

Experiment of a PEM electrolyser exposed to motion

Definition of H₂
production facilities
coupled with offshore wind

Designed with balance
of plant in mind

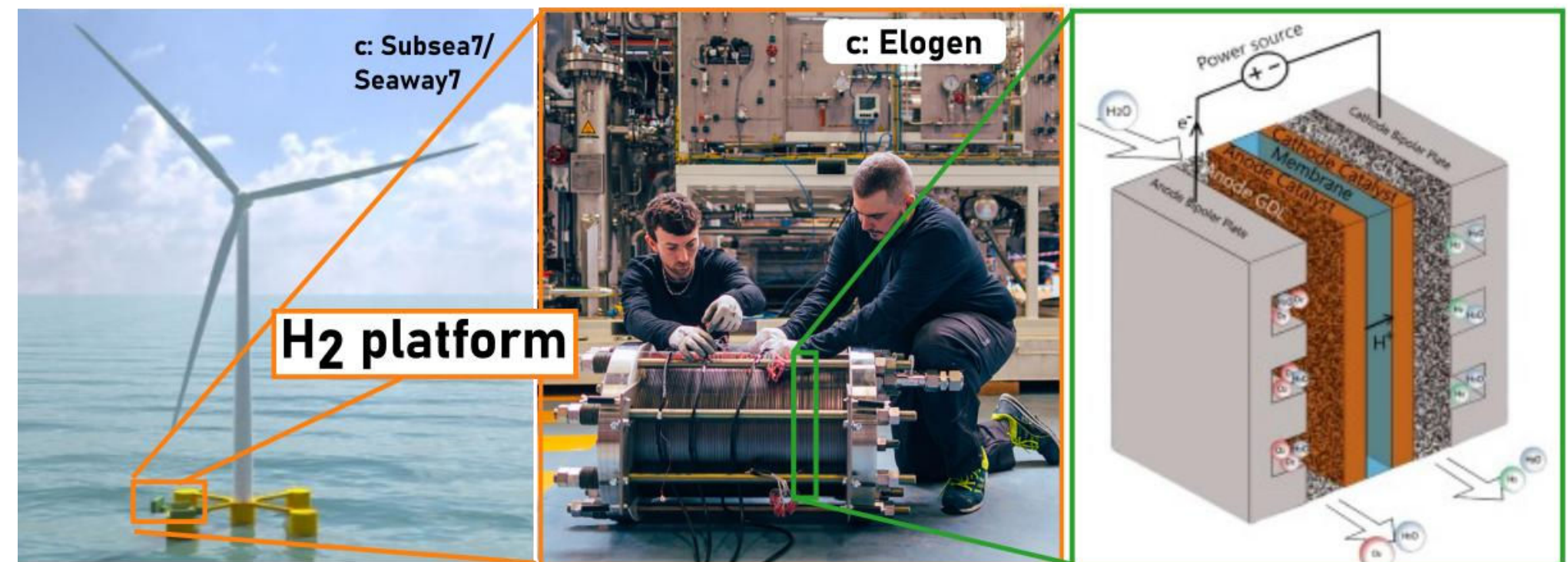
Representative hydrodynamic
simulations performed to assess
the response of the float to motion

Decentralized: 15 MW Floating Wind Turbine
with 10 MW electrolysis capacity

*B. Auriac (2025) Feasibility of decentralized H₂
production from offshore wind, WindEurope Annual
Event, Copenhagen, Denmark*

Centralized: Offgrid 760 MW Floating
offshore hydrogen substation coupled with 1
GW offshore wind farm

*M. Roulet et al. (2025) Pre-conceptual design of a
floating offshore hydrogen substation, IOWTC,
Toulon, France*

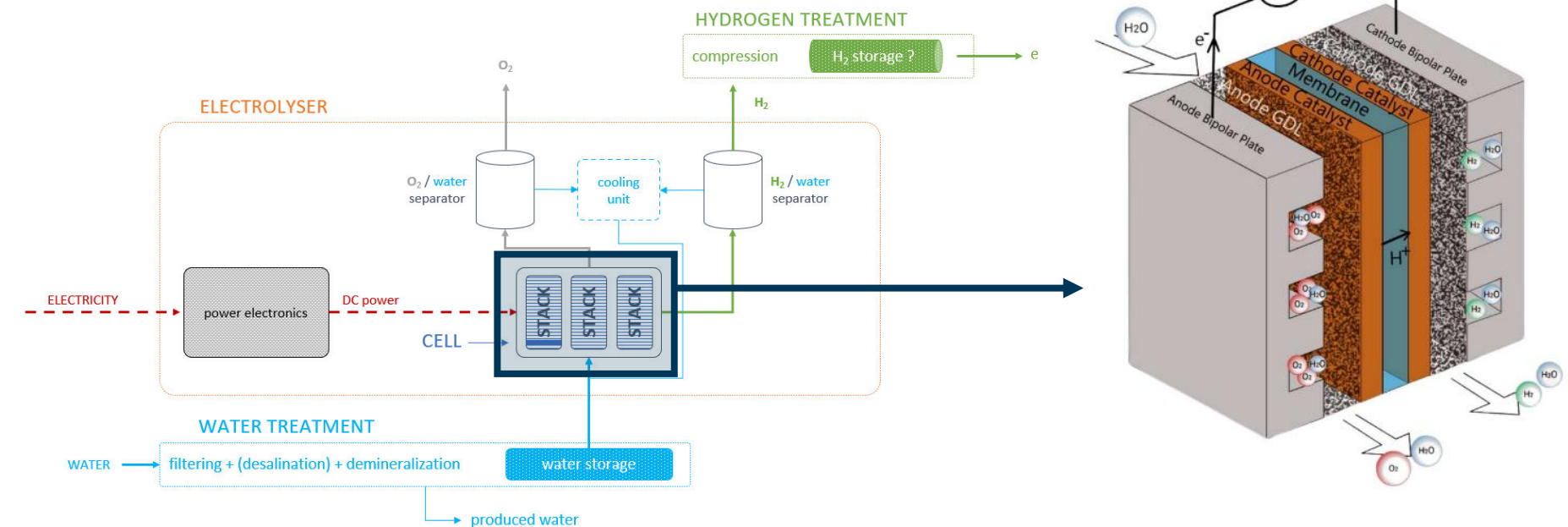




Testing influence of motion with lab setup

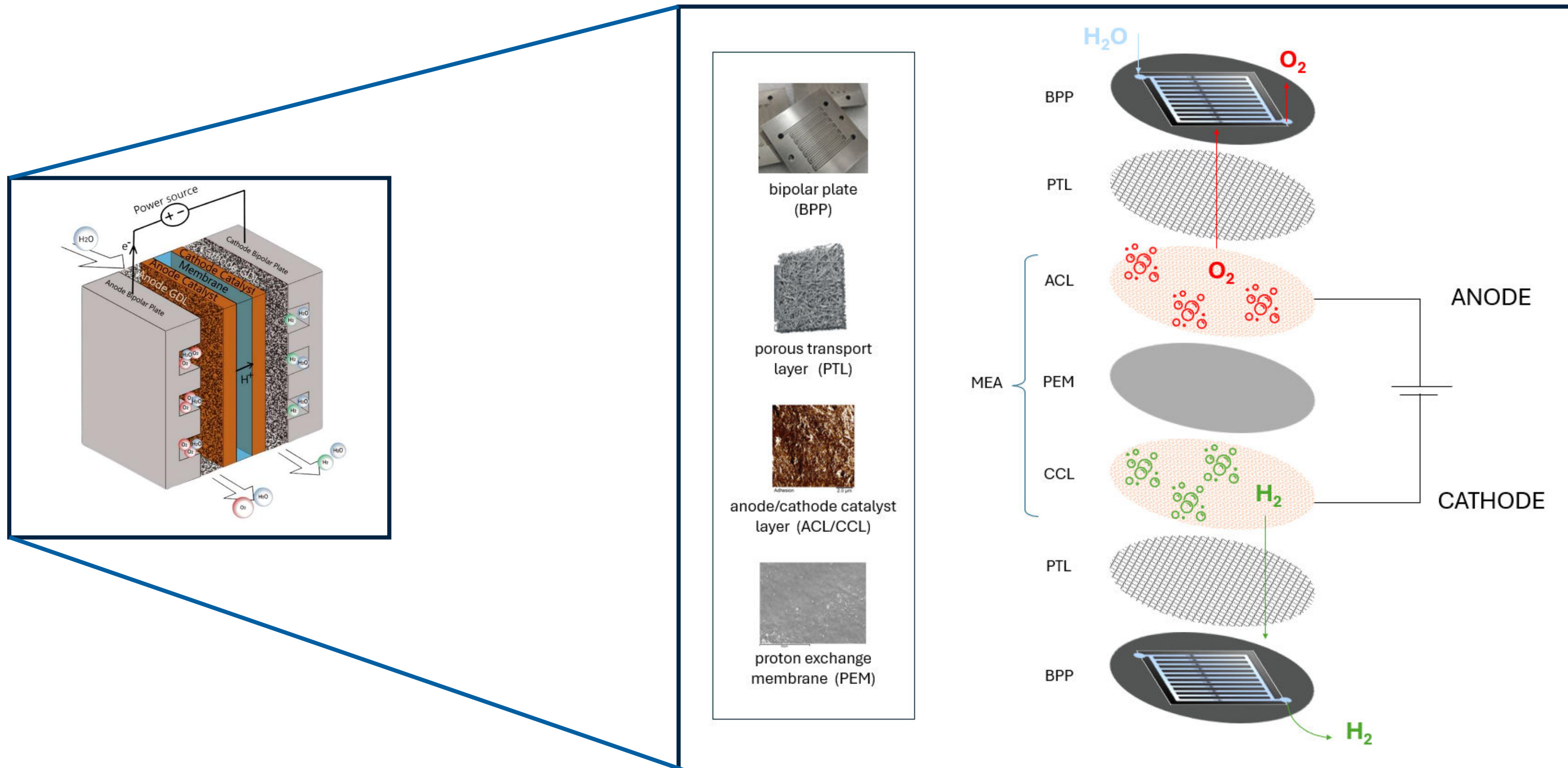
- Power supply
- Stack
- Fluidics
- Temperature control
- Gas separator
- ...

