Linköpings universitet
INSTITUTE OF TECHNOLOGY

On the performance of the Stravent ventilation system in an office space

Numerical and experimental investigations

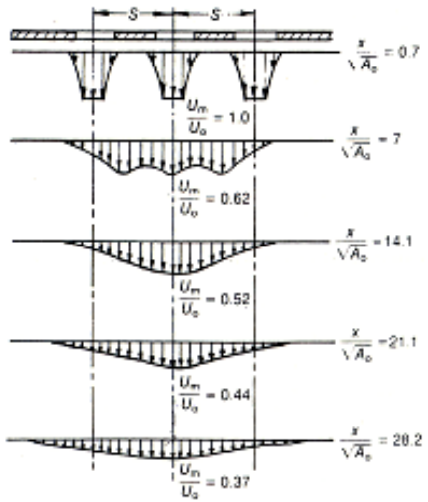
PhD student Setareh Janbakhsh
Professor Bahram Moshfegh
Linköping University and University of Gävle

UNIVERSITY OF GÄVLE

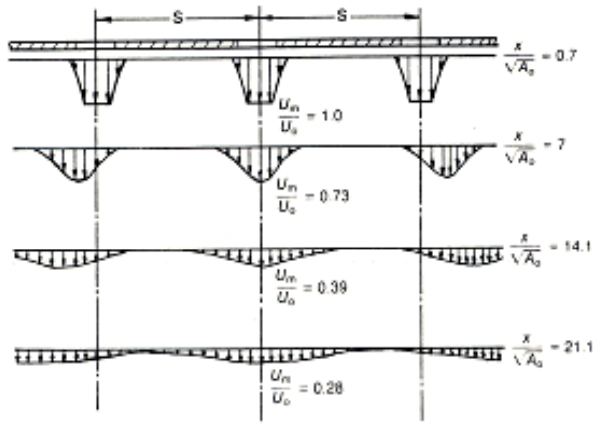
STRAVENT
CLIMATE SOLUTIONS

Confluent Jets

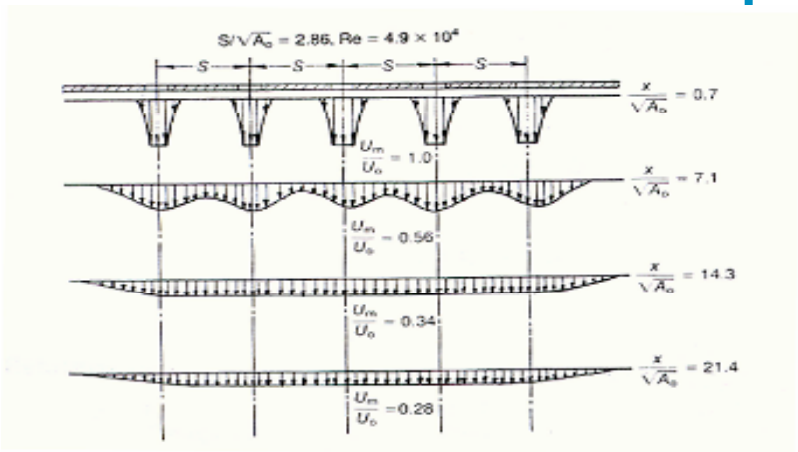
- When free circular jets issuing from different apertures in the same plane flow in parallel directions then at a certain distance downstream they coalesce and move as a single jet



(a)



(b)



(c)

Velocity profiles for confluent circular jets (d = 100 mm).

(a) Three apertures, Closely-spaced (S = 2d)

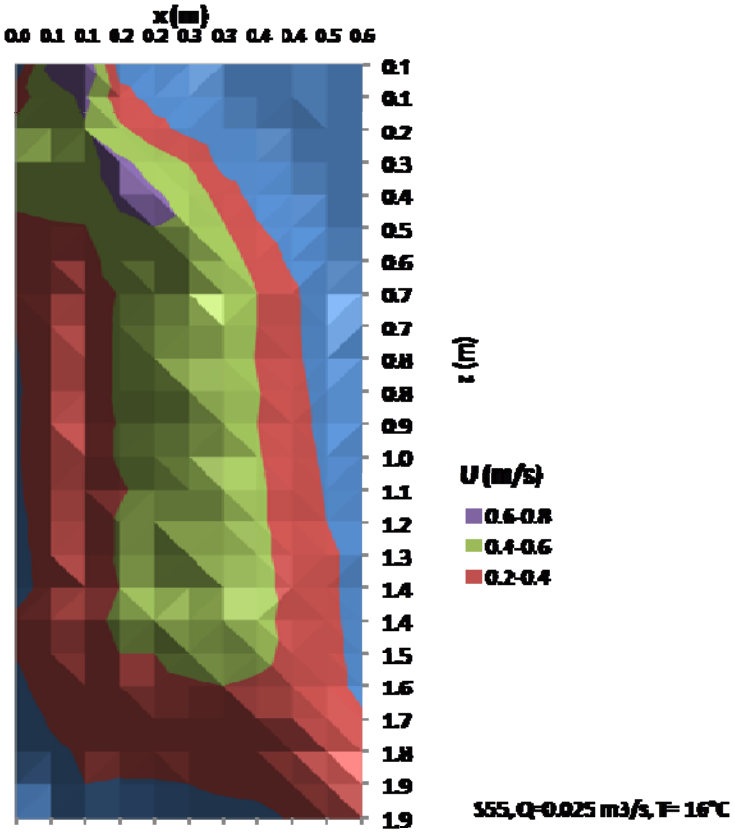
(b) Three apertures, widely-spaced (S = 4d)

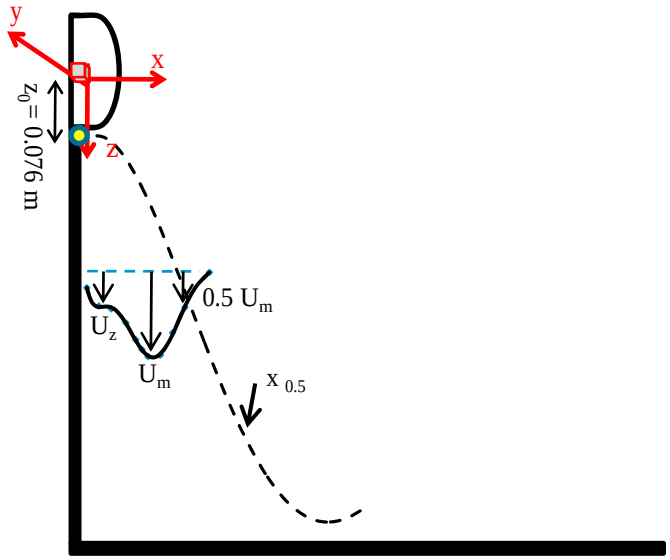
(c) Five apertures, Closely - spaced (S = 2d)

Ref: Awbi H "Ventilation of buildings" 2003

UNIVERSITY OF GÄVLE

Supply air diffuser





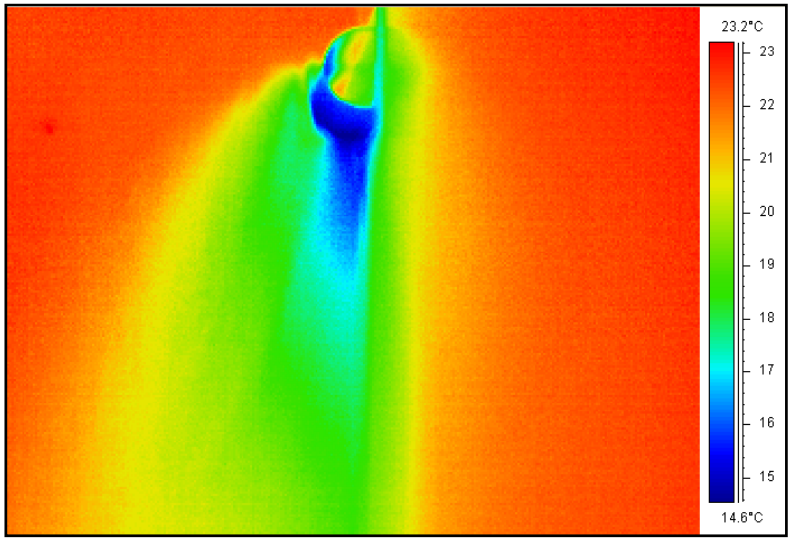
Flow pattern below the diffuser

The newly proposed supply air diffuser can be described as a number of free circular jets issuing from different apertures at the inlet of the supply device which is covered by convex perforate plate.

