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Flow characteristics in the occupied zone – an experimental study with symmetrically located thermal plumes and low-momentum diffuse ceiling air distribution

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Introduction

- **Mechanisms of airflow interaction** are not completely understood
- **Internal heat gains** => effect on thermal conditions and comfort
- **Draught risk** => increases with high heat gains
- Buoyancy flows <=> Air distribution => Airflow interaction
- Heat gains => Airflow motions => Heat transfer

=> Study for **improving knowledge** on indoor airflows

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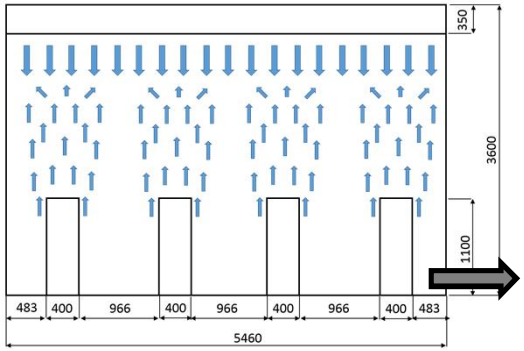

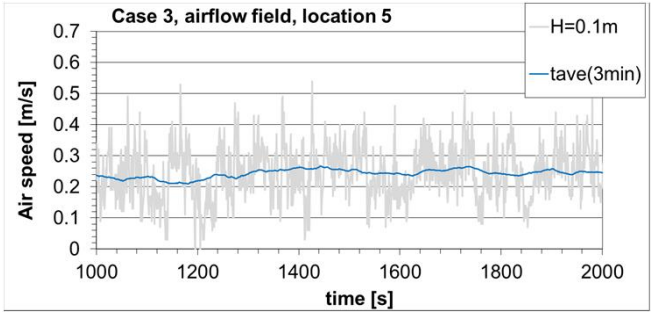

Objectives

- **Airflow characteristics** => properties functions gradients
- **Large-scale flows** => most energy slow motions
- **Airflow fluctuation** => frequency interference
- **Airflow interaction** => forces mixing vortices eddies

- **Physical basis** for characterizing internal airflows

=> Effects on **airflow conditions and thermal comfort**

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Heiselberg, P., & Nielsen, P. V. (1996). **Flow Element Models**. Aalborg: Dept. of Building Technology and Structural Engineering. (Indoor Evironmental Technology; No. 65, Vol. R9657).

