

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

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

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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?**

The screenshot displays the CONSELF Platform web interface for a simulation titled "OIBR-HeatExchanger". The browser address bar shows the URL <https://app.conself.com/#/simulations>. The interface includes a left sidebar with navigation options: Dashboard, Simulations, Storage, and Tools BETA. The main content area shows the simulation progress, with a "Steps Completed" button and a "Return to Simu..." button. The simulation is currently in the "Results" phase. A "Start from Step" dropdown is set to "CFD_2017-04-07_07:4", and a "Download Results" button is visible. The simulation parameters are displayed as follows:

- Representation: Surface
- Color: T
- Range: 288 to 288.1
- Source: Reconstructed Case

The central visualization shows a 3D model of a heat exchanger with streamlines representing the flow field. A color scale on the right indicates the temperature distribution, ranging from $-3.603e-01$ to $4.640e-01$.

Cloud Simulation
Platform

Why Cloud-Based? **Why not?**

The screenshot shows the CONSELF Platform interface for a CFD simulation. The main title is "OIBR-HeatExchanger" with a sub-label "Application [CFD » HVAC - Passive scalar transport]". A green button indicates "Steps Completed". The interface is divided into several sections:

- Left Sidebar:** Contains user profile information (consself), navigation links (Dashboard, Simulations, Storage, Tools BETA), and a "Reset User Session" button.
- Top Navigation:** Includes tabs for "Geometry", "Mesh", "CFD", and "Results".
- Main Content Area:** Features a "Start from Step" section with a dropdown menu showing "CFD_2017-04-07_07:4" and a "Download Results" button. Below this is a control bar with a play button and a time indicator of "2500".
- Simulation Settings:** A panel for "system.foam" with options for "Color Management" (Representation: Surface, Color: T, Range: 288 to 288.1) and "Source" (Case Type: Reconstructed Case).
- Visualization:** A central window showing a 3D model of the heat exchanger with streamlines. A color scale on the right indicates values from $-3.603e-01$ to $4.640e-01$.

OpenFOAM

code_aster

Cloud Simulation Platform

Case study: Clean Rooms - Nest consulting



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Headquarter:

Piazzale della Resistenza 3, 50018 - Scandicci (FI)

Services:

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

Case study: Clean Rooms - Nest consulting



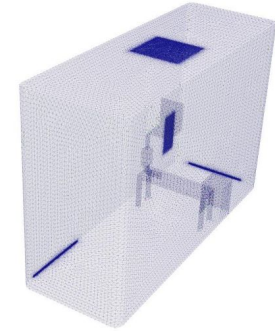
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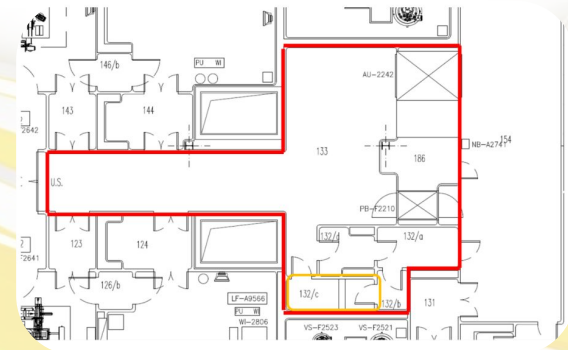
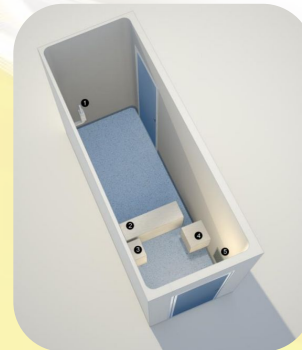
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Goals:

- 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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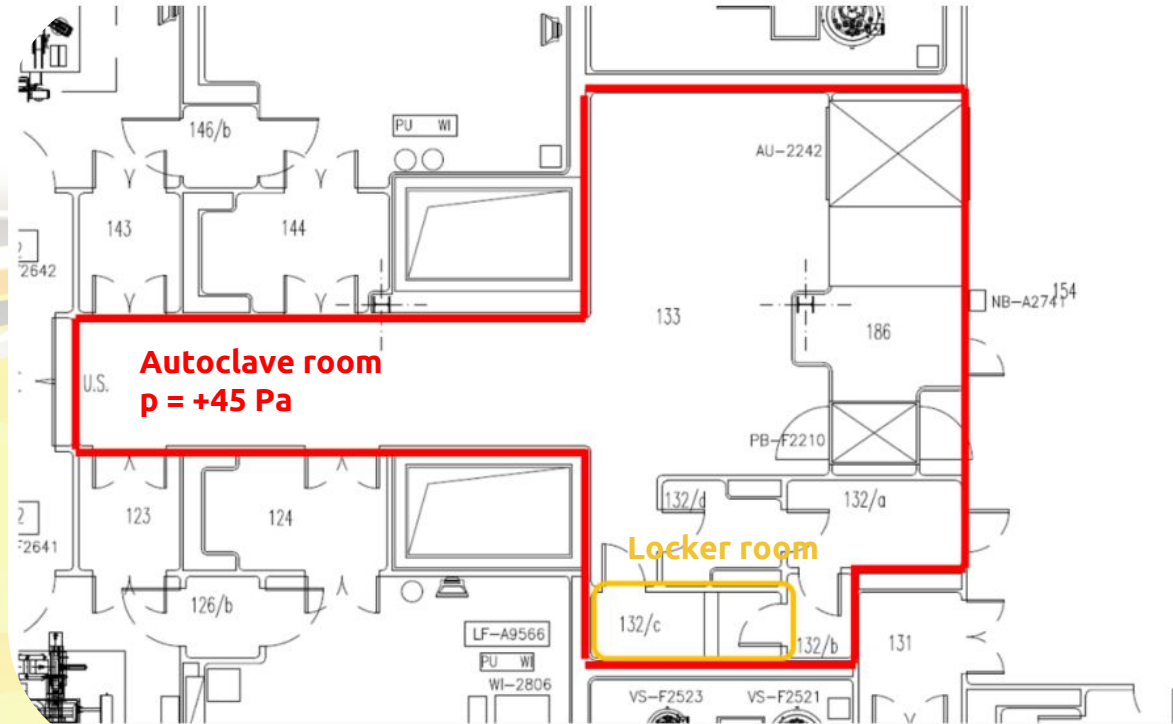
new
engineering
solutions & technologies

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 m² X 2.47 m

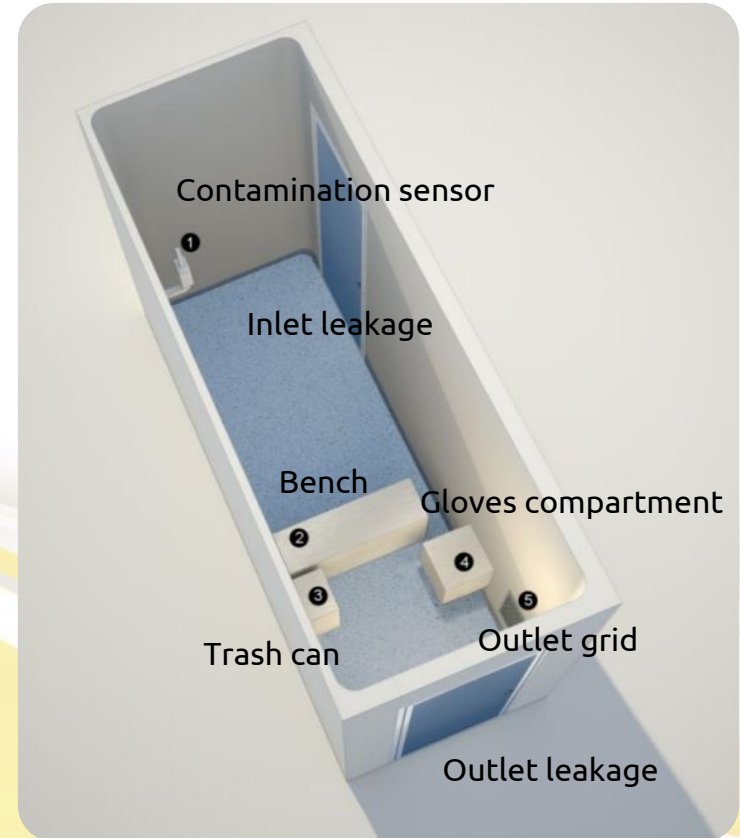
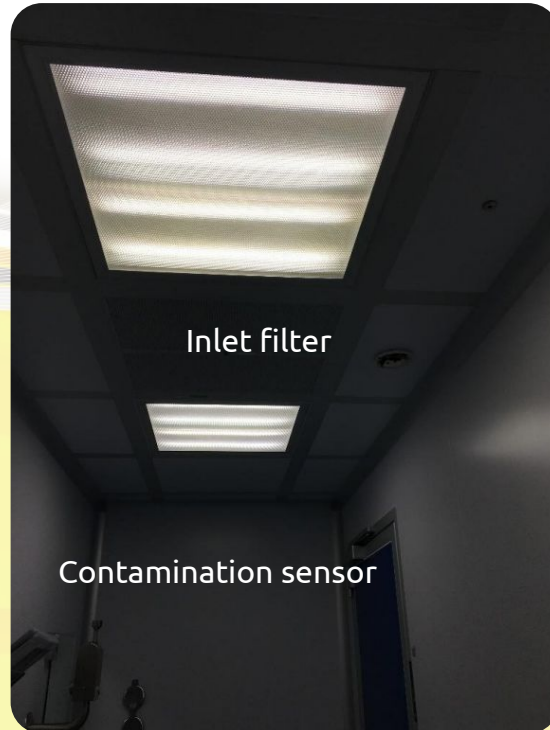
On site measurements for boundary conditions

