CFD Applications in Building Design and Planning

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Outline

- Background

  What, why, and how
- Indoor Applications

  Balcony Case
- Outdoor Applications

  Flow around building
- Conclusion

What is CFD?

- Computational Fluid Dynamics
- Divide a space into fine cells
- Predict the fluid motion under certain boundary conditions

What does CFD do?

- Airflow Distribution
- Temperature profile
- Contaminant Transport
- Thermal comfort

Why using CFD?

Existing methods to study fluid dynamics:

- Analytical or simple empirical models

  Not applicable for complex problems
- Full or reduced scale model Experiments

  Expensive, time consuming
- Numerical Methods (CFD)

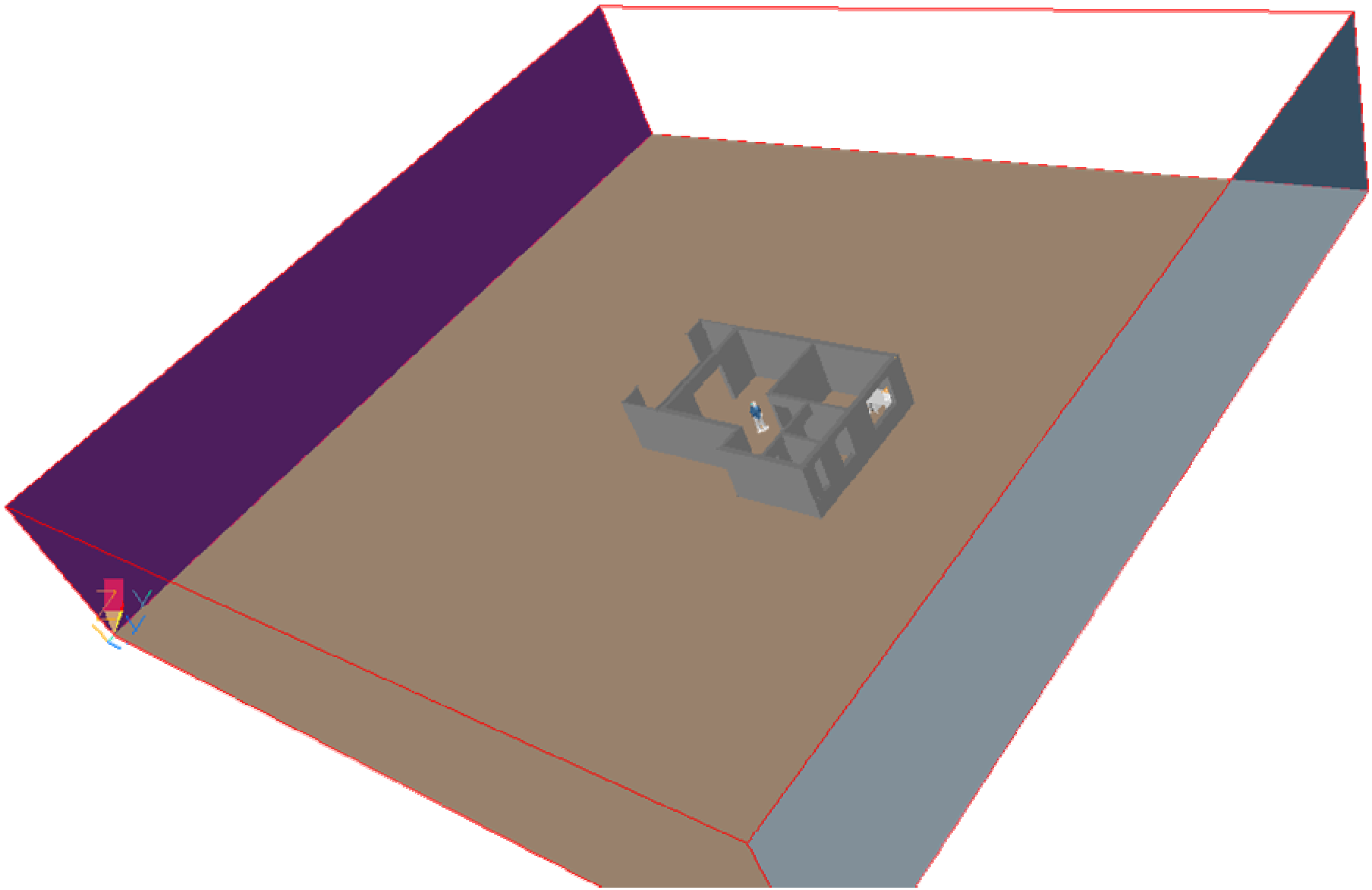
  Inexpensive, fast

How does CFD work?

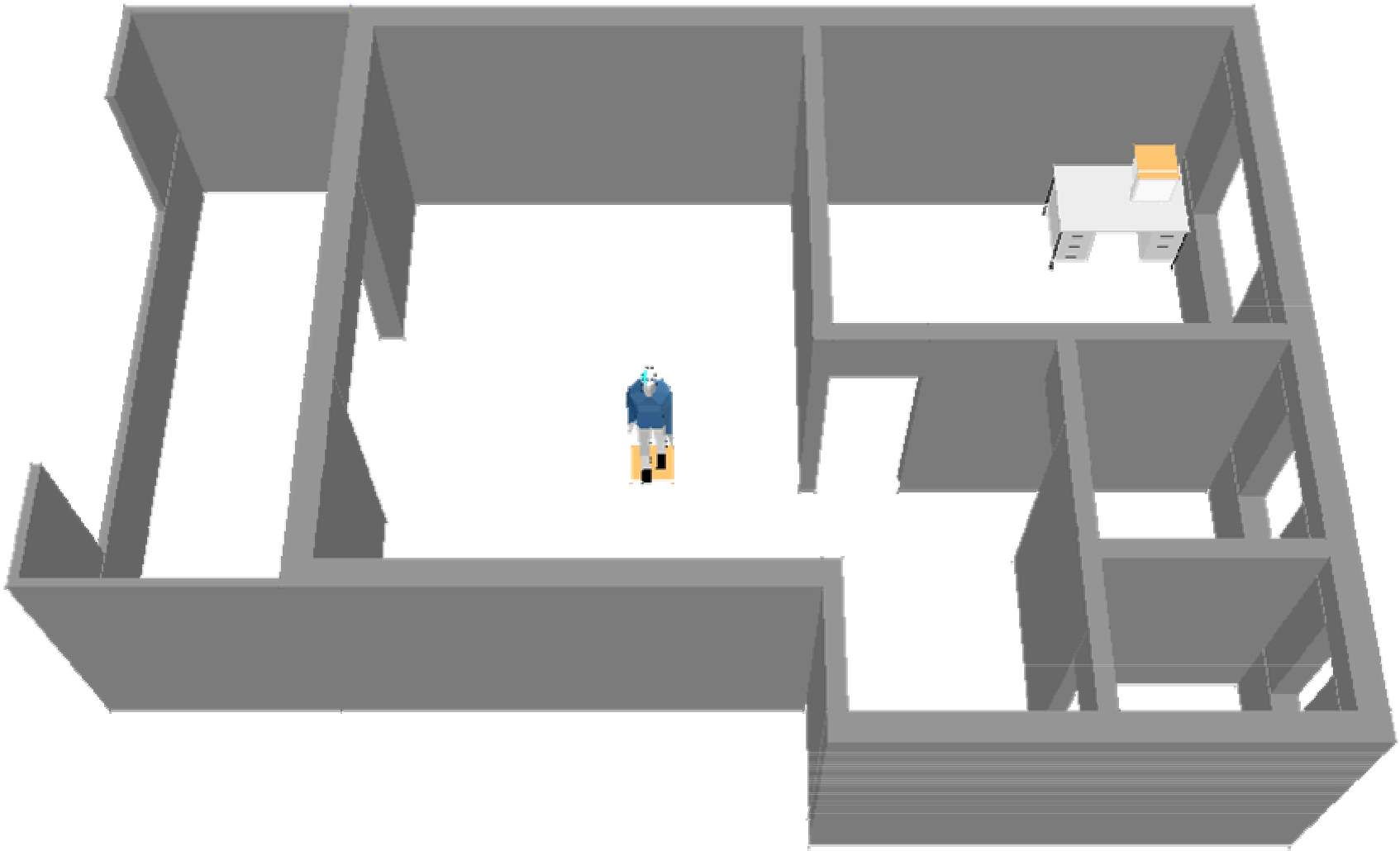
- Geometry input
- Boundary condition
- Preprocessing
- Calculation
- Post processing

