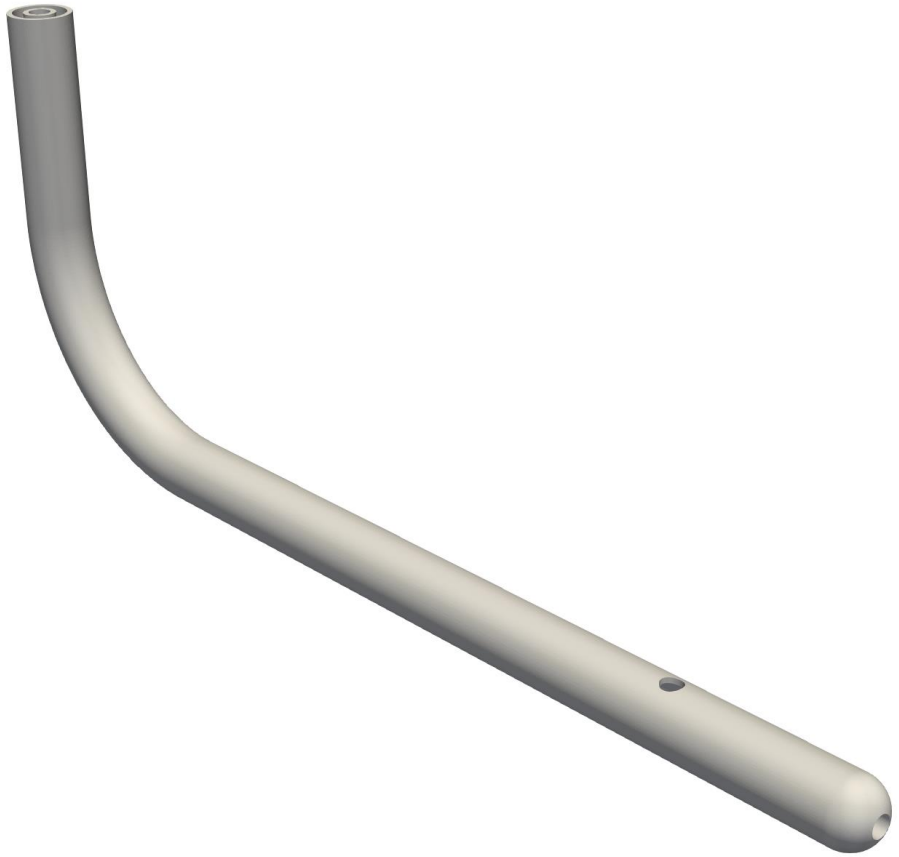
Simulation of a Pitot Tube

Submission for the Community Christmas Competition III



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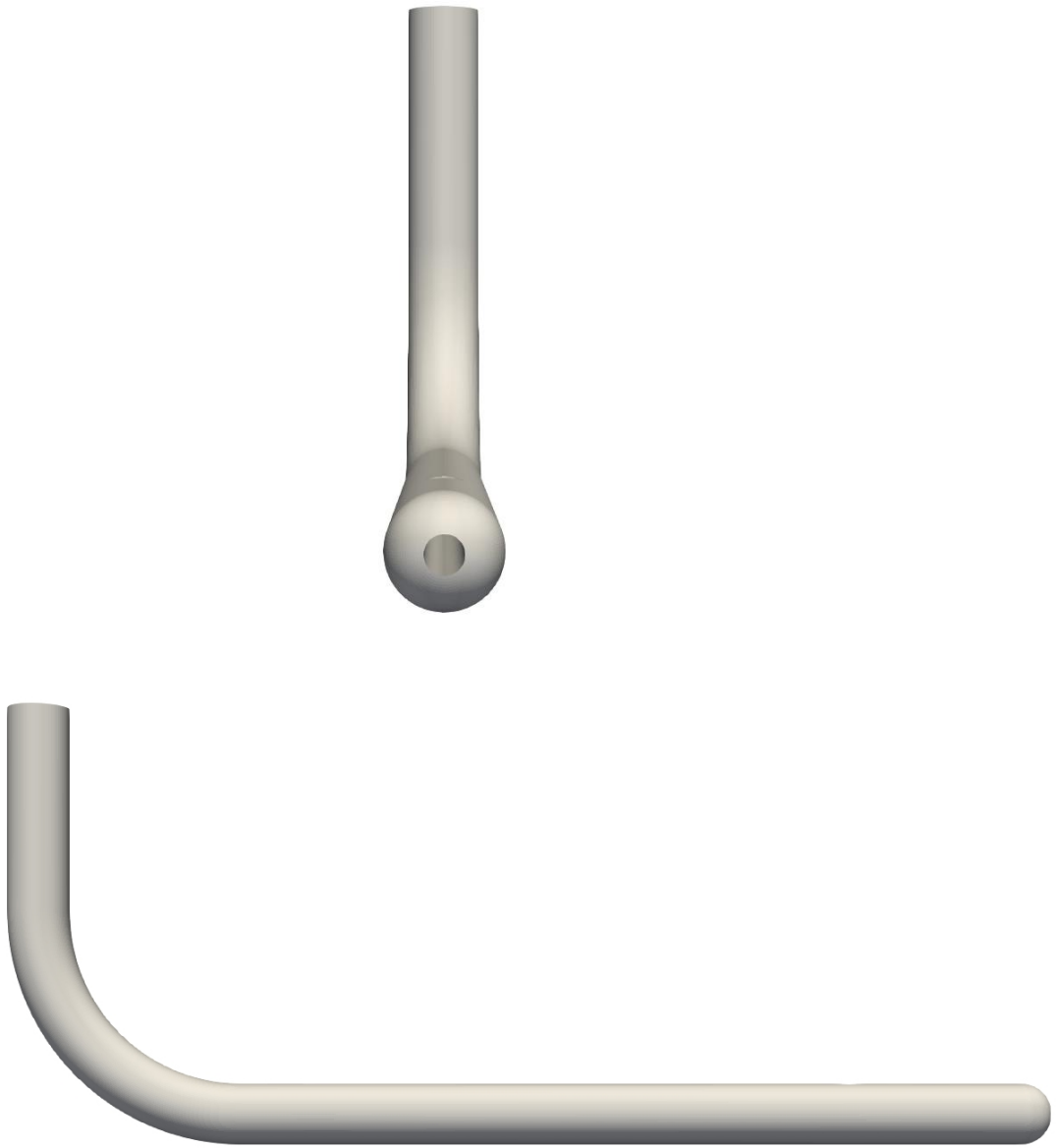

