CONSULTING ENGINEERS & SCIENTISTS

SLCan Webinar Series

High Performance Ventilation Design in Laboratories

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Overview

- Motivation
- Defining High Performance Ventilation
- Design Considerations
- Strategies for High Performance Ventilation
- Closing Thoughts
- Questions

Motivation

- Laboratories consume a lot of energy
- Largely driven by ventilation (44% based on I^2SL review)
- I^2SL estimates lab energy use for ventilation can be reduced by 30-50%

I^2SL- International Institute for Sustainable Laboratories

ACH- Air changes per hour

High Performance Ventilation

"Everything should be as simple as it can be, but not simpler" – Albert Einstein

- We should use as little energy as possible while:
  - Providing a safe environment
  - Meeting requirement for containment devices
  - Providing cooling to offset heat gains
  - Meeting minimum ventilation requirements

- High Performance Ventilation- meeting the needs of the space by using less air/energy while providing safe comfortable conditions

Design Considerations

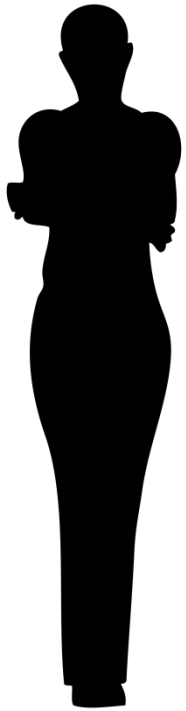
- A lot goes into designing a Lab*

Style of exhaust devices, capture velocities etc.

Changes in size and number of fume hoods

Decontamination provisions

Equipment Air (Fume hoods)



Increases in loads

Minimum Ventilation Requirements

Biological containment provisions

Temperature

Relative Humidity

Pressurization requirements

Exhaust and Intake Locations

Heat Gains

Air Quality

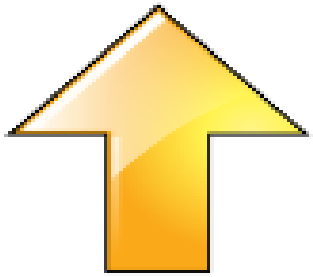
Standby equipment

*ASHRAE HVAC Applications 2011, Chapter 16.

Strategies for High Performance Ventilation

- Controlling Air Changes per Hour (ACH)
- Decoupling Heating/Cooling from Ventilation
- Fume Hood Selection
- Others

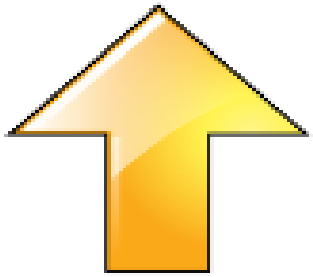
Controlling ACH –Current Practices



ACH = Safety

- Many labs are being designed at “high” air change rates
- Perceived notion of providing a “safer” working environment
- Consequence is tremendous consumption of energy
- Reluctance to reduce air flows because of perceived risk of creating “unsafe” conditions

Controlling ACH –Current Practices



ACH Safety

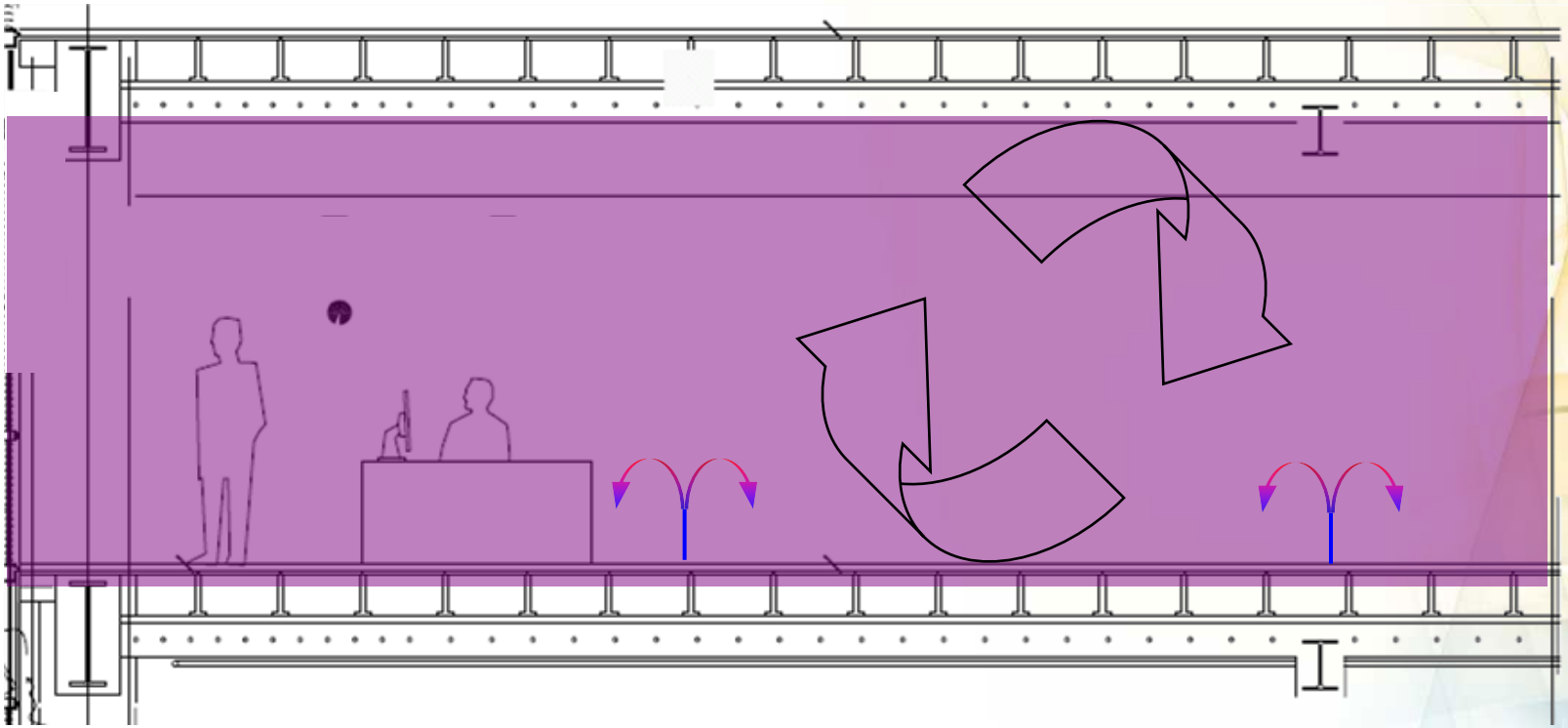
- The ability of air change rate to provide for, or even affect, the level of safety/exposure following a chemical release outside of a containment device is marginal at best

- Air change rate is basically irrelevant

However…

- Ventilation design strategies, such as supply and exhaust placement can have a much greater influence on overall air quality within a lab, and recovery from a spill, than air change rate

