# 3rd Iberian Congress – Advances on SPH

23 -24 January 2024, Ourense, Galicia, Spain

# Validation of DualSPHysics for Fluid-Structure interaction of waves and flexible floating structures

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NOVA SCHOOL OF SCIENCE & TECHNOLOGY

Ourense, 23rd January 2024

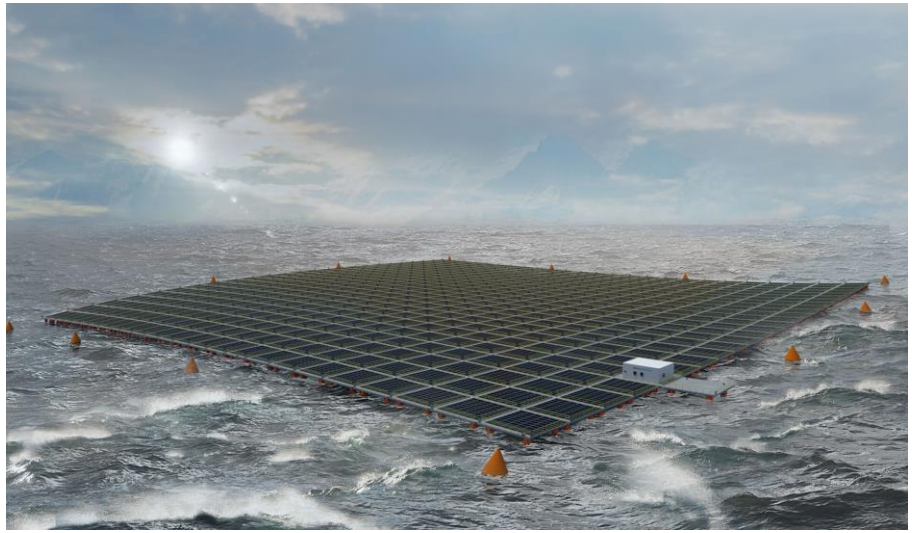
EPhysLab Campus da Auga Universidade de Vigo

# Summary

1. *Motivation*
2. *Objectives*
3. *Background*
4. *Experimental Methodology*
5. *Results*
6. *Future Objectives*

# Motivation

## Offshore Floating Photovoltaic Systems

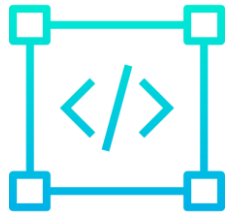


Example of a planned Floating PV system. (Marine Energy, March 20, 2020. Retrieved from: www.offshore-energy.biz/saipem-and-equinor-eye-offshore-floating-solar/)

Floating PV system sharing infrastructure with offshore wind turbine. (Bernadette Geyer, June 26, 2023. Retrieved from: www.pv-magazine.com/2023/06/26/offshore-floating-vs-land-based-pv-systems/)

# Motivation

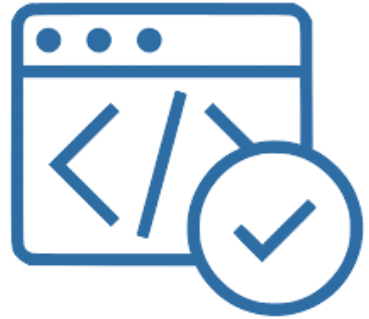
Lack of a fully coupled Fluid-Structure Interaction code for flexible structures



Advances in DualSPHysics Code allowing flexible structures

# Objectives

## Validate Dualshpysics for FSI with flexible structures

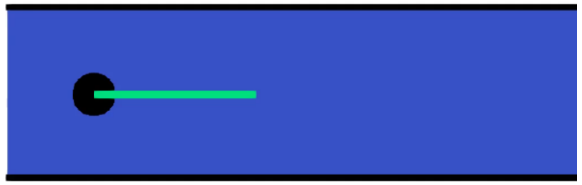


- Use data from literature or well known case studies
- Create our own experimental data

# Objectives

## Use data from literature or well known case studies

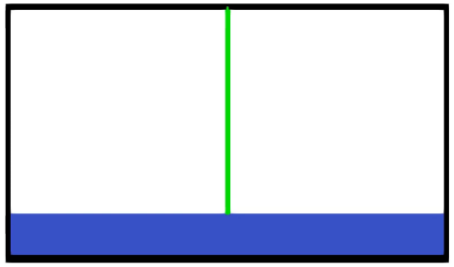
**CaseTurekHronFSI2**



Particles: 173,293
Physical time: 15 s
Runtime (RTX 3080 Ti): 2 h

Time: 0.00 s

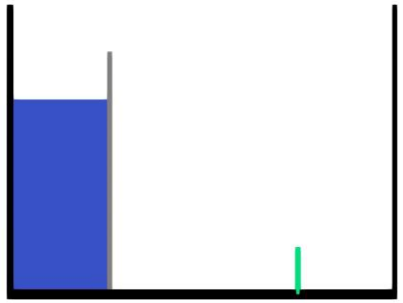
**CaseRollingTankHanging**



Particles: 50,022
Physical time: 5 s
Runtime (RTX 3080 Ti): 1.72 h

Time: 0.00 s

**CaseDambreak2D_FSI**



Particles: 27,946
Physical time: 1 s
Runtime (RTX 3080 Ti): 6.2 min

Time: 0.00 s

Three cases studied in DualSPHysics. (DualSPHysics youtube channel, October 16, 2022. Retrieved from: https://www.youtube.com/@DualSPHysics)

