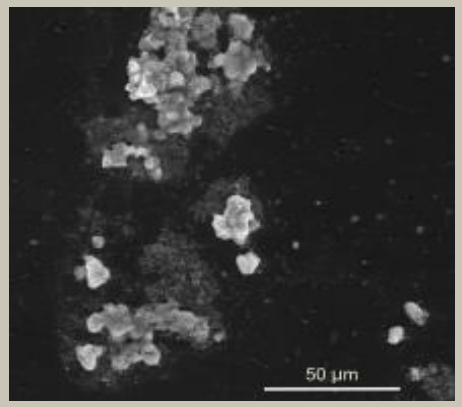
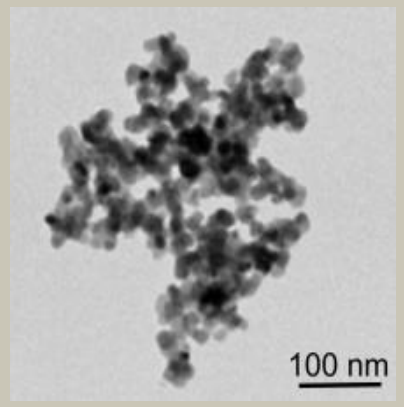
Control of worker exposure during handling of manufactured nanomaterials in fume hoods



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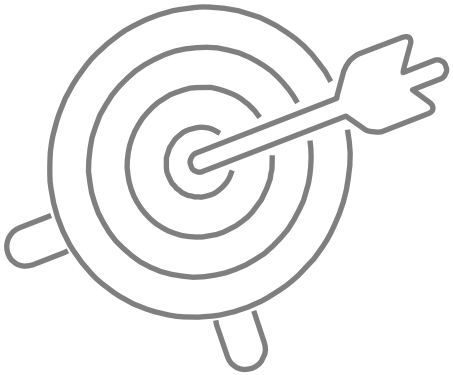
nanoSAFE