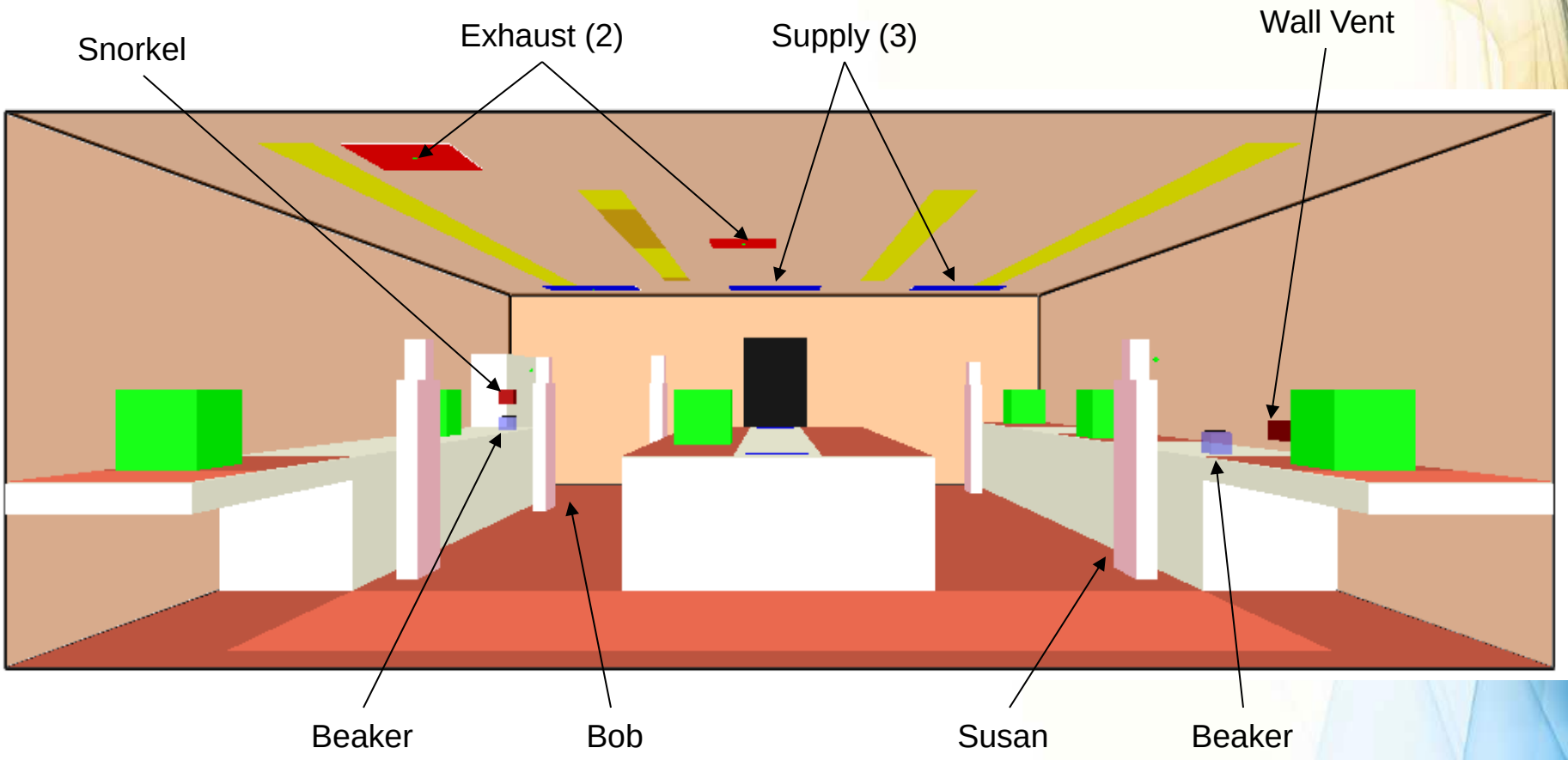
Controlling ACH- Why?



ACH is a simple measure of bulk air flow through a space

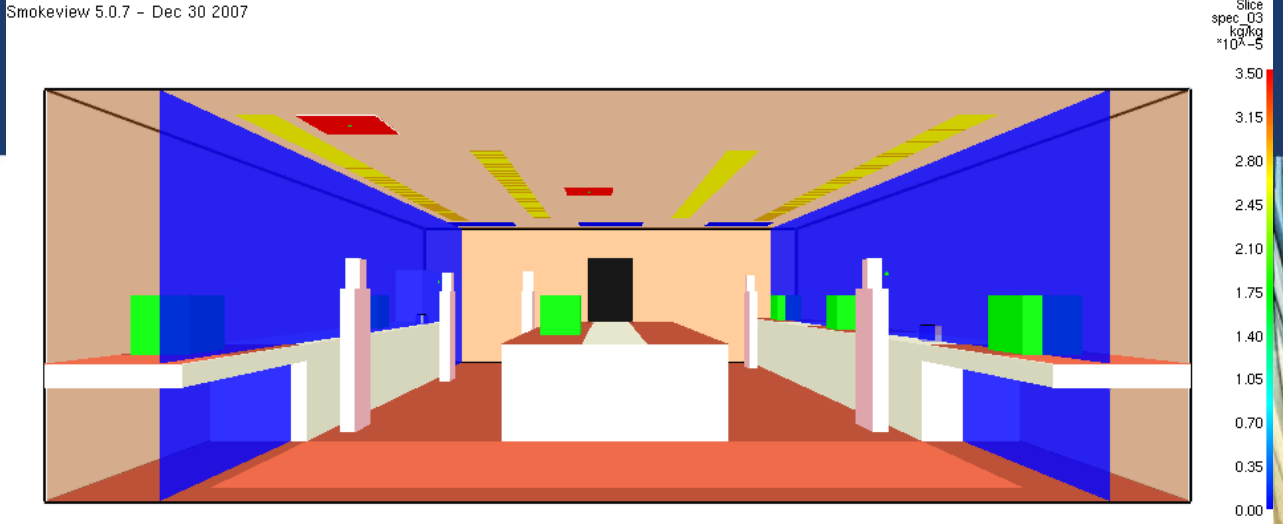
Case Study - Controlling ACH

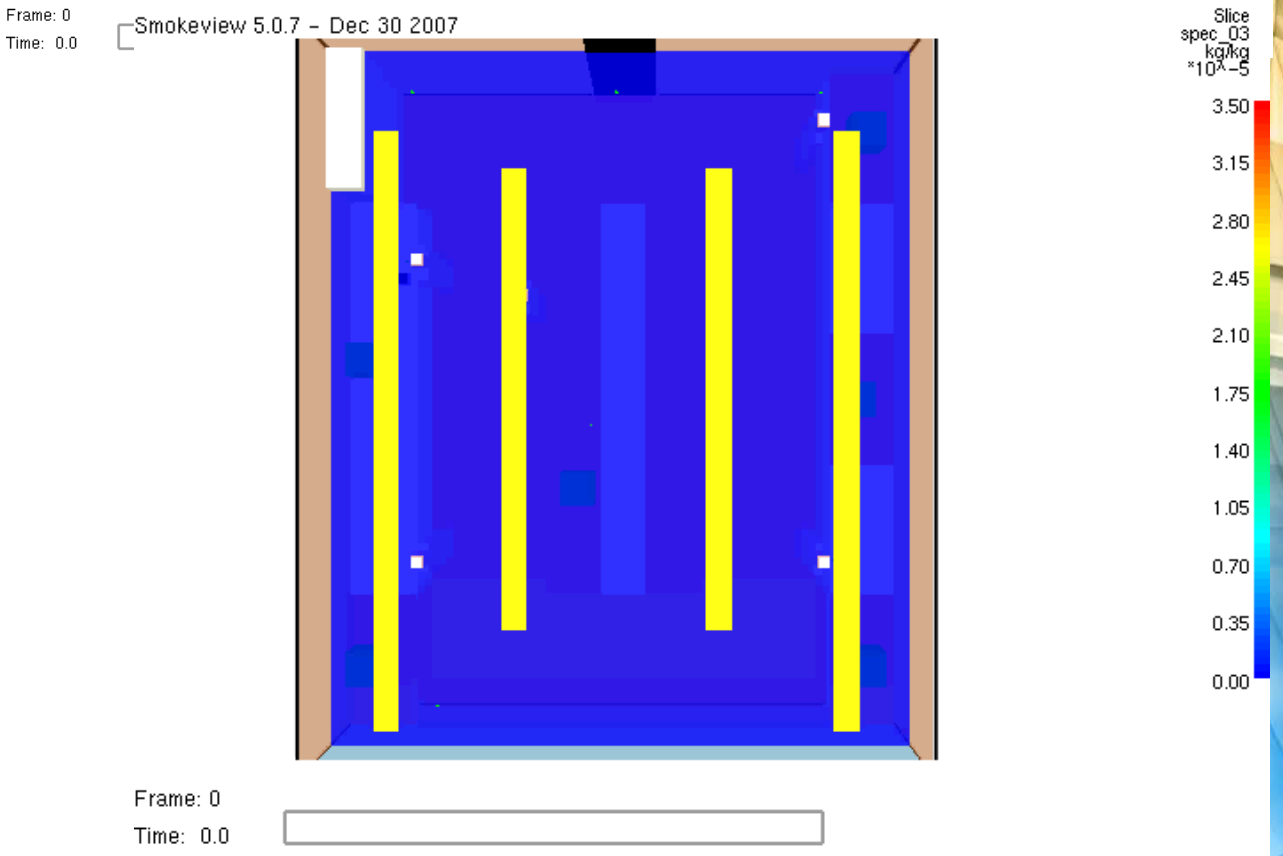
- 6 and 12 ACH
- With and without local extraction controls



