8th DualSPHysics Workshop

27 - 29 January 2026, Ourense, Spain

Experimental-Numerical Validation of DualSPHysics-FEA Coupling for Flexible Floating Bodies in a Sloshing Tank

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João Leal[3], Iván Martínez-Estévez[4], Alejandro J.C. Crespo[4]

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2. CERIS, Instituto Superior Técnico, Lisbon, Portugal

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4. EPHYSLAB, Environmental Physics Laboratory, CIM-UVIGO, Universidade de Vigo, Spain

Ourense, 29th January 2026

Motivation

Floating Photovoltaic Systems
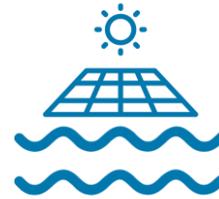
5MW Floating photovoltaic power plant installed in the Alqueva dam, Portugal.
Retrieved from https://www.edp.com/en/media/edp-stories/alquevas-floating-solar-panels on June 6, 2025

24.5 MW Floating photovoltaic power plant located in Austria.
Retrieved from https://www.ecowind.at/references/floating-photovoltaic-plant-in-grafenworth/?lang=en on June 6, 2025
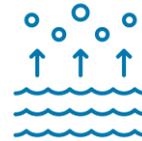
Motivation

Floating Photovoltaic Systems
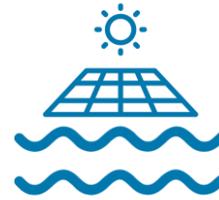
Advantages

1. Lower panel temperature → Better panel efficiency → More power output

2. Reduced water evaporation

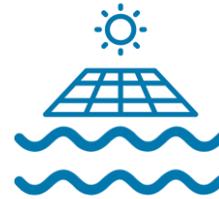3. No sunlight on water → Less algae → Better water quality

4. No land required → No need to buy large plots of land

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Motivation

Floating Photovoltaic Systems

Criticism

Photovoltaic power plant installed in Devon, UK.
Amy Oliver, Daily Mail, May 29, 2021. retrieved from:
https://www.dailymail.co.uk/news/article-9632831/A-toxic-blot-landscape-Solar-farms-ruining-views-causing-misery-residents.html
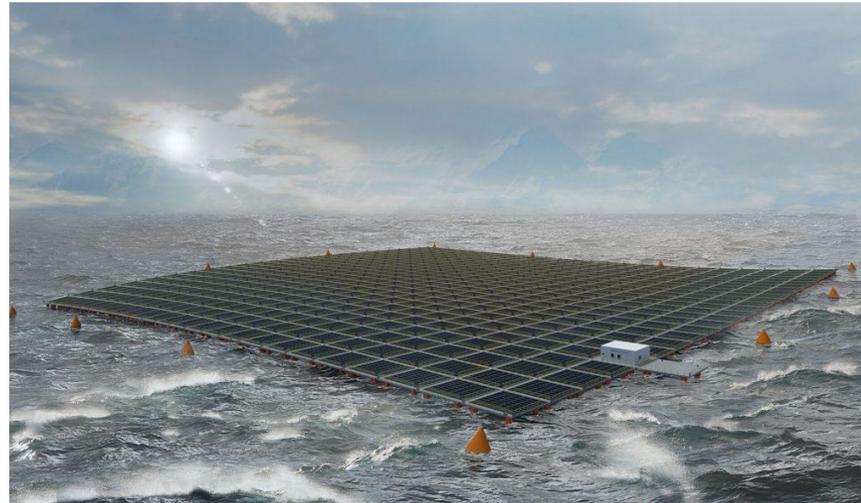
Photovoltaic power plants have received a lot of negative backlash for ruining the natural landscape on rural areas
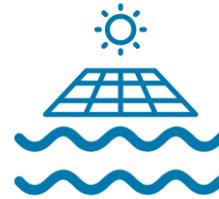
Motivation

Floating Photovoltaic Systems
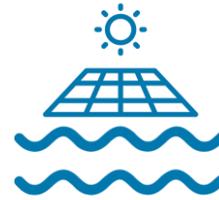
↳ **Offshore** Floating Photovoltaic Systems

Offshore photovoltaic plant concept
Offshore energy, June 6 2020. retrieved from:
https://www.offshore-energy.biz/floating-solar-takes-on-high-seas/

Motivation

Floating Photovoltaic Systems

Offshore Floating Photovoltaic Systems

Developer	Project Name	Location	Capacity [MW]	Status
Oceans of Energy	North Sea 2	North Sea, Netherlands	1	Operational (scale-up)
	North Sea 3	Ostend, Belgium	3	Deployed (2024)
Ocean Sun	MP Quantum Greece	Greece & Cyprus	4	Planned (delayed)
	Singapore Strait Pilot	Singapore	1.2	In development (delayed)
	Jurong Island Pilot	Singapore	1.5	Planned (commissioning ~2026)
Solar Duck	Hollandse Kust West VII	North Sea, Netherlands	5	Planned (target ~2026)
	Tokyo Bay ESG Project	Tokyo, Japan	5	Deployed demo (capacity likely <5 MW)
SolarinBlue	Arabian Sea Pilot	Mangalore, India	1	Planned / permitting

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Research Gap

Offshore Floating Photovoltaic Systems
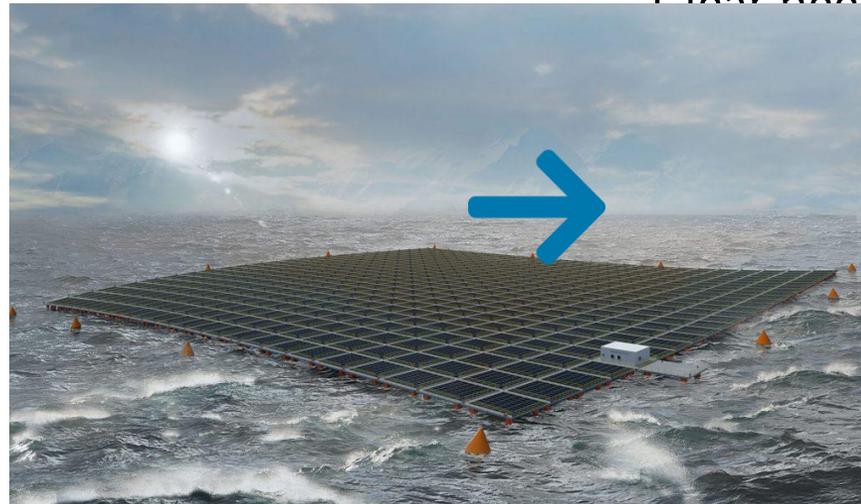
Clear need for a robust code for simulating ~~stru~~cture interactions with flexible structures

