Cloud-Based CFD simulations for Clean Rooms in the Pharma Industry

HPC Methods for Engineering Applications
CINECA - June 20th, 2017

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CINECA

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nest consulting
new engineering solutions & technologies

Why Cloud-Based?

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Mission

Provide design technology,
easy to use and accessible everywhere.

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Disrupt major barriers

- Software licences costs
- High performance hardware investments
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Collateral benefits

- Potentially unlimited parallelization capabilities
- Enhanced accessibility and collaboration
- Top customer support effectiveness

Why Cloud-Based? Why not?

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Incorporated:
April 2015

Headquarter:
Viale E. Forlanini 23, 20134 - Milano

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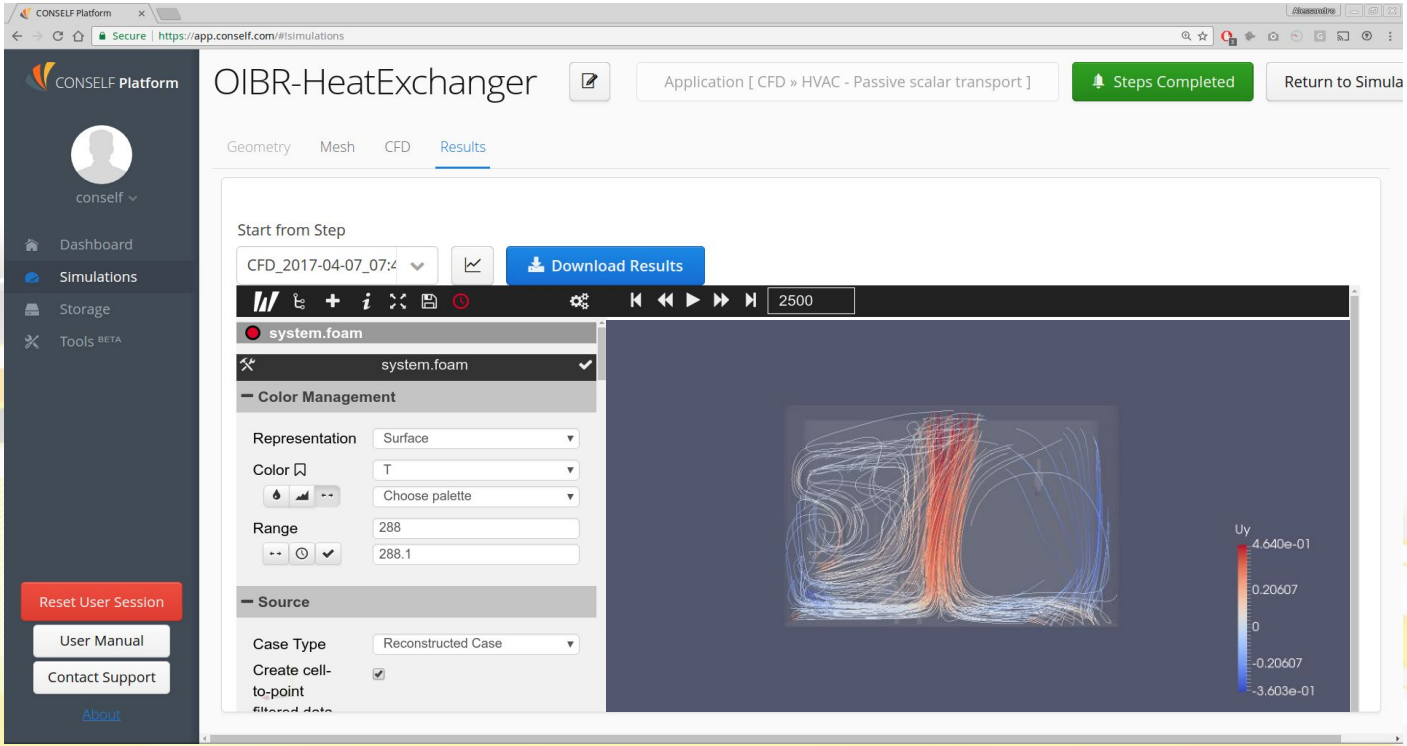
Alessandro Palmas
MSc Space Engineering
Turin Polytechnic, Milan Polytechnic, University of Glasgow

CONSELF Co-Founder
Responsible for:

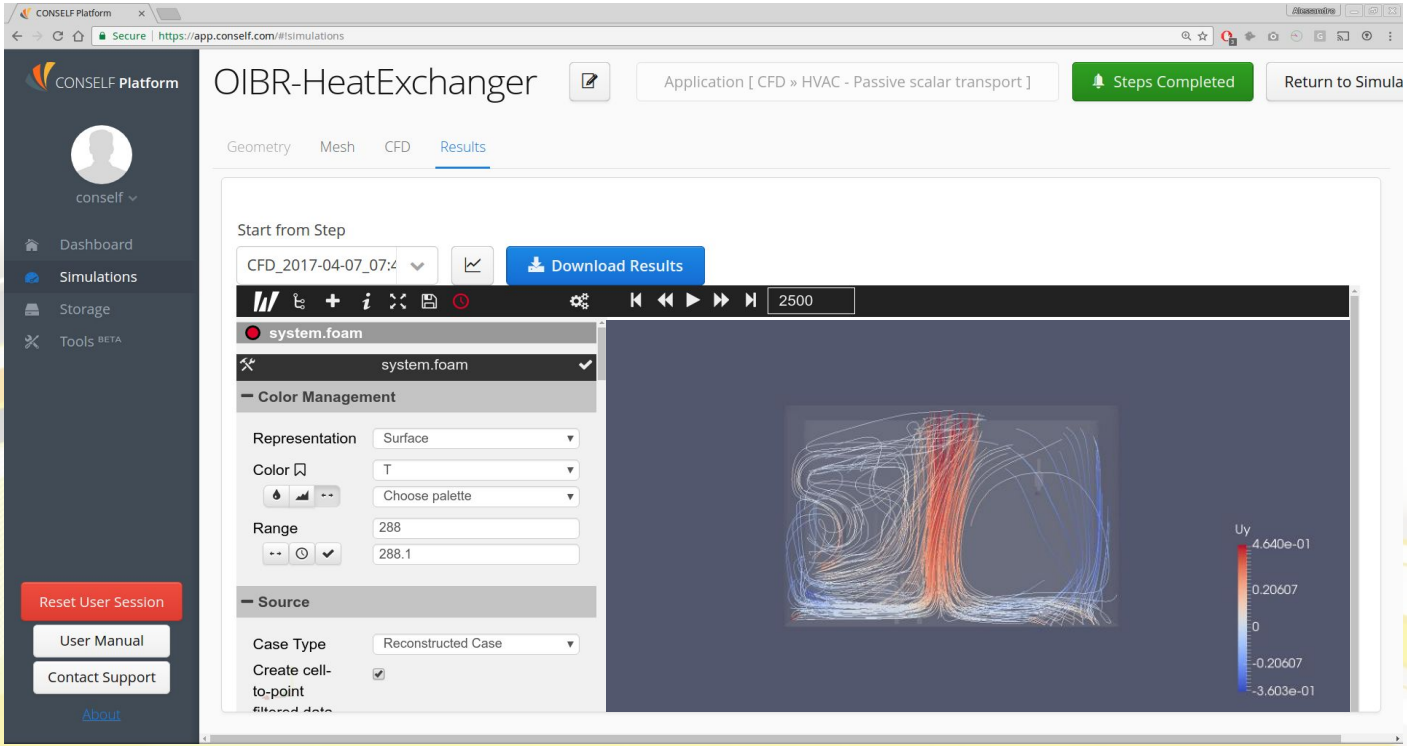
- CAD interface, Meshing Algorithms and Computational Geometry Tools
- International customers and resellers

Why Cloud-Based? Why not?



Cloud Simulation Platform

Why Cloud-Based? Why not?



OpenFOAM

code_aster

Cloud Simulation Platform

Case study: Clean Rooms - Nest consulting

new
engineering
solutions & technologies

Headquarter:
Piazzale della Resistenza 3, 50018 - Scandicci (FI)

Services:
Engineering and consultancy in the pharmaceutical, fine chemicals, healthcare and energy markets.

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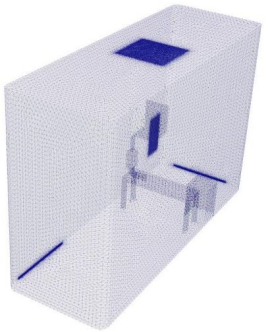
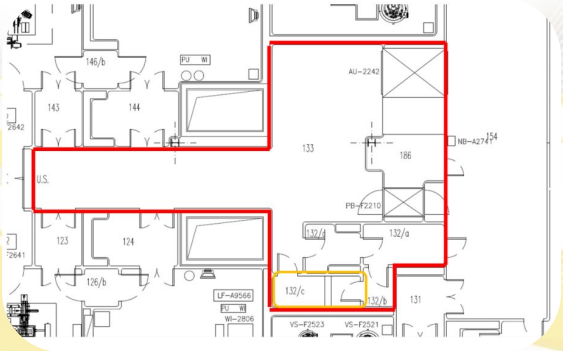


Goals:

- To analyze current hvac system performances inside a set of locker rooms of a pharmaceutical production plant providing access to a Class B autoclave room
- To identify technical solutions to mitigate frequent events of microbiological contamination



Case study: Clean Rooms - Nest consulting

Company key aspects:

- No previous experience in the field
- Young novice users of Computational Fluid Dynamics software suites
- Only academic (basic) knowledge of Computational Fluid Dynamics
- Only occasional requests for this specific analysis

