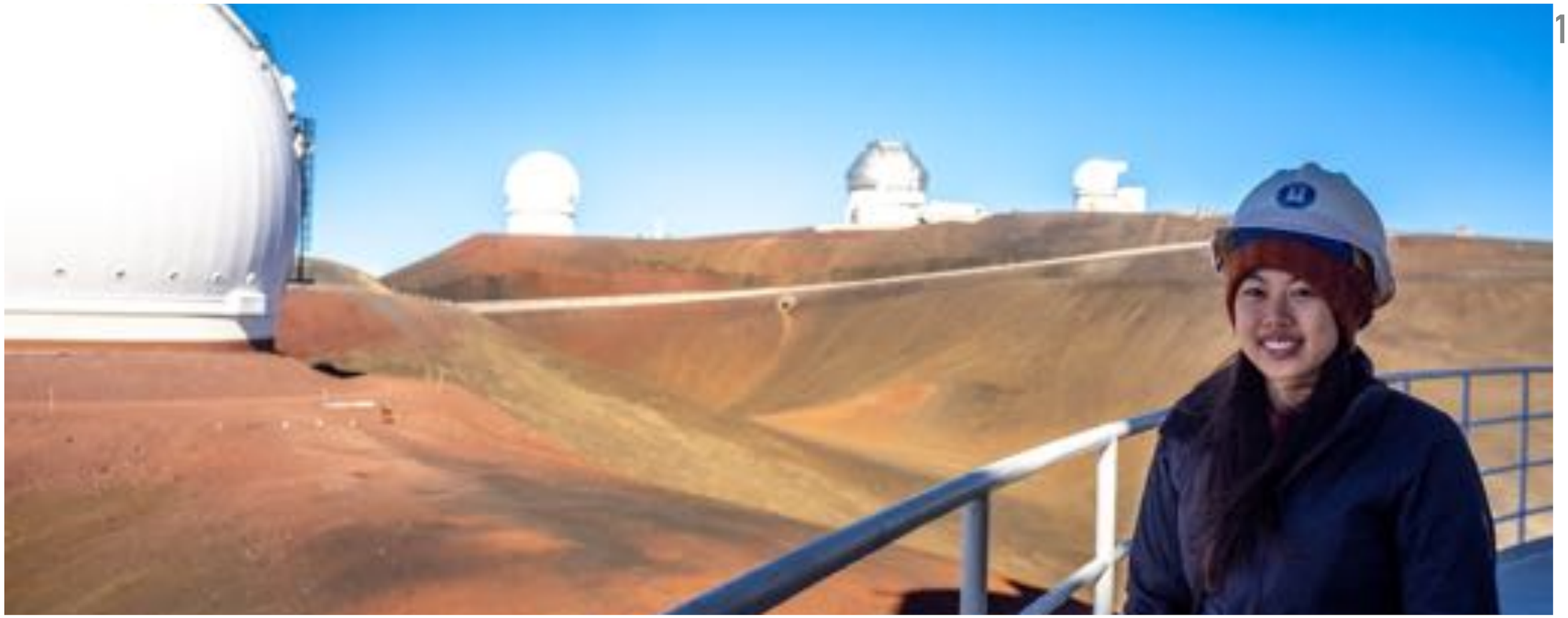


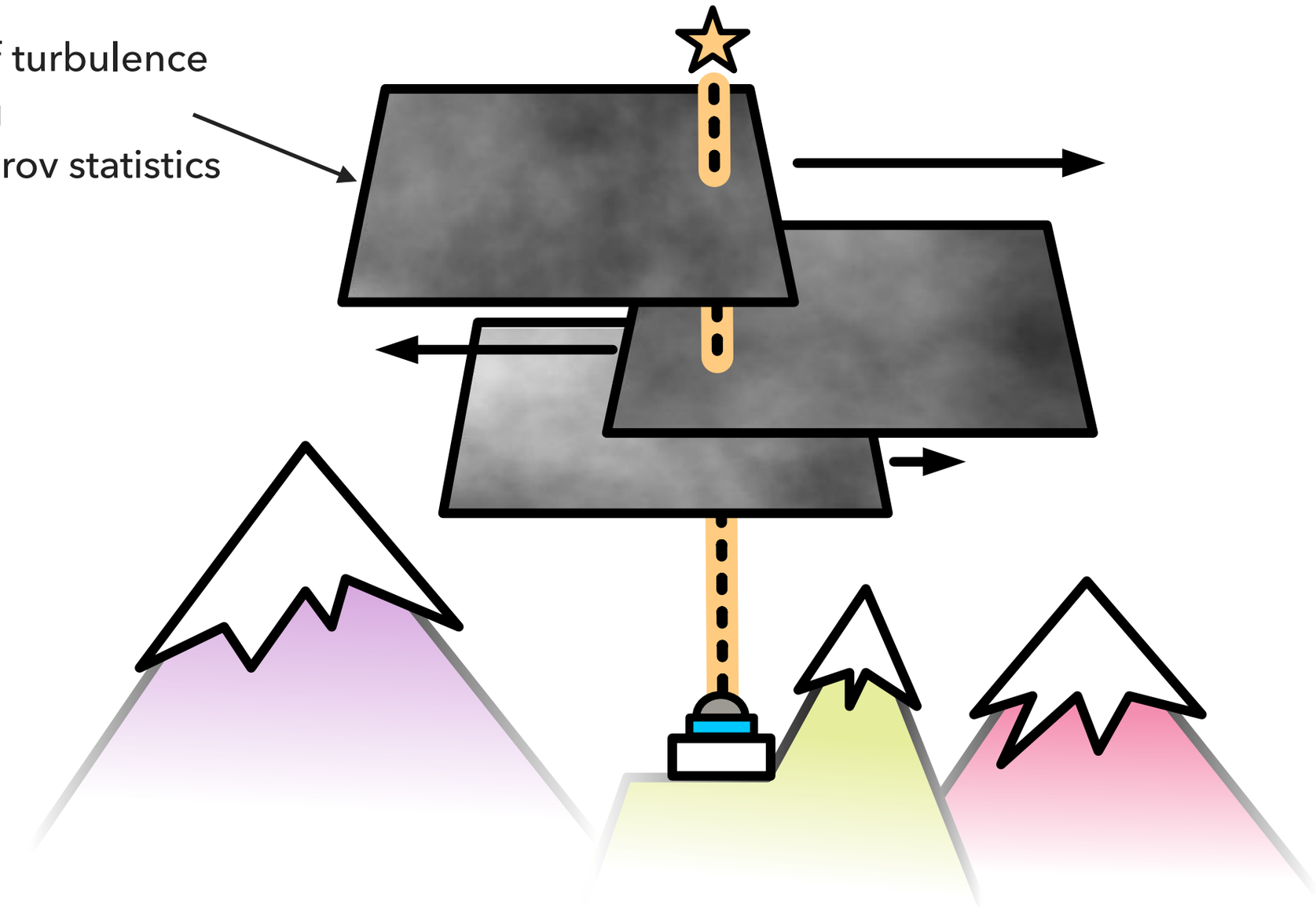
ALISON WONG

THE UNIVERSITY OF SYDNEY

Peter Tuthill
Barnaby Norris
Olivier Guyon

# MODERN NEURAL NETWORKS: A PATHWAY TO BETTER ADAPTIVE OPTICS

# A SIMPLE MODEL OF THE ATMOSPHERE



# ADAPTIVE OPTICS

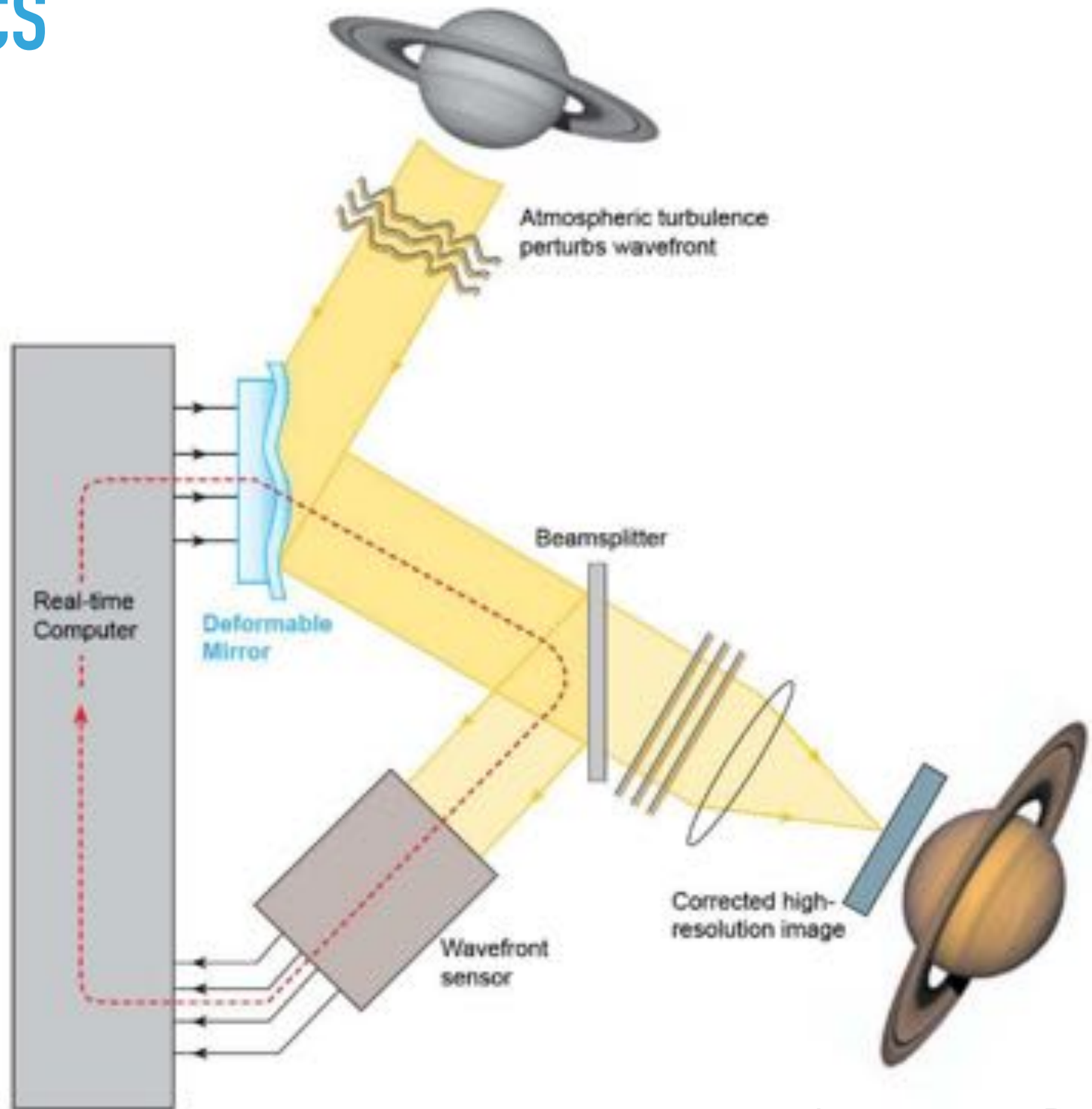
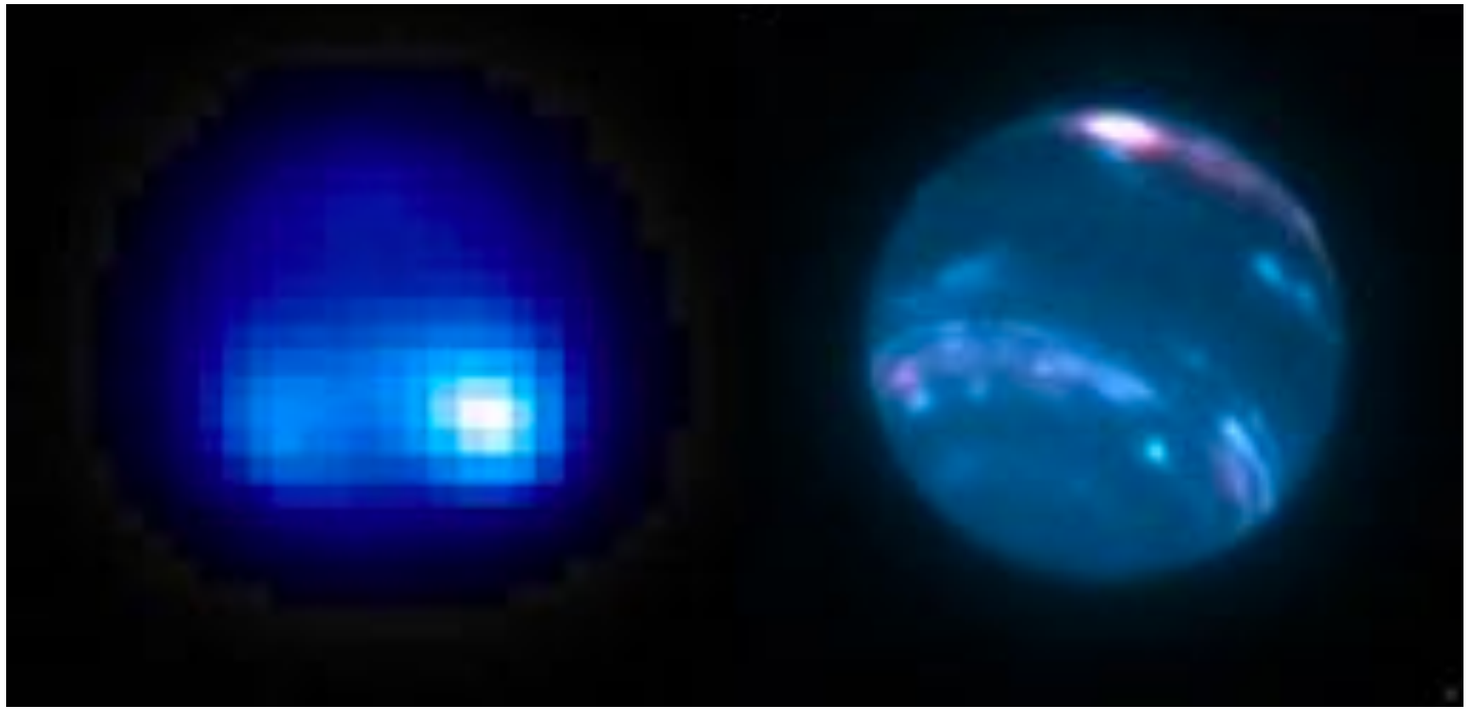



