Simulated Plant Approach

LIGO Caltech

Koji Arai, Joe Betzwieser,
Peter Kalmus, Rana Adhikari

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"Simulated Plant (SP)"

- An IFO emulator for digital control system

- A time domain simulator realized by realtime codes for the digital control system itself

- Imitating responses of interferometer components

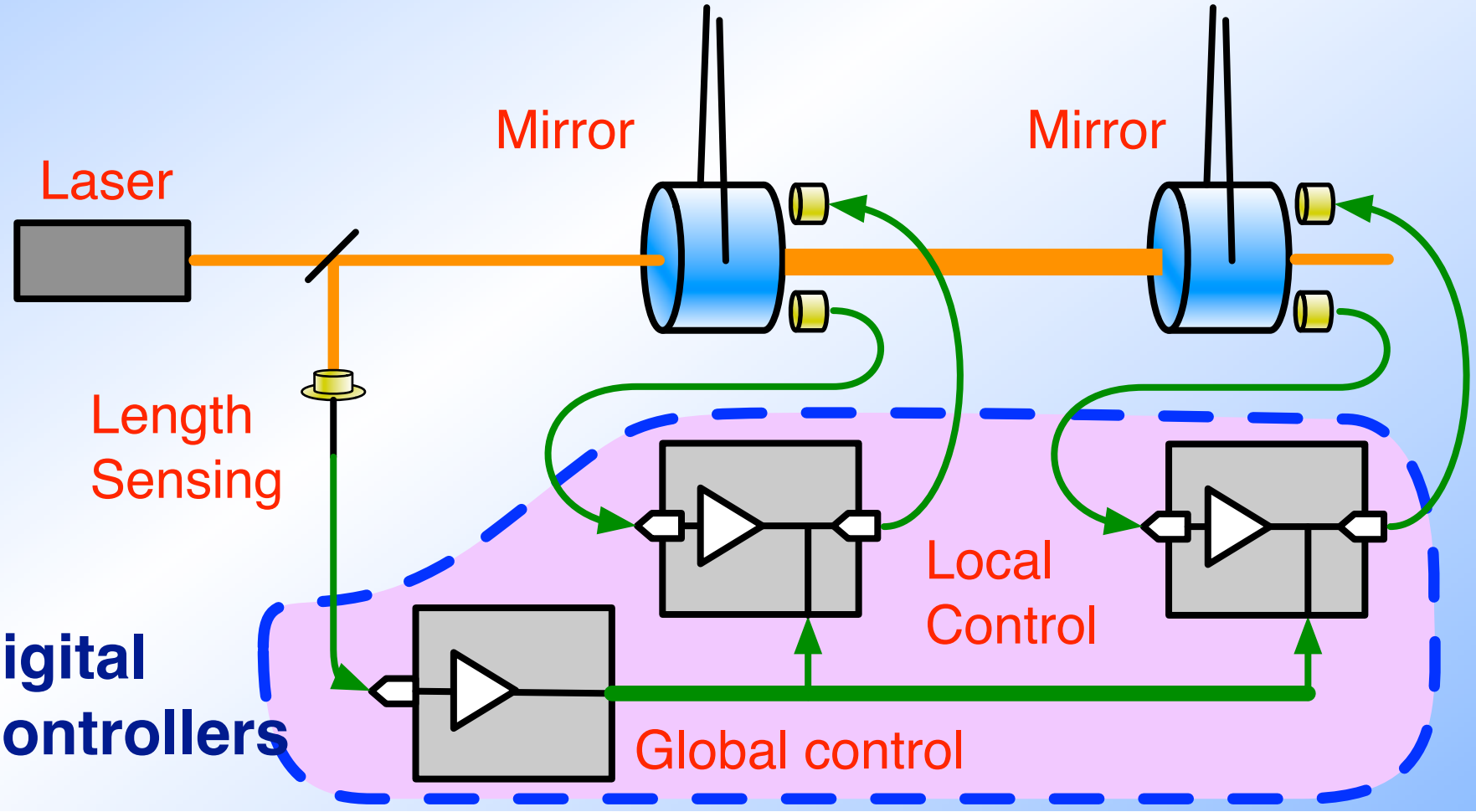
What is it? / Why is it good? / How is it realized?
What has been done at the Caltech 40m IFO

Basic Idea

Interferometer control:

Local control (suspension)

+ Global control (interferometric)