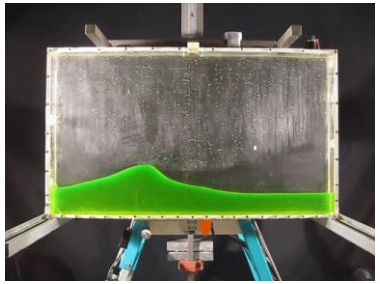
# Objectives

## 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

# Background

## Why the Sloshing tank ?

### Disadvantages

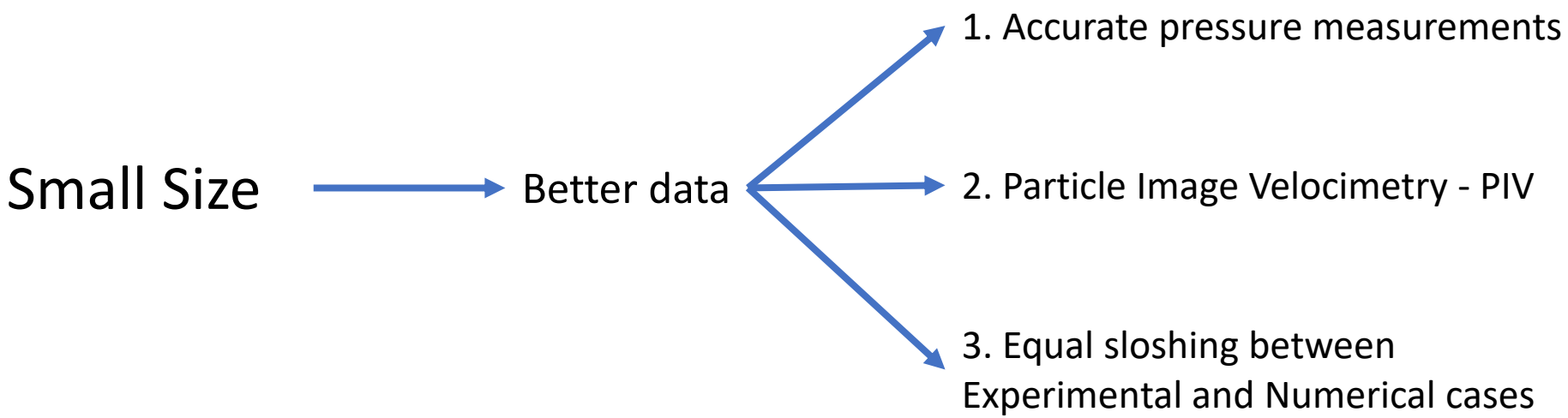
- Not real oceanlike waves
- Sidewalls

### Positive aspects

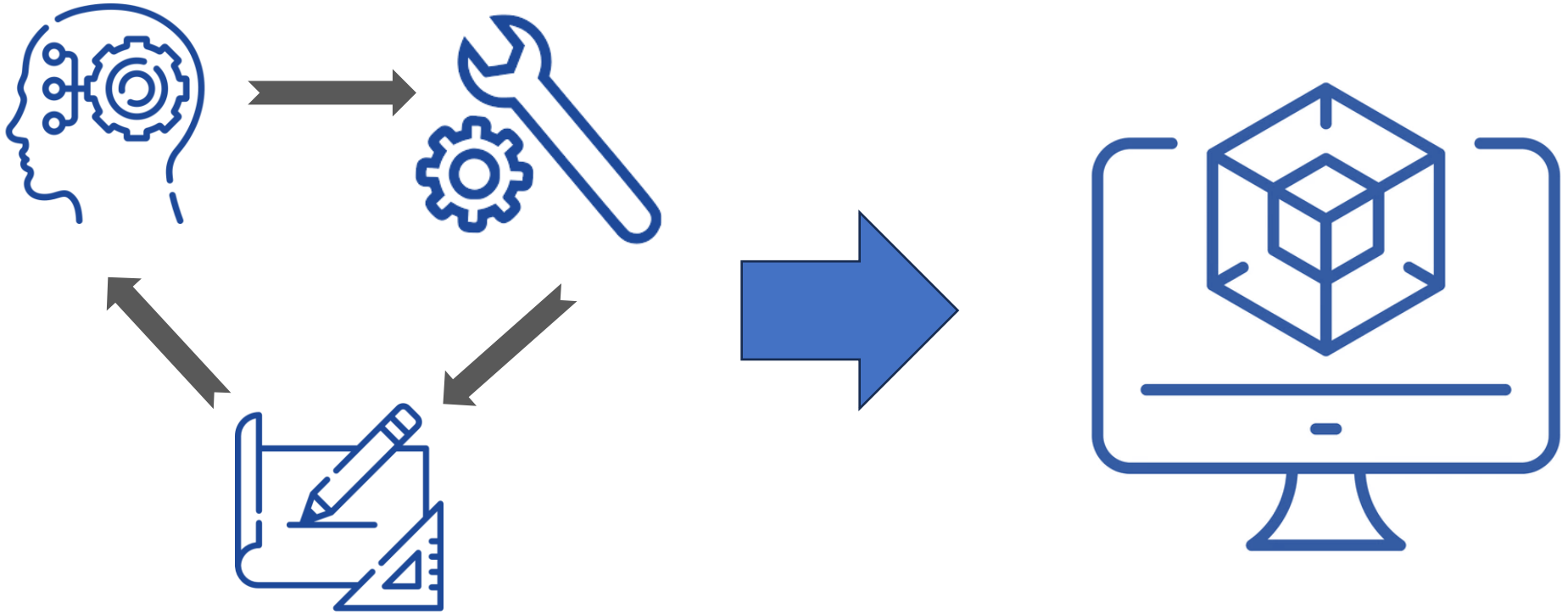
- Small size
  - Less particles in SPH
  - Better Experimental data

# Background

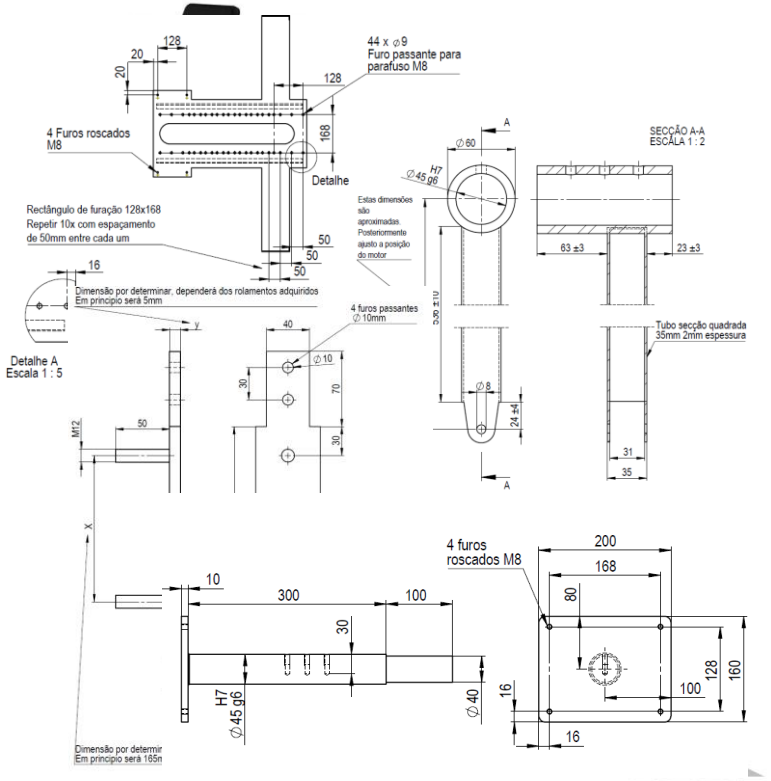
## Why the Sloshing tank ?