Image source: Davies & Kasper 2012

# MOTIVATION

Neptune



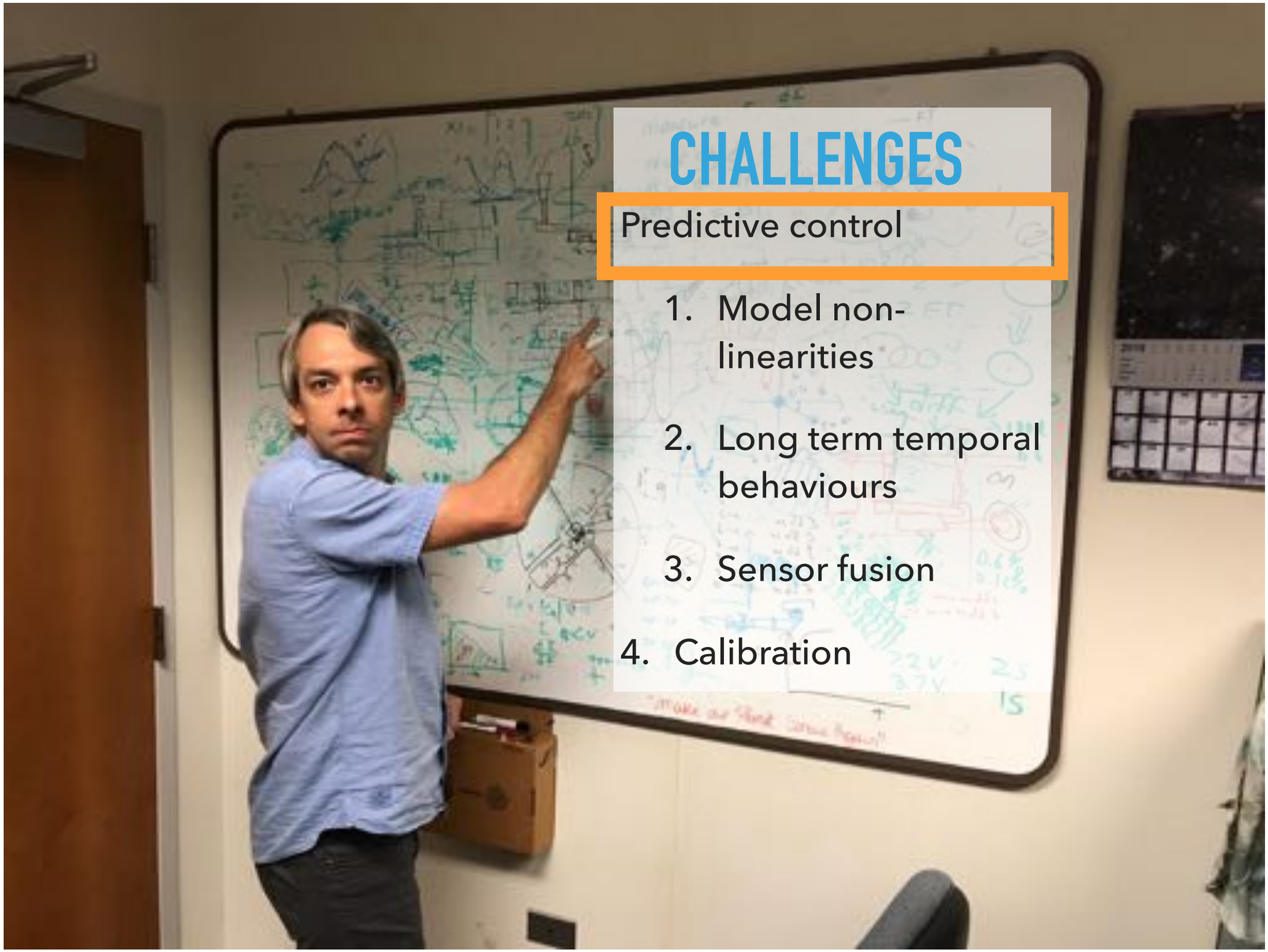
Without AO correction

- High resolution images of planets and moons in our solar system
- Study of protoplanetary disks
- Spectroscopic studies of distant galaxies
- Study of the Sun’s photosphere

With AO correction

- Direct imaging of exoplanets
- Imaging circumstellar disks
- Study of stellar multiplicity
- Determining masses of black holes

Image source: Wizinowich 2015


CHALLENGES
Predictive control
1. Model non-linearities
2. Long term temporal behaviours
3. Sensor fusion
4. Calibration