Agenda

- Introduction
- Objective
- Geometry
- Mesh
- Physics
- Results

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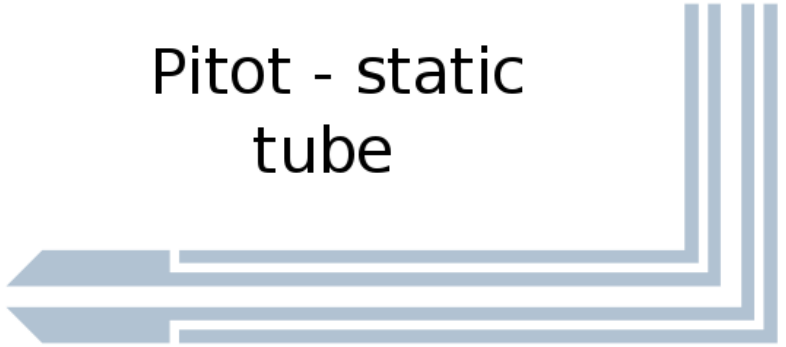
Introduction

- The pitot tube is device that measures the flow velocity
- The velocity is derived by taking two pressures measurements. One in the front of the tube wich is the stagnation pressure, and another measurement that is taking by the side of the tube that is the static pressure
- Then this two pressures can be used in Bernulli's Equation to solve for velocity of the flow:

$$U = \sqrt{\frac{2(p_t - p_s)}{\rho}}$$

- Where U is the flow velocity, p_t is the total pressure, p_s is the static pressure and ρ the density of the fluid



https://en.wikipedia.org/wiki/Pitot_tube

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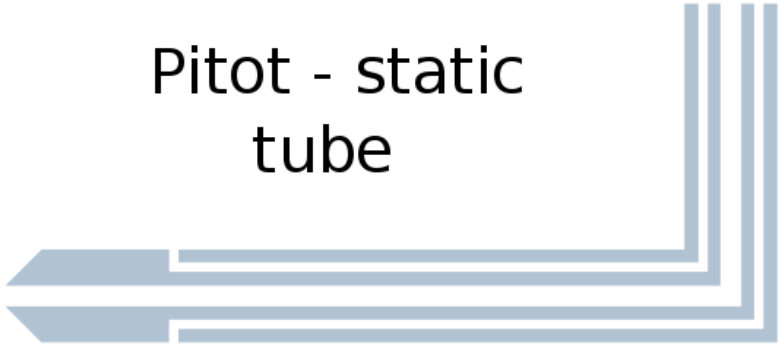
Objectives

This Community Christmas Competition III aims:

- Simulate the flow around a Pitot Tube using OpenFOAM
- Verify the free stream velocity by the measured pressures in the Pitot Tube
- Use the following flow stream velocities:

U_∞ [m/s]
240
100
67
1
0,1



https://en.wikipedia.org/wiki/Pitot_tube

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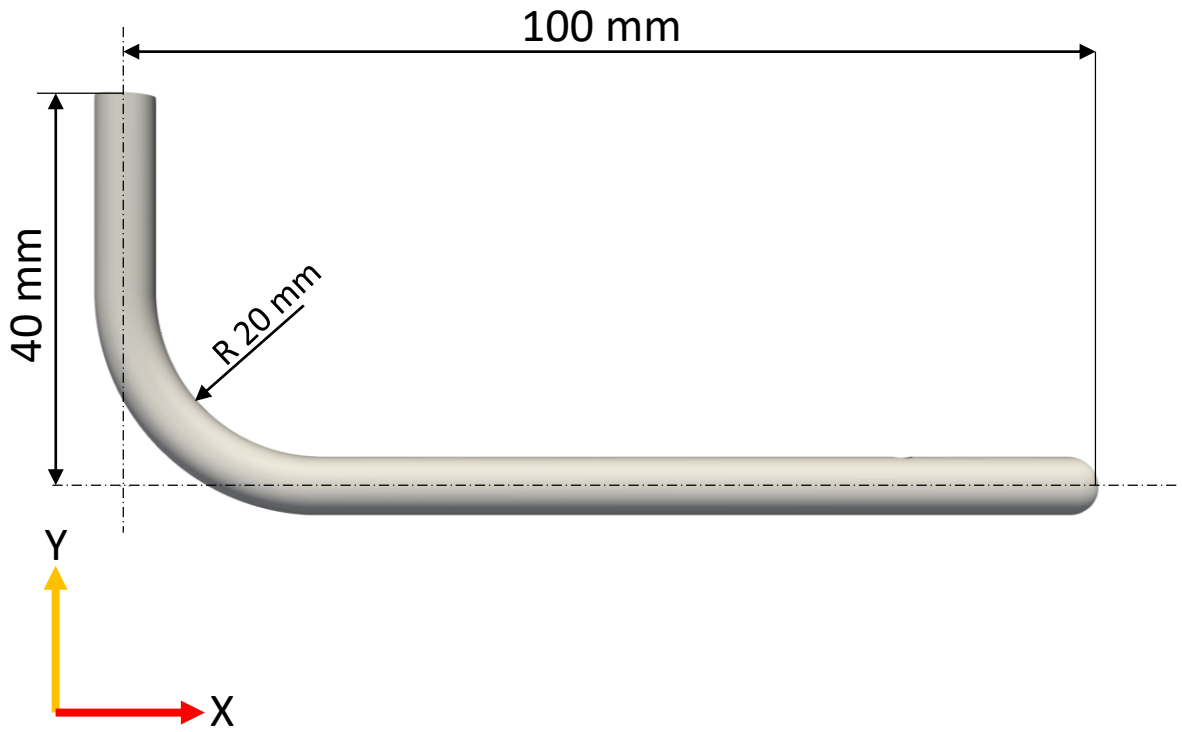
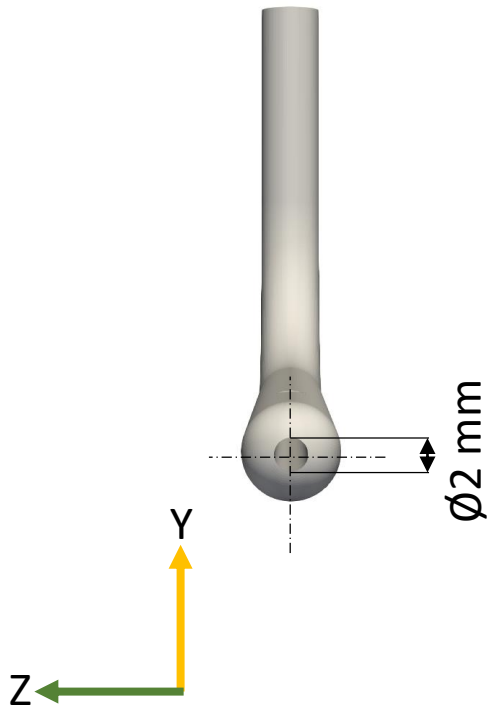
Geometry