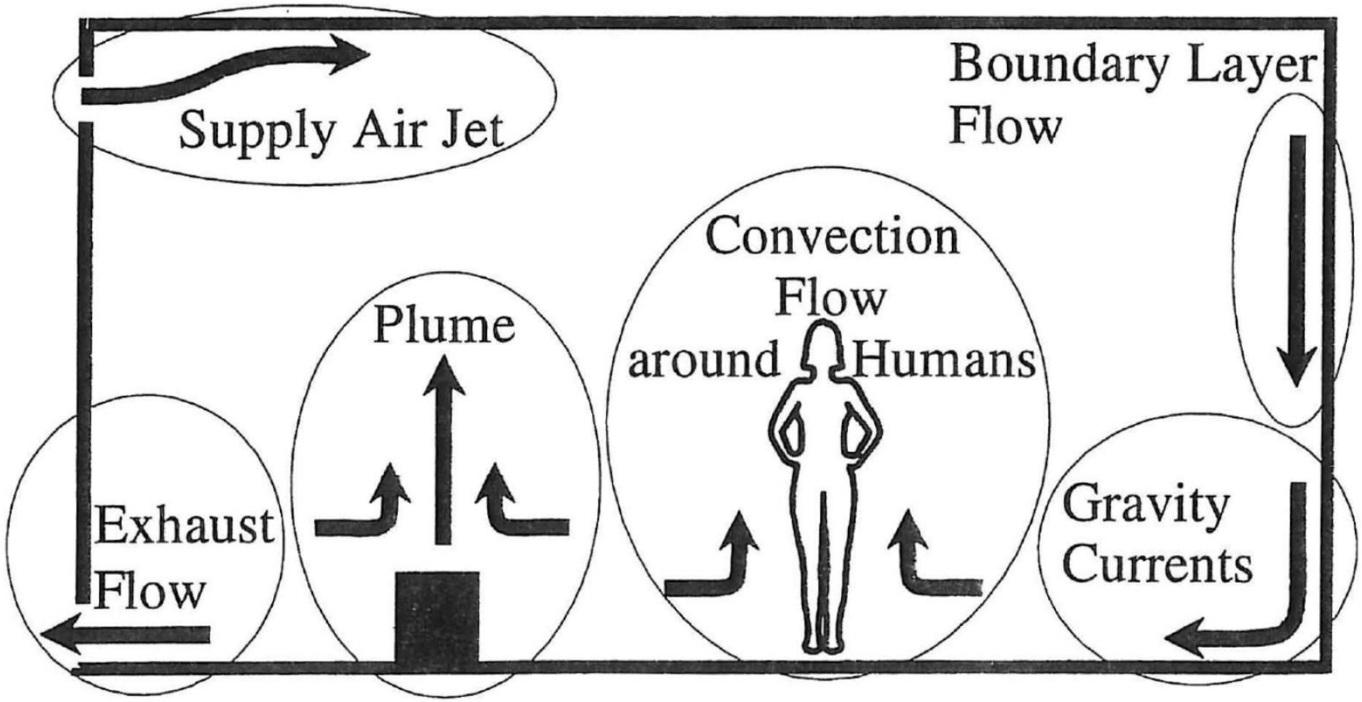

Figure 5. Airflow elements (Heiselberg and Nielsen, 1996).

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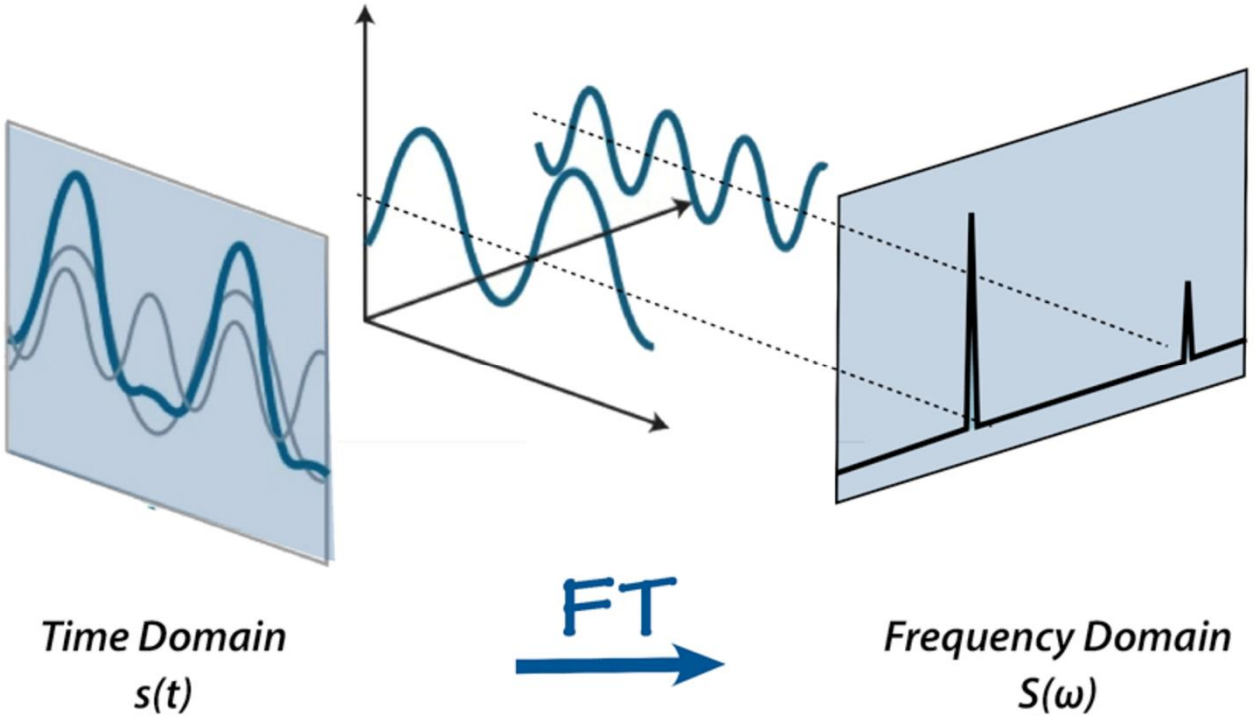
Fourier transform