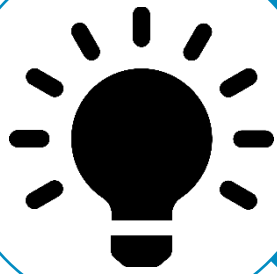
Focusing of the stack



A. Benmehel et al. (2024) PEM water electrolyzer modeling: Issues and reflections. *Energy Conversion and Management*, Vol. 24, 100738
<https://doi.org/10.1016/j.ecmx.2024.100738>

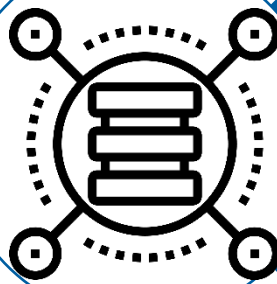
Reminder of the parameters driving H₂ electrolysis





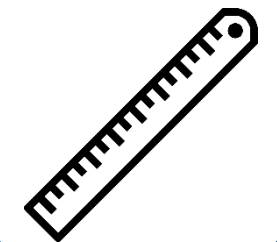
Testing influence of motion with lab setup

Laplace lab - CNRS, Toulouse, France



1 kW PEM electrolyser

Focusing on the stack



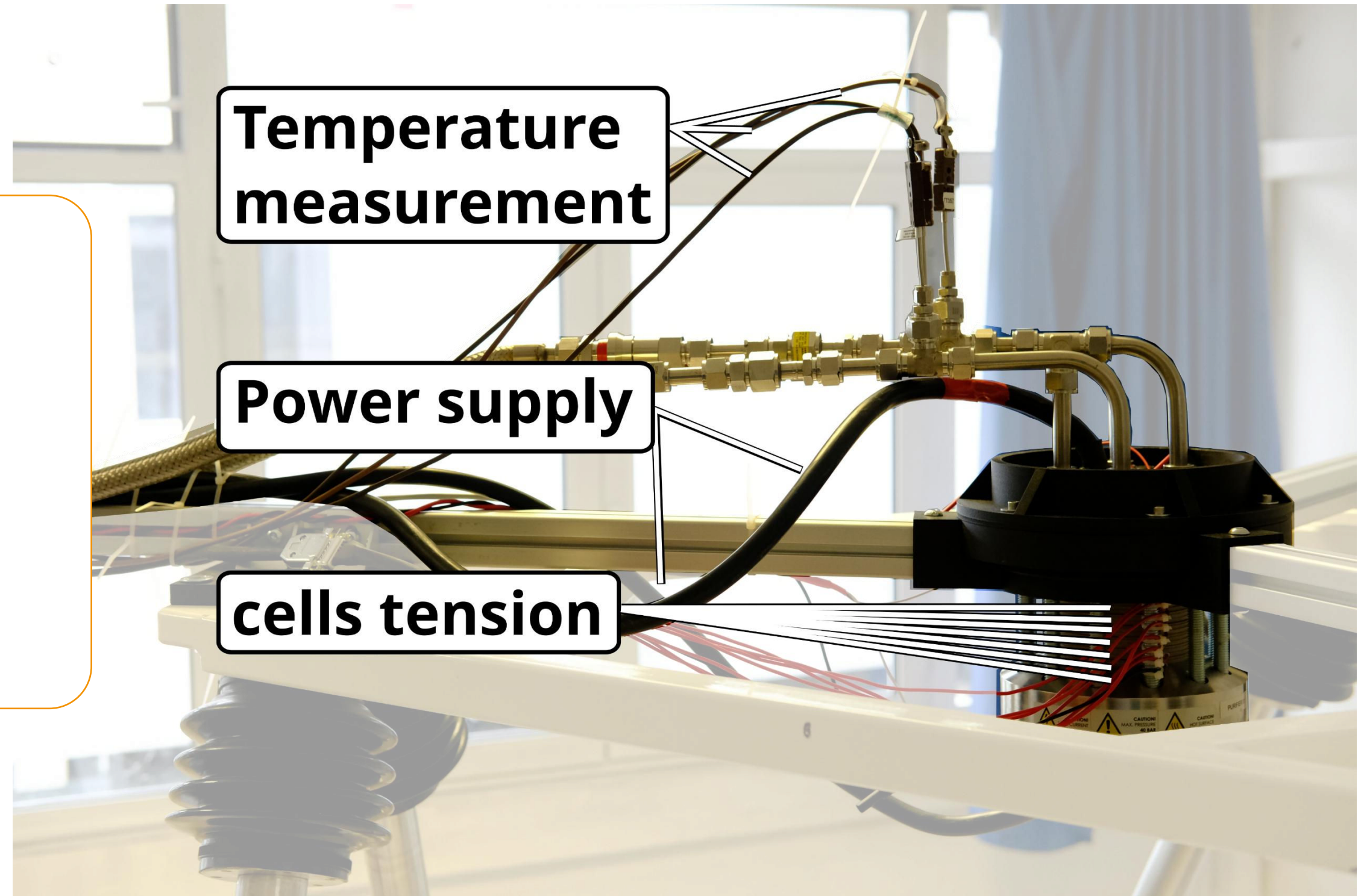
Froude scaling for consistent accelerations

λ 1:9, focus on the biphasic fluids



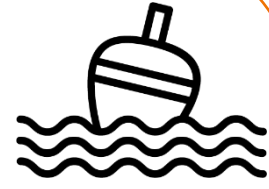
© Alice Design, Nareerat Jaikaew, Yugana / Noun Project

- Stack current & tension
- O_2 in H_2 & H_2 in O_2
- Inlet & outlet pressures
- Inlet & outlet temperature
- Motion trigger
- Individual cell tension



