
# Design of a large wind tunnel for risk assessment on-board Oil & Gas platforms

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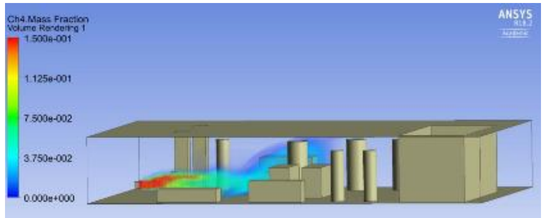
# Introduction

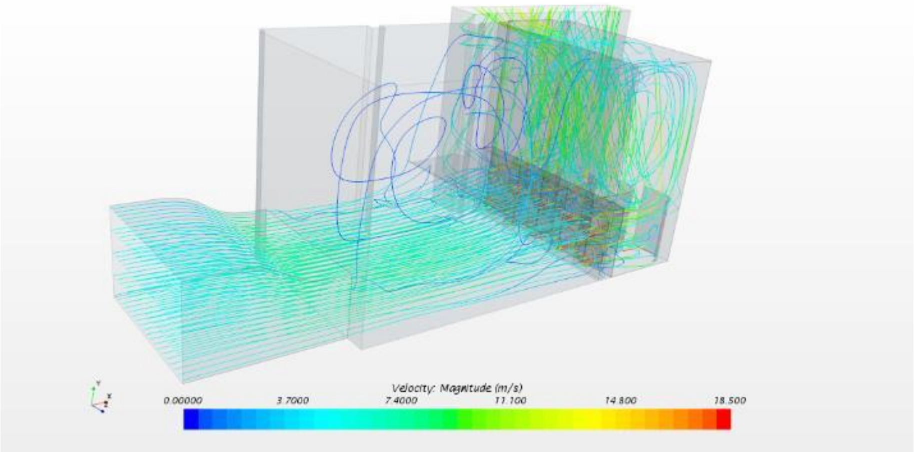
## Motivation:

- need for experimental validation of CFD approaches to risk assessment for supersonic accidental release in Oil & Gas offshore platforms
  - activity carried out at SEADOG Interdepartmental Center (Safety & Environmental Analysis Division for Oil & Gas)
  - project funded by the Italian Ministry for Economic Development (MISE), Directorate general for infrastructures and safety of energy and geo-mineral systems – National mining bureau for hydrocarbons and georesources (DGISSEG-UNMIG)
- scaling procedures require a sufficiently large offshore platform mockup:
  - experiments using a 1:10 scaled offshore platform mockup can provide significant results for validation
  - mockup dimensions about 3x3x3 m -> large wind tunnel




# Purpose of the paper

- We describe design and characteristics of SEASTAR, a large open-circuit and open-jet wind tunnel

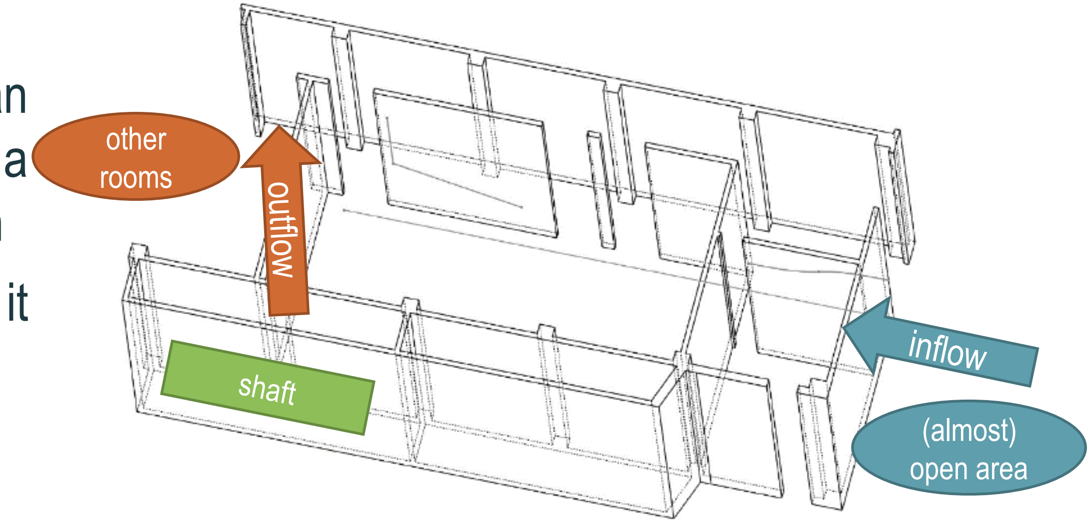



- The facility is based in Turin, in the premises of the Environment Park, a public joint-stock company that is an innovation accelerator for businesses looking to use eco-efficient solutions to expand their markets

