



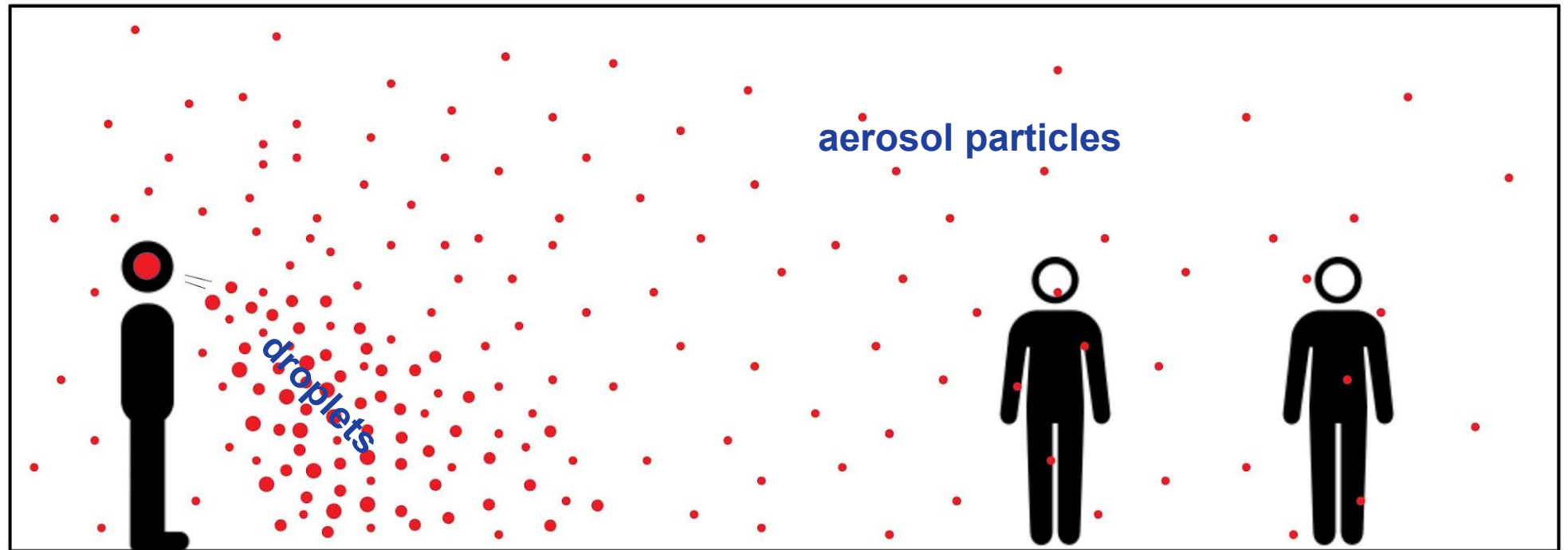
Modelling indoor turbulence to understand airborne transmission of pathogens

Results from the E3 -project

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Ilmatieteen laitos*

Introduction

Context: Indoor air hygiene & respiratory pathogen dispersion



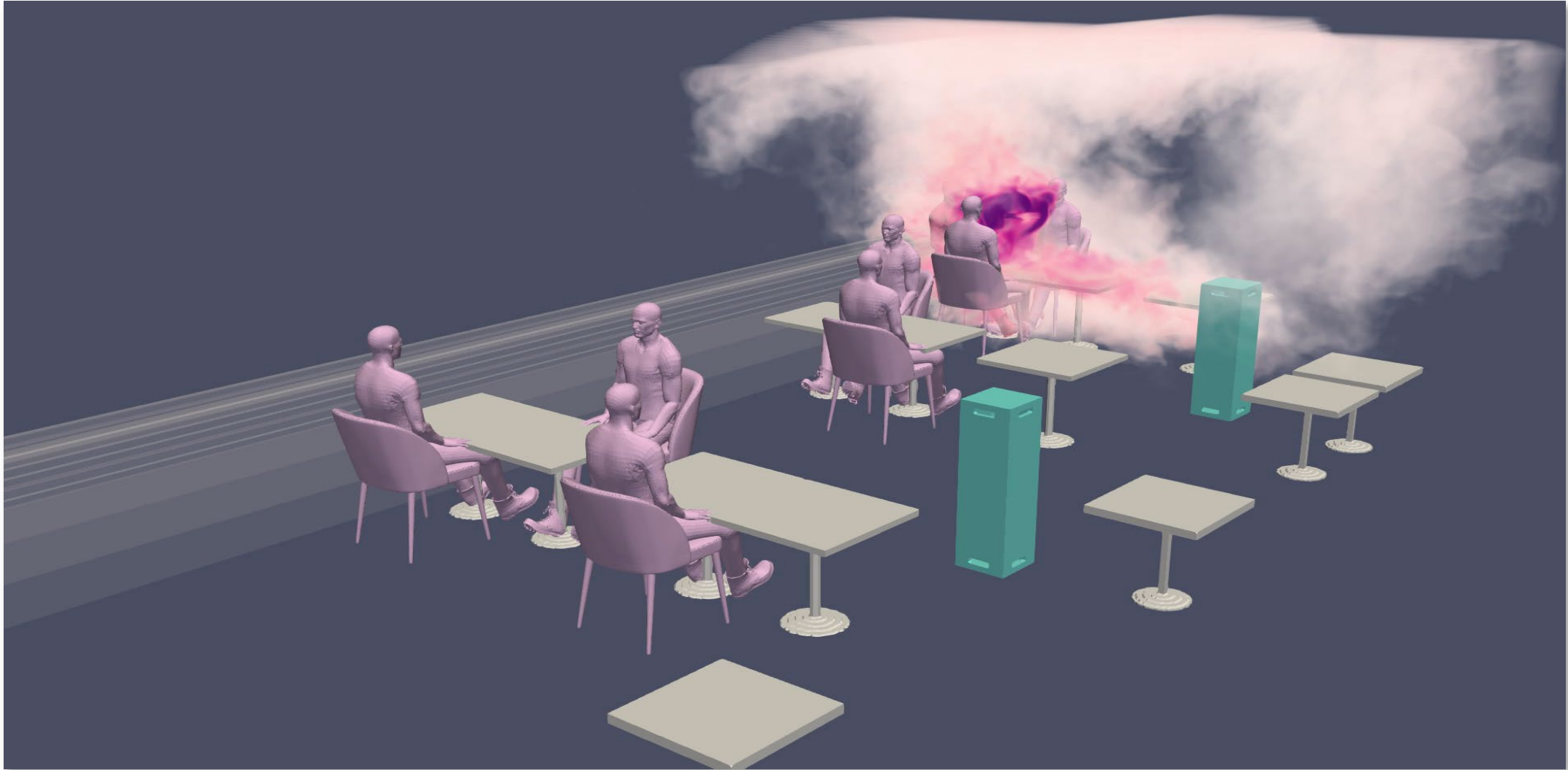
Aerosol or droplet?