Friday, 9 November 2018

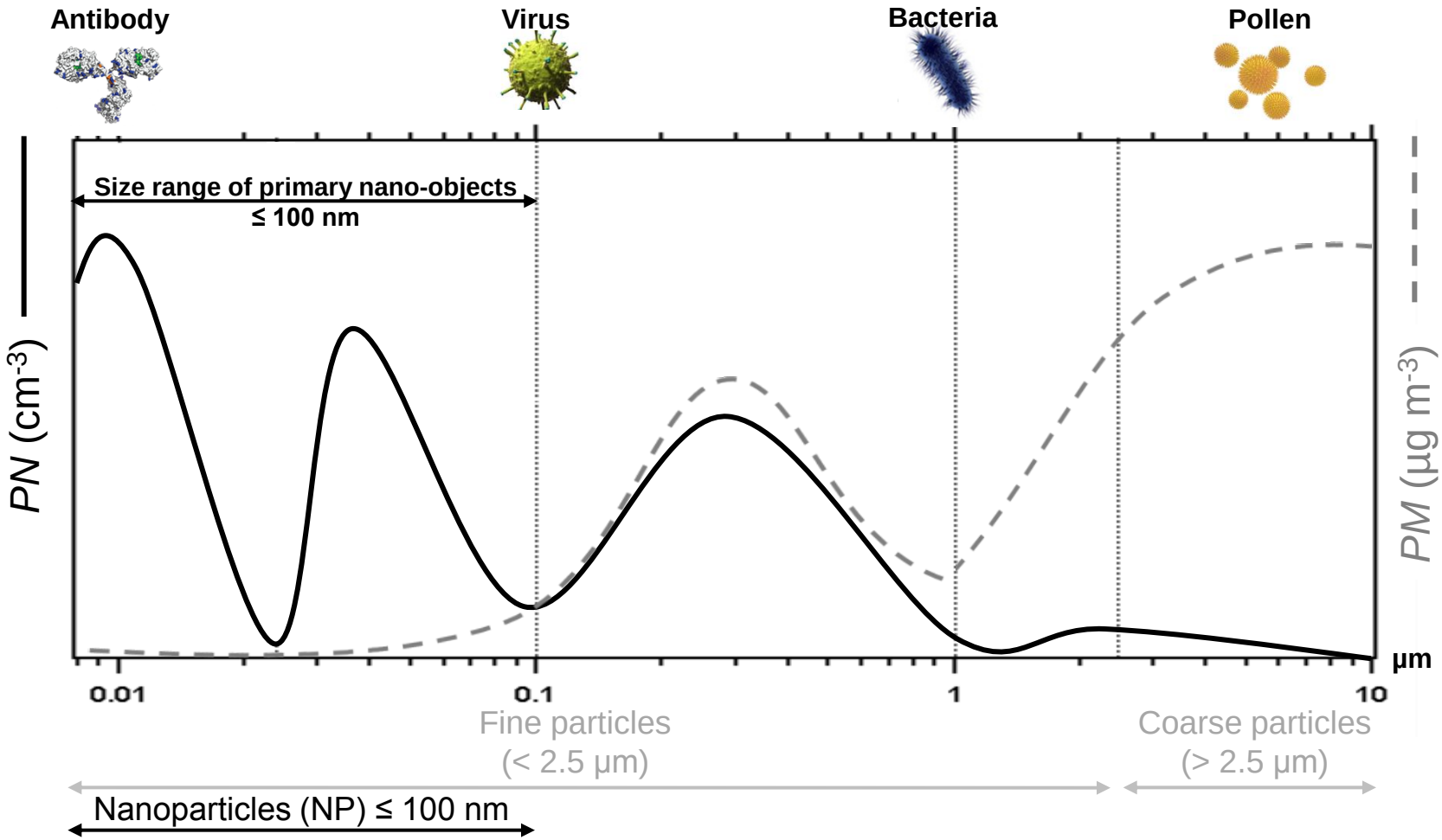
OUTLINE



- **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

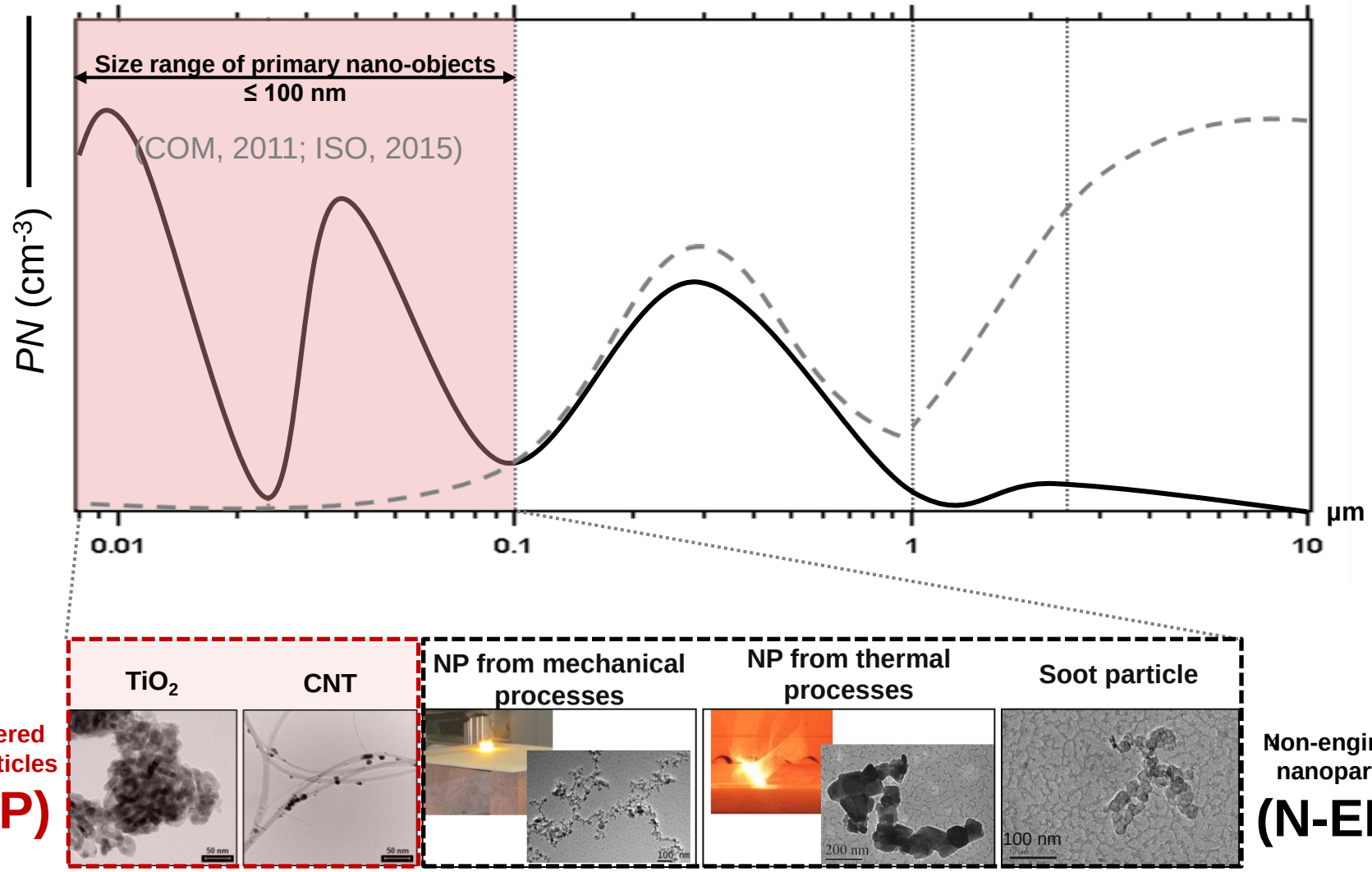


60 - 80 % indoors ⇨ **50% in the workplace**

(Klepeis *et al.*, 2001)

BACKGROUND

Particles impacting human exposure



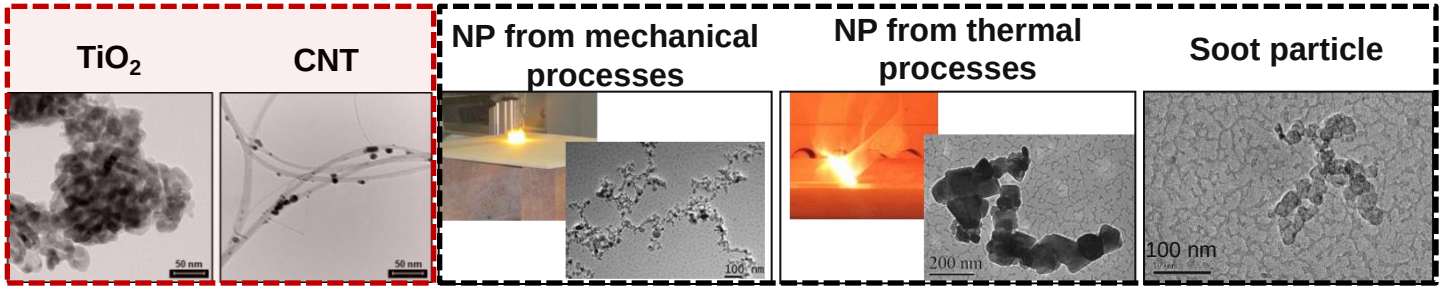
BACKGROUND

Particles impacting human exposure

Occupational settings dealing with ENP

New risks and uncertainties!