# WHY WE NEED PREDICTIVE CONTROL

Time delay →

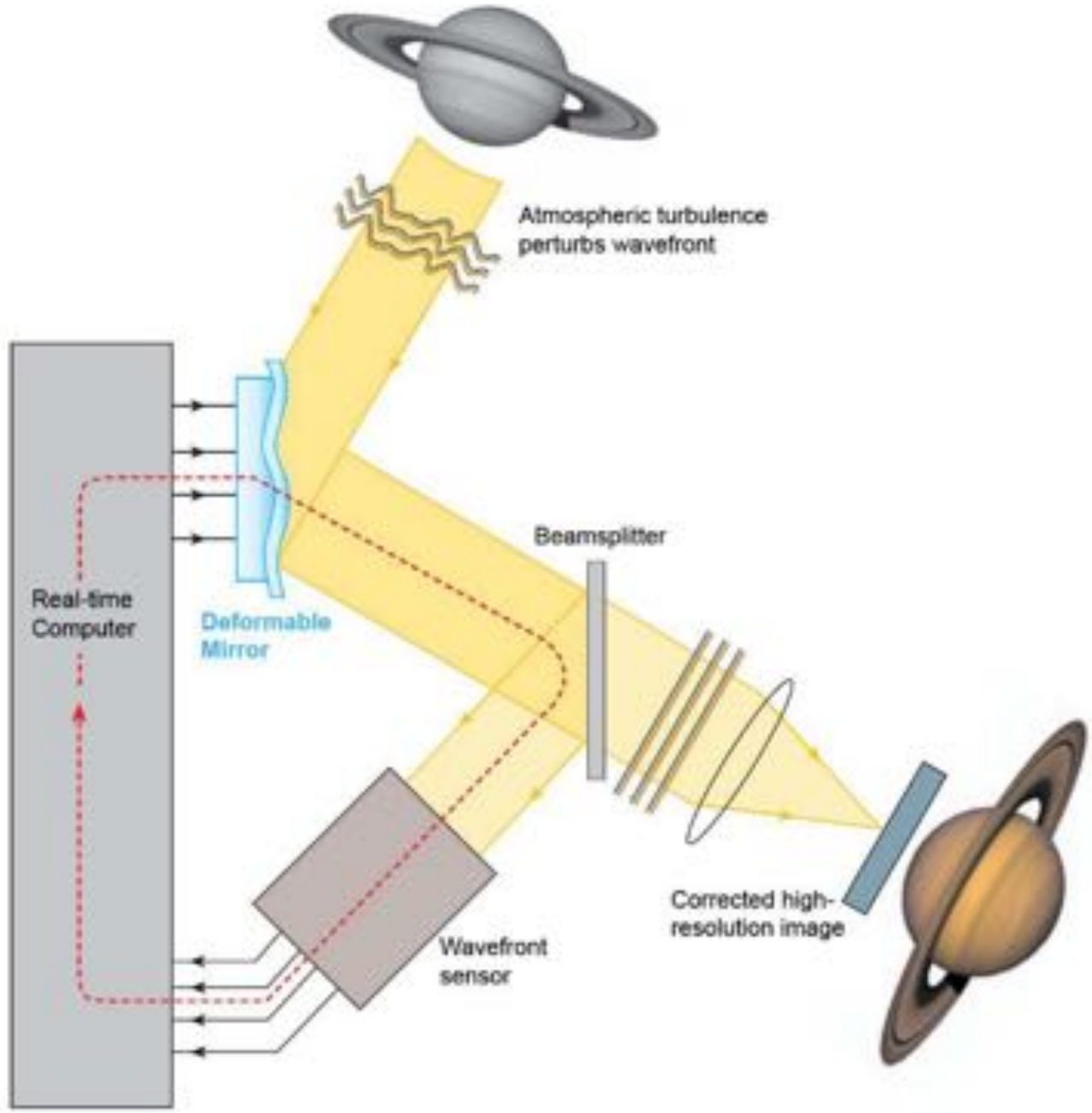
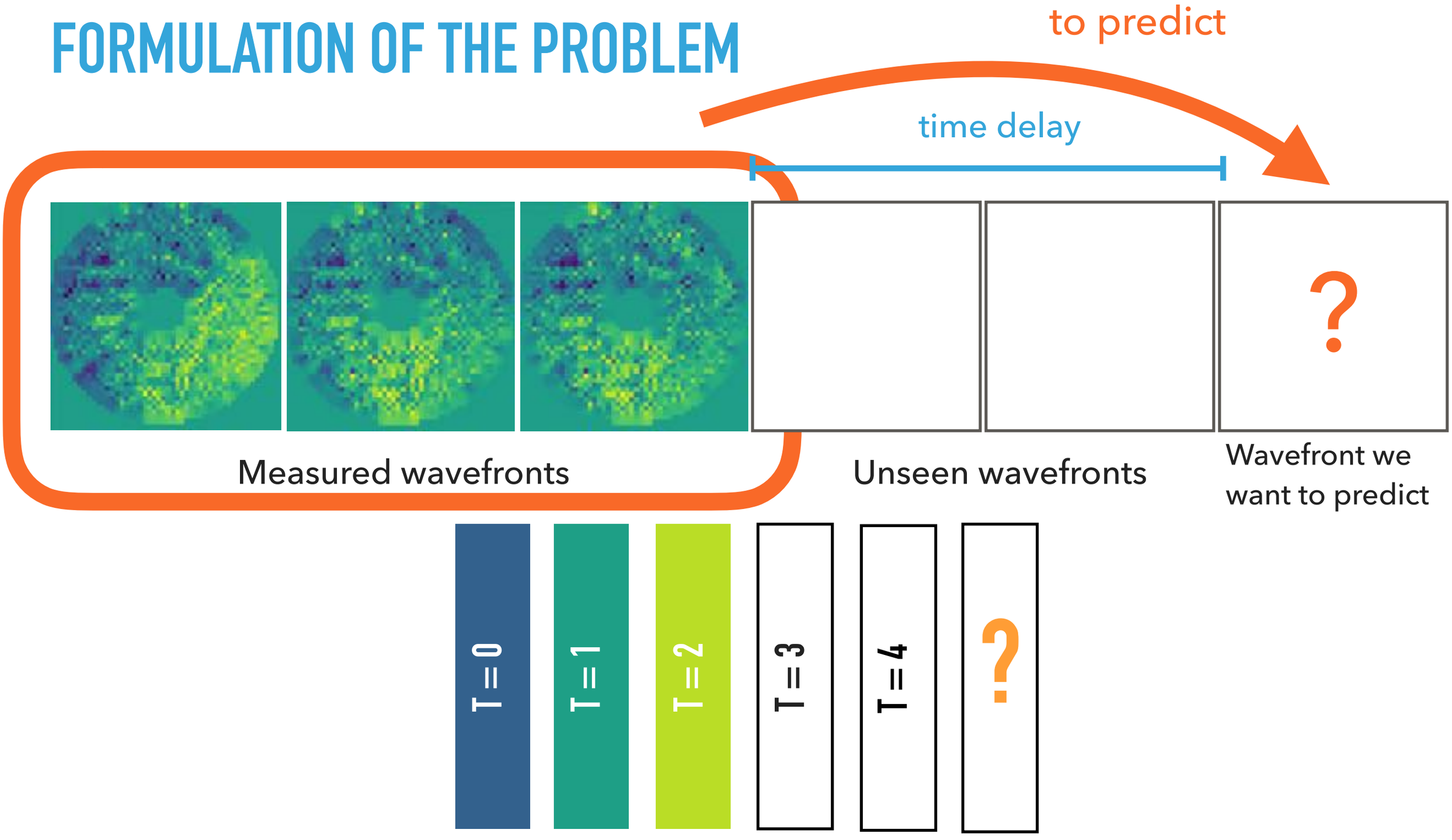
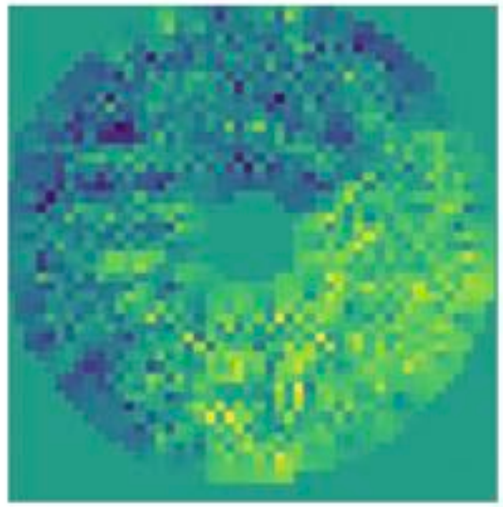