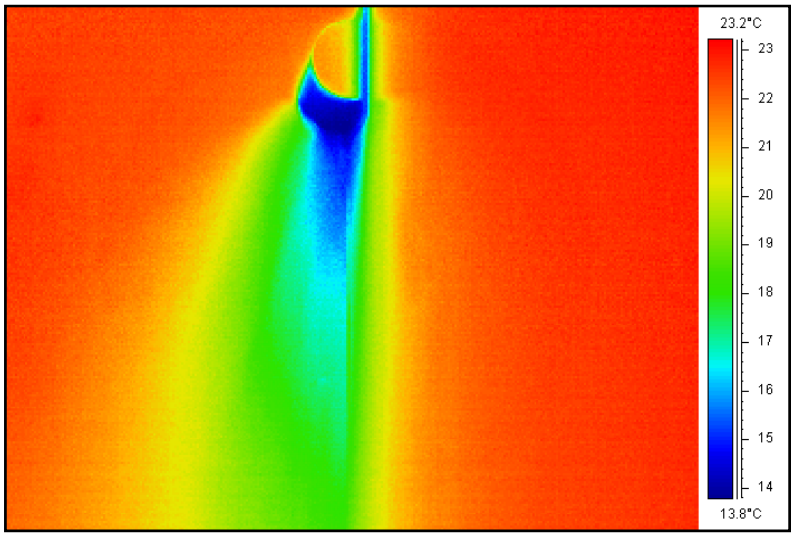
Linköpings universitet

UNIVERSITY OF GÄVLE

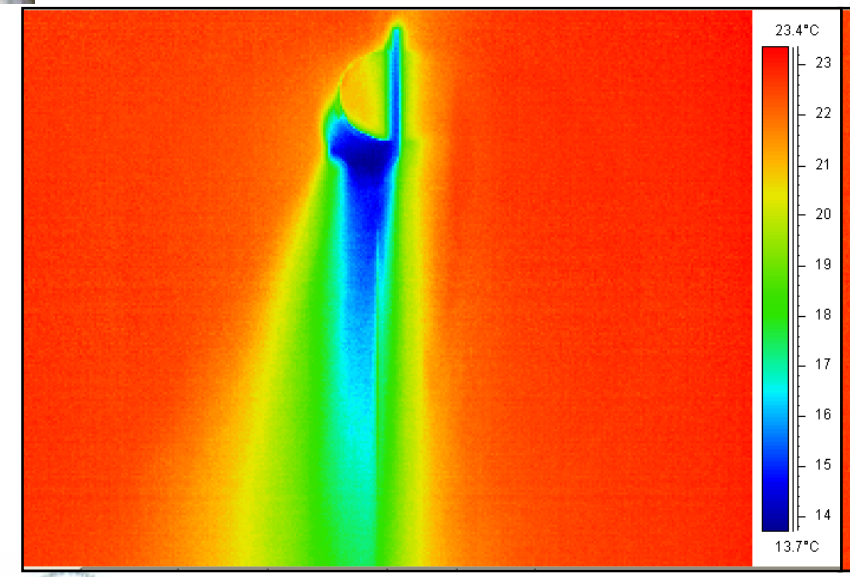
Infrared camera visualization



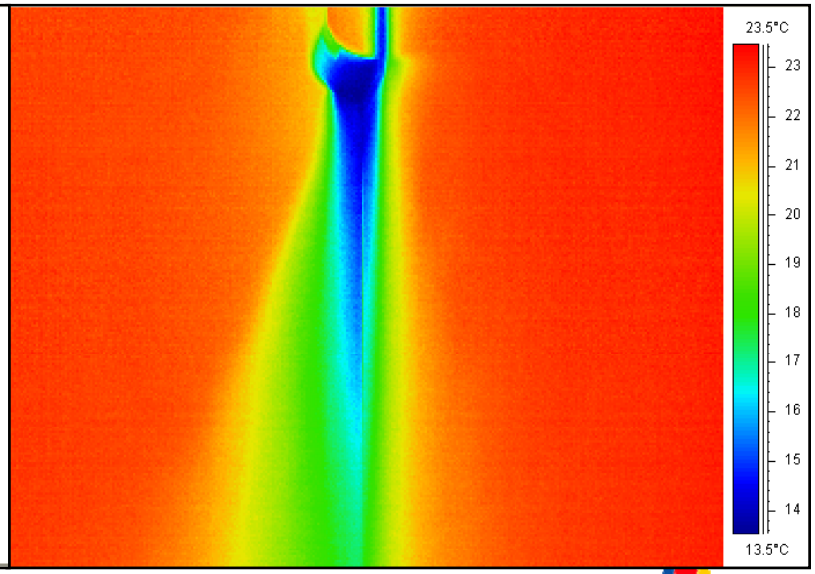
Full open



90°open- sides closed



60°open- sides closed

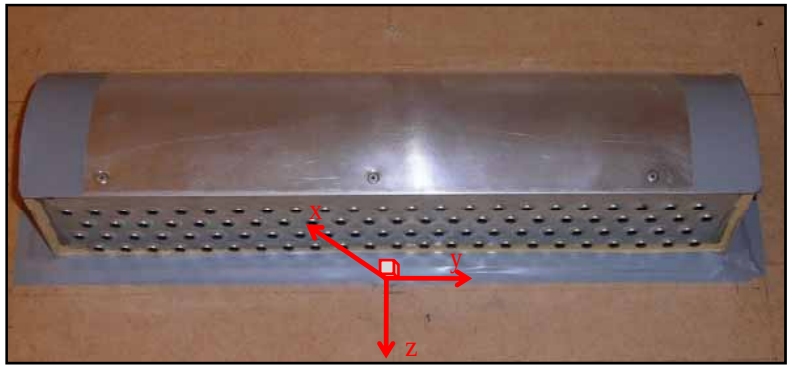


30°open- sides closed

Linköpings universitet

UNIVERSITY OF GÄVLE

New design supply air diffuser

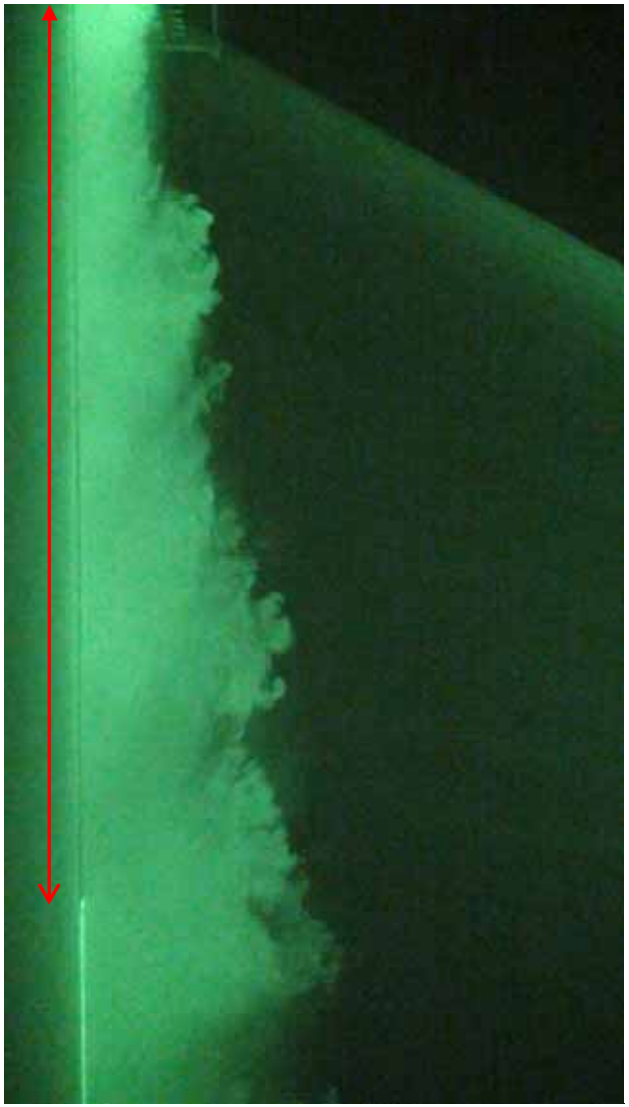


Linköpings universitet

UNIVERSITY OF GÄVLE

Smoke visualization

Air flow rate 0.025 m3/s
Supply temperature 16°C



Linköpings universitet

UNIVERSITY OF GÄVLE

Research process

Part 1 - Verification study

- CFD, Steady-state, two-equation turbulence models
- Purpose: verification of turbulence models, RNG k-ε and SST k-ε
- Measurement: IR-camera, Hot-wire anemometer and CTA

Part 2 - Detailed study

- RNG k-ε and SST k-ε
- Measurement: IR-camera, Hot-wire anemometer and CTA