Engineered nanoparticles **(ENP)**

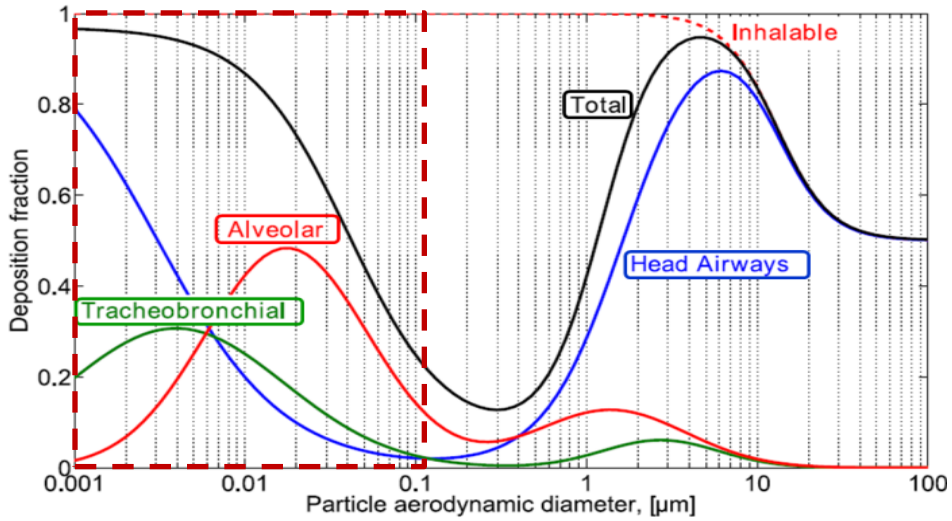


Non-engineered nanoparticles **(N-ENP)**

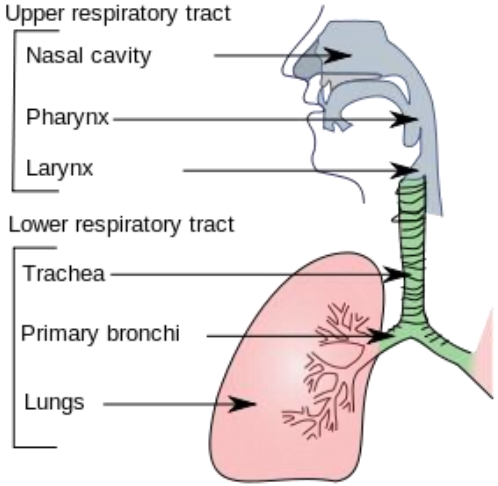
BACKGROUND

Adverse health effects

Higher potential for adverse health effects



Main exposure route



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

Ability to penetrate deeper in human lungs

Translocate to the blood circulatory system

Transported directly to the brain

European Agency for Safety and Health at Work

OSHA® Occupational Safety and Health Administration

ENP (<100 nm)

Major current emerging risks at workplaces!

RISK

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 x 10^4 cm^{-3}) have been detected while manufacturing and handling nanopowders (Tsai *et al.* 2009)

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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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Fonseca *et al*. (2018) J Nanopart Res., 20:48

OBJECTIVES

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

- **CuO**
- **TiO_2**
- **ZnO**

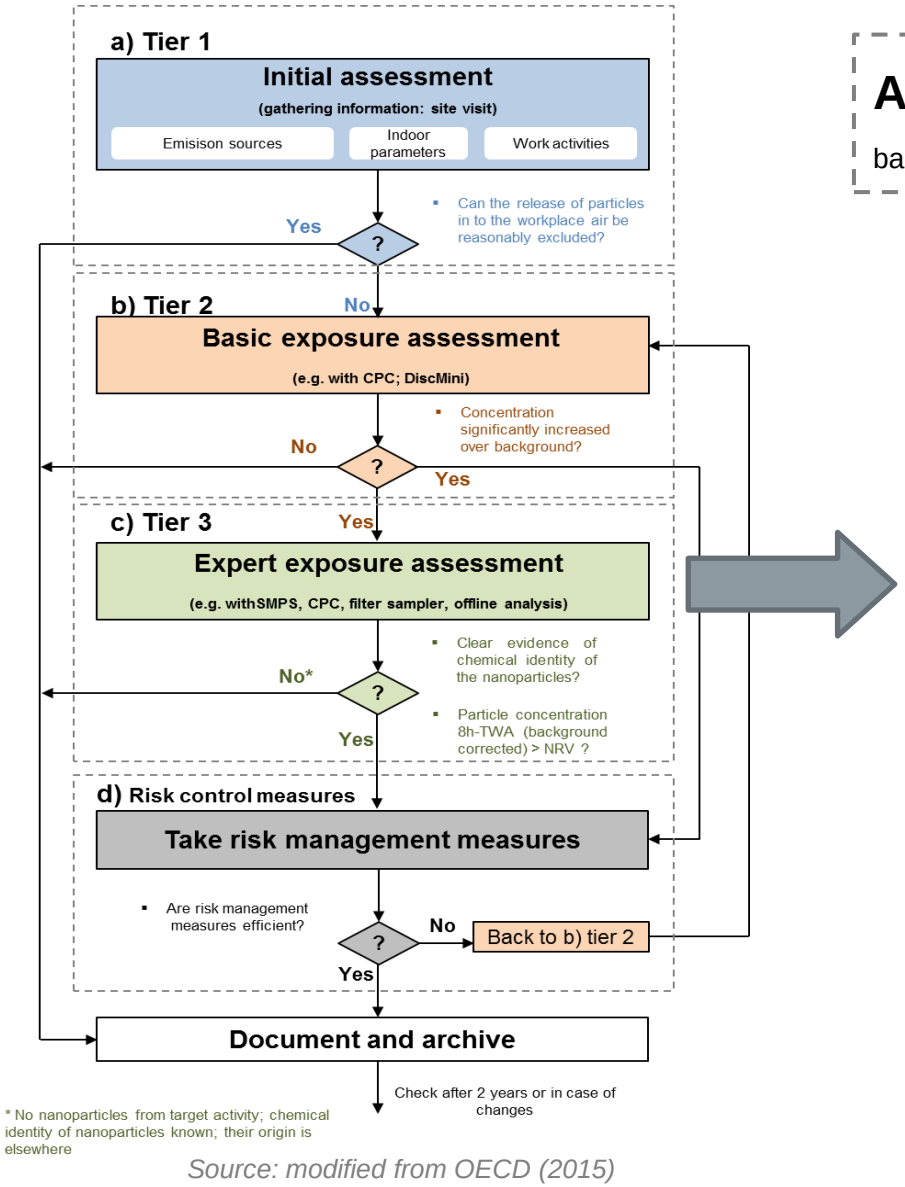
EVALUATION OF THE CAPACITY OF A FUME HOOD TO PREVENT PARTICLE RELEASE DURING SIMULATED SPILLAGE

