

UiO : Department of Mathematics
University of Oslo

Water wave experiments and applications

Atle Jensen

Contributions from:

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HYDRODYNAMICS LABORATORY

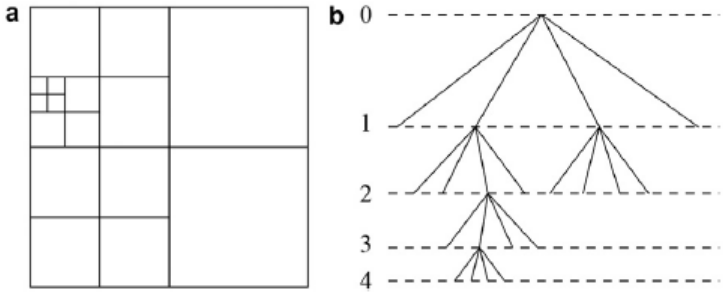
EARTH FLOWS

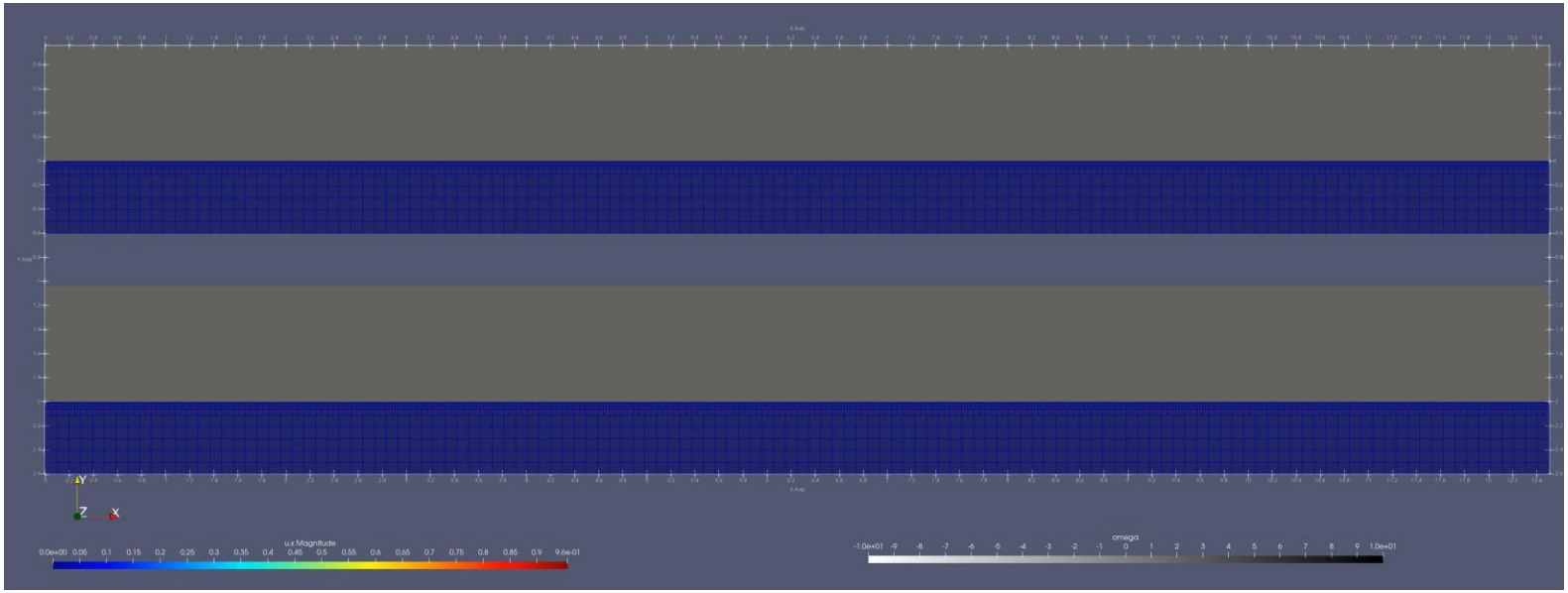
Outline

- Background/motivation
  - State-of-the-art modelling of water waves
- History
  - Hydrodynamics laboratory
  - C.A. Bjerknes laboratories
    - New 3D wave tank
- Floating wave energy converters
- Scaling and concluding remarks

Basilisk two-phase flow model

- Main features
  - Breaking focusing waves
  - Volume of fluids (2D & 3D)
  - Adaptive mesh refinement (quadtree/octr
  - Well balanced surface/momentum treatm



