COMSOL CONFERENCE EUROPE 2012

Coupling Forced Convection in Air Gaps with Heat and Moisture Transfer inside Constructions

M. Bianchi Janetti, F. Ochs, R. Pfluger

michele.janetti@uibk.ac.at

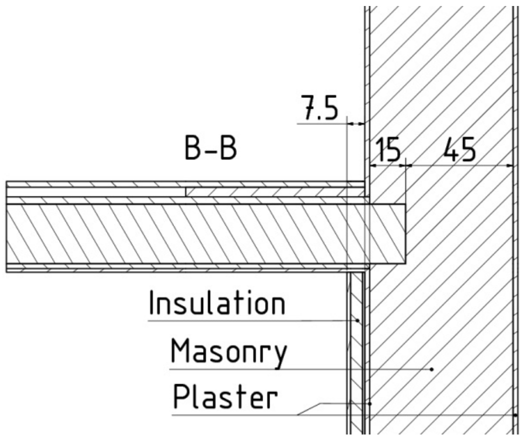
Excerpt from the Proceedings of the 2012 COMSOL Conference in Milan

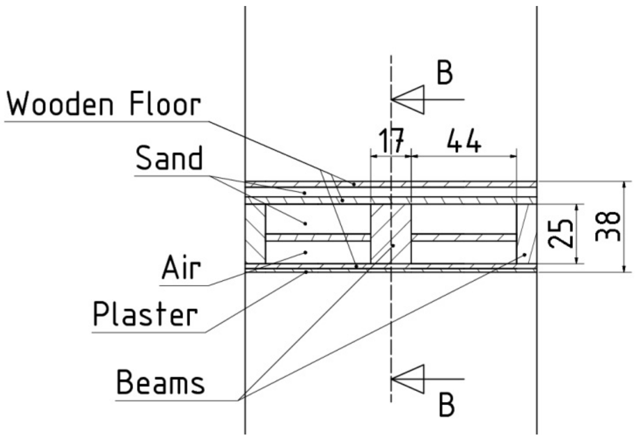
Content

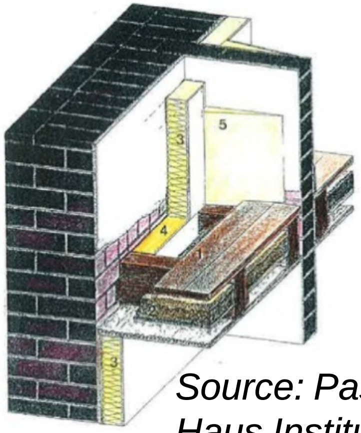
- Motivation
- Simulation Modell
- Results

Motivation

EU Projekt 3ENCULT (WP3): Hygrothermal Simulation of Beam-Ends

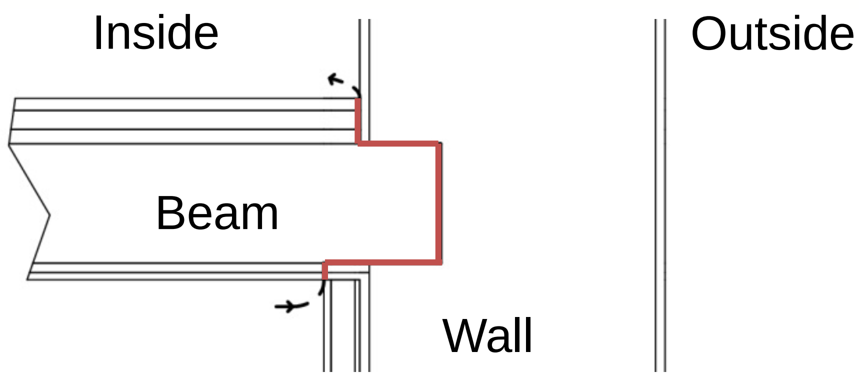






Source: Passiv Haus Institut, Protokollband Nr.32, Architekt Fingerling

Beam-End: Hygrothermal Simulation



- Heat and mass diffusion inside the solid domains
- Heat and mass convection through the air gap

Heat and Mass Diffusion inside the Solid Domains
PDE, Coefficient Form

$$\frac{\partial u}{\partial \varphi}\frac{\partial \varphi}{\partial t}+\nabla\cdot\left(-D_{m,\varphi}\nabla\varphi-D_{m,T}\nabla T\right)=0$$

