CERN

Thermal & CO_2 Leakage Analysis of ATLAS USA15 CV Room

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USA15 CV Room.

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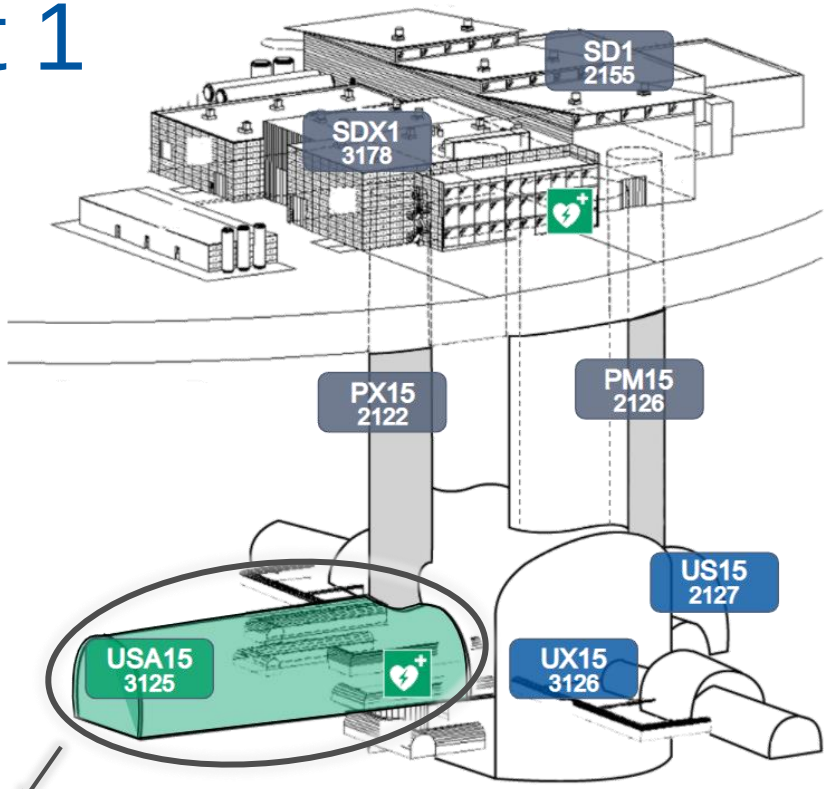
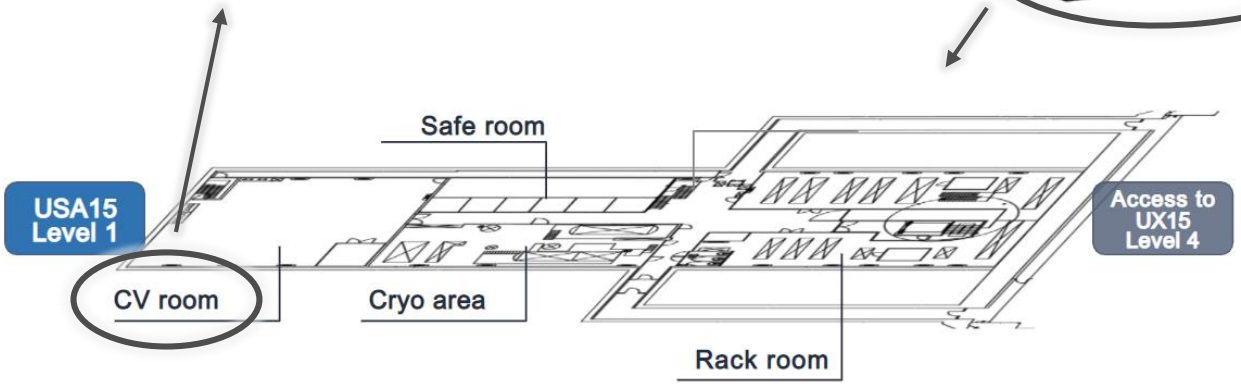
Introduction

- In this presentation, CFD simulation process and results for the USA15 CV Room are presented.
- The objective was to study the temperature and the CO_2 concentration distributions for different scenarios.
- This will demonstrate how CFD supports in the optimization of the CV room ventilation system and the risk assessment of CO_2 cooling systems.
- Insight in to required information, expected output and limitations/simplifications/assumptions.