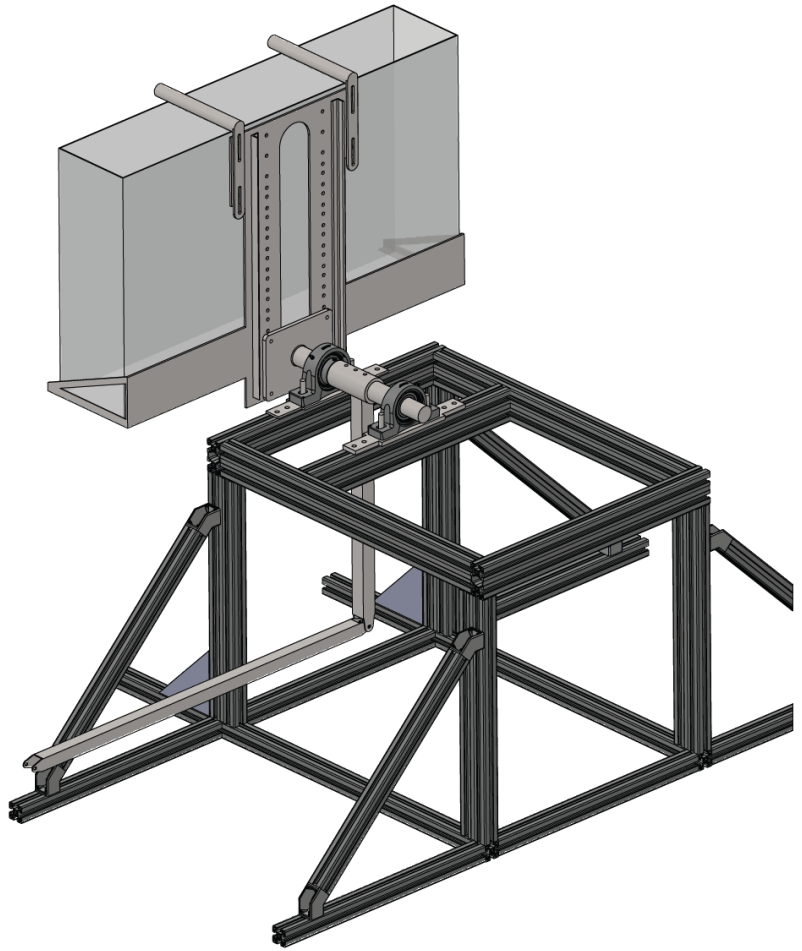


# Methodology

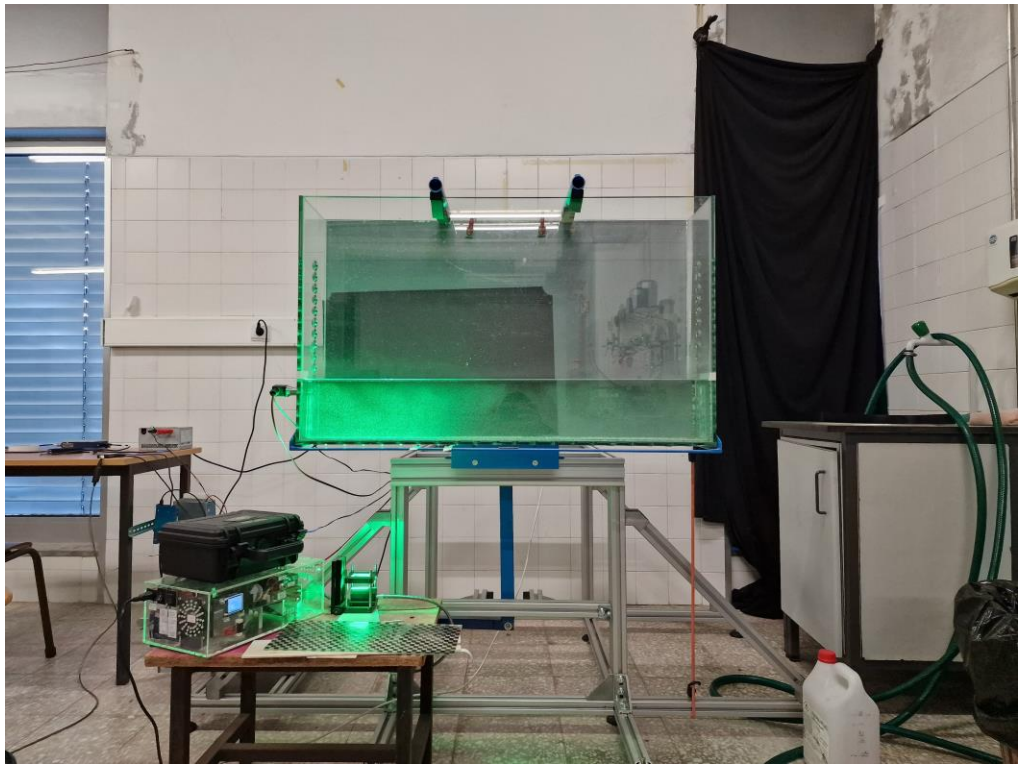


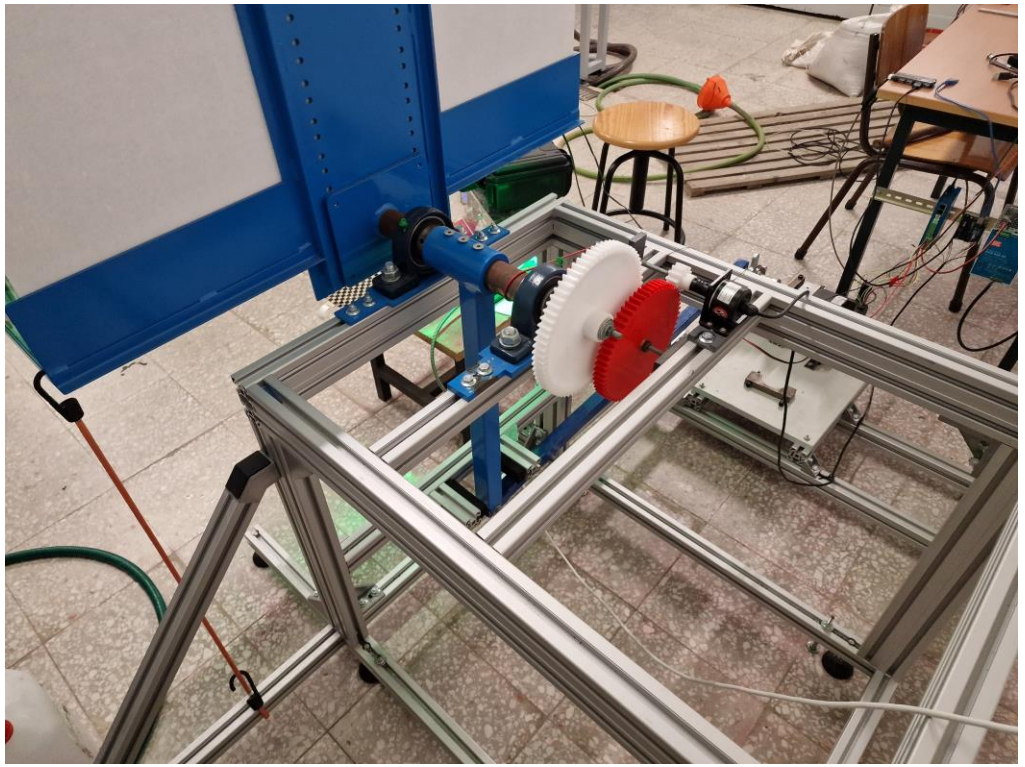
# Methodology



# Methodology

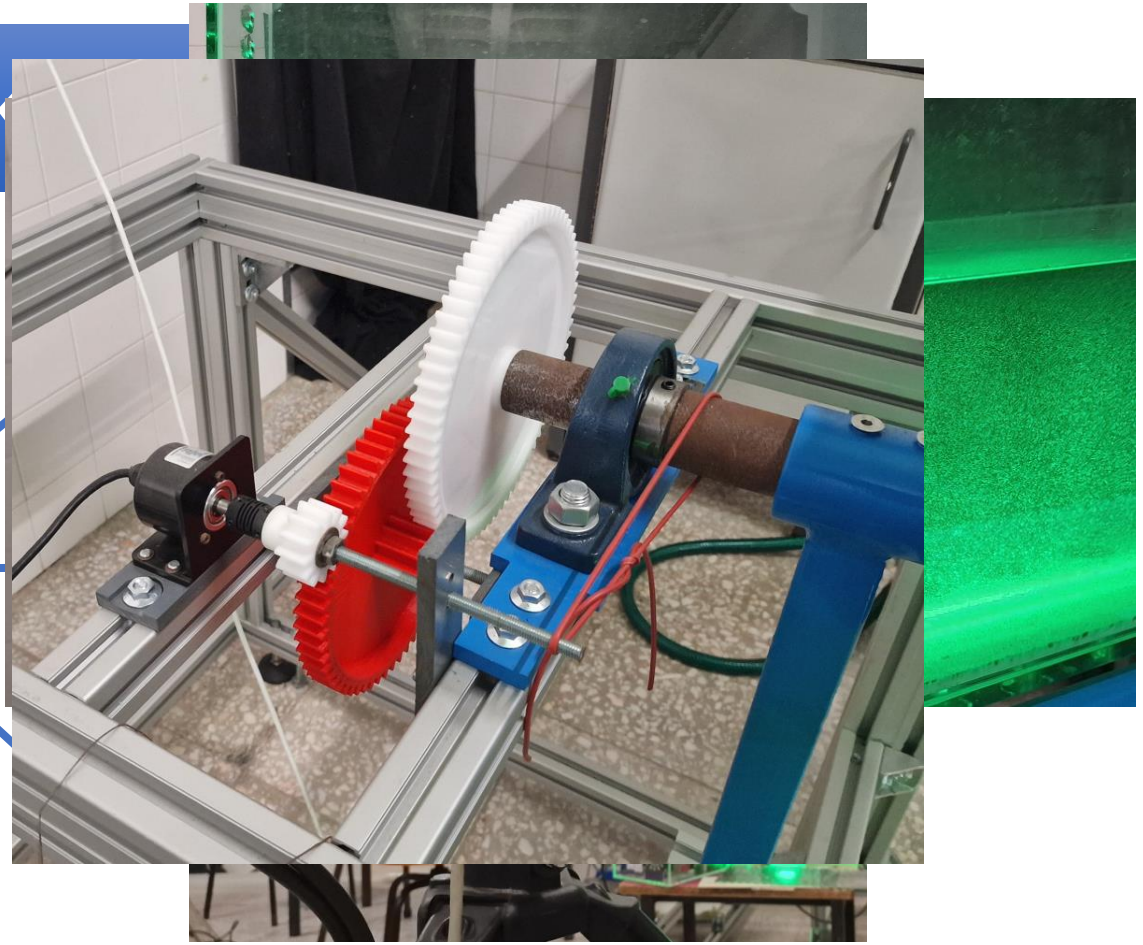




# Methodology

## Why the Sloshing tank

Small Size → Better data



# Methodology

1. Accurate pressure measurements

