Modeling airborne pathogen dispersion under different indoor ventilation conditions

Lessons from Matei Bals –case study

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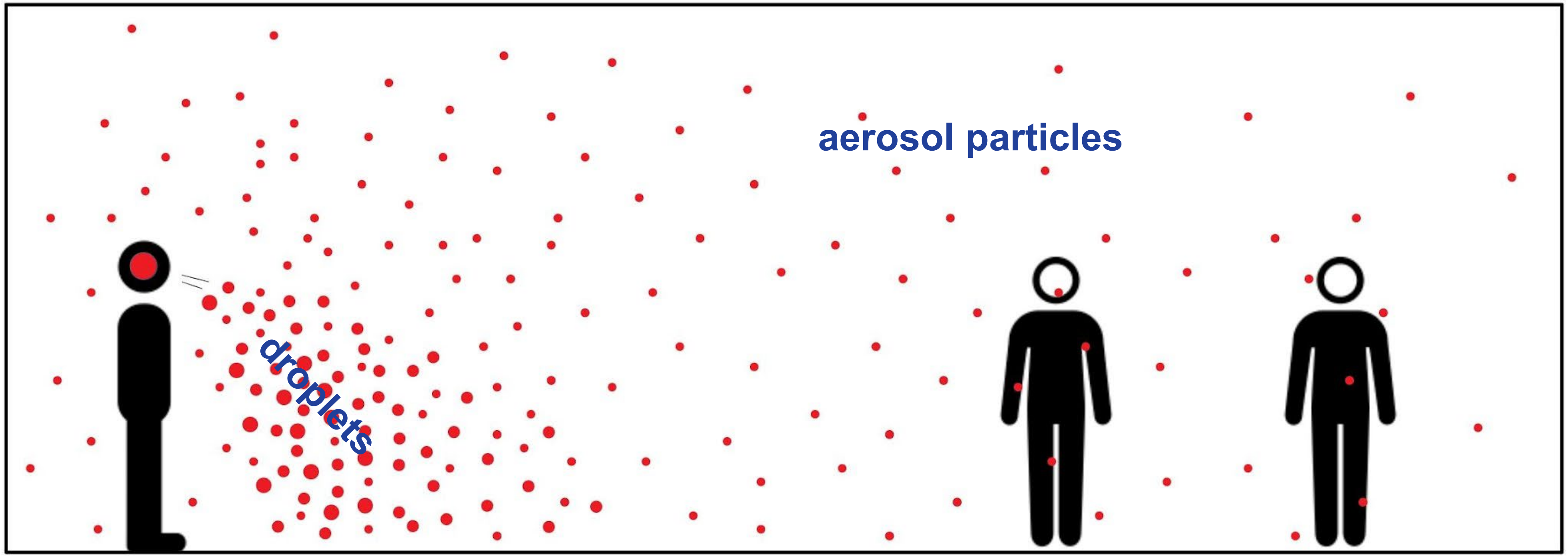
Introduction

Context: Indoor air hygiene & respiratory pathogen dispersion



Aerosol or droplet?

“Droplet drop” - ballistic, follow trajectory, settle quickly
“Aerosols can be inhaled” - follow air flows, float, remain in air longer, can travel long distances, **near and far**