- Purpose: Physics of the flow and optimization of the diffuser

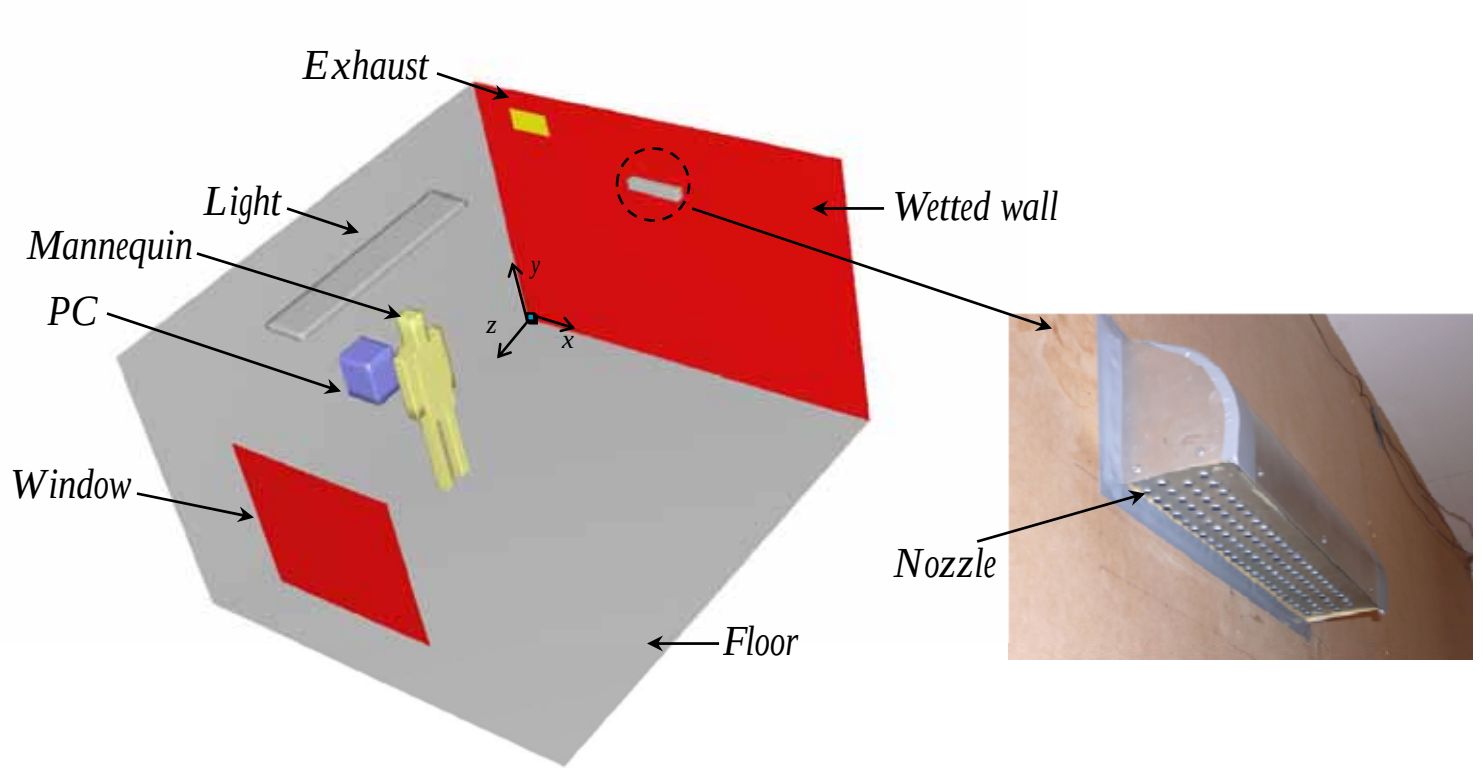
Part 3 - Case study

- Different heating and cooling loads
- Steady-State RNG k-ε and SST k-ε
- Purpose: Analyse the thermal comfort and air quality

UNIVERSITY OF GÄVLE

Office, test room

Floor area 15.1 m2 and a ceiling height of 2.5 m



PC-simulator (115 W)
Mannequin (95 W)
Lighting (144 W)
Heated floor and chilled ceiling beams
Artificial windows- electric heating foil

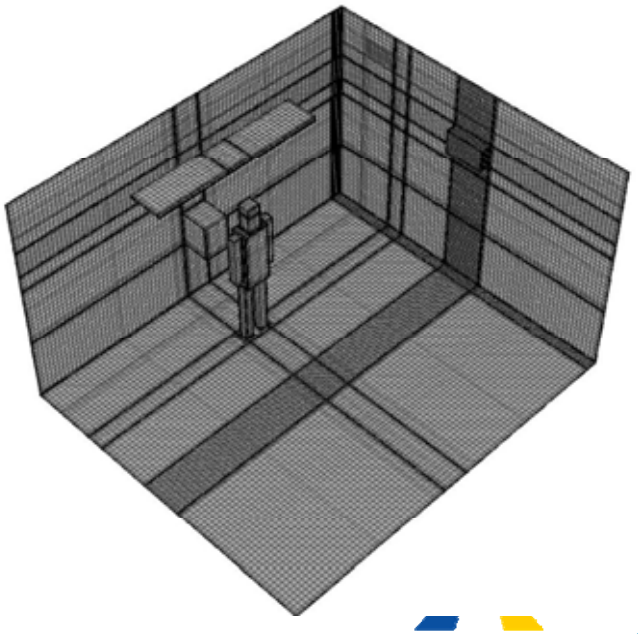
Linköpings universitet

UNIVERSITY OF GÄVLE

Verification study

Numerical simulation (CFD)

- Steady state
- Turbulence model: RNG k-ε
- Near-wall Treatment: Two-layer model with Enhanced wall functions ($y^+ < 1$)
- Heat transfer: Convection and Radiation
- Discretization Scheme: 2nd-order
- Pressure-Velocity-Coupling: SIMPLE
- Grid number: 2 279 089 Cells