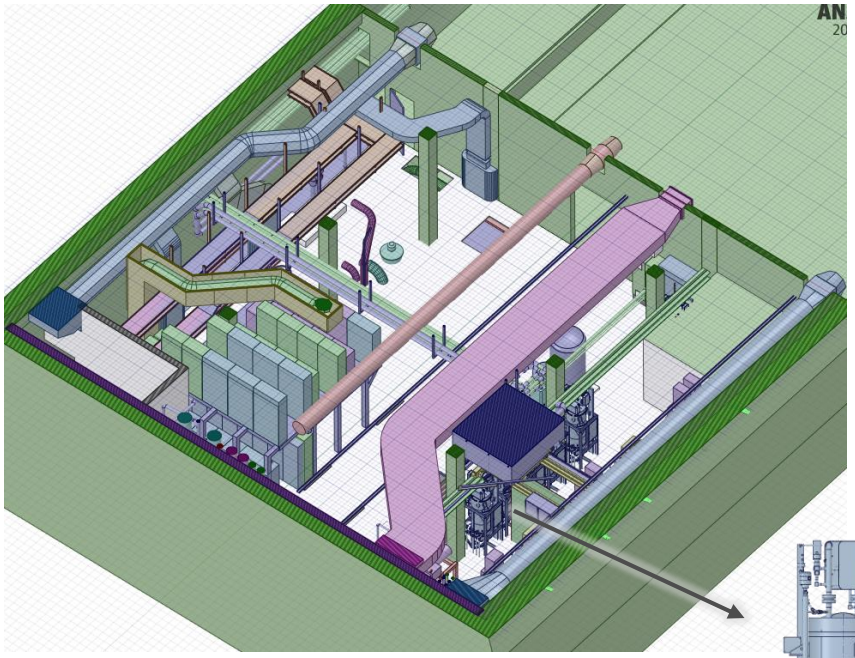
Location: ATLAS Point 1



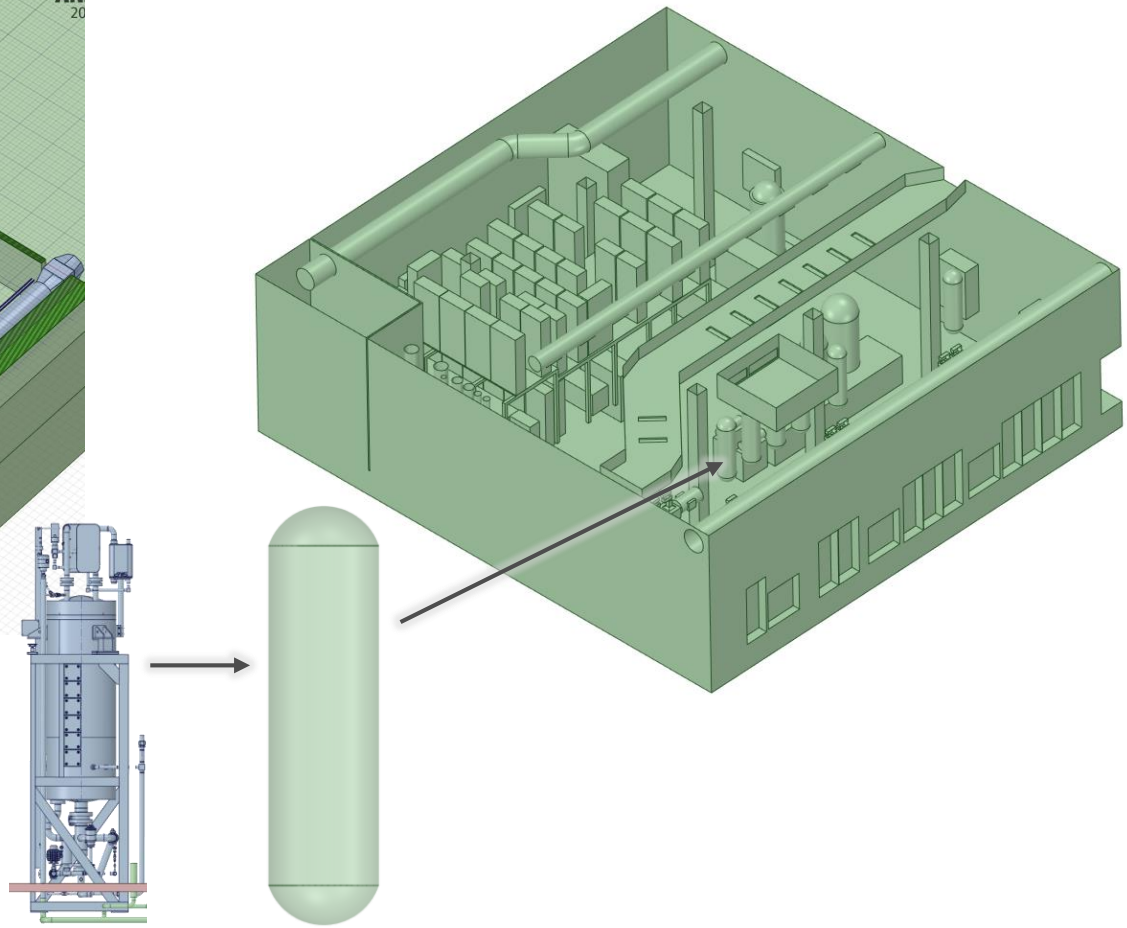


Geometry

CAD Model



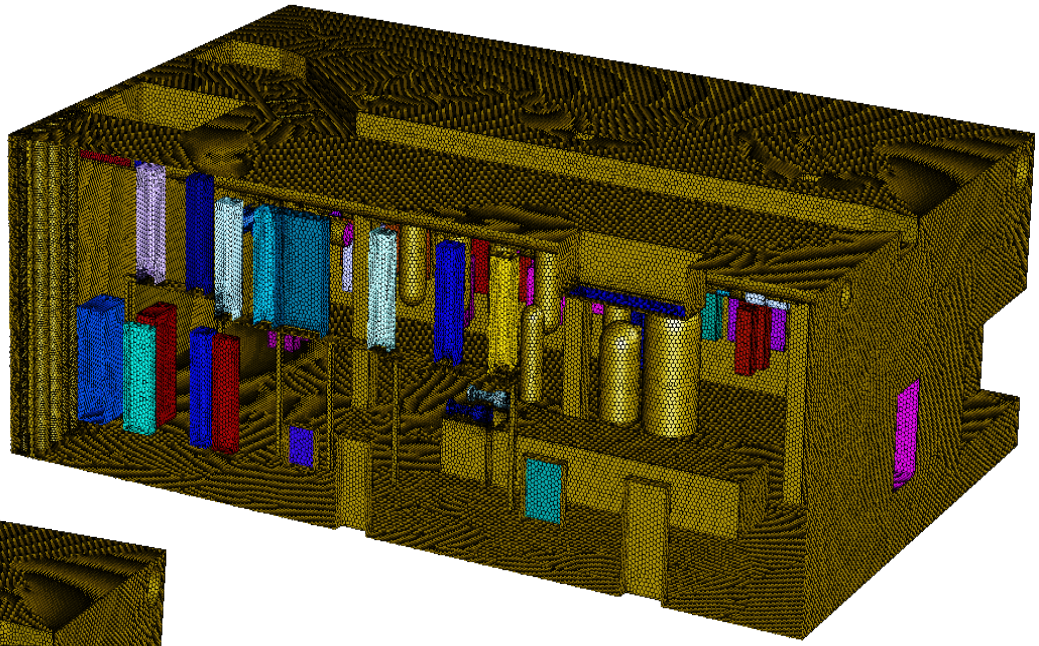
CFD Model

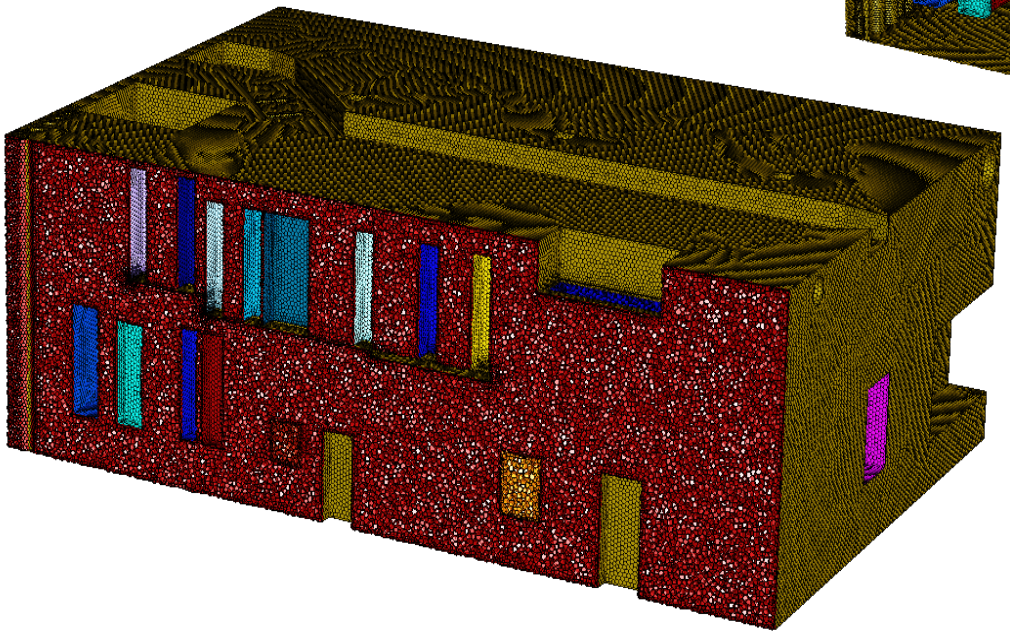


- Complex geometry takes a lot of computational effort.
- The solution is to simplify some elements of the geometry.

Meshing

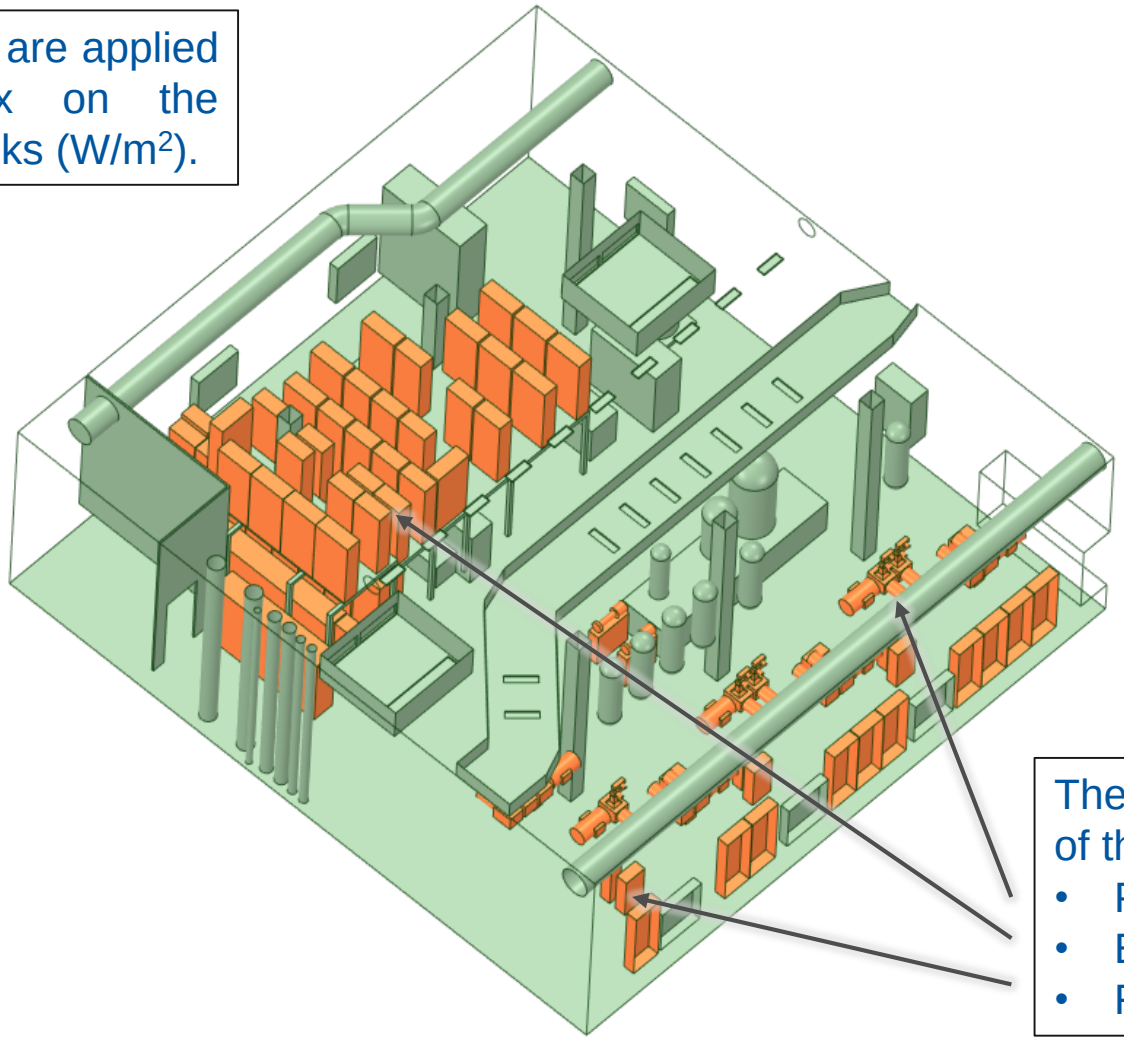
- Meshing is a process of creating CFD model from CAD model.
- In the CFD model, the fluid volume is discretized into many small cells, which cumulatively form mesh for CFD analysis.





