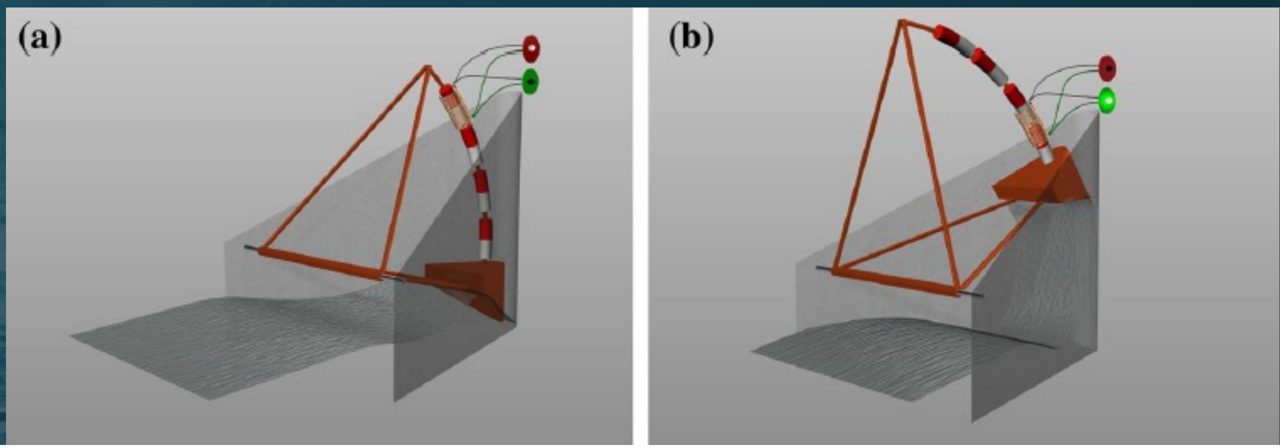
Rogue-wave energy device (Bokhove, Bolton, Thompson et al)

- V-shaped contraction designed to amplify incoming waves
- Buoy floating in contraction, follows fixed trajectory
- Magnets move through coils to generate electricity
- Lab modelling: https://www.youtube.com/watch?v=SZhe_SOxBWo&t=254s
- Bolton et al 2021 (**CDT**), Bokhove et al 2019, 2020; 2m x 0.3m x 0.3m tank in maths lab

