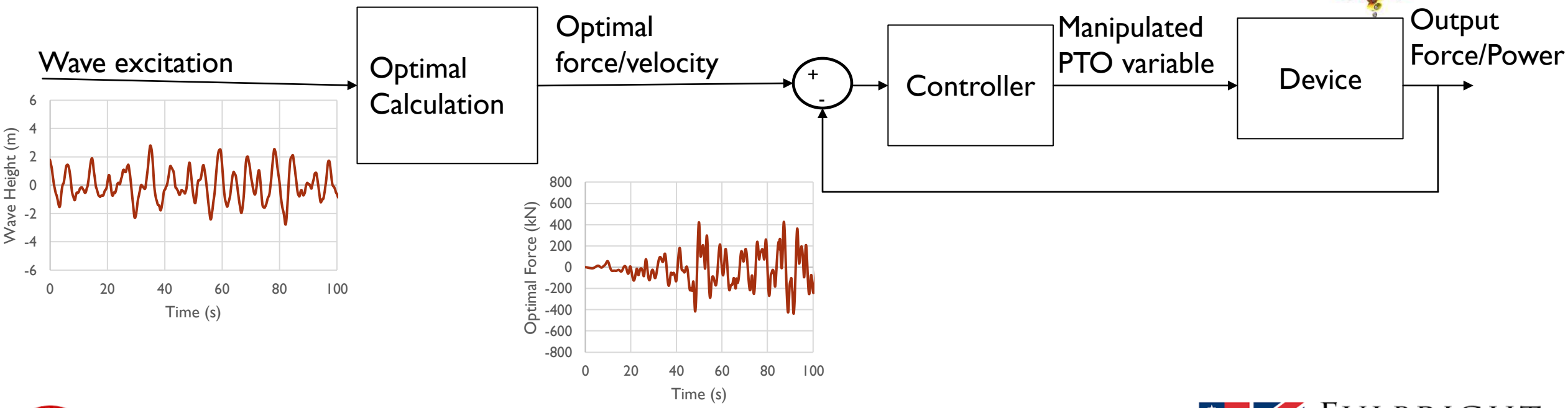
# Preliminary WEC Control Planning

Carrie Hall



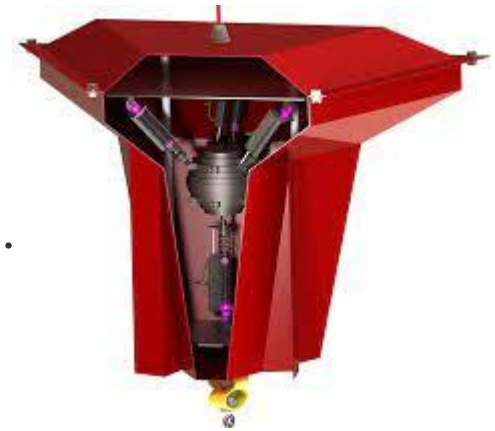

ILLINOIS TECH

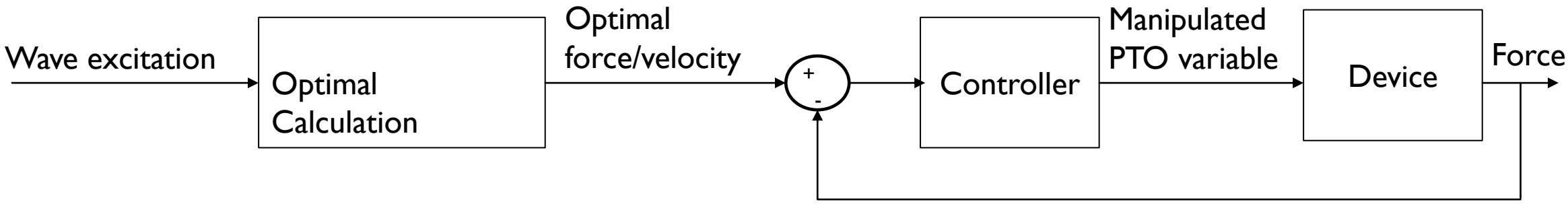
FULBRIGHT COMMISSION

EDUCATE ★ EXCHANGE ★ ENGAGE ★ LEAD

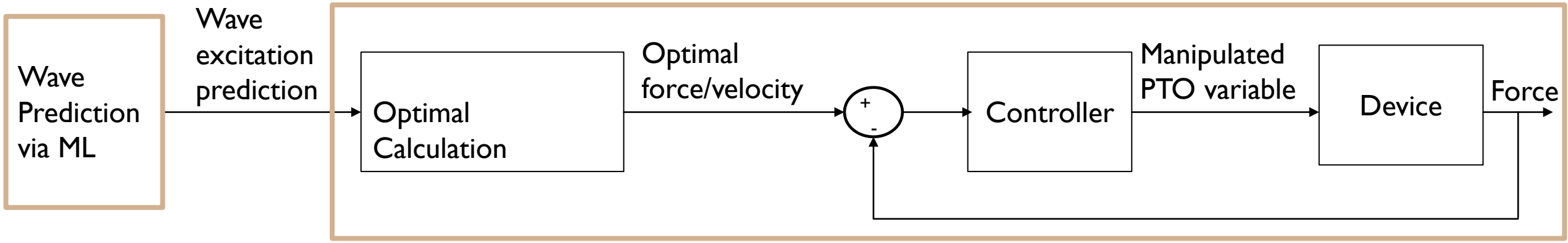
# WEC Control Background

- Optimal control is a logical choice for WEC