Balcony Case

Geometry – Calculation Domain



Geometry – Interior Layout



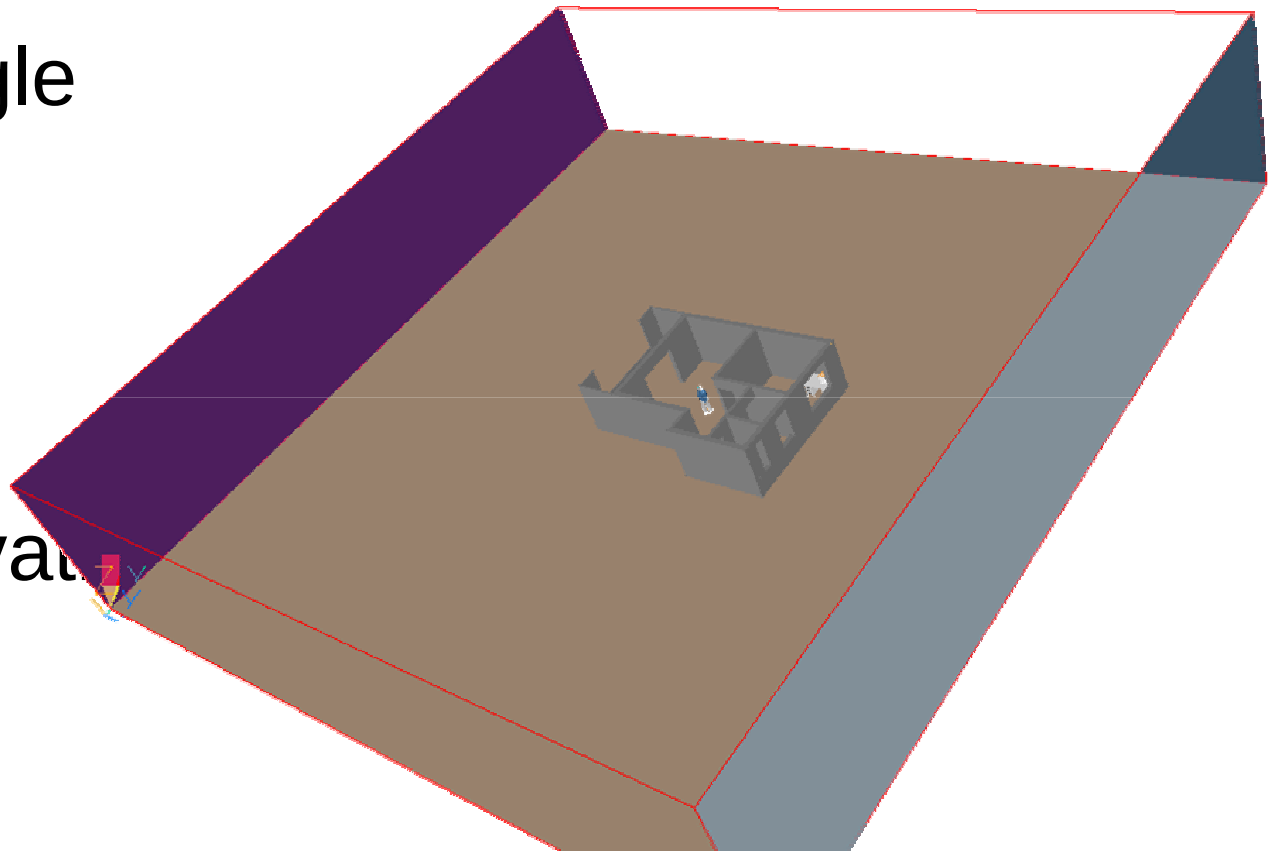
Boundary Conditions - Wind

- Wind direction

  0 incident angle
- Wind velocity

  2.0 m/s
- Outlet

  mass conservat



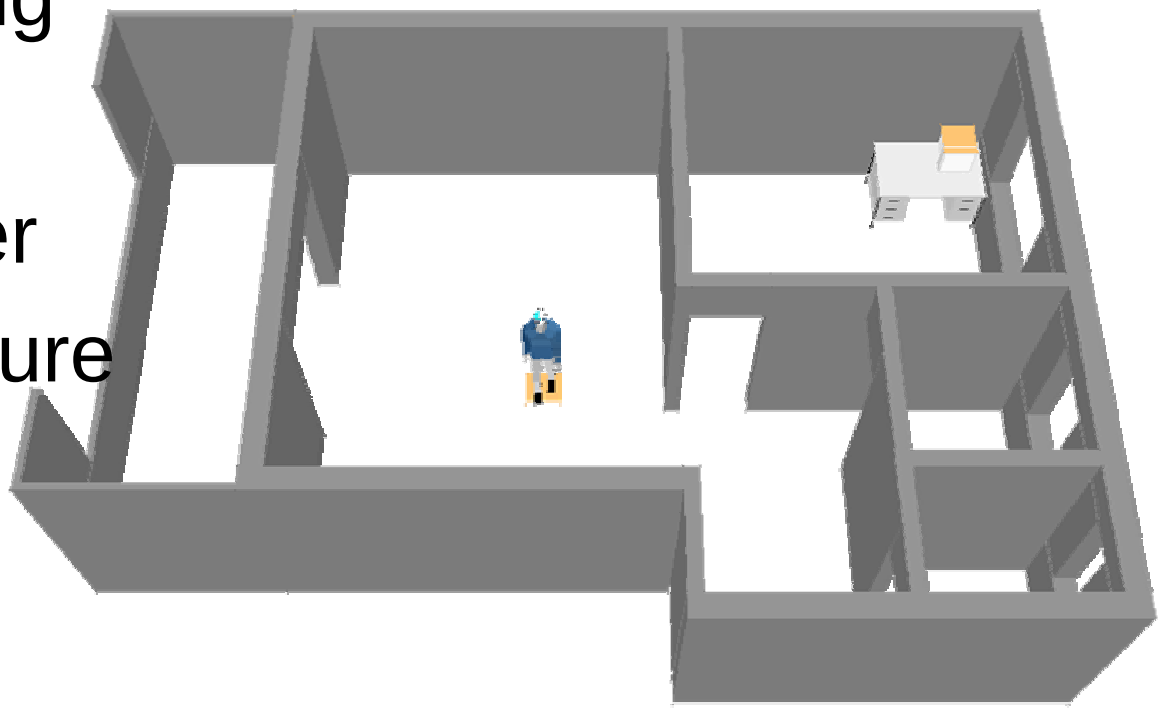
Boundary Conditions – Thermal

- Adiabatic

