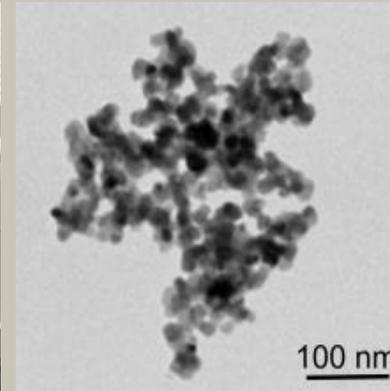
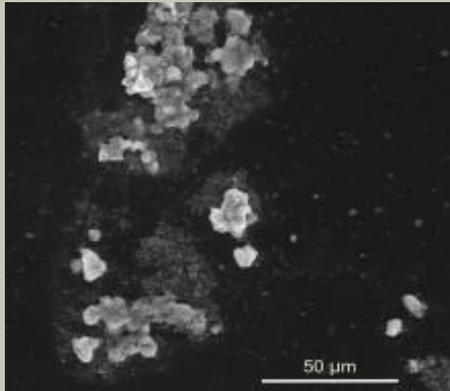


Control of worker exposure during handling of manufactured nanomaterials in fume hoods



Ana S. Fonseca^{1,*}, Eelco Kuijpers², Kirsten I. Kling¹, Marcus Levin¹, Antti J. Koivisto¹, W. Fransman², Yijri Fedutik³, Ismo K. Koponen¹, Keld A. Jensen¹

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DET NATIONALE
FORSKNINGS-CENTER FOR ARBEJDSMILJØ



Friday, 9 November 2018

OUTLINE



- **Background**

- Particles impacting human exposure
- Adverse health effects

- **Motivation and relevance**

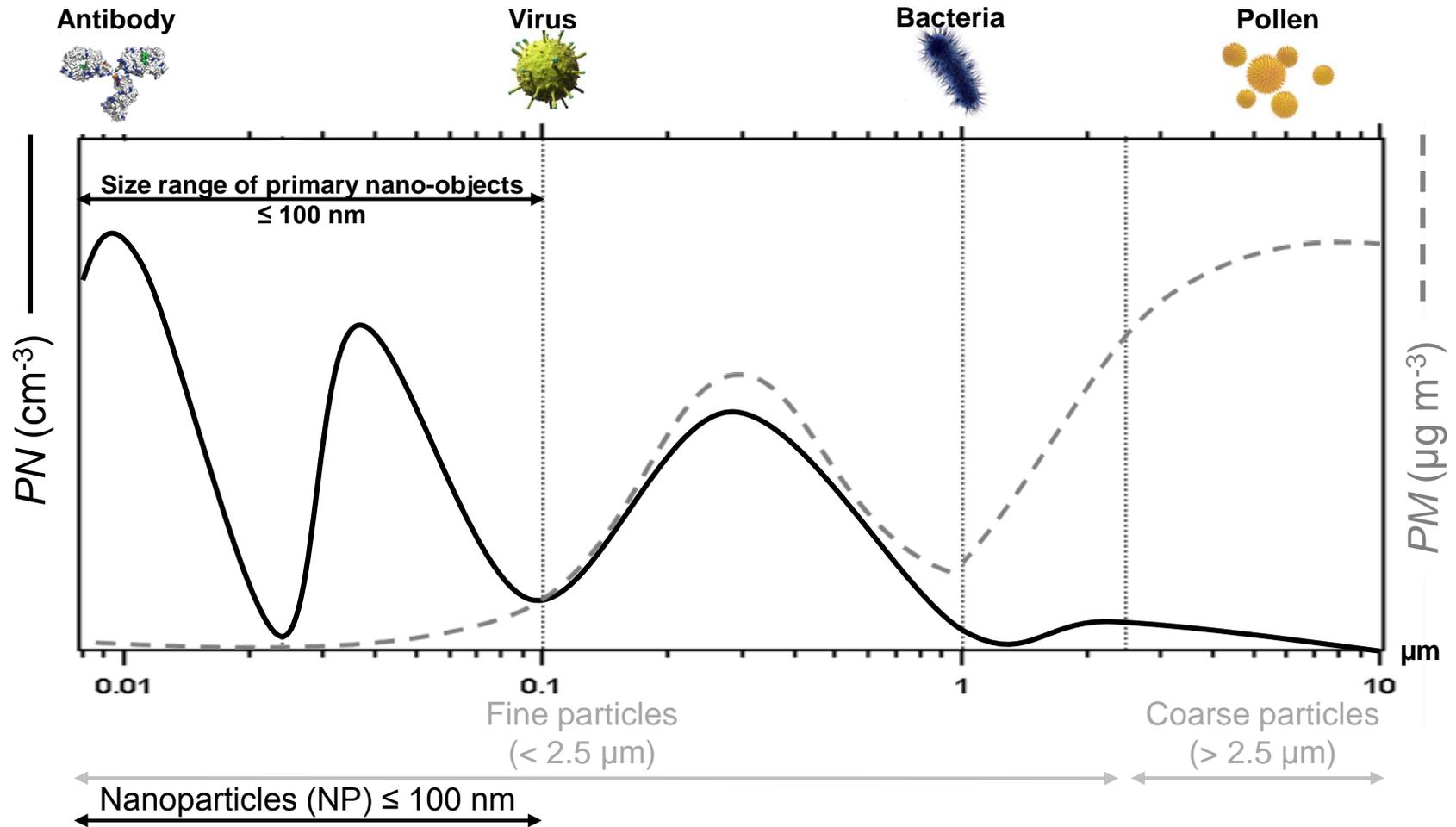
- **Particle release and control of worker exposure**

- Objectives
- Exposure assessment strategy
- Real case scenario: synthesis and handling of manufactured nanomaterials in fume hoods
- Simulated spills of manufactured nanomaterials in fume hoods