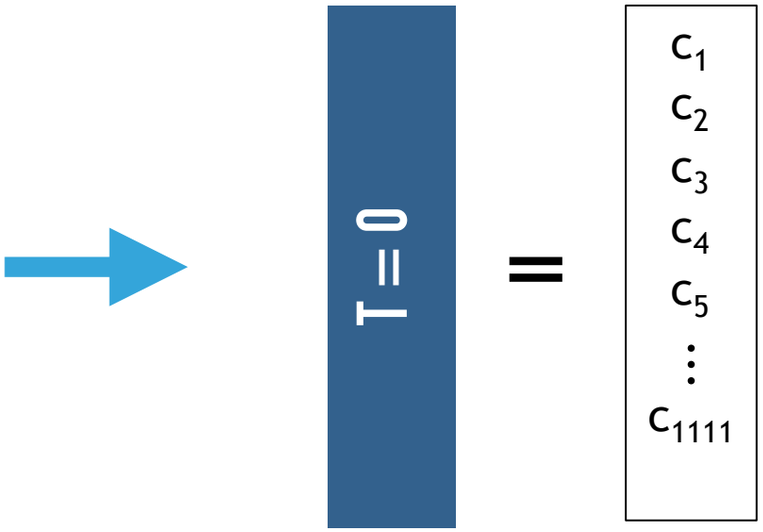

Image source: Davies & Kasper 2012

# FORMULATION OF THE PROBLEM

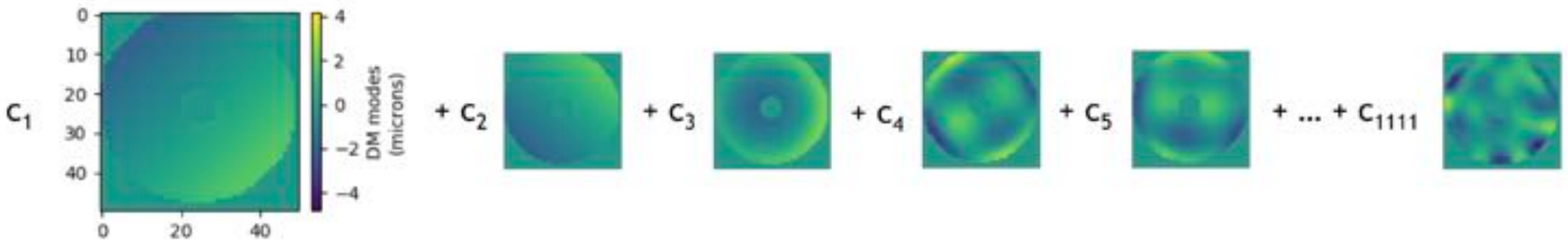


# REPRESENTATION OF THE WAVEFRONT






Vector representation

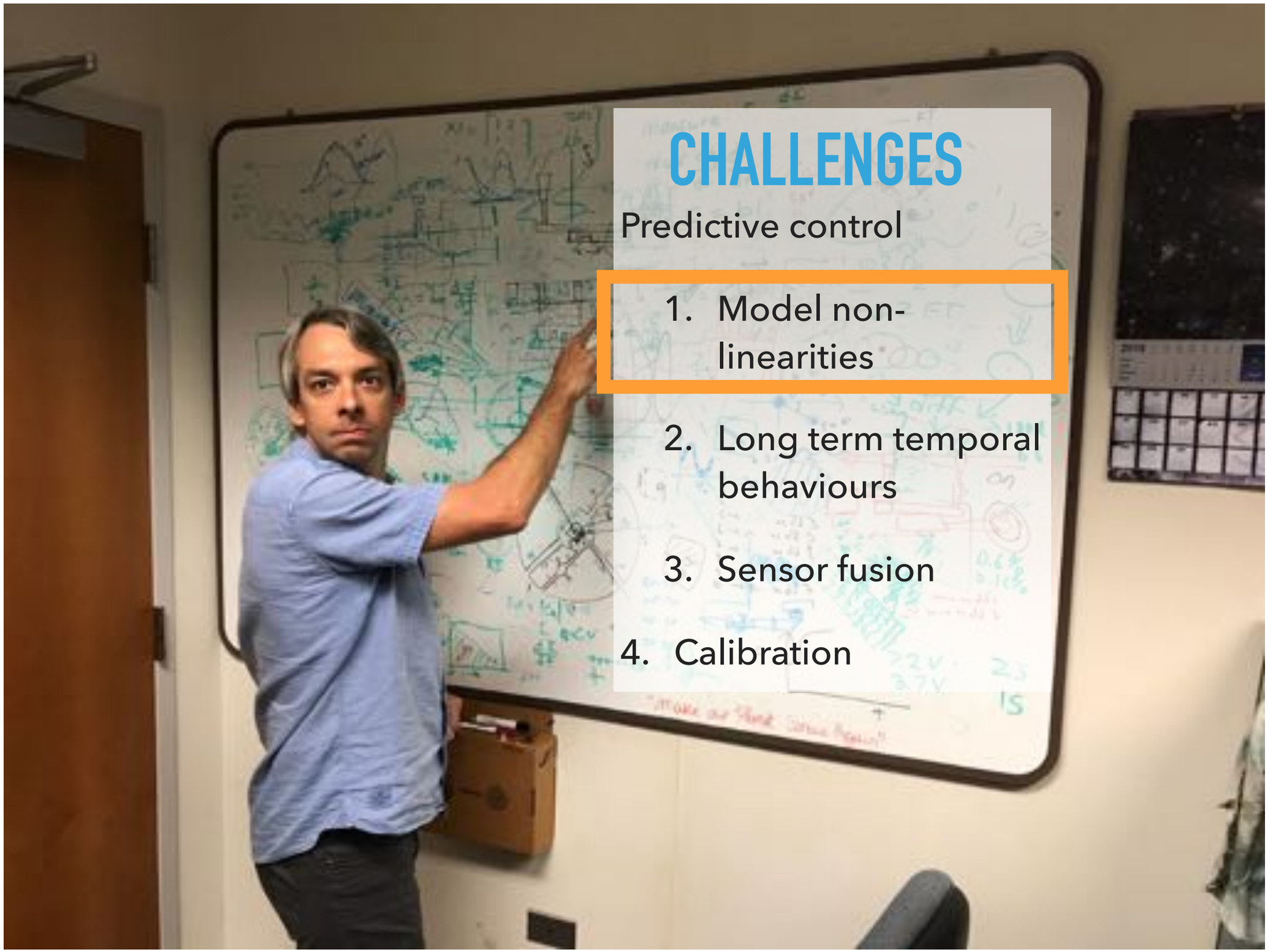


# PREDICTIVE CONTROL WITH LINEAR ALGEBRA

Predictive Filter

=

Guyon & Males 2017


CHALLENGES
Predictive control
1. Model non-linearities
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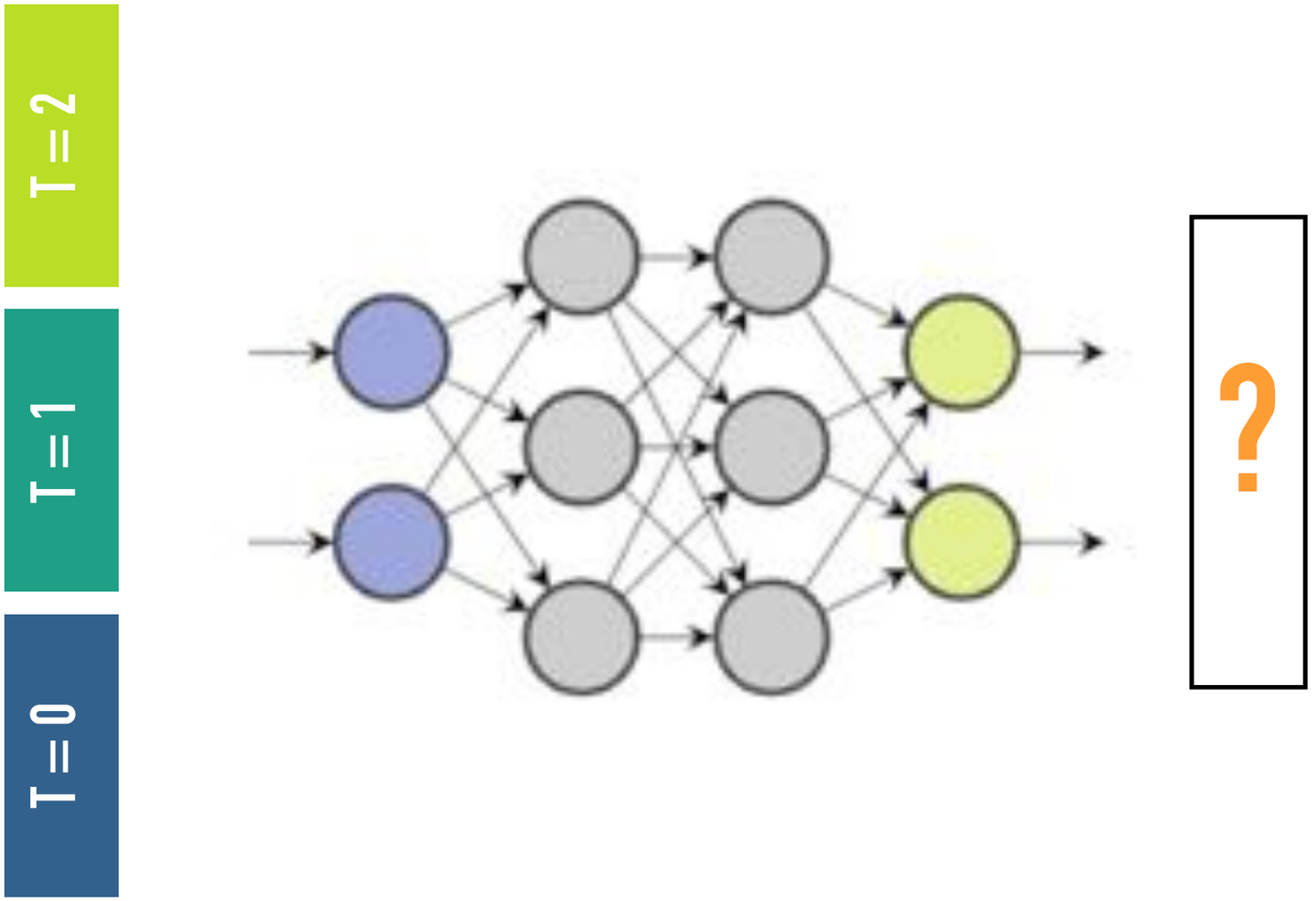
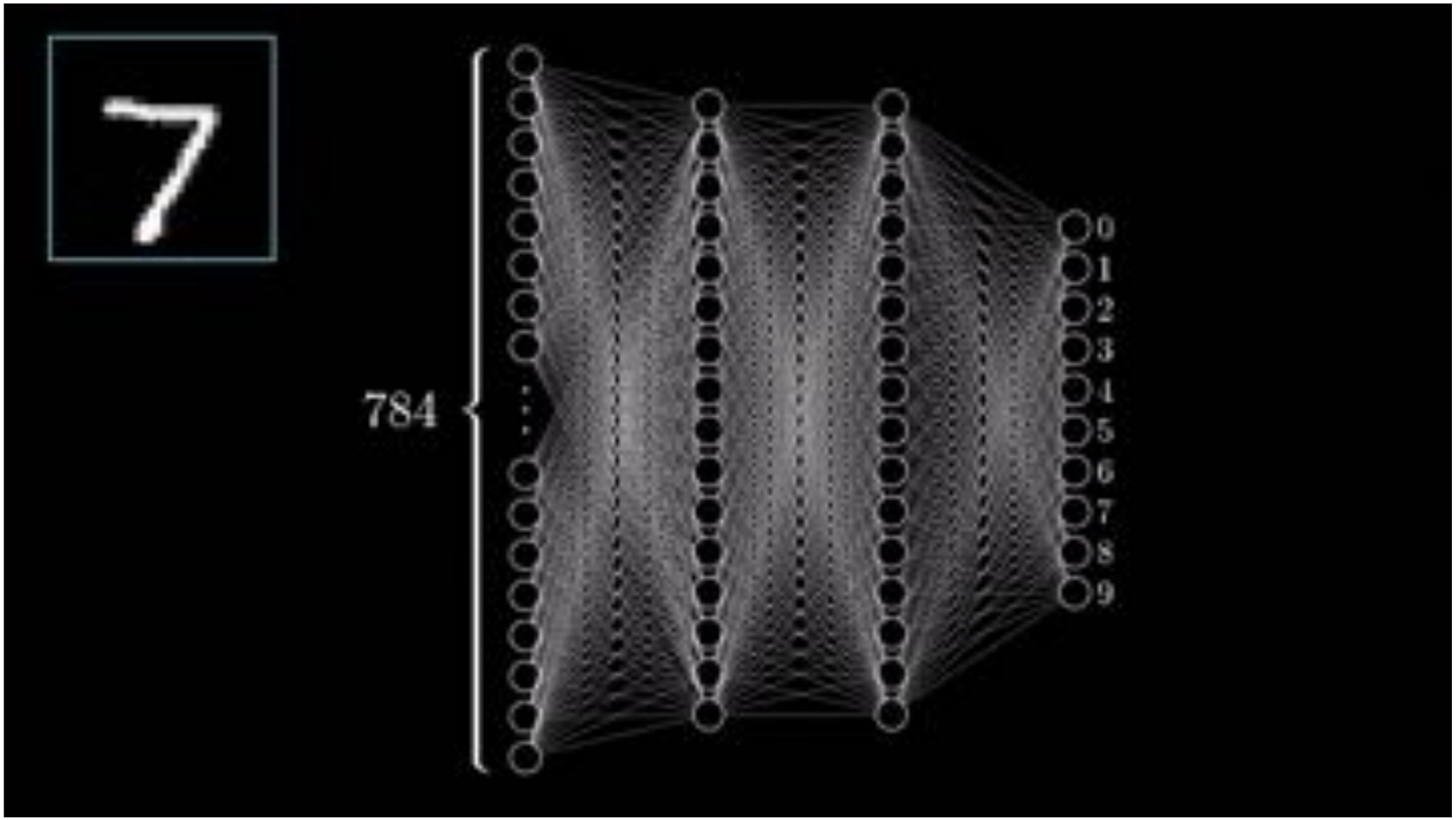
4. Calibration