  Wall, Floor, Ceiling
- Heat source

  Human, Computer
- Surface temperature

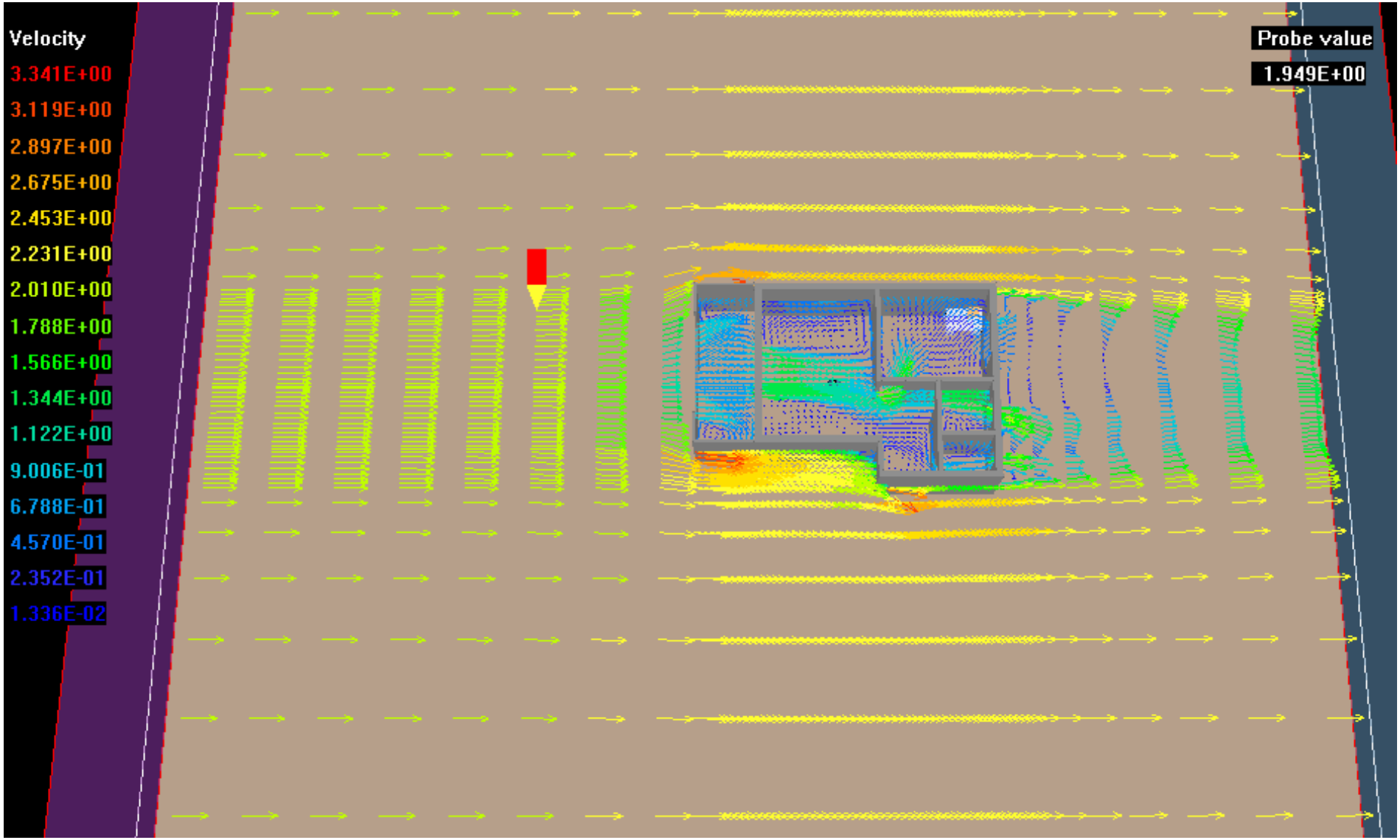
  Wall



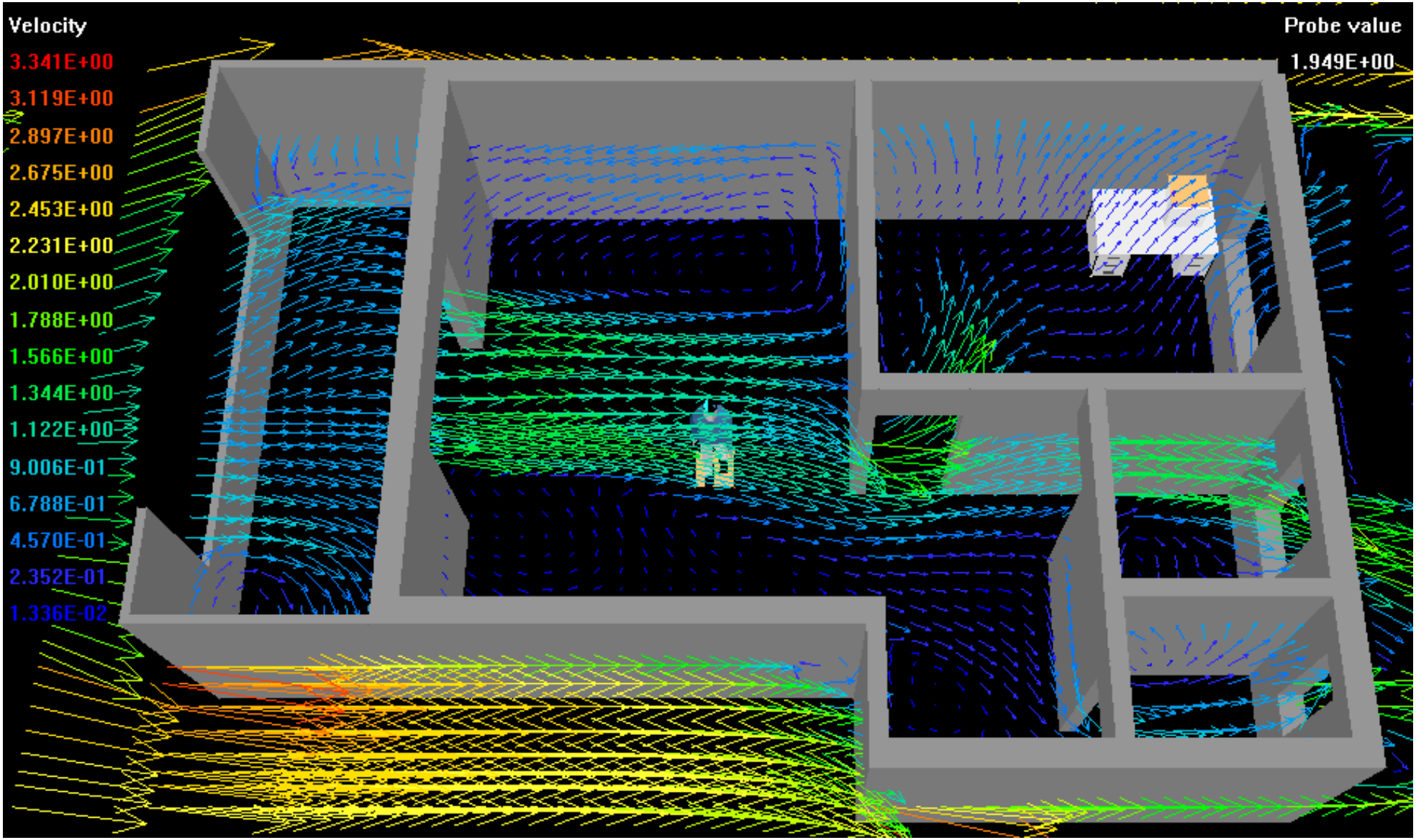
Numerical Settings

- Initial guess value
- Iteration control
- Relaxation control
- Output selection

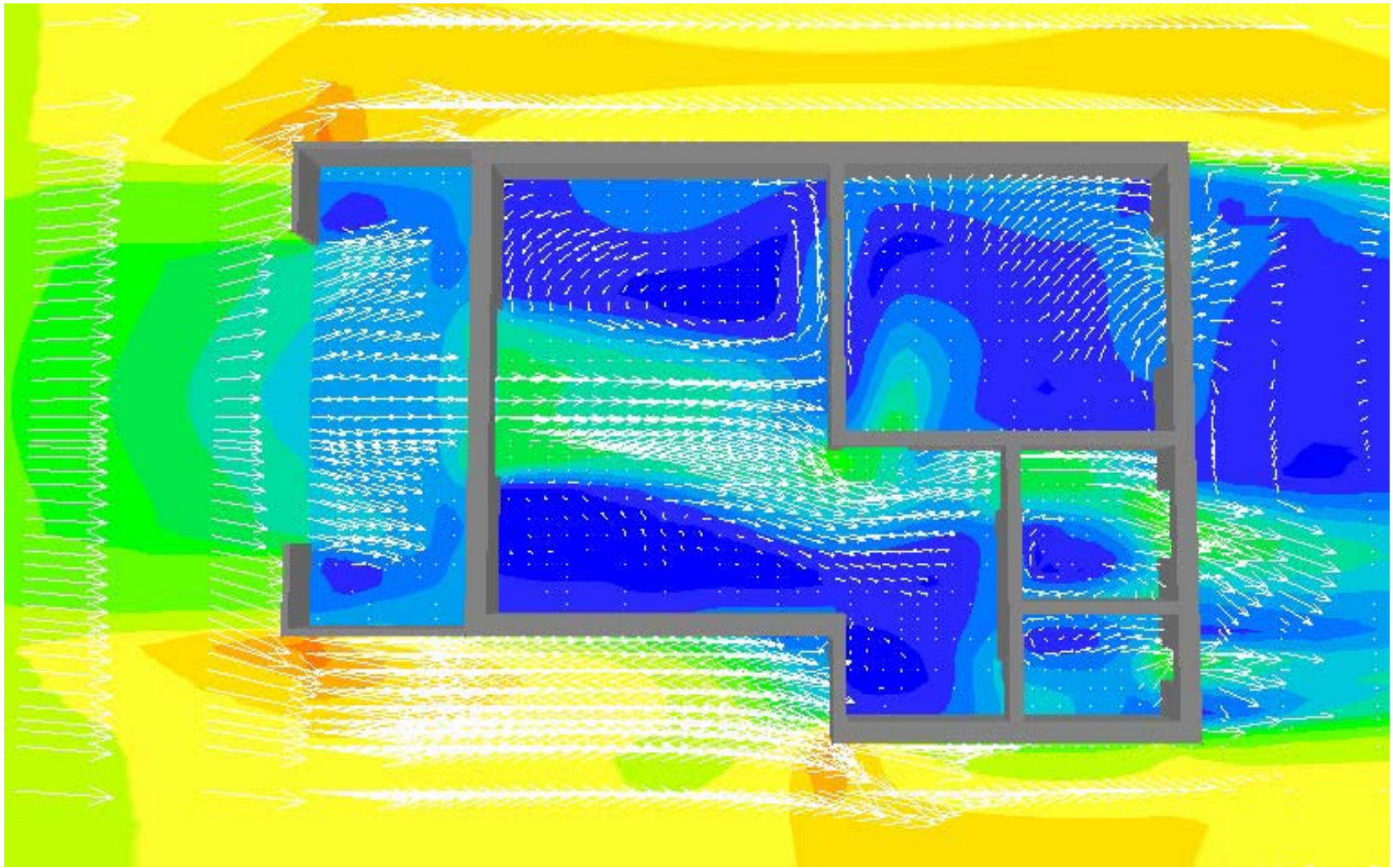
Result – Velocity (Aerial)