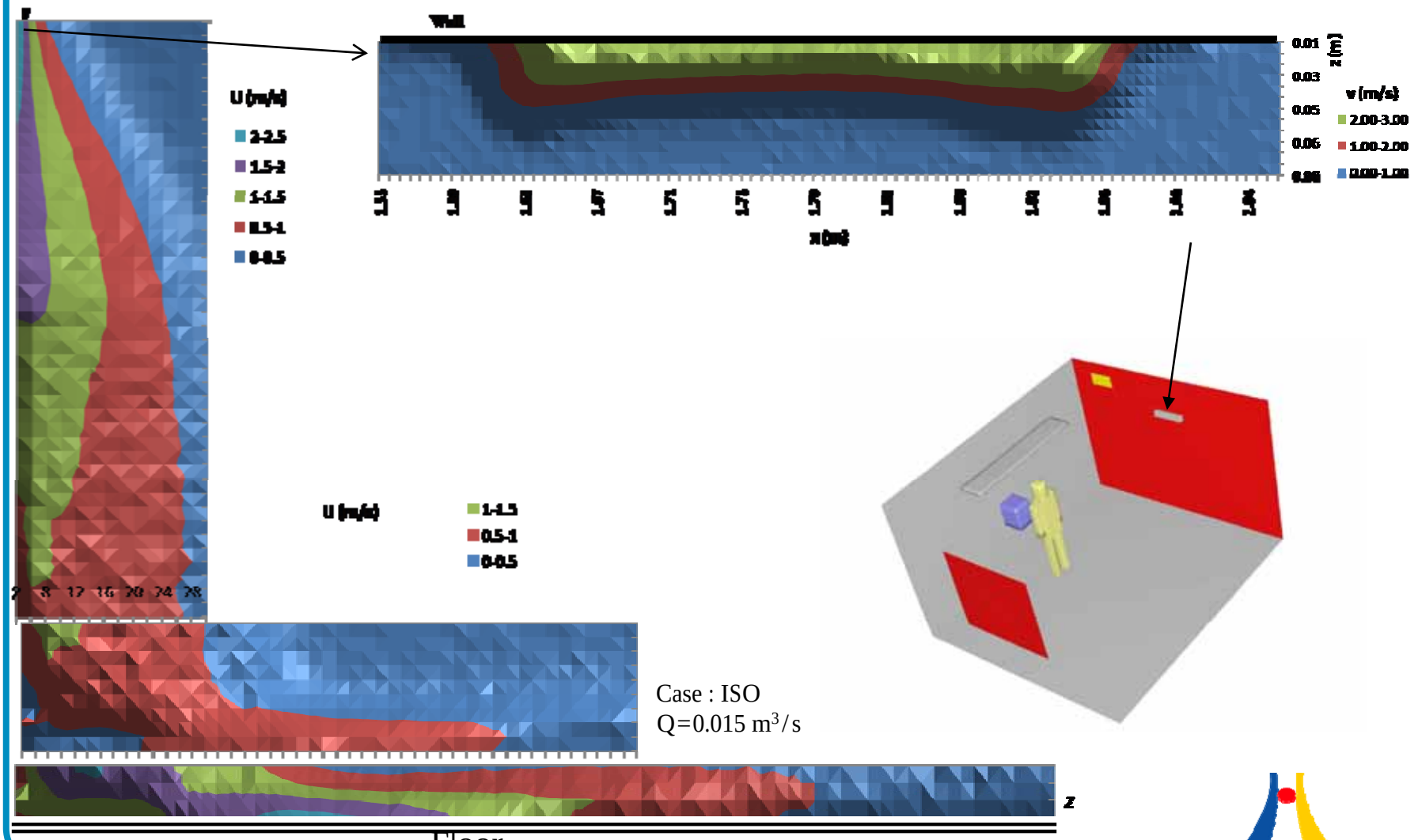
Verification

- IR-camera, Hot-wire and CTA

Tool

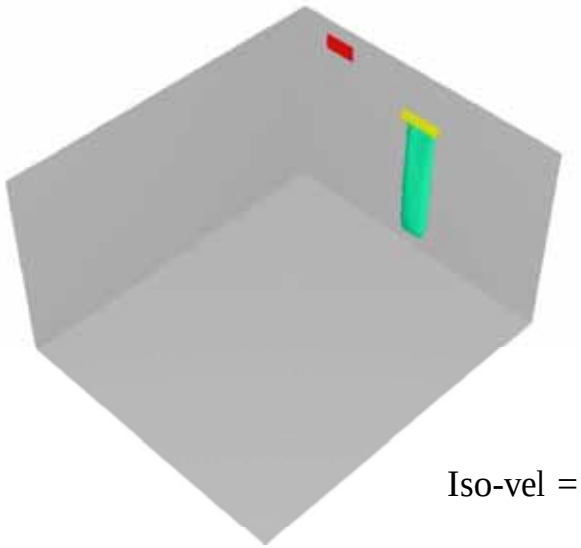
- FLUENT 7.1

Boundary condition, *Measurement*

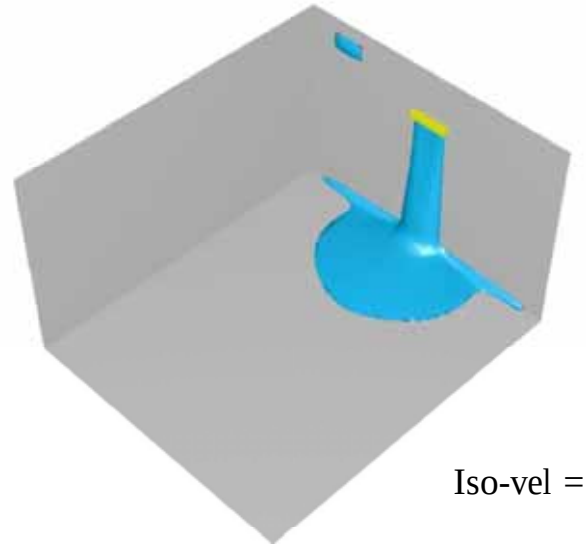


UNIVERSITY OF GÄVLE

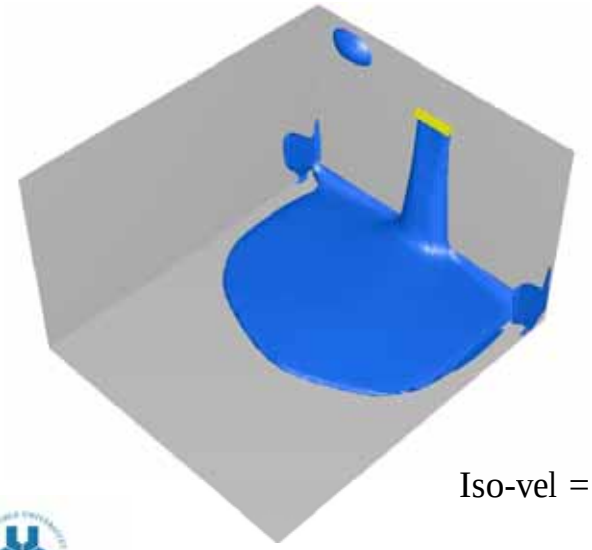
ISO velocity – isothermal case 15 l/s, *CFD*



