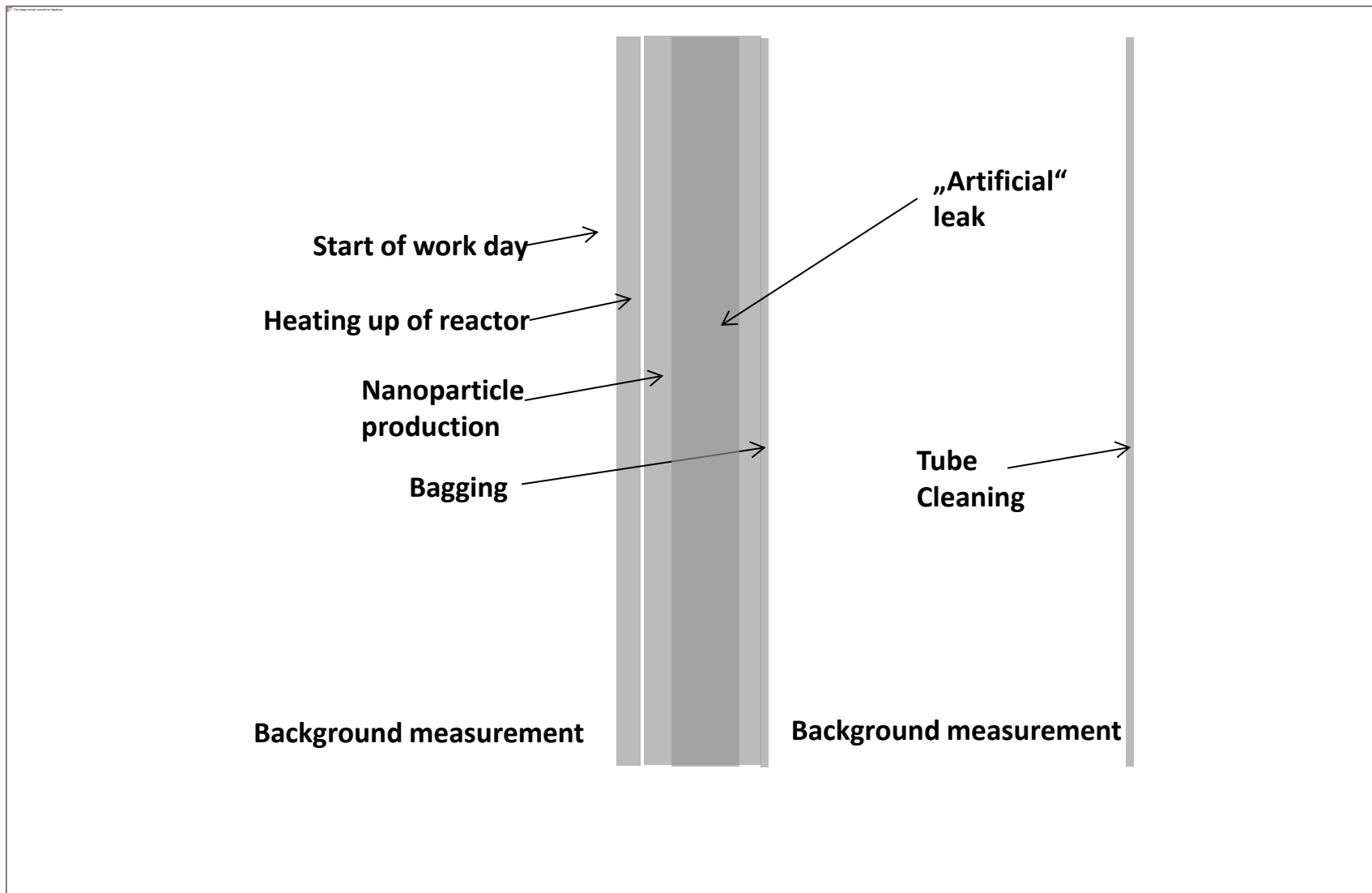
Results from monitoring (miniDiSC)



