APPLICATION OF URANS-VOF MODELS IN HYDRODYNAMIC STUDY OF OSCILLATING WATER COLUMN

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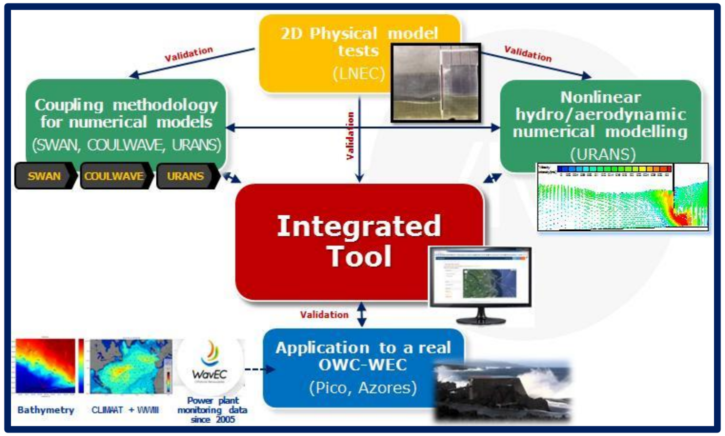
Framework

- Ditowec project
  - Development of an Integrated Tool for Numerical Modeling of Oscillating Water Column Wave Energy Converters integrated in Vertical Breakwaters
    - wave propagation (SWAN, Coulwave)
    - Wave-structure interaction (URANS models)
    - Complex non linear hydrodynamic and aerodynamic phenomena that occur in a device
    - Airflow in OWC
    - Pressure losses due to PTO systems
  - Case study
    - Pico power plant

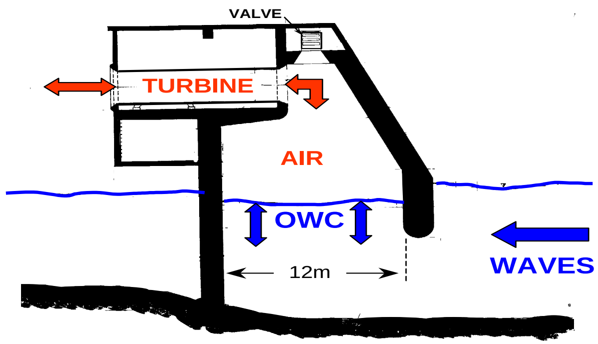


Outline

- Objectives/ Case study
- Physical modelling
- Numerical Modelling
  - FLUENT
  - IH2VOF
- Results
  - Experimental
  - Numerical
- Conclusions
- Research developments

Objectives

- Application of the URANS-VOF models for hydrodynamics studies of the OWC-WECs for modelling:
  - Wave-structure interactions
  - Hydrodynamics of a pneumatic chamber
  - URANS-VoF models
    - ANSYS FLUENT
    - IH2VOF (IHCantabria)



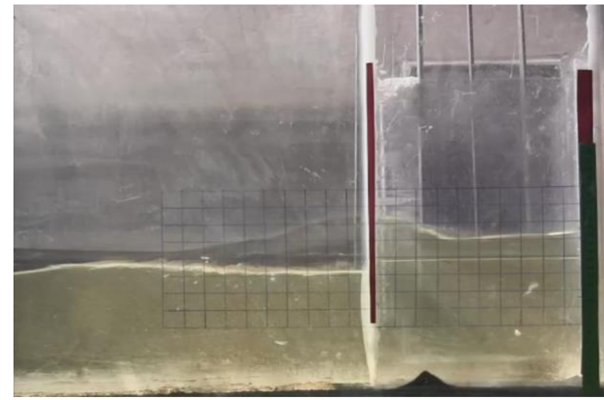
Pico OWC plant

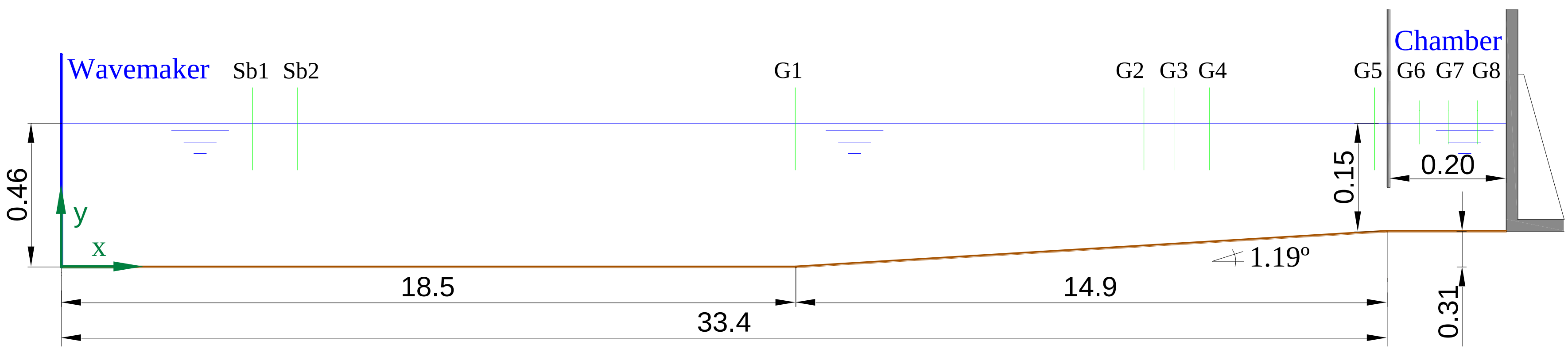
Physical modelling

- Obtain data for numerical models validation:
- Study the hydraulic characteristics
  - Wave flume dimensions (LNEC-COI1)
    - 49.4 m length,
    - 1.6 m wide
    - 1.2 m height
  - Resistive gauges