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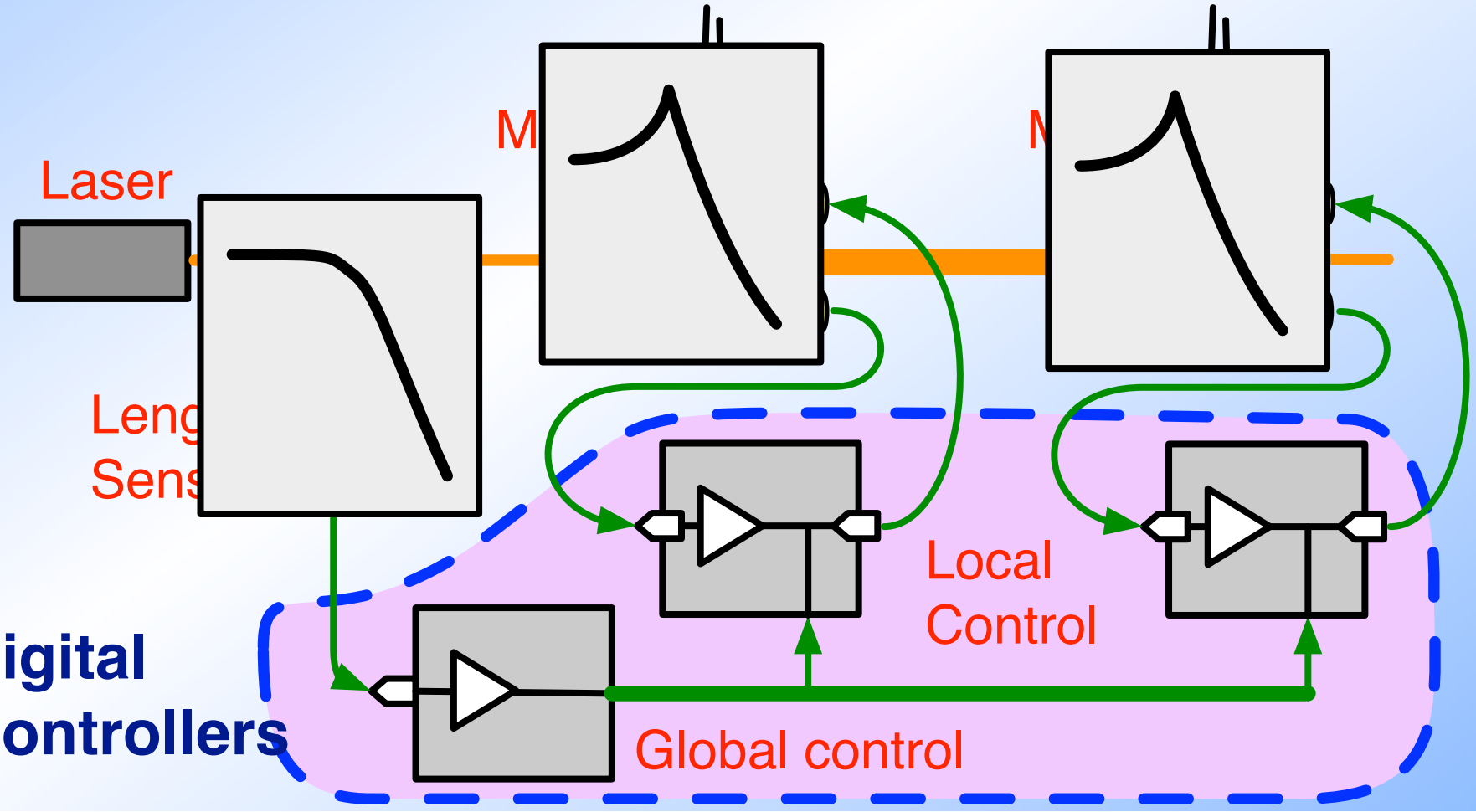
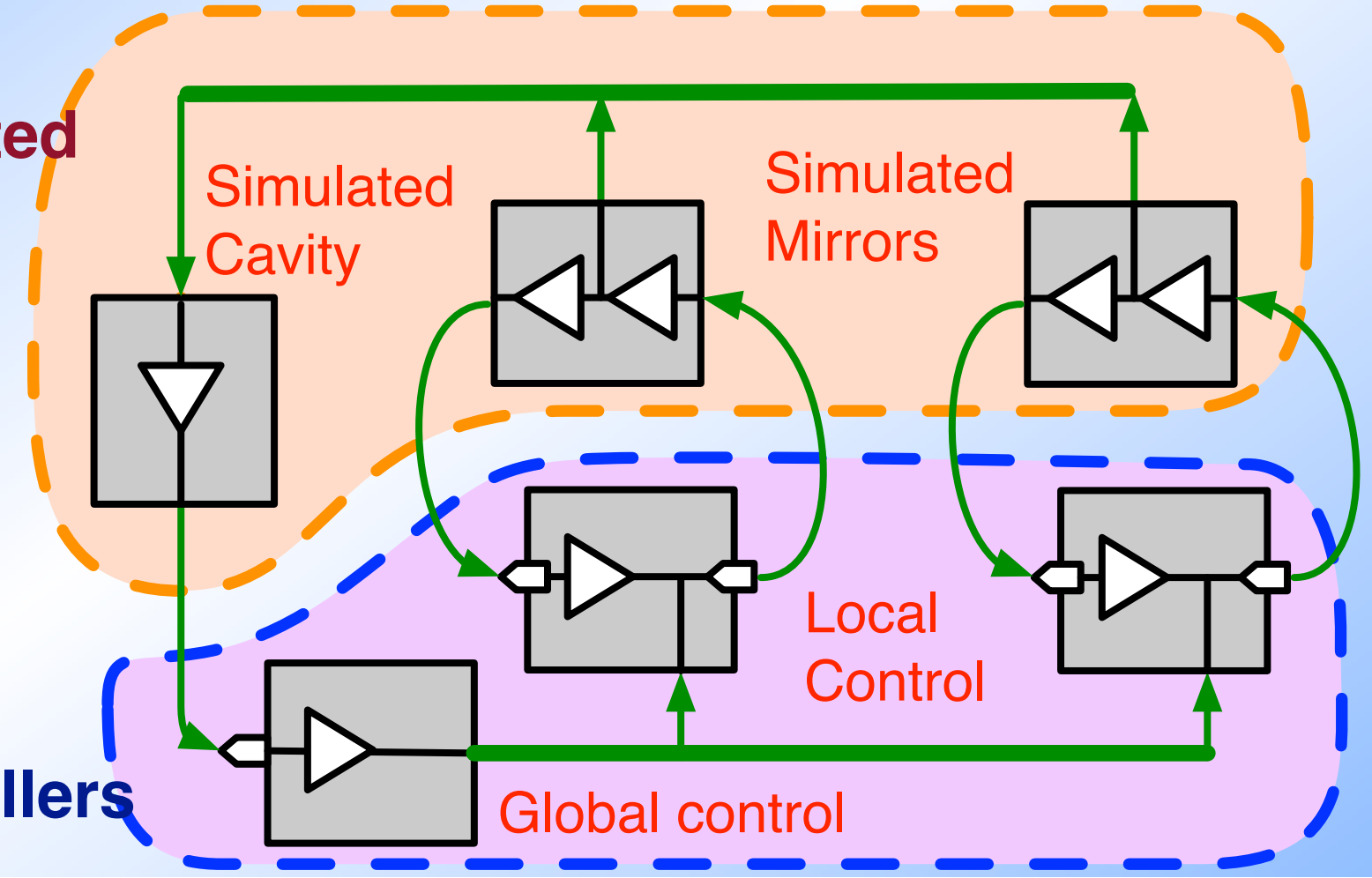


Basic Idea

Replaced hardware responses with digital filters

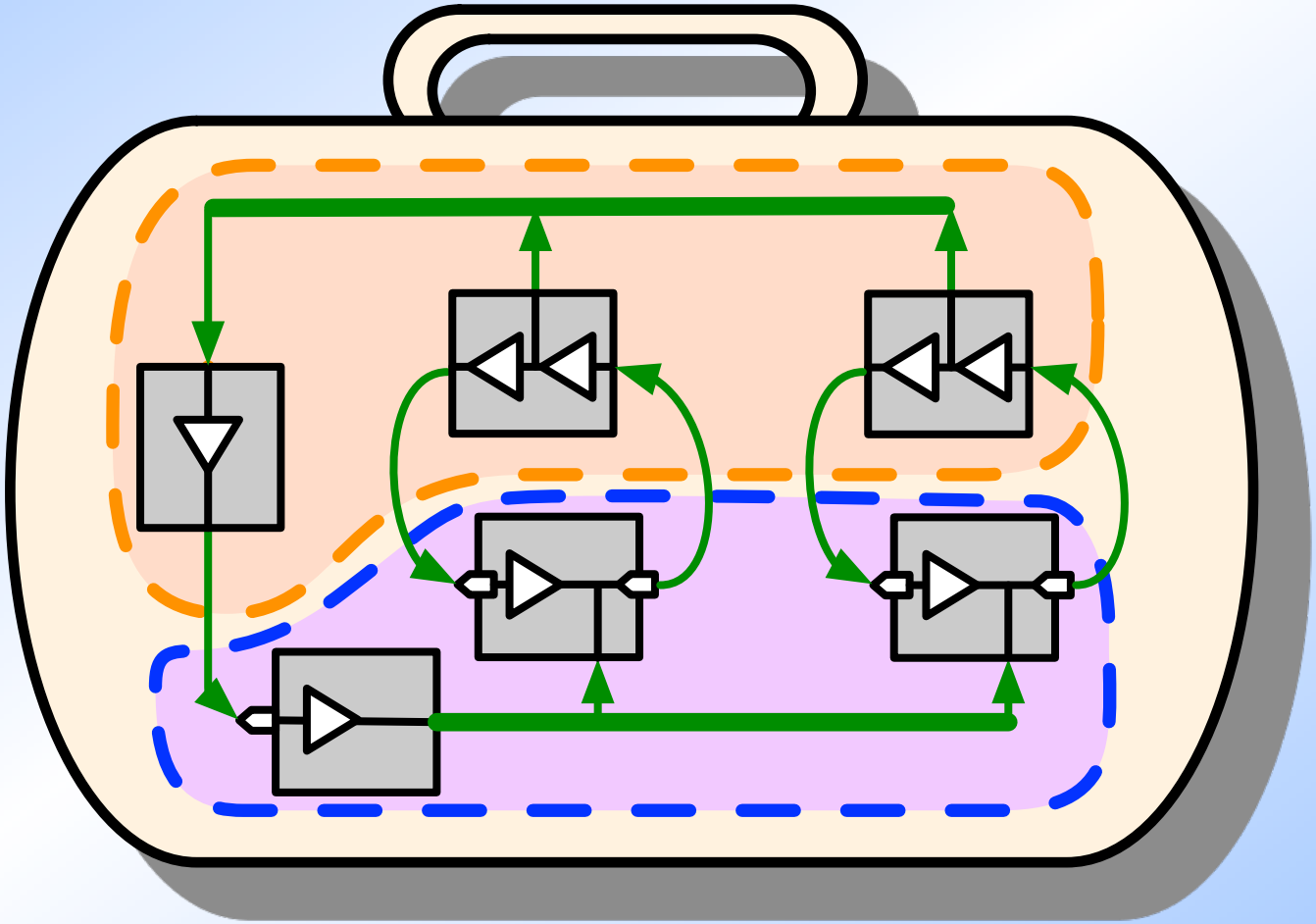
==> simulated plants

The servo loops remains stable



Basic Idea

You may be able to put them even in a single machine!



