



# Project “Luchtreiniging in de klas”

Achtergrond en stand van zaken

Prof. dr. ir. Bert Blocken

**TU/e** EINDHOVEN  
UNIVERSITY OF  
TECHNOLOGY

DEPARTMENT OF THE BUILT  
ENVIRONMENT

**KU LEUVEN**

DEPARTMENT OF CIVIL  
ENGINEERING

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# AEROSOLS

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# AEROSOLS

**Definition:** An aerosol is defined as:

***“a suspension of fine solid particles or liquid droplets in air or another gas.”***

Fine often means: diameter  $< 100 \mu\text{m}$

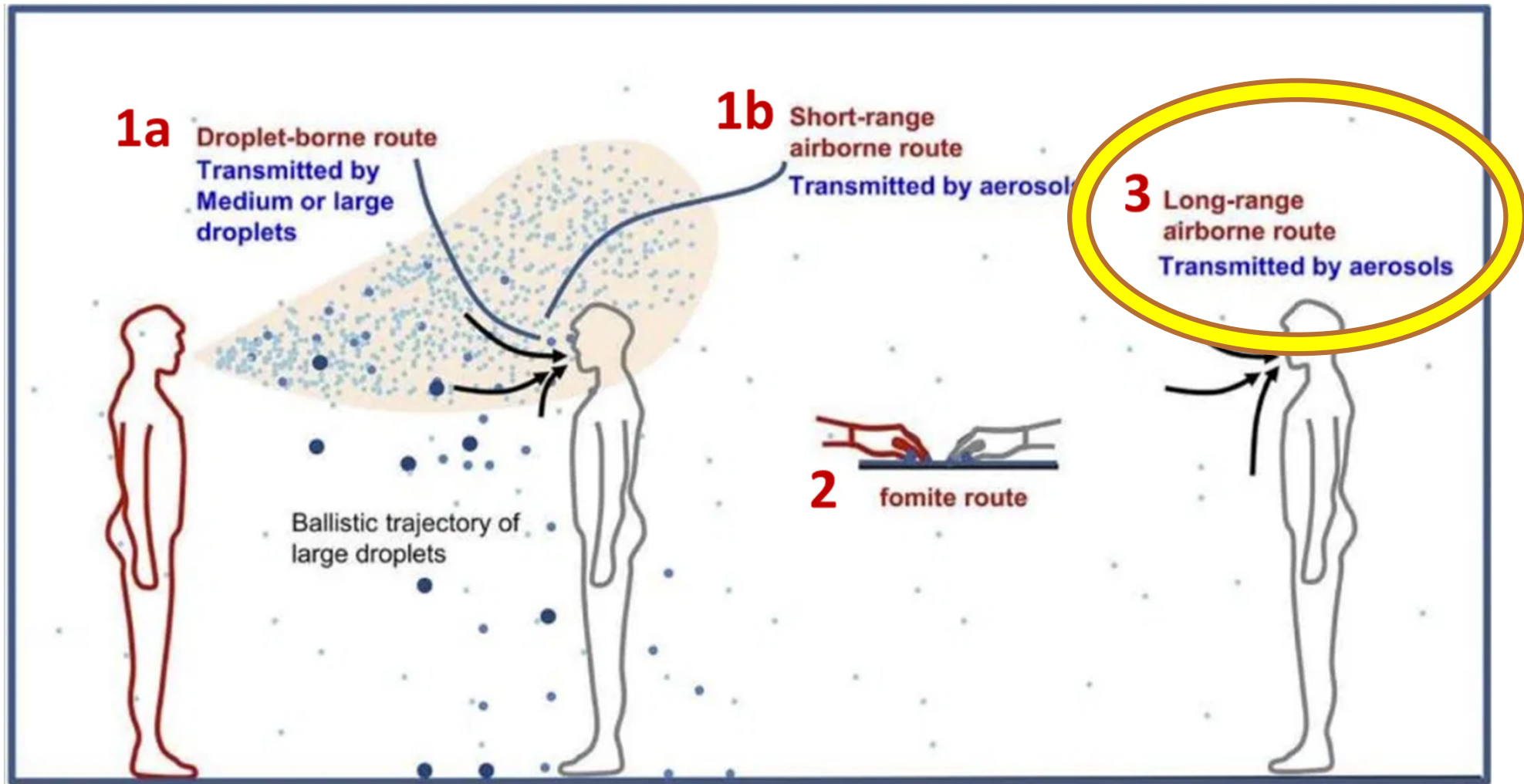
# AEROSOLS



**Respiratory aerosol particles are generally invisible, can only be seen with special lighting or by simulation**



# SARS-CoV-2 TRANSMISSION ROUTES



Source: Wei & Li (2016)

# SARS-CoV-2 TRANSMISSION ROUTES

## Mass infections

1. Large droplet or aerosol spray (direct)
2. Contact with infected surfaces (indirect)

## 3. Aerosols

nature

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EDITORIAL | 02 February 2021

## Coronavirus is in the air – there's too much focus on surfaces

Catching the coronavirus from surfaces is rare. The World Health Organization and national public-health agencies need to clarify their advice.



# SARS-CoV-2 TRANSMISSION ROUTES

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# SARS-CoV-2 TRANSMISSION ROUTES

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Champions League game Atalanta Bergamo vs. Valencia in stadium Giuseppe Meazza-stadion, Milano, 19 February 2020.

# SARS-CoV-2 TRANSMISSION ROUTES

## Mass infections

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Gazzetta FAN NEWS

Calcio Formula 1 Moto Basket Tennis Running Active Altro MISSIONI GFN TOP 10 AUTORI COME FUNZIONA

CALCIO / SERIE A / ATALANTA

20 febbraio 2020 - 09:53

## Notte magica a San Siro e lezione di calcio. Atalanta Valencia 4 a 1

L'invasione pacifica di Bergamo a San Siro per il primo ottavo di finale della storia della Dea non delude. Continua il sogno dei nero-azzurri oramai ai quarti!

di Antonio Chiera Master Fan Journalist (108 articoli pubblicati)

3 DI' LA TUA 0



www.gazzetta.it

La serata perfetta dei 40mila: un bergamasco su tre era a San Siro

Da Bergamo a Milano per la notte di gloria in Champions League: tante famiglie per un'esperienza da mettere nell'album

Francesco Fontana

20 febbraio - 8:04 - MILANO

È l'Atalanta delle meraviglie: il film del



# SARS-CoV-2 TRANSMISSION ROUTES

## Mass infections

1. Large droplet or aerosol spray (direct)
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Corriere dello Sport  
SOLAMENTE PODCAST

7 CALCIO 12 MIN

## Coronavirus, l'immunologo: Atalanta-Valencia partita zero

Parla Francesco Le Foche, in trincea contro l'epidemia: «Anomalia Bergamo: forse paga anche quella gara a porte aperte»

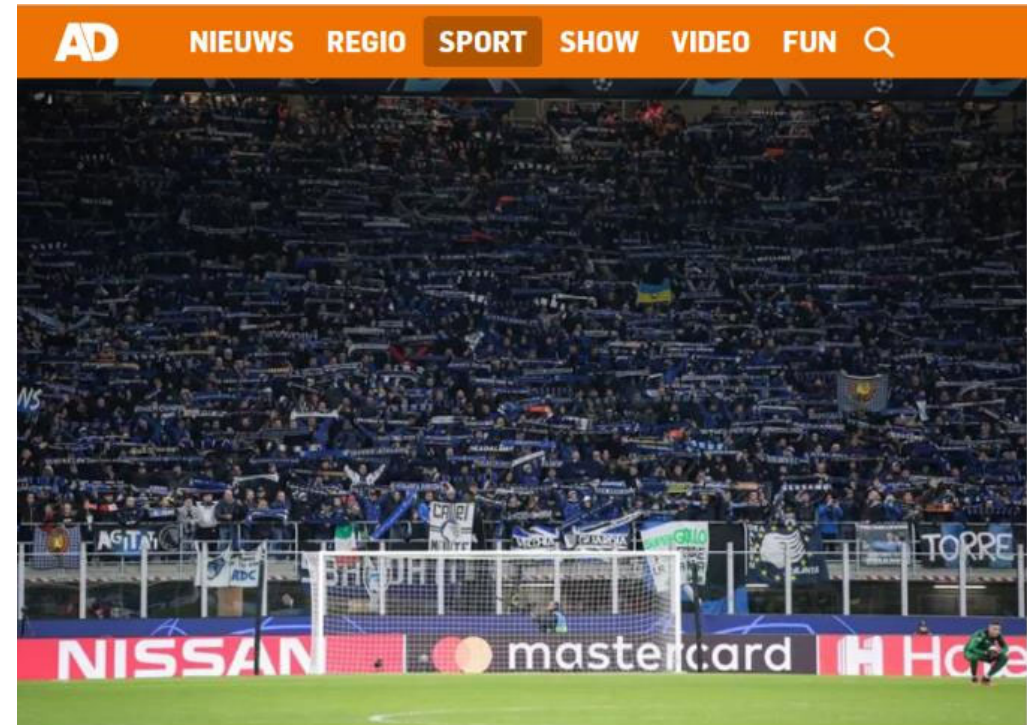


Giancarlo Dotto • 19.03.2020 19:10

LE INTERVISTE ESCLUSIVE

PARLA L'IMMUNOLOGO  
LE FOHE (OPINIONI)

«Il contagio  
è esploso  
a San Siro»



© Getty Images

De wedstrijd die nooit gespeeld had  
mogen worden. 'Atalanta - Valencia  
was biologische bom'

# SARS-CoV-2 TRANSMISSION ROUTES

## Mass infections

1. Large droplet or aerosol spray (direct)
2. Contact with infected surfaces (indirect)

## 3. Aerosols



Cup final KRC Genk – Standard in Koning Boudewijn stadium, Belgium, on 17 March 2018.

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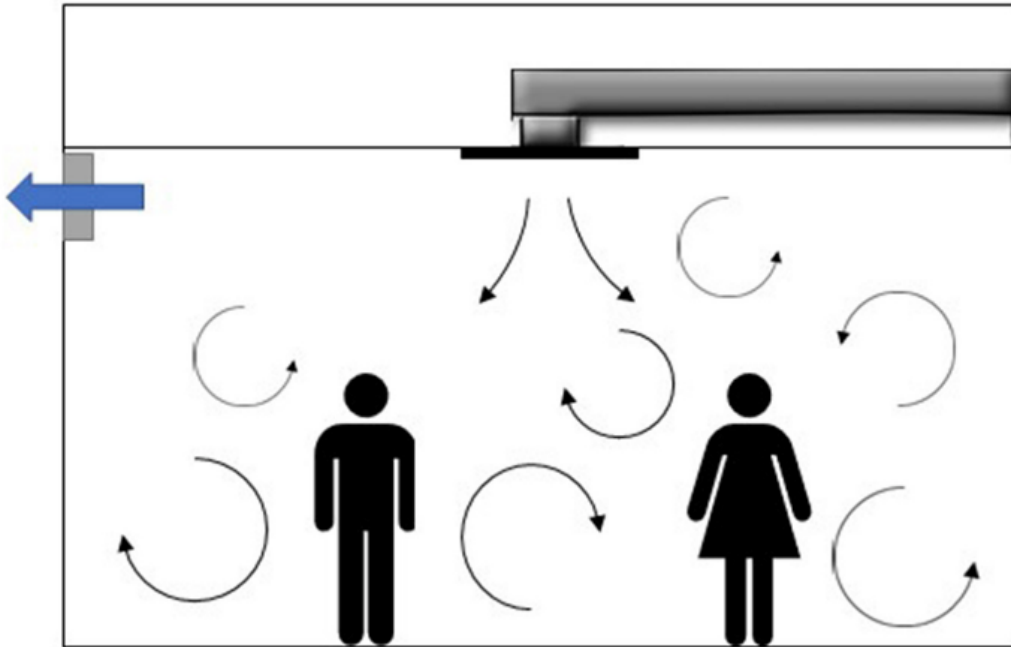
# **VENTILATION AND AIR CLEANING**

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# VENTILATION AND AIR CLEANING

## Definitions

**Ventilation:** the continuous replacement of stale air in a room by fresh air



Livios.be

# VENTILATION AND AIR CLEANING

## Definitions

**Ventilation:** the continuous replacement of stale air in a room by fresh air

**Airing:** the occasional replacement of stale air in a room by fresh air





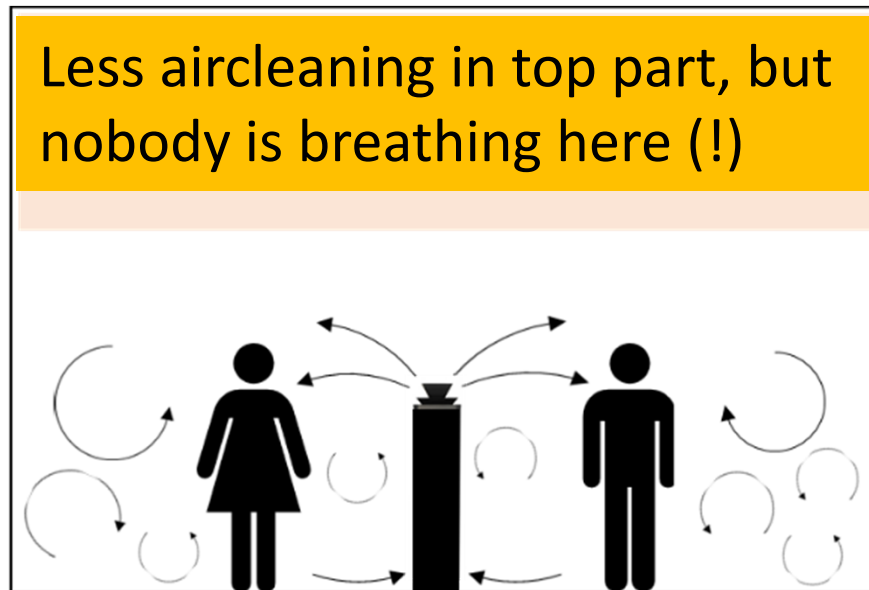
# VENTILATION AND AIR CLEANING

## Definitions

**Ventilation:** the continuous replacement of stale air in a room by fresh air

**Airing:** the occasional replacement of stale air in a room by fresh air

**Air cleaning:** the removal of harmful substances from air in a certain environment (indoor or outdoor)

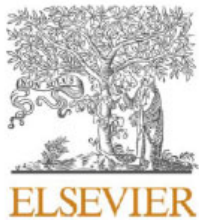


# VENTILATION AND AIR CLEANING

**Our first scientific paper suggesting use of ventilation, aircleaning and air quality label**  
(written April 2020, published May 2020)

2020 Top 100 Altmetric Article. Ranked in Top 100 of all 3.4 million articles worldwide tracked by Altmetric (= Top 0.003%).  
<https://www.altmetric.com/details/83415841> / <https://www.altmetric.com/top100/home/>

Building and Environment 180 (2020) 107022



Contents lists available at [ScienceDirect](#)

Building and Environment

journal homepage: <http://www.elsevier.com/locate/buildenv>



Can indoor sports centers be allowed to re-open during the COVID-19 pandemic based on a certificate of equivalence?



