Assessment and Management of Chemical Risks in Academic Laboratory(2)

-Influence of laboratory layout on airflow in university laboratory-

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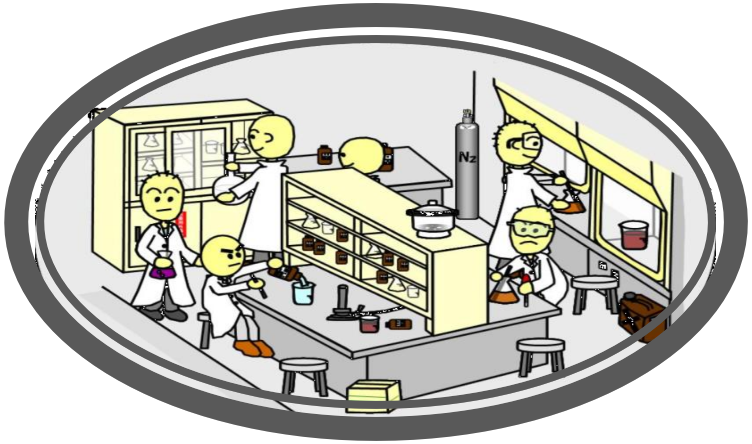
Chemical risks in the laboratory environment



- ✓ Risk of Exposure

  Experimenters are exposed to chemicals and easy to take chemicals in their body during experiments

- ✓ Risk of Inflammability and Explosion

  Organic solvents are volatile and easy to burn

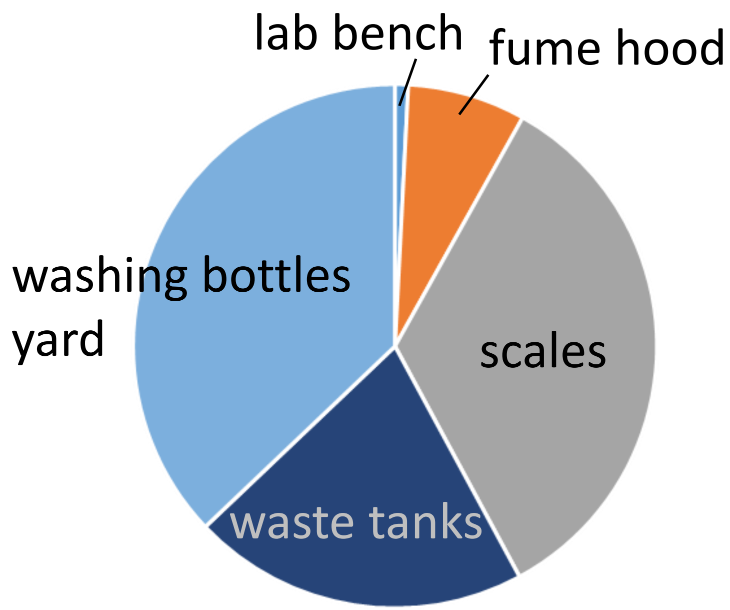
- ✓ Risk of Leakage to Environment

  Due to inadequate air balance and pressure condition of laboratory

➡ To reduce chemical risks, reducing chemical concentration and preventing chemical diffusion are important.

Usage of chemical substances in actual laboratory

Time duration for operation and usage of chemicals



Usage of chemicals by experimenter A
（total time using：9m11s）

Chemicals are not always handled in fume hood.

What we did in this study

Obtaining information of chemical concentration and chemical diffusion in experimental laboratories by

1. measurement of personal chemical exposure in actual laboratory
2. analysis on chemical diffusion in laboratory by Computational Fluid Dynamics (CFD) simulation
3. analysis of relationship between laboratory layout and airflow by Particle Image Velocity (PIV) with 1/10 scale laboratory model

Optimum airflow circumstance for reduction of chemical risks is discussed.

Objective

1. personal exposure measurement in actual laboratory

ex. personal exposure measurement by passive sampler

Experimenter		7/2		7/3	
A	experiment time[min]	none		325 min	
				acetone	$CHCl_3$
	time average concentration C[ppb]	none		4.11	3.67
	time to use chemicals			0.5 min	0 min
B	experiment time[min]	50 min		50 min	
		acetone	$CHCl_3$	acetone	$CHCl_3$
	time average concentration C[ppb]	26.05	1.55	25.51	11.06
	time to use chemicals	0 min	0.5 min	0 min	2.4 min

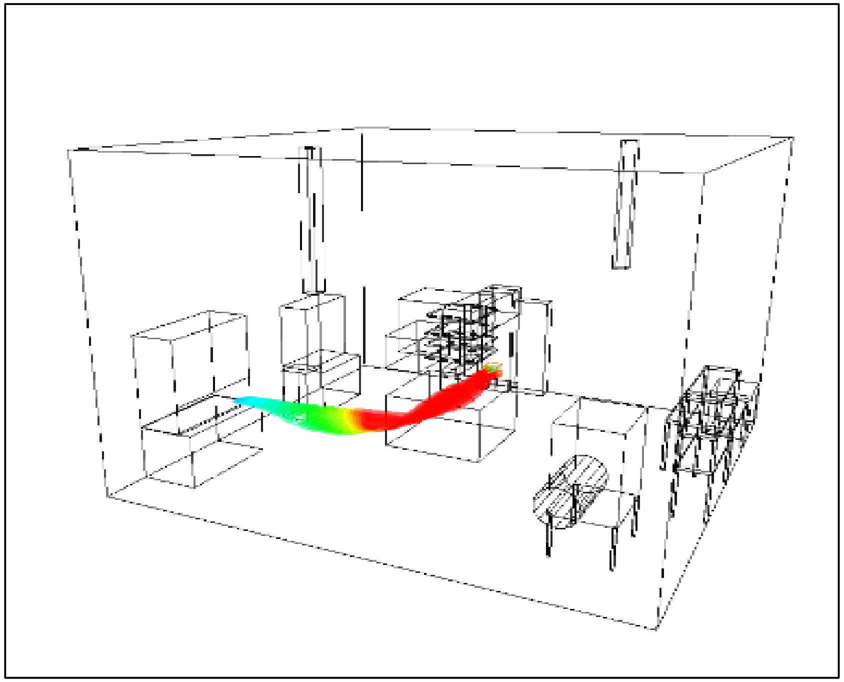
Possibility of unintended chemical exposure due to shared air quality in laboratory