Juntunen, T. (2016). Fourier transform: from data analysis to fundamental phenomena in nature, lecture material, Mathematical methods, Aalto University

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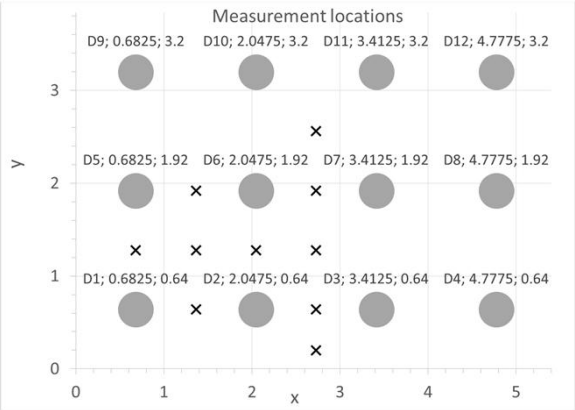

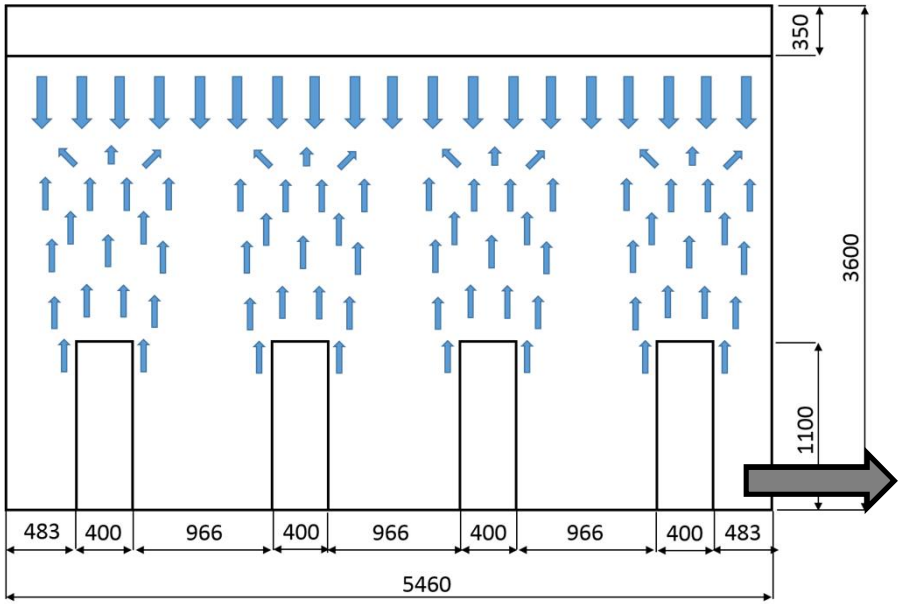

Methods

- **Test room** 5.5 x 3.8 x 3.2 m
- **Thermal plumes** => with **12** test dummies => **40** - **80** W / m^2-floor
- **Air distribution** => equally through ceiling => target **26** °C
- **Anemometers** at standard heights: 0.1 - 0.6 - 1.1 - 1.7 - 2.3 - 2.9 m
- **Visualization** with marker smoke