# A wind tunnel design subject to some constraints…

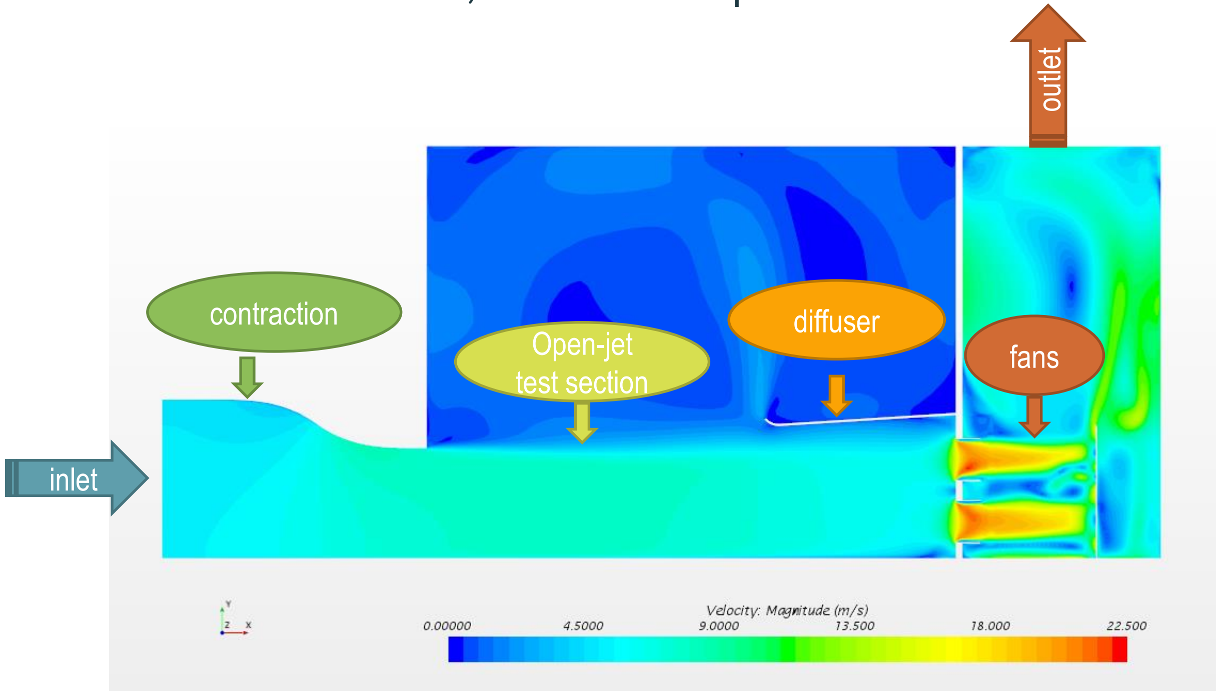
- The SEASTAR wind tunnel design was carried out by members of the Fluid Dynamics Group of the Department of Mechanical and Aerospace Engineering (DIMEAS) of the Politecnico di Torino

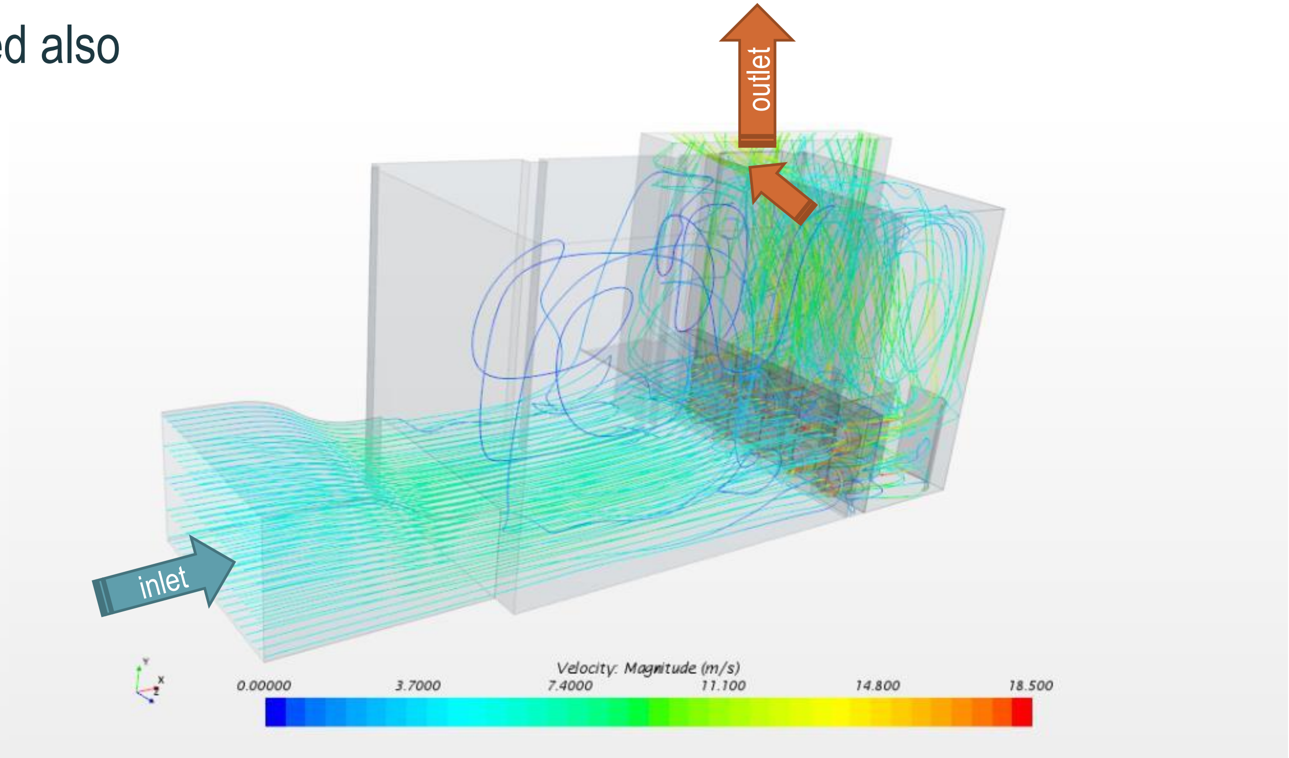
- The wind tunnel is in a large room inside a building in the Environment Park complex
  - due to the requirement of a large test section, an **open-circuit** design solution was decided, that is the wind tunnel is open on both ends
  - unfortunately, only one end of the room confines with an almost free, open space, so we decided to use the ceiling of a shaft that runs along one side on the room as the exit section
  - this was a major constraint that could result in a criticality as it would break the symmetry of the wind tunnel