Inlet filter: 0.47 m/s

Inlet leakage: 2.29 m/s

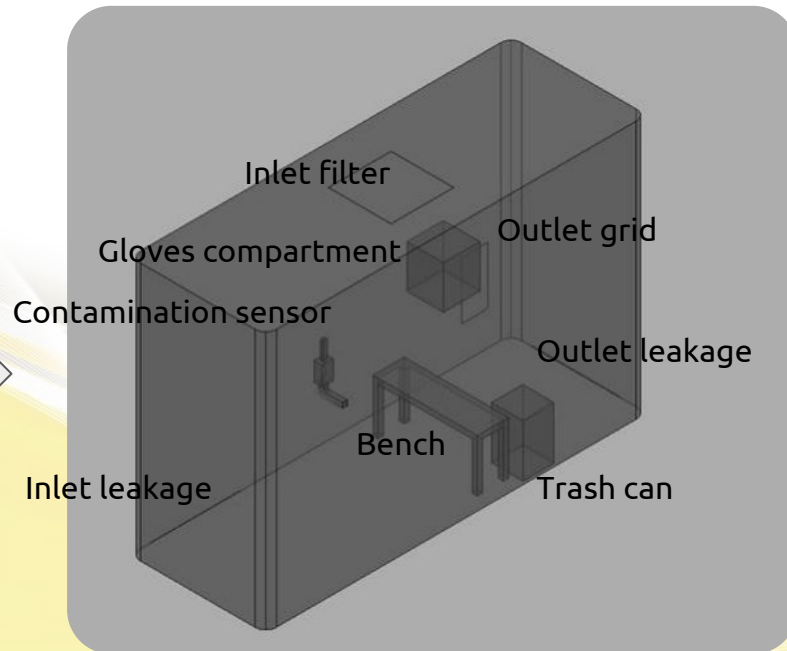
Outlet grid: 101369.5 Pa

Outlet leakage: 101355 Pa

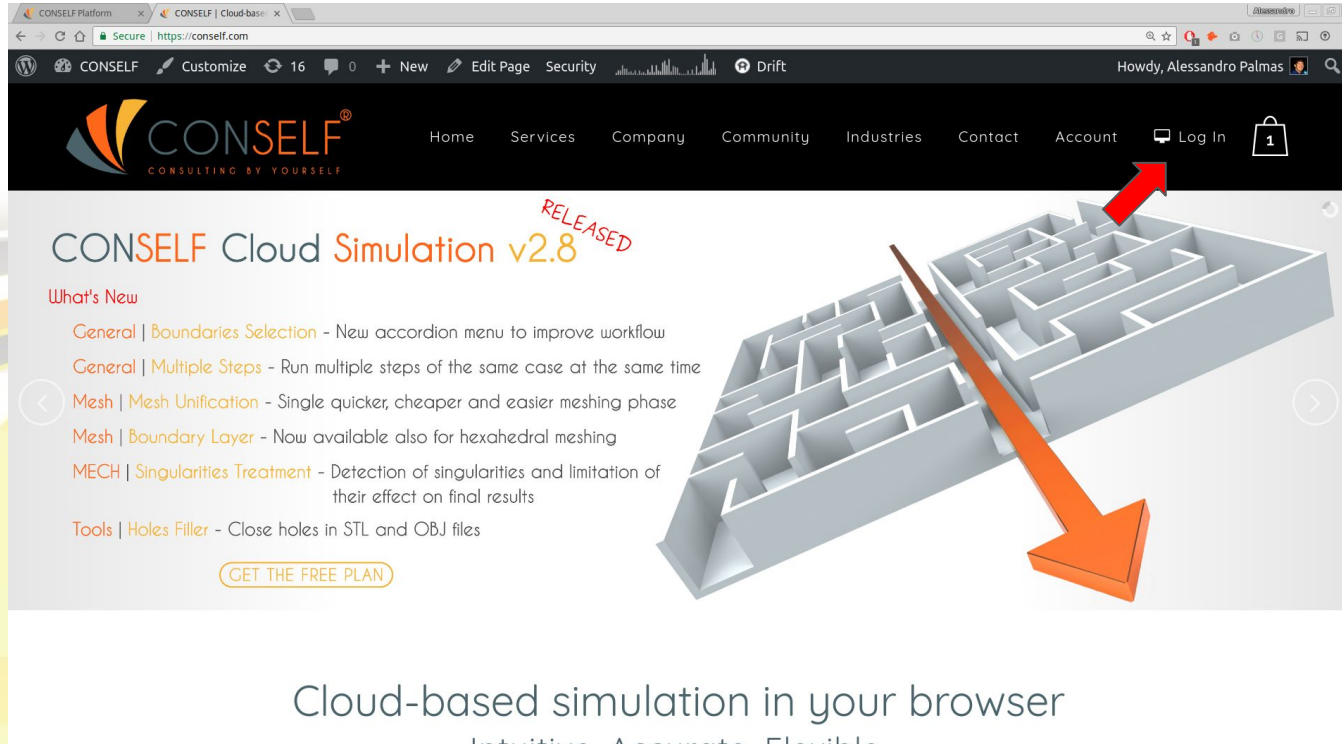


Case study: Clean Rooms - The problem

CAD preparation: creation of the fluid volume



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



CONSELF Platform x CONSELF | Cloud-base x

Secure | https://conself.com

CONSELF Customize 16 0 + New Edit Page Security Drift Howdy, Alessandro Palmas

CONSELF[®] CONSULTING BY YOURSELF Home Services Company Community Industries Contact Account Log In 1

CONSELF Cloud Simulation v2.8 *RELEASED*

What's New

- General | **Boundaries Selection** - New accordion menu to improve workflow
- General | **Multiple Steps** - Run multiple steps of the same case at the same time
- Mesh | **Mesh Unification** - Single quicker, cheaper and easier meshing phase
- Mesh | **Boundary Layer** - Now available also for hexahedral meshing
- MECH | **Singularities Treatment** - Detection of singularities and limitation of their effect on final results
- Tools | **Holes Filler** - Close holes in STL and OBJ files

[GET THE FREE PLAN](#)

Cloud-based simulation in your browser
Intuitive. Accurate. Flexible.