=> **Observations for combined effect on airflow characteristics**

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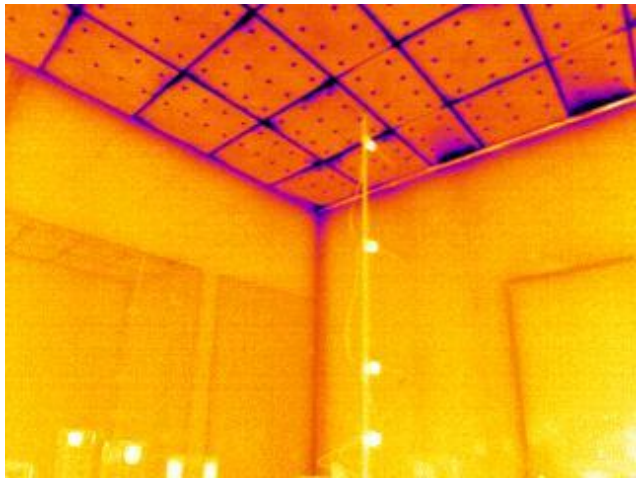
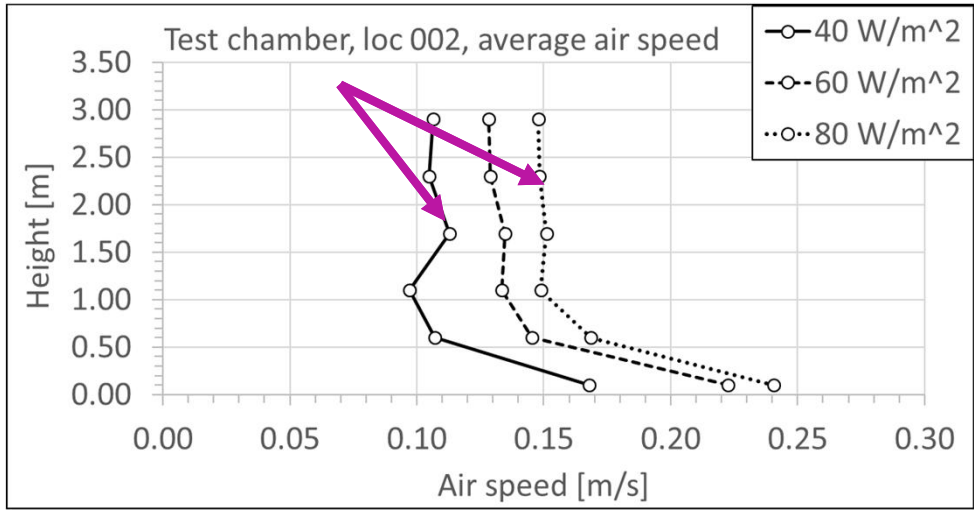
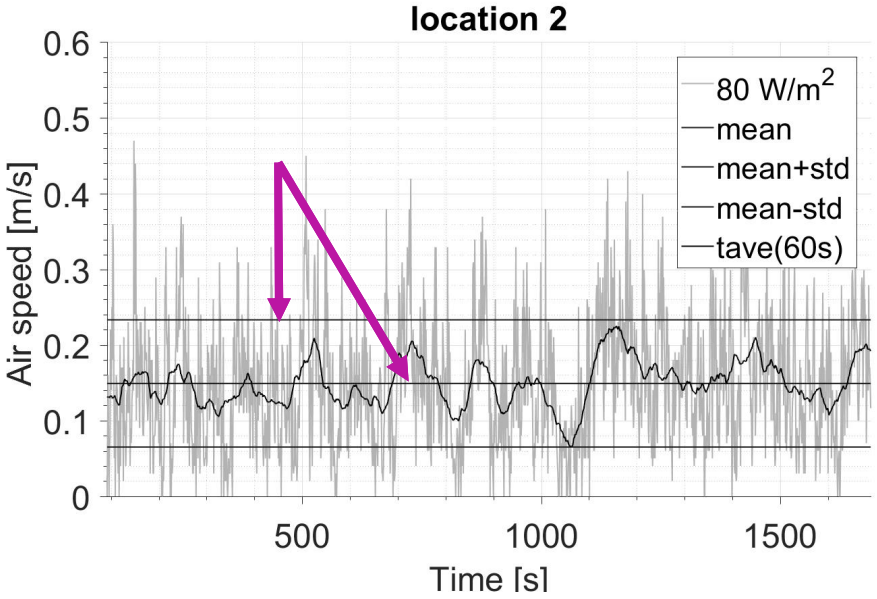
Results