Boundary Conditions: Thermal Loads

Thermal loads are applied as heat flux on the surfaces of racks (W/m^2).

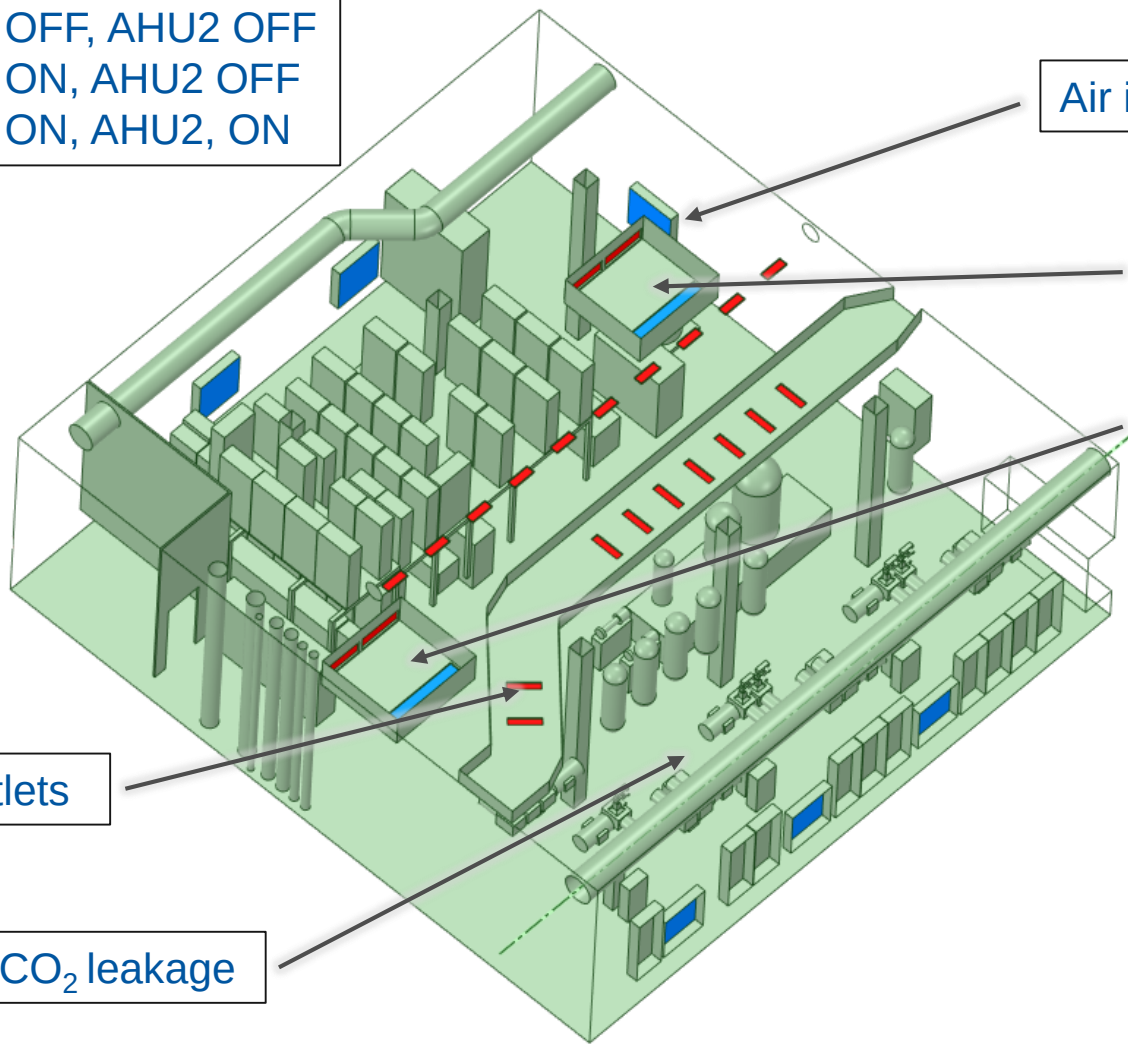


The main thermal loads of this problem are:

- Pumps.
- Electric racks.
- Frequency variators.