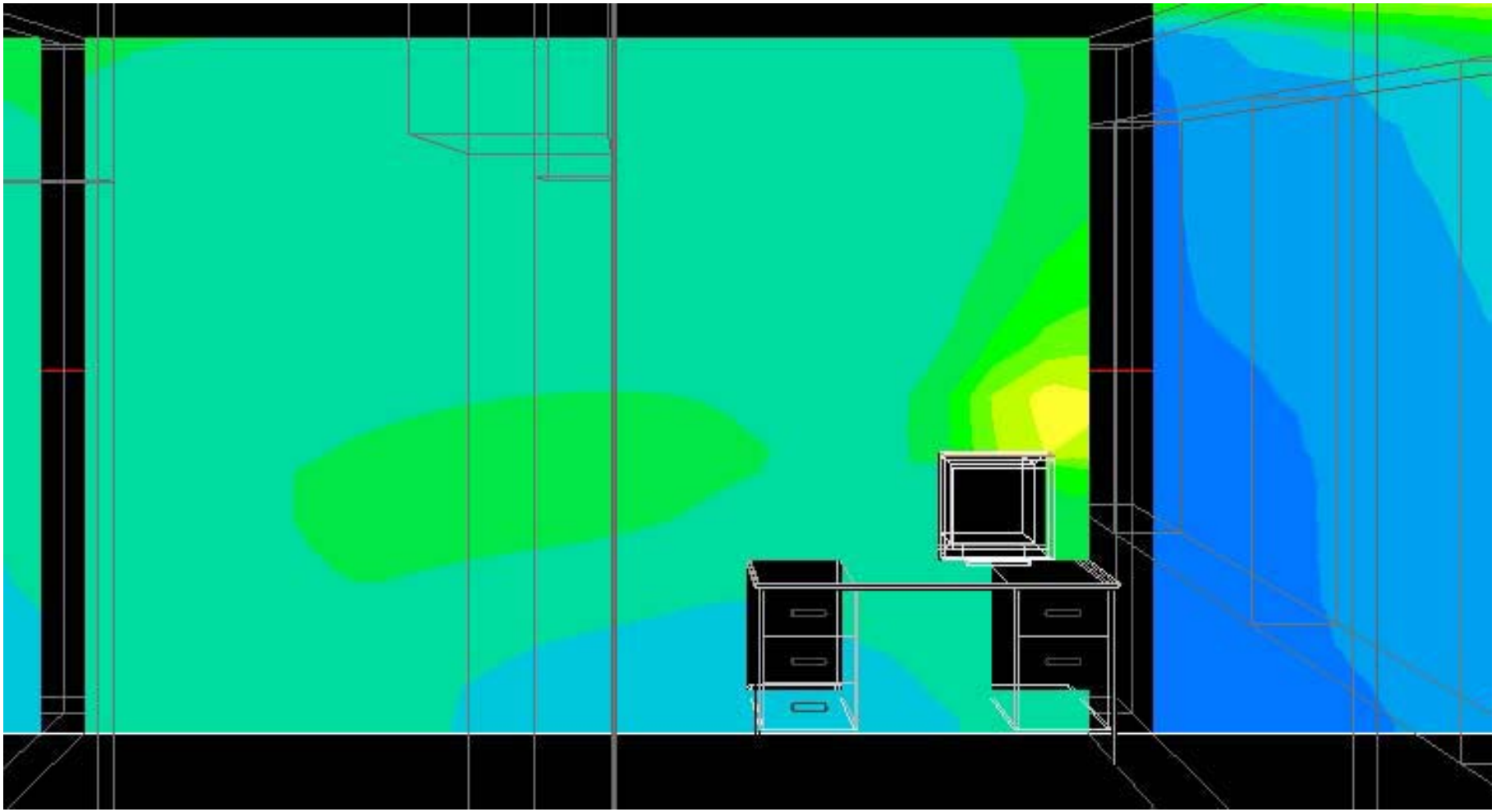
Result – Velocity (Interior)