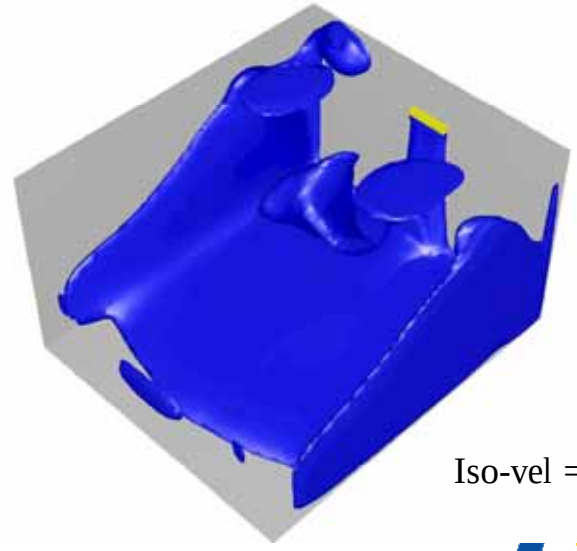
Iso-vel = 1 m/s



Iso-vel = 0.4 m/s



Iso-vel = 0.2 m/s

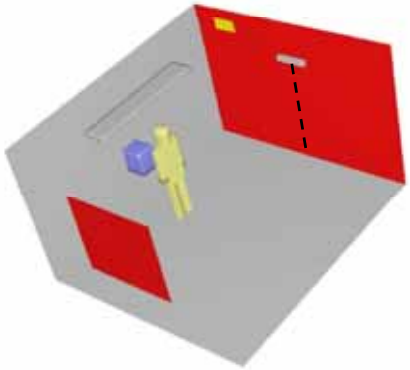


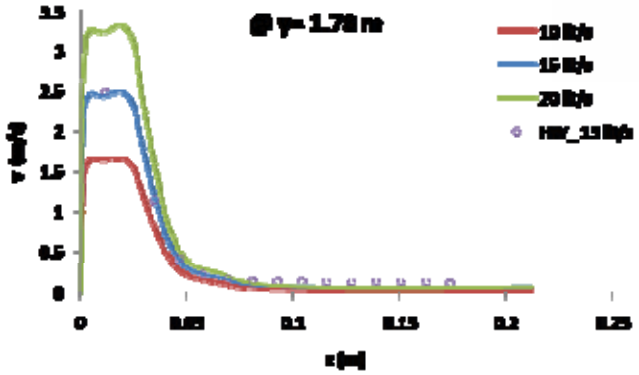
Iso-vel = 0.1 m/s

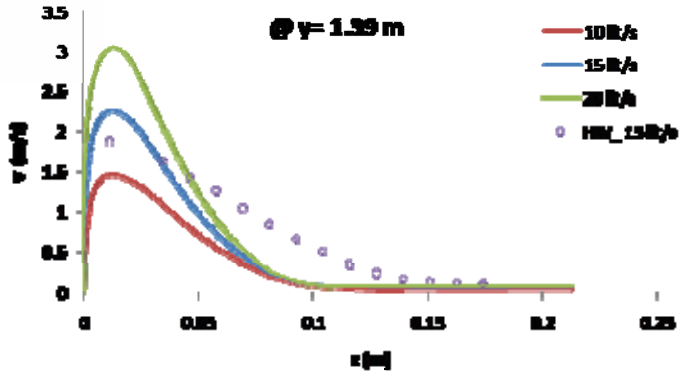
Linköpings universitet

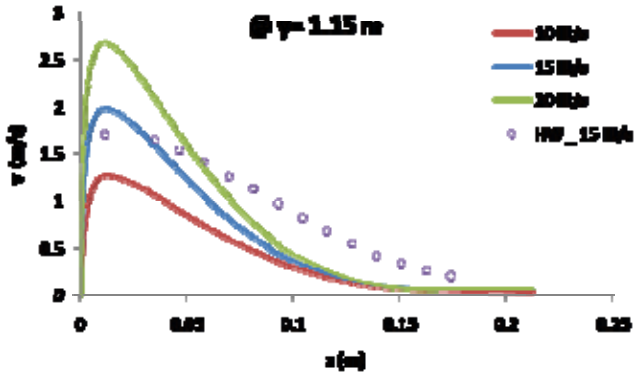
UNIVERSITY OF GÄVLE

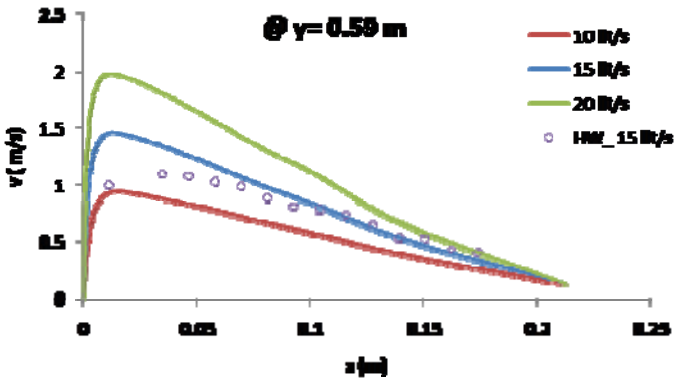
Velocity, *v*, at different heights from the floor – isothermal case