Boundary Conditions: Inlets & Outlets

Case 1: AHU1 OFF, AHU2 OFF
Case 2: AHU1 ON, AHU2 OFF
Case 3: AHU1 ON, AHU2, ON



Ventilation Optimization

Results: Temperature Distribution

AHU1: OFF
AHU2: OFF

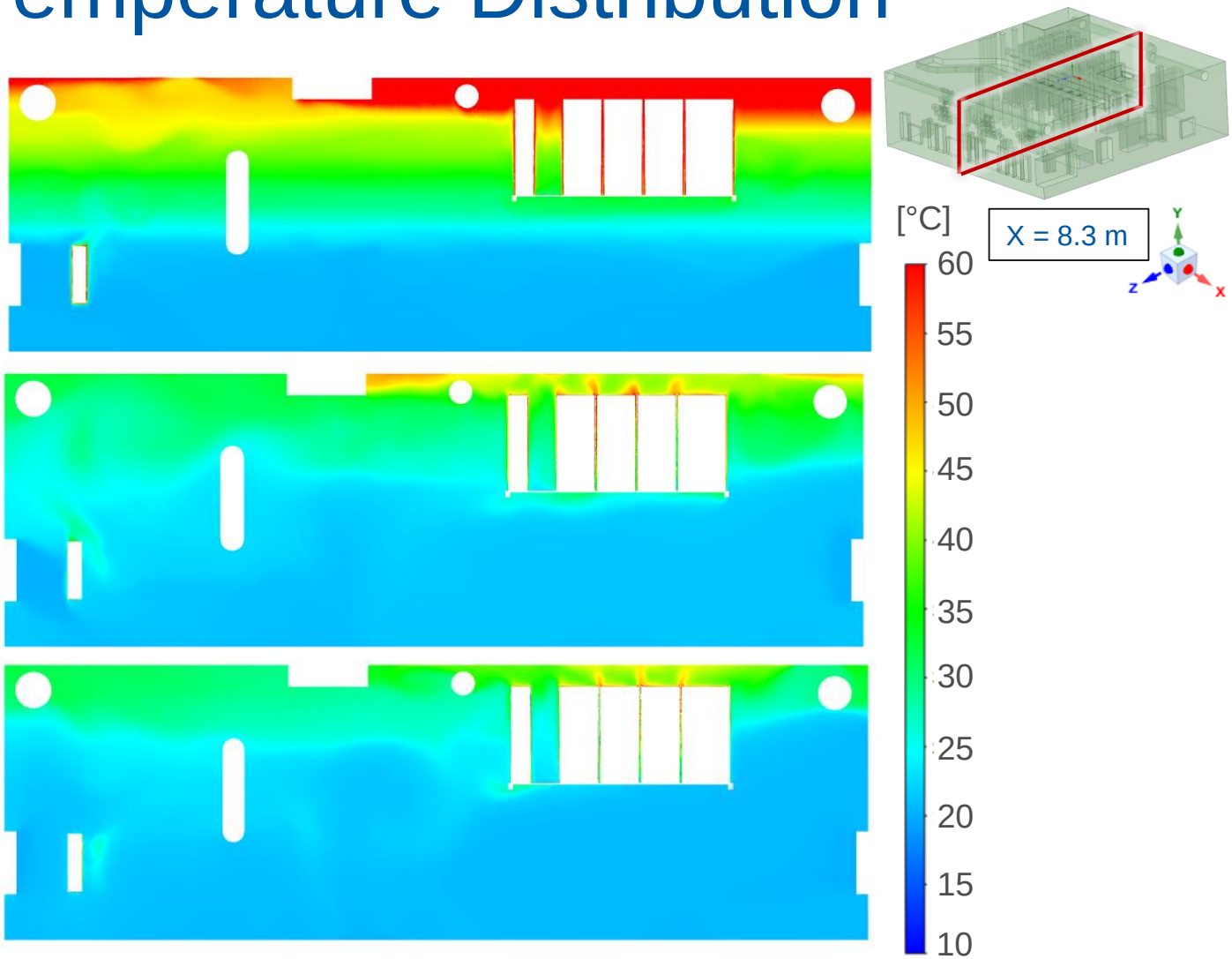
- $T_{ave.}$ = 30.3 °C
- $T_{max.}$ = 60 °C