- The pitot's geometry was created using a CAD software. And the pitot has the following dimensions:





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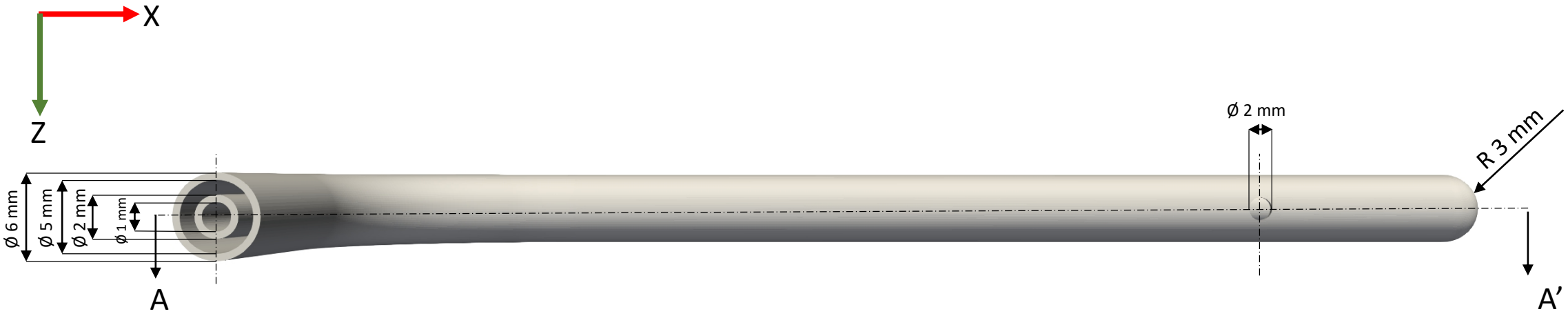
Geometry



A-A' section

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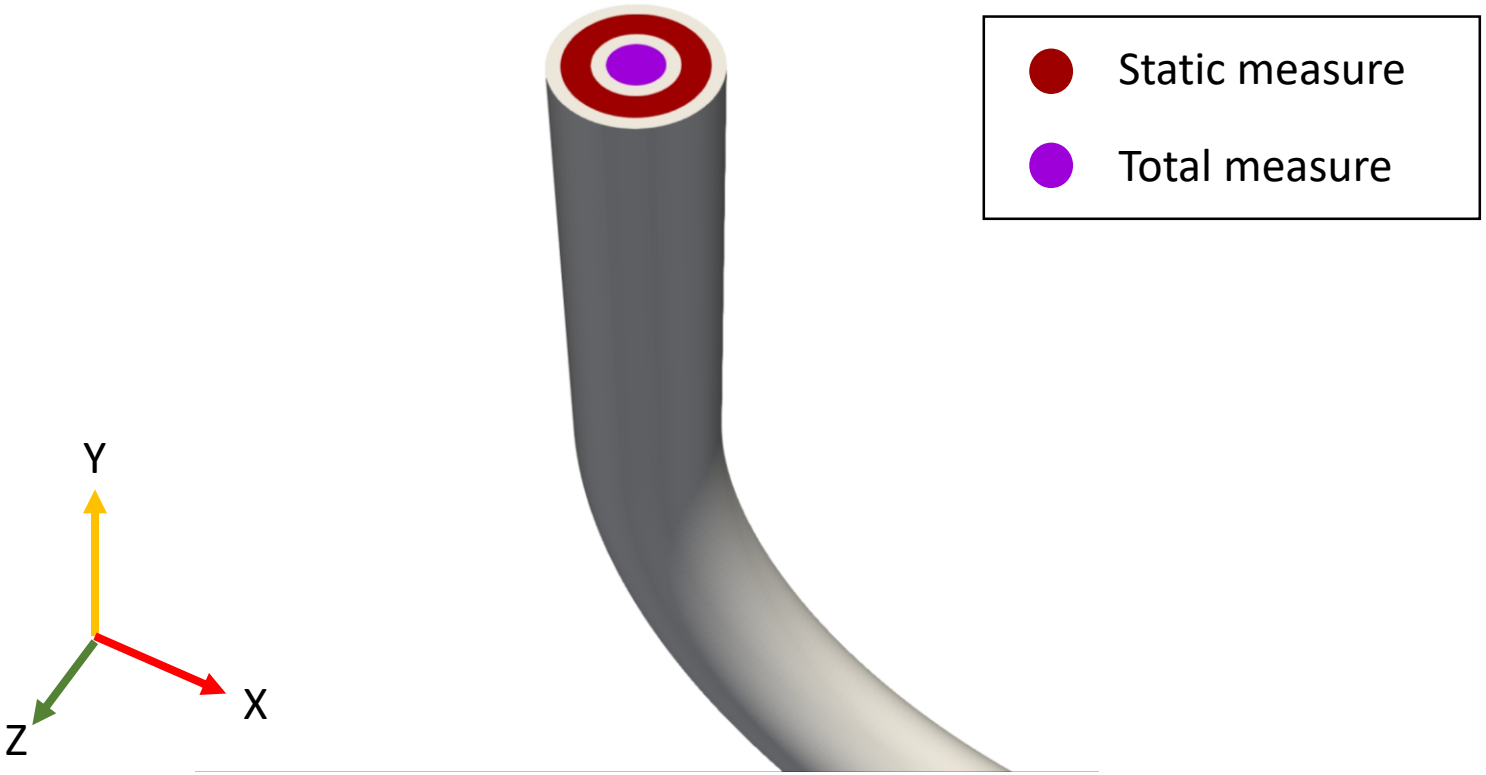
Geometry