systems but practical application is challenging due to:
  - Unknown future wave states for irregular waves
  - PTO motion and force constraints
  - Nonlinearity of WEC system
- TALOS also has the challenge of having to deal with capture in 6 degrees of freedom.





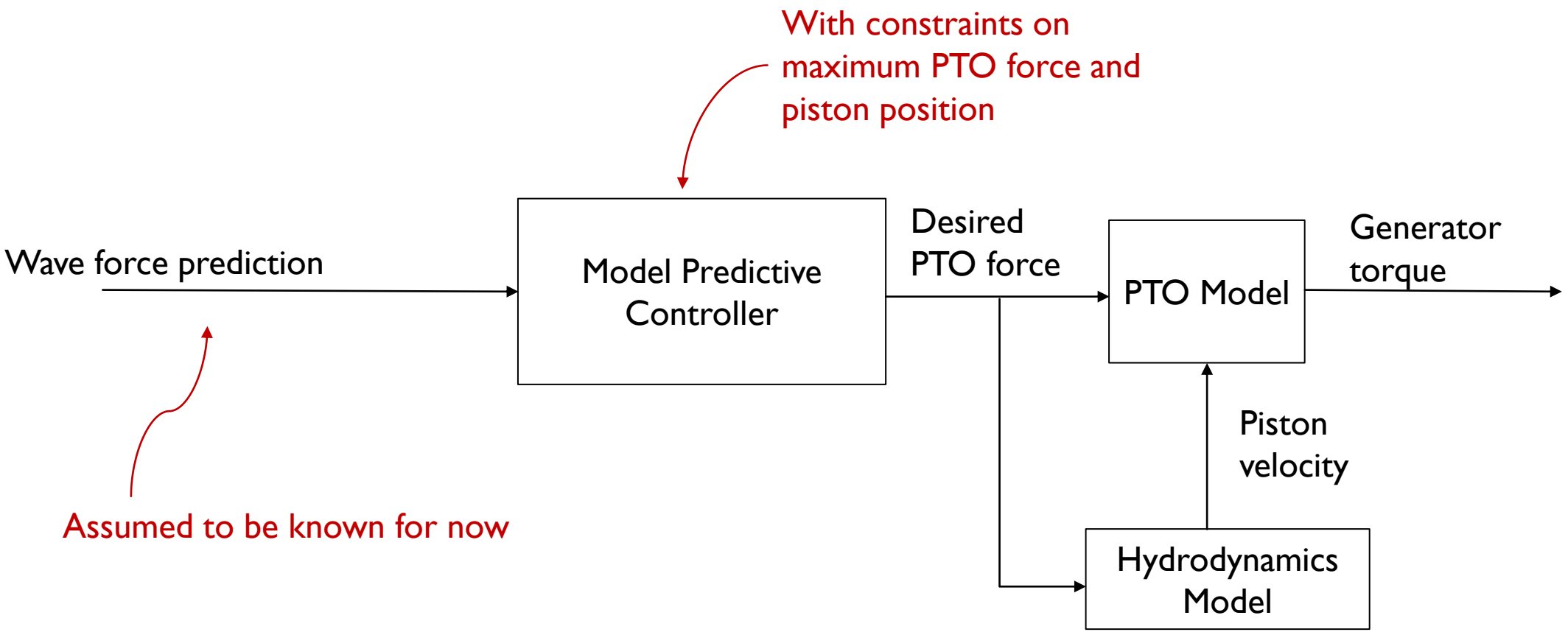
# Initial Examination of Impact of PTO Constraints