“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

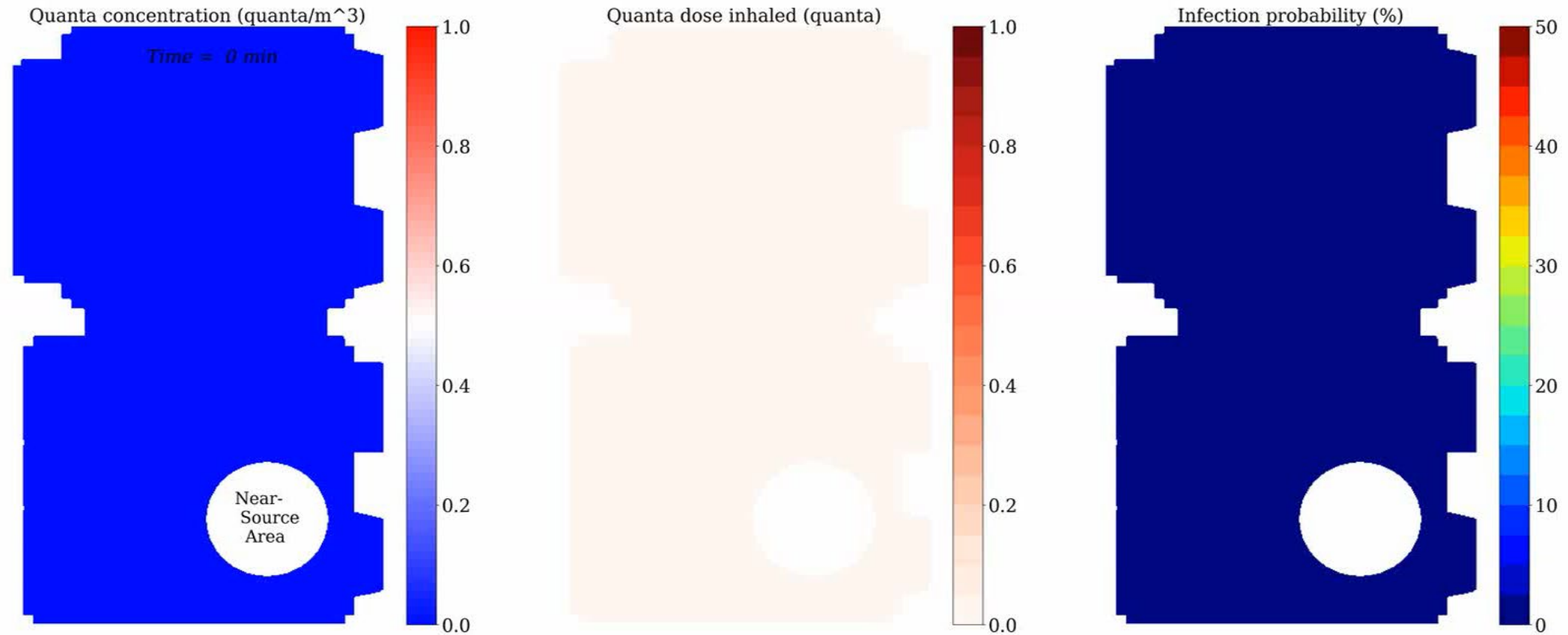
Introduction

Modelling pathogen dispersion indoors



Phase 0: Establishing Relevance, Methodology and Analysis

Modelling pathogen dispersion, exposure and infection probability