Material	***Drop height***	***Mass load***
TiO_2, SiO_2, and zirconia TZ-3Y	5-40 cm	5-125 g

Fonseca *et al*. (2018) J Nanopart Res., 20:48

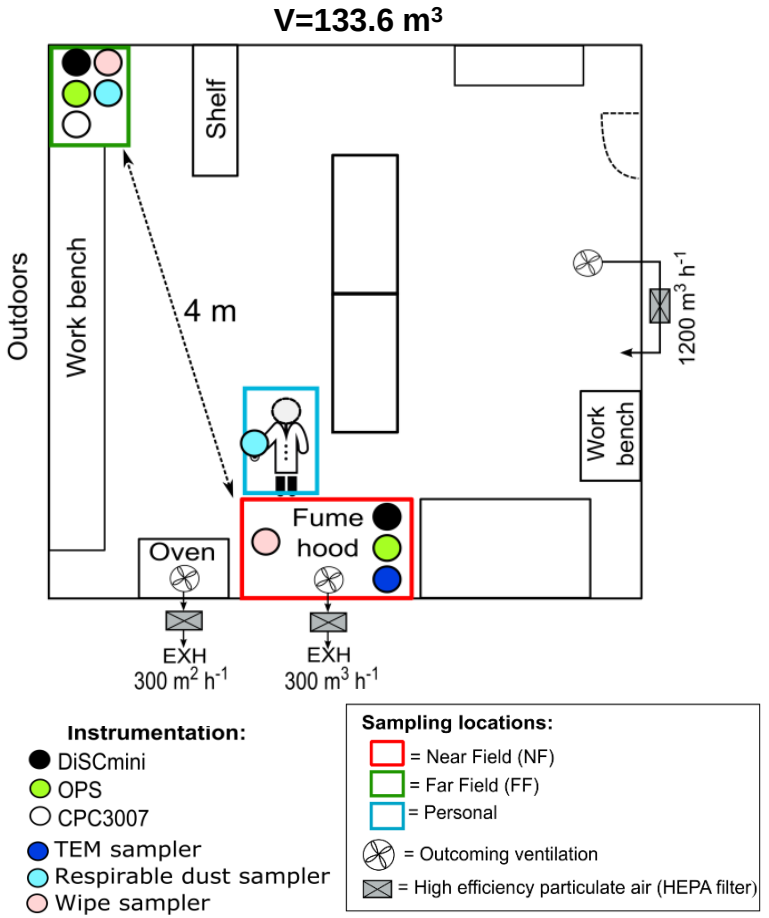
EXPOSURE ASSESSMENT STRATEGY

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



Source: modified from OECD (2015)