1. Focus on PTO Constraints

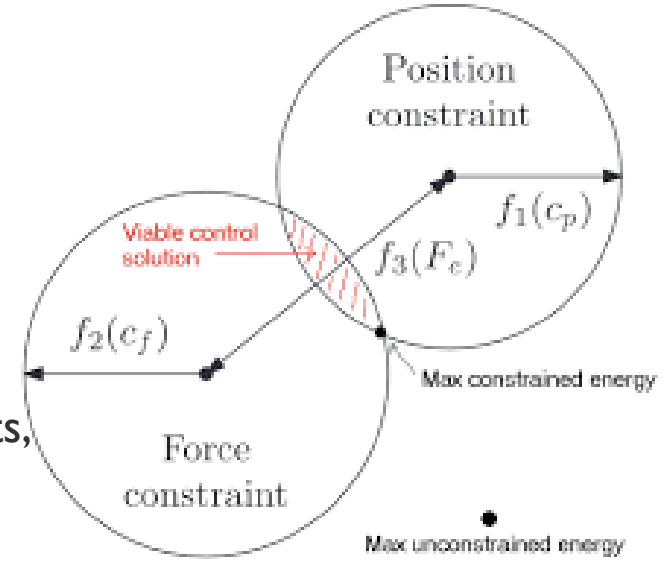
- How do we handle the underlying PTO constraints on position and force?
  - How is model predictive control impacted when these constraints are introduced?
  - How limiting are the constraints in real-life conditions with irregular waves?

# Initial Examination of Impact of PTO Constraints



# Initial Examination of Impact of PTO Constraints


- Most studies do not include PTO dynamics and hydrodynamics when examining MPC with constraints.
- Position and force constraints are not always able to be maintained simultaneously which complicates the control (see figure).
- Closest studies are Bacelli 2015, Karthikeyan 2019 and Meriguard 2020 which include physical constraints and PTO force constraints, but use a relatively simple PTO model with losses but no dynamics.