Offshore photovoltaic plant concept
Offshore energy, June 6 2020. retrieved from:
https://www.offshore-energy.biz/floating-solar-takes-on-high-seas/
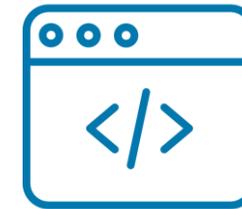
Research Gap
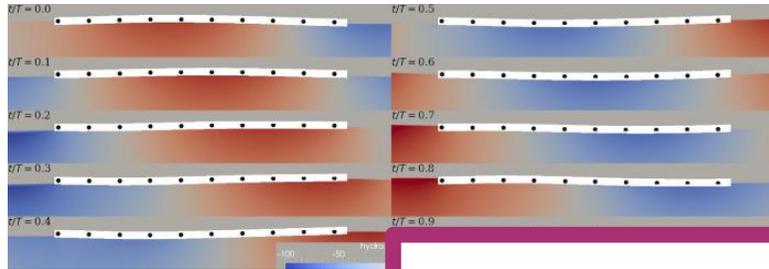
Mesh based FSI using OpenFOAM. Adapted from: [...] interaction for a flexible floating structure, https:/[...]
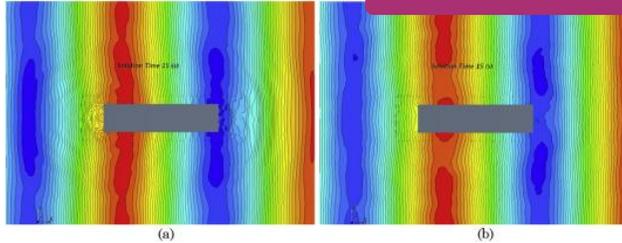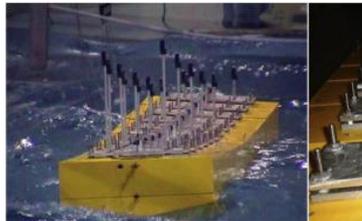
Mesh based FSI using Star-CCM+. Adapted from: Lakshmynarayanana P.A. et al, Application of CFD and FEA coupling to predict dynamic behaviour of a flexible barge in regular head waves, https://doi.org/10.1016/j.marstruc.2019.02.006

FVM struggle with highly flexible FSI & other limitations
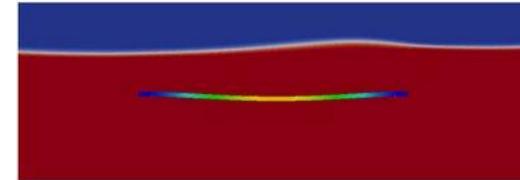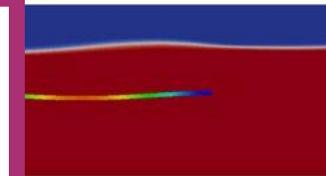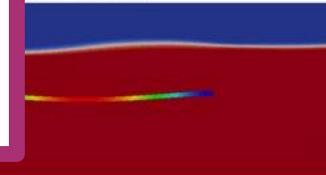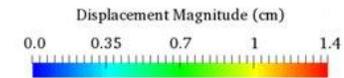
Mesh based FSI using OpenFOAM. Adapted from: Huang & Li, Design of the submerged horizontal plate breakwater using a fully coupled hydroelastic approach, https://doi.org/10.1016/j.marstruc.2019.02.006

Research Gap
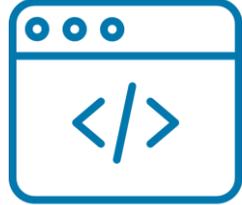
Clear need for a robust code for simulating fluid-structure interactions with flexible structures

1. No code clearly capable of solving fluid interactions with highly flexible structures
2. Recent advances in SPH coupling with Flexible bodies

1. O'Connor, J. & Rogers, B.D. (2021)
2. Martínez-Estévez, I. & Tagliafierro, B. & El Rahi, J. & Domínguez, J.M. & Crespo, A.J.C. & Troch, P. & Gómez-Gesteira, M. (2023)

Numerical Method

(I. Martínez Estévez et al. 2023)
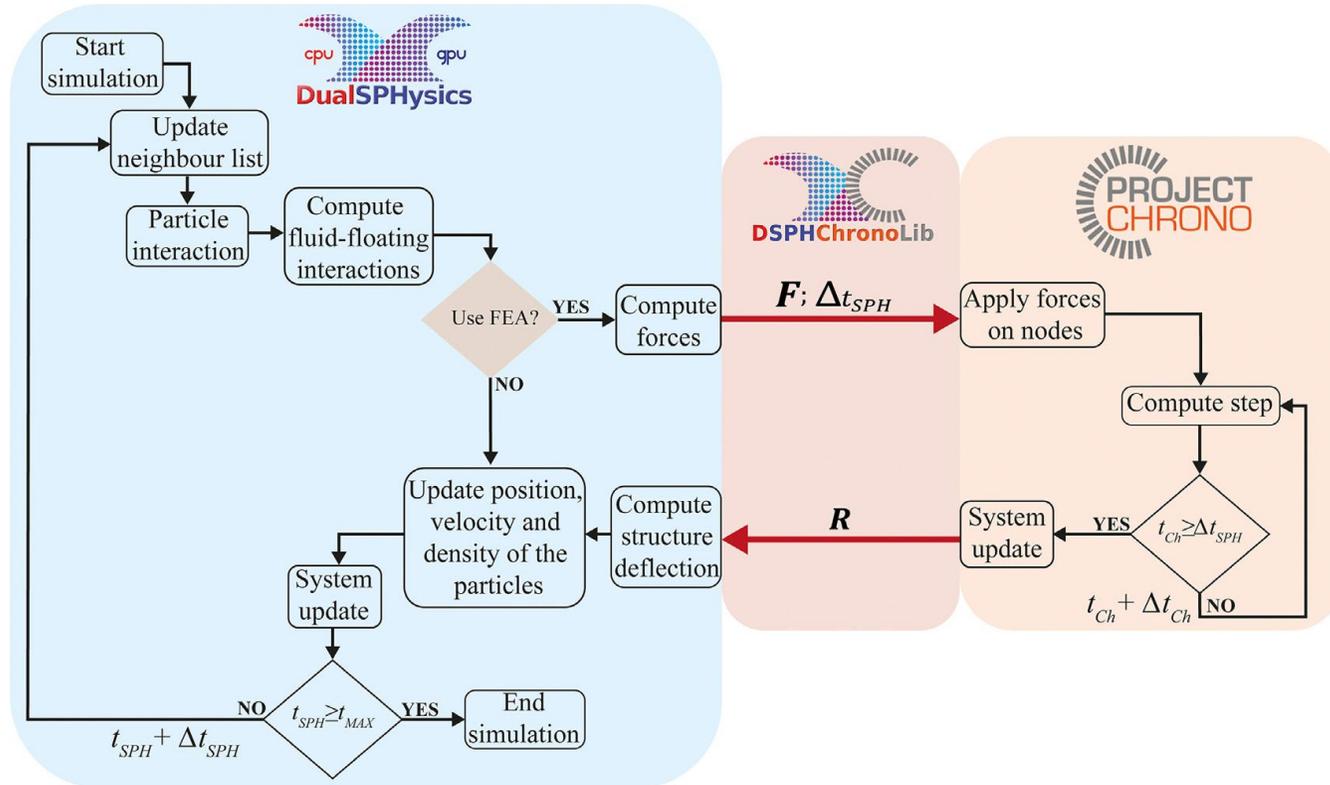
Martínez-Estévez, I., Tagliafierro, B., El Rahi, J., Domínguez, J. M., Crespo, A. J. C., Troch, P., & Gómez-Gesteira, M. (2023). Coupling an SPH–based solver with an FEA structural solver to simulate free surface flows interacting with flexible structures. *Computer Methods in Applied Mechanics and Engineering*, *410*, 115989. https://doi.org/10.1016/j.cma.2023.115989

Objective

DualSPHysics + PROJECT CHRONO FEA
(I. Martínez Estévez et al. 2023)
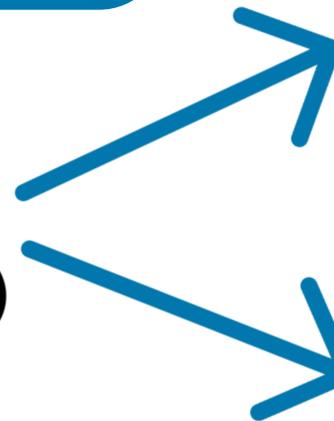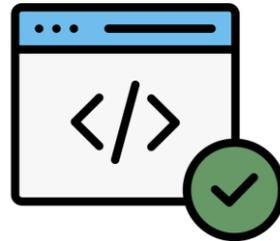
1. Use data from literature