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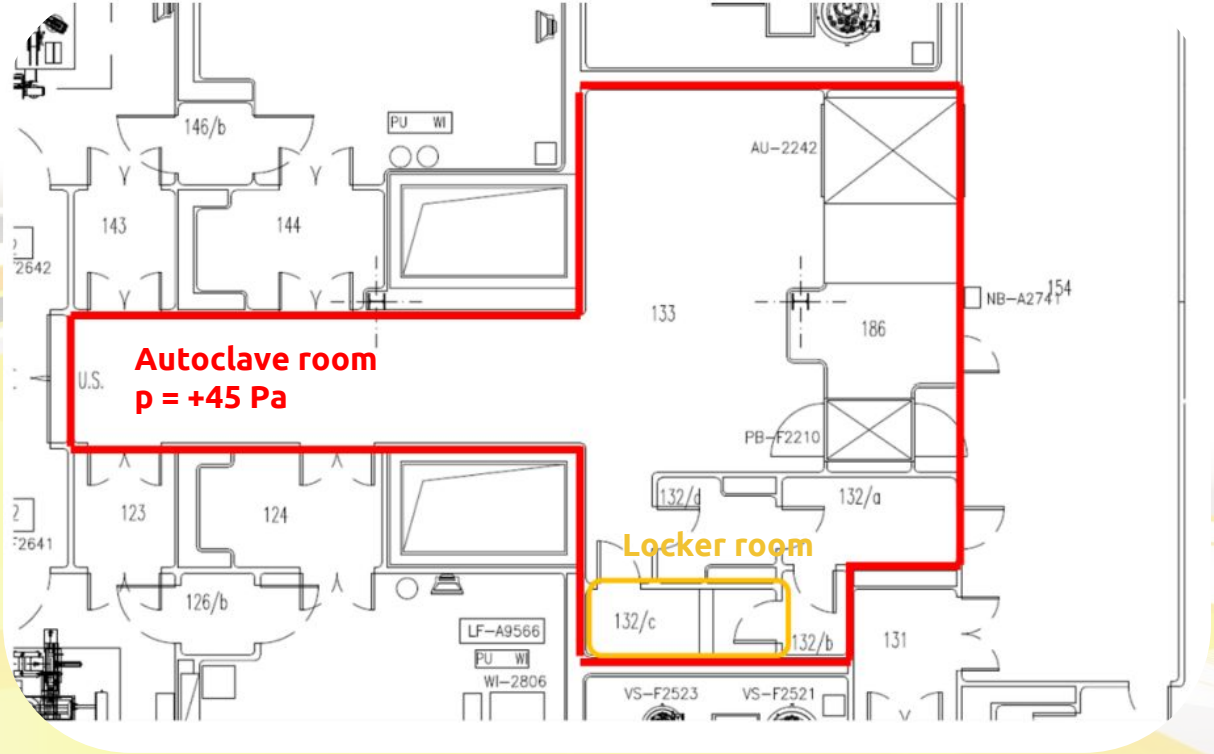
Tailored solution:

- 2-day training on:
  - CAD modeling for CFD
  - Meshing fundamentals and tactics
  - CFD theory and models
  - Simulation with CONSELF Platform
  - Post processing with Paraview
- Monthly subscription plan with 250 core hours
- Dedicated support

Case study: Clean Rooms - The problem



Case study: Clean Rooms - The problem

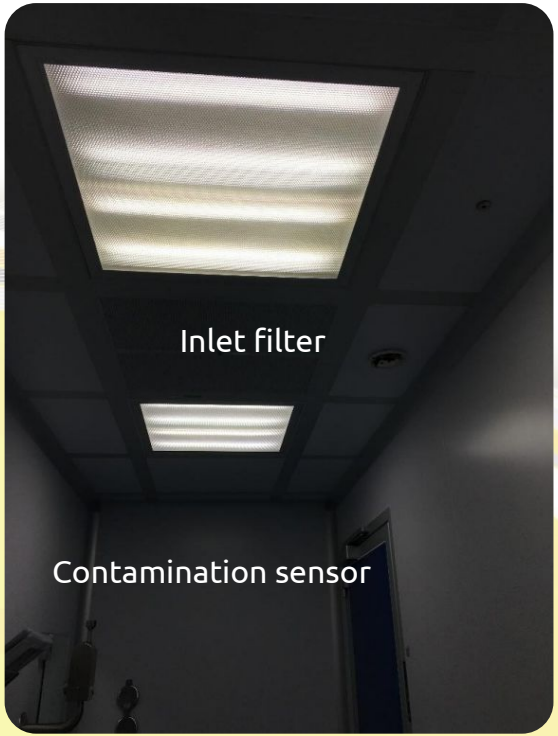
Locker room

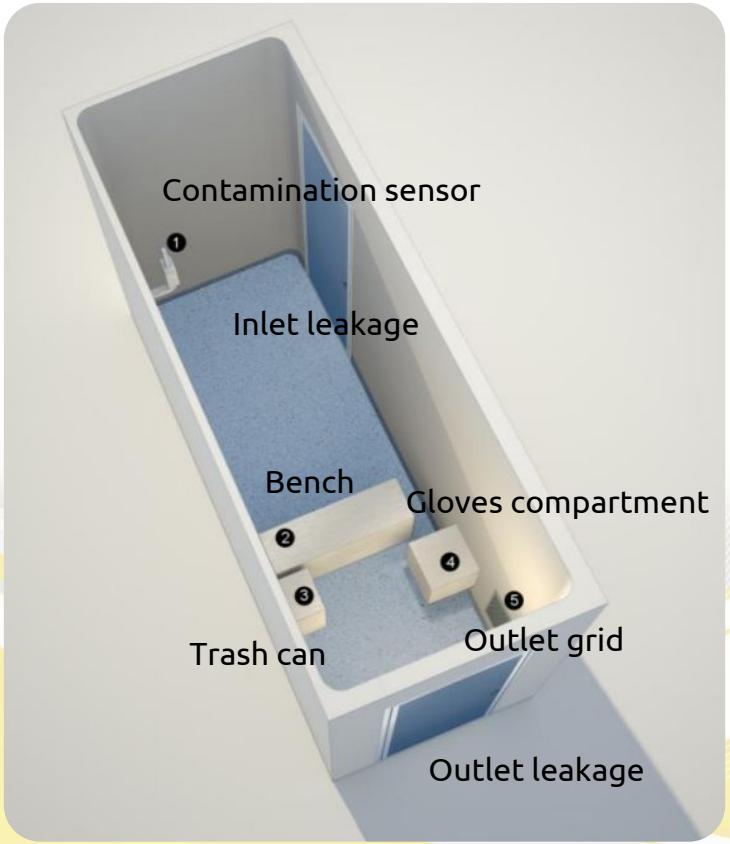
Size: 4.5 m^2 X 2.47 m

On site measurements for boundary conditions

Inlet filter: 0.47 m/s
Inlet leakage: 2.29 m/s

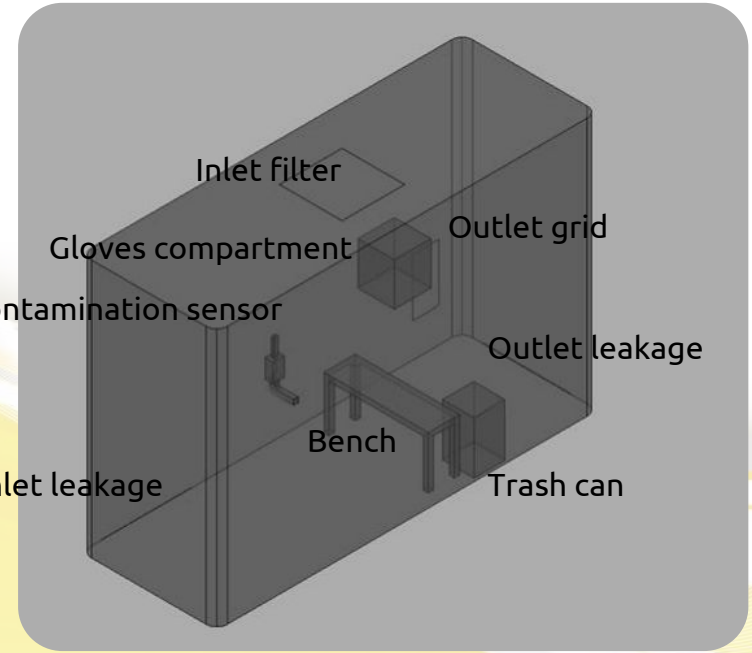
Outlet grid: 101369.5 Pa
Outlet leakage: 101355 Pa