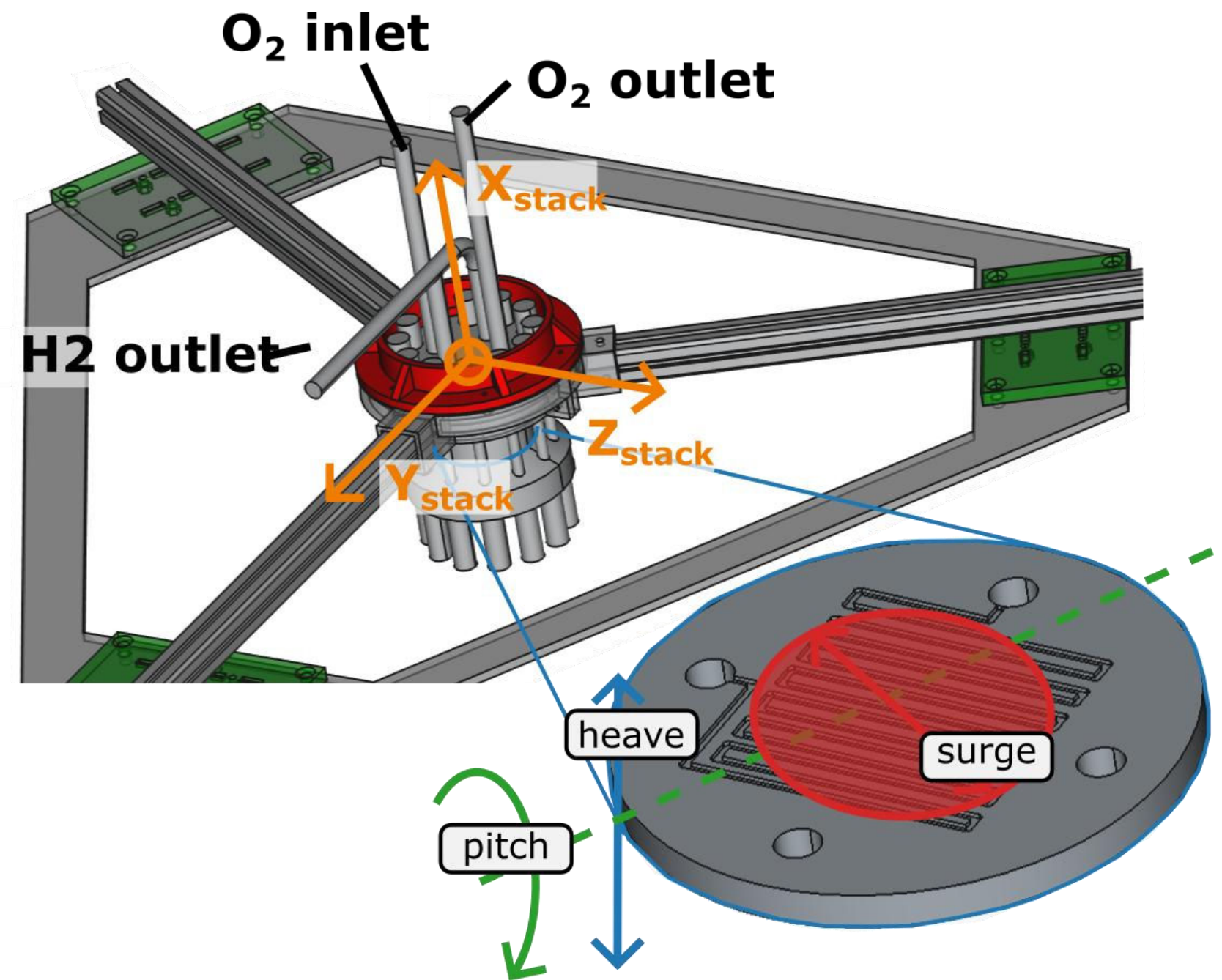
Types of motion tested

- Heave motion
- Pitch motion
- Surge motion



Objectives

- 1 DoF tests
=> Understanding of the influence of motion on the response
- 2 DoF tests for regular wave conditions
=> Representative conditions

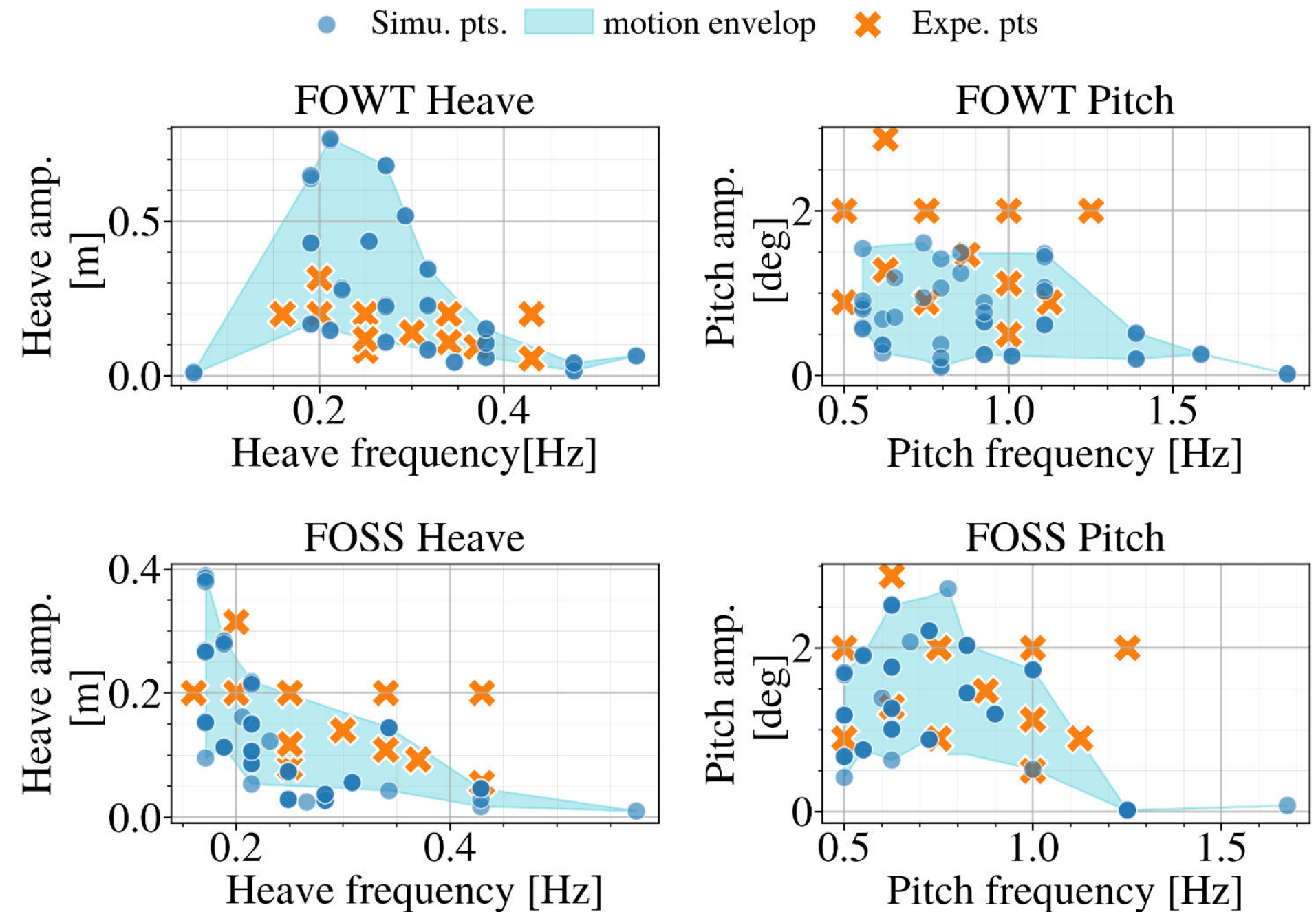


Tested with heave, pitch,
and surge motions

Representative amplitude
and frequency

Sinusoidal motion

Experimental plan measurements overlaid over simulations



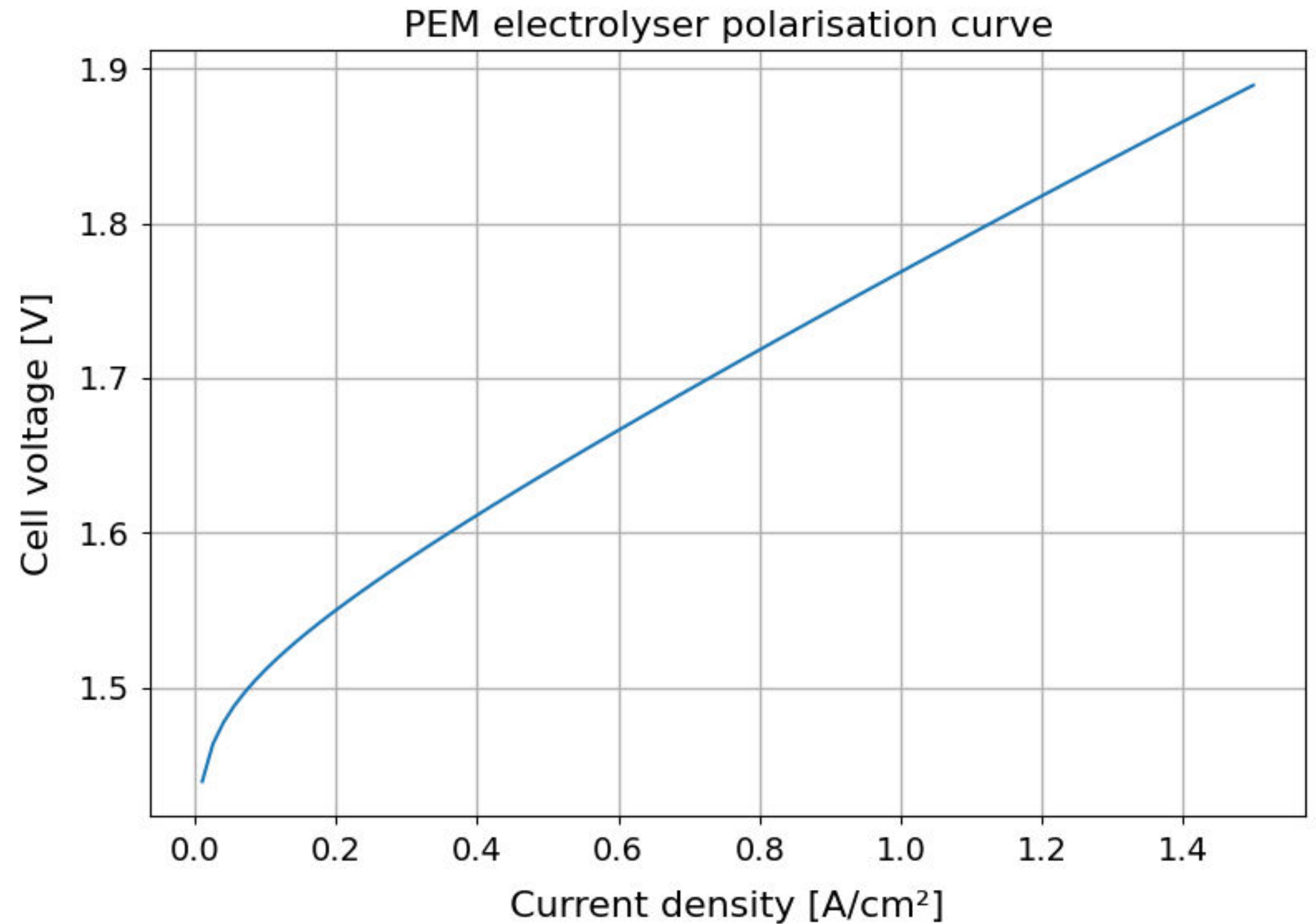
PEM electrolyser performances defined by polarisation curves