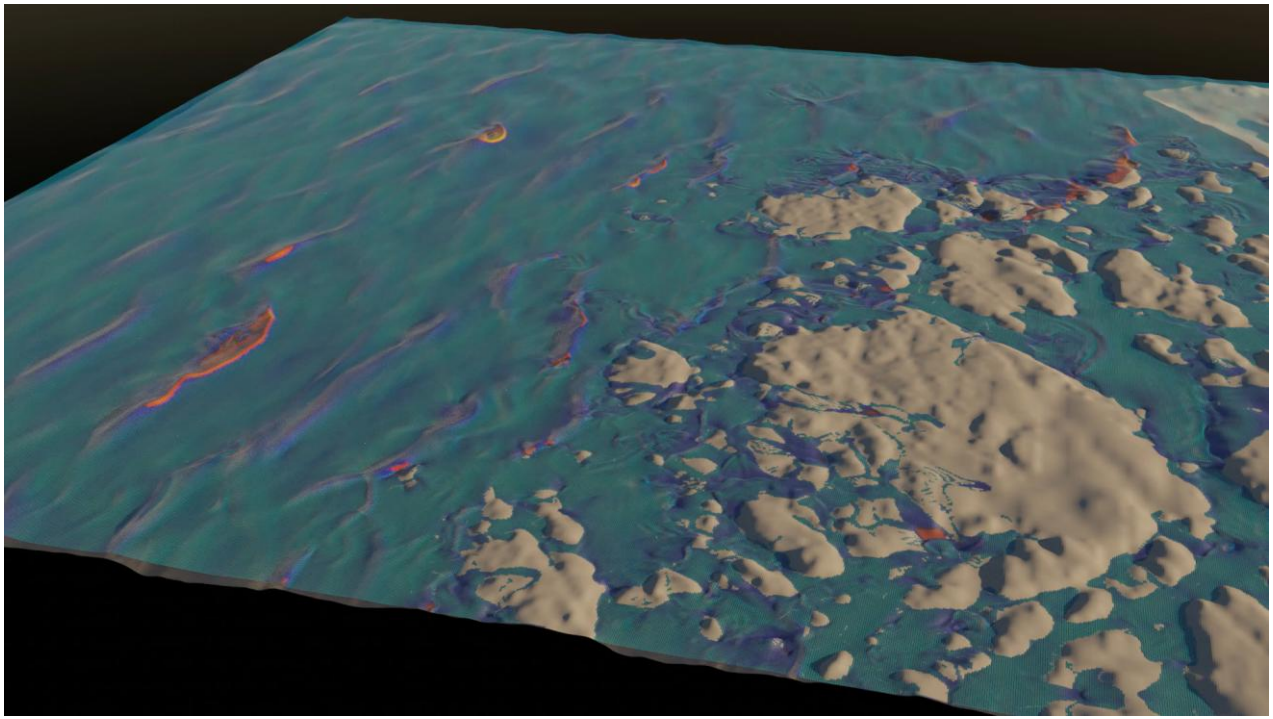


Wave model requirements

- Dispersion – inhomogeneous conditions, deep -> shallow water
- Reflection, diffraction
- breaking, overtopping?
- Energy dissipation (post breaking)

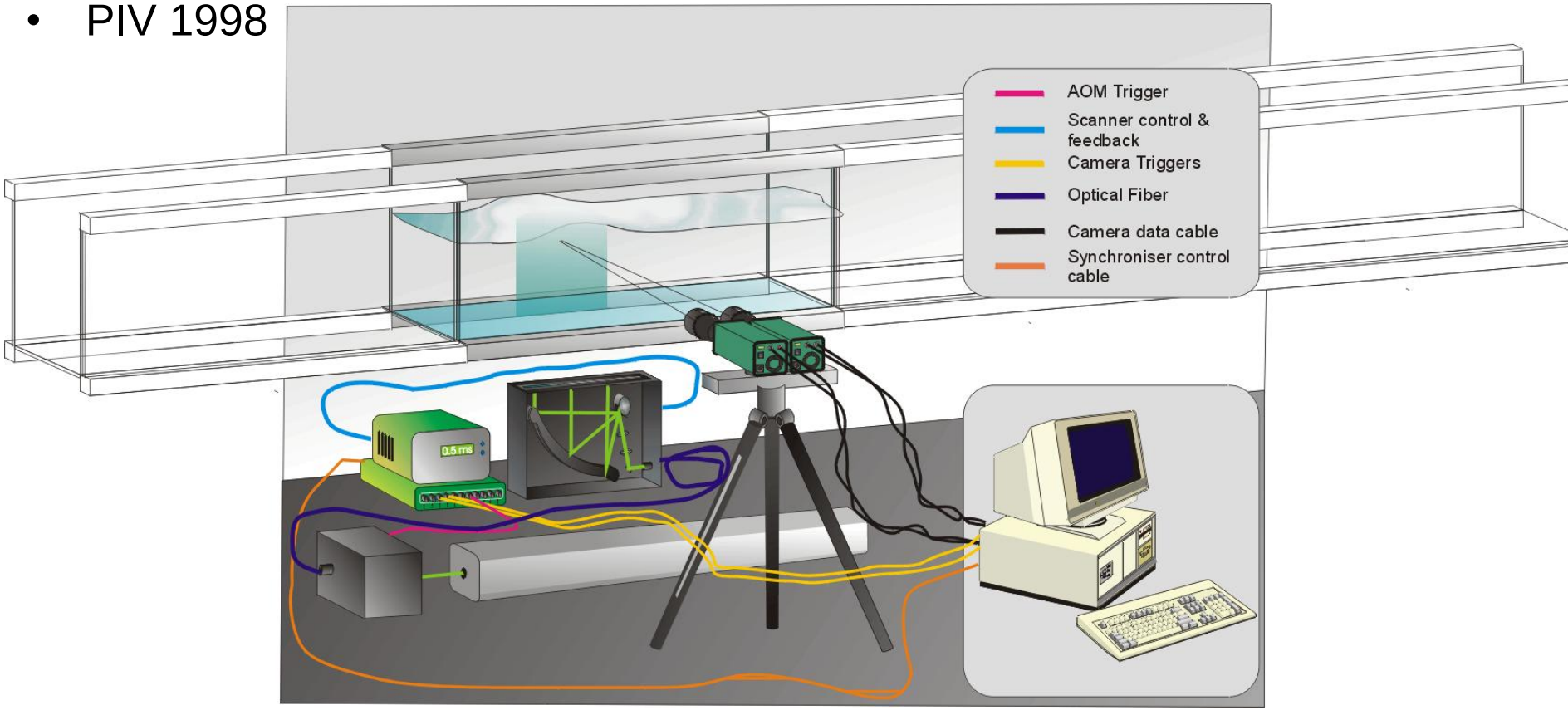
- Validation is needed

Basilisk multilayer solver (http://basilisk.fr), Lande et al. (2022)



