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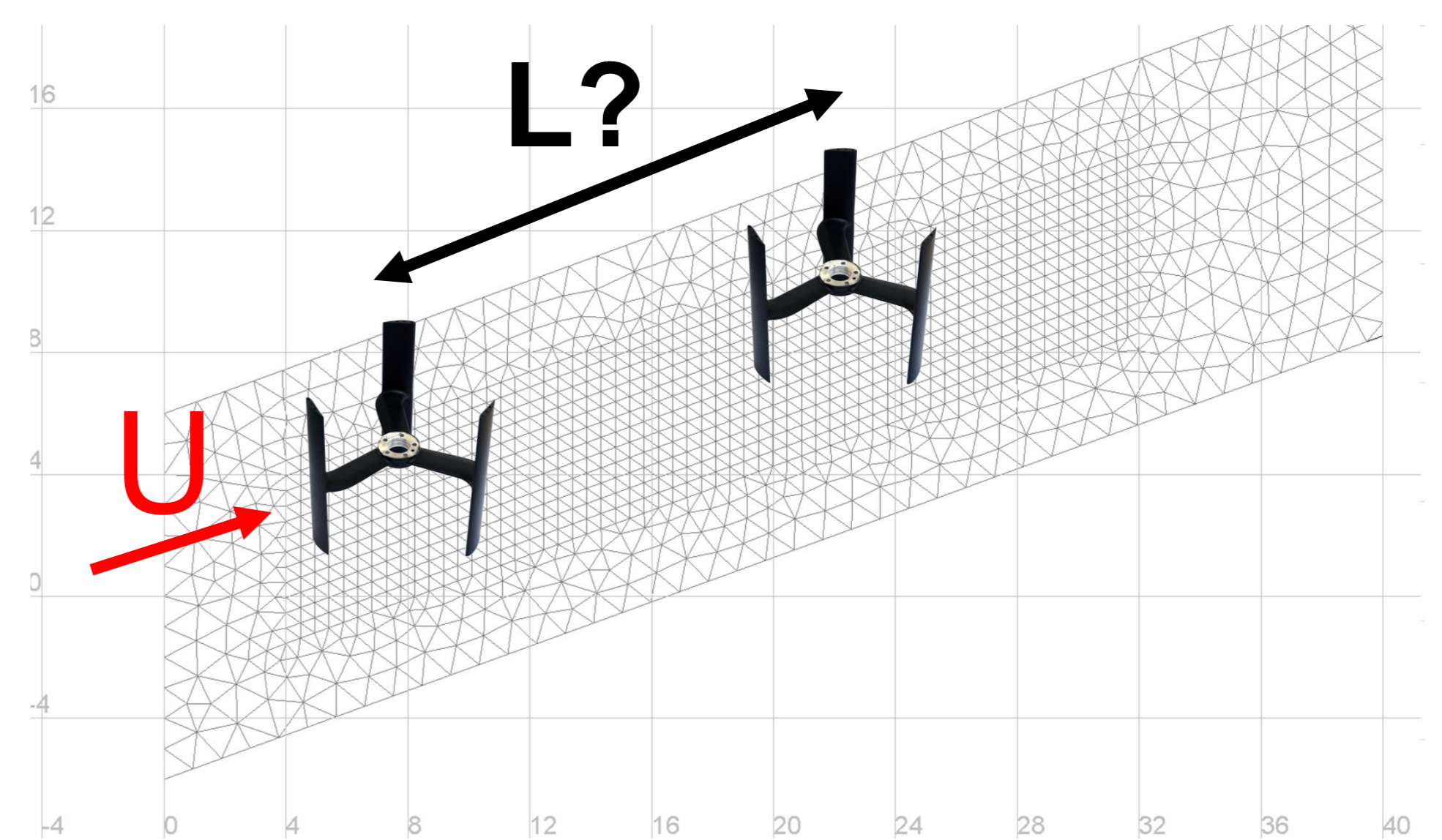
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A SIMPLE 3D RIVER/TIDAL TURBINE MODEL TO EVALUATE FARM POWER PRODUCTION