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

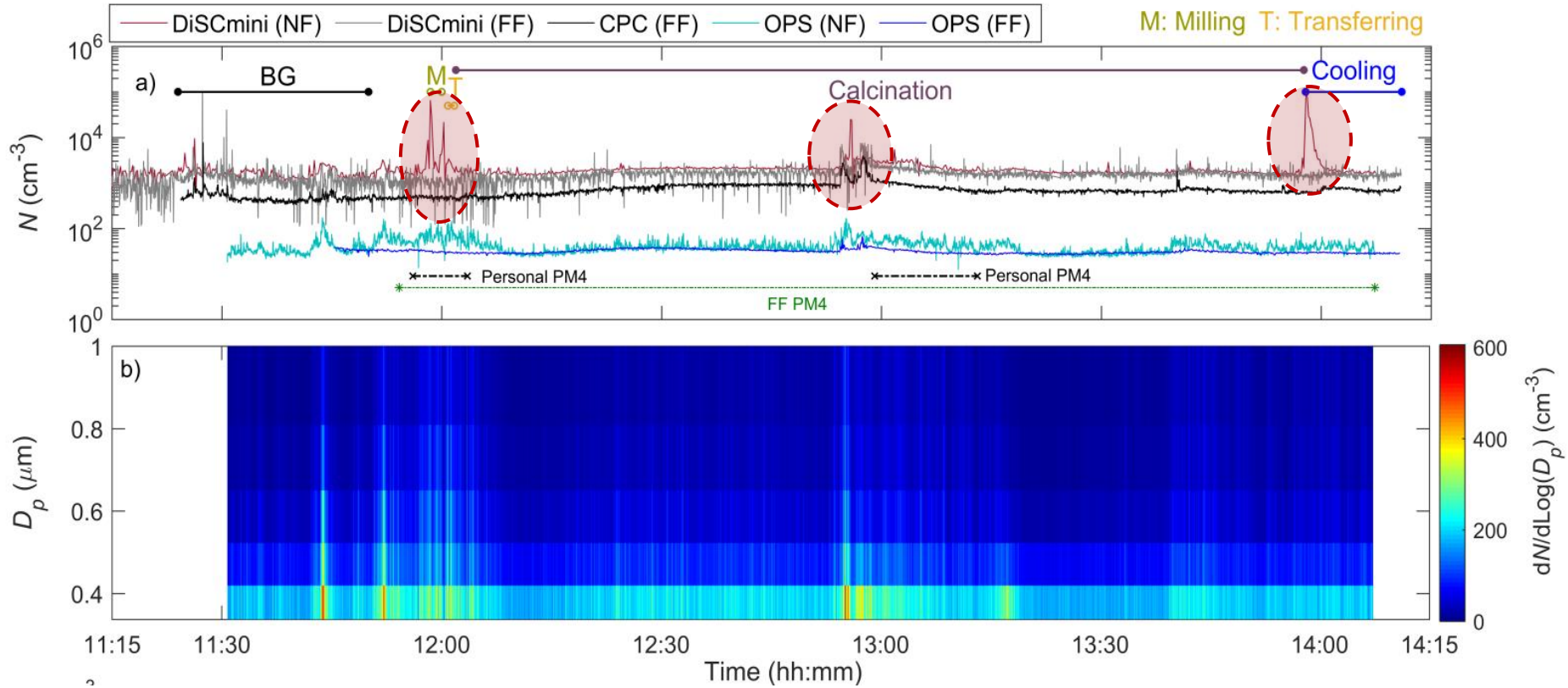


REAL CASE SCENARIO

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 µg m^{-3}



Ratio NF/FF= 2.8

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

REAL CASE SCENARIO

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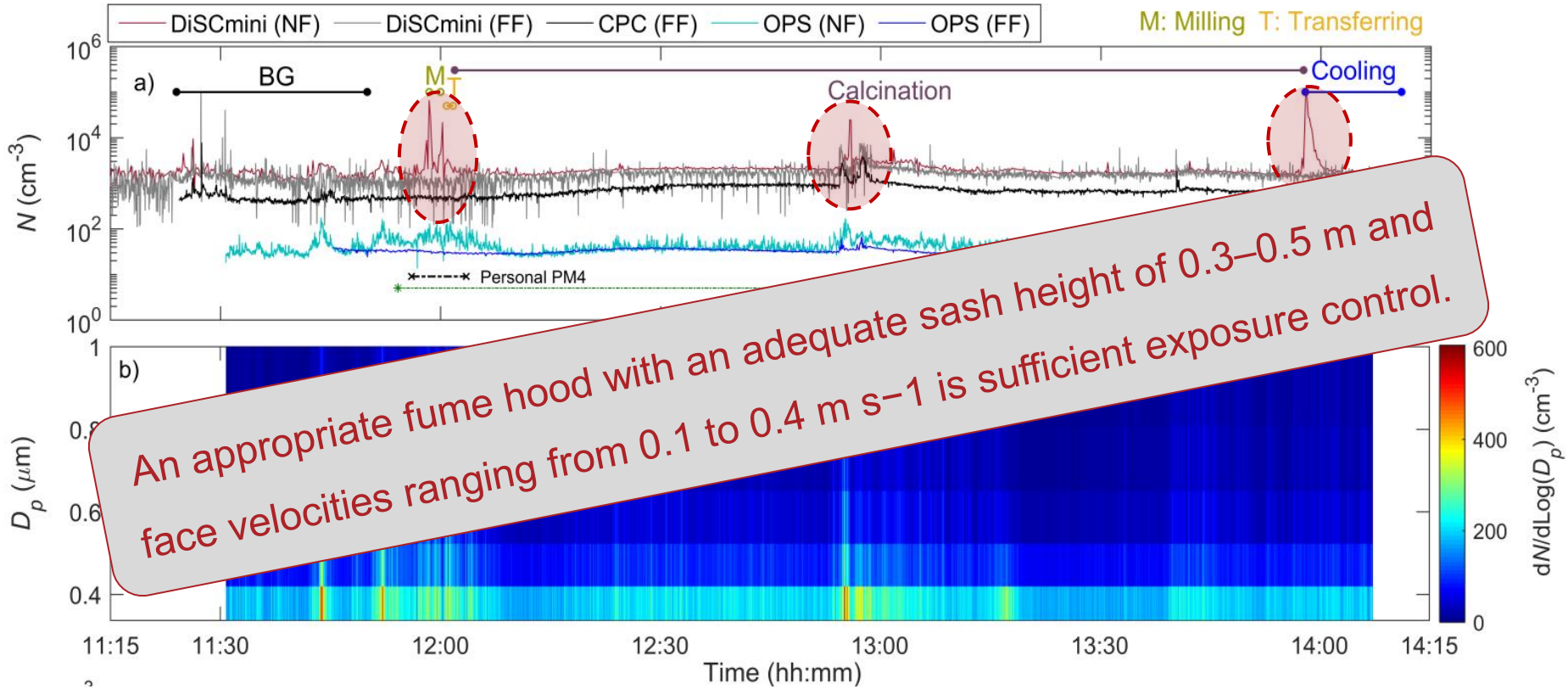


An appropriate fume hood with an adequate sash height of 0.3–0.5 m and face velocities ranging from 0.1 to 0.4 m s−1 is sufficient exposure control.