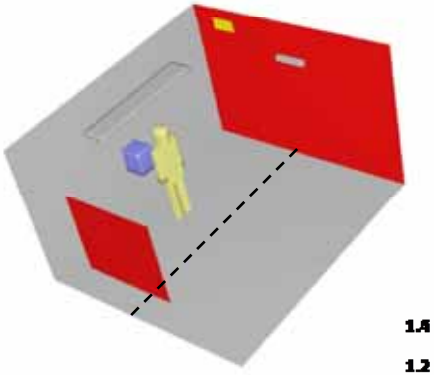


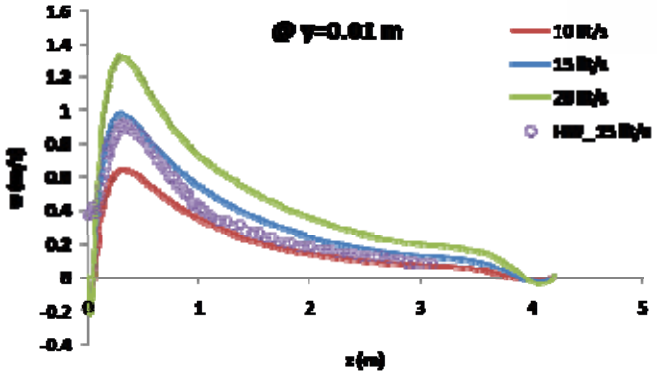


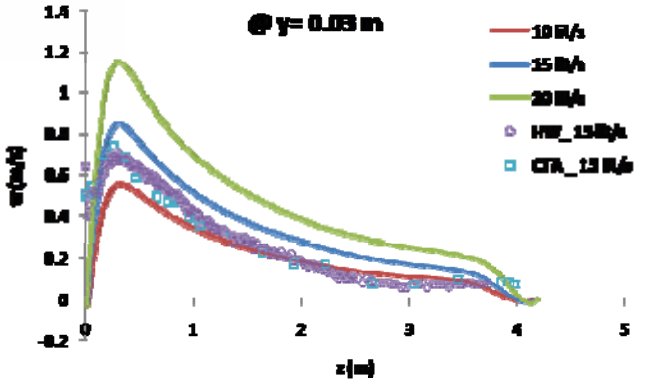
Linköpings universitet

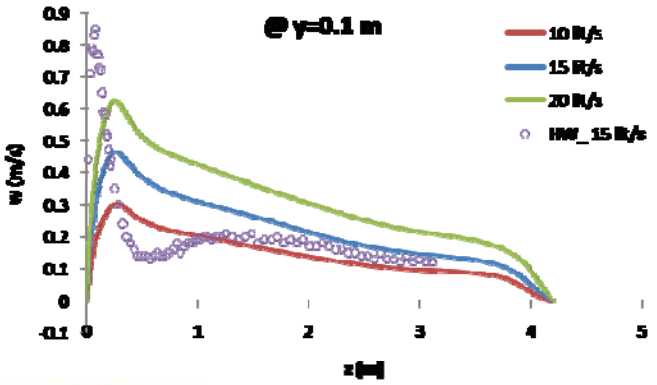
UNIVERSITY OF GÄVLE

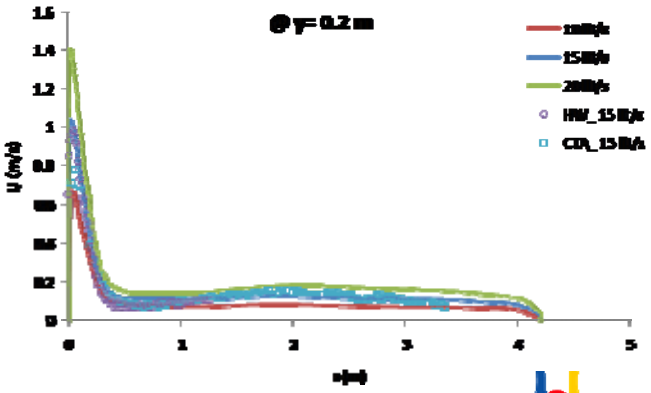
Velocity over floor – isothermal cases







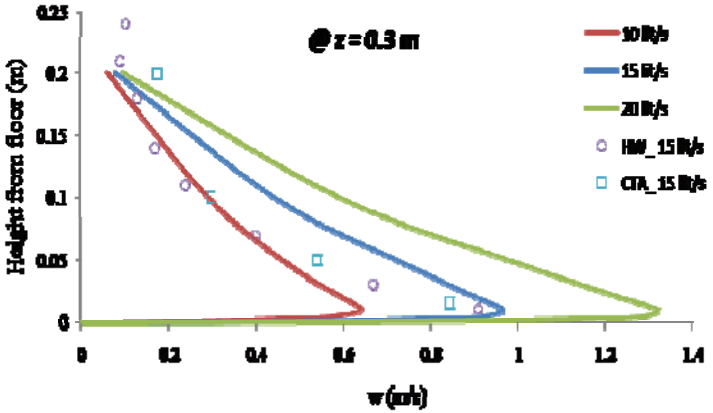


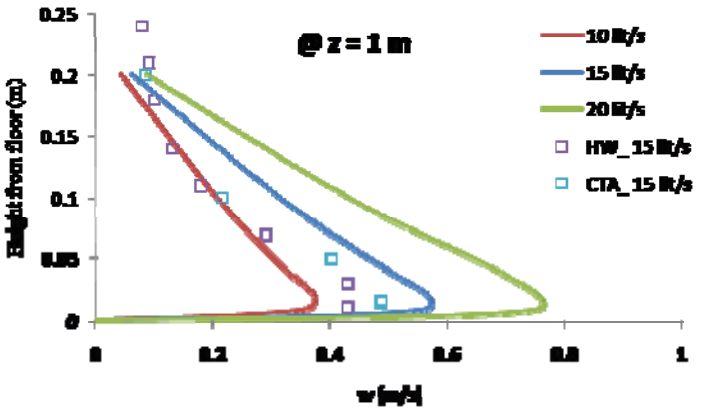


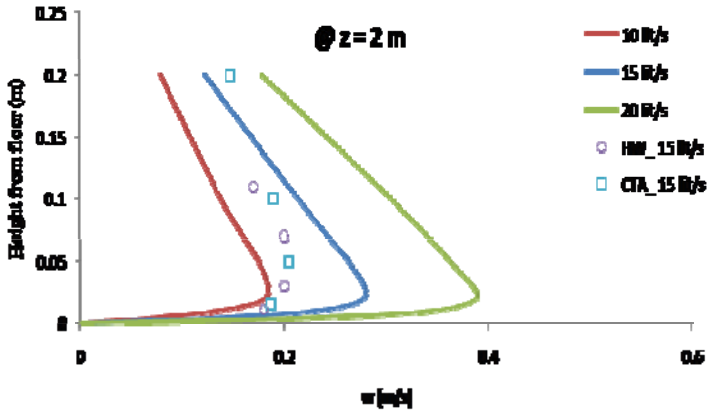
Linköpings universitet

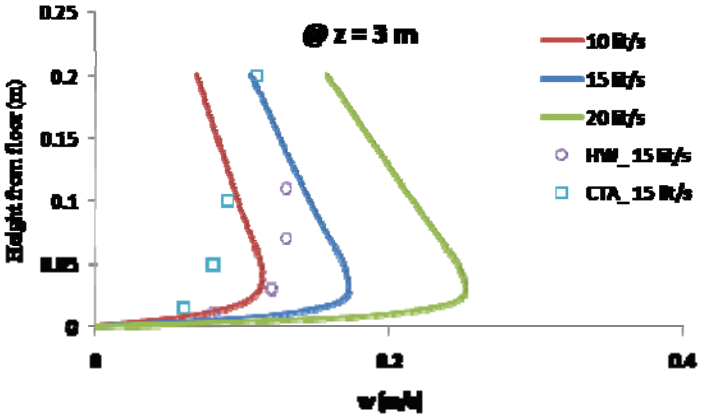
UNIVERSITY OF GÄVLE