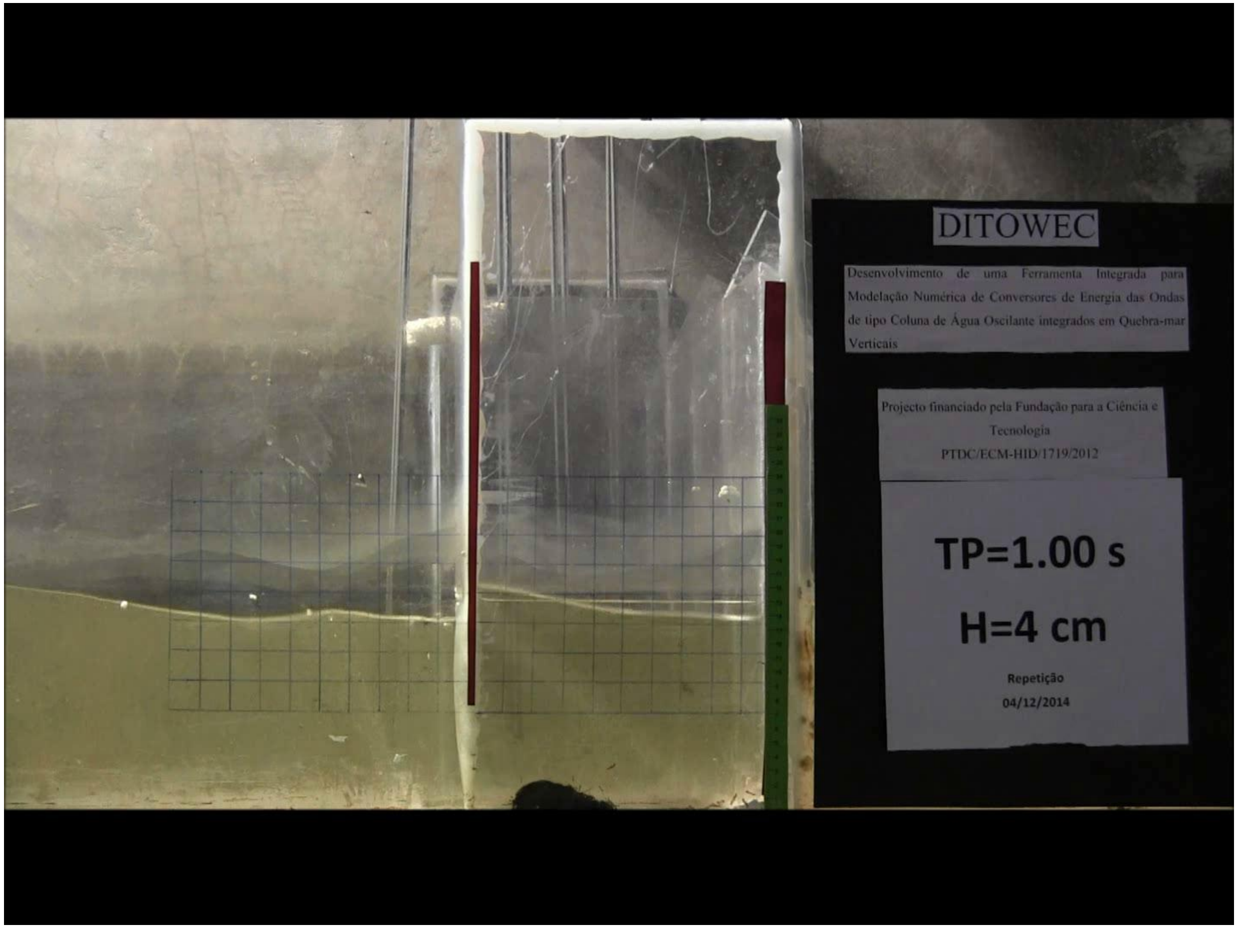
Physical modelling

- Physical modeling of a chamber with a fully open airway, in a geometric scale of 1:35
  - Regular waves
  - H=3.8 cm
  - Periods range between 0.67 and 2.30s.
  - 8 repetitions for each test
  - 10 wave gauges



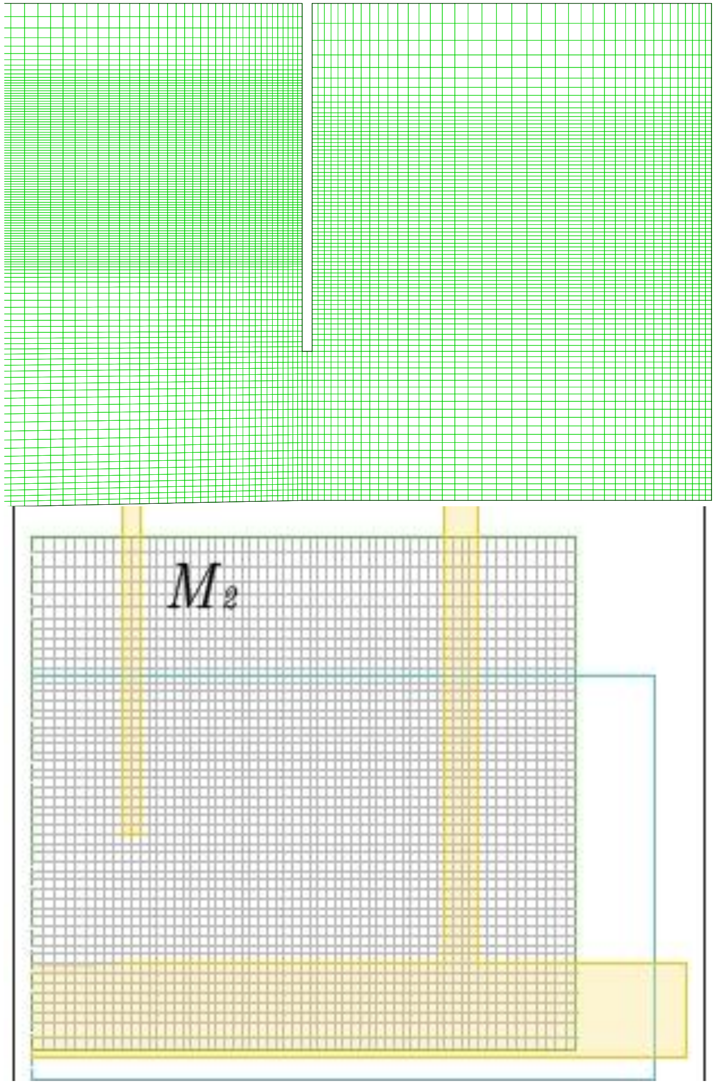


Physical modelling



Numerical Modelling

- Reproduce the same conditions of experimental test
- FLUENT
  - Finite volume technique
  - Regular mesh with 201 559 to 307 797 elements
  - k-ε turbulence model
  - Geo-reconstruct scheme for track volumetric fraction
- IH2VOF
  - 2DV Reynolds Average Navier–Stokes equations
  - Turbulence model: k- ε