# PREDICTIVE CONTROL WITH A NEURAL NETWORK

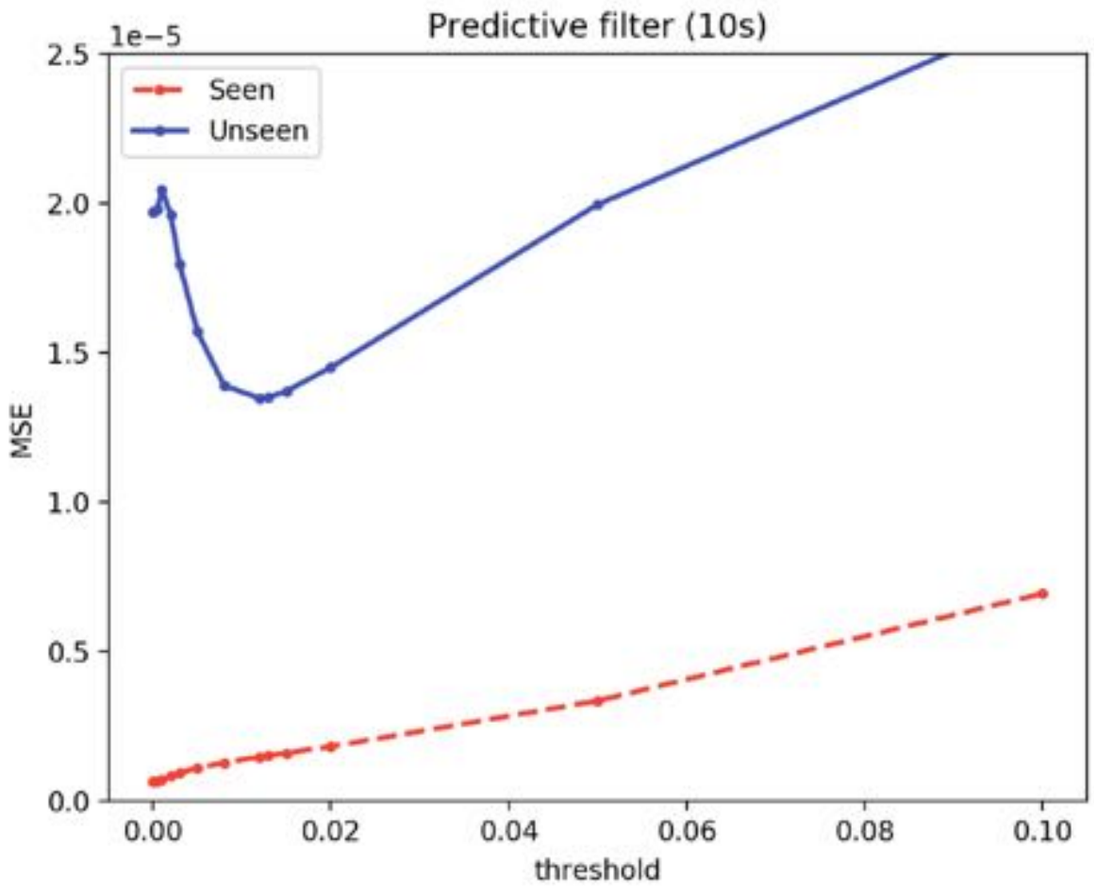


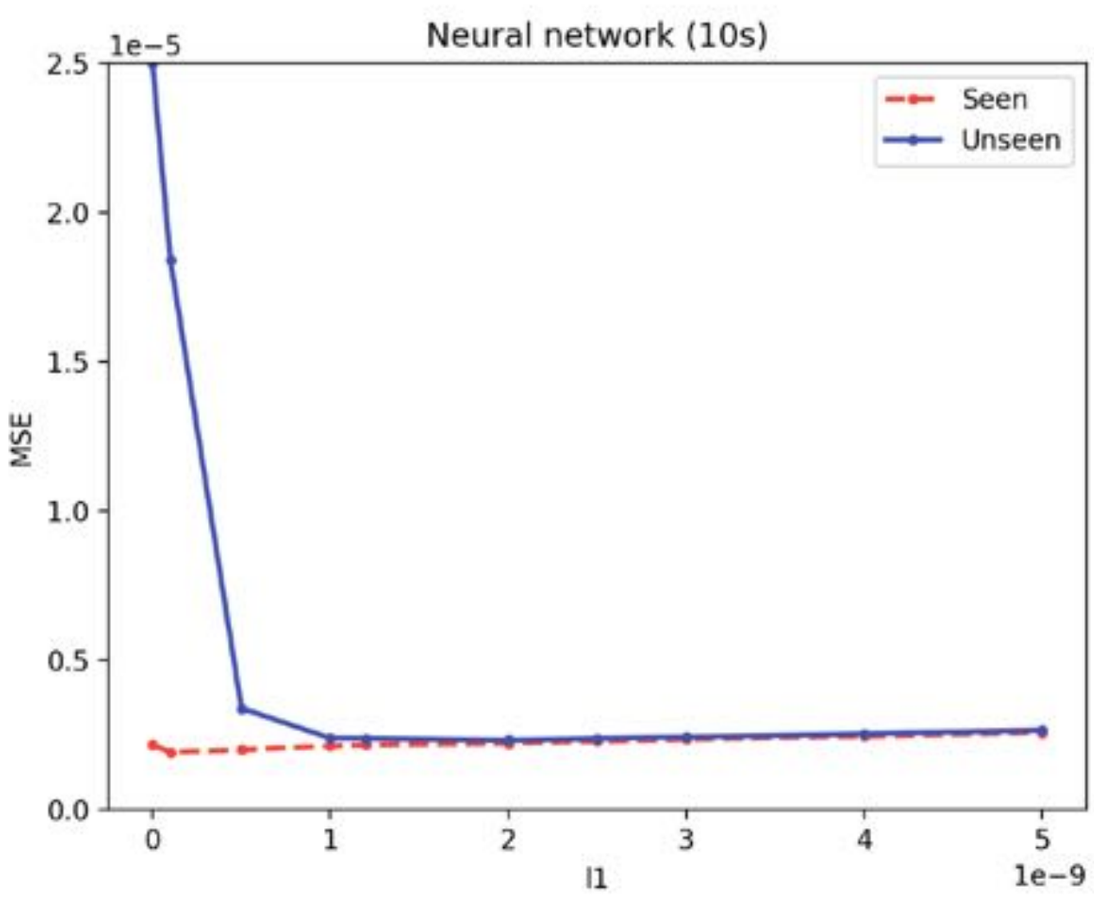
# FEEDFORWARD NEURAL NETWORK




Video source: https://www.youtube.com/watch?v=aircAruvnKk

# CURRENT RESULTS

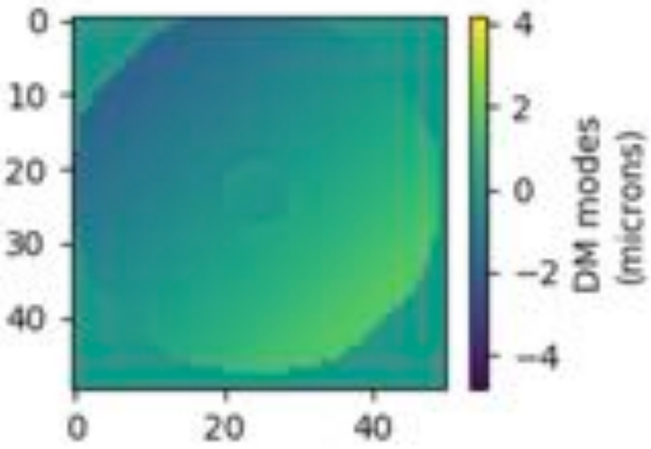


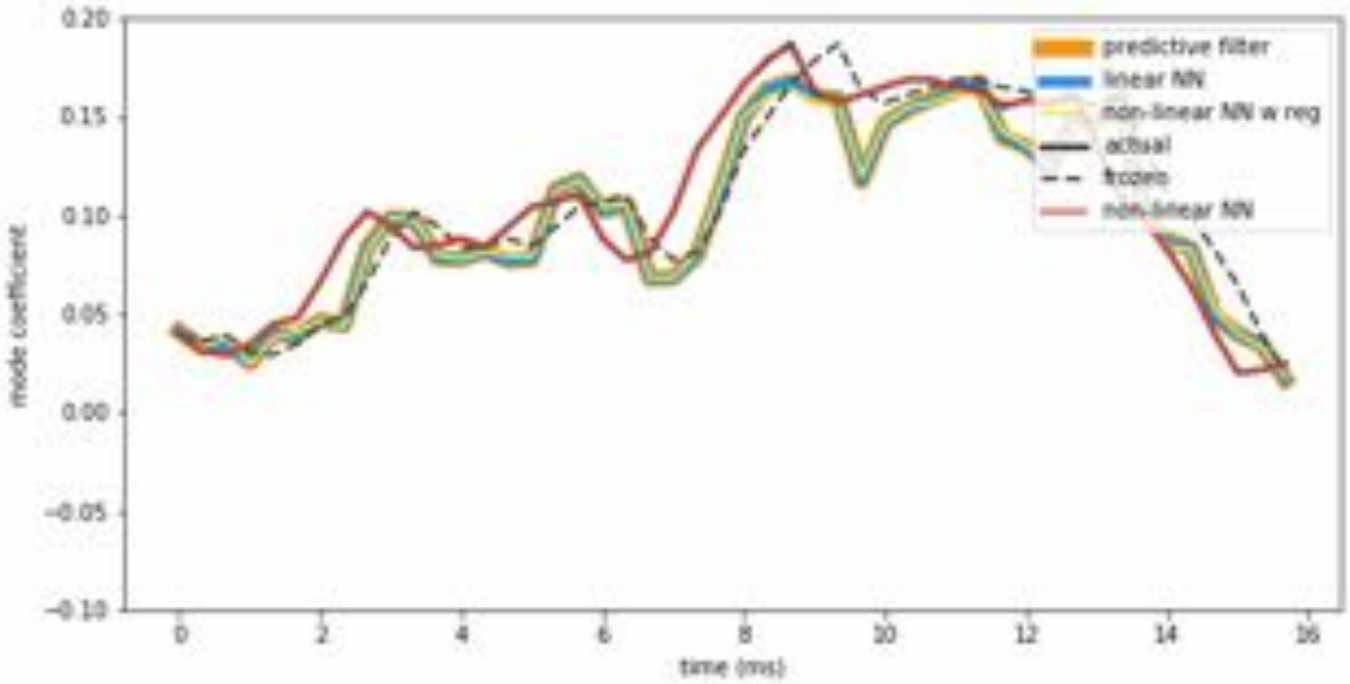

Linear neural network does better

- on small amount of data