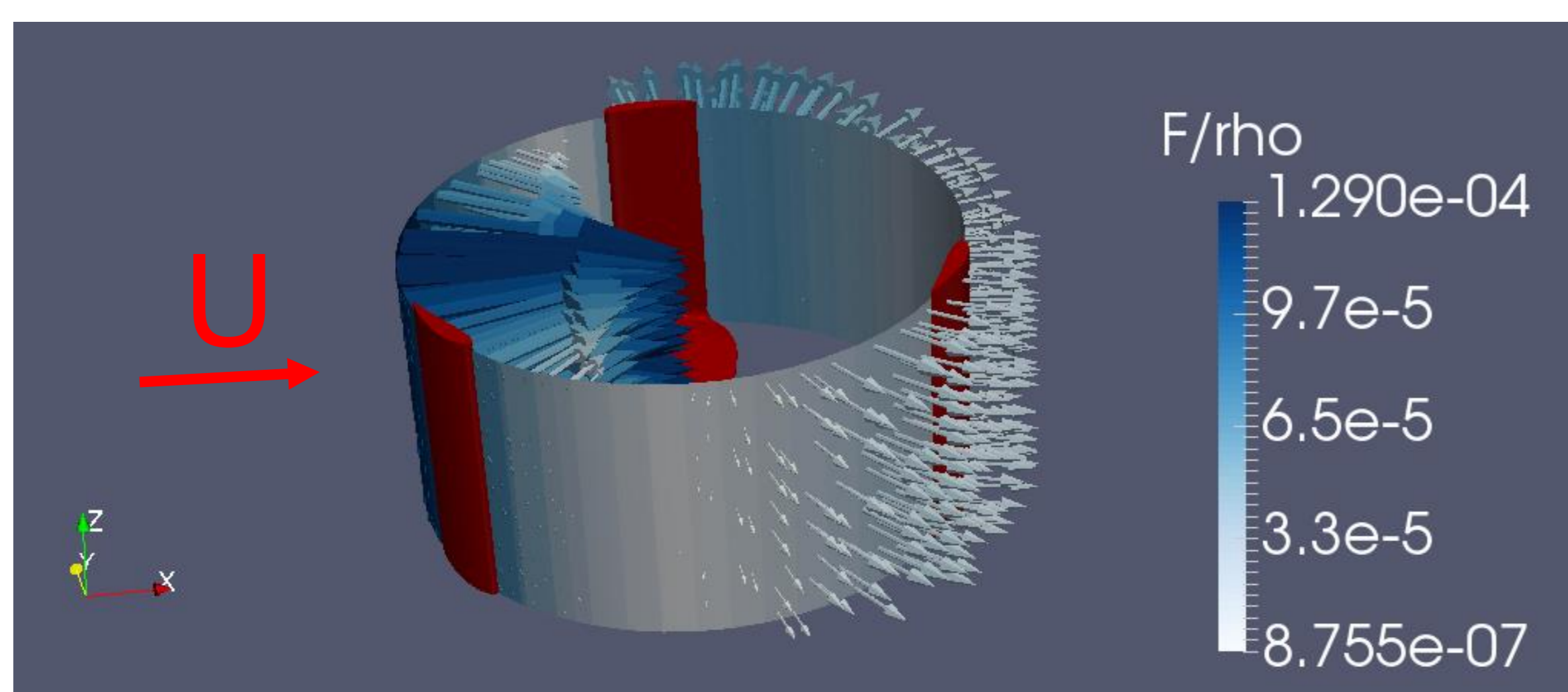
In a tidal or river stream turbine array, power production of a turbine is strongly influenced by the effects of the other turbines, especially the upstream turbine that creates a velocity deficit in its wake. To compute efficiently the power production of the turbines, CFD simulations of the array can be done. But a simplified model must be used to limit computation costs. It uses stationary RANS resolution method and is tested here on a single turbine. Results are compared to experiments of a reduced scale Darrieus turbine in a hydrodynamic tunnel.



Sketch of a future simulation enabled with the simplified model with corresponding refined mesh: 2 turbines in a row

Simplified model of a single Darrieus turbine

In the simplified model, the Darrieus turbine is modelled with a stationary force field added in the cylindrical volume swept by the blades. The three components of forces are added in the momentum equations. The force values are depending on the position.