Defines electrical consumption

$$P = UI$$

Defines hydrogen production

$$\dot{n}_{H_2} = \eta_F \frac{I}{2F}$$



PEM electrolyser performances defined by polarisation curves

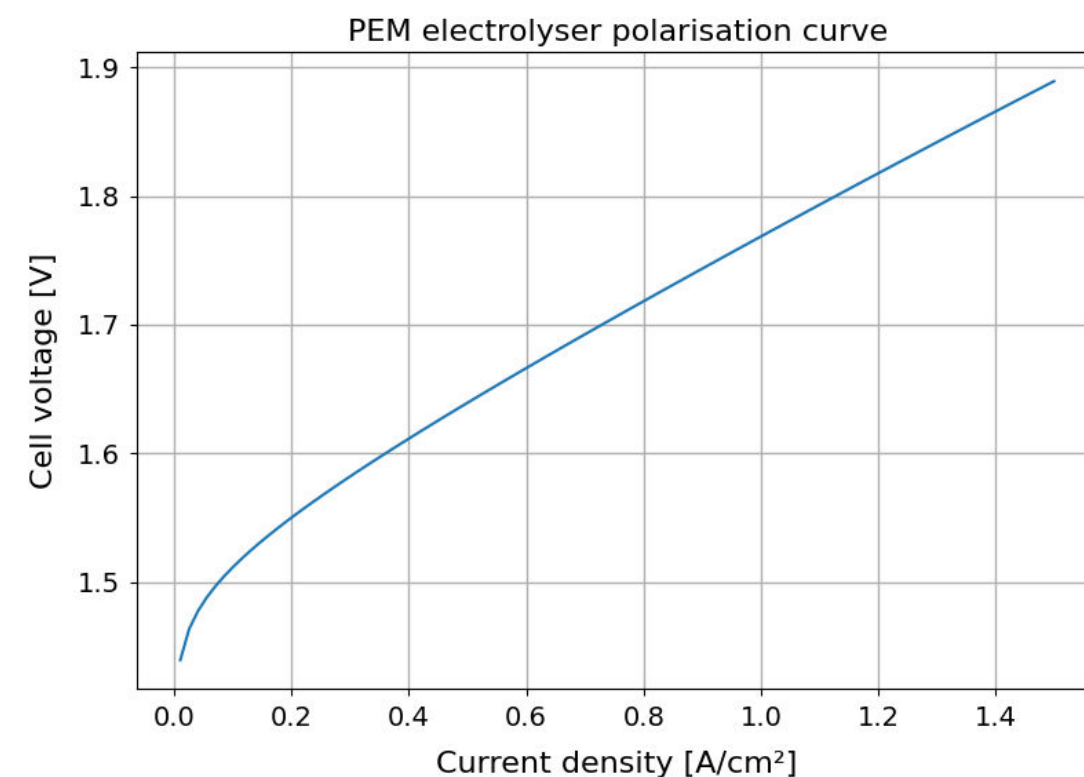
Defines electrical consumption and H₂ production

Polarisation curve

$$E_{elec} = E_{ref}(T, P) - \eta_{activation} - \eta_{species\ transport} - \eta_{load\ transport}$$

Measuring cell tension as a function of current density

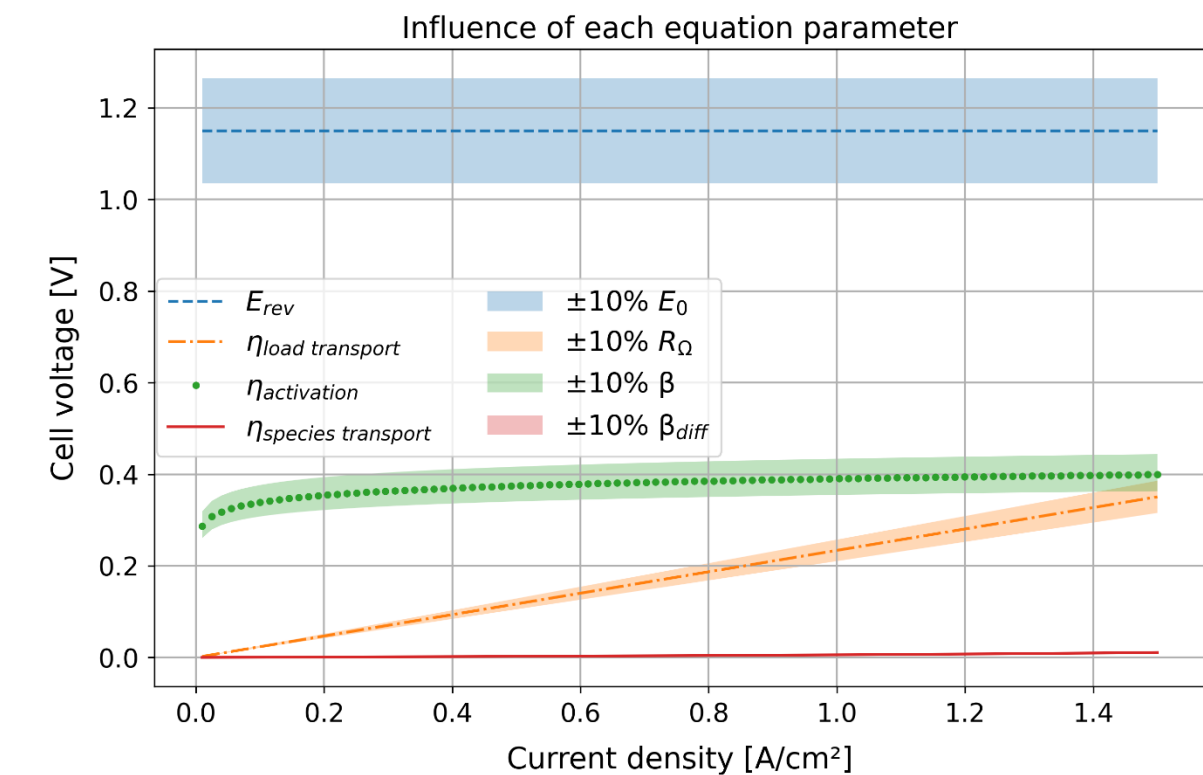
$$E_{elec} = E_{ref} + \frac{RT}{2\beta F} \ln\left(\frac{j}{j_0}\right) - R_{\Omega}jS - \frac{RT}{\beta_{diff}nF} \ln\left(1 - \frac{j}{j_{lim}}\right)$$