Navier Stokes Equations

$\nabla \cdot \vec{u} = 0$ → Conservation of Mass

2. Particle Image Velocimetry - PIV

$$\rho \frac{D\vec{u}}{Dt} = -\nabla p + \mu \nabla^2 \vec{u} + \rho \vec{F}$$

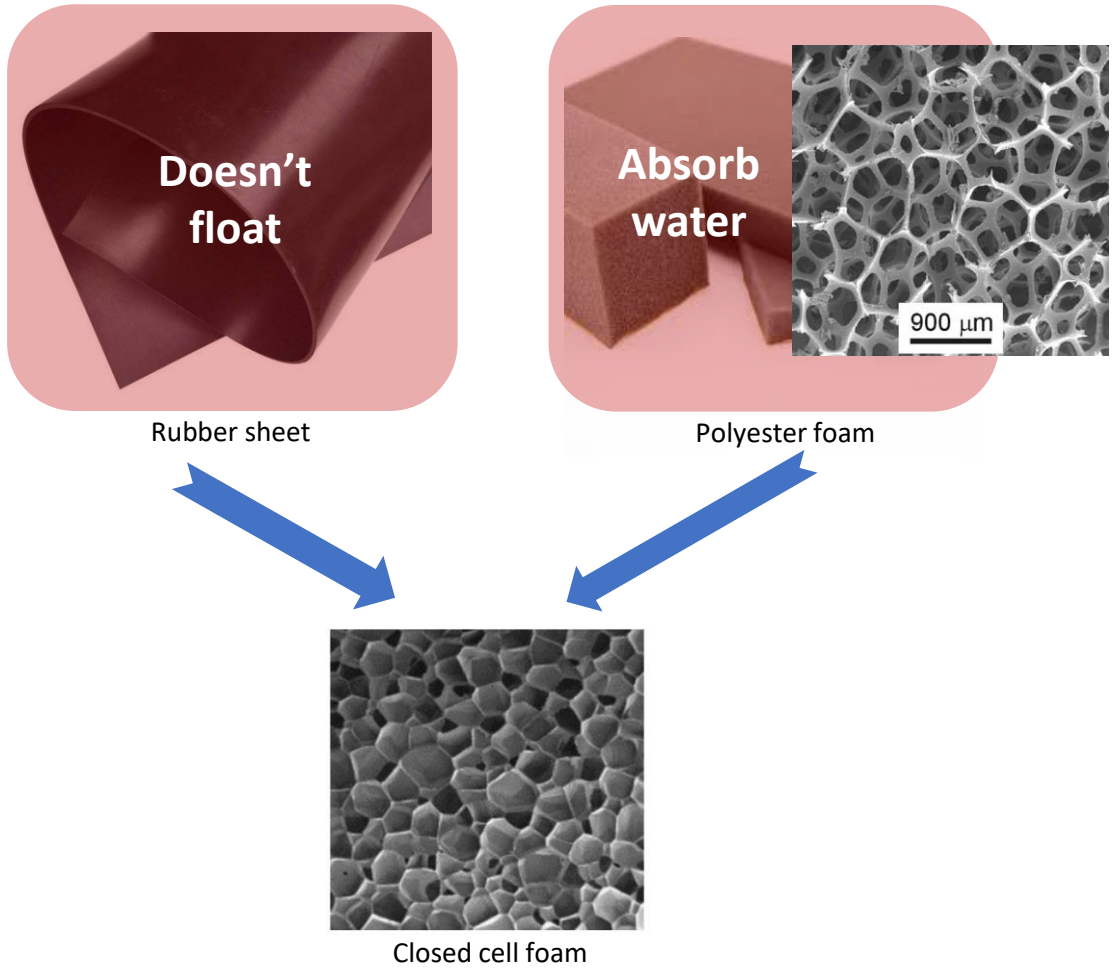
3. Equal sloshing between
Experimental and Numerical cases

# Methodology

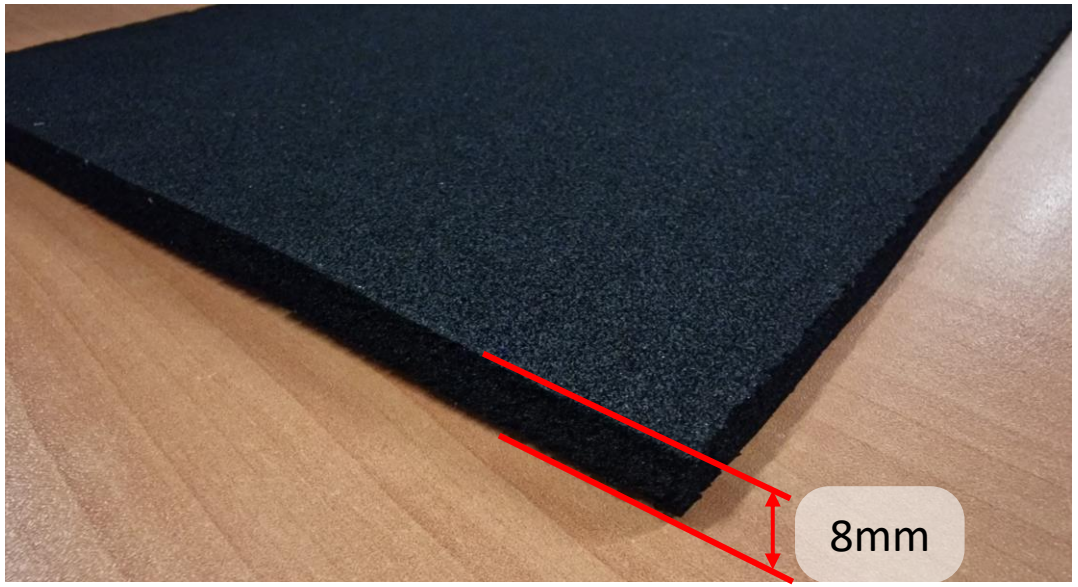
