



The role of computational simulations in the fight against the pandemic

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COVID-19 in numbers

765 000 000 cases

6 900 000 deaths

13 350 000 000 vaccine doses

Up to 16 000 000 000 000 €

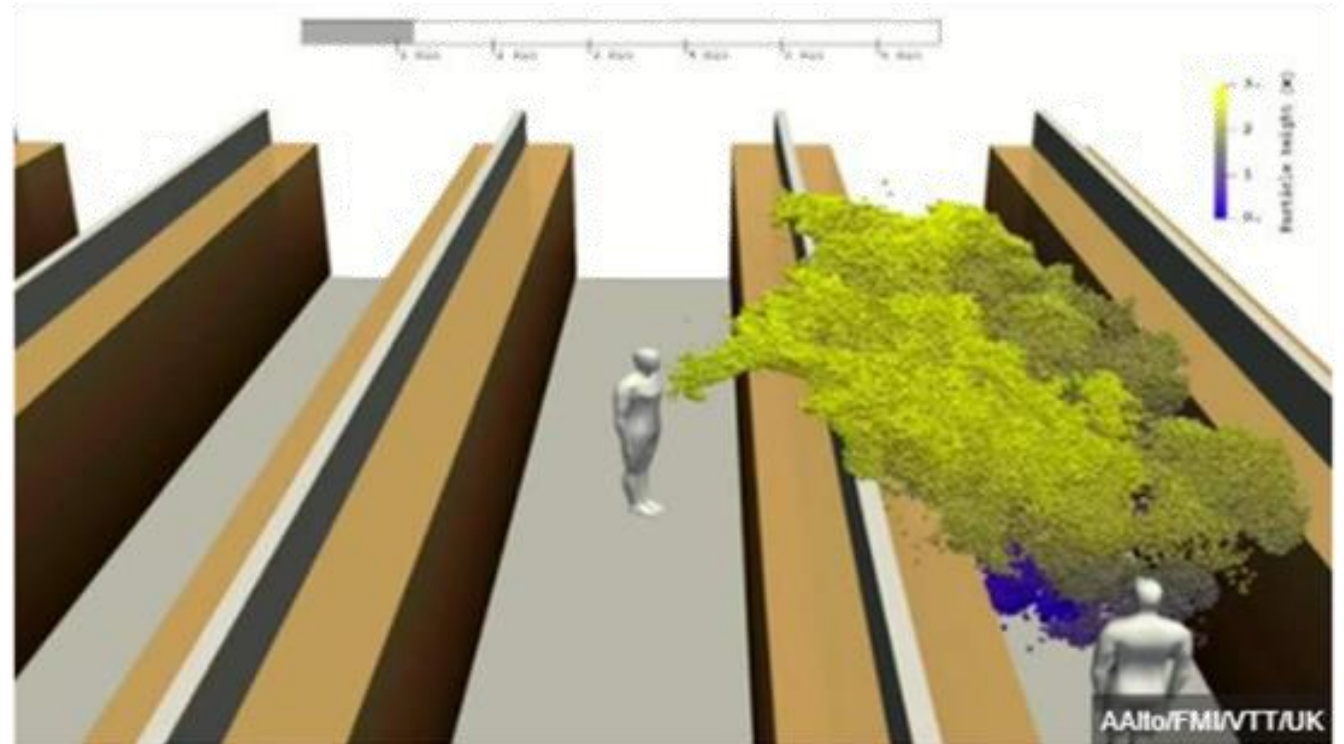
Computational Fluid Dynamics (CFD)

21:22 8 Apr 2020

How far can the coronavirus spread?

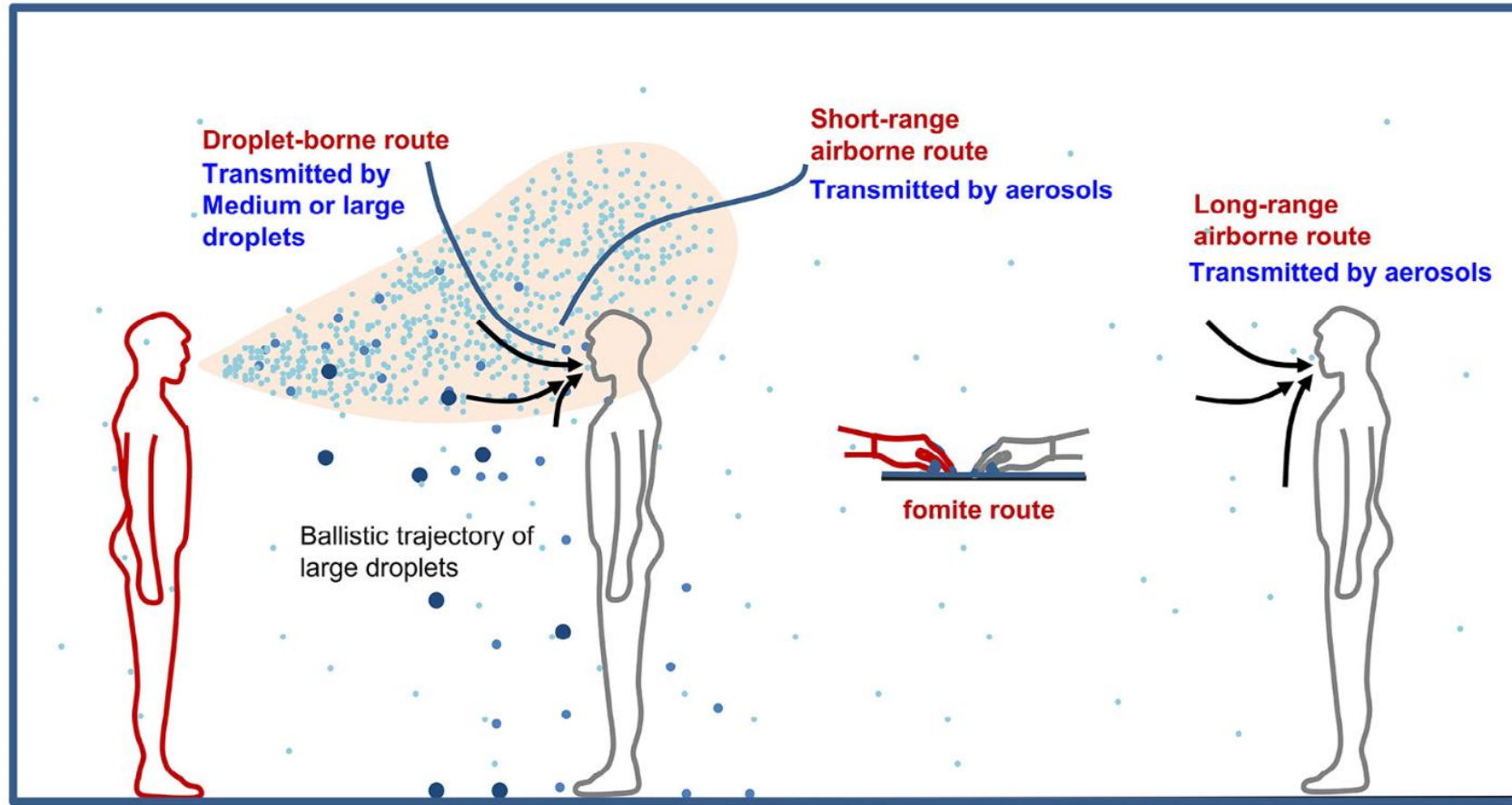


David Shukman
Science editor, BBC News



New computer models have simulated how people coughing can spread coronavirus in confined spaces like supermarket aisles.

Routes of Transmission



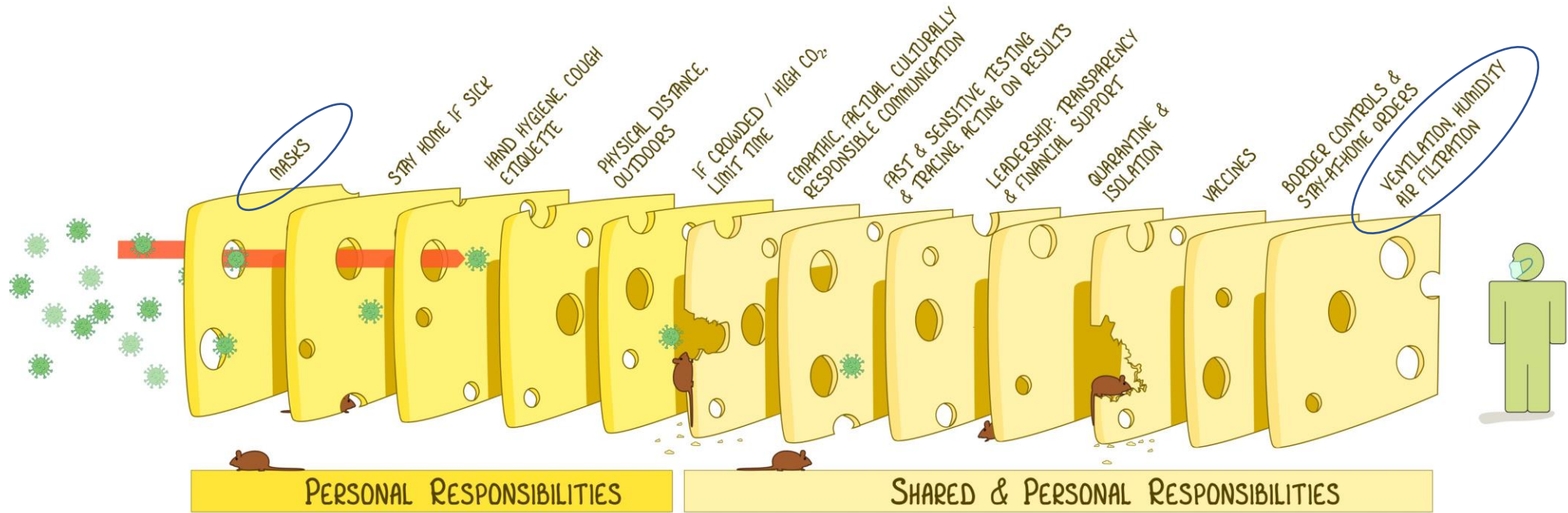
Wei, Jianjian, and Yuguo Li.
'Airborne Spread of Infectious Agents in the Indoor Environment'.
American Journal of Infection Control, Indoor Air as a Vehicle for Human Pathogens, 44, no. 9, Supplement (2 September 2016): S102-8.

What can we do?