decomposition

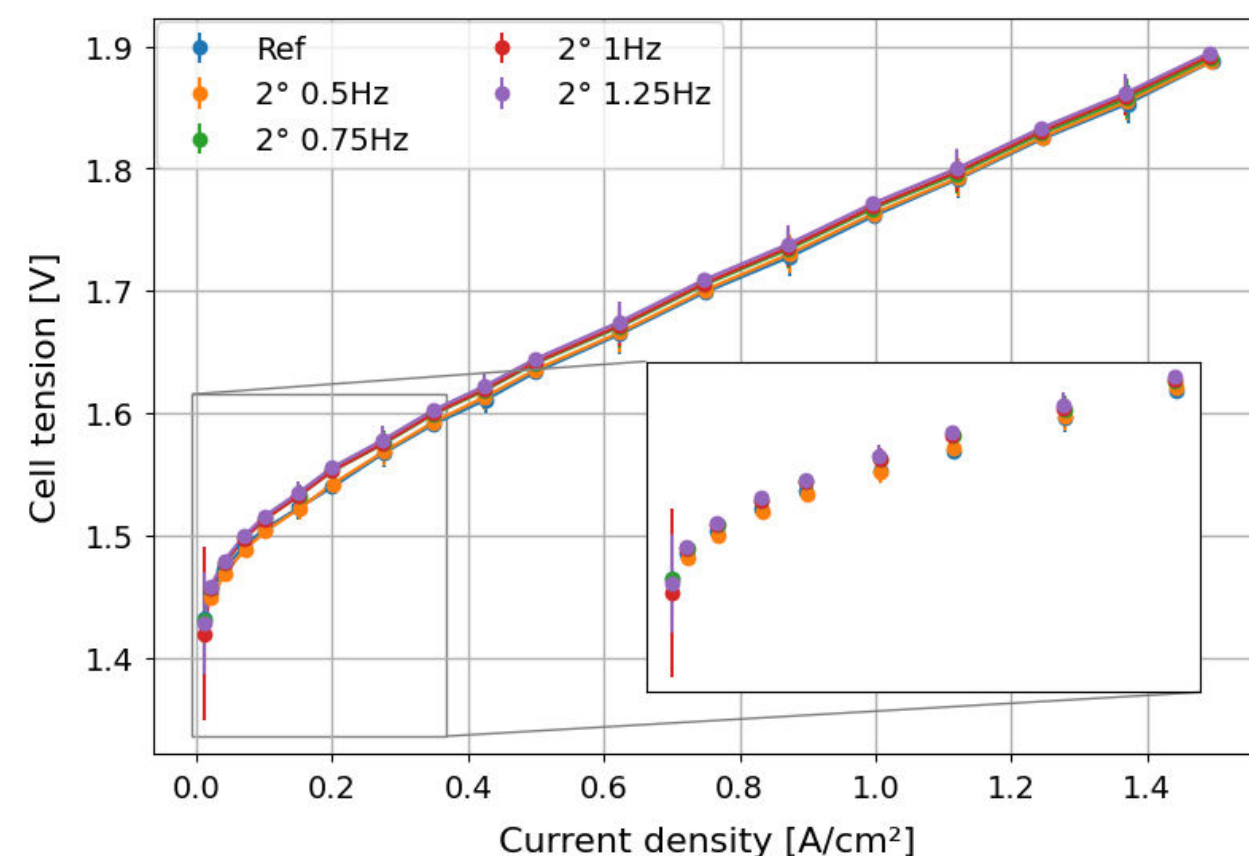
Indicator for

- Cell degradation: R_{Ω}
- Bubble generation: B_{diff}
- But also: α , E_{ref} ...



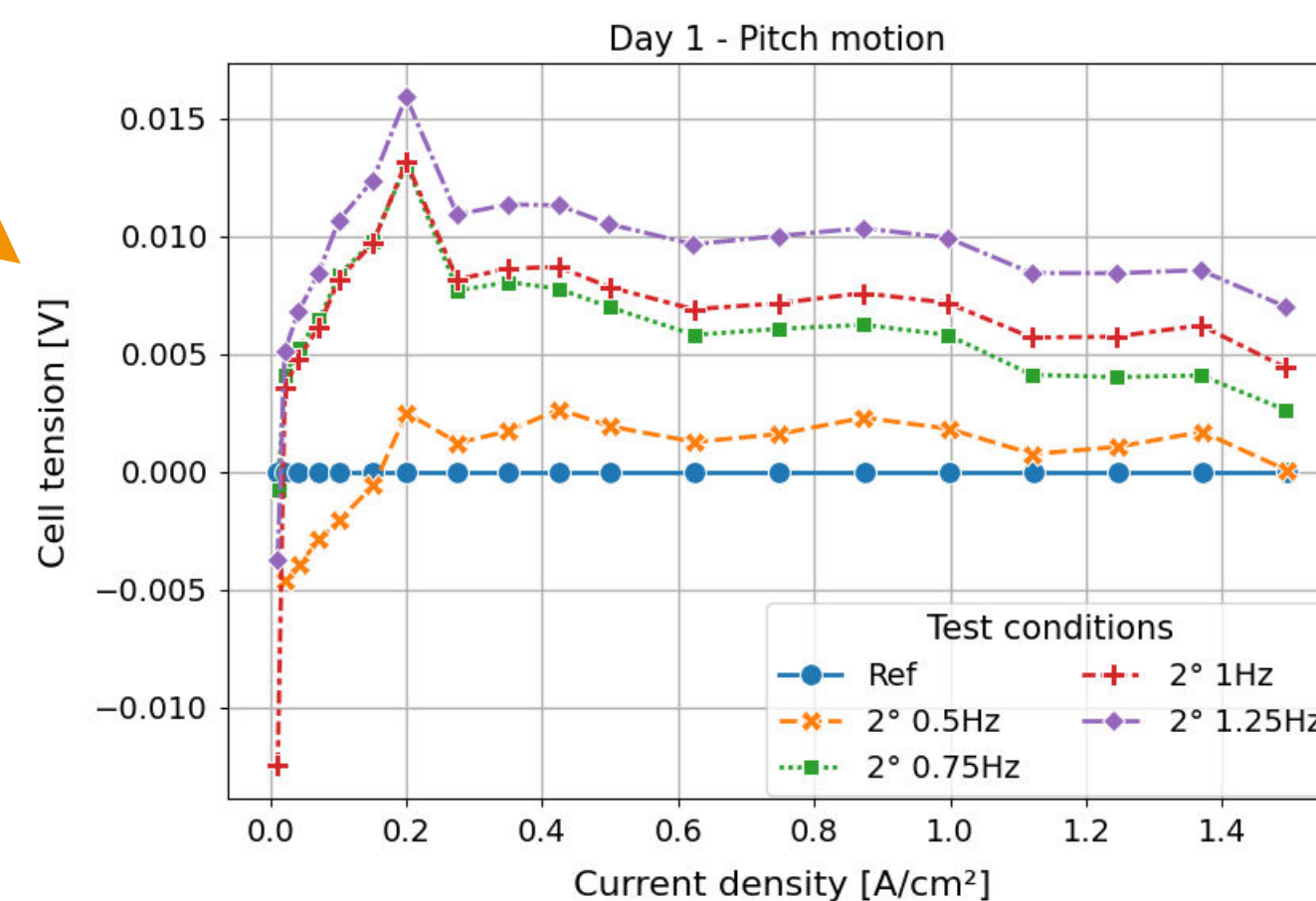
Small variations are observed, especially at the beginning of the curve

- Are they significant?



Measurements compensated for

- Day to day variations (compensated)
- Temperature variations during the measurements (compensated)
- Repeatability (1 to 2mV)