Case Study

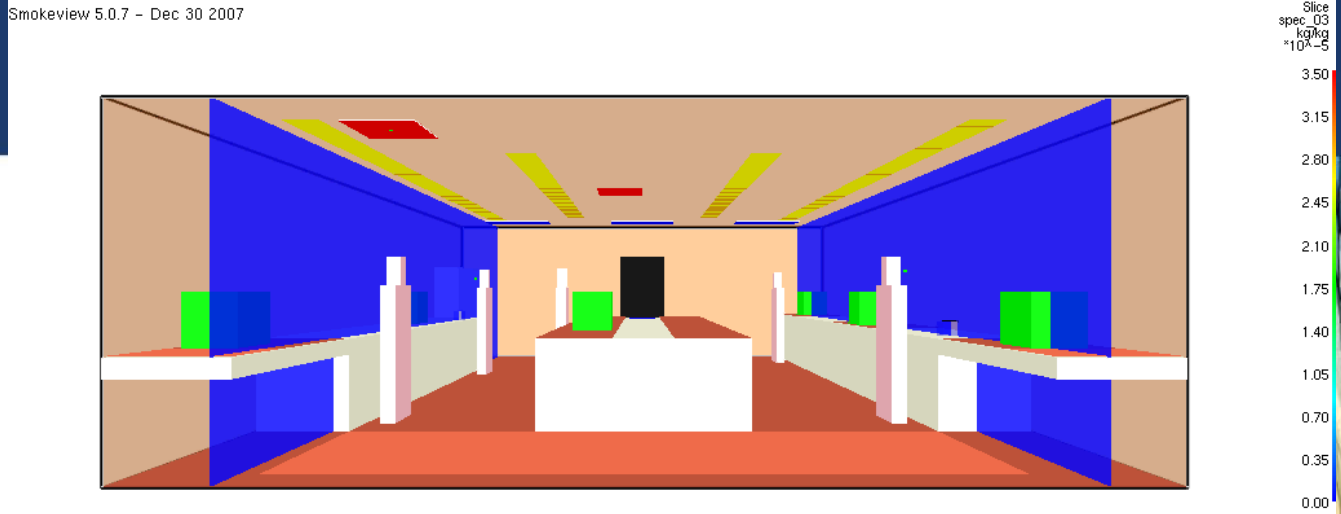
6 ACH
No Controls

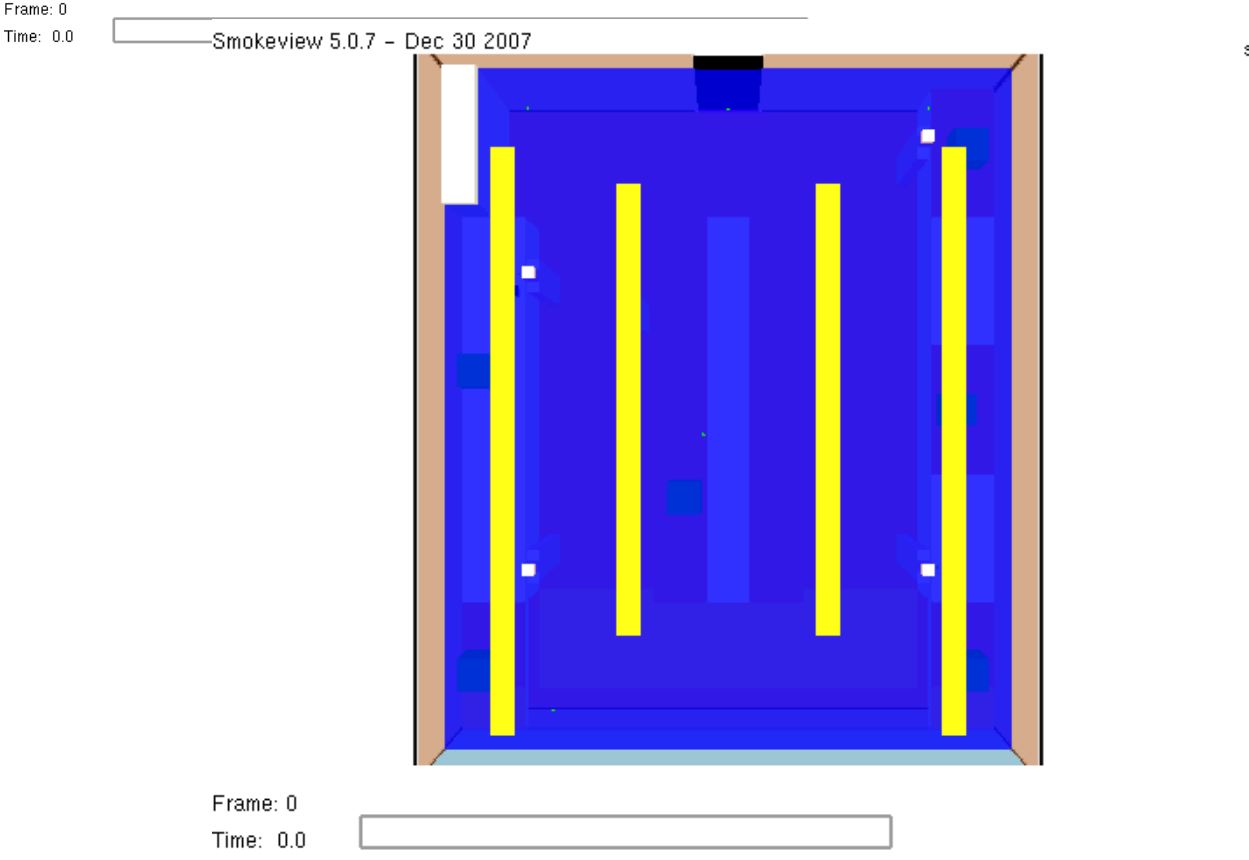




Case Study

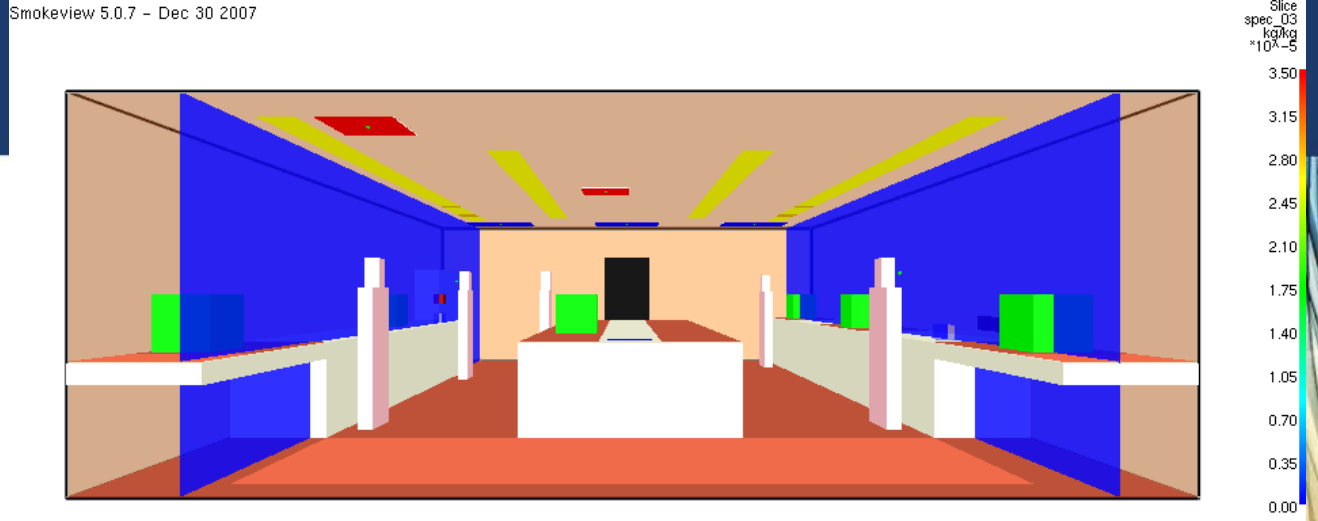
12 ACH
No Controls

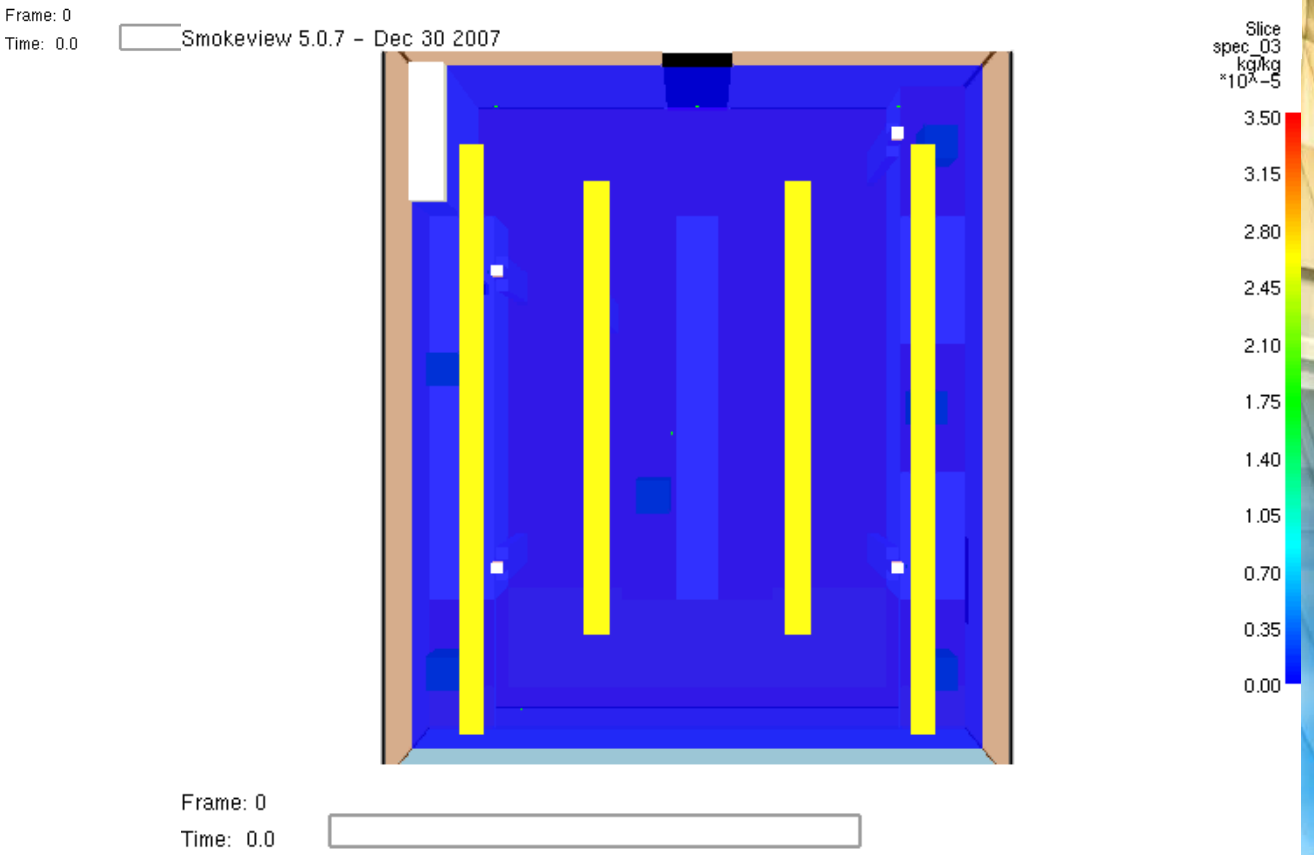




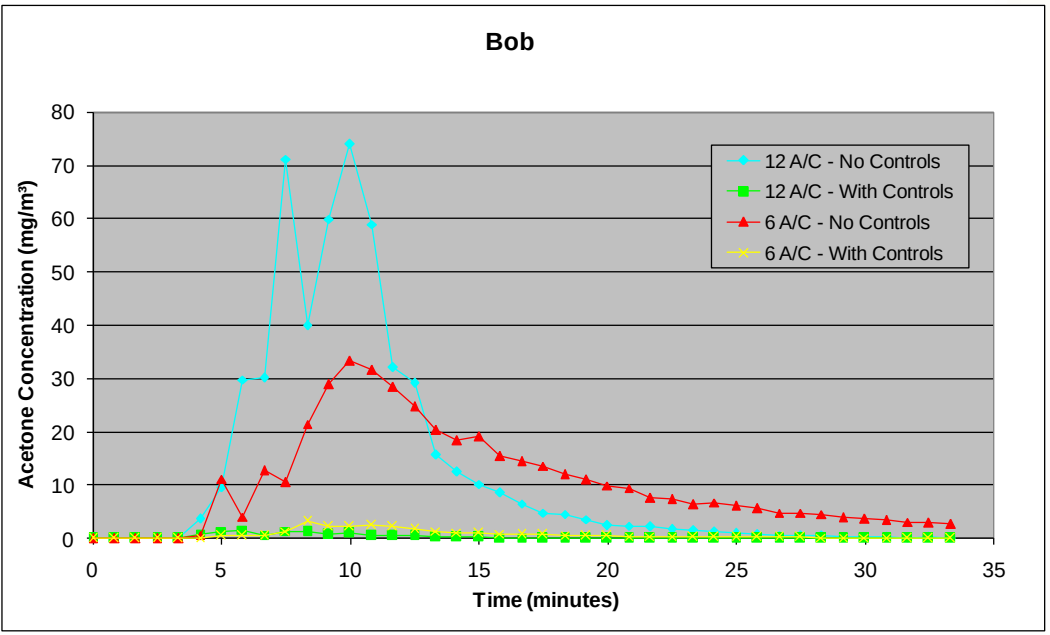
Case Study

6 ACH Controls



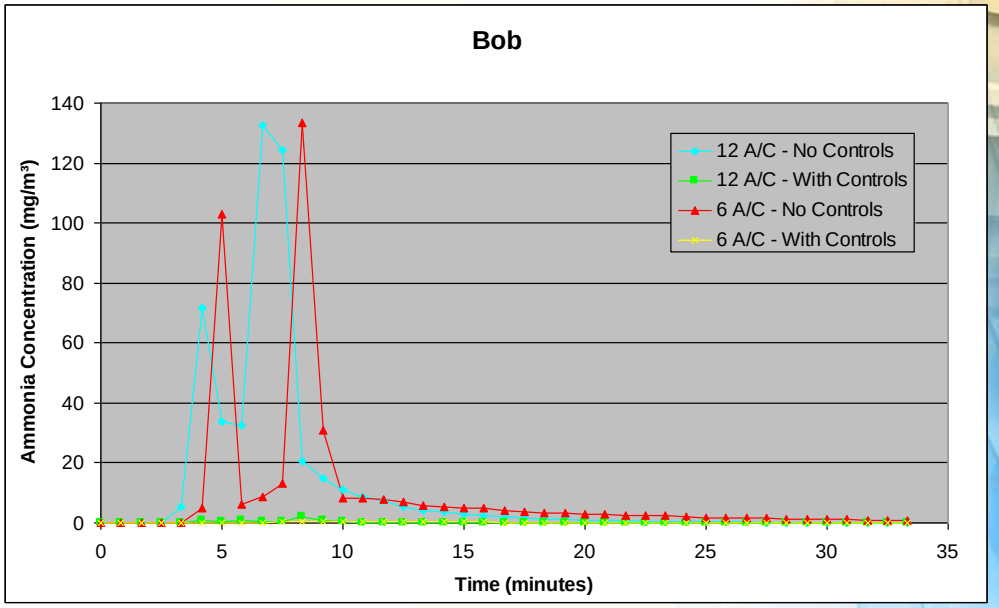


Case Study – Controlling ACH



Acetone

Ammonia

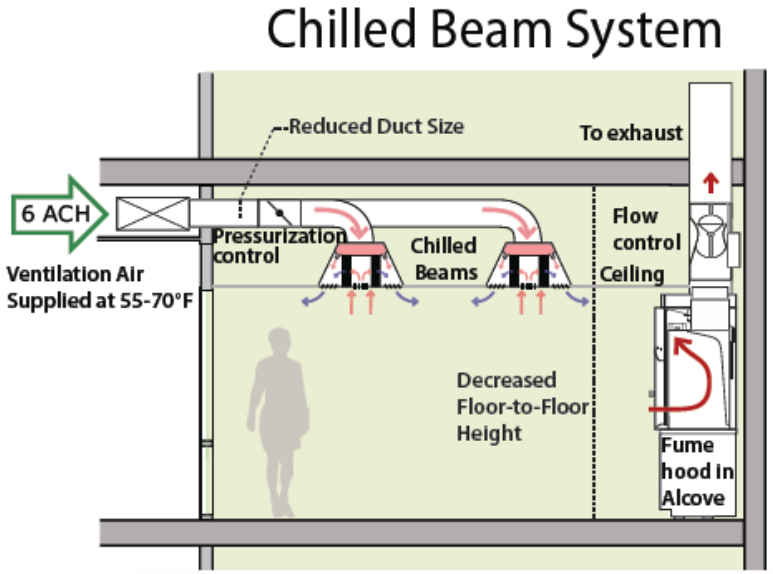


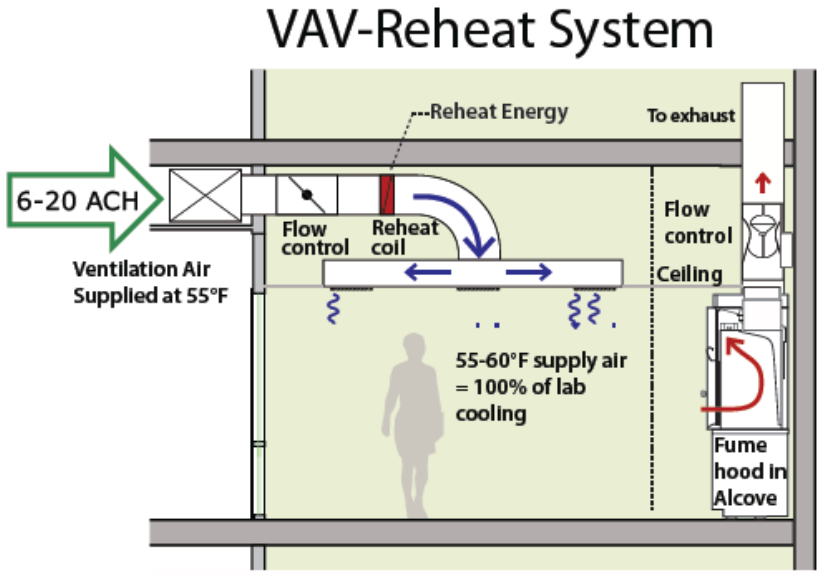
Case Study – Controlling ACH: Conclusions

- Occupant safety/exposure immediately following a chemical release is not affected by air change rate
