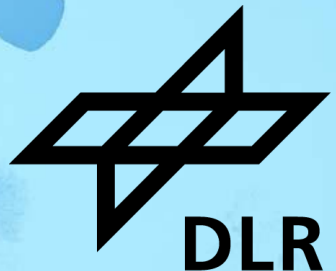


APPLICATION OF PROCAP TO TRAIN AND CAR VENTILATION RESEARCH

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**Deutsches Zentrum für Luft- und Raumfahrt (DLR)
Institut für Aerodynamik und Strömungstechnik (AS)**



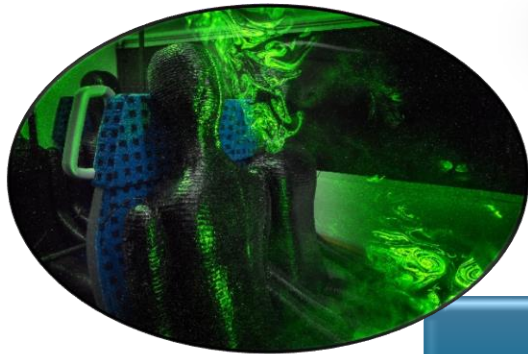
Aims and Challenges of Ventilation Concepts and HVAC Operation



Energy Demand



Task: optimization of HVAC concept depending on boundary conditions



Air Quality



Thermal Comfort



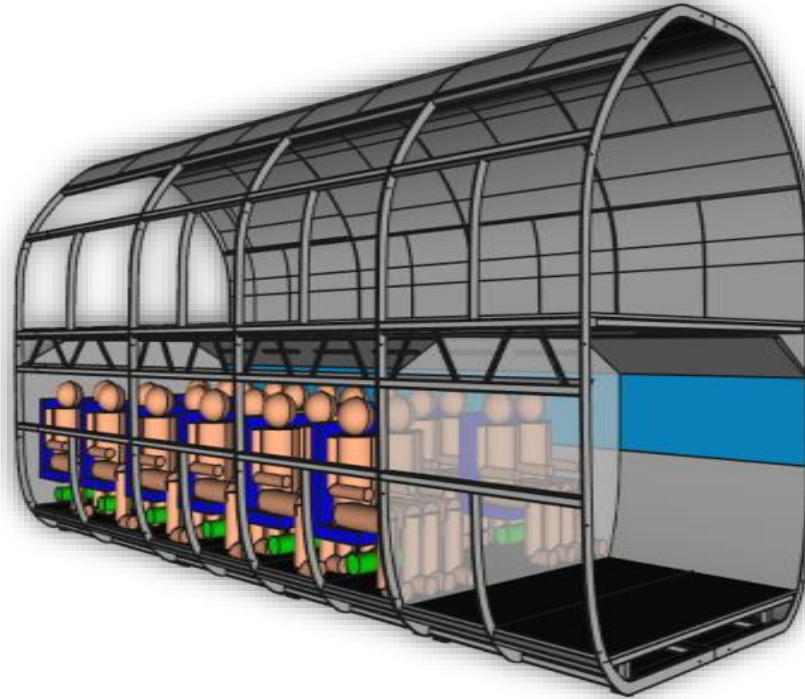
Measurement Environment 1

Train Ventilation

Probe: 3D ultrasonic
Software: ProCap Professional
Evaluation: Para View

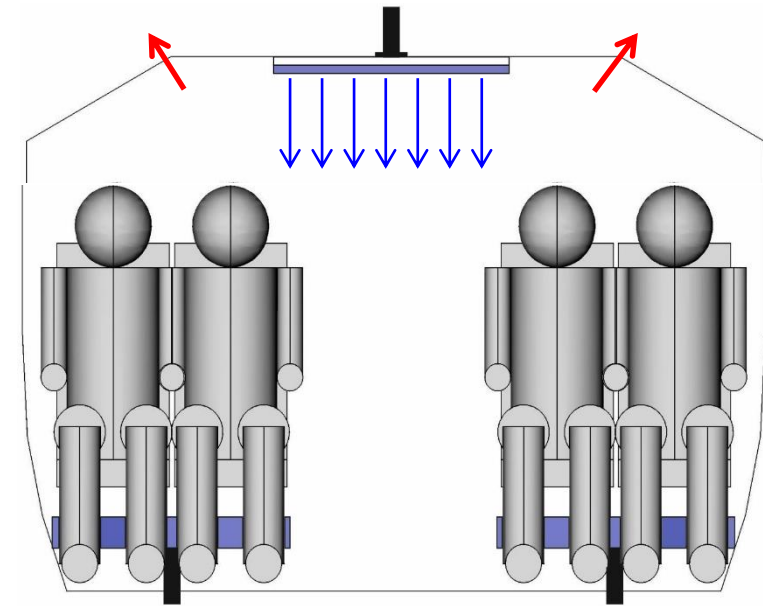
Next Generation Train Mock-Up (NGT)

- 1:1 scale NGT mock-up
 $6.0 \times 2.88 \times 1.95 \text{ m}^3$
- Various ventilation concepts can be integrated
- Lower floor fully equipped for 24
 - Thermal manikins
 - Subject tests



Ventilation scenario

Micro-Jet Ventilation State-of-the-art for train ventilation



Determination of

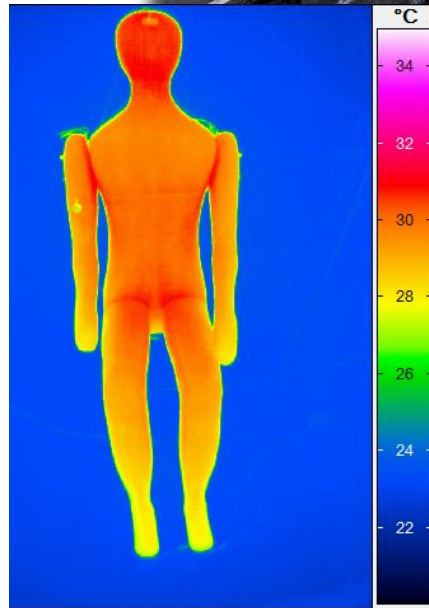
- local comfort parameters:
 - Fluid temperatures
 - Surface temperatures
 - Velocities
- Energy consumption



Thermal manikins

Simulation of Thermal Loads

- constant heat flux density (increased at head)
- individually controllable in a range of 0...150W
- realistic surface temperatures and buoyancy forces
- Adjustment of thermal manikins
→ human metabolism
 $T_{cab} = 23 \text{ }^\circ\text{C}$
→ $P_{TM} = 82.0 \text{ W}$

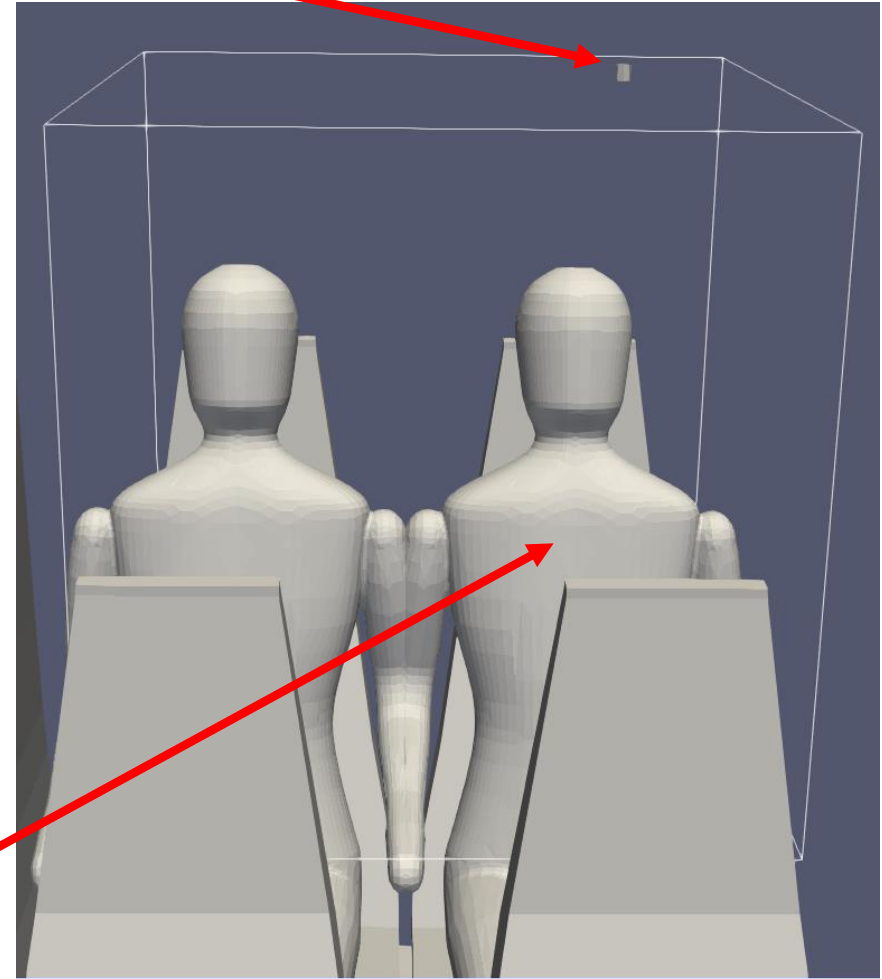
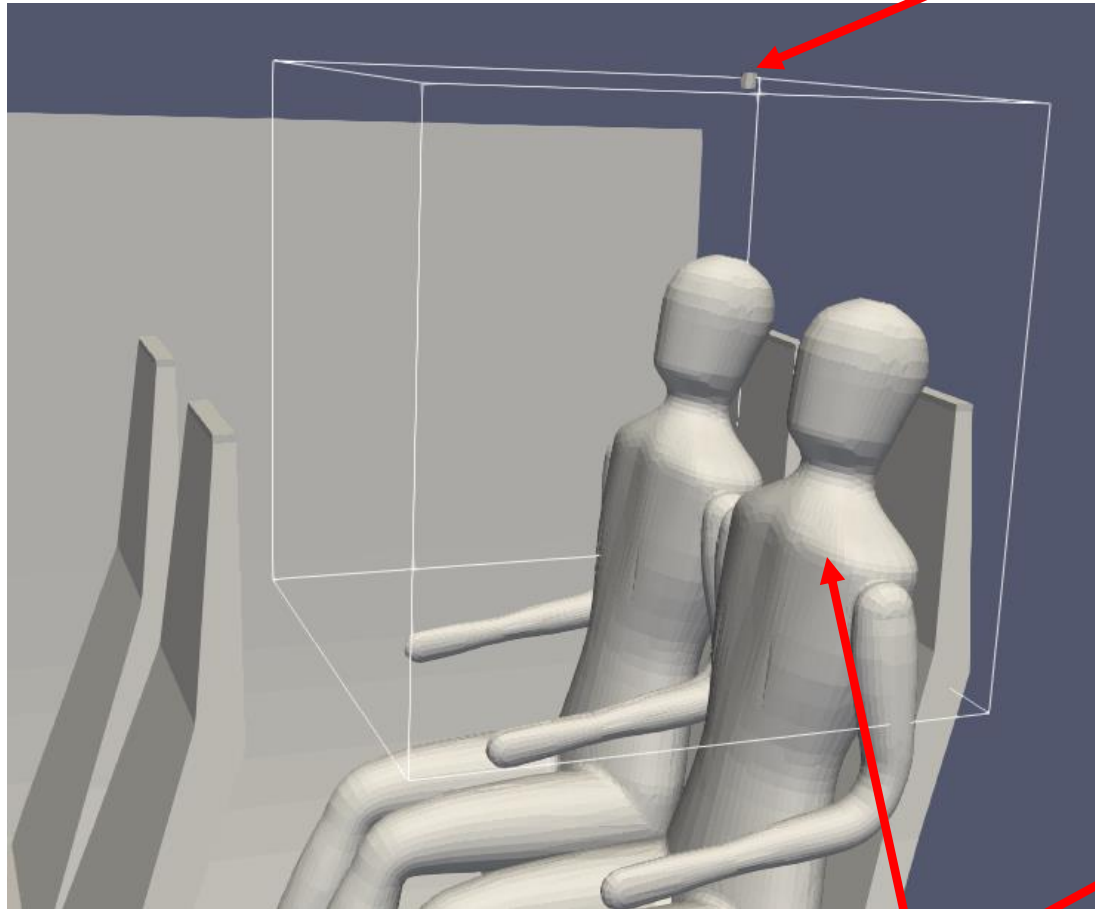