Quantification of influence of pitch motion on cell tension

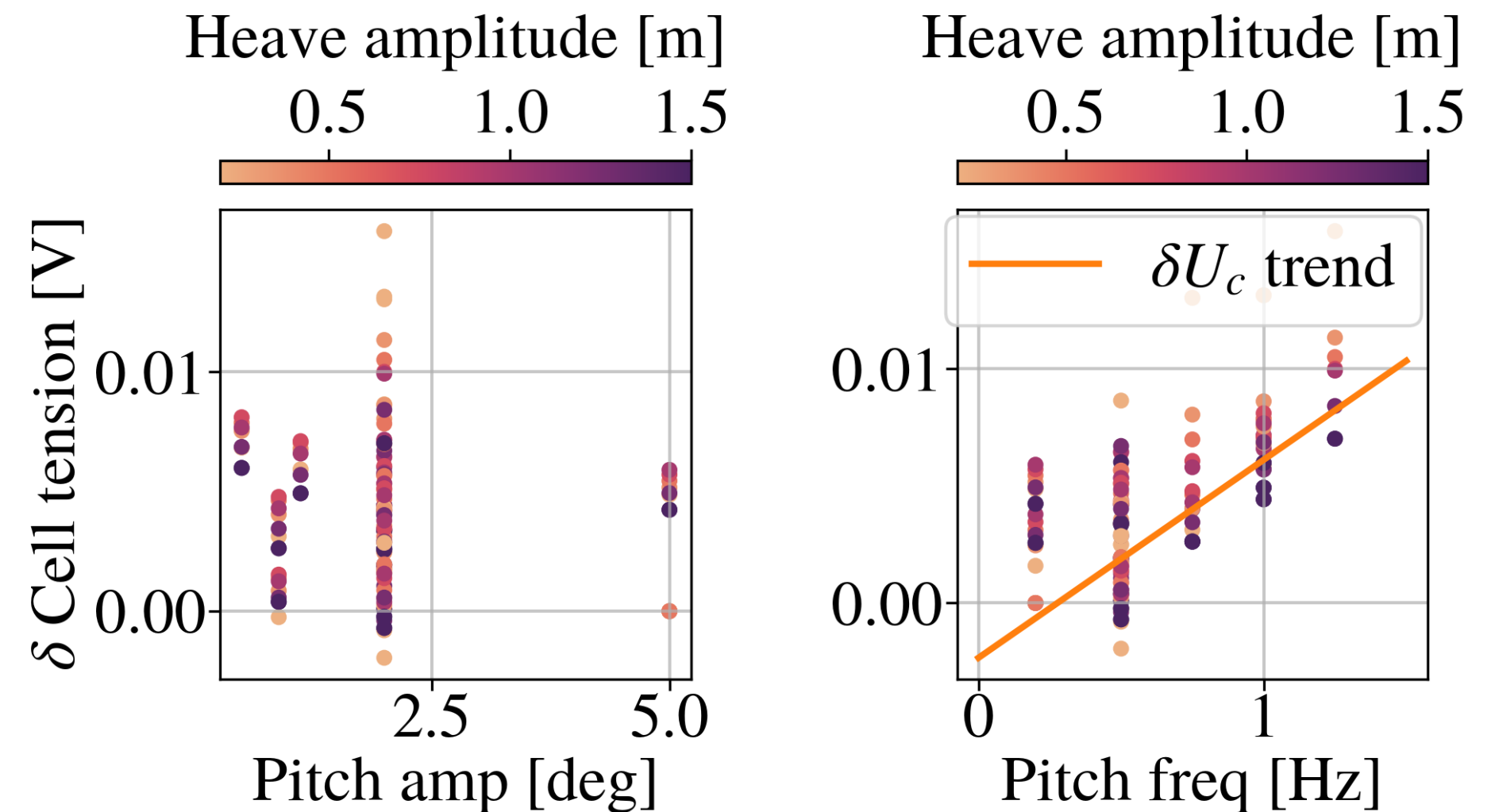
- **Correlated with pitch frequency**
- **Roughly 1% cell tension**

Compensated for daily variations

No influence of heave observed

Influence on hydrogen production from floating offshore wind farm

Cell tension variations over Pitch frequency and amplitude



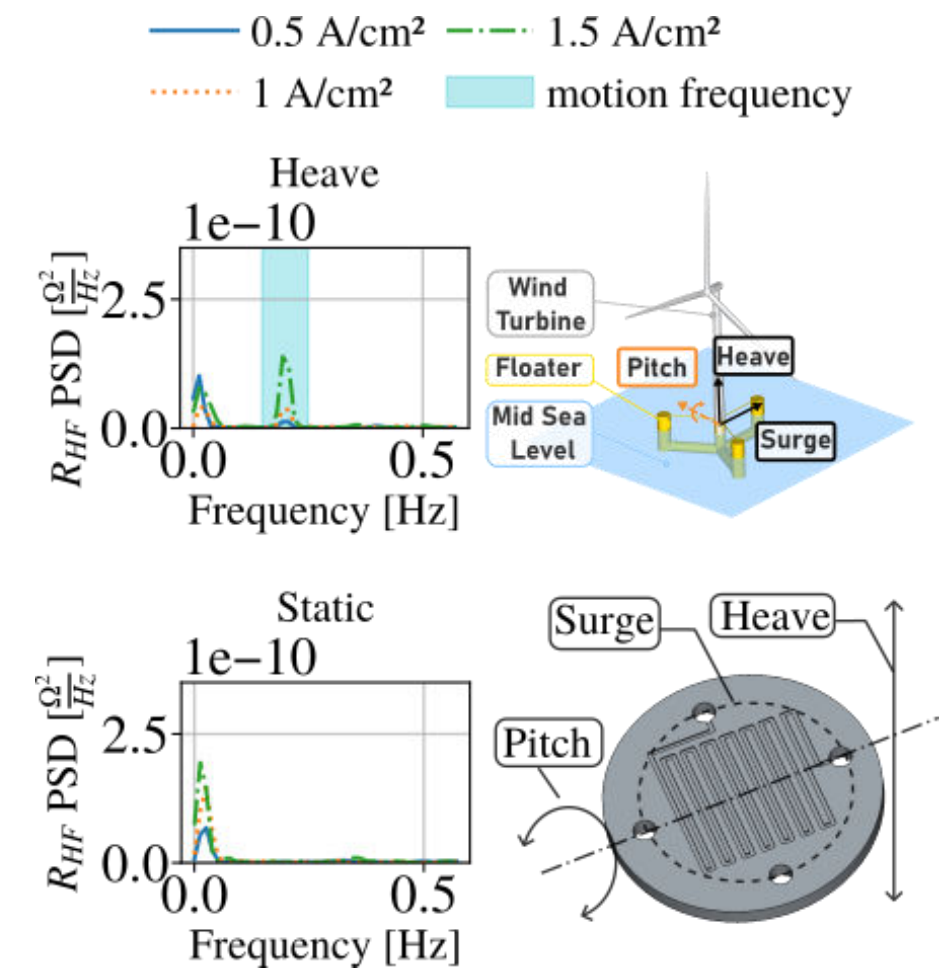
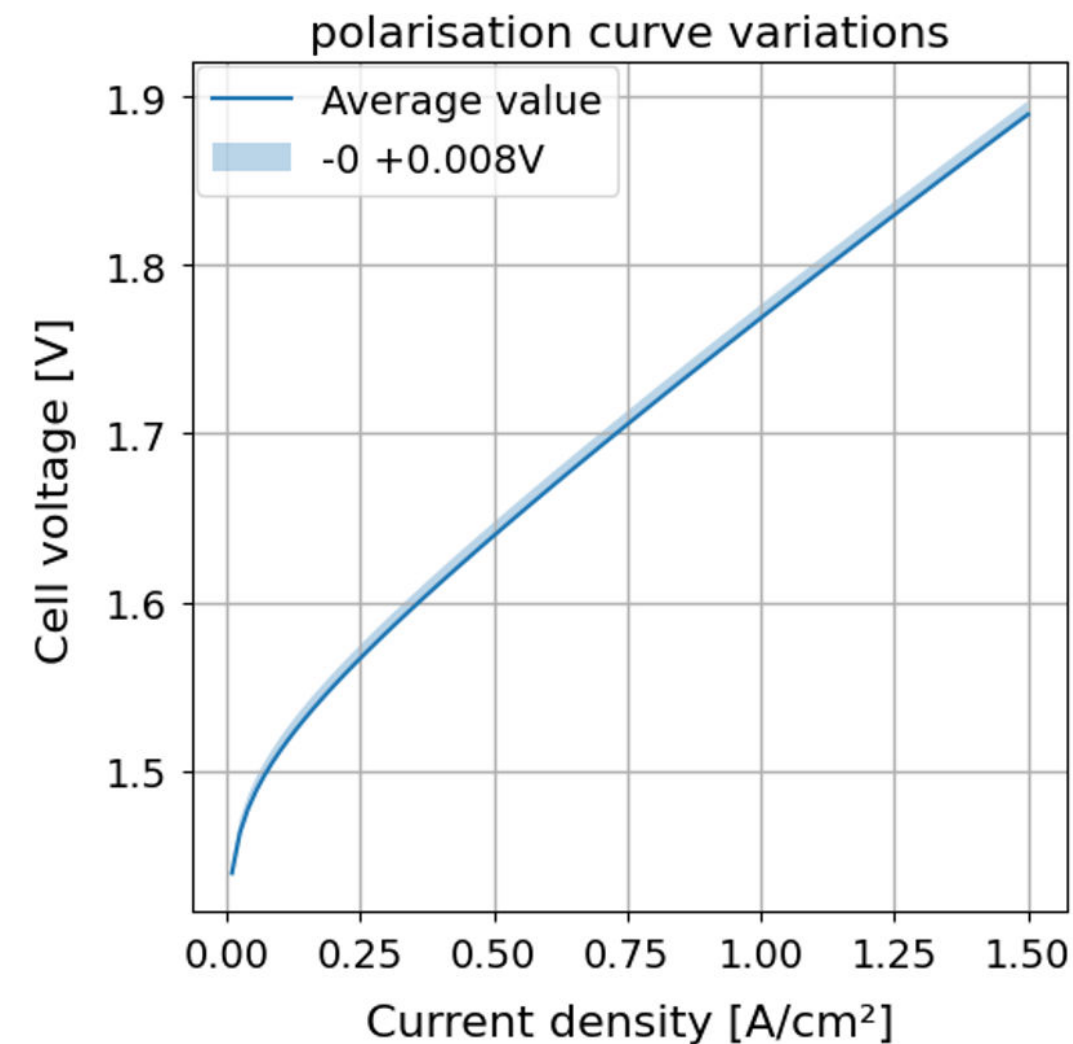
Observation of an influence of motion on R_{HF}