- **Conclusions and recommendations**

BACKGROUND

Particles impacting human exposure



60 - 80 %
indoors



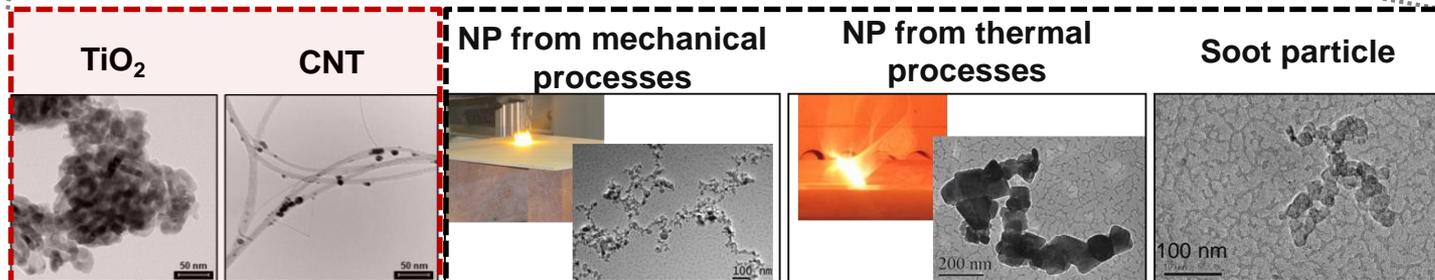
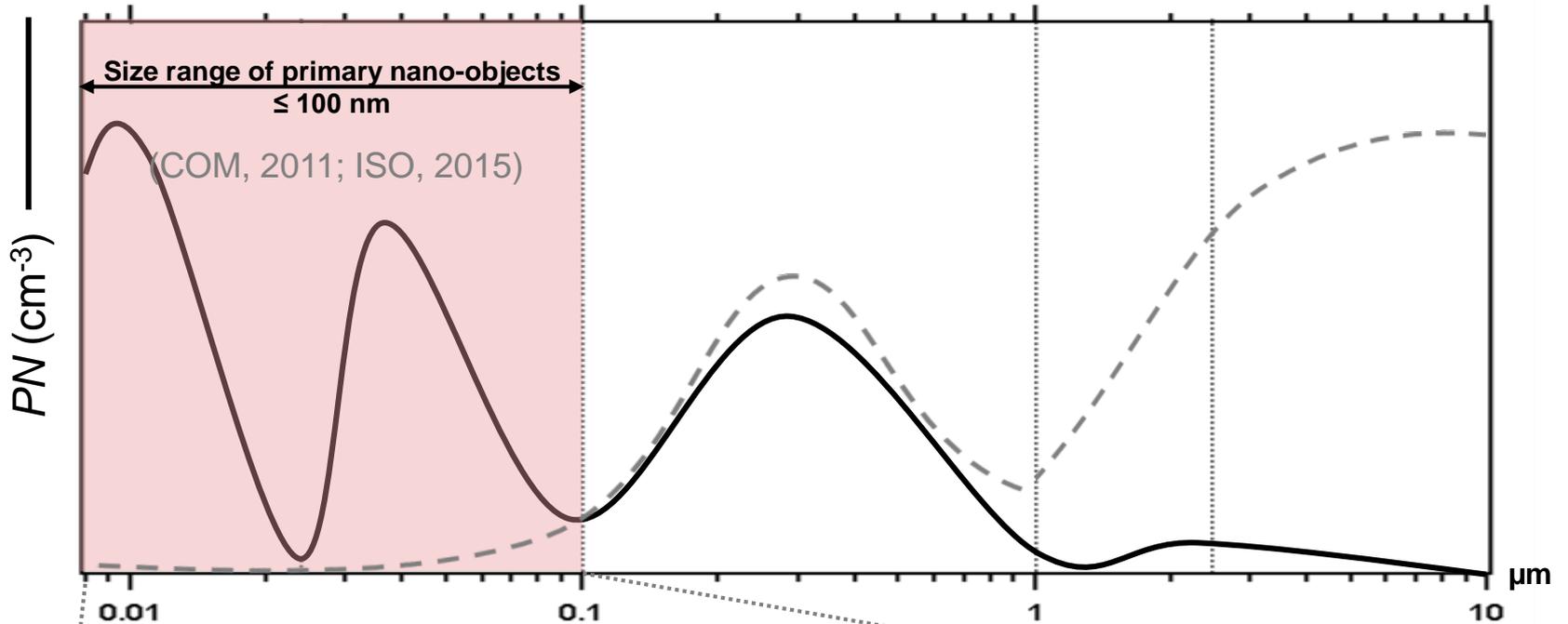
50% in the workplace

(Klepeis et al., 2001)



BACKGROUND

Particles impacting human exposure



Engineered nanoparticles
(ENP)

Non-engineered nanoparticles
(N-ENP)

BACKGROUND

Particles impacting human exposure

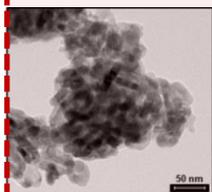
Occupational settings
dealing with ENP



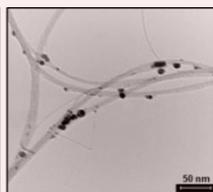
**New risks and
uncertainties!**



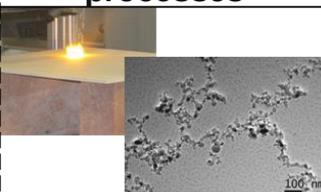
TiO₂



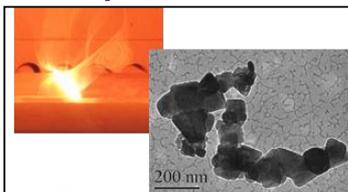
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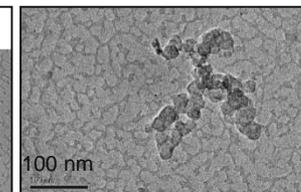
NP from mechanical
processes