Experimental Set-Up



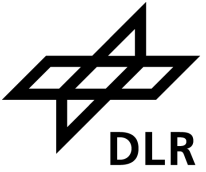
Measurement volume

One active additional air vent

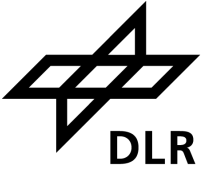


TM mainly influenced by the additional nozzle

Pictures of a working DLR employee 😊



Test Cases



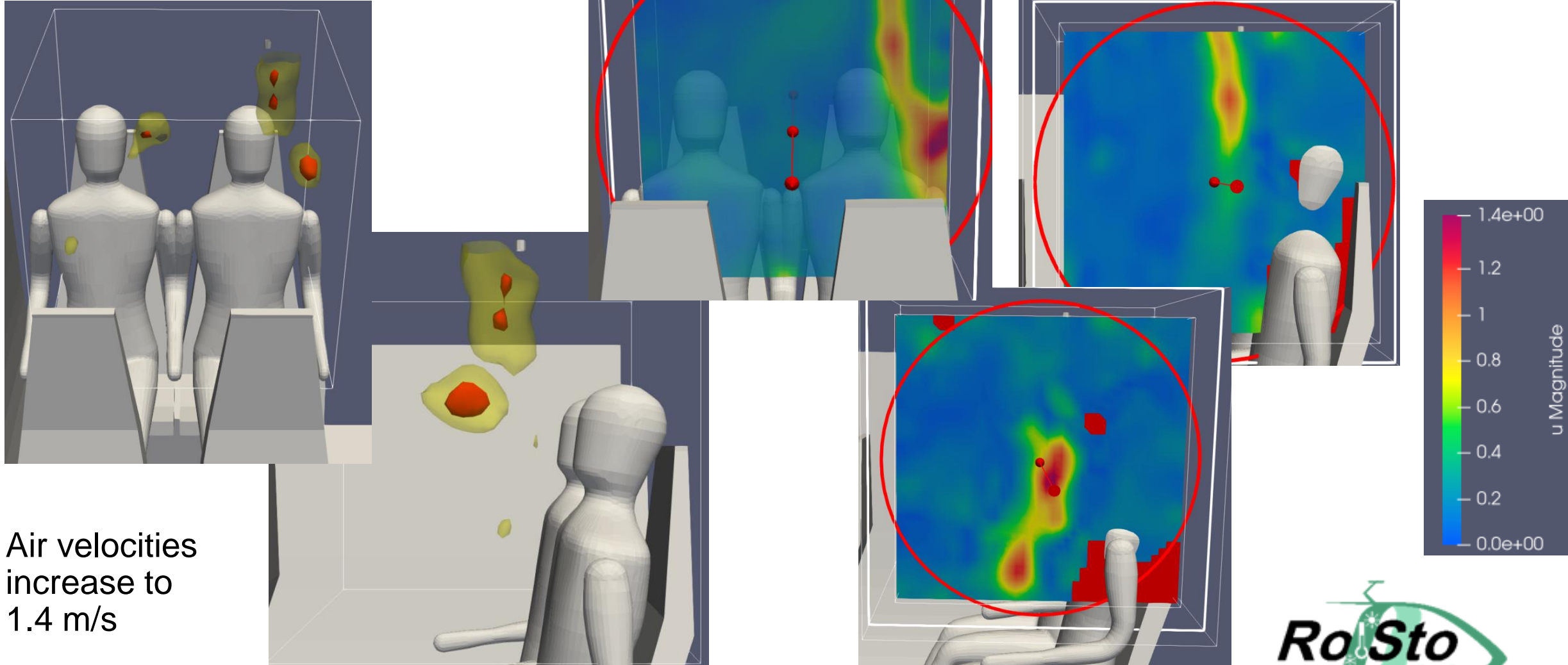
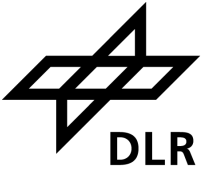
Case	Volume Flow	Nozzle Alignment
001	Off	-
002	Low	Straight down
003	Medium	Straight down
004	High	Straight down
005	Medium	Turned to the thermal manikin
006	Medium	Turned away from the thermal manikin



Results medium straight down

- Yellow 0.4 m/s
- Red 0.6 m/s

Apparently a mixing of the air from the nozzles with the MJV ventilation



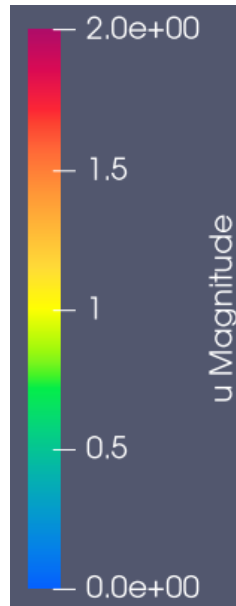
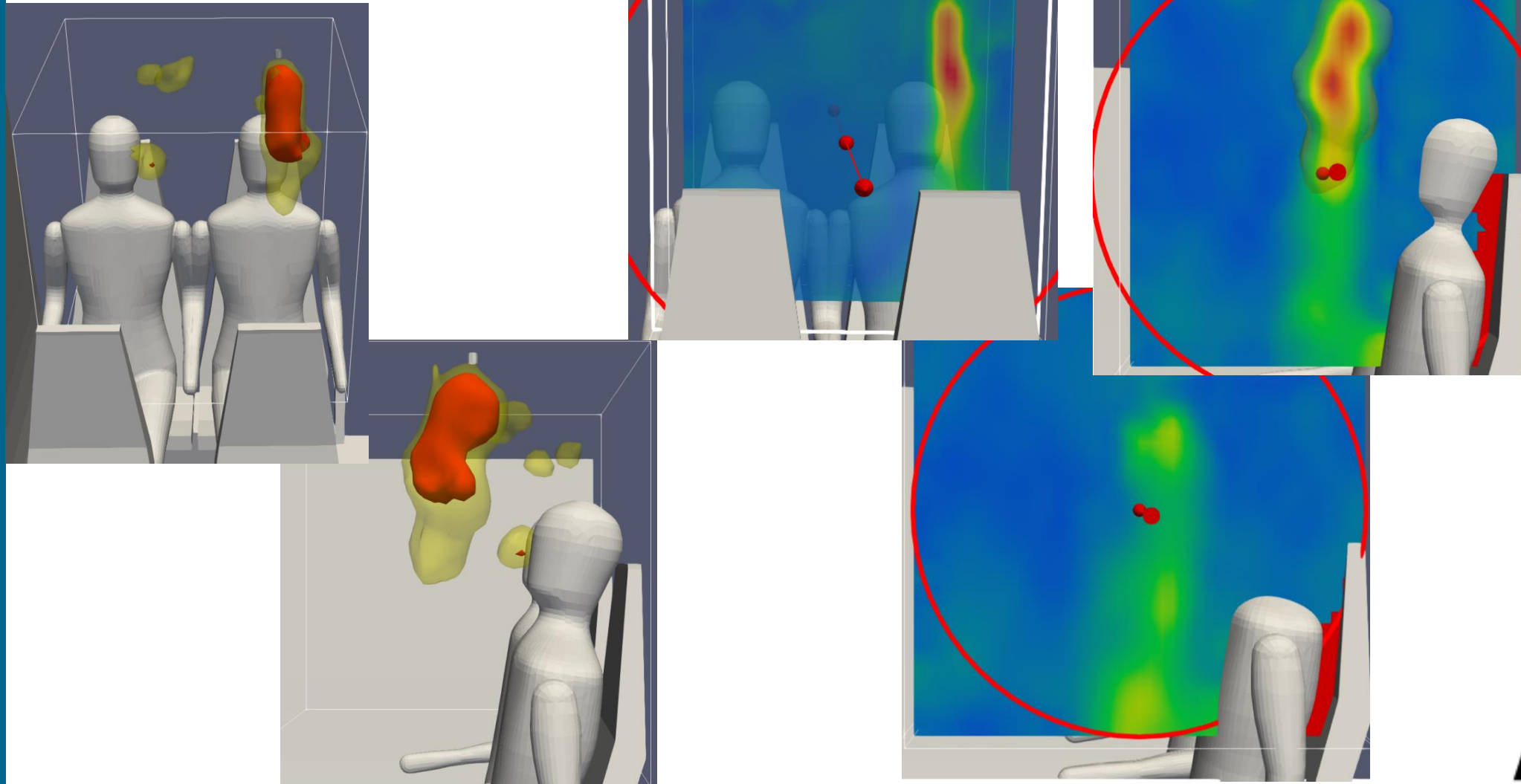
Air velocities increase to 1.4 m/s



Results high straight down

No mixing of the different supply air
Maximum velocities of 2 m/s

- Yellow 0.4 m/s
- Red 0.6 m/s

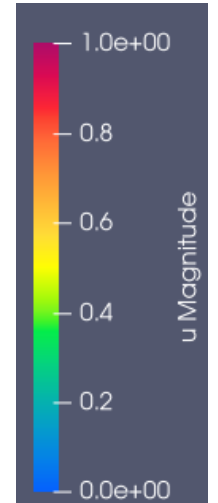
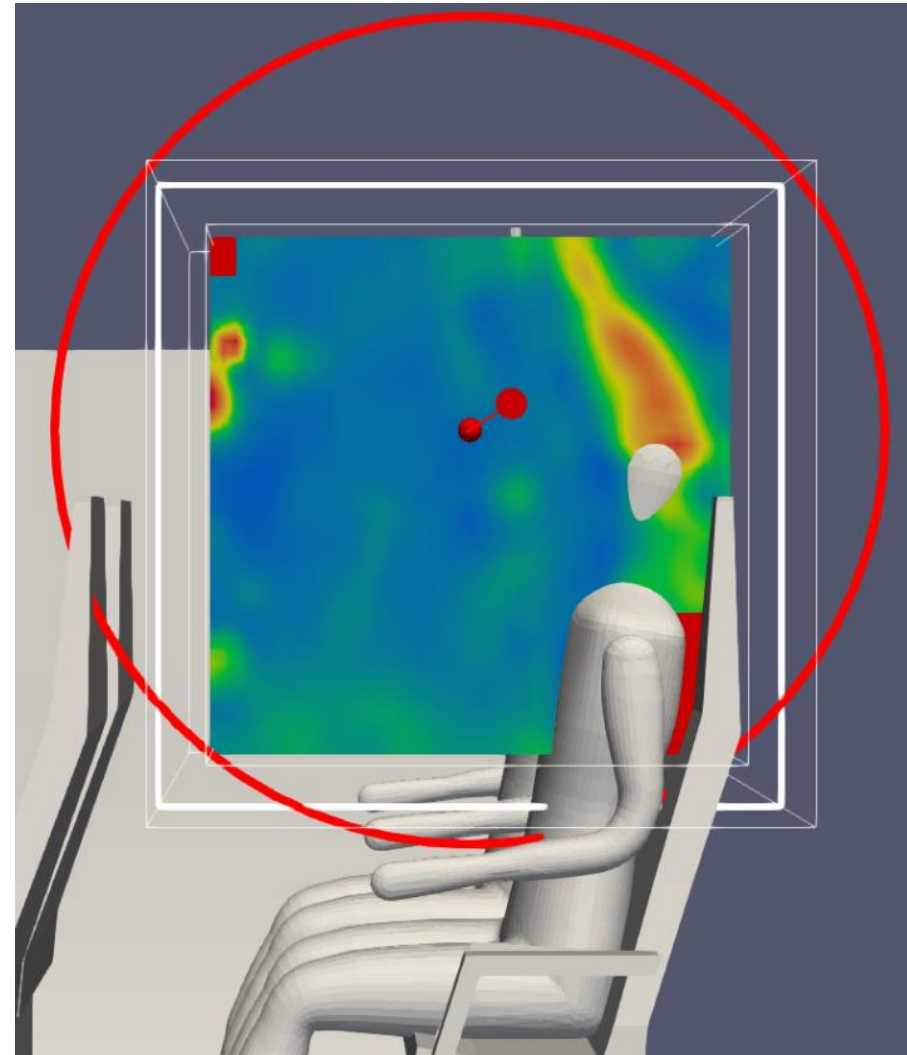
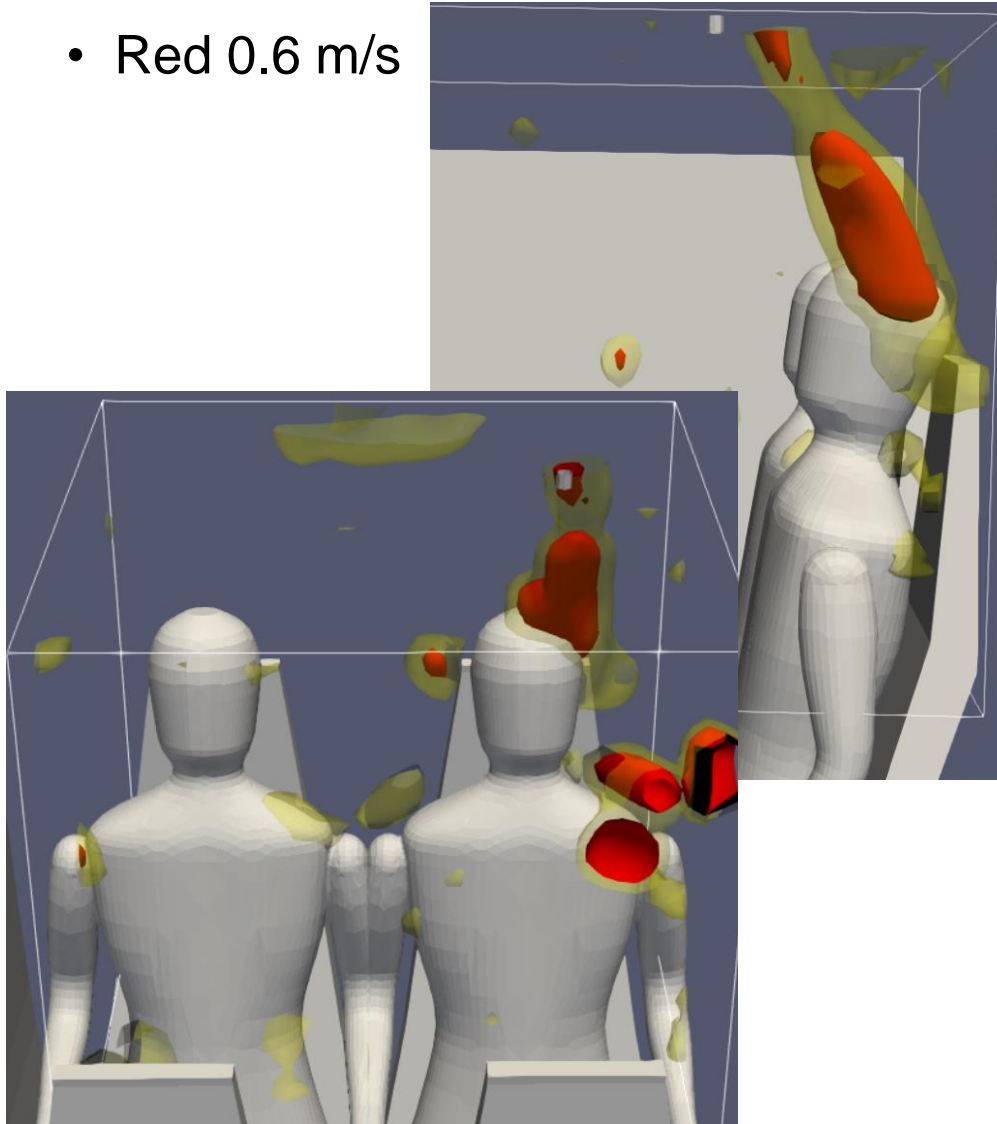