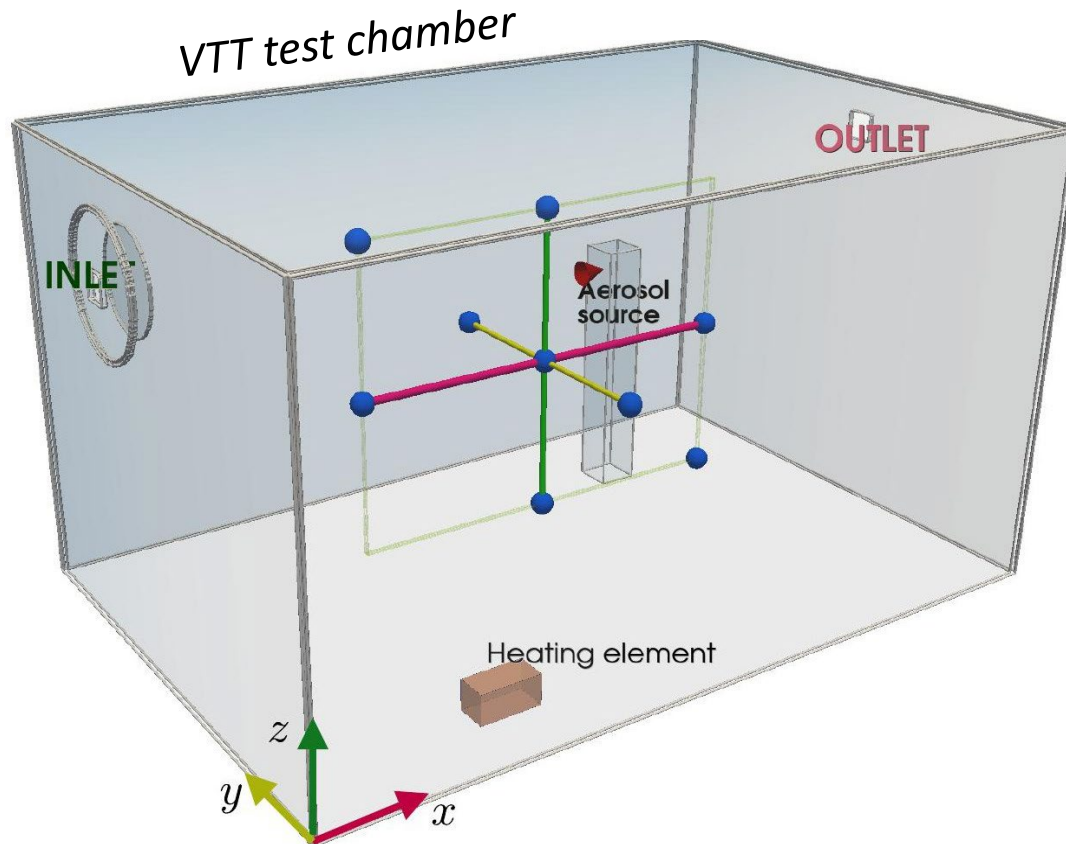


E3: Back to Basics

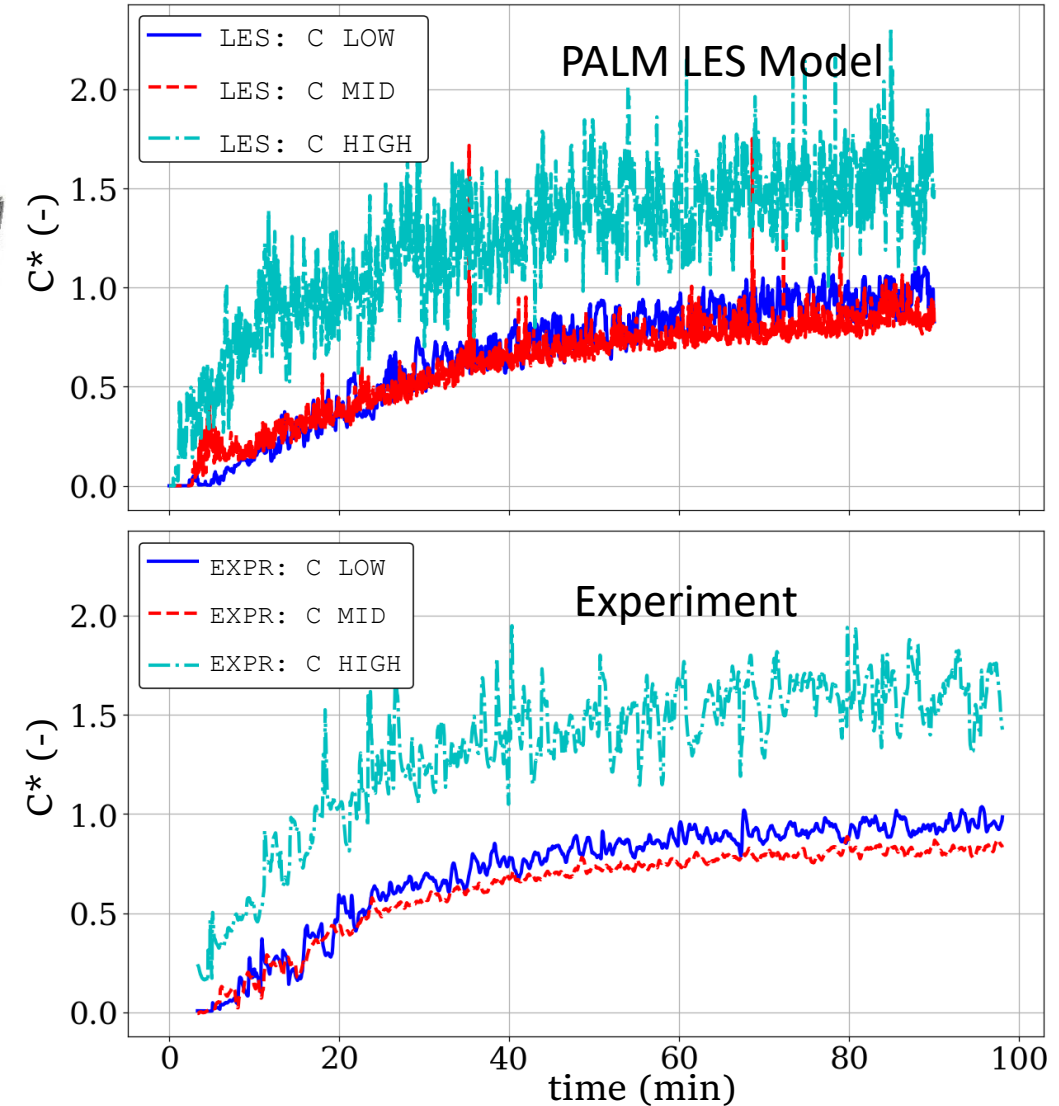


Phase I: Validation of the Numerical Model

Does our turbulence-resolving model capture the relevant phenomena?