THE SWISS CHEESE RESPIRATORY VIRUS PANDEMIC DEFENCE

RECOGNISING THAT NO SINGLE INTERVENTION IS PERFECT AT PREVENTING SPREAD



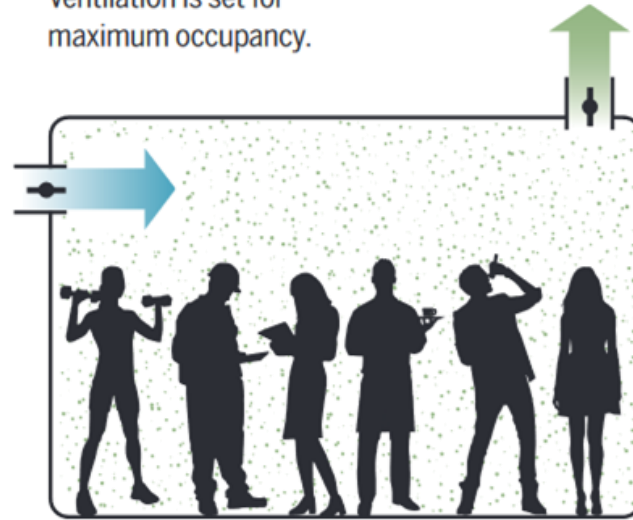
EACH INTERVENTION (SLICE) HAS IMPERFECTIONS (HOLES) WHICH CHANGE IN SIZE, NUMBER AND POSITION DEPENDING ON HOW THE INTERVENTION IS ROLLED OUT. MULTIPLE LAYERS IMPROVE SUCCESS.

 MISINFORMATION MOUSE

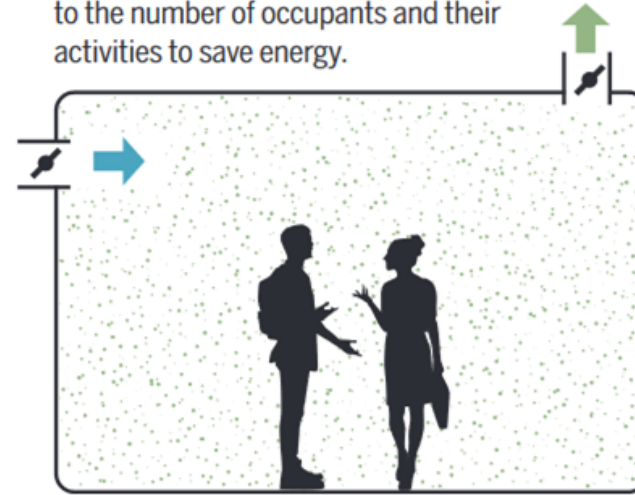
IAN M MACKAY
VIROLOGYDOWNUNDER.COM
WITH THANKS TO JODY LANARD, RATHERINE ARDEN & THE UNI OF QLD
BASED ON THE SWISS CHEESE MODEL OF ACCIDENT CAUSATION, BY JAMES T REASON, 1990
VERSION 4.3
UPDATE: 04SEPT2021

Ventilation

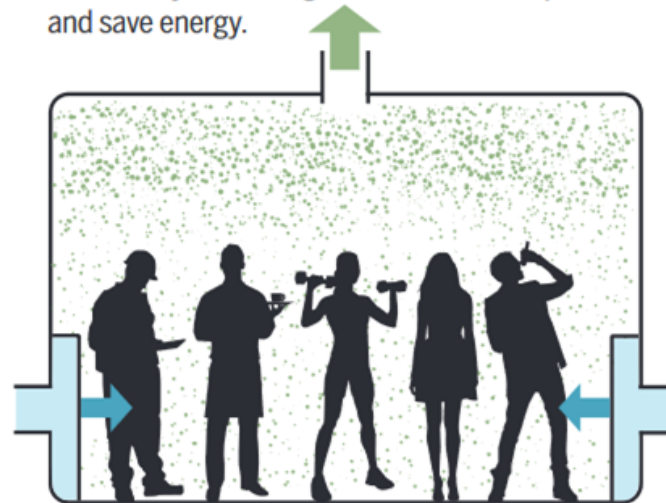
Design occupancy
Ventilation is set for maximum occupancy.



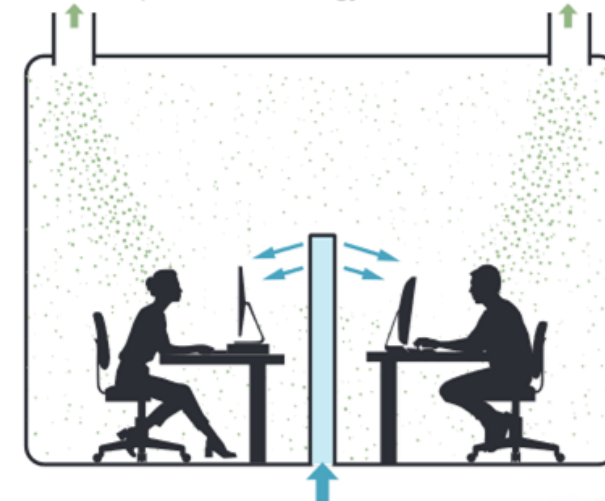
Demand controlled
Ventilation is adjusted according to the number of occupants and their activities to save energy.



Improved air distribution
Different system designs can decrease exposure and save energy.



Personalized ventilation
Clean air is supplied where needed to further reduce exposure and energy use.



Morawska, Lidia, Joseph Allen, William Bahnfleth, Philomena M. Bluyssen, Atze Boerstra, Giorgio Buonanno, Junji Cao, et al. 'A Paradigm Shift to Combat Indoor Respiratory Infection'. *Science* 372, no. 6543 (14 May 2021): 689–91.

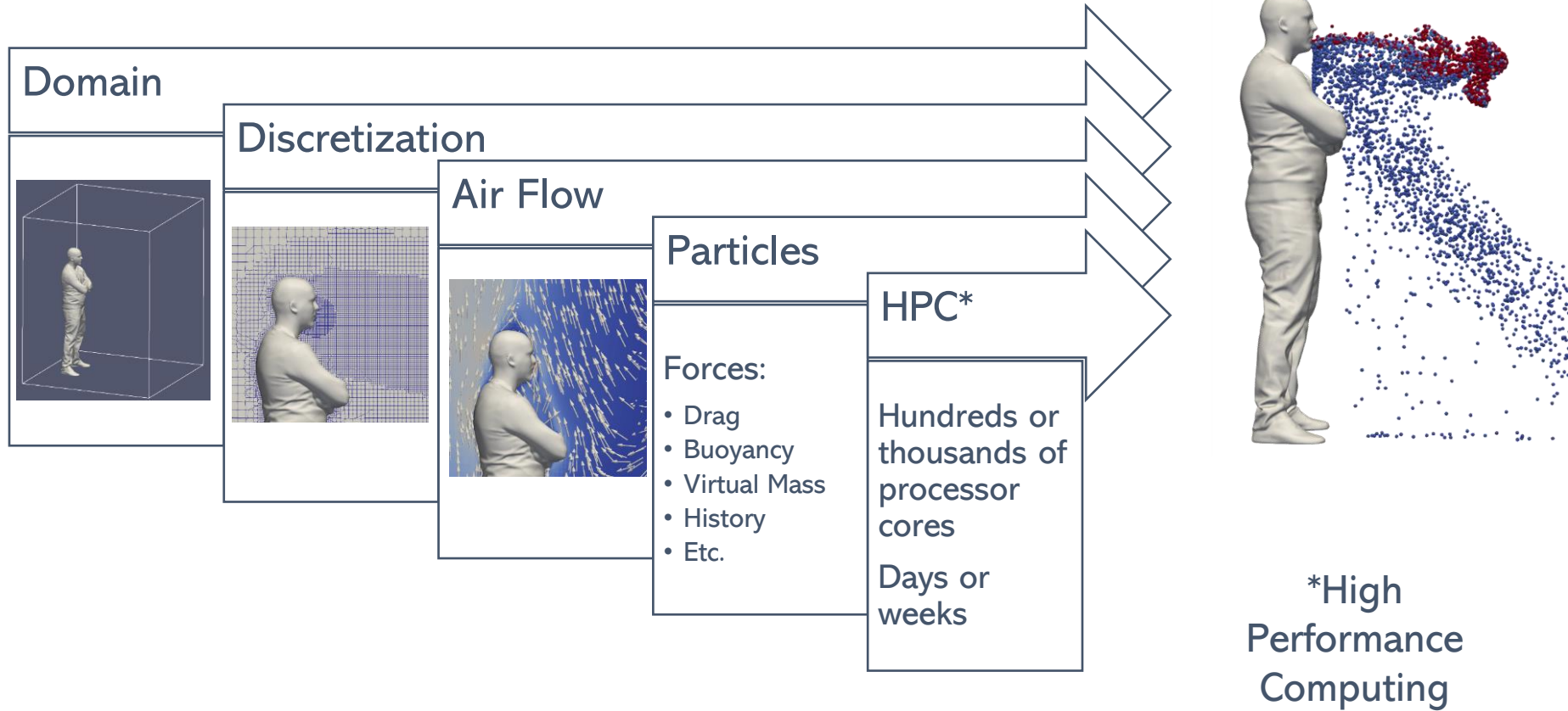
Computational Fluid Dynamics (CFD)

- Navier-Stokes equations:

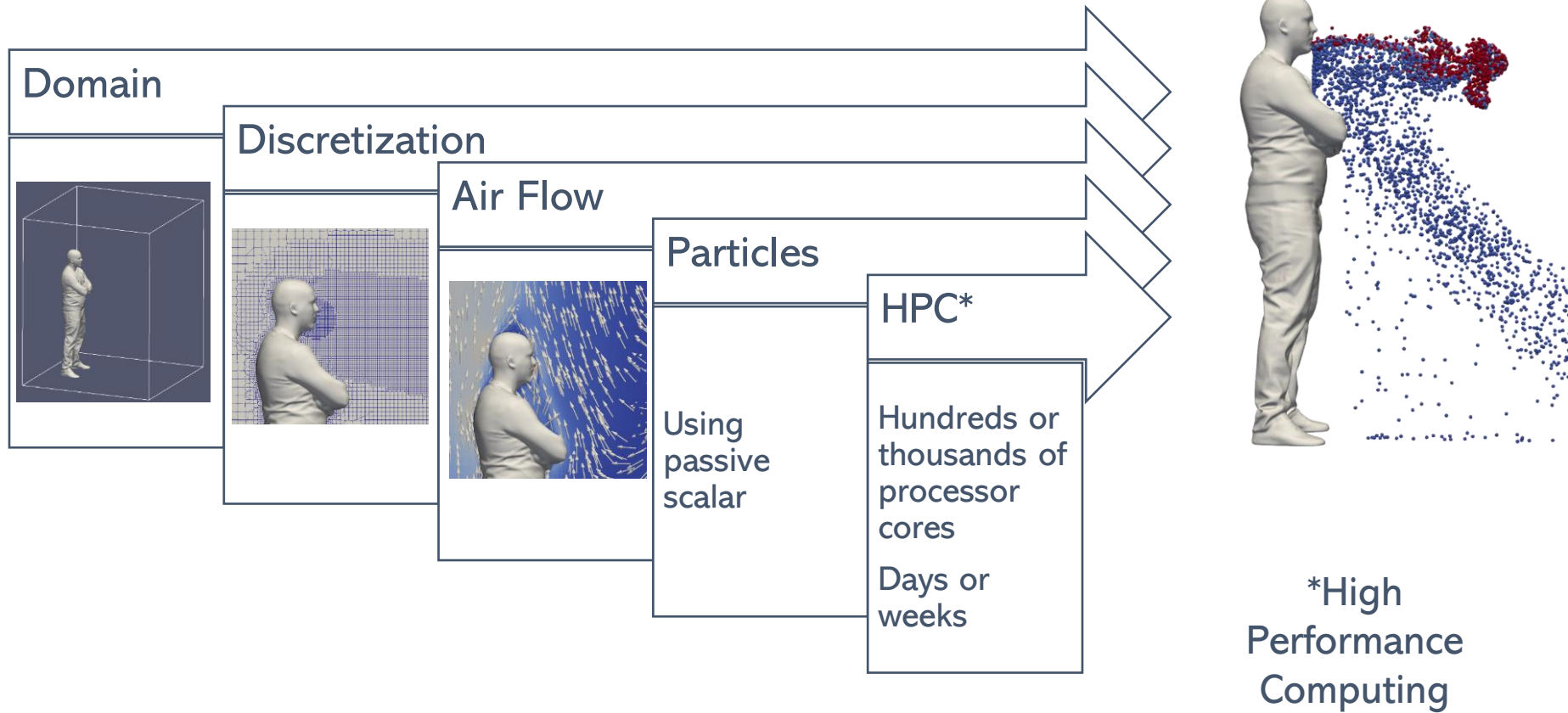
$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{u}) = 0$$

$$\frac{\partial}{\partial t}(\rho \mathbf{u}) + \nabla \cdot (\rho \mathbf{u} \otimes \mathbf{u}) = -\nabla p + \mu \nabla^2 \mathbf{u} + \frac{1}{3} \mu \nabla(\nabla \cdot \mathbf{u}) + \rho \mathbf{g}$$

Computational Fluid Dynamics (CFD)



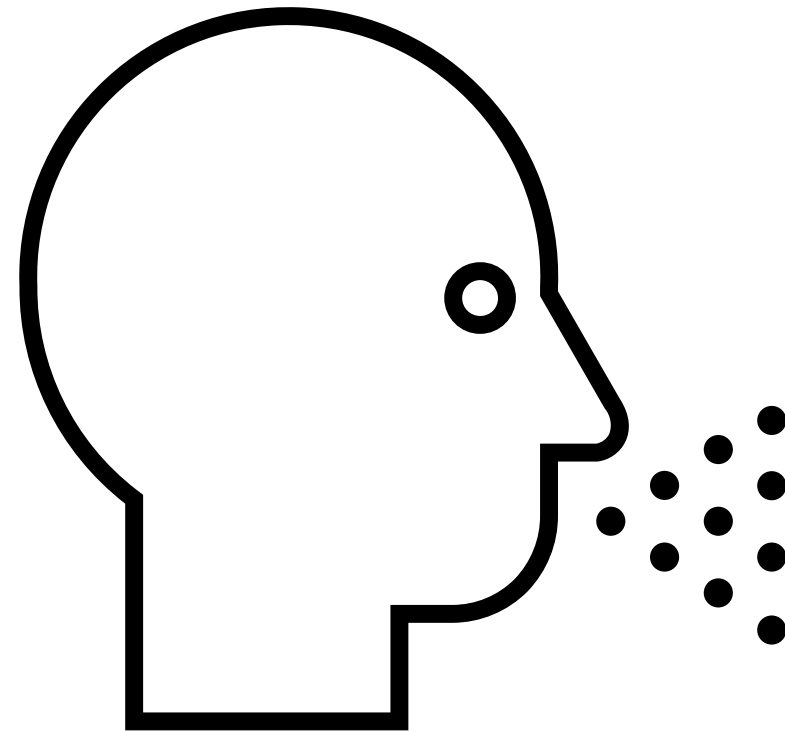
Computational Fluid Dynamics (CFD)