⇦ Moisture balance

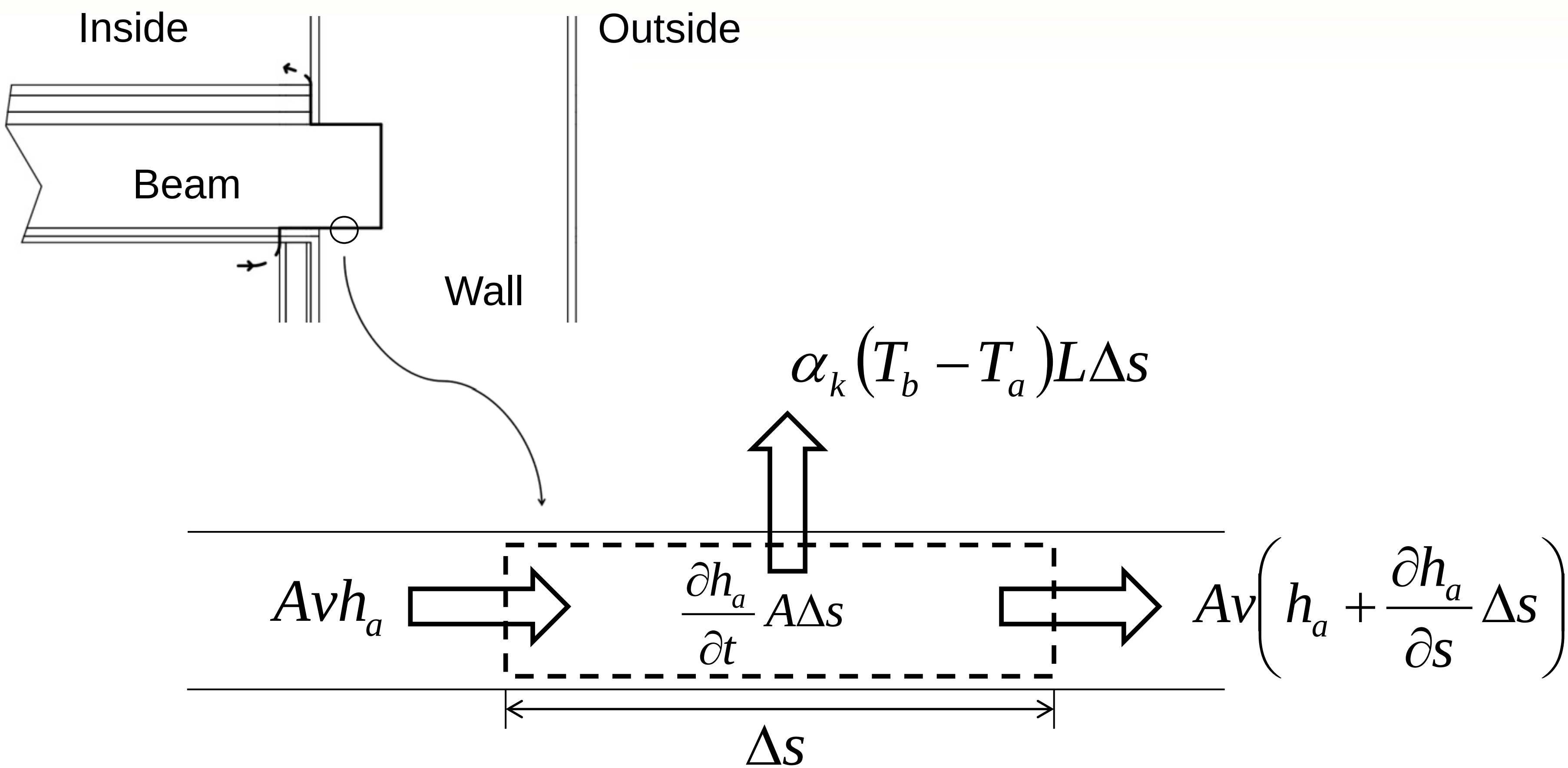
$$\frac{\partial h}{\partial T}\frac{\partial T}{\partial t}+\frac{\partial h}{\partial T}\frac{\partial \varphi}{\partial t}+\nabla\cdot\left(-D_{e,T}\nabla T-D_{e,\varphi}\nabla\varphi\right)=0$$

⇦ Energy balance

⇨
- Moisture distribution: $\varphi(x,y,t)$ or $a_w(x,y,t)$
- Temperature distribution: $T(x,y,t)$