- for longer delays

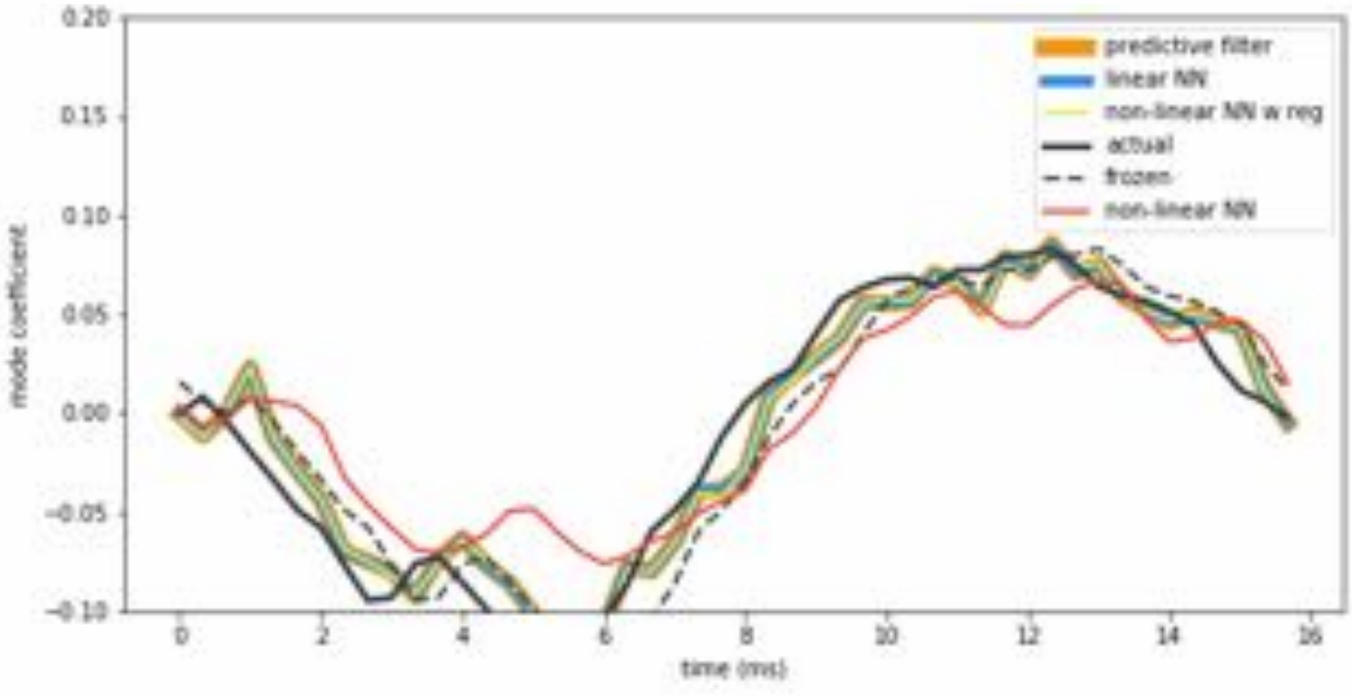
# CURRENT RESULTS

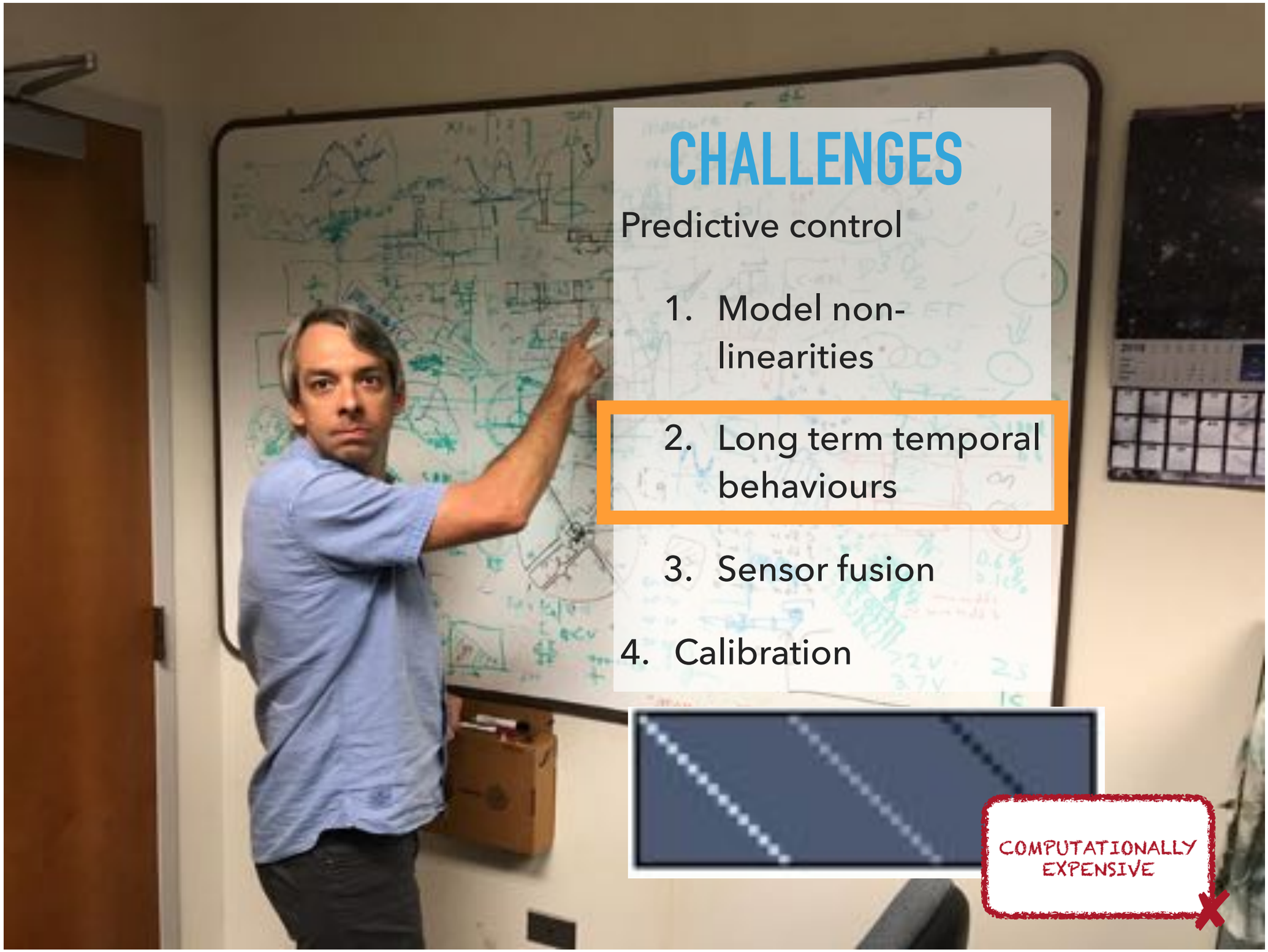



Seen data




Unseen data




CHALLENGES
Predictive control
1. Model non-linearities
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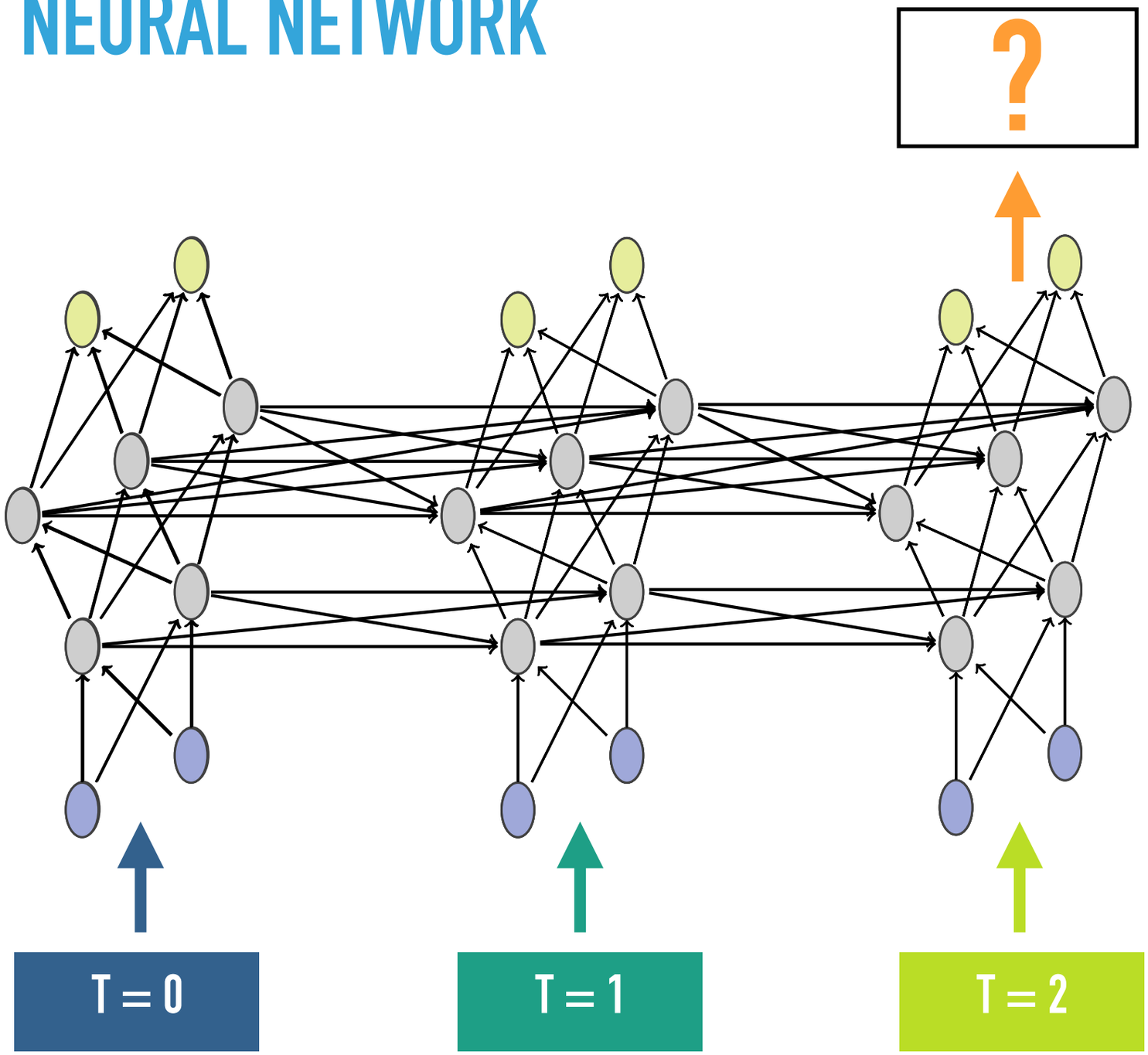
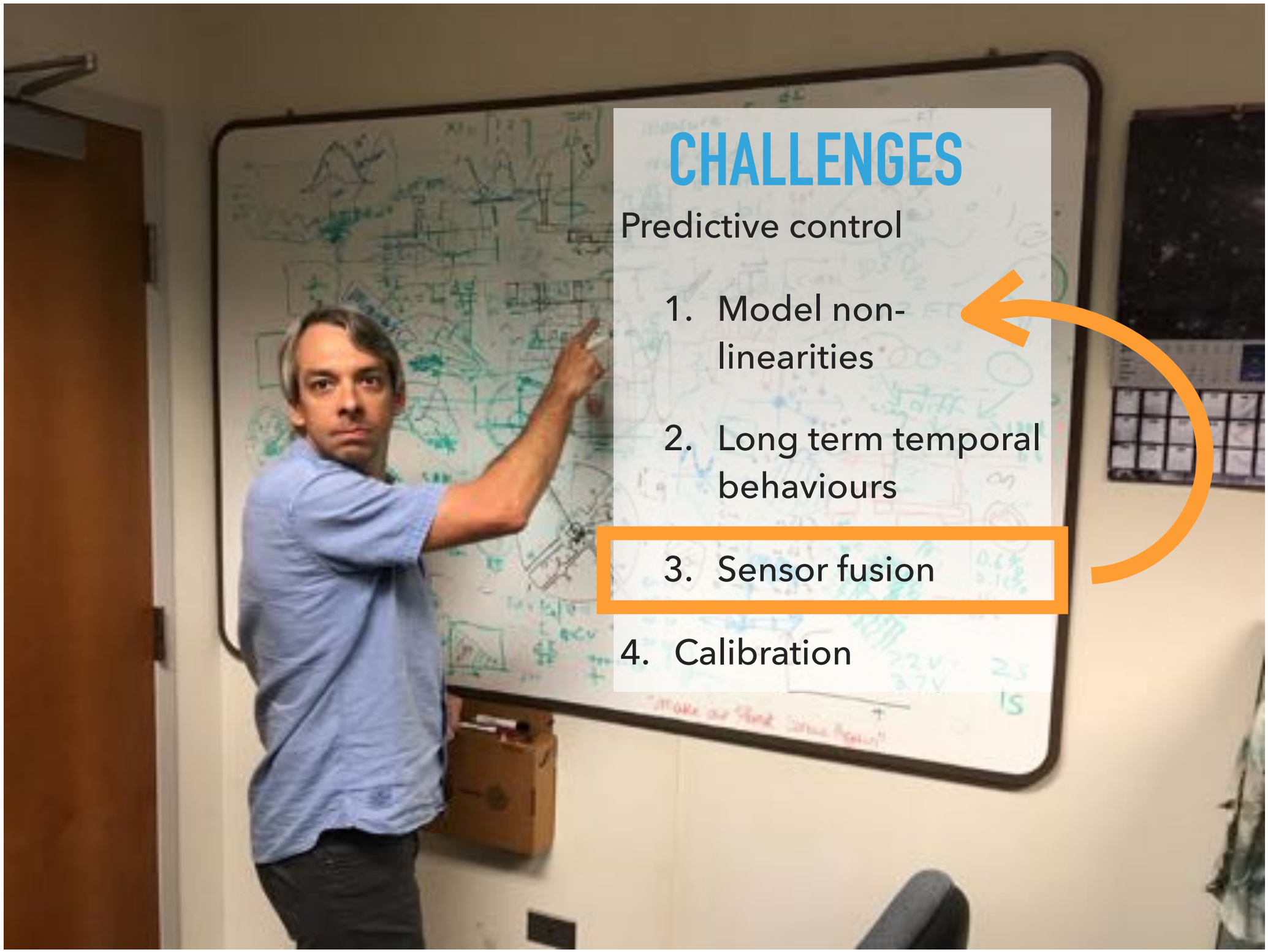
3. Sensor fusion
4. Calibration
COMPUTATIONALLY EXPENSIVE