Force vectors added in the simplified model equations to represent the Darrieus turbine (superimposed in red)

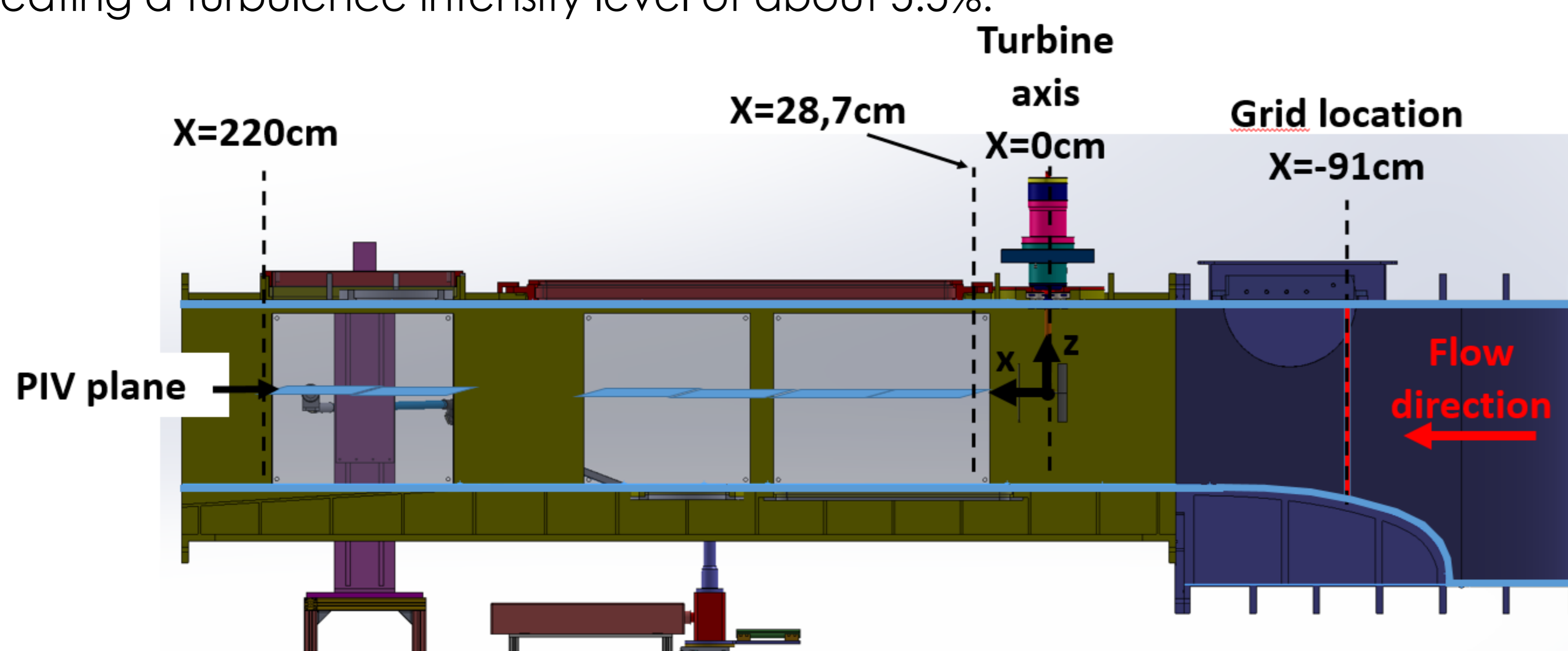
The force field values are obtained via a preliminary detailed URANS simulation of the flow through the real geometry of the Darrieus turbine. It also gives performances and wake results but calculation costs are high. Forces applied on the turbine are then time-averaged over one revolution to get a stationary force repartition. Using the simplified model provides a great calculation costs reduction.