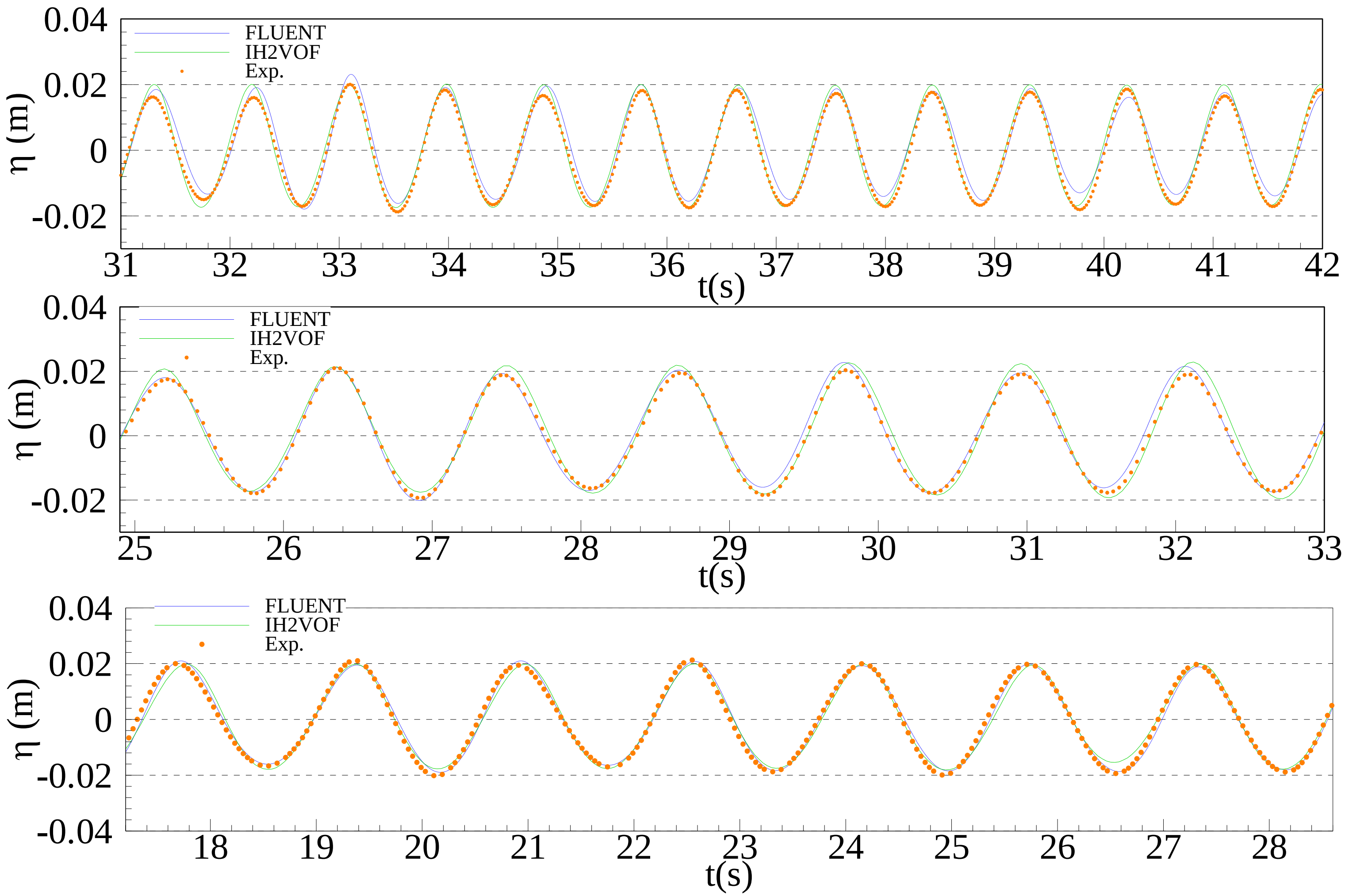
Results

Free surface level in a start of smooth ramp (G1 gauge)