Results & Discussion

2. chemical diffusion in a laboratory by CFD simulation

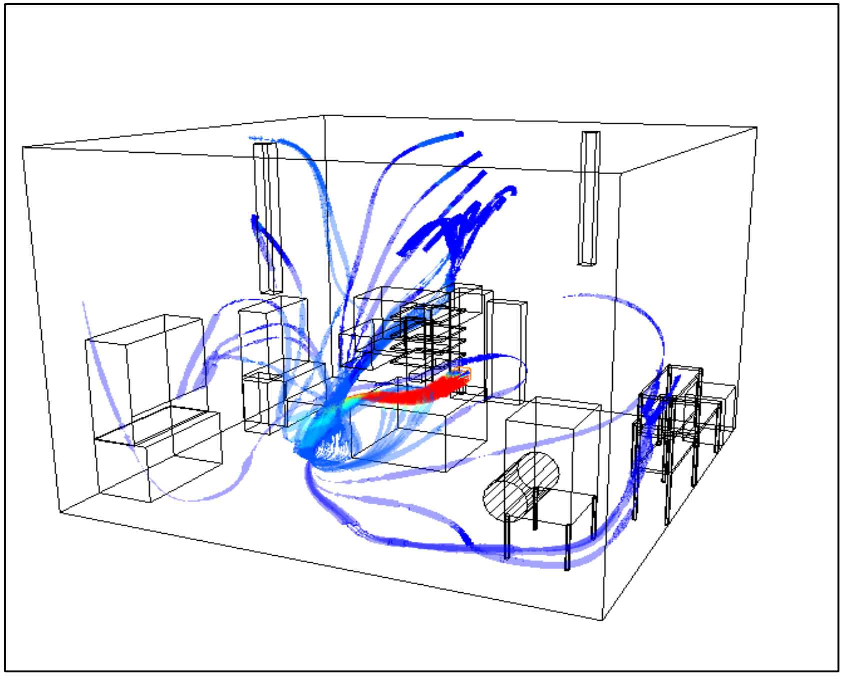
Dependence of trajectory of chemical on use of ventilation

Fume hood: ON
Room ventilation: OFF



smooth evacuation by FH

Fume hood: ON
Room ventilation: ON

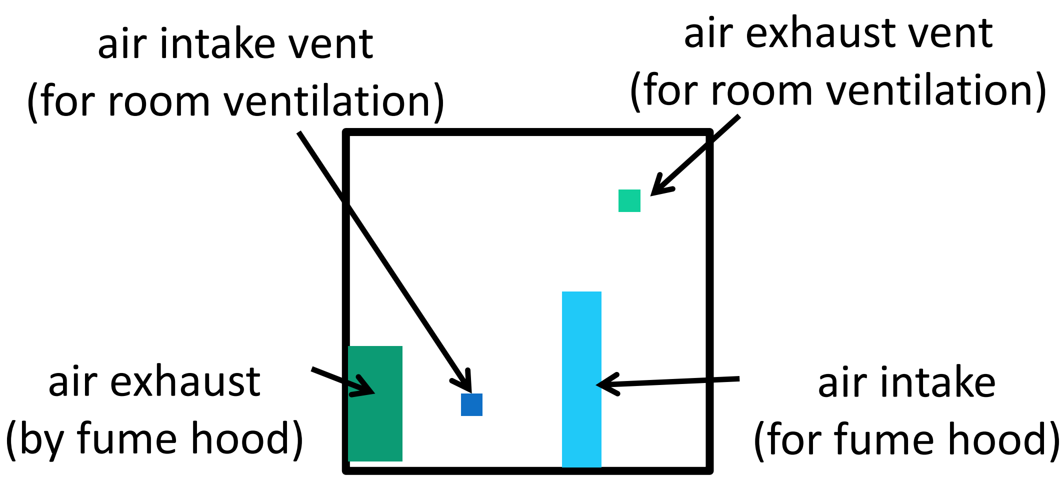


volatile substance spread out around the room on agitated airflow by room vent

Results & Discussion

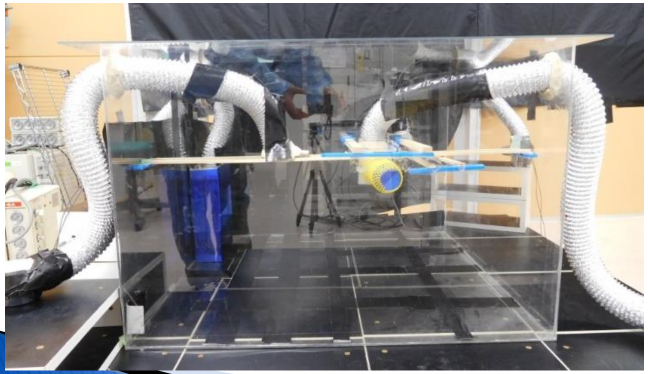
3. PIV analysis of airflow with 1/10 scale lab model

Full scale test room



- size: 7.2 × 7.0 × 5.0 m
- fume hood: 19.0 m^3/min
(face velocity: 0.5 m/s)
- ventilation: 4.9 m^3/min