Simulated Plant version of LIGO?

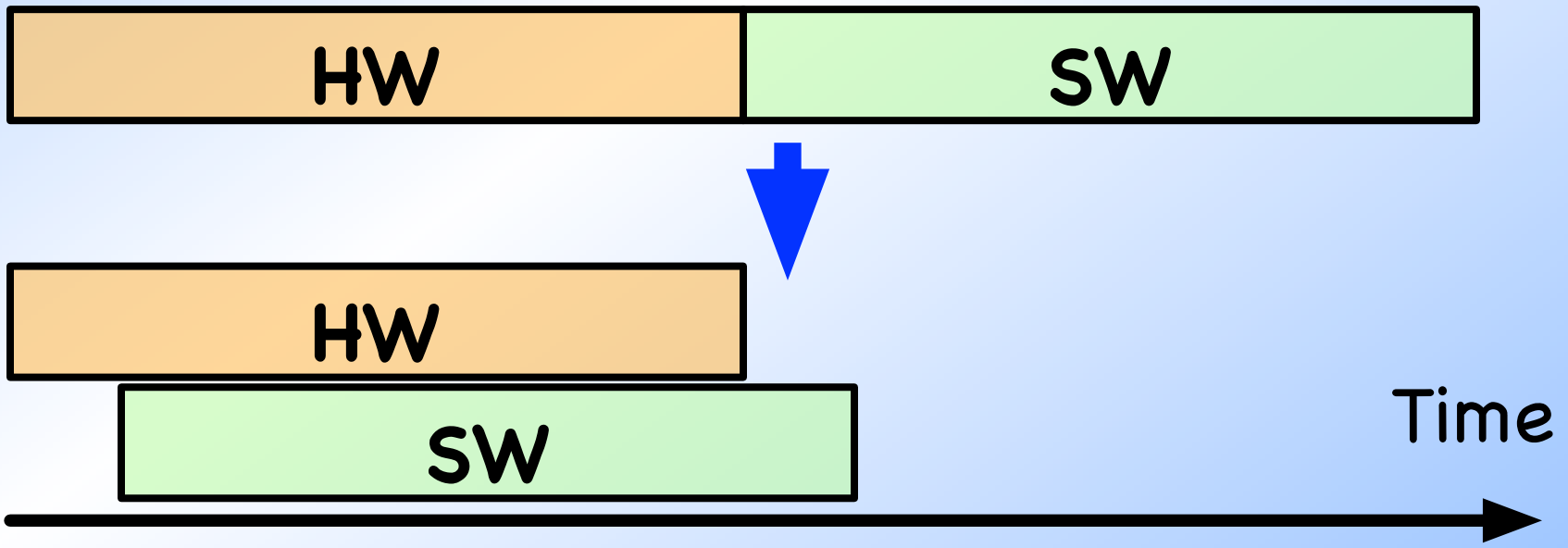
Benefit (1)

- Commissioning time is precious

Make the installation faster!

- Start building the control SW without actual HWs

Realtime codes / Scripts (auto locker / initial alignment)



Benefit (2)

- Commissioning time is still precious

Make it easier and faster

- Separate controller (computer) problems and SW development from the real HW issues

The controllers and its associated SWs must firstly be functional with SP!

Even a simple model is sufficient!

Benefit (3)

- Eventually we face with noise hunting

Make it more convenient

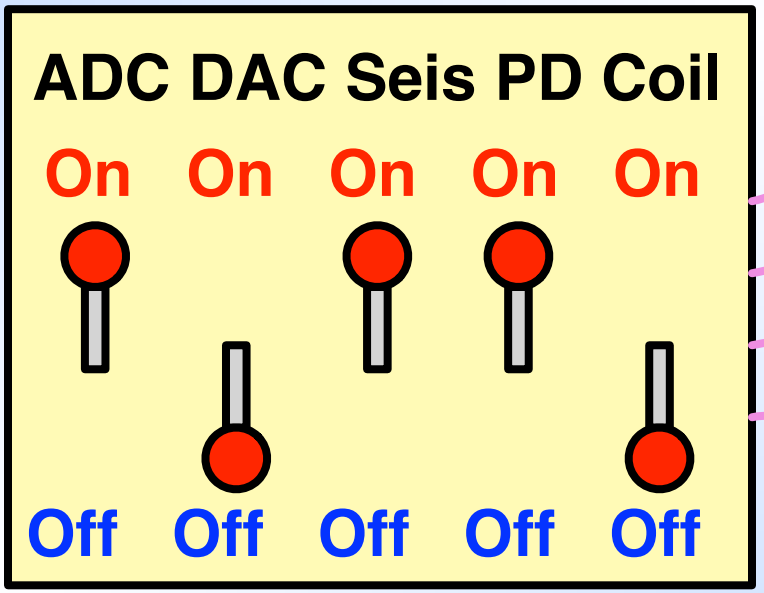
- Build diagnosis SWs offline

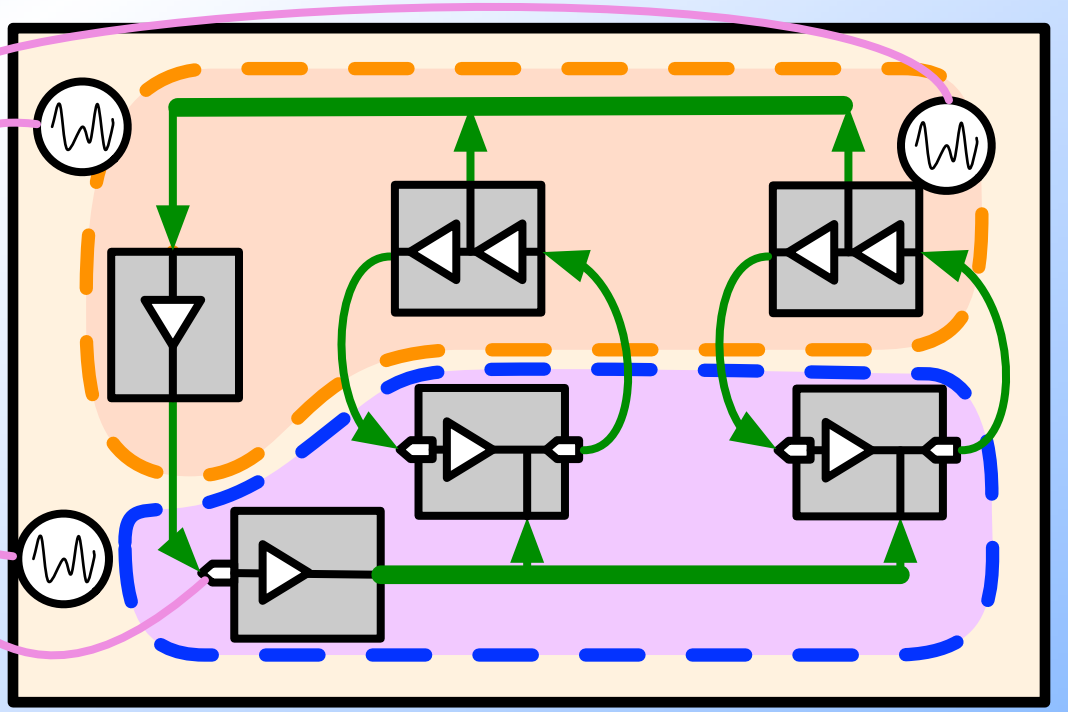
Calibration / Measurement templates / Auto noise budget