Introduction

Pathogen dispersion indoors … steps towards modeling

I. We have established how pathogen carrying aerosols become airborne

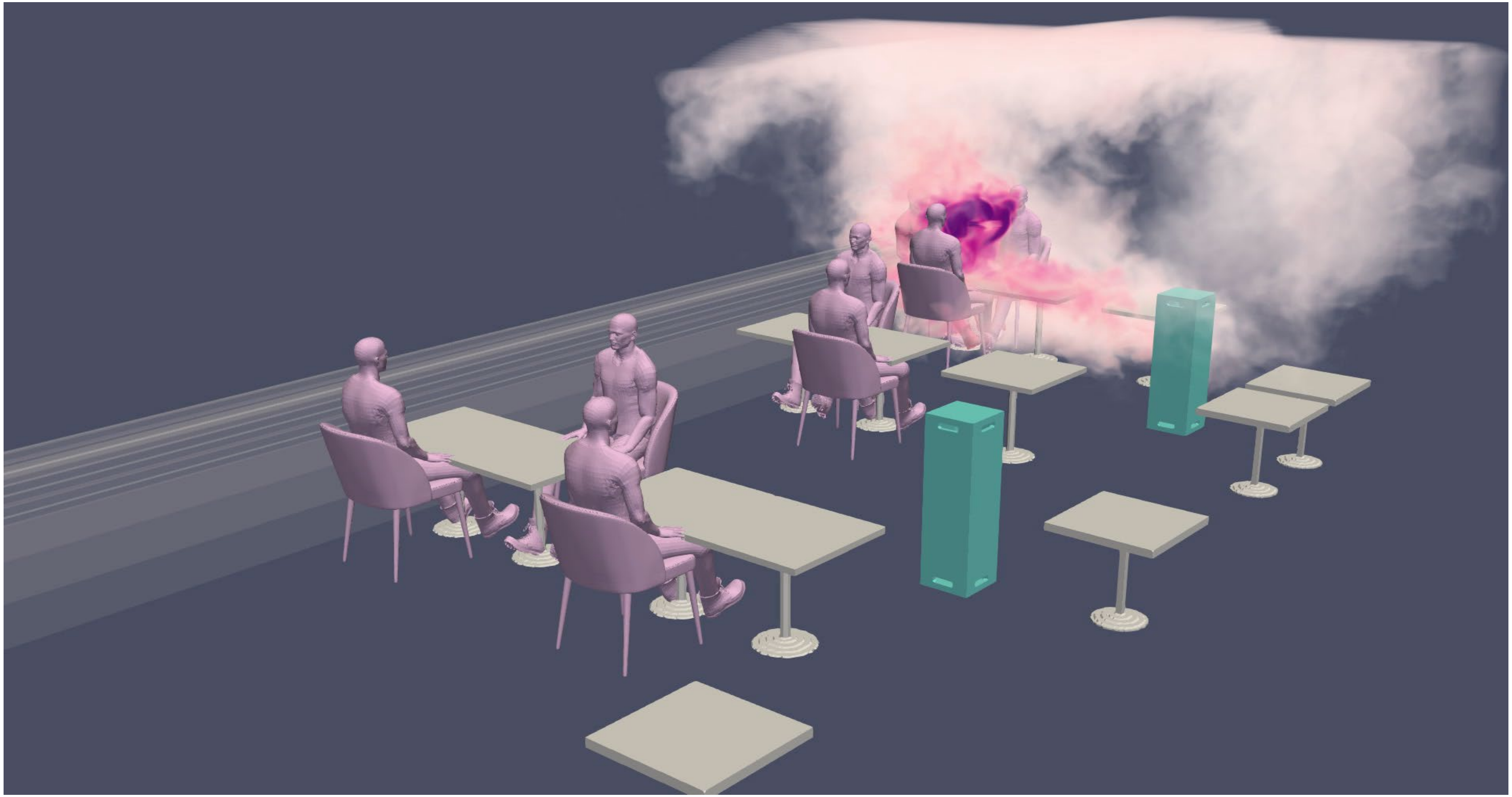
II. The next step in understanding airborne transmission mode relates to the *evolution* of the resulting aerosol cloud and possible exposure to it

III. This evolution is dictated by the surrounding air movement … which is driven by the indoor ventilation system and thermal differences

IV. Hence, airborne transmission of pathogens becomes a problem of **aerosol dispersion by indoor turbulence**

Introduction

Aerosol dispersion indoors

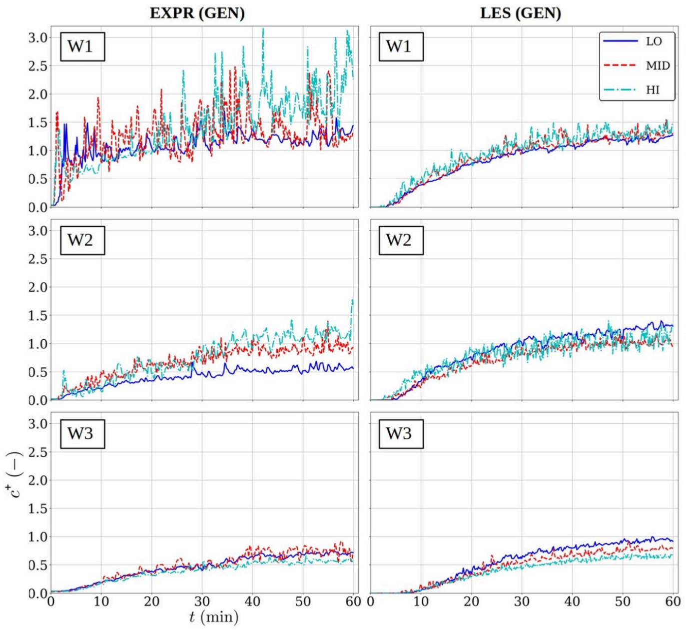


Numerical modeling: *PALM LES Solver*

Does the model capture the relevant phenomena?