# Wind tunnel elements

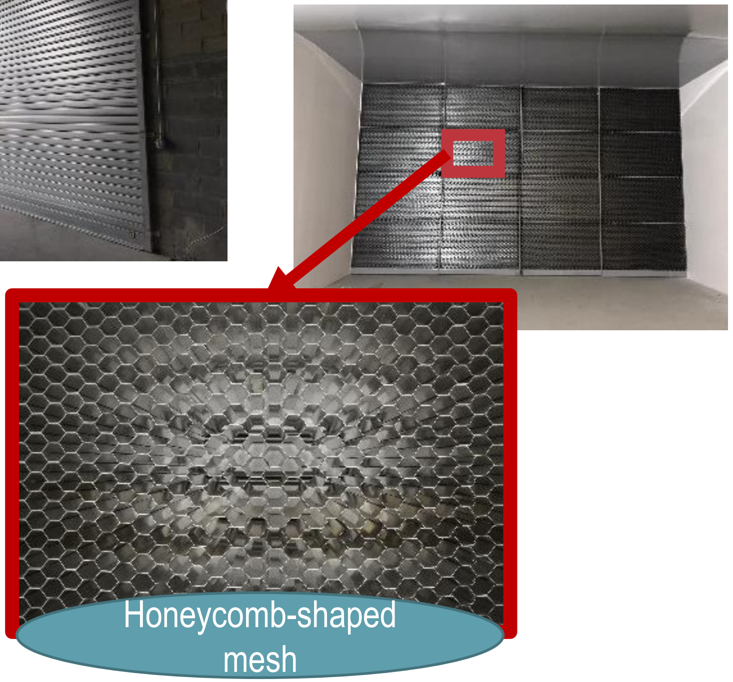
- the SEASTAR facility is an open-circuit, open-jet, rectangular section wind tunnel
- as in any wind tunnel, the basic parts are
  - the settling section, the contraction, the test section, the diffuser, the drive section (equipped with ten fans)
  - in this case, the flow exit path had to be considered also

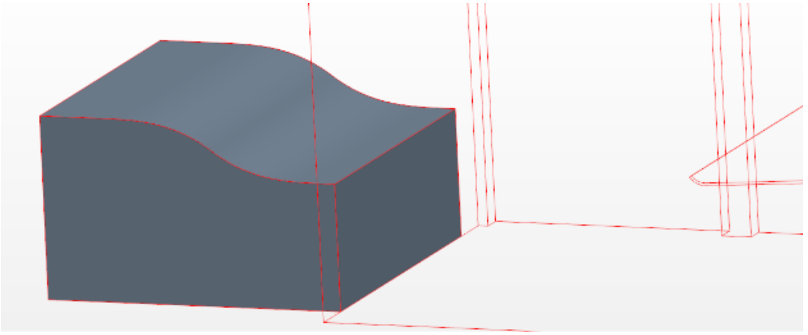


# Inlet, settling section and contraction

- the air flow
  - is taken from an almost free space outside the building
  - is straightened out and its turbulence level is reduced in a settling chamber equipped with a honeycomb-shaped mesh
  - is accelerated in a contraction channel
- the intake section dimensions are (6.4x3.6) m
- the contraction top side is shaped using two cubic curves, the contraction ratio is 1.44
- the dimensions of the contraction exit section are (6.4x2.5) m. This are the free-jet test section dimensions also.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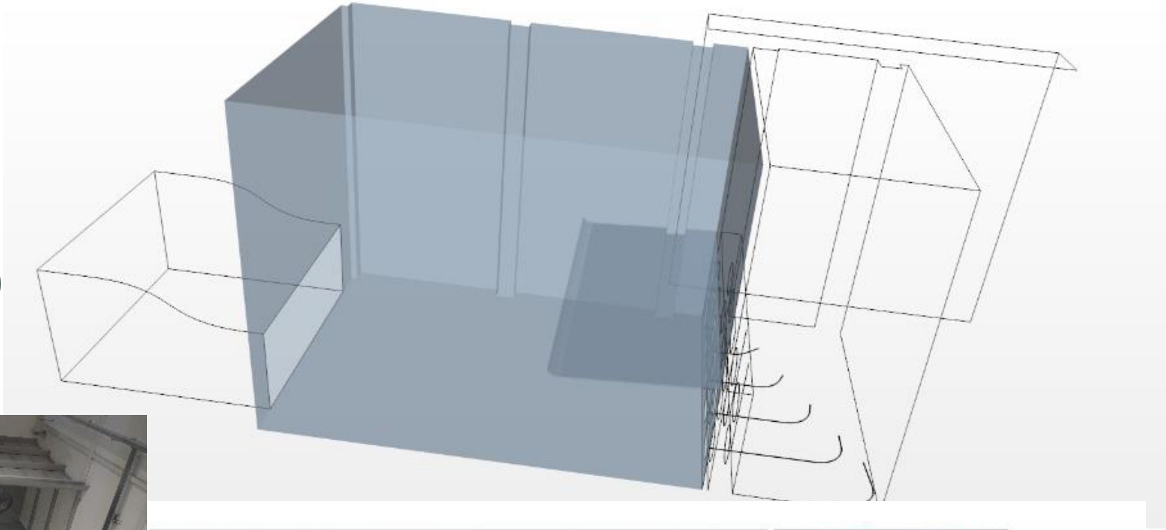
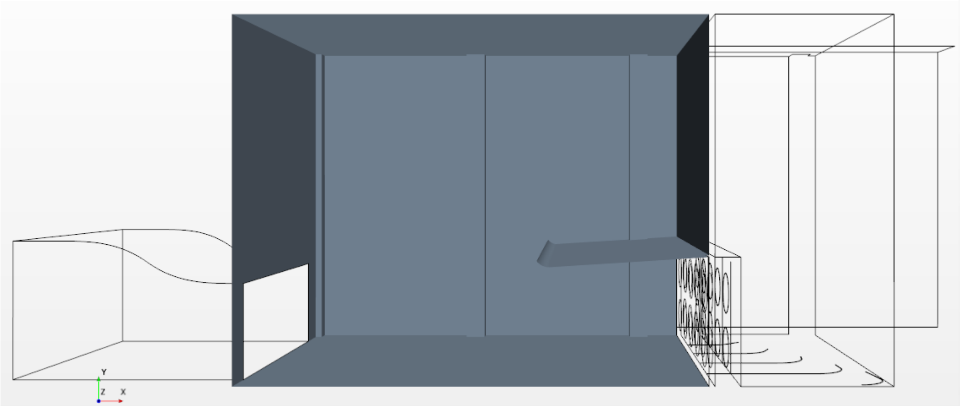
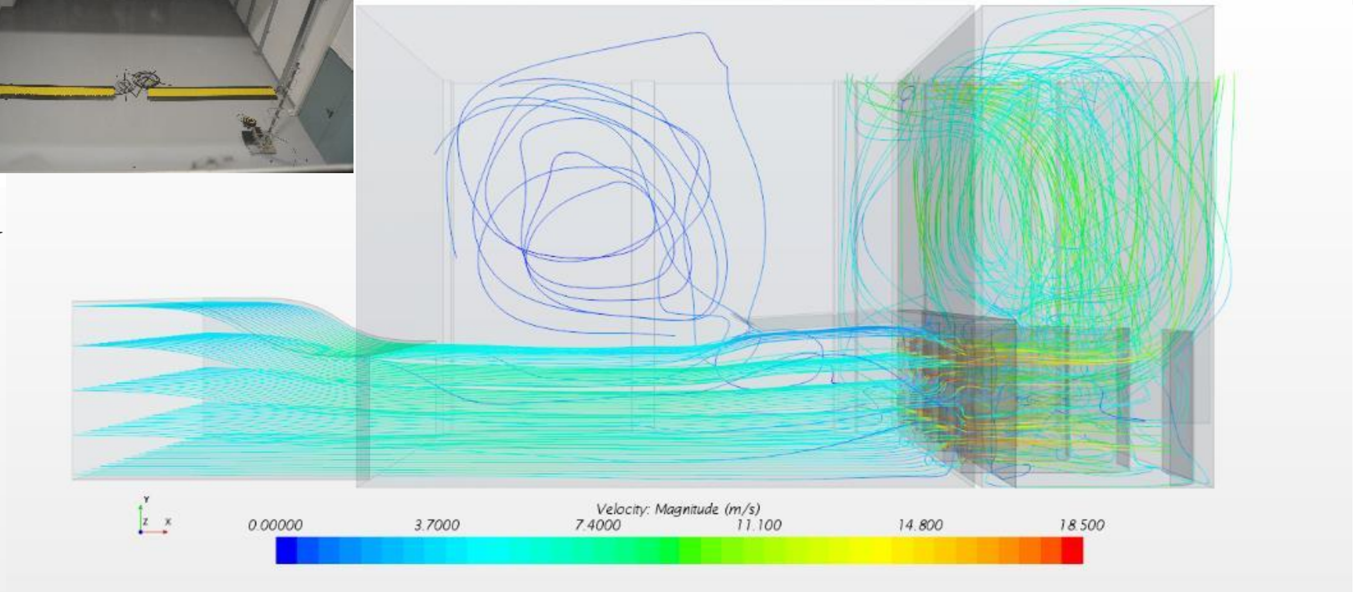
# Test section and diffuser