B. Blocken<sup>a,b,\*</sup>, T. van Druenen<sup>a</sup>, T. van Hooff<sup>a,b</sup>, P.A. Verstappen<sup>c</sup>, T. Marchal<sup>d,e</sup>, L.C. Marr<sup>f</sup>

<sup>a</sup> Building Physics and Services, Department of the Built Environment, Eindhoven University of Technology, P.O. Box 513, 5600, MB Eindhoven, the Netherlands

<sup>b</sup> Building Physics Section, Department of Civil Engineering, KU Leuven, Kasteelpark Arenberg 40, Bus 2447, 3001, Leuven, Belgium

<sup>c</sup> Sports Medical Center the Hague, Sweelinckplein 46, 2517 GP, The Hague, the Netherlands

<sup>d</sup> Ansys Belgium S.A., Centre d'Affaires "Les Collines de Wavre", Avenue Pasteur 4, 1300, Wavre, Belgium

<sup>e</sup> Avicenna Alliance for Predictive Medicine ASBL, Rue Guimard 10, 1040, Brussels, Belgium

<sup>f</sup> Department of Civil and Environmental Engineering, Virginia Polytechnic Institute and State University, 1145 Perry St. (0246), Durham 411, Blacksburg, VA 24061, USA

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**PROJECT 1:  
THE FITNESS CENTER**

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# The fitness center test: Eindhoven, the Netherlands: 11 July 2020





Aerosol reduction in indoor sports centre



**25**  
**25**  
**25**  
**25**

studenten  
sport  
centrum  
eindhoven

en.nl

**TU/e** Technische Universiteit  
Eindhoven  
University of Technology





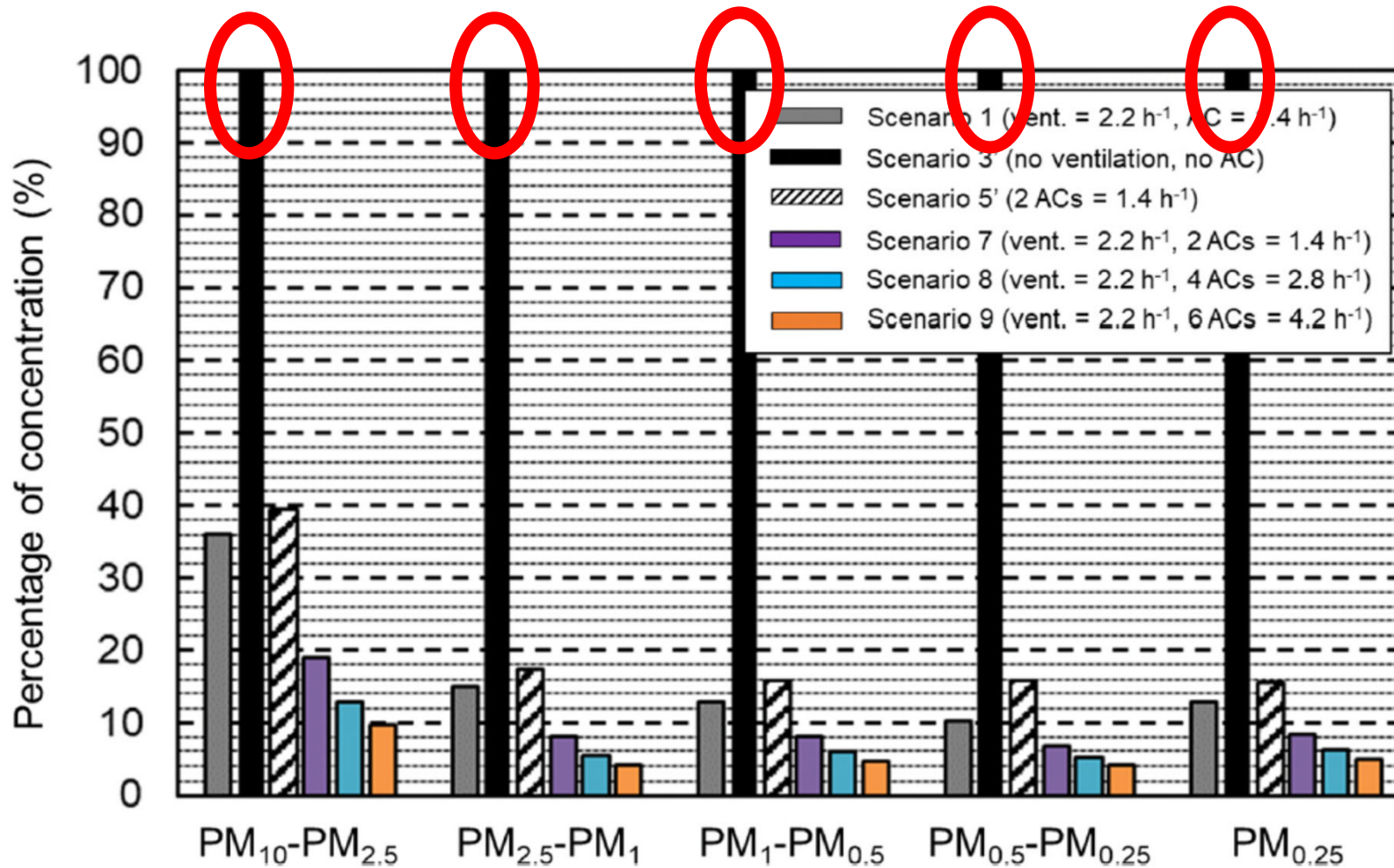
# Aerosol reduction in indoor sports centre





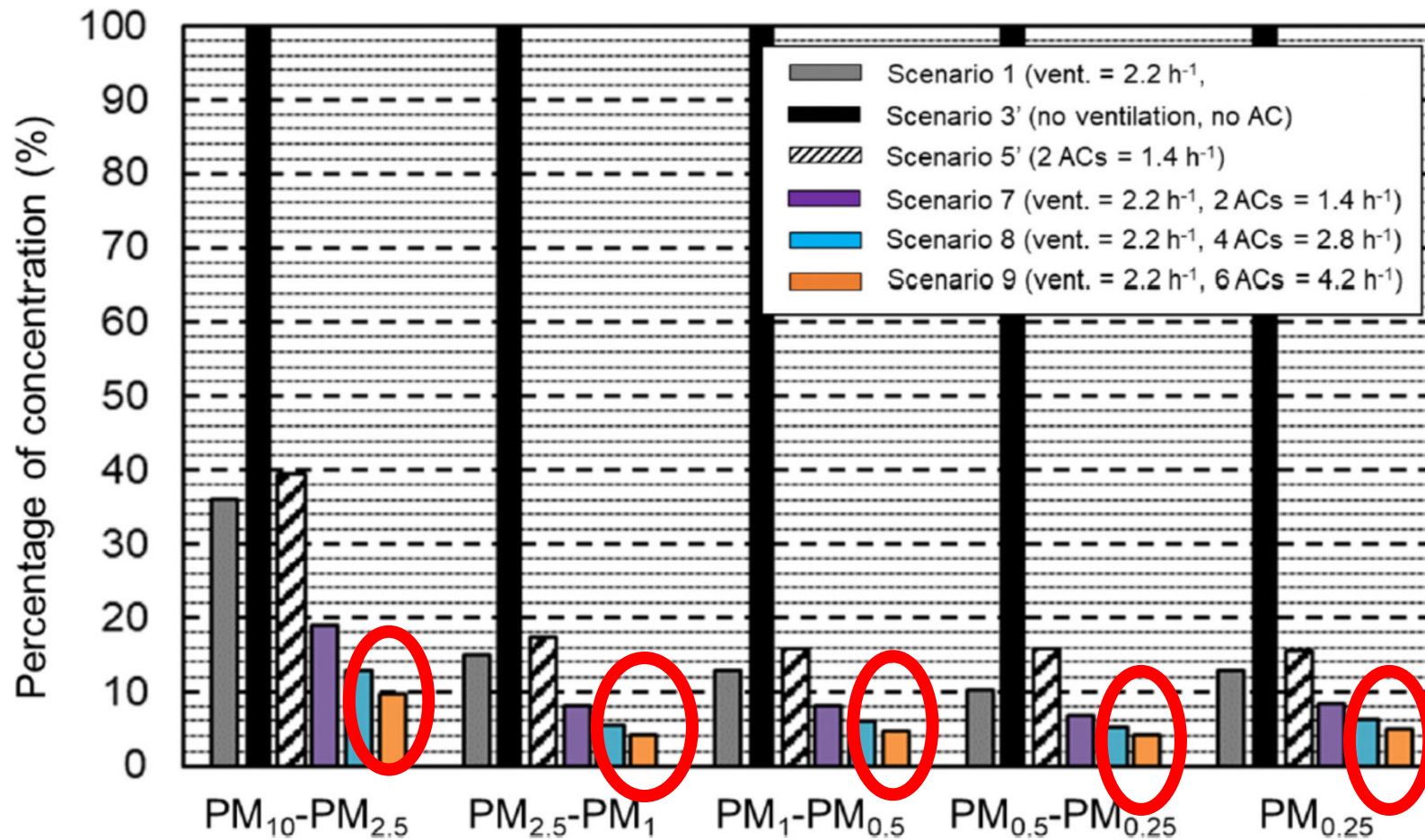
# AEROSOL REDUCTION IN GYMS

## Results:



# AEROSOL REDUCTION IN GYMS

## Results:



# AEROSOL REDUCTION IN GYMS

Building and Environment 193 (2021) 107659



Contents lists available at [ScienceDirect](#)

## Building and Environment

journal homepage: <http://www.elsevier.com/locate/buildenv>



## Ventilation and air cleaning to limit aerosol particle concentrations in a gym during the COVID-19 pandemic

B. Blocken<sup>a,b,\*</sup>, T. van Druenen<sup>a</sup>, A. Ricci<sup>a,b,c</sup>, L. Kang<sup>a</sup>, T. van Hooff<sup>a</sup>, P. Qin<sup>a</sup>, L. Xia<sup>a</sup>,  
C. Alanis Ruiz<sup>b</sup>, J.H. Arts<sup>d,e</sup>, J.F.L. Diepens<sup>a</sup>, G.A. Maas<sup>a</sup>, S.G. Gillmeier<sup>a</sup>, S.B. Vos<sup>d,e</sup>, A.  
C. Brombacher<sup>d</sup>

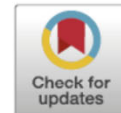
<sup>a</sup> Unit Building Physics and Services, Department of the Built Environment, Eindhoven University of Technology, P.O. Box 513, 5600MB Eindhoven, the Netherlands

<sup>b</sup> Building Physics and Sustainable Design, Department of Civil Engineering, KU Leuven, Kasteelpark Arenberg 40 - Bus 2447, 3001, Leuven, Belgium

<sup>c</sup> Department of Civil, Chemical and Environmental Engineering, University of Genoa, Genoa, Italy

<sup>d</sup> Department of Industrial Design, Eindhoven University of Technology, P.O. Box 513, 5600MB Eindhoven, the Netherlands

<sup>e</sup> School of Sport Studies, Fontys University of Applied Sciences, Theo Koomenlaan 3, 5644HZ Eindhoven, the Netherlands





# AEROSOL REDUCTION IN GYMS

**TU/e** EINDHOVEN  
UNIVERSITY OF  
TECHNOLOGY

**PLASMA**MADE<sup>®</sup>  
Absolute Science

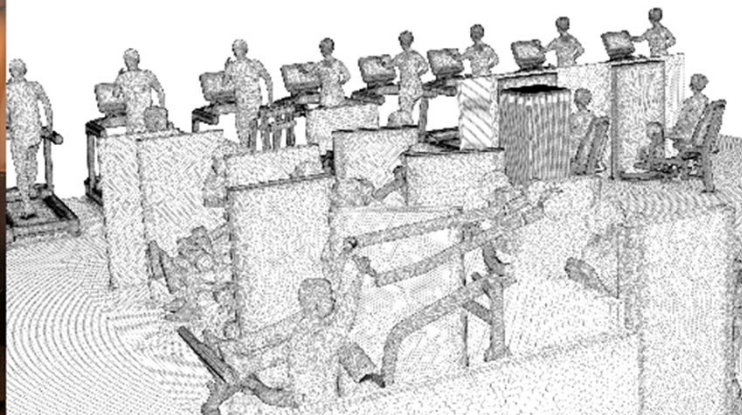
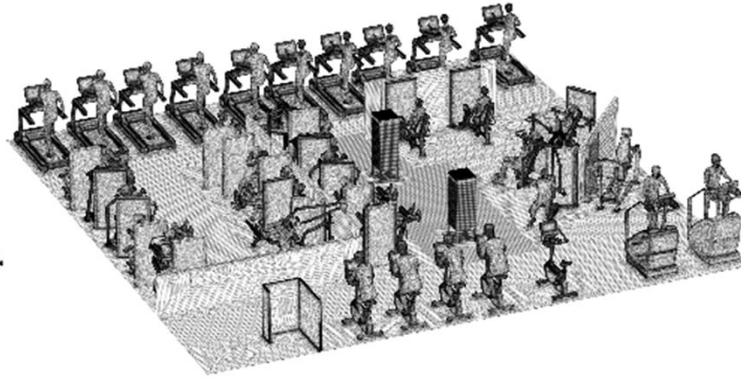
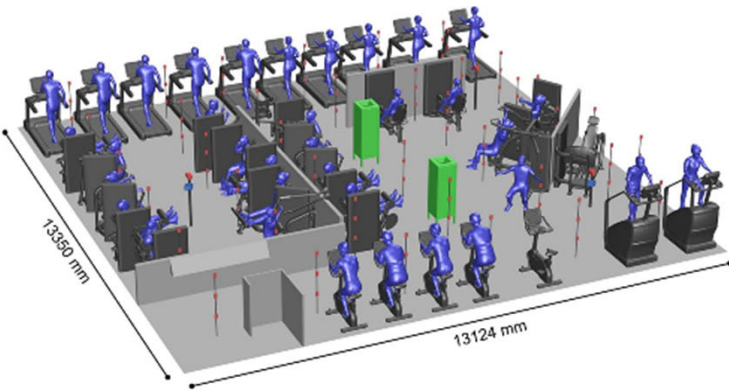


**KU LEUVEN**



**Ansys**

isala



## AEROSOL REDUCTION IN GYMS

I have recommended **aircleaners for all indoor environments** since April 2020. Published in international scientific magazine and in many media (TV in Netherlands, written media in Belgium).