NP from thermal
processes



Soot particle



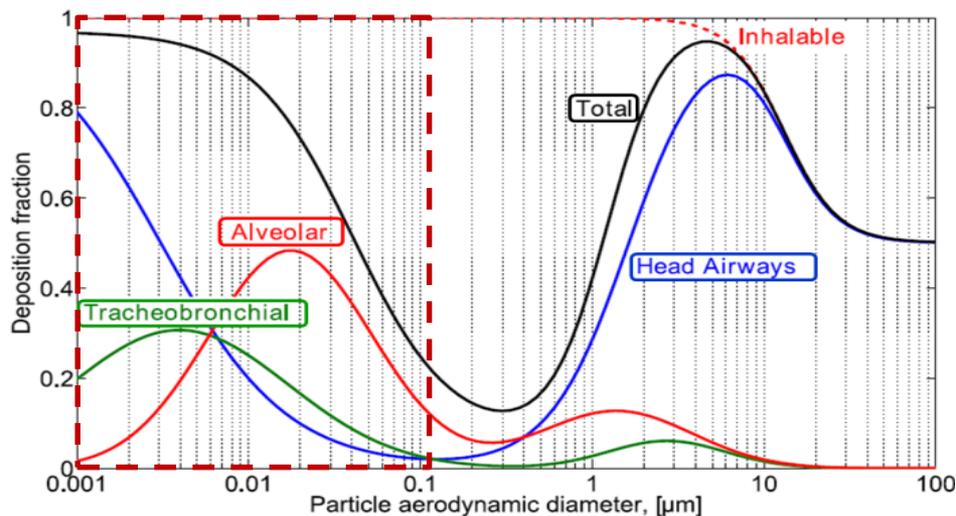
Engineered
nanoparticles
(ENP)

Non-engineered
nanoparticles
(N-ENP)

BACKGROUND

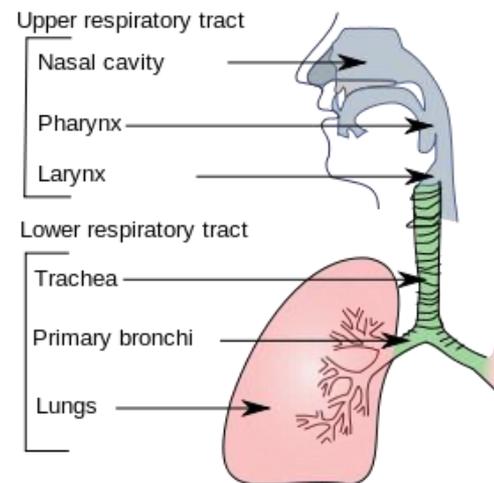
Adverse health effects

Higher potential for adverse health effects



Fractional deposition of inhaled particles in the human respiratory tract. Source: Koivisto (2013)

Main exposure route



Ability to penetrate deeper in human lungs



Translocate to the blood circulatory system



Transported directly to the brain



MOTIVATION AND RELEVANCE

Control of worker exposure

- Synthesis and handling of ENPs are common tasks in nanotechnology research
- Fume hoods have been used to protect workers from exposure to airborne ENPs
- Significant release of ENPs into the workplace air ($>1 \times 10^4 \text{ cm}^{-3}$) have been detected while manufacturing and handling nanopowders (Tsai *et al.* 2009)



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<https://doi.org/10.1007/s11051-018-4136-3>



RESEARCH PAPER

Particle release and control of worker exposure during laboratory-scale synthesis, handling and simulated spills of manufactured nanomaterials in fume hoods

Ana S. Fonseca · Eelco Kuijpers · Kirsten I. Kling · Marcus Levin · Antti J. Koivisto · Signe H. Nielsen · W. Fransman · Yijri Fedutik · Keld A. Jensen · Ismo K. Koponen