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

The image displays two overlapping screenshots of the CONSELF Platform web interface. The background screenshot shows the 'Dashboard' page with a sidebar on the left containing navigation options: Dashboard, Simulations, Storage, and Tools. The main content area features four summary cards: '69 Total GEOMETRY Steps', '119 Total MESH Steps', '101 Total CFD Steps', and '34 Total MECH Steps'. Below these are two charts: 'CONSELF CREDITS / YEAR' (a pie chart showing 'Spent' and 'Remaining' credits) and 'CONSELF CREDITS SPENT IN LATEST ACTIVE SIMULATIONS' (a horizontal bar chart). The foreground screenshot shows the 'Simulations' page. It includes a 'CREATION OF NEW CASE' section with a 'Case Name' input field, an 'Application' dropdown menu (currently set to 'CFD > GENERAL'), and a 'SELECTION OF CASE' section with a 'Case Name' dropdown (set to 'CNS-138 Simulazione') and an 'Open' button. A dropdown menu is open under 'Application', listing options: 'CFD > GENERAL', 'CFD > OIL&GAS - Flow with particles', 'CFD > OIL&GAS - Multiphase flow', 'CFD > HVAC - Passive scalar transport', 'CFD > TURBO - SRF pumps', and 'MECH > STATIC - Linear elastic'. Below this is a 'CASES IN PROGRESS' table.

Case Name	Step Name	State	Progress	ETA	Residuals	Stop
CNS-136-HalfFinal	MECH	Running	<div style="width: 20%;"></div>	~ 1 hour		
CNS-136-HalfFinal	MECH	Running	<div style="width: 20%;"></div>	~ 2 hours		
CNS-136-Half3	Mesh	Stopping	<div style="width: 60%;"></div>	Not available		

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

The screenshot shows the CONSELF Platform web interface. The browser address bar displays <https://app.conself.com/#simulations>. The page title is "OIBR-Pump". The application type is "Application [CFD » TURBO - SRF pumps]". A "Return to Simulations" button is visible in the top right.

The main navigation tabs are "Geometry", "Mesh", "CFD", and "Results". A red arrow points to the "Results" tab. The "Geometry" tab is active, showing the "1. File data" section. This section includes a "CAD model" area with "File Upload" and "Onshape Import" buttons, and a "File units" dropdown menu set to "Millimeters". There are also "Reset", "Back", "Next", and "Submit" buttons at the bottom of the "File data" section.

The right side of the interface features a 3D visualization of a clean room interior with a table and chairs. Above the visualization are controls for "Visualization", "Selection", and "Manage Bot".

The left sidebar contains the "CONSELF Platform" logo, a user profile icon, and navigation links for "Dashboard", "Simulations", "Storage", and "Tools BETA". At the bottom of the sidebar are buttons for "Reset User Session", "User Manual", and "Contact Support", along with an "About" link.

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

The screenshot displays the CONSELF Platform web interface for a simulation named "OIBR-Pump". The browser address bar shows the URL <https://app.conself.com/#simulations>. The application is identified as "Application [CFD » TURBO - SRF pumps]" and shows "Steps Completed". A navigation bar includes "Geometry", "Mesh", "CFD", and "Results", with a red arrow pointing to the "Results" tab. The "Mesh" section is active, showing a progress bar with three steps: "1. Volume mesh", "2. Surface refinement", and "3. Boundary layer". The "Boundary layer" step is selected, and the "Boundary selection" panel is open, showing settings for "Inlet":

- Wall settings
- Layers Number:
- First Wall Cell Height
- First cell height [m]:

Other boundary types listed include "Outlet", "Case", and "Perio1". At the bottom of the panel are "Reset", "Back", "Next", and "Submit" buttons. On the right, a 3D visualization of the clean room geometry is shown, including a desk and chair. The "Start from Step" dropdown is set to "GEOMETRY_2017-03-".

On the left sidebar, the user profile is "conself", and navigation options include "Dashboard", "Simulations", "Storage", and "Tools BETA". A "Reset User Session" button is highlighted in red, along with "User Manual" and "Contact Support" buttons.

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

The screenshot displays the CONSELF Platform web interface for a simulation named "OIBR-Pump". The browser address bar shows "https://app.conself.com/#simulations". The interface includes a sidebar with navigation options: Dashboard, Simulations, Storage, and Tools BETA. The main content area has tabs for Geometry, Mesh, CFD, and Results, with a red arrow pointing to the CFD tab. The CFD tab is active, showing a progress bar with four steps: 1. Fluid models, 2. Rotation settings, 3. Boundary conditions, and 4. Simulation settings. The Simulation settings section includes:

- Time evolution: Steady (dropdown menu)
- Iterations number: 3,000 (input field)
- Output frequency: Save solution every [iterations] 3,000 (input field)

At the bottom of the settings section are buttons for Reset, Back, Next, and Submit. On the right side, there is a "Start from Step" dropdown menu set to "MESH_2017-03-29_15" and a 3D visualization of the OIBR-Pump model with a mesh overlay.

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

CFD model

- Steady RANS solver
- Standard k- ϵ 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

The screenshot displays the CONSELF Platform web interface for a simulation titled "OIBR-HeatExchanger". The browser address bar shows the URL <https://app.conself.com/#simulations>. The main content area has tabs for "Geometry", "Mesh", "CFD", and "Results", with a red arrow pointing to the "Results" tab. The "Results" section includes a "Start from Step" dropdown set to "CFD_2017-04-07_07:4" and a "Download Results" button. Below this is a visualization window showing streamlines and a color scale for velocity (Uy) ranging from -3.603e-01 to 4.640e-01. The left sidebar contains navigation options: "Dashboard", "Simulations", "Storage", and "Tools BETA", along with a "Reset User Session" button and links for "User Manual" and "Contact Support".

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:

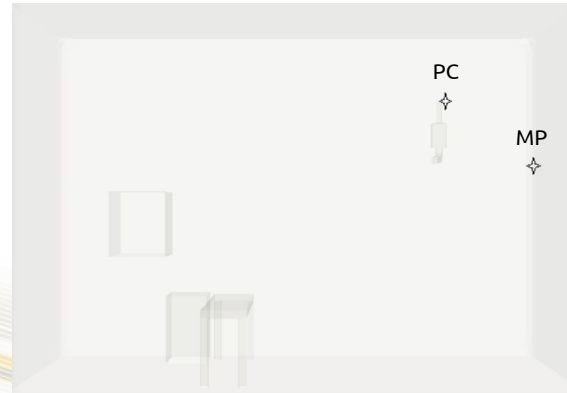
- Vertical velocity: if directed downwards it assures contaminants present on the floor do not reach higher zones of the locker rooms
- Recirculation zones: their absence helps maintaining a properly clean environment avoiding movement of contaminant deposits

Case study: Clean Rooms - Results

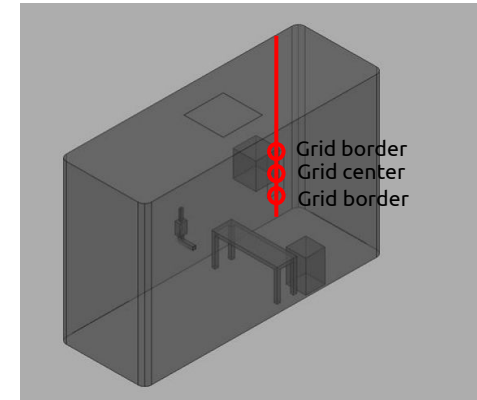
Location of control points

Eight control points

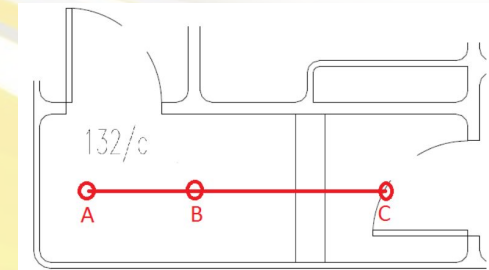
- Outlet grid borders (2)
- Outlet grid center (1)
- Locker room centerline point A (1)
- Locker room centerline point B (1)
- Locker room centerline point C (1)
- Microbiological plates MP (1)
- Parcels counter PC (1)