# RECURRENT NEURAL NETWORK




CHALLENGES
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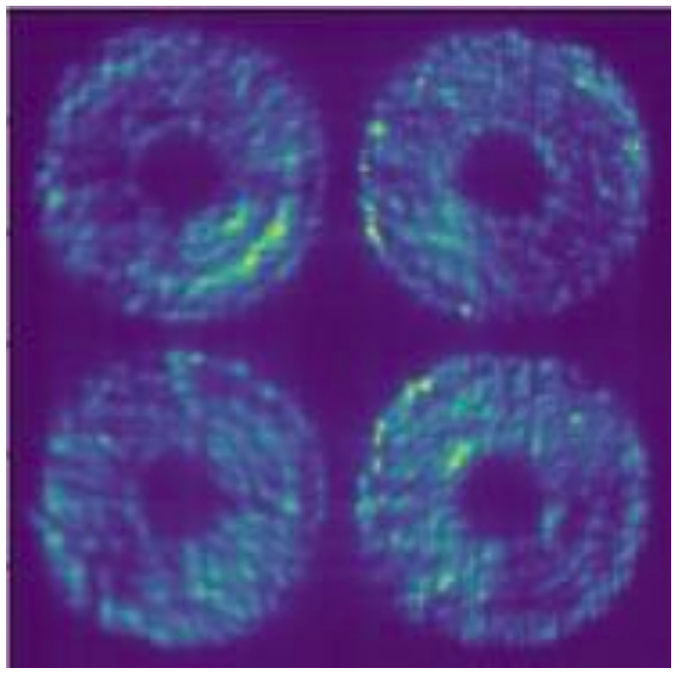
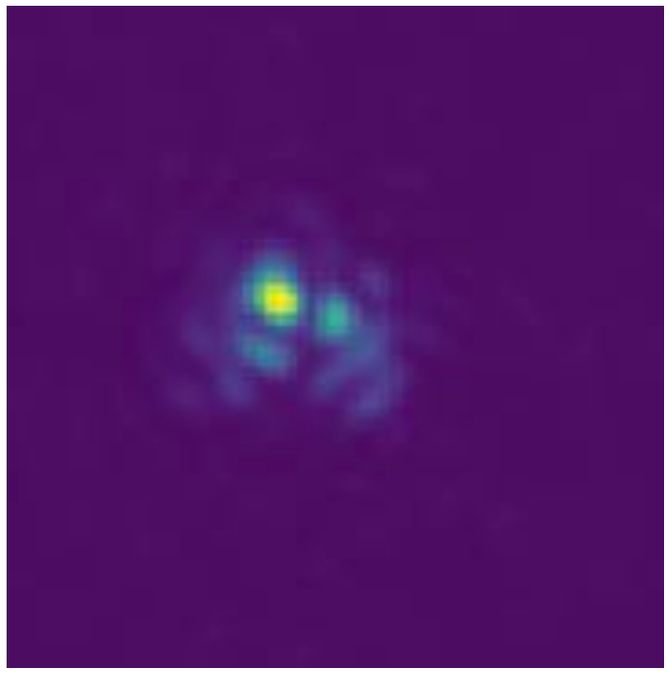
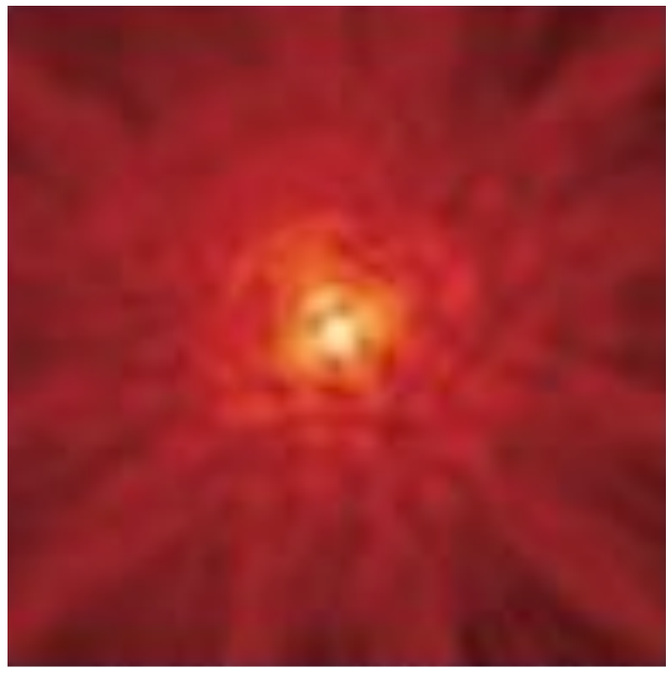
# SENSOR FUSION



Pyramid wavefront sensor images

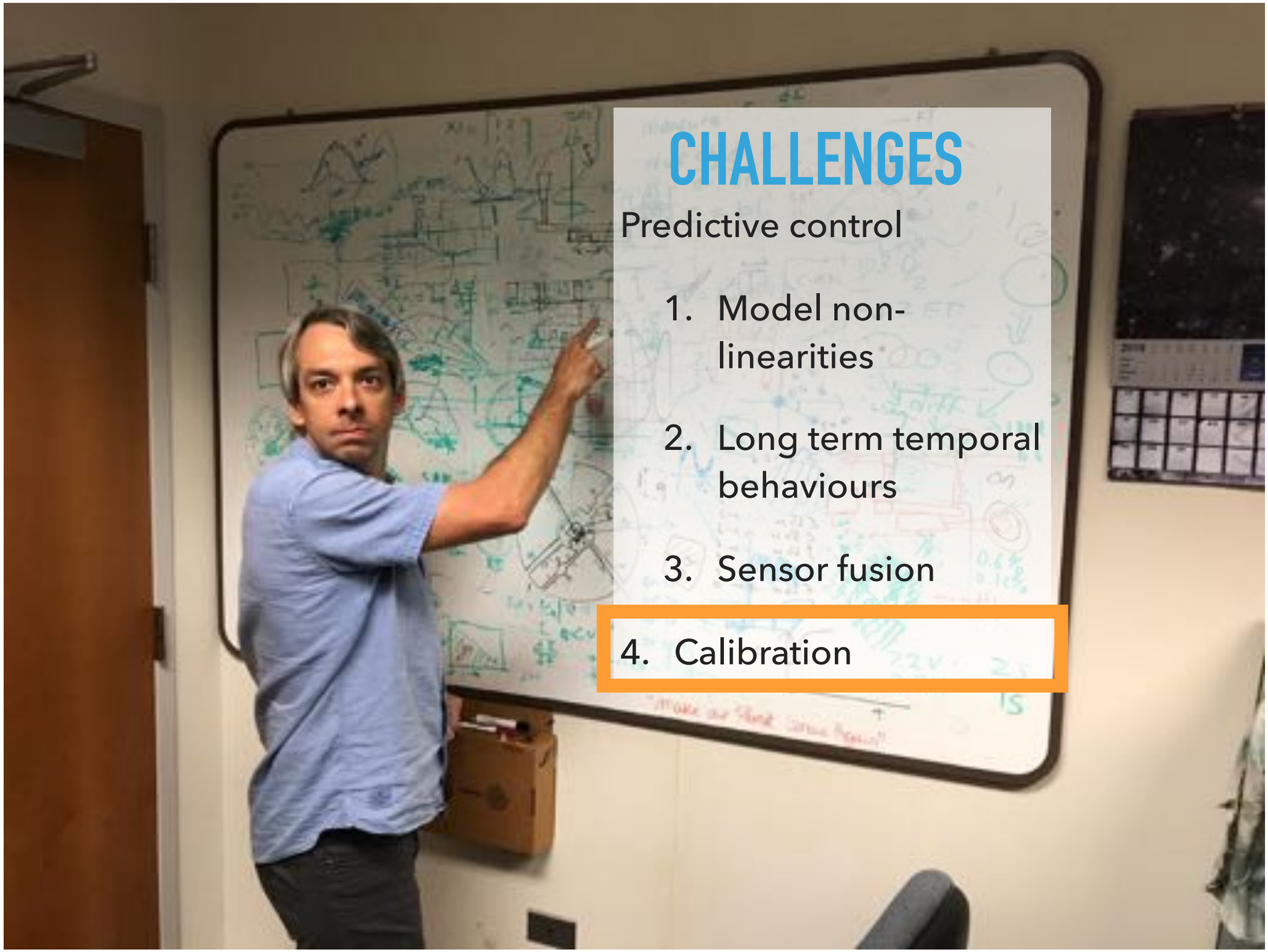


Point spread function



Point spread function (infrared)

Image source (right): https://wfirst.gsfc.nasa.gov/science/WFIRSTScienceSheetFINAL.pdf