## Material for floating body

### Requirements

- Highly flexible
- Float on water
- Isotropic



# Methodology




EPDM Rubber foam sheet

# Methodology

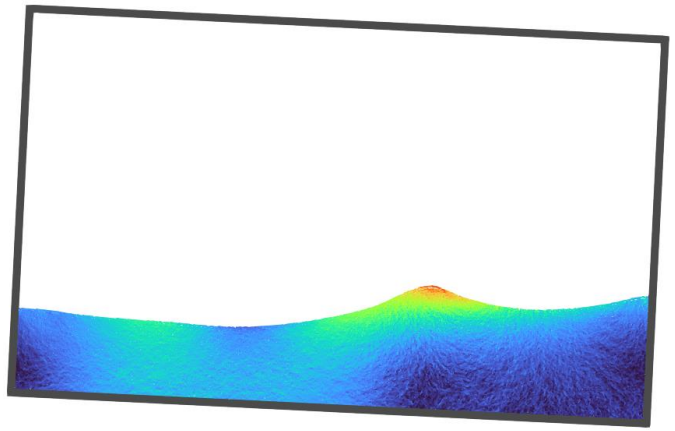
DualSPHysics_v5.2

/bin/windows

DualSPHysics5.2_win64

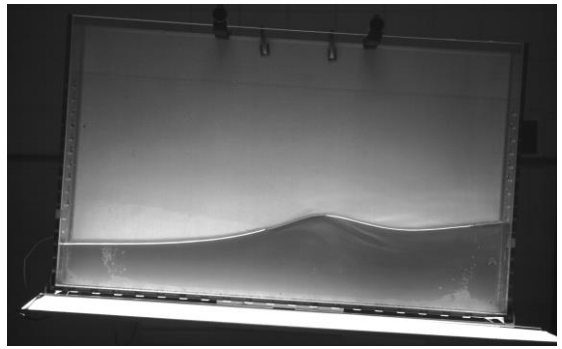
/FlexStruct/DualSPHysics5.2_FlexStruc_win64