MP and PC control points



Outlet grid control points

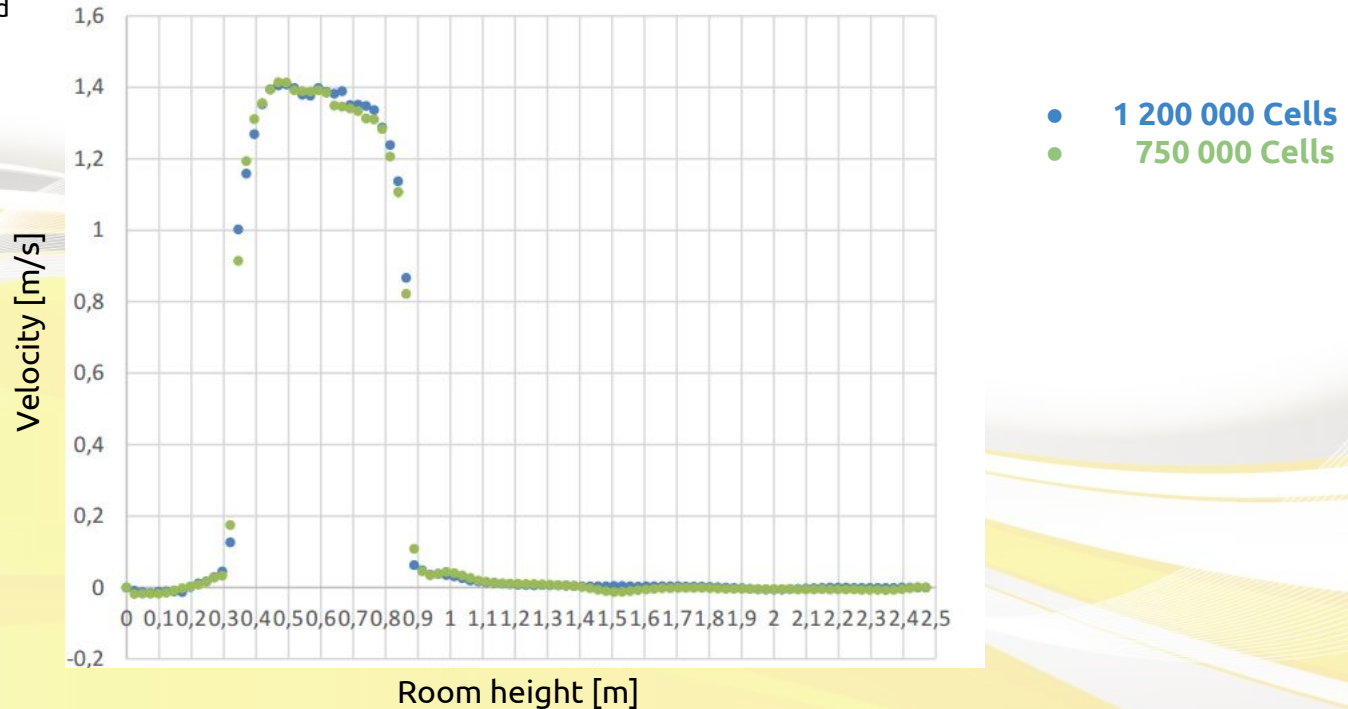


Locker room centerline control points

Case study: Clean Rooms - Results - Study A

Grid sensitivity analysis

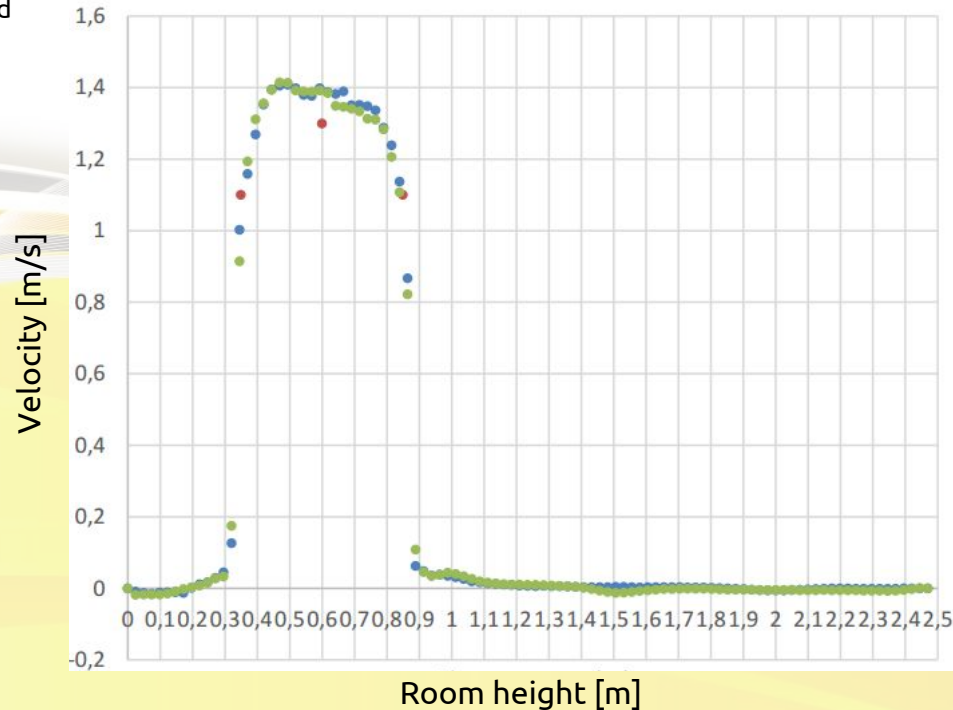
Velocity profile on outlet grid



Case study: Clean Rooms - Results - Study A

Comparison with experimental data

Velocity profile on outlet grid

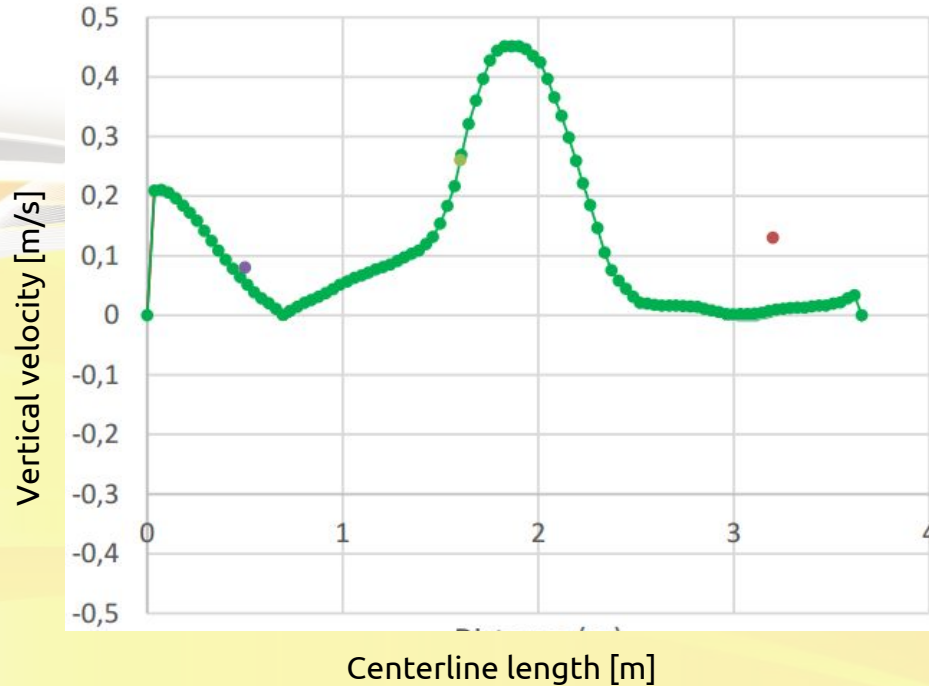


- 1 200 000 Cells
- 750 000 Cells
- Experimental data

Case study: Clean Rooms - Results - Study A

Comparison with experimental data

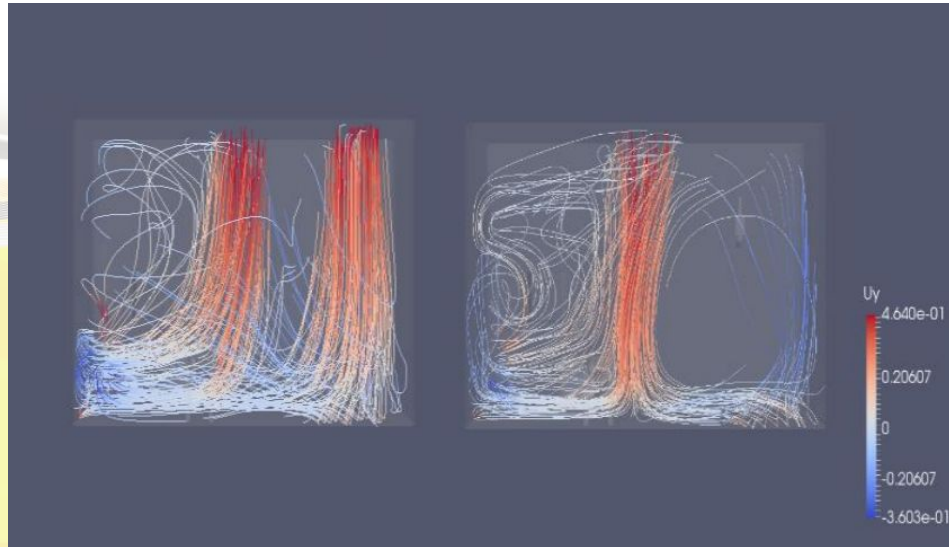
Vertical velocity profile on locker room centerline