- The test section is 7.5 meters long
  - according to our CFD simulations, a volume of sufficiently uniform flow with dimensions (6x5.5x2.3) m is available (experimental characterization is underway)



- The diffuser top side
  - is a flat diverging ramp with 3.58° angle
  - is 4 m long, with initial height of 3 m
  - is as wide as the room, that is 8.5 m





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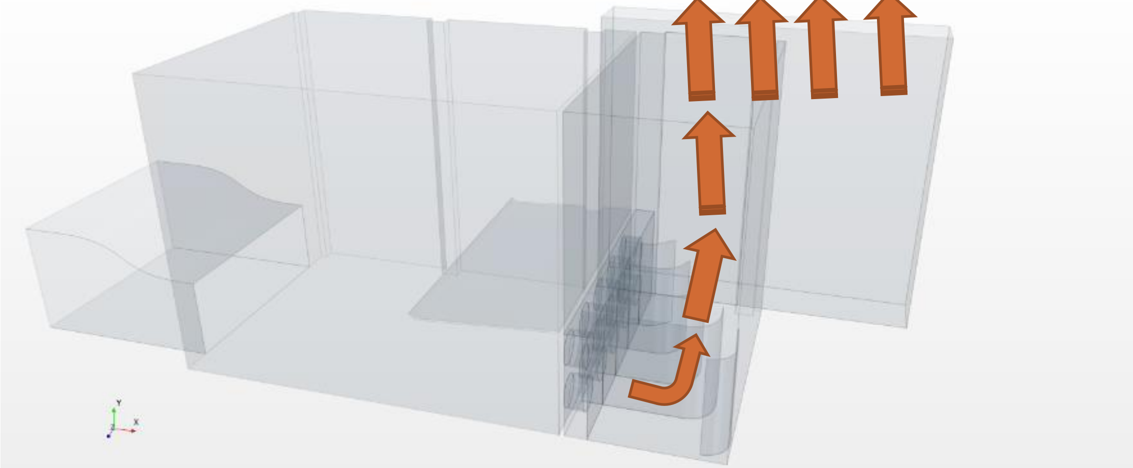
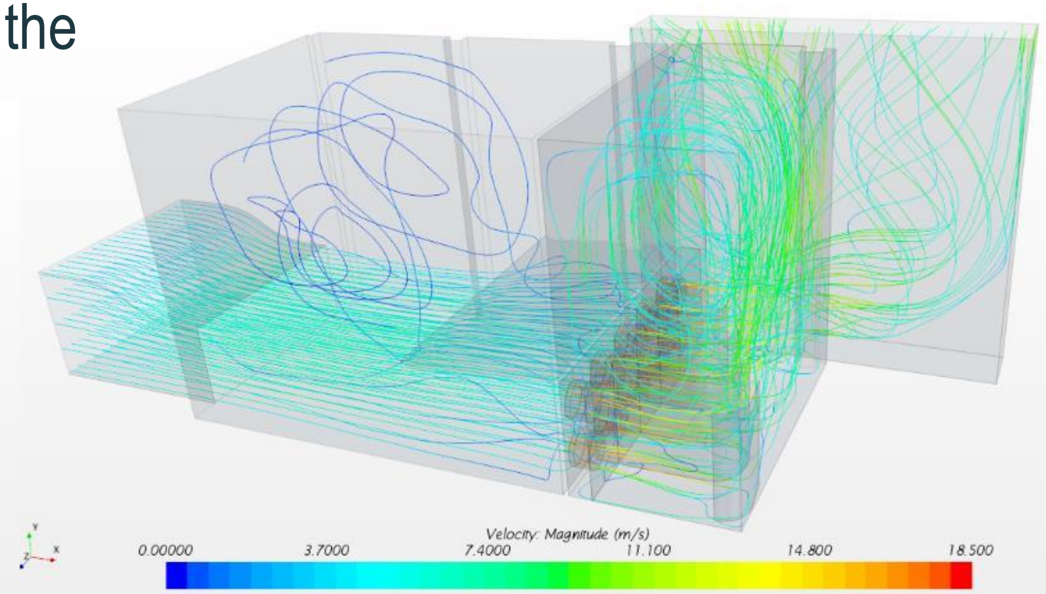
# Drive section with fans and air flow exit