2. Create new experimental data

Experimental Methodology

Create our own experimental data
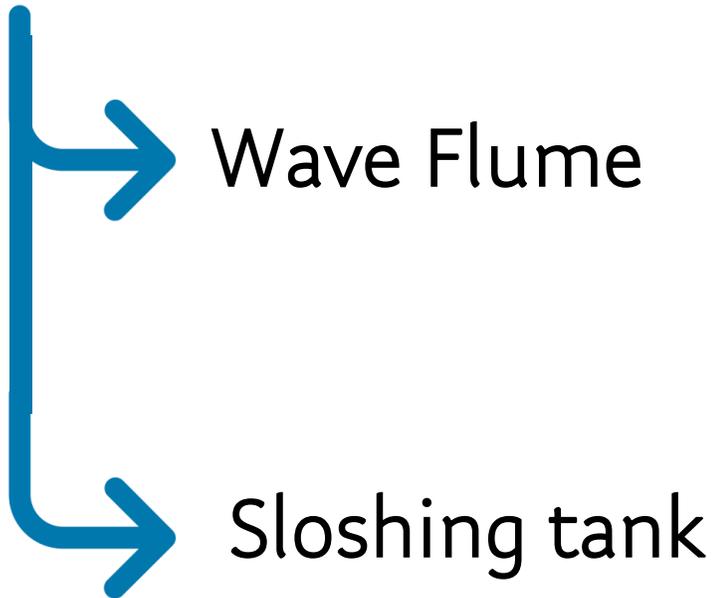
Wave Flume

Wave flume at DECivil, Instituto Superior Técnico, Lisbon, Portugal
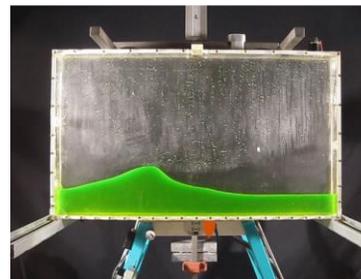
Sloshing tank

Sloshing tank at CEHINAV, Universidade Politécnica de Madrid, Madrid, Spain

Experimental Methodology

Create our own experimental data

Wave Flume →
1. More realistic ocean like waves
2. Include mooring

Sloshing tank →
1. Smaller numerical domain → Less particles for SPH
2. Smaller size → easier instrumentation
3. Purpose built → more specific instrumentation
4. Cheap to build
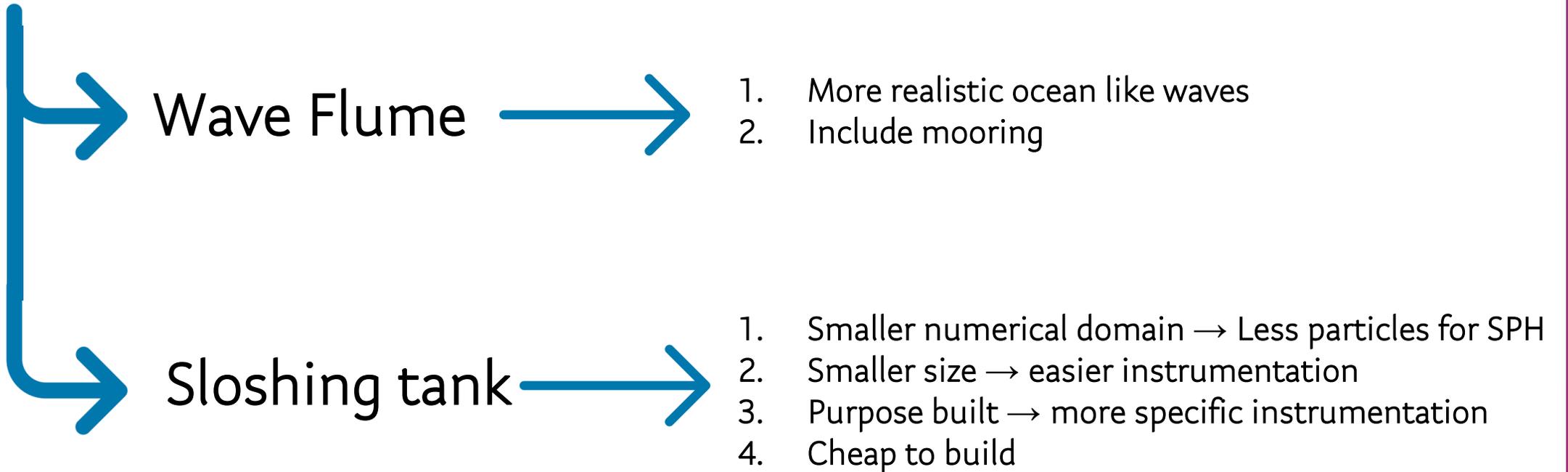
Experimental Methodology

Sloshing tank

Small and purpose built for this project → Design for better Data
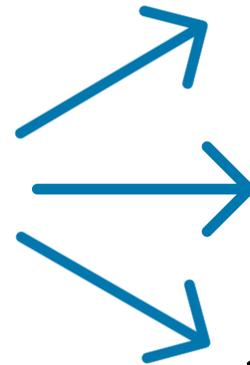
1. Accurate Pressure Results

2. Particle Image Velocimetry – PIV

3. Guarantee equal sloshing motion between experimental and numerical cases

Experimental Setup

Sloshing tank

Sloshing tank

Dimensions: $1m \times 0{,}6m \times 0{,}2m$

1. Accurate Pressure Results

2. Particle Image Velocimetry –

3. Guarantee equal sloshing motion between experimental and numerical cases
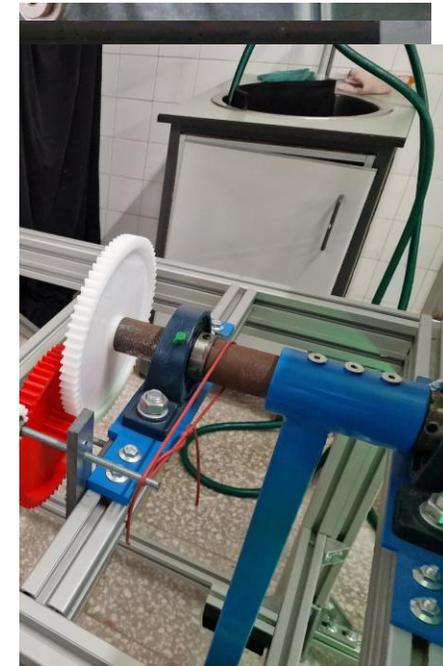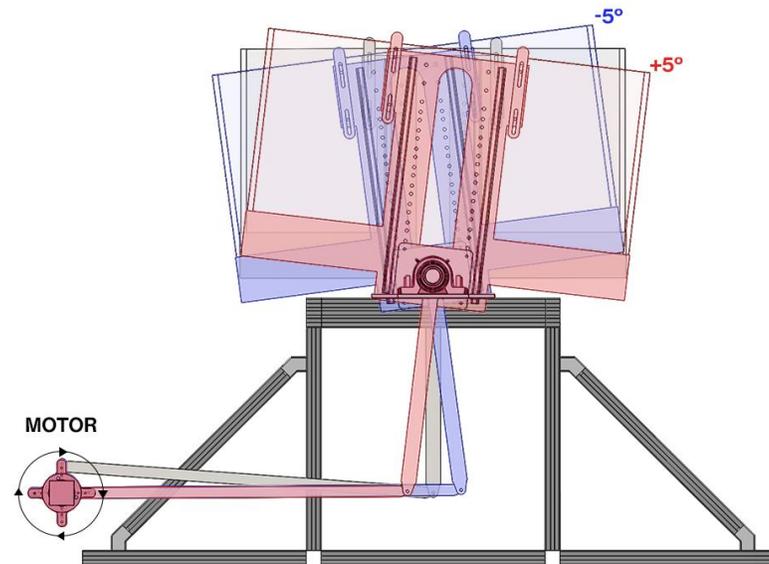
Flexible floating body