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OBJECTIVES



ASSESSMENT OF PARTICLE RELEASE AND WORKERS' INHALATION EXPOSURE DURING SYNTHESIS AND HANDLING UNDER A FUME HOOD

■ **CuO**

■ **TiO₂**

■ **ZnO**

EVALUATION OF THE CAPACITY OF A FUME HOOD TO PREVENT PARTICLE RELEASE DURING SIMULATED SPILLAGE



Material



Drop height



Mass load

TiO₂, SiO₂, and zirconia TZ-3Y

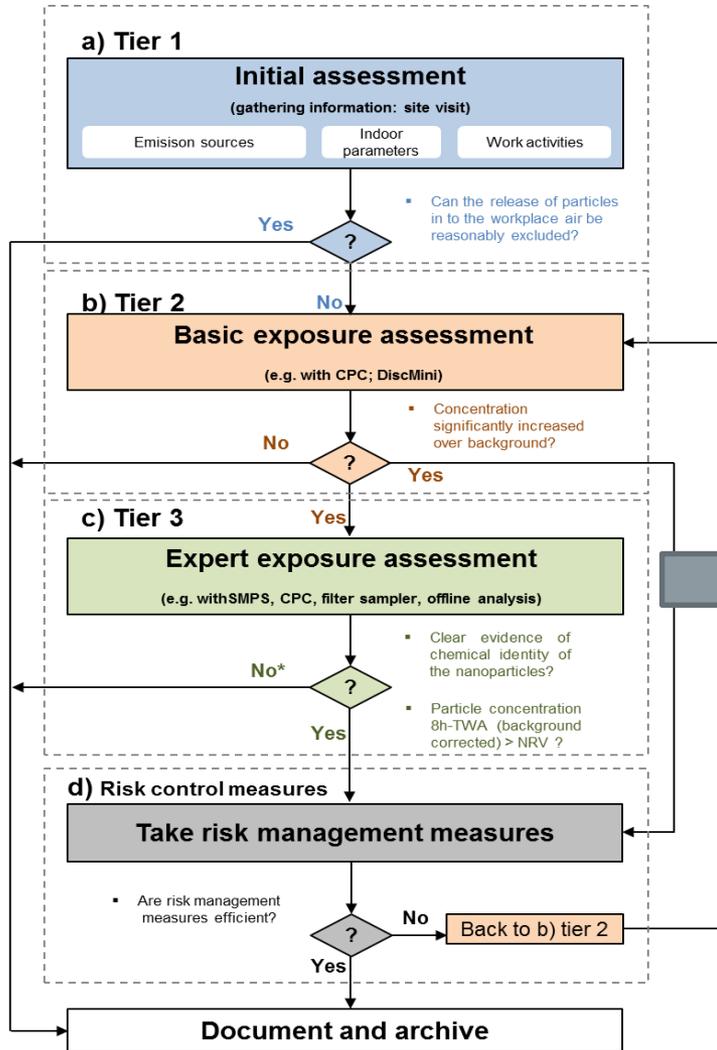
5-40 cm

5-125 g

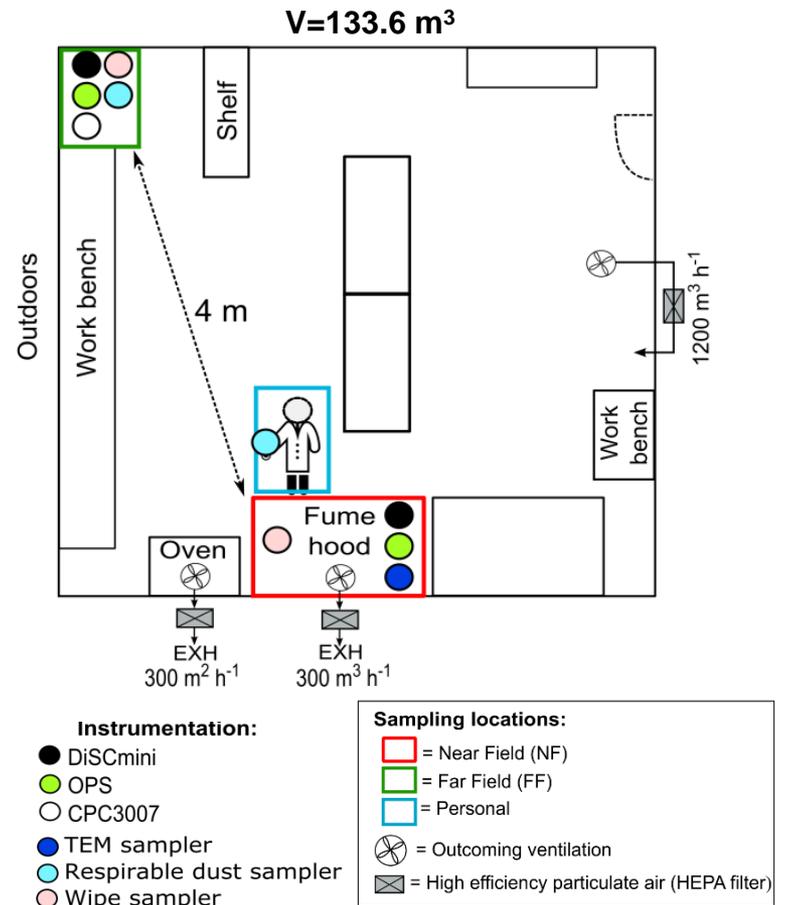


EXPOSURE ASSESSMENT STRATEGY

(Organization for Economic Co-operation and Development; OECD, 2015)



Approach: simultaneous measurements in emission (near field; NF), background location (far field; FF) and in breathing zone (BZ)



* No nanoparticles from target activity; chemical identity of nanoparticles known; their origin is elsewhere