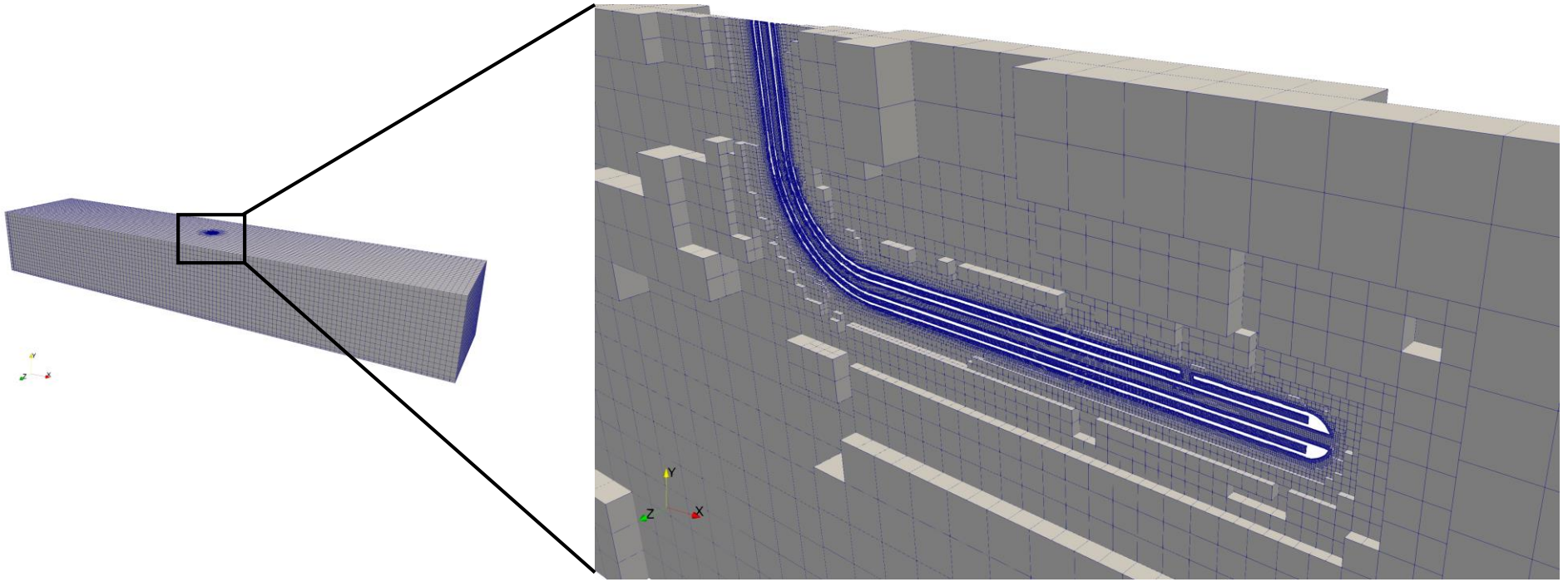
- Before the mesh generation, the STL file of the pitot tube was treated in Blender where the static and total measuring surfaces were created.



Mesh

- The mesh was generated with the snappyHexMesh utility in OpenFOAM

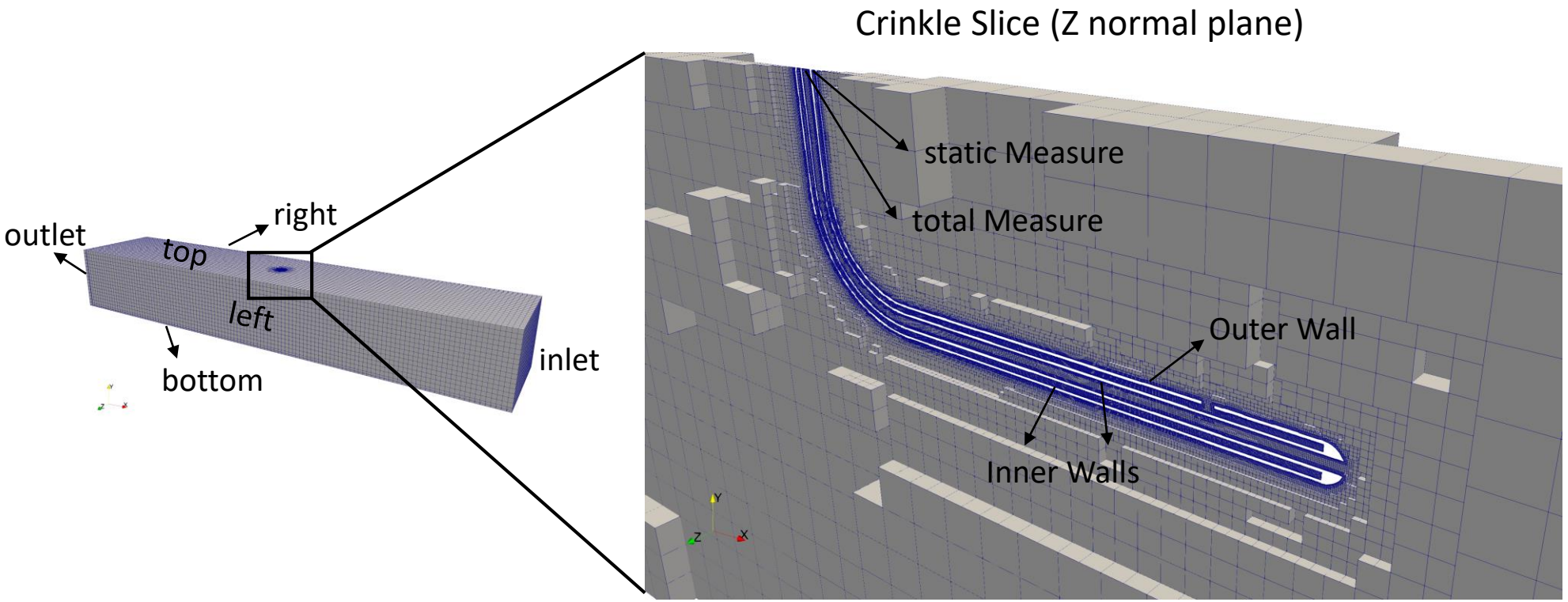
Crinkle Slice (Z normal plane)