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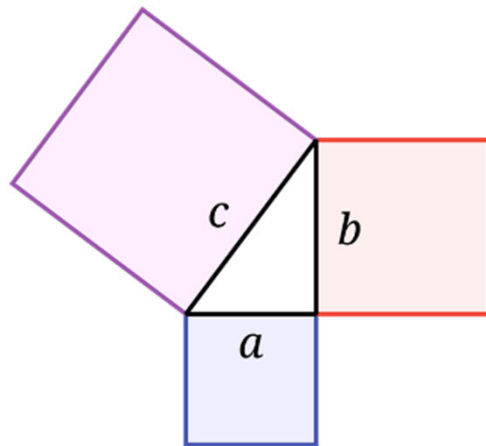
**PROJECT 2:**  
**THE 1000 CLASSROOMS**

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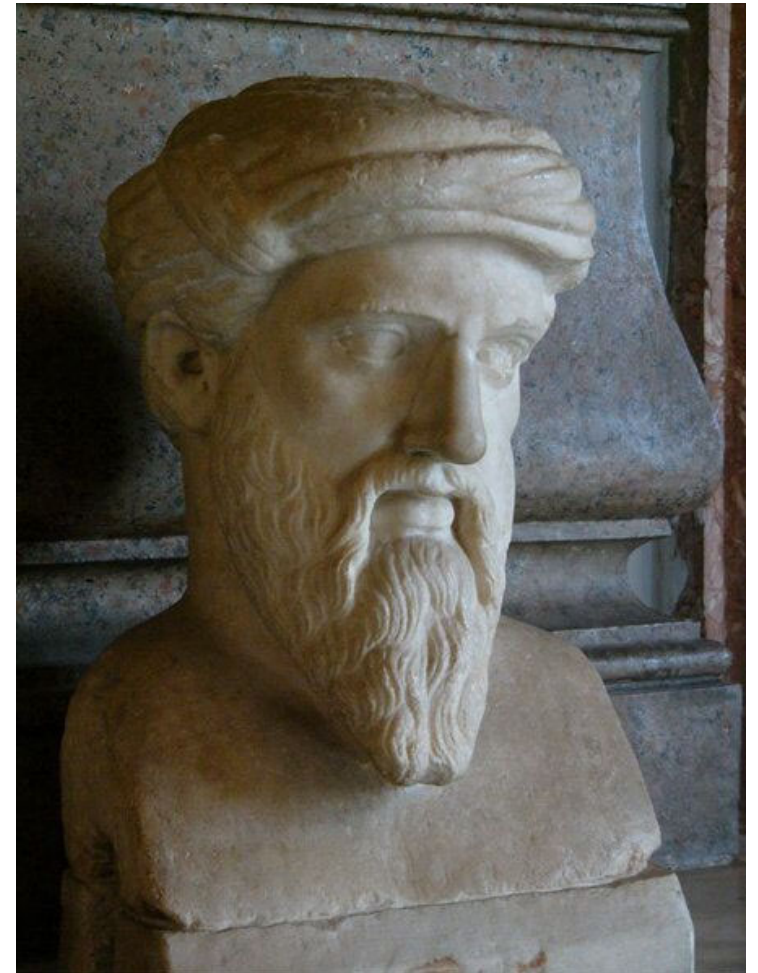
## QUOTE

“Αρχή πολιτείας απάσης νέων τροφά”

“The basis of the state is the education of the youth.”



$$a^2 + b^2 = c^2$$



Pythagoras of Samos (c. 570 BC – c. 496 BC), Ionian Greek philosopher, mathematician, mystic, scientist.



# PROJECT LEADERS



Prof. dr. ir. Bert Blocken  
**TU Eindhoven**  
**KU Leuven**

Expert aerodynamics  
Ventilation  
Aircleaning



Dr. ir. Leen Peeters  
**Th!nk-E**

Expert ventilation  
Energy in buildings  
Indoor climate



Prof. dr. Marc Van Ranst  
**KU Leuven**

Expert virology  
Epidemiology  
Immunology

# MOTIVATION

- Omikron wave in education and next waves (autumn 2022...)
- Worries of children, teachers, school directors, parents...
- **Our impatience and frustration**
- Ventilating classrooms with open windows and doors, which actually means heating up the outside air...
- And...

# MOTIVATION

- Omikron wave in education and next waves (autumn 2022...)
- Worries of children, teachers, school directors, parents...
- **Our impatience and frustration**
- Ventilating classrooms with open windows and doors, which actually means heating up the outside air...
- And... Mayor Johan Sauwens of Bilzen.

# THANK YOU TO THREE PEOPLE IN PARTICULAR



**Johan Sauwens**  
Bilzen



**Jo Brouns**  
Kinrooi



**Gwendolyn Rutten**  
Aarschot



# AIRCLEANERS

Why needed in terms of COVID-19? **A worst-case scenario**

- $t = \infty$
- **steady-state**
- **maximum occupancy**

# AIRCLEANERS

## Why needed in terms of COVID-19?

### A worst-case scenario

CO2 concentration inside (ppm)					
Air change rate (1/h)	1	2	4	6	8
<b>Schools</b>					
Kindergarten	1517	968	694	603	557
Primary school	2660	1540	980	793	700
Secondary school	3727	2073	1247	971	833
Higher education	3949	2185	1302	1008	861
<b>Horeca</b>					
Pub	7107	3764	2092	1535	1256
Regular restaurant	5770	3095	1757	1312	1089
Gastronomic restaurant	4878	2649	1535	1163	977
Company restaurant	9336	4878	2649	1906	1535
<b>Large enclosures</b>					
Cinema	9708	5064	2742	1968	1581
Theatre	5993	3206	1813	1349	1117
Disco	18996	9708	5064	3516	2742
<b>Fitness</b>					
Cardio & strength	2808	1614	1017	818	719
Spinning	15705	8063	4241	2968	2331
Dance classes	8609	4514	2467	1785	1444

# AIRCLEANERS

Why needed in terms of COVID-19?

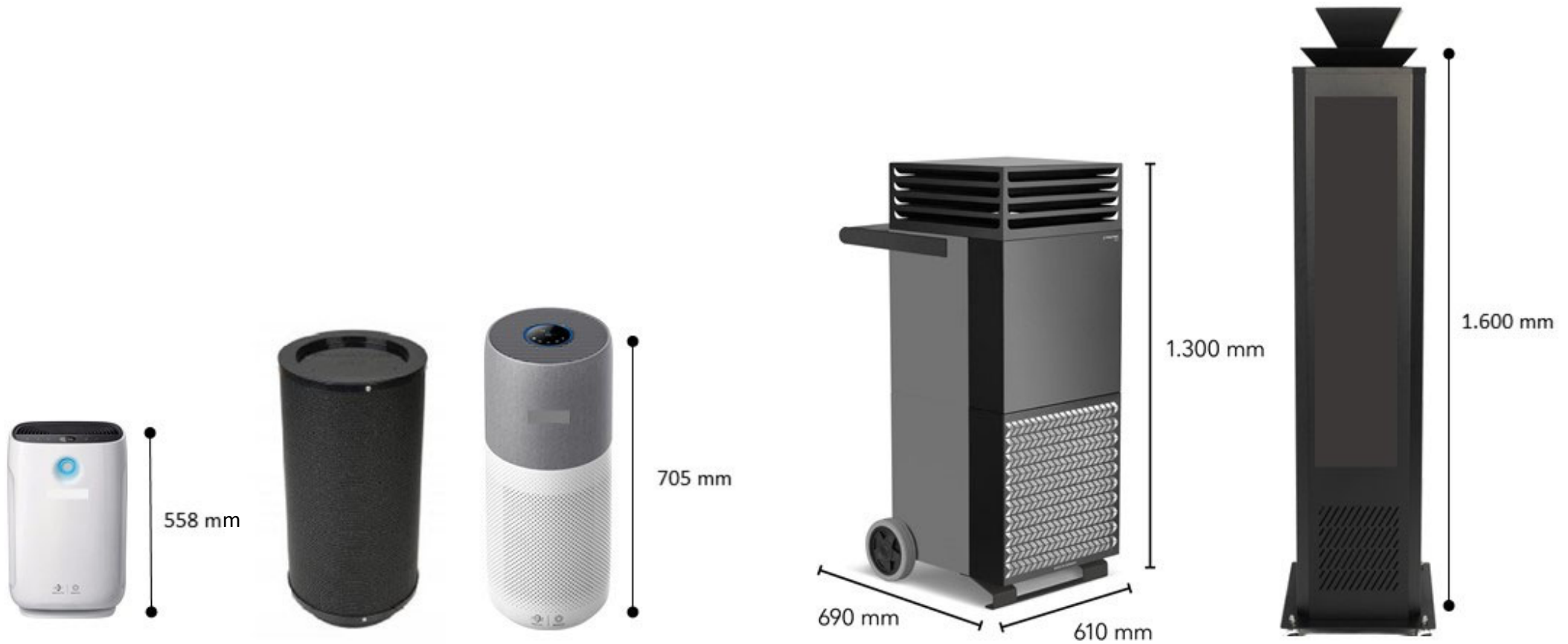
A worst-case scenario

**Ventilatieprof waarschuwt:  
“Mensen gaan schrikken als ze  
hun CO2-meter checken”**

HASSELT - “Mensen zullen schrikken als ze hun CO2-meter controleren. Uit ons onderzoek blijkt dat een waarde van lager dan 900 ppm, momenteel de richtlijn, moeilijk haalbaar is in oude gebouwen, kleinere zalen en zalen waar veel mensen actief bezig zijn”, zegt ventilatie-expert Bert Blocken.

# AIRCLEANERS

## Various shapes and sizes

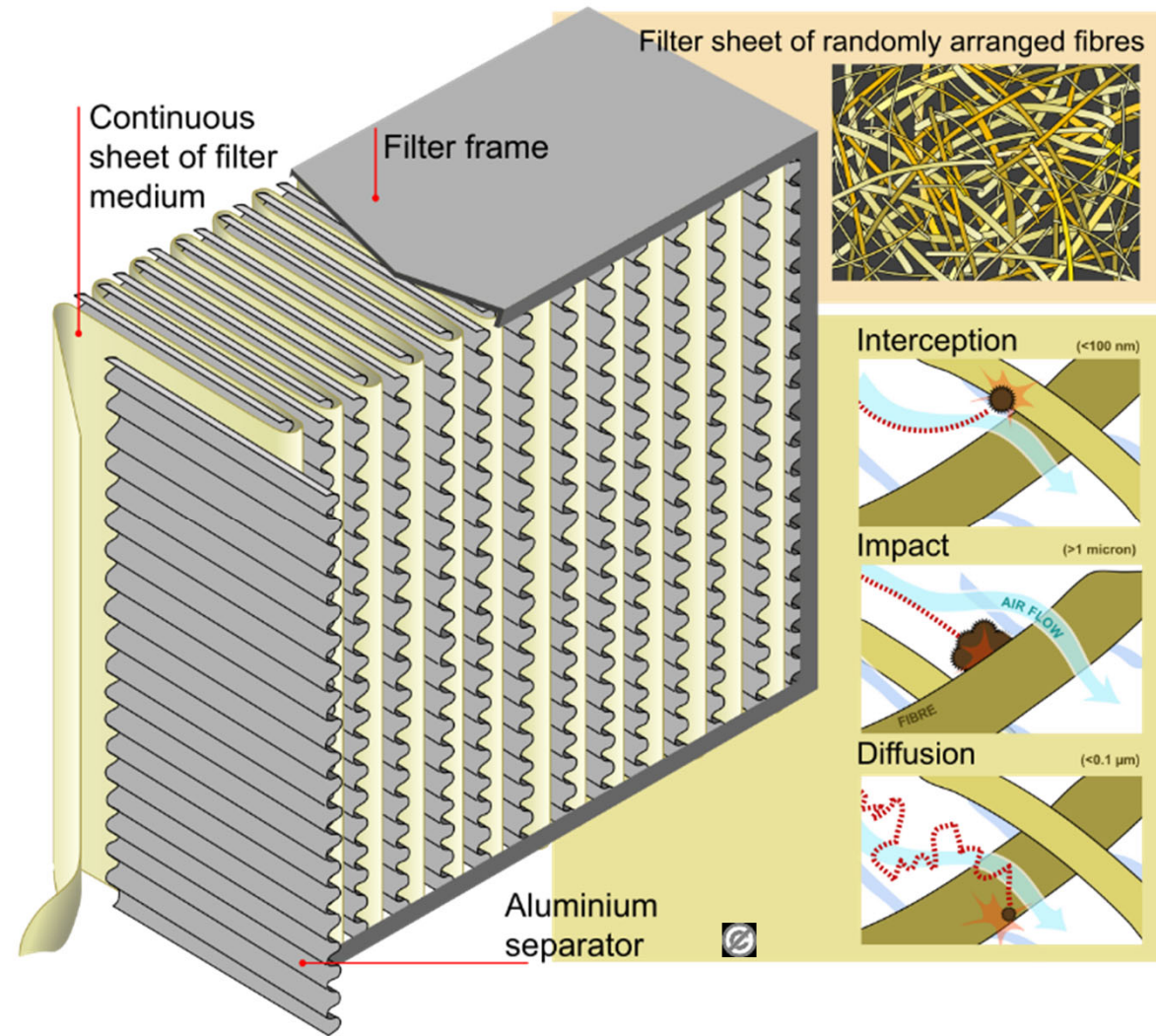




# AIRCLEANERS

## Various technologies

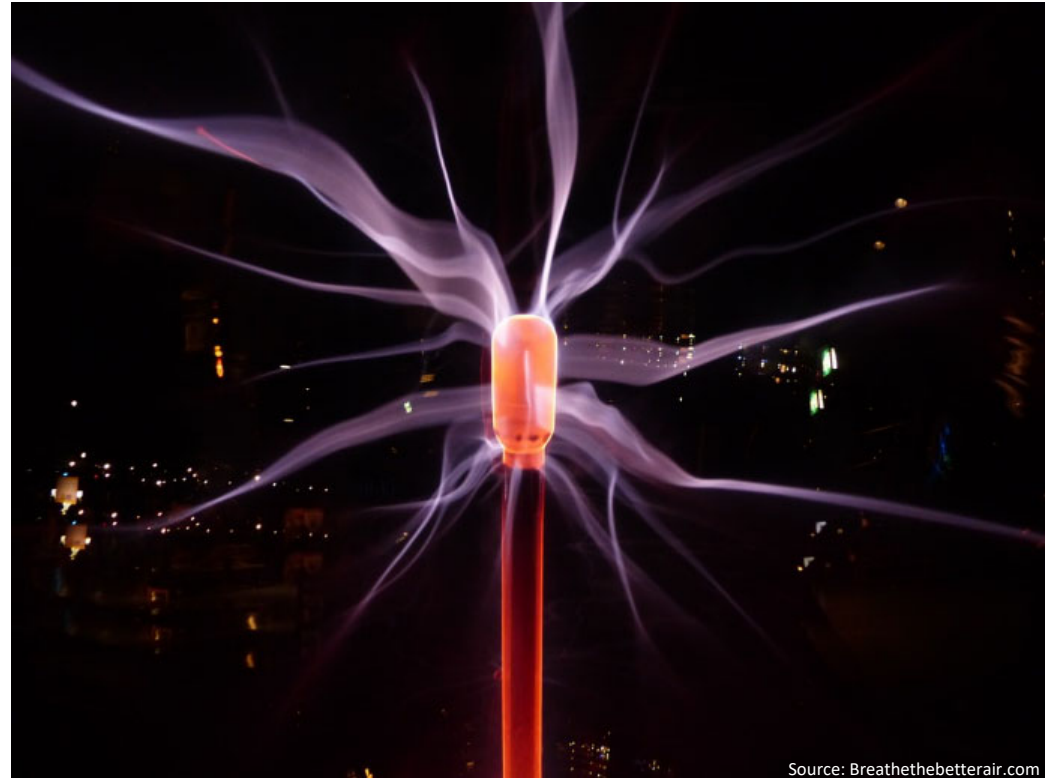
- Filtration (class > 13; ISO 35 H;  
> 99.95%)