- Exposure is more a function of the air flow patterns within the room
- Ventilation design strategies, such as supply and exhaust placement can have a much greater influence on recovery from a spill and overall air quality within a lab
- Moderate source control is significantly more effective than larger air flow rates in controlling air quality

Decoupling Heating/Cooling from Ventilation

- Ventilation and Cooling Loads have different driving forces
- Current Practice is often a mechanical system that couples them together (i.e. VAV-reheat)



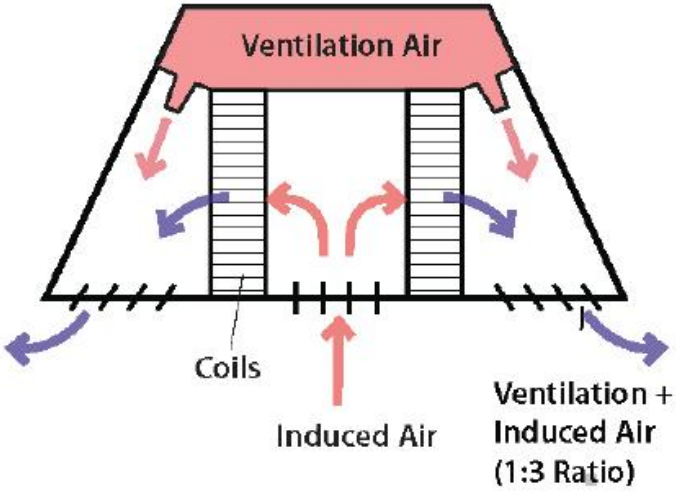


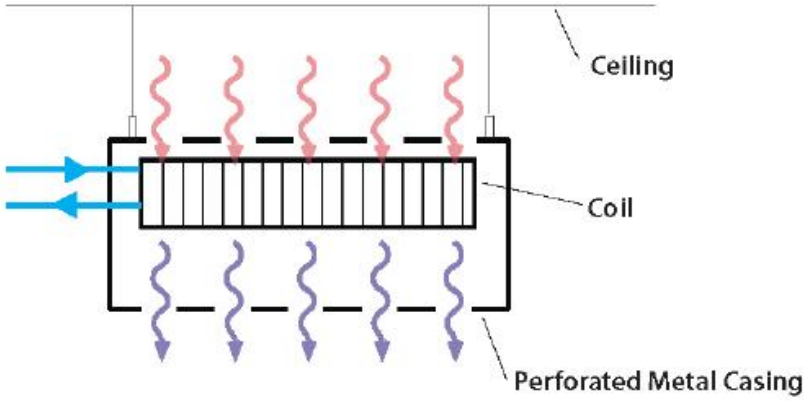
- Separating can significantly reduce energy requirements

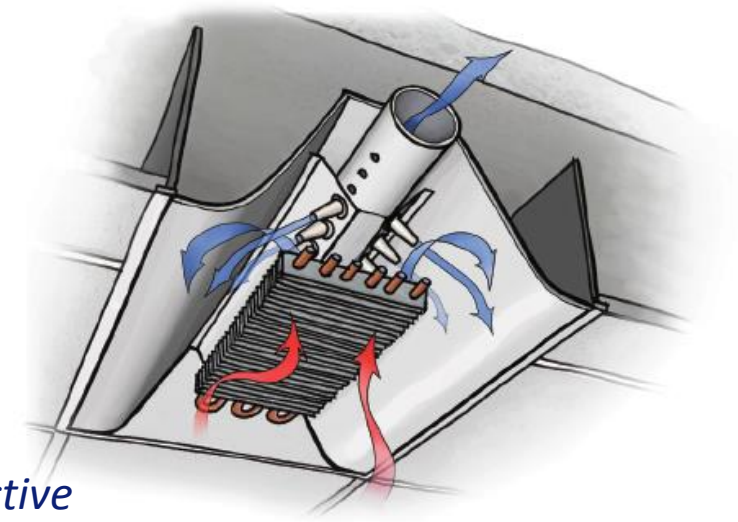
VAV- Variable Air Volume

Images from Labs21 Best Practices Guide: Chilled Beams in Laboratories

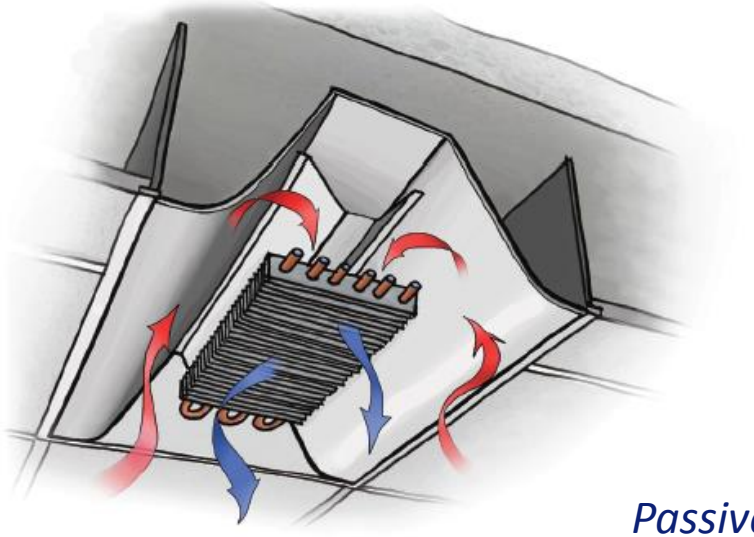
Chilled Beams







Active



Passive

Images from Labs21 Best Practices Guide: Chilled Beams in Laboratories

Chilled Beams

Where can chilled beams be used?

- Ventilation driven design
- Cooling load driven design
- Labs with two or fewer fume hoods

What's the hold up?