Results medium - Nozzle turned to Thermal Manikin



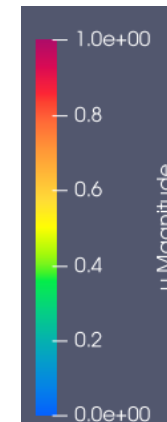
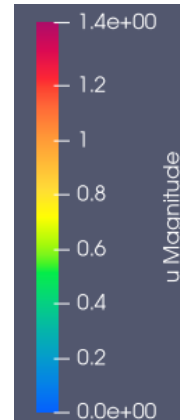
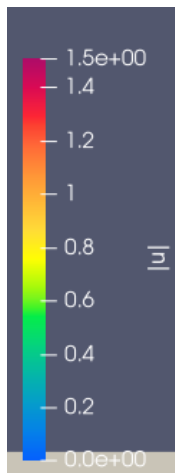
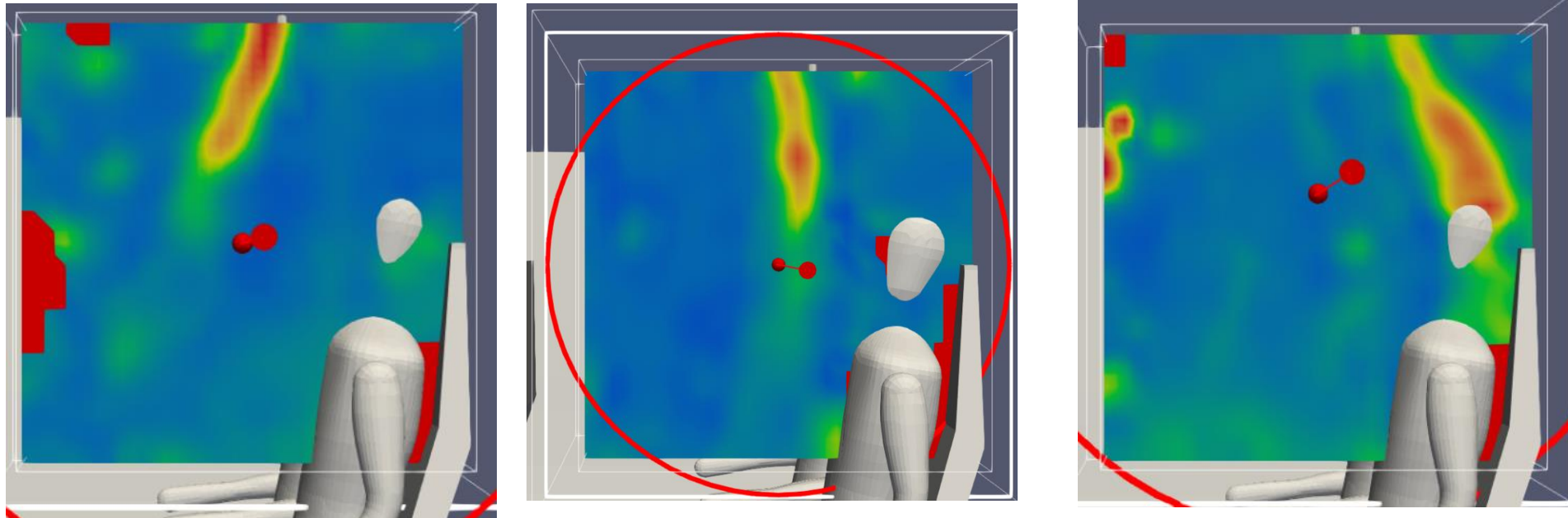
- Yellow 0.4 m/s
- Red 0.6 m/s

Head is hit directly by the additional nozzles



Results medium – 3 cases

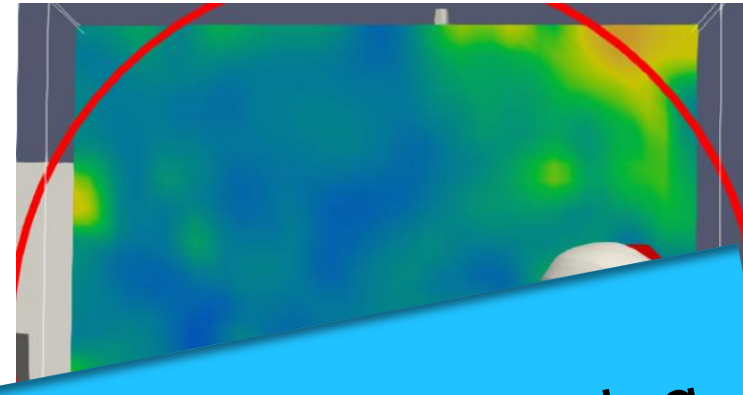
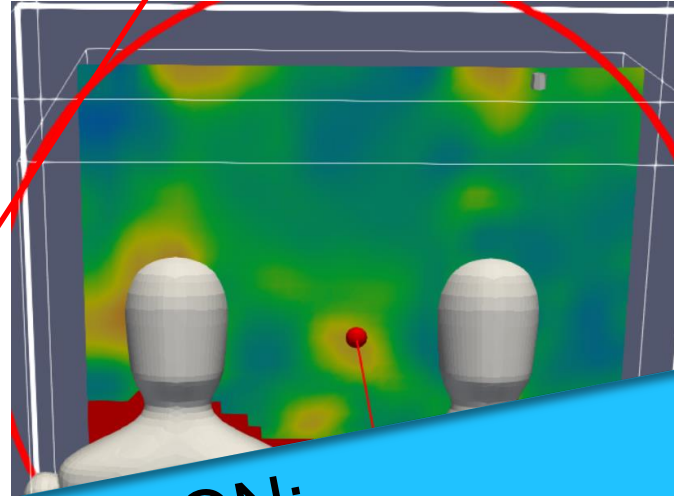
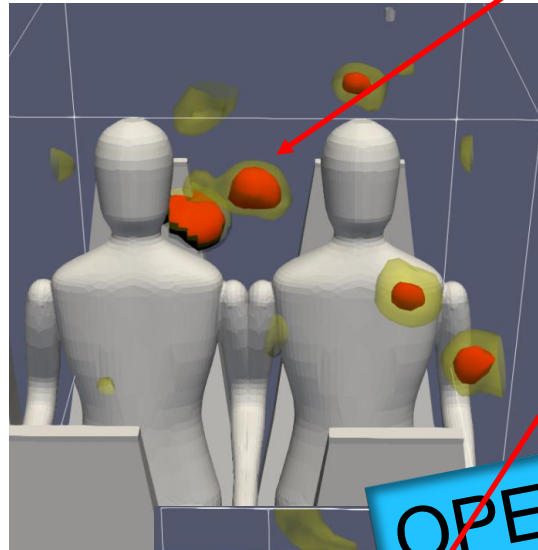
ProCap system: very well suited to show the high inflow velocities



Measurement Errors? (Nozzles off)

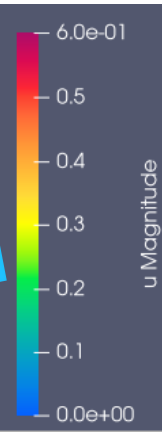
- Yellow 0.2 m/s
- Red 0.3 m/s

This is actually not really explainable



OPEN QUESTION:

- Is precise and frequent scanning of the measuring area sufficient for optimal data recording?
- What happens in the "blind spot" - flow onto the probe from above → mean calculation
- How often do I have to scan an area