- Pitch, Heave and Surge
- A qualitative approach

Corroborates previous results

Illustration on polarization curve

- Indicates variations of R_{Ω}
- Variations of hydrogen production for identical electrical consumption



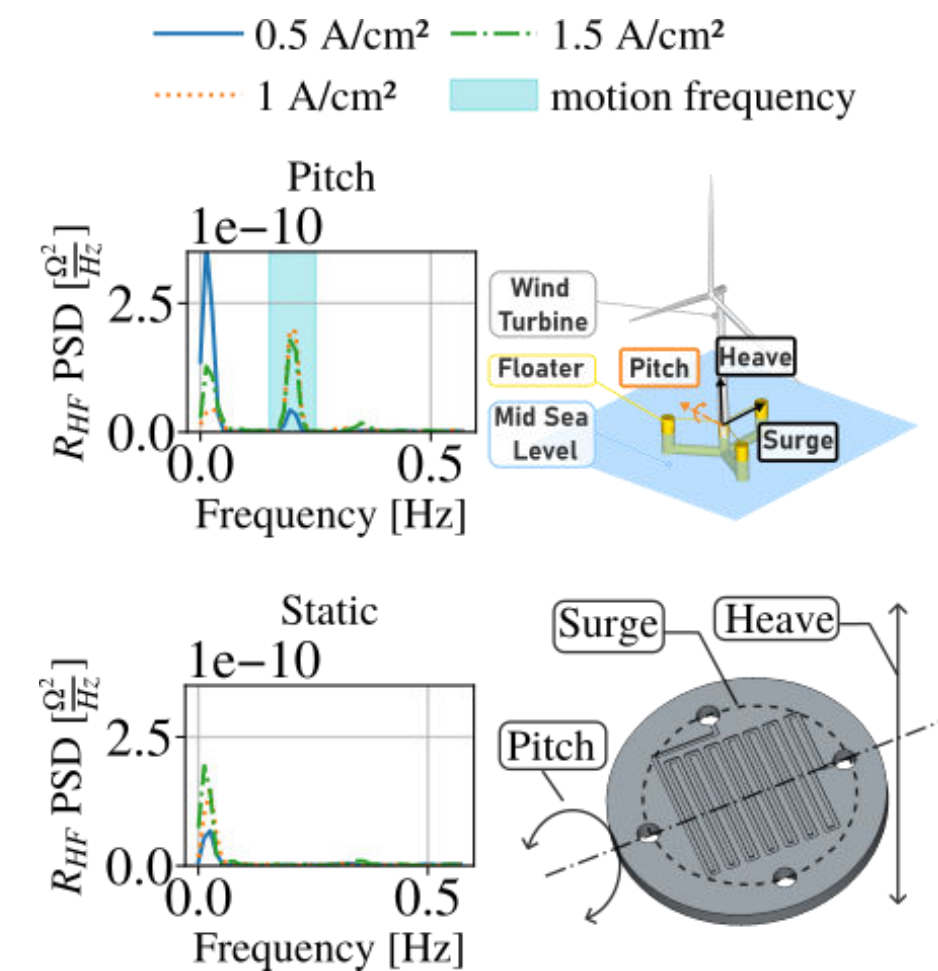
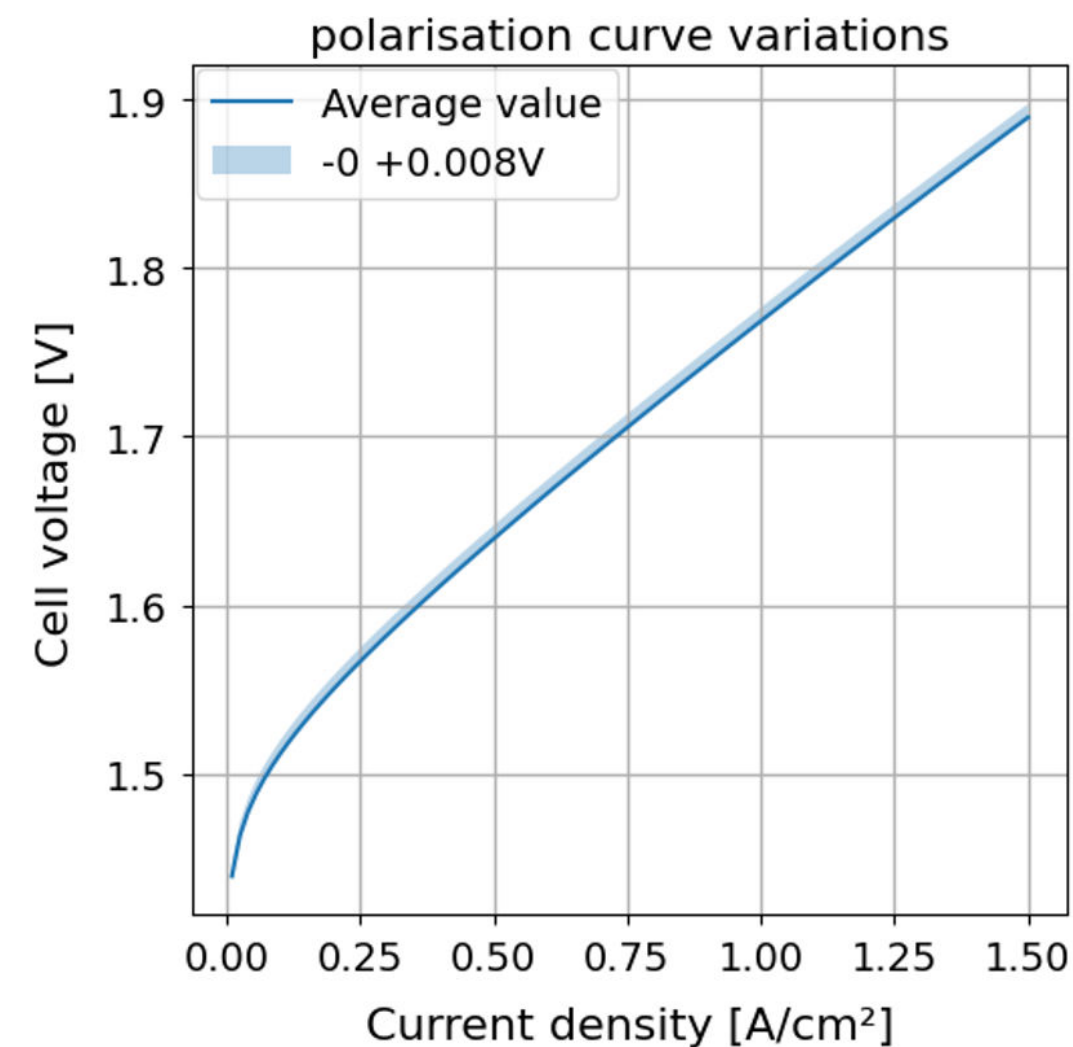
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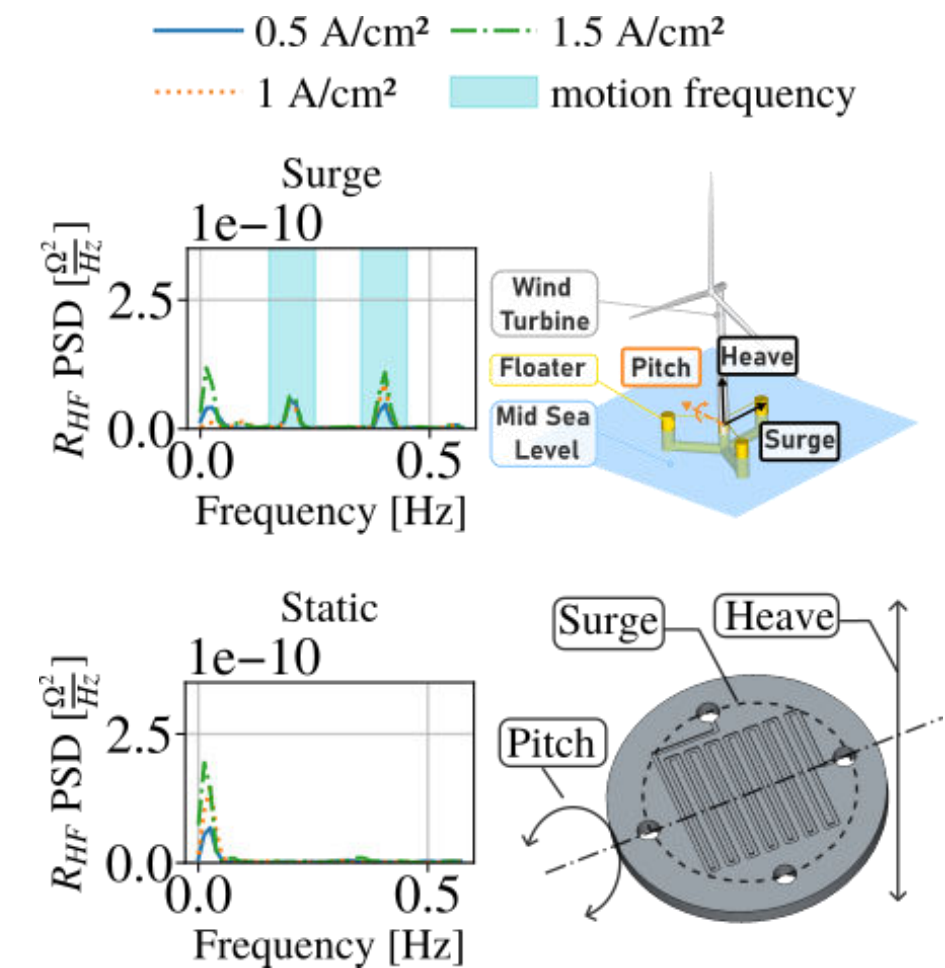
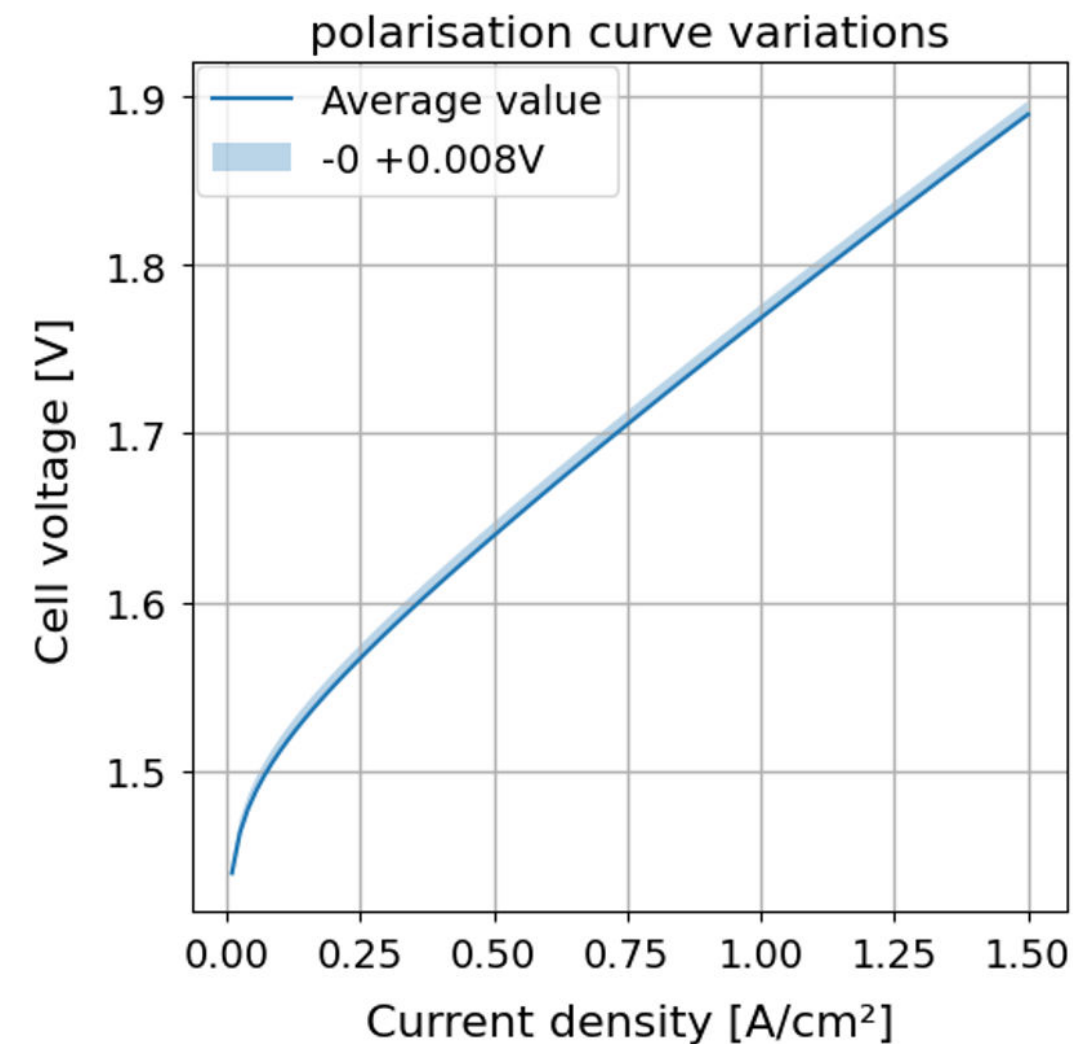
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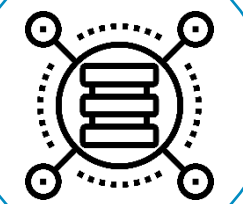
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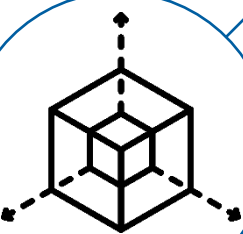