- Anticipate the noise spectra / saturations

Noise emulation: ADC / DAC / Electronics / Seismic / Laser

Timing errors





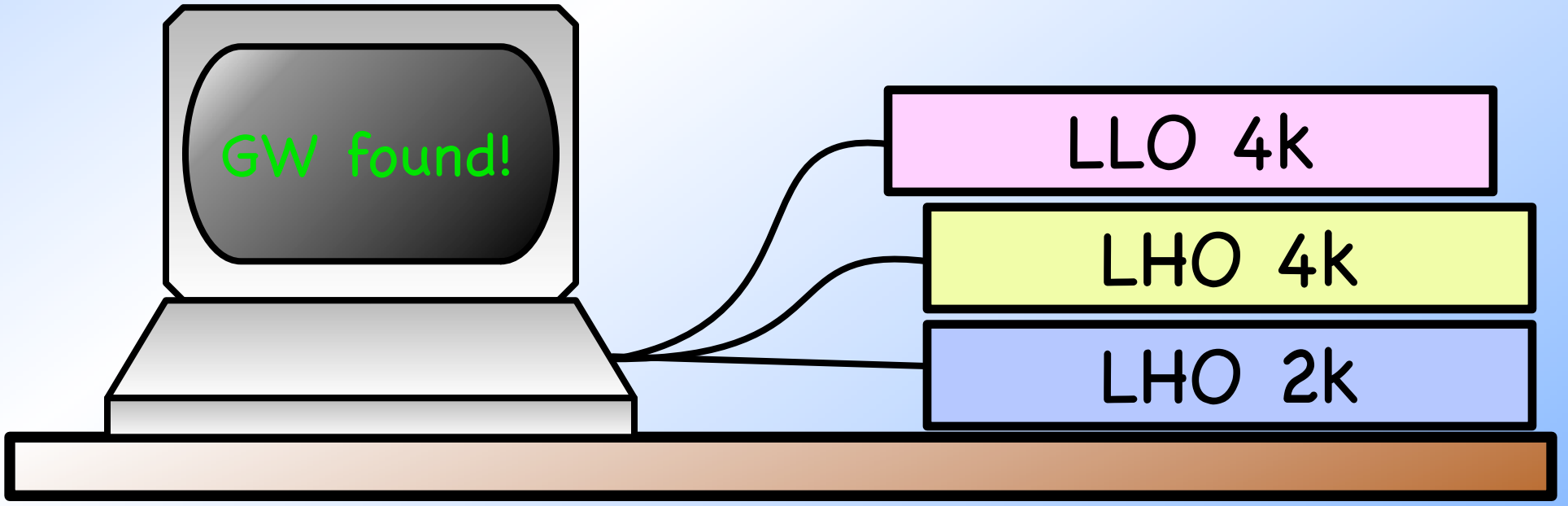
Benefit (4)

- Does SP only help the commissioning guys?

No! It will be useful to the data analysis people too!

HW Injection system / DA pipeline / Online monitor

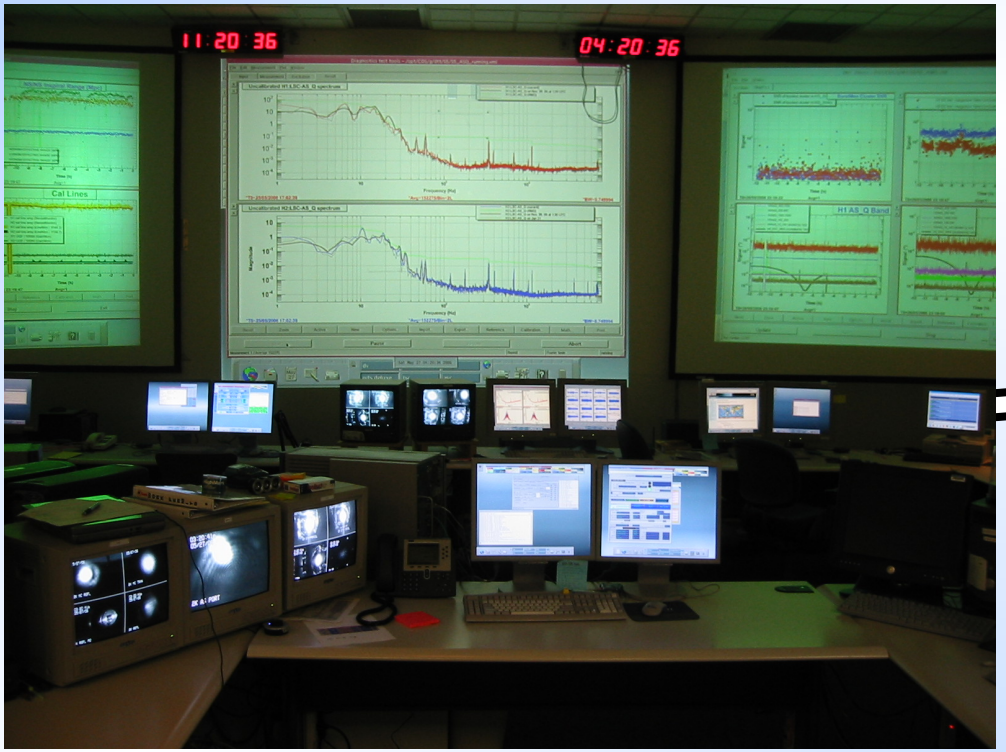
IMAGINE your desk...

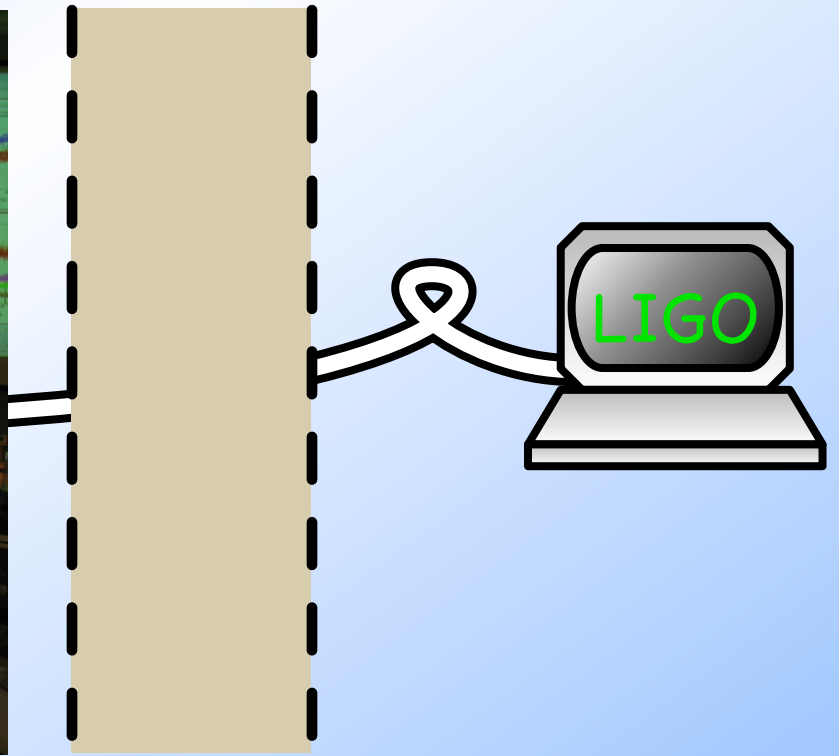


Some extra

- Give a virtual interferometer set to
  old bothering seniors (like me!)