Measurement Environment 2

Car Ventilation



Probe: 3D ultrasonic
Software: ProCap Professional
Evaluation: Para View

Technical University of Munich
Manuel Kipp



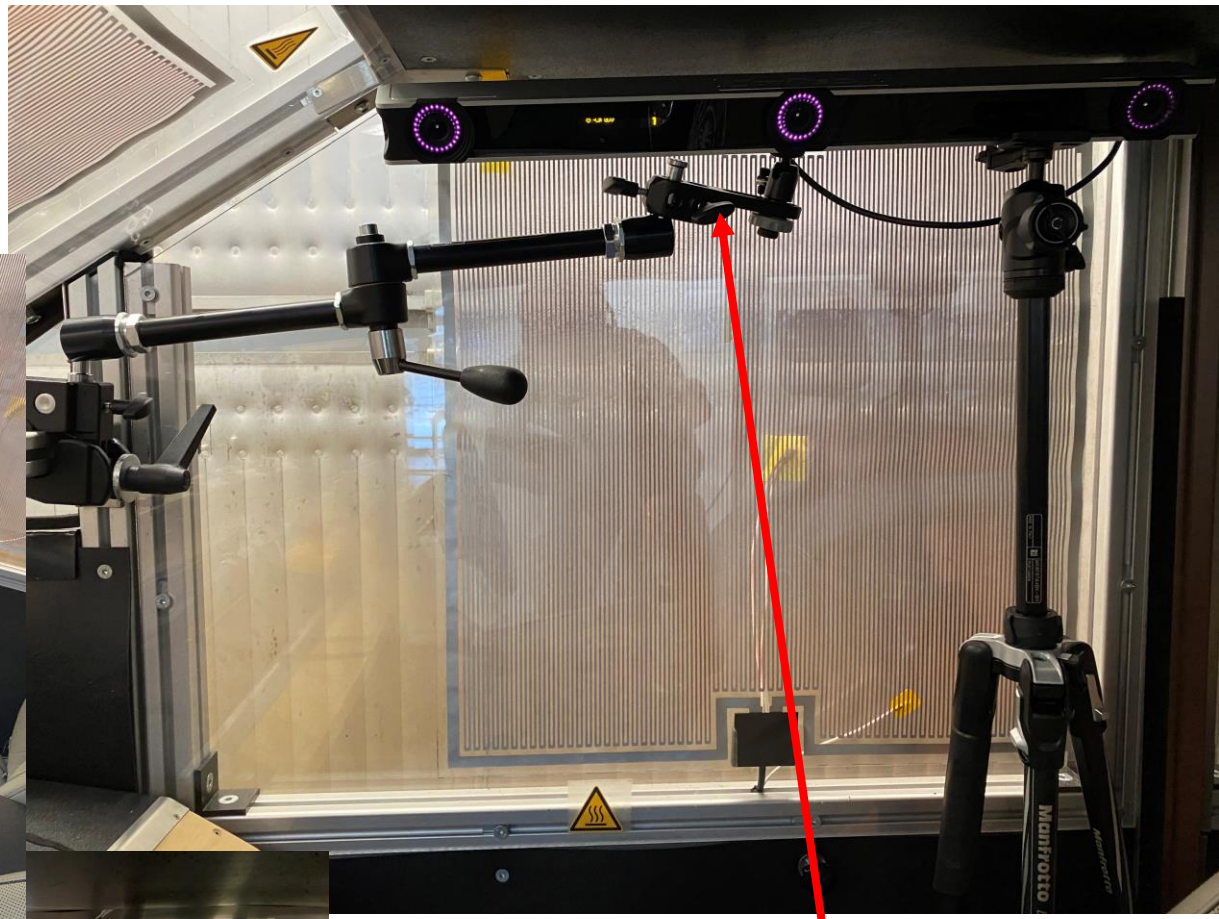
Car Mock-Up for 2 Persons

External
ventilation
system



Experimental Set-Up

Inlet nozzles in the dashboard

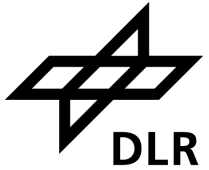


Camera setup installed in front of the right passenger window



That was also my place

Landjet Outflow System



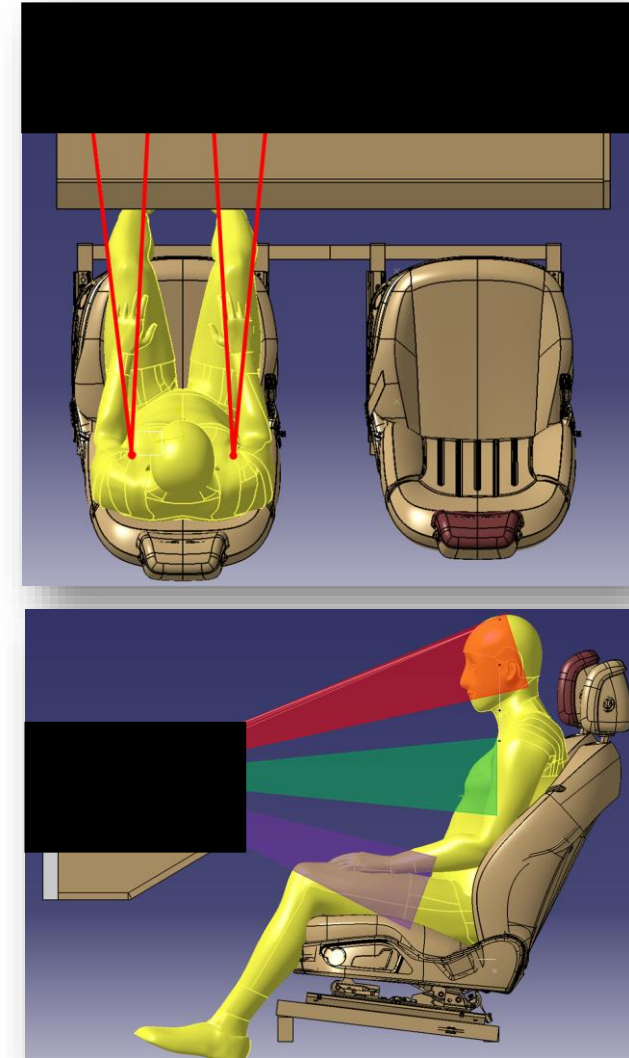
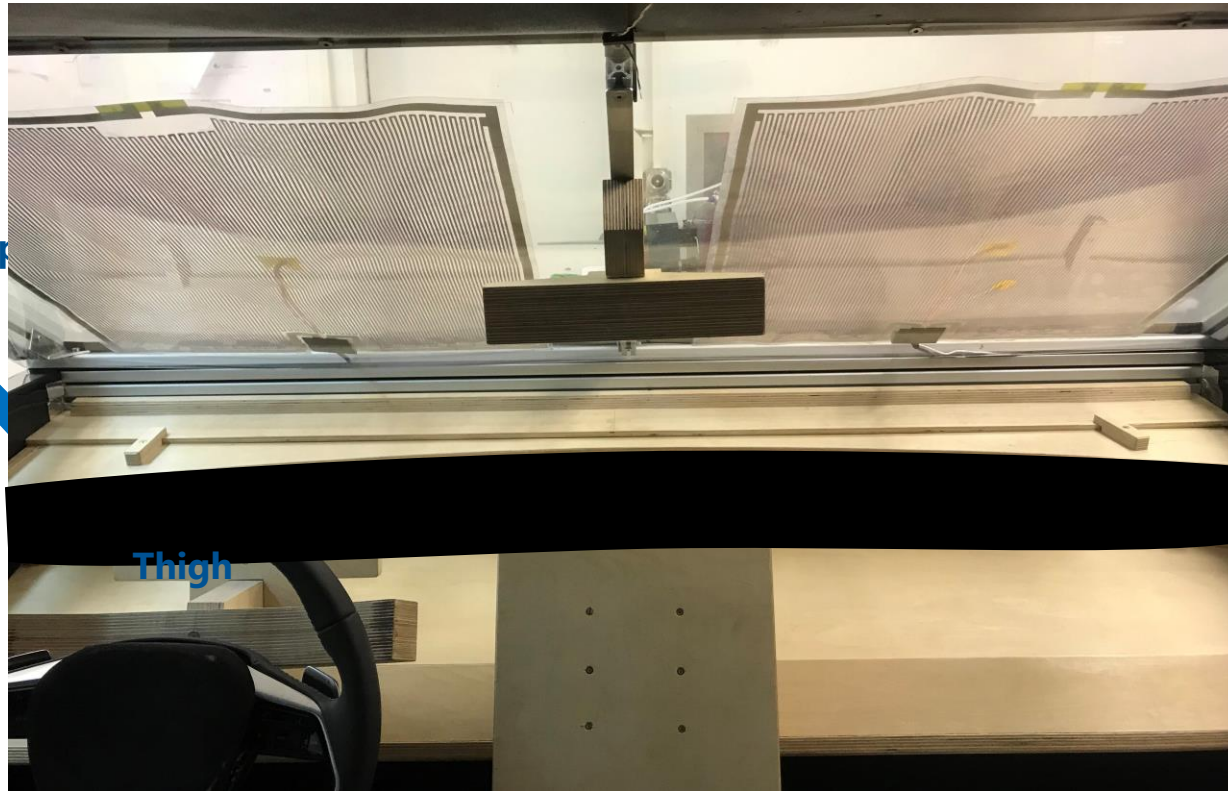
Setting options:

- volume flow
- outflow direction

Left upper arm

Right upper arm

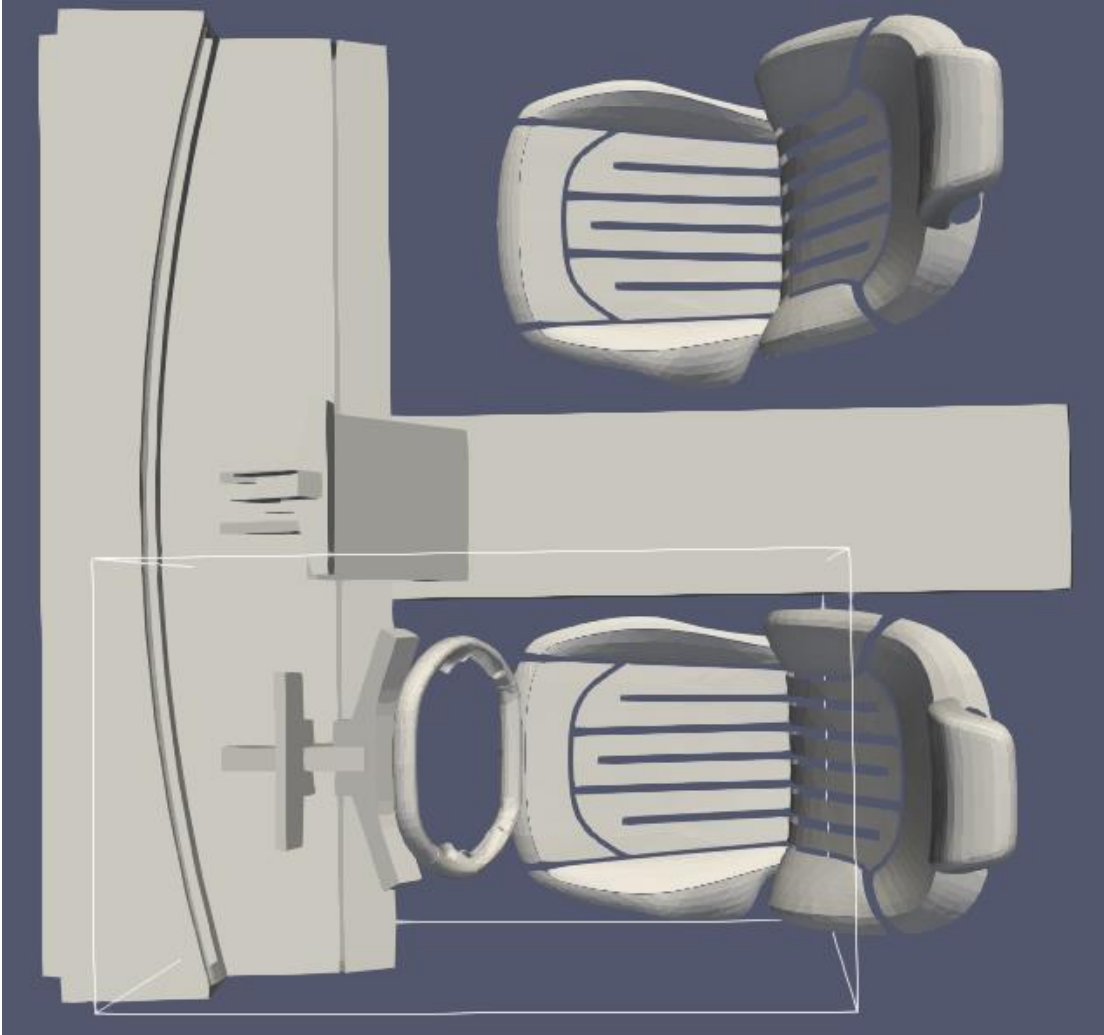
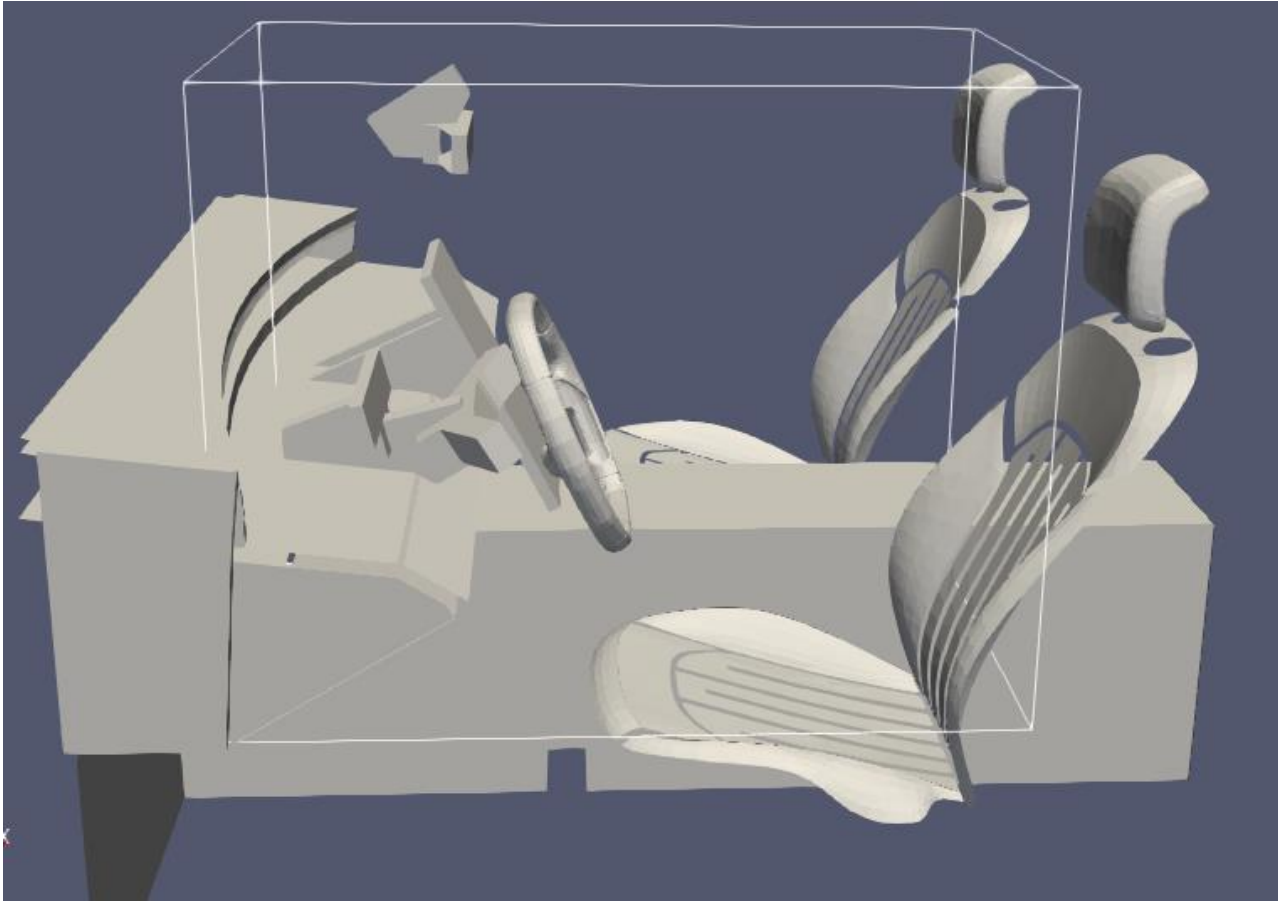
Thigh