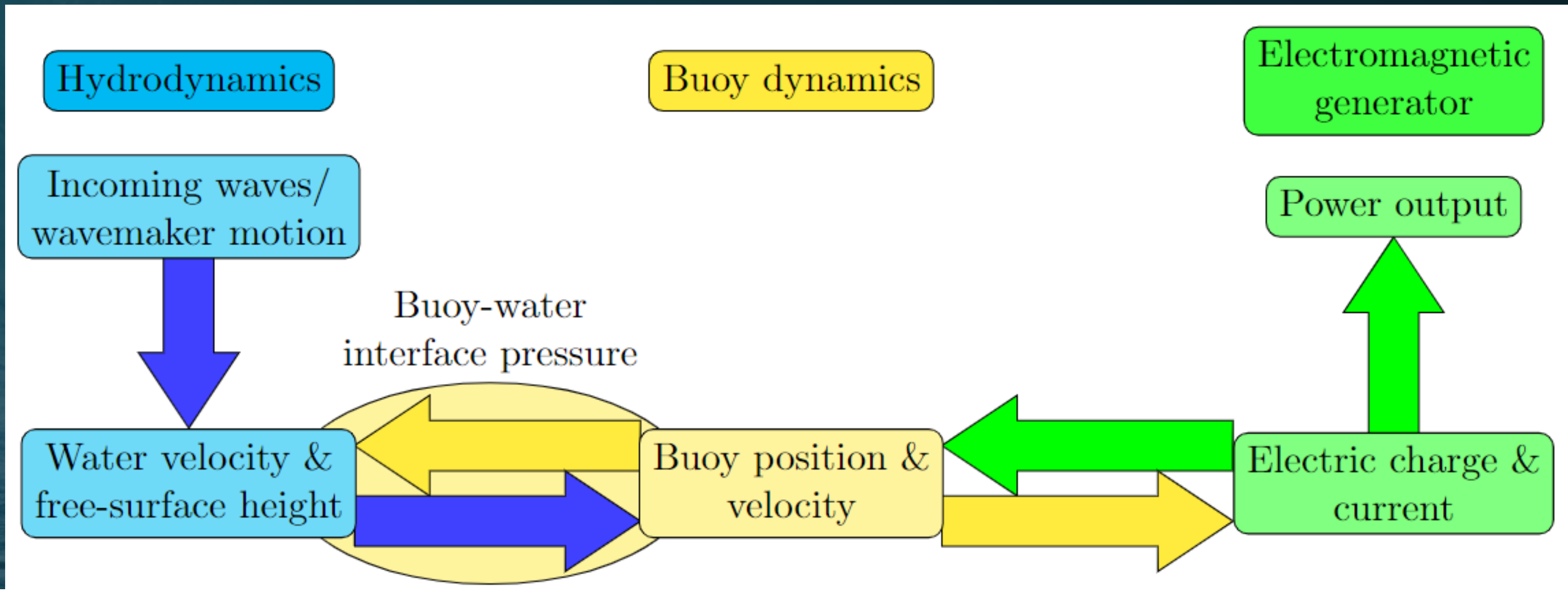


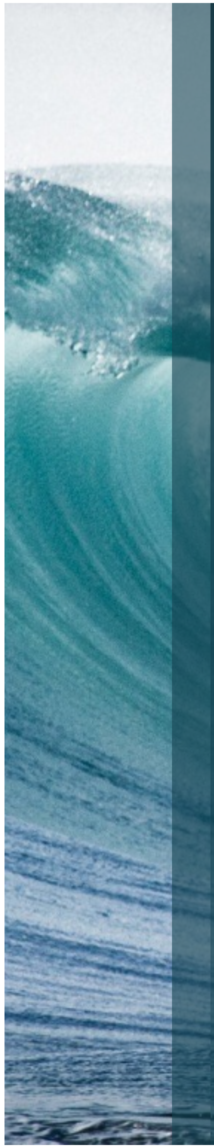
Complete wave-2-wire maths & numerical model

- **Unique** variational modelling with FEM: Python & Firedrake

$$\rho_0 \iint \left[\int_0^h \left\{ \frac{\partial \phi}{\partial t} + \frac{1}{2} \|\nabla \phi\|^2 + g(z - H_0) \right\} dz + \lambda (h - h_b) \Theta(\mathrm{y} - \mathrm{y_b}) \right] dxdy$$

$$- \frac{1}{2} M \dot{Z}^2 + MgZ - \frac{1}{2} L_i \dot{Q}^2 - \gamma G(Z) \dot{Z} Q$$