AHU1: ON
AHU2: OFF

- $T_{ave.}$ = 22.7 °C
- $T_{max.}$ = 52.4 °C

AHU1: ON
AHU2: ON

- $T_{ave.}$ = 19.5 °C
- $T_{max.}$ = 40.1 °C



Results: Temperature Distribution

AHU1: OFF
AHU2: OFF

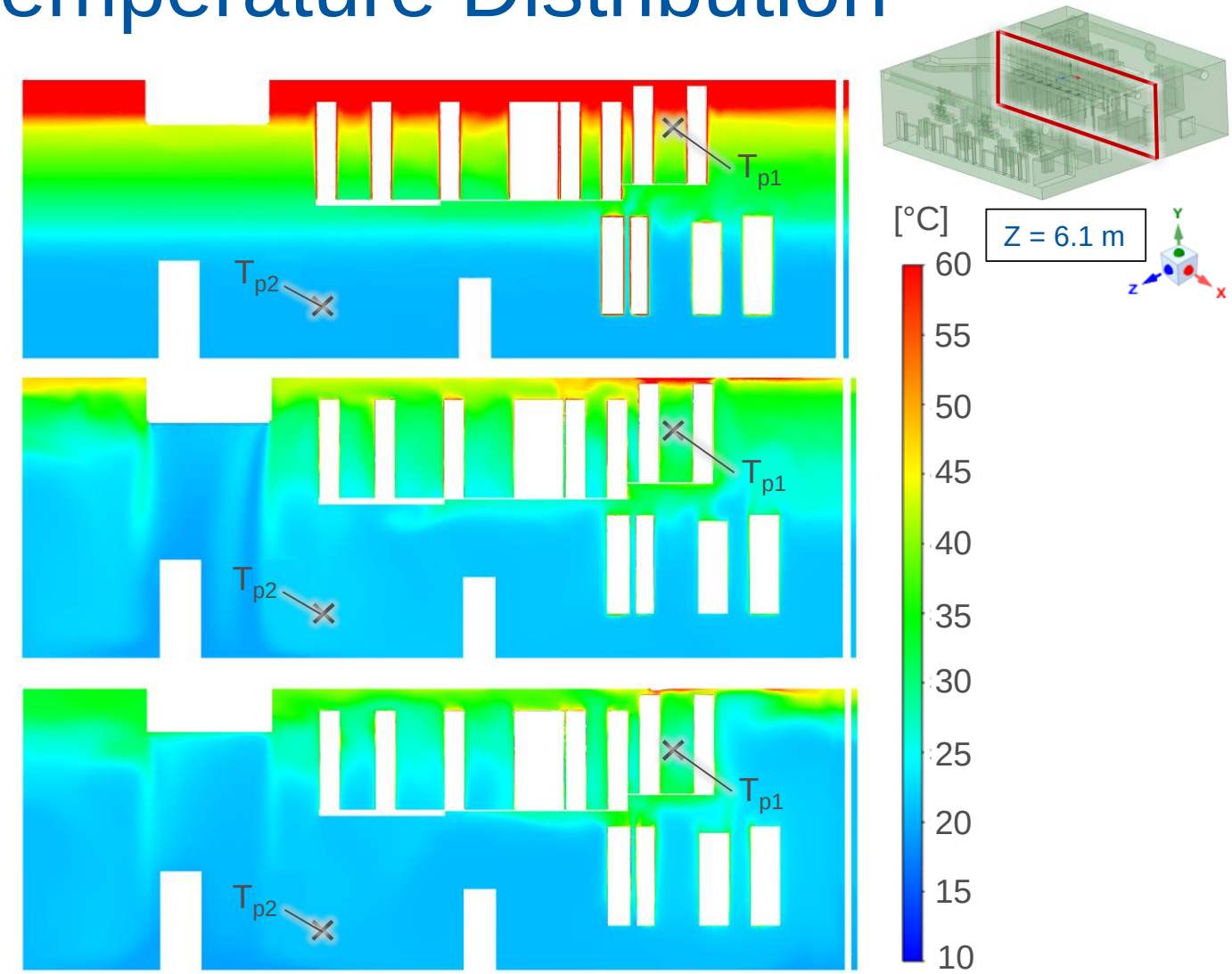
- T_{p1} = 45.7 °C
- T_{p2} = 20.3 °C

AHU1: ON
AHU2: OFF

- T_{p1} = 30.3 °C
- T_{p2} = 19.1 °C

AHU1: ON
AHU2: ON

- T_{p1} = 24.2 °C
- T_{p2} = 17.7 °C

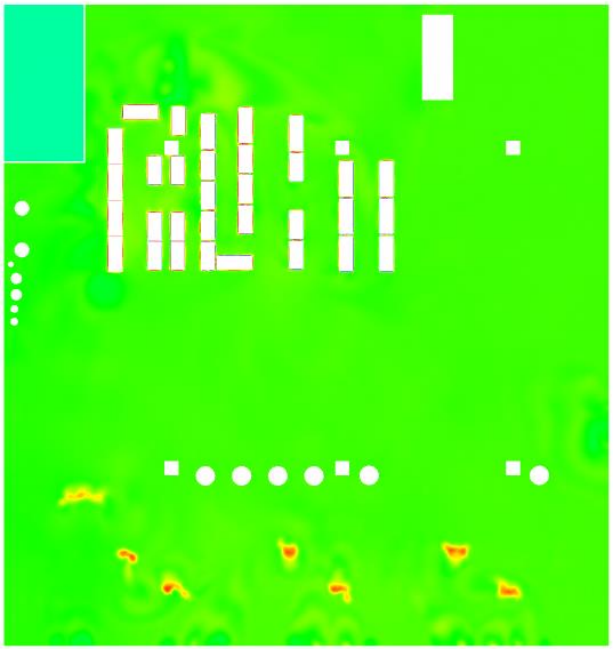


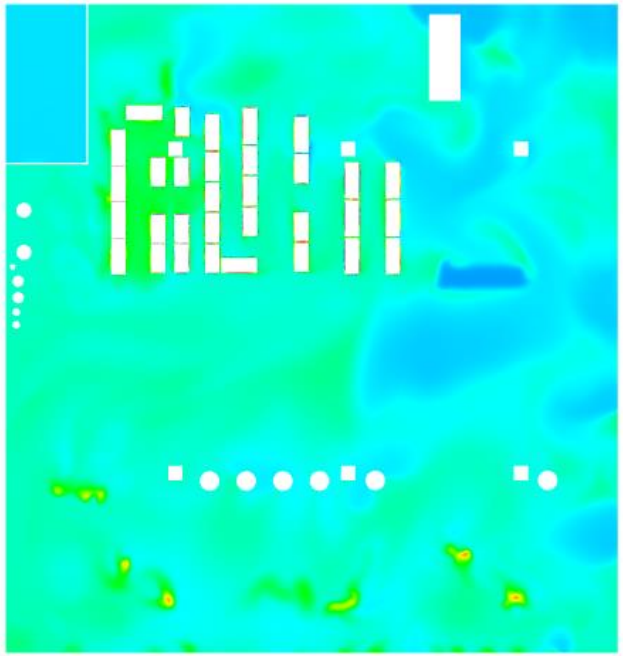
Results: Temperature Distribution

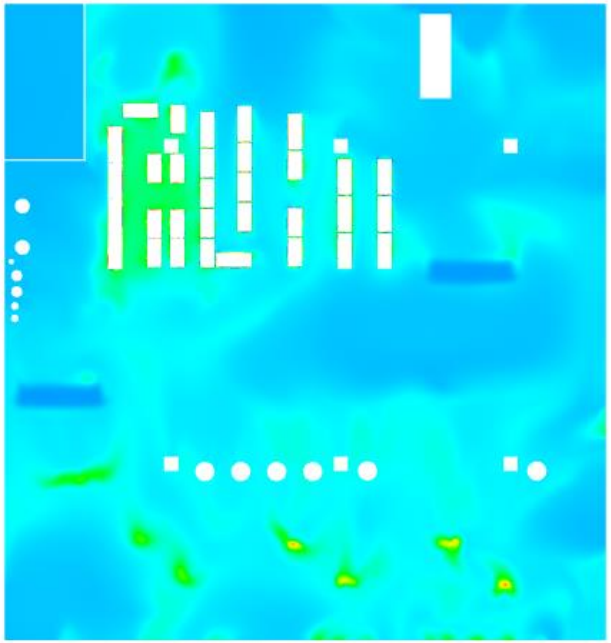
AHU1: OFF
AHU2: OFF

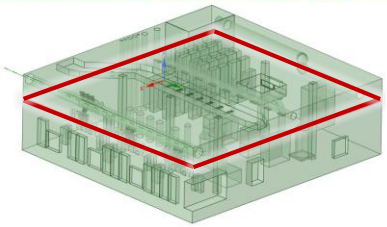
AHU1: ON
AHU2: OFF

AHU1: ON
AHU2: ON

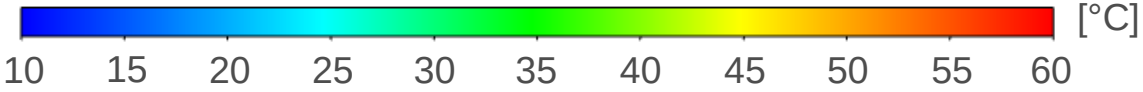








Y = 5 m



Results: Ventilation Optimization

Consequences of installing the CO_2 – 2PACL system:

- In the worst case scenario, AHU1 OFF & AHU2 OFF, the temperatures the workers will be exposed to are too high (>30 °C) for normal working conditions.

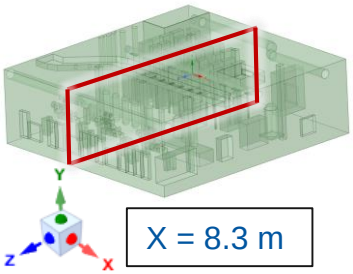
- In the current scenario, AHU1 ON & AHU2 OFF, the ground level temperatures are acceptable, but the mezzanine 2nd level will reach high local temperatures.

- If an additional AHU is installed, AHU1 ON & AHU2 ON, temperatures everywhere are in the safety limit of long – term working in underground caverns (< 26 °C).

CO_2 Leakage

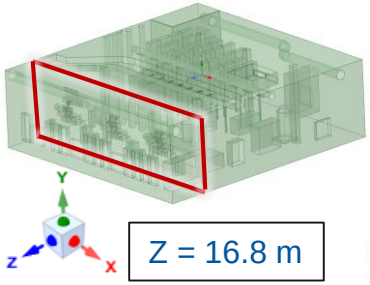
Results: Steady State

Leak enters at high speed (150 m/s).