Results from monitoring (miniDiSC) and background (FMPS)



Results from monitoring (miniDiSC)



Artificial Leak

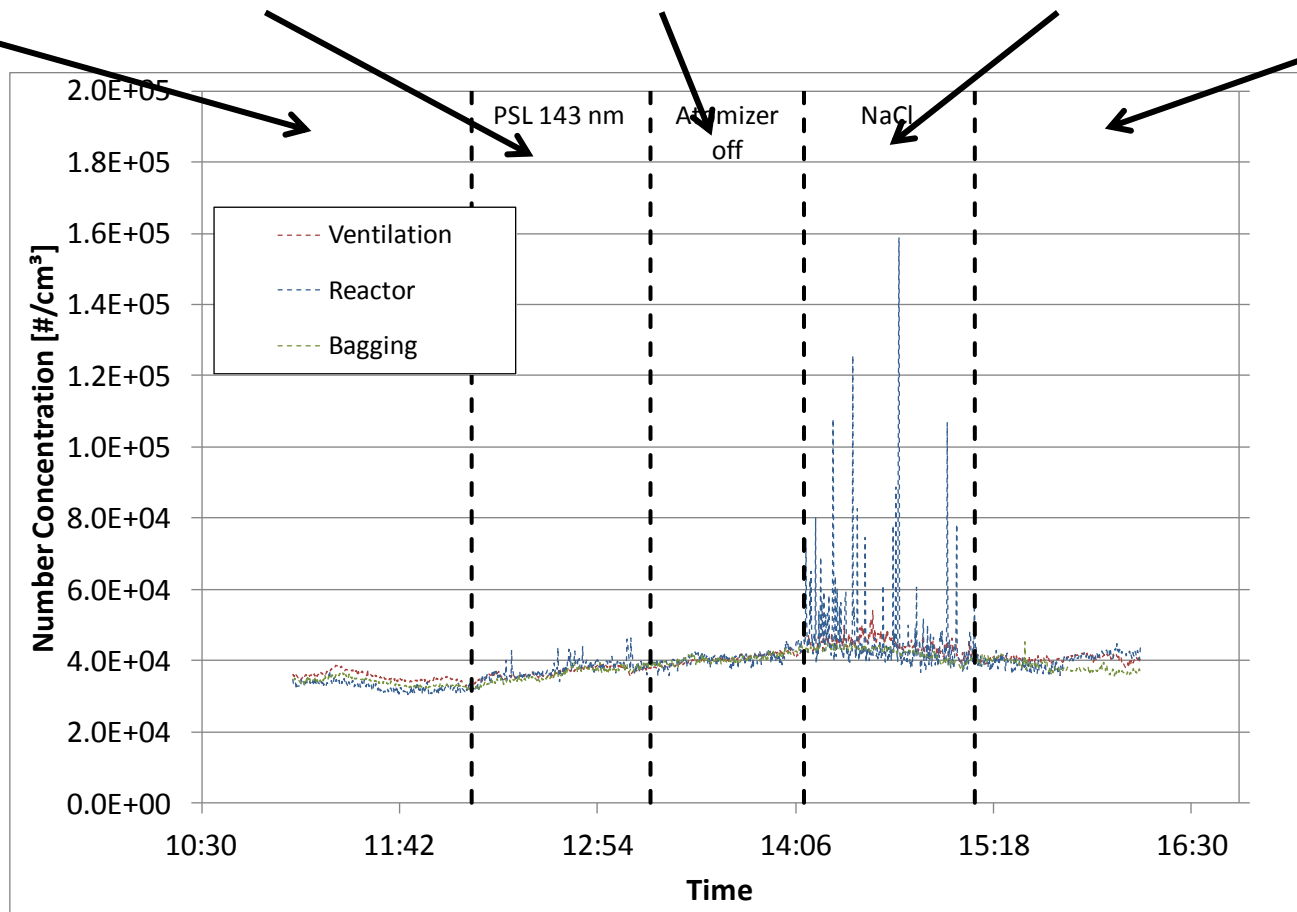
- It was expected that no particles would be emitted from pilot plant
- Therefore, a „leak“ was simulated by dispersing harmless particles (PSL and NaCl) into the workplace to test the measurement strategy