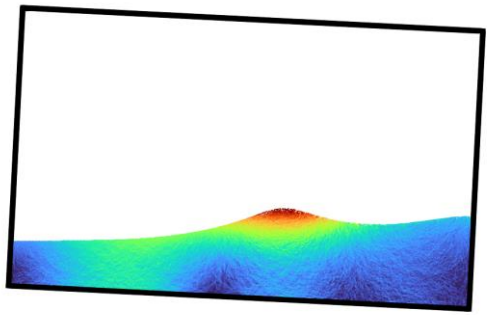
Both with mDBC on the tank walls



# Validation

## 1. WITHOUT FLOATING BODY



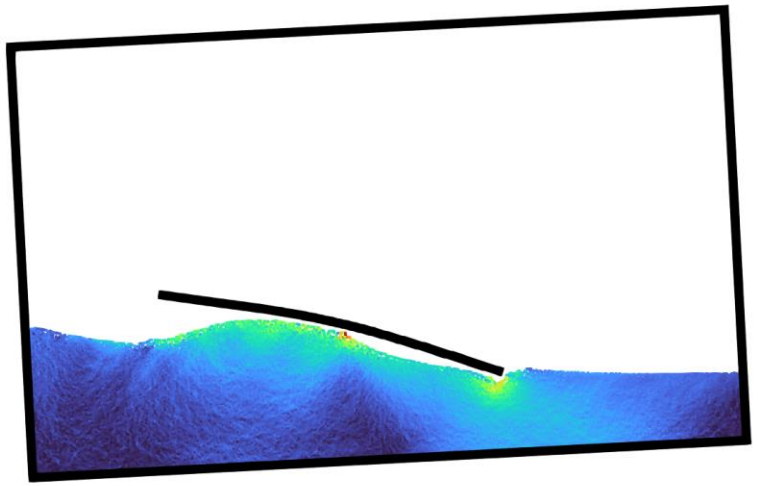


1. Pressure on tank walls

2. PIV

# Validation

## 1. WITH FLOATING BODY

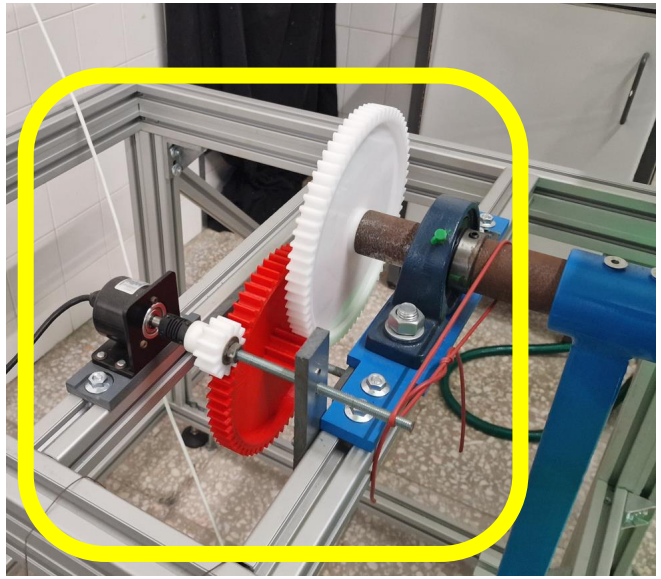


1. Pressure on tank walls

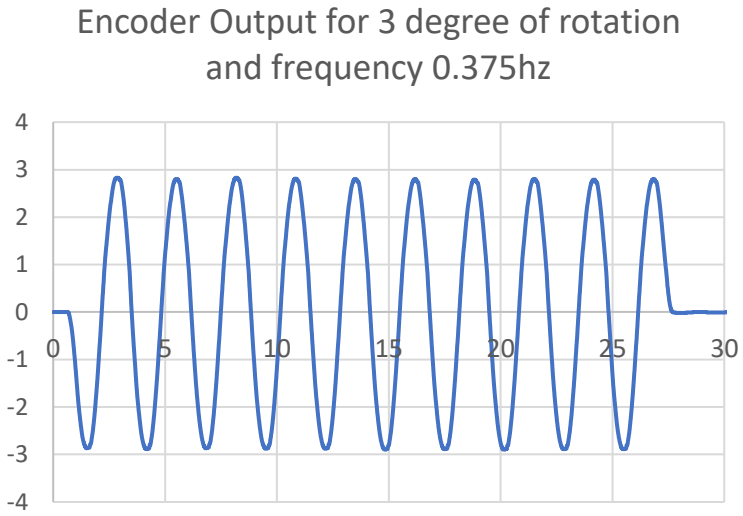
2. PIV

2. Body deformation

# Validation



Rotary encoder with precision of 1000 points/rotation
With gears to increase precision to 31250 points/rotation
or 87 points/degree

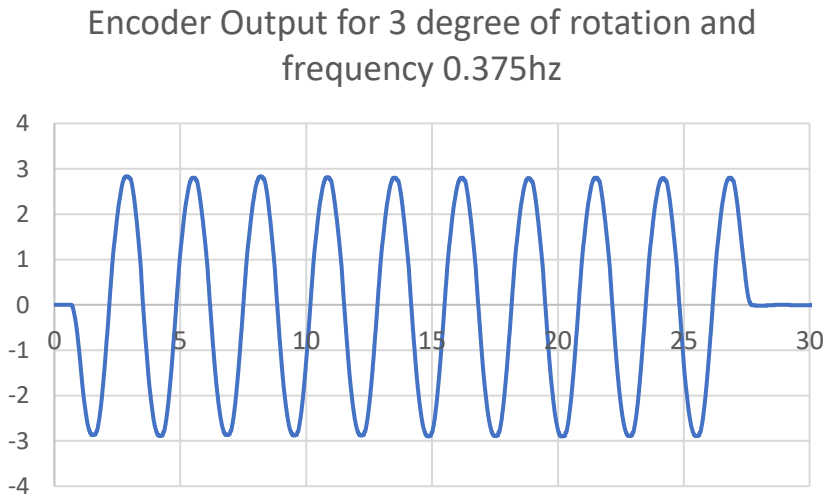



"CoolTermCapture.dat"