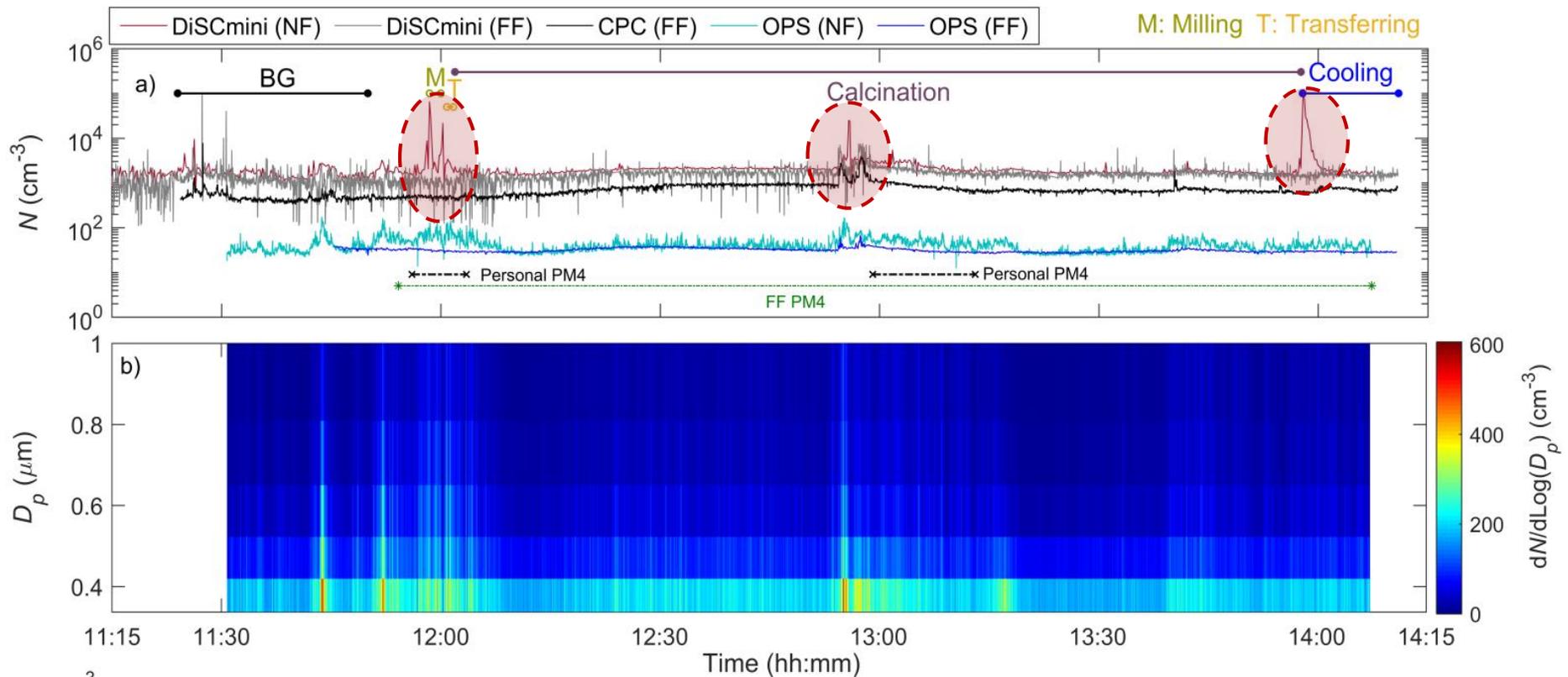


REAL CASE SCENARIO

Synthesis and handling CuO under a fume hood

- CuO (CAS No.1317-38-0)
- Primary size 40 ± 10 nm

CuO average exposure level
= $9.2 \mu\text{g m}^{-3}$



Ratio NF/FF= 2.8



NM exposure may occur if the fume-hood is not working properly!