3D Mesh
2840284 cells

Mesh

- The boundaries of the domain



3D Mesh
2840284 cells

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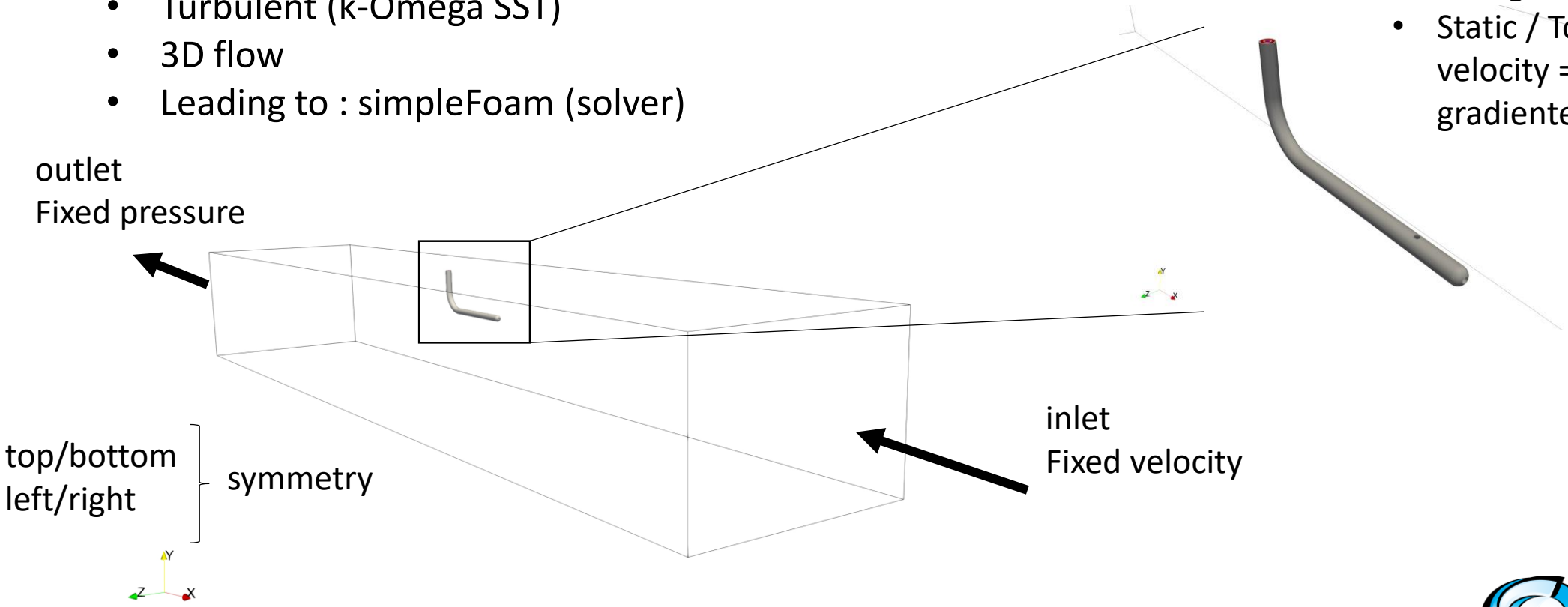
Physics

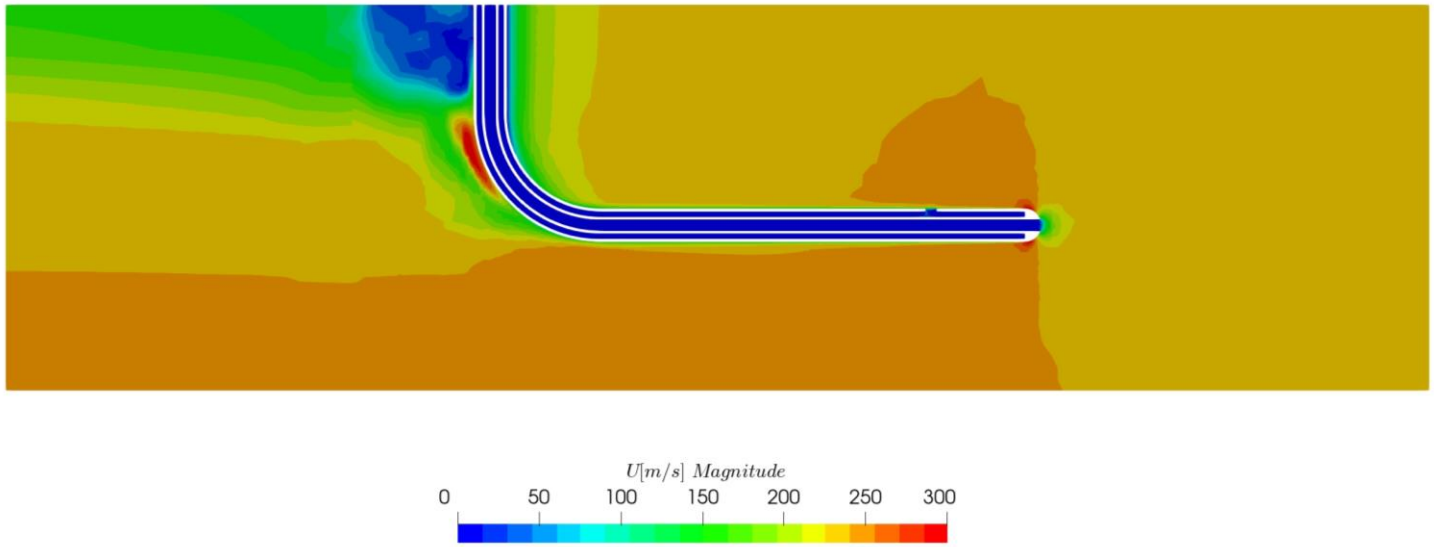
The physics considered in these simulations were :

- Steady-State
- Incompressible (Air : $\nu = 1,5\ x\ 10^{-5} m^2/s$)
- Turbulent (k-Omega SST)
- 3D flow
- Leading to : simpleFoam (solver)

- Inner/ Outer Walls : k and Omega wall functions
- Static / Total Measures : velocity = (0 0 0); Zero gradiente for pressure