cpu gpu DualSPHysics

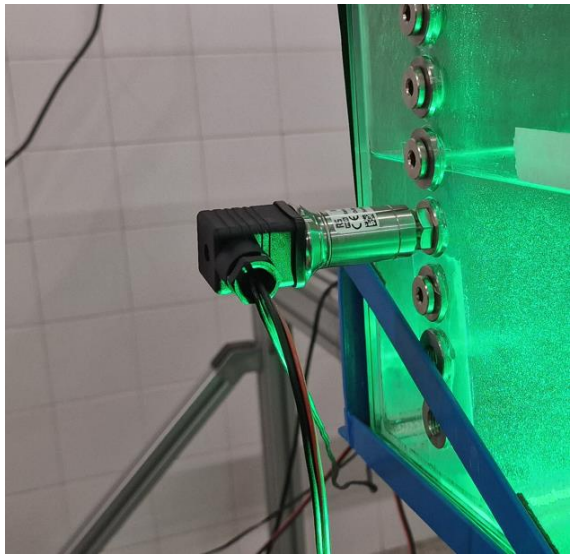
# Results

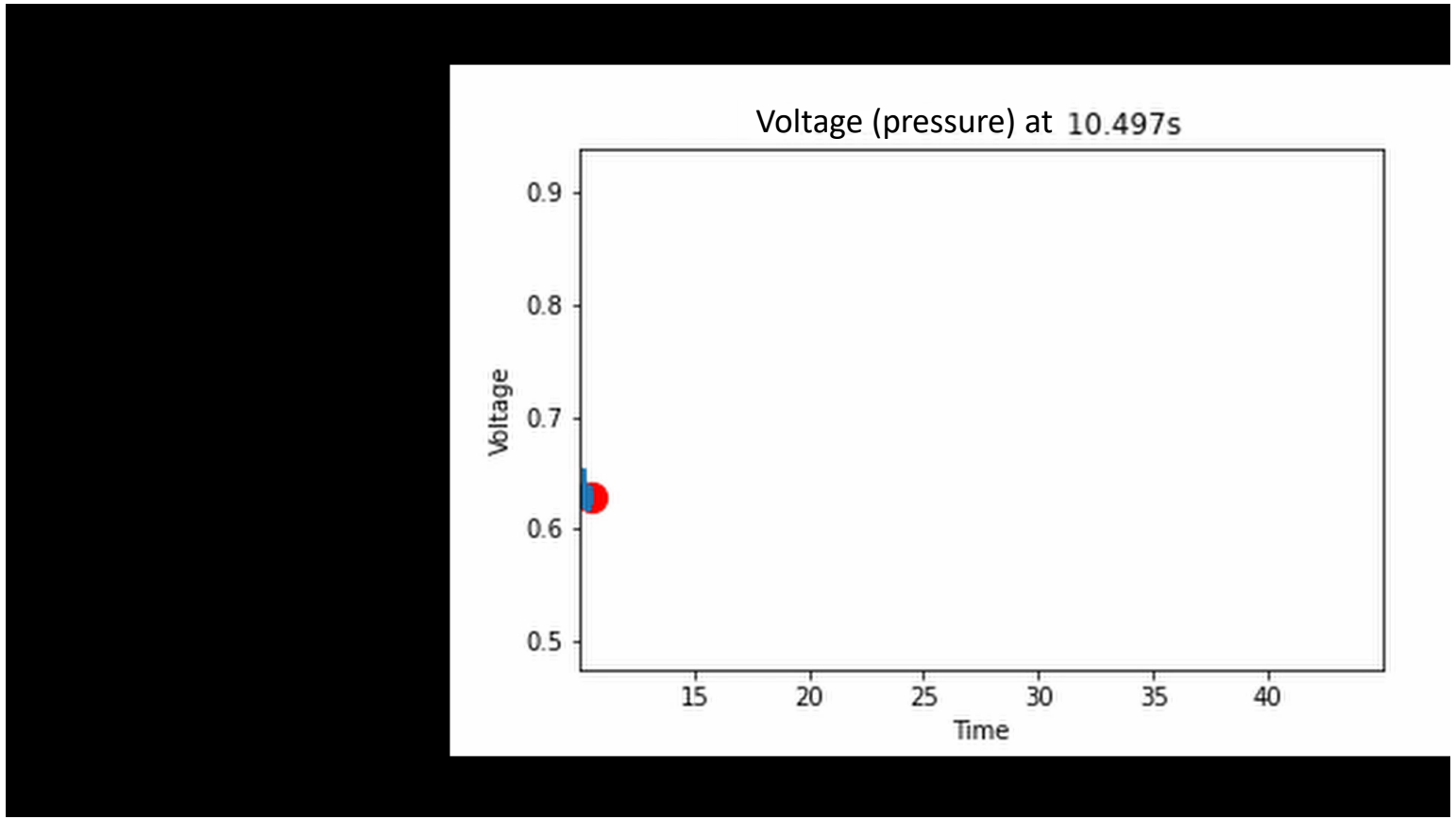
# Results


Encoder Output for 3 degree of rotation and frequency 0.375hz
4
3
2
1
0
-1
-2
-3
-4
0
5
10
15
20
25
30