Hydrodynamics lab, UiO

- Built by E. Høiland in 1965, PhD student of V. Bjerknes in 1939
- Refurbished 1994
- PTV 1996
- PIV 1998
- high speed in 2001
- Xray PTV in 2015
- Free Surface in 2017



C.A. Bjerknes laboratories

From 2D -> 3D, more realistic waves

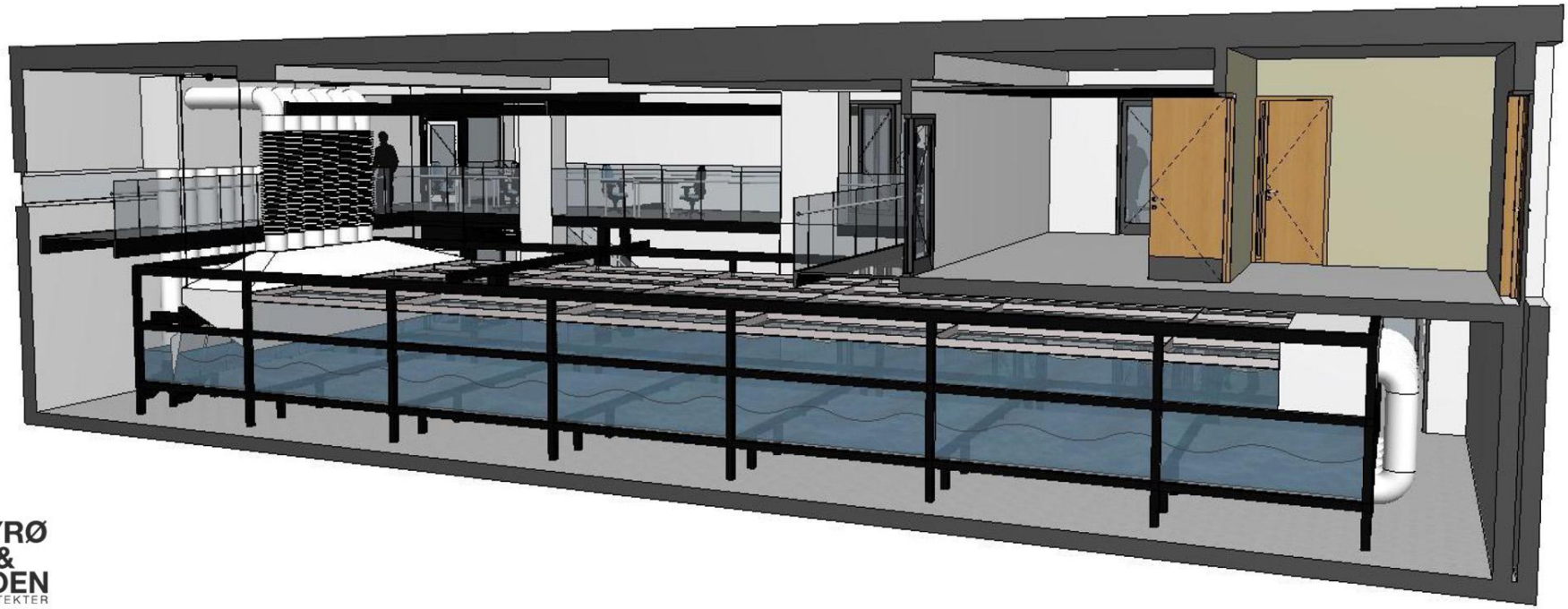




2014

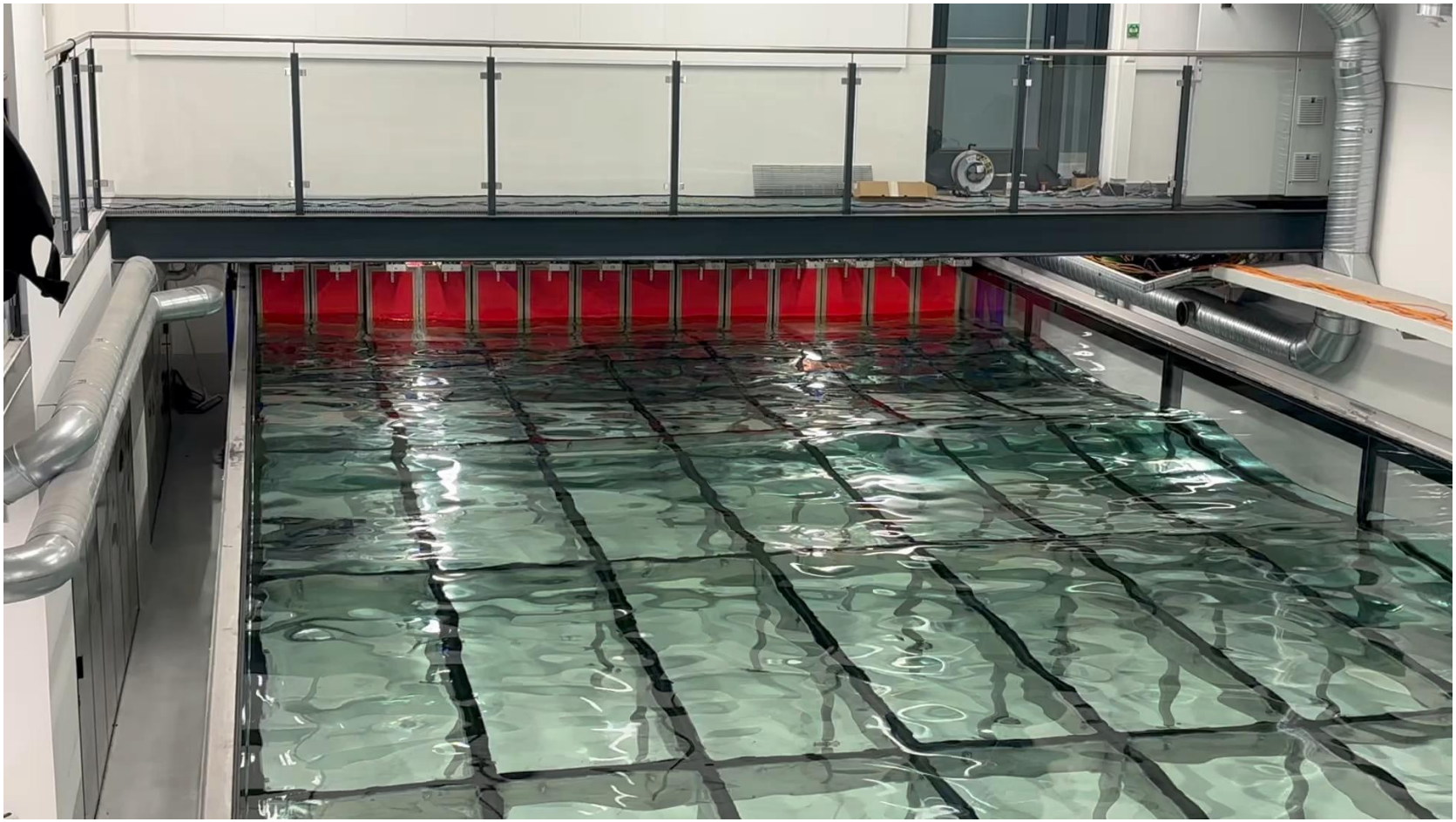
Hydrolab 2.0 - 2018

wind/waves facility
14 wave makers
size 20x7m