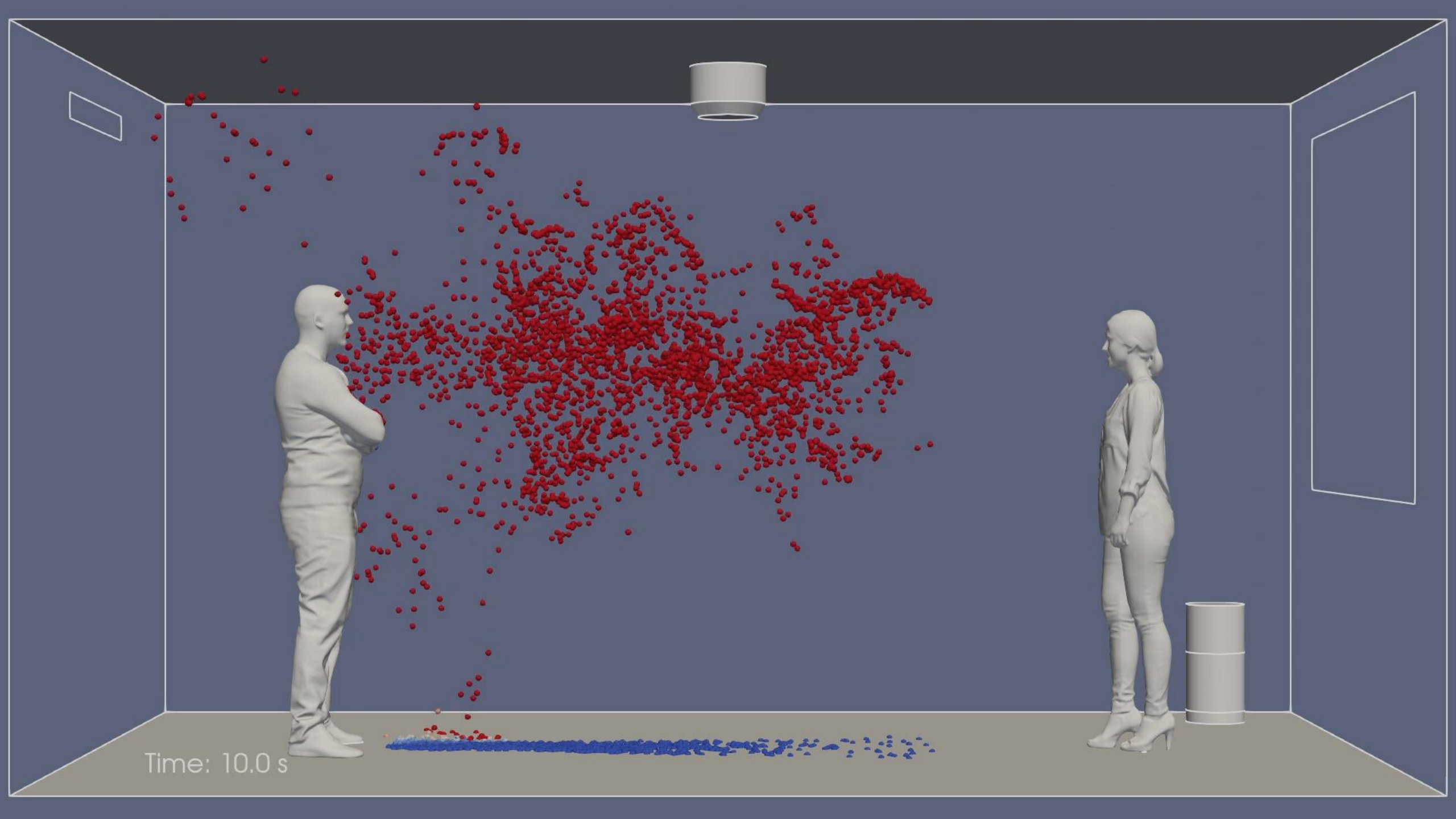


Examples



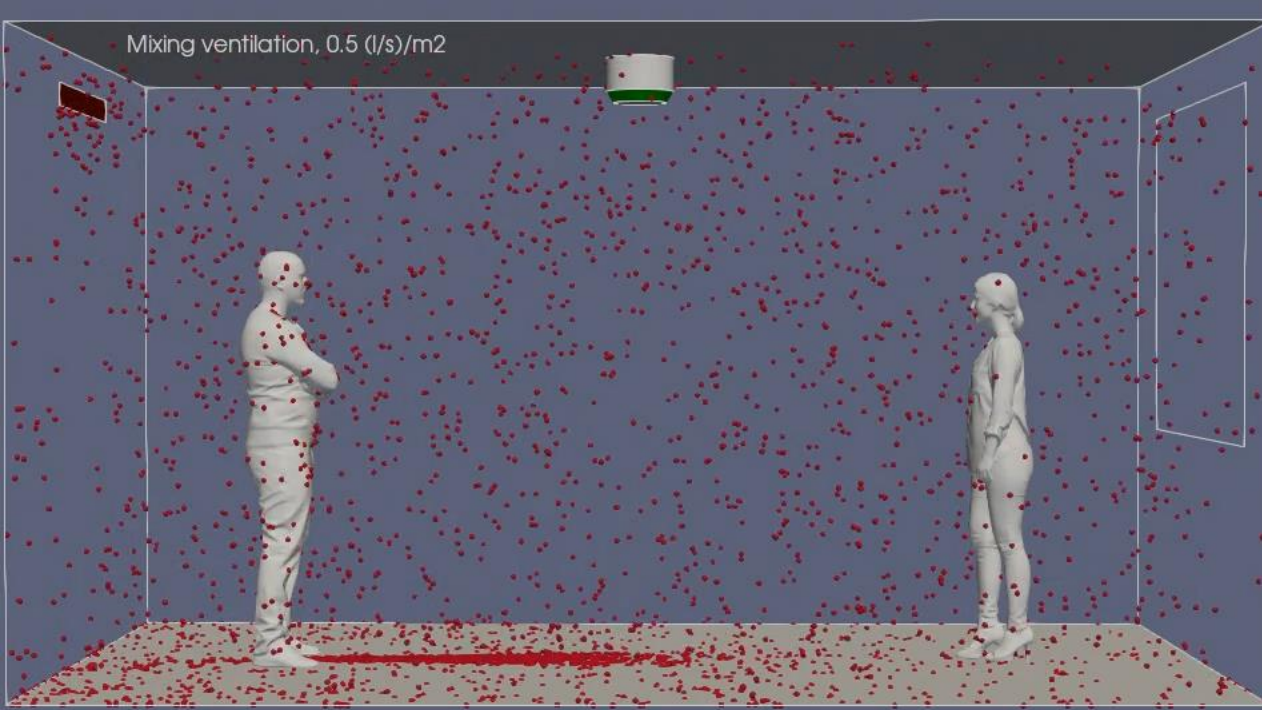
Coughing



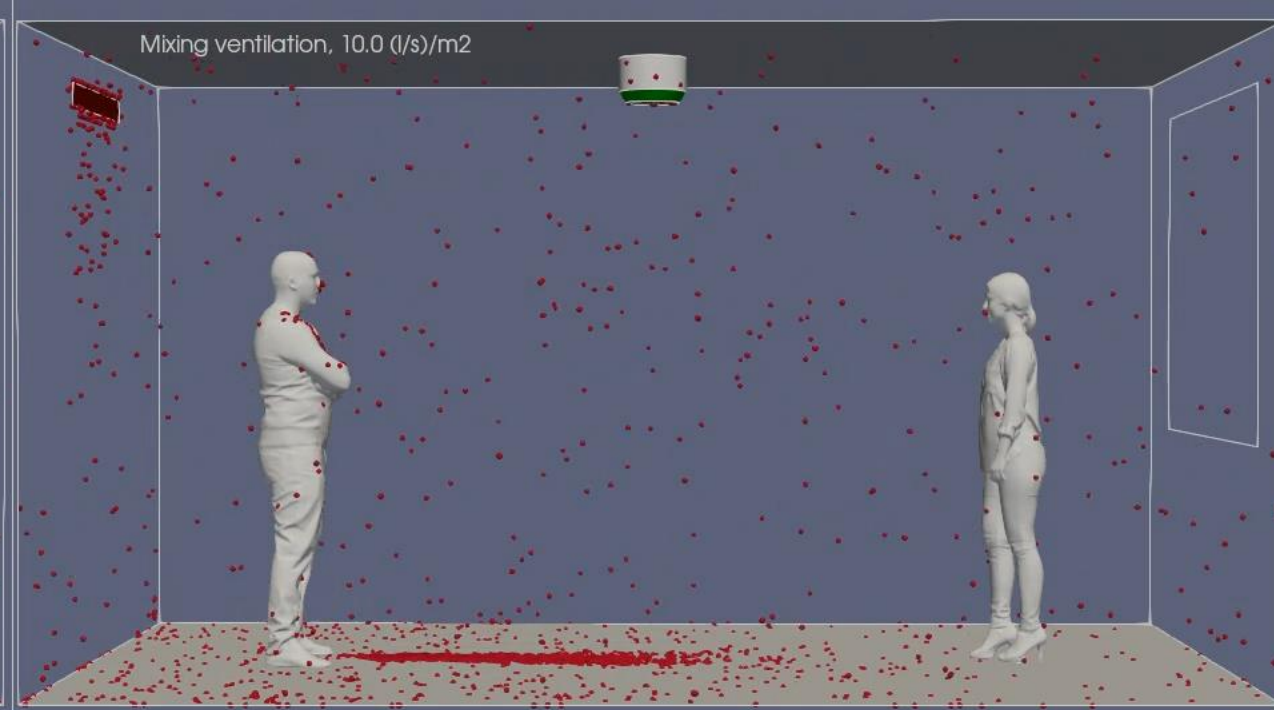


Time: 10.0 s

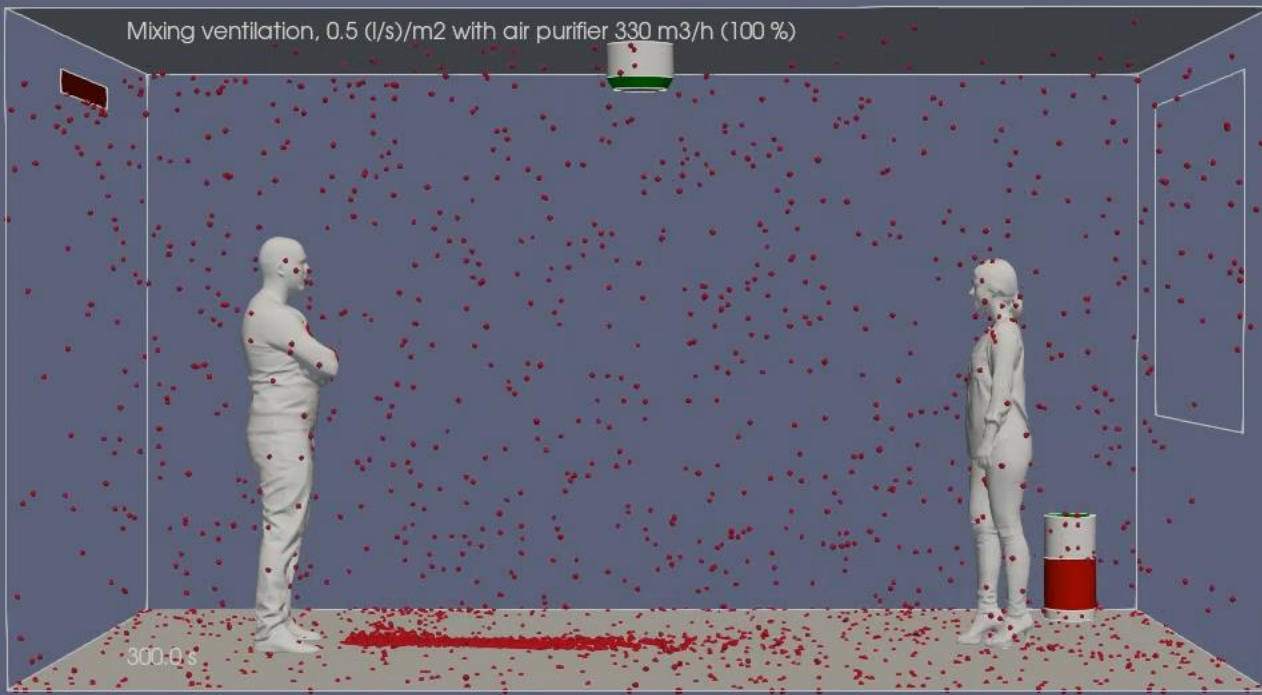
Mixing ventilation, 0.5 (l/s)/m²



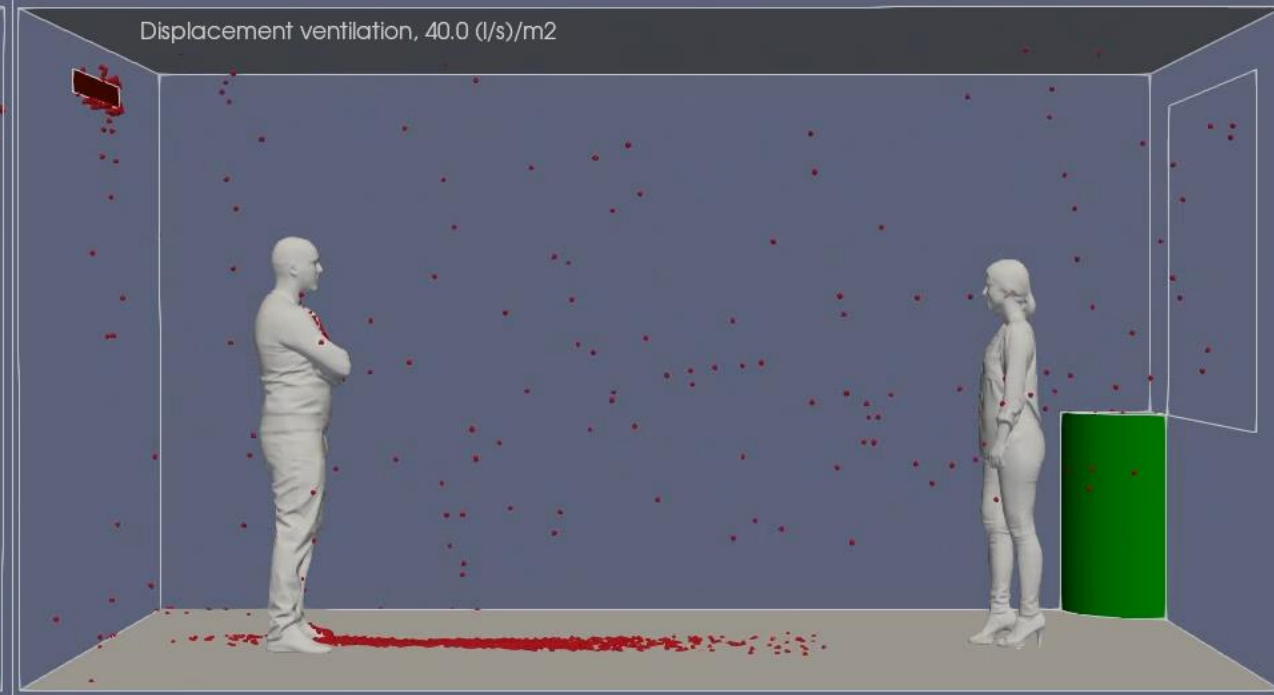
Mixing ventilation, 10.0 (l/s)/m²

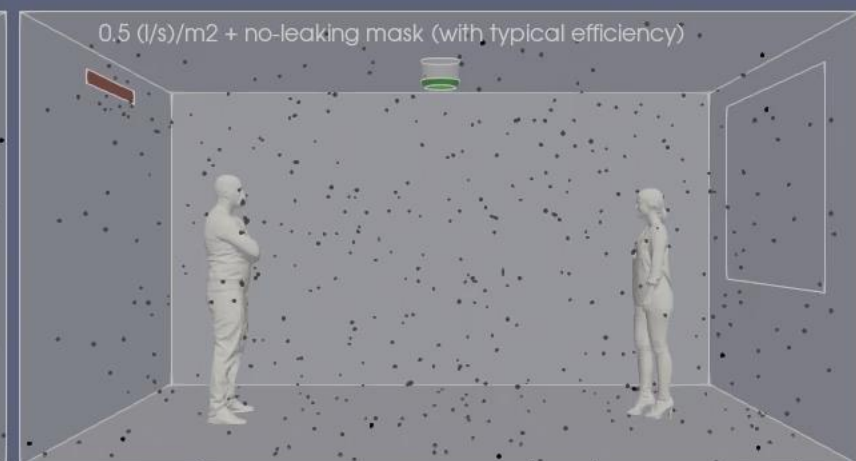