Result – Flow Visualization



Result – Temperature

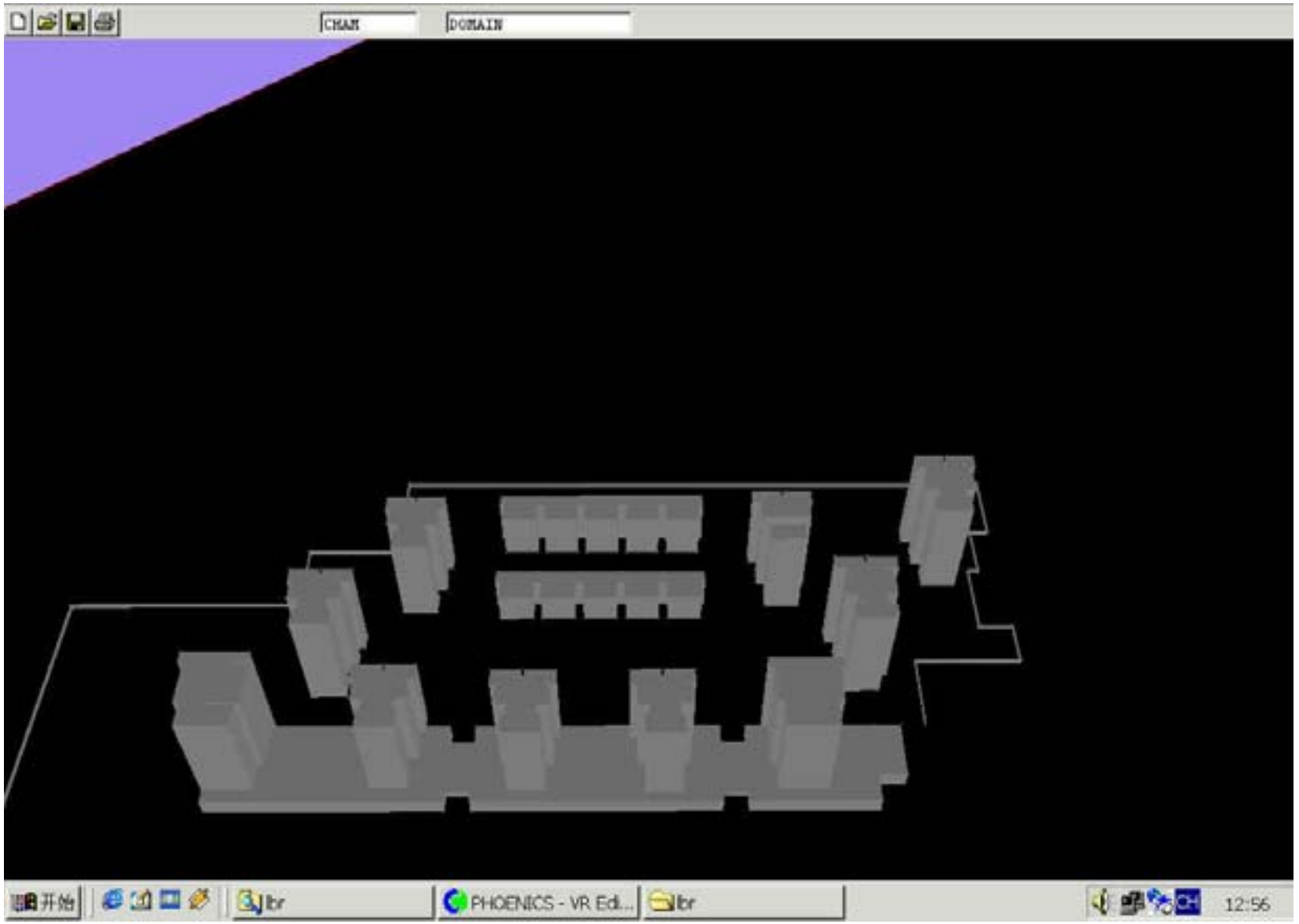


Outdoor Airflow

Outdoor Comfort Concept

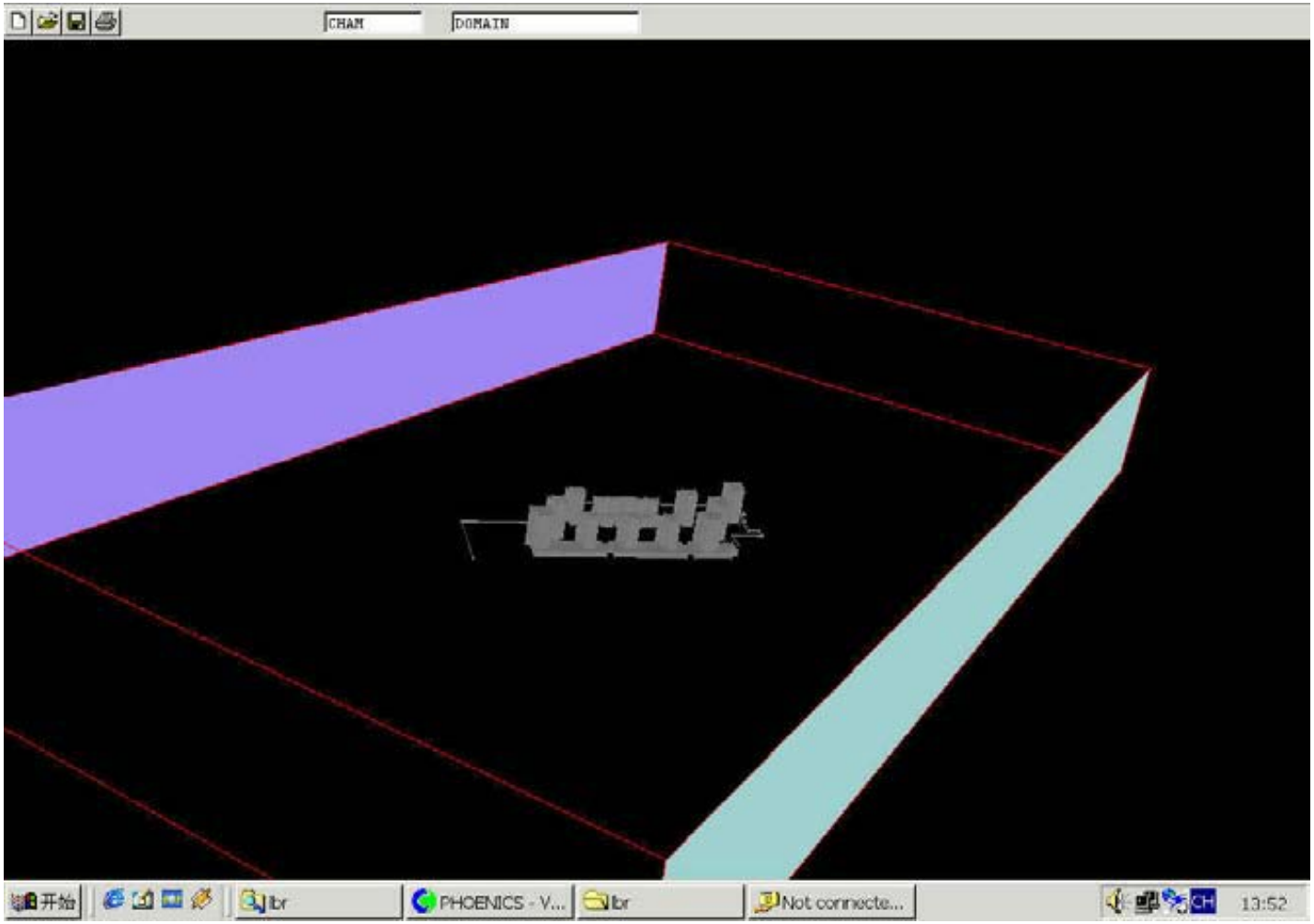
Beaufort No.	Description	Wind Velocity (m/s)	Wind Effect
2	Light breeze	1.6-3.3	Wind felt on face
3	Gentle breeze	3.4-5.4	Hair disturbed
4	Moderate breeze	5.5-7.9	Raise dust and loose paper
5	Fresh breeze	8.0-10.7	Wind force felt by body
6	Strong breeze	10.8-13.8	Umbrellas used with difficulty
7	Near gale	13.9-17.1	Inconvenience felt when walking
8	Gale	17.2-20.7	Generally impedes progress
9	Strong Gale	20.8-24.4	People blown over

Case - Lanqiying



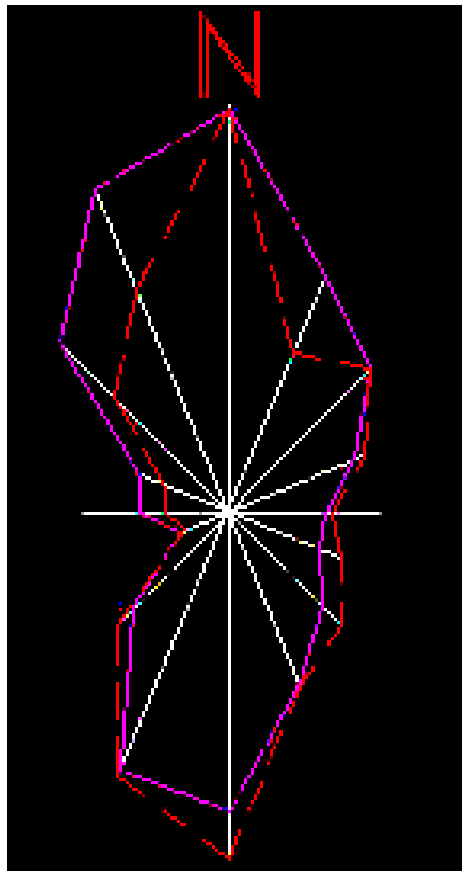
Calculation Domain

- Including all the buildings
- 3 times in width and length
- 5 times in height direction