Observation of a small but not negligible impact of the motion on the “Specific Energy Demand”



Experiment focused on stack exclusively, still a need to investigate the whole system

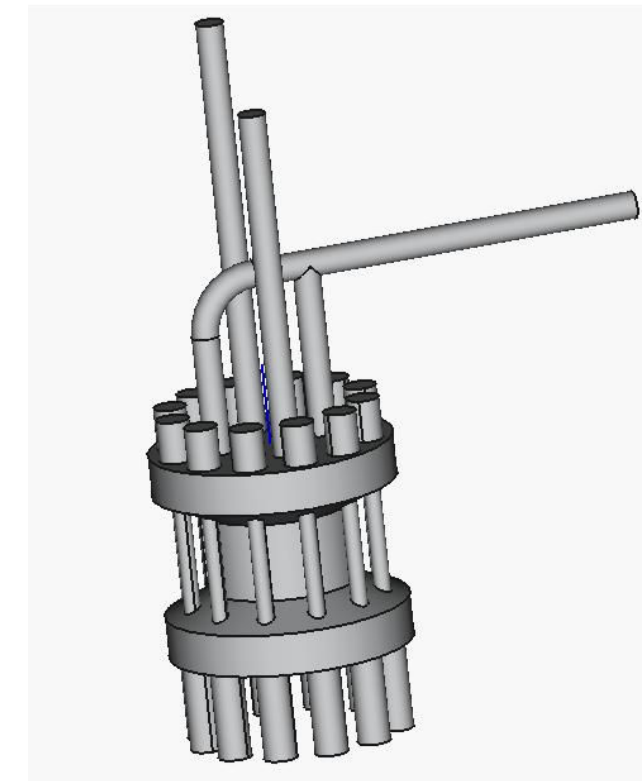


Results depend on stacks geometry and orientation

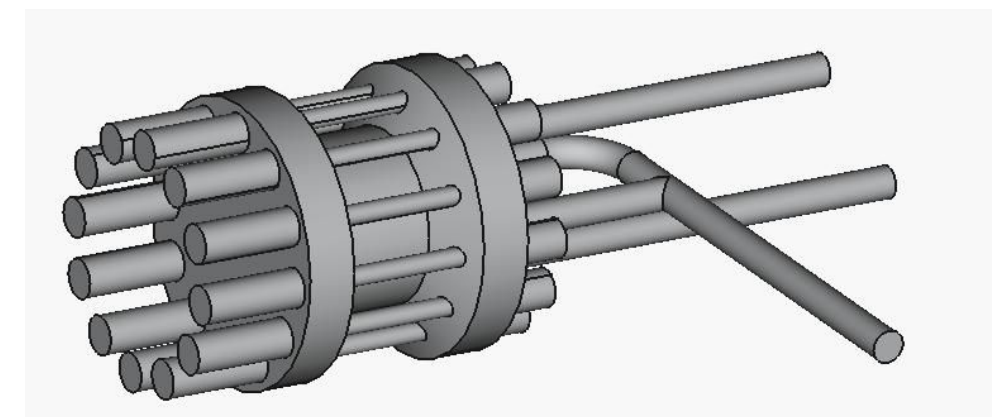


Influence of motion on the degradation and lifetime of the electrolyser is still pending

Vertical orientation



Horizontal orientation



Thank you for your attention!