# AIRCLEANERS

## Various technologies

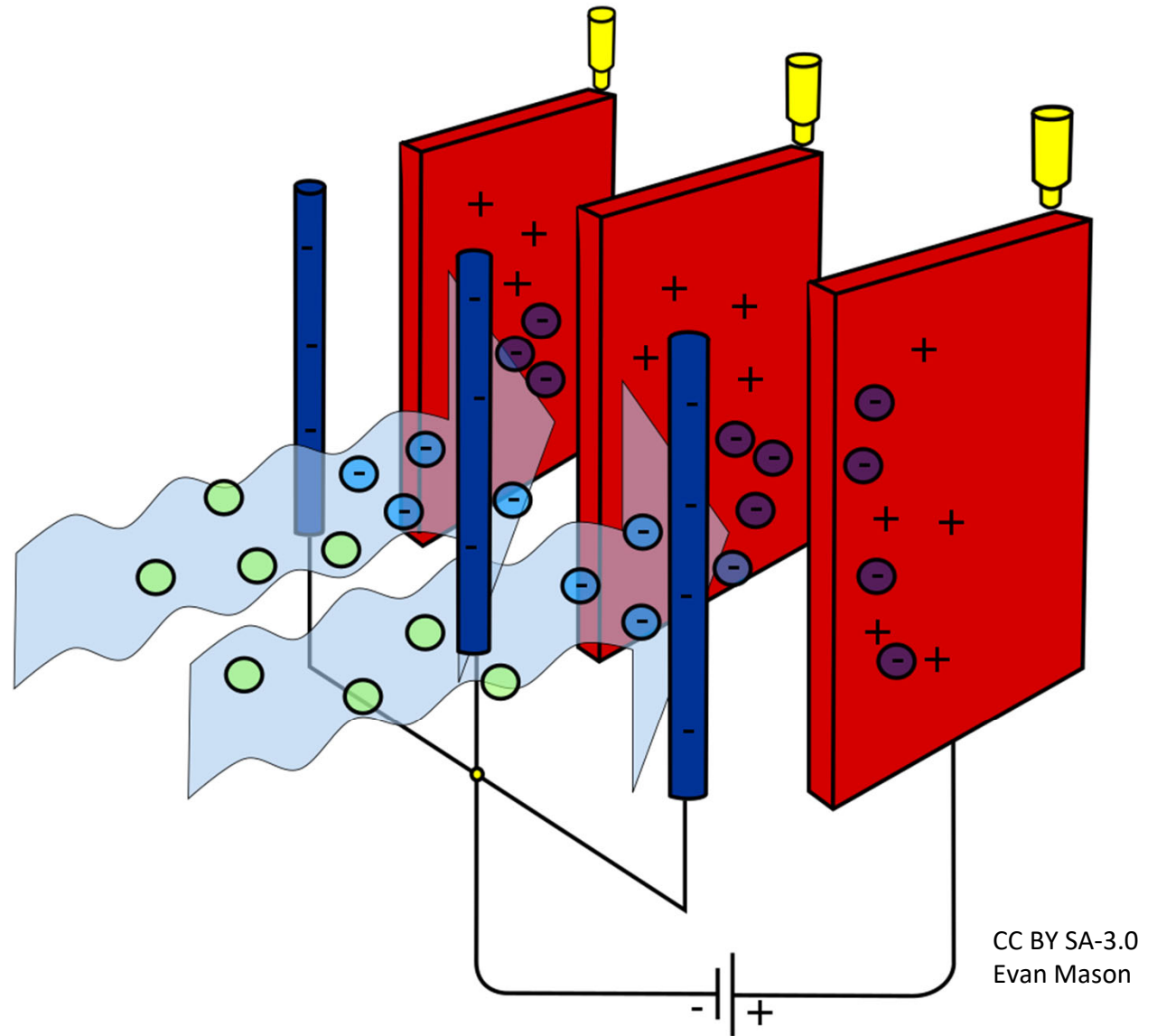
- Filtration (class > 13; ISO 35 H; > 99.95%)
- Cold plasma
- Electrostatic precipitation
- UV-C
- ...



# AIRCLEANERS

## Various technologies

- Filtration (class > 13; ISO 35 H; > 99.95%)
- Cold plasma
- **Electrostatic precipitation**
- UV-C
- ...

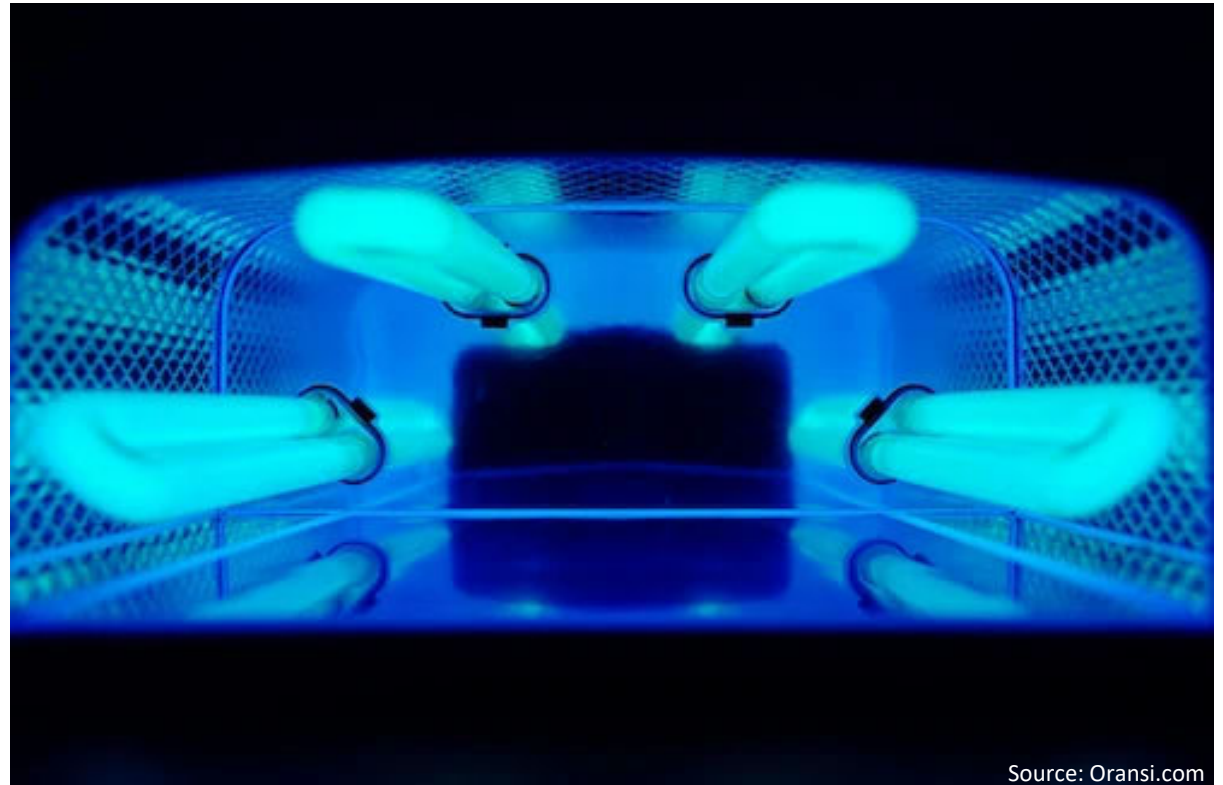


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Evan Mason

# AIRCLEANERS

## Various technologies

- Filtration (class > 13; ISO 35 H; > 99.95%)
- Cold plasma
- Electrostatic precipitation
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- ...





# AIRCLEANERS

## Various technologies

- Filtration
- Cold plasma
- Electrostatic precipitation
- UV-C
- ...

## Important:

- **Test reports** from established university or independent scientific organization
  - Efficiency
  - No harmful by-products
- Air cleaning frequency of **5 to 6 per hour**

# AIRCLEANERS

## Ministerial Decree 12 May 2021 – Ministry of Health (Frank Vandenbroucke)

SERVICE PUBLIC FEDERAL SANTE PUBLIQUE,  
SECURITE DE LA CHAINE ALIMENTAIRE  
ET ENVIRONNEMENT

[C – 2021/41483]

12 MAI 2021. — Arrêté ministériel déterminant provisoirement les conditions de la mise sur le marché des produits de purification de l'air dans le cadre de la lutte contre le SARS-CoV-2 en dehors des usages médicaux

Le Ministre de la Santé publique,

Vu la loi du 21 décembre 1998 relative aux normes de produits ayant pour but la promotion de modes de production et de consommation durables et la protection de l'environnement, de la santé et des travailleurs, l'article 5, § 3 ;

Vu l'avis n° 9616 du Conseil Supérieur de la Santé, émis le 3 février 2021 ;

Attendu que l'avis du Conseil Supérieur de la Santé n° 9616 considère qu'une ventilation adéquate des bâtiments avec de l'air neuf en dehors des bâtiments à fonction médicale est une condition nécessaire pour limiter la transmission de SARS-CoV-2 par voie aéroportée;

Considérant que le Conseil supérieur de la santé recommande l'aération et la ventilation des locaux fréquentés par le public lorsque la ventilation de base est insuffisante ou lorsque l'air est recirculé, mais prévient qu'aucune de ces deux mesures ne dispense de la mise en œuvre de mesures de lutte contre le SRAS-CoV-2, telles que le port d'un masque, le lavage des mains, le nettoyage des surfaces et le maintien d'une distance physique;

Attendu que le Conseil Supérieur de la Santé recommande l'exécution d'actions immédiates lorsque la concentration en CO<sub>2</sub> d'un local de bâtiment atteint la limite de 900 ppm. Ces actions visent entre autres à augmenter le débit de ventilation avec de l'air neuf, pour diluer la concentration de virus dans l'air et ainsi limiter la transmission de SARS-CoV-2 ;

FEDERALE OVERHEIDSDIENST VOLKSGEZONDHEID,  
VEILIGHEID VAN DE VOEDSELKETEN  
EN LEEFMILIEU

[C – 2021/41483]

12 MEI 2021. — Ministerieel besluit houdende de voorlopige bepaling van de voorwaarden voor het op de markt brengen van luchtzuiveringssystemen in het kader van de bestrijding van SARS-CoV-2 buiten medische doeleinden

De Minister van Volksgezondheid,

Gelet op de wet van 21 december 1998 betreffende de productnormen ter bevordering van duurzame productie en consumptiepatronen en ter bescherming van het leefmilieu, de volksgezondheid en de werknemers, artikel 5, § 3;

Gelet op het advies nr. 9616 van de Hoge Gezondheidsraad, uitgebracht op 3 februari 2021;

Overwegende dat het advies nr. 9616 van de Hoge Gezondheidsraad oordeelt dat een gepaste ventilatie met verse lucht van gebouwen, andere dan gebouwen met een medische functie, een noodzakelijke voorwaarde is om de overdracht van SARS-CoV-2 via de lucht te beperken;

Overwegende dat de Hoge Gezondheidsraad aanbeveelt om de door het publiek bezochte ruimten te verluchten en te ventileren bij onvoldoende basisventilatie of bij recirculatie van lucht, maar waarschuwt dat geen van beide vrijstelling verleent voor de uitvoering van de maatregelen ter bestrijding van SARS-CoV-2, zoals het dragen van een masker, het wassen van de handen, het schoonmaken van oppervlakken en het bewaren van een fysieke afstand;

Overwegende dat de Hoge Gezondheidsraad aanbeveelt om onmiddellijk acties te ondernemen wanneer de CO<sub>2</sub>-concentratie in de lokalen van een gebouw de grens van 900 ppm bereikt. Deze acties hebben onder meer tot doel om het ventilatiedebiet met verse lucht te verhogen, de virusconcentratie in de lucht te verdunnen en aldus de overdracht van SARS-CoV-2 te beperken;



# AIRCLEANERS

## List of “approved aircleaners” on website FOD Volksgezondheid (Belgium)

### Lijst van gecontroleerde en toegestane ventilatiezuiveringsproducten tegen Covid-19

16/12/2021

[Document downloaden](#)

#### Lijst van gecontroleerde en toegestane ventilatiezuiveringsproducten tegen Covid-19

NEDERLANDS



Lijst van gecontroleerde en toegestane ventilatiezuiveringsproducten tegen Covid-19  
XLSX document - 24,83 KB

#### Liste des produits de ventilation-purification contre le Covid-19 contrôlés et autorisés

FRANS



Liste des produits de ventilation-purification contre le Covid-19 contrôlés et autorisés  
XLSX document - 24,83 KB

# AIRCLEANERS

## List of “approved aircleaners” on website FOD Volksgezondheid (Belgium)

federaal overheidsdienst  
VOLKSGEZONDHEID, VEILIGHEID VAN DE VOEDSELKETEN EN LEEFMILIEU

Q E-DIENSTEN PUBLICATIES EN ONDERZOEK NIEUWS AGENDA OVER ONS CONTACT WERKEN BIJ ON S THEMAS

Lijst van gecontroleerde en toegestane ventilatiezuiveringsproducten tegen Covid-19

16/12/2021

Document downloaden

**BE CAREFUL: LIST IS CURRENTLY UNDER EVALUATION BY THE FOD VOLKSGEZONDHEID**

Lijst van gecontroleerde en toegestane ventilatiezuiveringsproducten tegen Covid-19  
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FRANS  
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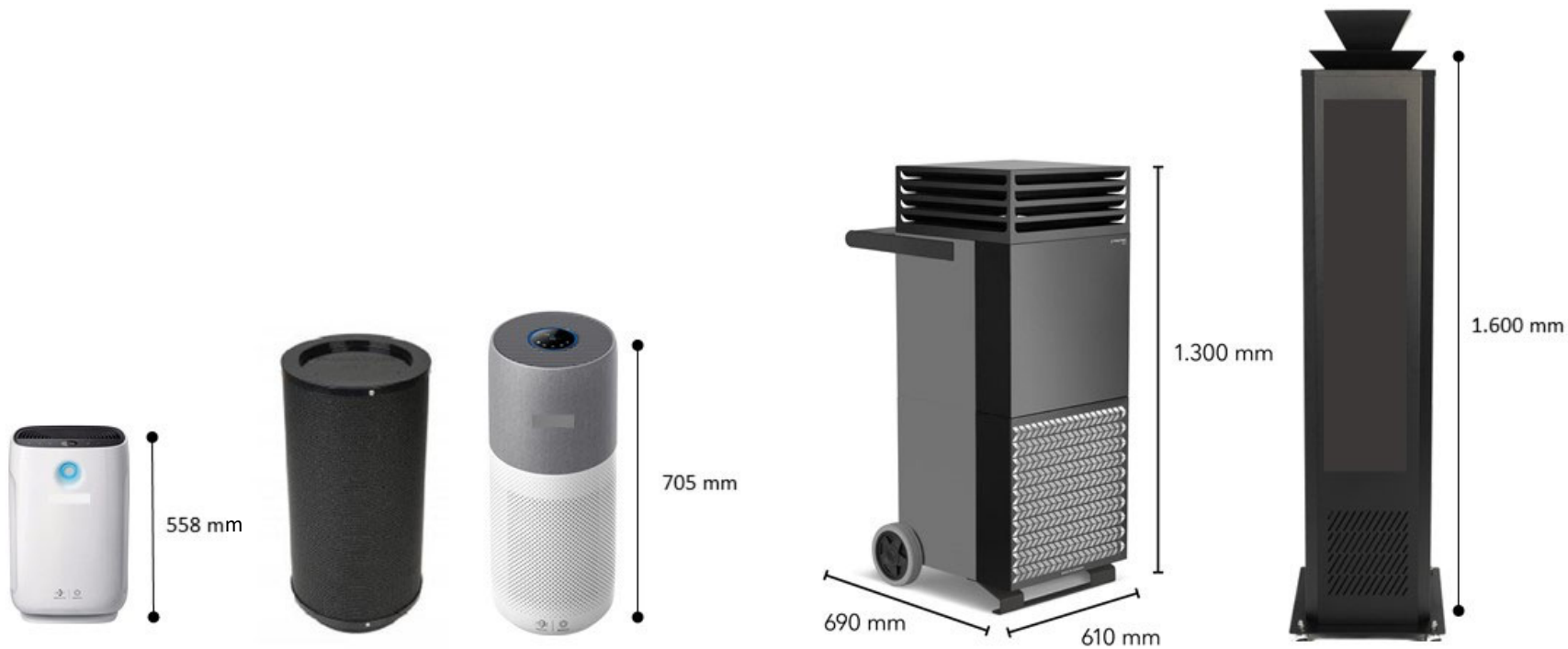


# AIRCLEANERS

## Advantages and disadvantage of use aircleaners

### Advantages

- Faster to install (no 5-year plan needed)



# AIRCLEANERS

## Advantages and disadvantage of use aircleaners

### Advantages

- Faster to install (no 5-year plan needed)
- Much cheaper than mechanical ventilation systems (600-1500 € versus 6000-20,000 €)
- Higher efficiency certainly in rooms with larger height



# AIRCLEANERS

## Advantages and disadvantage of use aircleaners

### Advantages

- Faster to install (no 5-year plan needed)
- Much cheaper than mechanical ventilation systems (600-1500 € versus 6000-20,000 €)
- Higher efficiency certainly in rooms with larger height

### Disadvantages

- Most aircleaners do not remove CO<sub>2</sub> → CO<sub>2</sub> cannot be used anymore as indicator of endogenous aerosol particle concentration.
- Be careful in selecting your aircleaner (very good, but also useless and even dangerous products on the market!)