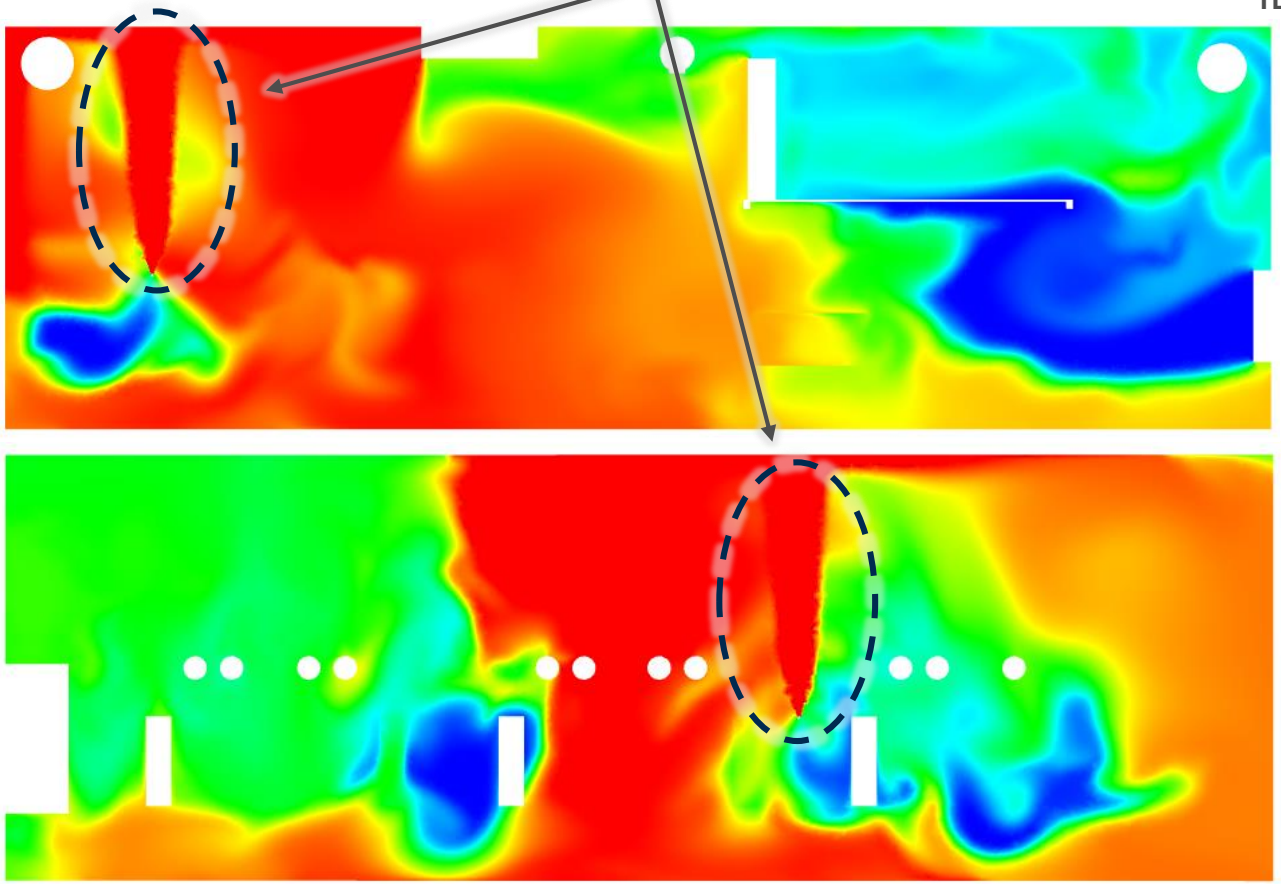


X = 8.3 m

Steady state
AHU1: OFF
AHU2: OFF
CO_2: 100 g/s

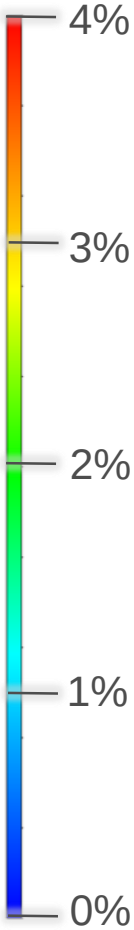


Z = 16.8 m

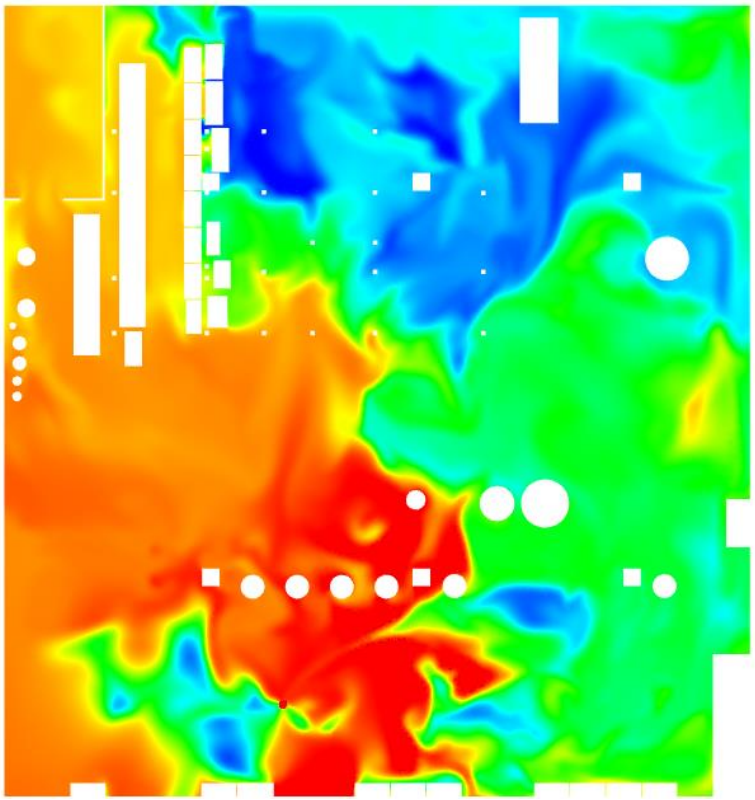


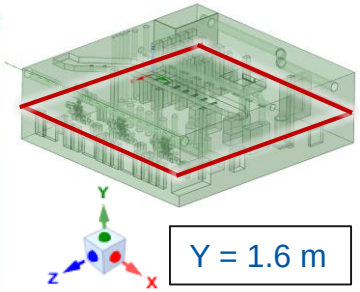
CO_2 conc.

IDTL



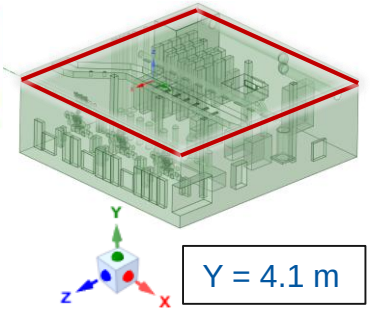
Results: Steady State



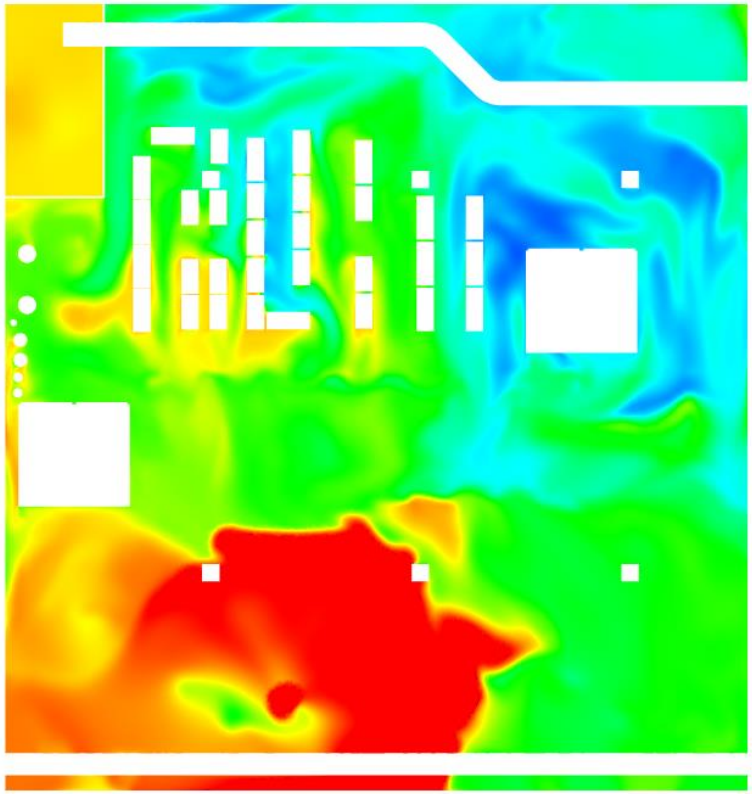


Y = 1.6 m

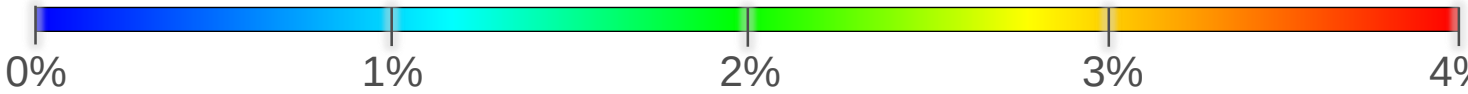
Steady state
AHU1: OFF
AHU2: OFF
CO_2: 100 g/s



Y = 4.1 m



IDTL



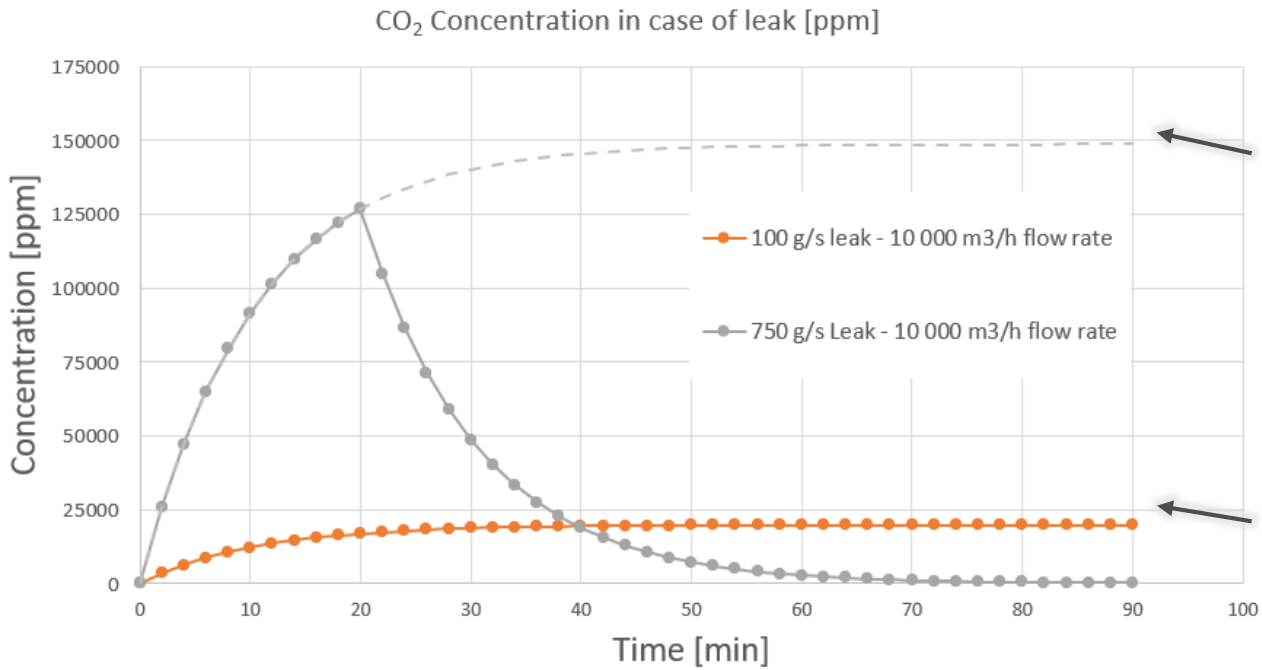
CO_2 conc.