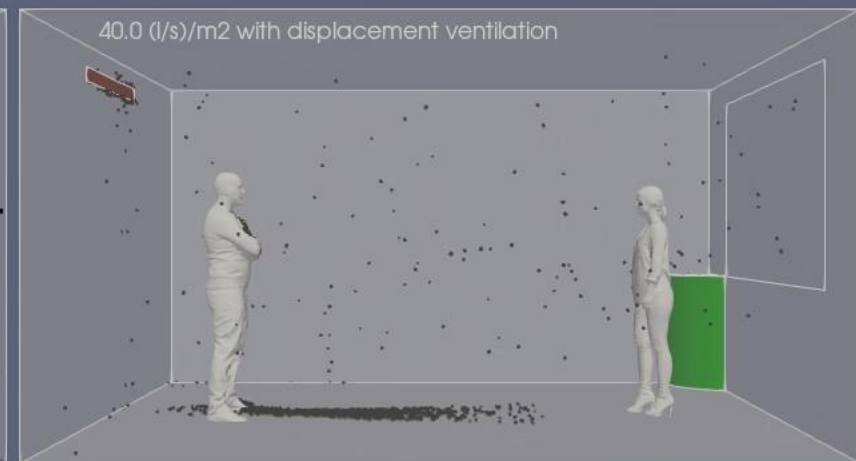
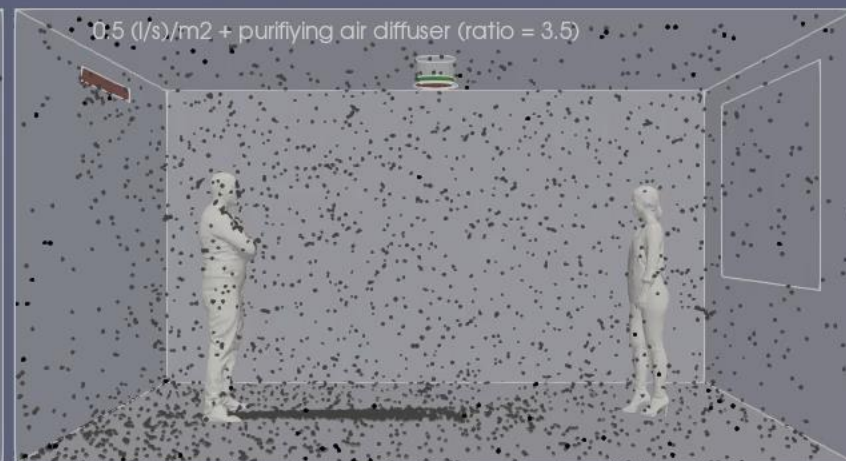
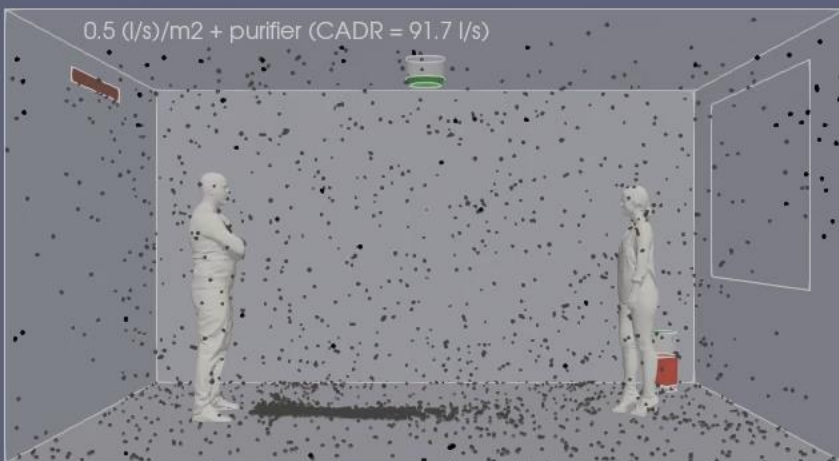
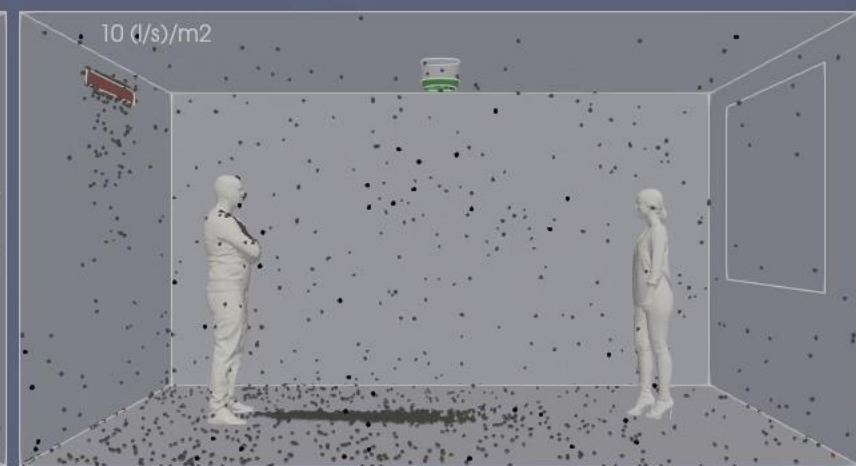
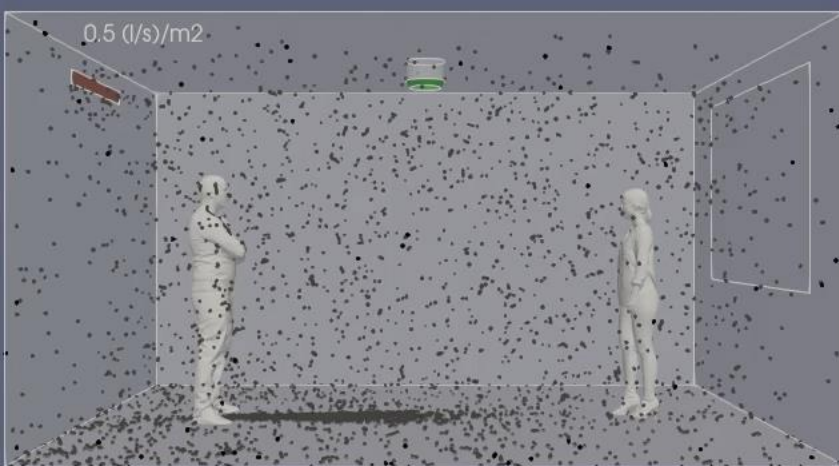


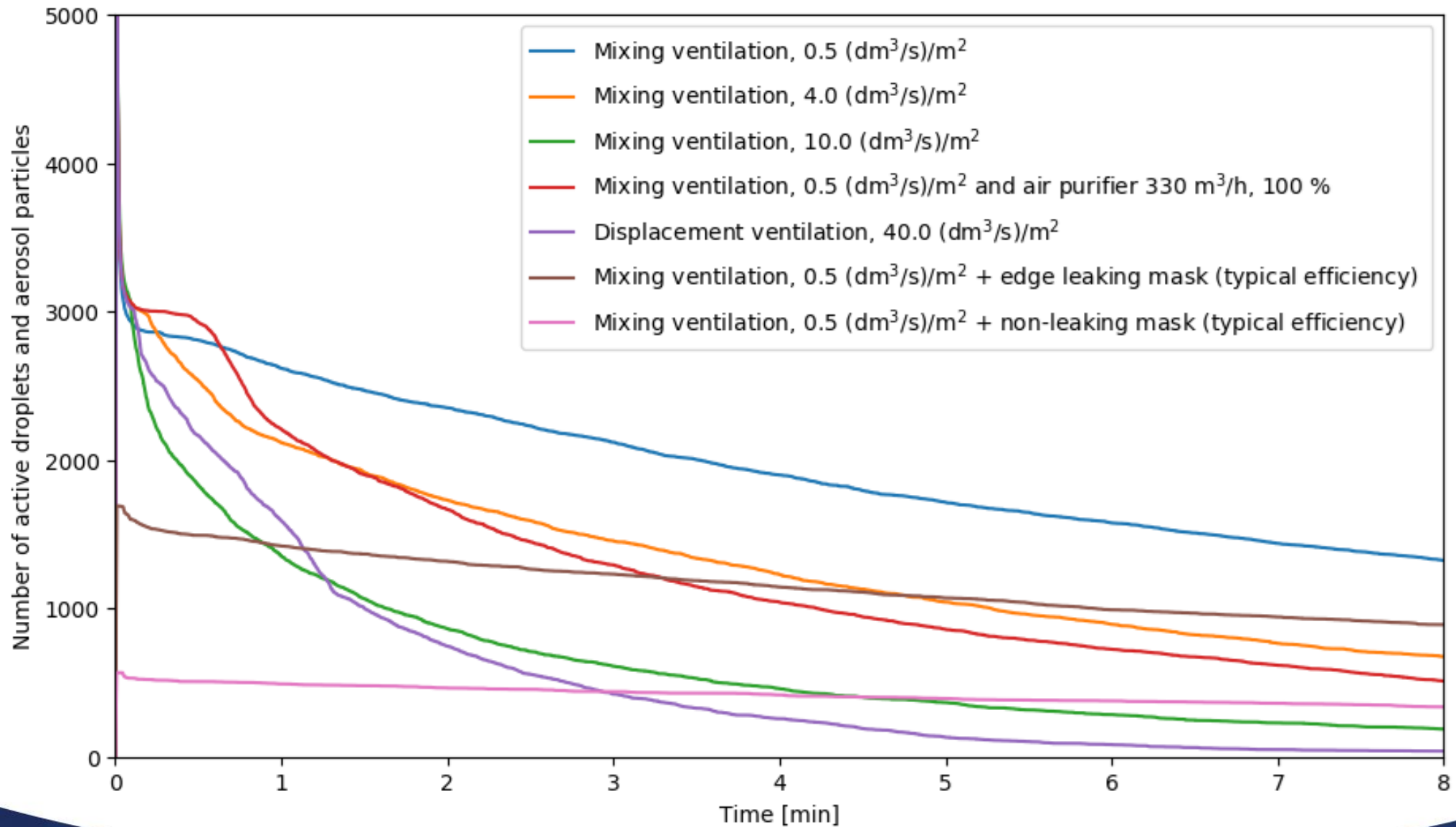
Mixing ventilation, 0.5 (l/s)/m² with air purifier 330 m³/h (100 %)