- Requires alternative design approach
- Accounting
- Critical mass

Case Study - Chilled Beams

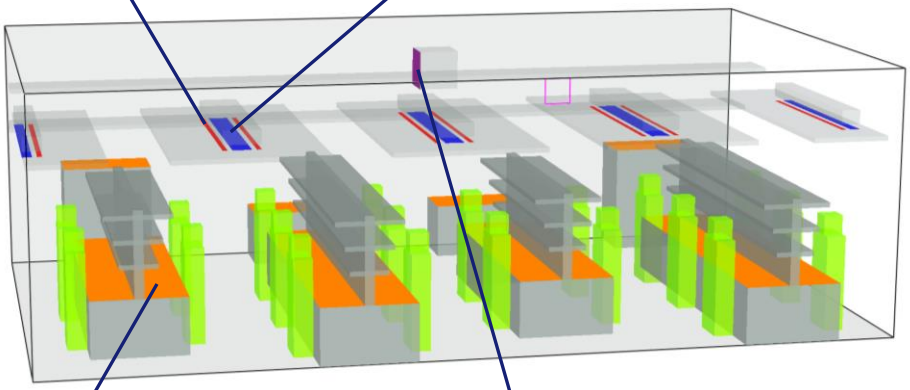
- University Research Lab
  - Cooling requirements driving design
  - No fume hoods
- Concern was drafts in occupied zone
- CFD used to analyze risk of drafts and performance

CFD –Computational Fluid Dynamics

Case Study - Chilled Beams

Supply Air (Chilled Beam)

Induced Air (Chilled Beam)

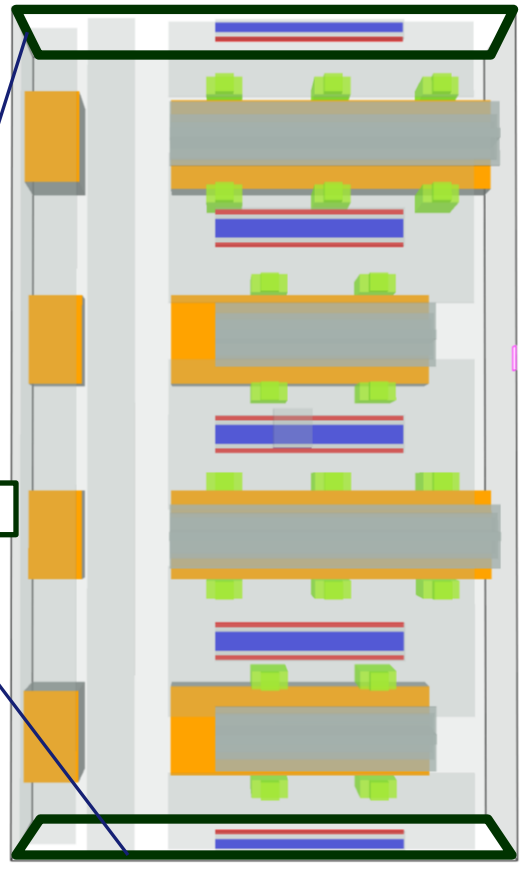


Exhaust Air

Heat gain
Lighting and Equipment

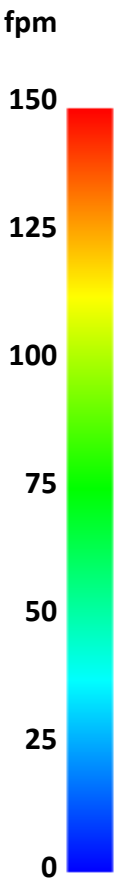
Summer Target Space Temperature
T=74 °F

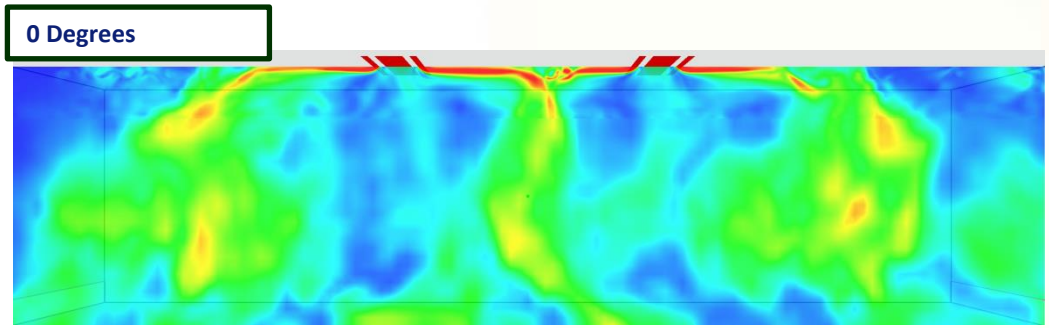
Symmetry Planes



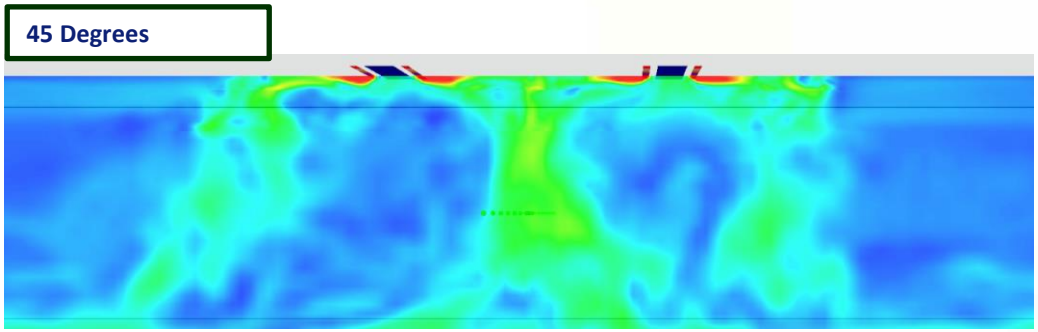
Top view

Case Study – Chilled Beams: Evaluating Conditions





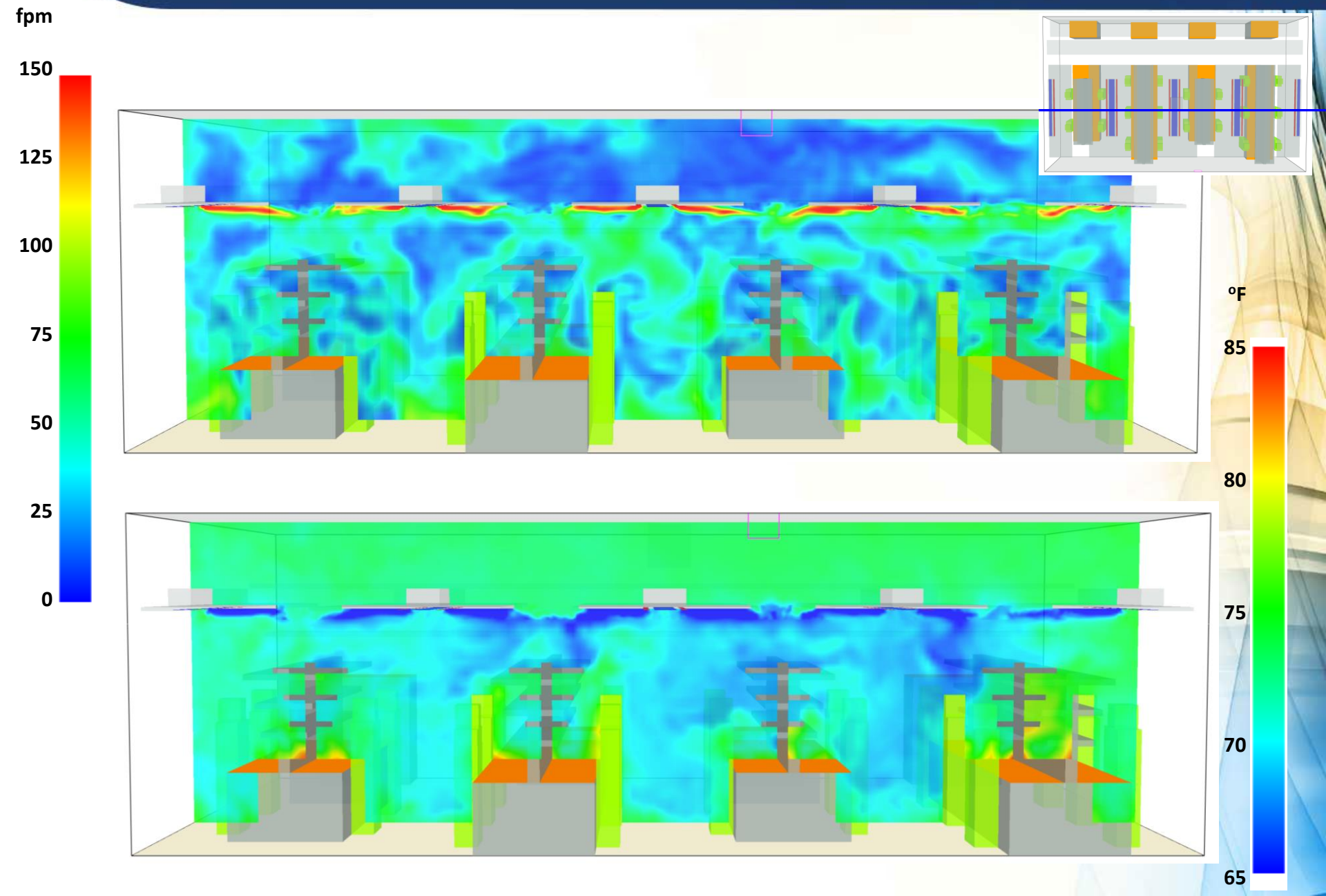
Primary Flow Rate = 250 CFM, Induction Ratio =3 (each beam)