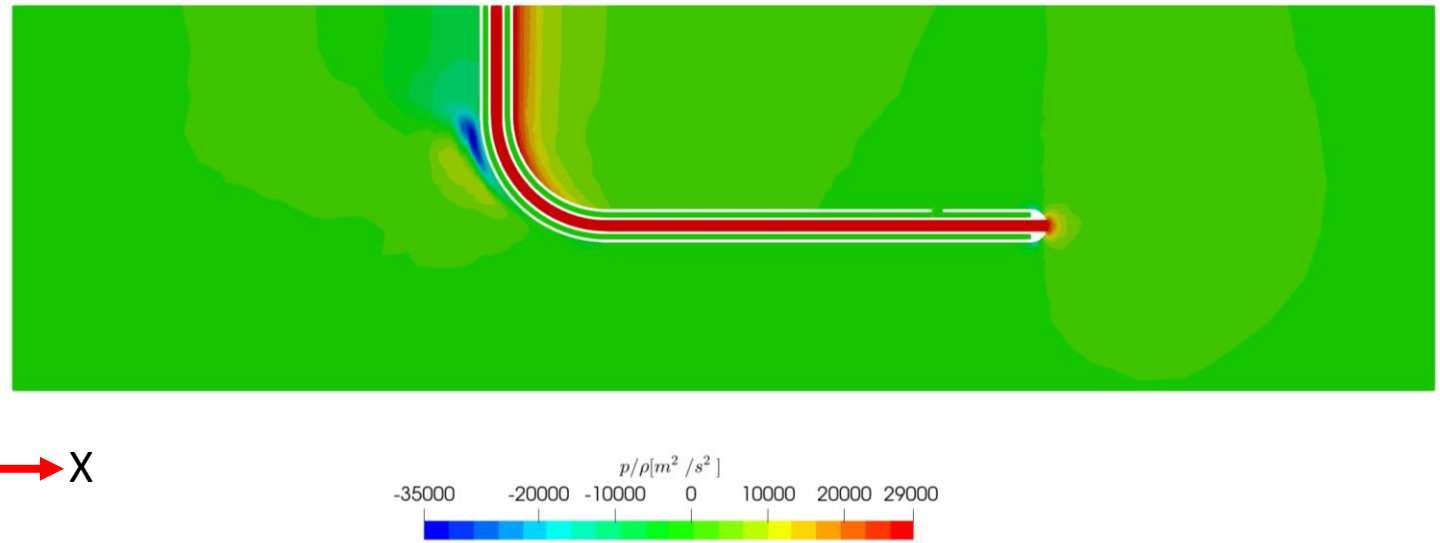


Results



Velocity Magnitude Countour

U_∞= 240 m/s
Slice (XY plane)



Kinematic Pressure Countour

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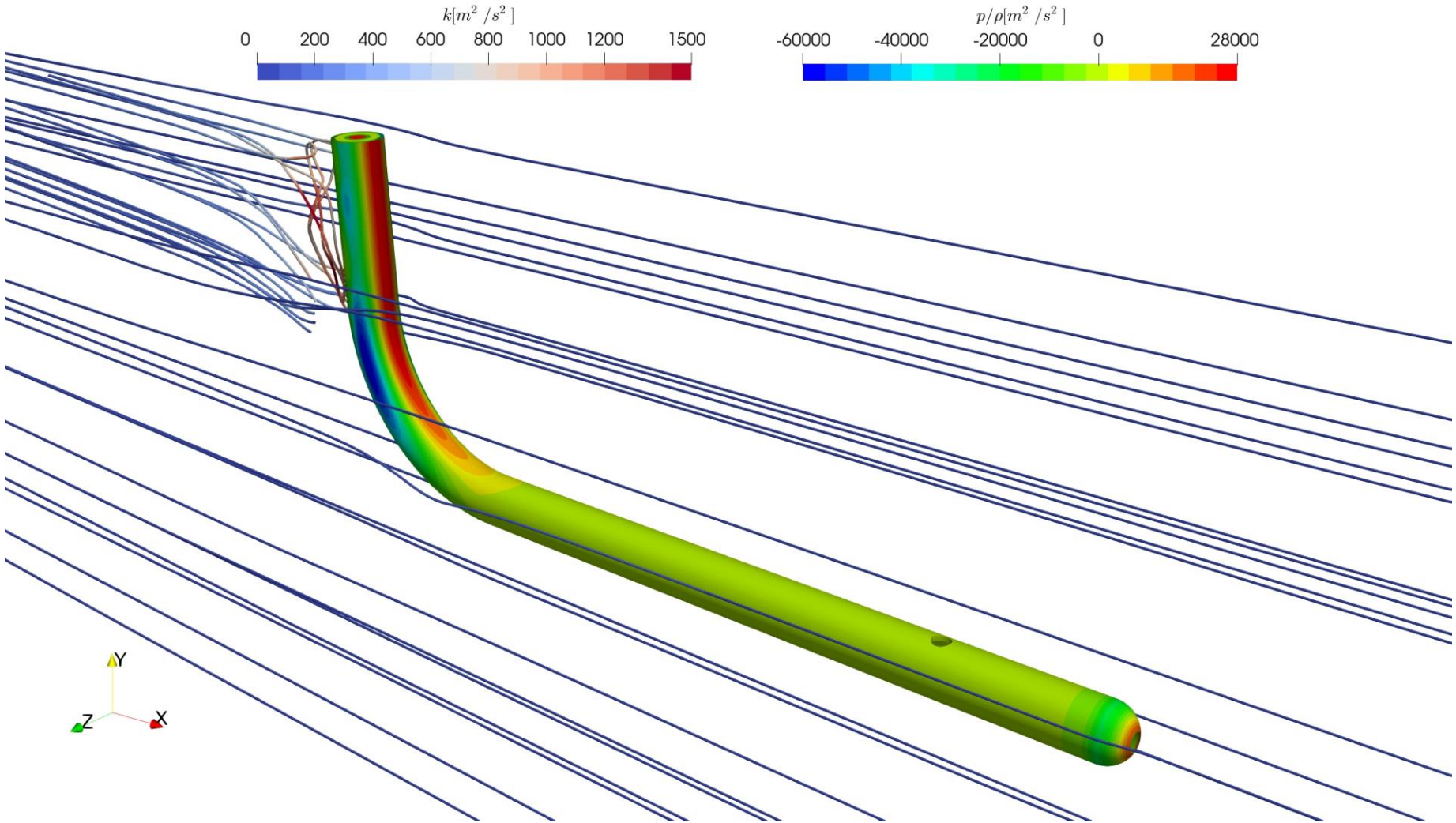
Results