Ratio NF/FF= 2.8

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

SIMULATED SPILLS

Material

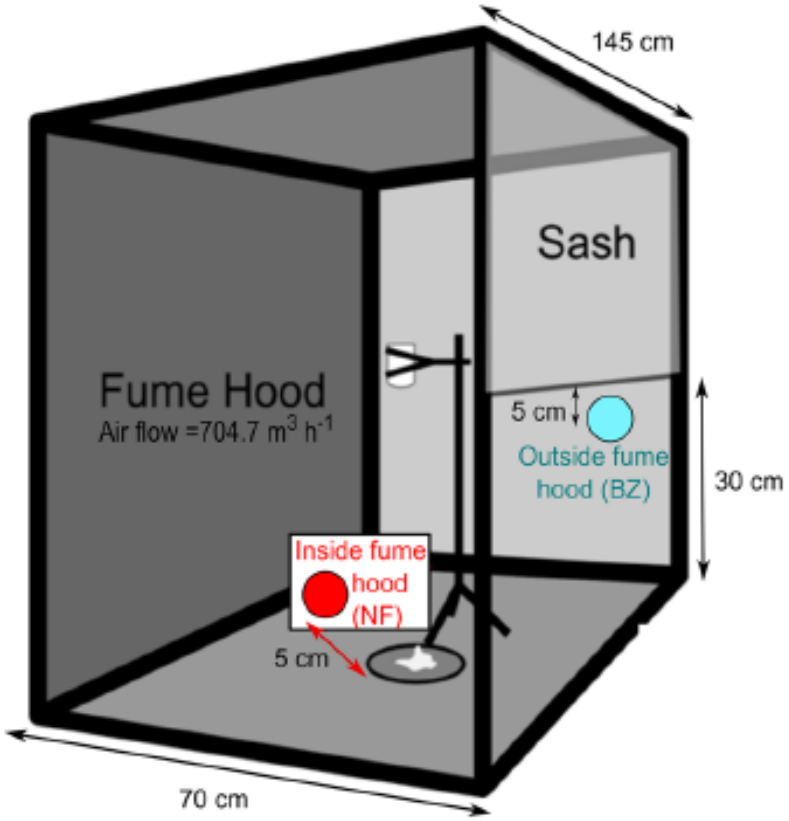
TiO_2, SiO_2, and zirconia TZ-3Y

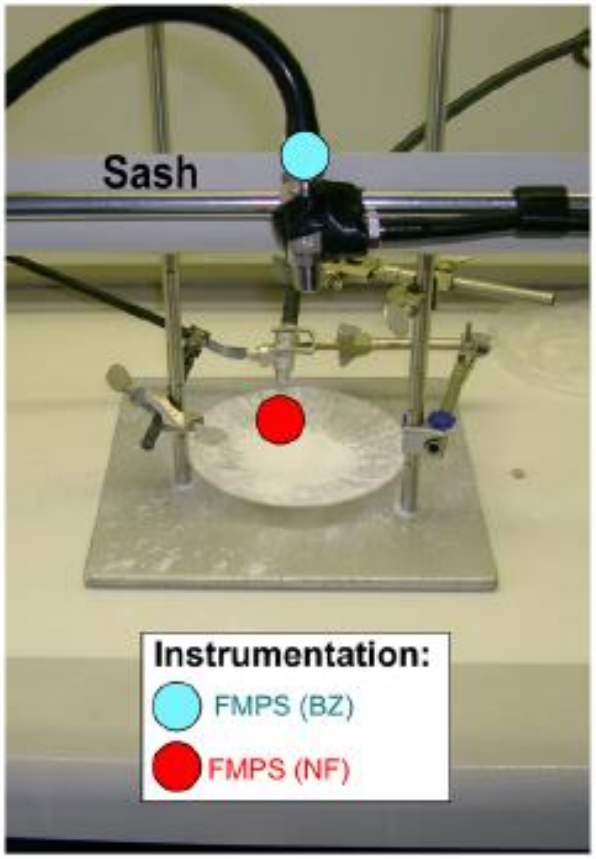
Drop height