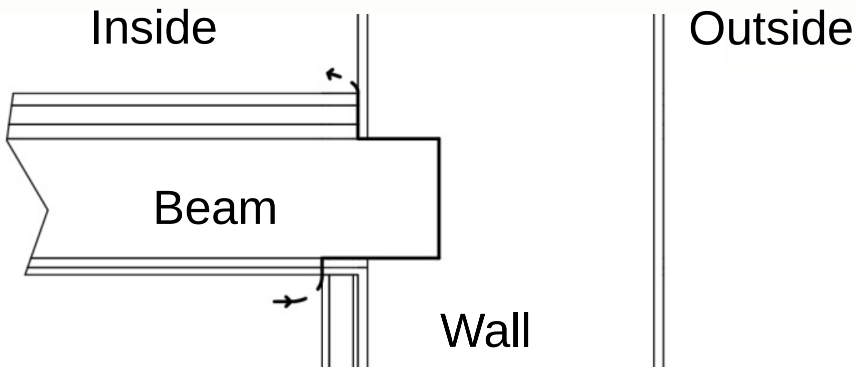
φ	Relative humidity
T	Temperature
u	Water content
h	Specific enthalpy

Forced Convection in the Air Gap



Example: Energy Balance

Forced Convection in the Air Gap: Governing Equations



ρ_v	Vapor density
h	Air enthalpy
A	Cross section area
L	Cross section perimeter
v	Air velocity

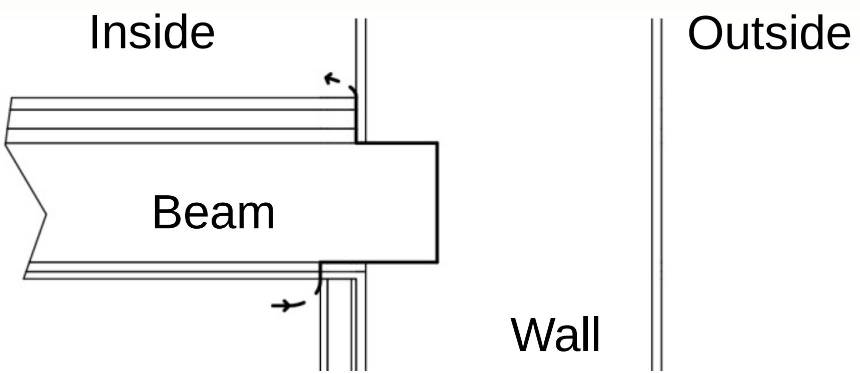
$$A\left(\frac{\partial\rho_v}{\partial t}+v\frac{\partial\rho_v}{\partial s}\right)=L\beta_k\left(p_{v,b}-p_v\right)$$

Moisture balance

$$A\left(\frac{\partial h}{\partial t}+v\frac{\partial h}{\partial s}\right)=L\alpha_k\left(T_b-T\right)$$

Energy balance

Weak Form on the Boundary



w	Test function

$$\int_0^S \left\{ w \left[\frac{\partial \rho_v}{\partial t} - \frac{L\beta_k}{A}\left(p_{v,b} - p_v\right) \right] - \frac{\partial w}{\partial s} v \rho_v \right\} ds + w\, v \rho_{v,S} - w\, v \rho_{v,0} = 0$$