- Mean air speed **increased** with heat gain
- Standard deviation **increased** with heat gain
- Heat gain had **small effect** on turbulence intensity





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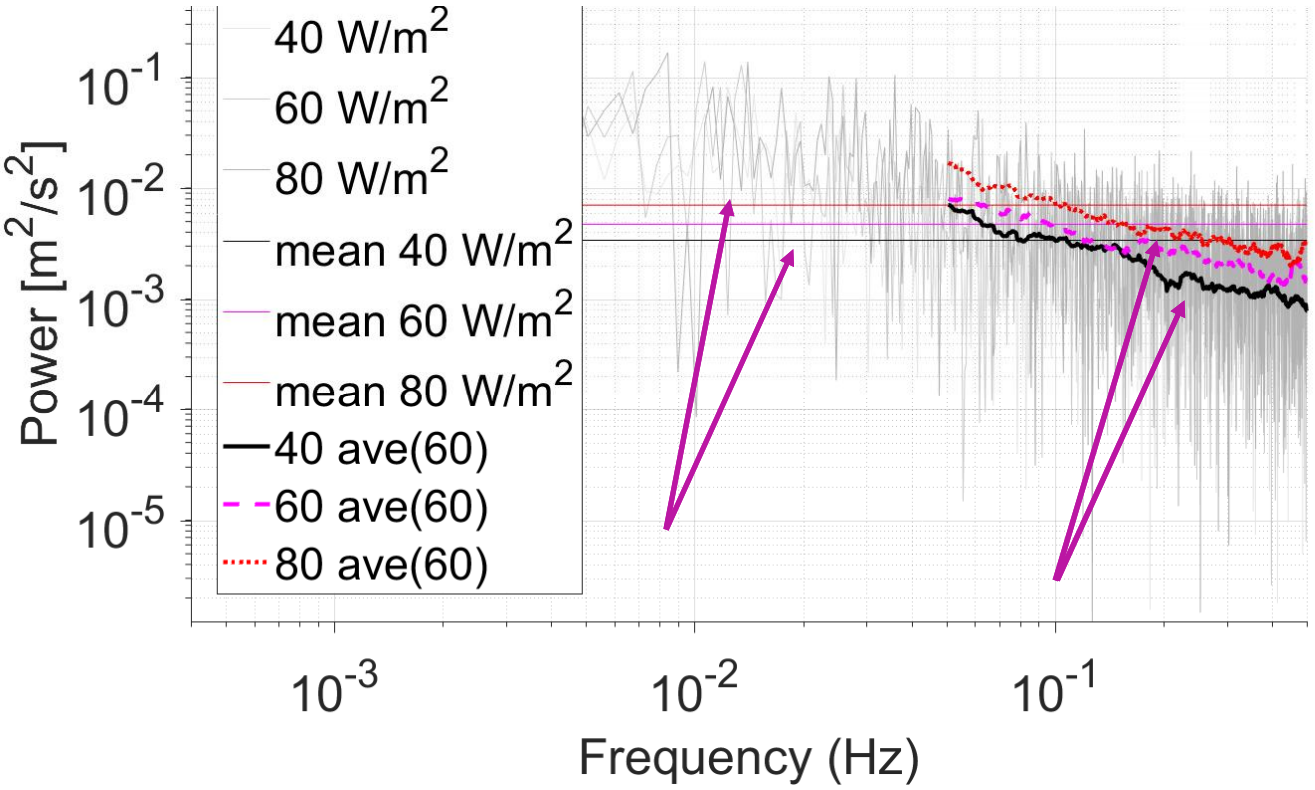
Results