Pre- E3 validation campaign

Physics of Fluids ARTICLE scitation.org/journal/phf



W1	RNMSE	FB	R
LO	0.40	-0.28	0.70
MID	0.51	-0.35	0.56
HI	0.51	-0.40	0.79

W2	RNMSE	FB	R
LO	0.89	0.71	0.96
MID	0.17	0.04	0.95
HI	0.25	0.05	0.87

W3	RNMSE	FB	R
LO	0.33	0.18	0.98
MID	0.22	-0.03	0.94
HI	0.18	0.02	0.98

Color map for evaluation metrics

RNMSE	|FB|	R
0.0*	0.0*	1.0*
[0.0, 0.6)	[0.0, 0.15)	[1.0, 0.9)
[0.6, 1.2)	[0.15, 0.3)	[0.9, 0.8)
≥ 1.2	≥ 0.3	≤ 0.8

Ideal: *

FIG. 8. Comparison of measured (left) and modeled (middle) normalized concentration time series in the window-side mast row without the air purifiers (GEN) and tabulated evaluation metrics (right) with color coding. The color coding and the acceptance criteria are tabulated on the lower right corner.

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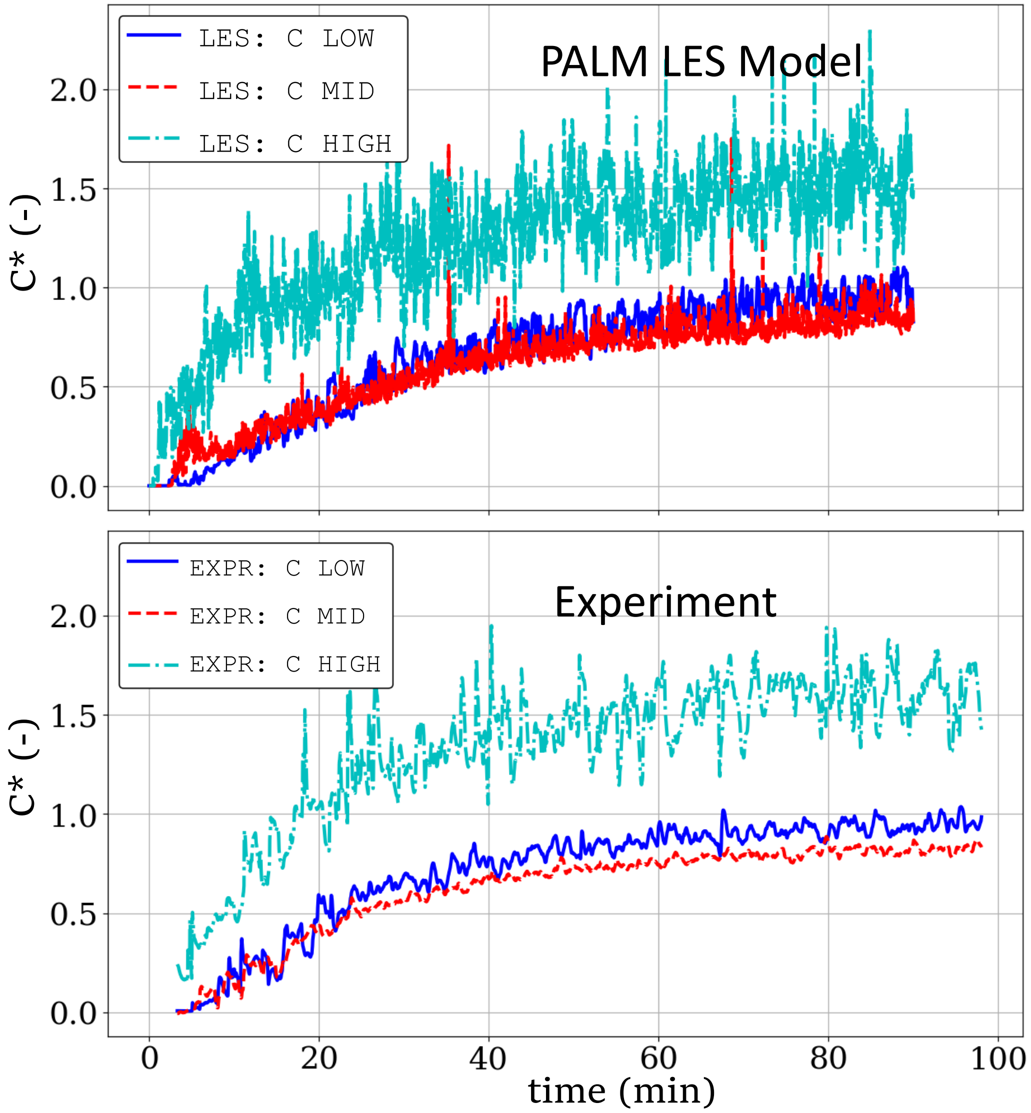
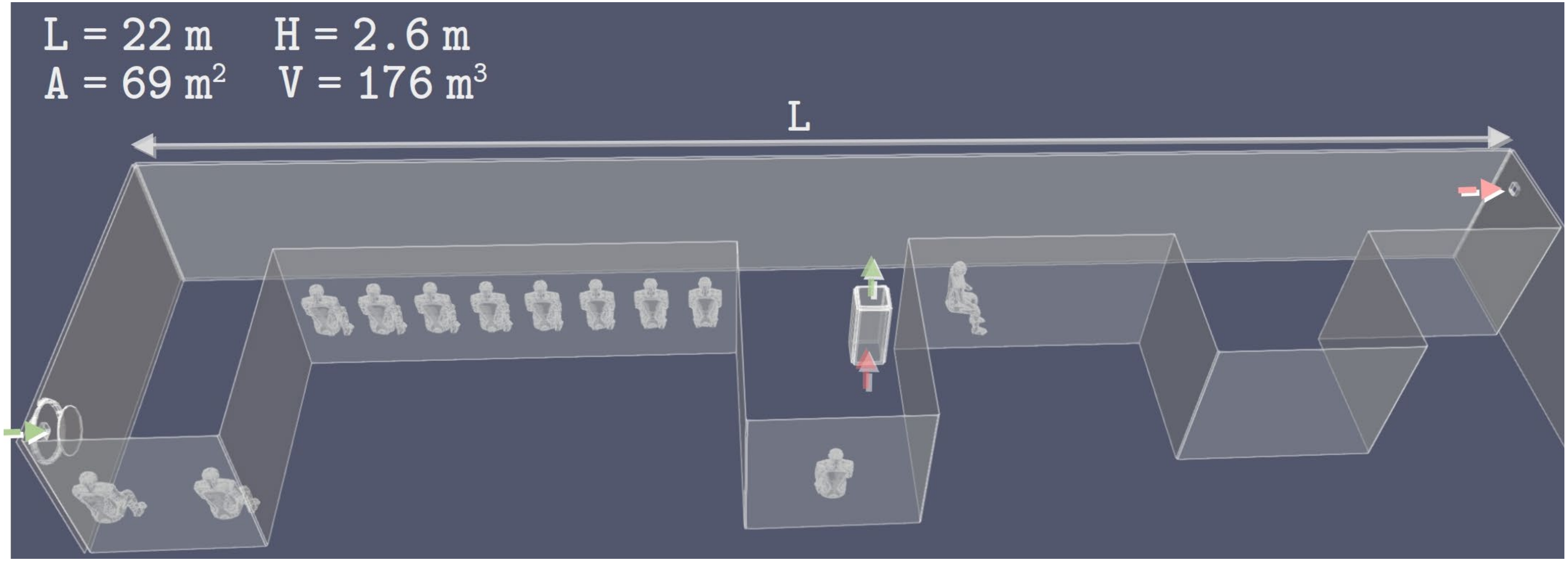
E3 VTT validation campaign