- Simulation
- Control Point A
- Control Point B
- Control Point C

Case study: Clean Rooms - Results - Study B

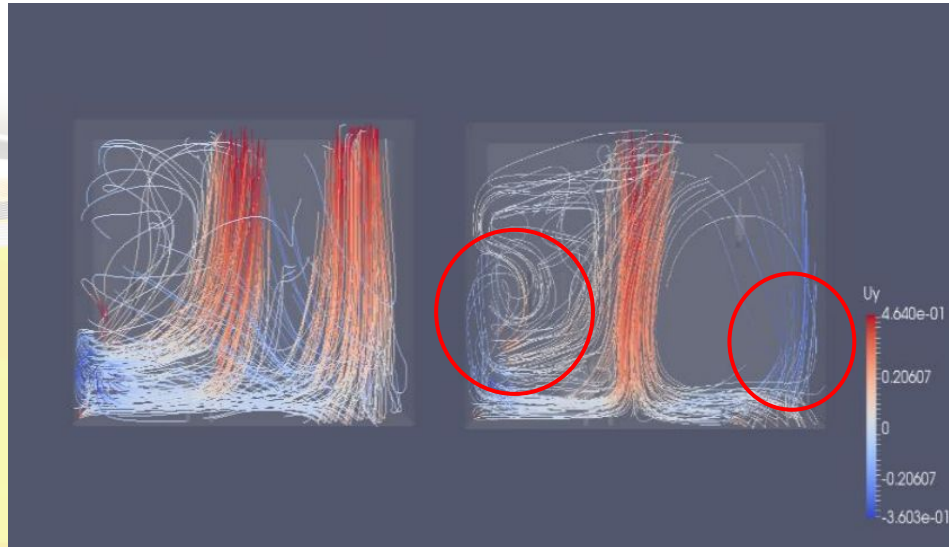
Vertical velocity colored streamlines comparison



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

Case study: Clean Rooms - Results - Study B

Vertical velocity colored streamlines comparison

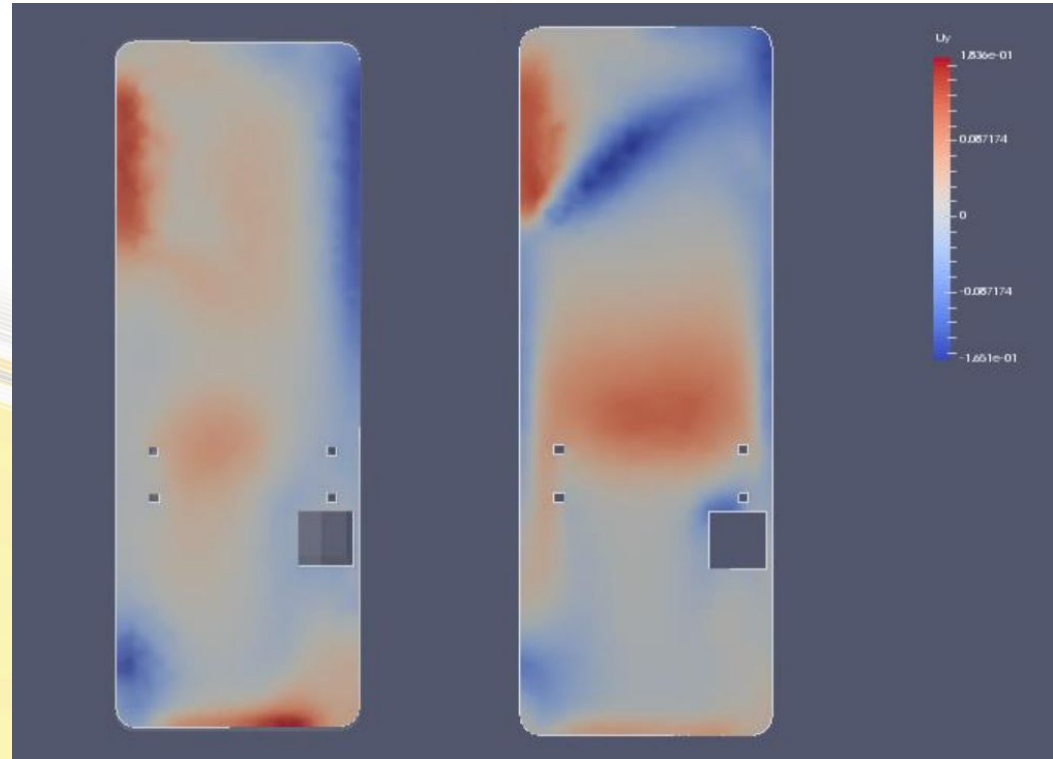


HVAC improvement proposal (left) compared with current system performances (right)

Case study: Clean Rooms - Results - Study B

Vertical velocity contours comparison
10 cm from the ground slice

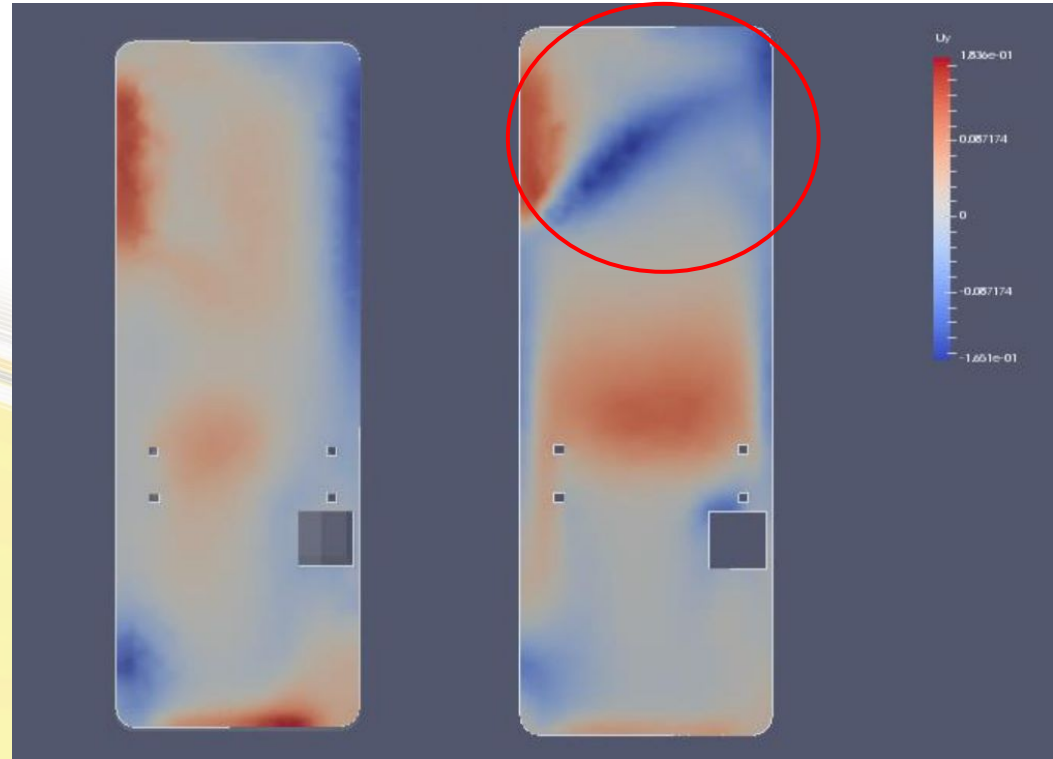
HVAC improvement proposal (left)
compared with current system
performances (right)