EPDM Rubber foam sheet, 8mm
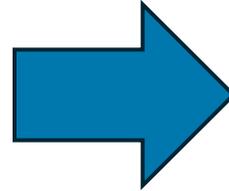
For validation, we need the exact material properties

Experimental Setup

Uniaxial Tensile test of the
EPDM Rubber foam
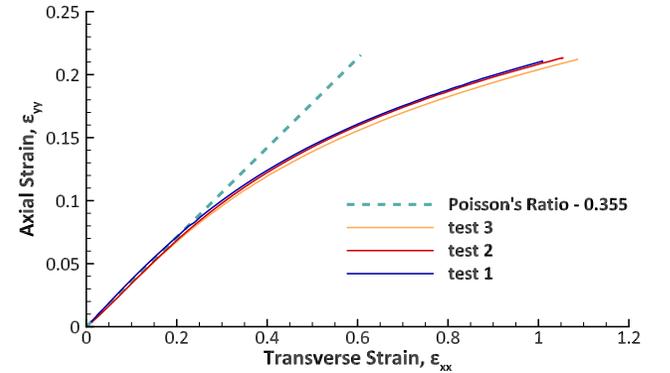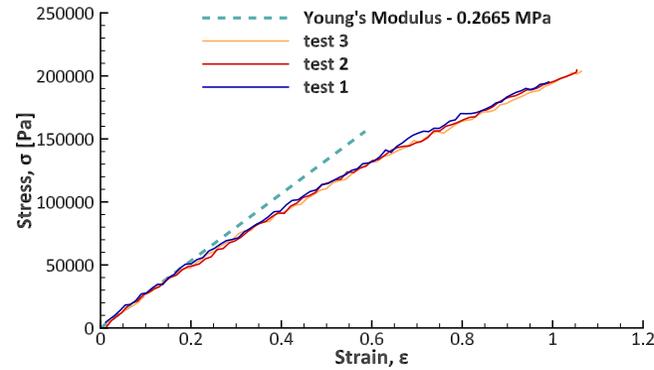
Density	Young's Modulus	Poisson's Ratio
$106.27\ kg/m^3$	$0.2665\ MPa$	0.355

Experimental Dataset
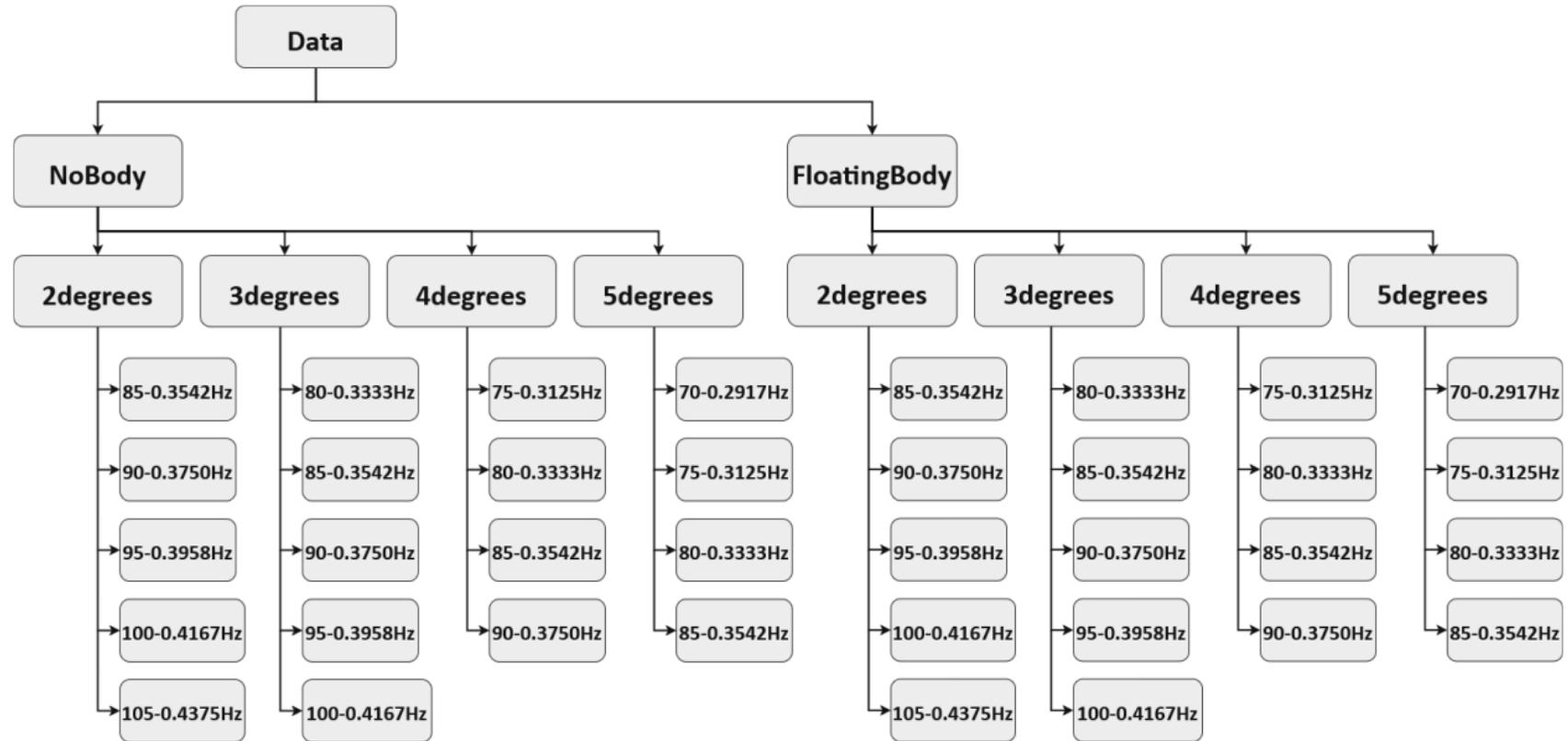
Experimental Dataset
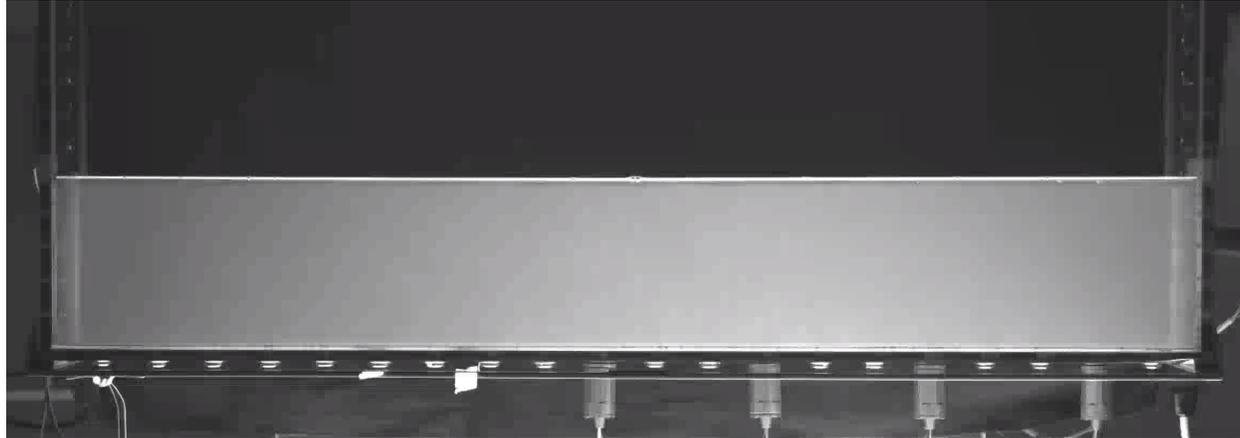
No body, simple sloshing