U_∞= 240 m/s

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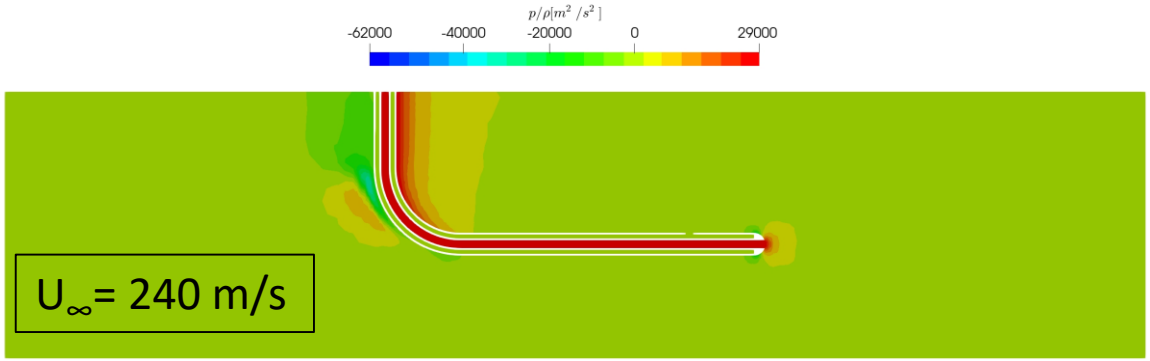
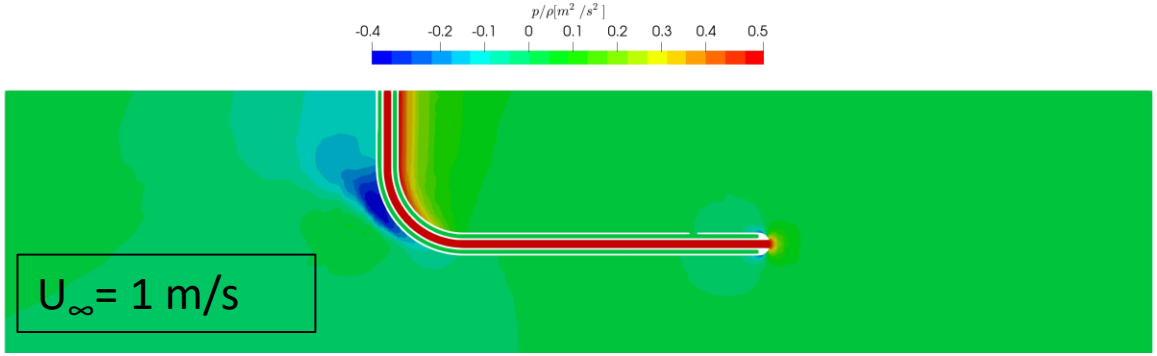
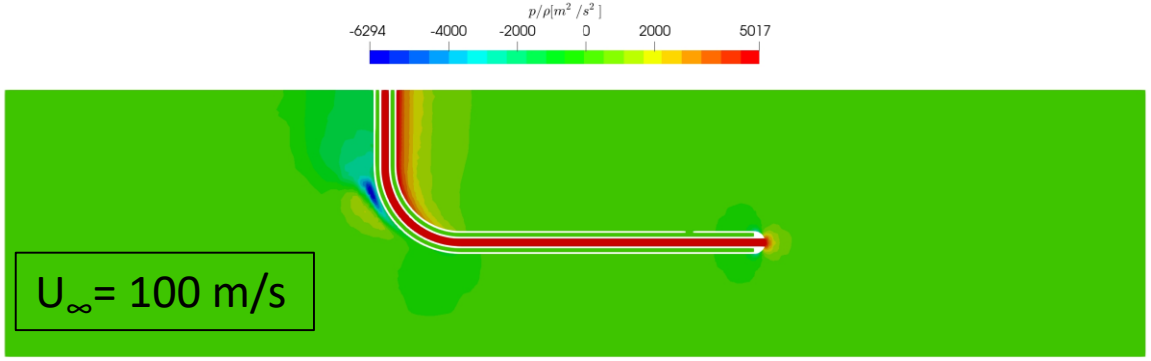
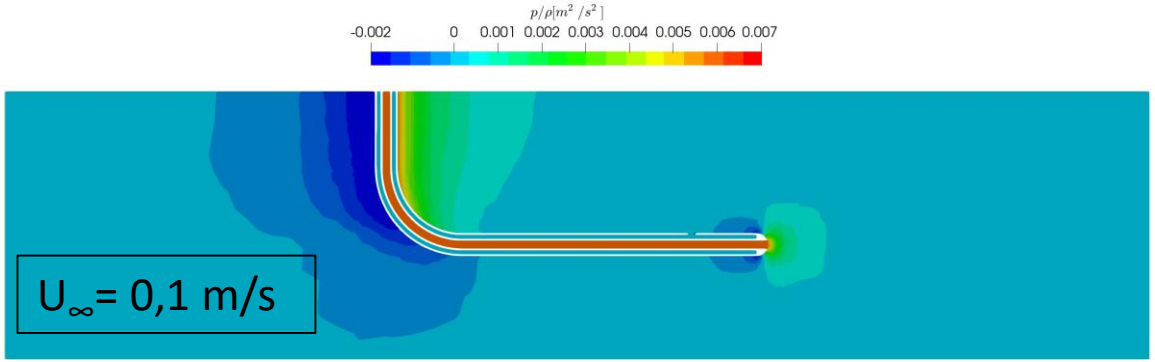
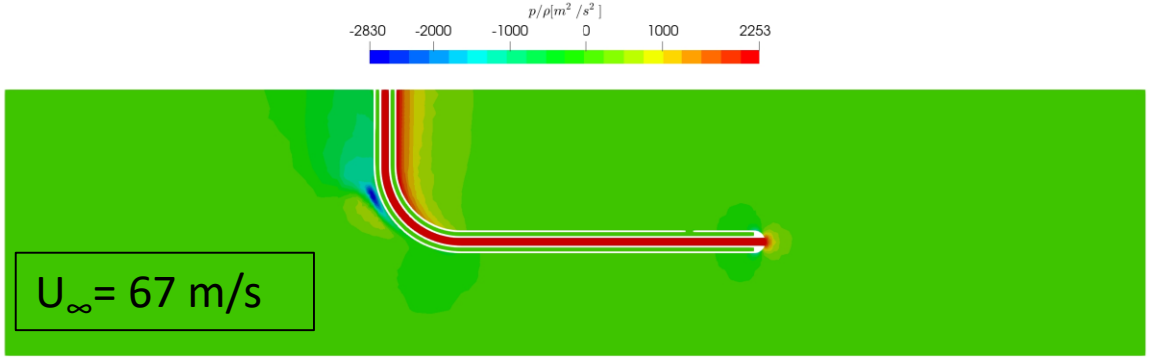
Results