# AIRCLEANING IN CLASSROOMS

Research project connecting building physics and virology

## Objectives

1. **Scientific evidence** of the importance of **aircleaning against COVID-19** and other respiratory viruses, particulate matter from traffic, allergens, etc.
2. Getting **acquainted** with the technology
3. Support **large-scale implementation** of aircleaners in education and beyond



# AIRCLEANING IN CLASSROOMS

## Research project connecting building physics and virology

### Phase 1: Preparation

1. **Recruitment** of municipalities and schools
2. **Testing** aircleaners in laboratory set-up
3. **Purchase or loan** of aircleaners for several classrooms

### Phase 2: Execution

4. Measurement of **aerosol concentration** reductions by aircleaners
5. Measurement of **virus load** in the classroom air
6. Registration of **number of infections** attributable to class-room environment

### Phase 3: Large-scale implementation

7. **Recruiting** government **funding** and/or funding by benefactors
8. **Guiding schools** in large-scale implementation

# AIRCLEANING IN CLASSROOMS - BELGIUM

Participating municipalities and schools (Belgium )



STAD  
PEER



Heusden-Zolder





Herentals



Gent



Roosdaal



Hoeselt



Antwerpen

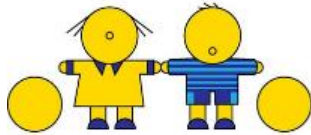


samen bouwen aan je toekomst

Dendermonde



Oudenaarde



Genk



St-Amands



Perwez



Hoeselt



Beringen



Roeselare



Hasselt



Roeselare



Poperinge



Diepenbeek



Antwerpen



Tielt



Schoten



Diksmuide



Boortmeerbeek



Boortmeerbeek



Boortmeerbeek



Halle



Deurne



Charleroi



Marche-en-Famenne

# AIRCLEANING IN CLASSROOMS - BELGIUM



Pelt



Dessel





# AIRCLEANING IN CLASSROOMS - NETHERLANDS (status Jan. 2022)

## Participating municipalities, universities and schools (Netherlands )



Kindcentrum  
**De Kiezel**

Best  
(2 locaties)



VPCO THOLEN e.o.

Tholen  
(4 locaties)



Helcherseeschool  
school voor p.c. basisonderwijs

Scharendijke



**De Stroom**  
openbaar kindcentrum

Helmond



OBS **DE REIS**  
VAN BRANDAAN

Eindhoven



Eindhoven



de **Torelaar**  
BASISSCHOOL

Reusel



de **Rozemarn**  
SIRIUS SCHOOL

Amsterdam



Cornelis Jetses  
SIRIUS SCHOOL  
Waar kinderen zichzelf mogen zijn.

Amsterdam



BASISSCHOOL  
**Samenspel**

Amsterdam



de **Ster**  
INTEGRAAL KINDCENTRUM

Amsterdam



Katholiek Basisonderwijs Hengelo-Zuid  
Locatie De Bleek

Hengelo



Hengelo



Hengelo



**Bernadette**  
BASISSCHOOL

Veghel



de **Empel**  
BASISSCHOOL

Erp



**Franciscus**  
BASISSCHOOL

St-Oedenrode



**Kienehoef**  
BASISSCHOOL

St-Oedenrode

# AIRCLEANING IN CLASSROOMS



# AIRCLEANING IN CLASSROOMS

Example: installation in Perwez, Belgium





# AIRCLEANING IN CLASSROOMS



# AIRCLEANING IN CLASSROOMS





# AIRCLEANING IN CLASSROOMS



# AIRCLEANING IN CLASSROOMS





# AIRCLEANING IN CLASSROOMS



## WEBSITES

<https://www.luchtreinigingindeklas.nl>

<https://www.luchtreinigingindeklas.be>

<https://www.purificationdelairdesclasses.be>

<https://www.aircleaningintheclassroom.eu>

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**GOVERNMENT  
IMPLEMENTATION IN BE  
AND OTHER COUNTRIES**

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# BELGIAN FEDERAL CORONA BAROMETER

## What the government has done



		BINNEN NIET-DYNAMISCH		
		Overwegend zittend consumerend publek, soms rustig bewegend. Onder meer restaurants,cafés, zittende cafés met bedienend personeel, maaltijd in groep (rouw), catering op recepties.		
		CODE GEEL	CODE ORANJE	CODE ROOD
MONDMASKERS		FFP2 aangeraden voor medisch kwetsbare mensen	verplicht voor personeel	verplicht voor klanten en personeel
COVID SAFE TICKET		geen CST	verplicht	verplicht
LUCHTKWALITEIT		CO2-meter, risico-analyse & actieplan	streefwaarde 900ppm (40m3 ventilatie) luchtzuivering vanaf 1200ppm limietwaarde 1500 ppm (18m3)*	streefwaarde 900ppm (40m3 ventilatie) luchtzuivering vanaf 1200ppm limietwaarde 1200 ppm (18m3)*
SLUITINGSUUR		geen sluitingsuur	geen sluitingsuur	23.00u - 1.00u
CAPACITEIT		geen beperking	plafonds mogelijk	6 personen/tafel, geen rechtstaand consumeren/toog ** plafonds mogelijk

# BELGIAN FEDERAL CORONA BAROMETER

## What the government has done

CO2-meter, risico-analyse  
& actieplan

streefwaarde 900ppm  
(40m3 ventilatie)  
luchtzuivering vanaf 1200ppm  
limietwaarde 1500 ppm (18m3)\*

streefwaarde 900ppm  
(40m3 ventilatie)  
luchtzuivering vanaf 1200ppm  
limietwaarde 1200 ppm (18m3)\*

# NEW AND AMBITIOUS VENTILATION PLAN FOR BELGIUM

## What the government is doing



Persbericht 4 april 2022

### Binnenluchtkwaliteit: beleid van de toekomst en wetgevend kader

**Op het Overlegcomité van 20 augustus 2021 werd beslist om een binnenluchtkwaliteitstrategie op lange termijn te ontwikkelen. Daarom werkt minister van volksgezondheid Frank Vandenbroucke nu aan het wetgevende kader voor een ambitieus plan rond gezonde binnenlucht in alle publiek toegankelijke ruimtes.**

Mensen brengen gemiddeld 85% van de dag binnen door. Gezonde binnenlucht is daarom van groot belang voor de algemene gezondheid van onze bevolking. Dit in het bijzonder voor de meest kwetsbare groepen zoals baby's, kinderen, ouderen of mensen die lijden aan bepaalde aandoeningen zoals allergiën. Werken, leren en leven in slecht verluchte binnenruimtes verlaagt ons welbevinden, onze concentratie en ook onze productiviteit.

# NEW AND AMBITIOUS VENTILATION PLAN FOR BELGIUM

## What the government is doing

1. Ambitious ventilation plan for health indoor air in all public spaces
2. With air quality label
3. With strong focus on aircleaning:

Technieken voor luchtzuivering krijgen - als aanvulling op de ventilatiesystemen - een belangrijke rol in het verbeteren van de binnenluchtkwaliteit. Luchtzuivering biedt heel wat mogelijkheden om potentieel besmettelijke aerosolen uit de lucht te verwijderen of te inactiveren. Bovendien zijn ze makkelijk en snel te installeren en is hun energieverbruik laag. Op plaatsen waar om praktische redenen met het ventilatiesysteem een onvoldoende debiet van verse lucht gehaald wordt, kunnen ze gebruikt worden.

# USA WHITE HOUSE ACTIONS

## USA

**122 Billion Dollar White House Project** on ventilation and aircleaning across states



BRIEFING ROOM

## Let's Clear The Air On COVID

MARCH 23, 2022 • OSTP BLOG

*By Dr. Alondra Nelson, head of the White House Office of Science and Technology Policy and Deputy Assistant to the President*

The most common way COVID-19 is transmitted from one person to another is through tiny airborne particles of the virus hanging in indoor air for minutes or hours after an infected person has been there. While there are various strategies for avoiding breathing that air – from remote work to masking – we can and should talk more about how to make indoor environments safer by filtering or cleaning air.



# USA WHITE HOUSE ACTIONS

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“Here are the basics:

**Ventilation:** Bringing in clean outdoor air is key...

**Air filtration:** Using high-quality air filters like HEPA or MERV-13 – connected to capable HVAC systems or portable air purifiers – to remove virus particles from indoor air is also important. Filtration is a great tool to supplement ventilation or to use if adequate ventilation isn't possible...

**Air disinfection:** By inactivating (“killing”) airborne virus through methods like ultraviolet germicidal irradiation (UVGI) systems, we can add another layer of protection in indoor spaces...”

# USA WHITE HOUSE ACTIONS

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“Here are the basics:

**Ventilation:** Bringing in **clean outdoor air** is key...

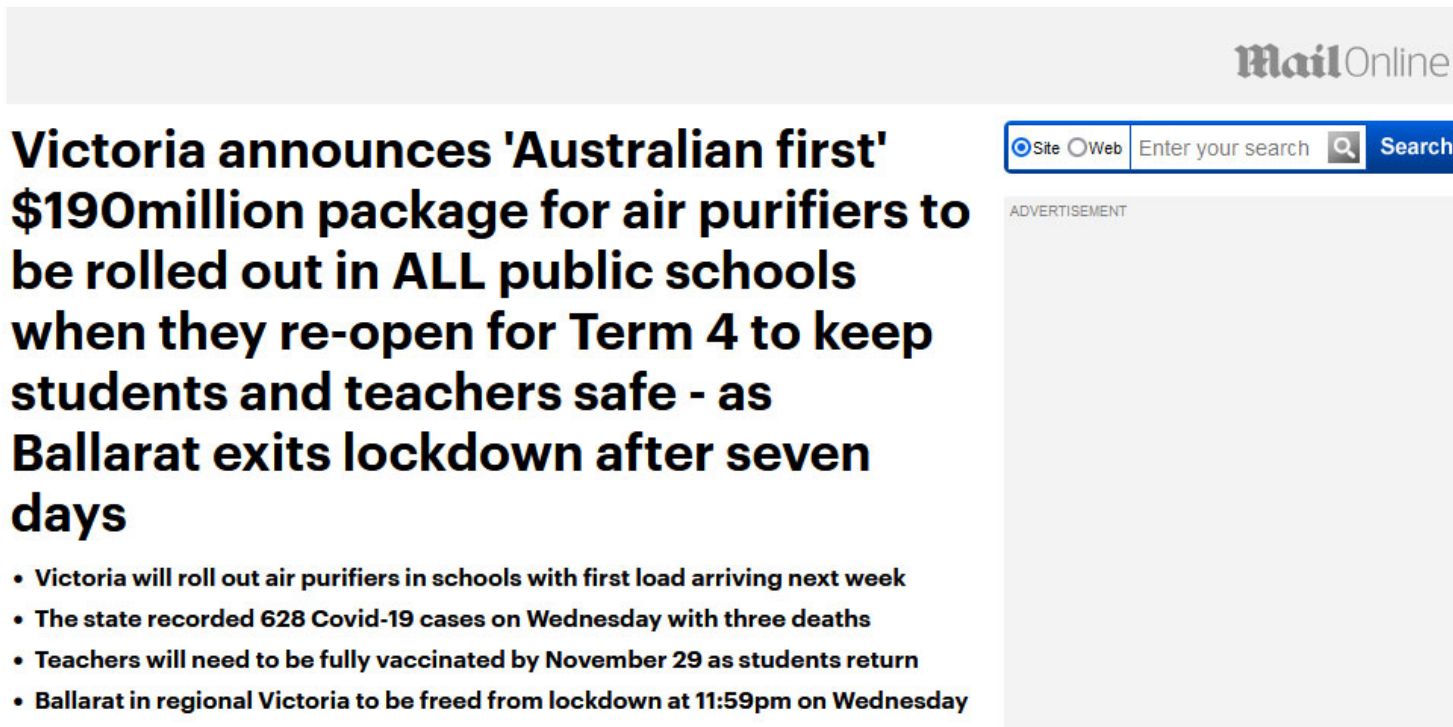
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**Air disinfection:** By inactivating (“killing”) airborne virus through methods like ultraviolet germicidal irradiation (UVGI) systems, **we can add another layer of protection in indoor spaces...**”

# AIRCLEANERS FOR CLASSROOMS IN AUSTRALIA

## The State of Victoria, Australia

**190 Million Dollar** purchase of aircleaners for ALL public schools



The screenshot shows a news article on the MailOnline website. The article title is "Victoria announces 'Australian first' \$190million package for air purifiers to be rolled out in ALL public schools when they re-open for Term 4 to keep students and teachers safe - as Ballarat exits lockdown after seven days". The article includes a list of four bullet points: "Victoria will roll out air purifiers in schools with first load arriving next week", "The state recorded 628 Covid-19 cases on Wednesday with three deaths", "Teachers will need to be fully vaccinated by November 29 as students return", and "Ballarat in regional Victoria to be freed from lockdown at 11:59pm on Wednesday". The website header includes the "MailOnline" logo, a search bar with "Site" and "Web" options, and a search button. An "ADVERTISEMENT" placeholder is visible on the right side of the article.