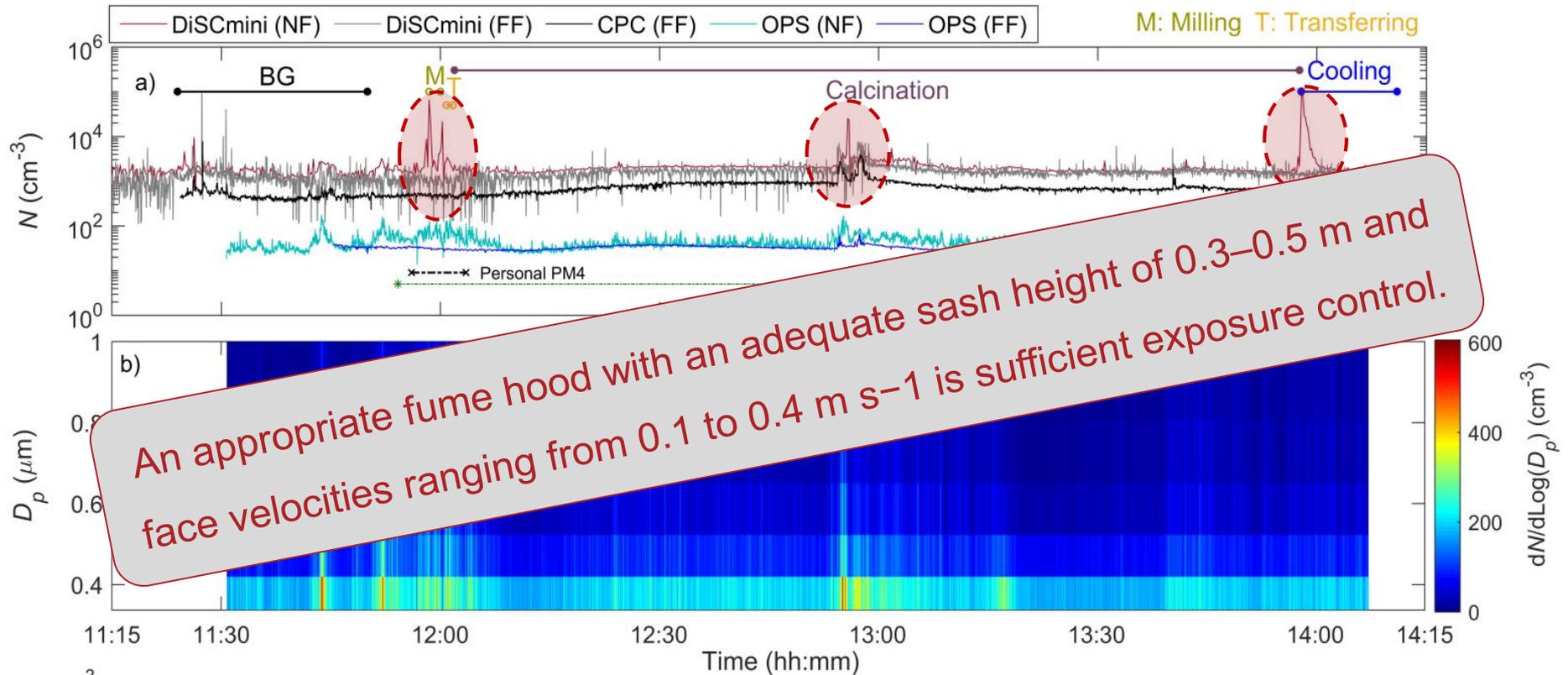


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SIMULATED SPILLS

Material

TiO₂, SiO₂, and zirconia TZ-3Y



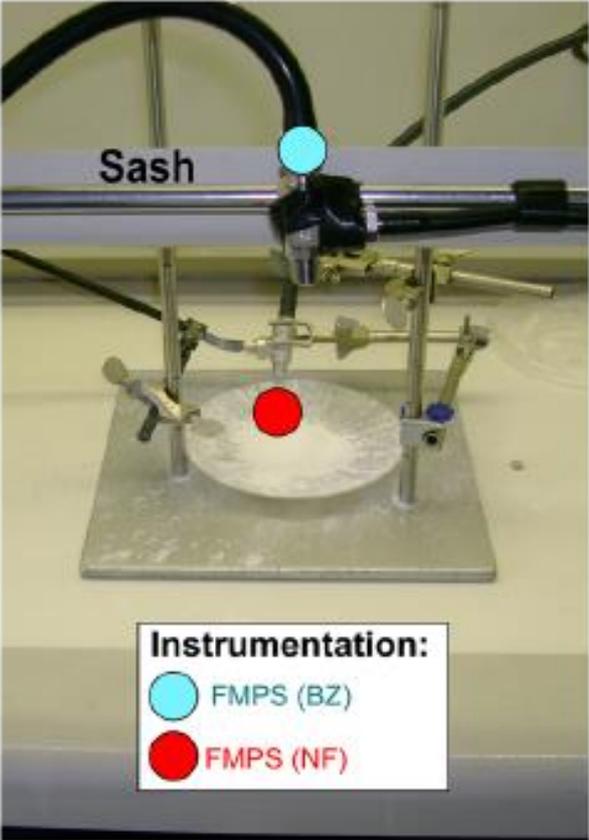
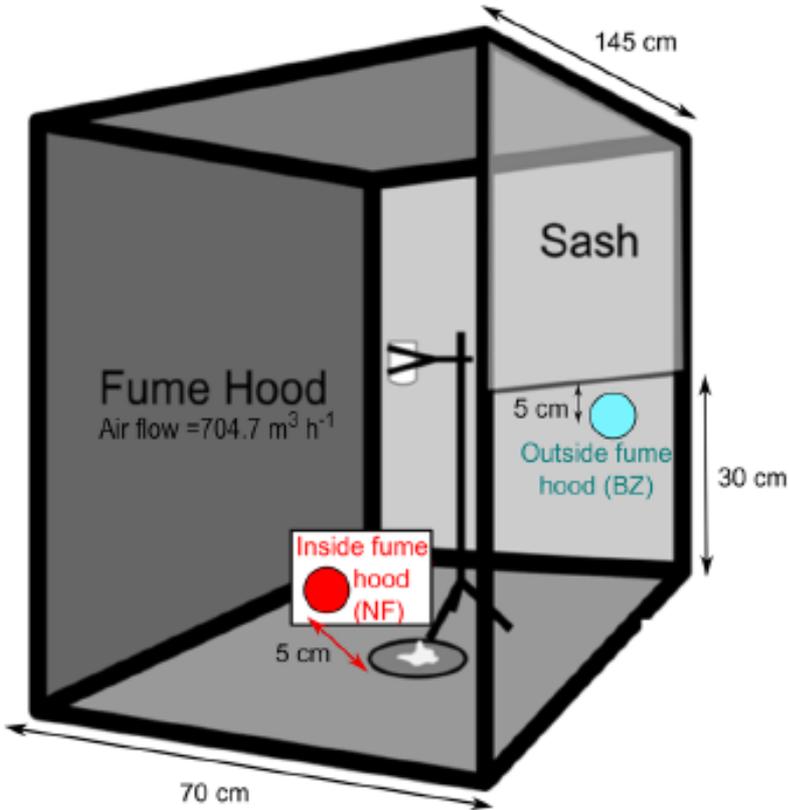
Drop height