3D PIV/PTV
Fully transparent

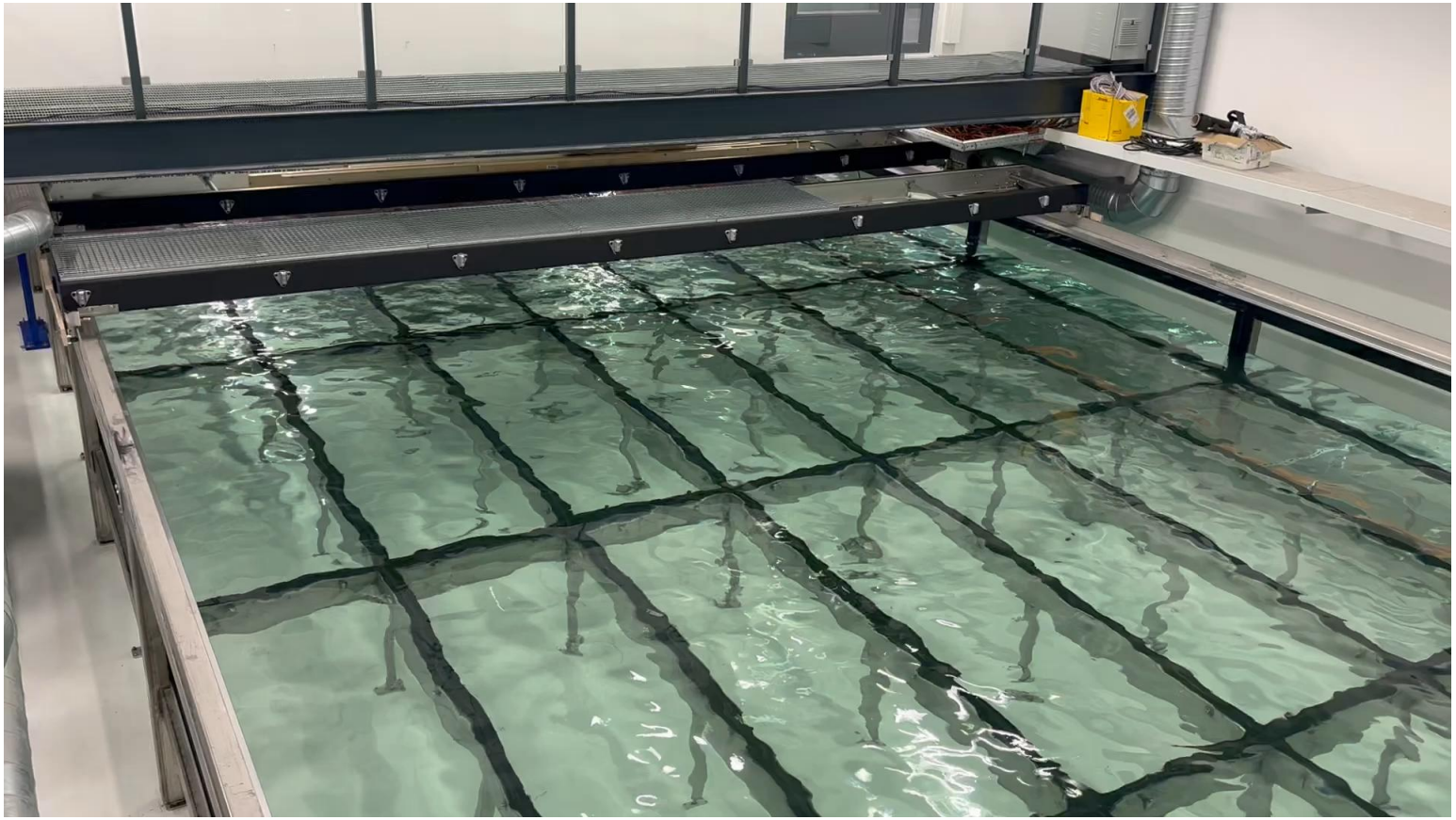


DYRØ & MOEN ARKITEKTER

First waves, 6th of June, 2024



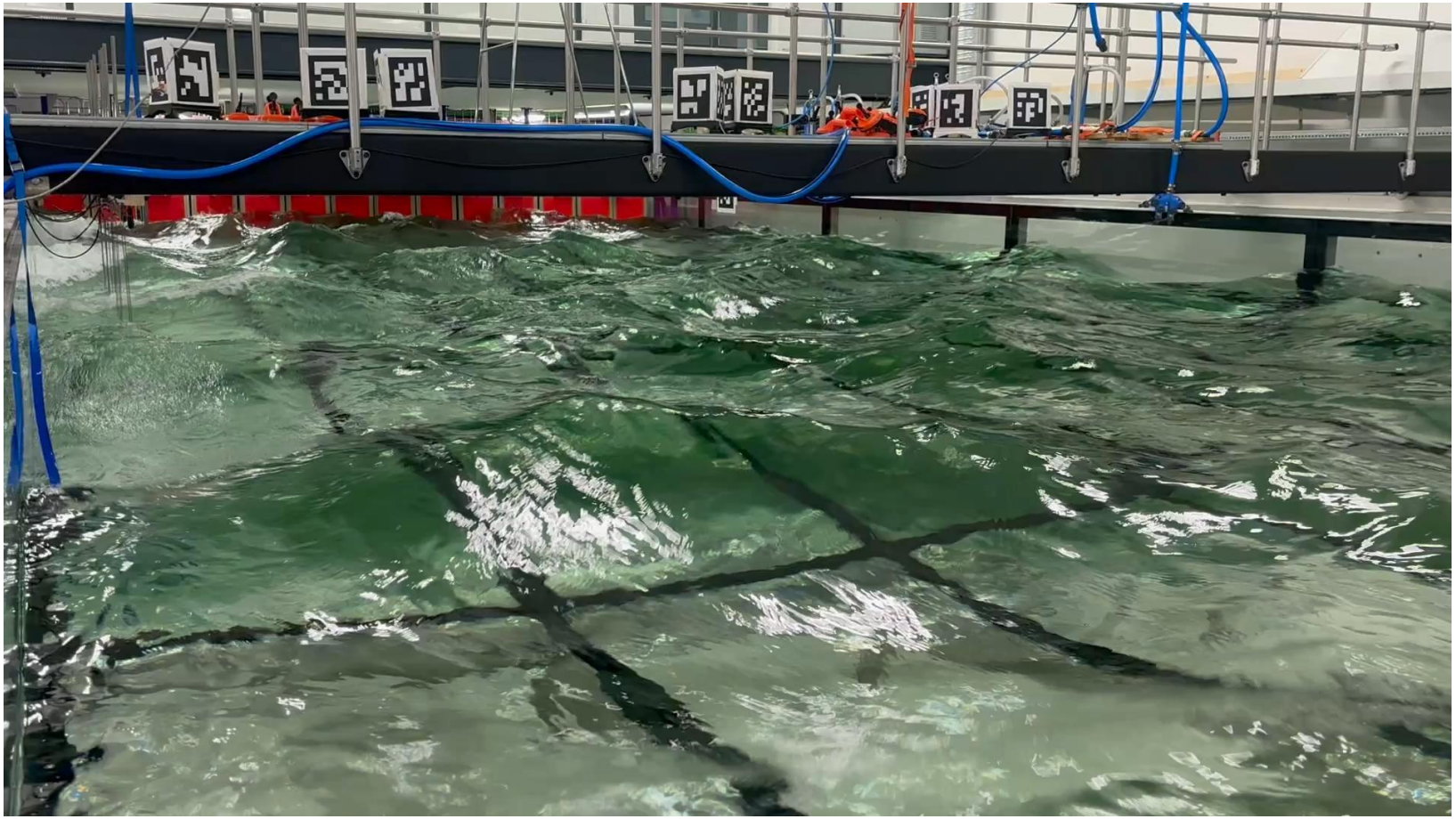
Breaking long waves, 2025



Focusing waves, 2025



Short crested



Possibilities

- 3D waves (and wind) generation
  - Wave spectra, e.g Jonswap – realistic ocean conditions
  - Short crested waves
  - Focusing waves, space and time
  - Solitary waves
- Instrumentation
  - 3D PTV/PIV; velocities, Eulerian and Langrangian
  - Wave elevation
  - Forces on structures
  - Motion capture – ArUco markers
- Modelling
  - Navier-Stokes
  - Physics-informed ML

Ongoing industry projects

- Floating solar energy – SunLit Sea (RCN funding)
- Offshore wave powered desalination – OceanOasis (RCN funding)
- Wave energy - Concrest Energy (UiO Growth House)