Case study: Clean Rooms - Results - Study B

Vertical velocity contours comparison
10 cm from the ground slice

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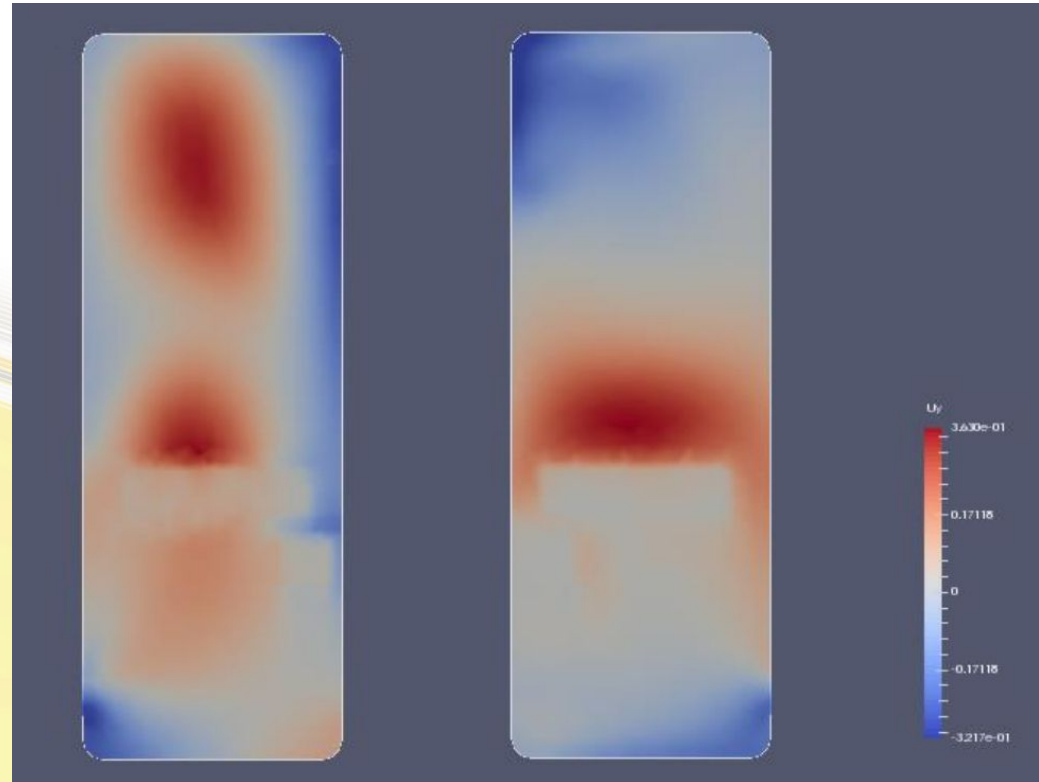


Case study: Clean Rooms - Results - Study B

Vertical velocity contours comparison

Bench seat slice

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

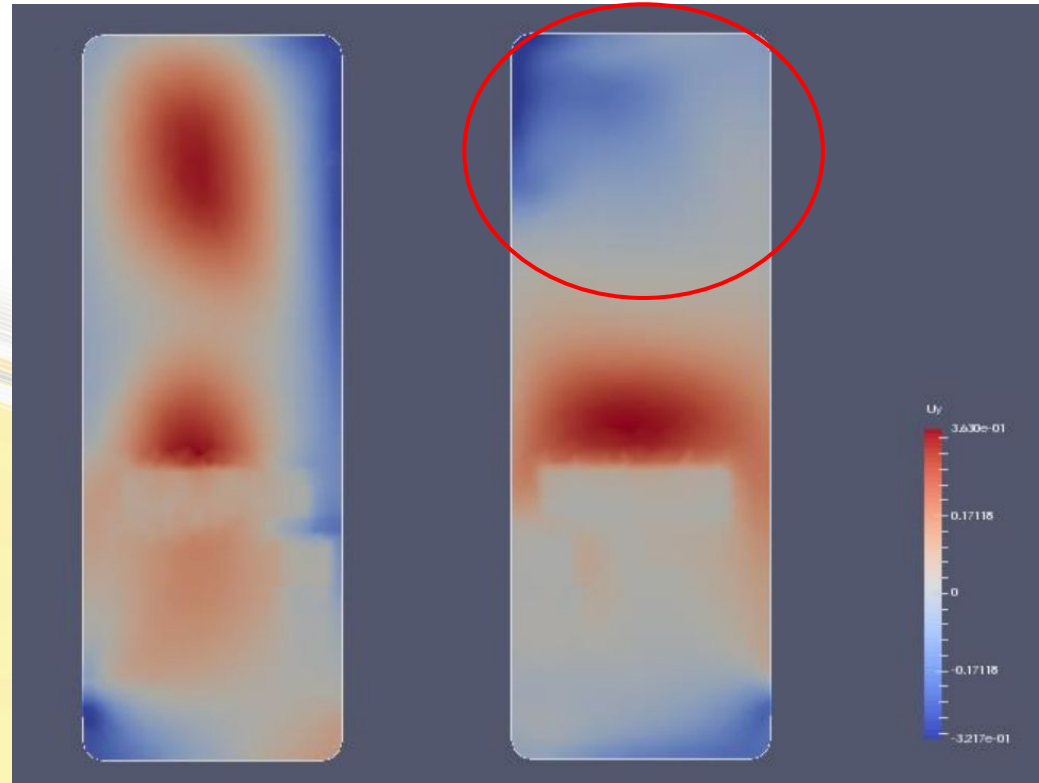


Case study: Clean Rooms - Results - Study B

Vertical velocity contours comparison

Bench seat slice

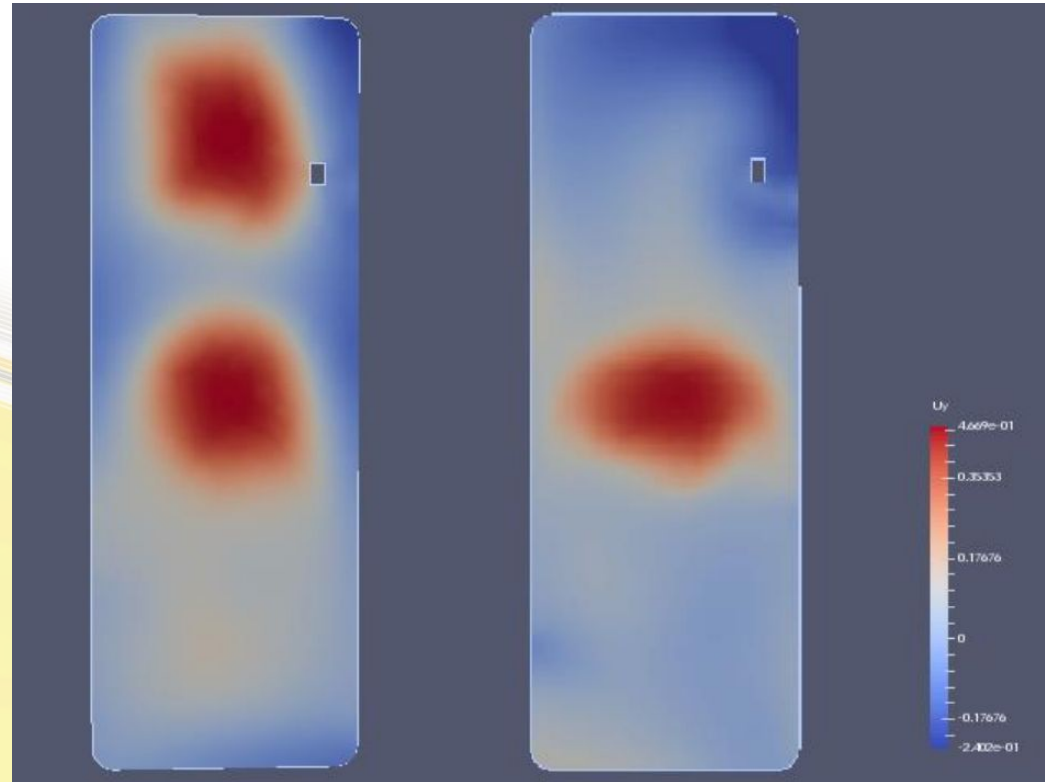
HVAC improvement proposal (left)
compared with current system
performances (right)