T=0.89s

T=1.15s

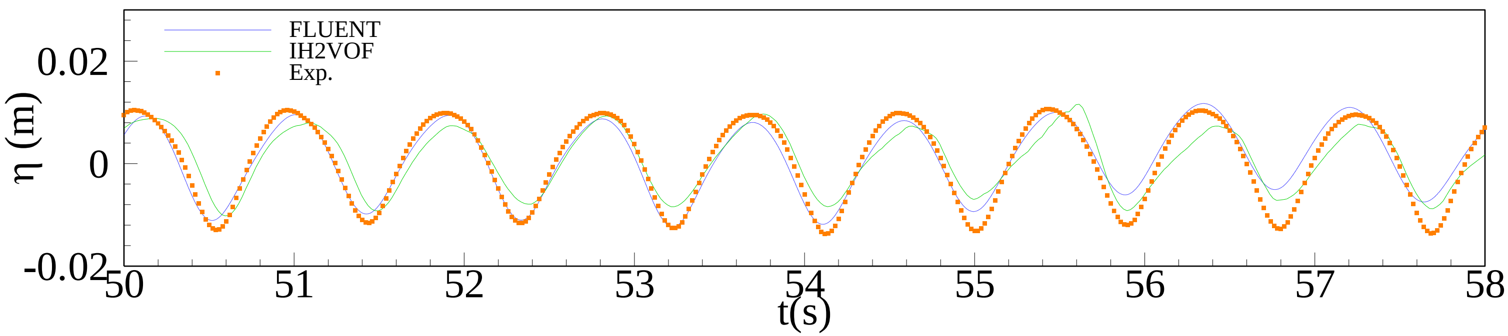
T=1.60s



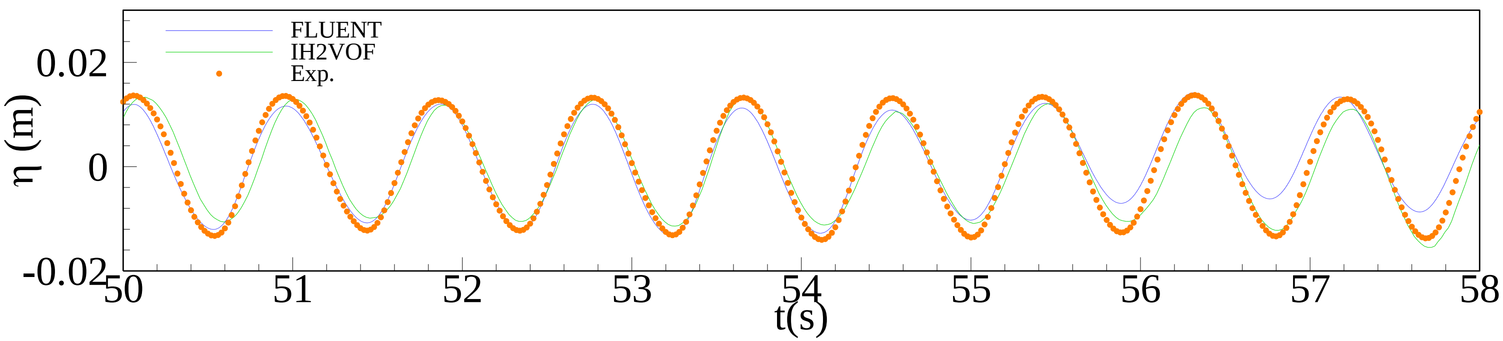
Results

Free Surface level inside the pneumatic chamber T=0.89s

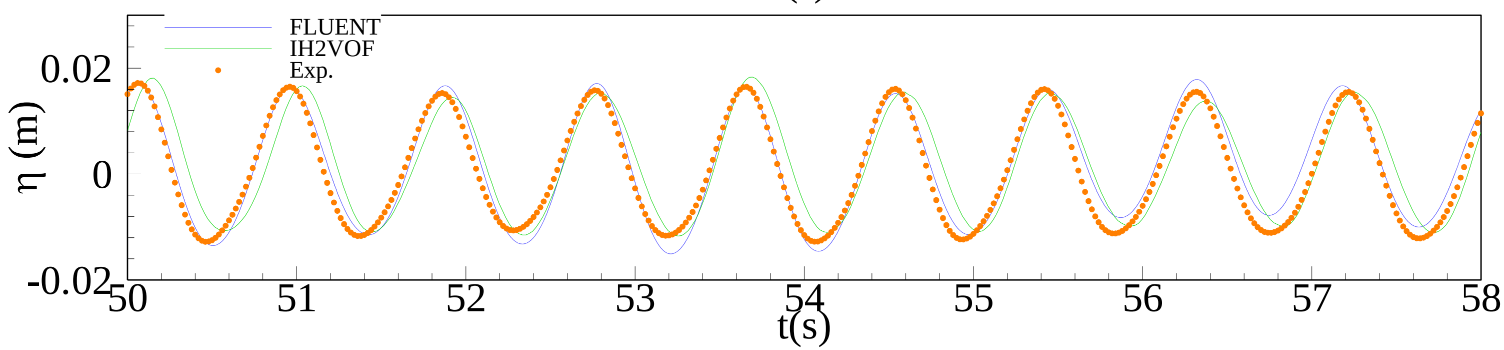
G6



G7



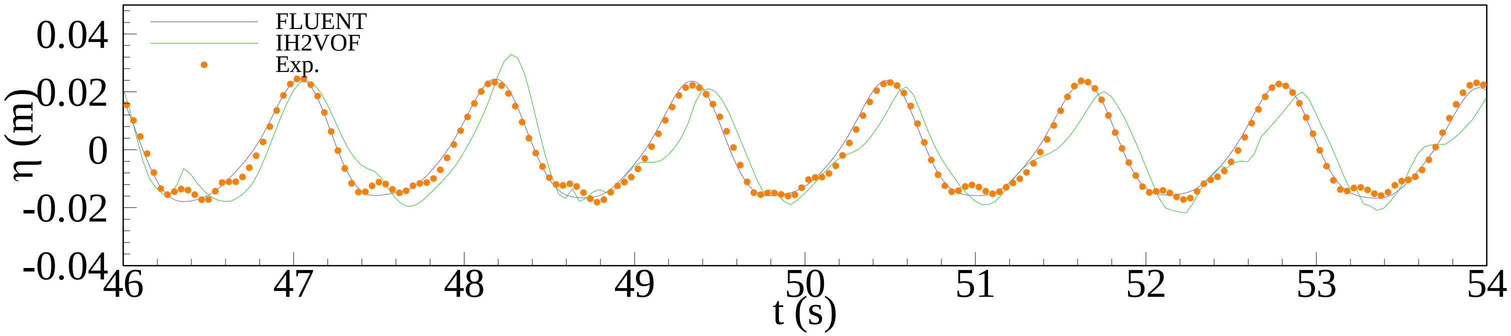
G8



Results

Free Surface level inside the pneumatic chamber T=1.15s

G6