Floating body

Numerical Setup
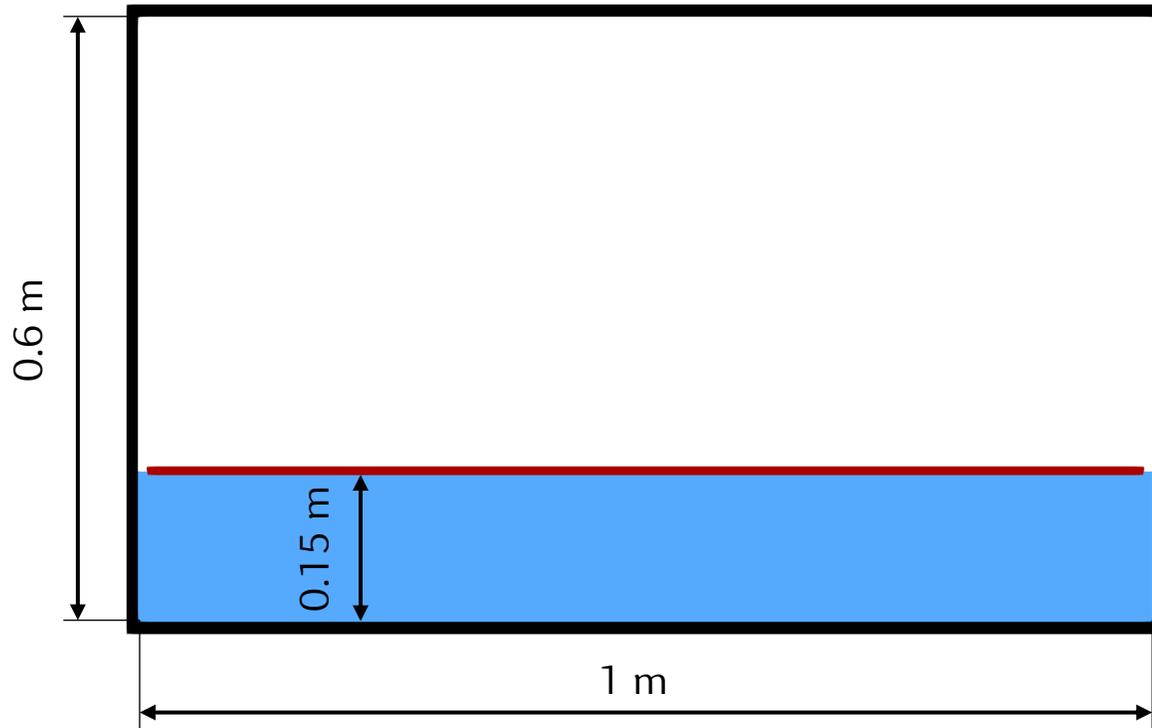
Same dimensions as the experimental tank

Flexible Beam of 50 elements

Dp = 0.002 m - 48k particles (12k of which Floating)

mDBC (NoSlip) is used on the tank and the floating body
(A. English, J. M. Domínguez, R. Vacondio, A. J. C. Crespo, P. K. Stansby, S. J. Lind, L. Chiapponi & M. Gómez-Gesteira 2022)

Both the tank and floating body are classified and TypeFloating objects to enable collision

coefSound = 40, ViscosityTreatment = Laminar

Simulation time of 36 seconds, ran on an –NVIDIA Quadro RTX 4000, for ~10 hours

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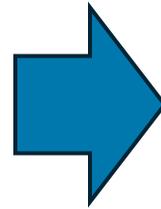
Numerical Setup

Tank Angle over time
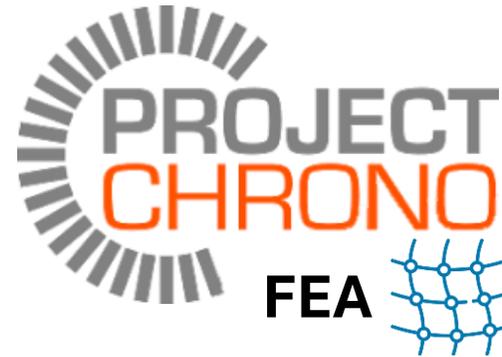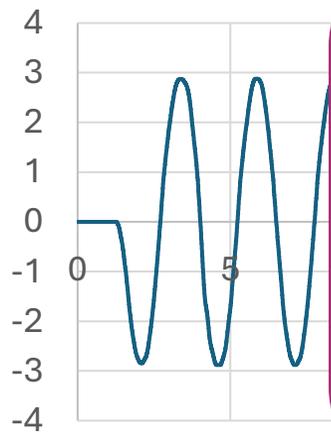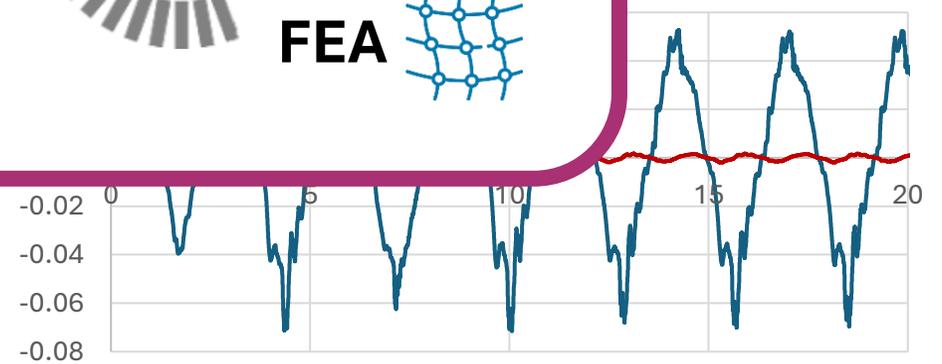
Numerical Setup

Numerical Setup

3 Sloshing conditions

Soft — 2deg_0.3958hz(95)