- The drive section contains 2 rows with 5 fans each
  - these are electric axial fans with 6 blades
  - each fan speed can be changed independently

- Behind the drive section, the flow recirculates in a large room, enters in the shaft and finally exits in the environment from the open top of the shaft





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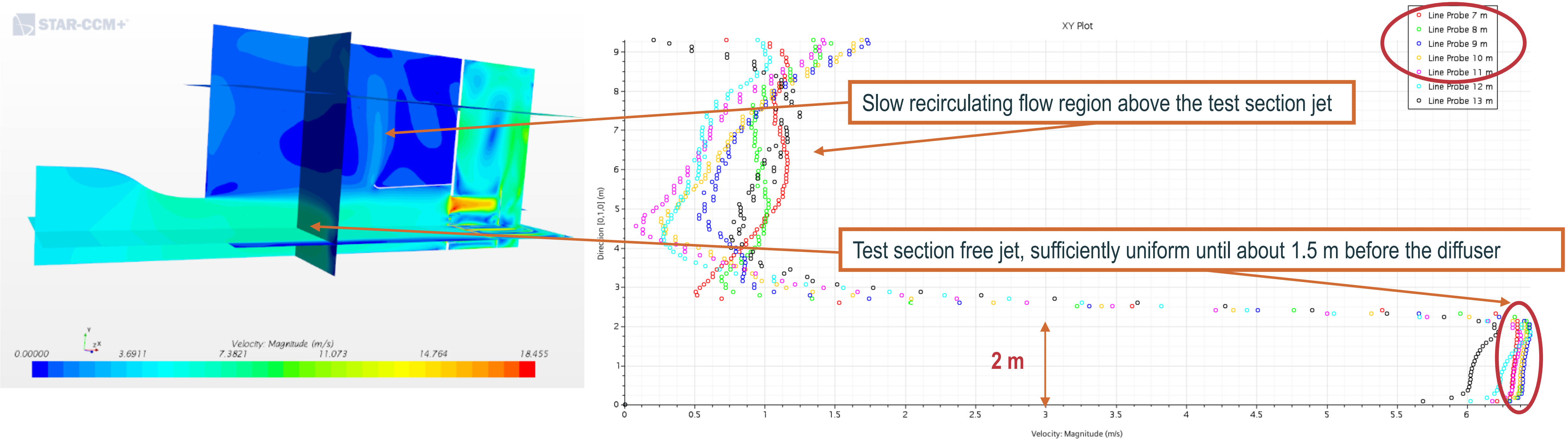
# CFD simulations and results

- The wind tunnel design was mostly based on CFD simulations using STAR-CCM+
  - after a grid convergence study, we reached the conclusion that a 3.6 millions cells grid provides sufficient accuracy (note that this is mostly a free flow moving in quite large environment with no small-scale features)
  - fans where simulated as “fan interfaces” using the pressure/volumetric flow rate curves provided by the fans manufacturer (curves where fitted using polynomial interpolation)



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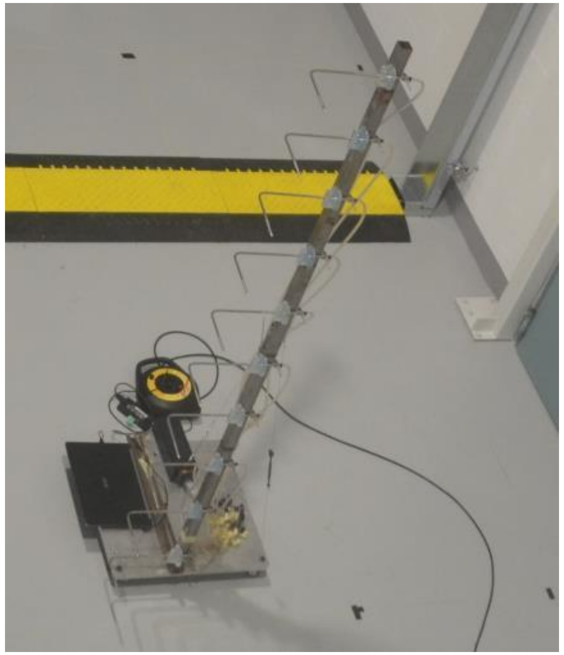
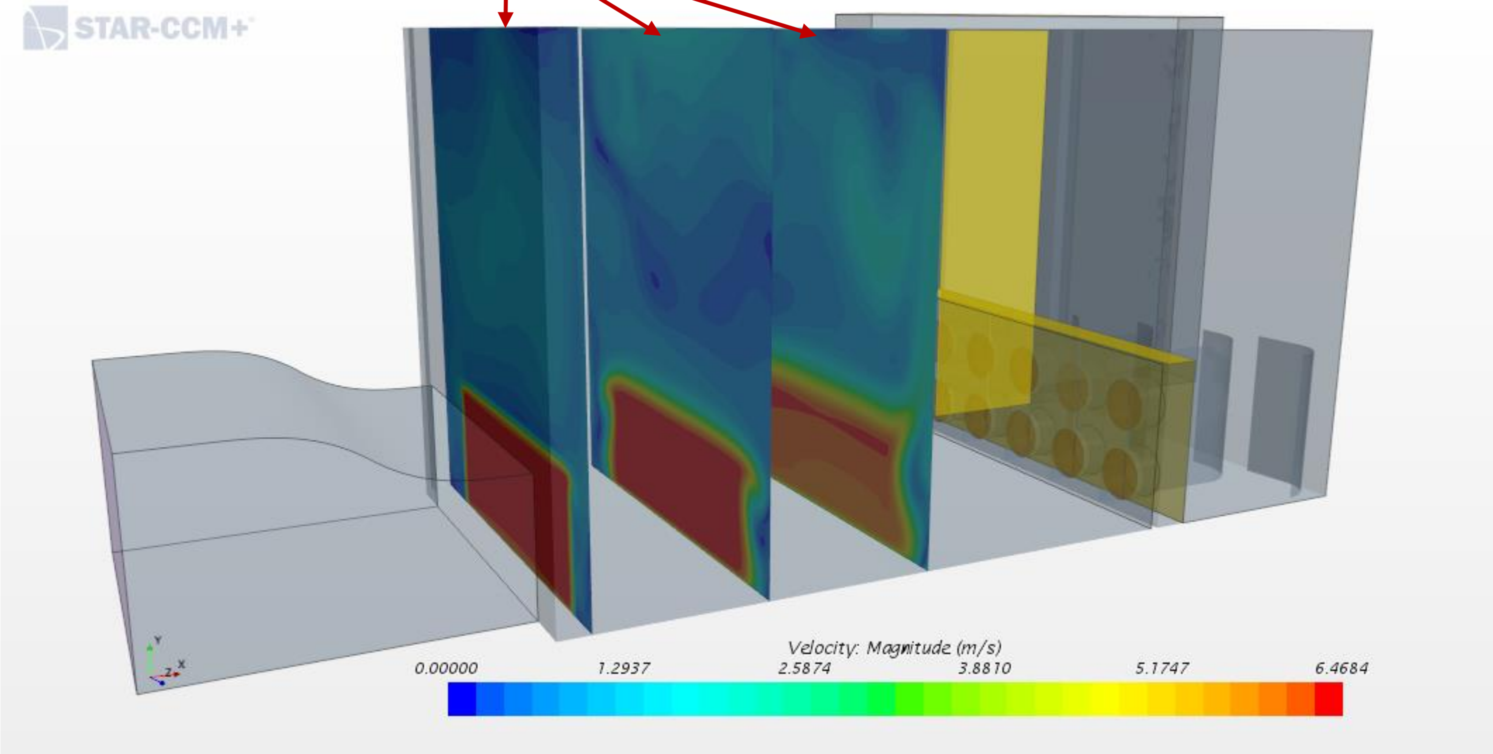
# Preliminary calibration results (I)