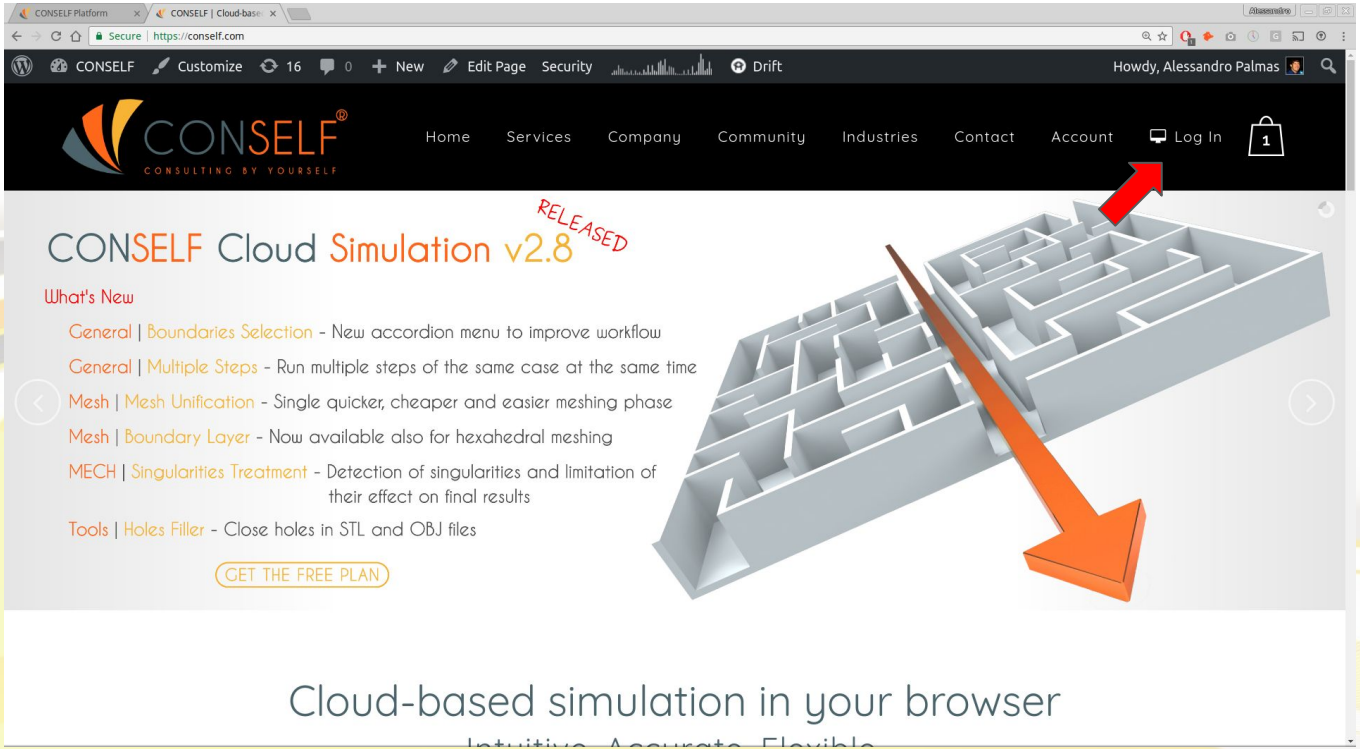


Case study: Clean Rooms - The problem

CAD preparation: creation of the fluid volume



Case study: Clean Rooms - Complete simulation cycle in a browser



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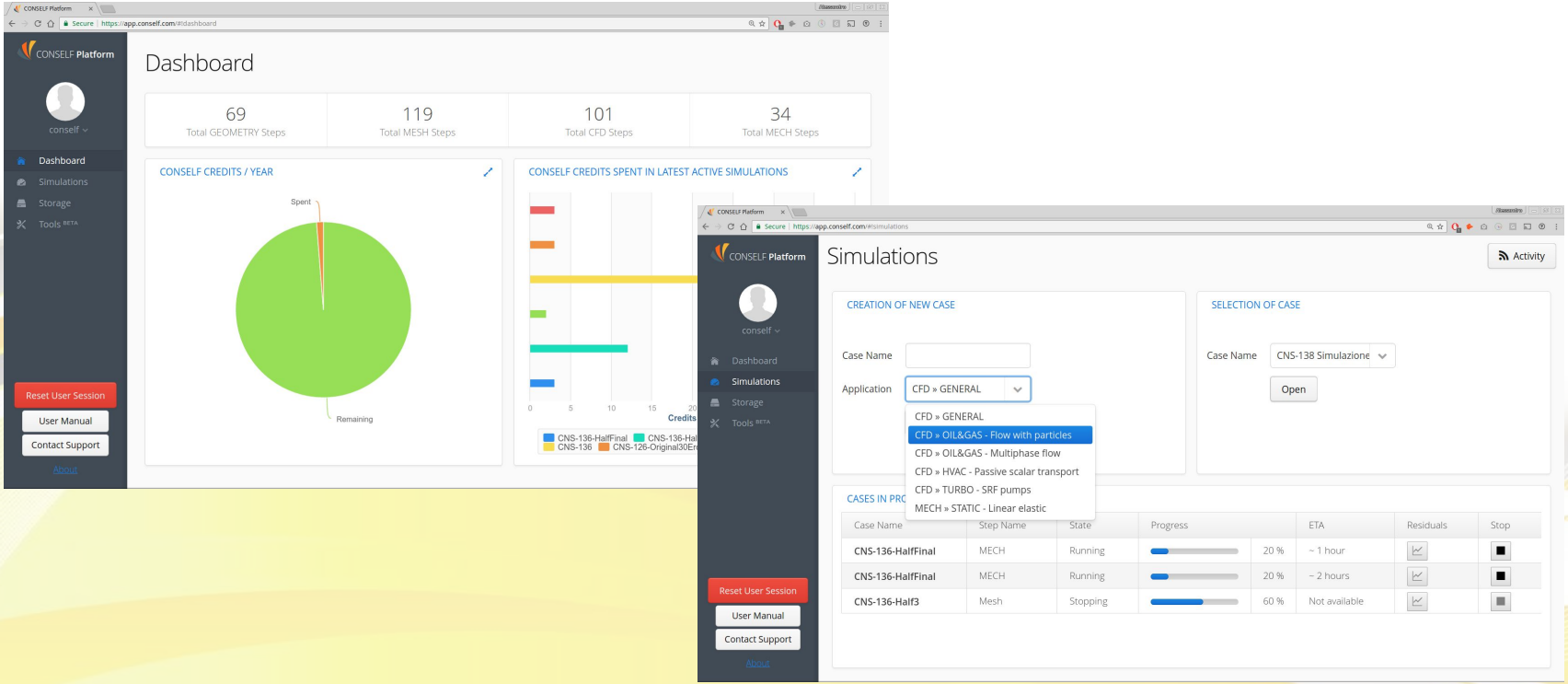
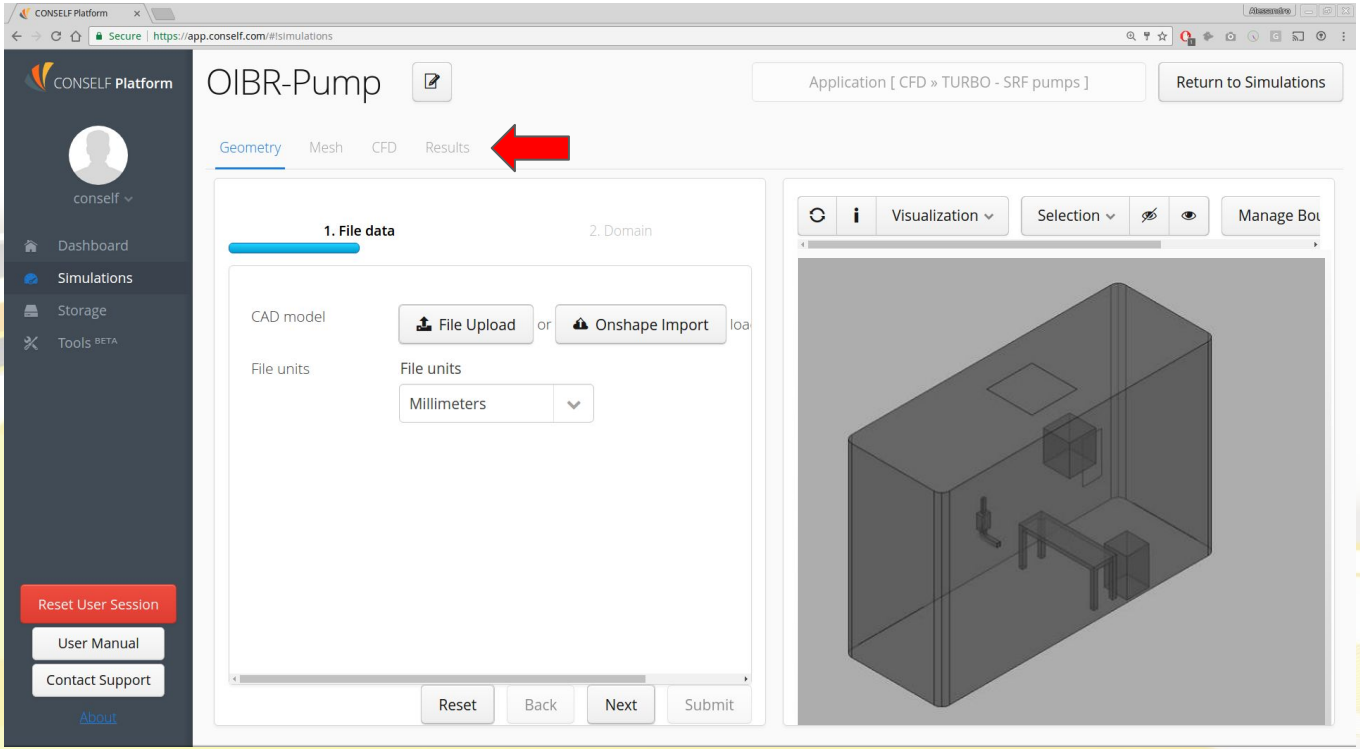