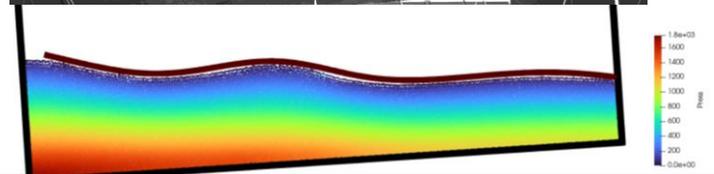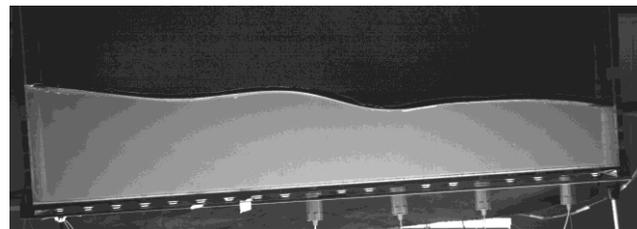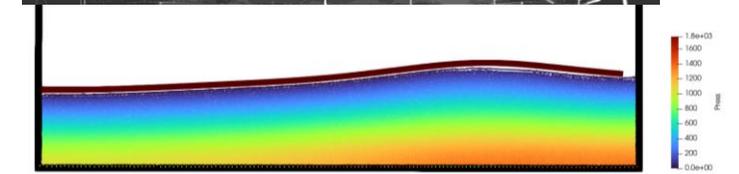Medium — 4deg_0.3542hz(85)
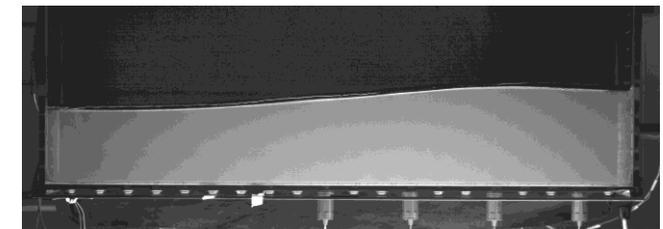
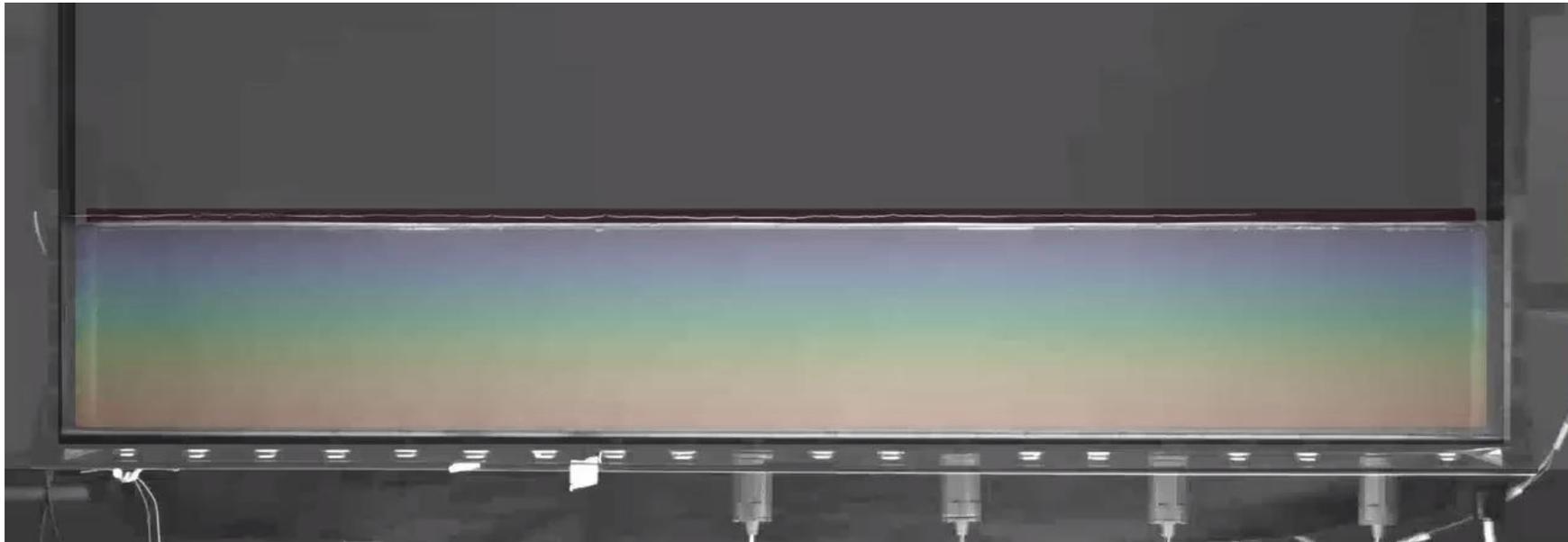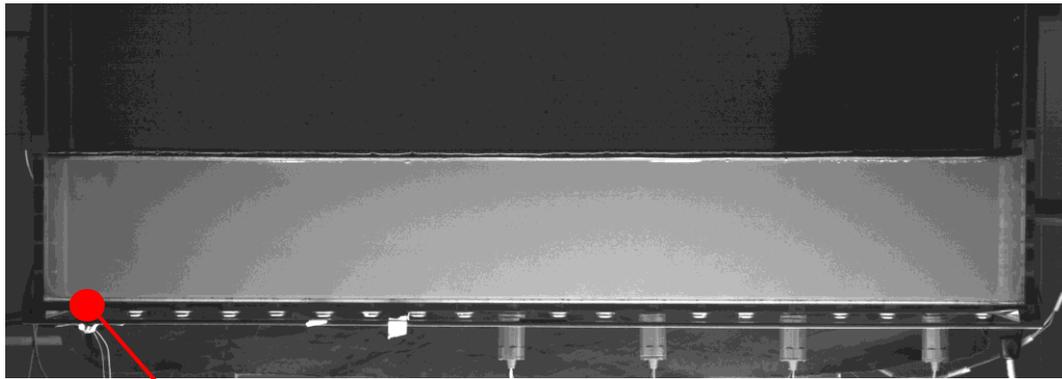Aggressive — 5deg_0.3542hz(85)
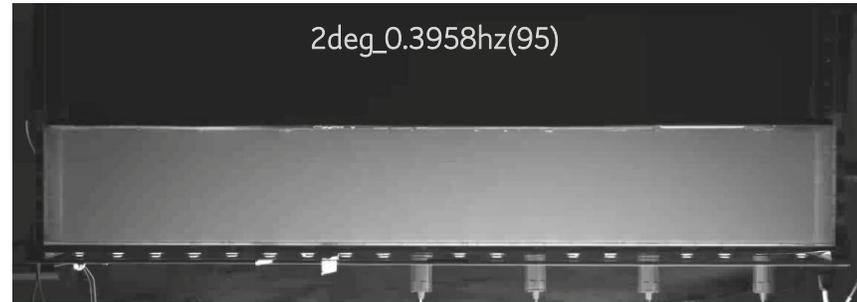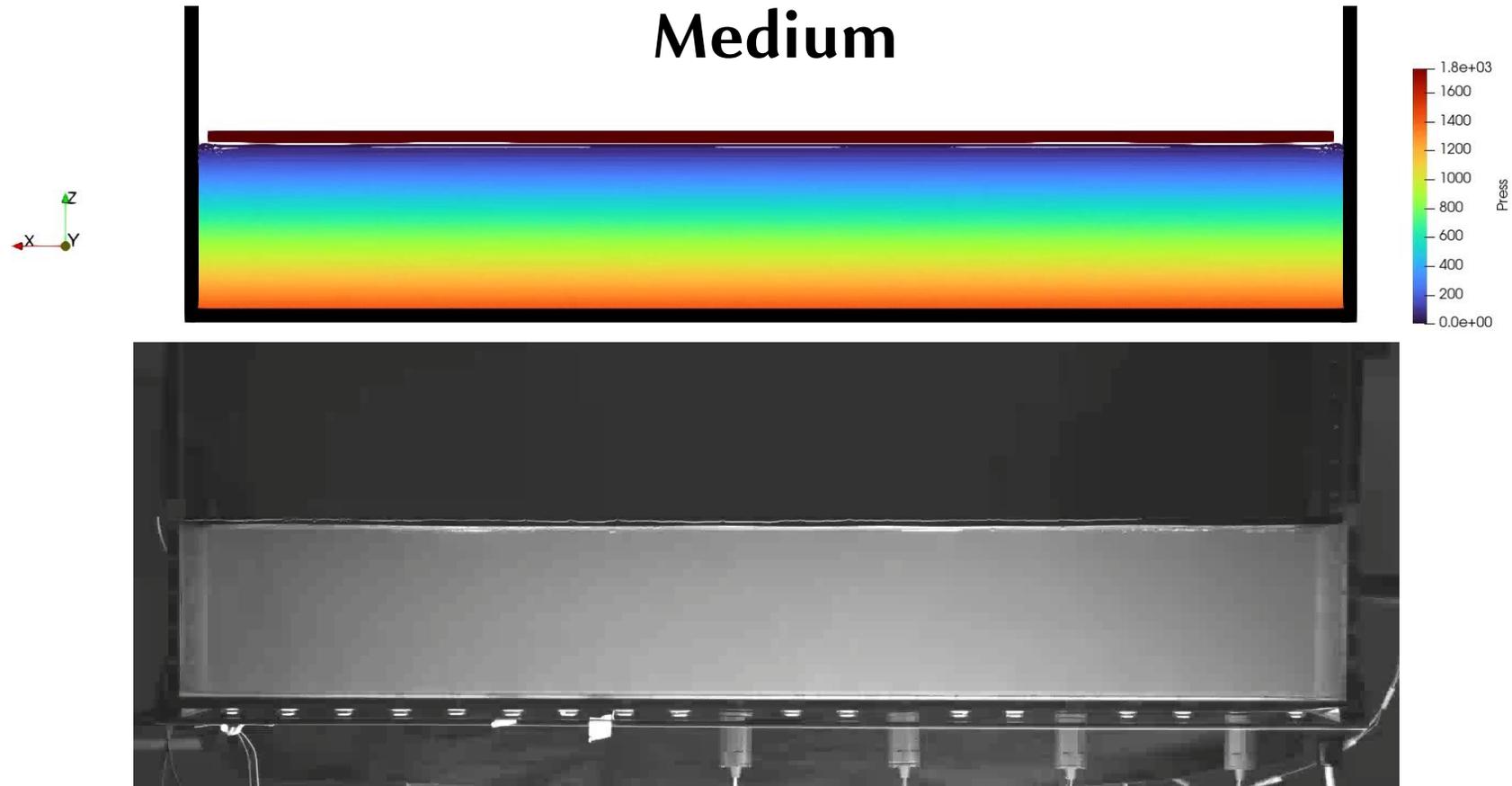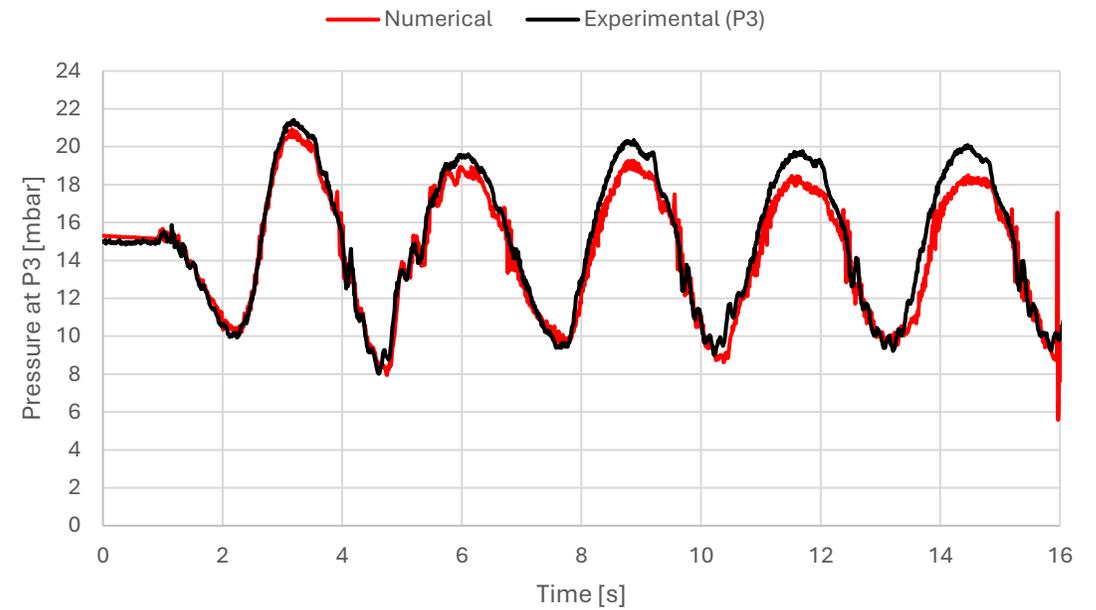
Results