MailOnline

Site Web Enter your search Search

ADVERTISEMENT

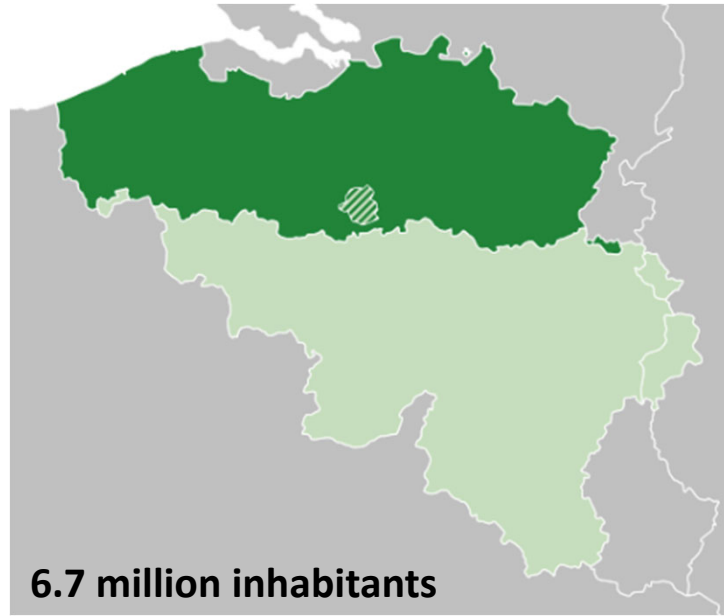
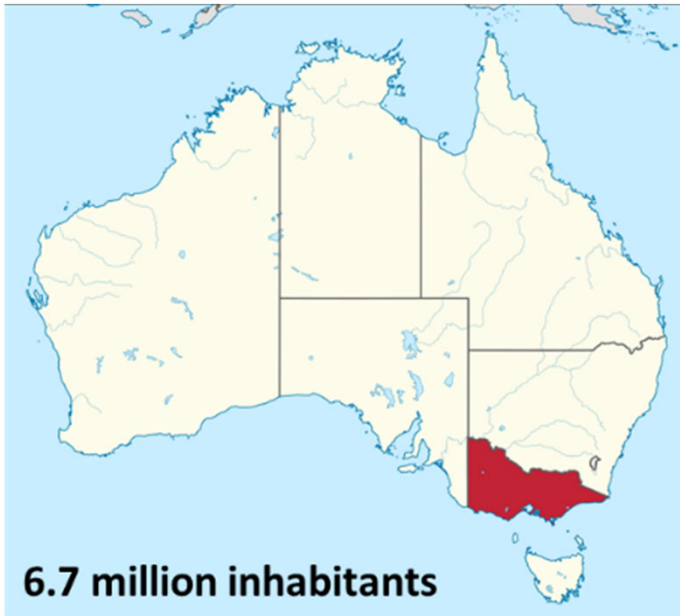
**Victoria announces 'Australian first' \$190million package for air purifiers to be rolled out in ALL public schools when they re-open for Term 4 to keep students and teachers safe - as Ballarat exits lockdown after seven days**

- Victoria will roll out air purifiers in schools with first load arriving next week
- The state recorded 628 Covid-19 cases on Wednesday with three deaths
- Teachers will need to be fully vaccinated by November 29 as students return
- Ballarat in regional Victoria to be freed from lockdown at 11:59pm on Wednesday

# AIRCLEANERS FOR CLASSROOMS IN AUSTRALIA

## The State of Victoria, Australia

**190 Million Dollar** purchase of aircleaners for ALL public schools



Flemish calculation:  
**120 million €** for  
aircleaners in all  
classrooms in the  
region.

= costs of 3 weeks  
PCR tests

= **“peanuts”** (© Pedro  
Facon)

# AIRCLEANING IN CLASSROOMS: first results

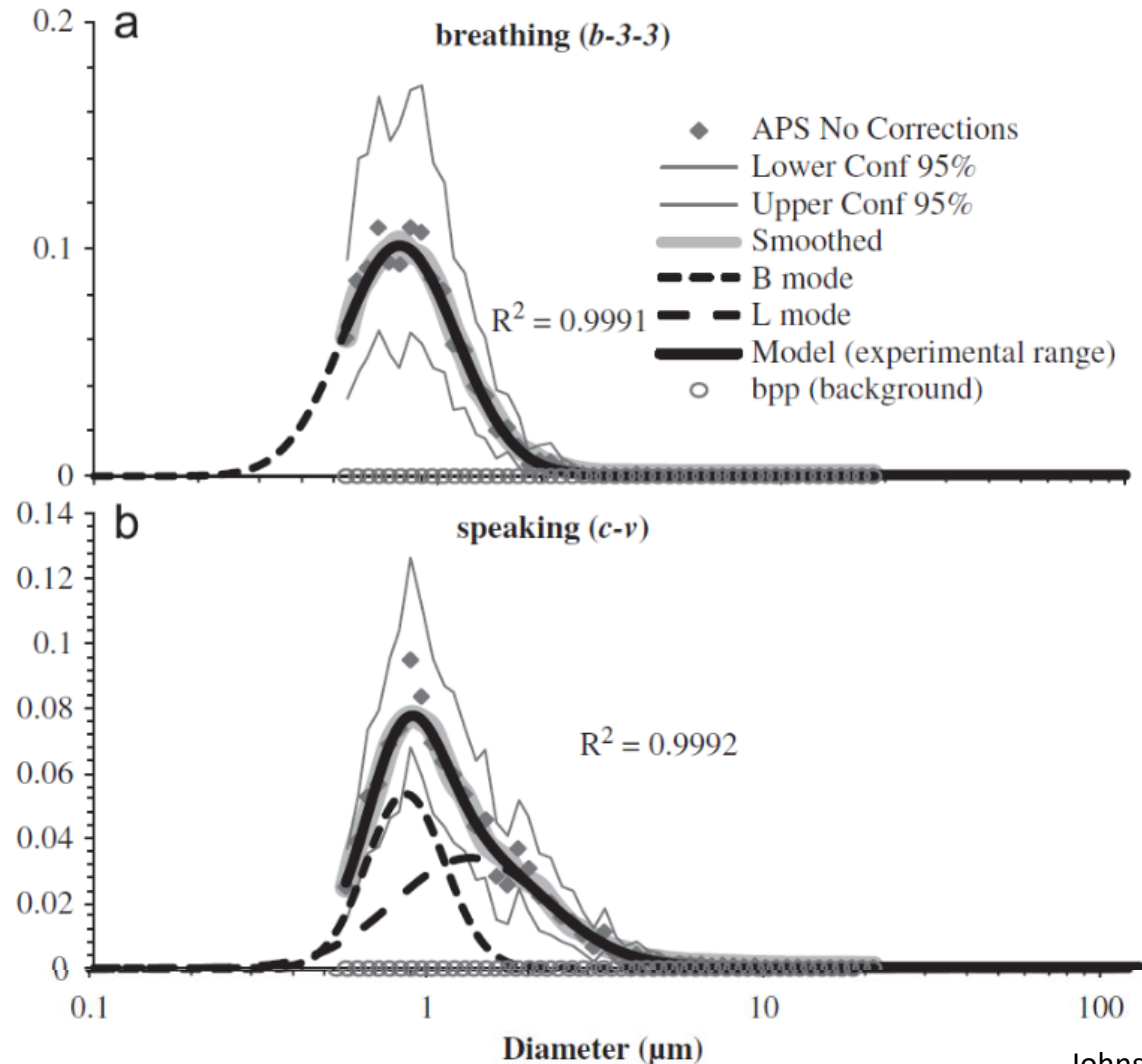
## Respiratory aerosols

**d: < 5  $\mu\text{m}$** : exhaling in rest, talking, laughing, singing

**d > 5  $\mu\text{m}$** : sneezing, coughing, more exceptionally: talking, laughing, singing

**d > 10  $\mu\text{m}$** : not considered as particulate matter anymore

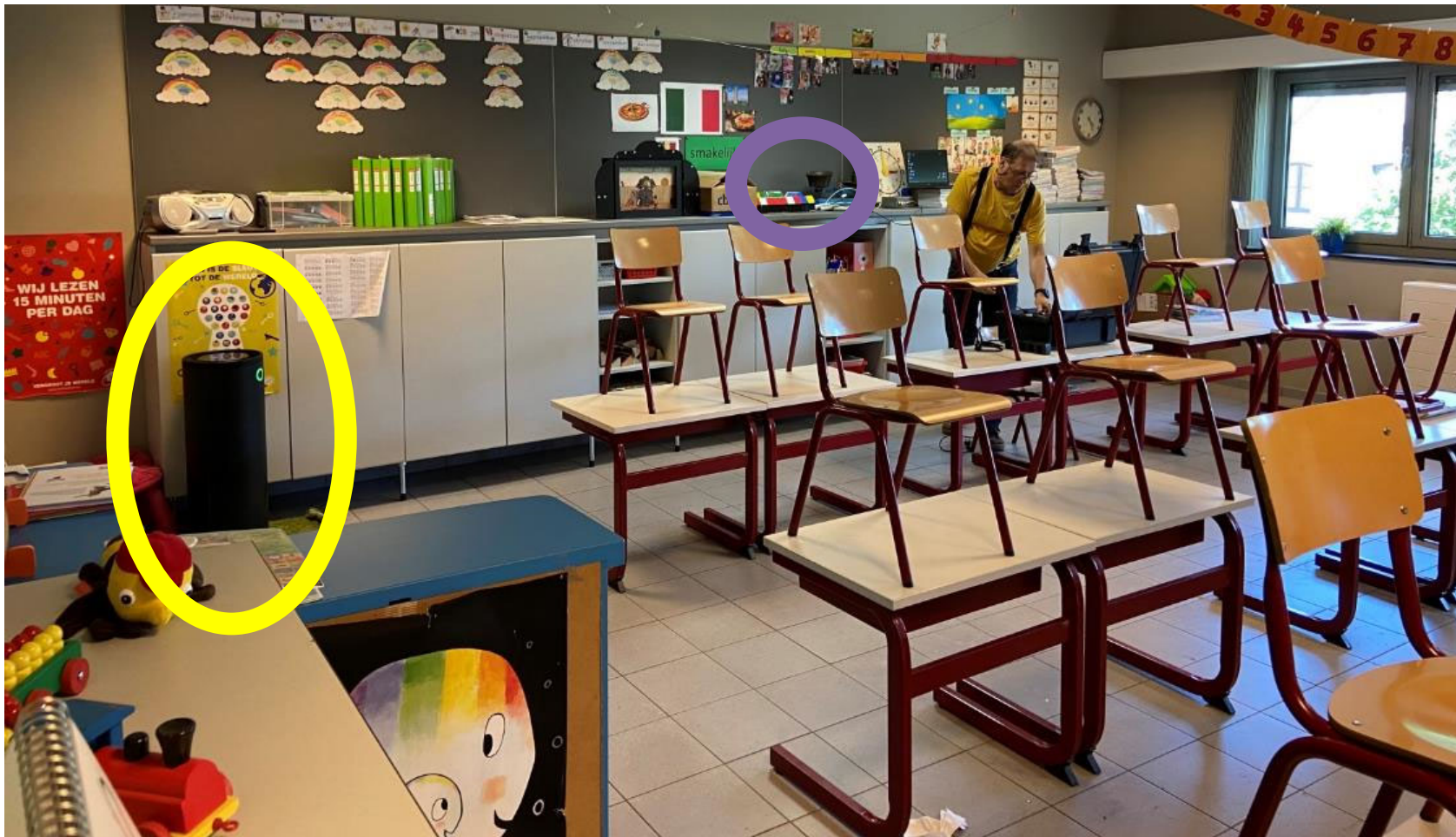
**d > 100  $\mu\text{m}$** : not considered as aerosol particle anymore (by some the limit is set at 5  $\mu\text{m}$  (!))





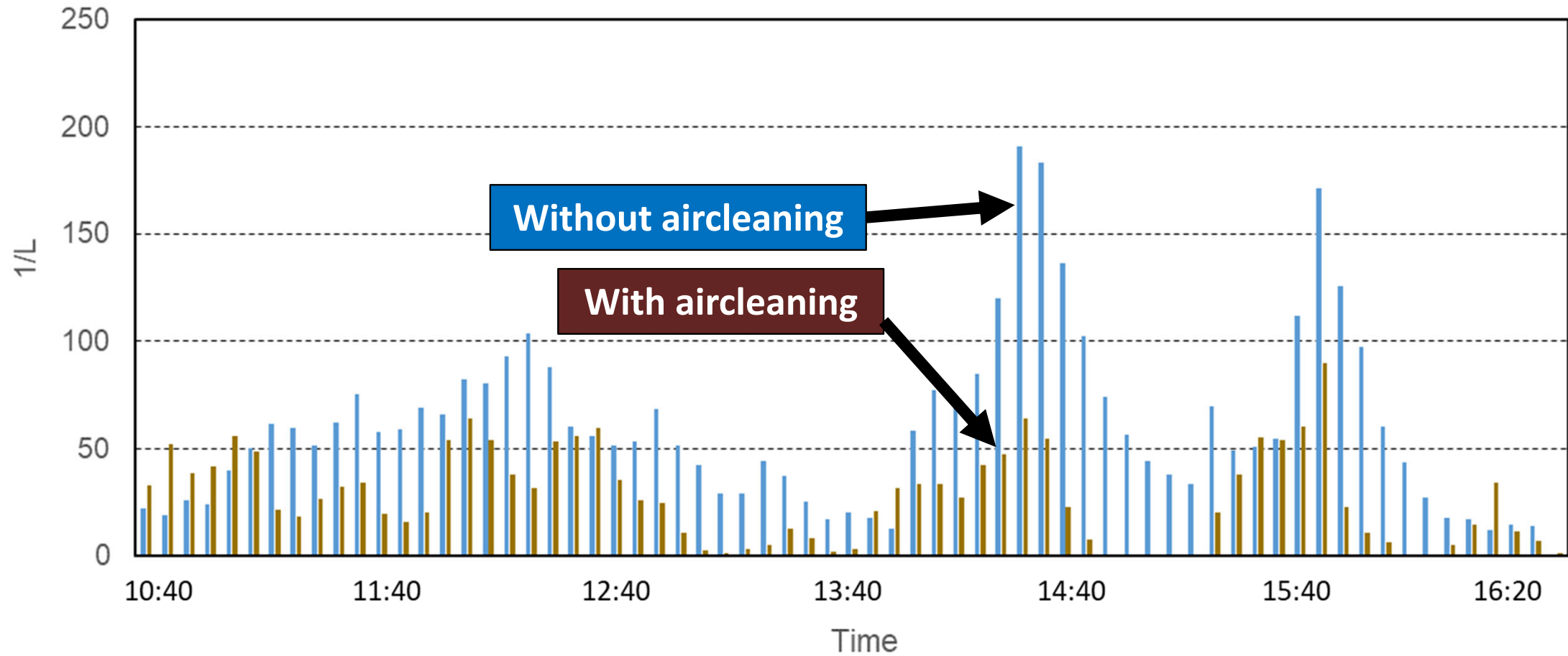
# AIRCLEANING IN CLASSROOMS: First results, De Halte, Bilzen

4 aircleaners at low speed (150 m<sup>3</sup>/h → 3-4 aircleaning frequency)