Case	Volume Flow	Angle adjustment
001	Medium	1
002	High	1
003	Low	2
004	Medium	2
005	High	2

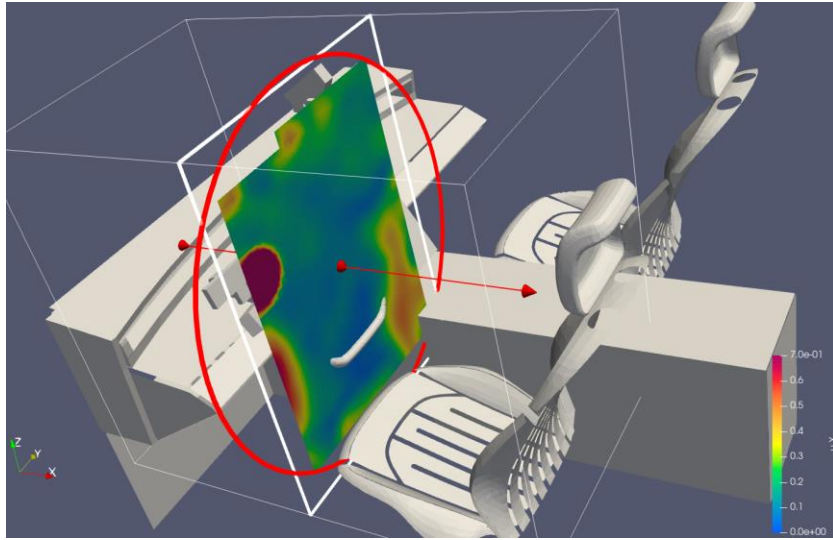


Measurement volume: driver's seat

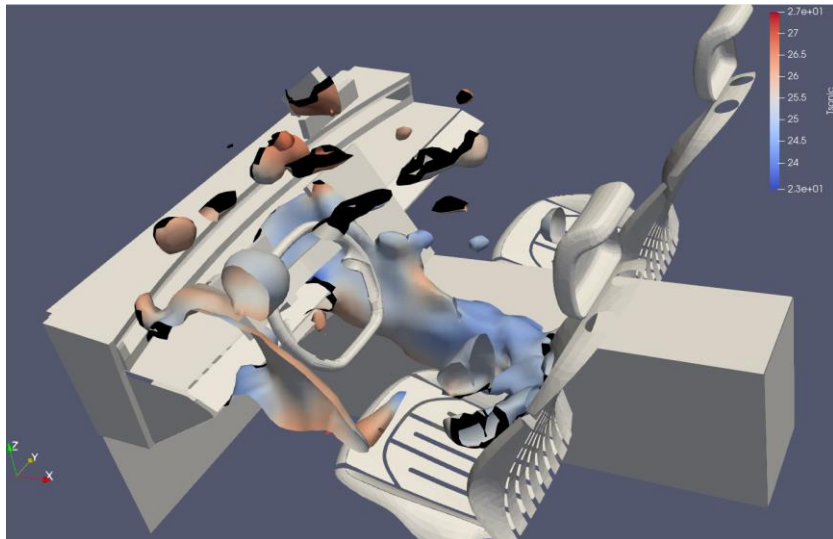


Results Case 001

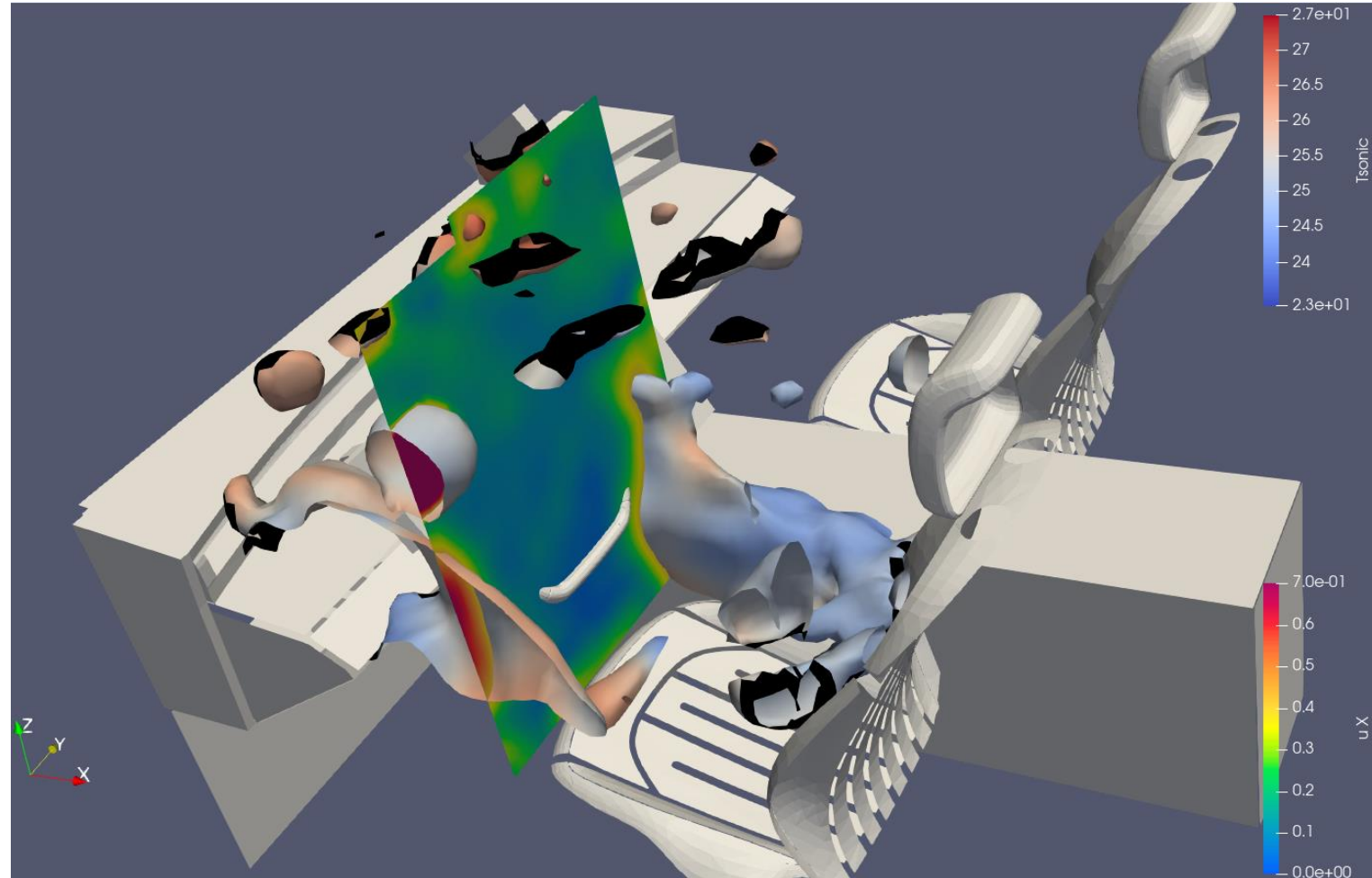
Velocity



Temperature

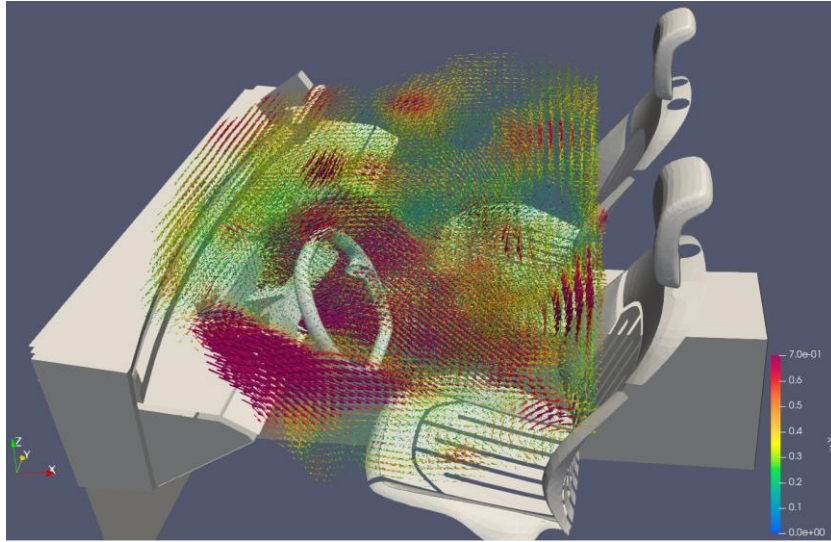


Areas of higher velocities comparable to temperatures

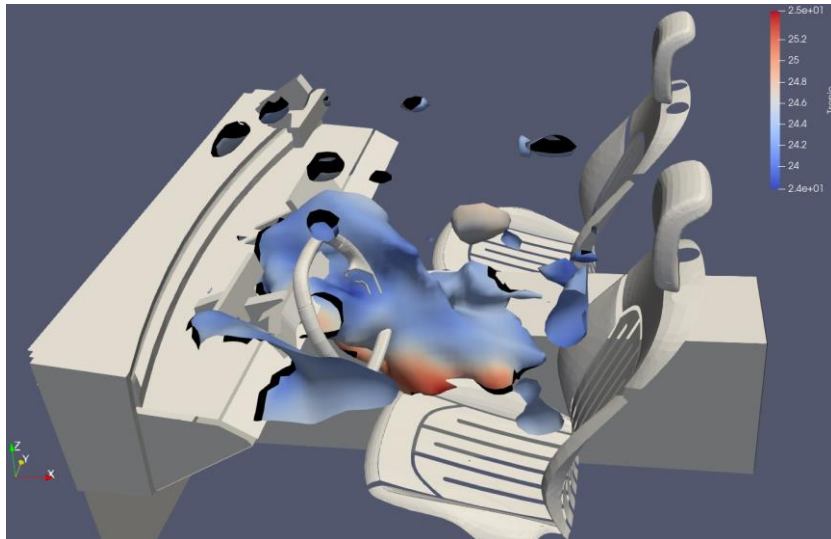