- 12:09 – 13:09 $1.6 \cdot 10^6 \text{ #/cm}^3$
 - 13:14 – 14:14 **Atomizer**
 - 14:19 – 15:19 **Atomizer**
- 
- „Leak“
- $1.6 \cdot 10^6 \text{ #/cm}^3$

Evaluation based on reactor miniDiSC

Background before PSL Concentration during PSL Background after PSL/before NaCl Concentration during NaCl Background after NaCl

$32,794 \pm 1120 \text{ \#/cm}^3$ $37,437 \pm 2025 \text{ \#/cm}^3$ $40,897 \pm 1420 \text{ \#/cm}^3$ $46,435 \pm 4270 \text{ \#/cm}^3$ $40,244 \pm 1549 \text{ \#/cm}^3$

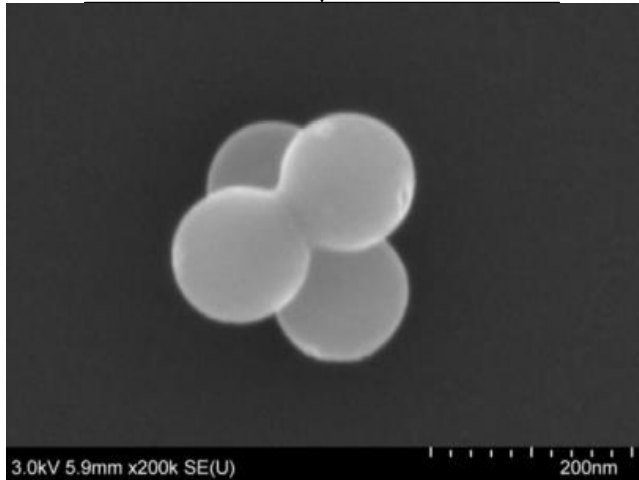


Evaluation based on reactor miniDiSC

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

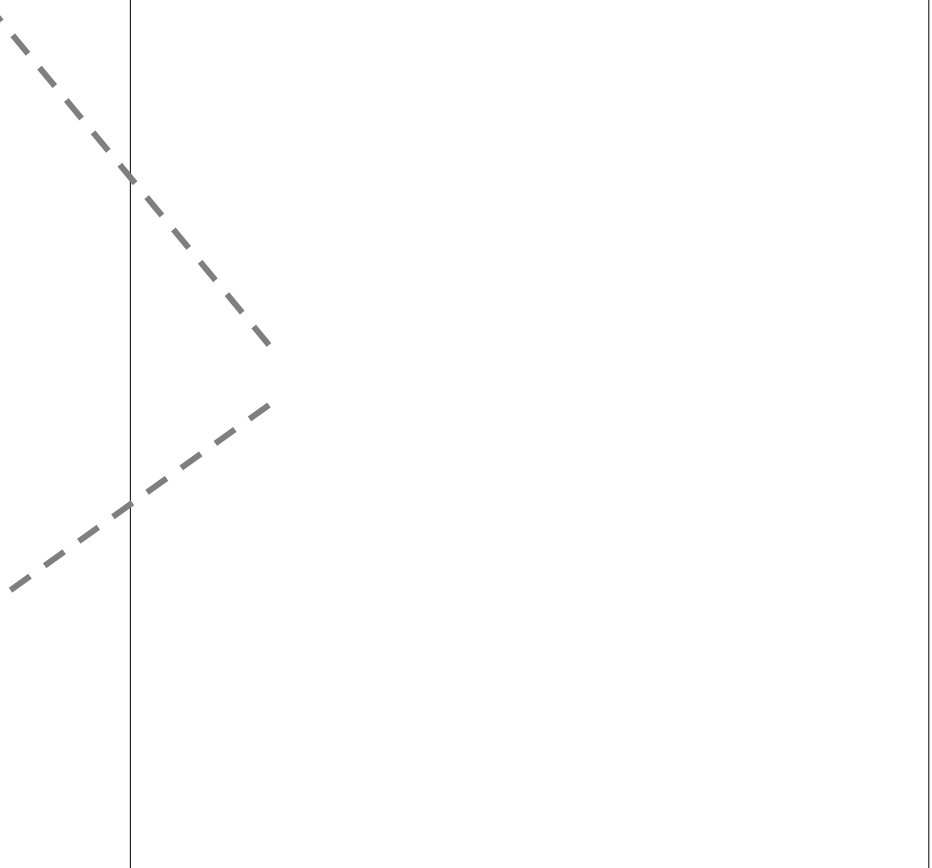
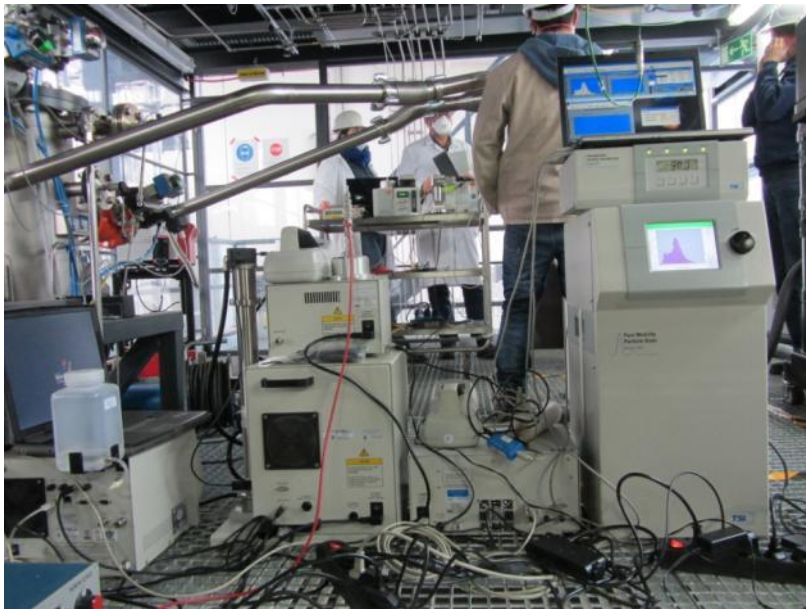
Average background PSL
 $36,845 \pm 4331 \text{ \#/cm}^3$

Average background NaCl
 $40,556 \pm 1493 \text{ \#/cm}^3$



Net Emission NaCl
 $5879 \text{ \#/cm}^3 > 3 * \sigma$
→ Significant

Tier 3: „Expert Assessment“



Simultaneous or consecutive measurement of background concentration/size distribution

Which metric to be used ~~in exposure assessment~~?



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Particle size distribution	0	+	-	+++	+++	++	+++	0	-
Particle reactivity	-	-	-	-	+++	-	+++	0	0



Assessment of Individual Exposure to manufactured nanomaterials by means of personal monitors and samplers

Funded in the framework of the
SIINN Era-Net program in EU-FP7



Start:
Duration:
Total funding:
Coordinator:

01. Juni 2013
36 Months
1.439.395 €
Christof Asbach



FP7 ERA-NET "Safe Implementation of Innovative Nanoscience and Nanotechnology" (SINN)



NanoIndEx Workshop

“Assessment of Individual Exposure to Nanomaterials”

November 21st, 2014
In Grenoble, France

For more information and registration, please visit:

www.nanoindex.eu



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This project is supported by



Thanks

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