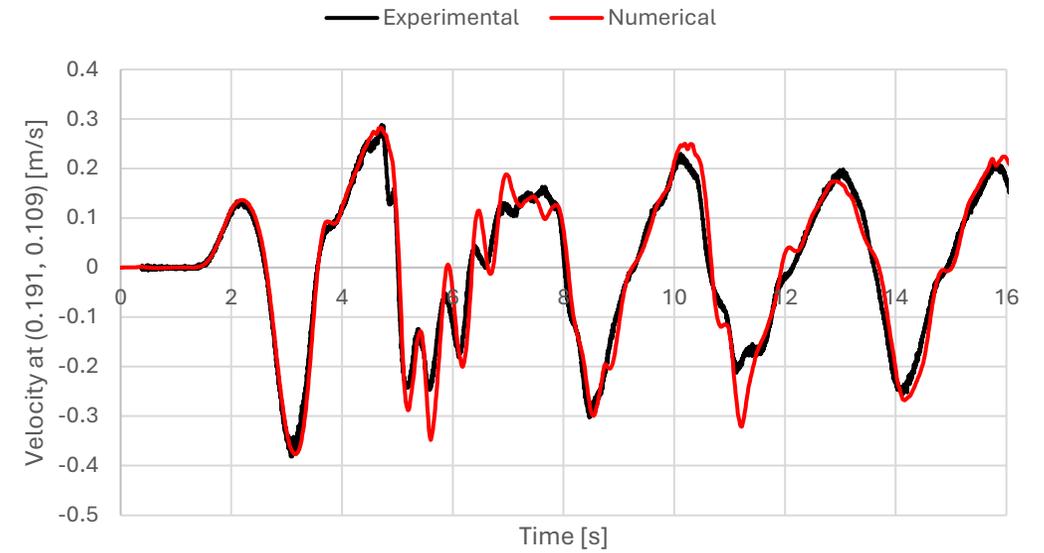Medium
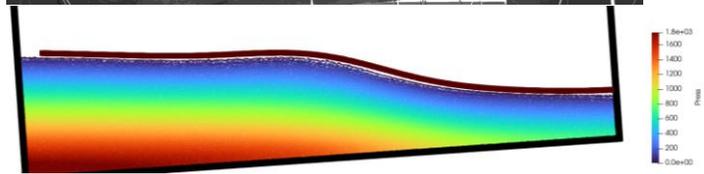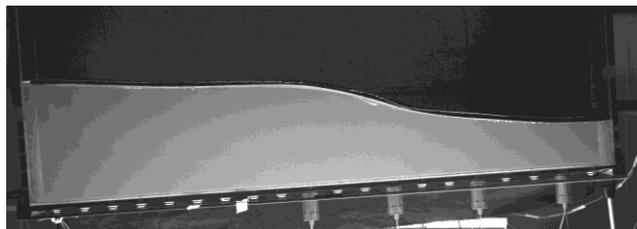
Results

