BERGISCHE UNIVERSITÄT WUPPERTAL

JÜLICH FORSCHUNGSZENTRUM

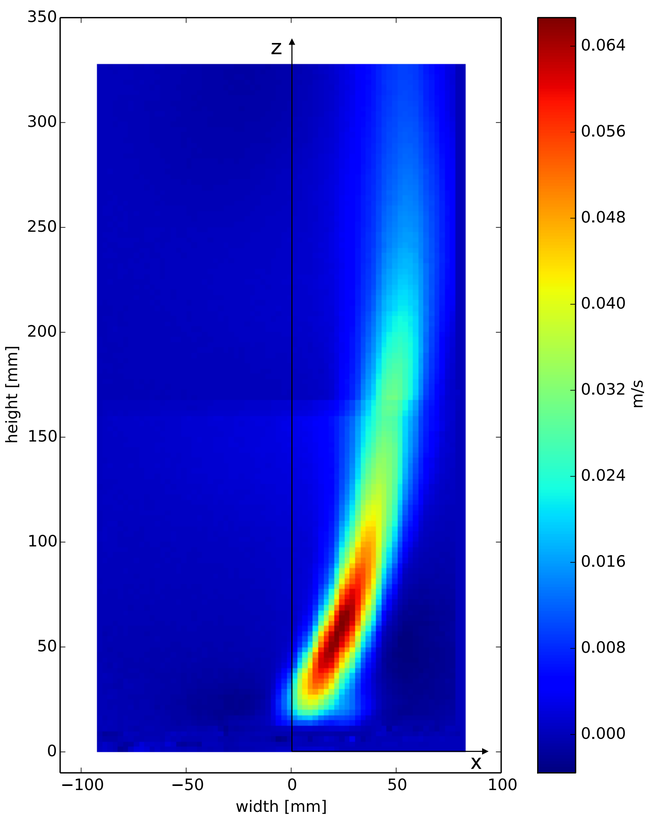
# DESIGN OF A TEST FACILITY TO INVESTIGATE THE TURBULENCE OF BUOYANCY-DRIVEN FLOWS DUE TO FLUID-FLUID-INTERACTION

Leonie Rommeswinkel, Alexander Belt and Lukas Arnold
Jülich Supercomputing Centre, Forschungszentrum Jülich, Wilhelm-Johnen-Strasse, 52428 Jülich (Germany)

## Motivation

- Design and construction of a small scale experimental facility to validate fluid models for buoyancy flows in CFD
- Experimental setup and diagnostics give insight on the turbulence intensity due to fluid-fluid-interaction in a plume

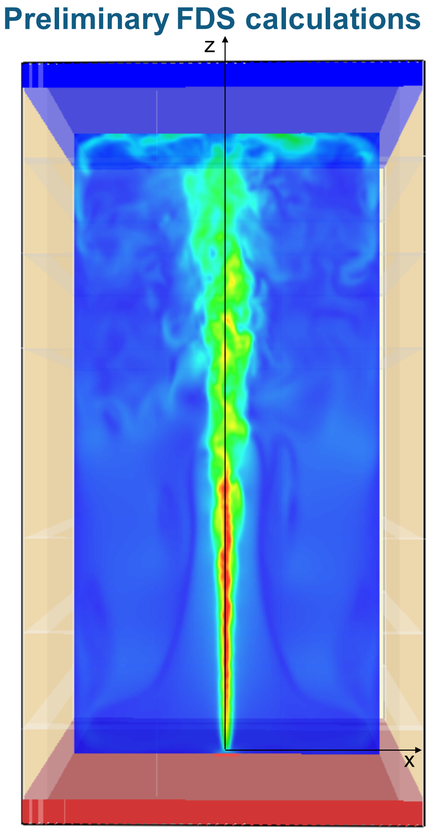
### First experiments in Plexiglas enclosure