- Preliminary calibration started a few days ago using a Pitot tubes rake that was moved in different positions to obtain a velocity map
- Different fan speeds where tested, in particular 30 Hz, 40 Hz and 50 Hz, which correspond to fan rotation speed of 832 rpm, 1136 and 1420 rpm, respectively

Pitot tubes rake

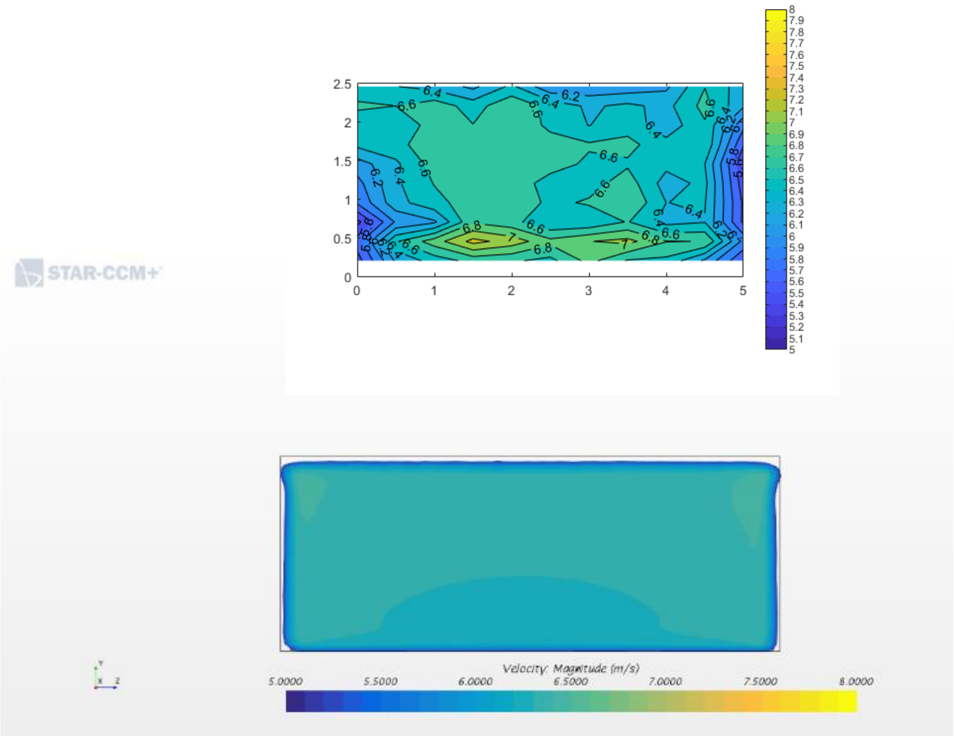


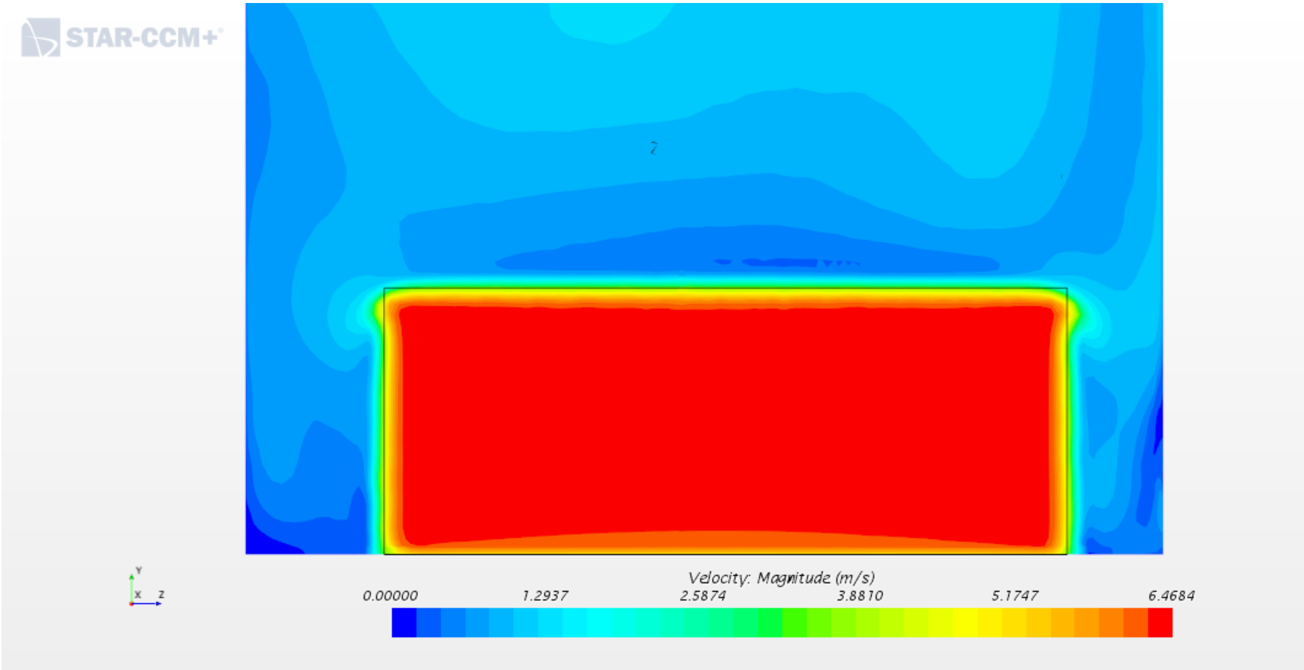
calibration sections preliminary positions as seen in CFD simulation



# Preliminary calibration results (II)

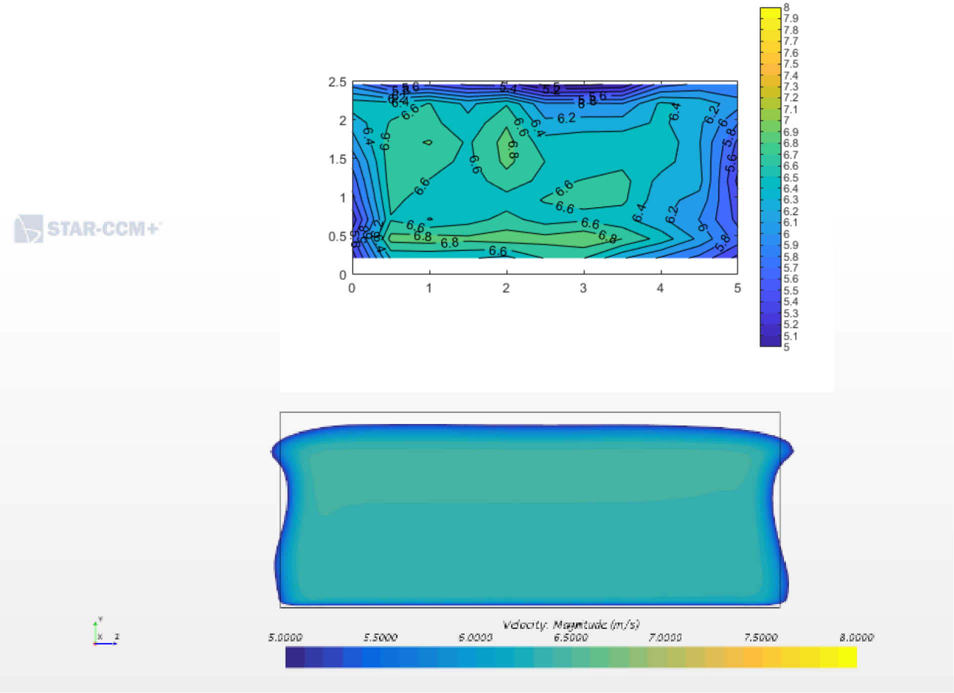