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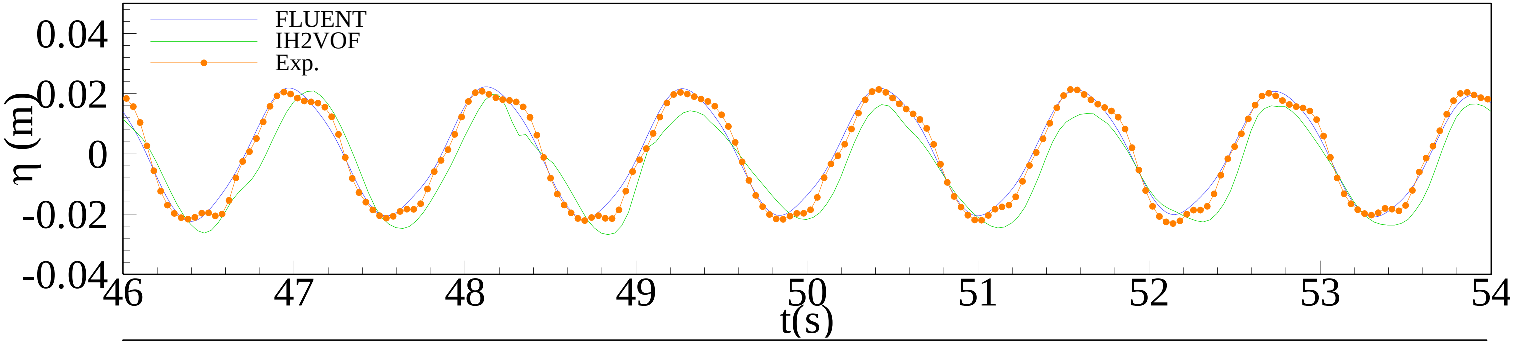

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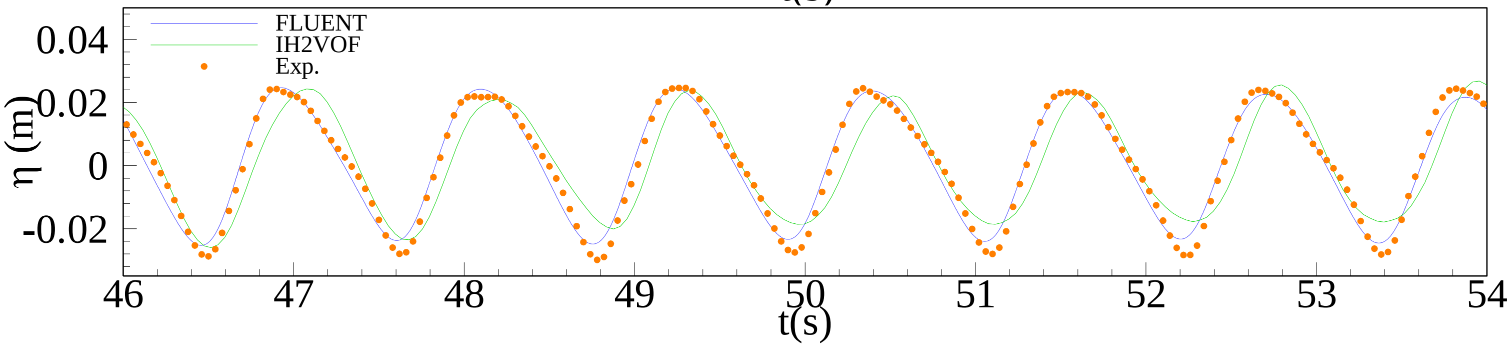
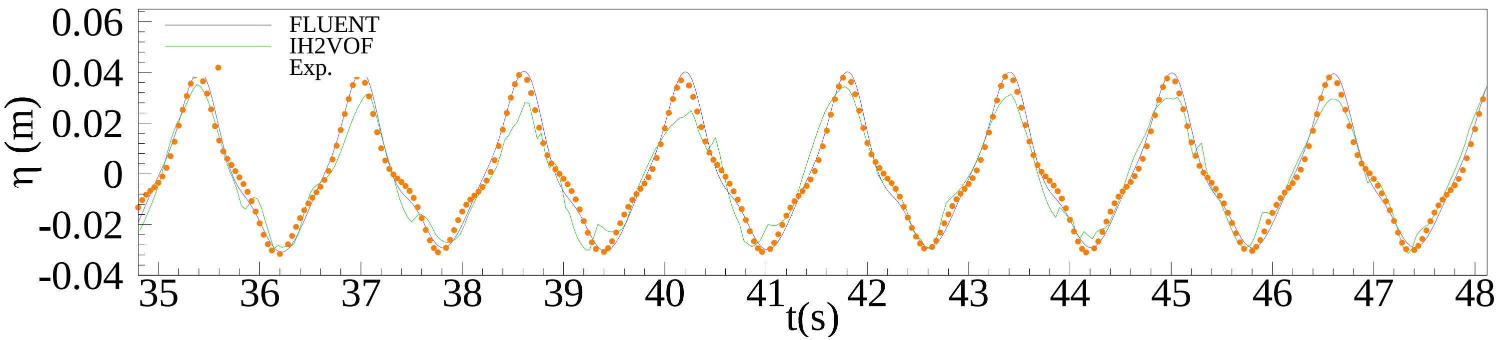


Results

Free Surface level inside the pneumatic chamber T=1.60s

G6



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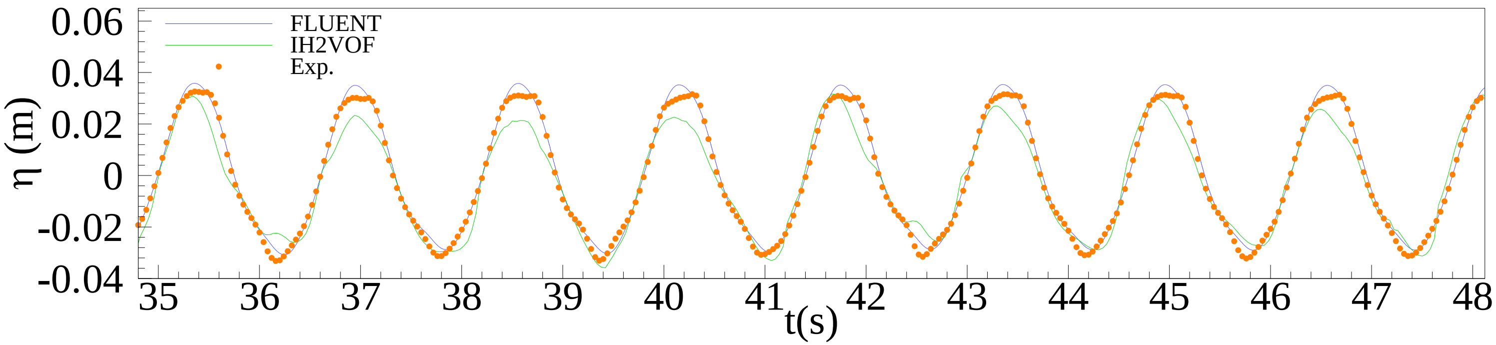