Case study: Clean Rooms - Results - Study B

Vertical velocity contours comparison
175 cm from the ground slice

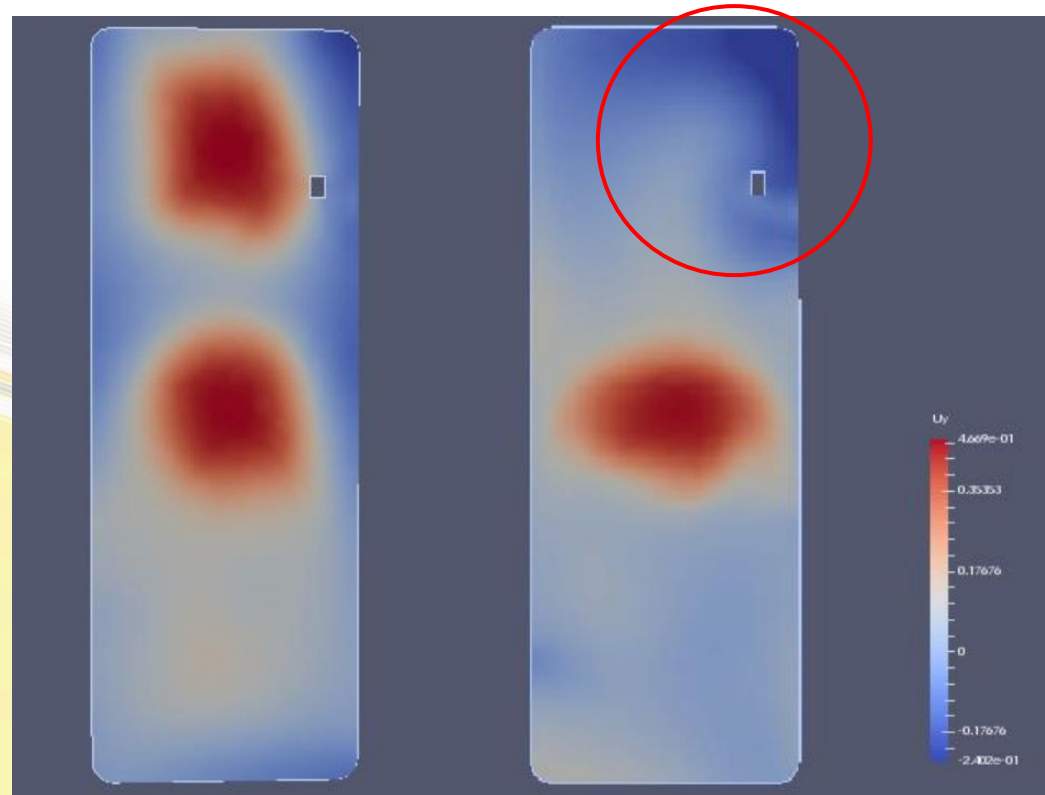
HVAC improvement proposal (left)
compared with current system
performances (right)



Case study: Clean Rooms - Results - Study B

Vertical velocity contours comparison
175 cm from the ground slice

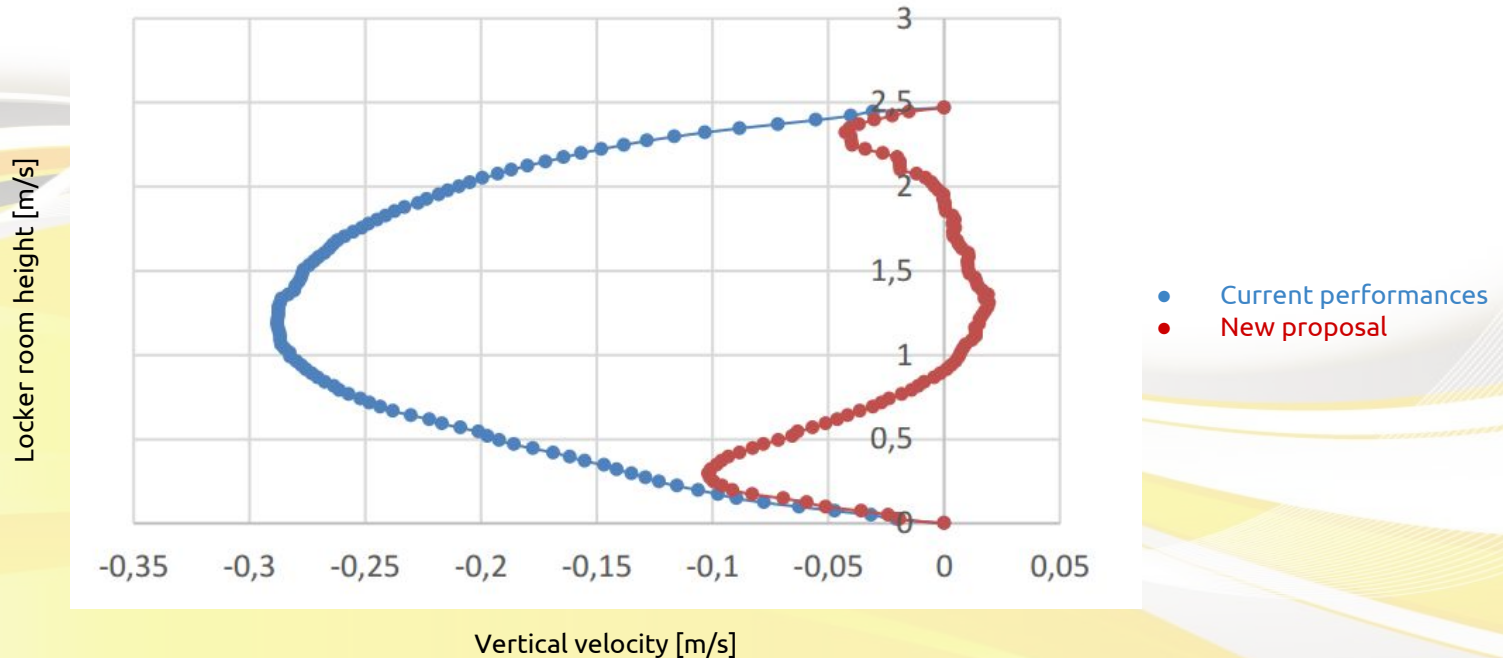
HVAC improvement proposal (left)
compared with current system
performances (right)