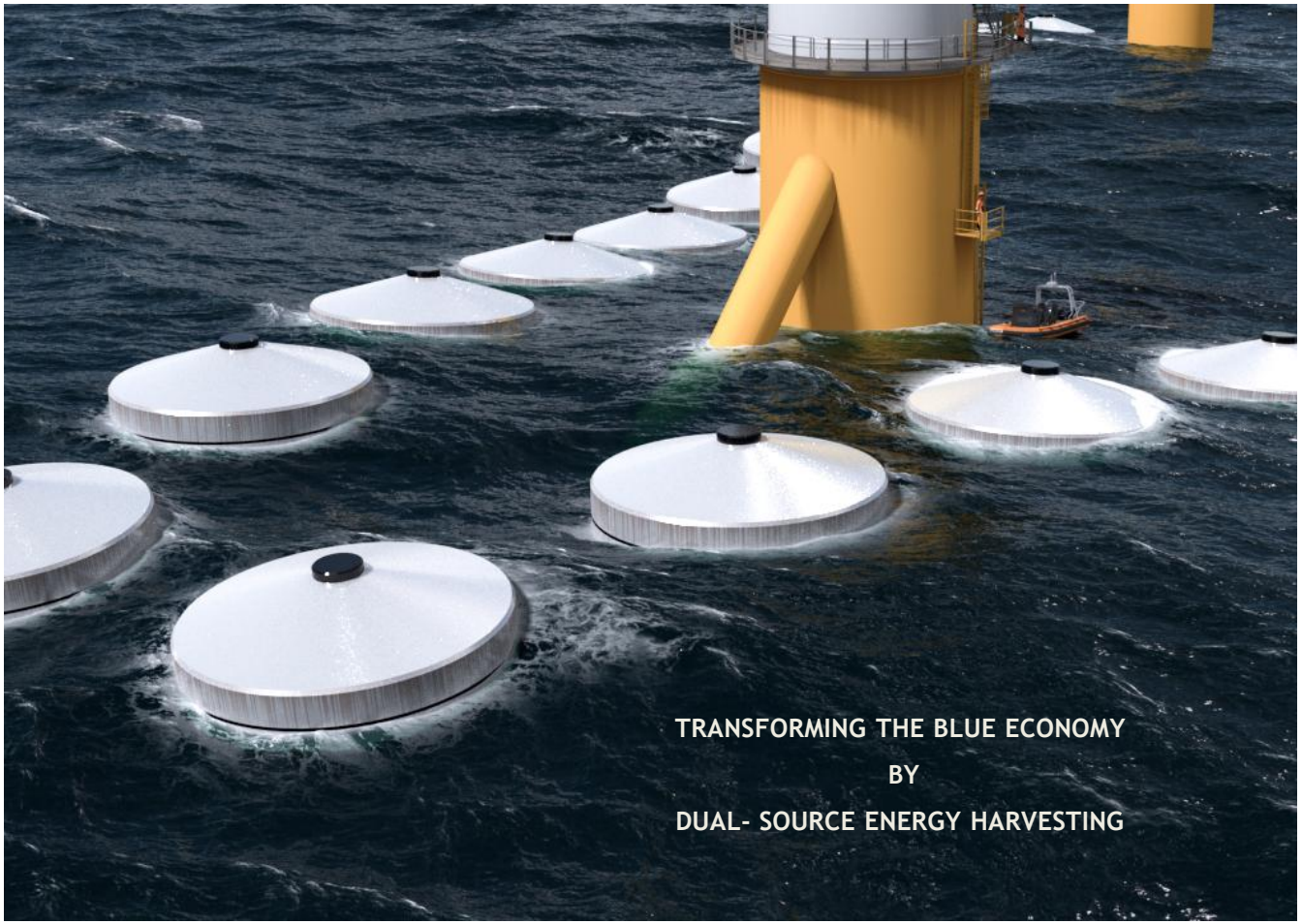
concrest ENERGY

ocean oasis

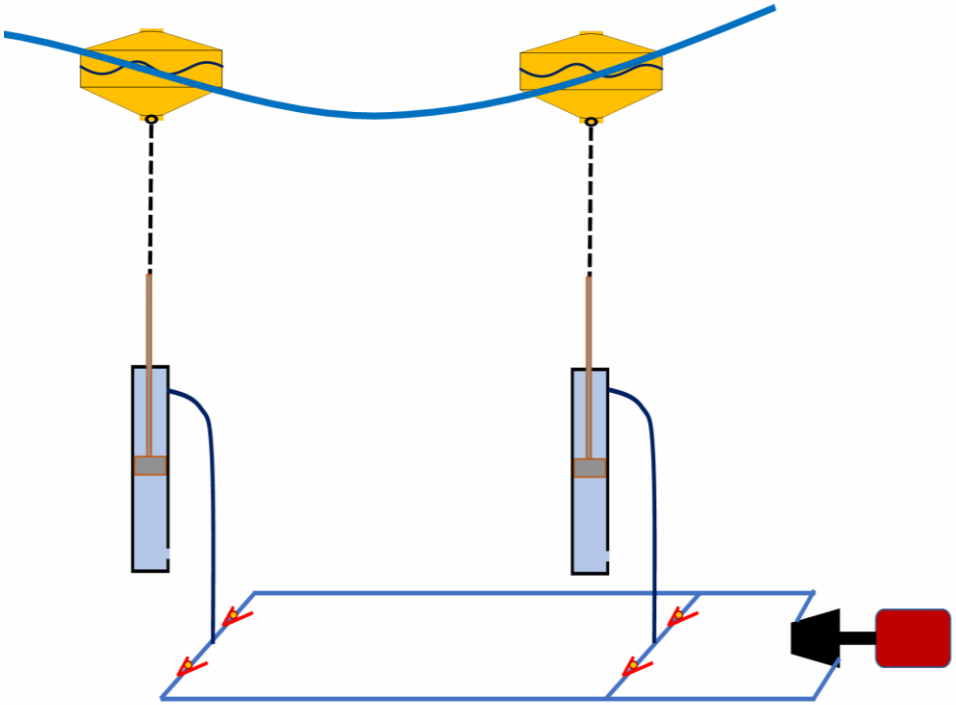
SUNLIT SEA

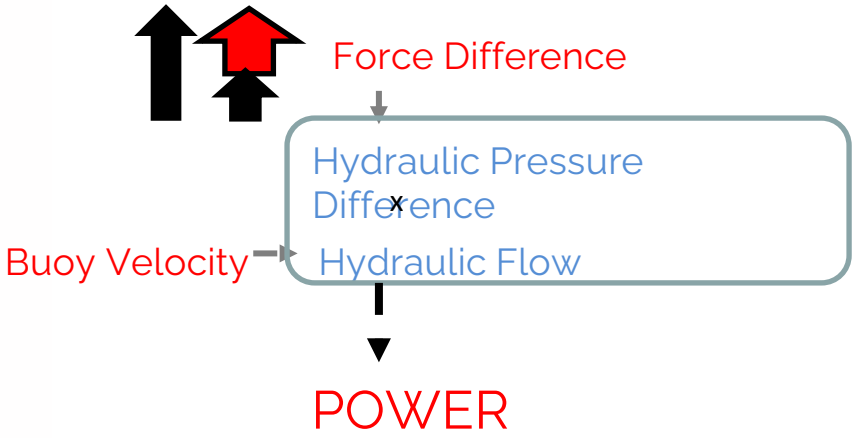
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AFFORDABLE & RELIABLE UTILITY-SCALE WAVE ENERGY