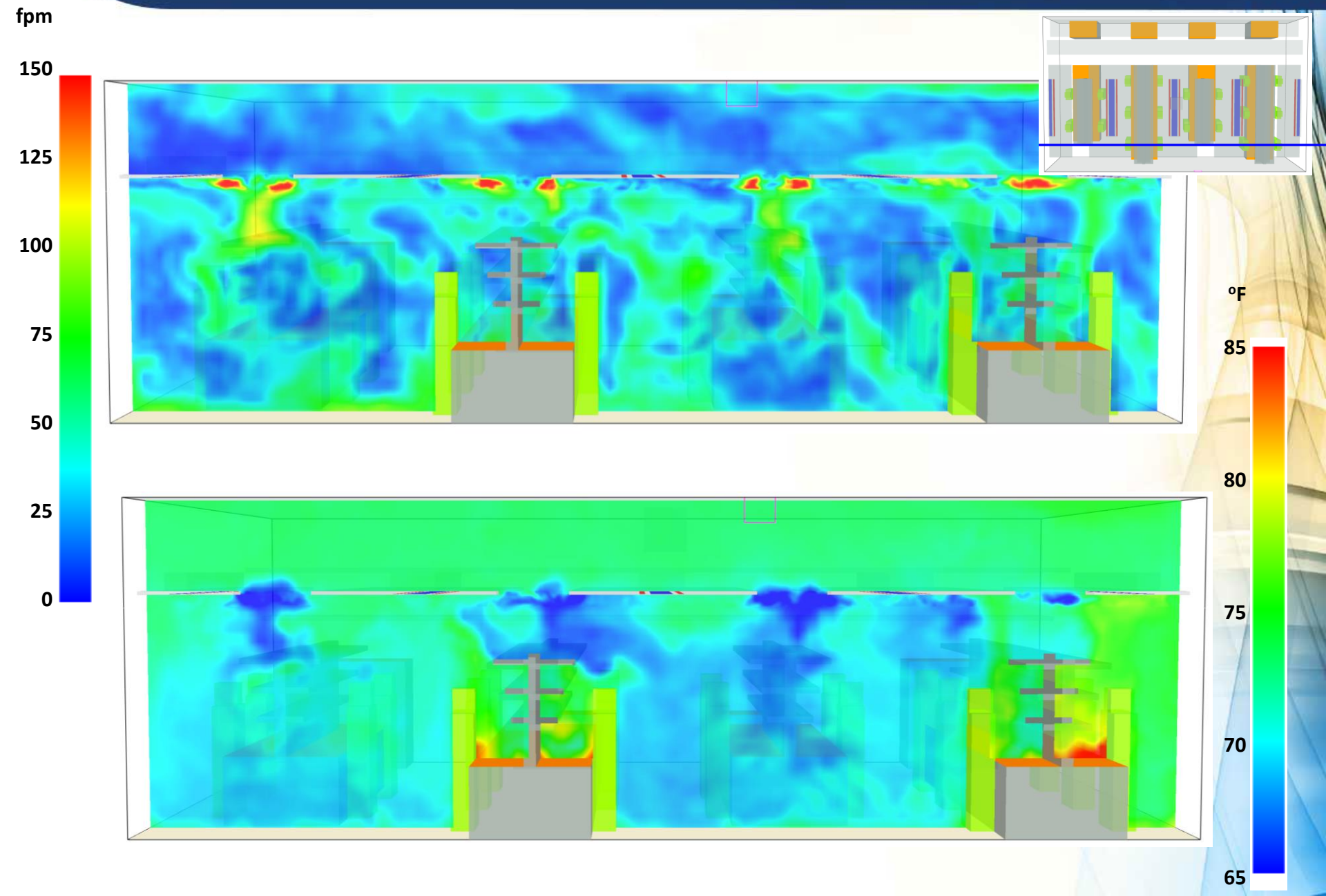
Primary Flow Rate = 250 CFM, Induction Ratio =3 (each beam)