Case study: Clean Rooms - Complete simulation cycle in a browser

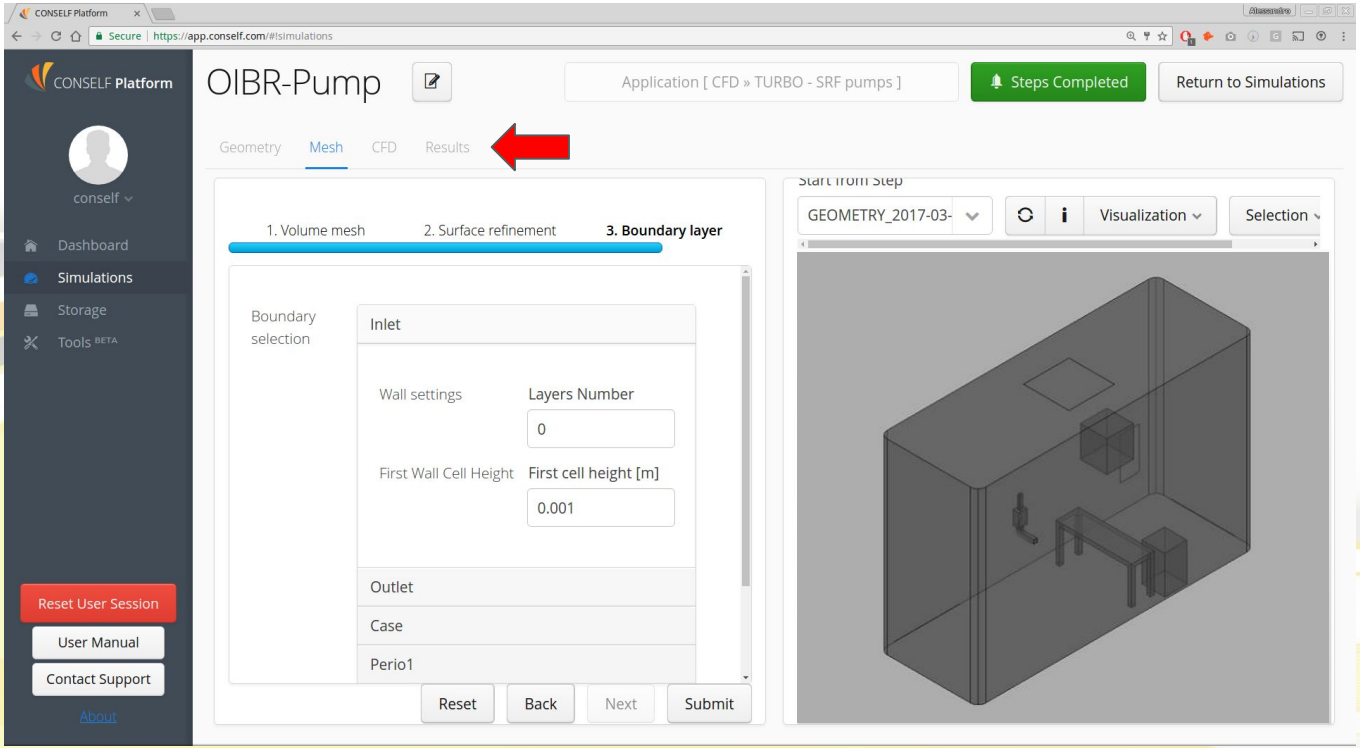
Simulation assumptions

- Heat transfer is negligible
- Turbulent flow
- No compressibility phenomena
- Leakages due to under door gaps of 6mm size

Case study: Clean Rooms - Complete simulation cycle in a browser - CAD



Case study: Clean Rooms - Complete simulation cycle in a browser - Mesh

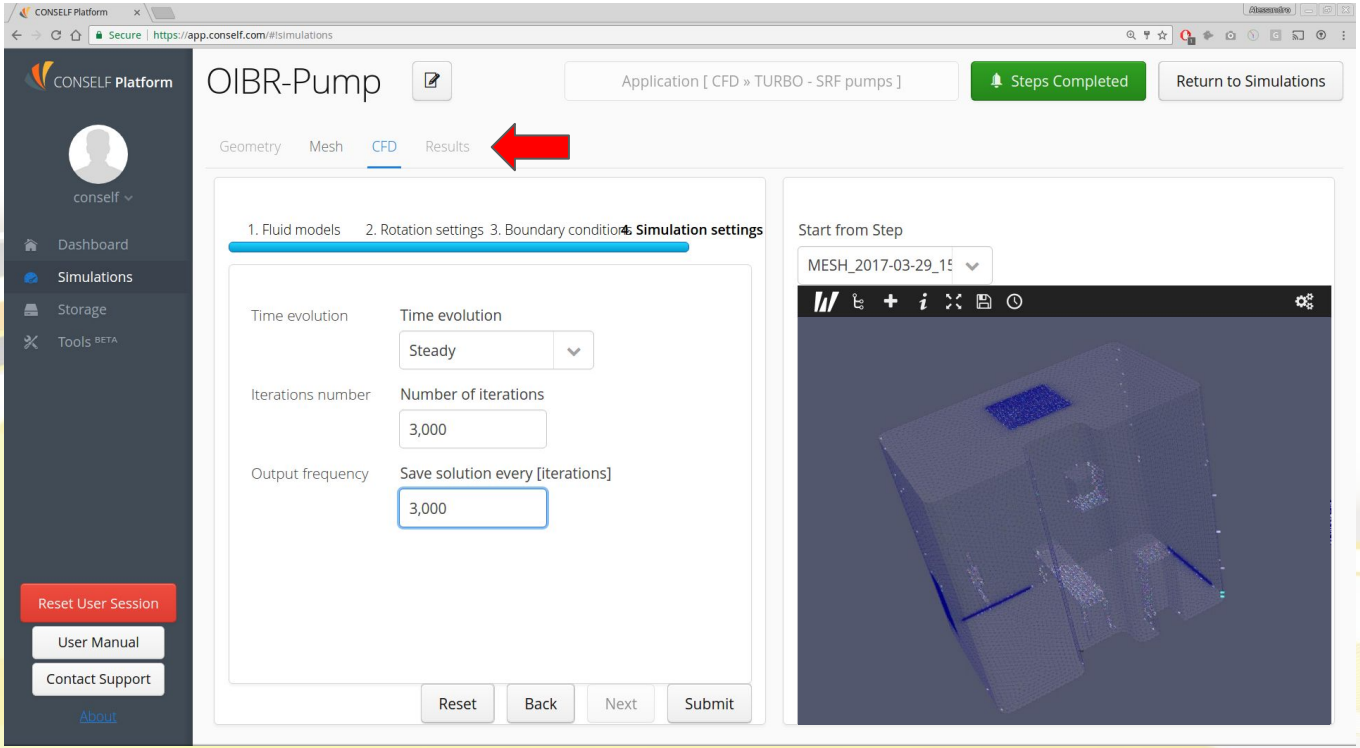


Case study: Clean Rooms - Complete simulation cycle in a browser - Mesh

Mesh specifications

- Unstructured tetrahedral mesh
- Maximum cell dimension 0.05 m
- Surface refinements
- Grid size:
  - Grid 1: 750 000 cells
  - Grid 2: 1 200 000 cells

Case study: Clean Rooms - Complete simulation cycle in a browser - CFD



Case study: Clean Rooms - Complete simulation cycle in a browser - CFD

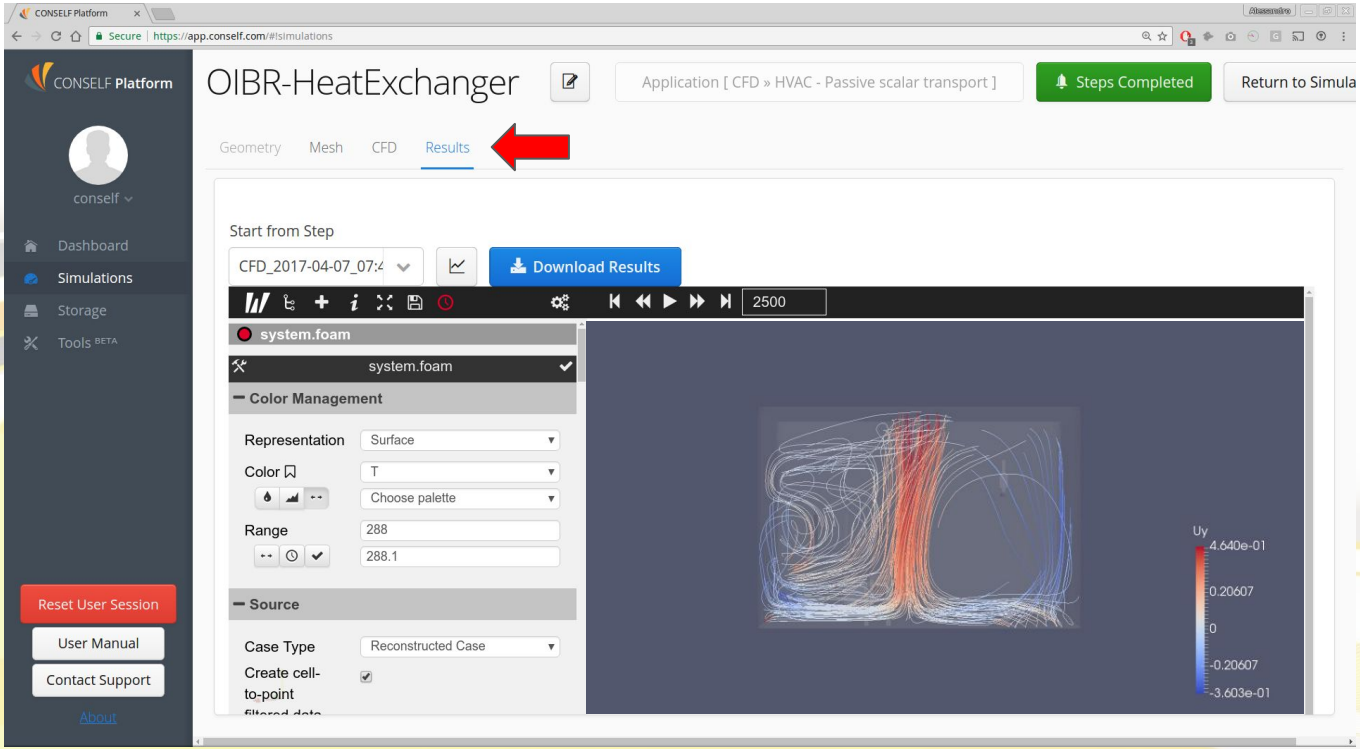
CFD model

- Steady RANS solver
- Standard k-Ɛ turbulence model

Boundary conditions

- Filter inlet: velocity inlet
- Leakage inlet: velocity inlet
- Outlet grid: pressure outlet
- Leakage outlet: pressure outlet
- All remaining surfaces: no slip wall

Case study: Clean Rooms - Complete simulation cycle in a browser - Results



Case study: Clean Rooms - Results

Study A: current HVAC system performances assessment

- Grid sensitivity analysis
- Comparison with experimental data

Study B: new proposal to improve performances (Additional inlet filter)