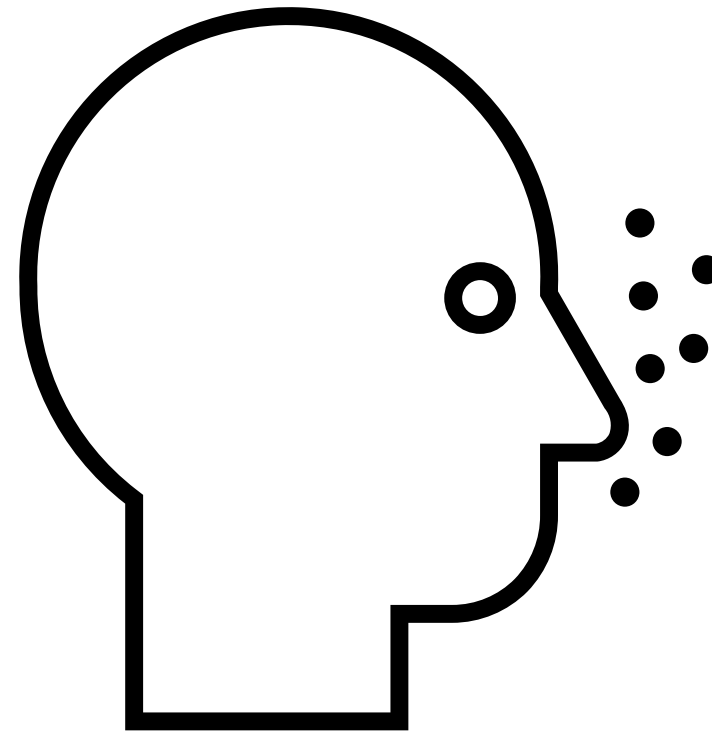
Displacement ventilation, 40.0 (l/s)/m²

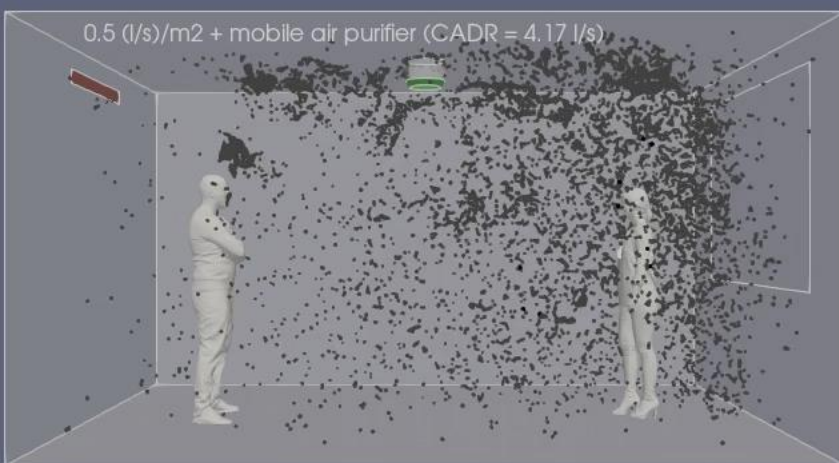
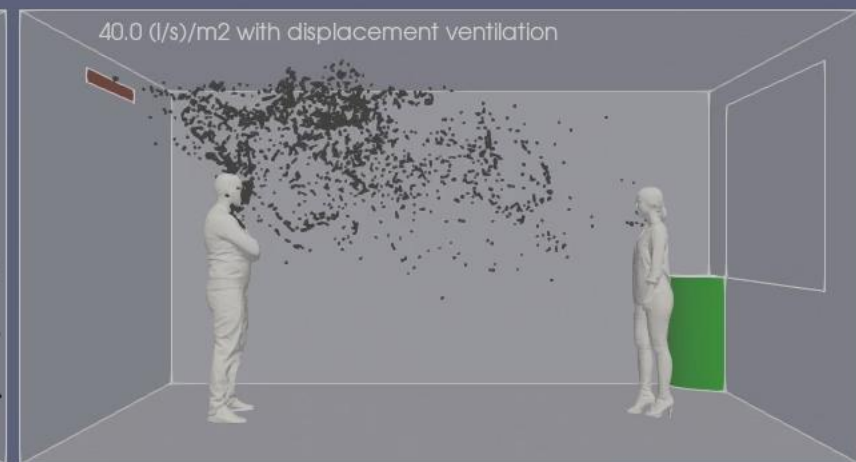
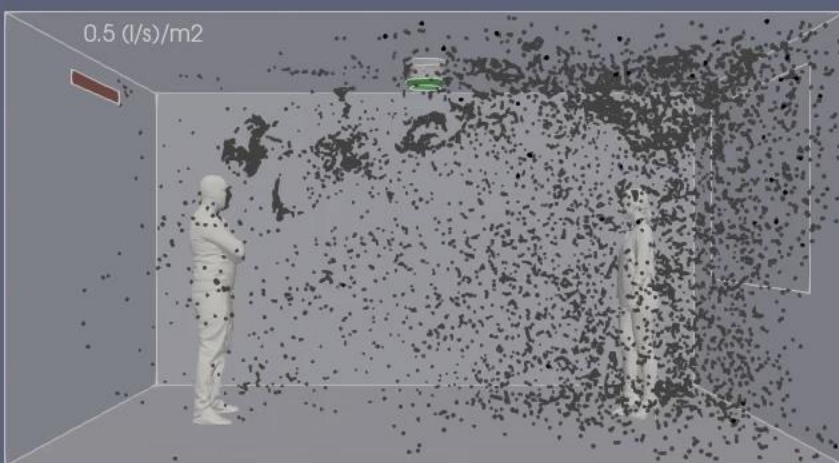