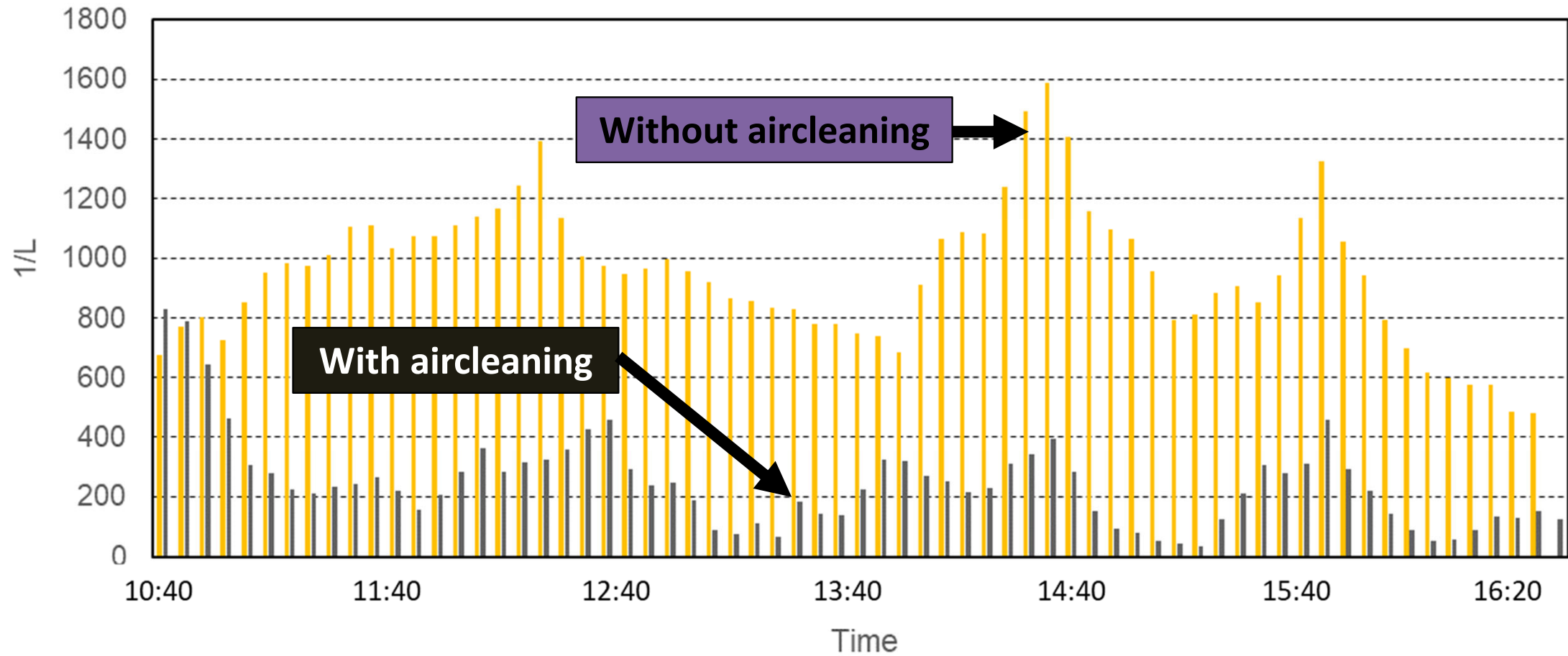
# AIRCLEANING IN CLASSROOMS: First results: De Halte, Bilzen

Particles between 5 and 10  $\mu\text{m}$



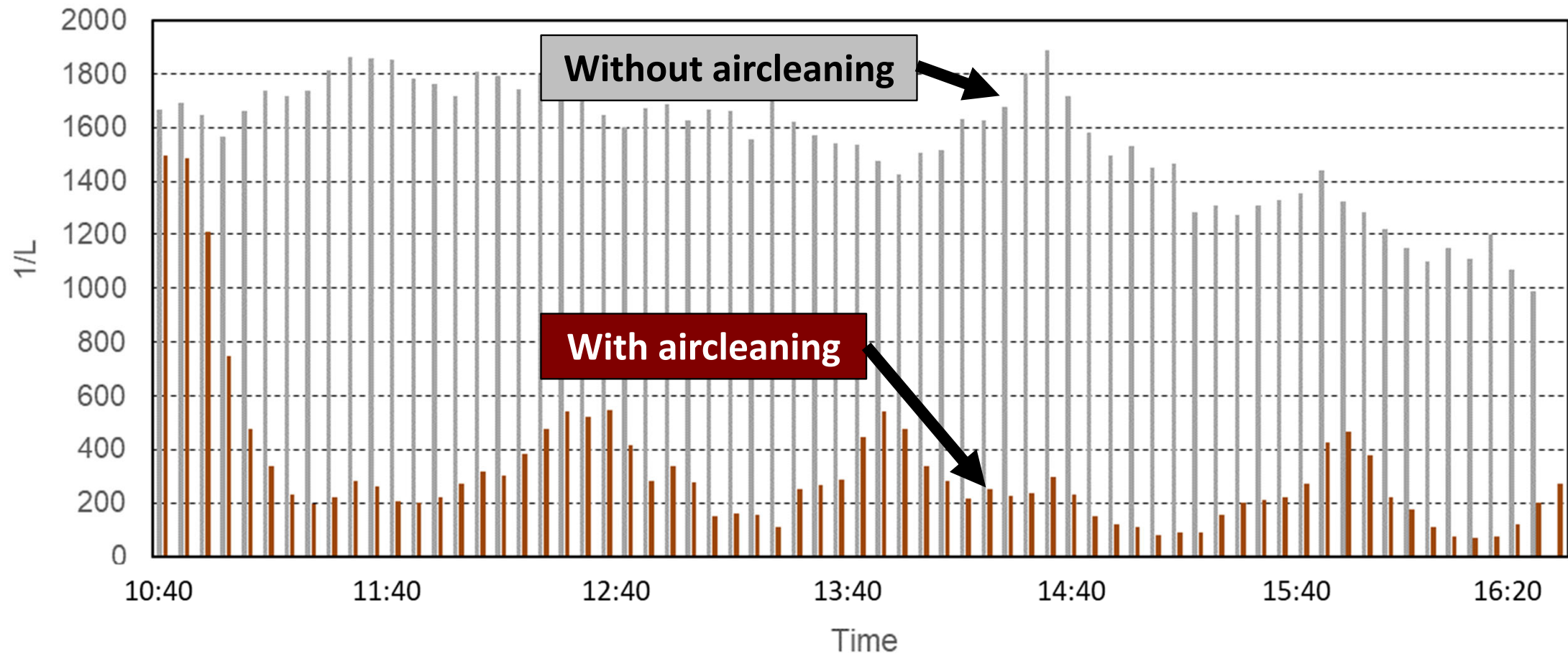
# AIRCLEANING IN CLASSROOMS: First results: De Halte, Bilzen

## Particles between 1 and 5 $\mu\text{m}$



# AIRCLEANING IN CLASSROOMS: First results: De Halte, Bilzen

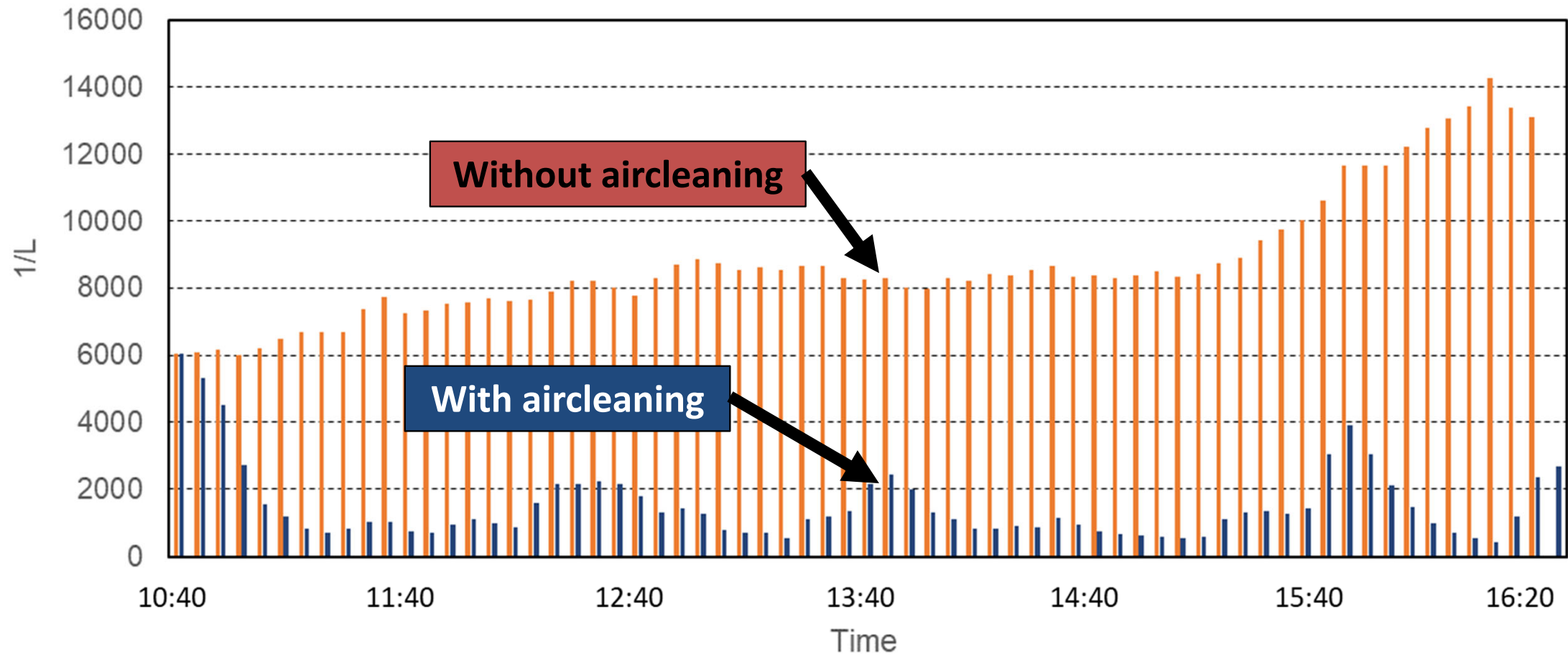
Particles between 0.5 and 1  $\mu\text{m}$





# AIRCLEANING IN CLASSROOMS: First results: De Halte, Bilzen

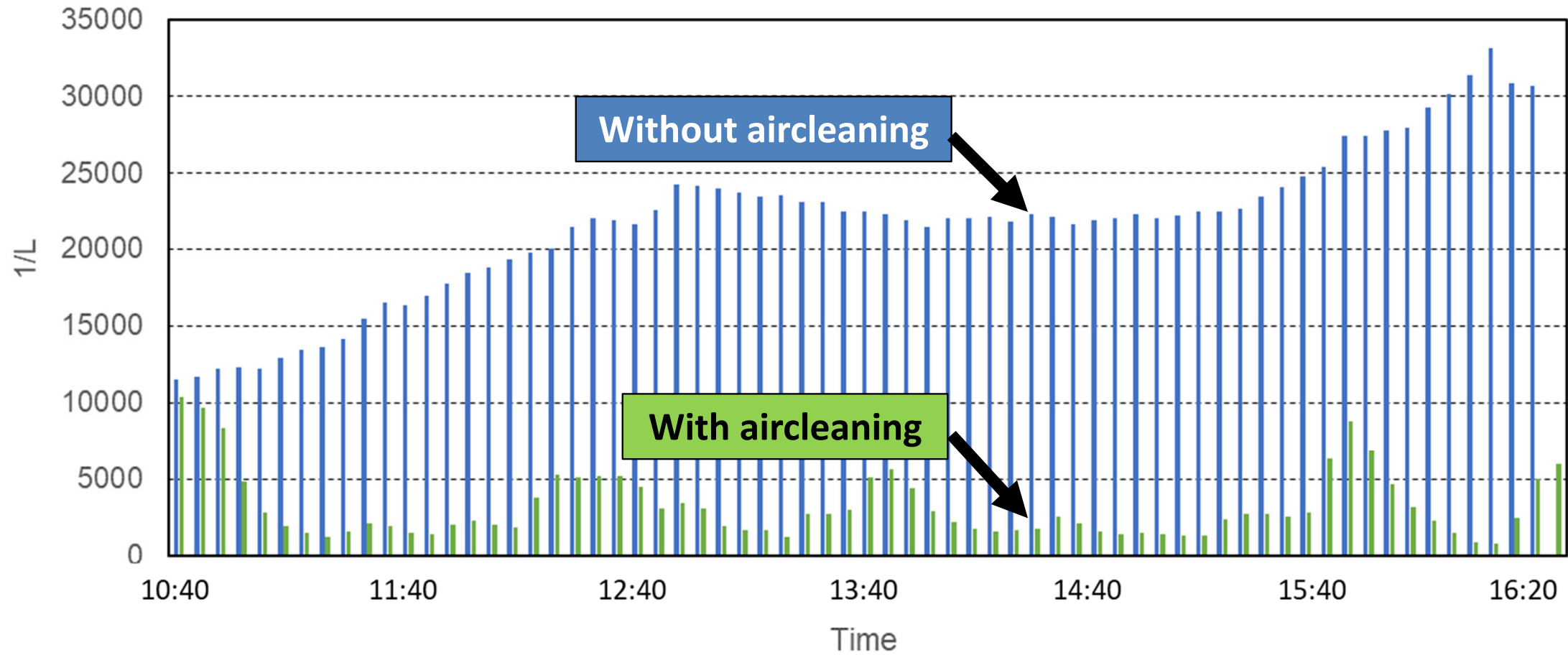
Particles between 0.25 and 0.5  $\mu\text{m}$





# AIRCLEANING IN CLASSROOMS: First results: De Halte, Bilzen

Particles smaller than  $0.25 \mu\text{m}$



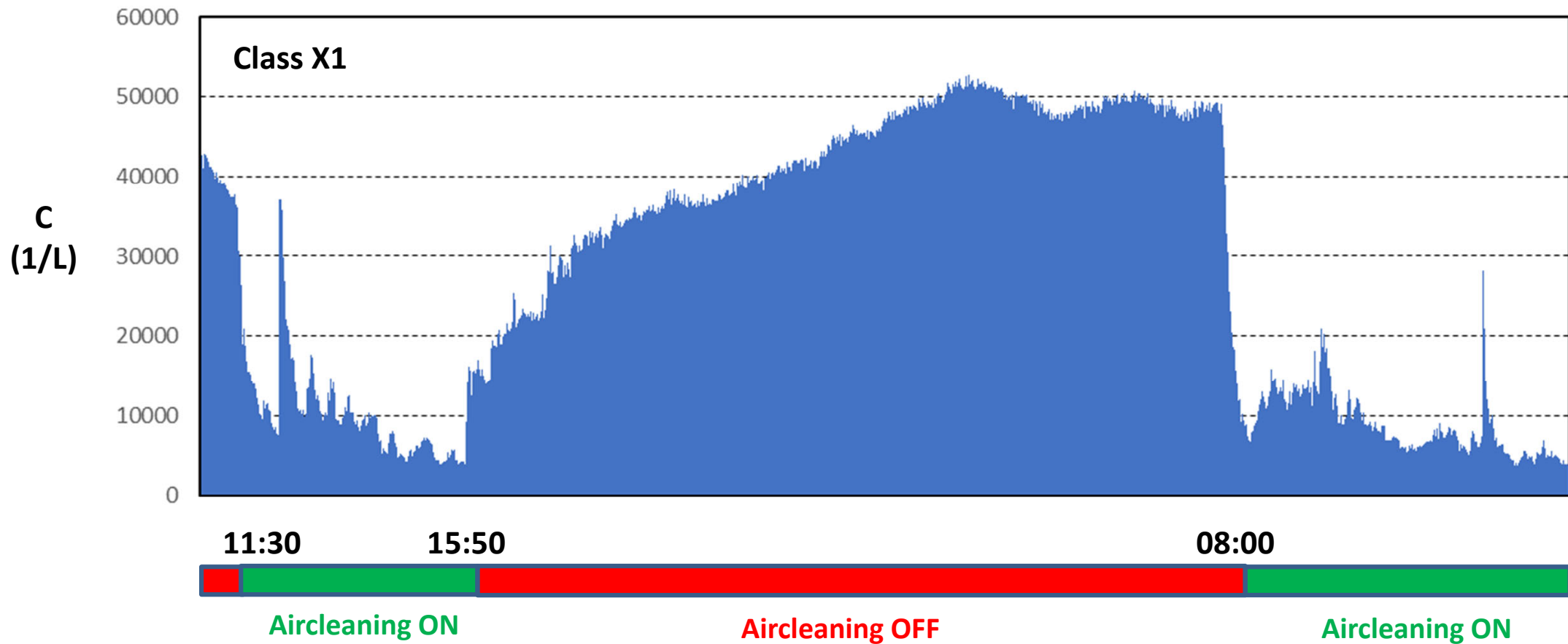
# AIRCLEANING IN CLASSROOMS: First results: Elzenhof, Aarschot