3 degree of rotation at 0.375hz

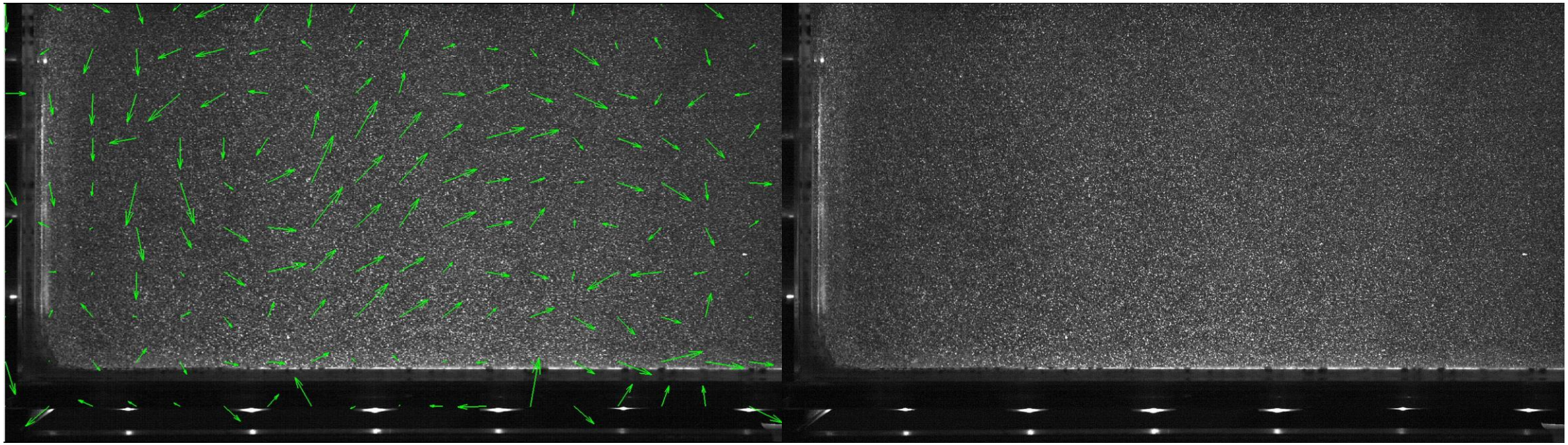
# Results




Voltage (pressure) at 10.497s
0.9
0.8
0.7
0.6
0.5
Voltage
15
20
25
30
35
40
Time

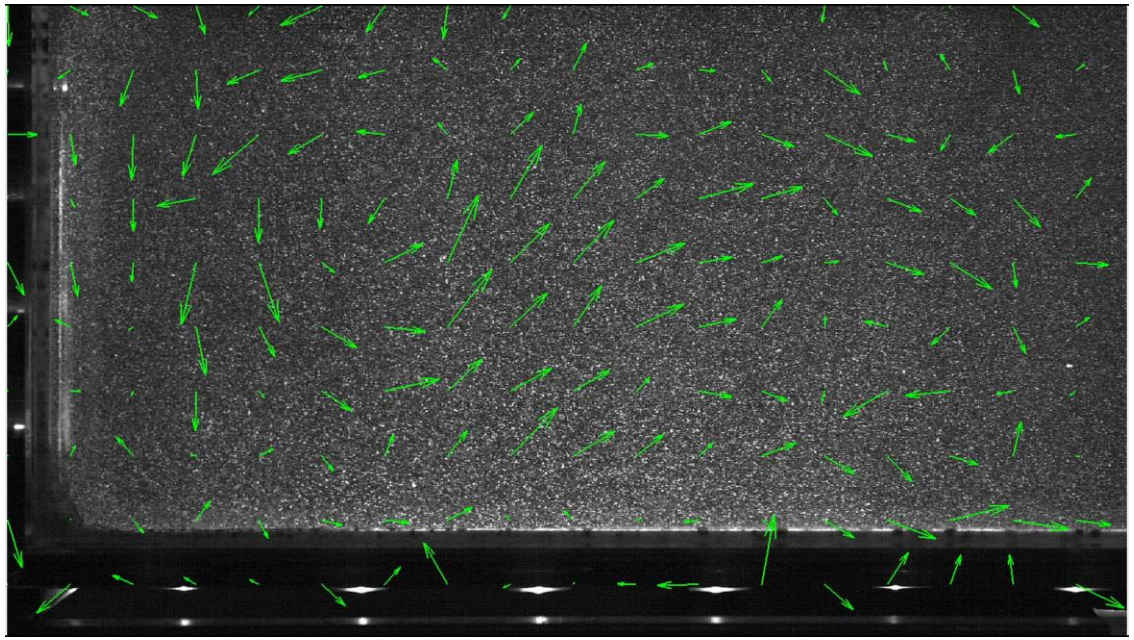
# Results

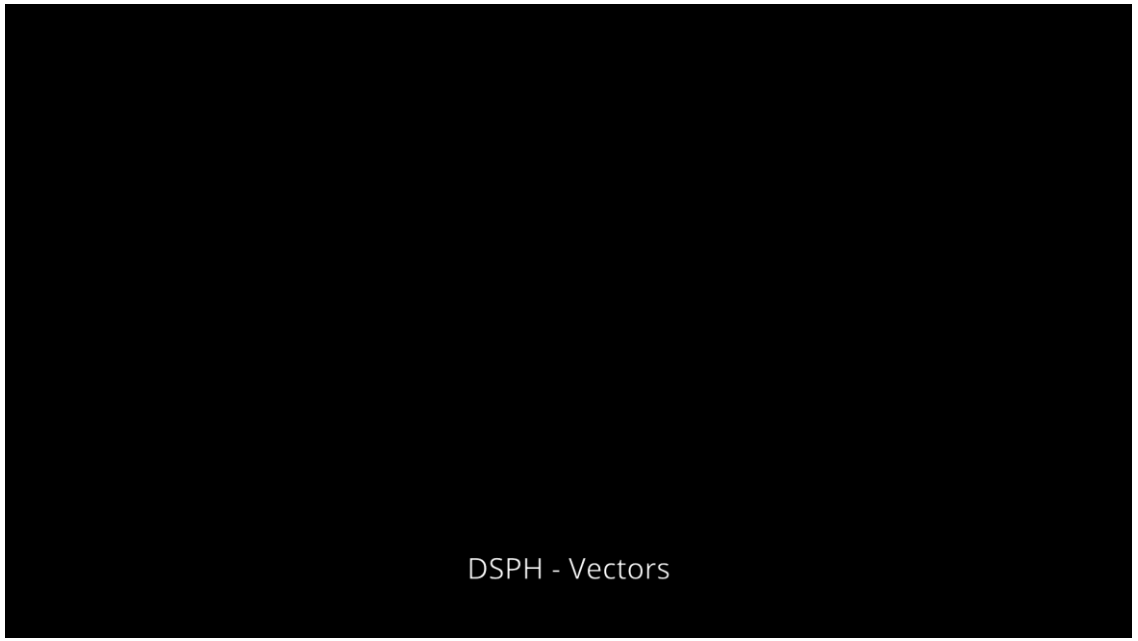
Particle Image Velocimetry



# Results

Particle Image Velocimetry





# Results

# Results

DualSPHysics does not yet contemplate collisions between type ‘moving’ objects

# Future

1. A lot of lab work, both numerical and experimental

   1. Publish Data Set Paper

      2. Publish DualSPHysics FlexStruct validation paper

2. Long term possibility: validation on wave flume

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