Breathing





Time: 60.0 s

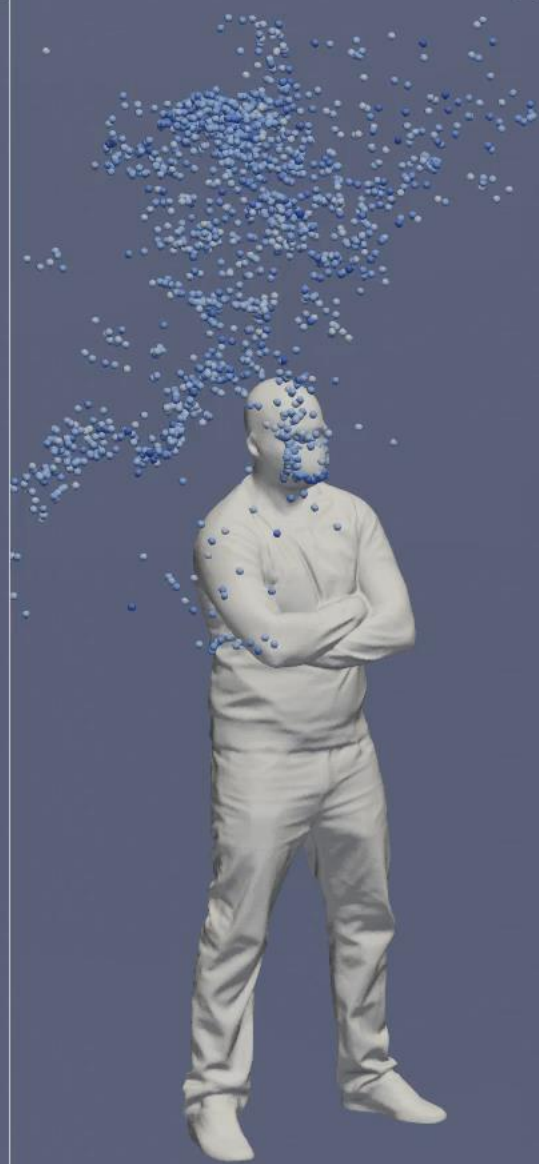
Masks



Without mask



With leaking mask

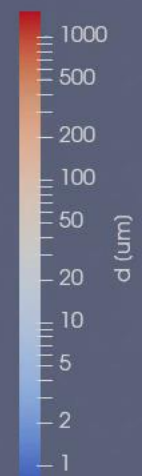


With no-leaking mask



Time: 10.00 s

Masks with typical efficiency



Pandemic Safe Office



Traditional ventilation

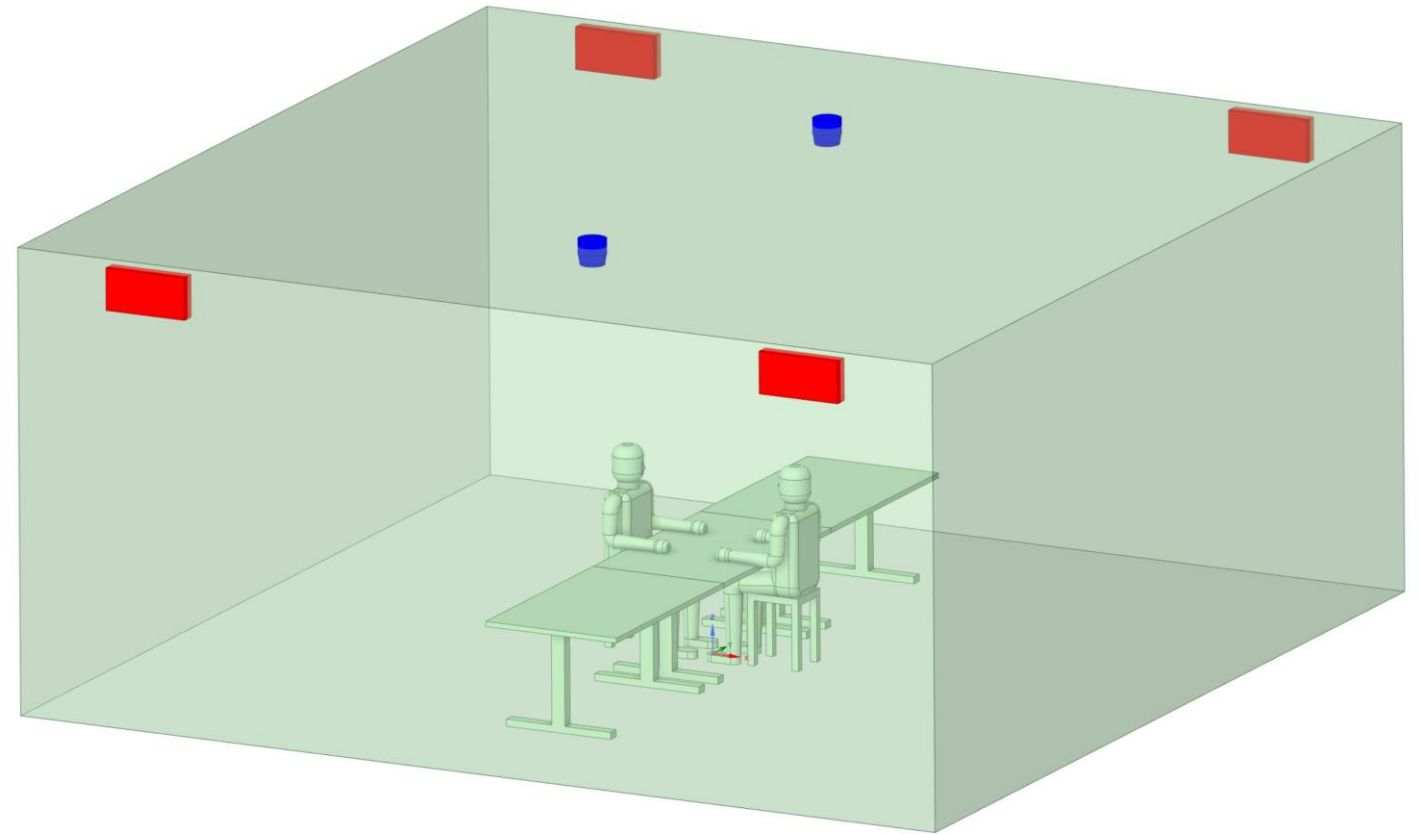


Pandemic safe ventilation



30.00 s

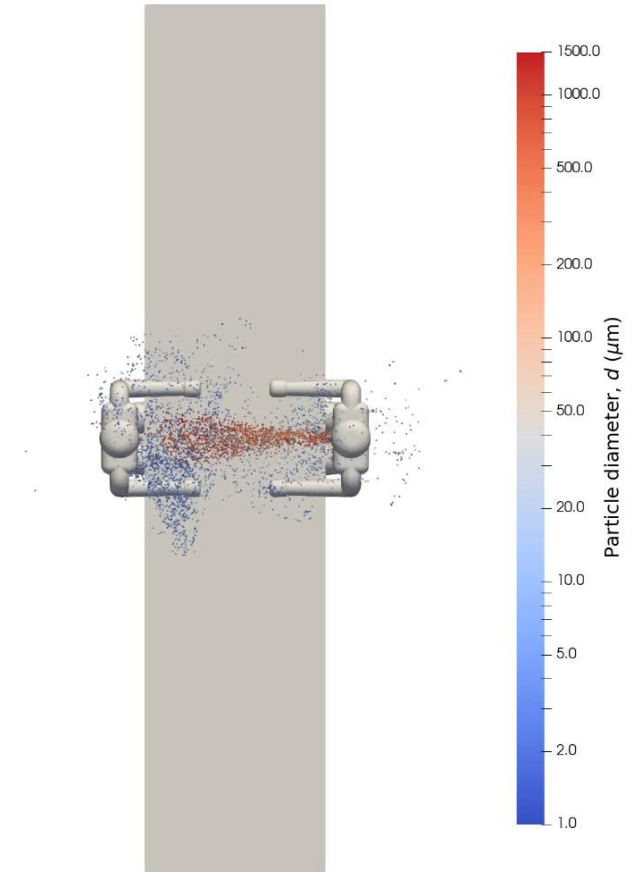
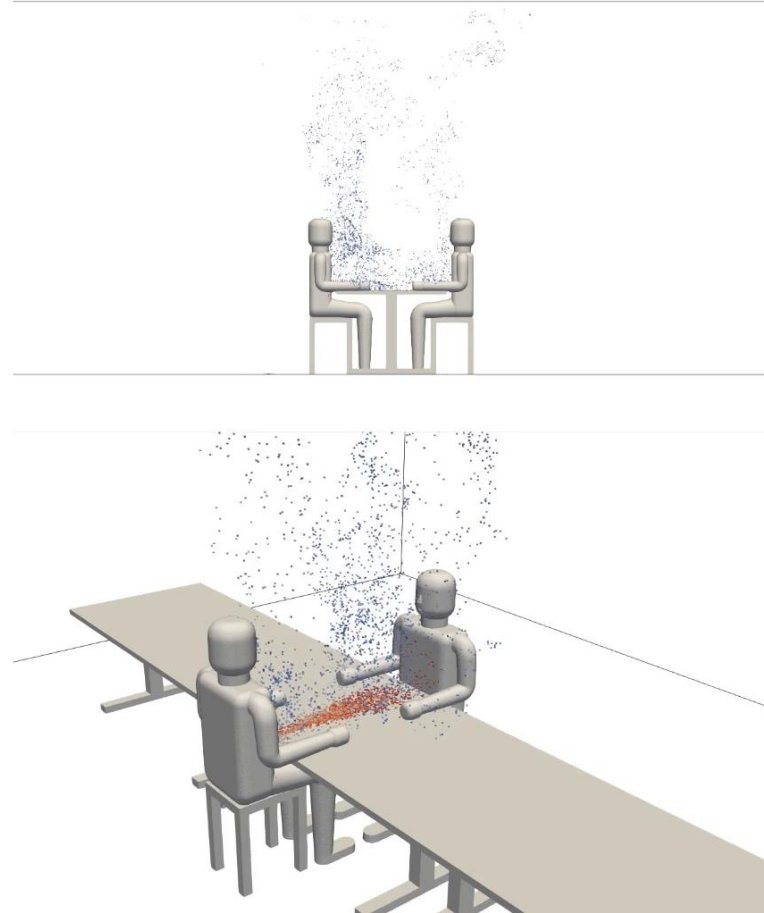
Low Plexiglass in the Control of Droplet Infection



Niko Siilin, VTT

Without plexiglass

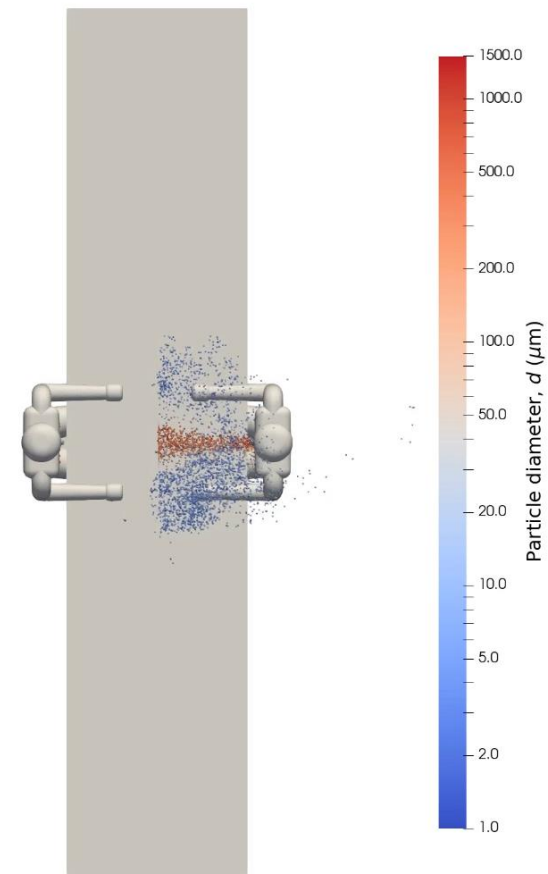
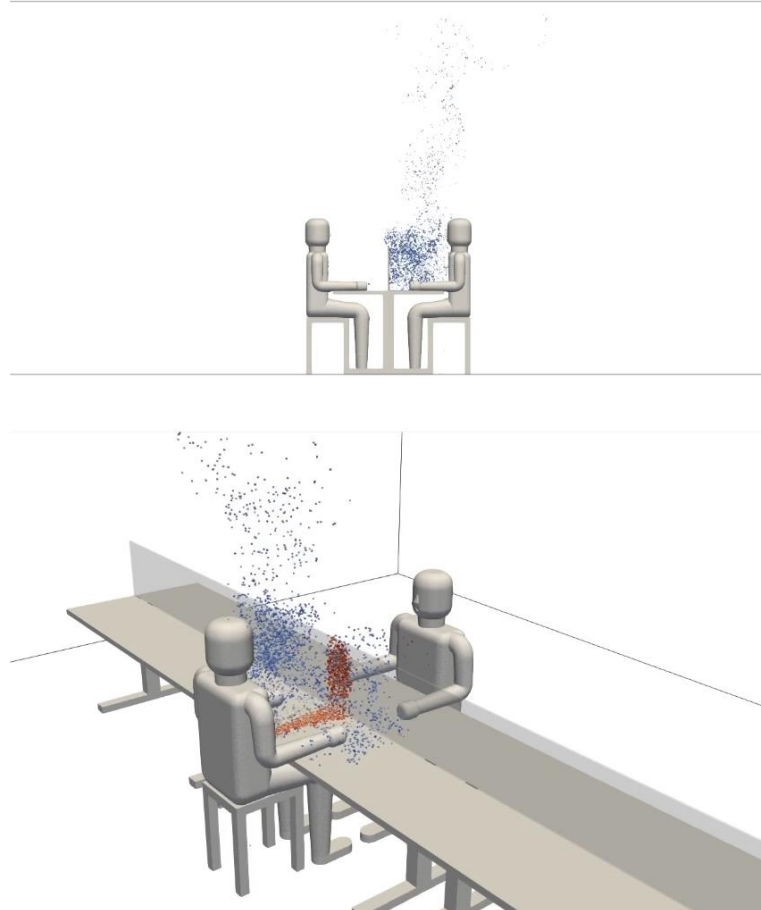
Time: 10.00 s