- Power spectral density **increased** with heat gain



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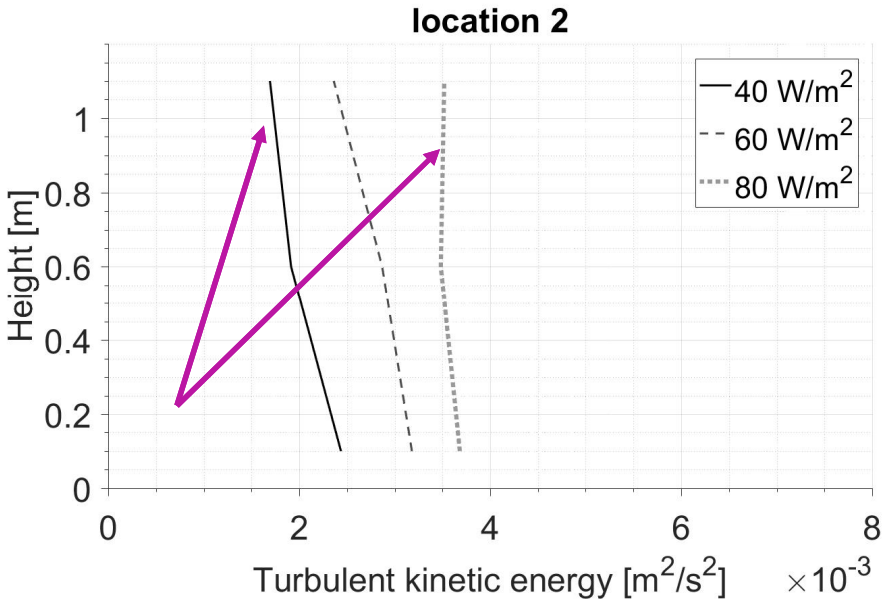
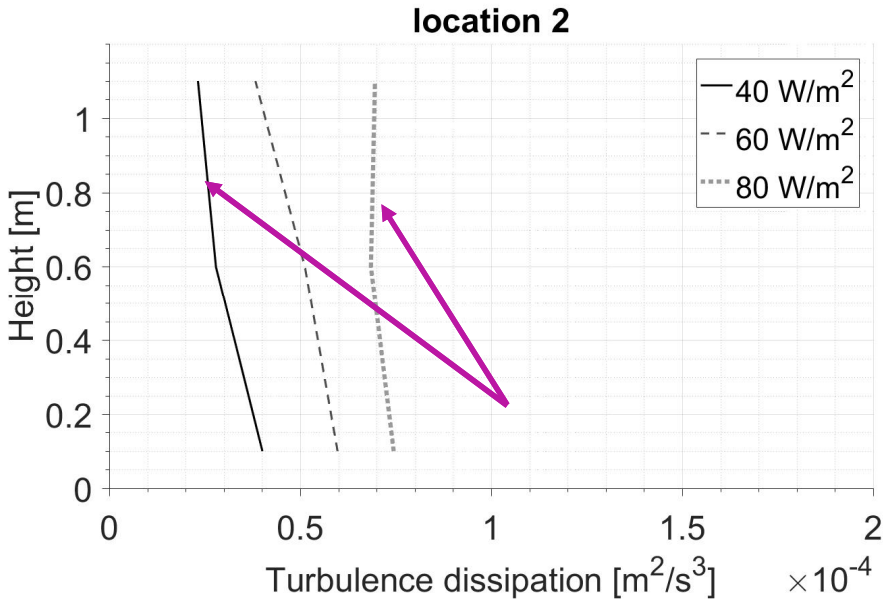
Results

- Turbulent kinetic energy **increased** with heat gain
- Turbulence dissipation **increased** with heat gain





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Conclusions

- **Internal heat gain** affects airflow conditions
- **Anemometers** were conducted for experiments
- **Airflow motions** increased with heat gain
- **Airflow interaction** may increase draught risk

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Thank you

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