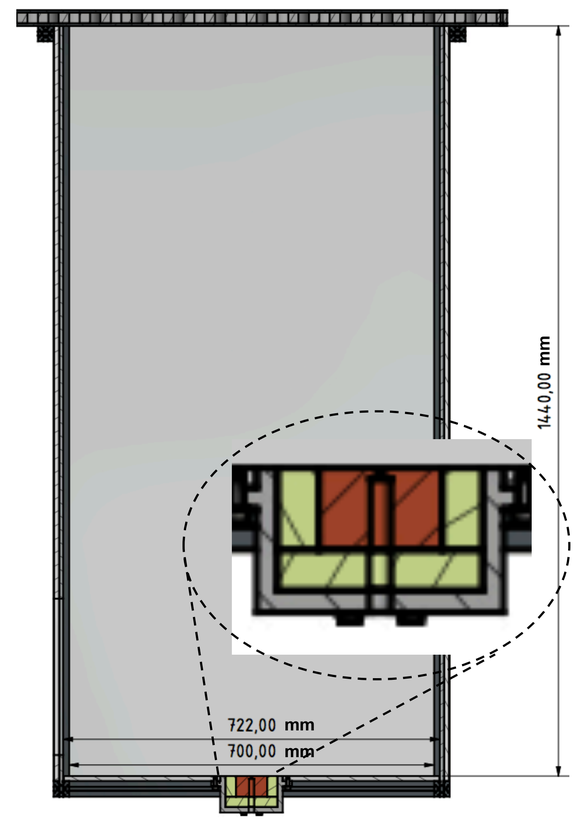

Asymmetrical flow conditions due to environmental influences, e.g. air conditioning and the cooling of the power supply of the Nd-YAG lasers

Improvement by preliminary FDS calculations with well defined boundary conditions and suitable construction measures

### Preliminary FDS calculations




### Construction for buoyancy driven flows




## Boundary Conditions

### Heating Source

- Previous experiment showed that the geometry of the heating block (flow separation at edges) has a strong influence on the turbulence intensity of the plume
- Heating source has been adapted, block has been lowered into the floor plate
- Heat release rate: $0.2\ W$ to $100\ W$ (total heat flux, i.e. convection and radiation)
- Surface temperature: $293.15\ K$ to $673.15\ K$

### Heat Exchanger at the Ceiling

- Inlet temperature: $283.15\ K$
- Expected maximal outlet temperature: $285.15\ K$
- Mass flow: $0.012\ \frac{l}{min}$
- Reynolds number: $456$
- Hydraulic diameter: $0.02\ m$
- Heat-transfer coefficient (HTC): $233.03\ \frac{W}{m^2 K}$

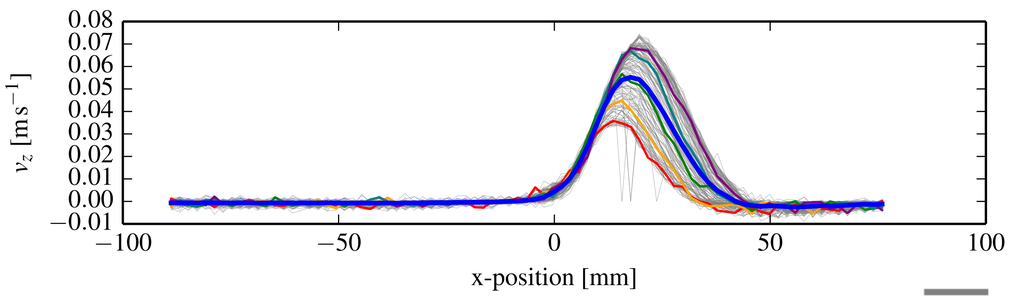
Rayleigh number (Ra): $5.91\times10^{9}$ to $2.2\times10^{10}$

## Further work

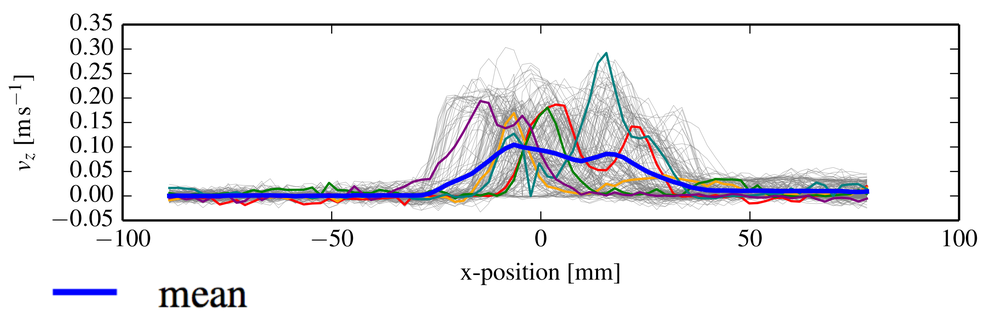
- Investigation of 3D-TKE (turbulent kinetic energy) of a pure buoyancy driven plume by means of stereo PIV
  3D-TKE : $k = \frac{1}{2}\left(\langle {v'_x}^2\rangle + \langle {v'_y}^2\rangle + \langle {v'_z}^2\rangle\right)$
- Derive critical Grashof Number ($Gr_{krit}$) for the transition from laminar to turbulent conditions of the plume
- Velocity fluctuations are determined by the Reynolds decomposition: $\vec{v} = \langle\vec{v}\rangle + \vec{v}'$
  and the measurement of the instantaneous velocity profiles



### 10 Volt instantaneous velocity profiles at z= 43.495 mm




### 50 Volt instantaneous velocity profiles at z= 43.495 mm




instantaneous mean

**Contact** l.rommeswinkel@fz-juelich.de **| Web** www.fz-juelich.de/ias/jsc/firesim