Let younger generations touch the real machine





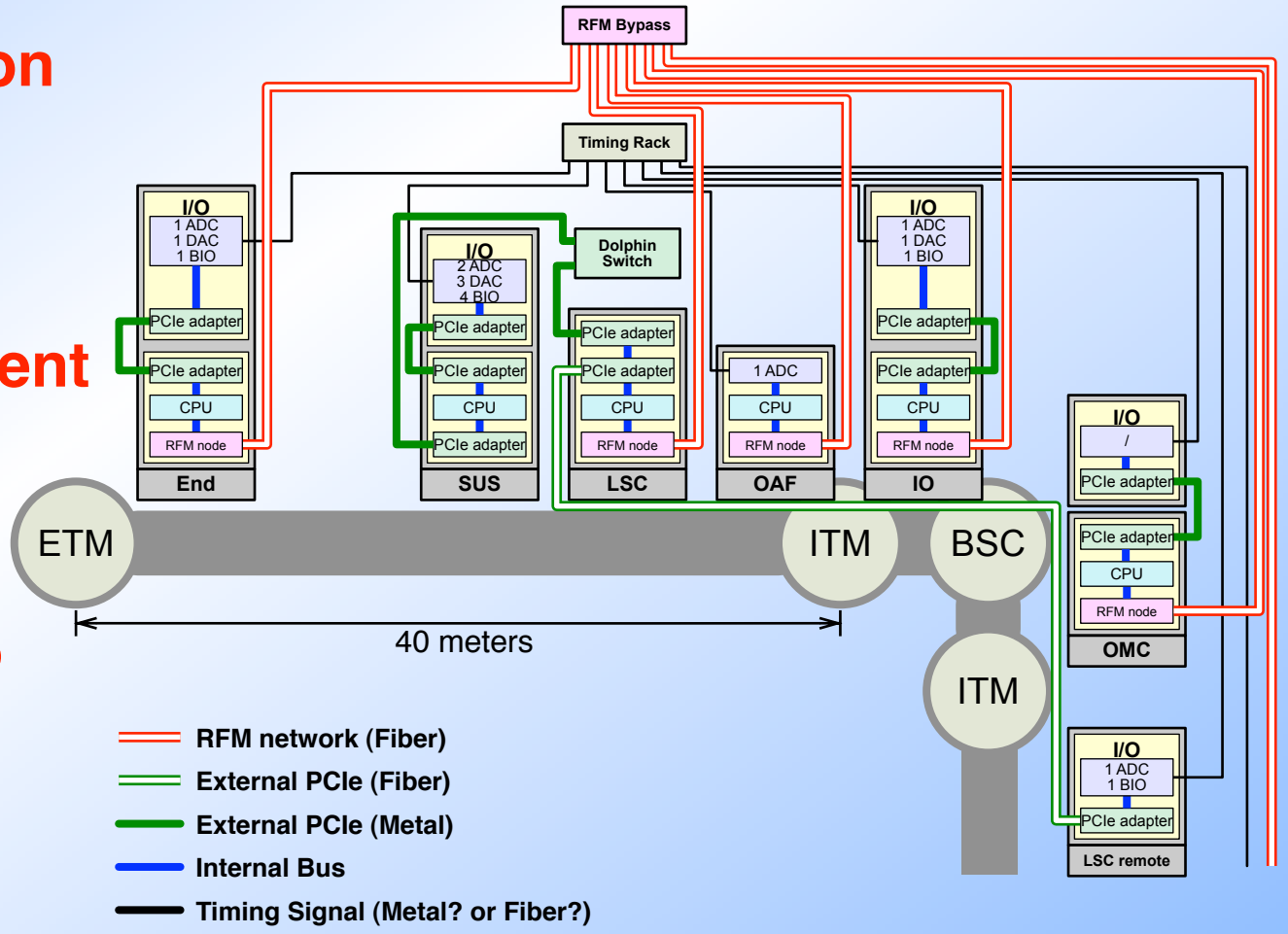
Realization of SP ~ LIGO CDS @ 40m

Major upgrade of the LIGO 40m prototype in progress
~ Advanced LIGO CDS being employed
- distributed machines connected by global shared memory

The HW installation in progress

But we also need the SW development

This is a perfect opportunity to work on the SP

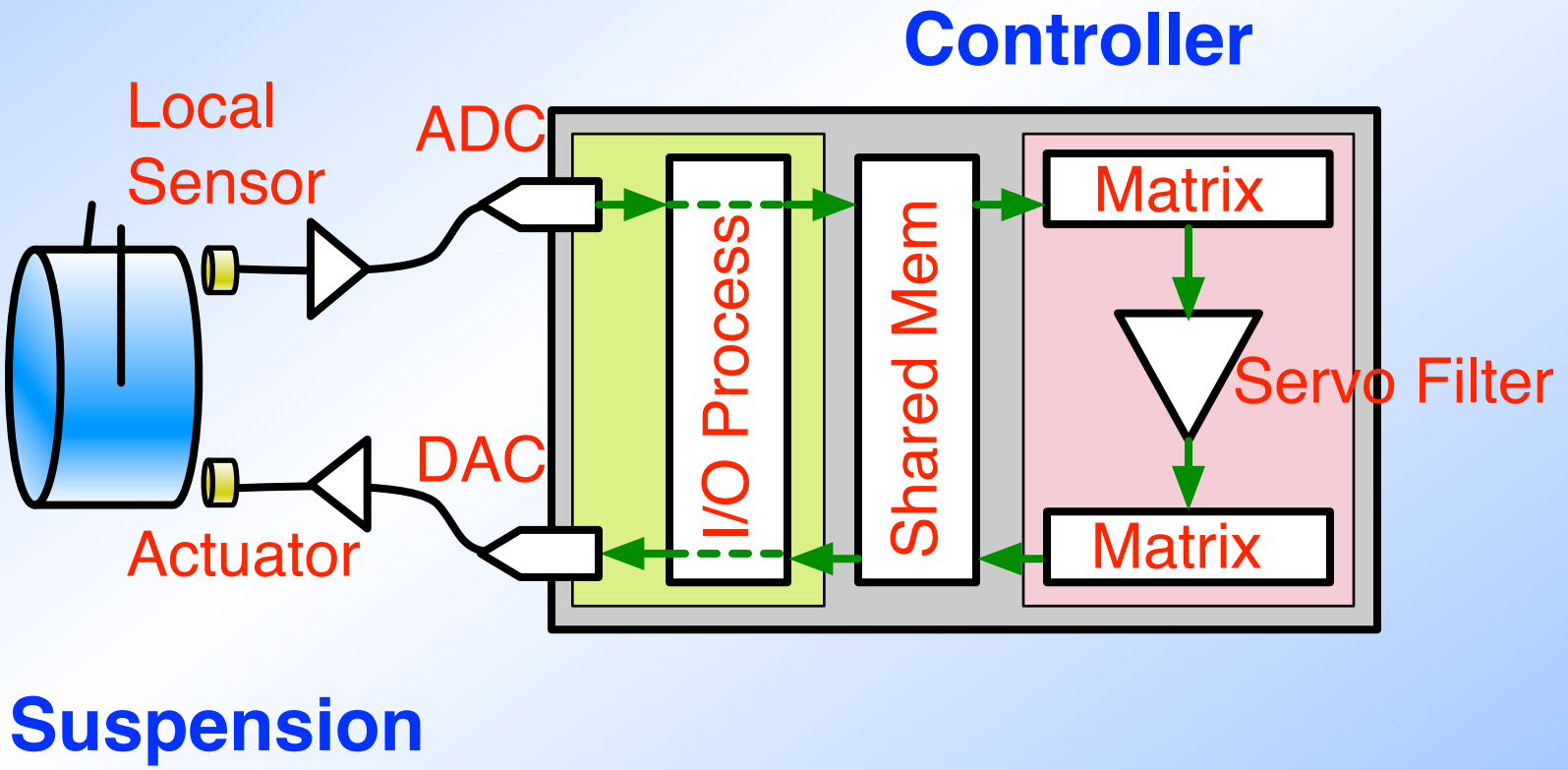


Simulated Plant ~ single machine case

- How to realize SP?