- Performances comparison

Key variable/aspects of interest:

- Vertical velocity: if directed downwards it assures contaminants present on the floor do not reach higher zones of the locker rooms
- Recirculation zones: their absence helps maintaining a properly clean environment avoiding movement of contaminant deposits

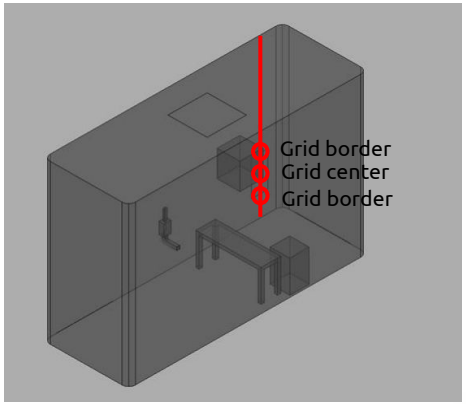
Case study: Clean Rooms - Results

Location of control points

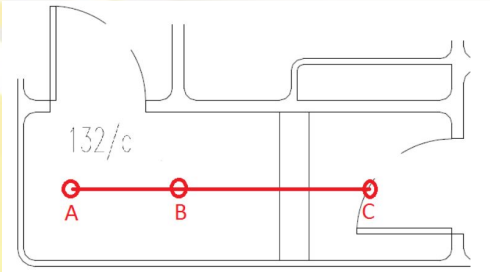
Eight control points

- Outlet grid borders (2)
- Outlet grid center (1)
- Locker room centerline point A (1)
- Locker room centerline point B (1)
- Locker room centerline point C (1)
- Microbiological plates MP (1)
- Parcels counter PC (1)