CHALLENGES
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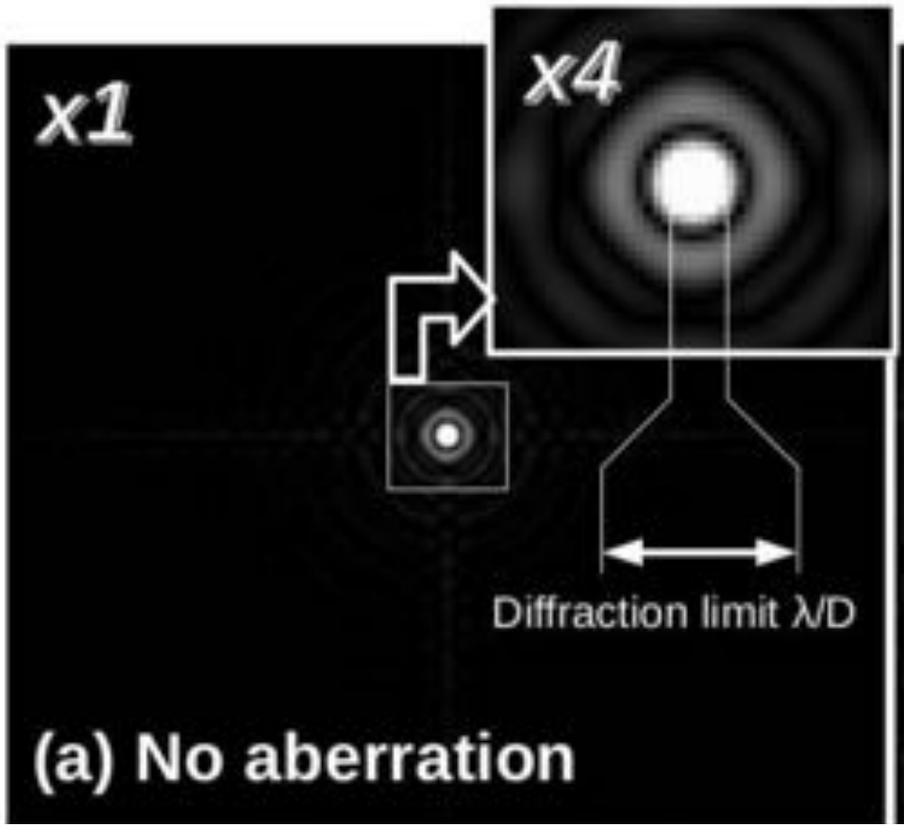
# THE POINT SPREAD FUNCTION (PSF)



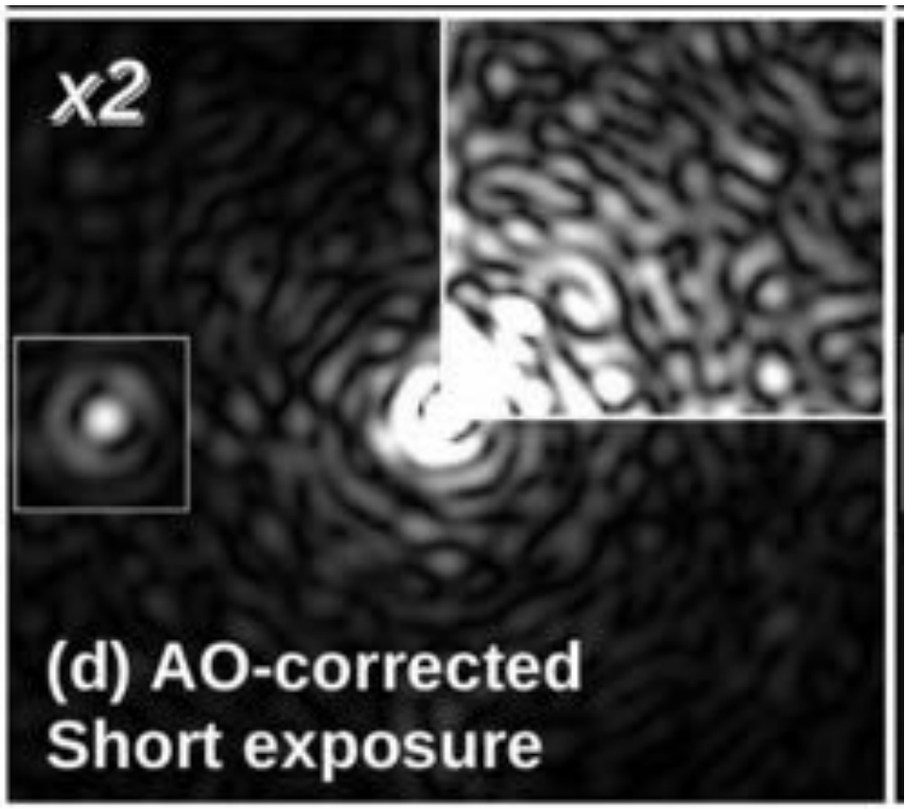



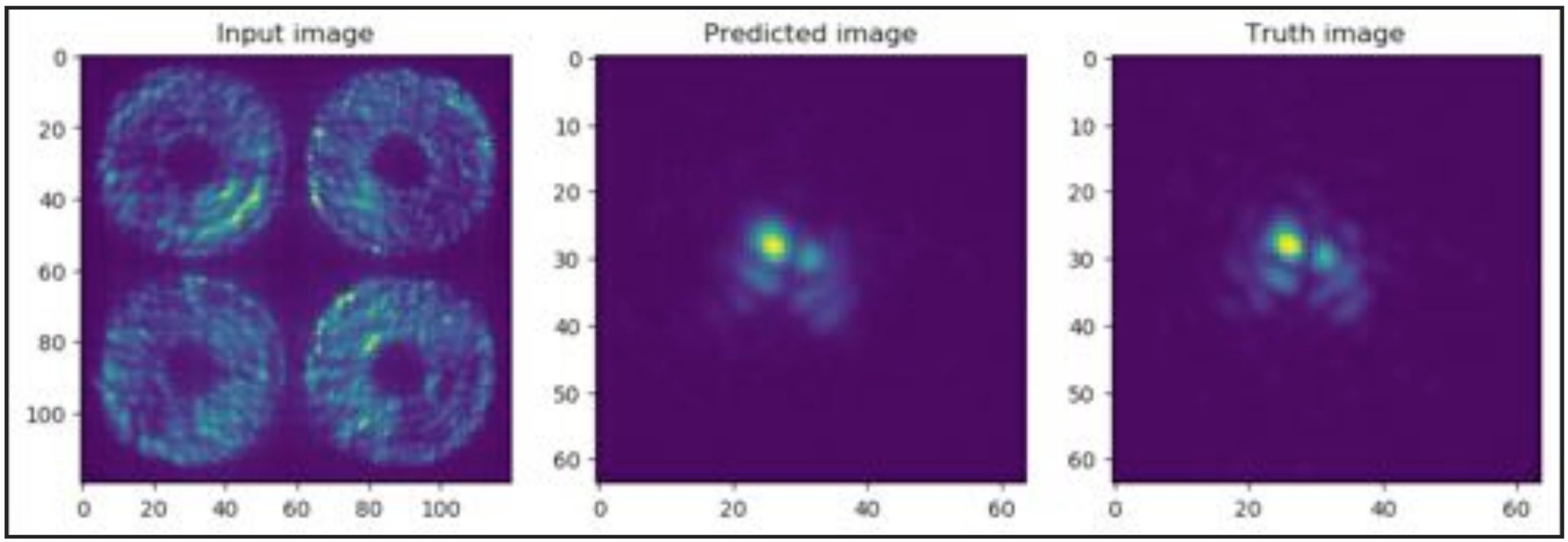

Image source: Guyon 2018

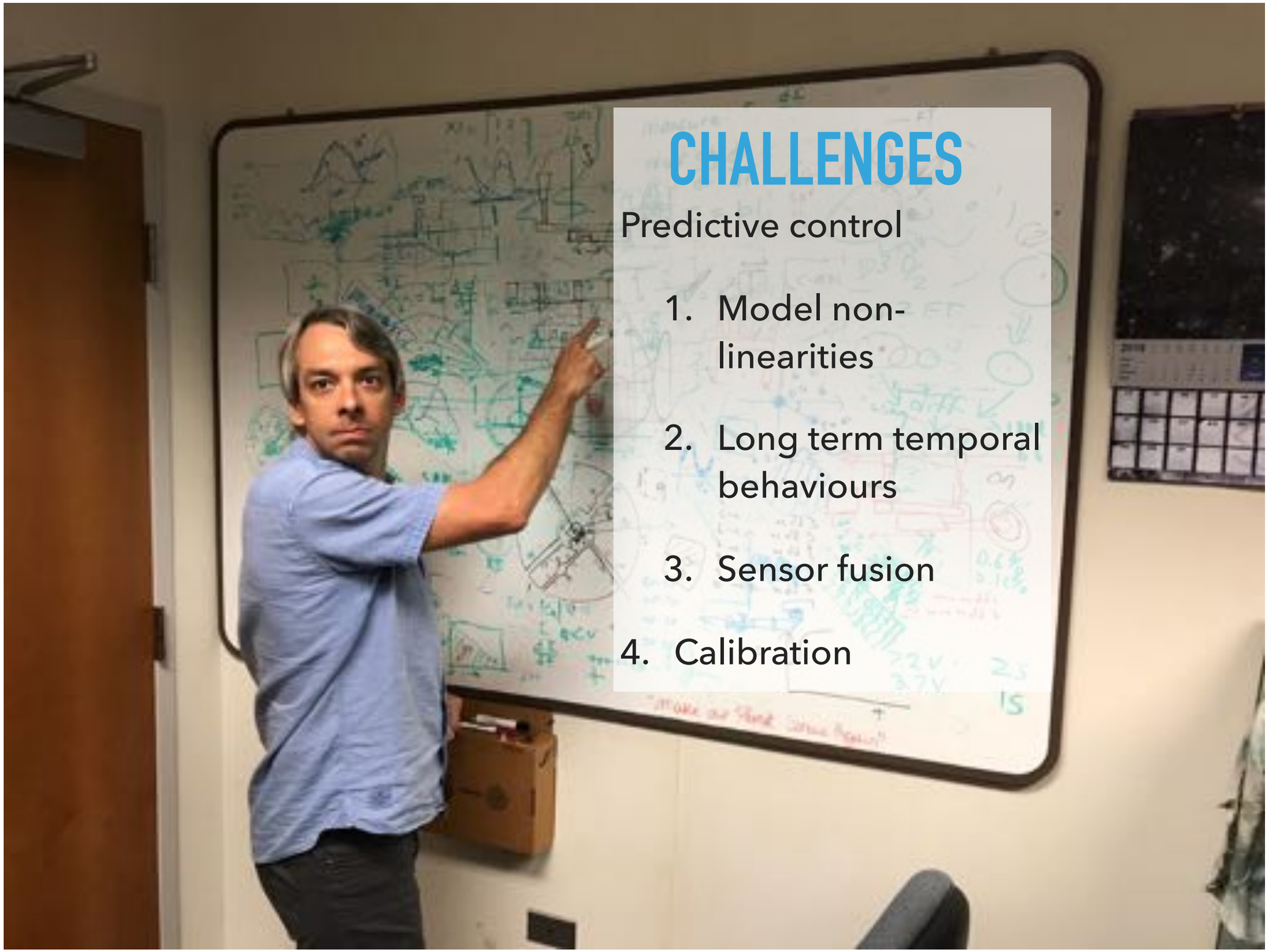
# CONVOLUTIONAL NEURAL NETWORK

Video source: https://www.youtube.com/watch?v=Oqm9vsf_hvU

# PSF PREDICTION

Barnaby Norris

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