1/10 model room

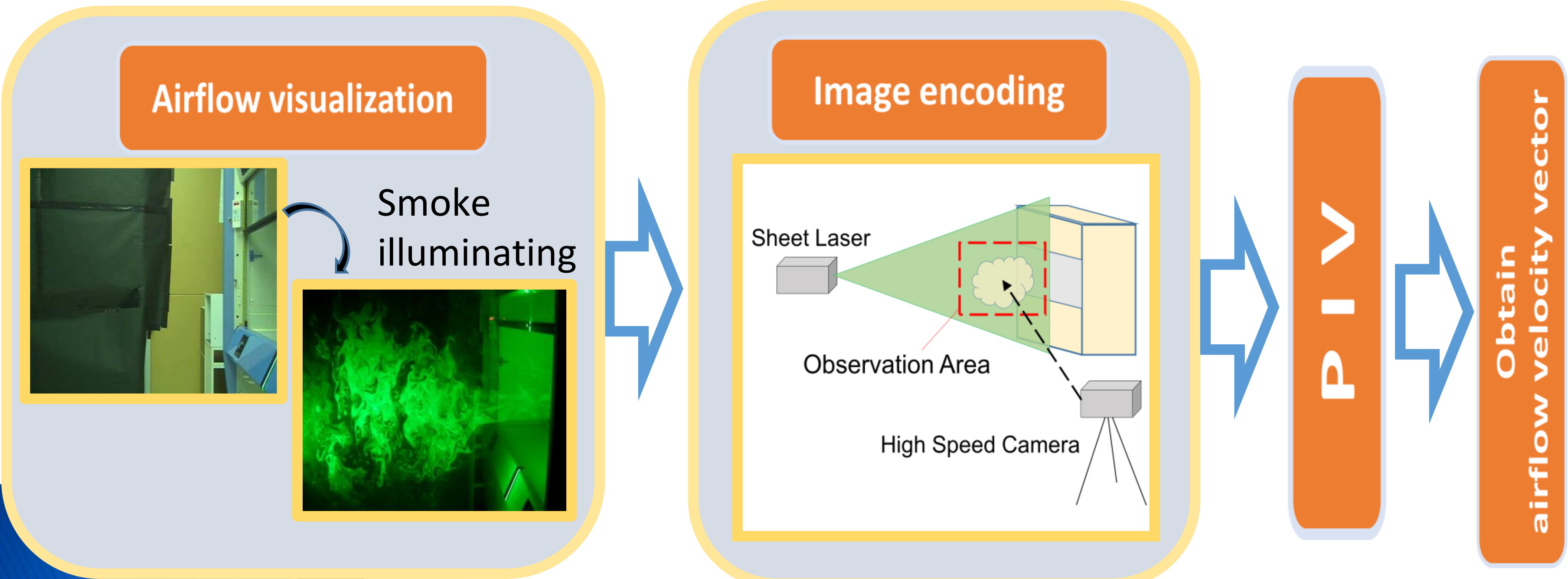


- walls: acrylic plate
- room size: 1/10 of full scale
- air velocity: coordinated by means of **Archimedes number**

What is PIV measurement ?

The airflow in the laboratory was visualized by illuminating smoke with a sheet laser. Visualization image can be converted to velocity vectors of smoke particles by PIV (Particle Image Velocimetry).

- PIV software: FlowExpert.
- Sheet laser: 1 W, 532 nm.
- High speed camera: 30 fps (flames per second)

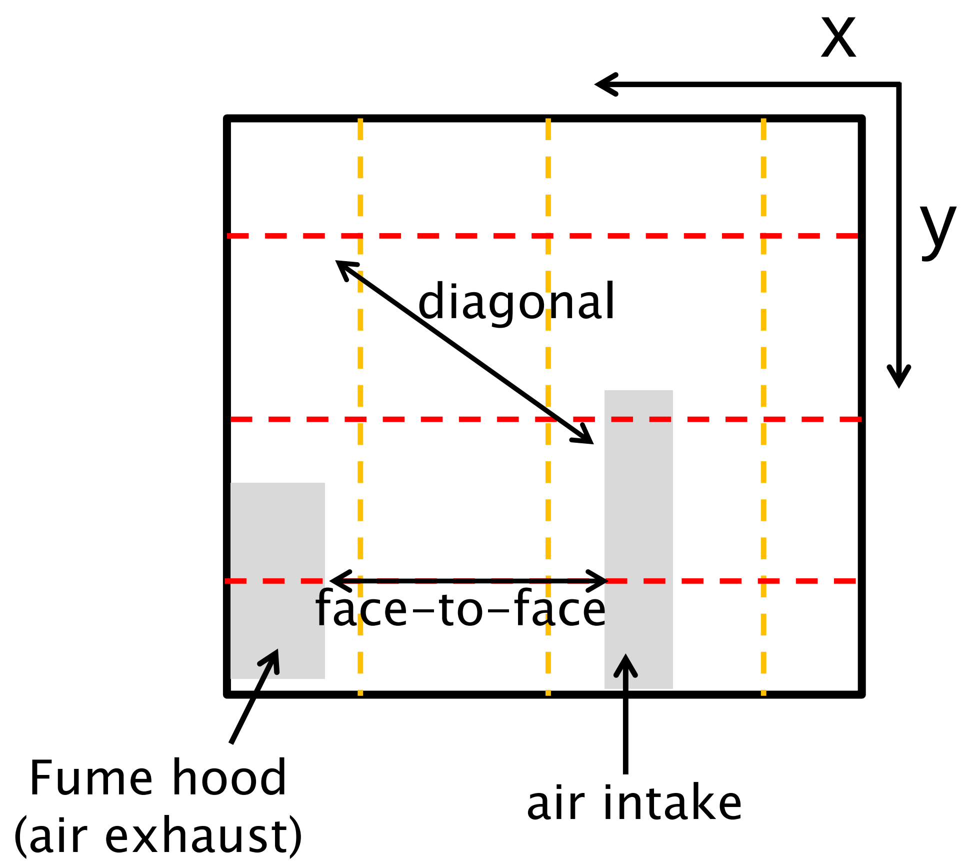


3.PIV measurement

Analysis-1: Dependence of airflow on positional relationship between fume hood exhaust and air intake