1 large aircleaner at medium speed (1000 m<sup>3</sup>/h → ~6 aircleaning frequency)



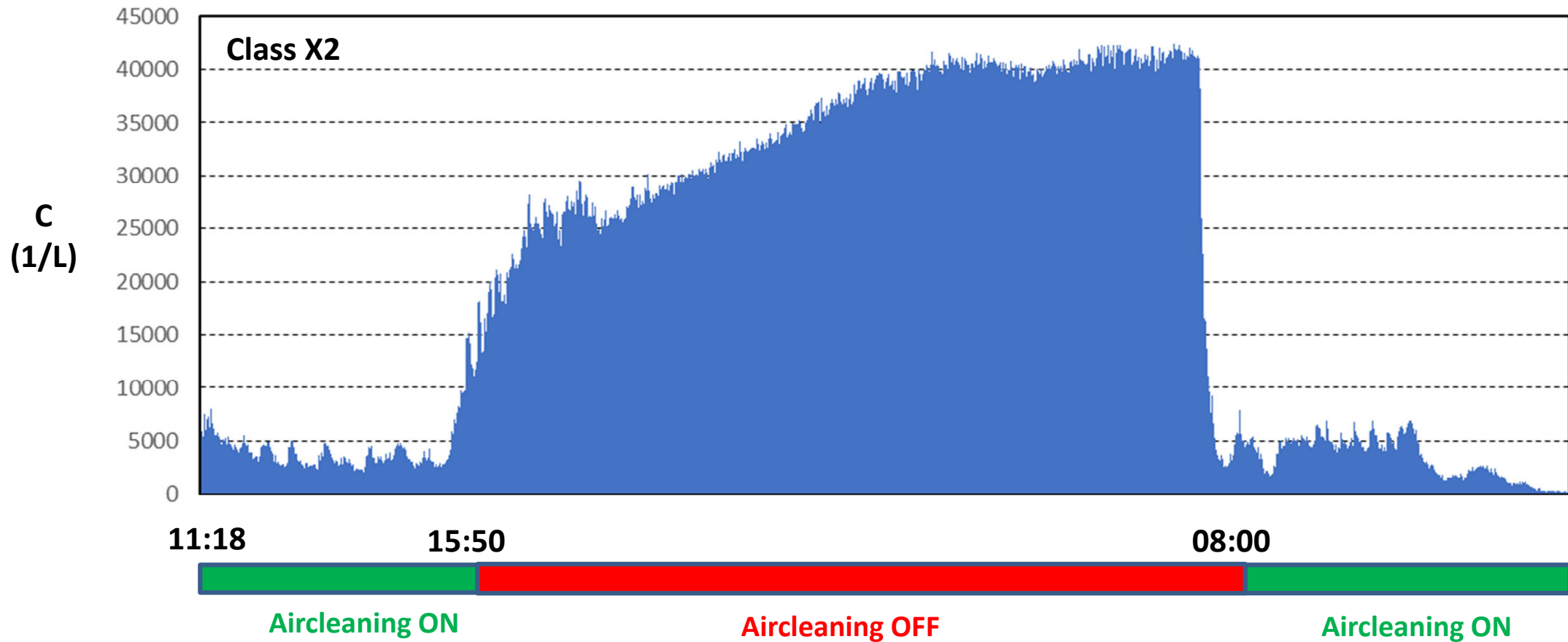
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Particles smaller than  $0.25 \mu\text{m}$



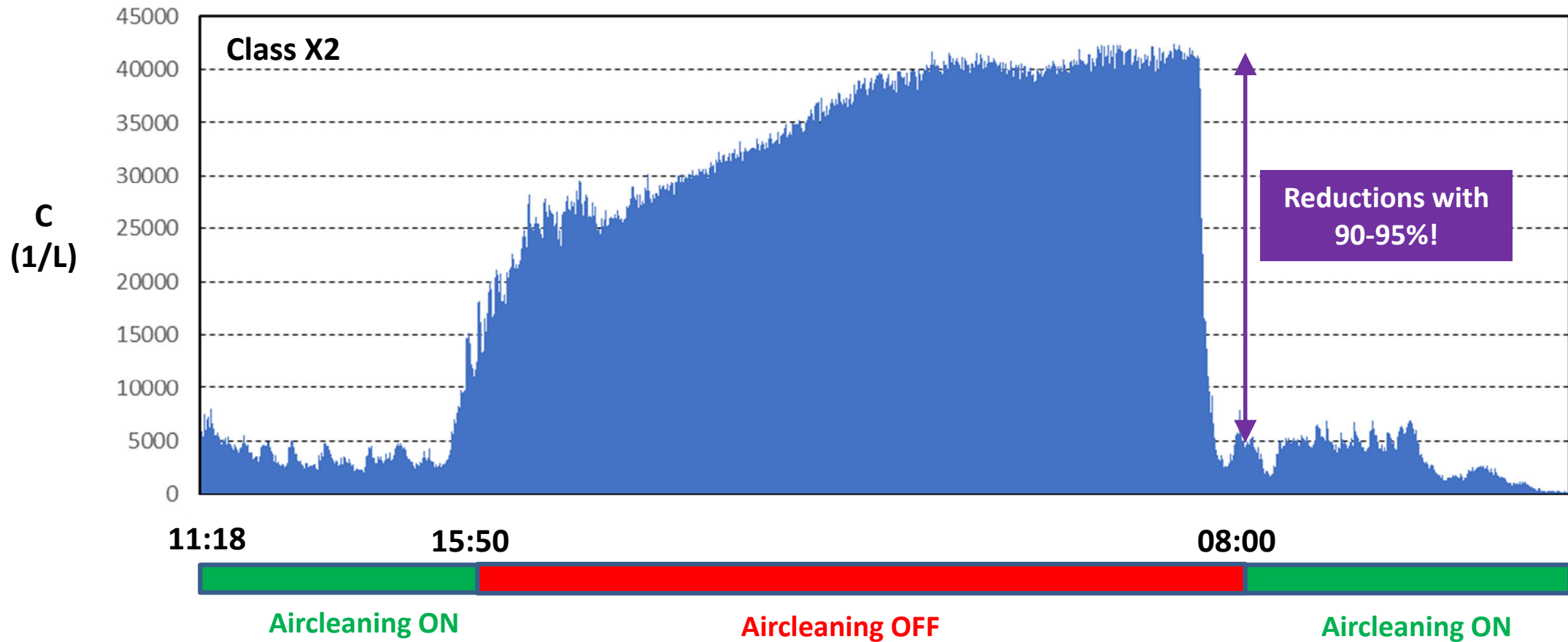
# AIRCLEANING IN CLASSROOMS: First results: Elzenhof, Aarschot

Particles smaller than  $0.25 \mu\text{m}$



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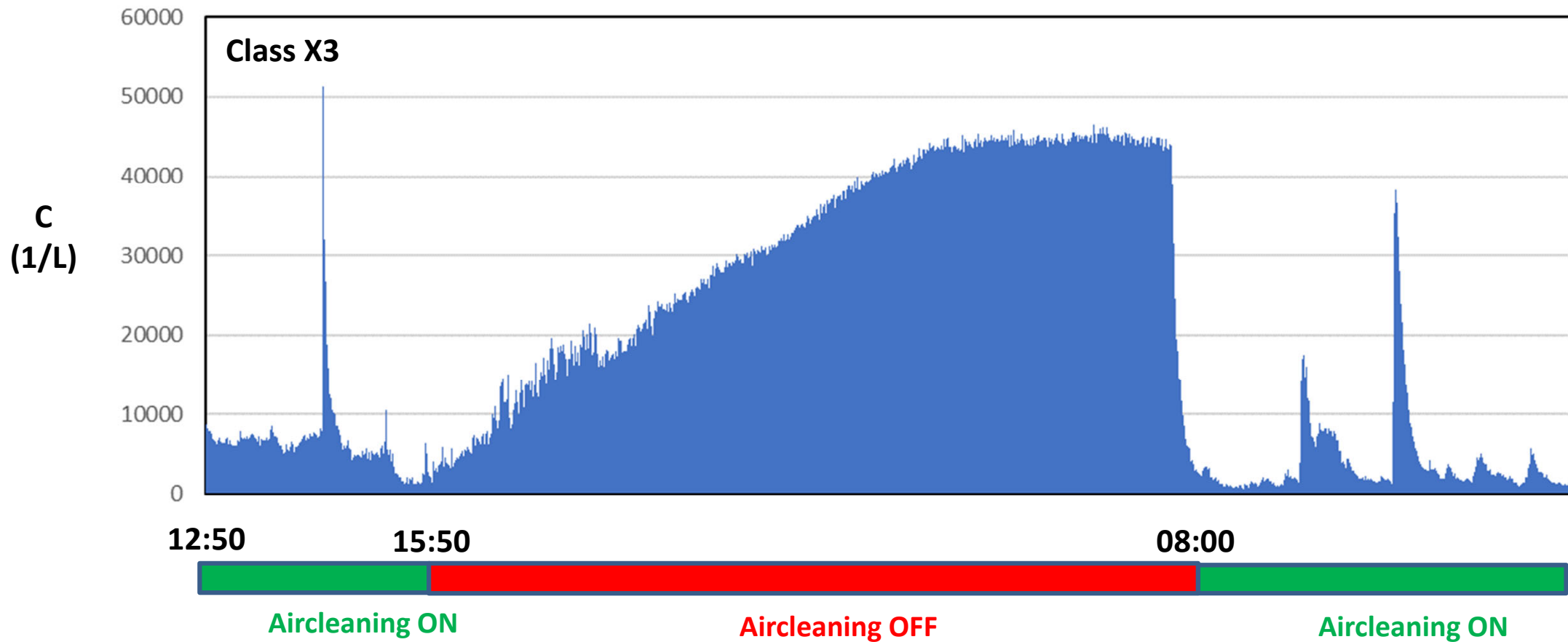
Particles smaller than  $0.25 \mu\text{m}$





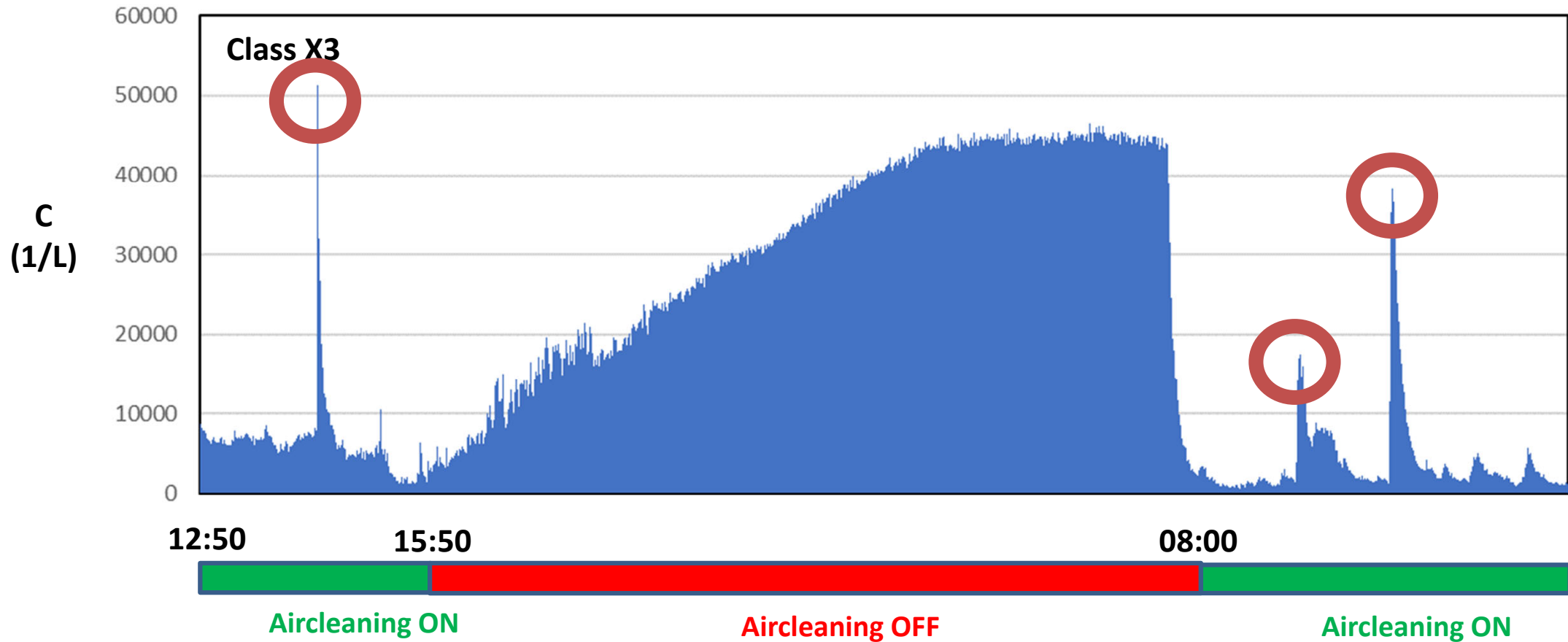
# AIRCLEANING IN CLASSROOMS: First results: Elzenhof, Aarschot

Particles smaller than  $0.25 \mu\text{m}$



# AIRCLEANING IN CLASSROOMS: First results: Elzenhof, Aarschot

Particles smaller than  $0.25 \mu\text{m}$



# AIRCLEANING IN CLASSROOMS: First results

## Consequences for infection risk?

$$P = \frac{C}{S} = 1 - e^{-Iqpt/Q}$$

Risk without aircleaning: 2.37%  
Risk with aircleaning (6x): 0.20%

Factor 12 reductie

- P = Infection risk (1 = 100%, 0 = 0%)  
I = number of source patients (infectors) = **1**  
P = pulmonary ventilation rate (m<sup>3</sup>/h) = **0.3**  
Q = room ventilation + aircleaning rate (m<sup>3</sup>/h)  
q = quantum generation rate (quantum/h) = **14-48**  
t = exposure time (h) = **2**

*A quantum is defined as the number of infectious airborne particles required to infect the person and may consist of one or more airborne particles.*

# AIRCLEANING IN CLASSROOMS: First results

## Consequences for infection risk?

$$P = \frac{C}{S} = 1 - e^{-Iqpt/Q}$$

Risk without aircleaning: 8.00%  
Risk with aircleaning (6x): 0.68%

Factor 12 reductie

- P = Infection risk (1 = 100%, 0 = 0%)  
I = number of source patients (infectors) = **1**  
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# Project “Luchtreiniging in de klas”

Dank u

Prof. dr. ir. Bert Blocken

**TU/e** EINDHOVEN  
UNIVERSITY OF  
TECHNOLOGY

DEPARTMENT OF THE BUILT  
ENVIRONMENT

**KU LEUVEN**

DEPARTMENT OF CIVIL  
ENGINEERING