Results Case 002

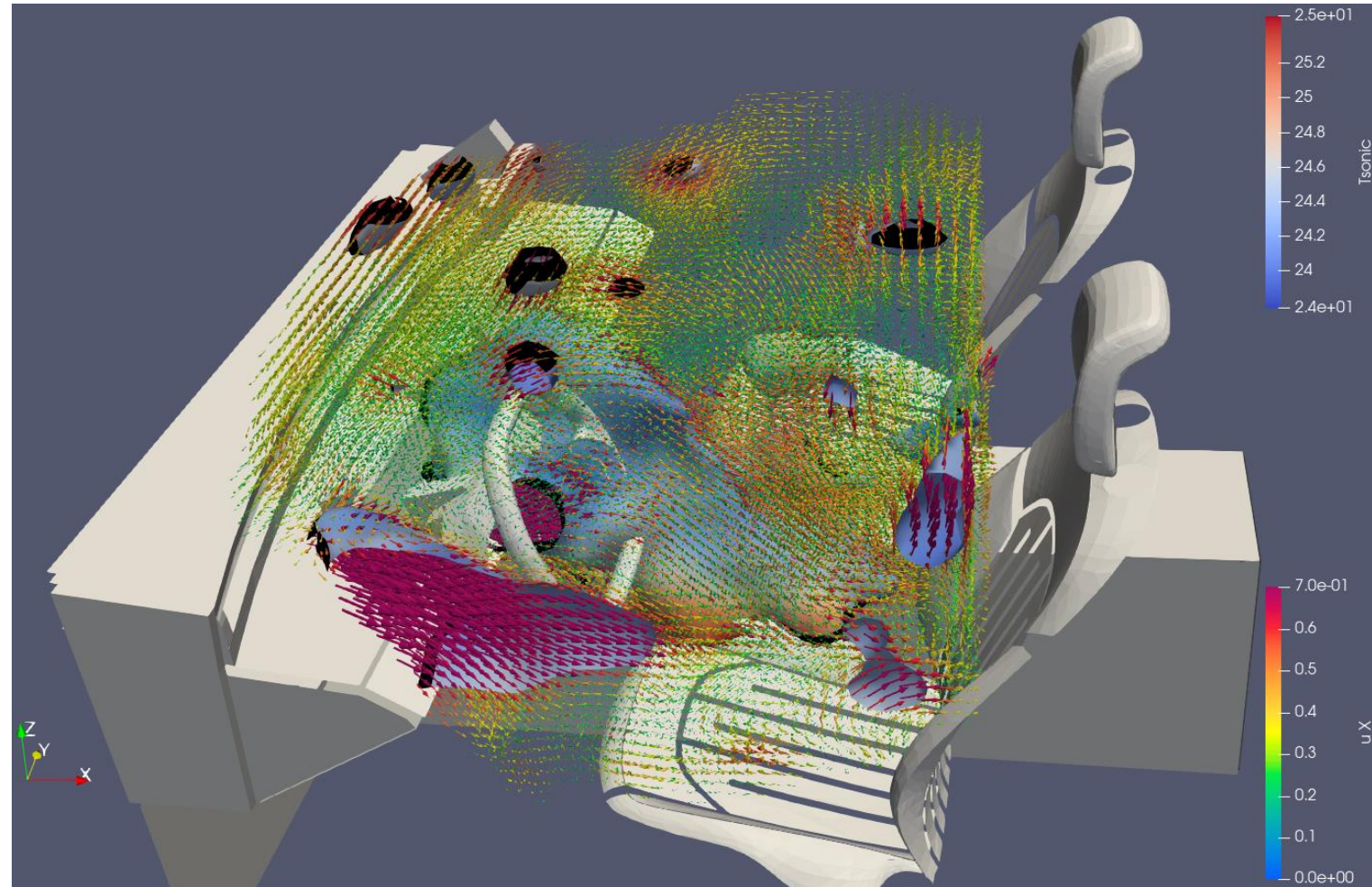
Velocity



Temperature



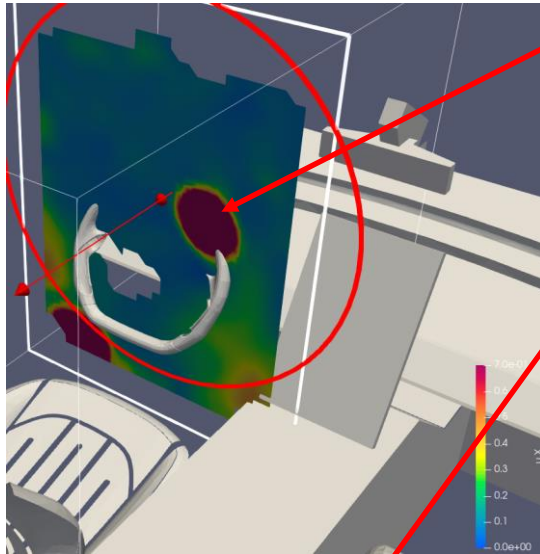
This also fits together



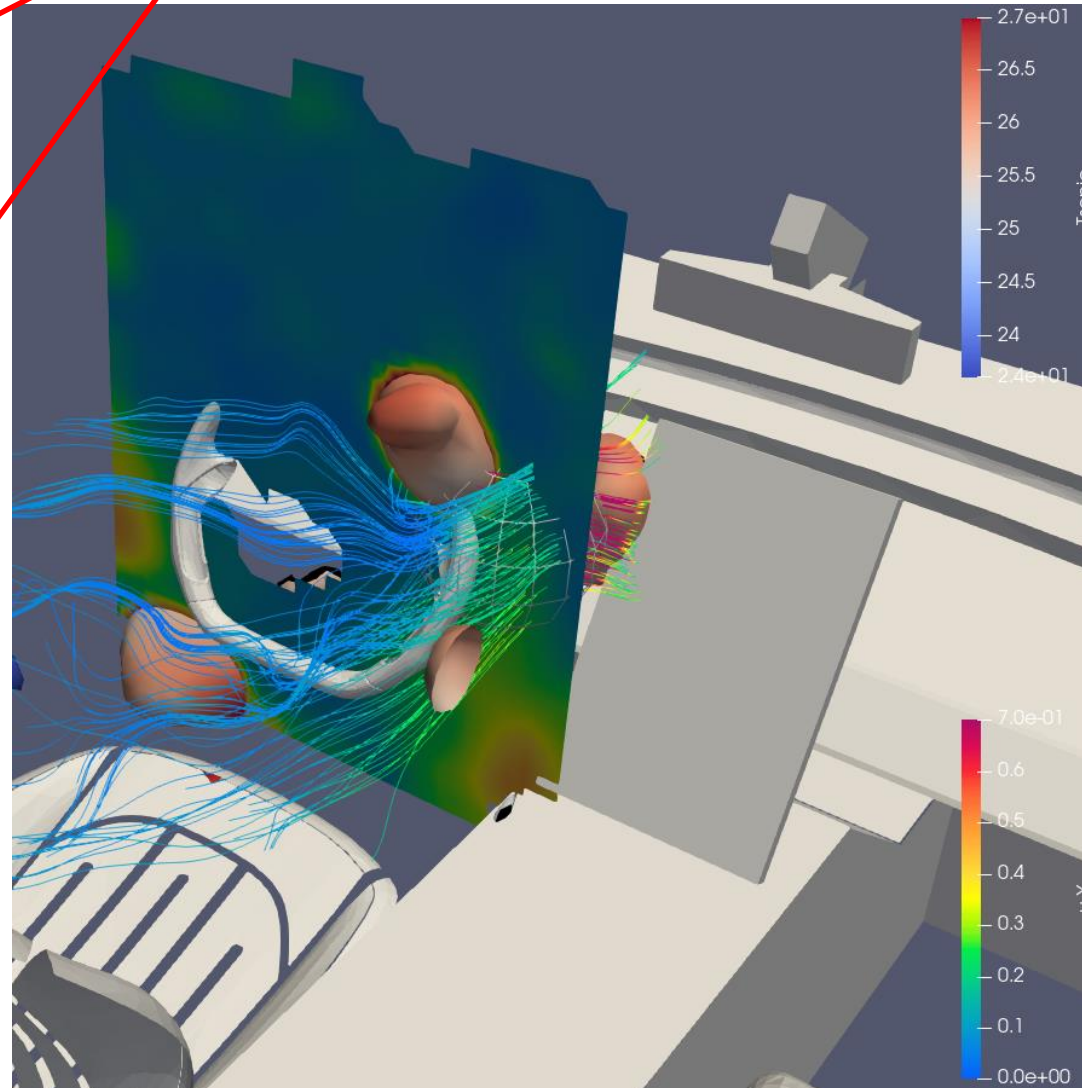
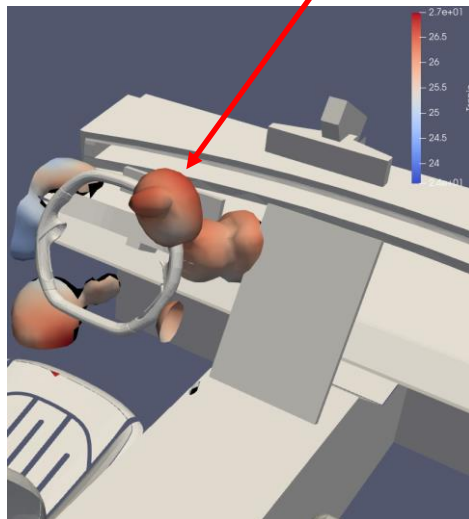
Results Case 003

This is actually not really explainable

Velocity



Temperature

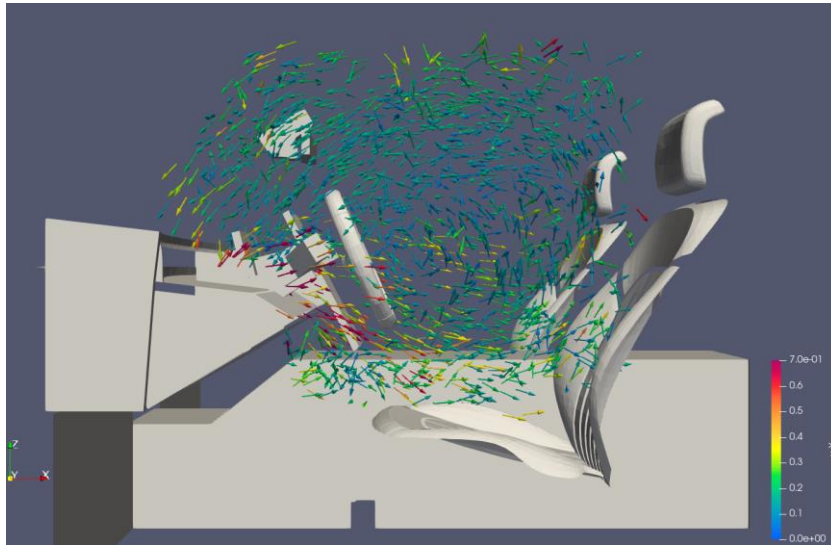


Streams can be used to beautifully display the flow.