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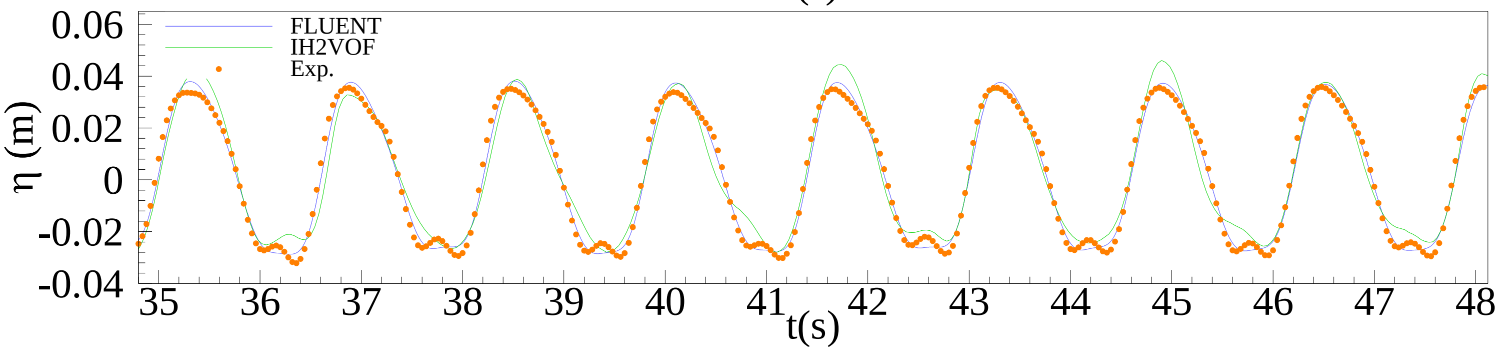
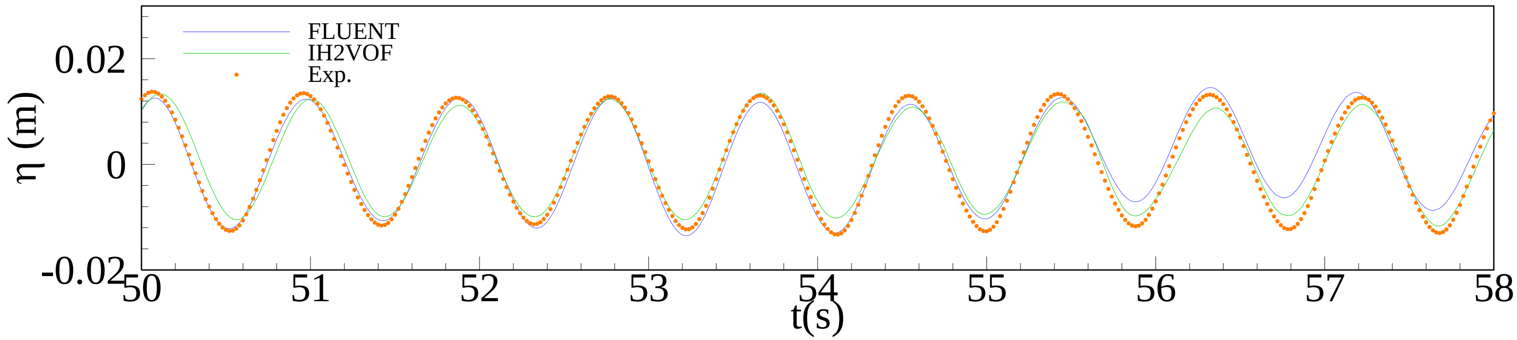