MP and PC control points



Outlet grid control points

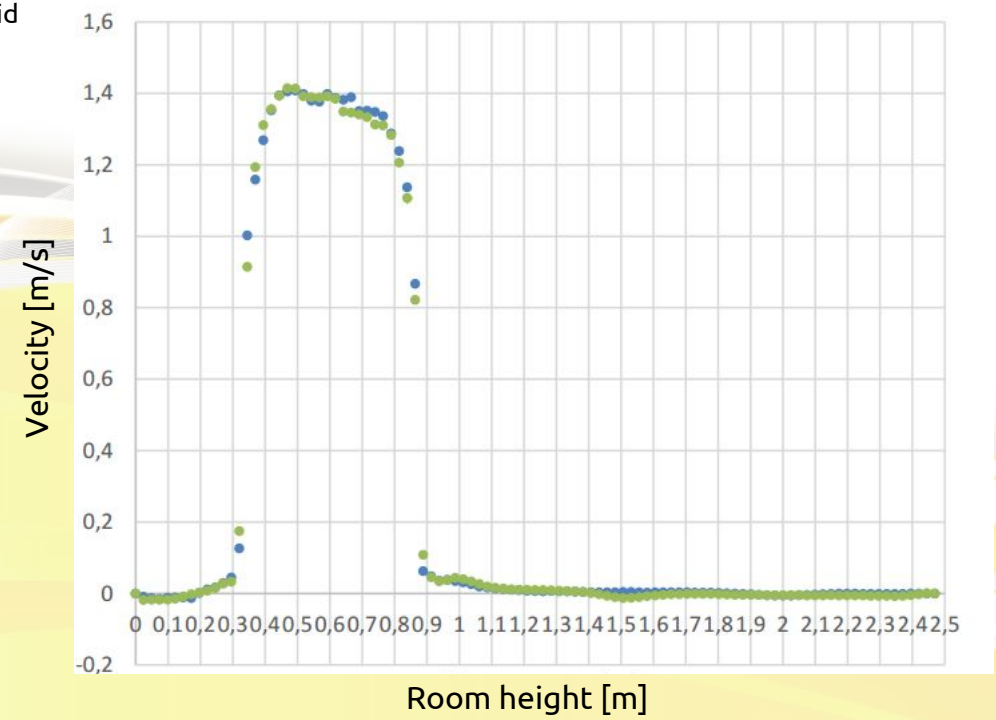


Locker room centerline control points

Case study: Clean Rooms - Results - Study A

Grid sensitivity analysis

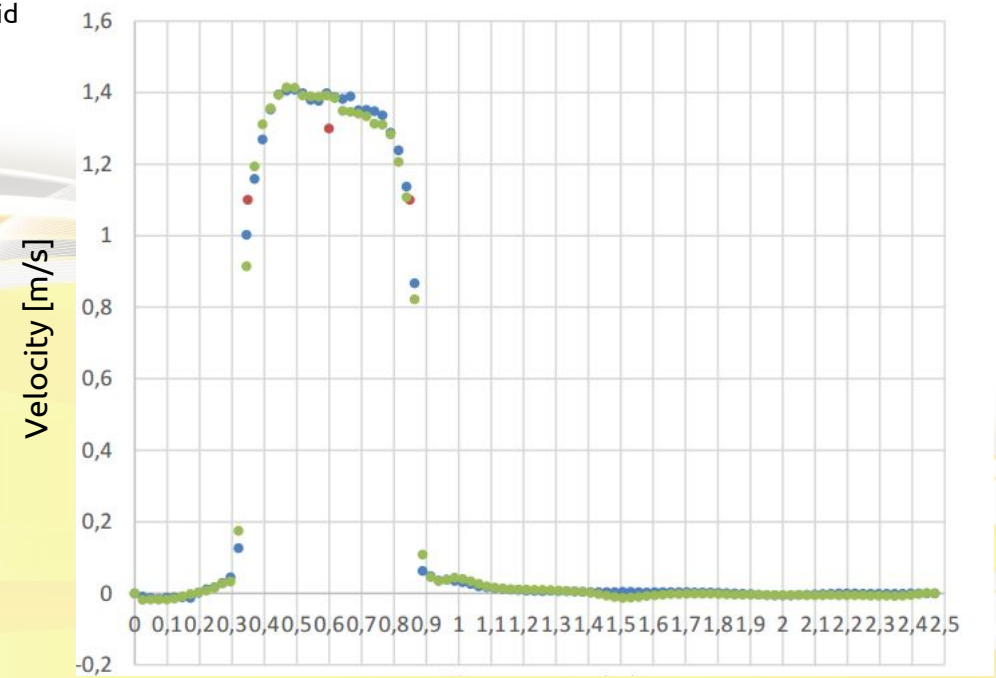
Velocity profile on outlet grid



Case study: Clean Rooms - Results - Study A

Comparison with experimental data

Velocity profile on outlet grid

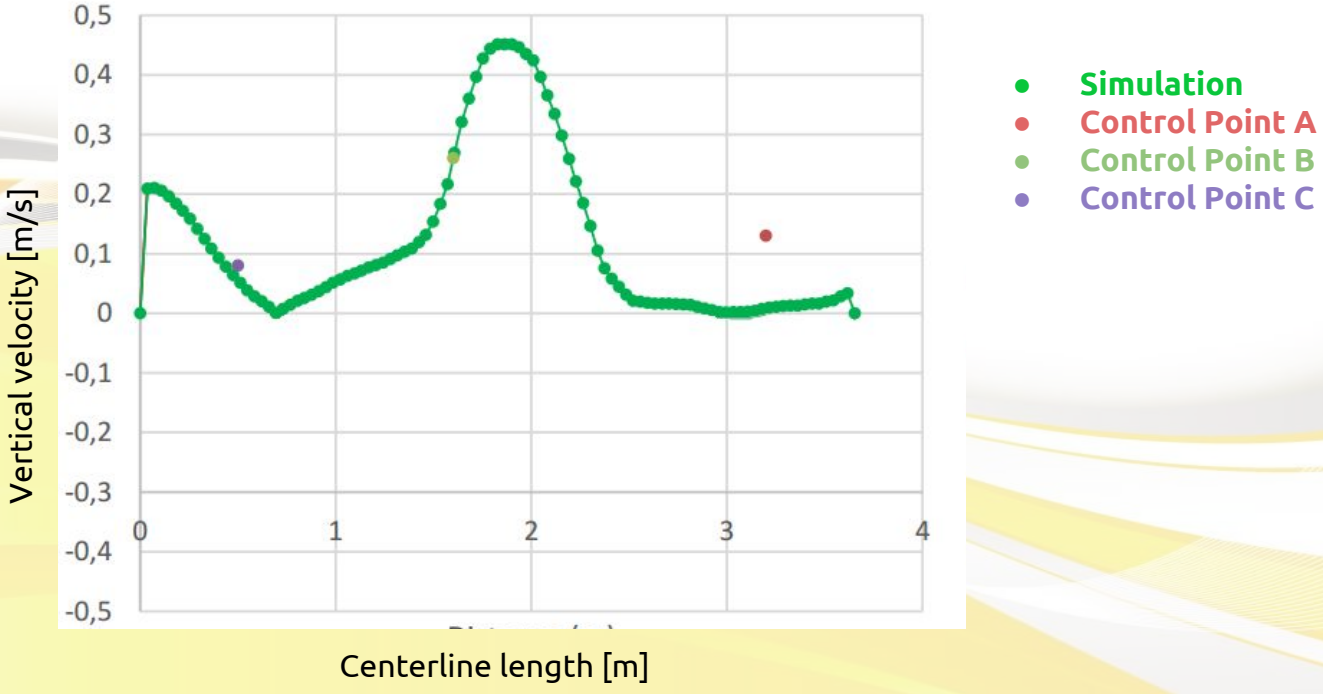


- 1 200 000 Cells
- 750 000 Cells
- Experimental data

Case study: Clean Rooms - Results - Study A

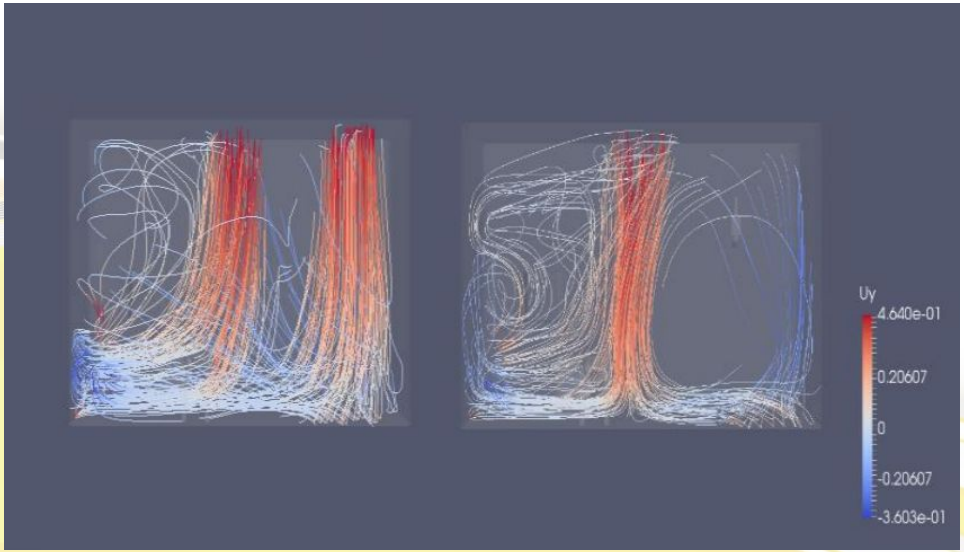
Comparison with experimental data

Vertical velocity profile on locker room centerline



Case study: Clean Rooms - Results - Study B

Vertical velocity colored streamlines comparison



HVAC improvement proposal (left) compared with current system performances (right)

Case study: Clean Rooms - Results - Study B

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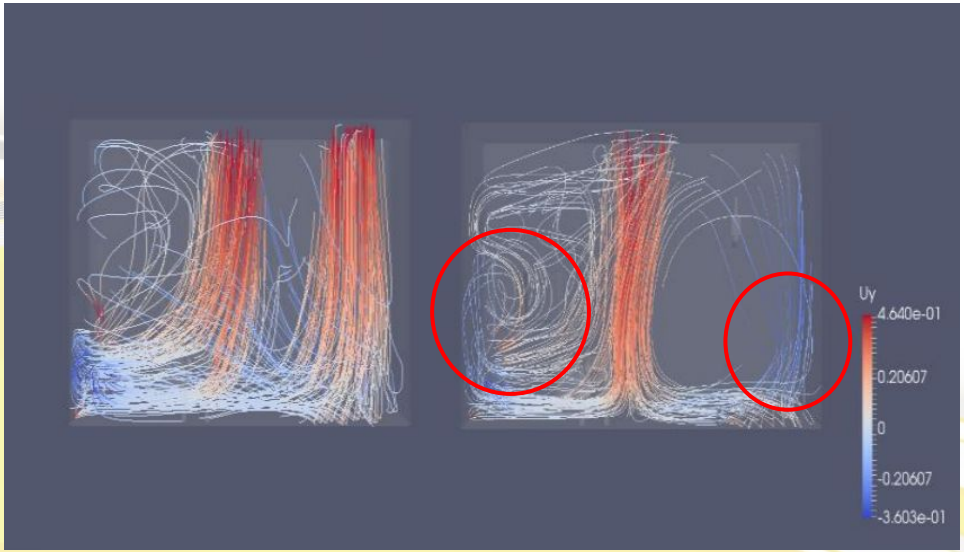

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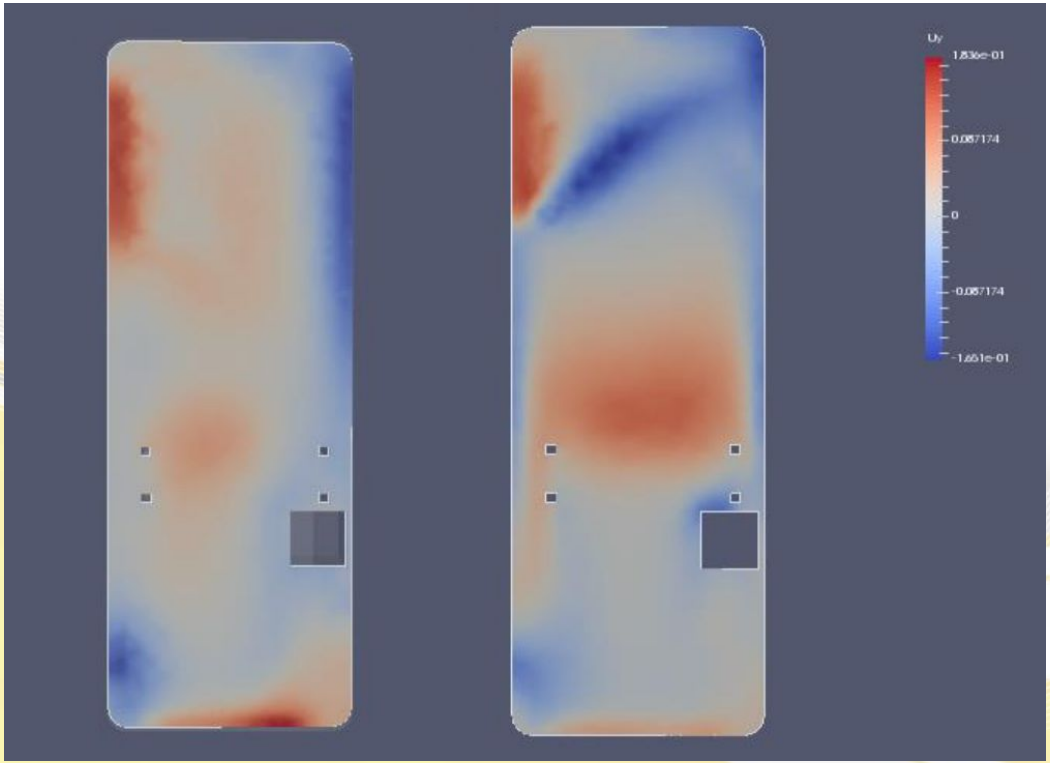
Case study: Clean Rooms - Results - Study B

Vertical velocity contours comparison
10 cm from the ground slice



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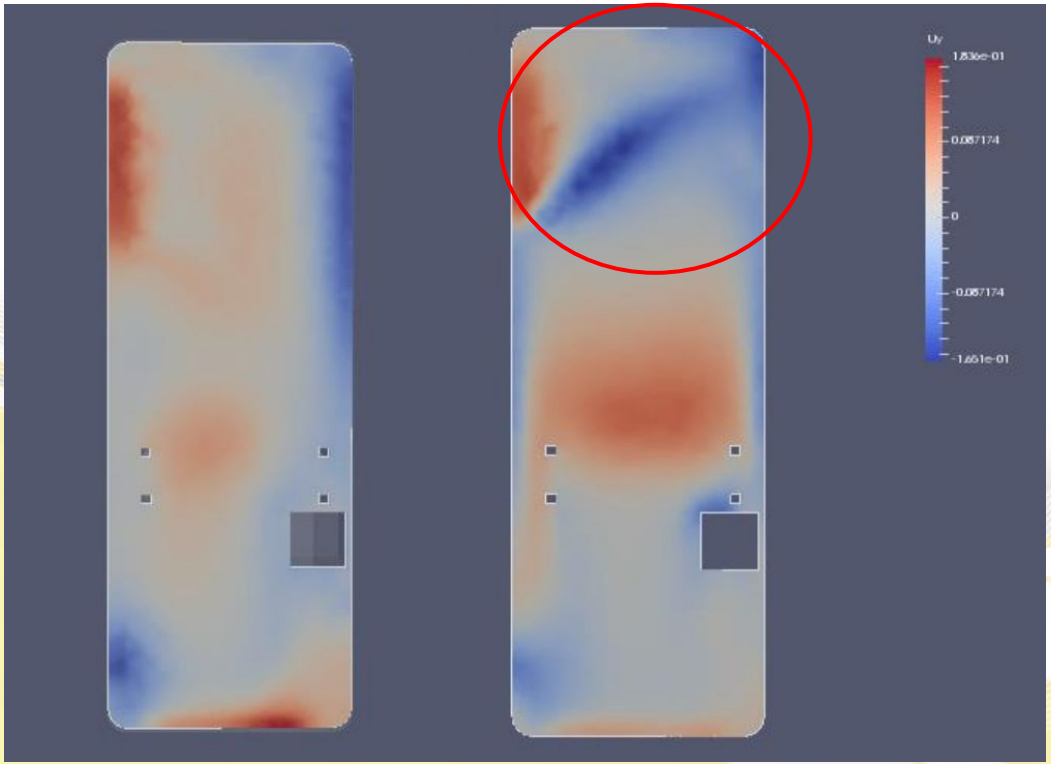

HVAC improvement proposal (left) compared with current system performances (right)