E3 VTT validation campaign



... to be published



Take home:

□ The relevant mechanisms governing pathogen dispersion **can be captured** by turbulence resolving LES modelling

* However, best-practice guidelines must be followed

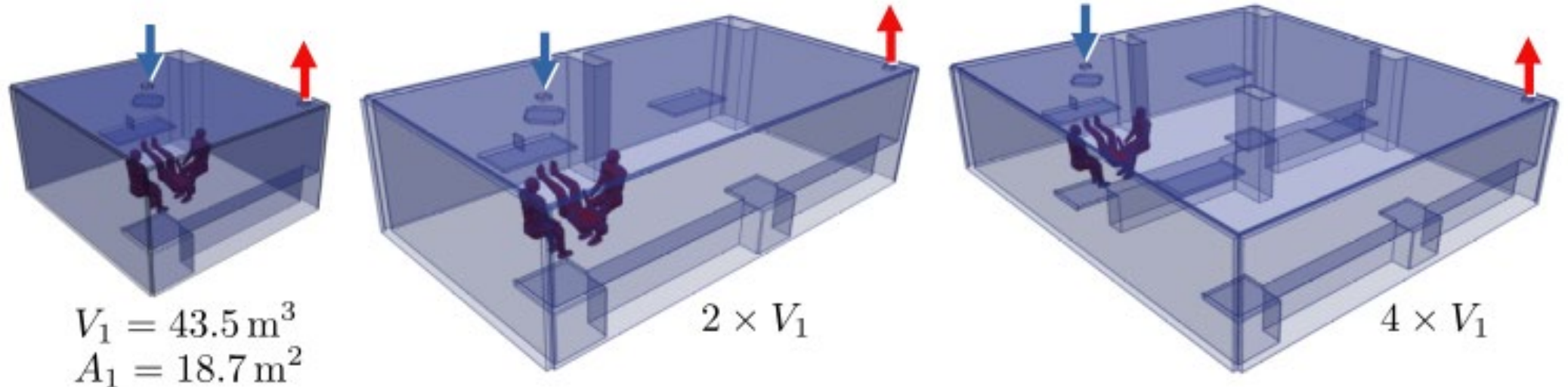
Phase II: Establishing fundamentals

Generalizing indoor air hygiene analysis

How does *indoor ventilation flow system* influence the *evolution of pathogen concentration indoors*?

Parameters characterizing *indoor ventilation flow system*:

- Ventilation rate
- Room size
- Added mixing power
- Implementation strategy:
 - Single outlet vs multiple outlets