Medium

t = 3.80s

t = 6.58s

t = 32.08s
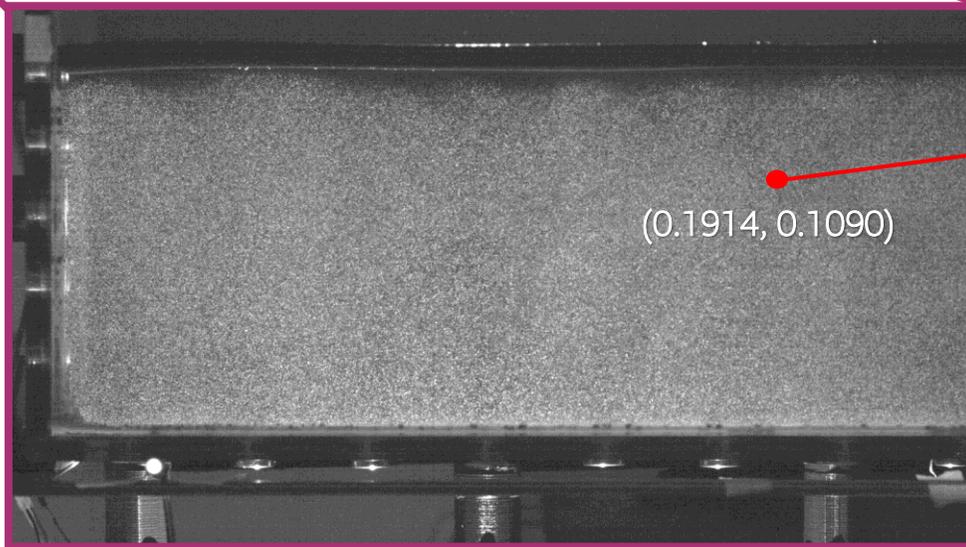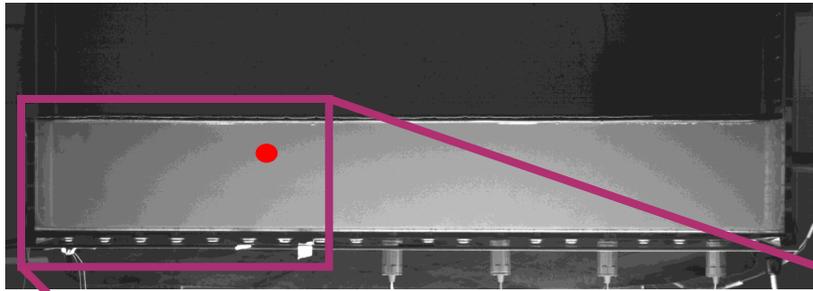
Results

Medium

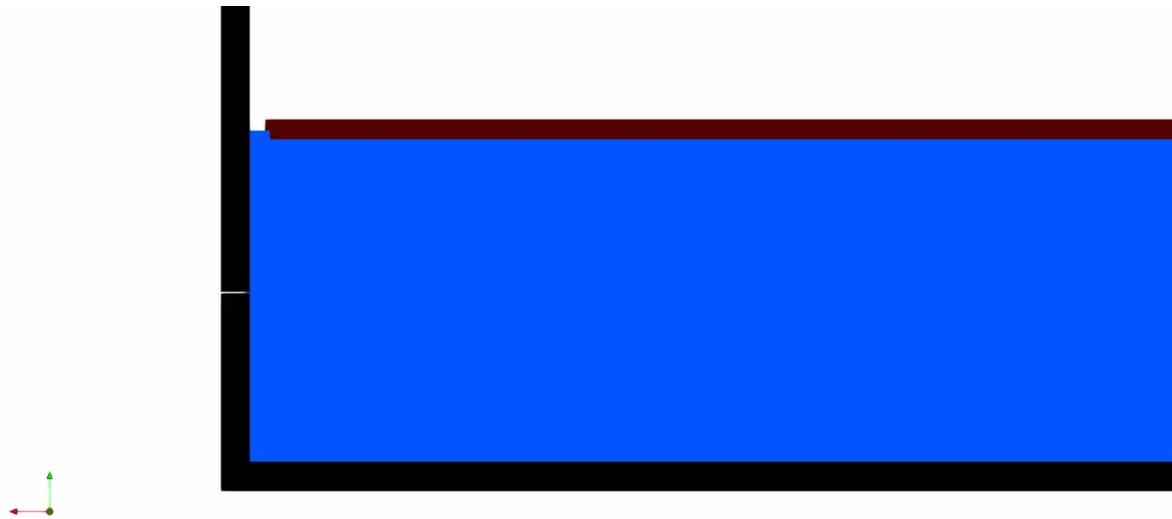# Results

Pressure

Pressure Sensor 3 (0.025,0)

Results

PIV Flow velocities

Results

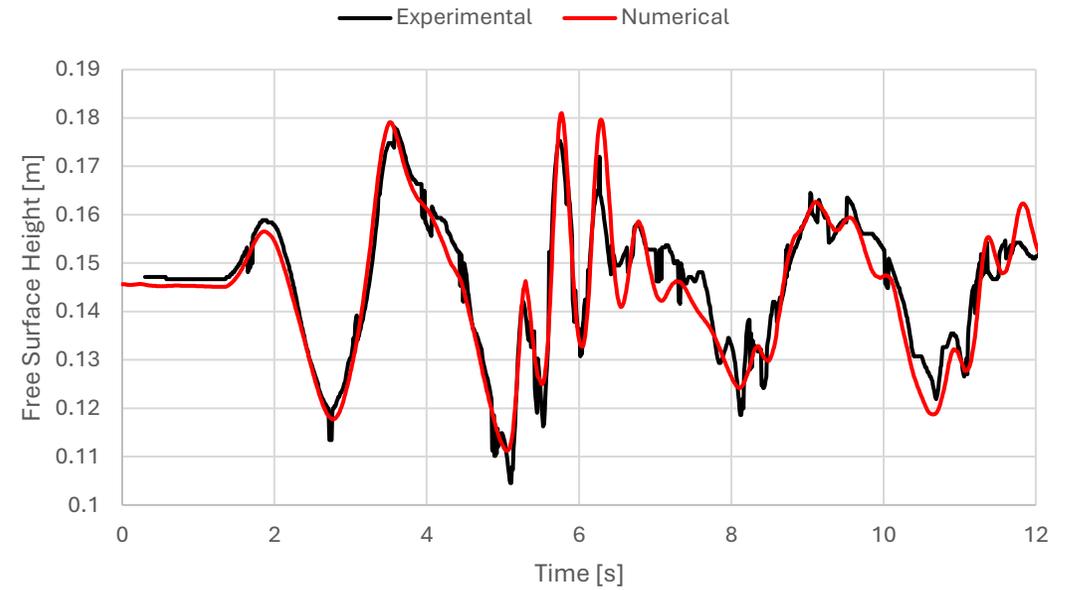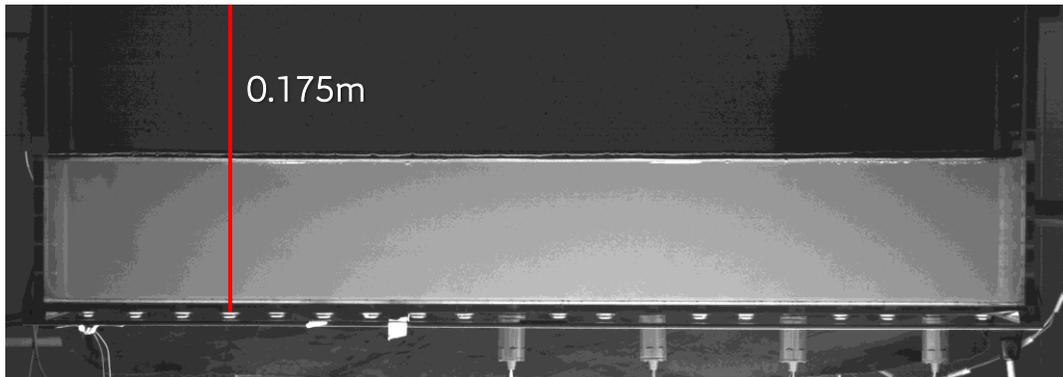## PIV Flow velocities

Results

Free-surface Elevation

Future Ideas

Currently working on:

1. Numerical Validation paper currently being developed

Possible future projects

1. Mooring implementation on a wave flume and/or 3D

2. Comparison with other codes, or other flexible materials

3. Dimensioneless parametric analysis

4. Complex floating photovoltaic platforms, such as the Alqueva dam

8th DualSPHysics Workshop

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Ourense, 29th January 2026

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