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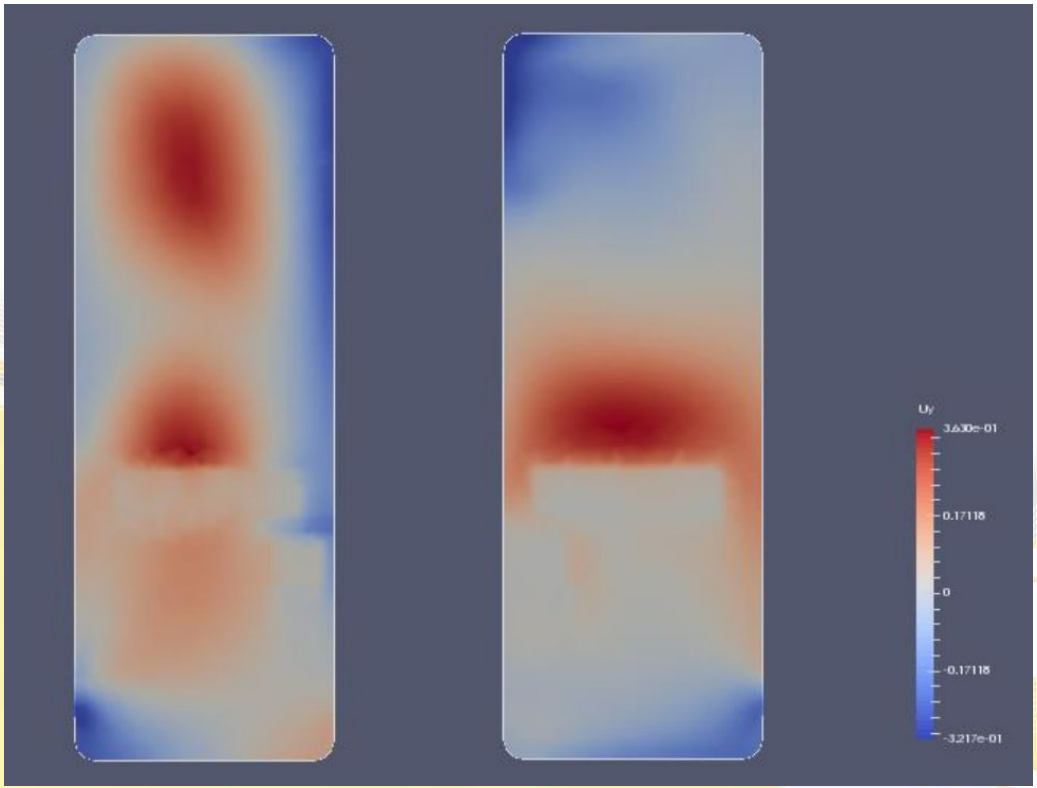
Vertical velocity contours comparison
Bench seat slice



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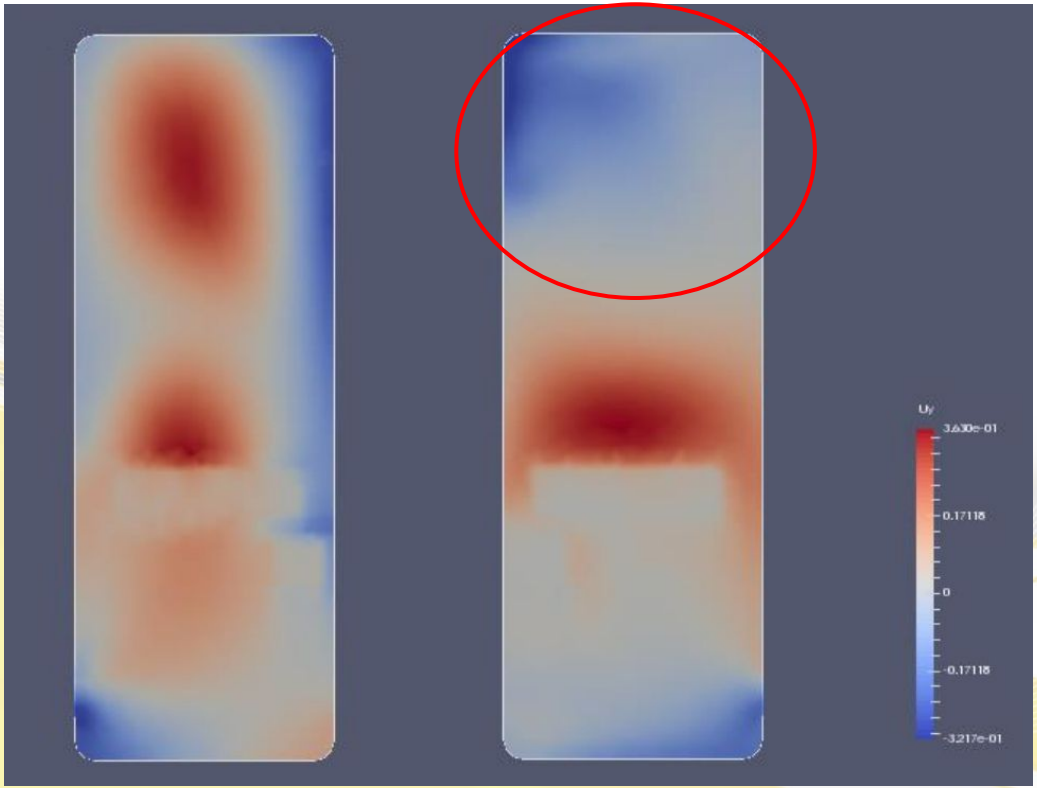
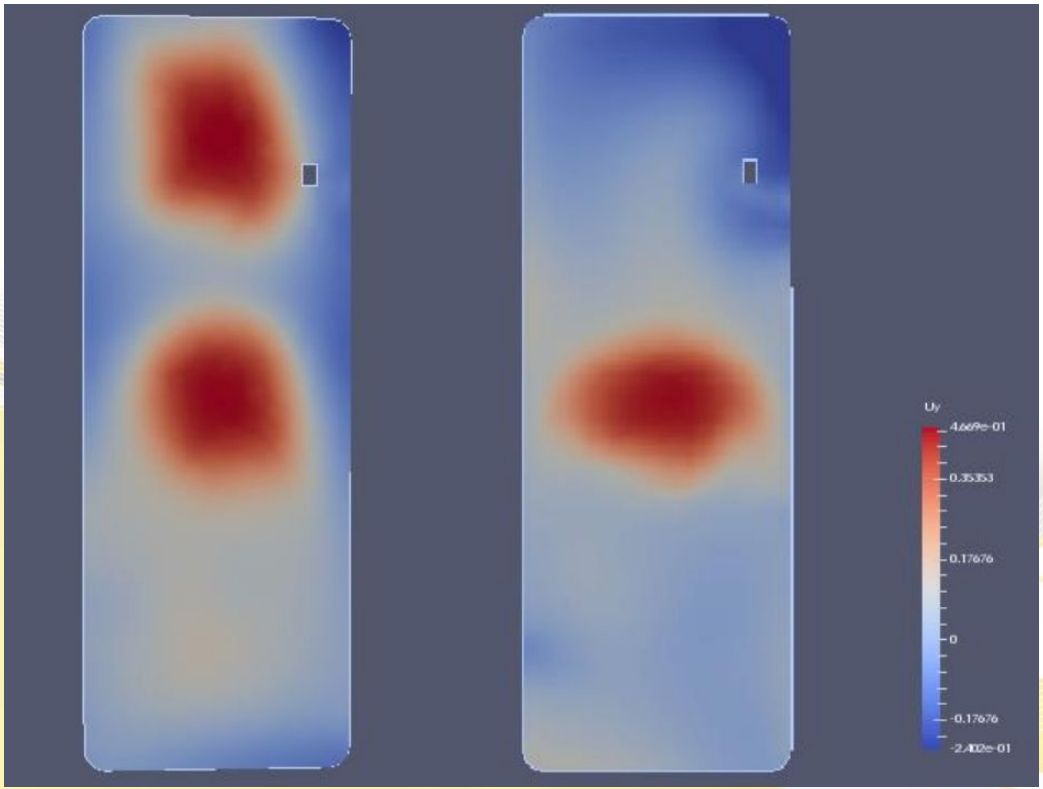


HVAC improvement proposal (left) compared with current system performances (right)

Case study: Clean Rooms - Results - Study B

Vertical velocity contours comparison
175 cm from the ground slice



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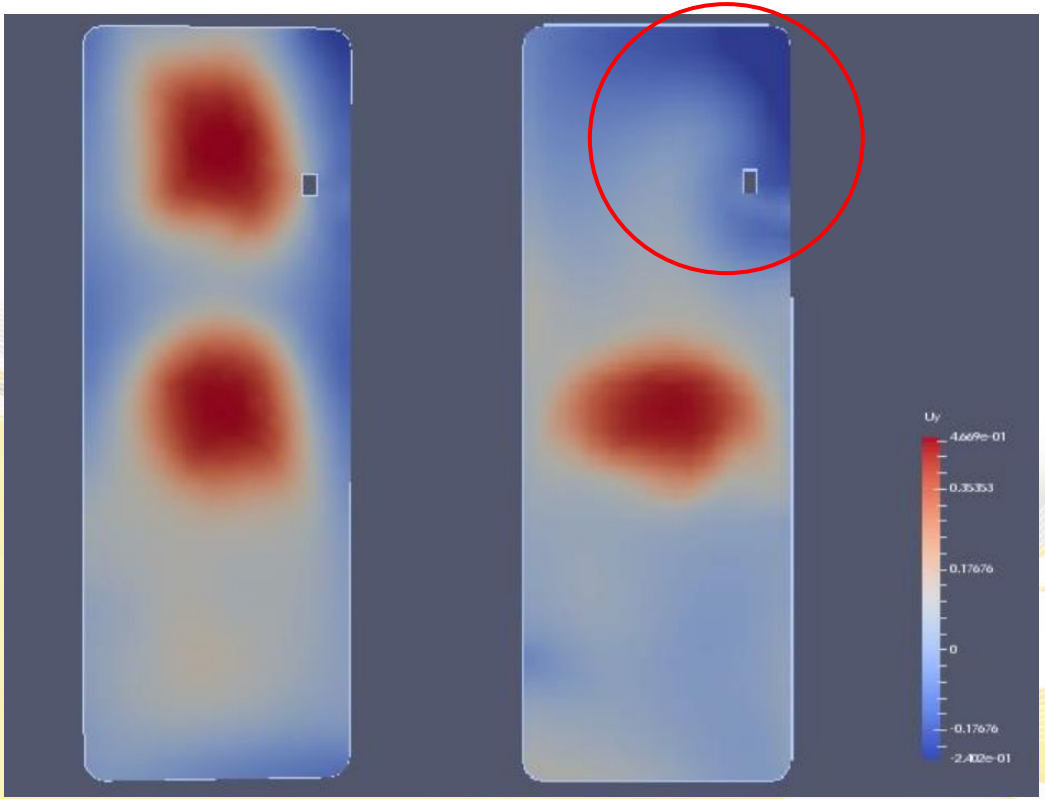