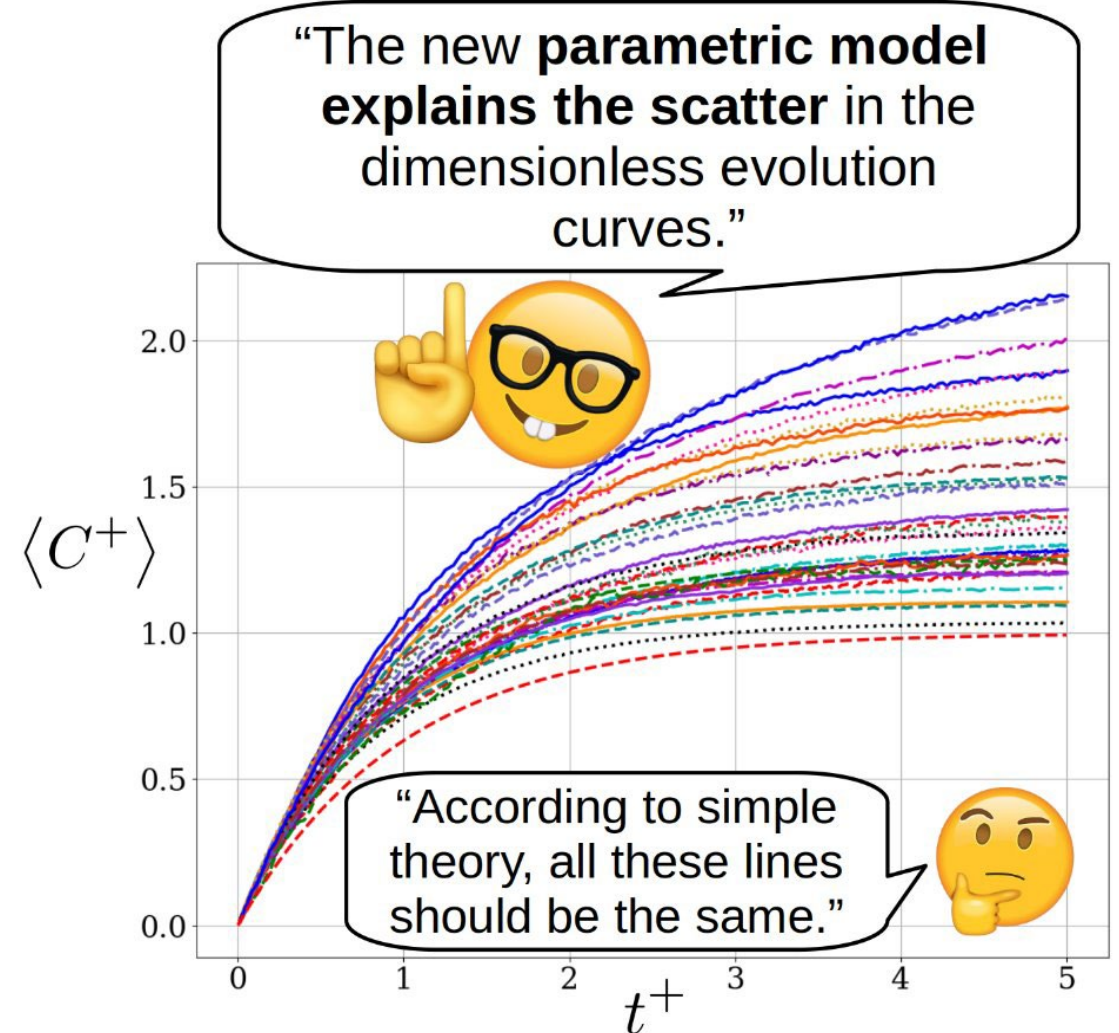
Phase II: Establishing fundamentals

Generalizing indoor air hygiene analysis

RESULT: A new **parametric model** providing generalizable estimates about the **state and evolution of indoor air hygiene** in relation to airborne transmission risks.

The model provides information concerning the (1) **severity**, (2) **temporal evolution** and (3) **statistical distribution of risk** within a mechanically ventilated space.

The model augments and outperforms in level of description the existing Wells-Riley model.

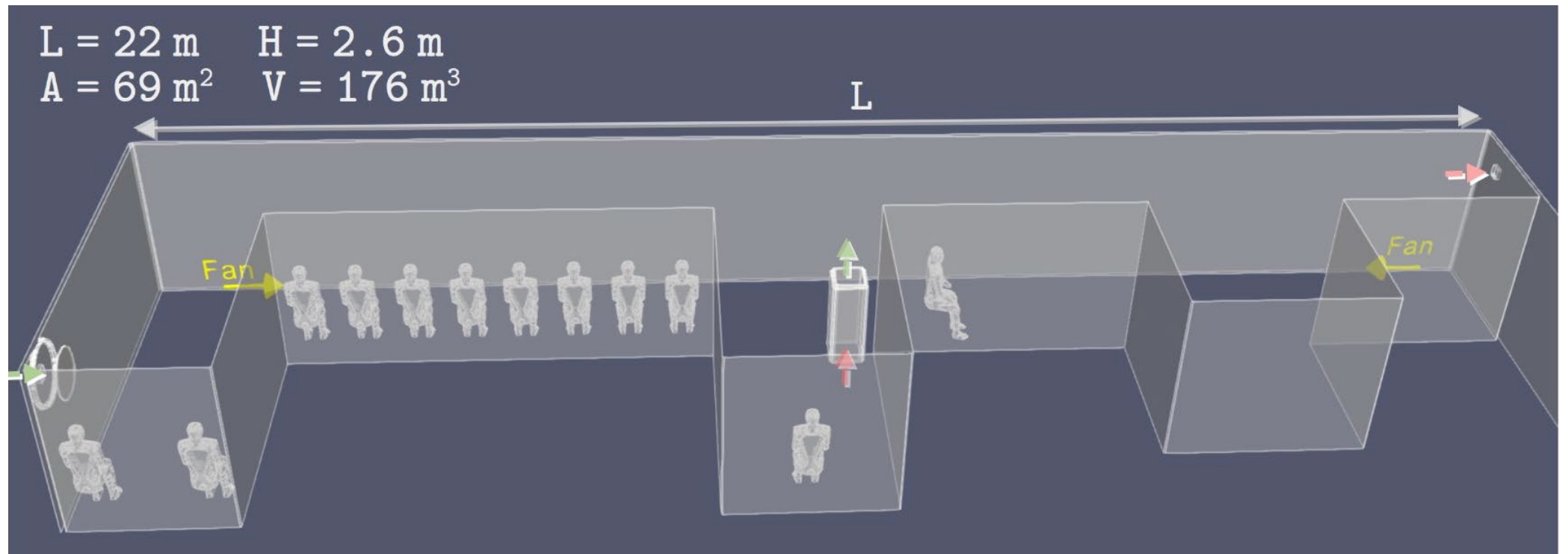


Take home:

- ❑ Enhanced mixing improves the air hygienic state of indoor spaces by
 - (1) diluting local concentration peaks
 - (2) improving the **robustness** and **predictability** of the system's performance
- ❑ System with multiple outlets clearly outperforms a ventilation system with a single outlet

Phase III: Air Purifiers in Corridor-like Spaces

CASE STUDY: *hospital waiting lobby*



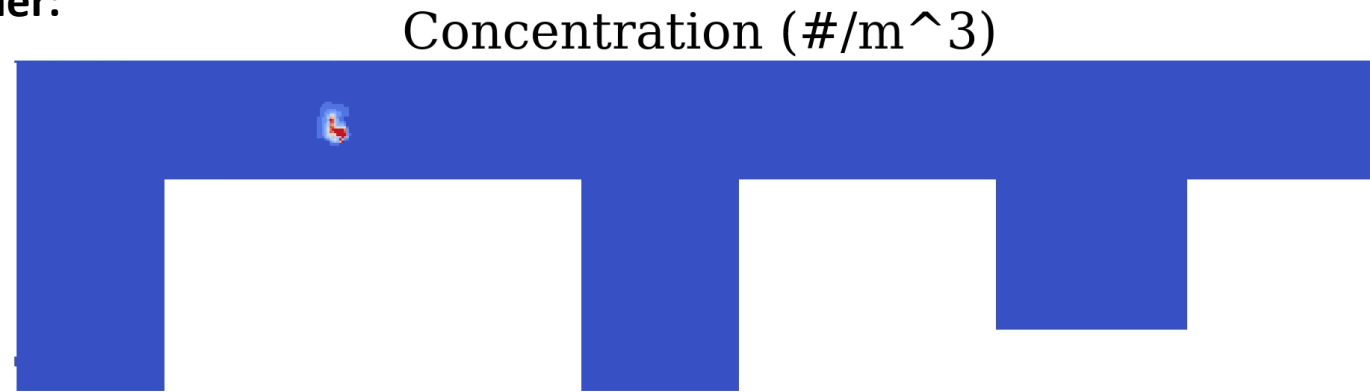
How to best utilize air purifiers in a poorly ventilated corridor-like indoor spaces?