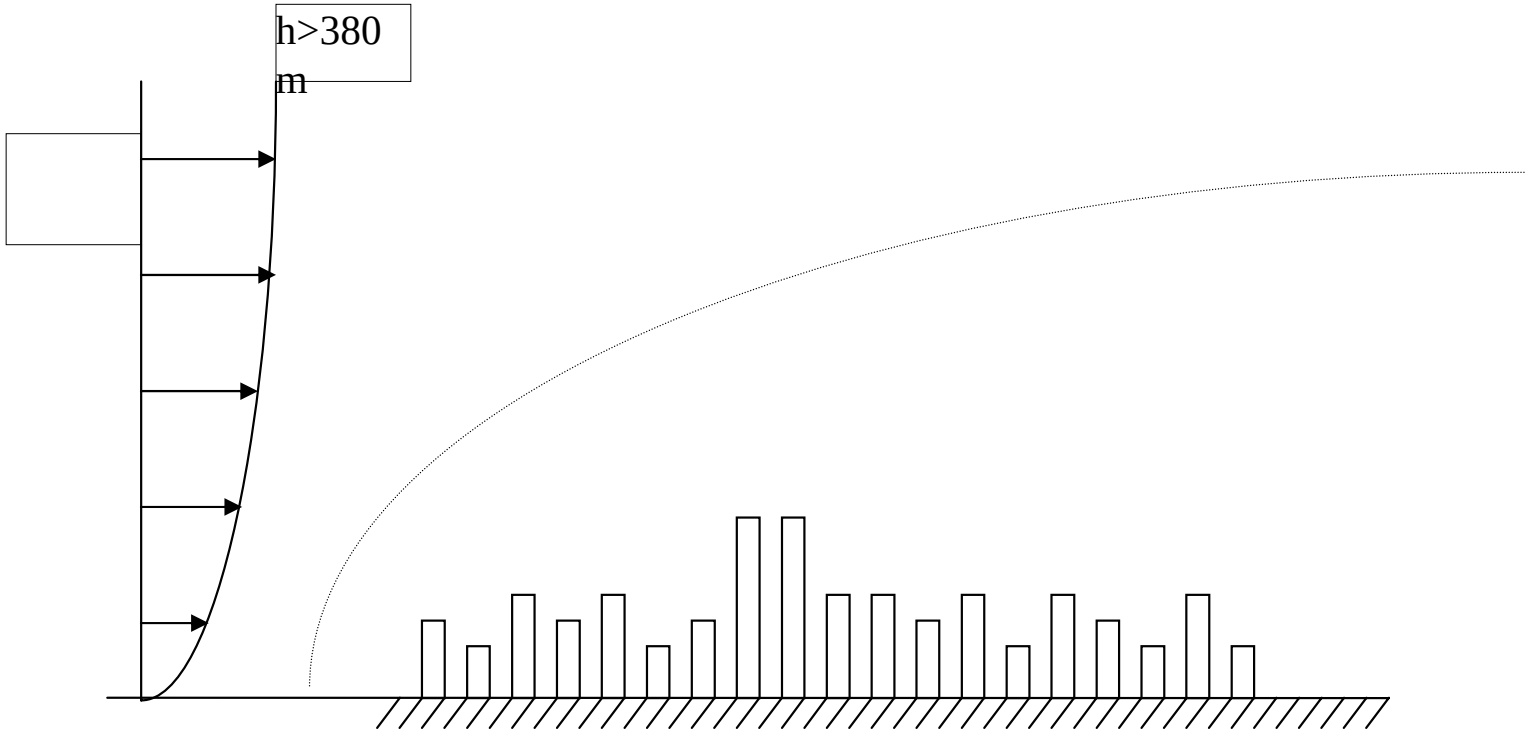


Boundary Conditions - Wind Direction

- Whether data in Beijing 1960-1990
- Wind Rose
- Fall & Winter – North and Northwest Average velocity 3m/s, frequent 5m/s
- Spring & Summer – South and Southwest Average velocity 5.5m/s