OpenFoam simulation case	Time step	Number of cells	Computation time
URANS full geometry model	0.33ms	16 million	30 days
Simplified model	None - 4000 iterations	1 250 000	1h

Computation times for the two CFD models on 1 node Xeon DELL C6320 128Go RAM with 20 cores (6Go RAM/core)

Experimental setup

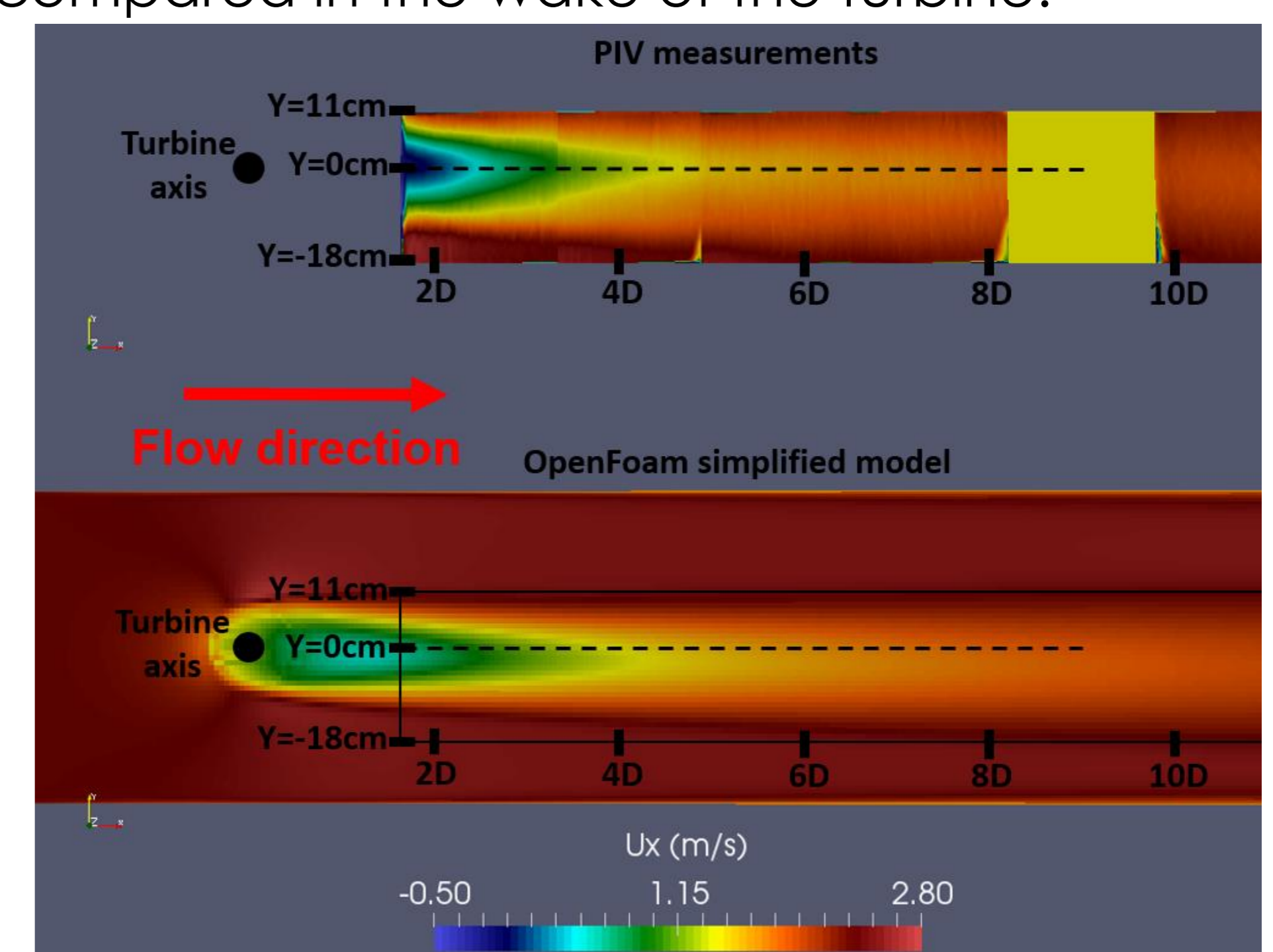
A comparison with experiments carried out at CERG is performed. A Darrieus turbine of 17.5cm height and 17.5cm diameter is tested in the center of a 55cm by 60cm rectangular section hydrodynamic tunnel. The length of the wake is measured via Particle Image Velocimetry (PIV), which gives the velocity field in the horizontal plane cutting across the middle of the channel. To control the turbulence level, a turbulence grid with regularly spaced bars is added upstream, creating a turbulence intensity level of about 5.5%.