5-40 cm

Mass load

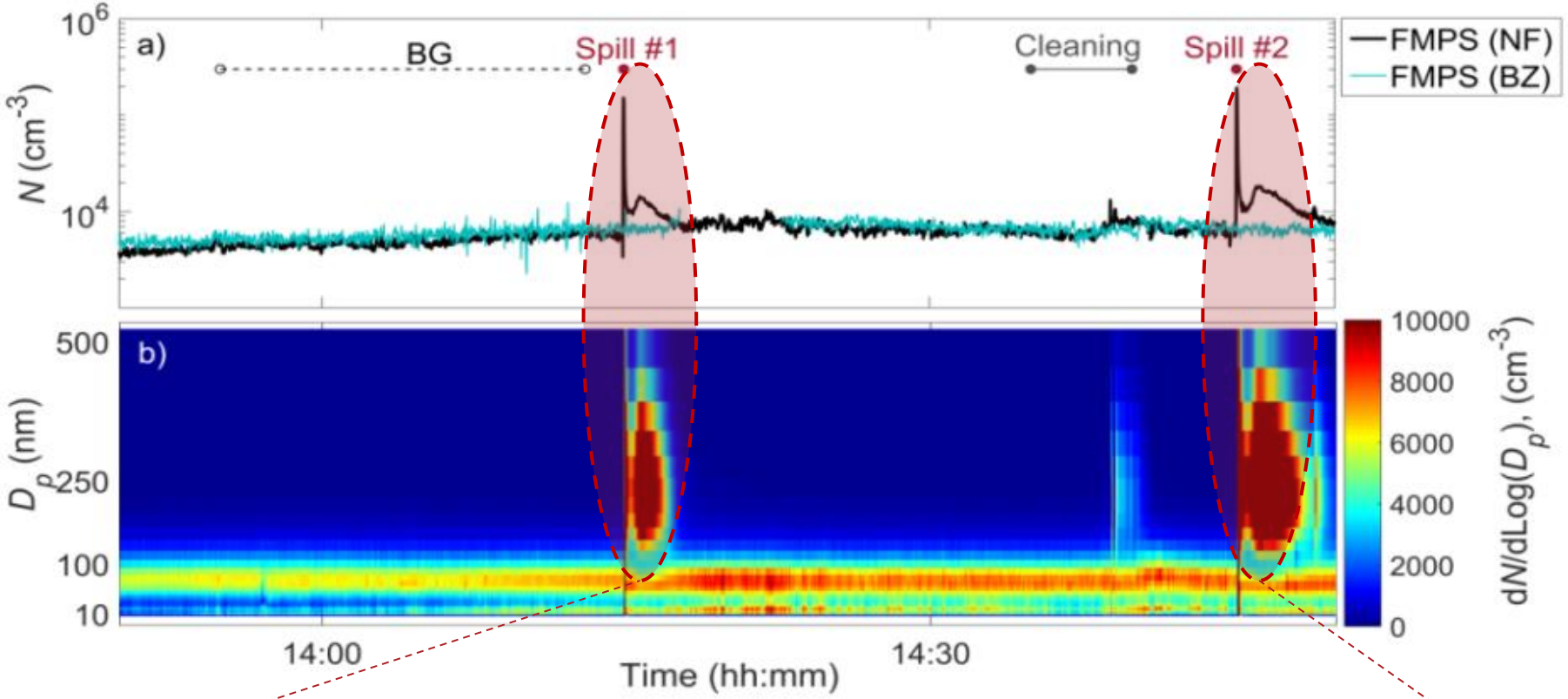
5-125 g





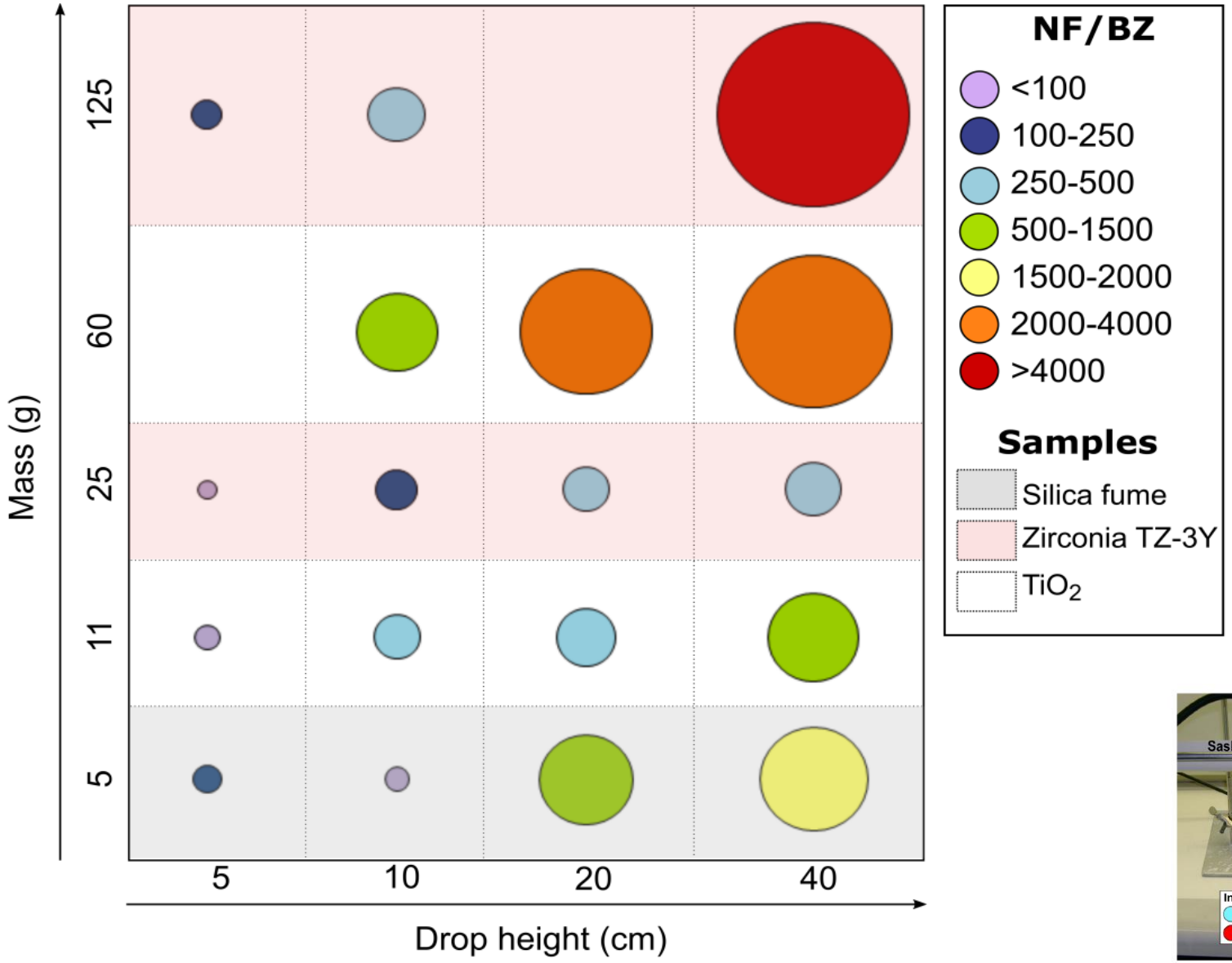
SIMULATED SPILLS

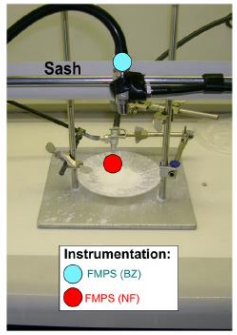
Example: 60 g TiO_2 (rutile) from 40 cm drop height