HVAC improvement proposal (left) compared with current system performances (right)

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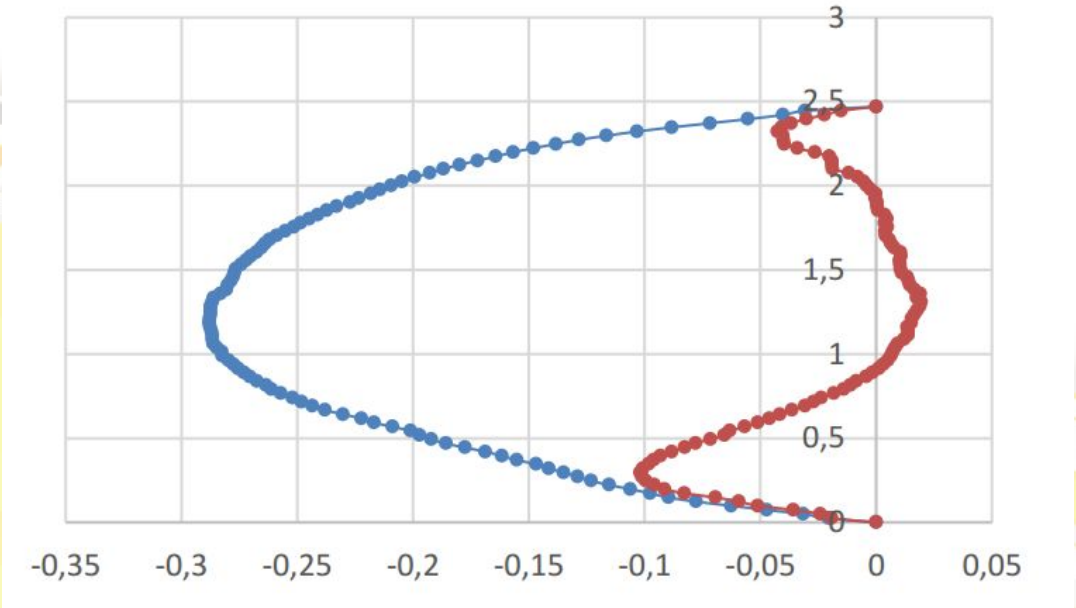
Vertical velocity profile comparison
MP control point



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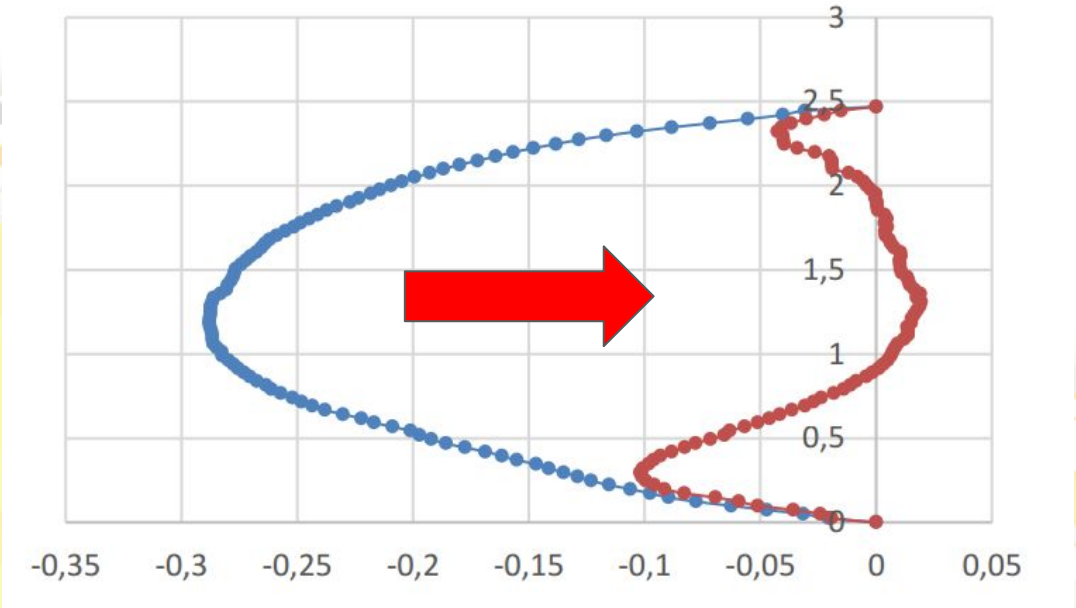
Vertical velocity profile comparison
MP control point



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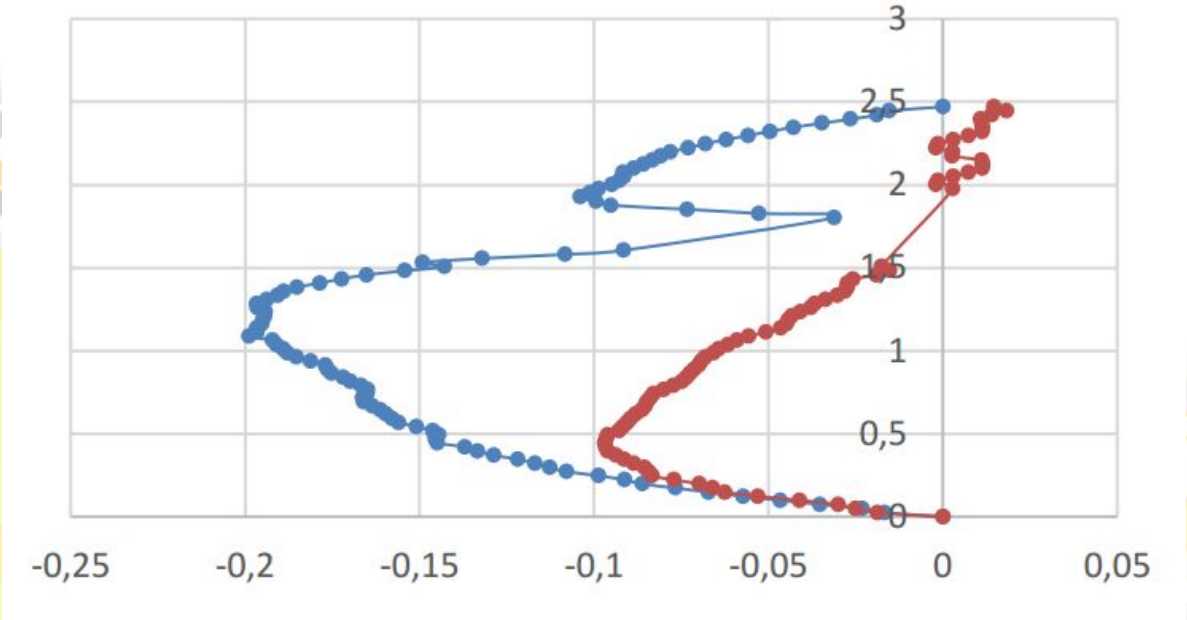
Vertical velocity profile comparison
PC control point



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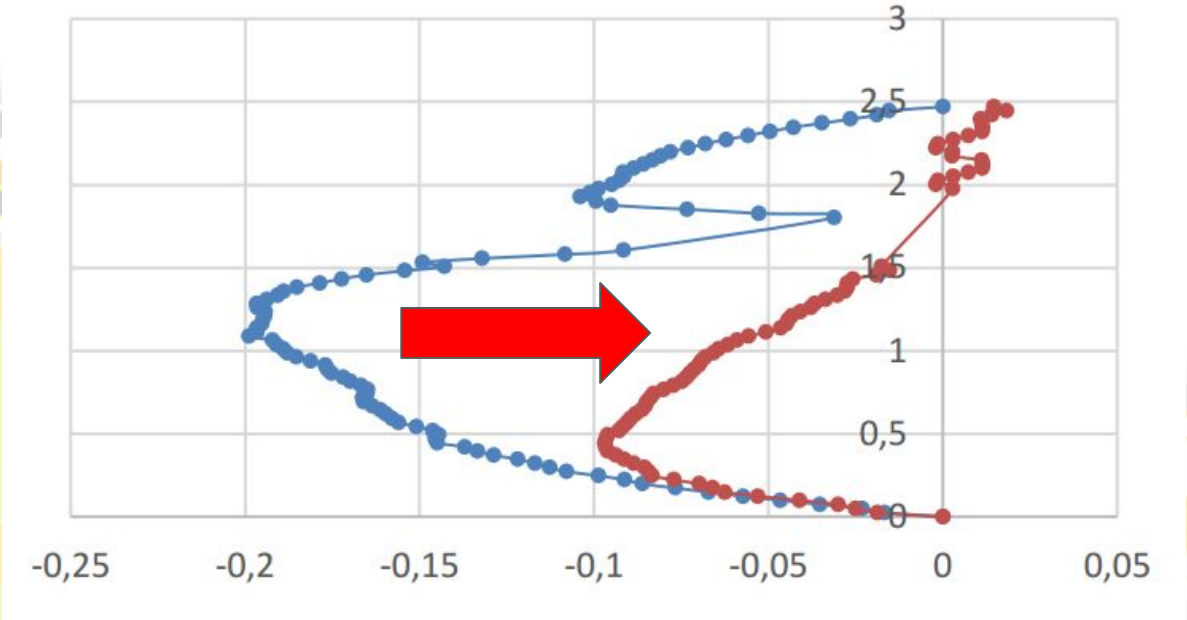
Vertical velocity profile comparison
PC control point



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