(1) face-to-face

(2) diagonal

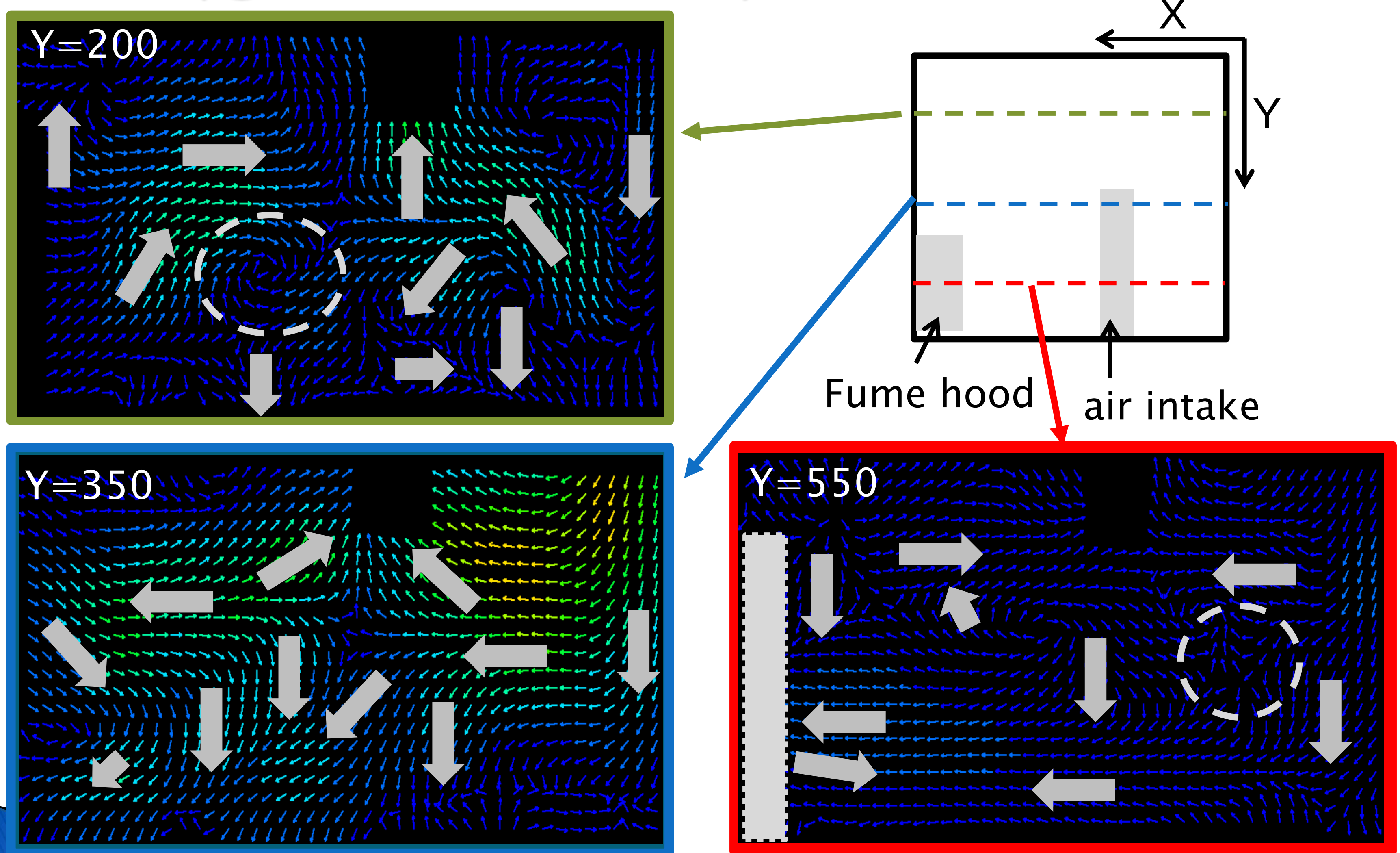


Results
& Discussion

3.PIV measurement - dependence on FH position

○Airflow (@X-Z cross section)

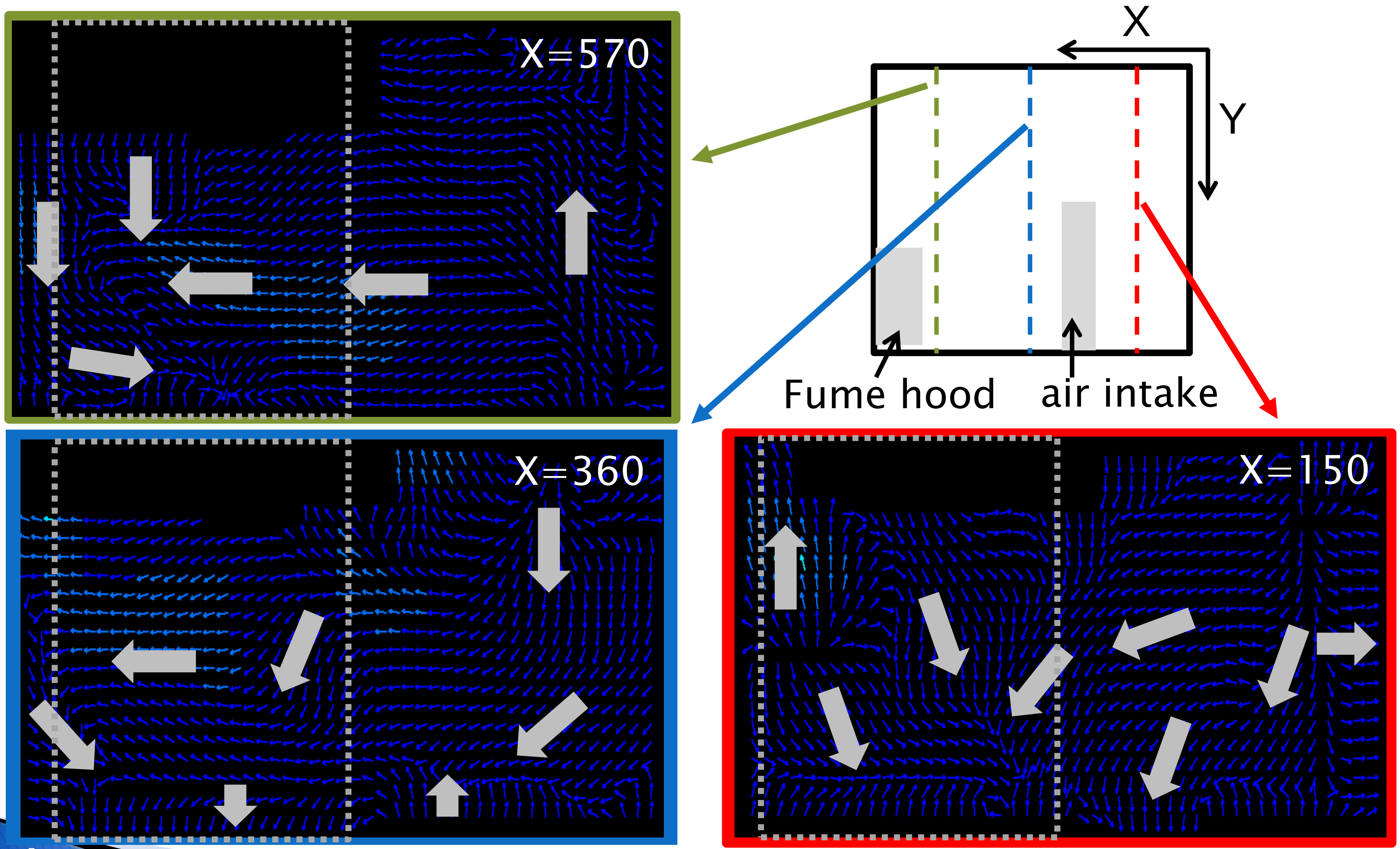
FH in "face-to-face" position



Results & Discussion

○Airflow (@Y-Z cross section)