Niko Siilin, VTT

With plexiglass

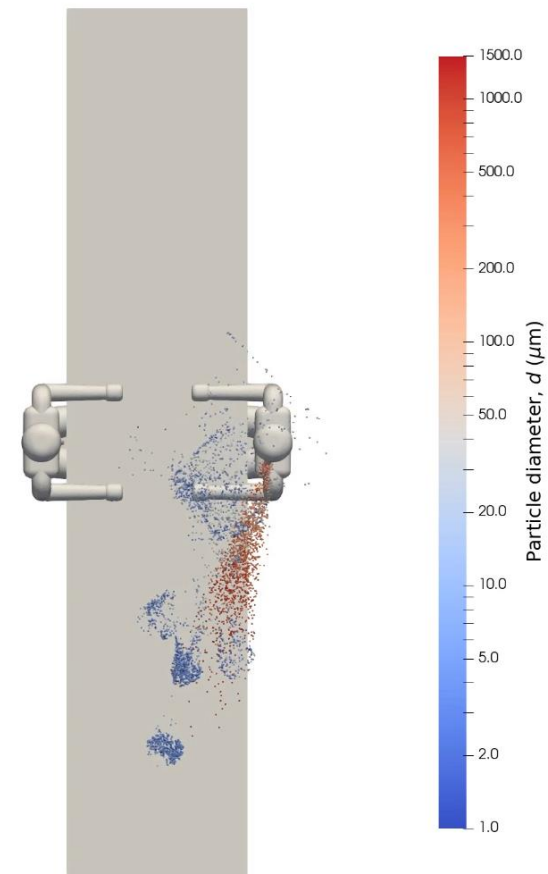
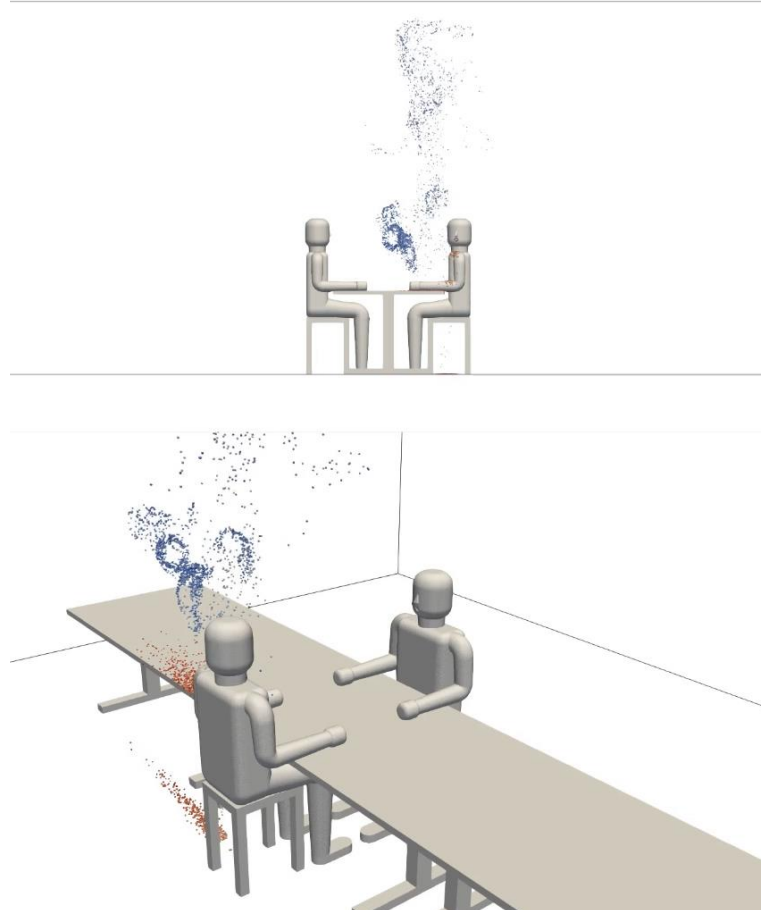
Time: 10.00 s



Niko Siilin, VTT

Coughing Aside

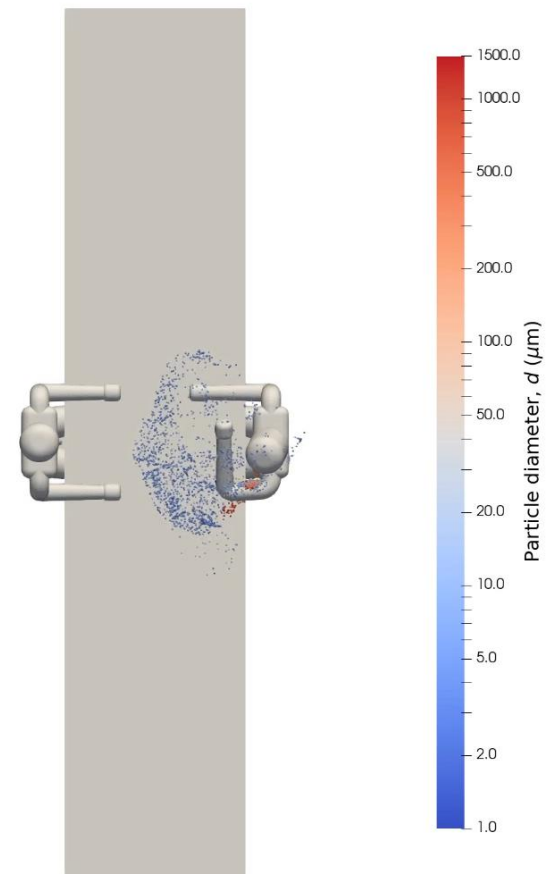
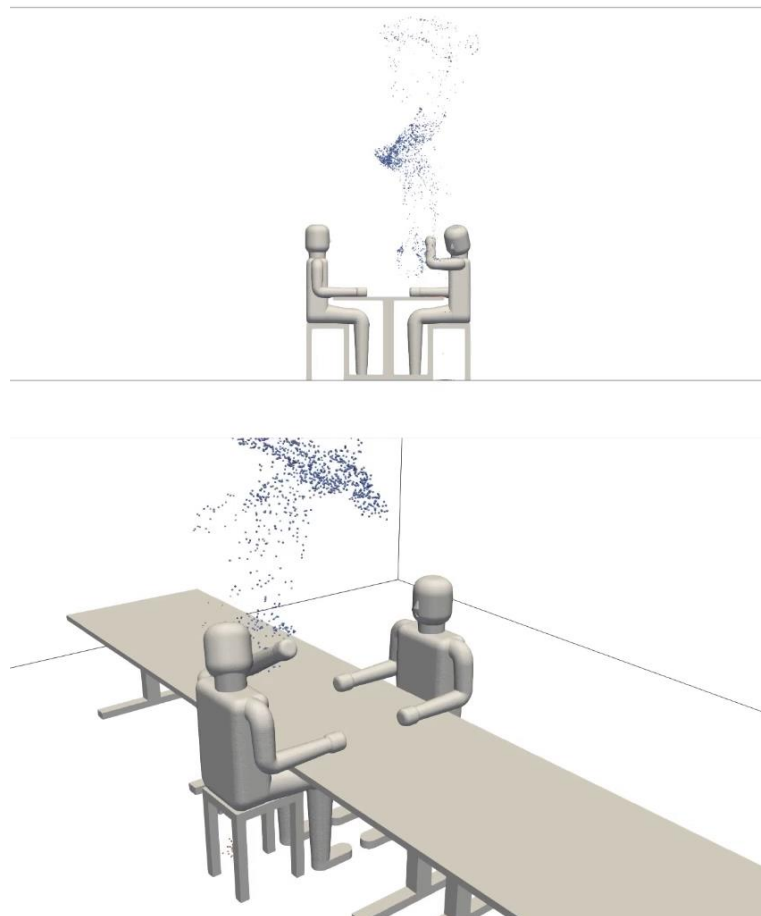
Time: 10.00 s



Niko Siilin, VTT

Coughing into the Sleeve

Time: 10.00 s



Niko Siilin, VTT

Dissemination



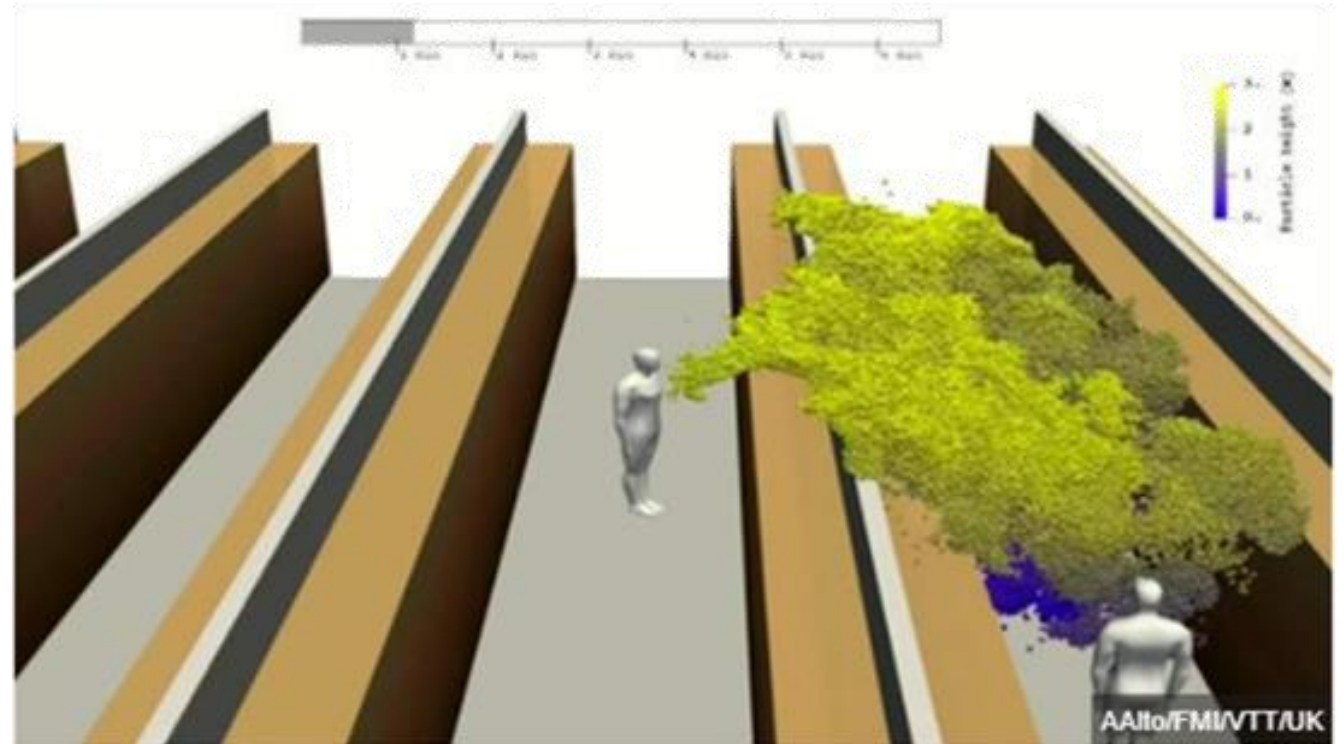
Dissemination

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Dissemination



Future applications

- More ventilation (in sustainable way)
- More efficient air distribution (without increasing ventilation)
- Personal ventilation
- Novel innovations

CFD can be used to combat pandemics

1

By raising public awareness of how the virus is spreading

2

By developing better technical control methods

Thank you!