LIGO CDS (Control and Data System)

Suspension Controller

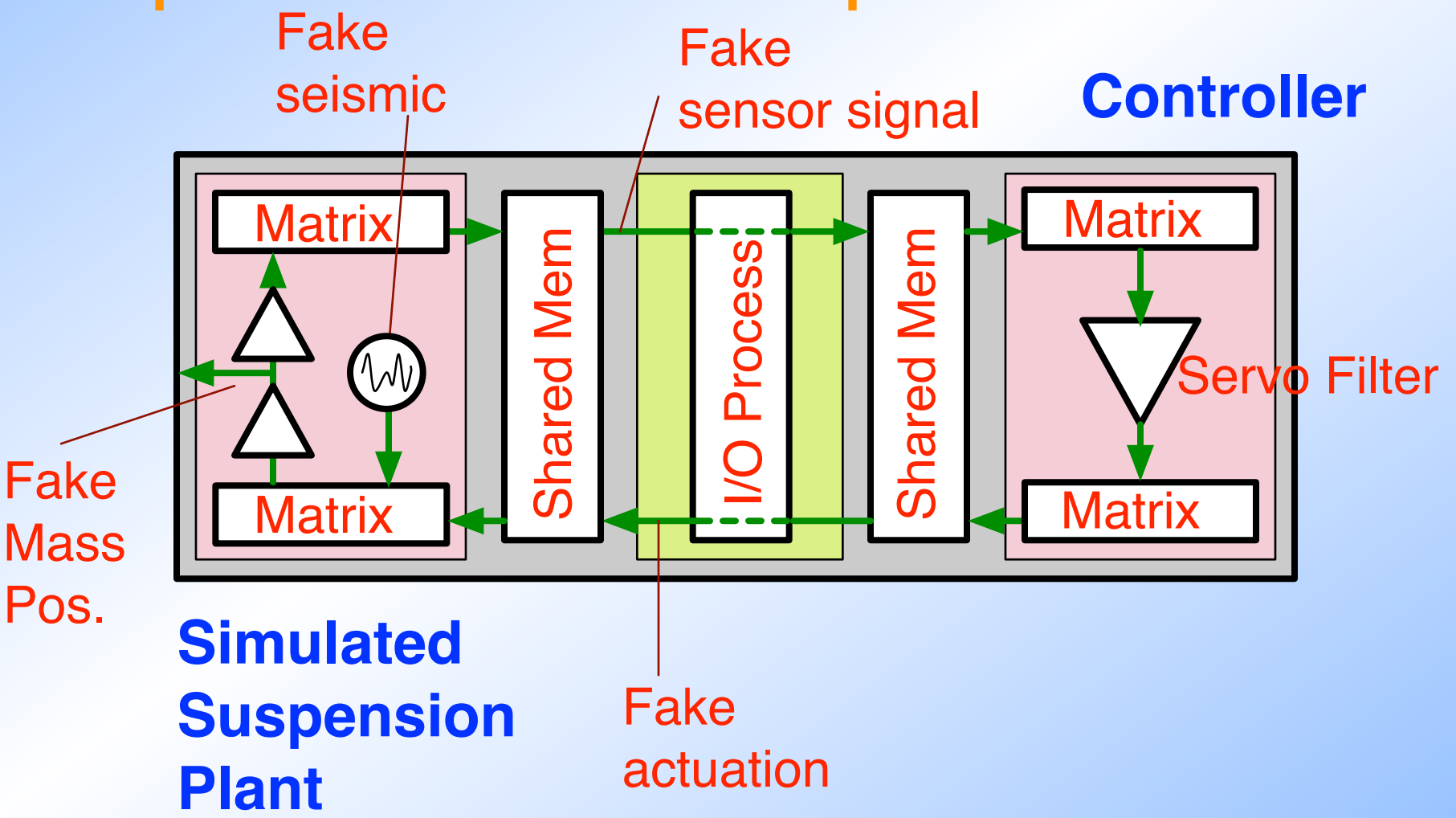


Simulated Plant ~ single machine case

- How to realize SP?

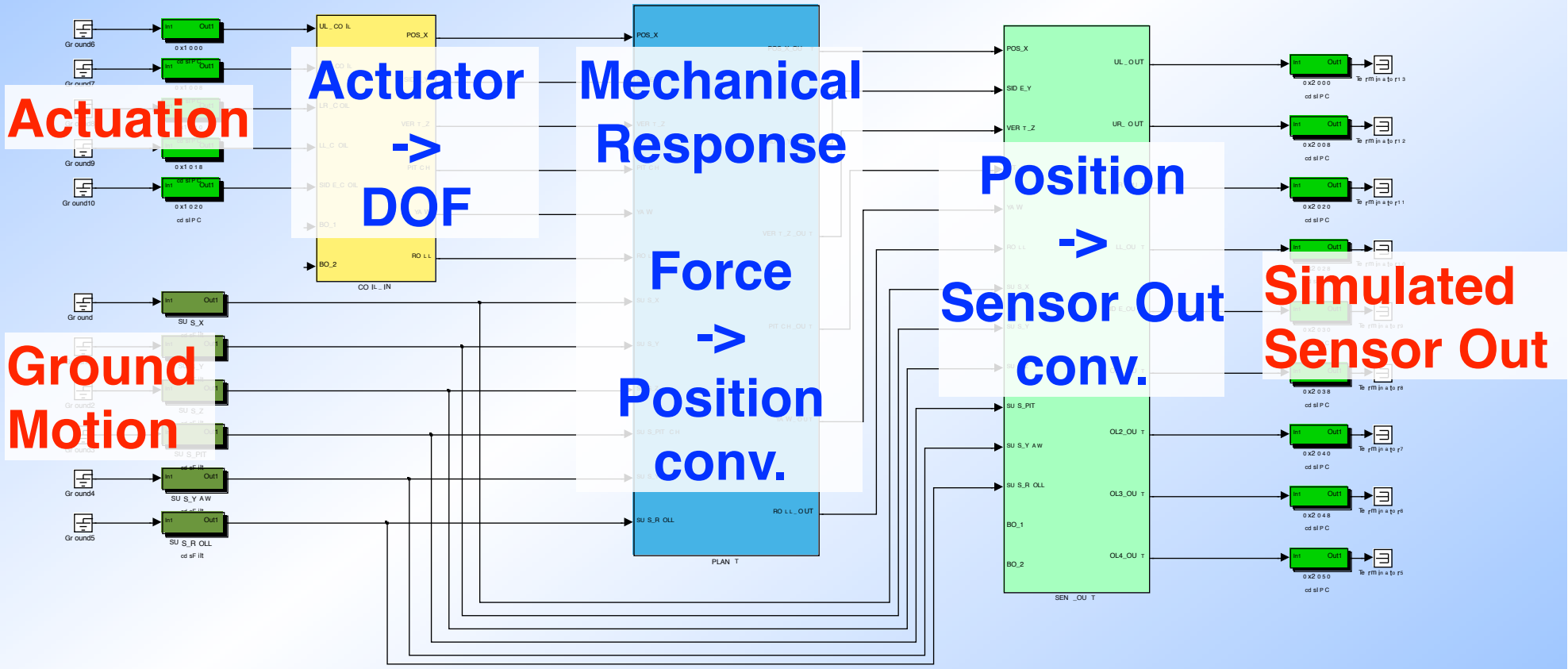
LIGO CDS (Control and Data System)