Results: Scenarios

Final concentration (assuming perfect mixing):

$$C = \frac{q_{CO_2}}{N\,V}\left(1 - e^{-Nt}\right)$$

The CO_2 leakage can bear 2 scenarios, considering a 1 ton reservoir.



Large leakage: a steady state is NOT achieved.

- E.g. with 750 g/s, CO_2 runs out after 20 min.

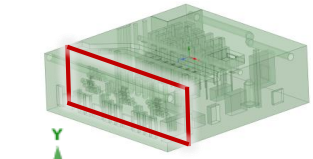
Small leakage: a steady state is achieved.

- E.g. with 100 g/s, CO_2 runs out after >2 hours.

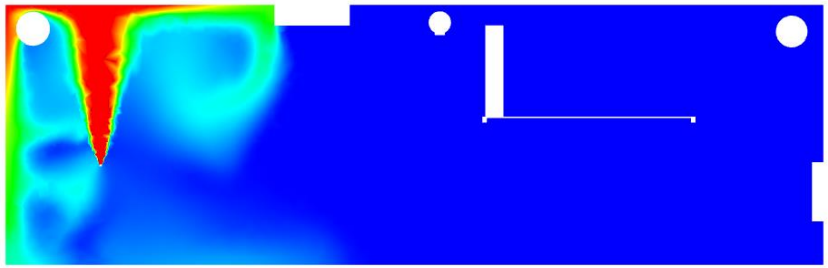
- Simulation of 20 minutes consumes too many resources (>20 days).
- Simulation of 2 minutes is enough: evacuation time for the room.

Results: Transient

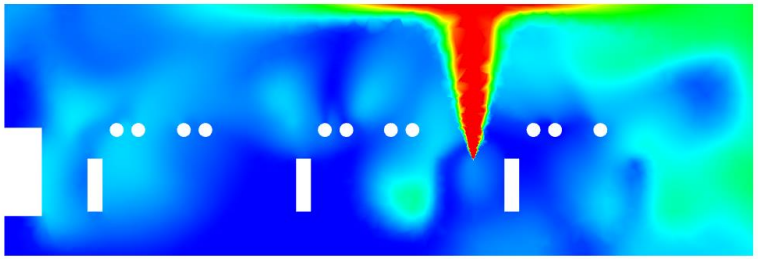
Transient: 2 min.
AHU1: OFF
AHU2: OFF
CO_2: 750 g/s