Phase III: Air Purifiers in Corridor-like Spaces

CASE STUDY: *hospital waiting lobby*

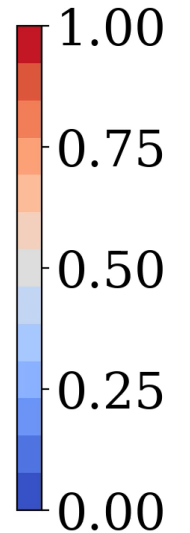
Effect of Air Purifier:

Reference
(Poor ventilation)



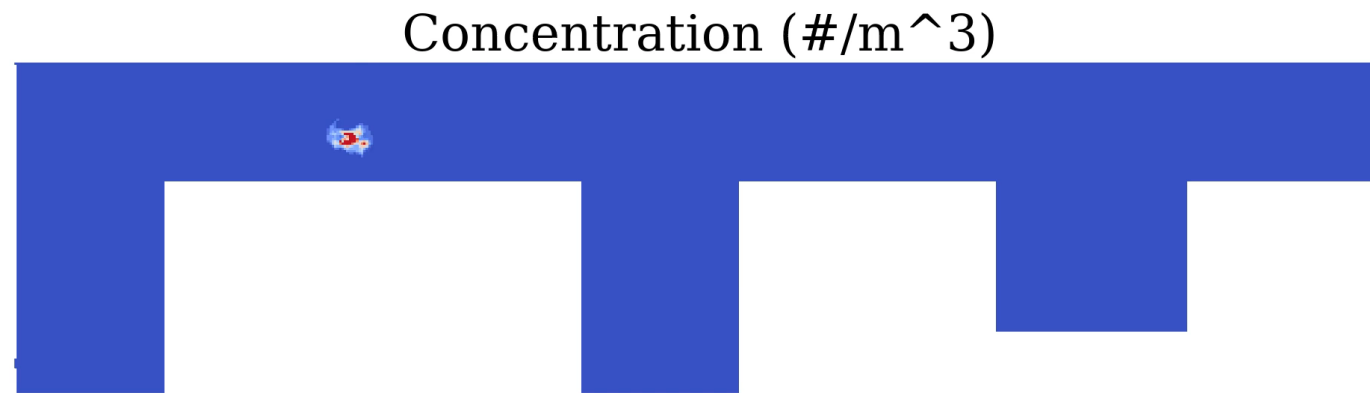
vs.

$ACH: VENT+FLT = 0.1+0.0$
 $time = 0 \text{ min}$

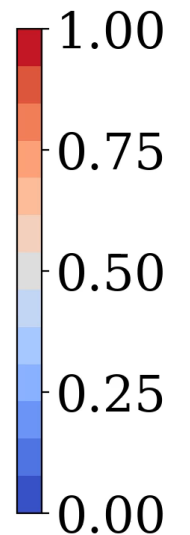


Reference +
Air purifier

(CADR= 2.2 V/h)



$ACH: VENT+FLT = 0.1+2.2$
 $time = 0 \text{ min}$



Phase III: Air Purifiers in Corridor-like Spaces

CASE STUDY: *hospital waiting lobby*

Added Mixing:

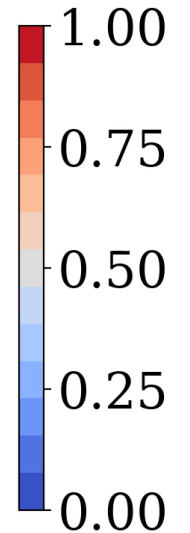
+ Air Purifier

Concentration ($\#/m^3$)



vs.

$ACH: VENT+FLT = 0.1+2.2$
 $time = 0 \text{ min}$



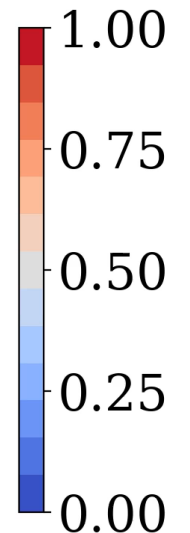
+ Air purifier
+ FAN

Concentration ($\#/m^3$)



(CADR= 2.2 V/h)