5-40 cm



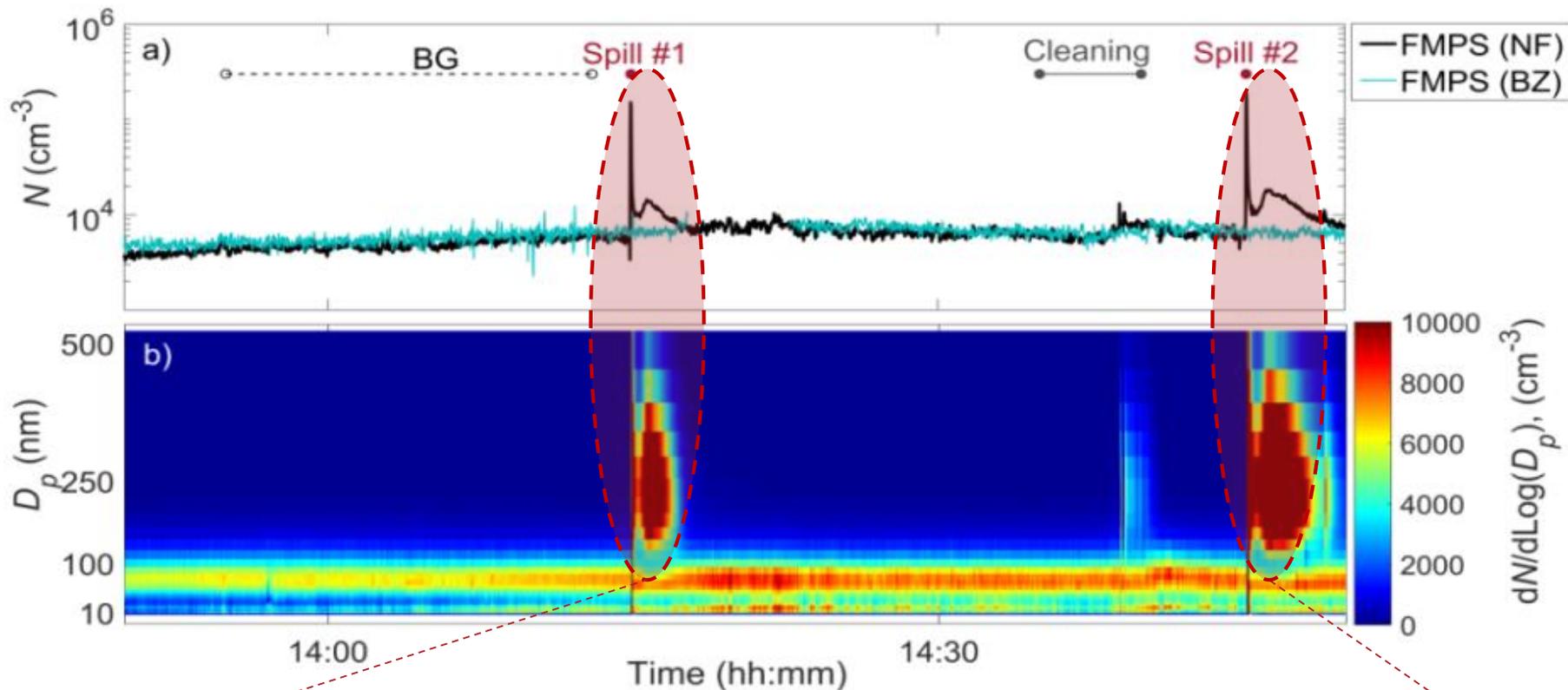
Mass load

5-125 g



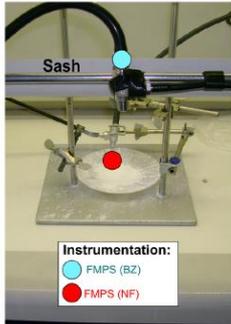
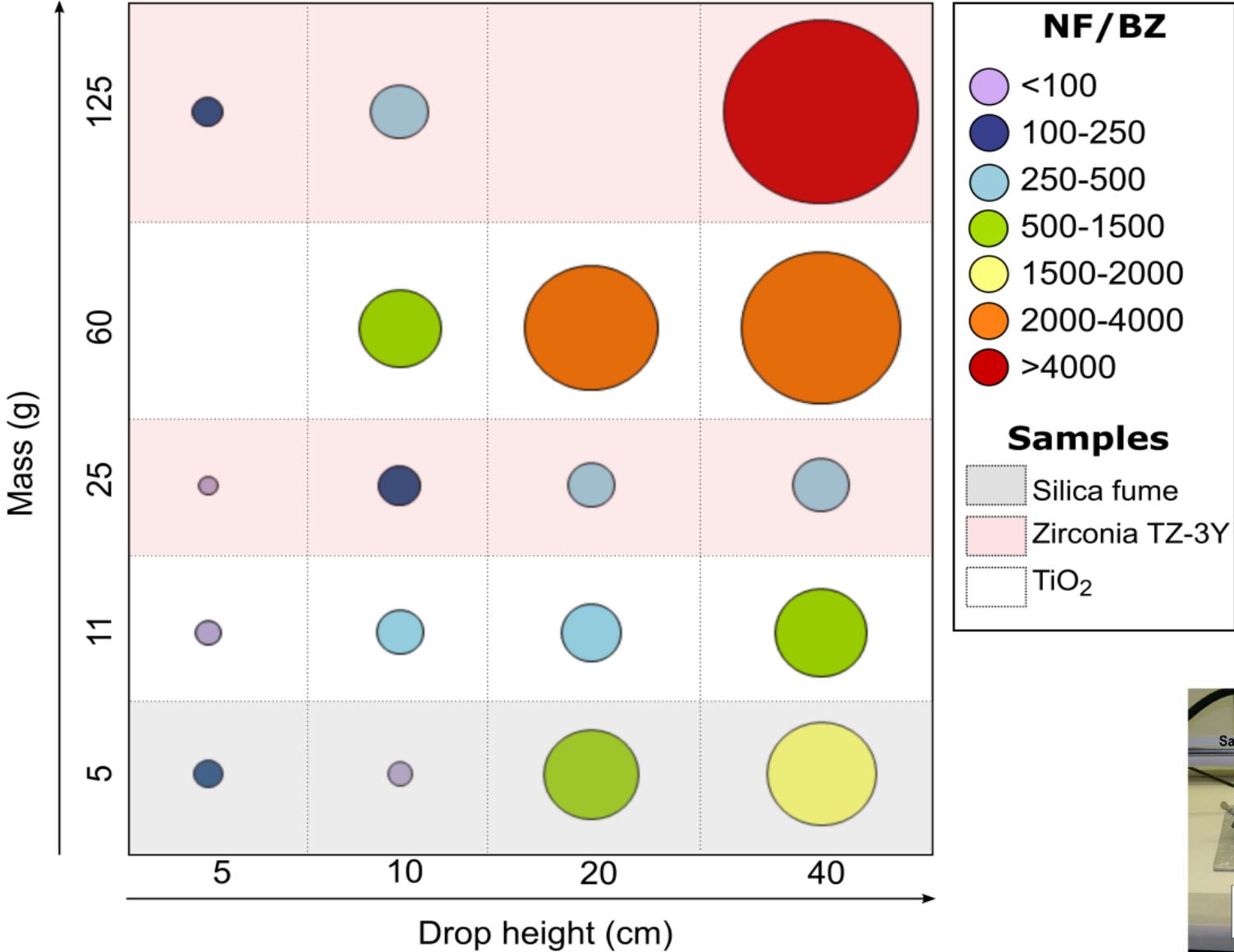
SIMULATED SPILLS