Case study: Clean Rooms - Results - Study B

Vertical velocity profile comparison

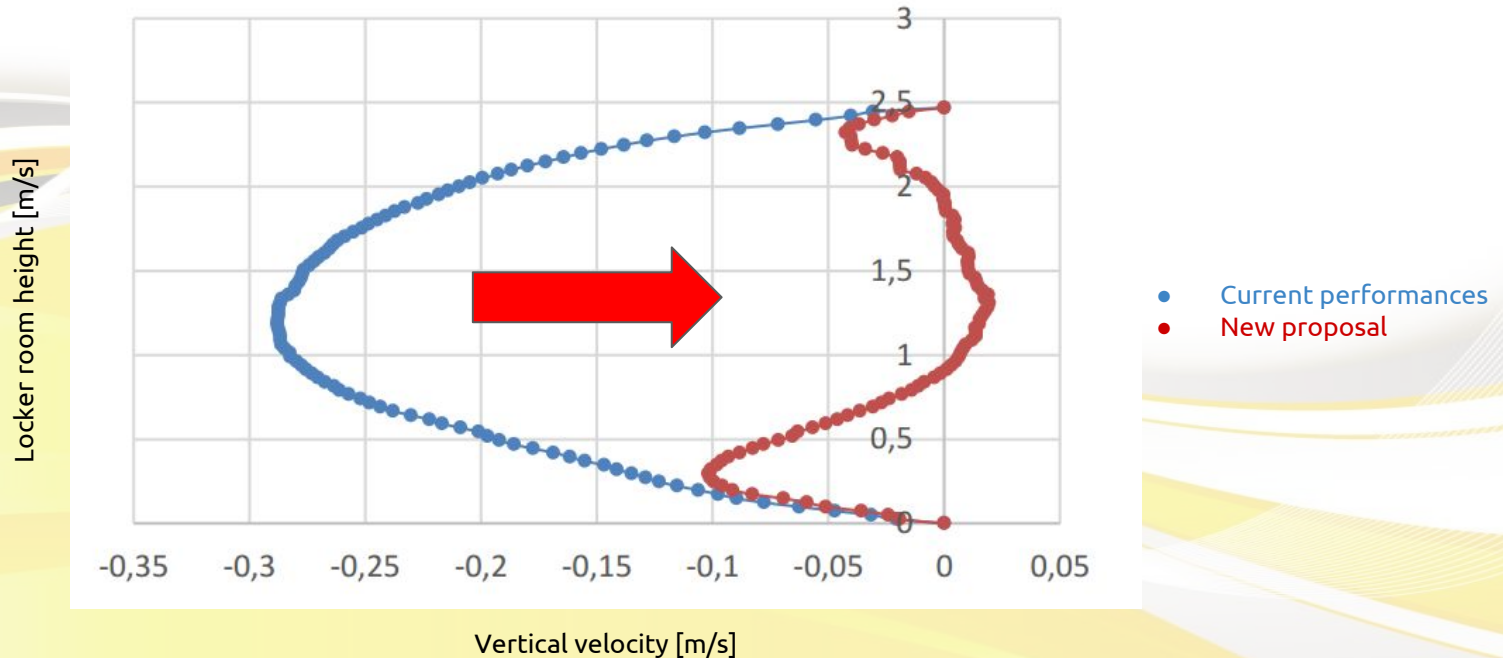
MP control point



Case study: Clean Rooms - Results - Study B

Vertical velocity profile comparison

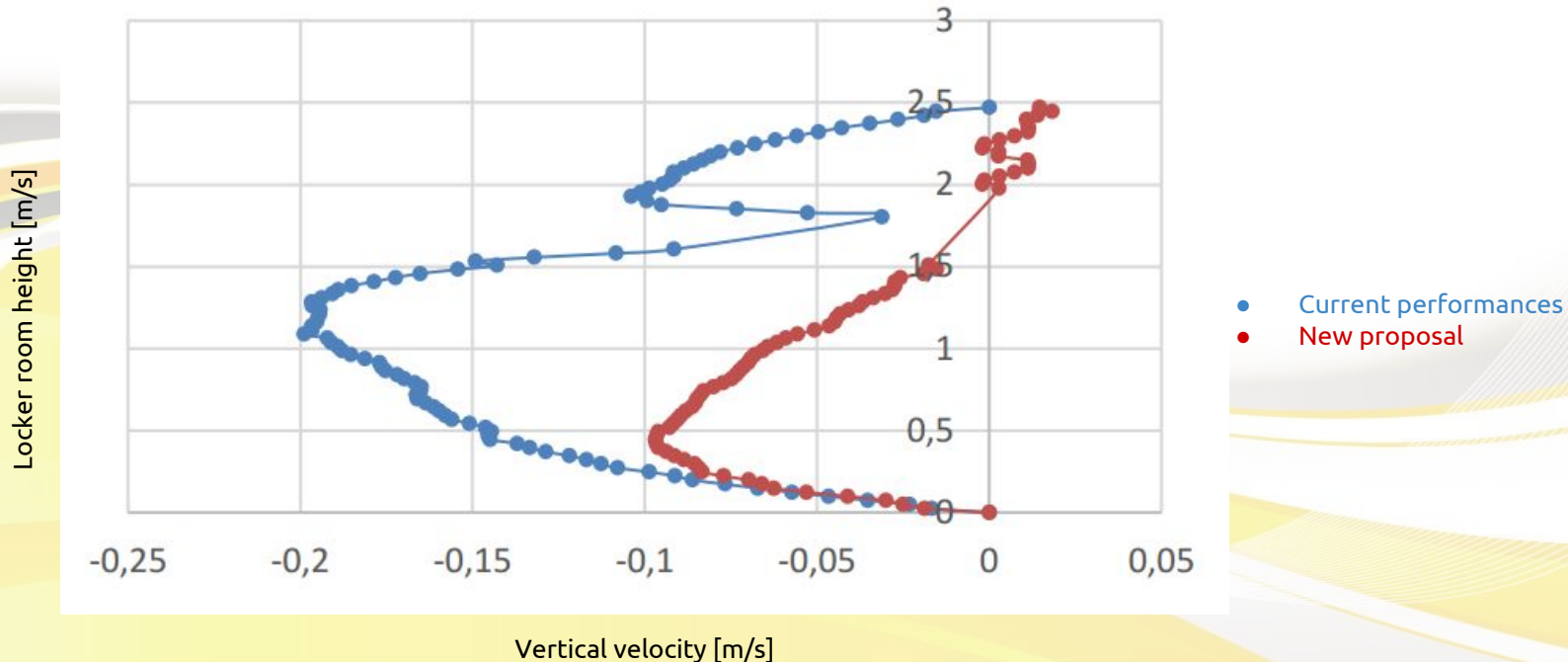
MP control point



Case study: Clean Rooms - Results - Study B

Vertical velocity profile comparison

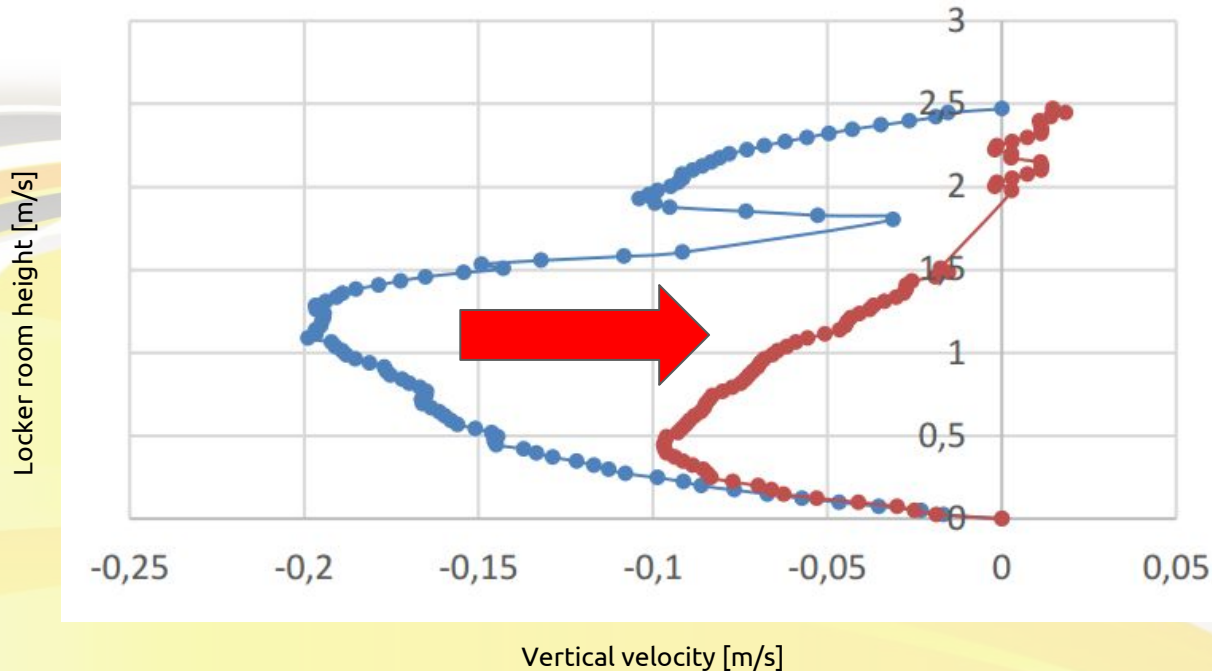
PC control point



Case study: Clean Rooms - Results - Study B

Vertical velocity profile comparison

PC control point



- Current performances
- New proposal



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