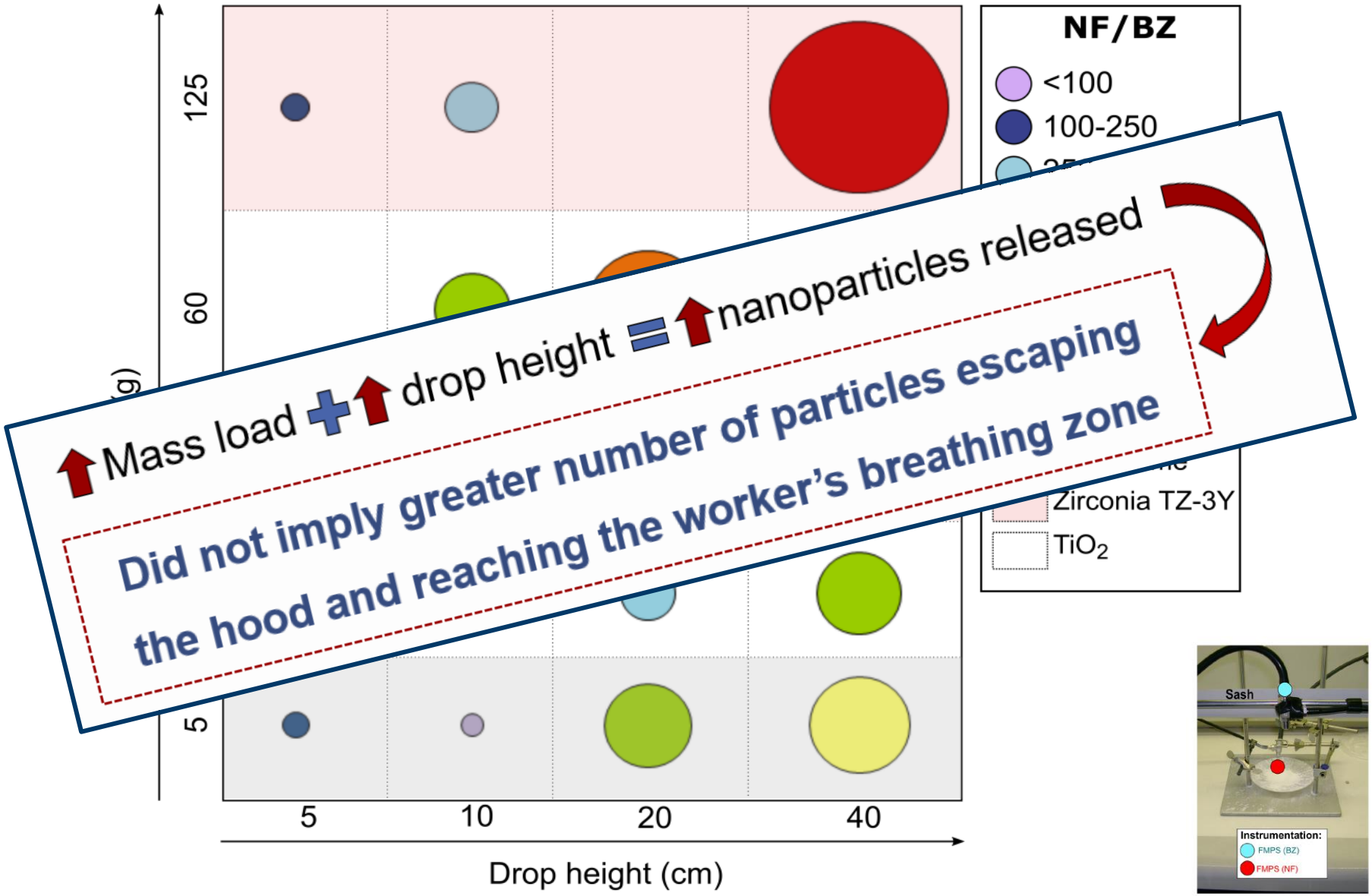
Notable increase in particle concentrations were rarely detected in the breathing zone of the worker

SIMULATED SPILLS



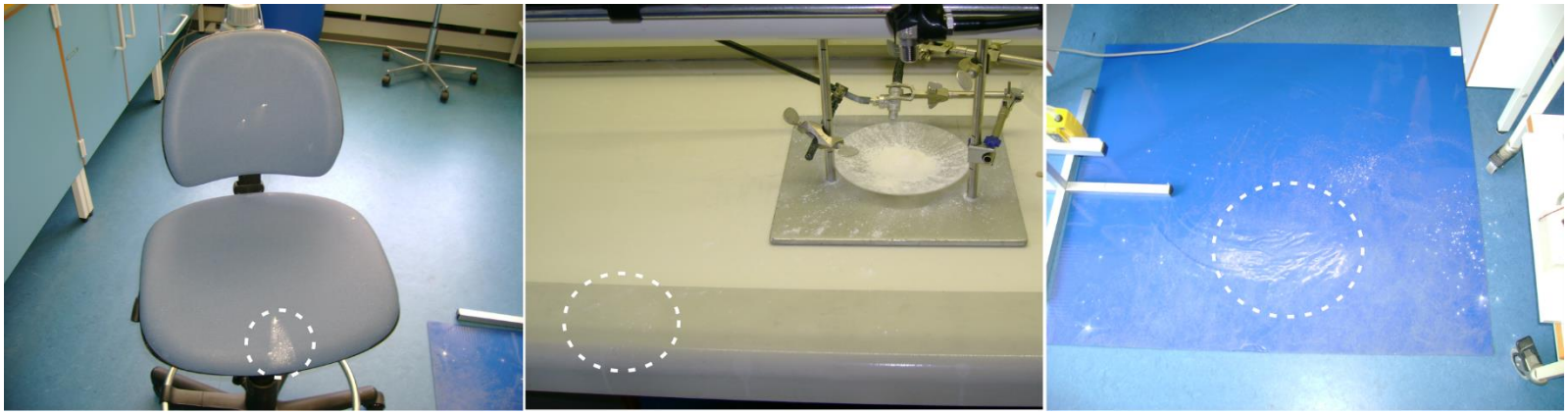


SIMULATED SPILLS



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.

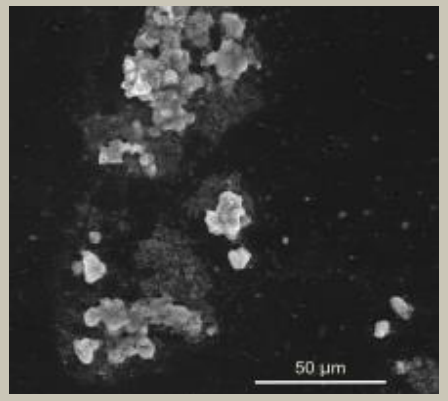
The average in-use protection efficacy was 98.3%

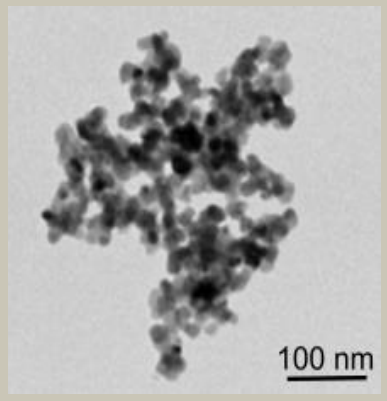
RECOMMENDATIONS:

- ✓ 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

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caLIBRAte nano risk governance

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