Velocity profile, *w*, at different downstream locations – isothermal cases





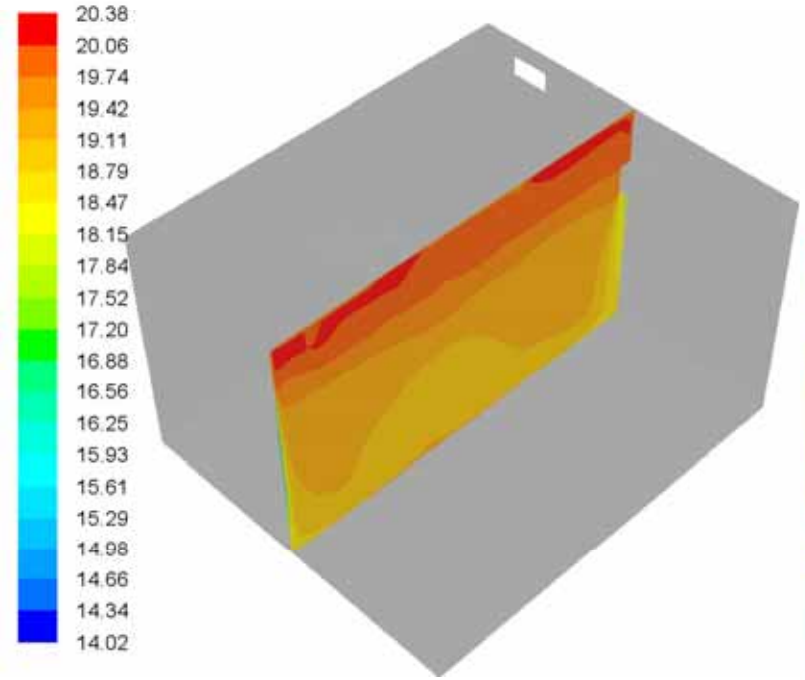


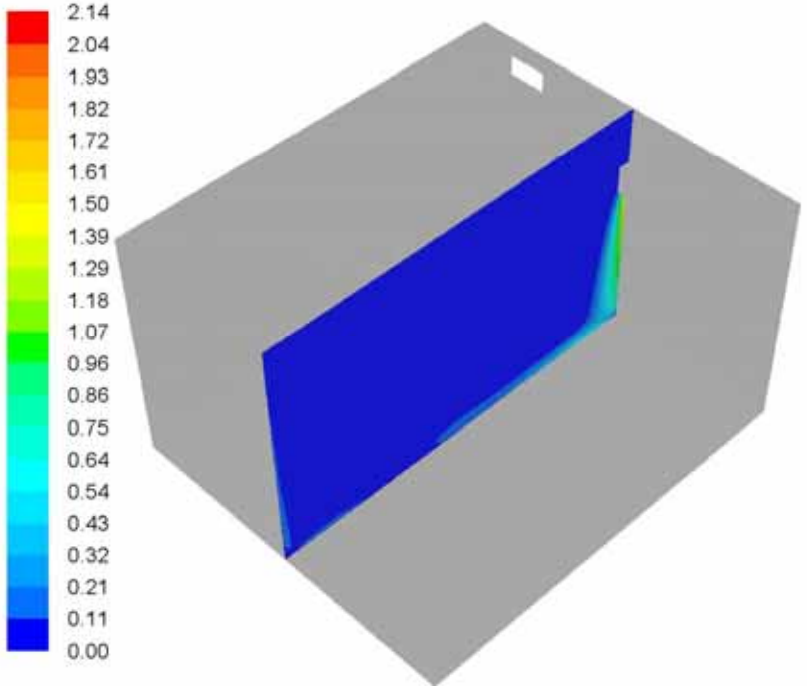


Linköpings universitet

UNIVERSITY OF GÄVLE

Temperature and velocity contours at the midplane – winter case

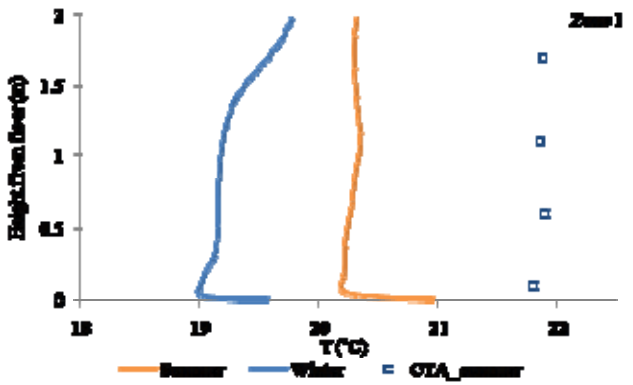


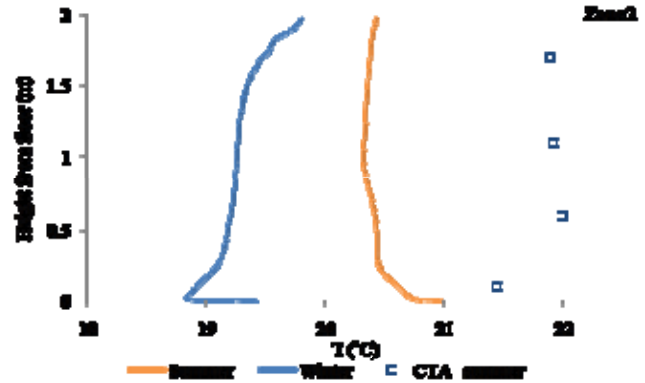


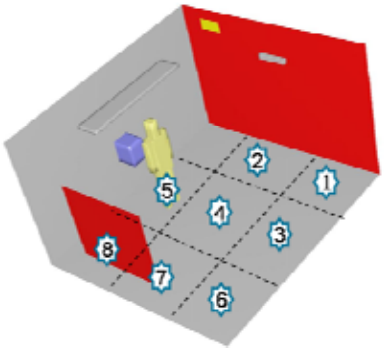
Linköpings universitet

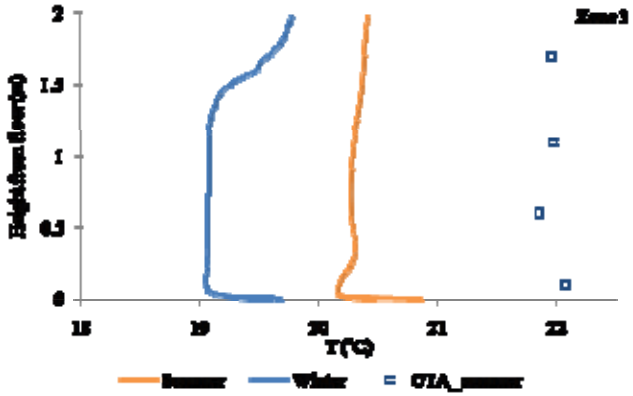
UNIVERSITY OF GÄVLE

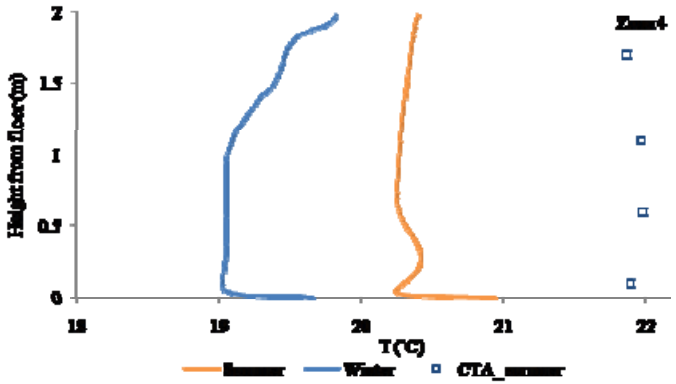
Temperature profiles – summer and winter cases