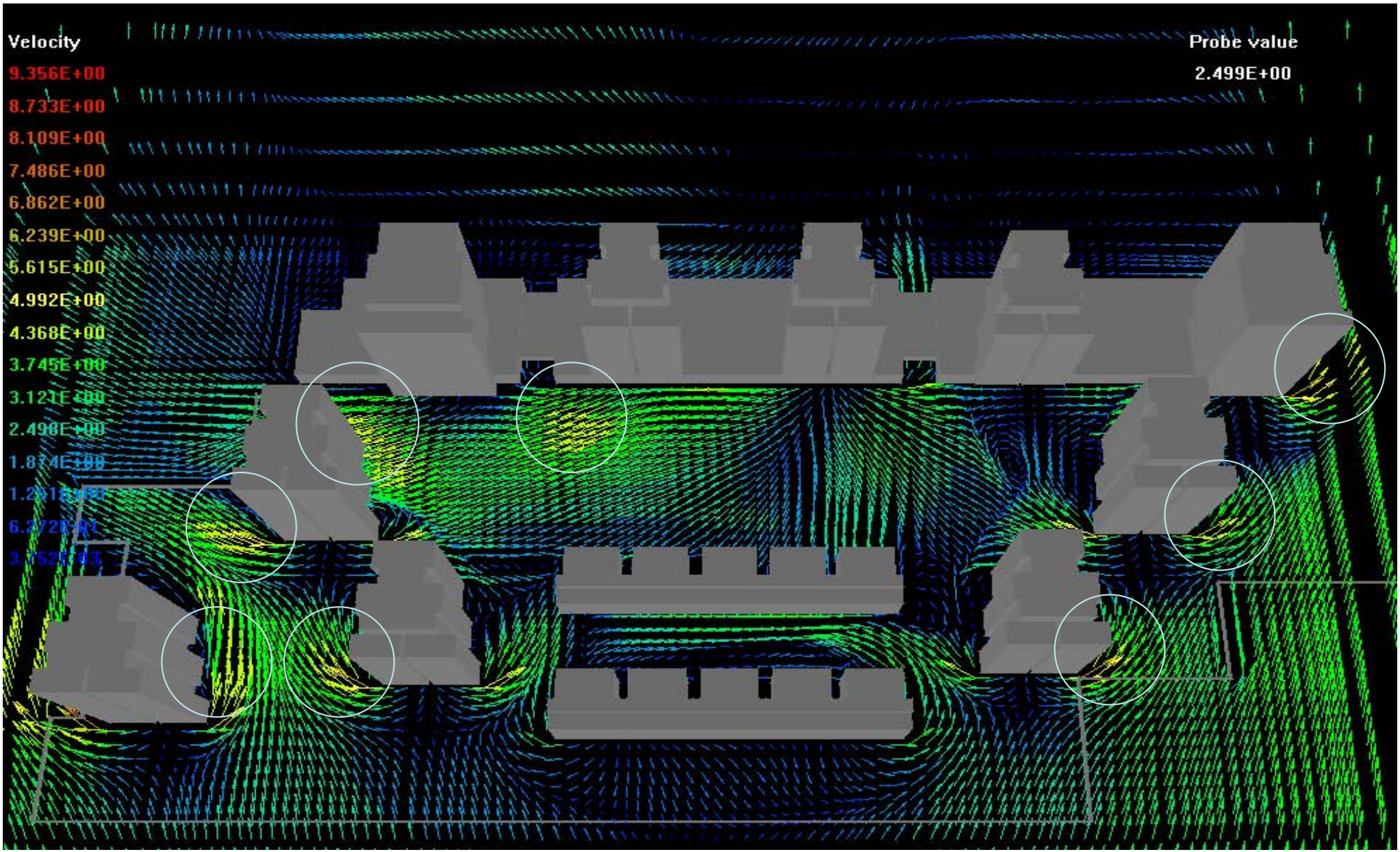
Boundary conditions – Wind profile



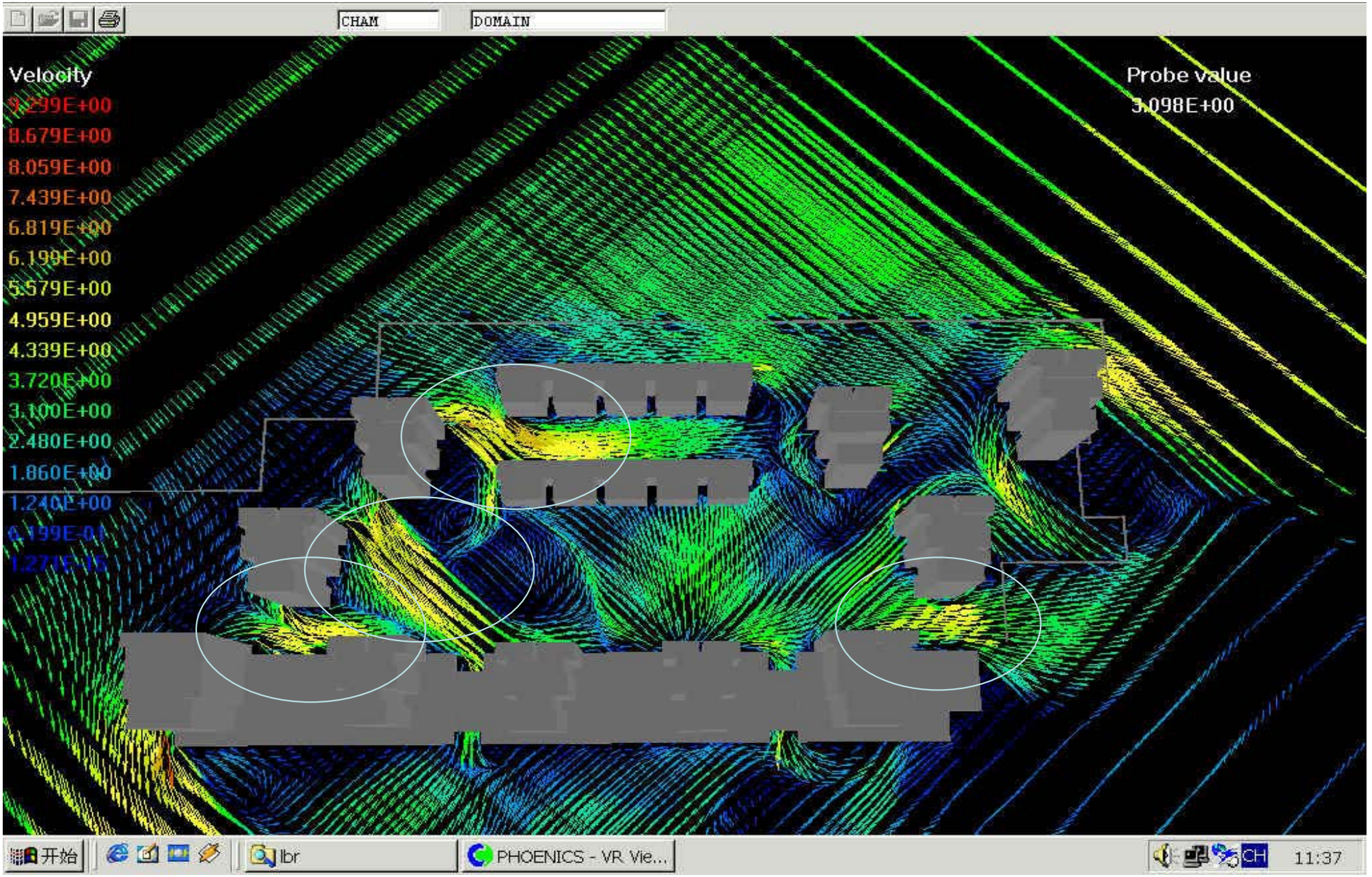
$$\frac{U}{U_g} = \left(\frac{Z}{Z_g} \right)^{0.28}$$

Z 10m U 5m/s

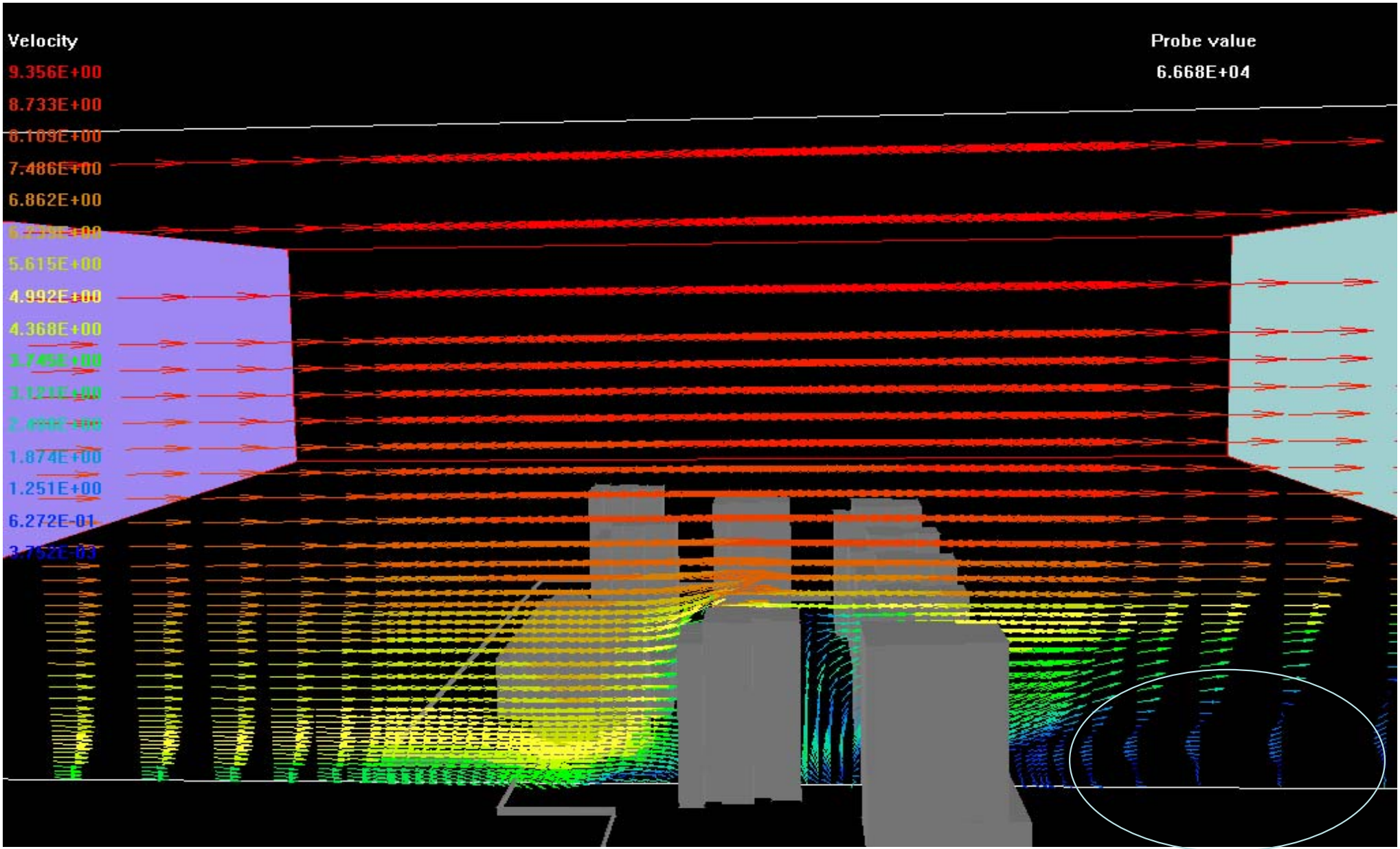
North Wind (1.5m above the ground)



Northwest wind, 1.5m



Vertical Distribution



Conclusion

- CFD is a fast and reliable tool for building analysis
- CFD can predict parameters such as Flow, temperature, CO2 concentration in great details
- CFD can be widely used to guide ventilation system design and building planning.

The END

Thanks!