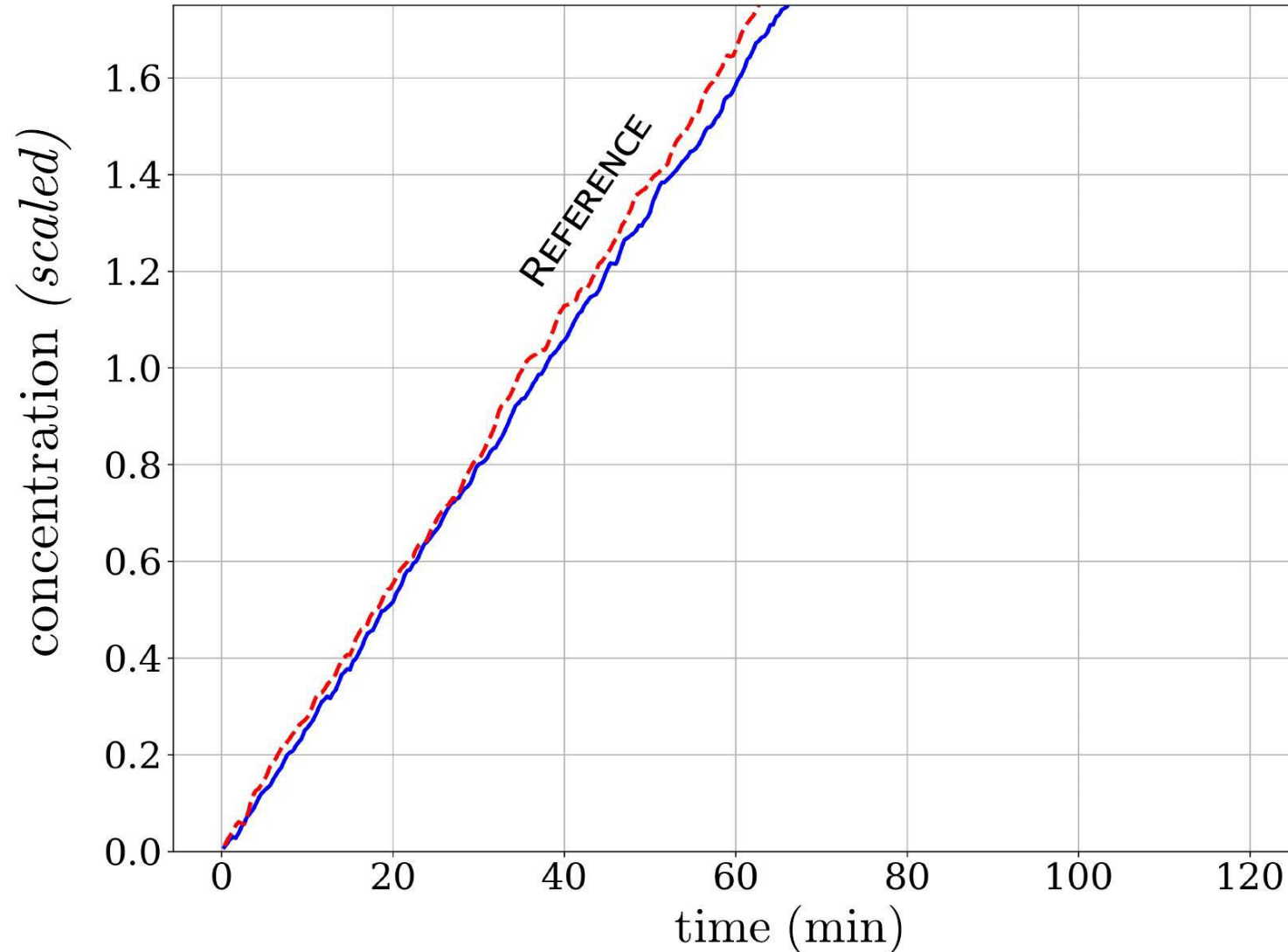
$ACH: VENT+FLT = 0.1+2.2 (+fan 10W)$
 $time = 0 \text{ min}$