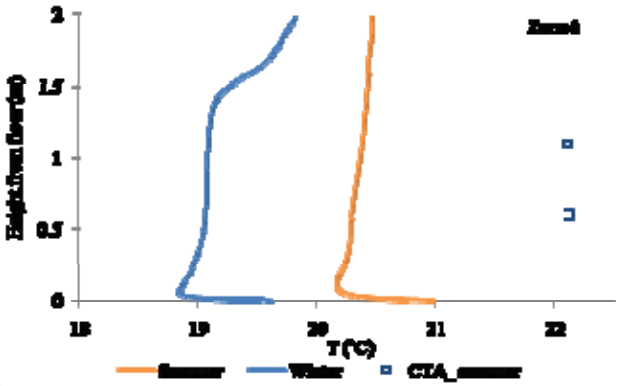


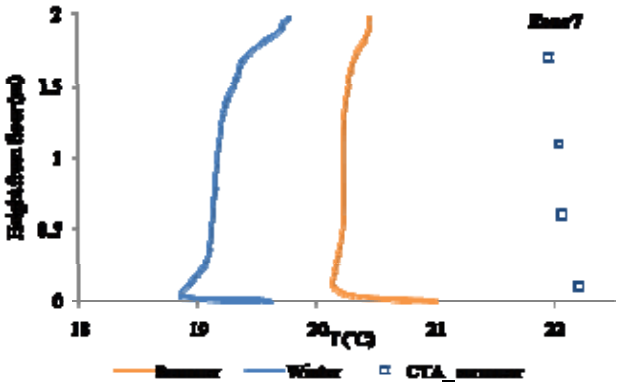






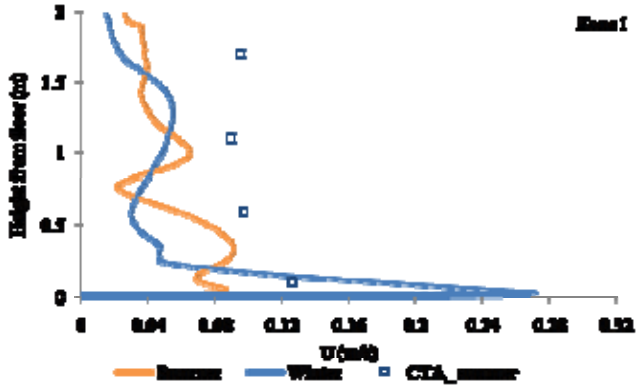


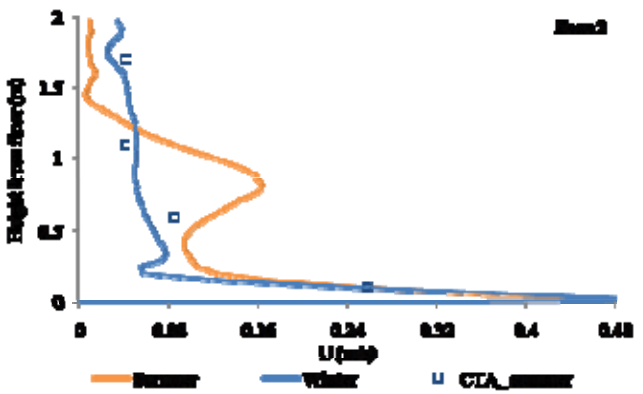


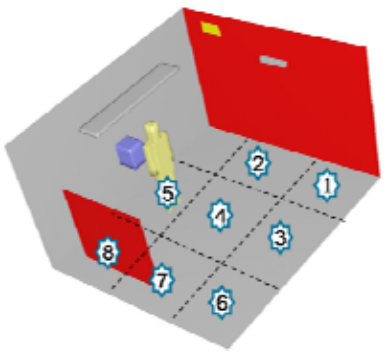


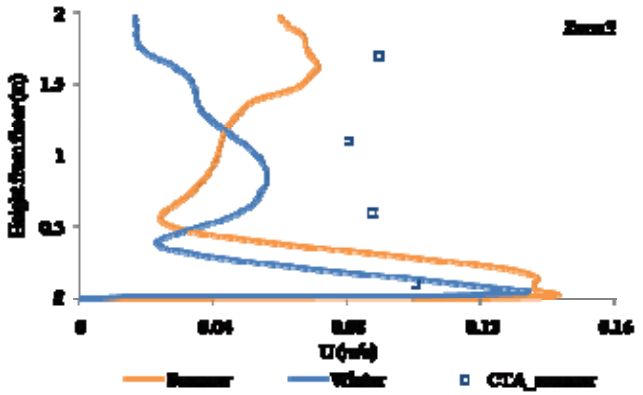
UNIVERSITY OF GÄVLE

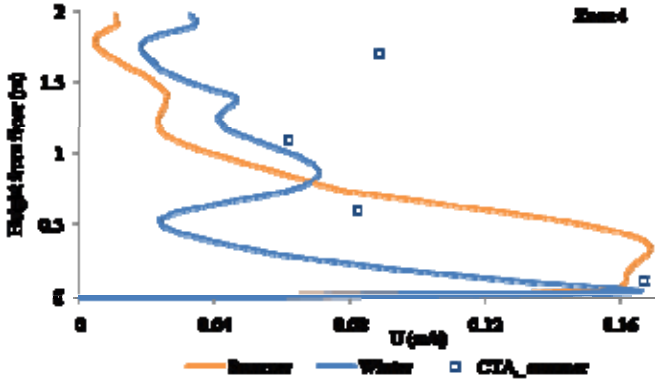
Velocity profiles – summer and winter cases

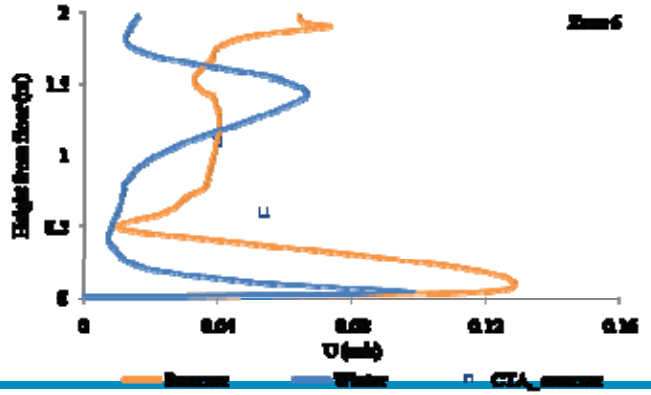


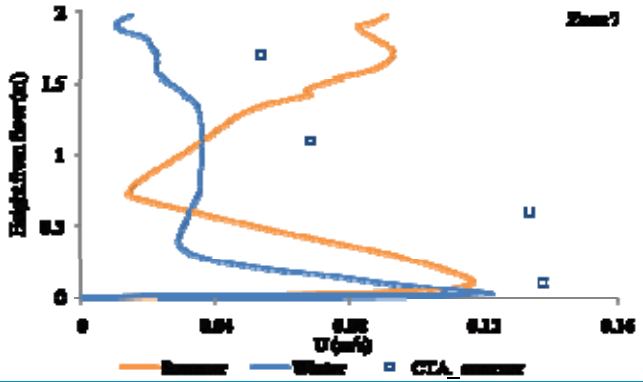






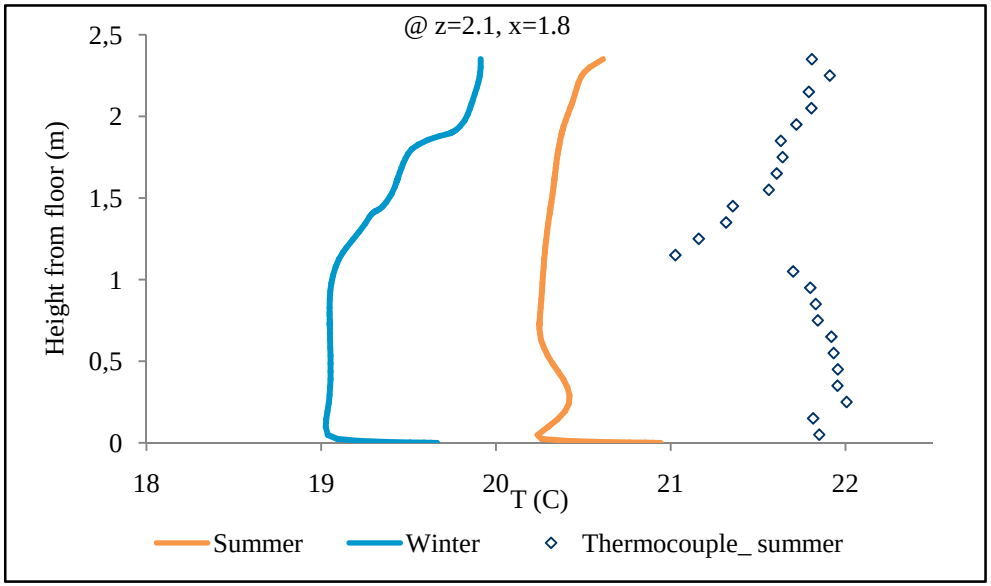


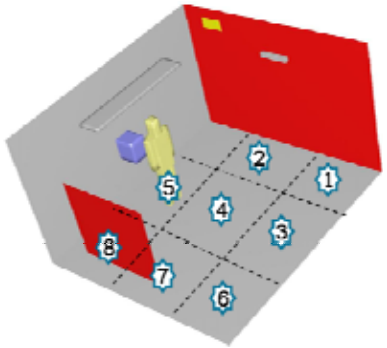




UNIVERSITY OF GÄVLE

Velocity &temperature profiles in the middle of the room





Linköpings universitet

UNIVERSITY OF GÄVLE

Conclusions

- ✓ The predicted air velocity along the wetted wall and the floor are in good agreement with the experimental values.
- ✓ The employed $y+$ captured the wall effect properly.
- ✓ The results also confirmed that the new supply device has low velocity decay due to quite slow diffusion and the momentum of the jet has been more conserved.
- ✓ Creates stable stratification in the room.
- ✓ The predicted velocity profiles along the wetted wall and the floor are quite similar for the isothermal and non-isothermal cases.