- Here we show a preliminary comparison at 1420 rpm. Section x1 (60 cm after the contraction)
  - *Experimental average speed: 6.48 m/s, with % variation 3.89%.*
  - *Numerical maximum speed:6.47 m/s, almost uniform*

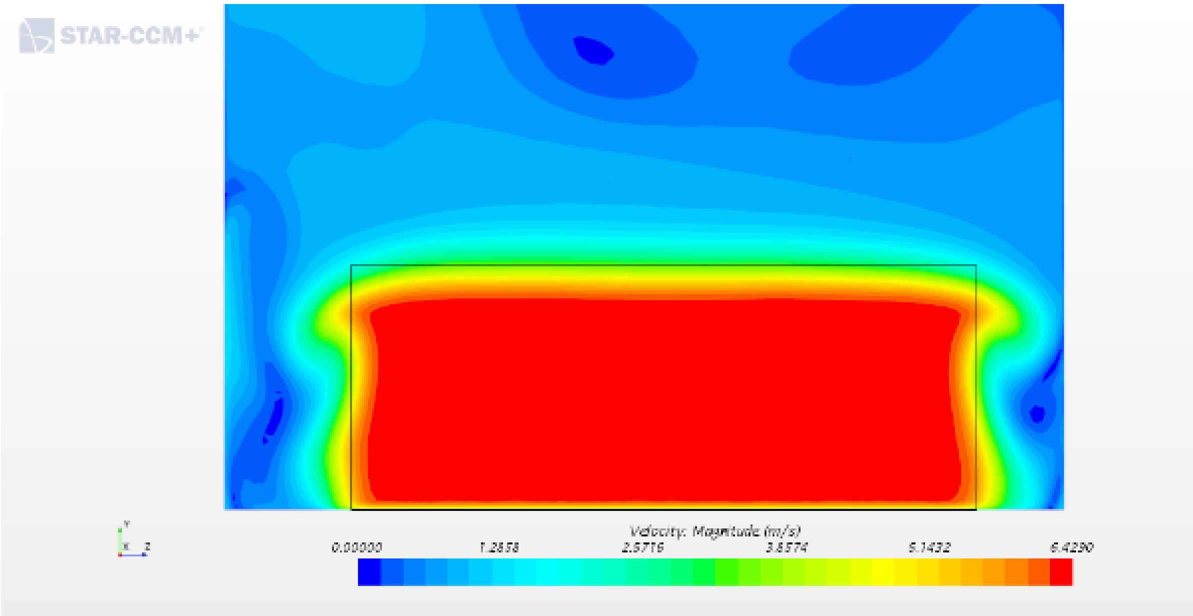


# Preliminary calibration results (III)

- 1420 rpm. Section x2 (3.75 m after the contraction exit)
  - *Experimental average speed: 6.35 m/s, with % variation 5.59%.*
  - *Numerical maximum speed:6.43 m/s, almost uniform*