Example: 60 g TiO₂ (rutile) from 40 cm drop height

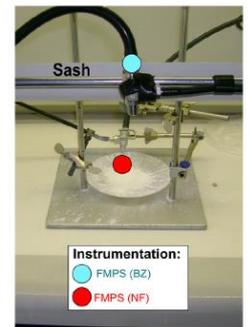
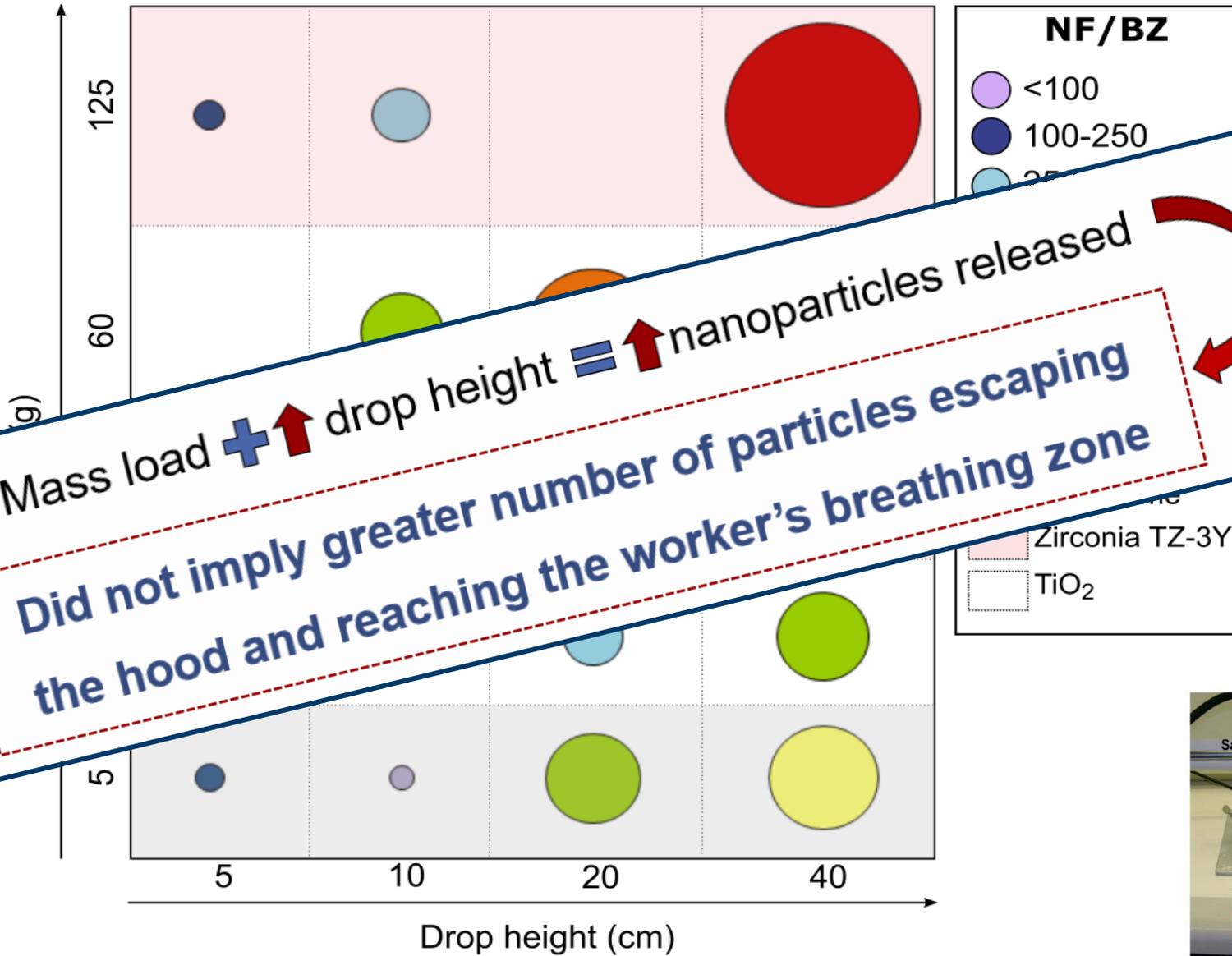


Notable increase in particle concentrations were rarely detected in the breathing zone of the worker

SIMULATED SPILLS



SIMULATED SPILLS



SIMULATED SPILLS

- Powder spills were sometimes observed to **eject into the laboratory room** and contaminate the workers' laboratory clothing but **rarely associated with significant particle release** from the fume-hood to the worker's BZ



Fume-hood protection factors

$$\varepsilon (\%) = 1 - \frac{N_{Spill,BZ} - N_{BG,BZ}}{N_{Spill,NF} - N_{BG,NF}} \times 100$$

mean efficacy of 98.3%
(total range from 78 to 99%)



Suggests that fume-hood effectiveness is independent of the type of NM

CONCLUSIONS

- This study confirms that an appropriate fume-hood **prevents well against particle release** into the general laboratory environment.



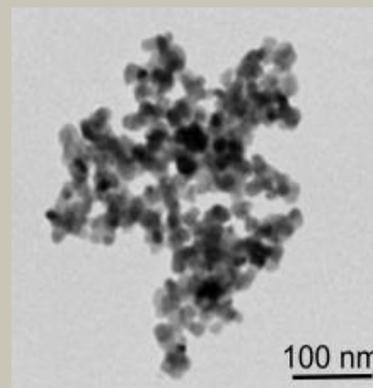
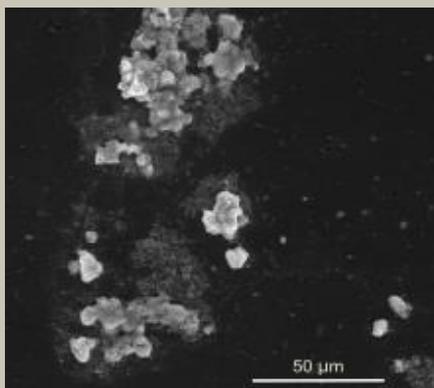
The average in-use protection efficacy was 98.3%

RECOMMENDATIONS:

- ✓ Safe approaches for cleaning powder spills should be prepared to prevent exposure via resuspension and inadvertent exposure by secondary routes.
- ✓ A regularly fume-hood's operational status checking is recommended.

CHECKED

THANK YOU VERY MUCH FOR YOUR ATTENTION!



Ana Sofia Fonseca

Contact: agf@nrcwe.dk

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FORSKNINGS-CENTER FOR ARBEJDSMILJØ



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