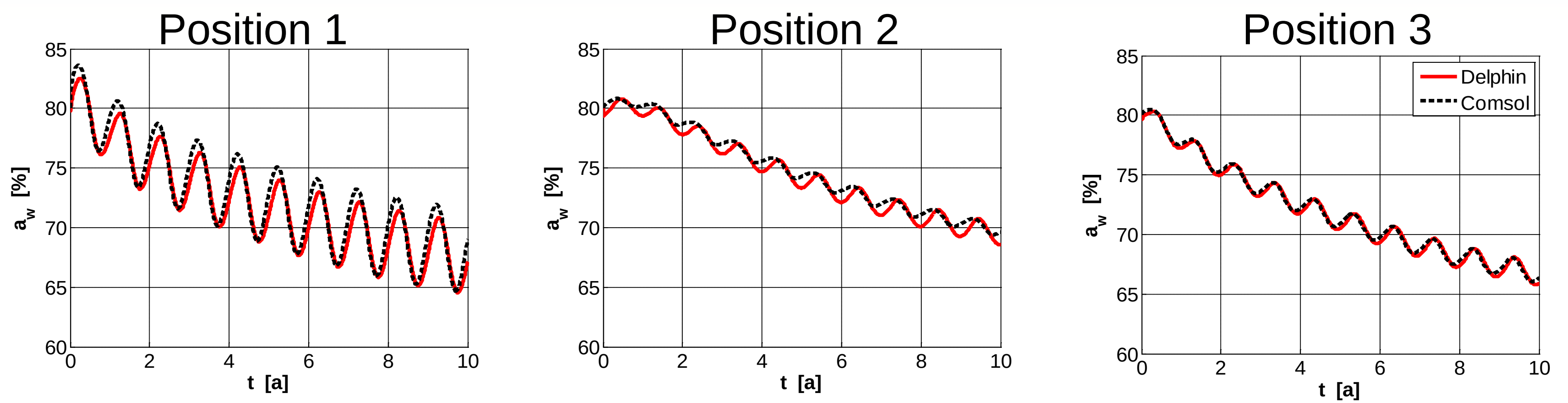
$$\int_0^S \left\{ w \left[\frac{\partial h}{\partial t} - \frac{L\alpha_k}{A c_p \rho}\left(h_b - h\right) \right] - \frac{\partial w}{\partial s} v h \right\} ds + w\, v h_S - w\, v h_0 = 0$$