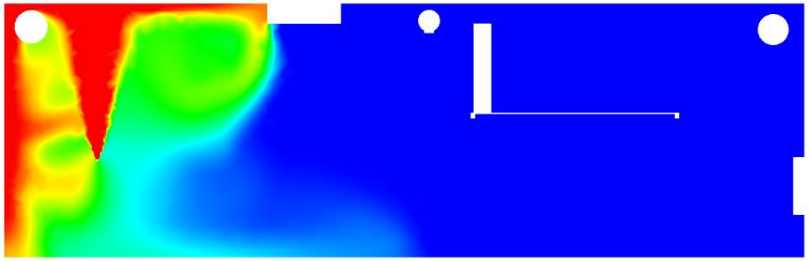


Z = 16.8 m

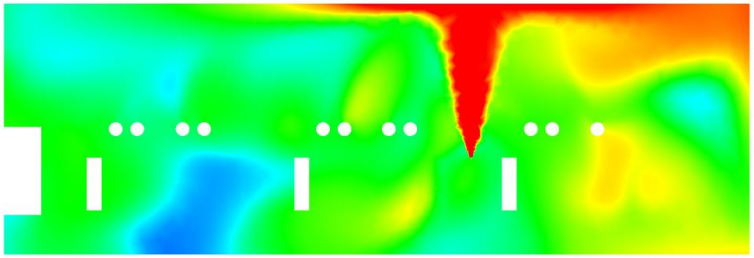


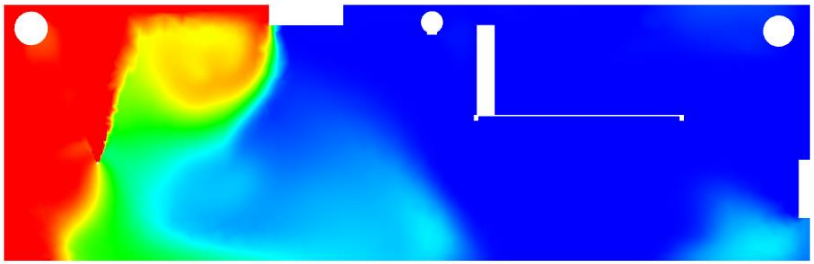
T = 10 s



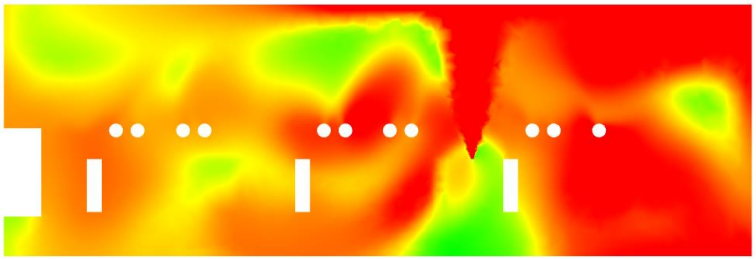


T = 1 min

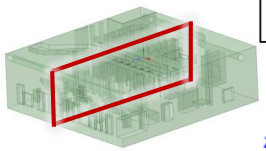




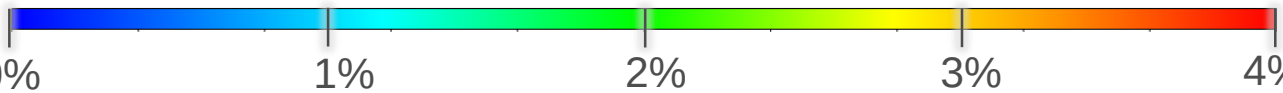
T = 2 min



X = 8.3 m

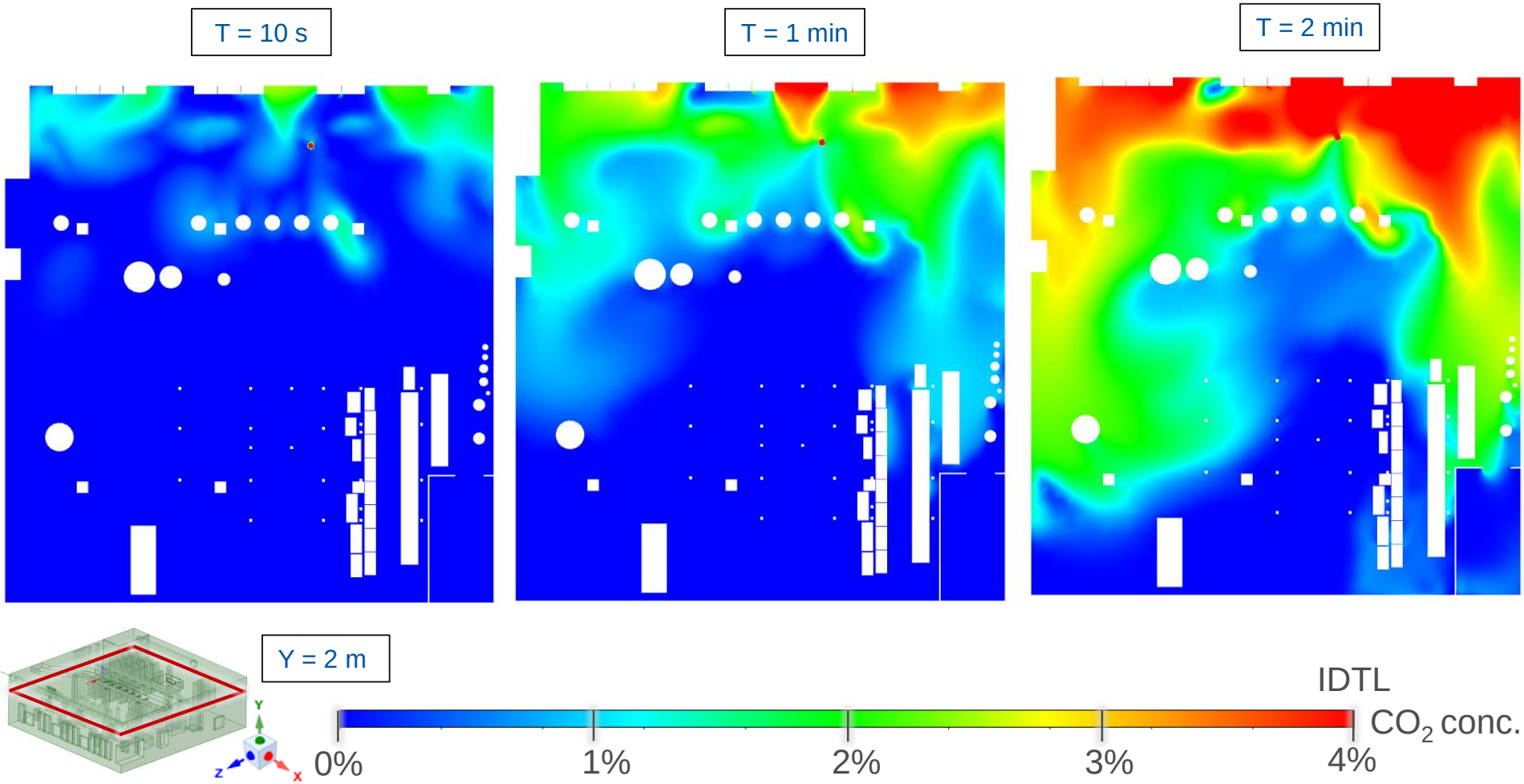


IDTL

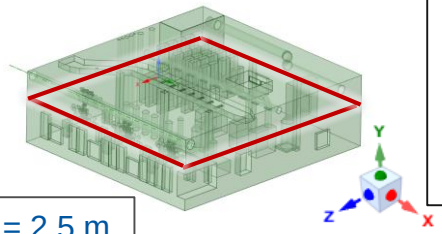


CO_2 conc.

Results: Transient

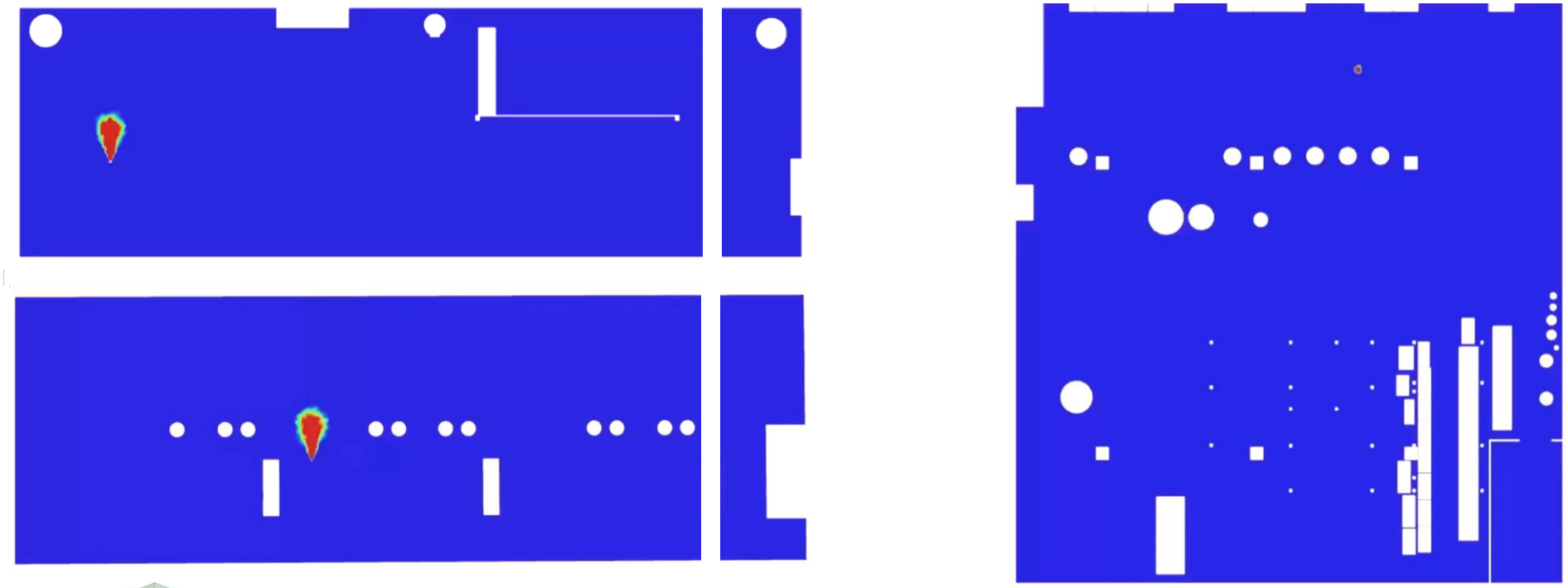


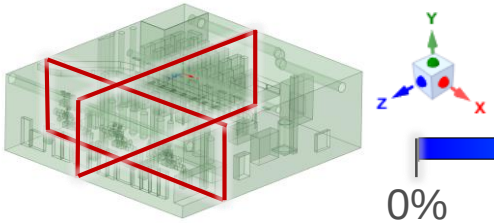
Results: Transient



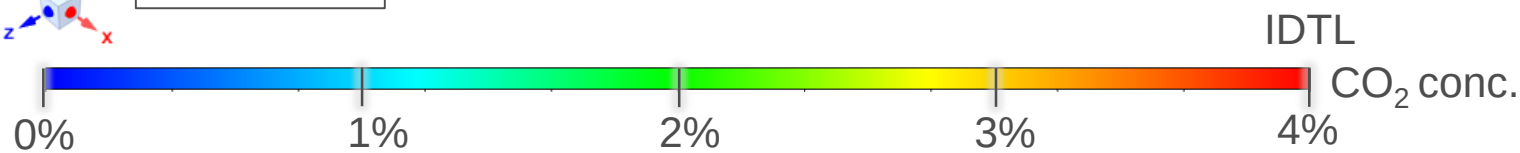
Transient: 2 min.
AHU1: OFF
AHU2: OFF
CO_2: 750 g/s

Y = 2.5 m





Vertical planes



Results: CO_2 Leakage

Consequences of installing the CO_2 – 2PACL system:

- The CO_2 quickly extends in the room, causing concentrations higher than the safety limits (IDTL, 4%).
- The areas immediately close to the leak reach the 4% IDTL in 40 seconds.
- The mezzanine area takes longer to increase the CO_2 concentration, due to the air renewal of the inlets and the distance with the leak.

Conclusion

CFD served as a powerful tool to solve the ventilation optimization and CO_2 leakage analysis of the CV Room at ATLAS:

- Accurate results concerning the air stratification in the CV room.
- Study of the ventilation system behavior in different scenarios (failure of AHUs, additional AHU, etc.).
- Examination of the CO_2 concentrations if a leak occurs in the 2PACL system.

Thank you for your attention!... Any questions?

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