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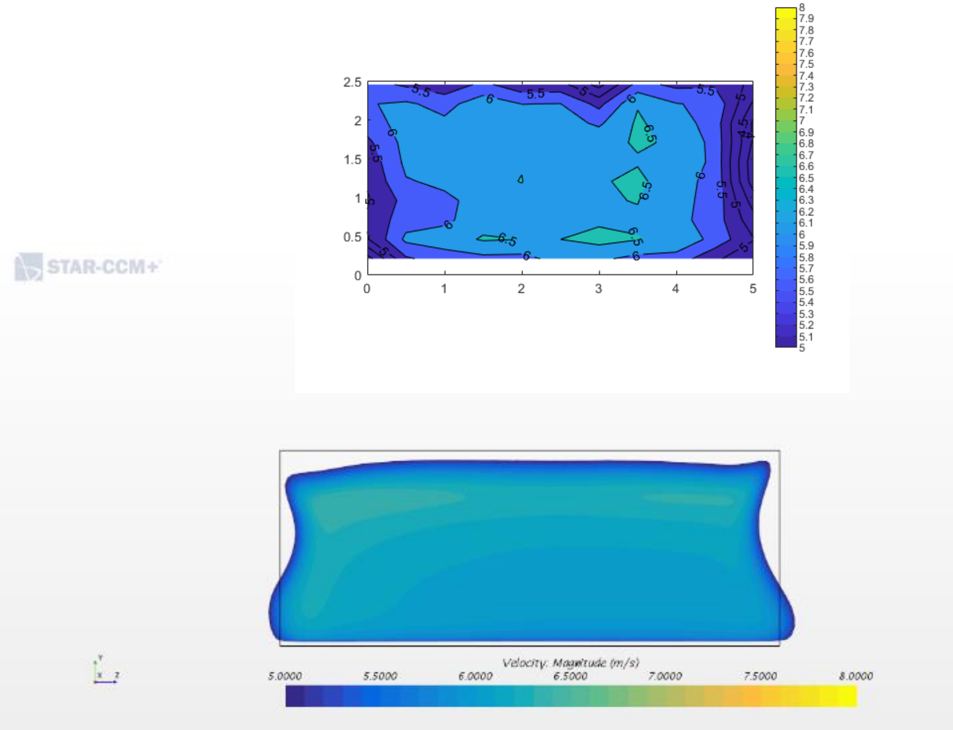
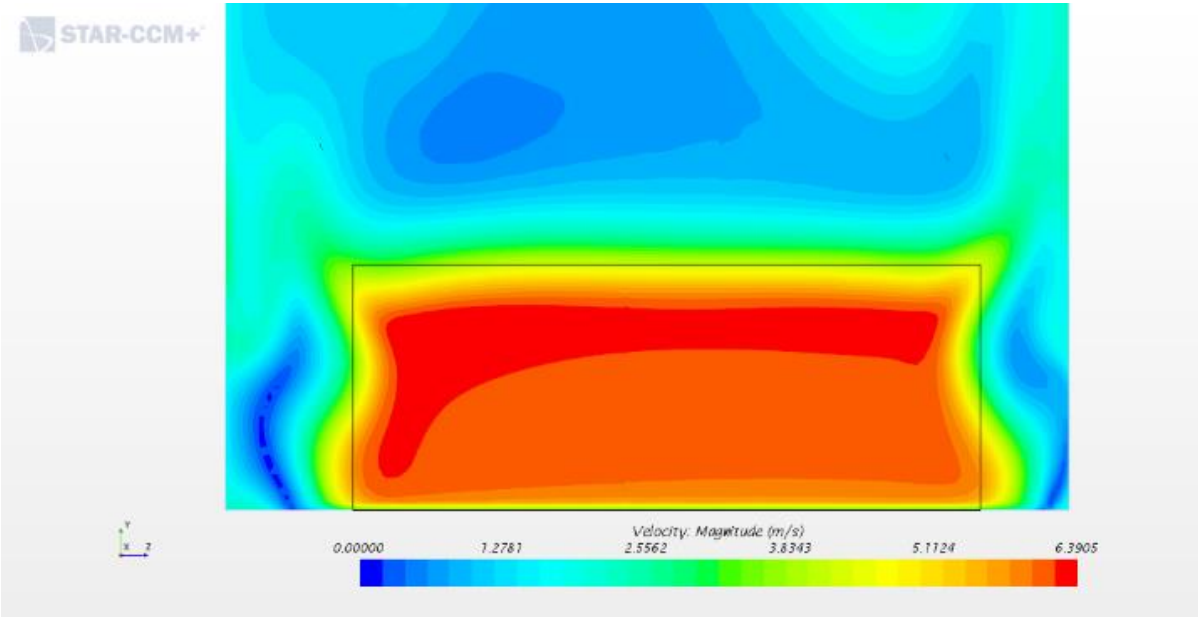
# Preliminary calibration results (IV)

- 1420 rpm. Section x3 (6.90 m after the contraction, close to the diffuser)
  - *Experimental average speed: 6.0 m/s, with % variation 8.42%.*
  - *Numerical maximum speed:6.39 m/s, some non-uniformity starts to appear*



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# Conclusions

- A new wind tunnel was designed by member of DIMEAS and DENERG at Politecnico di Torino
- The wind tunnel is located in the Environment Park in Turin
- Large almost uniform free-jet dimensions in the test chamber: 6x5.5x2.3 m
- Maximum speed about 7 m/s (about 25 km/h)
- Originally designed to test accidental gas releases in Oil & Gas platforms
- Can be used in aeronautics (for examples testing aerial drones in wind or advancing conditions), civil engineering (mockups of buildings, bridges, pollutants dispersion/diffusion)
- Available for cooperation, may also be rented


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