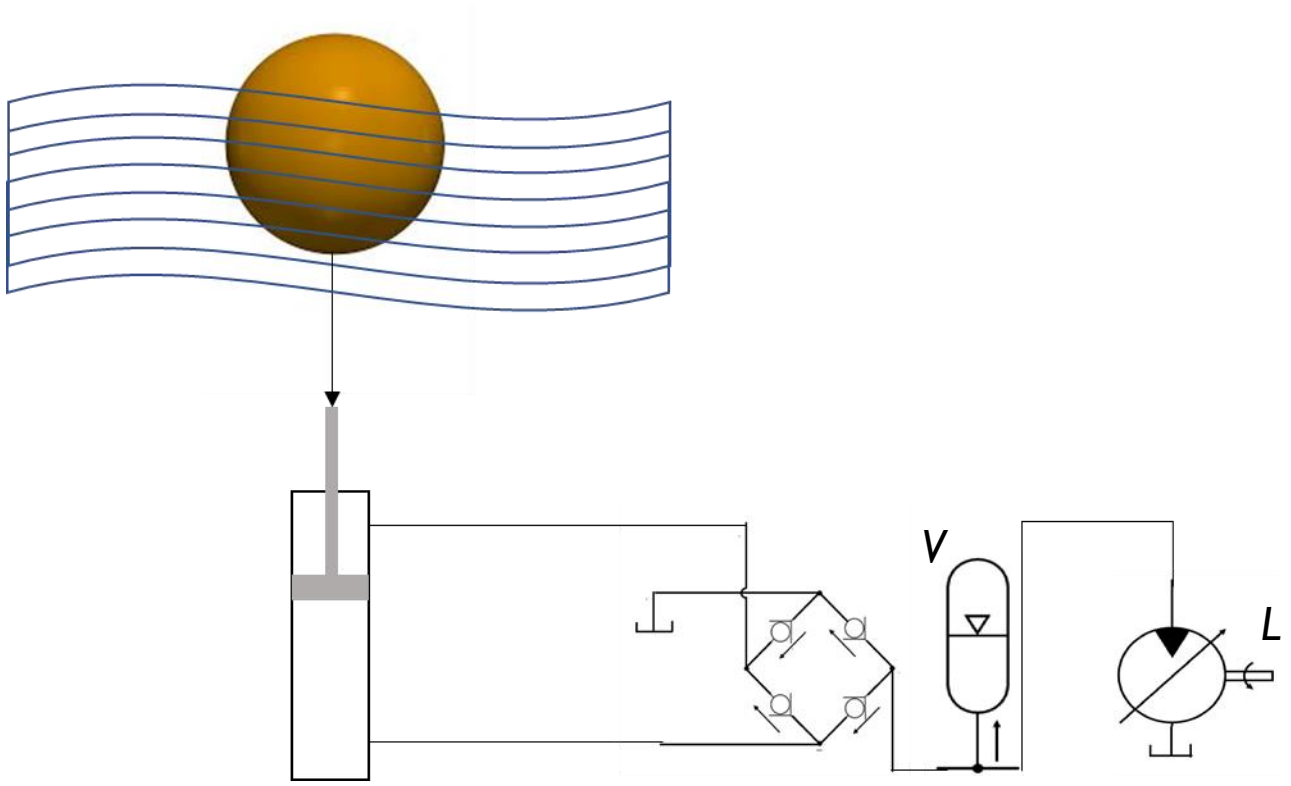
# Base Model for 1-D

- Leverage the traditional wave-structure interaction relationship

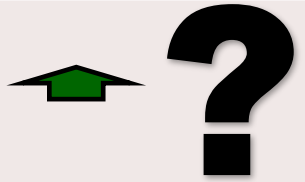
- Base model from Bacelli 2008 which captures the hydraulic PTO dynamics in two dynamic equation in terms of the gas accumulator volume (V) and the hydraulic motor shaft angular momentum (L)

$$\begin{cases} \dot{V} = -k_l \cdot h(V) - \dfrac{D}{J} \cdot L + S \cdot v \\ \dot{L} = D\eta_m \cdot h(V) - \dfrac{B}{J} \cdot L - T_G \end{cases}$$

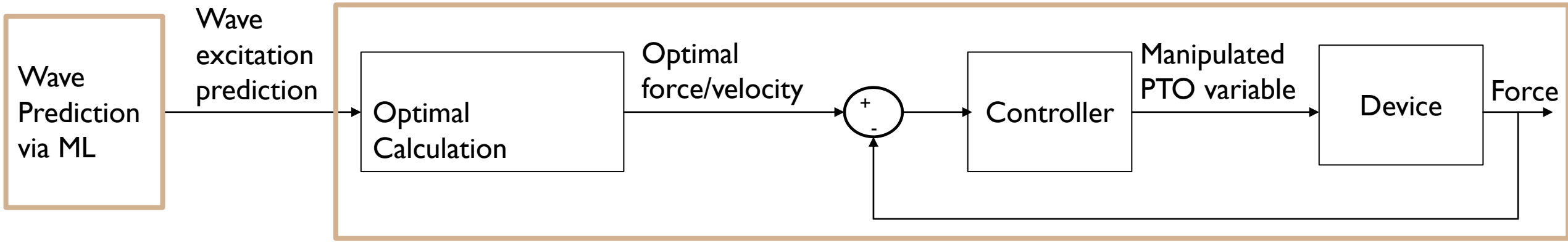
$$F_h = S \cdot h(V) + S \cdot k(S \cdot v)$$



# Control Investigation

| Control Option | PTO with Instant Response | Hydraulic PTO | Hydraulic PTO with Limits |
|---|---|---|---|
| Velocity Tracking | Base |  |  |
| Linear Model Predictive Control |  |  |  |
| Nonlinear Model Predictive Control |  |  |  |

# Also of interest…




11. Focus on Wave Prediction Impact

- How accurately can we predict future local wave conditions?
- How do we handle the uncertainty that comes from doing wave excitation predictions via machine learning?
  - How do we bound the uncertainty?
  - How does it affect controller performance?