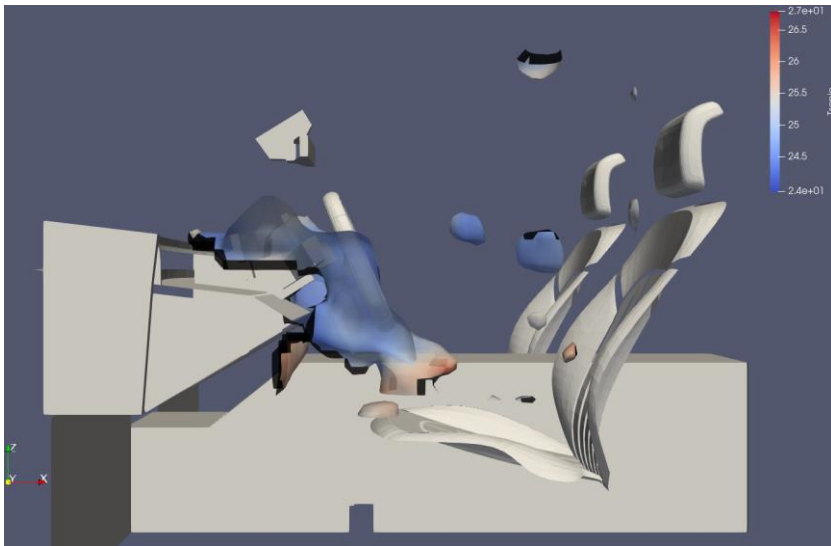
Results case 004



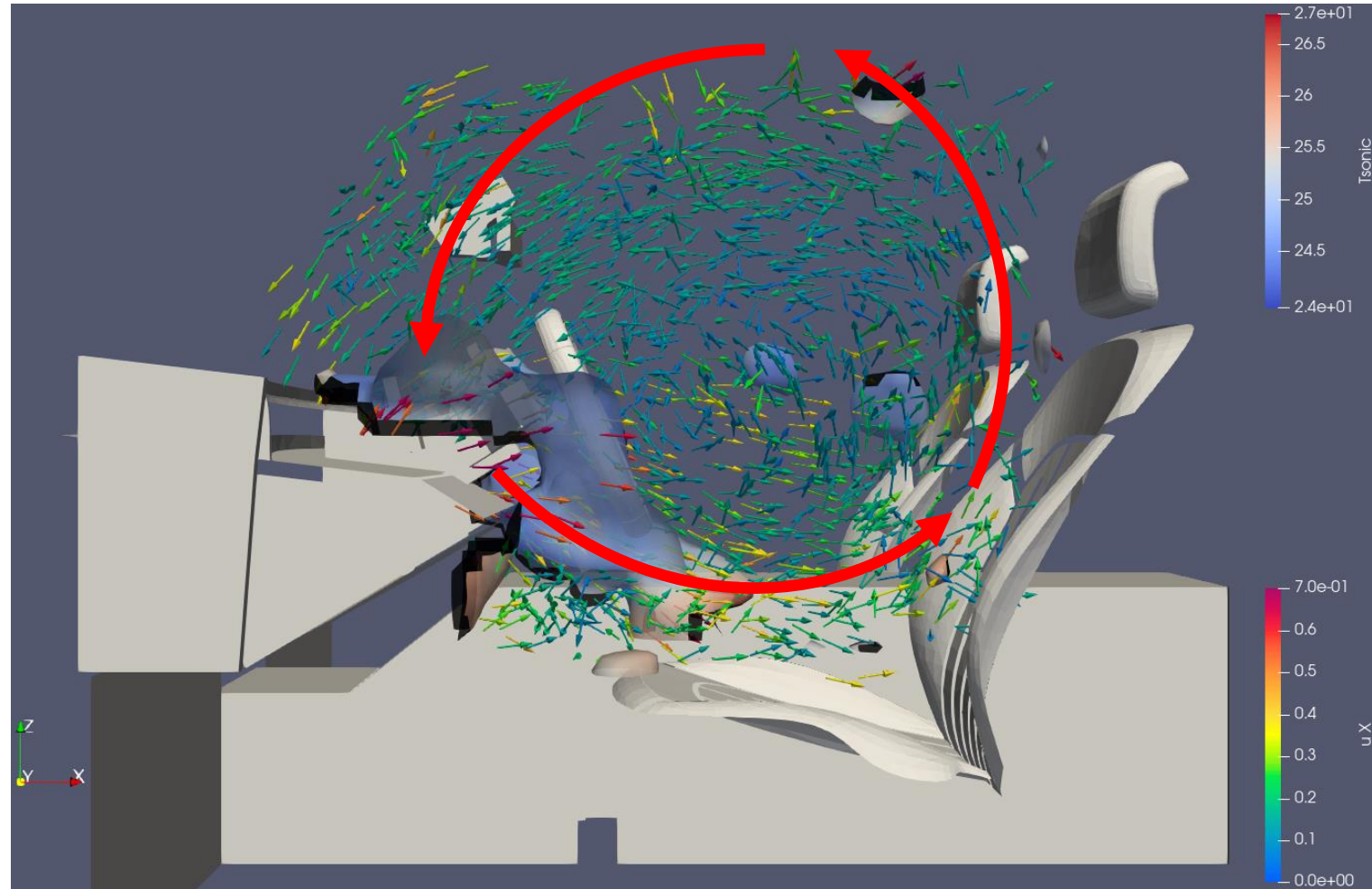
Velocity



Temperature

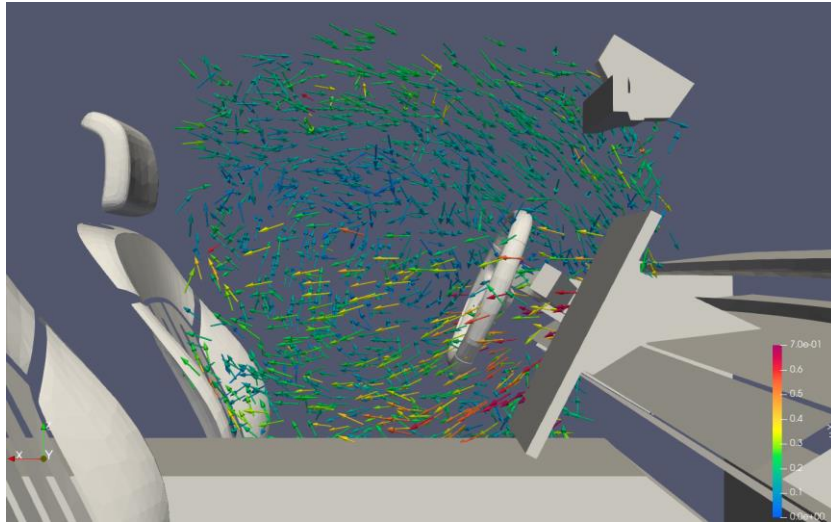


Very nice presentation of large-scale structures

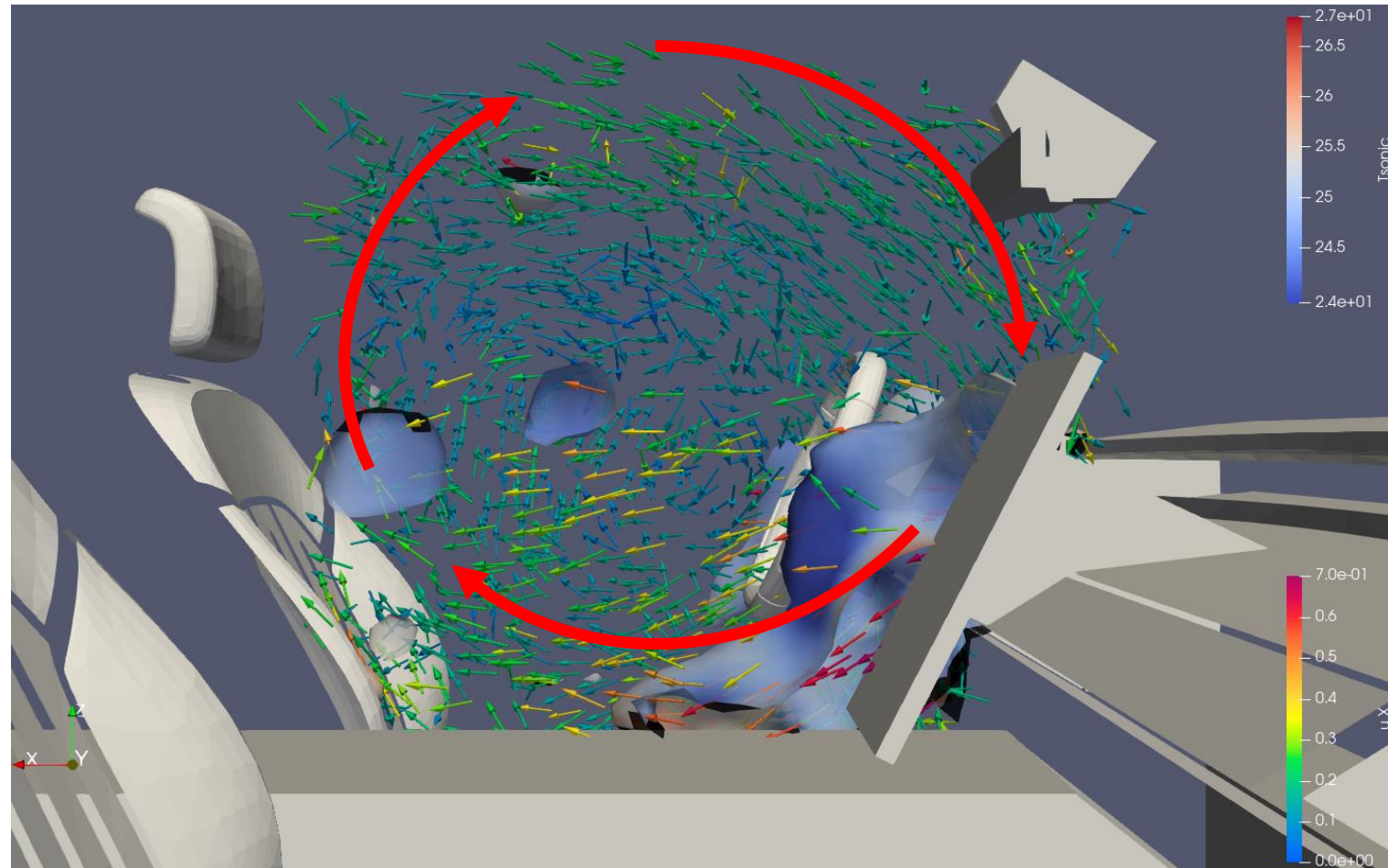
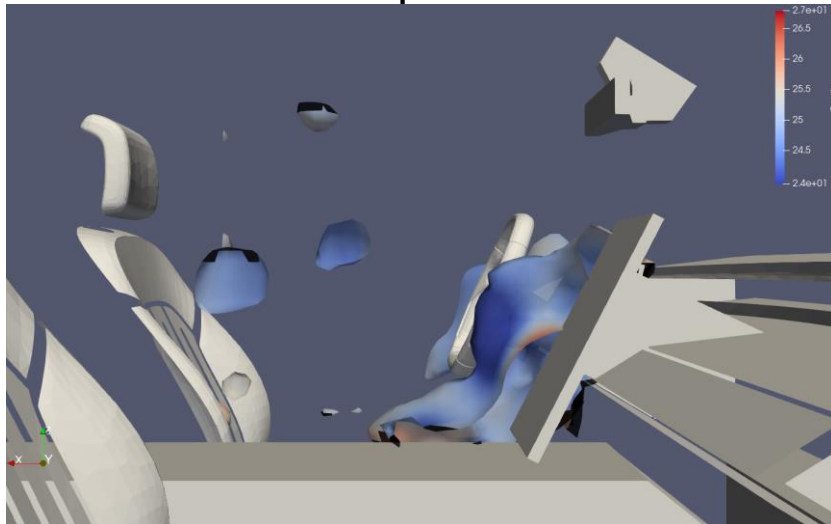


Results Case 004

Velocity

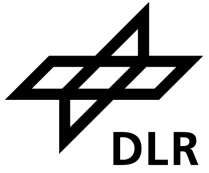


Temperature

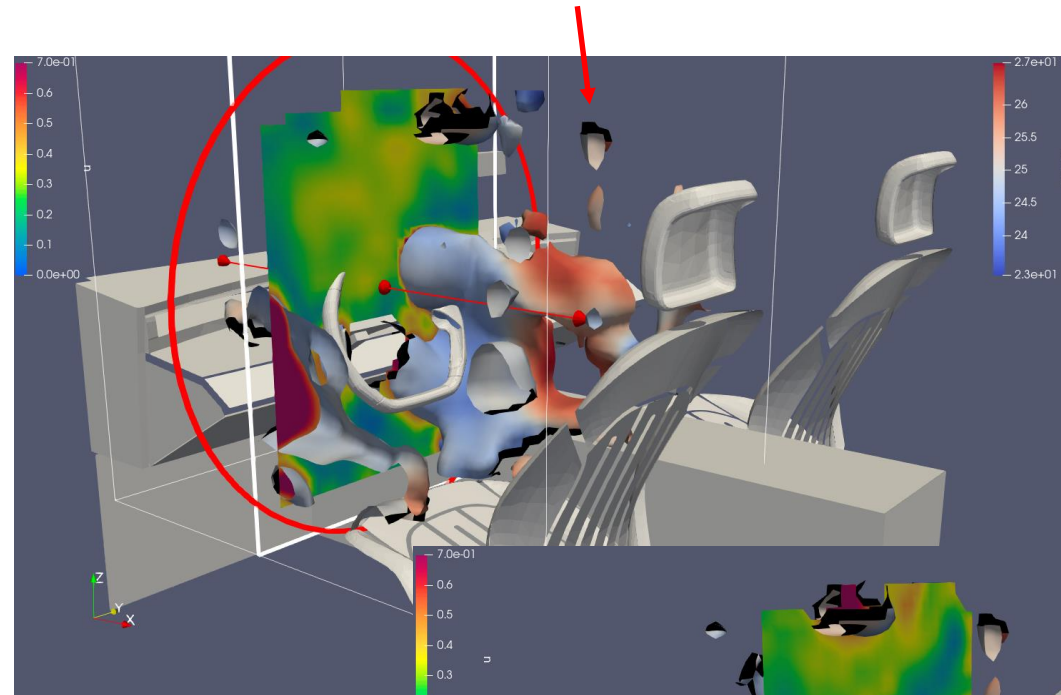
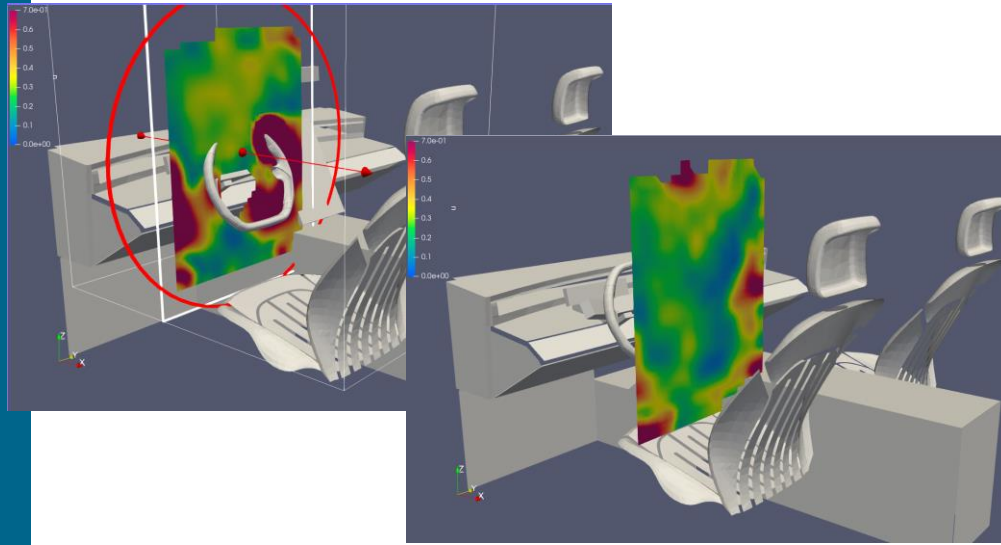