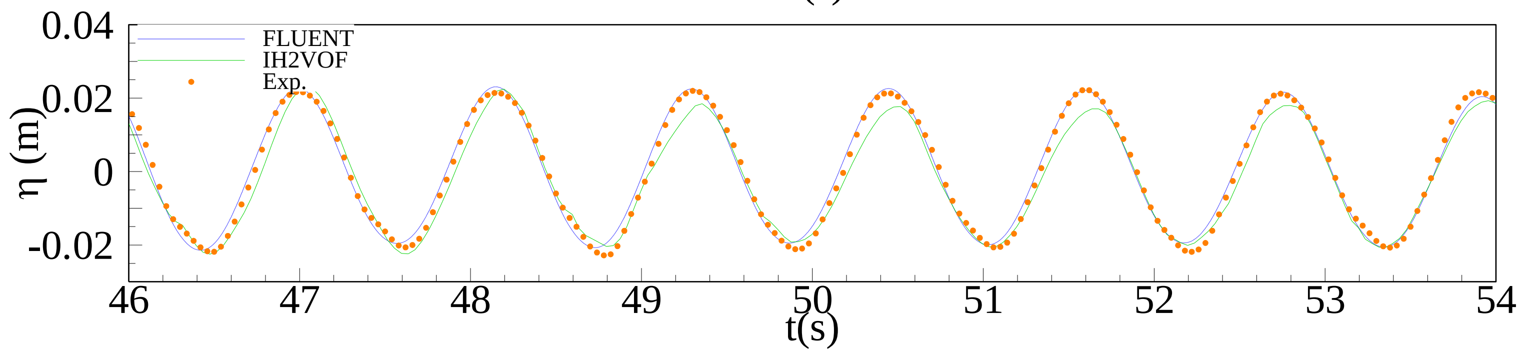
Results

Average free surface level inside the pneumatic chamber

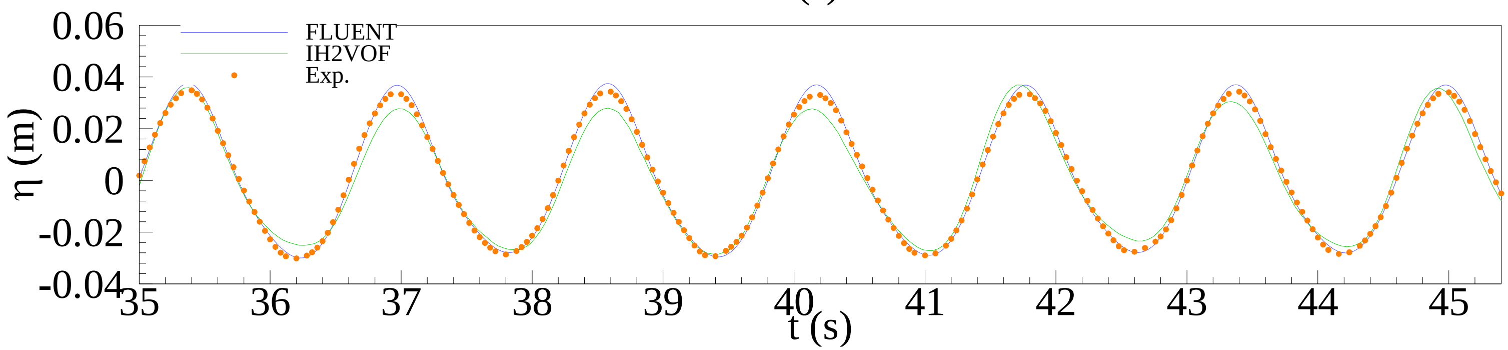
T=0.89s



T=1.15s



T=1.60s



Amplification factor

- Ratio between water column displacement and incident wave height

T (s)	FLUENT	IH2VOF	Experimental	E_{FLUENT} (%)	E_{IH2VOF} (%)
0.89	0,64	0.59	0.67	-5.30	-13.80
1.15	1.14	1.06	1.13	0.6	-6.8
1.60	1.72	1.52	1.66	3.6	-9.1

Phase angle

- Angular difference between the time series of the free surface elevation outside and inside the chamber

T (s)	FLUENT	IH2VOF	Experimental	E_{FLUENT} (%)	E_{IH2VOF} (%)
0.89	142.4	133.1	132.1	7.2	0.7
1.15	84.5	86.7	80.6	4.6	7.0
1.60	40.8	36.7	37.8	7.4	-2.9

Conclusions

- Both numerical models show a good agreement with experimental data for time series of free surface level, amplification factor and phase lag.
- Future steps
  - Modelling the aerodynamics effects and PTO devices
  - Experimental tests with a partially opened airway with/without a porous membrane to simulate the pressure loss due to turbine
  - Apply and validate the OpenFOAM model.

3D NUMERICAL MODELLING OF WAVE ENERGY CONVERTERS OF OSCILLATING WAVE COLUMN

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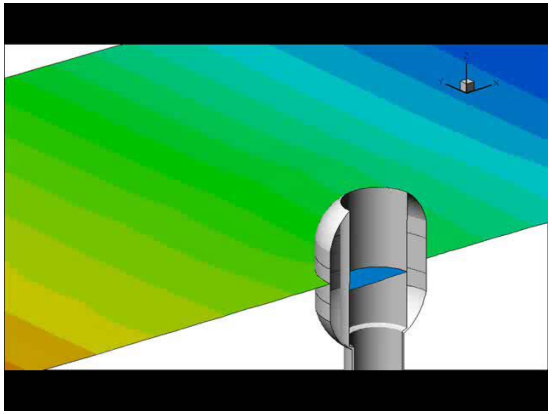
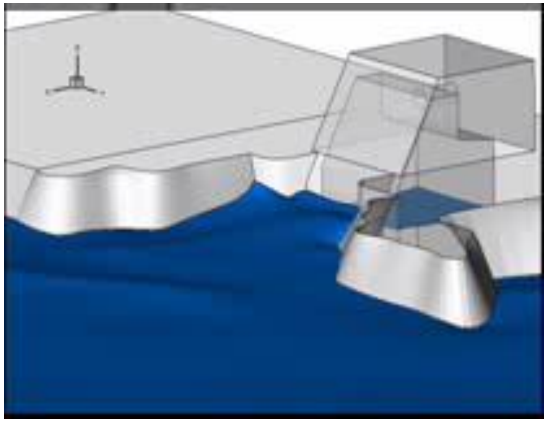
3D numerical modelling of wave energy converters of Oscillating Wave Column

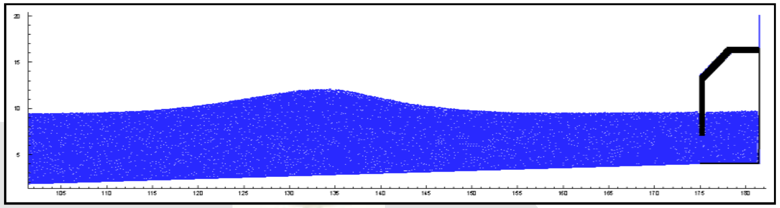
- **Wave energy converters**
  - Off-shore
  - On-shore, at the shoreline or breakwater
- **Numerical modelling performed using Reynolds Average Navier-Stokes models**
  - ANSYS-FLUENT – FVM+VOF
  - FLUINCO – FEM
- **Numerical modelling of hydrodynamic and aerodynamic flow considering**
  - Turbine characteristics of the OWC plant
  - Geometry of the OWC plant and bathymetry
  - Incident wave characteristics
- **Results:** pneumatic power, sloshing in the chamber, force on structure, aerodynamic flow in air chamber and turbine, hydrodynamic
- **SPH numerical model in development**