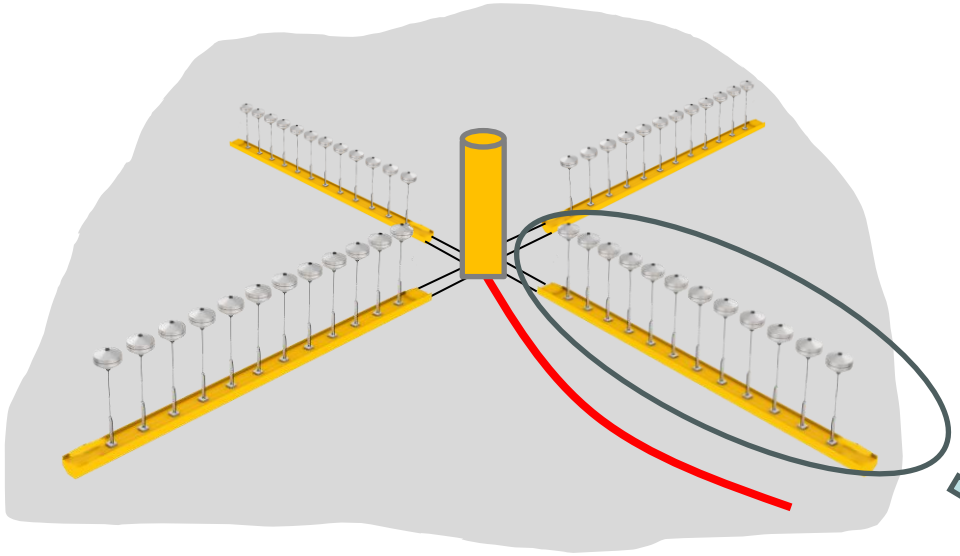


Operation is based on co-operative interaction between buoys

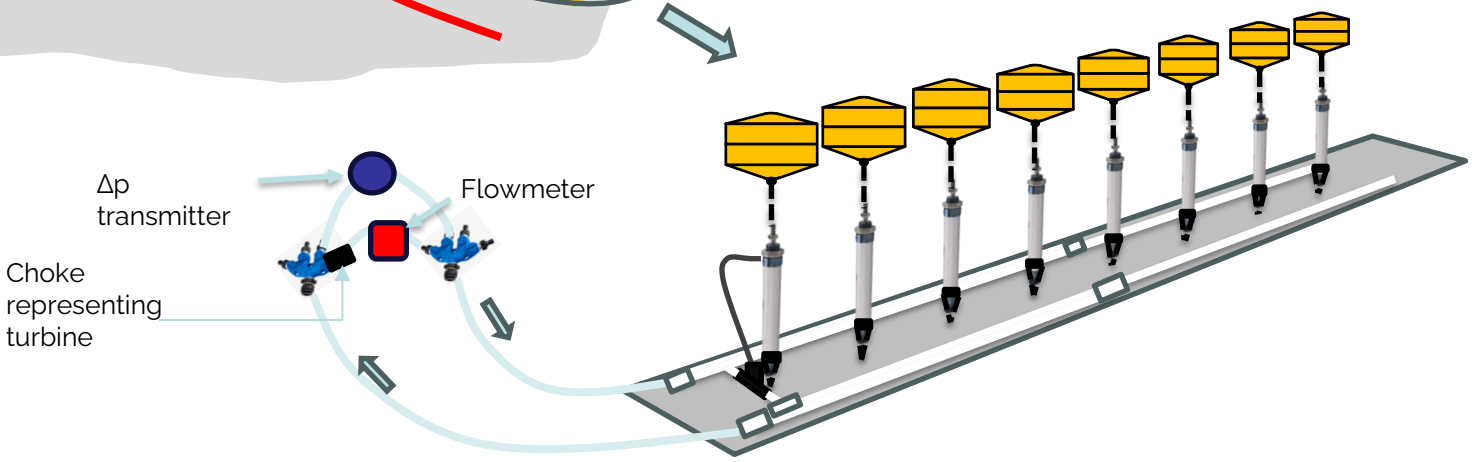




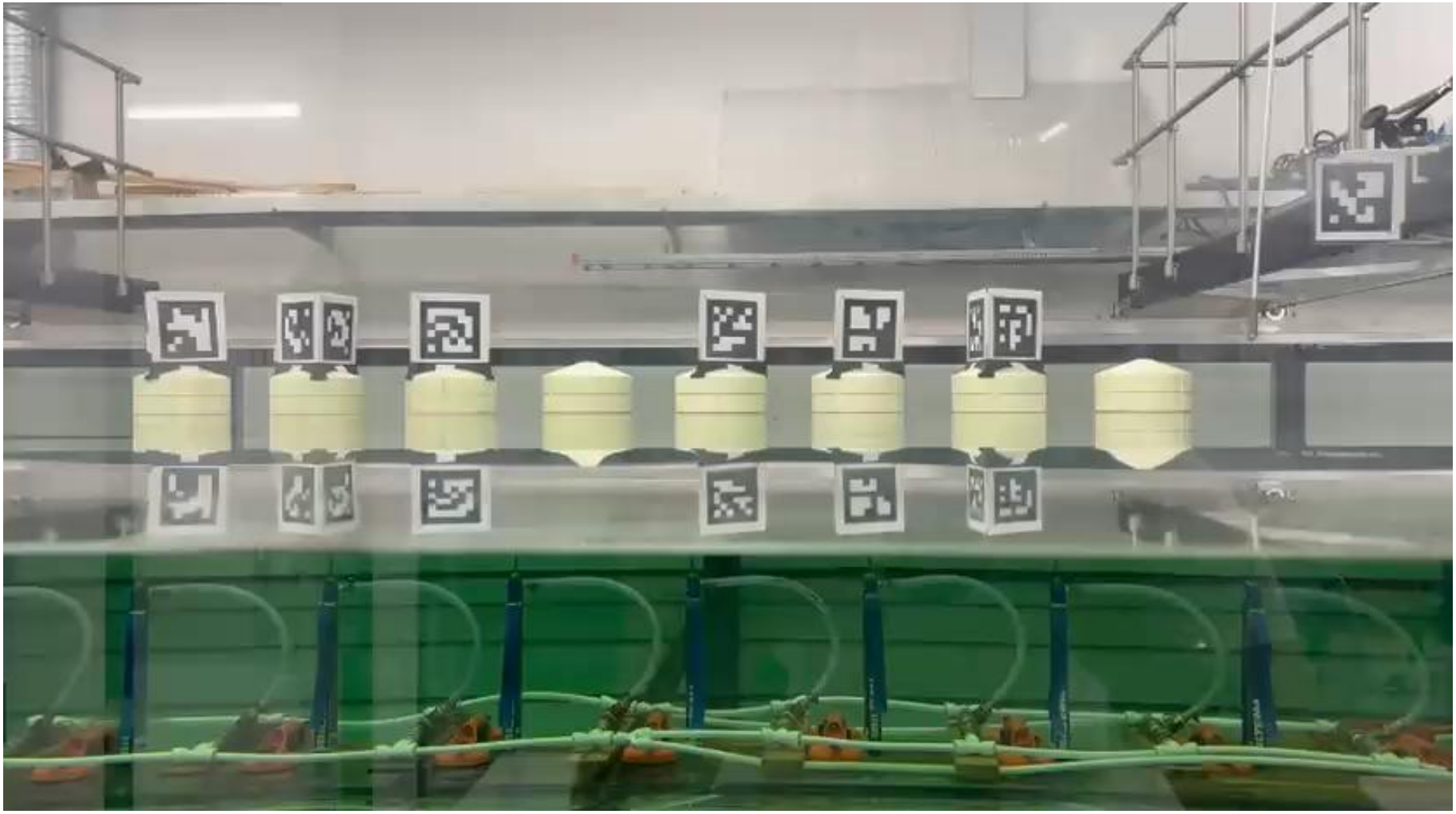
Scaled pool test , 1:40



- Verify performance capabilities
- Tune simulation tool
- Learn through parametric study
  - Variable buoy draught
  - Variable waves
  - Variable wave direction
  - Variable distance between buoys
  - Variable turbine load (choking)



f=0.8hz, λ=2.7m, a=2cm



What Cannot Be Scaled: The Reynolds Number Problem

by choosing what we scale and how we scale in fluid mechanics experiments - what get proper scaling versus improper scaling - we can largely control which mechanisms dominate and what results we obtain; this is perfectly acceptable as long as we're actively aware of it.

Why Laboratory Experiments Remain Essential Despite Advanced Numerical Modeling

- *Numerical models need experimental data to validate against—you cannot trust a model that has not been compared to reality*
- *What takes hours in a wave tank might take weeks or months on a computing cluster*
- *Boundary conditions in real structures are messy—experiments capture this naturally*
- *Experiments can reveal unexpected phenomena you did not know to look for in simulations*
- *Best approach: experiments to validate and guide models, models to explore parameter spaces and understand mechanisms that are hard to measure.*