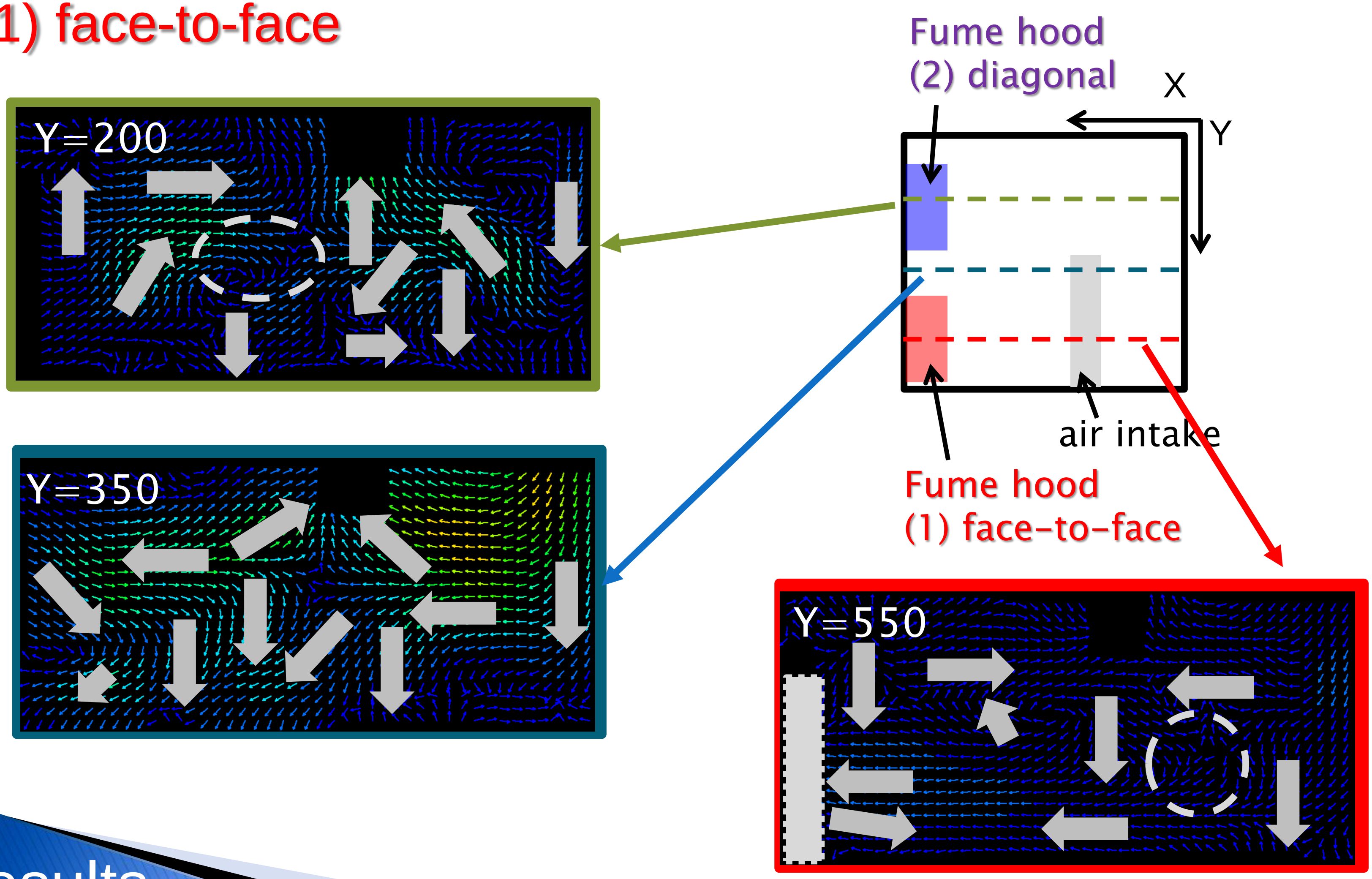
FH in "face-to-face" position



Results & Discussion

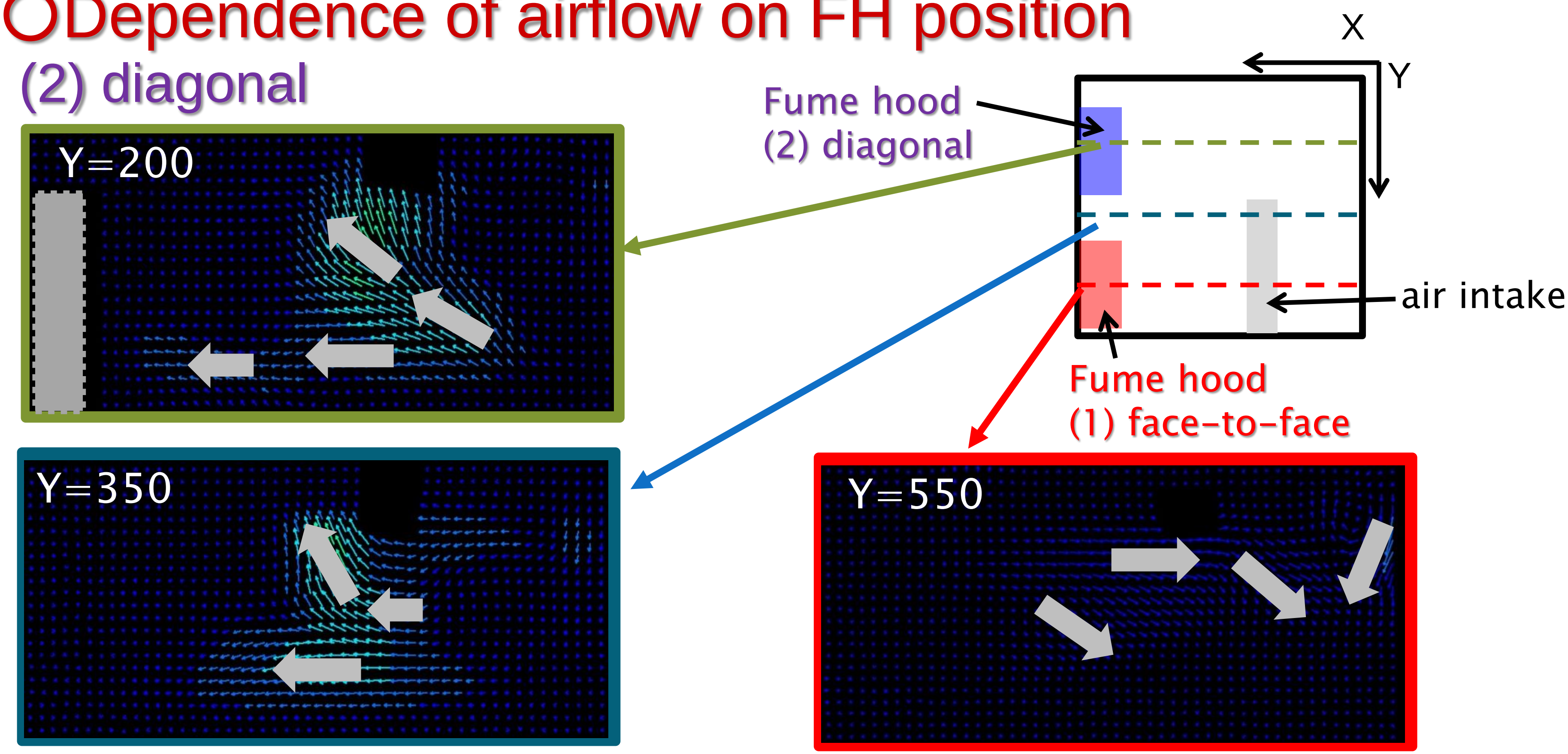
○Dependence of airflow on FH position

(1) face-to-face



○Dependence of airflow on FH position