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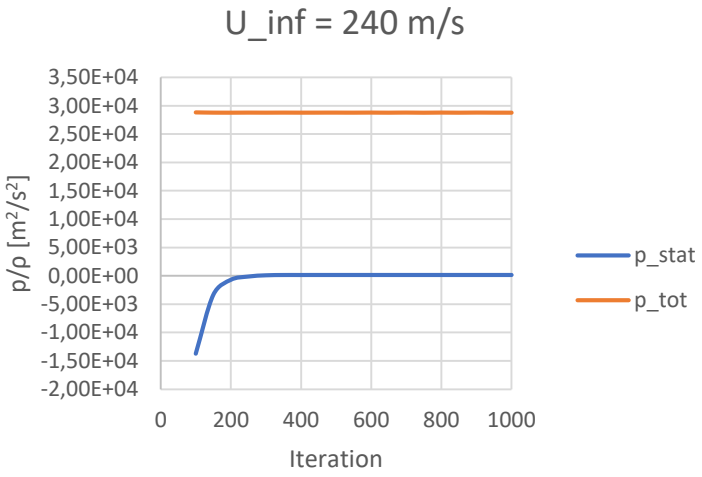
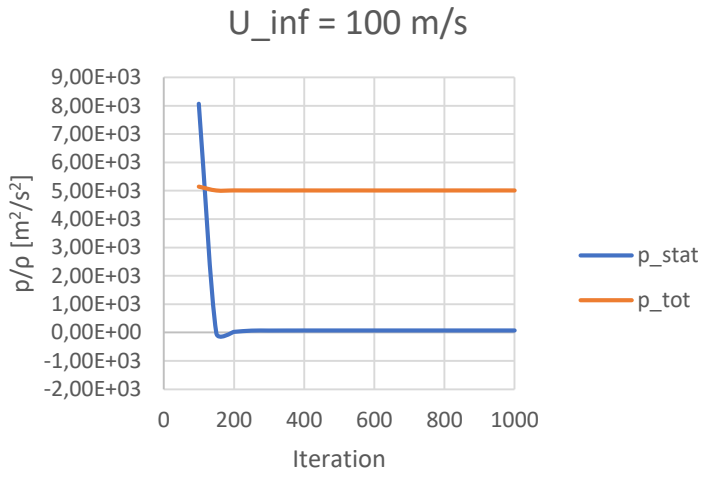
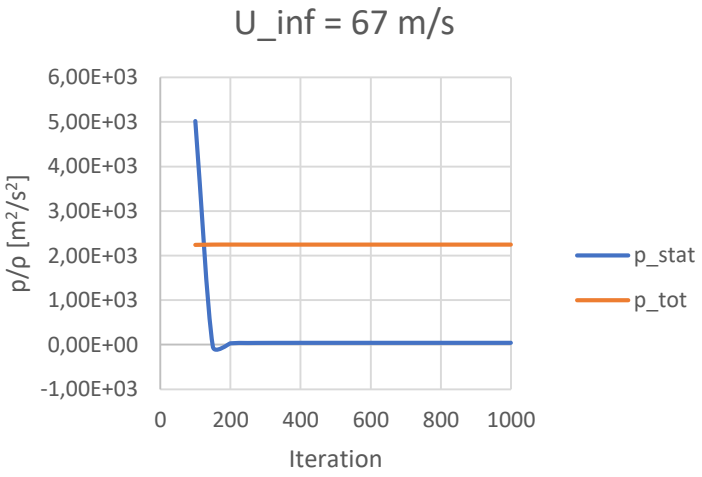
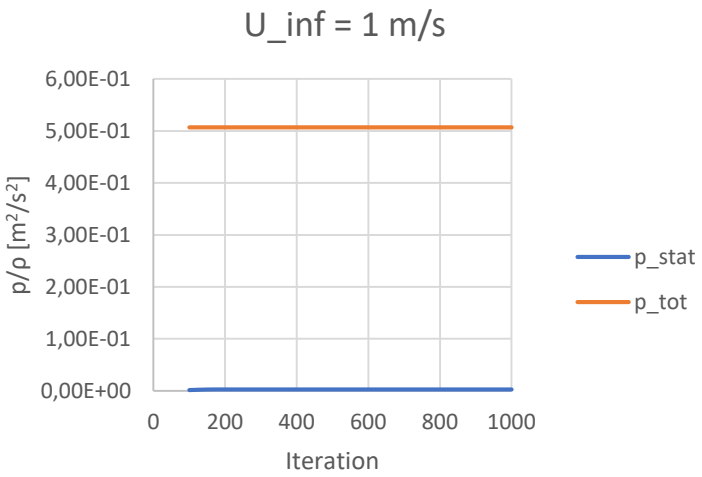
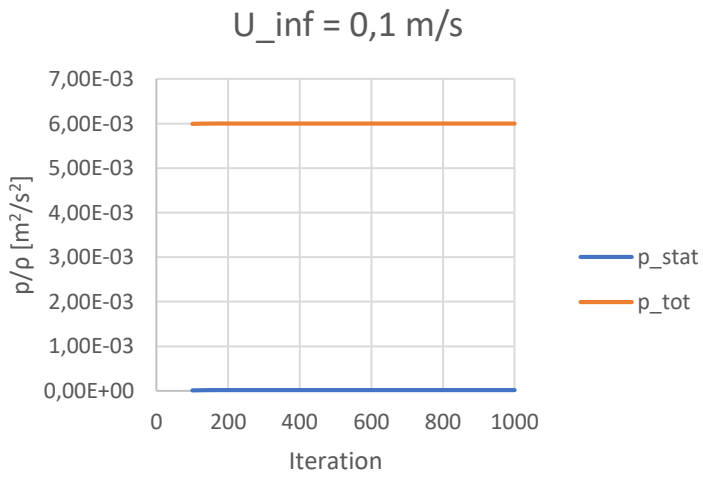
Results











- Convergence/ Monitoring of pressure results in staticMeasure and totalMeasure boundaries

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Results

Case	U_∞ [m/s]	$P_{totalMeasure}/\rho$ [m^2/s^2]	$P_{staticMeasure}/\rho$ [m^2/s^2]	Calculated U_∞ [m/s]	Rel. Error [%]
1	240	28818	134,2237	239,5152	0,202
2	100	5009,385	72,7171	99,36466	0,635
3	67	2249,822	44,63195	66,41069	0,880
4	1	0,5071537	0,002347069	1,004795	0,480
5	0,1	0,00600133	0,00001429373	0,109426	9,43