Numerical modeling

CASE STUDY: *MATEI BALS -hospital waiting lobby*



The actual waiting lobby doesn't have proper ventilation

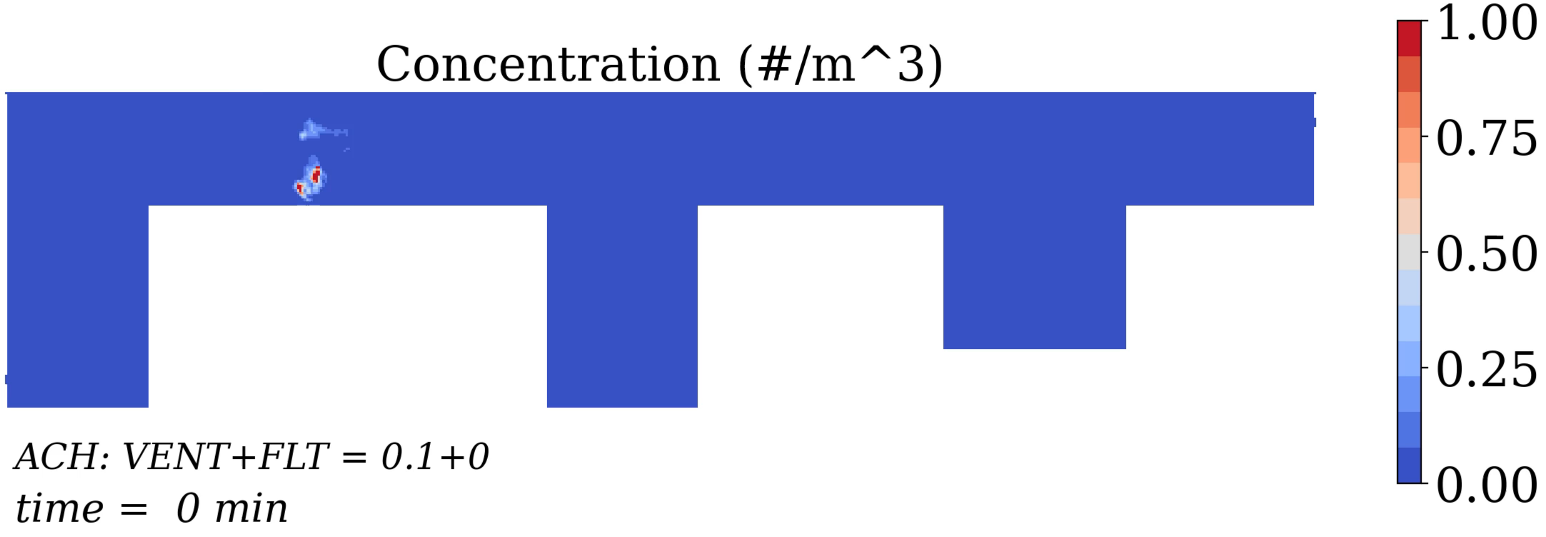
- The model is fitted with a conventional ventilation system to facilitate a more meaningful study
- At current stage, one air purifier is operational on site

Numerical modeling

CASE STUDY: *MATEI BALS -hospital waiting lobby*

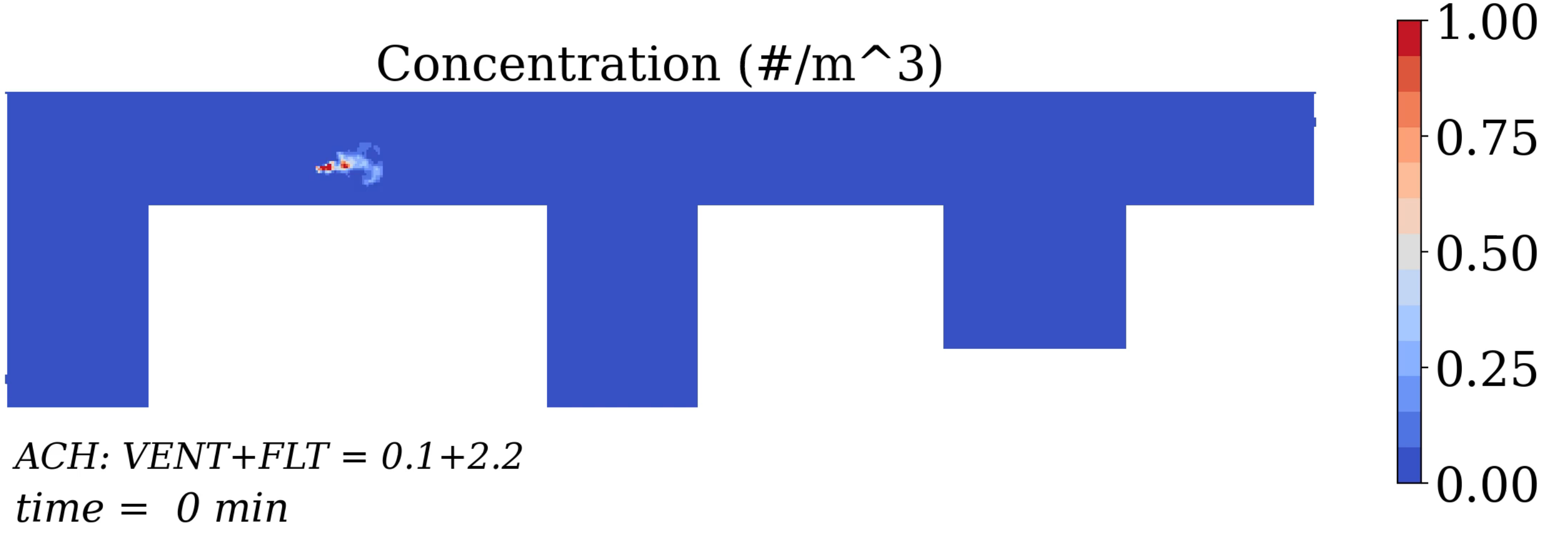
CASE 1:

Reference
(CADR=0.1)



vs.

Ref. + Air Purifier 80%
(CADR=2.3)

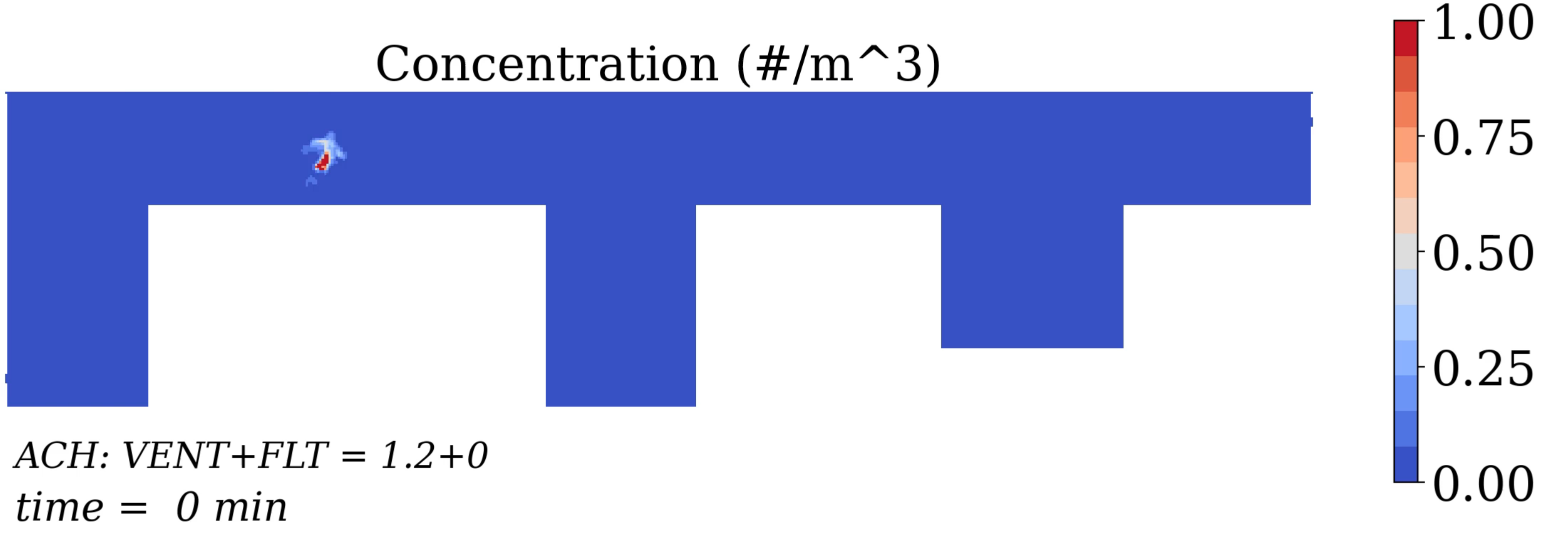


Numerical modeling

CASE STUDY: *MATEI BALS -hospital waiting lobby*

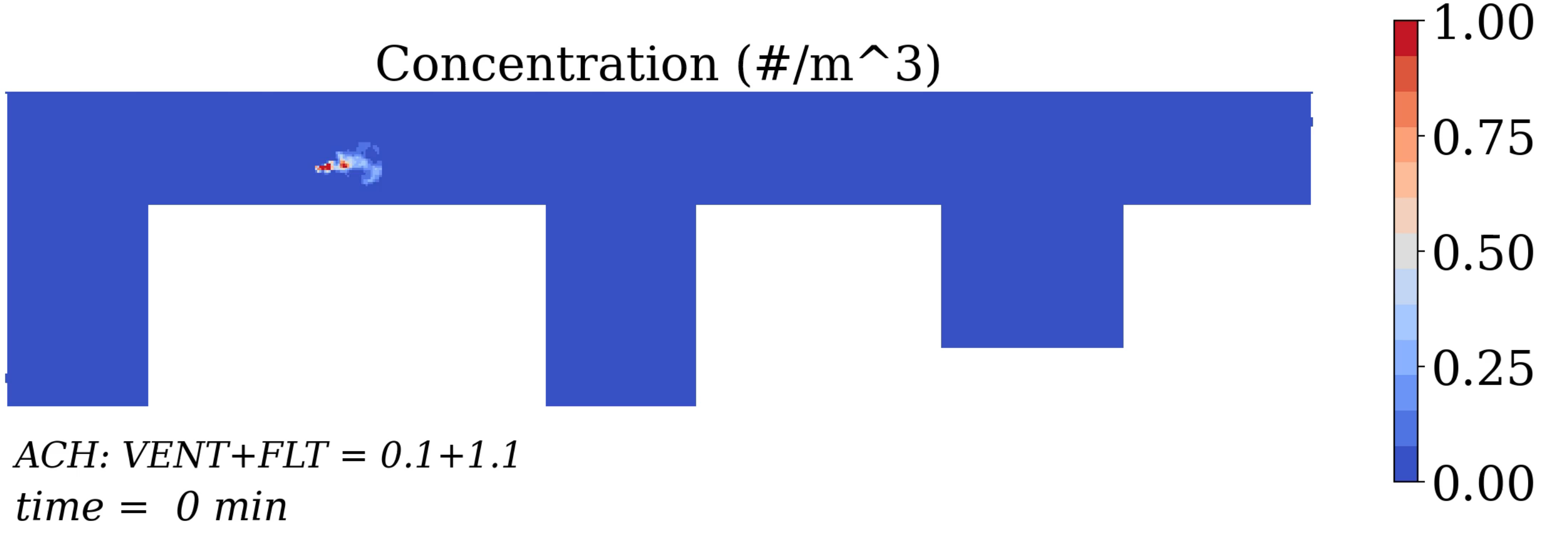
CASE 2: *Same CADR!

Basic ventilation
(CADR=1.2)*



vs.