Suspension Controller / Suspension Plant



Actual Suspension Simulated Plant

Formed by matrices and arrays(or matrices) of filter modules



Actual Suspension Simulated Plant

Formed by matrices and arrays(or matrices) of filter modules

Physics:
Mech. responses = transfer functions

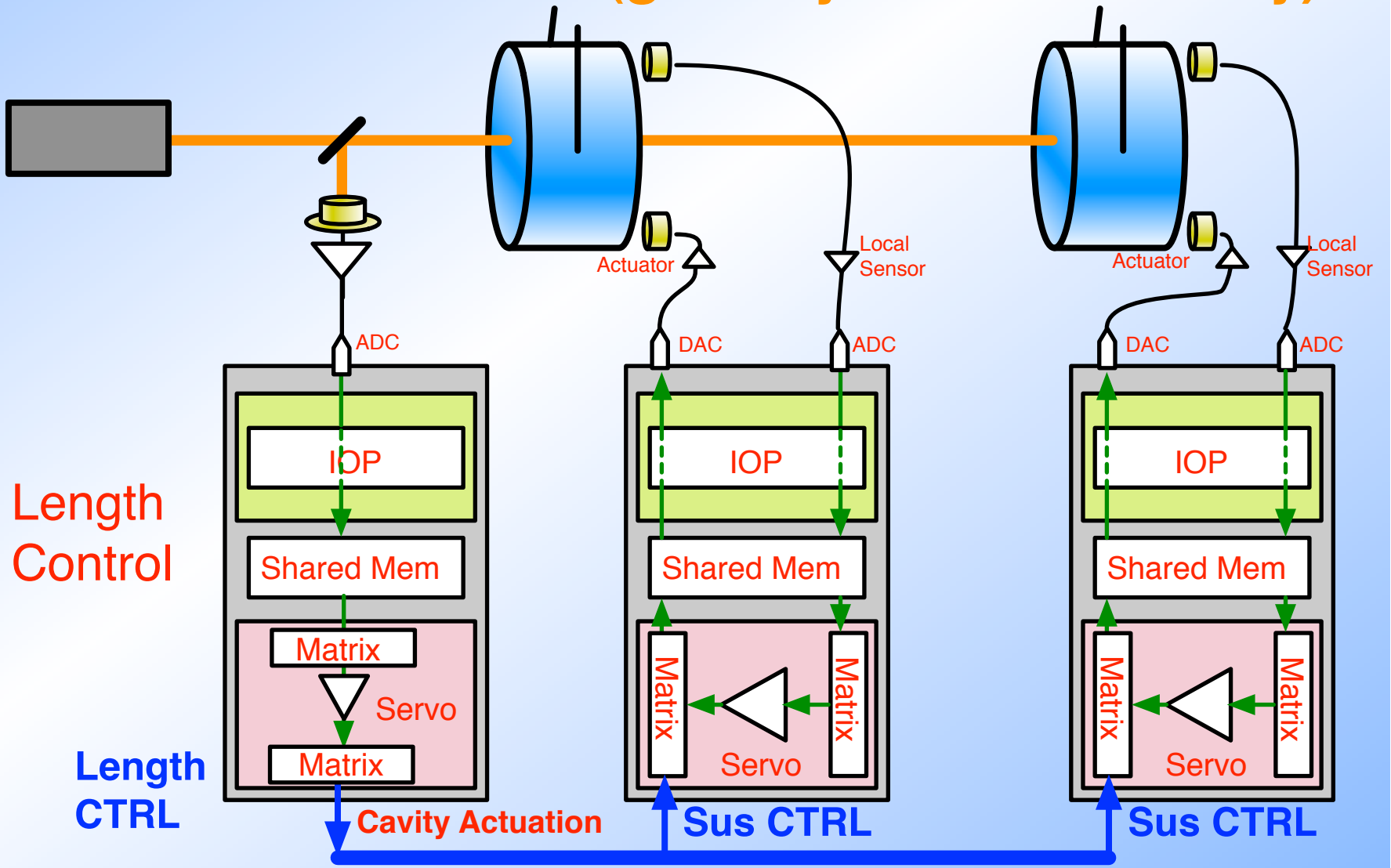
==> the responses are realized by the filters and matrix elements

Once the model is built, it is flexible
i.e. single pendulum, quad pendulum, etc...

Simulated Plant ~ multiple machine case

Length Controller ~ Multiple machine case

RFM/PCIe communication (globally-shared memory)



Simulated Plant ~ multiple machine case

Length Controller ~ Multiple machine case

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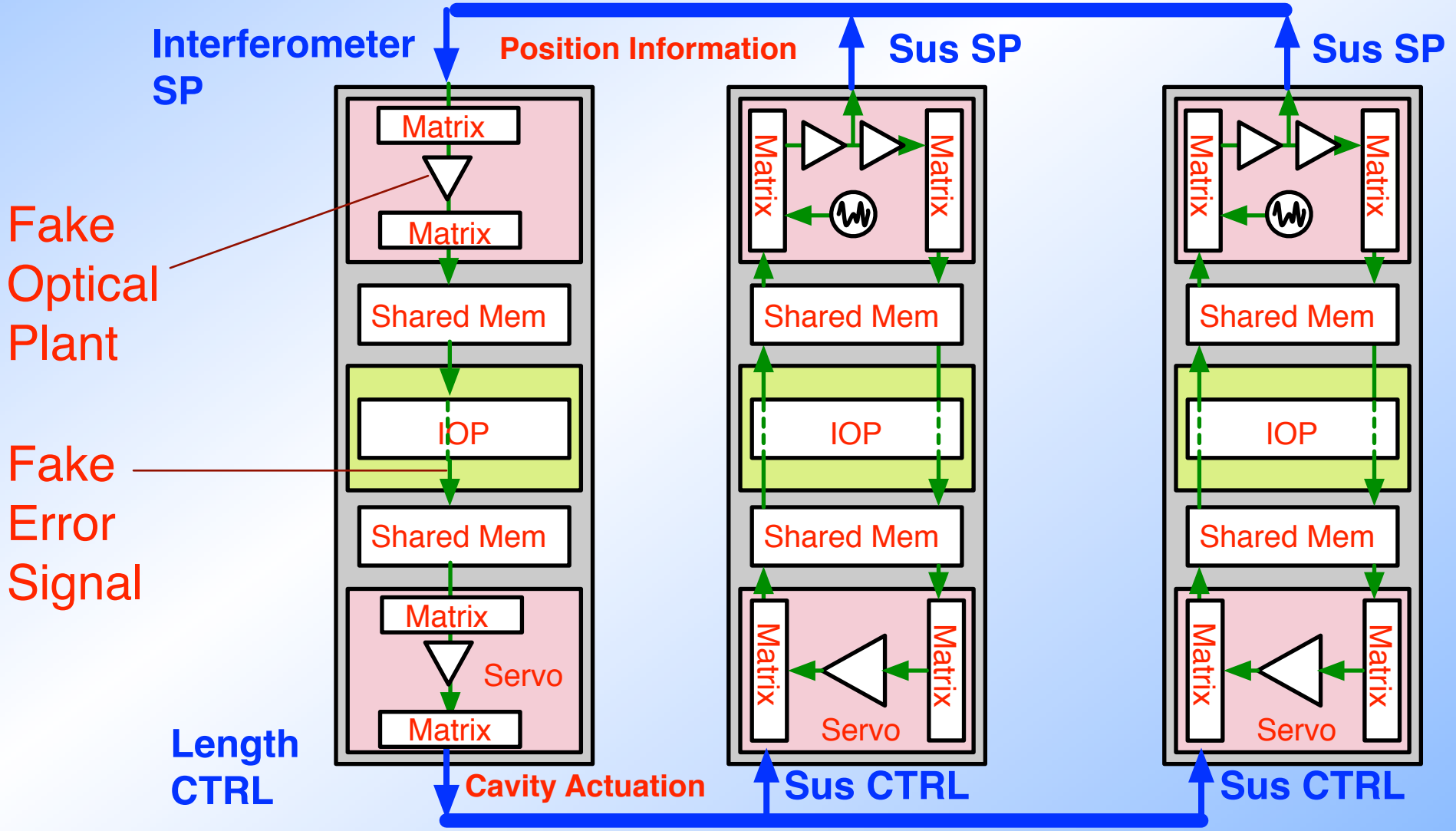
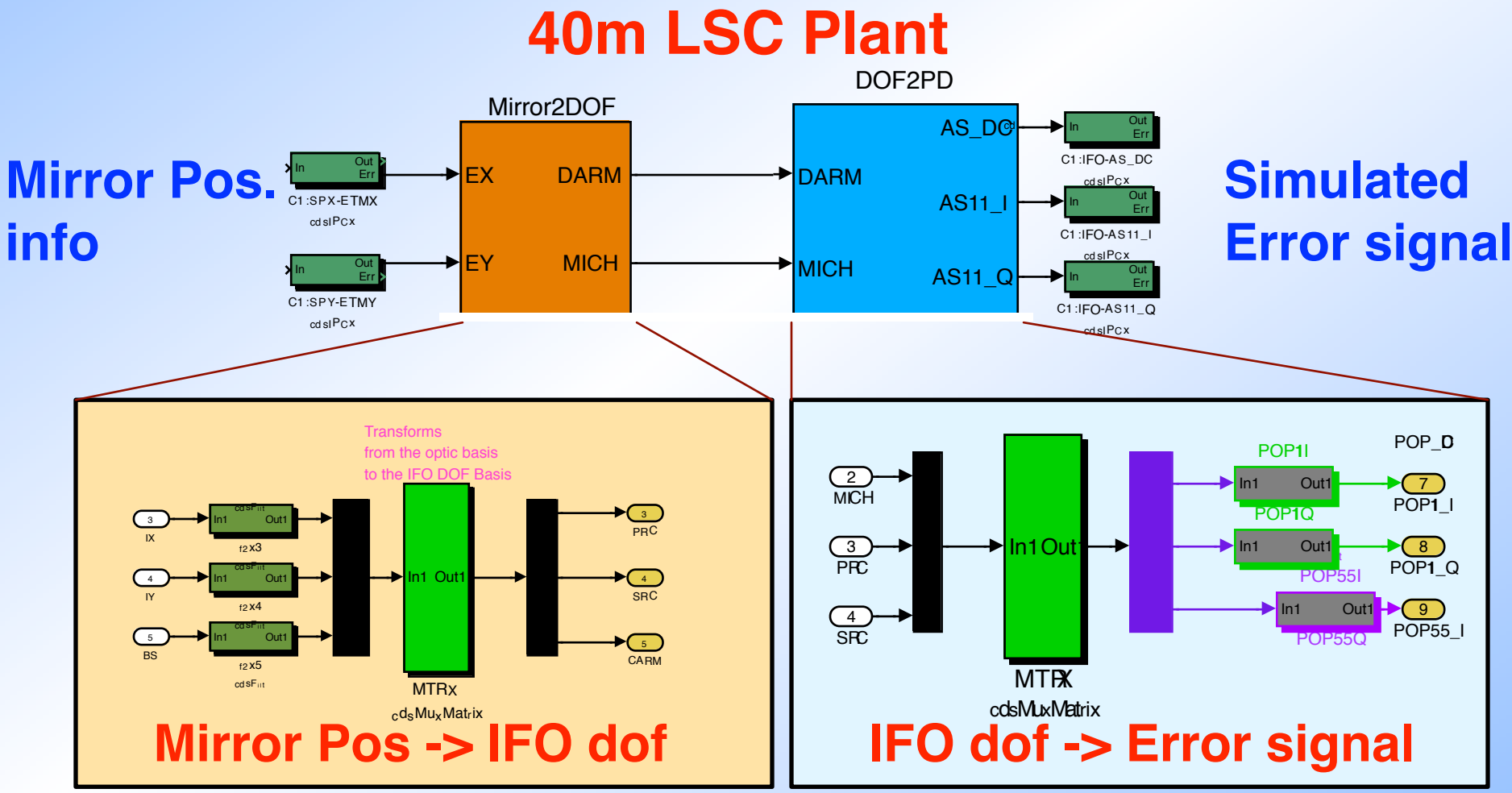