Phase II: Air Purifiers in Corridor-like Spaces

CASE STUDY: *hospital waiting lobby*

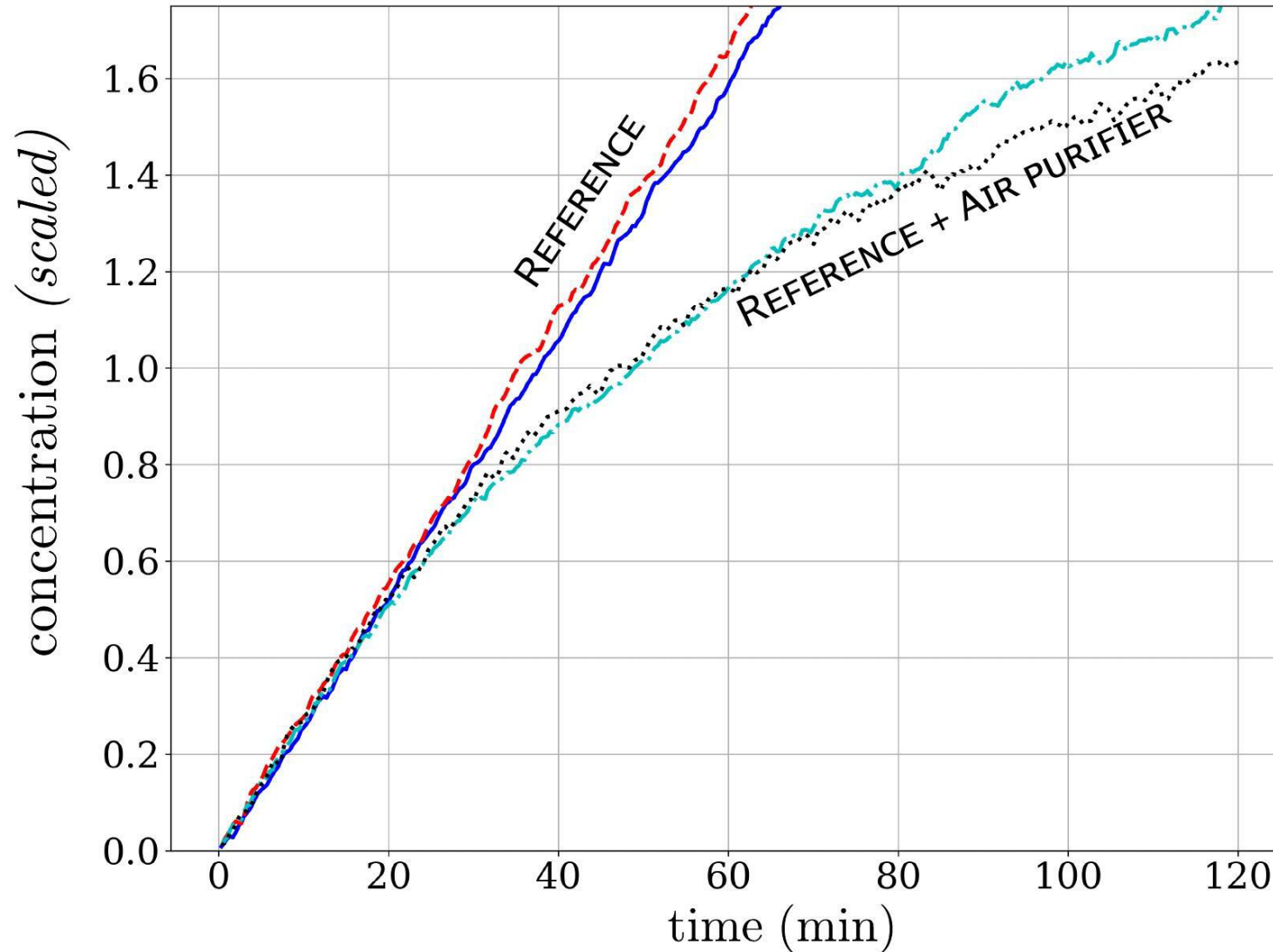
Evolution of mean concentration



Phase III: Air Purifiers in Corridor-like Spaces

CASE STUDY: *hospital waiting lobby*

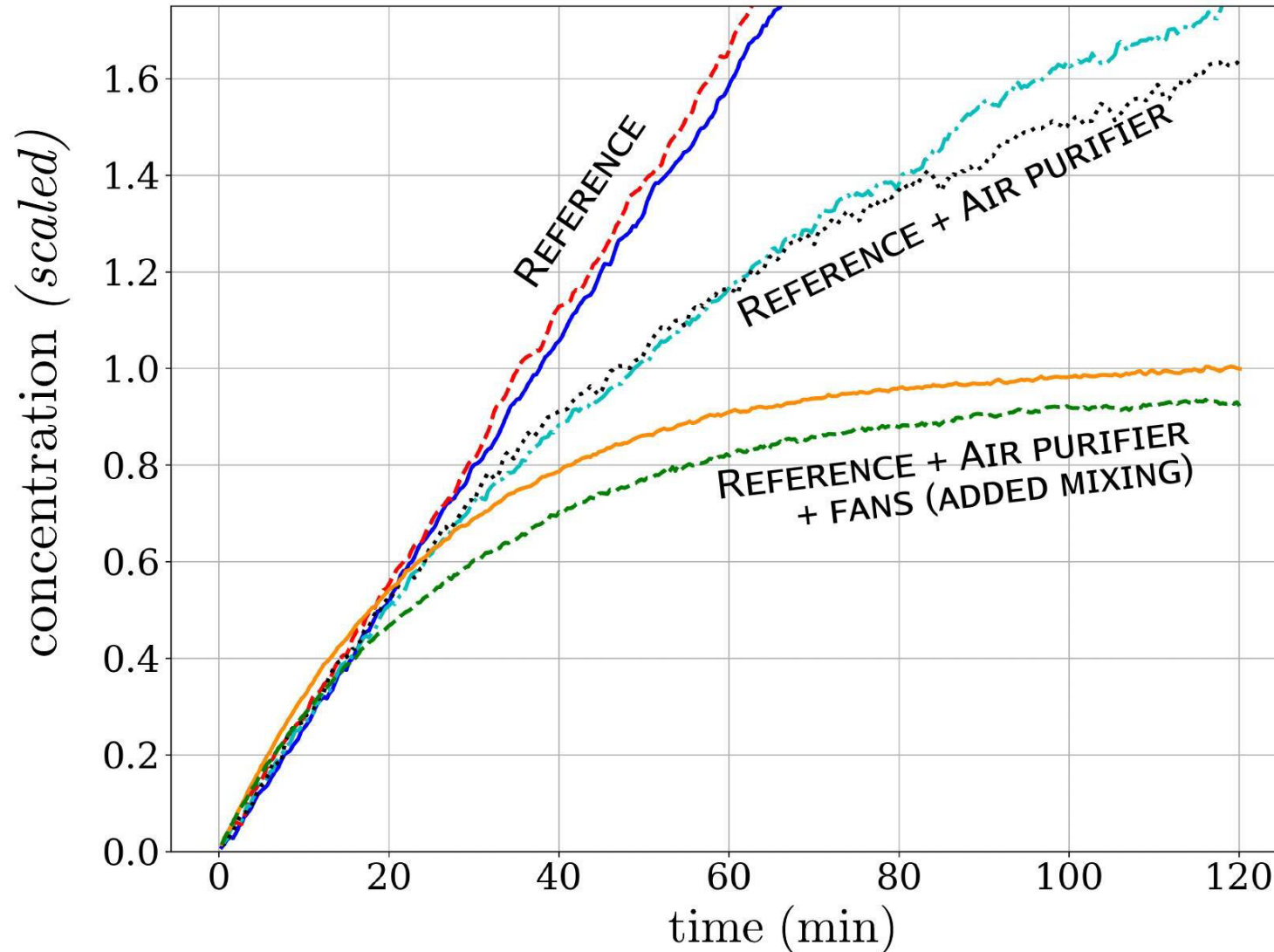
Evolution of mean concentration



Phase III: Air Purifiers in Corridor-like Spaces

CASE STUDY: *hospital waiting lobby*

Evolution of mean concentration



Take home:

- ❑ In large corridor-like indoor spaces the efficiency of an air purifier can be significantly increased by introducing enhanced mixing

Thank you!

For more information

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**EXCELLENCE IN PANDEMIC RESPONSE
AND ENTERPRISE SOLUTIONS**