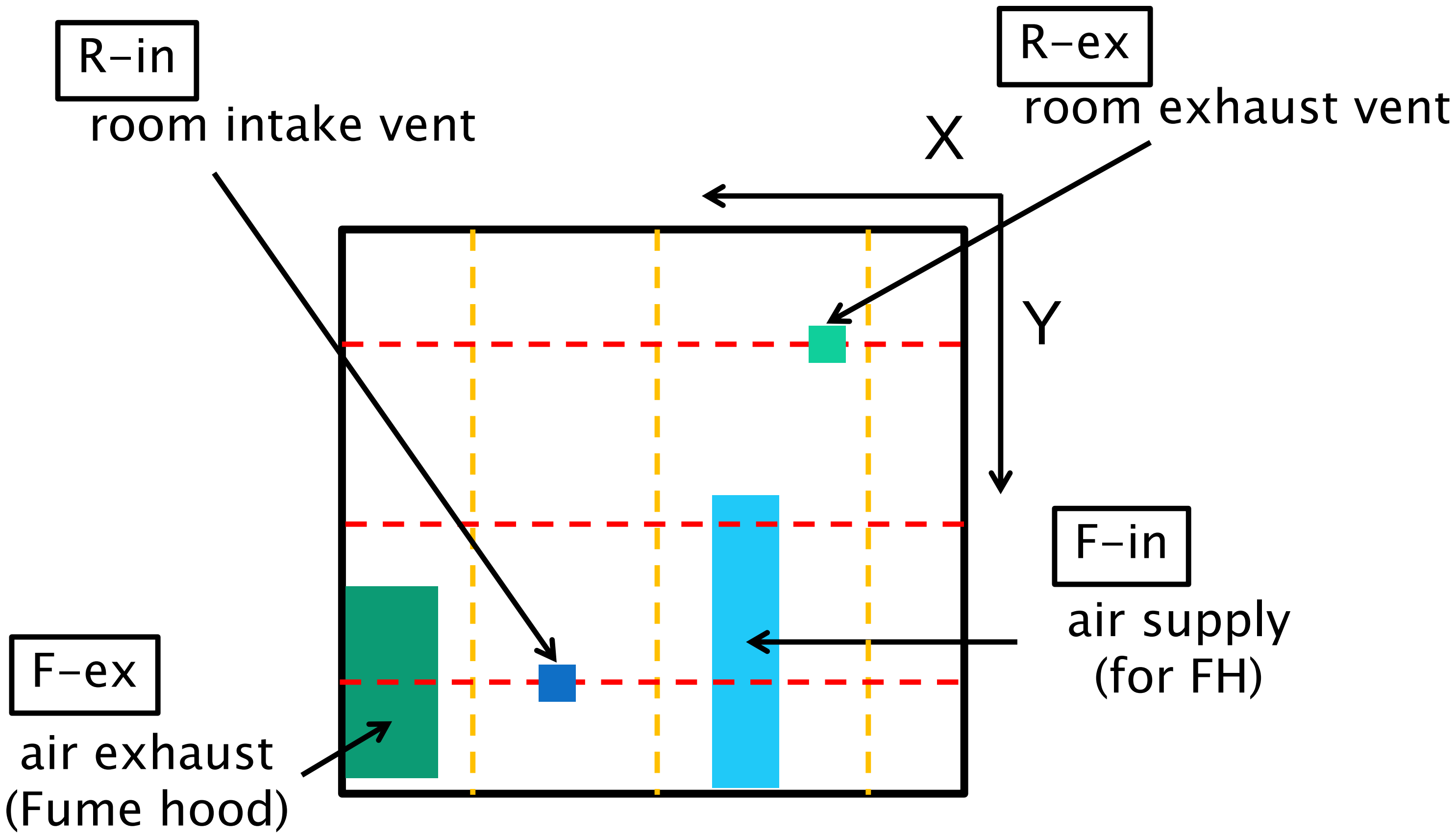
(2) diagonal



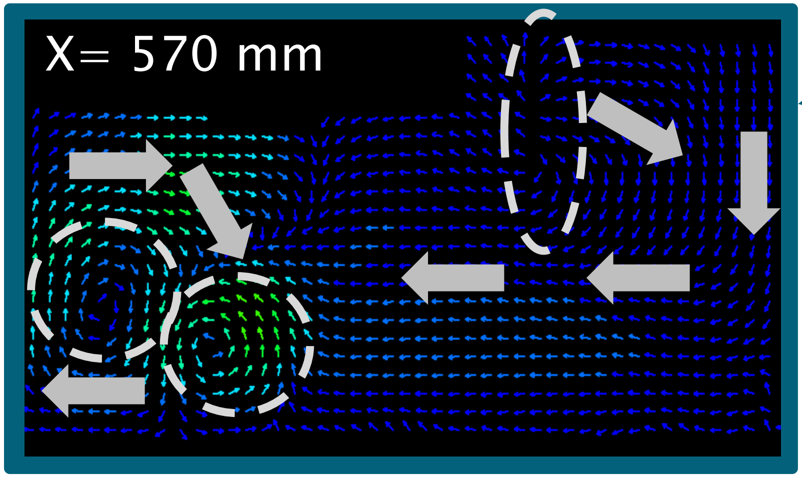
FH at diagonal position,

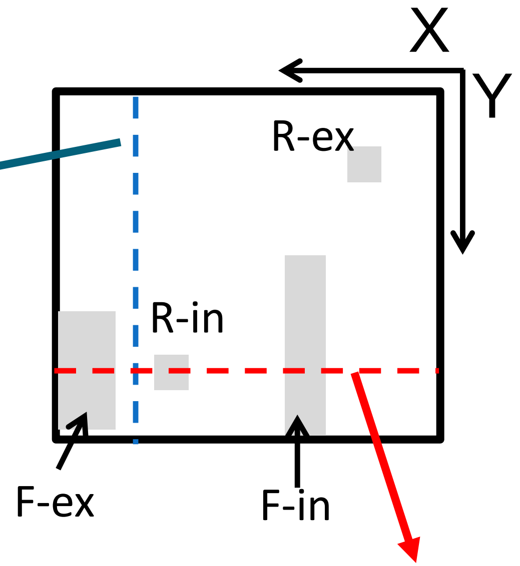
- smoother flow to FH
- less turbulent

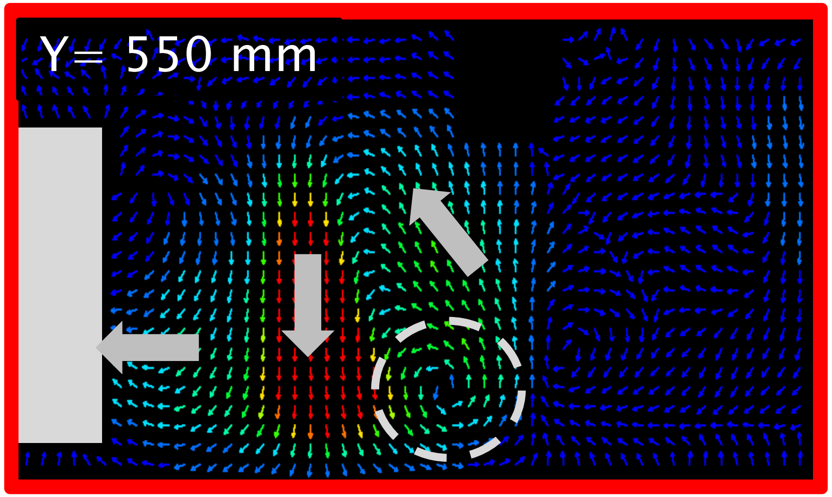