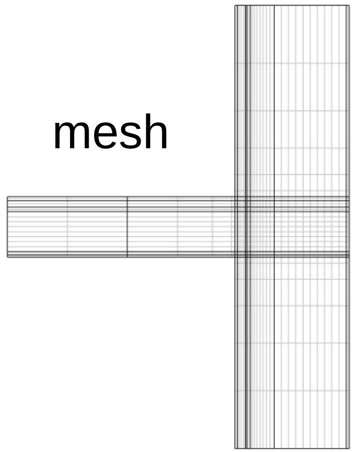
Boundary Settings

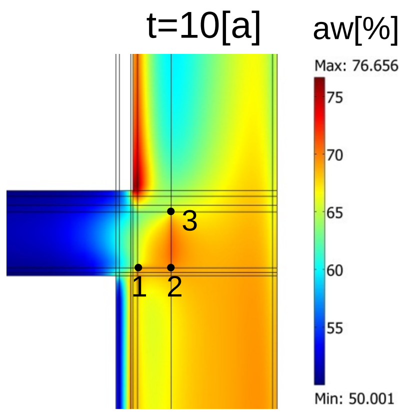
Point Settings

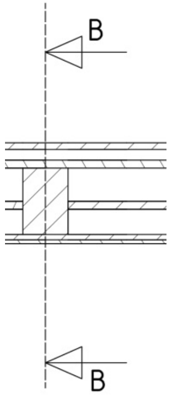
Comparison with Delphin

2D Modell without Convection

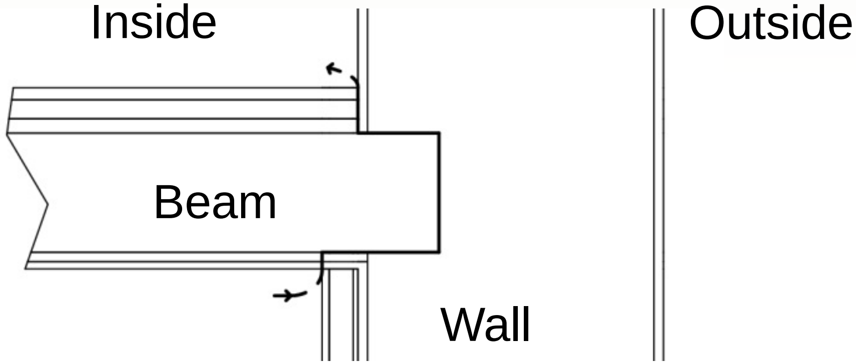




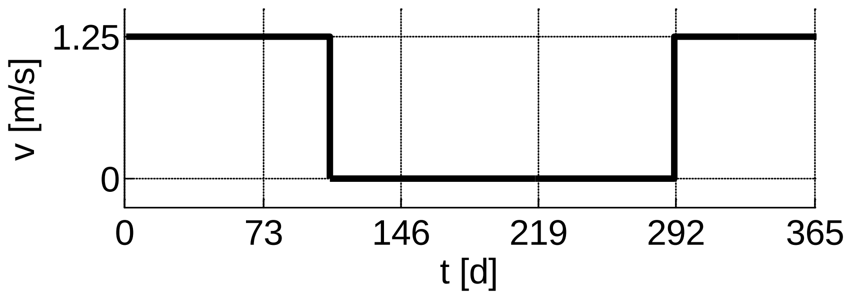




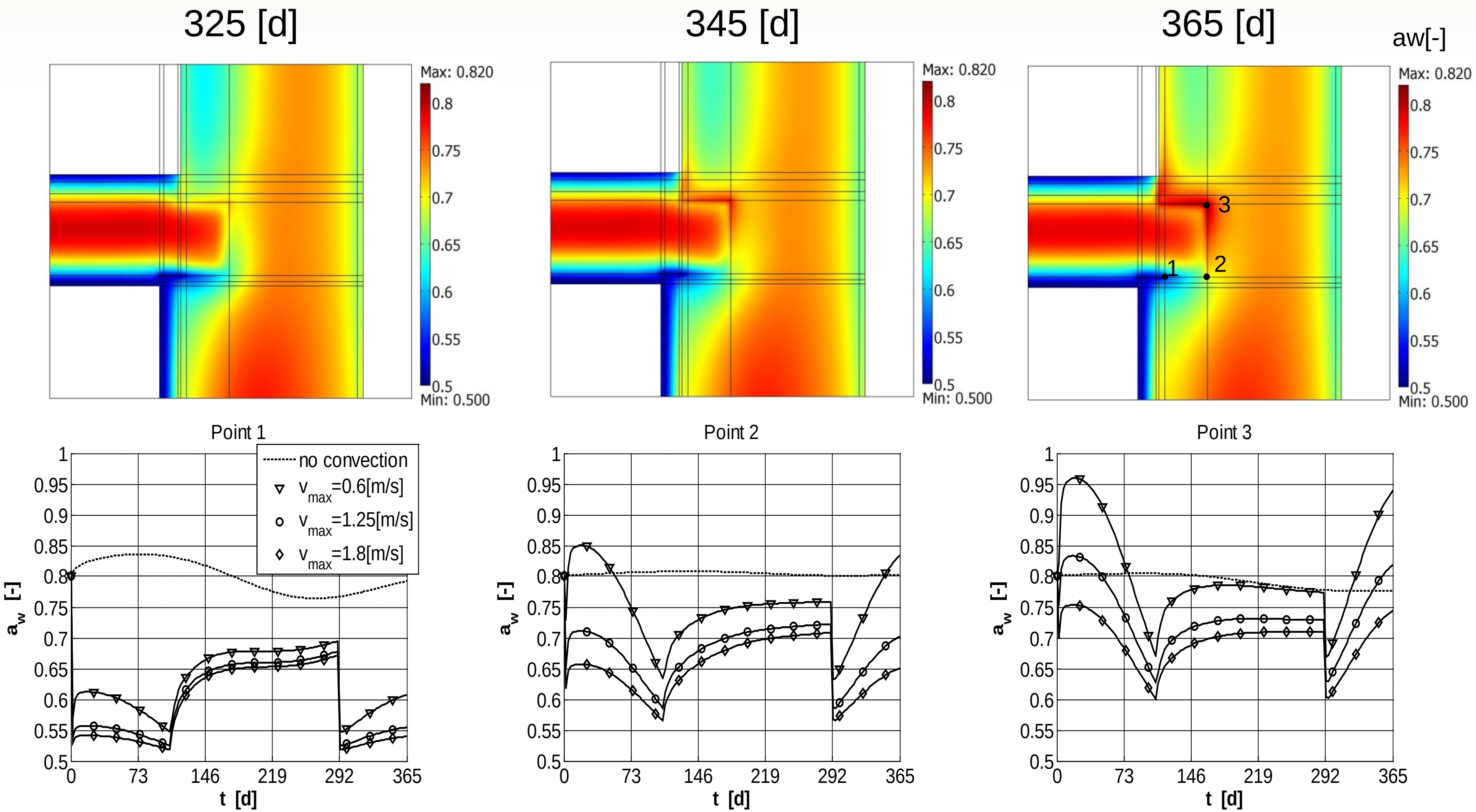
Forced Convection in the Air Gap: Air Velocity in the Gap



Development of the
Air Velocity in the Gap



Forced Convection in the Air Gap: Results



Outlook

Validation

- Numerical error analysis
- Experimental validation

Further development

- Free convection inside air cavities(CFD)

Thank you for your attention!

michele.janetti@uibk.ac.at