Ref. + Air Purifier 40%
(CADR=1.2)*

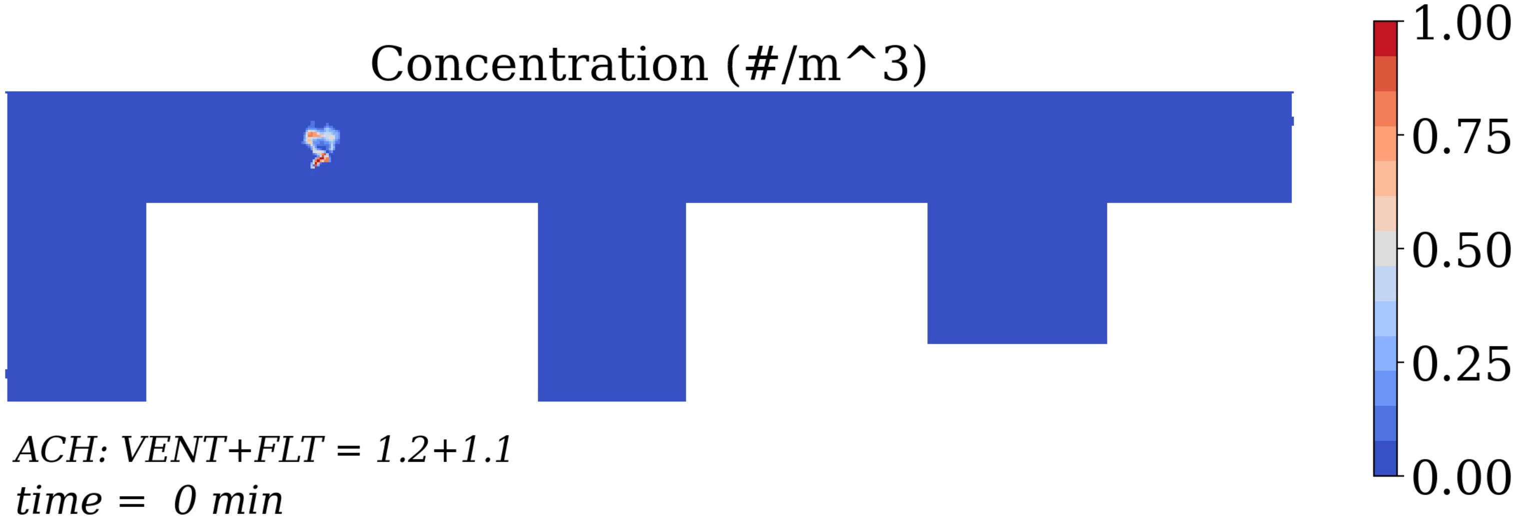


Numerical modeling

CASE STUDY: *MATEI BALS -hospital waiting lobby*

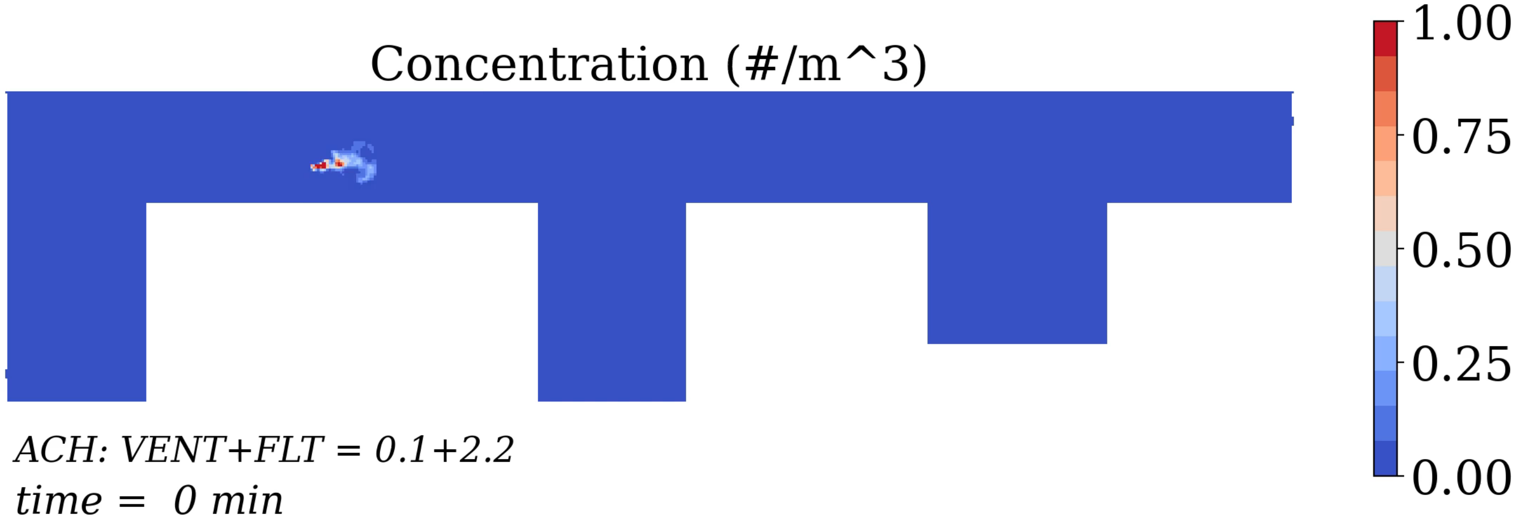
CASE 3: *Same CADR!

Basic + Air Purifier 40%
(CADR=2.3)*



vs.

Ref. + Air Purifier 80%
(CADR=2.3)*



Conclusions

High-resolution LES modeling, although expensive, has potential to

1. Identify and quantify generalizable mechanisms which improve indoor air hygiene
2. Reveal problematic configurations and examine the *robustness* of proposed solutions

The Matei Bals –case study:

1. Revealed that *a long, corridor type space* may require multiple air purifier units
2. Highlighted the importance of designing air purification solutions to work together with the existing ventilation system

Thank you!

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EXCELLENCE IN PANDEMIC RESPONSE AND ENTERPRISE SOLUTIONS