Analysis-2: Dependence of airflow on room intake/exhaust vents



3.PIV measurement - How room vents affect total airflow ?



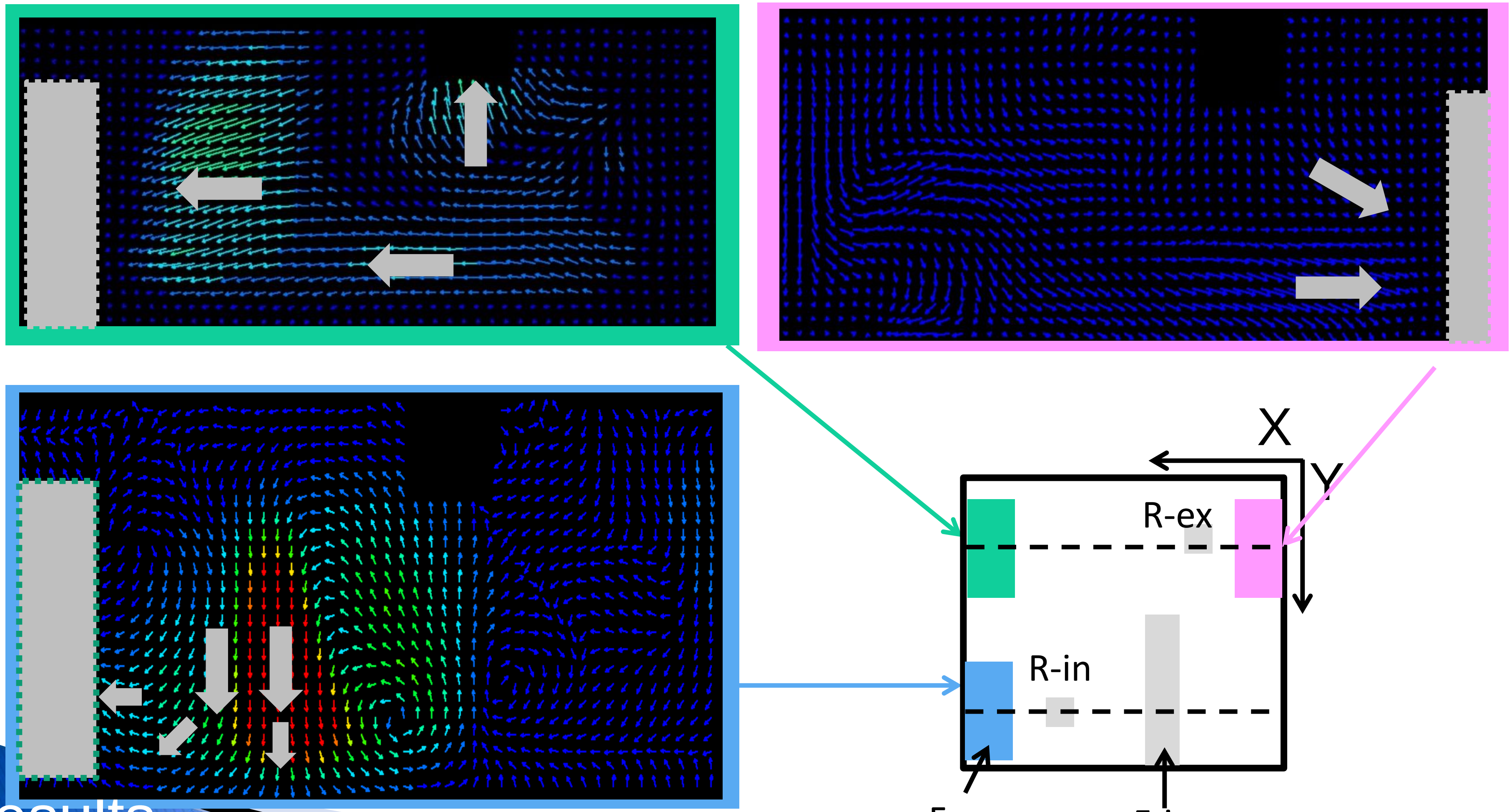




- airflow blocking (air curtain) by room intake vent
- isolated FH exhaust airflow by air curtain