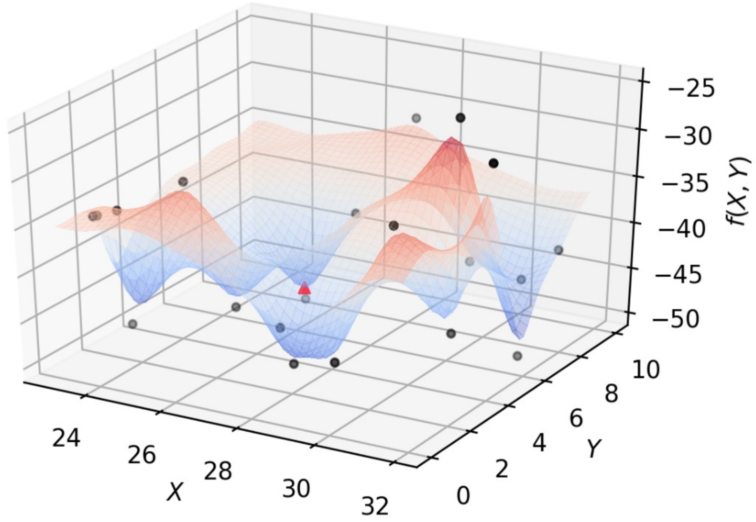


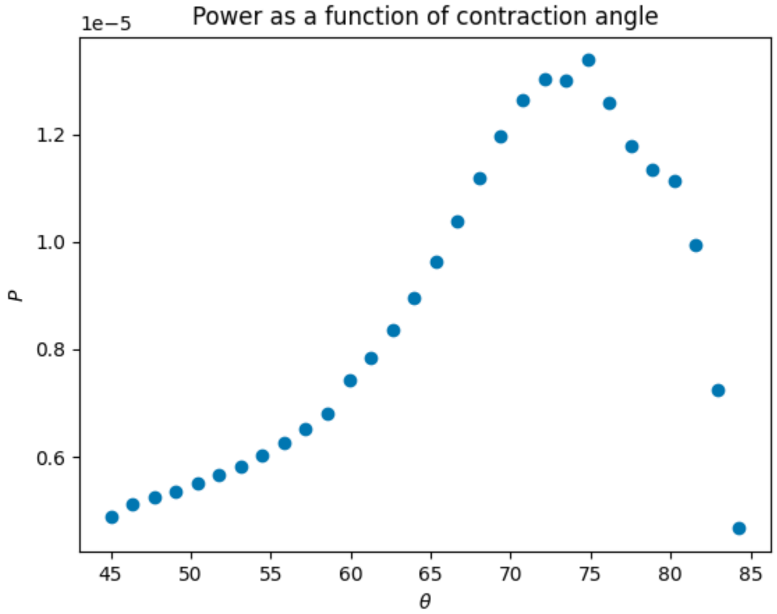


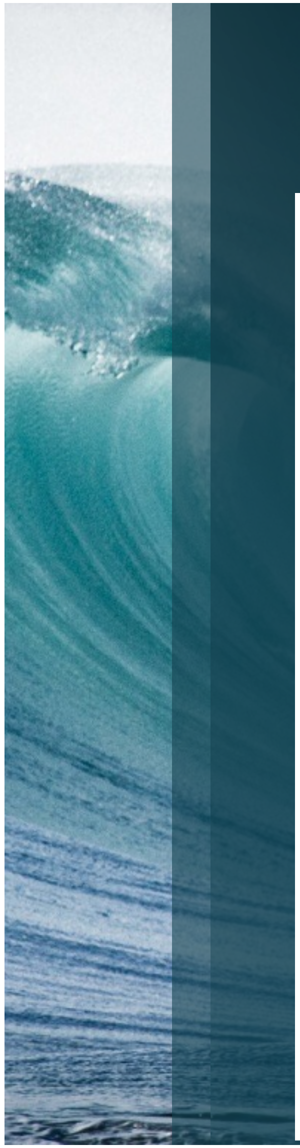
Power optimisation

- Latin hypercube Design-of-Experiment sampling as geometric constraints
- Use FEM code to generate dataset
- Produce surrogate model
    - Radial basis functions
    - Gaussian processes
- Optimise using surrogate (Bolton)
- Work in progress (w. Thompson)
- **Conclusion**:

- **Novel & niche** design 4 breakwaters
- Neural-network modelling for control?







Appendix – coupled wave-buoy EM eqns

Hydrodynamic PDEs

$$\nabla^2\phi = 0 \text{ in } \Omega, \qquad \frac{\partial h}{\partial t} + \nabla_H \phi \cdot \nabla_H h - \frac{\partial \phi}{\partial z} = 0 \text{ at } z = h$$

$$\frac{\partial \phi}{\partial t} + \frac{1}{2}\|\nabla\phi\|^2 + g(h - H_0) + \lambda\Theta(y - y_b) = 0 \text{ at } z = h$$

Boundary conditions *Interface constraint*

$$\frac{\partial \phi}{\partial y} = \dot{R} \text{ at } y = 0, \quad \nabla\phi \cdot \hat{\mathbf{n}} = 0 \text{ on } \partial\Omega_{\substack{y \neq 0, \\ z \neq h}}, \quad \lambda = 0 \text{ at } y = y_b, \quad h = h_b \text{ for } y \geq y_b$$

Buoy dynamic ODEs

$$\dot{Z} = W, \qquad M\dot{W} = -Mg - \gamma G(Z) I + \rho_0 \iint_{\partial\Omega} \lambda\Theta(y - y_b)\,\mathrm{d}x\,\mathrm{d}y$$

Electromagnetic generator ODEs

$$\dot{Q} = I, \qquad L_i \dot{I} = \gamma G(Z) W - I(R_c + R_i) - V(Q, I)$$

$$P_g = \frac{1}{T}\int_{t_1}^{t_2} VI\,\mathrm{d}t, \qquad P_l = \frac{1}{T}\int_{t_1}^{t_2} I^2 (R_c + R_i)\,\mathrm{d}t$$