Off-shore OWC – WavEC project



Pico OWC plant- Azores, Portugal



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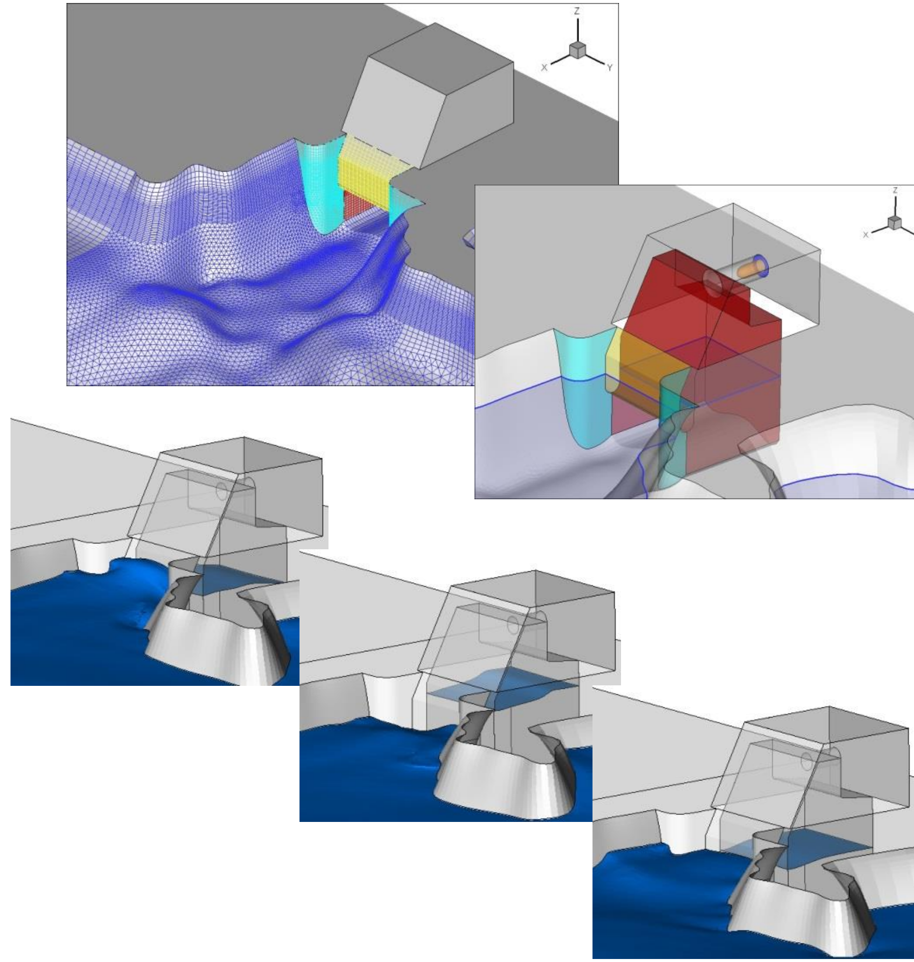
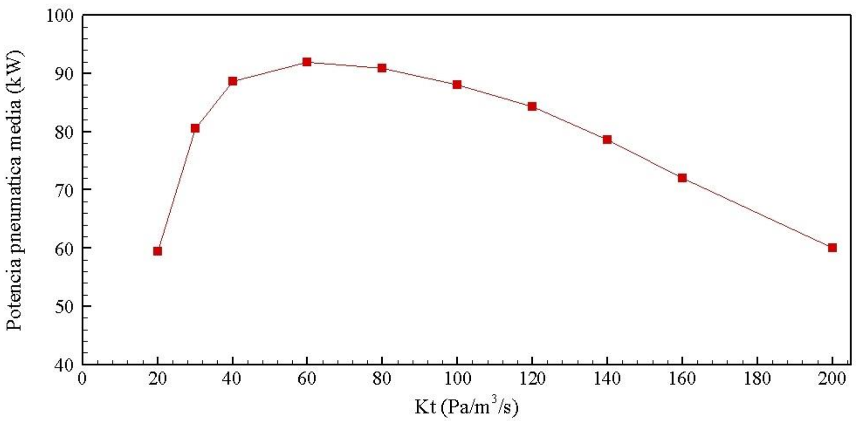
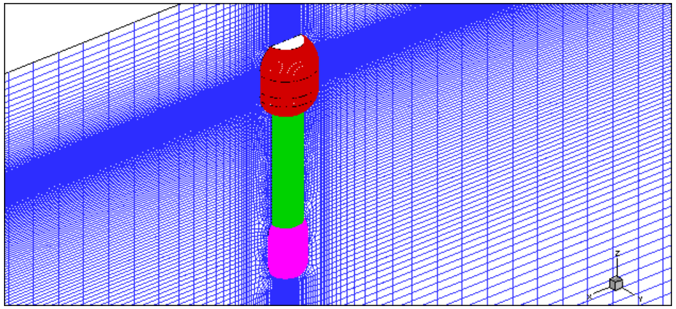
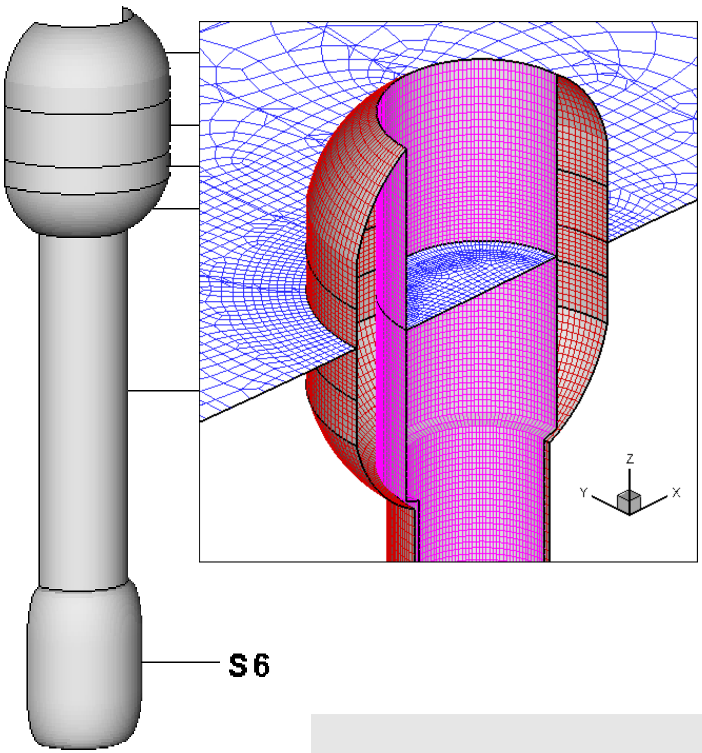




Off-shore OWC

Off-shore OWC – WavEC project





Off-shore OWC model tests with and without damping effects