Results Case 005

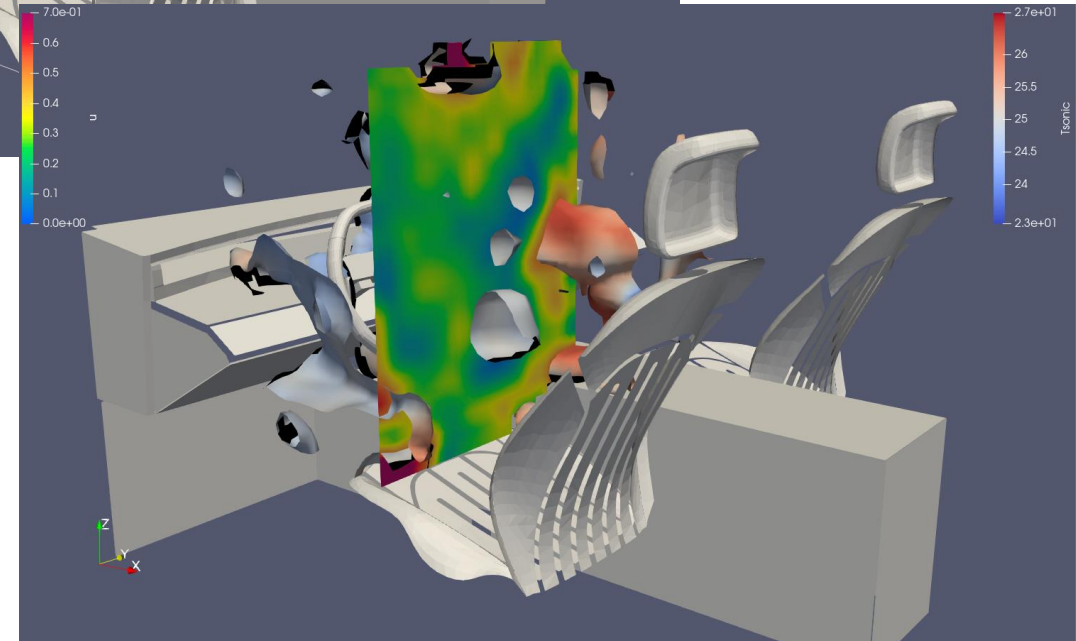
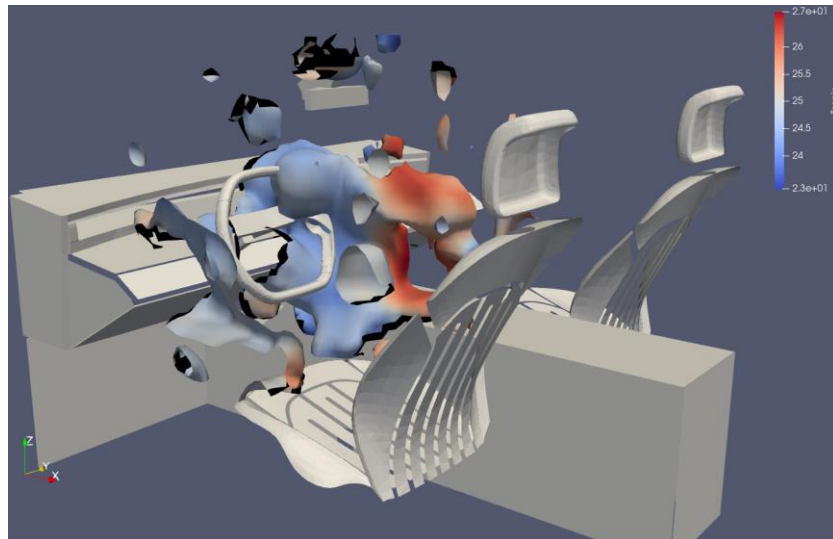
This is actually not really explainable



Velocity

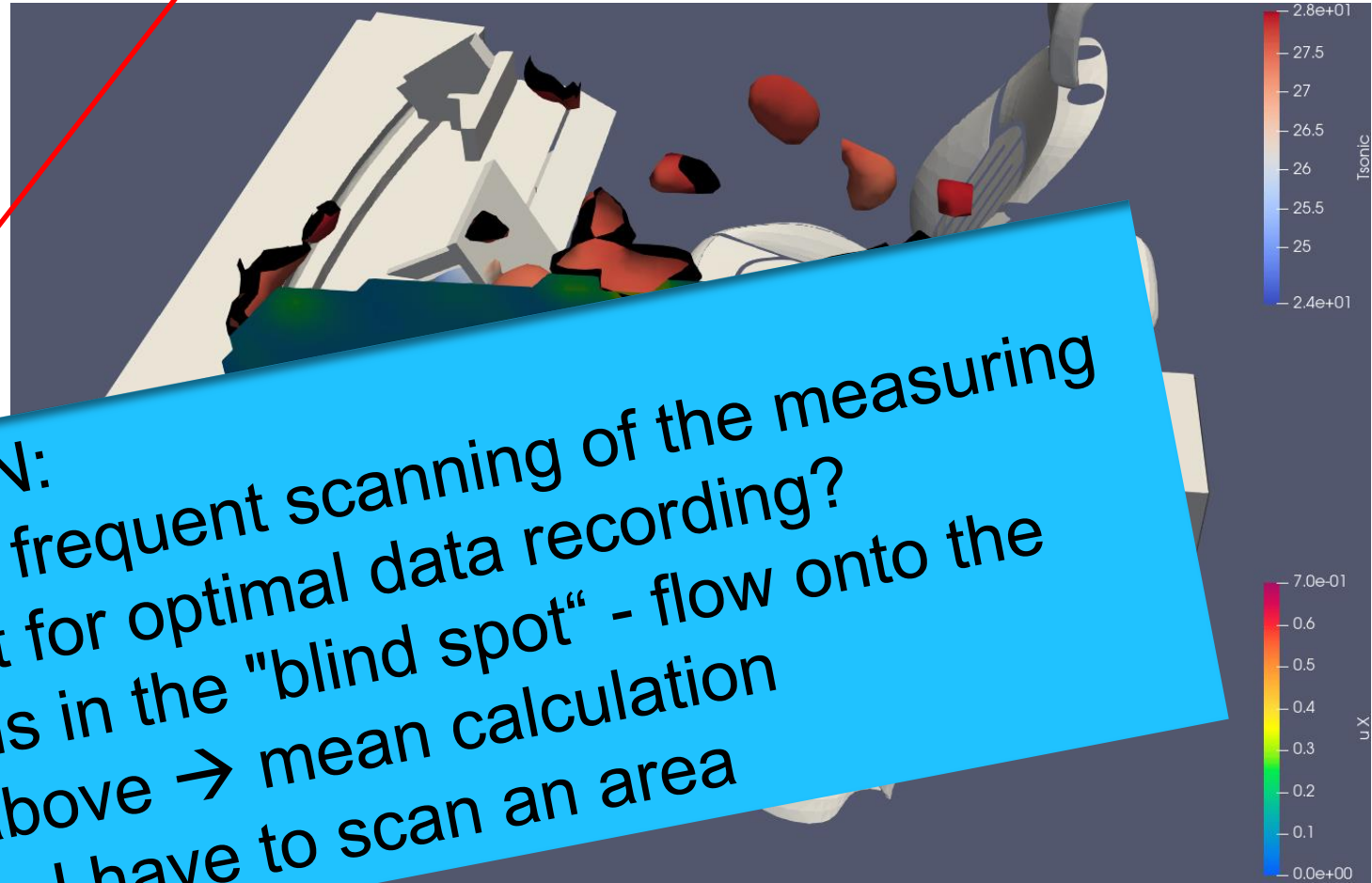
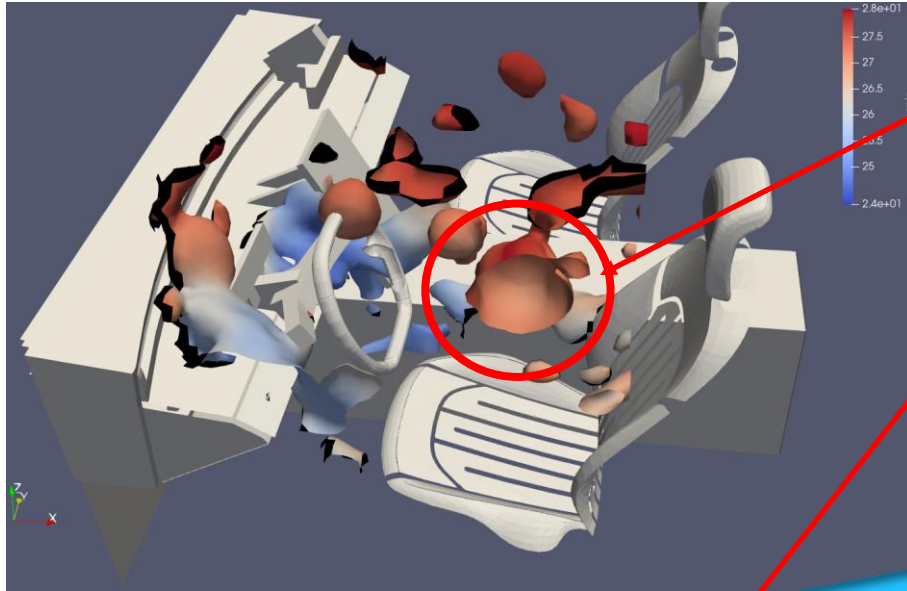


Temperature



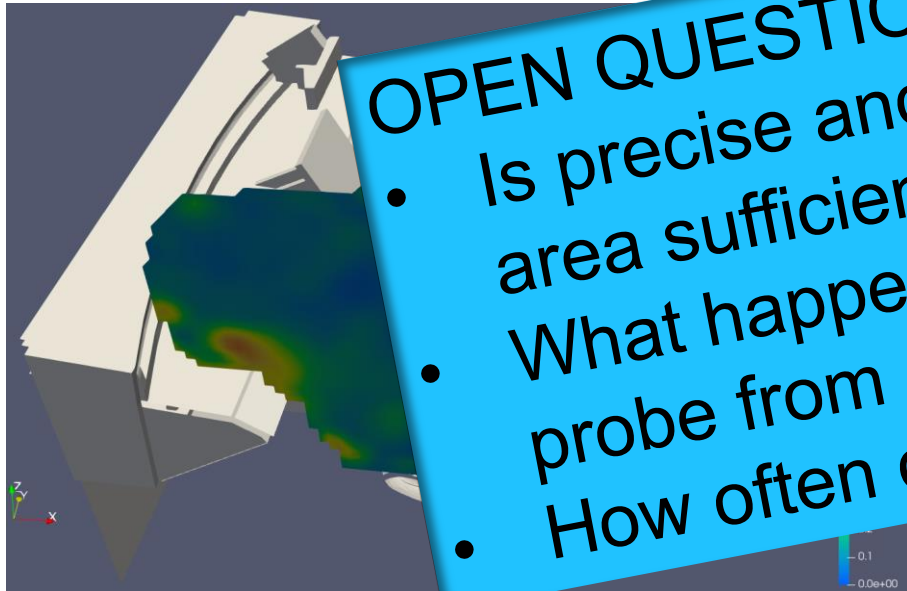
Results Measurement Errors

This is actually not really explainable



OPEN QUESTION:

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- How often do I have to scan an area





Thanks

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Imprint



Topic: Application of ProCap to Train and car Ventilation Research

Date: 2024-11-06

Author: Tobias Dehne

Institute: Aerodynamics and Flow Technology

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