CFM- Cubic feet per minute

Case Study - Chilled Beams: Evaluating Conditions



Case Study - Chilled Beams: Evaluating Conditions

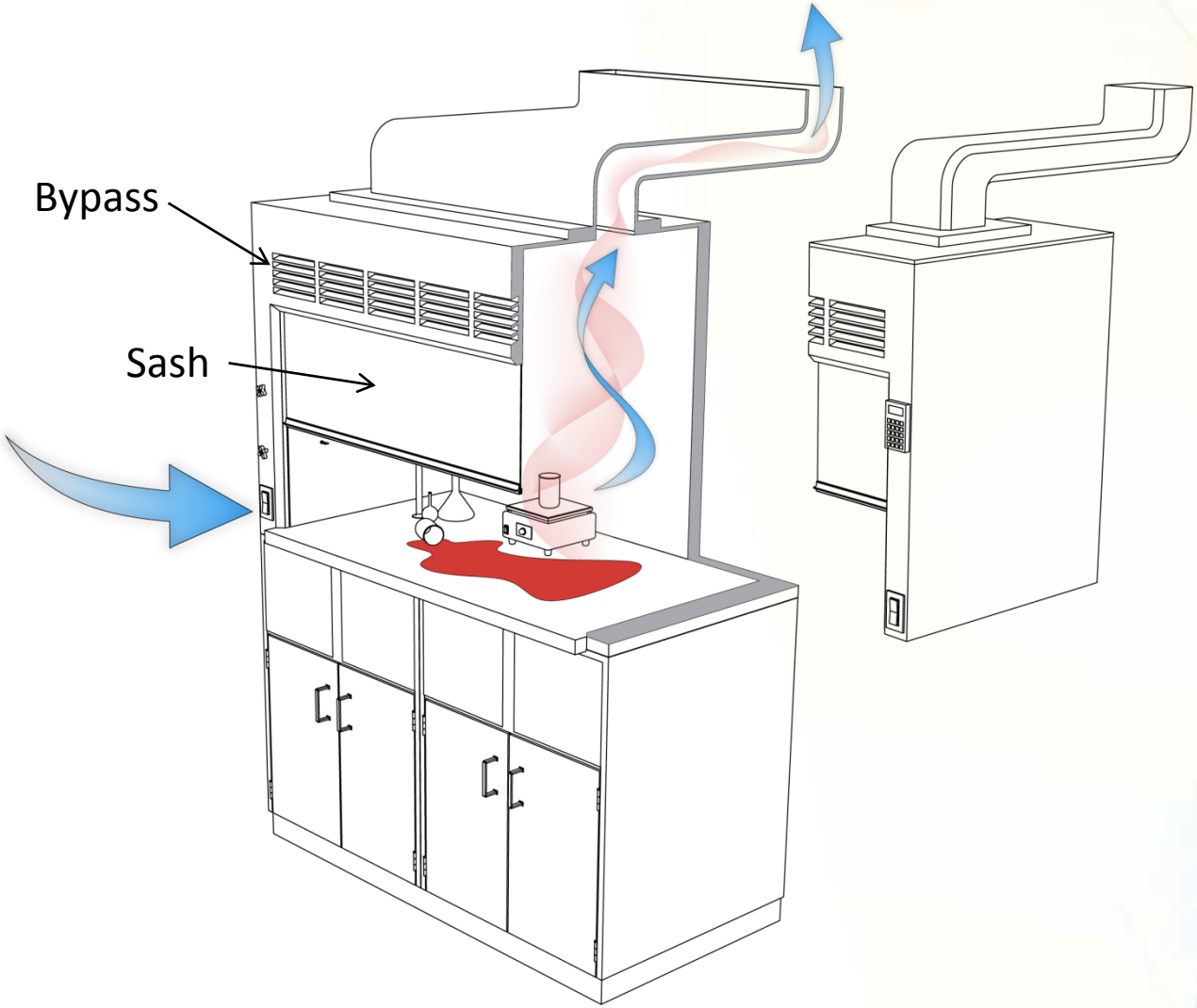


Case Study - Chilled Beams: Results

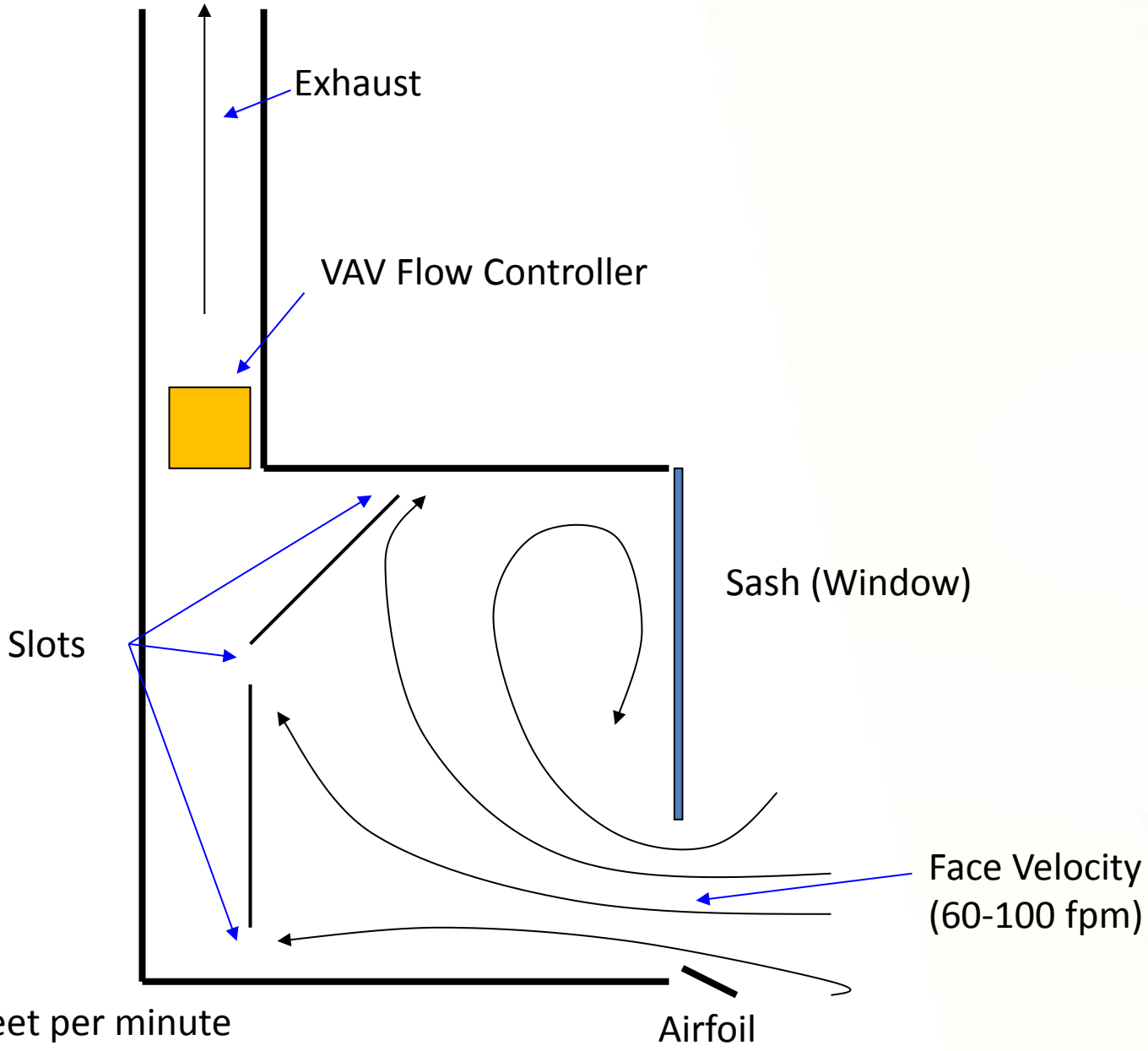
- Average Space Temperature = 74 ˚F
- Comfortable environment for occupants
- Chilled beams provided 230 CFM vent air and 480 CFM induced air
- Reduction in air quantities offered substantial savings!

CFM- Cubic feet per minute

Fume Hoods



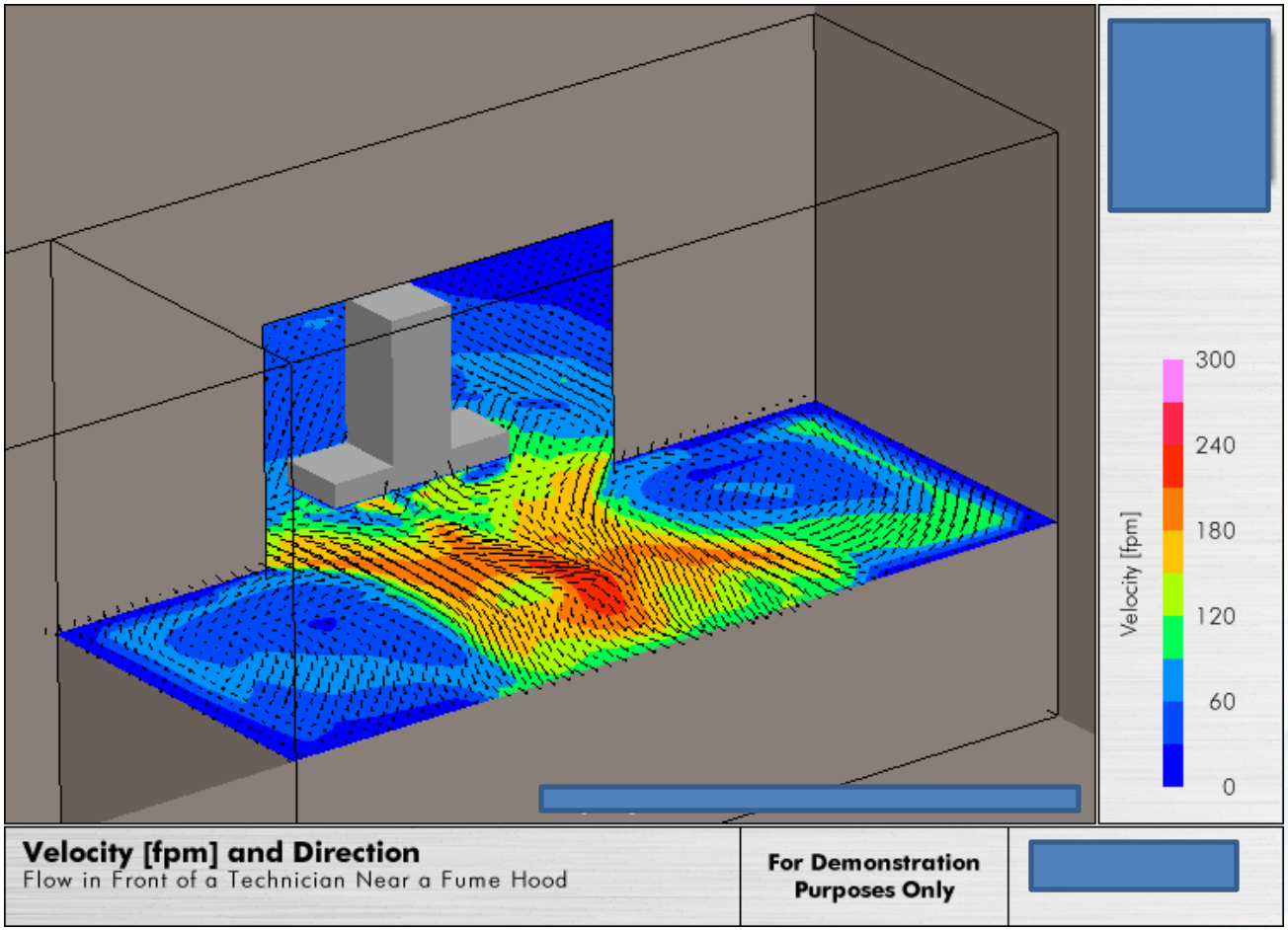
Fume Hoods –Variable Air Volume (VAV)



FPM- Feet per minute

Fume Hoods – High Performance

- Similar to Continuous Air Volume (CAV), but operate at reduced velocity
- Performance based



Other Strategies

- Controls:
  - Occupancy control
  - Demand control
  - Hazardous banding control
  - Task ventilation control (localized exhaust ventilation)
- Energy Recovery
- Manifolding and ducting
- Alternative HVAC systems(e.g. fan coil or dual-duct)

Closing Thoughts

- Intent of the Space
- Driving Force
- Implement High Performance Ventilation:
  - Controlling ACH
  - Decoupling Heating/Cooling from Ventilation
  - Fume Hood Selection
  - Others

Thank you for your time.

Questions?

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