IFO Simulated Plant

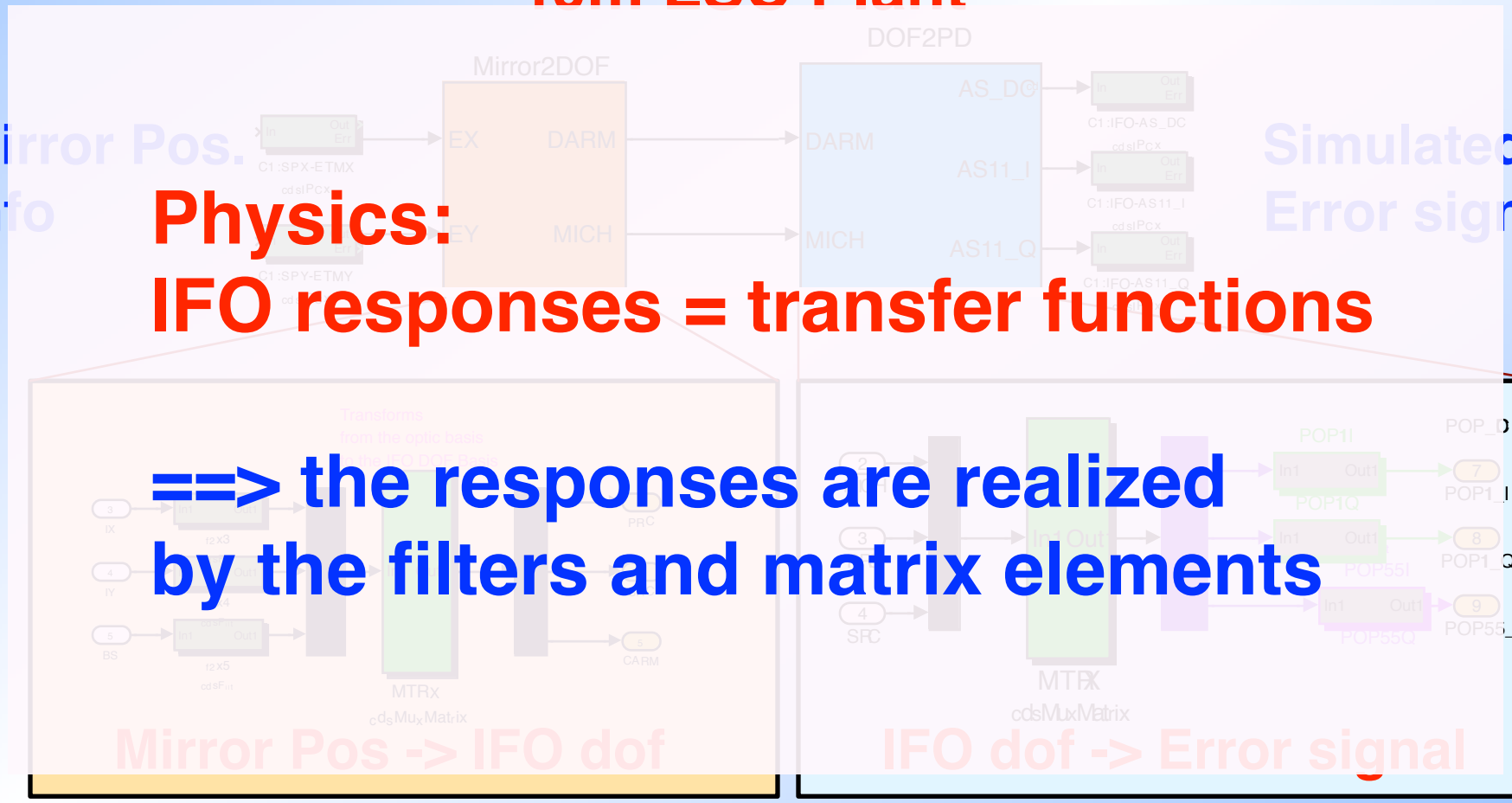
Formed by matrices and arrays(or matrices) of filter modules



IFO Simulated Plant

Formed by matrices and arrays(or matrices) of filter modules

40m LSC Plant



Summary

- Simulated plant: an IFO emulator for commissioning
  Realized by the digital control system itself

- Enables to run IFOs only with the SW
  Will help to squeeze the installation schedule
  Will make the commissioning easier & faster
  Will make the noise hunting easier & faster
  Will help the DA development / tests

- Implementing this idea to the 40m prototype

- We thank for the great supports
by Rolf Bork, Jay Heefner, Alex Ivanov and LIGO CDS group