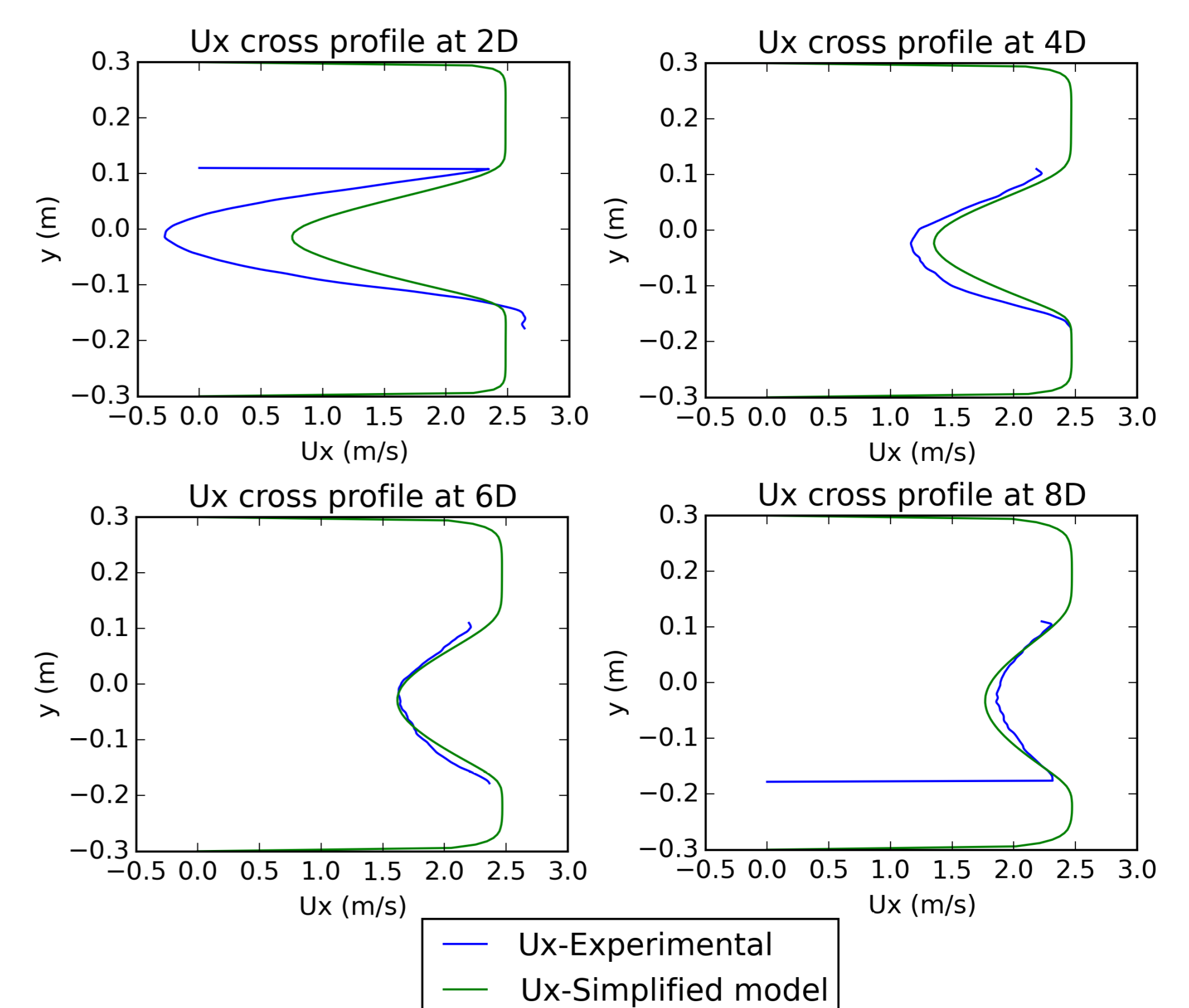
CAD view of the experimental setup at CERG

Results

Experimental and simulated velocity fields are compared in the wake of the turbine.



Experimental (top) and simulated (bottom) axial velocity



Velocity profiles for both cases at different x-positions

Results prove to be in good agreement in the zone $x \geq 4D$. This precision was possible thanks to the use of correct inlet turbulence conditions in the simulation. The accuracy of the turbulence parameters all along the wake still has to be studied in details.