○Dependence of airflow on FH position

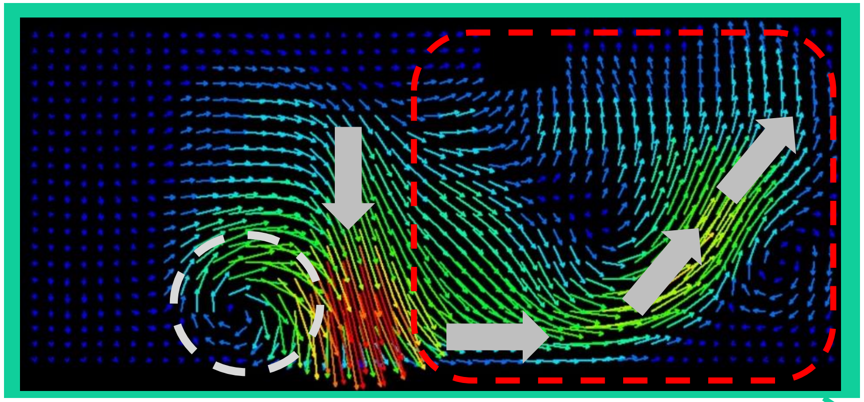
Airflow in front of each fume hood (@Y-Z cross section)

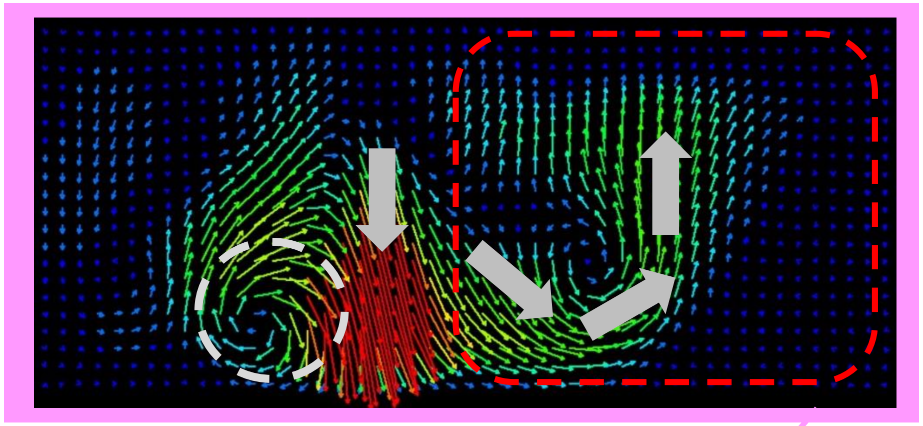


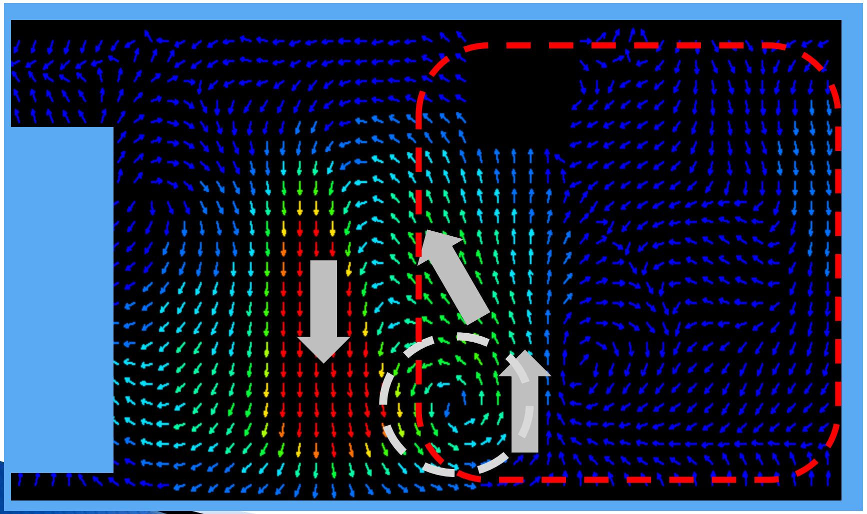
3.PIV measurement - How room vents affect total airflow ?

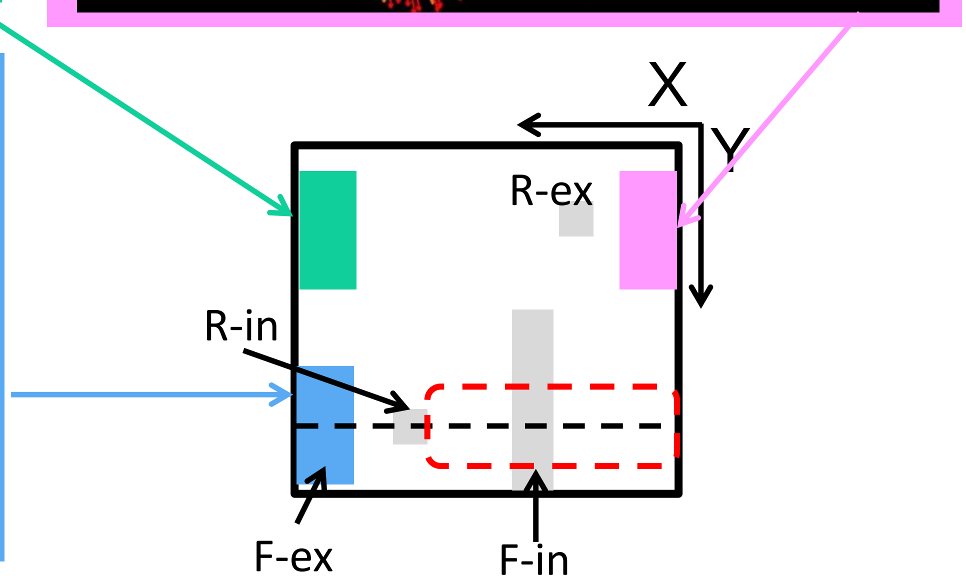
○Dependence of airflow on FH position

Airflow around room intake vent (@Y-Z cross section)









Results
& Discussion

Summary

- Must consider unintended chemical exposure by others' experiments due to shared air quality in laboratory
- CFD simulation suggests that trajectory of chemicals in laboratory strongly depends on use of room ventilation system
- Examined influence of fume hood location and intake/exhaust vents on indoor airflow by PIV analysis with 1/10 scale laboratory model

Quantitative analysis on indoor airflow aids formulating guidelines for proper laboratory design, and for developing technical countermeasures for assessing/reducing chemical risks in experimental laboratories

Acknowledgement

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